International Journal of Digital Earth

Story

Slides

Slide 1 The International Journal of Digital Earth
Slide 2 MindTouch Knowledge Base 1
Slide 3 MindTouch Knowledge Base 2
Slide 4 Excel Spreadsheet Knowledge Base
Slide 5 Cover Page
Slide 6 Climate Change: Ensemble Projections-Average
Slide 7 Climate Change: Ensemble Projections-Change
Slide 8 Climate Change: Metadata
Slide 10 Climate Change: Grid Projections-Average A2 SRES Scenario
Slide 11 Climate Change: Grid Projections-Average B1 SRES Scenario
Slide 12 Climate Change: Grid Projections-Average Metadata

Spotfire Dashboard

Research Notes

Data Sources
Digital Earth Summit on Geoinformatics: Tools for Global Change Research
The use cases of digital earth

Process
DIVA-GIS

Documentation
Climate data

Current climate (~1950-2000)
Future climate (2xCO2 climate conditions, CCM3 model)

Free Spatial Data
Country level
Global level
Global climate data
Species occurrence data
Crop (genebank) collection data
Near global 90 meter resolution elevation data
High resolution satellite images (LandSat)
A very good list
Climate Change Knowledge Portal: Ensemble Projections
International Journal of Digital Earth
Society information
Aims & scope
Overview
Thoughts on International Journal of Digital Earth
STAR
Disclaimer
Publication models and dates explained
Article history dates on Taylor & Francis Online
Routes to rapid online publication
Volume 7 2014
Issue 6 2014 pages 432-509
Geometrically modeling 2D scattered points: a review of the potential for methodologically improving mobile laser scanning in data processing
StarFL – a modularised metadata language for sensor descriptions
Simulated impacts of 3D urban morphology on urban transportation in megacities: case study in Beijing
Evaluation of different machine learning methods for land cover mapping of a Mediterranean area using multi-seasonal Landsat images and Digital Terrain Models
Issue 5 2014 pages 351-431
Spectral sensitivity of ALOS, ASTER, IKONOS, LANDSAT and SPOT satellite imagery intended for the detection of archaeological crop marks
Pervasive geo-security – a lightweight triple-A approach to securing distributed geo-service infrastructures
Coupling the 4M crop model with national geo-databases for assessing the effects of climate change on agro-ecological characteristics of Hungary
Enrichment of topographic road database for the purpose of routing and navigation
Issue 4 2014 pages 253-350
Analytical geospatial Digital Earth
Enhancing accessibility to web mapping systems with technology-aligned adaptive profiles
Using GIS to develop a mobile communications network for disaster-damaged areas
An open source, server-side framework for analytical web mapping and its application to health
Mapping ideas from cyberspace to realspace: visualizing the spatial context of keywords from web page search results
Multi-frame and multi-dimensional historical digital cities: the Como example
Issue 3 2014 pages 175-252
Building the World Wide Hypermap (WWH) with a RESTful architecture
Evaluation of diverse classification approaches for land use/cover mapping in a Mediterranean region utilizing Hyperion data
Using SPOT 5 fusion-ready imagery to detect Chinese tamarisk (saltcedar) with mathematical morphological method
A classification of water erosion models according to their geospatial characteristics
A changing environment for human security

Issue 2 2014 pages 93-174

Methods to extract impervious surface areas from satellite images
Remote sensing-based global crop monitoring: experiences with China's CropWatch system
A novel method for discovering spatio-temporal clusters of different sizes, shapes, and densities in the presence of noise
Remote sensing image fusion: an update in the context of Digital Earth
Only one Earth: the long road via Rio to sustainable development

Issue 1 2014 pages 1-92

Digital Earth: Big Earth Data
Advancing Digital Earth: beyond the next generation
Towards geospatial semantic search: exploiting latent semantic relations in geospatial data
A stream-based Parasitic Model for implementing Mobile Digital Earth
Web-based visualization of large 3D urban building models
A framework design for the Chinese National Disaster Reduction System of Systems (CNDRSS)
Does DE need a C? A proposal for a DE curriculum

Volume 6 2013

Supp 2 2013 pages 1-171

Opening the black box of donor influence on Digital Earth in Africa
Integration of hydrological observations into a Spatial Data Infrastructure under a Sensor Web environment
Integrated geoscience databanks for interactive analysis and visualization
First extensive and cost-effective quality check of Crisis Maps: presentation of assessment parameters and results
Results from a comprehensive GPS Network: natural gas pipeline GPS Network
Using remote sensing to assess impacts of land management policies in the Ordos rangelands in China
A Low-Cost Mobile Mapping System (LCMMS) for field data acquisition: a potential use to validate aerial/satellite building damage assessment
An object-based approach for flood area delineation in a transboundary area using ENVISAT ASAR and LANDSAT TM data
Multi-temporal remote sensing of land cover change and urban sprawl in the coastal city of Yantai, China
A digital lightning prototype system: DLPS/HUST

Supp 1 2013 pages 1-171
Recent progress in land remote sensing: algorithms and products
A long-term Global LAnd Surface Satellite (GLASS) data-set for environmental studies
Estimating global land surface broadband thermal-infrared emissivity using advanced very high resolution radiometer optical data
Preliminary validation of GLASS-DSSR products using surface measurements collected in arid and semi-arid regions of China
Preliminary evaluation of the long-term GLASS albedo product
Field validation of the GLASS land surface broadband emissivity database using pseudo-invariant sand dune sites in northern China
Land-surface temperature retrieval at high spatial and temporal resolutions based on multi-sensor fusion
Improving a Penman–Monteith evapotranspiration model by incorporating soil moisture control on soil evaporation in semiarid areas
A cloud detection method based on a time series of MODIS surface reflectance images

Issue 6 2013 pages 521-ebi
FROM-GC: 30 m global cropland extent derived through multisource data integration
Lake variations in response to climate change in the Tibetan Plateau in the past 40 years
Monitoring nitrogen concentration of oilseed rape from hyperspectral data using radial basis function
Analysing urban dynamics using multi-temporal satellite images in the case of a mountain area, Sinaia (Romania)
Developing a geospatial web-GIS system for landscape and urban planning
Application of digital techniques to identify aquifer artificial recharge sites in GIS environment
Precision agriculture for grain production systems

Editorial Board

Issue 5 2013 pages 427-520

Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS vegetation continuous fields with lidar-based estimates of error
Application of remote sensing for investigating mining geological hazards
Construction of a virtual lunar environment platform
Visualization of geologic geospatial datasets through X3D in the frame of WebGIS
Assessment of different topographic correction methods in ALOS AVNIR-2 data over a forest area

Issue 4 2013 pages 297-425

Redefining the possibility of digital Earth and geosciences with spatial cloud computing
Cloud computing for integrated stochastic groundwater uncertainty analysis
Utilize cloud computing to support dust storm forecasting
Prototyping an open environment for sharing geographical analysis models on cloud computing platform
Enabling Digital Earth simulation models using cloud computing or grid computing – two approaches supporting high-performance GIS simulation frameworks
Geoprocessing in Cloud Computing platforms – a comparative analysis

**Issue 3 2013 pages 203-296**

- Generation of high spatial and temporal resolution NDVI and its application in crop biomass estimation
- Remote sensing detection and verification of disappeared reservoirs along the Grand Canal of China
- A RESTful proxy and data model for linked sensor data
- Full polarimetric PALSAR-based land cover monitoring in Cambodia for implementation of REDD policies
- Assessment of surface and subsurface waterlogging, water level fluctuations, and lithological variations for evaluating groundwater resources in Ganga Plains

**Issue 2 2013 pages 103-201**

- SAR polarimetric change detection for flooded vegetation
- Exploring natural and anthropogenic risk for cultural heritage in Cyprus using remote sensing and GIS
- Mapping salt diapirs and salt diapir-affected areas using MLP neural network model and ASTER data
- Optimizing artificial neural network-based indoor positioning system using genetic algorithm
- GEOID: GRID Services for Earth Observation Image Data Processing
- Transferring Google Earth observations to GIS-software: example from gully erosion study

**Issue 1 2013 pages 1-102**

- Making Digital Earth on Earth
- Effects of LIDAR DEM resolution in hydrodynamic modelling: model sensitivity for cross-sections
- VGIS-AntiJitter: an effective framework for solving jitter problems in virtual geographic information systems
- Modeling the spread of spatio-temporal phenomena through the incorporation of ANFIS and genetically controlled cellular automata: a case study on forest fire
- Determining oil slick thickness using hyperspectral remote sensing in the Bohai Sea of China
- A tree counting algorithm for precision agriculture tasks

**Volume 5 2012**

**Issue 6 2012 pages 461-ebi**

- Monthly soil erosion monitoring based on remotely sensed biophysical parameters: a case study in Strymonas river basin towards a functional pan-European service
- Maize drought disaster risk assessment of China based on EPIC model
- List of Reviewers
- Editorial Board

**Issue 5 2012 pages 373-459**

- Global characterization and monitoring of forest cover using Landsat data: opportunities and challenges
Digital Earth from vision to practice: making sense of citizen-generated content
Harmonisation requirements and capabilities towards a European spatial data infrastructure (ESDI): the HUMBOLDT protected areas scenario
Seasonal dynamic pattern analysis on global FPAR derived from AVHRR GIMMS NDVI
Drought: past problems and future scenarios
Coal and peat fires: a global perspective: Volume 1: Coal–geology and combustion

Issue 4 2012 pages 283-371
Comparing spatiotemporal patterns in Eurasian FPAR derived from two NDVI-based methods
Satellite detection of increases in global land surface evapotranspiration during 1984–2007
Simulation analysis on the relationship between the leaf area index and polarimetric parameters of crops
Evaluation of environmental parameters in logistic regression models for landslide susceptibility mapping
Addressing administrative units in international tsunami early warning systems: shortcomings in international geocode standards

Issue 3 2012 pages 185-281
China's Earth observing satellites for building a Digital Earth
The application of China's land observation satellites within the framework of Digital Earth and its key technologies
Technical system design and construction of China's HJ-1 satellites
Engineering survey of the Environment and Disaster Monitoring and Forecasting Small Satellite Constellation
Overview of the key technologies for high-resolution satellite mapping
Earth observation satellite data receiving, processing system and data sharing
Improvements on global meteorological observations from the current Fengyun 3 satellites and beyond
The HY-2 satellite and its preliminary assessment

Issue 2 2012 pages 91-183
A novel approach for constructing a 3D model based on registering a mono image on a 3D model, applicable in Digital Earth
Modelling stratified forest attributes using optical/LiDAR features in a central European landscape
Estimation of the evaporative losses from Lake Nasser, Egypt using optical satellite imagery
Municipal solid waste landfill site selection for the city of Şanlıurfa-Turkey: an example using MCDA integrated with GIS
A new trapezoidal-mesh based data model for spatial operations

Issue 1 2012 pages 1-90
Digital Earth: a new challenge and new vision
Digital Earth 2020: towards the vision for the next decade
NIBU: a new approach to representing and analysing interior utility networks within 3D geoinformation systems
The challenges of developing an open source, standards-based technology stack to deliver the latest UK climate projections

Land cover mapping applications with MODIS: a literature review

Remote sensing and GIS technologies for monitoring and prediction of disasters

Volume 4 2011

Supp 1 2011 pages 1-130

Validation of EO-derived information for crisis management: a Digital Earth perspective in the VALgEO expert community

Development and implementation of a validation protocol for crisis maps: reliability and consistency assessment of burnt area maps

Generalisation, symbol specification and map evaluation: feedback from research done at COGIT laboratory, IGN France

Validation of GIS layers in the EU: getting adapted to available reference data

The independent service validation in GMES RESPOND: the flood validation exercise

Quality control, validation and user feedback of the European Flood Alert System (EFAS)

Monitoring changes in the Menik Farm IDP camps in Sri Lanka using multi-temporal very high-resolution satellite data

Analysis of built-up spatial pattern at different scales: can scattering affect map accuracy?

Mapping urban building stocks for vulnerability assessment – preliminary results

Issue 6 2011 pages 449-ebi

A capability matching and ontology reasoning method for high precision OGC web service discovery

Parallel algorithm for viewshed analysis on a modern GPU

Mapping alteration minerals using sub-pixel unmixing of ASTER data in the Sarduiyeh area, SE Kerman, Iran

Modelling and mapping third dimension in a spatial database

Analysis of the factors affecting LiDAR DTM accuracy in a steep shrub area

Editorial Board

Issue 5 2011 pages 365-447

A time series for monitoring vegetation activity and phenology at 10-daily time steps covering large parts of South America

Applicability of SRTM data for landform characterisation and geomorphometry: a comparison with contour-derived parameters

Preliminary study of a cluster-based open-source parallel GIS based on the GRASS GIS

Geospatial predictive modelling of the Neolithic archaeological sites of Magnesia in Greece

European digital archive on soil maps (EuDASM): preserving important soil data for public free access

Advanced Geoinformation Science

Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications

Issue 4 2011 pages 271-363

A European perspective on Digital Earth
Sensors, empowerment, and accountability: a Digital Earth view from East Africa
Spatial cloud computing: how can the geospatial sciences use and help shape cloud computing?
Impact of discretization methods on the rough set-based classification of remotely sensed images
Toward an improved data stewardship and service for environmental and ecological science data in West China
Geographic information systems and science
Risk and planet earth

Issue 3 2011 pages 185-270
The use of high-performance and high-throughput computing for the fertilization of digital earth and global change studies
China Digital Ocean Prototype System
Modeling sprawl of unauthorized development using geospatial technology: case study in Kuantan district, Malaysia
Drought mapping using Geoinformation technology for some sites in the Iraqi Kurdistan region
Land use and land cover changes over a century (1914–2007) in the Neyyar River Basin, Kerala: a remote sensing and GIS approach

Issue 2 2011 pages 93-184
A high-level architecture for a Geomatics Informatization Technology System: the Chinese case
Towards long-multitemporal change detection using SVI differencing by integrated DWT–ISOCLUS: a model for forest temporal dynamics mapping
A block-based selection method for road network generalization
Estimating evapotranspiration from terrestrial groundwater-dependent ecosystems using Landsat images
A virtual learning environment of the Chinese University of Hong Kong
Airborne and terrestrial laser scanning

Issue 1 2011 pages 1-92
EDITORIAL
The global Landsat imagery database for the FAO FRA remote sensing survey
Production of global land cover data – GLCNMO
Tracking desertification on the Mongolian steppe through NDVI and field-survey data
VGIS-COLLIDE: an effective collision detection algorithm for multiple objects in virtual geographic information system
SAR interferometric coherence analysis for snow cover mapping in the western Himalayan region
Atlas of remote sensing of the Wenchuan earthquake

Volume 3 2010
Supp 1 2010 pages 1-102
EDITORIAL
The implementation of international geospatial standards for earth and space sciences
The application of open standards to enhance the interoperability of geoscience information
Geological applications using geospatial standards – an example from OneGeology-Europe and GeoSciML

SeaDataNet – Pan-European infrastructure for marine and ocean data management: unified access to distributed data sets

Land Monitoring Network Services based on international geospatial standards: SOSI and geoland2/SDI Projects

Powered by standards – new data tools for the climate sciences

Issue 4 2010 pages 313-ebi

Early warning and disaster management: the importance of geographic information (Part B)

Selected issues of cartographic communication optimization for emergency centers

The role of GI-supported methods in crisis management

Dynamic analysis of the Wenchuan Earthquake disaster and reconstruction with 3-year remote sensing data

A low-cost PDGNSS-based sensor network for landslide monitoring – challenges, possibilities, and prospects

Development of an early warning information infrastructure using spatial web services technology

Research on fine Spatial Quantitative Model about vulnerability of hazard-affected bodies

Editorial Board

Issue 3 2010 pages 217-311

Early warning and disaster management: the importance of geographic information (Part A)

Understanding global natural disasters and the role of earth observation

Crowdsourcing geographic information for disaster response: a research frontier

Digital Earth’s Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information

Challenges of the Sensor Web for disaster management

Decision support system for the mobile volcano fast response system

The contribution of maps to the challenges of risk communication to the public

Issue 2 2010 pages 111-216

The framework of a geospatial semantic web-based spatial decision support system for Digital Earth

Morphometric aspects of a small tropical mountain river system, the southern Western Ghats, India

A comprehensive framework for exploratory spatial data analysis: Moran location and variance scatterplots

3-D visualizations of coastal bathymetry by utilization of airborne TOPSAR polarized data

Toward an integrated framework for geosensor grid

Issue 1 2010 pages 1-110

EDITORIAL

The history and development of the theory and practice of cybercartography

Geo-spatial information and technologies in support of EU crisis management

Digital Earth: decadal experiences and some thoughts
The circular dataimage, a graph for high-resolution circular-spatial data
Ability to detect and locate gross errors on DEM matching algorithm
Can we predict earthquakes with GPS data?
Spatially enabling Australia – the next decade
Space science & technology in China: a roadmap to 2050

Volume 2 2009

Supp 1 2009 pages 1-119
Towards Earth and Space Science digital infrastructures: network, computing and data services
Metadata requirements analysis for the emerging Sensor Web
Mediating among GeoSciML resources
Integrating the Climate Science Modelling Language with geospatial software and services
RESTful implementation of geospatial services for Earth and Space Science applications
The GEON service-oriented architecture for Earth Science applications
Enabling interoperability for Digital Earth: Earth Science coverage access services
Web-system for processing and visualization of meteorological data for Siberian environment research

Issue 4 2009 pages 291-402
A new global raster water mask at 250 m resolution
Identifying damage caused by the 2008 Wenchuan earthquake from VHR remote sensing data
A web-based, component-oriented application for spatial modelling of habitat suitability of mosquito vectors
A novel confidence estimation method for neural networks in multispectral image classification
Modelling of urban growth boundary using geoinformatics
Development of GIS-based environmental information system: an Indian scenario
Report on the Sixth International Symposium on Digital Earth
2009 Beijing Declaration on Digital Earth
Acknowledgements

Issue 3 2009 pages 195-289
Development of time series stacks of Landsat images for reconstructing forest disturbance history
The improvement of an object-oriented classification using multi-temporal MODIS EVI satellite data
Comparison between radarsat-1 SAR different data modes for oil spill detection by a fractal box counting algorithm
Buffering functions of mangroves in the 2004 tsunami
Fundamental aspects of access control for geospatial data

Issue 2 2009 pages 89-193
Multi-resolution integration of land cover for sub-pixel estimation of urban impervious surface and forest cover
Geomorphological monitoring of a highly dynamic estuary using oblique aerial photographs
On the benefits of using a high-resolution mesoscale model to improve wind field for the study of upwelling off the Indian coasts

GIS- and RS-based spatial decision support: structure of a spatial environmental information system (SEIS)

A method for groundwater prospect zonation in data poor areas using remote sensing and GIS: a case study in Kalikavu Panchayath of Malappuram district, Kerala, India

GIS-based optimisation of the hydrometeorological network in Greece

An approach to extracting information of residential areas from Beijing-1 image based on Gabor texture segmentation

Issue 1 2009 pages 1-87

Editorial

A digital earth prototype system: DEPS/CAS

The Sensor Web: systems of sensor systems

Measuring magnetic declination with a compass, virtual globes and a global positioning system

Gaia Journeys: a museum-based immersive performance exploration of the Earth

Arithmetic and Fourier transform for the PYXIS multi-resolution digital Earth model

Pinpointing the sources and measuring the lengths of the principal rivers of the world

Volume 1 2008

Issue 4 2008 pages 315-378

On generalised and specialised spatial information grids: are geo-services ready?

The role of GIS in Digital Earth education

Integrating data from remote sensing, geology and gravity for geological investigation in the Tarhunah area, Northwest Libya

Web service for biodiversity estimation using remote sensing data

Acknowledgements

Issue 3 2008 pages 247-314

Geospatial data infrastructure for sustainable development in sub-Saharan countries

Distributed geospatial information processing: sharing distributed geospatial resources to support Digital Earth

Atlas information systems and geographical names information systems as contributants to spatial data infrastructure

Flood prediction and assessment of vulnerability risk in the southern coasts of the Caspian Sea

View on Bay of Bengal upwelling area on the basis of 19-years of satellite sea surface temperature

Issue 2 2008 pages 171-245

Earth observation using radar data: an overview of applications and challenges

Integrating modelling and remote sensing to identify ecosystem performance anomalies in the boreal forest, Yukon River Basin, Alaska

An improved approach for the production of satellite-based geospatial reference imagery

Overview and preliminary idea for building Digital Earth with Grid computing technology

Issue 1 2008 pages 1-173
Story

**Digital Earth: Big Earth Data and Geospatial Analytics**

_Digital Earth Summit on Geoinformatics: Tools for Global Change Research_ said:

"Digital Earth is a visionary concept popularized by Nobel Laureate and the former US Vice President Al Gore for the virtual and three-dimensional representation of the Earth. This Digital Earth representation is spatially referenced and interconnected with digital knowledge archives from around the planet with vast amounts of scientific, natural, and cultural information to describe and understand the Earth, its systems and human activities."

Huadong Guo Editor-in-Chief of _The International Journal of Digital Earth_, says in his recent editorial:

"Human beings have entered the age of 'big data'.

The research on big data has gradually developed and become a focus of attention for many domains.

Looking more specifically at big geo-referenced data, the vast multi-dimensional and multi-perspective geo-data have proved to be extremely useful in assisting humans to better understand the Earth and to help policy-makers take certain actions to begin solving some of our most pressing problems. In many ways, Digital Earth, as a collection of technologies that has matured over the years, could be seen as a successful example of 'big data'.

Digital Earth integrates the huge and valuable geo-date resources into a digital representation of the planet. In this regard, Digital Earth performs well in acquiring, storing and applying quadrillions of bytes of geo-referenced information through the use of advanced sciences and technologies, including computational science, mass storage, satellite imagery, broadband networks, interoperability, and metadata (Gore, 1998). Furthermore, Digital Earth will simulate and render in real-time interactions among all Earth system processes in all spheres with respect to their physical, chemical, biological and social science elements by integrating various Earth observation data.

If we look back at the data we generated and the methodologies we used to manage these data, it becomes obvious that promoting better ‘use’ is the real target in the new era of big data.”

Dr. Huadong Guo directs the The Center for Earth Observation and Digital Earth, Chinese Academy of Sciences (CEODE) which supports The International Society for Digital Earth: a non-political, non-governmental and not-for-profit international organization, principally for promotion of academic exchange, science and technology innovation, education, and international collaboration. The purpose of the society is to promote international cooperation on the Digital Earth vision, and enable the Digital Earth technology to play key roles inter alia, in economic and social sustainable development, environmental protection, disaster mitigation, natural resources conservation and improvement of human being ‘living standard.

Analytical geospatial Digital Earth was special issue of The International Journal of Digital Earth in 2014 with a four fold focus on Digital Earth (see Editorial) as follows:

- Diverse information integration
- Participatory users
- Engaging analytical and visual capabilities
- Flexible, contextual technologies that enable this to happen

that published 5 original articles.

M.F. Goodchild (2008) said this about The use cases of digital earth:

“No such cases are readily apparent for the current generation of geobrowsers, though the text of the 1998 Gore speech refers to several. An analysis of the use cases of geographic information systems (GIS) reveals similarities with the functionality of geobrowsers, inviting the view that the two forms of geographic information technology will eventually converge. However, experience suggests that users are finding very different ways of exploiting geobrowsers, and two examples are discussed in detail. These uses can be interpreted within a broad framework of spatial concepts, and the paper concludes that this framework provides a better guide to the future of geobrowsers and Digital Earth than current GIS technology.”

So now Digital Earth is Geospatial Analytics on Big Data and the questions are where to get that big data and what analytical tools to use. I started to mine The International Journal of Digital Earth using the titles authors, and abstracts, but it was not generally possible to tell the big data sets used and certainly not there location. This is why Data Citations are needed as discussed in a previous story on Big Data Science for CODATA

I used Google Search for "climate change shapefiles" and found what seemed to be a number of good sources (see Research Notes below). First I need to explore them in Spotfire using their new Geospatial Analytics in version 6.0 (see New Features and Map Chart) as described recently in TIBCO Spotfire Puts Geospatial Analytics in Context:

"Data without context is generally useless, and when it comes to providing that context, location is usually everything."
At its TUCON 2013 conference this week, TIBCO Software moved to provide that context by releasing an upgrade to its TIBCO Spotfire analytics software that adds support for geospatial analytics based on technology that TIBCO gained when it acquired Maparama Solutions earlier this year.

According to TIBCO Senior Vice President Peter Lee, 80 percent of all data can be associated with geospatial analytics. Lee says adding those capabilities to version 6.0 of TIBCO Spotfire will make it a lot easier for users to discover the relationship between different data sets via multilayer maps and geo-coding of data from global to street-level."

The Goal is to find actual data and principal conclusions (e.g. nanopublication) from title, author(s), and abstract.

Process followed was:

• Data Preparation: Screen-scrape a sample of how it could be done manually so it can be done more automatically.

• Data Selection: Data may be at other locations like from a Google Search for "climate change shapefiles" that found:
  ◦ http://www.diva-gis.org/Data
  ◦ http://data.worldbank.org/data-catal...le-projections

• Data Completion: Screen scrape the rest using the initial pattern developed from experimentation and explore the easier to find data sources to make a selection.

The Results are shown in Slides that are screen captures of the Web Site, MindTouch, Excel, and Spotfire Knowledge Bases shown below.

The entire (publicly available) International Journal of Digital Earth has been copied into MindTouch and structured so a data publication index can be built in an Excel spreadsheet that can be used in Spotfire for content analytics and publication analytics along with Spotfire data analytics.

One significant highlight is the Spotfire visualization of the Climate Change: Grid Projections - Average A2 SRES Scenario superimposed on the global geospatial infrastructure, which is still a work in progress to measure all the parameters of interest on a grid like this, or at enough locations to be confidently interpolated to such a grid.

The Digital Earth Summit on Geoinformatics: Tools for Global Change Research also said:
"Geoinformatics developments are leading to global spatial infrastructures that are being used as Digital Earth models and to inquire attributes from each location on Earth. On the basis of simulations with numerical climate models and on the analysis of observational data, climate researchers have shown that human activities are likely to induce drastic climate changes within this century. Their success is emphasized by the recent Peace Nobel prize that was shared by Al Gore and the United Nations Intergovernmental Panel on Climate Change (PCC)."

The above illustrates the advantages of a closer cooperation between Geoinformatics specialists and scientists involved in Global Change Research. See Data Science for Climate Change.

MORE TO FOLLOW AFTER THE CONFERENCE

http://codata.org/blog/2014/05/21/pr...ic-programmes/

http://codata.org/blog/wp-content/up...amme-FINAL.pdf (PDF)

Slides

Slide 1 The International Journal of Digital Earth

The International Journal of Digital Earth

Slide 2 MindTouch Knowledge Base 1

https://semanticommunity.info/Data_Science/Big_Data_Science_for_CODATA/International_Journal_of_Digital_Earth

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Slide 3 MindTouch Knowledge Base 2

Slide 4 Excel Spreadsheet Knowledge Base


Slide 5 Cover Page

Web Player
Slide 10 Climate Change: Grid Projections-Average A2 SRES Scenario

Slide 11 Climate Change: Grid Projections-Average B1 SRES Scenario

Slide 12 Climate Change: Grid Projections-Average Metadata

Spotfire Dashboard

For Internet Explorer Users and Those Wanting Full Screen Display Use: Web Player Get Spotfire for iPad App
Research Notes

Data Sources

http://eusoils.jrc.ec.europa.eu/libr... countries.cfm

http://www.iscgm.org/

Digital Earth Summit on Geoinformatics: Tools for Global Change Research

About Digital Earth: Digital Earth is a visionary concept popularized by Nobel Laureate and the former US Vice President Al Gore for the virtual and three-dimensional representation of the Earth. This Digital Earth representation is spatially referenced and interconnected with digital knowledge archives from around the planet with vast amounts of scientific, natural, and cultural information to describe and understand the Earth, its systems and human activities.

Purpose of the Digital Earth Summit 2008: The development of Digital Earth technologies and the results of Global Change research are two areas where exciting progress has happened in recent years. Geoinformatics developments are leading to global spatial infrastructures that are being used as Digital Earth models and to inquire attributes from each location on Earth. On the basis of simulations with numerical climate models and on the analysis of observational data, climate researchers have shown that human activities are likely to induce drastic climate changes within this century. Their success is emphasized by the recent Peace Nobel prize that was shared by Al Gore and the United Nations Intergovernmental Panel on Climate Change (PCC).

The International Society for Digital Earth (ISDE) and the Society for Geoinformatics (GfGI) believe that it is about time that scientists from both communities come together to discuss the advantages of a closer cooperation between Geoinformatics specialists and scientist involved in Global Change research. Although both communities are involved in Digital Earth modelling, they have so far stayed very much within their respective scientific boundaries. Consequently, the Society of Geoinformatics (GfGI), which is based in Germany, Austria, and Switzerland and the International Society for Digital Earth will bring together scientists and practitioners from both fields during the Digital Earth Summit on Geoinformatics: Tools for Global Change Research.

The use cases of digital earth

Edit section

M.F. Goodchild

Abstract

The formal process of system design begins with the identification of use cases. No such cases are readily apparent for the current generation of geobrowsers, though the text of the 1998 Gore speech refers to several. An analysis of the use cases of geographic information systems (GIS) reveals similarities with the functionality of geobrowsers, inviting the view
that the two forms of geographic information technology will eventually converge. However, experience suggests that users are finding very different ways of exploiting geobrowsers, and two examples are discussed in detail. These uses can be interpreted within a broad framework of spatial concepts, and the paper concludes that this framework provides a better guide to the future of geobrowsers and Digital Earth than current GIS technology.

Process

Goal: Find actual data and principal conclusions (e.g. nanopublication) from title, author(s), and abstract

Data Preparation: Screen-scrape a sample of how it could be done manually so it can be done more automatically.

Data Selection: Data may be at other locations like from a Google Search for "climate change shapefiles" that found:
- http://www.diva-gis.org/Data

Data Completion: Screen scrape the rest using the initial pattern developed from experimentation and explore the easier to find data sources to make a selection

DIVA-GIS

DIVA-GIS is a free computer program for mapping and geographic data analysis (a geographic information system (GIS)). With DIVA-GIS you can make maps of the world, or of a very small area, using, for example, state boundaries, rivers, a satellite image, and the locations of sites where an animal species was observed. We also provide free spatial data for the whole world that you can use in DIVA-GIS or other programs.

You can use the discussion forum to ask questions, report problems, or make suggestions. Or contact us, and read the blog entries for the latest news. But first download the program and read the documentation.

DIVA-GIS is particularly useful for mapping and analyzing biodiversity data, such as the distribution of species, or other 'point-distributions'. It reads and write standard data formats such as ESRI shapefiles, so interoperability is not a problem. DIVA-GIS runs on Windows and (with minor effort) on Mac OSX (see instructions).

You can use the program to analyze data, for example by making grid (raster) maps of the distribution of biological diversity, to find areas that have high, low, or complementary levels of diversity. And you can also map and query climate data. You can predict species distributions using the BIOCLIM or DOMAIN models.

Shapefiles are the dominant file format used for spatial data (of the "vector" type: points, lines, polygons). All GIS programs can import them, and many, like DIVA-GIS, use them directly. A shapefile consists of multiple files: .shp, .shx, .dbf, and sometimes more. The attributes (data records) of the spatial features are stored in the .dbf file. That was convenient because these files could be easily edited with Microsoft Excel -- which is installed on the vast majority of windows computers. Unfortunately, in recent versions of excel (Office 2007) you can only open a .dbf file, but you can not save it. That is a real hassle for shapefile users.

My Note: I did not know this - so use Excel 2003?
Documentation
Source: http://www.diva-gis.org/documentation

My Note There may be something of value here

Climate data
Source: http://www.diva-gis.org/climate

Climate data are available from different sources and in different resolutions.

You need to unzip these files and copy them to the default DIVA-GIS climate data folder: "c:\program files\diva-gis\environ" or to any another folder, and change the Folder in the "Tools/Options/Climate" window.

Current climate (~1950-2000)
Source: Worldclim, version 1.3, October 2004
Resolution: 10 minutes (20 MB), 5 minutes (73 MB), 2.5 minutes (256 MB)

Future climate (2xCO₂ climate conditions, CCM3 model)

These data were subsequently down-scaled and matched to the WorldClim estimates of current climate.

Resolution: 10 minutes (20 MB), 5 minutes (73 MB), 2.5 minutes (256 MB)

Free Spatial Data
Source: http://www.diva-gis.org/Data

Country level
Download country level data for any country in the world: administrative boundaries, roads, railroads, altitude, land cover, population density.

Global level
A new file with the (2011) global country boundaries

Global climate data
See WorldClim or diva-gis specific data here
Species occurrence data

GBIF, HerpNet, MaNIS, OBIS, ORNIS, REMIB

Crop (genebank) collection data

GENESYS

Near global 90 meter resolution elevation data

Download

High resolution satellite images (LandSat)

for nearly all of the world can be downloaded here. They are in the MrSid format that can be visualized in DIVA-GIS (note: they are in UTM projections, so you will need to project your shapefiles to UTM as well).

A very good list

of data sources from the Eden project.

Climate Change Knowledge Portal: Ensemble Projections


Country Projections My Note: I downloaded this - see attached

Temp. Averages (SHP: 32MB) My Note: I downloaded this - see attached and Documentation

“Ensemble” temperature and precipitation data are derived from multiple global circulation models (GCMs). The ensemble data depict the range (10th percentile, median and 90th percentile) of model outputs run under each of two scenarios, A2 and B1, for four future time periods. The first listed download contains data aggregated to the country level; the remaining downloads are gridded data in shapefile format.

- Type: Time series
- Periodicity: Month
- Last Updated: 01-Dec-2011
- Economy Coverage: World, East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, South Asia, Sub-Saharan Africa, High income, Low or Middle income, IBRD, IDA
- Granularity: National
- Topics: Climate Change
- Update Frequency: No further updates planned
- Update Schedule: No further updates planned
- Contact Details: data@worldbank.org
International Journal of Digital Earth

Source: Official Journal of the International Society for Digital Earth

Society information

Official Journal of the International Society for Digital Earth

Supported by the Center for Earth Observation and Digital Earth, Chinese Academy of Sciences (CEODE)
The International Society for Digital Earth is a non-political, non-governmental and not-for-profit international organization, principally for promotion of academic exchange, science and technology innovation, education, and international collaboration. The purpose of the society is to promote international cooperation on the Digital Earth vision, and enable the Digital Earth technology to play key roles inter alia, in economic and social sustainable development, environmental protection, disaster mitigation, natural resources conservation and improvement of human being's living standard.

Individual members of the International Society for Digital Earth (ISDE) receive the journal as part of their membership. Please contact the ISDE for further details at: member@ceode.ac.cn.

Aims & scope

Source: http://www.tandfonline.com/action/journalreader/volume/0/iss/0#U1olF1WzGTM

Overview

Digital Earth is a virtual representation of the planet, encompassing all its systems and forms, both natural environment and human societies, manifested as a multi-dimensional, multi-scale, multi-temporal, and multi-layer information facility. Digital Earth is the framework for geographically linked research and applications in the physical and social domains of the Earth, a digital modeling platform to monitor, measure, and forecast natural and human activity on the planet, and a visualization of the world. It is three-dimensional, four-dimensional if a temporal monitoring component is added, and even five-dimensional if scale is treated as a variable instead of a set of discrete steps. As a global initiative, Digital Earth aims to improve social conditions, protect the environment, and support future sustainable development.

The International Journal of Digital Earth is a response to this initiative. This peer-reviewed academic journal (SCI-E) focuses on the theories, technologies, applications, and societal implications of Digital Earth and those visionary concepts that will enable a modeled virtual world. The journal encourages papers that:

• Progress visions for Digital Earth frameworks, policies, and standards;
• Explore geographically referenced 3D, 4D, or 5D models to represent the real planet, and geo-data-intensive science and discovery;
• Develop methods that turn all forms of geo-referenced data, from scientific to social, into useful information that can be analyzed, visualized, and shared;
• Present innovative, operational applications and pilots of Digital Earth technologies at a local, national, regional, and global level;
• Expand the role of Digital Earth in the fields of Earth science, including climate change, adaptation and health-related issues, natural disasters, new energy sources, agricultural and food security, and urban planning;
• Foster the use of web-based public-domain platforms, social networks, and location-based services for the sharing of digital data, models, and information about the virtual Earth; and
• Explore the role of social media and citizen-provided data in generating geo-referenced information in the spatial sciences and technologies.

For producing research papers to be published in the journal, the following associated technologies and fields of research may be relevant, but in all cases, should be clearly linked to the topics above or the general Digital Earth concept: Earth observation (including remote sensing and in situ sensors), geographic information systems and science, global navigation systems, information and communication technologies (ICT, including spatial data infrastructure and global databases), virtual reality and immersive technologies, visualization and numerical simulation, cloud computing and high performance computation, mobile mapping systems, empowering the community and engaging society, Earth-system science, and sustainable development.

The journal publishes primary research papers, review articles, and short technical letters on research that warrants fast publication. The journal also welcomes thoughtful outlook papers that can generate debate and catalyze ideas to advance the Digital Earth vision. In addition, special issues on specific topics of relevance to Digital Earth will be published to examine particular points in depth. The Journal is an official publication of the International Society for Digital Earth (http://www.digitalearth-isde.org)

Thoughts on International Journal of Digital Earth

“We clearly see the broad benefits from the publication of the International Journal of Digital Earth. This is an exciting area for innovations and research. I hope that this Journal will become the premier source of technical and scientific developments for the Digital Earth community.” - Vincent Tao, Director, Microsoft Virtual Earth and Local Search Business Unit.

“Digital Earth is a critical and most challenging initiative. This journal successfully threads together the multifarious elements necessary for establishing the framework of the next big-science.” - Richard Simpson, University of Auckland, New Zealand

“This is a wonderful new journal that simultaneously reaches out to both the technology communities and the sustainability communities.” - Peter Woodgate, CEO, Cooperative Research Centre for Spatial Information, Australia

“How wonderful it is to see former U.S. Vice President Al Gore’s digital earth vision is reflected by such a high quality international scientific journal.” - Dr. Gabor Remetey-Fülöpp, Secretary General, Hungarian Association for Geoinformation

International Journal of Digital Earth is an official journal of the International Society for Digital Earth (ISDE). Please visit the ISDE website here: http://www.digitalearth-isde.org/

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International Journal of Digital Earth is now able to publish uncorrected proofs online within 7 days, as part of its iFirst service.
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Publication models and dates explained

Source: http://www.tandfonline.com/page/mode...ates-explained

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Volume 7 2014

Issue 6 2014 pages 432-509

Geometrically modeling 2D scattered points: a review of the potential for methodologically improving mobile laser scanning in data processing

Yi Lin & Juha Hyyppä

Abstract

As a state-of-the-art mapping technology, mobile laser scanning (MLS) is increasingly applied to fields such as digital presentations of city environments. However, its application has recently met a bottleneck in data processing. It has been found that conventional methods for geometrically modeling 3D scattered points are inadequate when dealing with large volumes of MLS data. In fact, this is a challenge that has already been noted in the MLS-relevant fields, e.g. remote sensing, robot perception, and pattern recognition. A variety of algorithms under the schematic frame of analysis, modeling and synthesis (AMS) have been developed in these fields. The AMS paradigm is to first extract the implicit geometric primitives within each scan profile by geometrically modeling its 2D scattered points (GM2P). The resultant 2D geometric primitives are then integrated to restore the real 3D geometrical models. In this process, GM2P is a kernel procedure whereby a review of the GM2P algorithms is assumed to be of significance for developing new efficient algorithms for geometrically modeling 3D scattered points. This idea is supported by MLS sampling often being executed via parallel scan profiles. Indeed, the results of the literature review indicate an avenue for methodologically improving MLS in data processing.

StarFL – a modularised metadata language for sensor descriptions

Christian Malewski, Ingo Simonis, Andrew Terhorst & Arne Bröring

Abstract

An ever-increasing number of sensor resources are being exposed via the World Wide Web to become part of the Digital Earth. Discovery, selection and use of these sensors and their observations require a robust sensor information model, but the consistent description of sensor metadata is a complex and difficult task. Currently, the only available robust model is SensorML, which is intentionally designed in a very generic way. Due to this genericness, interoperability can hardly be achieved without the definition of application profiles that further constrain the use and expressiveness of the root language. So far, such SensorML profiles have only been developed up to a limited extent. This work describes a new approach for defining sensor metadata, the Starfish Fungus Language (StarFL) model. This language follows a more restrictive approach and incorporates concepts from the recently published Semantic Sensor Network Ontology to overcome the key issues users are experiencing with SensorML. StarFL defines a restricted vocabulary and model for sensor metadata to achieve a high level of interoperability and a straightforward reusability of sensor descriptions.

https://semanticommunity.info/Data_Science/Big_Data_Science_for_CODATA/International_Journal_of_Digital_Earth
Updated: Wed, 10 Jul 2019 02:21:32 GMT
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Simulated impacts of 3D urban morphology on urban transportation in megacities: case study in Beijing

Shuo Liu, Xiangtao Fan, Qingke Wen, Wei Liang & Yuanfeng Wu

Abstract

Urban morphology and morphology change and their impacts on urban transportation have been studied extensively in planar urban space. The essential feature of urban space, however, is its three-dimensionality (3D), and few studies have been conducted from a 3D perspective, overly limiting the accuracy of studies on the relationships between urban morphology and transportation. The aim of this paper is to simulate the impacts of 3D urban morphologies on urban transportation under the Digital Earth framework. On the basis of the principle that population distribution and movement are largely confined by 3D urban morphologies, which affect transportation, high spatial resolution remote sensing imagery and a thematic vector data-set were used to extract urban morphology and transportation-related variables. With a combination of three research methods – factor analysis, spatial regression analysis and Euclidean allocation – we provide an effective method to construct a simulation model. The paper indicates three general results. First, building capacity in the urban space has the most significant impact on traffic condition. Second, obvious urban space otherness, reflecting both use density characteristics and functional characteristics of urban space, mostly results in heavier traffic flow pressure. Third, no single morphology density indicator or single urban structure indicator can reflect its contribution to the pressure of traffic flow directly, but a combination of these different indicators has the ability to do so.

Evaluation of different machine learning methods for land cover mapping of a Mediterranean area using multi-seasonal Landsat images and Digital Terrain Models

Victor F. Rodriguez-Galiano & Mario Chica-Rivas

Land cover monitoring using digital Earth data requires robust classification methods that allow the accurate mapping of complex land cover categories. This paper discusses the crucial issues related to the application of different up-to-date machine learning classifiers: classification trees (CT), artificial neural networks (ANN), support vector machines (SVM) and random forest (RF). The analysis of the statistical significance of the differences between the performance of these algorithms, as well as sensitivity to data set size reduction and noise were also analysed. Landsat-5 Thematic Mapper data captured in European spring and summer were used with auxiliary variables derived from a digital terrain model to classify 14 different land cover categories in south Spain. Overall, statistically similar accuracies of over 91% were obtained for ANN, SVM and RF. However, the findings of this study show differences in the accuracy of the classifiers, being RF the most accurate classifier with a very simple parameterization. SVM, followed by RF, was the most robust classifier to noise and data reduction. Significant differences in their performances were only reached for thresholds of noise and data reduction greater than 20% (noise, SVM) and 25% (noise, RF), and 80% (reduction, SVM) and 50% (reduction, RF), respectively.

Issue 5 2014 pages 351-431

Spectral sensitivity of ALOS, ASTER, IKONOS, LANDSAT and SPOT satellite imagery intended for the detection of archaeological crop marks

Athos Agapiou, Dimitrios D. Alexakis & Diosfantos G. Hadjimitsis
Abstract

This study compares the spectral sensitivity of remotely sensed satellite images, used for the detection of archaeological remains. This comparison was based on the relative spectral response (RSR) Filters of each sensor. Spectral signatures profiles were obtained using the GER-1500 field spectroradiometer under clear sky conditions for eight different targets. These field spectral signature curves were simulated to ALOS, ASTER, IKONOS, Landsat 7-ETM+, Landsat 4-TM, Landsat 5-TM and SPOT 5. Red and near infrared (NIR) bandwidth reflectance were re-calculated to each one of these sensors using appropriate RSR Filters. Moreover, the normalised difference vegetation index (NDVI) and simple ratio (SR) vegetation profiles were analysed in order to evaluate their sensitivity to sensors spectral filters. The results have shown that IKONOS RSR filters can better distinguish buried archaeological remains as a result of difference in healthy and stress vegetation (approximately 1–8% difference in reflectance of the red and NIR band and nearly 0.07 to the NDVI profile). In comparison, all the other sensors showed similar results and sensitivities. This difference of IKONOS sensor might be a result of its spectral characteristics (bandwidths and RSR filters) since they are different from the rest of sensors compared in this study.

Pervasive geo-security – a lightweight triple-A approach to securing distributed geo-service infrastructures

Bernd Resch, Bernhard Schulz, Manfred Mittlboeck & Thomas Heistracher

Abstract

Security has recently become a major concern in distributed geo-infrastructures for spatial data provision. Thus, a lightweight approach for securing distributed low-power environments such as geo-sensor networks is needed. The first part of this article presents a survey of current security mechanisms for authentication and authorisation. Based on this survey, a lightweight and scalable token-based security infrastructure was developed, which is tailored for use in distributed geo-web service infrastructures. The developed security framework comprises dedicated components for authentication, rule-based authorisation and optimised storage and administration of access rules. For validation purposes, a prototypical implementation of the approach has been created.

Coupling the 4M crop model with national geo-databases for assessing the effects of climate change on agro-ecological characteristics of Hungary

Nándor Fodor, László Pásztor & Tamás Németh

Abstract

The 4M crop model was used to investigate the prospective effects of climate change on the agro-ecological characteristics of Hungary. The model was coupled with a detailed meteorological database and spatial soil information systems covering the whole territory of Hungary. Plant-specific model parameters were determined by inverse modeling. Future meteorological data were produced from the present meteorological data by combining a climate change scenario and a stochastic weather generator. Using the available and the generated data, the present and the prospective agro-ecological characteristics of Hungary were determined. According to the simulation results, average yields will decrease considerably (~30%) due to climate change. The rate of nitrate leaching will prospectively decrease as well. The fluctuations of both the yields and the annual nitrate leaching rates will most likely increase approaching the
end of the twenty-first century. On the basis of the simulation results, the role of autumn crops is likely to become more significant in Hungary. The achieved results can be generalized for more extended regions based on the concept of spatial (geographical) analogy.

Enrichment of topographic road database for the purpose of routing and navigation

Meng Zhang, Wei Yao & Ligiu Meng

Abstract

With growing demand on multi-purpose or multi-modal navigation, the route calculation needs to traverse semantically enriched road networks for different transportation modes. Currently, operational route planning algorithms reveal rather limited performances or their potential for comprehensive applications are constrained by the unavailable or insufficient interoperation among the underlying geo-data that are separately maintained in different spatial databases. To overcome this limitation, a novel approach has been proposed to integrate the routing-relevant information from different data sources, which involves three processes: (1) automatic matching to identify the corresponding road objects between different datasets; (2) interaction to refine the automatic matching result; and (3) transferring the routing-relevant information from one data-set to another. In process (1), the Delimited Stroke Oriented algorithm is employed to achieve the automatic data matching between different datasets, which has revealed a high matching rate and certainty. However uncertain matching problems occur in areas where topological conditions are too complicated or inconsistent. The remaining unmatched or wrongly matched objects are treated in process (2), with the help of a series of interaction tools. On the basis of refined matching results after the interaction, process (3) is dedicated to automatic integration of the routing-relevant information from different data sources.

Issue 4 2014 pages 253-350

Special Issue: Analytical Geospatial Digital Earth

Analytical geospatial Digital Earth

Bert Veenendaal, Songnian Li, Suzana Dragicevic & Maria Antonia Brovelli
Enhancing accessibility to web mapping systems with technology-aligned adaptive profiles

Jacob Delfos, Bert Veenendaal & Tele Tan

Abstract

Web-based geographic information systems have advanced rapidly on the back of web-based technologies, increased bandwidths and access to Digital Earth imagery and functionality. However, these advances are causing its capabilities to slowly overtake those of end-users. Additionally, the introduction of non-desktop devices such as smartphones, tablets and netbooks is starting to undo progress made towards standardisation of web-based technology. Large variations in screen sizes, computational power, bandwidth, and operating environments are once again introducing the need to ensure software remains functional across different platforms, standards-compliant or not. These two issues highlight the need for a mechanism to tune content and capability to end-users and their environment, to prevent information and complexity overload in a field already troubled by poor usability, while promoting cross-platform
compatibility. This paper proposes the use of adaptivity to accommodate for users from different backgrounds accessing web mapping systems in different technical environments. It describes adaptive profiles aligned to the finite number of states a system can adopt, rather than the limitless range of user or environment characteristics that cannot be adapted to. Each profile consists of a combination of adaptive states comprising functionality, information detail, or technical demands to optimise for individual users or technical environments.

**Using GIS to develop a mobile communications network for disaster-damaged areas**

Youhei Kawamura, Ashraf M. Dewan, Bert Veenendaal, Masahiro Hayashi, Takeshi Shibuya, Itaru Kitahara, Hajime Nobuhara & Kento Ishii

**Abstract**

Communications network damage resulting from a large disaster causes difficulties in the ability to rapidly understand the current situation and thus make appropriate decisions towards mitigating problems, such as where to send and dispense emergency supplies. The research outlined in this paper focuses on the rapid construction of a network after a disaster occurs. This study suggests ZigBee and geographic information systems (GIS) technologies to resolve these problems and provide an effective communication system. The experimental results of the ZigBee network system are presented, examples are provided of the mapping and analysis undertaken using GIS for the disaster-stricken area of Tsukuba City, Japan, and the communications node arrangements are determined for this region. These results demonstrate the effectiveness of establishing such a communications system for supporting efforts to relieve disaster-damaged areas.

**An open source, server-side framework for analytical web mapping and its application to health**

Simon Moncrieff, Geoff West, James Cosford, Narelle Mullan & Andrew Jardine

**Abstract**

In this paper, we detail the design and the implementation of an open source, server-side web mapping framework for the analysis of health data. The framework forms part of a larger project, the goal of which is to provide an analytical web geographical information system (GIS) that enables health experts to analyse spatial aspects of health data. The aim of the framework is to provide a method for the dynamic and flexible spatial visualisation of health data to facilitate data exploration and analysis. Consequently, a dynamic thematic web mapping technique, an extension to the Open Geospatial Consortium (OGC) web map service standard, was developed. The technique combines a data query, processing technique and styling methodology on the fly to generate a thematic map. The resulting thematic map represents a virtual map layer that enables a user to rapidly visually summarise properties of a data-set. A test web interface was developed to assess the efficacy of the web mapping technique. As the dynamic web mapping method builds on existing OGC web mapping standards, it can be readily integrated with the existing lightweight slippy map web clients and virtual globes.
Mapping ideas from cyberspace to realspace: visualizing the spatial context of keywords from web page search results

Ming-Hsiang Tsou, Ick-Hoi Kim, Sarah Wandersee, Daniel Lusher, Li An, Brian Spitzberg, Dipak Gupta, Jean Mark Gawron, Jennifer Smith, Jiue-An Yang & Su Yeon Han

Abstract

We introduce a new method for visualizing and analyzing information landscapes of ideas and events posted on public web pages through customized web-search engines and keywords. This research integrates GI Science and web-search engines to track and analyze public web pages and their web contents with associated spatial relationships. Web pages searched by clusters of keywords were mapped with real-world coordinates (by geolocating their Internet Protocol addresses). The resulting maps represent web information landscapes consisting of hundreds of populated web pages searched by selected keywords. By creating a Spatial Web Automatic Reasoning and Mapping System prototype, researchers can visualize the spread of web pages associated with specific keywords, concepts, ideas, or news over time and space. These maps may reveal important spatial relationships and spatial context associated with selected keywords. This approach may provide a new research direction for geographers to study the diffusion of human thought and ideas. A better understanding of the spatial and temporal dynamics of the ‘collective thinking of human beings’ over the Internet may help us understand various innovation diffusion processes, human behaviors, and social movements around the world.

Multi-frame and multi-dimensional historical digital cities: the Como example

Luana Valentini, Maria Antonia Brovelli & Giorgio Zamboni

Abstract

In this article, we present the realization of a multi-frame and multi-dimensional WebGIS that allows users to simultaneously analyze a specific portion of the Earth taking into account the historical information, too. Two graphical panels have been realized: one for the usual 2D view and one for a more realistic 3D view. Both panels display historical maps of the city, the current orthophoto and the digital topographical map. The 3D frame is based on NASA World Wind, an open source virtual globe from where 3D buildings are shown extruding the 2D shapes using their mean height. Thanks to a specifically designed graphical user interface, it is also possible to dynamically thematise the buildings on the globe according to different criteria (e.g. the construction time span) so that only the geometries fulfilling the request are turned on. Within the proposed application, a synchronisation between the two panels has been implemented, in order to maintain a constant alignment of the two viewers. The application is also open to the time dimension. In fact, assigning to each geometry two dates (e.g. ‘year of construction’ and ‘year of demolition’), it is possible to dynamically view how buildings have changed over time, both in their shape and height. Future developments of this work will concern the possibility of implementing a city model with a higher level of detail.

Issue 3 2014 pages 175-252
Building the World Wide Hypermap (WWH) with a RESTful architecture

Joan Masó, Xavier Pons & Alaitz Zabala

Abstract

The hypermap concept was introduced in 1992 as a way to hyperlink geospatial features to text, multimedia or other geospatial features. Since then, the concept has been used in several applications, although it has been found to have some limitations. On the other hand, Spatial Data Infrastructures (SDIs) adopt diverse and heterogeneous service oriented architectures (SOAs). They are developed by different standard bodies and are generally disconnected from mass market web solutions. This work expands the hypermap concept to overcome its limitations and harmonise it with geospatial resource oriented architecture (ROA), connecting it to the semantic web and generalising it to the World Wide Hypermap (WWH) as a tool for building a single ‘Digital Earth’. Global identifiers, dynamic links, link purposes and resource management capabilities are introduced as a solution that orchestrates data, metadata and data access services in a homogeneous way. This is achieved by providing a set of rules using the current Internet paradigm formalised in the REpresentational State Transfer (REST) architecture and combining it with existing Open Geospatial Consortium (OGC) and International Organization for Standardization (ISO) standards. A reference implementation is also presented and the strategies needed to implement the WWH, which mainly consist in a set of additions to current Geographic Information System (GIS) products and a RESTful server that mediates between the Internet and the local GIS applications.

Evaluation of diverse classification approaches for land use/cover mapping in a Mediterranean region utilizing Hyperion data

Alata Elatawneh, Chariton Kalaitzidis, George P. Petropoulos & Thomas Schneider

Abstract

Information on Earth’s land surface cover is commonly obtained through digital image analysis of data acquired from remote sensing sensors. In this study, we evaluated the use of diverse classification techniques in discriminating land use/cover types in a typical Mediterranean setting using Hyperion imagery. For this purpose, the spectral angle mapper (SAM), the object-based and the non-linear spectral unmixing based on artificial neural networks (ANNs) techniques were applied. A further objective had been to investigate the effect of two approaches for training sites selection in the SAM classification, namely of the pixel purity index (PPI) and of the direct selection of training points from the Hyperion imagery assisted by a QuickBird imagery and field-based training sites. Object-based classification outperformed the other techniques with an overall accuracy of 83%. Sub-pixel classification based on the ANN showed an overall accuracy of 52%, very close to that of SAM (48%). SAM applied using the training sites selected directly from the Hyperion imagery supported by the QuickBird image and the field visits returned an increase accuracy by 16%. Yet, all techniques appeared to suffer from the relatively low spatial resolution of the Hyperion imagery, which affected the spectral separation among the land use/cover classes.

Using SPOT 5 fusion-ready imagery to detect Chinese tamarisk (saltcedar) with mathematical morphological method

Q.S. Liu, G.H. Liu, C. Huang & C.J. Xie
Abstract

Chinese tamarisk (saltcedar) is a deciduous shrub that occurs widely across the Yellow River Delta in China. The spatial structure of Chinese tamarisk is believed to have an influence on the landscape and habitats of rare birds. In this study, first, Chinese tamarisk is detected using Canny edge detector and mathematical morphological operators based on SPOT 5 fusion-ready imagery. Then the numbers, areas, locations, and patch spacing of Chinese tamarisk patches are calculated. The experiments show that the detection accuracy of Chinese tamarisk patches is about 93.4% after the disconnection of connected patches. The distribution orientation of about 70% of the patches is approximately south–north. About 91% of the minimum distances among the patches are between 12.5 and 57.5 m. The rose graph indicates that the main azimuth between patches is north–northwest, and the second is northeast and southeast. The present study indicates that the integrating Canny edge detector with the algorithms for extracting circular and elliptical objects based on mathematical morphology is simple and effective for detecting Chinese tamarisk patches and is easy to identify the spatial structure of Chinese tamarisk patches, which reduces the time and labor for the visual interpretation of Chinese tamarisk patches.

A classification of water erosion models according to their geospatial characteristics

Christos G. Karydas, Panos Panagos & Ioannis Z. Gitas

Abstract

In this article, an extensive inventory in the literature of water erosion modelling from a geospatial point of view is conducted. Concepts of scale, spatiality and complexity are explored and clarified in a theoretical background. Use of Geographic Information Systems (GIS) is pointed out as facilitating data mixing and model rescaling and thus increasing complexity in data-method relations. Spatial scale, temporal scale and spatial methodologies are addressed as the most determining geospatial properties underlying water erosion modelling. Setting these properties as classification criteria, 82 water erosion models are identified and classified into eight categories. As a result, a complete overview of water erosion models becomes available in a single table. The biggest share of the models is found in the category of the mechanistic pathway-type event-based models for watershed to landscape scales. In parallel, geospatial innovations that could be considered as milestones in water erosion modelling are highlighted and discussed. An alphabetical list of all models is also listed in the Appendix. For manipulating scale efficiently, two promising spatial theories are suggested for further exploitation in the future such as hierarchy theory and fractals theory. Regarding erosion applications, uncertainty analysis within GIS is considered to be necessary for further improving performance of erosion models.

A changing environment for human security

J.L. van Genderen
Methods to extract impervious surface areas from satellite images

Dengsheng Lu, Guiying Li, Wenhui Kuang & Emilio Moran

Abstract

Impervious surface area (ISA) is an important parameter for many environmental or socioeconomic relevant studies. The unique characteristics of remote sensing data made it the primary data source for ISA mapping at various scales. This paper summarizes general ISA mapping procedure and major techniques and discusses impacts of scale issues on selection of remote sensing data and corresponding algorithms. Previous studies have indicated that ISA mapping remains a challenge, especially in urban–rural frontiers and in covering a large area. Effectively employing rich spatial information in high spatial resolution imagery through texture and object-based methods is valuable. Data fusion of multi-resolution images and spectral mixture analysis are common approaches to reduce the mixed pixel problem in medium spatial resolution images such as Landsat. Coarse spatial resolution images such as MODIS and DMSP-OLS
are valuable for national and global ISA mapping but more research is needed to effectively integrate multisource/scale data for improving mapping performance. Development of an optimal procedure corresponding to specific study areas and purposes is required to generate accurate ISA mapping results.

**Remote sensing-based global crop monitoring: experiences with China's CropWatch system**

Bingfang Wu, Jihua Meng, Qiangzi Li, Nana Yan, Xin Du & Miao Zhang

Abstract

Monitoring the production of main agricultural crops is important to predict and prepare for disruptions in food supply and fluctuations in global crop market prices. China's global crop-monitoring system (CropWatch) uses remote sensing data combined with selected field data to determine key crop production indicators: crop acreage, yield and production, crop condition, cropping intensity, crop-planting proportion, total food availability, and the status and severity of droughts. Results are combined to analyze the balance between supply and demand for various food crops and if needed provide early warning about possible food shortages. CropWatch data processing is highly automated and the resulting products provide new kinds of inputs for food security assessments. This paper presents a comprehensive overview of CropWatch as a remote sensing-based system, describing its structure, components, and monitoring approaches. The paper also presents examples of monitoring results and discusses the strengths and limitations of the CropWatch approach, as well as a comparison with other global crop-monitoring systems.

**A novel method for discovering spatio-temporal clusters of different sizes, shapes, and densities in the presence of noise**

Qiliang Liu, Min Deng, Jiantao Bi & Wentao Yang

Abstract

The discovery of spatio-temporal clusters in complex spatio-temporal data-sets has been a challenging issue in the domain of spatio-temporal data mining and knowledge discovery. In this paper, a novel spatio-temporal clustering method based on spatio-temporal shared nearest neighbors (STSNN) is proposed to detect spatio-temporal clusters of different sizes, shapes, and densities in spatio-temporal databases with a large amount of noise. The concepts of windowed distance and shared nearest neighbor are utilized to define a novel spatio-temporal density for a spatio-temporal entity with definite mathematical meanings. Then, the density-based clustering strategy is employed to uncover spatio-temporal clusters. The spatio-temporal clustering algorithm developed in this paper is easily implemented and less sensitive to density variation among spatio-temporal entities. Experiments are undertaken on several simulated data-sets to demonstrate the effectiveness and advantage of the STSNN algorithm. Also, the real-world applications on two seismic databases show that the STSNN algorithm has the ability to uncover foreshocks and aftershocks effectively.

**Remote sensing image fusion: an update in the context of Digital Earth**

Christine Pohl & John van Genderen

Abstract
Remote sensing image fusion has come a long way from research experiments to an operational image processing technology. Having established a framework for image fusion at the end of the 90s, we now provide an overview on the advances in image fusion during the past 15 years. Assembling information about new remote sensing image fusion techniques, recent technical developments and their influence on image fusion, international societies and working groups, and new journals and publications, we provide insight into new trends. It becomes clear that image fusion facilitates remote sensing image exploitation. It aims at achieving better and more reliable information to better understand complex Earth systems. The numerous publications during the last decade show that remote sensing image fusion is a well-established research field. The experiences gained foster other technological developments in terms of sensor configuration and data exploitation. Multi-modal data usage enables the implementation of the concept of Digital Earth. In order to advance in this respect, we recommend that updated guidelines and a set of commonly accepted quality assessment criteria are needed in image fusion.

Only one Earth: the long road via Rio to sustainable development

J.L. van Genderen
Digital Earth: Big Earth Data

Huadong Guo  Editor-in-Chief

Abstract

The Digital Earth (DE) movement is gaining momentum. Much of it is unstructured. This paper examines a number of recent developments including those in health sensors (Wearable Absence, Q-Sensor, and Guardian Angels) and
systems frameworks (Gelernter's Mirror Worlds, Virtual Australia, and New Zealand). Consideration is given to the implications of DE for citizens and on citizen science, including those of ethics. A suite of principles to guide the development of DE is proposed.

**Towards geospatial semantic search: exploiting latent semantic relations in geospatial data**

Wenwen Li, Michael F. Goodchild & Robert Raskin

**Abstract**

This paper reports our efforts to address the grand challenge of the Digital Earth vision in terms of intelligent data discovery from vast quantities of geo-referenced data. We propose an algorithm combining LSA and a Two-Tier Ranking (LSATTR) algorithm based on revised cosine similarity to build a more efficient search engine – Semantic Indexing and Ranking (SIR) – for a semantic-enabled, more effective data discovery. In addition to its ability to handle subject-based search, we propose a mechanism to combine geospatial taxonomy and Yahoo! GeoPlanet for automatic identification of location information from a spatial query and automatic filtering of datasets that are not spatially related. The metadata set, in the format of ISO19115, from NASA's SEDAC (Socio-Economic Data Application Center) is used as the corpus of SIR. Results show that our semantic search engine SIR built on LSATTR methods outperforms existing keyword-matching techniques, such as Lucene, in terms of both recall and precision. Moreover, the semantic associations among all existing words in the corpus are discovered. These associations provide substantial support for automating the population of spatial ontologies. We expect this work to support the operationalization of the Digital Earth vision by advancing the semantic-based geospatial data discovery.

**A stream-based Parasitic Model for implementing Mobile Digital Earth**

Wenhang Li, Jianhua Gong, Ping Yu, Qishen Duan & Yuling Zou

**Abstract**

A Parasitic Model is proposed in this study for Digital Earth running on mobile phones through a mobile network. Because of mobile phones' limited capabilities in high-performance computing, rendering, storing, and networking (CRSN), these functions are accomplished by a superior host computer in this model. Rendered virtual scenes are compressed in a time-series as a data stream and are sent to the mobile phone through a mobile network, thus allowing Digital Earth to be operated on a mobile phone. This study examines a prototype and shows that a Mobile Digital Earth based on a Parasitic Model can achieve functionality beyond the mobile phone's actual hardware capabilities and can reduce network traffic. These results demonstrate quasi-real-time interactions, but with bandwidth increases in next-generation mobile networks such as 4G and 5G, there is potential for real-time interactions in the near future.

**Web-based visualization of large 3D urban building models**

Liqiang Zhang, Chunming Han, Liang Zhang, Xiaokun Zhang & Jonathan Li

**Abstract**
Adaptive rendering of large urban building models has become an important research issue in three-dimensional (3D) geographic information system (GIS) applications. This study explores a way for rendering web-based 3D urban building models. A client–server hybrid rendering approach is presented for large 3D city models, stored on a remote server through a network. The approach combines an efficient multi-hierarchical building representation with a novel image-based method, 3D image impostor generated on demand by a remote server. This approach allows transferring complex scenes progressively while keeping high visualization quality. We also evaluated the rendering and data transferring performance of the proposed approach.

A framework design for the Chinese National Disaster Reduction System of Systems (CNDRSS)

Deren Li, Linglin Zeng, Nengcheng Chen, Jie Shan, Liangming Liu, Yida Fan & Wei Li

Abstract

China is one of the most disaster-prone countries in the world. Currently, the disaster prevention and relief mechanism in China is mainly based on single disaster types and is implemented by different ministries and divisions in single administrative regions. Subsequently, the available resources, including data, services, materials, and human resources, cannot be shared and used effectively. Based on the idea of an observation system of systems and a business system of systems, this paper presents an integrated framework for a Chinese National Disaster Reduction System of Systems (CNDRSS) to address this issue. The CNDRSS framework aims to achieve data sharing and collaboration among different disaster-related ministries/institutions by providing one-stop services for all phases of disaster management and linking together existing and planned disaster-related business systems and observation systems. The key technologies use federated databases and a web service to integrate multiple disaster management systems among different ministries/institutions and a sensor web to integrate airborne, space-borne, and in-situ observations through the web service. These event-driven focused-services connecting the various observations, processing, and mapping processes can meet the requirements for complex disaster-chain systems.

Does DE need a C? A proposal for a DE curriculum

Tim Foresman, Sven Schade, Yola Georgiadou & Josef Strobl

Abstract

The vision of a digital earth (DE) is continuously evolving, and the next-generation infrastructures, platforms and applications are being implemented. In this article, we attempt to initiate a debate within the DE and with affine communities about ‘why’ a digital earth curriculum (DEC) is needed, ‘how’ it should be developed, and ‘what’ it could look like. It is impossible to do justice to the Herculean effort of DEC development without extensive consultations with the broader community. We propose a frame for the debate (what, why, and how of a DEC) and a rationale for and elements of a curriculum for educating the coming generations of digital natives and indicate possible realizations. We particularly argue that a DEC is not a déjà vu of classical research and training agendas of geographic information science, remote sensing, and similar fields by emphasizing its unique characteristics.
Opening the black box of donor influence on Digital Earth in Africa

Kate T. Lance, Yola P. Georgiadou & Arnold K. Bregt

Abstract

Africa’s participation in Digital Earth is uneven. There is a tendency to ascribe this state to prevailing governance and cultural challenges in Africa. However, foreign actors such as donors have an apparent role in shaping geospatial policies and outcomes. Thus far, the complex linkages between external aid and improved social and environmental monitoring and decision-making have been handled as a kind of ‘black box’. To better understand the situation, we open the box and focus on the interaction between donors and policy-makers. We use a heuristic from political science, as well as empirical evidence, to describe the policy-influencing tools that donors employ based on four basic resources donors possess: organization, authority, treasure, and nodality. We show an evolution of tool usage as donors shift from ‘old aid’ to ‘new aid’ modalities. The new tools include: technical assistance for geospatial curriculum development, inscription of standards and data access requirements in contracts and grants, cross-agency project design, best-practice analysis, portfolio management, and the use of language to promote participation and accountability. Though these tools reflect donor intent to partner in the realization of Digital Earth, the tools stem from a persisting asymmetric power dynamic between donors and policy-makers.

Integration of hydrological observations into a Spatial Data Infrastructure under a Sensor Web environment

Zhong Zheng, Nengcheng Chen, Pengfei Li & Wei Wang

Abstract

Various sensors connected to the World Wide Web are used to obtain real-time hydrological observations. Thus, real-time management and utilization of such distributed in situ observations in the cyber-physical environment becomes possible. A Sensor Observation Service (SOS) chaining Web Feature Service (WFS) method is proposed to integrate geographical reference observation data collected by a hydrological Sensor Web into a virtual globe. This method hides the complexity of a series of information and service models in the Sensor Web realm to enable the integration of heterogeneous distributed hydrological data sources into a Spatial Data Infrastructure (SDI). The core components – a dynamic schema transformer and automatic information extractor – were designed and implemented. The SOS schema is matched to WFS schema that uses the schema transformer dynamically. The information extractor extracts and serves features automatically, conforming to standard SOS operations for observation retrieval and insertion. Feasibility experiments conducted on the Jinsha River tested this proposed method. Results show that the proposed approach allows the integration of SOS servers into legacy applications that have a higher degree of availability within many SDIs. However, this is accompanied with the drawback that only a limited part of the SOS functionality is available to clients.
Integrated geoscience databanks for interactive analysis and visualization

Khalid Amin Khan, Gulraiz Akhter & Zulfiqar Ahmad

Abstract

There has been a worldwide revolution in geoscientific data availability and access. An effectively infinite and instantaneous free access to geoscientific data from the World Wide System of Geoscience Data Centers and Virtual Observatories is available. In addition, national databanks and commercially available large exploration data-sets also exist. These distributed data resources impose challenges for the future to move toward their objective integration and visualization to discover new knowledge. Such advancements can facilitate meaningful interpretations and decision-making for the benefit of society at global and local scales. This article presents the Digital Earth initiative at a national level to address multiple domains, such as effective management of natural resources, interactive planning of exploration activities and monitoring, mapping and mitigation of natural hazards. It discusses a distributed geospatial data infrastructure and its importance in geoscientific data integration for efficient and interactive data retrieval, analysis and visualization. Some examples are presented to demonstrate the advantages of integrated visualization in geoscientific analysis.

First extensive and cost-effective quality check of Crisis Maps: presentation of assessment parameters and results

D. Carrion, C. Corbane, M. Broglia & M. Pesaresi

Abstract

The digital representation of disaster situations into maps, mainly based on remotely sensed observations, is becoming a widely used instrument for emergency management. Thousands of maps are being produced all over the world and big attention is paid by international institutions, such as the World Bank, the United Nations and the European Commission to these tools. The quality of crisis maps is a crucial element to ensure effectiveness in the disaster response chain, but it is often neglected with respect to the need for a rapid delivery. In this paper a sample of crisis maps produced between 2005 and 2010 by world leader providers has been evaluated through around 40 parameters assessed by visual analysis and extracted from the validation protocol designed at the Joint Research Centre (JRC) of the European Commission. The maps turned out to be in most cases clearly readable, but some gaps and inconsistencies have been singled out, due to the lack of international standard references. The results are analysed in detail and some remarks are presented.

Results from a comprehensive GPS Network: natural gas pipeline GPS Network

O. Yildirim

Abstract

Developing the Nabucco engineering infrastructure was the most challenging task imaginable and required state-of-the-art technologies. For this purpose, a Nabucco-Global Positioning System (GPS) Network was established. It is 762 km long. Nine-hundred and two ground control unit points were established. In order to provide the relationship with ITRF96
datum, it was surrounded by TFNGN (Turkish Fundamental National GPS Network) and TNVCN (Turkish National Vertical Control Network) checkpoints. GPS observations were evaluated in the form of a unique network. After being reduced to projection segments, coordinates in ED50 datum were provided between datums by 2D-Helmert Transformation. Orthometric heights related to the GPS Network were obtained by the improvement of TG-03 data based on a GPS/leveling procedure. The objective of the study is to present the results of a comprehensive engineering project which involved many geodetic considerations including GPS, orthometric heights, and geoid undulations and gives insight into the accuracy and precision of such large projects in terms of recent geodetic practice. In this study, a Global Navigation Satellite System (GNSS)-based geodetic infrastructure is presented, methods to obtain the necessary precision requirements are provided, and experience is shared in order to provide an example of a large-scale pipeline project, and to provide insight into the planning necessary for future similar engineering projects.

**Using remote sensing to assess impacts of land management policies in the Ordos rangelands in China**

Weicheng Wu, Eddy De Pauw & Claudio Zucca

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Abstract

Implementation of land management policies influences land use and hence causes environmental change. Taking the Ordos rangelands in China as a case study, this paper explores the potential of remote sensing to assess in dryland areas the impacts of policies on the environment. Thirteen Landsat images of the period 1978–2010 were acquired and those corresponding to the starting dates of implementation of different policies were selected for land-cover change analysis; others were used to check the detected change and track the normalized difference vegetation index (NDVI) trajectory matched with time series of meteorological data for calibration of natural response of rangelands to rainfall. The results indicate that policy impacts are complex and include both positive and negative aspects depending on the locality in space. On one hand, policies have aroused the enthusiasm of people in agricultural production and sand-control leading to the recovery of about 2618 km$^2$ of desertified rangeland and sandy land, and economic growth, on the other hand, provoked vegetation degradation with an accumulated area of 2439 km$^2$ when policies cannot reconcile the conflict between environmental protection and the interest of rural people. However, degradation is not absolute and can be mitigated by the implementation of rational policies.

**A Low-Cost Mobile Mapping System (LCMMS) for field data acquisition: a potential use to validate aerial/satellite building damage assessment**

Andrea Ajmar, Simone Balbo, Piero Boccardo, Fabio Giulio Tonolo, Marco Piras & Jan Princic

Abstract

Among the major natural disasters that occurred in 2010, the Haiti earthquake was a real turning point concerning the availability, dissemination and licensing of a huge quantity of geospatial data. In a few days several map products based on the analysis of remotely sensed data-sets were delivered to users. This demonstrated the need for reliable methods to validate the increasing variety of open source data and remote sensing-derived products for crisis management, with the aim to correctly spatially reference and interconnect these data with other global digital archives. As far as building damage assessment is concerned, the need for accurate field data to overcome the limitations of both vertical and oblique view satellite and aerial images was evident. To cope with the aforementioned need, a newly developed Low-Cost Mobile Mapping System (LCMMS) was deployed in Port-au-Prince (Haiti) and tested during a five-day survey in
February–March 2010. The system allows for acquisition of movies and single georeferenced frames by means of a transportable device easily installable (or adaptable) to every type of vehicle. It is composed of four webcams with a total field of view of about 180 degrees and one Global Positioning System (GPS) receiver, with the main aim to rapidly cover large areas for effective usage in emergency situations. The main technical features of the LCMMS, the operational use in the field (and related issues) and a potential approach to be adopted for the validation of satellite/aerial building damage assessments are thoroughly described in the article.

**An object-based approach for flood area delineation in a transboundary area using ENVISAT ASAR and LANDSAT TM data**

Giorgos Mallinis, Ioannis Z. Gitas, Vassileios Giannakopoulos, Fotis Maris & Maria Tsakiri-Strati

**Abstract**

The aim of this study was to develop a straightforward approach for flood area mapping in a transboundary riverbed using Geographic Object-Based Image Analysis. Weak bilateral/multilateral cooperation among neighboring countries hampers effective disaster management and mitigation activities over transboundary areas and strengthens the demand for reliable remote-sensing-derived information. Three object-based classification approaches using ENVI SAT/ASAR and multi-temporal LANDSAT TM data were developed and validated for flood area delineation. The accuracy assessment of the classification results was based on oblique air photo interpretation and an area-based comparison with the official flood map. The bi-level object-based model using the Normalized Difference Water Index and the original post-flood TM bands attained 92.67% overall accuracy in inundated-areas detection, while the ENVISAT/ASAR classification was the least accurate (85.33%), probably due to the lower spatial resolution of the Synthetic Aperture Radar image. A strong agreement (92.14%) was found between the LANDSAT flood extent and the official flood map, suggesting that the proposed method has the potential to be employed in the future as a standard part of a flood crisis management process.

**Multi-temporal remote sensing of land cover change and urban sprawl in the coastal city of Yantai, China**

Xinyang Yu, Anding Zhang, Xiyong Hou, Mingjie Li & Yingxiao Xia

**Abstract**

The importance of accurately mapping and monitoring land cover changes over time is increasing, especially in rapidly growing coastal cities. In this study, three pairs of Landsat images of Yantai, a representative coastal city in China, from 1989, 1999, and 2009 were selected to monitor land cover changes and urban sprawl dynamics. To improve the classification accuracy, three classification methods together with the minimum noise fraction (MNF) and pixel purity index (PPI) calculations were performed on the images. The classification results showed that the overall five-class classification accuracies averaged 91.38% for the 20-year period, which produced an accuracy of 83.78% for change maps. The analysis of change maps indicated that from 1989 to 2009, the percentage of urban area increased from 31.41% to 50.28% of the total area, and the newly urbanized area was mainly located in residential areas and the reclaimed harbor region. Analysis of the relationships between urban area and its driving forces obtained from statistical data found that the urban sprawl of Yantai before 2000 was relatively extensive, which is consistent with the conclusion
drawn by using remote sensing techniques. The research results could be used as inputs for sustainable urban management and establishing Digital Earth database.

A digital lightning prototype system: DLPS/HUST

Shengmei Yang, Qiwen Zhang, Yongzhi Zhang, Wenguang Wei & Tingting Shi

Abstract

Digital lightning is an important thematic branch of the digital earth. Lightning data are complex, momentary, discrete, dynamic and spatio-temporal in nature. Hence, making great progress in their management, analysis and service is challenging. Many studies have been directed towards this field all over the world. Some different relevant systems are currently available. However, most of them focus on a single or a few aspects of lightning applications, rather than taking an overall account of lightning detection, management, analysis and service from the strategic perspective of the digital earth. Lightning disaster also demands a better developed spatial information technology in this field than at present. The idea of the digital earth offers a reasonable scheme to address these issues. Based on reviews of the concept, development and progress of the digital earth, an integrated technical framework of a digital lightning prototype system (DLPS) is proposed, including its data, functions and implementation of subsystems, which aims at the facilitation, management, accessing, visualisation, application, release and sharing of lightning data. Some key technologies are also carefully discussed to facilitate the construction of the DLPS. This framework could provide a helpful guide to future lightning research and hazard mitigation, as well as enrich connotation on the digital earth. So far, there are still many difficulties in multi-level grid construction that need to be solved.

Supp 1 2013 pages 1-171

Special Issue: The Recent Progress in Land Remote Sensing

Recent progress in land remote sensing: algorithms and products

Shunlin Liang, Ainong Li & Jianchang Shi
A long-term Global LAnd Surface Satellite (GLASS) data-set for environmental studies

Shunlin Liang, Xiang Zhao, Suhong Liu, Wenping Yuan, Xiao Cheng, Zhiqiang Xiao, Xiaotong Zhang, Qiang Liu, Jie Cheng, Hairong Tang, Yonghua Qu, Yancheng Bo, Ying Qu, Huazhong Ren, Kai Yu & John Townshend

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Abstract

Recently, five Global LAnd Surface Satellite (GLASS) products have been released: leaf area index (LAI), shortwave broadband albedo, longwave broadband emissivity, incident short radiation, and photosynthetically active radiation (PAR). The first three products cover the years 1982–2012 (LAI) and 1981–2010 (albedo and emissivity) at 1–5 km and 8-day resolutions, and the last two radiation products span the period 2008–2010 at 5 km and 3-h resolutions. These products have been evaluated and validated, and the preliminary results indicate that they are of higher quality and accuracy than the existing products. In particular, the first three products have much longer time series, and are therefore highly suitable for various environmental studies. This paper outlines the algorithms, product characteristics, preliminary validation results, potential applications and some examples of initial analysis of these products.
Estimating global land surface broadband thermal-infrared emissivity using advanced very high resolution radiometer optical data

Jie Cheng & Shunlin Liang

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Abstract
An algorithm for retrieving global eight-day 5 km broadband emissivity (BBE) from advanced very high resolution radiometer (AVHRR) visible and near-infrared data from 1981 through 1999 was presented. Land surface was divided into three types according to its normalized difference vegetation index (NDVI) values: bare soil, vegetated area, and transition zone. For each type, BBE at 8–13.5 µm was formulated as a nonlinear function of AVHRR reflectance for Channels 1 and 2. Given difficulties in validating coarse emissivity products with ground measurements, the algorithm was cross-validated by comparing retrieved BBE with BBE derived through different methods. Retrieved BBE was initially compared with BBE derived from moderate-resolution imaging spectroradiometer (MODIS) albedos. Respective absolute bias and root-mean-square error were less than 0.003 and 0.014 for bare soil, less than 0.002 and 0.011 for transition zones, and −0.002 and 0.005 for vegetated areas. Retrieved BBE was also compared with BBE obtained through the NDVI threshold method. The proposed algorithm was better than the NDVI threshold method, particularly for bare soil. Finally, retrieved BBE and BBE derived from MODIS data were consistent, as were the two BBE values.

Preliminary validation of GLASS-DSSR products using surface measurements collected in arid and semi-arid regions of China

Guanghui Huang, Weizhen Wang, Xiaotong Zhang, Shunlin Liang, Shaomin Liu, Tianbao Zhao, Jinming Feng & Zhuguo Ma

Abstract
Global Land Surface Satellite-downward surface shortwave radiation (GLASS-DSSR) products have been routinely produced from 2008–2010 based on an improved look-up table algorithm, which explicitly accounts for the variations of cloud optical depth, water vapor content, and elevation. In this study, we validated and assessed the accuracy of these products in arid and semiarid regions of China. Toward this goal, observation data-sets provided by the Arid and Semiarid Region Collaborative Observation Project as well as four other metrological sites were collected, chosen, and preprocessed for the final validation. Due to the possible effect of spatial collocation and the strong adjacency pixel effect in instantaneous products, we used a more sophisticated validating scheme in order to reduce the impacts from these effects as much as possible. Evidences indicate that the GLASS-DSSR products are considerably accurate over most parts of arid and semiarid regions in China, but in complex terrain areas the products might need further refinements. The $R^2$ at all sites (except Naqu) was larger than 0.8 with a root mean square error (RMSE) range of about 90–130 W/m$^2$. Linear regression analyses suggest that GLASS-DSSR products tend to overestimate DSSR in the interval of low surface-measured values and symmetrically underestimate DSSR in the interval of high values. This systematic error may result from inappropriate assumptions about clouds and aerosol loadings over the regions in the operational algorithm.

Preliminary evaluation of the long-term GLASS albedo product

Qiang Liu, Lizhao Wang, Ying Qu, Nanfeng Liu, Suhong Liu, Hairong Tang & Shunlin Liang
Abstract

Land surface albedo is an important parameter to describe the radiant forcing in the climate system. A long-time series of global albedo products is needed to understand the mechanism of climate change. Aiming to support global change and Earth system studies, GLASS (Global LAnd Surface Satellites) provides long-term global land surface albedo product from 1981 to 2010, which are generated from multisource remote sensing data and newly developed algorithms. It is critical to assess the quality of the GLASS product when it is released to the public. This paper first introduced the algorithms and then analyzed the integrity, accuracy, and robustness of the GLASS albedo product. The results show that the GLASS albedo product is a gapless, long-term continuous, and self-consistent data-set with an accuracy similar to that of the widely acknowledged MODIS MCD43 product. The quality flag, which is provided along with the black-sky and white-sky albedo, gives a pertinent indication of the expected uncertainty in the product.

Field validation of the GLASS land surface broadband emissivity database using pseudo-invariant sand dune sites in northern China

Lixin Dong, Juyang Hu, Shihao Tang & Min Min

Abstract

The land surface broadband emissivity (LSBE) is a key parameter for estimating surface radiation, and there have been many studies of the LSBE at global or local scales. However, few studies have validated the surface emissivity database with multi-point field measurement data using infrared radiometry, especially in China. In this study, we focus on the validation of the emissivity product of the global land surface satellite (GLASS) LSBE database for northern China for the period from 2006 to 2011. Specifically, we have employed an eight-day averaged, gridded emissivity product in the 8–13.5 µm spectral range produced at a spatial resolution of 1000 m from the Moderate Resolution Imaging Spectrometer albedo product using a new algorithm. The GLASS LSBE database was validated over bare surfaces with field measurement data from sand samples collected at many pseudo-invariant sand dune sites located in western and northwestern China. By comparing measured emissivity for different land surface types at different sites and different times, it was shown that the results were consistent and that the accuracy of the field measurements was reliable. The results of the validation of GLASS LSBE with these field emissivity data showed very good agreement.

Land-surface temperature retrieval at high spatial and temporal resolutions based on multi-sensor fusion

Penghai Wu, Huanfeng Shen, Tinghua Ai & Yaolin Liu

Abstract

Land-surface temperature (LST) is of great significance for the estimation of radiation and energy budgets associated with land-surface processes. However, the available satellite LST products have either low spatial resolution or low temporal resolution, which constrains their potential applications. This paper proposes a spatiotemporal fusion method for retrieving LST at high spatial and temporal resolutions. One important characteristic of the proposed method is the consideration of the sensor observation differences between different land-cover types. The other main contribution is that the spatial correlations between different pixels are effectively considered by the use of a variation-based model. The method was tested and assessed quantitatively using the different sensors of Landsat TM/ETM+, moderate resolution imaging spectrometer (MODIS).
resolution imaging spectroradiometer and the geostationary operational environmental satellite imager. The validation results indicate that the proposed multisensor fusion method is accurate to about 2.5 K.

**Improving a Penman–Monteith evapotranspiration model by incorporating soil moisture control on soil evaporation in semiarid areas**

Liang Sun, Shunlin Liang, Wenping Yuan & Zhongxin Chen

Abstract

Penman–Monteith (PM) theory has been successfully applied to calculate land surface evapotranspiration (ET) for regional and global scales. However, soil surface resistance, related to soil moisture, is always difficult to determine over a large region, especially in arid or semiarid areas. In this study, we developed an ET estimation algorithm by incorporating soil moisture control, a soil moisture index (SMI) derived from the surface temperature and vegetation index space. We denoted this ET algorithm as the PM-SMI. The PM-SMI algorithm was compared with several other algorithms that calculated soil evaporation using relative humidity, and validated with Bowen ratio measurements at seven sites in the Southern Great Plain (SGP) that were covered by grassland and cropland with low vegetation cover, as well as at three eddy covariance sites from AmeriFlux covered by forest with high vegetation cover. The results show that in comparison with the other methods examined, the PM-SMI algorithm significantly improved the daily ET estimates at SGP sites with a root mean square error (RMSE) of 0.91 mm/d, bias of 0.33 mm/d, and $R^2$ of 0.77. For three forest sites, the PM-SMI ET estimates are closer to the ET measurements during the non-growing season when compared with the other three algorithms. At all the 10 validation sites, the PM-SMI algorithm performed the best. PM-SMI 8-day ET estimates were also compared with MODIS 8-day ET products (MOD16A2), and the latter showed negligible bias at SGP sites. In contrast, most of the PM-SMI 8-day ET estimates are around the 1:1 line.

**A cloud detection method based on a time series of MODIS surface reflectance images**

Hairong Tang, Kai Yu, Olivier Hagolle, Kang Jiang, Xiurui Geng & Yongchao Zhao

Abstract

The Moderate Resolution Imaging Spectroradiometer (MODIS)-Terra surface reflectance product (MOD09A1), with bands 1 to 7, is a gridded, eight-day composite product derived from the MODIS-Terra top of atmosphere reflectance swaths. It performs cloud detection and corrects for the effects of atmospheric gases and aerosols. The cloud mask (CM) algorithms for MODIS are based on empirical thresholds on spectral reflectance and brightness temperature. Since the spatial resolution of the thermal band is 1000 m, while that of MOD09A1 is 500 m, many undetected and false clouds are observed in MOD09A1. These errors always result in temporal and spatial inconsistencies in higher-level products. In this paper, a cloud detection algorithm (TSCD) based on a MOD09A1 time series is introduced. Time series cloud detection (TSCD) algorithm is based on the relative stability of ground reflectance and the sudden variations in reflectance that result from cloud cover. The algorithm first searches the clear-sky reference data, and then discriminates clouded and unclouded pixels by detecting a sudden change of reflectance in the blue wavelength and spectral correlation coefficient at the pixel level. Compared with cloud cover assessments obtained from MODIS’ original CM, TSCD provides similar or better discrimination in most situations when the land surface changes slowly.
FROM-GC: 30 m global cropland extent derived through multisource data integration

Le Yu, Jie Wang, Nicholas Clinton, Qinchuan Xin, Liheng Zhong, Yanlei Chen & Peng Gong

Abstract

We report on a global cropland extent product at 30-m spatial resolution developed with two 30-m global land cover maps (i.e. FROM-GLC, Finer Resolution Observation and Monitoring, Global Land Cover; FROM-GLC-agg) and a 250-m cropland probability map. A common land cover validation sample database was used to determine optimal thresholds of cropland probability in different parts of the world to generate a cropland/noncropland mask according to the classification accuracies for cropland samples. A decision tree was then applied to combine two 250-m cropland masks: one existing mask from the literature and the other produced in this study, with the 30-m global land cover map FROM-GLC-agg. For the smallest difference with country-level cropland area in Food and Agriculture Organization Corporate Statistical (FAOSTAT) database, a final global cropland extent map was composited from the FROM-GLC, FROM-GLC-agg, and two masked cropland layers. From this map FROM-GC (Global Cropland), we estimated the global cropland areas to be 1533.83 million hectares (Mha) in 2010, which is 6.95 Mha (0.45%) less than the area reported by the Food and Agriculture Organization (FAO) of the United Nations for the year 2010. A country-by-country comparison between the map and the FAOSTAT data showed a linear relationship (FROM-GC = 1.05*FAOSTAT −1.2 (Mha) with $R^2 = 0.97$). Africa, South America, Southeastern Asia, and Oceania are the regions with large discrepancies with the FAO survey.

Lake variations in response to climate change in the Tibetan Plateau in the past 40 years

Jingjuan Liao, Guozhuang Shen & Yingkui Li

Abstract

The Qinghai-Tibetan Plateau plays an important role in global climate and environmental change and holds the largest lake area in China, with a total surface area of 36,900 km$^2$. The expansion and shrinkage of these lakes are critical to the water cycle and ecological and environmental systems across the plateau. In this paper, surface areas of major lakes within the plateau were extracted based on a topographic map from 1970, and Landsat MSS, TM and ETM+ satellite images from the 1970s to 2008. Then, a multivariate correlation analysis was conducted to examine the relationship between the changes in lake surface areas and the changes in climatic variables including temperature, precipitation, evaporation, and sunshine duration. Initial results suggest that the variations in lake surface areas within the plateau are closely related to the warming, humidified climate transition in recent years such as the rise in air temperature and the increase in precipitation. In particular, the rising temperature accelerates melting of glaciers and perennial snow cover and triggers permafrost degradation, and leads to the expansion of most lakes across the plateau. In addition, different distributions and types of permafrost may cause different lake variations in the southern Tibetan Plateau.
Monitoring nitrogen concentration of oilseed rape from hyperspectral data using radial basis function

Fumin Wang, Jingfeng Huang, Yuan Wang, Zhuanyu Liu, Dailiang Peng & Feifeng Cao

Abstract

Remote sensing technology is the important tool of digital earth, it can facilitate nutrient management in sustainable cropping systems. In the study, two types of radial basis function (RBF) neural network approaches, the standard radial basis function (SRBF) neural networks and the modified type of RBF, generalized regression neural networks (GRNN), were investigated in estimating the nitrogen concentrations of oilseed rape canopy using vegetation indices (VIs) and hyperspectral reflectance. Comparison analyses were performed to the spectral variables and the approaches. The Root Mean Square Error (RMSE) and determination coefficients ($R^2$) were used to assess their predictability of nitrogen concentrations. For all spectral variables (VIs and hyperspectral reflectance), the GRNN method produced more accurate estimates of nitrogen concentrations than did the SRBF method at all ranges of nitrogen concentrations, and the better agreements between the measured and the predicted nitrogen concentration were obtained with the GRNN method. This indicated that the GRNN method is prior to the SRBF method in estimation of nitrogen concentrations. Among the VIs, the Modified Chlorophyll Absorption in Reflectance Index ($MCARI$), $MCARI_{1510}$, and Transformed Chlorophyll Absorption in Reflectance Index are better than the others in estimating oilseed rape canopy nitrogen concentrations. Compared to the results from VIs, the hyperspectral reflectance data also gave an acceptable estimation. The study showed that nitrogen concentrations of oilseed rape canopy could be monitored using remotely sensed data and the RBF method, especially the GRNN method, is a useful explorative tool for oilseed rape nitrogen concentration monitoring when applied on hyperspectral data.

Analysing urban dynamics using multi-temporal satellite images in the case of a mountain area, Sinaia (Romania)

Alina Elena Huzui, Abdellaoui Abdelkader & Ileana Patru-Stupariu

Abstract

The purpose of this study is to produce an analysis of the urban expansion in the case of a mountain resort in the Romanian Carpathians through the integration of different cartographic and ancillary material in the remote sensing imagery processing. The spatial pattern analysis of the changes underwent by the urban landscape was based on multi-temporal information sources, covering 28 years, which highlighted the major turning points in landscape evolution, meaning industrial development under the communist production planning and residential expansion in recent years. To fully exploit the combination of satellite image processing in IDRISI, the manual image classification and database interrogation in ArcGis, we used a uniform grid, representing a set of vector data for each year available from the Landsat image archive. The image comparison was completed by using appropriate quantitative techniques. In conclusion the urban landscape evolution was linked to the socio-economic context. At a historic scale the main phenomenon identified is the concentration of mass tourism facilities, located in contiguity to a protected area, a situation reflected in the constant fragmentation of surfaces covered with vegetation at the urban fringe. In the digital earth science, the interplay between mountain ecosystems and human activities encompasses a key role in the management of viable mountain landscapes.
Developing a geospatial web-GIS system for landscape and urban planning

Junghoon Ki

FREE ACCESS

Abstract
This study discusses a geographical information system (GIS) for operating a local government's landscape and urban planning activities via a website. Implementing this web-GIS system will help build a more realistic landscape and urban planning model that includes citizen participation and city marketing. The approach is applicable to ubiquitous city (u-city) development based on geospatial web and its related systems. The approach presented is built on six selected elements of a u-city system. The outcome of the study includes sustainable analysis, environmental planning, urban planning, and city marketing. The outcome is applicable to cities that are planning to adopt the u-city system or advanced telecommunication or planning tools into their urban frameworks.

Application of digital techniques to identify aquifer artificial recharge sites in GIS environment

A. Mahdavi, S.H. Tabatabaei, R. Mahdavi & M.R. Nouri Emamzadei

FREE ACCESS

Abstract
Because the groundwater is considered as the major source of 99% of all retrievable fresh water, optimization of its usage would be very crucial. Groundwater artificial recharge (GAR) using surface water is the recommended solution because that increases the aquifer storage. Detection of aquifer storage site is the first step in designing GAR projects. The main objective of this research is the identification of suitable GAR sites scattered in the Shahrekord plain, Chaharmahal-va-Bakhtiari province of Iran, using Boolean and Fuzzy logic. Data affecting GAR including ground surface slope, soil infiltration rate, vadoze zone thickness, electrical conductivity of the surface water, land-use, and stream network were collected. After provision of digital maps, they were classified, weighted, and integrated through Boolean and Fuzzy operators. The result revealed almost 4.25% of the whole plain area is appropriate for GAR based on Boolean. Also, 4.79 and 17.94% of the plain area are suitable and rather favorable, respectively, based on Fuzzy. Finally, 34 locations were introduced with priorities A, B, and AB as being potentially suitable for GAR. The relationship between geomorphology and suitable areas for GAR based on Boolean and Fuzzy method indicated that the majority of these areas were located on colluvial fans units.

Precision agriculture for grain production systems

J.L. van Genderen
BOOK REVIEW

Precision agriculture for grain production systems, by Brett Whelan and James Taylor, Collingwood, Victoria, CSIRO Publishing, 2013, 208 pp., AUD $89.95 (paperback), ISBN 9780643107472

This excellent little book will be of great interest to many readers of this journal, in that it treats in considerable detail the concepts, tools, and techniques of precision agriculture (PA), to help ensure food security for future generations. All over the world, more and more grain farmers are adopting the PA methodology, as well as in a broad range of other cropping industries.

The book, written by two recognized experts in this field, consists of eight chapters. Chapter 1 gives a very concise introduction to PA. This is followed by a good chapter on the Global Navigation Satellite Systems (GNSS) and PA. This describes in very clear terms the agricultural uses for Global Position System (GPS). Chapters 3 and 4 describe the hardware and software required for PA. It is followed by a chapter on data management. Chapters 6 and 7 go into much more detail on how to make and interpret maps for PA and on yield variability and site-specific crop management. The final chapter is on the economics of PA in Australian grain crops. The following paragraphs describe in more detail about the content of these chapters.

The introductory chapter gives two very good definitions of PA. The first one is: ‘PA is an integrated information- and production-based farming system that is designed to increase long-term, site-specific, and whole-farm production efficiency, productivity, and profitability while minimizing unintended impacts on wildlife and the environment’.

The second definition narrows down the PA philosophy of timely management of variation down to its implementation in cropping systems, what the authors call ‘site-specific crop management’ (SSCM), defined as: ‘A form of PA whereby decisions on resource application and agronomic practices are improved to better match soil and crop requirements as they vary in the field’. SSCM, the authors show can help achieve the farmers’ objectives of optimizing production efficiency, optimizing quality, minimizing the environmental impacts of farming practices, and minimizing risk. The chapter contains some nice figures, diagrams, and tables on the role of georeferencing, and on stages for the progressive adoption of PA in grain production.

Chapter 2 on GNSS has a very good section on all the possible errors of GPS measurements, which may be critical for high accuracy applications of PA. It also contains a useful section on GNSS-based vehicle navigation systems, which can help
Abstract

We developed a global, 30-m resolution dataset of percent tree cover by rescaling the 250-m MOderate-resolution Imaging Spectroradiometer (MODIS) Vegetation Continuous Fields (VCF) Tree Cover layer using circa-2000 and 2005 Landsat images, incorporating the MODIS Cropland Layer to improve accuracy in agricultural areas. Resulting Landsat-based estimates maintained consistency with the MODIS VCF in both epochs (RMSE = 8.6% in 2000 and 11.9% in 2005), but showed improved accuracy in agricultural areas and increased discrimination of small forest patches. Against lidar measurements, the Landsat-based estimates exhibited accuracy slightly less than that of the MODIS VCF (RMSE = 16.8% for MODIS-based vs. 17.4% for Landsat-based estimates), but RMSE of Landsat estimates was 3.3 percentage points lower than that of the MODIS data in an agricultural region. The Landsat data retained the saturation artifact of the MODIS VCF at greater than or equal to 80% tree cover but showed greater potential for removal of errors through calibration to lidar, with post-calibration RMSE of 9.4% compared to 13.5% in MODIS estimates. Provided for free download at the Global Land Cover Facility (GLCF) website (http://www.landcover.org), the 30-m resolution GLCF tree cover dataset is the highest-resolution multi-temporal depiction of Earth's tree cover available to the Earth science community.
Application of remote sensing for investigating mining geological hazards

Qinjun Wang, Huadong Guo, Yu Chen, Qizhong Lin & Hui Li

Abstract

To investigate geological mining hazards using digital techniques such as high-resolution remote sensing, a semi-automatically geological mining hazards extraction method is proposed based on the case of the Shijiaying coal mine, located in Fangshan District, Beijing, China. In the method, the vegetation is first removed using the normalized difference vegetation index (NDVI) on the GeoEye-1 data. Then, geological mining hazards interpretation features are determined after color enhancement using principal component analysis (PCA) transformation. Bitmaps mainly covered by geological mining hazards are isolated by masking operation in the environment for visualizing images software. Next, each bitmap is classified into a two-valued imagery using support vector machine algorithm. In the two-valued imagery, 1 denotes the geological mining hazards, while 0 denotes none. Afterwards, the two-valued imagery is converted into a vector graph by corresponding functions in the ArcGIS software and no geological mining hazards regions in the vector graph are deleted manually. Finally, the correlation between factors (such as mining activity, lithology, geological structure, and slope) and geological mining hazards is analyzed using a logistic regression and a hazardous-area forecasting model is built. The results of field verification show that the accuracy of the geological mining hazards extraction method is 98.1% and the results of the hazardous-area forecasting indicate that the logistic regression is an effective model in assessing geological hazard risks and that mining activity is the main contributing factor to the hazards, while geological structure, slope, lithology, roughness of the surface, and aspect are the secondary.

Construction of a virtual lunar environment platform

Min Chen, Hui Lin, Yongning Wen, Li He & Mingyuan Hu

Abstract

Many of the world's powerful and wealthy nations, including China, have devoted both large amounts of funding and considerable promotion to lunar research and exploration. The launch of Chinese Chang'e-1 satellite and the construction of the scientific observation data platform created a favourable opportunity for research into the lunar geometrical, physical and chemical environment. Based on this background, a Wide Area Network (WAN) based virtual lunar environment was constructed for observation data sharing and further exploration. The systematic architecture and framework were introduced and then strategies of mass data (e.g. lunar digital elevation model, lunar digital orthophoto map and typical thematic lunar data) organisation, integration, management and scheduling were then set up to achieve the 3D visualisation of typical lunar geomorphic features. Furthermore, the integration method of 3D lunar data and the process model of impact craters were studied; thus, the whole lunar and celestial collision process could be dynamically simulated. The results indicate that the WAN-based virtual lunar platform can be used effectively for public information sharing, scientific exploration and further to promote the development of deep space exploration in China.

Visualization of geologic geospatial datasets through X3D in the frame of WebGIS

Frederik von Reumont, Jamal Jokar Arsanjani & Andreas Riedl
Abstract

3D geo spatial data have become the normal. However, to view the data, usually expert software is required, which have up to now hindered the wide spread use of 3D scenes for the display of geological data. The internet real time 3D rendering framework X3D is assessed regarding its suitability for building a geological GIS on the internet. Especially important for geological data, 3D rendering enhances the intuitive grasp of the data and enables the user to interactively explore it. It is often necessary to find a solution to distribute this data to a wide range of interested parties, experts and non-experts alike. According to the nature of 3D data, the best technique to display geo-data, the modeling of objects and unresolved issues have to be taken into consideration. The internet is the apparent tool for the public distribution and visualization of 3D data and it was found that through the open ISO-standardized format X3D it offers a multitude of possibilities. A 3D geological interactive map was created with these prerequisites to identify challenges and possibilities through this process. It was found that the use of lead to satisfactory results, that could probably not have been achieved with another technology.

Assessment of different topographic correction methods in ALOS AVNIR-2 data over a forest area

Nafiseh Ghasemi, Ali Mohammadzadeh & Mahmod Reza Sahebi

Abstract

Because the removal of topographic effects is one the most important pre-processing steps when extracting information from satellite images in digital Earth applications, the problem of differential terrain illumination on satellite imagery has been investigated for at least 20 years. As there is no superior topographic correction method applicable to all areas and all images, a comparison of topographic normalization methods in different regions and images is necessary. In this study, common topographic correction methods were applied on an ALOS AVNIR-2 image of a rugged forest area, and the results were evaluated through different criteria. The results show that the simple correction methods [Cosine, Sun-Canopy-sensor (SCS), and Minnaert correction] are inefficient in exceptionally rough forests. Among the improved correction methods (SCS+C, modified Minnaert, and pixel-based Minnaert), the best result was achieved using a pixel-based Minnaert approach in which a separate correction factor in various slope angles is used. Thus, this method should be considered for topographic correction, especially in forests with severe topography.

Issue 4 2013 pages 297-425

Special Issue: Cloud Computing

Redefining the possibility of digital Earth and geosciences with spatial cloud computing

Chaowei Yang, Yan Xu & Douglas Nebert

Abstract

Global challenges (such as economy and natural hazards) and technology advancements have triggered international leaders and organizations to rethink geosciences and Digital Earth in the new decade. The next generation visions pose grand challenges for infrastructure, especially computing infrastructure. The gradual establishment of cloud computing as a primary infrastructure provides new capabilities to meet the challenges. This paper reviews research conducted
using cloud computing to address geoscience and Digital Earth needs within the context of an integrated Earth system. We also introduce the five papers selected through a rigorous review process as exemplar research in using cloud capabilities to address the challenges. The literature and research demonstrate that spatial cloud computing provides unprecedented new capabilities to enable Digital Earth and geosciences in the twenty-first century in several aspects: (1) virtually unlimited computing power for addressing big data storage, sharing, processing, and knowledge discovering challenges, (2) elastic, flexible, and easy-to-use computing infrastructure to facilitate the building of the next generation geospatial cyberinfrastructure, CyberGIS, CloudGIS, and Digital Earth, (3) seamless integration environment that enables mashing up observation, data, models, problems, and citizens, (4) research opportunities triggered by global challenges that may lead to breakthroughs in relevant fields including infrastructure building, GIScience, computer science, and geosciences, and (5) collaboration supported by cloud computing and across science domains, agencies, countries to collectively address global challenges from policy, management, system engineering, acquisition, and operation aspects.

**Cloud computing for integrated stochastic groundwater uncertainty analysis**

Yong Liu, Alexander Y. Sun, Keith Nelson & Wesley E. Hipke

**Abstract**

One of the major scientific challenges and societal concerns is to make informed decisions to ensure sustainable groundwater availability when facing deep uncertainties. A major computational requirement associated with this is on-demand computing for risk analysis to support timely decision. This paper presents a scientific modeling service called ‘ModflowOnAzure’ which enables large-scale ensemble runs of groundwater flow models to be easily executed in parallel in the Windows Azure cloud. Several technical issues were addressed, including the conjunctive use of desktop tools in MATLAB to avoid license issues in the cloud, integration of Dropbox with Azure for improved usability and ‘Drop-and-Compute,’ and automated file exchanges between desktop and the cloud. Two scientific use cases are presented in this paper using this service with significant computational speedup. One case is from Arizona, where six plausible alternative conceptual models and a streamflow stochastic model are used to evaluate the impacts of different groundwater pumping scenarios. Another case is from Texas, where a global sensitivity analysis is performed on a regional groundwater availability model. Results of both cases show informed uncertainty analysis results that can be used to assist the groundwater planning and sustainability study.

**Utilize cloud computing to support dust storm forecasting**

Qunying Huang, Chaowei Yang, Karl Benedict, Songqing Chen, Abdelmounaam Rezgui & Jibo Xie

**Abstract**

The simulations and potential forecasting of dust storms are of significant interest to public health and environment sciences. Dust storms have interannual variabilities and are typical disruptive events. The computing platform for a dust storm forecasting operational system should support a disruptive fashion by scaling up to enable high-resolution forecasting and massive public access when dust storms come and scaling down when no dust storm events occur to save energy and costs. With the capability of providing a large, elastic, and virtualized pool of computational resources, cloud computing becomes a new and advantageous computing paradigm to resolve scientific problems traditionally...
requiring a large-scale and high-performance cluster. This paper examines the viability for cloud computing to support dust storm forecasting. Through a holistic study by systematically comparing cloud computing using Amazon EC2 to traditional high performance computing (HPC) cluster, we find that cloud computing is emerging as a credible solution for (1) supporting dust storm forecasting in spinning off a large group of computing resources in a few minutes to satisfy the disruptive computing requirements of dust storm forecasting, (2) performing high-resolution dust storm forecasting when required, (3) supporting concurrent computing requirements, (4) supporting real dust storm event forecasting for a large geographic domain by using recent dust storm event in Phoniex, 05 July 2011 as example, and (5) reducing cost by maintaining low computing support when there is no dust storm events while invoking a large amount of computing resource to perform high-resolution forecasting and responding to large amount of concurrent public accesses.

Prototyping an open environment for sharing geographical analysis models on cloud computing platform

Yongning Wen, Min Chen, Guonian Lu, Hui Lin, Li He & Songshan Yue

Abstract

The sharing of geographical analysis models is of crucial importance for simulating geographic processes and phenomena in the current geographical information systems (e.g. Digital Earth), but there remain some issues that have not been completely resolved. The challenges include, eliminating model heterogeneity and searching for suitable infrastructures to support the open sharing and effective execution of models. Taking advantage of cloud computing, this article aims to address the above issues and develop an open environment for geographical analysis model sharing. On the basis of the analysis of the applicability of cloud computing, the architecture of the open environment is proposed. More importantly, key strategies designed for heterogeneous model description, model encapsulating as well as model deploying and transparent accessing in the cloud are discussed in detail to establish such an environment. Finally, the prototype environment is implemented, and experiments were conducted to verify the environment's feasibility to support the sharing of geographical analysis models.

Enabling Digital Earth simulation models using cloud computing or grid computing – two approaches supporting high-performance GIS simulation frameworks

Ick-Hoi Kim & Ming-Hsiang Tsou

Abstract

Geospatial simulation models can help us understand the dynamic aspects of Digital Earth. To implement high-performance simulation models for complex geospatial problems, grid computing and cloud computing are two promising computational frameworks. This research compares the benefits and drawbacks of both in Web-based frameworks by testing a parallel Geographic Information System (GIS) simulation model (Schelling's residential segregation model). The parallel GIS simulation model was tested on XSEDE (a representative grid computing platform) and Amazon EC2 (a representative cloud computing platform). The test results demonstrate that cloud computing platforms can provide almost the same parallel computing capability as high-end grid computing frameworks. However, cloud computing resources are more accessible to individual scientists, easier to request and set up, and have more scalable software architecture for on-demand and dedicated Web services. These advantages may attract more geospatial scientists to utilize cloud computing for the development of Digital Earth simulation models in the future.
Geoprocessing in Cloud Computing platforms – a comparative analysis

Peng Yue, Hongxiu Zhou, Jianya Gong & Lei Hu

Abstract

The emergence of Cloud Computing technologies brings a new information infrastructure to users. Providing geoprocessing functions in Cloud Computing platforms can bring scalable, on-demand, and cost-effective geoprocessing services to geospatial users. This paper provides a comparative analysis of geoprocessing in Cloud Computing platforms – Microsoft Windows Azure and Google App Engine. The analysis compares differences in the data storage, architecture model, and development environment based on the experience to develop geoprocessing services in the two Cloud Computing platforms; emphasizes the importance of virtualization; recommends applications of hybrid geoprocessing Clouds, and suggests an interoperable solution on geoprocessing Cloud services. The comparison allows one to selectively utilize Cloud Computing platforms or hybrid Cloud pattern, once it is understood that the current development of geoprocessing Cloud services is restricted to specific Cloud Computing platforms with certain kinds of technologies. The performance evaluation is also performed over geoprocessing services deployed in public Cloud platforms. The tested services are developed using geoprocessing algorithms from different vendors, GeoSurf and Java Topology Suite. The evaluation results provide a valuable reference on providing elastic and cost-effective geoprocessing Cloud services.

Issue 3 2013 pages 203-296

Generation of high spatial and temporal resolution NDVI and its application in crop biomass estimation

Jihua Meng, Xin Du & Bingfang Wu

Abstract

While data like HJ-1 CCD images have advantageous spatial characteristics for describing crop properties, the temporal resolution of the data is rather low, which can be easily made worse by cloud contamination. In contrast, although Moderate Resolution Imaging Spectroradiometer (MODIS) can only achieve a spatial resolution of 250 m in its normalised difference vegetation index (NDVI) product, it has a high temporal resolution, covering the Earth up to multiple times per day. To combine the high spatial resolution and high temporal resolution of different data sources, a new method (Spatial and Temporal Adaptive Vegetation index Fusion Model [STAVFM]) for blending NDVI of different spatial and temporal resolutions to produce high spatial–temporal resolution NDVI datasets was developed based on Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM). STAVFM defines a time window according to the temporal variation of crops, takes crop phenophase into consideration and improves the temporal weighting algorithm. The result showed that the new method can combine the temporal information of MODIS NDVI and spatial difference information of HJ-1 CCD NDVI to generate an NDVI dataset with both high spatial and high temporal resolution. An application of the generated NDVI dataset in crop biomass estimation was provided. An average absolute error of 17.2% was achieved. The estimated winter wheat biomass correlated well with observed biomass (R² of 0.876). We conclude that the new dataset will improve the application of crop biomass estimation by describing the crop biomass accumulation in detail. There is potential to apply the approach in many other studies, including crop production.
estimation, crop growth monitoring and agricultural ecosystem carbon cycle research, which will contribute to the implementation of Digital Earth by describing land surface processes in detail.

**Remote sensing detection and verification of disappeared reservoirs along the Grand Canal of China**

Biao Deng, Yueping Nie, Huadong Guo, Changlin Wang, Shenglin Lei & Rong Li

**Abstract**

Digital Earth is an information-rich expression of the real Earth and is a new way of understanding the Earth in the twenty-first century. Archeology has found great potentialities in Digital Earth, strongly increasing its development and its interdisciplinary experimentations. With the rapid development of remote sensing, the importance of applying Earth observation technology to archeological research has caught a great amount of attention worldwide. The objective of this study is to apply Radarsat-1 and Landsat imagery, historical maps, and aerial photographs in the detection and verification of disappeared reservoirs built 500 years ago as part of the Grand Canal of China. The results of the study show that the potential sites present distinct variations in soil moisture, biomass, and biological vigor, characterized by weak backscattering in Radarsat imagery; high vegetation indices in Landsat imagery; and distinct anomalies in a Landsat principle components image. Historical maps and aerial photographs also verified the existence of the sites of disappeared reservoirs. Since the sites have so far not been extensively explored, the results should represent a significant contribution to the understanding of the Grand Canal of China and its auxiliary facilities.

**A RESTful proxy and data model for linked sensor data**

Krzysztof Janowicz, Arne Bröring, Christoph Stasch, Sven Schade, Thomas Everding & Alejandro Llaves

**Abstract**

The vision of a Digital Earth calls for more dynamic information systems, new sources of information, and stronger capabilities for their integration. Sensor networks have been identified as a major information source for the Digital Earth, while Semantic Web technologies have been proposed to facilitate integration. So far, sensor data are stored and published using the Observations & Measurements standard of the Open Geospatial Consortium (OGC) as data model. With the advent of Volunteered Geographic Information and the Semantic Sensor Web, work on an ontological model gained importance within Sensor Web Enablement (SWE). In contrast to data models, an ontological approach abstracts from implementation details by focusing on modeling the physical world from the perspective of a particular domain. Ontologies restrict the interpretation of vocabularies toward their intended meaning. The ongoing paradigm shift to Linked Sensor Data complements this attempt. Two questions have to be addressed: (1) how to refer to changing and frequently updated data sets using Uniform Resource Identifiers, and (2) how to establish meaningful links between those data sets, that is, observations, sensors, features of interest, and observed properties? In this paper, we present a Linked Data model and a RESTful proxy for OGC's Sensor Observation Service to improve integration and inter-linkage of observation data for the Digital Earth.

**Full polarimetric PALSAR-based land cover monitoring in Cambodia for implementation of REDD policies**

Ram Avtar, Wataru Takeuchi & Haruo Sawada
Abstract

Forest cover monitoring plays an important role in the implementation of climate change mitigation policies such as Kyoto protocol and Reducing Emissions from Deforestation and Forest Degradation (REDD). In this study, we have monitored land cover using the PALSAR (Phased Array type L-band Synthetic Aperture Radar) full polarimetric data based on incoherent target decomposition. Supervised classification technique has been applied on Cloude–Pottier decomposition, Freeman–Durden three component, and Yamaguchi four component decomposition for accurate mapping of different types of land cover classes. Based on confusion matrix derived from the predicted and defined pixels, the evergreen and sparsely deciduous forests have shown high producer's accuracy by Freeman–Durden three component and Yamaguchi four component classifications. The overall accuracy of Maximum Likelihood Classification by Yamaguchi four component is 94.1% with 0.93 kappa coefficient as compared to the 90.3% with 0.88 kappa coefficient by Freeman–Durden three component and 89.7% with 0.88 kappa coefficient by Cloude–Pottier decomposition. High accuracy of classification in a forested area using full polarimetric PALSAR data may have been because of high penetration of L-band SAR. The content of this study could be useful for the forest cover mapping during cloudy days needed for proper implementation of REDD policies in Cambodia.

Assessment of surface and subsurface waterlogging, water level fluctuations, and lithological variations for evaluating groundwater resources in Ganga Plains

Arvind Chandra Pandey, Suraj Kumar Singh, M.S. Nathawat & Dipankar Saha

Abstract

In the present study, the multi-temporal satellite images of IRS P6 LISS III were used to map waterlogging dynamics over different seasons. An area of 594.36 km² (6.75%) and 4.17 km² (0.04%) was affected by surface waterlogging during pre and postmonsoon season, respectively. The average annual groundwater level fluctuations were calculated using 18 years (1990–2007) pre and postmonsoon groundwater level data to identify the areas which are under groundwater induced waterlogging conditions. The soil map clearly indicates that salinity and sodicity exhibit the highest severity and occur in areas with shallow groundwater levels. The hydrogeomorphical units mapped using IRS P6 LISS III satellite images are flood plain, alluvial plain, paleochannels, and oxbow lakes. The study revealed that 44.65% areas have very good to excellent groundwater resources. The litholog data clearly indicate an alternating sequence of clay and sand in which deep aquifers made up of coarse sand would be best suited for adequate water supply and good groundwater quality. The integrated study utilizing digital spatial data pertaining to waterlogging, soil salinity, water level fluctuation, and lithological variation proved that planning of any surface and subsurface water resources development activity should be taken up after assessments of said parameters.

Issue 2 2013 pages 103-201

SAR polarimetric change detection for flooded vegetation

B. Brisco, A. Schmitt, K. Murnaghan, S. Kaya & A. Roth

Abstract
Due to spatial and temporal variability an effective monitoring system for water resources must consider the use of remote sensing to provide information. Synthetic Aperture Radar (SAR) is useful due to timely data acquisition and sensitivity to surface water and flooded vegetation. The ability to map flooded vegetation is attributed to the double bounce scattering mechanism, often dominant for this target. Dong Ting Lake in China is an ideal site for evaluating SAR data for this application due to annual flooding caused by mountain snow melt causing extensive changes in flooded vegetation. A curvelet-based approach for change detection in SAR imagery works well as it highlights the change and suppresses the speckle noise. This paper addresses the extension of this change detection technique to polarimetric SAR data for monitoring surface water and flooded vegetation. RADARSAT-2 images of Dong Ting Lake demonstrate this curvelet-based change detection technique applied to wetlands although it is applicable to other land covers and for post disaster impact assessment. These tools are important to Digital Earth for map updating and revision.

**Exploring natural and anthropogenic risk for cultural heritage in Cyprus using remote sensing and GIS**

Diofantos Hadjimitsis, Athos Agapiou, Dimitrios Alexakis & Apostolos Sarris

Abstract

On site observation is the most common way of monitoring cultural heritage sites and monuments in Cyprus. However, this procedure that includes data collection, periodical observations, and multivariate risk assessment analysis is difficult to accomplish with the traditional practices and methods since it is time consuming and expensive. Furthermore, many archaeological sites and monuments are located at inaccessible areas, far away from the main road network and urban areas. Satellite remote sensing and Geographical Information Systems (GIS) can successfully confront this problem by providing the scientists with integrated monitoring of the study areas and the unique advantage to store and manipulate a large amount of spatial and attribute data simultaneously. Actually the monitoring and identification of several natural and anthropogenic hazards in the vicinity of the cultural heritage sites in Cyprus, seems to be one of the main priorities of its governmental and municipal authorities. This study aims to integrate both satellite remote sensing techniques and GIS in a multidisciplinary approach, for monitoring anthropogenic and natural hazards with the use of archived and up-to-date multitemporal remotely sensed images in the study area, namely in areas nearby cultural heritage sites and monuments in Cyprus. In this study anthropogenic hazards include urbanisation and extended land use changes in the surroundings of archaeological sites and natural hazards concern seismicity and sea erosion.

**Mapping salt diapirs and salt diapir-affected areas using MLP neural network model and ASTER data**

Mohammad H. Tayebi, Majid H. Tangestani & Hasan Roosta

Abstract

This study employs visible-near infrared and short wave infrared datasets of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) to map salt diapirs and salt diapir-affected areas using Multi-Layer Perceptron (MLP) in the Zagros Folded Belt, Iran, and introduces the role of earth observation technology and a type of digital earth processing in lithological mapping and geo-environmental impact assessment. MLP neural network model with several learning rates between 0.01 and 0.1 was carried out on ASTER L1B data, and the results were compared using confusion matrices. The most appropriate classification image for L1B input to MLP was produced by learning rate of
0.01 with Kappa coefficient of 0.90 and overall accuracy of 92.54%. The MLP result of input data set mapped lithological units of salt diapirs and demonstrated affected areas at the southern and western parts of the Konarsiah and Jahani diapirs, respectively. Field observations and X-ray diffraction analyses of field samples confirmed the dominant mineral phases identified remotely. It is concluded that MLP is an efficient approach for mapping salt diapirs and salt-affected areas.

Optimizing artificial neural network-based indoor positioning system using genetic algorithm

Hamid Mehmood & Nitin K. Tripathi

Abstract

The Global Positioning System (GPS) is expected to play an integral role in the development of digital earth; however, the GPS cannot provide positioning information in regions where a majority of the population spends their time, that is, in urban and indoor environments. Hence, alternate positioning systems that work in indoor and urban environments should be developed to achieve the vision of digital earth. Wi-Fi-based positioning systems (WPS) stand out because of the near-ubiquitous presence of the associated infrastructure and signals in indoor environments. The WPS-based fingerprinting is the most widely adopted technique for position determination, but its accuracy is lower than that of techniques such as time of arrival and angle of arrival. Improving the accuracy is still a challenging task because of the complex nature of the propagation of Wi-Fi signals. Here, a novel server-based, genetic-algorithm-optimized, cascading artificial neural network-based positioning model is presented. The model is tested in 2D and 3D indoor environments under varying conditions. The model is thoroughly investigated on a real Wi-Fi network, and its accuracy is found to be better than that of other well-known techniques. A mean accuracy of 1.9 m is achieved with 87% of the distance error within the range of 0–3 m.

GEOID: GRID Services for Earth Observation Image Data Processing

Nitant Dube, R. Ramakrishnan & K.S. Dasgupta

Abstract

Recent developments in space technology and exponential increase in demand of earth observation data from space have generated a requirement of a data processing environment, where users can discover the data and process, based on their requirements. Grid Services for Earth Observation Image Data Processing (GEOID) is proposed with a motivation to cater to future earth observation applications requirements of digital earth. This paper discusses the overview of the GEOID architecture, its deployment scenario, use-cases and simulation results. Core technologies used for implementation include Grid computing and Service Oriented Architecture. GEOID provides capability to address requirements of applications such as real-time monitoring, time series data processing and processing with user required quality to meet the requirements of end user applications. GEOID allows users to access the archive products or the raw satellite data stream and process their area of interest. Simulations show that applications such as time series analysis show considerable improvement in processing time by using GEOID.
Transferring Google Earth observations to GIS-software: example from gully erosion study

Amaury Frankl, Ann Zwertvaegher, Jean Poesen & Jan Nyssen

Abstract

High-resolution images available on Google Earth are increasingly being consulted in geographic studies. However, most studies limit themselves to visualizations or on-screen measurements. Google Earth allows users to create points, lines, and polygons on-screen, which can be saved as Keyhole Markup Language (KML) files. Here, the use of R statistics freeware is proposed to easily convert these files to the shapefile format [or `.shp file format`], which can be loaded into Geographic Information System (GIS) software (ESRI ArcGIS 9 in our example). The geospatial data integration in GIS strongly increases the analysis possibilities.

Issue 1 2013 pages 1-102

Making Digital Earth on Earth

Guo Huadong
Effects of LIDAR DEM resolution in hydrodynamic modelling: model sensitivity for cross-sections

M. Podhorányi, J. Unucka, P. Bobál & V. Říhová

Abstract

With the development of science and technology the entire Earth, together with all of its phenomena, is gradually becoming an object of computer digitisation. For several years, this process has also affected water components, which are essential for the development of humans and economies on Earth. Therefore, monitoring of its resources and movement across the Earth’s surface is the main object of investigation of several research institutions. In recent years, hydraulic modelling has experienced significant development that meets water and computer connection conditions. This study consequently dealt with hydraulic modelling and uncertainties in the data that may affect the resulting flood zone. We analysed the effect of cross-sections generated and the subsequent inundation areas in Digital Elevation Models of different resolutions. The basic DEM was constructed from data obtained by the LIDAR method. Hydraulic
results were obtained using a one-dimensional (1-D) model, HEC-RAS, and its extension, HEC-GeoRAS. The Olšě and Stonávka river junction, located in the northeast region of the Czech Republic, was selected for investigation. The resolutions selected for the study to generate cross-sections and the subsequent inundation areas were 1 m, 5 m and 10 m. The resulting cross-sections were confronted with the actual surveyed cross-sections.

**VGIS-AntiJitter: an effective framework for solving jitter problems in virtual geographic information systems**

Feixiong Luo, Ershun Zhong, Guofeng Cao, Ricardo Delgado Tellez & Pengqi Gao

Abstract

With the proposition of the Digital Earth (DE) concept, Virtual Geographic Information System (VGIS) has started to play the role of a Digital Earth prototype system. Many core problems involved in VGIS, such as out-of-core management and interactive rendering of very large scale terrain and image data, have been well studied in the past decades. However, the jitter problem, a common problem in VGIS that often causes annoying visual artefacts and deteriorates the output image quality, draws little attention. In this paper, after an intensive analysis of the jitter problem, a comprehensive framework is proposed to address such a problem while accounting for the characteristics of different data types in VGIS, such as terrain or ocean mesh data, vector data and 3-D model data. Specifically, this framework provides an improved dynamic local coordinate system (DLCS) method for terrain or ocean mesh data. For vector data, the framework provides a simple and effective multiple local coordinate systems (MLCS) method. The framework provides a MLCS method for 3-D model data making full use of the existing local coordinate system of the model. The advantages of the proposed methods over current approaches are analysed and highlighted through case studies involving large GIS datasets.

**Modeling the spread of spatio-temporal phenomena through the incorporation of ANFIS and genetically controlled cellular automata: a case study on forest fire**

Mohammad H. Vahidnia, Ali A. Alesheikh, Saeed Behzadi & Sara Salehi

Abstract

Virtual representation and simulation of spatio-temporal phenomena is a promising goal for the production of an advanced digital earth. Spread modeling, which is one of the most helpful analyses in the geographic information system (GIS), plays a prominent role in meeting this objective. This study proposes a new model that considers both aspects of static and dynamic behaviors of spreadable spatio-temporal in cellular automata (CA) modeling. Therefore, artificial intelligence tools such as adaptive neuro-fuzzy inference system (ANFIS) and genetic algorithm (GA) were used in accordance with the objectives of knowledge discovery and optimization. Significant conditions in updating states are considered so traditional CA transition rules can be accompanied with the impact of fuzzy discovered knowledge and the solution of spread optimization. We focused on the estimation of forest fire growth as an important case study for decision makers. A two-dimensional cellular representation of the combustion of heterogeneous fuel types and density on non-flat terrain were successfully linked with dynamic wind and slope impact. The validation of the simulation on experimental data indicated a relatively realistic head-fire shape. Further investigations showed that the results obtained using the dynamic controlling with GA in the absence of static modeling with ANFIS were unacceptable.
Determining oil slick thickness using hyperspectral remote sensing in the Bohai Sea of China

Yingcheng Lu, Qingjiu Tian, Xinyuan Wang, Guang Zheng & Xiang Li

Abstract

Determining oil slick thickness plays an important role in assessing oil spill volume and its environmental impacts on the ocean. In this study, we used a Hyperion image of an oil spill accident area and seawater and fresh crude oil samples collected in the Bohai Sea of China. A well-controlled laboratory experiment was designed to simulate spectral responses to different oil slick thicknesses. Spectral resampling and normalization methods were used to reduce the differences in spectral reflectances between the experimental background seawater sample and real background seawater. Fitting the analysis with laboratory experimental data results showed a linear relationship between normalized oil slick reflectance and normalized oil slick thickness \( R^2 = 0.92938, n=49, p<0.01 \), 26th band \( R^2 = 0.93806, n=49, p<0.01 \), 29th band \( R^2 = 0.93288, n=49, p<0.01 \). By using these statistical models, we successfully determined the normalized oil slick thickness with the Hyperion image. Our results indicate that hyperspectral remote sensing technology is an effective method to monitor oil spills on water. The spectral ranges of visible green and red light were the optimal bands for estimating oil slick thickness in case 2 water. The high, stabilized spectral reflectance of background seawater will be helpful in oil slick thickness inversion.

A tree counting algorithm for precision agriculture tasks

Franco Santoro, Eufemia Tarantino, Benedetto Figorito, Stefania Gualano & Anna Maria D’Onghia

Abstract

This study proposes an automatic procedure for individual fruit tree identification using GeoEye-1 sensor data. Depending on site-specific pruning practices, the morphologic characteristics of tree crowns may generate one or more brightness peaks (tree top) on the imagery. To optimize tree counting and to minimize typical background noises from orchards (i.e. bare soil, weeds, and man-made objects), a four-step algorithm was implemented with spatial transforms and functions suitable for spaced stands (asymmetrical smoothing filter, local minimum filter, mask layer, and spatial aggregation operator). System performance was evaluated through objective criteria, showing consistent results in fast capturing tree position for precision agriculture tasks.

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Monthly soil erosion monitoring based on remotely sensed biophysical parameters: a case study in Strymonas river basin towards a functional pan-European service

Panos Panagos, Christos G. Karydas, Ioannis Z. Gitas & Luca Montanarella

Abstract
Currently, many soil erosion studies at local, regional, national or continental scale use models based on the USLE-family approaches. Applications of these models pay little attention to seasonal changes, despite evidence in the literature which suggests that erosion risk may change rapidly according to intra-annual rainfall figures and vegetation phenology. This paper emphasises the aspect of seasonality in soil erosion mapping by using month-step rainfall erosivity data and biophysical time series data derived from remote-sensing. The latter, together with other existing pan-European geo-databases sets the basis for a functional pan-European service for soil erosion monitoring at a scale of 1:500,000. This potential service has led to the establishment of a new modelling approach (called the G2 model) based on the inheritance of USLE-family models. The G2 model proposes innovative techniques for the estimation of vegetation and protection factors. The model has been applied in a 14,500 km² study area in SE Europe covering a major part of the basin of the cross-border river, Strymonas. Model results were verified with erosion and sedimentation figures from previous research. The study confirmed that monthly erosion mapping would identify the critical months and would allow erosion figures to be linked to specific land uses.

Maize drought disaster risk assessment of China based on EPIC model

Huicong Jia, Jingai Wang, Chunxiang Cao, Donghua Pan & Peijun Shi

Abstract

Digital Agriculture is one of the important applications of Digital Earth. As the global climate changes and food security becomes an increasingly important issue, agriculture drought comes to the focus of attention. China is a typical monsoon climate country as well as an agricultural country with the world's largest population. The East Asian monsoon has had a tremendous impact upon agricultural production. Therefore, a maize drought disaster risk assessment, in line with the requirements of sustainable development of agriculture, is important for ensuring drought disaster reduction and food security. Meteorology, soil, land use, and agro-meteorological observation information of the research area were collected, and based on the concept framework of 'hazard-inducing factors assessment (hazard)-vulnerability assessment of hazard-affected body (vulnerability curve)-risk assessment (risk),' importing crop model EPIC (Erosion-Productivity Impact Calculator), using crop model simulation and digital mapping techniques, quantitative assessment of spatio-temporal distribution of maize drought in China was done. The results showed that: in terms of 2, 5, 10, and 20 year return periods, the overall maize drought risk decreased gradually from northwest to southeast in the maize planting areas. With the 20 year return period, high risk value regions (drought loss rate ≥0.5) concentrate in the irrigated maize region of Northwest China, ecotone between agriculture and animal husbandry in Northern China, Hetao Irrigation Area, and north-central area of North China Plain, accounting for 6.41% of the total maize area. These results can provide a scientific basis for the government's decision-making in risk management and drought disaster prevention in China.


Zhen Li, Qiang Xing, Shiyin Liu, Jianmin Zhou & Lei Huang

Abstract
This paper presents the first measurement of multi-decadal thickness and volume changes (1969–2000) of the Dongkemadi Ice Field (DIF) in the Tanggula Mountains, central Qinghai-Tibetan Plateau, China, using multi-source remote sensing data. These include the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) acquired in February, 2000, a DEM generated by digitising analogue topographic maps from 1969, and Landsat ETM+ imagery from 2000. Digital glacier outlines and GIS-based processing were used to calculate an elevation difference map to evaluate the relative elevation error of these two DEMs over ice-free areas. This method was also used to identify regions of glacier elevation thinning and thickening corresponding to glacier mass loss and gain. Analysis of 67,520 points on flat grass and rock terrain surrounding the DIF, with a slope less than 25°, showed a mean elevation difference of −0.90 m and a standard deviation of 5.58 m. A thickness change error within ±6 m was estimated. Between 1969 and 2000, 76.51% of the whole DIF area appeared to be thinning while 23.49% showed thickening. The average glacier surface thinning was −12.58 m with a standard deviation of 18.29 m and the estimated volume loss was 1.17 km$^3$. The standard deviation of volume change was 0.0006 km$^3$ over the DIF. A thinning rate up to 0.41±0.194 m a$^{-1}$ or 0.038 km$^3$ a$^{-1}$ for the volume loss was observed for the whole ice field, which seems to be evidence for the ongoing retreat of glaciers on the Qinghai-Tibetan Plateau. It was found that the spatial thickness change pattern derived from the remote sensing method was consistent with the thickness change results of the Small Dongkemadi Glacier (SDG) from field measurements. The estimated error of the annual thickness change rate was on the order of 5%. The relationship between elevation change and absolute glacier elevation over typical glaciers was also analysed, showing considerable variability. These changes have possibly resulted from increased temperature and decreased precipitation in this region.
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Global characterization and monitoring of forest cover using Landsat data: opportunities and challenges

John R. Townshend, Jeffrey G. Masek, Chengquan Huang, Eric F. Vermote, Feng Gao, Saurabh Channan, Joseph O. Sexton, Min Feng, Raghuram Narasimhan, Dohyung Kim, Kuan Song, Danxia Song, Xiao-Peng Song, Praveen Noojipady, Bin Tan, Matthew C. Hansen, Mengxue Li & Robert E. Wolfe

Abstract

The compilation of global Landsat data-sets and the ever-lowering costs of computing now make it feasible to monitor the Earth's land cover at Landsat resolutions of 30 m. In this article, we describe the methods to create global products of forest cover and cover change at Landsat resolutions. Nevertheless, there are many challenges in ensuring the creation of high-quality products. And we propose various ways in which the challenges can be overcome. Among the challenges are the need for atmospheric correction, incorrect calibration coefficients in some of the data-sets, the different phenomenologies between compilations, the need for terrain correction, the lack of consistent reference data for training and accuracy assessment, and the need for highly automated characterization and change detection. We
propose and evaluate the creation and use of surface reflectance products, improved selection of scenes to reduce phenological differences, terrain illumination correction, automated training selection, and the use of information extraction procedures robust to errors in training data along with several other issues. At several stages we use Moderate Resolution Spectroradiometer data and products to assist our analysis. A global working prototype product of forest cover and forest cover change is included.

**Digital Earth from vision to practice: making sense of citizen-generated content**

M. Craglia, F. Ostermann & L. Spinsanti

Abstract

The vision of Digital Earth (DE) put recently forward under the auspices of the International Society for DE extends the paradigm of spatial data infrastructures by advocating an interactive and dynamic framework based on near-to-real time information from sensors and citizens. This paper contributes to developing that vision and reports the results of a two-year research project exploring the extent to which it is possible to extract information useful for policy and science from the large volumes of messages and photos being posted daily through social networks. Given the noted concerns about the quality of such data in relation to that provided by authoritative sources, the research has developed a semi-automatic workflow to assess the fitness for purpose of data extracted from Twitter and Flickr, and compared them to that coming from official sources, using forest fires as a case study. The findings indicate that we were able to detect accurately six of eight major fires in France in the summer of 2011, with another four detected by the social networks but not reported by our official source, the European Forest Fire Information Service. These findings and the lessons learned in handling the very large volumes of unstructured data in multiple languages discussed in this study provide useful insights into the value of social network data for policy and science, and contribute to advancing the vision of DE.

**Harmonisation requirements and capabilities towards a European spatial data infrastructure (ESDI): the HUMBOLDT protected areas scenario**

Paolo Villa, Roderic Molina, Mario A. Gomarasca & Emanuele Roccatagliata

Abstract

The HUMBOLDT project has the aim of implementing a Framework for harmonisation of data and services in the geoinformation domain, under the Infrastructure for Spatial Information in Europe (INSPIRE) Directive and in the context of the Global Monitoring for Environment and Security (GMES) Initiative. The two-pronged approach of HUMBOLDT comprises a technical side of software framework development and an application side of scenario testing and validation. Among the HUMBOLDT Application Scenarios designed to demonstrate the capabilities of the Framework there is the one covering Protected Areas themes and use cases. It aims to transform geoinformation, managed by park authorities, into a seamless flow that combines multiple information sources from different governance levels (European, national, regional), and exploits this newly combined information for the purposes of planning, management and tourism promotion. The Scenario constitutes a step further towards the integration of monitoring systems envisaged in the view of Digital Earth. Protected Areas Scenario creates an examples of the use of the HUMBOLDT tools in Desktop and Web GIS environment, together with setting up a server environment exploiting HUMBOLDT harmonisation framework as
taking into account user requirements and needs and providing benefits for making the road to ESDI establishment easier.

**Seasonal dynamic pattern analysis on global FPAR derived from AVHRR GIMMS NDVI**

Daijiang Peng, Bing Zhang, Liangyun Liu, Dongmei Chen, Hongliang Fang & Yong Hu

Abstract

The purpose of this paper is to develop Advanced Very High Resolution Radiometer (AVHRR) Global Inventory Modelling and Mapping Studies (GIMMS) Normalised Difference Vegetation Index (NDVI; AVHRR GIMMS NDVI for short) based fraction of absorbed photosynthetically active radiation (FPAR) from 1982 to 2006 and focus on their seasonal and spatial patterns analysis. The available relationship between FPAR and NDVI was used to calculate FPAR values from 1982 to 2006 and validated by Moderate-resolution Imaging Spectroradiometer (MODIS) FPAR product. Then, the seasonal dynamic patterns were analysed, as well as the driving force of climatic factors. Results showed that there was an agreement between FPAR values from this study and those of the MODIS product in seasonal dynamic, and the spatial patterns of FPAR vary with vegetation type distribution and seasonal cycles. The time series of average FPAR revealed a strong seasonal variation, regular periodic variations from January 1982 to December 2006, and opposite patterns between the Northern and Southern Hemispheres. Evergreen vegetation FPAR values were close to 0.7. A clear single-peak curve was observed between 30°N and 80°N – an area covered by deciduous vegetation. In the Southern Hemisphere, the time series fluctuations of FPAR averaged by 0.7° latitude zones were not clear compared to those in the Northern Hemisphere. A significant positive correlation ($P<0.01$) was observed between the seasonal variation of temperature and precipitation and FPAR over most other global meteorological sites.

**Drought: past problems and future scenarios**

J.L. van Genderen
BOOK REVIEWS


This is a most interesting and useful book for readers of this Journal, as it is very relevant to the Digital Earth topic of monitoring changes at global, regional and local levels. The book has eight chapters, which describe and discuss the occurrence of global drought events, their characteristics, causes and impacts, going from the Holocene (the last 12,000 years), through the twentieth century to the present day. It also gives expected trends to the end of the twenty-first century. The chapters describe the physical processes of drought development and the science behind drought reconstruction, observation and modelling. The book also places drought into the broader issue of Global Change.

In addition to these eight scientific chapters, there is an interesting Preface, which argues that of all natural disasters, drought is probably the most problematic, causing immense social, economic and ecological damage. The book is illustrated by some 70 useful figures, plus diagrams and also has 25 colour plates.

Chapter 1 is the Introduction. It is an easy to read chapter, which gives the setting of ‘Drought Today’, shows the relation between drought and Global Change, and explains the authors’ motivation for having written this book. This chapter also provides an overview of the whole book.

Chapter 2 provides a basic overview of the impacts of drought in the past few decades, based on reports and databases from around the world. This book focuses mainly on the physical aspects of drought. Of course, droughts have enormous impact on populations living in the affected drought areas, but if readers want to learn about the social aspects, they should read other books on drought. This book just touches on the subject of the socio-economies of drought, and provides some references for further reading.

Chapter 3 discusses the science of drought, starting with a good overview of the hydrological cycle, and its variations in space and time. These last two aspects come back again later in the book, and are the ones where Digital Earth researchers can make the biggest contribution to the study and understanding of drought, as Earth Observation techniques are the best ways to monitor the location, spread, effects and impacts of droughts, regionally and globally, through time.

These tools for the scientific gathering and analysis of drought-related data have greatly advanced in recent years. Chapter 4 describes some of the methods for monitoring and predicting drought. Many techniques are described, from in-situ measurement devices, models of climate and hydrology, various remote sensing techniques, and the use of palaeoclimatic data (e.g. tree-ring chronologies, cave

Coal and peat fires: a global perspective: Volume 1: Coal–geology and combustion

J.L. van Genderen
Comparing spatiotemporal patterns in Eurasian FPAR derived from two NDVI-based methods

Dailiang Peng, Bing Zhang & Liangyun Liu

Abstract

A long-term, consistent Fraction of Absorbed Photosynthetically Active Radiation (FPAR) product is necessary to study the spatial and temporal patterns of vegetation dynamics associated with climatic changes and human activities. In this study, Eurasia was selected as the study area. The relationship between FPAR and simple infrared/red ratio relationship (SR FPAR), and that between Moderate Resolution Imaging Spectroradiometer (MODIS) FPAR and a Normalised
Difference Vegetation Index (NDVI) look-up table (LUT FPAR) were employed to estimate FPAR from 1982 to 2006 by different land cover types, focusing on the comparisons of spatiotemporal FPAR patterns between the two FPAR datasets. The results showed high agreement between MODIS standard FPAR and estimated FPAR in seasonal dynamics with peak values in July. The LUT FPAR was close to MODIS standard FPAR and larger than SR FPAR. The SR and LUT FPAR showed the same spatial distribution and inter-annual variation patterns and were primarily determined by land cover types. An overall increasing trend in FPAR was observed from 1982 to 2006, with reductions from 1991 to 1994 and 2000 to 2002. The inter-annual dynamics in evergreen broadleaf forests showed a decreasing trend over 25 years, while non-forest vegetation FPAR values had slow, stable growth in inter-annual variation.

**Satellite detection of increases in global land surface evapotranspiration during 1984–2007**

**Yunjun Yao, Shunlin Liang, Qiming Qin, Kaicun Wang, Shaomin Liu & Shaohua Zhao**

**Abstract**

As a key component of digital earth, remotely sensed data provides the compelling evidence that the amount of water vapour transferred from the entire global surface to the atmosphere increased from 1984 to 2007. The validation results from the earlier evapotranspiration (ET) estimation algorithm based on net radiation ($R_n$), Normalised Difference Vegetation Index (NDVI), air temperature and diurnal air temperature range (DTaR) showed good agreement between estimated monthly ET and ground-measured ET from 20 flux towers. Our analysis indicates that the estimated actual ET has increased on average over the entire global land surface except for Antarctica during 1984–2007. However, this increasing trend disappears after 2000 and the reason may be that the decline in net radiation and NDVI during this period depleted surface soil moisture. Moreover, the good correspondence between the precipitation trend and the change in ET in arid and semi-arid regions indicated that surface moisture linked to precipitation affects ET. The input parameters $R_n$, $T_{air}$, NDVI and DTaR show substantial spatio-temporal variability that is almost consistent with that of actual ET from 1984 to 2007 and contribute most significantly to the variation in actual ET.

**Simulation analysis on the relationship between the leaf area index and polarimetric parameters of crops**

**Lu Zhang, Huadong Guo & Xinwu Li**

**Abstract**

The leaf area index (LAI) is an important parameter to quantitatively describe the structure of vegetation and crops. Uncertainty in the relationship between the LAI and polarimetric parameters is the key problem for LAI estimation from polarimetric synthetic aperture radar (POLSAR) data. However, the existing POLSAR data have difficulties meeting the demand of the aforementioned research. This paper analyses the correlations between the LAI and the polarimetric parameters derived from Cloude and Freeman decompositions using simulated POLSAR data based on a coherent scattering model for maize and wheat. The results show: (1) The POLSAR data at C-band with a large incidence angle (40 degrees) are very suitable for finding the LAI for maize and wheat. (2) For maize there is a strong correlation between the scattering type angle and the LAI at C-band with a large incidence angle, and the coherency entropy, anisotropy, and the power of the double-bounce scattering power component also have significant correlations with the LAI. (3) For wheat at C-band with a high incidence angle, although the correlation coefficient is low, there is still a
correlation between the entropy, anisotropy and LAI. Besides, the volume scattering is suitable for extracting the LAI for wheat at X-band.

Evaluation of environmental parameters in logistic regression models for landslide susceptibility mapping

Mehmet Lütfi Süzen & Basak Şener Kaya

Abstract

The aim of this study was to determine how well the landslide susceptibility parameters, obtained by data-dependent statistical models, matched with the parameters used in the literature. In order to achieve this goal, 20 different environmental parameters were mapped in a well-studied landslide-prone area, the Asarsuyu catchment in northwest Turkey. A total of 4400 seed cells were generated from 47 different landslides and merged with different attributes of 20 different environmental causative variables into a database. In order to run a series of logistic regression models, different random landslide-free sample sets were produced and combined with seed cells. Different susceptibility maps were created with an average success rate of nearly 80%. The coherence among the models showed spatial correlations greater than 90%. Models converged in the parameter selection peculiarly, in that the same nine of 20 were chosen by different logistic regression models. Among these nine parameters, lithology, geological structure (distance/density), landcover-landuse, and slope angle were common parameters selected by both the regression models and literature. Accuracy assessment of the logistic models was assessed by absolute methods. All models were field checked with the landslides resulting from the 12 November 1999, Kaynaşlı Earthquake (Ms = 7.2).

Addressing administrative units in international tsunami early warning systems: shortcomings in international geocode standards

Matthias Lendholt & Martin Hammitsch

Abstract

Administrative units reflect the territorial hierarchies established within all countries of the world. The units are addressable with geocodes that provide a bijective mapping between territories and unique identification codes. Early warning systems for natural or man-made hazards often map affected or threatened areas to administrative units to establish a spatial reference that is comprehensible to all parts of the population. Addressing these territories in an international context has several requirements, such as worldwide coverage, completeness and topicality, which must be met by geocode standards. In this paper, the practicability and suitability of international geocode standards are examined in the context of the requirements of large-scale early warning systems. This paper exposes the insufficiencies and limitations of existing geocode standards International Organization for Standardization (ISO)-3166, Second Administrative Level Boundaries data set project (SALB) and Nomenclature of the Territorial Units for Statistics (NUTS) and emphasises the suitability of the non-official hierarchical administrative subdivision codes (HASC). The analysis is framed in the context of addressing affected areas for an Indian Ocean tsunami early warning system. This system was developed within the Distant Early Warning Systems project according to the requirements of the United Nations Educational, Scientific and Cultural Organization (UNESCO) Intergovernmental Oceanic Commission for Regional Tsunami Watch Providers (RTWPs).
China's Earth observing satellites for building a Digital Earth

Huadong Guo

China's Earth observing satellites for building a Digital Earth

Digital Earth is the inevitable outcome of the space era and evolutionary development of the information society, characterized by global coverage by Earth observing satellites. Thus, the Earth observing satellite is a key technology for building a Digital Earth.

China has placed great importance on the development of Earth observing satellites. The four satellite series in China, which include resource satellites, environment satellites, meteorological satellites and ocean satellites, have been developed within the past few decades. The main characteristics of these satellite series are summarized in Table 1.

Resource satellite series
The first resource satellite, the China–Brazil Earth Resources Satellite program (CBERS), was successfully launched in October 1999. Up to now, five satellites have been launched: CBERS-01, 02, 02B and 02C, and the first civilian high-resolution stereo mapping satellite, named ZY-3, was launched in December 2011. The succeeding satellites, CBERS-03 and CBERS-04, will be launched in the coming years.

Environment satellite series
The mission of this satellite series is for both environment and disaster monitoring. The first two satellites of the HJ Satellite Constellation, HJ-1A with a hyperspectral imager and HJ-1B with an infrared camera, were launched in September 2008. The third in the series, HJ-1C with an S-band SAR, will be launched this year. A follow-up '4 + 4' satellite constellation including four optical and four radar satellites is to be developed.

Meteorological satellite series
A meteorological satellite, the so-called Fengyun (FY), is composed of a sun-synchronous series and geostationary series. So far, a total of six FY polar satellites and five FY geostationary satellites have been launched since 1988. At present, three FY polar satellites and three FY geostationary satellites are operating in orbit. FY-3A and FY-3B constitute a sun-synchronous constellation to provide global observation for the Earth four times each day.

The application of China's land observation satellites within the framework of Digital Earth and its key technologies

Wen Xu
Abstract

Digital Earth is an interdisciplinary field involving space technology, information technology, and geoscience. This article introduces the land observation satellite system of China and discusses the requirements for satellite payloads in terms of spatial, temporal, and spectral resolution to establish a Digital Earth. The applications of land satellites under the framework of Digital Earth are introduced from the perspectives of data support, special subject services, and integrated information services. It is concluded that China's land observation satellites and ground processing systems will be fundamental components of the Digital Earth system, in which satellite data and their derived information will serve as the principal information source and greatly promote applications of Digital Earth.

Technical system design and construction of China's HJ-1 satellites

Qiao Wang

Abstract

The Chinese Government attaches great importance to applications of satellite remote sensing in environmental monitoring. On 6 September 2008, the first two satellites of the Environment and Disaster Monitoring and Prediction Satellite Constellation (HJ), HJ-1A and HJ-1B, were successfully launched, which started a new era of satellite applications for environmental monitoring in China. An introduction to the satellite, instrument, and ground systems of HJ-1A and HJ-1B is presented in this article, and an analysis of their technical performance and characteristics is also given. Focusing on the operational needs of environmental monitoring in China, the general design, functional construction, and operational mode of the application system of HJ-1A and HJ-1B are detailed, and the operations and applications of the two satellites are also discussed.

Engineering survey of the Environment and Disaster Monitoring and Forecasting Small Satellite Constellation

Yida Fan, Qi Wen & Shirong Chen

Abstract

The Environment and Disaster Reduction Satellite Constellation is a small satellite constellation developed by China for disaster monitoring. The two primary optical satellites, HJ-A and HJ-B, were successfully launched in September 2008. The satellites carry a charge-coupled device, hyperspectral imager, and infrared scanner, and have the capability for wide coverage and rapid revisits in disaster reduction applications. Also scheduled to be launched is the HJ-C, which will carry synthetic aperture radar and have the ability to provide all-weather observations at any time. A follow-up ‘4 + 4’ satellite constellation including four optical satellites and four radar satellites is in the works, to achieve the capability of quantitative, all-weather, all-time disaster forecasting, monitoring and assessment. The corresponding disaster reduction application system has a series of functions including remote sensing data processing, disaster monitoring and assessment, decision support, and user service and information distribution, which serves the whole process of disaster management. Since its construction has been carried out, the system has successfully dealt with several huge domestic and international natural disasters, and effectively improved scientific decision support. The follow-up system's construction will integrate, update, and extend the original system to fulfill large-scale, quantitative, all-weather disaster operation application needs.
Overview of the key technologies for high-resolution satellite mapping

Xinming Tang & Junfeng Xie

Abstract

As the important infrastructures for land mapping and resource monitoring, high-resolution remote sensing satellites (HRSS) are urgently demanded for the development of China. In this article, the key technologies of the main HRSS are summarized, and these technologies include sensor design, attitude and orbit determination, geometric calibration, imaging model construction, and block adjustment, etc., which involve the mapping accuracy of HRSS. Finally, the system design of the ZY-3 Satellite (China’s first civil stereoscopic surveying and mapping satellite, to be launched in 2012) is introduced, which mainly include satellite technical specifications and strategies design based on these key technologies research.

Earth observation satellite data receiving, processing system and data sharing

Huadong Guo, Jianbo Liu, An Li & Jianguo Zhang

Abstract

The China Remote Sensing Satellite Ground Station was established in 1986. It currently has three receiving stations in the north, west, and south of China, with the capacity to receive data from 15 international and domestic Earth observation satellites covering the entire Chinese territory and 70% of Asia. Meanwhile, a systematic, integrated, and standardized spatial information service system has been built. A data-sharing project for medium-resolution Earth observation satellites has been conducted and plays an important role in land, ocean, and atmospheric resource investigation and environmental monitoring.

Improvements on global meteorological observations from the current Fengyun 3 satellites and beyond

Jun Yang, Peng Zhang, Naimeng Lu, Zhongdong Yang, Jinming Shi & Chaohua Dong

Abstract

The Fengyun 3 (FY-3) series is the second generation of Chinese sun-synchronous meteorological satellites. The first two, FY-3A and FY-3B, were launched successfully on 27 May 2008 and 5 November 2010, respectively. FY-3A and FY-3B share the same design, equipped with 11 payloads to observe the Earth system, but FY-3A is on a monitoring-orbit and FY-3B is on an afternoon-orbit. As a satellite constellation, FY-3A and FY-3B comprehensively improved meteorological observations in spectral wavelength, spatial coverage, and temporal frequency. This paper summarizes the improvements of the FY-3A and FY-3B satellites. New features, including optical imaging capacity from kilometer to hundred-meter resolution, passive microwave imaging, atmospheric temperature and moisture sounding, atmospheric chemistry remote sensing, and Earth radiation budget measurement, are presented with demonstrations of their use. Instruments scheduled for the FY-3C and beyond are introduced as well.
The HY-2 satellite and its preliminary assessment

Xingwei Jiang, Mingsen Lin, Jianqiang Liu, Youguang Zhang, Xuetong Xie, Hailong Peng & Wu Zhou

Abstract

The HY-2 satellite was successfully launched on 16 August 2011. It carried four microwave instruments into space for operationally observing dynamic ocean environment parameters on a global scale. The HY-2 satellite altimeter provides sea surface height (SSH), significant wave height (SWH), sea surface wind (SSW) speed, and polar ice sheet elevation, while the HY-2 satellite scatterometer provides SSW fields. At the same time, other oceanic and atmospheric parameters such as sea surface temperature (SST) and wind speed, water vapor and liquid water content can also be obtained by its onboard scanning microwave radiometer. In this paper, we show the data processing methods of the HY-2 satellite's payloads. The preliminary results show that wind vector, SSH, SWH, and SST conform to the designed technical specifications.

Issue 2 2012 pages 91-183

A novel approach for constructing a 3D model based on registering a mono image on a 3D model, applicable in Digital Earth

Amir Saeed Homainejad

Abstract

The effect of Digital Earth on our life is vital. Developing and updating Geospatial data in Digital Earth is also essential. This paper presents the application of a new approach of image registration in Digital Earth. The approach was developed based on registering a mono photograph on a master 3D model. The result is a 3D vector model, which can be broadly applied in visualisation, mapping, geographic information system (GIS), planning, change detection, as well as Digital Earth. The approach does not require parameters of correction for transformation. The accuracy of the output depends on the accuracy of the master data. This approach is very versatile and able to register any image on the digital elevation model, digital surface model and topographic 3D model.

Modelling stratified forest attributes using optical/LiDAR features in a central European landscape

Hooman Latifi, Arne Nothdurft, Christoph Straub & Barbara Koch

Abstract

Improvements in the acquisition of three-dimensional (3D) information from the Airborne Laser Scanner (ALS) increase its applications for studying Earth’s surface. The use of ALS data in natural resource inventories is still in an experimental stage in central Europe. Here, a survey was completed in Germany, where plot-level features from LANDSAT Thematic Mapper and ALS data were applied. An automated process was developed for forest stratification using orthoimages. A genetic algorithm was applied for variable screening. Variable subsets of different sizes were employed for simultaneous predictions of structural forest attributes using the ‘Random Forest’ (RF) method. Performance was assessed by leave-one-out cross-validations on bootstrap resample data. Results indicate that the
stratification of forest notably improved the results of predictions. The improvements were more obvious for the strata-related attributes. Accuracy was enhanced as the number of selected variables increased. However, parsimonious models are still essentially required for practical applications. The RF errors were slightly greater than those from least squares regression, as the non-parametric methods do not share the same mix of error components as regression. Through the combination of remote sensing and modelling, we conclude that our results are helpful for bridging the gap between regional earth observation and on-the-ground forest structure.

**Estimation of the evaporative losses from Lake Nasser, Egypt using optical satellite imagery**

Islam H. Abou El-Magd & Elham M. Ali

Abstract

Water shortage in the arid region is an existing and future severe problem that threatens this part of the world. Egypt has a limited budget of 55 BM$^3$ per year from the river Nile basin that has always been stored in the Lake Nasser reservoir, southern Egypt. It has been estimated that the water losses from the lake ranges from 10 to 20 BM$^3$ a year$^{-1}$. This paper discusses the possibility of estimating the surface evaporation from Lake Nasser using optical remotely sensed data. The surface energy balance algorithm for land (SEBAL) algorithm was used to estimate the monthly evaporation rate using National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer (NOAA-AVHRR) satellite images based on the energy balance components. The main variable within these components is the surface temperature, which was calculated by a calibrated split window equation from the remotely sensed data. Twenty-four satellite images during the year 2008 were used to estimate the maximum and minimum evaporative losses from the lake at 16.3 and 12.5 BM$^3$ year$^{-1}$, respectively. When compared with the Penman-Monteith mathematical formula, a high correlation was obtained with $r^2=0.78$. The study demonstrated that remotely sensed data can provide a robust estimate of evaporative losses from Lake Nasser that can aid decision makers in better management and Digital Earth studies.

**Municipal solid waste landfill site selection for the city of Şanliurfa-Turkey: an example using MCDA integrated with GIS**

M. Irfan Yesilnacar, M. Lütfi Süzen, Başak Şener Kaya & Vedat Doyuran

Abstract

A municipal solid waste (MSW) management system needs solid waste management (SWM) techniques where the presence of a sanitary landfill is vital. One of the most important issues of sanitary landfilling is to locate the facility to an optimal location. Despite the versatility and case-dependent nature of conventional expert-based site selection procedures, the number of sites to be chosen increases with increased population forcing a number of constraints. Consequently, constraints and environmental regulations mechanically mask unsuitable areas, leaving very little areas to be assessed. This turns the situation into a challenging issue for a geographical information system (GIS) used with multi-criteria decision analysis (MCDA), to select optimal site.

The study aims to apply MCDA integrated with GIS to select possible sites of a MSW landfill with the same expert and same cognitive parameters while compared with the already present one. Results of this study revealed that
conventional expert-based methods could not always evaluate all constraints at the same time and map reproduction is limited when parameter maps are changing rapidly in time. In order to produce cognitive and reproducible analyses, GIS with MCDA integration offers a good solution for site selection issue and forms a good alternative for conventional methods.

**A new trapezoidal-mesh based data model for spatial operations**

Jiechen Wang, Can Cui, Gang Chen, Yingxia Pu & Jinsong Ma

Abstract

This paper presents a new spatial data model based on trapezoidal-mesh for implementing spatial operations within geographical information systems (GIS). Based only on the solid foundation of spatial operations, diversified application models can be established to bridge the gap between Digital Earth models and the real world with its real-world problems ('connecting through location'). In this paper, the involved polygon features are decomposed into a series of trapezoidal-meshes. Then, geo-processing operations are employed on these meshes rather than the original polygon features, resulting in a relatively simple spatial computation. As a kind of model designed by integrating raster with vector, the model presented here has advantages over other models when carrying out spatial operations insofar as providing a solid foundation for achieving the grand goal of Digital Earth. The concept of this data model and the two extensive examples of its application in spatial operations are elaborated upon in this article. As a result, this article and the research that supports it, proves that the adoption of the trapezoidal-mesh model greatly improves the efficiency of spatial operations in GIS.

**Issue 1 2012 pages 1-90**

**Digital Earth: a new challenge and new vision**

Huadong Guo
Digital Earth 2020: towards the vision for the next decade

Max Craglia, Kees de Bie, Davina Jackson, Martino Pesaresi, Gábor Remetey-Fülöpp, Changlin Wang, Alessandro Annoni, Ling Bian, Fred Campbell, Manfred Ehlers, John van Genderen, Michael Goodchild, Huadong Guo, Anthony Lewis, Richard Simpson, Andrew Skidmore & Peter Woodgate

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Abstract
This position paper is the outcome of a brainstorming workshop organised by the International Society for Digital Earth (ISDE) in Beijing in March 2011. It argues that the vision of Digital Earth (DE) put forward by Vice-President Al Gore 13 years ago needs to be re-evaluated in the light of the many developments in the fields of information technology, data infrastructures and earth observation that have taken place since. The paper identifies the main policy, scientific and societal drivers for the development of DE and illustrates the multi-faceted nature of a new vision of DE grounding it with
a few examples of potential applications. Because no single organisation can on its own develop all the aspects of DE, it is essential to develop a series of collaborations at the global level to turn the vision outlined in this paper into reality.

**NIBU: a new approach to representing and analysing interior utility networks within 3D geo-information systems**

Ihab Hamzi Hijazi, Manfred Ehlers & Sisi Zlatanova

Abstract

Facility management departments' responsibilities include monitoring and maintenance of building infrastructure, such as water, gas or electricity. Very often these tasks are completed using paper maps, which make integrated analysis of networks challenging. Ability to consider interior network structure and provide semantic and connectivity information supporting the required analysis operations are thus crucial.

This paper presents an approach relying on Building Information Model (BIM) as a data source for obtaining information about interior utilities. The semantic and connectivity information of BIM is mapped onto a new model called Network for Interior Building Utilities (NIBU). NIBU is based on the semantic categorisation of utilities, and the spatial functions that have to be performed. Three scenarios ('maintenance operation', 'emergency response' and 'inspection operation') are developed to test the proposed approach.

The model and its functions are implemented in spatial DBMS. The model is populated directly from a BIM server applying an Industrial Foundation Class (IFC) parser developed in-house. Five analysis functions are implemented to support spatial operations: trace upstream, trace downstream, find ancestors, find source and find disconnected. The investigation proves that BIM provides both the required semantics and attributes, and connectivity information that can facilitate analysis of interior utility networks. NIBU provides a simple yet flexible way to manage interior network information, which can be integrated into Digital Earth.

**The challenges of developing an open source, standards-based technology stack to deliver the latest UK climate projections**

Ag Stephens, Philip James, David Alderson, Stephen Pascoe, Simon Abele, Alan Iwi & Peter Chiu

Abstract

To improve the understanding of local and regional effects of climate change, the UK government supported the development of new climate projections. The Met Office Hadley Centre produced a sophisticated set of probabilistic projections for future climate. This paper discusses the design and implementation of an interactive website to deliver those projections to a broad user community. The interface presents complex data sets, generates on-the-fly products and schedules jobs to an offline weather generator capable of outputting gigabytes of data in response to a single request. A robust and scalable physical architecture was delivered through significant use of open source technologies and open standards.

**Land cover mapping applications with MODIS: a literature review**

Tzitziki J. García-Mora, Jean-François Mas & Everett A. Hinkley
Abstract

Land use/land cover monitoring and mapping is crucial to efficient management of the land and its resources. Since the late 1980s increased attention has been paid to the use of coarse resolution optical data. The Moderate Resolution Imaging Spectroradiometer (MODIS) has features, which make it particularly suitable to earth characterization purposes. MODIS has 10 products dedicated mainly to land cover characterization and provides three kinds of data: angular, spectral and temporal. MODIS data also includes information about the data quality through the ‘Quality Assessment’ product. In this paper, we review how MODIS data are used to map land cover including the preferred MODIS products, the preprocessing and classification approaches, the accuracy assessment, and the results obtained.

Remote sensing and GIS technologies for monitoring and prediction of disasters

Ranjani Wasantha Kulawardhana
Validation of EO-derived information for crisis management: a Digital Earth perspective in the VALgEO expert community

C. Corbane, M. Pesaresi & D. Carrion

New generation remote sensing technologies today open new application areas and demonstrate their effectiveness providing geo-information in support of disaster management. At the same time, new challenges can be identified and among them the validation of geo-information under the new specific constraints dictated by the disaster management application area has a crucial role. In the frame of the Digital Earth concept, geo-information is a sharable resource, and a resource is truly shareable not only if we know the formal code used to make it – and then we can read it – but also and in particular during disaster – if we know the reliability of this information. This is crucial in order to avoid information overflow and time wasting during the decision-making process in support of disaster management. The International workshop on validation of geo-information products for crisis management, VALgEO 2009, was held at the Joint Research Centre, in Ispra, Italy on 21–23 November 2009. The purpose of this first workshop was to initiate a dialog between the main actors of Emergency Response Services around validation and to raise awareness of the necessity for an independent formal assessment of geo-information for disaster management. This special issue includes a collection of invited papers presented at the workshop. It gathers interdisciplinary initiatives where the majority of the contributions either directly or implicitly address different aspects of validation of geo-information generated following a disaster, ranging from flood information to forest fires and earthquake damage assessments.

1. Earth Observation (EO) for disaster management

The tremendous development of space technologies in the last decade has opened new possibilities to use remotely sensed image data in support of new application areas including disaster management. Improved spatial, temporal, and spectral sensors are available today. The meter or sub-meter spatial resolution available now in remote sensors allows the observation, recognition, and reporting about targets and phenomena present on the ground that were impossible to detect a few years ago with a spatial resolution of about 5–10 meters or more. Moreover, constellations of these new Earth Observation (EO) platforms are assuring an increased temporal resolution, with increased spectral capabilities including more visible and infrared bands in the optical domain, and recently also including microwave (SAR) very high resolution data.

These new generation EO image data can represent a precious source of information in support of the whole cycle of crisis management activities, including risk assessment, disaster preparedness, warning, alerting, damage assessment, needs
Development and implementation of a validation protocol for crisis maps: reliability and consistency assessment of burnt area maps

C. Corbane, D. Carrion & M. Broglia

Abstract

Validation is an emerging topic in the field of geospatial information for emergency response. In the framework of the Global Monitoring for Environment and Security initiative, the Services and Applications for Emergency Response project seeks to implement and validate the pre-operational version of Emergency Response Core Services. In that context, a dedicated effort has been made in the development and implementation of a comprehensive, product-oriented validation protocol tailored to crisis maps and data sets. This paper presents the approach for validation of crisis maps and its application in the context of rapid mapping of forest fires in Corsica during the summer of 2009. It also discusses the main challenges and the critical aspects of validation of geospatial information in emergency response services.

Generalisation, symbol specification and map evaluation: feedback from research done at COGIT laboratory, IGN France

C. Duchêne, S. Christophe & A. Ruas

Abstract

This paper presents an overview of research studies made at the COGIT laboratory of IGN France in the fields of generalisation and symbol specification, particularly considering evaluation aspects. It then discusses how generalisation and symbol specification interact. Finally it explores some possible adaptations of the presented works in generalisation and symbol specification to cartography in the context of crisis management.

Validation of GIS layers in the EU: getting adapted to available reference data

Francisco Javier Gallego

Abstract

An optimal validation of a thematic map would ideally require in-situ observations of a large sample of units specifically conceived for the map under validation. This is often not possible due to budget limitations. The alternative can be using photo-interpretation of high or very high resolution images instead of in-situ observations or using available data sets that do not fully comply with the ideal characteristics: unit size, reference date or sampling plan. This paper illustrates some examples of use of available data in the European Union. For land cover maps, the best existing data set is probably Land Use/Cover Area-frame Survey (LUCAS) that has been conducted by Eurostat on four occasions since 2001. Because LUCAS is based on systematic sampling, advantages and limitations of systematic sampling are discussed. A fine-scale population density map is presented as an example of a situation in which reference data on a statistical sample cannot be collected.

The independent service validation in GMES RESPOND: the flood validation exercise

M. Shimoni, M. Crosetto, S. Lang, P. Bally & F. Boubila
Abstract

This article is aimed at providing a detailed description of the Flood Validation Exercise organised by the Independent Service Validation Group of the Global Monitoring for Environment and Security (GMES) RESPOND project. The aims of the validation exercise were: (1) providing a practical example of validation procedures in the frame of the GMES Emergency Response services; (2) executing a full-scale validation exercise able to cope with the requirements of an emergency service; and (3) better understanding the performances and limitations of Earth observation services for Flood Damage Mapping. This validation exercise is a first step of the main task to define the whole validation process for GMES services. When this is achieved, there will be knowledge concerning how well services meet the service specifications derived from the user needs. The present exercise has the purpose of gathering this knowledge. The output of this validation exercise can be used to characterise and qualify the performance and timeliness of Crisis and Damage Mapping Services. This paper summarises the methodology for the flood exercise validation and the results of product validation and inter-comparison.

Quality control, validation and user feedback of the European Flood Alert System (EFAS)

Ad De Roo, Jutta Thielen, Peter Salamon, Konrad Bogner, Sebastien Nobert, Hannah Cloke, David Demeritt, Jalal Younis, Milan Kalas, Katalin Bódis, Davide Muraro & Florian Pappenberger

Abstract

The quality control, validation and verification of the European Flood Alert System (EFAS) are described. EFAS is designed as a flood early warning system at pan-European scale, to complement national systems and provide flood warnings more than 2 days before a flood. On average 20–30 alerts per year are sent out to the EFAS partner network which consists of 24 National hydrological authorities responsible for transnational river basins. Quality control of the system includes the evaluation of the hits, misses and false alarms, showing that EFAS has more than 50% of the time hits. Furthermore, the skills of both the meteorological as well as the hydrological forecasts are evaluated, and are included here for a 10-year period. Next, end-user needs and feedback are systematically analysed. Suggested improvements, such as real-time river discharge updating, are currently implemented.

Monitoring changes in the Menik Farm IDP camps in Sri Lanka using multi-temporal very high-resolution satellite data

T. Kemper, M. Jenerowicz, L. Gueguen, D. Poli & P. Soille

Abstract

This paper presents the results of the application of mathematical morphology for the automatic quantification of the number of tents and the detection of changes in the Menik Farm IDP camp in Sri Lanka. The tents were retrieved using an area-constraint top-hat opening applied to WorldView-1 data. The counting of tents was based on the centroids of the automatically detected structures indicating an overall number of 25,150 tents on the 26 June 2009. The comparison with a visual interpretation produced an $R^2$ of 0.97 with an error of 1.25%. In addition, an automated detection of changes inside a camp area was conducted. The comparison of the satellite image of 26 June 2009 (WorldView-1) and an image of 28 February 2010 (GeoEye-1) is based on mutual (mixed) information metric, after using morphological
image processing techniques and previously specified criterion. Changes are observed on a terrain of around 15.2% of the total camp area and 3813 of previously detected structures disappeared in a period of 8 months.

**Analysis of built-up spatial pattern at different scales: can scattering affect map accuracy?**

**P. Tenerelli & D. Ehrlich**

Abstract

Settlement maps derived by Earth Observation data represent a critical dataset for building stock quantification. The accuracy of the settlement maps varies across the different spatial scales and across the space according to specific spatial patterns. The aim of this paper is to assess the accuracy of the settlement map at different scales, and to analyze the relationships between spatial allocation of error and built-up distribution patterns. The paper identifies two general trends. First that the building stock overestimation error increases with increasing values of spatial scattering. Second that at coarser scales the relation between building area overestimation and spatial scattering became stronger. The results have important implications when settlement maps are used to estimate the building stock.

**Mapping urban building stocks for vulnerability assessment – preliminary results**

**Keiko Saito & Robin Spence**

Abstract

This paper discusses a methodology to collect building inventory data by combining image processing techniques, field work or tools such as Google Street View and applying statistical inferences. Following the methodology outlined in Marinescu (2002), a family of Gabor filters are first constructed, which are then applied to an optical high-resolution image. The output from the processed image is segmented using Self-Organising Maps. This paper examines the relationship between the segmented areas in the image and the building type distribution within each segmented area, by deriving the distribution from field data. The relationship between the average number of buildings in these cells against the number of grid cells allocated to each segmentation cluster is also investigated. Finally, using these results, the overall building inventory distribution for the whole of the case study site of Pylos is presented.
components are distributed OWS, the OWS search engine, the OWS ontology generator, the ontology-based OWS catalog service, and the ontology-based multi-protocol OWS client. Experimental results show that the execution time of this proposed method equals only 0.26 of that of Nutch's method. In addition, the precision is much higher. Moreover, this proposed method can carry out complex OWS reasoning-based queries. It is being used successfully for the Antarctica multi-protocol OWS portal of the Geo-Information Web Service Portal of the Polar.

Parallel algorithm for viewshed analysis on a modern GPU

Fang Chao, Yang Chongjun, Chen Zhuo, Yao Xiaojing & Guo Hantao

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Abstract
Spatial analysis, including viewshed analysis, is an important aspect of the Digital Earth system. Viewshed analysis is usually performed on a large scale, so efficiency is important in any Digital Earth application making these calculations. In this paper, a real-time algorithm for viewshed analysis in 3D scenes is presented by using the parallel computing capabilities of a graphics processing unit (GPU). In contrast to traditional algorithms based on line-of-sight, this algorithm runs completely within the programmable 3D visualization pipeline to render 3D terrains with viewshed analysis. The most important difference is its integration of the viewshed calculation with the rendering module. Invisible areas are rendered as shadows in the 3D scene. The algorithm process is paralleled by rasterizer units in the graphics card and by vertex and pixel shaders executed on the GPU. We have implemented this method in our 3D Digital Earth system with the DirectX 9.0c API and tested on some consumer-level PC platforms with interactive frame-rates and high image quality. Our algorithm has been widely used in related systems based on Digital Earth.

Mapping alteration minerals using sub-pixel unmixing of ASTER data in the Sarduiyeh area, SE Kerman, Iran

Mahdieh Hosseinjani & Majid H. Tangestani

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Abstract
This paper is an attempt to introduce the role of earth observation technology and a type of digital earth processing in mineral resources exploration and assessment. The sub-pixel distribution and quantity of alteration minerals were mapped using linear spectral unmixing (LSU) and mixture tuned matched filtering (MTMF) algorithms in the Sarduiyeh area, SE Kerman, Iran, using the visible-near infrared (VNIR) and short wave infrared (SWIR) bands of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument and the results were compared to evaluate the efficiency of methods. Three groups of alteration minerals were identified: (1) pyrophyllite-alunite, (2) sericite-kaolinite, and (3) chlorite-calcite-epidote. Results showed that high abundances within pixels were successfully corresponded to the alteration zones. In addition, a number of unreported altered areas were identified. Field observations and X-ray diffraction (XRD) analysis of field samples confirmed the dominant mineral phases identified remotely. Results of LSU and MTMF were generally similar with overall accuracy of 82.9 and 90.24%, respectively. It is concluded that LSU and MTMF are suitable for sub-pixel mapping of alteration minerals and when the purpose is identification of particular targets, rather than all the elements in the scene, the MTMF algorithm could be proposed.

Modelling and mapping third dimension in a spatial database

F. Döner & C. Bıyık

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Abstract
In this paper, an overview of phases for modelling and mapping third dimension of spatial objects in a database is presented based on a selected spatial database management system (DBMS). These phases include (1) defining a spatial reference system for representing three-dimensional (3D) objects with real-world coordinates, (2) geometric modelling of 3D objects in the database, (3) 3D spatial indexing for fast accessing/querying the 3D data, 3D spatial queries and representation of 3D data. Then, a case study is performed to assess needs, possibilities and potential limitations of 3D data modelling in the spatial database.

Analysis of the factors affecting LiDAR DTM accuracy in a steep shrub area

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Abstract
The creation of a quality Digital Terrain Model (DTM) is essential for representing and analyzing the Earth in a digital form. The continuous improvements in the acquisition and the potential of airborne Light Detection and Ranging (LiDAR) data are increasing the range of applications of this technique to the study of the Earth surface. The aim of this study was to determine the optimal parameters for calculating a DTM by using an iterative algorithm to select minimum elevations from LiDAR data in a steep mountain area with shrub vegetation. The parameters were: input data type, analysis window size, and height thresholds. The effects of slope, point density, and vegetation on DTM accuracy were also analyzed. The results showed that the lowest root mean square error (RMSE) was obtained with an analysis window size of 10 m, 5 m, and 2.5 m, rasterized data as input data, and height thresholds equal to or greater than 1.5 m. These parameters showed a RMSE of 0.19 m. When terrain slope varied from 0–10% to 50–60%, the RMSE increased by 0.11 m. The RMSE decreased by 0.06 m when point density was increased from 4 to 8 points/m², and increased by 0.05 m in dense vegetation areas.
A time series for monitoring vegetation activity and phenology at 10-daily time steps covering large parts of South America

Clement Atzberger & Paul H.C. Eilers

Abstract

It is widely accepted that natural resources should only be sustainably exploited and utilized to effectively preserve our planet for future generations. To better manage the natural resources, and to better understand the closely linked Earth systems, the concept of Digital Earth has been strongly promoted since US Vice President Al Gore’s speech in 1998. One core element of Digital Earth is the use and integration of remote sensing data. Only satellite imagery can cover the entire globe repeatedly at a sufficient high-spatial resolution to map changes in land cover and land use, but also to
detect more subtle changes related for instance to climate change. To uncover global change effects on vegetation activity and phenology, it is important to establish high quality time series characterizing the past situation against which the current state can be compared. With the present study we describe a time series of vegetation activity at 10-daily time steps between 1998 and 2008 covering large parts of South America at 1 km spatial resolution. Particular emphasis was put on noise removal. Only carefully filtered time series of vegetation indices can be used as a benchmark and for studying vegetation dynamics at a continental scale. Without temporal smoothing, subtle spatio-temporal patterns in vegetation composition, density and phenology would be hidden by atmospheric noise and undetected clouds. Such noise is immanent in data that have undergone solely a maximum value compositing. Within the present study, the Whittaker smoother (WS) was applied to a SPOT VGT time series. The WS balances the fidelity to the observations with the roughness of the smoothed curve. The algorithm is extremely fast, gives continuous control over smoothness with only one parameter, and interpolates automatically. The filtering efficiently removed the negatively biased noise present in the original data, while preserving the overall shape of the curves showing vegetation growth and development. Geostatistical variogram analysis revealed a significantly increased signal-to-noise ratio compared to the raw data. Analysis of the data also revealed spatially consistent key phenological markers. Extracted seasonality parameters followed a clear meridional trend. Compared to the unfiltered data, the filtered time series increased the separability of various land cover classes. It is thus expected that the data set holds great potential for environmental and vegetation related studies within the frame of Digital Earth.

Applicability of SRTM data for landform characterisation and geomorphometry: a comparison with contour-derived parameters

V. Prasannakumar, R. Shiny, N. Geetha & H. Vijith

Abstract

Geomorphologic and hydrologic research heavily depends on digital elevation models (DEM) which are currently being prepared from digital contours. The present study examines the use and applicability of freely available global elevation data source (3 arc seconds finished Shuttle Radar Topography Mission (SRTM)) in landform characterisation, geomorphometry, river basin studies and other allied scientific applications in comparison with contour elevation data derived from the surveyed topographical sheets. The relief data extracted from a conventionally digitised geo-information science dataset of topographic contours (1:50,000) are compared with the SRTM-DEM and the variations are analysed. The automated geomorphometric and landform parameters derived from the contour DEM and the computed statistical properties of those parameters have substantial agreement with the same parameters derived from the SRTM-DEM. At the same time, localised variations also exist in some spatial domains. Derivative landscape analysis outputs from the SRTM-DEM suggest the wide acceptability and applicability of the freely available SRTM data source, especially in the regional scale applications related to hydrological modelling, terrain characterisation, disaster management and land degradation studies.

Preliminary study of a cluster-based open-source parallel GIS based on the GRASS GIS

Fang Huang, Dingsheng Liu, Xiaowen Li, Lizhe Wang & Wenbo Xu

Abstract
In response to the problem of how to give geographic information system (GIS) high-performance capabilities for certain specific GIS applications, a new GIS research direction, parallel GIS processing, has emerged. However, traditional research has focused mostly on implementing typical GIS parallel algorithms, with little discussion of how to parallelize an entire GIS package on clusters based on theory. Therefore, the authors have chosen the geographic resources analysis support system (GRASS) GIS as the object of their research and have put forward the concept of a cluster-based open-source parallel GIS (cluster-based OP-GIS) as a tool to support Digital Earth construction. The related theory includes not only the parallel computing mode, architecture, and software framework of such a system, but also various parallelization patterns. From experiments on the prototype system, it can be concluded that the parallel system has better efficiency and performance than the conventional system on certain selected modules.

Geospatial predictive modelling of the Neolithic archaeological sites of Magnesia in Greece

Konstantinos G. Perakis & Athanasios K. Moysiadis

Abstract

Sources of heterogeneous geospatial data such as the elevation, the slope, the aspect, the water network and the current settlements related to the known Neolithic archaeological sites of Magnesia, are used in an attempt to confirm the existence and allow for the prediction of other archaeological sites using predictive modelling theory. Predictive modelling allows the update of the problem solving strategy as soon as new data layers are available. The Dempster–Shafer Theory also commonly referred to as evidential reasoning (ER) is used to compose probability maps of areas of archaeological interest from physiographical and historical data. The advantage of this theory is that the ignorance is quantified and used to compose the probability maps named as belief, plausibility and belief interval for the archaeological sites. The final digital probability maps show that the Neolithic archaeological sites can be detected in the prefecture of Magnesia. This research study forms a methodological tool for the prediction of new archaeological sites in other areas of archaeological interest according to the physiographical and historical characteristics of the archaeological period being examined. It also contributes to the digital earth modelling and archaeological site protection, one of the most critical and challenging global initiatives.

European digital archive on soil maps (EuDASM): preserving important soil data for public free access

Panos Panagos, Arwyn Jones, Claudio Bosco & P.S. Senthil Kumar

Abstract

Historical soil survey paper maps are valuable resources that underpin strategies to support soil protection and promote sustainable land use practices, especially in developing countries where digital soil information is often missing. However, many of the soil maps, in particular those for developing countries, are held in traditional archives that are not easily accessible to potential users. Additionally, many of these documents are over 50 years old and are beginning to deteriorate. Realising the need to conserve this information, the Joint Research Centre (JRC) and the ISRIC-World Soil Information foundation have created the European Digital Archive of Soil Maps (EuDASM), through which all archived paper maps of ISRIC has been made accessible to the public through the Internet. The immediate objective is to transfer paper-based soil maps into a digital format with the maximum possible resolution and to ensure their preservation and easy disclosure. More than 6,000 maps from 135 countries have been captured and are freely available.
available to users through a user-friendly web-based interface. Initial feedback has been very positive, especially from users in Africa, South America and Asia to whom archived soil maps were made available to local users, often for the first time. Link: http://eusoils.jrc.ec.europa.eu/library/maps/country_maps/list_countries.cfm

Advanced Geoinformation Science

J.L. van Genderen

BOOK REVIEWS

In this issue of the International Journal of Digital Earth, I review two books, rather similar in style, but on two different topics related to Digital Earth. One is entitled “Advanced Geoinformation Science”, and the other: “Advances in Environmental Remote Sensing: Sensors, Algorithms and Applications”. What the two books have in common is that they are written by a large group of authors. The first mentioned book has 50 authors, and the other has 44 contributing authors. This is also the weakness of these two books. They have too many topics covered by different experts in different depth, style, quality, etc. Whilst the titles of both books indicate that the reader will have the latest state of the art in these fields, this is not really achieved. The books are too general. For example, in Chapter 9 of the Advances in Geoinformation Science book, 16 authors each write a paragraph or two about their particular application. This makes the books too fragmented. I will be very interested to receive feedback from IJDE readers on their opinions about this type of book. The best chapter of the first book is the final chapter on “Vision for Geoinformation Science”. Here there is some discussion about Digital Earth, but the book fails to mention anything about either the International Society of Digital Earth or the International Journal of Digital Earth. The best part of the Advances in Environmental Remote Sensing book is the section on Algorithms, which has some good chapters. Anyway, I hope you will enjoy reading these reviews, and let me know if you would like more such books reviewed for IJDE or not.

Prof. (Em.) Dr. J.L. van Genderen,
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This book has an excellent title, but its contents do not meet the expectations of the title.

It is based on an international training course given to groups of Chinese staff from a provincial mapping agency, at the Center for Intelligent Spatial Computing (CISC) at George Mason University in the USA, by many Chinese and other American staff.

The editors have tried to provide a systematic overview of geoinformation science in 10 chapters. Chapter 1 is an introduction, stating the problems and reasons behind...

Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications

J.L. van Genderen
Abstract

The purpose of this paper is to contribute to the definition of a European perspective on Digital Earth (DE), identify some actions that can contribute to raise the awareness of DE in the European context and thus strengthen the European contribution to the International Society for Digital Earth (ISDE). The paper identifies opportunities and synergies with the current policy priorities in Europe (Europe 2020, Innovation Union and Digital Agenda) and highlights a number of key areas to advance the development of DE from a European perspective: (1) integrating scientific research into DE; (2) exploiting the Observation Web with human-centred sensing; and (3) governance, including the establishment of
stronger linkages across the European landscape of funding streams and initiatives. The paper is offered also as a contribution to the development of this new vision of DE to be presented at the next International DE Conference in Perth, Australia, in August 2011. The global recognition of this new vision will then reinforce the European component and build a positive feedback loop for the further implementation of DE across the globe.

**Sensors, empowerment, and accountability: a Digital Earth view from East Africa**

Yola Georgiadou, Benson Bana, Robert Becht, Robert Hoppe, Justinian Ikingura, Menno-Jan Kraak,Kate Lance, Rob Lemmens, Juma Hemed Lungo, Michael McCall, Gianluca Miscione & Jeroen Verplanke

Abstract

Several innovative 'participatory sensing' initiatives are under way in East Africa. They can be seen as local manifestations of the global notion of Digital Earth. The initiatives aim to amplify the voice of ordinary citizens, improve citizens' capacity to directly influence public service delivery and hold local government accountable. The popularity of these innovations is, among other things, a local reaction to the partial failure of the millennium development goals (MDGs) to deliver accurate statistics on public services in Africa. Empowered citizens, with access to standard mobile phones, can 'sense' via text messages and report failures in the delivery of local government services. The public disclosure of these reports on the web and other mass media may pressure local authorities to take remedial action. In this paper, we outline the potential and research challenges of a 'participatory sensing' platform, which we call a 'human sensor web.' Digital Africa's first priority could be to harness continent-wide and national data as well as local information resources, collected by citizens, in order to monitor, measure and forecast MDGs.

**Spatial cloud computing: how can the geospatial sciences use and help shape cloud computing?**

Chaowei Yang, Michael Goodchild, Qunying Huang, Doug Nebert, Robert Raskin, Yan Xu, Myra Bambacus & Daniel Fay

FREE ACCESS

Abstract

The geospatial sciences face grand information technology (IT) challenges in the twenty-first century: data intensity, computing intensity, concurrent access intensity and spatiotemporal intensity. These challenges require the readiness of a computing infrastructure that can: (1) better support discovery, access and utilization of data and data processing so as to relieve scientists and engineers of IT tasks and focus on scientific discoveries; (2) provide real-time IT resources to enable real-time applications, such as emergency response; (3) deal with access spikes; and (4) provide more reliable and scalable service for massive numbers of concurrent users to advance public knowledge. The emergence of cloud computing provides a potential solution with an elastic, on-demand computing platform to integrate – observation systems, parameter extracting algorithms, phenomena simulations, analytical visualization and decision support, and to provide social impact and user feedback – the essential elements of the geospatial sciences. We discuss the utilization of cloud computing to support the intensities of geospatial sciences by reporting from our investigations on how cloud computing could enable the geospatial sciences and how spatiotemporal principles, the kernel of the geospatial sciences, could be utilized to ensure the benefits of cloud computing. Four research examples are presented to analyze how to: (1) search, access and utilize geospatial data; (2) configure computing infrastructure to enable the computability of intensive simulation models; (3) disseminate and utilize research results for massive numbers of concurrent users; and (4) adopt spatiotemporal principles to support spatiotemporal intensive applications. The paper concludes with a discussion of opportunities and challenges for spatial cloud computing (SCC).
Impact of discretization methods on the rough set-based classification of remotely sensed images

Y. Ge, F. Cao & R.F. Duan

Abstract

In recent years, the rough set (RS) method has been in common use for remote-sensing classification, which provides one of the techniques of information extraction for Digital Earth. The discretization of remotely sensed data is an important data preprocessing approach in classical RS-based remote-sensing classification. Appropriate discretization methods can improve the adaptability of the classification rules and increase the accuracy of the remote-sensing classification. To assess the performance of discretization methods this article adopts three indicators, which are the compression capability indicator (CCI), consistency indicator (CI), and number of the cut points (NCP). An appropriate discretization method for the RS-based classification of a given remotely sensed image can be found by comparing the values of the three indicators and the classification accuracies of the discretized remotely sensed images obtained with the different discretization methods. To investigate the effectiveness of our method, this article applies three discretization methods of the Entropy/MDL, Naive, and SemiNaive to a TM image and three indicators for these discretization methods are then calculated. After comparing the three indicators and the classification accuracies of the discretized remotely sensed images, it has been found that the SemiNaive method significantly reduces large quantities of data and also keeps satisfactory classification accuracy.

Toward an improved data stewardship and service for environmental and ecological science data in West China

Xin Li, Zhuotong Nan, Guodong Cheng, Yongjian Ding, Lizong Wu, Liangxu Wang, Jian Wang, Youhua Ran, Hongxing Li, Xiaoduo Pan & Zhongming Zhu

Abstract

Sharing of scientific data can help scientific research to flourish and facilitate more widespread use of scientific data for the benefit of society. The Environmental and Ecological Science Data Center for West China (WestDC), sponsored by the National Natural Science Foundation of China (NSFC), aims to collect, manage, integrate, and disseminate environmental and ecological data from western China. It also aims to provide a long-term data service for multidisciplinary research within NSFC's "Environment and Ecology of West China Research Plan" (NSFC West Plan). An integrated platform has been developed by the WestDC, and this has the function of data sharing, acting as a knowledge repository. Major data sets developed by the WestDC include basic geographic data, the regionalization of global data set for China, scientific data for cold and arid regions in China, scientific data for the cryosphere in countries that neighbor China, data relating to the inland river basins in northwestern China, and data submitted by the NSFC West Plan projects. In compliance with the “full and open” data sharing policy, most data in the WestDC can be accessed online. Highlights include detailed data documentation, the integration of data with bibliographic knowledge, data publishing, and data reference.
BOOK REVIEWS


This major textbook is now in its third edition! Even some 10 years after it first appeared, it is still one of the best selling textbooks in the field of Geographic Information Systems (GIS). The 539 pages are crammed with information and many teaching aids for educators. This completely updated version of the book now includes sections on Google Earth, Google Maps and their equivalents from Microsoft and Yahoo. The book now has its own website (www.wileycollege.com/longley) with many interesting instructor lists and tips on how to use this book for undergraduate and post graduate courses. The website also contains a very useful ‘Instructor Manual’.

Teachers wishing to use this book as their main resource will find it a very rich source! There are numerous links to other more detailed sources of information, such as can be found at: www.spatialanalysisonline.com, which has a comprehensive search facility and related printed and PDF versions of the web material. This book does not only provide the principles, techniques and applications of GIS, but also provides links to many practical, hands-on laboratory exercises. These are available free to any reader working in an Institution that has an ESRI (Redlands, USA) site license (see: training.esri.com/campus/catalog/licenses/courselist.cfm?id=43). These are cross-linked in the book to individual sections and chapters. Many other laboratory teaching courses/materials are also given in the book, such as those to be found at: training.esri.com/tech200/lowdeltcfm?DID=6&Product_ID=821 (a six-module ‘Turning Data into Information’ course), or www.unige.ch/training.esri.com/gateway/index.cfm, and www.worldcampus.psu.edu.

The book is organized into five major sections, namely:

1. Introduction (Chapters 1 and 2)
2. Principles (Chapters 3–6)
3. Techniques (Chapters 7–11)
4. Analysis (Chapters 12–16)
5. Management and policy (Chapters 17–20)

At the end of the book there is a very long Index of some 14 pages, but readers of this Journal will be disappointed, for when one looks for ‘Digital Earth’ there is nothing

Risk and planet earth

J.L. van Genderen
The use of high-performance and high-throughput computing for the fertilization of digital earth and global change studies

Yong Xue, Dominic Palmer-Brown & Huadong Guo

Abstract

The study of global climate change seeks to understand: (1) the components of the Earth's varying environmental system, with a particular focus on climate; (2) how these components interact to determine present conditions; (3) the factors driving these components; (4) the history of global change and the projection of future change; and (5) how knowledge about global environmental variability and change can be applied to present-day and future decision-making.

This paper addresses the use of high-performance computing and high-throughput computing for a global change study
on the Digital Earth (DE) platform. Two aspects of the use of high-performance computing (HPC)/high-throughput computing (HTC) on the DE platform are the processing of data from all sources, especially Earth observation data, and the simulation of global change models. The HPC/HTC is an essential and efficient tool for the processing of vast amounts of global data, especially Earth observation data. The current trend involves running complex global climate models using potentially millions of personal computers to achieve better climate change predictions than would ever be possible using the supercomputers currently available to scientists.

China Digital Ocean Prototype System

Xin Zhang, Wen Dong, Sihai Li, Jiancheng Luo & Tianhe Chi

Abstract

Digital Ocean is a new research domain of Digital Earth. Because of the spatio-temporal, three-dimensional (3D) and intrinsically dynamic nature of ocean data, it is more difficult to make a breakthrough in this domain. The construction of the China Digital Ocean Prototype System (CDOPS) pushes Digital Ocean a step forward from its operation as a mere concept to its achievement as a realistic system. In this paper, the technical framework of the CDOPS is discussed, including its data, function, and application layers. Then, two key technologies are studied in detail that will enable the construction of the 3D ocean environment and the visualization of the ocean model output data. Practical demonstrations show that the CDOPS provides a technical reference for the development of Digital Ocean. This paper is based on an ongoing research project of the development of CDOPS that aims at the facilitation, integration, sharing, accessing, visualization, and use of the ocean data and model computing data from the Digital Earth perspective.

Modeling sprawl of unauthorized development using geospatial technology: case study in Kuantan district, Malaysia

Mazlan Hashim, Norzailawati Mohd Noor & Maged Marghany

Abstract

The paper explores a framework combining remote sensing and GIS-cellular automata (CA) concepts aimed at improving the modeling of unauthorized land use sprawl. Remote sensing data have been used in urban modeling and analysis, the use of high-resolution remote sensing data in assessing unauthorized development is quite unexplored. This work has demonstrated systematic combination utilization of geospatial analyses tools to acquire a new level of information to enable urban modeling and sprawl analysis in assisting urban sustainable management. In this study, Kuantan city, Malaysia was selected in simulation of the unauthorized land use with CA concept for a period of 15 years (2000–2015), with main input time-series land use observation from 1995 to 2005. The 2000 and 2005 land use input was also used as calibrated and test assessment of the simulation. The results show excellent agreement between in-situ changes of the unauthorized land use classes and the corresponding simulated classes within the same periods. In conclusion, CA model can lead to new levels of understanding of how urban areas grow and change as in view of digital earth aspiration.
Drought mapping using Geoinformation technology for some sites in the Iraqi Kurdistan region

Ayad Mohammed Fadhil

Abstract

Iraq has suffered severely from drought in recent years and the year 2008 was the driest, particularly in the Iraqi Kurdistan region. This study incorporated Geoinformation technology into mapping the drought that severely affected the Kurdistan region in the years 2007–2008. Geoinformation technology provides support in the theories, methods and techniques for building, and development of Digital Earth aspect. Five vegetation, soil, water, and land surface temperature (LST) indices were applied to two Landsat 7 ETM+ imageries of June 2007 and June 2008, to assess the drought impacts in Erbil governorate Kurdistan during the study period. The indices that were employed in this study were Normalized Difference Vegetation Index, Bare Soil Index, Normalized Differential Water Index, Tasseled Cap Transformation Wetness, and LST. The results revealed a significant decrease in the vegetative cover (56.7%) and a decline in soil/vegetation wetness (29.9%) of the total study area. Likewise, there was a significant reduction in the water bodies surface area in the region such as Dokan Lake, which lost 32.5% of its surface area in comparison with the previous year, 2007. The study results showed that the soil moisture content was the most effective actor on the vegetative cover, LST, and drought status in the study area.

Land use and land cover changes over a century (1914–2007) in the Neyyar River Basin, Kerala: a remote sensing and GIS approach

R.V. Sheeja, Sabu Joseph, D.S. Jaya & R.S. Baiju

Abstract

Land use and land cover change, perhaps the most significant anthropogenic disturbance to the environment, mainly due to rapid urbanization/industrialization and large scale agricultural activities. In this paper, an attempt has been made to appraise land use/land cover changes over a century (1914–2007) in the Neyyar River Basin (L=56 km; Area = 483.4 km$^2$) in southern Kerala – a biodiversity hot spot in Peninsular India. In this study, digital remote sensing data of the Indian Remote Sensing satellite series I-D (LISS III, 2006–2007) on 1:50,000 scale, Survey of India (SOI) toposheet of 1914 (1:63,360) and 1967 (1:50,000) have been utilized to map various land use/land cover changes. Maps of different periods have been registered and resampled to similar geographic coordinates using ERDAS Imagine 9.0. The most notable changes include decreases in areas of paddy cultivation, mixed crops, scrub lands and evergreen forests, and increases in built-up areas, rubber plantations, dense mixed forests, and water bodies. Further, large scale exploitation of flood plain mud and river sand have reached menacing proportions leading to bank caving and cut offs at channel bends. Conservation of land and water resources forms an important aspect of ecosystem management in the basin.

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A high-level architecture for a Geomatics Informatization Technology System: the Chinese case

Jixian Zhang, Weisen Li & Liang Zhai

Abstract

https://semanticommunity.info/Data_Science/Big_Data_Science_for_CODATA/International_Journal_of_Digital_Earth

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China will, as a component of ‘Digital Earth,’ establish a Geomatics Informatization Technology System (GITS) which is characterized by real-time acquisition, automatic processing, networking service, and socialized application with fundamental geographical information. The basic composition of GITS is proposed. GITS covers four layers and six platforms. The four layers are data acquisition, processing, management, and application and services. The six platforms are informative geodetic datum, high-precision geo-spatial data acquisition, automatic geo-spatial data processing, grid-based geo-spatial information management, comprehensive geo-spatial information sharing and service, and geo-spatial information integration and application. The informative geodetic datum platform provides a carrier for all the four layers and a base for the other five platforms. The high-precision geo-spatial data acquisition platform belongs to the acquisition layer. The automatic geo-spatial data processing platform belongs to the processing layer. The grid-based geo-spatial information management platform belongs to the management layer and is a bridge connecting geo-spatial data acquisition and spatial information sharing service and integrated applications. The comprehensive geo-spatial information sharing and service platform belongs to the application and service layer. Finally, this paper presents thoughts for constructing GITS.

Towards long-multitemporal change detection using SVI differencing by integrated DWT–ISOCLUS: a model for forest temporal dynamics mapping

Yashon O. Ouma & Ryutaro Tateishi

Abstract

Characterisation and mapping of land cover/land use within forest areas over long-multitemporal intervals is a complex task. This complexity is mainly due to the location and extent of such areas and, as a consequence, to the lack of full continuous cloud-free coverage of those large regions by one single remote sensing instrument. In order to provide improved long-multitemporal forest change detection using Landsat MSS and ETM + in part of Mt. Kenya rainforest, and to develop a model for forest change monitoring, wavelet transforms analysis was tested against the ISOCLUS algorithm for the derivation of changes in natural forest cover, as determined using four simple ratio-based Vegetation Indices: Simple Ratio (SR), Normalised Difference Vegetation Index (NDVI), Renormalised Difference Vegetation Index (RDVI) and modified simple ratio (MSR). Based on statistical and empirical accuracy assessments, RDVI presented the optimal index for the case study. The overall accuracy statistic of the wavelet derived change/no-change was used to rank the performances of the indices as: RDVI (91.68%), MSR (82.55%), NDVI (79.73%) and SR (65.34%). The integrated discrete wavelet transform–ISOCLUS (DWT–ISOCLUS) result was 42.65% higher than the independent ISOCLUS approach in mapping the change/no-change information. The methodology suggested in this study presents a cost-effective and practical method to detect land-cover changes in support of decision-making for updating forest databases, and for long-term monitoring of vegetation changes from multisensor imagery. The current research contributes to Digital Earth with regards to geo-data acquisition, data mining and representation of one forest systems.

A block-based selection method for road network generalization

F. Gülgen & T. Gökgöz

Abstract
When road symbols are shown in a size proportionate to the reduced scale, several problems of legibility may arise concerning the urban blocks. By the method proposed in this paper, in order to overcome these problems, urban block areas are enlarged through amalgamation and the intervening roads in the amalgams are eliminated. This method includes two new approaches for computation of threshold used in determination of important roads based on the connectivity measure, and for definition of minimum block space and area requirements based on graphic limits. A block life cycle was designed for amalgamation of blocks. For the amalgamation process, a new algorithm was developed. The experimental testing indicates that important roads and the roads surrounding the urban area have been preserved. A simpler and more legible road network has been acquired. This method can be described as a more holistic approach as the buildings are taken into account. The problems arising in the experimental testing indicate that the cartographic selection/elimination process is not sufficient by itself for road network generalization, which can be assumed as one of the integral parts of Digital Earth. As well as the selection/elimination, processes such as displacement and caricaturizing are also needed.

**Estimating evapotranspiration from terrestrial groundwater-dependent ecosystems using Landsat images**

*Xihua Yang, Peter L. Smith, Tao Yu & Hailiang Gao*

**Abstract**

Understanding and mitigating against the impact of groundwater extraction on groundwater-dependent ecosystems (GDE) requires information of evapotranspiration (ET) of these ecosystems. In this pilot study, we tested two remote-sensing methods, Surface Energy Balance Algorithms for Land (SEBAL) and Vegetation Index/Temperature Trapezoid (VITT), for ET estimation from terrestrial GDEs. Multi-temporal Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM + ) images were used to derive vegetation indices and land surface temperatures for ET estimation. Radiative transfer model was used for atmospheric correction of the Landsat images. Field measurements were used to validate the remote sensing estimation of VI and surface temperature. Both methods have been implemented in a geographic information system (GIS) using automated scripts and ancillary GIS data for quality control process. Comparison of predicted ET by SEBAL to VITT model indicates relatively good agreement ($R^2 > 0.90$) and promise for use in groundwater management. The average ET from woodland GDEs within the zone of influence of the pumping stations is in general lower than similar woodlands outside of the pumping area, particularly in summer seasons which demonstrates that the pumping regime has an impact on those GDEs. The study also demonstrates that even a simple physical ET model can provide useful information for groundwater management, and more broadly other applications in hydrologic modelling and digital earth studies.

**A virtual learning environment of the Chinese University of Hong Kong**

*Mingyuan Hu, Hui Lin, Bin Chen, Min Chen, Weitao Che & Fengru Huang*

**Abstract**

This paper introduces a scalable virtual learning environment of the Chinese University of Hong Kong; an explicitly geographical, immersive, and sharable 3D learning space with comprehensive social elements. It is characterized by multi-user collaborative modeling, group learning approaches of geo-collaboration, social space-oriented hierarchical avatars, and knowledge exchanging and sharing based on virtual geographic experiments. Applications for the purpose
of public education and virtual geographic experiment, and indicated future works prove the possibility to offer a greater opportunity to foster interdisciplinary collaborations, revitalize teaching patterns and learning contents, improve learners' cognitive abilities to solve problems, and enhance their understanding of scientific concepts and processes.

Airborne and terrestrial laser scanning

J.L. Van Genderen

BOOK REVIEW


This is one of the first textbooks on the subject of airborne and terrestrial laser scanning. The two editors, both experienced educators, have done a good job to put together this textbook. Although the book has 12 different authors, the editors have managed to produce a book in a relatively uniform style for each of the chapters.

The book gives a rather complete overview of the principles and techniques of airborne and terrestrial laser scanning technology, as well as provides chapters which introduce some of the main applications. Each of the chapters has a good list of literature for further reading, as well as a nice summary of the chapter. The book is well illustrated with simple diagrams, and avoids using too many mathematical formulas.

The book starts with an introduction to the technology of airborne and terrestrial laser scanning. This first chapter covers most of the topics related to this technology. It has six sections, namely: Basic measurement principles of laser scanners, Components of laser scanners, Basics of airborne laser scanning, Operational aspects of airborne laser scanning, Airborne LIDAR bathymetry, and on Terrestrial laser scanners.

In Chapter 2, entitled ‘Visualization and Structuring of Point Clouds,’ the authors discuss the techniques to visualize both the original point clouds and rasterized data. This chapter also deals with the techniques of data structures and provides several of the most common segmentation algorithms. Chapter 3, on ‘Registration and Calibration’ deals with the registration of multiple data-sets and the calibration of airborne and terrestrial laser scanners. It focuses on the two key factors that influence data quality, namely, registration and calibration. The chapter deals with the following topics: a description of the geometric models for terrestrial and airborne laser scanning observations, the coordinate systems in which they are parameterized and the transformations between systems. Secondly, the error sources that act as perturbations to the geometric observation models and their analytical models are reviewed. The last two sections of the chapter cover registration methods and calibration methods, with particular emphasis on system self-calibration.

Chapters 4-6 deal with various applications of aerial laser scanning, and Chapters 7-9 cover some of the terrestrial applications of laser scanning.

Chapter 4 is entitled ‘Extraction of Digital Terrain Models,’ and explains the procedures for filtering of point clouds and DTM generation. This is followed in Chapter 5 by an excellent overview of the methods of building extraction. It clearly explains and describes the models and methods of building reconstruction, and deals with most of the issues involved in building reconstruction. Chapter 6 is a short
The global Landsat imagery database for the FAO FRA remote sensing survey


Abstract

To collect and provide periodically updated information on global forest resources, their management and use, the United Nations Food and Agriculture Organization (FAO) has been coordinating global forest resources assessments (FRA) every 5–10 years since 1946. To complement the FRA national-based statistics and to provide an independent assessment of forest cover and change, a global remote sensing survey (RSS) has been organized as part of FAO FRA 2010. In support of the FAO RSS, an image data set appropriate for global analysis of forest extent and change has been produced. Landsat data from the Global Land Survey 1990–2005 were systematically sampled at each longitude and latitude intersection for all points on land. To provide a consistent data source, an operational algorithm for Landsat...
data pre-processing, normalization, and cloud detection was created and implemented. In this paper, we present an overview of the data processing, characteristics, and validation of the FRA RSS Landsat dataset. The FRA RSS Landsat dataset was evaluated to assess overall quality and quantify potential limitations.

**Production of global land cover data – GLCNMO**

Ryutaro Tateishi, Bayaar Uriyangqai, Hussam Al-Bilbisi, Mohamed Aboel Ghar, Javzandulam Tsend-Ayush, Toshiyuki Kobayashi, Alimujiang Kasimu, Nguyen Thanh Hoan, Adel Shalaby, Bayan Alsaideh, Tsevengee Enkhzaya, Gegentana & Hiroshi P. Sato

Abstract

Global land cover is one of the fundamental contents of Digital Earth. The Global Mapping project coordinated by the International Steering Committee for Global Mapping has produced a 1-km global land cover dataset – Global Land Cover by National Mapping Organizations. It has 20 land cover classes defined using the Land Cover Classification System. Of them, 14 classes were derived using supervised classification. The remaining six were classified independently: urban, tree open, mangrove, wetland, snow/ice, and water. Primary source data of this land cover mapping were eight periods of 16-day composite 7-band 1-km MODIS data of 2003. Training data for supervised classification were collected using Landsat images, MODIS NDVI seasonal change patterns, Google Earth, Virtual Earth, existing regional maps, and expert's comments. The overall accuracy is 76.5% and the overall accuracy with the weight of the mapped area coverage is 81.2%. The data are available from the Global Mapping project website (http://www.iscgm.org/). The MODIS data used, land cover training data, and a list of existing regional maps are also available from the CERes website. This mapping attempt demonstrates that training/validation data accumulation from different mapping projects must be promoted to support future global land cover mapping.

**Tracking desertification on the Mongolian steppe through NDVI and field-survey data**

Troy Sternberg, Renchin Tsolmon, Nicholas Middleton & David Thomas

Abstract

Changing environmental and socio-economic conditions make land degradation, a major concern in Central and East Asia. Globally satellite imagery, particularly Normalized Difference Vegetation Index (NDVI) data, has proved an effective tool for monitoring land cover change. This study examines 33 grassland water points using vegetation field studies and remote sensing techniques to track desertification on the Mongolian plateau. Findings established a significant correlation between same-year field observation (line transects) and NDVI data, enabling an historical land cover perspective to be developed from 1998 to 2006. Results show variable land cover patterns in Mongolia with a 16% decrease in plant density over the time period. Decline in cover identified by NDVI suggests degradation; however, continued annual fluctuation indicates desertification – irreversible land cover change – has not occurred. Further, in situ data documenting greater cover near water points implies livestock overgrazing is not causing degradation at water sources. In combination of the two research methods – remote sensing and field surveys – strengthen findings and provide an effective way to track desertification in dryland regions.
VGIS-COLLIDE: an effective collision detection algorithm for multiple objects in virtual geographic information system

Feixiong Luo, Ershun Zhong, Junlai Cheng & Yuefeng Huang

Abstract

Collision detection is an important component in simulation applications which are based on virtual geographic information system (VGIS). In this paper, an effective collision detection algorithm for multiple objects in VGIS, VGIS-COLLIDE, is presented. The algorithm firstly integrates existing quadtree, which is the global hierarchical structure of VGIS, with axis-aligned bounding box of object to perform the broad-phase of collision detection. After that, exact collision detection between two objects which have passed the broad-phase of collision detection is performed. The algorithm makes no assumption about input primitives or object's motion and is directly applicable to all triangulated models. It can be applicable to both rigid and deformable objects without preprocessing. The performance of the algorithm has been demonstrated in several environments consisting of a high number of objects with hundreds of thousands of triangles.

SAR interferometric coherence analysis for snow cover mapping in the western Himalayan region

Vijay Kumar & Gopalan Venkataraman

Abstract

Information of snow cover (SC) over Himalayan regions is very important for regional climatological and hydrological studies. Precise monitoring of SC in the Himalayan region is essential for water supply to hydropower stations, irrigation requirements, and flood forecasting. Microwave remote sensing has all weather, day and night earth observation capability unlike optical remote sensing. In this study, spaceborne synthetic aperture radar interferometric (InSAR) coherence analysis is used to monitor SC over Himalayan rugged terrain. The feasibility of monitoring SC using synthetic aperture radar (SAR) interferometry depends on the ability to maintain coherence over InSAR pair acquisition time interval. ERS-1/2 InSAR coherence and ENVISAT ASAR InSAR coherence images are analyzed for SC mapping. Data sets of winter and of snow free months of the Himalayan region are taken for interferogram generation. Coherence images of the available data sets show maximum decorrelation in most of the area which indicates massive snowfall in the region in the winter season and melting in the summer. Area showing coherence loss due to decorrelation is mapped as a snow-covered area. The result is validated with field observations of snow depth and it is found that standing snow is inversely related to coherence in the Himalayan region.

Atlas of remote sensing of the Wenchuan earthquake

J.L. van Genderen
EDITORIAL

Stefano Nativi & George Percivall

FREE ACCESS

The Earth and space sciences are rapidly implementing international open standards for discovery, access, and processing of geospatial information. These standards provide for interoperability well tuned to the Earth and space sciences, because the standards were developed by members of the same community and are now being refined as best practices.
This *IJDE* issue discusses some of the latest advances in implementing open standards for access to sensor data, processing of the data suitable for a specific decision or research context, and presentation of the information to the various communities ranging from researchers, policy makers, and general public. These interoperability solutions are extremely important to build advanced Digital Earth infrastructures and support multi-disciplinary systems and applications.

The present *IJDE* issue covers most of the presentations invited to a special session held at the European Geosciences Union (EGU) General Assembly in 2009. This event was jointly organized by the EGU Earth and Space Science Informatics (ESSI) division and the Open Geospatial Consortium (OGC).

Discussion by the session participants resulted in additional feedback to the standards bodies (e.g. OGC, ISO, etc.) to further advance the standards applicability to geosciences and contribute to the Digital Earth vision.

Guest Editors Stefano Nativi & George Percivall

**The implementation of international geospatial standards for earth and space sciences**

*Stefano Nativi*

**Abstract**

The Earth and Space Sciences Informatics division of European Geosciences Union (EGU) and the Open Geospatial Consortium jointly organised a special event entitled: ‘Implementation of international geospatial standards for earth and space sciences event’ – at the EGU General Assembly meeting held in Vienna, April 2009. The event objectives included: (a) to discuss the integration of information systems from different geosciences disciplines; (b) to promote and discuss the present process to scale from specific and monolithic systems towards independent and modular enabling infrastructures – forming an earth system science (ESS) infrastructure; and (c) to show some of the latest advances in implementing open standards. This manuscript introduces the event motivations and describes the abstract and holistic framework, which can be used to situate the topics and the developments presented by the event speakers. This manuscript introduces important, and relatively new technologies to build a multi-disciplinary geosciences information system: the System of Systems approach and the Model Driven Approach. To achieve that, three important information infrastructure categories are recognised: (a) ESS information infrastructure; (b) geospatial information infrastructure; and (c) distributed information infrastructure. Digital Earth should support the discussed framework to accelerate information transfer from theoretical discussions to applications, in all fields related to global climate change, natural disaster prevention and response, new energy-source development, agricultural and food security, and urban planning and management.

**The application of open standards to enhance the interoperability of geoscience information**

*G. Percivall*

**FREE ACCESS**

**Abstract**

We can adequately study broad global issues and policies only by taking geosciences into account. Our research and decision-making must share and make effective use of interdisciplinary data sources, models, and processes. Non-interoperability impedes sharing of data and computing resources. Standards from the Open Geospatial Consortium (OGC) and other organizations are the basis for successfully deploying a seamless, distributed information infrastructure...
for the geosciences. Several specifications now adopted by the OGC consensus process are the result of OGC interoperability initiatives. The OGC standards, deployment architectures, and interoperability initiatives are described showing how the OGC standards baseline has been developed and applies to the geosciences.

**Geological applications using geospatial standards – an example from OneGeology-Europe and GeoSciML**

John Laxton, Jean-Jacques Serrano & Agnes Tellez-Arenas

Abstract

The Geoscience Markup Language (GeoSciML) has been developed to enable the interchange of geoscience information, principally that portrayed on geological maps as well as boreholes. A GeoSciML testbed was developed both to test the implementation of the data model and its application in web services. The OneGeology-Europe project aims to use the GeoSciML data model, and build on the experience of the GeoSciML testbed, in implementing a geoportal for a harmonised geological map of Europe at 1:1 million scale. This involves the integration of web services from 20 participating organisations. An important objective of OneGeology-Europe is to contribute to Infrastructure for Spatial Information in the European Community (INSPIRE), both through the development of a geological data specification and the use of the INSPIRE technical architecture. GeoSciML and the OneGeology-Europe project are also steps towards incorporating geoscience data into a Digital Earth. Both the development of GeoSciML and the implementation of web services for GeoSciML and OneGeology-Europe, have followed a standards-based methodology. The technical architecture comprises a geoportal providing access to a Catalogue Service for the Web for metadata describing both the data and services available. OneGeology-Europe will provide both Web Map Services view and Web Feature Services download services, which aim to be compliant with the INSPIRE implementing rules.

**SeaDataNet – Pan-European infrastructure for marine and ocean data management: unified access to distributed data sets**

Dick M.A. Schaap & Roy K. Lowry

Abstract

Data availability is of vital importance for marine and oceanographic research but most of the European data are fragmented, not always validated and not easily accessible. In the countries bordering the European seas, more than 1000 scientific laboratories from governmental organisations and private industry collect data using various sensors on board of research vessels, submarines, fixed and drifting platforms, aeroplanes and satellites to measure physical, geophysical, geological, biological and chemical parameters, biological species and others. SeaDataNet is an Integrated Research Infrastructure Initiative (I3) (2006–2011) in the EU FP6 framework programme. It is developing an efficient distributed Pan-European marine data management infrastructure for managing these large and diverse data sets. It is interconnecting the existing professional data centres of 35 countries, active in data collection and providing integrated databases of standardised quality on-line. This article describes the architecture and the features of the SeaDataNet infrastructure. In particular it describes the way interoperability is achieved between all the contributing data centres. Finally it highlights the on-going developments and challenges.
Land Monitoring Network Services based on international geospatial standards: SOSI and geoland2/SDI Projects

Stephan Meissl & Gerhard Triebnig

Abstract

Spatial Observation Services and Infrastructure is a project to develop and verify innovative infrastructure and services within the context of land monitoring and Earth Observation initiatives at European and Member State (MS) levels. The project's results contribute to the concept definition of the Shared Environmental Information System (SEIS) emphasising symmetrical online sharing of information as opposed to unidirectional reporting. In a pre-operational set-up, involving the European Environment Agency (EEA), four MS sites and the European Space Agency (ESA), a decentralised information system respecting the Infrastructure for Spatial Information in Europe (INSPIRE) principles is demonstrated integrating distributed data and processing services as well as interactive multi-lingual access.

The geoland2 project is carried out in the context of Global Monitoring for the Environment and Security (GMES), a joint initiative of the European Commission and ESA, aiming to build up a European capacity for GMES. The Spatial Data Infrastructure (SDI) task shall set up operational services for the discovery, viewing, access and delivery of all products generated in the geoland2 project.

The paper presents the projects along the five International Standards Organisation (ISO)/Reference Model of Open Distributed Processing viewpoints and concludes with the main recommendation that service provisioning can strongly benefit from a (re-) utilisation of the Service Support Environment (SSE) technology provided sustainably by ESA and from the related rich experience.

Powered by standards – new data tools for the climate sciences

Andrew Woolf

Abstract

The ultimate goal of much current research in earth science informatics is to enable more efficient discovery and use of environmental data. Large-scale efforts are underway at regional and global levels. For instance the European INSPIRE Directive (2007/2/EC) and international GEOSS initiative will both provide unprecedented catalogues of earth observation and environmental data, with links to online services providing direct access to digital data repositories. While the motivation for these emerging infrastructures is clear (e.g. understanding global change), it is less obvious how they might be implemented. Standards will play a major role and considerable effort is currently being devoted to their development by bodies like the International Organisation for Standardisation and the Open Geospatial Consortium. Internet search engines are amongst the most popular websites visited today. Using the metaphor of a web search portal, we review the potential of new geospatial standards to provide an advanced, user-friendly approach to discovery and use of climate-science data.

Issue 4 2010 pages 313-ebi

Special Issue: Early warning and disaster management: the importance of geographic information (Part B)
Early warning and disaster management: the importance of geographic information (Part B)

Milan Konečný & Wolfgang Reinhardt

Abstract

Cartographic communication and support within emergency management (EM) are complicated issues with changing demands according to the incident extent and phase of the EM cycle. Keeping in mind the specifics of each purpose, it is obvious that spatial data used for maps preparation and production must be differently visualized even for the same...
type of emergency incident (traffic accident, fire, and natural disaster). Context-based cartography is a promising methodology to deal with the changing demands of an operational EM center. An overview of cartographic communication is presented within the context of an operational EM center, activities of particular actors, and map use supporting the incident elimination. The authors of the paper respond to a series of questions, for example: what is the current cartographic support of operational EM in the Czech Republic in Digital Earth conditions? What possibilities are there to improve the cartographic communication? How can contextual cartographic services be implemented in a Web environment and how can the usability of results be tested? The paper gives several examples of the usage of cartographic technologies in map creation for various emergency situations.

**The role of GI-supported methods in crisis management**

Hannes Seppänen & Kirsi Virrantaus

Abstract

Crisis and disaster management has become an important research field in GIS during recent years. Risk assessment and situation picture-related work are particularly important areas of interest. There are distinct phases in different crises; these can be roughly divided into mitigation, preparedness, response, and recovery. In this paper a general classification of methods in each phase is given with examples on recent or ongoing research projects. The framework is based on literature and experiences from crisis and disaster-related exercises. Three case studies are based on those exercises. The goal is to clarify the role and usability of various GI-supported methods in the crisis management process by outlining a theoretical framework and presenting examples of the developed methods. Continuously increasing amount of spatially related geographic information is a huge potential to the GI analysis and modeling methods; the concept of digital earth is the underlying mainstream that gives lots of promise to the research and development work in this field.

**Dynamic analysis of the Wenchuan Earthquake disaster and reconstruction with 3-year remote sensing data**

Huadong Guo, Liangyun Liu, Liping Lei, Yanhong Wu, Liwei Li, Bing Zhang, Zhengli Zuo & Zhen Li

Abstract

Earth observation is an effective technique that plays an important role in earthquake damage reduction and reconstruction. This paper introduces the results of dynamic analysis on monitoring and assessing heavily impacted areas affected by the Wenchuan Earthquake using remote sensing data acquired in the past 3 years from 2008 to 2010. Immediately after the disaster on 12 May 2008, the Chinese Academy of Sciences launched a project entitled ‘Wenchuan Earthquake Disasters Monitoring and Assessment Using Remote Sensing Technology.’ More than 400 images from 17 satellites and 20.2TB airborne remote sensing data were acquired to facilitate quick monitoring and evaluation of severely damaged areas in 14 counties. Results of the image analyses were forwarded on a timely basis to assist with consultative service and decision-making support. In subsequent years, in order to monitor the process of environmental restoration and reconstruction, airborne optical remote sensing images covering most of the severely damaged areas were again acquired in May 2009 and April 2010. These images were analyzed and compared along with images from 2008. Results were useful in support of further work on environmental protection and reconstruction in earthquake-damaged areas. Three typical areas were selected for illustrative purposes including Tangjiashan Barrier.
Lake, Beichuan County, and counties of Yingxiu and the new Beichuan. These results well demonstrate the importance and effectiveness of the utility of earth observation for disaster mitigation and reconstruction.

A low-cost PDGNSS-based sensor network for landslide monitoring – challenges, possibilities, and prospects

Jessica Glabsch, Otto Heunecke & Stefan Schuhbäck

Abstract

Simple navigation receivers can be used for positioning with sub-centimeter accuracy in a wireless sensor network if the read-out of the carrier phase (CP) data is possible and all data are permanently broadcast to a central processing computer. At this base station an automated near real-time processing takes place and a precise differential GNSS-based positioning of the involved sensor nodes is computed. The paper describes the technical principles of such a system with its essential demands for the sensing, the communication, and the computing components. First experiences in a research project related to landslide monitoring are depicted. Of course the developed system can also be embedded for location finding in a widespread multifunctional geo sensor network. The quality of the obtained result is restricted due to the fact that the CP measurements must be recorded over a certain time span, usually a few minutes for every independent position solution. As far as possible a modular structure with commercial off-the-shelf components, e.g. standard wireless local area network for communication, and in cooperation of existing proofed and powerful program tools is chosen. Open interfaces are used as far as possible.

Development of an early warning information infrastructure using spatial web services technology

Kai Walter

Abstract

Current high-performance monitoring and early warning systems are comparatively expensive and inflexible. The project described here aims for a systematic development of a prototypical alarm and early warning system for landslides utilising low-cost ad hoc wireless sensor networks and flexible spatial web service technology. Using web-based services as tools to exchange environmental data is an important step towards addressing today's larger scale environmental problems. The project's information system functions for notification, data access and analysis are implemented utilising Open Geospatial Consortium web service specifications. Approaches to implementing the orchestration of operation workflows and production of near real-time information products are illustrated.

Research on fine Spatial Quantitative Model about vulnerability of hazard-affected bodies

Zhang Bin, Yuan Hongyong, Huang Quanyi, Wen Renqiang & Gu Junqiang

Abstract

The seriousness of losses caused by disaster dependent on the hazard degree of environment, vulnerability of hazard-affected bodies, and emergency response capacity of the region is studied in this article. The study on hazard-affected bodies is of importance to disaster risk management, regional hazard prevention, reduction, and investment in disaster
insurance. With summarizing of various assessment methods of vulnerability of hazard-affected bodies, this paper presents a refined Spatial Quantification Model of regional vulnerability which combines refined spatial geographic data and land-use type data. A quantitative study on regional vulnerability was carried out by defining fine spatial grid as the basic evaluation unit based on GIS.

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**Issue 3 2010 pages 217-311**

Special Issue: Early warning and disaster management: the importance of geographic information (Part A)

**Early warning and disaster management: the importance of geographic information (Part A)**

Milan Konečný & Wolfgang Reinhardt

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Natural disasters such as volcanic eruptions, earthquakes, tsunamis, floods, fires, droughts, landslides and others occur frequently in most parts of our world. Therefore, many activities are being carried out to improve especially the Early Warning (EW) for disasters, but also all other phases of Disaster Management (DM) such as preparedness, awareness, response, recovery and mitigation.

Nowadays, there is a general awareness that geographic information and related technologies are playing an important role in all these phases.

Early Warning is obviously a central point within the whole chain, as proper warning systems can save lives and can protect people, infrastructures and other facilities. Proper Early Warning systems are pretty much dependent on the kind of the disaster, although there are technologies such as sensor networks which play a common role. Related issues within EW are for example sensor technologies, the combination of different sensors, fusion of data from different sensors, organisation of sensor networks but also numerical models and simulations. Therefore in many research projects a specific focus is placed on improving the methodology of Early Warning. But, as already mentioned, other aspects of DM are also important research issues, which is impressively shown in the papers of this and the following issue of this journal.

EW and DM are also processing oriented activities. Information and data coming from various sources are permanently handled, identified, interpreted, and visualized, so that responsible persons or institutions can recognize which kind of dangerous situations can or could occur. Disaster Management starts with the information of imminent dangerous phenomena (id. to EW) or situation, continues with the management of all active processes, helping to solve situations, caring about people, properties, nature, etc. and finishes when the last person or group of people are outside of the dangerous locations. Activities connected with decision making and needs of users in EW and DM situations are of specific interest, but are different, and it is an ambition to visualize running processes in real time, by various tools and according to the requests of users, including decision makers and inhabitants. Also the crowd sourcing concept plays a major role in this context.

It is not possible to give a complete overview on all aspects of EW and DM in this introduction but it should be mentioned that the challenges in these fields are manifold and need cooperation, integration of the methods and approaches developed by different scientific disciplines, including natural, social, environmental and other ones.

EW and DM are treated in many ways on a worldwide, regional (e.g. EU and China), national and sub-national level, in policies in action plans, directives, etc. and also in research and development projects. For example in the EU Sixth Framework Program (FP6) three calls in 2003, 2005 and 2006 aimed for: in-situ monitoring and smart sensor networks, risk information infrastructure and generic services, public safety communication, alert systems and rapidly deployable emergency telecommunications systems, emergency management and rescue operations, distributed tsunami early warning and alert system (Europe & Indian Ocean), etc.

In the EU, problems of EW and DM are connected with the Safety and security agenda in the 7th Framework Program as a part of the research agenda on Space (7FP). The expected Activities in the Space-based applications at the service of the European Society are based on development projects and realization of directives such as GMES, INSPIRE, SEIS and several others.

Perhaps one of the best examples of a political and policy approach is the Chinese document approved on May 11 by the Chinese Cabinet, just one year after the catastrophic Wenchuan earthquake. The document, entitled “China’s Actions for Disaster Prevention and Reduction” used much international knowledge and experiences from many UN organizations as well as from the USA, Europe and other continents. Amongst others, the document also describes Strategic goals and tasks for disaster reduction such as: to build a relatively complete working system and operational mechanisms regarding disaster reduction; to greatly enhance the capabilities related to disaster monitoring and early warning, prevention and preparation, emergency handling, disaster relief, and rehabilitation and reconstruction; to notably raise public awareness of disaster reduction and emergency rescue skills; and to significantly reduce human casualties and direct economic losses caused by natural disasters.
For EW and DM, Digital Earth (DE) is very important. DE is a powerful metaphor for the organisation and access to digital information through a multi-scale, three-dimensional representation of the globe as needed for EW and DM. Globally, DE is developing at different speeds in different parts of the World, and with different priorities for its various components (e.g. in Europe and particularly in the EU it is considered as a new idea, with a focus on methodology, integration of technologies and strong participation of people). DE has a global dimension, including multiple applications and themes. It has had strong political backing since the beginning. DE has a strong technological component and provides a flexible framework to adapt to evolving technologies.

The authors of this introduction have been involved in quite a number of projects related to EW and DM, and especially the first Co-editor has organised numerous conferences and seminars related to the topic. For example, in cooperation with the China National School of Administration, Embassy of the Czech Republic in Beijing which held the rotating Presidency of the EU and the Delegation of the European Commission in Beijing, the “China-EU Early Warning and Emergency Management Seminar –Challenges, Best Practices and Perspectives” was held at the Chinese National School of Administration (CNSA) premises in Beijing from 13 – 14 May 2009. The Seminar confirmed that China has numerous large catastrophes with a scale progressively larger than those in Europe and with many tragic consequences. Other countries can find much vital scientific knowledge in China on this topic. On the other hand, Europe and other developed countries of the World have plenty of knowledge, experience and developed models of disaster reduction of hazard situations based on work with individual inhabitants at the personal level, with help of the newest information (e.g. GMES, INSPIRE, SEIS) and communication technologies using ideas of e-governance and e-government, other digital initiatives, existence of services for crises situations, etc. Another important outcome of the seminar was the recommendation to intensify international cooperation in the field.

Also relevant for this specific issue is the pre-conference Workshop “GI@EarlyWarning” of AGILE 2009, held in June in Hannover, which was organised by Martin Breunig and Wolfgang Reinhard and the Joint Symposium of International Cartographic Association-ICA Working Group on Cartography in Early Warning and Crises Management (CEWaCM) and JBGIS Geo-information for Disaster Management (Gi4DM) entitled “Cartography and Geoinformatics for Early Warning and Emergency Management: Towards Better Solutions” organized in January 2009 in Prague by Milan Konečný. In addition, a series of seminars/workshops devoted to EW and DM have been held as part of the biannual Cartography and GIS conferences organized by T. Bandrova and M. Konečný in Bulgaria and the annual EW and DM seminars held as part of the Geo-Siberia Trade Fair and Conference in Novosibirsk organized by Vladimir Lisickij and Milan Konečný in Novosibirsk. The same tradition has been developed as part of the AutoCarto conferences in North America.

This Special Issue A is part of a double issue (the Special Issue B will be published in the next issue of this journal) and contains six papers:

Guo Huadong provides a comprehensive description and potential of Earth observations in disaster mitigation, and real and quasi-real-time monitoring and assessment using advanced optical and microwave earth observation capacities, while digital earth technologies provide a very important role in rapidly acquiring spatial information of the disaster areas. His paper “Understanding global natural disasters and the role of earth observation” concentrates on the characteristics of the three main global natural disasters-earthquakes, tropical storms, and floods from a scientific point of view, and analyses their patterns of distribution, origin and result, as well as the extent of their damage and measures of disaster mitigation and prevention.

Michael F. Goodchild and J. Alan Glennon's paper on: „Crowdsourcing geographic information for disaster response: a research frontier” touches one of the rapid growth areas of Geographic Information created by amateur citizens, also known as volunteered geographic information. Recently, this has started to provide an interesting alternative to traditional authoritative information from mapping agencies and corporations. Data quality is a major concern of such volunteered geographic information, an aspect which the authors discuss extensively and in considerable detail. At the end of their paper, a real example of four wildfires that impacted the Santa Barbara area in 2007-200 is discussed, together with lessons learnt.
Bertrand De Longueville et al. in their paper “Digital Earth's Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information” gives a unique approach of new realization of the DE idea. They see progress in further integration of the temporal and voluntary dimension which is needed to better portray the event-based nature of our world. The authors aim to extend the DE vision with a Nervous System in order to provide decision makers with improved alerting mechanisms: the volunteered geographic information (VGI). Although workflows have been implemented to create, validate and distribute VGI datasets for various thematic domains, its exploitation in real time and its integration into existing concepts of DE, such as spatial data infrastructures, still needs to be further addressed. The authors propose to solve the problem through Sensor Web Enablement for VGI, where VGI sensing becomes a sense of the DE's nervous system. The approach is discussed in the context of a forest fire scenario.

The paper “Challenges of the Sensor Web for disaster management” from Fei Wang and Hongyong Yuan addresses another very important issue. The role of the sensor web for disaster management has been investigated widely but the vulnerability of a sensor web in case of severe weather conditions, damaged infrastructures, fires, etc. have often been neglected. This may cause the Sensor Web to be out-of-service. The paper discusses these challenges and possible solutions.

Stefan Bernsdorf et al. describe a mobile volcano fast response system (VFRS) that can be used for volcano monitoring in case of volcanic unrest anywhere in the world, which is currently under development in Germany under the Program “Geotechnologien”. The main focus of this paper is an overview on the common web GIS interface which allows users access to the system and serves as a decision support system to assist scientists and local authorities in deciding how to react in the case of volcanic unrest.

Doris Dransch et al. discuss “The contribution of maps to the challenges of risk communication to the public” which addresses the central topic of how to improve public risk awareness and mitigation. Because of the strong spatio-temporal component of natural hazards, maps can obviously play a decisive role in communicating risk information, which is convincingly shown in the paper.

The Guest Editors believe that all the papers selected for Special Issue A (and also for those forthcoming in Special Issue B) show many important aspects of all the complex processes which should be integrated, in order to act as powerful processes, flexible, smart, intelligent, understandable and user friendly tools for EW and DM solutions.

**Understanding global natural disasters and the role of earth observation**

**Huadong Guo**

**FREE ACCESS**

**Abstract**

Since earthquakes, tropical storms, and floods are the three main global natural disasters causing the biggest loss, they should be the main focus of research in disaster science and disaster mitigation and prevention. This paper discusses the characteristics of these three global natural disasters from a scientific point of view, and analyses their patterns of distribution, origin and result, as well as the extent of their damage and measures of disaster mitigation and prevention. The paper, at the technical level, introduces the role of earth observation (EO) technologies in disaster mitigation, and real and quasi-real-time monitoring and assessment using advanced optical and microwave EO capacities, while digital earth technologies provide a very important role in rapidly acquiring spatial information of the disaster areas. The paper concludes by discussing the relationship between man and natural disasters, and proposes the viewpoint that man and nature should be able to harmoniously co-exist, and the importance of understanding disasters from an earth system science perspective so as to better meet the challenges of natural disasters.
Crowdsourcing geographic information for disaster response: a research frontier

Michael F. Goodchild & J. Alan Glennon

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Abstract

Geographic data and tools are essential in all aspects of emergency management: preparedness, response, recovery, and mitigation. Geographic information created by amateur citizens, often known as volunteered geographic information, has recently provided an interesting alternative to traditional authoritative information from mapping agencies and corporations, and several recent papers have provided the beginnings of a literature on the more fundamental issues raised by this new source. Data quality is a major concern, since volunteered information is asserted and carries none of the assurances that lead to trust in officially created data. During emergencies time is the essence, and the risks associated with volunteered information are often outweighed by the benefits of its use. An example is discussed using the four wildfires that impacted the Santa Barbara area in 2007–2009, and lessons are drawn.

Digital Earth’s Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information

Bertrand De Longueville, Alessandro Annoni, Sven Schade, Nicole Ostlaender & Ceri Whitmore

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Abstract

Digital Earth (DE) is a powerful metaphor for the organisation and access to digital information through a multi-scale three-dimensional representation of the globe. Recent progress gave a concrete body to this vision. However, this body is not yet self-aware: further integration of the temporal and voluntary dimension is needed to better portray the event-based nature of our world. We thus aim to extend DE vision with a Nervous System in order to provide decision makers with improved alerting mechanisms. Practical applications are foreseen for crisis management, where up-to-date situational awareness is needed. While it is traditionally built through trusted sources, citizens can play a complementary role by providing geo-referenced information known as Volunteered Geographic Information (VGI). Although workflows have been implemented to create, validate and distribute VGI datasets for various thematic domains, its exploitation in real time and its integration into existing concepts of DE, such as spatial data infrastructures, still needs to be further addressed. In this paper we suggest to bridge this gap through Sensor Web Enablement for VGI, where VGI sensing becomes a sense of the DE’s Nervous System. We discuss this approach and its applicability in the context of a forest fire scenario.

Challenges of the Sensor Web for disaster management

Fei Wang & Hongyong Yuan

Abstract

Sensor Web has been widely promoted and its application has evolved from original military usages to current ubiquitous civil and commercial applications. Its emergence has become a great strength to facilitate the Digital Earth concept. Although many Sensor Web applications and methods have been proposed to assist disaster management, they are not well suited to the unique features and application requirements of disaster management. Most researches focus on how to use the Sensor Web to monitor a certain phenomenon before a disaster happens and to provide early warning. However, there is a lack of study on the negative effects that a disaster may bring to the Sensor Web. For
example, severe weather conditions, damaged infrastructure, and spatial isolation may directly make the Sensor Web out-of-service. Besides, disaster management is a complex subject and its domain knowledge needs to be clarified. In this paper, the domain of the disaster management is explored and its unique features are analyzed. Then the Sensor Web concept and its role in disaster management are explained. Afterwards, the challenges of the Sensor Web for disaster management and the possible solutions are discussed. Based on the above, we introduce a high-mobility emergency system to demonstrate a good solution of the Sensor Web for multi-purpose disaster management.

**Decision support system for the mobile volcano fast response system**

S. Bernsdorf, R. Barsch, M. Beyreuther, K. Zakšek, M. Hort & J. Wassermann

Abstract

A mobile volcano fast response system (VFRS) that can be used for volcano monitoring in case of volcanic unrest anywhere in the world is currently under development in Germany. The main goal of the project called Exupéry is to provide the communication technology for stations in the field and an expert system that collects all data from various sources, assembles them in a database, and allows users to assess the data through one common web GIS interface. The system also includes an integrated automatic alert level including the alert level estimation in order to characterize the activity state of the volcano. The web GIS interface serves as a decision support system to assist scientists and local authorities in deciding how to react in the case of volcanic unrest.

**The contribution of maps to the challenges of risk communication to the public**

Doris Dransch, Henry Rotzoll & Kathrin Poser

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Abstract

Risk communication is a significant challenge in risk management. It serves different purposes; an important one is to improve the public risk awareness and mitigation. Because of the strong spatio-temporal component of natural hazards, maps can play a decisive role in communicating risk information. The application and design of maps for risk communication especially to the public has not been investigated comprehensively. Specific constraints and challenges of risk communication have not been considered systematically in the map design process so far. This study aims at developing a frame for the application and design of interactive risk and hazard maps for the public which is based on the specific constraints and challenges of risk communication. In a literature review it introduces concepts and methods from social sciences and psychology, which have been assessed as important for communicating risk information. The concepts and methods are adapted to map-mediated risk communication according to the approaches of Activity Theory. Communication objectives and tasks which are essential to improve risk mitigation are identified and geovisualization methods for information presentation are related according to the degree which they are able to serve them. Based on this, some principles for map-based risk communication are established.

**Issue 2 2010 pages 111-216**

**The framework of a geospatial semantic web-based spatial decision support system for Digital Earth**

Chuanrong Zhang, Tian Zhao & Weidong Li
Abstract

While significant progress has been made to implement the Digital Earth vision, current implementation only makes it easy to integrate and share spatial data from distributed sources and has limited capabilities to integrate data and models for simulating social and physical processes. To achieve effectiveness of decision-making using Digital Earth for understanding the Earth and its systems, new infrastructures that provide capabilities of computational simulation are needed. This paper proposed a framework of geospatial semantic web-based interoperable spatial decision support systems (SDSSs) to expand capabilities of the currently implemented infrastructure of Digital Earth. Main technologies applied in the framework such as heterogeneous ontology integration, ontology-based catalog service, and web service composition were introduced. We proposed a partition-refinement algorithm for ontology matching and integration, and an algorithm for web service discovery and composition. The proposed interoperable SDSS enables decision-makers to reuse and integrate geospatial data and geoprocessing resources from heterogeneous sources across the Internet. Based on the proposed framework, a prototype to assist in protective boundary delimitation for Lunan Stone Forest conservation was implemented to demonstrate how ontology-based web services and the services-oriented architecture can contribute to the development of interoperable SDSSs in support of Digital Earth for decision-making.

Morphometric aspects of a small tropical mountain river system, the southern Western Ghats, India

Jobin Thomas, Sabu Joseph & K.P. Thrivikramaji

Abstract

The Muthirapuzha watershed (MW) is one among the major tributaries of Periyar – the longest west flowing river in Kerala, India. A morphometric analysis was carried out to determine the spatial variations in the drainage characteristics of MW and its 14 fourth order sub-watersheds (SW1–SW14) using Survey of India topographic maps and Landsat ETM+ imagery. The study revealed that the watershed includes a sixth order stream and lower order streams dominate the basin. Results did indicate that rainfall has a significant role in the drainage development whereas structure and relief of rocks dictate the drainage pattern. The asymmetry in the drainage distribution is correlated with the tectonic history of the Munnar plateau in the late Paleocene age. The watershed is moderate to well-drained and exhibited a geomorphic maturity in its physiographic development. The shape parameters revealed the elongated nature of MW and drainage network development in the watershed. Further, the analysis provided significant insight into the terrain characteristics. This study strongly brings to light, (a) the tendency of the watershed to soil loss and (b) the hydrological makeup of the sub-watersheds, which combined helped to formulate a comprehensive watershed management plan.

A comprehensive framework for exploratory spatial data analysis: Moran location and variance scatterplots

J.G. Negreiros, M.T. Painho, F.J. Aguilar & M.A. Aguilar

Abstract

A significant Geographic Information Science (GIS) issue is closely related to spatial autocorrelation, a burning question in the phase of information extraction from the statistical analysis of georeferenced data. At present, spatial autocorrelation presents two types of measures: continuous and discrete. Is it possible to use Moran's I and the Moran
scatterplot with continuous data? Is it possible to use the same methodology with discrete data? A particular and
cumbersome problem is the choice of the spatial-neighborhood matrix \( \mathbf{W} \) for points data. This paper addresses these
issues by introducing the concept of covariogram contiguity, where each weight is based on the variogram model for that
particular dataset: (1) the variogram, whose range equals the distance with the highest Moran I value, defines the
weights for points separated by less than the estimated range and (2) weights equal zero for points widely separated
from the variogram range considered. After the \( \mathbf{W} \) matrix is computed, the Moran location scatterplot is created in an
iterative process. In accordance with various lag distances, Moran's I is presented as a good search factor for the
optimal neighborhood area. Uncertainty/transition regions are also emphasized. At the same time, a new Exploratory
Spatial Data Analysis (ESDA) tool is developed, the Moran variance scatterplot, since the conventional Moran
scatterplot is not sensitive to neighbor variance. This computer-mapping framework allows the study of spatial patterns,
outliers, changeover areas, and trends in an ESDA process. All these tools were implemented in a free web e-Learning
program for quantitative geographers called SAKWeb© (or, in the near future, http://myGeooffice.org).

**3-D visualizations of coastal bathymetry by utilization of airborne TOPSAR polarized data**

Maged Marghany, Arthur P. Cracknell & Mazlan Hashim

Abstract

Multi-frequency C and L bands in the TOPSAR data have been utilized to reconstruct three-dimensional (3-D)
bathymetry pattern. The main objective of this study is to utilize fuzzy arithmetic to reduce the errors arising from speckle
in synthetic aperture radar (SAR) data when constructing ocean bathymetry from polarized SAR data. In doing so, two
3-D surface models, the Volterra algorithm and a fuzzy B-spline (FBS) algorithm, which construct a global topological
structure between the data points, were used to support an approximation to the real surface. Volterra algorithm was
used to express the non-linearity of TOPSAR data intensity gradient based on the action balance equation (ABC). In this
context, a first-order kernel of Volterra algorithm was used to express ABC equation. The inverse of Volterra algorithm
then performed to simulate 2-D current velocities from \( C_{VV} \) and \( L_{ HH} \) band. Furthermore, the 2-D continuity equation then
used to estimate the water depth. In order to reconstruct 3-D bathymetry pattern, the FBS has been performed to water
depth information which was estimated from 2-D continuity equation. The best reconstruction of coastal bathymetry of
the test site in Kuala Terengganu, Malaysia, was obtained with polarized L and C bands SAR acquired with HH and VV
polarizations, respectively. With 10 m spatial resolution of TOPSAR data, bias of –0.004 m, the standard error mean of
0.023 m, \( r^2 \) value of 0.95, and 90% confidence intervals in depth determination was obtained with \( L_{HH} \) band.

**Toward an integrated framework for geosensor grid**

Zhou Huang, Yu Fang & Mao Pan

Abstract

Grid computing is deemed as a good solution to the digital earth infrastructure. Various geographically dispersed
geospatial resources can be connected and merged into a ‘supercomputer’ by using the grid-computing technology. On
the other side, geosensor networks offer a new perspective for collecting physical data dynamically and modeling a real-
time virtual world. Integrating geosensor networks and grid computing in geosensor grid can be compared to equipping
the geospatial information grid with ‘eyes’ and ‘ears.’ Thus, real-time information in the physical world can be processed,
correlated, and modeled to enable complex and advanced geospatial analyses on geosensor grid with capability of high-performance computation. There are several issues and challenges that need to be overcome before geosensor grid comes true. In this paper, we propose an integrated framework, comprising the geosensor network layer, the grid layer and the application layer, to address these design issues. Key technologies of the geosensor grid framework are discussed. And, a geosensor grid testbed is set up to illustrate the proposed framework and improve our geosensor grid design.

**Issue 1** 2010 pages 1-110

**EDITORIAL**

Huadong Guo

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The best news for the *International Journal of Digital Earth (IJDE)* in 2009 is that the Journal has been selected for SCI coverage. Beginning with V.1(1) 2008, *IJDE* has been indexed and abstracted in Science Citation Index Expanded, Journal Citation Reports/Science Edition, and Current Contents/Physical Chemical and Earth Sciences.

One scholar has exclaimed that it is a ‘miracle getting SCI approval within only 20 months of launch! Especially considering that it normally takes at least three years before you can even apply!’ Another expert evaluated this as a ‘realization of the issue which I, as a researcher and university professor recognized during the time *IJDE* has been in existence.’

The Journal has indeed been performing very well since its launch. It is available to institutions and subscribers throughout Africa, Australia, Asia, Europe and America, and its now also accessible to more libraries through EBSCO full-text databases. The number of downloads has increased steadily over the two years of its publication.

*IJDE* has been widely accepted by the digital earth community. With the development of digital earth, *IJDE* has shown its great influence worldwide. If we say that digital earth is a global initiative aimed at addressing challenges to human society as natural resource depletion, food and water insecurity, energy shortages, environmental degradation, natural disasters response, population explosion, and, in particular, global climate change, then *IJDE* serves as a platform for academic communication regarding the implementation of the global initiative using digital earth. In this point, *IJDE* is and will be of deep significance in its existence.

In the new year of 2010, *IJDE* will continue to aim to be a first class and leading journal in digital earth and related fields. *IJDE* will work towards improving its academic quality and impact to meet the needs of the research community by enhancing the journal impact factor. *IJDE* also particularly encourages and welcomes youth scientists to contribute more to digital earth science and technology communication.

On the special occasion of our journal beginning its third year, I would like to thank the Editorial Board members, authors, reviewers, and everyone who has made a contribution to *IJDE*. Any advice or suggestions on any aspect of the journal which might help to improve the work and help the journal to reach its goal are welcome. Let’s work together for the future of our common journal and digital earth.

Huadong Guo Editor-in-Chief

**The history and development of the theory and practice of cybercartography**

D.R. Fraser Taylor & Stephanie Pyne

https://semanticommunity.info/Data_Science/Big_Data_Science_for_CODATA/International_Journal_of_Digital_Earth

Updated: Wed, 10 Jul 2019 02:21:32 GMT

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Abstract

This paper describes the development of cybercartography since the introduction of the term in 1997. Although the origins of cybercartography were largely conceptual in nature, the evolution of cybercartography to date has been an iterative process reflecting the creative interplay between theory and practice. A major step forward was made in 2002 when the Geomatics and Cartographic Research Centre at Carleton University received a $2.5 million grant from the Social Sciences and Humanities Research Council of Canada to explore the utility of cybercartography to what was described as the New Economy. By 2006, the interaction between theory and practice had led to considerable advances in cybercartography as a holistic, location-based concept and two new cybercartographic products, the Cybercartographic Atlas of Antarctica and the Cybercartographic Atlas of Canada's Trade with the World, were produced. Between 2006 and 2009, cybercartography was further developed as a result of interaction with indigenous communities, especially in Canada's north and new interactive atlases such as the Kitikmeot Place Names Atlas and the Community Atlas of Arctic Bay were created in cooperation with the communities involved. The Nunaliit Cybercartographic Atlas Framework, built using open source software and open specifications and standards, was developed to facilitate direct input to these atlases. Cybercartography is now entering a new phase in both theory and practice building on a recently completed prototype atlas of Indigenous Perspectives and Knowledge.

Geo-spatial information and technologies in support of EU crisis management

Delilah H.A. Al-Khudhairy

Abstract

This paper discusses the challenges in operational crisis management and describes the role of information and geo-spatial technologies in meeting those challenges. The paper discusses two main sources of data, Web and very high resolution (VHR) earth observation sensors, in terms of relevance to crisis management and techniques for information extraction and analysis. Although research in information text extraction and analysis is more advanced than in information image extraction and analysis, further research is required in both these fields to take advantage of the increasing complexity but richness of open source and VHR satellite data. The paper also discusses the use of Web, GIS and Digital Earth technologies in facilitating collaborative work, decision-making and information sharing in crisis management. Despite exciting and relevant advances in information sources, information extraction and analysis methods, and collaborative crisis technologies, the main challenge remains to convince stakeholders in operational crisis management that the adoption of these technologies will lead to enhanced and effective crisis management.

Digital Earth: decadal experiences and some thoughts


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Abstract

The understanding that mankind should reasonably exploit and utilize earth resources and effectively protect the planet on which we live, is now widely accepted. However, effective actions can only be conducted if we better understand and visualize the earth. To meet this need, digital earth science and technology have been put forward and developed. This paper introduces the evolution and development process of digital earth, and presents an overview by reviewing and
analyzing the 1999 and 2009 *Beijing Declaration on Digital Earth*, the scientific and commercial digital earth systems, global and regional digital earth research, and some existing platforms of digital earth science. It also presents some thoughts about digital earth's future development.

**The circular dataimage, a graph for high-resolution circular-spatial data**

William J. Morphet & Jürgen Symanzik

Abstract

Vectors and periodic phenomena, e.g. traffic versus time, have direction on a circular scale of 360°. An overview of existing methods for the display of circular-spatial and vectorial-spatial data, such as arrow plots, is given. We introduce the circular dataimage, a new type of graphic for the display of circular-spatial data. It is defined by encoding direction in a spatial display by using colors from a color wheel constructed by connecting three or more two-color gradients with color continuity at the connections. Therefore, image discontinuity from using a single-color gradient, e.g. blue–red, does not occur. High-resolution global views of ocean wind direction are used as a running example throughout the paper. Advantages and disadvantages of circular dataimages compared to arrow plots were obtained from a usability study. Circular dataimages provide for simultaneous recognition of fine structure on a small-scale and large-scale structure on a global scale.

**Ability to detect and locate gross errors on DEM matching algorithm**

T. Zhang, M. Cen, Z. Ren, R. Yang, Y. Feng & J. Zhu

Abstract

Digital elevation model (DEM) matching techniques have been extended to DEM deformation detection by substituting a robust estimator for the least squares estimator, in which terrain changes are treated as gross errors. However, all existing methods only emphasise their deformation detecting ability, and neglect another important aspect: only when the gross error can be detected and located, can this system be useful. This paper employs the *gross error judgement matrix* as a tool to make an in-depth analysis of this problem. The theoretical analyses and experimental results show that observations in the DEM matching algorithm in real applications have the ability to detect and locate gross errors. Therefore, treating the terrain changes as gross errors is theoretically feasible, allowing real DEM deformations to be detected by employing a surface matching technique.

**Can we predict earthquakes with GPS data?**

Shunji Murai

Abstract

Prediction of earthquakes using GPS remains an unsolved but important problem. Pre-signals in terms of changes in triangular networks of GPS Stations were examined for many large earthquakes in Japan and in other Asian regions. I discovered that the occurrence and location of an earthquake can be predicted with pre-signals found in GPS data analysis. However, more research is required to predict how many days after the pre-signals an earthquake will occur.
Spatially enabling Australia – the next decade

Peter Woodgate

Abstract

A strategy for the development of the Australian spatial information industry called ‘Spatially Enabling Australia’ has recently been developed by the Cooperative Research Centre for Spatial Information. It comprises three fundamental research programs and an integrated applications program. Research Program 1, ‘Positioning,’ underpins a full framework of continuous operating reference stations to ultimately enable all of continental Australia to be capable of real-time precise positioning services based on global navigation satellite systems. Research Program 2, ‘Automated Spatial Information Generation,’ addresses complex processing of multiple remote sensing sources. Research Program 3, ‘Spatial Infrastructures,’ helps form the foundation for development of an Australian Spatial Marketplace that will make accessible vast amounts of government held data under a new licensing and access regime which supports combination with user-generated content from the mass market. The three core programs are integrated with Program 4, ‘Applications,’ to support users from the Health, Defense and Security, Energy and Utilities, Urban Development, and Agriculture–Natural Resources–Climate Change sectors. Program 4 drives outputs from the three core research programs in sector-specific deployments for high impact. This will see a rapid acceleration of the use and value adding of information products and services that utilize spatial information. There are considerable research and development challenges that must be met in order to achieve the strategic outcomes.

Space science & technology in China: a roadmap to 2050

J.L. van Genderen
Towards Earth and Space Science digital infrastructures: network, computing and data services

Stefano Nativi, Mohan Ramamurthy & Andrew Woolf

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Earth and Space scientists are engaged in integrating knowledge stemming from different disciplines about the constituent parts of the complex Sun–Earth system with the objective of understanding its properties as a whole. Earth and Space system analysis is as real a challenge for information technology as it is for scientists. In fact, the scope and complexity of Earth and Space system investigations demand the formation of distributed, multidisciplinary collaborative

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teams. The development and deployment of advanced digital infrastructures (e.g. e-infrastructure and cyber-infrastructures) will support the needs of the Earth and Space Systems Science Community and facilitate multidisciplinary knowledge integration.

Both the US and European premier scientific unions are recognising this – the American Geophysical Union (AGU) has established an Earth and Space Sciences Informatics (ESSI) Focus group, and the European Geosciences Union (EGU) has recently created a new scientific division for ESSI. The EGU–ESSI division is conceived as a European forum for the Earth and Space Systems Science multidisciplinary community, within the broader international framework of geospatial information technology. The ESSI division aims at facilitating the integration of information systems from different geoscience disciplines, addressing the heterogeneity that characterises their data and metadata models, protocols, interfaces, semantics and embedded knowledge.

In order to achieve these objectives, it is important to promote the present best practice to scale from specific, monolithic and data-centric systems towards independent, modular and service-oriented infrastructures. This approach aims to provide scientists, researchers and decision makers with a persistent set of independent services and information that scientists can integrate into a range of more complex analyses. These infrastructures will support Earth and Space scientists to leverage the recent advances in information and communication technologies, including: Model Driven Architectures (MDA); Service-Oriented Architectures (SOA); semi-structured data model and encodings, and consequent infrastructures – e.g. Internet, GRID and Cloud computing.

There has been a steady increase in interest in the application of information technologies to the Earth and Space sciences, as evidenced by the substantial investment by science funding agencies such as the US National Science Foundation and EC Research & Development Framework Programmes. Considerable intellectual innovation is occurring as a result of data, services, information and knowledge sharing across traditional disciplinary and geographic boundaries.

Several important international initiatives and programmes have been launched to cover this emerging multi-disciplinary field – e.g. GEOSS, GMES, NSDI, INSPIRE, NFGIS NEON and EuroGEOSS. Many others are in the planning stages and will likely be launched in the coming years. There is a clear need to report and discuss initiatives, experiences, opportunities and concerns of the Geosciences Community as far as Informatics-related topics are concerned. Such forums play a prominent role in bringing the ESSI community together and towards influencing specifications and standardising conventions and data formats, and lead efforts to integrate geosciences data with GIS, Digital Earth, SOA and other emerging technologies.

In essence, we envision the development of Earth and Space Science digital infrastructures, which will serve the international Digital Earth community. For Digital Earth, an important goal is to integrate data and services from multidisciplinary and disparate sources. Interoperability and metadata are key instruments to reaching that goal. They are achieved by adopting and applying international standards and special arrangements for network, computing and data services.

**Metadata requirements analysis for the emerging Sensor Web**

Liping Di, Karen L. Moe & Genong (Eugene) Yu

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Abstract

The Sensor Web has emerged from Earth Science research with the development of Web technology, to achieve process automation, sensor interoperation, and service synergy. These promises require the discovery of the right sensor at the right time and the right location with the right quality. Metadata, for sensor, platform, and data, are crucial for achieving such goals. However, analysis and practical use of these metadata reveals that the metadata and their associations are not applicable or suitable for the Sensor Web. The shortfalls are (1) the non-standard metadata
expression language; (2) the missing link between sensor and domain knowledge; (3) the insufficiency in the information for geographic locating and sensor tasking; and (4) the enhanced requirements on the quality, security, and ownership of both sensors and their sensed data. This paper reviews the current standards that have metadata components for the sensor and its platform, especially those from ISO TC211, Open Geospatial Consortium Inc., and The National Aeronautics and Space Administration Global Change Master Directory. A recommendation on metadata that meets the requirement of cross-mission sensor discovery in a pervasive Web environment is derived from them. The recommendation addresses issues on language formalization, sensor geolocation, semantics, quality, and accessibility. Roles of the emerging semantic Web technology for enabling robust discovery of sensor are discussed.

Mediating among GeoSciML resources
Chaitan Baru & Kai Lin

Abstract
Integration of data across multiple independently developed data sources can be challenging due to a variety of heterogeneities that exist across such systems. Data mediation technologies provide approaches for overcoming these heterogeneities. Standards such as Geoscience Markup Language can address some of the heterogeneity issues by providing schema standards which sources can adhere to. This article addresses the issue of semantic heterogeneity across information resources by using domain ontologies and registering schema elements and data values to such ontologies. Registering data to ontologies provides a powerful search and data integration capability across disparate geoscience information resources.

Integrating the Climate Science Modelling Language with geospatial software and services
D. Lowe, A. Woolf, B. Lawrence & S. Pascoe

Abstract
Much consideration is rightly given to the design of metadata models to describe data. At the other end of the data-delivery spectrum much thought has also been given to the design of geospatial delivery interfaces such as the Open Geospatial Consortium standards, Web Coverage Service (WCS), Web Map Server and Web Feature Service (WFS). Our recent experience with the Climate Science Modelling Language shows that an implementation gap exists where many challenges remain unsolved. To bridge this gap requires transposing information and data from one world view of geospatial climate data to another. Some of the issues include: the loss of information in mapping to a common information model, the need to create ‘views’ onto file-based storage, and the need to map onto an appropriate delivery interface (as with the choice between WFS and WCS for feature types with coverage-valued properties). Here we summarise the approaches we have taken in facing up to these problems.

RESTful implementation of geospatial services for Earth and Space Science applications
P. Mazzetti, S. Nativi & J. Caron

Abstract
In the recent years, Representational State Transfer (REST) has been proposed as the architectural style for the World Wide Web. REST promises of scalability and simple deployment of Web Services seem to be particularly appealing for Earth and Space Science (ESS) applications. In fact, most of the available solutions for geospatial data sharing, applying standard interoperability specifications, require complex service-oriented infrastructures; these are powerful and extensible environments, but they usually result in difficult to deploy and manage for ESS research teams. Thus, ESS researchers would gain great benefit from an easy way of sharing geo-information using the international interoperability standards. The variety and complexity of geo-information sharing services poses several architectural issues; in fact these services encompass sensor planning and observation, coverages and features publication and retrieving, models and simulations running, data citation and annotation. Consequently, the adoption of a specific architectural style must be carefully evaluated against these specific requirements. In this work we analyse the existing geospatial services from an architectural perspective and investigate their possible RESTful implementation. Particular attention is paid to the OGC Web Coverage Service (WCS). Possible benefits and drawbacks, along with open issues and possible solutions are discussed. Our investigation suggests that REST may fit well to the typical ESS research usage cases. However, the architectural choice (e.g. Simple Object Access Protocol (SOAP) vs REST) will depend on a case-by-case analysis. Other important factors must be considered, such as the application context: a valuable example in point are the e-Business and e-Government application scenarios which require message based solutions – like those implemented by SOAP. In any case, there is a clear need for harmonization and reconciliation of these two approaches.

The GEON service-oriented architecture for Earth Science applications

Chaitan Baru, Sandeep Chandra, Kai Lin, Ashraf Memon & Choonhan Youn

Abstract

The Geosciences Network (GEON) project has been developing cyberinfrastructure for data sharing in the Earth Science community based on a service-oriented architecture. The layered architecture consists of Core, Middleware, and Applications services. Core services provide system-level functions (e.g. user authentication), Middleware services provide generic capabilities (e.g. catalog search), and Application services provide functions that users directly interact with, including applications that are specific to Earth Sciences. The GEON 'service stack' includes a standardized set of these services and the corresponding software modules. The GEON Portal provides Web-based access to these services via a set of portlets. This service-oriented approach has enabled GEON to expand to new partner sites and leverage GEON services for other projects. To facilitate interoperation in a distributed geoinformatics environment, GEON is focusing on standards for distributed search across federated catalogs.

Enabling interoperability for Digital Earth: Earth Science coverage access services

S. Nativi & B. Domenico

Abstract

For Digital Earth, an important priority is to integrate data from multiple sources. Interoperability and metadata are key instruments to reach such an objective. Interoperability is achieved by adopting and applying international standards for service interfaces and data models. As far as geospatial information is concerned, interoperability recognizes three important, interrelated data concepts: feature, coverage, and map. The present work deals with Web services for
coverage access. Coverage perspectives characterizing three geospatial communities - i.e. the Earth Science (ES), GIS and Digital Earth communities, are discussed. ES community requirements for coverage access services are presented and discussed making use of two methods concurrently: Critical Success Factor (CSF) analysis method supplemented through the use of Usage Cases. A CSF hierarchy and derived critical requirements and problems are introduced. An implementation approach consisting of four general principles is proposed. Access service categories emerging from the analysis are presented and their comparison with the present access services for the ES is discussed.

Web-system for processing and visualization of meteorological data for Siberian environment research
A. Titov, E. Gordov, I. Okladnikov & T. Shulgina

Abstract

At present, mainly GIS software is used for exploration and visualization of spatially distributed data. At the same time an approach based on the combination of advanced web technologies along with the standard rules of information-computational system development is more suitable for performing tasks requiring more sophisticated data analysis.

In this report, functional capabilities of the information-computational system created for meteorological and climatic data processing and online visualization are introduced. The system represents a dedicated web-interface, which allows performing of mathematical and statistical operations on the diverse observational and model data and to determine characteristics of global and regional climate changes.

Currently such datasets as NCEP/NCAR Reanalysis, ECMWF ERA-40 Reanalysis, etc. are available for processing. In particular, the system allows calculating of temporal average and extremum values, time trends, etc. at arbitrary spatial and temporal ranges for different meteorological parameters. The possibility of online intercomparison of meteorological characteristics calculated for different datasets is also realized in the system. The final version of the system being developed is supposed to find application in meteorological and climatological investigations and should help researchers to save time during performing routine analytical tasks by simplifying handling of huge arrays of spatially distributed meteorological data.

Issue 4 2009 pages 291-402

A new global raster water mask at 250 m resolution
M.L. Carroll, J.R. Townshend, C.M. DiMiceli, P. Noojipady & R.A. Sohlberg

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Abstract

Accurate depiction of the land and water is critical for the production of land surface parameters from remote sensing data products. Certain parameters, including the land surface temperature, active fires and surface reflectance, can be processed differently when the underlying surface is water as compared with land. Substantial errors in the underlying water mask can then pervade into these products and any products created from them.

Historically many global databases have been created to depict global surface water. These databases still fall short of the current needs of the terrestrial remote sensing community working at 250 m spatial resolution. The most recent attempt to address the problem uses the Shuttle Radar Topography Mission (SRTM) data set to create the SRTM Water
Body Data set (SWBD 2005). The SWBD represents a good first step but still requires additional work to expand the spatial coverage to include the whole globe and to address some erroneous discontinuities in major river networks. To address this issue a new water mask product has been created using the SWBD in combination with MODIS 250 m data to create a complete global map of surface water at 250 m spatial resolution. This effort is automated and intended to produce a dataset for use in processing of raster data (MODIS and future instruments) and for masking out water in final terrestrial raster data products. This new global dataset is produced from remotely sensed data and provided to the public in digital format, free of charge. The data set can be found on the Global Land Cover Facility (GLCF) website at http://landcover.org. This dataset is expected to be a base set of information to describe the surface of Earth as either land or water which is a fundamental distinction upon which other descriptions can be made.

**Identifying damage caused by the 2008 Wenchuan earthquake from VHR remote sensing data**

D. Ehrlich, H.D. Guo, K. Molch, J.W. Ma & M. Pesaresi

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Abstract

The paper discusses the potential of very high resolution (VHR) satellite imagery for post-earthquake damage assessment in comparison with the role of aerial photographs. Post-disaster optical and radar satellite data are assessed for their ability to resolve collapsed buildings, destroyed transportation infrastructure, and specific land cover changes. Optical VHR imagery has shown to be effective in quantifying building stock and for assessing damage at the building level. High-resolution synthetic aperture radar (SAR) imagery requires further research to identify optimum information extraction procedures for rapid assessment of affected buildings. Based on current technical and operational capabilities increasing efforts should be devoted to the generation of spatial datasets for disaster preparedness.

**A web-based, component-oriented application for spatial modelling of habitat suitability of mosquito vectors**

P. Zeilhofer, P.S. Arraes Neto, W.Y. Maja & D.A. Vecchiato

Abstract

This paper proposes a web-enabled computational environment for the spatial modelling of habitat suitability of mosquito vectors. Under a component-based architecture and implemented using an object-oriented data model, we integrate database interfaces, Web feature services (WFS) based on the open GIS consortium (OGC) protocols, and the data-mining tool WEKA, coupled through Java servlet scripts (JSP). The prototype, based exclusively on freely available libraries and software components, provides basic dynamic spatial simulation capabilities using logistic regression to end-users engaged in local and regional health administration and planning but who lack access to specific software and/or detailed knowledge of spatial modelling techniques. The component-based approach facilitates system maintenance and future expansion of functionality, and guarantees the reusability of developed modules in new spatial modelling applications of health and environmental-related phenomena. Functionality of the WWW-application was validated in a study of habitat suitability mapping of the Malaria vector *Anopheles darlingi*, in an area surrounding the Manso River hydropower plant, Central Brazil.

**A novel confidence estimation method for neural networks in multispectral image classification**

O. Arslan
Abstract

The Digital Earth concept has attracted much attention recently and this approach uses a variety of earth observation data from the global to the local scale. Imaging techniques have made much progress technically and the methods used for automatic extraction of geo-related information are of importance in Digital Earth science. One of these methods, artificial neural networks (ANN) techniques, have been effectively used in classification of remotely sensed images. Generally image classification with ANN has been producing higher or equal mapping accuracies than parametric methods. Comparative studies have, in fact, shown that there is no discernible difference in classification accuracies between neural and conventional statistical approaches. Only well designed and trained neural networks can present a better performance than the standard statistical approaches. There are, as yet, no widely recognised standard methods to implement an optimum network. From this point of view it might be beneficial to quantify ANN's reliability in classification problems. To measure the reliability of the neural network might be a way of developing to determine suitable network structures. To date, the problem of confidence estimation of ANN has not been studied in remote sensing studies. A statistical method for quantifying the reliability of a neural network that can be used in image classification is investigated in this paper. For this purpose the method is to be based on a binomial experimentation concept to establish confidence intervals. This novel method can also be used for the selection of an appropriate network structure for the classification of multispectral imagery. Although the main focus of the research is to estimate confidence in ANN, the approach might also be applicable and relevant to Digital Earth technologies.

Modelling of urban growth boundary using geoinformatics

B. Bhatta

Abstract

Urban growth boundary (UGB) is a regulatory measure of local government for delineating limits of urban growth over a period of time. Land within the UGB allows urban development, while the land outside of this boundary remains primarily non-urban. The increasing popularity of UGB demands an easy and effective method to design this boundary. This article introduces a new concept, Ideal Urban Radial Proximity (IURP), to designate a spatial UGB using geoinformatics in the digital environment. The Kolkata urban agglomeration was considered to demonstrate this model. Remotely sensed imageries of three temporal instants (years 1975, 1990 and 2005) were considered to determine the information on urban extent and growth of the city. These data were then used as inputs to model the UGB for the years 2020 and 2035. The proposed model discourages scattered development and increase in urban growth rate. It preserves urban vegetation, water bodies and any other important non-urban areas within the inner city space. The IURP concept will also be useful to make the cities circular and polycentric urban blobs into a monocentric tract. Apart from the proposed model and derived results, this research also proves the potential of geoinformatics in modelling a UGB.

Development of GIS-based environmental information system: an Indian scenario

R. Vijay, D.R. Satapathy, B. Nimje, S. Nema, S. Dhurve & A. Gupta

Abstract
Ideally, scientists should be able to format, explore, analyse, and visualise data in a simple, powerful and fast application that would seamlessly integrate georeferenced data from a variety of data sources into an intuitive visualisation. The focus of an Environmental Information System is providing environmental information to decision makers, policy planners, scientists and engineers, research workers, etc. which ensures integration of data collection, collation, storage, retrieval and dissemination to all concerned. All such queries should be responded to supplying substantive information in the form of reports. The paper presents an innovative way to utilise the geographic information associated with the environmental data. The stand-alone application is the integration of using ArcObjects Environmental System Research Institute ArcGIS Engine 9.1 and VB.Net. The geographic information system (GIS)-based application, a framework of digital earth in terms of environmental information system provides a user-friendly query interface, which gives information about various environmental parameters in tabular as well as on map display. It also provides the visual interpretation to make further analysis and future decisions at multiple scales, locations and extents. The facility for modifying the map attributes and corresponding databases is integrated to update the information system. Output spatial data are produced in the form of reports using selected fields with display on map.

Report on the Sixth International Symposium on Digital Earth

Zhen Liu
Report on the Sixth International Symposium on Digital Earth

Zhen Liu*

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The Sixth International Symposium on Digital Earth (ISDE6) was successfully convened in Beijing, China, from 9 to 12 September 2009. ISDE6 was hosted by the International Society for Digital Earth and the Chinese Academy of Sciences (CAS), organized by the Chinese National Committee of the International Society for Digital Earth and the CAS Center for Earth Observation and Digital Earth, with co-sponsorship of 16 Chinese government departments, institutions and international organizations. More than 1000 scientists, engineers, educators, entrepreneurs, managers, administrators, and representatives of civil societies from more than 40 countries, international organizations, and NGOs attended the symposium. ISDE6 focused on the theme of ‘Digital Earth in Action.’ Some 900 abstracts and 500 full papers were submitted to the symposium, of which about 210 were presented as oral presentations at plenary and parallel sessions, and over 400 participants presented their poster papers.

ISDE6 commenced on 9th September. At the opening ceremony, Prof. Lu Yongxiang, vice chairman of the Standing Committee of the National People’s Congress, chairman of the International Society for Digital Earth, and president of the Chinese Academy of Sciences, delivered a welcoming speech. In his speech, Prof. Lu Yongxiang reviewed the development of digital earth and the ISDE over the past decade, and pointed out that thanks to the joint efforts of scholars, policy-makers, and enterprises worldwide, great achievements have been made in the field of digital earth, and international academic building in digital earth has also been constantly promoted. He proposed that in the process of building the digital earth, we must make full use of advanced earth observation technologies, new generations networking and sensing technologies, search technologies, browser technologies, and cloud computation technologies to improve the public service level, reduce service costs, bring digital earth to every corner of the earth, and make digital earth an information platform for decision-makers and a real information homeland that is jointly built and shared by all mankind. Next, Cao Jianlin, vice minister of the Ministry of Science and Technology read the letter of congratulations from Ms. Liu Yandong, the member of the Political Bureau of the CPC Central Committee and State Councilor. Representatives from international organizations such as the United Nations Educational, Scientific and Cultural Organization, the Food and Agriculture Organization of the United Nations, the Group on Earth Observations, the

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2009 Beijing Declaration on Digital Earth

We scientists, engineers, educators, entrepreneurs, managers, administrators, and representatives of civil societies from more than forty countries, international organizations and NGOs, once again, have assembled here, in the historic city of Beijing, to attend the Sixth International Symposium on Digital Earth, organized by the International Society for Digital Earth and the Chinese Academy of Sciences, with co-sponsorship of sixteen Chinese Government Departments, Institutions and international organizations, being held from September 9–12, 2009.

Noting That

Significant global-scale developments on Digital Earth science and technology have been made over the past ten years, and parallel advances in space information technology, communication network technology, high-performance computing, and Earth System Science have resulted in the rise of a Digital Earth data-sharing platform for public and commercial purposes, so that now Digital Earth is accessible by hundreds of millions, thus changing both the production and lifestyle of mankind.

Recognizing

The contributions to Digital Earth made by the host countries of the previous International Symposia on Digital Earth since November 1999, including China, Canada, the Czech Republic, Japan, and the USA, and by the host countries of the previous Summit Conferences on Digital Earth, including New Zealand and Germany, for the success of the meetings as well as further promotion of Digital Earth;

Further, that the establishment of the International Society for Digital Earth and the accomplishments of its Executive Committee, the launch of the International Journal on Digital Earth, and its global contribution to cooperation and data exchange;

That the themes of the previous seven meetings: Towards Digital Earth, Beyond Information Infrastructure, Information Resources for Global Sustainability, Digital Earth as Global Commons, Bring Digital Earth down to Earth, Digital Earth and Sustainability, Digital Earth and Global Change, and Digital Earth in Action, have laid out a panoramic scenario for the future growth of Digital Earth;
Development of time series stacks of Landsat images for reconstructing forest disturbance history


Abstract

Forest dynamics is highly relevant to a broad range of earth science studies, many of which have geographic coverage ranging from regional to global scales. While the temporally dense Landsat acquisitions available in many regions
provide a unique opportunity for understanding forest disturbance history dating back to 1972, large quantities of Landsat images will need to be analysed for studies at regional to global scales. This will not only require effective change detection algorithms, but also highly automated, high level preprocessing capabilities to produce images with subpixel geolocation accuracies and best achievable radiometric consistency, a status called imagery-ready-to-use (IRU). This paper describes a streamlined approach for producing IRU quality Landsat time series stacks (LTSS). This approach consists of an image selection protocol, high level preprocessing algorithms and IRU quality verification procedures. The high level preprocessing algorithms include updated radiometric calibration and atmospheric correction for calculating surface reflectance and precision registration and orthorectification routines for improving geolocation accuracy. These automated routines have been implemented in the Landsat Ecosystem Disturbance Adaptive System (LEDAPS) designed for processing large quantities of Landsat images. Some characteristics of the LTSS developed using this approach are discussed.

The improvement of an object-oriented classification using multi-temporal MODIS EVI satellite data

Y. Gao, J.-F. Mas & A. Navarrete

Abstract

This paper investigates the contribution of multi-temporal enhanced vegetation index (EVI) data to the improvement of object-based classification accuracy using multi-spectral moderate resolution imaging spectral-radiometer (MODIS) imagery. In object-oriented classification, similar pixels are firstly grouped together and then classified; the produced result does not suffer the speckled appearance and closer to human vision. EVI data are from the MODIS sensor aboard Terra spacecraft. 69 EVI data (scenes) were collected during the period of three years (2001–2003) in a mountainous vegetated area. These data sets were used to study the phenology of the land cover types. Different land cover types show distinct fluctuations over time in EVI values and this information might be used to improve object-oriented land cover classification. Two experiments were carried out: one was only with single date MODIS multispectral data, and the other one including also the 69 EVI images. Eight classes were distinguished: temperate forest, tropical dry forest, grassland, irrigated agriculture, rain-fed agriculture, orchards, lava flows and human settlement. The two classifications were evaluated with independent verification data, and the results showed that with multi-temporal EVI data, the classification accuracy was improved 5.2%. Evaluated by McNemar's test, this improved was significant, with significance level $p=0.01$.

Comparison between radarsat-1 SAR different data modes for oil spill detection by a fractal box counting algorithm

M. Marghany, A.P. Cracknell & M. Hashim

Abstract

This work presents a modified formula for the fractal box counting dimension. The method is based on the utilisation of the probability distribution formula in the fractal box count. The purpose of this method is to use it for the discrimination of oil spill areas from the surrounding features, e.g. sea surface and look-alikes, using RADARSAT-1 SAR Wide beam mode (W1), Standard beam mode (S2) and Standard beam mode (S1) data acquisition under different wind speeds. The results show that the new formula is able to discriminate between oil spills and look-alike areas. The results also
Illustrate that the new fractal formula identifies well the deficiency of oil spills in pairs of S2 data. Further, there are no significant differences between fractal values of look-alikes, low wind zone, and current shear features in different beam modes for acquisition of RADARSAT-1 SAR data. The W1 mode data, however, show an error standard deviation of 0.002, thus performing a better discrimination of oil spills than the S1 and S2 mode data.

Buffering functions of mangroves in the 2004 tsunami

T. J. Oyana, W. Sun & P. Sirikulchayanon

Abstract

The complex nature of coastal ecosystems and their protection require a deeper understanding of land cover change and dynamics. Although a number of ecological studies have been conducted to realise this important objective, little information is available regarding the quantification of this land cover change. The role of mangroves as living barriers was under appreciated prior to the 2004 tsunami event. In this paper, we investigate the buffering functions of mangroves in the 2004 tsunami by employing the methodology developed in our companion paper. We focus more on mangrove distribution patterns in different buffer zones before and after the 2004 tsunami. The presence of mangroves before and after the event was statistically significant for the North ($\chi^2 = 154.08, p \leq 0.001$) and Upper South ($\chi^2 = 62.25, p \leq 0.001$). We observed positive linear relationships suggesting a loss of mangrove resulted into a gain of barren and sand land cover as a result of a devastating impact from the 2004 tsunami event. There are pockets of inland tsunami inundations and penetrations in the North and Upper-South in part owing to the river mouth profiles and dense mangrove trees. Although the North and Upper South Regions of the study area with large mangrove forest areas suffered slight damages, these regions put up a strong buffer against the tsunami suggesting that mangrove forests play a significant role in shoreline protection.

Fundamental aspects of access control for geospatial data

J. Lin, Y. Fang, W. Zhang & Z. Huang

Abstract

In recent years, geographical information systems have been employed in a wide variety of application domains, and as a result many research efforts are being devoted to those upcoming problems. Geospatial data security, especially access control, has attracted increased research interests within the academic community. The tendency towards sharing and interoperability of geospatial data and applications makes it common to acquire and integrate geospatial data from multiple organisations to accomplish a complex task. Meanwhile, many organisations have the requirement for securing access to possessed sensitive or proprietary geospatial data. In this heterogeneous and distributed environment, consistent access control functionality is crucial to promote controlled accessibility. As an extension of general access control mechanisms in the IT domain, the mechanism for geospatial data access control has its own requirements and characteristics of granularity and geospatial logic. In this paper, we address several fundamental aspects concerning the design and implementation of an access control system for geospatial data, including the classification, requirements, authorisation models, storage structures and management approaches for authorisation rules, matching and decision-making algorithms between authorisation rules and access requests, and its policy
enforcement mechanisms. This paper also presents a system framework for realising access control functionality for geospatial data, and explain access control procedures in detail.

**Issue 2 2009 pages 89-193**

**Multi-resolution integration of land cover for sub-pixel estimation of urban impervious surface and forest cover**

Ying Zhang & Bert Guindon

Abstract

A methodology is presented for estimating percent coverage of impervious surface (IS) and forest cover (FC) within Landsat thematic mapper (TM) pixels of urban areas. High-resolution multi-spectral images from Quickbird (QB) play a key role in the sub-pixel mapping process by providing information on the spatial distributions of ISs and FCs at 2.4 m ground sampling intervals. Thematic classifications, also derived from the Landsat imagery, have then been employed to define relationships between 30 m Landsat-derived greenness values and percent IS and FC. By also utilizing land cover/land use classification derived from Landsat and defining unique relationships for urban sub-classes (i.e. residential, commercial/industrial, open land), confusion between impervious and fallow agricultural lands has been overcome. Test results are presented for Ottawa-Gatineau, an urban area that encompasses many aspects typical of the North American urban landscape. Multiple QB scenes have been acquired for this urban centre, thereby allowing us to undertake an in-depth study of the error budgets associated with the fractional inference process.

**Geomorphological monitoring of a highly dynamic estuary using oblique aerial photographs**

I. Abou El-Magd & P.F. Hillman

Abstract

Bad weather in many countries limits the use of optical satellite imageries in spatial and temporal monitoring of the environment. In this paper, a series of low-altitude oblique aerial photos taken on daily, weekly and monthly intervals were used to monitor the geomorphological changes in the upper part of the Mersey Estuary, northwestern England. This low-altitude aerial photo methodology reveals itself to be a satisfying compromise between cost, accuracy and difficulty of implementation. It offered a large amount of information on a spatial and temporal scale aiding in the understanding of channel mobility. This was an important consideration in the sitting and installation of new bridge pier foundations. This series of oblique aerial photos was used in a dynamic model to determine the migration of the ebb channel and was effective in identifying the main route of flow. Few uncertainties were encountered and the level of accuracy achieved in resolving these uncertainties in the images was in the range from 40 cm to a maximum of 1.7 m. This was compared with historical navigation charts and showed good correlation. Further applications are required to improve the quality of the data output from these images and the development of the technique.

**On the benefits of using a high-resolution mesoscale model to improve wind field for the study of upwelling off the Indian coasts**

Kailasam Muni Krishna

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142
Abstract

Upwelling favourable winds along the Indian coasts were studied using a high-resolution (9 km grid) atmospheric mesoscale model (MM5) reanalysis from 1 to 5 June 2006, off the west coast of India and from 5 to 10 December 2005, off the east coast of India. Model winds are verified with satellite winds at two areas. Model wind hind-casts from the above periods reveal narrow bands (about 10×50 km) of strong winds to the coast and adjacent to the major coastal promontories. These bands, which are sub-grid scale in operational models, were capable of generating local upwelling greater than 10 m/s. Both the mean and spatial components of the model alongshore wind increase by a factor of 3 to 4 from the south to the north along the west coast, and by a factor of 2 to 3 from the north to the south along the east coast of India. Wind field increases will drive enhanced ocean upwelling along the west coast of India, and the new hypothesis suggests that the variations in local wind may contribute to the coastal upwelling in this region.

GIS- and RS-based spatial decision support: structure of a spatial environmental information system (SEIS)

G. Bareth

Abstract

The development of spatial decision support for environmental resource management, e.g. forest and agroecosystem management, biodiversity conservation, or hydrological planning, started in the 1980s and was the focus of many research groups in the 1990s. The combined availability of spatial data and communication, computing, positioning, geographic information system (GIS)- and remote sensing (RS)-technologies has been responsible for the implementation of complex SDSS since the late 1990s. The regional GIS-based modelling of environmental resources, and therefore ecosystems in general, requires setting-up an extensive geo and model database. Spatial data on topography, soil, climate, land use, hydrology, flora, fauna and anthropogenic activities have to be available. Therefore, GIS- and RS-technologies are of central importance for spatial data handling and analysis. In this context, the structure of spatial environmental information systems (SEIS) is introduced. In SEIS, the input data for environmental resource management are organised in at least seven sub-information systems: base geodata information system (BGDIS), climate information system (CIS), soil information system (SIS), land use information system (LUIS), hydrological information system (HIS), spatial/temporal biodiversity information system (STBIS), forest/agricultural management information system (FAMIS). The major tasks of a SEIS are to (i) provide environmental resource information on a regional level, (ii) analyse the impact of anthropogenic activities and (iii) simulate scenarios of different impacts.

A method for groundwater prospect zonation in data poor areas using remote sensing and GIS: a case study in Kalikavu Panchayath of Malappuram district, Kerala, India

B.C. Thomas, S.L. Kuriakose & S.K. Jayadev

Abstract

The present study was an attempt to delineate potential groundwater zones in Kalikavu Panchayat of Malappuram district, Kerala, India. The geo-spatial database on geomorphology, landuse, geology, slope and drainage network was generated in a geographic information system (GIS) environment from satellite data, Survey of India topographic sheets and field observations. To understand the movement and occurrence of groundwater, the geology, geomorphology,
structural set-up and recharging conditions have to be well understood. In the present study, the potential recharge areas are delineated in terms of geology, geomorphology, land use, slope, drainage pattern, etc. Various thematic data generated were integrated using a heuristic method in the GIS domain to generate maps showing potential groundwater zones. The composite output map scores were reclassified into different zones using a decision rule. The final output map shows different zones of groundwater prospect, viz., very good (15.57% of the area), good (43.74%), moderate (28.38%) and poor (12.31%). Geomorphic units such as valley plains, valley fills and alluvial terraces were identified as good to excellent prospect zones, while the gently sloping lateritic uplands were identified as good to moderate zones. Steeply sloping hilly terrains underlain by hard rocks were identified as poor groundwater prospect zones.

GIS-based optimisation of the hydrometeorological network in Greece

E.A. Baltas & M.A. Mimikou

Abstract

The operation of a network of hydrometeorological stations constitutes basic infrastructure for the management of water resources. Despite the increased need for rational water management in Greece, there is not a single network of hydrometeorological stations. Various State Services have established sectional networks of limited coverage, resulting in many disadvantages. This study aims at the optimisation of the existing network, using GIS methods. An optimum network of hydrometeorological stations is designed, which constitutes the base for the optimisation of the present network. The optimum network consists of 1379 hydrometeorological stations and is based on the guidelines of international organisations. The uniform spatial distribution of the stations and criteria concerning the selection of the appropriate site, such as the low terrain slope, easy accessibility and proximity to special interest points, were of special importance for its development. Eventually, only the 20% of the existing stations remain at their locations and are included in the optimised network. The rest of the stations should be redistributed according to the proposed sites of the optimum network.

An approach to extracting information of residential areas from Beijing-1 image based on Gabor texture segmentation

J. Gong, X. Yang, F. Su, Y. Du & D. Zhang

Abstract

According to the features of high-resolution panchromatic imagery of Beijing-1 small satellite, an approach to extracting information of residential areas is proposed in this paper based on Gabor texture segmentation. The algorithm extracts the features in different directions and different scales by building the Gabor filter, uses cluster analysis of multiple features to segment the image, and performs the fusion processing based on morphological scale space. It solves the problems in image processing resulting from low contrast between remote sensing objects and background, the blurring of image edges and high noise. It has the benefits of direction selection and frequency selection with strong self-adaptive ability. Our experiments prove the effectiveness of the approach for extracting information of residential areas from Beijing-1 high-resolution imagery.
Editorial

Huadong Guo

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The *International Journal of Digital Earth* (IJDE) was first published in 2008, and is now proudly entering its second year. This second year is as important as the first for the new journal, as it marks the continuation of the publication’s long-term publishing strategy.

Twenty-five papers were published in Volume 1 of the IJDE. Through its inter-disciplinary links across many specialties, the journal has featured papers from a wide variety of research fields, including geoinformatics, earth observation, virtual reality, geographical information systems, geospatial data infrastructure, spatial information grids, web geo-services, etc. The papers in the first Volume covered a range of topics including digital earth technologies and applications, case studies and education, digital earth applications for local issues, and impacts of global change.

As conceived, IJDE was designed to be an open international forum to exchange ideas, methodologies and research results in the fields of digital earth. The aim of IJDE is to be the first place that authors turn to submit their work, and the first publication that readers look to for new information about advanced digital earth theories and technologies.

In 2009, IJDE will continue its support and assistance to authors to publish their academic research results and attempt to bridge the gap between researchers and readers, scientists, businesses and Government organizations. As well as its regular issues, in 2009 IJDE will publish a Special Issue on the 6th International Symposium on Digital Earth which will be held in Beijing, China this year. In addition, a 2008 Supplementary Issue on the theme of “Towards Earth and Space Science Digital Infrastructures: Network, Computing and Data Services” will be published early in 2009. These are seen as an effective means to help more researchers to publish their papers and to exchange ideas in the broad fields of digital earth, especially for some timely research issues. I believe that there will be a high level of interest in the papers in these two Issues.

I am certain that 2009 will be a good start to the second decade of the development of digital earth. Over its ten-years in development, from 1999 to 2009, issues such as global change, regional development, energy shortages, resource exploitation, etc., have imposed ever-higher demands on science and technology. The rapid improvement and expansion of spatial, information and communication technologies, geo-sciences, environmental sciences, etc., have resulted in the increased development of digital earth. With the multiple efforts of Governments, technology, and business groups, it is foreseen that digital earth will continue to undergo incredible expansion over the coming decade.

At the beginning of this New Year, I would like to thank all the authors and reviewers for their contributions to IJDE Volume 1, and to thank all IJDE Editorial Board members and others who provided direct and indirect support to the IJDE. With your continued support, the IJDE will continue to progress and expand in 2009.

A digital earth prototype system: DEPS/CAS

H. Guo, X. Fan & C. Wang

Abstract

Digital Earth is an information expression of the real Earth, and is a new way of understanding the Earth in the twenty-first century. This paper introduces a Digital Earth Prototype System (DEPS) developed at the Chinese Academy of Sciences (CAS) and supported by the Knowledge Innovation Program of the Chinese Academy of Sciences. Discussions are made to the theoretical model and technical framework of the Digital Earth, and its related key technologies on spatial information processing, spatial data warehouse technology, virtual reality technology, high-
performance and parallel computing. The DEPS consists of seven sub-systems including the spatial data, metadata, model database, Grid geoscience computing, spatial information database, maps service and virtual reality. Meanwhile, we developed a series of application systems such as the environment monitoring for the Olympic Games 2008 in Beijing, natural disasters evaluation, digital city, digital archeology, Asia regional aerosol and climate change. The DEPS/CAS displayed the application ability and potential of the Digital Earth in three levels: the global, national and regional.

The Sensor Web: systems of sensor systems
T. L. van Zyl, I. Simonis & G. McFerren

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Abstract
Global Earth Observing System of Systems (GEOSS) presents a great challenge of System of Systems integration across organisational and political boundaries. One existing paradigm that can address the scale of the challenge is that of the Sensor Web. In this paradigm, the internet is evolving into an active, macro sensing instrument, capable of drawing sensory data from around the globe to the fingertips of individuals. The Sensor Web will support scientific research and facilitate transparent political decision making. This article presents some of the technologies explored and activities engaged in by the GEOSS Sensor Web community, towards achieving GEOSS goals.

Measuring magnetic declination with a compass, virtual globes and a global positioning system
William P. O'Brien Jr

Abstract
Earth's magnetic declination was experimentally measured at 15 sites in western USA from Alaska to Texas; each site exhibited a large linear feature identifiable in virtual globe imagery (NASA's World Wind or Google Earth). The difference between the geographic bearing of the linear feature measured directly on a virtual globe image and the magnetic bearing of the same linear feature measured on the ground with a compass defines the magnetic declination $\delta$ for that site. For all 15 sites, $\delta$ values, determined by this differencing procedure, ranged from about 20° to 5° E and fell within 1° (over half within 0.5°) of expected values. Global positioning system (GPS) data recorded at most sites and plotted on virtual globe images aided in the identification of relevant features. This straightforward method for determining magnetic declination using virtual globe software and a compass provides a contemporary geospatial field/laboratory activity that dramatically elucidates and contrasts features of magnetic and geographic coordinate systems for students in various disciplines involving geomagnetism, navigation, geography or spherical polar geometry.

Gaia Journeys: a museum-based immersive performance exploration of the Earth
K.C. Yu, K. Williams, D. Neafus, L. Gaston & G. Downing

Abstract
Gaia Journeys is a collaborative multimedia musical and virtual reality art performance conceived by author Williams, with the aid of staff at the Denver Museum of Nature & Science. Inspired by astronauts who spoke of seeing a border-
less world from orbit, *Gaia Journeys*’ chief goal was to deliver this experience to museum audiences via photo-realistic virtual depictions of the Earth (from orbit as well as via spherical photographic panoramas taken from the ground) choreographed to live musical accompaniment. *Gaia Journeys* took place in the high resolution digital ‘fulldome’ Gates Planetarium, with Williams playing the violin and keyboards, enhancing a previously recorded backing track, while visuals were generated with SCISS AB’s Uniview. The eight tracks of audio were three-dimensionally spatialised to the 16.4 sound system of the Gates Planetarium, providing an immersive sound experience to match the visuals. The audience feedback was generally positive, with great interest in repeat or similar future programming. These visitor evaluations suggest the potent power of the new class of digital planetaria for displaying virtual globe datasets to the public, via both multimedia entertainment like *Gaia Journeys* as well as traditional lectures.

**Arithmetic and Fourier transform for the PYXIS multi-resolution digital Earth model**

*A. Vince & X. Zheng*

**Abstract**

This paper investigates a multi-resolution digital Earth model called PYXIS, which was developed by PYXIS Innovation Inc. The PYXIS hexagonal grids employ an efficient hierarchical labeling scheme for addressing pixels. We provide a recursive definition of the PYXIS grids, a systematic approach to the labeling, an algorithm to add PYXIS labels, and a discussion of the discrete Fourier transform on PYXIS grids.

**Pinpointing the sources and measuring the lengths of the principal rivers of the world**

*S. Liu, P. Lu, D. Liu, P. Jin & W. Wang*

**Abstract**

Cultures throughout the world are associating with the rivers. People depend upon the rivers and their tributaries for food, water, transport, and many other aspects of their daily lives. Unfortunately, human beings have not calculated the accurate lengths for the great rivers even today. The lengths of the rivers are very different in popular textbooks, magazines, atlases and encyclopedias, etc. To accurately determine the lengths of the principal rivers of the world, the combination of satellite image analysis and field investigations to the source regions is proposed in this paper. The lengths of the Nile, Amazon, Yangtze, Mississippi, Yellow, Ob, Yenisey, Amur, Congo and Mekong, with lengths over or close to 5000 km, were calculated using the proposed method. The results may represent the most reliable and accurate lengths of the principal rivers of the world that are currently achievable.

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**On generalised and specialised spatial information grids: are geo-services ready?**

*D. Li*
Abstract

After the set-up of a spatial data infrastructure (SDI) and a national information infrastructure (NII) in many countries, the provision of geo-services became one of the most important and attractive tasks. With the integration of global positioning system (GPS), geographic information system (GIS) and remote sensing (RS), we can, in principle, answer any geo-spatial related question: when and where what object has which changes? An intelligent geo-service agent could provide end-users with the most necessary information in the shortest time and at the lowest cost. Unfortunately there is still a long way to go to achieve such goals. The central component in such geo-services is the integration of the spatial information system with a computing grid via wire- and wireless communication networks. This paper will mainly discuss the grid technology and its integration with spatial information technology, expounding potential problems and possible resolutions. A novel categorising of information grids in the context of geo-spatial information is proposed: generalised and specialised spatial information grids.

The role of GIS in Digital Earth education

J.J. Kerski

Abstract

A growing number of educators worldwide have become convinced that geotechnologies – including geographic information systems (GIS), global positioning systems (GPS), and remote sensing – are key technologies to prepare students to be tomorrow's decision makers. Grappling with local, regional, and global issues of the 21st century requires people who think spatially and who can use geotechnologies. Some educators teach geotechnologies as a discipline, emphasising skills. Other educators use geotechnologies as a tool to teach content, such as geography, history, environmental studies, Earth Science, biology, mathematics, economics and other disciplines. Issues such as traffic, population growth, urban sprawl, energy, water, crime, human health, biodiversity and sustainable agriculture are growing in complexity, exist at every scale and increasingly affect people's everyday lives. Each of these issues has a spatial component. Drivers for geotechnology education include educational content standards, constructivism, the school-to-career movement, active learning, citizenship education, authentic practice and assessment, interdisciplinary education, community connections and a sustained, increasing demand for GIS professionals. Digital Earth is an ideal framework for contextualising domains of inquiry. The Digital Earth community can have a significant impact on the growth of geotechnologies in education, and conversely, the growth of geotechnologies in education and society can foster the forward movement of Earth systems concepts.

Integrating data from remote sensing, geology and gravity for geological investigation in the Tarhunah area, Northwest Libya

N.M. Saadi, E. Aboud, H. Saibi & K. Watanabe

Abstract

The present work deals with the integration of remote-sensing, surface-geology and gravity-survey data to improve the structural knowledge of the Tarhunah area, northwest Libya. Geological information and remote-sensing data provided information about the surface structure. A gravity survey was conducted to decipher the subsurface structure. The
results revealed that a basin having a width of 39 to 48 km trends NE. A two-dimensional (2-D) schematic model shows that the basin gradually deepens toward the southwest. Faults determined from a horizontal gradient, tilt derivative, and Euler deconvolution show a depth range of 2.5 to 7.5 km. The integration and interpretation of the results indicate that volcanic activity was related to the tectonic activity of an anticlinal structure called the Jabal Uplift.

Web service for biodiversity estimation using remote sensing data

Mikhail A. Popov, Nataliia N. Kussul, Sergey A. Stankevich, Anna A. Kozlova, Andrii Yu. Shelestov, Oleksii M. Kravchenko, Mykhailo B. Korbakov & Serhiy V. Skakun

Abstract

This paper presents a technique for the assessment and mapping of land biodiversity by using remote sensing data. The proposed approach uses a fuzzy model that encapsulates different ecological factors influencing biodiversity. We implemented our approach as a web service for the Pre-Black Sea region of the Ukraine.
Acknowledgements

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Issue 3 2008 pages 247-314

Geospatial data infrastructure for sustainable development in sub-Saharan countries

A. Ayanlade, I.O.O. Orimoogunje & P.B. Borisade

Abstract

People are now using geoinformation for many different purposes and consequently one can confidently say that the need for geospatial data infrastructure (GDI) cannot be overstated in sub-Saharan Africa. Geospatial information (GI) is essential to socio-economic planning and development of sub-Sahara African countries. This paper therefore examines: GI during the last centuries in sub-Sahara Africa; recent paradigms in GDI in sub-Sahara Africa; the benefit of GDI to the African economy and the future of GDI in sub-Sahara Africa. This study discovered that most countries in sub-Saharan
Africa did not have timely access to accurate geospatial data throughout the last centuries. This significantly hindered meaningful social and economic development. Development of GDI nonetheless, will enhance search and retrieval of geospatial data in Africa. This is one of the benefits that can be derived from implementing GDI in sub-Saharan Africa. Therefore, it is necessary to review cadastral survey laws and regulations so as to incorporate the use of recent geospatial equipment.

**Distributed geospatial information processing: sharing distributed geospatial resources to support Digital Earth**

Chaowei Yang, Wenwen Li, Jibo Xie & Bin Zhou

**Abstract**

This paper introduces a new concept, distributed geospatial information processing (DGIP), which refers to the process of geospatial information residing on computers geographically dispersed and connected through computer networks, and the contribution of DGIP to Digital Earth (DE). The DGIP plays a critical role in integrating the widely distributed geospatial resources to support the DE envisioned to utilise a wide variety of information. This paper addresses this role from three different aspects: 1) sharing Earth data, information, and services through geospatial interoperability supported by standardisation of contents and interfaces; 2) sharing computing and software resources through a GeoCyberinfrastructure supported by DGIP middleware; and 3) sharing knowledge within and across domains through ontology and semantic searches. Observing the long-term process for the research and development of an operational DE, we discuss and expect some practical contributions of the DGIP to the DE.

**Atlas information systems and geographical names information systems as contributants to spatial data infrastructure**

V. S. Tikunov, F. Ormeling & M. Konecny

**Abstract**

National and international programs dealing with spatial data infrastructures (SDI) made it possible to compile a uniform digital base and a universal toolkit for the integrated description of territories on global to national scales. Atlas information systems (AIS) are considered to be an integrating tool for diverse information resources (modelling, visualisation and analysis), as well as for the elaboration of various scenarios and the possible development of alternatives for such complex systems as those of nature-society-economy. As there is an increased use of digital maps at spatial data infrastructures all aspects related to geographical names are of particular importance in this application of AIS to SDI. It is important to realise a toponymic project, dealing with place-names and their variants depending on the language and time period when a specific place-name was used. The layer of geographical names is considered to be one of the three most important data components of AIS.

**Flood prediction and assessment of vulnerability risk in the southern coasts of the Caspian Sea**

S. Shataee & J. Malek

**Abstract**
The southern part of the Caspian Sea shoreline in Iran with a length of 813 km has different topographic conditions. Owing to sea fluctuation, these zones have various dimensions in different times. During the last years, the Caspian Sea experienced enormous destructive rises. The historical information and tidal gauge measurements showed different ranges of sea rise from −30 m to −22 m from the mean sea level. On the other hand, the probable flooding zone is related to slope gradient of coasts. To help the determination of the probable flooding area owing to sea level rises, the coastal zones can be modelled using geographic information system (GIS) environment as vulnerability risk rates. These rates would be useful for making decisions in coastal management programs. This study examined different scenarios of sea rise to determine hazard-flooding rates in the coastal cities of the Mazandaran province and classified them based on vulnerability risk rates. The 1:2000 scale topographic maps of the coastal zones were prepared to extract topographic information and construct the coastal digital elevation model. With the presumption of half-metre sea rise scenarios, the digital elevation models classified eight scenarios from −26 to −22 m. The flooding areas in each scenario computed for 11 cities respectively. The vulnerability risk rate in each rise scenario was computed by dividing the flooded area of each scenario to city area. The results showed that in the first four scenarios, from −26 to −24 m, the Behshahr, Joibar, Neka and Babolsar cites would be more vulnerable than other cites. Moreover, for the second four scenarios from −24 to −22 m sea level rise scenario, only the coastal area of Chalous city would be vulnerable. It was also observed that the coastal region of Behshahr would be critical in total scenarios. Further studies would be necessary to complete this assessment by considering social-economic and land use information to estimate the exact hazardous and vulnerable zones.

View on Bay of Bengal upwelling area on the basis of 19-years of satellite sea surface temperature

K. Muni Krishna

Abstract

The seasonal and interannual variation of upwelling along the east coast of India between 6°N and 22°N was studied for the period 1985–2003 using NOAA–AVHRR sea surface temperature data. The seasonal migration of pronounced upwelling, which follows the seasonal shift of the winds in transition period and northeast monsoon, was confined. The temporal mean sea surface temperature images clearly show the upwelling season, as does the seasonal sea surface temperature anomaly. These dominant features of the upwelling system are also the most variable, with most of the variance being explained by the seasonal cycle. Quasi-cyclic behaviour of sea surface temperature on interannual scales has also been observed.

Earth observation using radar data: an overview of applications and challenges

C. Palmann, S. Mavromatis, M. Hernandez, J. Sequeira & B. Brisco

Abstract

The first pictures of the earth were taken from a balloon in the mid-19th century and thus started ‘earth observation’. Aerial missions in the 20th century enabled the build-up of outstanding photographic libraries and then with Landsat-1,
the first civilian satellite launched in 1972, digital images of the earth became an operational reality. The main roles of earth observation have become scientific, economic and strategic, and the role of synthetic aperture radar (SAR) is significant in this overall framework. Radar image exploitation has matured and several operational programs regularly use SAR data for input and numerous applications are being further developed. The technological development of interferometry and polarimetry has helped further develop these radar based applications. This paper highlights this role through a description of actual applications and projects, and concludes with a discussion of some challenges for which SAR systems may provide significant assistance.

Integrating modelling and remote sensing to identify ecosystem performance anomalies in the boreal forest, Yukon River Basin, Alaska

B.K. Wylie, L. Zhang, N. Bliss, L. Ji, L.L. Tieszen & W.M. Jolly

Abstract

High-latitude ecosystems are exposed to more pronounced warming effects than other parts of the globe. We develop a technique to monitor ecological changes in a way that distinguishes climate influences from disturbances. In this study, we account for climatic influences on Alaskan boreal forest performance with a data-driven model. We defined ecosystem performance anomalies (EPA) using the residuals of the model and made annual maps of EPA. Most areas (88%) did not have anomalous ecosystem performance for at least 6 of 8 years between 1996 and 2004. Areas with underperforming EPA (10%) often indicate areas associated with recent fires and areas of possible insect infestation or drying soil related to permafrost degradation. Overperforming areas (2%) occurred in older fire recovery areas where increased deciduous vegetation components are expected. The EPA measure was validated with composite burn index data and Landsat vegetation indices near and within burned areas.

An improved approach for the production of satellite-based geospatial reference imagery

J.R. Gibson & S. Nedelcu

Abstract

An innovative and practical satellite image product is described that is ideal for applications in Northern Canada because of its wide area coverage and mapping-quality features. This product is generated from a new procedure developed at the Canada Centre for Remote Sensing (CCRS) for processing Landsat 7 imagery, and by extension, imagery from other Earth Observation satellites. By working with multiple satellite passes, each containing the equivalent of multiple scenes, the new procedure could dramatically reduce the turn-around time for generating georeferenced image products, and also increase their geometric and radiometric accuracy compared to those produced by the current methods. The objective of the process has been to generate satellite image mosaics covering large areas (e.g. >500 000 km\(^2\)) with uniformly distributed errors at sub-pixel resolution. The paper discusses the theoretical basis of a photogrammetric adjustment for satellite imagery and the results obtained from several tests. The process is generic, involving a sensor model, a satellite orbit model and ground control information; thus it may be easily adapted to any satellite that allows for repeat coverage with overlapping paths. By performing an adjustment to correct the satellite position and attitude data prior to the production of orthoimage products, it is possible to create a mosaic with a single resampling process which minimises both the radiometric and geometric resampling artifacts. The results from three
separate tests are presented, along with a discussion of the procedures that were followed in each case. All three tests have successfully demonstrated that sub-pixel sample size errors may be consistently obtained over large areas. A by-product process developed to support the measurement of ground control point coordinates for the satellite adjustment was the automatic matching of geographic features such as lakes and islands in vector data format. This has been a significant development in that it has eliminated manual intervention in the measurement of these features in the imagery, allowing the ground control for entire passes containing several scenes to be obtained in minutes instead of hours.

**Overview and preliminary idea for building Digital Earth with Grid computing technology**

Yong Xue, Huadong Guo, Wei Wan, Jianqin Wang & Ying Luo

Abstract

Digital Earth is an important field of information technology and a research frontier of geosciences in the 21st century. So far, the Grid computing technique is one of the best solutions for Digital Earth infrastructure. Digital Earth can only be realised through the interaction of people, heterogeneous computing resources, information systems, and instruments, all of which are geographically and organisationally dispersed. Earth observation (EO) includes information acquisition, processing and applications. Information acquisition provides a vast amount of spatial data for building the fabric resource infrastructure. Information processing means that spatial information processing middleware is used with large amounts of secure Grid computing resources for real-time processing of all kinds of spatial data. We are currently working on the development of core-middleware for EO data processing and applications for the Digital Earth Prototype System, which is available in the Institute of Remote Sensing Applications (IRSA), Chinese Academy of Sciences (CAS) The further results will be available soon.

**Issues 1 2008 pages 1-173**

**Foreword**

Human beings have only one planet Earth, but who can say one knows the Earth quite well? Since the start of civilization, people began to try to understand, adapt and modify our own planet — the Earth. While we are still learning about the planet where we live, it becomes apparent that we increasingly need more and more information relating to our daily life, including natural, human, geospatial and social strategy information. With such a massive database of the Earth—terrestrial, oceanic, air-borne and space-borne data—it becomes necessary to find an effective way to combine all this information together to encompass the globe. This is really an incredible challenge, because the information is exceedingly huge. In the meantime, it covers a wide spectrum of disciplines, including remote sensing, GIS, GPS, and computer science, virtual reality and so on. Therefore, the integration and application of geo-information is an extremely complicated scientific and technical system. No single individual, or research institute, or even a country could complete it independently.

The advent of the digital earth concept provides a new way for this. With the development of high technology we can obtain access to spatial data covering natural and human information with high social welfare and sharing strategy information resources. Modern information technology can integrate large amounts of data relevant to the natural and human information on the Earth. Then, the next important task is to effectively promote the cooperation amongst global data infrastructures and appropriately utilize these digital data sources to achieve a sustainable development in the future.

It is really worthwhile reviewing the speech that the 2007 Nobel Peace Prize winner, Al Gore, addressed in 1998: “We have an unparalleled opportunity to turn a flood of raw data into understandable information about our society and our
planet. If we are successful, it will have broad societal and commercial benefits in areas such as education, decision-making for sustainable future, land-use planning, agricultural and crisis management."

Undeniably, the IJDE will provide a mechanism for more people to share geospatial information and also will serve as a powerful vehicle for helping us to respond to global environmental challenges (both those induced by man as well as those occurring naturally).

The International Journal of Digital Earth, as the official publication of the International Society for Digital Earth, aims to provide a predominant academic forum for people to exchange ideas, to carry out research and to discuss development problems. The Journal focuses not only on the theory and technology related to research on digital earth, but also on the many applications of relevance to society. It is earnestly hoped that this journal will be a popular, influential and successful publication.

Prof. Dr-Ing. LU Yongxiang  
President of International Society for Digital Earth 
December, 2007

Editorial

Professor Guo Huadong

Over the past years, a wide spectrum of disciplines covering geoscience, space science and information science and technology have made rapid progress with great social and economic benefits. With the advances of these digital techniques and their broad applications in the very fabric of modern life and society, the demand has been raised for combining and distributing this information about these enormous and dynamic, multi-resolution and three dimension description data sets. Digital earth is the ideal way to integrate, utilize and share data and information resources, the principal part of information resources in achieving sustainable development, and the important area to develop global service. It can be expected that the raised emphasis and pursuit of global technology groups, enterprise groups and government groups on digital earth must result in the predominant development in human being's history as digital earth.

Against this background, it becomes necessary to provide an academic forum for scholars and researchers and those who are interested in digital earth's science and technology. There is an increasing need to exchange ideas, discuss research approaches and report research findings, in order to enhance the cooperation in the construction of the infrastructures of digital database of the earth, improve the sharing of the global information resources in a wider range, and better realize the application of digital techniques in various fields in the modern world to address problems appearing with the social development. To meet this demand and further serve the needs of academia, industry and policy analysts, we are pleased to announce the launch of a new global and multidisciplinary journal the International Journal of Digital Earth (IJDE).

IJDE will be published as a peer-reviewed journal, founded by the International Society for Digital Earth (ISDE), with cooperation of Taylor & Francis Group in England. Initially, it will be a quarterly periodical publication in English. The mission of this journal is to offer an academic platform for scientist and researchers to publish and exchange their interesting, challenging and innovative research findings across various disciplines related to the monitoring, measuring and forecasting of natural and human activity on the planet.

IJDE welcomes papers with respect to Digital Earth science and technology in the following areas: digital earth theory, digital earth framework, digital earth architecture and standards, digital earth and earth system, geoinformatics, geospatial science, mobile mapping system, visualization and numerical simulation, visible and microwave earth observation, data fusion and integration algorithm, data mining and artificial intelligence, data processing, and integration of remote sensing-GIS-GPS. Besides, IJDE will also focus on the application of digital earth in society, such as earth systems and global data bases, location based services, global climate change and global-to-local linkages of natural and human systems to improve human conditions, protect ecological systems and support future sustainable development for environmental, social and economic conditions. In addition to the interest in full scientific research or technological and application papers, shorter papers of academic interest, reports on conferences and reviews of books in relevant fields are also welcome.

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After a year of preparatory work, *IJDE* is now ready to launch. On this special occasion, I would like to express my sincere thanks to Professor Lu Yongxiang, President of the International Society for Digital Earth (ISDE), the Executive Committee members of ISDE, especially Professor John van Genderen, all members of the Editorial Board of *IJDE*, our publisher, Taylor & Francis Group, all authors as well as all expert reviewers who have made significant contributions to the publication of this journal. It is with their support that the editorial team has been able to put together this inaugural issue.

The *International Journal of Digital Earth* hopes to be a success in serving as an international academic forum for scholars to communicate and exchange their ideas, research approaches, results and experiences. I welcome your comments on this first issue and suggestions for future ones, as well as on any other aspect of the *IJDE*. I hope we can count on your support, which would be a strong driving force for us in our efforts to continually improve the quality and influence of the journal.

Professor Guo Huadong  
Editor-in-Chief  
December, 2007

**Evolution and implementation of the Digital Earth vision, technology and society**

T.W. Foresman

Abstract

Digital Earth's framework can be traced to evolutionary threads with historic foundations that fostered the fertile conceptual and technological incubation. These threads incorporate writings, such as those of the visionary engineering-genius, Buckminster Fuller, in conjunction with an array of space age developments in computers, internet and communications, satellites, and education. In 1998, when Vice President Al Gore articulated the Digital Earth Vision, he portrayed the vision based upon myriad technology factors for the intellectual foundation and sparked a worldwide phenomenon that fortuitously included the Chinese leadership's recognition and acceptance. The Beijing Declaration is recognised for its role promulgating the International Digital Earth Symposium series to promote better understanding of the impacts of Digital Earth technology and applications on behalf of all humankind. Combinations of industrial, academic, and government organisations have advanced the technological components necessary for implementing the Digital Earth Vision at a prodigious rate. Commercial leaders, such as Google, have accelerated the influence of large segments of society towards components of the Digital Earth Vision. However, challenges still remain regarding requisite collaboration on international standards for metadata, interoperability, and data formats for space and time that will affect Digital Earth implementation scenarios. Functional requirements for the model Digital Earth geobrowser remain to be fully articulated. The current paper presents an overview of the historical components, the key players on the international scene, the catalytic technological advances, and the societal response to the growth of the Digital Earth community.

**Geoinformatics and digital earth initiatives: a German perspective**

M. Ehlers

Abstract

This paper discusses the role of Geoinformatics as a new scientific discipline designed for handling of geospatial information. Depending on the scientific background of the people involved in shaping the emerging discipline, emphasis may be placed on different aspects of Geoinformatics. Applications and developments may address geoscientific, spatial planning, or computer science related matters. The scientific field of Geoinformatics encompasses the acquisition and storing of geospatial data, the modelling and presentation of spatial information, geoscientific analyses and spatial planning, and the development of algorithms and geospatial database systems. It is the position of the author that these tools from Geoinformatics are necessary to bridge the gap between Digital Earth models and the real world with its real-
world problems (‘connecting through location’). It is, however, crucial that Geoinformatics represents a coherent integrated approach to the acquisition, storage, analysis, modeling, presentation, and dissemination of geo-processes and not a patchwork solution of unconnected fields of activity. Geoinformatics is as such not a part of Geography, Surveying, or Computer Science, but a new self-contained scientific discipline. The current paper highlights international and national trends of the discipline and presents a number of Geoinformatics initiatives. The research and teaching activities of the newly formed Institute for Geoinformatics and Remote Sensing (IGF) at the University of Osnabrueck serve as an example for these initiatives. All these developments have lead to the long overdue formation of a scientific ‘Society for Geoinformatics’ (German: Gesellschaft für Geoinformatik – GfGI) in Germany.

The use cases of digital earth

M.F. Goodchild

Abstract
The formal process of system design begins with the identification of use cases. No such cases are readily apparent for the current generation of geobrowsers, though the text of the 1998 Gore speech refers to several. An analysis of the use cases of geographic information systems (GIS) reveals similarities with the functionality of geobrowsers, inviting the view that the two forms of geographic information technology will eventually converge. However, experience suggests that users are finding very different ways of exploiting geobrowsers, and two examples are discussed in detail. These uses can be interpreted within a broad framework of spatial concepts, and the paper concludes that this framework provides a better guide to the future of geobrowsers and Digital Earth than current GIS technology.

Digital Earth in support of global change research

C. Shupeng & J. van Genderen

Abstract
The Digital Earth concept as originally proposed by former US Vice president Al Gore is now well established and widely adopted internationally. Similarly, many researchers world-wide are studying the causes, effects and impacts of Global Change. The authors commence by describing a five-step approach to the development of Digital Earth technologies. This is followed by a detailed account of Digital Earth research and developments in China. The authors then present the research results of Global Change studies carried out in China, based on the Digital Earth approach. These research results are based on a classification of global change regions. This covers the following global change situations:

Forest and grassland fires in Northern China, temperate region desertification and dust storms, underground coal fires, deforestation and carbon sequestration, protection and utilisation of wetlands, Avian Influenza and the spread of diseases, Tibet Plateau uplift and sub-tropical monsoon climate region, and sea-level rise. The research results show that the environment does not behave in a way easily understood by the traditional disciplinary approach. Although man is clearly a contributing factor to certain Global Change aspects, such as underground coal fires, desertification, land use changes etc., many of the aspects of Global Change are naturally occurring phenomena which have been changing over centuries, and will continue to do so, no matter what actions we undertake to reverse these processes. Hence, in their conclusions, the authors propose that the communities involved in Digital Earth modelling and in Global Change research co-operate closer to overcome the limitations inherent in the current ‘conventional’ scientific approach, where scientists have very much stayed within their respective scientific boundaries. Such an integrated approach will enable us to build the next level of scientific infrastructure required to understand and predict naturally occurring environmental changes, as well as that of coupled human–environmental systems.

Virtual Australia: its key elements – know, think, communicate

Abstract

Virtual Australia is not a well-defined or agreed concept. This discussion paper conceptualises Virtual Australia as a ‘virtual [digital] model containing and representing all non-trivial objects and their contextual environment – from blue sky to bedrock – in real world Australia’. It describes a scenario for Virtual Australia, one or two decades from now, in which the locations and conditions of non-trivial objects and their environment are updated automatically through a combination of remote sensing and wireless communication technologies in support of a ‘Supranet’. It then examines the concept of the ‘Supranet’ – a pervasive information network based largely on wireless technology linking the physical world to a virtual model in real time – and develops and discusses three principal characteristics of the Supranet: the ability to have or collect specific information (know); the ability to process information (think); and the ability to communicate that information. If, in the near future, any or all non-trivial devices are to some extent able to know, think and communicate, the potential for object autonomy will be realised.

Reality-based generation of virtual environments for digital earth

A. Gruen

Abstract

Digital Earth essentially consists of 3D and moreD models and attached semantic information (attributes). Techniques for generating such models efficiently are required very urgently. Reality-based 3D modelling using images as prime data source plays an important role in this context. Images contain a wealth of information that can be advantageously used for model generation. Images are increasingly available from satellite, aerial and terrestrial platforms. This contribution briefly describes some of the problems which we encounter if the process of model generation is to be automatised. With the help of some examples from Digital Terrain Model generation, Cultural Heritage and 3D city modelling we show briefly what can be achieved. Special attention is directed towards the use of model helicopters for image data acquisition. Some problems with interactive visualisation are discussed. Also, issues surrounding R&D, professional practice and education are also addressed.

Virtual representations of antique globes – new ways of touching the untouchable

F. Hruby, A. Riedl & H. Tomberger

Abstract

The starting point of this paper is the idea that a comprehensive understanding of the earth and its systems calls for consideration of bygone views of the world. Creating facsimiles of antique globes in the form of digital globes provides a new opportunity to make such bygone world views accessible to a wide scientific audience. However, up to now, little practical experience in applying digital technology on globes has been made. Considering these attempts by thorough synopsis, this article deduces a comprehensive approach on virtual representations of antique globes that can be described by the superordinate concept of virtual representation. This concept comprises facilities of data acquisition of the original globe, ways of visualising the digitised globe and its final cartographic preparation. Applications that arise from this procedure are exemplified through both virtual hyperglobes and tactile hyperglobes. New findings on a 16th century earth globe are encouraging results of the presented virtual representation approach, which may offer a sustainable visualisation platform of interdisciplinary research.

Monitoring the source of trans-national dust storms in north east Asia

R. Tsolmon, L. Ochirkhuyag & T. Sternberg

Abstract

The vast expanse of the Gobi desert across the Mongolian plateau experiences frequent dust storms. In this isolated region remote sensing techniques can provide an effective measurement of dust storms. Brightness temperature
channels 4, 5 of AVHRR/NOAA satellite data, emissive bands of MODIS/TERRA satellite data and meteorological station measurement data were used and tested for dust and sandstorm mapping in the desert area of Mongolia and northern China. The differences between thermal bands in combination with geographic information system (GIS) layers were used for mapping in this study. The results show that dust and sand storm maps can be achieved from emissive bands for monitoring of dust and sandstorms. Most active dust storm sources can occur in truly remote areas where there is little or no human activity, although many sources are associated with areas where human impacts are well documented. Thus, on a regional scale dust mobilisation appears to be dominated by natural sources.

**Water resource applications with RADARSAT-2 – a preview**

B. Brisco, R. Touzi, J.J. van der Sanden, F. Charbonneau, T.J. Pultz & M. D'Iorio

Abstract

Fresh water is arguably the most vital resource for many aspects of a healthy and stable environment. Monitoring the extent of surface water enables resource managers to detect perturbations and long term trends in water availability, and set consumption guidelines accordingly. Potential end-users of water-related observations are numerous and reflect society as a whole. They encompass scientists and managers at all levels of government, aboriginal groups, water/power utility managers, farmers, planners, engineers, hydrologists, medical researchers, climate scientists, recreation enthusiasts, public school to post-graduate students, many special interest groups and the general public. Water data and analyses generate information products that benefit water resources planning and management, engineering design, plant operations, navigation activities, health research, water quality assessments and ecosystem management. As well, they serve as inputs for flood and drought warnings and weather and climate prediction models. Radar data in general, and RADARSAT in particular, are very good for detecting open surface water and have been used operationally for flood monitoring in many countries. Significant radar data archives now exist to analyse seasonal, annual and decadal trends, in order to attain a better understanding of the freshwater cycle. Radar data are also useful for wetland classification and soil moisture estimation. With the increasing pressure on water resources, both from a quality as well as a quantity perspective, the need will continue to increase for reliable information. RADARSAT-2 has several innovations that will enhance the ability to provide useful information about water resources. This paper provides an overview of the use of radar in general, and RADARSAT-2 in particular, for the generation of information products useful to water resource managers.

**3D visualisations in simulations of future land use: exploring the possibilities of new, standard visualisation tools**

J. Rodríguez Lloret, N. Omtzigt, E. Koomen & F.S. de Blois

Abstract

Three-dimensional (3D) visualisations are an interesting method for representing model outcomes. Most visualisation techniques require expensive software and a lot of time to create them. When the visualisations need to be adapted frequently, a faster and more flexible method is needed. The first step of the proposed model is to create the 3D elements. These elements are combined with the base map, and distributed to the public using Google Earth. Both freely available and commercial software are used in this process.

**Reclamation areas and their development studied by vegetation indices**

L. Halounová

Abstract

Large areas in the Czech Republic were used for open casts of brown coal mining. Many of them have been already closed. Reclamation of them and of their dumps is the next step in their development. It is possible to divide used reclamations into the forest, hydrologic, agricultural and other ones – roads, etc. Their age varies from 45 years to as yet...
unfinished. Reclaimed areas are documented in reclamation projects. Information about age and land use determined groups of these areas to be evaluated by vegetation indices. 100 areas with forest type were evaluated. Eight vegetation indices (NDVI, DVI, RVI, PVI, SAVI, MSAVI, TSAVI and EVI) were calculated and their average value in each area in 1988, 1992 and 1998 Thematic Mapper data were compared. Changes over years showed close relation to precipitations of previous periods. This relation was confirmed by evaluation of forest areas situated near reclamation areas. Positive/negative changes of vegetation indices were different for different groups and different vegetation indices. An overview of results of vegetation indices is presented for individual areas whose land use comprised at least partly forest stand. Results in a 4-year period (1988–1992) were in many areas by many indices negative, changes in 10 years were in most areas by most vegetation indices positive. Changes, minimum values and maximum values in groups were compared. Evaluation of vegetation indices brought again various results. One vegetation index is not sufficient to prove improvement/deterioration of vegetation changes. Precipitation state before measurement should be controlled. Temporary shortage of precipitation can cause vegetation cover deterioration, which is also only temporary. The best development derived from vegetation indices evaluation was found at forest reclamation with mixed tree stand that was 10–20 years old. The method was derived as a tool for post-finishing control of vegetation development of reclamation performed in several year periods.

BOOK REVIEW


To my knowledge, this is the first book published, which is specifically dedicated to the concept of 'Digital Earth'. Geo-information science and digital earth is a compendium of the work carried out by the author over a ten-year period, from 1993 to 2003 and is a follow-up of the author's previous book, The starting of remote sensing and GIS in China published in 1993 (also published by Science Press). Together the two books form an almost complete history and overview of developments in earth observation and geo-information science in China.

However, this book on digital earth is much more global in its perspective and not limited to Chinese applications. It consists of a Preface, five main parts, a series of appendices, and more than 50 pages of color illustrations.

The five parts are:

- Earth observation and digital earth;
- Geoinformation science and technology;
- Studies on global change;
- Applications for river deltas and coastal zones;
- Applications for urbanization and regional sustainable development.

Part 1 consists of 140 pages with 13 papers.

The author outlines his vision of digital earth and shows how the rapid advances in science and technology have allowed the digital earth concept to develop and build on the foundations of remote sensing and earth observation into a more complete integrated strategy of studying the earth. He outlines five steps in this process.

'Digitization' which involves the procedures of radiometric/geometric corrections, large data storage, and database construction to provide data query and exploitation services.
‘Informationization’ (almost as impossible a word as the title of my chair at ITC ‘operationalization’ but most people understand what is meant by the word!) In this step, the author envisions tasks, such as extracting effective information from the large data sets by statistical analysis, data mining, image and graphic information processing and analysis, as well as studying dynamic change by means of spatio-temporal modelling.

‘Knowledgeability’. (Although in general the book's English is very good, there are at times some ‘Chinglish’ words and sentence constructions in the book, which the reader needs to read twice before understanding exactly what the author is trying to say. However, the effort is worth it, as the author has enormous experience, vision and wisdom to share with the reader.) This involves applying various types of application models, extracting some objective ‘Laws’ from the data, in order to provide a scientific bases for design and measurement of the information systems.

‘Reproduction’. The fourth step involves virtual reality type modelling based on sound scientific principles and some boundary conditions, thereby allowing us to predict future trends and propose alternative scenarios.

‘Decision making’ is the fifth step in which the decision-makers can select from the multiple choices/options available, the optimum one to solve a particular local, regional, national or global problem.

The author then elaborates on this five-step approach to show how it helps to foster global economic development, advance science and technology, share information resources and aid sustainable development. In other essays in this section, the author outlines the rapid development of earth observation in China over the past thirty years.

This started in 1977 when Professor Fang Yi, President of the Chinese Academy of Sciences and Director of the National Science and Technology Commission of China, sent a delegation to Europe to study remote sensing. I was fortunate enough to meet and discuss with this delegation (of which Professor Chen Shupeng was a member) during their stay in the UK. Consequently, I paid my first visit to China in the Spring of 1978 to assist Professor Shupeng in his efforts to set up the Institute of Remote Sensing Application in Beijing, which formally started in 1980, with Professor Chen Shupeng as its first Director.

From these humble beginnings, earth observation has become a key element of China's science development, and indirectly to the rapid socio-economic development of China. From the beginning, the Chinese focused on applications and problem solving. The various essays in Part I trace this development to the stage where China now has its own sensor development, satellite launching capabilities, and an active earth observation satellite programme covering many aspects, such as operational meteorological satellites, high resolution mapping satellites as well as building a constellation of small satellites for natural disaster monitoring.

Part 2 of this book contains ten papers by the author on the role and development of GIS and other geo-information sciences in China, and how the interdisciplinary nature of geo-information technology and earth observation contribute to Digital Earth and the new economic era. On page 206, he gives a very interesting schematic to show how the geo-information flow has changed over the past three millennia, from data capture, storage and search analysis, and products, and how these have evolved through the stages of hand-drawn maps, through printed maps, image maps, digital maps to virtual maps, web-based products and services.

Part 3 of the book is particularly noteworthy as it contains eight papers on global change and how digital earth, geo-information science enable global change studies to be placed in perspective. This section includes global change studies of forests, land cover, water resources, etc.

The author’s breadth and depth of knowledge on all aspects of geography, cartography and earth observation is shown in an interesting paper entitled ‘Bridging civilizations and safeguarding the global village’.

Parts 4 and 5 provide more than 20 scientific papers on the applications of geo-information science and digital earth in the field of river delta studies (particularly on the Yangtze and Yellow rivers in China), on coastal zones, flooding, urban development (especially his paper on ‘digital city’ is very stimulating) and on sustainable regional development.
The book concludes with a mixed collection of appendices consisting of some of the author's opening keynote addresses at various international conferences.

Besides being an excellent scholar and scientist, Professor Chen Shupeng is a great human being, and with his humble character, cheerful personality, and good communication skills, he is quite rightly considered the 'Father of remote sensing, GIS, earth observation and Digital Earth in China'.

He is to be congratulated on producing this book on Geo-information Science and Digital Earth. It is to be hoped that the book will stimulate many young researchers to contribute to the rapid and exciting developments in this field, as well as encouraging more senior academics/researchers to produce more specialized, up to date books on Digital Earth.

Professor John van Genderen
Department Earth Observation Sciences, ITC

Report on the 5th International Symposium on Digital Earth

T.W. Foresman
The 5th International Symposium on Digital Earth was successfully convened at the University of California, Berkeley, USA on 5–9 June 2007. It is another successful conference since the launch of the first International Symposium on Digital Earth held in Beijing in 1999. Some 390 delegates from 28 countries representing different governments, academic agencies, industries, NGOs, and private organisations, attended. Participants focused on the conference theme ‘Bringing Digital Earth Down to Earth,’ through an impressive array of presentations and discussions that highlighted the active areas of applications using Google Earth, Microsoft's Virtual Earth, NASA's WorldWind, and many others. Examples of leading applications ranged from exposing human rights abuses in Darfur to mountain top removal for coal in the Appalachian Mountains.

The symposium started on 5 June, World Environment Day, which reinforced the strong linkage of Digital Earth to the litany of environmental problems, such as climate change, facing all nations. On behalf of Norway, the host nation for World Environment Day in 2007, Mr Jan-Gunnar Winther, Director of the Norwegian Polar Institute, gave a live online presentation on the topic of climate change impacts on Arctic nations. Next, California's Lt. Governor John Garamendi, welcomed all participants on behalf of the host state and emphasised the significant links between critical issues of water and agriculture in the face of climate change and the need for raising the topic of global climate change research. Professor Xu Guanhua, the former Minister of the Chinese Ministry of Science and Technology and the honorary president of the Chinese National Committee of International Society for Digital Earth, addressed relevant areas related to digital earth in China. Mr Tom Kalil from the Office of the vice Chancellor of the University California Berkeley delivered a warm welcome and introduced the role of universities for science applications. Dr Tim Foresman, the symposium director-general and local organiser, reviewed the development of digital earth and introduced previous symposia, the summit of Digital Earth, and the International Society for Digital Earth.

Seven special invited reports were presented at the conference on the first day. Dr Edgar Mitchell, the sixth human to walk on the Moon as the 14th Apollo astronaut, used ESRI's ArcGIS Explorer to recreate his three-dimensional (3D) lunar landing activities. Ambassador John McDonald shared his experiences with the UN environmental, economic and social affairs and testified to the potential of using the UN system to benefit human beings and the planet. Dr Doug Engelbart, inventor of the computer mouse and a trailblazer of interactive computers, presented a report titled Technology for Change, which introduced the idea that human beings can solve complicated and unexpected challenges through network cooperation and collective wisdom. The first morning was capped off by approximately 100 students from New Zealand and America in the Youth Insight Collaboratory who introduced and interviewed famous scientists focusing on the future of our planet Earth in relation to Digital Earth.

In the afternoon, Mr James H. Kunstler presented a report entitled Challenges for the Long Emergency and Dr Elisabet Sahtouris presented a report entitled Sustainable Solutions for a Hotter Planet. Both reports concentrated on the environmental and energy resources problems that challenge the Earth's social and environmental systems. Mr Michael T. Jones, Google Earth's chief technical officer, presented the report Google Earth: A Commitment to Community. He
documented the impact of Google Earth by citing their statistics for 200 million hits. Dr David Maguire, vice-president of ESRI next presented the report One Earth, Multiple Globes: Exploring the Earth with GIS, which explored the role of GIS in the virtual geographic world.

The second day of the conference focused on the relationship between the virtual earth representation and the realistic society. Dr Peter Worden, the NASA Ames Research Center director, gave a report on Global Challenges and Earth Observation to introduce NASA WorldWind products and demonstrated how to make use of earth observation data to serve the public, especially in response to global climate change. Dr Bob Corell provided a timely and interesting report on Global Changes for Climate and Environment, International Polar Year 2007–08: the Big Picture. A series of special reports was [this relates to the word 'series', not the word 'reports] provided on the application of virtual earth and special-geo information system in the research fields of North and South Polar, mangrove, Amazon Forest, Sudan Darfur human rights risk, redwood tree protection, and community activist addressing mountain top removal. Reports in the afternoon cover six subjects, including 20 reports, such as the application of geo-spatial technology in retrieving the biodiversity, the application of digital earth in education, visualisation, et cetera. Dr Vincent Tao from Microsoft presented a report on Empowering the Digital Earth Community through Virtual Earth, which emphasised the value of the application of Virtual Earth in the work of government departments.

On the third day, the application of digital earth technology for local governance issues and indigenous people's empowerment on local, national and global scales became the central theme. Former Wyoming Governor Jim Geringer introduced the latest progress in applying spatial information technology in the government management model to the living areas of indigenous people. Representatives from the Yukon River Intertribal Watershed Council, including Chief Peter Captain, Sr., spoke about the self-governance issues 65 indigenous tribes are tackling with the use of spatial technologies. In the afternoon, reports focused on the developing situation of Digital Earth in different countries, the integration of disciplines, International Polar Year, the application of Digital Earth for environmental protection and sustainable development, and human health. Along with many interesting presentations, Professor Guo Huadong introduced the Chinese Academy of Sciences' digital earth prototype system. Professor Li Deren introduced the function of Visioncruser TM system developed by Wuhan University in digital earth and Dr Gabor Remetey from Hungary introduced National Agendas for Digital Earth Progress.

On the fourth day of the symposium, effects of technology on the social development were topics of focus beginning with Dr Doug Engelbart presenting the report, Technology for Collaboration and Infrastructure. Mr John Graham next introduced the application of super computers in visualisation followed by Dr Tetsuya Sato, director of the Japanese Earth Simulator who talked about the challenging applications for the world's super computers. Dr Greg Withee, of NOAA emphasised the role of Earth observation systems in the construction of digital earth in his report on Global Earth Observation System of Systems: Critical Content for a Digital Earth.

Virtual Globes for Science and Technology was the afternoon focus with several leading experts, including Bill Gail (Microsoft Virtual Earth), Chuck Stein (Geofusion), David Maguire (ESRI), Ron Ledany (Skyline Software), Pat Hogan (NASA), and Brian McClendon (Google Earth). A comprehensive perspective of the maturity and range of applications from the Digital Earth geobrowsers was provided from these organisations.

On the fifth and final day, Mr Mike Liehold from the Institute for the Future gave the report Digital Earth Exchange as a Digital Commons. He proposed that a better understanding of the combination of technology and human cogitative behaviour is necessary for more effective development of the Digital Earth. One consistent theme throughout the 5th ISDE was the discussion on best methods to spread Digital Earth knowledge around the world to benefit society and the Earth's life-support systems. The Youth Insight Collaboratory was able to provide a grand finale with their group presence and express their understanding of the Digital Earth vision and the future.

The 5th ISDE initiated the first International Digital Earth 3D Visualization Challenge with the six Grand Challenge Winners for ‘Servir-VIZ’, ‘Grifino’, ‘The 3D Commenting Tool’, ‘Idiom Media watch on climate Change’, ‘UNEP Atlas of our Changing Environment’ and ‘Tomorrow Calling.’ Winners from America, Australia, Denmark, and Britain were awarded certificates at the awards ceremony held on 7 June. Dr Roger F. Tomlinson, the founder of GIS, was awarded a Lifelong Achievement Award. Two other Lifetime Achievement awards were presented to Ms Bonnie DeVcaro and Ms Joyce Lynn Foresman for their service to the Digital Earth community over the past decades.

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Symposium corporate sponsors included Google Earth, ESRI, the International Center for Remote Sensing Education, NASA, NOAA, Geofusion, Microsoft, SPOT Image, Imaging Notes, Bioneers, The Buckminster Fuller Institute, and Taylor & Francis. The combination of corporations and user communities provided support for active discussions on market trends and capacity in Digital Earth technologies. The symposium provided opportunities for participants to engage in dialogue at the many social events giving all participants a memorable experience.

Digital Earth Summit on Geoinformatics: Tools for Global Change Research

About Digital Earth

Digital Earth is a visionary concept popularized by Nobel Laureate and the former US Vice President Al Gore for the virtual and three-dimensional representation of the Earth. This Digital Earth representation is spatially referenced and interconnected with digital knowledge archives from around the planet with vast amounts of scientific, natural, and cultural information to describe and understand the Earth, its systems and human activities.

Purpose of the Digital Earth Summit 2008

The development of Digital Earth technologies and the results of Global Change research are two areas where exciting progress has happened in recent years. Geoinformatics developments are leading to global spatial infrastructures that are being used as Digital Earth models and to inquire attributes from each location on Earth. On the basis of simulations with numerical climate models and on the analysis of observational data, climate researchers have shown that human activities are likely to induce drastic climate changes within this century. Their success is emphasized by the recent Peace Nobel prize that was shared by Al Gore and the United Nations Intergovernmental Panel on Climate Change (PCC).

The International Society for Digital Earth (ISDE) and the Society for Geoinformatics (GfGI) believe that it is about time that scientists from both communities come together to discuss the advantages of a closer cooperation between Geoinformatics specialists and scientist involved in Global Change research. Although both communities are involved in Digital Earth modelling, they have so far stayed very much within their respective scientific boundaries. Consequently, the Society of Geoinformatics (GfGI), which is based in Germany, Austria, and Switzerland and the International Society for Digital Earth will bring together scientists and practitioners from both fields during the Digital Earth Summit on Geoinformatics: Tools for Global Change Research.

The summit will be organized together with the Potsdam Institute for Climate Impact Research (PIK) and the GeoResearchCenter Potsdam (GFZ). The Summit will bring together leading scientists from Geoinformatics and Global Change research and will foster the exchange of ideas, cooperation between so-far disjoint scientific fields and provide time for in-depth discussion. Invited key note speakers will cover relevant topics in Geoinformatics, Global Change research, Spatial Data Infrastructures, Digital Earth initiatives, and Earth Observation activities as well as the interaction between these fields.