GUEST EDITORIAL PREFACE

Special Issue on Analysing, Modelling and Visualizing Spatial Environmental Data (Part 1)

Beniamino Murgante, University of Basilicata, Italy

Antonino Marvuglia, Public Research Centre Henri Tudor (CRPHT), Luxembourg

Mikhail Kanevski, University of Lausanne, Switzerland

Maurizio Cellura, University of Palermo, Italy

INTRODUCTION

During the past decades the main problem of geographical analysis and environmental modeling and monitoring was the lack of data. On one hand the wide diffusion of electronic devices containing geo-referenced information, the relatively cheap deployment of sensor networks, the widespread access to remote sensed data and the overall development of database technology (with massive data storage devices) gives now access to significant amount of information for any kind of analysis (let us not think only of spatial data analysis, but also, for example, of countless and more and more complex applications nowadays carried out in the life cycle assessment field). However, this large amount of data often needs to be organized and integrated in a suitable structure which makes it possible extracting and processing the relevant information useful to support decision analysis (Murgante et al., 2009). It is also often the case that, mostly due to faults of the acquisition system, databases may have data holes and may require data validation before starting the phase of analysis.

It is thus clear that this fast evolution of the spatial and temporal information requires an equivalent availability of new analytical and processing tools flexible enough to deal with the variety of new arising challenges. These tools can be provided by integrating modern approaches with geographical information processing (such as temporal Geographical Information Systems (GIS) and Spatial Online Analytical Processing (Spatial OLAP)) and powerful modeling frameworks such as machine learning, data mining and new generation computing systems. The latter ones play a very important role both in the phase of data gathering and data processing and interpretation which starts when data is available and ready to use in a database. During recent years, this has led to the emergence of Environmental Informatics or Enviromatics (Environmental Information and Decision Support Systems). This is a novel field of Applied Informatics which is concerned with the application of computer science techniques to solve environmental problems.

It is certainly true that the multidisciplinary nature of environmental problems needs environmental informatics as a bridge and mediator between environmental sciences and modern informatics, offering novel solutions based on extracting from the collected data the information and knowledge needed for problem solving in that domain. This mediator role of Environmental Informatics is also stressed by Hilty et al. (2006), since, on the one hand, it is called to analyze real-world problems in the environmental sector field, while on the other hand, brings the problem solving potential of Information Technology (IT) to this application field.

Environmental sciences have substantially benefited from the use of IT tools in different fields, such as:

- Satellite meteorology and oceanography (e.g., classification, pattern recognition, retrieval algorithms, bathymetric surface modelling, etc.) (Krasnopolsky & Fox-Rabinovitz, 2006a; Krasnopolsky et al., 2008);
- Archaeological Analysis and Landscape Archaeology (Masini & Lasaponara, 2006; Masini et al., 2009; Danese et al., 2009);
- Geology (soil classification, sedimentation modelling, soil erosion) (Bhattacharya & Solomatine, 2006);
- Climate and weather numerical models and data assimilation systems (e.g., fast emulation of physical processes, fast forward models for data assimilation) (Krasnopolsky & Fox-Rabinovitz, 2006b);
- Geophysical data fusion and data mining (Grandjean et al., 2009);
- Ecological modelling and environmental risk assessment (predictive modelling of: freshwater fish stocks; air and water pollution; forest fires; avalanches danger; ecological time series data; habitat distribution; species' distributions, phytoplankton production, occurrence and succession; animal and macro-invertebrates abundance and micro-habitat use; nutrients flows; populations dynamics; species diversity; community composition; effects of climate changes; habitat suitability and evaluation of environmental variables, etc.) (Guisan & Zimmermann, 2000; Leathwick et al., 2006; Phillips et al., 2006; Pozdnoukhov et al., 2011; Telesca & Lasaponara, 2010; Hansen, 2011);
- Hydrologic applications (e.g., modelling rainfall–runoff relationships; flood forecasting; precipitation forecasting; hydro systems modelling) (Hong, 2008);
- Energy related applications (decision support in energy and environmental planning, smart grids, decentralized storage, etc.) (Beccali et al., 2010; Di Piazza et al., 2010; Jackson, 2010; Foresti et al., 2011; Danese et al., 2011; Murgante et al., 2011).
- Urban sprawl, Land Use Dynamics and Soil Consumption (Batty, 2005; Beekhuizen & Clarke, 2010; Clarke, 2008; Murgante & Danese, 2011)

SPECIAL ISSUE CONTRIBUTIONS

This special issue encompasses: 1) combined applications of Spatial information and Remote Sensing to environmental modelling (with an application in the field of hydrological modelling and an application in the field of landslide change detection); 2) applications of GIS for energy planning (estimation of regional biomass production potential for energy purposes); 3) an application of a gradient descent technique for the solution of the inventory problem in Life Cycle Assessment (LCA).

The paper by Alarcon and McAnally presents a methodology for estimating nutrient concentrations of total phosphorus (TP) and total nitrogen (TN) in watersheds through the use of hydrological modelling, remote sensing, and nutrient export coefficients.

The authors produced a seamless topographical mosaic using several Digital Elevation Models (DEMs) that covers the area of the Upper Tombigbee watershed, located in the northern Mississippi-Alabama region (USA). US Geological Survey (USGS) GIRAS (1986), NASA MODIS MOD12Q1 (2001-2004) land use datasets, and USGS-DEM topographical datasets were used to characterize the physiography of the watershed. Hydrological modelling of the Upper Tombigbee watershed was performed using the Hydrological Simulation Program Fortran (HSPF). Simulation results provided time-series of runoff, sediment load, and nutrient and pesticide concentrations, along with time-series of water quantity and quality, at any point in a watershed.

In the paper by Pascale et al., two statistical approaches (texture measure approach and texture spectrum approach) have been applied to texture enhancement and discrimination for seed-automated mapping morphology from aerial photographic data. The study identified the areas subject to erosion and displacement present in the investigated area (town of Montescaglioso, in southern Italy). The proposed methodology seems to land itself very well to the creation of risk maps to support local planning.

Borruso accomplished a detailed screening of the available resources for the exploitation of the energy potential from biomass originating from cattle and swine breeding in the region Friuli Venezia Giulia (Italy). The analysis of data coming from several statistical sources and the application of GIS and map algebra analyses, helped the author to come to the conclusion that the energy potential of the region, both in terms of thermal and electric energy, is quite promising, especially in terms of intra-sector consumption (the theoretical ideal potential from breeding - hypothesizing a full conversion of wastes from breeding in biogas - reaches nearly 25 % of the sector's demand).

In the paper by Messineo et al. the authors address the problem of energy generation from biomass not only from the resource estimation point of view, but also from a technical and economical perspective. The case study presented in the paper deals with the territory of region Sicily (Italy). The authors propose a technical solution consisting in a 1MW Organic Rankine Cycle (ORC) turbine coupled with a biomass-fired boiler and carry out an economical evaluation. A GIS was used to optimize the siting of the plant. The thermodynamics of the plant as a whole were also analyzed and two different scenarios (based on two different biomass mixes) were simulated for the financial evaluation of the project.

The paper by Marvuglia et al., addresses the solution of the inventory problem, occurring in the Life Cycle Assessment (LCA) domain when aiming at quantifying the environmental burdens (pollutants emissions and natural resources depletion) related to the whole life cycle (from raw material extraction, to actual production and/or assembly, to the use and disposal phases) of a product or service. The authors apply a modified version of the Orthogonal Regression technique (also known as Total Least Squares) – a linear parameter estimation technique that has been devised to compensate for data errors – to the solution of the over-determined systems of equations occurring in inventory problems involving processes delivering more than one valuable output (such as, e.g., a cogeneration process delivering at the same time electricity and heat, which are both used downstream the process). The technique, which has been successfully applied in other research areas (such as deconvolution techniques in renography, signal processing, geology, etc.), is here implemented in a new parametrized version and compared with its explicit mathematical formulation already existing in literature. The obtained results are also compared with two variants of this least squares technique: the well-known Ordinary Least Squares and the Data Least Squares.

All the papers show different applications of informatics-based tools for the analysis, processing and interpretation of environmental data, in the continuous effort to provide novel solutions to complex environmental problems. This is the direction towards which modern computer science is leaning during the last decades, with disciplines like Environmental Informatics, Ecological Informatics and Computational Sustainability, where many interesting and fascinating applications have already showed very promising results.

Beniamino Murgante,
Antonino Marvuglia,
Mikhail Kanevski,
Maurizio Cellura,
Guest Editors
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Beniamino Murgante is Assistant Professor of Spatial planning at the University of Basilicata (Southern Italy). He took his PhD in "Sciences and methods for European cities and territory" at the Department of Civil engineer of the University of Pisa and he carried out other researches in Lyon at the Laboratory for Information System Engineering directed by Robert Laurini. His main research interests are focused on the use of technologies in supporting spatial decision. He has published papers and books in the field of spatial analysis, modelling, geocomputation and planning. He has been member of scientific committees of several international conferences and he has been Chair/Co-chair of several international workshops.

*Antonino Marvuglia graduated in Environmental Engineering in 2003 and obtained his PhD in Environmental Applied Physics in 2007, both from the University of Palermo, Italy. From June 2009 to June 2010 he has been a Marie Curie Post-doc fellow at the Cork Constraint Computation Centre (4C) of University College Cork (Ireland), working on a project titled CREEDS (Constraint Reasoning Extended to Enhance Decision Support). From July 2010 he is a R&D Engineer at the Resource Centre for Environmental Technologies (CRTE) of the Public Research Centre Henri Tudor (Luxembourg). His main research interests include the implementation of supporting tools for environmental assessment and management, as well as energy and environmental planning. He is a member of the Editorial Board of "*The Open Renewable Energy Journal*".*

Mikhail Kanevski received the PhD degree in plasma physics from the Moscow State University, Moscow, Russia, in 1984, and the Doctoral theses in computer science from the Institute of Nuclear Safety, Russian Academy of Science, Moscow, in 1996. Until 2000, he was a Professor with the Moscow Physico–Technical Institute (Technical University) and the Head of laboratory with the Moscow Institute of Nuclear Safety, Russian Academy of Sciences. Between 1999 and 2002, he was an Invited Professor with the IDIAP Research Institute, Switzerland. Since 2004, he has been a Professor with the Institute of Geomatics and Analysis of Risk (IGAR), University of Lausanne, Lausanne, Switzerland. He is a Principal Investigator of several national and international grants. His research interests include geostatistics for spatio-temporal data analysis, modelling and visualization, environmental modeling, computer science, numerical simulations, socio-economic and financial time series analysis and prediction and machine learning algorithms. Remote sensing image classification, natural hazard assessments (forest fires, avalanches, and landslides), and time series predictions are the main applications considered at his laboratory.

Maurizio Cellura graduated in Civil Engineering in 1988 and obtained his PhD in Applied Physics in 1994. Today he is an Full Professor at the University of Palermo, teaching applied physics and principles of industrial ecology. His research interests encompass environmental impact assessment; solid waste management and disposal; energy and acoustic planning; Life-cycle Assessment (LCA), with particular interest in building materials and renewable energy sources; industrial ecology; and dynamic simulation of the thermal behaviour of buildings. He is the National Coordinator of the Italian network of LCA on technology assessment. From 2000 to 2004 he was a member of the Italian competent body for EMAS and Ecolabel.