

TITLE: Integrated Geomatics and Environmental Applied Research

SOME KEY POINTS FOR DISCUSSION:

- harmonization in georeferencing and mapping
- data and metadata standards and (distributed) database structuring
- use of geobrowsers (Google Earth, Microsoft Virtual Earth, Poly9 Free Earth, etc.)
- use of sensor networks and virtual observatories or HUBs
- spatio-temporal processes, identification, modeling and prediction
- multiple resolutions in scale, frequency and time
- Monte Carlo simulations and inferred predictions
- Web collaboration with interactive visualization

DRAFT:

With the new Cyber-Infrastructure and the ever increasing data collections, environmental research scientists and graduate students often have to sharpen their computational skills and familiarize themselves with distributed computing and web services. This is becoming very important in advanced geocomputations, interactive visualization and web-based collaboration [Blais and Esche, 2008; Blais, 2008]. These information processing advances and changing work environments can only be expected to continue and even accelerate in the coming years so that inter-disciplinary collaboration is becoming all the more important.

Among the many challenges in the environmental sciences, especially in Northern regions, are the harmonization in georeferencing field observations and measurements so that data and metadata be structured and stored according to national and international standards. This is very important for web-based processing, visualization and analysis in the context of regional, national and international collaboration with multi-disciplinary partners. At each one of the levels, there are warehouse services for all kinds of geoscience and related data, computational tools and reference information available over the web (see e.g. [Blais, 2008] for details). Exchanges of open-source data and computer software are becoming more and more user friendly with web-based communications.

For environmental research involving satellite imagery and other space data, interactive processing and mapping greatly facilitate collaboration and publication of results. In some contexts, virtual globes (e.g. Google Earth, Microsoft Virtual Earth and Poly9 Free Earth) are most appropriate for interactive web-based displays of results. In other contexts involving networked remote sensors, virtual observatories (e.g. the National Virtual Observatory) and HUBs are more appropriate with web-networked sensors and laboratories. With most of these computer packages, software development kits (SDKs) are available for interfacing and extending the tools for specialized environmental and other applications.

Web services which involve intercomputer communications are quite common for all kinds of services such as commercial transactions and conference services. In the environmental

sciences, they are also used in weather station and road transportation systems. Remote sensors are becoming more important in environmental research with the availability of sensor webs providing near realtime data to researchers and managers. With the new Cyber-Infrastructure providing high-bandwidth communications, advanced languages and protocols can be used to network computer clusters, plug-and-play sensors, simulations and processes into seamless contributions to management and decision support systems. Furthermore, recent advances in electronic circuit miniaturization and Micro-Electro-Mechanical Systems (MEMS) have led to the creation of small sensor nodes integrating several sensors, a Central Processing Unit (CPU), a memory and wireless transceiver [Newman, 2006]. Such networking of smart sensors has already been experimentally implemented in the Environment Canada RésEau initiative (<http://map.ns.ec.gc.ca/reseau/>) for water system networking and monitoring, the Prion project (<http://www.prioninstitute.ca>) for cattle and other animal surveillance such as for BSE, and the Road Weather Information Systems of the Intelligent Transportation System (<http://www.its-sti.gc.ca>) with meteorological and other environmental sensors.

Environmental research often involves spatio-temporal processes whose mathematical identification can be problematic. Hence environmental scientists need to know about the mathematical and statistical characteristics of different types of stochastic processes and their applications to spatio-temporal contexts. Furthermore, environmental processes often have multiple resolutions in scale, time and frequency. For instance, the identification and modeling of some process at the local scale may be different from the regional and continental scales. Similarly, seasonal identification and modeling may be quite different from annual and multiannual realizations. Also, with multispectral imagery and the like, principal components may be advantageous in identification and modeling over single frequency or channel observations or measurements.

Furthermore, the modeling of spatio-temporal processes as stochastic processes for data assimilation and predictions is often required. Under simplifying assumptions in terms of system identification, evolutionary mean-square spatial representations in terms of Karhunen-Loève principal components and multiresolution wavelets can be formulated using linear autoregressive or similar interaction schemes [Blais, 2003]. With observations or measurements available only at specific epochs, prediction information can be obtained from the interaction model while observational data enable possible refinements of those predictions. Much more research is needed for data assimilation and prediction, especially in connection with the climate change and environmental implications [Mutulu et al, 2004].

With incomplete observations and measurements, simulations may be the only avenue for studying spatio-temporal and other environmental processes. Monte Carlo simulations using pseudo-random, quasi-random and even chaotic numbers are very well known in such contexts as econometric and financial modeling. The computational efforts required for meaningful simulations can be demanding and hence, such computations are often carried out in parallel on computer clusters and computational grids. Again this is an application area for multidisciplinary collaboration in a distributed environment.

References:

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