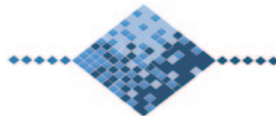




INTERNATIONAL  
SYMPOSIUM ON  
**DIGITAL**  
EARTH

OCTOBER 5-9, 2015 · HALIFAX, NOVA SCOTIA, CANADA

9th Symposium of the International Society for Digital Earth (ISDE)  
meeting jointly with



GEOMATICS ATLANTIC 2015  
*Atlantic Canada's Contribution to the Blue Planet*

# Abstract Volume

[DigitalEarth2015.ca](http://DigitalEarth2015.ca)

This volume collates the abstracts of oral and poster presentations scheduled for Digital Earth 2015 the 9th International Symposium of Digital Earth. The alpha-numerical system refers to the sequence for:

- K** Keynotes
- S** Special Sessions
- G** General Sessions
- P** Posters

This abstract volume reflects the status of presentations as of September 27, 2015. The full program of the symposium and last minute updates to it are posted at **[digitalearth2015.ca](http://digitalearth2015.ca)**.

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# K1

## Keeping the Dream Alive

Goodchild, M

Enormous progress has been made in achieving the dream of a Digital Earth, as it was initially described almost a quarter of a century ago. Standards have been adopted, making it possible for massive amounts of Earth-observation data to be shared among the research community. Other aspects of the dream remain elusive, however: the technical sophistication of Digital Earth limits its accessibility to the general public, especially children; social data remain comparatively hard to come by for many parts of the Earth; and metadata and information on provenance are often lacking. Simple questions, such as “what is at x?” or “where is z?” are not easily answered, and neither are requests of the form “find me places similar to x”. The problems of representing and visualizing data over the curved surface of the Earth are largely solved today, but a very large research agenda remains if one interprets Digital Earth as essentially an integration engine, an important component of the emerging world of Big Data.

# S1-1

## Broadening access to geospatial data, computation, and visualization

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Responding to the widespread need for geospatial capabilities in web platforms, a Purdue University team is developing geospatial support in the HUBzero Platform for Scientific Collaboration in a four-year project as part of the NSF Data Infrastructure Building Blocks (DIBBS) initiative. This addition to HUBzero, already an open source platform used in 60+ sites (hubs) of various domains with 1.8 million visitors annually, will enable researchers and educators to create and share geospatial data and modeling tools without requiring significant IT expertise. The project will leverage and augment open source software developed and validated by the science community and bring such capabilities to the masses so that any domain scientist and non-specialist can develop and deploy geospatial applications with graphical user interfaces on the web. This project will enable any user to build and publish geospatial datasets and modeling and analysis tools on a HUBzero hub, including support for vector and raster image data, as well as other files and spreadsheets. A user may invoke models or analysis from a relevant dataset. Model outputs can be published from within an online tool. The result will be a simplified workflow from contributing data, to running simulations, to publishing the result by the researchers themselves. This presentation will provide an overview of the project,

use-case examples, technical design and implementation, and demonstration of tool concepts, as well as solicit community feedback on usability and potential applications in addressing the collaborative global-scale modeling and data needs.

# S1-2

## Construction of a rapid remote sensing application system

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Massive remote sensing data sharing and large-area geoscience applications of remote sensing data have a great use of memory space, and the construction of the corresponding system involves a lot of technology, such as web technology, workflow, algorithmic scheduling, high performance computing and model matching technology. To build the corresponding application system, we need a large number of repeated computer programming, and a lot of time and manpower. This paper start from the common function of application system, and uses layered architecture, template technology, component technology, semantic technology, and cloud computing technology to build a geoscience platform. This platform has a clear architecture with a flexible and simple application interface that can quickly achieve remote sensing data sharing and publishing, rapidly deploy geo-algorithms, and flexibly customize the user interface. The ultimate goal is to quickly build different geoscience applications systems.

# S1-3

## A distributed platform for large-scale collaborative remote sensing workflows processing across data centers

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With the proliferation of data, large-scale applications are exploiting regional to global multi-temporal remote sensing (RS) data for processing. Unfortunately, data are naturally scattered across distributed data centers or organizations. As a result, the collaborative multi-stage workflow processing of these RS data across data centers at such an extreme scale and volume is quite challenging. Moreover, the multi-center environment over Ethernet is normally characterized by uncertainty and dynamism of network and resources, as well as the heterogeneity of data centers. Thus, how to ensure efficiency and dynamically choose

the optimal RS data, algorithms, and computing resources for global workflow optimization is a big problem worth exploring.

To properly address this issue, we propose a distributed platform for collaborative RS workflow processing, in which a centralized data center is adopted for global managing and monitoring of the distributed data centers. The main contribution of this multi-center platform would be a rule-based dynamic workflow resource allocation strategy. Based on both scheduling rules and a multi-objective optimization model, the optimal resources of data centers would be dynamically allocated for each Kepler workflow stage during runtime, according to the status of network, data center, and dataset parameters. In addition, the distributed system monitoring and statistics across multiple data centers would be performed by virtue of Ganglia. With this multi-center platform, the global processing task would be interpreted as a logical workflow, and mapped into a concrete Kepler workflow collaboratively implemented across data centers for overall performance optimization.

## S1-4

### **QUT cube visualisation and Big Data analytics facility: new paradigm for Digital Earth governance, trade, and commerce.**

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Member nations collectively met in 2014 for the international summit in Brisbane, Australia, where national delegations received their first digital earth experience at the Queensland University of Technology (QUT) Cube Globe visualisation facility. World leaders were engaged with the three-story high QUT Cube, which incorporates touch screen interactive big data analytic and visualisation performance using integrated world trade and commerce data. A global perspective for the Cube user interface incorporates the open-source Ceisium tessellation engine to implement a functional digital earth environment. The Cube visualisation and big data analytics capabilities were also made available to international delegations via smartphone application, as well as multiple mirrored stand-alone display presentations throughout the 2014 Brisbane venue. This real world debut has created significant interest by multiple nations and organisations seeking a similar digital-earth capacity demonstrated by QUTs Cube Globe.

QUTs Cube Global was designed, along with its surrounding building, to incorporate very large public projections on four 10-meter walls using multi-panel screens and interactive touch screen operations within a cluster server farm. The custom built facility, which initially applied a commercial tessellation and search engine, migrated to an open-source geobrowser. Success for the Cube Globe extends beyond last years international debut

to the hands-on experiences of tens of thousands of school children, citizens, and dignitaries. Discussion includes technical specifications, overview of tessellation programming, and future exploitation for utility in business, international commerce and economics, government, research, as well as education using this digital-earth facility.

## G1-1

### **Multisensor image fusion guidelines in remote sensing**

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Remote sensing delivers multimodal and -temporal data from the Earths surface. In order to cope with these multidimensional data sources and to make the most out of them, image fusion is a valuable tool. It has developed over the past few decades into a usable image processing technique for extracting information of higher quality and reliability. As more sensors and advanced image fusion techniques have become available, researchers have conducted a vast amount of successful studies using image fusion. However, the definition of an appropriate workflow prior to processing the imagery requires knowledge in all related fields - i.e. remote sensing, image fusion and the desired image exploitation processing. From the findings of this research it can be seen that the choice of the appropriate technique, as well as the fine tuning of the individual parameters of this technique, is crucial. There is still a lack of strategic guidelines due to the complexity and variability of data selection, processing techniques and applications. This paper gives an overview of the state-of-the-art in remote sensing image fusion and provides an overview of sensors and applications. It describes aspects of data selection, application requirements and issues in the choice of a suitable image fusion technique. Putting research results in image fusion from the past 15 years into a context and drawing similarities and contradictions provides a new view on the subject and helps other researchers to build their innovation on these findings.

## G1-2

### **Building change detection using multi-sensor and multi-view-angle imagery**

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Change detection of buildings in urban areas is very challenging due to the inherent geometric distortion of the Very High Resolution images which creates problems in the co-registration

step. Thus, exploiting images acquired by the different sensors and different view angles is not possible using the conventional change detection methods since establishment of an accurate global co-registration is not possible. Therefore, the majority of studies in this field avoid using multi-sensor and multi-view angle images. In this study a novel co-registration method, called patch-wise co-registration, is used to improve the mentioned problem. This method integrates the sensor model parameters into the co-registration process to relate the corresponding pixels and accordingly segments (patches). Later on, the brightness values of the matching pixels/segments are compared in order to detect changes. Here, MAD transform is used for identifying the changed segments. The proposed method provides the opportunity to utilize various images as bi-temporal sets for change detection.

## G1-3

### **Integration of a spatial-temporal-spectral blending model using satellite images**

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Due to budget and technical limitations, remote sensing sensors trade spatial resolution, swath width and spectral resolution. Consequently, no sensor can provide high spatial resolution, high temporal resolution and high spectral resolution simultaneously. However, earth observation at fine resolution is urgently needed for global change science. One possible solution is to blend the reflectance from high spatial resolution with less frequent coverage (e.g. Landsat), daily, global data (e.g. MODIS, Moderate Resolution Imaging Spectroradiometer), and high spectral resolution with low re-visit cycle (e.g. Hyperion). However, previous algorithms for blending multi-source remotely-sensed data have some shortcomings, especially for less consideration of hyperspectral information.

To overcome this shortcoming, this study has developed a SPATial-Temporal-Spectral blending model (SPATS) which can simulate surface reflectance with high spatial-temporal-spectral resolution. SPATS is based on existing models for spatial-temporal image fusion and spatial-spectral image fusion. Taking Landsat, Hyperion and MODIS data as examples, the performance of SPATS was tested with both simulated and observed satellite data, especially for heterogeneous landscapes. The results show that the high spatial-temporal-spectral resolution reflectance data can be applied to research into how global landscapes are changing at different temporal scales.

## G1-4

### **Fusing real-time geo-information for a raster-based least cost navigation in an SDI**

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We present an SDI-based navigation approach that fuses real-time information from remote sensors and smartphone measurements for navigating through dense human crowds. Optical images acquired and transmitted by a real-time airborne camera system are used to calculate an estimation of a crowd density map. In addition, movement speeds of the visitors is gathered via a smartphone app and are directly transferred to a geo-database on a webserver. Here, the point speed information is converted into rasterised density information to enhance the density estimation derived from the aerial images with more up-to-date information. The combined density information is afterwards used for a least-cost navigation performed with GRASS GIS. We utilize the native GRASS GIS support of the pyWPS to integrate our navigation approach in an SDI. Two possible scenarios are presented, namely i) an emergency application and ii) a basic navigation application. A prototypic implementation of the complete system is conducted as proof of concept and allows for presenting preliminary navigation results.

## G2-1

### **Augmenting geographic space: an exploration of methodological opportunities and new conceptual constructs**

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Societys use of spatial information in virtual spaces (internet, social networks, massively multiplayer online games, shared virtual environments) has proliferated in a way that influences and has become intertwined with real spaces, social practice, behavior and environmental perception. The power of emerging geovisual interface technologies is their ability to deliver new ways to represent, explore, and understand complex geographic phenomena. These visual interface technologies reveal new modalities of geographic representation, mediation, interaction, experience and knowledge exchange.

This paper presents examples of geovisual mixed reality interfaces developed by the Spatial Interface Research Lab and others, to examine the potential and implications of augmenting everyday space. After presenting a selection of enabling technologies and their capabilities, we will explore

selected issues raised by augmented spaces and mixed realities. How should we augment geographic spaces? How do you design augments? How to select from a multitude of reality-virtuality transducers, and tune them to geospatial information applications? Where does reality end, and where geo-virtuality begin? How do persistent virtual environments and mixed realities mediate analytical geographic realities? There is much exciting work to be done, to develop and evaluate these and other conceptual constructs for the Digital Earth community.

## G2-2

### **Streamlining geospatial metadata in the semantic web**

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In the geospatial realm, data annotation and discovery rely on a number of ad-hoc formats and protocols. These have been created to enable domain-specific use cases generalized search is not feasible for. Metadata are at the heart of the discovery process and nevertheless they are often neglected or encoded in formats that either are not aimed at efficient retrieval of resources or are plainly outdated. Particularly, the quantum leap represented by the Linked Open Data (LOD) movement did not induce so far a consistent, interlinked baseline in the geospatial domain. In a nutshell, datasets, scientific literature related to them, and ultimately the researchers behind these products are only loosely connected; the corresponding metadata intelligible only to humans, duplicated on different systems, seldom consistently.

Instead, our workflow for metadata management envisages i) editing via customizable web-based forms, ii) encoding of records in any XML application profile, iii) translation into RDF (involving the semantic lift of metadata records), and finally iv) publication as Linked Data and back-translation into the original XML format with added discovery and internationalization capabilities. Phase iii) hinges on relating resource metadata to RDF data structures that represent keywords from code lists and controlled vocabularies, toponyms, researchers, institutes, and virtually any description one can retrieve (or directly publish) in the LOD Cloud. In the context of a distributed Spatial Data Infrastructure (SDI) built on free and open-source software, we describe our workflow for the semantics-aware management of metadata related to geographic information, either traditional datasets and sensors.

## G2-3

### **A dynamic systems approach to streaming natural time series: boosting the effectiveness of data handling in the framework of Digital Earth**

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The paper presents a novel method for the evaluation of pattern variability and the reliable detection of pattern change in continuously streaming data. The method relies on a process of data property scanning using variable granularity. The analyzed time series is seen as the trace of the temporal evolution of a dynamic system to which a set of states is available, with the actual set depending on the granularity applied at each step of the analysis. The time series is thereby converted to a dynamic system state matrix reflecting the transition frequency characterizing the system (a) for different levels of granularity and (b) on a range of temporal scales.

The resulting scale-granularity-time configuration offers a system dynamics landscape that is subject to multiscale analysis, which leads to a sensitive detection of change and a comprehensive characterization of pattern variability. Application examples illustrate the effectiveness of the method, which proves capable of identifying subtle and/or intricate change even in strongly irregular patterns. These methodological strengths are coupled with an algorithm designed to drastically decrease processing time and to enhance the analysis efficiency in the case of streaming time series. The paper also explains and illustrates with real environmental data the ways in which the new method effectively supports a range of challenging data handling tasks of Digital Earth.

## G2-4

### **Symmetry in big data: a new methodology and its theoretical and practical implications for Digital Earth**

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This paper introduces a methodological approach designed to effectively address environmental records characterized by strong variability, wide diversity, and large volume and/or high data flux, which represent features of big data that take a key position in the framework of Digital Earth. The principle of this new approach consists of assessing pattern properties through the lens of coupled symmetry evaluations, and includes three modules. In each module, scale symmetry is coupled with a second form of pattern symmetry: translation, reflection, and rotation symmetry, respectively. The resulting distance from

symmetry determined with the help of the coupled symmetry evaluation is used to determine the trajectory of the studied system in phase space. A calibration process designed to divide up phase space in representative regions can then be used to effectively characterize and interpret changes in the patterns.

While application areas include a large variety of scalar fields, the temporal change in vector fields is effectively addressed as well. Examples concern datasets as different as patterns of earthquake occurrence, surface air temperature, river discharge, wind speed, and wind direction. Moreover, the paper reveals the implications of the methodology for the Digital Earth framework, from enhanced power to handle pattern diversity to stronger support provided to information integration operations.

## K2

### Digital Earth for the Next Generation

Moorman, L, Boxall, J

In the seminal paper by Goodchild et al. “Next Generation Digital Earth” (2012), excellent and essential directions for new research and development relating to the scientific rigour, accuracy of data, and computational infrastructure were made. However, to realize such advances, and ensure Digital Earth’s sustainability, means that the next generation of users must be geoliterate. The case for such literacy is being made around the world more than ever before, with varying degrees of success. Current efforts in Canada may well provide direction and models to address the situation. Our intent is a concerted focus and collaborative approach akin to the Moon Shot of the 1960s; educational, business, scientific and governmental sectors focused on a goal that reverberated around the world and captured the attention of the public, causing future generations to dream of doing more. For Digital Earth, success is dependent upon an understanding at a foundational level of how people make meaning of and use Digital Earth information, in particular those at the k-12 level. Moreover, tools and professional development for educators is essential for integration of digital earth in the classroom. These requirements are being met through research, educational initiatives, national strategies, and international collaboration, as well the formation of an umbrella organization (Canadian GeoAlliance) which provides a united voice for the geospatial sector. Outcomes of these actions are shaping the environment for both enhancing further development of Digital Earth, and preparing the next generation of users, ultimately leading the way to “Digital Earth for the Next Generation”.

## S2-1

### Aligning emerging Digital Earth capability with global challenges – a vision of the new Open Digital Earth Foundation

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A revolution in spatial technologies is occurring. Three thousand satellites are on the books to be launched over the next few years, both imaging and GPS-like satellites, which together will put precise positioning of a few centimetres accuracy into the hands of anyone with a mobile device, anywhere, anytime. At the same time our increasingly globalised world is facing growing challenges in sustainability of resource use, in inequity between nations and communities, and from changes to earth system processes, notably climate. Recognising the scale and consequences of these challenges, the worlds key global research programmes (IGBP, Diversitas, IHDP, and WCRP) have come together to form an Earth System Science Partnership.

Perhaps the most important test for the emerging Digital Earth capability over the next decade will be the extent to which it grows to be coherent and integrated, shared and accessible, and applied to assist in solutions to these growing global challenges. The new Open Digital Earth Foundation aims to build collaborative partnerships to support applications of Globe technologies for societal benefits, including in developing and Least Developed Countries. As an early step to assist understanding of how Globes can be used, the Foundation has reviewed sixteen digital earth globe platforms and their associated visualisation applications. Next steps involve building partnerships to support the application of Globe technologies for education, research, and public social good, relating to economic and risk management outcomes. As well as addressing these issues, the Foundations new Globe will be demonstrated in the presentation.

## S2-2

### A next generation Globe for supporting vulnerable communities in the South Pacific

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On 13 March cyclone Pam devastated Vanuatu with wind gusts up to 165 mph (270 mph) killing 15 people. Over 132,000 people were affected with communications, power, water supplies all severely disrupted, and widespread damage to buildings and

other critical infrastructure. Other nations including Tuvalu and the Solomon Islands were also badly affected. Within a couple of days An on-line Globe had been established showing images of pre and post damage, with a sea level rise and flooding tool based on IPCC (Intergovernmental Panel on Climate Change) estimated to permit real time estimates of the number of buildings damaged and the length of road inundated. The Globe and sea level rise tool quickly attracted over 1000 users and helped with the rescue and recovery efforts. The paper will explore the Globe, the sea level rise tool and the underpinning DEM architecture. On 13 March cyclone Pam devastated Vanuatu with wind gusts up to 165 mph (270 mph) killing 15 people. Over 132,000 people were affected with communications, power, water supplies all severely disrupted, and widespread damage to buildings and other critical infrastructure. Other nations including Tuvalu and the Solomon Islands were also badly affected. Within a couple of days An on-line Globe had been established showing images of pre and post damage, with a sea level rise and flooding tool based on IPCC estimated to permit real time estimates of the number of buildings damaged and the length of road inundated. The Globe and sea level rise tool quickly attracted over 1000 users and helped with the rescue and recovery efforts. The paper will explore the Globe, the sea level rise tool and the underpinning DEM architecture.

## S2-3

### **The Semantic Web and its relevance to advanced globe processing**

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The majority of digital globe applications currently available are built manually by identifying relevant datasets, transforming them and visualising them on a globe. There have been efforts to automate the procedure including on the fly generation of data for visualisation. In the future there will be more reliance on the automatic finding and manipulation of data and information for display. Tim Berners-Lee has proposed a solution for this called the Semantic Web that combines database and artificial intelligence aspects. This relies on various standards and protocols developed under the auspices of the World Wide Web Consortium such as XML and RDF for data representation and database querying via SPARQL and rule based methods such as Description Logics and Semantic Web Rule Languages.

This presentation will detail a number of research activities designed to enhance globe processing. These include searching for data, federating and conflating data from various sources and automating complex workflows to generate information as requested by the user. The processing from raw data to information visualisation requires the user to be able to assess the correctness of the visualisation. To this end, provenance

is required so the user can check through the data and the processing and decide if they believe the resulting visualisation. Examples in the Australian context will demonstrate why this is needed and initial results will show how these identified problems are overcome.

## G3-1

### **Sensor metadata blueprints and computer-aided editing for disciplined SensorML**

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The need for accurate and comprehensive environmental knowledge has led to an increase in sensor observation systems. The Sensor Web Enablement initiative aims at fostering interoperability among sensor systems. The provision of metadata according to the prescribed SensorML schema is a key component for achieving this and nevertheless availability of correct and exhaustive metadata cannot be taken for granted. On the one hand, it is awkward to provide sensor metadata because of the lack in user-oriented, dedicated tools. On the other, the specification of invariant information for a given sensor category or model (e.g., observed properties, manufacturer information, etc.), can be labour- and time-consuming. Moreover, the provision of these details is error prone and subjective i.e., may differ greatly across distinct descriptions for the same system.

We provide a user-friendly, template-driven metadata authoring tool composed of a backend web service and an HTML5/javascript client. This results in a form-based user interface that conceals the high complexity of the underlying format. This tool also allows for plugging in external data sources providing authoritative definitions for the aforementioned invariant information. Leveraging these functionalities, we compiled a set of SensorML prototypes, that is, sensor metadata blueprints allowing end users to focus only on the metadata items that are related to their specific deployment. The natural extension of this scenario is the involvement of end users and sensor manufacturers in the crowd-sourced evolution of this collection of prototypes. We describe the components and workflow of our framework for computer-aided management of sensor metadata.



## G3-2

### **Geovisualization and analysis of the Good Country Index**

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The Good Country Index measures the contribution of a single country in humanity and health aspects that are beneficial to the planet. Countries, which are globally good for our planet, do not necessarily have to be good for their own citizens. The Good Country Index is based on the following seven categories: science and technology, culture, international peace and security, world order, planet and climate, prosperity and equality, and health and wellbeing. The Good Country Index is focused on external effects. Contrarily, there are plenty of other global indices (for example, Human Development Index, or Social Progress Index) showing the level of development of a single country in benefiting its own citizens. The authors verify if these global indices may be good proxies as potential drivers, as well as verification of a country's goodness.

Non-spatial analysis included analyzing relationships between the overall Good Country Index, and the seven contributing categories, as well as between the overall Good Country Index, and other global indices. Data analytics were used for building various predictive models and selecting the most accurate model to predict the overall Good Country Index. The most important rules for high and low index values were identified. Spatial analysis included spatial autocorrelation to analyze similarity of index values of a country in relation to its neighbors. Hot spot analysis was used to identify and map significant clusters of countries with high and low index values. Similar countries were grouped into geographically compact clusters and mapped.

## G3-3

### **Comparison of assigning color techniques to point clouds obtained by mobile and terrestrial laser scanning**

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Nowadays laser scanning is considered as one of the most advanced data acquisition methods. Big data for various areas can be collected in a very short time. Visualization of these data serves an important purpose for faster solutions to different applied tasks. Assigning colors to point clouds obtained by laser scanning is one of the ways of visualization. The basic principle of assigning color techniques depends on a camera position.

Photographic survey can be carried out by a camera from any position or by a camera rigidly fixed to a scanner. In the first case it is necessary to specify tie points between a point cloud and each image separately. In the second case calibration parameters for camera position should be determined. Then colors can be automatically assigned to the whole point cloud using images taken from a one camera installation. The position calibration technique of a camera being a part of the mobile laser scanning system differs from that for a camera mounted on a special platform fixed above a terrestrial laser scanner. The result of assigning color to a point cloud will also differ depending on the scanning method. We compared camera position calibration methods while applying mobile and terrestrial laser scanning for some area of Novosibirsk city. Comparative accuracy was estimated for the results of assigning colors to point clouds for the same area obtained by different laser scanning methods. Advantages and disadvantages of various assigning color techniques are considered.

## G3-4

### **Assessing the evolution and application of Digital Earth technologies for Tidal Wetland Restoration in Nova Scotia**

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Tidal wetlands play a key role in our environment, particularly in the face of climate change and rising sea levels. Restoration of these habitats provides many benefits to both human and animal populations and is a field that has grown considerably in the past decade. From digital elevation models to habitat mapping, the use of digital earth technologies has played a significant role in both the design and monitoring of these projects. This paper will focus on the evolution and application of several complementary geospatial technologies as applied to a series of tidal wetland restoration projects in Nova Scotia. These technologies include low-altitude aerial photography, Lidar, and various flood modeling approaches. We will discuss how restoration methodologies have changed in response to increasingly accurate and computationally demanding technologies. Finally we will address whether this increased level of technology has improved restoration success and what future developments could hold.

## G4-1

### **Exploiting three decades of continuous satellite data with the Canada Centre for Remote Sensing Long Term Satellite Data Records**

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How can decades of satellite data help us understand our planet and manage our activities? Canada is vast and has extensive sparsely populated areas. Thus, spatially explicit and detailed long-term records of the environment do not exist for the majority of the country. To assess and address change consistently across Canada, the best available data is satellite imagery spanning decades. However, extracting systematic and meaningful information from raw satellite data requires methods to address a wide range of issues including clouds, cloud shadow, atmospheric haze, viewing geometry, and geolocal accuracy, among others.

The Canada Centre for Remote Sensing has addressed these challenges, generating the Long Term Satellite Data Records. The foundation of these records are national scale 10-day cloud free composites spanning decades. These data products and their associated methods are used by a wide range of governmental agencies, academia, and commercial groups for monitoring, reporting, decision-making, and facilitating further analysis and research.

There are currently over 1,000 composites spanning 30 years of environmental change across Canada. For the first time, these datasets are available to the public through a public data access portal. An overview will be provided on the implementation and exploitation of these datasets, including methods and development for LTSDR successor sensors, application of LTSDR methods to moderate resolution sensors, and efforts to produce comprehensive value-added datasets of national interest, such as land cover, snow cover, albedo, and vegetation indices. Examples will illustrate what these data are telling us about the state of Canada.

## G4-2

### **Monitoring the topographic and land cover change on Sable Island, Nova Scotia**

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Sable Island is a unique sand dune system approximately 50 km long and located nearly 300 km southeast of Halifax, Nova Scotia. One of the largest dune systems in Eastern Canada, Sable

Island is well known as the Graveyard of the Atlantic, the home to about 500 unmanaged horses, the largest breeding colony of Harbour Seals, and the nesting grounds of the Ipswich Sparrow. The Sable Island National Park Reserve was established in 2013 and the island has since been managed by Parks Canada. The Applied Geomatics Research Group (AGRG) has conducted three aerial mapping campaigns of the island (i.e., in 2002, 2009, and 2014), and has been working with Parks Canada to help establish ecological monitoring protocols to better understand the topographic and land cover change taking place on the island.

In August 2009 and September 2014, AGRG carried out Light Detection And Ranging (LiDAR) and aerial photography surveys of Sable Island. The resulting Digital Surface Models (DSMs) and photo-mosaics have provided an excellent opportunity to analyze the landscape change that has occurred over the five year period. September 2014 fieldwork resulted in the collection of 111 ground-truth plots being sampled across the entire island. The 2mx2m plots were positioned using RTK GPS and photographed from both the ground and an Unmanned Aerial Vehicle (UAV) to assist with the interpretation of the aerial imagery. Project results help Parks Canada fulfil their ecological integrity monitoring requirements and guide them as they prepare a management plan for one of Canadas newest national parks.

## G4-3

### **Building Virtual Geographic Environments (VGEs) for a better understanding of the planet**

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Virtual Geographic Environments (VGEs) are regarded as a new generation of geographic analysis tool. With supporting multi-channel interaction, geo-simulation, and geo-collaboration, and integrated with geographic phenomena and rules, VGEs can provide digital geographic environments to allow users to experience various spaces virtually with visual images. These spaces may be those in which they live or unfamiliar ones that they have not previously experienced. Users can thereby gain a better understanding of the simulated environments.

In this paper, we explain why and how to build VGEs, and provide some case studies. The first one is a visual moon, with which the topography and impact craters of the moon can be analyzed. The second one is a visual environment that supports simulating and analyzing air pollution and water pollution in the PRD area in China to contribute to a blue world. A summary of future work for developing better VGEs is also presented.

## G4-4

### **Assessment of winter wheat loss risk impacted by climate change from 1982 to 2011**

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The world's farmers will face increasing pressure to grow more food on less land in the next few decades, because it seems that population growth will extend several decades into the future, as will the use of agricultural products for biofuels. Therefore, the increased demand for food supply worldwide calls for improved accuracy of crop productivity estimation and assessment of grain production loss risk. Extensive studies have been launched to evaluate the impacts of climate change on crop production based on various crop models employing global or regional climate model (GCM/RCM) output. However, assessment of climate change impacts on agriculture productivity is plagued with uncertainties of the future climate change scenarios, and with the complexity of crop models. Therefore, given uncertain climate conditions and a lack of model parameters, these methods are strictly limited in application.

In this study, an empirical assessment approach for crop loss risk impacted by climate change has been used to evaluate the risk of winter wheat loss in China, United States, Germany, France, and United Kingdom from 1982 to 2011. According to the results, the study has important implications for further application of operational assessment of crop loss risk at a country or regional scale.

## G5-1

### **Latest generation remote sensing systems: real world applications**

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The pace of development in remote sensing technology is unprecedented. Improvements in spatial and spectral resolution have expanded analytical possibilities, while smaller form factor and lower power consumption enable acquisition efficiencies. The benefit of these advances are not fully realized until they can be applied to real world applications. In response to end user requests, LEG has employed diverse back-end processing expertise to provide improved decision support in sectors such as forestry, hydrography, and energy.

Hyperspectral imaging and LiDAR for detection of vegetation stress: Complementary to our existing Enhanced Forest Inventory (EFI) solution, we have assessed the improvements in quality and expansion of predictions describing forest health and composition that are possible with a wide array, hyperspectral

system. The hyperspectral sensors selected were the iTres CASI-1500h visible near Infrared (VNIR) sensor, and the iTres SASI-1000A hyperspectral SWIR imaging system.

Multi-spectral LiDAR for shallow water bathymetry: The Leica Chiroptera II system combines a 500 KHz topographic scanner, 35 KHz hydrographic scanner, and a 60 MP Leica RCD30 photogrammetric camera. The Chiroptera II is designed to penetrate up to 1.5 x Secchi depth, to map submerged vegetation and topography.

Small form factor, wide scan angle LiDAR for corridor mapping with associated meteorological data: The RIEGL VP-1 LiDAR scanning unit, mapping camera, and integrated meteorological measurement instrument are used to accurately map transmission line infrastructure in their As-Built state. This enables users to model operational scenarios such as the maximum electrical load, on the hottest day and lowest wind scenario.

## G5-2

### **CCD camera boresight calibration of a LiDAR system with virtual ground control points**

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CCD camera is an indispensable sensor of a modern airborne LiDAR system. The Positioning and Orientation System (POS) of a LiDAR system provides the position and attitude of the camera during the flight, indicating that direct georeferencing for the acquired images is possible. However, this requires strict parallel between the camera body coordinate system and the IMU body coordinate system, which is impossible despite the manufactures efforts to do so. The slight misalignments between the two coordinate systems are often termed as boresight errors and must be removed to improve the direct georeferencing accuracy. Camera boresight calibration is therefore one of the several preprocess steps to process the data a LiDAR system acquired. Conventionally, this is conducted by space resection with enough ground control points. In this paper, however, point features are extracted by Fostner point detector and are adopted as ground control points, bearing in mind that LiDAR data possess high positional accuracy in nature. Georeferencing errors caused by boresight misalignment are analyzed and the adjustment process for calibration are derived in the paper. The proposed method is double verified by the production of digital orthophoto map (DOM) from multiple images and the registration between the direct georeferencing image and LiDAR point cloud. Both results show the effectiveness of our method. The method also simplifies the flight plan over a calibration site.

## G5-3

### DigitalGlobe's Global Basemap in the context of Canada's national and regional baseline map

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DigitalGlobe's Global Basemap is an on-demand subscription-based offering that provides easy access to the geospatial industry's largest online image library. Global Basemap is able to deliver baseline context of the entire landmass of the Earth, and enables users to better understand and analyze specific geographies of interest, whether they are state-wide, country-wide, regional, or global. Using complete, high- and mid-resolution, exceptionally accurate, orthorectified imagery coverage, and providing continual updates, Global Basemap's large-area mosaics provide unmatched consistency and currency, creating the most useful imagery basemap commercially available today. The Global Basemap model offers multiple configuration options to provide users with a high degree of flexibility in meeting the requirements that best fit their project, budget, or organization.

This paper will explore how GlobalBaseMap can be used as a national and regional baseline map in Canadian context.

## G5-4

### Submeter Deimos-2 and Its Operational 24/7 Services

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Deimos-2 is a very-high resolution, agile satellite capable of providing 75-cm pan-sharpened imagery with 4 bands (G, R, B and NIR), with a swath of 12 km. Deimos-2, launched in 2014, is the second satellite owned by Elecnor Deimos (a subsidiary of the Spanish industrial group Elecnor) and it is the only European fully-private satellite capable of providing sub-metric multispectral imagery.

The end-to-end Deimos-2 system is designed and operated to provide a highly responsive service including a 24/7 service which provides near-real time image tasking, downloading, processing, and delivery to the end user. The paper also discusses the analysis of the initial operations and the resultant quality of the imagery, and provides updated information on the mission status.

MDA, Deimos Canadian distributor, is starting provision of Deimos-2 data to federal government users (through National Master Standing Offer), as well as other government and commercial users.

## S3A-1

### The Making of a Global Grid

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Quaternary Triangular Mesh (QTM) is a spherical subdivision scheme designed to encode vector geodata across a planet using recursive triangular subdivisions of an octahedron. Surprisingly, this model of location and its hierarchical coordinate system evolved from experiments with a raster data structure for encoding terrain relief, which also was hierarchical. That model was named DEPTH, for Delta Encoded Polynomial Terrain Hierarchy. This hierarchical 2D grid encoded attributes (surface elevations) explicitly and locations (grid cell indices) implicitly. QTM encodes locations explicitly and can carry metadata about them; attributes/elevations are not included. This paper describes how DEPTH evolved into QTM through an intermediary data structure called Geodesic Elevation Model (GEM), which more resembled QTM than DEPTH, but like DEPTH was designed to encode surface elevations in hierarchies of spherical triangles. DEPTH, GEM, and QTM are similar in that they all encode geospatial data hierarchically. Consequently, they can make limitations of data accuracy and scale explicit. For raster surface data, DEPTH and GEM capture elevations as ranges of values that decrease as the grid densifies. QTM, however, captures vector data by encoding 2D locations as precisely as their locational measurements (based on map scale or metadata) warrant.

The paper is also a memoir that attempts to recreate the thinking that went into these data models, and explores how properties and deficiencies in one led to the other. It does not present new scientific breakthroughs or new applications. Rather, it documents inventions that influenced subsequent development of discrete global grids.

## S3A-2

### A taxonomy of Discrete Global Grid Systems

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The Discrete Global Grid System (DGGs) is a spatial reference system that defines a multiresolution tessellation on the globe in order to partition it into a hierarchy of cells in a refinable manner. While various DGGs share this core concept, a wide spectrum

of possibilities exists when constructing a DGGs, and several of these possibilities have seen use in start-of-the-art methods for constructing a Digital Earth. They may be characterized according to the initial discretization, the shapes of the cells, the cell refinements, the projection methods, and the indexing method used to refer to these cells. We provide an overview of DGGs and present a taxonomy of them as characterized by these factors. We also discuss some of the key research areas relevant to DGGs.

## S3A-3

### The rHEALPix Discrete Global Grid System

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In this paper we extend the HEALPix Discrete Global Grid System (DGGs) to ellipsoids of revolution, thereby broadening its possible applications. Elaborating on the work of Calabretta and Roukema, we also rearrange the HEALPix map projection and build a new DGGs on top of it, which we call the rHEALPix DGGs. The rHEALPix DGGs has all the key features of the HEALPix DGGs, making it excellent for applications that require harmonix analysis. Additionally, its planar projection consists of horizontal-vertical aligned nested square grids, which are easy to understand and display. We present all the formulas and algorithms necessary for a basic implementation of the rHEALPix DGGs and link to our own open source implementation.

## S4A-1

### The GEO Global Agricultural Monitoring (GEOGLAM) initiative: overview and prospective

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Designed to enhance the use of Earth Observations for Agricultural Monitoring, the GEO-Global Agricultural Monitoring (GEOGLAM) initiative was launched in 2011. The initiative was prompted and endorsed by the Group of Twenty (G20) agriculture ministers, jointly with the Agricultural Market Information System (AMIS), in response to growing calls for improved agricultural information to help stabilize markets and better manage global food supply. GEOGLAM was built on the activities developed under the preparatory GEO Agricultural Monitoring Task, initiated in 2007.

The main objective of GEOGLAM is to reinforce the international community's capacity to produce and disseminate relevant, timely, and accurate information on agricultural conditions and production at national, regional, and global scales using

Earth Observation data. This information generation and dissemination is achieved by: enhancing national agricultural reporting systems through capacity building, integrating satellite observations with ground-based monitoring systems; establishing an international network of research organizations and practitioners that focus on agricultural research in support of operational monitoring; and harmonizing the global agricultural monitoring system through exchange of information on methods.

One of GEOGLAM's major activities is the coordination of satellite observations to meet the needs of agricultural monitoring, working closely with the Committee on Earth Observing Satellites (CEOS). Since 2013, through its Crop Monitor, GEOGLAM has also been providing AMIS with a monthly synthesis of the conditions of the world's major crops. A number of operational research and development and capacity building efforts are now underway, to enhance the use of earth observations for agricultural monitoring.

## S4A-2

### Stimulating innovation for global monitoring of agriculture and its impact on the environment in support of GEOGLAM

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In June 2011 the GEOGLAM initiative was launched by the G20, with the main objective to improve crop yield forecasts as an input to the Agricultural Market Information System (AMIS), in order to foster stabilization of markets and increase transparency on agricultural production. In response to this need, the European Commission decided in 2013 to fund an international partnership to contribute to GEOGLAM and its research agenda. The resulting SIGMA project (Stimulating Innovation for Global Monitoring of Agriculture), a partnership of 23 globally distributed expert organizations, focuses on developing innovative techniques and datasets in support of agricultural monitoring and its impact on the environment in support of GEOGLAM.

SIGMA has three generic objectives which are: (i) develop and test methods to characterize cropland and assess its changes at various scales; (ii) develop and test methods to assess changes in agricultural production levels; and; (iii) study environmental impacts of agriculture. Firstly, multi-scale remote sensing data sets, in combination with field and other ancillary data, will be used to generate an improved global agro-ecological zoning map and crop mask. Secondly, a combination of agro-meteorological models, satellite-based information, and long-term time series will be explored to better assess crop yield gaps and shifts in cultivation. The third research topic entails the development of

best practices for assessing the impact of crop land and cropping system change on the environment. This paper presents the SIGMA partnership and its research agenda, as well as the first outputs to support global agricultural monitoring.

## S4A-3

### **The Joint Experiment for Crop Assessment and Monitoring (JECAM) initiative: developing methods and best practices for global agricultural monitoring**

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The monitoring of food production and food security globally using remote sensing and digital data sets is becoming increasingly more accurate with advances in the number and quality of satellites and geospatial information at global scales. Agricultural systems differ significantly throughout the world, making a one size fits all approach to remote sensing and monitoring of agricultural landscapes problematic. The Joint Experiment for Crop Assessment and Monitoring (JECAM) was established in 2009 to bring together the global scientific community to work towards a set of best practices and recommendations for using earth observation data to map, monitor, and report on agricultural productivity globally across an array of diverse agricultural systems.

The JECAM initiative brings together researchers from a large number of globally distributed, well monitored agricultural test sites that cover a range of crop types, cropping systems, and climate regimes. Each test site works across multiple sites to test methods, sensors, and field data collection techniques to derive key agricultural parameters, including crop type, crop condition, crop yield, and soil moisture. The outcome of this project will be a set of best practices that cover the range of remote sensing monitoring and reporting needs, including satellite data acquisition, pre-processing techniques, information retrieval, and ground data validation. These outcomes provide the research and development foundation for GEOGLAM and will help to inform the development of the GEOGLAM system of systems for global agricultural monitoring. Early results from the JECAM project will be discussed.

## G6-1

### **Remote sensing for grassland monitoring – a case study in the Alberta mixed grass sub-region**

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The native grassland of the Canadian Prairies provides a variety of ecosystem services. Despite their importance these grasslands are under threat as a result of conversion to cultivated cropping systems, urban development, oil and gas development, grazing pressure, climate change and the encroachment of invasive plant species. This presentation will provide an overview of an on-going case study in the mixed grass sub-region of Alberta in which remote sensing tools are being developed to address some of these threats as well as to estimate grassland productivity levels.

Multi-temporal Landsat-5 imagery showed promise to estimate changes in native grasslands, providing a relatively accurate (overall accuracy of 95%) detection for land use change of converting native grasslands to croplands and offers the potential to update the Grassland Vegetation Inventory, the current baseline for grassland spatial extent in Alberta. A time series of MODIS data combined with climate data and a process model are being used to estimate the seasonal patterns of grassland productivity. In addition, the capacity of high spatial resolution satellite sensors to map encroachment by invasive species such as leafy spurge is being investigated in simulation studies using the AISA Airborne Imaging Spectrometer. A minimum ground cover fraction of 30% leafy spurge appears to be necessary for detection. The results of the case study will be discussed in relationship to the potential remote sensing offers in terms of monitoring aspects of native grassland status and health.

## G6-2

### **Geospatial analysis for long-term changes of net primary productivity in Inner Mongolian Desert steppe region, China**

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Net primary productivity (NPP) is a quantitative measure of the carbon absorption by plants per unit time and space. The NPP is a key indicator to evaluate the productivity of vegetation communities in the natural environment, and consistent data on terrestrial NPP are urgently needed to constrain model estimates of carbon fluxes and hence to refine our understanding of ecosystem responses to climate change. It also could be an

indicator to represents one of the land cover characteristics. This study analyzed long-term NPP changes from 1998 to 2013 in the Inner Mongolian desert steppe region, China, through estimation of annual NPP using multiyear 10-day SPOT VEGETATION NDVI data (<http://proba-v.vgt.vito.be/content/data>) and meteorological observation data from 1998 to 2013 by the modified Carnegie-Ames-Stanford Approach (CASA) model.

This study employed widely used ArcGIS and ENVI software for spatial data processing and NPP inversion, and an integrated program for the modified CASA model. We also used spatial information technologies, such as Geographic Information System, Global Navigation Satellite System and Remote Sensing technology, to determine some randomly sampled 1km<sup>2</sup> pixels and regularly selected four 1m<sup>2</sup> quadrats in each pixel, and measured field aboveground net primary productivity (ANPP) by the harvesting approach for accurate assessment of modelled NPP. The final results show that the NPP had many obvious geospatial changes during the period from 1998 to 2013 in the Inner Mongolian desert steppe region.

## G6-3

### **A study of indicative methods applied to microrelief mapping**

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Remote sensing technologies are widely used for producing Digital Elevation Models (DEMs), and geomorphometry techniques are also valuable tools for DEM analysis. One application for these technologies and techniques is relief mapping. In the simplest case, we can allocate the relief forms using DEM analysis and produce a map or map series showing the relief structure. However, the traditional techniques could fail when we map microrelief structures (forms of size up to first tens meters). In this case high microrelief dynamics leads to technological and conceptual difficulties, and moreover the erosion of microrelief forms cannot be detected from an initial evolution stage using the DEM modeling and analysis only.

We recognize the possibilities and specific techniques of microrelief erosion forms allocation and mapping. The core toolset includes analysis of soil pollutants, and spatial redistribution and phytoindication methods, in addition to DEM modeling and geomorphometric analysis. We use field surveys of the test area, which is arable territory with high erosion risks. Our main conclusion at the current stage is that the indicative methods are effective for erosion microrelief forms allocation and need to be formalized for convenient use. The study was partially supported by Russian Foundation for Basic Research (RFBR), research project No. 15-05-07463 A.

## G7-1

### **Agriculture and water pollution monitoring: integration of the Open Farm Management Information System into the Global Earth Observation System of Systems and Digital Earth**

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From a global perspective, agriculture is the single largest user of freshwater resources, each country using an average of 70% of all its surface water supplies. An essential proportion of agricultural water is recycled back to surface water and/or groundwater. Agriculture and water pollution is therefore the subject of (inter) national legislation, such as the Clean Water Act in the United States of America, the European Water Framework Directive, and the Law of the Peoples Republic of China on the Prevention and Control of Water Pollution.

Regular monitoring by means of sensor networks is needed in order to provide evidence of water pollution in agriculture. This paper depicts the benefits of, and open issues stemming from regular sensor monitoring provided by an Open Farm Management Information System. Emphasis is placed on descriptions of the processes and functionalities available to users, the underlying open data model, and definitions of open and lightweight application programming interfaces for the efficient management of collected (spatial) data. The presented Open Farm Management Information System has already been successfully registered under Phase 8 of the Global Earth Observation System of Systems (GEOSS) Architecture Implementation Pilot in order to support the wide variety of demands that are primarily aimed at agriculture and water pollution monitoring. The final part of the paper deals with the integration of the Open Farm Management Information System into the Digital Earth framework.

## G7-2

### **Spectral error assessment of airborne imaging spectroscopy data – A case study of Atihau, New Zealand**

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Imaging spectroscopy (IS) sensors have the capability to detect the radiation reflected back from an object, such as the Earth surface, in narrow and contiguous spectral bands of the electromagnetic spectrum. Error associated with data acquisition and processing of airborne IS, however, is poorly

known. The assessment of error introduced to the imagery due to instrumental errors and error created during data processing can be assessed using ground reference data acquired using a field spectroradiometer. In this study, we assessed the performance of a physically based atmospheric correction method using ATCOR-4. A visibly homogenous paddock with grazed pasture was selected where ground and aerial spectral sampling was carried out simultaneously using a FieldSpec 4 ASD and an AISAFenix sensor, respectively. A total of 75 reference sites were surveyed with an ASD, while a smaller subset of the IS image data was used to create a sequence of atmospherically corrected imagery using ATCOR4, obtained through changing the method of estimating water vapour using wavelength of 820 nm, 940 nm and 1130 nm. These images were then compared statistically with the airborne imagery using regression analysis. This study showed that there is a little (1%) difference between two atmospheric processing methods; consequently the physically based atmospheric correction approach is recommended. Based on the good fit (R-squared = 0.830.99) between ASD and airborne imagery, the AISAFenix sensor is found to be very suitable for mapping vegetation and to estimate the biochemical component of landscapes at a much higher spatial resolution than satellite imagery.

### S3B-1

#### **Rapid geospatial data integration using a Discrete Global Grid System**

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Geospatial Data Integration has long been a challenge. It is typically the most costly operation, beyond data acquisition, within the geospatial decision-making cycle. Expert analysts, using sophisticated geographic information system software, are deployed in the process of combining geospatial data sources so that decision-makers can gain insight to their pressing geospatial questions. The requirement result in an expensive, time-consuming, and controlling bottle-neck where the flow of almost all rich spatial content must pass from the originator through an intermediary before being of value to the end-user. The fruition of a digital-Earth is exemplified by the promise of a young child able to search, explore and share insights on her own. This is powerful reminder that geospatial integration on-demand is necessary and the solution must be simple and elegant.

Recent advancements in user interface and the optimization of discrete global grid systems (DGGs) have solved this grand-challenge enabling streams of geospatial content to be integrated on-demand and unassisted. DGGs are spatial references that use a hierarchical tessellation of cells to partition and address the entire globe. The trend to more open on-demand

systems where end-users gain insight by searching and pulling together their own information has been demonstrated using the WorldView DGGs in a number of Open Geospatial Consortium (OGC) and Global Earth Observation System of Systems (GEOSS) pilot projects. The authors will present use cases that exemplify societal benefits. We will also show 10 year old children delighted to use the same DGGs to explore the Earth and its systems.

### S3B-2

#### **Data transmission in discrete global grid systems**

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Discrete Global Grid Systems (DGGs) are effective reference models of the Earth for the integration, management and visualization of geospatial data in different formats and scales. To respond to the geo-analysis queries of public clients, appropriate datasets of the DGGs server must be detected, retrieved, and transmitted accurately and quickly. Since data types of DGGs are quite diverse and versatile, a robust method compatible with the underlying representation of DGGs is needed to store, retrieve, and transmit large datasets of these data types. We propose such methods for Icosahedral Snyder Equal Area Aperture 3 Hexagonal Grid (ISEA3H) DGGs employed in the PYXIS framework. Based on the data type and the received query, efficient methods are used to transmit the data in ISEA3H DGGs. For instance, a hierarchical tree structure based on PYXIS tiles is used for transmitting vector data sets. This structure enables us to retrieve vector data associated with a given area. As a result, the necessary portion of data for the client can be detected based on the specified area and transmitted through the network. In addition, for optimizing queries for datasets with multiple attributes, a compact representation of histograms is created using wavelet transforms. Using wavelets, clients queries can be handled with a reasonable estimation and can be progressively improved by transmitting additional wavelet details.



## S3B-3

### Mathematical properties of the aperture 4 hexagonal discrete grid system

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Discrete Global Grid Systems (DGGS) are spatial references that use a hierarchical tessellation of cells to partition and address the entire globe. It provides an organizational structure that permits fast integration between multiple sources of large and variable geospatial data. Compared with quadrilateral and triangular discrete grids, hexagonal one is proved the superior alternative which is the potential data structure for massive geospatial modeling, processing and simulation. Despite the advantages of the hexagon grid, there is one very important factor that has hindered its adoption in multi-resolution applications: the fact that hexagons are not self-similar. Although a few schemas, such as Generalized Balanced Ternary (GBT), PYXIS, Modified GBT (MGBT), Hexagonal Quaternary Balanced Structure (HQBS), have been implemented to describe the hierarchy of hexagonal DGGS, essential mathematical properties of the aperture 4 one is still unrevealed.

This paper simplifies the planar aperture 4 hexagonal discrete grid system into a multi-resolution lattice system model which is proved to be a radix system in the complex plane. By proving mathematical properties of the radix system, it reveals that the aperture 4 hexagonal discrete grid system is equivalent to the set of particular form complex numbers. By proving addition (subtraction) and multiplication defined on the set are all close operations, it reveals that the set with operations is the algebraic structure of ring.

## S3B-4

### Areal distortion in mappings between spherical and ellipsoidal Discrete Global Grid Systems

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The Earth has been approximated by spheres, ellipsoids, and geoids. Of these, the sphere is the least accurate, exhibiting significant deviations at the poles and the equator, with distances exceeding the height of Mount Everest. However, many Discrete Global Grid Systems make use of the sphere due to its mathematical simplicity and the number of available schemes for equal-area partitioning. In this work, we examine the areal distortions inherent in various common mappings between the

sphere and ellipsoid, in order to gauge the accuracy loss incurred by spherical representations of the Earth in comparison to ellipsoid models such as WGS 84. For this purpose, we examine small areas at various locations of interest on the sphere and analyze the areal distortions they undergo under each mapping process.

## S4B-1

### Update of CropWatch: a global crop monitoring system

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Monitoring the production of main agricultural crops is important to the global food market. Accurate and timely information on crop condition and crop production is essential to both food producers and consumers.

Taking advantage of multiple new remote sensing data sources, CropWatch has expanded the scope of its international analyses through the development of new indicators and an upgraded operational methodology in November 2013. The new monitoring approach adopts a hierarchical system covering four spatial levels of detail: global (sixty-five Monitoring and Reporting Units, MRU), seven major production zones (MPZ), thirty-one key countries (including China), and sub-countries. The system employs two types of indicators: agro-meteorological and remote sensing indicators.

Starting in 2015, more detailed information will be provided for sub-national levels crop monitoring and prospects. Twenty out of the 31 countries targeted by CropWatch will be divided into several regions according to the agro-meteorological zones and cropping patterns. A few new and upgraded indicators will be added into the monitoring system. Synthetic indicators covering the whole growing season (from sowing to monitoring time) will be introduced to better characterize the agro-meteorological and agronomic conditions. A new method to integrate the cropped arable land fraction (CALF) and the agro-meteorological risk index (AMRI) will be developed to derive global and regional crop prospects at early growing stages, which could contribute to global food security early warning.

## S4B-2

### **Asian rice crop monitoring for GEO-GLAM**

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Asian countries are responsible for approximately 90% of the world's rice production and consumption. As a result, rice is the most significant cereal crop in Asia. The Japan Aerospace Exploration Agency (JAXA) led development of a work plan for Asia rice crop monitoring within GEO global agriculture monitoring (GEO-GLAM). By using new SAR satellite fleets including Canadian Radarsat-2, European Sentinel-1, JAXA's ALOS-2 and others, the Asia rice crop team has completed phase 1 proof of concept in 100km x 100km square technical demonstration sites (about one province area in Indonesia, Thailand, Philippines and Vietnam). The outputs estimate rice crop area / production as well as provision of monthly outlook activity using agro-meteorological information. This paper presents an overview of Asia rice crop monitoring in GEO-GLAM and the status of phase 1 implementation.

## S4B-3

### **Monitoring Canada's agricultural productivity using earth observation data: operational activities at Agriculture and Agri-Food Canada**

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The agriculture sector in Canada is geographically diverse and faces numerous stresses and risks from weather and climate variability. Policy and programs to help deal with the associated risks are only as good as the information upon which they are based. Further, markets require timely authoritative information on the status of crops to reduce volatility. Consequently information on what crops are grown, where they are grown, area of different crops, estimated crop yields, and crop condition throughout the growing season is critical to the agricultural sector overall. Due to the extent and complexity of the Canadian landscape, earth observation has become an increasingly valuable tool to address these information needs. Agriculture and Agri-Food Canada implemented operational geospatial monitoring that integrates the best available science to produce data, information, and tools to support monitoring, forecasting, and ultimately proactive response and adaptation in the agriculture sector. These data sets use information from across the remote sensing spectrum, including optical, infrared, active and passive microwave. This presentation will give an overview

of the methods and data sets used for crop inventory, crop condition, phenology, climate, and tools such as yield forecasting and land cover change.

## G8-1

### **Coastal web atlases for coastal policy and decision-making: a study of four operational atlases**

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Information plays a key role in evidence-based science policies. Many pressing environmental decisions need to be made at local or regional levels, but several factors may enable or prevent decision-makers from receiving and using environmental information. For example, Nova Scotia is a coastal province with many different activities and resources occurring in its marine areas. Correspondingly, many different stakeholders are involved in generating and using marine data and information around the province. However, no single tool presently exists to amalgamate the wide variety of data and information that exists in Nova Scotia. Coastal web atlas tools have been suggested to aid with information management as well as coastal policy and decision-making.

By interviewing users and developers associated with four recently developed coastal web atlases in different jurisdictions (Maryland, Massachusetts, Scotland, and British Columbia), this research addressed the following question: are coastal web atlases proving to be a useful tool for data management as well as coastal policy and decision-making? The results from this study indicate that users and developers in these four jurisdictions find their respective atlases useful for several reasons, including: increased transparency through the open access nature of the data, increased decision-making confidence, and ability to easily access a wide variety of credible information in a single location. Interviewed users and developers noted that the following factors contribute to the success of coastal web atlases in local and regional decision-making: high quality metadata, understanding audience and user group, and iterative and incremental development.

## G8-2

### **Understanding risk of petroleum contamination to coastal habitats on the island of Newfoundland**

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The ACZISC Secretariat, in collaboration with Dr. Norm Catto at the Department of Geography at Memorial University, is conducting the project Reducing vulnerability of coastal habitats to petroleum contamination on the island of Newfoundland through funding from the Environment Canada Atlantic Ecosystem Initiative. The project is focusing on seven communities on the island of Newfoundland. The objectives of the project are to identify vulnerable coastal habitats and petroleum contamination risks, and to investigate methods for reducing vulnerability. This presentation focuses on the data that has been collected for the seven communities that leads to a better understanding of the vulnerabilities and risks that are present. These layers include: ship tracks; on-land storage facilities; detailed information about specific shoreline features close to the seven communities; mammal, fish, and bird occurrences; and coastal characterization and a petroleum vulnerability index (developed by Dr. Norm Catto). The geospatial information is available online through viewing the custom COINAtlantic Search Utility for this project by pulling layers from WMS (web mapping services), ArcGIS REST Services and KMLs (keyhole markup Language) from several locations.

## G8-3

### **Community responses to marine and coastal hazards – a meta-approach**

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Coastal communities are unique places where society, ocean, air and earth intersect. This nexus makes coastal communities across the globe vulnerable to a complex series of coastal hazards, ranging from climate change impacts to oil spills, each with resulting social-ecological degradation. Communities, in turn, while having no control over the occurrence or magnitude of coastal hazards, can influence the local impacts of these hazards through their subsequent responses.

Through a systematic literature review, we have assembled a global database of thousands of documented experiences with marine and/or terrestrial hazards, compiling from this database over 900 community-level responses to those hazards. We

present results from a meta-analysis of these data, reflecting the global state of the art in community responses to hazardous events. Our research also provides a knowledge repository that provides insights to particular communities about how people elsewhere in the world are coping with similar kinds of threats. Lastly our meta-analysis demonstrates to governmental authorities that communities are not just clients but also resources with which they can partner in planning for and coping with coastal hazards. Thus communities, researchers, and governments can use this information and together develop best practices for coastal and other communities, based on experiences of their counterparts worldwide.

## G8-4

### **Smart sensor-based geospatial architecture for dike monitoring**

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Artificial hydraulic structures like dams or dikes used for water level regulation or flood prevention are continuously under the influence of the weather and variable river regimes. Thus, ongoing monitoring and simulation is crucial in order to determine status and condition. Potentially life-threatening situations, in extreme case a failure, must be counteracted by all available means. Nowadays flood warning systems rely exclusively on water level forecasts without considering the state of the structure itself. Spatial knowledge of the condition of dams and dikes, including time dependent changes, increases the capability of recognizing and locating vulnerable spots for early treatment. In case of a predicted breach, the advance warning time may be extended for alerting affected citizens.

Our approach composes of smart sensors integrated in a service-oriented geospatial architecture to monitor and simulate artificial hydraulic structures continuously. The sensors observe not only the inner state of the structure, such as soil moisture or stress and deformation over time, but also various external influences like water levels or wind speed. They are interconnected in a distributed network architecture by a so-called sensor bus system based on lightweight protocols like Message Queue Telemetry Transport for Sensor Networks (MQTT-SN). These sensor data streams are transferred into an OGC Sensor Web Enablement (SWE) data structure that provides high-level Geo Web services to end users. Bundled with third party Geo Web services (WMS etc.) powerful processing and simulation tools can be invoked using the Web Processing Service (WPS) standard. Results will be visualized in a geoportal allowing users to access the information available.

## G9-1

### **Open data and a new biological earth observing system - the Ocean Tracking Network**

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Acoustic telemetry fits aquatic animals with acoustic tags and documents their movements and survival by detecting the animals on prepositioned receivers at various points in the environment. The challenges of conveying acoustic telemetry results include visualizing geospatial data in time, representing uncertainty in location, aggregating results from many stationary receivers, and representing larger populations with limited sample sizes and detection rates. To make predictions about animal movements in a changing climate, animal detection data must be coupled with environmental observations, and/or with oceanographic model results. By observing and supporting the latest geospatial data standards as well as marine and acoustic detection metadata standards, we are able to optimize usability and relevance while preserving the choice of visualization strategy for the researcher.

The Ocean Tracking Network (OTN) is a global project uniting telemetry researchers through equipment and data sharing. Its policy makes tracking data accessible while respecting the intellectual property rights of its collaborators. OTN's novel approach to aggregating acoustic telemetry data lets tag owners leverage the network of affiliated global acoustic receivers to detect long distance movements of their tagged animals, and to use oceanographic observations from stationary platforms and mobile AUVs to characterize the habitat during the tag detection period.

## G9-2

### **Use of IRS-P4 ocean color monitor (OCM) images for determining the red edge position of vegetation reflectance spectrum**

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The Ocean color monitor (OCM) sensor on board the Indian remote sensing satellite IRS P4 was meant for oceanographic information extraction. The archived OCM images also contain significant amounts of land cover information, which is a valuable yet unexplored collection of digital information on earth observation. The present work utilizes the land cover portions of existing OCM images for determining the red edge position of the reflectance spectra of terrestrial vegetation. Two standard techniques for determining the red edge, namely Gaussian inversion and Lagrange interpolation, were employed. In order to test their suitability for OCM data handling, two

independent sets of model wavebands were generated. One was created by measuring reflectance spectra of fresh green leaves over ultraviolet, visible and near-infrared wavelengths at the resolution of almost 1 nm and averaging over the eight discrete wavebands corresponding to those of the OCM sensor. The other set was generated from vegetation reflectance data derived from Hyperion hyperspectral images for the same wavelength range and averaged over the same bands. Both types of reflectance possessed actual red edge that was retraced and compared with the model wavebands. The possible extent of error was estimated. The two techniques were applied to the actual OCM bands and red edge values were computed for evergreen, deciduous and mangrove vegetated regions of the images for winter and spring seasons. The seasonal changes were consistent with NDVI changes. Fitting the computed values of red edge, a continuous curve was generated and different vegetation indices were determined.

## G9-3

### **Monitoring the North Atlantic using ocean colour data**

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The Remote Sensing Unit at BIO (Bedford Institute of Oceanography) has been monitoring the North Atlantic using ocean colour products since 1997. Optical sensors used include SeaWiFS, MODIS/Aqua and MERIS. The group provides composite images for various products in several formats and with a choice of temporal and spatial resolution. Statistics for pre-defined areas of interest are compiled for each product. The monitoring area was originally confined to the Atlantic Zone as defined by AZMP (Atlantic Zone Monitoring Program) but certain products are now available for the extended North Atlantic which extends into Arctic waters, and for all Canadian waters, which include the Pacific coast.

The products currently available at 1.5 km resolution include chlorophyll, total suspended matter, and SST (sea surface temperature). There are also lower resolution (4 or 9 km) products: kd<sub>490</sub>, PIC, and primary production. Products are available with temporal resolutions of weekly, bi-weekly, and monthly. Climatologies and anomaly maps are also routinely produced. Custom products are often created by request. As well as the operational work that produces the composite images and statistics, the Remote Sensing Unit is also involved in several projects. These include ongoing validation of the satellite data, characterizing the phenology of spring and fall phytoplankton blooms, computing primary production, and using ocean colour to aid in EBSA (Ecologically and Biologically Significant Areas) definition. Upcoming operational products include diatom distribution and biogeochemical province boundaries.

## G9-4

### **Hydrographic processing considerations in the “Big Data” age – a focus on technology trends in ocean and coastal surveys**

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The quantity of information generated by survey sensors for ocean and coastal zone mapping has reached the Big Data age. This is influenced by the number of survey sensors available to conduct a survey, high data resolution, commercial availability, as well as an increased use of autonomous platforms. The number of users of sophisticated survey information is also growing with the increase in data volume. This is leading to a greater demand and broader use of the processed results, which includes marine archeology, disaster response, and many other applications.

Data processing and exchange techniques are evolving to ensure this increased accuracy in acquired data meets the user demand, and leads to an improved understanding of the ocean environment. This includes the use of automated processing, models that maintain the best possible representation of varying resolution data to reduce duplication, as well as data plugins and interoperability standards. Through the adoption of interoperable standards data can be exchanged between stakeholders, and used many times in any GIS to support a wider range of activities. The growing importance of Marine Spatial Data Infrastructure (MSDI) is also contributing to the increased access of marine information to support sustainable use of the ocean and coastal environments.

## K4

### **Toward a Digital Resilience for the Coast and Ocean**

Wright, D

As we contend with human impacts on the biosphere, there is rightfully a great emphasis now on community adaptation and resilience to climate change. Recent innovations in information technologies and analyses are helping communities to become more resilient. However, often not discussed is a path toward digital resilience. If information tools are to help communities (including a “Digital Earth” comprised of digital technologies to monitor, map, model, and manage), it stands to reason that they must engender some resilience themselves if they are to continue to be effective. This talk reviews and recommends some practices for the ocean and the coastal regions of our blue planet, particularly from a GIS standpoint and from a policy-making and conservation perspective.

## S3C-1

### **Watershed-based inquiry: Integrating earth observations on the WorldView Discrete Global Grid System**

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A drainage basin is a fundamental unit of activity and analysis for many environmental systems. Gathering, integrating, and conforming various data sources to a particular boundary is generally an onerous operation. It is even more so for a drainage basin where the delineation of its watershed boundary is based on the ad hoc placement of an outlet. The authors will present a method that permits rapid and comprehensive analysis of drainage basin characteristics using the WorldView discrete global grid system (DGGs). DGGs are spatial references that use a hierarchical tessellation of cells to partition and address the entire globe. DGGs provide a reference frame for repeating the location of measured Earth observations, feature interpretations, and extrapolated predictions. Cells of a DGGs are designed to provide statistically valid sampling of values from conventional geospatial data sources. Information integration, decomposition, and aggregation can be optimized in the hierarchical structure, which can be exploited to support data processing, storage, discovery, transmission, visualization, computation, analysis, and modeling.

As a demonstration, several elevations models are seamlessly combined on the WorldView DGGs. Other geospatial data sources - land use, vegetative cover, soil type, species observations, demographics, hydrological data, remotely sensed rainfall intensity, and streamflow data - are integrated on-demand. Watershed boundaries can be delineated by selecting an outlet point. Summative and statistical characteristics of the drainage basin are extracted from the content bounded by the resulting drainage basin. Multi parametric indices are calculated. Hydrological responses and runoff are estimated. Streamflows are modeled.

## S3C-2

### **Multilevel focus+context visualization leveraging a Discrete Global Grid System**

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A Discrete Global Grid System (DGGs) is a powerful system for creating reference models for geospatial data and implementing a Digital Earth (DE). However, the growing size and number of datasets associated to each client-query limit

consumers accessibility of data for generating visual analytics. To address this problem, we present a portable DE that runs in web-browsers on the client-side and efficiently communicates with the DGGs on the server-side to allow the interactive creation of innovative and purposeful visualizations capable of handling large-scale datasets.

Exploiting multilevel focus+context visualizations is an effective way for the exploration and navigation of large-scale data. Therefore, we enable interactive generation of multilevel focus+context visualization hierarchies exploiting on-demand streaming of geospatial data on the client-side. The regions of interest (ROIs) in such context-aware visualizations have varying degrees of interest (DOIs). We rely on these DOIs to trigger view-dependent requests for data and to control the level of details for rendering purposes. In this work, the client-side is responsible for rendering, triggering queries for missing data, the management of viewing area and local visualization hierarchies, and styling of data. On the other hand, with complete knowledge of the inner workings of the DGGs in use, the server-side is responsible for generating data representations for appropriate DGGs cells in response to queries from clients.

### S3C-3

#### **Indexing and Searching Text on a Discrete Global Grid**

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Extremely rich and diverse knowledge about places across the world is available in a variety of forms, including not only traditional structured spatial data but also natural language descriptions. The associations between geographic and thematic contents in unstructured data can provide a rich groundwork to organize information for exploratory research, and has potential to aid a number of applications from education to scientific analysis. In this presentation I will discuss the architecture of an interactive thematic map search engine, Frankenplace, we have designed to facilitate document exploration at the intersection of theme and place. The map interface enables a user to zoom the geographic context of a query in and out, and quickly explore through thousands of search results in a meaningful way. Frankenplace utilizes a novel indexing method called geoboost for boosting terms associated with cells on a discrete global grid.

The system is currently indexed with over 5 million documents from the web, including the English Wikipedia and online travel blog entries.

### S3C-4

#### **The role of Discrete Global Grid Systems in national data infrastructures**

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The rapid growth in global sensor networks is leading to an explosion in the volume, velocity and variety of geospatial and geoscientific data. This, coupled with the increasing integration of geospatial data into our everyday lives, is also driving an increasing expectation of spatial information on-demand, and with minimal delay. However, there remains a gap between these expectations and the present reality of accessible national data infrastructures. A solution can only be achieved through the conversion of traditional data archives into standardized data architectures that support parallel processing in distributed and/or high performance compute environments.

Success has been achieved using Discrete Global Grid Systems (DGGs). A DGGs is a form of Earth reference system that represents the Earth using a tessellation of discrete nested cells and is designed to ensure a repeatable representation of measurements that is better suited to today's requirements and technologies rather than for primarily navigation and manual charting purposes. A DGGs presents a common framework that is capable of linking very large multi-resolution and multi-domain datasets together to enable the next generation of analytic processes to be applied. We discuss two examples of national data infrastructures: the Australian Geoscience Data Cube (AGDC), an operational High Performance Data Infrastructure; and, the Spatial Computation Engine for New Zealand (SCENZ-Grid), a DGGs.

### S5-1

#### **Modeling land cover dynamics to assess the sustainability of wetland services; a case study of the Grand Lake Meadows, Canada**

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The ever growing human activities and economic development will eventually change the relationships between humans and the environment. A matter of grave concern is the unsustainable patterns of land use that are considered a major cause of deterioration of the environment. The Grand Lake Meadows is an important part of the Saint John River wetlands that form the largest freshwater wetland habitat in the Maritimes (eastern Canada). Changes in land cover and land use around wetlands significantly impact their biotic diversity and alter the

ecosystem, affecting their ability to support human needs.

In this paper, remotely sensed images were used to map the state of land use and cover in Grand Lake Meadows over a 30-year time period. The goal was to undertake a detailed, spatially explicit inventory of local trends in land use and land cover changes by classifying historical images. Other available data were combined with this information to create a database that was used to investigate the causes and consequences of land use/cover change. The results demonstrated the flexibility and the effectiveness of this technology in establishing the necessary baseline and support information for sustaining the eco-services of a wetland. In turn, the findings of this study will aid decision makers to understand the dynamics of change, leading to better planning and implementation of land use management.

## S5-2

### **A novel registration-based technique for mapping off-terrain objects' disparity**

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Third-dimension information is of great importance for several remote sensing applications including 3-D city modeling and building detection. The main data-source for these applications is very high resolution (VHR) satellite images which allow detailed mapping of complex urban environments. Stereo VHR satellite images, acquired by the off-nadir acquisition capability, allow the extraction of two correlated types of third-dimension information: disparity and elevation information. While the disparity is measured directly, the elevation information is derived computationally. To measure the disparity information, two overlapped images are matched. However, for the backward and forward off-nadir VHR stereo images, the same building facades cannot be seen in both images. This is due to the push-broom scanning mode of the line sensors used in VHR satellite systems. Hence, this occlusion creates many data gaps which destroy the quality of the modeling/mapping applications when the third-dimension information of the aboveground features (e.g., building roofs) is required. Therefore, this paper proposes a registration-based technique to measure directly the disparity of the aboveground objects. The technique includes constructing an epipolar pair with minimal terrain relief distortions and registering the terrain features in both epipolar images to allow direct disparity mapping for only the off-terrain objects. After the implementation, the technique mitigates the negative effects of building lean, facades and occlusions in the off-nadir VHR stereo images acquired over dense urban areas. Furthermore, it is found to be efficient and straightforward. The disparity map generated is found to represent successfully the above-ground objects only.

## S5-3

### **Rasterizing vector data for 3D visualization**

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In the past few years, storage and organization of global massive multi-dimensional remote sensing data had a big impact on the performance of Web mapping systems as well as standalone applications. With the increasing popularity of global online mapping web applications (e.g. Google Maps, Microsoft Virtual Earth, Yahoo Maps), Tile technique is widely used. This technique allows for flexibility in serving satellite images and other forms geospatial and non-geospatial data on a multi zoom level platform with different levels of details. There is also a path towards providing more information to users, adding depth data to existing maps and satellite images is highly valuable especially given the recent hardware development in 3D displays and peripherals. To implement a 3 dimensional Web mapping system, we propose a modified version of global grid division pyramid hierarchical method for vector data rasterization.

This paper proposes a solution for creating raster layer on top of satellite image providing hybrid map information on top of a 3D visualized satellite image mosaic created with Digital Elevation Model for 3D visualization. In this approach, different options for automatically rasterizing vector data for each zoom level based on level of details model are investigated and 3D visualization considerations are taken into account. This approach has been tested on small and large datasets and is able to create high quality 3D rasterized layer on top of satellite image.

## S5-4

### **Using locality-constrained linear coding in automatic target detection of HRS images**

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Automatic target detection with complicated shape in high spatial resolution images is an ongoing challenge in remote sensing image processing. Most methods use spectral or texture information, which are not sufficient for detecting complex shapes. In this paper, a new detection framework based on Spatial Pyramid Matching (SPM) and Locality-constraint Linear Coding (LLC) is proposed to solve this problem. The process starts with partitioning the image into sub-regions and trying to generate a unique histogram for local features of each sub-region. Finally, linear Support Vector Machines (SVMs) detect objects based on a pyramid-matching kernel, which analyses the descriptors inside patches in different resolution. In order to generate the histogram, first a point feature detector (e.g. SIFT) is

applied on the patches, and then a quantization process selects local features. In this step, the k-mean method in conjunction with locality-constrained linear coding method is used. The LLC forces the coefficient matrix in the quantization process to be local and sparse as well. As a result, the speed of the method improves approximately 24 times in comparison to using sparse coding for quantization. Quantitative analysis also shows improvement in comparison to just using the k-mean. However, the accuracy in comparison to using sparse coding is similar. Besides, rotation and shift of the desired object has no effect on the obtained results. The speed and accuracy of this algorithm for high spatial resolution images make it capable to be used in real-world applications.

## G10-1

### **Naïve (Commonsense) geography and geobrowser usability after ten years of Google Earth**

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In 1995, geographers Egenhofer and Mark presented the concept of nave geography as an area of cognitive geographic information science representing the body of knowledge that people have about the surrounding geographic world and reflecting the way people think and reason about geographic space and time, both consciously and subconsciously. They identified the need to incorporate such commonsense knowledge and reasoning into design of geospatial technologies—specifically geographic information systems—but cited challenges in formalizing these relationships and processes in software implementation. Ten years later, Google Earth was released, marking the beginning of a new era of lay-person access to and application of geographic data and information in society. Fast-forward to today, and the opportunity presents itself to take stock of twenty years of nave geography and a decade of the ubiquitous virtual globe.

This paper explores the current level of integration of commonsense geography concepts within the Google Earth platform. A qualitative content analysis of identifiable nave geography elements represented in select Google Earth applications is presented, along with results of a small-group usability review focused on support for spatial reasoning skills among stakeholders possessing basic geospatial technology fluency and engaged in a continental-scale resource management issue. Potential for greater integration of nave geography in virtual globes is assessed and recommendations on criteria for future geobrowser design and usability assessment methods are proposed.

## G10-2

### **COINAtlantic philosophy and tools for accessing geospatial information online**

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Modern GIS systems provide users with functionality to access geospatial information from the internet. However, there is a continuing struggle to share map information on the Web. Open Source GIS and standards for Web Map Services (WMS), Web Feature Services, and Catalogue Services are useful tools to enable easier access to geospatial information from the internet. With today's infrastructure, standards, and computing power it is possible to publish, find, and view geospatial data from anywhere. A Coastal and Oceans Information Network (COINAtlantic) core philosophy on information access recognizes that information comes from many different organizations and that no one organization could, or should, manage all of the disparate types of information relating to coasts and oceans. The COINAtlantic approach relies on data-providing organizations delivering data and information from well managed systems to the internet using standard methods and formats, and metadata that is searchable on the internet.

COINAtlantic has implemented a distributed system which does not harvest data or store geospatial information in a warehouse or portal. However, it does provide users with a search tool to find and display geospatial information from anywhere on the internet that is published as WMS or KML OGC standards. Three key tools have been developed to support this approach: the COINAtlantic GeoContent Generator for publishing metadata online; the COINAtlantic Search Utility for finding and viewing geospatial information online; and, the COINAtlantic Data Accessibility Self-Assessment Tool for assessing data-providing organizations effectiveness of delivering accessible information online.

## G10-3

### **From global to personal spatial data infrastructures**

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Since 1994, national and state-level government organizations have invested billions of dollars in spatial data infrastructure (SDI) implementation. Similarly, recent developments in indoor location-based services demonstrate increasing private



investments in creating private positioning and mapping infrastructures inside stores and malls, hospitals, convention centres, warehouses and elsewhere to facilitate individual positioning and navigation, customer tracking business intelligence, distribution logistics, and emergency response. In this context, notification of changes updates for personal and collective use is already an important consideration. The challenge is to determine which particular combination of channels provides an optimal combination of applicability, reliability, timeliness and cost for a given organization or individual. How transparently and effectively future consumers will balance tradeoffs between the convenience of one service and the ability to mix the best channels of information products and services to create their own personal SDI (or pSDI) remains to be seen.

In such a pSDI, individuals will employ mobile services that will accomplish the following: (1) learn and predict patterns of usage, consumption and travel (especially indoor travel) over time; (2) select, contribute to, and integrate data from a wide range of different public, commercial, social and personal geospatial data channels; and (3) employ the result to intuitively and transparently serve that persons own unique collection of personal and business needs in different contexts through a given day. This paper introduces technical and social tradeoffs involved in the transparent integration of multiple services and volunteered contributions to create such pSDIs.

## G10-4

### **Evaluating image segmentation quality through automated shape comparison from high spatial resolution images**

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The increasing use of object-based image analysis (OBIA) methods on very high spatial resolution imagery has raised several questions related to quality of objects extracted from image data. Image segmentation is often the first step in OBIA framework, and the efficiency and accuracy of the subsequent operations often depend on the segmentation quality. Although a large number of segmentation algorithms have been developed, there are no standard toolsets/models to objectively guide the assessment of segmentation quality. In this paper we present a tool set for evaluating image segmentation quality by comparing shapes automatically generated from various segmentation parameter sets. Several shape-related measures have been implemented to evaluate the different aspects of segmentation quality. The iterative segmentation is initiated and results are compared against the reference feature automatically, until an optimal is achieved. Different geometrical properties of shapes are used to create an index which describe

the closeness of reference and target features. The output from these measures allows users to loop through a range of segmentation parameters and select the optimal ones.

## G11-1

### **Connecting ground based in-situ observations, ground-based remote sensing, and satellite data within the Pan Eurasian Experiment (PEEX) program**

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The new Pan-Eurasian Experiment (PEEX) program is aimed to understand the Earth system and the influence of environmental and societal changes in both pristine and industrialized Pan-Eurasian environments. A crucial part of the program activities is to establish a process to sustain long-term, continuous, and comprehensive ground-based, airborne, and seaborne research infrastructures, and to utilize satellite data and multi-scale model frameworks to fill gaps in the in-situ observational network, especially in the Arctic-boreal region. PEEX will contribute to regional climate scenario development work and determine the relevant factors and interactions influencing human and societal wellbeing in these regions. The development of research infrastructure in the Northern Pan-Eurasian region will be one of the first activities of PEEX. PEEX will find synergies with the major European land-atmosphere observation infrastructures (ICOS, ANAEE; ACTRIS) when designing, reorganizing, and networking existing station networks. It is also important to connect the comprehensive ground-based data to satellite observations in order to understand the overall context and relevance of the ground-based observations. Of particular interest in the context of PEEX are land, lake, and atmospheric observations. The atmospheric observations are complementary to those from the stations described above in that they provide information on atmospheric concentrations of aerosols, trace gases, and GHG. In this contribution, we underline general features of the satellite observations relevant to the PEEX research program, and discuss how satellite observations connect to the ground based observations.

## G11-2

### **Application of the GLobeLand30 landcover dataset in the BCC\_CSM climate model**

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The new higher-resolution global land cover (LC) dataset, GlobeLand30 provides a new choice for climate system models. In this paper, the new dataset is employed for the first time in a climate system model, specifically the Beijing Climate Center Climate System Model (BCC\_CSM). The strategy for the new dataset application in the model is to revise the model LC information based on GlobeLand30, and also enlarge the plant function types with reference to other land cover products. The land cover types as well as their fractions were made according to the aggregated up-scaling of land areas. The land cover data was introduced in the model system as an input file of the land surface component model (BCC\_AVIM1.0).

The simulation results show that with the new LC datasets, the BCC\_AVIM1.0 and BCC\_AGCM2.1 land surface model can reasonably reproduce the climate features of land and atmosphere. The effects of PFT dataset updates were generally larger than those of glaciers and water bodies (lake and wetland). The composed updates of all land cover types had the most significant impacts. The applications of the new LC datasets were effective in decreasing the model bias of precipitation at the mid-high latitude and in part of the Amazon basin, and of air temperature in some regions of the southern hemisphere.

## G11-3

### **Mapping latent and sensible heat fluxes over sparse vegetation from a two-source model based on HJ-1B remote sensing data**

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Land surface heat fluxes (sensible and latent) play important roles on the terrestrial water cycle. The two-source energy balance (TSEB) model of Norman et al. (1995) has been widely applied over sparse vegetation based on land surface temperature (LST) derived from thermal sensors. In this paper, several HJ-1B images covering the middle reaches of the Heihe River Basin, China, were selected for LST estimation using the image based single-channel (IBSC) method proposed by Chen et al. (2015) and for surface parameters calculation, such as normalized differential vegetation index (NDVI), leaf area index (LAI) and surface roughness length for momentum transfer

(z0m). Then, the latent and sensible heat fluxes were computed by TSEB model based on LST and surface parameters. The results were validated by measurements from eddy covariance systems, indicating that the performance of the TSEB model in estimating latent and sensible heat compares well to ground truth and that HJ-1B remote sensing data can be applied to monitor the land surface energy budget with reasonable accuracy.

## G11-4

### **Weather monitoring and modeling to support agricultural production in southwestern Nova Scotia**

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The Applied Geomatics Research Group (AGRG) has been monitoring the weather conditions of the Annapolis Valley for over a decade, and the southwestern portion of Nova Scotia since 2011. About 75 temperature data loggers were deployed throughout the Annapolis Valley starting in 2003. Data collected from these loggers were processed and shared with the Grape Growers Association of Nova Scotia (GGANS) who used the results to better understand the growing conditions of the Valley region. These loggers were maintained until 2011 when AGRG began a project with the Community Business Development Corporation (CBDC) and expanded the study area to all of the southwestern region. Now in the fifth year of operation, the 75 weather station network records temperature, relative humidity, solar radiation, rainfall, and wind speed/direction. Cellular modems are used to automatically transmit the results to AGRGs office.

Access to the weather conditions in the region and growing season summaries are provided by way of web-based mapping applications. Data are integrated with other landscape layers (i.e., topography, coastline proximity, solar potential) to create temperature maps for the region. In turn, these maps are integrated with other layers (i.e., soils, land cover, road networks, etc.) to implement crop suitability models. A LiDAR and aerial photography survey of the station locations has been used to model the local landscape conditions. Although primarily a resources for the agricultural community, the results of this sensor network have also been used to support other application areas (i.e., transportation conditions, alternate energy production, and habitat analyses).

## K5

### **Google Earth and Earth Engine: Democratizing and Scaling the Digital Earth vision**

Moore, R

In 2005, Google launched Google Earth, which soon became an extraordinarily popular digital earth implementation, downloaded more than two billion times and ushering in a new era of geoliteracy. In 2010, Google unveiled Google Earth Engine ([earthengine.google.org](http://earthengine.google.org)), a highly-scalable cloud-based geocomputation platform which maps, measures and monitors our changing planet at unprecedented detail in near real-time. Applications include tracking and reducing global deforestation ([reported in the journal Science in 2013](#)); mapping global surface water resources over time; estimating global crop yields to enhance food security; mapping and mitigating the risks of earthquakes and extreme weather events such as floods and drought; and predicting future risks of vector-borne diseases such as malaria.

Together, these digital earth technologies form a bridge from science to society. Combined with recent advances in AI-based machine learning and Virtual Reality, we can envision a truly-immersive, dynamically-updating dashboard of the planet, available to all.

## G12-1

### **The RADARSAT program**

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Canada has been providing without interruption C-band Synthetic Aperture Radar (SAR) data since 1995 with the launch of RADARSAT-1, and with the introduction of RADARSAT-2 in 2007. There is also a clear commitment to maintain data continuity in the future with the current development of the next generation mission; the RADARSAT Constellation. This perennial data supply enables the users at national and international levels to integrate valuable information derived from it into their operational applications.

Since the first mission, the RADARSAT program gained an excellent reputation based on the high-quality imagery provided on an operational basis to commercial, government and scientific users worldwide as well as for the significant flexibility in imaging at various incidence angles, resolutions swath widths, beams and modes offered by the systems.

## G12-2

### **Use of ALOS-PALSAR and RADARSAT-2 images in various environmental applications**

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The paper will present permafrost and wetland maps obtained using a combination of RADARSAT-2 and/or ALOS-PALSAR images with LANDSAT images. In the first study, the NEST model was calibrated against data acquired over nine peatland sites located in a discontinuous permafrost region of northern Ontario. The model was used to derive permafrost maps from land cover and surficial material maps that were extracted from RADARSAT-2 and LANDSAT-7 ETM+ images. Both maps have a mapping accuracy higher than 98%. This study was supported by the Canadian Space Agency, NSERC, NBIF, the Canadian Forest Service, the Ontario Ministry of Natural Resources, and De Beers Canada. In the second study, LANDSAT-5 TM, RADARSAT-2 C-band and ALOS-PALSAR L-band SAR images were used to map wetlands in New Brunswick. The resulting maps were compared to GPS field data as well as the NB Department of Natural Resources maps. The study shows that the RADARSAT-2 C band is better to detect marshes than the ALOS-PALSAR L band, but the opposite is true for shrub wetlands. A combined use of both kinds of SAR images gives the best mapping accuracy (98.6%). The study was funded by the NB Environmental Trust Fund grants and supported by a NASA Interdisciplinary Science Program grant.

## G12-3

### **Enabling technologies for large-scale environmental monitoring – exploring new opportunities for mass Earth observation data exploitation based on integrative services and platforms.**

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The upcoming suite of Sentinel satellites in combination with their free and open access data policy will open new perspectives for establishing a spatially and temporally detailed monitoring of the Earth's surface. The Sentinel fleet will provide a so-far unique coverage with Earth observation (EO) data and new possibilities with respect to the implementation of

innovative methodologies, techniques and geo-information products and services. However, the capability to effectively and efficiently access, process, analyze and distribute the mass data streams from the Sentinels and high-level information products derived from them poses a key challenge. This is also true with respect to the necessity of flexibly adapting the processing and analysis procedures to new or changing user requirements and technical developments. Hence, the implementation of operational, modular and highly automated processing chains, embedded in powerful hard- and software environments and linked with effective distribution functionalities, is of central importance. This paper introduces concepts for the utilization of modern information technology functionalities and services to bridge the gap between the technology-driven EO sector and the information needs of environmental science, planning, and policy. Key components of such systems are currently developed in the projects OPUS-GMES and TEP Urban. This includes the implementation of an open, web-based platform employing distributed high-level computing infrastructures (Platform as a Service PaaS) as well as providing key functionalities for i) high-performance access to thematic data (Information as a Service IaaS), ii) modular and generic state-of-the art pre-processing, analysis, and visualization (Software as a Service SaaS), iii) customized development and dissemination of algorithms, products and services, and iv) networking and communication. These services and functionalities are supposed to enable any interested user to easily exploit and generate thematic information on the status and development of the environment based on EO data and technologies.

## G13-1

### **On-the-fly analysis of multidimensional rasters in a GIS**

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Geographic Information Systems (GIS) and other mapping applications that specialize in image analysis routinely process high-dimensional gridded rasters as multivariate data cubes. Frameworks responsible for processing image data within these applications suffer from a combination of key shortcomings like: inefficiencies stemming from intermediate results being stored on disk, or the lack of versatility from disparate tools that don't work in unison, or the poor scalability with increasing volume, range, or dimensionality of the data.

Here, we present raster functions as a powerful mechanism for processing and analyzing multidimensional rasters designed to overcome these crippling issues. A raster function accepts multivariate hypercubes and processing parameters as input and produces one output raster. Function chains and their parameterized form, function templates, represent a complex

image processing operation constructed by composing simpler raster functions. We discuss extensibility of the framework via Python, the portability of templates via XML, and dynamic filtering of data cubes using SQL. This paper highlights how ArcGIS employs raster functions in its mission to convert geographic data and science into actionable information by shrinking the lag between the acquisition of raw multidimensional raster data and the ultimate dissemination of derived image products. ArcGIS has a mature raster I/O pipeline based on GDAL, and it manages gridded multivariate multidimensional cubes in mosaic datasets stored within a geodatabase atop an RDBMS. Bundled with raster functions, we show those capabilities make possible up-to-date maps that are driven by distributed geoanalytics and powerful visualizations against large volumes of near real-time gridded data.

## G13-2

### **Information model for managing multidimensional gridded data in a GIS**

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Earth observation agencies like NASA and NOAA produce huge volumes of historical, near real-time, and prediction data representing terrestrial, atmospheric, and oceanic phenomena. The data drives climatological and meteorological studies, and underpins operations ranging from weather pattern prediction and forest fire monitoring to global vegetation analysis. These gridded data sets are distributed as files in HDF, GRIB, or netCDF format and quantify variables like precipitation, soil moisture, or sea surface temperature, along one or more dimensions like time and depth. Although the data cube is a well-studied model for storing and analyzing multidimensional data, the GIS community remains in need of a solution that simplifies interactions with the data, and elegantly fits with existing database schemas and dissemination protocols.

This paper presents an information model that enables Geographic Information Systems (GIS) to efficiently catalog very large heterogeneous collections of geospatially-referenced multidimensional rasters towards providing unified access to the resulting multivariate hypercubes. We show how the implementation of the model encapsulates format-specific variations and provides unified access to data along any dimension. We discuss how this framework lends itself to familiar GIS concepts like image mosaics, vector field visualization, layer animation, distributed data access via web services, and scientific computing. Global data sources like MODIS from USGS and HYCOM from NOAA illustrate how one would employ this framework for cataloging, querying, and intuitively visualizing such hypercubes. ArcGIS an established platform for processing, analyzing, and visualizing geospatial data serves to demonstrate

how this integration brings the full power of GIS to the scientific community.

## G13-3

### **Construction of the real-time Digital Earth – A case study in real-time Digital Park**

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Currently, sensors over the Earth's surface increased not only in numbers, but also in types. Real-time data will become a very important part of the future mass data. This data level development trend will push current time interval Digital Earth to real-time Digital Earth, and thus bring new applications. On the basis of the existing Digital Earth Platform, this paper developed a method to access multi-channel digital video pushed by camera network video server to three-dimensional visualization of the digital earth scenes. All the accessed real-time video data were registered according to spatial coordinate of the static Digital Earth in order to restore the spatial position of each video pixel. Further, on the basis of time synchronization multi-channel video, spatial overlap part of the multiple real-time video data were cut and then mosaic them into an integrated video. Finally, the integrated real-time video after mosaic was overlapped into digital earth according to spatial coordinates and thus a real-time digital earth carrying high temporal resolution video basing on static spatial information was formed. Taking Digital Park as a case, this paper constructed a real-time digital agriculture park system using the above method. Aim to real-time monitoring of animals as well as rapid screening of diseases in precision animal husbandry, the real-time digital earth system was applied and verified.

## G14-1

### **'Sense of Urban': A new perspective on understanding the physical and dynamic structures of urban space**

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Peoples sense of the urban space and their surroundings depends on a variety of static and dynamic spatial factors, and results in experiencing a wide variety of emotions. These emotions are spatiotemporal distributed over the urban space describing what the city's happiness or stress state might be like. In this research, we take urban space as a vital body and define this emotional distribution as the Sense of Urban. This research presents a fundamental and technical framework following the

concept of Sense of Urban, which comprises two major parts: 1) providing a high accuracy contextual emotion sensing method by using mobile EEG recorders; 2) supporting a semantic and computational process to the social media networks in urban spaces through location based service and emotional data mining, in order to enrich and ground-truth the contextual emotional data.

Sense of Urban makes it possible to directly sense the emotional state of people on a massive scale, to map the regional happiness/stress spatial-temporal distribution and to further explore key factors in static or dynamic urban space. It is also possible to provide insights to reveal the physical and social structures of inherently complex urban environments from the perspective of human cognition. The research shows its long-term significance through the following two aspects: the framework of human-centered contextual emotion extraction used to provide decision support for urban planning and healing environment building, and the methodology of emotional big data mining to facilitate the discovery of spatial knowledge.

## G14-2

### **A wireless Sensor network for urban environmental monitoring: UrbanSense**

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We are quickly becoming an urban species. More than 80% of Canadians and 50% of people worldwide live in urban environments. Urban areas become generators of environmental emissions such as carbon dioxide (CO<sub>2</sub>), harmful air pollutants and noise, all with the potential to negatively impact the health and well being of its human and non-human inhabitants. Urban areas are responsible for approximately 70% of all energy-related CO<sub>2</sub> emissions. There is an urgent need to understand the characteristics of urban areas associated with variability in emissions and the potential for exposure to potential harmful environmental conditions.

This talk is focused on UrbanSense, a wireless sensor network (WSN) infrastructure designed to monitor environmental conditions at different temporal and spatial scales. The scalable infrastructure includes an extended range outdoor wireless sensing and data aggregation system, a web-based data management and visualization platform, and real-time event-based data stream integration. Sensors will monitor changes in carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), noise (db) and a variety of meteorological conditions including wind speed and direction, temperature, relative humidity and precipitation. The implementation will provide opportunities for real-time data integration and an analysis system for environmental quality assessment, and may be realized on top of products

arising from spatio-temporal (statistical) analyses and remotely-acquired data products such as satellite data. Sensor swapping and co-location with sensors from projects with different aims (traffic volume modeling and human tracking research) will add value for research in transportation planning, environmental regulation and policy and human health research.

## G14-3

### **Crowd evacuation simulation in multi-exit environments based on five-factor model**

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In view of the lack of differences among individuals and diversity in the expression of crowd evacuation, especially the influence of individual psychological differences in Multi-exit environments, a crowd evacuation simulation model based on personality model was proposed in this paper. Exit selection is not only affected by objective exit conditions, but also affected by individual psychology. First of all, a Five-factor model describing personality widely used in psychology was introduced, quantified and mapped the relationship between personality factors and behavioral parameters in order to understand senior psychological modeling and autonomous behavior of virtual human. Then, a path planning algorithms affected by the personality factors was presented. This algorithm combines global path planning and local collision avoidance within his algorithm, which we can implement a real diverse motion selection between individuals while establishing a natural reasonable path of crowd. Finally, a method of action implementation of virtual human was designed, which is driven by the personality factors, and realizes it based on skinned mesh animation technology.

Based on the Digital Earth Science Platform (DESP) which was developed by the Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, a simulation system of virtual crowd has been created. The experimental results show that the proposed simulation model of crowd behavior can effectively express the impacts of psychological differences between individuals in Multi-exit environment crowd evacuation, so as to make crowd simulation more realistic and reliable than existing classic models.

## K6

### **Viewing the Earth's Global Environment from Space: from Scientific Knowledge to Societal Benefits**

Green, D

The vantage point of space provides an excellent way to realize the concept of the Digital Earth, using digital technologies to monitor, map, model, and manage our common home. Earth observations from satellites are now providing quantitative information about how the Earth system varies on a variety of spatial and temporal time scales, documenting longer-term evolution as well as stresses in near real-time, and providing information that can inform prediction and enable better policy and management decisions. Satellite-based data products and information help improve understanding not only of how individual Earth system components (atmosphere, ocean, cryosphere, biosphere, Earth surface) evolve but how they interact with each other and both contribute and respond to naturally-occurring and human-induced change. NASA currently has a fleet of 17 orbiting satellite missions, and information from these missions is advancing science across many relevant disciplines and being shared opening and freely with those who use that information in addressing societally relevant activities in assessment, forecasting, management, and policy development. Space-based information is complemented by that from NASA's aircraft, surface based measurements, and computational models, as well as the observational and scientific activities of other agencies and partners in the U.S. and around the world. This talk will provide a guide to the current status and future evolution of our capability and the projected and potential utilization. The presentation will include examples of what is being learned about the Earth system and how that information is being shared with and utilized by an ever-increasing set of domestic and international partners, to increase our environmental intelligence, to save lives and protect economies, and to expand the world's digital knowledge.

## K7

### **The use of earth observation technologies by Canada's East Coast Navy**

Newton, J

Over the past decade, Earth Observation and display technologies have revolutionized intelligence gathering, surveillance and reconnaissance in the Royal Canadian Navy. As the commander of Canada's East Coast fleet, Rear-Admiral Newton has seen these changes first-hand.

From the formation of the Marine Security Operations Centres to the development of RadarSat and Space-Based AIS, the east coast Navy has been a key player in the gathering, distribution and analysis of remote sensor data.

In this keynote, Admiral Newton talks about the role of technology in Naval operations, and its particular role in revealing the archeological remains of the legendary Franklin Expedition in Canada's North.

## S6A-1

### **Marine traffic risk management in the North**

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Maritime traffic volume in the Arctic is growing for several reasons: climate change is resulting in less ice in extent, duration, and thickness; and economic drivers are inducing growth in resource extraction traffic, transarctic shipping (through the Northern Sea Route), community size (affecting resupply) and adventure tourism. This dynamic situation, coupled with harsh weather, variable operating conditions, remoteness, and lack of straightforward emergency response options, demands robust risk management processes. Risks can be mitigated via improved prevention and/or response. Ship design, maintenance and inspection, crew training, national and international regulations, and route planning all contribute to avoiding problems in the first place. On the response side, tracking vessels and mapping hazardous areas and conditions can help improve preparedness planning and resource allocation.

Ideally, risk management is supported by evidence-based models, including threat identification (types and frequency of hazards), exposure levels, and receptor characterization. Most of this information relies on remote sensing. Given the paucity of land-based sensors in the north, much of the information is collected via satellite. Ship positions are largely captured via satellite reception of Automatic Identification System (AIS) ship transmissions. Since there are gaps in coverage for a number of reasons, and the fact that AIS generally applies only to large vessels, this information can be supplemented with Satellite SAR (synthetic aperture radar) and/or optimally positioned land-based sensors. Ice charts (Canadian Ice Service) and bathymetric data (Canadian Hydrographic Services) are integral parts of northern navigation as well as providing crucial spatial information for route planning and risk modelling.

## S6A-2

### **Re-imagining the Arctic: geo-visualization as a tool for cross-cultural knowledge mobilization**

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The main goal of this paper is to propose that a new vision of Arctic communities is needed, based on the recognition that mobility is a central element of Inuit culture. Inuit have developed a long-established transportation system in the Arctic, based on an intricate network of routes that has linked communities with resources and with other communities through generations. This aspect of Inuit occupancy has been unrecognized by most non Inuit, mainly because the routes are largely invisible to the eye or at least ephemeral in nature. Mainstream maps of the Canadian Arctic depict communities that are geographically isolated, or sites that are grounded in specific and bounded locations. Inuit routes, however, reveal a territory that is embedded with social interactions, interconnections with the environment, and cultural meaning. This paper argues that visualizing the Inuit transportation system across the Canadian Arctic might be a crucial step towards recognizing critical elements of Inuit occupancy and Inuit culture, which could help in understanding the past, assessing the present, and planning the future of Inuit communities.

Maps and GIS can play a crucial role in making this transportation system explicit. The rationale for this argument is that visualization has the ability of mobilizing knowledge cross-culturally. This approach, based on mapping oral geographic knowledge through participatory mapping techniques, could influence the way in which we think about the Arctic and about Inuit communities.

## S6A-3

### **Satellite-based AIS: trafficability studies and monitoring for the Canadian Arctic.**

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Monitoring Canadian Arctic traffic is essential, not only in terms of maritime domain awareness, but also in terms of understanding and assessing the effects of the activity on the ecosystem, the economy, the geopolitics of the region, and the First Nations population.

While recent advances in satellite-based and land-based sensors have improved trafficability studies and risk assessment, the Arctic poses particular challenges due to its remoteness and gaps in coverage. However, the satellite-based Automatic Identification System (S-AIS) seems to be well- suited for monitoring high

latitude areas as it provides visibility for real-time operations, as well as the capability to analyze, integrate, and share large volumes of historical data in an interactive environment for marine traffic analysis (patterns, anomalies, forecasting, etc.).

exactEarth, a world leader in collecting, post-processing, and disseminating satellite-based AIS data, has produced within their exactAIS service an Arctic package of shipping data capturing every vessel movement in this traditionally unmonitored remote area since July 2010. They also provide live monitoring of shipping in the Arctic as well as the possibility to request various views such as density maps.

## G15-1

### **Modeling the distribution of global human population**

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Gridded Population of the World, version 4, depicts the distribution of human population across the globe. A collection of 14 million census boundaries and population estimates are used to create global gridded, or raster, surfaces of population counts for the period 2000-2020. Additional variables including age, sex, and urban categories are available for select dates. Multiple models have been used to estimate the distribution of population; all of the results permit rapid analysis on a global or regional scale in desktop and online systems.

Data from the first model, based on simple proportional allocation, are appropriate for use as independent variables with biophysical data. Additional modeling uses parameters from satellite-derived lights at night and human settlement extent to create two additional surfaces with a refined spatial distribution that better approximates population distribution for applied applications, such as analyzing exposure to natural hazards. Web services for quickly visualizing the data and estimating population within arbitrary units of analysis are available. The data and services are available for download and use within Digital Earth or other systems at no charge.

## G15-2

### **Rural water supply and Digital Earth technologies in Sub-Saharan Africa**

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Virtually all government agencies using Digital Earth technologies in Africa received their initial thrust from projects funded

by foreign donors, international financing institutions, and philanthropic foundations, here referred to as development partners. However, the expected outcomes on the ground --better planning, informed decision-making, equitable public services, improved natural resources management etc-- remain elusive. In this paper, we attempt to understand the shortage of desired outcomes by focusing on the practices of capturing data, related to tens of thousands of rural water points, to populate a Rural Water Database (RWD), which aims to improve the monitoring of the status of rural water supply in a sub-Saharan African country. We show that the problems that plagued the RWD are largely due to the penchant of development partners and the country's government to tackle rural water supply as a well-structured (or tame) policy problem, as opposed to the unstructured (or wicked) policy problem rural water supply really is.

## G15-3

### **Geographical aspects of geoarbitrage: Work in Canada and life in countries with low cost of living**

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The geoarbitrage means taking advantage of the difference in living costs between different geographic locations. This paper focuses on geographical aspects of international geoarbitrage based on differences in the cost of living from one country to another. More precisely, the paper shows the perspective for a Canadian (student, volunteer, entrepreneur, IT person, or retiree) with some sort of mobile income or savings who wishes to travel to another country to take advantage of the price difference. The project is based on world development indicators, which cover a wide range of criteria when moving to another country. The data were collected for approximately 200 countries and represent such criteria as: cost of living (economic factors), standard of living (such as safety, health care, environmental issues), and personal preferences (such as distance to home, Internet access or popularity of English language).

The user input is required to rank or weight the importance of each of the criteria when moving to another country. One model was developed to emphasize the cost of living by controlling the weights behind-the-scenes. The results produced a list of the top suitable countries to practice geoarbitrage. Another model allowed the user to input weights for each criteria instead of ranks. The results from either of the models were mapped based on resulting suitability values. The top selected suitable countries were mapped, and the more specific information on each selected country are presented to the user, including the detailed cost of living, and current travel warnings.



## G16-1

### **Estimation of rice biophysical parameters using multi-temporal RADARSAT-2 images**

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Compared to optical sensors, synthetic aperture radar (SAR) sensors have the special capability to acquire images in all weather conditions. Thus, SAR images are more suitable for use in rice-growing regions that are characterized by frequent cloud cover and rain. The objective of this paper was to evaluate the probability of rice biophysical parameters estimation using multi-temporal RADARSAT-2 images. Three RADARSAT-2 images were acquired during the critical growth stages in 2014 in Meishan county, Sichuan province, Southwest China. Leaf area index (LAI), the fraction of photosynthetically active radiation (FPAR), height, biomass and water content were measured at 30 experimental plots over five periods. The relationship between RADARSAT-2 backscattering coefficients ( $\sigma_0$ ) or their ratios and rice biophysical parameters were analyzed. The LAI, FPAR and biomass were significantly and consistently correlated with the VV and VH 0 ratio (0VV/0VH) throughout all growth stages, and the coefficient of determination ( $R^2$ ) reached to 0.655, 0.715 and 0.692, respectively. The 0VV/0VH also has a certain sensitivity to rice canopy height and water content. The results suggest that RADARSAT-2 data has great potential capability for rice biophysical parameters estimation and timely rice growth monitoring.

## G16-2

### **The role of radar remote sensing in oil palm plantation monitoring**

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Oil palm is recognized as golden crop, producing highest oil yield among oil seed crops. Malaysia, the world's second largest producer of palm oil, has 16% of its land planted with oil palms. To cope with the increasing global demand on edible oil, additional areas of oil palm are forecasted to increase globally by 12 to 19 million hectares by 2050. Large-scale conversion of natural tropical forest into plantation is a well-known phenomenon influencing effects in climate change, emission of greenhouse gases (GHG) and biodiversity reduction due to the loss of critical habitats for endangered species. Others include soil erosion, air pollution, soil and water pollution. Due to limited land bank in Malaysia, new strategies have to be developed to avoid unauthorized clearing of primary forest for the use of oil

palm cultivation. Microwave remote sensing could play a part by providing relevant, timely and accurate information to be used in a plantation monitoring system. The use of synthetic aperture radar (SAR) has the advantage of being daylight- and weather-independent, a criterion very relevant in constantly cloud-covered tropical regions. Using interferometric SAR, topographical and tree height profiles of oil palm plantations can be produced. This information is useful in the effort of mapping oil palm age profiles of plantations in the country. With this monitored, the replanting programme could be effectively managed to maximize national production without increasing plantation area. The study serves as feasibility study to the application of SAR in the oil palm industry for sustainable management.

## G16-3

### **A SAR knowledge-based system and its application**

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In this paper, we will introduce a backscattering knowledge-based system (BKBS), which is composed of a scattering model database, a scatterometer measurement database and a SAR image database. The application for wheat identification and wheat biomass retrieval is studied and shown as an example of the effectiveness of the system. The management of the database is based on Oracle and ArcGIS software, and the development environment of the whole system is Visual Studio 2010 with C#. The scattering model database includes scattering models of six typical targets and dielectric models of three targets so far, which are scattering models of soil, wheat, corn, paddy, forest and snow, as well as dielectric models of soil, vegetation and snow. On this basis, the scattering model database can provide theory simulation evidence for SAR image application.

As an example, the backscattering interaction mechanism between radar signal and wheat and the coherent scattering model of wheat is developed; the attenuation of the backscattering coefficient and the dominant factor of the scattering mechanism of wheat are studied. Also, factors such as azimuthal angle, band, linespacing, and incidence, which could influence the backscattering coefficient of wheat, are analyzed using scatterometer measurements. At the same time, the backscattering characteristics versus time are studied on the basis of multi-temporal quad-polarimetric SAR imagery using polarimetric synthesis and decompositions methods. From the experiment validation for wheat identification and biomass retrieval, we can conclude that the BKBS will assist effectively SAR data interpretation, identification, and parameter inversion.

## S6B-1

### Multi-sensor data fusion

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Satellite-based AIS (S-AIS) is a powerful, standardized, and proven technology for vessel traffic monitoring. It turns out, however, that S-AIS alone is not sufficient to provide continuous and comprehensive maritime domain awareness (MDA). Reasons are: temporal gaps due to limited satellite coverage and low reporting frequency, the fact that AIS transponders are not mandatory for small vessels, and false AIS reports due to technical failure or even spoofing.

In this contribution we will show which and how complementary sensors - space borne, airborne, and ground based - may contribute to an enhanced MDA. For remote areas such as the Canadian Arctic, satellite SAR (synthetic aperture radar) and optical imagery, naturally, play a key role and can be used not only for earth observation but also for vessel traffic monitoring purposes. For more local tasks such as choke point and perimeter control, or search and rescue operations, remote sensor data can be supplemented, e.g., by ground based active and passive radar systems. Based on sensor performance models, we present possible multi-sensor solutions to enhance the maritime situation picture for realistic, operationally relevant scenarios. Key elements to achieve this are robust multisource tracking algorithms that are able to cope with different heterogeneous and potentially delayed, imprecise, or misaligned sensor data, as well as contextual information.

## S6B-2

### Using message brokering and data mediation to query distributed data networks of earth science data to enhance global maritime situational awareness.

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Maritime Situational Awareness is the understanding of anything associated with the maritime domain that could impact security, safety, economy, or environment. The European Commissions Joint Research Centre (JRC) has developed the Blue Hub as an in-house research and development platform for integrated maritime surveillance and maritime situational awareness. It is applied, for example, to support counter-piracy around Africa, and to monitor the growing ship traffic in the Arctic. In order to improve maritime awareness and support risk assessment, the JRC has started to integrate data from the marine science

community. In particular the JRC is interested in using forecasts from operational ocean models and weather models. For the Blue Hub, message brokering and data mediation have become essential tools for the accessing of ocean forecast data as quickly as possible in easy to use formats.

NOAA (National Oceanic and Atmospheric Administration) is making global oceanography data available through the Environmental Research Divisions Data Access Program (ERDDAP) data broker. ERDDAP provides RESTful machine to machine communication, data brokering and data mediation by converting data to a number of standard and developer friendly ways, including some Open Geospatial Consortium formats. In this presentation we demonstrate how data brokering and mediation is making complex scientific data efficiently accessible. We show how such data are being integrated into the Blue Hub system to enhance maritime situational awareness.

## S6B-3

### Route planning and evaluation for polar ship operations: a multi-criteria risk analysis approach

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Vessels planning a passage in the Canadian Arctic face many risks, most notably from ice, extreme weather, and uncharted or poorly charted bathymetry. Many of these risks are not unfamiliar to experienced navigators in the region, but the seasonal variability of conditions in the Arctic still presents a significant challenge to vessel route planning and evaluation. Many of these risks can be mitigated, but first we must be able to characterize their impact on polar ship operations. In this talk we will discuss the use of multi-criteria risk analysis to assess the risk to ships operating in the Arctic maritime domain.

Risk assessment and visualization will be aided by the construction of a range-dependent risk grid where risk attribute data values and risk index outcomes are assigned, supporting both risk calculation and visualization. The underlying assumption of the risk grid is that at a particular point in time, geographically distributed phenomena (risk attributes and index values) possess a fixed location, which can be identified by means of a spatial referencing system. We will provide an example of how the risk grid can be used to assess the potential impact of ice conditions on planned routes through the Canadian Arctic.

## S6B-4

### **Maritime surveillance: from stakeholders' requirements to system support**

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There are several challenges when designing an innovative maritime surveillance system with respect to the basic functionalities of the system. One of the most important hurdles is incorporating the interests and requirements of multiple stakeholders within a single system. These include, but are not limited to, the agencies responsible for navigation in the Arctic, the commercial and private vessel operators, and northern communities that could be affected by traffic in their vicinity. Therefore, the system to be designed must serve as a traffic management system as well as a support system for planning and executing safe journeys through the Canadian Arctic. This talk provides a more in-depth view of one stakeholder perspective in terms of their interests in, requirements of, and purpose for using a green, efficient, and secure maritime surveillance system.

## G17-1

### **Delivering a modern geomatics program in the public sector**

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Public sector agencies at municipal, provincial, and federal levels are faced with a variety of challenges such as expenditure management, resource constraints, an aging workforce, a demand for increased transparency while client service expectations are rising. These challenges place unprecedented pressures on programs to meet expected service levels while budgets are decreasing. Additionally, the level of change in the technology landscape for geomatics is unprecedented. Long term visioning and planning in the face of short term budget reductions is critical.

A modern vision for a public sector geomatics program will be discussed with emphasis on strategy, delivering service excellence, realizing efficiencies, governance, accountability, shared services, and managing transformational change from a geomatics perspective. Providing long term, sustainable, and relevant geomatics services that reflect the requirements of the Province of Nova Scotia is the ultimate goal.

## G17-2

### **Laying the foundation for a digital Nova Scotia**

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In 2013, the Province of Nova Scotia began an effort to modernize its spatial referencing infrastructure known as the Nova Scotia Coordinate Referencing System (NSCRS). At this time, eight active GPS stations were installed in southwest Nova Scotia to evaluate the technology and its ability to address the Province's spatial referencing needs. The success of the test phase has helped to build a business case for implementing the technology across the entire Province.

It is anticipated that by the end of 2015, 40 active GPS stations will be in place across Nova Scotia. This infrastructure, known as the Nova Scotia Active Control Stations (NSACS) network, will allow for instantaneous, centimeter level positioning across the Province. Originally designed to address the needs of the surveying community, the technology has also proven to have applications in mapping, machine automation, agriculture, navigation, emergency response, earthquake detection and other areas. In the foreseeable future, all spatial data sets captured in Nova Scotia will either be directly or indirectly derived from the NSACS network. The technology will promote high accuracy and homogenous spatial data sets across the Province.

The technology behind the NSACS and the development of the system are described. Examples of how the technology is contributing to a digital Nova Scotia are presented. Future applications of the technology are also considered.

## G17-3

### **Building a spatial data infrastructure in Province of Nova Scotia**

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The design and implementation of a corporate Spatial Data Infrastructure (SDI) goes far beyond the I in SDI. As with all successful projects, there needs to be a well thought-out plan which takes into account all aspects of the project. As the Province of Nova Scotia started down the road to develop a plan for the Provincial SDI, a number of key components had to be taken into consideration that would assist in a successful implementation. One of the key components identified early on was how best to address the diversity of geographic data, technologies and requirements within the Province that would allow for the development of an SDI to support an ever expanding GIS community. The project team began its work by adopting an inclusive approach to better understand

and address any concerns of the community. As the business requirements started to take shape the project team put together a model that would address any concerns and would ultimately lead to an overall approach to implement a successful SDI. The project team put forward a flexible plan with key components to ensure successful implementation. With the guidance and help of a governance committee, stewardship and custodial models, approval committees, as well as the adoption of current standards and policies, the implementation of the Provincial Spatial Data Infrastructure has been a success and will continue to be in the future.

## G17-4

### **The evolution of a digital age at Halifax Water – developing data, apps, and people**

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Like many organizations, Halifax Water is on a journey from a paper-based to a digital world. The impact of this transition is significant for the day to day business processes and the people who perform them. This transition comes at a time when databases are being populated and new enterprise systems are being implemented. More efficient business processes are being implemented to accommodate the new enterprise systems. Many of these business processes and their resulting services are spatial in nature and require the use of spatial data often originating within a GIS. At Halifax Water, the focus is on support for real-time operations, a practice that while on-going for many years still has much growth potential. The challenge is overcoming the growing pains in getting there, including implementing an enterprise Computerized Maintenance Management System (CMMS) and overcoming traditional organization silos.

The baby steps taken at Halifax Water have already demonstrated the benefits of having GIS support for real-time operations; including faster response times in emergency situations, better informed staff, reduced environmental impact, and improved workflow efficiency. We expect the benefits will grow proportionately to the growth in GIS operations support. This presentation will look at our existing GIS and corporate initiatives underway to improve GIS support, including staff development, building the database, internal GIS emergency response measures, and an ArcGIS Online initiative for public emergency response. Finally, we will outline where we want to be and how we might achieve that goal.

## G18-1

### **Remote sensing modelling and analysis of spatial and temporal dynamics of gully erosion in Anambra State, South East Nigeria**

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Soil erosion caused by flood water, arising from increased precipitation has resulted in the development of deep gullies in different parts of South Eastern Nigeria. Soil erosion is described as an accelerated process under which soil is bodily displaced and transported away faster than it can be formed. Soil erosion starts with the delayed type of rainfall droplets, dislodging particles of soils, removing them and eventually depositing them at new location different from the original site. Flood water accelerates the process of soil erosion in areas where the soil is not protected by vegetation cover.

In South East Nigeria, the most predominant and destructive erosion type in the area is gully erosion. Annually, human lives and properties are lost to expanding gullies in the State. Both the State and Federal Governments through the World Bank assisted Nigerian Erosion and Watershed Management Project (NEWMAP) have invested large sums of money in fighting this ecological monster. However, with the increased rainfall and subsequent large volumes of overland flow, assisted by deforestation and uncontrolled urbanization in the area, the number of deep gully sites keeps increasing. This paper presents a study carried out to map and analyse the spatial and temporal dynamics of gully erosion in parts of Anambra State in South East Nigeria. The methodology integrates Remote Sensing, GIS and GPS techniques to capture and characterize the spatio-temporal dynamics of gullies in the area. The annual rate of expansion of the gullies in the area was found to be 0.0657 Sq. Km.

## G18-2

### **Mapping the extension and intensity of natural disasters by using social media data**

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Acquiring timely, accurate, and cost effective data is a priority to reinsurance companies to insure insurance companies. When a reinsurance company assesses the damage of a natural disaster, it usually sends experts to the disaster area in order for them to accurately report on the extent and intensity of the disaster. These experts take photographs and describe the damages and estimate the forthcoming claims people will make to insurance companies in order for the reinsurance company to appropriately allocate the necessary funds to insurance

companies. This is a costly process, especially with respect to time. The benefit of a near real-time estimation of disaster claims using social media networks is that it can provide this information in a cost-effective manner. This research aims to develop an analytical workflow to explore the potential use of geotagged photographs in the Flickr social network to map the extent and intensity of a natural disaster. The first step is to retrieve a subset of data that includes only the relevant geotagged photographs. Once this step is performed, the extension and the intensity of the disaster can be computed through spatial analysis and visualization techniques. Hurricane Arthur and Hurricane Sandy were used in the investigation as examples and the area of focus was New York in the USA and the Maritime Provinces in Canada. The results show that the extent and intensity of the hurricanes were best computed by using the buffering zones and spatial aggregation methods.

## G18-3

### **Earthquake area estimation using DMSP-OLS night-time imagery and statistical data**

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In recent years, several earthquakes caused massive bodily injury and property damage. The lack of information about earthquake damaged areas hampers effective emergency response and relief. Remote sensing data is a useful information source about earthquake location, extent of damage, and loss distribution. Especially, night-time images are useful to estimate earthquake area. We employ the DMSP-OLS night-time images and other statistical data to estimate earthquake areas for the WenChuan earthquake and YuShu earthquake.

In this paper, we propose a new program to analyze earthquake area and estimate the disaster loss. 1) Acquire the corresponding DMSP/OLS night-time images of the earthquake area. The images include VNIR images before and after the earthquake. 2) Estimate the damaged areas by analyzing the statistical data and the light images with a disaster statistical model. 3) Create a thematic map to present the estimation results. 4) Publish the thematic map on our Digital Earth Science Platform. This platform can display various types of data including high resolution images, DEM, and DMSP/OLS night-time images, so the earthquake thematic map can be browsed and used by researchers, rescue workers, and government departments.

## G18-4

### **Parallel numerical study on the assessment of earthquake-triggered landslide with remote sensing image calibration**

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Earthquake-induced landslides are serious natural hazards that caused casualties and large economic damage in many mountainous regions around the world. The Wenchuan earthquake, which occurred on May 12, 2008 with the highest magnitude of Ms8.0, triggered widespread and destructive landslides and rockfalls in the Longmen Shan area of a densely populated mountainous area in Sichuan Province of China, and cause serious economic and property losses. Possibly due to the complexity of the seismic dynamic characteristics and local geo-environment conditions, predicting earthquake-induced landslides is difficult with the limited knowledge of predictions of where and when earthquakes will occur in future. Nowadays GIS-based methods of landslide susceptibility mapping are widespread because of the relative low costs and the better effectiveness. But, in many cases such kind of approaches suffers from over-simplification and needs a deeper review of applied techniques. Stability analysis on the earthquake-induced landslide requires consideration of earthquake shaking influencing on the stress-deformation behavior and failed pattern of the slope. In this study, we obtain the stress fields and strong ground motion based on the three-dimensional model incorporated with high accuracy digital elevation model and key fault parameters.

## G19-1

### **Climate change adaptation and coastal communities: a global assessment**

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Adapting to climate change is becoming a political imperative globally, and this is especially true in coastal regions that are highly vulnerable to flooding and sea level rise. Coastal regions are also vulnerable social-ecological hotspots owing to the high level of biodiversity and natural resources, maritime industries, human population clusters, and multiple stakeholders. Supporting adaptation decision-making of coastal communities, and corresponding governmental policymakers, is crucial in securing critical coastal infrastructure, livelihoods, and maritime

industries. To this end, a worldwide systematic review and geo-spatial mapping process has been carried out to identify and assess where and how climate change adaptation initiatives are taking place globally, and what policy lessons and best management practices are available for potential replication and scaling-up.

Preliminary results indicate adaptation interventions are taking place through various entry points. Key amongst these are disaster risk reduction, development planning, ecosystem health, and resource-based livelihoods. Various patterns also emerge, such as an emphasis on institutional planning and knowledge transfer, as well as on soft measures that target natural resources and environmental management. Thus, communities that are better prepared or ready to cope with coastal hazards are those that take an integrated approach, and are well engaged, resourceful and empowered to take local actions across multiple sectors and institutional levels. Our findings have implications for adaptation planning and mainstreaming efforts, and in building the local adaptive capacity for vulnerable coastal regions.

## G19-2

### **The Community Adaptation Viewer (CAV): a web GIS tool to support community response to climate change**

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Drawing from a case study situated in southeast New Brunswick - an area vulnerable to coastal flooding from sea level rise - this study presents the findings of the Community Adaptation Viewer (CAV), a web-based spatial decision support system (SDSS) software project. The thin-client, Javascript enabled web-SDSS software was constructed to allow interaction with urban infrastructure, and support on-the-fly assessment of social and economic vulnerability. Facilitated, decision-making workshops were conducted with small groups of stakeholders to evaluate the effectiveness of the prototype. The test case illustrates that high levels of information integration are practical to achieve, and that the SDSS can significantly enhance the ability of communities to conduct elaborate, geographically-specific climate change adaptation planning. However, significant impediments can continue to limit the ability of communities to proactively respond to the findings of such projects: lack of leadership, unwillingness on the part of the community to face their vulnerability, lack of public awareness, and lack of resources.

## G19-3

### **Responses of coastal flood risk to climate change: A comparative analysis of hanghai and Jakarta**

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Currently, sea levels around the world are rising due to global warming which dramatically increases the odds of damaging floods in coastal zones. It is difficult, however, to predict exactly how coastal flood risk will change in response to a specific rise in sea level at a particular location in time. The ability to predict this change is limited by uncertainties in both currently available data that describes the coastal environment, as well as gaps of appropriate models to simulate the flooding process in national-scale. The present work: (1) Comprehensively analyses satellite altimetry product and tide-gauge station record, and predict changes of extreme high water level under future global change using extreme value theory; (2) Demonstrates an innovative framework for large-scale coastal flood risk analysis. The framework integrates remote sensing images and hydraulic model for rapid and high-performance simulation of coastal flood events and prediction of future flood risk responses to different sea level scenarios. (3) Focusing on two big coastal cities Shanghai in China and Jakarta in Indonesia, we have a comparative analysis of the two cities to project coastal flood risk in different future sea level rise scenarios. Spatial and temporal progress of coastal flood in big cities is visualized based on a virtual globe, digital earth science platform (DESP). The research will contribute to a better understanding of coastal flood risk changes from sea level rise and provide methodology and information for management and ensuring sustainable development for coastal zones.

## G19-4

### **Dynamic spatial-temporal analysis of China's coastal vulnerability due to climate change**

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In the context of global climate change and the further implementation of China's economic reform and opening-up policy, coastal zones in China become more and more vulnerable, which has attracted wide attention from the society and scientists. Several studies have investigated the impacts of climate change on the Chinese coastal regions based on the assumption that the coastal system is static, and less attention has been paid

to the dynamic variation of the coastal vulnerability to climate change. Considering the complexity and dynamic nature of coastal systems, this paper introduces a spatial-temporal dynamic analysis approach to assess coastal vulnerability in China. The dynamic analysis approach integrates System Dynamics modeling, the Digital Earth Science Platform and multi-criteria analysis method all together. The coastal vulnerability temporal model is developed based on System Dynamics and multi-criteria analysis. The coastal vulnerability spatial model is established on the Digital Earth Science Platform. Several scenarios for climate change and social-economic situations are proposed to simulate the complex and interactive coastal systems. The coastal vulnerability under the assumed scenarios is assessed by the loosely coupled temporal model and spatial model. The results of the dynamic vulnerability assessment indicate that, the main three deltas: the Yellow River Delta, the Yangtze River Delta and the Pearl River Delta show distinct variation in vulnerability due to sea level rise and rapid urbanization.

## K8

### **New Approaches to Observing the Ocean Frontier**

Wallace, D

The ocean is a frontier that defines and connects nations, continents, economies and communities. The ocean frontier offers both risk and enormous opportunity and sustains the Earth and our human systems. As global population advances towards 10 billion and technology advances, the ocean frontier take on ever greater importance for ecosystem services, food, energy and global trade. Yet the ocean frontier remains largely unexplored and poorly understood. And it is changing: maybe faster than we can measure or comprehend. Arguably, the ocean's vastness and opacity to exploration, observation and communication contribute to a false sense of planetary security ("out of sight, out of mind"). The presentation will survey ocean change and the changes in how we observe our ocean environment. The need for vastly improved methods of ocean observation and information sharing will be emphasized.

## S7-1

### **Airborne Lidar Bathymetry (ALB) in the Canadian Hydrographic Service (CHS) and the Department of Fisheries and Oceans (DFO), Atlantic Region (2011-2015).**

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By conducting annual investigative and production ALB surveys of various areas in Atlantic Canada the CHS and DFO have been

actively involved in introducing this technology into program operations since 2011. These surveys have been conducted to investigate the implementation of ALB technology for hydrographic surveying, the production of various nautical publications (such as charts), and to support multiple DFO science program objectives. An overview of ALB surveys between 2011 and 2015 conducted in Atlantic Canada by CHS and DFO is provided with a description of the scientific and hydrographic applications of this data for recent projects. Within this overview, several areas of detailed study and application are presented relating to combined ALB and Multibeam Sonar surveys in Mahone Bay and Halifax Harbour, NS. Study areas that primarily involved ALB data collected in Kingsport, Lobster Bay, and Isle Madame, NS, are also described in the context of the DFO science projects they support.

ALB technology has proven extraordinarily productive in relation to quantitative data collection, but the analysis and application of these large data sets can be very challenging. The unique issues of using ALB point cloud data, reflectivity information, and associated high resolution imagery in conjunction with other hydrographic and science data sets is presented in the context of the evolving analytic methods and project management requirements. A summary of findings is included, along with our shared experiences from these projects and a forward view of CHS and DFO activities that can benefit from this maturing technology.

## S7-2

### **Results from shallow water topo-bathymetric lidar surveys in Maritime Canada**

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Nearshore coastal areas are highly productive and dynamic and are not well mapped as a result of the limitations using traditional mapping methods designed for land or deeper water areas. The nearshore is often depicted on maps with interpolated data or a data gap, known as the white ribbon. A new generation of shallow water topo-bathymetric lidar sensors offers the ability to survey these areas at a lower cost and at higher resolution compared to traditional larger deep water bathymetric lidars. Nine separate areas were surveyed in Maritime Canada in Sept. 2014 using the Leica AHAB Chiroptera II topo-bathymetric lidar coupled with an RCD30 camera. The study areas ranged from bays along the Northumberland Strait in New Brunswick and Nova Scotia and two sites on the Atlantic coast. Weather conditions were suitable for flying and acquisition although the wind did cause some issues with increased turbidity of the water in some locations. Seamless DEMs have been constructed from the data to depths of 6 m below sea-level to support hydrodynamic modelling to support applications such as aquaculture site selection and oil spill preparedness. In addition to mapping the bathymetry, the

lidar and photos have been used to develop a variety of methods to map sea grass with accuracies of 80%. To date the derived lidar point cloud has been used for the processing, while current research efforts are focused on the ability to extract more metrics and points from the waveform data that are stored for every bathymetric laser return.

## S7-3

### **Assessment of airborne LIDAR bathymetry performance with Chiroptera I**

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Understanding water clarity, which directly limits Lidar depth penetration performance, is a challenging task for airborne bathymetric surveys. Sediment particles, organic matter, the reflectivity of the water surface and the bottom, and other causes quickly attenuate the light beam return energy, ultimately limiting the penetration depth.

This study presents a quantitative assessment of water quality conditions and their direct impact on bathymetric Lidar penetration performance. We have collected airborne Lidar data at three different locations (North Slope, Alaska; Shamrock Cove, Texas; and Lake Travis, Texas) and assessed our findings. Field water analyses have been conducted at Shamrock Cove and Lake Travis, while the Alaska survey findings were correlated from RapidEye spectral imagery. These findings are expected to help to characterize bathymetric waveform performance in turbid water conditions, and contribute towards building and validating the sea-bed reflectance (SRA) algorithm, which can be used to validate and improve the murky water algorithm (MWA).

## G20-1

### **An unsupervised change detection procedure using luminance and saturation for multispectral remotely-sensed images**

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Unsupervised change detection techniques have been widely employed in remote sensing when suitable reference data is not available. Image (or Index) differencing is one of the most commonly used methods due to its simplicity. However, past applications of image differencing were often inefficient in separating real change from noise, due to the lack of steps for feature selection and integration of contextual information. To address these issues, we propose a novel unsupervised procedure which uses two complementary features, namely luminance and

saturation extracted from multispectral images, and combines T-point thresholding, Bayes fusion, and Markov Random Fields. Through a case study, the performance of our proposed procedure was compared with three other unsupervised change-detection methods: Principal Component Analysis (PCA), Fuzzy c-means (FCM), and Expectation Maximum-Markov Random Field (EM-MRF). The change detection results from our proposed method are more compact with less noise than those from other methods over urban areas. The quantitative accuracy assessment indicates that the overall accuracy and Kappa statistic of our proposed procedure are 95.1% and 83.3% respectively, which are significantly higher than for the other three unsupervised change detection methods.

## G20-2

### **Speckle reduction in SAR images using filters of adaptive window size**

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Speckle is a challenging phenomenon in Synthetic Aperture Radar (SAR) images which degrades the radiometric quality and makes the visual interpretation of such images more difficult. Since the early days of SAR image processing, several speckle suppression algorithms have been introduced in the SAR community. A problem associated with the previous methods is the selection of filters window size which is not straightforward, particularly for the images containing natural and man-made objects of different size. In this paper, we propose a speckle filtering approach in which the window size is selected automatically. The proposed method applies the Gaussian filter in different scales (sizes) from small to large to the SAR image. A Gaussian filter was selected because it does not make an interruption in filtering as a result of the slow change in its coefficients, but it gradually cuts down on the effect of filtering. Moreover, its effect is circular and not rectangular, which is more harmonious with real world objects. While applying a Gaussian filter in different scales, the standard deviation of pixels within the window is calculated for each scale and the scale with minimum standard deviation is selected. The proposed method was implemented on a single channel SAR image of San Francisco. Visual results show that the method perfectly preserves the edges. Moreover, for polarimetric SAR images the scale is selected using all three polarimetric channels. Results show that for PolSAR imagery, the proposed approach outperforms the Lee filter in that edges are perfectly preserved and speckle is effectively reduced.



## G20-3

### **Using 3D geovisual analysis to quantify the performance of tsunami risk communication**

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Tsunami risk mitigation programs often include evacuation signage to direct locals and visitors to safety during a tsunami event. This paper describes research we performed to quantify the performance of evacuation signage visibility using LiDAR data and visibility analysis. Detailed signage attributes (not just location) were used to assess their visibility relationships with landscape, buildings, infrastructure, vegetation, land use types, and likely citizen exposure in Seaside, Oregon. We developed a topologically 3D approach to visibility analysis using raw LiDAR datasets, enabling quantification of areas from which evacuation routes might be identified (through visibility of signage), and comparison of conventional and 3D visibility analyses.

Our work revealed patterns of differential evacuation signage visibility in residential, commercial and recreational regions of the landscape. Our 3D versus 2D approach to the conceptualization of signage attributes and their analysis delivers a methodology with which to systematically assess the performance of alternative signage deployment strategies, taking into account the morphological complexities of unique coastal environments at risk from tsunamis. This work also underscores the importance of developing three-dimensional GIScience methods for inherently three-dimensional challenges, and their potential for use in hazards research.

## G21-1

### **EO-based indicator development for measuring sustainable urban transportation in the Great Lakes region**

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Urbanization is a global trend and has significant implications for resource consumption and environmental quality through transportation activities. The level of travel activity and hence the level of transportation related energy consumption thus air pollution are influenced by the land use structure of cities, i.e. their urban forms. Satellite remote sensing is an effective source to provide spatial information on urban land use. Moreover, for measuring the impacts of urban form on urban transportation, it needs integration of the land use information derived from remote sensing with relevant demographic information. This presentation demonstrates a comprehensive regional urban database, the Great Lakes Urban Survey (GLUS) created for

improving understanding of the effects of urban form on transportation activities. The GLUS includes the information based on integration of land cover land use maps derived from Landsat imagery with demographic data for 22 major urban centers in the southern part of the Great Lakes watershed. Furthermore, the application of GLUS to provide insights into the urban form and transportation link through quantification of indicators (such as urban intensity, transportation mode and land use mix) is also presented.

## G21-2

### **Visual reconstruction research of Cambodian Takeo Temple based on DESP and construction rules**

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The Chinese- Cambodia Government Regulatory Assistance Project for conservation and restoration of Angkor Takeo temple started in 2010, and will last for the next eight years. Due to rain erosion and war, Takeo has been badly damaged: the structure is not complete, components have been lost, and there are no ancient architectural blueprints left. Based only on the existing ruin, how can reconstruction work be pushed forward? To solve this problem, the Virtualization Technology department of the International Centre on Space Technologies for Natural and Cultural Heritage (HIST) of UNESCO combined parametric building modeling technology and a priori construction rules about Angkor to create a complete virtual simulation model of Takeo temple based on the Digital Earth science platform (DESP). The first step was to scan the existing Takeo sites by Lidar. The second step split the cloud-generated model into building parts according to Angkor construction characteristics. In the third step we visually re-created Takeo from small to large scale, in accordance with Angkor building rules, from components to structure to distribution. Finally, we present a complete Takeo temple model, affirmed by Cambodian Angkor Wat heritage experts and administration for further restoration.

## G21-3

### **Road pavement condition mapping and assessment using remote sensing based on MESMA**

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Hyperspectral remote sensing holds the advantages of wide band coverage and high spectral resolution that can be used to map the pavement condition. Previous studies concluded

that different pavement conditions are characterized by distinct spectral information, such as brightness, reflectance, emissivity and temperature etc. However, limited spatial resolution always restricts classification accuracy because of massive mixed pixels. Pure road surface pixels are rare, and surrounding land cover types affect the spectral signal and add significant variability and uncertainty to the analysis of road conditions. Multiple Endmember Spectral Mixture Analysis (MESMA) is a useful tool to improve the mapping result for mixed pixels; it has been used extensively to evaluate the vegetation fractional coverage.

In this paper, the asphalt concrete road was the subject of our research. Based on extensive field spectrum measurements, we summarized the spectral characteristics of asphalt pavement undergoing different degrees of aging, and subdivided pavement conditions into five classes, i.e. excellent, good, fair, poor, and very poor. Then the MESMA was first tested to map the asphalt pavement condition using WorldView-2 satellite imagery with eight bands spanning from the visible to the infrared. Pure pixels corresponding to different road surface conditions were extracted from the imagery and field spectrometer data, respectively. Supervised and unsupervised classification methods were employed simultaneously. The result indicated that MESMA was well suited to classify the mixed pavement pixels polluted by lateral vegetation or buildings. It could provide detailed pavement condition information comparable with common mapping methods, and it can further improve classification accuracy.

## G21-4

### **Early aerial photography and its contribution to Digital Earth – the case of the Halifax Air Survey Mission in 1921**

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The paper presents research into the military and civilian history, technological development, and practical outcomes of aerial photography in Canada immediately after the First World War. The collections of early aerial photography in Canada and elsewhere, as well as the institutional and practical circumstances and arrangements of their creation, represent an important part of remote sensing heritage. It is argued that the digital rendition of the air photos and their representation in mosaic form can make valuable contributions to Digital Earth historic inquiries and mapping exercises today.

An episode of one of the first urban surveys, carried out over Halifax, Nova Scotia, in 1921, is highlighted and an air photo mosaic and interpretation is presented. Using the almost one hundred year old air photos and a digitally re-assembled mosaic of a substantial portion of that collection as a guide, a variety of features unique

to the post-war urban landscape of the Halifax peninsula are analyzed, illustrated and compared with current land use.

The pan-chromatic air photo ensemble at a nominal scale of 1:5,000 is placed into the historical context with contemporary thematic maps, ground-based photography, and modern satellite imagery, and also with artists representations, which similar to the 1921 air photos have preserved urban streetscapes that no longer exist. Further research opportunities concerning outcomes and present day applications of early Canadian aerial photography are discussed.

## G22-1

### **The Digital Earth Science Platform: An integrated platform for the next generation Digital Earth**

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Over the past two decades, Digital Earth has provided a novel vision for human to understand the Earth. Spatial information service software typified by Google Earth have been used and have played important roles in spatial information retrieval and location based service. These improvements have already made digital earth technologies a popular tool which greatly influences various aspects of humans modern day life. However, the digital earth system is more than an information retrieval and location based service. An advanced digital earth system needs to take full advantage of the next-generation technologies, including full-spectral, wide-field, and long-term earth observation, big data management and processing, and multi-dimensional visualization and simulation.

The Digital Earth Science Platform (DESP) is an integrated system for the next-generation Digital Earth, which is developed by the Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences. It has achieved significant achievements in a series of key technologies, such as platform construction, spatial data acquisition, multiple heterogeneous data processing and analysis, petabytes spatial information management and service, geo-information accurate inversion and application, and high-precision complex three-dimension scenario simulation. The DESP is composed of a technology system and an application system. It realizes efficient analysis on earth science data from remote sensing observation as well as applications in multiple fields. It has played important roles in global climate change and emergency response for earthquake disasters.

## G22-2

### **Technology system of the Digital Earth Science Platform: a system of systems**

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To meet the demands of public access to science and national application in several fields, such as global climate change and natural hazards, we developed an integrated Digital Earth Science Platform (DESP) technology system, which is the specific execution system for the platform. The DESP technology system is a seamless complex system. It is composed of five sub-systems. The five sub-systems include a rapid planning and processing sub-system for multi-source remote sensing data, a management and aggregation sub-system for massive spatial data, a spatial information service and scientific data sharing sub-system, a data-intensive analysis and high performance computing sub-system, and a geographic simulation and visualization sub-system. The DESP technology system is not only an operational platform for earth system research and application, but also an information release and visualization terminal.

The DESP technology system makes progress in a series of key technologies, including multi-dimensional visualization in uniform geographic framework, high performance computing of geo-information, spatial data analysis and simulation. It solves the key issues in programming and scheduling of satellite orbits, and distributed heterogeneous spatial data storage and management. Also, it builds a common framework for data-intensive rapid processing, which integrates more than 150 kinds of visualization models and algorithms. The DESP technology system is able to provide integrated processes including rapid plan and data processing, data service and sharing, cooperative information analysis, accurate simulation and assessment, and scientific decision-making.

## G22-3

### **Multi-viewpoint autostereoscopic visualization for 3D Digital Earth**

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In this paper we introduce a multi-viewpoint autostereoscopic visualization approach to express 3D digital earth information.

Multi-viewpoint autostereoscopic visualization technology allows for viewers to obtain stereoscopic effect without wearing glasses. Viewers can get different stereo images at different positions from autostereoscopic display devices, so it can provide more information for viewers. By increasing viewpoints, the viewer can be getting more spatial information; when the count of viewpoints is more than a certain number and its resolution is enough, the display effect can be the same as a holographic picture. The technology can slip the leash of a single 2D image and greatly promote viewers to intuitively comprehend spatial information in 3D digital earth, such as height or gradient information. The paper is composed of three parts: the virtual cameras configuration method to get autostereoscopic images in Digital Earth; the fast algorithm to generate multiviewpoint autostereoscopic images based on DIBR (depth image based rendering) technology; the influence of display device parameters on the expression of 3D digital earth information. The effectiveness of our approach is demonstrated with a twenty-eight viewpoint autostereoscopic display device that can display dynamic 3D digital earth scenes with stereo parallax and movement parallax.

## G22-4

### **Augmented virtual environments: Fusion of real-time Video and 3D models on the Digital Earth Science Platform**

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The entire process of establishing a wide-field Augmented Virtual Environment (AVE) by fusing real-time videos with 3D models is presented: acquisition, projection, tracking and fusion. The Real Time Streaming Protocol and custom image conversion algorithm had been used to acquire and decode the real-time videos and then convert them to image streams which are supported by a 3D rendering engine. The reverse projection culling algorithm and depth test algorithm were applied to the fragment shader based on OpenGL Shading Language (GLSL) to eliminate the errors of reverse projections and texture distortions which resulted from the technology of projective texture mapping. In order to track the moving objects in the video, display them in the 3D environment and draw their trajectories, continuous frame difference and real-time location methods were applied during decoding the video and projecting the video texture. Finally, a horizontal weighted algorithm and diagonal weighted algorithm based on GLSL were implemented and applied to fuse the overlap area of two adjacent videos to eliminate the obvious video seams.

Based on Digital Earth Science Platform (DESP) which was developed by the Institute of Remote Sensing and Digital

Earth, Chinese Academy of Sciences, a realistic and wide-field Augmented Virtual Environment had been created. The result showed that the proposed algorithms could fuse multiple real-time videos with 3D models and track moving objects efficiently, running a 3D scene containing 2 million triangular facets and 6 real-time videos at more than 40fps[DVP1] on a computer with 1GB graphics card memory.

## K9

### **Big Data, Open Data and the Ethics of Data-Driven, Networked Urbanism**

Kitchin, R

There is a rich history of data being generated about cities concerning their form, their citizens, the activities that take place, and their connections with other locales, with various kinds of data-informed urbanism occurring. A new era is presently unfolding, however: data-driven, networked urbanism. Here, urban operational governance and city services are becoming highly responsive to a form of networked urbanism in which big data systems are prefiguring and setting the urban agenda and are influencing and controlling how city systems respond and perform. Many of these data are becoming open in nature and thus sharable and re-usable in diverse ways. Data-driven, networked urbanism is, I argue, the key mode of production for what have widely been termed smart cities. This paper considers the promises and perils of smart cities and the ethics of data-driven, networked urbanism focusing on the politics of urban data, the corporatisation of governance (data ownership, data control, data coverage and access); the creation of buggy, brittle, hackable urban systems (data security, data integrity); social, political, ethical effects (data protection and privacy, dataveillance, social sorting, and anticipatory governance); and technical data issues (data quality; veracity of urban data models and data analytics; data integration and interoperability). It contends that a key challenge facing urban managers and citizens in the age of smart cities is to realise the benefits of data-driven, networked urbanism whilst minimizing its pernicious effects.

## K10

### **Big Data in Smart City**

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In this Lecture, Prof LI Deren will introduce the concept of smart city and summarise its development process. Then, he will describe the key technologies of smart city and the proposed smart city infrastructure. Smart city is based on digital city, Internet of things (IOT) and cloud computing, which will integrate the real world with the digital world. In order to

achieve a comprehensive awareness and control of people and things, with intelligent service followed, smart city with mass sensors will continue to collect vast amounts of data which is called Big Data. Some typical kinds of Big Data such as geospatial image, graph and video data are analyzed. The Big Data of smart city is not only a scientific frontier, but also the driving force to promote the development of smart city, which will bring new opportunities and challenges. After that, Prof Li will propose a strategy to deal with spatial data mining and knowledge discovery from the Big Data as well as define the basic framework for smart city big data operation center, which eventually shape a bright future of for the smart city.

## S8-1

### **Aggregation and spatial analysis of walking activity in an urban area: results from the Halifax space-time activity survey.**

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This study examines neighborhood characteristics affecting the incidence of walking trips in urban and suburban areas of Halifax, Canada. We employ data from the Space-Time Activity Research (STAR) survey, conducted in 2007-8. Primary respondents completed a two-day time-diary survey, and their movements were tracked using a GPS data logger.

Primary respondents logged a total of 5,005 walking trips, specified by 781,205 individual GPS points. Redundant and erroneous points, such as those with zero or excessive speed, were removed. Data points were then imported into ArcGIS, converted from points to linear features, visually inspected for data quality, and cleaned appropriately.

From mapped walking tracks we developed hypotheses regarding variations in walking density. To test these, walking distances were aggregated by census tracts, and expressed as walking densities (both per resident and per metre of road). We employed multivariate regression to examine which neighborhood variables are most useful as estimators of walking densities. Contrary to much of the planning literature, built-environment measures of road connectivity and dwelling density were found to have little estimating power. Office and institutional land uses are more useful estimators, as are the income and age characteristics of the resident population.

## S8-2

### **Understanding human activity patterns from space-time-semantics**

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Human activity influences the way urban system formulates. The urban system, on the other hand, mediates feedback to human activity through a diverse set of processes and mechanisms, including behavior, thoughts, language, and psychology. Figuring out how the pattern of human activity forms thus plays a key role in various applications concerned with the urban environment. Existing work on modeling human activity patterns mainly focuses on spatial-temporal dimensions, which lack consideration of related semantic information. In fact, what people do at some places cannot be ignored because the motivation behind the movement to those places is important when considering activity patterns related to the movement. If a mobility pattern is illustrated as a type of expression of human behavior in terms of its spatial-temporal dimension, the mechanism that leads to the formation of such expression should be a type of reflection of the related semantic information (i.e., text recording normal life and opinion on current events) pattern.

In this study, we aim to model human activity patterns based on space, time and semantics. We develop a method to express human activity patterns by using topic models to compute the probabilistic distribution in terms of space, time and topics. A case study is conducted using Twitter data in Toronto. We look into the difference between the patterns with and without involving semantic information. The result shows that although some people have highly similar mobility patterns, the similarity of their activity patterns may be different after considering related semantic information, which is captured from tweets.

## S8-3

### **ChoroChronos: a geoportal towards mobility data provenance**

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Currently, there is a strong interest in developing advanced methods for knowledge extraction from massive amounts of moving-object related data. Related to this need, the community requires methods and tools that allow keeping track of the ancestry of data in terms of events that take place during its lifecycle and other related information associated with its creation, processing, and archiving. In this paper, we outline the architecture

and functionality of the ChoroChronos web-based geo portal (online available at [www.chorochronos.org](http://www.chorochronos.org)) for delivering, sharing, and testing mobility data sets and algorithms. Bottom-up, the portal comprises a moving-object database engine for the efficient storage and management of the spatiotemporal content, an open source content management system for the flexible organization of the associated metadata, and a collection of appropriate tools for the geo-visualization of the mobility data. ChoroChronos aims to serve as an infrastructure for the development of various types of mobility-centric applications, a useful tool for researchers in the areas of mobility data management, analysis, and mining, and, ultimately, a means towards mobility data provenance.

## S8-4

### **Contextual Line Simplification**

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In this paper, we develop a constrained Douglas-Peucker algorithm using a polyline to be simplified and other geometries as contextual constraints. We develop a contextual model that incrementally rewinds to the original polyline with relevant characteristic vertices to resolve contextual conflicts. Constraints covered in this paper are topology and direction. Our implementation shows a consistent representation and a technique to accelerate multi-scale simplification of polylines.

## G23-1

### **A comparison of in-person versus digital earth environmental scans for population health studies**

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In this paper, we compare the efficacy of using digital earth (i.e. Google Streetview and remotely sensed data) versus walking environmental scans to assess health risks associated with the built urban environment. Environmental scans involve systematically assessing features of the built environment that are correlated with a specific risk. Increasingly environmental scans are used in spatial epidemiology and population health to determine which, if any, elements of the built urban environment are associated with increasing incidence of injury or risk of disease. These scans are, however, expensive and people-intensive as they require multiple in-person visits to the area under investigation. When the hotspots are in low resource or remote areas, these costs escalate. Here, we describe the protocol developed by the authors to conduct environmental scans for population health studies and compare it to the results of digital environmental scans using both Google Streetview and high-resolution remotely

sensed data. The comparison is conducted to assess both pedestrian injury hotspots and childrens play deserts, as each of these health risks is associated with very different elements of the built urban environment. We then present the pros and cons of each method of assessment, and suggest best practices for the use of digital methods both in digitally well-documented urban areas and in low resource and remote settings.

## G23-2

### **Citizens, empowerment, and accountability on the World Wide Web 2.0**

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In May 2012, faculty from the technical and social sciences at the University Twente and at the University Dar es Salaam launched a multi-year research project titled Sensors, Empowerment and Accountability in Tanzania. Our research approach follows the grain of citizen-government relations in Tanzania and is against the tide of the dominant discourse that looks at the World Wide Web 2.0 (WWW 2.0), democracy, empowerment, voice, accountability, and good public services as magic variables linked in a mutually beneficial way - all good things go together. We developed a political application on the WWW 2.0, called SEMA, with a deceptively simple design, and tested it in the field. With the SEMA app, citizen-sensors can sense the quality of government services, e.g. rural water supply, and upload the data via standard mobile phones on a dashboard. Government officials can view the data and respond by alerting citizens that the problem is acknowledged and will be resolved. In this paper, we present preliminary answers to the question: to what extent can citizens directly exact accountability from water providers with political apps on WWW 2.0?

## G23-3

### **Pixels, plows & partnerships: Designing for food deserts**

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Food security is a growing dilemma among today's low-access and low-income communities. Poor nutrition literacy, inadequate transportation, and substandard product quality all contribute to the emergence of food deserts, affecting millions of families worldwide. Meanwhile, consumer behavior that responds favorably to grocery apps (which are marketed to the same demographic as other health-related information

goods) does not always scale. The current retail landscape is increasingly subject to Walmartization, where shoppers' choices are limited by their reliance on assistance-benefit spending and stores' overabundance of non-perishable stock.

Developing and maintaining healthy behaviors is a learned skill with many cultural and socioeconomic influences. Inspired by technology startups in developing countries, social enterprises around the globe have succeeded in delivering innovative, cost-effective solutions where government interventions have failed. Renewed interest in local agriculture, particularly among members of urban tech communities, reveals new strategies for how people use the Internet to acquire and use the food they eat. This research, based on real-world case studies, examines the technological and societal aspects of nutrition literacy. By exploring the impacts of interaction design and personal empowerment on food distribution, we can uncover surprising ways in which digitally interconnected marketplaces are bridging the gap between farms and forks.

## G23-4

### **Digital collaboration around the globe: crowdsourcing of local experiences on community-based conservation**

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Environmental and natural resource challenges are faced in every local community on the planet, ranging from a polluted river to a depleted forest to one of many impacts of climate change. Many communities are taking action to deal with these challenges, linking together community-based conservation and pursuit of sustainable livelihoods. The Community Conservation Research Network (CCRN) is a global initiative examining community-based conservation through a Social-Ecological Systems framework that integrates human and natural systems, and incorporates environmental, economic, and social outcomes.

The goal is to effectively assess the practical features and subsequent impacts of conservation initiatives carried out at a local level, as well as the policy interactions with those initiatives. To achieve this goal on a global basis, iMapp has been developed as an online application through which local experiences of community-based conservation worldwide are being crowdsourced into a single interactive database, providing both a research tool and an educational resource. We show how a meta-analysis enabled by iMapp identifies the conditions under which communities remain resilient in the face of environmental and economic challenges. We discuss, in particular, results which show how values and incentives affect stewardship outcomes and how governance arrangements encourage healthy stewardship and livelihood outcomes. We conclude by showing

how these global results can be used by local-level communities to achieve better conservation and livelihood outcomes.

## G24-1

### **Mapping renewable potential to accelerate the transition to clean energy.**

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Geographic Information Systems present layers of data for better understanding and a clearer path for the future. Three nations, the United States, India, and China are crucial to the transition to renewable energy. In 2015, all three nations continue to use a majority of fossil fuels and each is a net-importer of fossil fuels; yet our maps reveal that each nation has over-abundant renewable potential capacity within its own borders. Each of these nations has the adequate resolve, technological know-how, and economic flexibility to move to a 100%-renewable solution. The importance of these three nations is immediately apparent in any plan to mitigate the consequences of climate change.

The Global Energy Network Institute (GENI) has been creating renewable energy potential maps, at <http://www.geni.org/globalenergy/library/gis>, which focus on solar and wind resources. GENI provides a consistent view as local and regional efforts unfold. Today's net importers can be motivated to renewable-based self-sufficiency as a matter of national security and stability. With the potential to be exporters of clean energy comes income and increased regional stability. GENI's plan for the interconnection of electric power networks between communities, nations, and continents considers the optimal locations for renewable development and the necessary transmission lines needed to get the power to markets. As the highest priority of the World Game, per R. Buckminster Fuller, linking renewable energy between nations mollifies conflicts, grows economies, and increases the quality of life and health for all.

## G24-2

### **An online GIS decision making tool for tidal energy in Atlantic Canada**

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In-stream tidal energy development is underway in several high flow locations in Nova Scotia, Canada. Significant effort and funding have been focused on site assessment and

environmental studies aimed at supporting risk reduction and informed decision making for the developing industry. Given that much of the data available for the tidal energy industry in Nova Scotia is in the form of lengthy technical reports and large data sets housed by numerous institutions, extensive legwork is required to access information that is needed for business development and community engagement.

The Acadia Tidal Energy Institute (ATEI), a multidisciplinary team of Acadia University faculty, staff, students, and associates, and the Fundy Ocean Research Centre for Energy (FORCE), in conjunction with Tekmap Consulting, have developed an online tool that consolidates the collected geospatial data and displays it in a manner that can provide stakeholders with a means to both visualize and manipulate otherwise disparate sets of site specific data. Layers include physical, environmental, and socioeconomic features that pertain to several high flow sites and can be scored within the website to determine such things as optimal placement of in-stream turbines.

## G24-3

### **The derivation of interactive solar energy registers: Identifying solar energy potentials and intensifying the climate-friendly use of photovoltaics within urban areas.**

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The demand for solar energy has increased recently, especially when looking at current issues of limited non-renewable fossil energy reserves and the essential ideas of sustainability. Solar panels mounted on roofs generate electricity using the energy radiated from the sun by taking advantage of the photovoltaic effect. A solar energy register provides detailed and neutral information on roofs being suitable for carrying solar panels. These data help house owners to calculate their financial investment and to obtain a bank loan more easily or to ask for subsidies from the German government.

The analyses are based on a digital elevation model derived from airborne laser scanning data of high accuracy. The main task is to estimate the 3D-roof-area that is suitable regarding exposure and slope and that is not shaded by surrounding trees or buildings. Thus we have developed a fully automated technology to classify the points related to three groups: building, ground, or vegetation. The roof points are separated related to their single roof sides and are converted into polygons. Then four site-related factors have been computed (exposure, slope, size of the roof, and particularly shading effects) to calculate the solar potential of each roof side of all city buildings. We compute the installable capacity, the expected generation of electricity, and the estimated earnings per year. A web-GIS visualizes the analysis

results. For each roof you can get the data concerning economic and financial aspects as well as the CO<sub>2</sub>-saving potential per year in comparison to the consumption of fossil fuels.

## G24-4

### **Star Schema database for demographic and renewable energy predictions**

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Optimizing the layout for a global electricity-exchanging network can be reduced to solving one or more worst-case distribution problems. In 2014, regional and global peak days occurred in the late summer months, during maximum refrigeration and air-conditioning use in the most developed countries. However, such days offered the most potential for solar power generation, with a diurnal function not far shifted from the utilization curve.

The Global Energy Network Institute (GENI) modelling team developed a MySQL-based database solution to combine data from a variety of sources including the World Bank, EIA, CIA, and USDA. This work emphasizes the Star Schema, as an optimal and extensible relational database construct, and the coupled differential equation system, which serves as our prediction model for future population and energy needs. The design is incredibly forward-looking, as our repository can serve to integrate local data sources having diverse periodicity and fidelity. Our predictive capability serves to explore a variety of roll-out scenarios for developing nation grid integration. As a global grid, GENI considers data from northern and southern hemispheres (including transequatorial energy distribution). Emphasis on horizontal connections across the shortest submarine pathways in the North is evident in our recent calculations and in the inspirational World Game concept by R. Buckminster Fuller dating back to 1969. The researchers at GENI seek to develop collaborative international solutions for an era of increasing renewable energy reliance.

## G25-1

### **Deforestation monitoring in the Amazon River estuary by multi-temporal ENVISAT ScanSAR data**

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In this study, we have capitalized on the all-weather, all-day operational capability of spaceborne synthetic aperture radar (SAR) systems and used multi-temporal (from 2002 to 2006), multi-track (track 174, 360 and 447) ENVISAT ScanSAR amplitude

images for deforestation mapping and change detection in the Amazon River estuary. A synergistic approach to deforestation mapping was adopted using SAR backscattering anomalies, the forest-neighborhood constraint and DEM-derived slopes based on the three following characteristics: 1) backscattering is reduced in regions suspected to have undergone deforestation; 2) open regions without forest-neighborhood were identified for removal; 3) false-alarms linked to water bodies are mitigated using the shape threshold of flat-slope objects. Our results show that deforestation in the Amazon River estuary continues to be a serious problem, particularly along the rivers, streams or roads that were more susceptible to anthropogenic activities than other areas. Up to 2006, the deforested portion accounts for 4.6% (3,096,000 pixels) of the entire study site of approximately 458,000 square kilometers (67,320,000 pixels). However, this figure, validated by ETM images, may have over-estimated deforestation to some extent. Nevertheless, multi-temporal analysis using SAR systems, as done in this study, have a clear potential for surveillance of deforestation in the Amazon, particularly due to the frequent cloud cover typical of the area and the limitations of deforestation monitoring by means of optical satellites.

## G25-2

### **Remote sensing of spruce budworm defoliation using EO-1 Hyperion hyperspectral data: An example in Quebec, Canada**

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Each year, the spruce budworm (SBW) disease causes severe and widespread damage to spruce and true fir stands in eastern Canada. Early estimation of the defoliation will provide crucial support to mitigate the socio-economic impact on vulnerable forests. Remote sensing techniques are more suitable to investigate the affected region which usually consists of large and inaccessible forested areas. Derived from satellite images, surface reflectance at two or more wavelengths are combined to generate vegetation indices (VIs) which indicate a relative abundance of features of interest. Forest health analysis based on VIs is considered as one of the primary information sources for monitoring vegetation conditions. Especially the spectral resolution of Hyperion hyperspectral imagery used in this study allows for examination of the red-NIR spectrum in more detail, which helps to identify areas of stressed vegetation. Several narrow-band vegetation indices are used to indicate the overall amount and quality of photosynthetic material and moisture content in vegetation. By integrating the information from VIs that focused at different aspects of overall health and vigor in forested areas, the study aims at detecting defoliated condition in a forested region in the province of Quebec, Canada. Two



Hyperion images applied in this study were acquired in June and August of 2014 respectively from NASA. The changes of health and vigor are observed and quantitatively compared as remote sensing images from different time are applied. The experimental results suggest the VIs based forest health analysis to be effective in estimating of SBW defoliation in the study area.

## G26-1

### **Case study of lightweight geospatial web servers' implementation**

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Nowadays a wide diversity of geospatial software and libraries are presented for Web-based data representation. In many cases, these tools are developed as easily accessible open source software. Nevertheless, when we need just to publish data in the Web, we need to use bulky Web server software with many additional but unusable functions. In the case of static geospatial data, which were fully prepared in desktop software, this wide functionality unnecessarily complicates server installation and administration.

We discuss ways for implementation of lightweight geospatial data providing servers, which afford only necessary and sufficient functionality for data serving and accessing. We use the Python programming language as the primary development tool. We examine server functions, which we need to implement the server in a minimal configuration using non-specialized Web hosting. The main conclusion of our current work is that the selected approach is applicable and effective for small-scale projects. Lightweight Web servers for geospatial data publishing may be a good solution when we need to publish segregated datasets in the form of Web services.

## G26-2

### **Acquiring geographical data with web harvesting**

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Many websites contain very attractive and up-to-date geographical information. This information can be extracted, stored, analyzed, and mapped using web harvesting techniques. Poorly organized data from websites are transformed with web harvesting into a more structured format, which can be stored in a database and analyzed. Almost 25% of web traffic is related to web harvesting, mostly while using search engines. This paper presents how to harvest geographic information from web documents using the free tool called the Beautiful Soup,

one of the most commonly used Python libraries for pulling data from HTML and XML files. It is a relatively easy task to process one static HTML table. The more challenging task is to extract and save information from tables located in multiple and poorly organized websites. Legal and ethical aspects of web harvesting are discussed as well.

The paper demonstrates two case studies. The first one shows how to extract various types of information relating to the Good Country Index from multiple websites, load it into one attribute table, and map results. The second case study shows how script tools and GIS can be used for extracting information from 136 websites about Nova Scotia wines. In a little more than three minutes a database containing 106 liquor stores selling these wines is created. Then the availability and spatial distribution of various types of wines (by grape types, by wineries, and by liquor stores) are mapped and analyzed.

## G26-3

### **Newspaper archives + text mining = rich sources of historical geospatial data: a flood database case study**

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Newspaper archives are rich sources of cultural, social, and historical information. These archives, even when digitized, are typically unstructured and organized by date rather than by subject, and require substantial manual effort to analyze. However, the effort of journalists to be accurate and precise means there is often rich geospatial data embedded in the text, alongside text describing events that editors considered to be of sufficient importance to the region or the world to merit column inches. Given that a regional newspaper can add over 100,000 articles to its database each year, extracting these data for even a single country would pose a substantial Big Data challenge.

In this presentation, we describe our experience extracting these valuable structured data from a 2-million article dataset. Our goal was to construct a database of historical flood events (location, date, cause, magnitude) to be used in flood assessment projects, for example to calibrate models, estimate frequency, establish high water marks, or plan for future events in contexts ranging from urban planning to climate change adaptation. In addition to releasing this dataset as Open Data, we created a web application for general users to explore and browse historical flood events in locations of interest to them. We suggest future avenues of research building on this pilot study, to broaden the extraction of existing geospatial data from unstructured newspaper text.

## G27-1

### **Monitoring of cultural heritage sites in China with high-resolution SAR images**

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As one of the four civilized ancient countries, China holds large numbers of cultural heritage sites, and monitoring of them is an urgent and tough work. Conventional techniques cannot satisfy our needs due to their poor efficiency, high , and potential destructiveness, while the development of high-resolution spaceborne SAR gives a new opportunity for quick, large-area, and high-precision monitoring. What is more, SAR is sensitive to the ground roughness, humidity, micro-terrain, and deformation, all of which are important indications of cultural heritage sites, and its capability of a certain penetration helps to detect archaeological targets buried underground. In this study, the White Horse Temple in Luoyang and the Summer Palace in Beijing are selected as our study areas. The former is suffering city subsidence caused by groundwater mining, while the latter is affected by both landslide hazards and construction of the subway. An advanced multi-temporal interferometric synthetic aperture radar (MTInSAR) technique will be used to derive their deformation, and in particular we prepare to extract distributed scatters (DS) for increasing the point density, and then a novel phase optimization algorithm will be applied. Forty COSMO-SkyMed SAR images acquired from 27 February to 17 October, 2013, and 20 acquired from 4 January 2009 to 6 October 2010, will be used for the SAR interferometry analysis. Specific attributes of these data are respectively X-band, HH polarization, ascending mode, and a center incidence angle of about 20.

## G27-2

### **Vehicle position estimation for automated driving using LiDAR and vision**

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Image and laser sensors for geospatial information acquisition are an integral part of Digital Earth Vision. One of the key applications of such geospatial technology is autonomous vehicle navigation, which has been an active research field in recent years. In order to achieve fully autonomous driving, various types of sensors are often equipped with the test car for vehicle localization and mapping of the surrounding environments. Seamless integration of these sensors for

automated driving require efficient and robust image and data processing algorithms. This paper addresses the issues of camera position estimation in a known 3D environment modelled by a 3D LiDAR scanner. A 2D/3D feature matching approach is adopted to estimate cameras orientation and position using 3D landmark dataset. The performance and accuracy issues of the developed algorithms is evaluated as well as its usability in autonomous vehicle navigation.

## G27-3

### **Making a semi-convex focus area in a Focus+Glue+Context map in consideration of map visibility and the locations of transportation access points**

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We previously implemented the Focus+Glue+Context map system EMMA which provides local detailed data in Focus, global context data in Context, and connection data between in the same view. Introducing the Glue area between Focus and Context areas makes it possible to provide uniform scaling of them. This paper enhances the EMMA by the implementation of a Focus creation function considering transportation access points such as stations and bus stops. The enhanced EMMA searches a route from the current location to the transportation access point, and enables users to identify the spatial relations between the various locations in the small scale Context, and to view the route from the current location to transportation access points in the large scale Focus. However, if the Focus is too large because of having unnecessary area to identify the route, some parts of the Context might be hidden by the Focus.

The proposed system solves the above problem by implementing the following functions. (1) It searches stations adjacent to the current location and makes a semi-convex Focus including the current location and them so that the Focus includes really necessary areas. (2) It reduces distortion of Focus by setting a fixed point to the center of the Focus area. (3) It smoothes out the shape of Focus so as improve visibility in the Glue area. We have developed a prototype of the proposed system that implements these functions, and evaluated the effectiveness of the proposed system.

## P-1

### **Mineral mapping in the West Kunlun Mountains area using Tiangong-1 hyperspectral imagery**

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The unmanned space module Tiangong-1 of China was launched in September 2011 and the hyperspectral sensor onboard provides hyperspectral data with high spatial and spectral resolutions. A Tiangong-1 hyperspectral image contains 65 visible-near infrared spectral bands covering the 0.4-1 mm spectral range and 65 short-wave infrared spectral bands spanning the 1-2.5 mm spectral range. The spaceborne hyperspectral data with high spatial and spectral resolutions are very suitable for mineral mapping.

In this study, Tiangong-1 hyperspectral data were employed for mineral mapping in the West Kunlun Mountains area, an important metallogenic belt in China located at the west of the Qinghai-Tibet plateau. The Spectral Hourglass Wizard (SHW) method was used to detect common minerals from Tiangong-1 VNIR and SWIR surface reflectance data with reference to the ENVI spectral libraries. Common minerals, such as quartz, gypsum, calcite, dolomite, and chlorite, were mapped from the hyperspectral data and the resulting mineral maps were highly correlated with the reference geological maps, proving that the hyperspectral data are suitable for mineral mapping. Moreover, compared with multispectral ASTER imagery currently widely used, more minerals with higher accuracy were extracted from the Tiangong-1 hyperspectral imagery, demonstrating the potential of the latter for geological exploration in alpine mountain areas.

## P-2

### **A new PCA-based method for snow cap extraction in alpine mountain areas**

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Snow caps in alpine mountain areas, as a part of the hydrosphere, significantly affect global climate, and as a result, their monitoring is an important part of global climate monitoring. In order to accurately detect snow caps in alpine mountain areas of West Kunlun, China, a new method based on principal component analysis (PCA) is proposed. It is found in the

study area that that normal snow has reflectance higher above 0.6 in visible and near-infrared spectral ranges and new snow can reach 0.95-0.99. Moreover the spectral reflectance of snow is similar in the range 380-700nm, begins to decline after 700nm, and falls greatly after 900nm. According to these characteristics of snow, Landsat-7 ETM+ bands 1, 4, 5, and 7, representing the spectral characteristics of snow caps are selected, converted to reflectance values, and transferred to principal components. After that, a principal component closely related to snow caps is applied with a threshold to yield a snow cap map. In a test using Landsat-7 ETM+ imagery acquired in 2001 covering an alpine mountain area, the proposed method offered snow cap maps with higher accuracy than the current snow cap index and maximum likelihood classification-based methods.

## P-3

### **Remote sensing data application for pasture monitoring in Kazakhstan**

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Kazakhstan is among the five world leaders of pasture resources. In particular in the southern oblasts there are seasonal pastures for year-round grazing. Over the recent decades geobotanists observed the degradation of natural grassland in densely populated areas. It is suggested that restoration of grazing systems based on pasture rotation, definition of feed capacity and optimum load of grazing would improve the situation.

At present time information on the condition and productivity of grassland ecosystems is obtained by means of various remote sensing methods. A year-analogue method was developed for remote assessment of the condition and productivity of Kazakhstan rangelands. It is based on the comparison of the current seasonal distribution of NDVI with the long-term NDVI signatures for the different pastures. The definition of the correcting coefficient and the calculation of the seasonal productivity for certain plant association is done on the basis of observed seasonal minimum and maximum yield for the same plant association using GIS-based data.

TERRA/MODIS data from 2001 to 2012 was used for the analysis of NDVI distribution for different grassland types in the southern oblasts. NDVImax and NDVImin were calculated for each pixel and each decade of the spring and summer seasons. The results of comparisons of NDVI values for 2014 in the corridor of maximum and minimum NDVI values allowed us to calculate the yields for all types of pastures in Almaty, Zhambyl, South-Kazakh and Kyzylorda oblasts. The accuracy of the data in comparison with ground-based observations was 90%.

P-4

### **NRCan Canadian Geodetic Survey: geodetic tools and services for high precision geodetic positioning applications**

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Whether it is for mapping, navigation, boundary demarcation, crustal deformation studies, or other georeferenced applications, users rely on the Canadian Spatial Reference System (CSRS) to provide the fundamental reference values that are used as standards for measurement of latitude, longitude, elevation, and gravity anywhere in Canada. At the heart of the CSRS, the Canadian Active Control System (CACS), consisting of a network of unattended GPS/GNSS continuous tracking stations, provides value-added products that facilitate access to NAD83(CSRS), the most accurate coordinate system in North-America used for georeferencing.

To ease client access to the CSRS, the Canadian Geodetic Survey (CGS) offers FREE online tools, applications and services that will enable users to improve the quality of their GPS positioning solutions by two orders of magnitude (from meters to centimeters), depending on their application. This poster will provide an overview of the Web services provided by CGS and highlight the functionality and performance of the GPS-based CSRS Precise Point Positioning (CSRS-PPP) application. A tool for conversion of geospatial information between various datums (TRX) will also be presented to emphasize the important considerations users should make when integrating high-resolution geospatial information in the national framework.

P-5

### **A comparative mapping study of wetlands in Nova Scotia using polarimetric RADARSAT-2 combined with two different scales of optical imagery and elevation derivatives**

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Nova Scotia introduced a new wetland policy in 2011 which included a goal to have no net loss of wetlands. In order to meet this goal, the Nova Scotia government has committed to updating the provincial wetland inventory. However, based on anecdotal evidence and communications with provincial staff there are likely a number of actual wetlands that are omitted from the inventory. The objective of this study will be to assess the accuracy of wetland identification using advanced remote

sensing technology and processes based on RADARSAT-2 polarimetric SAR images, optical imagery and elevation data.

Polarimetric radar images were acquired between 2010 and 2013 over an area southwest of Halifax. Two sources of optical imagery (Quickbird and SPOT-5) and two sources of terrain information (lidar and provincial government contours) were available and combined in various arrangements with the radar. A non-parametric supervised Random Forest classifier was applied to the different combinations. Accuracy of classified images was assessed against field-based wetland identification. Our results showed that using RADARSAT-2 combined with either source of optical imagery and either source of elevation data improved the accuracy of wetland identification over the existing air photo interpreted inventory. The combination of the higher resolution Quickbird image and the lidar data provided the best result overall, correctly identifying 90% of the field-verified wetlands.

P-18

### **Spectral error assessment of airborne imaging spectroscopy data – A case study of Atihau, New Zealand**

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Imaging spectroscopy (IS) sensors have the capability to detect the radiation reflected back from an object, such as the Earth surface, in narrow and contiguous spectral bands of the electromagnetic spectrum. Error associated with data acquisition and processing of airborne IS, however, is poorly known. The assessment of error introduced to the imagery due to instrumental errors and error created during data processing can be assessed using ground reference data acquired using a field spectroradiometer. In this study, we assessed the performance of a physically based atmospheric correction method using ATCOR-4. A visibly homogenous paddock with grazed pasture was selected where ground and aerial spectral sampling was carried out simultaneously using a FieldSpec 4 ASD and an AISAFenix sensor, respectively. A total of 75 reference sites were surveyed with an ASD, while a smaller subset of the IS image data was used to create a sequence of atmospherically corrected imagery using ATCOR4, obtained through changing the method of estimating water vapour using wavelength of 820 nm, 940 nm and 1130 nm. These images were then compared statistically with the airborne imagery using regression analysis. This study showed that there is a little (1%) difference between two atmospheric processing methods; consequently the physically based atmospheric correction approach is recommended. Based on the good fit (R-squared = 0.830.99) between ASD and airborne imagery, the AISAFenix sensor is found to be very suitable for mapping vegetation and to estimate

the biochemical component of landscapes at a much higher spatial resolution than satellite imagery.

## P-19

### **Where ever you go, there you are: mapping psychogeography using GIS**

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Understanding our world means not only recording and visualizing measurable facts and statistics about particular landscapes and environments, but also grappling with the human emotional and behavioural experience in such environments. Following the work of Guy Debord, psychogeography is the study of how geographic environments impact individuals emotions and behaviour and is a complicated practice to map. Through psychogeography we can learn how urban environments influence our perception by examining closely the sounds, smells and sights of streets and buildings and the people who reside and travel throughout them.

Data for this project was collected using the technique of drive, or drifting, as outlined in by Debord. By using textually recorded field notes and a Global Positioning System (GPS) tracker to collect data the feelings of spaces were captured. Using ArcGIS and by applying or subverting cartographic conventions of colour, typography, and symbols, a map of the walk was created. Through map media my work tries to articulate and describe the subjective association of emotion in urban structure, and, in part, challenges traditional cartography. Using ArcGIS to rearrange the urban environment I focused on my experience of the city, rather than the accuracy of a map. This project assesses the ability of a GIS to visualize the emotional and behavioural aspects of an urban environment and how we can incorporate these aspects into a better understanding of our world.

## P-6

### **Urban land use change and ecological risk assessment in the middle reaches of the Yangtze River, China-A case study of Changzhutan metropolitan areas**

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The urban land use change is one of the most important forms of global environmental changes. Changzhutan metropolitan

areas in the middle reaches of the Yangtze River, China has been experiencing significant growth in both population size and urban area since 1990s.

In this study, we use Landsat data from 1993 to 2013 to map and analyze the dynamic changes of urban land use. Further, using ecological risk assessing method, we evaluate the temporal and spatial variation of ecological risks in the study area. The results indicated that: (1) In the last 20 years, significant changes in urban land use have taken place in the study area. The construction land increased continuously, cultivated land and forest land reduced significantly. (2) In the last 20 years, regional ecological risk levels changed dramatically. The moderate, higher and high risk areas increased in volatility, while the low risk areas reduce in variations. In 1990s, low risk and moderate risk were dominant types, and ecological risk was relatively low in the study area. Since the 21st century, low risk areas reduced gradually, moderate, the higher and high risk areas increased gradually, especially after 2006, there was a remarkable increase in higher and high risk areas that was shifted from medium-risk areas.

This study may be helpful to sustainable urban land use, the ecological restoration in the middle reaches of the Yangtze River, China. It also provides an effective method for the quantitative assessment of regional ecological risk.

## P-7

### **Simulation of Future Urban Land Use Changes in Changzhutan Metropolitan Areas, Central China**

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As the economic development policies are being implemented in China, China has experienced unprecedented economic growth and rapid urbanization since 1980s. While in the last decade, Changzhutan metropolitan areas in the middle reaches of the Yangtze River, China has been experiencing significant growth in both population size and urban area. Rapid urbanization and accelerated urban expansion have converted natural landscape to largely impervious land use patterns, which are important factors that contribute to ecological and climatic changes at local, regional, and global levels and affect regional sustainable development. Therefore, it is important to quantitatively reveal urban expansion in future. This study simulates land use patterns in 2020. Using CLUE-S model considering land use neighborhood relationship, future land use changes in study area are simulated under four different scenarios, that is, natural growth scenario,

land use planning scenario, farmland protection scenarios and ecological protection scenario. The quantitative information about urban expansions in future would be of great interest to urban planning, water and land resource management, and climate change research.

## P-9

### **Information system for evaluation of avalanche hazard in mountain regions of Czechia**

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This paper summarises the final results of an applied research project that focused on the creation of an information system for snow-avalanche hazard evaluation in mountainous regions of Czechia. The project is based on the needs of mountain rescue service and focuses on the application of mathematical models for calculating snow distribution, snow stability and avalanche hazard level in Czechia. The results of the project fundamentally change methods for identifying avalanche hazard and assessing hazardous areas. A combination of snow distribution and stability models are used to delimit areas with higher probability of avalanche initiation. Snow distribution is modelled by using a distributed model based on HBV-ETH code and an energy balance approach. Snowpack stability is modelled using SNOWPACK code. Both models are using data from the Czech Hydrometeorological Office. Avalanche susceptibility and run-out modelling was performed using a Decision Tree method with a C4.5 algorithm and RAMMS modelling code, respectively. All the project results are available via WebGIS on a webpage [www.laviny.info](http://www.laviny.info). WebGIS comprises of two parts. The first part is intended for general public use while the second part is for expert usage only. The results significantly increase the security of citizens and rescue service staff during presence and rescue operations in the mountains of Czechia.

## P-10

### **An improved k-NN method based on multiple-point statistics for classification of high-spatial resolution imagery**

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In this study, the potential of multiple-point statistics (MPS) for object-based classification is explored and a modified k-nearest neighbour (k-NN) classification method based on MPS is

proposed. The k-NN classifier retains the location information associated with training data, such that a geographical weighting can be integrated easily into the classifier. It has been shown that both a distance weighting scheme and a geostatistical scheme can lead to sound classification results. It is, therefore, of interest to explore whether MPS can further increase the achievable accuracy. This study focuses on the object-based classification of fine spatial resolution imagery. Therefore, two goals are expected to be achieved in this paper: (i) a new MPS spatial weighting for remotely sensed contextual classification is proposed using the k-NN classifier as an example, and (ii) the applicability of the new method for handling objects is explored.

The method first utilises a training image derived from a classified map to characterise the spatial correlation between multiple points of land cover classes, overcoming the limitations of two-point geostatistical methods, and then the spatial information in the form of multiple-point probability is incorporated into the k-NN classifier. In a classification test focusing on the land cover types of bare land and buildings, an IKONOS subscene of the Beijing urban area was object-based classified using the multiple-point weighted k-NN and other classification methods. It was demonstrated that the proposed approach significantly increased the classification accuracy relative to the alternatives, and it is appropriate for identifying objects with different spatial distributions.

## P-11

### **Investigation of self-organized criticality aspects of landslide dynamics through the use of cellular automata models**

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A better understanding of landslide dynamics is an important scientific goal, as it is a key factor in the process of improving risk assessment and mitigation. Some of the most interesting and fruitful frameworks for the study of this class of phenomena are provided by self-organized criticality theory. We explore this framework in connection to scale-invariant aspects of landslide processes using Cellular Automata Models (CAMs). In our CAMs, real topographic surfaces acquired from digital elevation models are used to define the altitude values in the initial state of the system. Other environmental features such as geology and land use are included in order to represent the spatial variability of local conditions.

The landslide dynamics are defined by (i) a stability threshold, which is used to decide when a site of the area becomes unstable, (ii) a transition function, which defines how instabilities propagate within the system depending on slope gradients,

and (iii) a driving rule, which describes the weakening of the material over time, thus driving the system toward instability. Changes in the generated landslide event size distributions and in topography characteristics are monitored over time. In order to explore the relation between weakening and the stationary state of the system, a sliding range of values for the weakening rate is applied. Results show that the proposed models display key features of self-organized criticality, thus offering a series of useful insights into the dynamics of landslide processes.

## P-12

### **A novel image fusion method using auxiliary data**

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Remote sensing image fusion techniques are widely used to fuse a multispectral (MS) image with a panchromatic (PAN) band. Typically, the boundaries between vegetation and non-vegetation within the resulting fused MS image are blurred and the spectral distortions of the relevant fused boundary pixels are significant. As a consequence, it is difficult to accurately recognize such boundaries in the fused image and classify related objects. The blurred boundaries along with the spectral distortions are mainly due to the improper image fusion of mixed MS sub-pixels, in which the fused versions of the mixed MS sub-pixels remain spectrally mixed. Conversely, in imaging with different spatial resolutions, some mixed sub-pixels of low spatial resolution will be spectrally un-mixed to be pure pixels at high spatial resolution, and the relevant boundaries between vegetation and non-vegetation will become clearer. In order to improve fused images, auxiliary data should be employed in image fusion to complement the original PAN band so that mixed MS sub-pixels can be classified and spectrally un-mixed to be pure pixels, for instance, a second PAN band with different spectral responses. Based on the concept above, a novel method is proposed in this paper to merge an MS image with dual PAN bands. Using Landsat 7 MS and PAN images together with a Landsat 8 PAN band over Beijing urban areas, this method was verified and yielded fused images with minimized spectral distortions and greatly sharpened boundaries between vegetation and non-vegetation.

## P-13

### **Timely retrieval of the leaf area density of a single tree using terrestrial LiDAR data**

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As one of the canopy vertical structure parameters, the leaf area density (LAD) in each horizontal layer is generally used to quantify canopy leaves within a given volume. The LAD is defined as the total one-sided leaf area per unit of layer volume. Accurate retrieval of LAD is of great significance to the study of vegetation carbon and nitrogen cycles. In this paper, a broadleaf tree (magnolia tree) was scanned using a terrestrial light detection and ranging system (LiDAR) named Leica ScanStation C10 in Chengdu, China. A timely LAD model was developed based on point cloud segmentation and the voxel-based canopy profiling (VCP) method. First, the difference of normals (DoN) operator algorithm was used to separate the leaf point cloud and stem point cloud. Secondly, the VCP method was used to compute the LAD profiles by constructing the three-dimensional voxel model. In this step, the contact frequency, the correction coefficient for leaf inclination and the vertical projection area were computed for every horizontal layer thickness. The results showed that the selected magnolia tree LAD values tended to increase with the increase of the height at the middle and lower canopy and the maximum LAD value was 3.05 m<sup>2</sup>/m<sup>3</sup> at the height of 3.5 m, while the LAD values tended to decrease with the increase of the height.

## P-14

### **Research on 3D simulation of FY-2E infrared satellite cloud image based on the Digital Earth Science Platform**

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Infrared cloud imagery describes the intensity of infrared radiation of cloud and ground surfaces. The smaller the intensity of infrared radiation is received, the brighter colors are reflected on infrared cloud. Therefore, the infrared cloud itself contains three-dimensional information of space clouds, of which the light and dark colors represent the high and low level of cloud tops, and the gray values just below the cloud represents induction temperature determined mainly by the temperature of the cloud top.

In this paper, the basic theory underlying 3D visualization,

projection transformation for satellite cloud images and 3D information extraction was analyzed. According to the characteristics of AWX format of FY-2E infrared satellite cloud image, a method of obtaining the color and transparency of clouds was proposed. By way of quantity estimation of the satellite image, including the cloud surface detachment, cloud classification, and cloud top estimate, we obtained the cloud height estimated product. By drawing the triangle grid according to the cloud height estimate product, color rendering and coordinate transformation, we modeled the three dimensional cloud based on the Digital Earth Science Platform which can be consistent overall with the real cloud. The longitude-latitude projection of 5km resolution imagery of FY-2E was chosen as experimental data, and the temporal-spatial process visualization of Chinas ninth typhoon Rammasun in 2014 was based on Digital Earth Science Platform data. Experimental results show that this approach can obtain in real time more realistic 3D cloud information.

## P-15

### **Bridging domains: A web-enabled interoperable groundwater research framework**

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Geoprocessing algorithms and geocomputation in general solve domain specific, narrowly defined problems with spatial context. They require meaningful and compliant input data in well-defined formats and encodings. In contrast, available geo-spatial, geoscientific and environmental observation data are stored in various generic formats or have been specifically compiled for limited purposes only. A common challenge is to fit available input data correctly into required formats for specific geocomputation or geoprocessing algorithms as well as to make the results available again as inputs for subsequent analyses or presentation.

Data pre- and post-processing is often disjunctive from the execution of the computation. Traditionally the task of pre-processing input data and post-processing the results is a manual procedure conducted by the user, e.g. the researcher. Present research in hydrogeology and freshwater resources management can be significantly supported and accelerated by relating, reusing and combining existing datasets, models and simulations in a streamlined, computer-aided and networked fashion and yield more new and reproducible insights. We examine a collaborative, networked and open standards-based integration of storing, accessing and transformation of distributed hydrogeological data with domain specific geocomputation processes in the interdisciplinary case study field of groundwater research in New Zealand. A novel method is developed that applies an ontology-aided inference mechanism to a list of available data in predictable formats to prepare appropriate

inputs for a selected geocomputation algorithm. The result is also made accessible in the spatial data infrastructure again in re-usable open standards format for generic composition of subsequent workflows.

## P-16

### **An image fusion method based on the un-mixing of mixed MS sub-pixels**

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Numerous remote sensing image fusion algorithms have been proposed in recent decades to fuse multispectral (MS) and panchromatic (PAN) images. Although spectral distortions in fused images generated by current fusion methods have been significantly reduced, there remains the challenge of how to minimize the spectral distortions while improving the spatial details. In reality, a low-spatial-resolution mixed MS pixel contains multiple sub-pixels and the latter superimpose multiple high-spatial-resolution PAN pixels, some of which are mixed and others of which are pure. Typically, fused versions of mixed MS sub-pixels (MSPs) remain mixed in current image fusion, although some of the MSPs correspond to PAN pure pixels. The mixed fusion versions of MSPs near boundaries between vegetation and non-vegetation (VNV) cause blurred VNV-boundaries and significant spectral distortions in fused images. Spectral un-mixing of MSPs need to be considered in image fusion to improve fused images. An improved version of the Haze- and Ratio- based fusion method is proposed to realize the spectral un-mixing MSPs near VNV-boundaries during the fusion process. In this method, MSPs near VNV-boundaries are identified first and the corresponding PAN pixels then are classified into vegetation and non-vegetation categories. The identified MSPs are then set as pure vegetative or non-vegetative pixels with respect to the categories of the corresponding PAN pixels. In an experiment with WorldView-2 imagery of an urban area, the proposed method yielded fused images with significantly clearer VNV-boundaries and smaller spectral distortions than several current image fusion methods.

## P-17

### **An effective modified water extraction method for Landsat-8 OLI imagery in mountainous plateau regions**

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Water information extraction from remote sensing imagery is an efficient way to investigate and monitor water resources. In the study area of this research, a mountainous plateau in Kashgar region, there exist sparse vegetation and seasonal rivers, which affect water information extraction to a certain extent. In this study, a modified water information extraction method was proposed to extract surface water in the study area and tested using Landsat-8 OLI imagery. In this method, binary images are first generated using a multi-band spectral relationship method and a normalized difference water index method, and then applied with set operations to yield a mask. After that, water bodies are delineated by masking the Landsat-8 OLI imagery and then refined by eliminating false areas using supervised classification. It was demonstrated from the resulting water information maps that shadows in the imagery were effectively eliminated and river tributaries and artificial ditches were precisely delineated, with an accuracy up to 92.49%. Compared with several current water information extraction methods, the modified method yielded water information maps with better visualization and accuracy improvement of 7.79% on average.

## P-20

### **Applying principles of ecological resilience theory to model bird habitat in a context of climate change**

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There is increasing consensus that climate change will cause the ranges of many bird species to shift or contract in geographic space. Therefore, protecting the most resilient habitat (i.e. habitat likely to retain characteristic structures and functions) should increase the likelihood that vulnerable taxa persist over the long term. In this study, we use geographic information system (GIS) tools and maxent modeling to identify features of suitable habitat for 3 migratory songbirds in Nova Scotia, Canada: the Olive-sided Flycatcher (*Contopus cooperi*), the Canada Warbler (*Wilsonia canadensis*), and the Rusty Blackbird (*Euphagus carolinus*). In so doing, we focus on topographic variables which control moisture and nutrient accumulation, making the assumption that topography regulates the structure and composition of micro-scale habitat. We found that the topographic position index was a reliable predictor for the Olive-sided Flycatcher and the Canada Warbler, and we further noted that all 3 birds had higher relative occurrence probabilities in lowlands, likely because these areas favor wetland formation and nutrient accumulation. Variables related to favorable forest composition and configuration also demonstrated strong explanatory power, and distance to wetlands emerged as

significant for all species. Taken together, our results suggest that both topography and forest/wetland features influence the distribution of the focal birds in Nova Scotia. As topography will be largely unaffected by a changing climate, and as topographic processes help regulate micro-scale forest characteristics, identifying the intersection of suitable topo-scale and micro-scale features should enhance conservation applications by allowing for the most resilient habitat to be delineated.

## P-21

### **A tree canopy height delineation method based on multi-scale morphological reconstruction opening decomposition**

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For the purpose of forest management, high resolution LIDAR and optical remote sensing imageries are used for treetop detection, tree crown delineation, and classification. The purpose of this study is to develop a new crown horizontal cutting method of tree canopy height model (TCHM) to detect and delineate the tree crown from LIDAR of CHM, under the hypothesis that the treetop is the radiometric or altitudinal maximum, and the tree crown consists of multi-scale branches. The major concept of the method is to develop multi-scale morphological reconstruction open filtering on canopy decomposition (MRCD) to get morphological multi-scale features of TCHM by: cutting TCHM from treetop to the ground; analyzing and refining the dominant multiple scales with differential horizontal profiles to get treetops; and segmenting LiDAR DSM using a watershed segmentation approach marked with MRCD treetops. This method has solved the problems of false detection of TCHM side-surface extracted by the traditional morphological opening canopy segment (MOCS) method. The novel MRCD delineates more accurate multi-scale features of TCHM, and enables more accurate detection and segmentation of treetops and crown. The MRCD method can also be extended to high optical remote sensing tree crown extraction. In an experiment on aerial LiDAR DSM of forest of multi-scale tree crown, the proposed method yielded high-quality tree crown maps.