Providing a New Vision of Our Changing Environment

CEOS: The Next Five Years

2009-2014
We shall never achieve harmony with land, any more than we shall achieve absolute justice or liberty for people. In these higher aspirations, the important thing is not to achieve, but to strive.

— Aldo Leopold, 1887 – 1948
Arturo Sánchez-Azofeifa, Mario Nascimento and Pawel Gburzynski (left to right) continue expanding applications for wireless sensor data collection.

Background Image: Benthic Communities, a Neptune Canada project. Participating researcher CEOS member: Herb Yang.

Contribution of CEOS to quantifying tropical deforestation in Costa Rica.

Deforestation rate in Costa Rica, 1960-2005
The GOSAT “Ibuki” carbon-sniffing satellite.

Flux tower and phenology station at John Gamon’s Daring Lake, Alberta field site.

Tiny wireless sensors facilitate observation of remote ecosystems.
About CEOS

Our Mission
The Center for Earth Observation Sciences (CEOS) at the University of Alberta is committed to creating an objective, science-based, research-rich resource for improving human stewardship of our global ecosystems.

Our Vision
• To provide clear, accurate, comprehensive, cost-effective ways to identify, monitor and communicate changes in earth’s surface-level features.

• To optimize the benefits of satellite-derived earth observation data through cooperation of its members, resulting in the development of user-friendly web-accessible data products and applications designed to inform policy-makers.

• To coordinate and train resident and international personnel in cyberinfrastructure and eco-informatics.

• To develop sound monitoring approaches for earth properties and processes, including biodiversity, ecosystem function, disturbance, mineral resources, vegetation, snow and ice cover.

• To observe, monitor and assess industrial operations in order to improve natural resource extraction and processing efficiency, and reduce impacts on the environment.

CEOS Director Dr. Arturo Sánchez-Azofeifa in a Brazilian tropical dry forest. CEOS is training an international network of students to use sensor networks and monitor sensor data throughout the Americas and Europe.
Our People
CEOS combines the expertise of researchers from Earth and Atmospheric Sciences, Computing Science, and Civil and Environmental Engineering, Electrical and Computer Engineering and Renewable Resources to better understand and evaluate the fundamentals of earth observation: Remote Sensing, Intelligent Image Analysis, and spatio-temporal data management.

Our Places
CEOS participants derive and analyze data from sites ranging from Canadian arctic, tundra, and boreal and tropical forests. Through their existing international relationships, CEOS investigators participate in a network of research initiatives, funded by private and public provincial, national, and international agencies.
1. Human Impacts on Environmental Land Use and Land Cover Change

**Studying Tropical Dry Forests. Research by G. Arturo Sánchez-Azofeifa.**

Dr. Arturo Sánchez-Azofeifa studies the impacts of land use/cover change (LUCC) on biodiversity loss and habitat fragmentation in tropical dry forest environments. His primary research explores how the information captured using different earth observation satellites might be used over time to look at long-term changes to productivity patterns of tropical dry forests of the Americas, including changes in functional mechanisms and species diversity patterns. In addition, his research interests involve the development of techniques for the analysis and interpretation of the presence of non-self supporting tropical systems (lianas) and tropical hardwood species (e.g. Mahogany) at the leaf and canopy level. Dr. Sánchez-Azofeifa serves as director of GeoChronos and Tropi-Dry (a collaborative research network to study the human and biophysical dimensions of tropical dry forests in the Americas). He is the current CEOS Director.

**Studying Alberta’s Oil Sands from Space. Research by Petr Musilek, G. Arturo Sánchez-Azofeifa.**

Dr. Petr Musilek, whose research focuses on intelligent systems, data analysis, and environmental modeling and forecasting, is uniquely qualified to work with the massive satellite-derived datasets and GOSAT readings from Northern Alberta. The GOSAT project provides global green house gas measurements by satellite. Unprecedented resolution and coverage of these measurements, along with backtracking and inverse modeling, will tell the researchers if greenhouse gas readings in a particular region have been influenced by emissions from other sources, perhaps hundreds of kilometers away. Their modeling work will greatly increase our current understanding about how greenhouse gases behave, where they are generated, and how they are transported.
Dr. Christian Haas and a member of his team perform in-situ measurements of sea ice in the region of the North Pole. Haas also analyses the polar ice by means of airborne and satellite remote sensing and modelling. Insets: Dr. Haas’ two most important pieces of equipment: an ice auger and the EM Bird, an airborne sensor to measure ice thickness. The Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO) is one of only few programs worldwide to obtain systematic data of Arctic sea ice change.

2. Understanding the Impacts of Climate Change in the Canadian High Arctic

Sea ice-climate interactions in the Canadian Arctic. Research by Christian Haas. Related research by Martin Sharp, Jeff Kavanaugh, and Andy Knight.

Dr. Christian Haas leads CEOS’ sea ice group, one of only a few groups worldwide to obtain systematic observations of Arctic sea ice change. His research is oriented toward revealing the underlying causes of the recent, strong sea ice retreat in the Arctic. Through its high albedo, thermal insulation and moisture barrier effects, and role in the oceanic freshwater cycle, sea ice affects all other components of the Arctic climate, affecting human and natural ecosystems including the atmosphere, oceans, glaciers, wildlife and peoples of the North. This work is highly interdisciplinary and results have consequences for many of the other “Pillars of CEOS” and beyond.
Dr. Haas’ group performs regular field campaigns in the Arctic to obtain in-situ data and airborne measurements of sea ice thickness, properties and processes. The group is one of only two capable of performing airborne thickness measurements with a specially designed sensor, the so-called EM Bird, which can be operated by helicopters and fixed-wing aircraft for long-range surveys. Field campaigns are complemented by extensive satellite remote sensing observations, particularly utilizing radar imagery of the Canadian Radarsat and European Envisat satellites. The unique combination of in-situ, airborne and satellite data facilitates the development of new satellite algorithms for the retrieval of sea ice and snow properties. The group is also leading validation efforts of the upcoming European CryoSat mission, which is dedicated to measure the thickness of Arctic sea ice.

Dr. Haas is working on the development of new airborne and ground-based sensors and algorithms for sea ice and snow surveying that involve electromagnetic induction (EM) sounding, laser scanning, radar profiling, and DGPS surveying.

Glacier-climate interactions in the Canadian Arctic. Research by Martin Sharp. Related research by Christian Haas, Jeff Kavanaugh, Andy Knight

Dr. Martin J. Sharp’s research combines fieldwork and remote sensing to study the dynamics and ongoing changes of ice caps of the Queen Elizabeth Islands Archipelago in Arctic Canada, with fieldwork currently focused on the Devon Island Ice Cap. Devon Island’s 14,000 square kilometer ice cap is dynamically complex – consisting of a mix of fast and slow-flowing glaciers, and glaciers that terminate on the land (where they lose mass by melting), including glaciers that terminate in the ocean (where they lose mass by melting and iceberg calving). Comparable to Greenland’s 1.7 million square kilometer ice sheet, this ‘mini-version’ of the Greenland ice sheet is far more amenable to research, Dr. Sharp says. Using an array of field sensors and satellite information, Dr. Sharp and his students study how seasonal melting and meltwater runoff affect glacier flow and iceberg production, and how these processes alter the rate at which ice caps lose mass as climate changes. He has postulated that meltwater can force its way down glacial crevasses to the rock bed below the glacier, speeding up glacier movement in the warm season to up to four times their normal rate. This movement increases the flux of ice towards the ocean and results in faster loss of ice mass by iceberg calving into the ocean. Dr Sharp’s work contributes to solving the problem of explaining the current rate of global sea level change, and is
3. Hyperspectral Applications in Mining

*Use of hyperspectral sensors to maximize efficiency and profitability of oil extraction in Alberta and Canada. Research by Benoit Rivard and Michael Lipsett.*

Dr. Benoit Rivard’s recent work includes the use of hyperspectral technology to determine the bitumen content and grain size of oil sand samples prior to oil extraction. Variation in these factors affects processing efficiency. The most preferable oil sands’ raw materials (feedstock) are homogenous and predictable, hold a moderate amount of oil and have a moderately fine-grain. Traditionally, estimates of the ore blend are based on widely spaced, non-representative core sampling. In addition, important processing features are analyzed only intermittently, and are classified manually, resulting in prospective increases in error. Use of hyperspectral analysis of feedstock provides a real-time estimate of bitumen content and fines fraction, resulting in an ongoing evaluation of the quality of the ore both in terms of productivity and processability.

With Dr. Michael Lipsett, a similar hyperspectral analysis is being evaluated to estimate the properties of tailings materials, with a goal of accelerating reclamation, as this outcome will assist oil companies in meeting their regulatory and remediation objectives.

By speeding reclamation processes, reducing energy and equipment resources required for processing feedstock, and protecting against development of financially risky oil sands resource candidates, the work of Drs. Rivard and Lipsett assists petroleum producers in maximizing profits and minimizing environmental impacts.
4. Predicting, Preventing and Mitigating Natural Disasters

River Ice Breakup, Flooding. Research by Faye Hicks and Herb Yang. Related research by Thian Gan.

Dr. Faye Hicks’ primary research focus is river ice engineering, with projects in the field and in the laboratory. Dr. Hicks uses data to classify ice formation and characteristics, locate moving ice, stationary ice and open waters, and predict ice-jam formation and flooding. Her field work data are derived from multi-level source areas including ground-level field work, air, and satellite resources. Her detection tools include RADARSAT-1, RADARSAT-2, Ground Penetrating Radar (GPR), Lidar, surface velocity and temperature sensors, and analysis of standard photographic images.

In conjunction with CEOS participant Dr. Herb Yang, Dr. Hicks is working on a project that assists researchers in mapping surface ice concentration from an oblique photographic angle (an artifact of the camera angle necessitated by aerial photography) by automating calculations that were previously accomplished by a laborious manual tally.

For their work in modernizing the provincial River Ice Program, primarily through remote monitoring of river ice and snowline cover, former Hicks student and current CEOS boardmember Dr. Chandra Mahabir and her team won the 2008 Silver Premier’s Award of Excellence. Significant changes to the Provincial River Ice Program have improved the government’s ability to monitor, forecast and communicate conditions to communities at risk from river ice flood hazards. The team developed an integrated response to flood hazards, strengthened relationships and partnerships with clients ensuring long-term improvements in river ice management.

Background image: Athabasca River Ice Breakup, an NSERC project. Participating CEOS member: Faye Hicks.
5. Monitoring and Modelling Ecosystem Health

**Linking carbon and water fluxes to optical properties as indicators of ecosystem health and metabolism.**


By combining flux measurements with ground, air and satellite-derived optical measurements, Dr. John Gamon seeks to achieve a deeper understanding of fundamental patterns of carbon and water vapour fluxes, both indicators of ecosystem health and metabolism. This integrated study of the “breathing of the Earth,” focuses on the impacts of photosynthesis, respiration and evapotranspiration on Earth’s carbon and hydrological cycles, and subsequent impacts on atmospheric composition and climate. To evaluate Earth’s diverse array of ecosystems, studies include field sites ranging from the extreme arctic and boreal regions to the equatorial tropics. A primary objective is to evaluate perturbations to the Earth’s metabolism from disturbance (e.g. drought, fire, insect infestations) and climate change. For example, CEOS researchers use remote sensing to evaluate the effects of drought and grazing on the productivity of southern Albertan rangelands. Additional projects focus on the response of forest, arctic and tropical vegetation to climate change.
Identifying and predicting adaptive responses of ecosystems to climate change. Research by Andreas Hamann.

Dr. Andreas Hamann studies hardwood ecological genetics in Alberta, specifically, the impacts of climate change and adaptive responses incurred in plant species. Using remote sensing based analysis of plant-climate interactions, Dr. Hamann creates geneflow models in various landscapes. Dr. Hamann also investigates plant-climate interactions by studying long-term Alberta phenology data.

6. Maximizing use of hyperspectral imagery

Refining hyperspectral imagery to isolate and amplify robust surface-feature information. Research by Benoit Rivard.

Recent innovations in the field of hyperspectral imaging offer new research and classification opportunities in the assessment of earth’s biosphere and lithosphere. Dr. Benoit Rivard is developing technological advances leading to an expansion of the basic knowledge of spectral properties of natural materials. New hyperspectral methods will enhance detection of regional mineral patterns using algorithm-generated information retrieval, a computational method of improving the accuracy of abundance estimations and minimizing false identifications arising from the variability of spectral signatures.

Dr. Rivard, in conjunction with Goldbrook Ventures, Public Works Canada, Suncor and Syncrude, is developing advanced methods for the retrieval of information on surface geology and vegetation via airborne hyperspectral imagery. By detecting an increased range of plant communities, minerals and rock types and estimating their abundance and distribution patterns in a wide range of geological environments, significantly improved predictive exploration maps for resource assessment and planning can be prepared.
Dr. Rivard’s work is also positioning the province and the University of Alberta as leaders in the field of drill core imaging spectroscopy, acquiring valuable representations of the distribution of mineralogy. The resulting detailed maps could lead to new views of mineral deposits and be linked to surface views obtained from airborne platforms.

Another vital element in Dr. Rivard’s research includes expanding the capacity of tools that optimize and validate spectral analyses. Current software in development includes a spectral analysis tool that captures the textural properties of mineral alteration. This tool is used to provide texture information related to grain size variability (as opposed to mineral abundance), which resides in low frequency wavelets. Deeper analysis of these wavelets, particularly in the thermal infrared, can be used to reveal the dimensionality of the feature space (reflectance vs. multiple wavelets). In addition, specific wavelets show promise in improving feature detection (through regression analyses), abundance estimation, target detection, and the analysis of imagery of forest canopies for geobotanical information.

7. Spatio-temporal Data Collection and Management.

Developing innovative sensor technology, advanced geomatics and data management techniques. Research by Arturo Sánchez-Azofeifa, John Gamon, Mario Nascimento, Joerg Sander, Andy Knight, and Arie Croitoru.

CEOS scientists recognize that critical ecosystem changes often occur in remote locations that are difficult to monitor. In partnership with CEOS member Dr. Mario Nascimento, CEOS director Arturo Sánchez-Azofeifa has launched Project EcoNet (http://econet.cs.ualberta.ca), which has already trained dozens of international scientists to deploy and monitor numerous sensor networks throughout the tropics and beyond. These small, inexpensive sensor networks, in conjunction with satellite data, will form a useful picture of what is happening in these remote ecosystems.

Collecting and managing data in inaccessible locations presents unique and fundamental challenges, such as power-
Spatio-temporal Data Collection and Management, continued.

Dr. Andy Knight has created nimble, innovative power source machinery, which transforms relatively minute energy resources into usable power. In 2005, Knight presented a compact and reasonably priced wind power generator that could bring clean, renewable energy to remote locations. Dr. Knight’s CEOS research focuses on providing clean, reliable energy resources to power the sensor networks in the remote and extreme weather locations CEOS members investigate.

These small, powerful sensor networks, along with other ground-breaking automated earth monitoring technologies, have resulted in vast stores of time-referenced spatial data. Making the most of these resources involves a great deal of scrutiny of the data that simply cannot be done without some amount of automation. Dr. Joerg Sander shapes these data into more comprehensive categories to reveal interesting patterns and trends in the data that may be difficult to discern, given the massive amounts of data involved. Dr. Arie Croitoru’s work focuses on tracking moving objects in the field, as well as processing multi-dimensional trajectory data.

Dr. Mario Nascimento, in conjunction with Dr. Sander and others, approaches the challenge of abundant data from a different angle, researching methods of using intelligent programs to refine data at the source. Their adaptive processing research focuses on developing techniques that utilize a query efficiency method to use sensor-related elements’ integral computing components to refine data at the collection point, reducing power required to store, transmit and analyse data, in addition to decreasing post-collection processing error and providing additional capacity to collect data over larger areas for longer periods, and/or provide back-up capabilities to prevent catastrophic data loss.

An example of matching moving object trajectories. Participating CEOS member, Dr. Arie Croitoru.
The final piece of the data management system, the GeoChronos website, provides a virtual data resource centre, including a data repository and tool kit, geared toward facilitation of Earth Observation Science research across the globe. The GeoChronos informatics portal provides a state of the art data management system that includes social networking and cloud computing technologies in order to facilitate automated collection and management of data obtained at different spatial and temporal resolutions, among other resources. Funded by a grant from CANARIE, as part of their Network-Enabled Platforms (NEP) program, and Cybera, GeoChronos seeks to enable affiliates to share data and scientific applications and to collaborate more effectively, promoting new research, testing and refining methods, and facilitating continuing innovation in the field.
Center for Earth Observation Sciences

Selected Ongoing Funded CEOS Projects

Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO)
The focus of the sea ice group’s work is on establishing a Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO). The main study region of CASIMBO is between the coast of Ellesmere Island and the North Pole, but collaboration is sought with national and international partners to extend this over all of the Canadian Arctic and the Arctic Ocean. The primary activity is biannual campaigns to the region with measurements of ice and snow thickness and morphology, ice drift, and surface water properties. The data are used to support the development of satellite remote sensing products, which in turn are used to extrapolate the results of the field studies.
Funding Sources: Alberta Ingenuity Fund AIF, NSERC Discovery and RTI; by the Alberta Small Equipment Grant Program SEGP and the Canadian Foundation of Innovation; industry partners include Ferra Dynamics Inc. and Lake Central Air Services. Participating member: Dr. Haas.

Eco-Informatics for Carbon Sequestration (a Canada-California Strategic Innovation Partnership)
This collaborative project between CEOS and UC Davis seeks to develop transformative science-based partnerships leading to new industry opportunities and socio-economic benefit. Climate change is already having measurable impacts on both Canadian and Californian ecosystems, threatening the sustainability of large industries (e.g. fisheries, forestry, and agriculture). These effects, which are likely to increase in the coming decades, present significant challenges, as well as untapped opportunities, which this proposed initiative seeks to address. The central theme of this project involves a comprehensive evaluation of the biospheric potential for carbon loss and gain, since biosphere-atmosphere carbon exchange (photosynthesis and respiration by terrestrial ecosystems) is many times larger than anthropogenic carbon releases. Objectives of the bilateral initiative include a cost-effective “ecoinformatics” network to monitor biospheric carbon and inform carbon markets, with several potential economic benefits, along with the development of a unified Biospheric Carbon Index (BCI) that captures the dynamics of biological carbon exchange. Funding Source: the first Canada-California Strategic Innovation Partnership (CCSIP), funded through the University of California Office of the President (UCOP) and International Science and Technology Partnerships Canada. Participating member: Dr. Gamon.
**GeoChronos**

Several CEOS members, in conjunction with researchers at the Grid Research Centre, are developing a collaboration-enhancing platform, GeoChronos. The platform will feature architecture capable of housing new data sources and hosting new applications that can be assessed and enhanced by participating scientists. GeoChronos researchers describe the platform as a way to integrate tools, data, and computing resources into a single platform. A web-accessible spectral library is being developed, including portals for contribution to and query of the database. From *About GeoChronos*, “The overall goal is for the platform to become a one stop shop for earth observation science.”

*Funding Sources: Cybera-CANARIE. Participating members: Drs. Sánchez-Azofeifa, Croitoru, Gamon, Musilek, Nascimento, Rivard and Sharp.*

**“IBUKI” Greenhouse Gases Observing SATellite (GOSAT)**

GOSAT, a five-year collaboration with Japanese partners, will provide northern Alberta greenhouse gases data to researchers in order to quantify the impact of the oil sands. These data may present oil companies with a more definitive answer regarding the effect of oil sands on the environment.

*Funding Sources: Japan Aerospace Exploration Agency, Ministry of the Environment (MOE) of Japan, National Institute for Environmental Studies (NIES) of Japan, Canada School of Energy and Environment (CSEE). Participating members: Drs. Musilek and Sánchez-Azofeifa.*

**International Wireless Sensor Networks Deployment and Training of Highly Qualified Personnel**

Numerous CEOS members participated in sponsoring an international summer school, attended by graduate students from thirteen different nations. The course provided students with training in the fundamental principles of scientific instrumentation and the field deployment of sensors as they apply to the design and operation of wireless sensing networks (WSN), and to explore how the data they collect can be used in a timely manner to solve complex scientific questions and practical problems in environmental management via a multidisciplinary approach. The course was interdisciplinary in nature with topics covering areas associate to sensor design, software design and implementation, and deployment of wireless sensor networks.

*Funding Sources: Inter-American Institute for Global Change Research, University of Alberta. Participating members: Drs. Sánchez-Azofeifa, Croitoru, Gamon, Knight, Musilek, Nascimento, Sander and Sharp.*
Selected Ongoing Funded CEOS Projects

**Hyperspectral Imaging for Improved Oil Sand Process Monitoring**
This project addresses technology gaps in improving bitumen production performance, by establishing the proof of concept of using hyperspectral imaging for ore classification, and assessing its potential impact on the observability of batch, laboratory-scale, water-based extraction processes. The objective of this project is to determine hyperspectral feature sets, classification schemes and predictive models to discriminate samples with processibility issue; and examine the trade off of implementing these tools with instrumentation collecting broadband data. Funding source: Alberta Ingenuity Imperial Oil Center for Oilsands Innovation. Participating members: Drs. Rivard and Lipsett.

**Hyperspectral Imaging to Support Mineral Exploration in Northern Quebec**
Working with Goldbrook Ventures of Vancouver, this research team is developing the analysis of airborne imagery to derive predictive maps that can be used by exploration geologists. These maps convey information on the distribution rock units and minerals of relevance to nickel mining exploration. The intent is to focus the exploration of the most promising regions and provide the geologists with tools to make decisions as to “where to go next” thus minimizing logistical costs and the environmental footprint of exploration activities. Funding source: Goldbrook Ventures. Participating member: Dr. Rivard.

**Mountain Pine Beetle Research**
CEOS members are working together to investigate novel ways to use spectral data to detect the presence of new pine beetle infestations. Officials are keenly interested in detection methods that allow for removal of infested trees as quickly as possible in order to reduce the spread of pine beetle pests. Funding Sources: Alberta Environment, University of Alberta. Participating members: Drs. Rivard and Sánchez-Azofeifa.

**Surface Ice Mapping**
This project assists researchers in mapping surface ice concentration from an oblique photographic angle (an artifact of the camera angle necessitated by aerial photography) by automating calculations that were previously accomplished by a laborious manual tally. The algorithms generated by this project may prove useful to any researcher wishing to map earth surface features from oblique aerial photographs. Participating members: Drs. Hicks and Yang.
Proposed CEOS Projects

**CEOS Airborne Laboratory**

To facilitate airborne data collection, this project seeks to purchase or lease an aircraft specific to the needs of CEOS participants. A CEOS Airborne Laboratory, having obtained proper permits in advance for monitoring equipment, would be capable of generating data for all participating researchers who have sensors on board. Suggested sensors include: digital photography, IR, Radar (various), LIDAR, and a hyperspectral imaging spectrometer.

To provide full member access to the CEOS Airborne Laboratory, the Laboratory would be administered as a time-share project. Researchers would be allotted time slots for this aircraft in accordance with funding provided, scheduled in weekly segments, and would provide some flexibility for planning and access. This project would provide a natural locus for CEOS researchers, and facilitate the interdisciplinary exchange of ideas central to the CEOS goals and vision. Examples of other institutions employing fixed-wing aircraft in support of university research include the University of Helsinki, Simon Fraser University, and San Diego State University.

**ENVIRO-NET**

ENVIRO-NET (i4): An Integrative, Interdisciplinary, Industrial and International Graduate Program on Sensing Technologies for Environmental Monitoring (Applied). ENVIRO-NET (i4)’s mission is to provide a unique interdisciplinary training program (applied environmental sciences, computing science, and engineering) that will produce environmental monitoring professionals with extensive and diverse academic and professional skills that will meet the emerging needs of both industry and government employers. ENVIRO-NET (i4) aspires to train young scientists who will make fundamental inter-disciplinary contributions to environmental science. By means of thematic and team-based research and education, this new generation of scientists will investigate the responses of natural systems to global environmental change via the development and application of cutting-edge sensing technologies that address complex environmental monitoring and decision-making challenges. Graduates will meet the increasing demand for skilled professionals and provide a framework to facilitate advanced and rigorous training for all participating students, including future and current students.

**Hyperspectral infrared imaging facility for the non destructive spectroscopic scanning of geological core**

Support has been requested from the Canada Foundation for Innovation to develop a state of the art infrared imaging facility for the non destructive spectroscopic scanning of drill core. This facility will support research in earth sciences and the program of Rivard and CEOS collaborators. It will provide an near-infrared spectral imaging capability capturing key spectral features of minerals, oil, and water in core, rock chips and hand samples. The ensuing data is vital to address a range of problems in mine exploration (in Canada's north), mine exploitation, and environmental monitoring.
CEOS Members (in alphabetical order)

Walter Bischof, Ph.D.
Department of Computing Science, Professor and Associate Chair (Research)


Arie Croitoru, Ph.D.
Department of Earth & Atmospheric Sciences, Assistant Professor

Dr. Croitoru’s primary research interest is in the area of Computational GeoInformatics: the science and technology used for gathering, management, analysis, and visualization of spatial (and spatially-related) data in Geographic Information Systems (GIS). He is particularly interested in the development and utilization of information science and systems principles to address data-intensive problems in earth sciences. Current research efforts are centered on automated data mining and knowledge discovery in imagery time-series and spatiotemporal data from in-situ earth observation sensors. His overall goal is to develop an algorithmic foundation to derive high-level qualitative and quantitative knowledge from spatiotemporal data and facilitate various tasks such as indexing, clustering, classification, and summarization. In addition to these topics, he has also been active in several other research areas, concentrating primarily on Image Processing and Image Analysis, Digital Photogrammetry and Remote Sensing, and applications of Spatial Statistics in GIS for data quality evaluation.
Dr. Deutsch’s research work relates to the theory and application of geostatistics to earth sciences data, with emphasis on Petroleum Reservoir Characterization, Orebody Modeling, Environmental Site Characterization, Weed and Soil Characteristics, Evaluation of Land Properties for Agricultural Applications. The bulk of Dr. Deutsch’s most recent work focuses on petroleum reservoir characterization, his primary goal centering on geostatistics-based modeling for mining and environmental applications. His work is unique in that it employs numerical geological models and flow models of reservoirs and incorporate both field data and appropriate analog reservoir and outcrop data. Dr. Deutsch’s geographical visualizations include a) detailed numerical 3-D geologic models that combine a wide range of relevant geological, geophysical, and engineering data of varying degrees of resolution, quality, and certainty and b) translations of finely gridded numerical geological models of rock properties to coarsely gridded flow models that reproduce the historic production behavior of the reservoir and better predict its future performance.

Dr. Gamon studies the "breathing of the planet" - the exchanges of carbon and water vapour between the biosphere and the atmosphere that affect ecosystem productivity and help regulate our atmosphere and climate. Of particular interest are the effects of transformative processes and disturbance (fires, succession, weather events and climate change) on these basic processes. Additional research questions involve the detection of plant physiology, ecosystem function, species composition, and biodiversity using non-contact sampling methods. Much of this work is done with optical monitoring (remote sensing and automated field methods), and entails the development of new monitoring methods and related informatics tools. To encourage wider usage of these methods, Dr. Gamon co-founded SpecNet, (Spectral Network), a network of collaborating sites and investigators using optical sampling methods (particularly spectral reflectance) to study ecological questions. Dr. Gamon also pioneered the use of the reflectance index PRI, an indicator of xanthophyll cycle pigment levels that correlate with photosynthetic activity, which has resulted in a new tool for optical remote sensing of ecosystem health. To evaluate Earth’s diverse array of ecosystems, studies include field sites ranging from the extreme Arctic and boreal regions to the equatorial tropics.
Dr. Gan's research includes stochastic processes and hydroclimatatology, which explores applications of stochastic models on hydroclimatatology, examines biases of techniques used in estimating the fractal dimensions of hydrometeorological data and ways to correct them, and furthering study of nonlinear dynamics of our climate and hydrologic systems using these tools; climatic change studies of temperature and precipitation trends across Canada and north-eastern USA apply the non-parametric Kendall's test; dehydrologic effect on water basins resulting from greenhouse-induced, world-wide climatic change; the northern migration of permafrost in northern Alberta and southern Northwest Territories; water resources management and planning practices in the Canadian Prairie in response to potential droughts and climatic warming. Dr. Gan utilizes remotely sensed data from space platforms such as Landsat-TM, Landsat-MSS, NOAA-AVHRR, and Radarsat SAR data, primarily by means of an image analysis system called PCI-Geomatica and ArcGIS. Since 2004, Dr. Gan has been an honorary professor at Xian University of Technology, Xian, P.R. China, and has been a visiting scientist and guest professor at numerous American and European institutions.
Christian Haas, Ph.D.
Professor, Department of Earth & Atmospheric Sciences
Alberta Ingenuity Scholar

Dr. Haas is a sea ice geophysicist with a strong research interest in the role of sea ice in the climate system both in the Arctic and Antarctic, and its interaction with the biosphere. His research is also aiming at revealing the underlying causes for the recent, strong sea ice retreat in the Arctic. Dr. Haas is working on studies of sea ice properties and processes by means of in-situ measurements, airborne and satellite remote sensing, and modelling. His main activities are the establishment of operational ice thickness measurements in the Arctic Ocean, with the goal of systematic observations for climate studies, and satellite and in-situ investigations of snow processes on sea ice. Since coming to Alberta in 2007, Dr. Haas and his team have built an ice-thickness sensor and have visited the Arctic Ocean twice. On their latest trip, they obtained ice-thickness information over the Norwegian, Danish, Canadian and U.S. Arctic sectors – the first Arctic ice-thickness snapshot ever. Polar Ocean Physics Group head Peter Wadhams described Dr. Haas as ‘the acknowledged expert in the field’ of sea-ice measurement.

Ron Hall, Ph.D.
Adjunct Professor, Department of Earth & Atmospheric Sciences
Research Scientist, Natural Resources Canada, Canadian Forest Service

Dr. Hall is a Research Scientist with the Climate Change Impacts and Forest Productivity project team that focuses on the integration of remote sensing and geographic information systems to forest inventory and natural disturbance (e.g., insect defoliators, fire mapping and burn severity) in support of climate change science and forest carbon accounting. He recently coordinated the Prairie province contribution to a circa 2000 satellite land cover map (http://cfs.nrcan.gc.ca/subsite/eosd) and produced the first spatially contiguous forest biomass map of Canada (http://cfs.nrcan.gc.ca/subsite/eosd/biomass). Research interests include the modeling and mapping of forest structure and biophysical attributes, and the assessment and impacts of forest disturbances. He serves as an Adjunct Professor with the Department of Renewable Resources at the University of Alberta and the Department of Geography at the University of Lethbridge. He also functions as an Associate Editor in remote sensing for the Canadian Journal of Forest Research and The Forestry Chronicle.
Andreas Hamann Ph.D.
Assistant Professor, Department of Renewable Resources

Dr. Hamann’s two areas of interest include climate modeling & software development and climate change impact research. Modelling research includes development of windows-compatible applications generating high-resolution GIS coverages of climate data, and allow users to query information on biologically relevant climate variables, such as chilling and growing degree days, frost free period, snow fall, dryness indices, among other items. The program generates up to 50 variables for 30-year averages (climate normals), selected 5-year averages, more than 500 annual and monthly averages from 1960 to 2003, and predictions through the 2080’s from 18 global circulation models. Climate change impact research: Development and use of advanced statistical methods to synthesize information from extensive provincial databases, including timber supply inventories, botanical records, and genetic field trials to document the impact of climate change on forest genetic resources, and provide general ecological impact assessments. This research is inter-disciplinary by nature, including ongoing projects with wildlife biologists, forest pathologist, and community ecologists.

Faye Hicks, Ph.D., P.Eng.
Professor, Department of Civil and Environmental Engineering
Associate Chair

Dr. Hicks’ primary research focus is river ice engineering, with projects in the field and in the laboratory, and uses data to classify ice formation and characteristics, locate moving ice, stationary ice and open water, and predict ice-jam formation and predict flooding. Her field work data are derived from multi-level sources including ground-level field work, air, and satellite resources. Her detection tools include RADARSAT-1, RADARSAT-2, Ground Penetrating Radar (GPR), LiDAR, surface velocity and temperature sensors, and analysis of standard photographic images. Dr. Hicks also participates in C-CORE Northern View, a working group that discusses flooding issues in northern global regions. Dr. Hicks’ work involves testing the suitability of satellite radar imagery for ice jam detection and ice process mapping. Dr. Hicks’ most recent awards, too numerous to mention in their entirety, include the Hynes Lecturer Award (2009), Canadian Rivers Institute; Faculty of Engineering Undergraduate Teaching Award, (2009); Camille A. Dagenais Award, Canadian Society for Civil Engineering (2008); Premier’s Silver Award of Excellence, Province of Alberta (2008); Killam Professorship, University of Alberta (2008); Mentoring Award, Alberta Women’s Science Network (2008).
Dr. Kavanaugh’s current research is focused on how mechanical conditions at the glacier bed are controlled by hydraulic conditions in the subglacial water system. Because the flow and stability characteristics of ice masses are strongly influenced by conditions at the base of the ice, this question is central to the understanding of many interesting aspects of glacier behavior, such as fast flow exhibited by surging glaciers and ice streams. Furthermore, a realistic representation of basal processes is necessary to improve the accuracy of ice sheet models. Dr. Kavanaugh uses a variety of techniques to investigate the interactions between hydrological and mechanical conditions at the glacier bed, ranging from developing and installing novel subglacial instruments to developing and analyzing numerical models. Recently, Dr. Kavanaugh confirmed his earlier prediction of the existence of brief excursions, or "pulses," in subglacial water pressure generated by stress transients that compressed glacial water within the borehole, reaching magnitudes nearly three times the flotation value.

Dr. Knight’s recent, ongoing and planned research covers a range of topics related to power engineering and energy conversion. Aspects of such include analytical and numerical techniques to predict losses in large synchronous machines, numerical design optimization of induction motors, low cost grid connected wind turbine control, novel single-phase motor design and control, adaptive control of induction and permanent magnet motors, parallel solution of finite element analysis techniques, evaluation of losses in inverter fed induction machines, understanding of core loss due to non-sinusoidal supplies, electromagnetic loss characterization in inverter fed grid-coupled transformers, micro-actuators and pumps for microfluidic MEMS devices and energy harvesting devices & power management. Dr. Andy Knight recently received the 2008 Prize Paper Award from IEEE Power Engineering Society (PES) for his paper, “Investigation and Simulation of Fields in Large Salient Pole Synchronous Generators with Skewed Stator Slots.” Dr Knight is a Professional Engineer registered in the province of Alberta, Chartered Engineer and Member of the IET and a Senior Member of the IEEE. Within the IEEE he is a member of the Industry Applications Society, Power & Energy Society and Magnetics Society, and an Associate Editor for IEEE Transactions on Industry Applications. He is also a member of ICS, the International Compumag Society.
Michael Lipsett is a Professor in the Mechanical Engineering Department at the University of Alberta, with research interests in the reliability of energy systems and the development of new equipment and processes. He is currently working on integrated oil sands systems, an area which combines systems modeling and analysis, reliability engineering, and classification techniques. He is also interested in robotic systems for remote and hazardous environments, and making industrial processes more sustainable. Before coming to U of A, Michael was an industrial researcher in oil sands processes for Syncrude Canada Ltd., including mining automation and extraction processes. Prior to that, he conducted reliability research, and developed remote tooling and robotic systems, for Atomic Energy of Canada Ltd (AECL).

Petr Musilek, Ing., Ph.D., P.Eng., SMIEEE
Associate Professor, Department of Electrical and Computer Engineering

Dr. Musilek is interested in intelligent methods and techniques for modelling data and processes, and he develops software systems that improve our ability to understand, model, and forecasts associated events. He worked with the British Columbia Transmission Corporation (BCTC) in the area of weather-based prediction of hazardous situations in the power transmission networks. In cooperation with the Center for Energy Advancement through Technological Innovation (CEATI), he led a pilot study on the use of numerical weather prediction (NWP) systems to model and forecast icing on electric power network equipment. He is currently the principal investigator of an NSERC strategic research project that will develop a system for dynamic thermal rating of overhead power lines using NWP. In collaboration with the Japanese GOSAT project, Dr. Musilek is spearheading a project that will evaluate the applicability of the satellite data for monitoring green house gases (GHG) emissions in the oil sands production area of Alberta, Canada.
Dr. Nascimento focuses on ways of optimizing computer systems to improve data management performance. He has developed algorithms for sensor network querying systems that enhance querying efficiency by performing in-network querying, i.e., selecting only relevant material to be transmitted to a base station, therefore saving energy and extending the network’s lifetime. Dr. Nascimento’s recent research is focused on the unavoidable relationship between data processing in such wireless environments and the network protocols underneath such an environment. For instance, simply by changing the network topology, he has shown that the energy cost of existing algorithms can be decreased by a substantial margin. Finally, Dr. Nascimento has done a considerable amount of research in the domain of spatial-temporal data indexing, in particular, devising ways that data and queries can be remodeled so that existing techniques and structures can be re-used.

Dr. Rivard is a geologist with particular interest in the development of applied geological remote sensing. Remote sensing can be used to investigate processes that have modified planetary surfaces over wide ranging spatial and temporal scales. These modifications are represented in the material properties of the surface (mineralogy, composition, texture, physical state). The measurements of reflected and emitted radiation in the laboratory, the field, or from airborne or space-borne platforms carry fundamental information about the material properties. Through the use of models and analytical techniques, remotely sensed data can be reduced to provide useful information about the properties of surfaces. The challenge is to provide reliable predictions. In this respect, Dr. Rivard’s primary research concern includes the development of hyperspectral analyses using field, airborne and space-borne-derived data to improve the effectiveness of oil/mining industry, and mapping agencies to delineate and manage their targeted resources.
Gerardo Arturo Sánchez-Azofeifa Ph.D., P.Eng.
Professor, Department of Earth & Atmospheric Sciences
Director, Center for Earth Observation Sciences

Dr. Sánchez-Azofeifa’s research is related to the study of impacts of land use/cover change (LUCC) on biodiversity loss and habitat fragmentation in tropical dry forest environments. He uses remote sensing and geographic information systems to evaluate 1) the effectiveness of protected areas (National Parks and Biological Reserves) and 2) Payment of Environmental Services schemes to control tropical deforestation in Mesoamerica. His research also involves the study of theoretical linkages between remote sensing (multispectral and hyperspectral) and the spatio/temporal dynamics of Leaf Area Index (LAI), Primary Productivity (PP), Photosynthetic Active Radiation (PAR) and biodiversity in tropical secondary dry forests. In addition, his research interests involve the development of techniques for the analysis and interpretation of the presence of non-self supporting tropical systems (lianas) and tropical hardwood species (e.g. Mahogany) at the leaf and canopy level using hyperspectral remote sensing data bases. In 2009, Dr. Sánchez-Azofeifa’s research work entered the top 1% in the field of Environment & Ecology in Essential Science Indicators from Thomson Reuters.

Joerg Sander, Ph.D.
Professor, Department of Computing Science

Dr. Sander’s work involves developing techniques to efficiently amass, analyze and query complex data sets derived primarily from large time-series acquired from his own sensor networks. He uses numerous methods to illustrate interesting features of data in aggregate terms. He also acquires data from higher level hyperspectral scales (temperature, humidity) and observes whole value distribution and defines subsets in order to find useful correlations. He works in three primary areas including: clustering, data mining in spatial and biological databases, and spatio-temporal indexing and querying. Dr. Sander’s work on cluster analysis is a primary method for database mining, where the goal is to find the “natural” groups in a data set. Spatial data mining emphasizes the influence of attributes of the neighbors of some object of interest. Biological database data mining seeks new correlations in complex systems by integrating information from disparate databases. Spatio-temporal indexing and querying work seeks development of efficient and effective index structures for spatio-temporal data. Dr. Sander’s work allows for scalability with respect to database size, short update time, and fast query response time for these complex spatio-temporal queries.
Dr. Martin Sharp is a glaciologist with particular interests in interactions between glaciers and the climate system, and in hydrochemical processes in glacial environments. At present his research program is structured around field studies conducted at John Evans Glacier, Ellesmere Island, and combined field and remote sensing studies of the ice caps of the Queen Elizabeth Islands, Arctic Canada. Dr. Sharp's group runs the Glacier Hydrochemistry Lab (walk-in freezer and analytical facility) and is extremely well equipped for glaciological fieldwork (radio echo sounder, ice coring equipment, differential GPS and total station survey equipment, automatic weather stations and stream monitoring stations, digital borehole inclinometer). Recently, Dr. Sharp and his group created an unparalleled archive of imagery of the ice caps of the Canadian high Arctic (>10,000 aerial photographs, Landsat 7 ETM+ imagery, >200 Aster images, ERS-1/2 and RADARSAT SAR imagery (including interferometric coverage) and AVHRR and scatterometer imagery.

Dr. Yang’s research interest covers a wide range of topics in computer graphics and computer vision. In computer graphics, his interests include animation, environment matting, hardware accelerated graphics, motion editing, physics-based modelling, texture analysis and synthesis, and static and dynamic image-based rendering. Topics in computer vision include edge detection, face detection and recognition, light source estimation, motion estimation, segmentation, 2D and 3D shape analysis, and real-time multi-view stereo. Dr. Yang’s most recent work includes his participation with NEPTUNE Canada. By means of system of eight submerged cameras fixed in a circular array, Dr. Yang’s team has performed undersea long-term, real-time, continuous monitoring for the first time, capturing entirely new temporal information regarding these of natural deep sea processes. He is a senior member of the IEEE and serves on the Editorial Board of the journal Pattern Recognition. Dr. Yang has published over 100 technical papers in international journals and conference proceedings, co-edited one book and served as guest editor of an international journal. In addition, he has served as reviewer to numerous international journals, as a committee member in many conferences and on numerous review panels. Dr. Yang co-chaired Vision Interface 98.
Remote sensing by the LANDSAT-7 satellite

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