January 31, 2008

Dr. Renee Elio
Associate Dean, Research
Faculty of Science
G208 Biological Sciences Building
University of Alberta

Dear Dr. Elio:

RE: Centre for Earth Observation Sciences (CEOS) Annual Report, July 2006 to December 2007

Please accept the attached Annual Report for the Centre for Earth Observation Sciences (CEOS), for the period of July 1, 2006 to December 31, 2008.

Sincerely,

[Signature]
Arturo Sanchez-Azofeifa
Director

[Signature]
Benoit Rivard
Director

1-26 Earth Sciences Building
University of Alberta
Edmonton, Alberta, Canada T6G 2E3
Phone: (780) 492-9870 Fax: (780) 492-2030
www.ceos.ualberta.ca
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1. Introduction

The University of Alberta Centre for Earth Observation Sciences (CEOS) consolidates the strengths and research excellence of three distinct yet complementary groups. The Earth Observation Systems Laboratory, already distinguished in remote sensing with equally strong teams from the Departments of Computing Science and Civil and Environmental Engineering, contribute research expertise in a variety of areas, including image transmission, storage, analysis, and environmental modeling. The addition of a public policy component completes the package. With all these components, the Centre is ideally positioned to leverage existing resources and continue to foster industry and government collaborations.

2. Background

Earth Observation Science plays a key role in monitoring environmental changes, resource management, environmental risk mitigation, and the formulation of sustainable development policies. Basic and applied research initiatives support our ability to monitor biodiversity, track and control fires, enhance mineral and mining exploration, monitor snow cover and land ice, and produce maps of land cover. All these elements are central to the province's natural resource industries, as well as to public sector agencies that provide stewardship, set policy, and identify long-term strategy.

CEOS was initiated to regroup faculty expertise for three areas of science and technology that define current and future advances in these domains:

- **Remote sensing**, primarily through spectral and hyperspectral imaging, exploits the fact that most materials on the Earth's surface absorb, reflect, scatter and/or emit electromagnetic radiation in diagnostic or characteristic ways, enabling the identification of many important rock forming minerals (for mining applications) and the diagnosis of organic characteristics of vegetation, given its dependency on light absorption by photosynthetically active and photosynthesis pigments. These properties also can be used to determine the temperatures of surfaces, and whether or not snow and ice are melting.

- **Intelligent image analysis** is the development of algorithms aimed at 2D and 3D shape analysis, edge detection, segmentation, motion analysis, ultrasound image processing, color image processing, physics-based modeling and animation, rendering of realistic imagery, and image based rendering.

- **spatio-temporal data management** approaches for the co-analysis of imagery with data collected from networks of very small sensors spread over large areas of interest (e.g., forests). Using these approaches to synchronize the data from such networks with hyperspectral imagery collected either by airborne, satellite, or field spectrometers, scientists acquire very powerful abilities to identify and monitor surface level features. Research in image and video database organization and retrieval techniques is core to advancements in these areas. Efficient accessing and updating of such databases and wireless access are also crucial for earth observation scientists.
3. Goals

In its first year, CEOS has had three main goals:

- To consolidate the earth observation research capacity at the University of Alberta
- To develop new provincial, national, and international activities
- To advance its leadership to provincial and national interests in earth observation sciences and applications

Goal 1: To Consolidate the Current Research Capacity in Earth Observation Sciences and related fields at the University of Alberta

1) Key personnel and web site: Our first task was to hire an administrative assistant, Linda Abraham, who undertook the creation of the CEOS web site and content.

2) Workshops: One of the first undertakings for CEOS was to establish contacts and partnerships with researchers across campus, and then beyond the University environs [Appendix A, Appendix B]. To achieve this, CEOS invited possible stakeholders to a first CEOS workshop in November, 2006. At this meeting, participants were asked to give brief presentations, outlining their research interests and a discussion focused on possible new synergies and collaborations. From this meeting, specific research projects were identified and smaller meetings were held to discuss possible collaborations that could be pursued in the next year. They included a partnership with the Alberta government for the detection of mountain Pine beetle infestations and an equipment proposal concept for sensor networks.

3) Faculty hiring: We also succeeded in recruiting Dr. John Gamon, who specializes in ecoinformatics and remote sensing. Dr. Gamon was cross appointed to the Departments of Earth and Atmospheric Sciences and Biological Sciences. He will be joining CEOS in July 2008.

Goal 2: To Develop New Provincial, National, and International Activities

1) Funding initiative: In February, 2007, CEOS Directors met with representatives of the Alberta Government, as well as researchers from universities in Alberta and British Columbia, to discuss a possible collaborative research endeavour to address the mountain pine beetle issue that has been threatening our forests. Further discussions ensued, resulting in CEOS submitting a grant proposal in the fall of 2007 that is now funded for $147,000.

2) Conference: In June, CEOS began to coordinate SpecNet North 2007, an international 4-day conference that was held in September 2007. This activity was supported by iCORE, the University of Alberta and several private companies.

Goal 3: To Advance Its Leadership to Provincial and National Interests in Earth Observation Sciences and Applications

CEOS personnel have participated in meetings and consultations, sharing their expertise with various agencies and organizations locally, nationally, and internationally. Some of these
meetings are listed in Appendix C. For example, we met with representatives of the department of geomatics engineering and geography at the University of Calgary to present CEOS and foster a similar initiative at their institution in preparation for a potential joint response to a call for Alberta INGENUITY Centers.

We also invited Dr. Bob Harriss from the Houston Advance Research Centre (HARC) to share his experience in establishing national centers and we met with Alberta Ingenuity representatives.

In August 2007, we conducted a visit to the Institute for remote sensing applications in China and the Department of Geography at Pekin University. The main goal of this trip was to hold discussions to foster future collaborations among Chinese and CEOS researchers. The final outcome of this visit was an agreement to develop a Sino-Canadian joint workshop during 2008. As such, CEOS submitted a proposal to the China Fund administered by the University to seek financial support for this activity. Following our outreach activities, we have since received five inquiries for graduate and post graduate work from both Chinese institutions.

CEOS continues to attract excellent graduate students, and to cultivate top-quality researchers in various aspects of earth observation sciences, many of whom go on to successful employment in academia, government, and industry. A list of students involved in CEOS can be found in Appendix D.

4. Personnel

Co-Directors

**Dr. Arturo Sánchez-Azofeifa** (Department of Earth and Atmospheric Sciences), Co-director, Land Use/Cover Change, and Computing Science. Director of TROPI-DRY, a research network for tropical dry forests in the Americas, whose members come from the United States, Cuba, Venezuela, Costa Rica, Panama, Brazil, Mexico and Canada. Dr. Sánchez-Azofeifa also is past principal investigator for the Central American Project for Climate Change, and has served as a consultant and advisor to several international agencies including the United Nations, the World Bank, and the Inter American Development Bank, in areas associated with remote sensing and geographic information systems. His research focuses on the study of impacts of land use/cover change (LUCC) on biodiversity loss and habitat fragmentation in tropical dry forest environments.

**Dr. Benoit Rivard** (Department of Earth and Atmospheric Sciences), Co-director, Imaging and Resource Management. Dr. Rivard has led three multi-university, multi-year projects funded by the Geode Centre of the Networks of Centres of Excellence, and was a member of the research management committee of the Geode Centre. He is a member of the Canadian Space Agency HERO satellite scientific advisory panel and the Canadian Space Agency Space Exploration advisory council. Dr. Rivard’s research interests include the use of hyperspectral imaging for characterization of oil sands, support for underground mining operations, for regional mineral exploration, and for mapping agencies to delineate and manage targeted resources.

CEOS employs one .5 fte Administrative Assistant, Ms. Linda Abraham.
5. Research

Both basic and applied research initiatives are well advanced at the University of Alberta; CEOS has fostered initiatives spanning four departments within the Faculty of Science and the Faculty of Engineering:
- Earth and Atmospheric Sciences
- Computing Science
- Civil and Environmental Engineering, and
- Mathematical Sciences

Additional links have been established with the Department of Renewable Resources in the Faculty of Agriculture, Forestry, and Home Economics.

Scientists in these departments have long-standing, established contractual relationships with the corporate sector (e.g. Syncrude) and the provincial government sector (e.g. Alberta Environment), as well as national partners (e.g., Environment Canada, Canadian Space Agency) and international partners (NASA, the European Space Agency, the World Bank and several United Nations Agencies).

For example, researchers at the University of Alberta, under a $1.5 million contract, currently are completing a province-wide map of land cover at a resolution of 30m², using Landsat 7 satellite technology. This program will be used as the basic landmark tool for monitoring changes in land cover due to development, and for monitoring biodiversity, among other uses. This project was awarded the 2007 Canadian Forest Service Merit Award for its contribution to the National Project: Earth Observation for Sustainable Development (EOSD).

The Centre for Earth Observation Sciences is unique in that it combines Alberta’s strategic research and innovation pillars — life sciences (environment), energy (mining) and information technology — into a coherent research initiative. By including a social and public policy component aimed at biodiversity, ecological protection, and resource management, this Centre has a potential scope that will distinguish it from other research initiatives.

Provincial, national, and international partners regard the University of Alberta as an important player in the development of new and innovative approaches for image processing in resource management. CEOS researchers routinely are approached for significant research opportunities in environmental monitoring and modeling.

One of the goals of CEOS is to draw top scientists, graduate and post-doctoral fellows interested in developing new skills in land use/cover change, geological remote sensing, land ice monitoring and intelligent imaging applications to support natural resources development.

The research initiatives of CEOS fall squarely within the strategic priorities of the University of Alberta Faculty of Science, which are identified Integrated Environment and Landscape Management (IELM) and Research Geosciences as core interdisciplinary areas around which it conceived and designed the Centennial Centre for Interdisciplinary Science. We also are beginning to contribute to the northern research agenda.
The University of Alberta’s *Strategic Research Plan for the Canada Foundation for Innovation and Canada Research Chairs Program* (March, 2003, updated February 2006) identifies ecosystem management, geo-environmental engineering, and resource geo-science as areas of existing strength. Through its existing and increased collaborations with provincial and national partners in mining, agriculture, and environment, CEOS will continue to satisfy the University of Alberta’s objective for investment in partnerships with government agencies and industries.

These on-going initiatives clearly fit institutional and provincial strategies focused on interdisciplinary science for resource exploration, on northern research (e.g., the global land ice monitoring project in the Canadian arctic; the Canadian Circumpolar Institute) and on national and international collaborations with government and industry partners (e.g., International Polar Year; the TROPI-DRY project, European Cryosat mission).

In addition, a current national governmental initiative aims to develop Canadian satellite capability before 2010 (the HERO program), focusing on mineral exploration in the north, and on forest monitoring. Spectral imaging technologies are also starting to emerge for monitoring the status of vegetation cover prior to fires. This innovative spectral imaging approach links field sensing and remote sensing information with applications in ice river monitoring and in the development of early warning systems for forest fire prevention. Thus, spectral imaging technologies have the potential of playing an important provincial role in the development of long term monitoring policies for resource exploitation and ecosystem protection.

Finally, Radarsat and Radarsat 2, the two most prominent Canadian earth observation satellites, successfully completing the Antarctic Mapping Missions (AMM) with strong support from NASA and the Canadian Space Agency (CSA). CSA has envisioned significant Canadian involvement/leadership for the data acquisition portion of the program, and CEOS researchers have been asked to participate, and to assist in developing a national skill base in radar data processing and interpretation for large ice masses, capitalizing on Canada’s position at the forefront of developing and operating sensing technologies.

### 6. Plans for the Future

Our plans for 2008 are the following:

*Activity No. 1:* To develop a 5-year plan, to carry the Centre beyond 2010, and to secure major funding to support its ongoing growth and new activities. We will recruit world class personnel and, through the development of significant new courses and programs, will attract top-quality graduate and post-graduate students.

*Activity No. 2:* To work on the development of a joint proposal with the Universities of Alberta, Calgary, and Lethbridge aimed at creating an Alberta INGENUITY Centre on Geomatics and Earth Observation Sciences.
Activity No. 3: To continue building interactions among CEOS members through an annual workshop and other related activities (e.g., brown bag lunches, seminars, etc.).

Activity No. 4: To build key interactions with other University Centres and related organizations, specifically, the Center for Mathematical Biology and the School for Energy and Environment (SEE).

Submitted January 31, 2008

Arturo Sanchez-Azofeifa
Director
Centre for Earth Observation Sciences
University of Alberta

Benoit Rivard
Director
Centre for Earth Observation Sciences
University of Alberta
# Appendix A

## RESEARCH PARTNERS

### EXTERNAL

<table>
<thead>
<tr>
<th>Name</th>
<th>Contributions</th>
</tr>
</thead>
</table>
| Mr. Ken Dutschak, P.Biol. | • Leader of the Reconnaissance and Remote Sensing section of the Forest Protection Division, Alberta’s Sustainable Resource Development  
                          • Determines the provincial direction on the use of remote sensing for fire management, access information, and land use/cover change monitoring  
                          • Part of NASA’s Tactical Fire Remote Sensing Advisory Committee  
                          • Has extensive knowledge of government operations in the use of imagery and imagery related projects  
                          • Has been instrumental in the development of multi-agency initiatives and funding operations |
| Dr. John Gingerich    | • Former chief exploration geophysicist of Noranda Mining  
                          • Instigated the first international mining exploration program incorporating extensive hyperspectral imaging  
                          • Advisor to the Canadian Space Agency  
                          • Advisor to the Canada Centre for Remote Sensing in matters of sensor and market development for Earth Observation Science  
                          • Has extensive knowledge of the Canadian and international mining sector |
| Mr. Ron Hall          | • Remote Sensing Inventory Specialist Northern Forestry Centre, Canadian Forest Service  
                          • Conducts research on forest inventory and biophysical parameters (e.g., biomass, leaf area index) estimation from remote sensing.  
                          • Applies optical remote sensing to studies of forest disturbance (e.g., burn severity, insect defoliation, aspen dieback)  
                          • National team member to Earth Observation for Development of Forests project representing the Prairie Provinces (EOSD)  
                          • Associate Editor, The Forestry Chronicle |
| Ms. Chandra Mahabir   | • River Engineering Team Leader, Regional Environmental Management, Northern Region  
                          • Coordinates provincial initiatives associated with river ice monitoring  
                          • Works closely with researchers from the Department of Civil and Environmental Engineering |

### INTERNAL (UNIVERSITY OF ALBERTA)

## Civil & Environmental Engineering

<table>
<thead>
<tr>
<th>Name</th>
<th>Contributions</th>
</tr>
</thead>
</table>
| Dr. C. V. Deutsch | • Professor and Canada Research Chair in Natural Resources Uncertainty Management  
                          • Leader of the Centre for Computational Geostatistics (CCG), Geospatial modeling with direct measurements and remotely sensed information |
| Dr. T. Gan | • Professor, Department of Civil and Environmental Engineering  
                          • Researcher on the retrieval of seawater turbidity and ocean water quality for optical satellites  
                          • Researcher on the retrieval of snow water equivalent from passive microwave and soil moisture from active microwave satellites  
                          • Partner, Canada Centre for Remote Sensing |
Dr. F. Hicks
- Professor, Department of Civil and Environmental Engineering Researcher on the use of satellite radar for river ice characterization, primarily during breakup
- Currently collaborates with Alberta Environment, C-Core, INRS-Eau, and the Ugra research institute of information in Siberia, the ministry for nature protection of the Sakha Republic
- Vision based Ice Jam Monitoring System

Dr. C. D. Martin
- Professor, Department of Civil and Environmental Engineering
- Researcher on the use of 3D visualization and Lidar imaging for civil engineering

Dr. D. W. Smith
- Professor and Canada Research Chair in Environmental Engineering
- Researcher on cold region environmental research problems

Computing Science

Dr. W. F. Bischof
- Professor, Department of Computing Science
- Machine learning and algorithm development applied to the identification of static and dynamic patterns in aerial images

Dr. M. Nascimento
- Associate Professor, Department of Computing Science
- Spatio-temporal data management and access algorithms, particularly for widely dispersed sensor networks

Dr. J. Sander
- Associate Professor, Department of Computing Science
- Algorithms and index structures for spatio-temporal query processing for dynamic location data provided through sensor networks and GPS systems

Dr. H. Yang
- Professor, Department of Computing Science
- Computer graphics and computer vision, including 2D and 3D shape analysis, edge detection, segmentation, motion analysis, ultrasound image processing, color image processing, physics-based modeling and animation, rendering of realistic imagery, and image-based rendering
- Senior member of the IEEE
- Associate Editor for the journal *Pattern Recognition*
- Vision based Ice Jam Monitoring System

Dr. H. Zhang
- Professor, Department of Computing Science
- iCORE/NSERC Industrial Research Chair, Department of Computing Science
- Computer vision and imaging processing algorithms, particularly sensing algorithms that provide reliable size information for oil sand ore and analysis of texture images

Earth and Atmospheric Sciences

Dr. A. Croitoru
- Assistant Professor, Department of Earth and Atmospheric Sciences
- GeoInformatics: the science and technology used for gathering, management, analysis, and visualization of spatial (and spatially-related) data
- Development and utilization of information science principles to address data-intensive problems in geosciences.
- Photogrammetry, image processing and understanding, automated feature extraction
- Geographic Information Systems (GIS)
- Currently particularly interested in automated data mining and knowledge discovery in imagery time-series and spatio-temporal data.

Dr. T. Garvin
- Associate Professor, Department of Earth and Atmospheric Sciences
- Human geography policy development, environment and health
- Science to policy translations
Dr. M. Sharp

- Professor, Department of Earth and Atmospheric Sciences
- Monitoring summer melt, dynamics and thickness changes of the Canadian Arctic land ice masses, using optical, passive and active microwave remote sensing
- Member, calibration/validation team for the Cryosat mission headed by the European Space Agency. [CryoSat is the first in a new class of earth observation spacecraft, known as Earth explorers, which are small research missions designed to address critical issues of Earth science. The European mission focuses on the effects that global warming may be having on Earth’s polar ice masses.]
- Has been invited to participate in the third Antarctic Mapping Mission that will be conducted using RadarSat2

Mathematical and Statistical Sciences

Dr. S. Lele

- Professor, Department of Mathematical and Statistical Sciences
- Statistics for Ecology, Environmental Sciences and Public Health
- Spatial data analysis: Models and Inference

Renewable Resources

Dr. Janusz Zwiazek

- Professor and Associate Chair (Research), Department of Renewable Resources
- Tree physiology
- Effects of pollution, drought and other environmental stresses on function and structure of trees
- Stress resistance, physiological, biochemical and structural adaptations of trees to stress
- Tree improvement and stress conditioning
- Structure and function of cell membranes.
Appendix B

COMMUNITY INVOLVEMENT

RESEARCH PARTNERS

Provincial and Federal Government:
- Alberta Sustainable Resource Development: Forest Protection Division (Edmonton)
- Alberta Biodiversity Monitoring Program (Edmonton)
- Alberta Research Council (Edmonton)
- Canada Center for Remote Sensing (Ottawa)
- Canadian Forest Service: Northern Forestry Research Center (Edmonton)
- Canadian Space Agency (Montreal)
- CS Lord Northern Geoscience Center, Nunavut
- Environment Canada (Meteorological Service of Canada), Downsview
- Natural Resources Canada (National Glaciology Program), Ottawa
- C-Core (Private Corporation, St-John Newfoundland)
- INRS-Eau (Institut National Recherche Scientifique, Quebec city)

Industry:
- Syncrude (Edmonton, AB)
- Suncor (Fort McMurray, AB)
- Inco Ltd (Nickel mining company, Sudbury, ON)
- Telops Inc. (Optical instrument manufacturer, Quebec City, QC)
- Geoide National Center of Excellence (Quebec City, QC)
- Falconbridge (Nickel company, Sudbury ON)
- Noranda (Mining company Toronto, ON)
- Barrick Gold (Gold company, Toronto, ON)
- MacDonald Dettwiler (Vancouver, BC)
- AngloAmerican PLC (Mining company, London, England)
- Olsonet (Communications corporation, Ottawa, ON)

International Organizations:
- Inter American Institute for Global Change Research (IAI)
- DIVERSITAS: An international network for biodiversity research
- TROPI-DRY: An international network for the study of the human and biophysical dimensions of tropical dry forests
- Central American Commission for the Environment and Development (CCAD)
- Smithsonian Tropical Research Institute (STRI)
- Panama Canal Commission, Panama
- Organization for Tropical Studies
- Centre for Ecosystems Research (CIECO-UNAM), Mexico
- European Space Agency
- Ugra research institute of information in Siberia
- The ministry for nature protection of the Sakha Republic
Appendix C

CEOS ACTIVITIES
July 2006 to December 2007

July 2006
• Received approval from University of Alberta to form new Centre for Earth Observation Sciences
• Received start-up funding

August 2006
• Planning meetings held between co-directors
• Met with Faculty of Science Associate Dean, Research

September 2006
• Dr. Rivard presented CEOS to the Faculty of Geomatics Engineering, University of Calgary, Calgary, AB
• Developed a target hiring proposal for the appointment of John Gamon in Earth and Atmospheric Sciences

October 2006
• Hired part-time administrative staff Linda Abraham
• Began work on a grant proposal for the Natural Sciences and Engineering Research Council of Canada (NSERC)

November 2006
• Met with Alberta INGENUITY representatives to discuss possible research funding
• First CEOS researchers workshop to share research interests and to discuss possible research collaborations
• Met with Ken Dutchak from Alberta Sustainable Resource Development to discuss a strategy to deal with Mountain Pine Beetle and other remote sensing needs at the provincial level
• Dr. Rivard gave a presentation at the Yukon Geoscience Forum in Yellowknife, NWT
• Met with UofA researchers to follow-up on discussion begun at workshop regarding research collaboration

December 2006
• Met with ASRD representatives to further discuss mountain pine beetle research project
• Dr. Rivard made two invited presentations to the British Geological remote sensing society in London, UK
• Dr. Rivard met with the Canadian Space Agency in Montreal, QC
• Dr. Sanchez-Azofeifa gave a keynote presentation at the University of Montes Claros, Montes Claros, Brazil
• First regular CEOS strategic meeting

January 2007
• Met with ASRD representatives to further discuss mountain pine beetle research project
• Dr. Sanchez-Azofeifa gave a keynote presentation at the Universidad Federal de Minas Gerais, Belo Horizonte, Brazil

February 2007
• Hosted a live/conference call meeting with stakeholders from ASRD, UofA, and universities in Alberta and British Columbia to discuss the mountain pine beetle project
• Dr. Sanchez-Azofeifa participated in a meeting at Harvard University, Cambridge, MA
March 2007
- Dr. Sanchez-Azofeifa participated in a meeting in at the Venezuelan Institute for Scientific Research, Caracas, Venezuela
- Further meetings were held to develop a strategic plan for addressing the mountain pine beetle issue

April 2007
- CEOS personnel met with Dr. John Gamon to discuss the possibility of hosting SpecNet North 2007 conference in the fall of 2007
- Drs. Sanchez-Azofeifa, Rivard, and Sharp met with Dr. Peter Hackett, President and CEO of Alberta INGENUITY Fund to discuss the possibility of research funding for a CEOS project
- Dr. Sanchez-Azofeifa participated in a research meeting in Brazil

May 2007
- Dr. Sanchez-Azofeifa gave a keynote presentation at the University of Montes Claros, Montes Claros, Brazil

June 2007
- Dr. Rivard gave a computing demonstration and plenary talk at the NCE Geoide annual conference, Halifax, NS
- Dr. Sanchez-Azofeifa traveled to Ottawa, ON, by invitation to attend a meeting organized by Netera. He met with the CEO of Cybera (Alberta cyberinfrastructure organization) and gave a talk on Geochronos as part of a symposium on Cyber Infrastructure development in Canada.

July 2007
- Ms. Abraham met with GIS committee to plan GIS Day 2007. She will take the lead in coordinating this event with the help of past committee members.
- Ms. Abraham met with John Gamon and David Hik to discuss SpecNet North 2007, to be held in September.

August 2007
- Drs. Rivard, Sanchez-Azofeifa, and Feng traveled to China to discuss research activities and possible partnerships.
- Dr. Mariana Alvarez, graduate student, visited from Ecosystems Research Centre, Universidad Nacional Autonoma de Mexico (UNAM).

September 2007
- SpecNet North 2007. CEOS hosted the first SpecNet conference to be held in Canada.
- Drs. Sanchez-Azofeifa and Gamon met with Ms. Abraham to finalize SpecNet North 2007 agenda.
- Ms. Abraham attended a Canadian Consular Services Presentation at University of Alberta.
- CEOS personnel met to discuss ongoing strategy.

October 2007
- Dr. Patricia Morelato visited from State University of Sao Paolo, Brazil.
- CEOS strategy meetings continued.
- CEOS personnel developed a proposal for funding a project to address the Mountain Pine Beetle issue, through Alberta Sustainable Resource Development.
- Joint project begun between the Earth Observation Systems Laboratory, UofA, and Olsonet aimed at building ecological sensing networks based on Olsonet’s wireless technology.

November 2007
- Dr. Geraldo Wilson Fernandes visited CEOS for the month of November, from Federal University of Minas Gerais, Brazil.
- Dr. Mario Marcos do Espirito Santo visited from State University of Montes Claros, Minas Gerais, Brazil
- Dr. Rivard traveled to Hilo, Hawaii for a conference on remote sensing.
December 2007

- Drs. Sanchez-Azofeifa, Rivard, Elio, Croitoru, and Nascimento traveled to Calgary to meet with researchers regarding possible research partnerships.
- CEOS personnel met to discuss strategy.
- Dr. Sanchez-Azofeifa, and Ms. Mei Chong received the Canadian Forest Service Merit Award for 2006-2007, from Natural Resources Canada, for their contribution to the satellite land cover map for the forested area of Canada.
Appendix D

TRAINING OF HIGHLY QUALIFIED PERSONNEL

by Co-directors Rivard and Sanchez-Azofeifa

July 2006 to December 2007

Students Supervised:

<table>
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<tr>
<th>Masters</th>
<th>PhD</th>
<th>Post-Doctorate</th>
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<tbody>
<tr>
<td>• Nieves, Maria (2008) Leaf area Index &amp; remote sensing</td>
<td>• Correo-Montero (2008) Invasive species &amp; hyperspectral remote sensing</td>
<td>• Rogge, Derek (PhD 2006) Chemical effects on vegetation detectable in optical band 350-2500nm</td>
</tr>
<tr>
<td>• Ball, Aaron (2009) Ecosystem structure and composition of interactions dry forest/Cerrado in Brazil</td>
<td>• Huan, Yingduan (2010) Leaf phenology and phenology trends in the tropical dry forests of Mexico</td>
<td>• Feng, Jilu and Lyder, Dave Estimation of bitumen content and grain size distribution in oil sands with infrared spectroscopy</td>
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<tr>
<td>• Castillo, Mauricio (2009) Ecosystem structure and composition of tropical dry forests via Lidar and hyperspectral systems</td>
<td>• Portillo, Carlos (2010) Tropical dry forests of the Americas &amp; remote sensing</td>
<td></td>
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<tr>
<td>• Zabcic, Natalie (2008) Derivation of surfact pH-values based on mineral abundances estimated from hyperspectral imagery of mine tailings of the Sotiel Migollas Complex, South-West of Spain</td>
<td>• Hesketh, Michael (2012) Phenological properties of tropical dry forests at multiple scales and sensors</td>
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<td>• McLellan (2009) Human dimensions of tropical dry forests</td>
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<td>• Pujadas (2010) Human dimensions of tropical dry forests</td>
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<td></td>
<td>• Cheng, Tao (2010) Tree speciation of boreal forest with hyperspectral data</td>
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CEOS OPERATIONAL FUNDING

<table>
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<tr>
<th>Funding Source</th>
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<tr>
<td>Dept. Earth &amp; Atmospheric Sciences</td>
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<td>Dept. Civil &amp; Environmental Engineering</td>
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<td>Faculty of Science (cash)</td>
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<td>Faculty of Science (in-kind)</td>
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<td>Faculty of Engineering</td>
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<td>Vice-President (Research)</td>
<td>$20,000.00</td>
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</table>

Total Funding Available for Year 1 (2006-2007) $78,000.00

FUNDING APPLICATIONS SUBMITTED


2) Submitted a joint proposal with the Universities of Calgary and Lethbridge to the Alberta INGENUITY Fund for imaging innovation (AI4); proposal was declined.

3) Currently preparing a response to the Letter of Intent call for research centers by Alberta INGENUITY Fund.

4) Sanchez-Azofeifa, A. Natural Sciences and Engineering Research Council of Canada (NSERC) Equipment Grant. Wireless sensors for environmental monitoring. $35,400 for 1 year. Proposal submitted to NSERC.
Appendix F

CEOS-Related Courses Taught
by Co-directors Rivard and Sanchez-Azofeifa

*July 2006 to December 2007*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Section</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAS 208</td>
<td>Introduction to Global Change</td>
<td>LEC A1</td>
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<tr>
<td>EAS 333</td>
<td>Advanced Geology Field School</td>
<td>LAB</td>
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<tr>
<td>EAS 351</td>
<td>Environmental Applications of GIS</td>
<td>LEC A1</td>
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<td>Reading and Seminar Course</td>
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Appendix G

CEOS-RELATED PUBLICATIONS

July 2006 to December 2007

Refereed Journal Publications


Refereed Book Chapters


Other Refereed Publications (including refereed abstracts)


B. Rivard, H. Mumin, L. Corriveau, and D. Rogge. “Spectral signatures (0.4-2.5 µm) of IOCG alteration assemblages, Contact Lake”. 34th Yukon Geoscience Forum, Yellowknife, November 26-29, 2006.


Other Publications (reviews, edited books, bulletins, etc.)

Reports:


