

Annual Report for Research Centers and Institutes  
Reporting Period 2001 and 2002  
(April to April)

**Centre for Earth Observation Science (CEOS)**

Level 1 Centre of the Faculty of Arts  
Department of Geography, University of Manitoba

Prepared by:

David R. Mosscrop (Operations Manager) and David G. Barber (Director)



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## **Personnel**

### **Faculty**

#### *Internal*

Barber, D.G., Professor of Geography (50 percent)  
Baydack, R., Associate Professor NRI (10 percent)  
Bullock, P. Assistant Professor of Soils Science (10 percent)  
Campbell, M., Assistant Professor Recreation Studies (5 percent)  
Gardner, J. Professor of Geography ( 5 percent)  
Hanesiak, J. Assistant Professor of Geography ( 25 percent)  
Iacozza, J. Lecture in Geography (20 percent)  
Kenkel, N, Professor of Botany (10 percent)  
Papakyriakou, T, Assistant Professor of Geography (25 percent)  
Smith, G. Professor of Geography (10 percent)

#### *External*

Yackel, J. Professor of Geography University of Calgary (25 percent)

### **Post Doctorial Fellows**

Fortier, Martin (100 percent) (Supervisor: Dr. Barber)

### **Research Associates**

Mkanda, Francis (100 percent since Jan 02) (Supervisor: Dr. Barber)  
Walker, David (100 percent) (Supervisor: Dr. Barber)

### **Support Staff**

Fast, Doug, Cartographic support (10 percent)  
Mossdrop, David R., Operations Manager of CEOS. (50 percent)  
Roberecki, Aggie, Administrative support for CEOS, (50 percent)

### **Scientific Programmer**

Chan, Wayne, Programmer (100 percent)

### Students (Ph.D. Masters and honours)

The following students were supported (financially and/or logistically) over the reporting period, April 2001 to April 2002.

Name	Years Supervised	Degree (date)	Research Topic	Advisor
Cooley, P.	1996-2001 (continuing)	Ph.D. (2001)	Development of a GIS based biodiversity atlas for Lake Malawi, Africa.	Barber
Harouche, I.	1999-2001	MA (2001)	Microwave emission over snow covered sea ice	Barber
Hempel, R.	1998-2000 (continuing)	MA (2002)	Forrest Management in Indonesia	Barber
Hochheim, K.	1995-2000 (continuing)	Ph.D. (2002)	Microwave and optical remote sensing of agricultural surfaces.	Barber
Kirk, R	2001-2002	MA (2003)	Melt ponds on sea ice	Barber
McCullough, G.	1998-2002	Ph.D. (2002)	River Sediment loading studies in Lake Malawi.	Barber
Mkanda, F.	1997-2002	Ph.D. (2002)	Soil erosion modeling within a geographical information system.	Barber
Morris, K.	2001-2005	Ph.D (2005)	Remote sensing of the thermodynamic processes of snow on sea ice.	Barber
Mundy, C.J.	2001-2004	Ph.D. (2004)	Biological implications of snow thickness distributions on sea ice.	Barber
Saczuk, E.	1999-2002	PhD (2002)	Mass Wasting in the Himalaya	Gardner
Silvestrie, G.	1996-2001	PhD (2001)	Decision making of the Elderly	Smith
Thorgillson, W.	1998-2000 (continuing)	MA (2000)	Precision Agriculture	Barber
Wiseman, G.	2001-2003	MA (2003)	Mapping boreal ecosites and enhancing forest GIS inventories with remotely sensed data and evidential reasoning.	Barber.
Hay, J.	2001-2002	Honours	Melt ponds on sea ice	Barber
Vander Kruys, J.	1999-2001 (continuing)	MA (2001)	Cryosphere-climate interactions	Barber
Vasudevan, A.	2001-2003	MNRN	Incorporating Ecosite-level biodiversity values in forest management and decision support	Baydack
Smid, B	2000-2004	PhD (2004)	Using Recreational Habitat Suitability Indices (rHSI) to better manage the recreational potential of boreal ecosites .	Campbell

## **Thesis completed**

Harouche, I., Microwave emission over snow covered sea ice.

Mkanda, F., Soil erosion modeling within a geographical information system.

Walker, D., Riding Mountain National Park Vegetation Study.

## Activities and Research Projects

Selected activities are highlighted below:

### **Proposal Development:**

CASES group, lead by Dr. L. Fortier of University of Laval, submitted a CFI proposal for the necessary funds (\$27 million) to secure a northern research platform ( ‘an icebreaker for science’).

The Director of CEOS and Operations Manager of CEOS have both been involved and working with the Interm Dean and the various committees of the developing new Faculty of the Environment. CEOS sees an expand role in the new faculty, providing the IT infrastructure needed for both teaching and research and also a role in coordinating certain pieces of research equipment.

### **On-going Projects:**

*CASES 2000 – 2006*

The Canadian Arctic Shelf Exchange Study (CASES) was accepted as a 10 million dollar NSERC National Network contingent upon the success of a CFI International Opportunities proposal. Scientifically we propose to examine the relationship between the observed reduction in sea ice extent and volume with aspects of the marine ecosystem. This climate change study focuses on the processes which drive these relationships and will entail a year-long field experiment in the Beaufort Sea and Amundsen Gulf in Northern Canada. Conditionally funded by NSERC.

### *C-ICE*

The Collaborative Interdisciplinary Cryospheric Experiment (*C-ICE*) is a multi-year field experiment that integrates many individual projects, each with autonomous goals and objectives. The science conducted has directly evolved from research relating to one of four general themes: i. sea ice energy balance; ii. numerical modeling of atmospheric processes; iii. remote sensing of snow covered sea ice; and iv. ecosystem studies.

i. *Sea Ice Microclimate*: The energy balance over sea ice is understood only in a very rudimentary fashion. Due to the high contrast between the ocean and atmosphere, the intervening spatial pattern of the sea ice leads to dramatic fluctuations in energy transfer. The seasonal nature of radiative contributions further enhances the complexity of the system.

ii. *Numerical Modelling of Atmospheric Processes*: Scale is the primary focus of these studies, linking surface observations to numerical models of the atmosphere operating at regional to hemispheric scales. The objective is to provide estimates of the geophysical and/or energy parameters required by numerical models. Input variables are inverted

from remote sensing data of the surface and are used for both initialization and verification.

These baseline prerequisites are essential to monitoring marine cryospheric change. This issue forms a link with themes i., iii. and iv.

iii. *Remote Sensing of Snow Covered Sea Ice*: Energy will interact with the snow covered sea ice as a function of the physical characteristics. The basic premise of this work is that if both the state and seasonal evolution of the sea ice and snow microstructure are known, the interaction mechanisms at any wavelength of energy can be estimated. This leads to the idea that transfer functions must exist whereby interactions at one frequency may be used to estimate the interactions of energy at another frequency.

Due to atmospheric attenuation of incident visible wavelength radiation during the spring, micro-wavelengths are more appropriate for monitoring the metamorphic state of the snow covered ice surface than are visible wavelengths.

iv. *Ecosystem Studies*: The marine cryosphere provides habitat for a wide diversity of marine and avian species. The ramifications of change and variability must be coupled with adaptation responses of these biota since the biophysical processes are an integrator of the hydrospheric and atmospheric components of the system.

The *C-ICE* field program provides the surface data required to develop an understanding of the process linkages operating in an environment typical of fast ice conditions in the Canadian Arctic Archipelago. A modelling component within *C-ICE* operates in conjunction with the field activities, although the modelling aspects will assume greater importance as the existing field data are analyzed. The principal objective of this subgroup is to integrate the field data within numerical models of the primary processes operating in our area of interest, for the purpose of 'scaling up' observations to more regional scales.

Agencies participating in *C-ICE'2001* include: Centre for Earth Observation Science (University of Manitoba) (lead agency); University of Calgary; Canadian Ice Service, Polar Continental Shelf Project and Energy, Mines and Resources Canada, Environment Canada; Canada Centre for Remote Sensing; Atmospheric Environment Service, Downsview, Ontario; National Research Council, Ottawa, Ontario; the Winnipeg Climate Centre and Transport Canada.

The duration of this year's field program was 11 weeks, extending from day 120 (April 30) to day 194 (July 13). The base camp was established on Truro Island (75°14.686'N, 97°09.207'W). The camp was located approximately 80 km NW of Resolute, Nunavut. This location allowed easy access to the various sites on the first-year sea ice in McDougall Sound. Various physical measurements were made on the sea ice, less than 5 km from the location of base camp

NSTP fundees for CICE 2001 were:

Curtis Downie - 4th year env science - funded  
Shannon Roy - 4th year physical geography - funded  
Janet VanderKruys - 1st year Masters - funded  
Randall Scharien - 4th year physical geography - funded

#### *CEOS Web site*

The CEOS web site has a new look and is now maintained by the Department of Geography's cartographer under the direction of the CEOS Operations Manager.

#### *Development of an Ecosite-based Decision Support System for Sustainable Forest Management*

(<http://www.umanitoba.ca/geography/ecosite>)

This is a three year project fund as a CFS/NSERC/SSHRC FOREST RESEARCH PARTNERSHIPS PROGRAM.

#### Objectives

To develop an integrated ecosite level classification and sustainable forest management decision support system that incorporates conservation of biological diversity, nature-based outdoor recreation/tourism, and conservation of spiritual, cultural and aesthetic resources. The broad objectives of the project are to:

1. Develop a GIS database identifying ecosites for Manitoba.
2. Apply the ecosite classification to forest management in Manitoba.
3. Develop and apply a model for biodiversity conservation using ecosites.
4. Identify and correlate recreation/ tourism experiences based on ecosites.
5. Develop a decision support system for sustainable forest management linked to the ecosite classification.
6. Develop a mechanism to facilitate communication of our results to all partners.

The primary objective for the second funding year was to develop a descriptor database (ecosite fact sheets), publish these in a format available to all partners (web-based content server), and continue testing a preliminary ecosite classification and field key for the boreal and sub-humid mid-boreal region of Manitoba. This classification is the foundation for achieving the objectives of the project and its development is a critical goal in the project.

#### *Lake Winnipeg Research Consortium (LWRC)*

CEOS is a founding member of the Lake Winnipeg Research Consortium. This organization facilitates multi-disciplinary science, coordinates public and private research, and promotes information-sharing. This past summer was the second field



season for this group and CEOS actively collected field data for 15 days on the Lake and obtained remote sensing data for the entire field season of the group. CEOS also provided a portable GPS data collection system for use in vessel tracking on Lake Winnipeg and use one of CEOSs' spectral radiometers to collect reflectance data during the lake cruise.

#### *International Associate for Great Lakes Research (IAGLR)*

CEOS on behalf of the University of Manitoba and LWRC was successful in being selected the host of the 2002 annual conference to be held in June 2002. The conference is expected to attract ~400 international fresh water scientists.

#### **Completed Projects: International Field Work Indonesia Project Summary**

The Indonesia project has completed gathering data in the field with a second expedition lead by CIFOR staff.

#### **Malawi Project Summary**

Two remaining PhD students in the Lake Malawi Biodiversity Conservation Project at CEOS are Greg McCullough and Paul Cooley. They are in the last year of their studies, and publishing papers in support of their degrees.

### **Academic Contributions**

#### **Primary Publications**

- Yackel, J., J. Hanesiak, and D. G. Barber. 2000. Melt ponds on sea ice in the Canadian Arctic Archipelago. Part 1 – Variability in morphology and surface radiation. *Journal of Geophysical Research-Oceans* 105(C9): 22,049-22,060.
- Yackel, J. and D. G. Barber. 2000. Melt ponds on sea ice in the Canadian Arctic Archipelago. Part 2. On the use of RADARSAT-1 synthetic aperture radar for geophysical inversion. *Journal of Geophysical Research-Oceans*. 105(C9):22,061-22,070
- Barber, D.G., J. Yackel and J. Hanesiak. 2001. Perspectives on Sea Ice, RadarSat-1, and Arctic Climate Processes. *Canadian Journal of Remote Sensing*. 27(1):51-61.
- Hanesiak, J.M, D. G., Barber, R. De Abreu and J.J. Yackel. 2001. Local and regional albedo. Observations of arctic first-year sea ice during melt ponding. *Journal of Geophysical Research-Oceans*. 106(C1):1005-1016
- Barber. D.G., E. Sazuk, and P. Richard. 2001. Examination of beluga-habitat relationships through the use of Telemetry and GIS. *Arctic*. 54(3):305-316.

- Barber, D., R.Marsden, P. Minnett, G. Ingram and L. Fortier. 2001. Physical processes within the North Water (NOW) Polynya. *Atmosphere-Ocean* . 39(3):163-166.
- Hanesiak, J.M., D.G. Barber T.N. Papakyriakou and, P.J. Minnett. 2001. Parameterization Schemes of Incident Radiation in the North Water Polynya. *Atmosphere-Ocean* . 39(3):223-238.
- Wilson, K, D.G., Barber, and D. King. 2001. Validation and Production of RADARSAT-1 Derived Ice Motion Maps in the North Water Polynya (NOW), January-December 1998. *Atmosphere-Ocean*. 39(3):257-278.
- Yackel, J. and D.G. Barber and T.N. Papakyriakou. 2001. On the Estimation of Spring Melt in the North Water (NOW) using RADARSAT-1 SAR. . *Atmosphere-Ocean*. 39(3):195-208.
- Hanesiak, J. J. Yackel and D. Barber. 2001. Effect of Melt Ponds on First-Year Sea Ice Ablation-Integration of RADARSAT-1 and Thermodynamic Modeling. *Canadian Journal of Remote Sensing*. 27(5):433-442.
- Barber, D.G., J. Hanesiak, W. Chan and J. Piwowar. 2001. Spatial and temporal patterns of sea ice/atmosphere processes within the NOW polynya between 1978 and 1996. *Atmosphere-Ocean*. 39(3):343-359.
- Mundy, C.J., and D. G. Barber. 2001 On the relationship between spatial patterns of sea ice type and the mechanisms which create and maintain the North Water (NOW) polynya. *Atmosphere-Ocean*. 39(3):327-341.
- Fortier, L. M. Fortier, M. Fukuchi, D. Barber, Y. Gratton, L. Legendre, T. Odate and B. Hargrave. 2001. The International North Water Polynya Study (NOW): A progress report. *Memoirs of the national Institute of Polar Research, Special Issue 54(343-348)*. National Institute of Polar Research, Tokyo.
- Iacoza, J. and D.G. Barber. 2001. Ablation patterns of snow cover over smooth first-year sea ice in the Canadian Arctic. *Hydrological Processes*. 15:3359-3569
- Harouche, I. and D.G. Barber. 2001. Seasonal Characterization of Microwave Emissions Over Snow-Covered First-Year Sea Ice. *Hydrological Processes*. In press (Sept'01)
- Wilson, K, D.G., Barber, and D. King. A Case Study in Tracking 1998 Spring Ice Dynamics in the Smith Sound, North Water Polynya Region using RADARSAT-1, *Annals of Glaciology, International Glaciological Society*. 33:413-418.
- Ingram, G., J. Bacle, D. Barber, Y. Gratton, H. Melling. Physical Processes in the North Water Polynya. *Deep Sea Research*. In press (Jan'02).
- Cooley, P. and D.G. Barber. Remote Sensing of the Coastal Zone of Tropical Lakes using Synthetic Aperture Radar and Optical Data. *International Association of Great Lakes Research*. In Press (June'02).
- Hunter, F., Donald, D., F. Hunter, B. Johnson, W Hyde, J. Hanesiak, M. Kellerhals, R. Hopkinson and B. Oegema, 2002: The Vanguard torrential storm (Meteorology and Hydrology). *Can. Water Resour. J.*, 27, No. 2, 213-227.

## **Papers in review**

- Barber, D., J. Iacozza, and A. Walker. On the Estimation of Snow Water Equivalent (SWE) using microwave Radiometry over First-Year Sea Ice. Hydrological Processes. In Review (May'00).
- Nghiem. S.V., D.K. Perovich, A.J. Gow, R. Kwok, D.G. Barber, J.C. Comiso. Observation of Sea Ice Surface Thermal States under Cloud Cover. Journal of Geophysical Research (Oceans). In review (June'00).
- Hochheim, K.P. and D. G. Barber. The Seasonal Backscattering of Agricultural Crops as Observed by RADARSAT-1. Part 1. Wheat. International Journal of Remote Sensing. In review (Oct'00).
- Hochheim, K.P. and D. G. Barber. The Seasonal Backscattering of Agricultural Crops as Observed by RADARSAT-1. Part 2. Canola. International Journal of Remote Sensing. In review (Oct'00).

## **Technical/Conference Papers**

- McCullough, G.K., P.M. Cooley, and K. Hocheim, 2001. Retrospective study of suspended sediment patterns on Lake Winnipeg using NOAA AVHRR satellite imagery. Report to Canada Department of Fisheries and Oceans, Winnipeg, Canada. 72 p.+4 appendices.
- McCullough, G.K. 2001. Organic carbon, nitrogen and phosphorous fluxes in rivers flowing into and out of Lake Winnipeg with an analysis of discharges and nutrient fluxes between the North and South Basins. Report to Canada Department of Fisheries and Oceans, Winnipeg, Canada. 46 p.+10 appendices.
- Moss crop, D., D.G. Barber and J. M. Hanesiak, 2001: The Role of Geomatics in Climate Variability and Change: A scoping document to the Prairie Adaptation Research Cooperative (PARC), CEOS Technical Report 01-1, Geography Department, University of Manitoba, Winnipeg

## **Workshops/Meetings/Presentations**

- Dr. Hanesiak was co-author, Factors Influencing the Timing and Magnitude of the Sinking Export of ice Algae During the Spring and Summer, in the High Arctic, Oceans Science Meeting (hosted by AGU ASLO (American Geophysical Union and American Society of Limnology and Oceanography), Hawaii, USA, Feb. 2002.
- Dr. Hanesiak gave an oral presentation, A one-dimensional coupled snow sea-ice model, CASES Modelling Workshop, Quebec City, Quebec, Sept. 2001.
- Dr. Hanesiak was co-author, Analysis of the 1998 energy budget of the North Water Polynya, *Intl. Polynya Workshop*, Quebec City, Quebec, Sept 2001.

- Dr. Hanesiak was co-author, Sea ice and meteorological conditions of the NOW polynya since 1979, *Intl. Polynya Workshop*, Quebec City, Quebec, Sept. 2001.
- Dr. Hanesiak gave an oral presentation, Surface-Atmosphere Research at CEOS, U. Manitoba, *1st Manitoba Climate Change Workshop*, University of Winnipeg, Aug. 2001.
- Dr. Hanesiak gave an oral presentation, Connections between field observations, thermodynamics, and ice strength. *CIS Sea-Ice Thickness Redistribution Workshop*, July 25-26, 2001, Victoria, B.C.
- Dr. Hanesiak gave an oral presentation, Meteorological analysis of the 3 July 2000 Vanguard heavy rainfall storm. *Can. Meteorol. and Oceanog. Soc. Conf.*, Winnipeg, Manitoba, May 28 - June 1, 2001.
- Dr. Hanesiak gave an co-author, Water quality implications of a heavy rain event in southwestern Saskatchewan, *Can. Meteorol. and Oceanog. Soc. Conf.*, Winnipeg, Manitoba, May 28 - June 1, 2001.
- Dr. Hanesiak was an invited speaker, Linking Thermodynamic Sea Ice Modeling with Microwave Remote Sensing, International Arctic Research Center (IARC), Fairbanks, Alaska, April 2001.

### **CEOS Seminar Series**

CEOS organized a Hydrology and Climate Change Forum and invited four excellent speakers:

Alain Peitroniro  
National Water Resources Institute  
Tuesday March 12,2002  
Hydrology and Climate Change on the Prairies

Helen Fast  
Fisheries and Oceans Canada  
Tuesday March 19,2002  
Socio-economic Impacts in the Canadian Arctic due to Climate Change Effects

Stewart Cohen  
University of British Columbia  
Tuesday March 26,2002  
Implications of Climate Change for the Canadian Arctic

Dave Sauchyn  
University of Regina  
Tuesday April 2,2002  
Hydrologically Related Disasters and Impacts and Adaptations

## Funding Sources

CEOS receives an annual operating grant from the Faculty of Arts. The Department of Geography and CEOS also collaborate on providing teaching and research facilities within the Department. Currently we have one undergraduate lab, and two graduate research labs.

### *Funding held by CEOS Principle investigators*

The following research grants were obtained within the reporting period.

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<b>Principal Investigator</b>	<b>Grant Description</b>
Barber, D.G.	Support for the C-ICE'00 and '01 field experiments from the Canadian Ice Service
Barber, D.G.	C-ICE'00 - Polar Continental Shelf Project, Energy Mines and Resources. This is a grant of in-kind support for helicopter, twin otter and snow machine rental; room and board; field equipment and logistical field support.
Barber, D.G.	CFI equipment infrastructure grant to outfit a Canadian Ice Breaker for Marine Science Applications (\$980,000 total grant). Joint with U of Laval.
Barber, D.G.	Manitoba Hydro Supported Project to examine the utility of passive microwave remote sensing for SWE estimation.
Barber, D.G.	Northern Studies Training Program to support the C-ICE'00 experiment
Barber, D.G.	Meteorological Services of Canada. Research Grant to examine the role of clouds in microwave emission over sea ice.
Barber, D.G.	Meteorological Services of Canada. Research Grant to link microwave remote sensing to a one-dimensional thermodynamic model of snow covered sea ice.
Barber, D.G.	Northern Studies Training Program to support the C-ICE'01 experiment
Barber, D.G.	C-ICE'01 - Polar Continental Shelf Project, Energy Mines and Resources. This is a grant of in-kind support for helicopter, twin otter and snow machine rental; room and board; field equipment and logistical field support.

<b>Principal Investigator</b>	<b>Grant Description</b>
Barber, D.G.	Meteorological Services of Canada. CRYSYS Research Grant to examine aspects of remote sensing of snow on sea ice.
Barber, D.G.	Three year grant from the Canadian Forest Service, NSERC and SHRC tri-council to develop an ecological forest classification system in Manitoba (with Dr's Baydack and Campbell)
Barber, D.G.	University of Manitoba Research Support Grant to prepare an application for a Networks of Centre's of Excellence in Arctic System Science.
Hanesiak, J.M.	2002-2006(Feb.) Atmosphere-Sea Ice Coupling Funding Source: NSERC Program: Research Grants (individual)
Hanesiak, J.M.	2002 (Feb.) Tethersonde Meteorological Tower (TMT) for Atmosphere-Sea Ice Coupling Studies Funding Source: NSERC Program: Equipment Grants
Hanesiak, J.M.	2001 (Dec.) University of Manitoba Program: University Research Grants Program (URGP)
Hanesiak, J.M.	Title: Melt Pond Evolution Tower 2001 (Jun.) University of Manitoba (Faculty of Arts) Program: Start-up funding
Papakyriakou, T	2002-2006(Feb.) Relationship between complex snow surfaces and the atmosphere-surface-subsurface exchange of energy and mass Funding Source: NSERC Program: Research Grants (individual)
Papakyriakou, T	2002 (Feb.) Relationship between complex snow surfaces and the atmosphere-surface-subsurface exchange of energy and mass Funding Source: NSERC Program: Equipment Grants
Papakyriakou, T	Northern Studies Training Program to support the C-ICE'00 experiment
Yackel, J.C.	2002-2006(Feb.) Use of microwave remote

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Principal Investigator	Grant Description
Yackel, J.C	sensing for estimating the thermodynamic and ablation state of Arctic sea ice Funding Source: NSERC Program: Research Grants (individual) 2002 (Feb.) Use of microwave remote sensing for estimating the thermodynamic and ablation state of Arctic sea ice: equipment. Funding Source: NSERC Program: Equipment Grants

*Funding applied for by CEOS Principle investigators*

The following research grants were applied for within the reporting period.

Dr. D.G. Barber CRC-CFI Infrastructure project titled “Research Infrastructure for Support of a Tier II Research Chair in Arctic System Science”

Dr. J. Hanesiak, CFI New Opportunities titled “Ground-based remote sensing for atmosphere-surface climate interactions in the Canadian Arctic”

Dr. J. Yackel, CFI New Opportunities titled ‘Use of microwave remote sensing for estimating the thermodynamic and climate state variables from snow covered sea ice in the Canadian Arctic

The Centre has a reasonably good financial status. Most of the CEOS research support money is used to provide student stipends and purchase equipment. The operating grant from the Faculty of Arts will need to be increased in the near future if we are to maintain the current level of research and related activities.

## **Infrastructure**

### **Research Facilities**

CEOS considers remote sensing, geographic information systems, image analysis systems, global positioning systems, computer modeling and analytical methods as an integrated set of 'Geomatics' tools.

- Computer Hardware/software resources:
  1. CEOS has a state-of-the-art network computer facility with modern industry standard software; and
  2. Through the University of Manitoba CEOS is part of a GIS consortium, which has entered into a province-wide licensing agreement with ERSI to provide industry standard GIS software to students regardless of which institute they are attending.
- Field equipment:
  1. two VIS/NIR spectrometers,
  2. Trimble differential GPS base station and rover units, and
  3. surface energy balance and cloud physics instrumentation (radiometers, psychrometers, ceilometers, and an all sky cameras)
  4. various loggers and climate measuring equipment
  5. digital still and video cameras
  6. two 7 section parcels
  7. two Paraglider

### **Data:**

- MOUs between CEOS and the Province of Manitoba (Land Information Branch), NASA, CSA, NASDA, and ESA for access rights to data - with the qualification that these data must be used for research.
  - The University of Manitoba Libraries has entered into a licensing agreement with Linnet Geomatics to make the Land Information Navigator data available on campus. CEOS is the repository of one of four University held sets of these data.



## **Web Address**

To be kept up-to-date with the variety of CEOS activities and to be informed of upcoming events, check our World Wide Web page regularly.

[www.umanitoba.ca/ceos](http://www.umanitoba.ca/ceos)

[www.umanitoba.ca/geography](http://www.umanitoba.ca/geography)

email addresses:

- David Mosscrop – [David\\_Mosscrop@Umanitoba.ca](mailto:David_Mosscrop@Umanitoba.ca)
- David Barber – [dbarber@ms.umanitoba.ca](mailto:dbarber@ms.umanitoba.ca)