

Centre for Earth Observation Science (CEOS)

Clayton H. Riddell
Faculty of Environment, Earth, and Resources
University of Manitoba

April 1, 2006 – March 31, 2007

Prepared by:

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Executive Summary

This is the Annual Report for the Centre for Earth Observation Science (CEOS) for the period April 1, 2006 to March 31, 2007. CEOS is an integral part of the Clayton H. Riddell Faculty of the Environment, Earth, and Resources.

CEOS is a water-centric research centre with a particular interest in how climate forces variability and change in the hydrosphere. The overarching objective of CEOS is to:

“Understand how climate change forces various water related processes operating within the Earth System.”

The Centre for Earth Observation Science (CEOS) was established in 1994 with a mandate to research, preserve and communicate knowledge of earth system processes using the technologies of Earth Observation Science. Our research program continues to expand. Our training of HQP and list of publications demonstrate our success in preserving and communication our data and knowledge about the earth system.

The basis of CEOS is research partnerships, leveraging resources and providing a research umbrella under which members conduct multi-disciplinary collaborative research projects. Areas of application include climate change, particularly in the Arctic, agriculture, forestry, freshwater and geomatics.

CEOS is currently involved in 3 major collaborative international and many national research partnerships. CEOS has also been active in the community and surrounds. The Centre is a founding member and an active participant in the Lake Winnipeg Research Consortium (LWRC). These partnerships have provided funded research opportunities for Masters students and PhD students. Researchers operating under the CEOS umbrella currently hold ~\$5.7 million in research funds. NSERC is a major funding source.

Future research activities will continue to build on the research strengths of CEOS members and partners.

Highlights of the reporting period include the following:

- Award of the International Polar Year project: Circumpolar Flaw lead system study (CFL);
- Funding of two major climatologic research projects: Storms in the Arctic (STAR) and Drought Research Initiative (DRI);
- The renewal of Canada Research Tier II Chair held by Dr. D. Barber;
- Creation of a Department of Fisheries and Ocean’s chair in Arctic contaminants (first holder of the chair is Dr. Gary Stern, DFO FWI);

Over the past year CEOS researchers have moved closer to the Centre's five-year goals (2005-2010). These are:

- continuation of the ArcticNet Network of Centres of Excellence;
- increasing focus on water in Manitoba;
- increasing partnerships with Manitoba Hydro;
- increasing development of earth system science models;
- continued use and development of geomatics technologies and in particular integration of these technologies within numerical process models;
- increased responsibilities for geomatics and techniques courses in the new undergraduate laboratory of the Faculty;
- continuation of earth system studies with an increased emphasis on water and climate research;
- continuation of the Schools on board program aboard the Amundsen.

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A description Centre for Earth Observation Science

Bringing Technology to Earth
Senate Approved August 2, 1994

Mission Statement

The Centre for Earth Observation Science (CEOS) will research, preserve and communicate knowledge of earth system processes using the technologies of Earth Observation Science. These endeavours will contribute to the economic, cultural, and physical well-being of the people of Manitoba, Canada and the world.

The technological perspective of the Centre focuses attention on the development of new methodologies required for the study of Earth System Science. A multidisciplinary focus is maintained throughout the CEOS educational and research curriculum, with specific emphasis on how humans interact with the planetary systems.

CEOS was established as a Centre, in the Department of Geography, Faculty of Arts in 1994. In 2002 the Centre became part of the Clayton H. Riddell Faculty of Environment, Earth and Resources, and in 2005 the Centre was re-located from the Isbister Building on the Fort Garry Campus to the Wallace Building. The 8400 square foot space (for details see appendix) provides improvement in our ability to work as a coherent centre. CEOS has been able to establish a strong national and international research profile. In doing so, it has been able to form broad partnerships and leverage significant funding. This support has not only enhanced the research activities of the Centre, but it has also enabled the University to attract and retain new faculty and graduate students.

The basis of CEOS is research partnerships, leveraging resources and providing a research umbrella under which members conduct multi-disciplinary collaborative research projects. Future research activities will continue to build on the research strengths of CEOS members and partners. Areas of application include climate change, particularly in the Arctic, agriculture, forestry, freshwater, climatology and geomatics.

The Centre has baseline support from the University of Manitoba through operating grants from the Clayton H. Riddell Faculty of Environment, Earth and Resources. These funds provide CEOS with an annual budget of \$190K. These funds are used for staff salaries, for day-to-day operations, and to maintain an undergraduate teaching lab. CEOS attracts an average of between \$1M and \$2M annually in direct dollars and research support. Annually, CEOS operating funds (both external and internal) are used: to support graduate students, post docs and /or research associates (\$140K); to maintain infrastructure (\$40K); for new capital equipment (\$150K); for travel and research (\$80K); and for support of field logistics, satellite data and aircraft (\$400K).

Research Partnerships

CEOS is involved in major collaborative international research partnerships. These include:

- Circumpolar Flaw Lead Project (2007 -2009);
- ArcticNet Network Centres of Excellence (2001-2011);
- DRI (2005 – 2010);
- STAR (2006 – 2010);
- The Canadian Arctic Shelf Exchange Study (CASES) (2001 – 2006).

These partnerships have provided funded research opportunities for graduate students, postdoctoral fellows and undergraduate student assistants.

Increased Research and Training Capacity

The creation of a chair in Arctic Contaminants' Research complements the ongoing work of CEOS researchers working in high latitudes. Dr. Gary Stern is an active researcher in ArcticNet and a co-lead in the CFL project.

In the current fiscal year, there are 29 Masters and 15 PhD graduate students in the Centre, along with six Post-doctoral Fellows/ Research Associates.

Outreach and Community Involvement

CEOS researchers are active in the community, annually providing over 60 public lectures, radio, television, newspaper and web-based stories in the fields of climate change, weather, drought assessment, flooding, water quality, and freshwater eutrophication. As well, CEOS works closely with native and stakeholder communities with the objective of making the science that we conduct relevant to those with a stake in understanding variability and change. The Centre also runs the very successful Schools on Board program which brings public school children and teachers to the Arctic aboard the Amundsen icebreaker for an exhaustive immersion into the field of polar marine science.

CEOS researchers have been profiled on numerous national and international broadcasts on climate change. **Several full length documentaries highlighting research being conducted by CEOS staff were made over the past year,** The Centre has an international reputation as a 'Centre of Excellence' in Arctic marine systems and climate change. It is widely known to have played a key role in detecting changes in sea ice dynamic and thermodynamic processes driven by global scale climate change and in the determination of changes in the marine ecosystem driven by these physical change.

CEOS was instrumental in establishing MEGIC (Manitoba Educational GIS Consortium) representing six post-secondary educational institutions in Manitoba. This Consortium has facilitated teaching and research using the latest GIS software at a Province-wide level for a reduced price.

Academic Development

CEOS works with Physical Geographers and Environmental Scientists in the Department of Environment and Geography to secure support for new faculty positions which can

become associated with CEOS. We also work collaboratively with our partners from other faculties to enable the integration of new hires into the research umbrella supported by CEOS. To maximize the long-term success of the Centre, new hires in Environment and Geography will be required in a number of strategic areas. In order of priority these are:

- 1) Climate Modelling – our research program suffers from the lack of a climate science research member who has expertise in climate and/or atmospheric modeling, specifically at scales that couple atmosphere-surface interface processes. A new hire in this area would support a number of our key undergraduate/graduate degrees and research programs in terms of how the climate system will affect hydrometeorological and ecological related processes, in the next several decades. Most of our work is currently focused on contemporary processes. A modeling position would allow this work to become predictive.
- 2) Arctic Marine Ecosystem/Biogeography – CEOS works very closely with biologists on the coupling of physical and biological systems. We require a new hire to expand our research at this interface between physics and biology and to maximize existing partnerships with scientists from different universities.
- 3) Hydrologist – CEOS activities are water-centric, with growth in the area of biosphere/hydrosphere/atmosphere interactions. Currently there is no such specialist on campus, and the addition of this capacity through the SIP process would directly benefit CEOS projects, fill a hole in our academic programming, and foster collaboration with partner units.

Personnel

Faculty: Internal

(Principle Investigators in **bold**)

Barber, D.G., Professor of Environment and Geography (50 percent)

Baydack, R., Associate Professor Environment and Geography (10 percent)

Hanesiak, J., Assistant Professor of Environment and Geography (25 percent)

Hanson, M., Assistant Professor of Environment and Geography (project based participation)

Iacozza, J., Lecturer in Environment and Geography (20 percent)

Lobb, D., Professor Agriculture (ArcticNet)

Oakes, J., Assistant Professor of Environment and Geography (ArcticNet)

Papakyriakou, T., Assistant Professor of Environment and Geography (25 percent)

Riewe, R., Professor Zoology (ArcticNet)

Stern, G. , Arctic Contaminants Chair (50 percent)

Tenuta, M., Assistant Professor Agriculture (ArcticNet)

Walker, D., Assistant Professor of Environment and Geography (25 percent)

Wang, F., Associate Professor of Environment and Geography (10 percent)

Faculty: External

Belcher, B., CIFOR
Ferguson, S., Research Scientist Fisheries and Oceans (ArcticNet)
Fortier, L., Professor biology Laval University (ArcticNet)
Hecky, R., University of Waterloo (project based participation)
Macdonald, R., University of British Columbia (ArcticNet)
Outridge, P., Natural Resources Canada (Geological Survey of Canada) (ArcticNet)
Prinsenber, S., Department of Fisheries and Oceans (ArcticNet)
Richard, P., Research Scientist, Fisheries and Oceans (project based)
Snelgrove, K., Assistant Professor Engineering (ArcticNet)
Tang, C., Research Scientist Fisheries and Oceans (ArcticNet)
Yackel, J., Professor of Geography University of Calgary (25 percent)

Post Doctoral Fellows/Research Associates

Hochheim, K., (100 percent) (Supervisor: Dr. Barber)
Lawford, R., (100 percent STAR Project) (Supervisor: Dr. Hanesiak)
Lui, G., (100 percent DRI Project) (Supervisor: Dr. Hanesiak)
Lukovich, J., (100 percent) (Supervisor: Dr. Barber)
Granskog, M., (100 percent) (Supervisors: Drs. Barber and Papakyriakou)
McCullough, G., (100 percent) (Supervisor: Dr. Barber)

Support Staff

Anderson, J., ArcticNet theme 4.1 Coordinator (50 percent)
Barber, L., Schools on Board (100 percent)
Chan, W., Programmer (100 percent)
Collin, P., Schools on Board (50 percent), Laboratory Technician (50 percent)
Hodgson, R., Field Technician (100 percent)
Langlois, A., ArcticNet theme 3 coordinator (50 percent) (replaced Mundy)
Leitch, D., CFL Coordinator (100 percent)
Maconachie, T., Office support for CEOS (100 percent)
Moscrop, D. R., Operations Manager of CEOS (50 percent)
Mundy, C.J., ArcticNet theme 3 Coordinator (50 percent)
Petrusevich, V., CEOS Field Technician (100 percent) (replaced Hodgson in Jan 2007)
Whynot, D., Administrative support for CEOS (100 percent)

Students (Ph.D., Masters, Honours and Undergraduate Summer)

The following students were supported (financially and/or logistically) over the reporting period, April 2006 to March 2007.

Name	Degree (date)	Research Topic	Advisor
Arnold, G.	MEnv	Youth Perspectives on Environmental Change in Churchill	Oakes
Barber, L.	MEnv	Environmental Education and Scientific Outreach: a case study of the Schools on Board program	Oakes
Blouw, C	MSc.	Snow catchment, sea ice roughness and higher trophic habitats	Barber
Bhuiyan, H.	Ph.D.	Climate modeling of extreme weather.	Hanesiak
Brimelow, J.	Ph.D.	Prairie drought prediction/modeling	Hanesiak
Butler, J.	MSc	Blowing snow prediction on the Canadian Prairies and Arctic	Hanesiak
Carrie, J.	M. Env	Mercury biochemistry in the Mackenzie Basin	Wang/Stern
Chambellant, M.	PhD	Seals and climate change in Hudson Bay.	Ferguson
Chmelnitsky, E.	MSc	Movements and diving behaviour of ringed seals in Hudson Bay	Ferguson
Chen, Z.	MA	CO ₂ flux characteristics within a prairie agricultural landscape	Papakyriakou
Chow, L.	MEnv	Youth Education: Perspective on Environmental Change and the Passing Down of Knowledge from Elders to Children in Churchill	Oakes
Churchill, J.	MSc	Relation of Greenhouse Gas Emissions to Plant Communities and Edaphic Conditions at Churchill, Manitoba	Tenuta
Edye-Rowntree, J.	MEnv	Churchill Residents' Perspectives on the Lower Churchill River From 1970-2006	Oakes
Ehn, J.	PhD	Bio-optical modeling in marginal ice zones	Barber
Fisico, T.	MSc	Meteorological studies during CASES	Hanesiak
Galley, R.	PhD	Sea Ice/snow mass balance from ground penetrating radar	Barber/ Papakyriakou

Name	Degree (date)	Research Topic	Advisor
Geldsetzer, T.	PhD	Polarimetric Microwave Remote Sensing of Snow Covered Sea Ice	Yackel
Gilligan, J.	MA	Environmental Change and Off Road Transportation in Churchill	Oakes
Gislason, R.	MEnv	Inuit perceptions on beluga co-management in Kuujjuarapik and Umiujaq, Nunavik	Oakes
Green, T.	MSc	Marine Subsistence Fishery in the Churchill Region	Oakes
Hare, A.	PhD	Changing terrestrial-marine relationships and their effect of mercury cycling in the Hudson Bay area	Ferguson/ Stern
Hartwig, L.	MSc	Carbon Dynamics in a Prairie Wetland	Papakyriakou
Hwang, P.	PhD	Sea-ice microwave scattering	Barber
Iacozza, J.	PhD	Sea ice and Polar Bear Habitat	Barber
Isleifson, M.	MSc	Signal Processing over sea ice	Barber
Jin, X.	PhD	Atmospheric Remote Sensing and column Modelling	Barber/ Hanesiak
Kinghorn, A.	MSc	Mercury and selenium intake from beluga by Mackenzie Delta Inuit: industrial- and climate-driven changes in recent beluga contaminant loads	Outridge
Kuzyk, Z.	PhD	Climate Change and contaminants in the Hudson Bay ecosystem.	Stern
Langlois, A.	PhD	Snow on sea ice; dynamic and thermodynamic processes	Barber
Larter, J.	MSc	Peat islands in the Nelson River system	Barber
Leitch, D.	M. Sc	Mercury in the Mackenzie Basin: Distribution, speciation and seaward flux to the Beaufort Sea	Wang/ Stern
Loseto, L.	PhD	Ecological and contaminant relationships of beluga in the eastern Beaufort Sea.	Ferguson/ Stern
McCullough, G.	Ph.D.	River Sediment loading studies in Lake Malawi	Barber
Mundy, C.J.	Ph.D.	Biological implications of snow thickness distributions on sea ice	Barber
Owens, O.	MA	Gradients, fluxes and environmental controls of CO ₂ in fast ice of the Beaufort Sea	Papakyriakou
Pomerleau, L.	PhD	Contaminants, oceanographic provinces, climate change in Hudson Bay	Stern

Name	Degree (date)	Research Topic	Advisor
Rossnagel, A.	MSc	Physical processes in the MIZ	Barber
Scharien, R.	PhD	Geophysical and microwave remote sensing investigations of melt ponded first-year Arctic sea ice	Yackel
Scott, G.	MSc	Air-surface CO ₂ exchange in near-shore Hudson Bay: water dominated period	Papakyriakou
Shippam, G.	MSc	Optical Properties of Lakes	Barber
Smith, A.	Pre-MSc	Movement and behaviour of Hudson Bay beluga whales	Ferguson
Stainton, E.	MSc	Cold region estuary gas exchange	Barber/Papakyriakou
Tat, A.	MSc	Severe weather linkages to crops and soil moisture	Hanesiak
Tranchtenerg, M.	MSc	Polarimetric scattering over sea ice	Barber
Westdal, K.	MEnv	Movement and Diving of Northern Hudson Bay Narwhal Population: Relevance to Stock Assessment and Hunt Co-Management	Oakes
Wiseman, G.	MA	Mapping boreal ecosites and enhancing forest GIS inventories with remotely sensed data and evidential reasoning	Walker

Students who graduated in the reporting period 2006-2007

Name	Degree (date)	Research Topic	Advisor
McCullough, G.	Ph.D.	River Sediment loading studies in Lake Malawi	Barber
Leitch, D.	M. Sc	Mercury in the Mackenzie Basin: Distribution, speciation and seaward flux to the Beaufort Sea	Wang/Stern



The data collection site near Sanikiluaq, with one of the community monitors. The weather station transmits data by radio to a receiver in the community.

Also involved as co-investigators: Dr.s Hanesiak, Papakyriakou and Yackel.

Circumpolar Flaw Lead (CFL) System Study (2007-2009)



Led by Dr. D. Barber, the Circumpolar Flaw Lead (CFL) System Study is the largest International Polar Year (IPY) project in the world. It has become Canada's flagship project. The project aims to use the CCGS Amundsen icebreaker to study the Cape Bathurst Polynya in the southern Beaufort Sea over the course of a year, marking the first

time a flaw lead has been studied over an annual cycle. The project also involves a large traditional knowledge component and focuses on the “two ways of knowing”. The project is funded as follows:

- The Canadian IPY Federal Program Office (\$6M over 4 years for science);
- The Canadian IPY Federal Program Office (\$14.6M over 2 years for infrastructure support);
- NSERC (\$.8M over 3 years);
- CFI Leaders Edge Fund (LEP) (\$10.8M for the CCGS Amundsen to L. Fortier & D. Barber); and
- Approximately \$15M in in-kind contributions from national and international collaborators.

The project fits well with the IPY mandate of a collaborative international effort to learn more about the Arctic from both a natural science and cultural perspective. It involves approximately 200 researchers from 14 countries. Many students and research staff have been recruited both nationally and internationally (including a CFL project coordinator here at CEOS in Feb, 2007). The newly created CFL Scientific Steering Committee selected the team of Russian collaborators and projects to be funded. Other activities included planning for the first community consultations in Sachs Harbour, Paulatuk and Ulukhaktok (Holman) in early April; and making preparations for the first CFL Planning Meeting in Quebec at the end of April; and initiating the process of applying for Research Licenses



Schools on Board Field Program

Lucette Barber, Program Coordinator

The 2006 Schools on Board Field Program experienced a very successful year on-board Leg 2 of ArcticNet. This two-week adventure on an Arctic research icebreaker exposed our team of high school students and teachers to the research objectives and methods of the multidisciplinary team of scientists from across Canada. This year, we participated in research activities related to the Northern Labrador Fjord Study, which involved three full sampling stations in the Nachvak Fjord, Saglek Fjord and Anaktalak Bay. In addition to science, participants met with Johanne Gelinas, Canada’s Commissioner of Environment and Sustainability, and enjoyed a breakfast meeting with internationally re-known environmental spokesperson and Inuit representative, Sheila Watt-Cloutier during their visit in Iqaluit.



Other activities of the Schools on Board program included attendance at the Arctic Frontier Conference in Norway, designing, planning and promoting the next series of field programs that will include the upcoming 2008 International Field Programs and the Circumpolar Inuit Field Program, as part of the outreach activities that CEOS is planning for International Polar Year. With the help of Promoscience funding, Schools on Board was able to pilot 'Project Ant-Arctique' a classroom-based program with the Collège Jeanne Sauvé. This program adapted the science program of 3 grade 9 classrooms to reflect and promote an Arctic theme. The program identified specific links between the science education curriculum, and Arctic research. It included weekly email interactions with Arctic and Antarctic researchers, and classroom visits by scientists.

The success of the program was demonstrated at the 2006 ArcticNet Science Meeting, where a former Schools on Board student attended and presented her own research poster. She described research she had undertaken through a mentoring relationship with ArcticNet scientists, following her 2005 Schools on Board field experience.

Storm Studies in the Arctic (STAR Network)
(2006-2010)



STAR research group shot in front of NRC research aircraft that will be used for the field program. (l to r) John Hanesiak, Ron Stewart, Dave Hudak, Peter Johnson, Gabrielle Gascon, William Henson, Peter Taylor, Dave Barber, Dawn Conway, Gary Burke, George Liu, Erica Wilson, Bob Kochtubajda, Kent Moore, Mengistu Wolde, Stephen Bathory, Jamal Shirley.

Dr. Hanesiak is a co-PI in a CFCAS Network (based out of UofM) valued at \$3M focusing on arctic storms and their impacts on humans. This project is concerned with the documentation, better understanding and prediction of meteorological and related hazards in the Arctic including their modification by local topography and land-sea transitions and their impact on the local communities.

STAR completed work in 2006-2007 that prepared the way for the 2008 field season. This included publication by Ron Stewart of work that has provided STAR with relevant background research for better understanding winds in the region, and launching the STAR website (www.starnetwork.ca) in May 2006. Negotiations with the National Research Council secured the Convair 580 research aircraft for the 2007 field season in Iqaluit, Nu.. George Liu was hired by the Centre for Earth Observation Science (University of Manitoba) as the STAR data manager. The program coordinator's position is also based at CEOS. Data collection is currently underway.

Drought Research Initiative (DRI Network)
(2005-2010)



Dr. J. Hanesiak, is a co-investigator in a CFCAS Network (based out of McGill/Saskatchewan)

The Drought Research Initiative (DRI) is funded by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) with a budget of approximately \$3 Million over 5 years. CEOS scientists have been involved with the DRI program since its inception, and CEOS receives a portion of the overall DRI budget. CEOS research has focused on the coupling of atmospheric processes and hydrologic processes, assessments of the factors responsible for convection, drought characterization and coupling of downscaled atmospheric inputs to hydrologic models.

In the summer of 2006 CEOS took on the responsibility of coordinating this program by providing support to the DRI Network Manager. In the fall and early winter of 2006, the Network Manager was directed to develop an annual report and budget, and to make preparations for the DRI workshop held in January 2007. This workshop was held at the Inn at the Forks in Winnipeg. It attracted over 70 participants and garnered media attention for the drought issue. New results coming from the DRI research included an assessment of the role of virga under convective clouds during drought, the complex set of atmospheric circulation patterns that could maintain a drought once it had been established, and the options for modelling the runoff from regions which are non-contributing under dry conditions and contributing areas under wet conditions. CEOS members are also taking the lead on behalf of DRI in discussions with Manitoba Hydro about a possible extension of DRI directed at drought issues of specific concern to their hydroelectric system planning.



A Canadian Research Icebreaker

A program funded by the Canada Foundation for Innovation 'International Fund'.
(2002 – 2017)

Dr. Barber is a principal investigator in the CFI application to purchase and retrofit a Canadian Coast Guard Ship as a research platform for polar science. This application was funded at a level of \$27.7M. These funds have been used to retrofit the structure of the ship and to purchase in excess of \$8M in scientific equipment which is now integrated into the ship infrastructure. The ship forms the basis for a new polar science platform in which Canadians lead International investigators in multidisciplinary polar science. CEOS leads the sea ice components of this program and is responsible for sea ice and meteorological infrastructure of the ship.

Successful additional funding in 2006 by the Canada Foundation for Innovation Leading Edge Fund provided \$12 M dollars in new and upgraded research equipment to ensure that the CCGS Amundsen remains one of the premier research icebreakers in the world today.

Also involved as co-investigators: Dr.s Hanesiak, Papakyriakou, and Stern.

Lake Winnipeg Research Consortium (LWRC)

Investigator: Dr. Barber.

CEOS is a founding member of the Lake Winnipeg Research Consortium. With funding from a Canadian Space Agency GRIP (Government Related Initiatives Program) Grant, in partnership with the Canadian Department of Fisheries and Oceans, we continued a study of the potential use of satellite remote sensing data to improve algorithms for chlorophyll measurement and to discriminate cyanobacteria from other phytoplankton in Lake Winnipeg. Work in 2006/07 was restricted to re-analysis of data recorded on earlier surveys of Lake Winnipeg.

Blue /green band ratios traditionally used in chlorophyll investigations of Case I waters turn out to be very poor predictors of chlorophyll a concentration (chl) in the Case II waters (high, and highly variable inorganic suspended solids and dissolved organic carbon concentrations) characterizing Lake Winnipeg. Likewise, FLH (fluorescence line height) calculated using data from NASA's MODIS (MOderate Resolution Imaging Spectrometer) is only weakly correlated with chl in Lake Winnipeg. Among band ratios and indices tested, FLH and MCI (maximum chlorophyll index, both calculated from data recorded by MERIS – the European Space Agency's MEDium spectral Resolution Imaging Spectrometer) are the best overall predictors with a root mean square error of prediction of 7 to 8 mg m⁻³ over the *in situ* range 5 < chl < 32 mg m⁻³. Along a test transect north of the Narrows in Lake Winnipeg, MERIS MCI-derived chl a closely followed chl measured *in situ* with a Fluoroprobe, and MERIS FLH slightly under-predicted high chl (Figure 1).

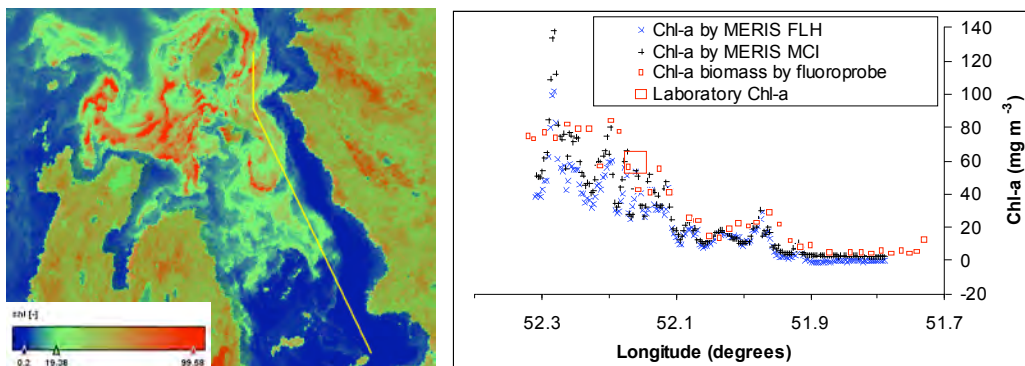


Figure 1. Transect from Berens Island to Matheson Island, showing chl a estimated *in situ* by Fluoroprobe, compared with chl a estimated by MERIS FLH (map a left, with chl units in ug/l).

The strong performance of FLH in predicting chl a is fortuitous in the sense that cyanophytes do not show the expected fluorescence peak at 685 nm. The FLH – chl a relationship is inverse, and is due to a local reflectance minimum caused by strong absorption by phycoerithrin at 675 nm. This effect appears to be strongest in cyanophyte-dominated algal assemblages characteristic of summer and autumn blooms on Lake Winnipeg, and weaker in bacillariophyte-cryptophyte assemblages which dominate the early open water season community (Figure 2).

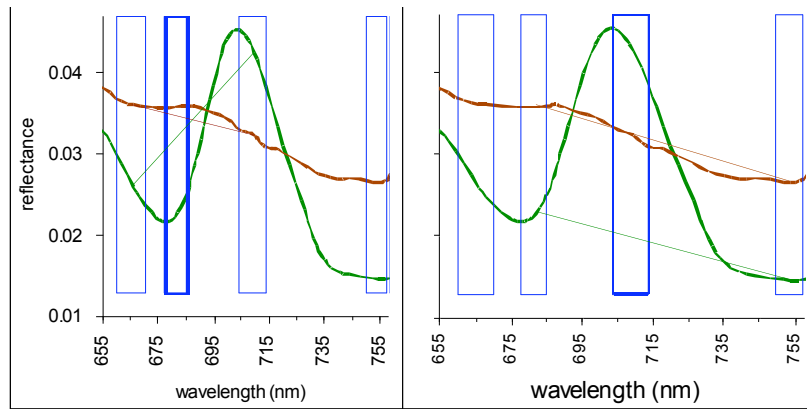


Figure 2. Spectra showing typical shapes for cyanobacteria-dominant (left) and bacillariophyte-dominant (right) algal communities. MODIS and MERIS spectral bands indicated on upper and middle panel respectively. MERIS FLH baselines indicated in left panel; MCI baselines shown at right.

Academic Contributions

Only contributions for the reporting year are listed. Previous year's contributions can be found in previous annual reports.

Primary Publications (C.1)

Carmack, E., D. Barber, J. Christensen, R. Macdonald, B. Rudels and E. Sakshaug. Climate variability and physical forcing of the food webs and the carbon budget on Panarctic shelves. *Progress in Oceanography*. 71(2006): 145-181.

Ehn, J.K., B.J. Hwang, R. Galley and D.G. Barber. Investigations of newly formed sea ice in the Cape Bathurst polynya: Part 1 Structural, physical and optical properties. *Journal of Geophysical Research (Oceans)*. vol. 112, C05002, doi:10.1029/2006JC003702.

Ehn, J.K., M. A. Granskog, T. Papakyriakou, R. Galley, and D. G. Barber. 2005. Surface albedo observations of Hudson Bay landfast sea ice during melt onset. *Annals of Glaciology*. In Press (Jan'06)

Ehn, J.K., M.A. Granskog, T. Papakyriakou, R. Galley, and D.G. Barber. 2006: Surface albedo observations of Hudson Bay land-fast sea ice during melt onset. *Annals of Glaciology*, International Glaciology Society, Vol. 44, In Press.

Fortier, L., P. Sirois, J. Michaud, and D.G. Barber. Sea surface temperature, sea ice concentration and the survival of Arctic cod larvae (*Borgeogadus saida*) in the Northeast Water polynya (Greenland Sea). *Canadian Journal of Fisheries and Aquatic Sciences* 63(7): 1608-1616.

Galley, R., D.G. Barber, and J. Yackel. On the link between spring sea ice melt and development of the summer ocean mixed layer in the North Water Polynya. *International Journal of Remote Sensing*. 28(18):3979-3994.

Geldsetzer, T., J.B. Mead, J.J. Yackel, R.K. Scharien, and S.E.L. Howell, 2007. Surface-based polarimetric C-band scatterometer for field measurements of sea ice, *IEEE Transactions on Geoscience and Remote Sensing EUSAR Special Issue*. 45(11): 3405-3416.

Granskog, M., R.W. MacDonald, C.J. Mundy and D. G. Barber. Distribution, Characteristics and potential impacts of chromophoric dissolved organic matter (CDOM) in Hudson Strait and Hudson Bay, Canada. *Continental Shelf Research* 27(15):2032-2050.

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Mucci, A., L. Miller, and T. Papakyriakou, Carbon exchange at the air-sea interface on the MacKenzie Shelf, Canadian Arctic. Preparation for JGR submission, Spring/Summer, 2007

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Books (B)

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Technical/Conference Papers (E.2)

Hanesiak, J. and J.C. Brimelow, 2006: Validation and Comparison of an AERI and Microwave Radiometer Thermodynamic Profiles During the 2006 Convective Season in Southern Manitoba, CEOS-tech-2006-1, Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB, R3T 2N2

Nawri N., R.E. Stewart, E. Roberts, K. Moore and J. Hanesiak, 2006: Climatology and forcing of strong boundary-layer winds in mountainous regions of the eastern Canadian Arctic, Canadian Alternative Energy Symposium, Aurora ON, April 10-12.

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Armstrong D. and Wang F. 2006. Lab Manual for Environmental Analysis. Department of Environment and Geography, and Department of Chemistry. September 2006, University of Manitoba, Winnipeg, Manitoba.

Posters/Workshops/Meetings/Oral Presentations/Planning Meetings (E.2)

Canadian Arctic Shelf Exchange Study 2005/2006 Annual General Meeting in Winnipeg, Manitoba, February 2006. Iacozza, J.

Title of Presentation: The role of sea ice roughness on snow catchment over landfast first-year sea ice (poster presentation). Iacozza, J.

Arctic Climate Change Youth Forum in Winnipeg, Manitoba, February 2006

Title of Presentation: Polar Bears and Sea Ice Habitat (oral presentation) Iacozza, J.

CRYSYS Science Meeting in Toronto, Ontario, February 2006

Title of Presentation: Key accomplishments of CRYSYS-supported research at the Centre for Earth Observation Science, University of Manitoba (oral presentation)

Title of Presentation: Planned CEOS contributions to IPY (oral presentation) Iacozza, J.

3rd ENVISAT Summer School: Earth System Monitoring and Modelling in Frascati, Italy, August 2006 Iacozza, J.

Identification of sea ice catchment and snow distribution from remote sensing data (poster presentation) Iacozza, J.

Churchill, J., Tenuta, Bello, Papakyriakou, 2006: Are greenhouse gas emissions related to plant community composition or edaphic conditions at Churchill, MB, Presented at the 2006 ArticNet Annual Assembly, Victoria, B.C., Dec. 14-17.

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Else, B. J. Yackel, and T. Papakyriakou, 2006: Bulk aerodynamic estimates of carbon dioxide flux in Hudson Bay. Presented at the 2006 ArticNet Annual Assembly, Victoria, B.C., Dec. 14-17.

Else, B., R. Kressal and T. Papakyriakou, 2006: Ship-based carbon dioxide flux measurements made during the 2006 ArcticNet Cruise of the CCGS Amundsen. Presented at the 2006 ArticNet Annual Assembly, Victoria, B.C., Dec. 14-17.

Papakyriakou, T., L. Miller, and O. Owens, 2006, Spring and wintertime CO₂ fluxes over Arctic first-year sea ice: Results from CICE02, Paper presented at the Annual Canadian Geophysical Union Meeting, Banff, AB., 14 to 17 May.

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Scott, G., Papakyriakou, T.N. 2006, Inter-seasonal air-surface flux variability on coastal Hudson Bay. Presented at the 2006 ArticNet Annual Assembly, Victoria, B.C., Dec. 14-17.

Hare A., Macdonald R., Stern G., Wang F., Lean D., Papakyriakou. 2006. The effect of snow, ice, and open water on methyl mercury in the Arctic Ocean. *8th International Conference on Mercury as a Global Pollutant*. August 7-11, Madison, Wisconsin, USA.

Leitch D., Carrie J., Wang F., Stern G., Lean D., Macdonald R. The Mackenzie River Basin as a source of mercury to the Beaufort Sea. *8th International Conference on Mercury as a Global Pollutant*. August 7-11, Madison, Wisconsin, USA.

Leitch D., Stern G., Wang F., Couture N., Pollard W. 2006. Coastal erosion and permafrost melt as a potential source of mercury to the Beaufort Sea. *8th International Conference on Mercury as a Global Pollutant*. August 7-11, Madison, Wisconsin, USA.

Leitch D., Carrie J., Lean D., and Macdonald R., Stern G., and Wang F. 2006. Riverine and coastal erosional input of mercury to the Beaufort Sea under a changing climate. *Coastal Zone Canada Conference*. August 14-18, Tuktoyuktuk, NWT, Canada.

Wang F., Stern G., Macdonald R., and Leitch D. 2006. Biogeochemical cycling of mercury in the Arctic Ocean: Gaps and progress. *Society of Environmental Toxicology and Chemistry (SETAC) – Asia/Pacific Annual Meeting*. September 18-20, Beijing, China.

Hanesiak, J. speaker at the PASPC Winnipeg Arctic forecasting workshop to present “Storm Studies in the Arctic (STAR): A major field project over southern Baffin Island”, Nov. 22, 2006. (oral)

Hanesiak, J. Invited talk, Mother Nature’s Fury: Severe Prairie Thunderstorms, “Get to know Research at your University” speaker series, University of Manitoba, Oct. 12, 2006 (oral)

Hanesiak, J. Co-Author with P. McCarthy, An F4 Winnipeg Tornado: A virtual Damage Assessment, 3rd annual Canadian Risk and Hazards Network Symposium, Montreal QC, Oct. 11-13, 2006 (oral)

Hanesiak, J. speaker to COMET program about blowing snow forecasting applications, Boulder, CO, Oct 24-25, 2006 (oral)

Hanesiak, J. Co-author with N. Nawri et al., Observations of strong boundary-layer winds in mountainous regions of the eastern Canadian Arctic, Workshop on wind energy, Toronto, ON, March 10, 2006 (oral)

Hanesiak, J. Co-author with P. McCarthy, P. and M. Russo, A Winnipeg F4 Tornado – A Virtual Damage Assessment, 40th annual CMOS Conference, Toronto, ON, May 29 – June 1, 2006 (oral)

Hanesiak et al., Storm Studies in the Arctic (STAR) – A major CFCAS initiative, 40th annual CMOS Conference, Toronto, ON, May 29 – June 1, 2006 (Oral)

Hanesiak et al., Significant Summer Rainfall on the Canadian Prairies: Modes and Mechanisms 2000 – 2004, 40th annual CMOS Conference, Toronto, ON, May 29 – June 1, 2006 (Oral)

Hanesiak, J. Co-author with Q. Huang (PDF), Visibilities during blowing snow in the Arctic: Measurements and Modeling, 40th annual CMOS Conference, Toronto, ON, May 29 – June 1, 2006 (Oral)

Hanesiak, J. Co-author with A. Tat (grad student), Severe Weather Linkages to Soil Moisture on the Canadian Prairies, 40th annual CMOS Conference, Toronto, ON, May 29 – June 1, 2006 (poster)

Hanesiak, J., Huang, Q. et al., Visibility during blowing snow events at Churchill, MB, 2nd annual CASES data workshop, Winnipeg, MB, Feb. 13-16, 2006. (poster)

Fisico, T and J. Hanesiak, The accuracy of regional models and re-analyses data during CASES 2003/2004, 2nd annual CASES data workshop, Winnipeg, MB, Feb. 13-16, 2006. (poster)

Yackel J.J., POL-ICE: Multipolarization SAR for Operational Sea Ice Monitoring 2007 Field Campaign Data Report, Technical Report for the Canadian Space Agency and MacDonald, Dettwiler and Associates Ltd, 2007 June, non-refereed technical report for research conducted in Finland (March, 2007)

Yackel J.J., POL-ICE Resolute 2006 Data Report: Multipolarization SAR for Operational Sea Ice Monitoring, Technical Report for the Canadian Space Agency and MacDonald, Dettwiler and Associates Ltd, 2006 August, non-refereed technical report, 57pp

Comparison of Texture from SAR and in situ data for Improved Surface State Estimation of Decaying First-Year Sea Ice, R.K. Scharien and J.J. Yackel, IEEE Geoscience and Remote Sensing Symposium (IGARSS) and 27th Canadian Symposium on Remote Sensing, Denver, Colorado, 2006 August

C-Band Polarimetric Scatterometer Studies Over Landfast First-year Sea Ice in the Canadian Arctic during Spring-Summer Melt, Scharien, R.K., J.J. Yackel and T. Geldsetzer, RADARSAT-2 Symposium, Saint-Hubert, Quebec, 2006 September

Bulk Aerodynamic Estimates of Carbon Dioxide Flux in Hudson Bay, Else, B.G.T., T.N. Papakyriakou, R. Kressal and J.J. Yackel, ArcticNET Annual Science Meeting, Victoria, British Columbia, 2006 December

Time Series Microwave Backscatter Investigations of Landfast First-Year Sea Ice for Spring Melt Timing Information in the Amundsen Gulf, J.J. Yackel, R.K. Scharien, B.

Else, T. Geldsetzer and S.E.L. Howell, IEEE Geoscience and Remote Sensing Symposium (IGARSS) and 27th Canadian Symposium on Remote Sensing, Denver, Colorado, 2006 August

Assessing Sea Ice Melt in the Canadian Arctic from SeaWinds/QuikSCAT and AVHRR Polar Pathfinder Observations, S.E.L. Howell, J.J. Yackel, A. Tivy and R.K. Scharien, IEEE Geoscience and Remote Sensing Symposium (IGARSS) and 27th Canadian Symposium on Remote Sensing, Denver, Colorado, 2006 August

The utility of multi-polarized SAR for obtaining enhanced sea ice information, Geldsetzer, T. and J. J. Yackel, IEEE Geoscience and Remote Sensing Symposium (IGARSS) and 27th Canadian Symposium on Remote Sensing, Denver, Colorado, 2006 August

Xin, J, J. Hanesiak and D. Barber, Time series of daily cloud fraction above CASES winter camp from multiple data sources, 2nd annual CASES data workshop, Winnipeg, MB, Feb. 13-16, 2006. (poster)

Xin, J, J. Hanesiak and D. Barber, Cloud vertical structure from radiosondes and MODIS during CASES field experiment, 2nd annual CASES data workshop, Winnipeg, MB, Feb. 13-16, 2006. (poster)

Funding Sources

CEOS receives an annual operating grant of ~\$65,000 from the Faculty of Environment, Earth, and Resources. The Department of Environment and Geography and CEOS also collaborate on providing teaching and research facilities within the Department. A separate budget amount of ~\$15,000 is allotted to CEOS for use maintaining the undergraduate teaching computer laboratory.

The operating grant from the Faculty will need to be increased in the near future if we are to maintain the current level of research and related activities.

With the experienced increase in activity the position of Operations Manager need to be 100% time and several new technical positions (field and computer) need to be funded from baseline.

The University of Manitoba, though the Faculty of Environment, Earth, and Resources, provides ~\$175,000 in budget funded support staff positions.

Grant Funding held by CEOS Principal investigators - Organization #328005

The following research grants (dollars and/or value-in-kind) were obtained or held within the reporting period.

Grantee	Fund	Amount
Barber, D.	301276-ARCTIC NET BARBER 3.0	\$60,000
Barber, D.	301283-ARCTIC NET/U LAVAL/NCE 4.1	\$83,000
Barber, D.	301284-ARCTIC NET/U LAVAL/NCE 3.1	\$61,000
Barber, D.	301912-NSERC CRC 950-201304	\$11,500
Barber, D.	301913-NSERC CRC 950-201304	\$88,500
Barber, D.	302304-NSERC RGPNS 305426-2004 Barber	\$10,000
Barber, D.	302306-NSERC RGPIN 155265-04	\$41,000
Barber, D.	302991-ARCTIC NET/U LAVAL/NCE 1.1	\$31,750
Barber, D.	303037-LAVAL U/03650-CG070800/NSERC	\$50,820
Barber, D.	303044-MCEF/ARCTIC NET	\$133,095
Barber, D.	307525-MB Hydro G228/J. Larter	\$17,300
Barber, D.	307690-ARCTIC NET/U LAVAL/NCE BARBER 3.6	\$15,000
Barber, D.	307936-MB Hydro/ArcticNet/D. Barber	\$241,000
Barber, D.	308262-U Laval/NSERC MFA/D. Barber	\$50,706
Barber, D.	308263-CFCAS/sub of F307755/D. Barber	\$124,500
Barber, D.	308404-U Laval ArcticNet Training Iacozza	\$3,165
Barber, D.	308729-U Of Laval Arcticnet NCE Barber	\$2,900
Barber, D.	308789-MB Hydro G240 / G. McCullough	\$30,000
Barber, D.	308790-CFI# 11393 Barber D. U Laval	\$1,685,604
Barber, D.	308791-MIF#11393 Barber D	\$1,685,604
Barber, D.	308845-IAND 487 (IPY) Barber	\$60,000
Ferguson, S.	301279-ARCTIC NET/U LAVAL/NCE 1.3	\$14,625
Ferguson, S.	301280-ARCTIC NET/U LAVAL/NCE 3.4	\$17,250
Ferguson, S.	302299-NSERC RGPIN 250465-03	\$20,000
Ferguson, S.	302843-MB HYDRO G203	\$21,000

M. Trachtenberg	MSc student (Barber)	\$2,155
A. Hare	Ph.D student (Stern)	\$2,245
M. Pazerniuk	MSc student (Stern)	\$2,575
R. Gislason	MEnv student (Oakes)	\$2,500
	Total	\$31,580

CEOS research money is used to provide student stipends and purchase equipment.

Grant Funded Appointments

(Benefits, pay levy, and vacation pay has not been included for grant funded positions)

Position	Number	Amount
Research Associates	3	\$130,073
Graduate Student Researchers	32	\$141,077
Post-doctoral Fellows	4	\$68,482
Undergrad Research Assistants	13	\$56,851
Support Staff (Technicians, Office Assistants & Work Study Assistants)	11	\$182,161
Total		\$578,644

Summarized Annual Operating Budget

Item	General classification	Amount	%
1	Publication charges	\$4,543.00	7
2	Consumables (Office supplies, equipment under \$1000.00, Lab supplies, gas, etc)	\$25,694.00	39
3	Communications (cell phones, telephone lines, postage, couriers etc)	\$22,030.00	33
4	Fees (Memberships, customs etc)	\$4,618.00	7
5	Electricity and propane	\$2,081.00	3
6	Equipment under lease (photocopiers)	\$2,490.00	4
7	Repair and Maintenance (equipment, space and vehicles)	\$5,465.00	8
8	Income (trust)	\$900.00	<-1
	Total	\$66,023.00	100

Details are in Appendix

Budget (Operating) Funded Appointments

University of Manitoba Employee	Position	Salary
Chan, Wayne	Computer/Technical Support	\$8,500
Mossdrop, David	Field/Logistics Management Support	\$70,000
Petrusevich, Vlad	Field Techniican	\$45,000
Whynot, Denise	Administrative/Office Management Support	\$51,000
	Total Budget Funded Positions	\$174,500

Five Year Research Plan

CEOS is a water-centric research centre with a particular interest in how climate forces variability and change in the hydrosphere. The overarching objective of CEOS is to:

“Understand how climate change forces various water related processes operating within the Earth System.”

Over the next five years CEOS will continue to grow in the areas of Polar Marine Science, Climate Change, Atmospheric Sciences, Freshwater Systems and Geomatics technologies. CEOS will continue to focus on how water interacts with the weather and climate system and in particular how climate change affects water in liquid, solid and gas phases within various aspects of our Earth System. Our five year plan revolves around currently funded projects which provide the resources required for our research. All of these projects follow the integrating philosophy of the centre, namely to study earth system processes from a highly multi and interdisciplinary perspective. The following highlight the key elements of our next 5 year cycle:

- Develop and implement the IPY-CFL project. The centre has taken the lead on a 40M\$ project known as the Circumpolar Flaw Lead (CFL) system study as part of the International Polar Year (IPY). This project brings over 200 investigators from 15 foreign countries to participate in an overwintering expedition of our research icebreaker (NGCC Amundsen) in the western high Arctic. The CFL project integrate this large international, multidisciplinary team, into a highly integrated system study including physical, biological, biogeochemical and human dimensions of how the circumpolar flaw lead system functions and how it is being affected by Arctic climate change. As the largest IPY project in the world the CFL project marshals a significant fraction of CEOS research and organizational expertise and will mean a significant increase in the number of staff, students, and logistics within CEOS. CEOS was also successful in a recent bid to outfit the Amundsen with new scientific equipment leading up to the CFL project. This CFI-LEF grant, for \$11M, is shared between Universite Laval and Manitoba.
- continuation of the ArcticNet Network of Centres of Excellence (NCE). The potential exists for the ArcticNet NCE to be extended an additional 7 years beyond the initial funding window. We are currently funded from 2004 to 2011 with the possible extension taking us out to 2018. ArcticNet brings together key CEOS researchers into a highly integrated multidisciplinary study of the effects of climate change on the coastal Canadian Arctic. CEOS has key research staff involved in sea ice studies, gas fluxes, modeling, community based research, contaminants, and extreme weather. ArcticNet provides a long-term and stable funding source for the development of our key Arctic System Science programs within CEOS. As the key longterm program for Arctic climate change much of our high latitude research is conducted under the umbrella of ArcticNet.
- increasing partnerships with Manitoba Hydro. Manitoba Hydro is a partner in

ArcticNet and is funding research in the estuaries of the Churchill and Nelson Rivers, which examines water quality and quantity over the annual cycle. The research involves multidisciplinary research into physical, biological and human dimensions of aspects of the system which are (or have the potential to be) impacted by hydroelectric development and operations in northern Manitoba. This partnership is a key element of the Theme 3 ArcticNet work on Hudson Bay. Manitoba Hydro is also a key partner in DRI through funding and collaboration to better understand drought and pluvial physical processes.

- Continuation of the STAR network. The Storms in the Arctic (STAR) project will examine the occurrence and effects of extreme weather in the Arctic. This research network will illuminate the meteorological forcing of storms and their effects on both the land and ocean surface in the high arctic. The project is funded by CFCAS but is also highly interconnected with ArcticNet themes 3 and 4.
- Continuation of the DRI network. The Drought Research Initiative (DRI) examines the climate forcing of water in Prairie Canada. The emphasis of this work is to understand the couplings between meteorological, surface hydrology and ground water components of droughts by focusing on the most recent drought (1999-2003) in the Prairies. The Objective of this work is central to the CEOS research objectives in understanding how climate change may force the occurrence and severity of droughts in the great plains.
- Development of the Unstable (UNderstanding Severe Thunderstorms and Alberta Boundary Layers Experiment) Network. This project involves a major field project in central Alberta in the summer of 2008 to better understand the physical processes leading to severe convective storms as well as severe storm evolution. The Meteorological Service of Canada (MSC) is leading this project, however, an NSERC CRD (Collaborative Research and Development) grant will be lead out of CEOS for academic support for the project.
- increasing focus on freshwater in Manitoba. The Lake Winnipeg Research Consortium (LWRC) now owns the research vessel Namao and has secured operating funding from Manitoba Hydro for the next 3 years. CEOS anticipates increased involvement with the LWRC focusing on coupling observed water quality and satellite remote sensing. Drs. Hanson and Walker's CFI funded laboratory will begin to look at freshwater marsh ecosystems that feed into Lake Winnipeg (Netley Marsh). Other CEOS staff members are examining climate forcing of the lake, it's ecosystem and remote sensing of selected biophysical variables. Our partnerships with Soils Science have also led to discussions about large scale integrative program proposals focused on Lake Winnipeg.
- increasing development of earth system science models. CEOS process studies have advanced to a point where we are beginning to use and develop various hydrological, sea ice and climate models. These models cover a range of hydroclimate conditions and are used to predict future conditions. Strategic

development in this area is tied to our SIP priorities.

- continued use of geomatics technologies. At the core of CEOS research remain a group of technologies (remote sensing, geographic information systems, image analysis systems, global positioning systems, computer modelling and analytical methods) which allow us to develop an understanding of the planet from the micro to the global scale.
- increased responsibilities for geomatics and techniques course in the new undergraduate lab. We plan to offer professional short courses in geomatics in the new laboratory facility.

The CEOS five year plan illustrates the direction and commitment that CEOS has to remaining a vibrant, active and significant international research centre. Our continued emphasis on water and climate research are important at all Provincial, National and International levels and will continue to position CEOS as the leading Environmental Research Centre at the University of Manitoba.

Web Addresses

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

www.ipy-cfl.ca

www.umanitoba.ca/environment/envirogeog

www.umanitoba.ca/environment

email addresses:

- David Moss crop – David_Moss crop@Umanitoba.ca
- David Barber – dbarber@cc.umanitoba.ca

Appendix

Space allotment details within Wallace building

Space classification	Room Type	Rm #	Area (Sq ft)	Totals
A20 Instructional Lab	471 Lab - Dry - Teaching Computer	321	1062	
	139 Server room	321A	112	1174
A31 Graduate Research	629 Office Grad Student (16)	463	799	
	629 Office Grad Student (16)	467	793	1592
A32 Academic Research	241 Secure Field Equipment Room	494	304	
	827 basement equipment storage	126	625	
	139 Computer Server/Equip Room	484B	115	
	471 Lab - Research Computer Lab	484	357	
	471 Lab - Dry	488	434	
	471 Lab - Wet	486	434	
	471 Lab - Calibration	492	439	
	471 Lab - Cold include vestibule	490	231	
	Met Data acquisition room	494	16	
	827 Storage Room (future elevator shaft)	480	126	3081
A42 Academic Office	626 Office Professor: Barber	476	160	
	626 Office Adjunct Professor: Stern	474	91	
	626 Office Professor: Hanesiak	468	143	
	629 Office: Professor: Walker	466	143	
	626 Office Professor: Papakyriakou	470	143	
	626 Office Professor: Oakes	464	143	
	629 Office: Research Associate: Lukovich	462	143	
	629 Office Sessional: Iacozza	472	143	
	629 Office: Post Doc: Shared (2)	482	156	1265
A43 Support Office	632 Office Support Staff: ArcticNet: Anderson	497	108	
	632 Office Support Staff: ArcticNet: Mundy	496	108	

	632 Office Support Staff: ArcticNet: L. Barber	498	108	
	632 Office Support Staff: Temp/Shared	495	110	
	632 Office Support Staff: Technician: Hodgson	494A	115	
	632 Office Support Staff: Admin CEOS: Whynot	460	112	
	629 Office: CEOS Programmer: Chan	484A	121	
	631 Office: System Analyst: CEOS Ops Manager: Mosscrop	499	130	912
A49 Office Service	141 Conference room (100% usage)	477	377	377
Total				8401

Detailed budget broken down by Account code

Operating Budget Expenditures		
704006	Faculty Publications	\$3,784
704101	Copying	\$759
	Subtotal	\$4,543
<hr/>		
706003	Office Consumables	\$3,517
706004	Office Furnishings - Under \$1000	\$945
706005	Office Equipment - Under \$1000	\$363
706102	Other Lab Supplies	\$4,208
706106	Laboratory Consumables	\$6,542
706107	Lab Equipment - Under \$1000	\$176
706202	Audio Visual Equip - Under \$1000	\$142
706205	Film Processing	\$18
706702	General Equipment - Under \$1000	\$2,309
706710	Other Materials & Supplies	\$4,445
706752	Meals for Staff Meetings	\$19
706753	Water Coffee Drinks etc.	\$326
706801	Computer Hrdwre - Under \$1000	\$574
706802	Computer Sftwre - Under \$1000	\$2,321
706803	Networking Hrdwre - Under \$1000	\$28
706901	Gasoline	\$3,087
	Subtotal	\$25,694
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708012	IST Cell Phones	\$1,504
708501	Telephone Line Rental	\$9,163
708502	Long Distance-IST Provided	\$670
708503	Cell Phone rental	\$1,244
708506	Courier	\$7,984
708508	Voice Mail	\$1,210
708513	Telephone Line Rntl-Vendor Provided	\$3,246
708515	Remove/Add Phones-IST Provided	\$40
708516	Global Internet	\$1,308
708550	Postage	\$72
708551	US Postage & Shipping	\$24
708555	Parcels	\$92
708557	Other Postage	\$36
708559	US Lettermail	\$6
708560	International Lettermail	\$7
	Subtotal	\$22,030
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710201	Institutional Memberships	\$1,400
710403	Other Services	\$126
710409	Computer Services	\$77
710431	Customs	\$763
710432	Brokerage	\$121
710433	Freight - Outbound	\$880
710434	Freight - Inbound	\$822

710447	Rush Cheque Fee	\$150	
710506	Automobile	\$159	
710902	Annual Licence Fees	\$120	
	Subtotal		\$4,618
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712003	Electricity	\$295	
712008	Propane	\$1,786	
	Subtotal		\$2,081
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724015	Miscellaneous Charges	\$2	
	Subtotal		\$2
726301	Equipment Under Capital Lease	\$2,490	
726411	Scientific & Rsrch Equipment	\$-	
	Subtotal		\$2,490
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740001	R & M - General Equipment	\$2,141	
740002	R & M - Vehicles	\$223	
740004	R & M - Computer Networks	\$65	
740106	R & M - Painting and Decorating	\$3,885	
740110	R & M - Electrical	\$1,338	
740127	R & M - Lab Equipment Parts	\$242	
	Subtotal		\$5,465
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820002	Interfund From Trust	\$(900)	
	Subtotal		\$(900)
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	2006-2007 Expenditures Only (non-salary)		\$66,023
Note:	Carryover from 2005-2006 (deficit)	\$(2,028)	
Note:	Annual (non salary) operating fund	\$57,723	