Mackenzie GEWEX Study (MAGS)

Reporting Period: 2005
Starting Date: 1994
End Date: 2005
URL: http://www.usask.ca/geography/MAGS/index_e.htm
Chair: Ming-ko Woo, Programme Leader, 2001-2005

Objectives:
(1) To understand and model the high-latitude energy and water cycles that play roles in the climate system, and
(2) To improve our ability to assess the changes to Canada's water resources that arise from climate variability and anthropogenic climate change.

Status:
(a) 2005 was the successful closure of the entire MAGS programme.
Major activities included
- Completion of all MAGS projects and writing up of final reports
- Participation at the annual meeting of the Canadian Geophysical Union and the Canadian Meteorological and Oceanographic Society
- Visiting aboriginal communities to interact with residents in Mackenzie Basin
- Culminating meetings (a) in Yellowknife with users of MAGS results

(b) In Ottawa, attended by MAGS investigators, NSERC and other partners
- All objectives achieved and the accomplishment of MAGS tasks exceeded expectation

New directions:
After MAGS, two major programmes were established in Canada with most of their investigators being former MAGS scientists and trainees. These projects expand upon MAGS and enable the transfer of MAGS results to other geographical regions.
(a) Drought Research Initiative (DRI):
In addition to being a follow-on project to MAGS, it is an example of a GEWEX extremes project that overlaps with CEOP, being part of the long-term GEWEX/GHP/CEOP strategy. Co-led by Ron Stewart and John Pomeroy, the objective of DRI is to better understand the physical characteristics of and processes influencing Canadian Prairie droughts, and to contribute to their better prediction, through a focus on the recent severe drought that began in 1999.
(b) Improved Processes and Parameterization for Prediction in Cold Regions (IP3):
Led by John Pomeroy and concentrating in the Rocky Mountains and northern territories, this study has the goals of (1) understanding key climate system processes relating to the hydrometeorology of cold regions, (2) parameterizing land surface hydrology processes that control the coupled atmospheric-hydrological system in cold regions, and (3) validating and improving models for weather, water and climate systems leading to better prediction and simulation of related atmospheric impacts on water resources and surface climates in cold regions.

Future:
(a) A DVD containing the data acquired during the MAGS period is produced. These data are also available from MAGS website http://www.usask.ca/geography/MAGS/lo_Data_e.htm
(b) A two-volume book that documents MAGS achievements is being prepared, with about 50 articles contributed by MAGS investigators. The book will be published by Springer US, with the titles of "Atmospheric Processes of a Cold Region: the Mackenzie GEWEX Study Experience Volume I" and "Hydrologic Processes of a Cold Region: the Mackenzie GEWEX Study Experience Volume II".

Key results:
Process studies improved understanding of the cold region phenomena.

Pacific and Cordilleran influences on the Mackenzie Basin:

- Significant moisture transport into the Basin through synoptic storms
- Development of anticyclones in blocking airflow from the Pacific
- Genesis of lee cyclones on the eastern side of the high Cordillera

Atmospheric processes in the Mackenzie Basin:

- The continental northern Basin as a preferred region of anticyclone development
- High percentage of clouds, especially summer and autumn
- Frequent moisture recycling that contributes to summer precipitation
- Lightning events causing fires in the boreal forest
- Large scale blowing snow events in northern Basin

Land surface processes:

- Different land surfaces produce large range in magnitudes of evaporative fluxes (including sublimation), surface moisture and surface heating
- Snow accumulation, redistribution, sublimation and melt processes are studied at different scales, from field sites to small basins to remote sensing of regions
- Ground freeze-thaw is strongly influenced by the ubiquitous peat cover; frozen soil infiltration depends on soil texture, snowmelt and antecedent moisture
- Lakes of various sizes affect the regional energy and water fluxes; large lakes modify the local climate and develop their thermal and circulation patterns
- Bedrock landscape is not necessarily impervious (due to fissures) and runoff production in the Shield is governed by the fill-and-spill (storage-related) process
- Complex mountain landscape gives rise to slope contrasts in soil, frost, snowmelt, flow production and runoff delivery

River flows:

- The dynamics of river ice and ice-jam floods are better understood and modelled
- Lake storage in the semi-arid Shield regulates flow generation along channels; large lakes modify the regime of major rivers, hence flow to the polar seas.

Water and energy balance

- Comprehensive climatology of the water and energy budgets was developed for the basin for 1997-2004
- Using Canadian Meteorological Centre and ERA-40 data, the energy and water budgets compare well with available observations

Modelling

- A suite of models is developed based on or making use of results from process studies (e.g. forest fire prediction, blowing snow, river ice hydraulics, ground thaw)
- Coupled models that incorporate feedback mechanisms, with CLASS providing linkages with the Canadian RCM, and with hydrologic model (WATCLASS)
- Models at various scales are used to investigate cold climate phenomena (e.g. snow distribution, subarctic river flow)

Climate variability and change

- the Basin experiences recent warming and large variations in winter temperature
- Through feedbacks involving the local topography and other factors, the Basin climate system generally acts in a manner to amplify external temperature perturbations in the cold season
- statistical analyses of reanalysis and hydrometric data were used to study trends and variability in the climate, snow cover, river ice and streamflow
- impacts of changes are simulated using macro-scale models and land surface schemes

Practical applications

- Collaborative projects conducted with stakeholders demonstrate important practical application of MAGS results (see item 9 below).

Issues and Recommendations:

- MAGS experience demonstrates the importance of studying the energy and water cycle on global and regional scales; it is useful to incorporate the distinct regional flavour of each CSE
- Process understanding is of paramount importance while field work, modelling and remote sensing are its major tools
- Cross disciplinary collaboration between scientists and engineers, atmospheric and hydrologic researchers, is a highly productive approach
- Application of research findings is a satisfying way to fulfill societal obligations while it also enhances the GEWEX profile
- Regular review of the research agenda and results is an essential means to ensure effectiveness of the programme and high standard of its deliverables.

Contributions to Society and to WCRP/GEWEX Visibility

- MAGS set up a Users' Advisory Group to facilitate information exchange with stakeholders
- MAGS entered into several collaborative projects with stakeholders to address problems of river ice and floods, hydrologic modelling and hydropower production, lightning and forest fire, snow and aviation weather forecast
- MAGS interacted with aboriginal communities and schools in the Mackenzie Basin, keeping them informed of the scientific work and answering questions on impacts of climate variation and climate change
- MAGS investigators contributed articles to newsletters and other vehicles of communication

Key Publications

Over the years, MAGS investigators have published over 200 articles in refereed journals, and numerous conference presentations, including two special issues in journals

"Towards understanding water and energy processes within the Mackenzie River Basin", edited by R. Stewart (2002): *Atmosphere-Ocean* 40(2), 97-278.

"The hydrometeorology of the Mackenzie River Basin during the 1998/99 water year", edited by J.R. Gyakum and P. Marsh (2003): *Journal of Hydrometeorology* 4.

List of Meetings, Workshops

- Annual meetings to present results, review progress and discuss future research
- Special thematic workshops to explore new initiatives and address particular questions
- A modelling seminar for in-house training of investigators
- Annual meeting with stakeholders to discuss application of MAGS results

List of Members

MAGS had two major phases of investigation, with some changes in partnership, funding support and personnel. In total, about 100 scientists and engineers participated at various stages of MAGS, and there were 45 MSc, 28 PhD and 10 PDF trained under MAGS. Membership under various committees were as follows

- Programme Leader – Phase 1: *K. Moore, R. Stewart and W. Rouse*; Phase 2: *M.K. Woo*
- Management Board (Chair - *J. Stone*, and 8 other members)
- Science Committee (Rotating Chair, and 8 other members)
- International Advisory Panel (Chair - *D. Lettenmaier*, with *J. Roads* and *T. Ohata*)
- User Advisory Group (Chair – *D. Milburn*, and 4 other members)
- Programme Manager – Phase 1: *G. Strong*; Phase 2: *P. diCenzo*
- Information Manager – *R. Crawford*