Climate Processes and Earth Observation Research Division
Scientific Highlights in 1998/99

The overall mission of the Division is to enhance our understanding of components of the water and energy cycle in cold climates. Given that water and energy cycles are critical elements of the climate system, improved understanding of these cycles will ultimately lead to improved predictions of climate and climate change in cold regions. Research is currently being conducted within three main themes: **Cold climate energy and water cycles, land surface processes and modelling, and cryosphere in the climate system. Measurement science** provides a cross cutting theme for the Division and support for AES and EC.

Cold climate energy and water cycles

Much of the water cycle research has been conducted within the context of the Mackenzie GEWEX Study (MAGS), which is the Canadian component of coordinated global investigations into the role of energy-water cycles in the climate system. At the international level, Dr. Ron Stewart became the first Senior Scientist of GEWEX within the World Climate Research Program. Hence, Canada has been able to have considerable influence on the program, in particular, emphasizing the importance of high latitude processes in the energy and water cycle. A key initiative in MAGS this year was the enhanced field program, CAGES, designed to gather enhanced measurements of water vapour, precipitation, snowcover, radiation, snowmelt, evaporation, stream discharge, and other variables. This has been a major co-operative effort in this otherwise data sparse geographic area.

Substantial progress was made in examining the Mackenzie climate system using the Regional Climate Model (RCM) and in improving this model's subsystems through scaling studies. The RCM was forced by CMC global analyses over the Mackenzie Basin and derived parameters were compared with observations in a comprehensive validation exercise. This is, to our knowledge, the first effort to use CMC large scale analyses for forcing and validating the RCM. An optimal experimental configuration for RCM applications in MAGS has been determined. In addition, scaling of atmospheric and surface elements for the RCM was advanced. Initial efforts have been with cloud systems, the results of which have been instrumental in parameterizing effects of subgrid precipitation variability in the RCM. Extension of this scaling strategy to investigate cold-season land surface processes over the Mackenzie is now in progress.

Moisture recycling over the Mackenzie Basin was also investigated. This is another important component of the regional climate system in that it addresses the issue of the relative importance of local versus external moisture sources for precipitation. The degree of recycling has been initially quantified and documented by using the NCEP (US National Center for Environmental Prediction) data set, and results have been compared to those found in other major river basins around the world.

Cryosphere in the climate system

CCRP's focus on cold climate processes is implemented also through its cryospheric initiatives. Notable among these is CRYSYS (Use of the Cryospheric System to monitor Global Change in Canada). CCRP has also, in the past year, become actively involved in developing the science and coordination plan for the new WCRP project, Climate and Cryosphere (CLIC) and has also provided leadership and coordination to development of a draft workplan for the cryosphere and climate component for the Canadian contribution to GCOS. CRYSYS has evolved into a strong interagency initiative involving 4 federal agencies and 15 universities across Canada. A special

"CRYSYS" issue of the Canadian Journal of Remote Sensing was published in 1999. Research within CCRP is a key contributor to CRYSYS investigations. Significant advances were made in the on-going effort to derive snow water equivalent (SWE) from passive microwave satellite data in diverse regions of Canada and use SWE in the assessment of climate and hydrologic changes. For climate analyses, a new unique "normal SWE" product from SSM/I satellite data has been developed, reviewed by EC and provincial co-operators and will be implemented next winter season. For operational hydrological use and climatological analysis, this will provide the mechanism for building and analyzing climatological time series of SWE from passive microwave satellite data.

Division research has shown how conventional and remotely sensed information are essential for climate analyses. The development of a gridded daily snow depth data set for North America covering the period 1915-1992, enabled investigations of 20th century variability in Northern Hemisphere snow cover and ENSO snow cover relationships. Investigation of *El Niño* impacts on the cryosphere was a special research thrust in 1998/99. The *El Niño* research activities led to the initiation of a "State of the Canadian Cryosphere" web site, (which will be further developed during 1999/00 within the CRYSYS web site), to provide a means to present up-to-date information on the current state and variability of cryospheric elements in Canada.

Land surface processes and modelling

Land surface processes are integral to energy and water cycles and to the cryosphere. CCRP led initiatives, particularly CLASS (Canadian Land Surface Scheme: a modelling study) and BERMS (Boreal Ecosystem Research and Monitoring Sites: a field study), have made significant strides forward. Much of this work is carried out by a group of scientists, led by CCRP's Dr. Diana Verseghy, that comprise the Land Surface Node of the Climate Research Network. CLASS continues to be acknowledged as one of the outstanding land surface schemes worldwide, as demonstrated by its performance in international intercomparisons such as the PILPS 2d experiment. Development of the next generation of CLASS (version 3) has been initiated. In a new initiative, observations are being collected at CARE to provide a quality data set, including winter processes, for a future PILPS intercomparison. CLASS is used as the land surface interface in many of our atmospheric models (see report of the Canadian Centre for Climate Modelling and Analysis). The utilization of satellite-derived information for initialization of CLASS variables and for validating output parameters is essential and there have been preliminary efforts made to assemble surface cover and lake temperature datasets over the BOREAS (Boreal Ecosystem-Atmosphere Study) study area for use in running regional climate simulations. The examination of satellite data at different scales has provided information critical for utilization of such data in conjunction with both Land Surface Process and Regional Climate Models.

The field research at the BERM Sites contributes directly to furthering the CLASS research programme through development and testing of new algorithms, as well as contributing essential knowledge on the functioning of the boreal system and its role in the carbon source/sink question. High quality climate measurements above and within the canopies (mature Aspen, old Black Spruce and old Jack Pine) and below surface are now available for our own and community use. Interannual variability in carbon sequestration was found to be significant and linked to previous winter conditions, a result that emphasizes how our cryospheric studies in the area are an integral part of understanding the carbon sequestration issue. During the year, in co-operation with university colleagues, re-establishment of flux measurements at the BERMS SOBS and SOJP sites, to be implemented in spring 1999 was initiated.

Measurement science

Progress in measurement science was focussed this past year on soil moisture, measurement of which is of increasing importance, not only for LSP modelling but also mesoscale forecasting. The Division has been testing new soil moisture retrieval methods, one in cooperation with NHRI, to infer the forest water balance on a scale of hectares, based on the accurate measurement of deep groundwater pore pressure. This method is being evaluated at the Aspen BERMS site and also at the CARE site, as part of the measurement science program. Results to date have been encouraging, and the techniques offer an interesting approach for measuring soil moisture over a small plot even in forested areas. One of the major contributions in the measurement science program has been the publication of the Final Report of the WMO Solid Precipitation Measurement Intercomparison and the acceptance of the study's recommendations by nations at CIMO-XII. Results from the WMO Solid Precipitation Measurement Intercomparison Study are being applied to Branch projects where improved precipitation fields are required. As a follow-on contribution, the Division has been involved in developing the specifications for precipitation sensors for use at autostations, designing the evaluation process and reviewing the results. This supports the AES Climate Modernization Program. Finally, the Division continued its active contribution to improving our knowledge on the use of GPS to retrieve water vapour mass. In cooperation with University of Waterloo and UNAVCO at NCAR 2 GPS receivers were acquired and installed, including one in the Mackenzie Basin for MAGS. Real time data are expected in mid 99/00.