Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

2007 DRI Progress Report

Project Title: SURFACE-ATMOSPHERE COUPLING DURING DROUGHT AND CONVECTIVE EVENTS

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1.0 Progress (beginning January 2007 to end January 2008)

1.1 **Describe progress towards meeting the project objectives for those theme areas where you have received funding for 2007-2008. How are the original milestones being met? List the key objectives and results achieved to date as well as any relevant application(s) of the results.**

My project objectives have not changed over the past year.

Project Objectives:
(1) examine the linkages between surface characteristics and other atmospheric forcing on deep convective activity (initiation and rainfall) during the drought period.
(2) examine regional climate model simulations of drought toward improved prediction

The methods to address objective 1 will fall under Themes 1-3 (via characterizing the drought, improve process understandings and modeling experiments) and Theme 2-3 for objective 2.

Theme 1 *(Drought Characterization)***:**

(related to Hanesiak Objective 1):

- We have begun the process of summarizing the main spatial and temporal larger scale characteristics of the drought through mapping several drought indices (monthly PDSI and SPI), monthly precipitation and temperature anomalies using the CanGrid dataset (anomalies calculated using the standard 1971-2000 means), prairie wide daily soil moisture and ET patterns using the PAM-II crop model as well as daily and monthly maps of lightning. Animations of these fields have also been produced. This work has been completed by my two PhD students Julian Brimelow and Hassan Bhuiyan and the help of two undergrad student research assistants funded by DRI (Dan Battencourt and Justin Hobson).
- Work is ongoing to examine convective activity in association with wet/dry areas identified by the crop model and other maps generated above. This will reveal whether deep convection is more associated with wet areas as opposed to dry.

- This has been the extent of Year 1 activity and follows the timelines set up in the original proposal.

Theme 2 & 3 *(Improved Process Understanding and Prediction)***:**

(related to Hanesiak Objective 1):

- In collaboration with Richard Raddatz (U. Manitoba), we have identified the key convective and non-convective forcing mechanisms during the drought and one non-drought year (2000-04) (this work has recently been accepted in the Intl. J. climatology).
- Much of the past year has been devoted to examining the ability of the PAM-II crop model in simulating soil moisture in the top 1.5m as well as ET to ensure it is representing the physical processes of these quantities correctly. Actual soil moisture data was acquired from Ab Agriculture from many sites and compared to the model's soil moisture fields. Results showed the model represented the spatial pattern of soil moisture quite well but quantitatively had some differences with observations in some cases. To this end, we used field data from AB Ag and Masaki Hayashi (DRI co-I) to drive the model and validate its soil moisture and ET fluxes over specific sites in Alberta with various types of cropped and grass vegetation. This work has almost been completed and it was found that an ensemble approach to simulating soil moisture and ET must be performed given the sensitivity of these parameters to the various possible actual soil retention characteristics of each site. The ensemble mean was found to track both soil moisture and ET fairly well (e.g. $R^2 = 0.8$ or higher with soil moisture RMSE's between 5-10 mm over the entire growing season), which is quite remarkable.
- This work will be presented at the Annual DRI workshop in January 2008.
- This work provides confidence in the crop model's ability to spatially and temporally represent and predict soil moisture and ET quite well over the growing season, and will be used in future work to examine more closely these process linkages to atmospheric convection initiation.

Theme 3 *(Improved Prediction)***:**

(related to Hanesiak Objective 2):

- CRCM hindscast output was acquired for an older model run (CRCM using a force restore surface scheme) and CRCM coupled to CLASS. There are many model parameter outputs, however, we have focused mainly on precipitation, temperature and snow cover thus far in the past year.
- Observational meteorological and surface data have been acquired for comparison to the CRCM model output.
- Work has been ongoing over the past year in terms of comparing the modeled snow cover, precipitation and temperature to observations. Overall, the CRCM coupled to CLASS reproduces these fields much more accurately than the non-CLASS version, both spatially and temporally. Quantification of these model errors is ongoing and will be used in future hydrological applications in specific basins during the drought.
- This work will be presented at the Annual DRI workshop in January 2008 and was also presented at the Theme 3 workshop in Montreal in September 2007.
- All of this work is being done by Hassan Bhuiyan (PhD student).

1.2. **What contributions have you made, if any, to the unfunded themes of DRI through support in kind.**

Theme 4: Compare the similarities and differences of the recent drought to previous droughts over this region and those in other regions, in the context of climate variability and change.
Theme 5: Apply our progress to address critical issues of importance to society.

none to date

1.3. **Describe you plans for research during the coming year and the following year and outline how the expected results will support the deliverables and goals of DRI.**

We will continue as planned for Brimelow's work on identifying wet/dry soil moisture and ET areas using the PAM-II crop model over the Prairie-wide region and linking these areas to convective cloud initiation, lightning and storm development. Field work will take place in summer 2008 during the Unstable field project toward measuring the horizontal and vertical distribution of water vapour and temperature across identified wet/dry boundaries. The purpose is to quantify boundary layer thermodynamic structure across these areas and its impact on convective cloud development. These measurements will then be used to investigate similarities and differences to numerical model simulations from GEM and GEM-LAM. Collaborations with Masaki Hayashi, Paul Bullock and Rick Raddatz will continue with this work.

We will also continue work as planned with Bhuiyan on historical CRCM simulations over the DRI period as well as other drought periods, with a primary focus on precipitation and large scale atmospheric circulation patterns. The work will also be extended to examining the utility of hydrological models over specific basins of importance to Manitoba Hydro with respect to the DRI period and other drought periods. Collaborations with Ouranos and Manitoba Hydro will continue for this work.

2.0 Impact

2.1 Describe the significance / impact of the results achieved to date and how this new knowledge has influenced research policy, enhanced research collaboration or competitiveness, or helped attract or train skilled personnel.

Address the following items, as appropriate:

- **The impact of the project on government policy development (federal, provincial or municipal);**
- **How the project has expanded contacts in partner organizations, or increased cross-disciplinary cooperation;**
- **Whether and how it has improved the reliability of predictive methods;**

- **The impact of the project on your own institution;**
- **Whether and how the project has helped increase funding from other agencies, or led to new partnerships;**
- **Any current (or potential) commercial or social applications, which the results may have;**
- **Links with international initiatives and the potential impact of these;**
- **Anticipated benefits of the work for Canadians.**

We have developed direct collaborations with Civil Engineering (Manitoba) who are working on a water and climate change NSERC project with Manitoba Hydro and Ouranos. We are in the process of developing a research proposal centred around DRI science focused on Manitoba Hydro water issues with major funding potentially coming from MB Hydro and NSERC.

3.0 Dissemination

3.1 Provide information on dissemination of the research results (publications, including journal names and whether refereed), conference contributions, seminars, workshops or videos, websites or other methods of transferring the results.

Raddatz, R.L. and J.M. Hanesiak, 2007: Significant Summer Rainfall in the Canadian Prairie Provinces: Modes and Mechanisms 2000 – 2004, accepted Intl. J. Climatology

Bhuiyan, H. and J. Hanesiak, "Regional Climate Model Simulations of the 1999-2004 Canadian Prairie Drought", DRI Theme 3 (Prediction) Workshop, Montreal, QC, Sept 20, 2007

Hanesiak, J., “An overview of Theme 1 activities”, 2nd annual Drought Research Initiative (DRI) workshop, Winnipeg, MB, Jan 11-13, 2007.