



Canadian Foundation for Climate
and Atmospheric Sciences (CFCAS)

Fondation canadienne pour les sciences
du climat et de l'atmosphère (FCSCA)

Final Progress Report

Project Title: Characterizing the Surface Dynamics of the 1999-2005 Canadian Prairie Drought

DRI Investigator: Elaine Wheaton

1.0 Project Work

1.1 Provide a summary description of a) the objectives of the study, b) the scientific findings and c) the project work undertaken.

1. Theme 1: Quantify the physical features of this recent drought:

This study relates to one of the main objectives of DRI, in that it quantifies the extent and severity of the 1999 to 2005 Canadian Prairie drought at a variety of spatial and temporal scales using several standard meteorological drought indices, including the Palmer Drought Severity Index (PDSI), the Palmer Z Index and the Standard Precipitation Index (SPI). Main deliverables included workshop presentations, a working document and a submitted journal article.

The journal article provides a detailed analysis of a six stage system we have developed for describing the evolution of droughts focusing on the 1999-2005 episode. The first stage is the onset or initiation of the drought. Stage two involves the growth or extension of the drought often with secondary peaks. The third stage is the drought persistence which often includes stage four, the peak of the drought. Stage five occurs during the decrease or retreat with a possibility of secondary peaks. Stage six is the termination of the drought with a return to near normal conditions. We also define and discuss the major characteristics of a drought including; duration, frequency, severity, area of origin and geographic pattern and extent. Examples of these characteristics are explained through our defined stages of drought and numerous figures.

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.

We have examined previous droughts that match or surpass the severity indicated by both the PDSI and SPI indices in the 1999-2005 drought. These drought years include 1918-1920, 1928-1932, 1961 and 1988. We have examined similarities in formation, origin, migration and termination.

Several new findings were made regarding drought dynamics and the comparisons of the two drought indices. Temporally, the SPI and PDSI can be used to characterize the 1999 to 2005

Prairie drought into six stages including 1) onset, 2) growth, 3) persistence, 4) peak, 5) retreat, and 6) termination. Specifically, severe drought conditions began in late spring 2001 and peaked in early winter 2002. They then persisted for several months ending in May 2003. Spatially, it appears that this drought migrated from the United States Great Plains into southwestern Alberta in late 1999/early 2000 and then intensified to cover much of south-central Alberta and Saskatchewan. In 2002, it moved into the northern agricultural regions of these two Provinces.

This was followed by a general retreat and north-eastward progression into Manitoba and a widespread end to drought conditions in 2004/2005. Comparisons with other major Prairie droughts during the 20th century (1918-1919, 1928-1932, 1936-1938, 1960-1962, and 1988-1989) revealed that the majority could also be classified into the aforementioned six stages with notable differences among the various episodes. For the most part, droughts identified by PDSI persisted longer than SPI due to the nature of the indices. Analyses also revealed that these major Prairie droughts originated in a variety of regions, although several can be traced back to the northern United States. Results from this investigation aid in the better understanding of temporal and spatial features associated with major Canadian Prairie droughts and can be used to help improve both preparation and coping mechanisms for future drought occurrences.

Theme 5: Apply our progress to address critical issues of importance to society.

Other contributions include work on the Partnership Advisory Committee and many publications from related research that addresses this topic. The Partnership Advisory Committee was created to help focus the applications aspects of DRI. It consisted of several of the DRI partners and was chaired by Harvey Hill, Agriculture and Agri-Food Canada.

1.3 Describe the tangible results or the measurable outputs generated by the project and how these results have been taken up by user groups for policy development or operational improvements.

Results will be synthesized into a journal article to be included in the special DRI issue of *Atmosphere-Ocean*. This article characterizes and compares the 1999-2005 drought with past droughts. Through this comparison we can establish that the six stage drought evaluation system is evident in other major droughts. This helps identify the stages of serious drought (onset, growth, peak, decline and termination). We are not aware of any methods available that currently do this. The deliverables will help improve the planning and preparation involved in coping with droughts through an improved ability to identify the different stages of drought, starting with the onset. The information would be valuable for local to national drought plans, actions and monitoring.

2.0 Impact

2.1 Describe in broad terms how your work has contributed to the overall objectives of DRI and to our scientific understanding of drought.

The work we have done in both our Working Document and journal article contribute to the overall objective of DRI because they improve understanding of the characteristics involved in the many different kinds of drought. Through new data sets and indices we were able to create tables and figures used to explore areas of drought research (e.g., the six stage drought system). With gains like this in mind, it is acceptable to say we have bettered our understanding

of drought characteristics such as duration, frequency, severity and geographic extent and pattern.

2.2 Describe the significance / impact of the results in terms of some or all of the following areas:

- **The impact of the project on government policy development (federal, provincial or municipal);** Our comparison of gridded climate data with observed station data permits improved selection of such databases
- **How the project has expanded contacts in partner organizations, or increased cross-disciplinary cooperation;** Contacts for our work included many partners such as Ted Hogg (Canadian Forest Service), Dan McKenney (Canadian Forest Service), Paul Bullock (U of Manitoba), John Hanesiak (U of Manitoba) Phillip Harder (U of Manitoba) Grace Koshida (Environment Canada)
- **Whether and how it has enhanced or improved the reliability of predictive methods related to the science;** Better understanding of the evolution of droughts provides understanding to help forecasting.
- **The impact of the project on your own institution (e.g. helped attract new students or personnel);** DRI work has several positive impacts on our institutions including the use of contacts, data and information to aid other research work. Research has contributed toward Environment Canada and Saskatchewan Research Council research mandates toward better understanding the extreme hydrologic events and their impacts on the hydrology and ecology of Saskatchewan and Canada.
- **Whether it has improved or increased the acquisition of funds from other agencies, or led to new partnerships;** DRI has increased- the visibility and integration of our institutions.
- **Any links with international initiatives and the potential impact of these (e.g. profile of Canadian science, influence on international programs);** The results have many socio-economic and environmental applications, some of which we are documenting in other project work as documented in section 1.6 with Theme 5 publications. These applications relate mostly to the vulnerability and adaptability of rural communities to water scarcity and climatic change.
- **Any commercial or social application the results may have had or could have;** DRI links well with our Institutional Adaptation to Climate Change project (funded by SSHRC) that compares the vulnerability and adaptability of rural communities regarding water scarcity and climate change.
- **The anticipated impact of the work on Canadians and their well-being;** We are just beginning to explore benefits and these include implications for water management, and community vulnerability. Through this project we hope to be able to help better identify the early warning signs of drought and other life stages with those reduce community vulnerability.

4.0 Reverse Impact Statement

4.1 Provide a reverse impact statement, describing what would have happened in terms of the project, the resulting science and the impacts on users/stakeholders, if the work had not been funded by CFCAS.

The results would not have provided the big picture. They would have been very local in scale which would have severely limited the benefits. Positions such as the research assistant would not have been created which would not have resulted in the involvement of any students. The training of future drought scientists would also not have been possible. Most importantly, the work has furthered both our understanding and ability to adapt with drought would not have been completed.

5.0 Follow-on Science

5.1. Based on the findings of your research identify any outstanding scientific questions that need to be addressed in future drought studies.

Developing advanced indices and other methods to improve understanding and characterization of droughts.

6.0 Dissemination

6.1 Provide information on the 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.

Journal articles

Bonsal B., E. Wheaton, Meinert, A. and E. Siemens. In preparation in January 2010. *Characterizing the Surface Dynamics of the 1999-2005 Canadian Prairie Drought*. Submitted to Atmosphere Ocean.

*Wheaton, E., S. Kulshreshtha, V. Wittrock, G. Koshida. 2008 Summer. Dry Times: Lessons from the Canadian Drought of 2001 and 2002. *The Canadian Geographer* **52(2)**:241-262. Saskatchewan Research Council (SRC) Publication No. 11927-6A06.

*Marchildon, G.P., Kulshreshtha, S., Wheaton, E., Sauchyn, D. 2008 June. Drought and Institutional Adaptation in the Great Plains of Alberta and Saskatchewan, 1914 – 1939. *Natural Hazards* **45**:391-411. SRC Publication No. 11899-6A07.

* Sauchyn, D., and S. Kulshreshtha (lead authors), E. Barrow, D., Blair, J. Byrne, D. Davidson, P. Diaz, N. Henderson, D. Johnson, M. Johnston, S. Kienzle, J. Klaver, J. Thorpe and E. Wheaton (contributing authors). 2008 February. Prairies; *In: Lemmen, D.S., F.J. Warren, J. Lacroix, and E. Bush (eds.) From Impacts to Adaptation: Canada in a Changing Climate 2007*. Government of Canada, Ottawa, ON, p. 275-328. Saskatchewan Research Council (SRC) Publication No. 11299-2A08.

Technical Reports

- Wittrock, V., S. Kulshreshtha, L. Magzul and E. Wheaton. 2008 September. *Adapting to Impacts of Climatic Extremes: Case Study of the Kainai Blood Indian Reserve, Alberta*. Prepared for Institutional Adaptation to Climate Change (IACC): A Project of SSRHC – MCRI Program. Saskatchewan Research Council (SRC) Publication No. 11899-6E08. 108 pp.
- Wheaton, E. 2008 July. *Scenarios of Future Climates: Characteristics Relevant to Stakeholders of the Boreal Plains Ecozone*. Prepared for the Government of Canada, Climate Change Impacts and Adaptation Program, Project A1383. Saskatchewan Research Council (SRC) Publication No. 12306-2E08, 21 p.
- Henderson, N., and D. Sauchyn (Eds.) Sauchyn, D., S. Kulshreshtha, E. Barrow, D. Blair, J. Byrne, D. Davidson, P. Diaz, N. Henderson, D. Johnson, M. Johnston, S. Kienzle, J. Klaver, J. Thorpe, and E. Wheaton (authors). 2008 April. *Climate Change Impacts on Canada's Prairie Provinces: A Summary of our State of Knowledge*. Prairie Adaptation Research Collaborative, Regina, SK. Saskatchewan Research Council (SRC) Publication No. 11299-3E08. 20 pp.
- Wittrock, V., S. Kulshreshtha, and E. Wheaton. 2008 April. *A Prairie Community's Exposure and Sensitivity to Climatic Extremes: Case Study of the Blood Indian Reserve, Alberta. Progress Report for April 2007 to March 2008*. Saskatchewan Research Council (SRC) Publication No. 11899-5E08, 3pp.
- Sauchyn, D., J. Byrne, N. Henderson, D. Johnson, M. Johnston, S. Keinzle, and E. Wheaton. 2008 April. *Alberta Vulnerability Assessment: Assessment of Biophysical Vulnerability*. Prepared for Prairie Adaptation Research Collaborative (PARC 08-01), University of Regina, Regina, SK. Saskatchewan Research Council (SRC) Publication No. 11299-1E08, 75 pp.

Presentations

- Bonsal, Barrie. E. Wheaton. E. Siemens and N. Nicolichuk. 2009 November. *Drought Characterizations* Presentation to *Climate Hazards Workshop*. SRC Publication No. 12829-3D09. 12 pp.
- Wheaton, E. 2008 September. *The Severe Drought of 2001-2002: An Overview of Impacts and Adaptations in the Canadian Prairies*. Invited presentation to the 2008 Canadian Drought Research Initiative (DRI) Conference, 26 September, Winnipeg, MB. Saskatchewan Research Council (SRC) Publication No. 11602-6D08. 108 pp.
- Meinert, A., B. Bonsal, and E. Wheaton. 2008 September. *Characterizing the 1999-2005 Canadian Prairie Drought: Drought Indices and their Associated Input Variables*. Invited presentation to the Canada Drought Research Initiative (DRI) Drought Characterization Workshop, Winnipeg, MB, 26 September. SRC Publication No. 11602-8D08. 16 pp.
- Hill, H., T. Rolfe, E. Wheaton, R. Lawford, J. Pomeroy, R. Stewart and N. Lee. 2008 May. *A Modest Attempt to Take the "I" out of the "Hydro-illogical" Cycle*. Invited Presentation to the CMOS Congress, Kelowna, May 28, 2008. Saskatchewan Research Council (SRC) Publication No. 11602-3D08, 19 pp.

- Meinert, A., B. Bonsal, and E. Wheaton. 2008 January. *Characterizing the Climatological Nature of the 1995-2005 Drought in the Canadian Prairies: Data Sources and Issues*. Invited presentation at the 2008 Drought Research Initiative (DRI) Workshop, Calgary, Alberta, January 17-19, 2008. Saskatchewan Research Council (SRC) Publication No. 11602-1D08. 17 pp.
- Meinhart, A. B. Bonsal. E. Wheaton. E. Siemens. *An assessment of various drought indices associated with the 1999-2005 Canadian Prairie Drought. A limited report/working document prepared for CFCAS Canada, Saskatchewan Research Council, Saskatoon.*
- *Diaz, P. S. Kulshreshtha, B. Matlock, E. Wheaton, and V. Wittrock. 2008 November. *Rural Community and Vulnerability to Climate Change: Case Studies of Cabri and Stewart Valley in Southwestern Saskatchewan*. Klima 2008/Climate 2008 Web Conference. Available at: <http://www.climate2008.net/index.html?a1=pap&cat=4&e=38> Saskatchewan Research Council (SRC) Publication No. 11899-10D08. 7pp.
- Wheaton, E. 2008 November. *Agriculture in a Changing Climate*. Invited presentation to the Saskatchewan Research Council Agriculture, Biotechnology and Food Division, Saskatoon, SK. SRC Publication No. 10432-5D08. 47 pp.
- Wheaton, E. 2008 November. *Weathering the Warming: Prairies and the World*. Invited presentation to Saskatchewan Research Council's Business Development Lunch and Learn. Saskatoon, SK. SRC Publication No. 10432-4D08. 40 pp.
- Koshida, G., E. Wheaton and V. Wittrock. 2008 October. *The 2001-2002 Canadian Drought Experience: Lessons Learned*. Invited presentation to the North American Drought Monitor-Canadian Workshop. 15 October, Ottawa, ON. Saskatchewan Research Council Publication No. 11602-7D08. 27 pp.
- Wittrock, V, S. Kulshreshtha, L. Magzul, and E. Wheaton. 2008 October. *Floods and Droughts / Friends or Foe?* Invited Presentation at the Saipoyi Elementary School, Standoff, Kainai Blood Indian Reserve, Alberta, October 22, 2008. Saskatchewan Research Council (SRC) Publication No. 11899-8D08. 20 pp.
- Wittrock, V., S. Kulshreshtha, L., Magzul, and E. Wheaton. 2008 October. *Droughts and Floods of the late 20th and early 21st Centuries on the Kainai Blood Indian Reserve*. Invited Presentation to the Blood Tribe Chief and Council, Standoff, Kainai Blood Indian Reserve, Alberta, October 21, 2008. Saskatchewan Research Council (SRC) Publication No. 11899-7D08. 34 pp.
- Wheaton, E. 2008 June. *Risks and Rewards: Global Warming and Prairie Agriculture*. Invited presentation to the 2008 Saskatchewan Assessment Appraisers' Association's, Annual Professional Development Workshop, June 18-20, 2008, Saskatoon, SK. Saskatchewan Research Council (SRC) Publication No. 10432-3D08, 50 pp.
- Wittrock, V., E. Wheaton, and S. Kulshreshtha. 2008 June. *Six Prairie Communities' Susceptibility to Drought*. Invited presentation at the 61st Annual National Conference of the Canadian Water Resources Association, June 17-19, 2008, Gimli, MB. Saskatchewan Research Council (SRC) Publication No. 11899-4D08, 31 pp.

- Wheaton, E. 2008 April. *Climate Change and Agriculture: Risks and Opportunities*. Invited presentation to the 2008 Saskatchewan Institute of Agrologists' Conference, Saskatoon, April 4, 2008. Saskatchewan Research Council (SRC) Publication No. 11178-3D08. 47 pp.
- Wittrock, V., P. Diaz, S. Kulshreshtha, B. Matlock, and E. Wheaton. 2008 April. *Rural Community Vulnerability to Climate Change: Saskatchewan Case Studies*. Invited Presentation to "Adaptation to Climate Change in the Canadian Plains", Saskatchewan Institute of Public Policy and Institutional Adaptation to Climate Change Project, Regina, April 22, 2008. Saskatchewan Research Council (SRC) Publication No. 11899-2D08, 19 pp.
- Wittrock, V., S. Kulshreshtha, and E. Wheaton. 2008 April. *Vulnerability of Prairie Communities to Drought: Comparing Outlook, Taber, Hanna, and Kainai Nation*. Invited Presentation to the Annual Meeting of the Institutional Adaptation to Climate Change Project Regina, SK April 23-25, 2008. SRC Publication No. 11899-3D08, 15 pp.
- Koshida, G., Wheaton, E., Wittrock, V., Stratton, E., and S. Butt. 2008 March. *Before the Tap Runs Dry: Identifying User Needs and Designing Better Drought Products*. Invited Presentation to the North American Drought Monitor-Canadian Workshop, March 5-6, 2008 Guelph, ON. Saskatchewan Research Council (SRC) Publication No. 11926-1D08. 38 pp.
- Wittrock, V. and E. Wheaton. 2008 March. *Large and Small Communities and Climate Change*. Invited Presentation at the University of Saskatchewan. Saskatchewan Research Council (SRC) Publication No. 11178-2D08, 109 pp.
- Wheaton, E., C. Beaulieu, J. Thorpe, and V. Wittrock. 2008 February. *Agriculture in a Warming Climate*. Invited Presentation at the University of Saskatchewan. Saskatchewan Research Council (SRC) Publication No. 11178-1D08, 78 pp.

6.2 Describe data management/sharing activities including organization of the metadata. Also, are the data being archived, and how will they be made available to other researchers?

Data are being managed by the DRI Data Managers and will be made accessible via the DRI website for as long as it is sustainable. The meta data form was completed and submitted.

6.3 Comment on any outreach or public information activities, including press interviews or other media interest or reports. Has the project helped to popularize science or increase public awareness?

As a result of the presentations listed in section 1.6, the project helped increase public awareness of drought characteristics, impacts, vulnerability and of adaptations to drought.

7.0 Training

7.1 Quantify student and PDF involvement (indicate the level of each: undergraduate, masters, doctorate or PDF). If possible and within the Federal Privacy Act rules governing the collection of personal information, provide a general indication of

their subsequent employment (i.e., university, industry, government, other, etc.), and indicate whether the employment was foreign or domestic.

On the job training for the Research Assistants.