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DRI

Drought Research Initiative
Initiative de recherche sur la sécheresse

A Drought Research Initiative for the Canadian Prairies

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Résumé: Les Prairies sont souvent exposées à la sécheresse et quelques fois de façon catastrophique. La plus récente sécheresse a eu lieu au cours de l'épisode 1999 à 2005, et elle a produite des conditions les plus sèches du dossier historique. Pour traiter de telles sécheresses, un réseau de recherche du nom de DRI (Drought Research Initiative – Initiative de recherche sur la sécheresse) a été formé. Le centre d'intérêt particulier du réseau DRI consiste à mieux comprendre la façon dont les sécheresses surviennent, évoluent et prennent fin afin de comprendre leur structure interne et de contribuer à une meilleure prédiction de tels événements. Afin de réaliser cet objectif, on considère la sécheresse sous différents points de vue en tenant compte de l'atmosphère, du sol incluant les processus de la végétation et du sous-sol. Cette sécheresse fut exceptionnelle de telle sorte que son processus à grande échelle a été assez variable dans le temps. De plus, on a noté que les nuages étaient fréquents et qu'à travers les Prairies il est arrivé de voir quelques fois, de façon simultanée, des records de grosses précipitations dans certaines régions. Pourtant, cette sécheresse a produit quelques-unes des plus grandes diminutions de l'humidité enregistrée en profondeur et a contribué à une diminution majeure de l'écoulement des rivières. De plus, la communauté de recherche du réseau DRI, à travers le Canada, travaille étroitement avec plusieurs partenaires concernés par la sécheresse et qui ont tous intérêt à faire face à de tels événements, dans le futur. Cet article résume l'Initiative de recherche sur la sécheresse en faisant valoir les caractéristiques de la récente épisode de sécheresse, ainsi que les objectifs du réseau DRI, les enjeux scientifiques clés, les récents progrès et les plans futurs.

1. Background

The occurrence of drought is a ubiquitous feature of the global water cycle. Such an extreme does not necessarily lead to an overall change in the magnitude of the global water cycle but it of course affects the regional cycling of water. Droughts are recurring aspects of weather and climate extremes, as are floods and tornadoes, but they differ substantially since they have long durations and lack easily identified onsets and terminations.

Drought can be considered as an anomaly within the atmospheric, surface and sub-surface cycling of water and energy (Figure 1). This anomaly is initiated through large scale atmospheric processes and is enhanced and maintained through regional to local atmospheric, surface hydrology, land surface and groundwater feedbacks that operate at various time scales over the growing season and during dormant snow-free and snow-covered periods.

Drought is a relatively common feature of the North American and Canadian climate system and all regions of the continent are affected from time-to-time. However, it tends to be most common and severe over the central regions of the continent. The agricultural areas of the Canadian Prairies are therefore prone to drought.

Droughts in the Canadian Prairies are distinctive in North America. The large scale atmospheric circulations are influenced by blocking from major orographic features to the west and long distances from all warm ocean-derived atmospheric water sources. Growing season precipitation is generated by a highly complex combination of frontal and convective systems. Seasonality is severe and characterized by a relatively long snow-covered season and short growing season; local surface runoff is primarily produced by snowmelt water; and the landscape has substantial water storage potential in the poorly drained, post-glacial topography; and aquifers are overlain by impermeable glacial till, but there are also important permeable aquifers in surficial deposits that have substantive water exchange with the surface.

One example of Prairie drought is the recent multi-year event that began in 1999 with cessation of its atmospheric component in 2004/2005 and many of its hydrological components in 2005. This event produced the worst drought for at least a hundred years in parts of the Canadian Prairies. An illustration of the severity is shown in Figure 2 for the 2000/01 agricultural year. This multi-year drought led to major impacts across the Prairies as discussed by Lawford et al. (2008).

Despite enormous economic, environmental, and societal impacts of drought, there has never been a coordinated and integrated drought research program in Canada. Given the importance of this extreme form of weather, it is critical that it be studied appropriately with the hope being that its occurrence and nature can be better anticipated on short and long term scales.

The purpose of this article is to provide a brief overview of a Drought Research Initiative (DRI).

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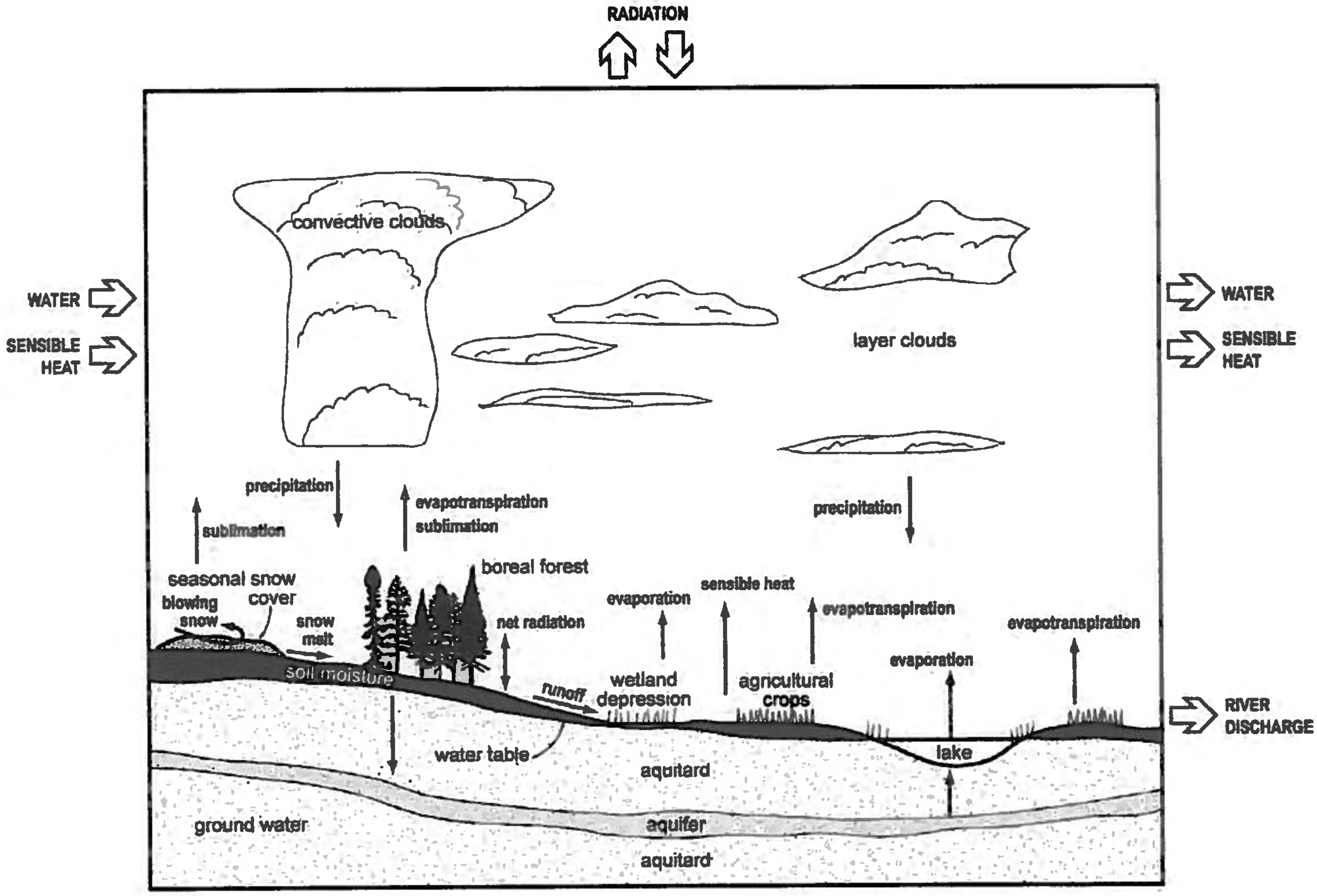

Figure 1. Water and energy cycling associated within Canadian Prairie drought.

2. Objectives

To begin to address these issues related to drought, the Drought Research Initiative, DRI was established. DRI is a research network largely funded by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS).

The overall 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 and largely ended in 2005"*.

To address this overall objective, the Network is focused on five research objectives:

1) To quantify the physical features of this recent drought;

2) To improve the understanding of the processes and feedbacks governing the formation, evolution, cessation and structure of the drought;

3) To assess and reduce uncertainties in the prediction of drought and its structure;

4) To 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; and

5) To apply our progress to address critical issues of importance to society.

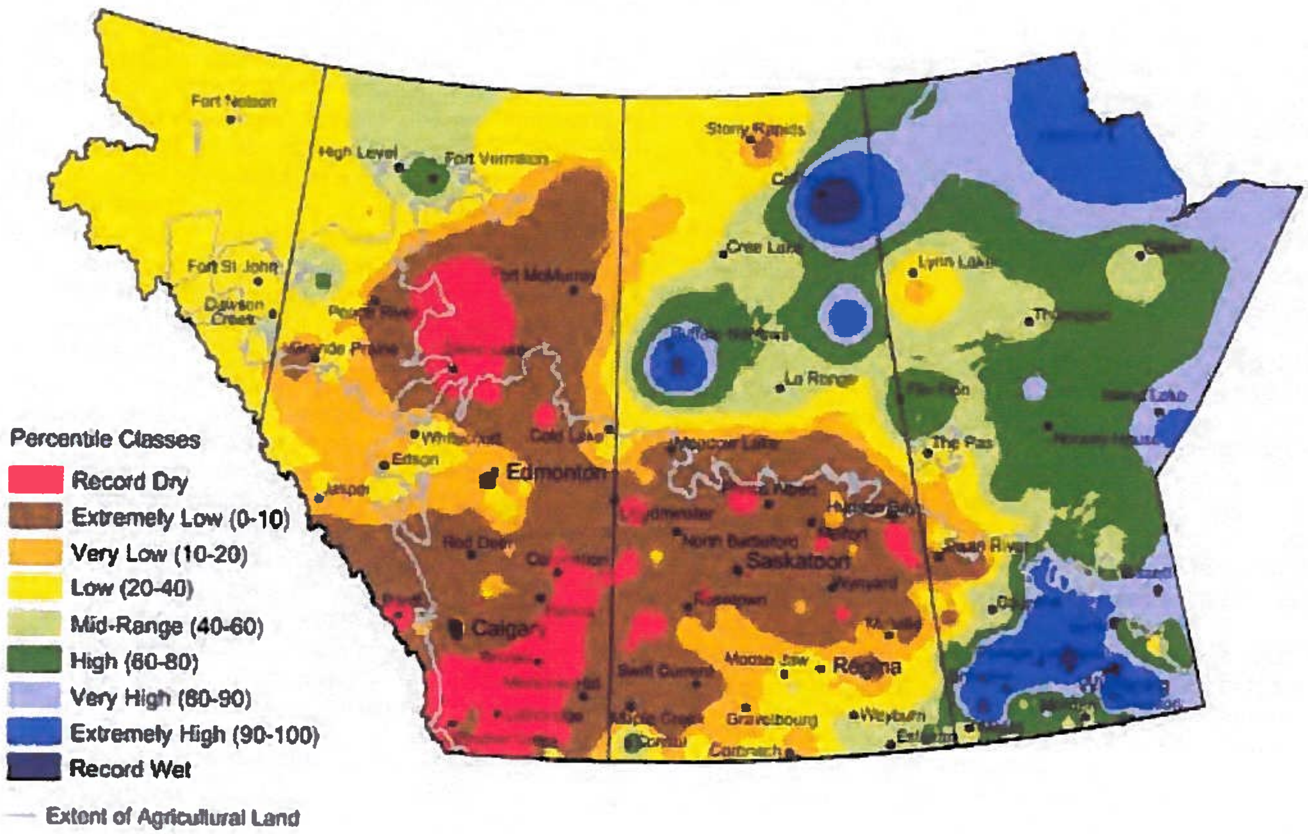

Figure 2. Example of the precipitation deviation from normal in the early drought period, September 1, 2000 - August 31, 2001. Courtesy of Prairie Farm Rehabilitation Administration.

DRI brings together many university and federal/provincial government researchers to address this issue with expertise encompassing the atmospheric, hydrologic, land surface and predictive aspects of droughts at a variety of spatial and temporal scales. As shown in Table 1, DRI is overseen by a Board of Directors, its scientific effort is driven by a Science Committee and its researchers have either CFCAS funding (investigators) or are carrying out contributing research through other means (collaborators). It should be noted that only Objectives 1-3 were able to be funded directly through CFCAS; objectives 4-5 are being addressed using other funds and linkages to the extent possible. Lawford et al. (2008) discusses the critical DRI Partners Advisory Committee that gives guidance directly to the Board of Directors.

To make progress on this critical issue over the 5-year period of a CFCAS Network, the project focuses, although not exclusively, on the recent drought over the Prairies. This drought was by far the best observed and modelled one over this region and its impacts are still fresh in people's memory. This strategy, a focus on physical processes and particular time periods or events, is a common one although not so for drought. For example, it has been applied successfully for IPY (International Polar Year) and for MAGS (Mackenzie GEWEX Study) which used it to examine a year with record low discharge from the Mackenzie River (Stewart et al., 2002). The assumption is that, in general, it is often only feasible to bring together for a particular event or period the necessary full complement of observations, models and scientific research capability to examine phenomena such as drought. In the case of DRI, one can even consider the focus on 1999-2005 drought as being a 'pilot' project for drought research including strong interactions with those affected by it.

From a longer-term perspective, it is envisioned that this 5-year Network represents an essential step towards our ultimate goals:

- To better predict droughts over Canada, their detailed structure and their impacts with increasing confidence;

- To better assess whether there will be a 'drying of the continental interior' in the future.

These two overarching issues directly address major issues for society. There needs to be better guidance on the likelihood of drought including its detailed and varying structure. Furthermore, there is tremendous concern that our changing climate will lead to more periods of drought in the future over the interior of North America (see for example Lemmen et al., 2008). The implications of this are so far reaching that this has to be our ultimate objective; to better assess the likelihood of such a scenario. With this Network, we will be moving systematically towards these two objectives.

3. Strategy

As outlined in Section 2 above, DRI will achieve its overall objective through a focus on five complementary, cross-cutting research objectives or themes. The five themes represent a logical sequence for such a network by including the quantification, understanding and better prediction of a particular drought and the subsequent comparisons of our findings with other droughts as well as the implications for society.

3.1 Theme 1

The first step towards the better understanding of the 1999-2005 drought involves the quantification of its atmospheric, hydrologic and land-surface physical features at a variety of spatial and temporal scales. As the drought is being quantified, this information forms much of the basis of Themes 2 through 5.

Theme 1 is being realized through three focussed questions:

- What variables are required to quantify the characteristics of this recent drought?
- What data sources and model outputs are available for quantification of these parameters?
- How do we characterize and "close the budgets" of water and energy over the Prairies?

The quantification of drought necessarily means that many fluxes and reservoirs need to be addressed. This is schematically illustrated in Figure 1. In particular, variables characterizing atmospheric, surface and sub-surface states are required. A three-dimensional assessment of the atmosphere during drought over various temporal scales requires, for example, knowledge of temperature, humidity, pressure, wind, clouds and precipitation amount. The transfer of heat and moisture between the surface and atmosphere must also be assessed. At the surface, the spatial and temporal characteristics of vegetative state (in terms of water stress) for major vegetation types (crops and boreal zones), soil moisture, stream network, river flows, lake levels, wetlands and depression storage are required to assess when and where drought is occurring. Sea surface temperatures are also needed to characterize global connections with prairie drought. The spatial characteristics of groundwater and sub-surface moisture are also an important long-term indicator of drought. An additional issue for the Prairies is that they are covered by undulating or hummocky terrains with numerous topographic depressions. The majority of individual depressions are too small to be captured in 1:50,000 topographic maps, but collectively they represent an enormous capacity to store surface water without allowing it to be drained to streams. Proper characterization of depression storage is essential for understanding the hydrology of the prairie region. It is not easy to acquire the needed observational information. First, there is operational instrumentation across the region that in some cases is arranged as networks. This includes weather stations, radars, lightning detectors, stream gauges, lake levels, vegetation assessment, crop yields, snow information, soil moisture and ground water. In general, though, there are relatively few of these sites. Others though have used some of these data in order to make gridded products that are extremely useful for characterizing drought. One example of this is the CANGRID precipitation information based on station information that has been homogenized and adjusted for all known measurement errors (Mekis and Hogg, 1999; Vincent and Gullett, 1999). Second, satellite-based observations are extremely important and they provide critical information on a host of variables in the atmosphere, at the surface and even sub-surface. Variables range from clouds and precipitation, to snowcover and vegetation, down to sub-surface water storage. Not all of the products are adequate however and many have limitations on temporal and spatial resolution. Third, there are a few locations (Figure 3) at which a large number of detailed measurements are carried out. This includes BERMS (Boreal Ecosystem Research and Monitoring Sites) in northern Saskatchewan, the St. Denis Wildlife area near Saskatoon, and the Assiniboine Delta Aquifer in western Manitoba. The types of data at these sites is not consistent though with some, for example, having a number of atmospheric-related measurements and others focused on surface and sub-surface variables. Fourth, some individual researchers have acquired their own unique field measurements. There is a wide variety of this information and much of it can be accessed through contacting the researcher directly.

Model products are being used to fill gaps in the observational record. These data sets include GEM (Global Environmental Multiscale model), ECMWF (European Centre for Medium range Weather Forecasting), CRCM (Canadian Regional Climate Model, and CCCMA (Canadian Centre for Climate Modelling and Analysis) to name a few. Each of these models has its own spatial and temporal resolution, from coarse spatial scales (of order a few hundred kilometres) to shorter mesoscale ones (a few tens of kilometres).

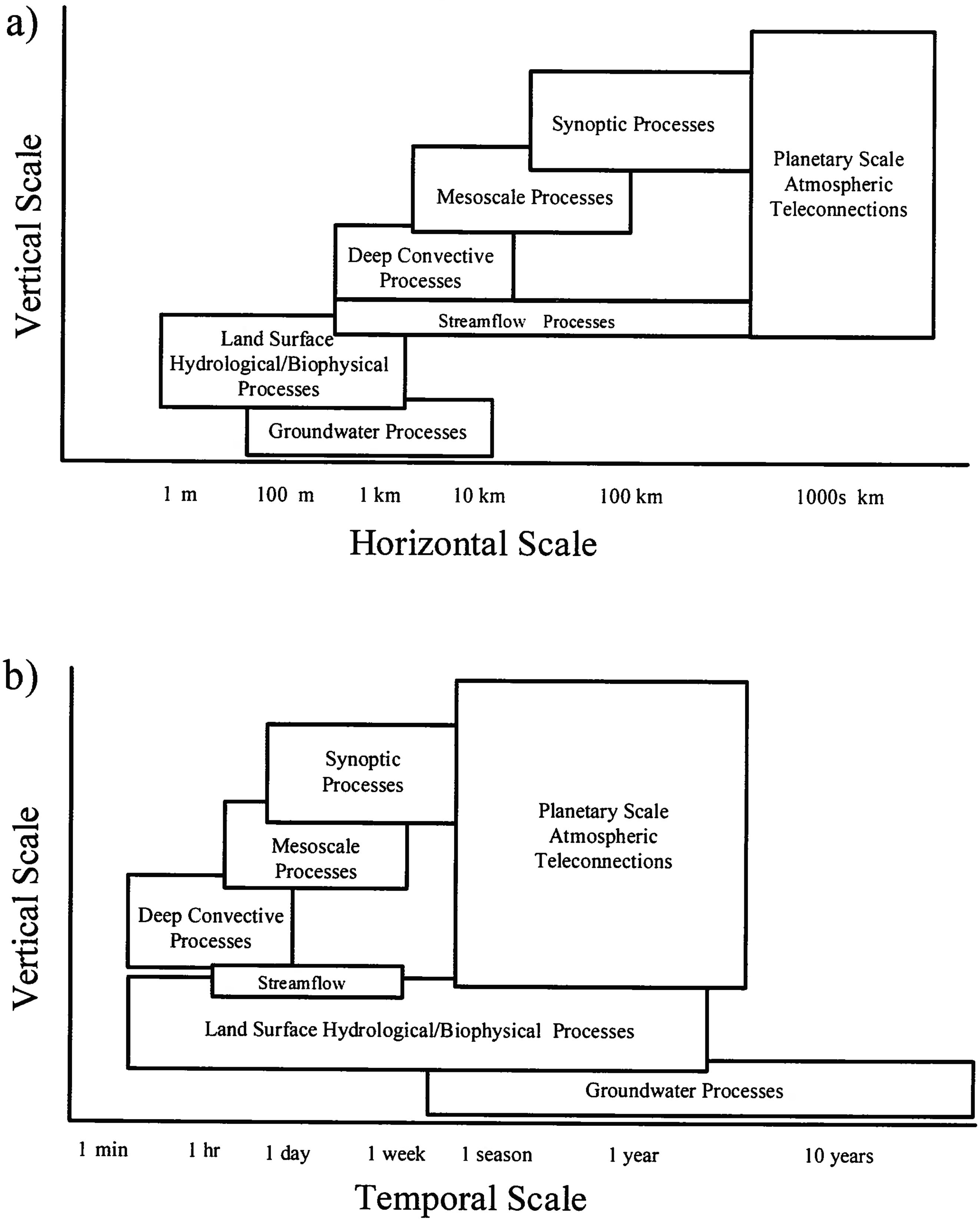

Figure 3: (a) Spatial and (b) temporal scales of processes associated with Prairie droughts. Note that 'mesoscale' refers to the atmospheric processes including the precipitation associated with frontal systems.

Hydrological and surface models are essential to DRI. Ones being used and/or improved extensively include MESH (MEC [Modélisation Environmentale Communautaire] Surface and Hydrology model interfacing with the GEM model), VIC (Variable Infiltration Capacity model), CRHM (Cold Regions Hydrological Model), SABAE-HW (Soil Atmosphere Boundary, Accurate Evaluations of Heat and Water), and CLASS (Canadian Land Surface Scheme). This effort includes coupling of surface and sub-surface water conditions.

Furthermore, the fluxes and budgets of water and energy through and within the Prairies during drought must be addressed. This needs to be accomplished through the analysis of the model and observational products described above. This DRI-wide activity is being addressed on scales ranging from long-term values over the entire Prairies to smaller scales less than a month over smaller domains that experienced different degrees of impact.

3.2 Theme 2

Given that the 1999-2005 drought and its features are being quantified in Theme 1, the next issue is to better understand the processes and the feedbacks responsible for the drought's initiation, persistence, and termination. This theme is addressing the following questions:

- What processes were responsible for the onset of the recent drought?

- What processes and feedbacks contributed to the drought's evolution, persistence, and spatial structure?

- What processes and feedbacks controlled the termination of this drought?

Much of DRI's effort is being devoted to better understanding processes and feedbacks. This recognizes that there has been relatively little attention paid to the mechanisms directly associated with Canadian drought. Prairie drought processes have characteristic spatial and temporal scales; these are shown in Figure 3. We hypothesize that atmospheric circulation patterns normally induce the onset of drought, but its termination is also linked with land surface and groundwater conditions as well as atmospheric conditions. It is also important to note that land surface hydrological/biophysical processes generally operate at small spatial scales (and with large inherent spatial variability) and that there is a hierarchy of atmospheric process scales. The horizontal scale link between land surface and groundwater processes (which produce many of the greatest societal impacts) and the large atmospheric scales is provided by a cascade of atmospheric processes and by large basin streamflow. Overall, however, the evolution of drought across different scales is not well understood, and DRI is directly addressing this issue.

It also needs to be recognized that there are many ways in which drought, basically a sustained precipitation deficit, can be prolonged. Some of the ways to reduce precipitation include, for example, large scale circulation anomalies, lack of moisture advected into a region, reduction of local moisture supplies, reduction of vegetation for evapotranspiration, reduction of sub-surface water supply for evaporation, production of virga as opposed to precipitation, and possibly even the role of aerosols in the dusty environment. Over the 5+ years of the drought, it is anticipated that all these, and numerous other factors, were operating at various times and locations to suppress the production of substantial precipitation.

3.3 Theme 3

Given that the 1999-2005 drought and its features are being quantified and the fundamental responsible processes better understood, the next issue is to assess and improve predictive techniques for it. The modelling tools used are global and regional climate models (GCMs and RCMs), and hydrological models. The hydrological models will be driven by output from the atmospheric models and observations from research sites and available reanalysis data. Atmospheric modelling spans scales from global to regional to watershed scales characteristic of the prairies, while hydrological modelling is accomplished using a hierarchy from small scale detailed process models to large scale models run over river basins. The major questions are:

- How well was the current drought predicted based on current techniques?

- To what extent could this prediction be improved through better initialization?

- To what extent could this prediction be improved through dynamical downscaling and better physics?

- What are the appropriate scales and processes for prediction of Prairie droughts?

Use will largely be made of archived information to address many of these issues. This, for example, is available from the Historical Forecast Project that addressed seasonal prediction as well as from operational seasonal forecasts of Environment Canada. DRI-related research is focussed on a particular extreme and examines many more variables than the traditional analysis of temperature and precipitation. As discussed under Theme 2, there are many ways in which a precipitation deficit arises and these need to be considered when analyzing prediction results. It is also expected that experiments will be carried out within DRI for assessing the role of soil moisture and perhaps snowcover on seasonal prediction.

3.4 Theme 4

Given that the 1999-2005 drought and its features are being quantified, better understood, and potentially better predicted, the next issue is to compare our progress with droughts occurring at other times and locations. The objectives of Theme 4 will be realized through the following research questions:

- How do the physical features, processes, and feedbacks of the recent Canadian Prairie drought compare with a) previous droughts over the Canadian Prairies, b) Canada-wide droughts, c) US Great Plains droughts, and d) droughts across the world?

- How does the prediction of the recent drought compare with predictions of other droughts?

- How does the recent drought compare with past climate variability and projected climate change?

Bonsal (2008) identified a number of aspects of the recent drought in relation to others based on circulation patterns and climate variables. To carry out comprehensive comparisons, however, these analyses have to be extended to include many more variables in the atmosphere and surface. Furthermore, these analyses have to examine the internal structure of drought, not just its presence over a particular region. Many droughts, including the one in 1999-2005, illustrate a complex, dynamic, internal structure of precipitation and possibly other variables, and the pattern changed dramatically during the drought. Such internal features can in some instances be just as important as the general occurrence of drought.

3.5 Theme 5

Theme 5, addressing the societal impacts of drought, can be broken down into sub-issues which include:

- What organizations are affected by drought?

- What is the nature of the drought's impact and how can these impacts be alleviated?

- Given the progress being made by DRI, how can it enable organizations affected by drought impacts to respond more effectively in the future?

A major portion of this effort is described in Lawford et al. (2008). This Theme relies heavily on the active two-way involvement of the partners. Progress being made by DRI needs to be conveyed to impacted groups and vice versa. In turn, impacted groups through this Theme inform the Network on critical issues, thresholds and other factors relating to drought, enabling DRI research to adjust and thereby more effectively address the concerns of Canadians.

4. Linkages

Whereas previous studies have focused on individual features occurring over the Prairies (e.g., large-scale circulation, storms, land surface processes, and river flows), DRI is focussing on the entire 'system' during periods of extreme dryness. Even though there are several international and, to a lesser extent, national programs that have addressed extremes in the water cycle, DRI fills a niche because none have specifically focused on the Canadian Prairies.

4.1 Canadian Linkages

On a research level, the Network has already linked several university-based researchers from institutions in Canada as well as a number of federal and provincial agencies and departments. At the federal level, it has also established collaborative links with several departments including several components of Environment Canada, Agriculture and Agri-Food Canada, and Natural Resources Canada. DRI has also established close links with Canadian GEO (Global Earth Observations) which is keenly interested in drought. DRI is exploring the feasibility for being a test-bed for their pilot projects and long-term plans.

DRI has established many linkages at the provincial level. Within the Prairie provinces this includes the Alberta Agriculture Food and Rural Development; Alberta Environment; Manitoba Agriculture, Food and Rural Initiatives; Manitoba Hydro; Manitoba Water Stewardship; Prairie Adaptation Research Collaborative; Saskatchewan Agriculture; Saskatchewan Environment; Saskatchewan Watershed Authority; and the Saskatchewan Research Council. Linkages also include the Prairie Provinces Water Board which considers water flows across provincial boundaries. Links have also been established with Ouranos, the Québec-based initiative concerned with regional climate.

The Network complements previous or current Canadian research studies. This includes the Mackenzie GEWEX Study (MAGS) that was concerned with Mackenzie basin water and energy cycle issues (Stewart et al., 1998), and Canadian CLIVAR activities that considered climate variability (Derome et al., 2004). DRI also has links with a recently initiated major project on institutional adaptation to climate change, especially water scarcity issues (a collaborative research initiative led by the University of Regina).

Although DRI can link with other Canadian activities, it is unique and fills an important gap. No other activity is addressing head-on the critical multi-disciplinary drought issue that regularly affects the Canadian Prairies.

4.2 International Linkages

Internationally, DRI has its strongest linkages with the United States. The western portion of the U.S. has also been experiencing drought conditions for several years and there is an increasing sense that a more coordinated effort is needed to address drought (Western Governors' Association, 2004). Although there is not yet a comparable U.S. Drought Network, strong linkages will be developed with organizations and individuals studying American droughts. There is, for example, a natural link with the GEWEX America Prediction Project (GAPP where GEWEX is the Global Energy and Water Cycle Experiment) which in turn is part of CPPA (Climate Prediction Program of the Americas). The Network will also interact with the U.S. Drought Mitigation Center, the North American Drought Monitor, and US CLIVAR activities.

DRI is also contributing to and taking advantage of research over other parts of the world. For example, both the World Climate Research Programme (WCRP) and GEWEX through it Coordinated Energy and water cycle Observation Project (CEOP) have recently initiated activities focussing on extremes such as droughts. The work in DRI is contributing directly to this and, to some degree, it is considered to be a model as to how one addresses extremes in a comprehensive manner.

Other collaborations will include the International Decade for Predictions in Ungauged Basins 2003-2012 (PUB), a hydrological decade for improving the understanding and prediction of hydrological systems where surface observations are not available for model calibration (Sivapalan et al., 2003). A particular emphasis of PUB is on hydrological prediction in semi-arid to sub-humid zones. Through exchange of techniques and information, DRI will both contribute to and benefit from links to PUB. The Network will continue links to the International Water Management Institute (IWMI) in its studies of drought assessment and mitigation in southern Asia; the IWMI currently uses Canadian water assessment methodologies in some of its hydrology studies

http://www.iwmi.cgiar.org/drought assessment/index.asp

The region has certain similarities to the Prairies in that snowmelt-fed mountain waters supply much of the water to a semiarid and sub-humid lowland region.

5. Progress and Update

DRI is midway through its activities. Substantial progress has been made on many fronts. A few illustrations of progress are mentioned here.

DRI has brought together an unprecedented amount of information on Canadian drought. On its web site

http://www.drinetwork.ca

one can find many links to various datasets that describe elements of drought in the atmosphere, at the surface or below the surface. Compiling a Prairie-wide database of provincial groundwater and water levels is part of this effort. This collective progress is in itself a major accomplishment. Now the task is to ensure that as much of this information as possible is integrated and made even more accessible. A synthesis article characterizing the 1999-2005 drought is in progress and this will be followed by another one addressing the water and energy budgets during the drought. In addition, new techniques of archiving and making available datasets are being explored as another legacy of DRI.

Tremendous progress has been made in examining the multitude of processes that operated during the drought. As discussed by Bonsal (2008) large scale factors illustrated consistencies with and differences from those associated with other droughts. However, a host of other atmospheric, surface and sub-surface processes including evapotranspiration, runoff generation and sub-surface water transport are also being studied and these can all affect the nature of drought. All of these issues will be brought together in a dedicated workshop over the next year to ensure that we have collectively addressed this key issue. This workshop will build on a successful evaporation workshop that was held in 2007.

There had not been a systematic study before of the capability of season-prediction systems to anticipate drought. This is currently underway within DRI although, in general terms, it appears that key aspects of the drought's persistence and end were not well-anticipated. In addition, it is recognized that initialization of these models with surface conditions (soil moisture, snowcover) may well improve predictive capabilities. Initial experience with these is anticipated by the end of DRI. Some of this work is being carried out in cooperation with GOAPP (Global Ocean-Atmosphere Prediction and Predictability, another CFCAS-sponsored Network). A dedicated workshop on this issue has been held and this activity will also work with our US colleagues to ensure as much progress as possible.

Largely through other funding beyond that of CFCAS, a number of researchers are able to carry out comparison studies. Bonsal (2008) has noted a number of differences and similarities at large scales for example between this recent drought and others. Much more needs to be done on this issue to apply our detailed knowledge of one drought to other, less well-understood ones. A dedicated workshop on this issue will be held in the last year of DRI with the intent being to apply our knowledge of the 1999-2005 drought to others and to place this drought into a larger context, including the extent to which it might be the harbinger of future drought over this region.

As mentioned earlier in this article, strong interactions have developed with those affected by drought. To move this along as efficiently as possible, the DRI Partners Advisory Committee was established, as discussed by Lawford et al. (2008). This Committee is, for example, organizing, funding permitted,'a simulation exercise' in which experiences from DRI are presented as if corresponding to a future drought. Such a learning experience will include both researchers and partners.

It should also be noted that there are many students working within DRI. These students are enjoying a unique opportunity to contribute to our knowledge of drought as well as to gain a wide perspective on the many issues linked with this phenomenon. The training of these students represents an important DRI legacy.

Table 1: DRI Board of Directors, Investigators and Some of the DRI Collaborators. Science Committee members are indicated by * and Theme Leads by "t". The number of collaborators continues to grow.

Board of Directors	**Jim Bruce** - - Chair	
	Gary Burke - - Member (Environment Canada)	
	Harvey Hill - - Member (Agriculture and Agri-Food Canada)	
	John Pomeroy - - Member (DRI Science Committee Co-Chair)	
	Ron Stewart - - Member (DRI Science Committee Co-Chair	
	Tim Aston - - Ex-Officio (CFCAS)	
Investigators	***t Barrie Bonsal** (Saskatchewan)	*** John Pomeroy** (Saskatchewan)
	Paul Bullock (Manitoba)	*** Ken Snelgrove** (Memorial)
	John Gyakum (McGill)	*** Ron Stewart** (McGill)
	***t John Hanesiak** (Manitoba)	**Geoff Strong** (Alberta)
	***t Masaki Hayashi**	**Garth van der Kamp** (Saskatchewan)
	Henry Leighton (McGill)	***t Elaine Wheaton** (Saskatchewan)
	***t Charles Lin** (McGill)	*** Al Woodbury** (Manitoba)
	Al Pietroniro (Saskatchewan)	
Collaborators	**Aaron Berg** (Guelph)	**Amir Shabbar** (EC)
	George Boer (EC)	**Dave Sills** (EC)
	Daniel Caya (Ouranos)	**Susan Skone** (Calgary)
	Jacques Derome (McGill)	**Craig Smith** (EC)
	Raoul Granger (EC)	*** Kit Szeto** (EC)
	Ted Hogg (NRCan)	**Brenda Toth** (EC)
	Bob Kochtubajda (EC)	**Jessica Toyra** (EC)
	Rick Raddatz (Manitoba)	**Alex Trishchenko** (NRCan)
	Hal Rithcie (EC)	**Anne Walker** (EC)
	Alonso Rivera (NRCan)	**Shusen Wang** (NRCan)
	Dave Sauchyn (Regina)	

6. Summary

Drought is a huge issue for Canada and DRI is addressing it in a comprehensive manner for the first time. This collaborative effort is providing a better understanding of the physical features of Prairie drought, the processes controlling it, and the capabilities to predict it. DRI is also comparing the recent drought with other earlier Prairie ones and with those occurring elsewhere; which will lead to a more complete picture of the implications for droughts occurring across Canada. Furthermore, interactions with the user community have been established so that DRI's progress contributes directly to these groups and their guidance influences research plans.

DRI is carrying out fundamental research on a climatic extreme but it is also targeted research. Given this reality, at the conclusion of the Drought Research Initiative in December 2010 we expect to say that:

"*We have greatly increased our understanding of drought through a focus on the recent 1999-2005 one over the*

Prairies and we have applied this to improved prediction. We have left a legacy of comprehensive datasets, improved observational and modelling techniques, a new generation of drought scientists, and a public better educated about drought. We have, in partnership with others in Canada and internationally, developed a plan to improve drought and water cycle prediction at multiple scales."

As one means of ensuring that these statements are realized, after each annual workshop, we issue a brief update statement. As of January 2008, DRI's status is:

"*We have continued to add datasets to characterize drought and to investigate the many factors leading to, sustaining and ending drought. We have developed interactions with other groups examining drought and other extremes in the United States and elsewhere. Our partners have organized an advisory group to ensure that there are strong two-way interactions with researchers. We are organizing our synthesis article on drought characterization and we have developed a strategy to assess and to contribute to improved predictive capabilities.*"

The next two years of DRI will bring our effort together through collective efforts that directly address our objectives. This period is also being used to establish a DRI Follow-On. Given its progress, DRI is uniquely positioned to address drought anywhere in Canada and indeed it is well-positioned to examine hydrometeorological extremes anywhere in Canada.

In summary, a comprehensive study of drought over the Canadian Prairies is underway. This has brought together researchers from several disciplines and it is working with partners affected by drought. DRI is making a difference.

Acknowledgements

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