Extremes Workshop
February 7-9, 2011

Programme and Abstracts

Inn at the Forks
Winnipeg, Manitoba

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

Table of Contents

Extremes Workshop Background and Objectives:

Overview:

Canada is, and always has been, buffeted by weather and climate extremes; these may become more frequent in the future. This issue may well be the key issue that the country has to face in terms of climate change. It affects virtually all aspects of society and our environment and it needs a coordinated private sector, government, academic effort to address it appropriately.

Background:

Extremes is arguably the most significant issue associated with climate change. The variations that will occur are expected to push the limits of extremes in heat, winds, precipitation, floods and droughts as well as their many associated features including forest fires, ecosystem changes, agricultural and infrastructure impacts. A component of these changes will come in temporal and geographical shifts in the boundaries between climate extremes.

To address these events in a spatio-temporal framework we need to consider the trends in extremes, the process responsible for them, and an assessment of future conditions across Canada but this can't be done without considering the whole continent. This will require a closer partnership between us in Canada and the US and Mexico in this area of climate research. This is also the time for a major thrust in this area because, for example, model outputs at high resolution (CMIP-5) will soon be available and satellite records are becoming long enough and of sufficient resolution that they can provide more insights on extremes.

Objectives:

a. To develop a consensus on the critical elements to be included in a science plan on understanding and adapting to extremes.
b. To develop a strategy for implementing a project to address these science and policy issues.

EXTREMES WORKSHOP AGENDA

Monday, February 7, 2011

07:45 - 08:30: Registration and Breakfast

08:30 - 09:00: Session #1: Welcoming remarks and introduction to the objectives of the Workshop

1.1 Motivation and Goals of the Workshop: Ron Stewart
1.2 Welcome from CFCAS: Dawn Conway
1.3 Self-introductions by participants

09:00 - 10:00: Session #2: Overview Presentations

2.1 Opportunities and Challenges of the International Disaster Reduction: Gordon McBean
2.2 Overview of statistical approaches to the study of Extremes: Francis Zwiers
2.3 Overview of phenomenological approaches to the study of Extremes: Ron Stewart

10:00 - 10:30: Coffee

10:30 - 12:15: Session #3: The Impacts of Extremes on socio-economic sectors

3.1 Agricultural Impacts: Harvey Hill
3.2 Water Resource Impacts: Bob Sandford, Rob Matthews
3.3 Infrastructure Impacts: Gregory Kopp
3.4 Drought Impacts in the USA: Mark D Svoboda
3.5 Discussion

12:15 - 13:15: Lunch

13:15 - 15:15: Session #4: Policy Issues

4.1 The economics of extremes: Suren Kulshreshtha
4.2 Systems and options for responding to Extremes: John Lindsay
4.3 Adapting to Extremes in Native Communities: Zachery Whitecap
4.4 Discussion

Session #5: The Science of Extremes

5.1 High resolution modeling of physical and ecological processes in diverse landscapes: Jim Byrne
5.2 Assessing changes in the occurrence of Extremes: Francis Zwiers for Xuebin Zhang
5.3 Climate, storm tracks and extremes: Philippe Gachon, John Gyakum

15:15 - 15:45: Health Break

15:45 - 18:00: Session #5: The Science of Extremes (Continued)

5.4 Monitoring Extremes: Aston Chipanshi
5.5 The role of oceanic and atmospheric circulations on extremes: Amir Shabbar, Ray Garnett
5.6 Drought Events: John Hanesiak, Barrie Bonsal , Kit Szeto
5.7 Discussion

18:00 - 19:30: Reception

Towards the end of the reception Jim Byrne will be showing a newly released film which he directed on Lake Winnipeg

Tuesday, February 8, 2011

07:45 - 08:15: Breakfast

08:15 - 10:30: Session #5: The Science of Extremes (Continued)

5.8 Soil Moisture and Hydrologic Processes: Paul Bullock
5.9 Hazardous Winter Precipitation Events: William Henson
5.10 Floods: Stephen Dery, Xiquan Dong
5.11 Forest Fires: Amir Shabbar, Bob Kochtubajda
5.12 Challenges and opportunities in using data to address extremes, In-situ: Steve Williams, Remote Sensing: Amir AghaKouchak

10:30 - 11:00: Coffee Break

11:00 - 13:15: Session #6: Extremes including their trends by region

6.1 Canadian overview: Ron Stewart, Francis Zwiers
6.2 Prairies: Bob Kochtubajda, Gerhard Reuter, Hank Venema
6.3 British Columbia: Stephen Dery
6.4 Central Canada: Jim Bruce
6.5 US: Mark Svoboda
6.6 Arctic Canada: John Hanesiak

13:15 - 13:50: Lunch

13:50 - 15:15: Session #7: Introduction to Breakout groups

7.1 Funding and research opportunities for work on Extremes
7.2 NSERC: Frank Nolan
7.3 Charge to Breakout Groups (Focus on Gaps in Scientific Understanding and the Science-Policy interface)
7.4 Breakout Groups

15:15 - 15:30: Coffee

15:30 - 16:15: Session #7: Breakout groups (Continued)

7.5 Reports from the Breakout Groups and Plenary Discussion

16:15 - 17:25: Session #8: Current Activities related to Extremes: (10 min maximum)

8.1 WCRP/GEWEX: Ron Stewart
8.2 US Efforts: Mark D Svoboda
8.3 NEWS: Xiquan Dong
8.4 IISD: Matt McCandless
8.5 GWSP: Rick Lawford
8.6 Weatherbug and CWB: Guy Ash

Wednesday, February 9, 2011

08:00 - 08:30: Breakfast

08:30 - 10:00: Session #8: Current Activities related to Extremes (Continued):

8.7 GEO: Rick Lawford
8.8 DRI Data Systems: Phillip Harder
8.9 NCAR Data Services: Steve Williams
8.10 Collaboration between EC and other Quebec organizations: Philippe Gachon
8.11 AAFC: Harvey Hill
8.12 NRCan CCIAD: Brian Horton
8.13 Environment Canada: Grace Koshida
8.14 Manitoba Water Stewardship: Bob Harrison

10:00 - 10:30: Coffee Break

10:30 - 11:30: Session #8: Current Activities related to Extremes (Continued):

8.15 Manitoba Climate Modeling Initiative: Avery Jodoin
8.16 PICS: Stephen Dery
8.17 PRAC: Ramon Sales
8.18 Discussion

11:30 - 12:00: Wrap-up

9.1 Plenary Discussion: What Needs to be done better? Why? When? Who?
9.2 Workshop Summary

12:00 - 13:00: Lunch

13:00 onwards: Red River Flood Workshop

EXTREMES WORKSHOP ABSTRACTS

Session #2: Overviews

Opportunities and Challenges of the International Disaster Reduction
GORDON MCBEAN

Around the world there are a large and increasing numbers of disasters with storms, floods and droughts being the cause of most of them. The International Council for Science, International Social Sciences Council and the United Nations International Strategy for Disaster Reduction have joined to create an new international program - Integrated Research on Disaster Risk. IRDR is integrated to bring together a multi-disciplinary approach, involving natural, social, health, engineering and other sciences to provide in-depth research on risk reduction - how to prevent hazards becoming disasters. Since there seems to be a larger number of research projects on the natural sciences of hazards, IRDR is initially focusing on in-depth analysis of past events - forensic investigations - to better understand what went wrong and how it could be corrected and on risk interpretation leading to action. The IRDR is also integrated over the hazards - what can we learn about combating floods and droughts from actions on earthquakes and vice versa.

The IRDR International Program Office is now established in Beijing and agreements are being made with, for example, the World Climate Research Program, to better coordinate our research activities.

Anthropogenic Influence on Long Return Period Daily Temperature and Precipitation Extremes
FRANCIS ZWIERS

There is now a well established approach to detecting and attributing the causes of observed changes in mean climatic conditions that has been applied progressively from global scales to regional scales to temperature, precipitation and other climate variables. While this research has provided a great deal of useful information about the causes of climate change observed during the past century or more, policy makers and others have also been demanding answers about whether there are attributable changes in the frequency and/or intensity of extreme weather and climate events. The statistical techniques required to respond to these questions are only now begin developed. This talk will describe a standard technique that is used in climate change detection and attribution research and will describe a couple of parallel approaches that have been proposed to assess whether there is a detectable human influence in the far tails of the distribution of climate variables such as daily maximum air temperature or daily precipitation amount. We also describe initial applications of these approaches, and discuss limitations and further areas of improvements. These applications suggest that human influence on the climate system has affected the extremes of daily maximum and minimum temperatures, and extreme daily precipitation amounts, altering the waiting times for events of a fixed amplitude. For example, on a global scale, waiting times for extreme annual minimum daily minimum and daily maximum temperatures events that were expected to recur once every 20 years in the 1960s are now estimated to exceed 35 and 30 years respectively. In contrast, waiting times for circa 1960s 20-

year extremes of annual maximum daily minimum and daily maximum temperatures are estimated to have decreased to less than 10 and 15 years respectively.

On phenomenological approaches to Extremes
RONALD STEWART

This discussion will examine some of the phenomena that are associated with extremes such as too little/too much precipitation, heat/cold and freezing precipitation. Such variables are linked with phenomena such as thunderstorms, drought and extra-tropical cyclones. We need to understand what processes have conspired to push the values of key variables into an 'extreme' category whether that be, for example, a change in occurrence or having a value below/above some threshold. Particular attention will be placed on inter-relationships in which one phenomena either precedes another or two may work in combination to produce an even more intense outcome. In summary, to adequately anticipate future extremes, one must properly account for phenomena and their interactions.

Session #3: The Impacts of Extremes on socio-economic sectors

Water Rights Licensing in Times of Scarcity
ROB MATTHEWS

Over the last decade information has been published by a number of sources on water rights licensing issues in Canada. Few of these sources dealt exclusively with the topic and many of the authors appear not to have spent much time, if any, consulting with the provincial employees who administer the various water rights licensing (and permit to take water) programs across the country. The talk will make direct reference to licensing on the Assiniboine River which is the largest river in Agro-Manitoba with headwater storage. The water stored behind the Shellmouth Dam allows for the provision of very high security water for domestic, municipal, irrigation, industrial, recreational and ecological use purposes. The talk is concluded with an explanation of how the principles of the Manitoba Water Rights Act might be applied in times of extreme shortages on the river.

Session #5: The Science of Extremes

High resolution modeling of physical and ecological processes in diverse landscapes
JAMES BYRNE, RYAN MACDONALD, EVAN BOOTH, SARAH DALLA VICENZA, SARAH BOON

The discussion will describe the continued development and application of the physically based hydrometeorological model GENESYS (GENerate Earth SYstems Science input). GENESYS was originally developed to simulate detailed terrain and landscape dependent micrometeorology needed for modeling daily snowpack processes in diverse terrain. GENESYS high resolution micro meteorology output has further applications in hydrology and ecology. We have developed routines to model: (i) spatial and temporal accumulation and ablation of alpine snowpacks; (ii) soil water processes including runoff. Ongoing developments include: biometeorology driven

species functions and processes; soil water associated drought and fire risk indices; glacial mass balance and glacial melt runoff routines; surface and groundwater interactive runoff module; and a daily stream channel water temperature variation. Future plans include characterizing resident terrestrial and aquatic species response(s) to climate change. The stream temperature model is the focus of a PhD thesis that incorporates atmospheric and hydrologic controls to estimate stream temperatures, with an end objective being assessment of environmental change on the habitat of salmonid species native to the Western Cordillera.

Storm tracks activities over the Hudson Bay area and links with surface extremes: past and future changes

PHILIPPE GAUCHON

The Hudson Bay (HB) area is strongly affected by large-scale teleconnection indices or various natural modes of atmospheric variability as Arctic oscillation, North Atlantic Oscillation, etc. which has resulted in a significant modification in sea-ice or oceanic and atmospheric conditions during the freeze-up and winter period over the last decades, as well as in extreme characteristics of both temperatures and precipitation. As the HB surface oceanic conditions affect the regional climate via the atmospheric circulation (and its response to oceanic state) and regional/local source or sink of heat according to air mass features during the year, all potential changes in the atmospheric circulation and storminess activities need to be carefully evaluated over this particular area. No in-depth analysis has been done considering the characteristics of storms and their evolvement in the course of past and future decades which specifically influences oceanic waves, sea-ice, or oceanic and atmospheric conditions, in general. This is needed to discriminate into more details the effects of natural variability and of potential changes in the HB climate system on natural and human environments. This is of particular importance in order to support vulnerability and adaptation study of the marine infrastructures, or other environmental studies to better anticipate and mitigate the impacts of climate change, on this vulnerable ecosystem. In this context, the main aim of this paper is to improve the knowledge on trajectories, the recurrence, duration/persistence and intensity of meteorological storms, as well as on the risk and scale of extreme events to come in links with the plausible evolvement of storms at intra- and inter-annual time scales over the HB area. This is also concerned by providing necessary information and advice that will help anticipate the impacts of climate change along the arctic coasts.

The role of explosive cyclogenesis in the northeastern Pacific, and its attendant latent heating, in producing a Beaufort Sea storm surge

JOHN GYAKUM

During September 1999, a strong storm surge event impacted the Beaufort coast of the Canadian Northwest Territories, particularly in the vicinity of Tuktoyaktuk. The surface winds exceeded 20 knots for much of the four-day period extending from 24 to 28 September. These speeds exceed the 95th percentile, based upon the climatological analysis of Small et al. (2011) for this location.

Though the presence of especially strong winds has often been linked with the passage of powerful cyclones in the Beaufort Sea, little attention has been paid to the

role of predecessor northeast Pacific cyclones in producing an environment conducive to the evolution of strong winds along the Beaufort coast.

The purpose of this study is to document the dynamic and thermodynamic processes crucial to the Beaufort coastal storm surge event at Tuktoyaktuk. Among the processes identified includes the latent heating associated with a relatively rare case of explosive cyclogenesis of 1.6 bergerons in the eastern North Pacific basin. We document the critical importance of this latent heating to the development of the strong storm-surge triggering surface winds occurring approximately two days later. The focus of previous research on explosive cyclogenesis has been limited to the processes leading up these cyclogeneses, with no discussion of the subsequent dynamical impacts. Additional dynamical impacts of the explosive cyclogenesis includes enhanced water vapor transport from the North Pacific basin, diabatic ridging at the dynamic tropopause occurring poleward into the Beaufort Sea, and cold low-tropospheric ridging that contributes to the strengthening of the pressure gradient and strong northwesterlies at Tuktoyaktuk.

Reference:
Small, D., E. Atallah, and J. R. Gyakum, 2011: Wind Regimes Along the Beaufort Sea Coast Favorable for Strong Wind Events at Tuktoyaktuk. J. Climatology and Appl. Meteorology, in press.

Is the SPI gamma function consistent in time and space for calculating extreme values of precipitation across Canada?

ASTON CHIPANSHI, RICHARD WARREN, DONZHI QI

As part of the EC/AAFC and NOAA suite of collaborative projects, this project focuses on evaluating the gamma function used in the SPI model in terms of consistency across Canada's complex climatic regions and whether the density function holds true at the weekly and bi-weekly time frames. We are also testing whether the function holds true when the climate reference period is changed. Using preliminary data, our results suggest that the gamma function may not represent humid regions adequately. Should other density functions be used where the gamma function appears inappropriate?

The association between Canadian Climate Extremes and Teleconnections.

AMIR SHABBAR

Extremes in Canadian winter temperatures are examined in relationship with interannual and interdecadal oscillations originating from the Pacific and the Atlantic oceans. Both in phase and out-of-phase impact of these oscillations are shown on the occurrences of temperature extremes in Canada.

Changing summer climate on the Prairies: from droughts to floods; A case study assessment of the causes and consequences of drought and flood years since 1990.

RAY GARNETT

Using rainfall data for the period 1950-2010 as a basis for comparison, there have been six extremely wet and two extremely dry May-July periods since 1990. The

May-July period of 2010 was the overall wettest. In July 2010 the federal and three prairie provincial governments announced $450 million in funding to assist waterlogged farmers. Causal factors leading up to a predominance of flood years since 1990 are considered to be a synergistic combination of low solar activity, a westerly phase of the quasi-biennial wind oscillation, El Nino conditions and below normal North American snow cover.

Characterizing the Surface Dynamics of Canadian Prairie Droughts
BARRIE BONSAL

Large-area, prolonged droughts are among Canada's costliest natural disasters having major economic and environmental impacts. At present, however, there is little (if any) advanced warning for drought occurrence, thus making preparation and any efficient response difficult. Although most areas of Canada periodically experience drought, the Canadian Prairies are most susceptible. Several studies have identified and to some extent, assessed the impacts of historical major dry episodes over the Prairies. However, none have comprehensively characterized them in terms of initiation, migration, persistence, and termination. These factors are critical with respect to better understanding of drought dynamics and prediction, and for relating their characteristics to the various impacts associated with severe drought occurrence.

Using the Standardized Precipitation Index and the Palmer Drought Severity Index, this study identifies, and then compares the spatial and temporal dynamics among several major Prairie droughts from 1901 to 2005. In particular, a concept of drought stages is devised to better categorize, compare, and understand their occurrence. Results show that the majority of severe droughts (including 1999 to 2005) can be characterized by six distinct stages including 1) onset, 2) growth, 3) persistence, 4) maximum extent, 5) retreat, and 6) termination. In addition, major Canadian Prairie droughts appear to have a variety of regions of origin, although several can be traced back to the northern United States. Results from this investigation provide a better understanding of the surface dynamics related to hydrologic extremes such as droughts that can help improve preparation and coping mechanisms for future extreme events.

Prairie Hydroclimate Extremes: Processes and Predictions
KIT SZETO

In this talk, I will give a brief overview of my research findings on hydroclimate extremes (e.g., extreme rain events and drought episodes) in the Canadian Prairies. The discussion will be focused on the physical processes that affect the development of these events. Based on the research findings, a new approach to the prediction of these events will be proposed.

Real-Time Soil Moisture Estimation in Western Canada: Needs and Issues
PAUL BULLOCK, ANDY NADLER, MIKE WROBLEWSKI, BRUCE BURNETT, GUY ASH, ASTON CHIPANSHI, JOHN HANESIAK, RICK RADDATZ, MANASAH MKHABELA, JULIAN BRIMELOW

There are widespread uses for soil moisture information in western Canada. Soil moisture affects agriculture (soil trafficability, crop yield, crop disease and pest risk), hydrology (runoff levels, flood risk, groundwater recharge) and weather (deep

convection, severe weather risk). In most cases, soil moisture information must be timely to facilitate decision-making by potential users of the information. But user needs vary widely in terms of scale, depth of moisture, unit of measurement, frequency and time period of interest. Soil moisture can be estimated with a number of methods including direct sampling, remote sensing, soil moisture sensor networks and soil moisture models that use weather and soil data. A methodology that combines all of these methods will help overcome the shortcomings of each one. An operational soil moisture monitoring group with representatives across various agencies, industry and universities is discussing the use of various soil moisture models that can be run with real-time weather data for the agricultural region of western Canada and verified with in situ measurements and remote sensing data. An in-situ soil moisture monitoring network established by the University of Manitoba and Manitoba Agriculture, Food and Rural Initiatives is in place and is expected to grow with the addition of monitoring sites by Agri-Environmental Services Branch of Agriculture & Agri-Food Canada. The group continues to meet and search for collaborative solutions to establish an accurate, operational soil moisture monitoring capability in western Canada.

A Preliminary Analysis of Hydrological Extremes in the Fraser River Basin
STEPHEN DERY, PHIL OWENS, ELLEN PETTICREW, MARGOT PARKES

The Fraser River drains one quarter of British Columbia and is its greatest river by annual discharge at over 100 cubic kilometres. As the most productive salmon river in the world, it remains an important river economically and culturally. The subsistence of many First Nation communities depends on salmon fishing along the many tributaries of the Fraser. Freshwater extracted from the Fraser River is used in many industries including agriculture, mining, pulp mills and forestry. Despite its national and international importance, recent streamflow variability and trends across the Fraser River watershed are poorly known. This presentation will provide a preliminary analysis of the interannual variability and interdecadal trends in discharge of the Fraser River along its main stem and its tributaries from 1950 to 2009. Data from over 100 gauges will be assessed to infer the variability and trends in annual discharge, including the occurrence of hydrological extremes.

The talk will end with a discussion on the possible implications of climate change on the observed variability and trends.

Investigation of the 2006 Drought and 2007 Flood Extremes at the SGP Through an Integrative Analysis of Observations
XIQUAN DONG, NASA NEWS EXTREMES WORKING GROUP

To integrate each individual PI's effort into the team effort, the four NEWS working groups have been established since fall of 2009. The Drought & Flood Extremes group focuses on the water and energy aspects of abrupt climate change, and is co-chaired by Drs. Dong and Deng. The overarching science goal of the NASA NEWS extreme working group in the next 5 years is to understand the variability of global/regional hydrological extremes, identify the linkage between changes in the characteristics of these extremes (e.g., frequency, duration, intensity, and sequence) and the global climate change, and explore the predictability of these extremes from intraseasonal to interdecadal time scales. This scientific goal reflects the general idea

of bridging the climate and weather scale events that have been treated separately in the past and eventually we can translate better observations and improved understanding of hydrological extremes into practically relevant information for multiple stakeholders in sectors such as agriculture, energy, water resource and risk management.

In this study, we present one of the NASA NEWS group efforts over the U.S. SGP region, published at JGR in 2011. Hydrological years 2006 (HY06, 10/2005-09/2006) and 2007 (HY07, 10/2006-09/2007) provide a unique opportunity to examine hydrological extremes in the central US because there are no other examples of two such highly contrasting precipitation extremes occurring in consecutive years at the Southern Great Plains (SGP) in recorded history. The HY06 annual precipitation in the state of Oklahoma, as observed by the Oklahoma Mesonet, is around 61% of the normal (92.84 cm, based on the 1921-2008 climatology), which results in HY06 the second-driest year in the record. In particular, the total precipitation during the winter of 2005-06 is only 27% of the normal, and this winter ranks as the driest season. On the other hand, the HY07 annual precipitation amount is 121% of the normal and HY07 ranks as the seventh-wettest year for the entire state and the wettest year for the central region of the state. Summer 2007 is the second-wettest season for the state. Large-scale dynamics play a key role in these extreme events. During the extreme dry period (11/2005-02/2006), a dipole pattern in the 500-hPa GH anomaly existed where an anomalous high was over the southwestern U.S. region and an anomalous low was over the Great Lakes. This pattern is associated with inhibited moisture transport from the Gulf of Mexico and strong sinking motion over the SGP, both contributing to the extreme dryness. The precipitation deficit over the SGP during the extreme dry period is clearly linked to significantly suppressed cyclonic activity over the southwestern U.S., which shows robust relationship with the Western Pacific (WP) teleconnection pattern.

The precipitation events during the extreme wet period (May-July 2007) were initially generated by active synoptic weather patterns, linked with moisture transport from the Gulf of Mexico by the northward low level jet, and enhanced the frequency of thunderstorms and their associated latent heat release. Although the drought and pluvial conditions are dominated by large-scale dynamic patterns, we have found two possible positive feedback processes during the extreme dry and wet periods in this study those play key certain roles to maintain and reinforce the length and severity of existing drought and flood events. For example, during the extreme dry period, with less clouds, liquid water path, precipitable water vapor, precipitation, and thinner Cu cloud thickness, more net radiation was absorbed and used to evaporate water from the ground. The evaporated moisture, however, was removed by low-level divergence. Thus, with less precipitation and removed atmospheric moisture, more absorbed incoming solar radiation was used to increase surface temperature and to make the ground drier.

Effects of Extreme Wind Storms on Residential Structures

GREGORY KOPP

Extreme wind storms are currently the cause of significant losses across North America. The presentation will highlight the state of our knowledge, including recent results from the 'Three Little Pigs' Project and the other new research facilities which

have emerged in the past few years. The challenges for adapting to a changing climate will be highlighted. Inexpensive retro-fits and mitigating water damage have proven elusive to date, but emerging test methods, which also incorporate aging effects, will be critical to reducing losses in the future.

Prediction of Forest Fire Severity from Large-Scale Climate Patterns in Canada
AMIR SHABBAR

Using the multivariate statistical technique of Maximum Covariance Analysis (MCA), the evolving nature of global SSTs and Canadian PDSI over winter and spring is used to predict following summer forest fire severity index over Canada. Skill measure of, correlation, mean absolute error and percent correct category, is evaluated in a cross-validation framework. The model delivers useable skill over the forested regions of Canada from the Yukon through the northern Prairies into eastern Canada.

Cloud-to-Ground Lightning in Yukon During A Season of Extreme Wildfire Activity
B. KOCHTUBAJDA, W.R. BURROWS, D. MCLENNAN, D. GREEN

The 2004 wildfire season and associated lightning activity in Yukon was unusual in many aspects. Climatologically, the summer season was much warmer and much drier than normal. The number of cloud-to-ground (CG) flashes, lightning-initiated forest fires and extent of the area burned exceeded historic records. This region typically experiences 141 wildfires annually which burn over 160,000 hectares between June and August. An annual average of over 20 thousand CG flashes account for about 54% of these ignitions. During the summer of 2004, over 40 housand CG flashes accounted for 88% of the 282 wildfires consuming over 1.7 million hectares of the territory.

Studies conducted in central United States and the Amazon region of Brazil found increases in the peak currents and percentages of positive CG flashes and decreases in negative peak currents. Lightning data from the Canadian Lightning Detection network for the period 1999-2008 are used to address several questions. What were the polarity and peak current lightning characteristics in Yukon during this extreme fire season? How do these characteristics in 2004 compare to the 1999-2008 period? How different or similar are the Yukon observations from those characteristics reported in southerly latitudes?

Application of Remotely Sensed Precipitation Data in Monitoring and Analysis of Extremes: Challenges and Opportunities
AMIR AGHAKOUCHAK

Over the past three decades, remote sensing of precipitation has emerged as a major source of information on rainfall variability, particularly over regions where in-situ measurement networks are sparse or nonexistent. Utilization of satellite data to improve hydrometeorologic predictions relies on the accuracy and reliability of remote sensing techniques in capturing the spatial and temporal distribution of precipitation. This presentation reviews the challenges and opportunities of using remotely sensed data for studying hydrologic extremes. Case studies include capturing precipitation extremes, pattern analysis of extremes, streamflow simulation, and drought analysis. Finally, the presentation summarizes the research priorities and discussions emerged from the Advanced Concepts Workshop on Remote Sensing of Precipitation that aimed to

develop a list of research recommendations in the field of remote sensing of precipitation.

Session #6: Extremes including their trends by region

Atmospheric Hazards in Prairie and Northern Region

BOB KOCHTUBAJDA

The Canadian Atmospheric Hazards Network was developed by Environment Canada to assist individuals, municipalities and provincial/territorial governments identify and assess their risks to atmospheric hazards for planning and decision-making activities, including the development of community and provincial emergency management plans. The site provides information on the types of atmospheric hazards common to each of the 5 Canadian regions and the climatology of these hazardous events.

Prairie and Northern Region (PNR) encompasses more than 50 percent of Canada's landmass. The landscape is diverse and spans many eco-climatic regimes including the Grasslands zone in the south, the Boreal, the Sub-Arctic, and Arctic regime in the North. Severe thunderstorms occur during the summer with a high frequency over the prairies. Weather phenomena associated with these storms include large hail, heavy rainfalls, lightning, flooding, tornadoes and other damaging winds. All of these phenomena exact heavy annual tolls in crop, infrastructure and other property damage, and all too often in human lives.

The Atmospheric Hazards portal for PNR was launched in 2009. This portal presents information in graphical and map formats. Supplementary datasets for select locations are also available. Several examples of severe weather represented on the site will be illustrated.

Extreme Events in a Changing Climate: Central Canada

JIM BRUCE

Trends in North American and global climate since about 1970 have been driven almost exclusively by increasing concentrations of greenhouse gases in the global atmosphere. This has been manifested in a central Canada (Ontario and southern Quebec) in modest increases in temperature and, as well, some rather startling increases in extreme events. Changes in frequency and intensity of intense rainfall and the implications for floods and water quality is one such trend. Others include changes in the Great Lakes-St. Lawrence system. Projected increases in freezing precipitation events are also a concern.

Session #8: Current Activities related to Extremes

DRI Data Services

PHILLIP HARDER

To facilitate the Drought Research Initiatives' (DRI) research program a major effort was undertaken within the network to centralize identification, collection and distribution of the many datasets related to the 1999-2005 prairie drought. Two systems were developed over the course of the project. The DRI Data and Information System

was developed to support DRI Investigators research data needs. The DRI Data Legacy in contrast is targeted towards other researchers and the general public and is making a large amount of the DRI data publicly available to users post-DRI in a permanent and open archive. The structure, development, data provided and lessons learned from the DRI data services experience will be discussed.

NCAR Data Services
STEVE WILLIAMS

An overview of NCAR's Data Services and Infrastructure will be presented. NCAR supports the international scientific community with a variety of data services and computational resources. Currently, a new Supercomputing Center is being constructed in Cheyenne, Wyoming, that will improve these data services to the community. NCAR data services include the field project data and archives at the Earth Observing Laboratory (EOL) as well as scientific data collections (e.g. climate time series) archived at the Computational and Information Systems Laboratory (CISL) Data Support Section. These data activities including access will be described as well as a lot of recent work with data stewardship.

Current activities related to Extremes: Environment Canada
GRACE KOSHIDA

This presentation will describe some of the products and tools developed by Environment Canada's Adaptation and Impacts Research Section and its partners to meet the growing demands of decision-makers concerned with climate extremes and disaster management. These products and tools include the Canadian Atmospheric Hazards Network (CAHN), Canadian Climate Change Scenarios Network (CCCSN.ca), climatic design values for National infrastructure codes and standards and other activities.

Extremes Workshop Registered Attendees

AghaKouchak, Amir	University of California	amir.a@uci.edu
Aider, Rabah	McGill University	rabah.aider@mail.mcgill.ca
Betancourt, Daniel	University of Manitoba	dbetanco2007@gmail.com
Bhuiyan, Hassan (AKM)	University of Manitoba	akmh.bhuiyan@gmail.com
Blair, Danny	University of Winnipeg	climateguy@gmail.com
Bohrn, Steven	University of Manitoba	umbohrn@cc.umanitoba.ca
Bonsal, Barrie	Environment Canada	Barrie.Bonsal@ec.gc.ca
Briggs, Burnid	Manitoba Water Stewardship	Burnid.Briggs@gov.mb.ca
Bruce, Jim	Consultant	jpbruce@sympatico.ca
Bullock, Paul	University of Manitoba	bullockp@cc.umanitoba.ca
Byrne, James M.	University of Lethbridge	byrne@uleth.ca
Chipanshi, Aston	AAFC-AESB	aston.chipanshi@agr.gc.ca
Conway, Dawn	CFCAS	conway@cfcas.org
Crawford, John	Manitoba Hydro	jcrawford@hydro.mb.ca
Dery, Stephen	University of Northern British Columbia	sdery@unbc.ca
Dong, Xiquan	University of North Dakota	dong@aero.und.edu
Fisico, Teresa	University of Manitoba	fisico@cc.umanitoba.ca
Fogg, Neil	University of Manitoba	neil.wfogg@gmail.com
Gachon, Philippe	Environment Canada	philippe.gachon@ec.gc.ca
Garnett, Ray	Agro Climatic Consulting	ergarnett@shaw.ca
Gislason, Robin	Red River Basin Commission	robin@redriverbasincommissio.org
Gyakum, John	McGill University	john.gyakum@mcgill.ca
Hanesiak, John	University of Manitoba	john_hanesiak@umanitoba.ca
Haque, Emdad	University of Manitoba	haquece@ms.umanitoba.ca
Harder, Phillip	Drought Research Initiative	harder.phillip@gmail.com
Harrison, Bob	Manitoba Water Stewardship	bob.harrison@gov.mb.ca
Hasell, Natalie	Environment Canada	natalie.hasell@ec.gc.ca
Henson, William	McGill University	william.henson@gmail.com
Hill, Harvey	Agriculture and Agri-Food Canada	harvey.hill@agr.gc.ca
Horton, Brian	NRCan	brhorton@nrcan.gc.ca
Islam, Faisal	University of Manitoba	imfaisal@gmail.com
Islam, Sabrina	University of Manitoba	sabrina.islam07@gmail.com
Jodoin, Avery	Manitoba Science, Technology, Energy and Mines	avery.jodoin@gov.mb.ca
Kashem, Abul	Manitoba Water Stewardship	abul.kashem@gov.mb.ca
Kochtubajda, Bob	Environment Canada	bob.kochtubajda@ec.gc.ca
Koenig, Kristina	Manitoba Hydro	kkoenig@hydro.mb.ca
Kopp, Gregory	University of Western Ontario	gakopp@uwo.ca
Korporal, Ken	Canada GEO	kenneth.korporal@ec.gc.ca
Koshida, Grace	Environment Canada	grace.koshida@ec.gc.ca
Kulshreshtha, Suren	University of Saskatchewan	suren.kulshreshtha@usask.ca
Lawford, Rick	University of Manitoba	lawfordr@cc.umanitoba.ca
Lindenschmidt, Karl-Erich	Manitoba Water Stewardship	Karl-Erich.Lindenschmidt@gov.mb.ca
Lindsay, John	Brandon University --	lindsayj@brandonu.ca

Liu, Zhuo(George)	University of Manitoba	zhuo_liu@umanitoba.ca
Loukili, Youssef	Manitoba Water Stewardship	youssef.loukili@gmail.com
Low, Cara	SGI CANADA Insurance	clow@sgicanada.ca
Luo, Bin	Manitoba Water Stewardship	Bin.Luo@gov.mb.ca
Mathur, Narendra	Manitoba Infrastructure and Transportation	narendra.mathur@gov.mb.ca
Matthews, Rob	Manitoba Water Stewardship	rob.matthews@gov.mb.ca
McBean, Gordon	University of Western Ontario	gmcbean@uwo.ca
McCandless, Matt	International Institute for Sustainable Development	mmccandless@iisd.ca
McCulloch, Chris	SGI CANADA Insurance	cmcculloch@sgicanada.ca
Mirza, Monirul	Environment Canada	monirul.mirza@utoronto.ca
Mkhabela, Manasah Sibusiso	University of Manitoba	mkhabela@cc.umanitoba.ca
Mutulu, Phillip	Manitoba Water Stewardship	phillip.mutulu@gov.mb.ca
Nolan, Frank	NSERC	frank.nolan@nserc-crsng.gc.ca
Paola, Rob	Environment Canada	robert.paola2@ec.gc.ca
Pittman, Jeremy	Saskatchewan Watershed Authority	jeremy.pittman@swa.ca
Raddatz, Rick	University of Manitoba	raddatz@cc.umanitoba.ca
Rasmussen, Peter	University of Manitoba	rasmusse@cc.umanitoba.ca
Reuter, Gerhard	University of Alberta	gerhard.reuter@ualberta.ca
Sagin, Jay	University of Manitoba	jay_sagin@umanitoba.ca
Sales, Ramon	Manitoba Conservation	ramon.sales@gov.mb.ca
Sandford, Bob	UN Water for Life Decade	sandford@telusplanet.net
Shabbar, Amir	Environment Canada	amir.shabbar@ec.gc.ca
Shymko, Randall	Manitoba Science, Technology, Energy and Mines	Randall.Shymko@gov.mb.ca
Singh, Purushottam Raj (Puru)	Manitoba Water Stewardship	Purushottam.Singh@gov.mb.ca
Slipec, Jim	Environment Canada	jim.slipec@ec.gc.ca
Smeh, Daria	Environment Canada	daria.smeh@gmail.com
Stadnyk, Trish	University of Manitoba	stadnykt@cc.umanitoba.ca
Stewart, Ronald	University of Manitoba	ronald.e.stewart@gmail.com
Svoboda, Mark	National Drought Mitigation Center	msvoboda@unlnotes.unl.edu
Szeto, Kit	Environment Canada	kit.szeto@ec.gc.ca
Tareghian, Reza	University of Manitoba	umtaregh@cc.umanitoba.ca
Teklemariam, Efrem	Manitoba Hydro	etyeklemariam@hydro.mb.ca
Uddin, Mohammed Salim	University of Manitoba	salimuddin07@yahoo.com
Venema, Henry D.	International Institute for Sustainable Development	sswidinsky@iisd.ca
Warkentin, Alf	Hydromet Services for Floods	uawarke@mts.net
Whitecap, Zachary	Red Earth Cree Nation	jeremy.pittman@swa.ca
Williams, Steve	NCAR	sfw@ucar.edu
Zdan, Terry	Manitoba Infrastructure & Transportation	terry.zdan@gov.mb.ca
Zwiers, Francis	Pacific Climate Impacts Consortium	fwzwiers@uvic.ca