Environnement Canada Environment Canada

UNderstanding **S**evere **T**hunderstorms and **A**lberta **B**oundary **L**ayers **E**xperiment (UNSTABLE)

Report on the meeting at the 40th CMOS Congress
Sheraton Centre Hotel, Toronto, May 30th 2006

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1. Introduction

The Understanding Severe Thunderstorms and Alberta Boundary Layers Experiment (UNSTABLE) is a proposed study to investigate boundary-layer processes associated with severe thunderstorm development over the Alberta foothills. The main atmospheric component of interest for the project is boundary-layer moisture and it's role in the initiation and evolution of severe thunderstorms. The project builds on an original proposal from what was formerly the Prairie Storm Prediction Centre (Winnipeg, Manitoba) and work led primarily by Dr. Geoff Strong and Julian Brimelow[1] (University of Alberta, Edmonton) and Dr. John Hanesiak (University of Manitoba).

The overall goals of the experiment may be summarized as follows:

- To better understand atmospheric processes leading to thunderstorm development over the Alberta foothills (both prior to and during convective initiation) with an aim to extend results to the rest of the Canadian Prairies
- To improve accuracy and lead time for severe thunderstorm watches and warnings
- To assess the utility of mesoscale models in resolving physical processes over the Alberta foothills and feed information back to modelers to improve model performance
- Through observational, case, and model studies refine current existing conceptual models describing convective initiation and the development of severe thunderstorms over Alberta and the western prairies

Specific objectives are to better understand, resolve, and quantify:

- *The spatial extent, depth and temporal evolution of water vapour in the boundary layer prior to and during convective initiation (CI)*
- *The processes leading to the development of mesoscale convergence, moisture or other boundaries that may inhibit (e.g., capping lid) or promote CI (e.g., dryline)*
- *The location, strength, spatial extent, duration and evolution of mesoscale boundaries and features associated with CI (drylines, convective rolls, low-level jets, convergence lines, thunderstorm outflow boundaries)*
- *Sensible and latent heat fluxes between the surface and atmospheric boundary layer (especially evapotranspiration and contributions to CI)*
- *The association of mesoscale boundaries and their behaviour with synoptic-scale atmospheric processes*
- *The association of mesoscale boundaries and their behaviour with non-meteorological factors such as land use / vegetation type, soil moisture, crop phenology*

The project is slated to include a two-stage field campaign, first a pilot experiment during July 2008, followed by a full-scale experiment in 2009 or 2010. The pilot project will be an Environment Canada led initiative with Dr. David Sills (Cloud Physics and Severe Weather Research Section) and Neil Taylor (Hydrometeorology and Arctic Lab) acting as co-principal investigators. The goals of the pilot are primarily to deploy a variety of data collection platforms over the Alberta foothills during July 2008 as a test for the later, full-scale experiment (see details below).

2. Meeting Participants

A preliminary meeting was held at the 40th CMOS Congress in Toronto on May 30th, 2006. The purpose of the meeting was to hold discussions with potential collaborators on the plans for the

[1] Current Affiliation: University of Manitoba.

pilot project. As evidenced by the participants listed in the table below, interest was high across a number of agencies and institutions.

Name	Affiliation	Name	Affiliation
Neil Taylor	HAL, EC	Peter Summers	Former ALHAS
Dave Sills	CPSWRS, EC	Nathan Maslanko	Student, U of A, HAL
Geoff Strong	University of Alberta	Brad Power	Student, U of A, HAL
Lesley Hill	University of Calgary	Bob Paterson	CPSWRS, EC
John Hanesiak	University of Manitoba	Patrick King	CPSWRS, EC
Pat McCarthy	PASPC-Winnipeg	Amin Erfani	CMC, EC
Jim Slipec	PASPC-Winnipeg	Peter Taylor	York University
Julian Brimelow	University of Manitoba	Lisa Alexander	York University
Bob Kochtubajda	HAL, EC	Sarah Scriver	York University
Ron Stewart	McGill University	Brian Owsiak	York University
Bill Burrows	CPSWRS / HAL, EC	Kerry Anderson	Can. Forest Service

3. Meeting Presentations and Discussion

Presentations were given by Dr. Geoff Strong, Neil Taylor and Dr. David Sills with content summarized below:

Dr. Geoff Strong, *Thunderstorms and Drought*
Dr. Strong summarized some problems associated with forecasting severe thunderstorms on the Canadian Prairies and work leading up to the development of an UNSTABLE proposal. His discussion included a review of some previous field studies over the region including the Alberta Hail Project (1974-1985) and LIMEX-85 (1985) that focused on severe hail and pre-storm and storm initiation stages of thunderstorm development over the foothills. The presentation concluded with a discussion of a 2002 UNSTABLE Letter of Intent (LOI) submitted to the Canadian Foundation for Climate and Atmospheric Sciences. The LOI was rejected on the basis that the initiative lacked a full-time academic principal investigator and strong research team (Dr. Strong is an adjunct professor at the University of Alberta).

Neil Taylor, *UNSTABLE from the HAL Perspective*
A summary was provided of a planning meeting that was held in Winnipeg at the Prairie Storm Prediction Centre in April, 2002. Discussions at that meeting included the CFCAS LOI, presentations describing science gaps associated with severe thunderstorms on the Canadian Prairies, refinement of the UNSTABLE objectives and some formulation of short- and long-term plans to facilitate an improvement in understanding and forecasting of severe thunderstorms on the prairies. Following a review of the UNSTABLE objectives, the presentation outlined a proposed project area (see section 4.1 of this report) and anticipated data collection platforms (see section 4.2 of this report) for the UNSTABLE 2008 pilot. The presentation concluded with a summary of HAL commitments to the UNSTABLE project and a proposal for a workshop in fall 2006.

Dr. David Sills, *UNSTABLE from the MRD Perspective*
Dr. Sills began by summarizing the ELBOW (Effects of Lake Breezes On Weather) 1997 pilot and 2001 experiment and lessons learned from them. One of the underlying statements was that good results and solid scientific research can come from a limited pilot project (in the case of ELBOW 97, field work and modeling efforts led to the successful completion of two Ph.D. degrees at York University). The presentation then touched on the scope of the UNSTABLE pilot and expected contributions from CPSWRS. Dr. Sills concluded with a brief discussion of funding strategies for the larger-scale UNSTABLE experiment in 2009 or 2010.

Following the presentations there were informal discussions among the group, some interesting points / issues raised included the following:

- Cloud photography and manual observations should be included in the data collection during the field campaign(s)
- Will likely have to use intensive observation periods for a shorter period of time (e.g., 2 weeks) during July 2008. Could there be people on standby for the remainder of the month? Logistical details need to be worked out.
- A dedicated logistics person is a necessity for success in coordinating the field campaign
- Expansion of GEM LAM BC window this summer will provide an opportunity to assess the skill / utility of GEM LAM for resolving AB convection and boundary-layer moisture on a day-to-day basis
- Leading up to the field project we should be re-running some historical cases using GEM LAM (something to consider this fall)
- A grad student at York University may be interested in applying slope wind research to the UNSTABLE problem in the next year or two
- Dr. Sills should explore the possibility of finding a post-doctoral fellow with which to work
- Feedback from the project needs to get back to model developers for future GEM LAM improvements
- Could the WMI radar site be used as a logistics headquarters during the field campaign? WMI is interested in supporting the project but to what extent has not been determined (radiosonde site likely)
- NWS could be contacted regarding participation in forecast support
- If MSC is investigating alternative technology to supplement the upper air network UNSTABLE would be a good opportunity to test equipment (against radiosonde data)
- A radiosonde launch site should be located east of Calgary to capture BL moisture changes due to advection (though it is not necessary for the mesonet to extend that far)
- Results and knowledge gained from UNSTABLE should be extended to the rest of the prairies to the extent possible
- Calgary should be included in the general project area due to population and potential funding sources – especially with respect to storm evolution and track research (i.e., storms may initiate elsewhere but track near Calgary)
- Are there going to be purchases of equipment for Vancouver 2010 that could be made available for UNSTABLE?
- An effort should be made to drum up media interest and exposure for both the pilot in 2008 and the large-scale experiment in 2009 or 2010
- Involvement by Severe Weather National Lab needs to be considered (contact Viateur Turcotte)

4. UNSTABLE 2008 Pilot Project

The main focus of the meeting was on the UNSTABLE pilot planned for 2008. With that in mind some details for a proposed project area and data collection platforms are included below.

4.1 Proposed Project Area

Some climatological data were presented at the meeting (Taylor) that suggested an area along the foothills west of 115˚W is a common convective initiation region. Figure 1 shows the 1998 – 2005 days with lightning and flash density over the Alberta foothills. The majority of both lightning days and flash density occurred near or west of 115˚W. This area corresponds with a well-known genesis region for Alberta thunderstorms. If processes leading to convective initiation are a main focus of UNSTABLE then this area should be included in a potential project area.

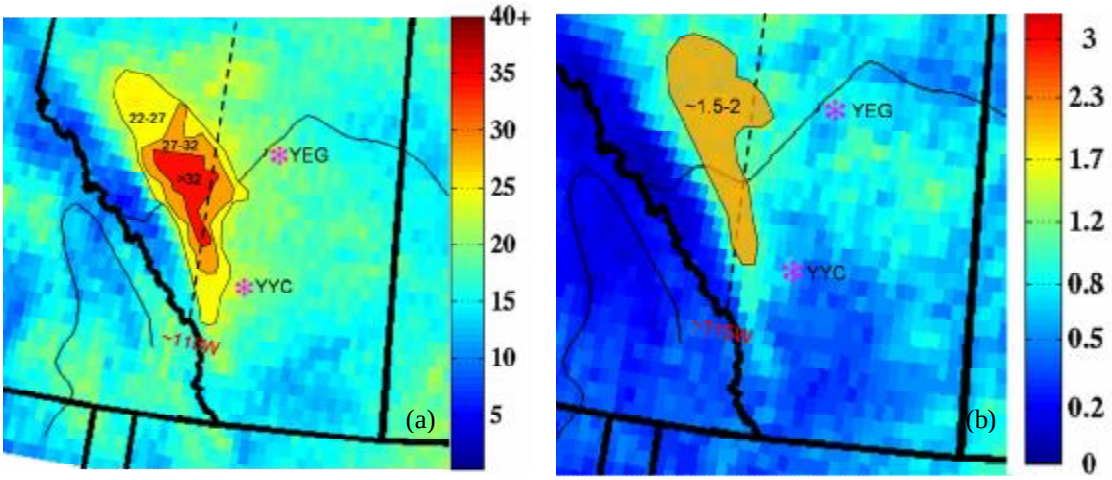

Figure 1: (a) Number of days with at least one cloud–cloud or cloud–ground lightning strike and (b) mean lightning flash density [average number flashes per year per km] from 1998 to 2005 using data from the Canadian Lightning Detection Network (Burrows 2005 – personal communication).

Contrary to the lightning data, most of the severe hail and tornado reports are received from locations east of 115˚W. With little doubt this result is heavily biased by the lack of population and infrastructure west of 115˚W. However, the argument can be made that it takes time for storms to produce severe weather so that, even if they develop further west, severe weather production could be limited to some time after the storms have propagated further east. Figure 2 shows locations of hail reports having diameter larger than 18mm and hail day frequency from the Alberta Hail Studies Project (Wojtiw 1975).

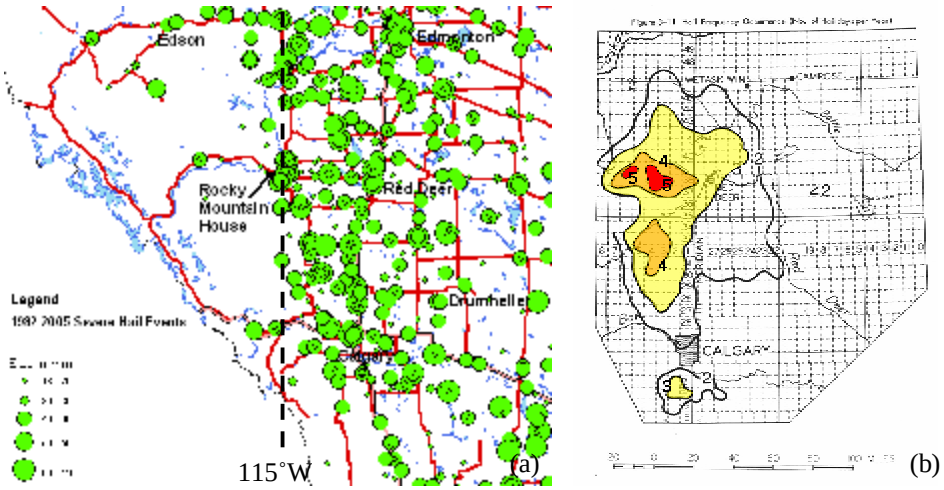

Figure 2: (a) Locations of hail reports with diameter of at least 18mm received by the Meteorological Service of Canada for the period 1982 to 2005 and (b) Hail occurrence (average number of days per year) during the period 1957-1973 as determined during the Alberta Hail Studies Project (Wojtiw 1975).

Figure 2a shows a varied distribution of ≥ 18mm hail reports (almost all of which are east of 115˚W) and hints at a higher density of large hail reports (e.g., > 40mm) in the region bounded to the north and south by the Red Deer to Rocky Mountain House corridor and Calgary, respectively. From the data collected during the Alberta Hail Studies (ALHAS) project the highest concentration of hail days was in a similar area along an axis from west of Red Deer to just north of Calgary.

Anderson (2004) has compiled the most complete climatology of reported tornadoes across the Canadian Prairies. Figure 3 shows the locations of reported tornadoes from the period 1828-

2004, with the inset enlargement highlighting the Edmonton to Calgary corridor and corresponding foothills region.

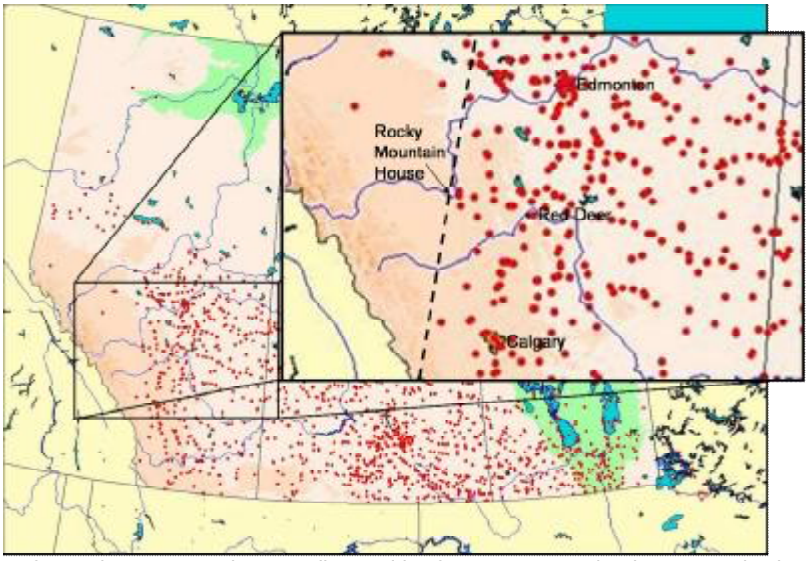

Figure 3: Locations of tornado reports on the Canadian Prairies from 1828-2004 (Anderson 2004). The dashed line on the inset enlargement approximates 115˚W.

Based partly on the material in the previous figures, a project area for mesonet stations and upper air sounding locations is proposed that straddles 115˚W and includes the southern portion of the thunderstorm initiation area as indicated by the lightning climatology data. This project area was selected to exploit existing surface stations and to capture a common thunderstorm initiation area that often results in severe weather within the Red Deer to Calgary corridor.

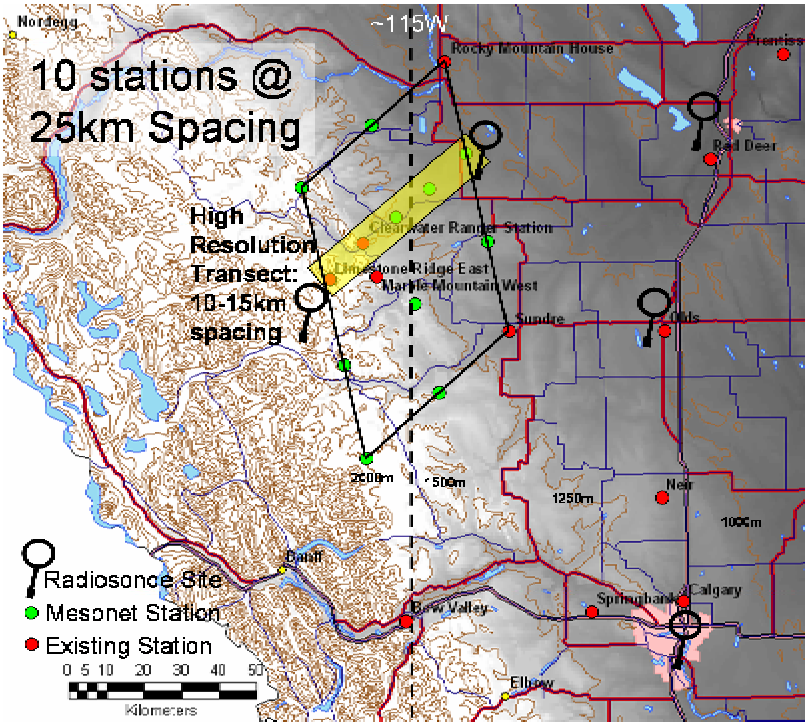

Figure 4: A proposed project area for the UNSTABLE 2008 pilot project. The mesonet configuration takes advantage of existing real-time observation stations and requires only 10 stations to be made available for the project. Radiosonde sites are included but their actual expected locations have not been determined. Not included are other data collection platforms that are anticipated for the project (see section 4.2 of this report).

The station spacing in figure 4 is ~25km but to determine what information can be obtained with greater spatial resolution the configuration includes a high resolution transect with 10-15km spacing. This transect takes advantage of existing stations operated by the Climate Research Branch of MSC as part of the Foothills Orographic Precipitation EXperiment (FOPEX). Data from this transect will aid in resolving the progression of drylines or other mesoscale boundaries through the project area and could be used in conjunction with aircraft measurements to produce high resolution, two-dimensional cross-sections of mesoscale boundaries and associated processes. It is anticipated that a number of radiosonde launch sites will be part of the UNSTABLE 2008 pilot. The locations of these sites in the map are only approximate, their actual locations have not yet been determined. It is also anticipated that at least one mobile data collection platform (temperature, humidity, pressure, wind speed and direction) will be available for high resolution transects across moisture, or other, boundaries within the project area. The locating of suitable sites for the mesonet stations will be a significant challenge due to terrain and tree cover over the Alberta foothills. It is expected that preliminary site investigations will commence as early as fall 2006.

Figure 5: Mobile data collection platform purchased by the Cloud Physics and Severe Weather Research Seciton of Environment Canada. The equipment is designed to be mounted using a standard roof rack.

4.2 Data Collection Platforms

The scope of the UNSTABLE 2008 pilot will depend, to a large extent, on the contributions of participants in the form of funding, instruments, students, etc. The Hydrometeorology and Arctic Lab (HAL) has committed to purchase expendables for a number of radiosonde releases during the pilot project as well as a significant portion of time from HAL staff (including students). The Cloud Physics and Weather Research Section of Environment Canada has committed at least 7 mesonet stations, the potential for additional instrumentation, and the time of Dr. David Sills to co-lead the project. The table below summarizes the status of various data collection platforms in terms of being available (there has been confirmation on their availability), anticipated (there has been a commitment by the owner to make them available), or desired (we are seeking availability for the pilot in 2008). At the current time we are exploring the availability of additional instruments not included in the table.

Notes:

- Table 1 highlights data collection platforms not currently in place. Remote sensing data available to MSC storm prediction centres has not been included in the table as these data will be available for the project via the Prairie and Arctic Storm Prediction Centre (e.g., satellite imagery, lightning data, existing surface observations, AMDAR temperature and wind profiles).

- There is a small chance that a portable x-band radar could be made available for UNSTABLE; otherwise radar data has not been included in the table (radar data from WMI is anticipated – at least for operational support).
- We will pursue the possibility of incorporating flux tower and soil measurements into the pilot since these should definitely be part of the large-scale experiment

Table 1: Available, anticipated, and desired data collection platforms for the UNSTABLE 2008 pilot experiment.

Parameter(s)	Platform	Owner	Details	Availability
Surface Measurements				
SFC T, T_d, Wind, P, PCPN, RAD, ΔT (9.5m-0.5m)	7x ATMOS mesonet stations	CPSWRS (Sills)	3 stations being tested summer '06	AVAILABLE
SFC T, T_d, Wind, P, PCPN	AUTO Wx Station	MSC Tech. Services	Emergency portable station	AVAILABLE
SFC T, T_d, Wind, P, PCPN	AUTO Wx Station	U of M (Hanesiak)	Planned as part of instrument trailer	ANTICIPATED
SFC T, T_d, Wind, P, PCPN, RAD, ΔT (9.5m-0.5m)	3-5x ATMOS mesonet stations	York U (Taylor)		ANTICIPATED
SFC T, T_d, Wind, P, PCPN, RAD, ΔT (9.5m-0.5m)	3x ATMOS mesonet stations	CPSWRS (Sills)	Request submitted to purchase	DESIRED
Vertical Profiles of Atmospheric Parameters				
T, RH, P, Wind	Radiosonde (Vaisala RS92 GPS Sondes)	MSC Tech. Services	Need to provide expendables	AVAILABLE
T, RH, P, Wind	Radiosonde (Vaisala RS92 GPS Sondes)	MSC CRB	Need to provide expendables	AVAILABLE
T, RH, P, Wind	Radiosonde (Vaisala RS92 GPS Sondes)	WMI (Krauss)	Need to provide expendables	ANTICIPATED
T, RH, P, Wind	Radiosonde (Vaisala RS92 GPS Sondes)	U of M (Hanesiak)	Need to provide expendables	ANTICIPATED
T, RH, P, Wind	Radiosonde (Vaisala RS92 GPS Sondes)	CPSWRS (Sills)	Need to provide expendables	ANTICIPATED
T, RH in lowest 3-4km	Atmospheric Emitted Radiance Interferometer (AERI)	U of M (Hanesiak)	Being tested against soundings August 2006	ANTICIPATED
T, Wind lowest 3.5km	Doppler Sodar	U of M (Hanesiak)	Being tested against soundings August 2006	ANTICIPATED
Wind, T_v	UHF Wind Profiler / RASS	CPSWRS (Donaldson)		ANTICIPATED
T, RH, liquid H_2O, integrated water	TP/WVP-3000 Radiometer	CPSWRS (Strapp)	Unlikely for pilot	DESIRED
T, RH, liquid H_2O, integrated water	TP/WVP-3000 Radiometer	U of M (Hanesiak)	Considering Purchase	DESIRED
T, RH, P, Wind below 1km	Vaisala Tethersonde	HAL/MSC	Investigating Purchase	DESIRED
T, RH	Radiometer	U of C (Skone)	Unsure of availability	DESIRED
T, RH, Wind, P	Cessna or other aircraft or UAV	CPSWRS	Unsure of availability	DESIRED
Precipitable Water				
	Atmospheric Microwave Radiometer (AMR)	U of M (Hanesiak)	Being tested against soundings August 2006	ANTICIPATED
	GPS Sensors	U of C (Skone)	Funding required for students	DESIRED

T – Temperature
T_d – Dew point temperature
P – Pressure
RH – Relative Humidity

CPSWRS – Cloud Physics and Severe Weather Research Section, EC
MSC – Meteorological Service of Canada
CRB – Climate Research Branch

U of M – University of Manitoba
U of C – University of Calgary
WMI – Weather Modification Incorporated

4.3 Next Steps

The HAL is planning to host a science workshop to be held in the fall of 2006 (location to be determined). Participants will be invited to give presentations on their specific areas of interest in the UNSTABLE project and their anticipated contributions and level of participation. A series of open forum / break-out discussions will be planned to address outstanding issues such as the following:

- Funding strategies for the pilot and large-scale UNSTABLE experiment in 2009 or 2010
- Refinement of the project area and time frame for both the pilot and large-scale experiment
- Incorporation of high resolution modeling into the project
- Logistical details with respect to deploying radiosondes, travel and accommodation for students, communication in the field, etc.

The meeting at the 40th CMOS Congress was a good first step in ensuring the UNSTABLE 2008 pilot project goes ahead. Response from the group and ensuing discussions were favourable. The intended underlying message to the group was that there is a commitment from Environment Canada to go ahead with a pilot project in 2008 even if it includes only a few data platforms and participants. Given the level of interest by those at the meeting we are optimistic that even the pilot project will provide an opportunity to collect some quality data for research. This work will help improve our understanding of boundary-layer processes leading to severe thunderstorm development on the Canadian Prairies and lead to improvements in the accuracy and lead time of severe weather watches and warnings.

5. References

Anderson, J., 2004: The Prairie and Arctic Storm Prediction Centre (PASPC) Tornado Database. Presented at the 2004 PASPC Change of Season Workshop, Winnipeg, Manitoba.

Wojtiw, L., 1975: Climatic summaries of hailfall in central Alberta (1957-1973). Alberta Research Council, Edmonton, Alberta, Atmos. Sci. Rep. 75-1, 102pp.

6. Contacts

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