Analyzing Precipitation on the Canadian Prairies During a Recent Drought: 1999-2004

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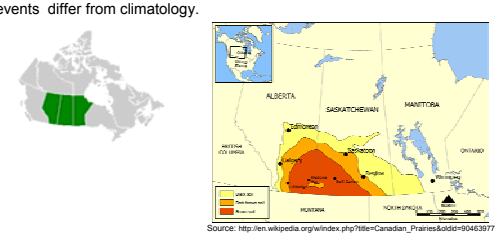
1. Background and Objective

Drought is a recurring feature of the climate over the Canadian Prairies, the most recent event occurring from 1999-2005. This drought had a catastrophic effect on the agricultural industry in Western Canada and subsequently the GDP of the entire country was significantly reduced. As a result, this drought has been touted as one of the costliest natural disasters in Canadian history (Environment Canada, 2003).

The objective of this study is to better characterize the precipitation that occurred during this drought and eventually to better understand how these events differ from climatology.



Source: http://en.wikipedia.org/w/index.php?title=Canadian_Prairies&oldid=90463977

Figure 1: *Map of the Canadian Prairie Provinces with the Palliser Triangle region shown, including our study locations: Calgary, Edmonton and Saskatoon.*

2. Data and Study Focus

- Amount–corrected daily total precipitation was obtained from Environment Canada (see Mekis and Hogg, 1999).
- Archived raw radar data was acquired from Environment Canada's Winnipeg office.
- METAR data was accessed via the U.S. National Severe Storms Laboratory
- Time-height cross sections were constructed using the North American Regional Reanalysis

Focus: The study is currently based on three locations: Calgary, Edmonton and Saskatoon (**Figure 1**). Radar analysis for Calgary is displayed to demonstrate its use as a tool for the identification of the type of precipitation events occurring (convective/stratiform) and for the possible identification of virga, which may be more prevalent during drought conditions.

5. Conclusions

Precipitation Characterization:

- The seasonal precipitation record shows near continuous deficits during the 2001-2002 period at all three stations. The cumulative effects of these deficits resulted in the progression from a meteorological drought to a socio-economic drought.
- Climatologically, low-accumulation precipitation events are an important source of moisture on the Canadian Prairies. During this drought, low-accumulation events remained important, accounting for an even greater majority of precipitation received.

Radar Analysis:

- Stratiform precipitation occurs during strong dynamic forcing for ascent, however only 2 cases occur during the summer of 2002 at Calgary.
- Convection is observed both pre- and post- (cold) front passage. There appears to be a preponderance of post-frontal events during this period suggesting lower available values of precipitable water, and consequently lower precipitation intensities.
- Preliminary event analysis indicates that virga occurs mainly in the following situations:
  - ➢ High ceilings and a relatively dry boundary layer: ascent in this situation may not result in precipitation reaching the surface.
  - ➢ Precipitation falling during cold air advection: forcing for descent may cause precipitation not to reach the surface even with relatively low ceiling heights and higher boundary layer humidity.

6. Acknowledgements and References

We would like to thank Éva Mekis (Environment Canada) for providing the amount-corrected precipitation data, and Dave Patrick (Environment Canada) for assisting with the archived radar data acquisition. Additionally, we would like to acknowledge the support of the CFCAS for this research.

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3. Precipitation Characterization

I. Annual Total Precipitation Amount

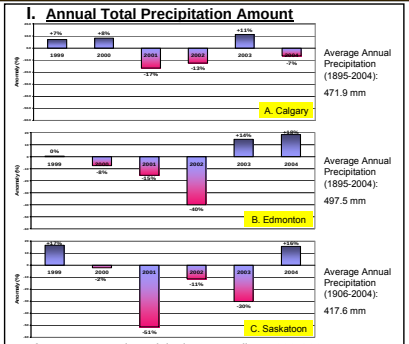


Figure 2: *Annual precipitation anomalies, 1999-2004*

When annual precipitation amounts are plotted, it becomes clear that there are both spatial and temporal variations during the drought. **Figure 2** indicates that drought was the most widespread during 2001 and 2002, with annual precipitation deficiencies occurring at all three locations. In fact, 2001 was a record breaking dry year: in Saskatoon it was the driest year on record by ~30% and in Edmonton it was the second driest year on record.

II. Seasonal Total Precipitation Amount

Classifying precipitation amount by season, we can see more clearly the patterns of positive and negative anomalies, as shown in **Figure 3**. Note that each location exhibits several consecutive seasons with below normal precipitation, particularly during the 2001-2002 period. While individual anomalies are not necessarily large, there was a building cumulative effect over these drier than normal seasons.

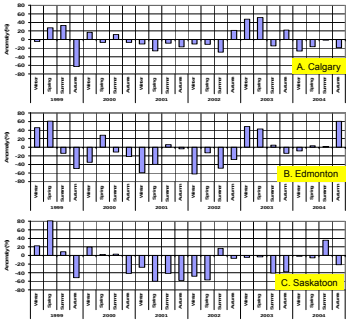


Figure 3: *Seasonal precipitation anomalies, 1999-2004*

III. Daily Total Precipitation Distribution at Calgary

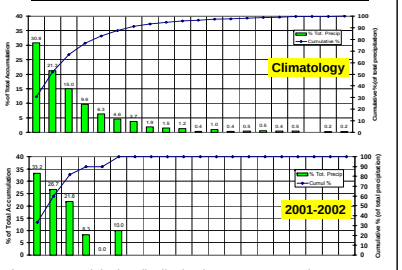
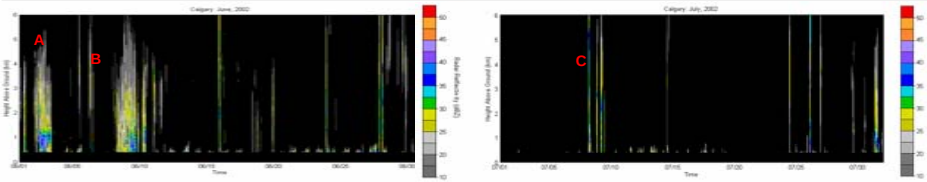


Figure 4: *Precipitation distribution by amount categories*

To analyze precipitation amount distributions, categories were defined using 5 mm increments. The daily total precipitation amounts were then sorted into these bins and plotted to show the distribution and relative contribution (%) of each bin to the total precipitation. As seen above, the low-accumulation events (defined as ≤ 10 mm) make a large contribution to the total precipitation in both cases. However, these events account for a greater proportion of the total precipitation during the height of the drought in Calgary in 2001 and 2002 (**Figure 4**).

4. Precipitation Event Analyses at Calgary



Radar reflectivities for June and July 2002 at Calgary. Event markers A, B and C refer to the cases analyzed in greater detail below. Event A is representative of stratiform precipitation, Event B is representative of virga and Event C is convective in nature. Stratiform events are characterized by broad reflectivities, whereas convective events appear as narrower, but deeper reflectivites that extend through the column. In general, Virga is associated with elevated reflectivities that are disconnected from the surface.

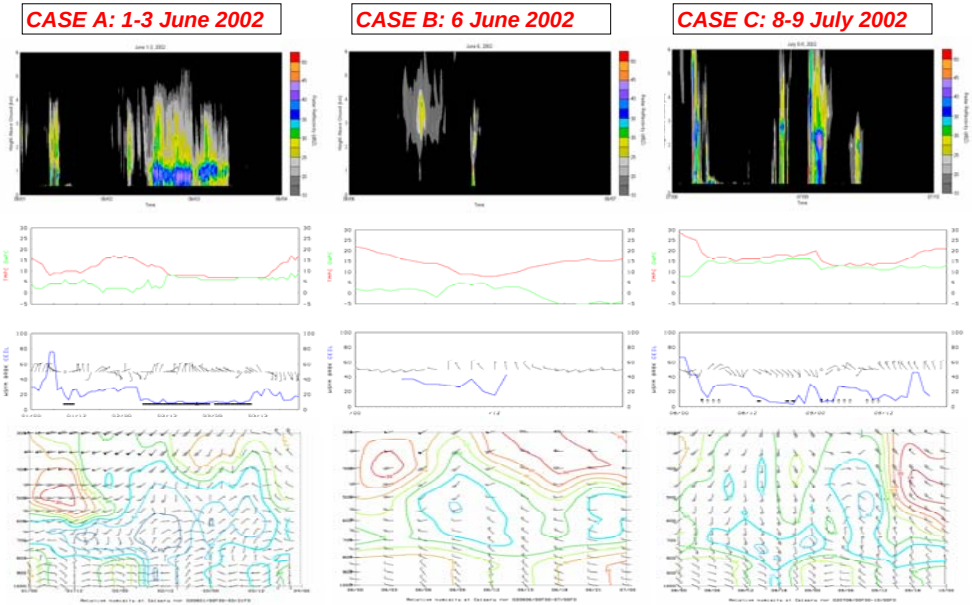
Description of figures for Calgary Events:

Top panel: Time-height cross section of radar reflectivities.

Middle panel: Time-series of METAR observations. Red line: temperature (°C); green line: dewpoint temperature (°C); blue line: ceiling height (m*100) for broken or overcast conditions only. Wind barbs (knots) and weather symbols are in black.

Lower Panel: Time-height cross section of relative humidity (%) and winds.

CASE A: 1-3 June 2002 | **CASE B: 6 June 2002** | **CASE C: 8-9 July 2002**



Case A:

- ***Stratiform*** event resulting in 29.3 mm of rain
- Precipitation preceded by an extended period of warm air advection.
- Initially, boundary layer is not saturated, resulting in highest reflectivities residing at >1 km above ground level (agl).
- Ceilings lower dramatically around 05 UTC 2 June concomitant with boundary layer saturation followed by 24 hours of steady rain. At this time the most intense radar reflectivities lower to < 1 km agl.
- Precipitation ends as upper level trough (500 hPa-not shown) passes to the east.

Case B:

- ***Virga*** event characterized by high ceilings and a relatively dry boundary layer initially.
- Highest reflectivities are confined to 3-4 km agl. Ceilings lower and boundary layer moistens around 11 UTC 6 June, but this occurs during a period of cold air advection implying forcing for descent.
- Result is no precipitation being observed at the surface.

Case C:

- ***Convective*** event.
- Convection is reported twice during this event at 03 UTC 8 July and again at 01 UTC 9 July.
- First report of thunder is associated with warm air advection ahead of a warm front.
- Second report occurs just ahead of a pre-frontal trough.
- During these times radar reflectivities show values greater than 20 dBZ extending from near the surface to 6 km agl.
- Precipitable water (PW) plots (not shown) indicate a ridge of high PW's stretching from the Gulf Coast north into southern Alberta.