Monitoring and Assessing Drought and Drought Impacts in Canada

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North American Drought Monitor Forum
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Presentation Outline

- The National Agroclimate Information Service
- Challenges in Drought Monitoring in Canada
- Advances in Canadian Monitoring Activities
  - The Canadian Drought Monitor
  - Network Density / Accessing Additional Data Networks
  - Monitoring in the Northern (Forested) Regions of Canada
  - Use of Remote Sensing
  - The Agroclimate Impact Monitoring Network and the Agroclimate Impact Reporter (AIR)
NAIS has the majority of climate expertise within AAFC …

- Develops and integrates agro-climate expertise
  - from research to policy to operational
- Works with a wide range of partners
  - ag sector, within AAFC, OGDs, provincial government, academia, private sector
- Provides information and tools to manage risks under climate variability now and in the future.
  - Monitoring weather and agroclimate impacts
  - Developing adaptation tools for risk management and decision support.

Monitoring of extreme weather and climate is increasingly important to agriculture, and the incidence of extreme weather is expected to increase.
Focus is climate-related risks to agriculture ...

1. **Assess climate-related risks to the agriculture industry**
   - Timely Climate Monitoring at National & Regional Scale

2. **Improve adaptation to climate-related risks**
   - Yield forecasting
   - Drought preparedness and planning
   - Vulnerability of systems to climate variability (e.g. watersheds)

3. **Data acquisition, development, web applications and web based delivery**
   - Help to identify probabilities, frequencies and potential changes in climate trends and extreme event patterns
   - Improved usage of remote sensing and other related information to assist in monitoring

4. **Analysis to support climate change adaptation**
   - Support to policy
Agroclimate Monitoring

- NAIS collects climate data from a variety of national, provincial and local networks from across the country and provide information products on a daily basis.

Products include:
- Seasonal and Annual Products
- Rolling Time Frames for various precipitation indicators (7-day out to 1 year)
- Dry Spell indicators:
  - 7, 14, 30, 60… days with < 0.5 mm
  - Consecutive days with < 0.5 mm
- Temperature
  - Max/Min temperature over 7-days
  - Heat waves
- Growing Degree Days (Base 0, 5, 10, and 15)
- Corn Heat Units

Over 500 maps produced every weekday

www.agr.gc.ca/drought
Canada’s Involvement in NADM

- Initially Canada was only assessing the agricultural areas and only in English (2002).
- Added northern regions of the prairies in the spring of 2004.
- Later in 2004 Areas outside the agricultural regions were added for other part of the Canadian Provinces.
- We have still not added the northern territories.
Challenges for Drought Monitoring in Canada

- Canadian environment is complex and drought indices need to be utilized in a way that reflects the regional differences.

- Quality and quantity of data is poor/incomplete. Data density and length of record are both significant challenges.

- Winter often puts a hold on drought impacts but not necessarily the drought. Indices/indicators do not account for this.

- Snow is hard to measure, it tends to move around before the moisture is accessible (Blowing, runoff, sublimation).

- There is also limited climate data and other drought information during the winter season.
The Canadian Drought Monitor

- In 2009, we experimented with the development of a Canadian Drought Monitor in conjunction with our work with the NADM as a proof of concept.
The Goals of the Can-DM were to:

- Allow AAFC to continue to report on Canadian specific drought concerns while still maintaining the Drought Monitor concepts and process,
- Provided the opportunity to introduce the drought monitor concept to a Canadian audience; increasing the use and exposure of the monitors,
- Allow AAFC to produce detailed information packages targeted to Canada with an emphasis on the Agriculture.
Results of Developing the Can-DM

• Very positive reaction, even though in the past couple years Canada has not experience significant widespread drought.
  – The Canadian version of the Drought Monitor is appearing in provincial and regional documents and reports, as well as limited interest from the media.
  – Provincial agencies have become more involved

• Up until now we have not had the ability to post this material to our website which has hampered our ability to reach more of an audience.

• We will be developing a website in the near future to host this information.
Can-DM is used as part of a suite of indicators for the assessment of the Prescribed Drought Regions for Livestock Tax Deferral.
2010-11 Pasture Recovery Program

- The Canadian Drought Monitor was used to develop an emergency assistance program for cattle producers who were being significantly affected by long term drought conditions.

<table>
<thead>
<tr>
<th>Province</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>Saskatchewan</td>
<td>$16,878,007</td>
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<tr>
<td>Alberta</td>
<td>$67,183,973</td>
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</table>
Distribution of Our Real Time Data Network

Near Real Time Network

SK Env

AARD

MB Ag
Exploring Commercially Available Data

WeatherFarm

Weather Innovations
CoCoRaHS is a pilot in Manitoba in 2012 ...

The Community Collaborative Rain, Hail and Snow Network is a national grassroots community based high density precipitation network across the United States, and now Canada.

www.cocorahs.org/
Obvious Differences in Coverage
Improve Density Without Destroying Integrity

• Gap filling must continue to be employed
  – Use data from one or more neighbour stations to assist
• Cluster approach - adjust method to create a pool of contributors for a small region (e.g. 5 to 10km radius)
• Use 10km gridded dataset to fill in a limited amount of historical information in order to keep stations alive
Current SPI and PDSI Maps

6-Month Standardized Precipitation Index (SPI)
March 2012

Palmer Drought Index (Drought Model)
March 2012
Canada’s Forests are Not Well Represented in the National and International Drought Products

Monitoring Outside the Agricultural Extent

Drought Watch (AAFC)
Monitoring Outside the Agricultural Extent

- Lack of accessible station data in northern regions.
- Lack the understanding of drought assessment and drought issues in northern areas (north of the tree line).
- Remote sensing may be able to assist in some regions.
- Research is ongoing on how to address these issues. Including the development of relative indicators for northern regions.
Developing Indicators for Forested Regions

- The Canadian Forest Service currently uses absolute indicators for drought monitoring specifically for forest fire applications.
- Relative indicators are being developed using Climate Moisture Index and the Fire Weather Drought Code (moisture deficit accounting indicator).
- Work has begun on creating a Relative indicator for the Drought Code using our percentile classes.
The Drought of 2001-2002 Impacted Forests

• Worst drought in >80 years across a large area of AB & SK
• Led to massive mortality of aspen forests
• Conifers and urban forests also affected

Drought-caused dieback resembling fire effects

Aerial view of mortality in the parkland (2004)

Drought-damaged aspen leaves (2002)

Drought-affected area showing severe dieback of aspen forests
Climate Moisture Index (CMI)


- Suitable for assessing spatial variation in annual moisture conditions relevant to forest responses.
  Showed severity & extent of the 2001-02 drought in the area where massive aspen mortality was recorded.

ANUSPLIN interpolation of CMI by D.T. Price, M. Siltanen & D. McKenney
Standardizing “absolute indicators”

Example using CMI for Edmonton

\[
\text{CMI} = P - \text{PET}
\]
(units in cm/year)

Period: 1951-2009
mean CMI = -1.8
SD of CMI = 9.9

Original CMI (absolute indicator) → Standardized CMI (relative indicator)

Climate Moisture Index
for Edmonton city centre

<table>
<thead>
<tr>
<th>Year</th>
<th>Climate Moisture Index (cm/year)</th>
</tr>
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<tbody>
<tr>
<td>1950</td>
<td>-40</td>
</tr>
<tr>
<td>1960</td>
<td>-30</td>
</tr>
<tr>
<td>1970</td>
<td>-20</td>
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<td>1990</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>10</td>
</tr>
<tr>
<td>2010</td>
<td>20</td>
</tr>
</tbody>
</table>

Standardized Climate Moisture Index
for Edmonton city centre

<table>
<thead>
<tr>
<th>Year</th>
<th>Standardized CMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>-3</td>
</tr>
<tr>
<td>1960</td>
<td>-2</td>
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<tr>
<td>1970</td>
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<tr>
<td>2000</td>
<td>2</td>
</tr>
<tr>
<td>2010</td>
<td>3</td>
</tr>
</tbody>
</table>
Drought Code Example - September 30, 2009

The map shows the drought conditions across Canada and the United States on September 30, 2009. The intensity codes represent different levels of drought severity:

- **D0 Abnormally Dry**
- **D1 Drought - Moderate**
- **D2 Drought - Severe**
- **D3 Drought - Extreme**
- **D4 Drought - Exceptional**

Intensities are shaded in yellow, orange, red, and dark red, respectively. The map also includes symbols indicating drought impact types:

- **A** = Agriculture
- **H** = Hydrological (Water)

The map highlights areas affected by each level of drought, with specific codes (e.g., D0, D1, D2-D3) indicating the severity and extent of the drought conditions.
Drought Code Example - September 30, 2010
Developing Blended Indicators

- Canada will be attempting to develop Blended Indicators.

- This will allow us to operationally Integrate multiple indicators in a weekly or monthly update using a percentile ranking method.

- This is not an easy task:
  - Convert all our data types to percentiles
  - Determine the appropriate blend or more likely blends
  - Data history may be an issue. Would need serially complete data, so could not be computed on station data

**Short-Term Blend**
- 35% Palmer Z Index
- 25% 3-Month Precip.
- 20% 1-Month Precip.
- 13% CPC Soil Model
- 7% Palmer Drought Index

**Long-Term Blend**
- 25% Palmer Hydro. Index
- 20% 24-Month Precip.
- 20% 12-Month Precip.
- 15% 6-Month Precip.
- 10% 60-Month Precip.
- 10% CPC Soil Model
Challenges Using Just Climate Records

• Often making drought assessments on climate data alone does represent reality, therefore we frequently use other sources of information such as remote sensing and drought impact reports.

• It is often more important to know the consequences resulting from drought than the climatic details.
Increase Use of Remotely Sensed Data

Near-Real-Time NDVI composite generation from MODIS

Weekly NDVI, AVHRR Data

Weekly NRT surface wetness and surface temperature anomaly data from passive microwave data
SMOS - Weekly Satellite Soil Moisture Estimates

SMOS Satellite Surface Soil Moisture (National)
Week 14 (April 2 - April 8), 2012

Surface Soil Moisture
- < 5%
- 5 - 10%
- 10 - 15%
- 15 - 20%
- 20 - 25%
- 25 - 30%
- 30 - 35%
- 35 - 40%
- 40 - 45%
- 45 - 50%
- > 50%

This map represents the volumetric soil moisture for the surface layer (~6 cm), averaged for the week. The map is produced from passive microwave satellite data collected by the Soil Moisture and Ocean Salinity (SMOS) satellite and converted to soil moisture using version 6 of the SMOS soil moisture processor and gridded to a resolution of 30 kilometres.

Prepared by Agri-Culture and Agri-Food Canada's Earth Observation Service

[Map of Canada showing soil moisture levels across different regions]
Prospects of expanding VegDRI over the major agricultural regions of Canada to support Canada`s monitoring ability is promising.

Southern Regions Of Canada Including much of the Agricultural zone is currently included in the geographic coverage of historical satellite data (AVHRR and MODIS NDVI) that has been processed by USGS.
Assessing the Impacts of Drought

- Agriculture and Agri-Food Canada coordinates a network of approximately 350 volunteer farmers in the prairie region, who provide information on the impacts of drought and other extreme weather impacts.

- For over 10 years we have been collecting information on agricultural water supplies, forage supplies and forage productions.
2010 MONTHLY WATER SUPPLY AND FORAGE CONDITIONS MONITORING
PRODUCER QUESTIONNAIRE

DATE: ____________  DUID: ____________

Family name: ____________  Ccn: ____________  Email: ____________

CURRENT POTENTIAL FORAGE PRODUCTION

1. If you are experiencing weather/climate related forage losses on your farm, please indicate the major cause(s). (Check ALL that apply)
   - Drought
   - Flood/Excess moisture
   - Heat
   - Other

2. How does the forage production in your area, at this time of year, compare to the 10-year average?
   - Well below average (less than 50%)
   - Below average (50 to 90%)
   - Average (90 to 110%)
   - Above average (110 to 150%)
   - Well above average (greater than 150%)

FORAGE SUPPLIES

1. Do you anticipate any forage shortages in your area?
   - Forage shortages occurring
   - Forage shortages anticipated

3. In general, how would you rate the price of hay (tame/native) in your area?
   - Below average
   - Average
   - Above average

4. If known, what would you estimate the price to be?  (Please specify the measure provided)

ON FARM SURFACE WATER SUPPLIES

1. What is the average level of the reservoir in your area?
   - Unsatisfactory/Dry
   - 1/4 full
   - 1/2 full
   - 3/4 full
   - Full

2. Do you anticipate any water shortages for your area?
   - Water shortages occurring
   - Water shortages anticipated
   - No water shortages anticipated

EXCESS MOISTURE

1. To what degree has the recent flooding/excessive moisture conditions impacted animal health in your region?
   - Severe
   - Moderate
   - Low
   - None

   a) If you answered "Severe", are wet conditions creating increased incidence or cost of care?
      - Yes
      - No

   b) If you answered "Yes", what is the percentage of increase?
      - Greater than 75%
      - 50 to 75%
      - 25 to 50%
      - Less than 25%

   c) Are wet pasture conditions resulting in increased levels of hoof rot?
      - Yes
      - No

   d) If you answered "Yes", what is the percentage of increase?
      - Greater than 75%
      - 50 to 75%
      - 25 to 50%
      - Less than 25%

3. How wet pasture conditions forced you to re-locate cattle to different forage pastures?
   - Yes
   - No

4. Please comment on any significant damage the recent storms and excessive moisture may have caused.
   (Soil erosion, infrastructure damage (please be specific), well contamination, washout, etc.)

5. What is your best estimate as to the percentage of unseeded acres in your region? ____________ %

6. What is your best estimate as to the percentage of seeded but now flooded acres in your region? ____________ %
We are currently:

- Transitioning to a new resource framework
- Developing a new online data collection tool (Agroclimate Impact Reporter)
- Increasing the density of the volunteer network
- Expanding the geographical scope of the program (Including B.C. in 2012)
- Increasing the value of the information collected.
The Agroclimate Impact Reporter

• The Agroclimate Impact Reporter is being developed in response to the need for a **National Agroclimate Impacts Database** and a tool to collect, manage and display various forms impacts of climate on the agricultural systems throughout Canada.

• The Impact Reporter will provide the ability to collect information from anonymous sources as well as registered users for the assessment of drought, floods and other climate related impacts.
Examples of Output from the AIR System

Point values used to classify Municipalities

Interpolated to provide a complete coverage
Summary

• Canada has made significant steps in developing tools to advance the monitoring drought.
• Increasing the data networks, adjusting the data models, developing indices for northern regions, and increasing the collection of impact information will significantly improve our ability to accurately assess and analyze drought.
• Increasing the profile of the Canadian Drought Monitor has begun to increase partnership and interest in the product. This will only increase the accuracy of the assessments Canada provides to the NADM.
Thank You

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What a difference a year makes…

- One year ago, the Canada was dealing with unprecedented flooding, after record snow fall and spring rain.
- This year we have had one of the driest and warmest winters on record and there is great concern for drought.
6 Month SPI

6-Month Standardized Precipitation Index (SPI)
March 2012

The map may not be accurate for all regions due to data availability and data errors.
Palmer Drought Index

Palmer Drought Index (Drought Model)

March 2012

PDI
- ≤ -5.00
- -4.99 to -4.00
- -3.99 to -3.00
- -2.99 to -2.00
- -1.99 to -1.00
- -0.99 to 0.99
- 1.00 to 1.99
- 2.00 to 2.99
- 3.00 to 3.99
- 4.00 to 4.99
- ≥ 5.00

Extent of Agricultural Land

Produced using near real-time data that has undergone initial quality control. The map may not be accurate for all regions due to data availability and data errors.

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www.agr.gc.ca/drought
Much of Canada has been consistently 5 degrees warmer than normal for the past 4 months.
Long Range Forecasts

3 Month Temperature Forecast

1 Month Precipitation Forecast