



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



Monitoring Soil Moisture in Agricultural Regions using Passive Microwave Satellites

Catherine Champagne

Yinsuo Zhang, Trevor Hadwen, Patrick Cherneski and Andrew Davidson

National Agroclimate Information Service (NAIS)

Agro-Climate, Geomatics & Earth Observation Division,

Science & Technology Branch

Agriculture and Agri-Food Canada

Canada 


 Search

- Programs and Services ▾
- Industry, Markets and Trade ▾
- Science and Innovation ▾
- Help ▾

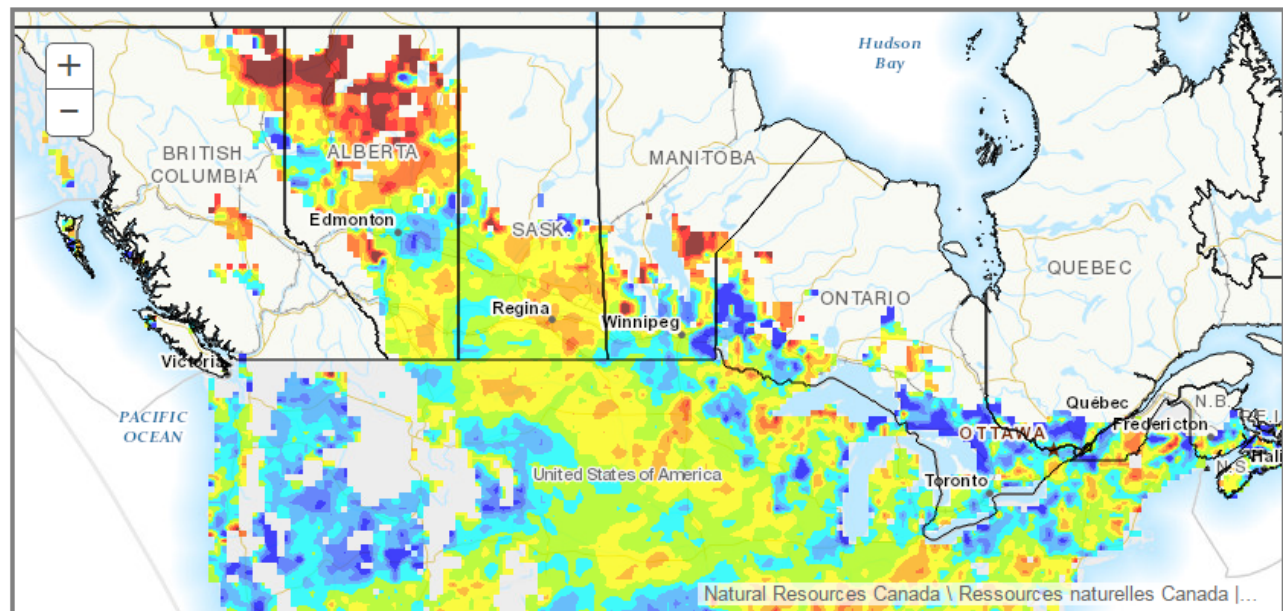
Home → Programs and Services → List of Programs and Services → [Drought Watch](#) → Satellite Soil Moisture

- Drought Watch
- Agroclimate Maps
- Canadian Drought Monitor
- Satellite Soil Moisture**
- Agroclimate Impact Reporter
- Livestock Tax Deferral Provision
- Managing Agroclimate Risk
- Related Links

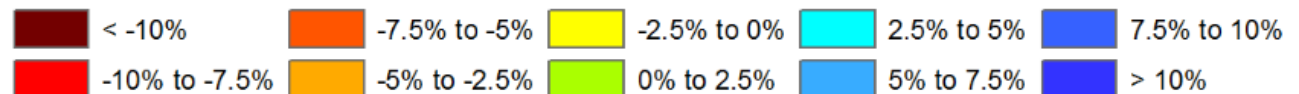
Satellite Soil Moisture

The following maps and data show levels of moisture in the top five centimeters of soil in Canada on a weekly, bi-weekly and monthly basis. These information products highlight where conditions are wetter or drier than normal.

Soil moisture difference from average – interactive map showing data from previous month



Legend:



► Description – Legend

ARL = 7-8

Updated every week!

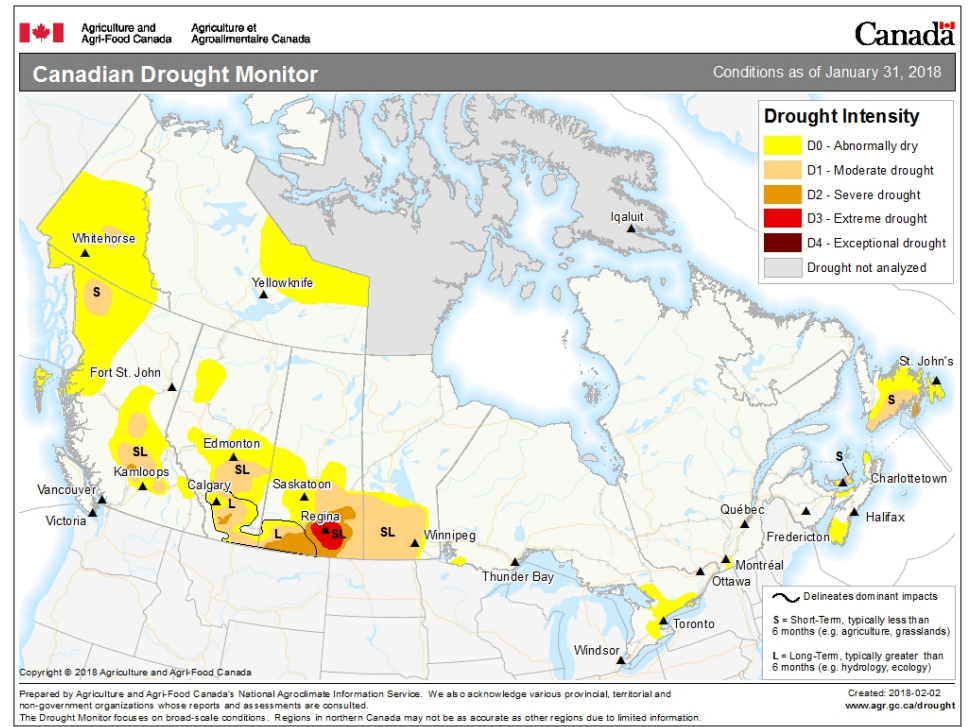
Agricultural Applications of Satellite Soil Moisture at AAFC (Passive Microwave)

- Assessing weather-related risk to agricultural production
 - Predicting crop yields in areas where water stress is a key factor in determining yield
 - Assessing excess moisture impacts for soil trafficability
- Determining the extent and severity of drought

2016 National Dashboard of Agroclimate Risks

Date	BC	AB	SK	MB	ON	QC	ATL
06-Dec	excess moisture, snow	excess moisture, snow	excess moisture	excess moisture			
01-Nov		excess moisture, cool temperatures, snow	excess moisture, cool temperatures	excess moisture	low soil moisture		
04-Oct	excess moisture	excess moisture	excess moisture, frost	excess moisture	low soil moisture	low soil moisture	drought, dry
20-Sep	excess moisture	excess moisture, cool, frost	excess moisture, cool, frost	excess moisture	drought, low soil moisture	low soil moisture	drought, dry
07-Sep		excess moisture, cool temperatures	excess moisture	excess moisture	low soil moisture	low soil moisture	dry
23-Aug	dry, heat	excess moisture, humidity	excess moisture, thunderstorms	excess moisture	low soil moisture	dry	dry
09-Aug		thunderstorms, hail	thunderstorms, excess moisture	excess moisture, wind	drought, heat	heat, drought	drought
26-Jul			excess moisture, thunderstorms	excess moisture, wind	drought	disease	
12-Jul	dry	excess moisture	excess moisture, flooding	excess moisture	drought	low soil moisture	
28-Jun	flooding, dry			excess moisture	dry, low soil moisture	low soil moisture	
14-Jun	dry, low snowpack	low soil moisture		excess moisture			
31-May	dry	low soil moisture			dry	dry	
17-May	dry	drought, wind, wildfire	dry, wildfire				
03-May	dry	drought, wind, wildfire	dry, wildfire				

Green/Yellow/Orange/Red is a continuum of No significant risk to Large or Urgent risk



Production Risk

Drought Monitoring

Global Soil Moisture from Passive Microwave

Soil Moisture and Ocean Salinity Mission (SMOS)

- Launched November 2009, in operation until the present
- L-Band passive microwave sensor
- Produces global ascending/descending soil moisture every 3 days (more frequent towards the poles) ~40km

Soil Moisture Active-Passive Mission (SMAP)

- Launched January 2015, in operation until the present
- L-Band passive microwave sensor + L-Band active microwave sensor (ceased operation in July 2015)
- Produces global ascending/descending soil moisture every 3 days at ~40k + 9km spatially enhanced product

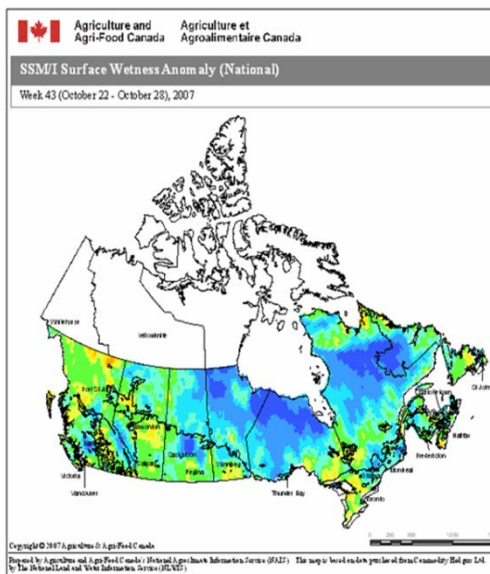
European Space Agency Climate Change Initiative Soil Moisture (ESA-CCI)

- Blend of soil moisture derived from passive and active sensors 1979 – 2016 (SMMR, SSM/I, AMSR-E, TRMM, Windsat, SMOS / ERS, METOP, ASCAT)
- Dataset is updated annually, not currently available for real time monitoring

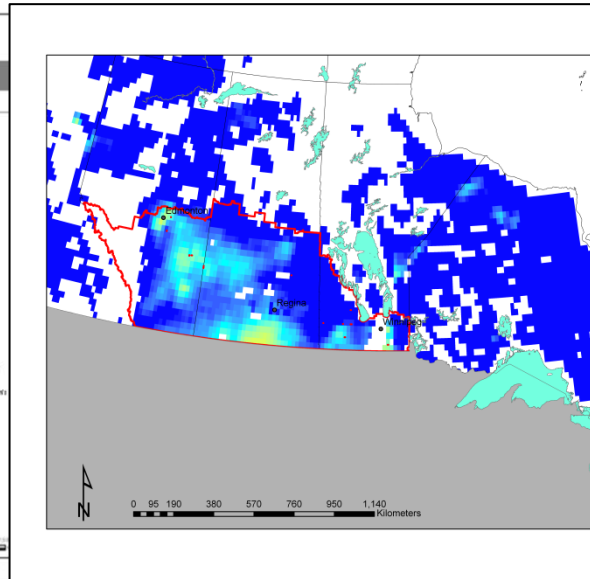
Both SMOS & SMAP have met their mission requirements of 4% volumetric soil moisture accuracy; improvements to retrieval models are ongoing to solve for higher errors in specific regions

Where does satellite soil moisture fit it?

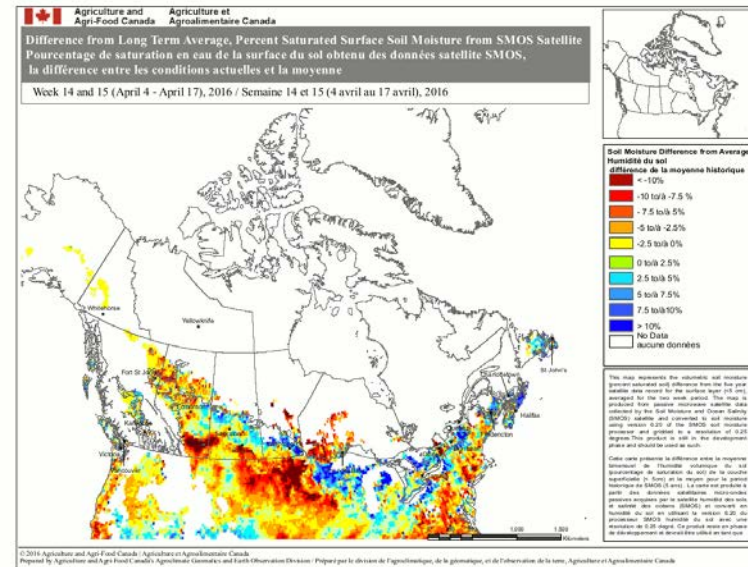
- Satellite soil moisture quantifies surface moisture, so when used directly to assess moisture availability for agriculture, it provides a 'wetness index' for the surface that accounts for differences in soil water holding capacity
- Simple difference from long term average provides a fairly robust indicator of moisture extremes



SSM/I Water Index



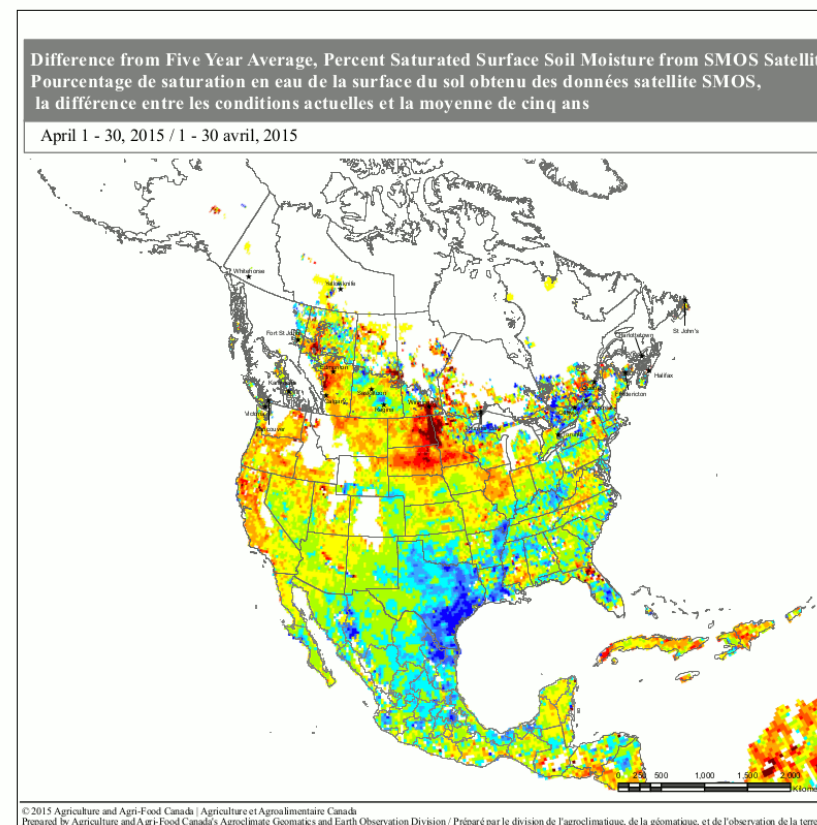
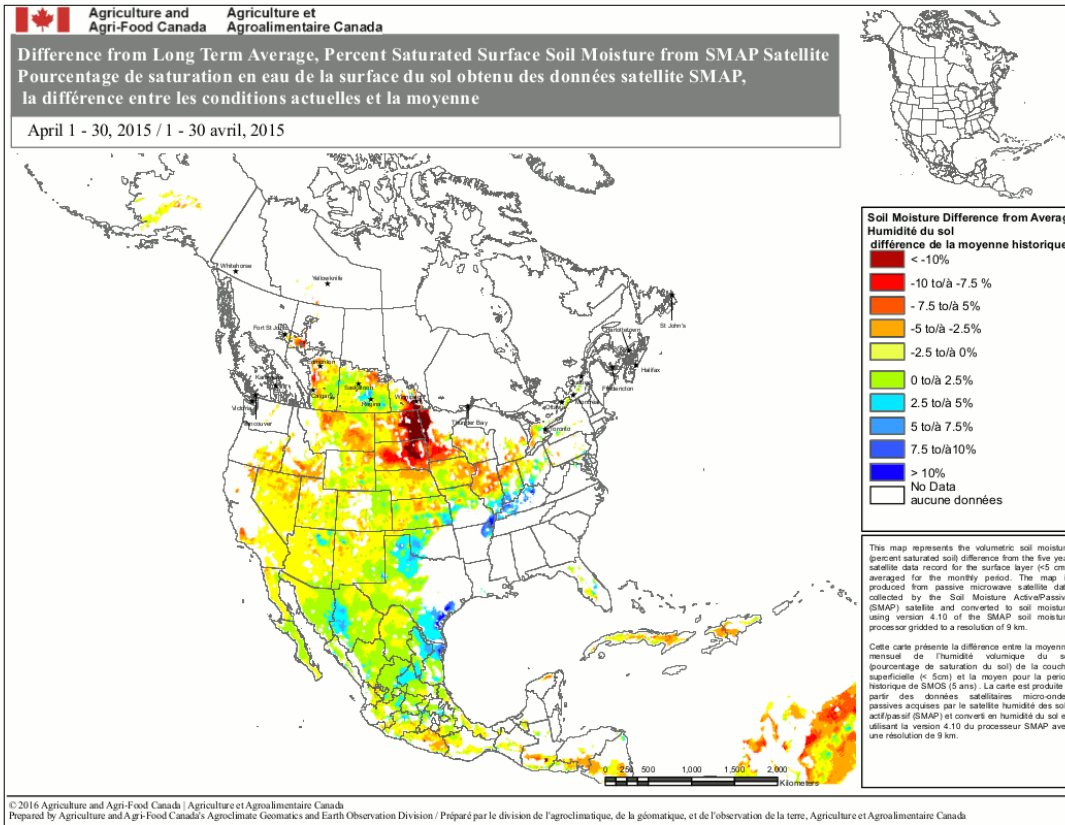
AMSR-E



SMOS

Provides a useful index that can be combined with other data sets for risk assessment

Comparing SMOS and SMAP



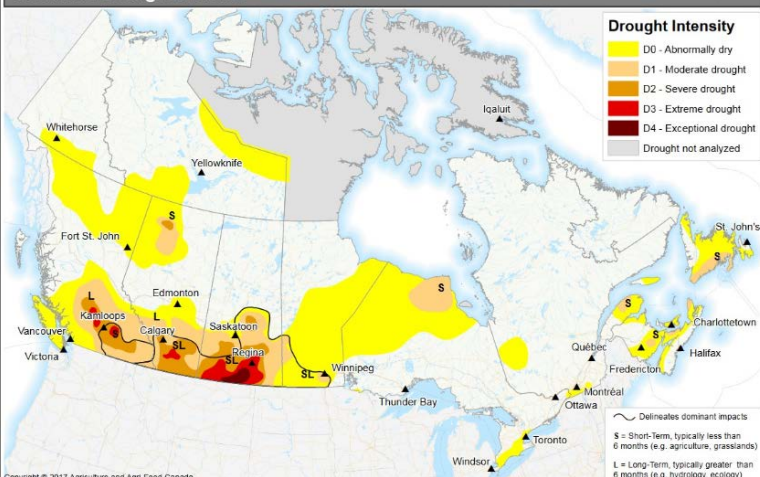
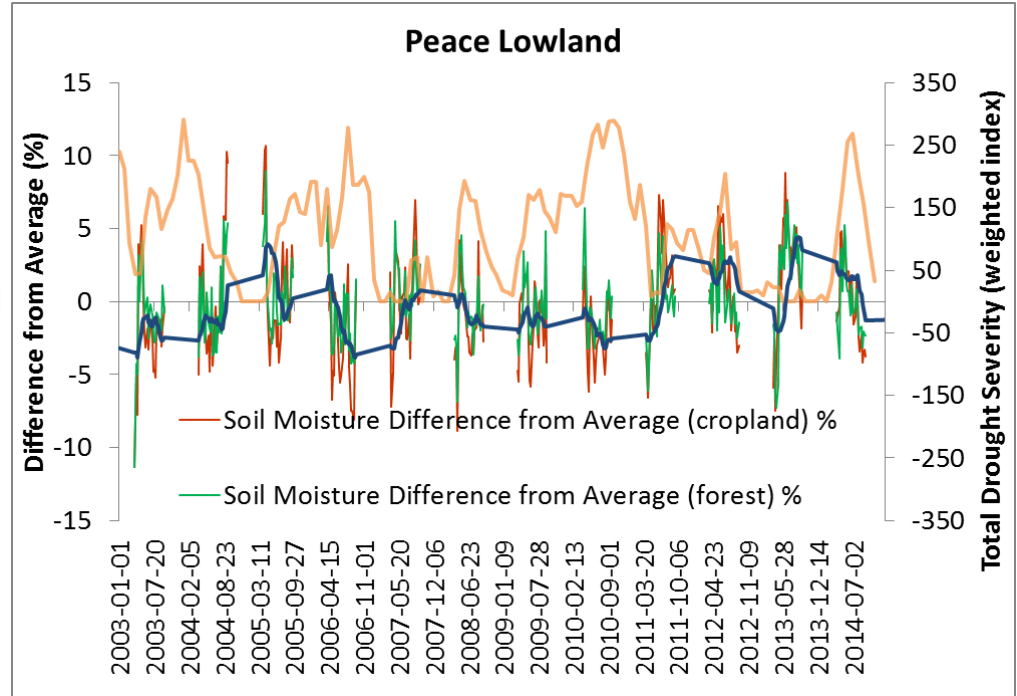
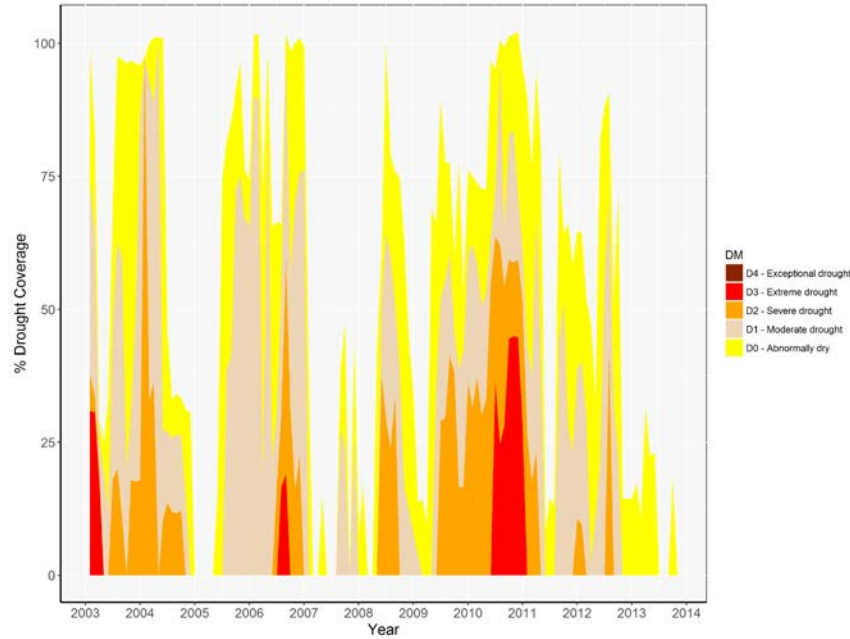
SMAP Soil Moisture (9km Passive Enhanced)

SMOS Soil Moisture (Level 2)

- Compare SMOS and SMAP time series
- Use SMOS history recalibrated to SMAP soil moisture to create SMAP soil moisture index
- Compared against Climate Risk Reports, Drought events and in situ stations

Severity and Extent of Drought

Drought Intensity Coverage in Peace Lowland



Dryness Categories

D0 Abnormally Dry—used for areas showing dryness but not yet in drought, or for areas recovering from drought.

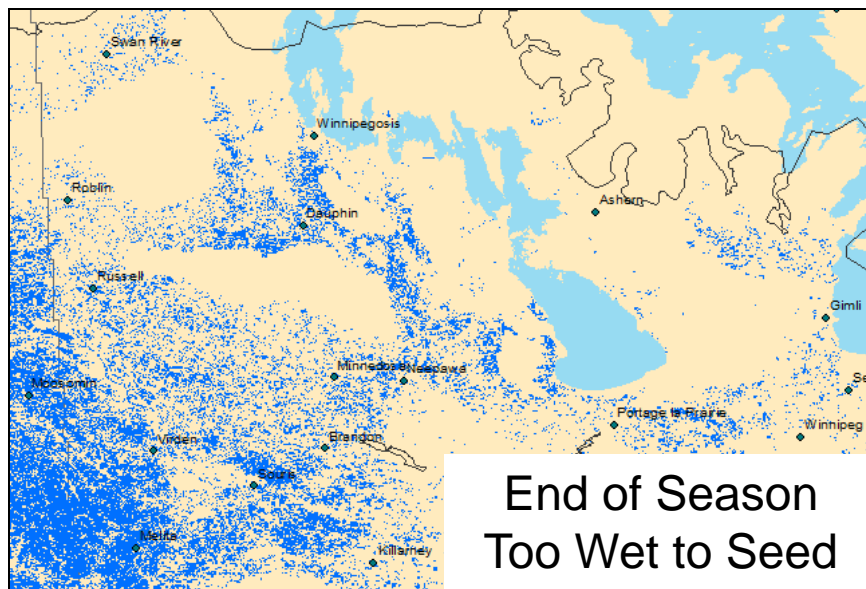
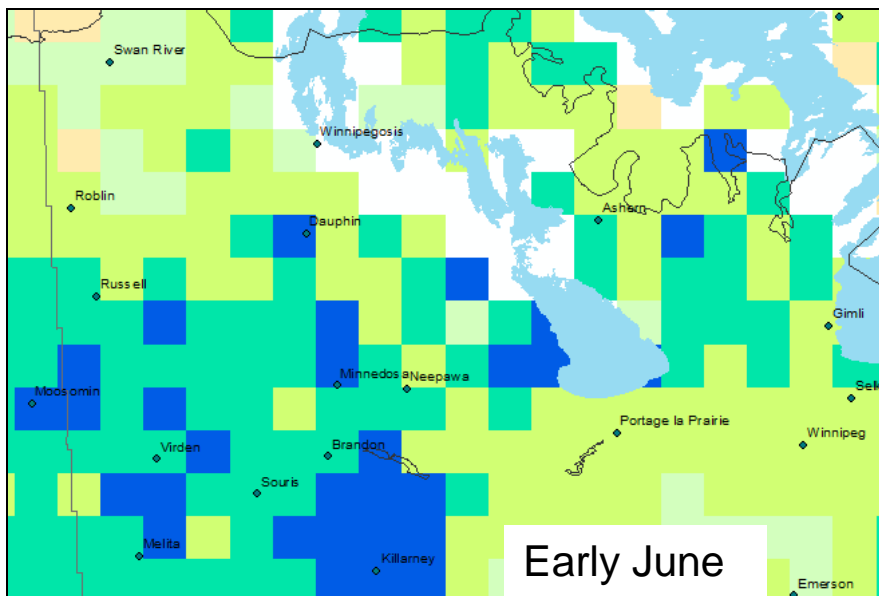
Drought Intensity Categories

- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Drought or Dryness Types

- S Short-Term, typically less than 6 months (e.g. agricultural, grasslands)
- L Long-Term, typically greater than 6 months (e.g. hydrologic, ecological)

Thresholds of Soil Moisture for Soil Trafficability



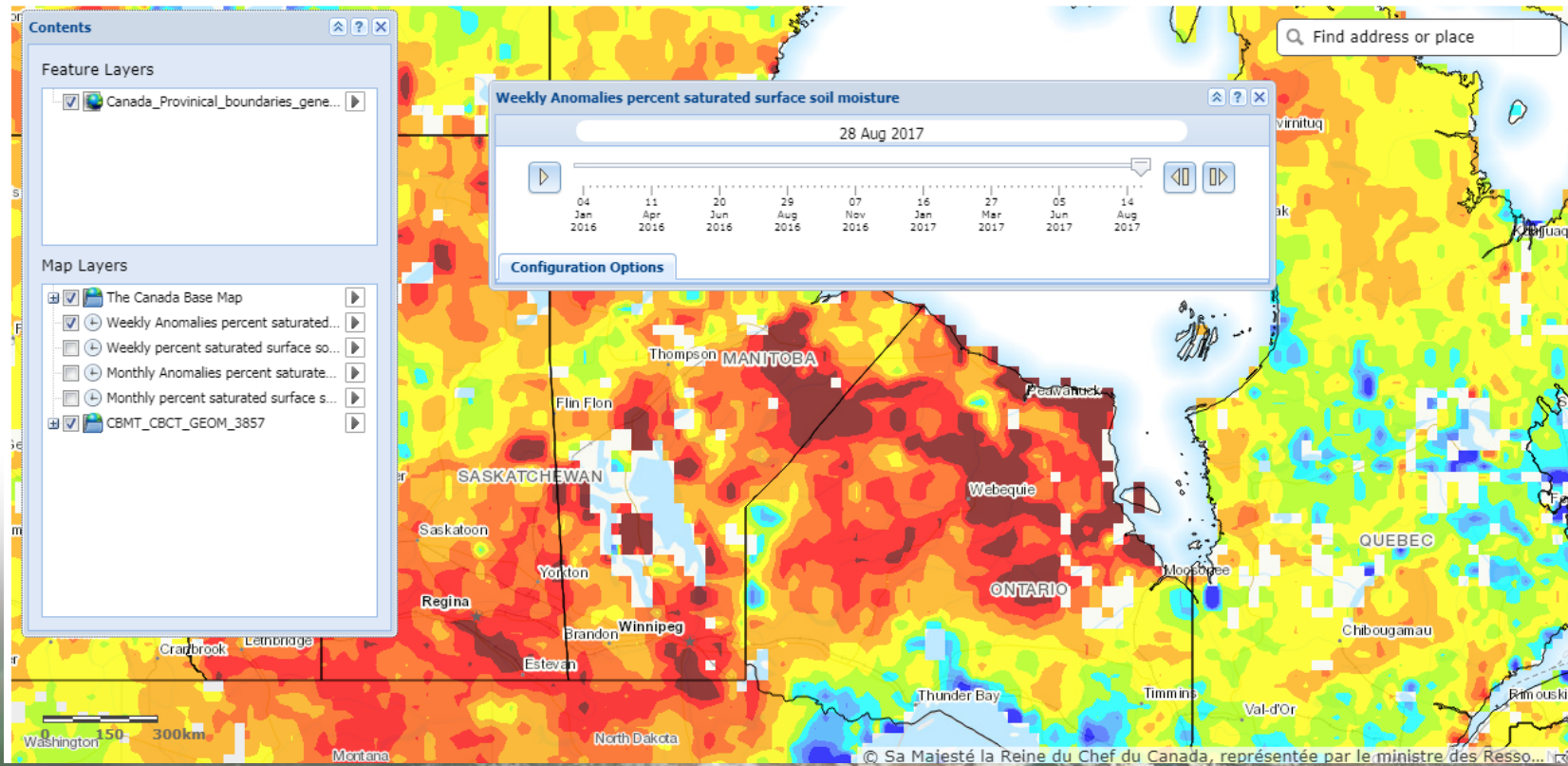
Percentage of Maximum
Soil Moisture from SMOS

- < 25 %
- 25 - 50 %
- 50 - 75 %
- 75 - 90 %
- > 90 %

*Higher
resolution
data
would be
useful!*

Web Mapping Application

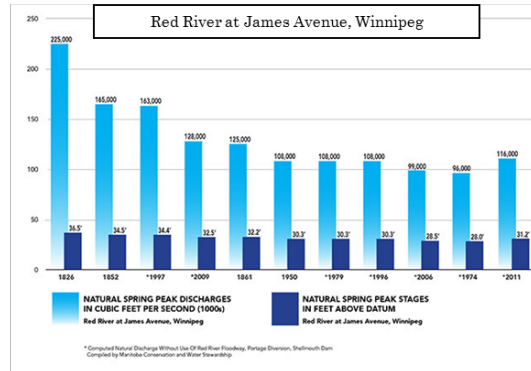
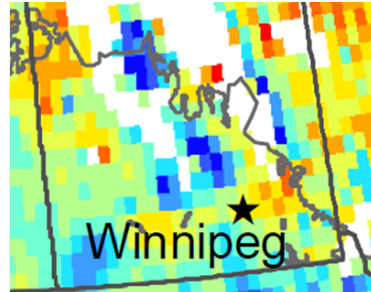
Percent Saturated Surface Soil Moisture from SMOS Satellite Data



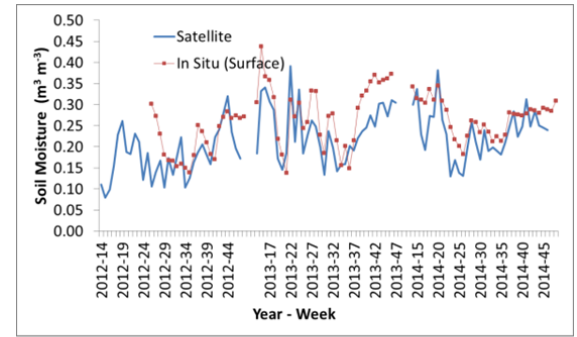
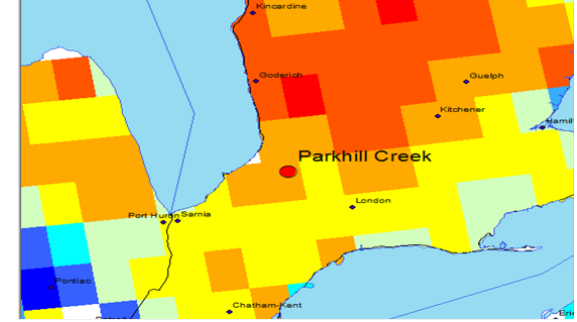
Who's Using It?



Source: Aaron Berg, U of G



Wet antecedent conditions, spring 2011 led to record flooding



Satellite surface soil moisture can help scale ground based measurements used to develop conditions reports

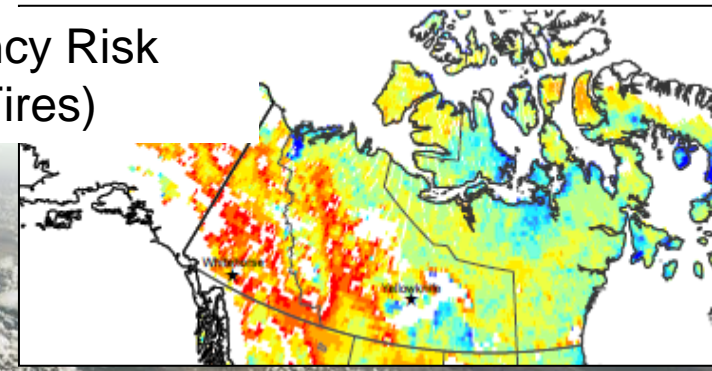
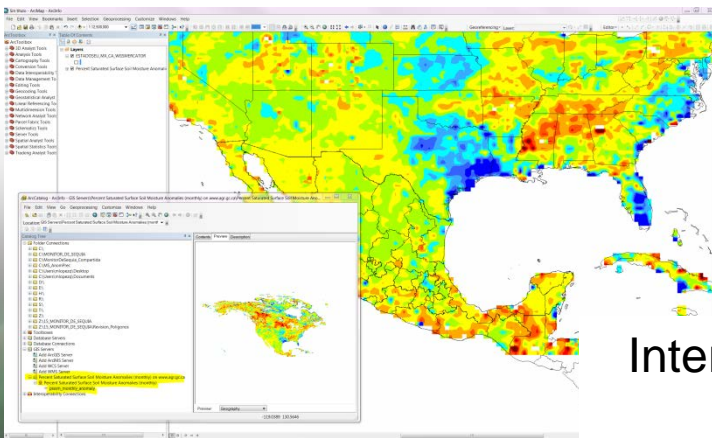
Research & Development

Provincial Flood Forecasting

Provincial Drought Monitoring

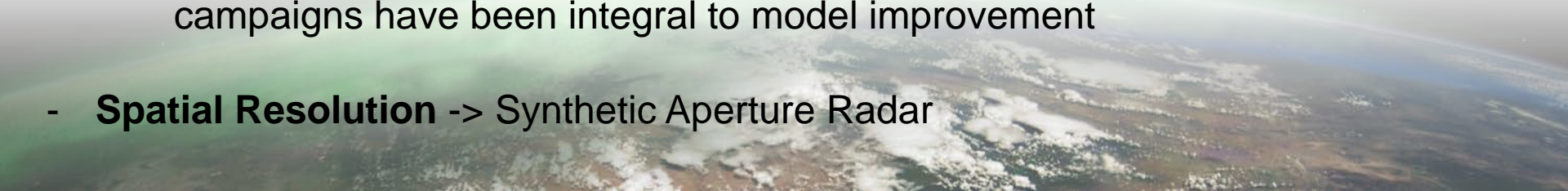
Emergency Risk (Forest Fires)

International Drought Monitoring



Challenges, Gaps, Opportunities

- **Need more robust proof of concept on integration of satellite soil moisture into applications**
 - Critical thresholds for identifying severity and risk type
 - Quantification of water budgets
 - Crop yield forecasting / Assimilation into statistical/process based crop models
- **Long term, inter-calibrated data sets**
 - Particularly critical for risk assessment; user agencies don't have resources to do this work themselves
 - Data sets need to be updated in real time to be useful for monitoring rapidly changing conditions
 - Operational sensors: SMOS/SMAP provide good 'insurance' against satellite failure: can't build operation systems without data continuity
- **Continuous improvement of retrieval accuracy**
 - Improved soil moisture estimation under vegetation canopies -> cal/val campaigns have been integral to model improvement
- **Spatial Resolution** -> Synthetic Aperture Radar



2018 North American Drought Monitor Forum

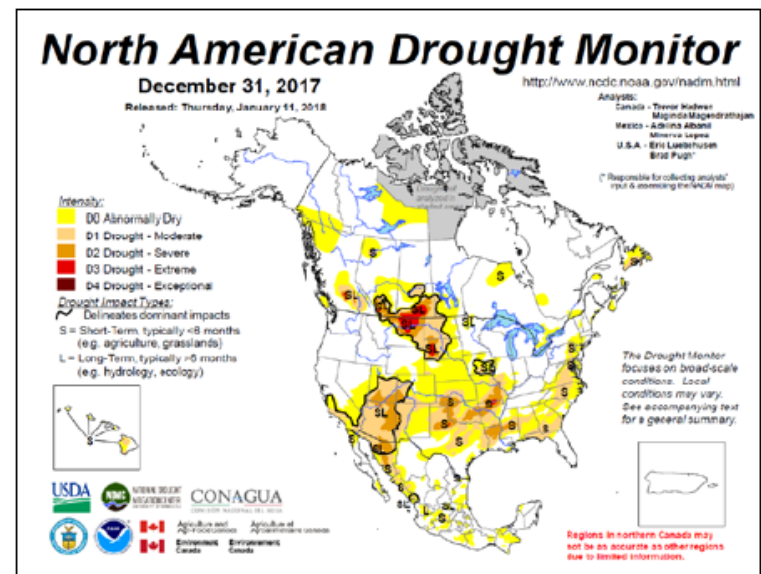
Calgary, Alberta, Canada - May 1-3, 2018



The North American Drought Monitor (NADM) is a cooperative effort between drought experts in Canada, Mexico, and the United States to monitor drought across the continent on an ongoing basis. The activity was initiated in April 2002 as part of a larger effort to monitor drought and other extremes; to share knowledge, data, and human resources; and to improve capacity to provide information.

Agriculture and Agri-Food Canada's National Agroclimate Information Service will host the 2018 North American Drought Monitor Forum. This year's bi-annual meeting will bring together scientists from across North America involved in various aspects of drought research, applications, and monitoring, to discuss the science of drought monitoring and to build cross-border collaborations. Some of the key topics will include:

- The 2017 Drought
- Drought Monitoring in Cold Climates
- Drought Outlooks / Forecasting Drought
- Flash Droughts
- Agricultural Drought
- Transboundary Collaboration



In addition to the key topics, there will be a discussion on the progress of action items from 2016's meeting, and updates from each of the three countries.

Catherine Champagne

Lead, Agroclimate Applications of Earth Observation
National Agroclimate Information Service (NAIS)
Science and Technology Branch
Agriculture and Agri-Food Canada
960 Carling Avenue, Rm. 4110
Ottawa, Ontario K1A-0C6

catherine.champagne@agr.gc.ca

Open Data:

<http://www.agr.gc.ca/atlas/geoplatform#home>
www.data.gc.ca

Drought Watch:

<http://www.agr.gc.ca/drought>