Monitoring Soil Moisture in Agricultural Regions using Passive Microwave Satellites

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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

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

Drought Monitoring

Production Risk
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

- 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

**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, ecologic)
Thresholds of Soil Moisture for Soil Trafficability

Early June

End of Season
Too Wet to Seed

Late June

Percentage of Maximum Soil Moisture from SMOS

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

Higher resolution data would be useful!
Web Mapping Application
Who's Using It?

Research & Development

Provincial Flood Forecasting

Provincial Drought Monitoring

Emergency Risk (Forest Fires)

International Drought Monitoring

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
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
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.
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Open Data:
http://www.agr.gc.ca/atlas/geoplatform#home
www.data.gc.ca

Drought Watch:
http://www.agr.gc.ca/drought