Using Earth Observation to Monitor Drought Characteristics & Impacts in Canada

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Earth Observation of Water Cycle

- Over the last decade a proliferation of missions and data sets dedicated to monitoring water cycle over land areas
  - *SMAP/SMOS dedicated soil moisture missions*
  - “*Long term*” vegetation health records from MODIS/AVHRR
  - *Global Precipitation Mission (GPM)*
  - *GOES thermal/optical remote sensing over North America*
  - *GRACE & GRACE follow on gravity mission*
  - *Landsat – Sentinel 1 (Radar) & 2 (Optical) sensors, operational at 10-30m resolution*
- records (15+ years) are now more common
- there is a need for better assessment of how these reflect different time scales of drought over different landscapes, and how errors in satellite data records impact interpretation of these data sets
- Potential to use these data sets to better understand drought characteristics by linking observations of different aspects of water cycle together
Satellite Soil Moisture

Difference from Long Term Average, Percent Saturated Surface Soil Moisture from SMOS Satellite
Pourcentage de saturation en eau de la surface du sol obtenu des données satellite SMOS,
la différence entre les conditions actuelles et la moyenne

April 1 - 30, 2018 / 1 - 30 avril, 2018

This map represents the volumetric soil moisture (percent saturated soil) difference from the five year satellite data record for the surface layer (< 5 cm), averaged for the monthly period. 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 6.20 of the SMOS soil moisture processor and gridded to a resolution of 0.25 degrees. This product is still in the development phase and should be used as such.

Cette carte présente la différence entre la moyenne mensuelle de l'humidité volumique du sol (pourcentage de saturation du sol) de la couche superficielle (< 5 cm) et la moyenne pour la période historique de SMOS (6 ans). La carte est produite à partir des données satellites micro-waves passives acquises par le satellite SMOS et converti en humidité du sol en utilisant la version 6.20 du processeur SMOS humidité du sol avec une résolution de 0.25 degré. Ce produit reste en phase de développement et devrait être utilisé en tant que tel.
Evaporative Stress Index
MODIS NDVI Anomalies
Remote Sensing of Drought & Drought Impacts

MODIS Normalized Difference Vegetation Index (NDVI) 2000 – present
230m resolution
(Agriculture and Agri-Food Canada & USGS)

GOES Evaporative Stress Index (ESI) 2001 – present
10km resolution
(NOAA – Martha Anderson and Chris Hain)

ESA CCI Soil Moisture 1979 – present
25km resolution
(European Space Agency Climate Change Initiative)

GRACE Total Water Storage 2002 – 2017
1 degree resolution
(NASA & Natural Resources Canada)

All remote sensing data-based data sets were converted to relative values with a mean of zero.
Study Area

Selected Eight EcoRegions in Canada covering four dominant land cover types:

- Cropland
- Forest
- Wetland
- Grassland

Areas were selected based on occurrence of drought within the last 15 years of assessment by the Canadian Drought Monitor.

Assessed earth observations over 2003-2016 period for dominant land cover type within each region.
Drought Conditions Over the Study Period

Forest

Cropland

Wetland

Grassland
Comparing Scales and timing of Drought

- ESI fluctuates most, difficult to distinguish short term/long term drought

- SMDA fluctuates in time but temporal averages show early signs of drought onset and capture some nuance in severity

- GRACE follows DM most closely, droughts lasting more than one season show annual cycles of recharge but recharge is less in multi-season droughts

- NDVI tends to trail drought peaks and not necessarily tied to drought events

Cropland > Grassland > Forest > Wetland
Individual NDVI curves in different years show lower than average conditions in drought years (particularly forested, wetland and grassland).

NDWI shows more pronounced response than NDVI in drought years in cropland areas.

Response is lower than average seasonal values, changes in timing of peak greenness/greenness onset.
Using NDVI to Isolate Anomalies Due to Drought: Vegetation Drought Response Index (VegDRI)

• Hybrid drought index that combines satellite observations of vegetation health with climate station information and land biophysical information

VegDRI Canada Model Evaluation

VegDRI ratings compared favourably to Canadian Drought Monitor assessment and showed good correlation with crop yields in areas where water stress is a dominant factor in determining yield.

Vegetation Drought Response Index (VegDRI) Canada

- Canadian 7-Day MODIS NDVI as input using UNL models
- Worked with UNL to transfer the mapping methods to AAFC; will produce maps in 2017 and 2018 for evaluation with public release of data in later in 2018 or 2019
Canadian Crop Yield Forecaster

Percent Departure of the Forecasted 2017 Canola Yield from the Mean Yield of 2012-2016

Forecast based on inputs for the period from May 1 to June 30

Inputs:
- NDVI: 1984-present

Station Based Climate Indicators

Historical Crop Yield
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
Quantifying Climate Related Risk

Combining Satellite and Models for Root Zone & Multi-scale Soil Moisture

Soil Moisture Difference from Average June 2017

RDPS from ECCC

SMOS

30 Year Reanalysis Data Set coming soon!
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:

- < -10%
- -10% to -7.5%
- -7.5% to -5%
- -5% to -2.5%
- 0% to 2.5%
- 2.5% to 5%
- 5% to 7.5%
- 7.5% to 10%
- > 10%

Updated every week!
Want Access to Data?

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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/eng/?id=1326402878459
Moving Forward

• How can we better utilize Earth Observation for Drought Monitoring & Support Drought Management?