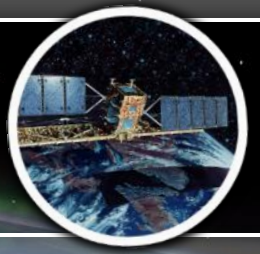
Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada



Monitoring agri-environmental risk using satellite soil moisture from SMAP

Catherine Champagne
Patrick Cherneski, Trevor Hadwen, Andrew Davidson, Yinsuo Zhang, Richard Warren, Dwayne Chobanik, Aston Chipanshi and Allan Howard
National Agroclimate Information Service
Science and Technology Branch

Canada

Agri-Environmental Risk Monitoring at AAFC

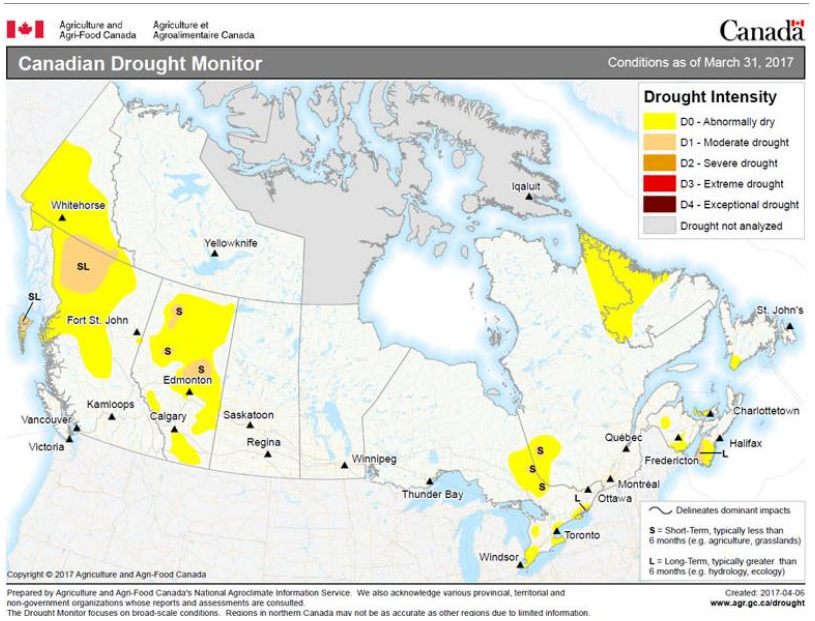
Risks *= short or long term exposures to conditions that negatively impact agricultural production or the long term sustainability of agricultural lands*

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

Assessing Risk Using Geospatial Data

Risk reporting and modelling integrates a large number of spatial data sets to achieve a confluence of evidence approach to determine risk

Risk assessments are largely based on characterizing historical risks and using current data to identify and model impacts

Data need to provide both current and historical characterization of conditions, therefore climate stations have been the most reliable source of information for this

- *Stations lack spatial representation, particularly in rural areas where it is most needed*
- *Remote sensing data lacks historical data, and doesn't map well statistically to more traditionally used data sets*

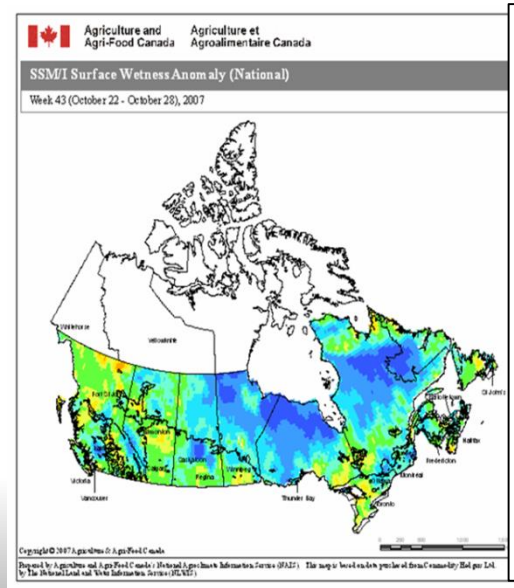
- **Use a confluence of evidence approach – need multiple data sets to verify spatial extent, intensity and duration of risk events**

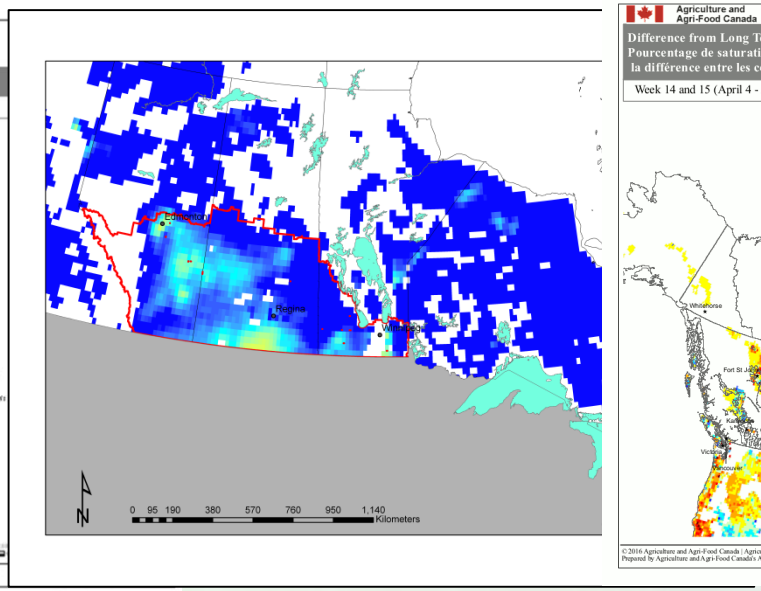
- **Link to impacts – can data sets and thresholds be established that map to specific impacts (crop loss, too wet to seed)**

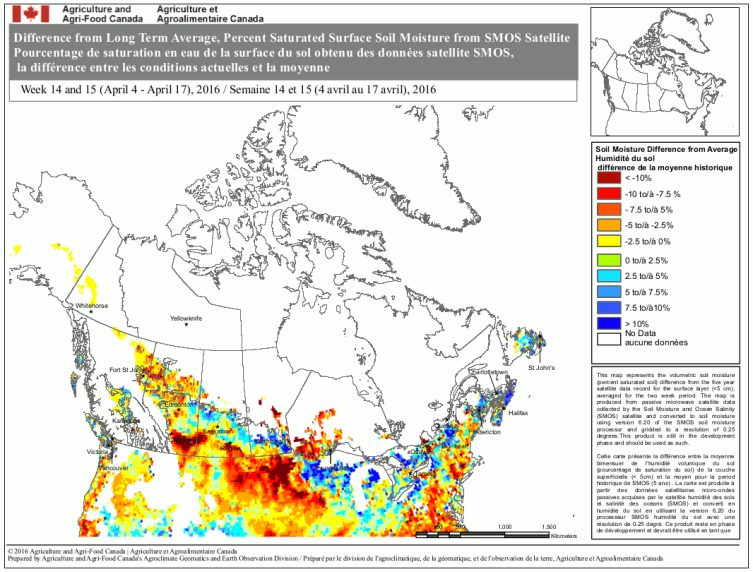
Where does satellite soil moisture fit it?

- 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

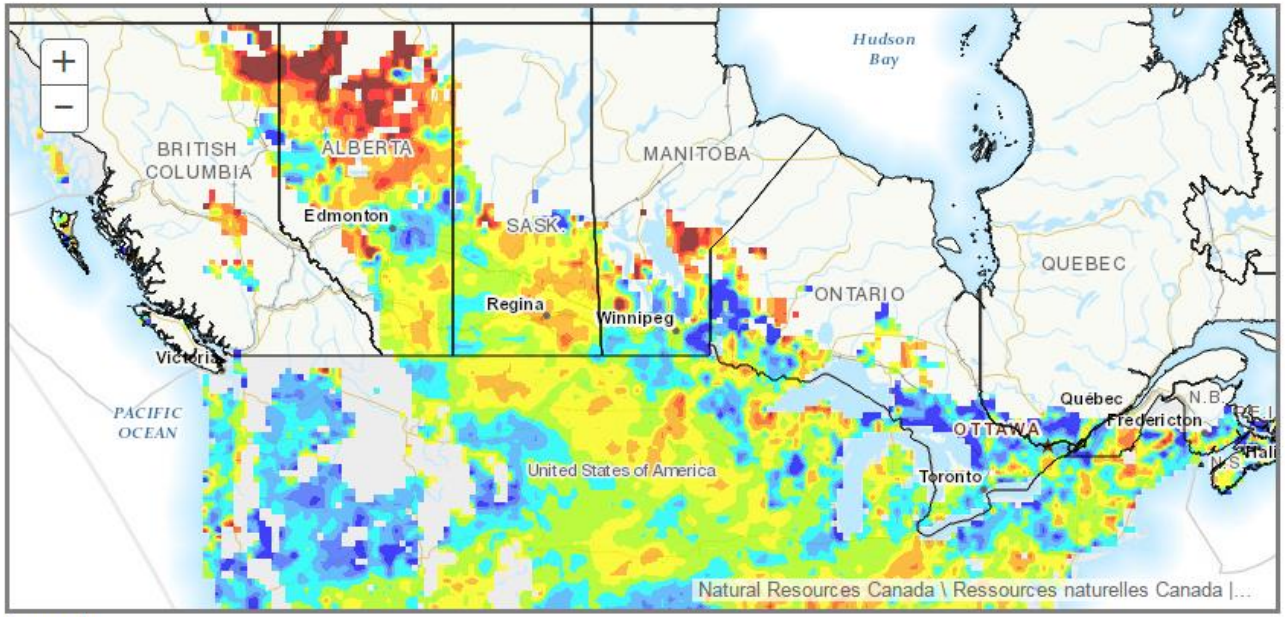
Drought Watch

- 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:

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

▶ Description – Legend

Evaluation of SMAP for Agricultural Risk Assessment

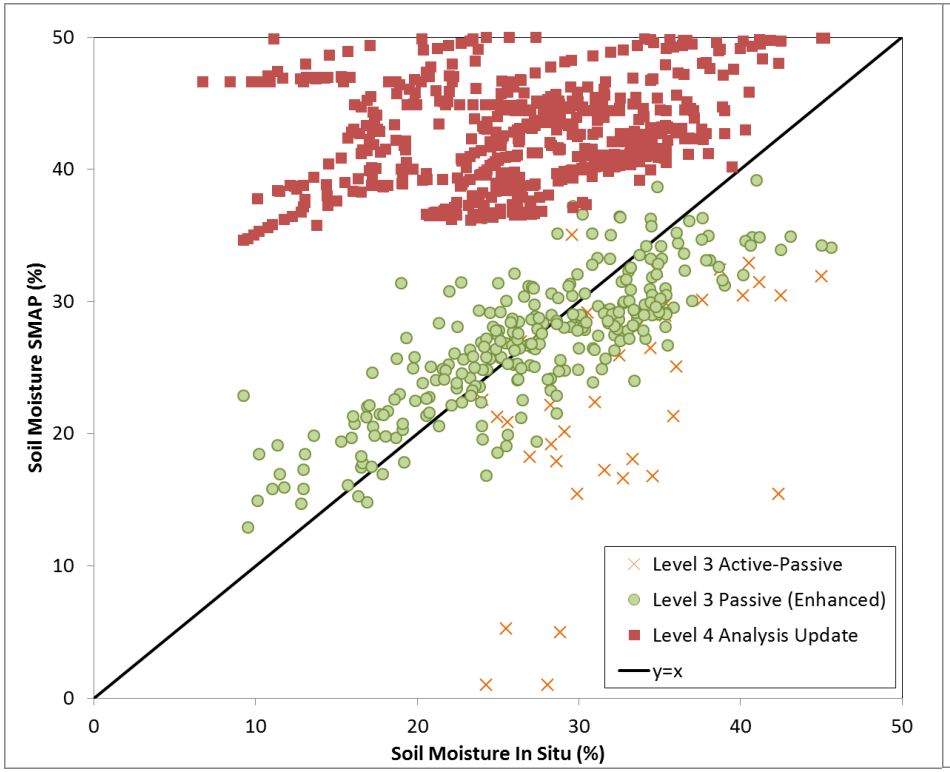
Objectives for SMAP

- Evaluate SMAP soil moisture data sets (Active-Passive, Passive, Level 4 Analysis Update) for use in agricultural risk assessment over two growing seasons
  - Evaluate for accuracy in capturing relevant trends during the growing season
  - Does SMAP improve assessment of surface hydrology relevant to risk assessment
  - Can SMAP improve prediction of impacts to agriculture (ie improved quantification of crop water stress for yield forecasting)

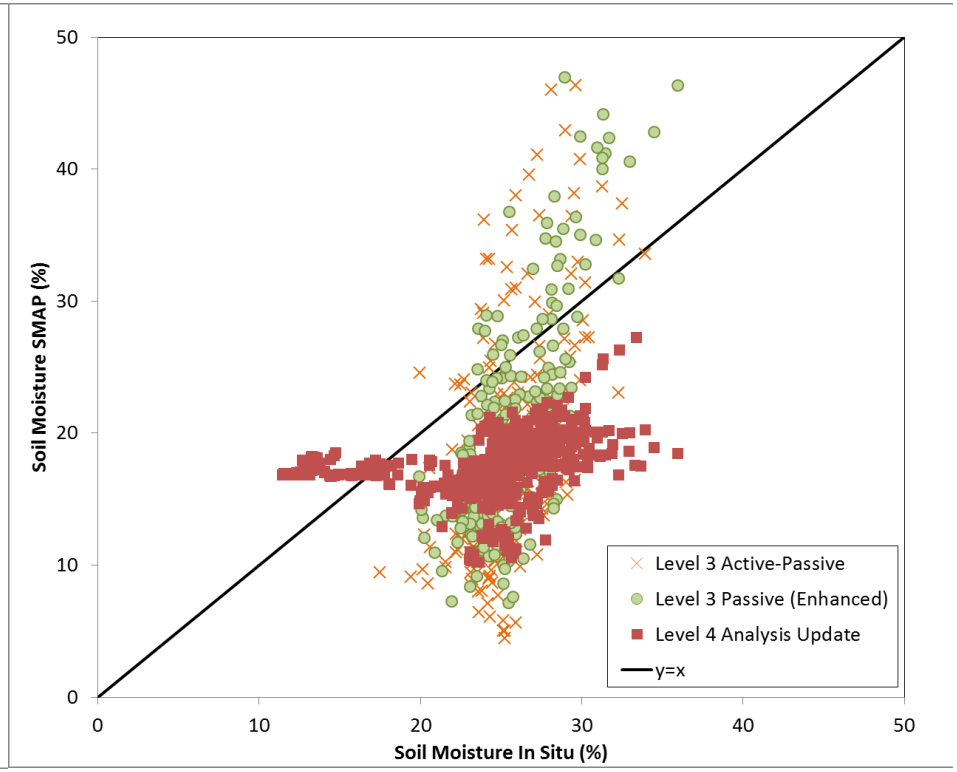
- Compare against current tools in use (SMOS, VSMB modelled water uptake)

- Preliminary Results

Evaluation Against In Situ Sensors (RISMA sites)

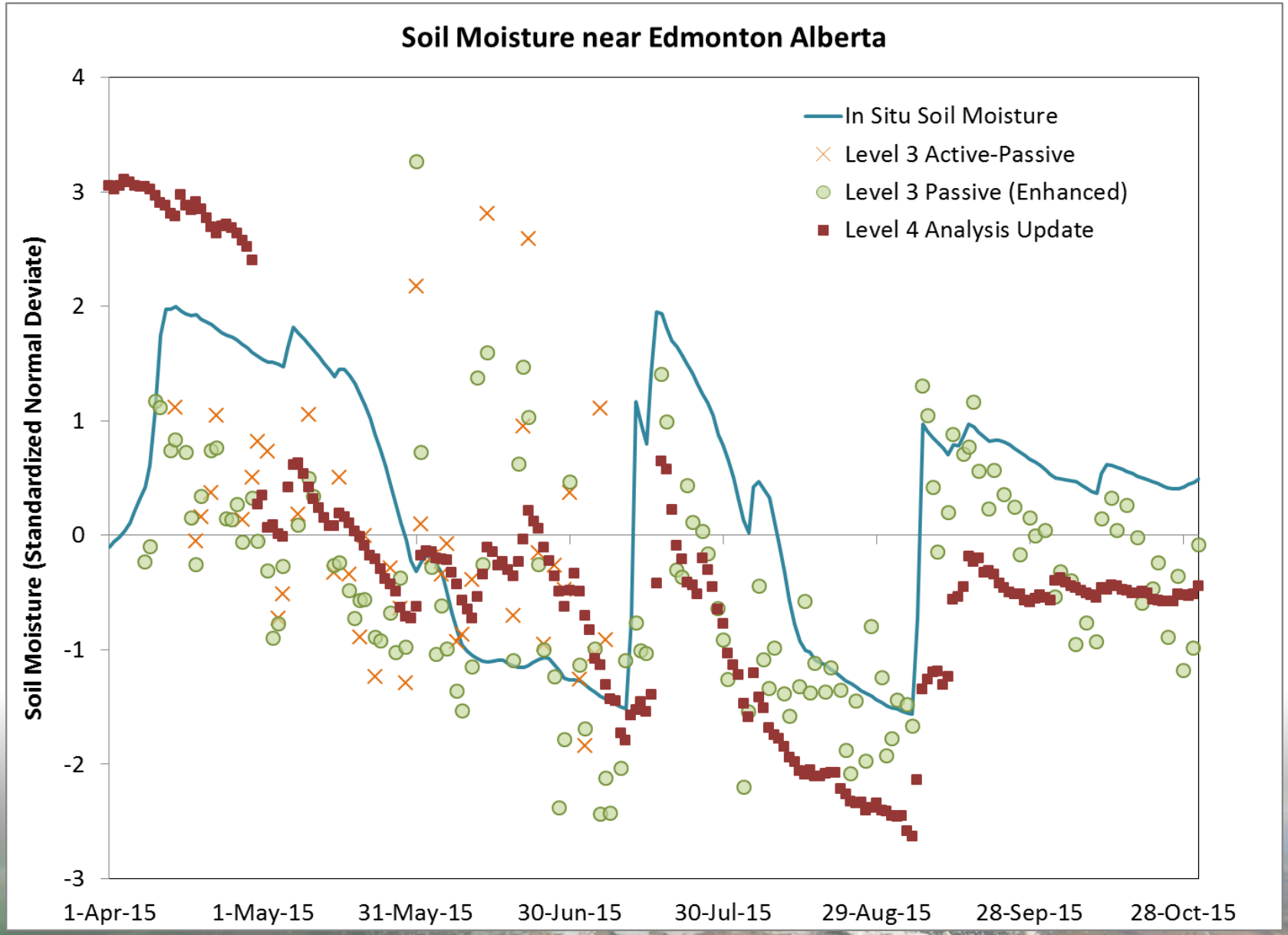


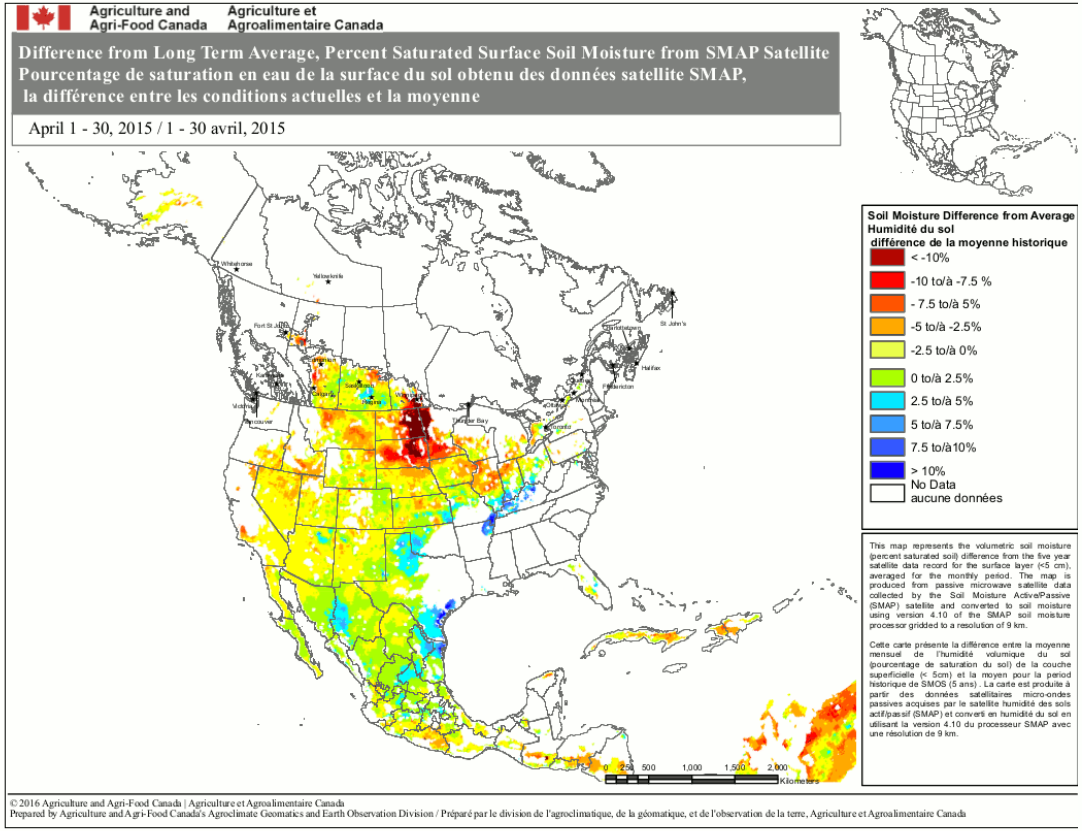
Ontario

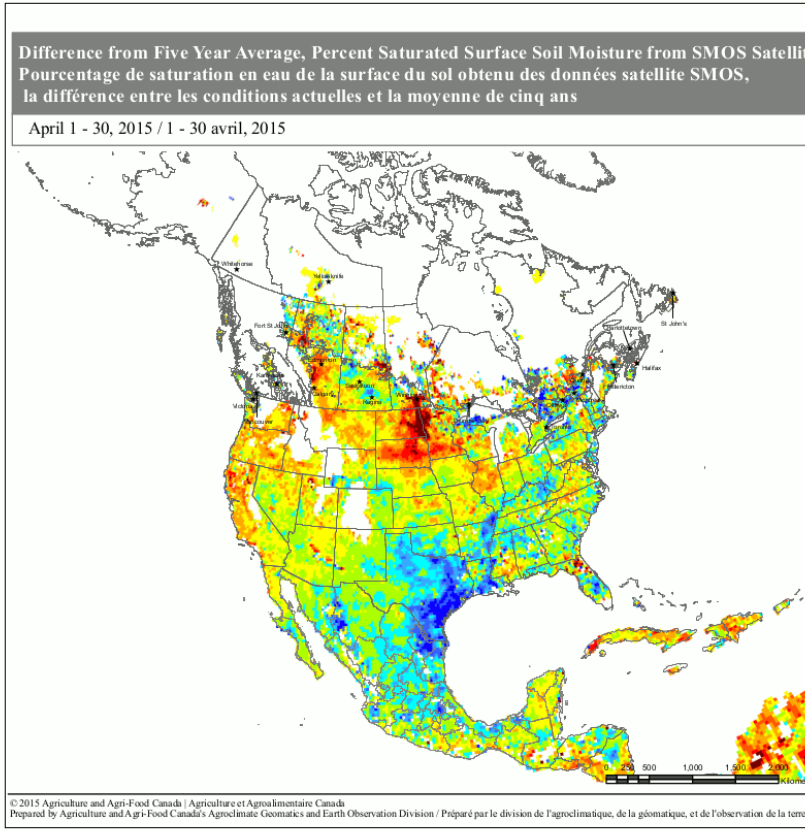


Manitoba

SMAP Soil Moisture Trends







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

Used RQF flag to remove SMAP soil moisture retrievals over areas with greater error in the retrieval (SMOS is not flagged for high VWC)

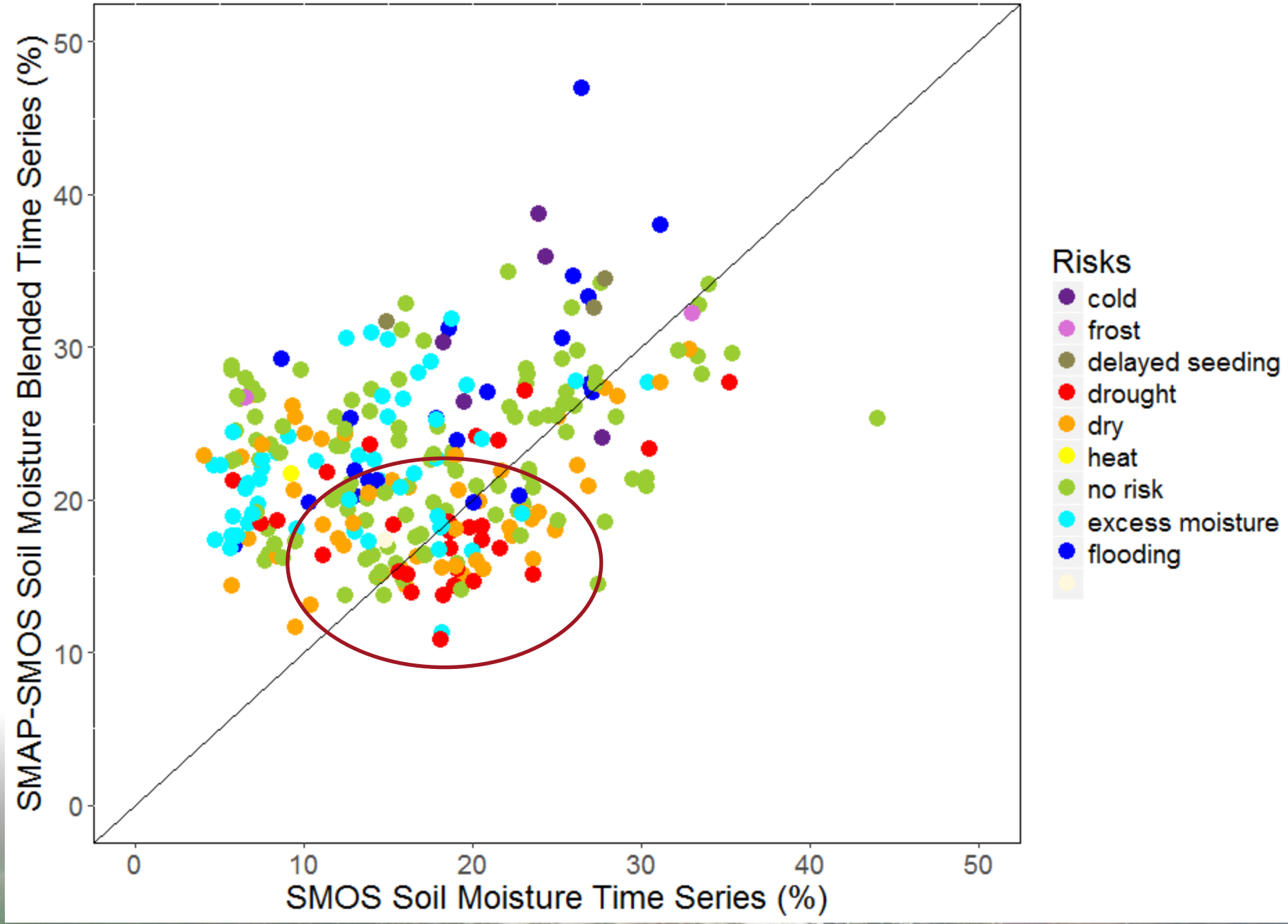
Climate Production Risk Categories

2016 National Dashboard of Agroclimate Risks

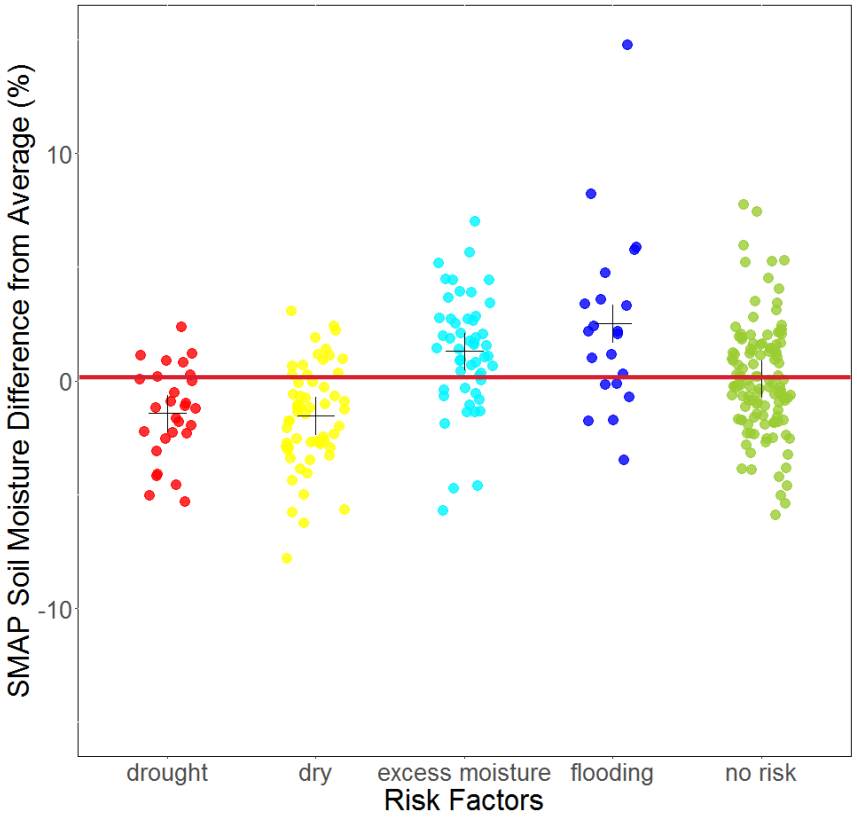
Date	BC	AB	SK	MB	ON	QC	ATL
06-Dec	excess moisture, snow	excess moisture, snow	excess moisture	excess moisture			
01-Nov		excess moisture, cool temperatures, snow	excess moisture, cool temperatures	excess moisture	low soil moisture		
04-Oct	excess moisture	excess moisture	excess moisture, frost	excess 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'.

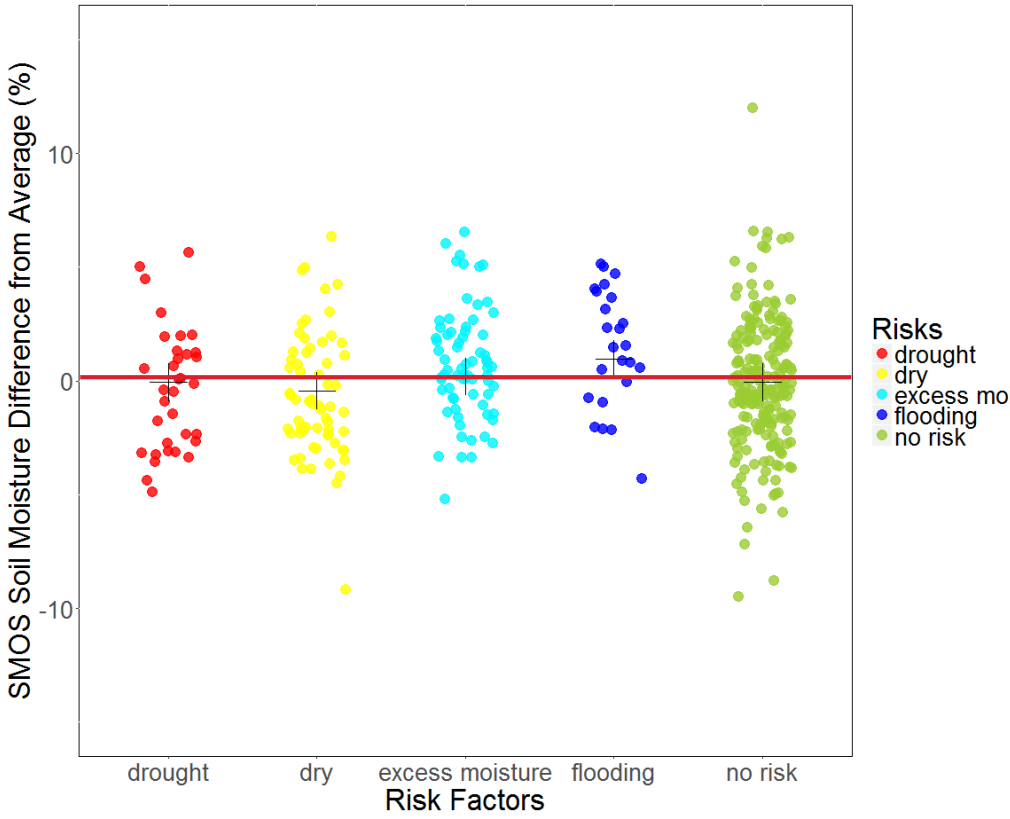
- SMOS and SMAP soil moisture for each province was extracted at a monthly time scale and categorized according to risk severity and risk type


SMAP-SMOS Soil Moisture Blended Time Series (%)
SMOS Soil Moisture Time Series (%)
0
10
20
30
40
50
Risks
cold
frost
delayed seeding
drought
dry
heat
no risk
excess moisture
flooding

Designating Risk Groups with SMOS and SMAP



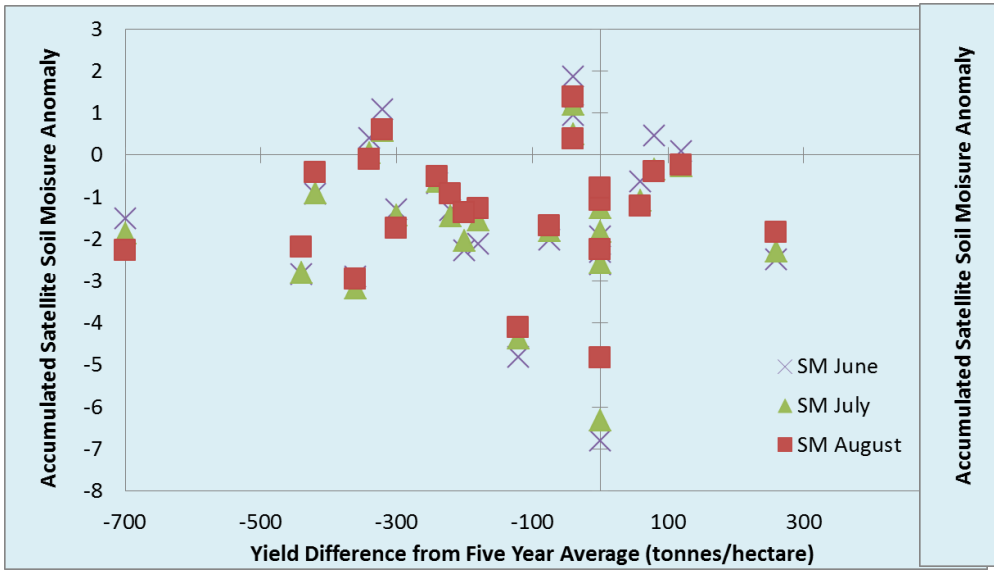
SMAP Soil Moisture Index



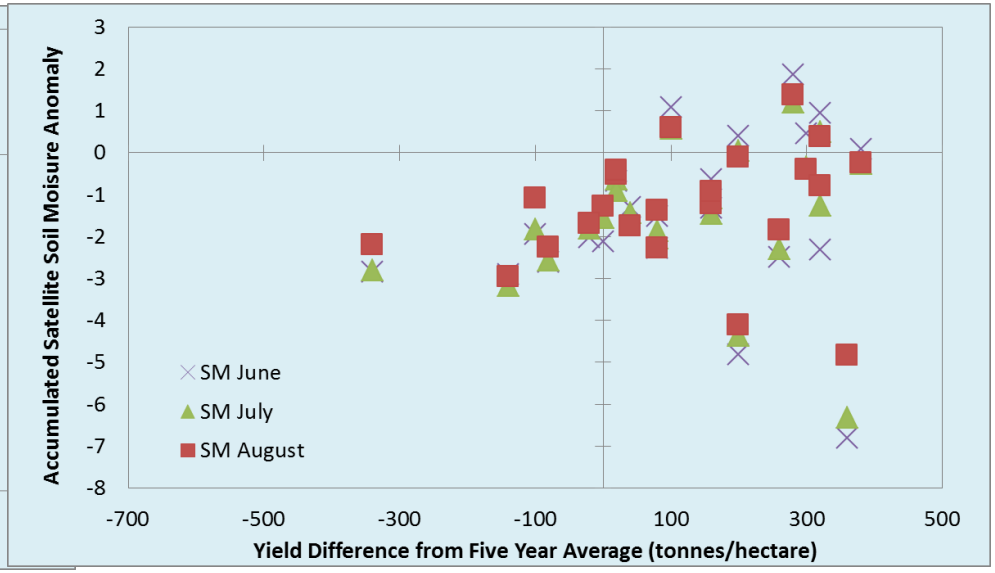
SMOS Soil Moisture Index

Relating Soil Moisture to Impacts – Crop Yield

2015 Wheat Yield AB & SK



2015 Canola Yield AB & SK



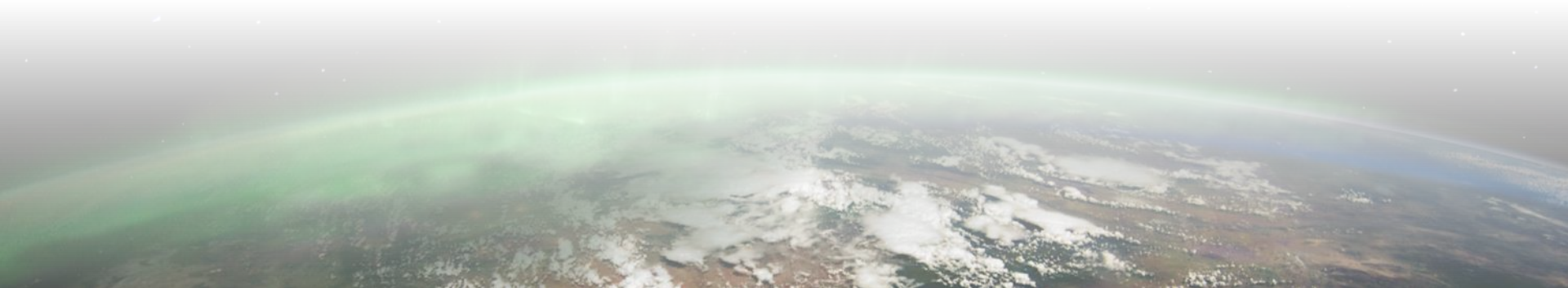
- Relationship between yield and satellite soil moisture is crop dependent and region dependent
- Need to improve understanding of how soil moisture from satellites tracks yield variation
- How accurate does soil moisture need to be to quantify yield differences?

Preliminary Conclusions

- Improved accuracy of SMAP showing a small improvement in assessing risk areas at provincial scale – need to look at localized impacts to better assess magnitude of the improvement

- Crop water stress is a significant factor in determining yields, but the magnitude is region and crop dependent – need to improve regional assessment of soil moisture impacts on crop yield
  - Township level assessment using statistical and process based methods (DSSAT)

- SMAP-SMOS have both provided improvements in assessing risks to agriculture; further improvements in data accuracy and spatial support of measurements (ie root zone measurements) will likely further improve this assessment.



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/eng/?id=1326402878459