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Calibration/Validation Activities for SMAP Over Several Sites in Canada

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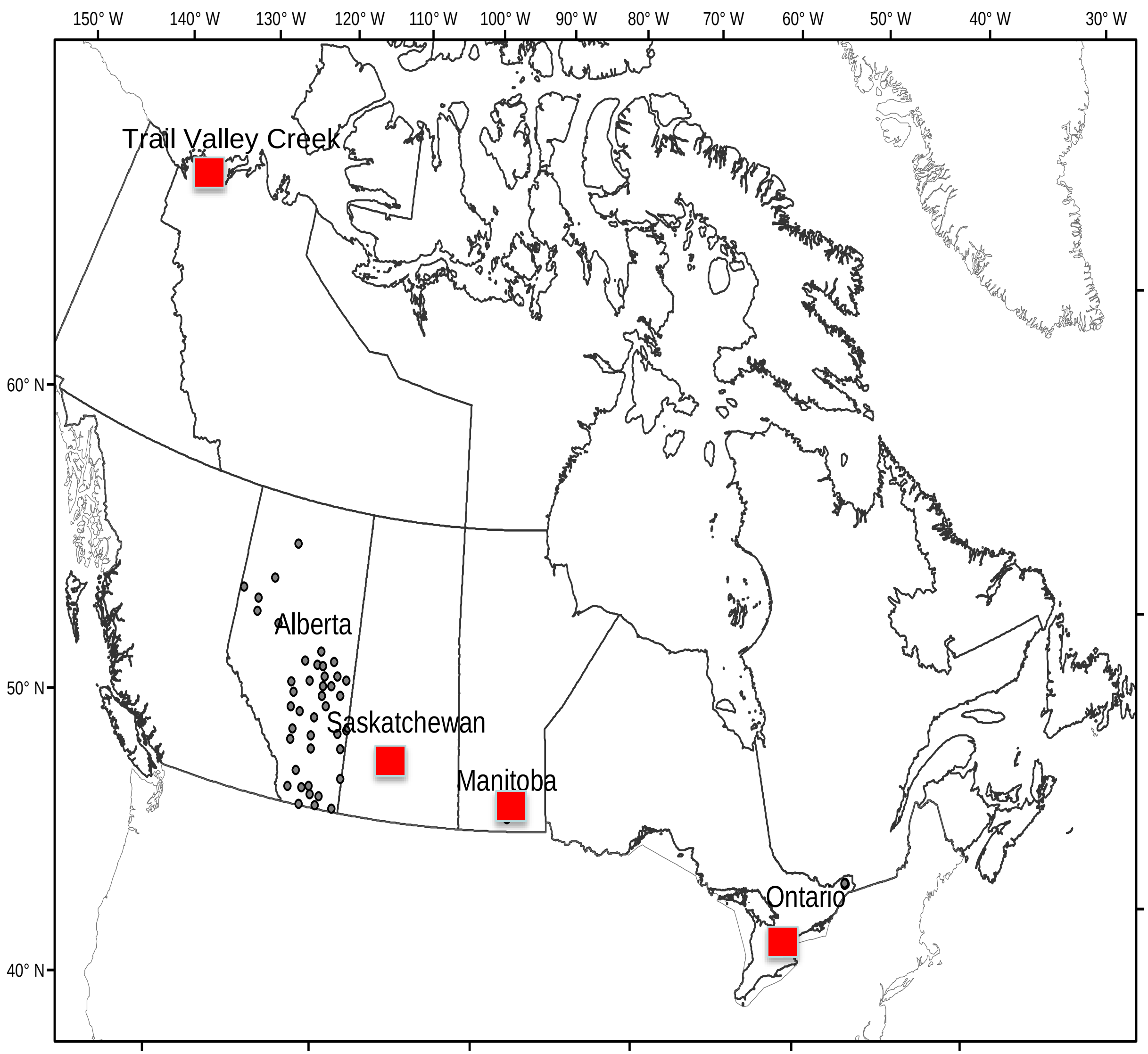
Outline

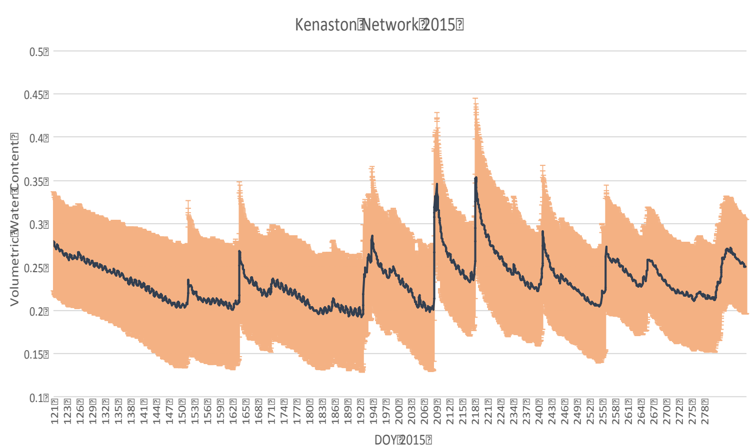
- **Soil Moisture**
  - Activities at the Kenaston validation site
  - SMAP product evaluation over an arctic tundra region
- **Soil Freeze Thaw**
  - Ground-based networks
  - A soil-freeze thaw validation campaign for SMAP

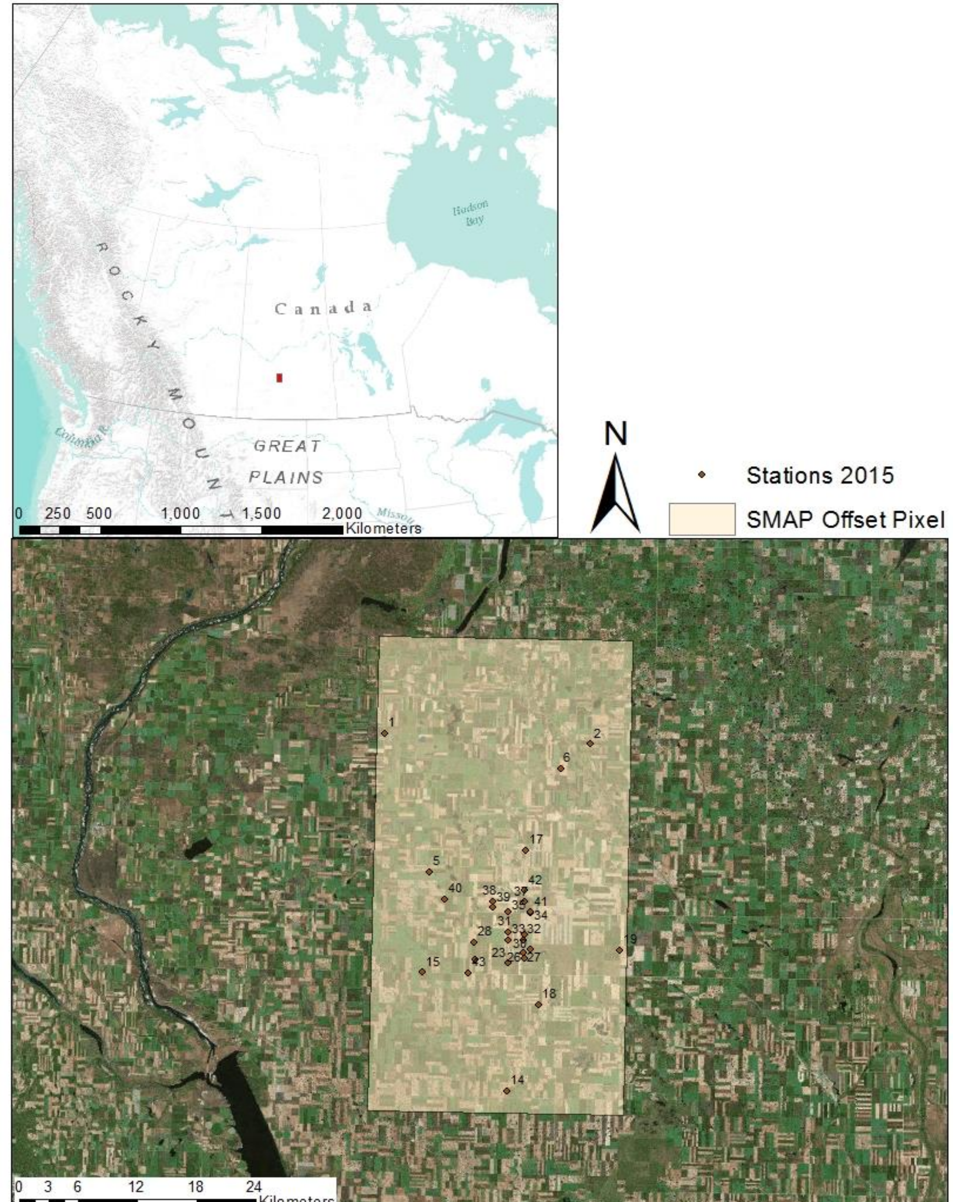
Soil Moisture Networks in Canada



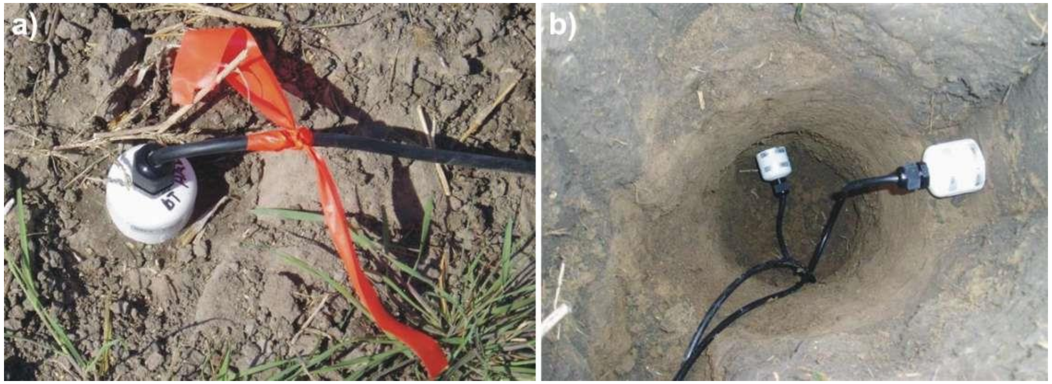
Kenaston SMAP Core Validation Site: Saskatchewan

Product	Grids with 5 or more sites
3km Radar SM/FT	2
9km (Radar+Radiometer)	4
36km (Radiometer)	2





Kenaston SK Network : Overview

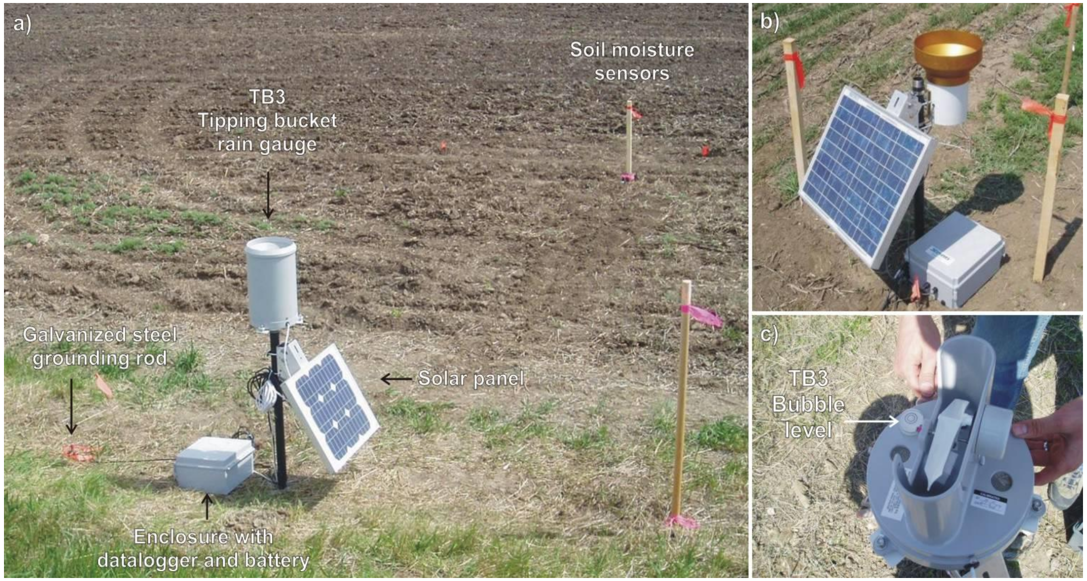


3 depths/orientation
•0-5 cm vertical (EC), 5 cm horizontal (EC and U of G)
•20 cm horizontal
•50 cm horizontal
Stevens Hydra Probe II
Site specific calibration

EC 24 sites
U of G 15 sites
Temporal Frequency: half-hourly
Variables Observed:

- Soil temperature
- Soil Moisture
- Precipitation
- 2 M air temp/humidity

Latency: NRT
Instrumented for Freeze/Thaw



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Kenaston Site Upscaling Strategies

- Upscaling procedures are necessary to ensure that the measurements from the individual network locations are representative of the soil moisture within the larger SMAP pixel.
- Several different upscaling strategies have been described including arithmetic average (AA), inverse distance weighting (IDW), Kriging (K), Voronoi diagrams (VD), temporal stability (TS) and soil weighted averages (SWA).
- Here we evaluate differences from the use different upscaling techniques to generate a representative footprint scale soil moisture average for the validation of the SMAP products.
- We also evaluate the sensitivity of strategies to station loss

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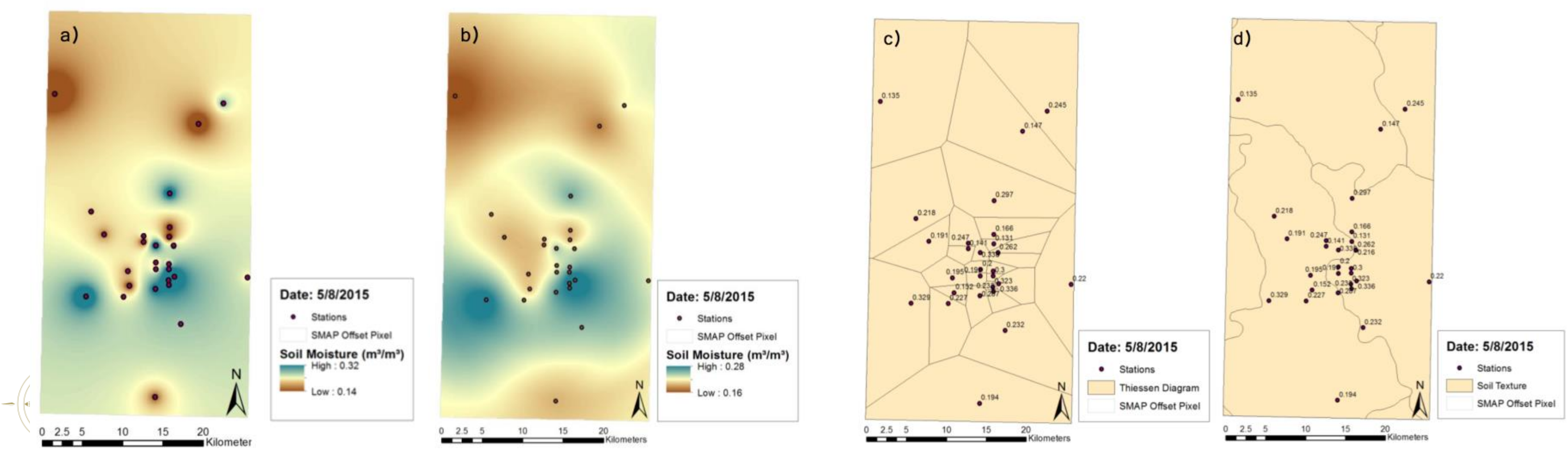
Woodley et al. in Prep.

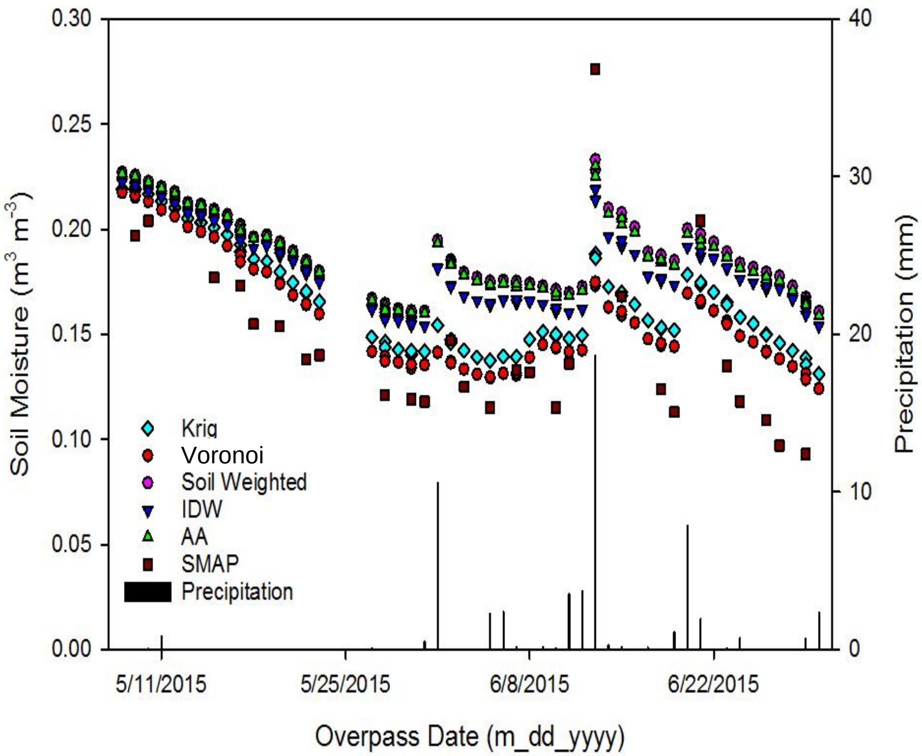
Variation among upscaling strategies: Methods

- Six upscaling techniques were examined: Arithmetic Average (AA), Inverse Distance Weighting, Kriging, Voronoi diagrams, and Soil Weighted Average

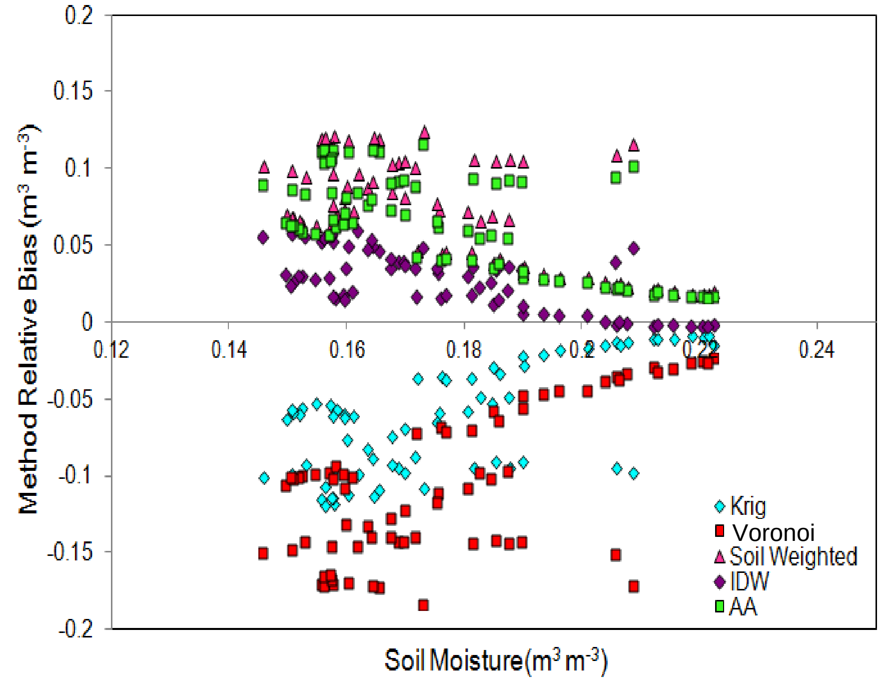
- Impacts of station drop out were assessed by randomly eliminating stations from the upscaling method, with the simulated network ranging from 30 stations to 5 sampling from all possible random combinations to a maximum of 10,000 combinations



Variation among upscaling strategies: Results



Time series of the upscaling methods and the SMAP soil moisture retrievals with precipitation events.



Relative bias of individual methods versus an average of all five of the methods (proxy data set). Note the decreasing bias as the average soil moisture increases

Variation among upscaling strategies: Results

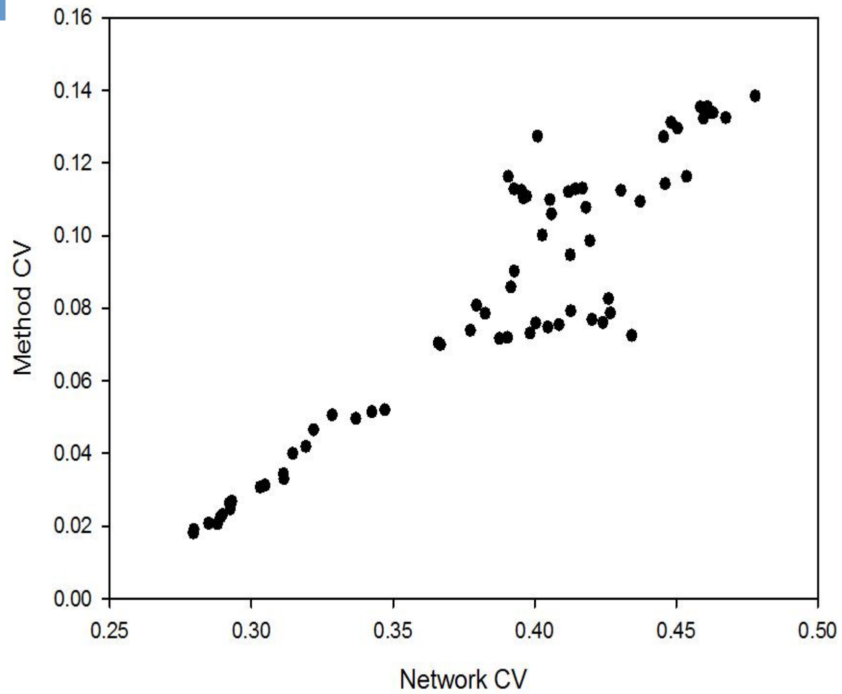
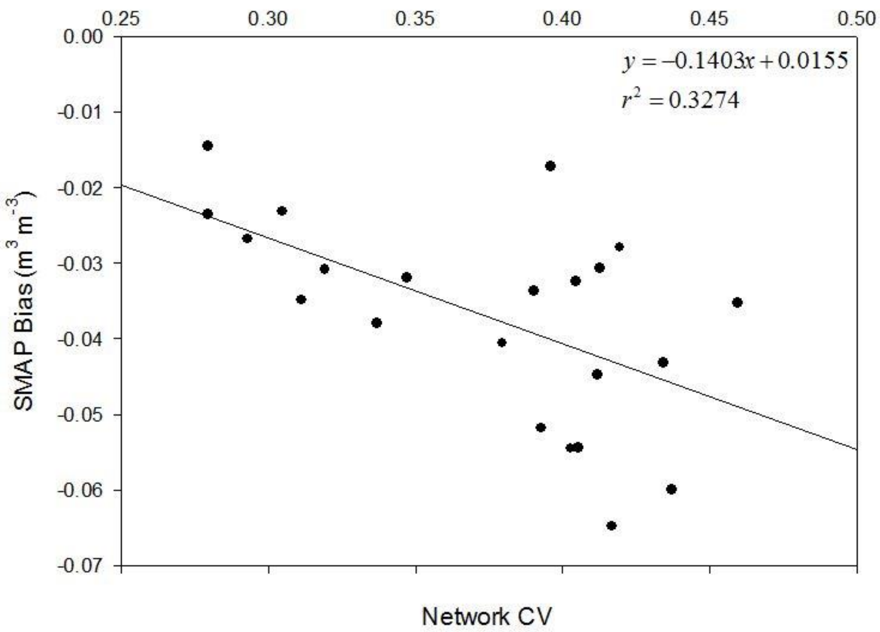


Fig. 3: As the network CV increases (which occurs at lower soil moisture conditions), the CV of the methods also increases.



Relationship between the network CV and the SMAP soil moisture bias

Knowledge of the network CV could provide insight into time periods when the network should be used with caution for cal/val activities

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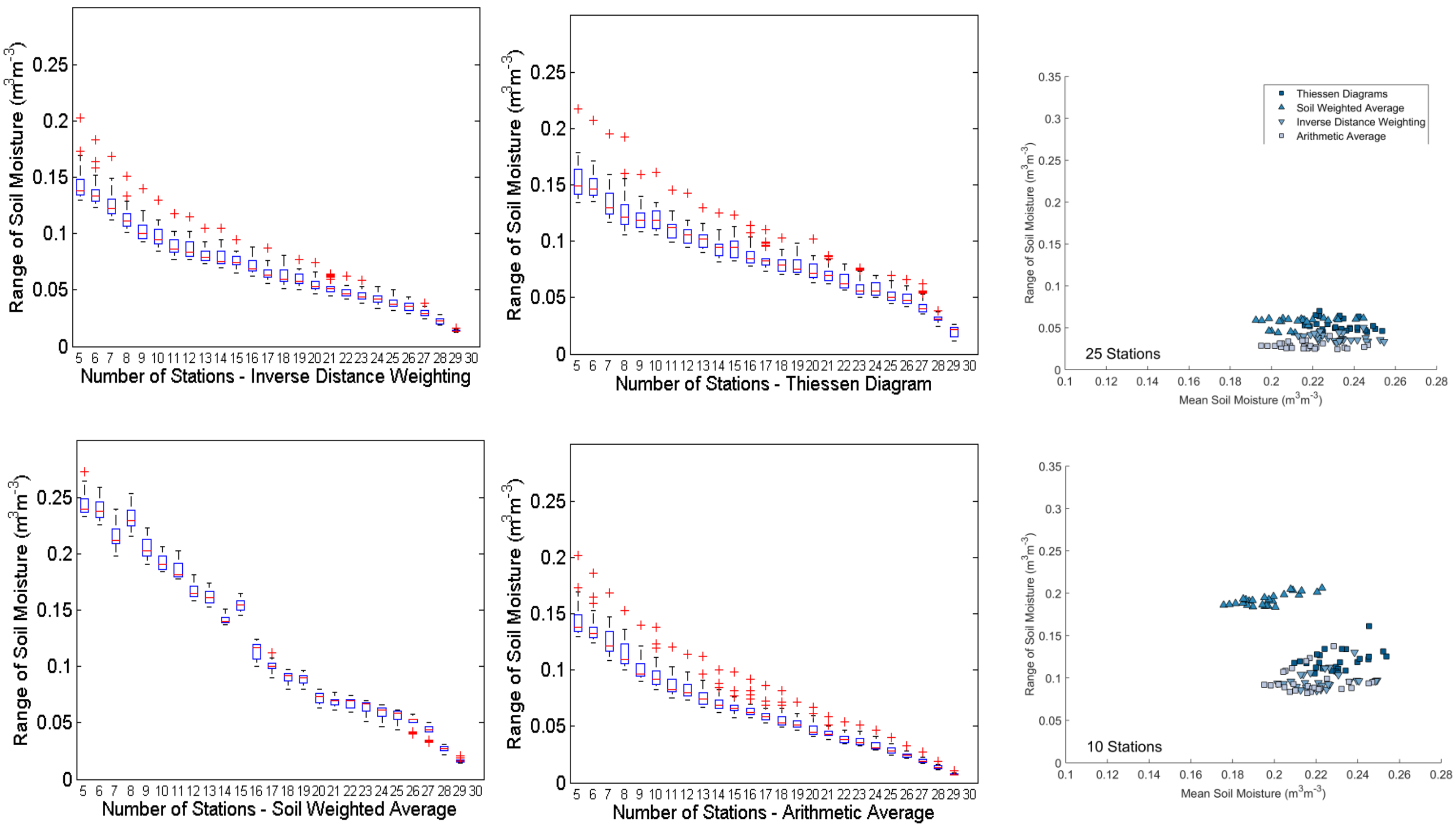
Variation among upscaling strategies: Results



The range in upscaled soil moisture across all possible random combinations of stations from 5 to 30. Soil weighting and Voronoi diagrams show less stability .

Trail Valley Creek NT Network

- Trail Valley Creek Watershed
  - Continuous permafrost
  - Open tundra, North of Boreal tree line
  - Gentle topography
  - Grasses, lichens, mosses
  - Hummocky terrain
    - Mineral earth hummocks
    - Thin organic layer

Trail Valley Creek SMAP Comparison

- Numerous methods of in situ soil moisture estimation do not show relationship with SMAP products

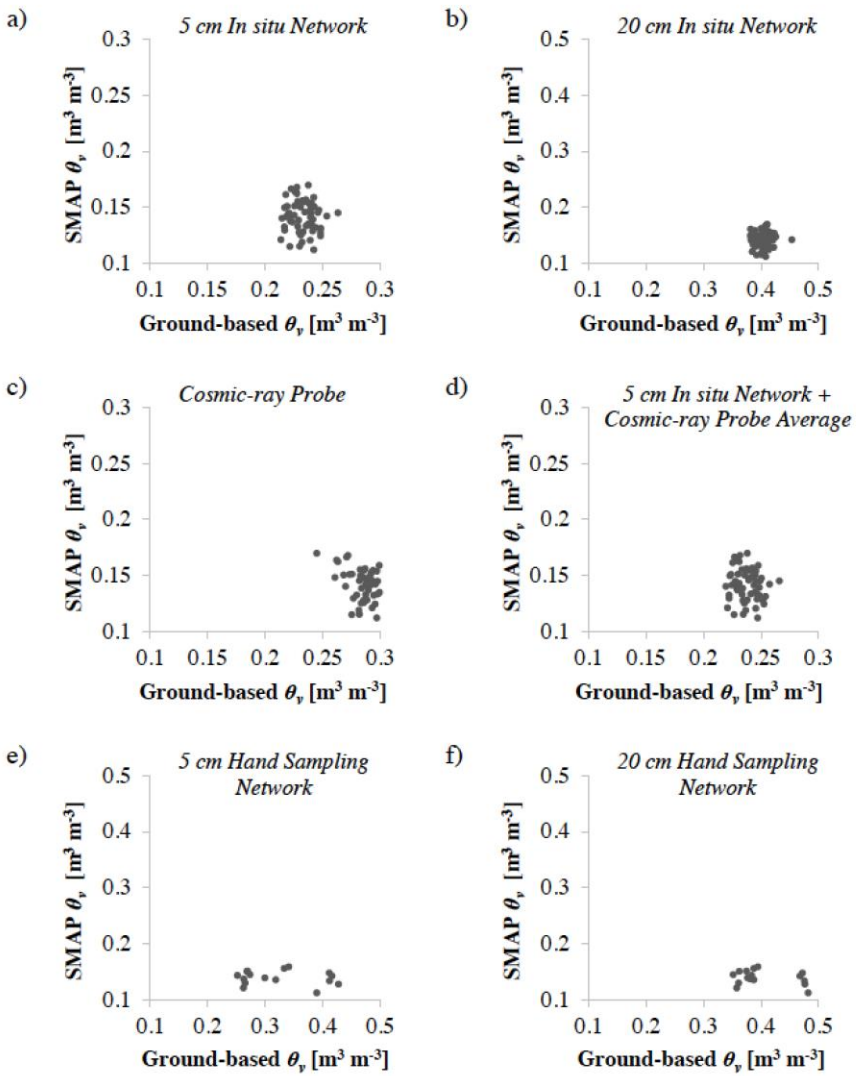
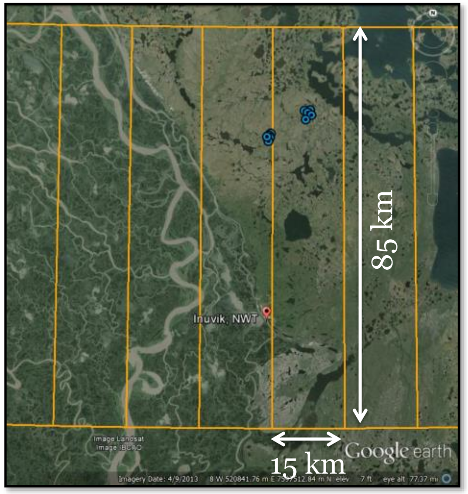
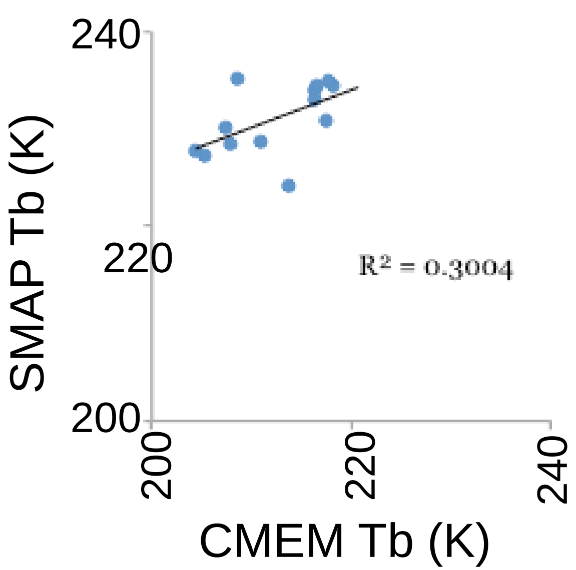


Figure 17 Correlation between SMAP-derived soil moisture product and all ground-derived estimates of soil moisture.

Wrona et al. 2017 GRL

Trail Valley Creek SMAP Comparison



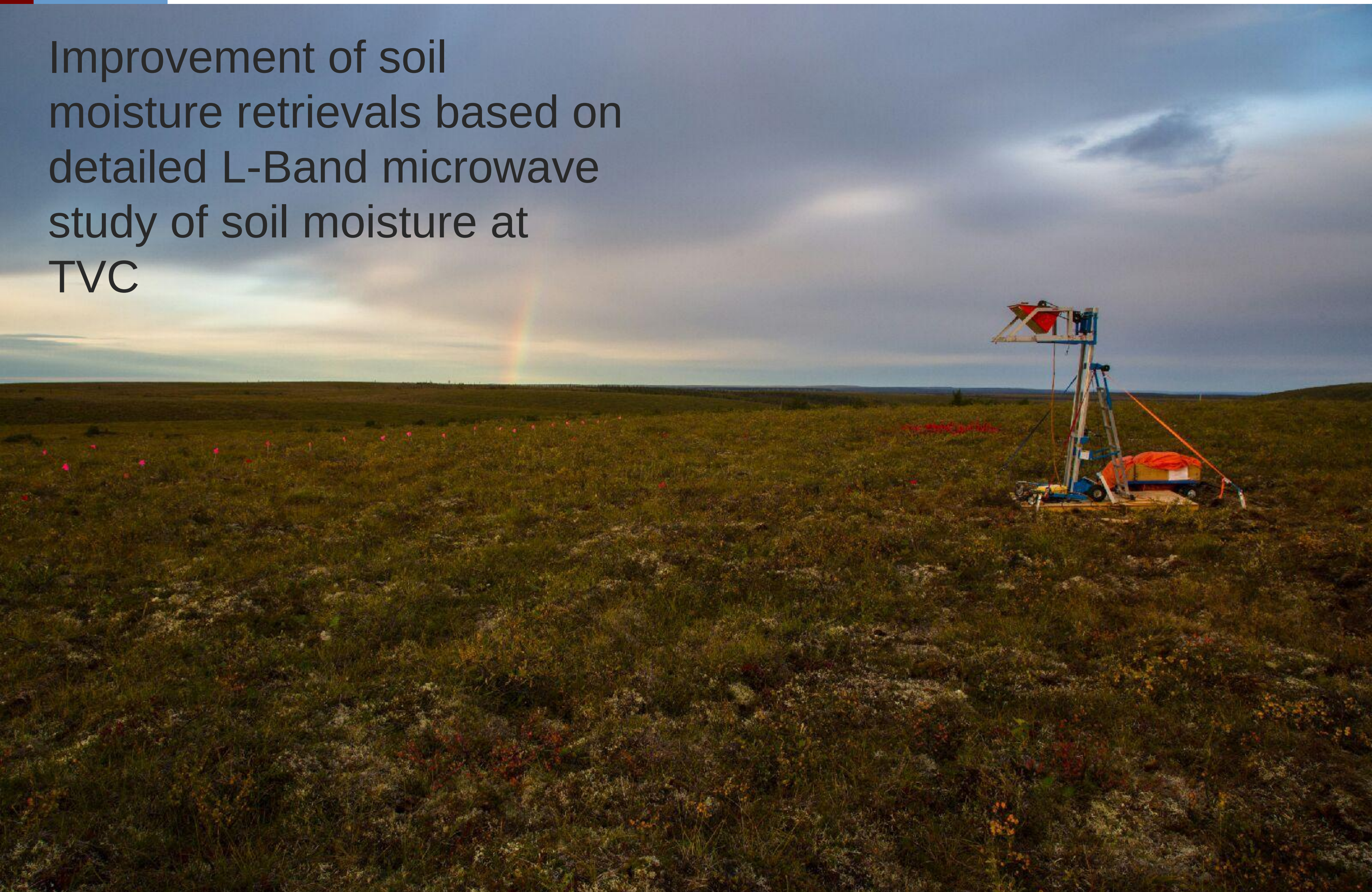


SMAP products are processed and provided on global EASE 2.0 grids that may not be representative of the brightness temperature observation

Using a forward modelling approach (the Community Microwave Emission Model (CMEM)) with observed soil moisture and site parameters modeled microwave brightness values vs. observed brightness temperatures show significant relationship

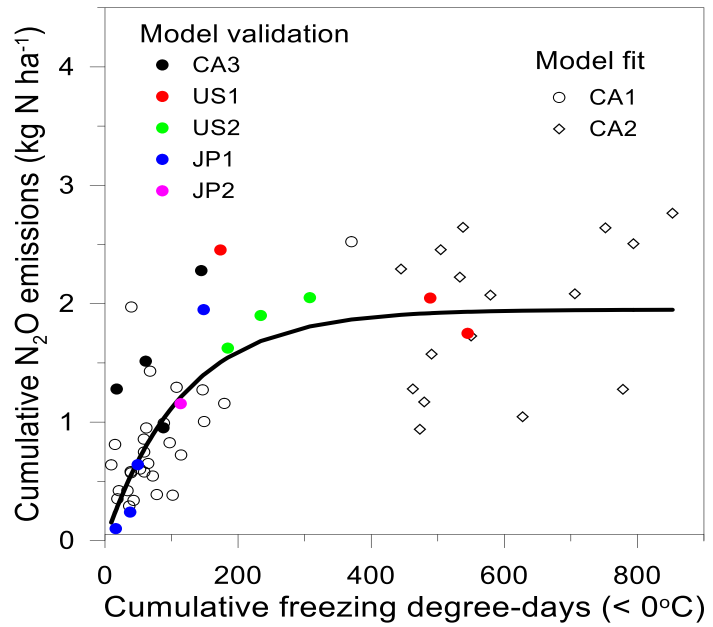
Further TVC Activities

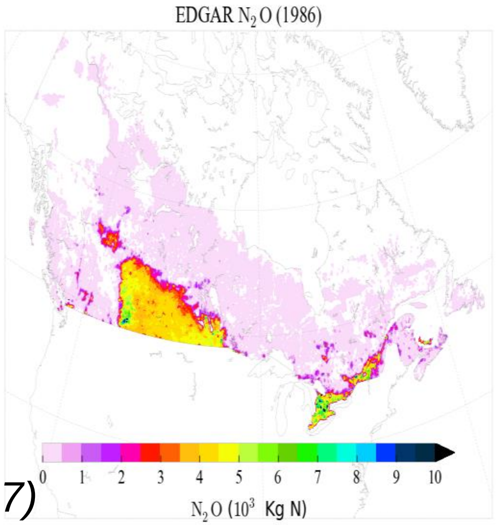
Improvement of soil moisture retrievals based on detailed L-Band microwave study of soil moisture at TVC



Importance of Soil Freeze State

- N_2O is a potent greenhouse gas (~300x CO_2)
- Spring N_2O flux is associated with the soil freeze cycle and extent of freezing
- Current global estimates only consider warm season



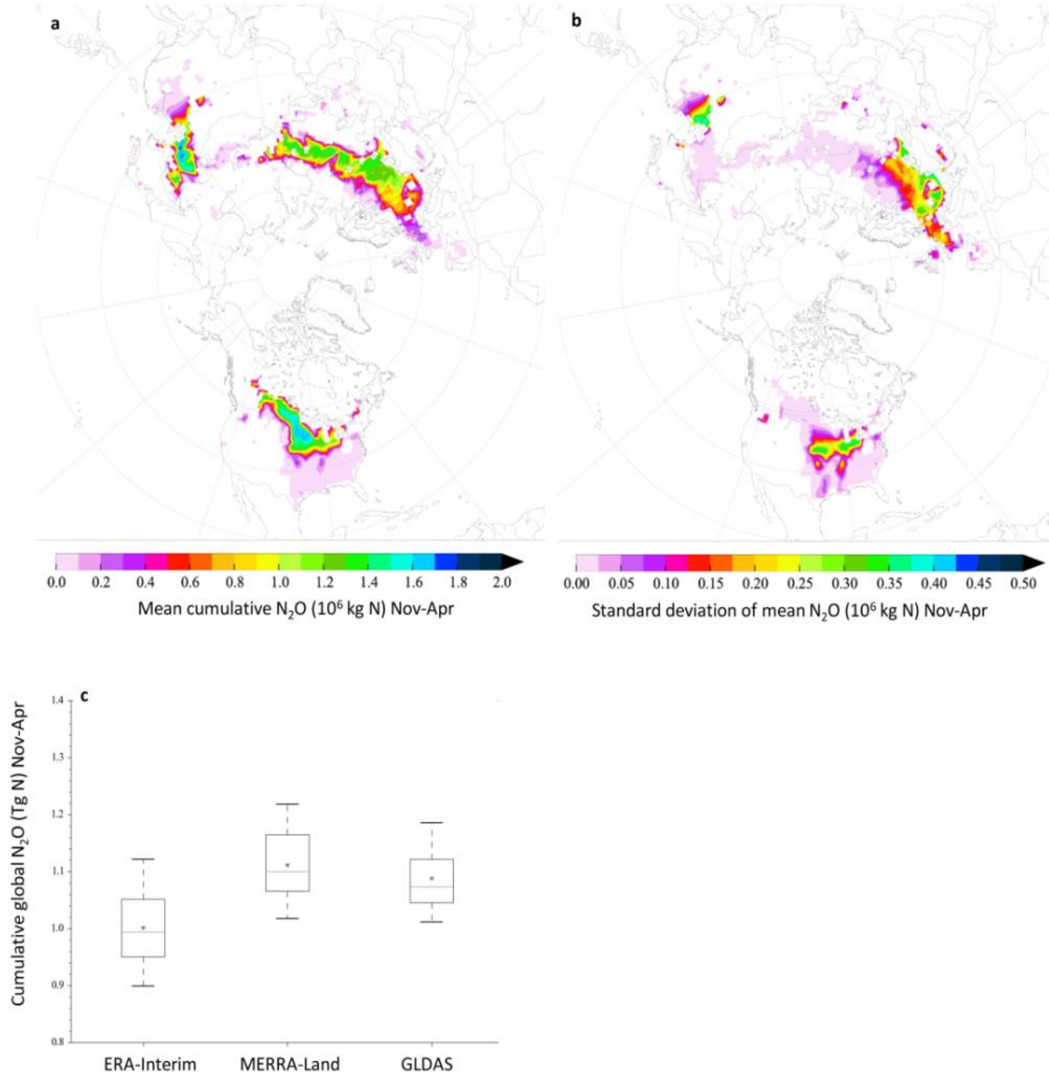


Wagner-Riddle et al. 2017 Nature Geoscience 10, 279–283 (2017)

Importance of Soil Freeze State

- Our analysis shows that seasonally frozen cropland contributes an average 1.07±0.29 Tg N_2O-N annually to the global anthropogenic N_2O budget. This translates to a 23-39% underestimate of total global agricultural N_2O emissions

- There is significant variation in the global estimate based on the freeze-thaw representation in global reanalysis products (and their associated land surface models)



Wagner-Riddle et al. 2017

Validation of the Soil Freeze Thaw State: Context

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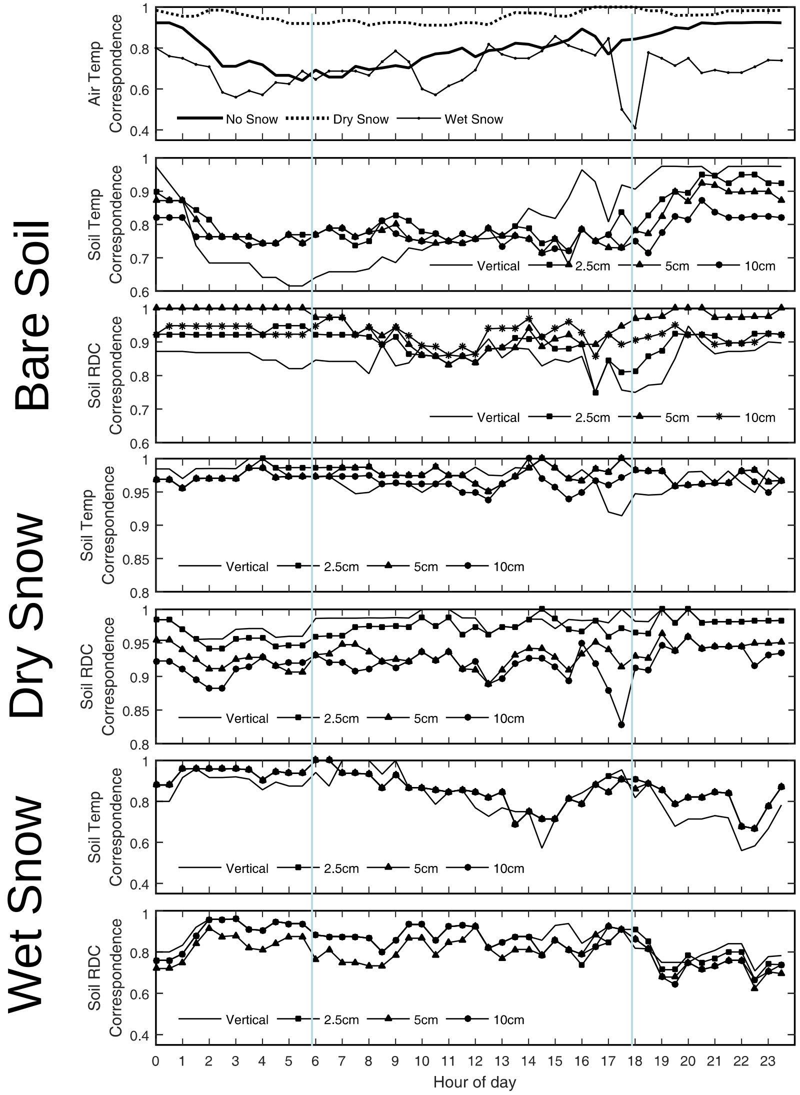
- We are attempting to evaluate and improve the observation of the soil freeze thaw state from SMAP (in Collaboration with Derksen, Toose, Roy, Royer)

- Using ground-based radiometer what the optimal ground-based sensing depths and measurement types for validation efforts?

L-band radiometer observing soil freeze thaw state near Saskatoon, Saskatchewan

Williamson et al. in prep; Williamson et al. 2017; Roy et al. 2017

Validation of the Soil Freeze Thaw State: Results



Correspondence among ground-based soil freeze thaw indicator and L-Band radiometer estimate (using the seasonal threshold algorithm)

Air Temperature (top panel) good proxy under dry snow conditions, however very poor under wet or bare soil.

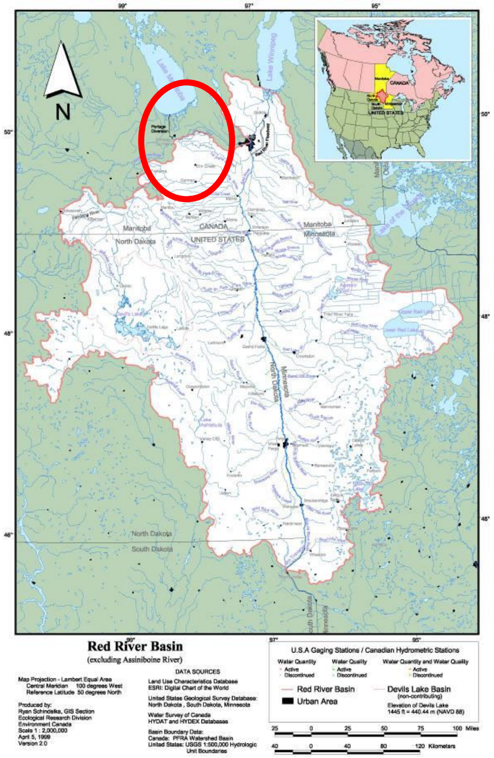
Under Bare soil conditions, soil dielectric measurements (near but not at surface) correspond most closely

Under dry snow conditions, soil temperature measurements near surface correspond most closely

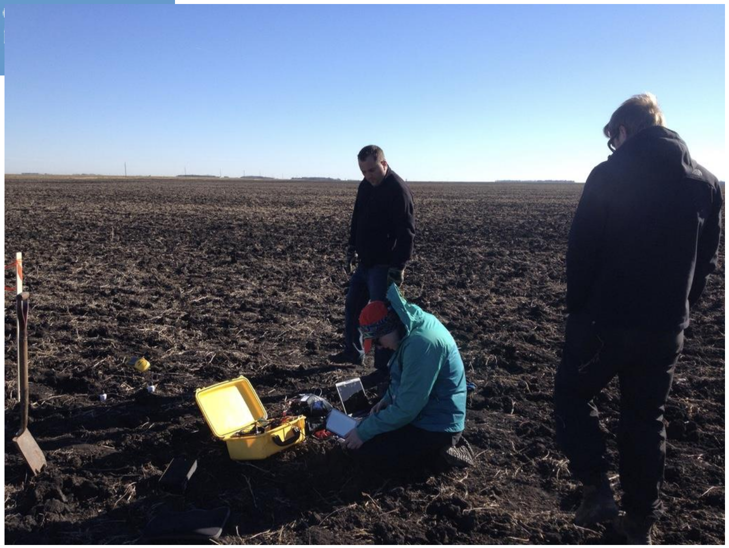
Under wet snow both soil temperature or soil dielectric are similar, both greatly exceed air temperature proxy

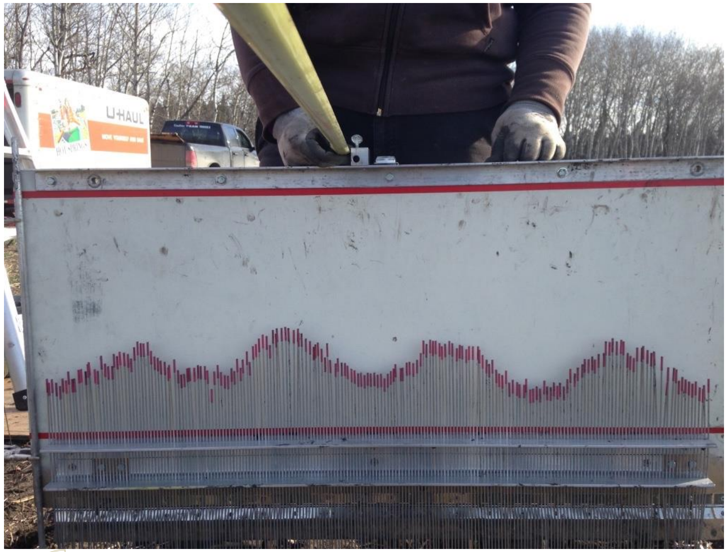
Soil Freeze Thaw SMAP Experiment

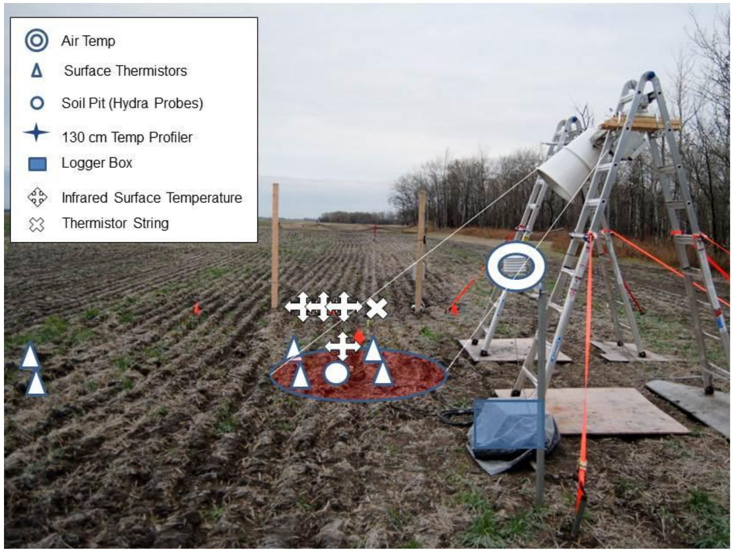
- October 28-November 11, 2015 we conducted a freeze thaw SMAP experiment near Carmen, Manitoba
- Morning and afternoon flights of NASA's King-Air aircraft carrying their Scanning L-band active passive sensor (SLAP)
- Ground crews observing freeze/thaw state (temperature), soil freezing state and soil moisture



Detection of Soil Freeze State







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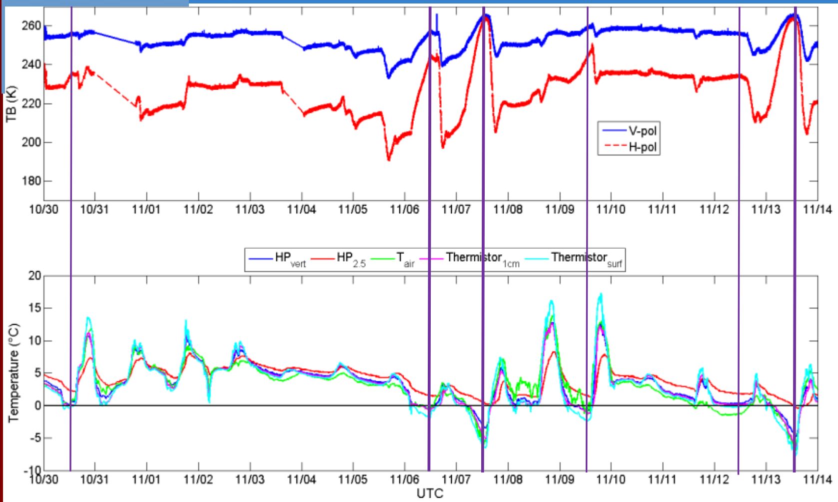

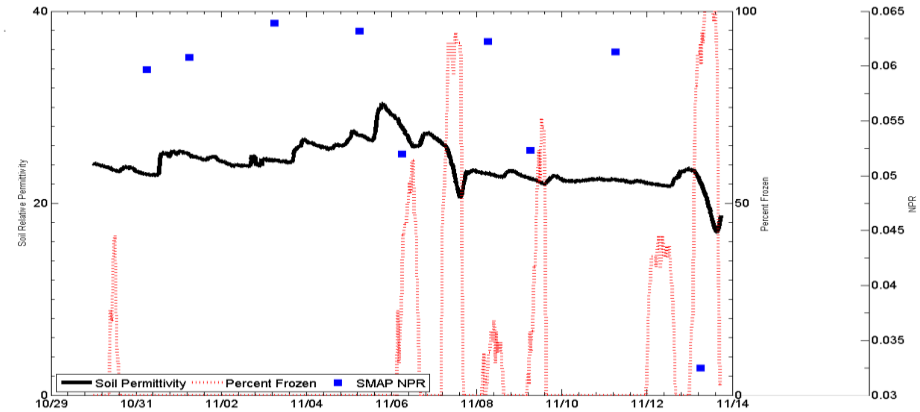

- Preliminary results demonstrate several full or partial freeze thaw events
- The ground radiometers show high-sensitivity to diurnal F/T events for near surface freezing
- SMAP responds to both partial and full freeze events

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Final Notes

- Poor correlation with ground observations may be related to scaling of validation estimates, at time of high variance the uncertainty of the upscaled estimate is low
- Use of SMAP products at high latitude is cautioned however retrieval on polar grid should be attempted
- Soil freeze validation should not be conducted using air temperature if bare soils or wet snow is likely
- SMAP shows high sensitivity to soil freeze conditions under both partial and total freeze of the pixel

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