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Cartel Centre d'applications et de recherches en télédétection

UNIVERSITÉ DE SHERBROOKE

Analysis of SMAP data retrieval for soil temperature under snow cover

Alexandre Roy, PhD student

Team: Pr. Alain Royer, Alexandre Langlois

Students: Nicolas Marchand, Benoit Montpetit, Florent Dupont

Collaborators: Ludovic Brucker[1], Chris Derksen[2], Ghislain Picard[3]

1: NASA-GSFC; 2: Climate Res. Div., EC; 3: LGGE-UJF, Grenoble

Outline

- Background
  - Why the soil temperature under snow is important?
  - Passive Microwave and temperature under a snowpack
  - Soil temperature inversion
- SMAP T_B Modelling
  - DMRT-ML model
  - Sensitivity to soil temperature under snow
  - Effect of vegetation
- Experimental results at 10.7 GHz (AMSR-E)

- Perspective for SMAP assimilation

Background (1/3)

Why soil temperature under snow?

- Important for daily estimates of surface energy balance = *f*(Tsoil)
- Related to thawing permafrost (active layer thickness, ALT)

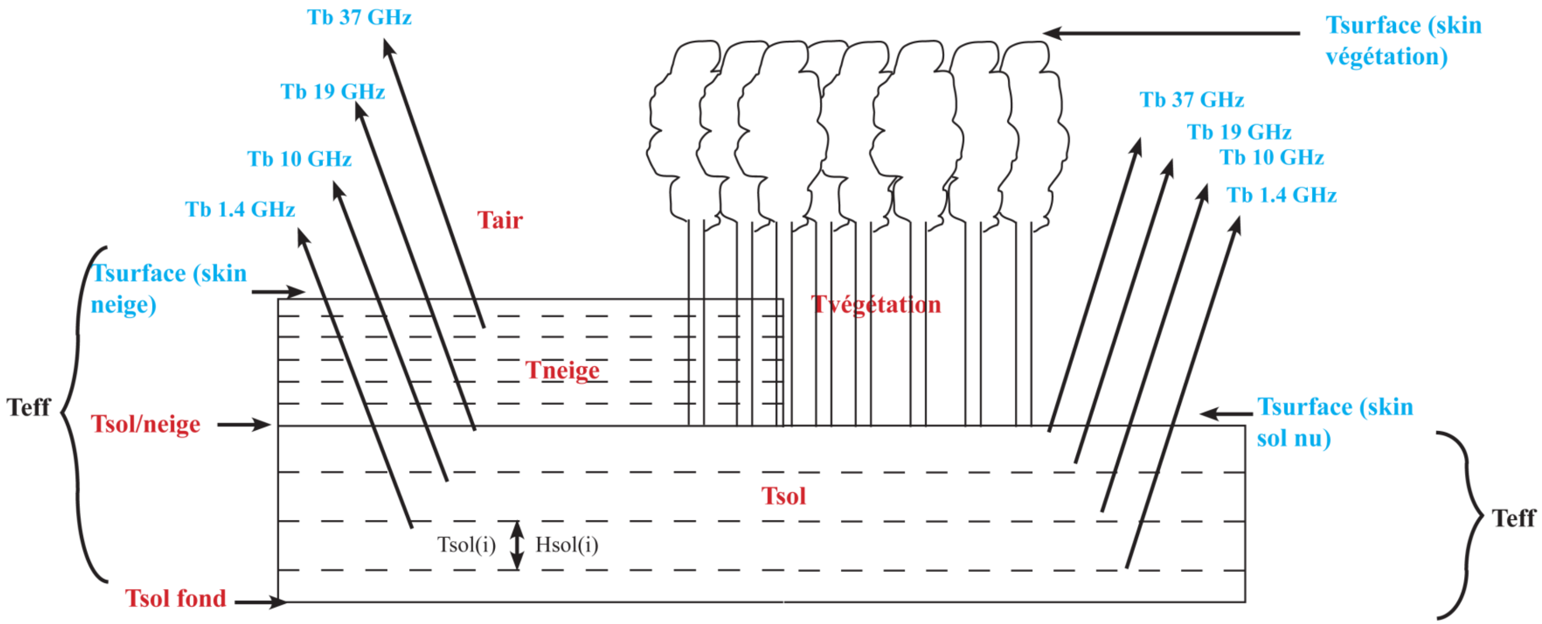
  ALT ~ (Thawing Degree-Days)$^{1/2}$ ~ Σ_{year}(Tsoil>0)$^{1/2}$
- Boreal forest soil CH_4 and CO_2 fluxes are controlled by Tsoil

  (Ullah et al., *Can. J. For. Res.*, 2009)
- Gives a Soil Freeze/Thaw product

Background (2/3)

Passive Microwave and temperature under a snowpack

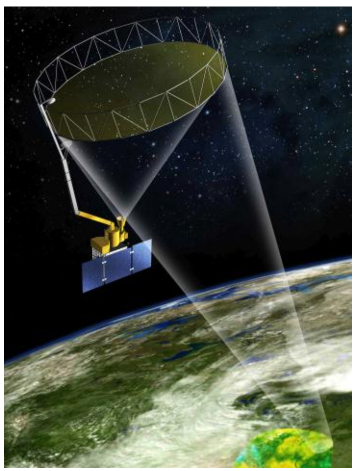
Low frequencies can penetrate the snow and responds to variations from underlying ground properties

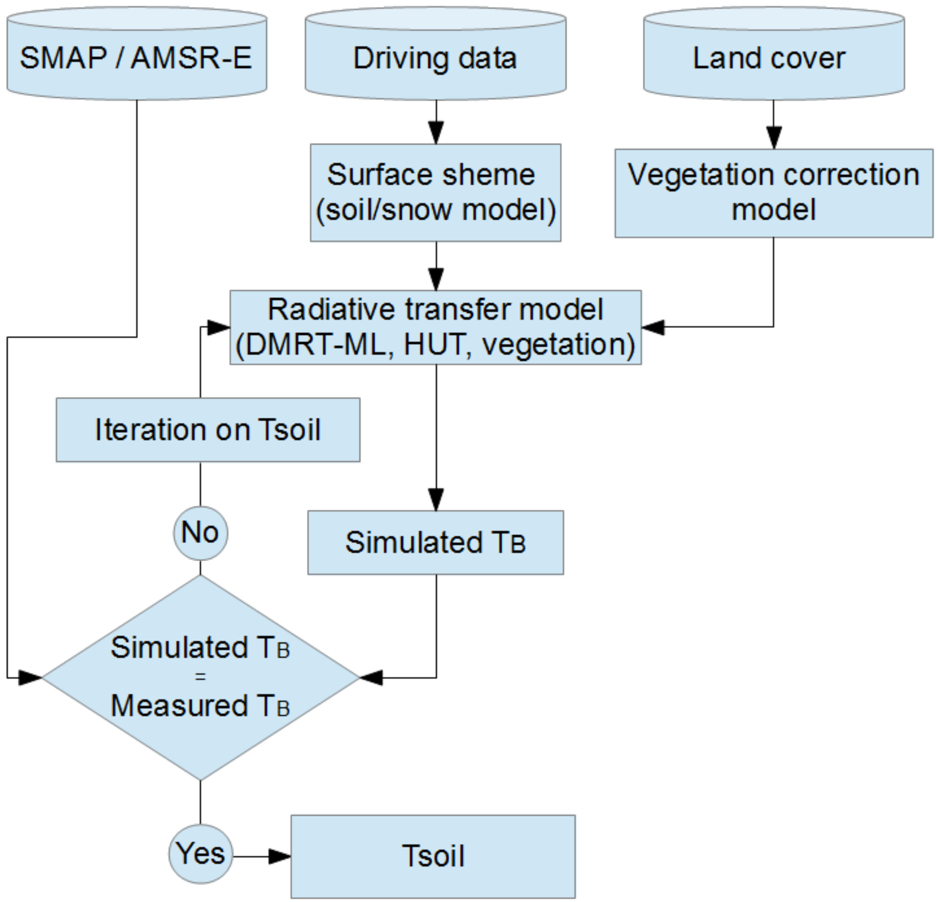


Blue: radiometric temperatures ; Red: physical temperatures

Background (3/3)

Soil Temperature Inversion

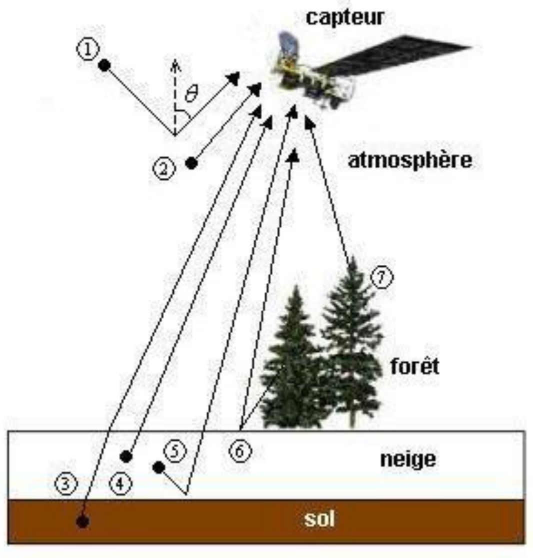




Modelling (1/4)

DMRT-ML model

- Dense media radiative transfer model - multi layered (DMRT-ML) is a physically based microwave emission model (Picard et al., 2013).
- DMRT-ML model requires several parameters to simulate a T_B emitted by snow-soil surface.
- A correction for vegetation must also be considered (τ-ω)

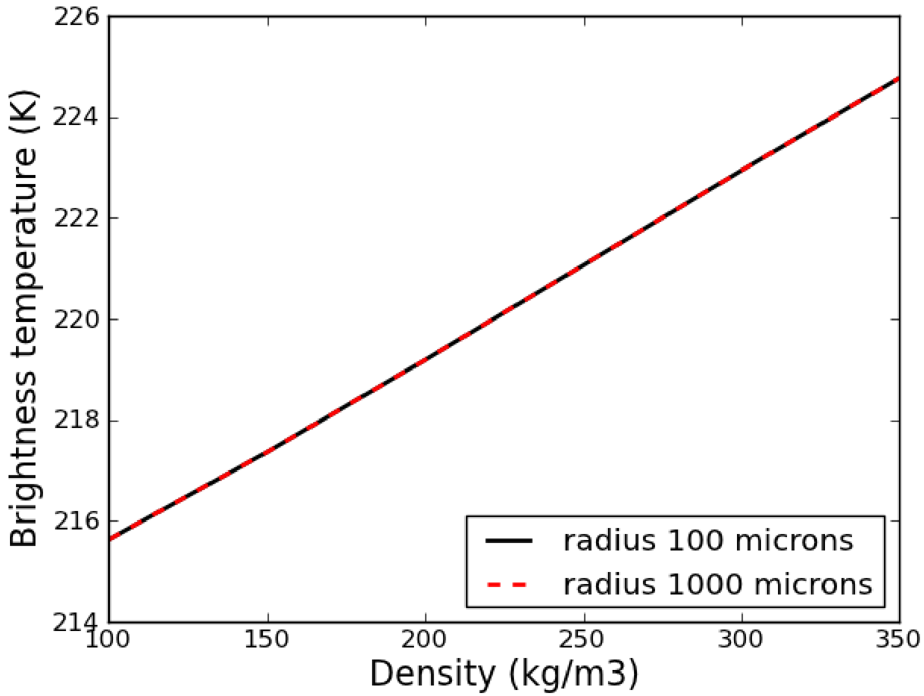


Modelling (2/4)

Low sensitivity to dry snow at 1.4 GHz

- No sensitivity to grain size as well as snow depth (no scattering)
- Low sensitivity to snow density: ~ 4 K / 100 kg m^{-3}

Simulations at 1.41 GHz

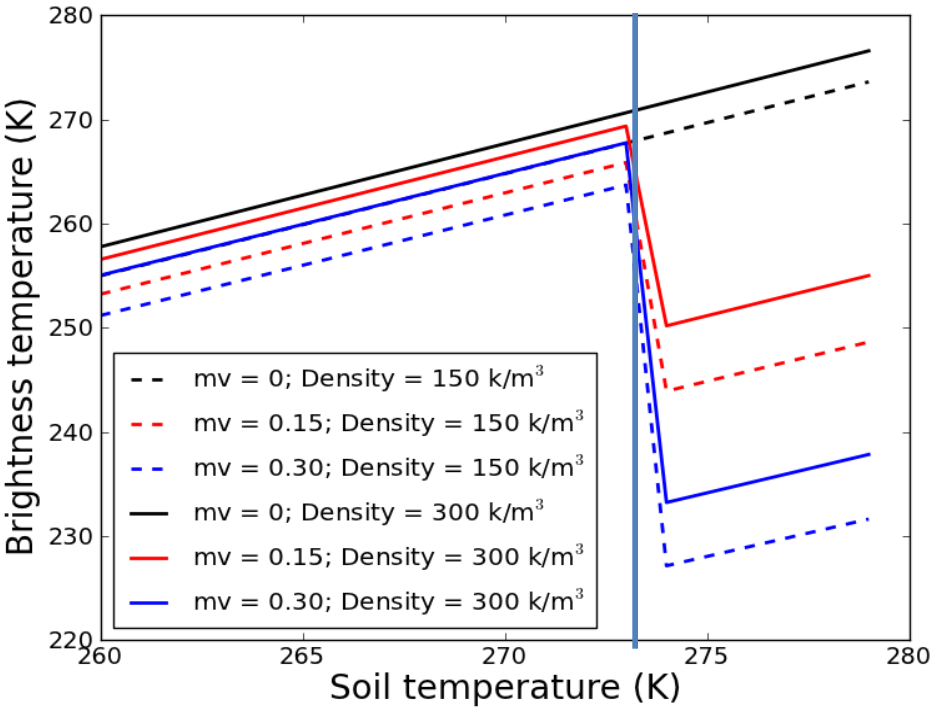


Modelling (3/4)

Sensitivity to soil temperature

- Drastic T_B decrease with water phase changes (273 K)
- Low sensitivity to moisture volume (mv) when the soil is frozen
- Low sensitivity to snow

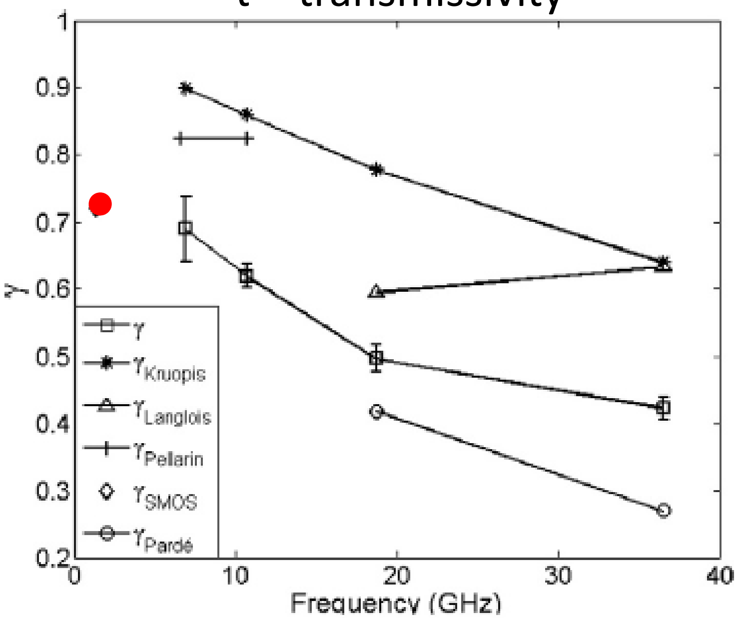
Simulations at 1.41 GHz



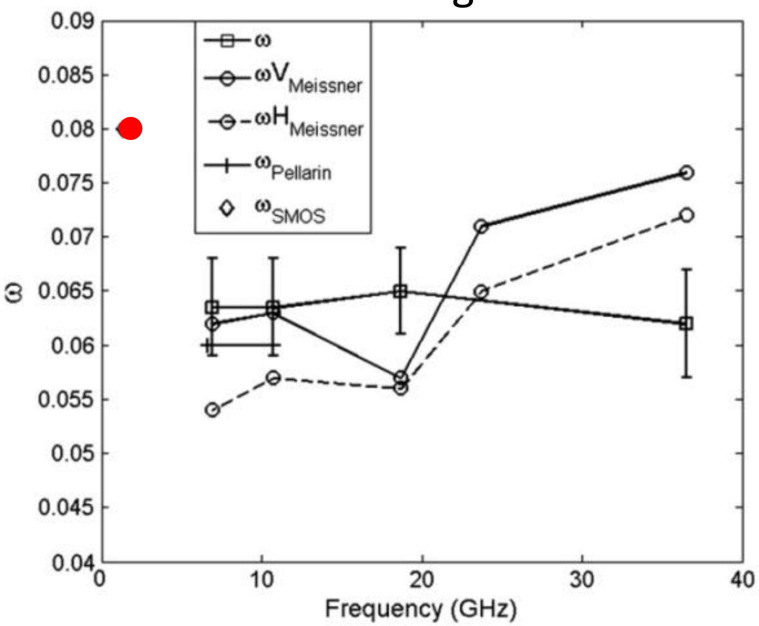
Modelling (4/4)

Vegetation correction (τ-ω) for spaceborne applications

τ = transmissivity



ω = scattering albedo



Roy et al., RSE, (2012)

Experimental results (1/3)

Method

- Inversion algorithm for the estimation of surface soil temperature using AMSR-E satellite data (10.7 GHz)
- Coupling of snow-soil model SNTHERM with radiative transfer model (HUT) for the simulation of T_B.

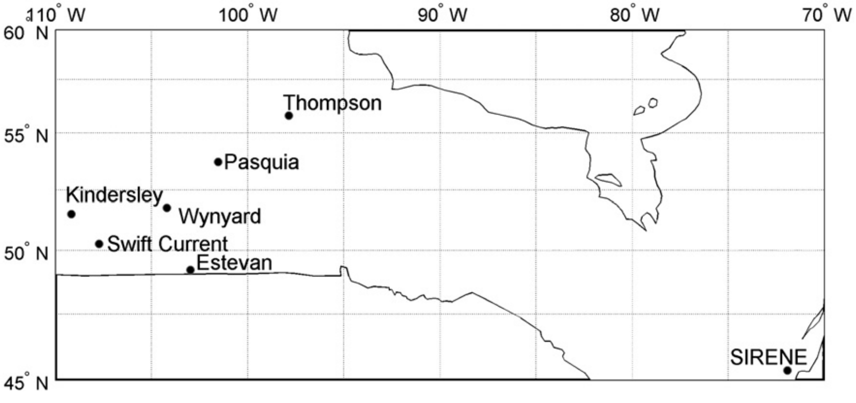


Fig. 2. Location of the different reference stations in Canada (see Table 1).

Kohn and Royer, RSE, 2010

Experimental results (2/3)

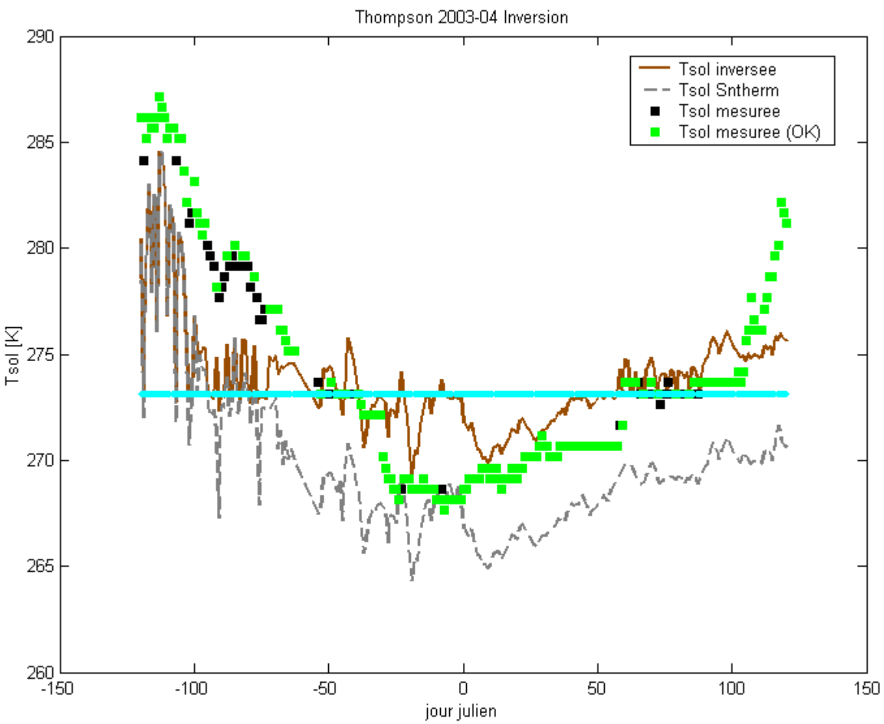
AMSR-E inversion results

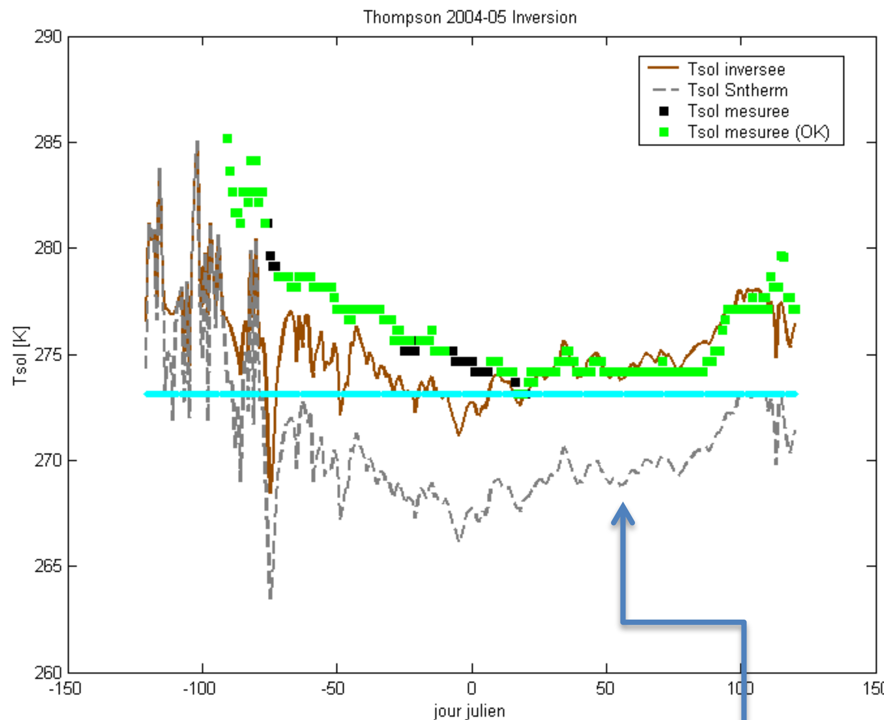
Brown: Inverted Tsoil (AMSR-E)

Gray : SNTHERN alone

Green dots : Measured Tsoil (well diagnosed)

Black dots : Measured Tsoil (not well diagnosed)



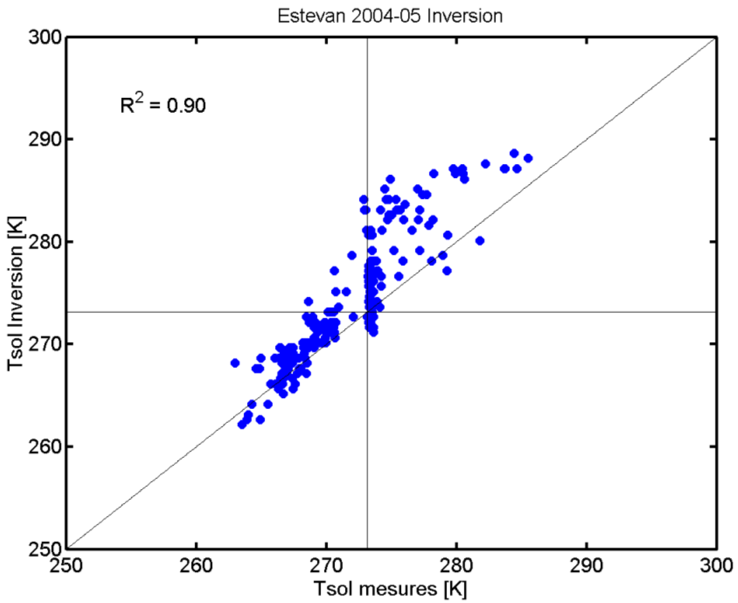


Unfrozen soil well diagnosed with satellite data inversion but not by the model.

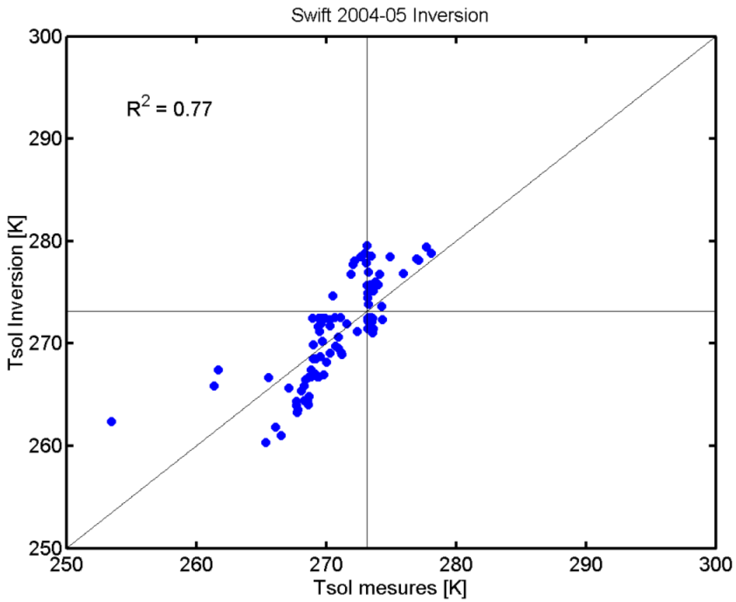
Experimental results (3/3)

AMSR-E inversion results

Correlation between retrieved and observed soil temperatures



Station *Estevan*
R^2 =0.90



Station *Swift*
R^2 =0.77

Frost detection probability = 0.86

Perspective for SMAP

- Use of AMSR-E 10.7 GHz for soil temperature and frost retrieval.
- SMAP 1.41 GHz should be more sensitive to soil temperature under snow.
- Ground-based radiometric measurements will help to improve the models.
- Actual work on coupling DMRT-ML with Canadian Land Surface Scheme (CLASS) for permafrost monitoring using AMSR-E.
- Blended Active/Passive Freeze/Thaw.

Thanks for your attention