Soil moisture retrieval from SMAPVEX12 and SMAPVEX16-MB data

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Outline

- **Context**

- **Results from recent investigations with SMAPVEX12 data**
  - Empirical soil moisture retrievals over wheat fields;
  - Polarimetric soil moisture retrievals;

- **Current works on SMAPVEX12 and SMAPVEX16-MB data**

Context

Project designed in the context of the Canadian science plan for SMAP mission

Financial partners:

Canadian Space Agency (CSA)

Natural Sciences and Engineering Research Council of Canada (NSERC)

Collaborators:

Environment Canada (EC)

Agriculture and Agri-Food *Canada (AAFC*)

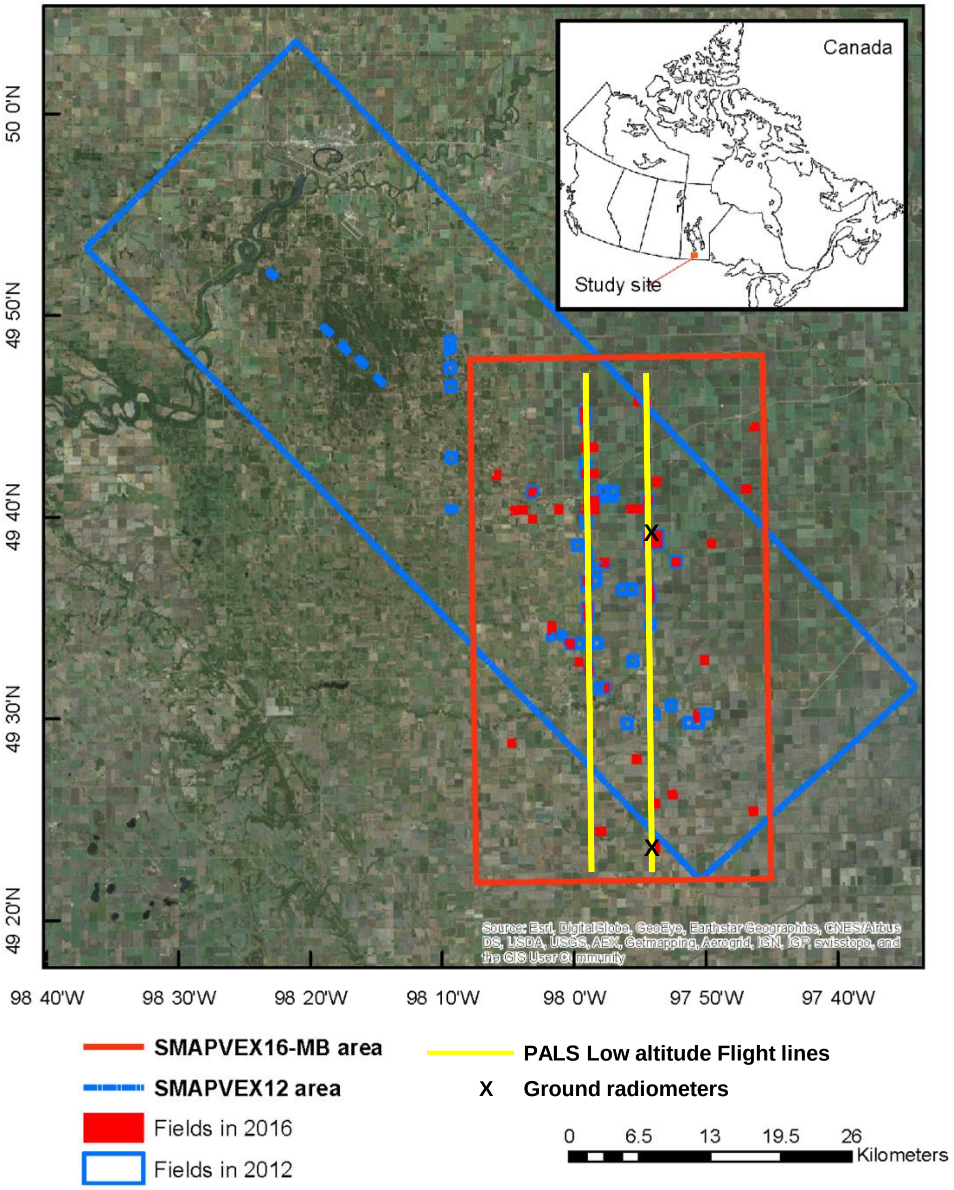
University (Sherbrooke, Manitoba, Guelph)

National Aeronautics and Space Administration (NASA), USDA, JPL

CESBIO, France

DLR Microwaves and Radar Institute, Germany

Study area and data



SMAPVEX12 and SMAPVEX16-MB fields

Collection of ground (soil and vegetation) data

network data (SM and temp.)

L-band radiometers

airborne PALS data

airborne UAVSAR data (2012 only)

satellite data

Empirical soil moisture retrievals over wheat fields from RADARSAT-2 data

Empirical Soil moisture estimation over wheat fields from RADARSAT-2

- Multiple linear regressions

$$m_v = \beta_1 X_1 + \cdots + \beta_i X_i + \cdots + \beta_p X_p + \beta_0 + \epsilon$$

1) **Consider all the variables X_i (incoherent + coherent)**
2) **Reduce the dimension by using only selected non-correlated variables**
3) **Use stepwise regression**

Empirical Soil moisture estimation over wheat fields (cont.)

- Results from SMAPVEX12

Model	Nb of fields	Nb of Observations	R^2	RMSE (m^3/m^3)	Variables	β	p-value
4	8	60	0.598	0.078	σ^0_{HH}	0.107	0.000
					σ^0_{HV}	-0.117	0.000
					σ^0_{VV}	0.057	0.005
					ϕ_{HH-VV}	-0.003	0.000
					Hs	2.072	0.000
					A	-1.637	0.008
5	8	60	0.510	0.084	**(Intercepte)**	0.662	0.000
					σ^0_{HH}	0.036	0.000
					ϕ_{HH-VV}	-0.004	0.000

Polarimetric soil moisture retrievals

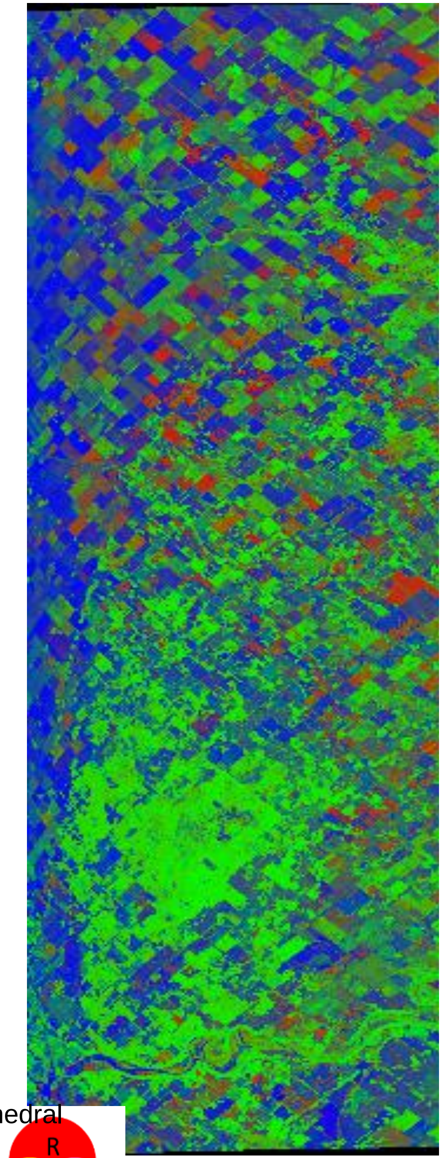
Polarimetric soil moisture retrievals

- **Compare** 3 model-based polarimetric decompositions (Freeman-Durden, Hajnsek and An) for soil moisture retrievals from L-band UAVSAR data;

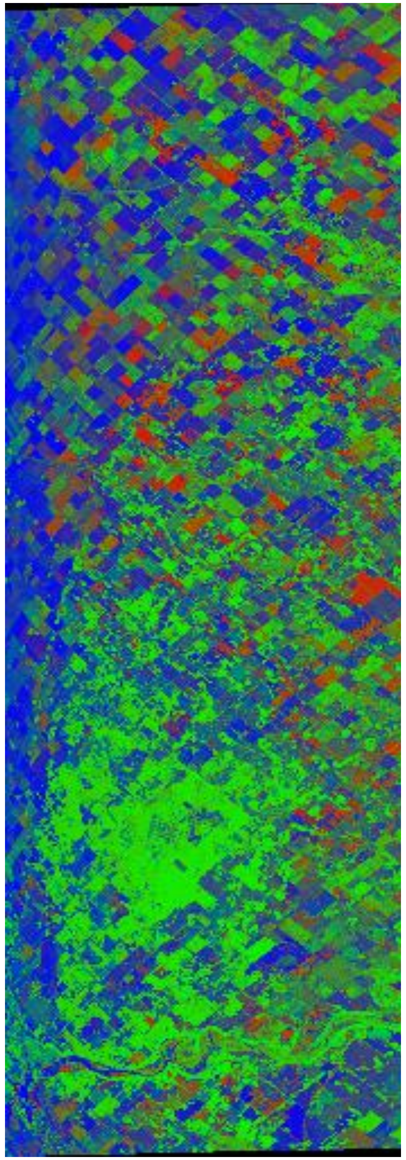
- Apply the best approach to **Multi-angular UAVSAR**

Comparison of 3 polarimetric methods : RGB composite of scattering powers

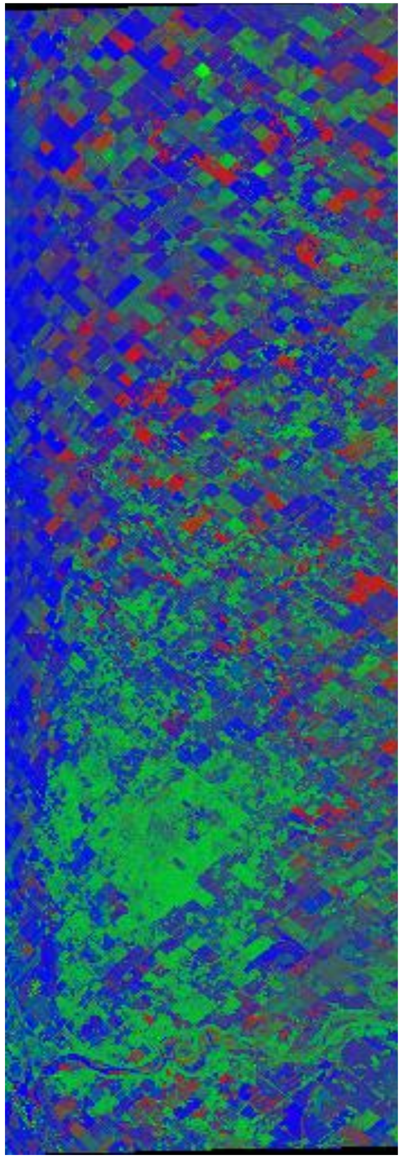
Freeman-Durden



Hajnsek

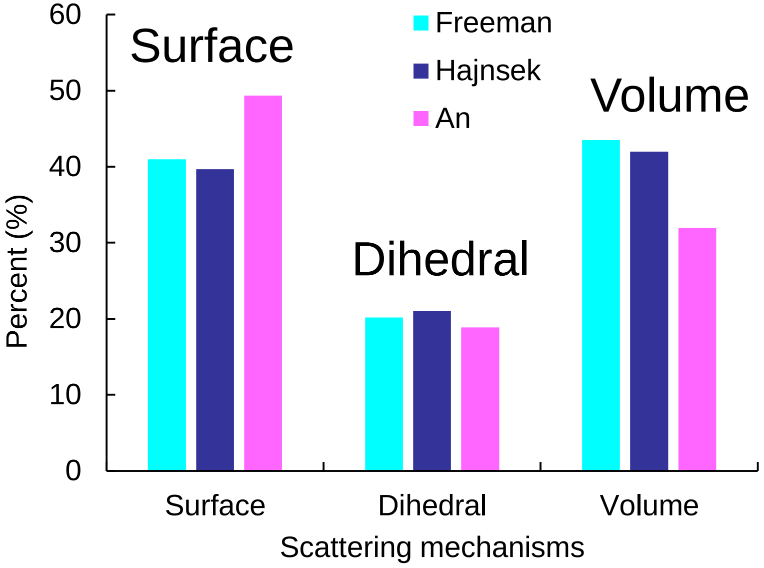


An



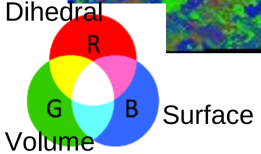
Classified Image

2012-06-17



Legend

- Agricultural sampling points
- Forest sampling points
- Canola
- Corn
- Soybean
- Wheat
- Pasture
- Forest
- Other crops



More surface scattering power in An decomposition

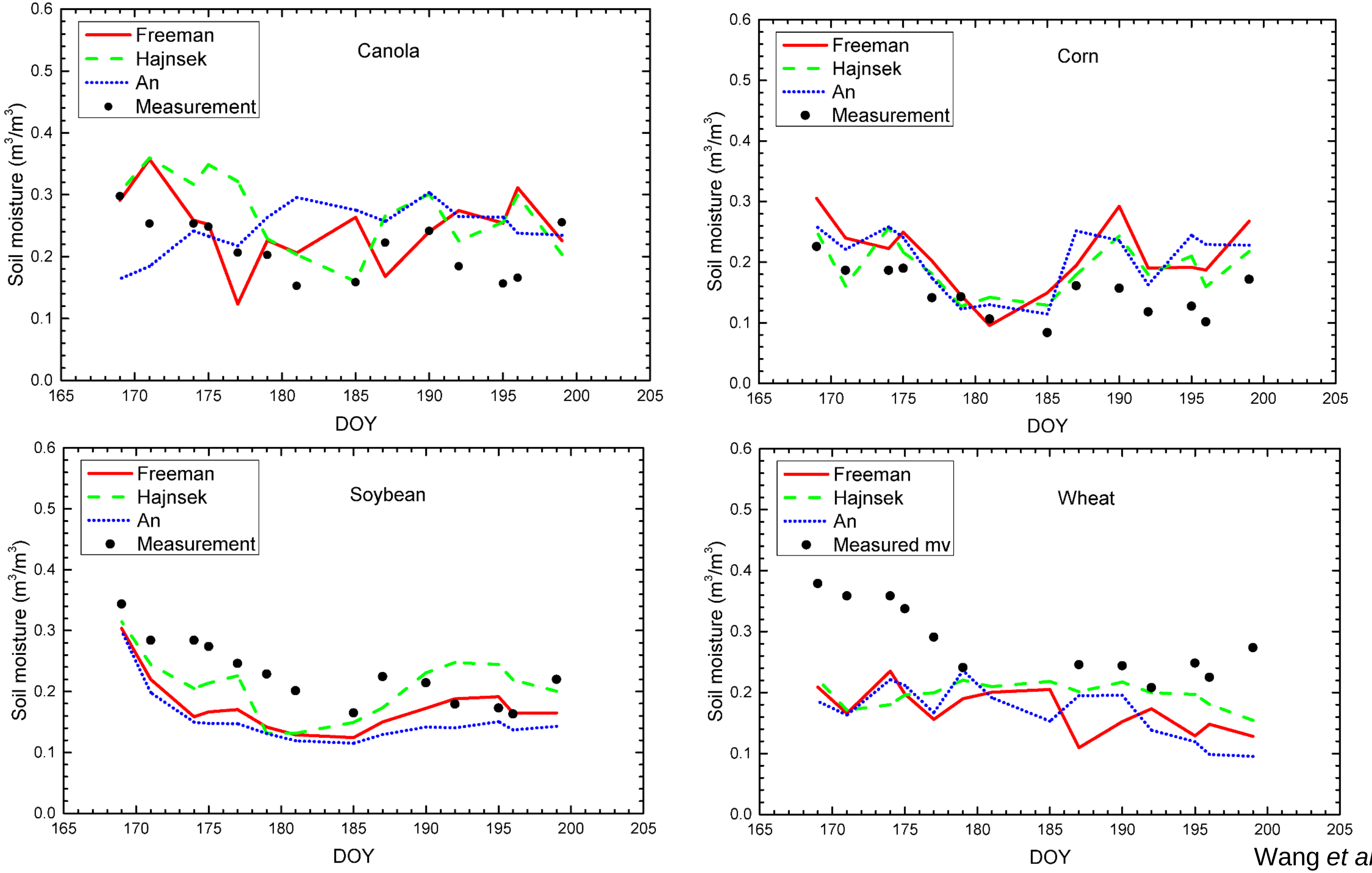
Wang *et al*. 2016 IEEE GRSL

Wang *et al*. 2016 Remote sensing

Wang *et al*. 2017 RSE (under review)

Comparison of 3 polarimetric methods (cont.)

Results of soil moisture retrieval from the dominant surface or dihedral scattering component



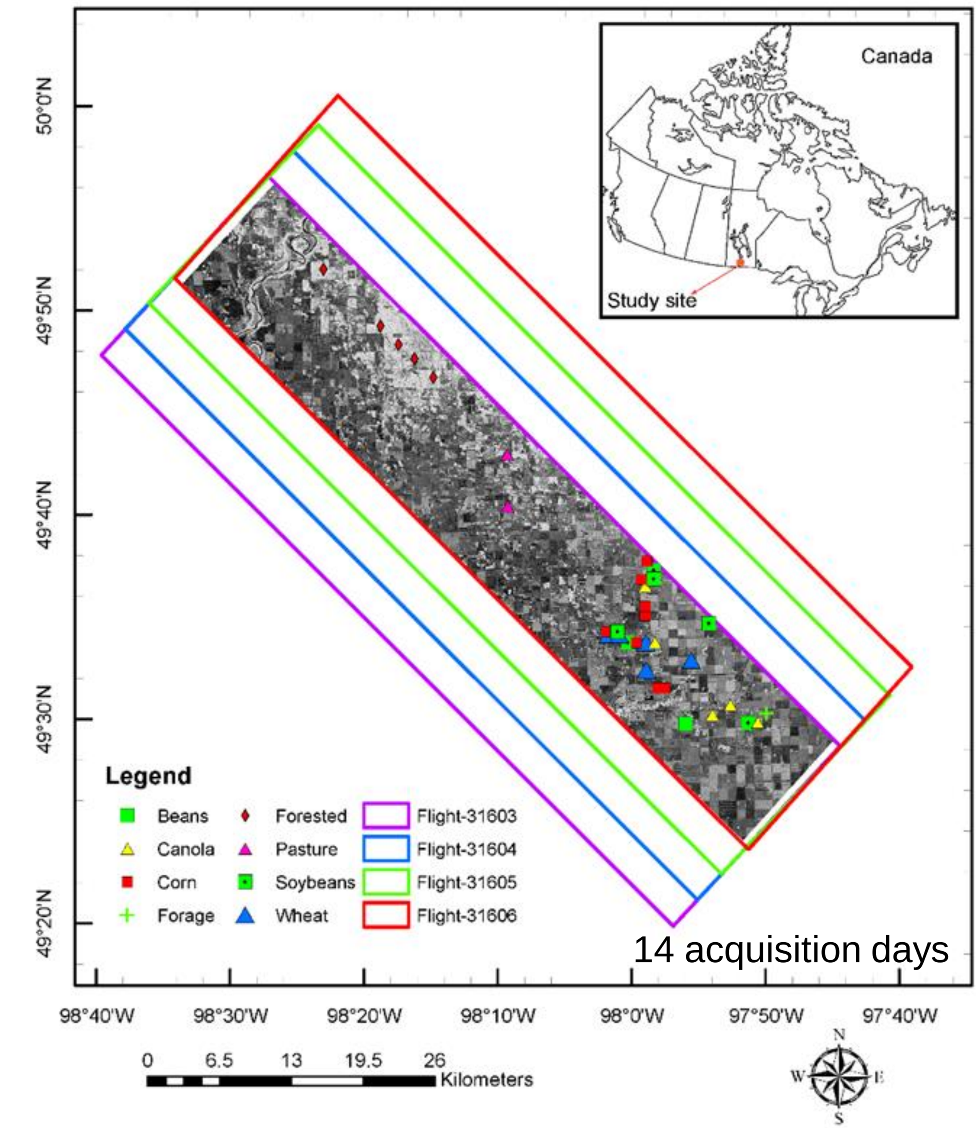
Wang *et al*. 2016 IEEE GRSL

Wang *et al*. 2016 Remote sensing

Wang *et al*. 2017 RSE (under review)

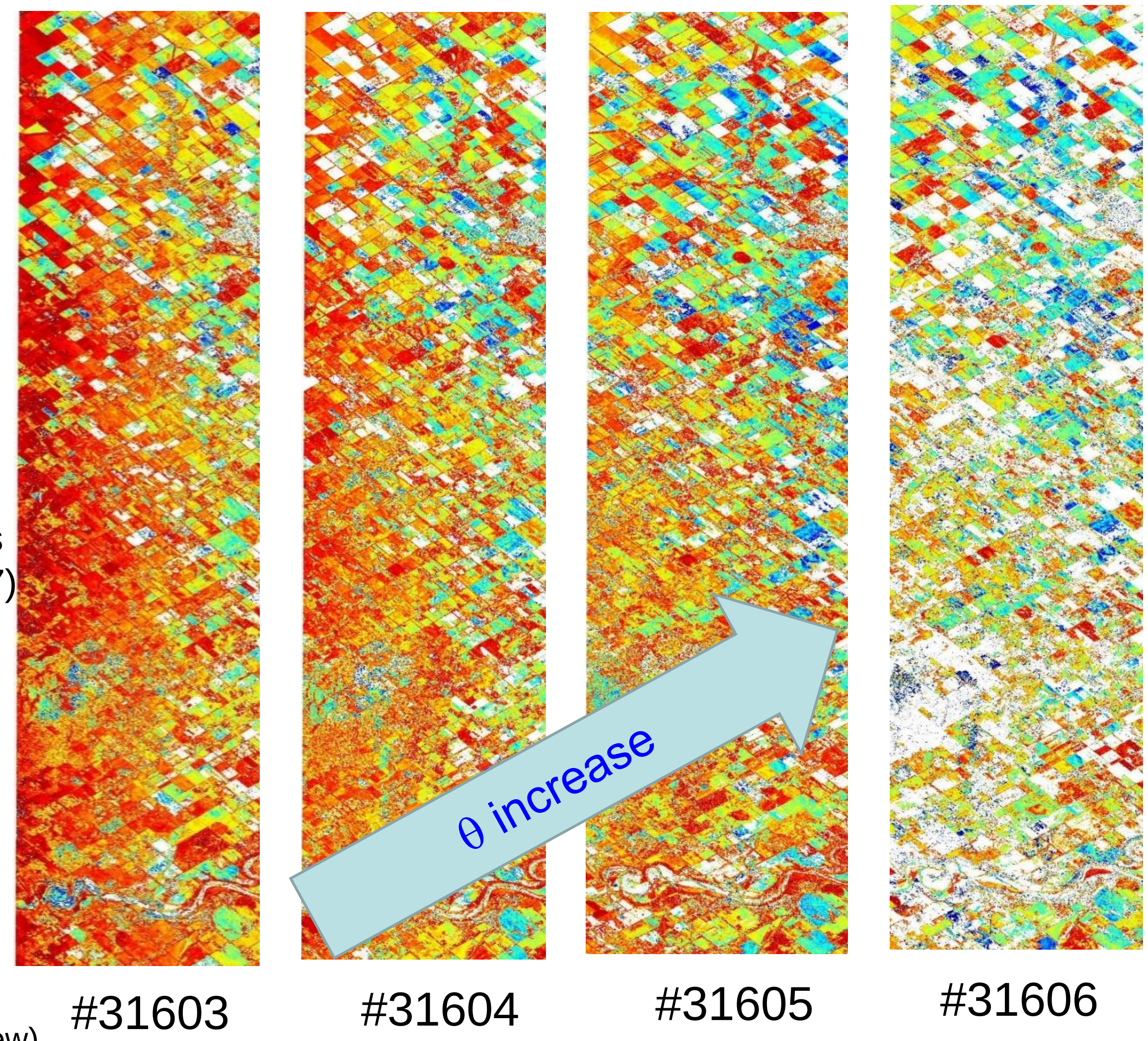
Best retrieval with Hajnsek method

Polarimetric decomposition of Multi-angular UAVSAR data



Flight lines
(2012-06-17)

Surface scattering component



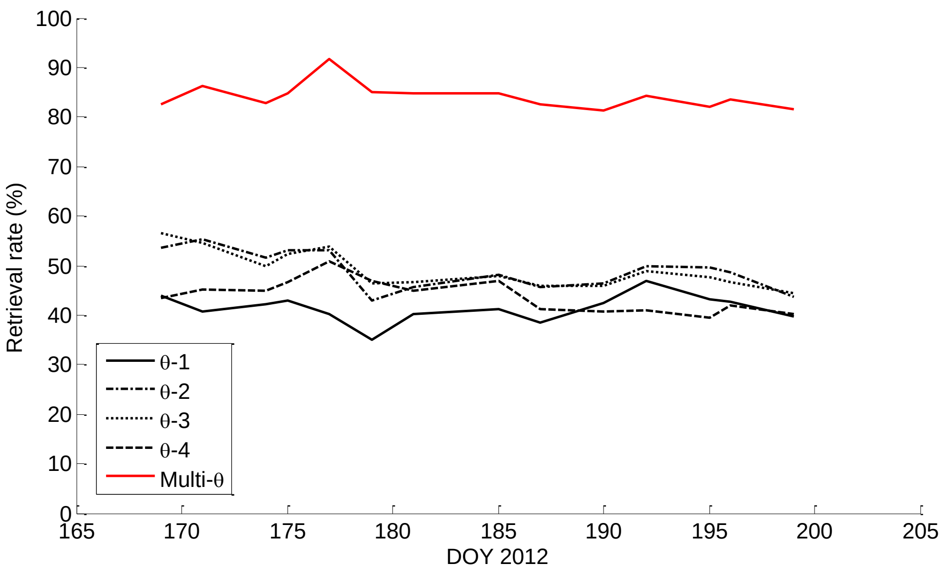
Wang *et al*. 2016 IEEE GRSL

Wang *et al*. 2017 IEEE TGRS (under review)

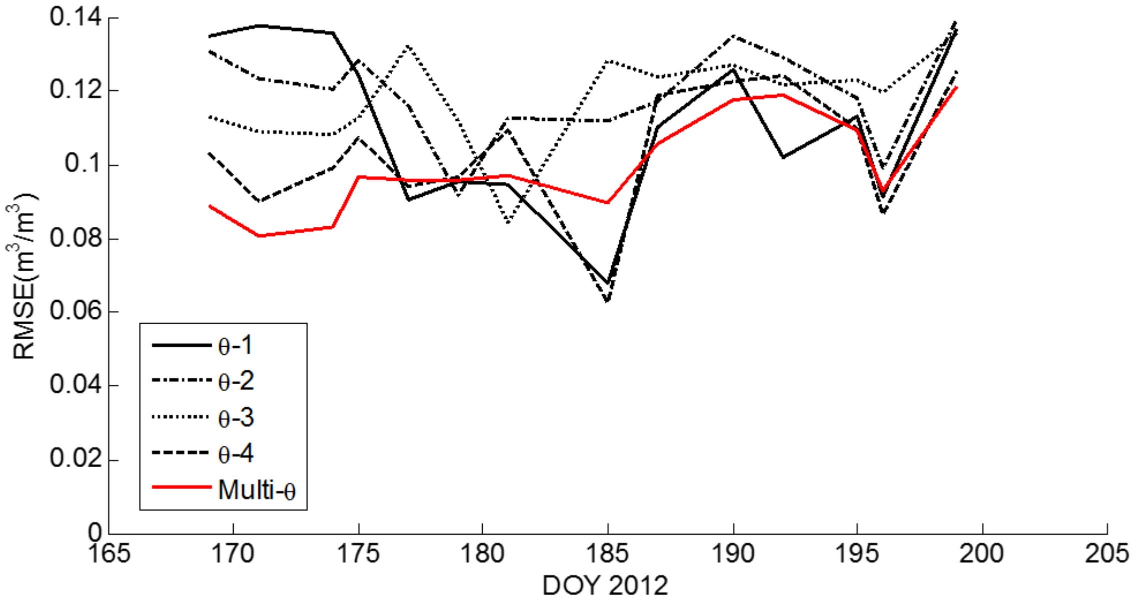
Polarimetric decomposition of Multi-angular UAVSAR data (cont.)

- Results

Retrieval rate



RMSE



Multi-incidence angle ➔ **increases the retrieval rate and decreases the RMSE**

Wang *et al*. 2016 IEEE GRSL

Wang *et al*. 2017 IEEE TGRS (under review)

Current works with SMAPVEX12 and SMAPVEX16-MB data

Preliminary analyses

SMAPVEX 12 & 16-MB PALS TB (Low altitude) to soil moisture

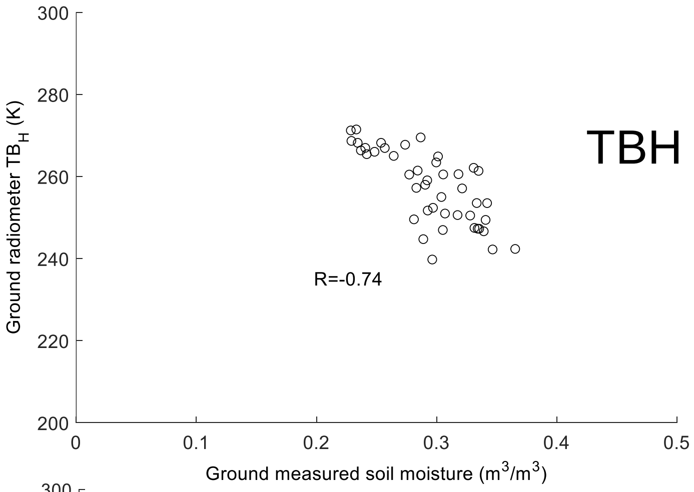
→ **Objective : Understand the effects of soil and vegetation conditions on TB for soil moisture retrieval**

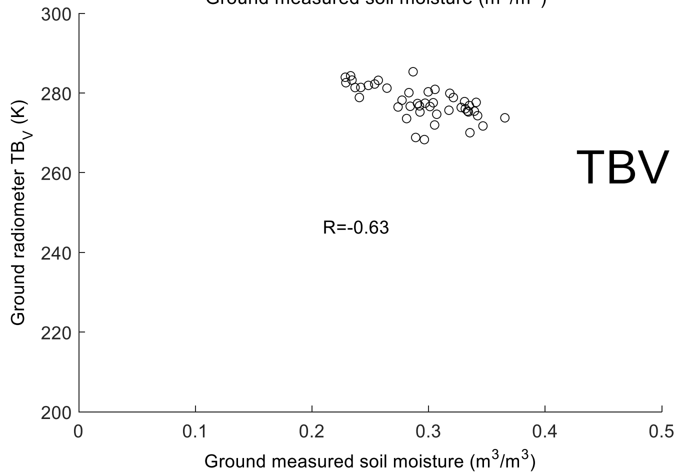
Field campaigns	**Data analyses**
SMAPVEX16-MB	**L-band Radiometers :** **Ground *vs* soil moisture** **Ground *vs* low altitude PALS** **Low altitude PALS *vs* soil moisture**
SMAPVEX12 and SMAPVEX16-MB	**Comparison of low altitude PALS**
	Modelling results

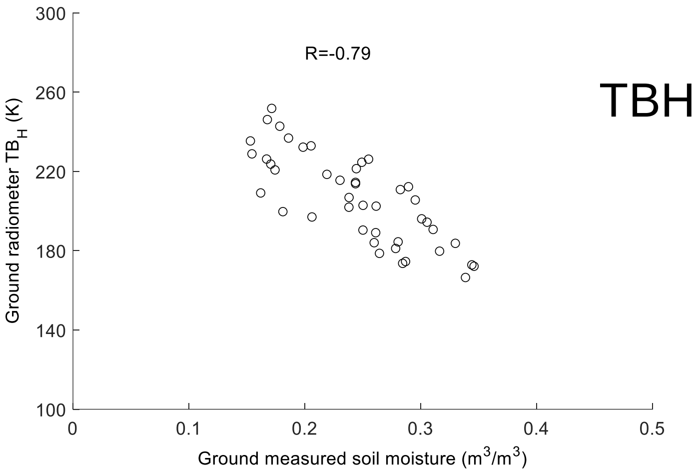
Ground radiometer TB versus soil moisture

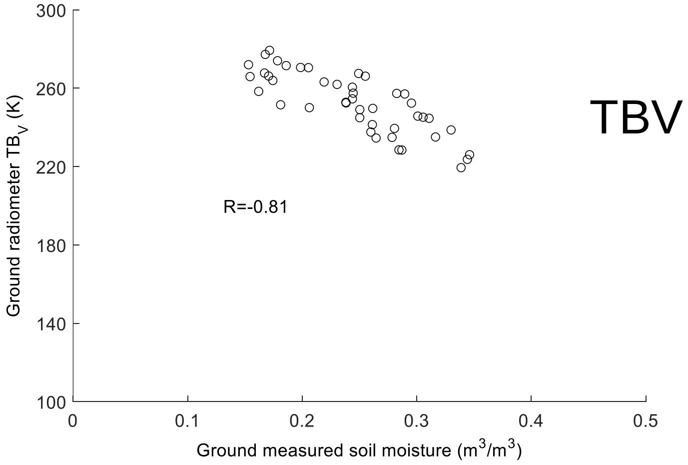
- Field #105: Wheat

Field #202: Canola (Low vegetation)





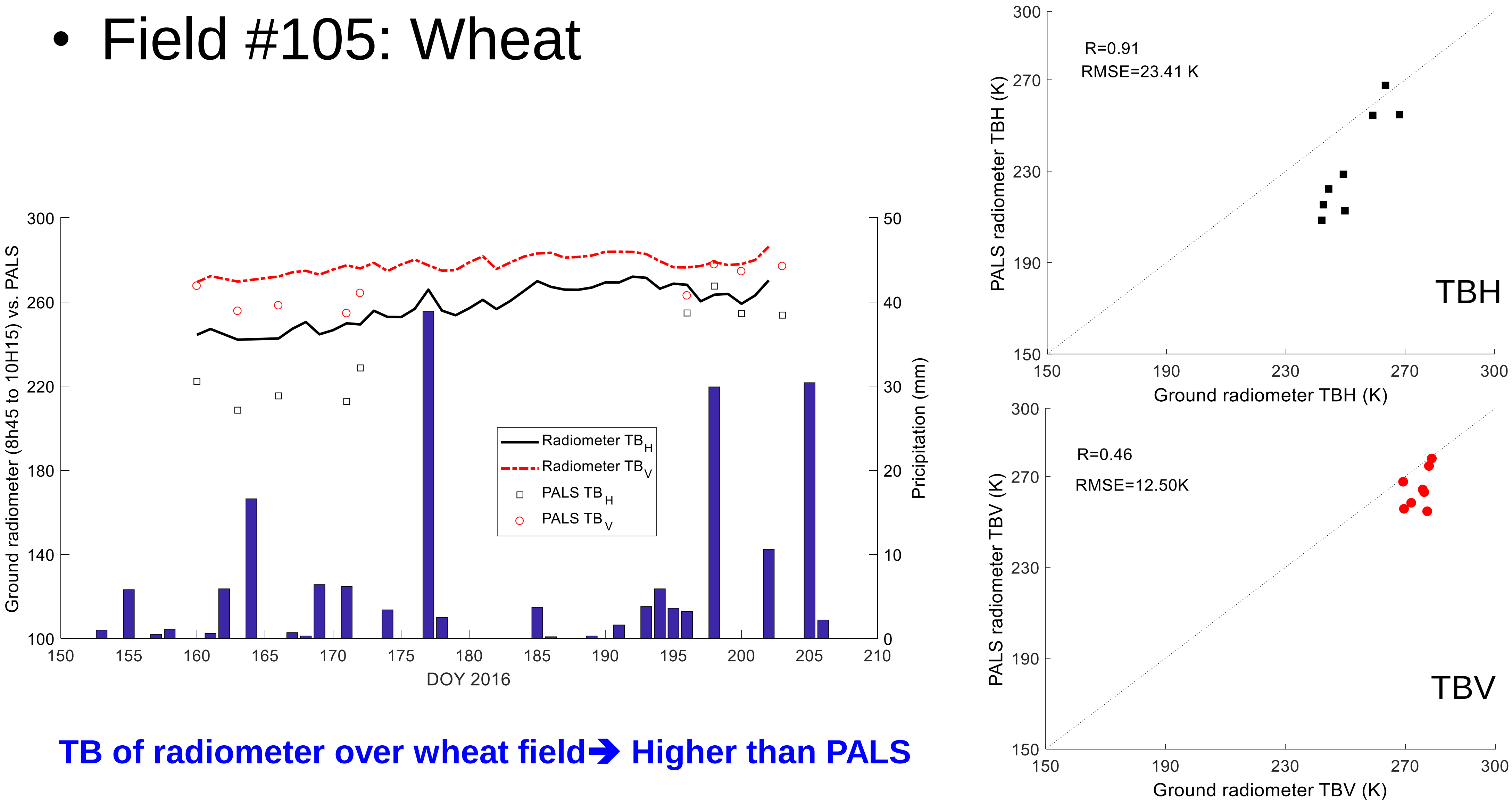




Less vegetation over Field #202➔ Higher sensitivity to soil moisture

Ground radiometer versus PALS

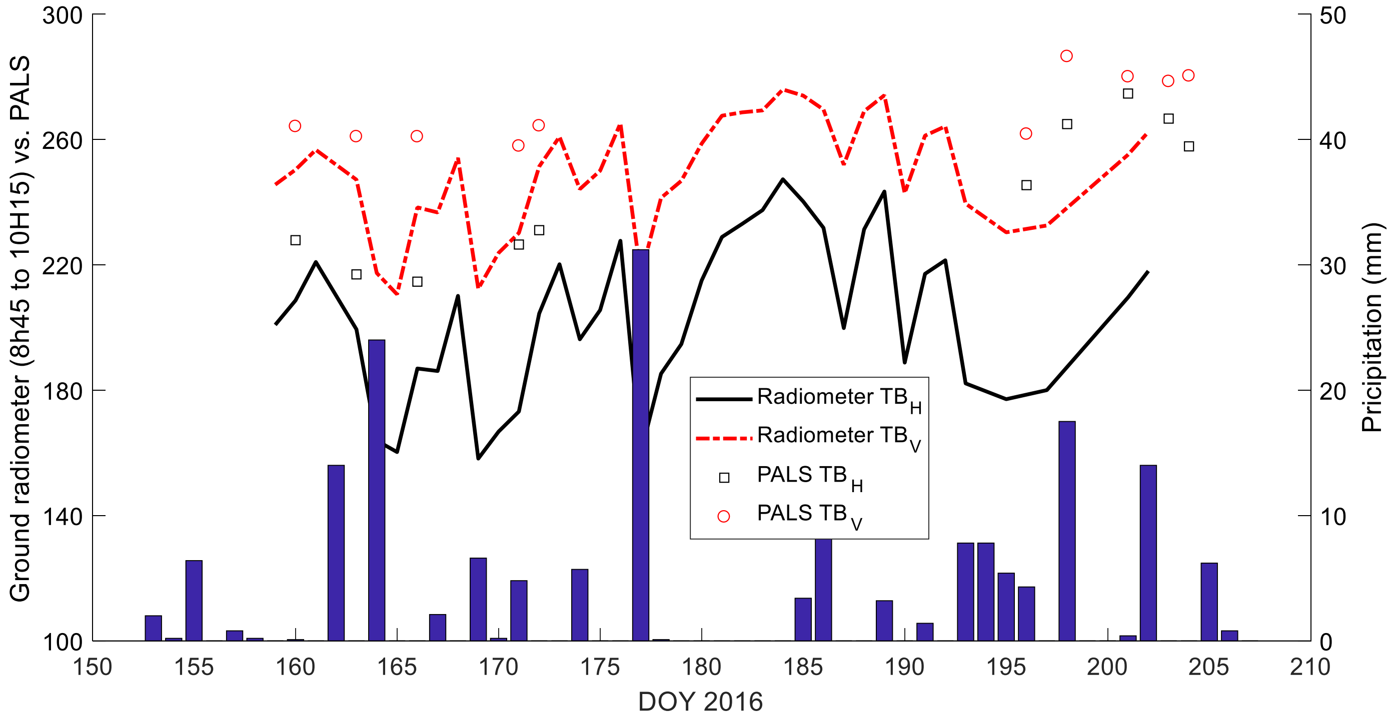
- Field #105: Wheat

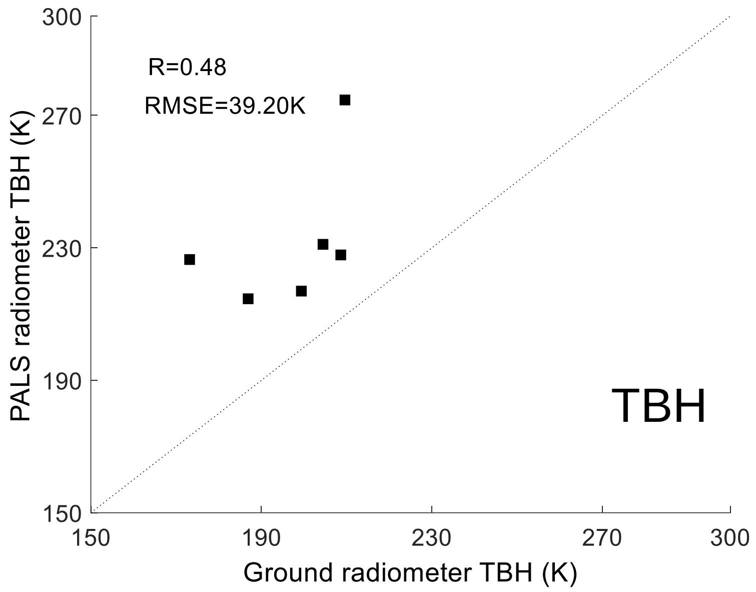


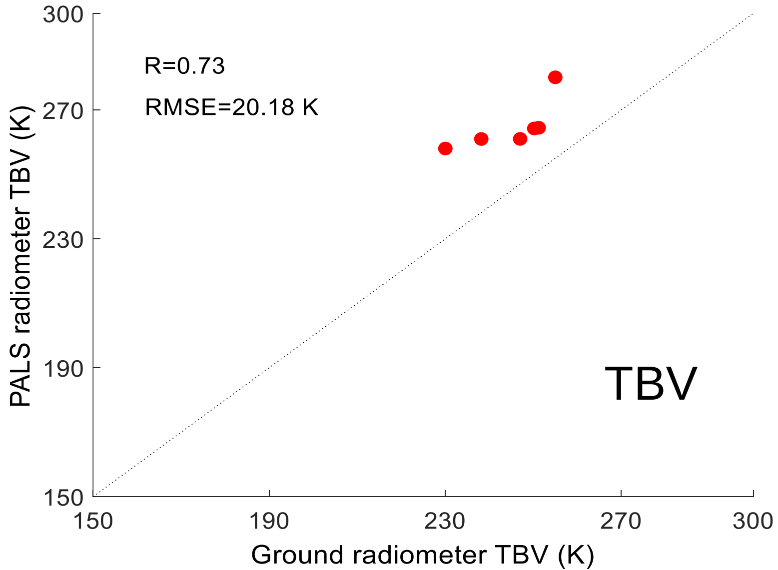
TB of radiometer over wheat field➔ Higher than PALS

Ground radiometer versus PALS (cont.)

- Field #202: Canola







TB of radiometer over canola field→ Lower than PALS

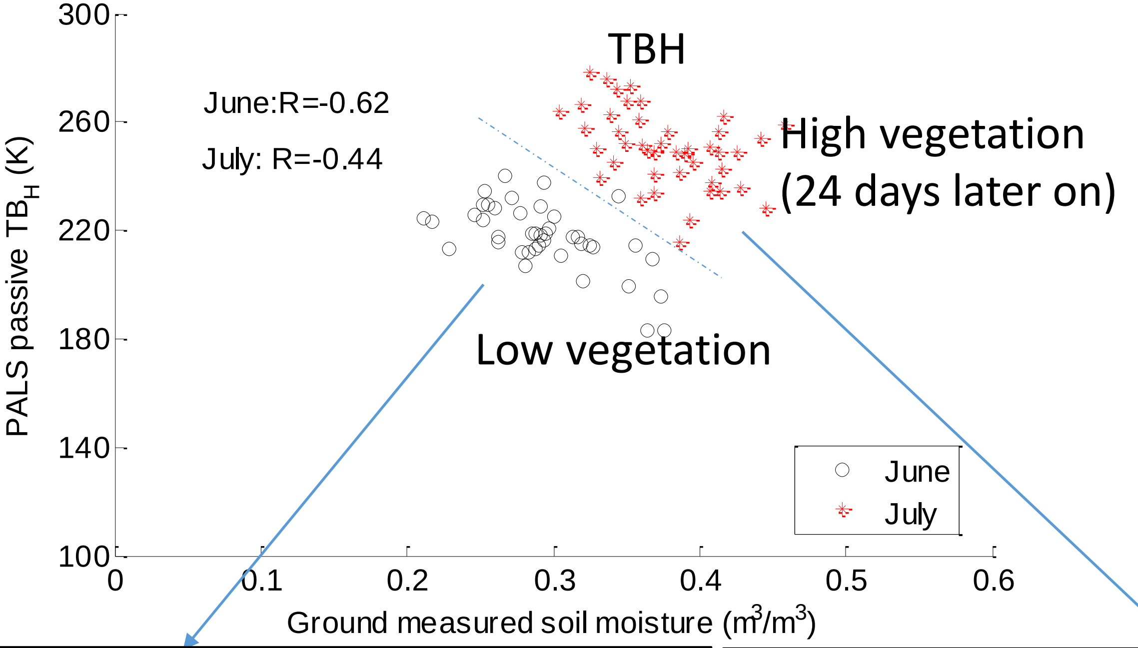
Preliminary analyses

SMAPVEX 12 & 16-MB PALS TB (Low altitude) to soil moisture

Canola

Sensitivity of SMAPVEX16 PALS passive signal to soil moisture

24 days observation gap from June to July (very different vegetation status)



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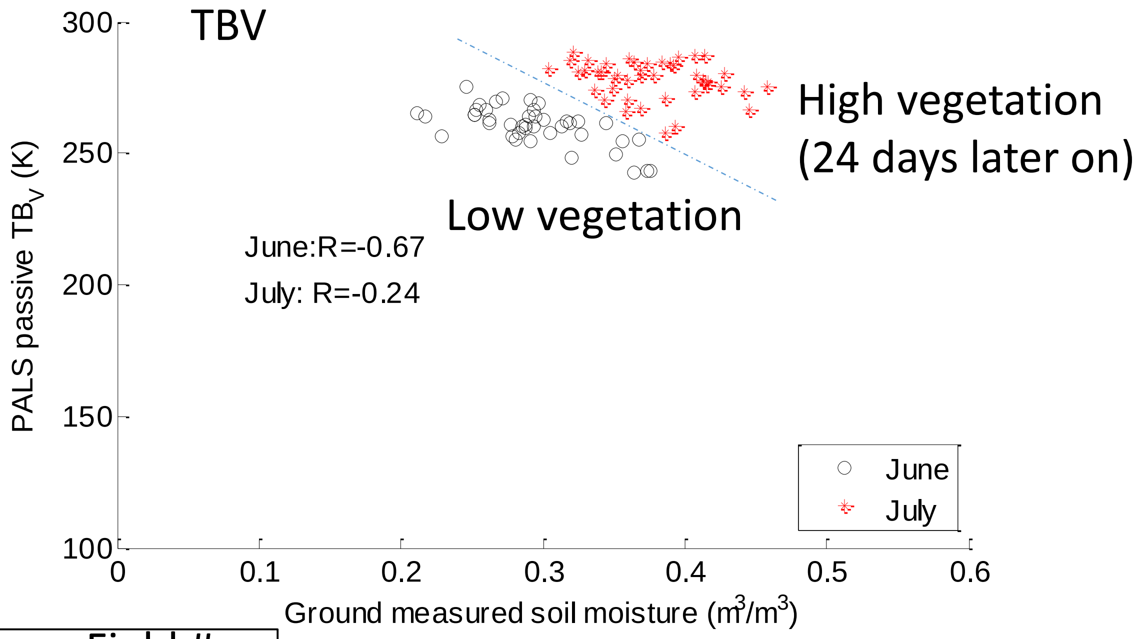
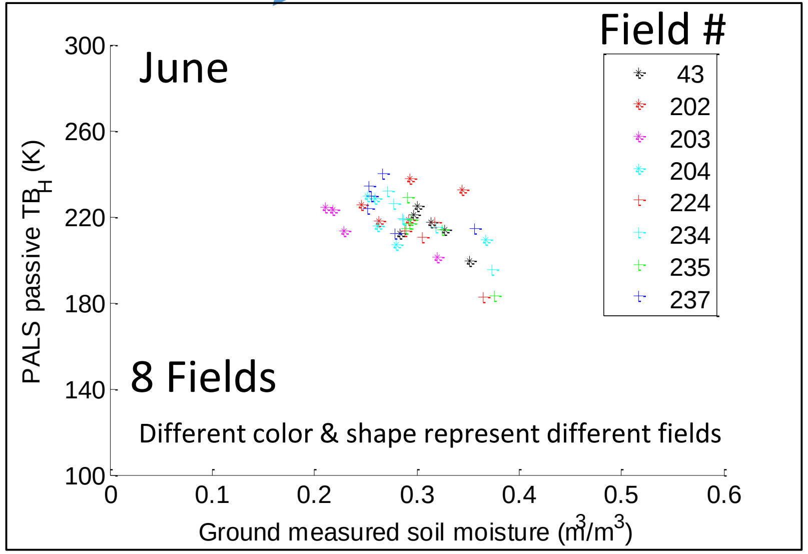
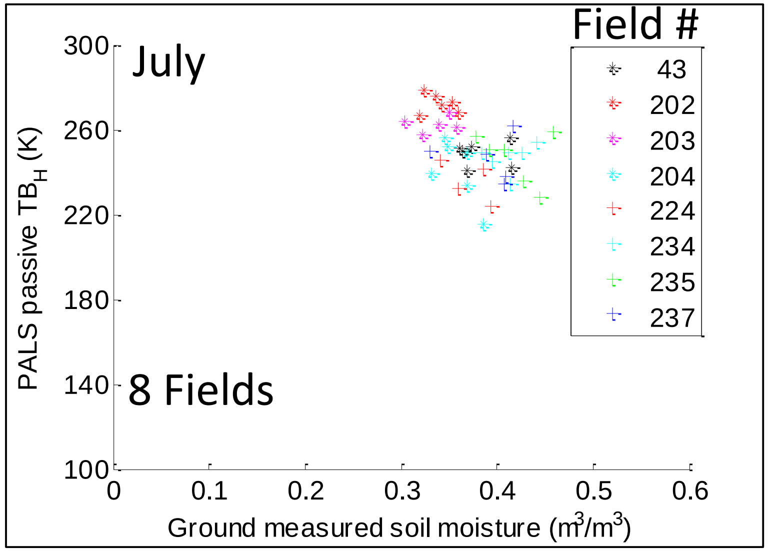


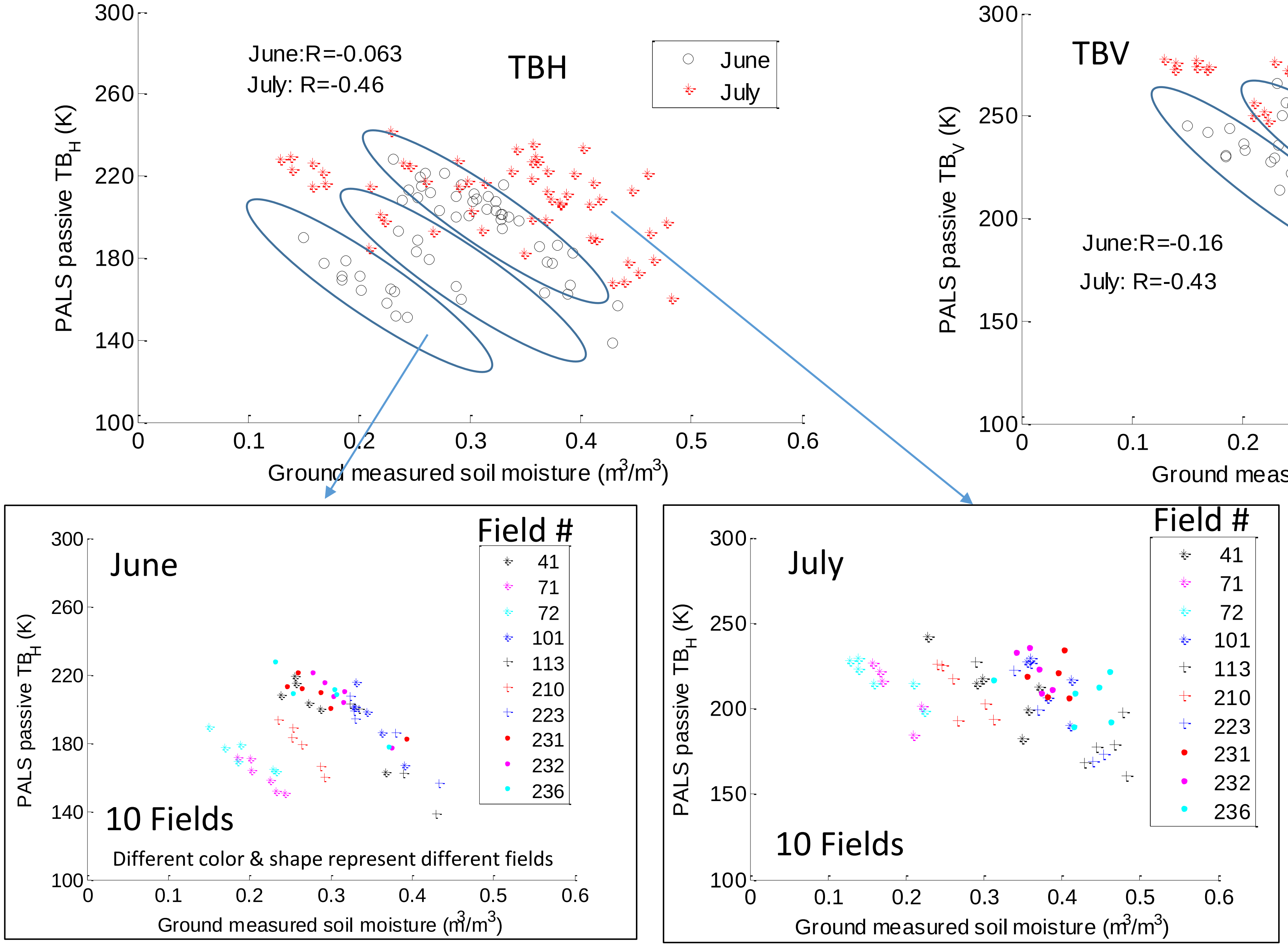




More vegetation effect in **July 14-22** than in **June 08-20**

Sensitivity of SMAPVEX16 PALS passive signal to soil moisture

Soybean

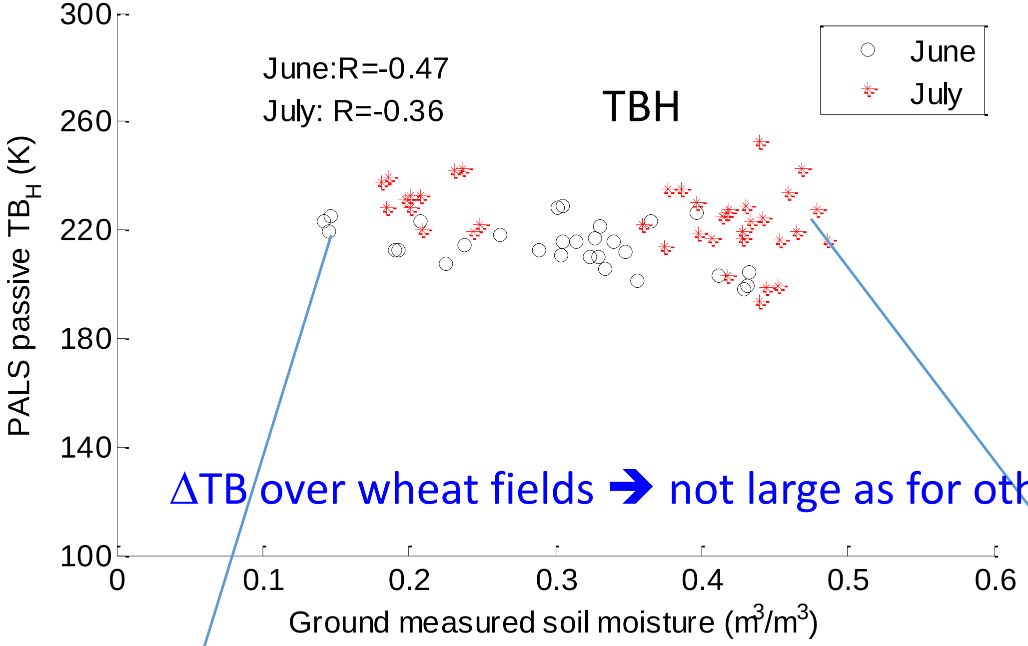


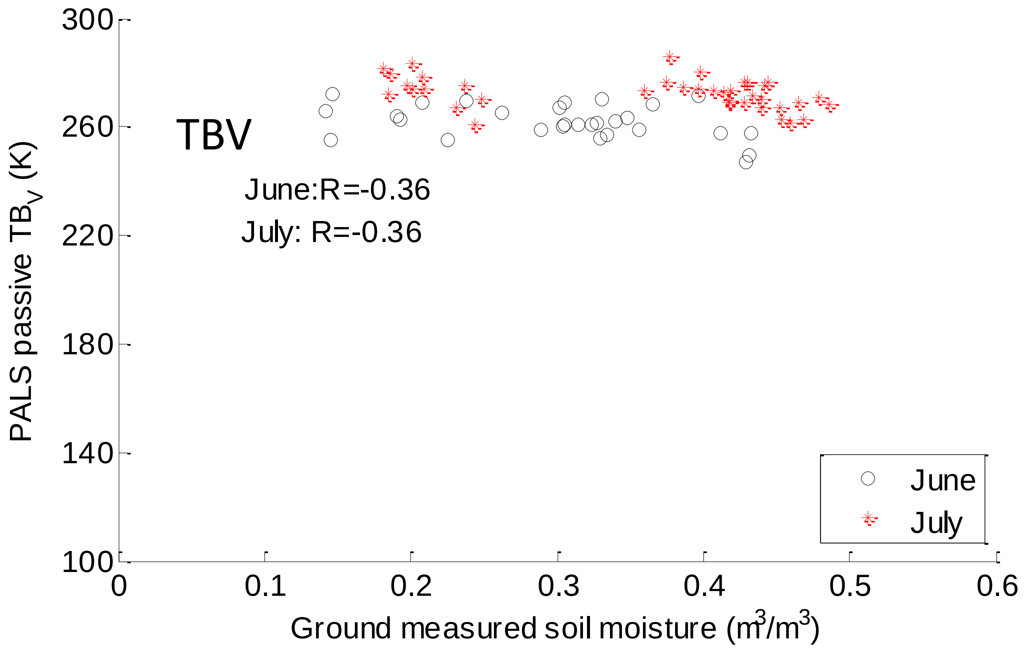
Diversity in soil conditions particularly for soybean;

For June and July, clusters of points.

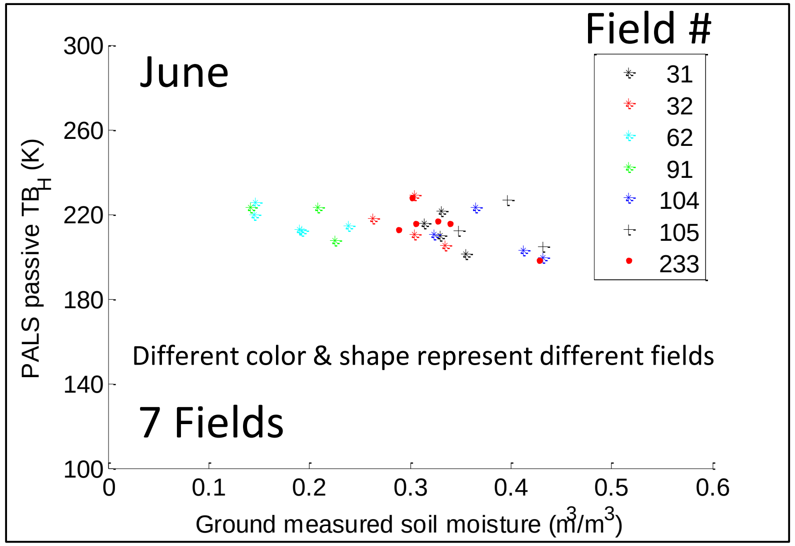
Wheat

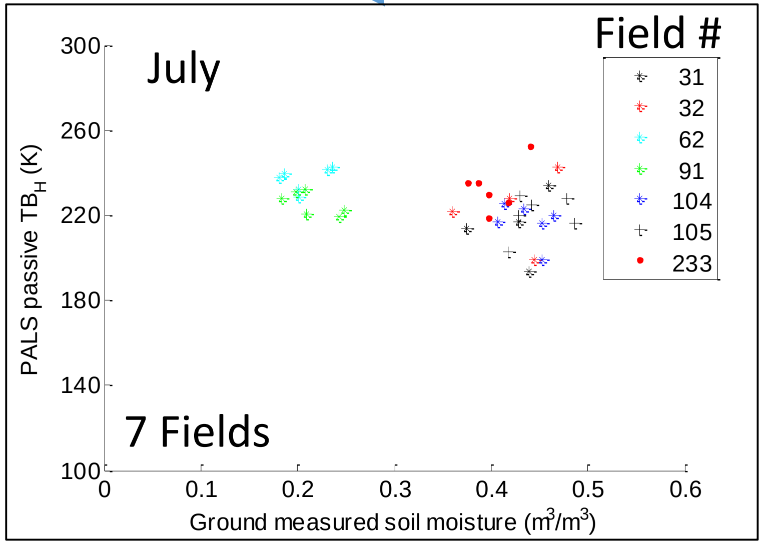
Sensitivity of SMAPVEX16 PALS passive signal to soil moisture





ΔTB over wheat fields ➔ not large as for other crops





Less sensitivity to soil conditions

Preliminary analyses

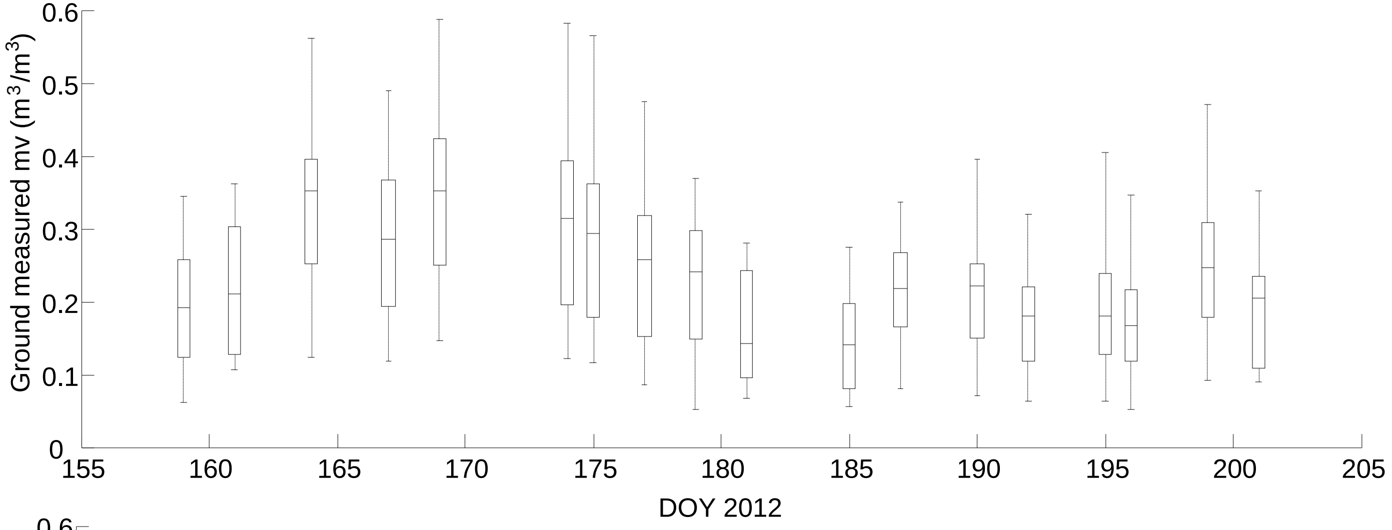
SMAPVEX 12 & 16-MB PALS TB (Low altitude) to soil moisture

→ **Objective : Understand the effects of soil and vegetation conditions on TB for soil moisture retrieval**

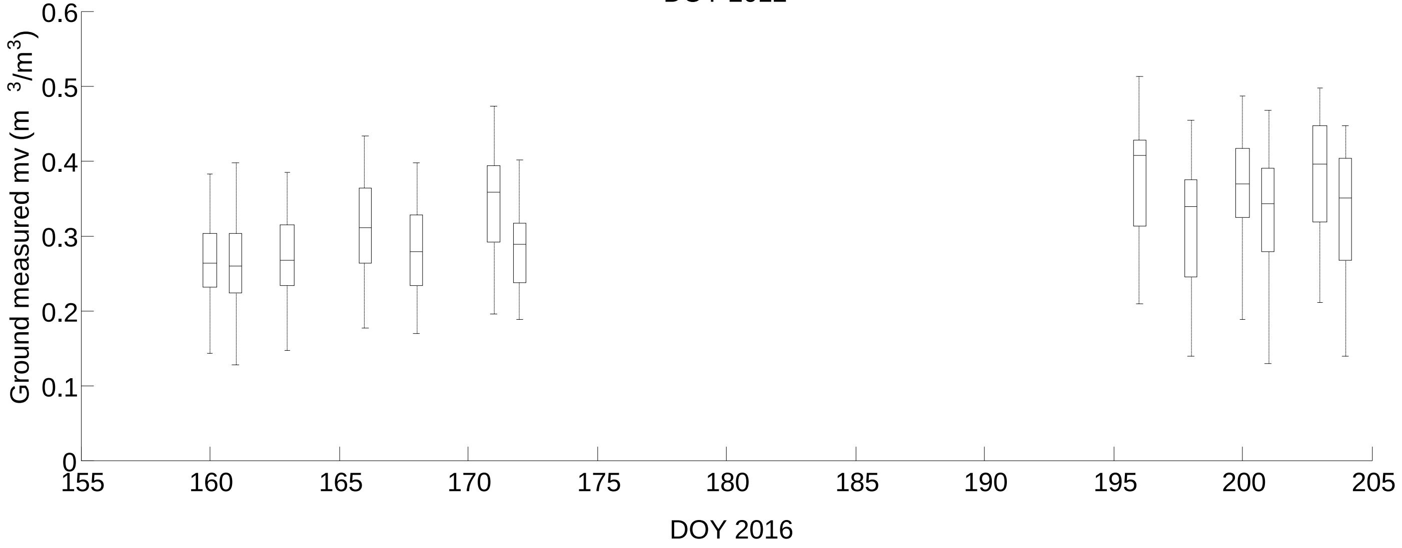
Field campaigns	Data analyses
SMAPVEX16-MB	L-band Radiometers : Ground *vs* soil moisture Ground *vs* low altitude PALS Low altitude PALS *vs* soil moisture
SMAPVEX12 and SMAPVEX16-MB	Comparison of low altitude PALS
	Modelling results

Soil moisture conditions in 2012 and 2016

- Ground measurements *mv*



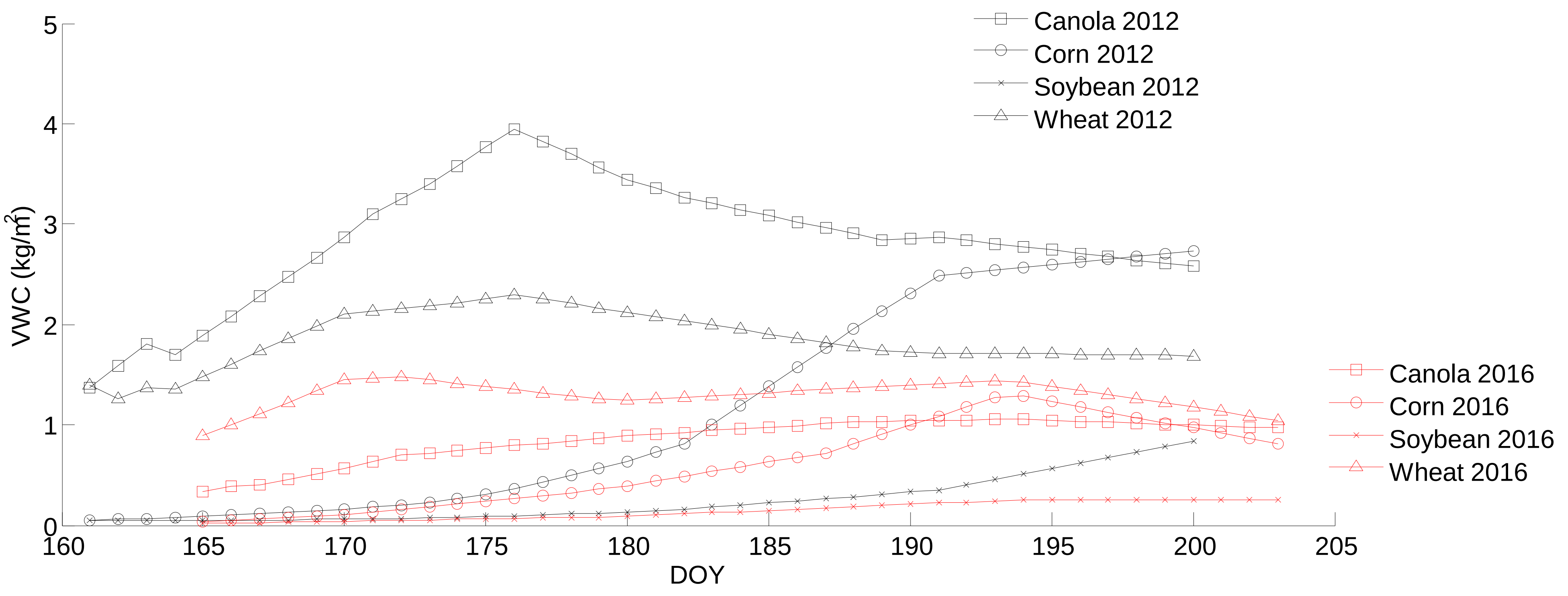
SMAPVEX12



SMAPVEX16-MB

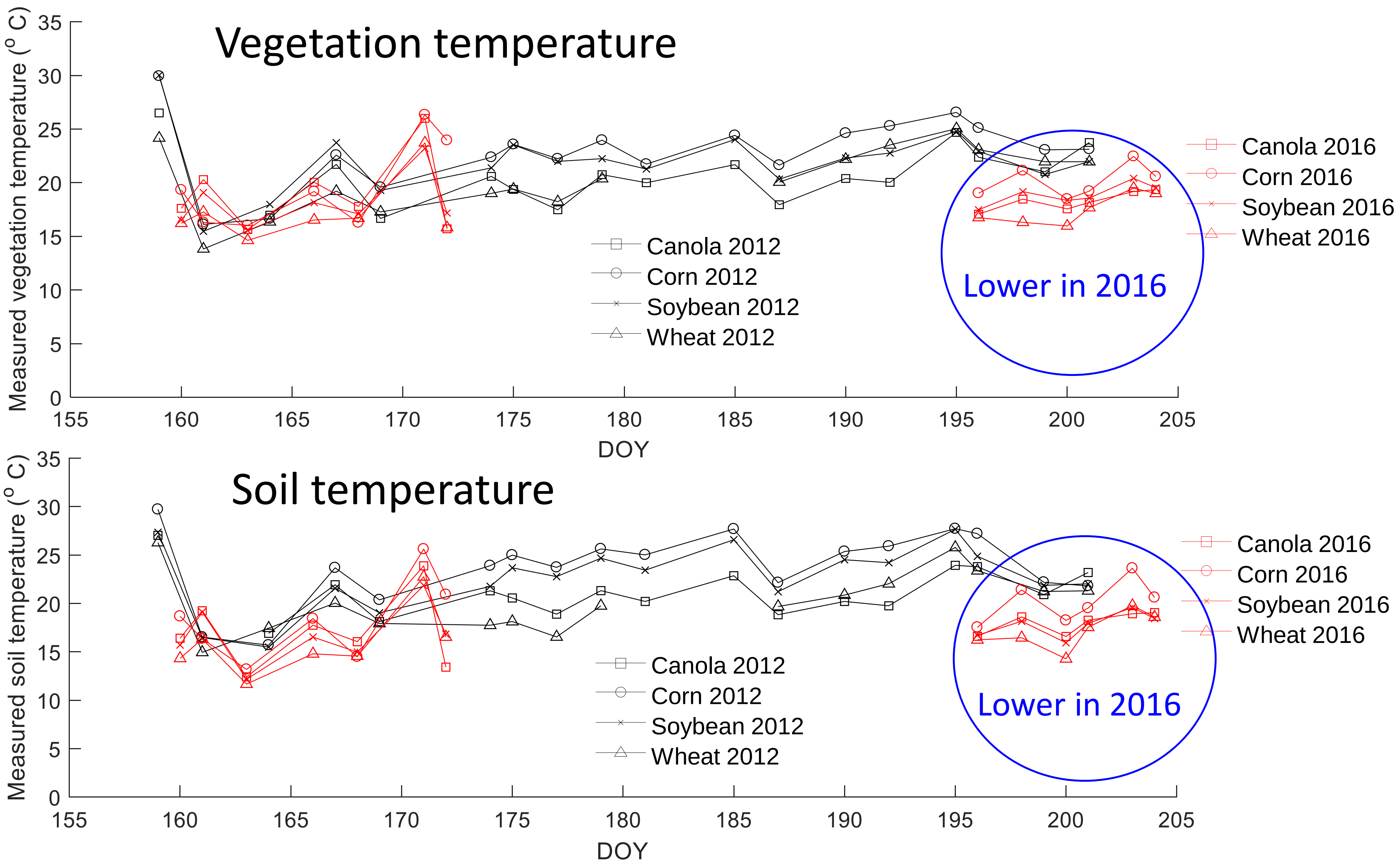
Vegetation conditions in 2012 and 2016

- Ground measurements VWC



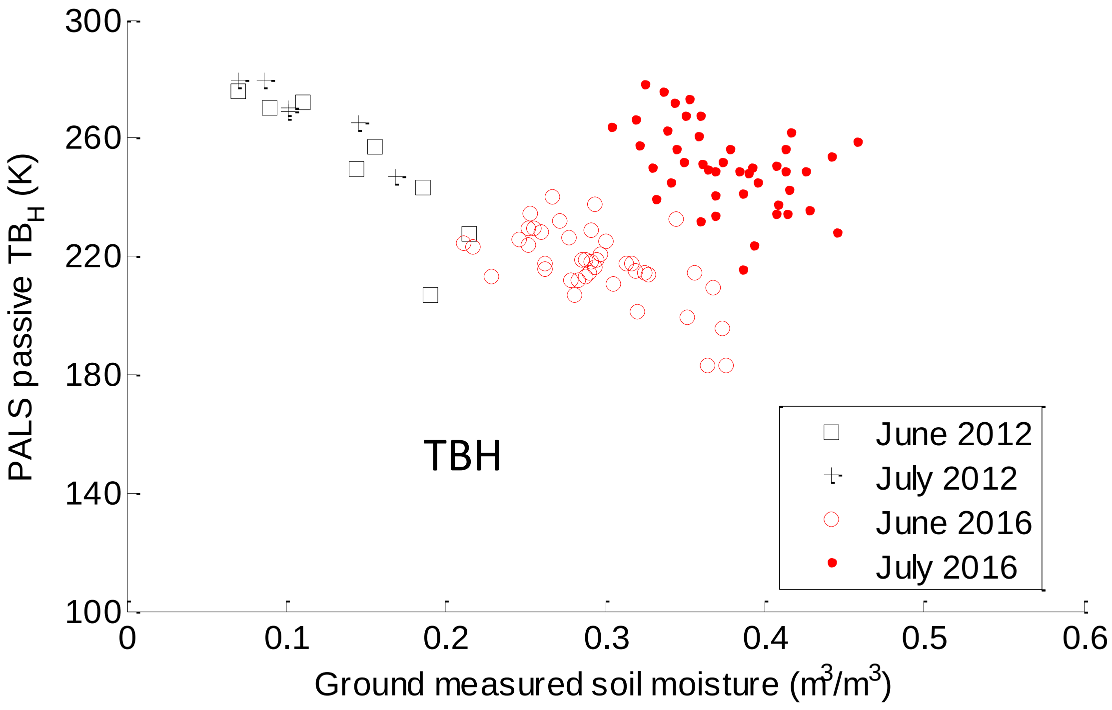
Lower VWC in SMAPVEX16-MB than SMAPVEX12

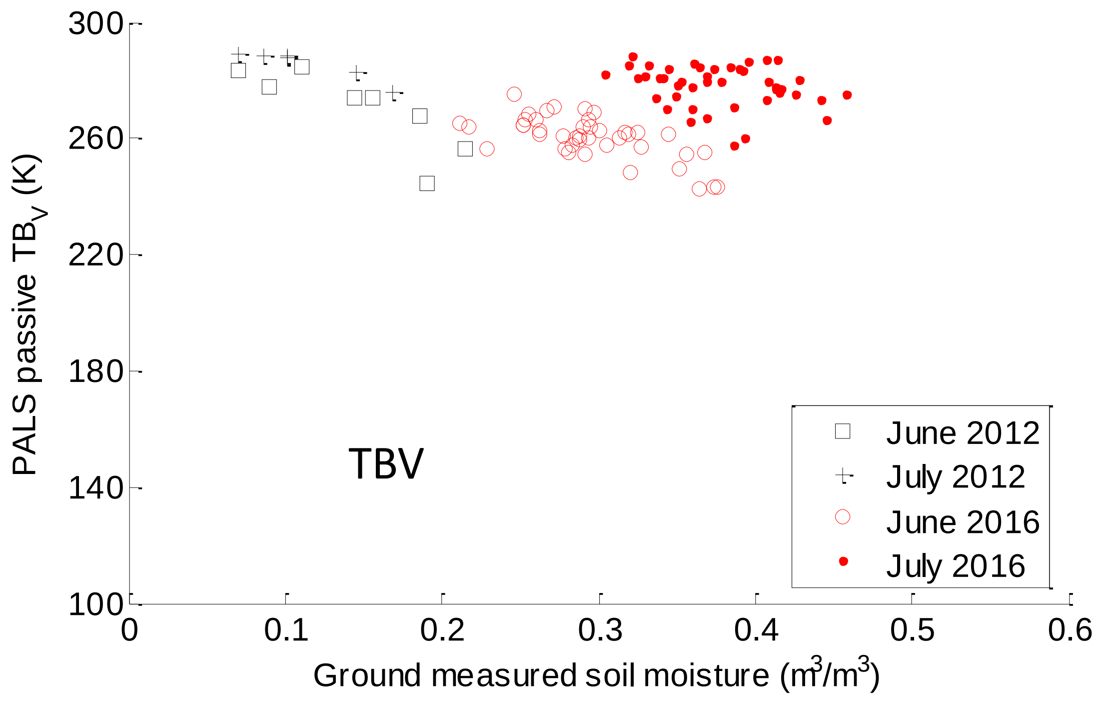
Temperature conditions in 2012 and 2016



Comparison between 2012 and 2016 PALS data

Canola



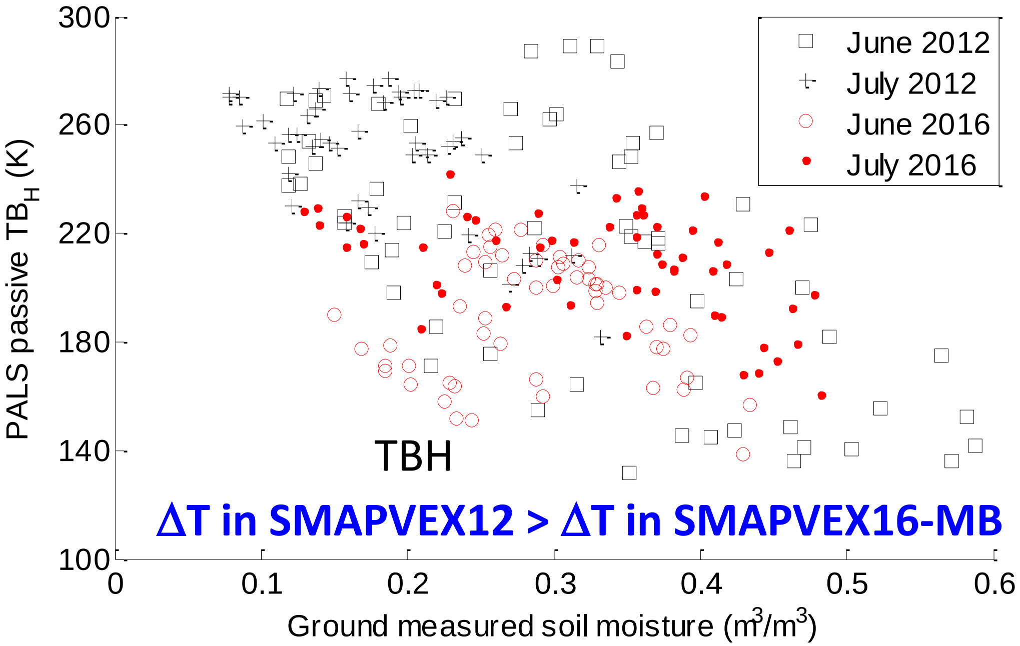


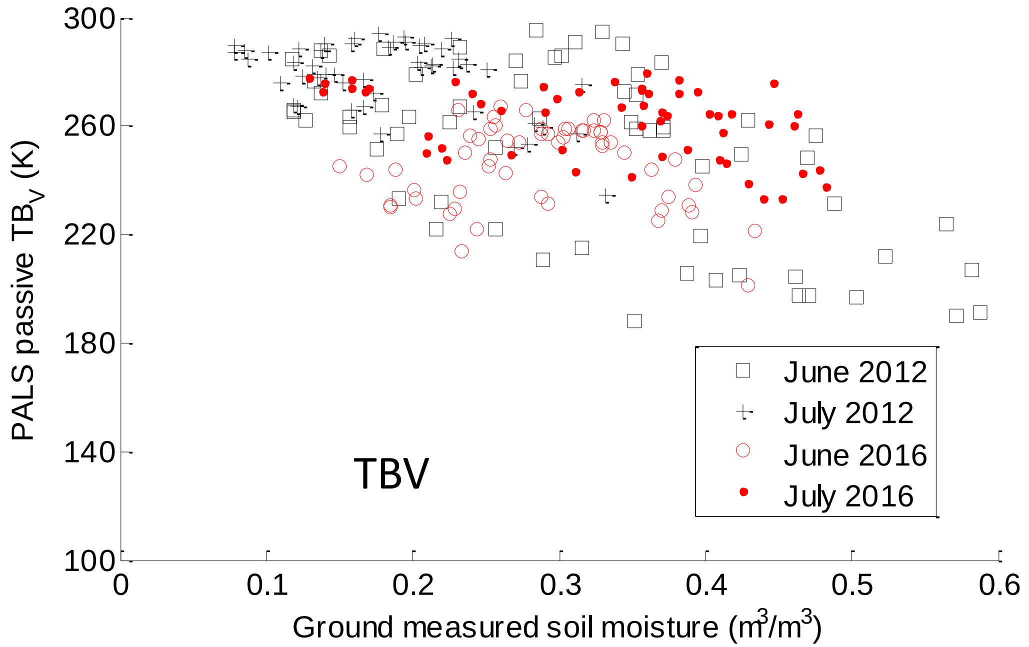
Low soil moisture during SMAPVEX12 ➔ Low contrast between June and July 2012

High soil moisture during SMAPVEX16 ➔ High contrast between June and July 2016

Comparison between 2012 and 2016 PALS data

Soybean

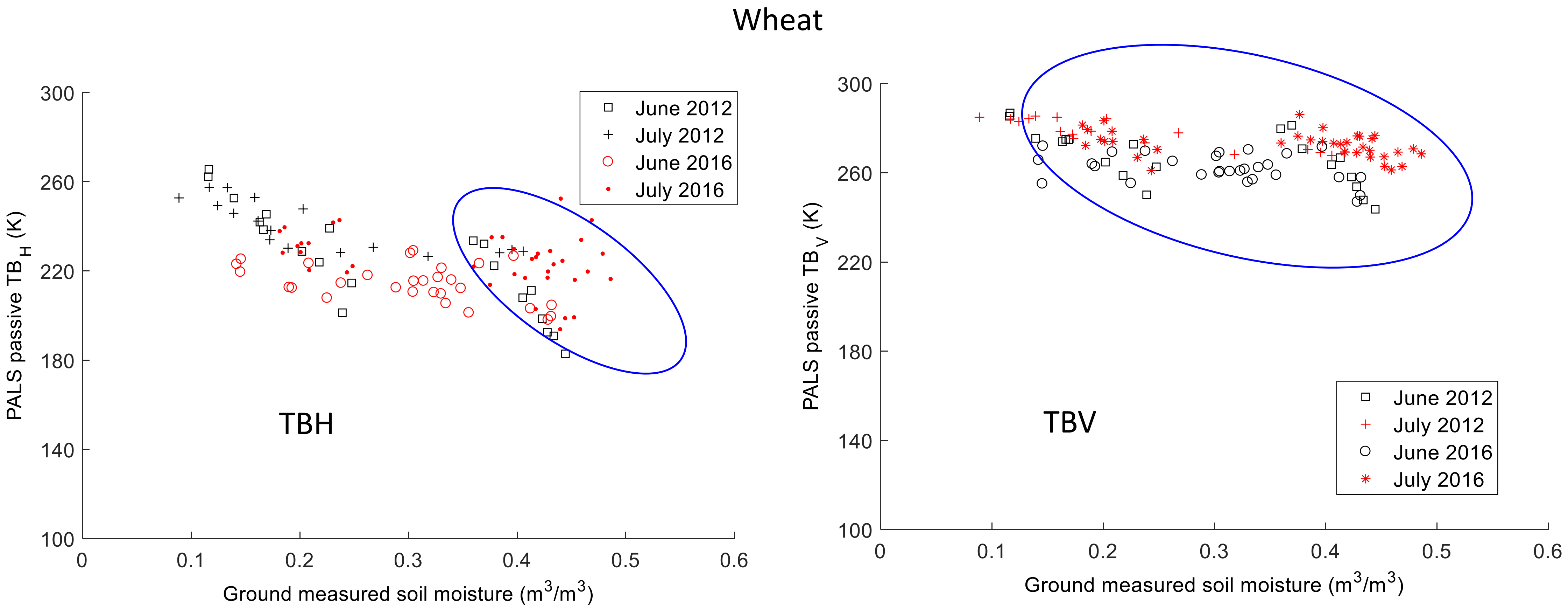




Lower VWC & Surface and vegetation temperature for all crops during SMAPVEX16-MB

➔ TB in 2016 should be lower than TB 2012: not always observed

Comparison between 2012 and 2016 PALS data



Lower VWC & Surface and vegetation temperature for all crops during SMAPVEX16-MB

➔ TB in 2016 should be lower than TB 2012: not always observed

Preliminary analyses of modelling results obtained with SMAPVEX12 and SMAPVEX16-MB data

$$TB_p = (1 - \mathrm{R}_p)\gamma_p T_{soil} + (1-\omega)(1-\gamma_p)\mathrm{T}_{vege} + (1-\omega)(1-\gamma_p)\mathrm{T}_{vege}\mathrm{R}_p\,\gamma_p$$

$$\gamma_p = e^{-\tau_p/\cos(\theta)} = e^{-b_p * VWC/\cos(\theta)}$$

Objective : Soil moisture mapping

- Use of SMAPVEX12 PALS data into L-MEB model to **estimate b_p** parameters (p is the polarization);
- Analyze the performance of b_p parameters with SMAPVEX16-MB PALS data;
- Develop the retrieval approaches (not yet done)

Preliminary analyses of modelling results with SMAPVEX12 data (cont.)

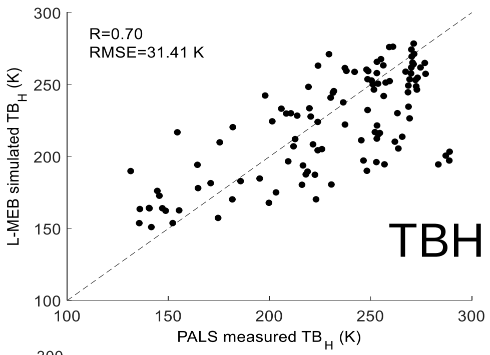
- Optimal *b* parameters obtained from low altitude PALS TB in 2012

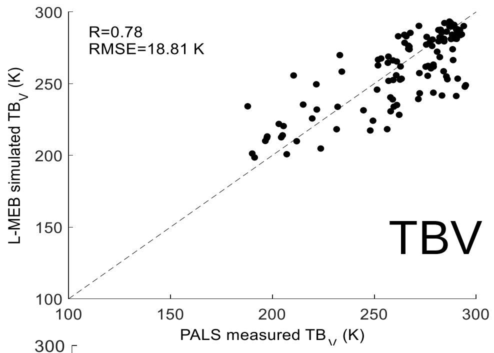
	Canola	Corn	Wheat	Soybean
b_h	0.1548	0.1729	0.0953	0.2504
b_v	0.1935	0.1574	0.2556	0.3280

Preliminary analyses of modelling results with SMAPVEX12 data (cont.)

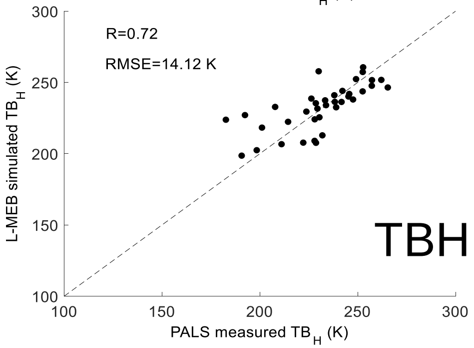
- Performance of optimization

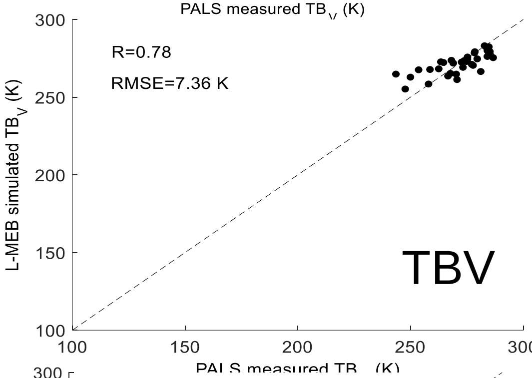
Soybean (9 fields, 17 days)



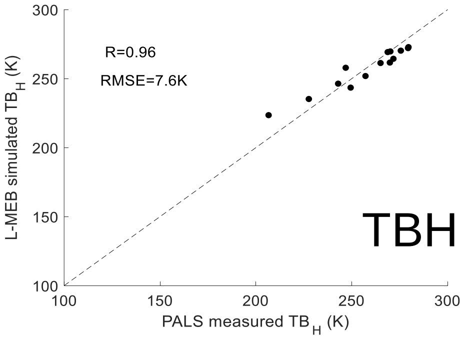


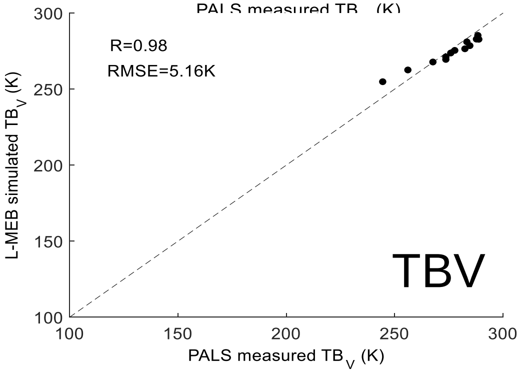
Wheat (4 fields , 17 days)





Canola (1 field , 17 days)

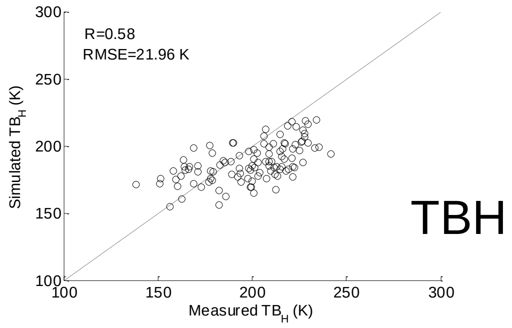


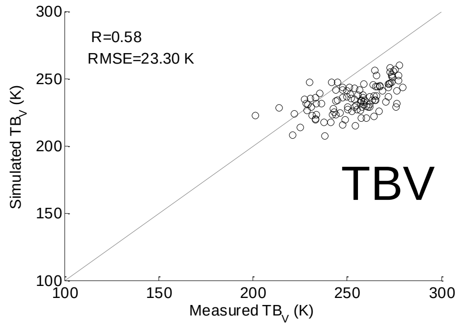


The *b* parameter of canola➔ based only one field

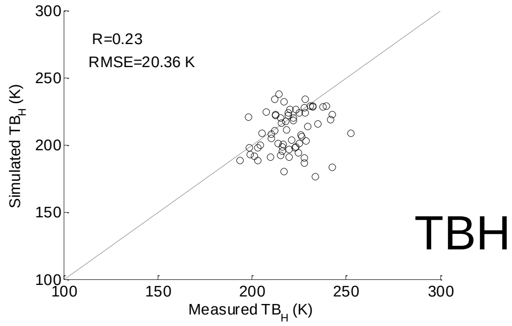
Preliminary analyses of modelling results with SMAPVEX16-MB data (cont.)

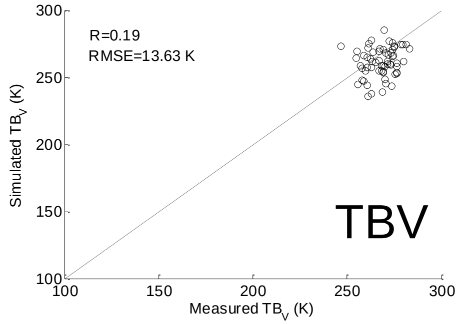
- Performance of *b* parameter



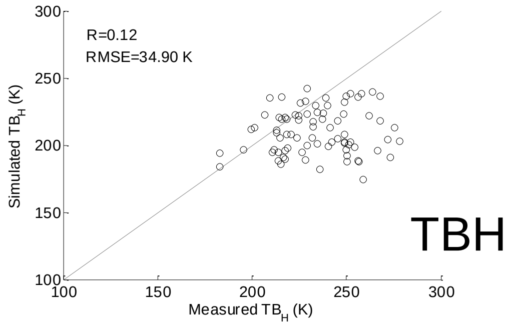


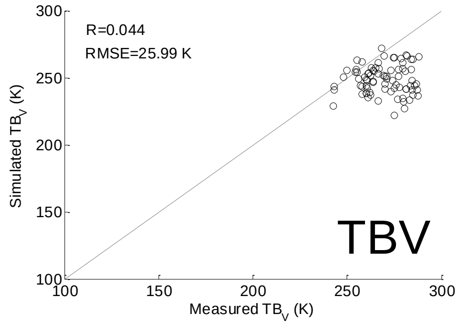
Soybean (10 fields , 12 days)





Wheat (7 fields , 12 days)





Canola (8 fields , 12 days)

Calibrated L-MEB underestimates PALS TB in 2016
Roughness or vegetation water content or both??

Perspectives

- Refine the data analysis and model calibration;
- Develop the retrieval algorithms of soil moisture;
- Soil moisture disaggregation with RADARSAT-2.

Acknowledgments

Canadian Space Agency (CSA)

Natural Sciences and Engineering Research Council of Canada (NSERC)

Environment Canada (EC)

Agriculture and Agri-Food *Canada (AAFC*)

University (Sherbrooke, Manitoba, Guelph)

National Aeronautics and Space Administration (NASA)

United States Department of Agriculture (USDA)

Jet Propulsion Laboratory (JPL)

CSA-SOAR program

CESBIO, France

DLR Microwaves and Radar Institute, Germany