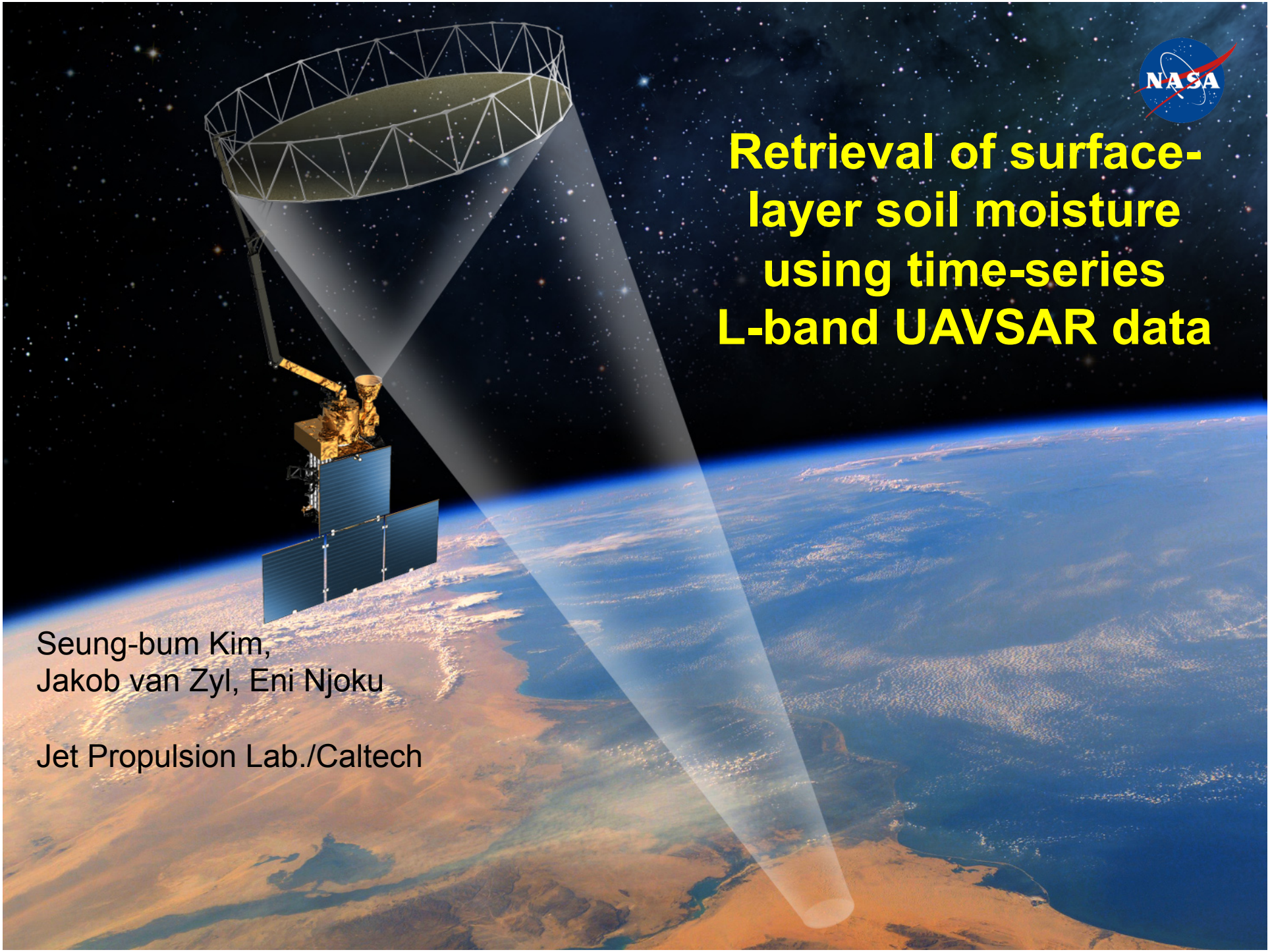
NASA
Retrieval of surface-layer soil moisture using time-series L-band UAVSAR data
Seung-bum Kim,
Jakob van Zyl, Eni Njoku
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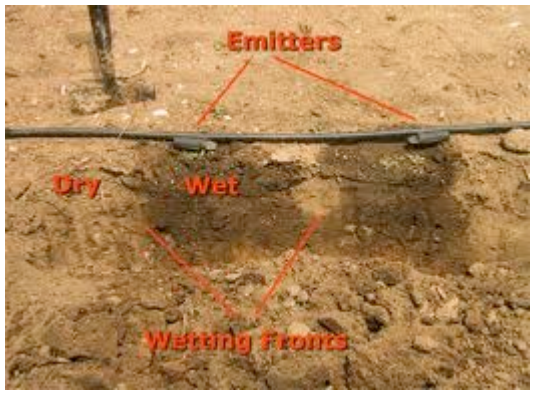
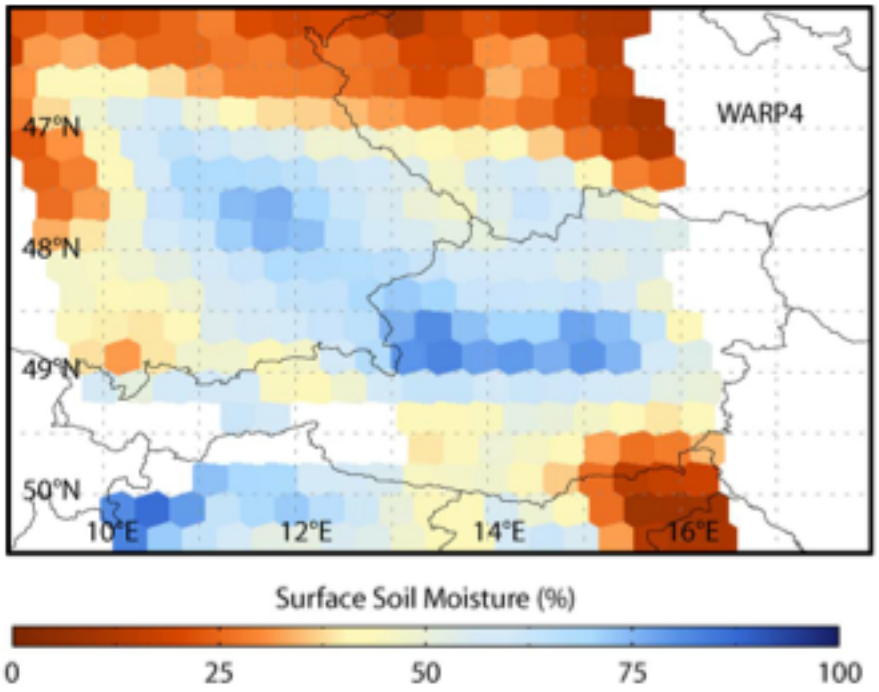
Need for Global Soil Moisture Information



Ranges from 0.03 to 0.5 cm3/cm3

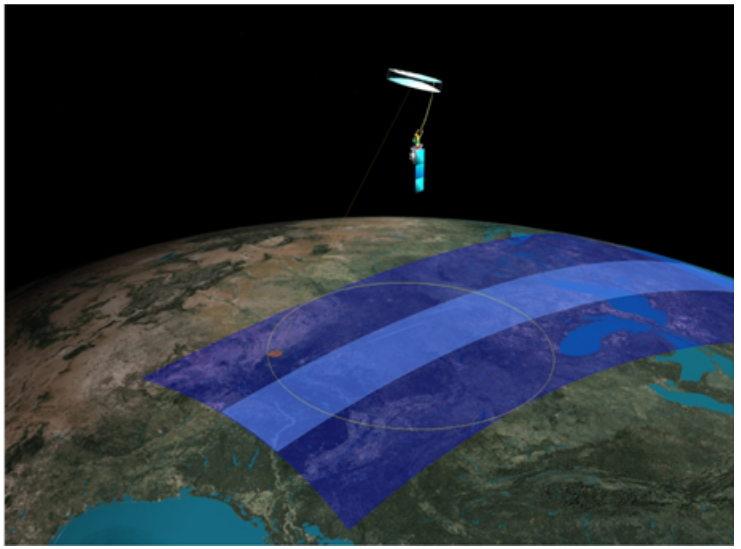


Naeimi, Scipal, Bartalis, Hasenauer, Wagner, IEEE Trans. Geoscience Remote Sens. 47(7): 1999-2012

- Global data
  - SMOS, Aquarius, AMSR-E radiometer (35-100km), Metop ASCAT scatterometer (25km), ENVISAT ASAR (1km)
  - ASCAT & ASAR: Index has been produced.

Objectives

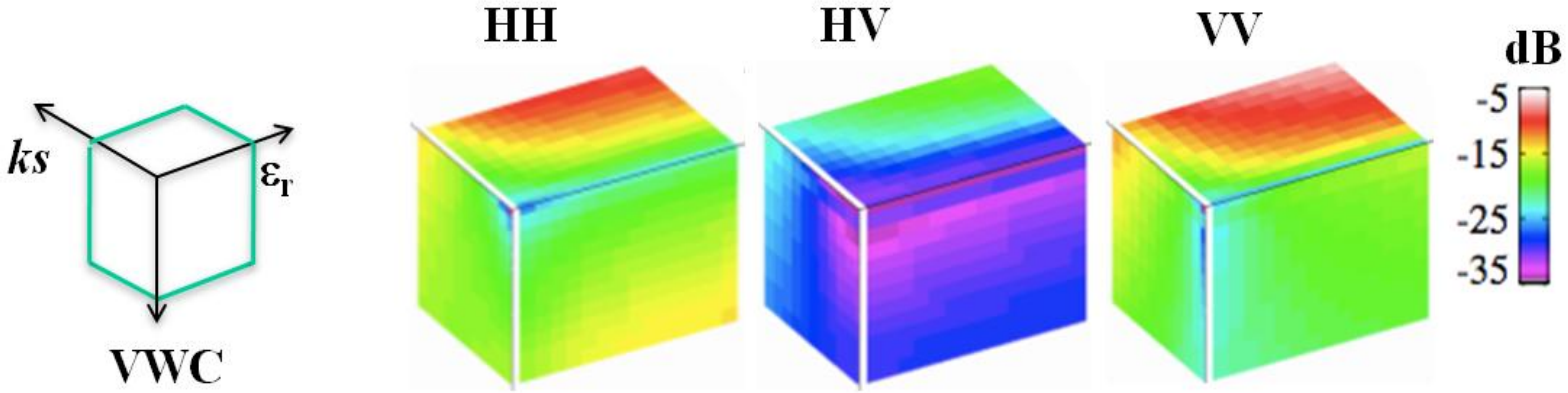
- NASA's SMAP mission
  - Global, high-resolution mapping of soil moisture (top 5cm) and its freeze/thaw state
  - Three year mission, due for launch in 2014
  - 1000 km-wide swath, enabling 2−3 day revisit
  - Retrievals with radiometer (36km resolution), SAR (3km), and SAR/radiometer combined (9km)
  - Multi-pol (HH, VV, HV)
  - As a tradeoff of the frequent global coverage, measurement error ranges from 0.5dB (13%) to 0.7dB (17%)



- Use L-band UAVSAR as a test bed for SMAP
  - 36 looks at 7 m posting (UAVSAR); 30 to 100 looks at 3km posting (SMAP)
  - ~ 0.3dB calibration error (UAVSAR); about 0.4 dB calibration error (SMAP)
  - - 45 dB noise floor (UAVSAR); about -30dB noise floor (SMAP). But most of land surfaces have sigma0 > -25dB

Issues with soil moisture retrieval

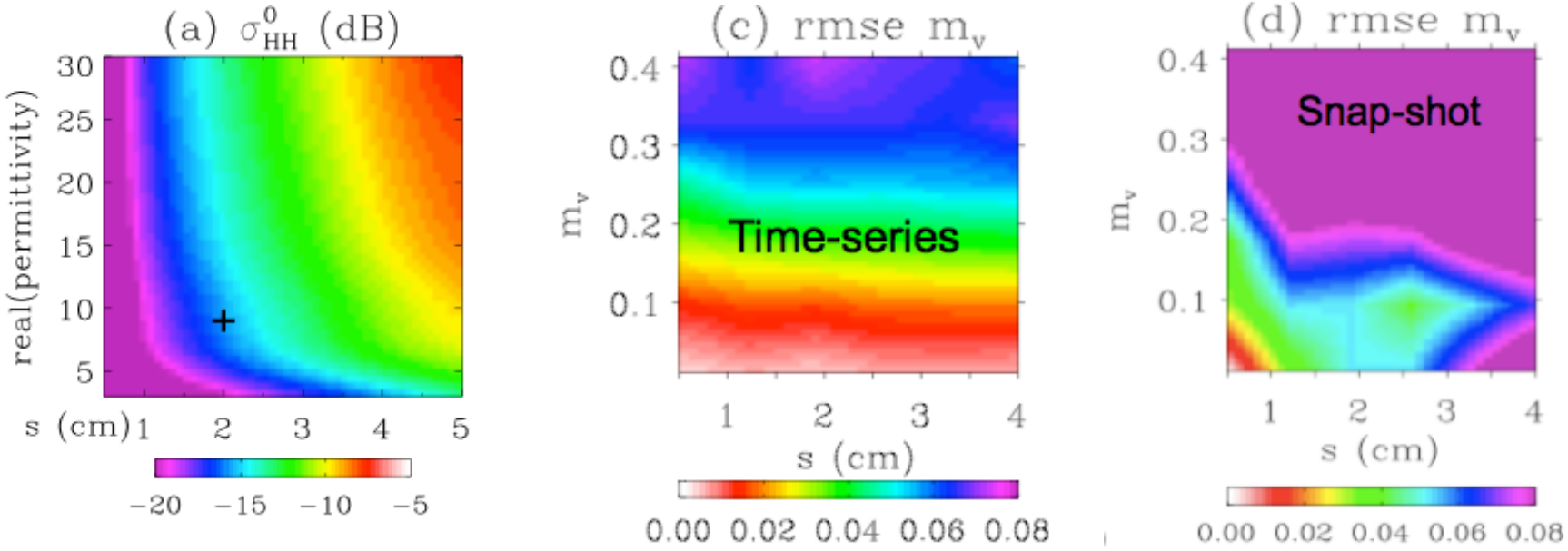
- Reliable retrieval requires
  - Reliable forward model
  - Reliable retrieval algorithm
- Reliable forward model
  - Generated sophisticated forward models for 12 IGBP vegetation classes for global retrieval
  - Three axes parameters: dielectric constant (ε), soil roughness (ks), vegetation water content (VWC) → datacube.
  - Use an allometric relationship for modelling: VWC = spatial density * volume * water fraction



Durden, van Zyl, and Zebker, IEEE Trans. Geosci. Remote Sens., vol. 27, pp. 290-301, 1989.
Moghaddam, Saatchi, and Cuenca, J. Geophys. Res., vol. 105, pp. 14,899-14,911, 2000.
van Zyl, 2011, Synthetic Aperture Radar Polarimetry, Wiley.
Huang, Tsang, Njoku, Chen, 2012. IEEE Trans. Geoscience Remote Sens. 48(6) 2557-2567.
Burgin, Clewley, Lucas, Moghaddam, 2011. IEEE Trans. Geoscience Remote Sens. vol. 49, pp. 4832-4845
Kim, Moghaddam, Tsang, Burgin, Xu, Njoku, 2013, IEEE Trans. Geoscience Remote Sens, in press

Issues with soil moisture retrieval

- Ambiguity between soil moisture and surface roughness
  - May result in a large error when Kp is not small (0.7dB Kp)



- Use time-series data as a solution (Mv – soil moisture; s – surface roughness)

Retrieval method	unknown	Indep. input
snapshot	2 (s, Mv)	2 (HH, VV)
time-series	N (Mv)+1 (s)	2N (HH, VV)

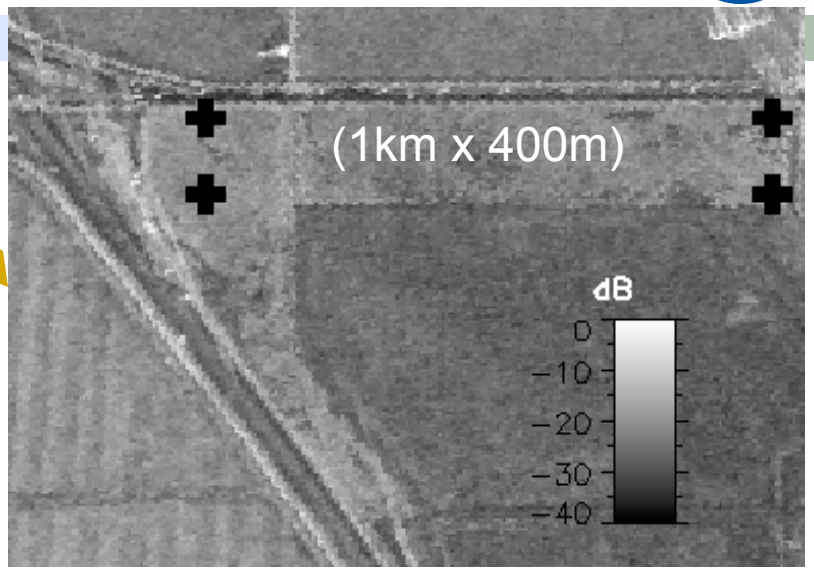
Kim, Tsang, Johnson, Huang, van Zyl, and Njoku, *IEEE Trans. Geosci. Remote Sens.*, vol. 50, pp. 1853-1863, 2012.

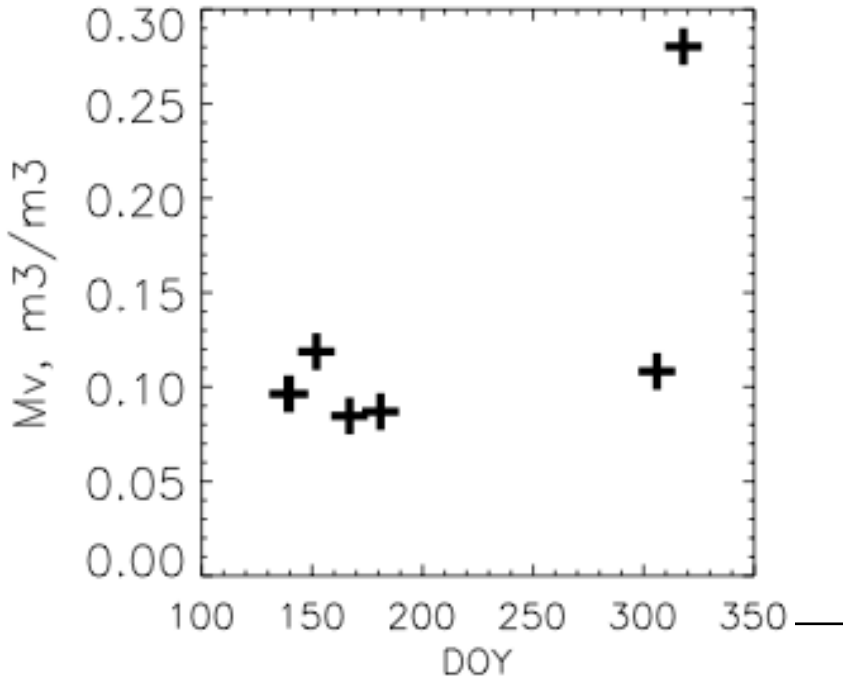
Retrieval Experiment - I

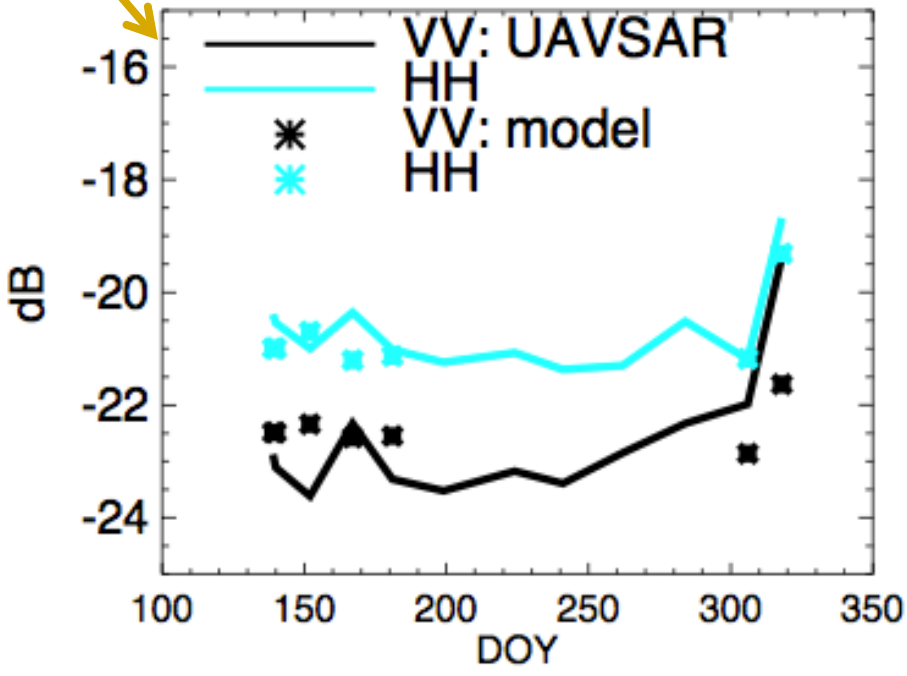
UAVSAR airborne radar image (study site)

In situ soil moisture variations

Comparison of UAVSAR sigma0 and in situ soil moisture

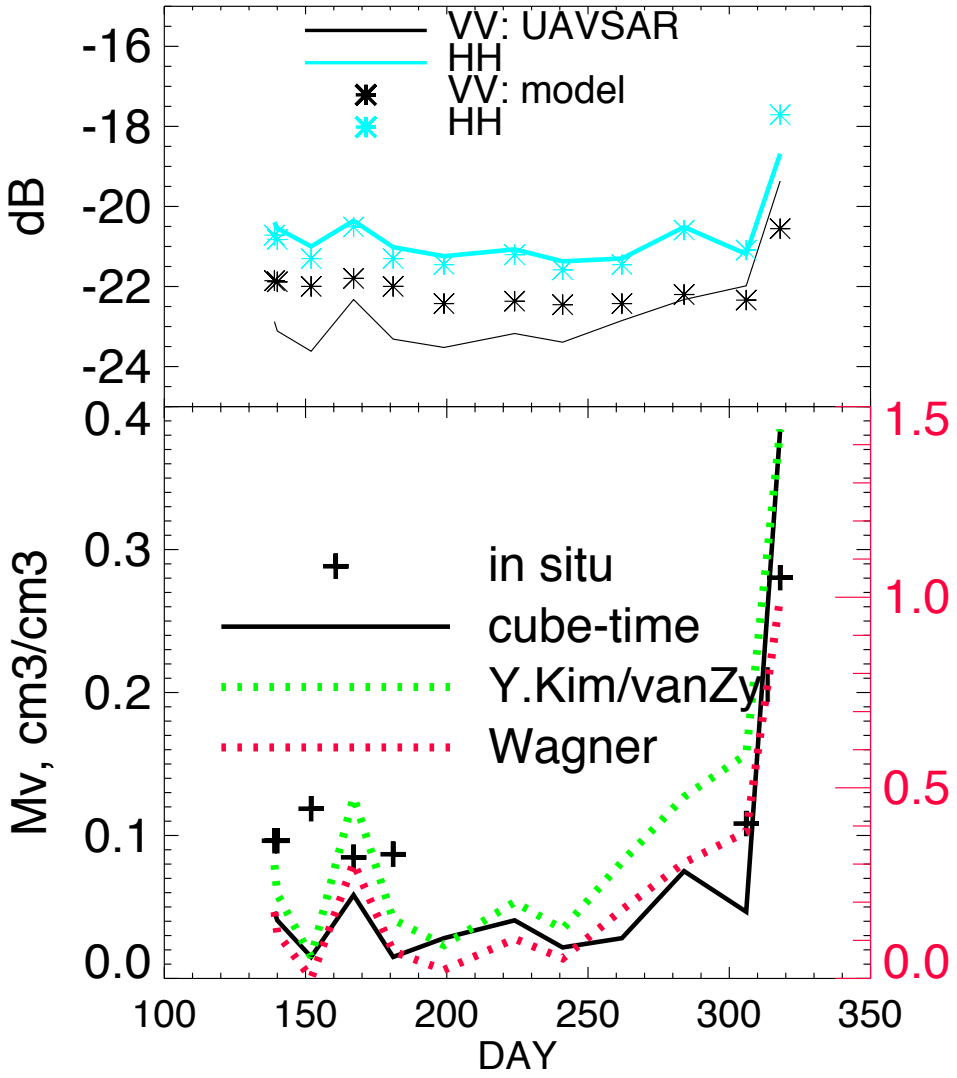






Retrieval Experiment - I

	RMSE (cm^3/cm^3)	Corr.
Cube-time	0.072	0.97
Y.Kim/vanZyl	0.065	0.89
Wagner	-	0.89
Dubois	0.14	
Cube-snap	1.13	



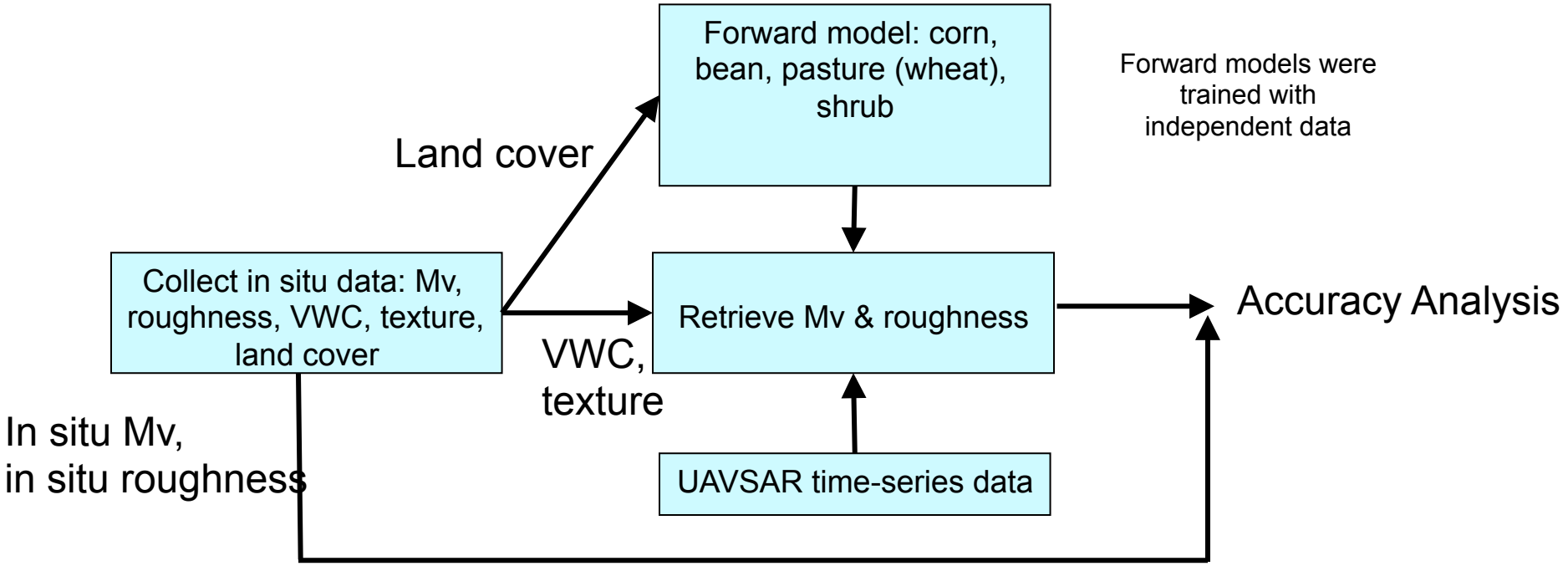
Y. Kim/van Zyl (2009)

$$f(\sigma_{hh}, \sigma_{vv}) = C_0 + C_1 \frac{\sigma_{hh} + \sigma_{vv}}{2}$$

Wagner et al. (1999-)

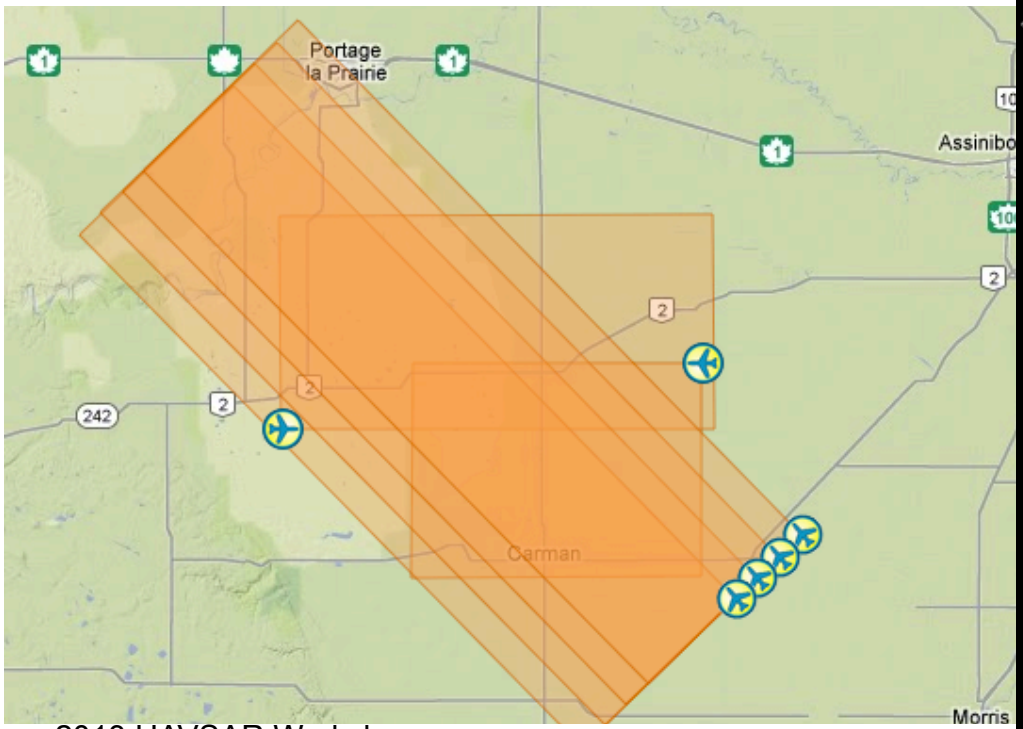
$$M_S = \left(\sigma^0(t) - \sigma^0_{dry}\right) / \left(\sigma^0_{wet} - \sigma^0_{dry}\right)$$

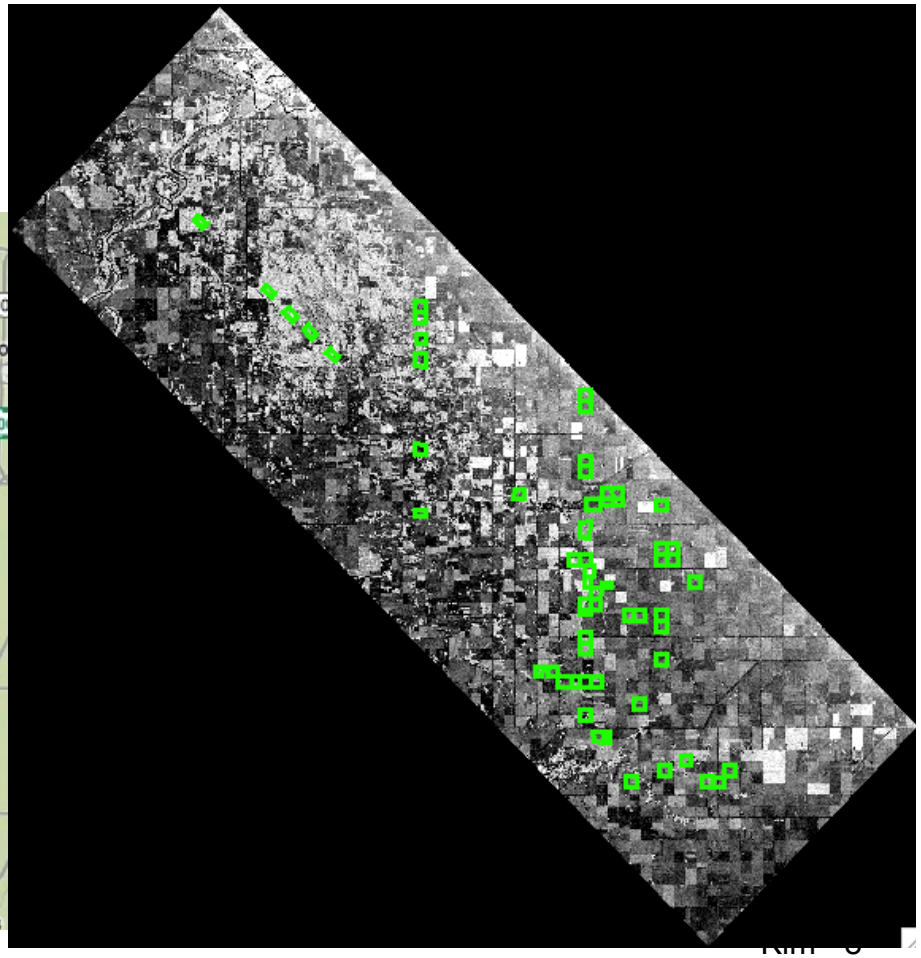
Soil moisture retrieval: flowchart



Retrieval Experiment - II

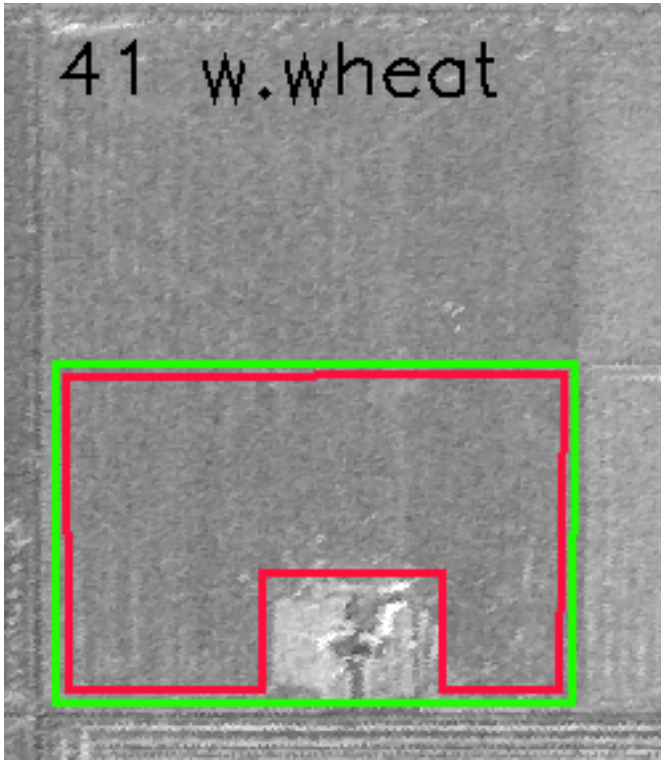
- Winnipeg, Manitoba, Canada
- 13 temporal acquisitions over 40 day period in June-July, 2012

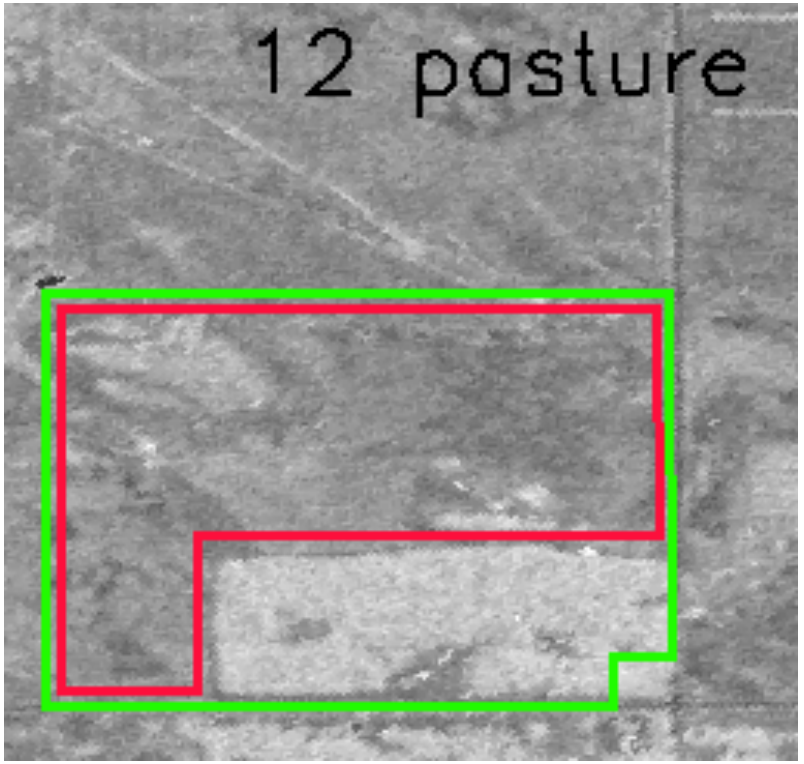




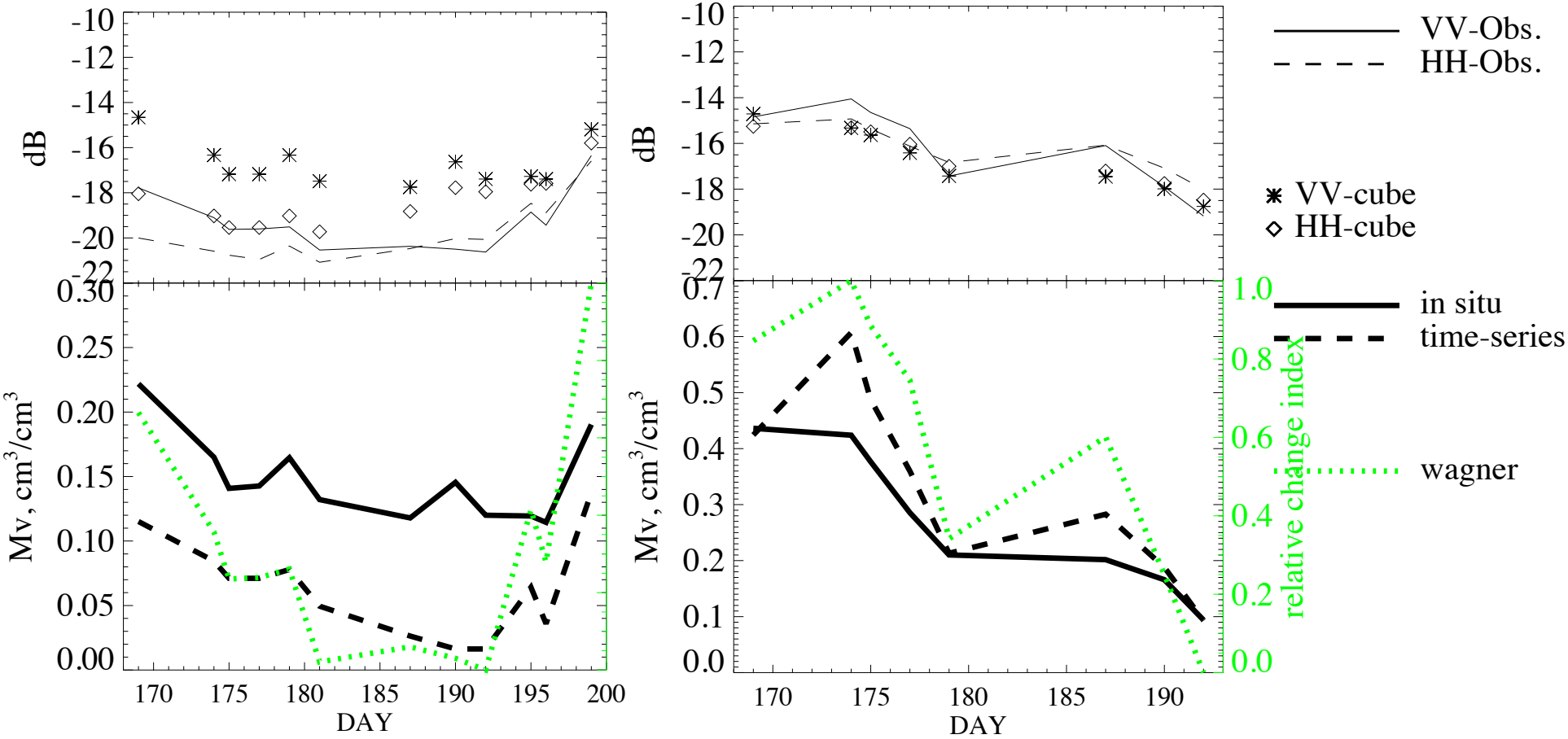
Retrieval Experiment - II

- Green and red polygons are the field boundaries before and after the filtering, respectively.





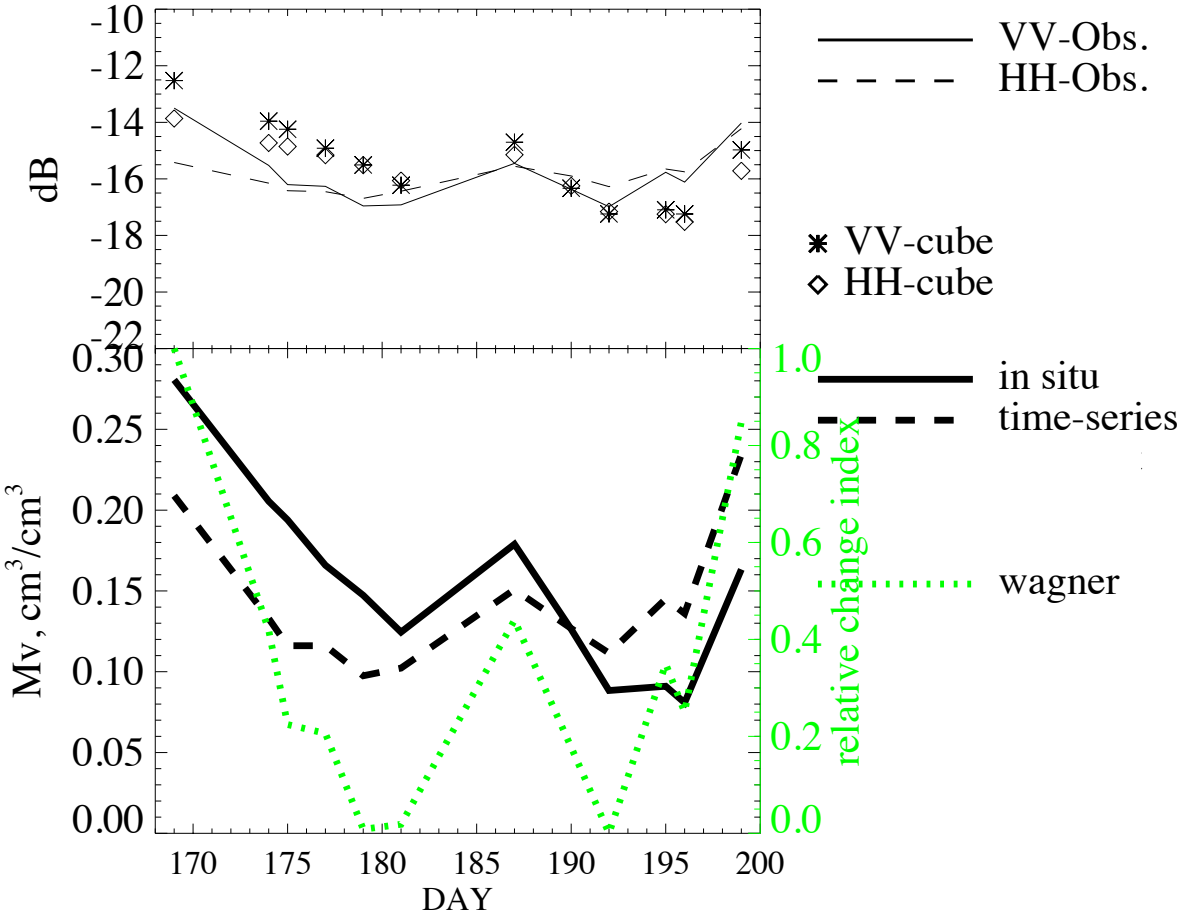
Retrieval Experiment - II



Pasture field, VWC ~ 0.3 kg/m2
Mv RMSE: 0.086, mean Δ: -0.084
r (time-series), r(Wagner): 0.81, 0.71

Wheat field: VWC = 1.7 to 2.5 kg/m2
Mv RMSE: 0.086, mean Δ: -0.058
r (time-series), r(Wagner): 0.94, 0.94

Retrieval Experiment - II



- Time-series datacube method provides additional info (absolute soil moisture) compared with change detection method

Bean field: VWC=0.1 to 1.9 kg/m2
Mv RMSE: 0.053, mean Δ: -0.013
r (time-series) r(Wagner): 0.45, 0.66

[McNairn et al., in preparation]

Summary

- In situ and airborne data were collected to perform the soil moisture retrieval over shrublands & agricultural fields to assist the Soil Moisture Active Passive (SMAP) science
- UAVSAR data are useful testbeds for SMAP SAR
- Soil moisture was retrieved by inverting radar scattering models
- Retrievals with an rmse of 0.05 to 0.08 cm3/cm3 (need to improve mean error)
- Currently retrievals were applied to field-average sigma0 (Kp of ~ 0.3dB); in the future retrieval will be applied to individual pixel (Kp of ~0.7dB like SMAP's)

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