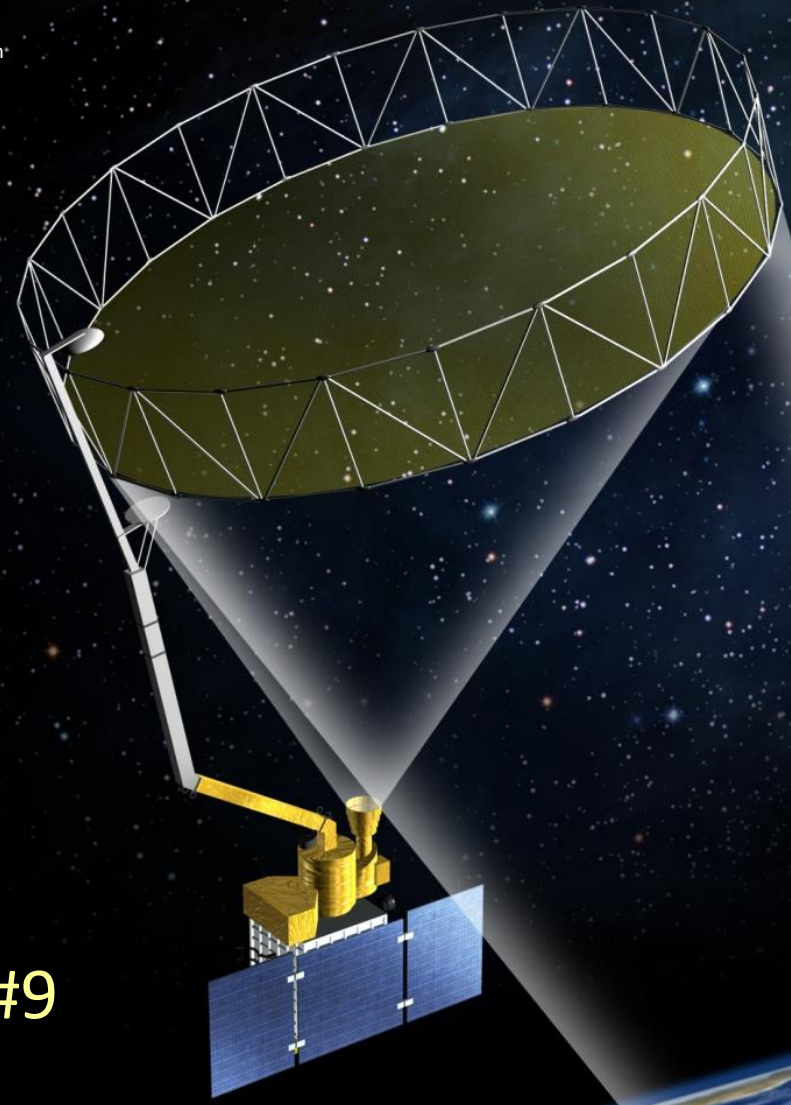
National Aeronautics and Space Administration

SMAP Soil Moisture Product Bias Analysis

Soil Moisture Active Passive Mission

SMAP



Cal/Val Workshop #9

October 22-23, 2018

A. Colliander[1], W. Crow[2], F. Chen[2], M. Cosh[2], M. Moghaddam[3], J. Whitcomb[3], J. Peng[4], S. Misra[1], A. Bringer[5], J. Johnson[5]

1) Jet Propulsion Laboratory, California Institute of Technology

2) USDA ARS Hydrology and Remote Sensing Laboratory

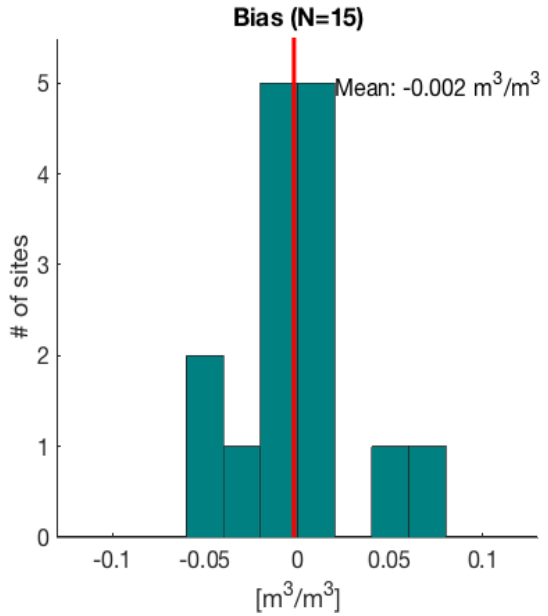
3) University of Southern California

4) NASA Goddard Space Flight Center

5) Ohio State University

Core Site Metrics: L2SMP_E

Ref Pixel	Bias	ubRMSE	RMSE	R	N
Reynolds Creek (0401-33-02)	-0.013	0.040	0.042	0.644	141
Walnut Gulch (1601-33-02)	0.018	0.024	0.030	0.834	188
TxSON-Evett (4802-33-01)	-0.009	0.022	0.024	0.932	406
Fort Cobb (1603-33-02)	**-0.045**	0.028	0.053	0.879	447
Little Washita (1602-33-02)	-0.018	0.022	0.028	0.912	429
South Fork (1607-33-02)	**-0.038**	0.055	0.067	0.671	265
Little River (1604-33-05)	**0.062**	0.037	0.072	0.781	419
Kenaston (2701-33-01)	0.006	0.027	0.028	0.800	187
Carman (0901-33-11)	**-0.047**	0.064	0.080	0.571	237
Monte Buey (1902-33-01)	-0.016	0.049	0.052	0.838	191
REMEDHUS (0301-33-02)	0.012	0.039	0.041	0.846	348
Twente (1204-33-06)	**0.045**	0.054	0.071	0.889	347
HOBE (6701-33-01)	-0.003	0.036	0.036	0.860	117
MAHASRI (5301-33-01)	0.003	0.032	0.032	0.799	222
Yanco (0701-33-01)	0.015	0.040	0.043	0.936	321
MEAN:	**-0.002**	**0.038**	**0.047**	**0.813**	
MAB:	**0.023**				



Confidence intervals

Ref Pixel	Bias	ubRMSE	RMSE	R	N
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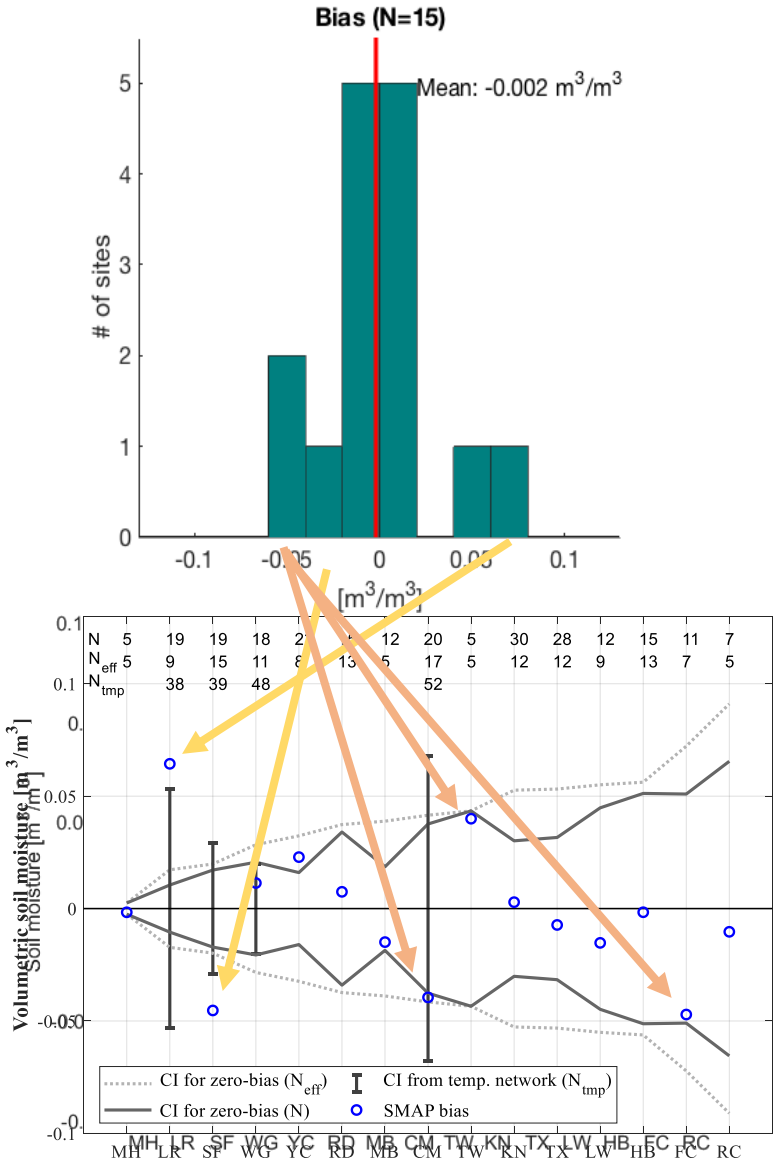
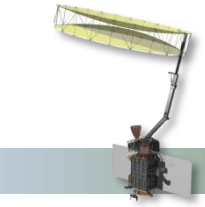


Fan Chen, Wade Crow

Uncertainty Table

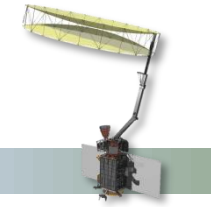


Site Name	Current performance (L2SMP_E T15570)		"Top-down" statistical analysis: Confidence intervals		Scaling Associated Uncertainties		Vertical Profile (based on an experiment, fits with literature)		In situ calibration (literature)		TB calibration: Solar Reflection & Antenna Reflector[3]		RFI	
	Bias	ubRMSE	Bias	ubRMSE	Bias	ubRMSE	Bias	ubRMSE	Bias	ubRMSE	Bias	ubRMSE	Bias	ubRMSE
Walnut Gulch	0.018	0.024	0.027[1]	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Reynolds Creek	-0.013	0.040	0.091	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
TxSON	-0.009	0.022	0.053	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Fort Cobb	-0.045	0.028	0.072	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Little Washita	-0.018	0.022	0.055	< 0.01	TBD	T								~0
South Fork	-0.038	0.055	0.033[1]	< 0.01	TBD	T								~0
Little River	0.062	0.035	0.068[1]	< 0.01	TBD	T								~0
Kenaston	0.006	0.027	0.053	< 0.01	TBD	T								~0
Carman	-0.047	0.064	0.069[1]	< 0.01	TBD	T								~0
Monte Buey	-0.016	0.049	0.039	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
REMEDHUS	0.012	0.039	0.037	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Twente	0.045	0.054	0.043	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Mongolia	0.003	0.032	0.002	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0
Yanco	0.015	0.043	0.032	< 0.01	TBD	TBD	~0[2]	0.016	~0.01	~0.01	~0	~0	~0	~0
HOBE	-0.003	0.036	0.056	< 0.01	TBD	TBD	-0.012	0.016	~0.01	~0.01	~0	~0	~0	~0

Scaling associated uncertainties: Estimate based on permanent vs. temporary network averages over four sites: SF, CM, WG, LR

1) Based on temporary network; 2) Vertically installed sensor; 3) Reflector effects being investigated

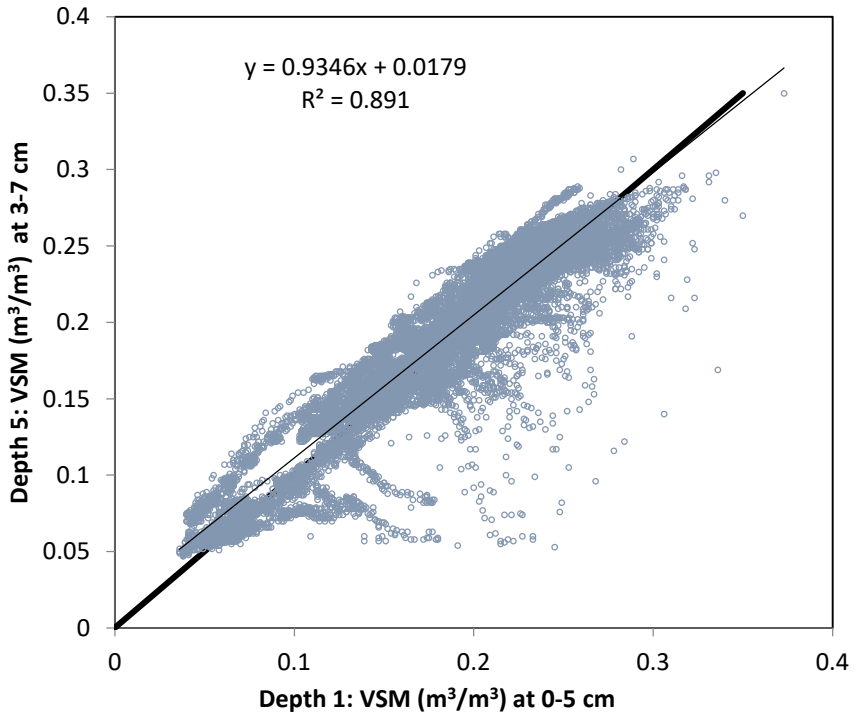
Scaling Associated Uncertainties



- Difference between the true average soil moisture and the estimated average soil moisture because not capturing the spatial distribution of soil moisture in a correct way
- Temporary networks provide an improved estimate of the true average soil moisture with respect to the permanent installation
- Methods
  - Direct comparison
  - Random forest (Mahta Moghaddam)
  - Hydrological modeling (Eric Wood, AAFC team)
- Random forest and hydrological modeling pursued to offer insight on the scaling issues and potentially offer new upscaling approaches
- Random forest approach offers straightforward solution but is dependent on the soil moisture station locations
- Hydrological modeling offers insights beyond what is observed by the stations, but accuracy remains a challenge

Vertical Profile

Most soil moisture installations are installed at a depth of 5 cm with variable sensing volumes. The Stevens Hydra Probe (common sensor) has an approximate 2.5-7.5 cm sensing depth. A set of Hydras have been installed at depths from 2.5 and 5 cm depths (in triplicate).



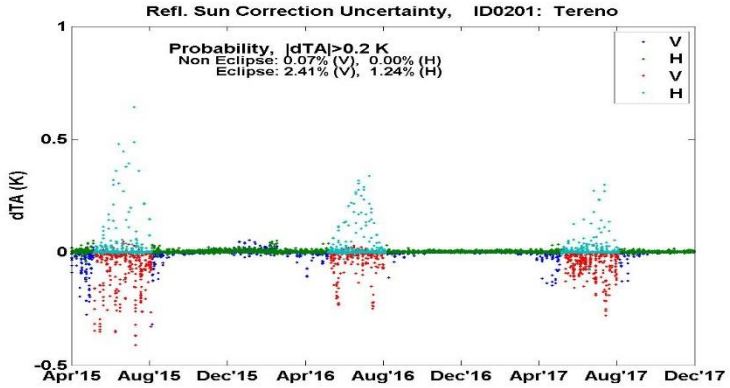
Comparing depths of installation between 2.5 and 5 cm below the surface. Increasing depth yields increased error, on par with error of the instrument of 0.01 m^3/m^3.

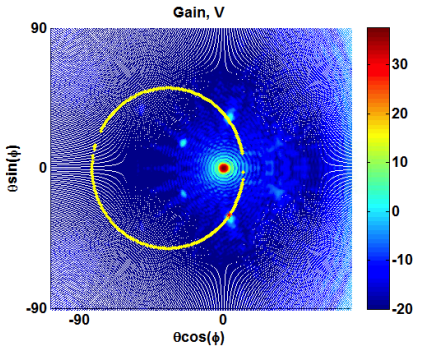
	0-5 cm versus 2.5-7.5cm
Bias	-0.012
RMSE	0.020
ubRMSE	0.016
Fit-RMSE	0.016

Mike Cosh

CVS Bias due to Reflect Sun Correction

- The uncertainty in Reflect Sun Correction at Cal/Val sites is variable
  - Using maximum value
  - No impact to 11 Cal/Val Sites
  - Impact to 20 Cal/Val Sites
    - relatively larger impact during eclipse season
    - Solar glint point on the Earth's surface close to mainbeam or high gain region

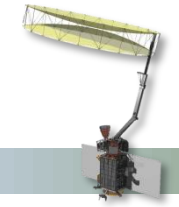




- Zero/negligible bias and ubRMSE
  - Few tenth Kelvin or 0.004 m^3/m^3 (maximum) uncertainty with small probability overall for Cal/Val sites.

Jinzheng Peng

RFI



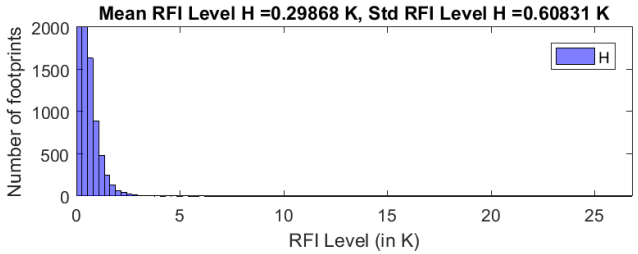
Cal Val Site	Potential RFI bias (K)
'Tereno'	0.03
'REMEDHUS'	0.02
'Reynolds Creek'	0.01
'Kuwait'	0.03
'HOAL'	0.14
'Yanco'	0.01
'Kyeamba'	0.06
'Carman'	0.01
'Naqu'	0.01
'Maqu'	0.11
'Ngari'	0.02
'Twente'	0.03
'Walnut Gulch'	0.01
'Little Washita'	0.04
'Fort Cobb'	0.01
'Little River'	0.04
'St Josephs'	0.01
'South Fork'	0.14
'Sodankyla'	0.02
'Bell Ville'	0.03
'Monte Buey'	0.02
'Tonzi Ranch'	0.13
'Millbrook'	0.06
'Kenaston'	0.01
'Tabasco'	0.01
'Valencia'	0.02
'Niger'	0.01
'Benin'	0.02
'TxSON'	0.01
'Mongolia'	0.05

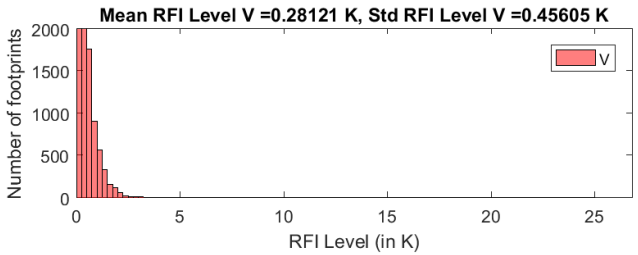
- RFI bias calculated by calculating spillover from nearby strong sources that remain un-flagged
- Assumptions made about the type of RFI source
- Difficult to separate RFI bias from incomplete RFI spectral flagging
- For the most part, RFI at most sites seems to be a non-factor <0.1K

Sidharth Misra

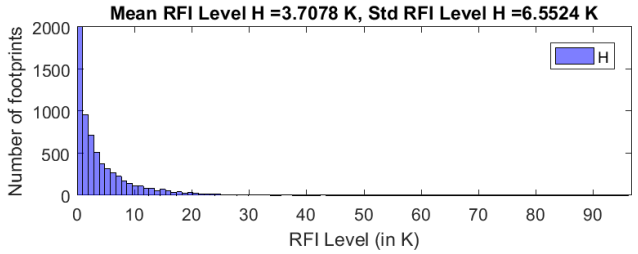
RFI

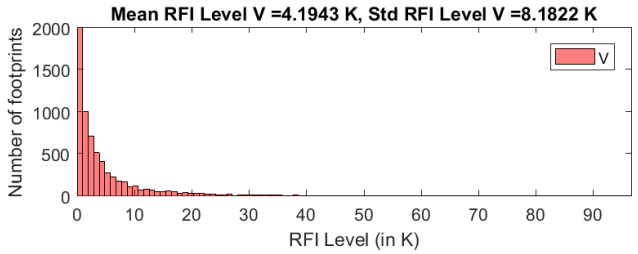
Yanco



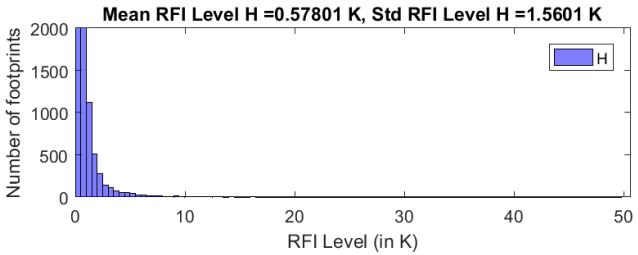


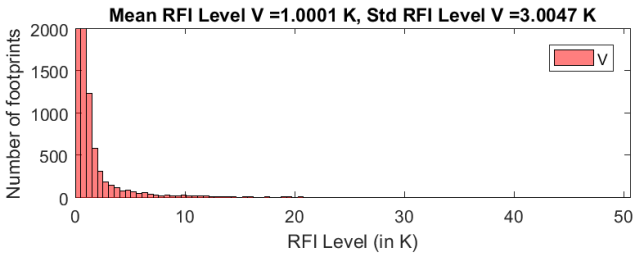
Kuwait



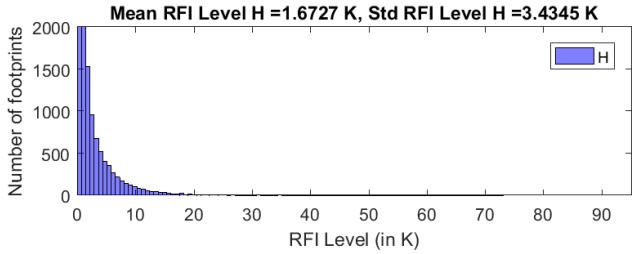


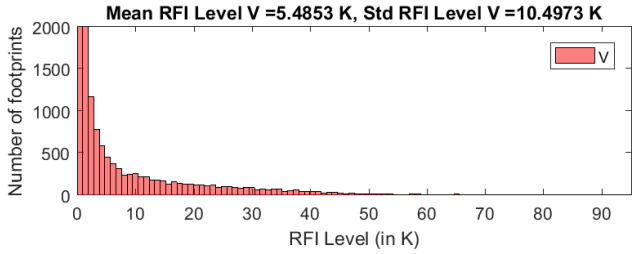
Little Washita





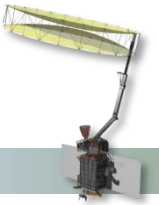
Twente (the Netherlands)





Alexandra Bringer, Joel Johnson

Conclusions



- Radiometer calibration and RFI: OK
- Work to
  - reduce bias uncertainty
  - better define scaling uncertainty
  - better assess the impact of vertical non-uniform profile
  - develop a systematic approach to validate spatially disaggregated product