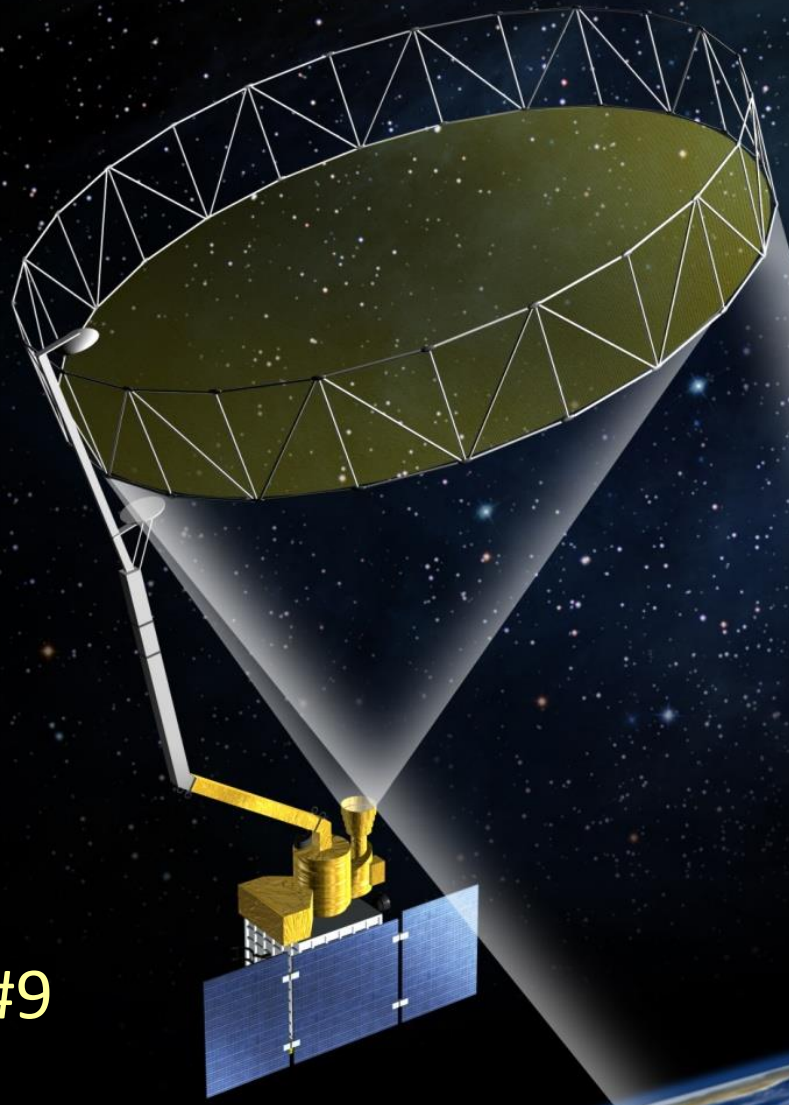
National Aeronautics and Space Administration

Soil Moisture Active Passive Mission

SMAP



Uncertainty of Reference Pixel Soil Moisture Averages Sampled at SMAP L2SM_P_E Core Validation Sites

Fan Chen (USDA ARS)

Wade T. Crow (USDA ARS)

Michael Cosh (USDA ARS)

Andreas Colliander (Caltech/NASA JPL)

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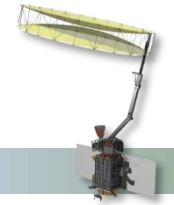
California Institute of Technology

Uncertainties in in situ reference pixel average soil moisture and the impact on SMAP validation metrics



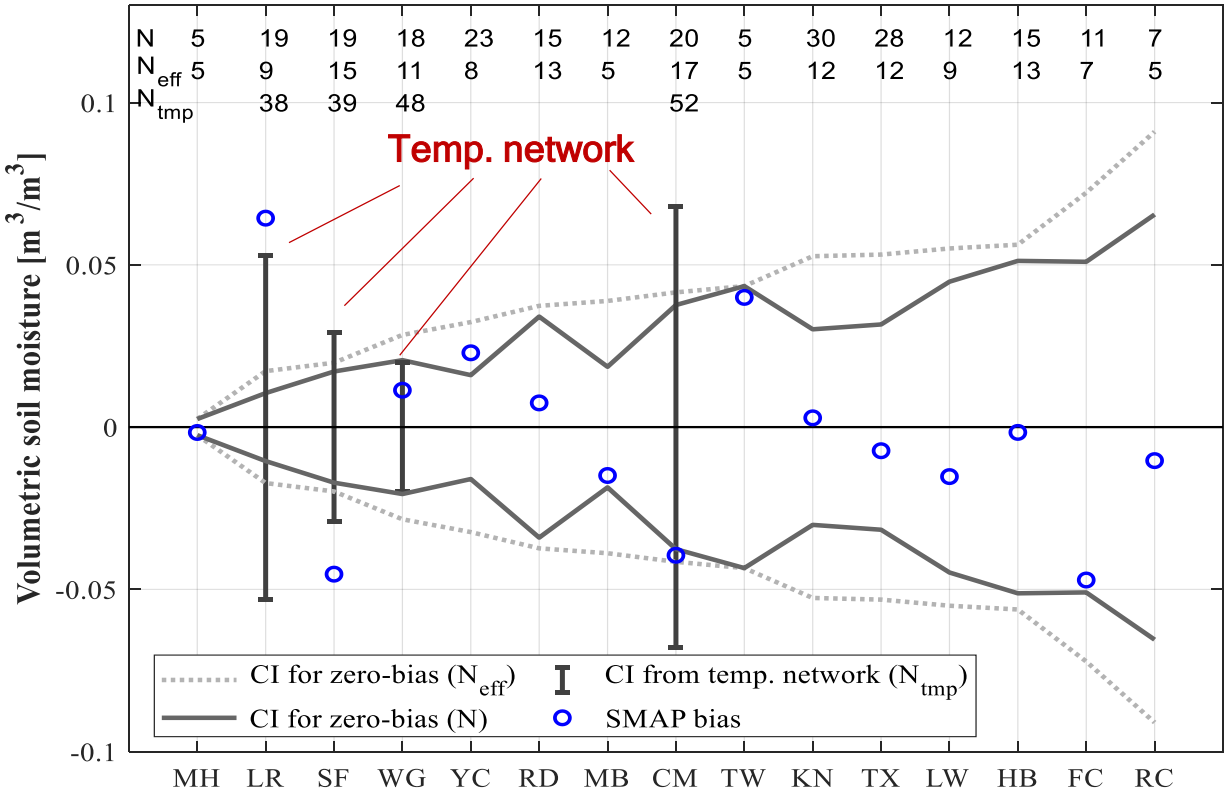
- SMAP core validation sites (CVS) upscaled reference pixel soil moisture (CSASM) may not accurately represent the average soil moisture of the reference pixel due to sampling limitations such as low density (e.g. TW, RC), clustering (e.g. MB, HB, YC) or biased sampling (e.g. LR)

- Uncertainties in CSASM reduce confidence in the CSASM-based SMAP validation metrics
  - Uncertainty in CSASM temporal average → uncertainty in SMAP bias (no correction)
  - CSASM ubRMSE → inflates SMAP ubRMSE (partial correction available)

Uncertainty in CSASM temporal average

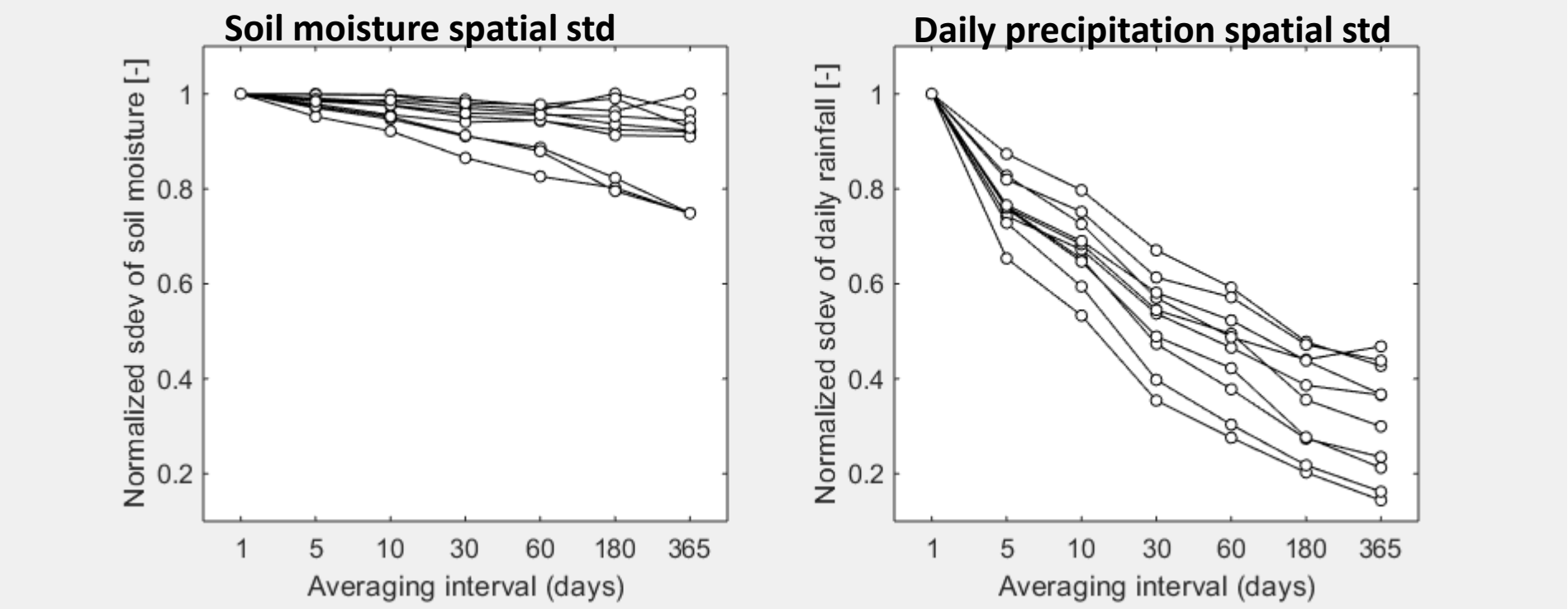
- Estimated by central-limit theorem based statistical analysis assuming random spatial sampling.
- Determined by spatial variability sampled by CVS sensor network and sample size
  - *N* vs. $N_{effective}$ $(= 1/\Sigma {w_i}^2)$
- Large CSASM uncertainty leads to statistically insignificant SMAP bias
- Temporary network results indicate underestimated uncertainty based on permanent network observations.

Confidence interval for CSASM temporal avg. & SMAP bias



SMAP bias based on L2SMP_E, ver. 4, T15570, ascending/descending, 3/31/2015 – 2/28/2018

Persistent soil moisture spatial variability behind CSASM temporal average uncertainty



- Soil moisture spatial variability controlled by static distribution of surface characteristics (soil texture, landcover etc.)
- Subpixel variability (and bias uncertainty) unlikely to be reduced by extended length of observation without increasing sampling density.

Options for reducing bias uncertainty in CVS

Estimated effective sampling sizes for SMAP L2SMP_E reference pixels to achieve ≤0.03 m^3/m^3 of bias uncertainty

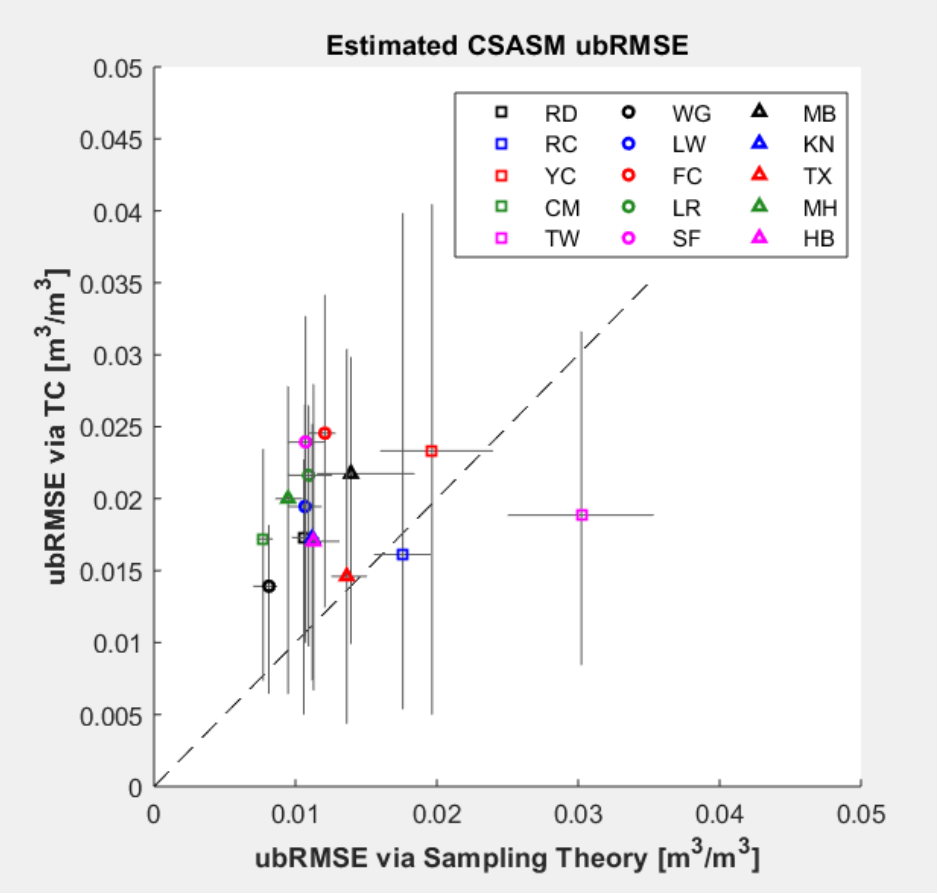
	Current N	N_{eff} for CI ≤ 0.03 m^3/m^3	N deficit
TW	5	**8**	3
RC	7	**15**	8
FC	11	**16**	5
LW	12	**17**	5
RD	15	**17**	2
HB	15	**34**	19
CM	20	**26**	6
TX	28	**14**	-
KN	30	**13**	-

- Increasing network density: e.g. TW, RC, FC, LW, RD, HB, CM
- Optimizing sampling locations: e.g. TX, KN
- Calibrating the upscaling function: e.g. LR

CSASM ubRMSE and impact on SMAP ubRMSE

- Sampling theory approach
- Triple collocation

CSASM - SMAP/SMOS/ASCAT - ECMWF/NR



$$ubRMSE_{SMAP,T} = \sqrt{ubRMSE^2_{SMAP,CSASM} - ubRMSE^2_{CSASM,T}}$$

L2SMP_E CVS	CSASM ubRMSE*	sampled SMAP** ubRMSE	corrected SMAP ubRMSE
TX	0.014	0.022	**0.017**
LW	0.011	0.023	**0.021**
WG	0.008	0.025	**0.023**
FC	0.012	0.030	**0.027**
MH	0.009	0.031	**0.030**
KN	0.011	0.035	**0.034**
LR	0.011	0.037	**0.036**
RD	0.010	0.038	**0.036**
RC	0.018	0.041	**0.038**
YC	0.020	0.044	**0.040**
MB	0.014	0.045	**0.043**
HB	0.011	0.045	**0.044**
SF	0.011	0.060	**0.059**
TW	0.030	0.060	**0.052**
CM	0.008	0.074	**0.073**
Average	0.013	0.041	**0.038**

* Sampling theory-based estimates

** L2SMP_E, ver. 4, T15570, ascending/descending, 3/31/2015 – 2/28/2018

Summary

- Large uncertainty in CSACM temporal average obtained from current sensor network leads to large uncertainty in sampled SMAP bias
  - At most CVS, sampled SMAP bias is statistically insignificant (more so with R16)
  - Bias uncertainty is difficult to remove and correct due to persistent soil moisture spatial variability
  - Still, available estimates of uncertainty range likely underestimated

- CSASM ubRMSE generally adequate for estimating SMAP ubRMSE.
  - ubRMSE of CSASM is generally in the range 0.01 ~ 0.02 m^3/m^3
  - Correction for CSASM ubRMSE gives small decrease of SMAP ubRMSE