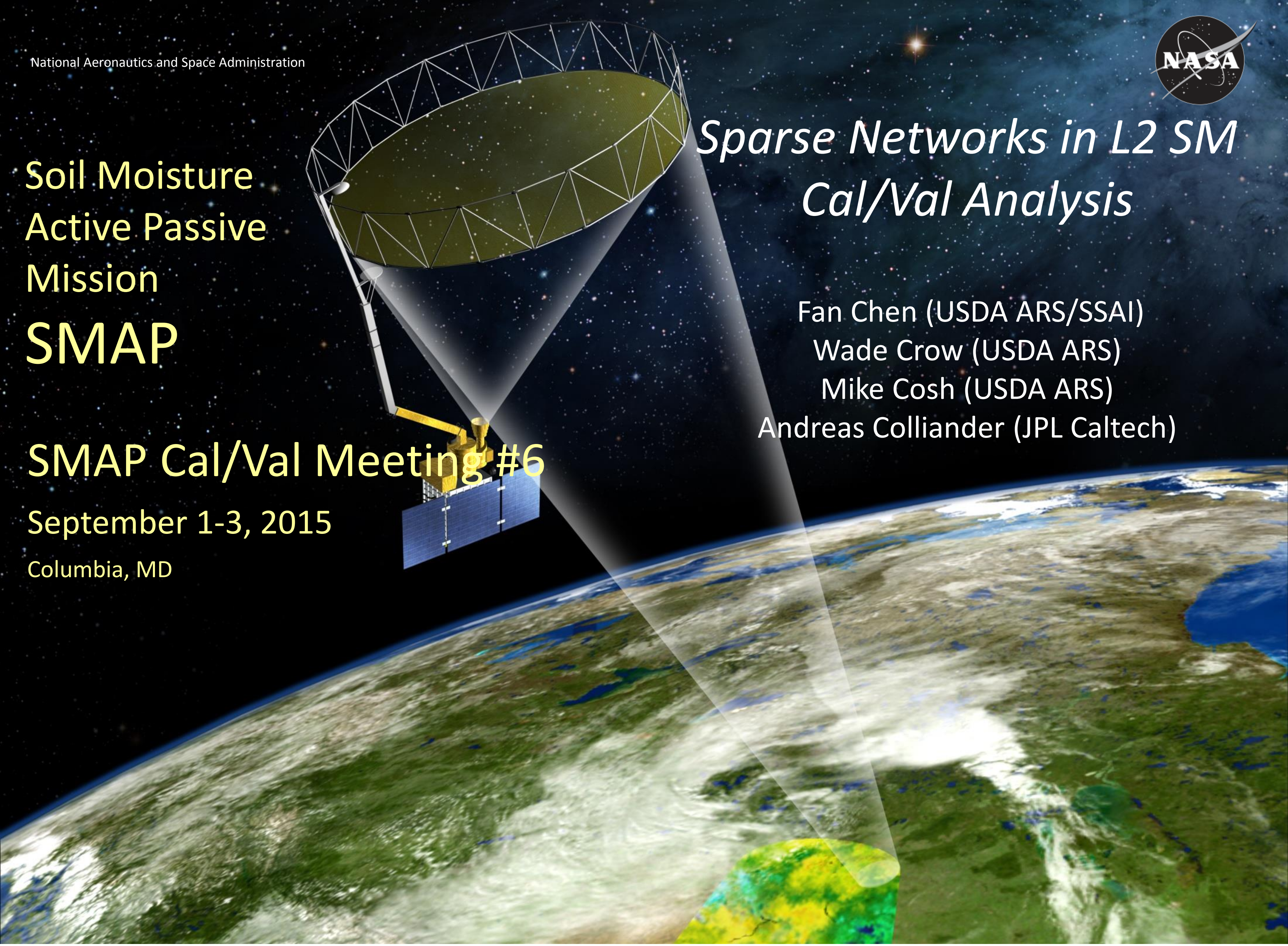


National Aeronautics and Space Administration

Sparse Networks in L2 SM Cal/Val Analysis

Soil Moisture Active Passive Mission

SMAP

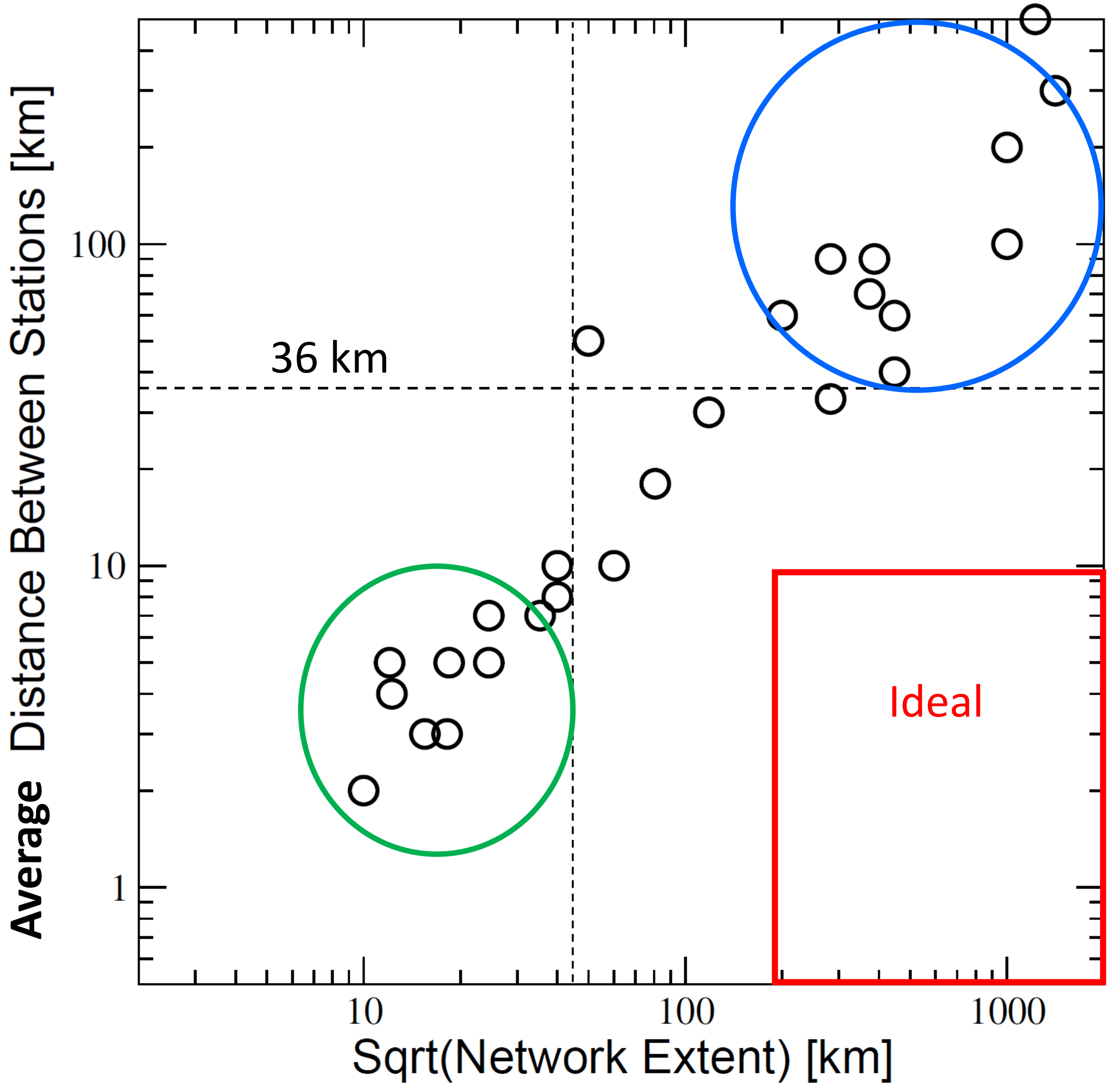
Fan Chen (USDA ARS/SSAI)
Wade Crow (USDA ARS)
Mike Cosh (USDA ARS)
Andreas Colliander (JPL Caltech)

SMAP Cal/Val Meeting #6

September 1-3, 2015

Columbia, MD

Spatial Attributes of Current Networks



"**Core**" SMAP validation networks (~5-10 obs/SMAP footprint).

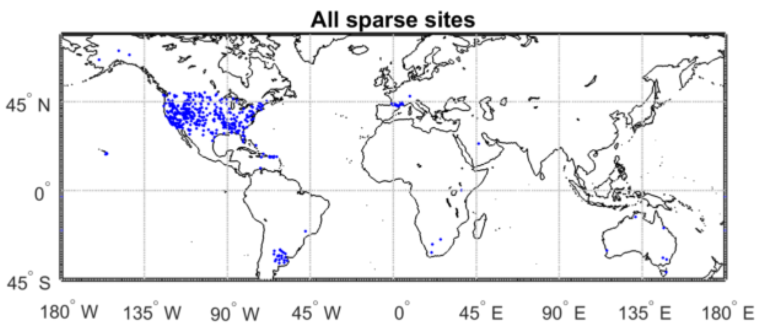
Limited extent but covering a range of biomes/climate/land cover.

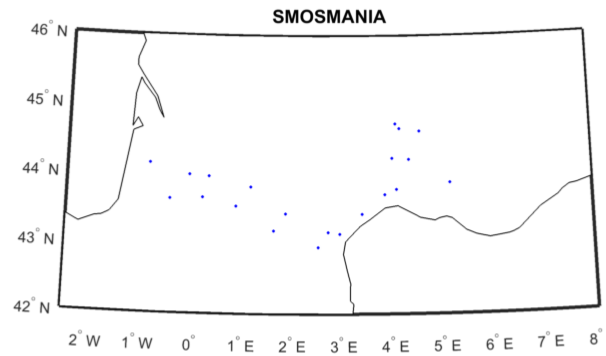
Backbone of SMAP validation efforts.

"**Sparse**" SMAP validation networks (~1-2 obs/ SMAP footprint).

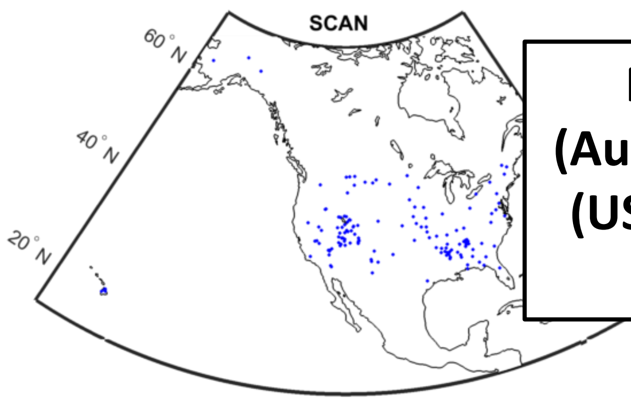
Supplemental but a validation resource that cannot be neglected.

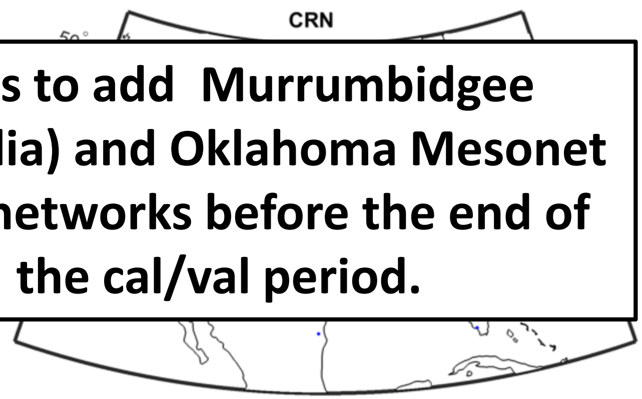
Sparse Network Locations



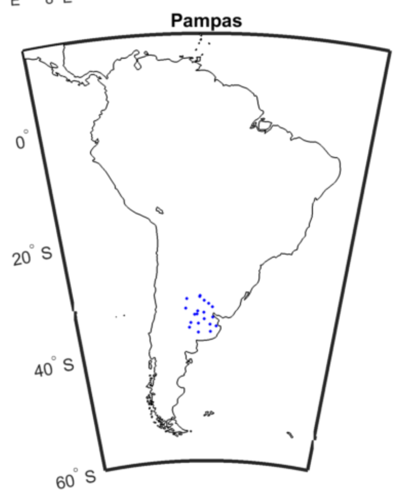


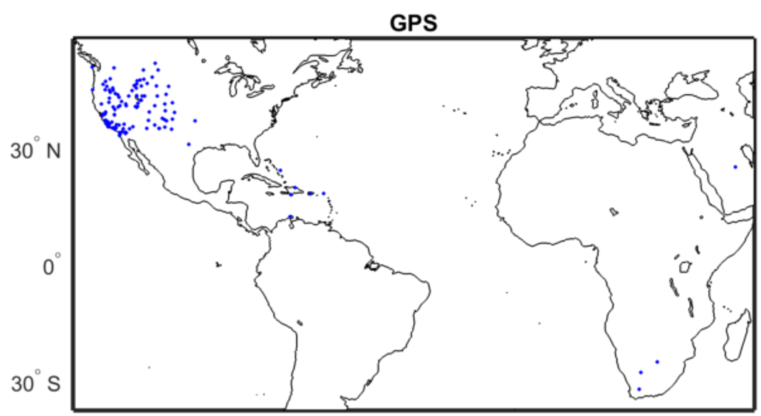
Total sites: 482/394

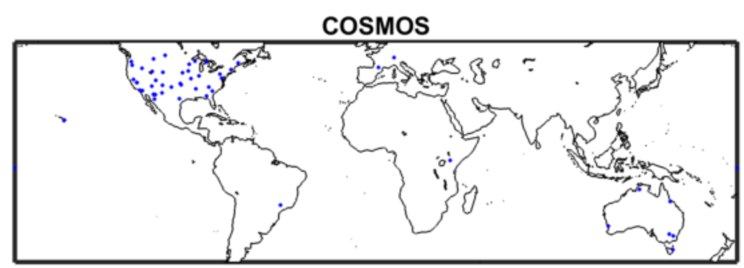




Plans to add Murrumbidgee (Australia) and Oklahoma Mesonet (USA) networks before the end of the cal/val period.







Outline of Talk

I. Sparse Network Overview

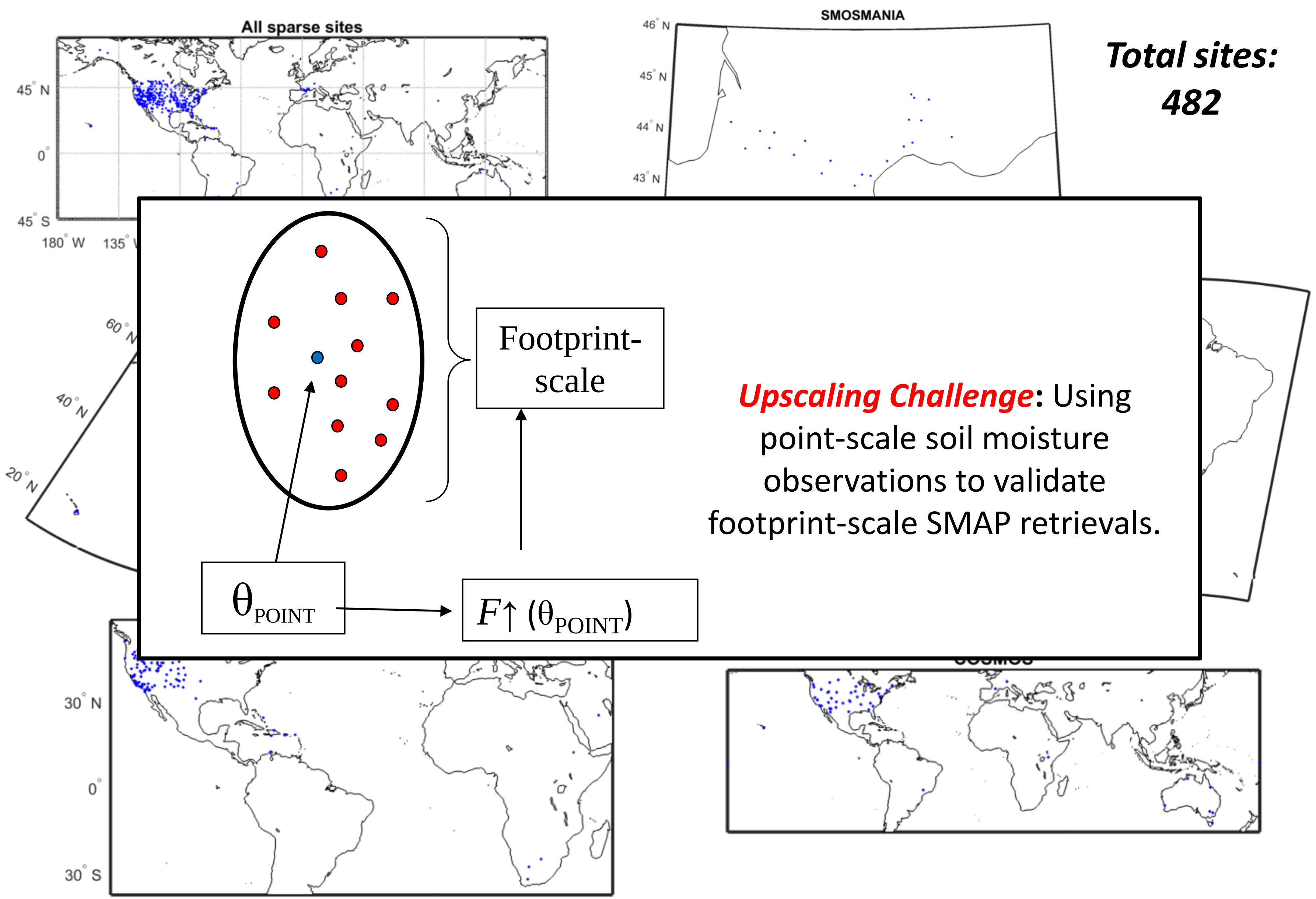
II. Triple Collocation Methodology/Verification

Is TC working as an upscaling tool?

III. Sparse Network Results (emphasis on L2_SM_P)

Sparse Network Locations

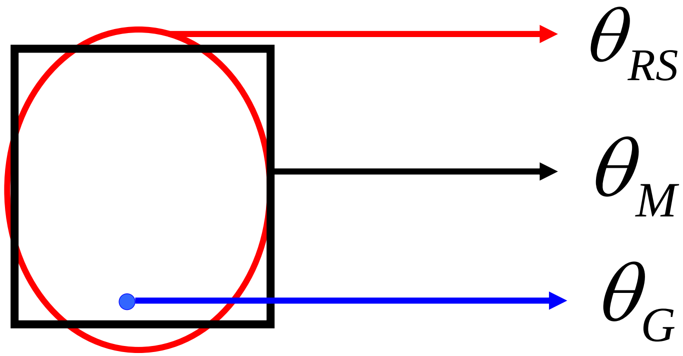
Total sites: 482



Upscaling Challenge: Using point-scale soil moisture observations to validate footprint-scale SMAP retrievals.

Application of Triple Collocation for Sparse Network Validation

1) Obtain three independent (and uncertain) estimates of *footprint-scale* soil moisture:



Remote Sensing (RS)

Land Surface Model (M)

Sparse Ground Observation (G)

2) Assume products can be modeled as:

$$\theta_{RS} = \alpha_{RS}\theta_{True} + \varepsilon_{RS} + \mu_{RS}$$

$$\theta_{M} = \alpha_{M}\theta_{True} + \varepsilon_{M} + \mu_{M}$$

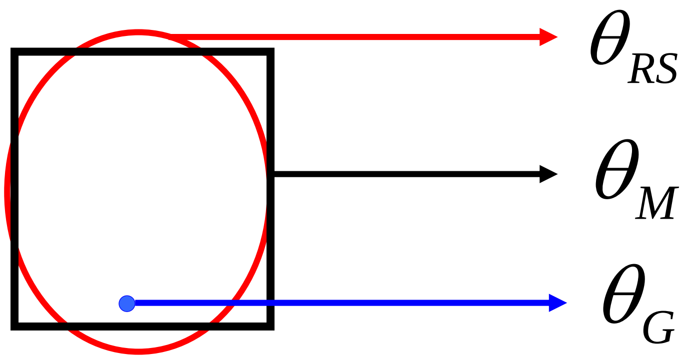
$$\theta_{G} = \alpha_{G}\theta_{True} + \varepsilon_{G} + \mu_{G}$$

3) Triple Collocation can provide:

1) Ratios: α_{RS}/α_M, α_{RS}/α_G and α_M/α_G

2) Variances of: $\varepsilon_{RS}, \varepsilon_G$ and ε_M

Application of Triple Collocation for Sparse Network Validation



$$\theta_{RS} = \alpha_{RS}\theta_{True} + \varepsilon_{RS} + \mu_{RS}$$

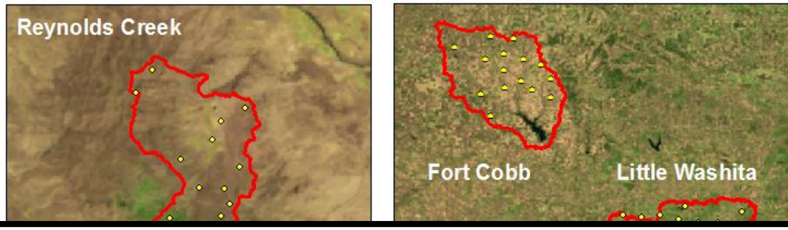
$$\theta_{M} = \alpha_{M}\theta_{True} + \varepsilon_{M} + \mu_{M}$$

$$\theta_{G} = \alpha_{G}\theta_{True} + \varepsilon_{G} + \mu_{G}$$

RMSE depends on: 1) additive bias [$\boldsymbol{\mu \neq 0}$], 2) multiplicative bias [$\boldsymbol{\alpha \neq 1}$] and 3) random error variance [**Var[$\boldsymbol{\varepsilon}$] > 0**].

TC provides no absolute information concerning *μ or α,* so a reference data set must be available where μ=0 and α=1 (i.e., one data set is unbiased).

Use of Sparse Ground-based Observations as a Scaling Reference



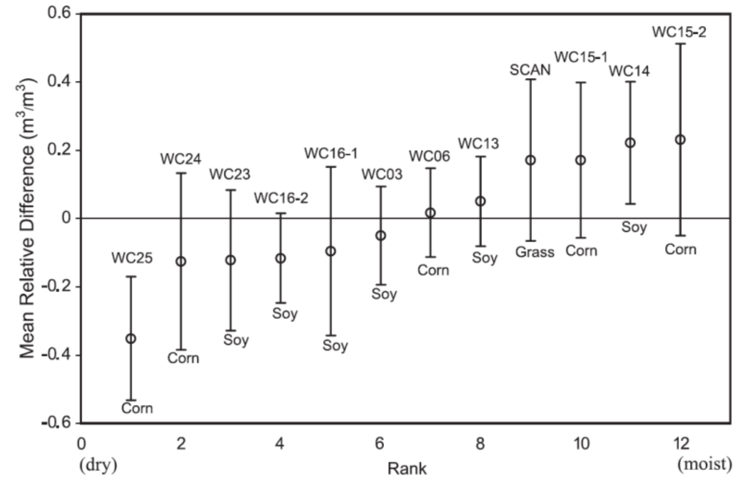
Conclusion: Point-scale ground based observations are have multiplicative and additive biases which preclude their use as an scaling reference.

RMSE correction is problematic – focus instead on correlation-based measures of error.

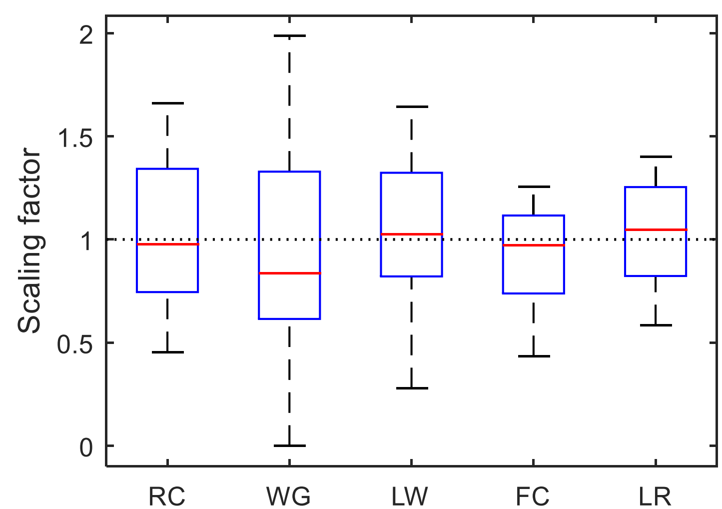
[Draper et al. (2012); McColl et al. (2014); Gruber et al. (2015)]

Watershed Average Soil Moisture (WASM)

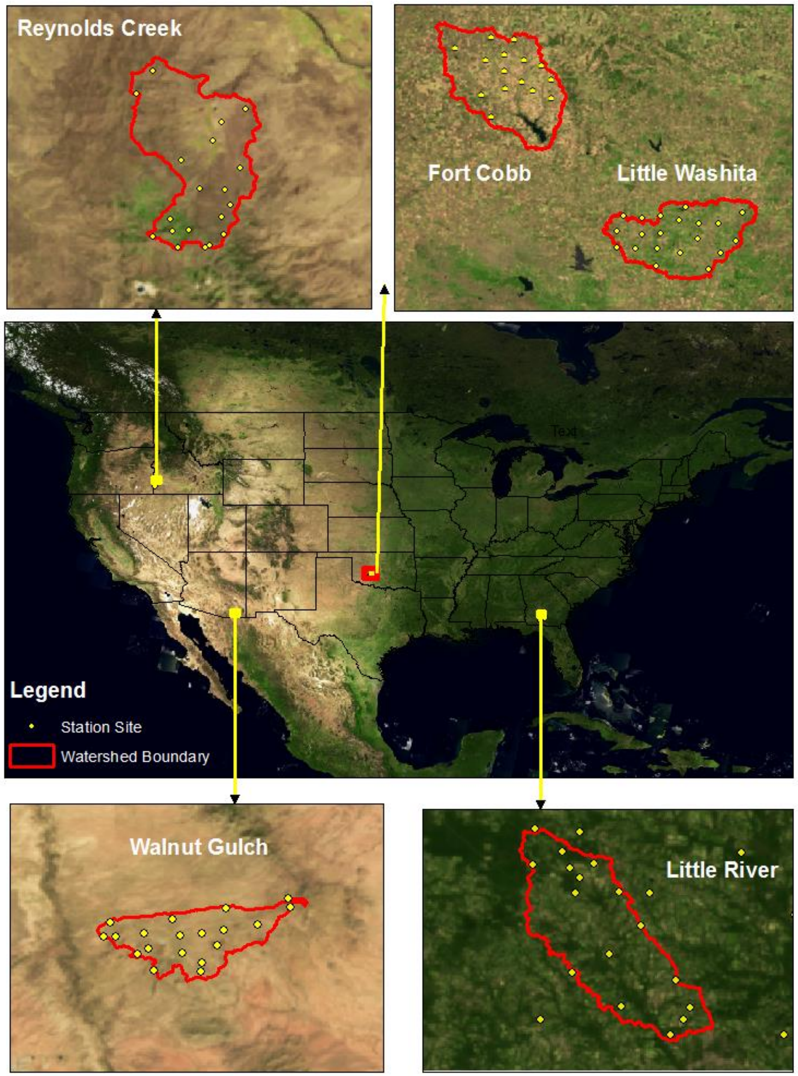
Biases w.r.t. areal averages:



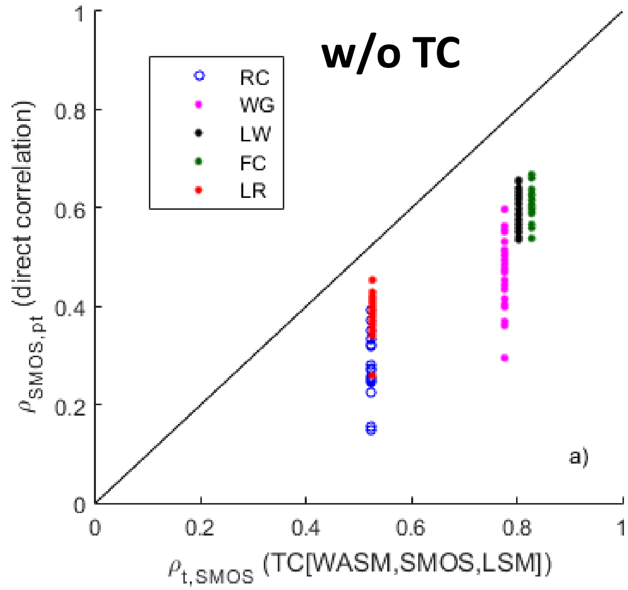
Wrong dynamic range w.r.t. to areal averages:

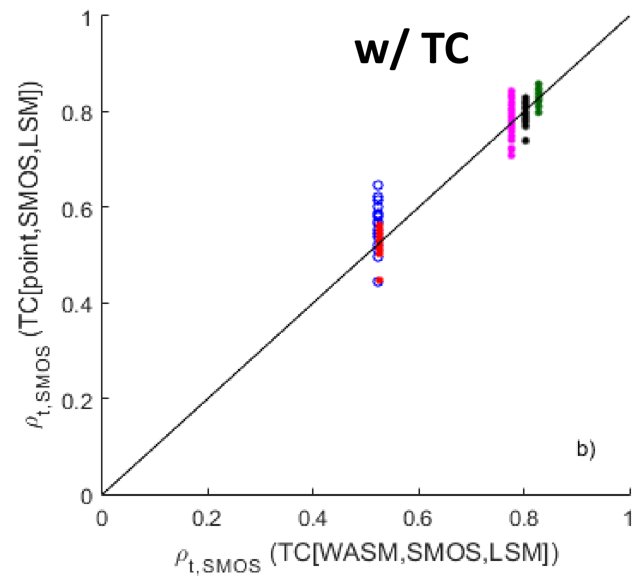


Validation of TC-based Correlation Results for SMOS Retrievals



Watershed Average Soil Moisture (WASM)





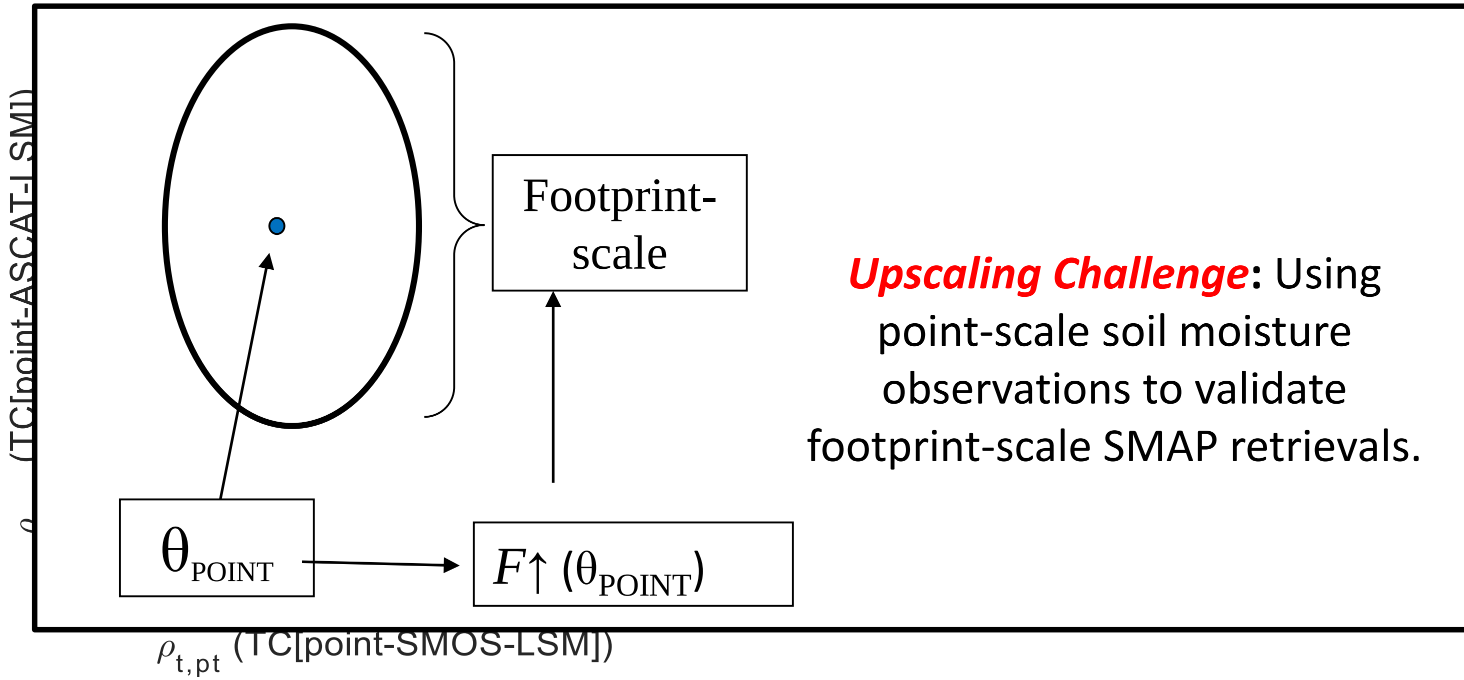
n
using

ore site

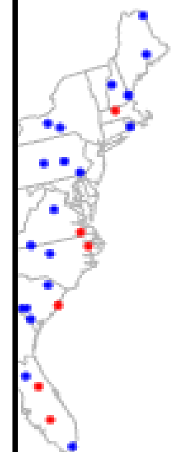
core

Evaluation of Sparse Site Representativeness Error

Goal: Estimate the correlation between a point-scale observation and true footprint-scale soil moisture. Use this estimate to evaluate individual sparse site locations.



***Upscaling Challenge*:** Using point-scale soil moisture observations to validate footprint-scale SMAP retrievals.



Evaluation should be independent of satellite product (ASCAT versus SMOS).

Qualitative evaluation of CRN and SCAN sparse network locations.

Outline of Talk

I. Sparse Network Overview

II. Triple Collocation Methodology/Verification

III. Sparse Network Results (emphasis on L2_P_SM)

Is TC analysis adding anything to SMAP cal/val?

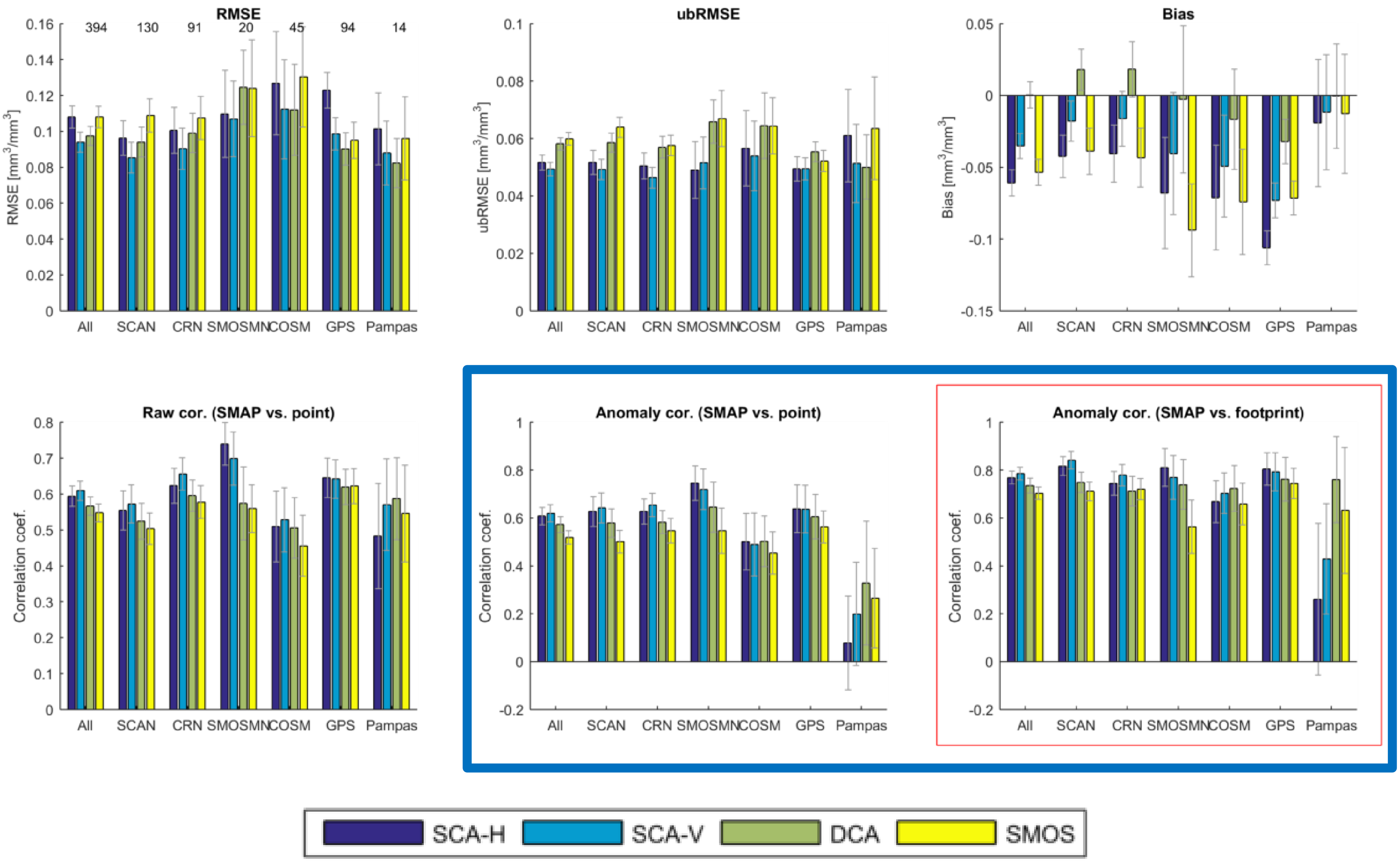
SMAP L2_SM_P descending/standard grid comparison at sparse networks

Fan Chen
USDA-ARS-HRSL

3/31– 8/23 SMAP L2_SM_P
(T1180 Beta release version)

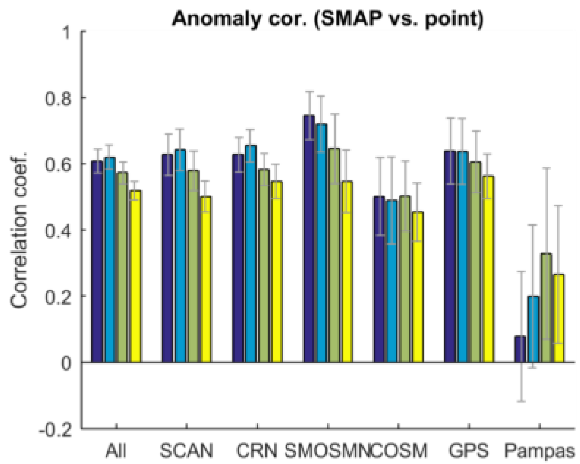
***Including SMOS L2 results…however, SMAP/SMOS cross-comparisons are not yet objective/fair (lack of consistent quality-control)**

L2 SM_P (stratified by sparse network)



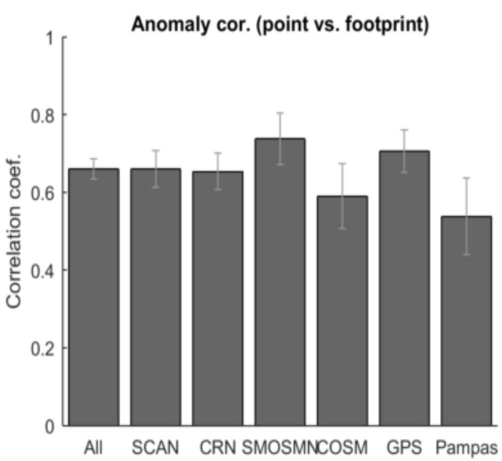
L2 SM_P (stratified by sparse network)

No TC - Point versus SMAP (degraded by *both* ground errors and SMAP errors)

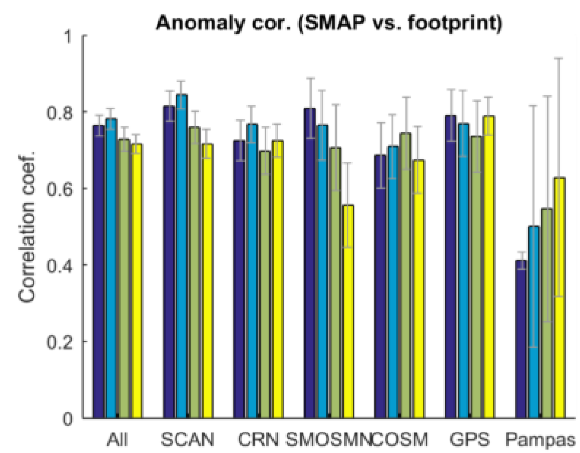


Point versus Truth

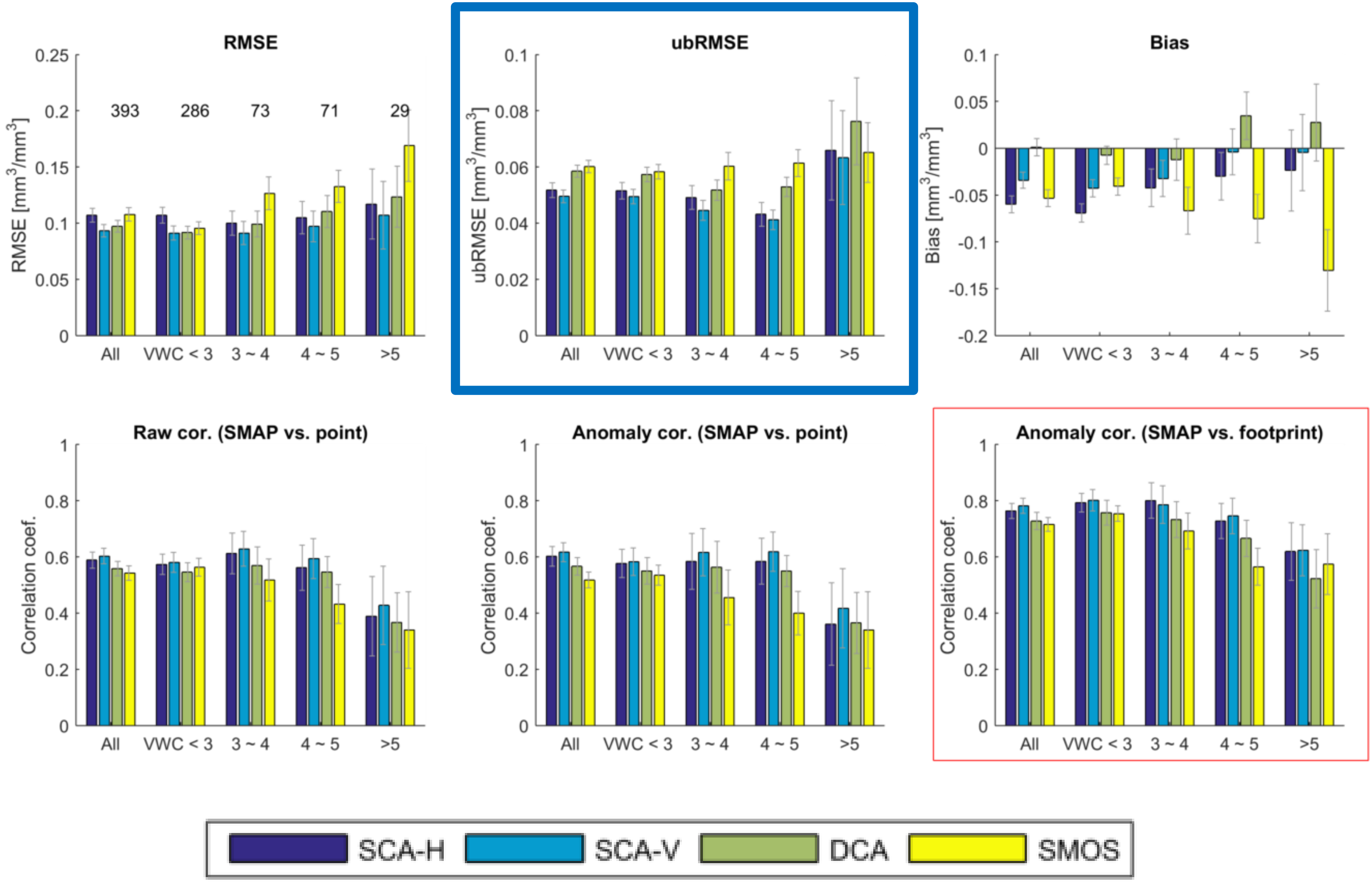
SMAP versus Truth



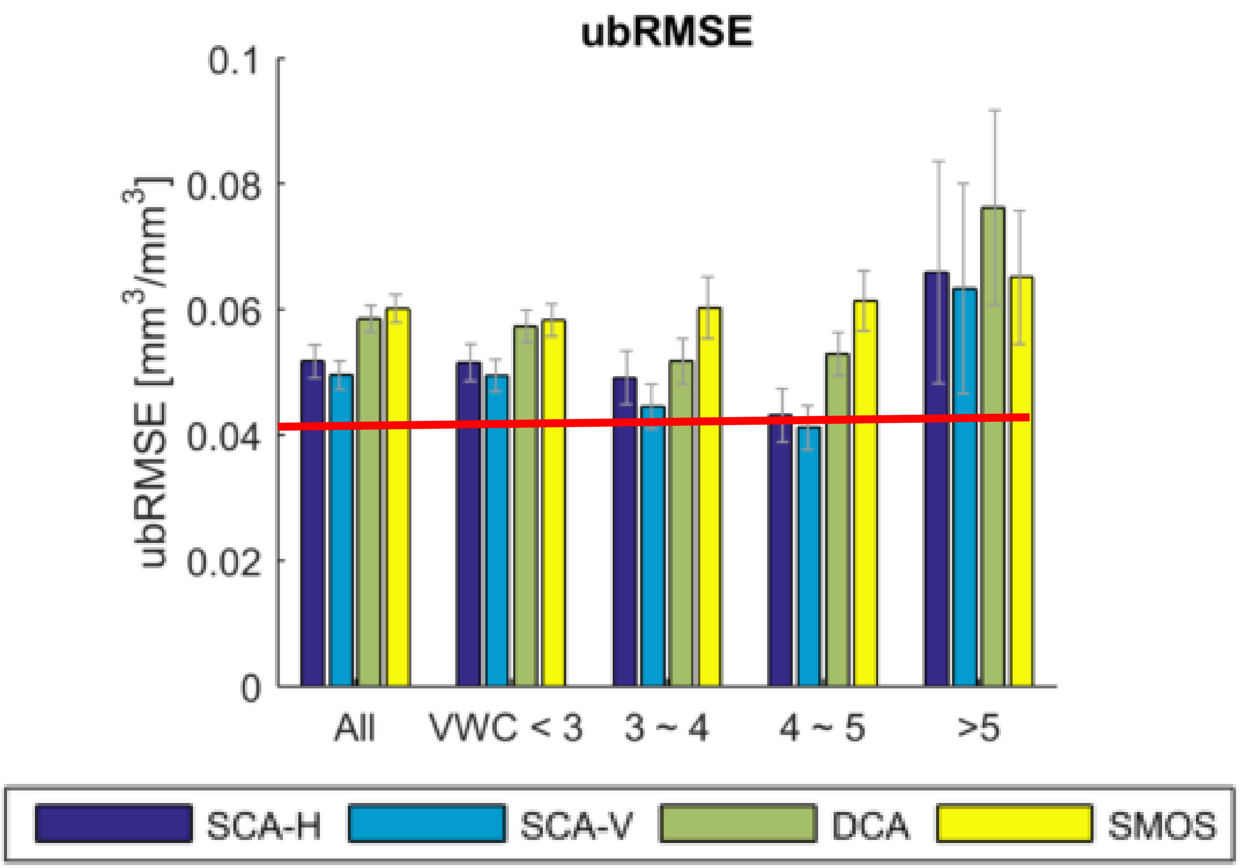
TC-based Decomposition



L2 SM_P (stratified by VWC)

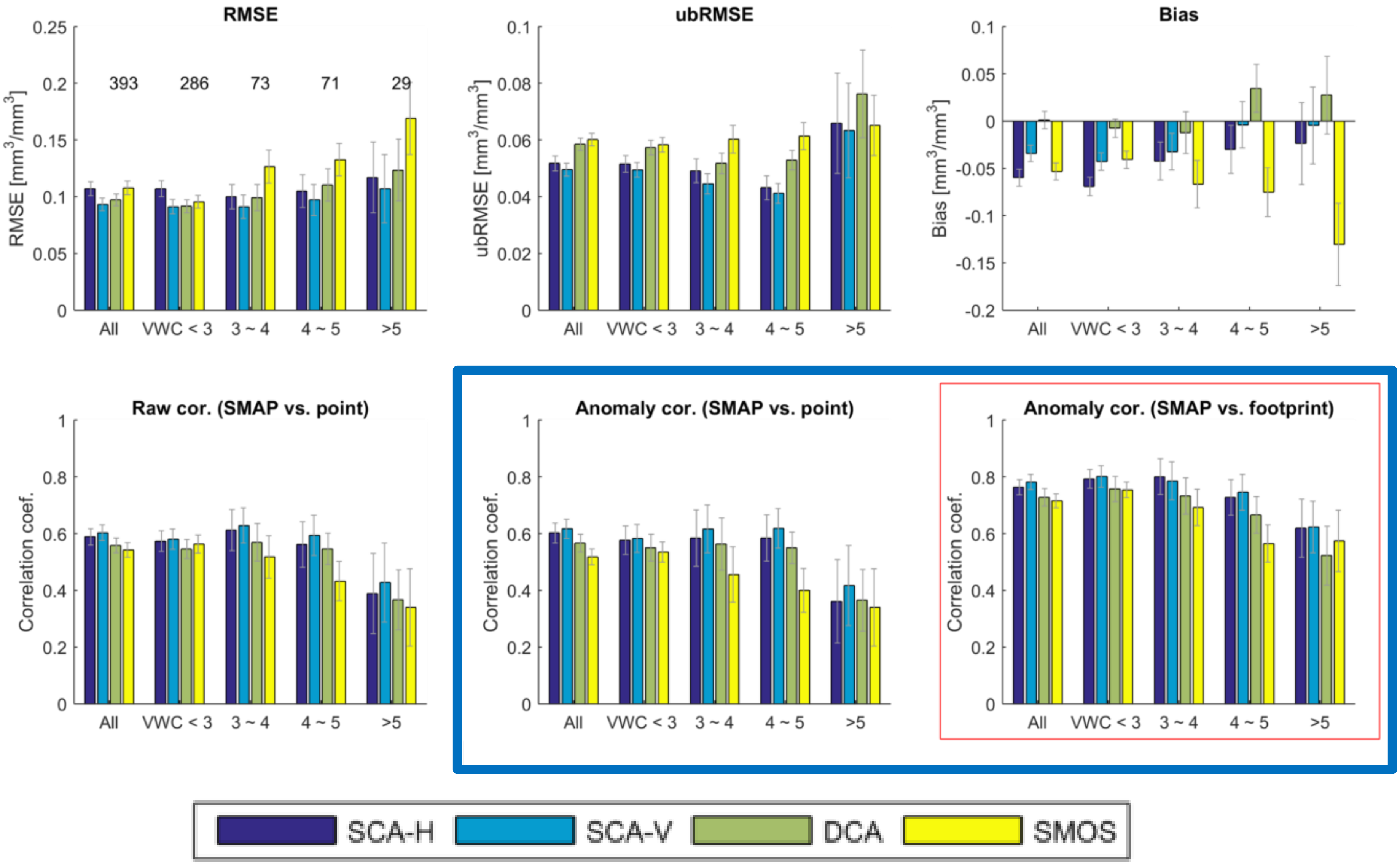


L2 SM_P (stratified by VWC)



Relative errors closely mirror core site results…for VWC < 5 kg m^{-2} SCA-V is near 0.04 m^{3}m^{-3} accuracy goal (*despite impact of up-scaling errors*).

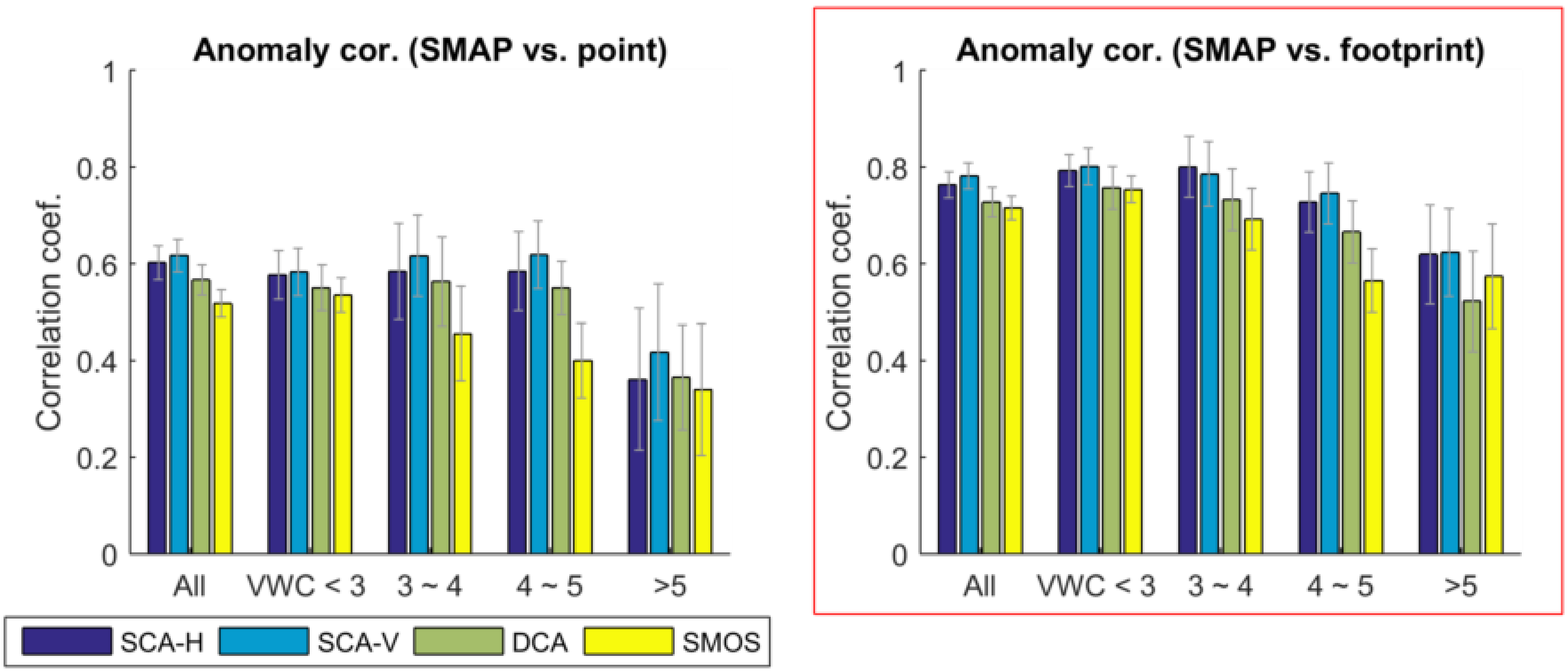
L2 SM_P (stratified by VWC)



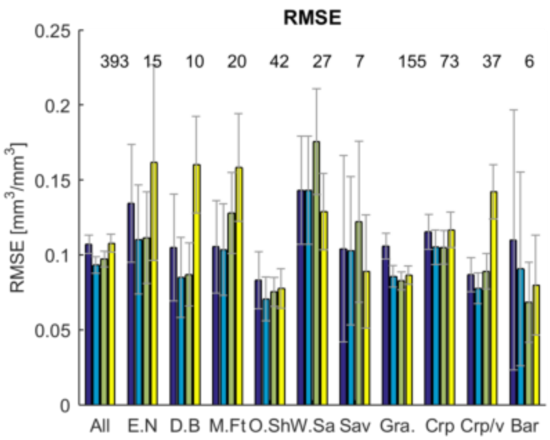
L2 SM_P (stratified by VWC)

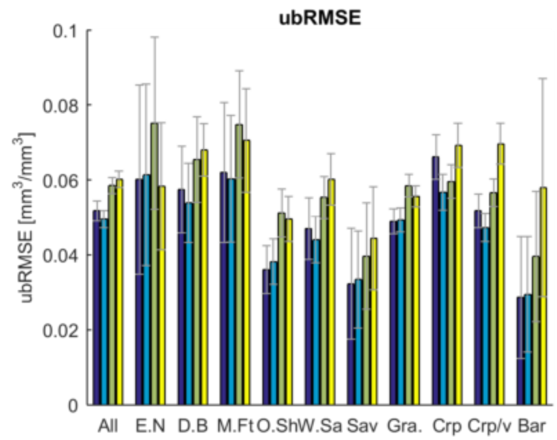
Without TC

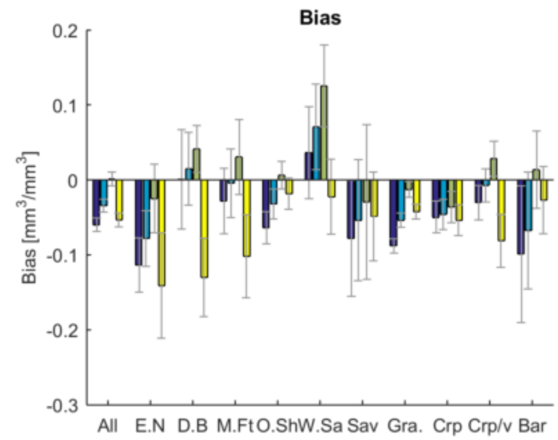
With TC



L2 SM_P (stratified by land cover type)

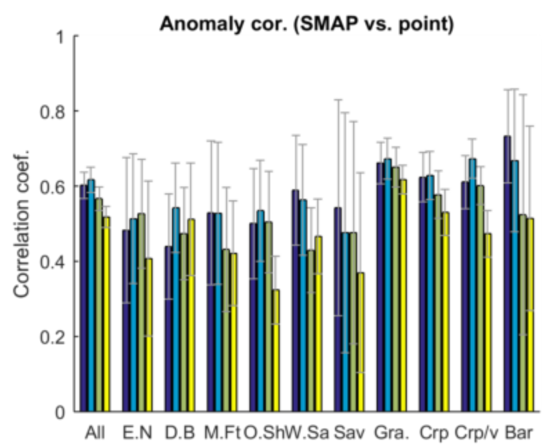


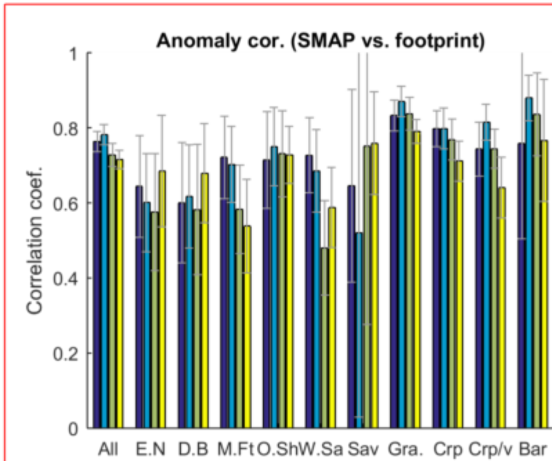




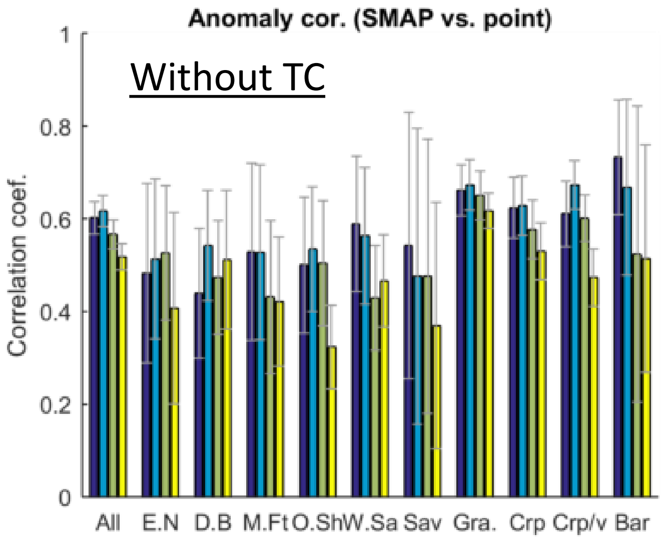
Landcover types

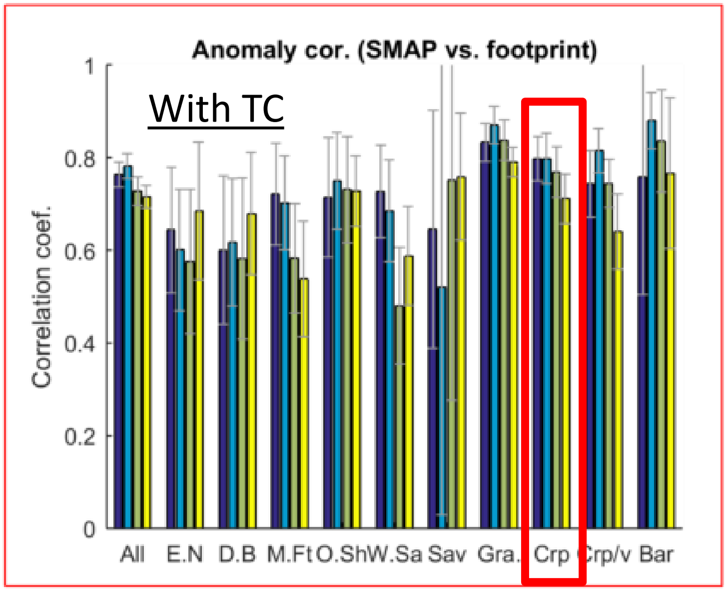
E.N	Evergreen Needleleaf Forest
E.B	Evergreen Broadleaf Forest
D.N	Deciduous Needleleaf Forest
D.B	Deciduous Broadleaf Forest
M.Ft	Mixed Forests
C.Sh	Closed Shrublands
O.Sh	Open Shrublands
W.Sa	Woody Savannas
Sav	Savannas
Gra	Grasslands
Wet	Permanent Wetlands
Crp	Croplands
Urb	Urban and Built-Up
Crp/v	Cropland/Natural Vegetation Mosaic
Sno	Snow and Ice
Bar	Barren or Sparsely Vegetated





L2 SM_P (stratified by land cover type)





Landcover types

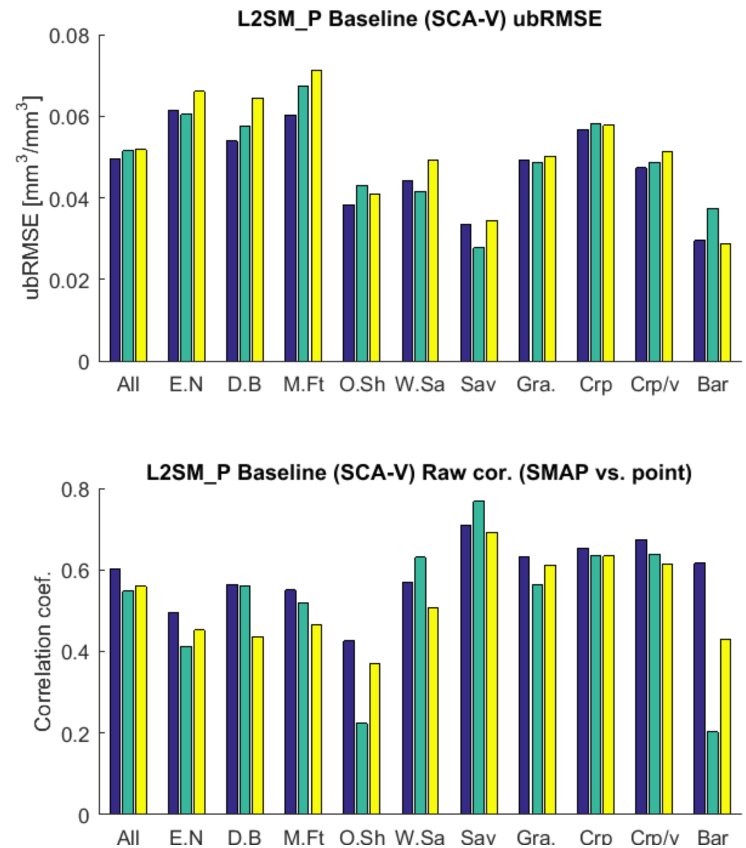
E.N	Evergreen Needleleaf Forest
E.B	Evergreen Broadleaf Forest
D.N	Deciduous Needleleaf Forest
D.B	Deciduous Broadleaf Forest
M.Ft	Mixed Forests
C.Sh	Closed Shrublands
O.Sh	Open Shrublands
W.Sa	Woody Savannas
Sav	Savannas
Gra	Grasslands
Wet	Permanent Wetlands
Crp	Croplands
Urb	Urban and Built-Up
Crp/v	Cropland/Natural Vegetation Mosaic
Sno	Snow and Ice
Bar	Barren or Sparsely Vegetated

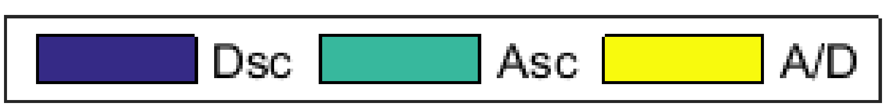
72 “Croplands” sites

L2 SM_P (stratified by land cover type and ascending/descending)

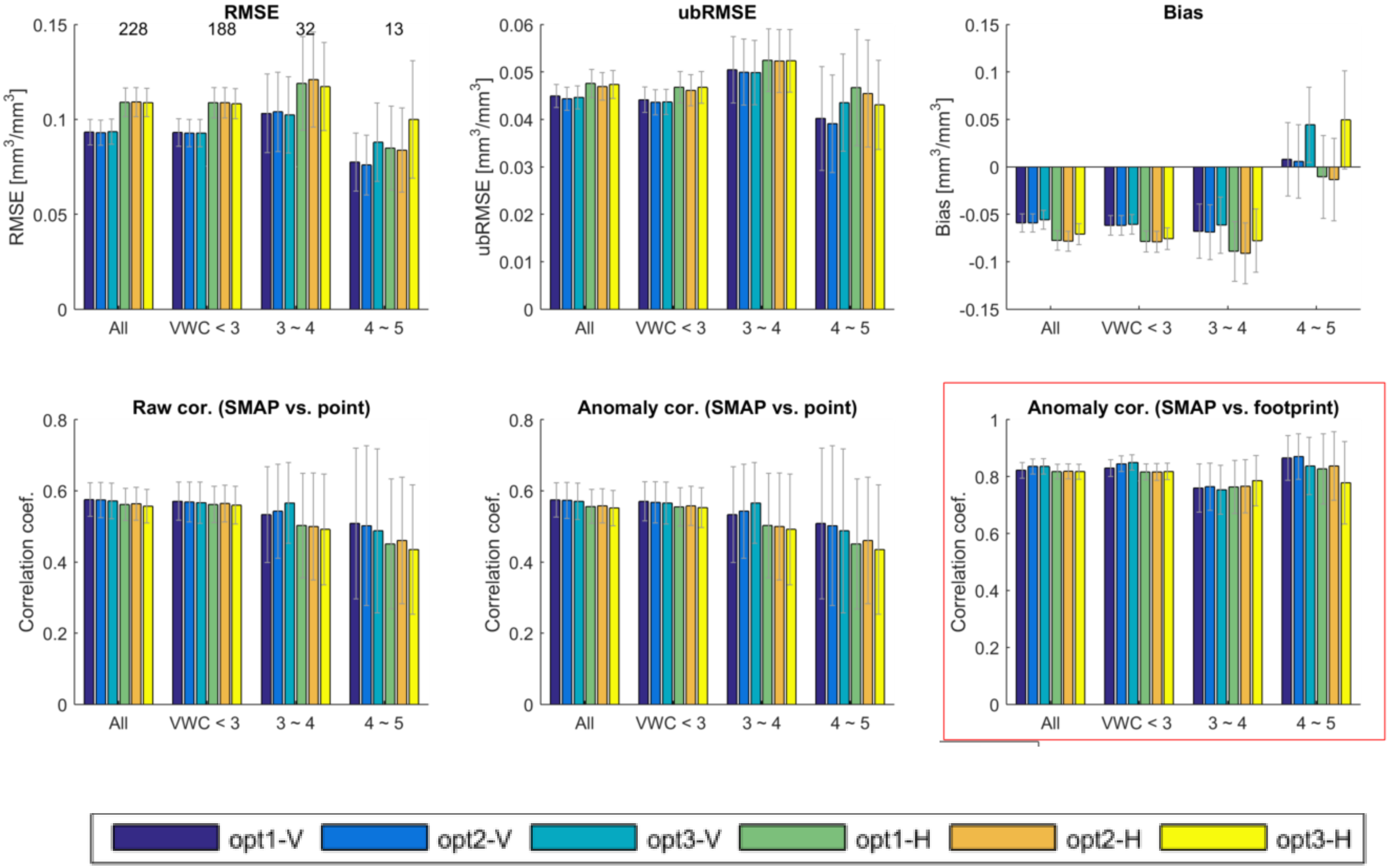
Landcover types

E.N	Evergreen Needleleaf Forest
E.B	Evergreen Broadleaf Forest
D.N	Deciduous Needleleaf Forest
D.B	Deciduous Broadleaf Forest
M.Ft	Mixed Forests
C.Sh	Closed Shrublands
O.Sh	Open Shrublands
W.Sa	Woody Savannas
Sav	Savannas
Gra	Grasslands
Wet	Permanent Wetlands
Crp	Croplands
Urb	Urban and Built-Up
Crp/v	Cropland/Natural Vegetation Mosaic
Sno	Snow and Ice
Bar	Barren or Sparsely Vegetated

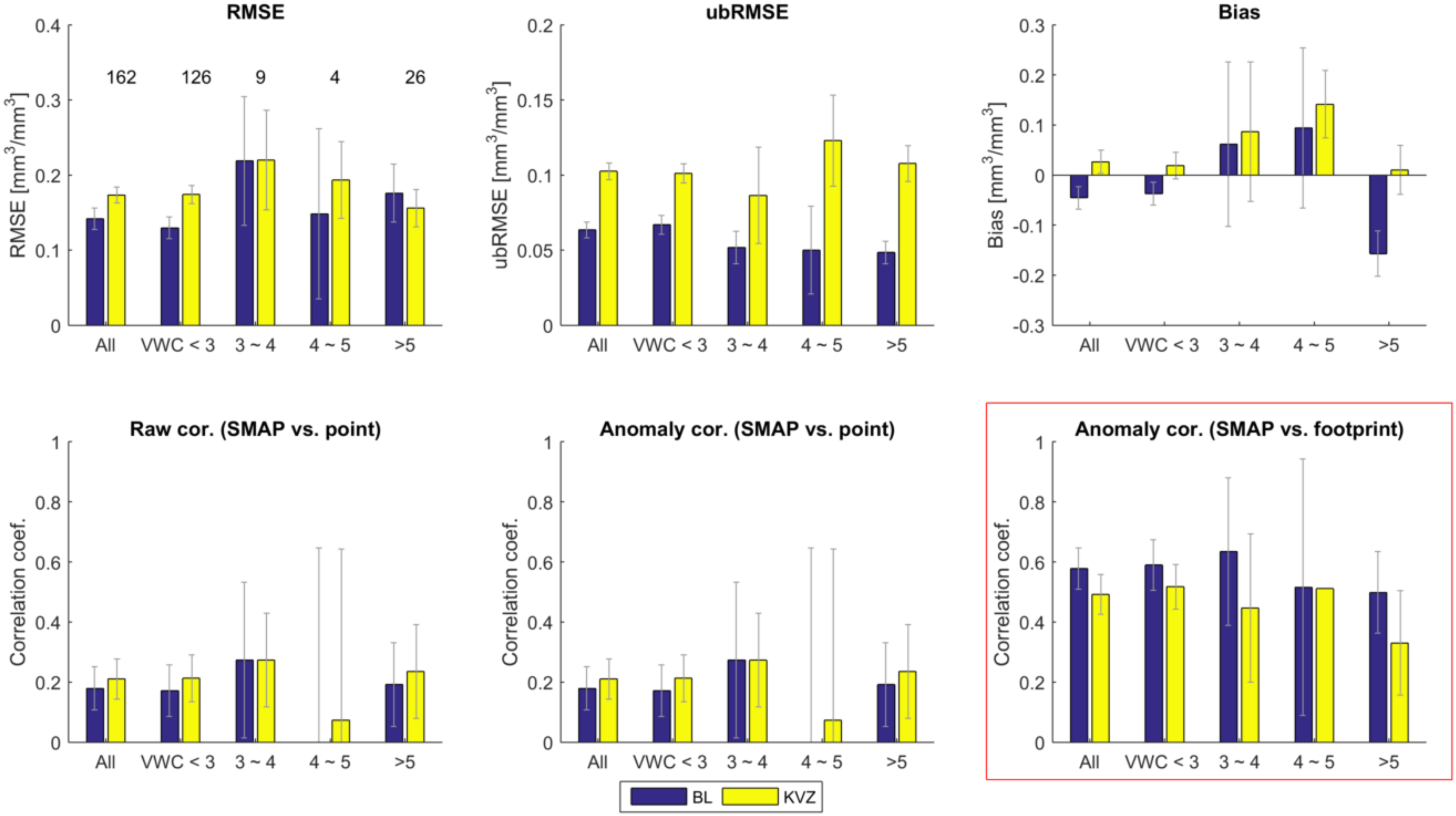




L2 SM_AP (stratified by VWC)



L2 SM_A (stratified by VWC)



Outline of Talk

I. Sparse Network Overview

II. Triple Collocation Methodology

III. Sparse Network Results

Does TC work?:

Correlation-based TC correction is working, RMSE-based TC correction does not appear to be robust.

Does TC help?:

*Yes…but it is not a necessary processing step to extract valuable relative accuracy information from sparse networks observations (**supplemental but not critical**).*

Future plans:

- Integrate L4_RZSM evaluation.

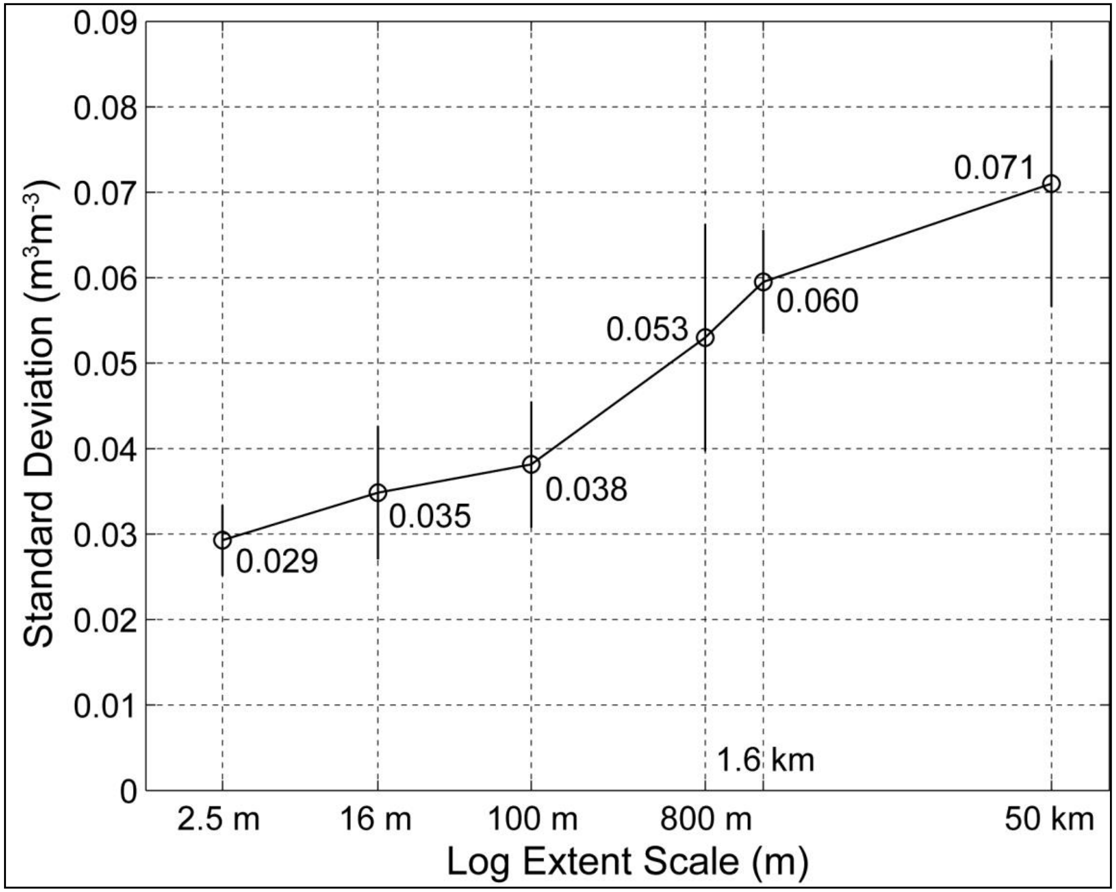
- More thought on error bars (for hypothesis testing).

- [SMAP/Core/model] TC for core-site evaluation .

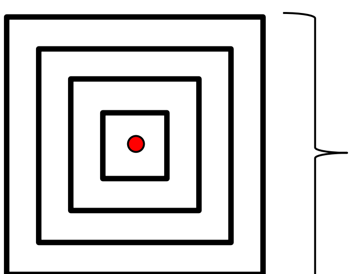
- [SMAP/ASCAT/model] TC for spatially-continuous evaluation.

Thank you…

Scope of Spatial Upscaling Problem

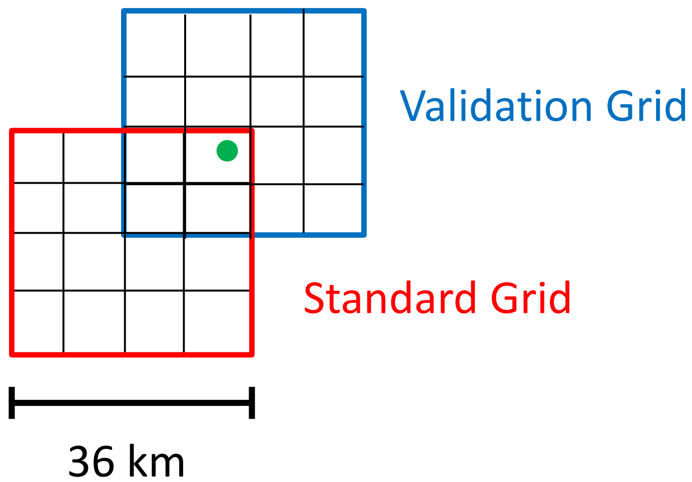


(Famiglietti et al., 2008)



RMSE in using a single point-scale observation to characterize spatially-averaged soil moisture within various extent scales.

Impact of Validation Grids



Orbits		RMSE	ubRMSE	Bias	R(SMAP, pt) [raw]	R(SMAP, pt) [anomaly]	R(SMAP, truth) [anomaly]
A only	standard grid	**0.080**	**0.044**	**-0.036**	**0.675**	**0.663**	**0.765**
	validation grid	**0.080**	**0.043**	**-0.036**	**0.687**	**0.629**	**0.744**
A+D	standard grid	**0.092**	**0.047**	**-0.037**	**0.643**	**0.635**	**0.770**
	validation grid	**0.090**	**0.047**	**-0.039**	**0.667**	**0.662**	**0.815**

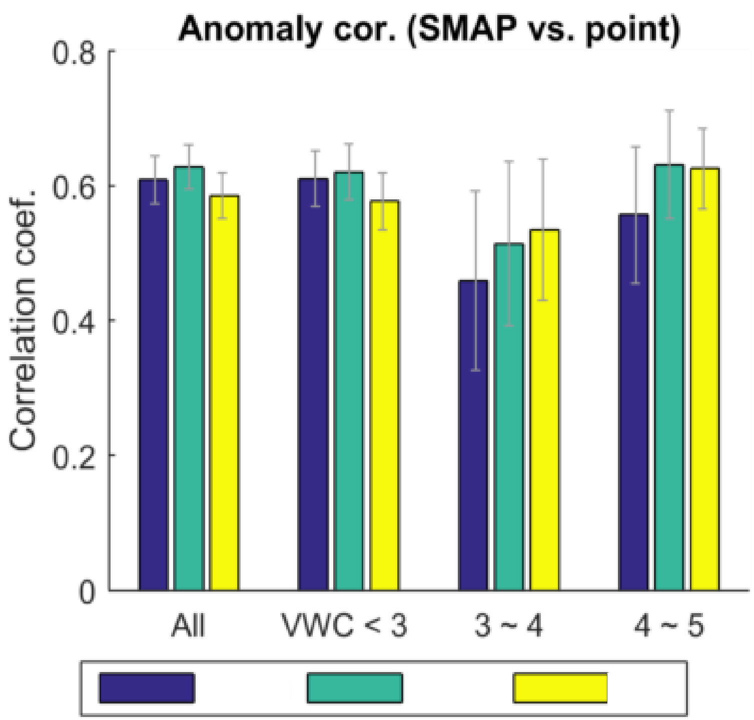
Note: Validation grids are primarily intended for core site analysis…

Preliminary L2_P soil moisture SMAP cal/val results

Temporal correlation results for all sparse sites (SCAN + CRN + Cosmos + SMOSMANIA + GPS) stratified by vegetation water content (VWC) and passive microwave retrieval algorithm:

Highly preliminary and completely un-calibrated (~4 month of data)!

Before TC (raw point versus SMAP):



Retrieval Algorithms

Post TC ("truth" point versus SMAP):