Validation and Applications of Global Soil Moisture Retrievals from SMAP for NOAA operations

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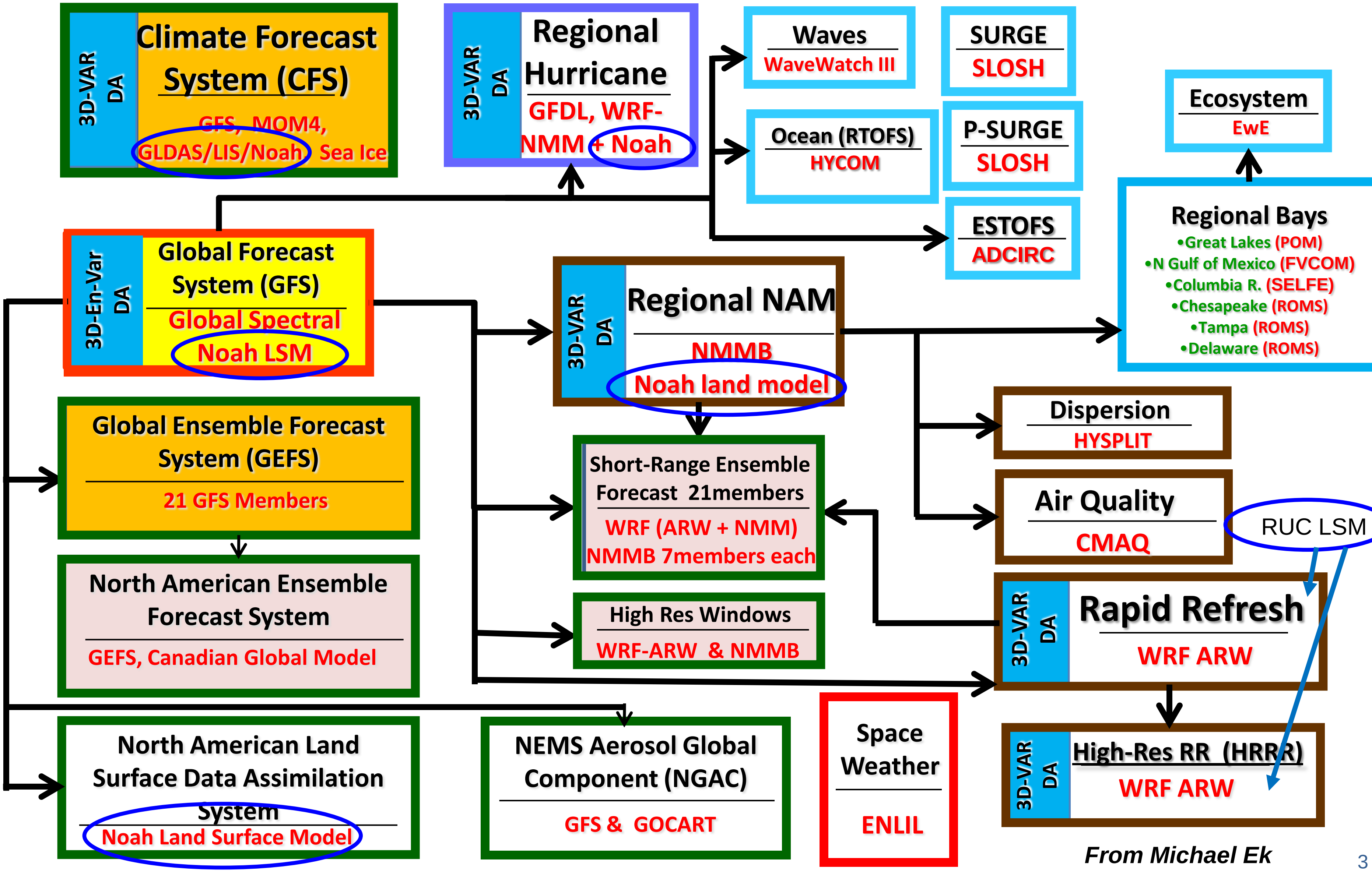
OUTLINE

- NOAA Weather and Climate Operations
- NESDIS SMOPS
- NASA JPL NRT SMAP TB data
- Validation of SMAP SM from SMOPS
- Applications of SMAP SM in Operations
- Summary

Land Prediction in Weather & Climate Models: NOAA's Operational Numerical Guidance Suite



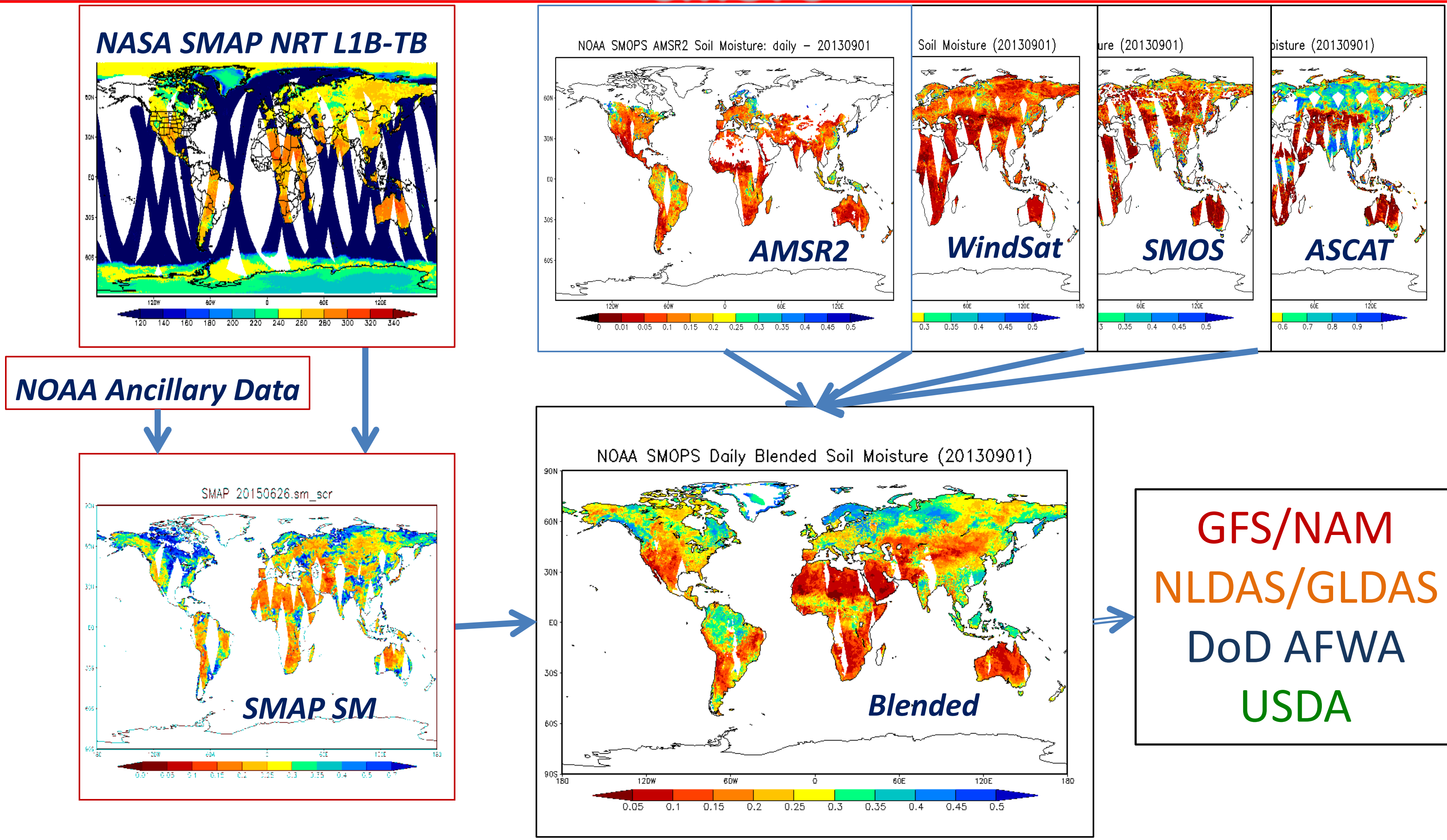
From Michael Ek

Caveats on NCEP Data Need for SMAP Products

- *SM impact intra-seasonal, inter-seasonal, to inter-annual climate variabilities.*
- *SM are needed in model initializations.*
- *SM observational data are also important for LSM validation as well as other land remote sensing data, e.g.: soil Temperature, snow, albedo, green vegetation fraction.*
- *Operational use of land remote sensing data including SM will start from North America Land Data Assimilation System (NLDAS) that is current operational at NCEP Center of Operations*
- *SMAP soil moisture is processed through NESDIS SMOPS*

From Weizhong Zheng & Michael Ek

Soil Moisture Operational Product System
SMOPS



NESDIS SMOPS Ingests NASA SMAP NRT Data to retrieve global soil moisture with NOAA ancillary Data and blends them with other satellite observations for NOAA uses

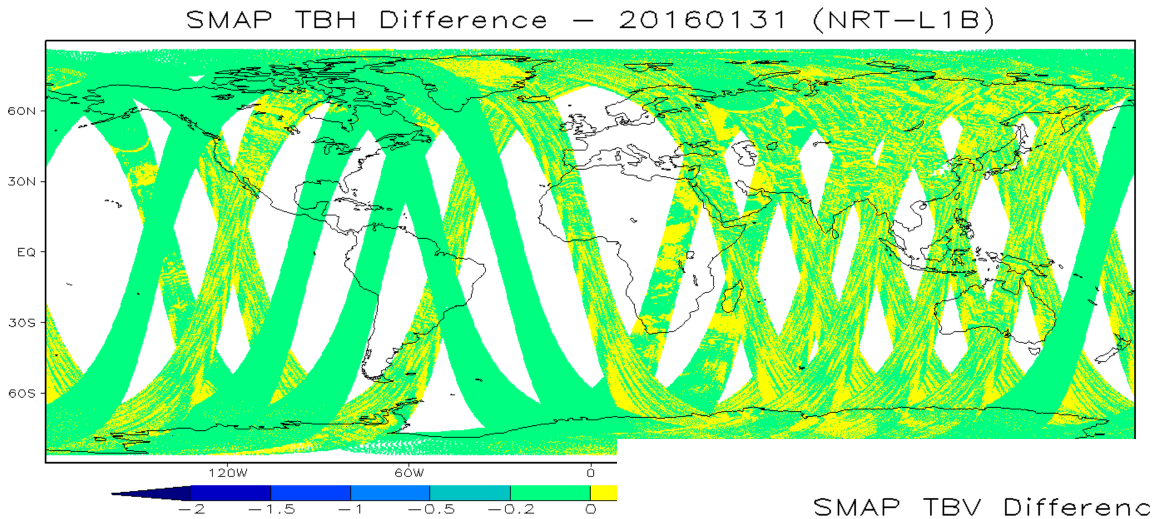
Latencies of SMAP L1B-TB Data from JPL NRT Data Server

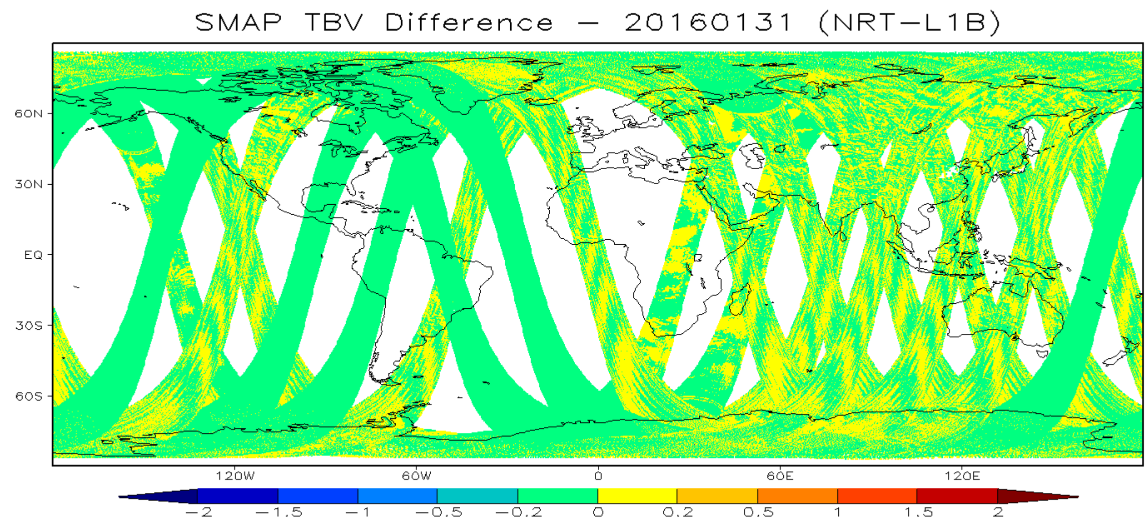
Date	Total_In	Total_Orbits	Percent_In	Minimum	Median	Average	Maximum
Oct 1	11	29	38	1:33	3:56	4:17	6:09
2	14	27	52	1:20	3:57	4:02	5:51
3	13	29	45	1:23	3:30	3:50	5:54
4	14	28	50	1:58	3:56	4:04	5:39
5	12	30	40	1:28	3:59	9:30	87:25
6	14	27	52	1:32	4:13	4:01	5:50
7	13	28	46	1:33	4:33	4:12	5:22
8	13	27	48	1:35	4:15	4:10	6:05
9	11	29	38	1:58	4:07	4:15	5:29
10	11	28	39	1:20	4:31	4:11	5:48
11	11	27	41	1:23	4:02	4:07	5:32
12	14	29	48	1:46	4:35	4:16	5:39
13	13	26	50	1:28	4:12	3:54	5:43
14	11	28	39	1:10	3:57	4:01	5:39
15	13	28	46	1:28	4:07	3:58	6:00
16	12	27	44	1:30	3:51	3:58	6:01
17	12	29	41	1:28	3:59	4:08	6:20
18	13	28	46	1:16	3:55	4:04	5:48
19	13	26	50	1:18	3:48	3:55	5:53
20	13	27	48	1:41	4:08	4:04	5:34
21	11	27	41	1:58	3:53	4:13	8:26

Latencies of SMAP L1B-TB Data from NSIDC Data Server

Date	Total_In	Total_Orbits	Percent_In	Minimum	Median	Average	Maximum
Oct 1	1	30	3	4:29	5:37	7:49	15:41
2	5	28	18	4:29	5:20	5:47	12:31
3	6	30	20	4:43	5:17	5:38	10:40
4	7	29	24	4:36	5:13	5:30	6:37
5	6	32	19	4:34	5:06	10:33	87:43
6	5	33	15	4:36	5:22	40:23	351:13
7	2	29	7	4:45	323:45	252:09	344:13
8	3	29	10	4:05	5:05	5:25	6:57
9	6	30	20	4:08	5:16	5:31	7:00
10	6	29	21	4:29	5:17	5:33	6:28
11	5	29	17	4:31	5:19	5:28	6:29
12	7	29	24	4:54	5:23	5:35	6:39
13	5	30	17	4:34	5:09	5:28	6:40
14	4	29	14	4:52	6:02	12:21	26:03
15	2	29	7	4:29	5:43	8:08	16:13
16	5	29	17	4:26	5:14	5:27	6:36
17	6	30	20	4:22	5:09	5:28	7:12
18	5	29	17	4:29	5:17	5:33	6:51
19	3	29	10	4:32	5:22	5:36	7:18
20	2	29	7	4:55	11:16	15:22	29:14
21	5	30	17	4:59	5:30	6:32	11:25

SMAP L1B_TB: JPL NRT vs NSIDC





More than 99% of footprint TBs have difference smaller than 0.2 degree.

Soil Moisture Retrieval Algorithm

Single Channel Algorithm (SCA) :

(Jackson, 1993)

$$T_{Bh} = T_s \left[1 - (1 - e_r) \exp(-2\tau / \cos\theta)\right]$$

$$\tau = b * VWC, \quad VWC = f(NDVI)$$

$$e_h = f(e_v, h, Q)$$

$e_s = f(\varepsilon)$ -- Fresnel Equation

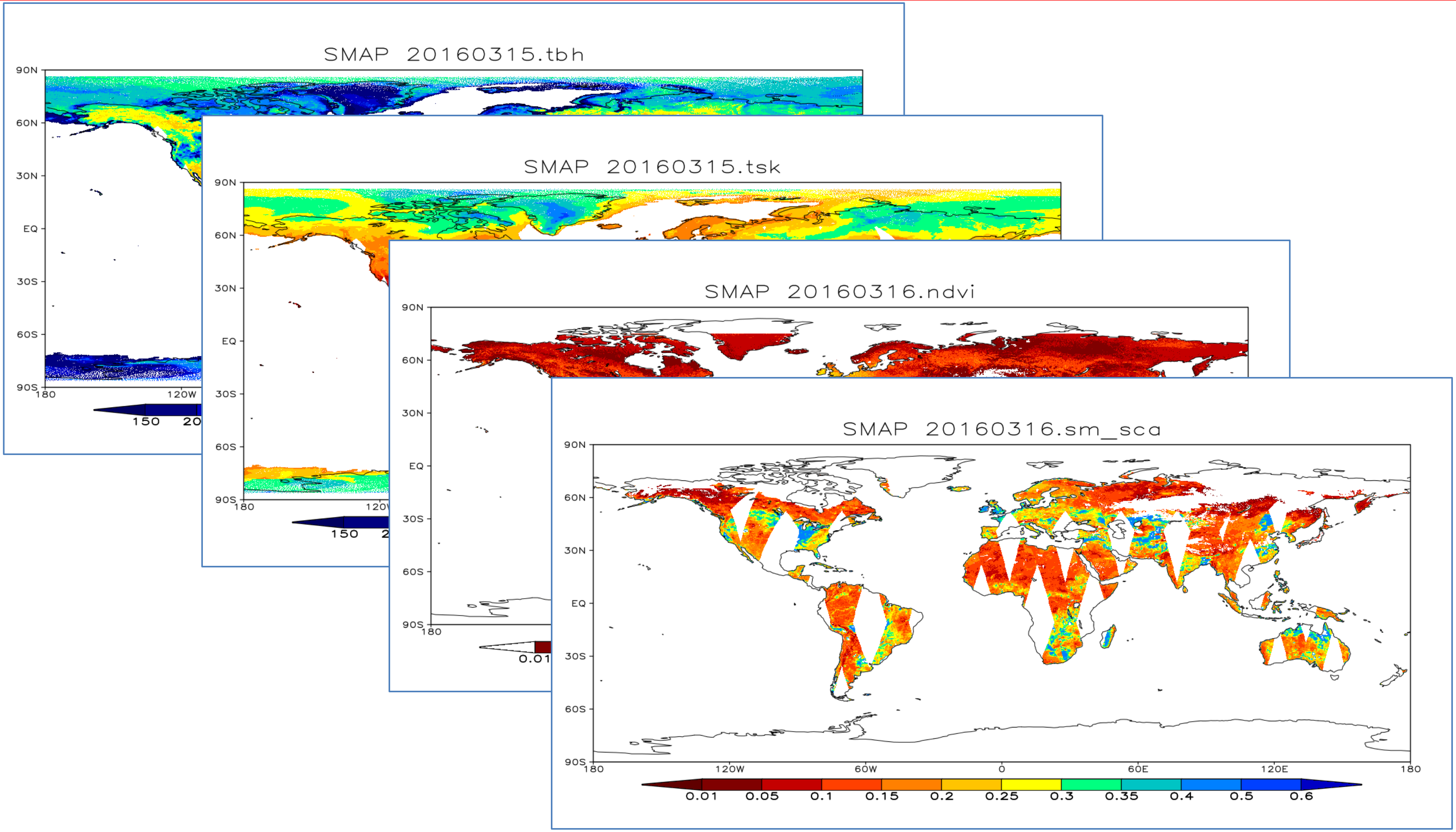
$\varepsilon = f(SM)$ -- Mixing model

$$T_s = T_s^{LSM}$$

NDVI = VIIRS near real time

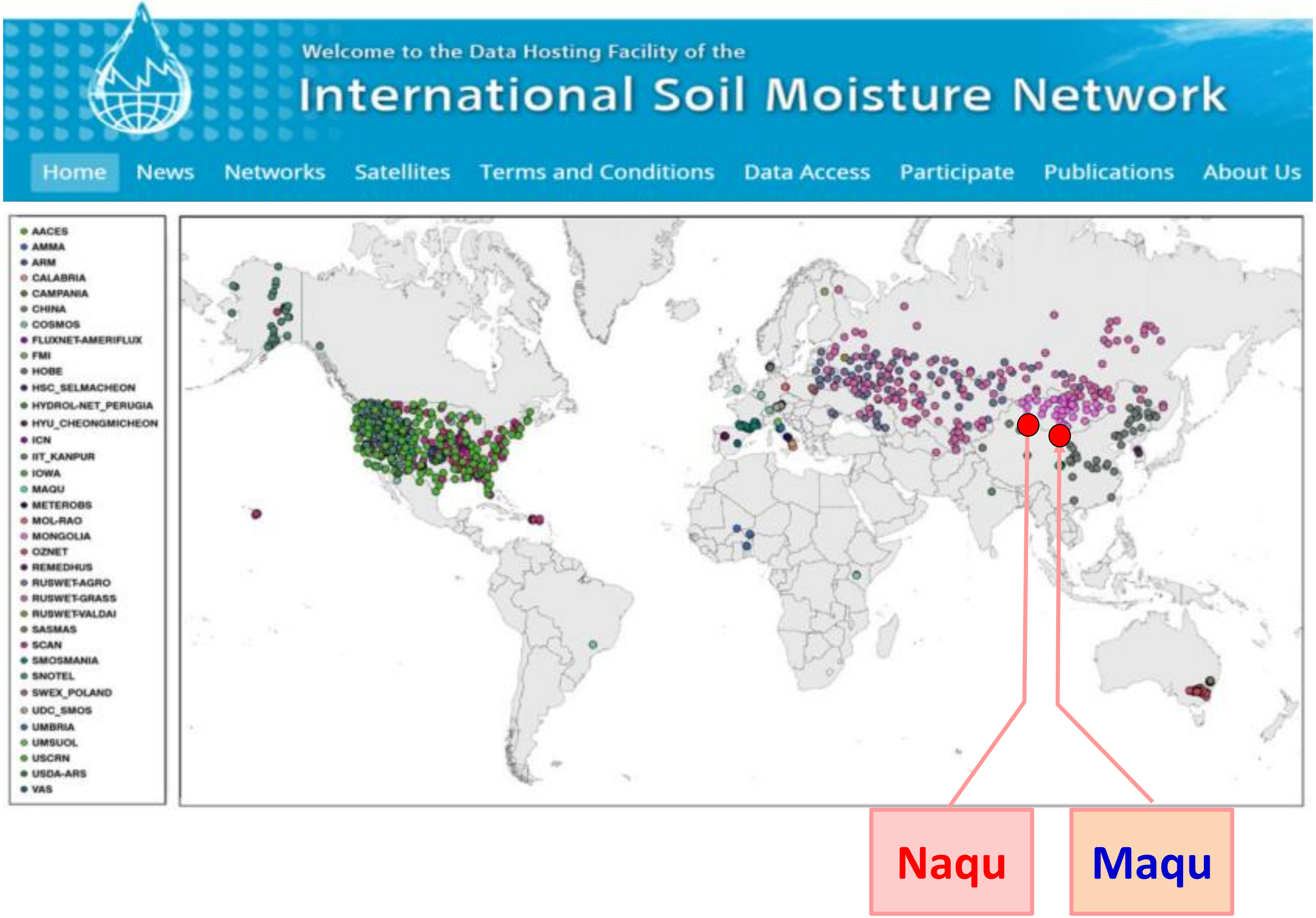
T_s^{LSM} *= GFS Tskin*

SMAP Soil Moisture Retrieved from SMOPS



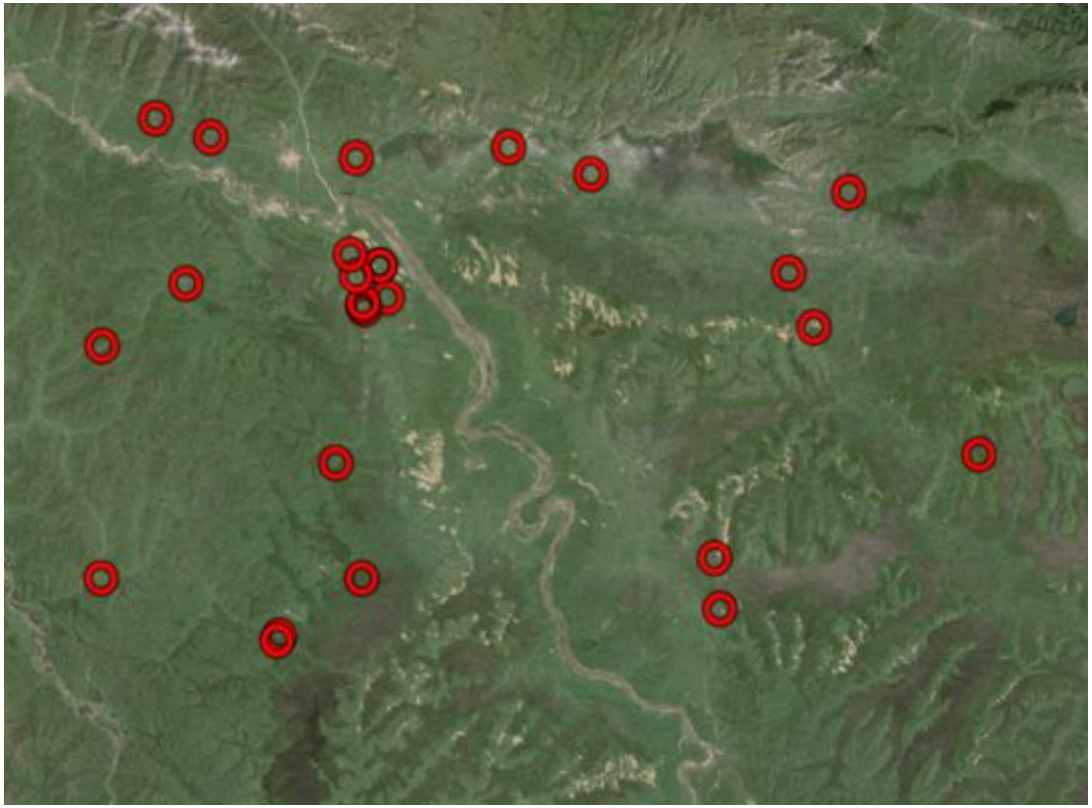
NESDIS SMOPS uses NASA SMAP NRT L1B_TB and NOAA ancillary data (GDAS Tskn and VIIRS NDVI) to retrieve soil moisture

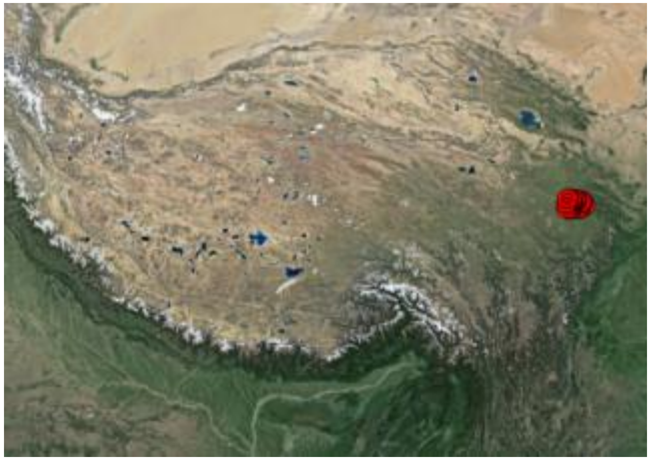
Validation of SMAP SM from SMOPS



Maqu SM Network of CAS

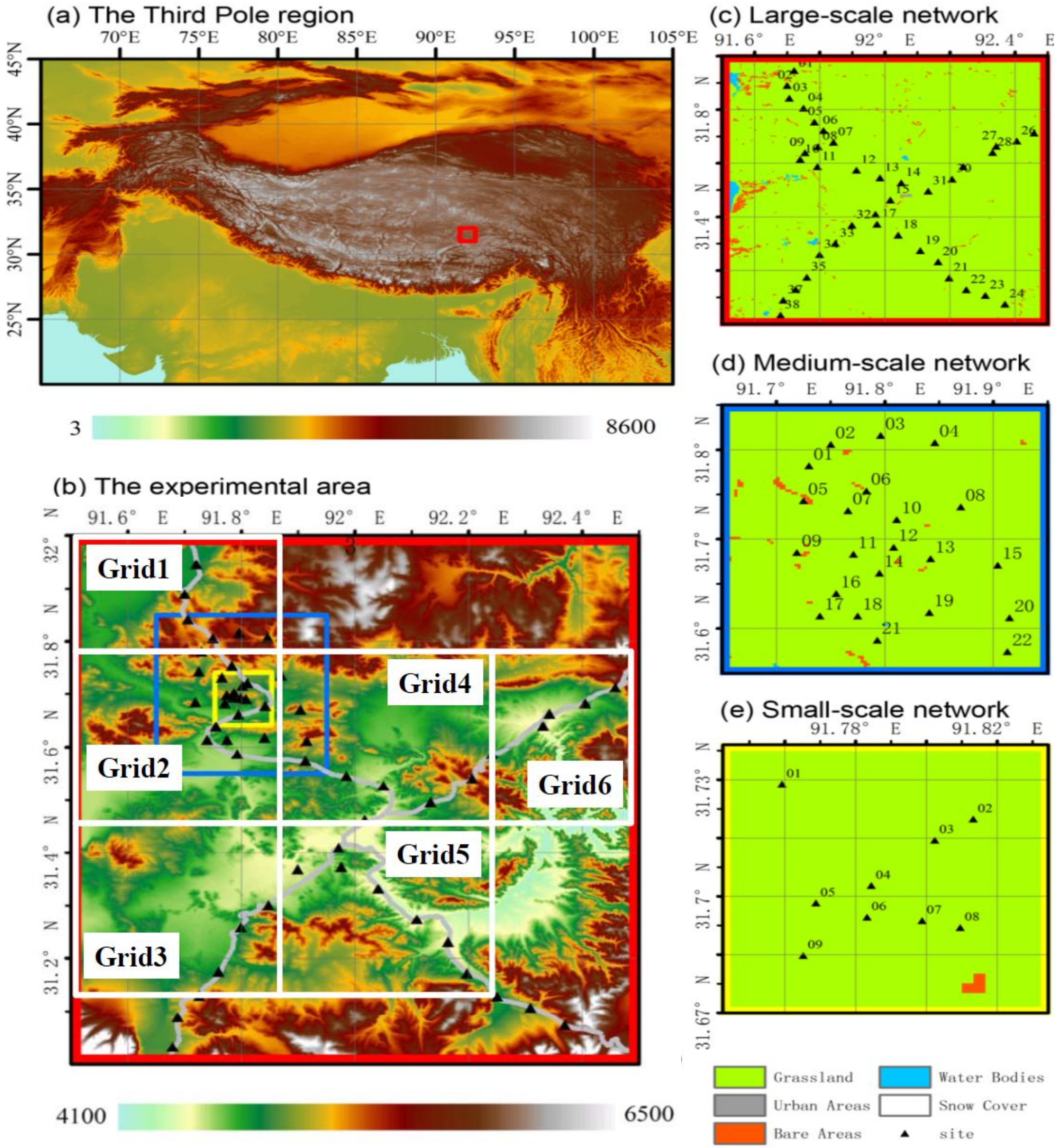
In the east TP, about 25 sites,
sensors at 5, 10, 20, 40, 80cm depths,
covers about 100km × 60km area.
Obs period: 2008-now





From Jun Wen of CAS

Naqu SM Network of CAS



- 56 stations
- 4 observations at each station：
  0-5, 10, 20, 40 cm
- 3 spatial scales：
  1.0, 0.3, 0.1 degree
- 3 field campaigns since 2010

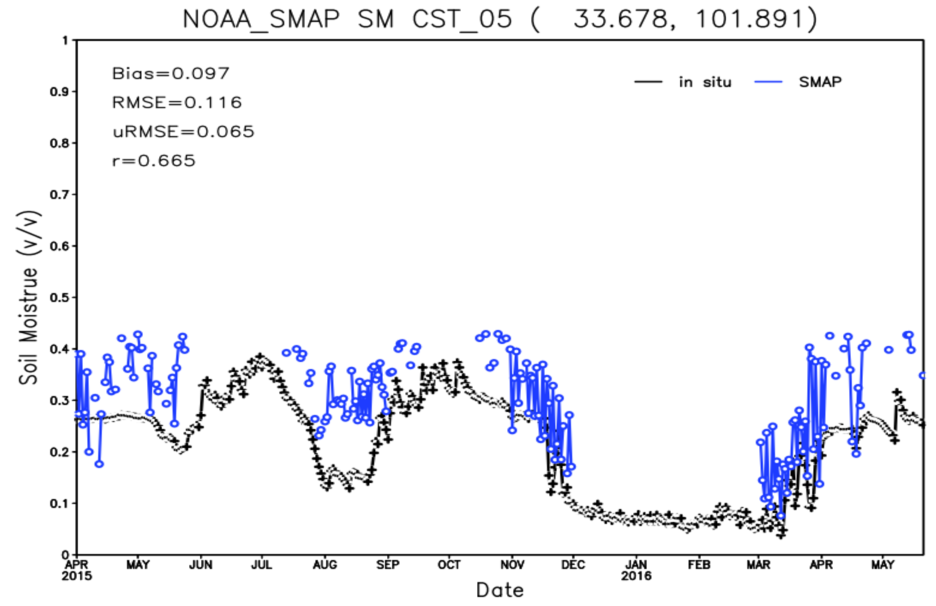
Soil profile samples are collected at each station; soil carbon content (SOC) and soil texture are measured.

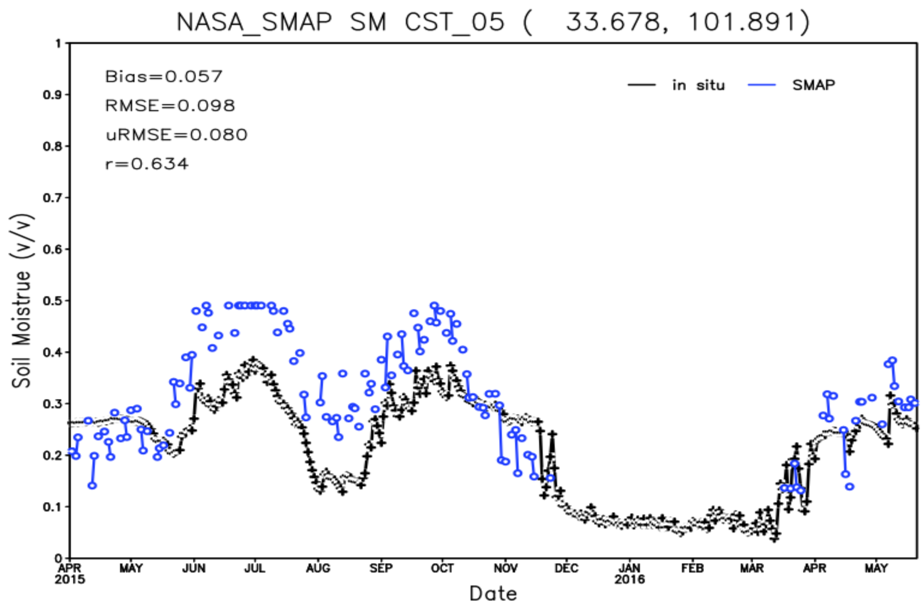
High SOC contents are found in top layer (0-20cm), which will dramatically affect the thermal properties and dielectricity of soil.

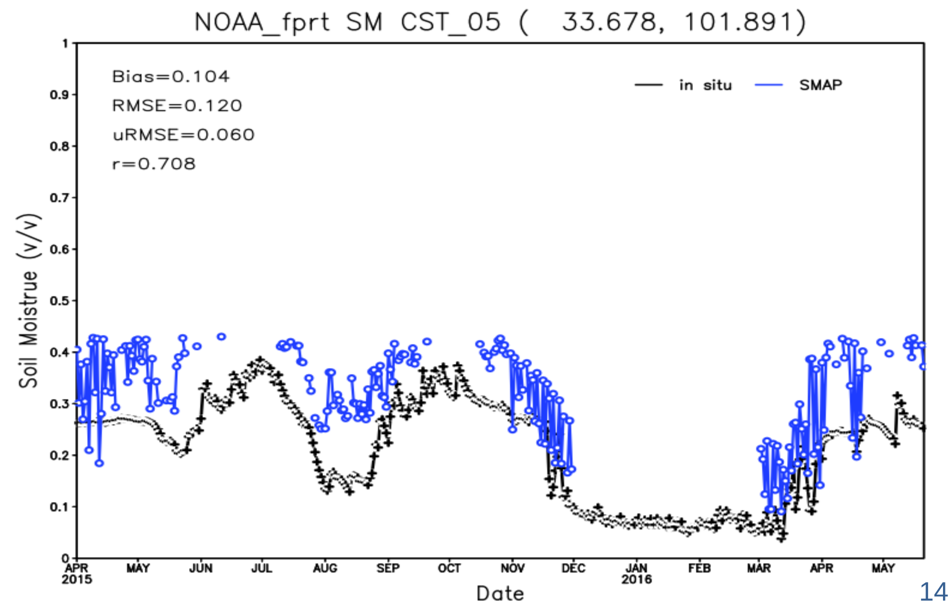
From Kun Yang of CAS

Validation of SMAP SM from SMOPS

Maqu CST_05

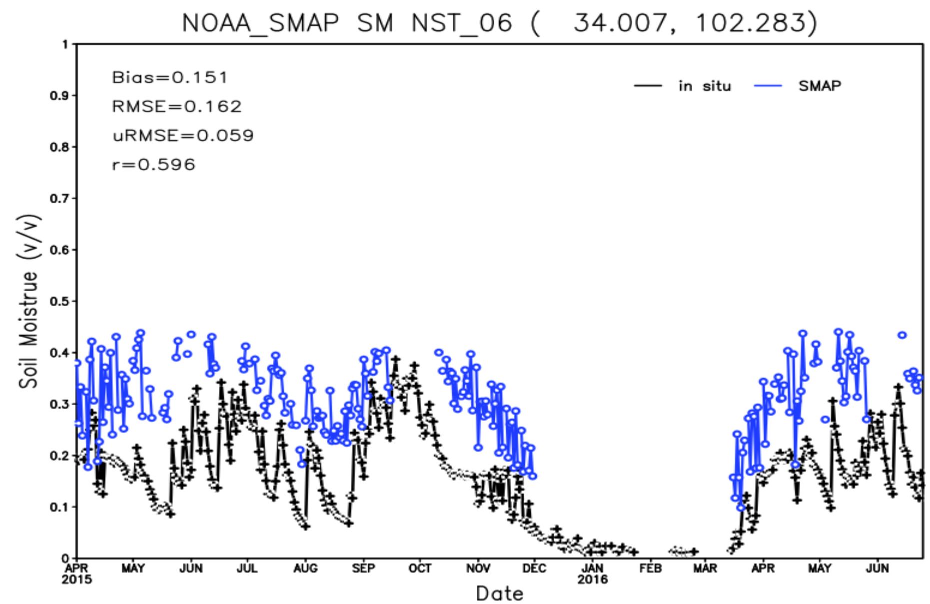


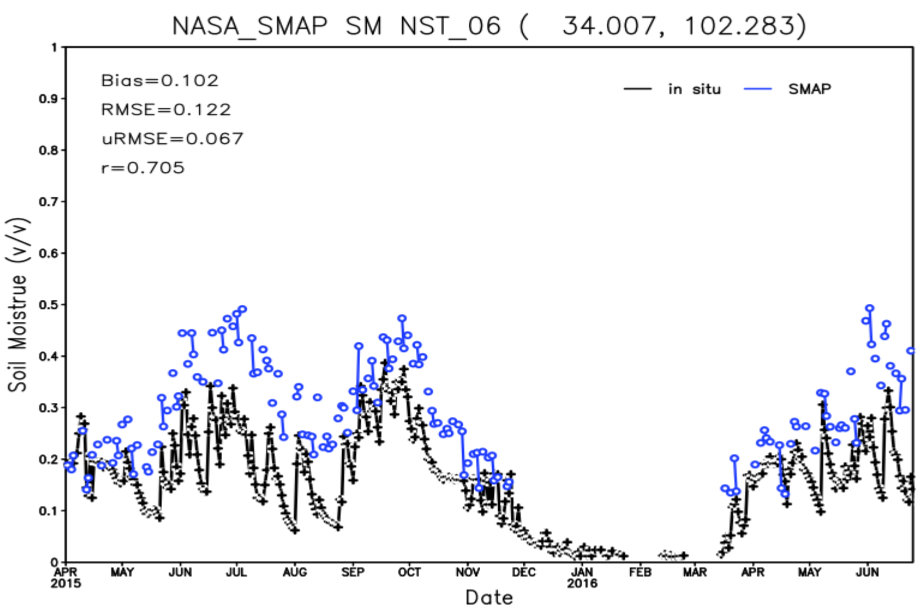


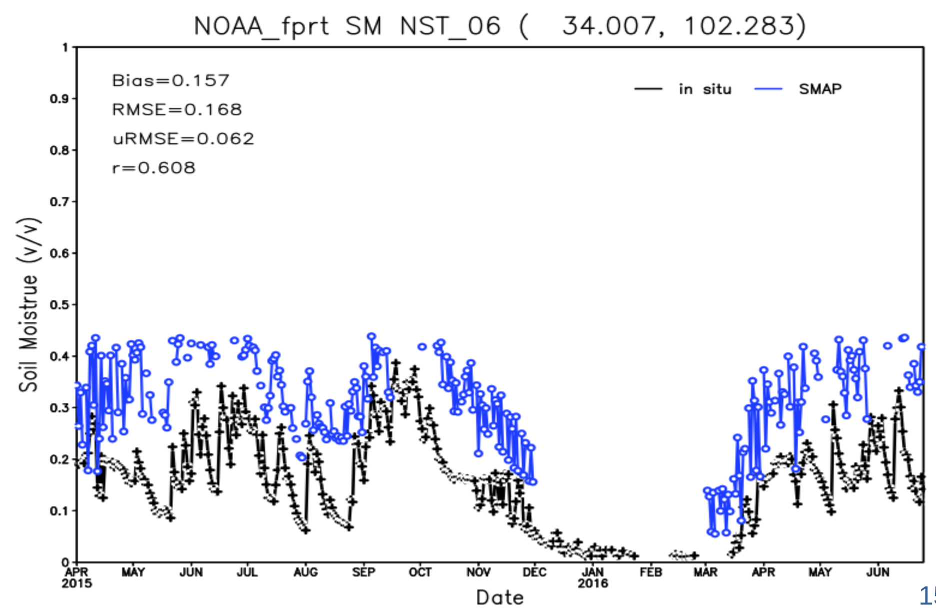


Validation of SMAP SM from SMOPS

Maqu NST_06

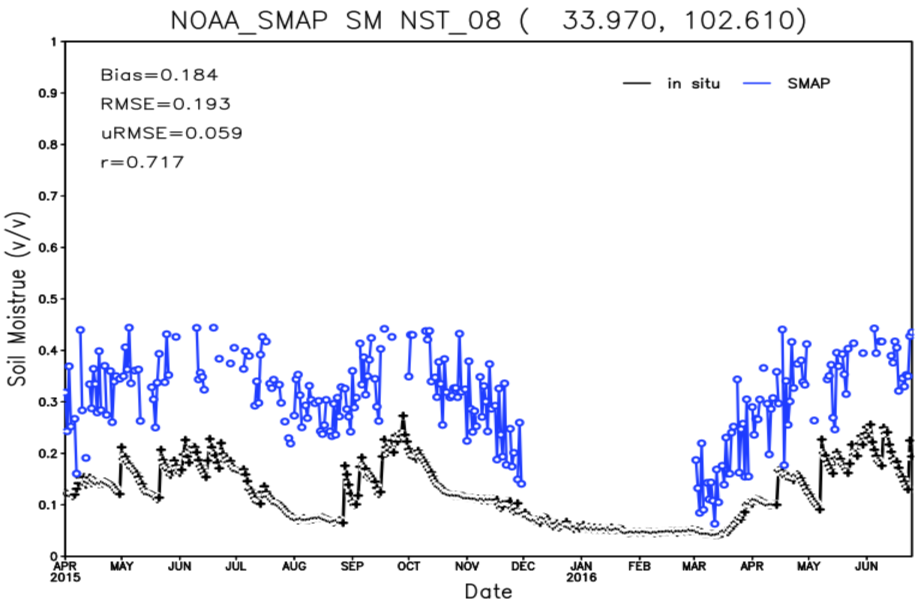


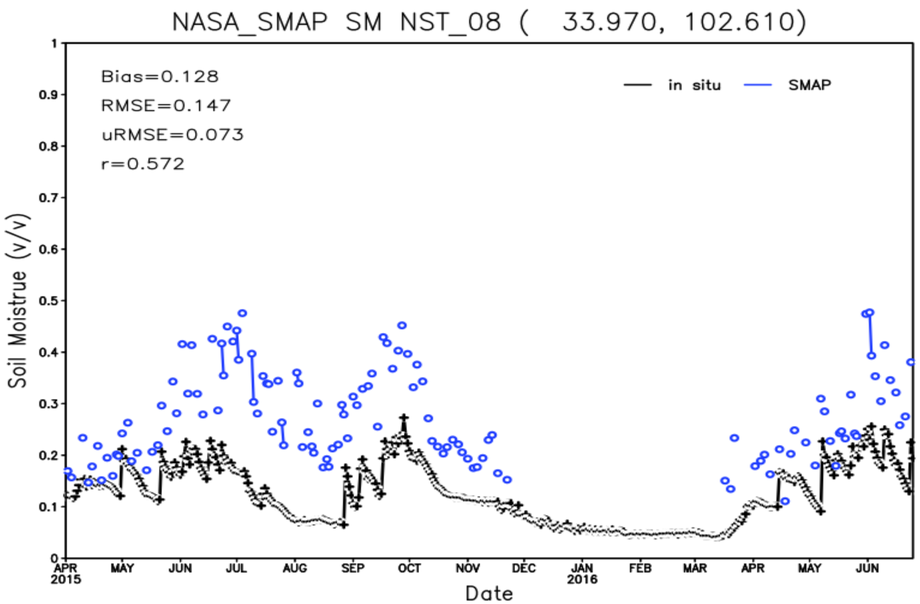


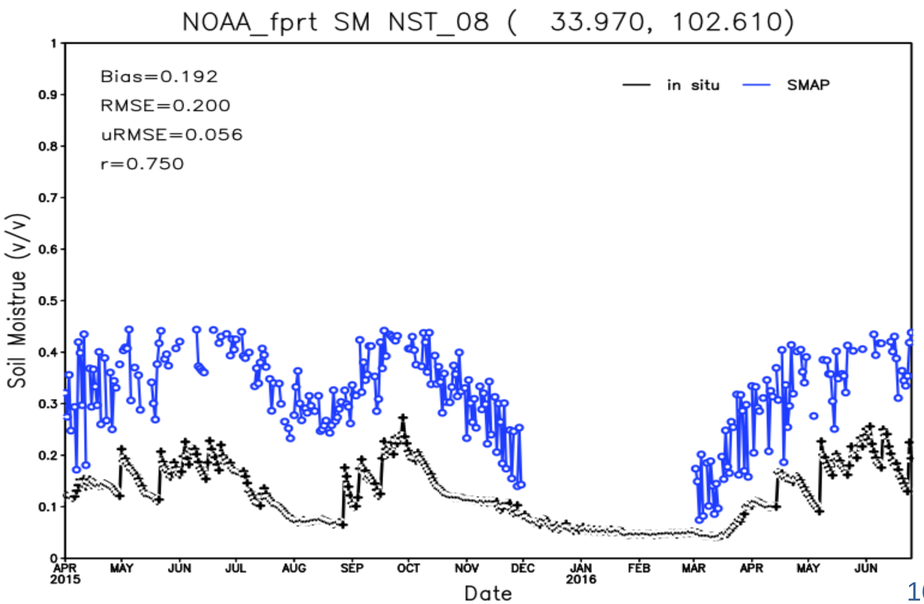


Validation of SMAP SM from SMOPS

Maqu NST_08

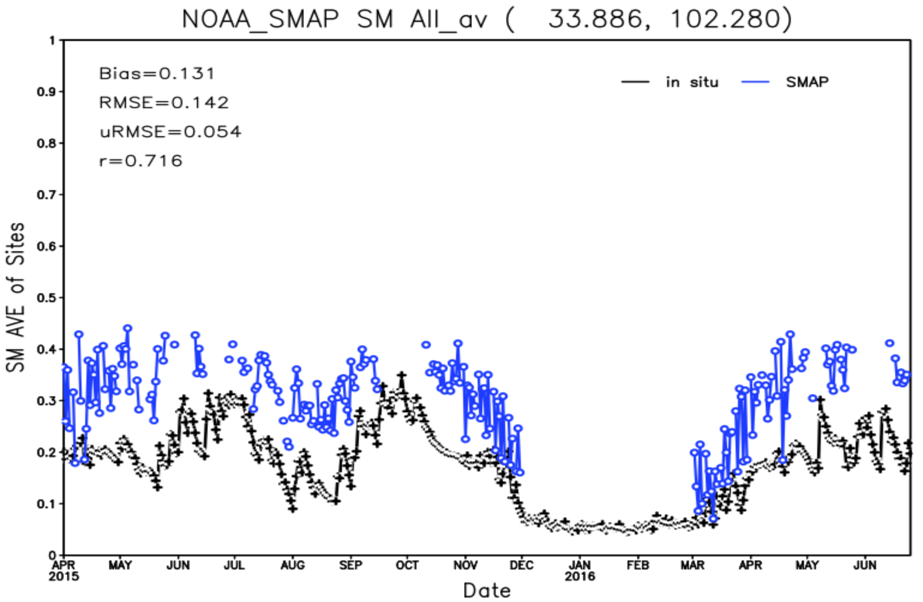


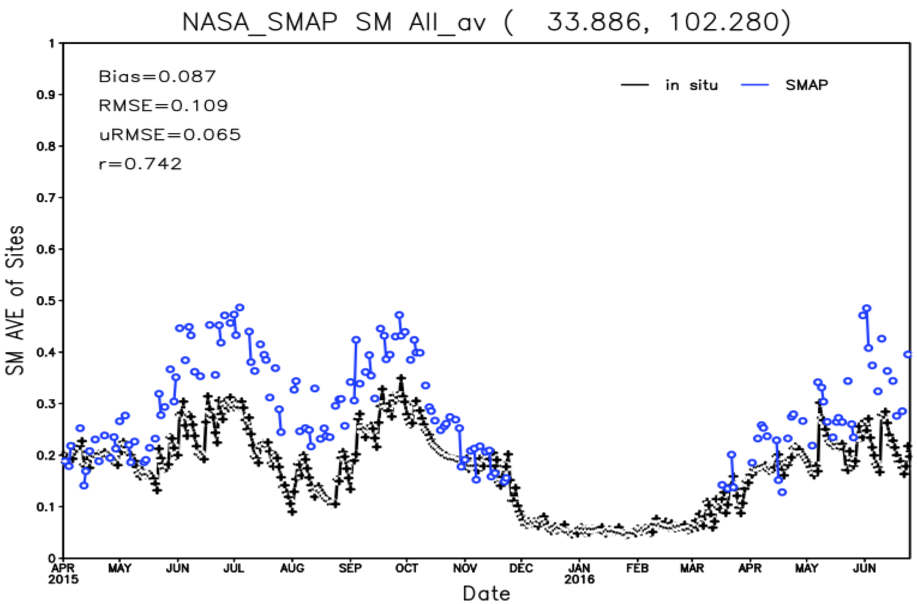


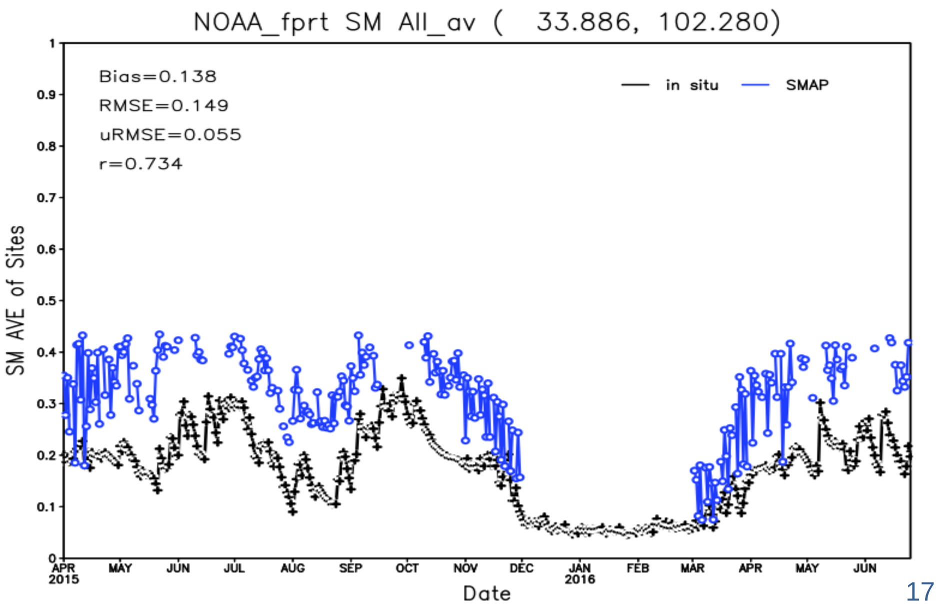


Validation of SMAP SM from SMOPS

Maqu All Ave







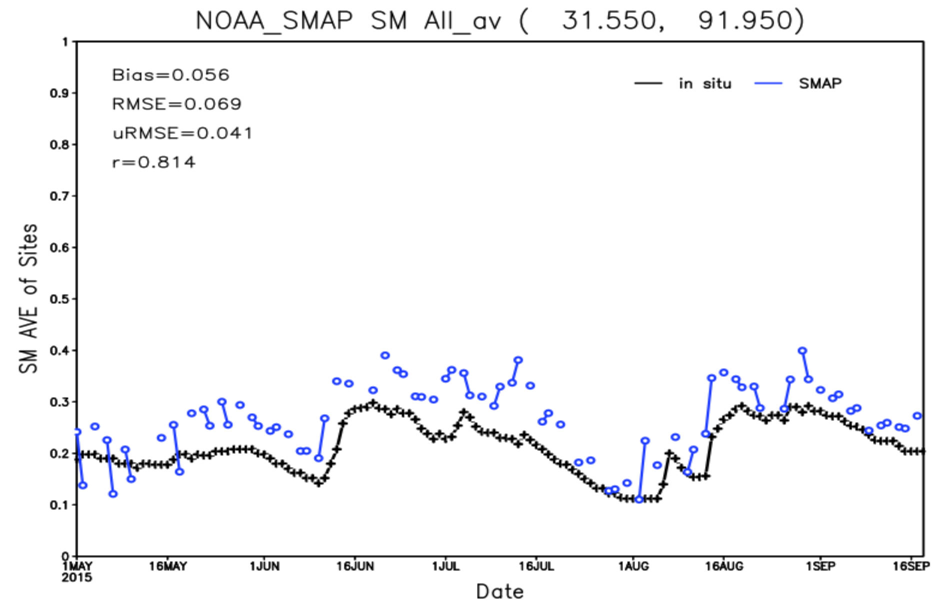
Validation of SMAP SM from SMOPS

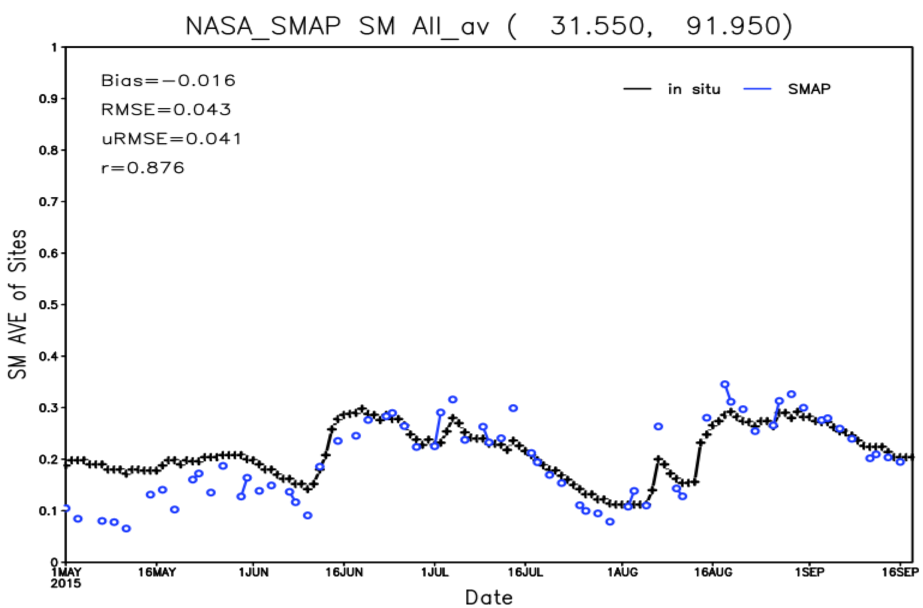
Maqu	*ubRMSE*			*r*		
Site	NASA	NOAA	NFPR	NASA	NOAA	NFPR
CST_05	0.080	0.065	0.060	0.634	0.665	0.708
NST_01	0.070	0.065	0.067	0.660	0.624	0.652
NST_03	0.080	0.070	0.066	0.644	0.581	0.628
NST_06	0.067	0.059	0.062	0.705	0.596	0.608
NST_07	0.071	0.065	0.066	0.653	0.545	0.559
NST_08	0.073	0.059	0.056	0.572	0.717	0.750
NST_09	0.058	0.062	0.059	0.769	0.537	0.604
Ave	0.065	0.065	0.055	0.742	0.716	0.734

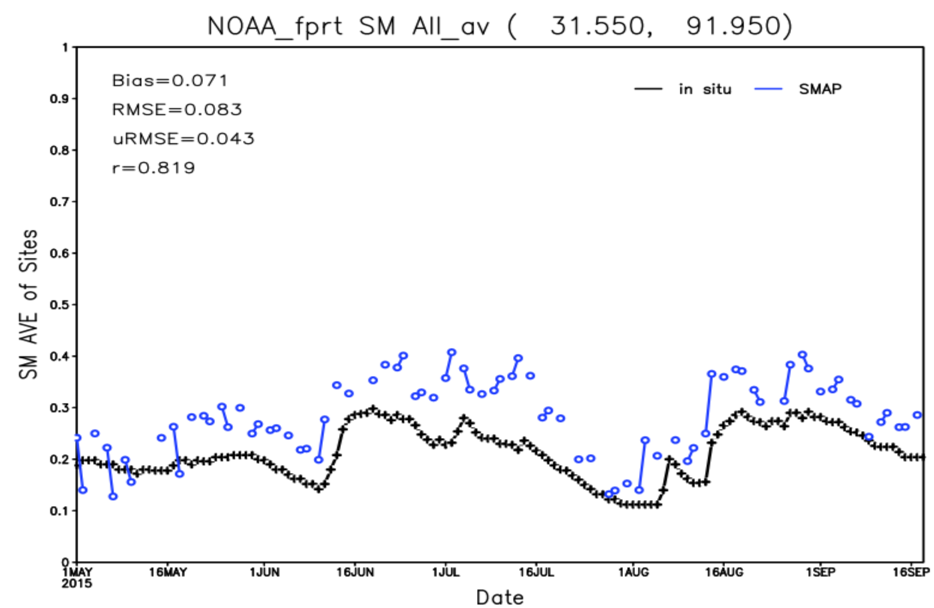
- *SMAP SM retrievals from gridded TBs in SMOPS is compatible with NASA baseline products*
- *SMAP SM retrievals from footprint TBs in SMOPS could be slightly better than those from gridded TBs*

Validation of SMAP SM from SMOPS

Naqu Large Scale Averages (1d x 1d)







OUTLINE

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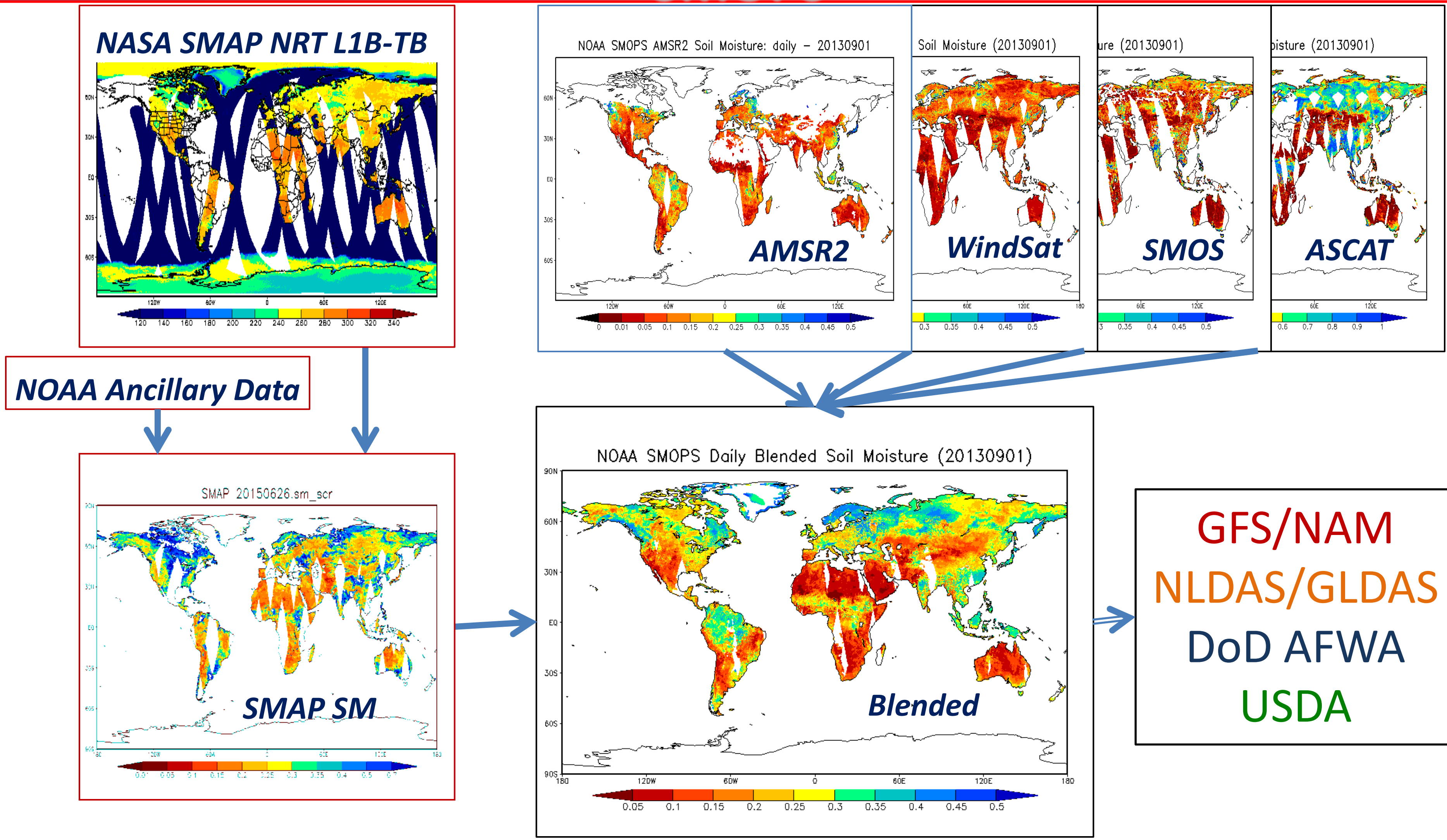
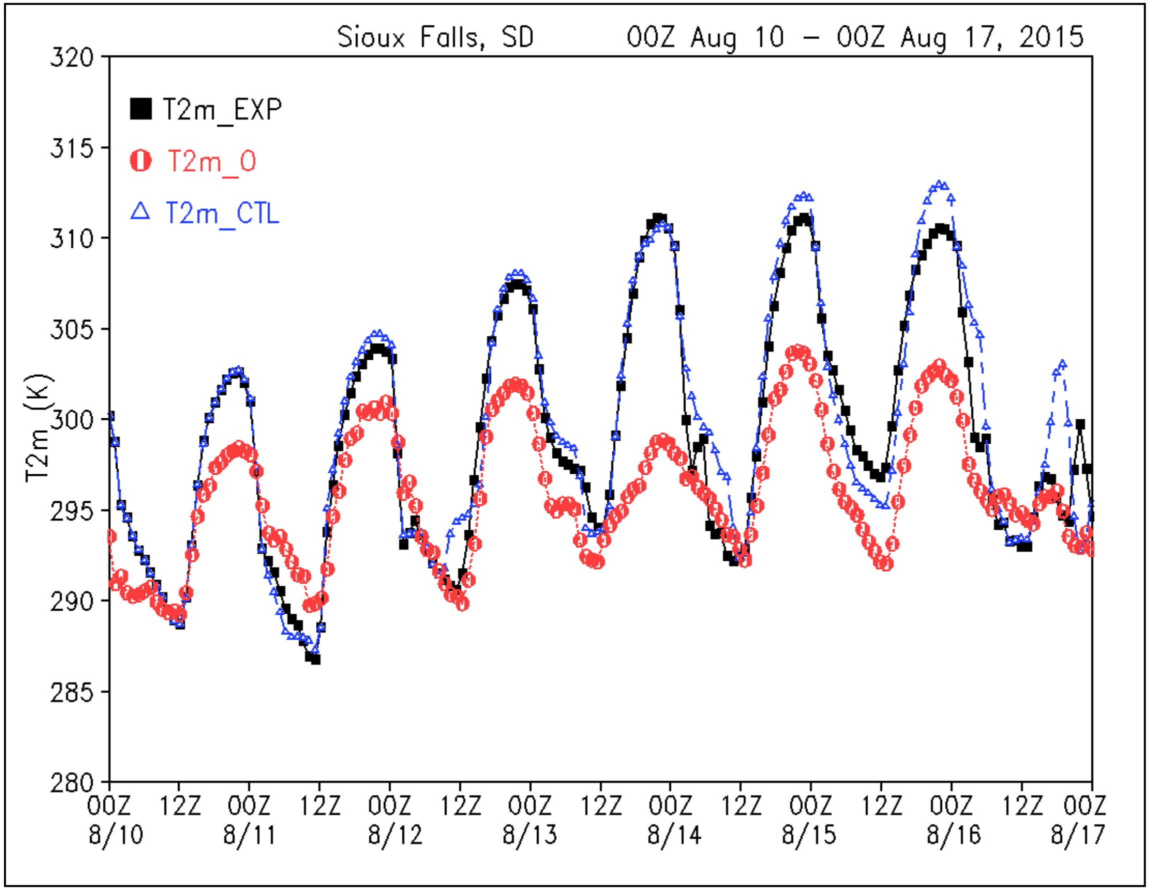
Soil Moisture Operational Product System
SMOPS



NESDIS SMOPS Ingests NASA SMAP NRT Data to retrieve global soil moisture with NOAA ancillary Data and blends them with other satellite observations for NOAA uses

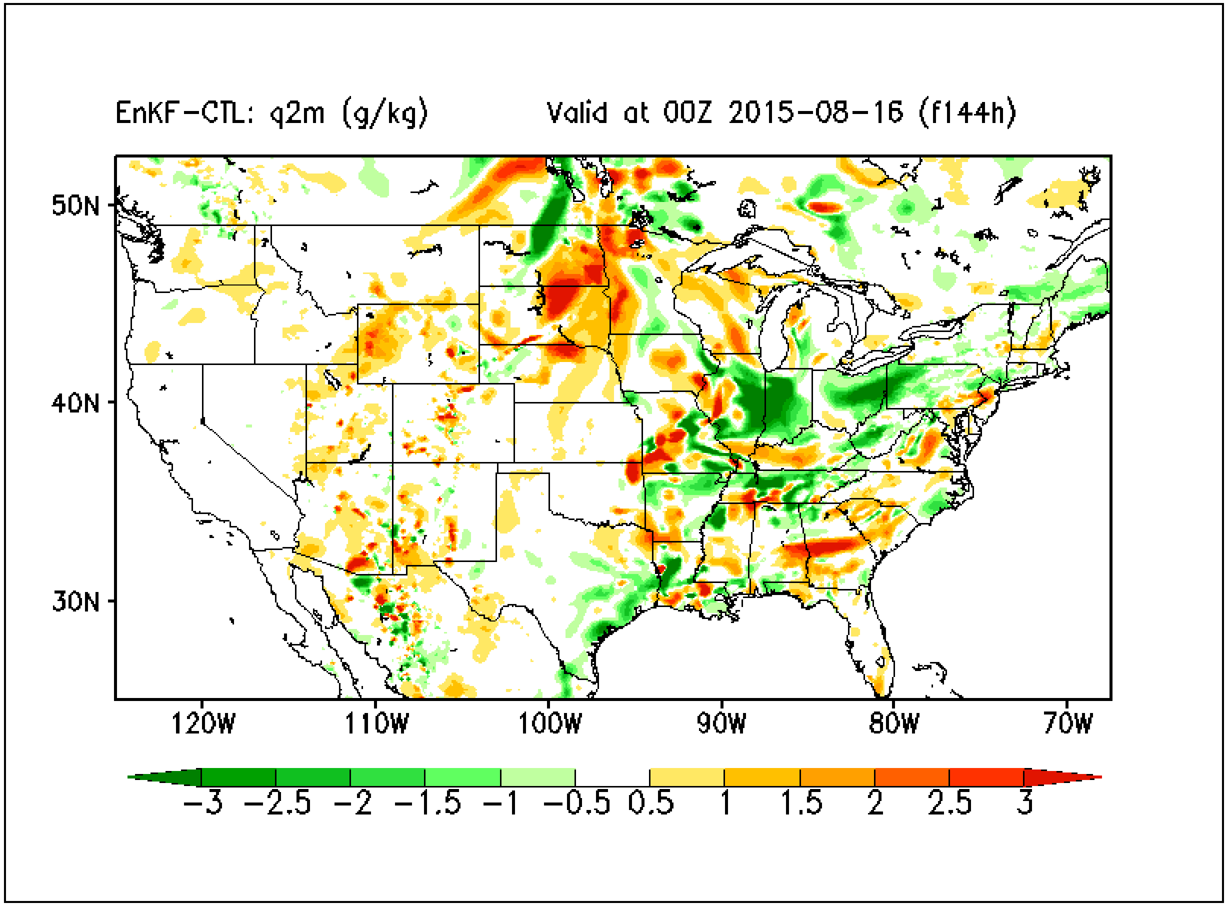
SMAP SM Impact on GFS Forecasts



Assimilating SMAP SM from 8/1 – 8/10/2015 Reduces the warm biases of NCEP GFS seven (7) day forecasts of day time 2 meter air temperature

From Weizhong Zheng & Michael Ek

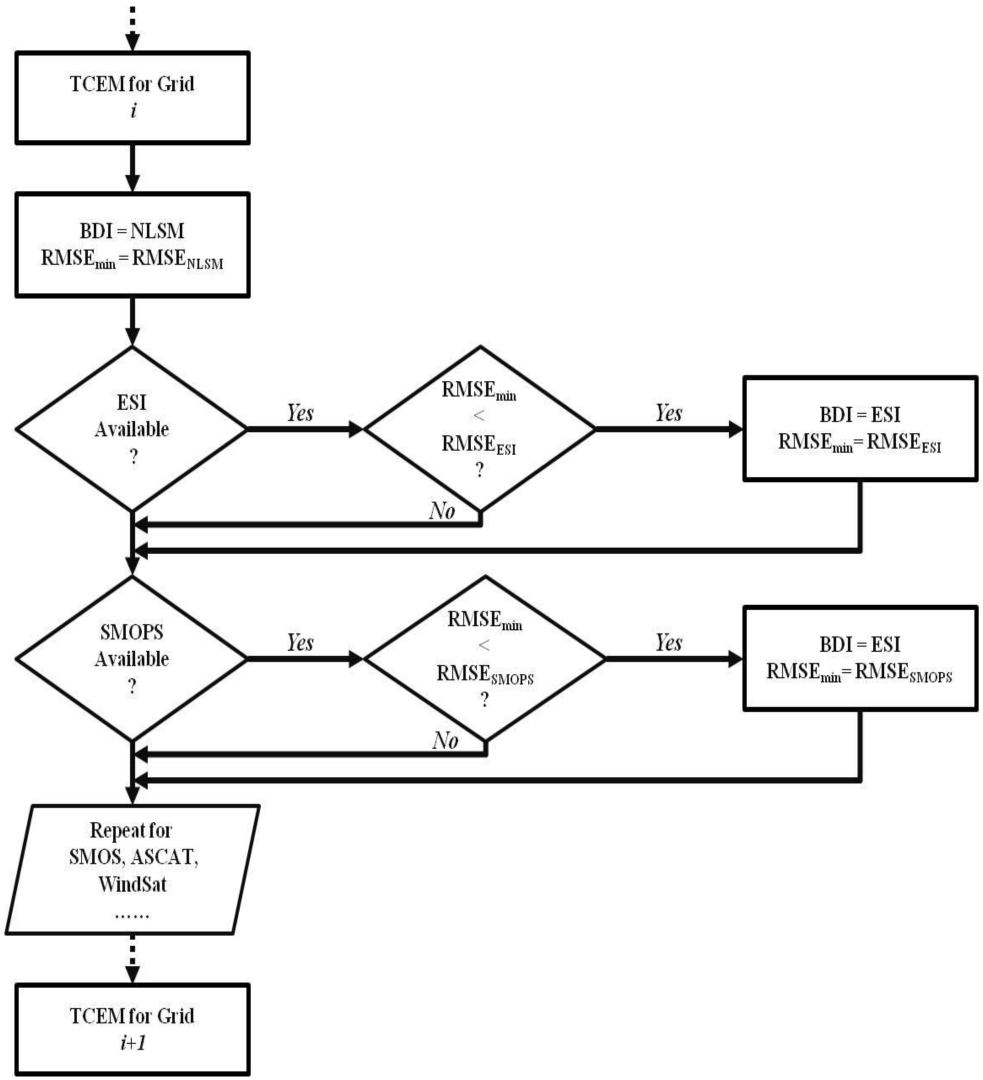
SMAP SM Impact on GFS Forecasts



Impact of assimilating SMAP SM from 8/1 – 8/10/2015 on NCEP GFS four (4) day forecasts of 2 meter specific humidity varies significantly spatially

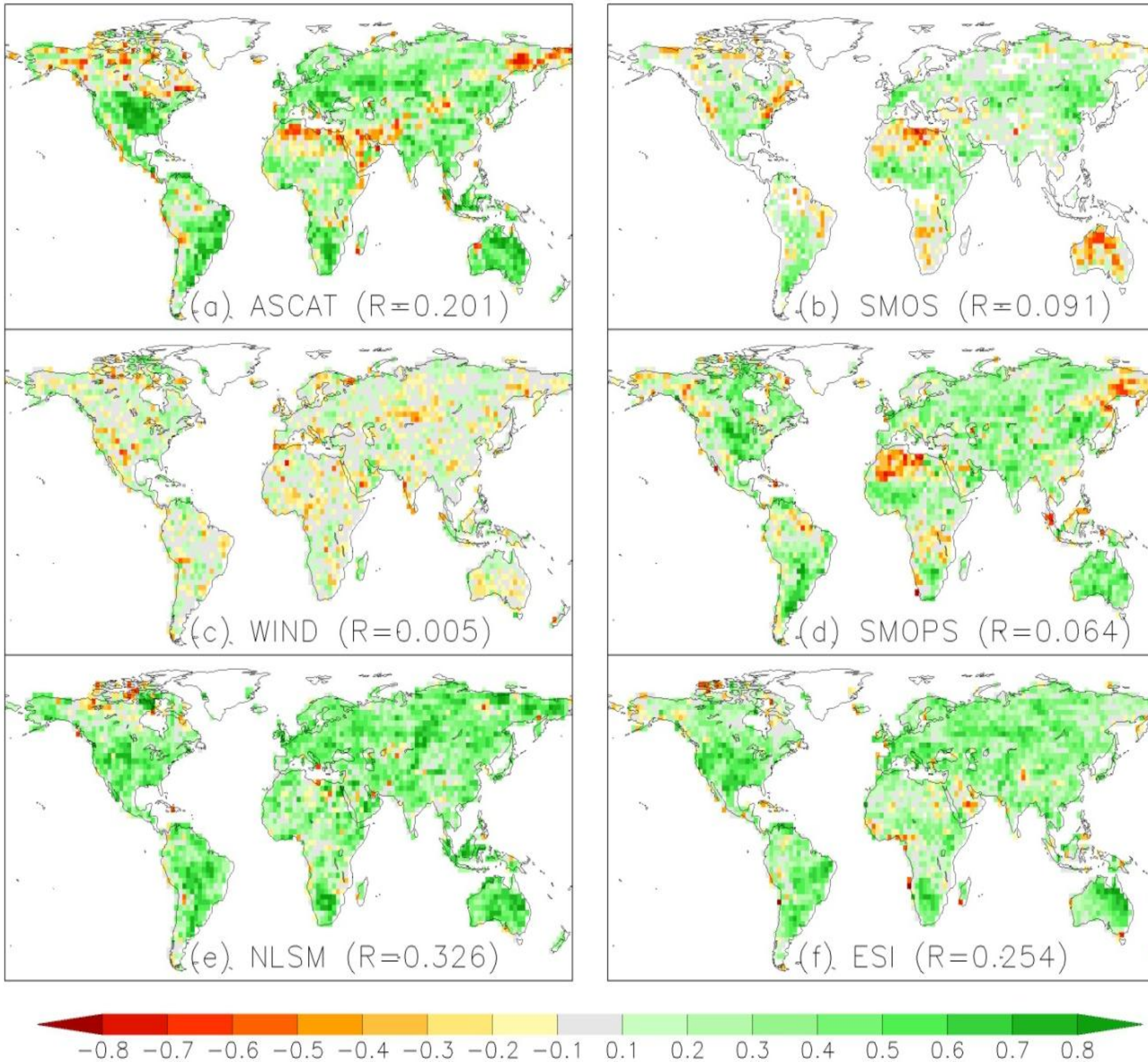
From Weizhong Zheng & Michael Ek

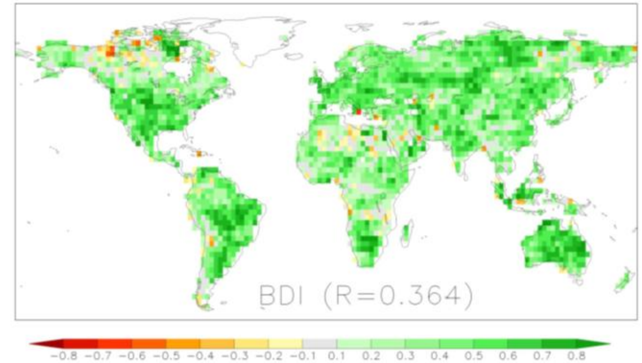
Blending Sat SM for Drought Monitoring



Procedure of constructing the Blended Drought Index (BDI) using the RMSEs estimated from the Triple Collocation Error Model implemented for each grid in each calendar month. $RMSE_{min}$ is the minimum RMSE for the grid. And $RMSE_{SMOPS}$, $RMSE_{NLSM}$ and $RMSE_{ESI}$ are the monthly RMSE values for soil moisture data sets from SMOPS, NLSM and ESI cases, respectively.

Blending Sat SM for Drought Monitoring





Correlation coefficients (R) between PDSI standard anomalies (against 1985-2014 averages) and drought estimations for (a) ASCAT, (b) SMOS, (c) WindSat, (d) SMOPS, (e) NLSM and (f) ESI cases. Grey color indicates insignificant correlation. The Blended Drought Index (BDI) has better correlation than all other data sources

SUMMARY

- *NOAA NESDIS SMOPS is capable of processing SMAP **NRT** L1-TB to generate soil moisture data products for NWS operation and research uses*
- *Preliminary validation results indicated that the quality of the NOAA SMAP SM data product with **better latency** is compatible with NASA baseline retrievals*
- *Retrieving soil moisture for SMAP **footprints** may produce better data products than grid retrievals*
- *Making use of SMAP data in NOAA weather forecasts and drought monitoring could have **positive** impacts*
- *Further algorithm refinement is still going on*

Thanks for your attention!