NOAA Soil Moisture Operational Product System (SMOPS) Version 3.0: Validations and Improvements

Jicheng Liu[1, 2], Xiwu Zhan[2], Limin Zhao[3], Jifu Yin[1,2], Li Fang[1,2] , Mitch Schull[1,2] , Weizhong Zheng[4,5], and Micheal Ek[4]

[1] Earth System Science Interdisciplinary Center/Cooperative Institute for Climate and Satellites-Maryland, University of Maryland, College Park, MD 20740, USA.
[2] Center for Satellite Applications and Research, NOAA/NESIDS, College Park, MD 20740, USA.
[3] Office of Satellite an Product Operations, NOAA/NESIDS, College Park, MD 20740, USA.
[4] Environmental Modeling Center, NOAA/NCEP, College Park, MD 20740, USA.
[5] I.M. Systems Group, Rockville, MD 20852, USA.

Outline

- Objectives
- SMOPS
- Methodology
- Version History
- Validation Efforts
- Next Steps

Objectives

- Global soil moisture is one of the critical land surface initial conditions for numerical weather, climate, and hydrological predictions.
- Land surface soil moisture remote sensing provides a practical tool.
- A number of soil moisture products have been produced from different satellite sensors (SMOS, ASCAT-A/B, AMSR2, SMAP etc).
- Time latency of some of the products are too long for operational use.
- Different data formats, projection and insufficient spatial and temporal coverage of soil moisture products from individual sensors.
- SMOPS is to:
  1. Produce SM products directly from TB when the latency of the official SM product is too long for operational use.
  2. Provide an operational blended SM product that has better spatial coverage and short latency for operational use.
  3. Provide a one-stop shop for most of the available operational soil moisture products.

SMOPS

http://www.ospo.noaa.gov/Products/land/smops/index.html

- The Soil Moisture Operational Products System (SMOPS) is one-stop shop for all available operational soil moisture products from different satellite sensors.
- SMOPS provides a blended soil moisture product that has improved spatial and temporal coverage.
- Operationally running at NOAA/NESDIS/OSPO.
- Updated with newly launched sensors.

Operational data access contact: Limin.Zhao@noaa.gov

Historical data contact: Xiwu.Zhan@noaa.gov, Jicheng.Liu@noaa.gov

What is SMOPS: SM Products

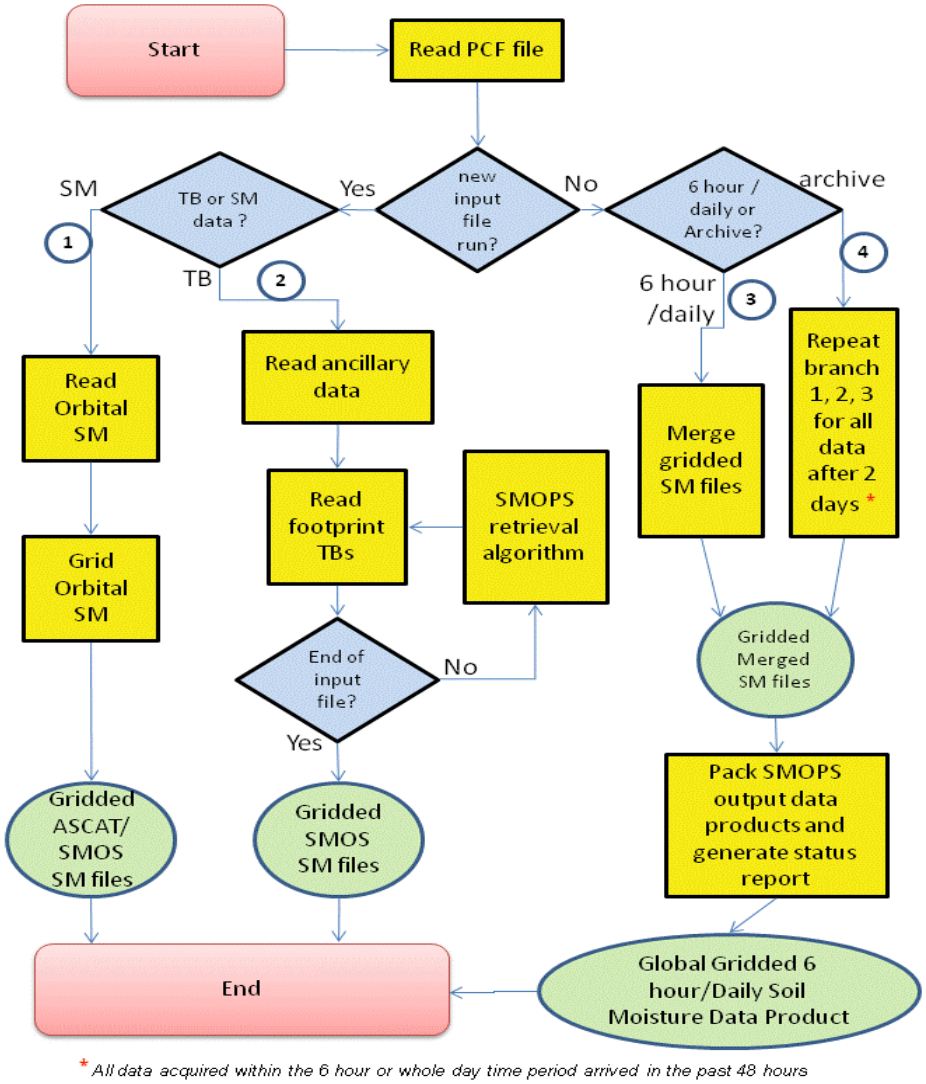
Major SMOPS External Output Description

Item	Description	Format	Projection	Spatial Coverage	Spatial Resolution	Data Latency	Main Purpose
SMOPS 6 Hour Product	SMOPS 6 hour Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degree (720x1440)	3 Hours	Operational
SMOPS Daily Product	SMOPS Daily Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degree (720x1440)	6 Hours	Operational
SMOPS Archive Product	SMOPS Daily Gridded Soil Moisture	netCDF4	Lat/Long	Global	0.25 degree (720x1440)	2 Days	Archive

What is SMOPS: What's Inside

Layer #	Data Description	Units / Format	Data Type	Fill Value	Valid Range	Scale Factor
1	Blended Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
2	NRT SMOS Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
3	ESA SMOS Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
4	ASCAT-A Soil Moisture	%/%	2-byte signed integer	-9999	0 – 1000	1000
5	ASCAT-B Soil Moisture	%/%	2-byte signed integer	-9999	0 – 1000	1000
6	AMSR2 Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
7	GMI Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
8	NRT SMAP Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
9	SMAP Soil Moisture	%/%	2-byte signed integer	-9999	0 – 500	1000
10	SD of Blended SM	%/%	2-byte signed integer	-9999	0 – 500	1000

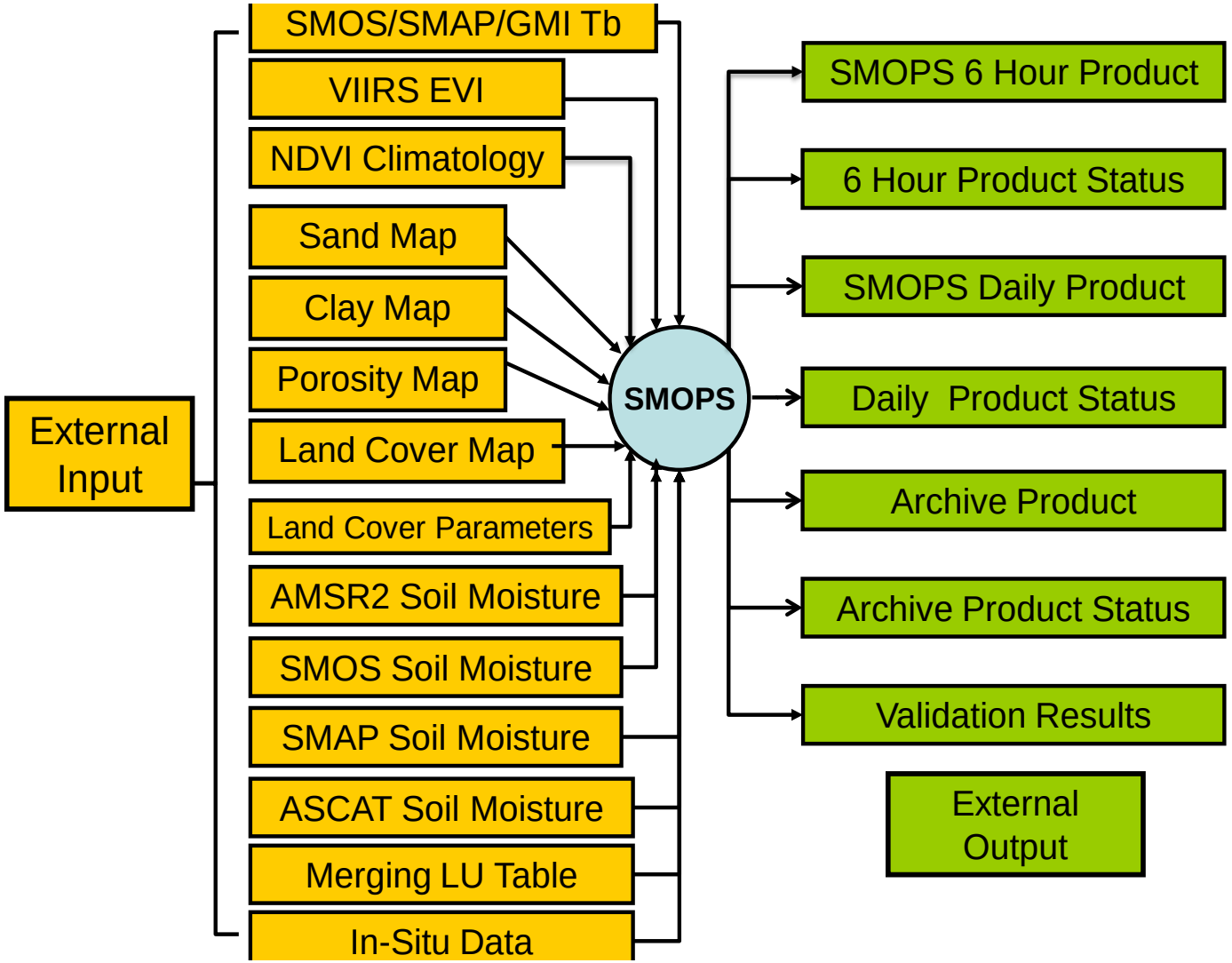
Methodology



* All data acquired within the 6 hour or whole day time period arrived in the past 48 hours

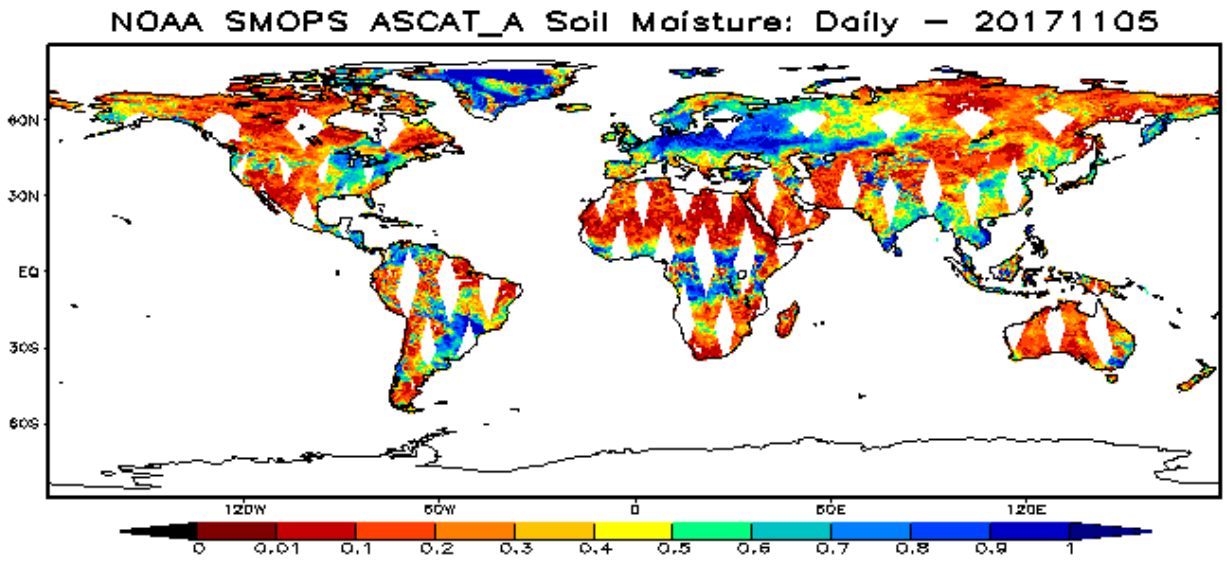
- Branch 1 is the SM Pre-Processing function
- Branch 2 is the Retrieval function
- Branch 3 is the Merging function
- Branch 4 is a reprocessing step for the Archive Product
  - » There is a possibility that the delivery of SM data from individual sensors acquired in the past 24 hours is delayed.
  - » If these data becomes available within the next day (i.e. the past 48 hours), another SMOPS archive run will be activated to generate the daily global soil moisture product for archiving.

Methodology

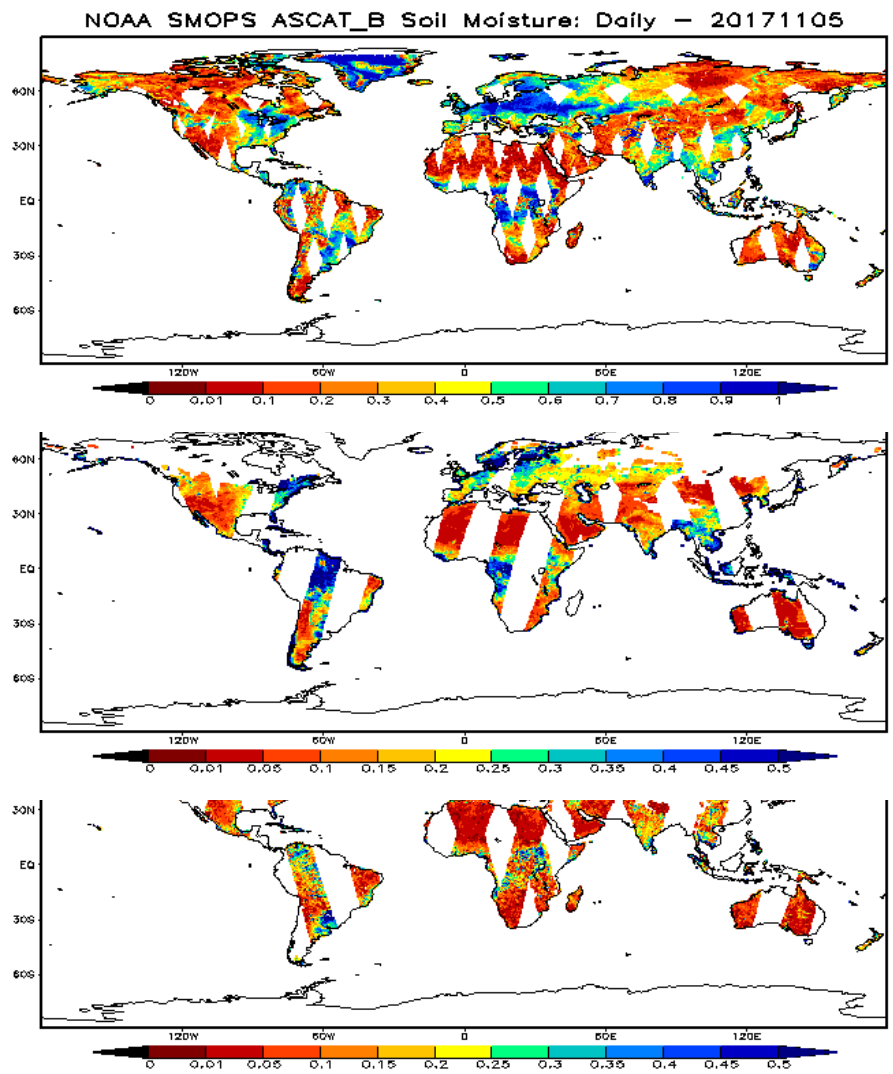


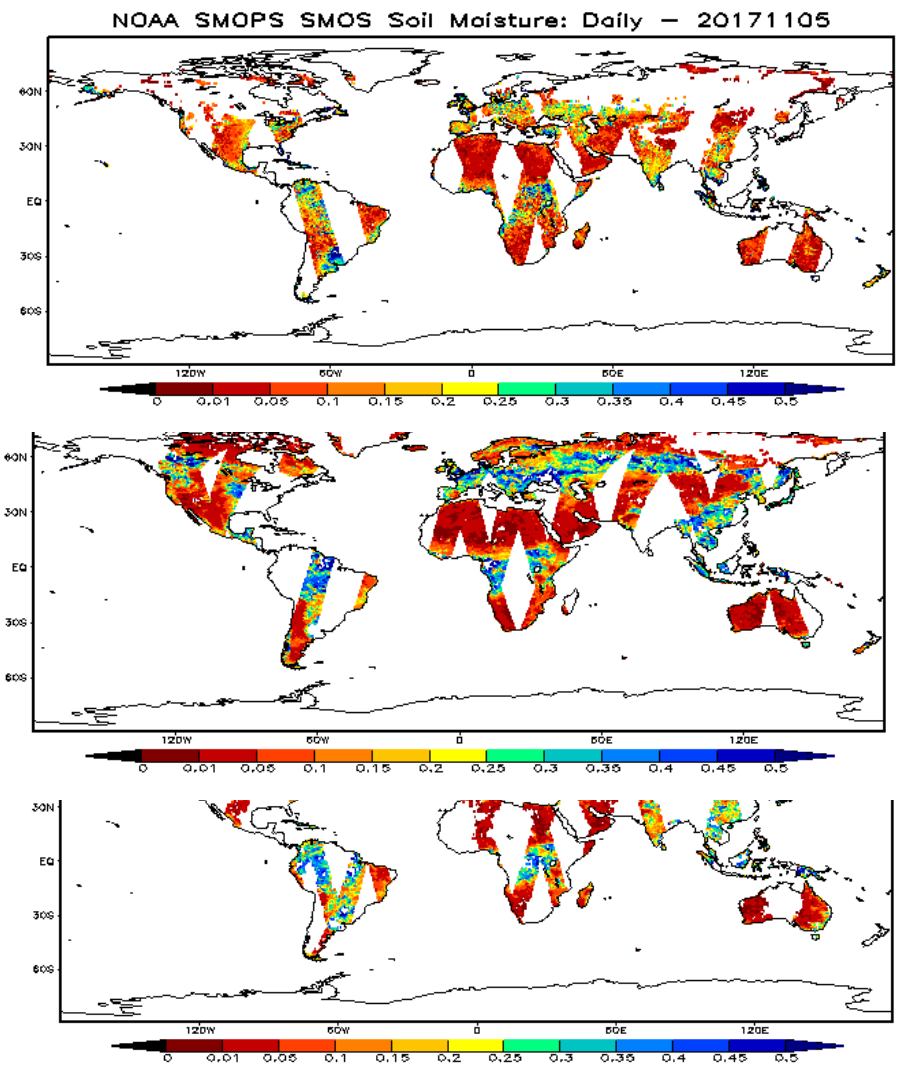
Methodology

- All microwave soil moisture remote sensing satellites, currently in space or to be launched in near future, do not have a full global coverage for every day.
- The map shows example of soil moisture map retrieved from ASCAT-A. Significant gaps exist.



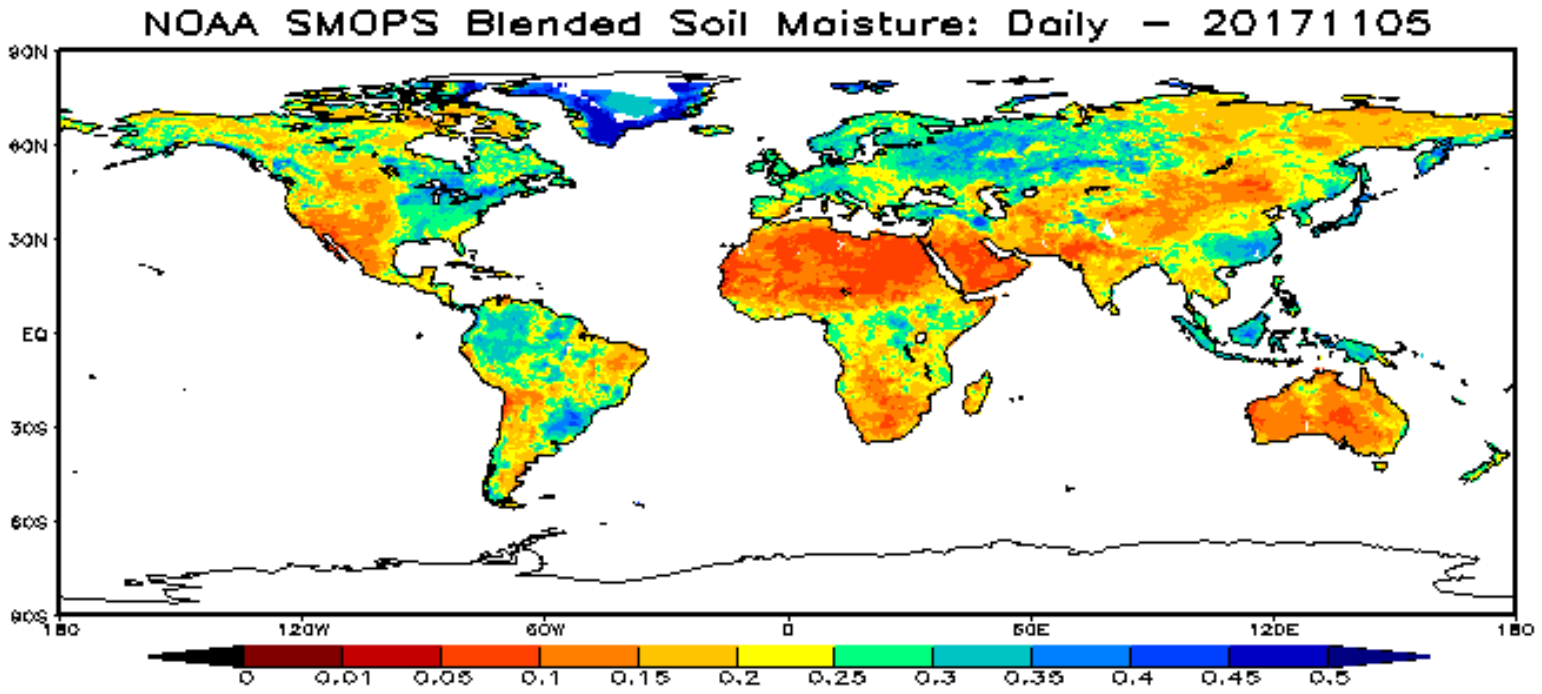
Methodology





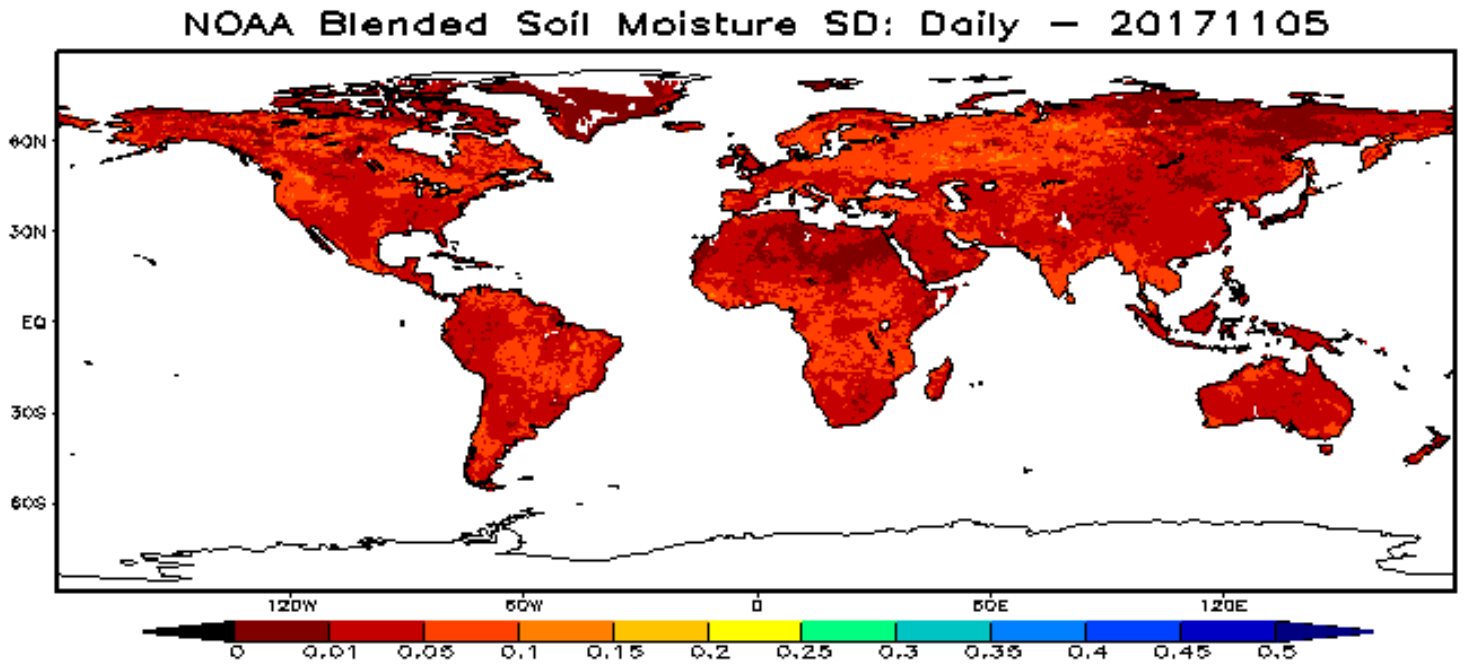
Methodology

- To increase the spatial coverage of daily soil moisture retrievals, SMOPS provides a soil moisture data layer that merges all available satellite soil moisture retrievals in addition to the individual soil moisture retrievals from each of the available satellites.



Methodology

- Version 3.0 also includes a layer that shows the standard deviation for generating the blended SM map.



SMOPS Version History

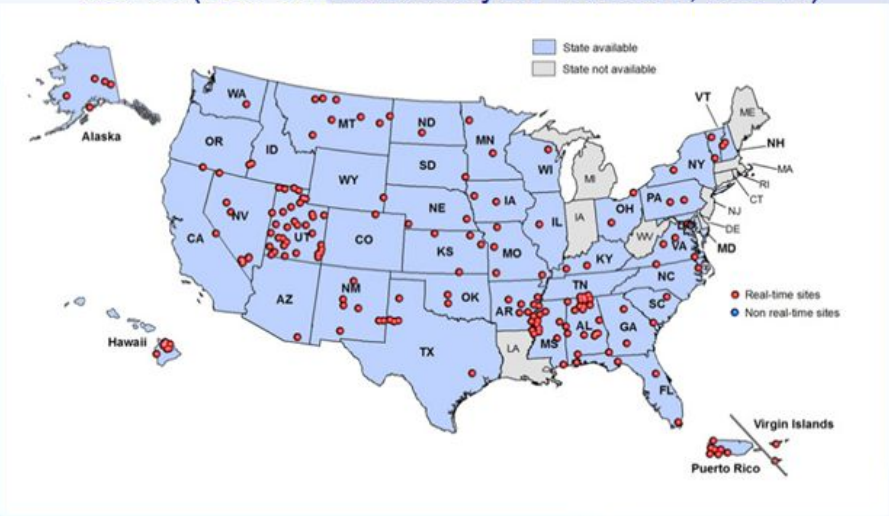
- **Version 1.0 went operational: September, 2012**
- **Version 1.1: June, 2013 (SMOS data format change)**
- **Version 1.2: Feb., 2015 (Added ASCAT-B)**
- **Version 1.3: May, 2015 (SMOS data format change)**
- **Version 2.0: October, 2016 (Added AMSR2 and NRT SMOS)**
- **Version 3.0: September, 2017, Updated with SMAP and GMI**

SMOPS Version History

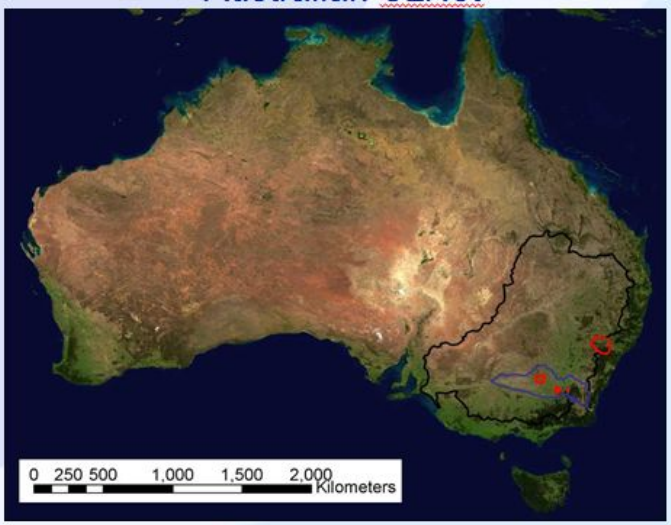
Soil Moisture Product	SMOPS Version 1.3	SMOPS Version 2.0	SMOPS Version 3.0
SMOPS Blended	√ (1)	√ (1)	√ (1)
NOAA AMSR-E	√ (2)	×	×
NRT SMOS	×	√ (2)	√ (2)
ESA SMOS	√ (3)	√ (3)	√ (3)
EUMETSAT ASCAT-A	√ (4)	√ (4)	√ (4)
EUMETSAT ASCAT-B	√ (5)	√ (5)	√ (5)
NOAA WindSat	√ (6)	×	×
NOAA AMSR2	×	√ (6)	√ (6)
GMI	×	×	√ (7)
NRT SMAP	×	×	√ (8)
NASA SMAP	×	×	√ (9)
Blended SD	×	×	√ (10)

Validation Data Sets

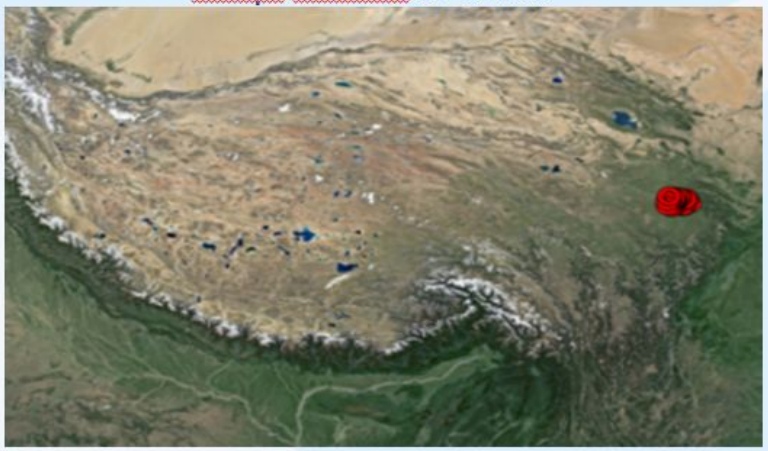
SCAN (Soil Climate Analysis Network, USDA)



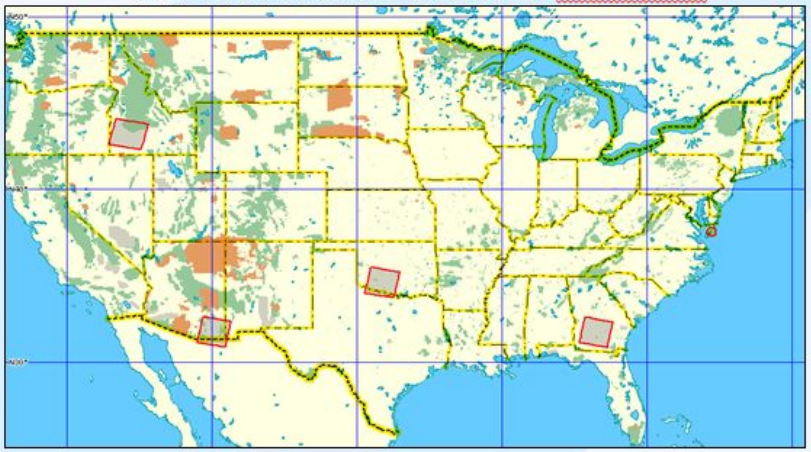
Australian OzNet



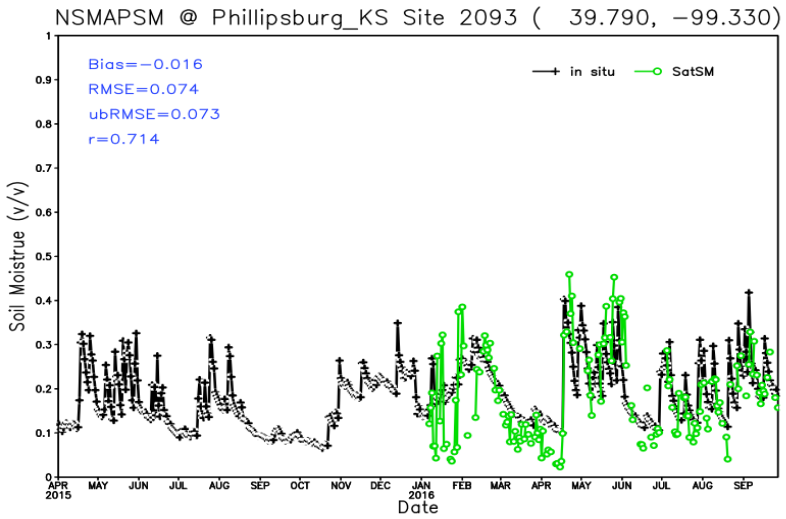
Maqu SMNet of China

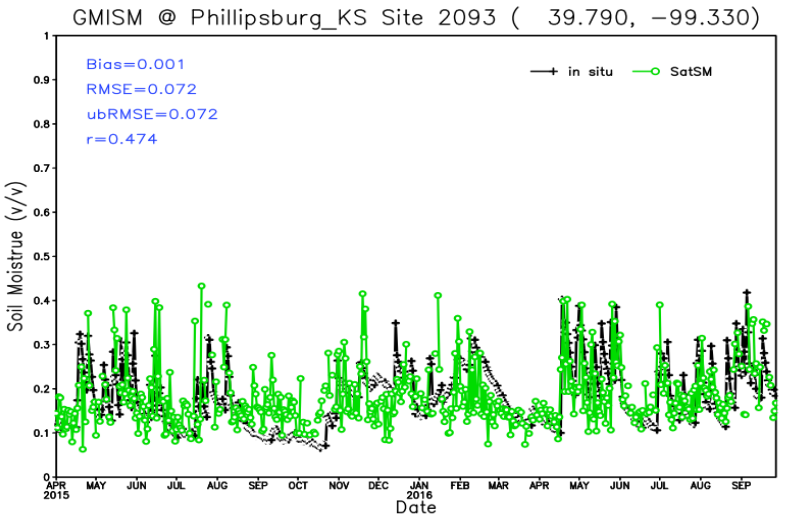


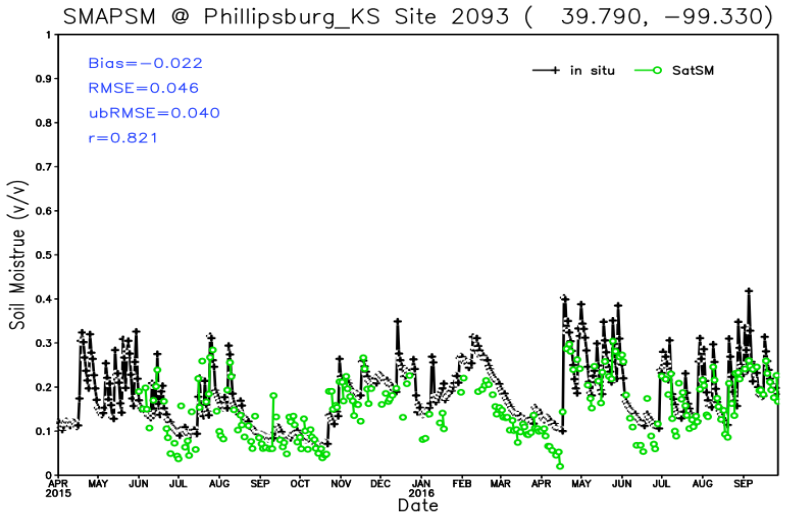
USDA-ARS Soil Moisture MicroNet

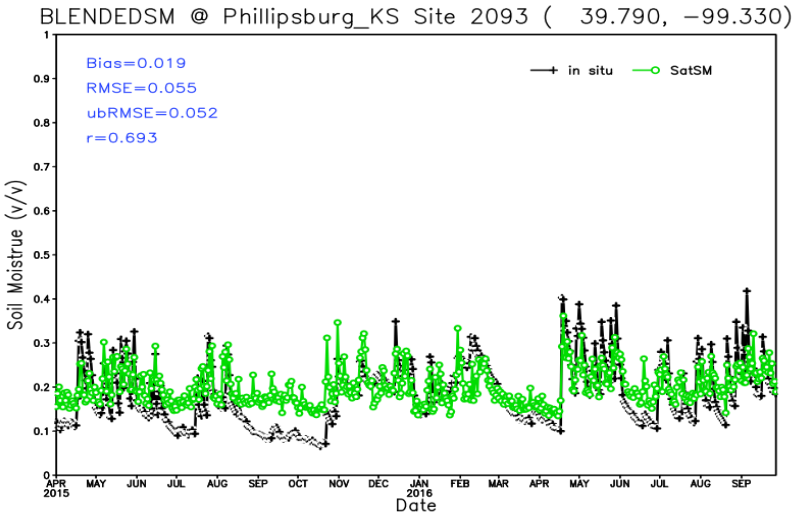


CASE 1: SMOPS SM vs Phillipsburg_KS

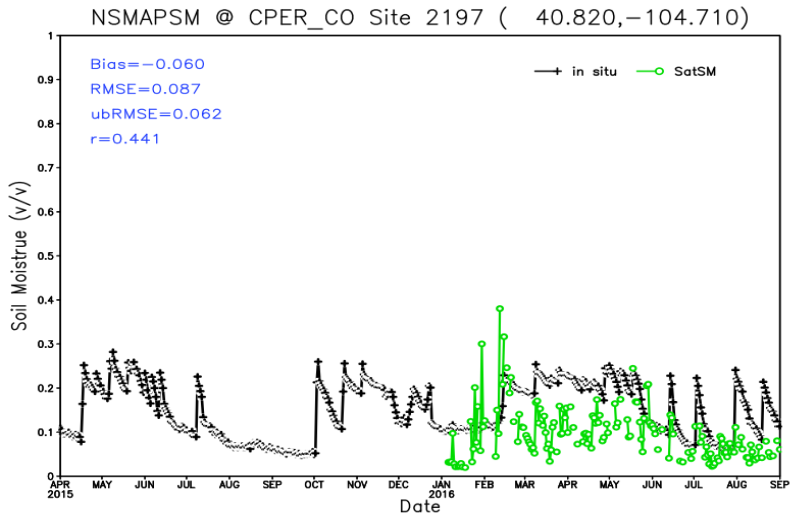


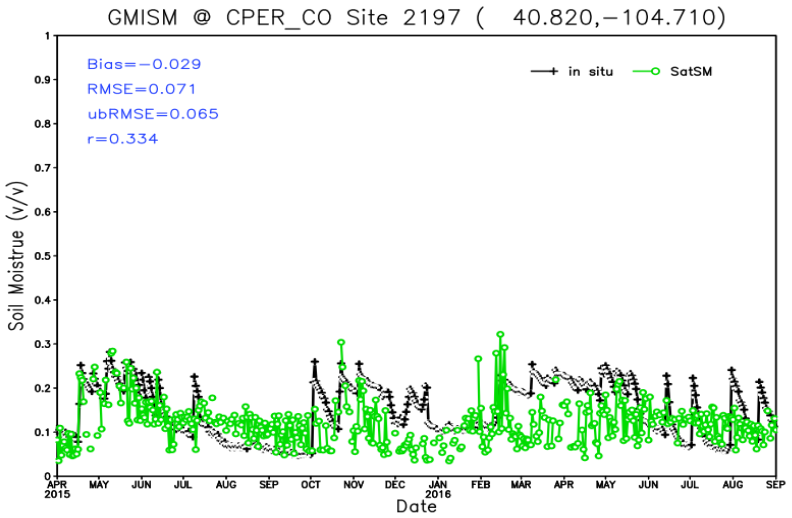


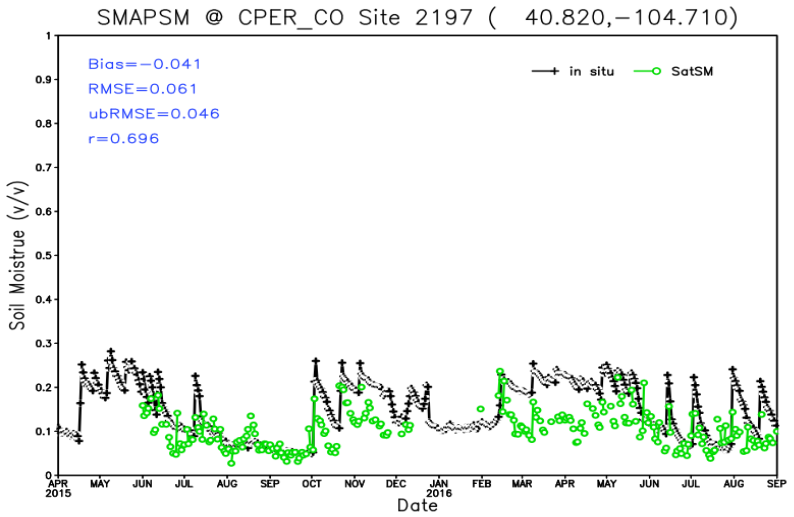


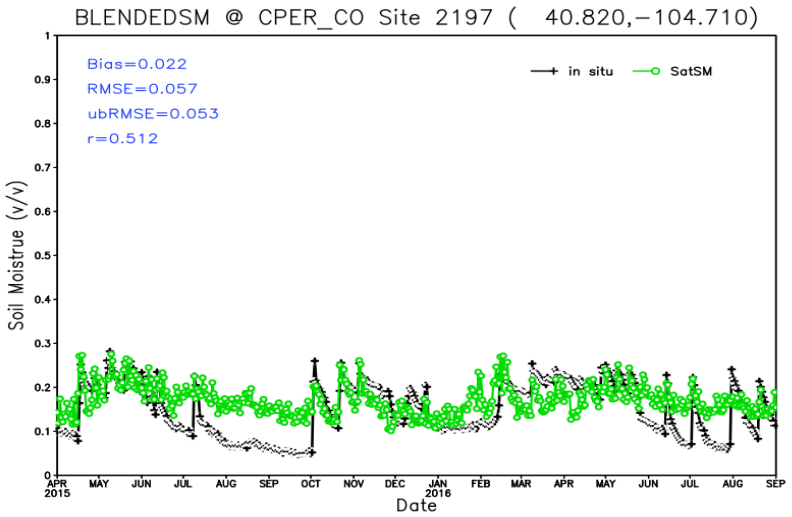


CASE 2: SMOPS SM vs CPER_CO

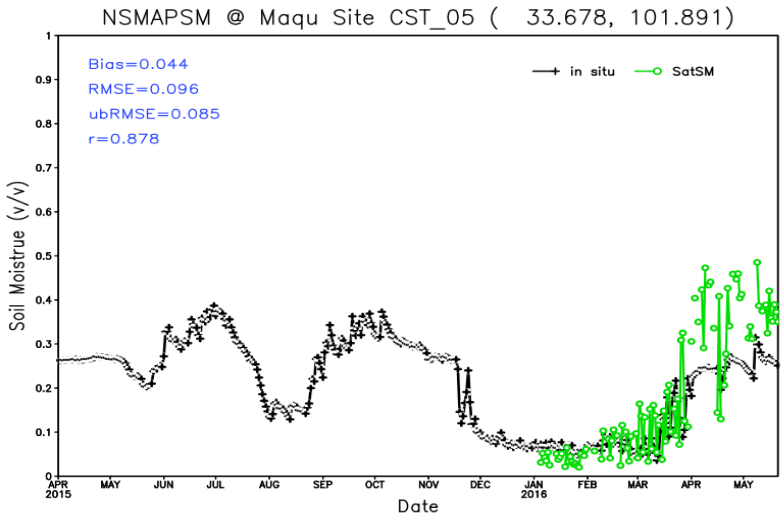


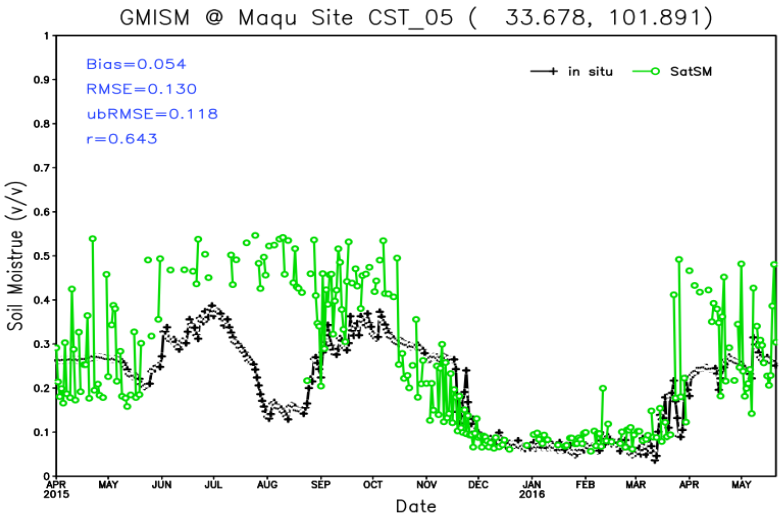


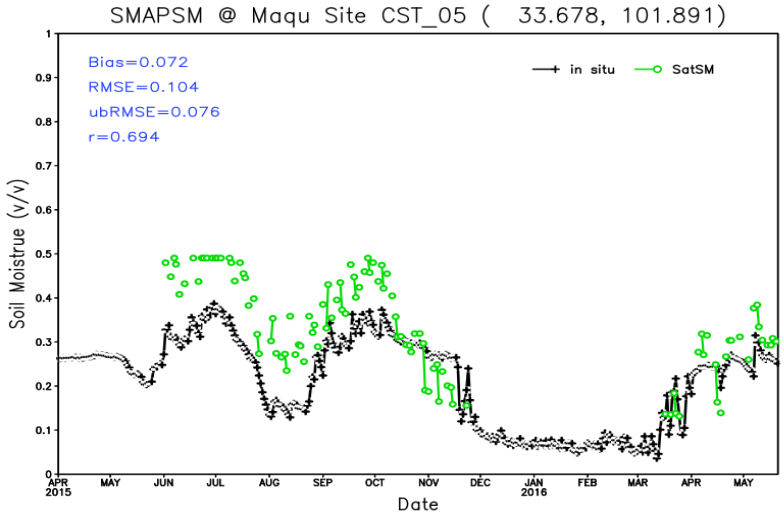


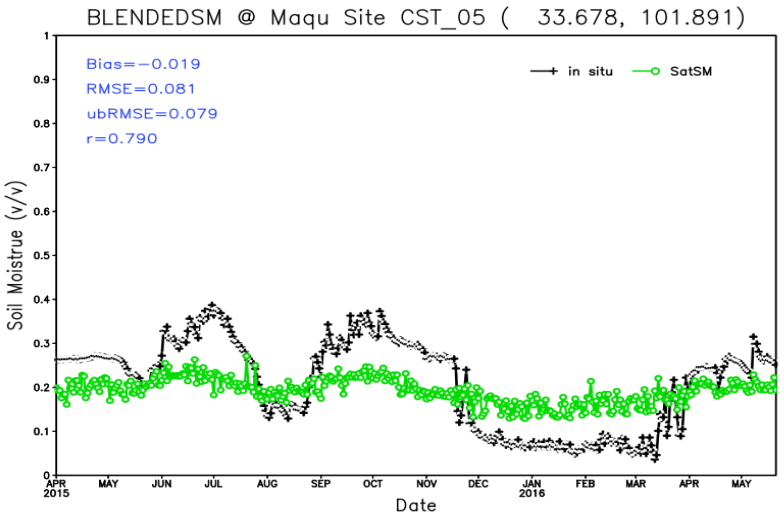


CASE 3: SMOPS SM vs Maqu_CN

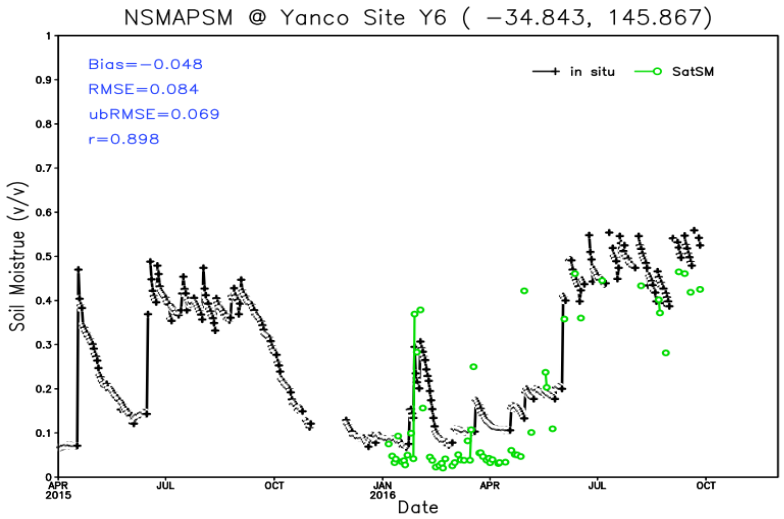


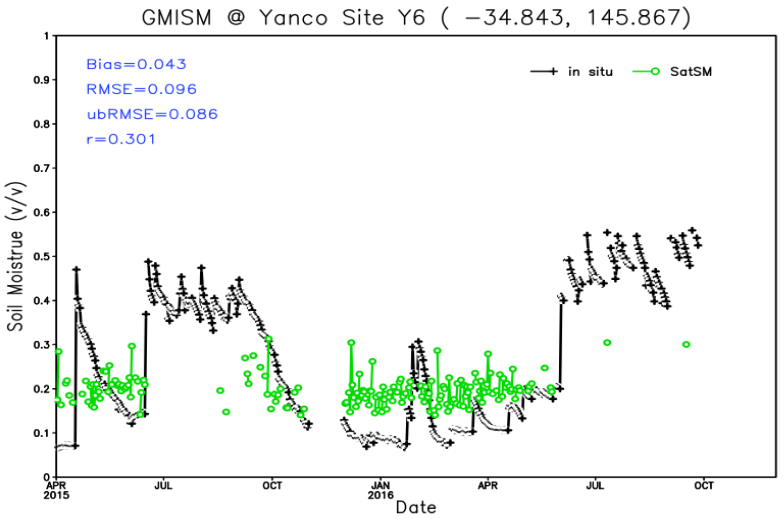


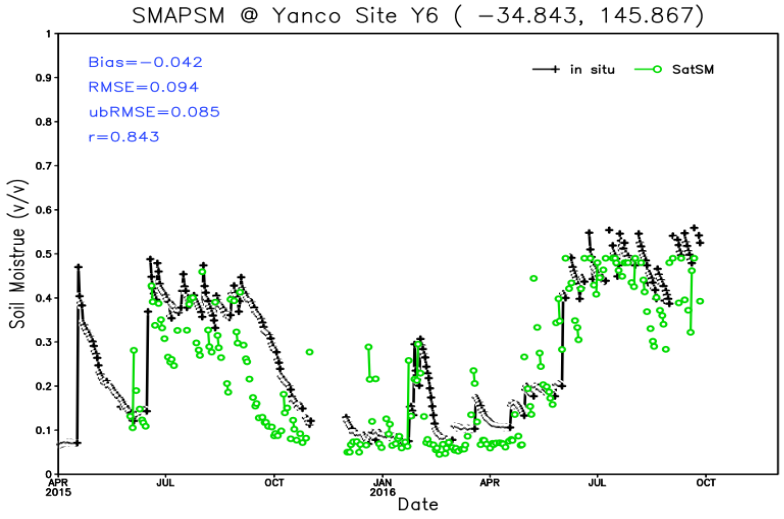


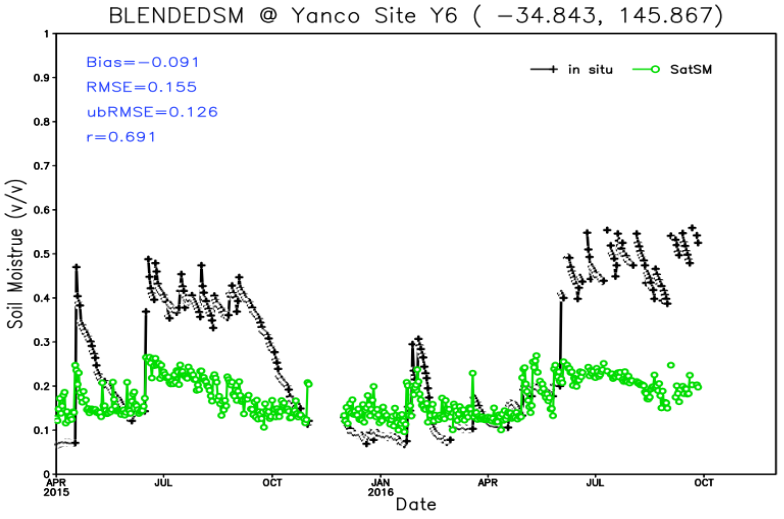


CASE 4: SMOPS SM vs Yanco_OZ

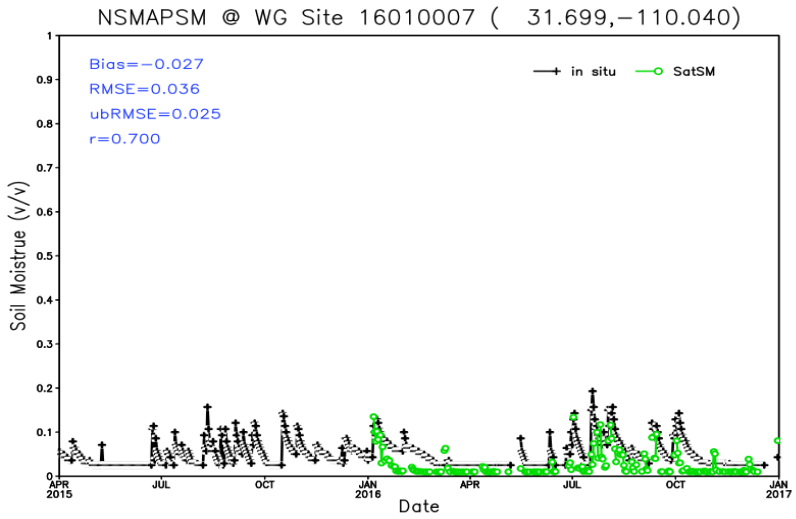


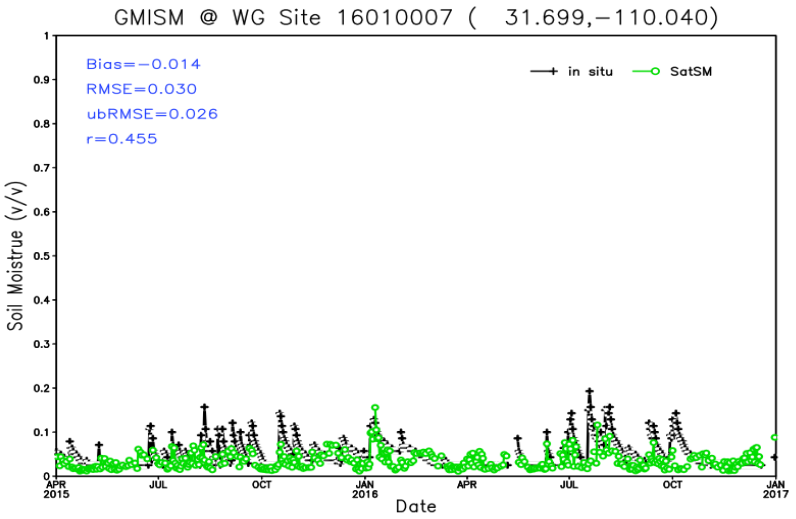


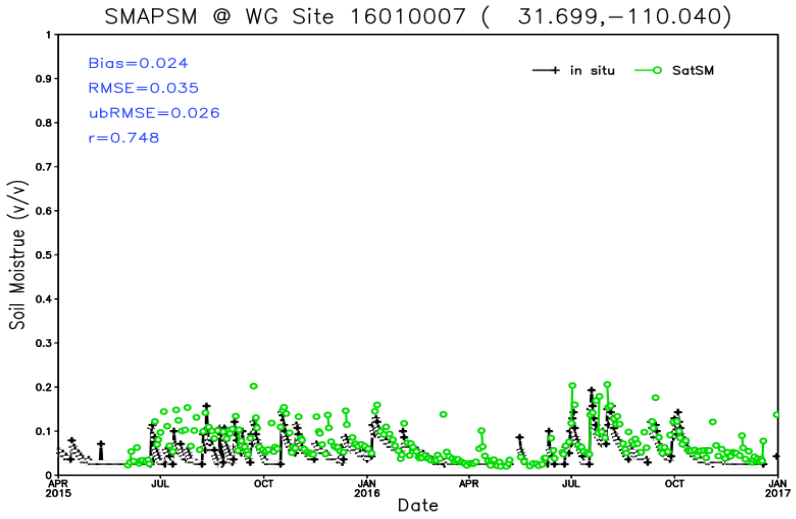


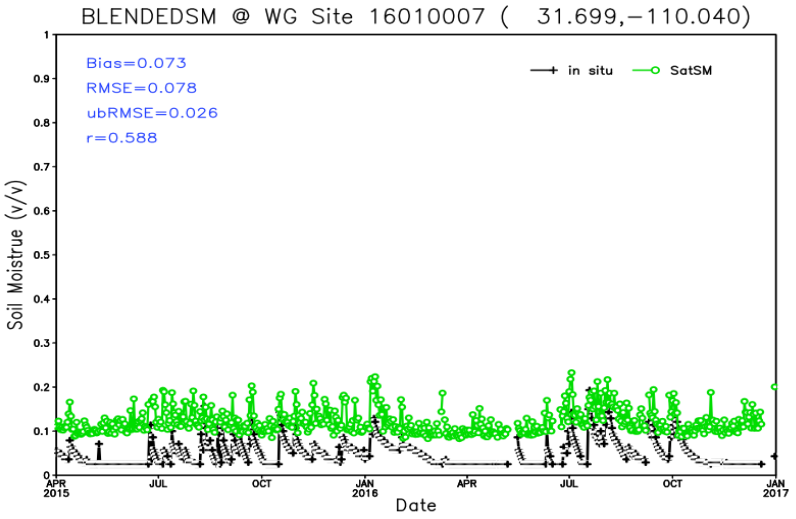


CASE 5: SMOPS SM vs WG_AZ

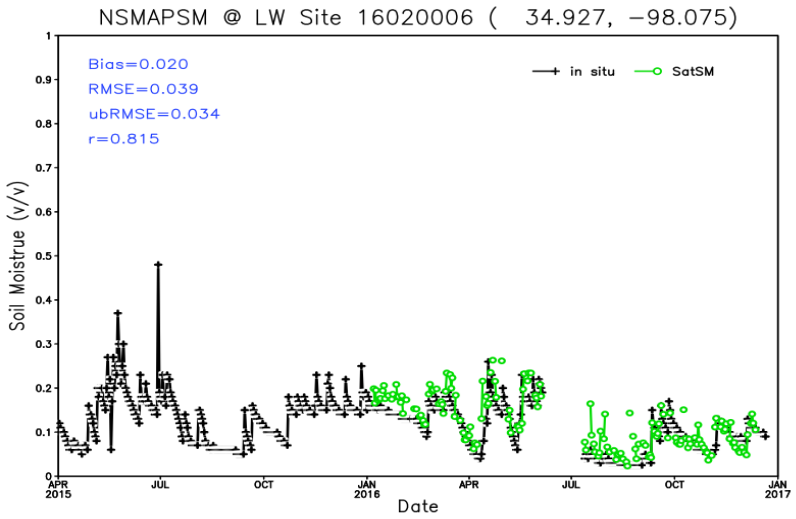


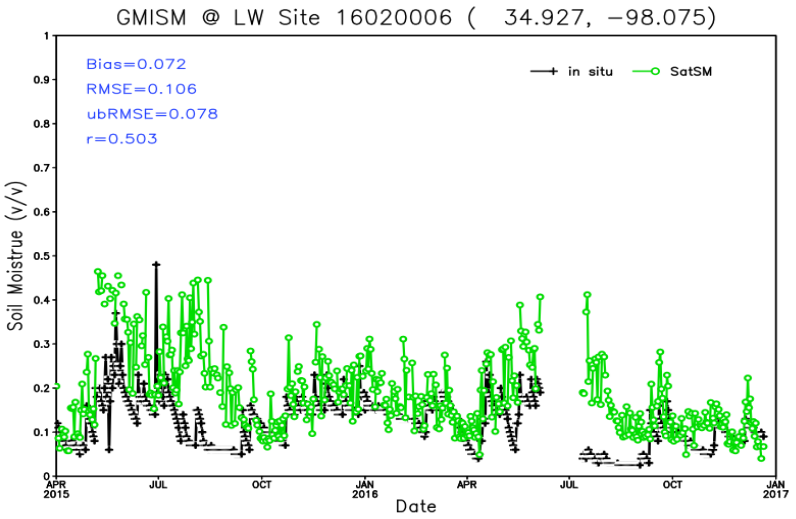


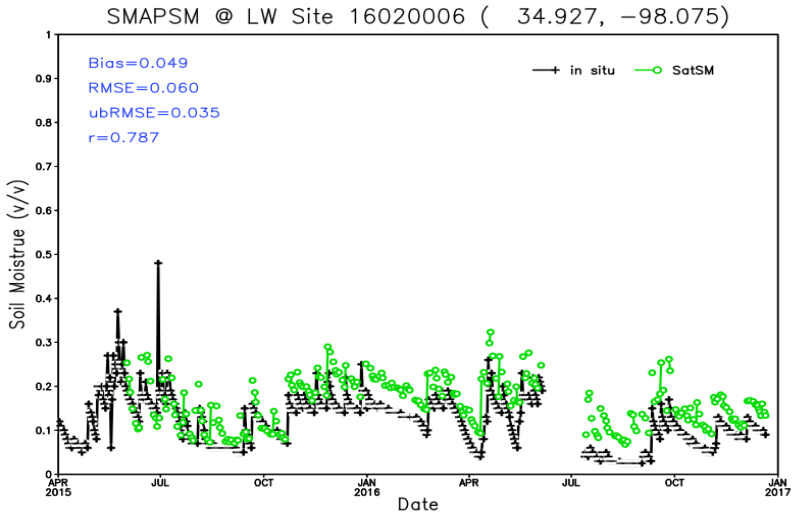


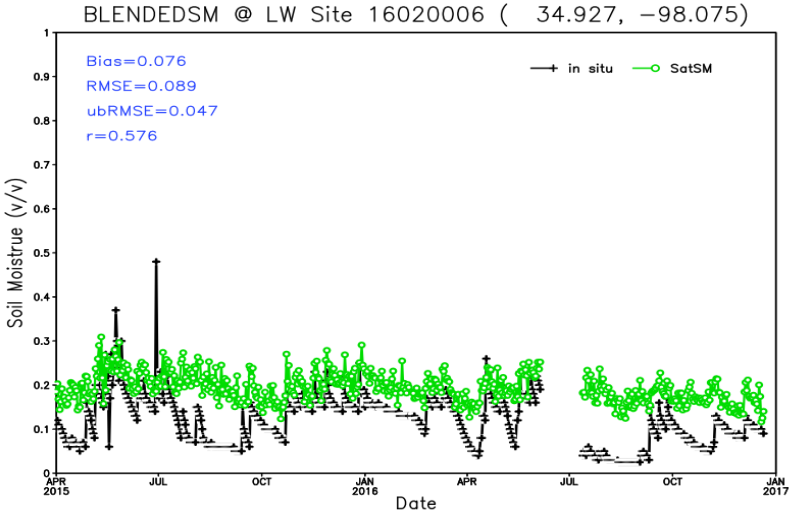


CASE 6: SMOPS SM vs LW_OK









SMOPS SM Product Validation

In situ Sites	Correlation Coefficient (r)			
	GMI	NSMAP	SMAP	Blended
Phillipsburg, KS	0.474	0.714	0.821	0.693
CPER, CO	0.334	0.441	0.696	0.512
Torrington, WY	0.437	0.684	0.711	0.577
Geneva, NY	0.355	0.501	0.779	0.486
Maqu, China	0.643	0.878	0.694	0.790
Yanco, Australia	0.301	0.898	0.843	0.691
WG, AZ	0.455	0.700	0.748	0.588
LW, OK	0.503	0.815	0.787	0.576
Average	**0.438**	**0.704**	**0.760**	**0.614**

- *Different products have different performance, which could be caused by the different heterogeneity feature of in situ site and product accuracy*

SMOPS SM Product Validation

In situ Sites	Unbiased Root-mean-square-error(ubRMSE)			
	GMI	NSMAP	SMAP	Blended
Phillipsburg, KS	0.072	0.073	0.040	0.052
CPER, CO	0.065	0.062	0.046	0.053
Torrington, WY	0.047	0.034	0.035	0.040
Geneva, NY	0.064	0.094	0.047	0.066
Maqu, China	0.118	0.085	0.076	0.079
Yanco, Australia	0.086	0.069	0.085	0.126
WG, AZ	0.026	0.025	0.026	0.026
LW, OK	0.078	0.034	0.035	0.047
Average	**0.070**	**0.060**	**0.049**	**0.061**

- *The ubRMSE average **6.1%** [v/v] meets the **4-10%** requirement specified in the NCEP user request (SPSRB requirement **#0707-17**).*

SMOPS SM Product Validation

Strengths and weaknesses

- Soil moisture value differs from different products
- SMOPS brings in the available value with best quality to the blended product
- For most of the validation sites with relatively homogeneous land surface type, RMSE values of SMOPS blended product are less than 0.05.
- The coverage of blended product is the best, in terms of both spatial and temporal samplings.

Next steps

- Continue to improve data quality from individual sensors
- Better CDFs method for larger temporal variations of blended product
- To use different weights in blending based on the performance of individual sensors
- Ready for next new sensor

Thank you!