

NOAA Soil Moisture Operational Product System (SMOPS): Version 2

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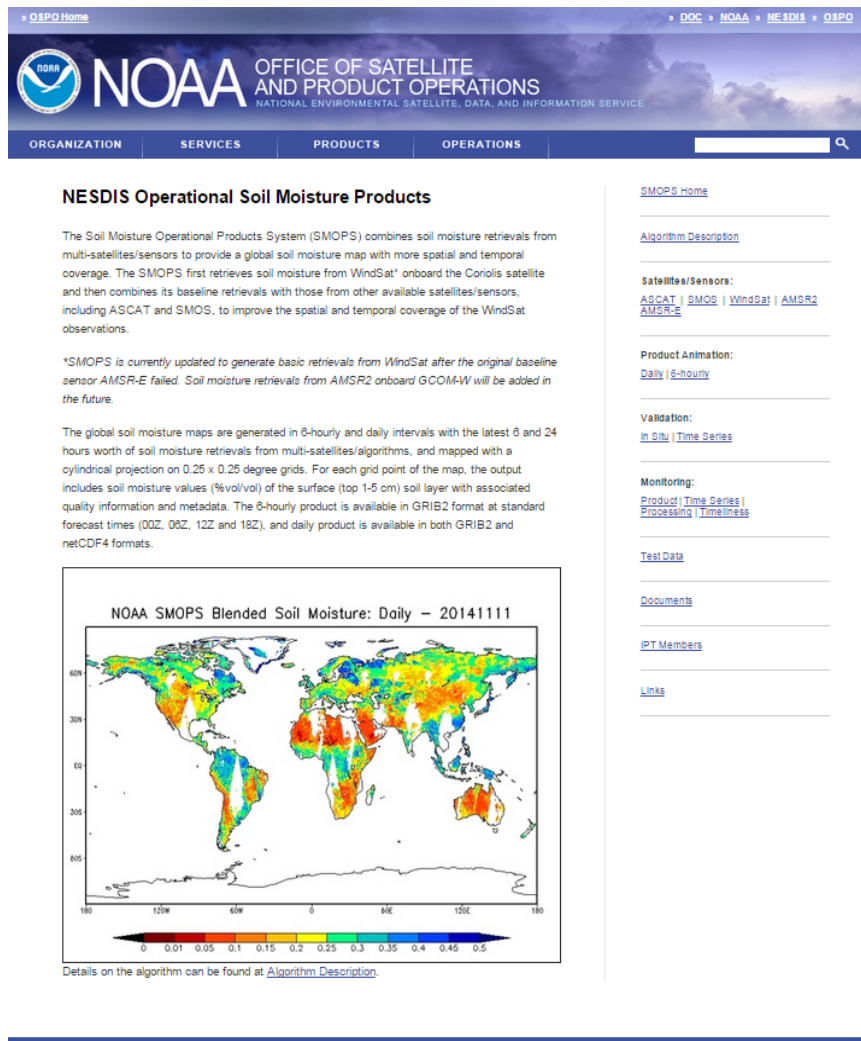
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Outline

- **What's SMOPS**
- **Why**
- **How**
- **When**
- **Who cares**
- **What else**

What's SMOPS

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



The screenshot shows the NOAA Office of Satellite and Product Operations (OSPO) website. The header includes the NOAA logo and the text "OFFICE OF SATELLITE AND PRODUCT OPERATIONS NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE". The main content area is titled "NESDIS Operational Soil Moisture Products". It describes the SMOPS system, which combines soil moisture retrievals from multi-satellites/sensors to provide a global soil moisture map. The text mentions that the SMOPS first retrieves soil moisture from WindSat* onboard the Coriolis satellite and then combines its baseline retrievals with those from other available satellites/sensors, including ASCAT and SMOS, to improve the spatial and temporal coverage of the WindSat observations.

*SMOPS is currently updated to generate basic retrievals from WindSat after the original baseline sensor AMSR-E failed. Soil moisture retrievals from AMSR2 onboard GCOM-W will be added in the future.

The global soil moisture maps are generated in 6-hourly and daily intervals with the latest 6 and 24 hours worth of soil moisture retrievals from multi-satellites/algorithms, and mapped with a cylindrical projection on 0.25 x 0.25 degree grids. For each grid point of the map, the output includes soil moisture values (%vol/vol) of the surface (top 1-5 cm) soil layer with associated quality information and metadata. The 6-hourly product is available in GRIB2 format at standard forecast times (00Z, 06Z, 12Z and 18Z), and daily product is available in both GRIB2 and netCDF4 formats.

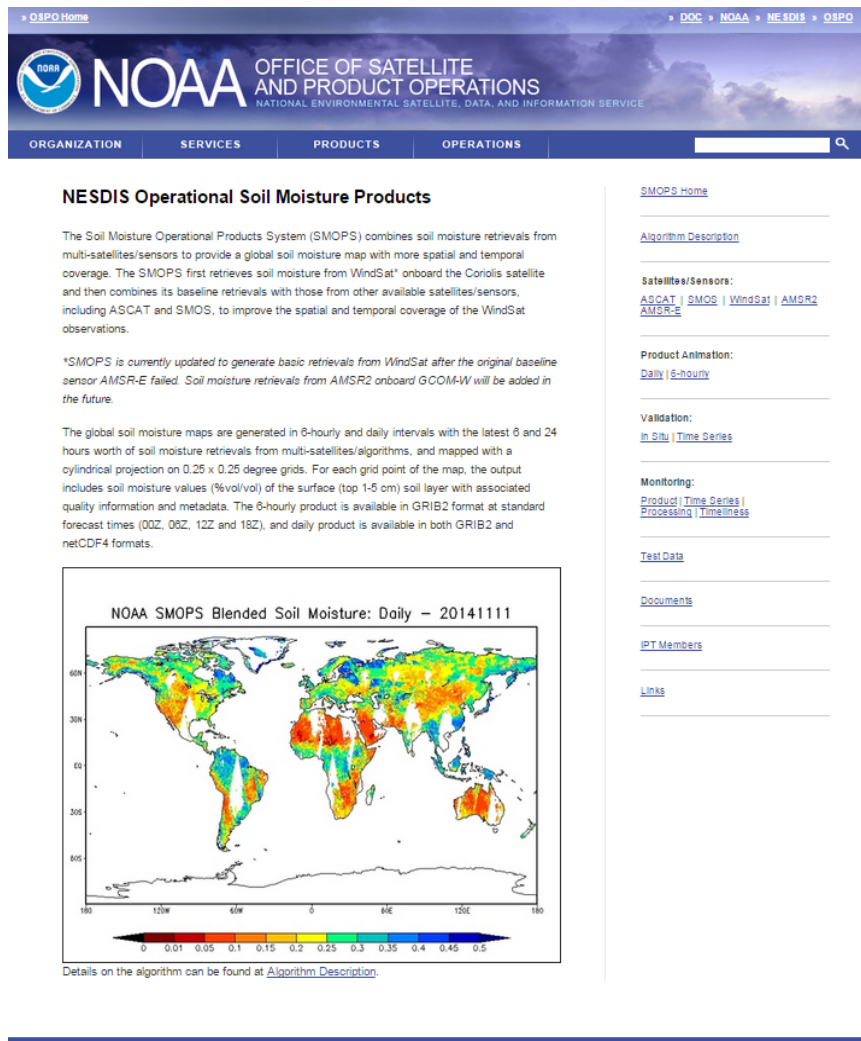
The figure shows a global map titled "NOAA SMOPS Blended Soil Moisture: Daily - 20141111". The map displays soil moisture values across the globe, with a color scale ranging from 0 to 0.5. The map shows higher soil moisture values (red/orange) in the Amazon basin and lower values (blue/green) in the Sahara and Australia.

Details on the algorithm can be found at [Algorithm Description](#).

The Soil Moisture Operational Products System (SMOPS) combines soil moisture retrievals from multi-satellites/sensors to provide a global soil moisture map with more spatial and temporal coverage. The SMOPS first retrieves soil moisture from WindSat onboard the Coriolis satellite and then combines its baseline retrievals with those from other available satellites/sensors, including ASCAT and SMOS, to improve the spatial and temporal coverage of the WindSat observations.

What's SMOPS

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



The screenshot shows the NOAA Office of Satellite and Product Operations (OSPO) website. The header includes the NOAA logo and navigation links for Organization, Services, Products, and Operations. The main content area is titled "NESDIS Operational Soil Moisture Products". It describes the SMOPS system, which combines soil moisture retrievals from multi-satellites/sensors to provide a global soil moisture map with more spatial and temporal coverage. The text mentions that the SMOPS first retrieves soil moisture from WindSat* onboard the Coriolis satellite and then combines its baseline retrievals with those from other available satellites/sensors, including ASCAT and SMOS, to improve the spatial and temporal coverage of the WindSat observations.

A note states: "SMOPS is currently updated to generate basic retrievals from WindSat after the original baseline sensor AMSR-E failed. Soil moisture retrievals from AMSR2 onboard GCOM-W will be added in the future."

The text further explains that the global soil moisture maps are generated in 6-hourly and daily intervals with the latest 6 and 24 hours worth of soil moisture retrievals from multi-satellites/algorithms, and mapped with a cylindrical projection on 0.25 x 0.25 degree grids. For each grid point of the map, the output includes soil moisture values (%vol/vol) of the surface (top 1-5 cm) soil layer with associated quality information and metadata. The 6-hourly product is available in GRIB2 format at standard forecast times (00Z, 06Z, 12Z and 18Z), and daily product is available in both GRIB2 and netCDF4 formats.

A world map titled "NOAA SMOPS Blended Soil Moisture: Daily - 20141111" is displayed, showing soil moisture values across the globe. A color scale at the bottom ranges from 0 to 0.5, with colors transitioning from blue (low) to red (high).

Details on the algorithm can be found at [Algorithm Description](#).

The right sidebar contains links for SMOPS Home, Algorithm Description, Satellites/Sensors (ASCAT, SMOS, WindSat, AMSR2, AMSR-E), Product Animation (Daily, 6-hourly), Validation (In Situ, Time Series), Monitoring (Product, Time Series, Processing, Timeliness), Test Data, Documents, IPT Members, and Links.

- Developed by NOAA/NESDIS/STAR
- Operationally running at NOAA/NESDIS/OSPO

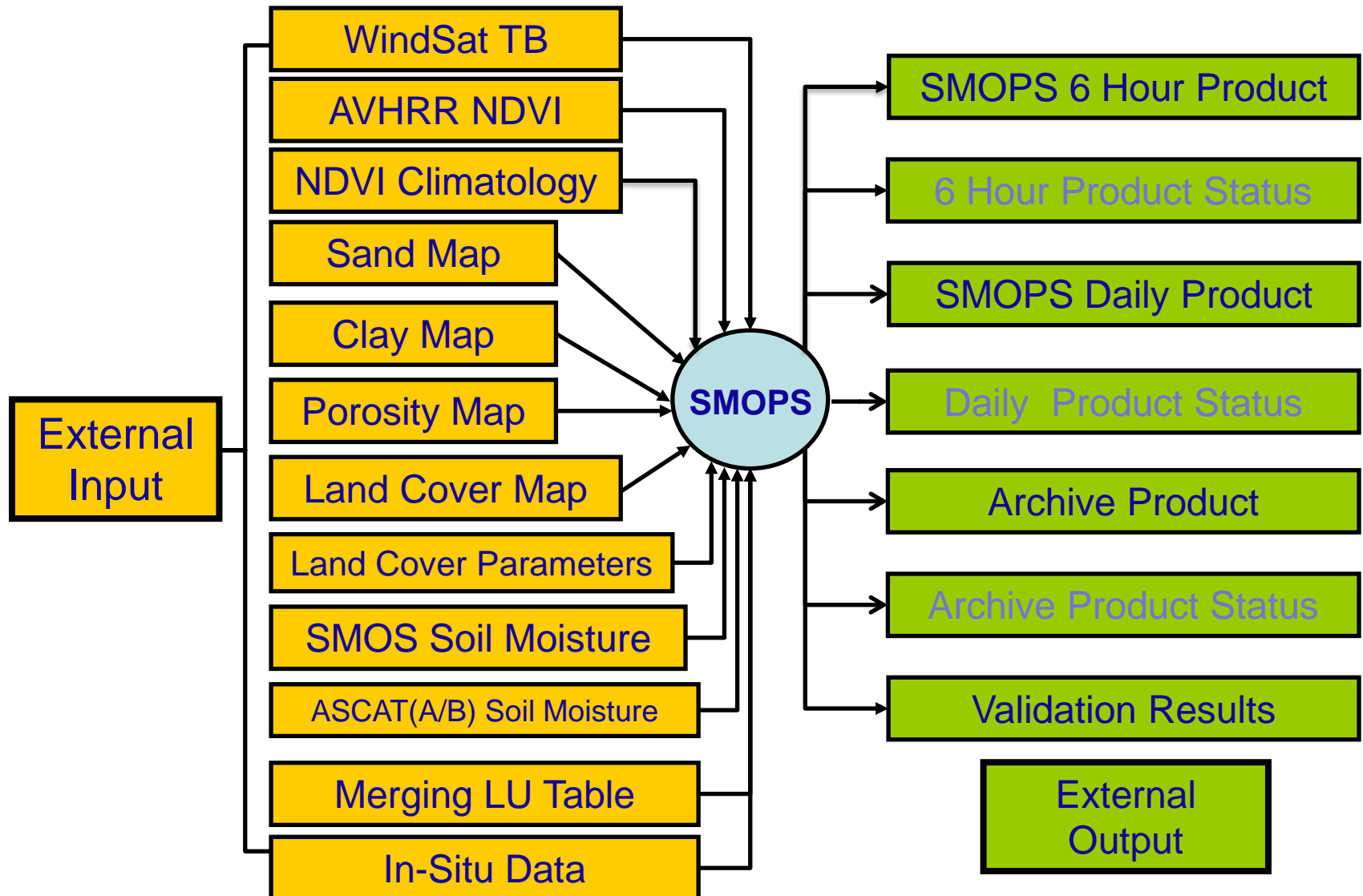
Operational data access contact:
Limin.Zhao@noaa.gov

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

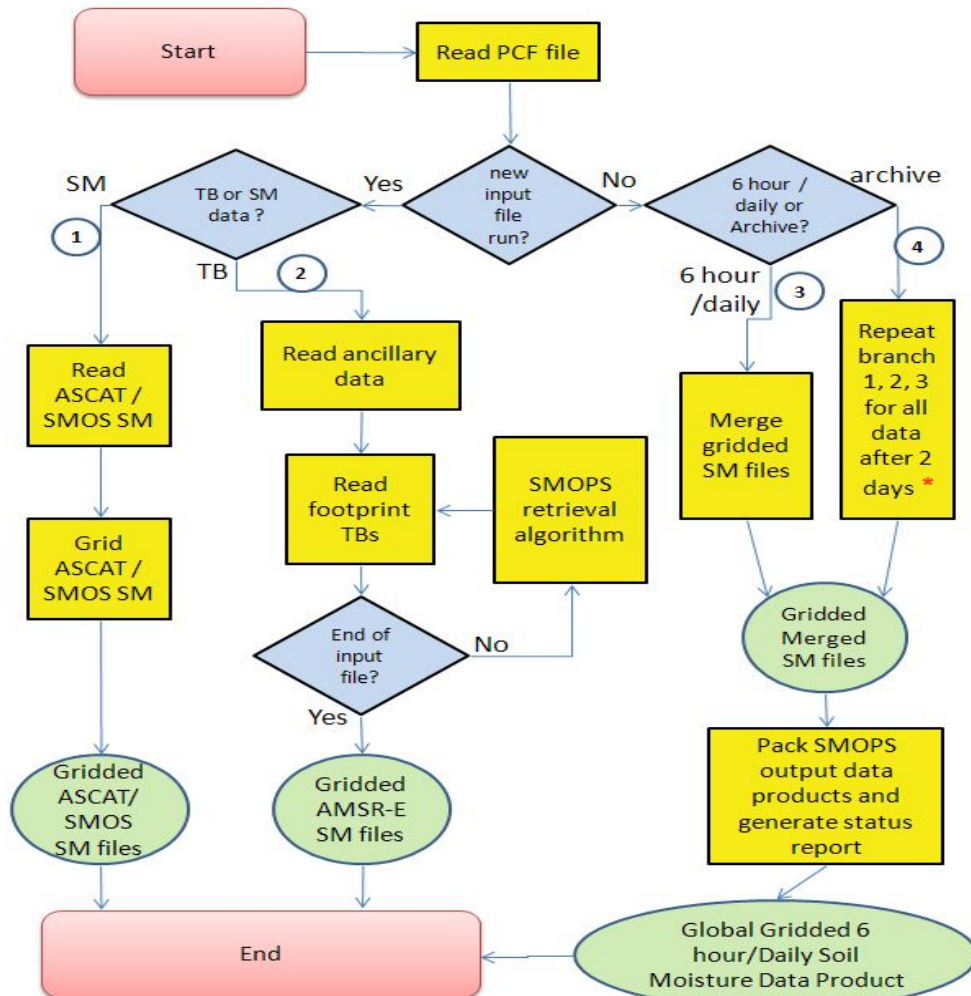
Why SMOPS

- **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 (AMSR-E, SMOS, ASCAT, WindSat, AMSR2, etc).**
- **Different data formats, projection and insufficient spatial and temporal coverage of soil moisture products from individual sensors.**
- **SMOPS is to:**
 1. **Provide a one-stop for most of the available operational soil moisture products.**
 2. **Provide a blended soil moisture layer that is merged from soil moisture retrievals from all available products.**

How SMOPS Works



SMOPS Process Flow



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

- Branch 1 is the 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

How SMOPS Works

Major SMOPS External Output Description

Item	Description	Format	Projection	Spatial Coverage	Spatial Resolution	Main Purpose
SMOPS 6 Hour Product	SMOPS 6 hour Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degree (720x1440)	For NCEP
SMOPS Daily Product	SMOPS Daily Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degree (720x1440)	For NCEP
SMOPS Archive Product	SMOPS Daily Gridded Soil Moisture	netCDF4	Lat/Long	Global	0.25 degree (720x1440)	For CLASS

How SMOPS Works

SMOPS Product Data Layers

Layer #	Data Description	Data Type	Fill Value	Valid Range	Scale Factor
1	Blended Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
2	AMSR-E/2 Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
3	SMOS Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
4	ASCAT-A Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
5	ASCAT-B Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
6	WindSat Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
7	NOAA SMOS Soil Moisture	2-byte signed integer	-999	0 – 1000	1000
8-21	Observation Time Layers	1-byte signed integer	-99	0 – 23 0 – 59	1
22-28	Bit-packed Quality Assessments	2-byte signed integer	-999	N/A	N/A

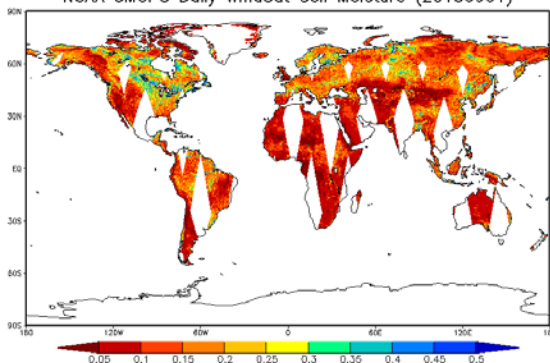
How SMOPS Works

WindSat

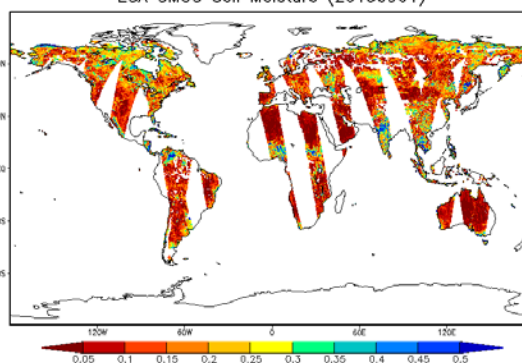
SMOS

ASCAT

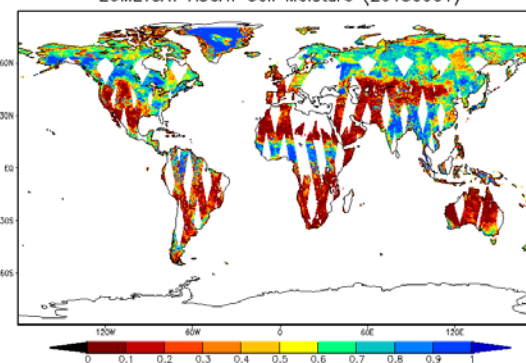
NOAA SMOPS Daily WindSat Soil Moisture (20130901)



ESA SMOS Soil Moisture (20130901)

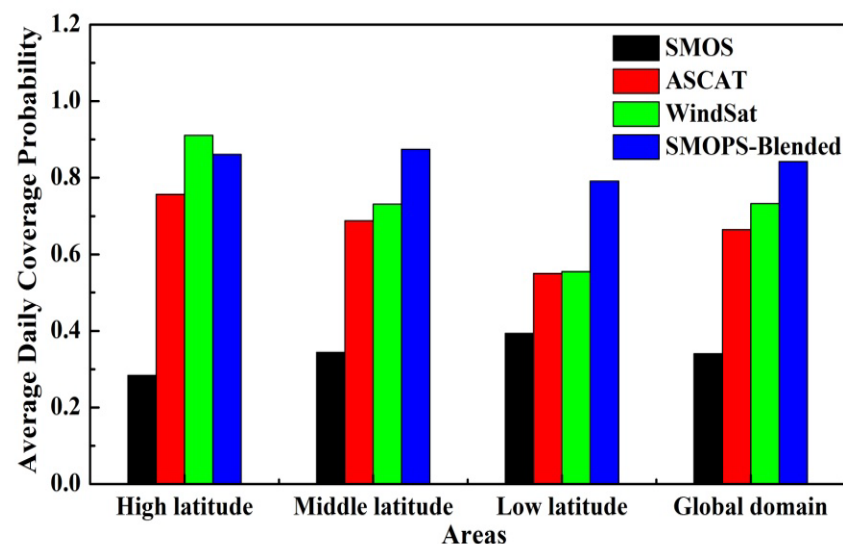
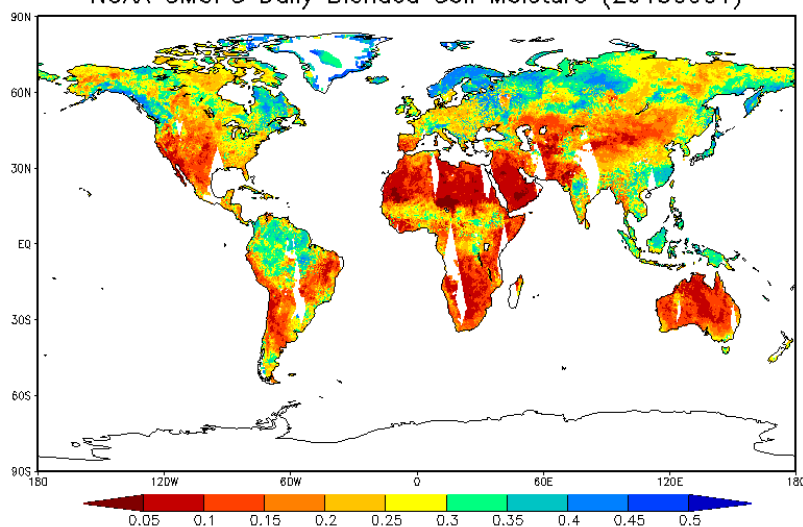


EUMETSAT ASCAT Soil Moisture (20130901)



Blended

NOAA SMOPS Daily Blended Soil Moisture (20130901)



SMOPS Project Milestones

- **Gate 3 Review – Dec 14, 2009**
- **Preliminary Design Review – May 26, 2010**
- **Critical Design Review – Oct 28, 2010**
- **System Readiness Review – Sep 13, 2011**
- **Delivery to Operations – Oct 7, 2011**
- **Version 2 Update – Early 2015**

Who Cares about SMOPS

Does Global Forecast System (GFS) Care?

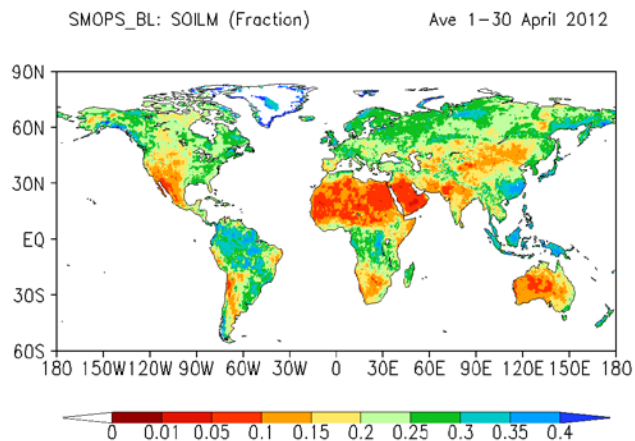
Experiment:

Control Run: GFS run without SM assimilation

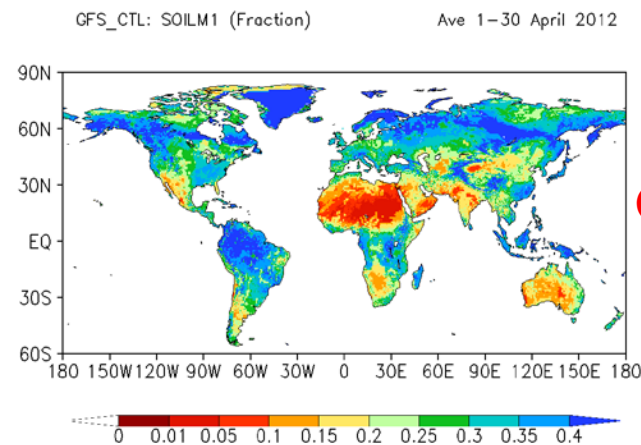
**EnKF run: GFS run with SMOPS Blended SM
assimilated using Ensemble Kalman
Filter.**

Comparison of soil moisture maps (18Z, 1-30 April 2012)

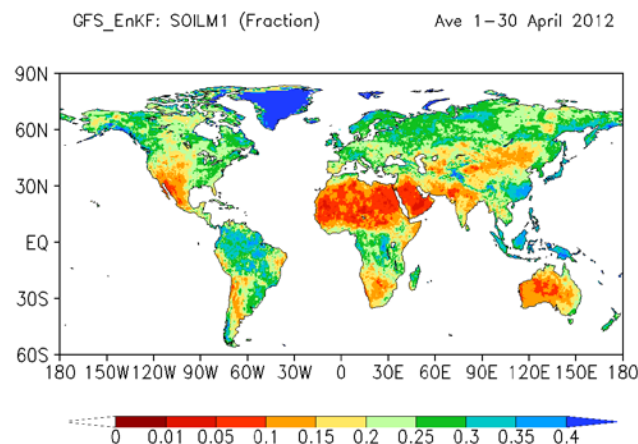
**SMOPS
Blended SM**



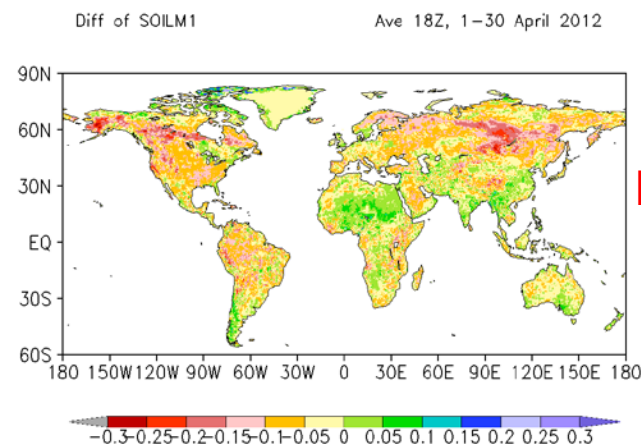
GFS_CTL



GFS_EnKF



EnKF-CTL

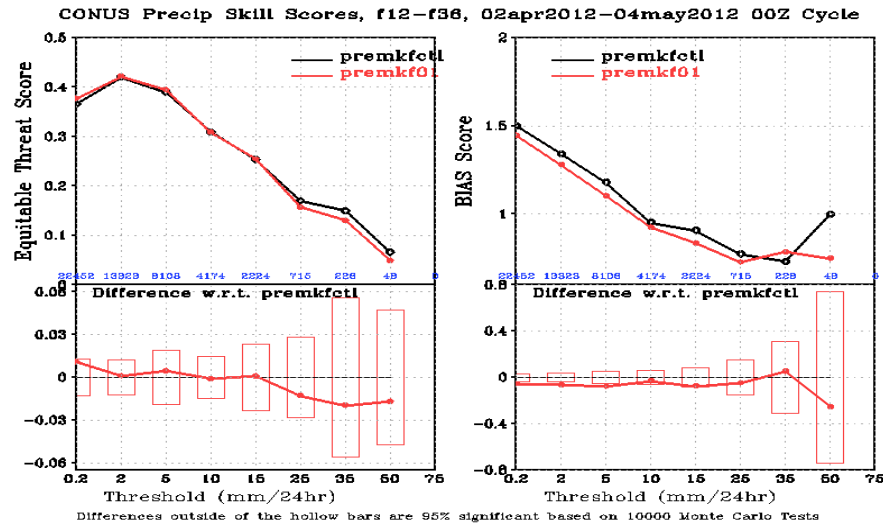


Who Cares about SMOPS

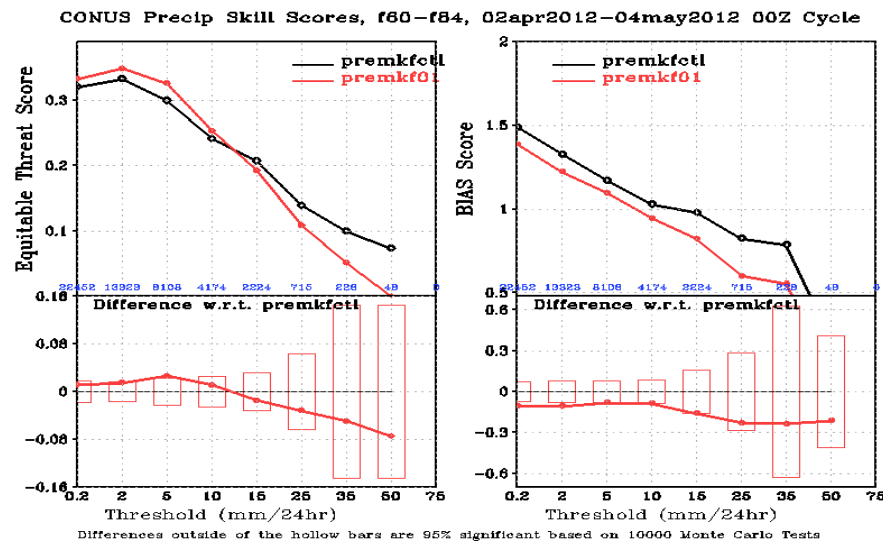
GFS Cares:

("Assimilation of Blended Soil Moisture Products from SMOPS in the NCEP GFS", W. Zheng *et al.*, *JCSDA Quarterly*, Dec. 2013)

"The satellite soil moisture blended products from SMOPS were assimilated in NCEP GFS and the result shows 1) *Improved GFS deeper layer soil moisture estimates comparing with in situ measurements*; 2) *Improved GFS forecast scores and reduced its bias and root-mean-square errors*; and, 3) *Showed some positive impact on precipitation on CONUS but not for heavy precipitation.*"



12h



60h

Who Cares about SMOPS

GFS Cares: (W. Zheng et al.: JCSDA Quarterly, Dec. 2013)

Validation using USDA-SCAN ground observations.

	East CONUS (26 sites)			West CONUS (25 sites)			Whole CONUS		
	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>
CTL	0.135	0.046	0.565	0.124	0.033	0.448	0.129	0.040	0.508
EnKF	0.130	-0.031	0.613	0.114	-0.021	0.549	0.123	-0.031	0.587

❖ Improved GFS SM product quality with SMOPS SM assimilated.

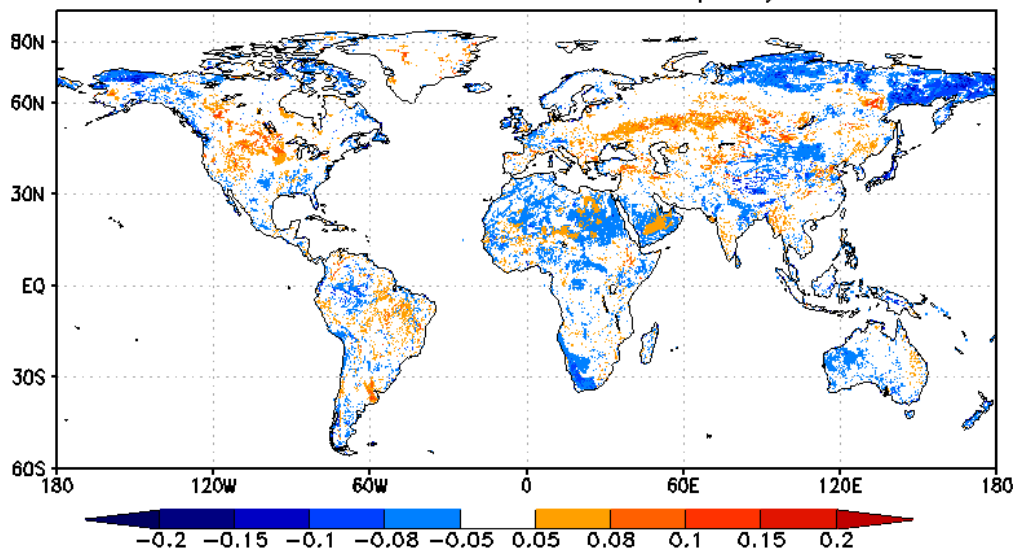
Who Cares about SMOPS

GFS Cares:

“Enhancing Model Skill by Assimilating SMOPS-Blended Soil Moisture Product into Noah Land Surface Model”, J. Yin *et al.*, *Journal of Hydrometeorology*, 2014)

“The improvements of assimilating SMOPS-Blended data on model soil moisture and soil temperature can be seen not only in low and middle GVF areas, but also in high GVF areas, and the best performance is shown in middle GVF areas. Temporal correlations between *in-situ* observations and SWnet/LWnet are stronger with assimilating SMOPS-Blended product than without the benefit of data assimilation.”

RMSD-DA Minus RMSD-OLP for Top Layer SM



Negative (Blue): Increased model performance.

What else we need to do about SMOPS?

Soil Moisture Product	SMOPS Version 1	SMOPS Version 2
SMOPS Blended	✓	✓
NOAA AMSR-E	✓	✗
ESA SMOS	✓	✓
EUMETSAT ASCAT-A	✓	✓
EUMETSAT ASCAT-B	✗	✓
NOAA WindSat	✓	✓
NOAA AMSR2	✗	✓
NOAA SMOS	✗	✓
SMAP	✗	✗
Other Products		

What else we need to do about SMOPS?

- **To include more soil moisture products**
- **To update CDFs for blended product regularly**
- **To improve retrieval algorithm**
- **To do more DA experiments**



Go SMOPS!



Thank you!