

# Soil Moisture Operational Product System for NCEP GFS Land Data Assimilation

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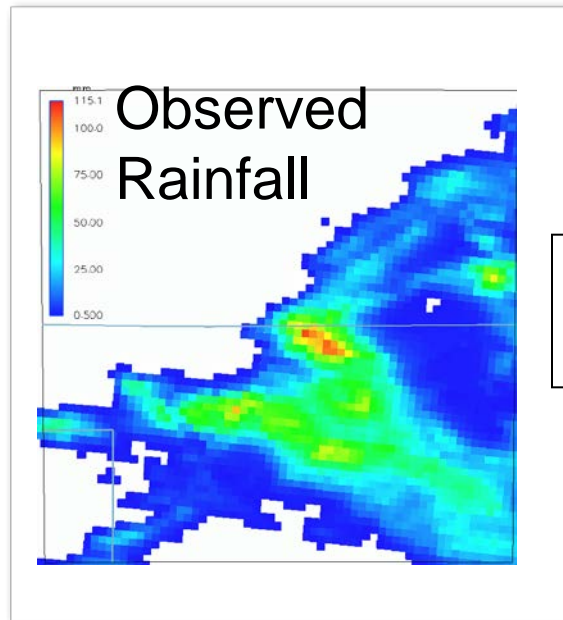
**L. Zhao**

**NESDIS Office of Satellite and Product Operations, College Park, MD**

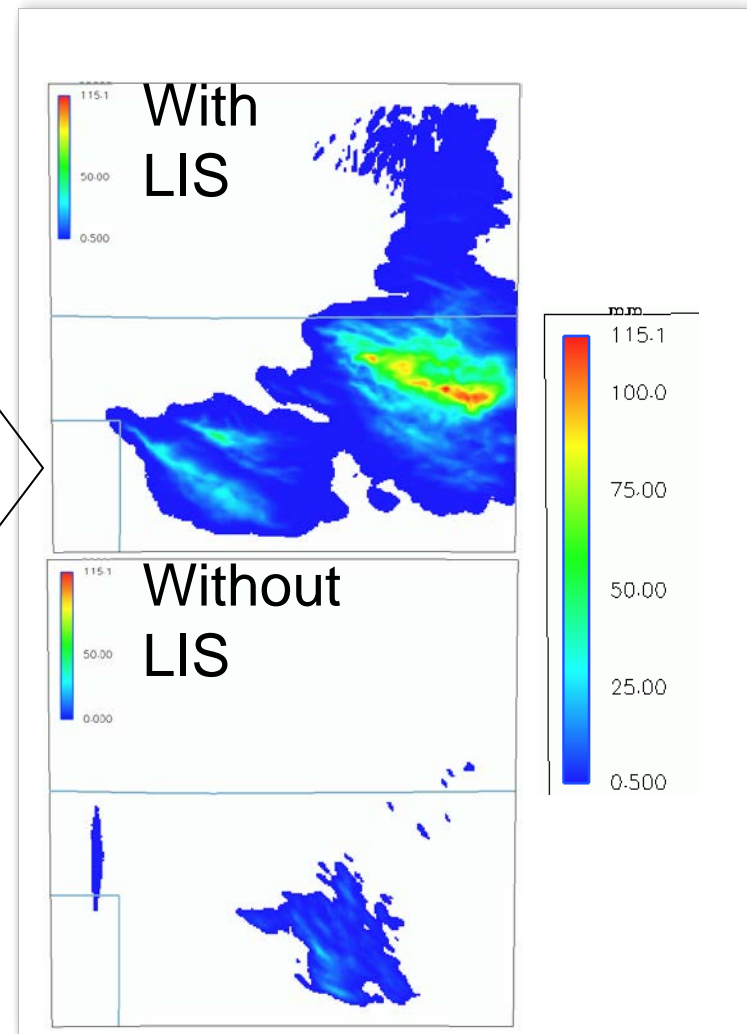
# OUTLINE

- ❖ *Objective*
- ❖ *SMOPS and Products*
- ❖ *EnKF in NCEP GFS*
- ❖ *Impact of SM DA on GFS*

# Soil Moisture Impact on NWP Models



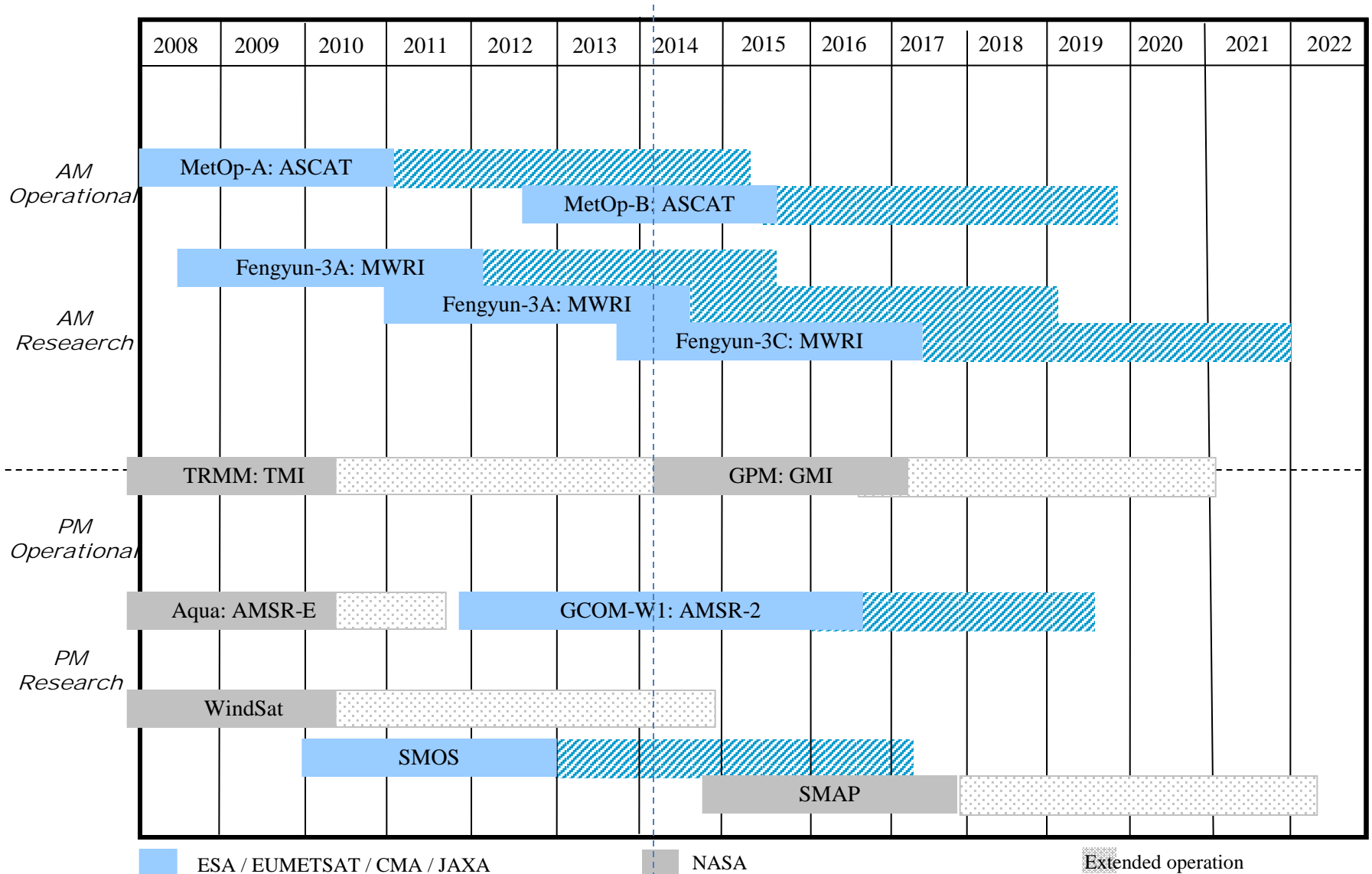
12-Hours Ahead  
Weather Forecasts



**Forecast rainfall more accurate  
with LIS-initialized soil moisture**

*Peters-Lidard, et al, 2006*

# Current and Future Soil Moisture Satellites



# Satellite Soil Moisture Products

- ✓ **GSFC SMMR (Owe et al, 2001)**
- ✓ **USDA TMI (Bindlish et al, 2003)**
- ✓ **Princeton TMI (Gao et al, 2006)**
- ✓ **NASA AMSR-E (Njoku et al, 2003)**
- ✓ **USDA AMSR-E (Jackson et al, 2007)**
- ✓ **VUA AMSR-E (Owe et al, 2008)**
- ✓ **USDA WindSat (Jackson et al, 2008)**
- ✓ **NRL WindSat (Li et al, 2008)**
- ✓ **ESA SMOS (Kerr et al, 2005)**
- ✓ **EUMETSAT/VUT ASCAT (Wager et al, 2013)**
- ✓ **.....**

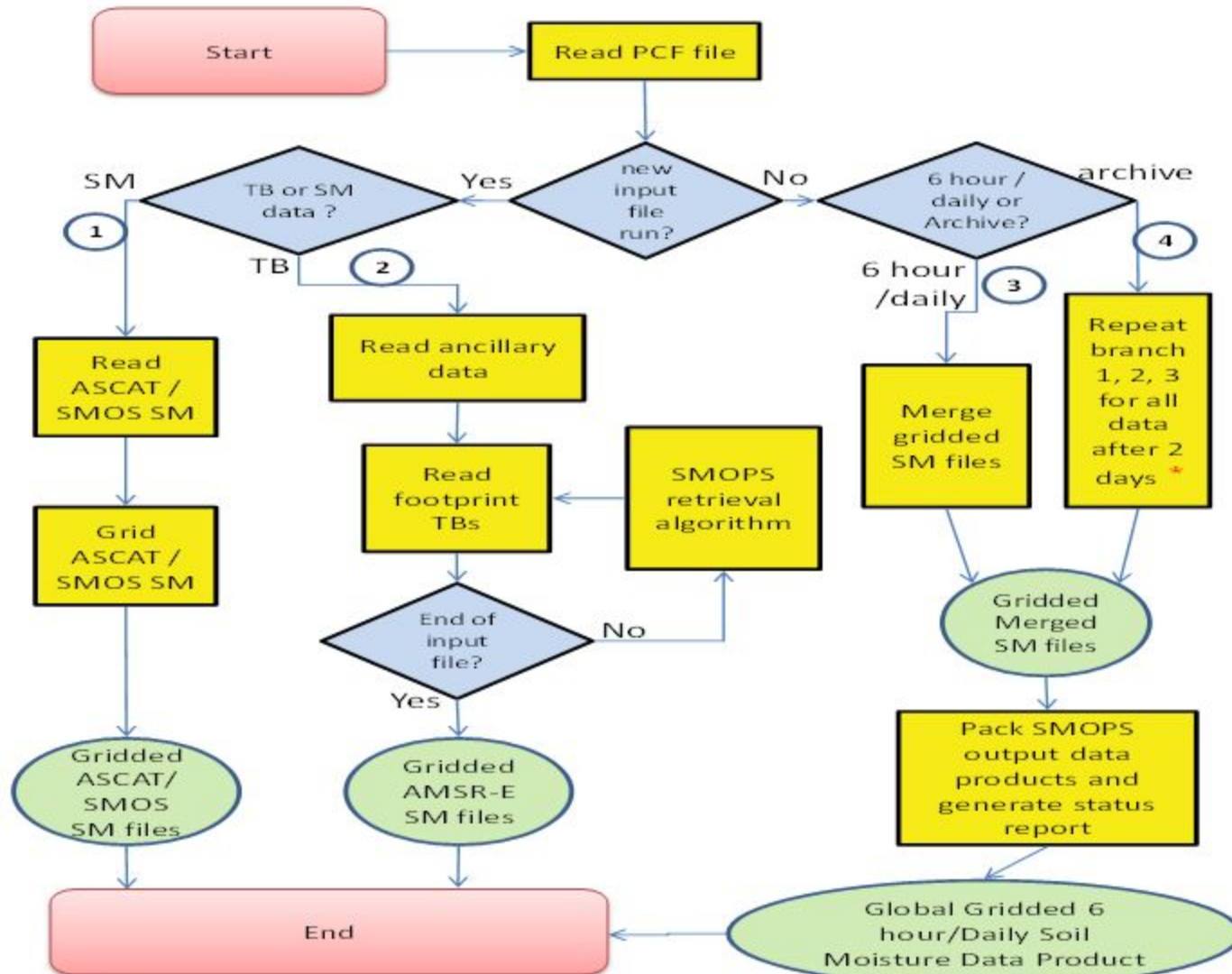
# Why SM data are not used in NWP yet?

- ❖ *Data not conveniently available to users*
- ❖ *Users not confident in data impact*
- ❖ *Data assimilation utilities not ready/tested*

# Objectives

- ❖ *Build SMOPS for NCEP NWP models*
- ❖ *Build a SM DA utility for NCEP GFS*
- ❖ *Test the SM DA utility*

# Soil Moisture Operational Product System (SMOPS)

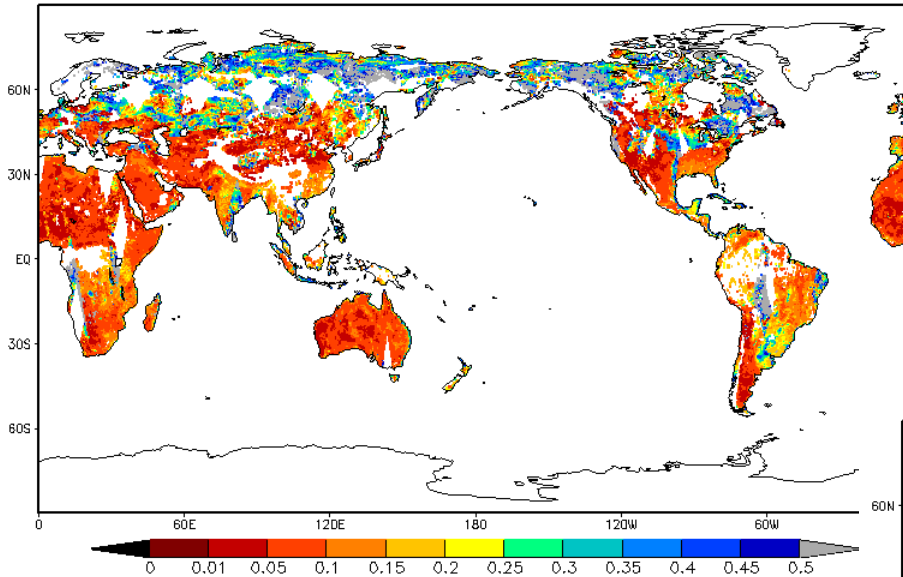


\* All data acquired within the 6 hour or whole day time period arrived in the past 48 hours

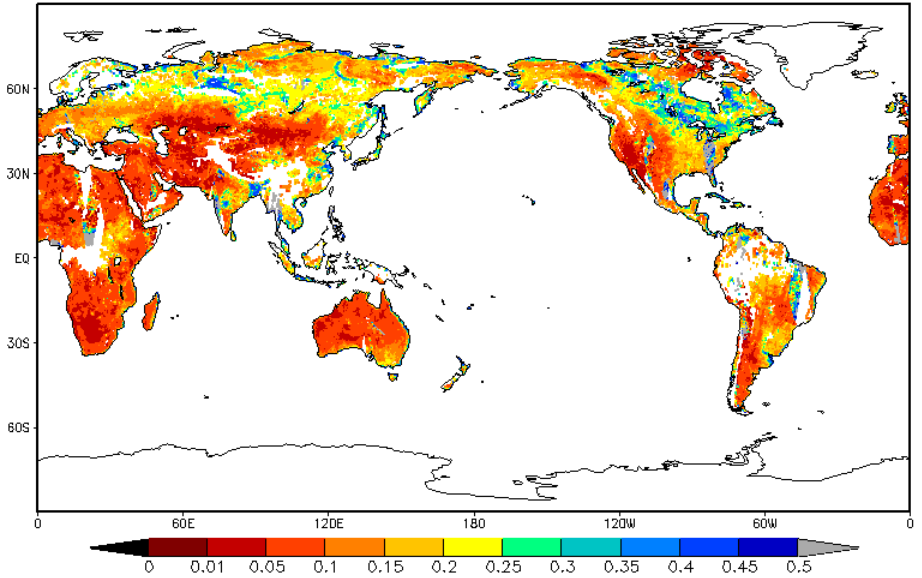


# Microwave Soil Moisture Products from SMOPs

mrg1asae 20100112



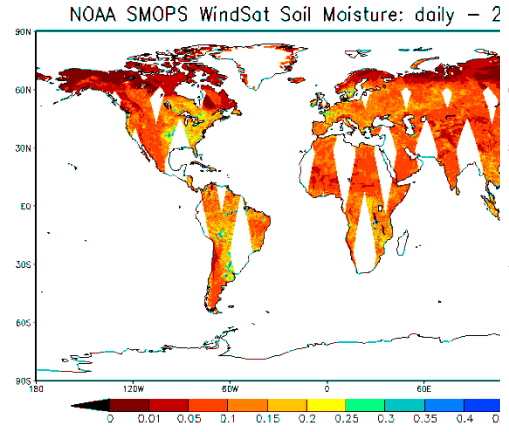
mrg1asae 20100701



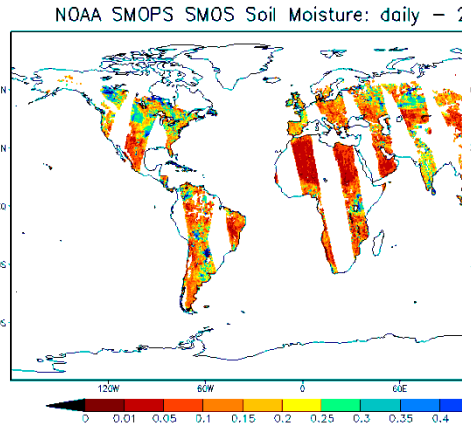
- ❖ Increased spatial coverage
- ❖ Multi retrieval variance could be used as error estimate

# Microwave Soil Moisture Products from SMOPS

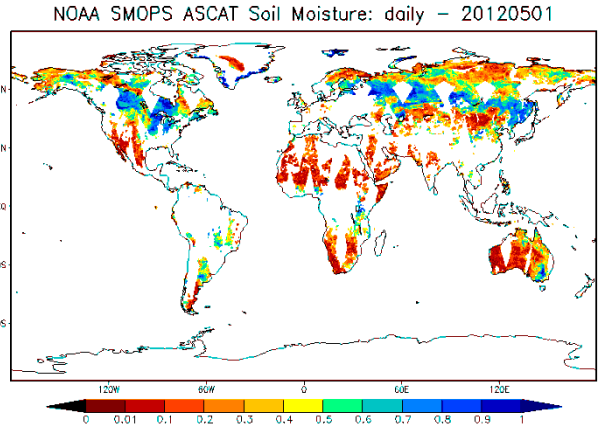
*WindSat*



*SMOS*

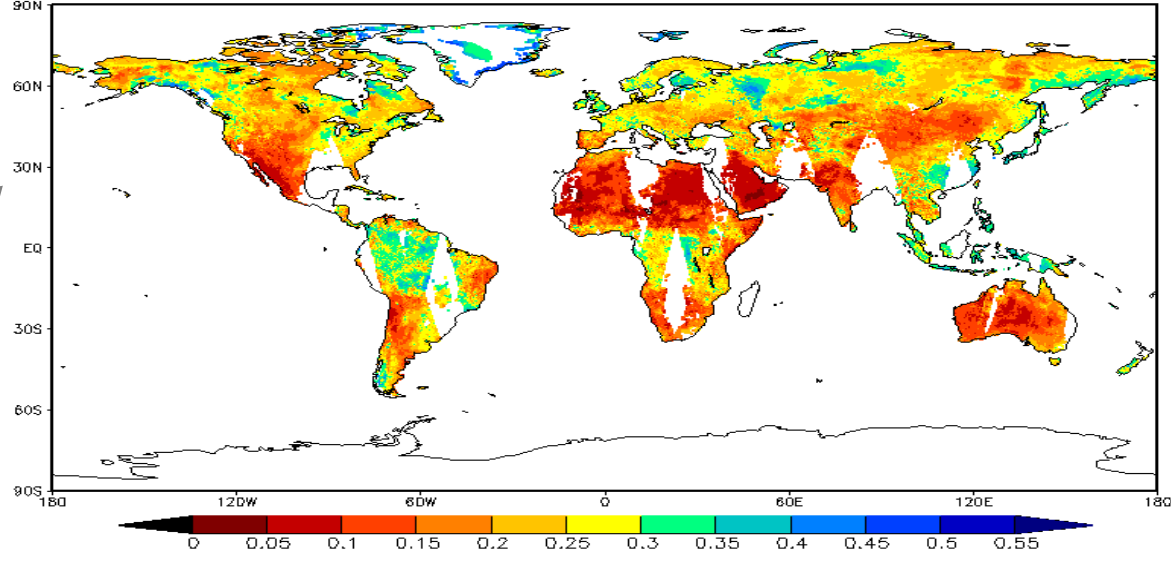


*ASCAT*

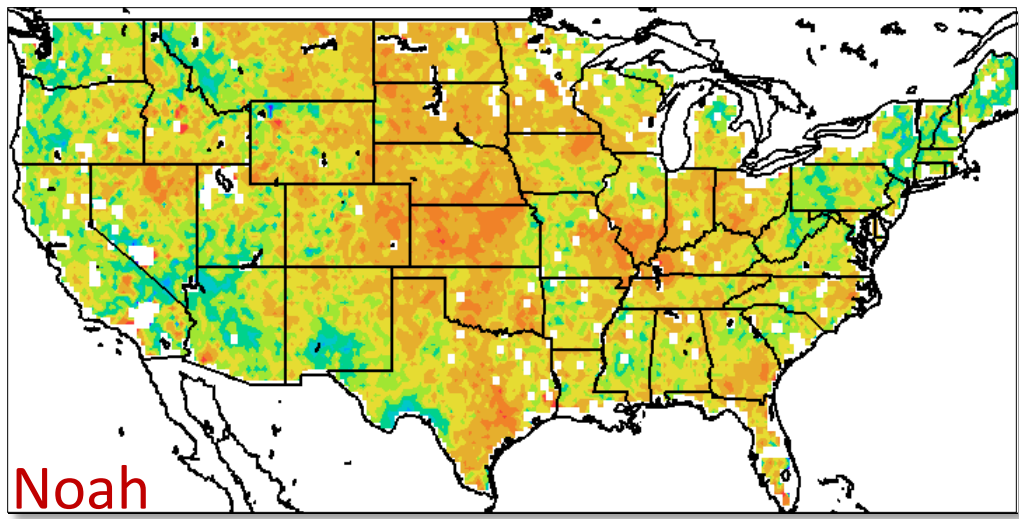


NOAA SMOPS Blended Soil Moisture: daily - 20120501

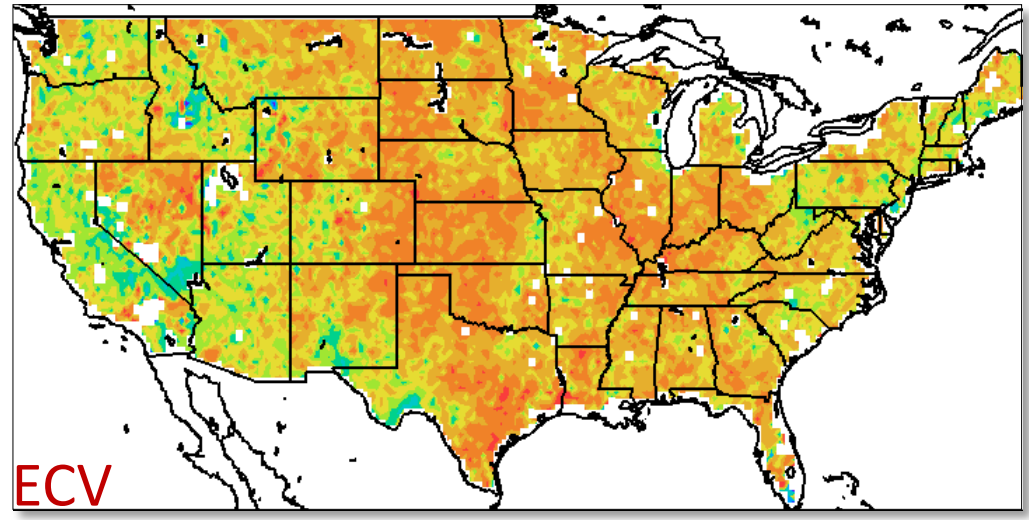
*Blended*



# Microwave Soil Moisture Products from SMOPS



SMOPS SM correlation with other SM products (2007-2010)





[Soil Moisture Home](#) > [Daily Maps](#)

## Soil Moisture Daily Maps

To display maps, please select a data type, region, year, month, and date, and then click 'Refresh'.

Use the '<' and '>' buttons to step ahead or backward through the images. Soil moisture is expressed in Volumetric Soil Moisture Content [ $m^3$  water/ $m^3$  soil] (see [Documents](#) for details).

<b>Data type</b> NOAA-AMSR-E	<b>Region</b> Global	<b>Year</b> < 2004 >	<b>Month</b> < 7 >	<b>Day</b> < 1 >	<input type="button" value="Refresh Map"/>
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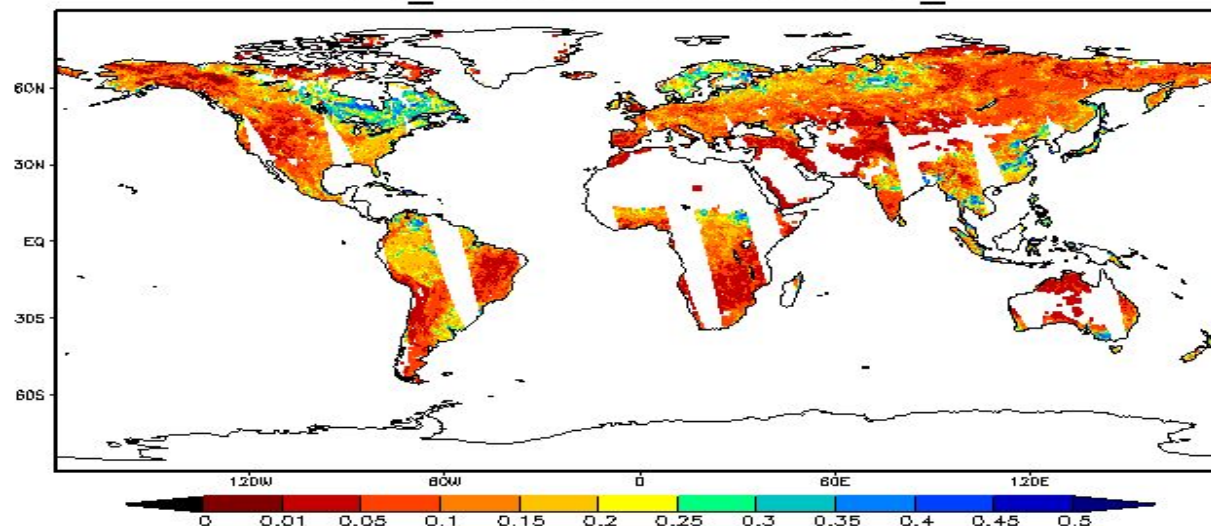
### Regions:

- ▶ Global, North America, South America, Africa, Eurasia, Australasia, Asia, CONUS, China, India, South Africa.

### Data Types:

- ▶ **NOAA-AMSR-E**  
NOAA Soil Moisture from AMSR-E: Land surface soil moisture retrieved from AMSR-E X-band brightness temperature (TB10H) observations using the Single-Channel-Retrieval (SCR) algorithm.
- ▶ **NOAA-WindSat**  
NOAA Soil Moisture from WindSat: Land surface soil moisture retrieved from Navel Research Lab's (NRL) WindSat X-band brightness temperature (TB10H) observations using the Single-Channel-Retrieval (SCR) algorithm.
- ▶ **NOAA-TMI**  
NOAA Soil Moisture from TMI: Land surface soil moisture retrieved from the X-band brightness temperature

AMSR\_E Soil Moisture 20040701\_A



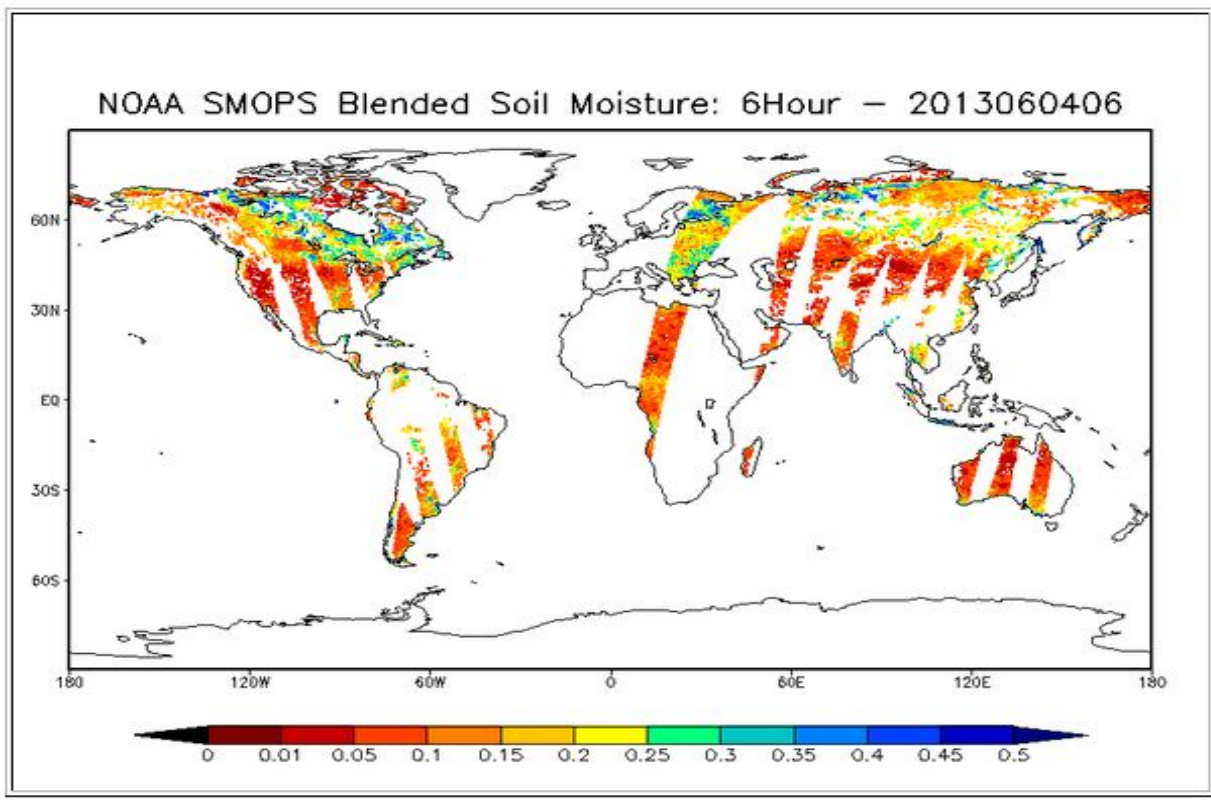




## Soil Moisture Products - 6 Hour

Start Stop | << NOAA\_SMOPS\_Blended\_SoilMoistur >>

Start: May 28 2013 End: Jun 4 2013 Reload



[SMOPS Home](#)

[Algorithm Description](#)

**Satellites/Sensors:**

[ASCAT](#) | [SMOS](#) | [WindSat](#) | [AMSR-E](#)

**Product Animation:**

[Daily](#) | [6-hourly](#)

**Validation:**

[In Situ](#) | [Time Series](#)

**Monitoring:**

[Product](#) | [Time Series](#) | [Processing](#) | [Timeliness](#)

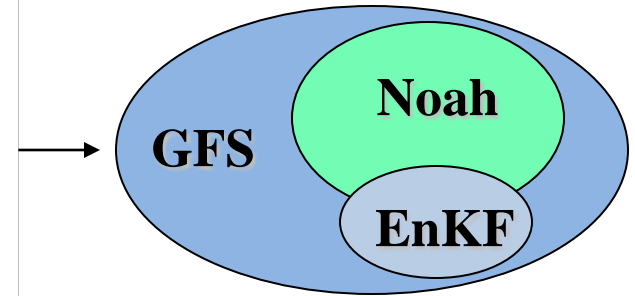
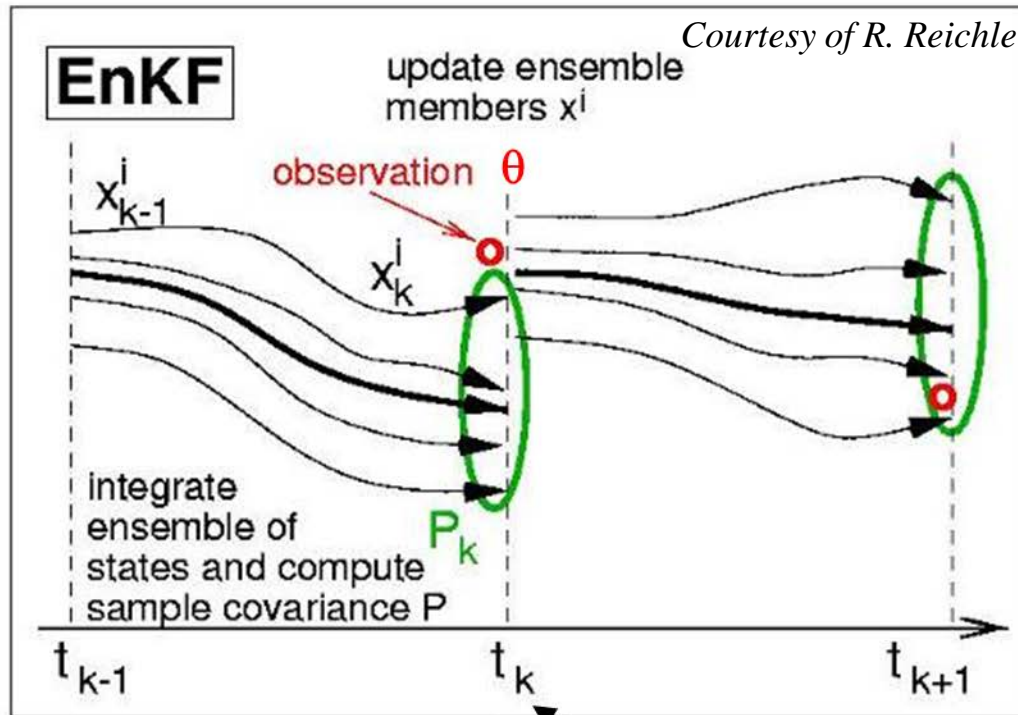
[Test Data](#)

[Documents](#)

[IPT Members](#)

[Links](#)

# SM Data Assimilation Utility for NCEP GFS



Propagation  $t_{k-1}$  to  $t_k$ :

$$x_k^{i+} = f(x_{k-1}^{i-}) + w_k^i$$

$w$  = model error

For Noah LSM 4 layer SM:

$$x_j^{i+} = x_j^{i-} + (\theta^{i-} - x_j^{i-}) * P_{j1} / (P_{11} + R)$$

No matrix inversion. Scalars only

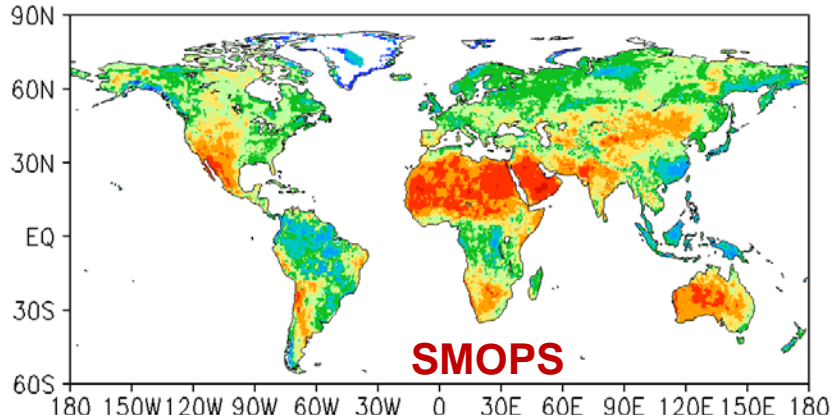
# Assimilation of MW SM into NCEP GFS

- ❖ **Time:** *DA at 00z*  
*from April 1 – May 5, 2012*
- ❖ **Data:** *SMOPS Blended Surface SM*
- ❖ **Method:** *EnKF DA within GFS/GSI*
- ❖ **Experiments:**
  - ❖ **CTL:** *Regular GFS run without SM DA*
  - ❖ **EnKF:** *Daily EnKF run*

# Assimilation of MW SM into NCEP GFS

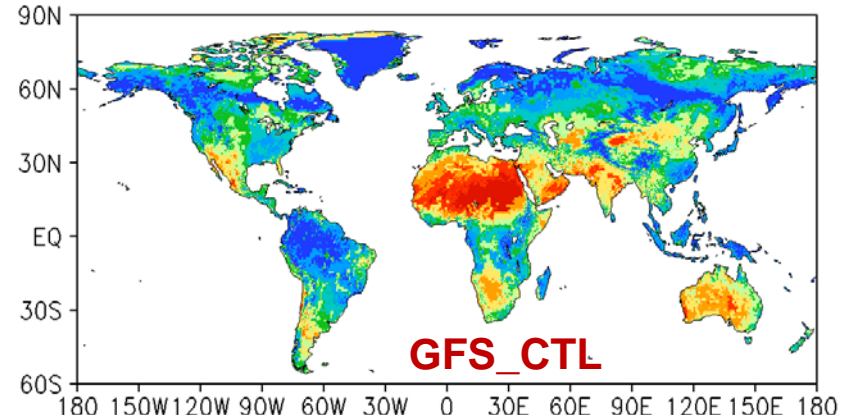
SMOPS\_BL: SOILM (Fraction)

Ave 1-30 April 2012



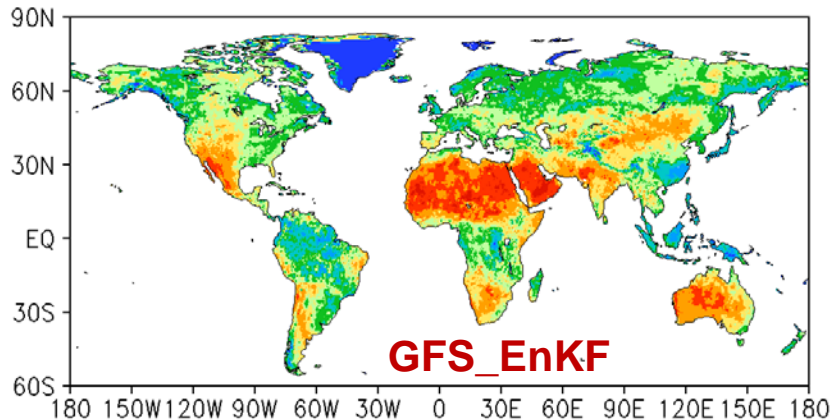
GFS\_CTL: SOILM1 (Fraction)

Ave 1-30 April 2012



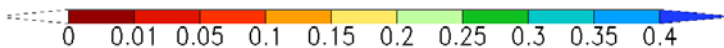
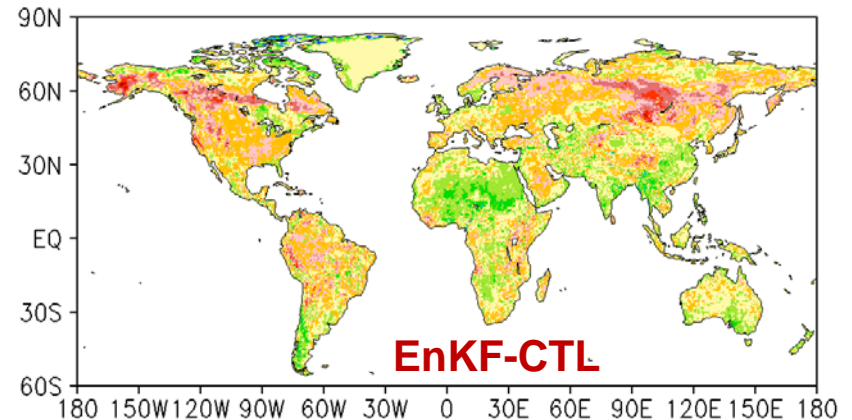
GFS\_EnKF: SOILM1 (Fraction)

Ave 1-30 April 2012



Diff of SOILM1

Ave 18Z, 1-30 April 2012





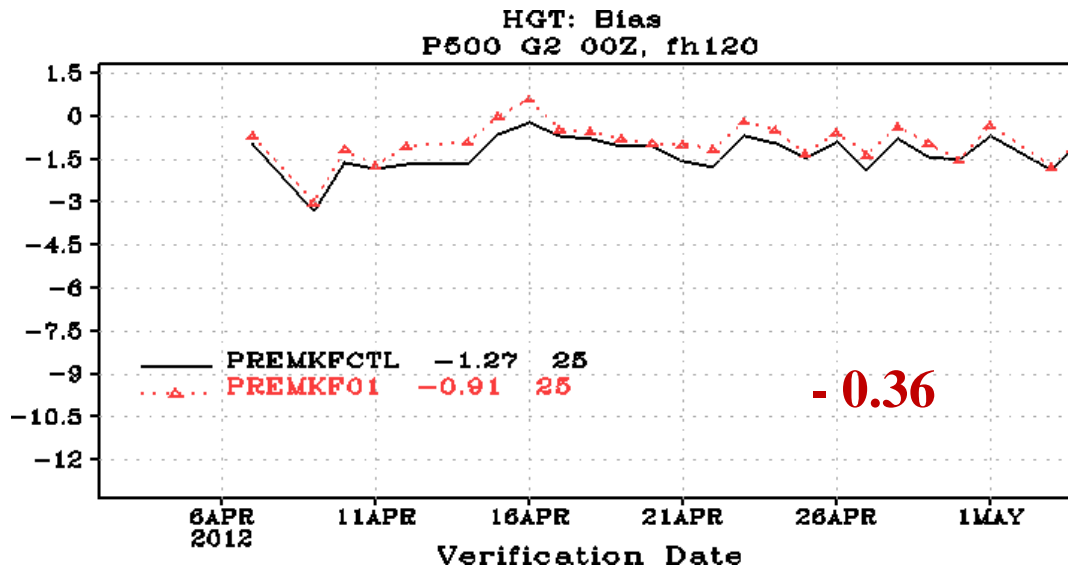
# GFS Soil Moisture Validation

With USDA-SCAN Measurements  
1-30 of April, 2012

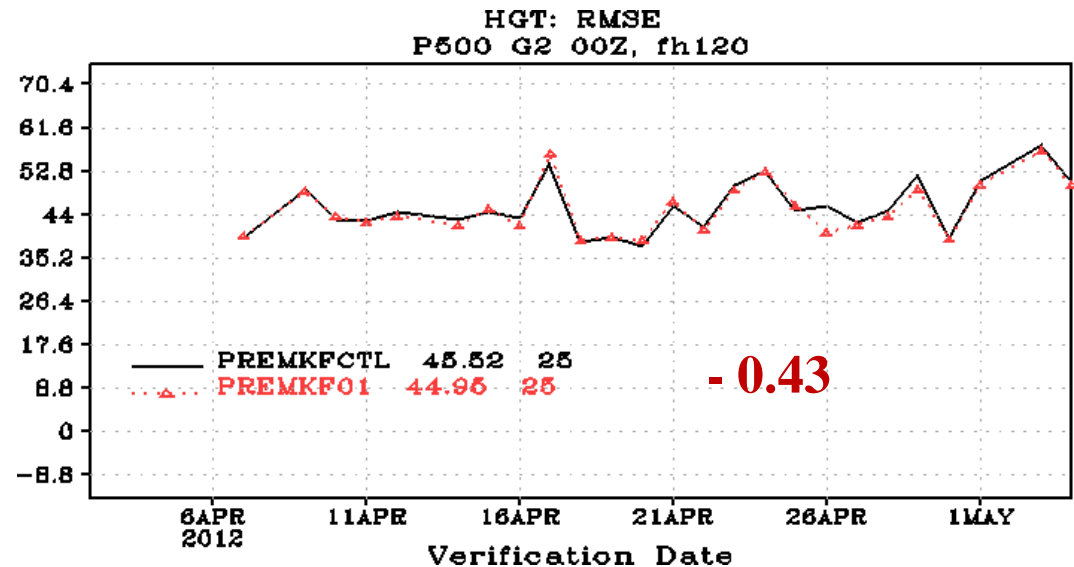
	East CONUS (26 sites)			West CONUS (25 sites)			Whole CONUS		
	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>	<i>RMSE</i>	<i>Bias</i>	<i>Corr-Coef</i>
CTL	0.135	0.046	0.565	0.124	0.033	0.448	0.129	0.040	0.508
EnKF	0.130	-0.031	0.613	0.114	-0.021	0.549	0.123	-0.031	0.587
SMOPS	0.133	-0.055	0.601	0.098	-0.036	0.402	0.117	-0.048	0.524

# GFS SM Data Assimilation Impact

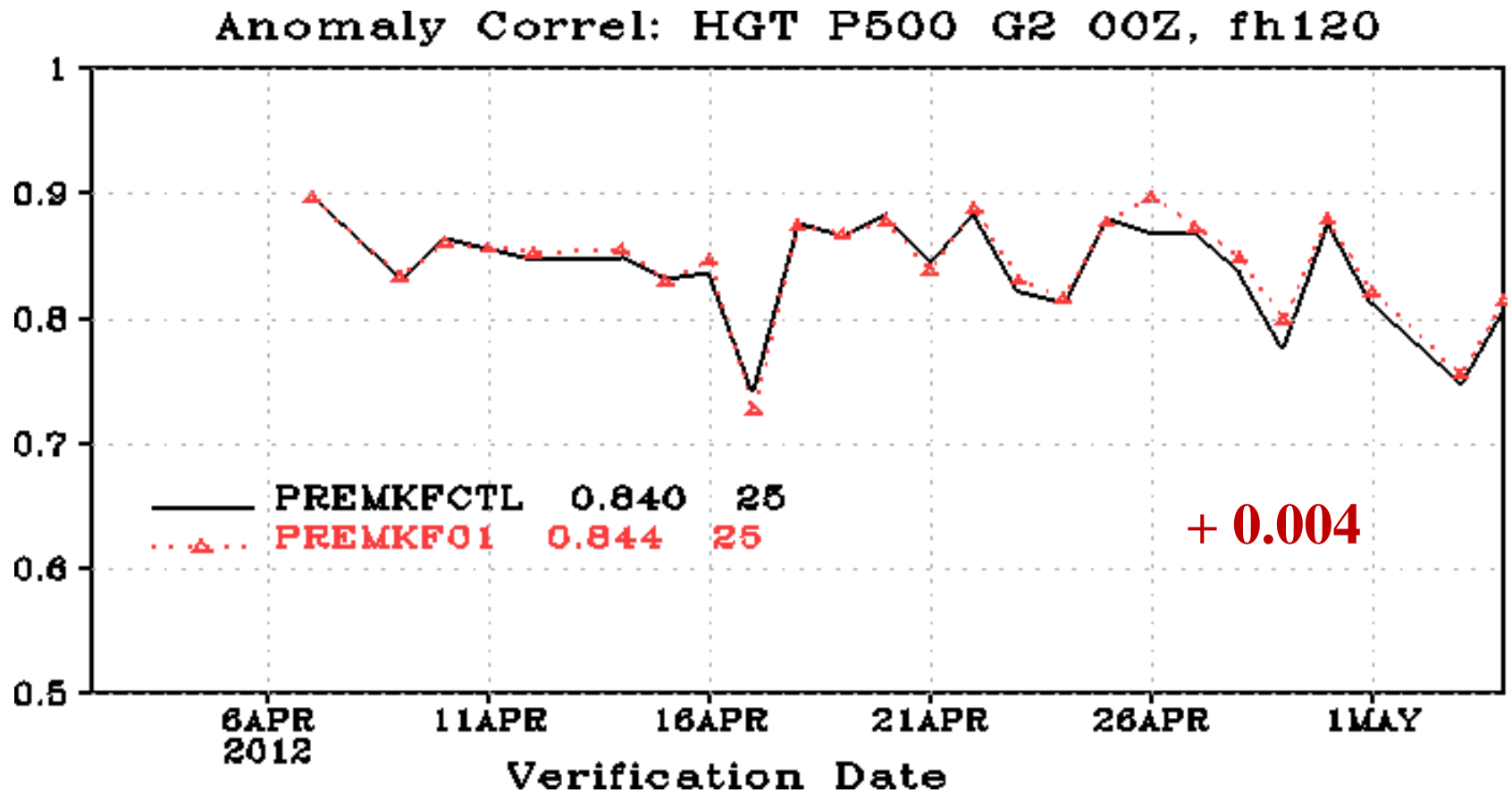
Bias



RMSE



# GFS SM Data Assimilation Impact



# SUMMARY

- ❖ *Many satellite land data products are available, but not used yet for NWP model assimilation*
- ❖ *NESDIS SMOPS is built to serve NCEP SM data assimilation needs*
- ❖ *An EnKF utility is built in NCEP GFS for SM DA*
- ❖ *GFS forecasts are improved by assimilating SMOPS daily soil moisture products*
- ❖ *More test and evaluation are needed*

**Thanks .....**

