NESDIS Satellite Land Data Products for NCEP NWP and Drought Monitoring

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OUTLINE

- ***Satellite Soil Moisture Data Products***
- ***SM Data Assimilation for Drought Monitoring***
- ***SM Data Assimilation for NCEP NWPs***
- ***Future Data Assimilation Plan***

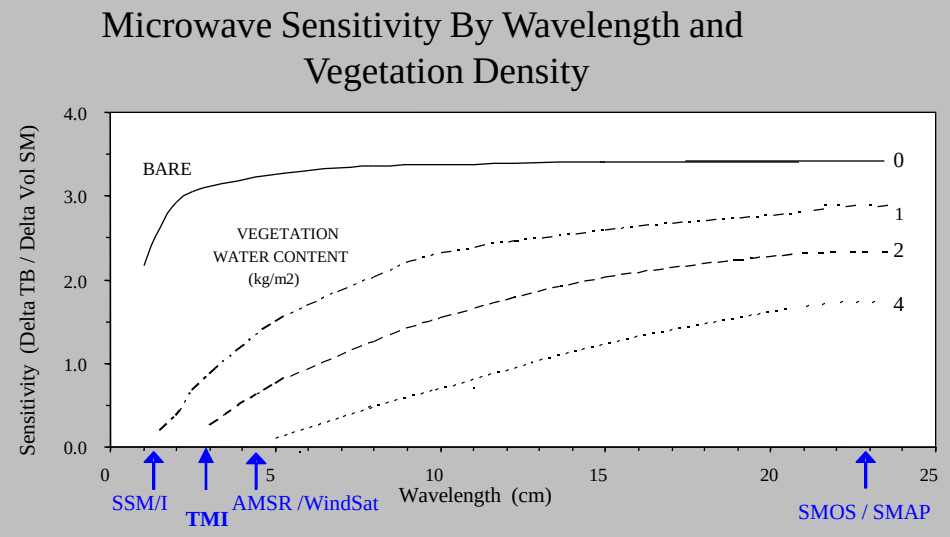
NESDIS Satellite Land Data Products

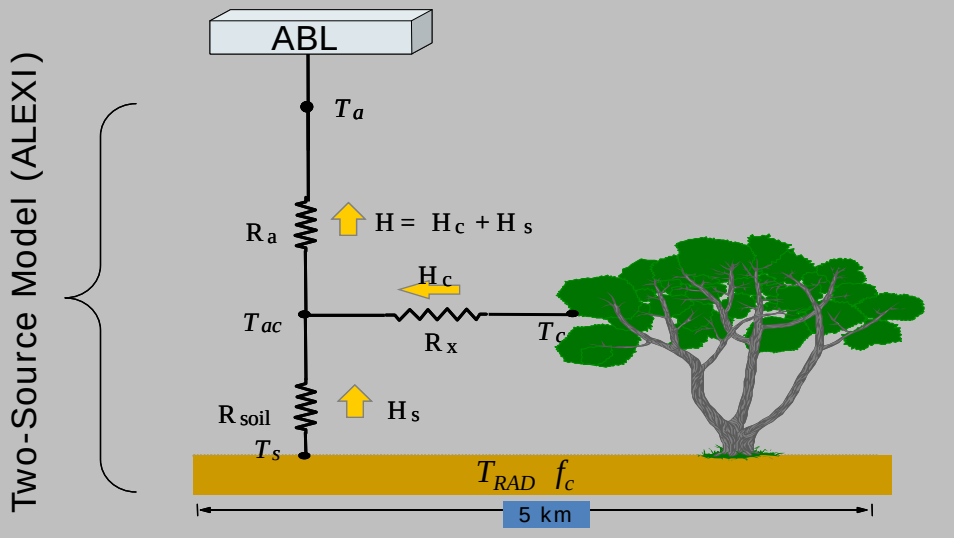
Name	Satellite/Sensor/System
Albedo	NOAA, MetOp, NPP/JPSS, GOES/GOES-R
Fire	NOAA, MetOp, NPP/JPSS, GOES/GOES-R
LST	NOAA, MetOp, NPP/JPSS, GOES/GOES-R
NDVI/GVF	NOAA, MetOp, NPP/JPSS, GOES/GOES-R
Sfc Emissivity	MSPPS/MiRS
SM	GOES/GOES-R, GCOM-W1, SMOPS
Snow	AutoSnow, MSPPS/MiRS
SWE	AutoSnow, MSPPS/MiRS

Satellite Soil Moisture Remote Sensing Science

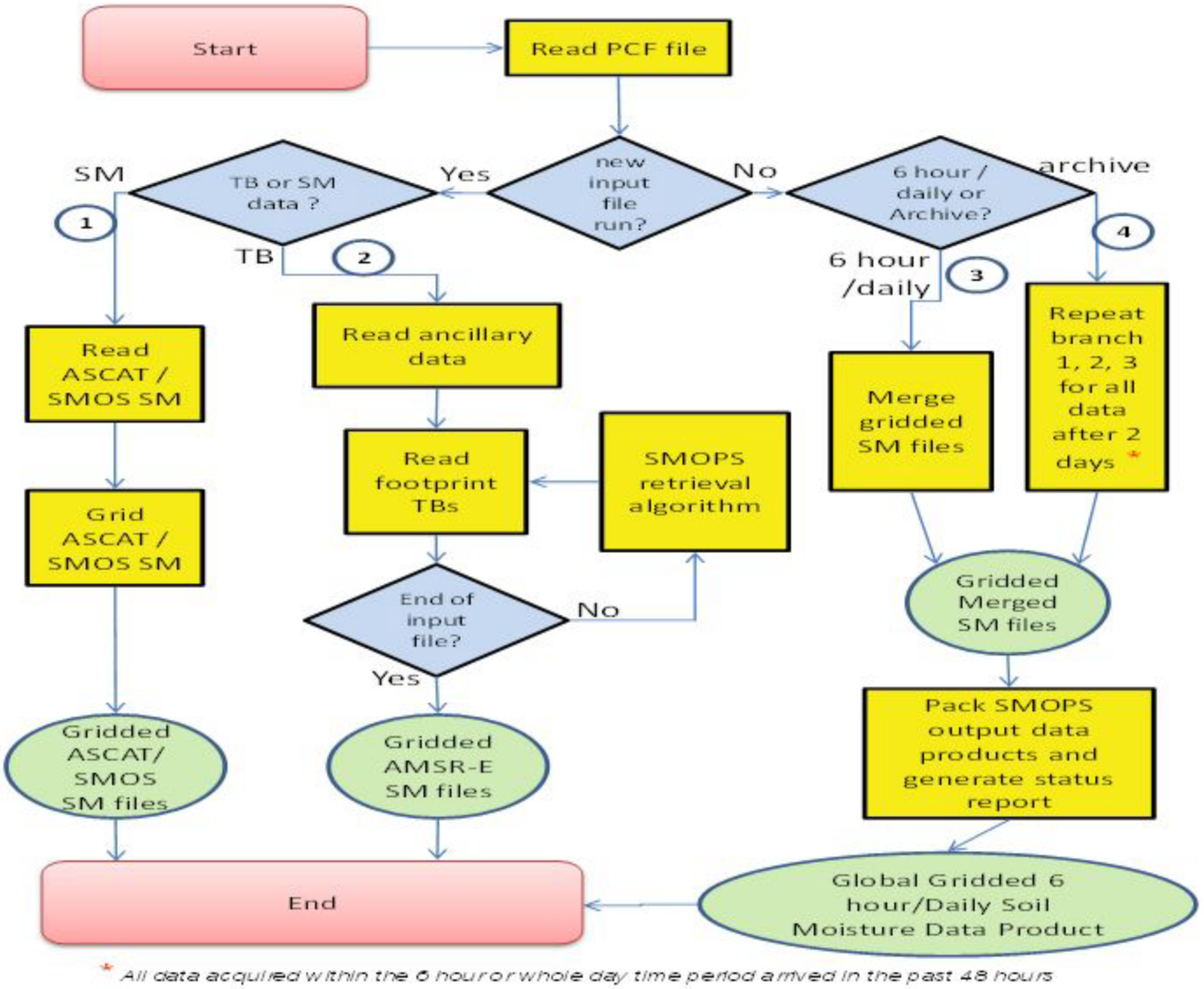
Two ways to retrieve soil moisture from satellites:

- Microwave (MW): Observed MW brightness temperature depends on soil dielectric constant that is related to soil moisture:
  - **Strength:** higher reliability based on direct physical relationships
  - **Weakness:** antenna technology limits spatial resolution
- Thermal Infrared (TIR): Observed surface temperature changes result from surface energy balance that is dependent on soil moisture:
  - **Strength:** TIR sensor could have higher spatial resolution
  - **Weakness:** relies on land surface energy balance model that is prone to input data errors.

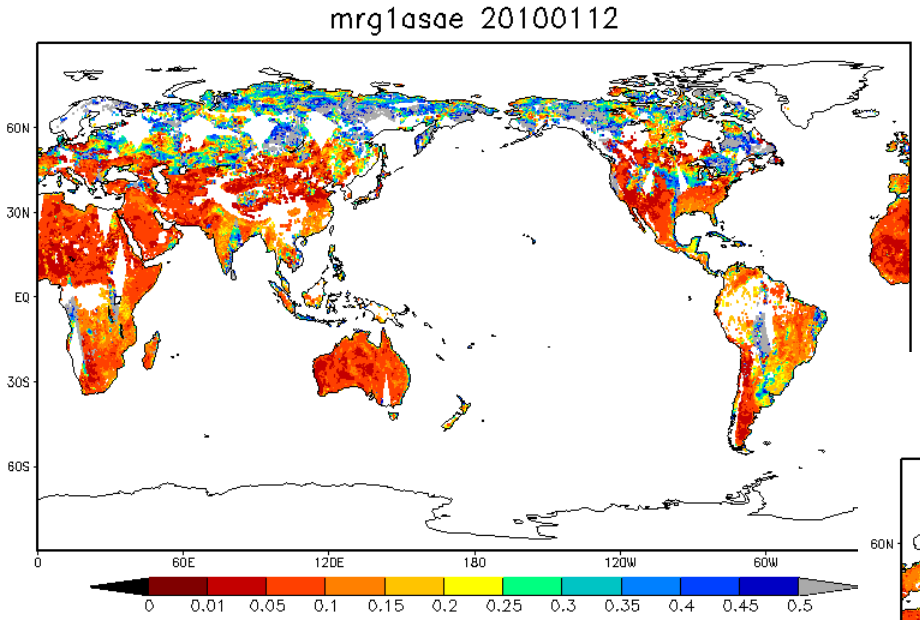


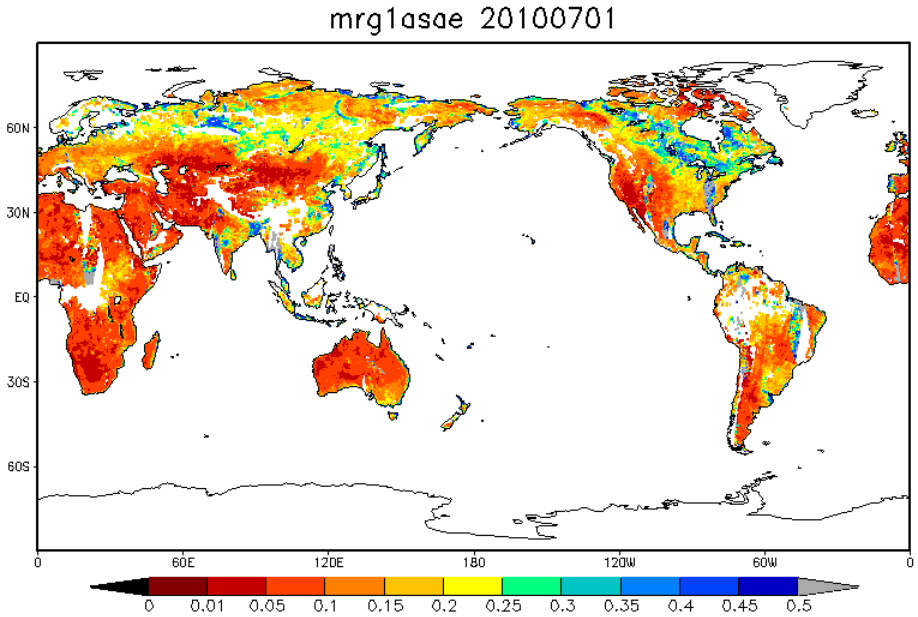


Soil Moisture Operational Product System (SMOPS)



Microwave Soil Moisture Products from SMOPS

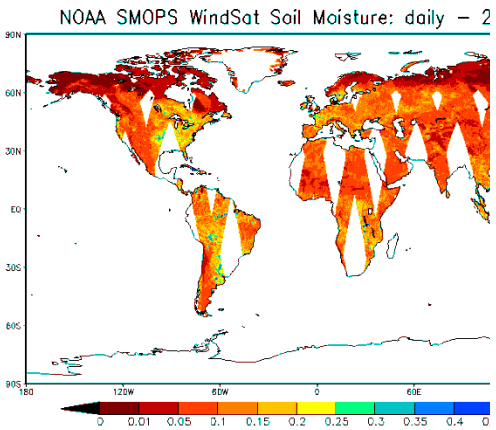




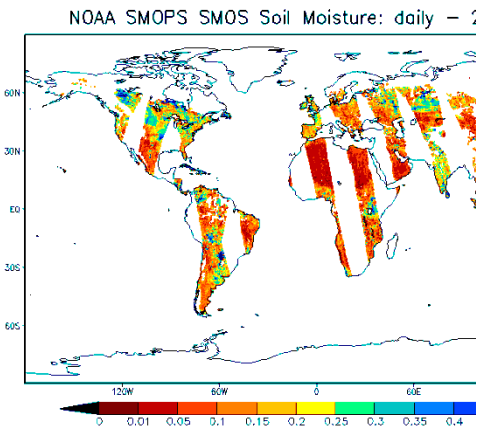
- Increased spatial coverage
- Multi retrieval variance could be used as error estimate

Microwave Soil Moisture Products from SMOPS

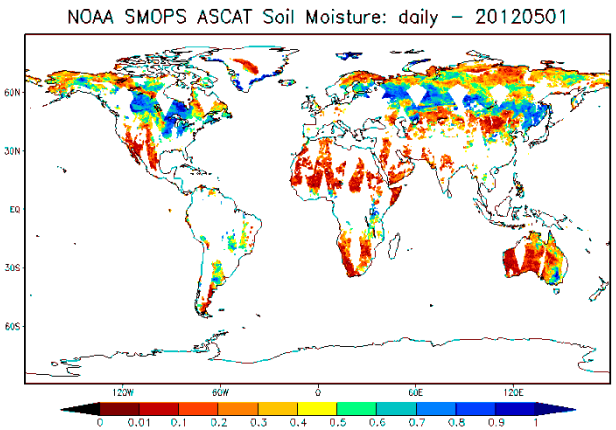
WindSat



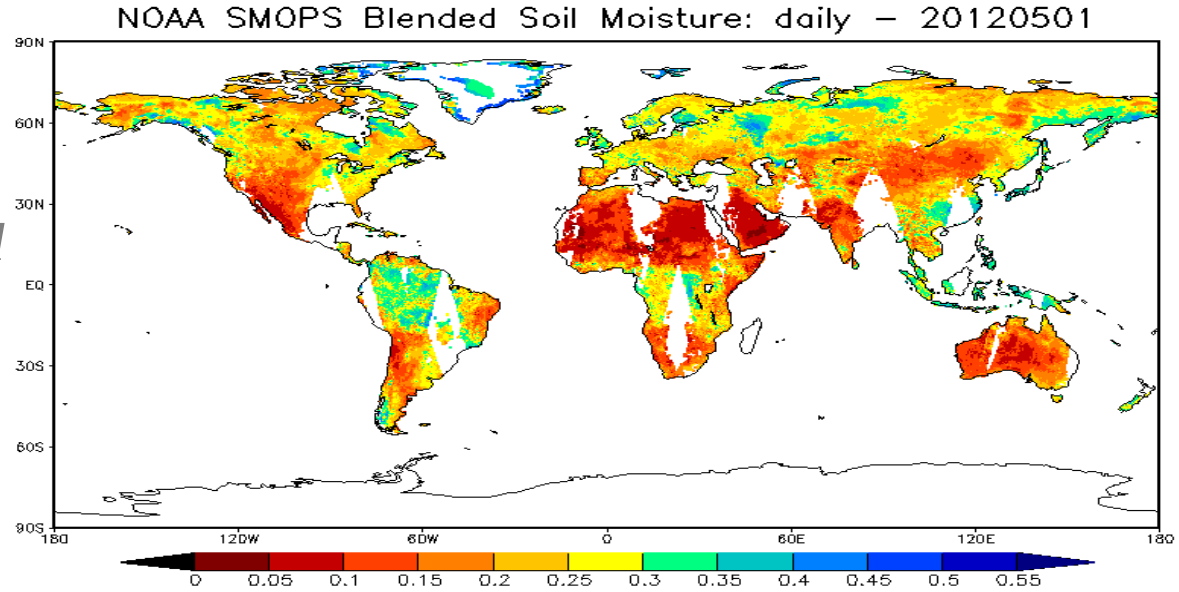
SMOS



ASCAT



Blended



STAR - SMCD - EMB - Soil Moisture Project - Daily Maps - Mozilla Firefox

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http://www.orbit2.nesdis.noaa.gov/smcd/emb/soilmoisture/DailyMaps.php

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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).

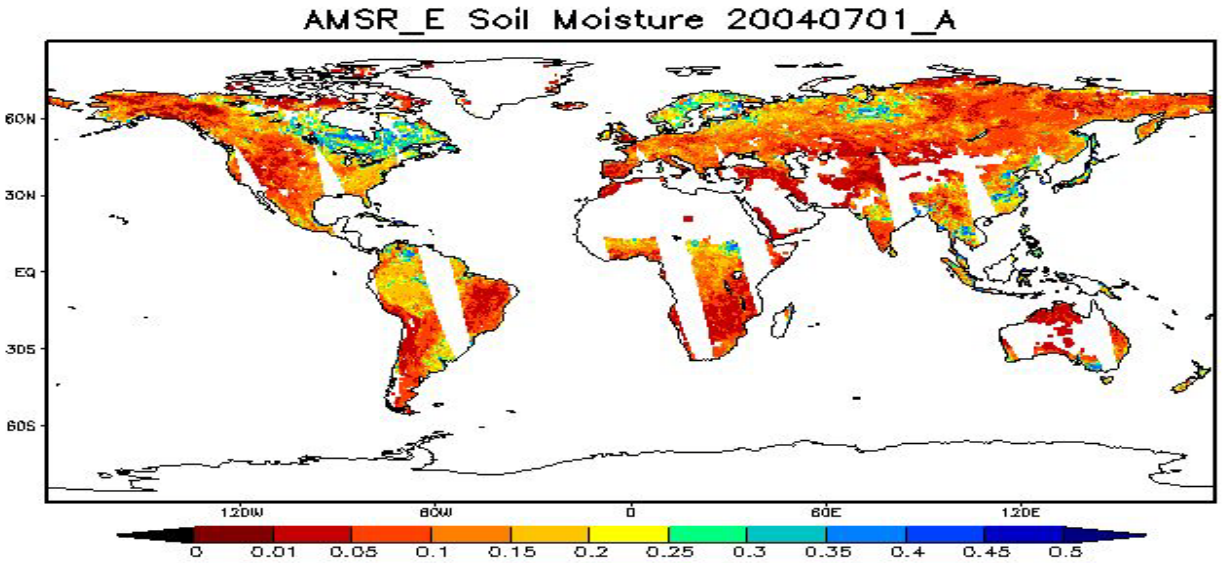
Data type	Region	Year	Month	Day	
NOAA-AMSR-E	Global	< 2004 >	< 7 >	< 1 >	Refresh Map

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

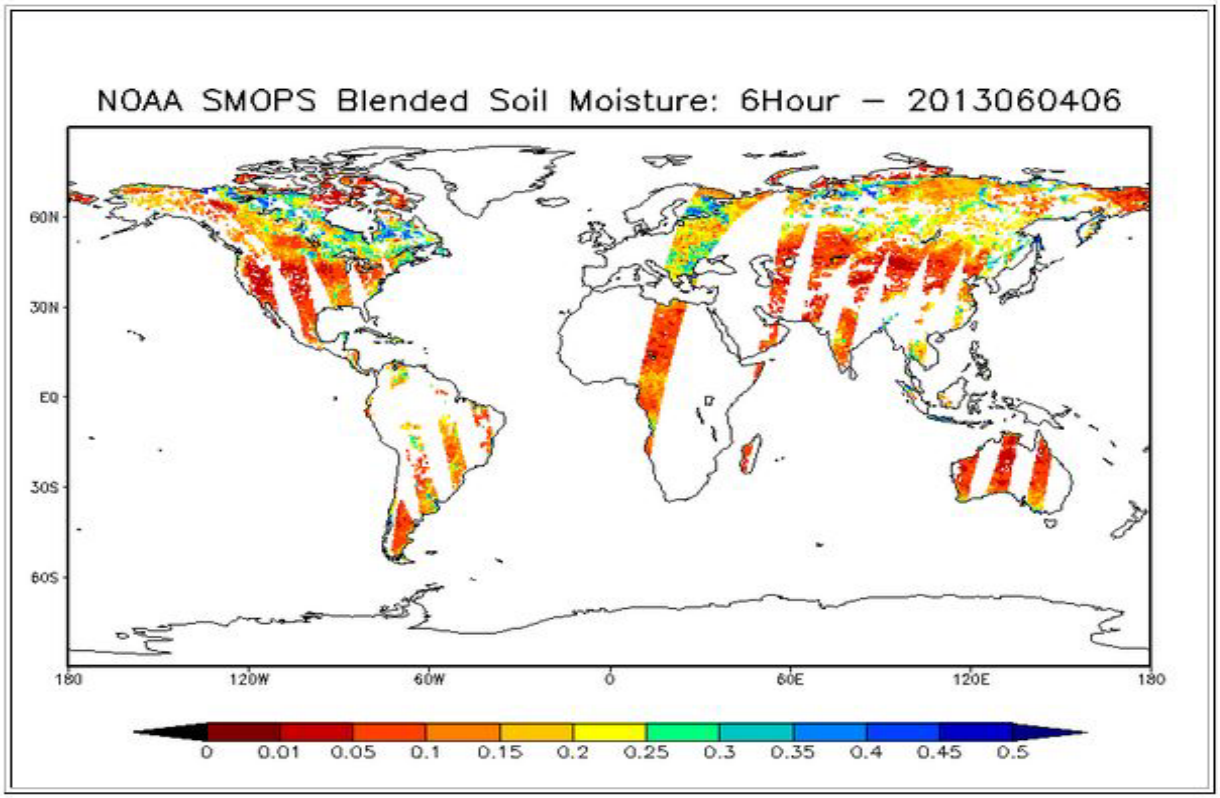


Done

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

Thermal Infrared Remote Sensing for SM

- ***Land surface temperature (LST) and solar insolation (Rs) from NOAA Geostationary Operational Environmental Satellite (GOES) imager and future GOES-R Advance Baseline Imager (ABI) are used in an Atmosphere-Land Exchange Inversion (ALEXI) model to generate ET and an Evaporative Stress Index (ESI) for drought monitoring.***

- ***ALEXI model output using GOES data have good agreement with field observations and full-scale land surface model simulations of ET.***

- ***ALEXI ET and ESI data products are being used at US operational drought monitoring.***

OUTLINE

- ***Satellite Soil Moisture Data Products***
- ***SM Data Assimilation for Drought Monitoring***
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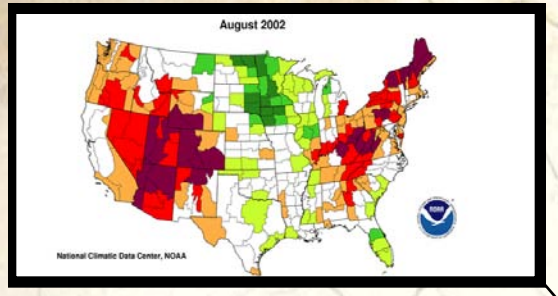
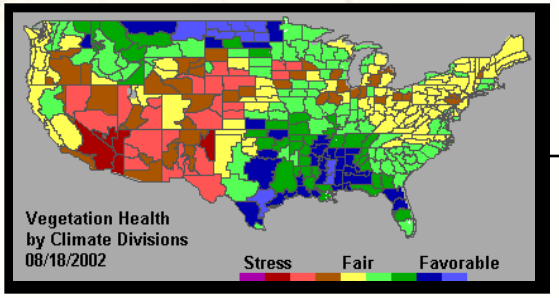
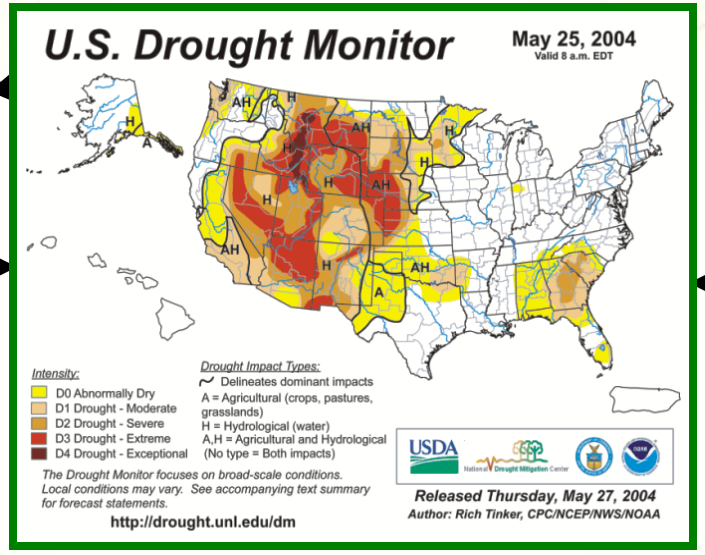
Current US Drought Monitoring

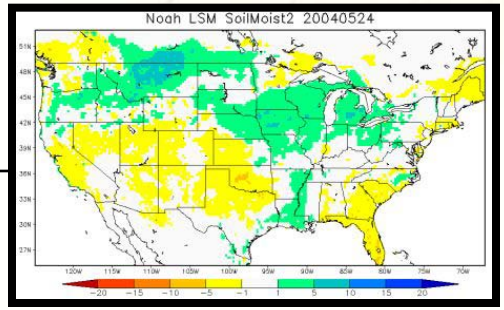


Palmer Drought Index



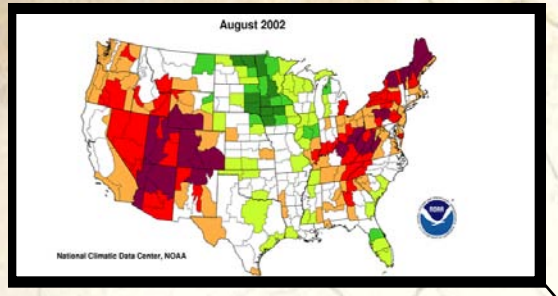
Vegetation Health Index



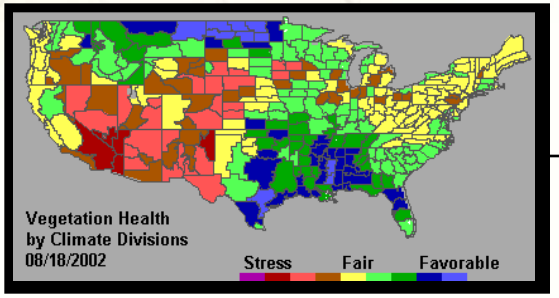


LSM SM Output

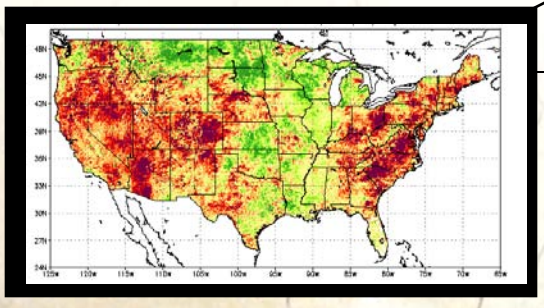
Enhanced Drought Monitoring



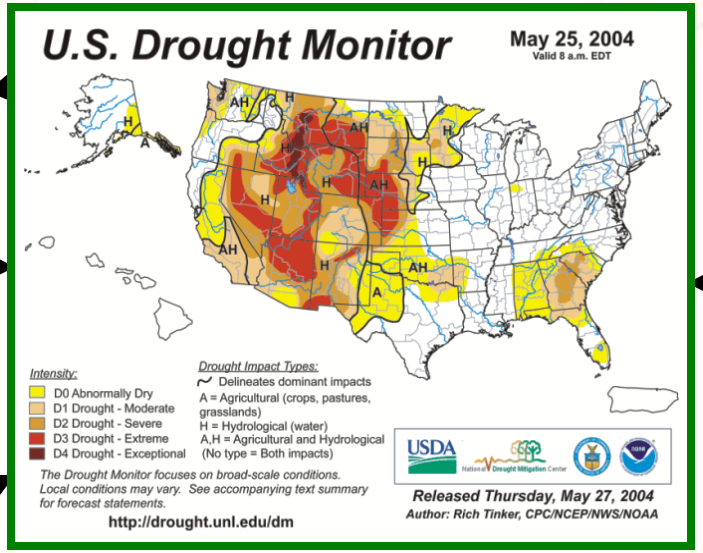
Palmer Drought Index

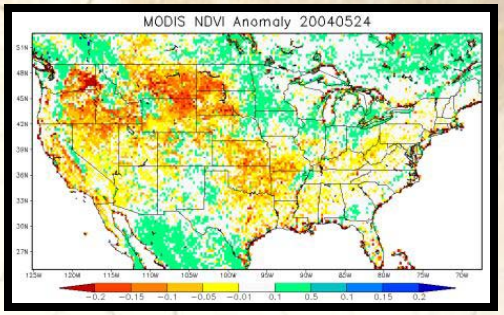


Vegetation Health Index

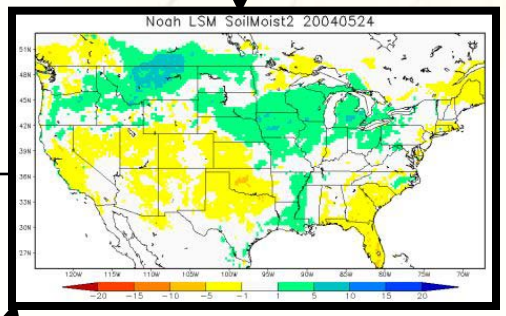


GOES/GOES-R ESI

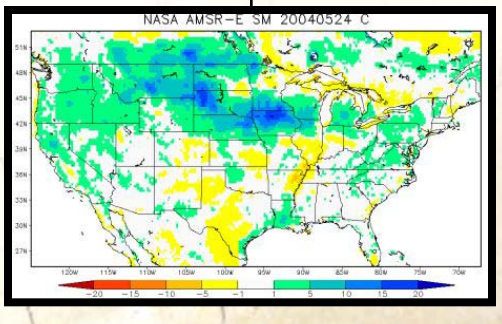




Satellite ST, Alb, GVF/VI

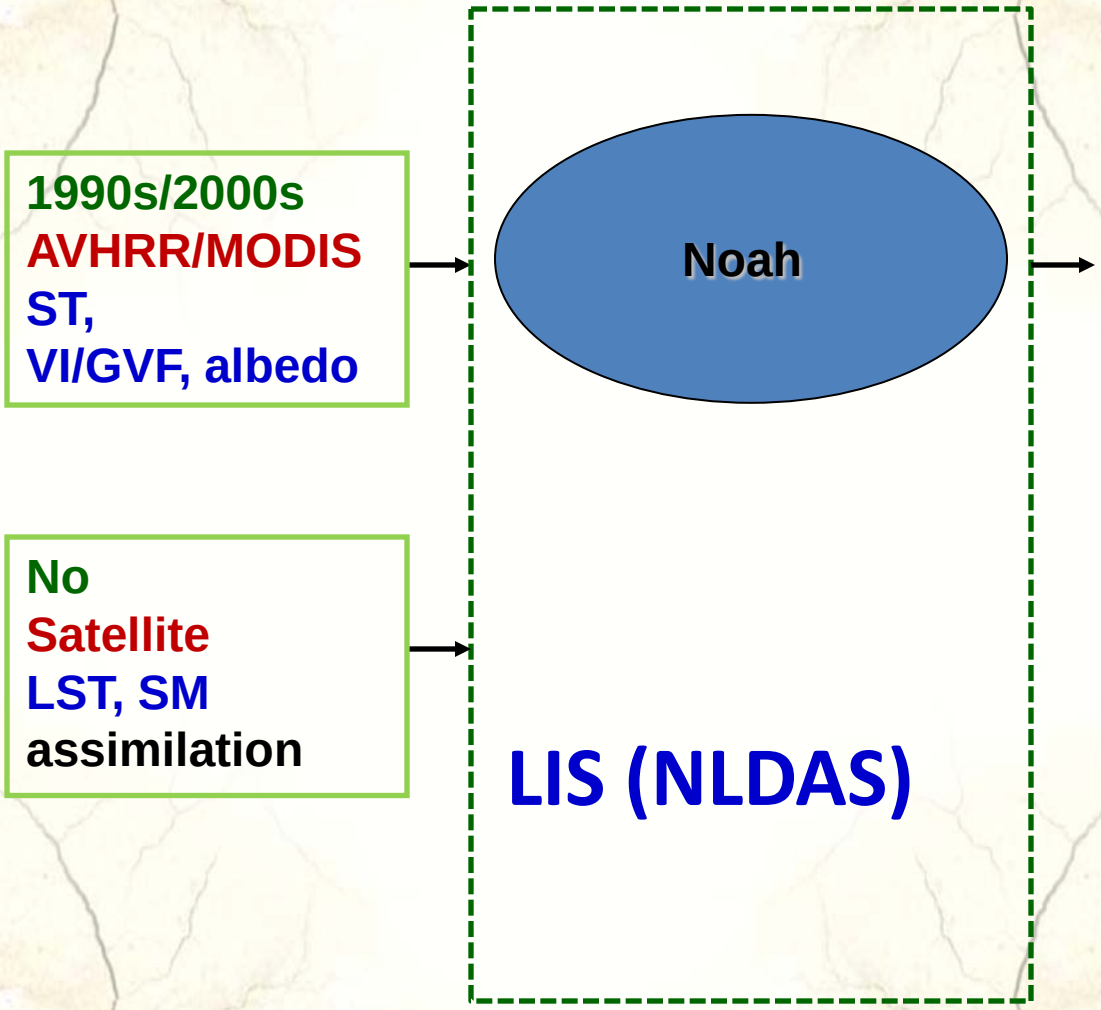


LSM SM Output

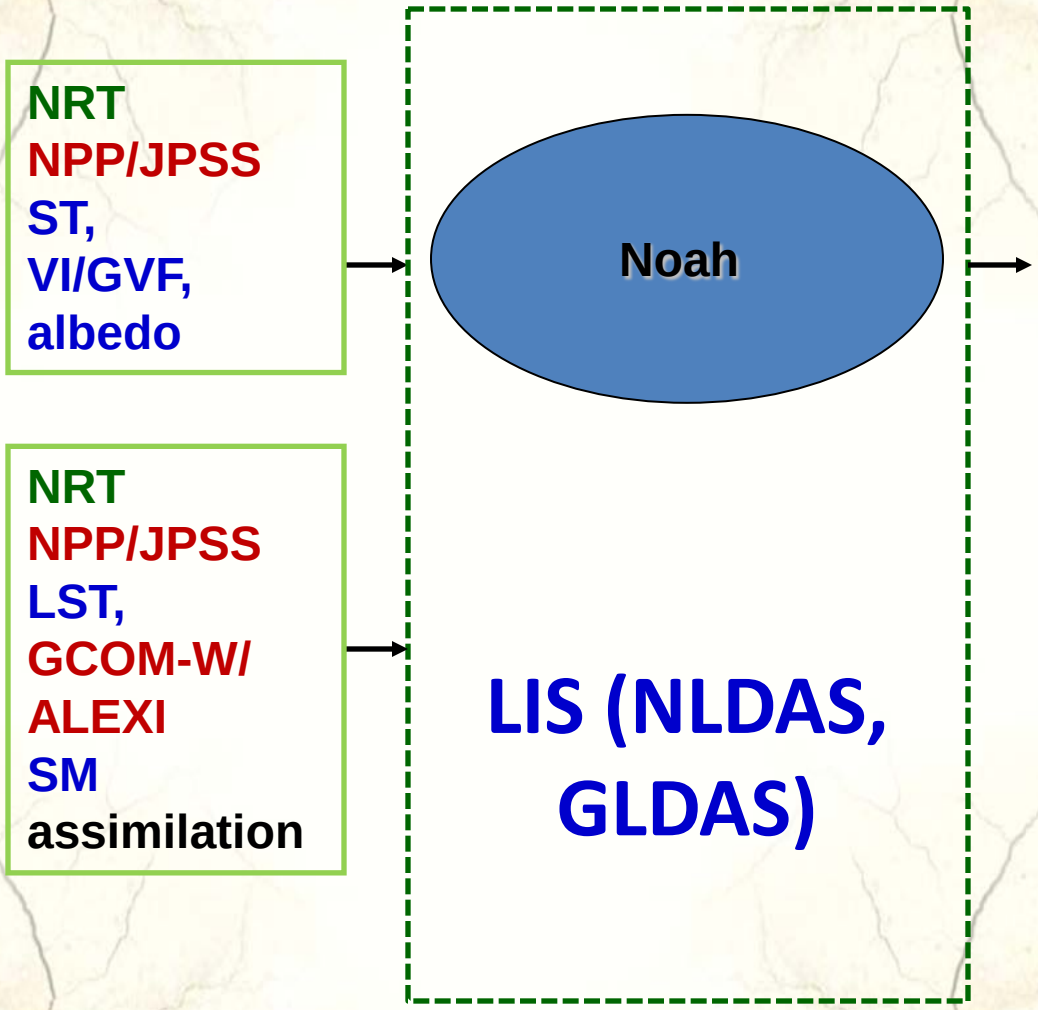


Satellite SM

Current Noah LSM Runs



Enhanced Noah LSM Runs

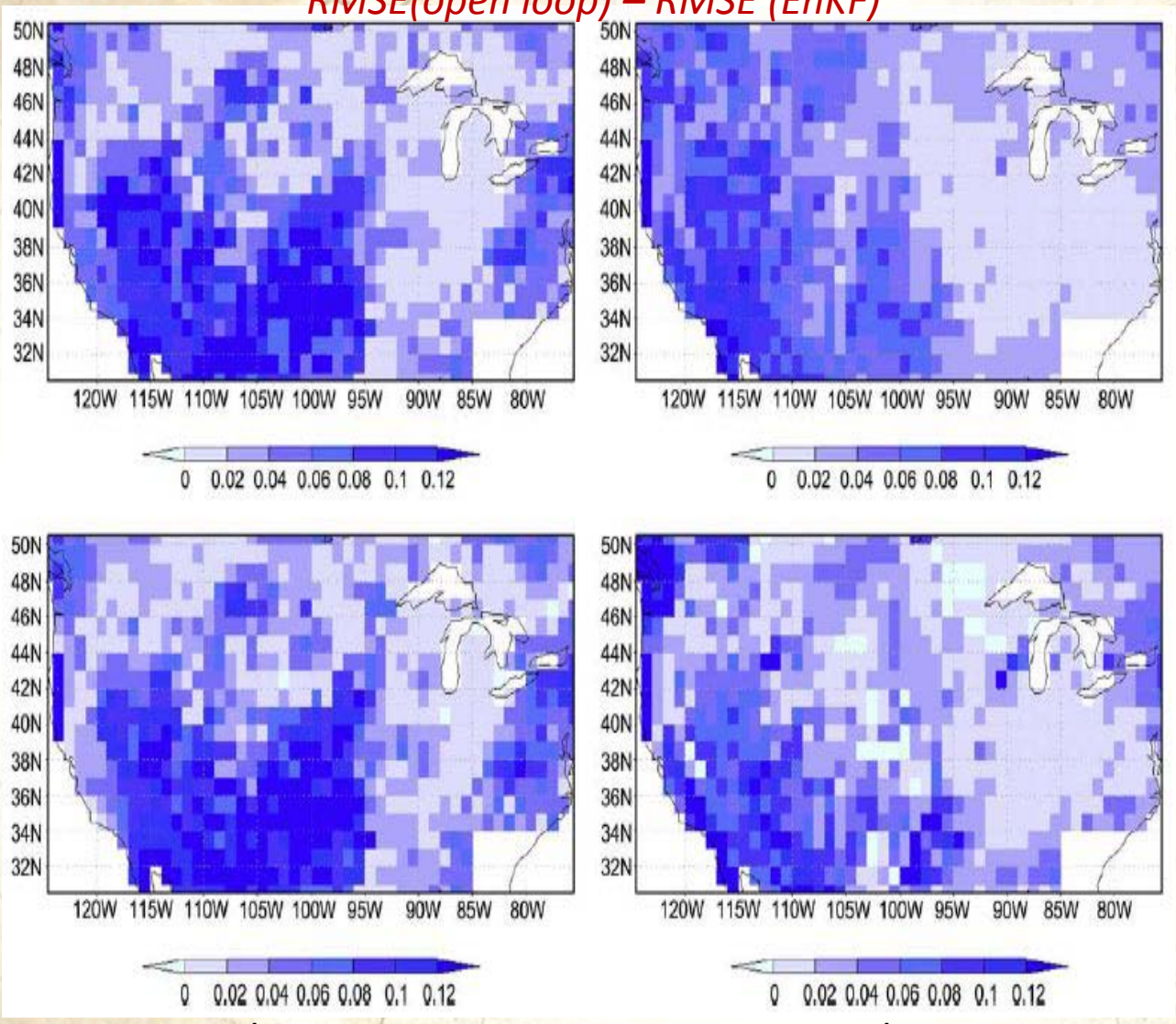


Sat SM DA Improves LSM Runs

RMSE(open loop) – RMSE (EnKF)

Top Layer

Root-zone



Catchment LSM *Noah LSM*

Time averaged improvement metric (RMSE(open loop) – RMSE (EnKF)) for (top) surface soil moisture and (bottom) root zone soil moisture from the (left) Catchment LSM and the (right) Noah LSM assimilation experiments. Units are volumetric soil moisture (m^3/m^3) (Kumar et al 2008)

Dual Assimilation of MW and TIR Sat SM

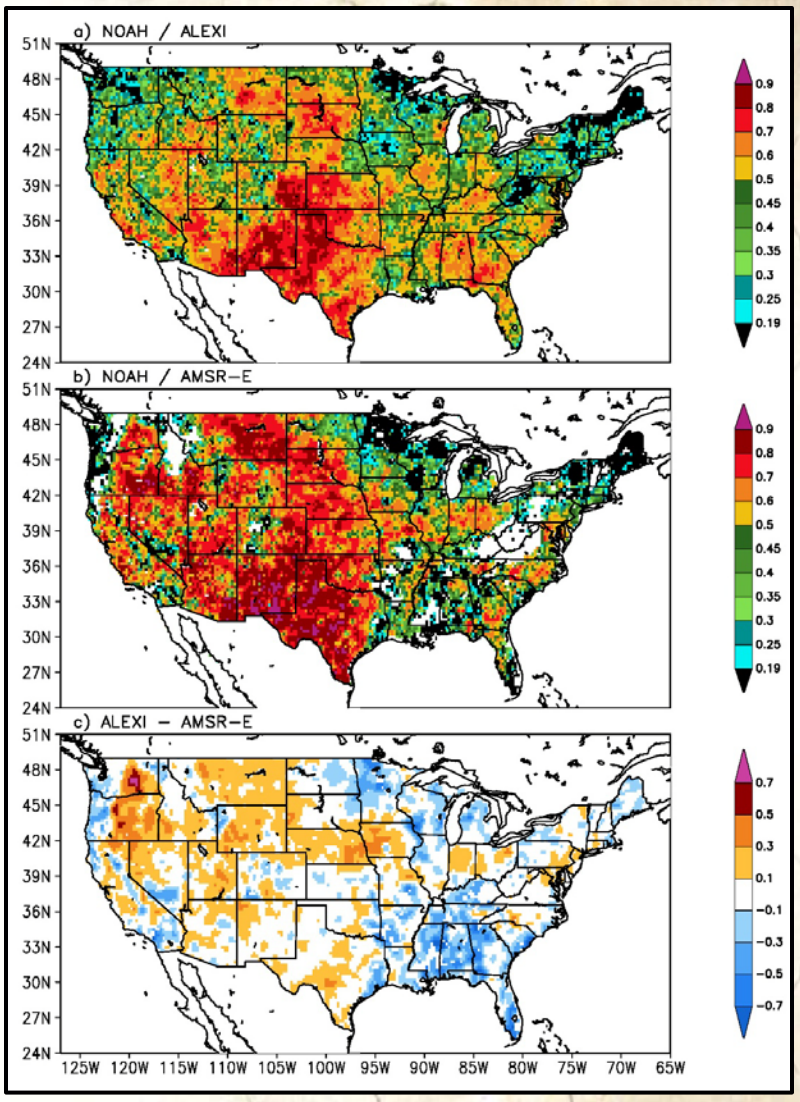
Synergy between TIR and MW Methods

TIR methods provide:

- **Relatively higher spatial resolution (100 m to 10 km)**
- **Potential for SM retrievals over a wider range of vegetation cover**
- **Longer repeat cycles (2 to 7 days, depending on cloud climatology**

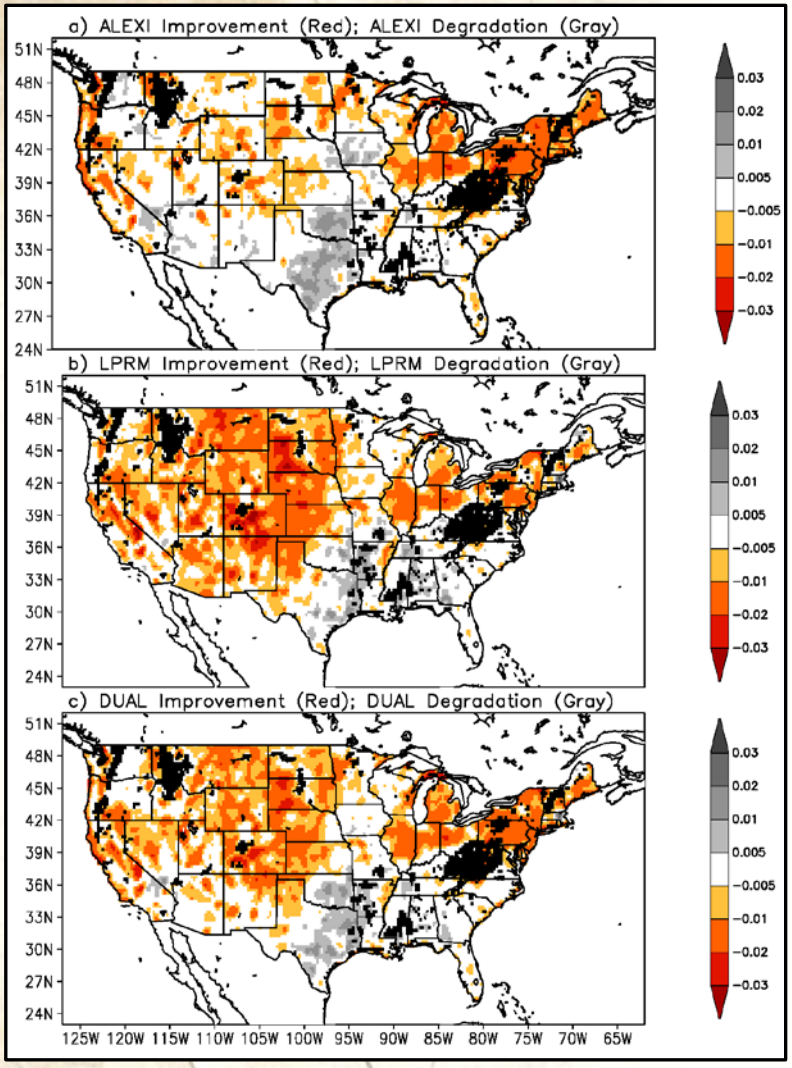
MW methods provide:

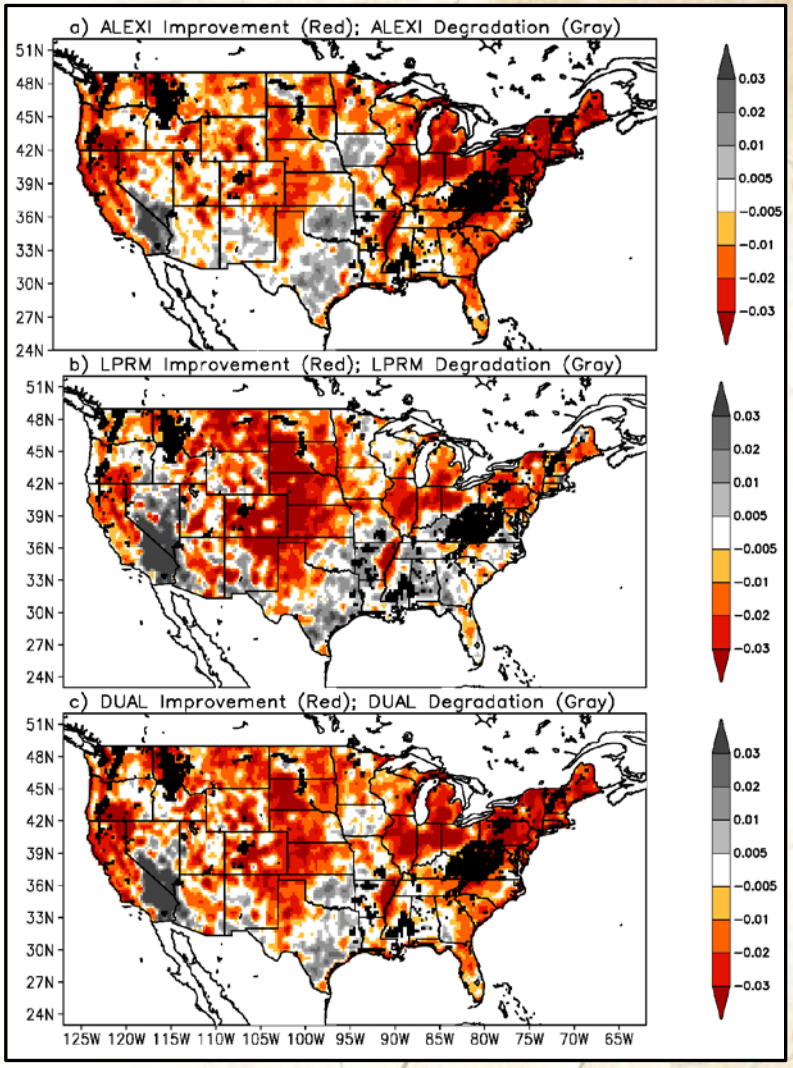
- **Relatively low spatial resolution (25 to 60 km)**
- **High temporal resolution (1 to 2 days)**
- **No retrievals over dense vegetative canopies**



Time Series Anomaly Correlation (2003-2008)

Dual Assimilation of MW and TIR Sat SM



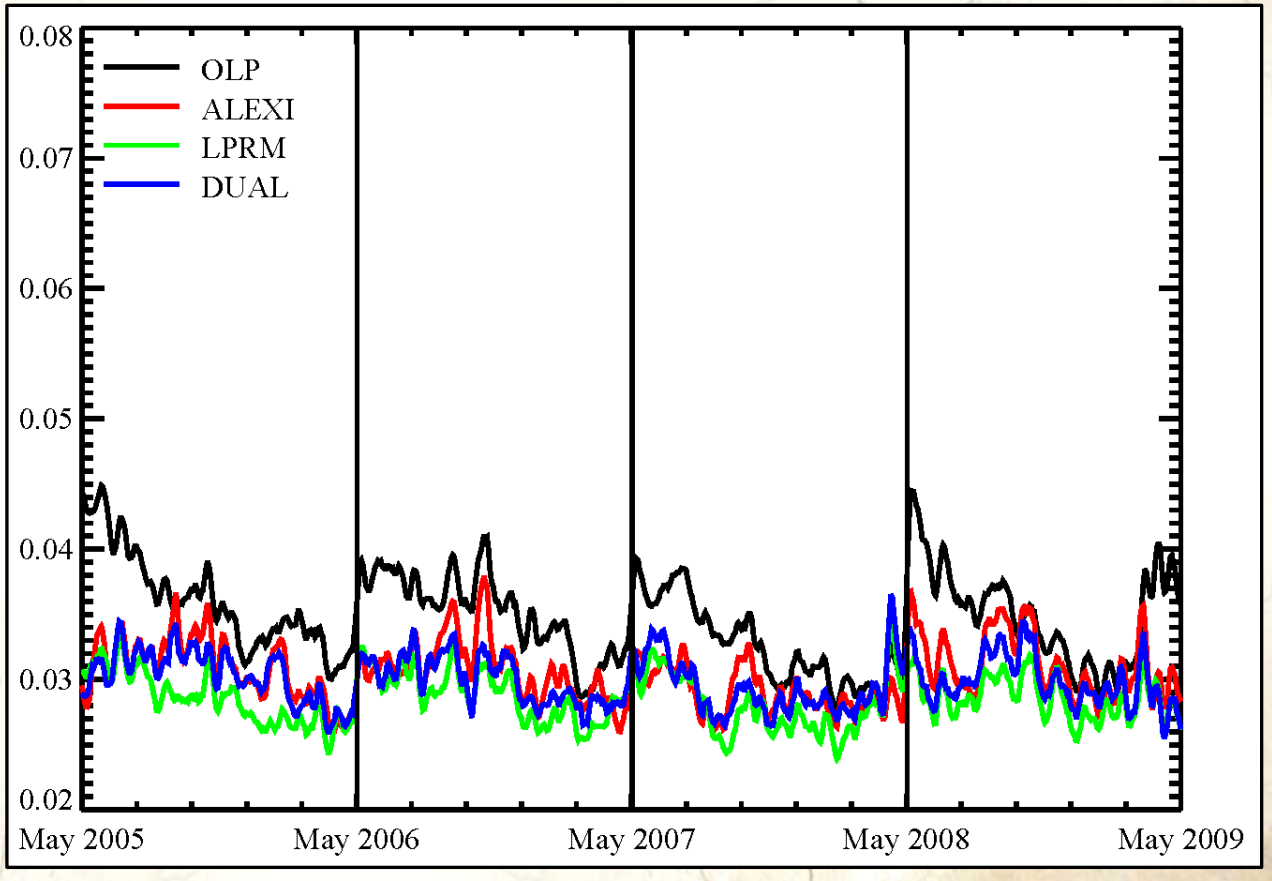


Averaged RMSD [$m^3\ m^{-3}$] in (a) 0-5 cm SM and (b) 5-100 cm SM predictions

Dual Assimilation of MW and TIR Sat SM

- NLDAS is tested with or without ALEXI (TIR) and AMSR-E (MW) soil moisture assimilation

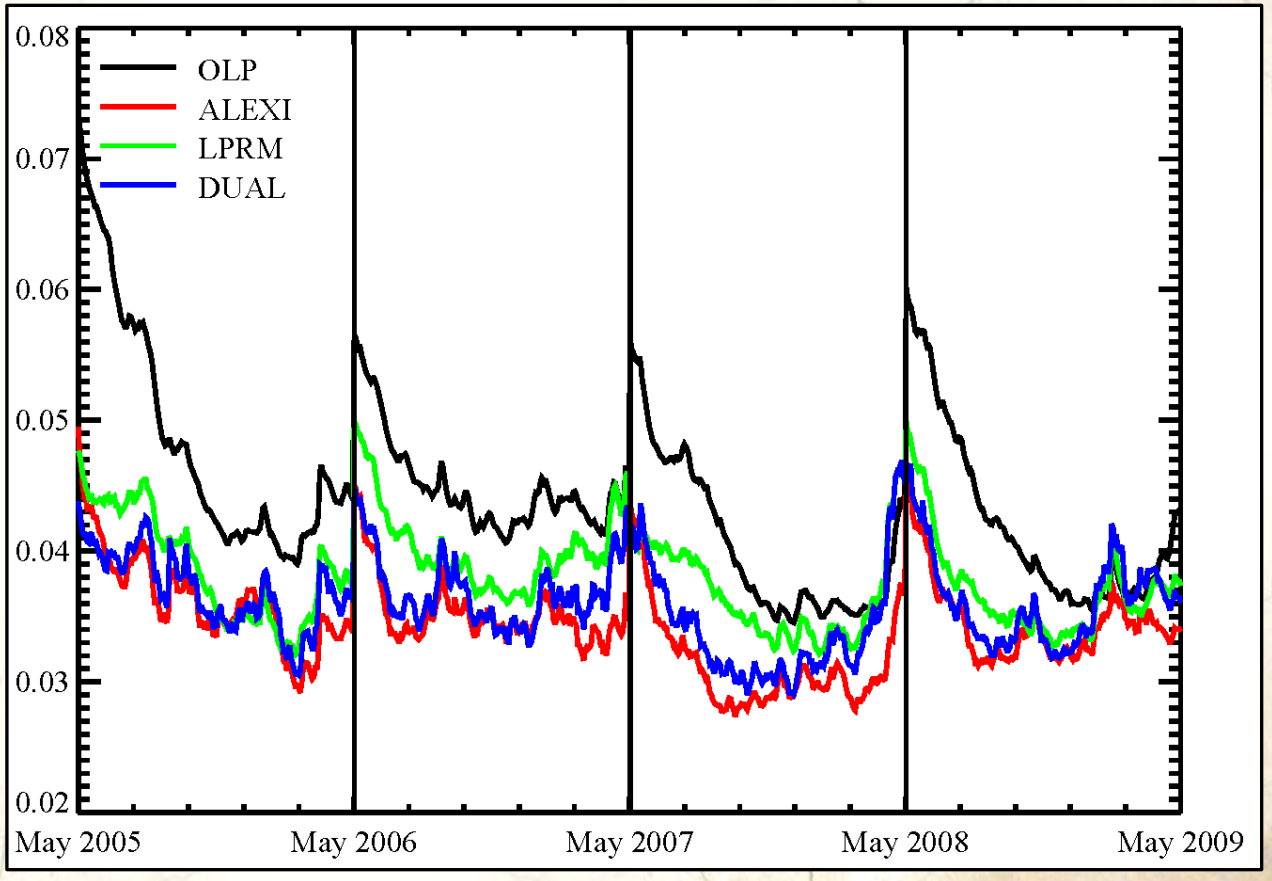
CONUS-Average SFC Soil Moisture RMSD			(m^3 m^{-3})
OLP	0.045	ALEXI	0.039
LPRM	0.037	DUAL	0.037



Dual Assimilation of MW and TIR Sat SM

- NLDAS is tested with or without ALEXI (TIR) and AMSR-E (MW) soil moisture assimilation

CONUS-Average RZ Soil Moisture RMSD			(m^3 m^{-3})
OLP	0.055	ALEXI	0.042
LPRM	0.044	DUAL	0.042



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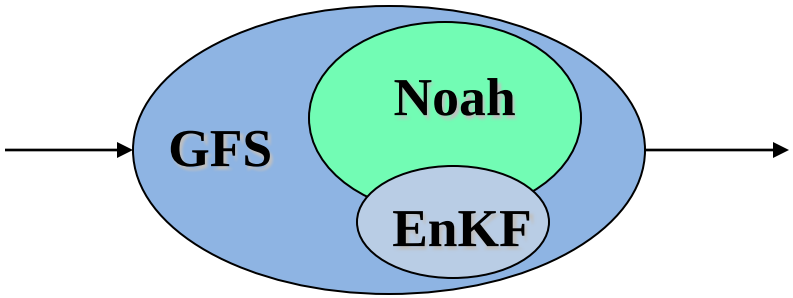
Assimilation of MW SM into NCEP GFS



Pros:

GFS can demonstrate SM impact on forecasts

GFS may take advantage of satellite SM obs earlier than full scale implementation

Cons:

Hardwiring limits more flexibility for assimilating other observational data

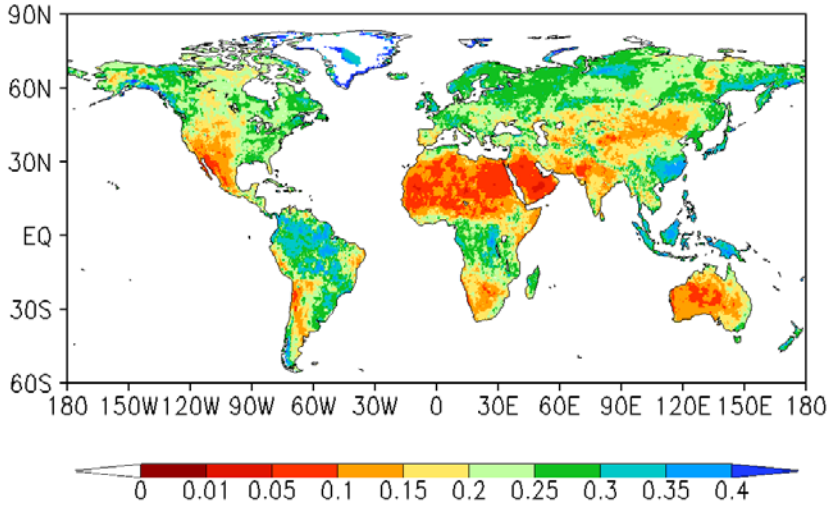
Assimilation of MW SM into NCEP GFS

- ***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***

Comparison of soil moisture from SMOPS Blended 18Z, 1-30 April 2012

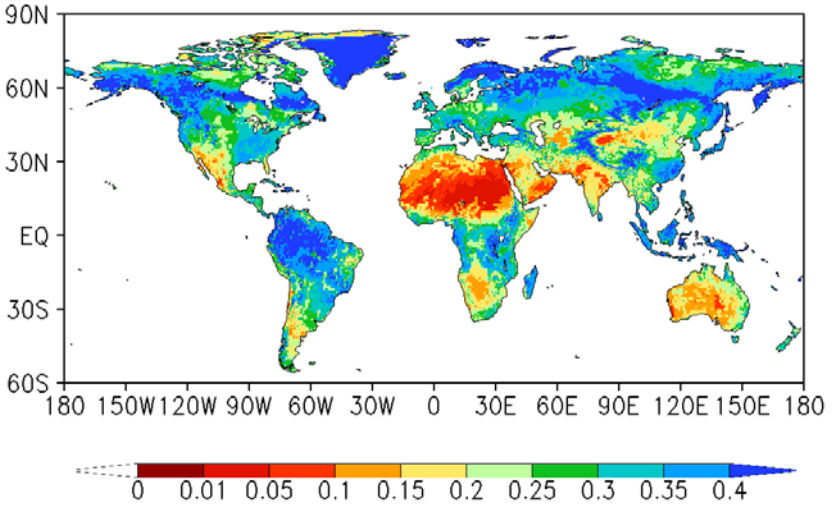
SMOPS_BL: SOILM (Fraction) Ave 1-30 April 2012

SMOPS



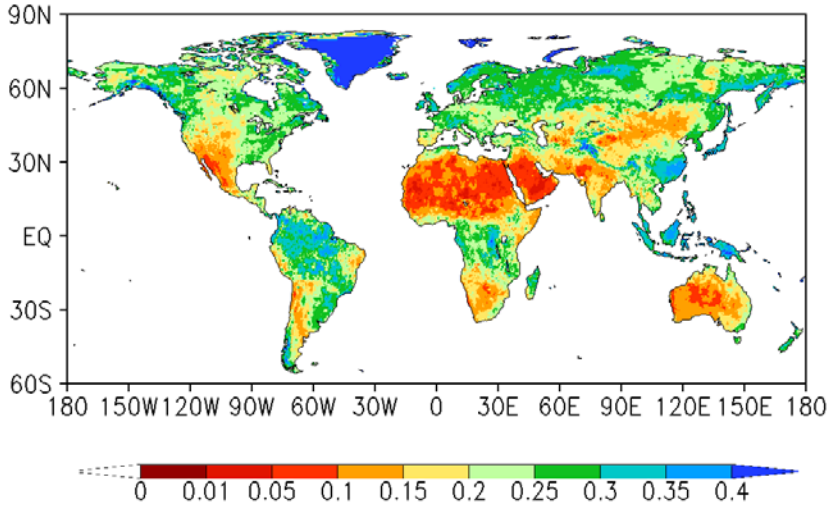
GFS_CTL: SOILM1 (Fraction) Ave 1-30 April 2012

GFS_CTL



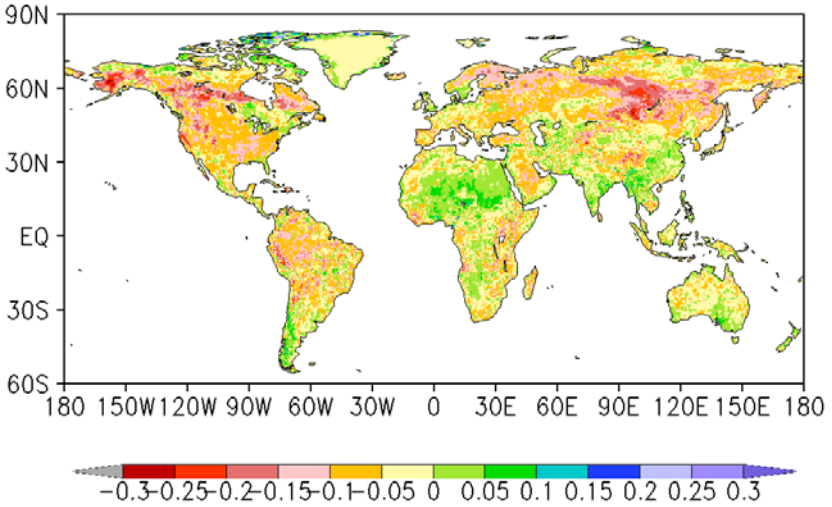
GFS_EnKF: SOILM1 (Fraction) Ave 1-30 April 2012

GFS_EnKF

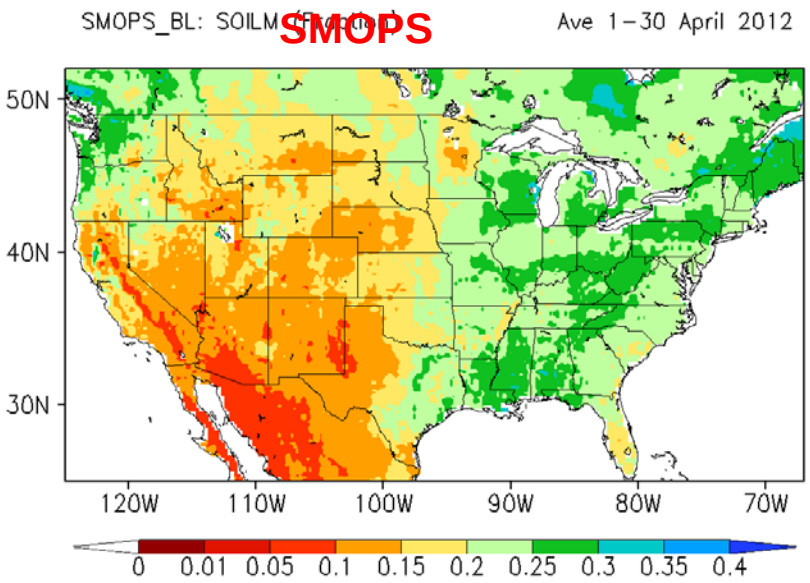


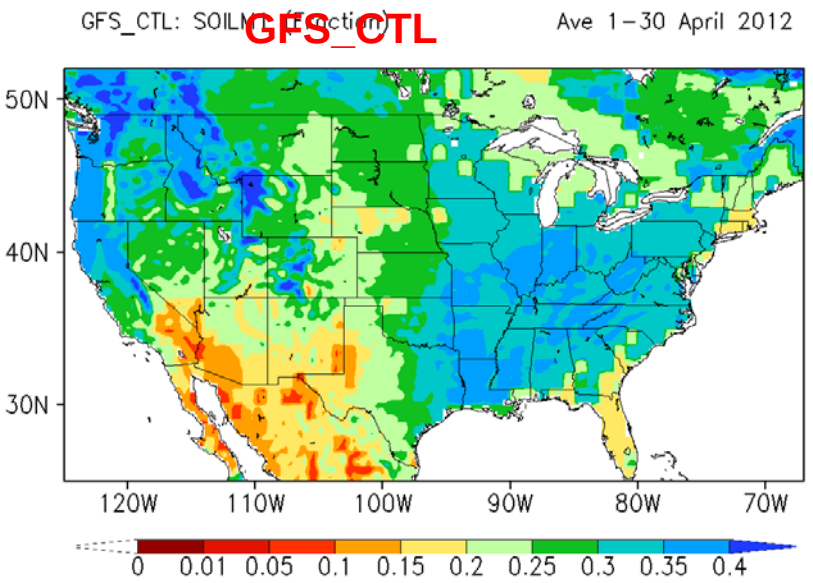
Diff of SOILM1 Ave 18Z, 1-30 April 2012

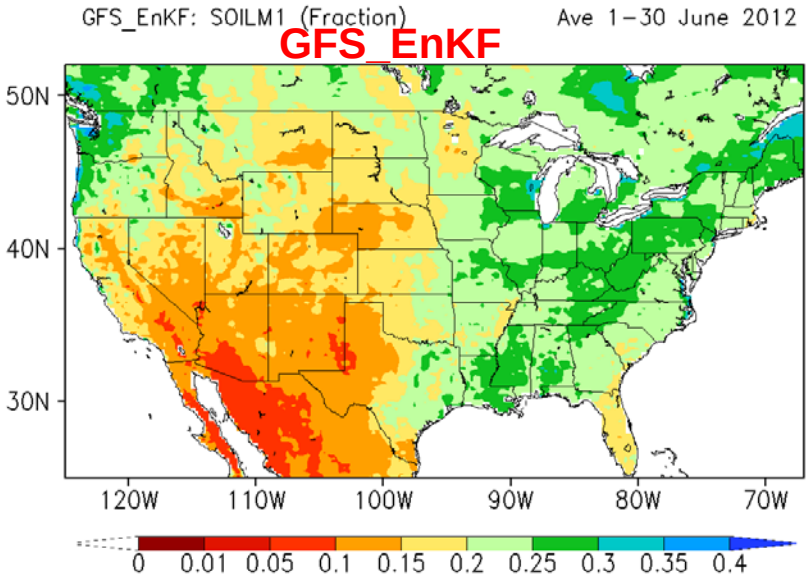
EnKF-CTL

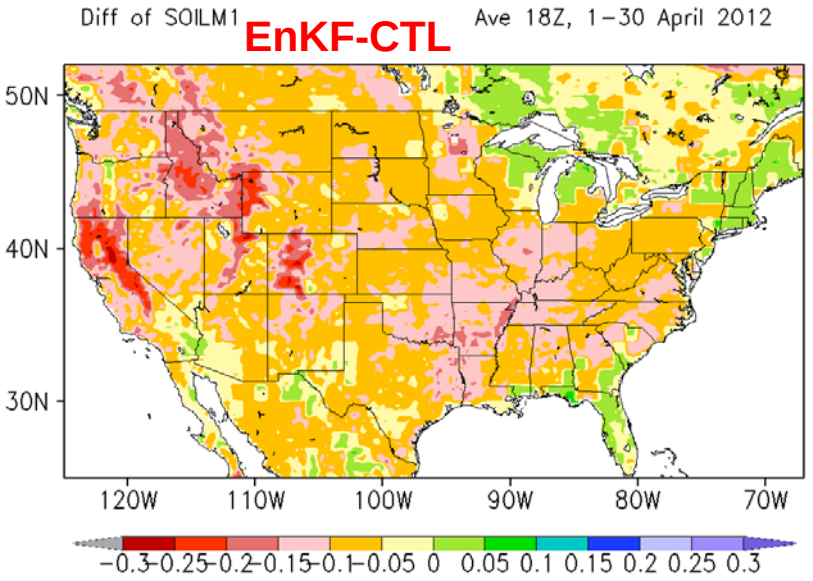


Comparison of soil moisture from SMOPS Blended 18Z, 1-30 April 2012









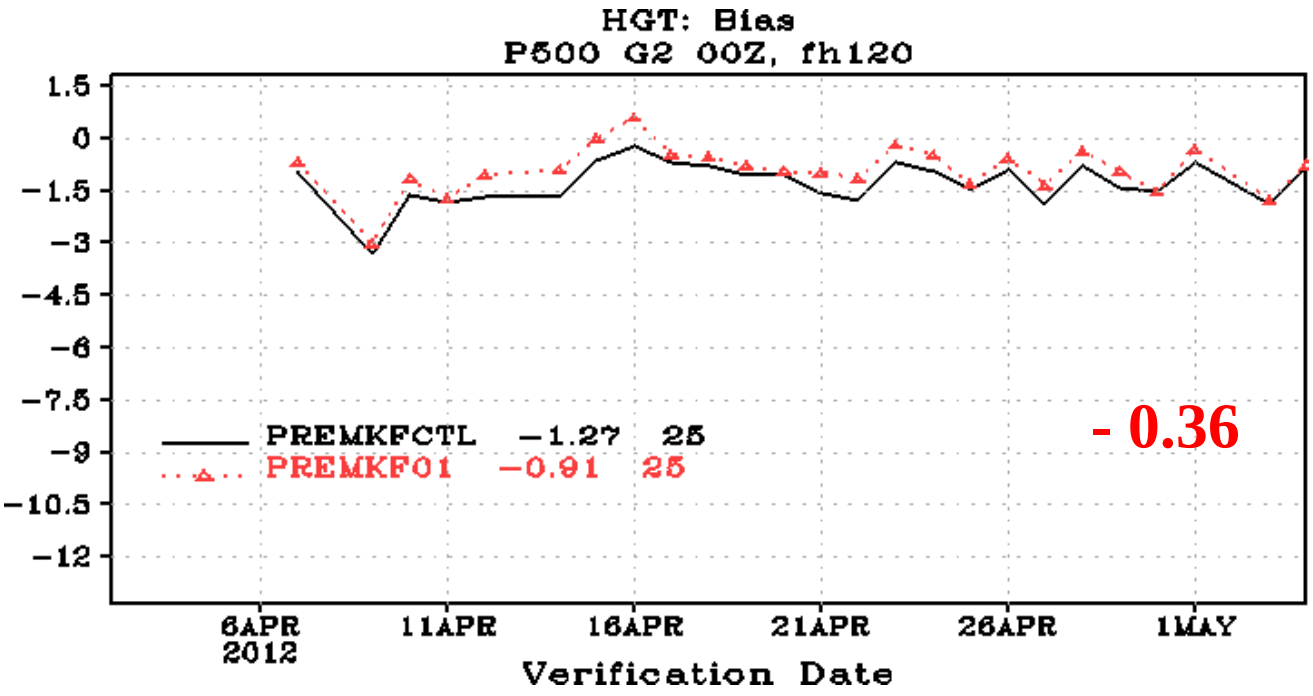
GFS Top Layer SM Validation

With USDA-SCAN Measurements

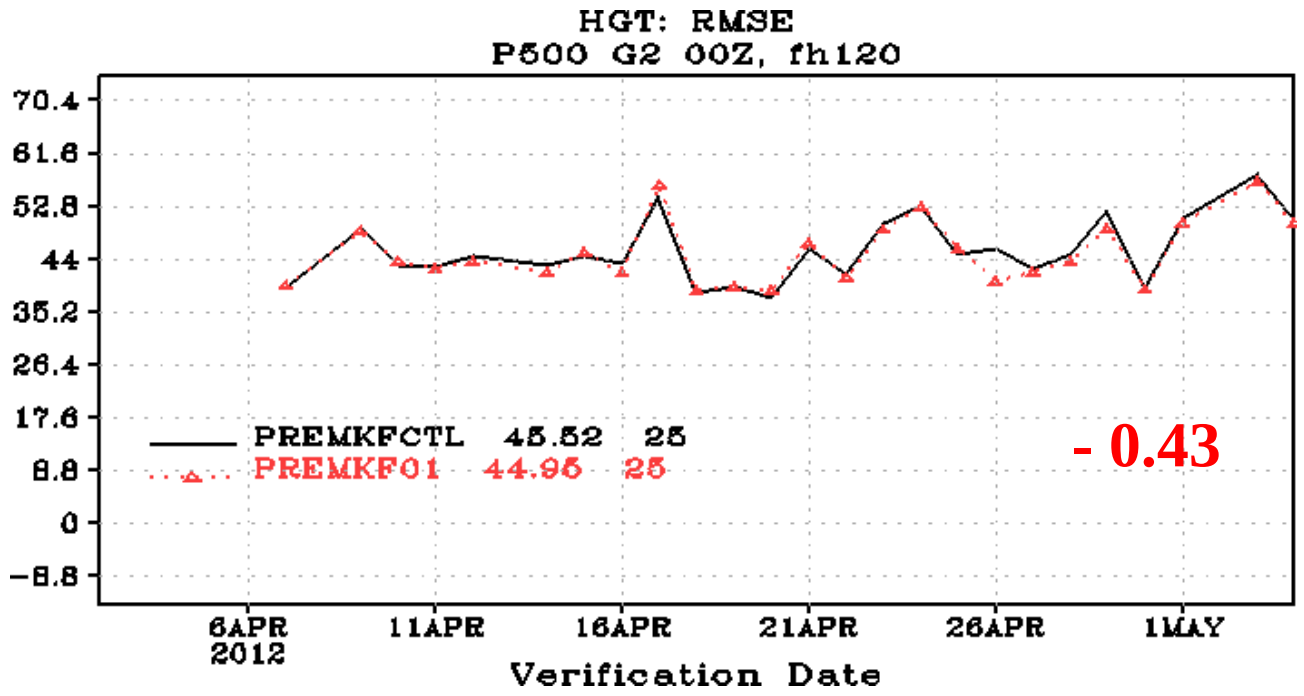
1-30 of April, 2012

	East CONUS (26 sites)			West CONUS (25 sites)			Whole CONUS		
	RMSE	*Bias*	*Corr-Coef*	*RMSE*	*Bias*	*Corr-Coef*	*RMSE*	*Bias*	*Corr-Coef*
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

Bias


HGT: Bias
P500 G2 00Z, fh120
1.5
0
-1.5
-3
-4.5
-6
-7.5
-9
-10.5
-12
PREMKFCTL -1.27 25
PREMKF01 -0.91 25
- 0.36
6APR
2012
11APR
16APR
21APR
26APR
1MAY
Verification Date

RMSE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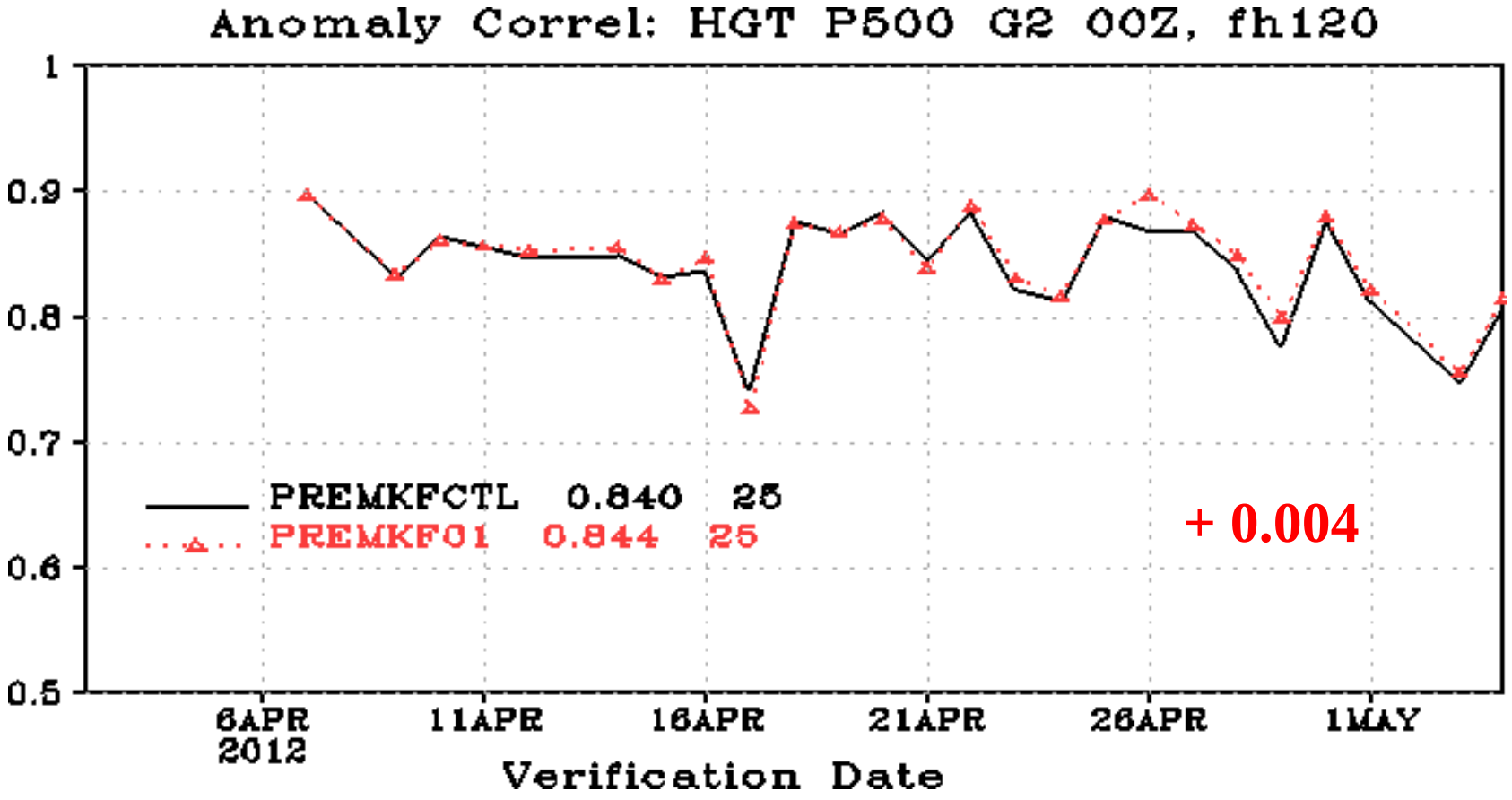
P500 G2 00Z, fh120
70.4
61.6
52.8
44
35.2
26.4
17.6
8.8
0
-8.8
PREMKFCTL 45.52 25
PREMKF01 44.95 25
- 0.43
6APR
2012
11APR
16APR
21APR
26APR
1MAY
Verification Date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1
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0.8
0.7
0.6
0.5
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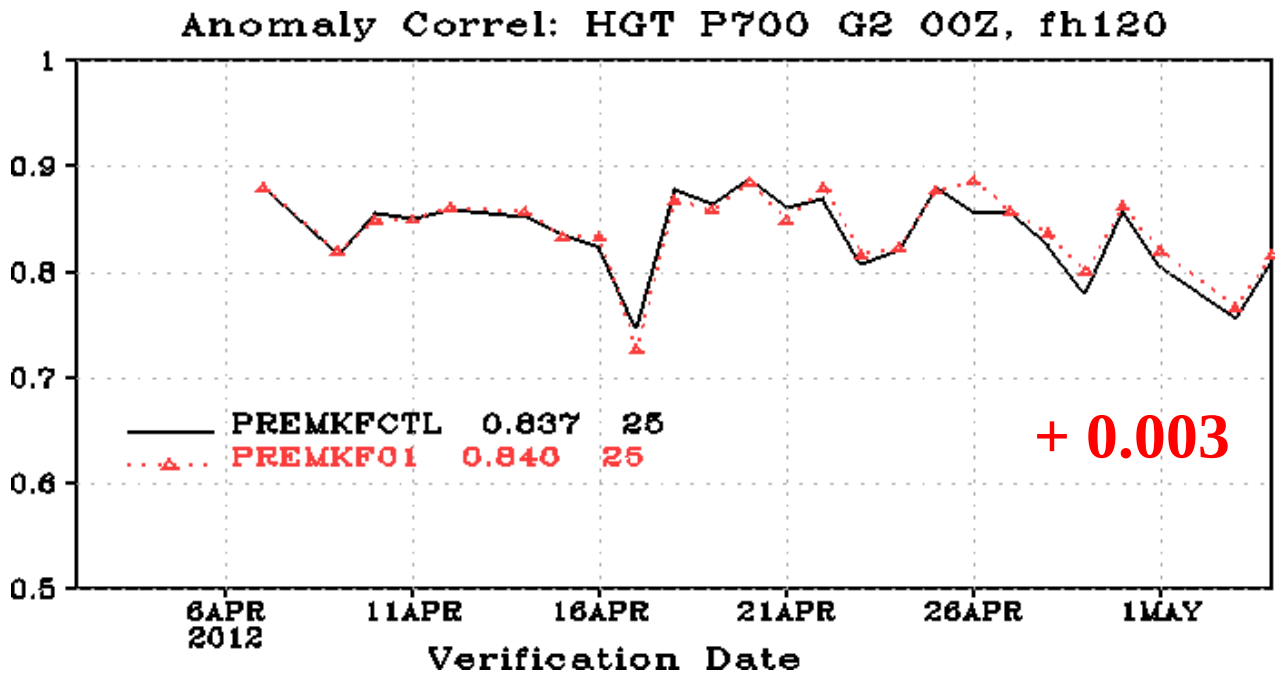
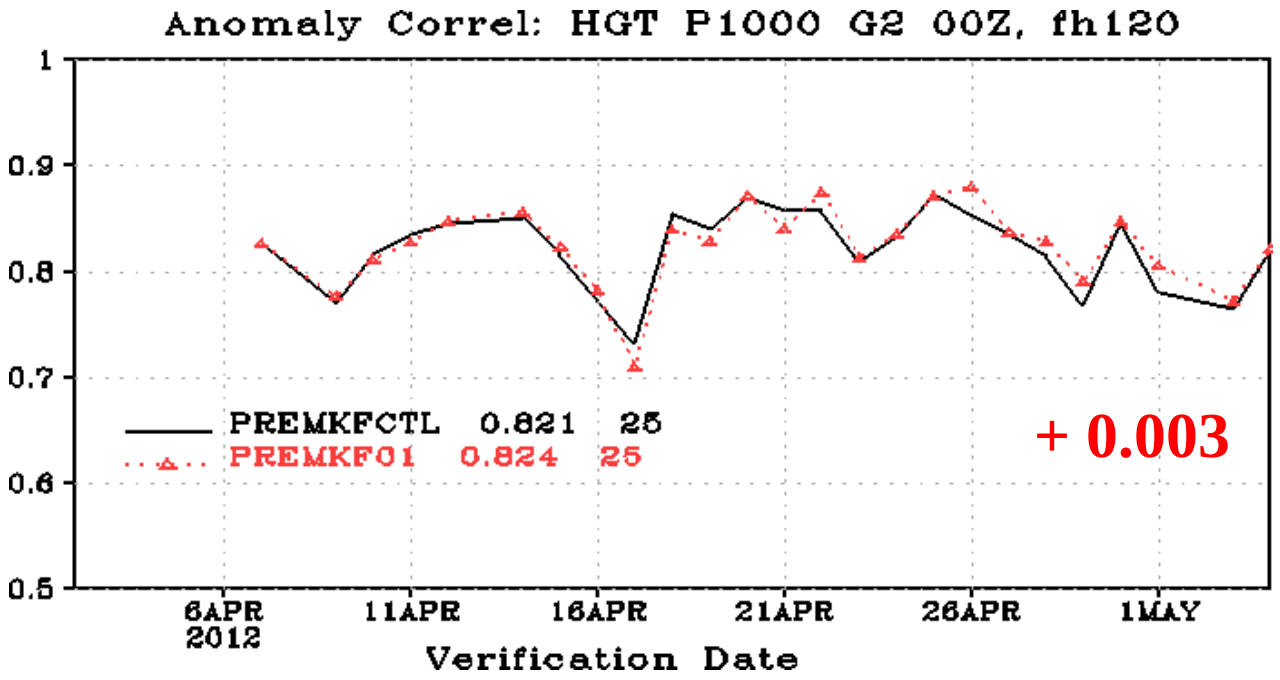
6APR
2012
11APR
16APR
21APR
26APR
1MAY
Verification Date

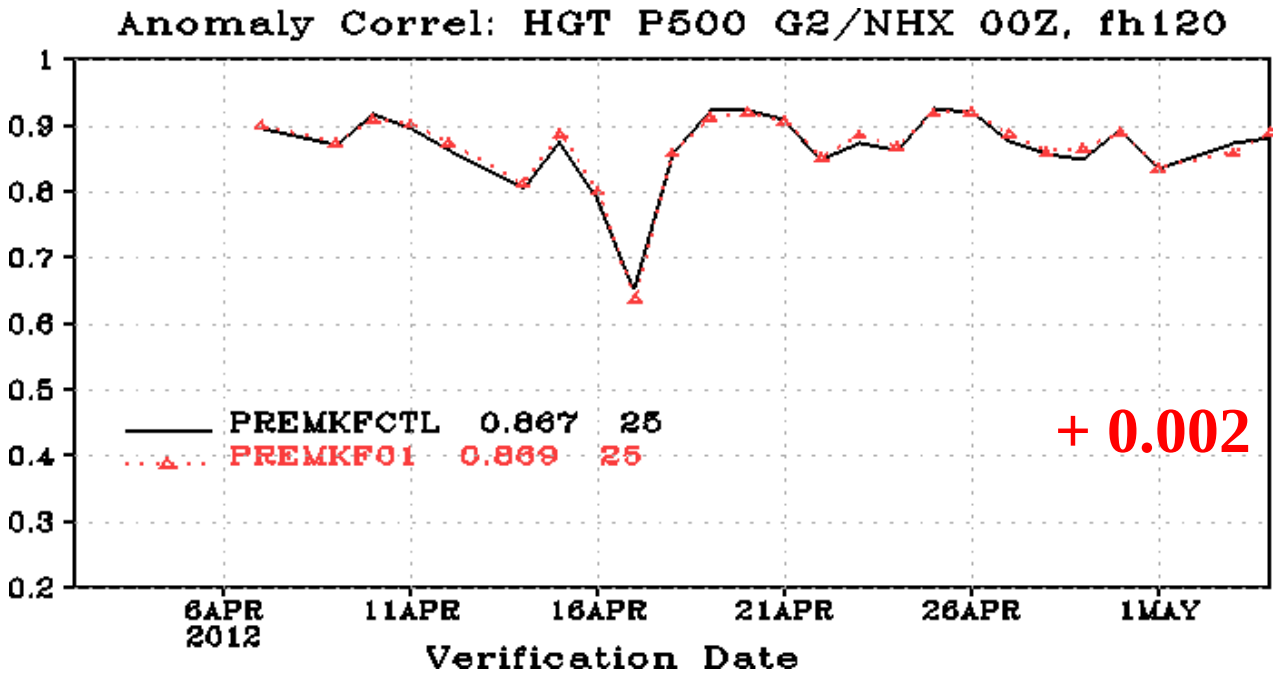
700 hPa



1000 hPa



NHX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0.2
PREMKFCTL 0.867 25
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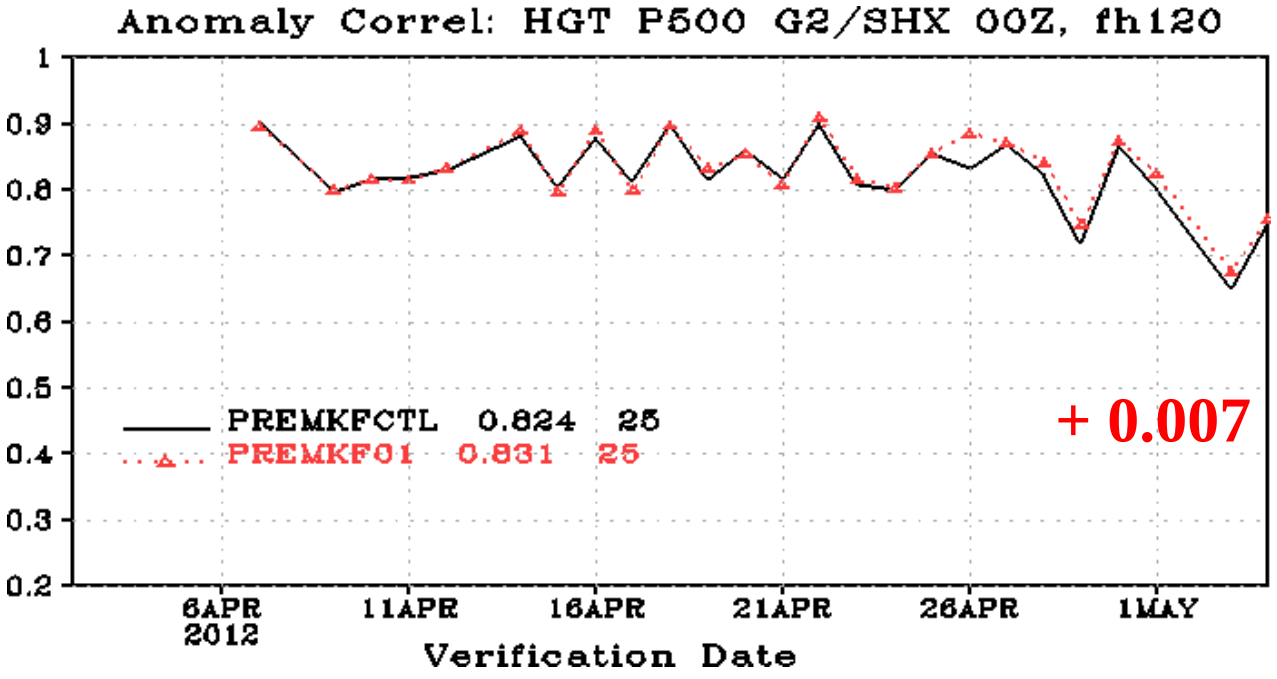
6APR
2012
11APR
16APR
21APR
26APR
1MAY
Verification Date

SHX


Anomaly Correl: HGT P500 G2/SHX 00Z, fh120
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0.4
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PREMKF01 0.831 25
+ 0.007
6APR
2012
11APR
16APR
21APR
26APR
1MAY
Verification Date

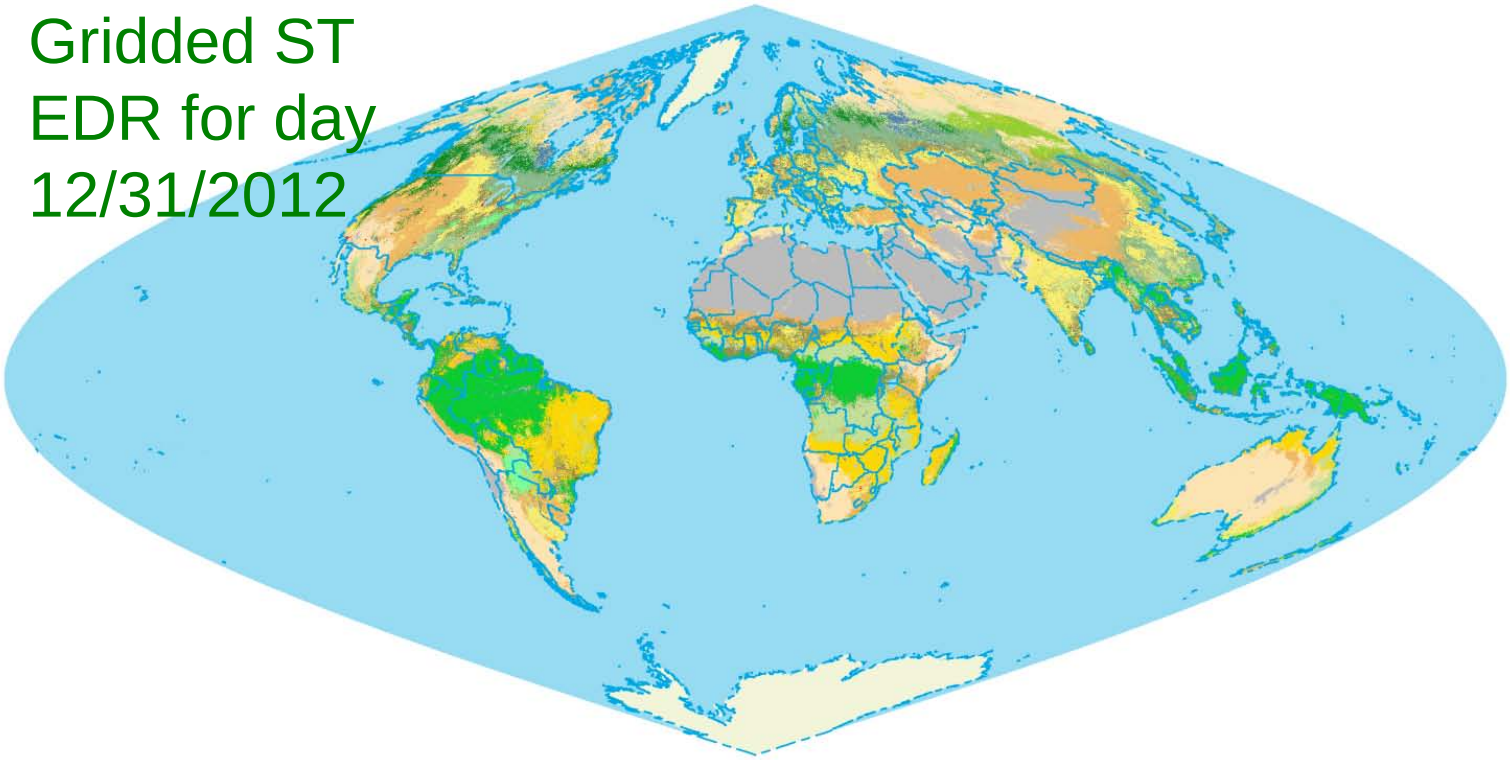
OUTLINE

- ***Satellite Soil Moisture Data Products***
- ***SM Data Assimilation for Drought Monitoring***
- ***SM Data Assimilation for NCEP NWPs***
- ***Future Data Assimilation Plan***

Assimilation of S-NPP/JPSS Land EDRs

- S-NPP/JPSS data processing tools ready for input files of albedo, GVF, ST and LST to LIS (NLDAS/GLDAS)

Gridded ST EDR for day 12/31/2012



Assimilation of S-NPP/JPSS Land EDRs

- GLDAS is tested using either old AVHRR ST map or newer VIIRS QST IP seed (MODIS C5). Impact of ST changes LSM runs is studied

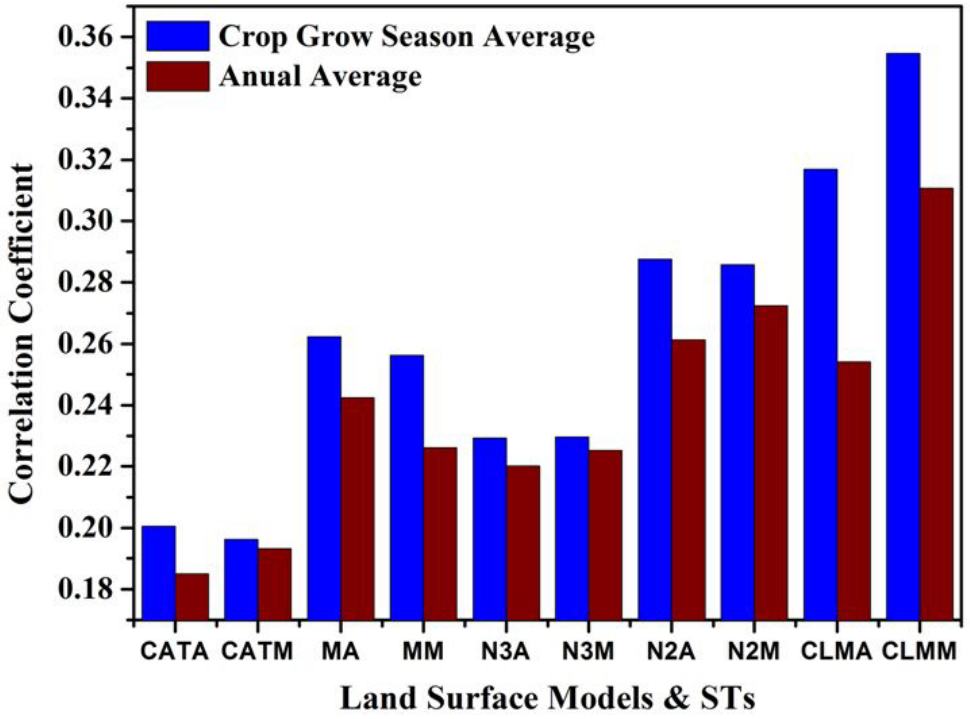
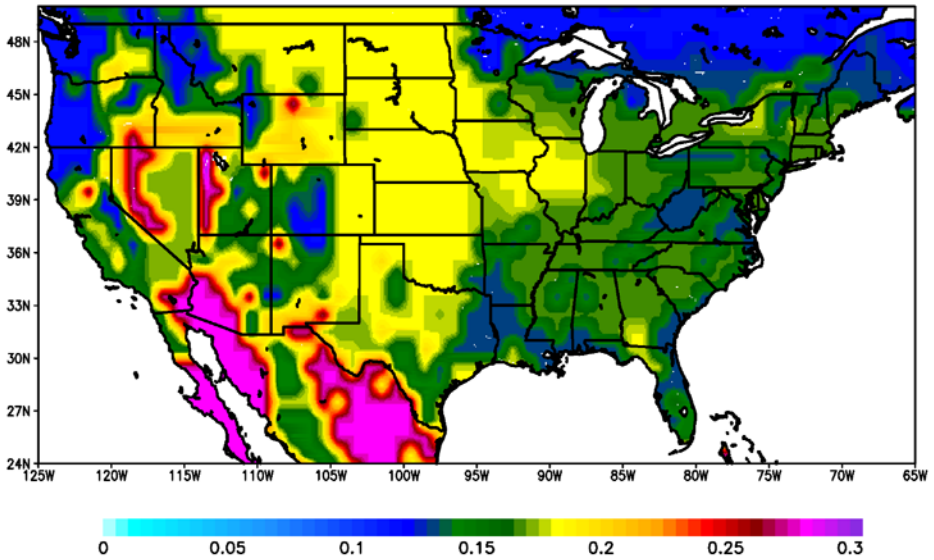


Fig. 1. The relationship between in-situ observational relative soil moisture of 108 stations and soil moisture simulated by land surface models with AVHRR and MODIS land cover over China mainland from January 2011 to December 2012. For each month, the sample size is 324, consisting of 108 stations data for every ten-day observation time interval. If correlation coefficients are more than o.16, 0.22 and 0.29, they are significant with credibility level 0.05, 0.01 and 0.001 separately. Crop grow season is from April to September in 2011 and 2012. The symbols of CATA, CATM, MA, MM, N3A, N2A, N2M CLMA and CLMM indicate Catchment, Mosaic, Noah3.2, Noah2.7.1 and CLM2.0 land surface models (LSM) implemented in LIS respectively. ST is surface type.

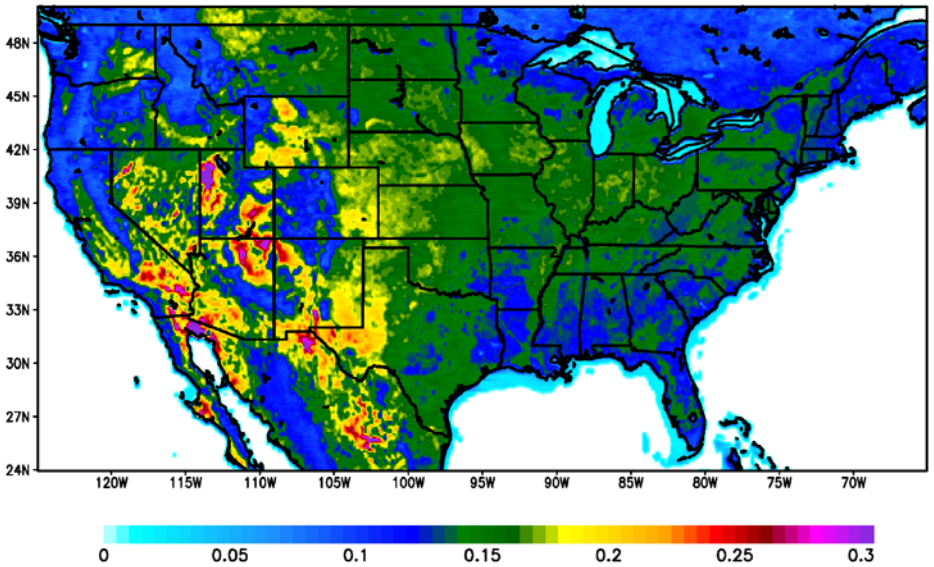
Assimilation of S-NPP/JPSS Land EDRs

- NLDAS is being tested using either multi-year albedo average or NRT MODIS monthly values

a) Original Vegetation Type-dependent Albedo



b) Satellite-based MODIS Albedo



SUMMARY

- ***Many satellite land data products are ready for NWP model assimilation***
- ***Drought monitoring could be significantly enhanced by dual assimilation of both MW and TIR soil moisture observations***
- ***GFS forecasts are improved by assimilating SMOPS daily soil moisture products***
- ***More land data could be tested if ……***

Thanks ……