Impact Study of AMSR2 Soil Moisture Product in the NCEP Global Forecast System

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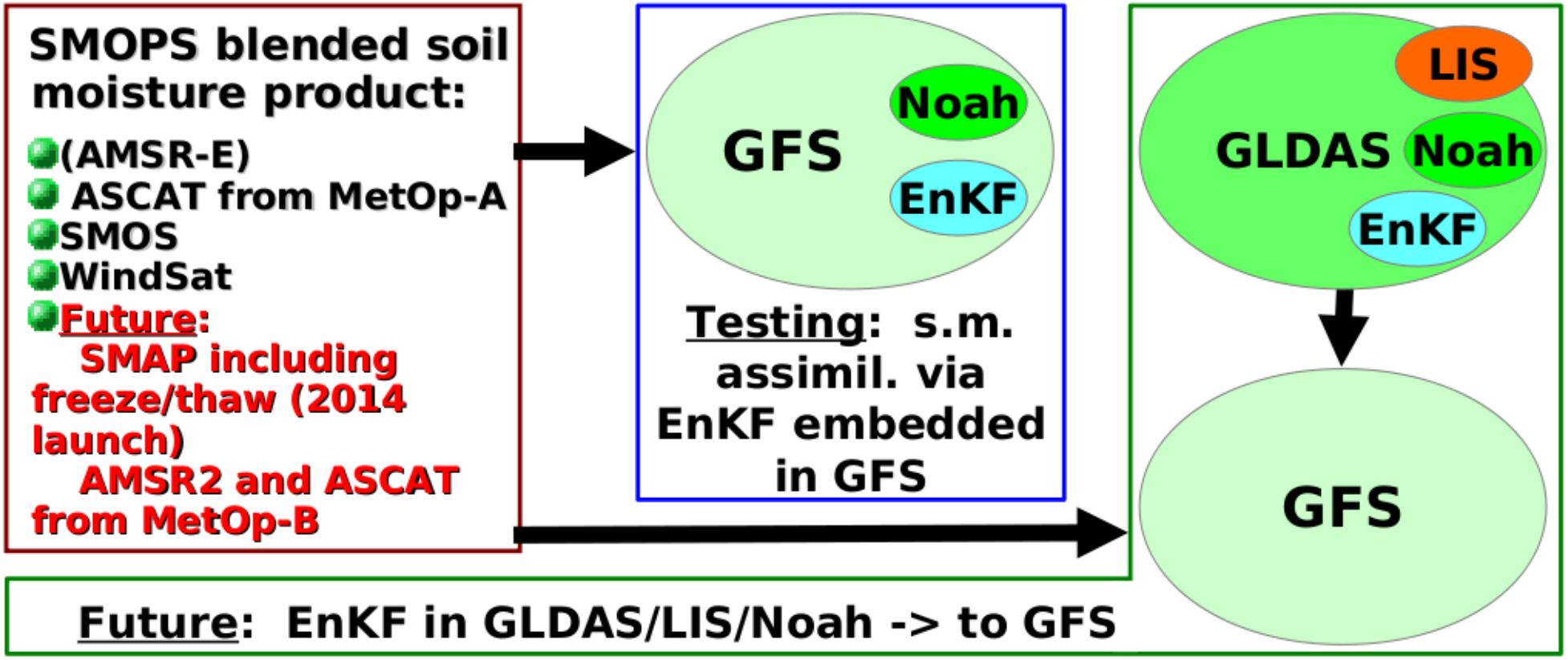
OUTLINE:

- ***Objective***
- ***Embed EnKF in GFS***
- ***Testing with SMOPS Blended SM***
- ***Testing with AMSR2 SM***
- ***Summary and future plan***

OBJECTIVES

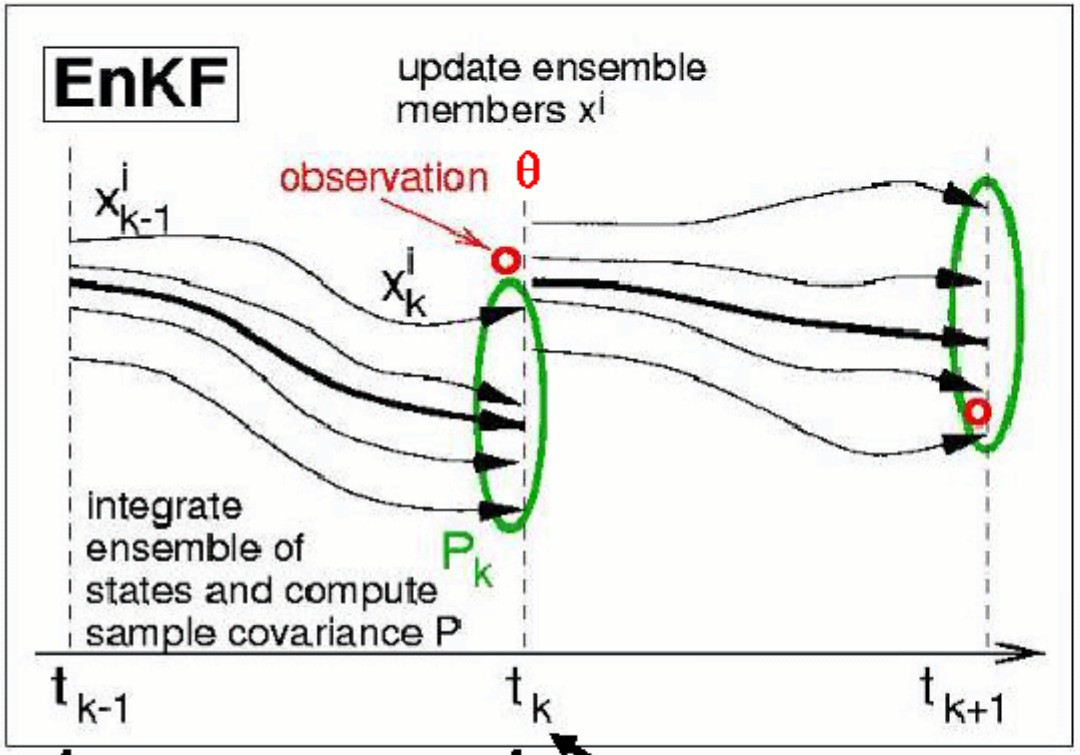
- ***"Online" satellite soil moisture data assimilation in NCEP GFS***
- ***Examine how satellite SM data impact on NCEP GFS forecasts***

Schematic representation of assimilating satellite soil moisture products from NESDIS/SMPOS into NCEP Global Forecast System (GFS)



Global Land Data Assimilation System (GLDAS), NASA Land Information System (LIS), Noah land-surface model

EnKF for Noah LSM in GFS



Nonlinearly propagates ensemble of model trajectories.

Can account for wide range of model errors (incl. non-additive).

Approx.: **Ensemble size.**

Linearized update.

$\mathbf{x_k^i}$	state vector (eg soil moisture)
$\mathbf{P_k}$	state error covariance
$\mathbf{R_k}$	observation error covariance

Propagation t_{k-1} to t_k:

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

w = model error

For Noah LSM 4 layer SM:

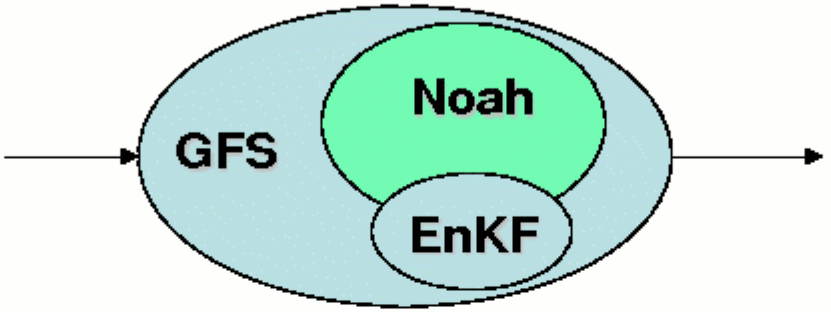
$$x_j^{i+} = x_j^{i-} + (\theta^i - x_j^{i-}) * P_{j1} / (P_{11} + R)$$

No matrix inversion. Scalars only

Courtesy of R. Reichle

Embed Simplified EnKF in GFS

EnKF Embedded in GFS



Pros:

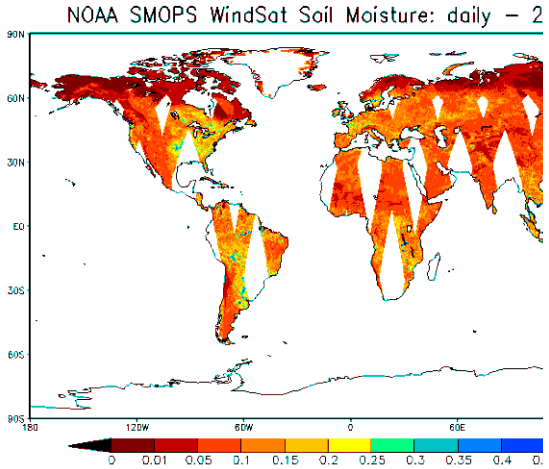
GFS can demonstrate SM impact on forecasts
GFS may take advantage of satellite SM obs ASAP

Cons:

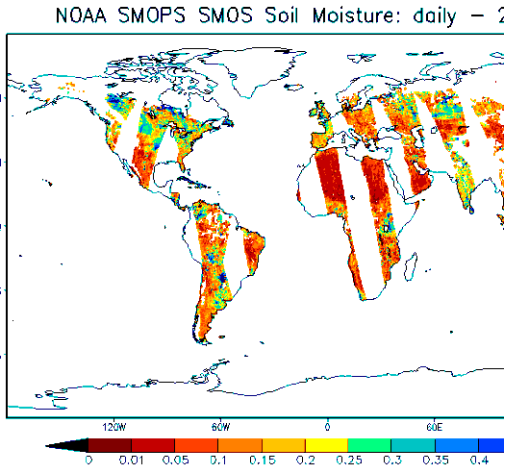
Hardwiring limits more flexibility for assimilating other observational data

SMOPS Daily Product Sample: 1 May 2012

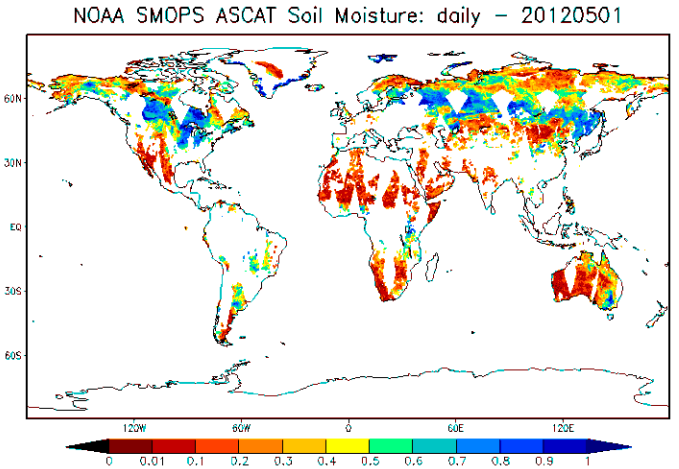
WindSat



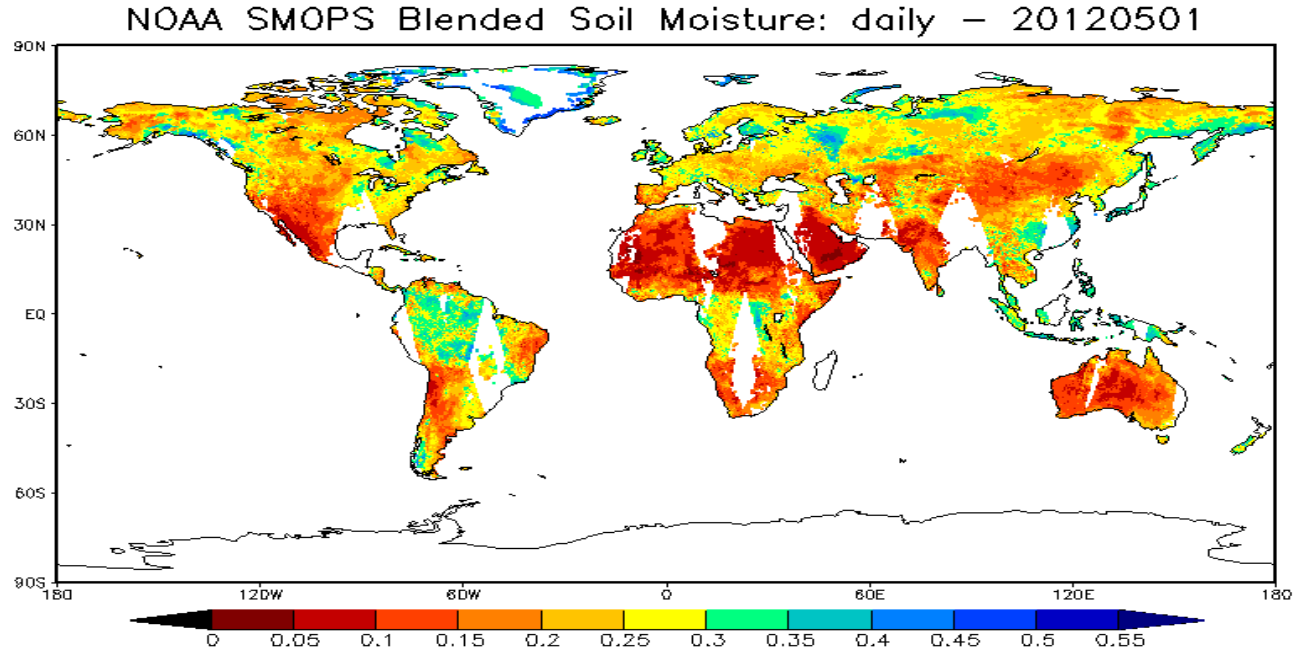
SMOS



ASCAT



Blended



GCOM-W1 AMSR2 Soil Moisture Product

- ***End of AMSR-E era: Oct 4, 2011***
- ***GCOM-W1 was launched on May 18, 2012***
- ***SM Environmental Data Record (EDR) from AMSR2***
- ***Part of JPSS GCOM-W plan***
- ***Server as SM DA input, or part of input, to GFS model***

➔ ***Reflector system: 2.0m diameter (1.6m for AMSR-E)***

➔ ***Identical Frequency set as AMSR-E except 7.3GHz channel for RFI mitigation***

➔ ***Sensor depth: Surface to -0.1 cm (skin layer)***

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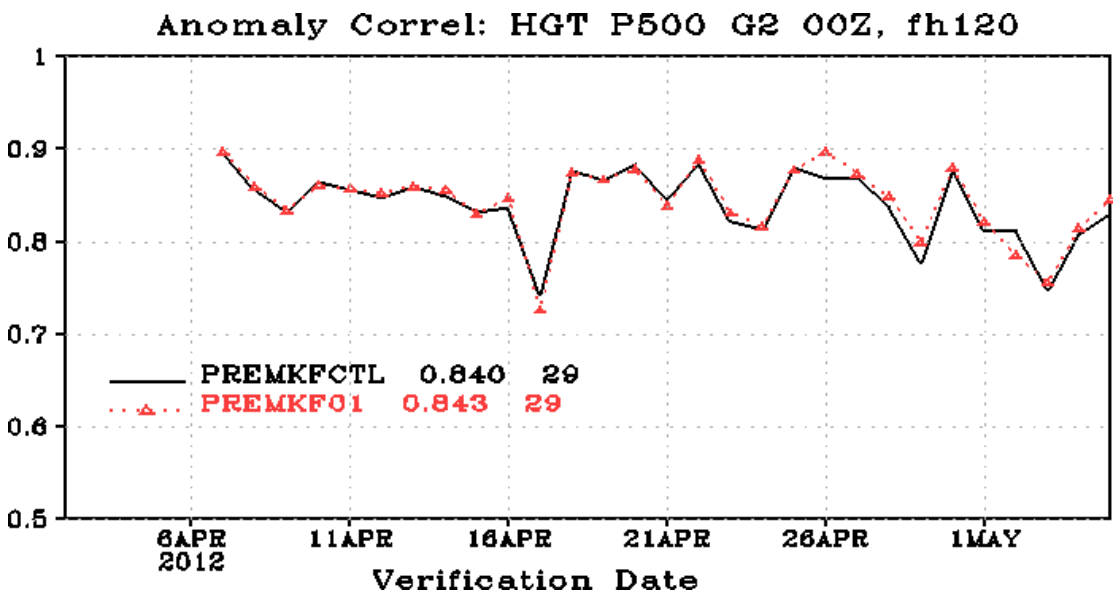
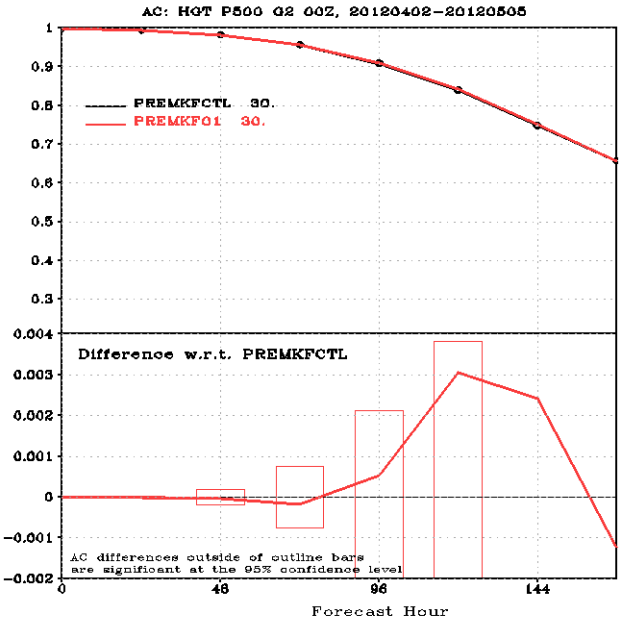
GFS Top Layer SM Validation

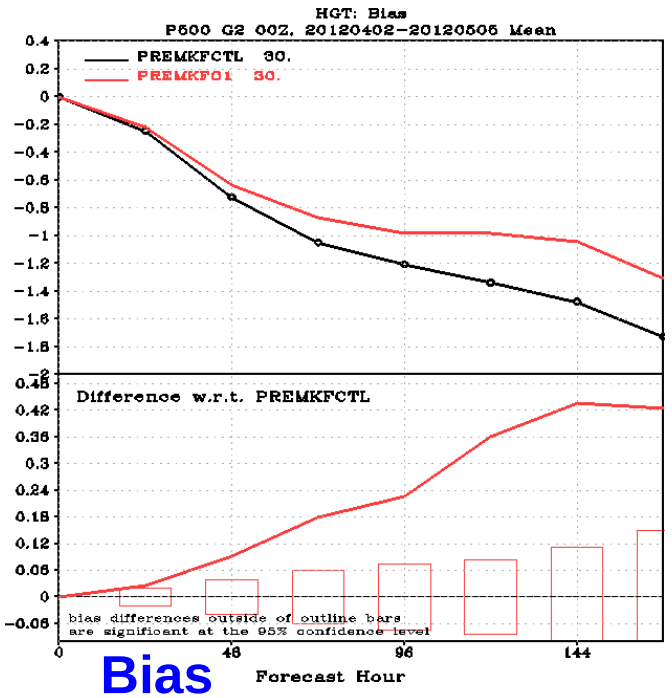
With USDA-SCAN Measurements
1-30 of April, 2012

	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	-0.026	0.587
SMOPS	0.133	-0.055	0.601	0.098	-0.036	0.402	0.117	-0.048	0.524

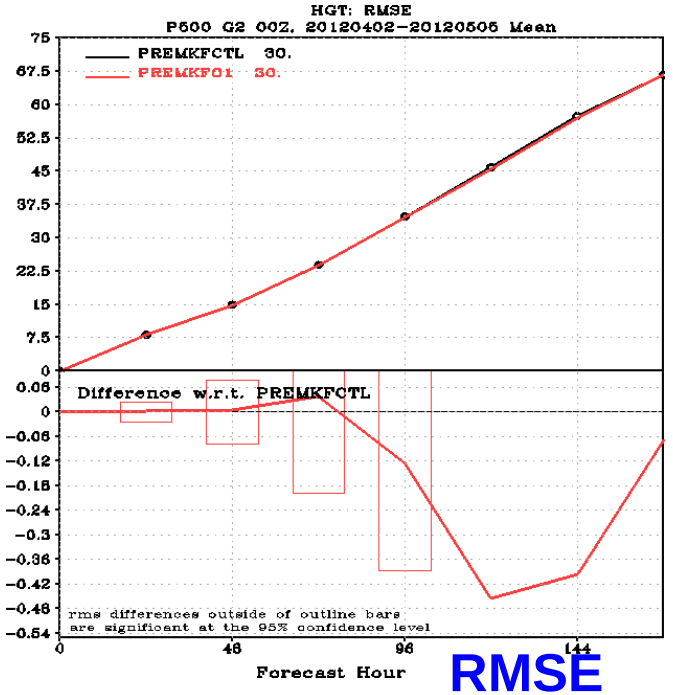
Analysis on Anomaly Correlation at 500 hPa: Day5







Bias



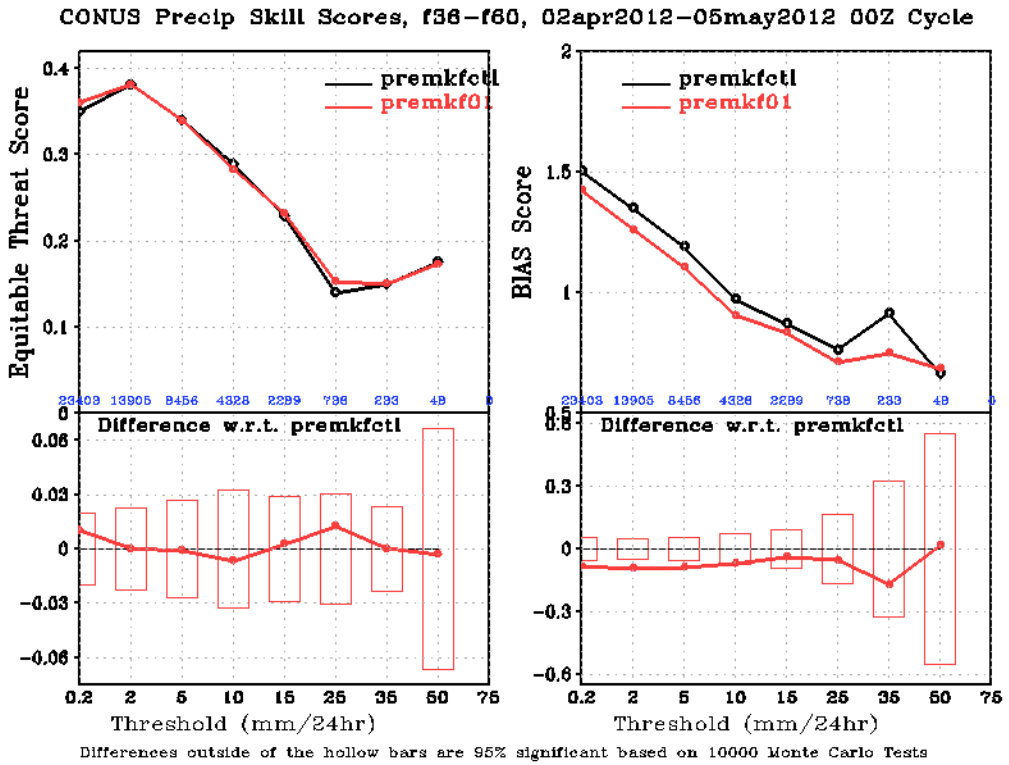
RMSE

500 hPa HGT:

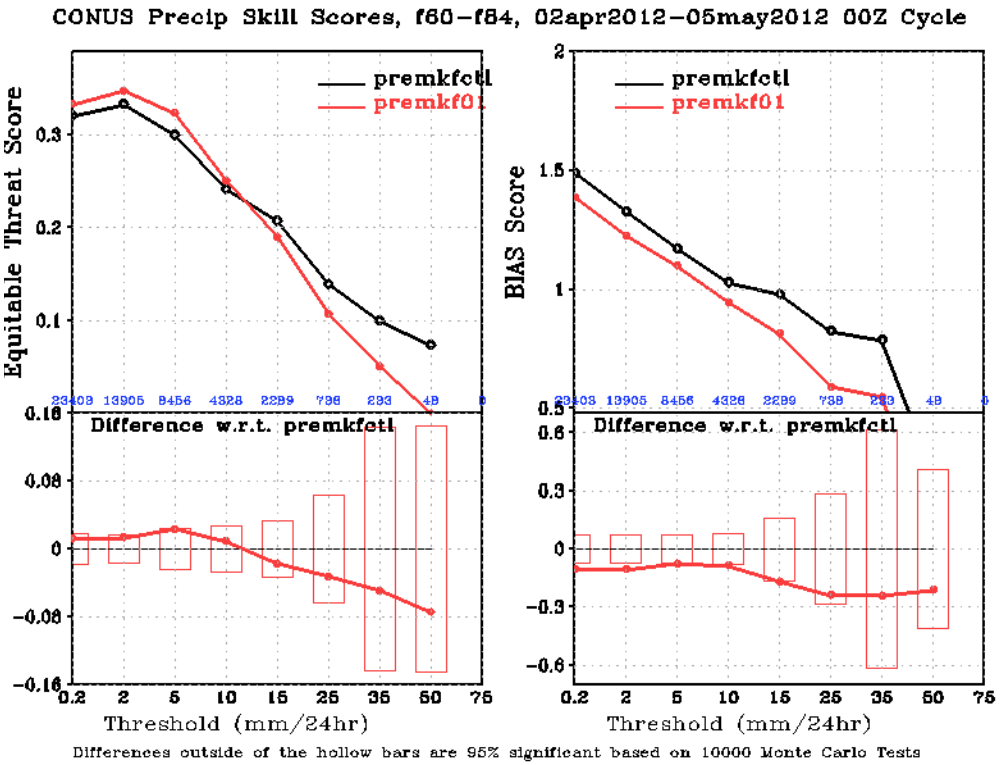
Reduced the bias; Reduced the rmse after day 4.

Precipitation Skill Scores over CONUS with SMOPS: f36-f60; f60-f84

f36 - f60



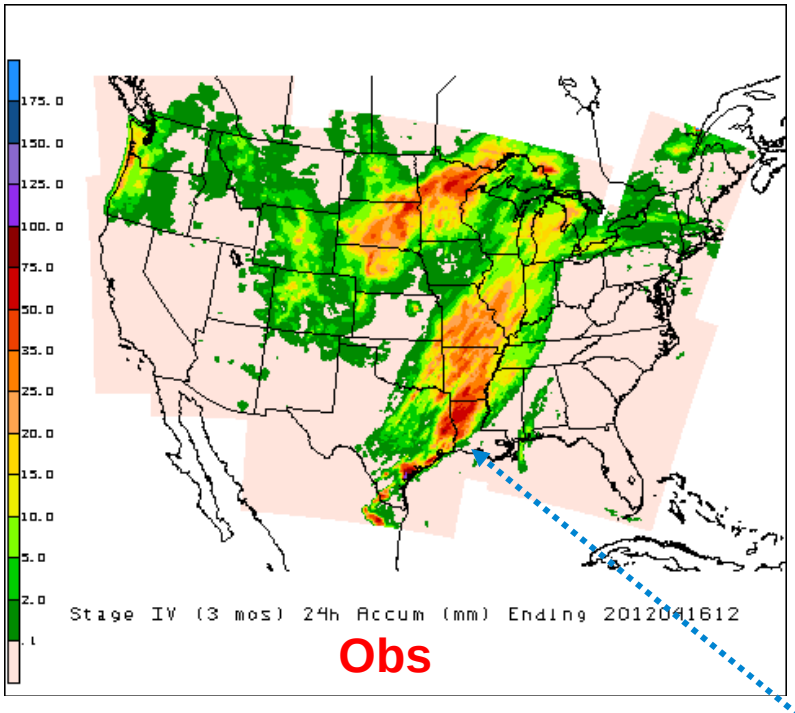
f60 - f84



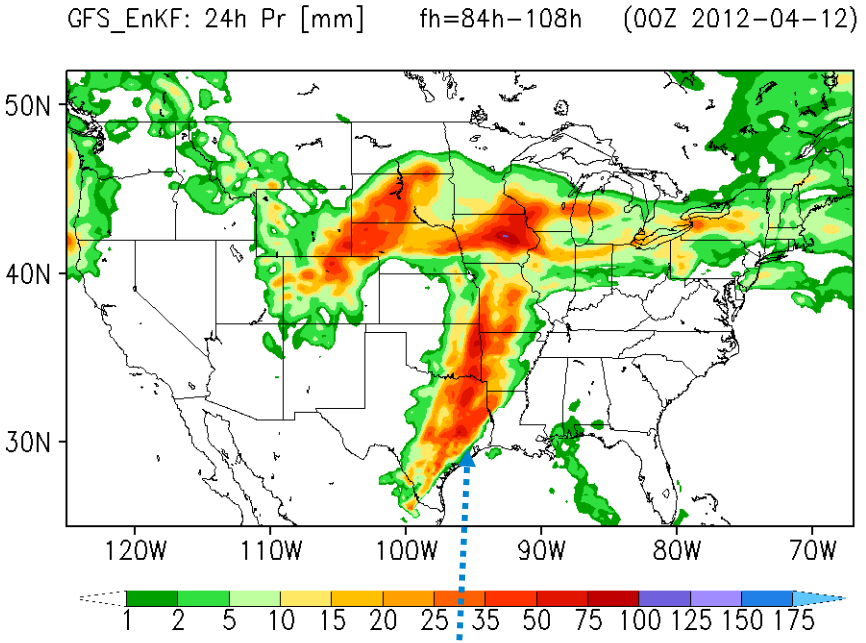
f36-f60: Improved slightly the scores and reduced the bias;

f60-f84: Improved the scores for light and medium precipitation but not for heavy precipitation. Good improvement for the bias.

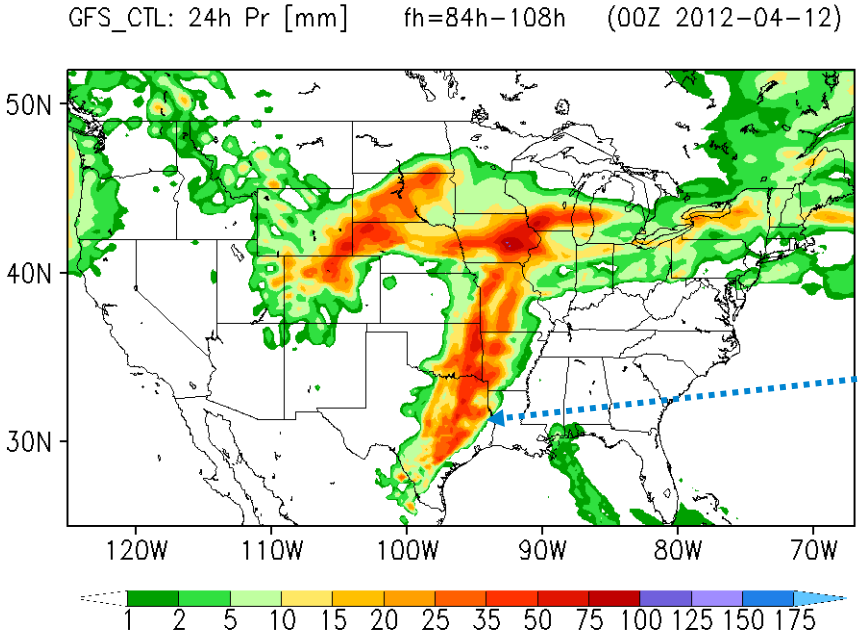
Precipitation forecast with SMOPS 24h Accum (mm) Ending at 12Z 16 Apr 2012



Obs



EnKF: 84-108h



CTL: 84-108h

Improved !

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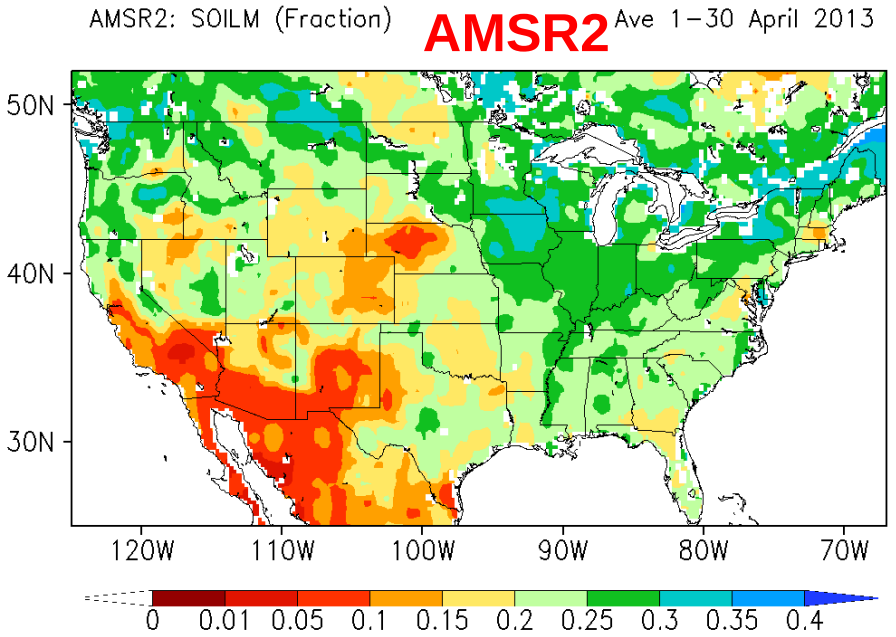
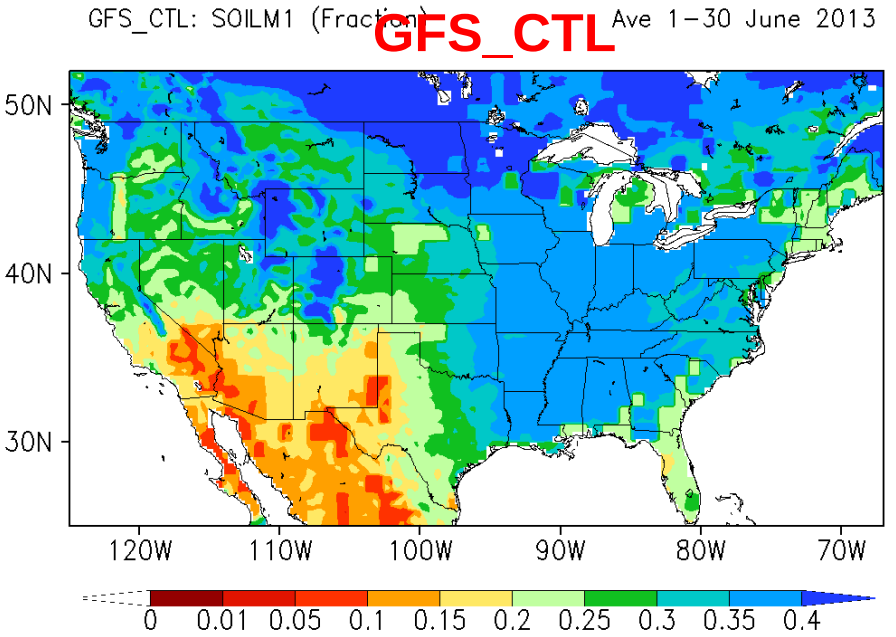
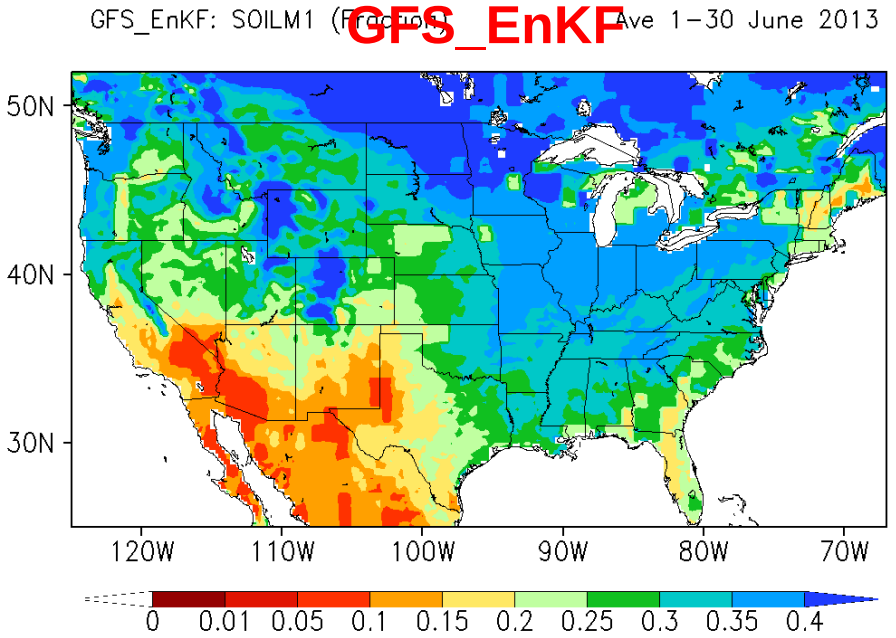
Comparison of soil moisture from AMSR2 and GFS tests for mean April 2013

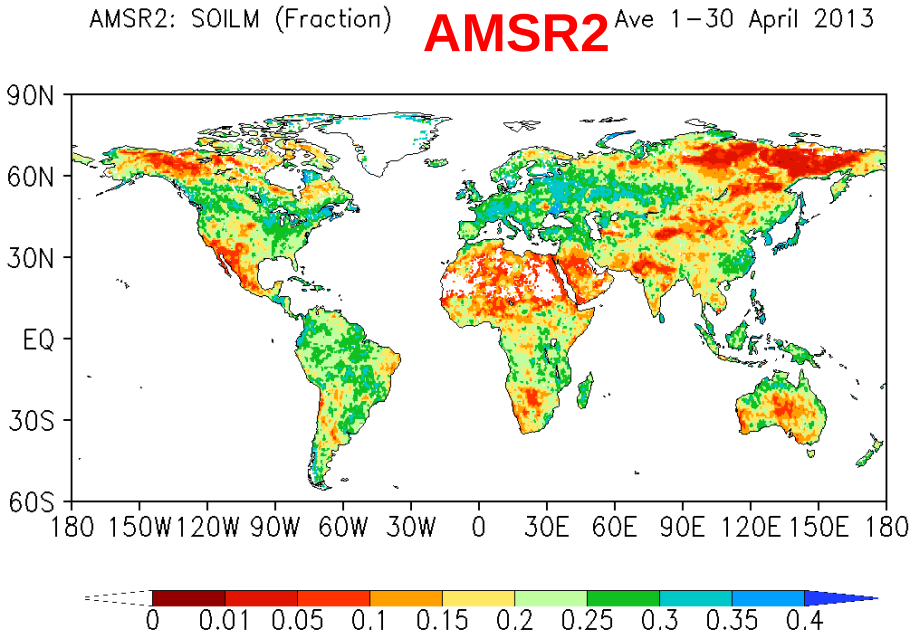


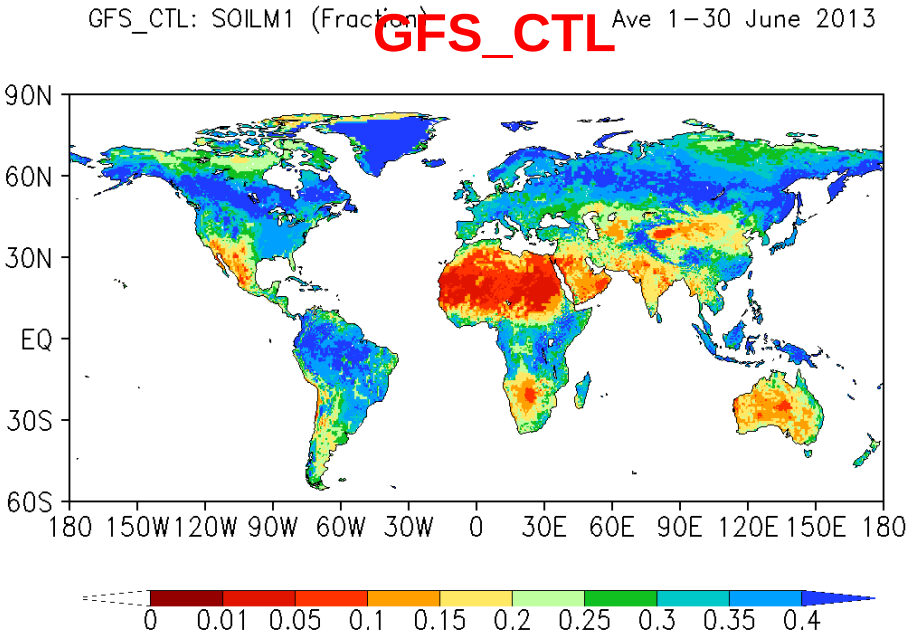


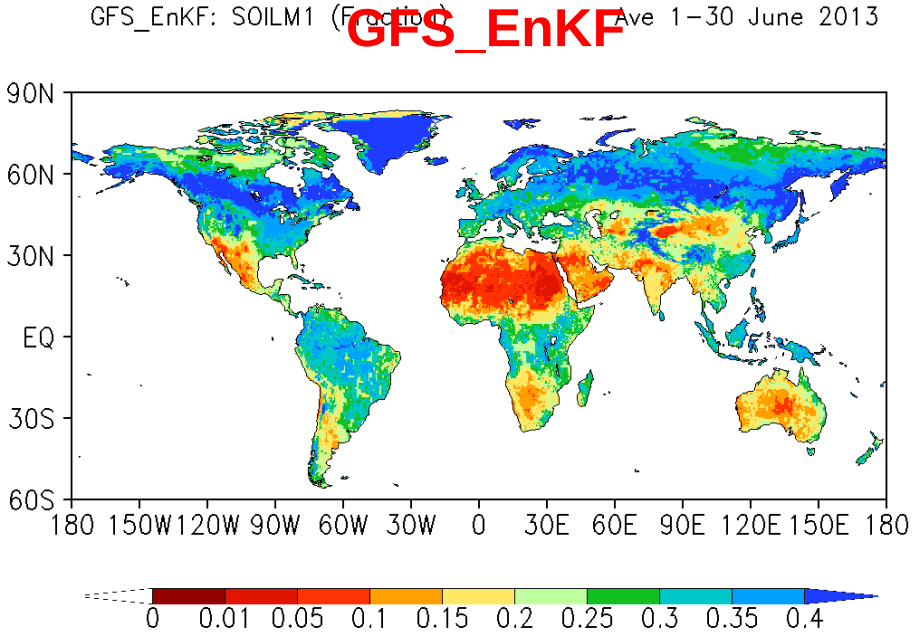


The Noah LSM multiple year grid-wise means and standard deviations are used to scale the surface layer soil moisture retrievals before assimilation (Zhan et al. 2012).

Comparison of soil moisture from AMSR2 and GFS tests for mean April 2013

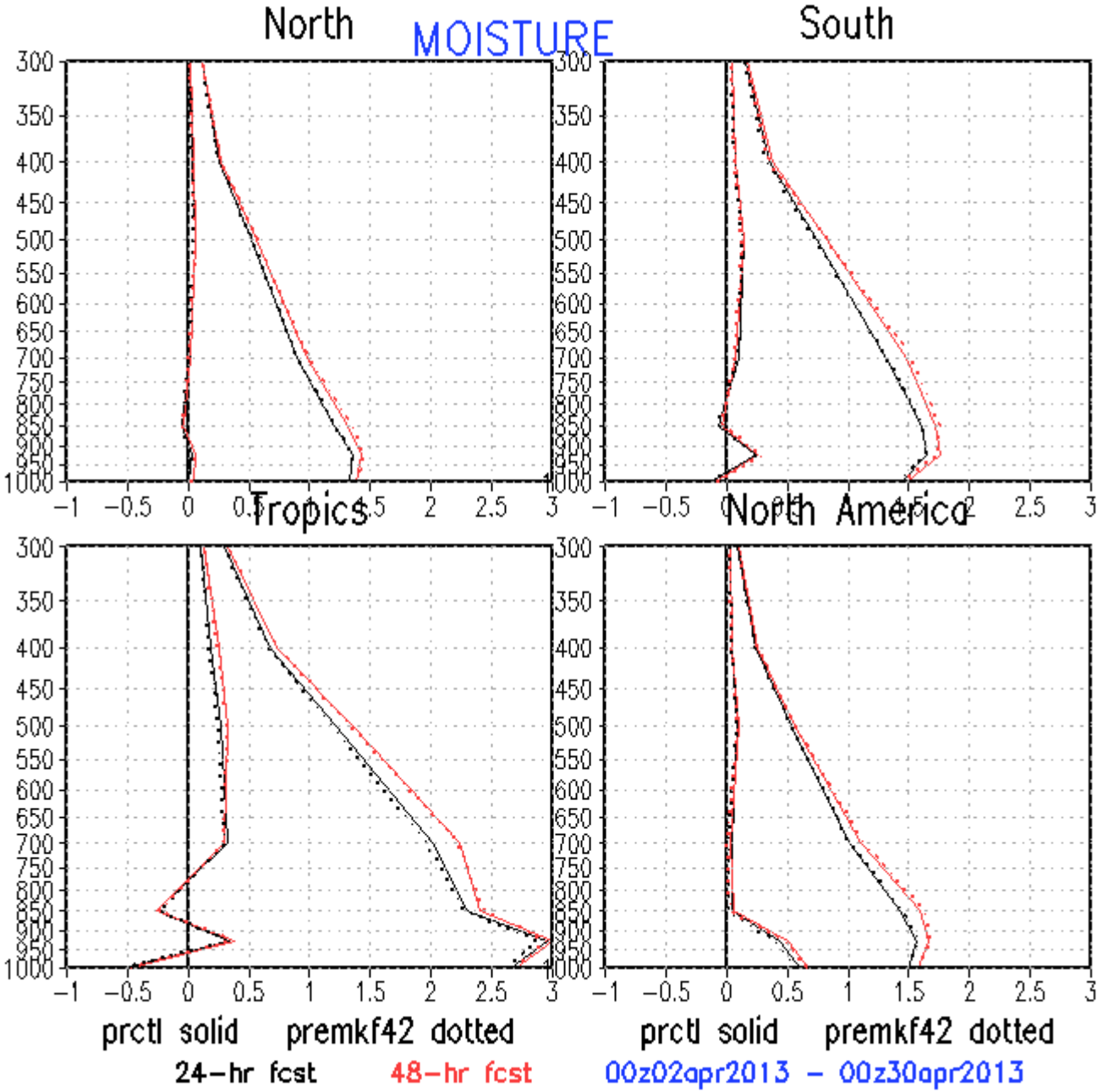






The Noah LSM multiple year grid-wise means and standard deviations are used to scale the surface layer soil moisture retrievals before assimilation (Zhan et al. 2012).

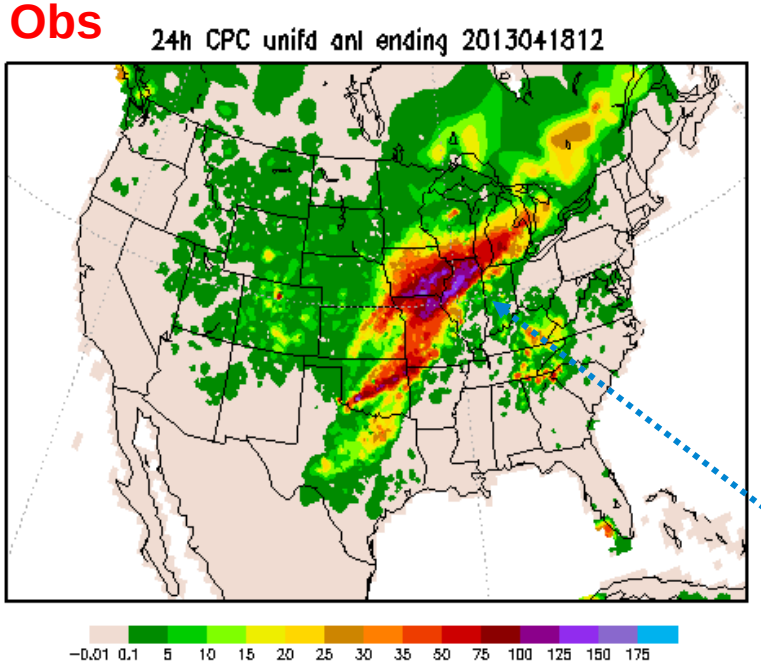
Moisture forecasts: Fit to the sounding (24 hr & 48 hr fcst)

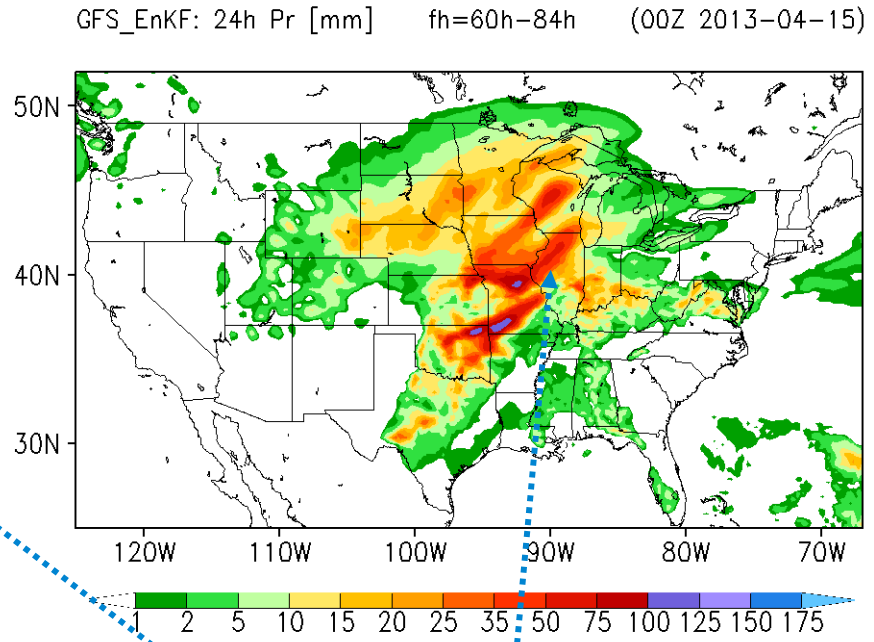


Slightly improved moisture profiles in Tropics and North America

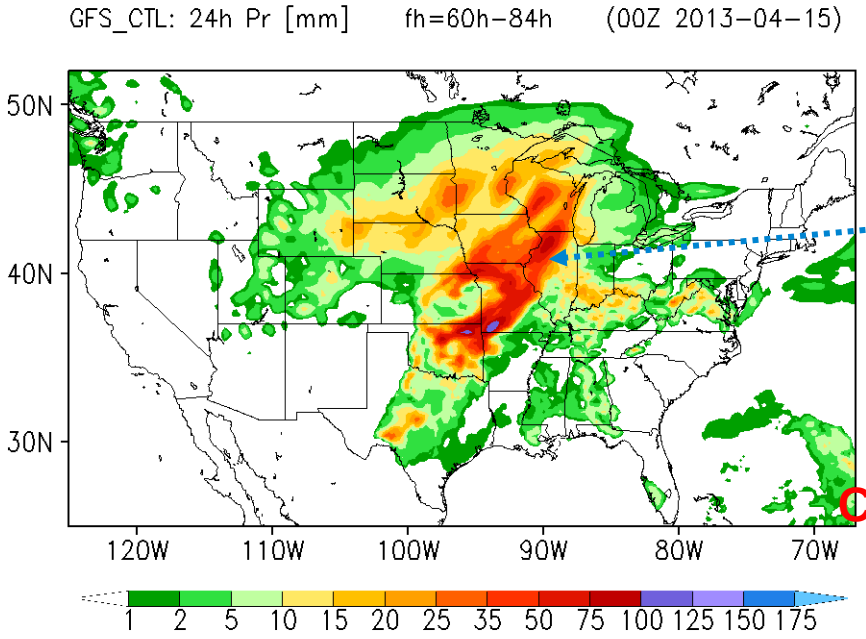
Precipitation forecast with AMSR2 24h Accum (mm) Ending at 12Z 18 Apr 2013

Obs





EnKF: 84-108h

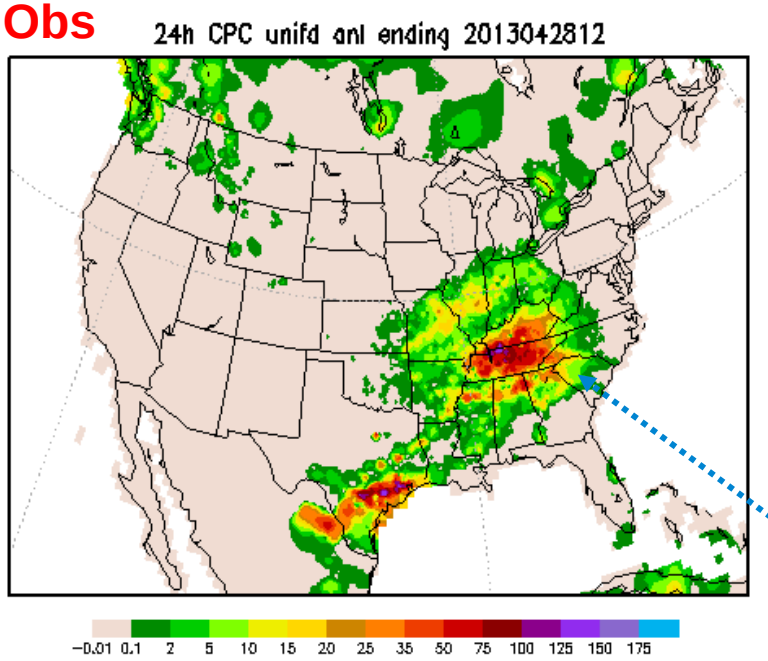


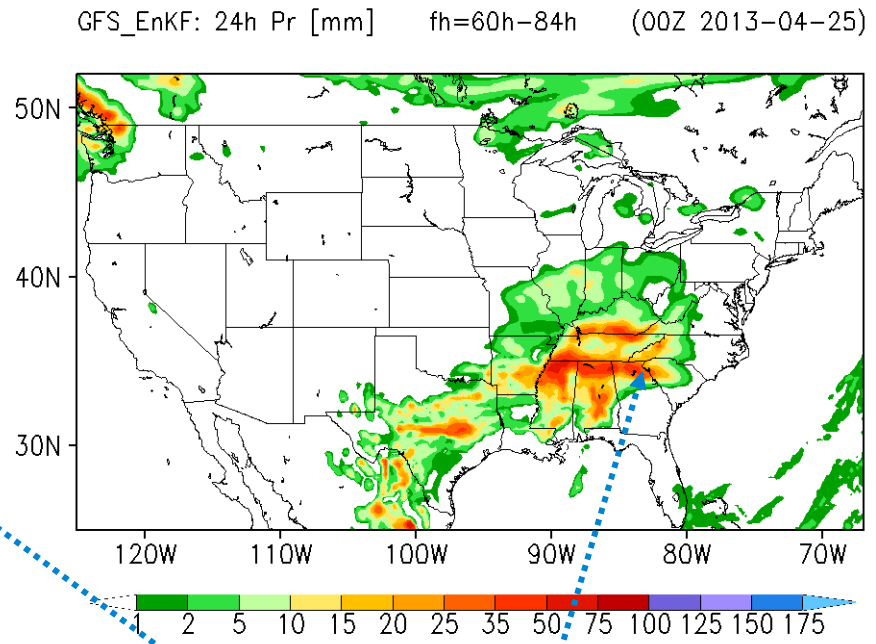
CTL: 84-108h

Slight intensity improvement

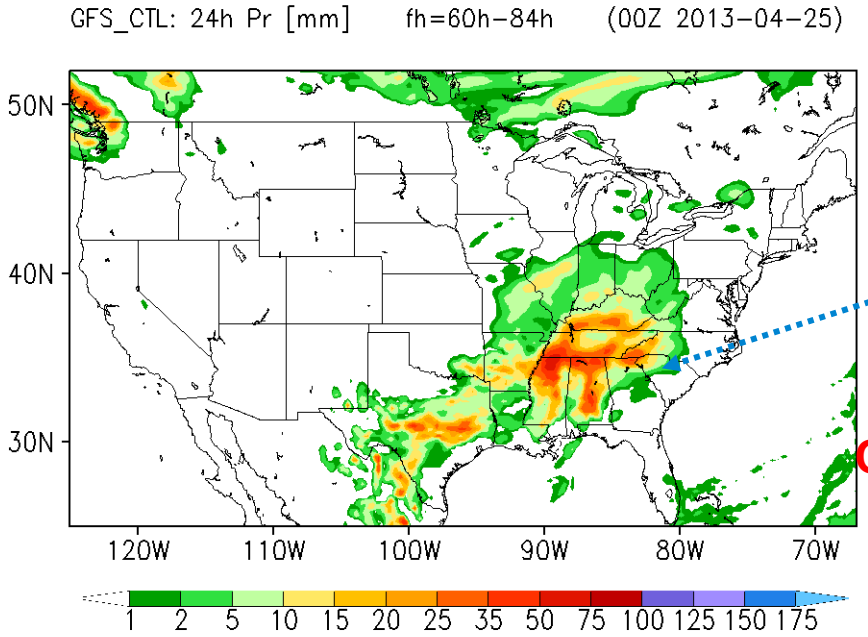
Precipitation forecast with AMSR2 24h Accum (mm) Ending at 12Z 28 Apr 2013

Obs





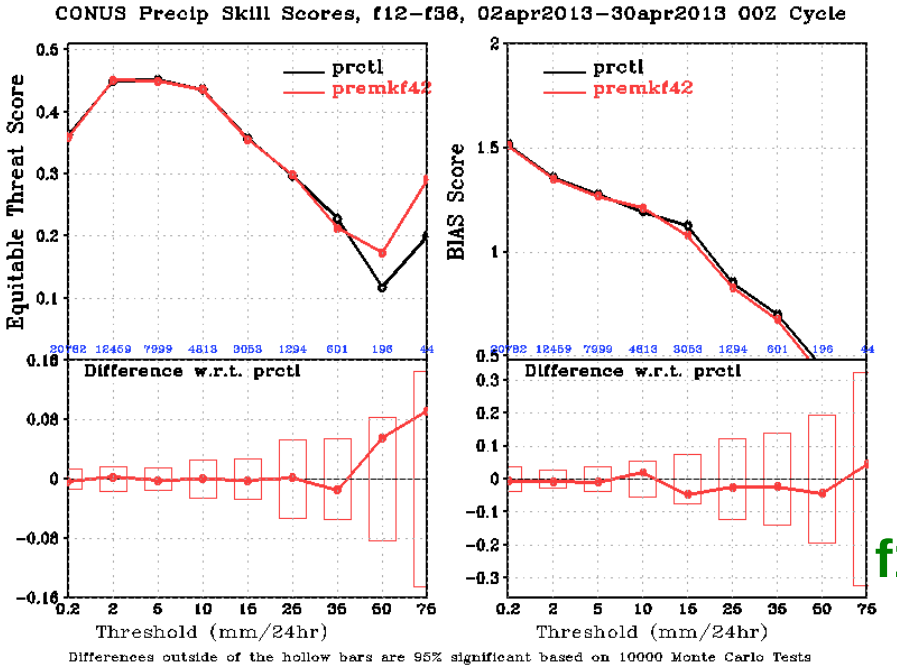
EnKF: 84-108h



CTL: 84-108h

Slight intensity improvement?

Precipitation Skill Scores over CONUS with AMSR2

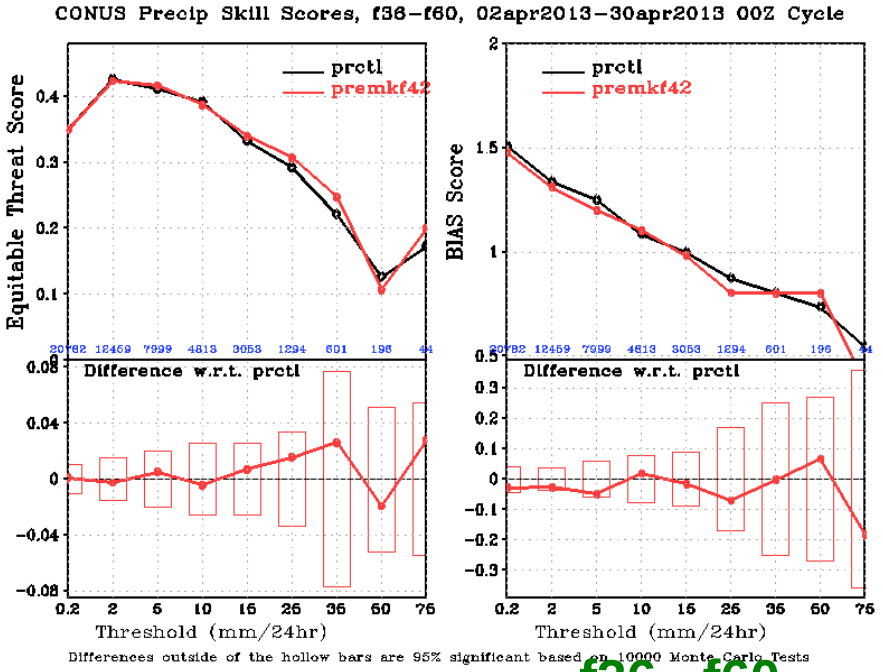


f12 - f36

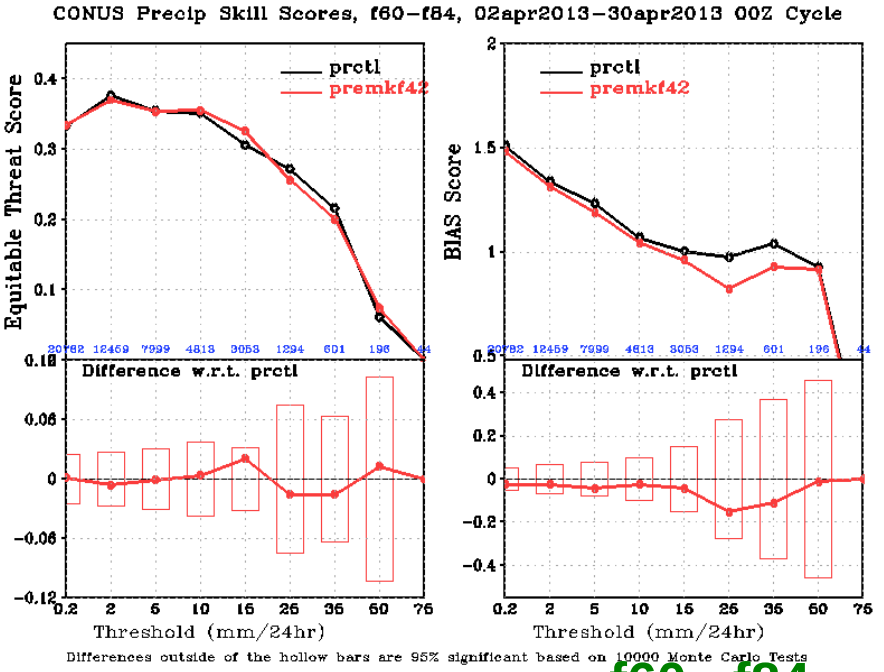
f12-f36: **Improved slightly the scores for heavy prec.**

f36-f60: **Improved slightly the scores and bias;**

f60-f84: **Improved slightly the bias.**



f36 - f60



f60 - f84

Summary:

The satellite soil moisture products from the blended SMOPS or AMSR2 were tested in NCEP GFS and the result shows as follows:

➔ ***The EnKF was embedded in the GFS model to assimilate soil moisture products.***

➔ ***SMOSP: improved GFS deeper layer soil moisture estimates comparing with in situ measurements; improved GFS anomaly correlation of Geopotential Height at 500 hPa and reduced its bias and root-mean-square error; showed some positive impact on precipitation on CONUS.***

➔ ***AMSR2: improved GFS moisture field; slightly improved precipitation on CONUS.***

➔ ***Future:***

(a) Merge AMSR2 to SMOPS blended products;

(b) Assimilate SMAP (remote sensing);

(c) Validate against COSMOS & other in situ measurements.