# Application of Satellite Land Surface Observations in Improving NCEP Numerical Weather Prediction


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**The 12th JCSDA Technical Review Meeting & Science Workshop, May 21-23, 2014**

***<u>Objective:</u>*** ***To improve satellite data utilization over land in NCEP data assimilation system and then improve the numerical weather prediction (NWP).***

## *Land satellite data assimilation:*

- **<u>Utilization of satellite data sets in the models</u> (e.g., *GVF, snow, burning area, albedo, vegetation and soil type*)**

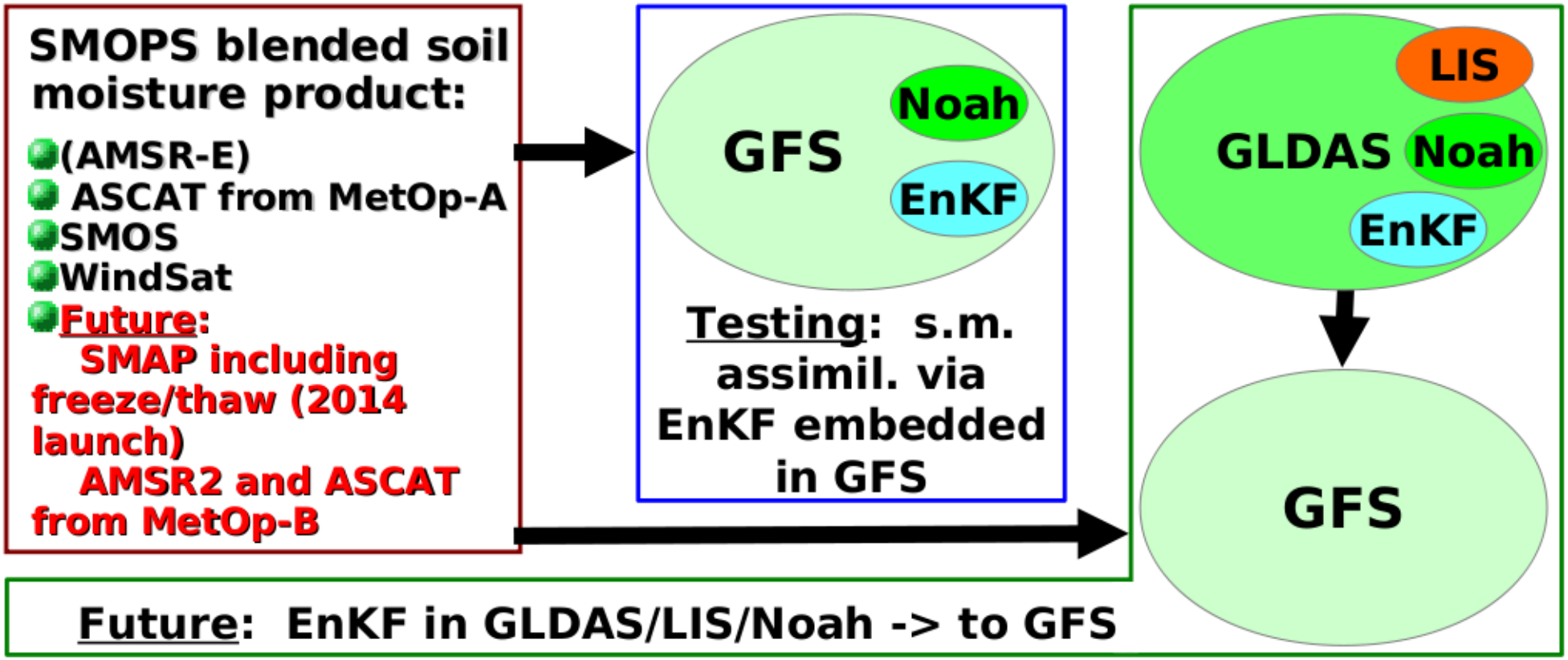
- **<u>Assimilation of satellite products</u> (e.g, Soil moisture: *AMSR2 data; snow*);**

- **<u>Direct radiance assimilation (Tb)</u>**

  **Requiring a forward radiative transfer model (RTM) to calculate Tb with input of model *atm* profiles and *sfc* parameters.**

  **Surface-sensitive channels Tb simulation over land:**
  **(a) *Sfc parameters* such as LST and soil moisture;**
  **(b) *Sfc emissivity* (IR/MW)**
  **(c) *Sub-grid scale land surface*.**

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




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

**Cooperators: Xiwu Zhan & Jicheng Liu (NESDIS/STAR)**

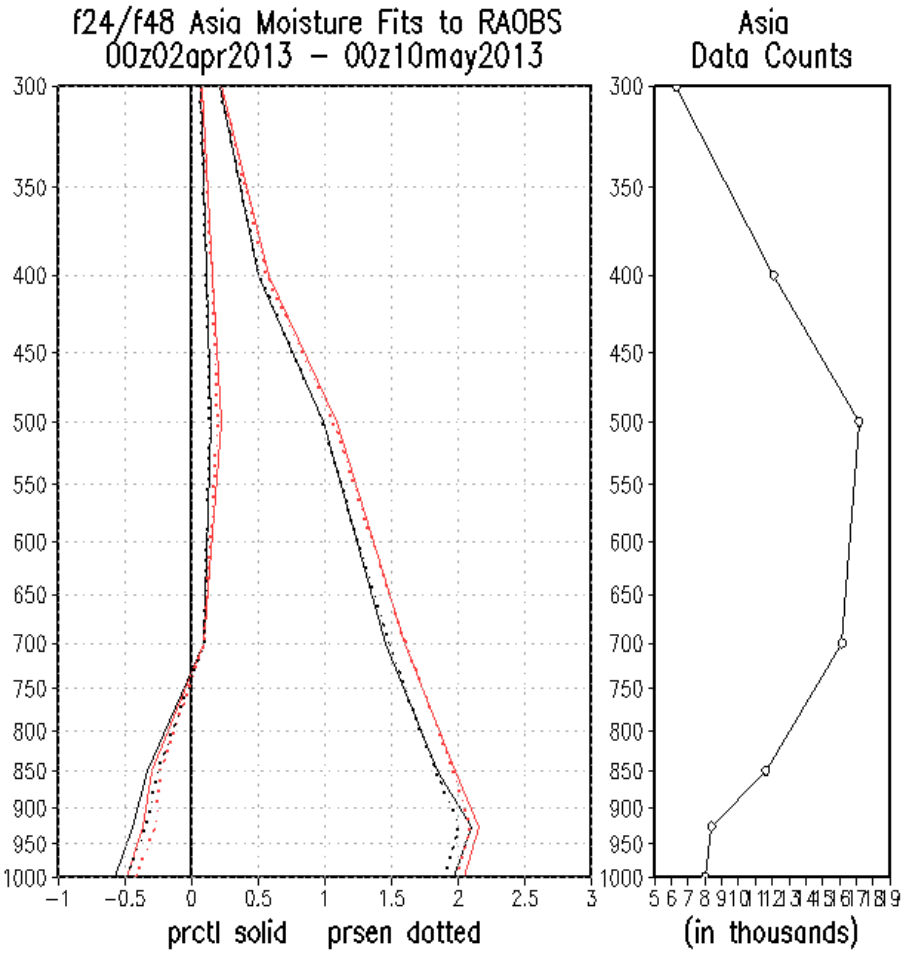
## *Assimilation of Satellite Soil Moisture Product from AMSR2 in NCEP Global Forecast System*

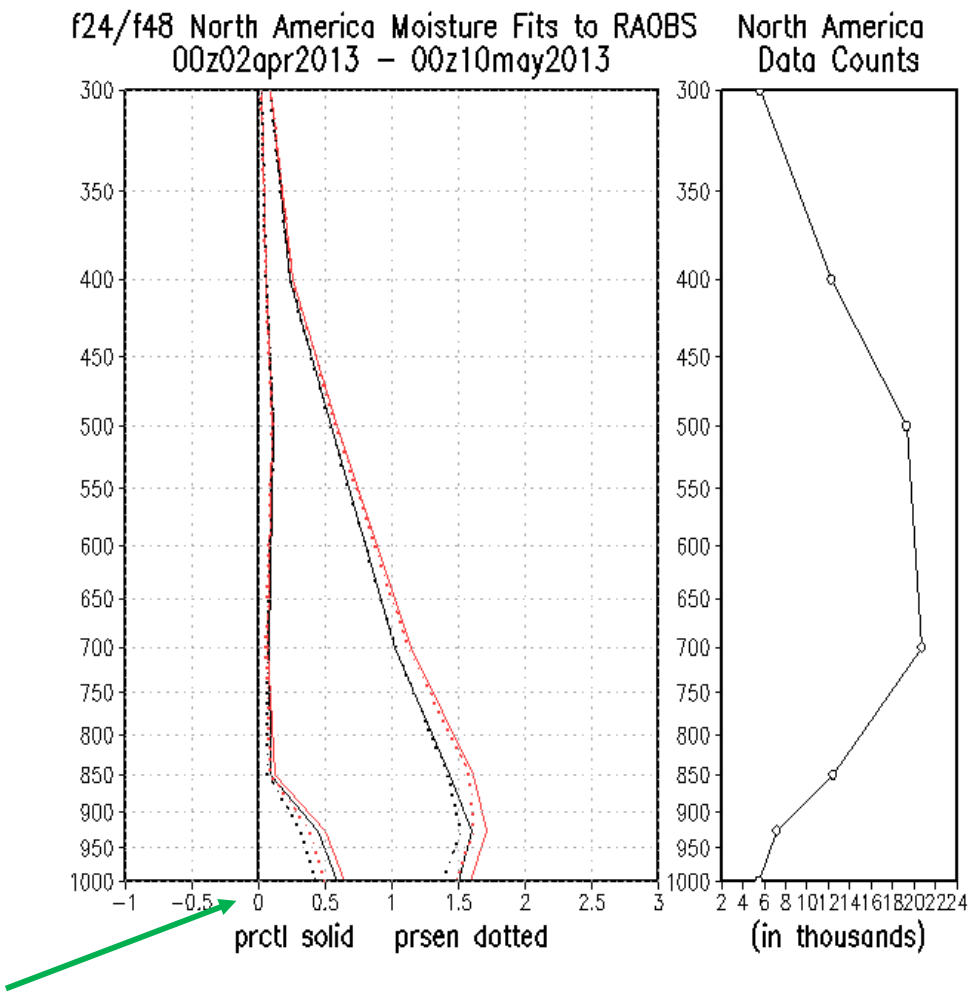
- **Case: Starting from 00Z April 1–May 10, 2013. (GFS/GSI)**

- **Experiments:**
  **CTL: Control run**
  **EnKF: Sensitivity run (20 ensemble members)**
  **And precipitation perturbation.**

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

# *Moisture fits to RAOBS: f24 and f48: Asia and North America*

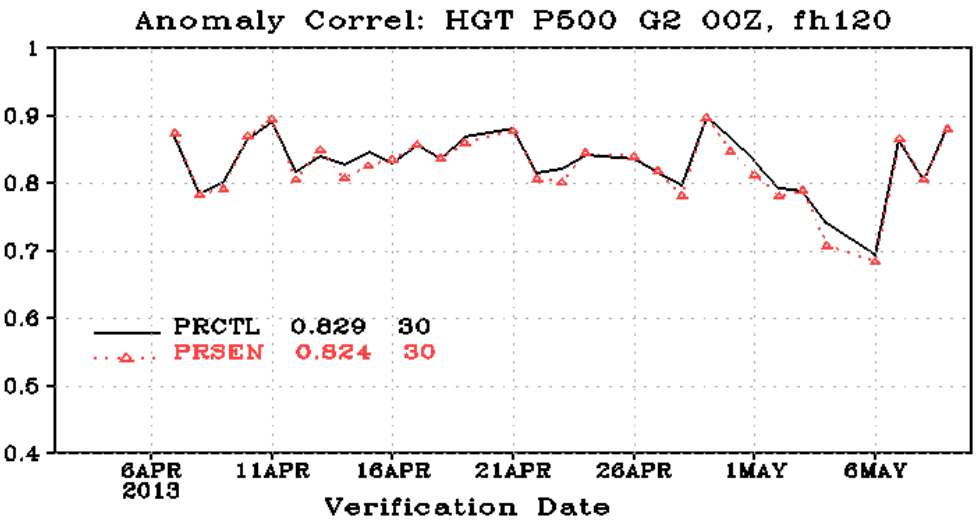


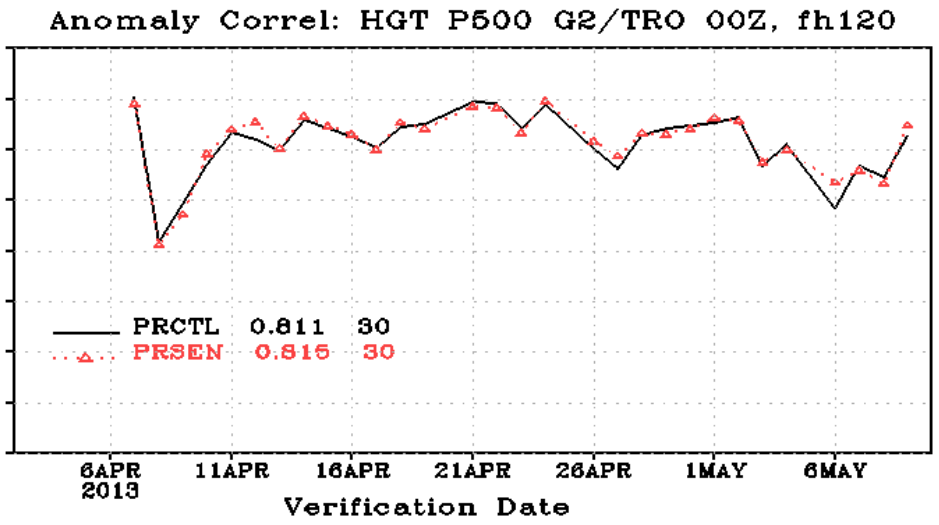

**Bias and rmsq reduced in the lower atmosphere**

# *Analysis on Anomaly Correlation at 500 hPa: Day5*

## Global



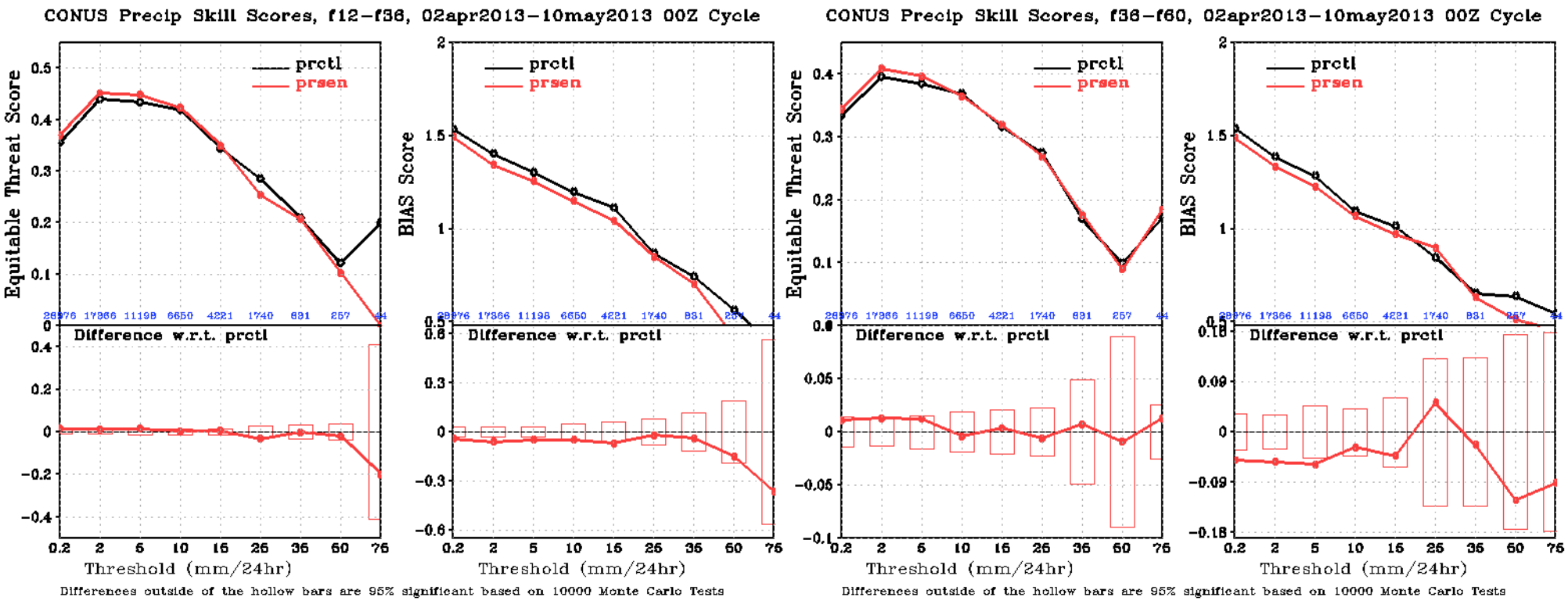

## Tropics




Slightly improved the scores in the tropical but slightly degraded in globally

# *Precipitation Skill Scores over CONUS: f12-f36 and f36-f60*

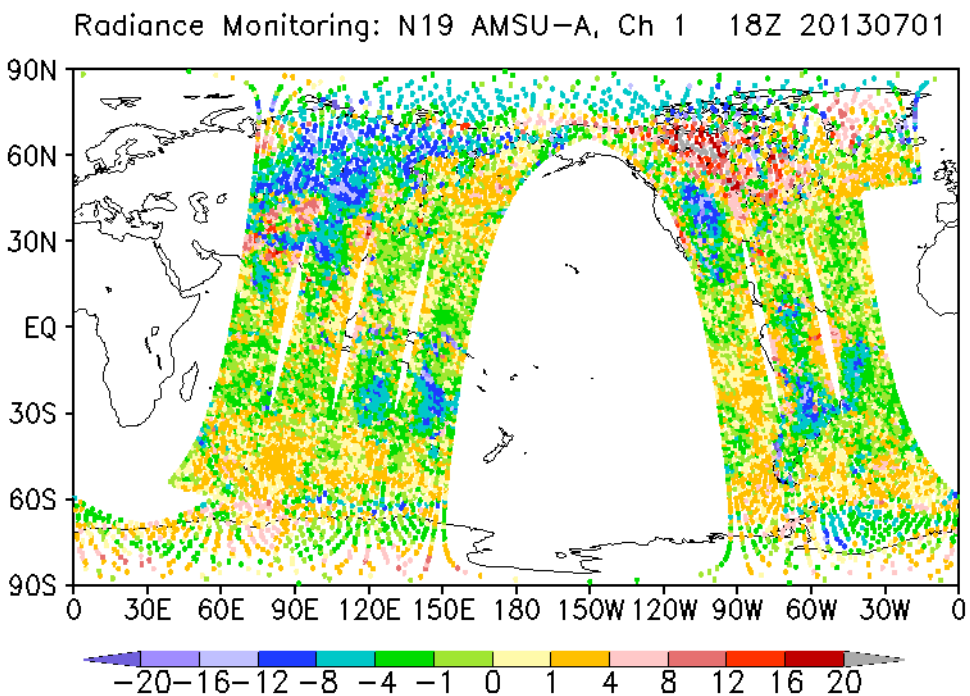
**f12 - f36** **f36 - f60**




***f36-f60 & f60-f84:*** Slightly improved the scores for light and medium precipitation and reduced the biases

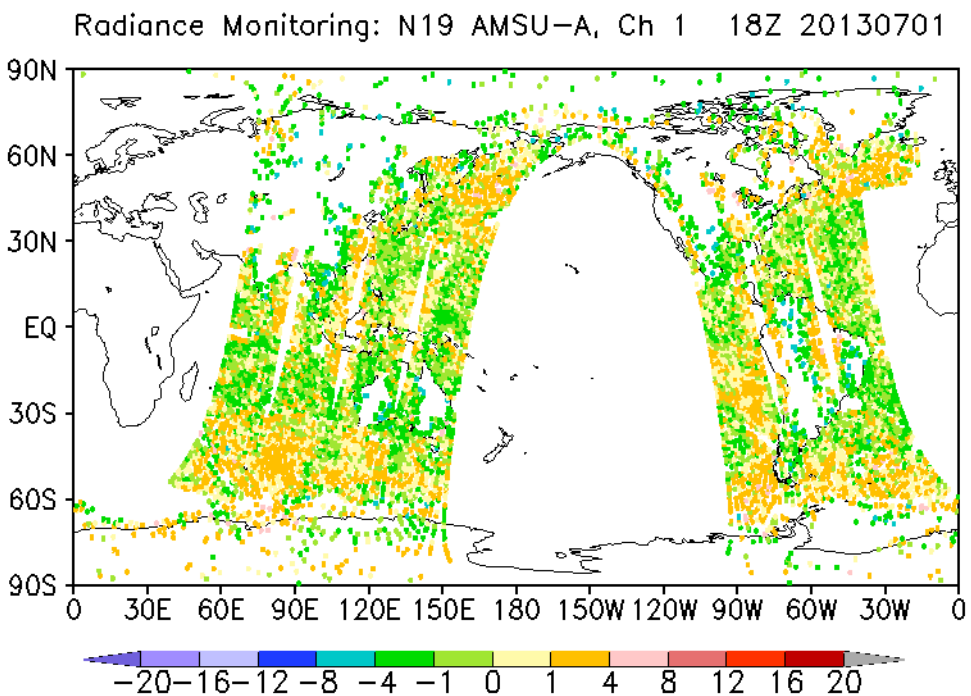
# Sub-grid Scale Problem in Brightness Temperature Simulation

**Ops Radiance Monitoring:** **NOAA-19 AMSU_A Ch1** **18Z July 1, 2013**



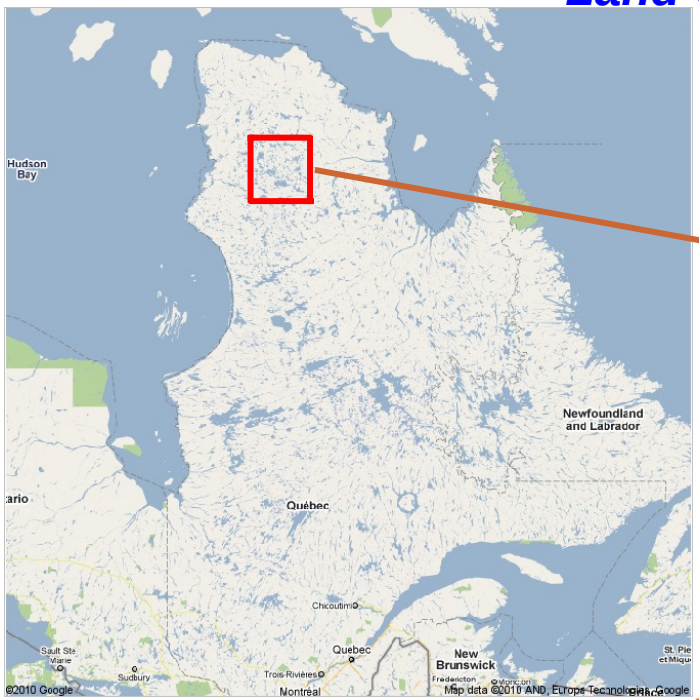

**Cold Tb bias** **Warm Tb bias**

***Tb simulation bias: all data***

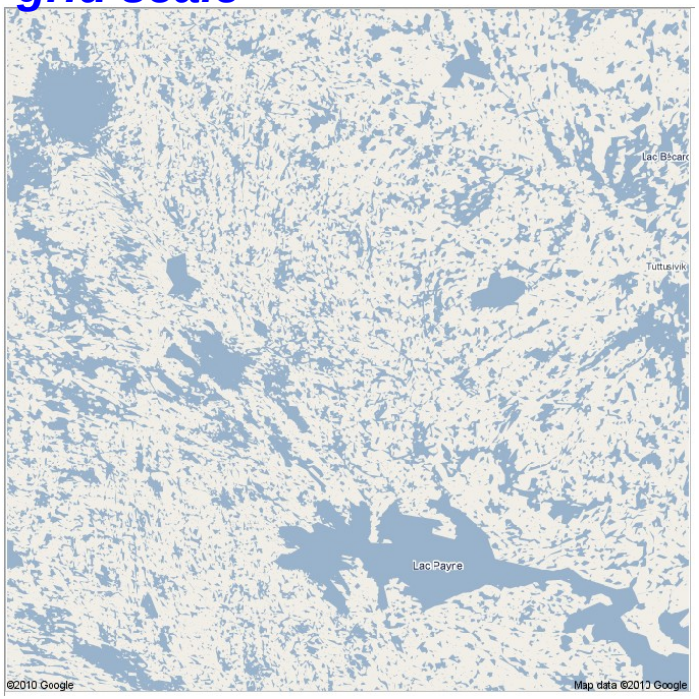



***Assimilated data in GSI***

# Land Cover: Sub-grid scale




Google Map

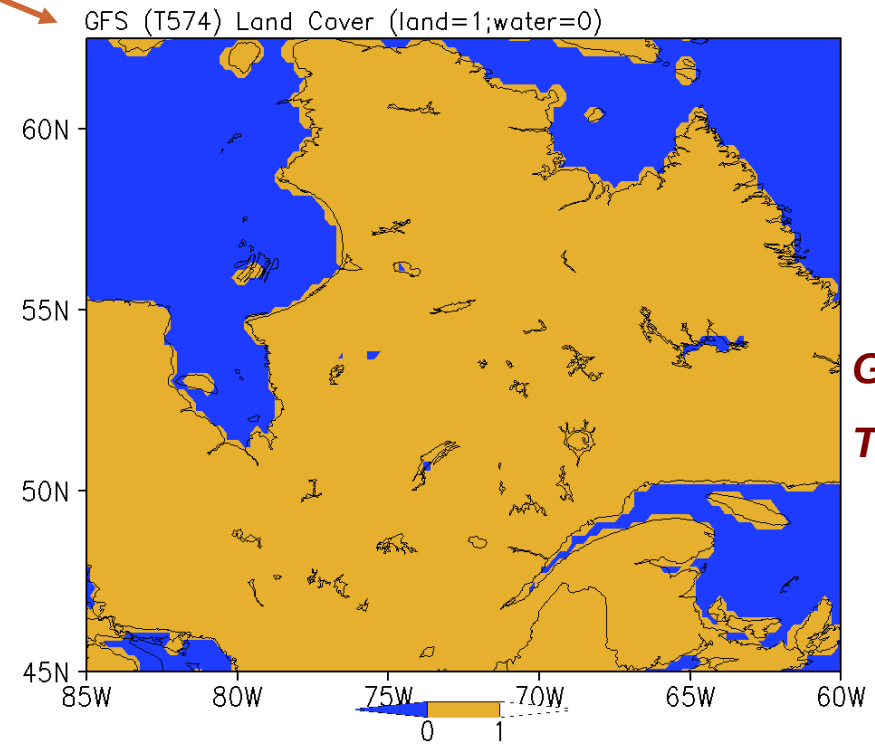



Many lakes included in GFS grid boxes

**Tsfc & ε ==> Tb**

Lakes: create strong cold signal, masking soil signal.

**Diff SH/LH**




GFS T574

# Determine land surface type and interpolate surface fields:

- ***Bi-linear interpolation***

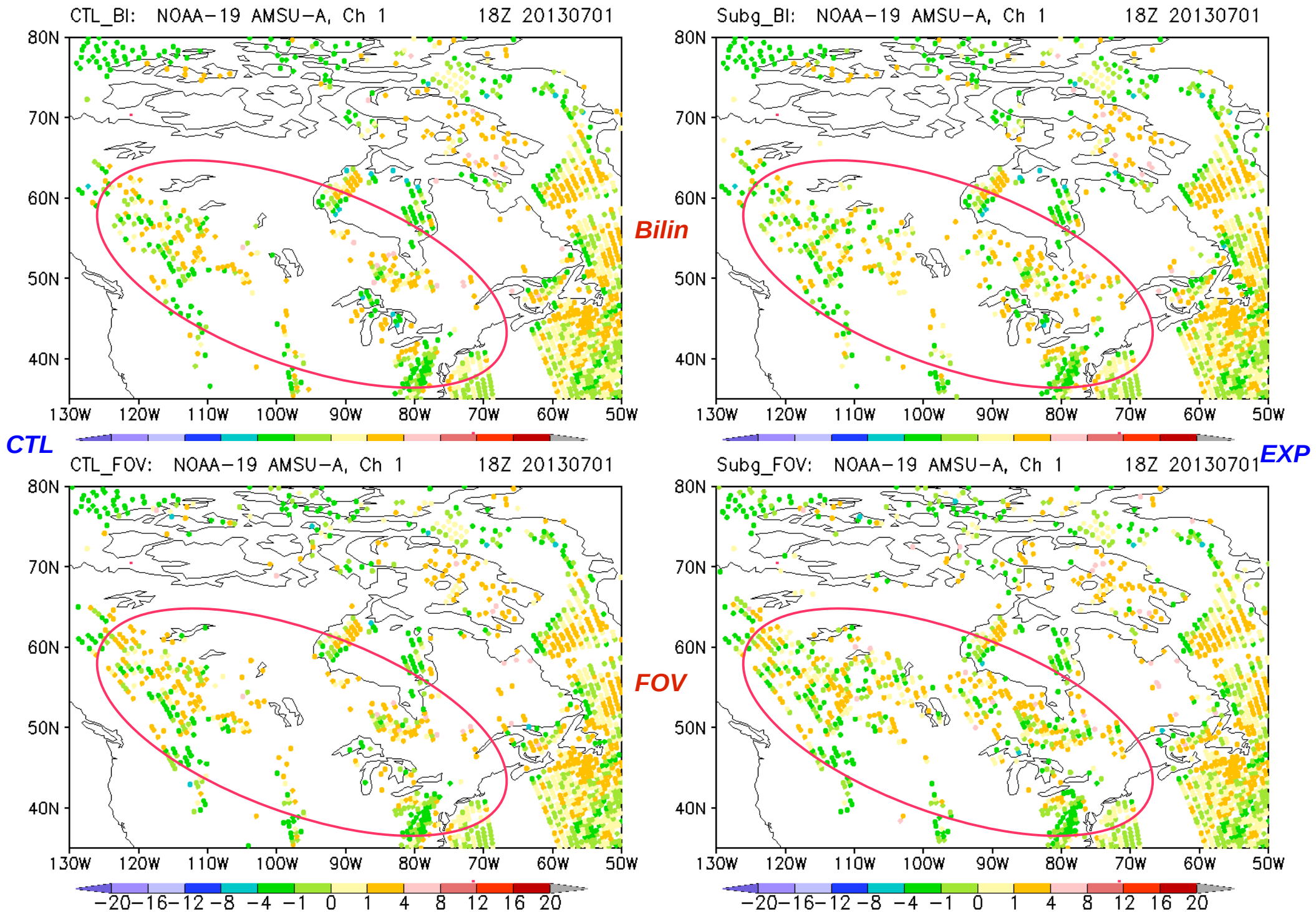
**Uses bi-linear interpolation of continuous fields and predominate category for others.**

- ***FOV method by George Gayno et al.***

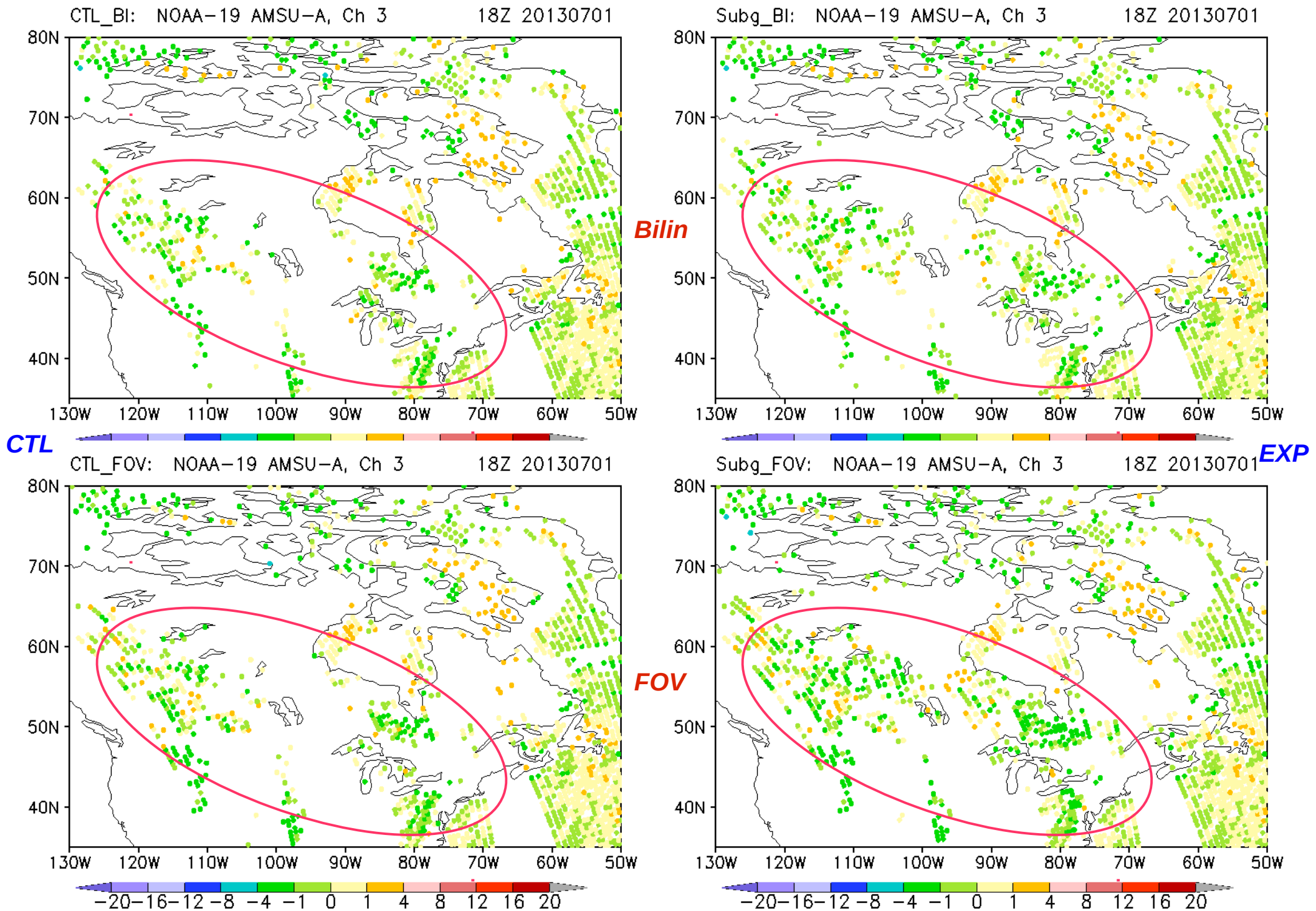
**Determines surface characteristics within a field of view based on model information and the size/shape of the field of view (FOV).**

**Sensors: AMSU-A/B, ATMS, HIRS, MSU, MHS, AVHRR, AIRS, SSMI/S, AMSR-E.**

# Assimilated data with sub-grid scale: Bilinear/FOV N19 AMSU_A Ch1 18Z 7/1/2013



# Assimilated data with sub-grid scale: Bilinear/FOV N19 AMSU_A Ch3 18Z 7/1/2013



# Comparison of GVF between VIIRS and Climatology

***Climatology data:*** *(Gutman & Ignatov, 1998)*

- 5 year mean monthly climatology from AVHRR;
- Resolution: 0.144 degrees (~16km);
- Period: April 1985 – March 1991 (1988 excluded)

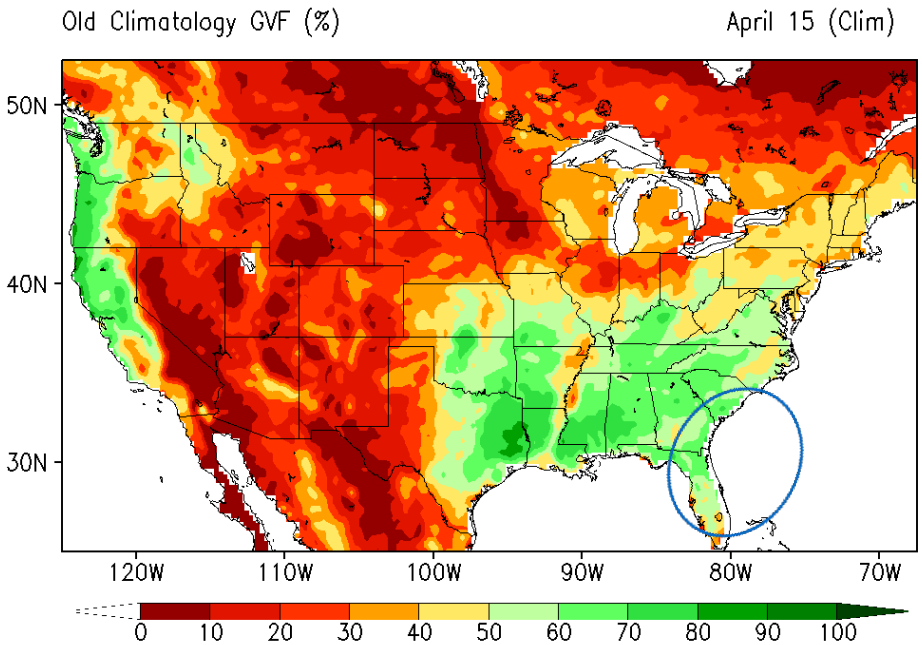
***VIIRS weekly real-time data:***

*By Marco Vargas et al. (see Zhangyan Jiang's poster)*

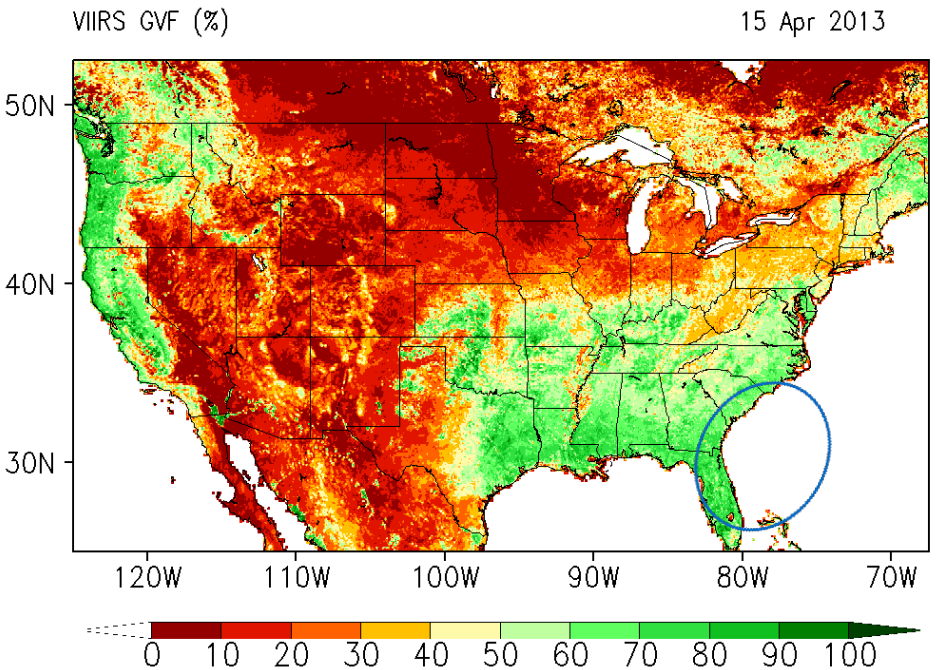
- Weekly real-time;
- Resolution: 0.036 degrees (~4km, global) & 0.009 degrees (~1km, regional)
- Algorithm: Uses VIIRS red (I1), near-infrared (I2) and blue (M3) bands centered at 0.640 µm, 0.865 µm and 0.490 µm, respectively, to calculate the Enhanced Vegetation Index (EVI) and derive GVF from EVI.

# Comparison of GVF between VIIRS (0.036) and Clim (0.144): Spring

***Clim***




***VIIRS***

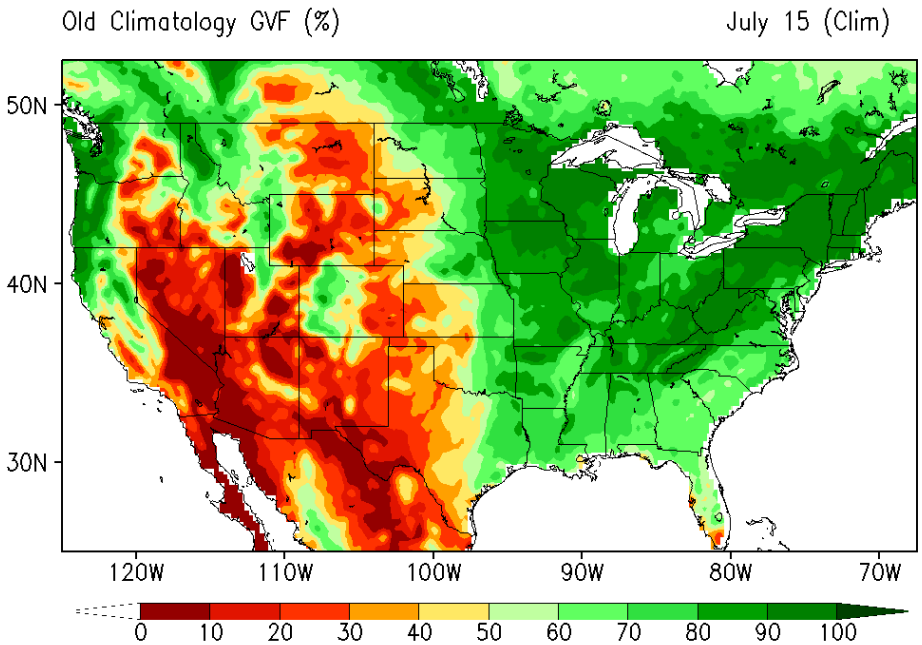



***Note: GVF in Midwestern US from VIIRS is much lower than that from Clim. Data, while quite green in Florida and near the east coast lines.***

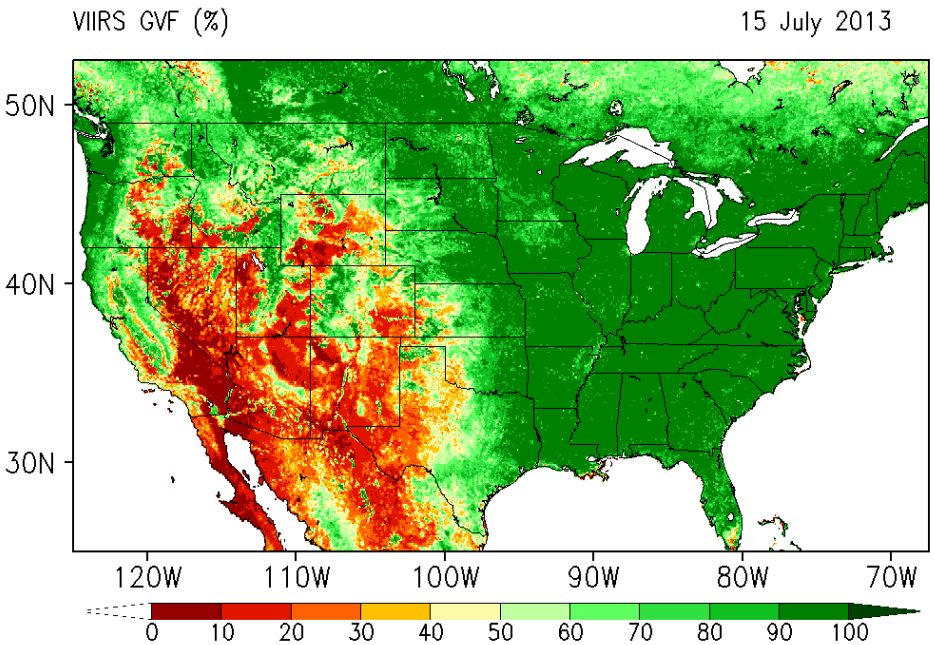
**R. Seigel (University of Miami; April 14, 2014):**
**What is going on in South Florida? It is quite green down here!**

# Comparison of GVF between VIIRS (0.036) and Clim (0.144): Summer

***Clim***



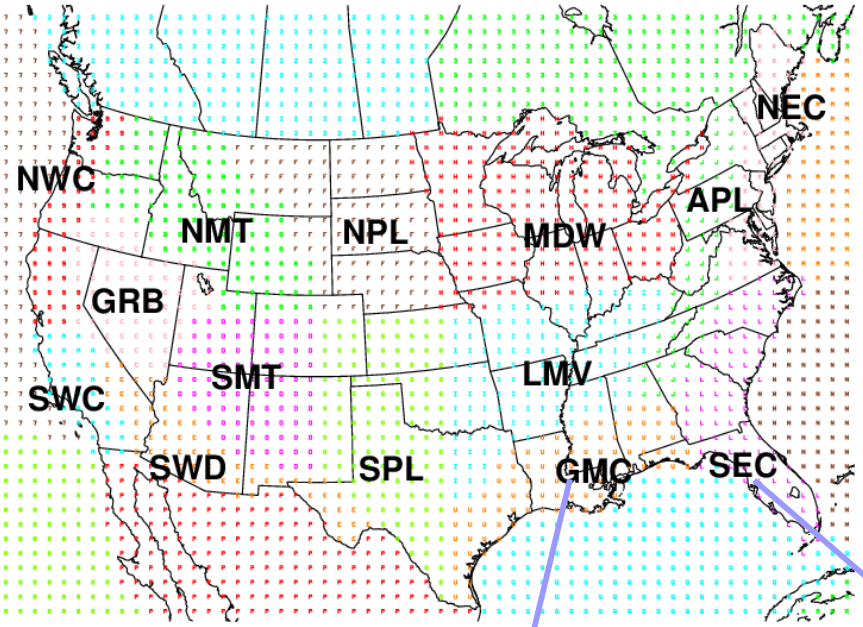

***VIIRS***

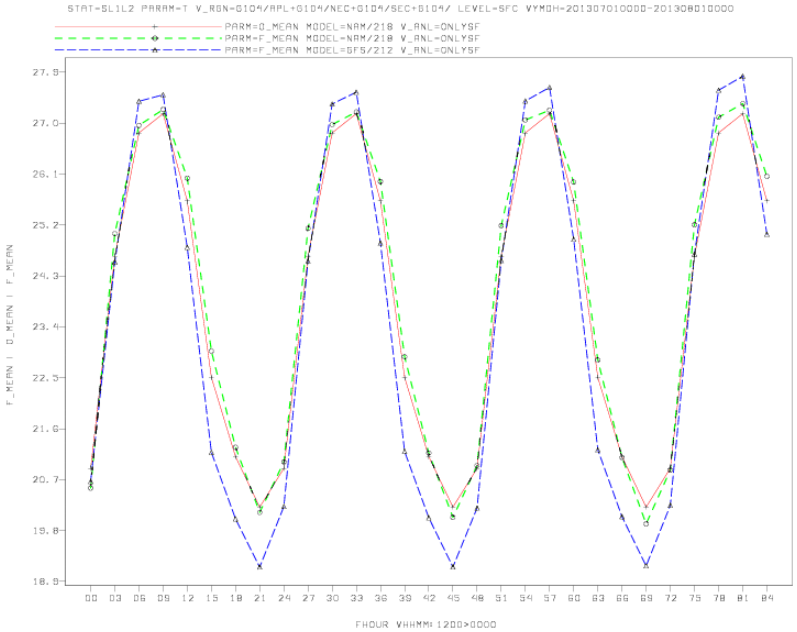



***Note:***

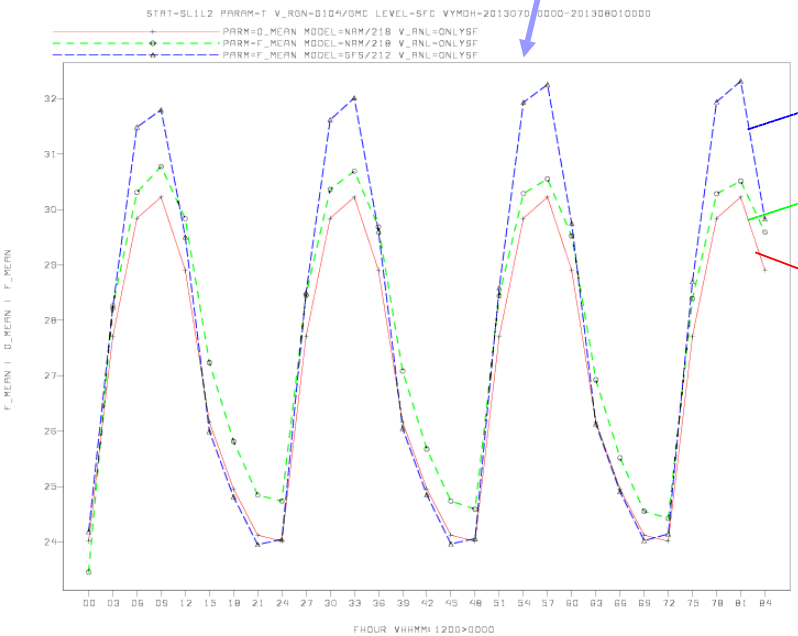
***VIIRS GVF in North-western & South-eastern US is higher than Clim. Data.***

# Near-Surface Forecast Verification Statistics for Ops NCEP models: July 2013



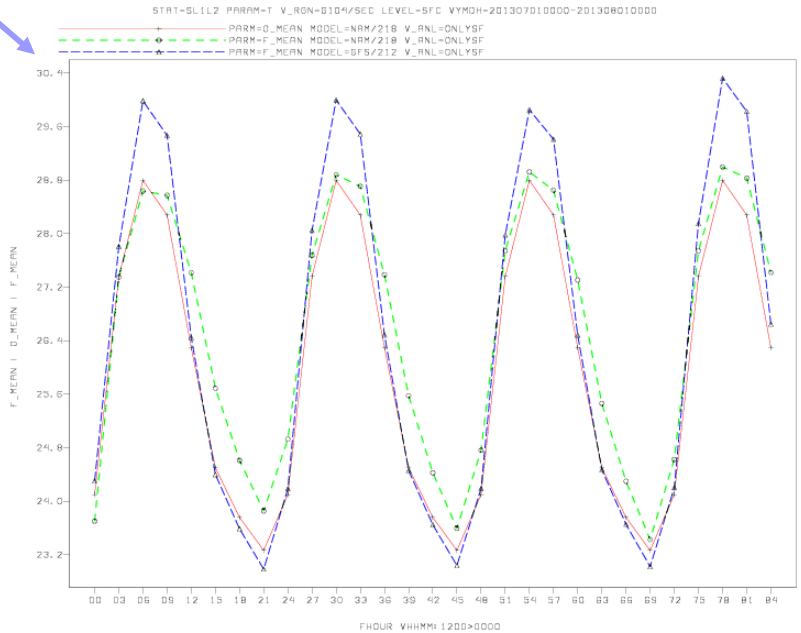

*East CONUS*




*GFS*

*NAM*

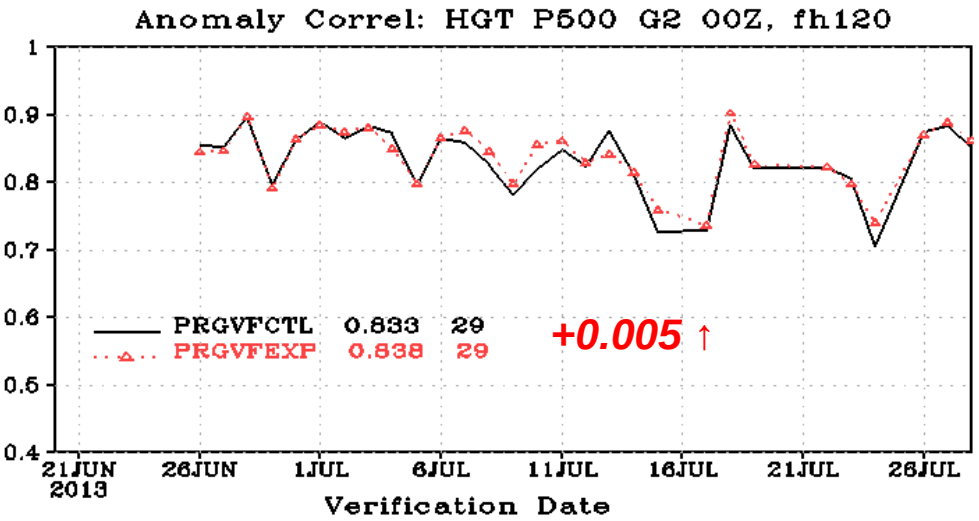
*Obs*

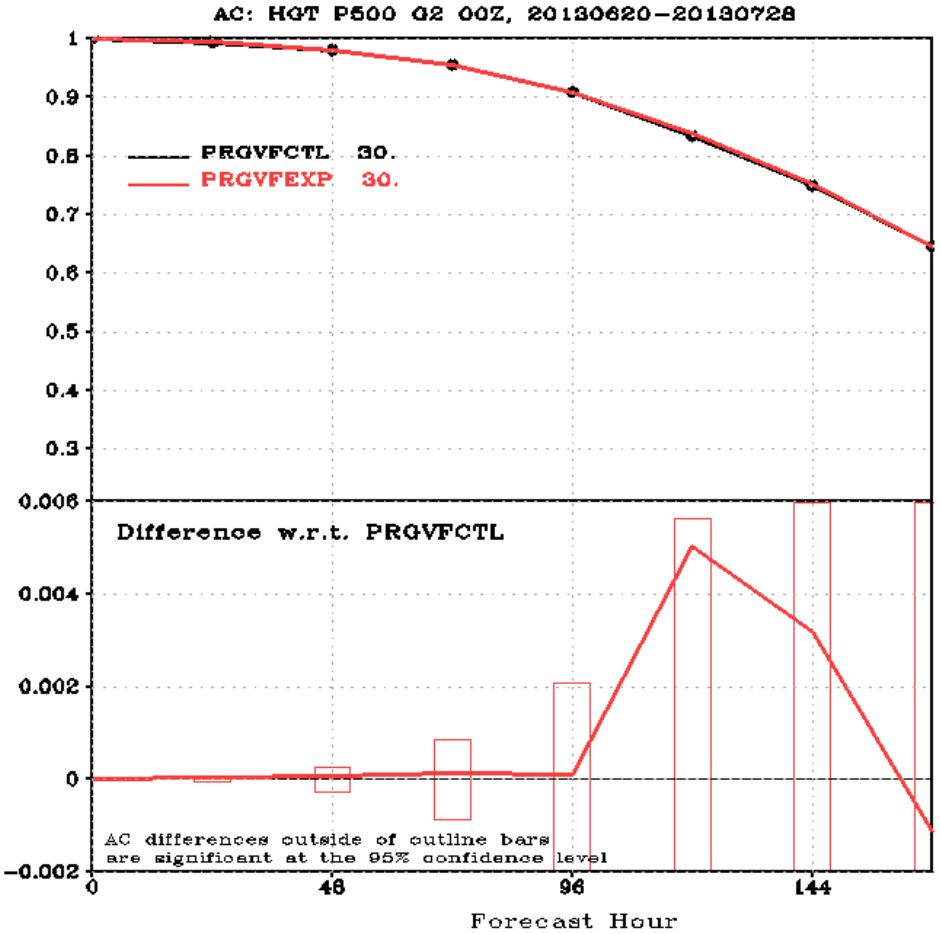



***GMC: 1.5-2 °C GFS daytime warm bias***

***SEC: 1-1.5 °C GFS daytime warm bias***

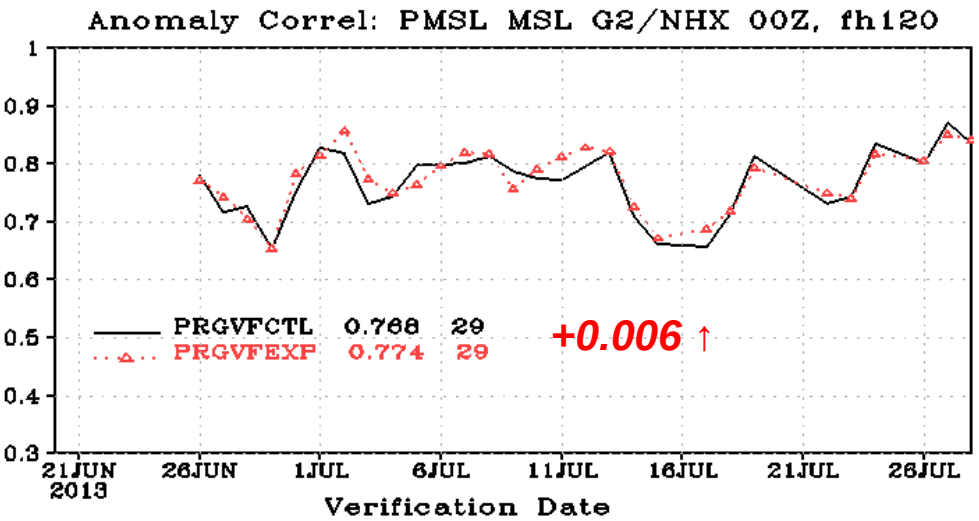
# *Analysis on Anomaly Correlation at 500 hPa: Day5*

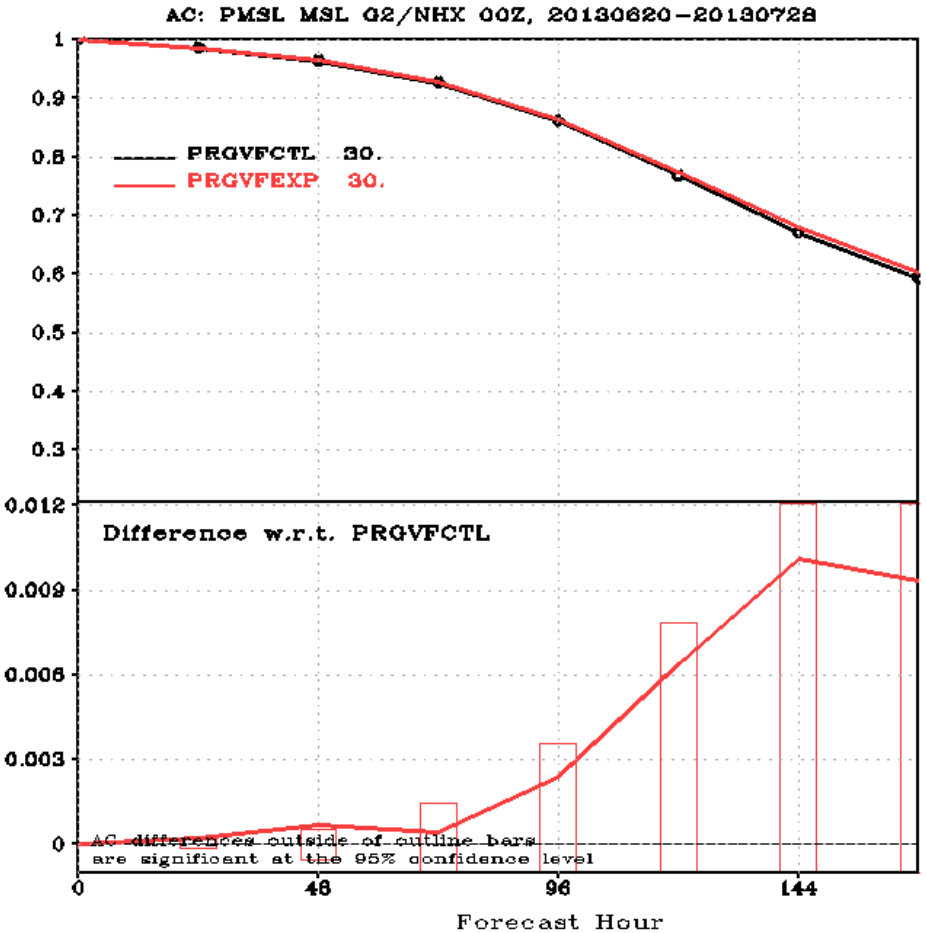



**Slightly improved the AC scores at 500 hPa in globally.**

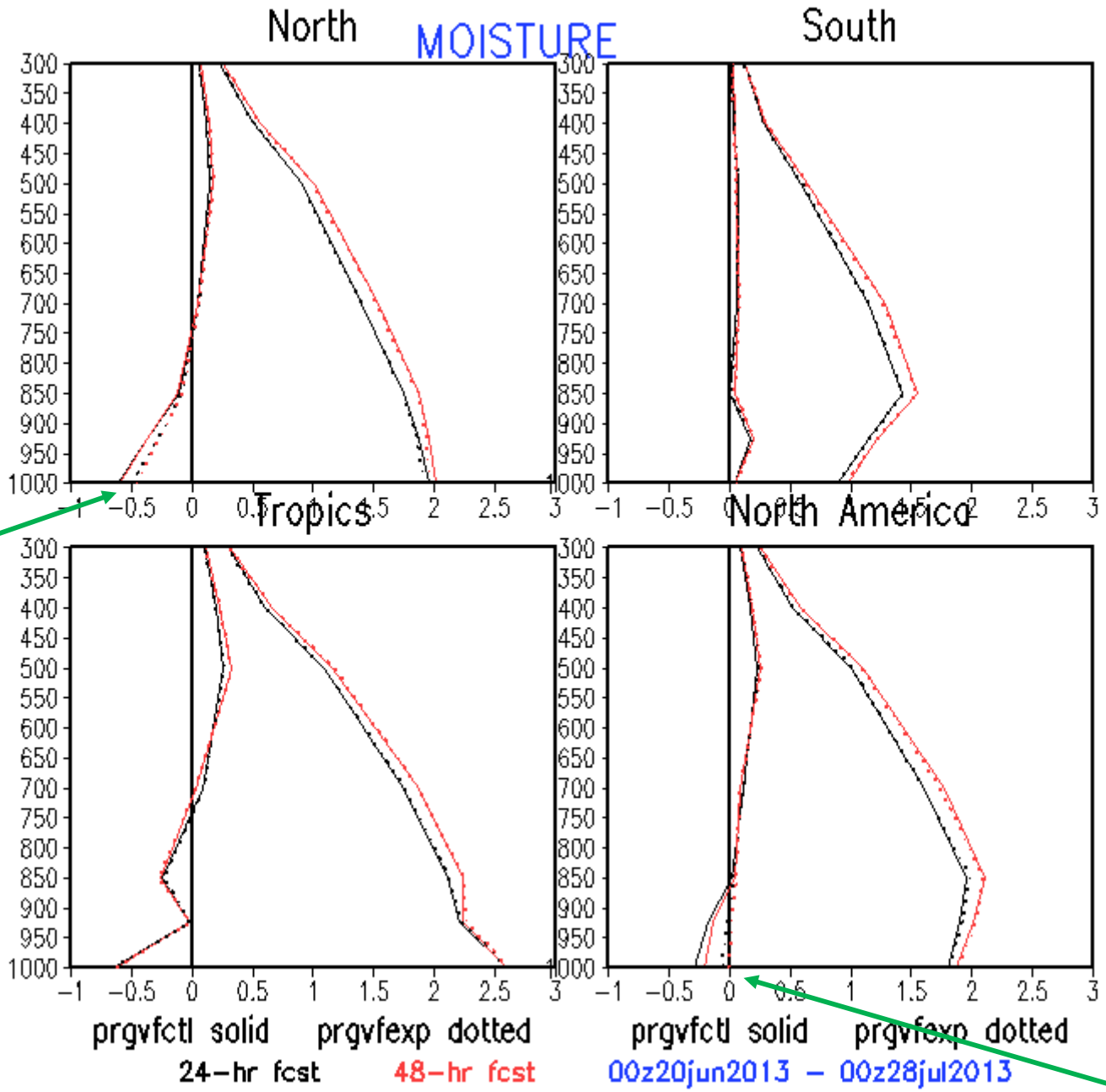
# *Analysis on Anomaly Correlation at PMSL: Day5*



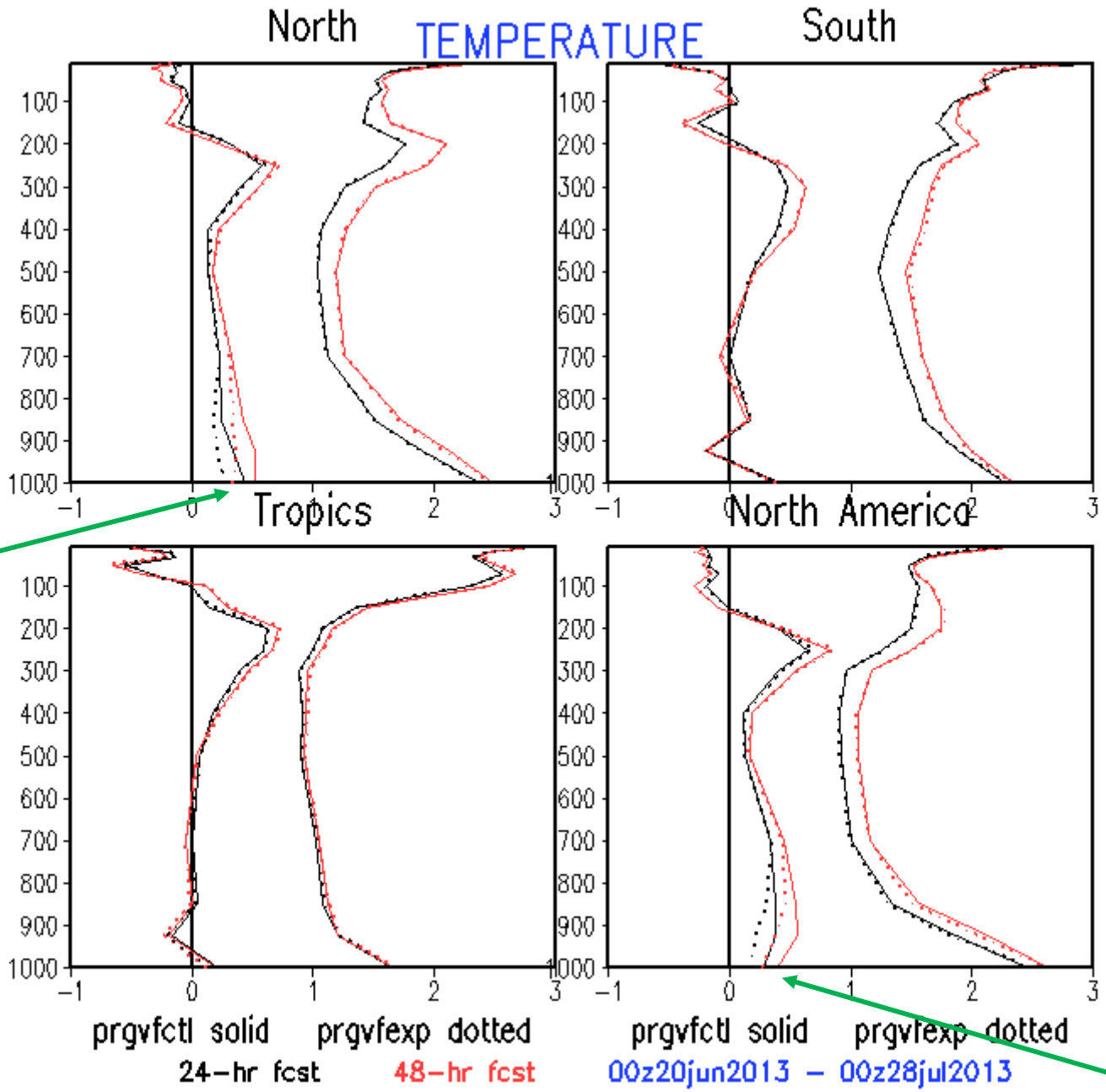

**Good improvement of the PMSL scores in NH.**

# *Moisture fits to RAOBS: f24 and f48*



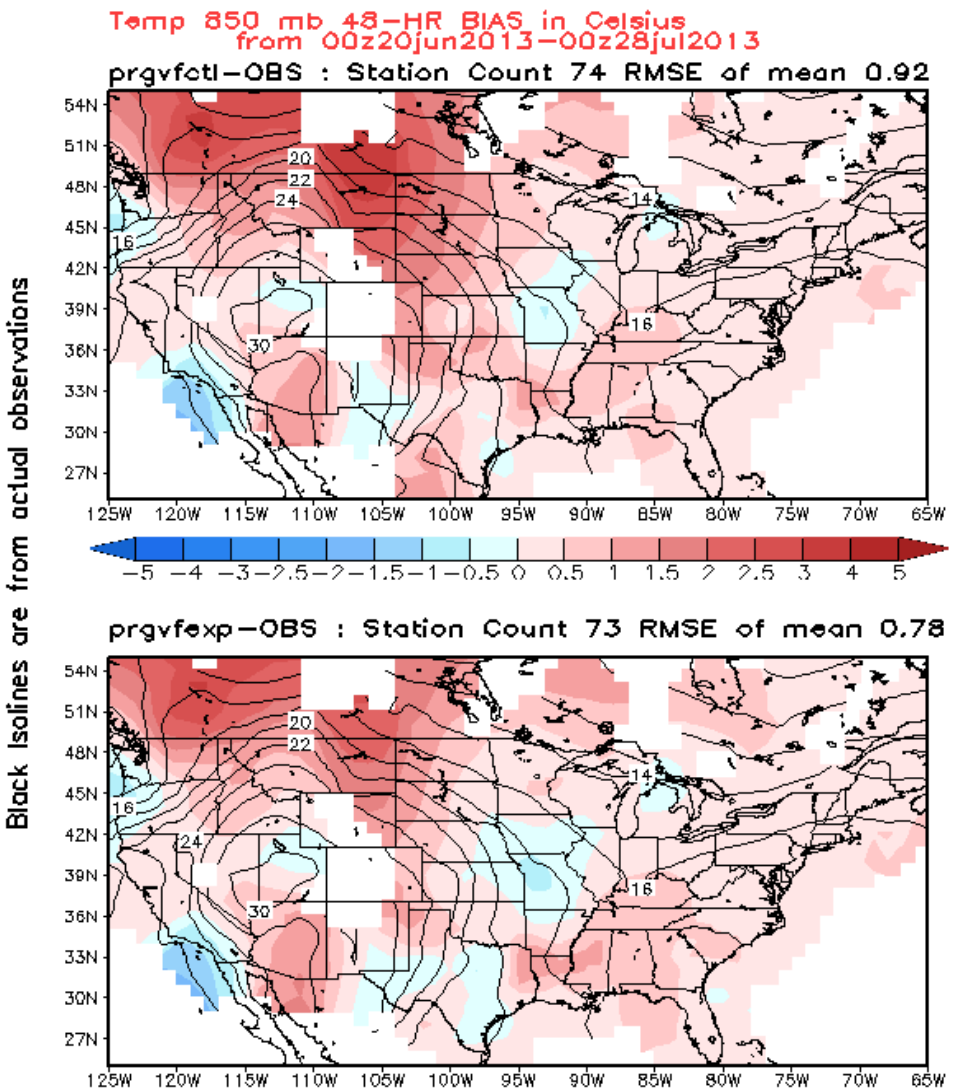

**Bias reduced in the lower atmosphere**

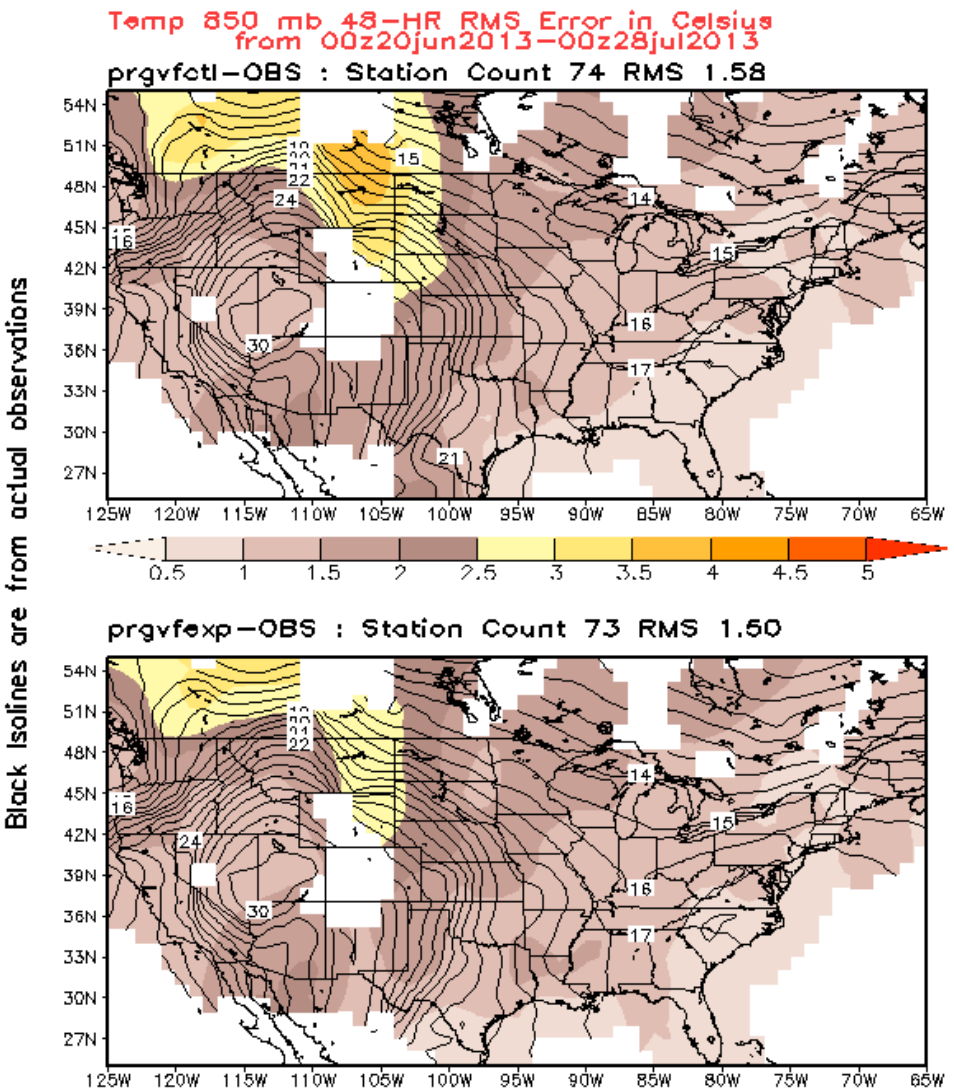
# *Temperature fits to RAOBS: f24 and f48*




**Reduction of warm bias near the surface.**

# Temperature 850 mb 48-h BIAS and RMSE

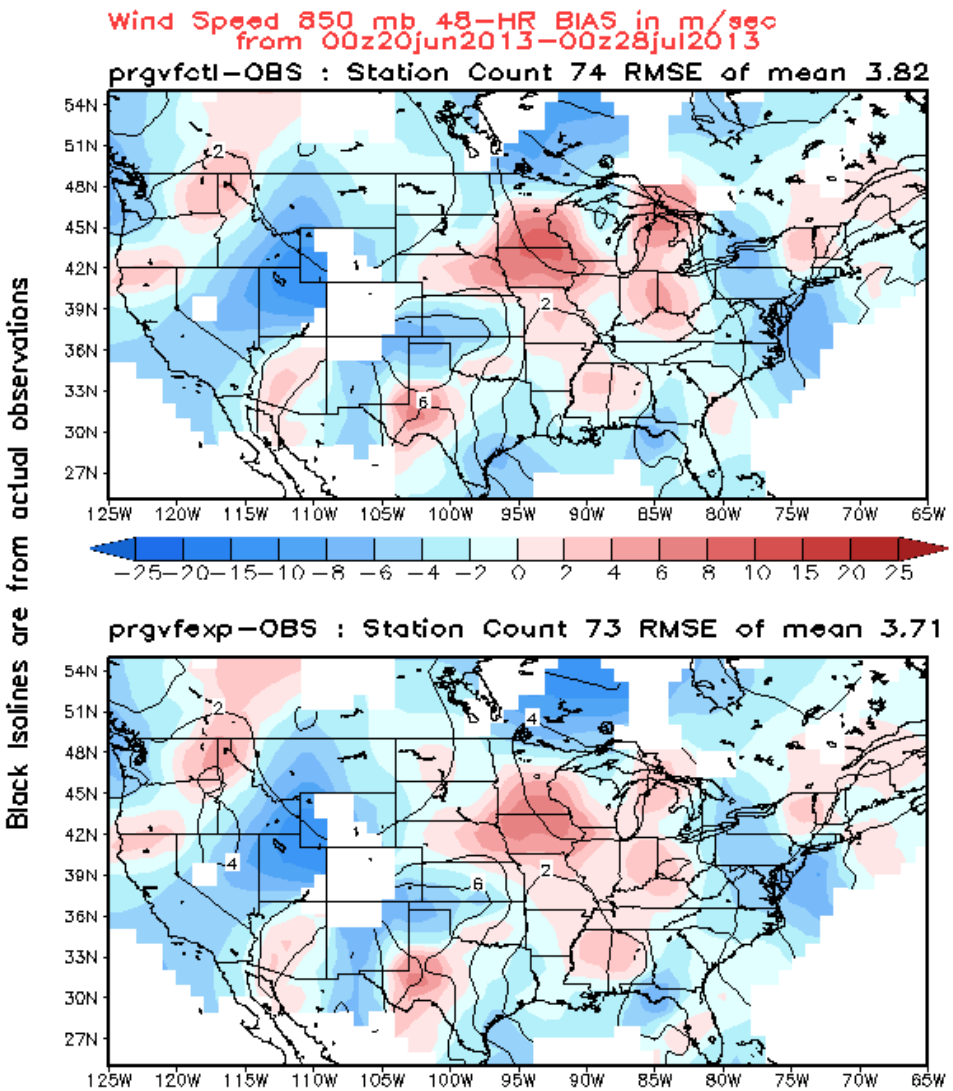


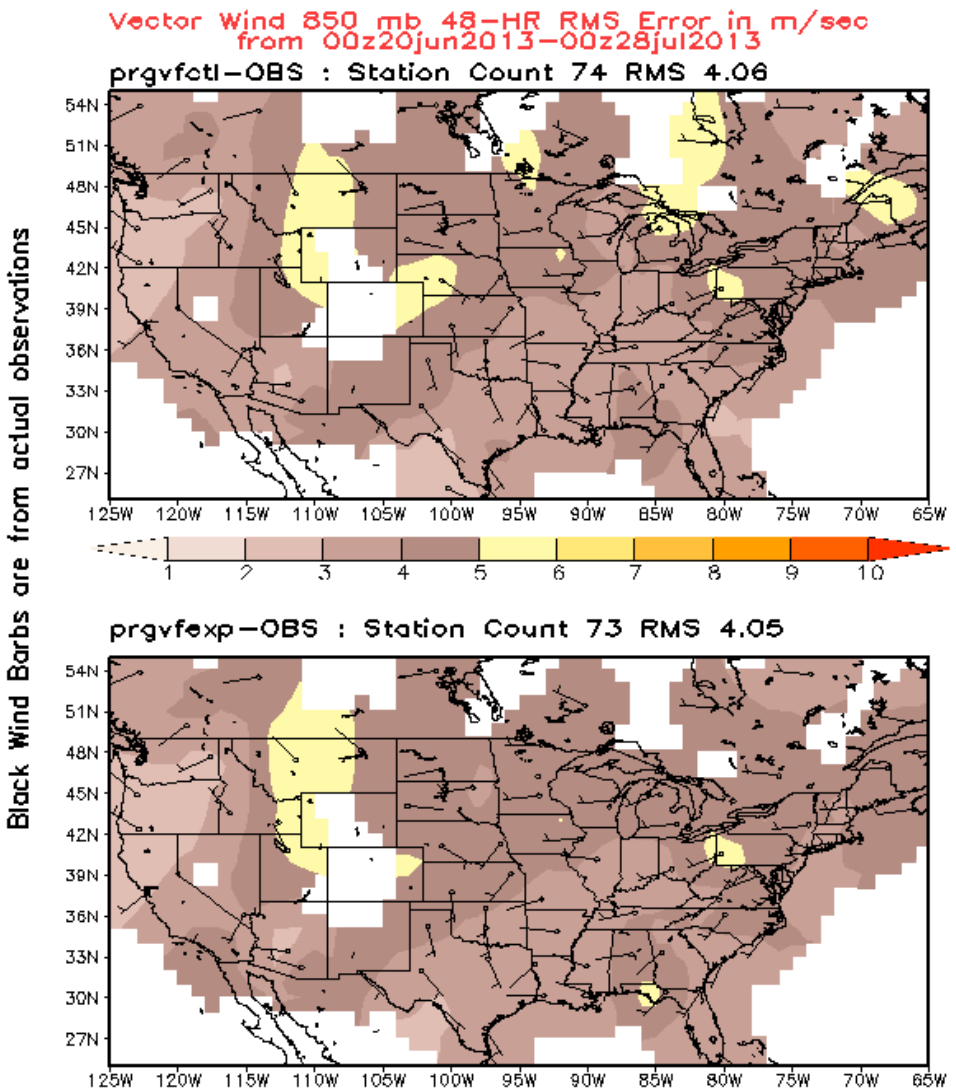




**Bias: 0.14↓**

**RMSE: 0.08↓**

# Wind Speed 850 mb 48-h BIAS and RMSE

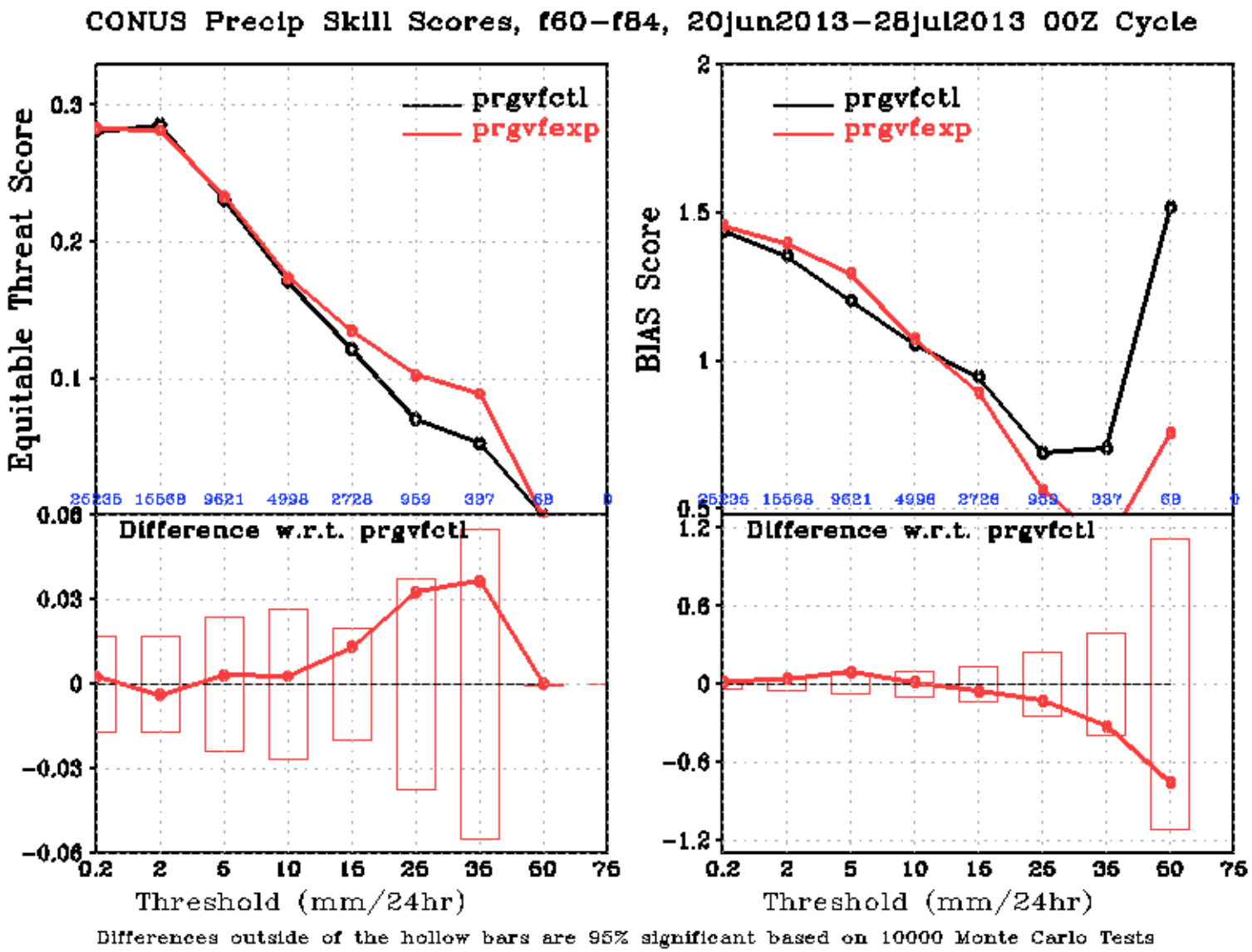



**Bias: 0.11↓**

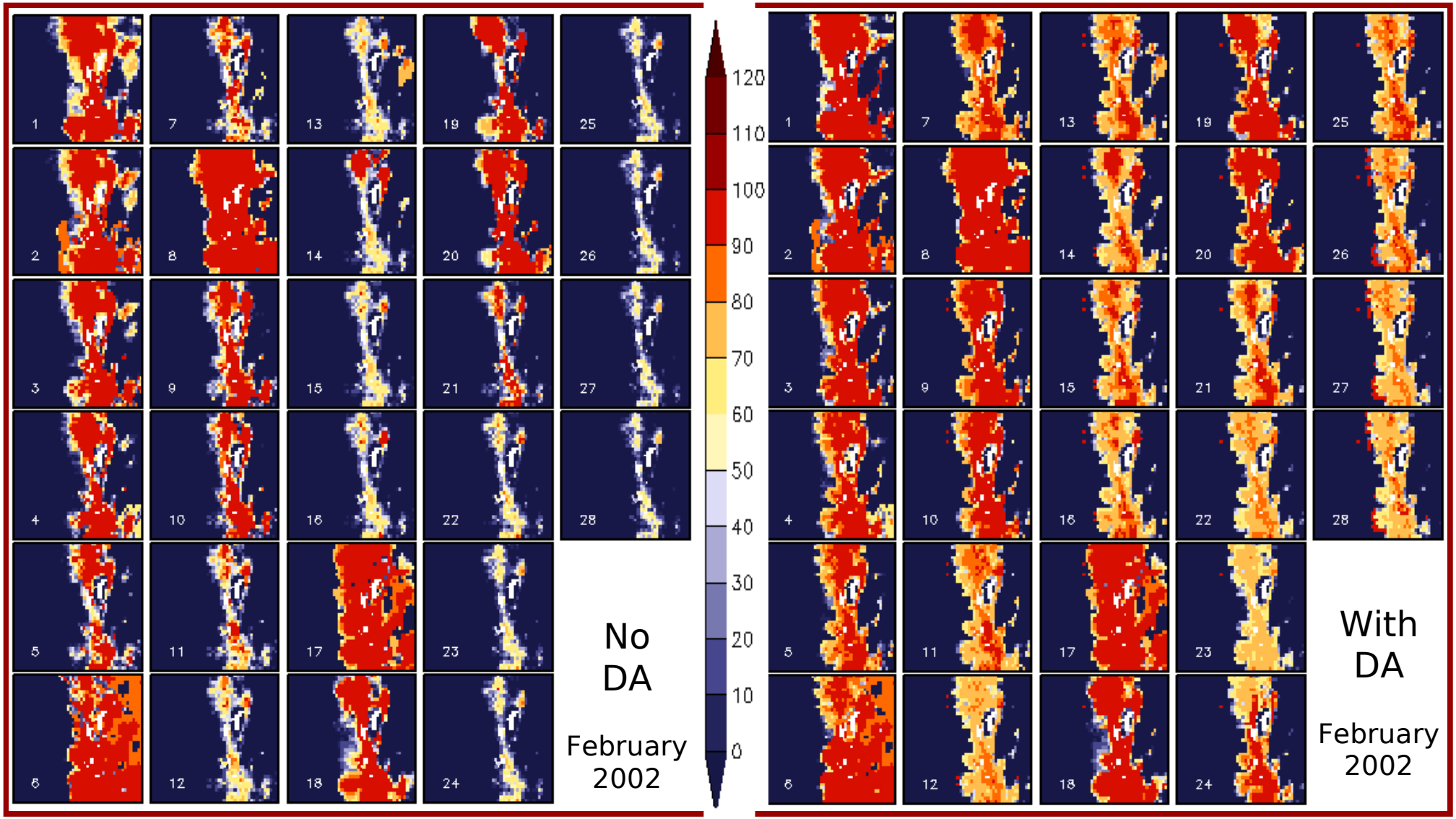
**RMSE: 0.01↓**

# *Precipitation Skill Scores over CONUS: f60-f84*




**Improved scores for medium & heavy precipitation but slightly degraded biases.**

# Snow Data Assimilation (spatial comp.)

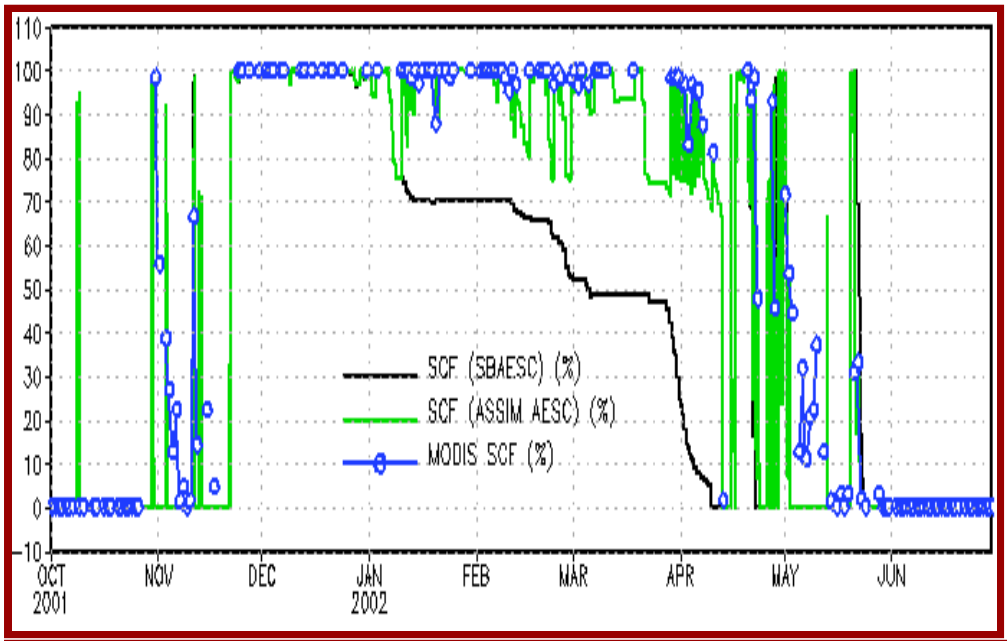



*We perform two runs in parallel over the Sierra-Nevada region. One is without using assimilation (left), and the other is applying the data assimilation of MODIS fractional snow cover (right). We apply the direct insertion algorithm in our assimilation. The LIS model is operating from October 1, 2001 to September 30, 2002.*



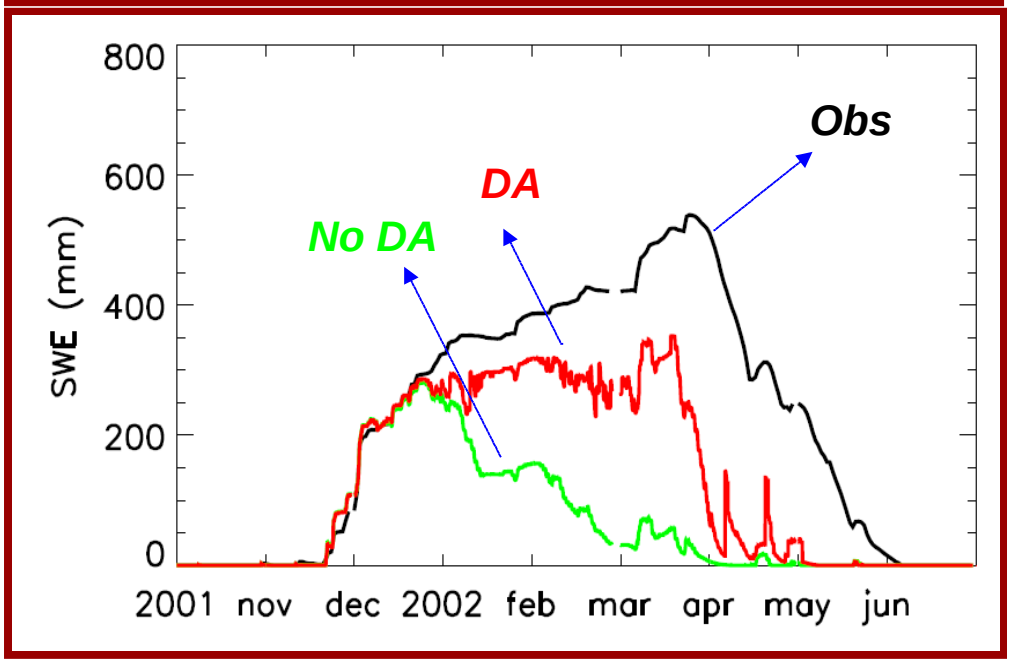
**** Jiarui Dong (NCEP/EMC)***

# Snow Data Assimilation (temporal comp.)




## Snow Cover Fraction

Comparison of snow cover fraction between the MODIS (blue circles), the open loop simulation (black line) and the assimilation simulation (green line).



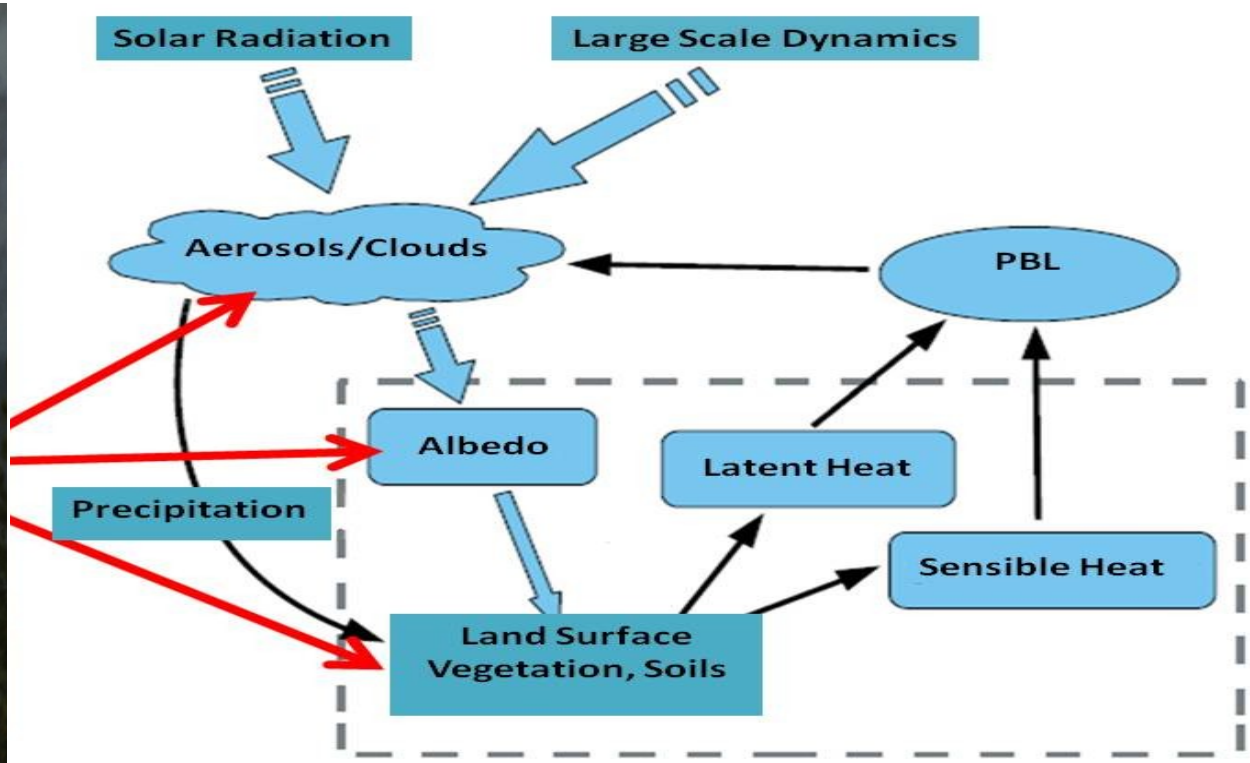

## Snow Water Equivalent

Comparison of snow water equivalent between the open loop simulation (green), the assimilation simulation (red) and the in-situ measurement (black) averaged over all SNOTEL sites in the study region.

** Jiarui Dong (NCEP/EMC)*

# *Land Conditions: Wildfire Effects*

Wildfires affect weather/climate systems:
(1) atmospheric circulations
(2) aerosols and clouds
(3) **land surface states** (green vegetation fraction, albedo and surface temperature etc.) --> impact on surface energy budget, boundary-layer evolution, clouds & convection.






** Yihua Wu (NCEP/EMC)*

# Fire Weather Project: Burning area products

- Burning area products are produced operationally,
- Two products are available:(NESDIS/STAR):
  - 1 km resolution, 2x/day, 20N-70N
  - 12 km resolution, 4x/day, Equator-NP
- Fire can affect weather/climate systems:
  - atmospheric circulations
  - aerosols and clouds
  - **land surface states** (green vegetation fraction, albedo and surface temperature etc.) --> impact on surface energy budget, boundary-layer evolution, clouds & convection.
- **Ingested into NMMB by Launcher**, with adjustments to surface characteristics:
  - reduced: albedo, GVF, roughness, soil moisture
  - increase: surface & soil temperatures

**** Yihua Wu (NCEP/EMC)***

# *Summary*

- **Several satellite data sets developed recently were tested in the NCEP models and the results show good improvements, compared with the current data sets;**

- **The AMSR2 soil moisture product was assimilated in the GFS and it shows some positive impacts on NWP;**

- **Sub-grid scale land surface is included in the Tb calculation and more satellite data are assimilated in the GSI;**

- **We have been continuing our efforts and working with many research teams to improve satellite data utilization over land in NCEP data assimilation system and then improve the GFS numerical weather prediction (NWP).**