Incorporation of near-real-time Suomi NPP Green Vegetation Fraction and Land Surface Temperature data into the NCEP Land modeling suite

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Project objectives

- **Improve** the use of two operational **land surface data products** derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (SNPP) Satellite.
- **Comprehensive evaluation** of the impact of the operational SNPP **Green Vegetation Fraction** (GVF) product
- **Integration** of a SNPP **Land Surface Temperature** (LST) product and model performance evaluation

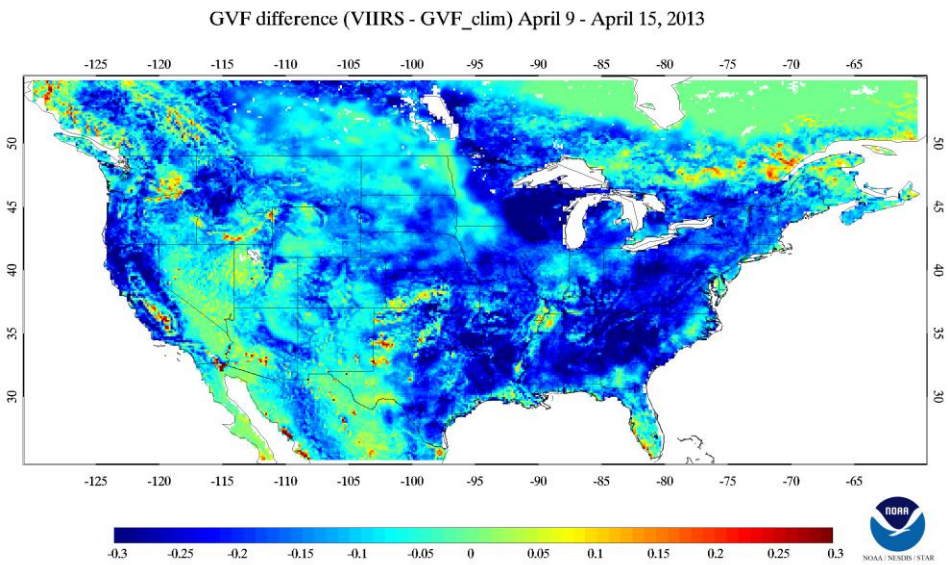
Project team

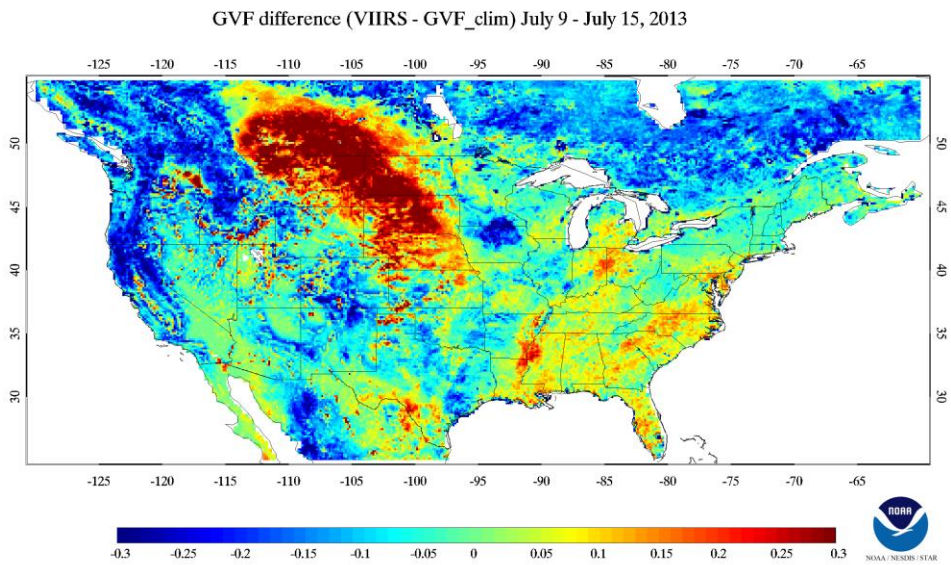
- STAR:
  - Ivan Csiszar: PI; overall management (STAR)
  - Marco Vargas: GVF product lead (STAR)
  - Zhangyan Jiang: GVF support (Riverside / AER)
  - Yunyue Yu: LST product lead (STAR)
  - Zhen Song: LST support (UMD/CICS)
- EMC:
  - Mike Ek: co-PI (EMC)
  - Yihua Wu (IMSG)
  - Weizhong Zheng (IMSG)
  - Helin Wei (IMSG)

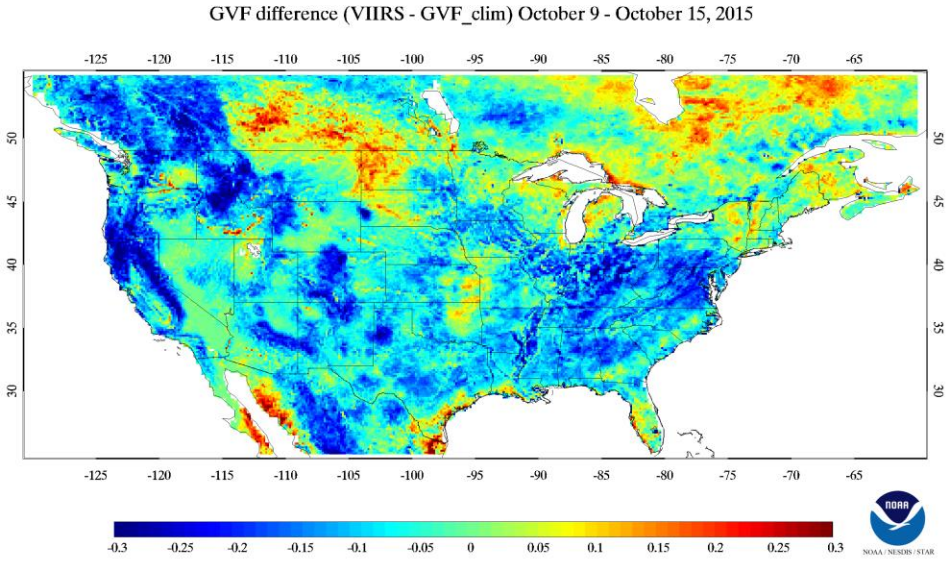
VIIRS GVF PRODUCT DEVELOPMENT

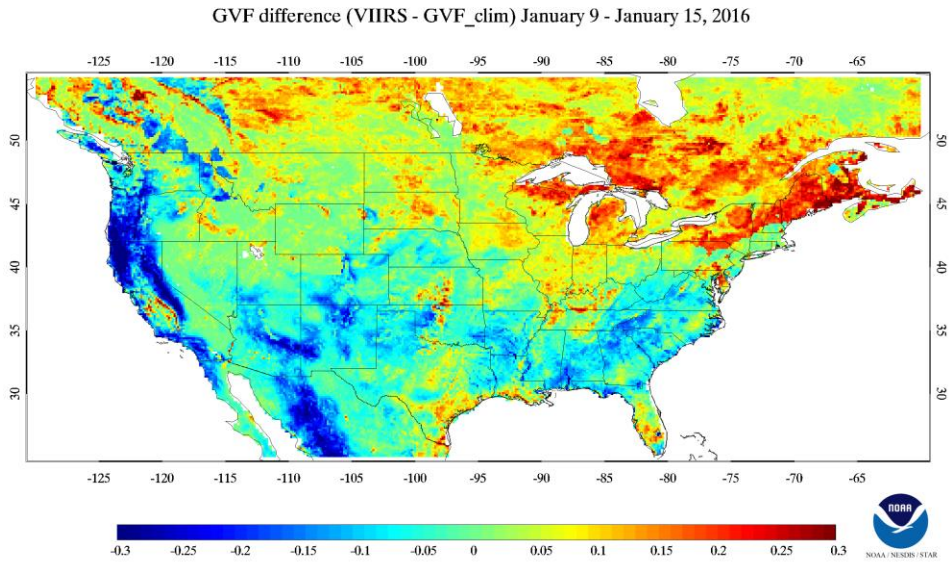
- VIIRS GVF PRODUCT has been developed
- VIIRS-AVHRR GVF comparison revealed a fairly consistent shift in the representation of the phenological cycle
- The major cause of this shift was found to be the temporal smoothing technique applied in the VIIRS GVF product
- A new VIIRS GVF dataset was derived and was shown to reflect a more consistent phenology with AVHRR

GVF difference (VIIRS-AVHRR clim.)



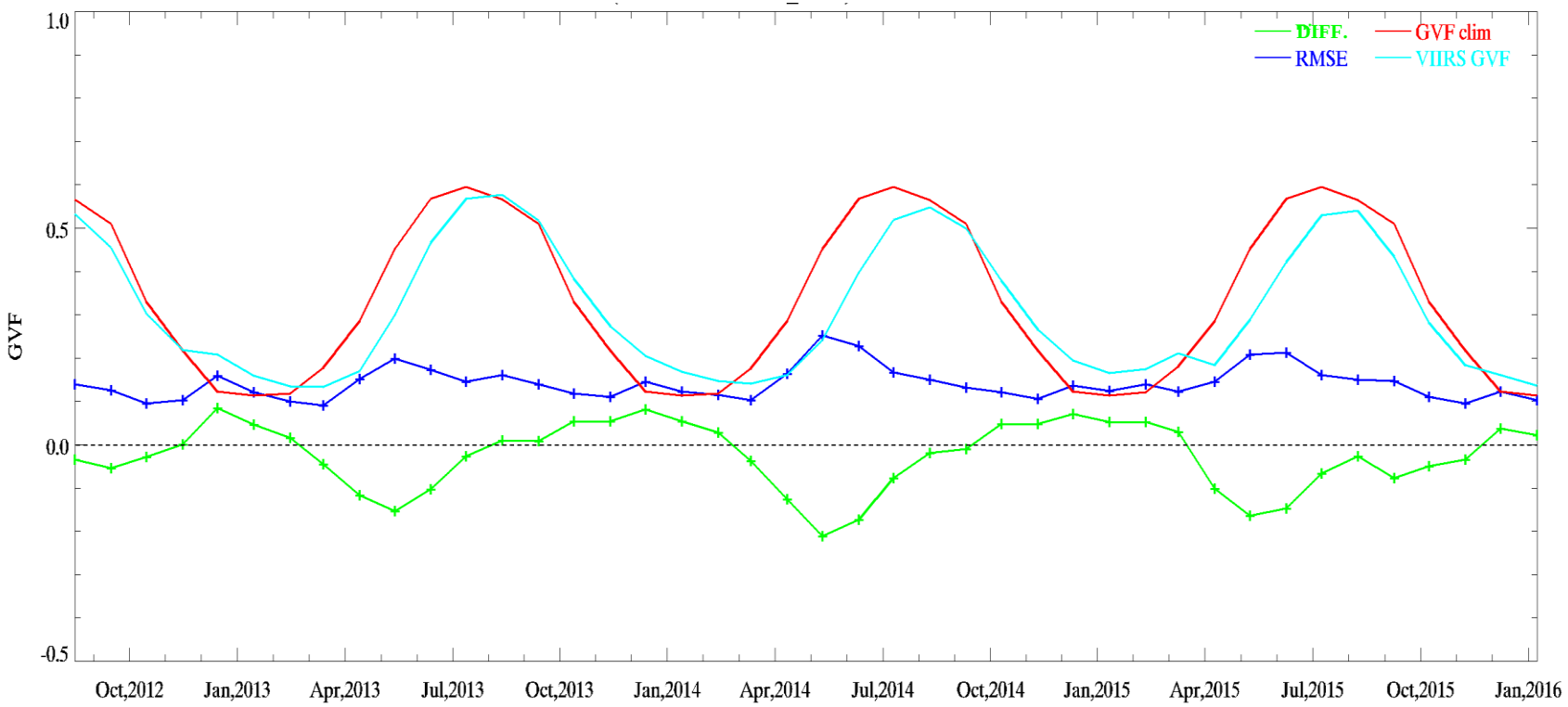






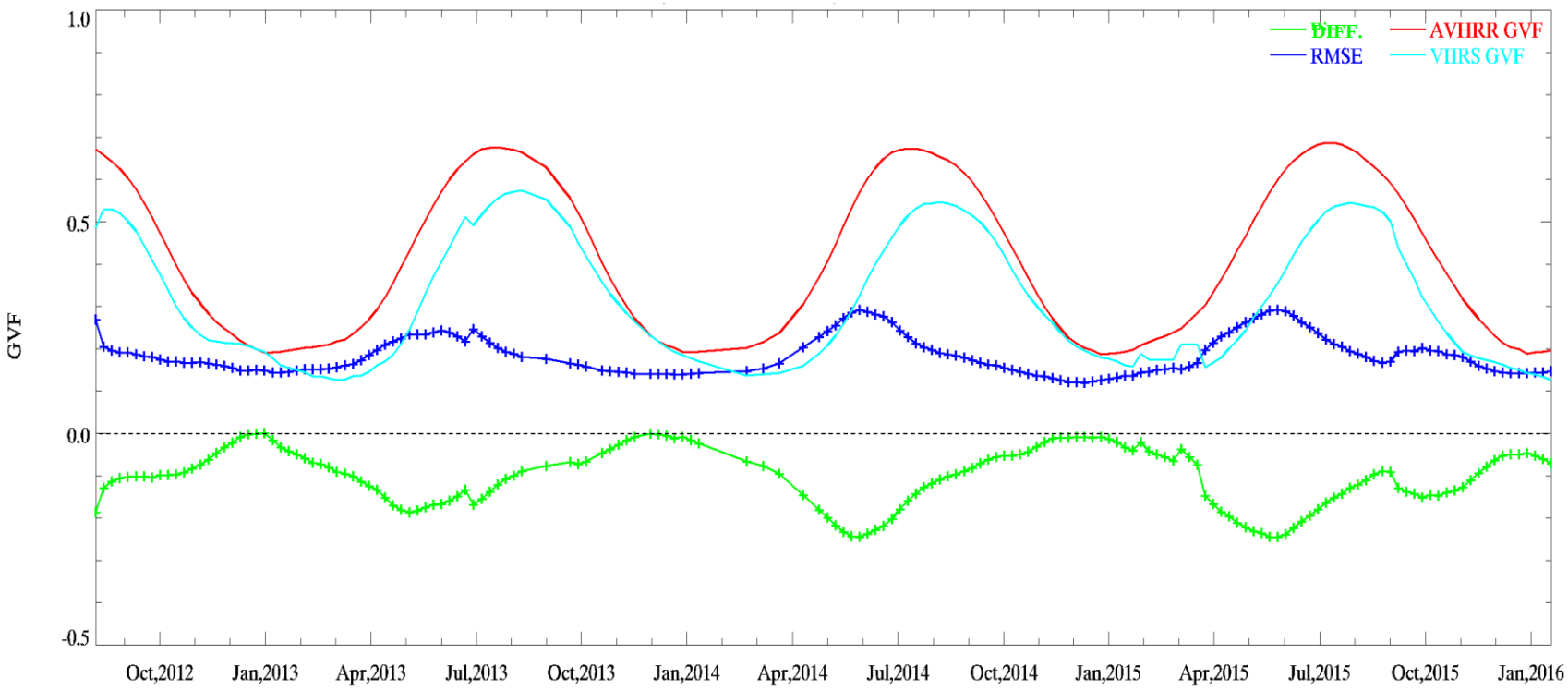
GVF climatology is higher than VIIRS GVF over vegetated area in spring

Difference and RMSE between VIIRS and AVHRR GVF Climatology over CONUS



- Mean GVF climatology is slightly higher than VIIRS GVF
- Positive difference in winter and negative difference in spring and summer
- RMSE is relatively low

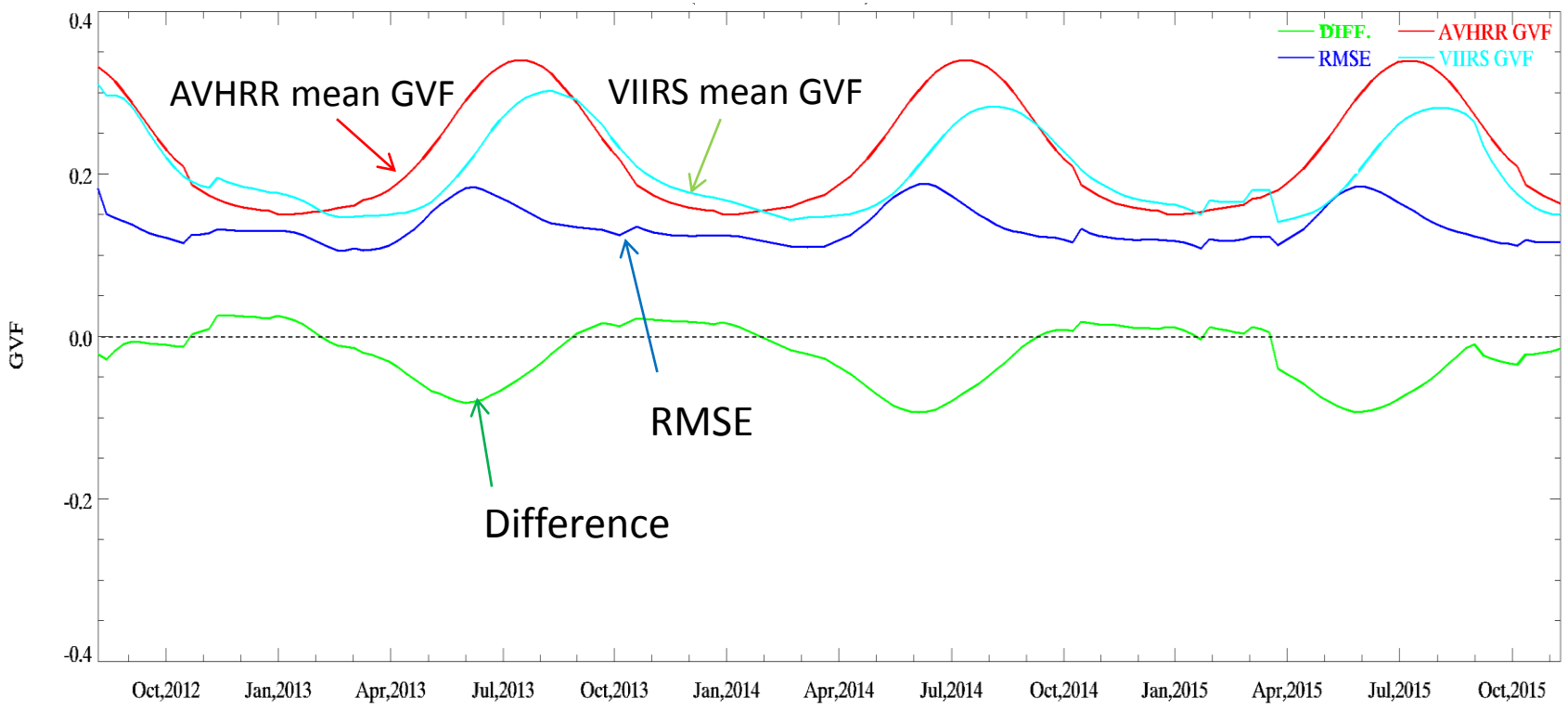
Difference and RMSE between VIIRS and AVHRR GVF Over CONUS



- AVHRR GVF is higher than VIIRS GVF in all seasons
- GVF difference is small in winter, big in spring and summer

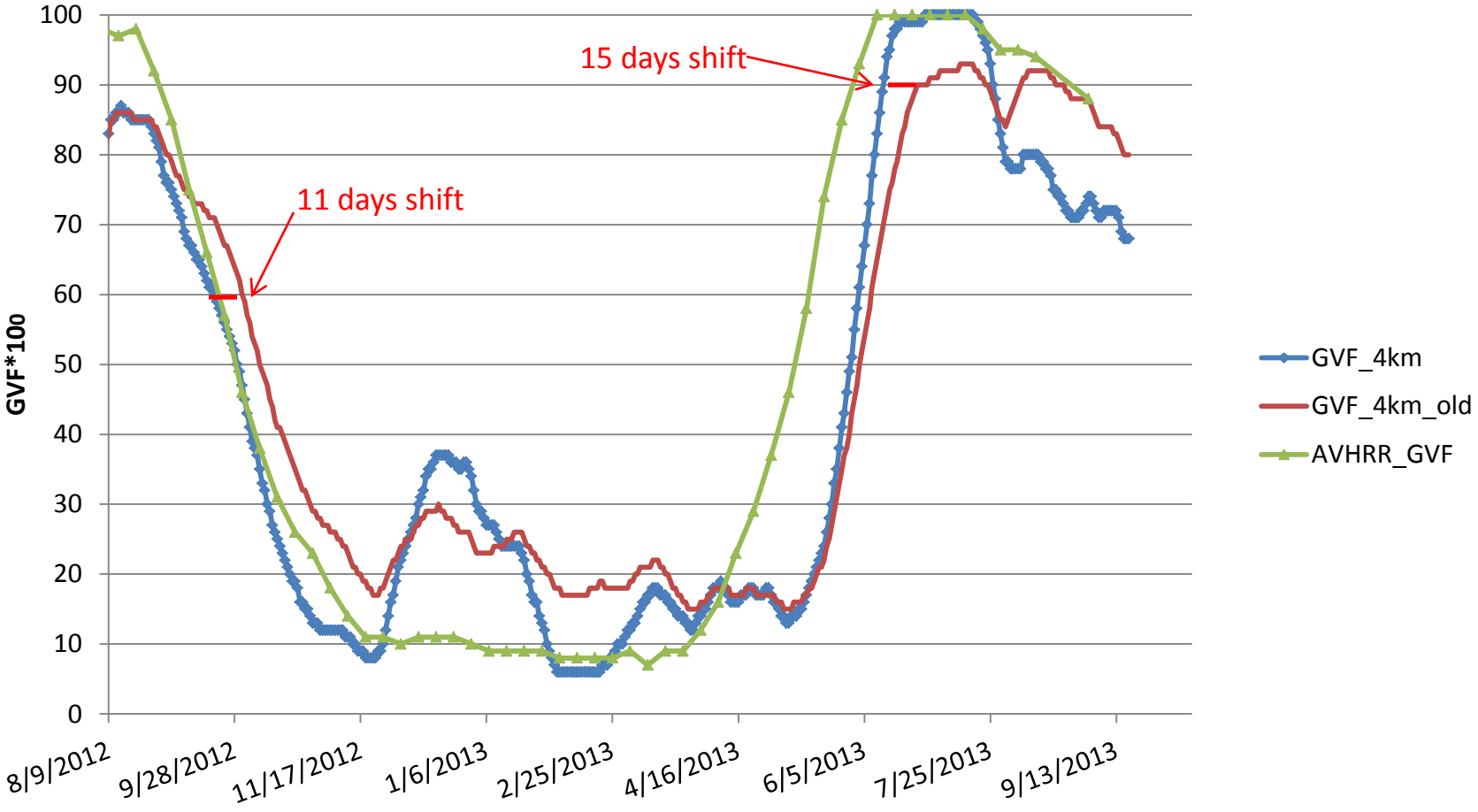
GVF difference and RMSE (VIIRS VS. AVHRR GVF)

Global



- AVHRR GVF greens up earlier than the VIIRS GVF
- AVHRR GVF is higher than VIIRS GVF in summer globally
- Negative GVF difference and relatively high RMSE in spring and summer, small difference and RMSE in other seasons

Updated VIIRS GVF at Changbai mountain



Biome: Mountain Forest

VIIRS LST LST PRODUCT DEVELOPMENT

- Regional and global gridded LST products were developed, LST, QC for LST, View time and View angle are all provided in the VLSTL3 products
- LST data for appropriate time windows have been extracted to enable forecast evaluation at specific times
- A diurnal cycle model is being developed to fill LST data between VIIRS observing times

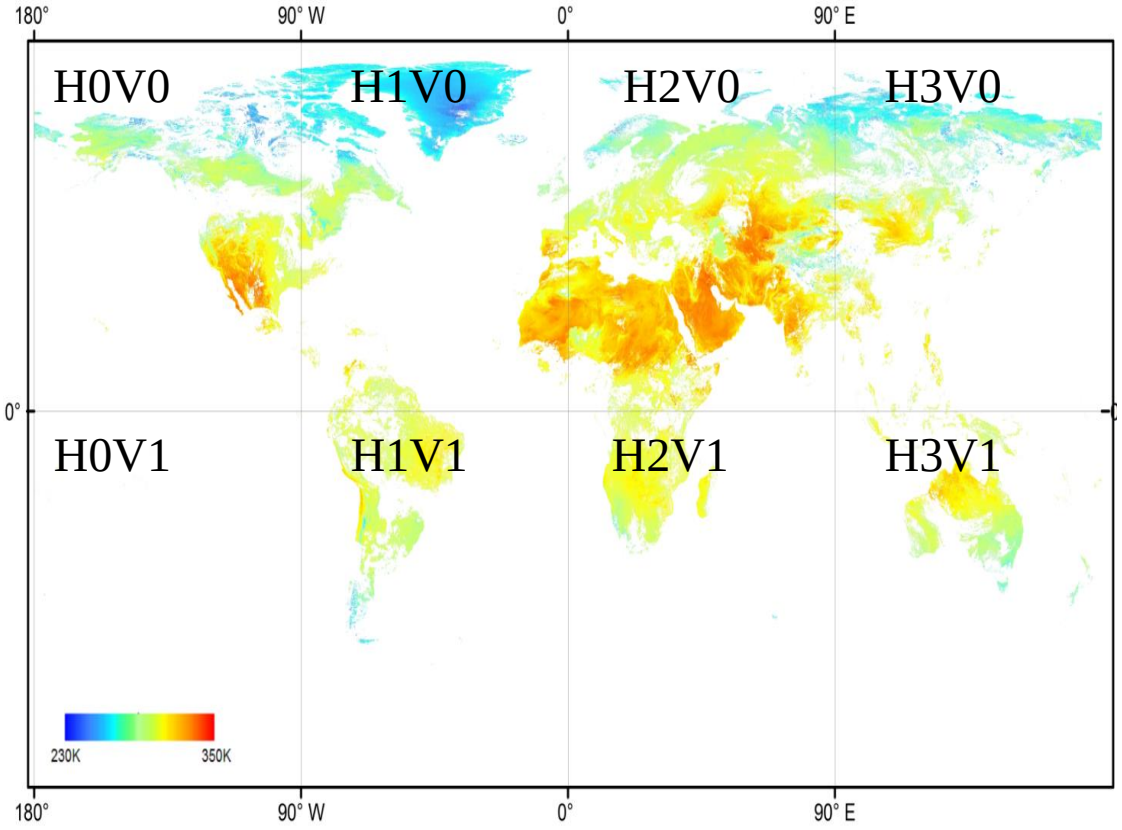
Towards Hourly Gridded LST

- Data: GOES LST & VIIRS LST
- Testing region: CONUS
- Method: Build diurnal temperature model (DTM) Look-up-table(LUT) by geostationary LST (GOES), then apply to polar-satellite LST (VIIRS) to get high spatial-temporal resolution LST
  - Collect monthly diurnal LST from GOES in different groups divided by longitude, latitude, land cover and elevation
  - Match the diurnal temperature model (*Gottsche and Olesen* semi-physical model) by non-linear least square fit
  - Build the LUT for DTM parameters (On-going and improving)
  - Predict the hourly LST by DTM LUT and VIIRS LST (Next step)

VIIRS gridded LST (Level 3 LST,VLSTL3)

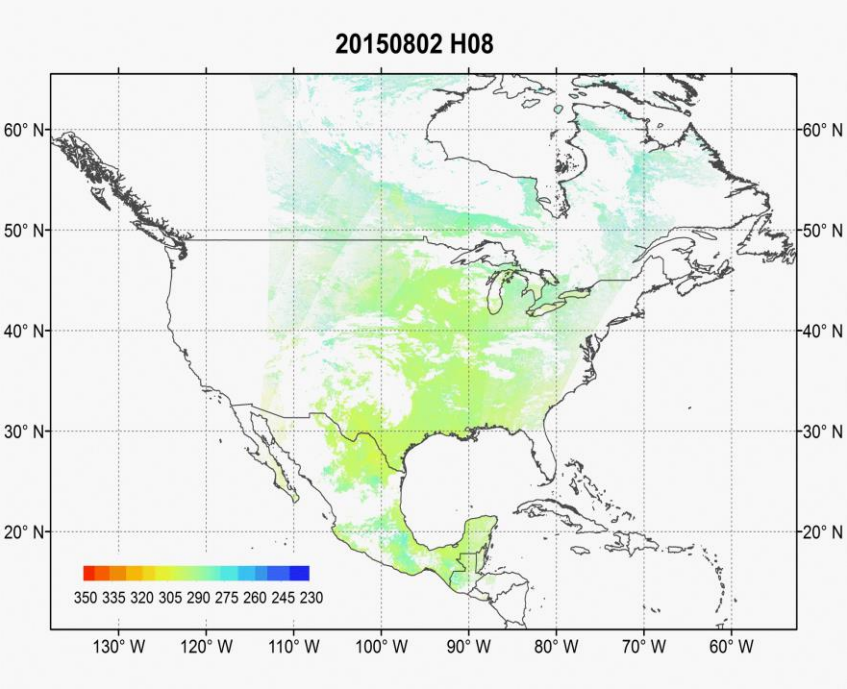
- **Gridded composite global products suitable for integration and model performance evaluation**:
- 0.01 degree, daily
- 8 tiles for global, day/night separately, each tile within 150M
- Processing time less than 1.5hr for daily products

Example products: 20150602 VLSTL3 for Daytime

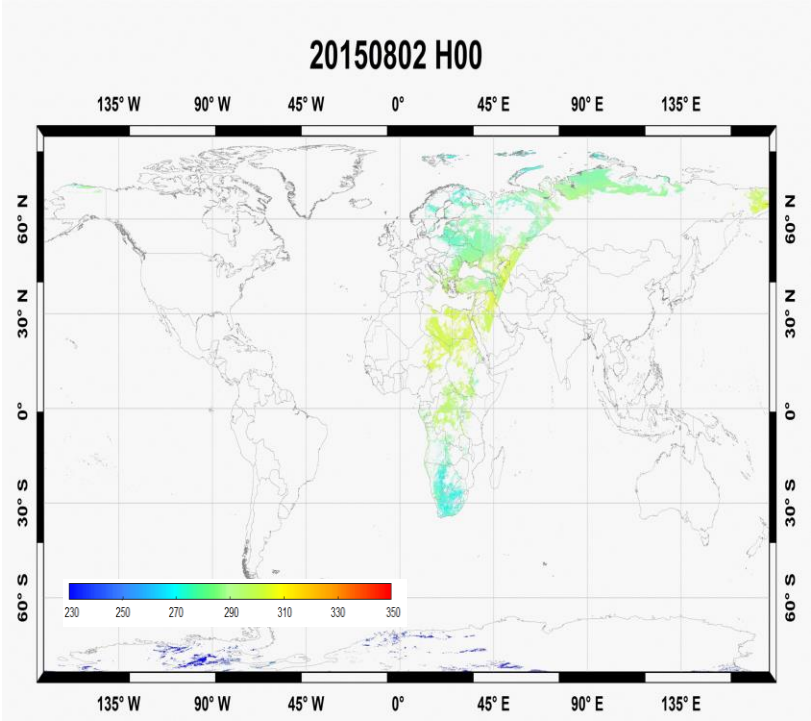


Test products

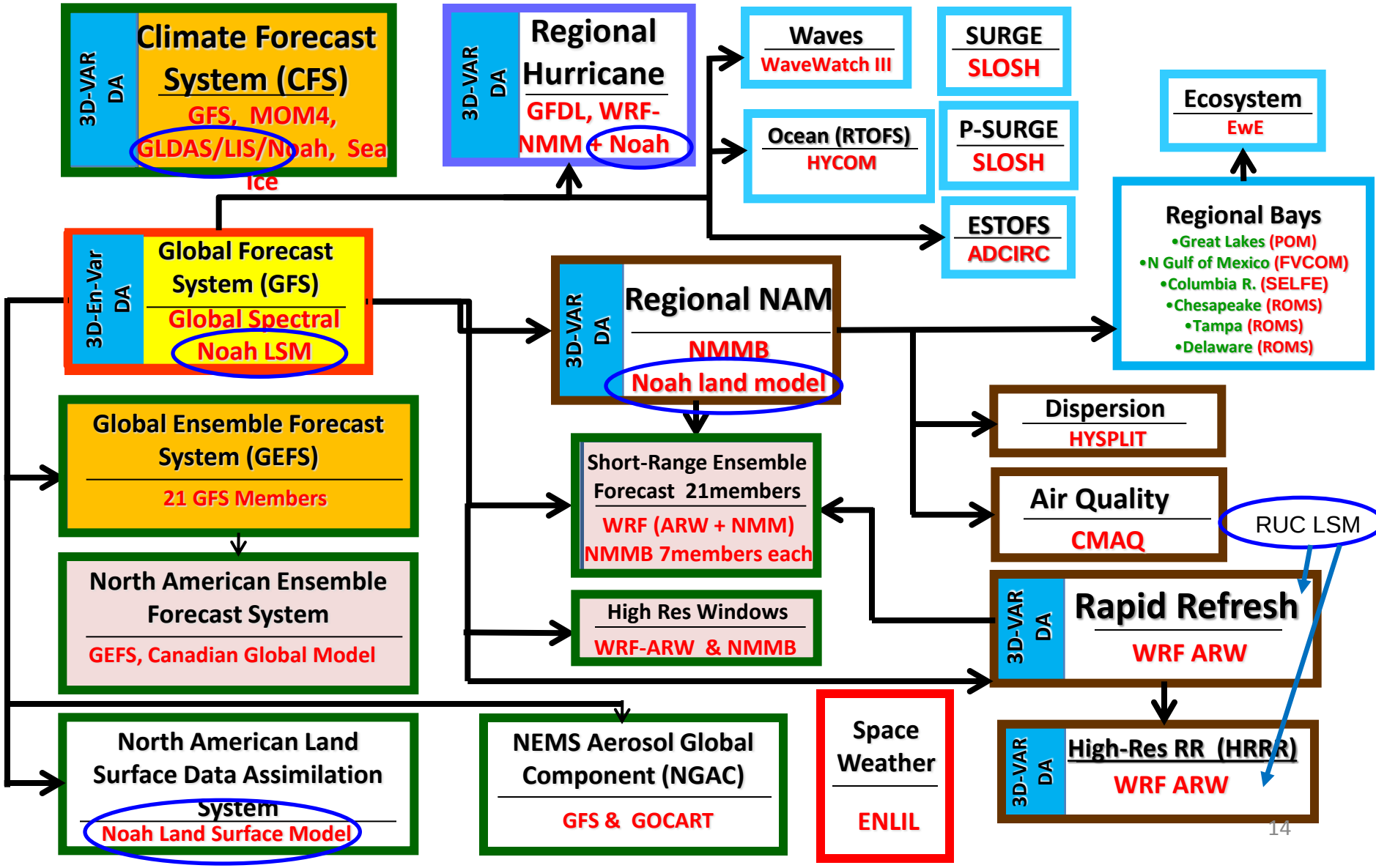
0.009 Degree for NAM CONUS



0.036 Degree for GFS GLOBAL



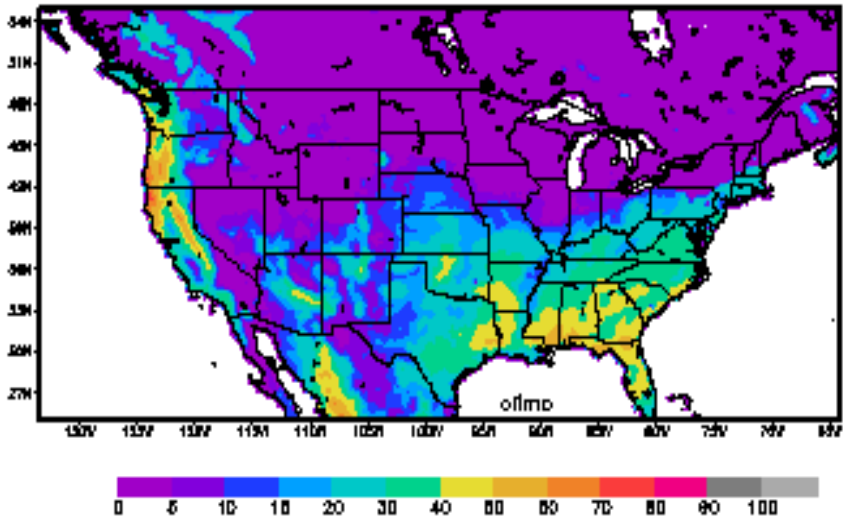
Land Prediction in Weather & Climate Models: NOAA's Operational Numerical Guidance Suite

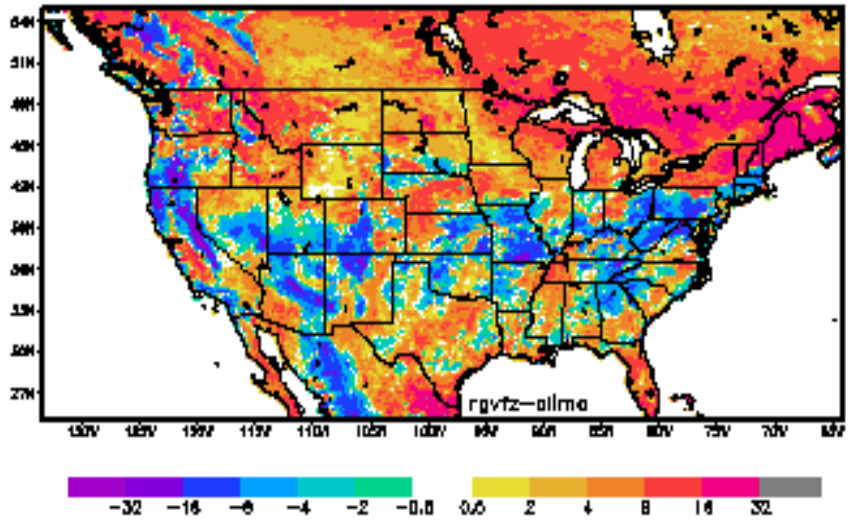


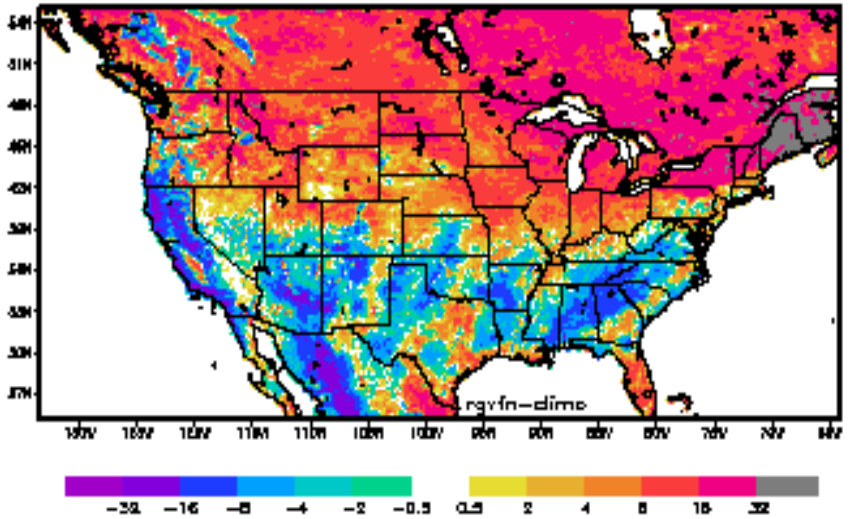
NAM GVF Testing

- NAM was run with 3 GVF products for 2014: AVHRR climatology, 2 real time VIIRS GVF
- Climatology (1981-1985)
- 2014 RGVF (RGVF1 or RGVFZ) developed by Xiaoyang Zhang et al.
  1) VIIRS + correction using phenology forecast
  2) 4 km resolution
  3) Does not cover the high latitude region which is blended by climatology
- 2014 RGVF (RGVF2 or RGVFN) developed by Marco Vargas' group
  1) VIIRS + blended with previous week values
  2) 1 km resolution
  3) Global
- The BUDGET method was used to interpolate the products to the NAM domain (at least 25 points are chosen in one model grid box, then are weighted with area to get one value for the model grid box)
- Data on 24 days (two from each month) were used for tests. Total 72 runs were conducted with NAM and the 3 GVF products.

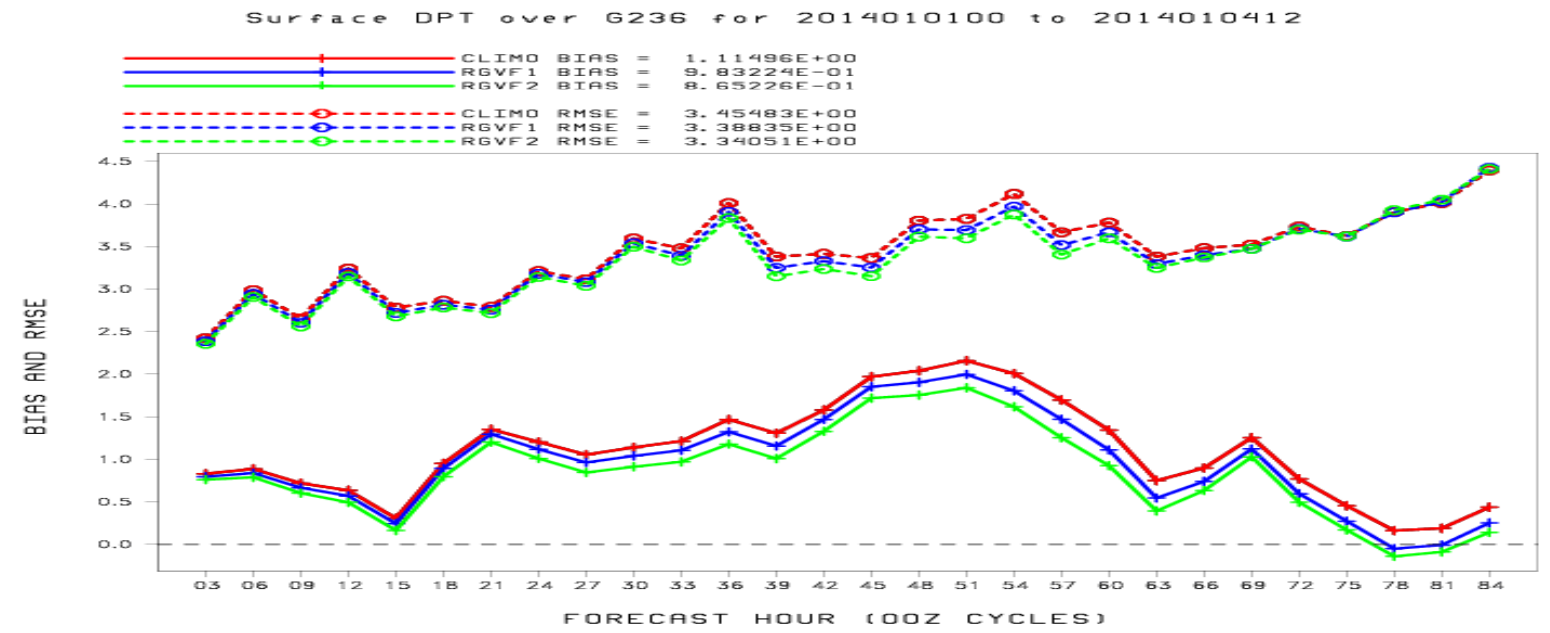
20140101

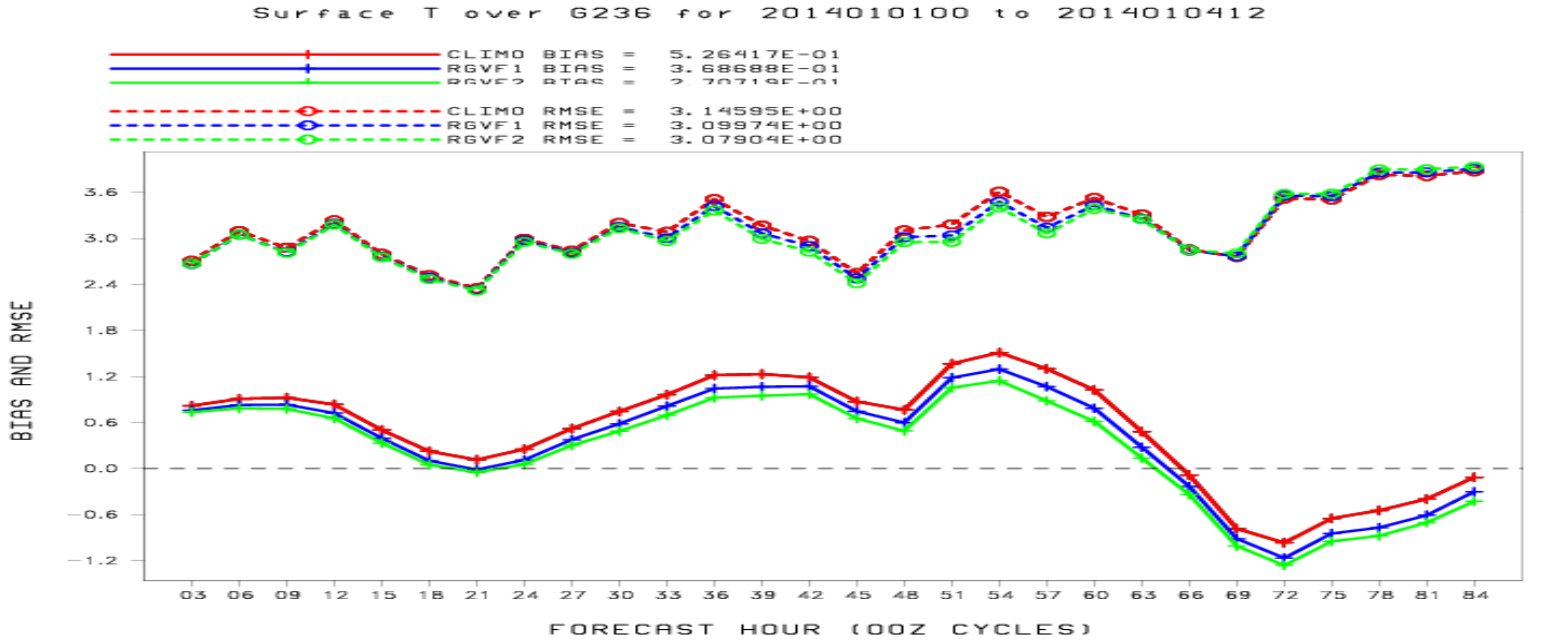






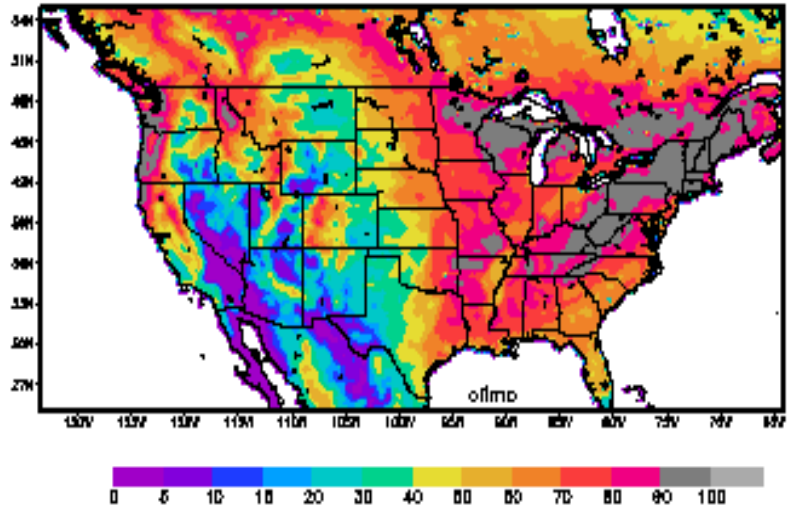
- GVF in Climatology is less than in RGVFZ and GVFN at high latitude
- GVF in RGVZ is less between 35 N and 45 N than in Climatology
- GVF in RGVN is less than in Climatology below 35 N
- GVF in RGVN is less than in RGVFZ at the GMC

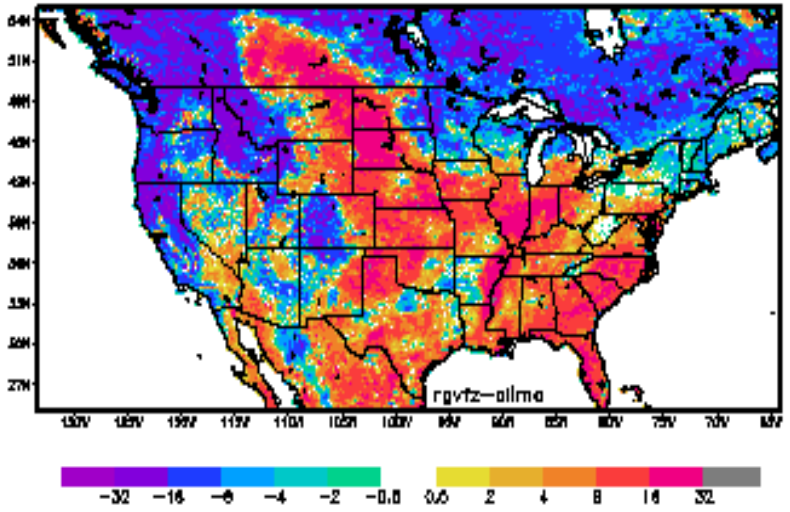


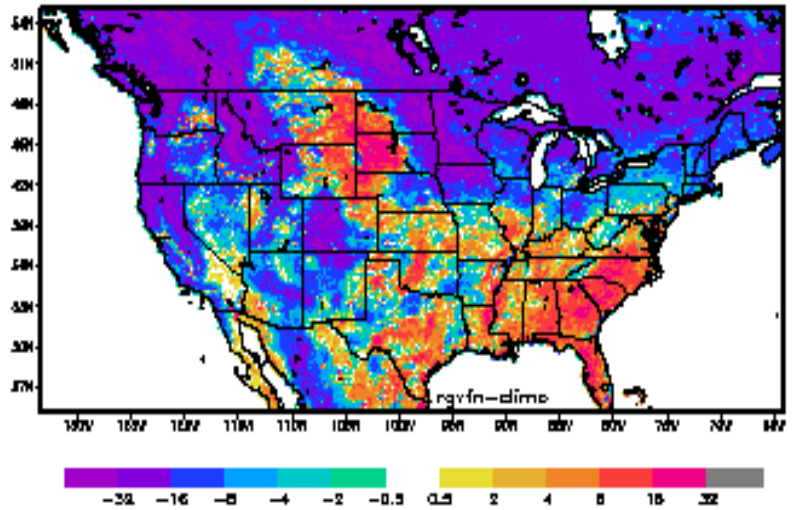


RGVF1-Zhang; RGVF2-Vargas

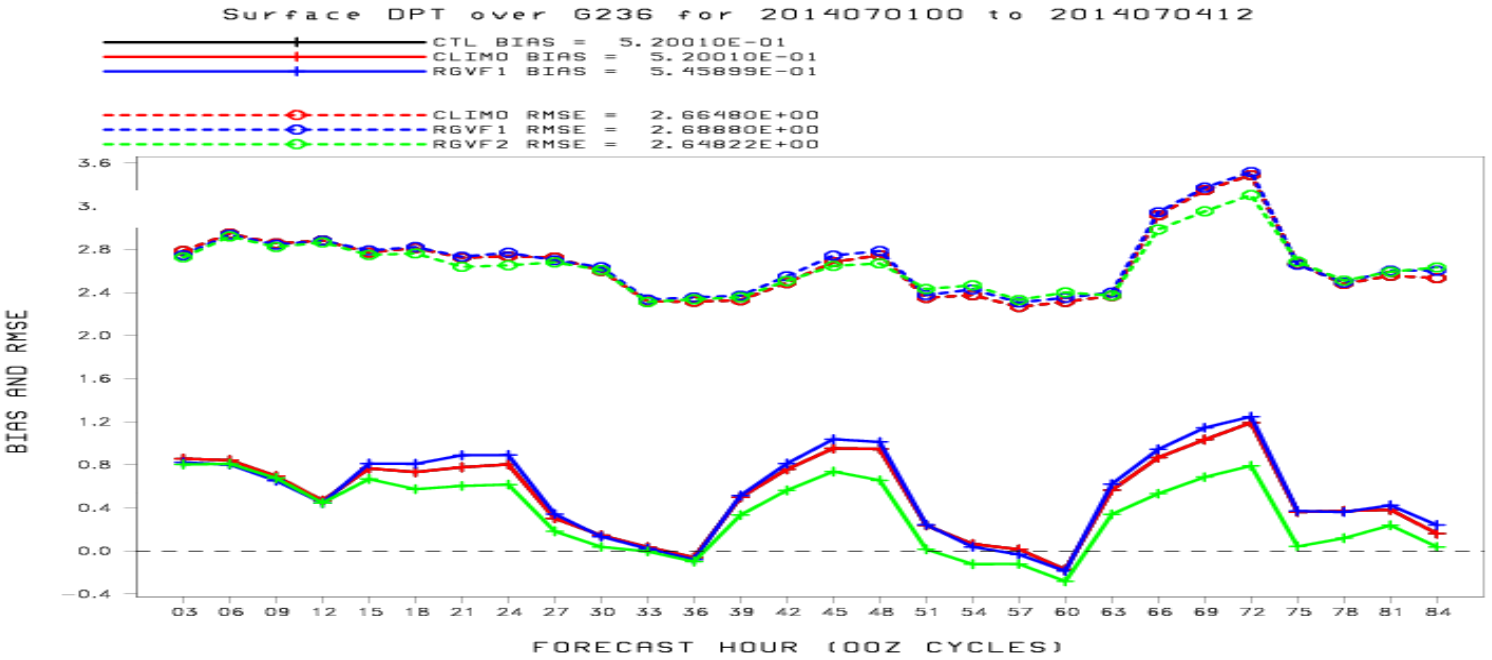
20140701

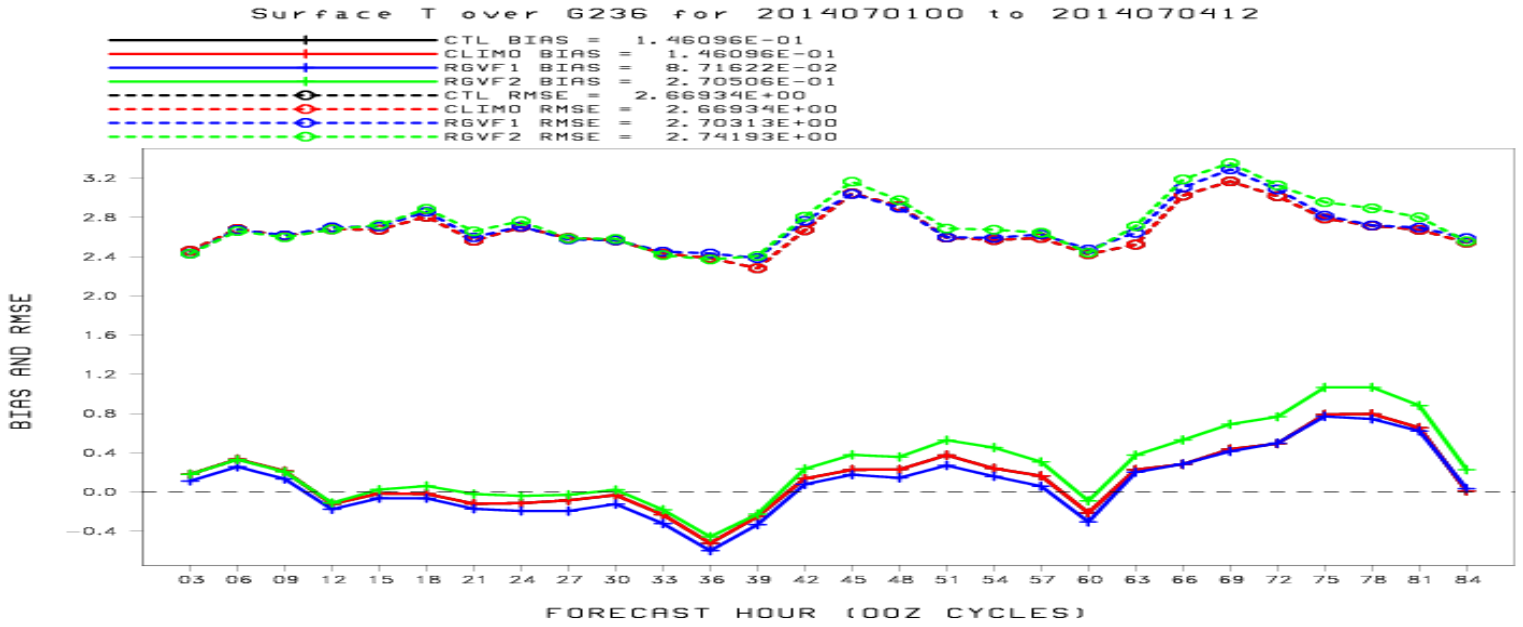




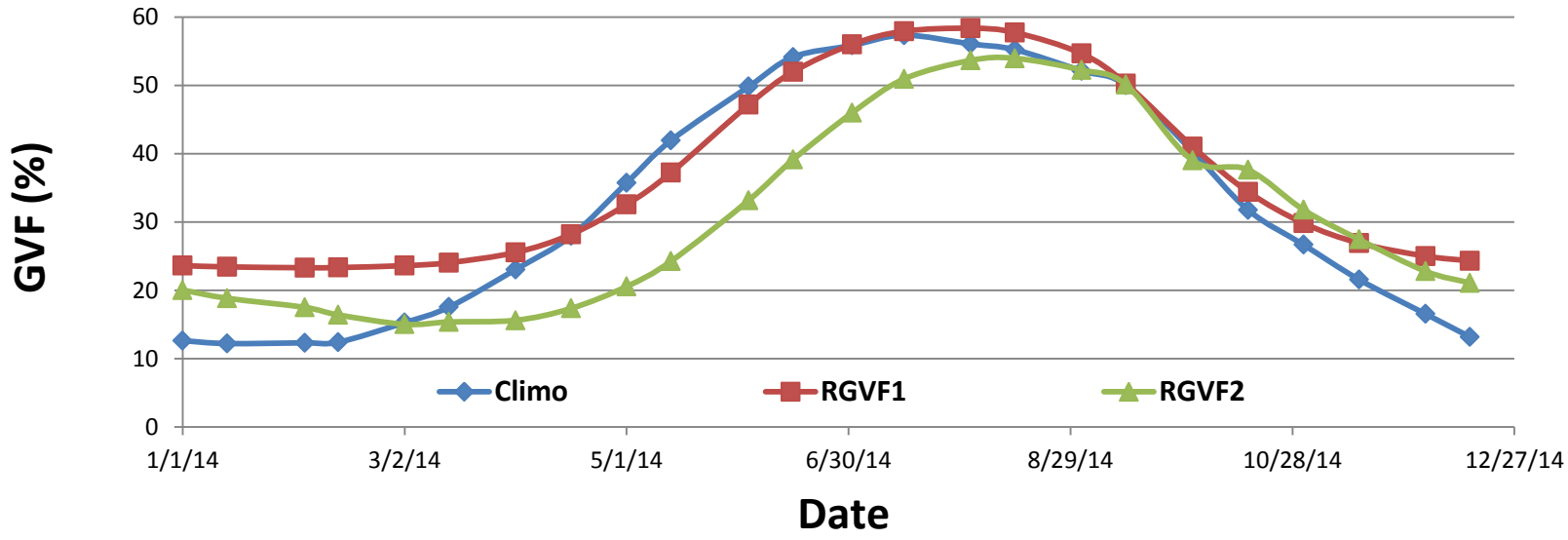


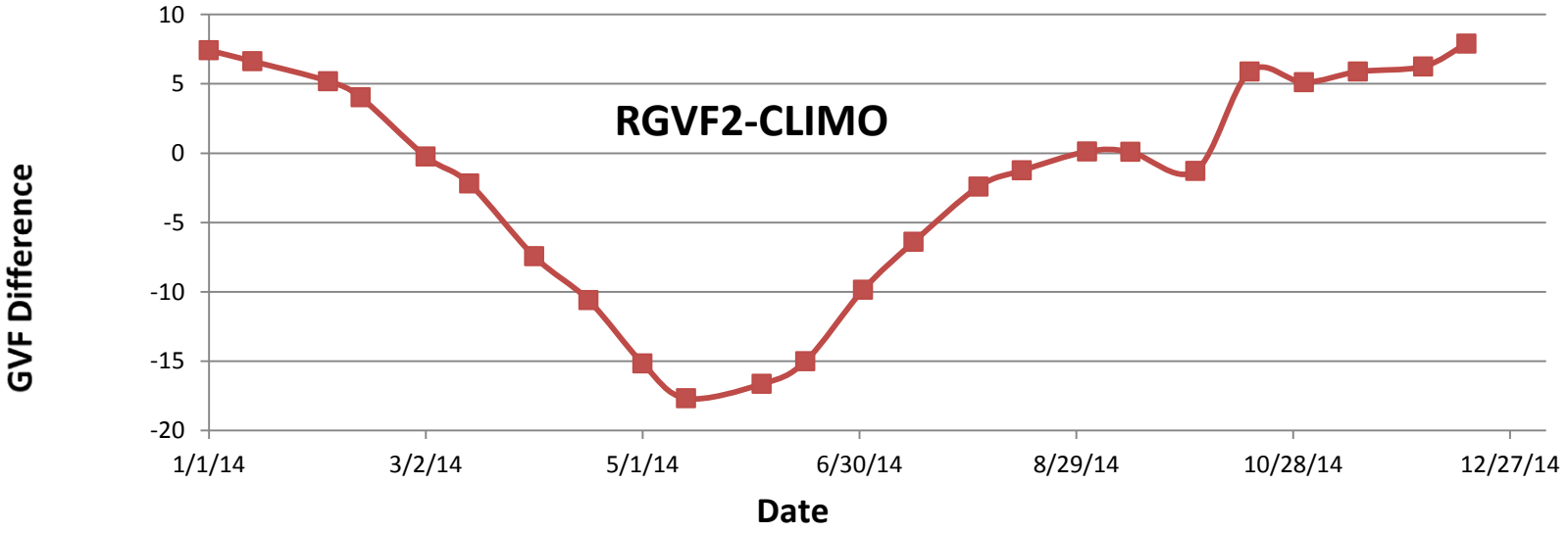
- GVF in RGVFN has the smallest value at high latitude
- GVF in Climatology is less than in RGVFZ and RGVFN in the Great Plains
- GVF in RGVFZ has the largest values in the Great Plains


Surface DPT over G236 for 2014070100 to 2014070412
CTL BIAS = 5.20010E-01
CLIMO BIAS = 5.20010E-01
RGVF1 BIAS = 5.45899E-01
CLIMO RMSE = 2.66480E+00
RGVF1 RMSE = 2.68880E+00
RGVF2 RMSE = 2.64822E+00
BIAS AND RMSE
FORECAST HOUR (00Z CYCLES)

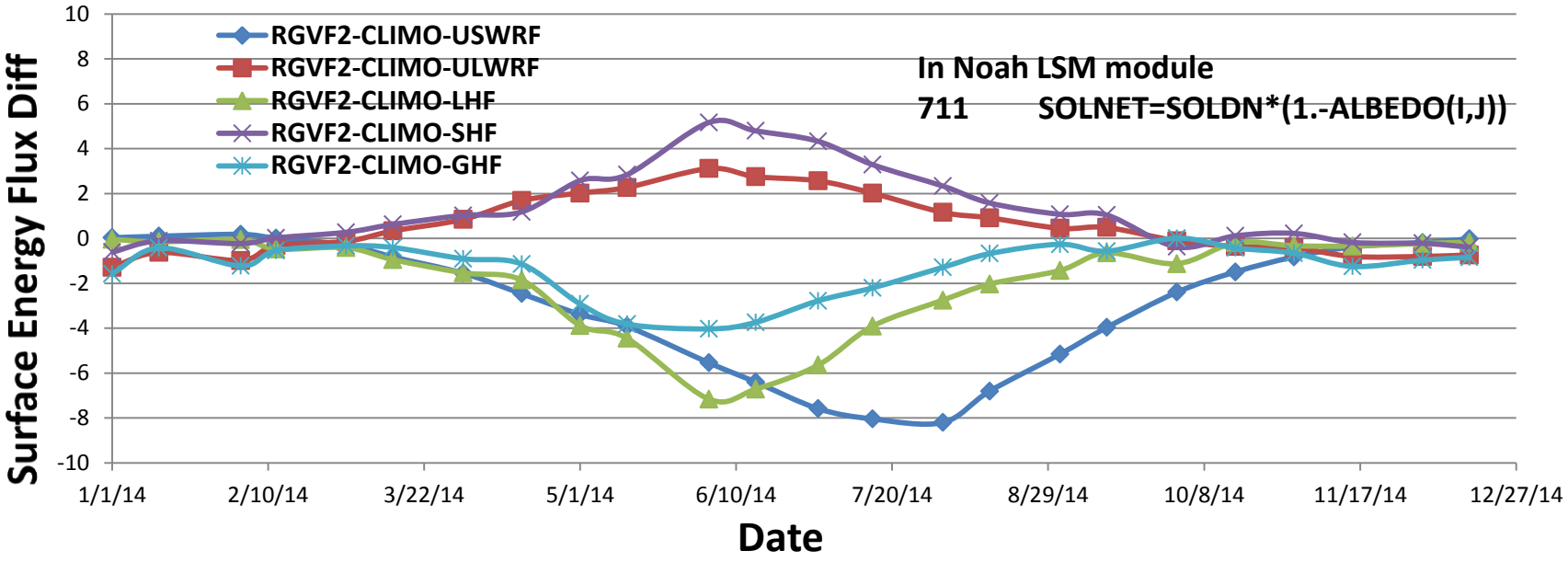

Surface T over G236 for 2014070100 to 2014070412
CTL BIAS = 1.46096E-01
CLIMO BIAS = 1.46096E-01
RGVF1 BIAS = 8.71622E-02
RGVF2 BIAS = 2.70506E-01
CTL RMSE = 2.66934E+00
CLIMO RMSE = 2.66934E+00
RGVF1 RMSE = 2.70313E+00
RGVF2 RMSE = 2.74193E+00
BIAS AND RMSE
FORECAST HOUR (00Z CYCLES)

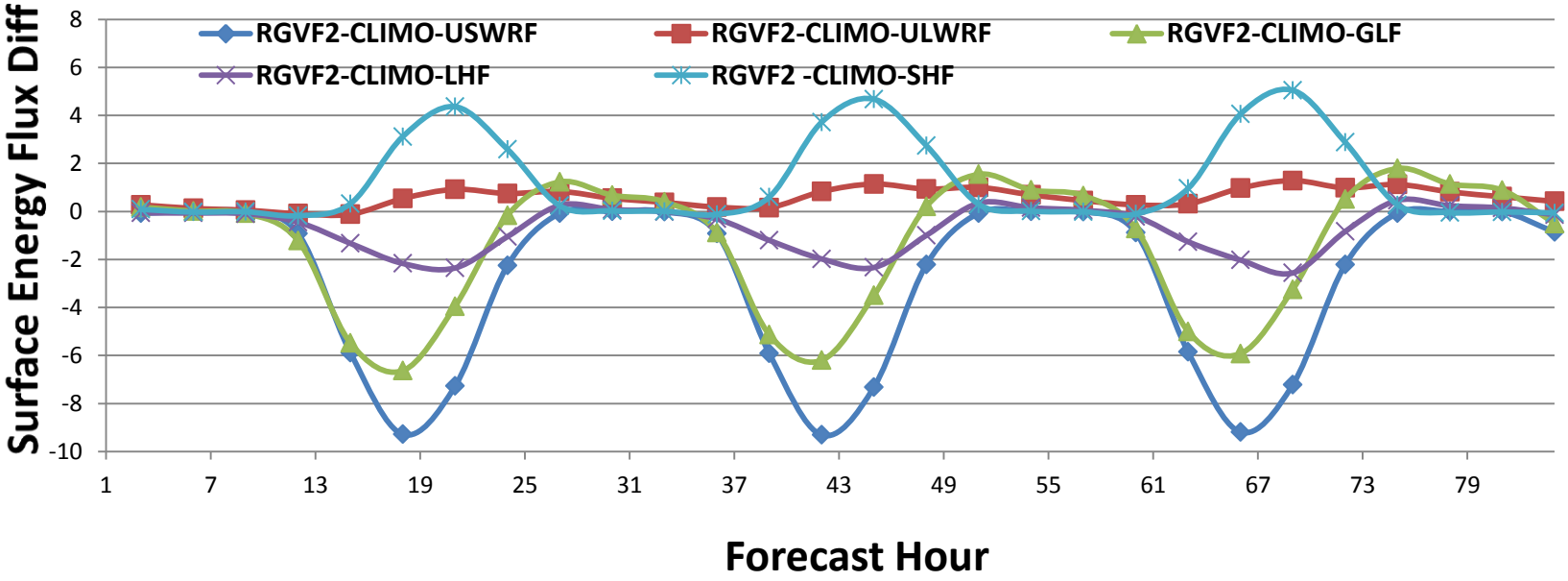
Land point averages over Grid218 Domain



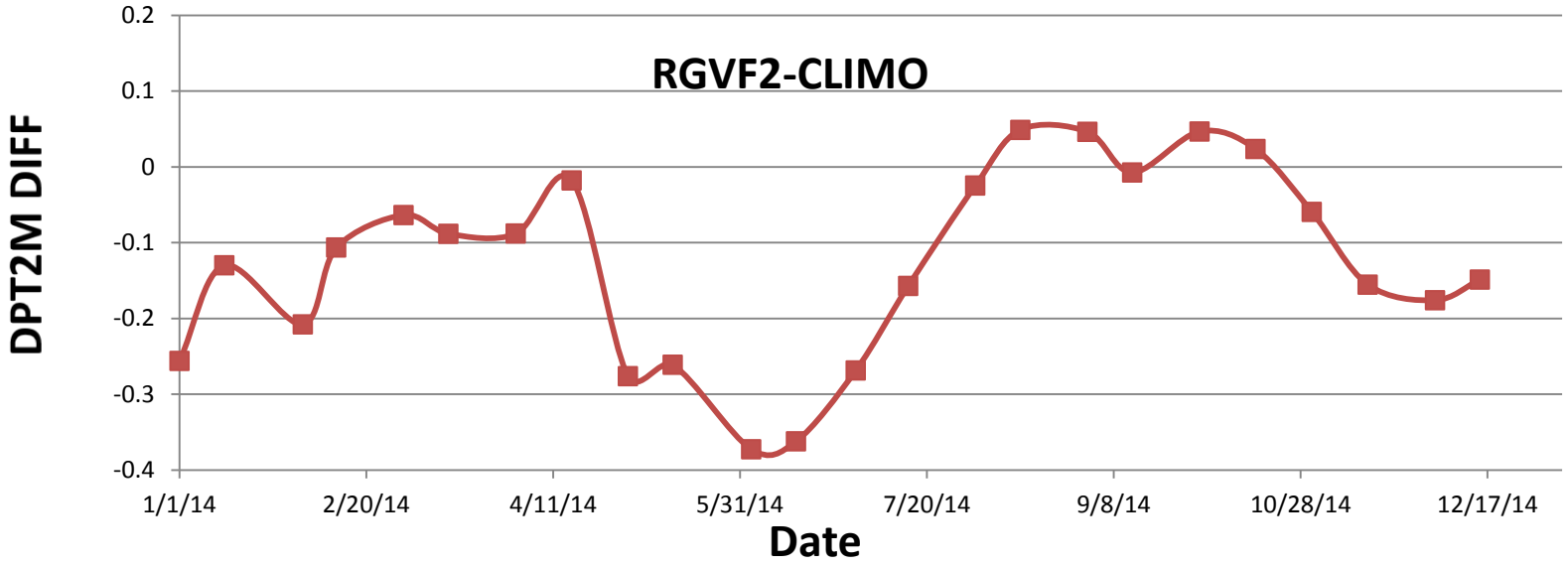


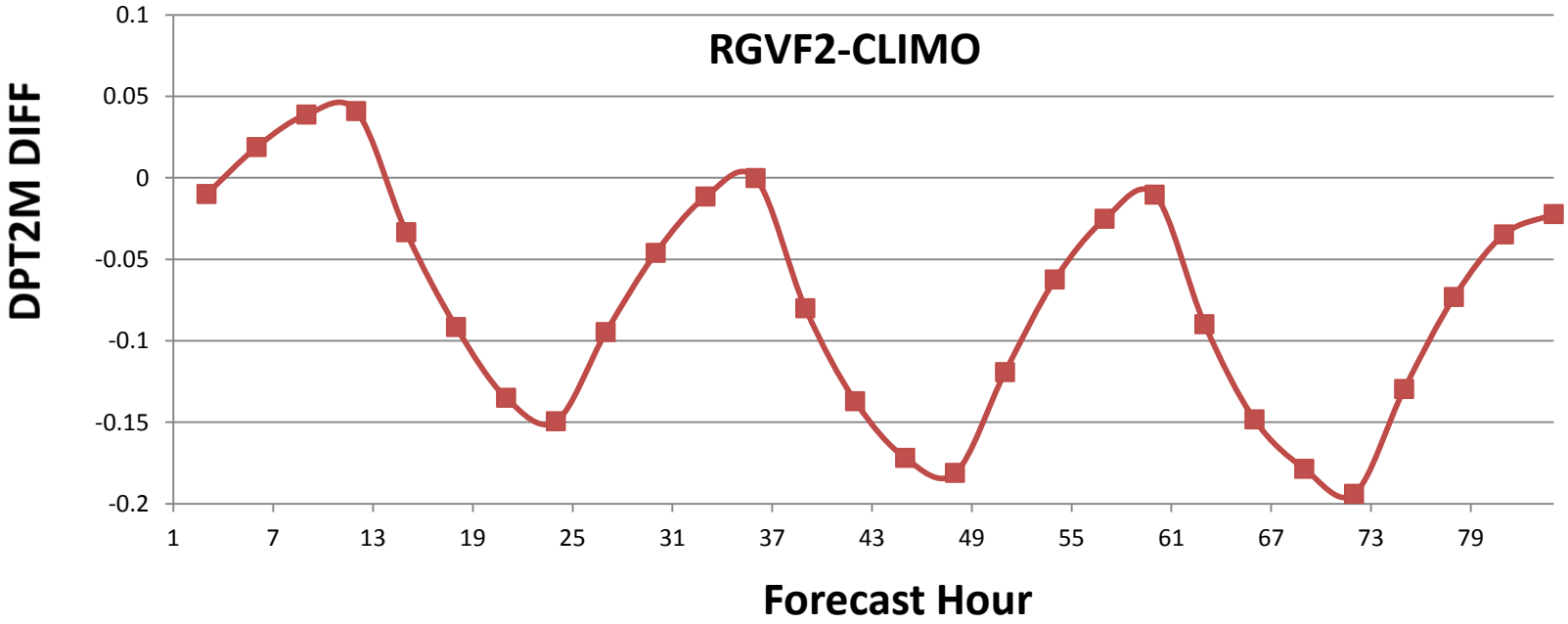
Land point averages over Grid218 Domain





Land point averages over Grid218 Domain



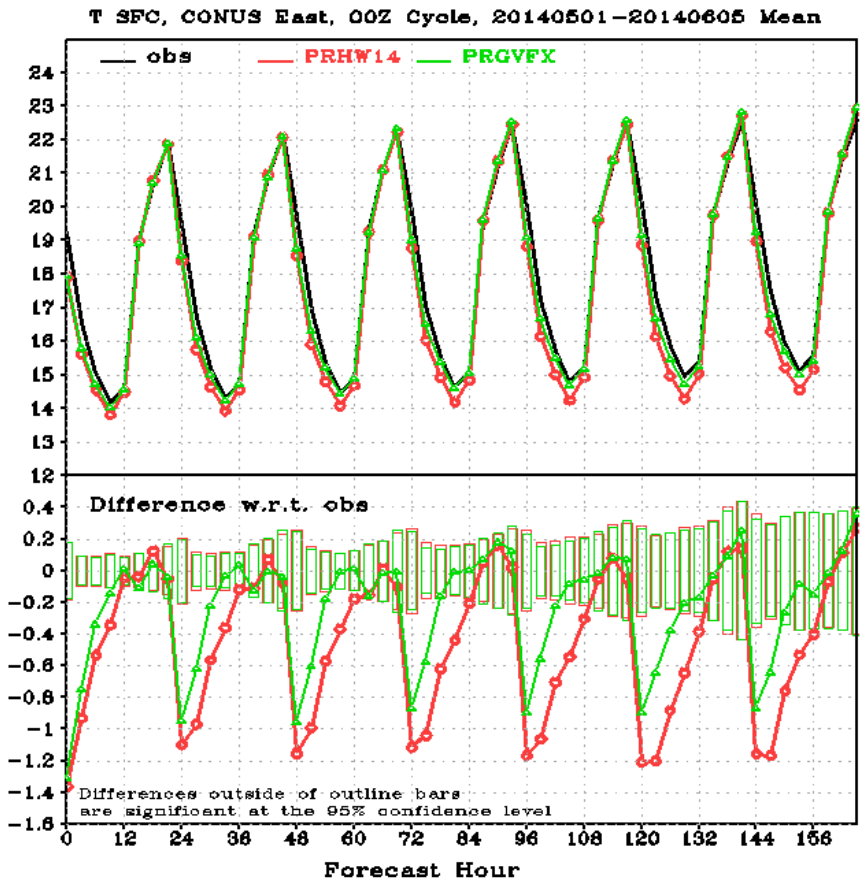


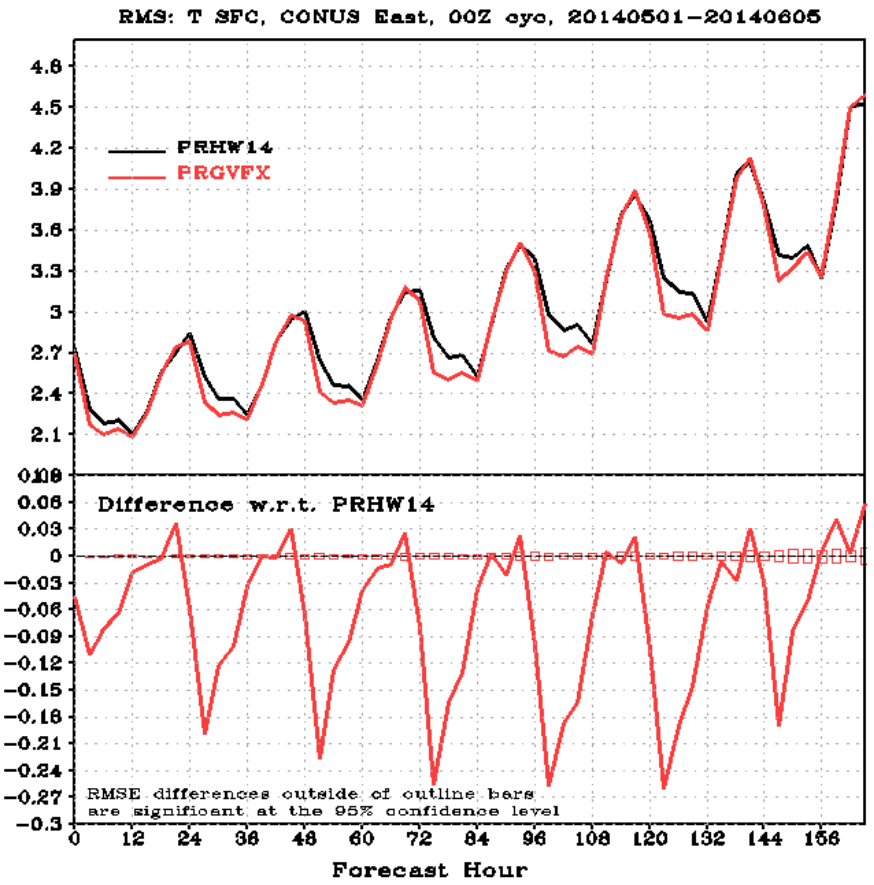
NAM GVF test summary

- Total 72 runs were conducted with NAM and 3 GVF products: climatology GVF and two near real time GVF.
- Replacing Climatology GVF changes not only GVF, but also surface albedo.
- Model (NAM) is sensitive to GVF changes
- There are big differences between the two near real time GVF – which one is closer to the real world? Validation is needed.
- GVF1 overestimates the real GVF? GVF2 has phase shift error? Both near real time GVF products need improvement
- Should albedo be a function of GVF?

GFS testing

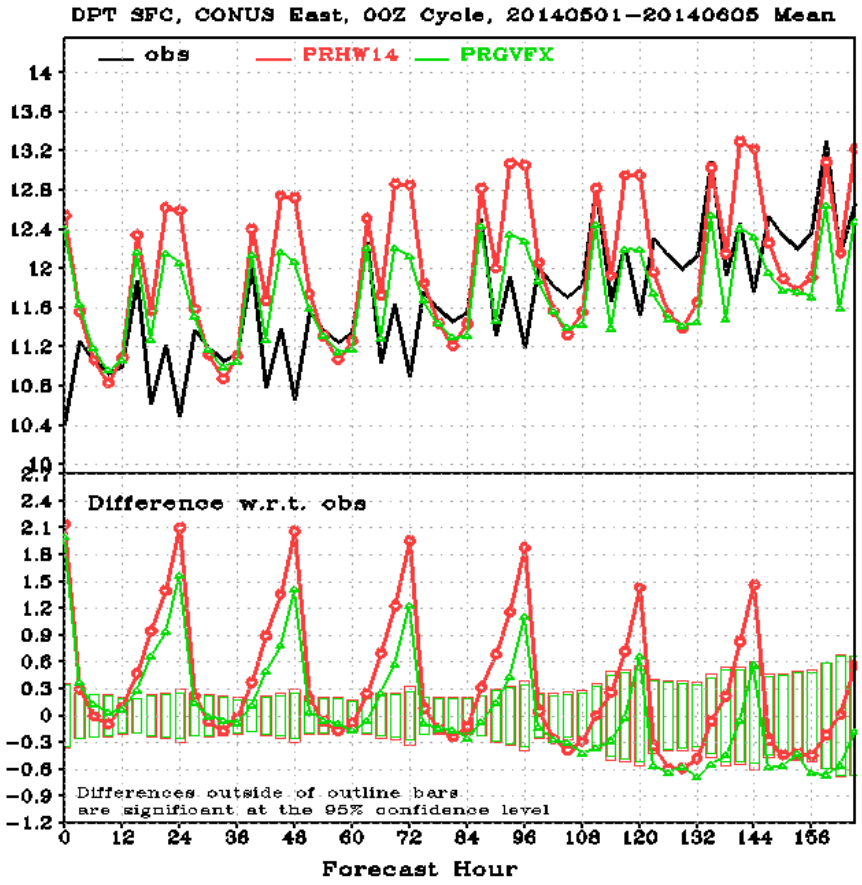
Surface temperature and its RMSE CONUS East

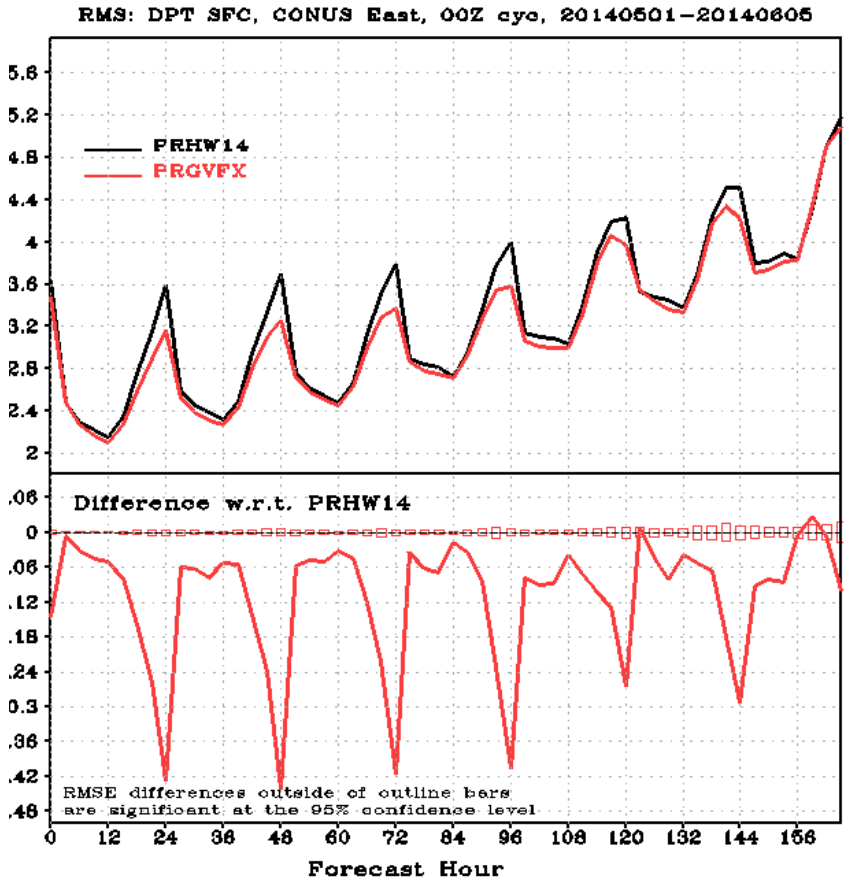




Reduced cold bias(~0.5 °C) and RMSE (~0.25 °C) afternoon and nighttime

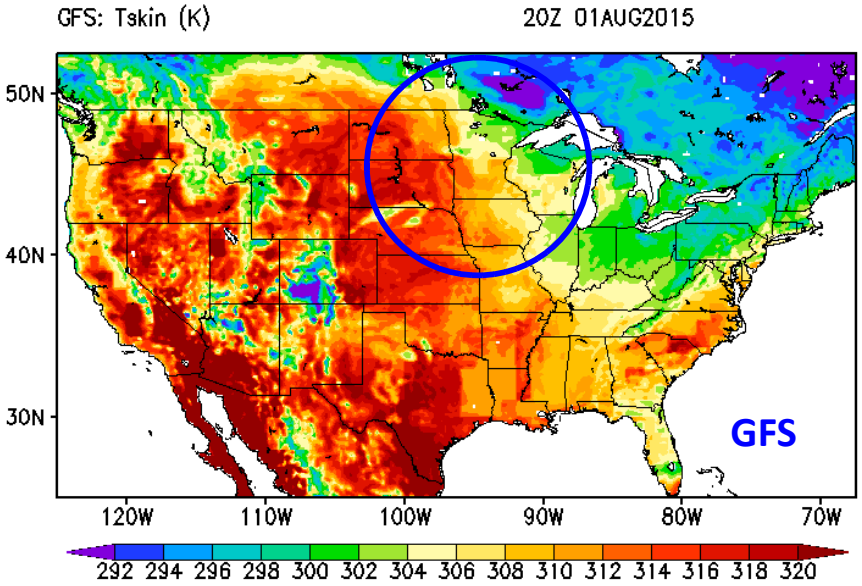
Surface dew point temp and its RMSE CONUS East

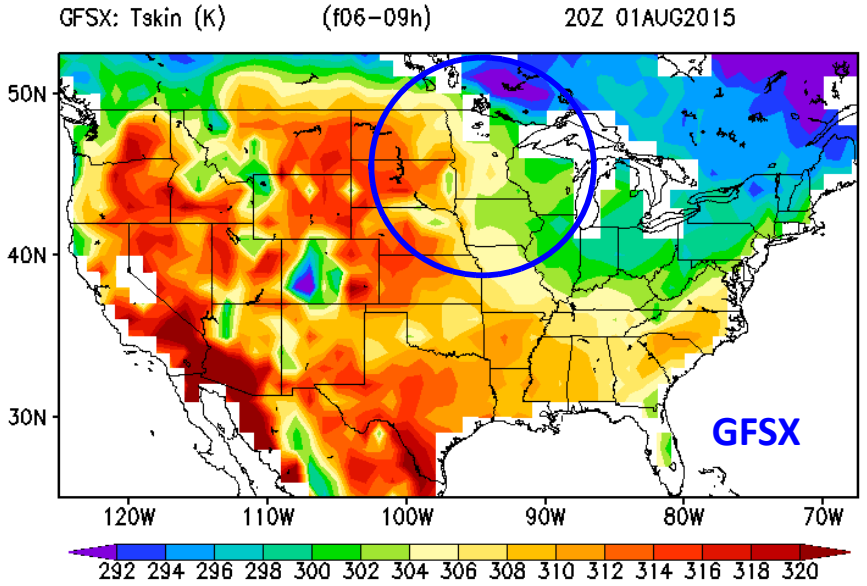




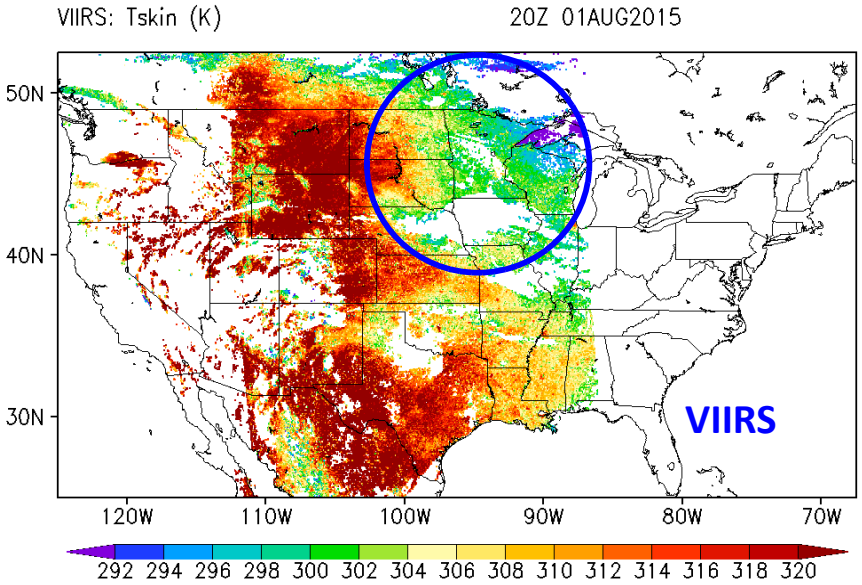
Reduced wet bias and RMSE afternoon and nighttime (~0.4 °C)

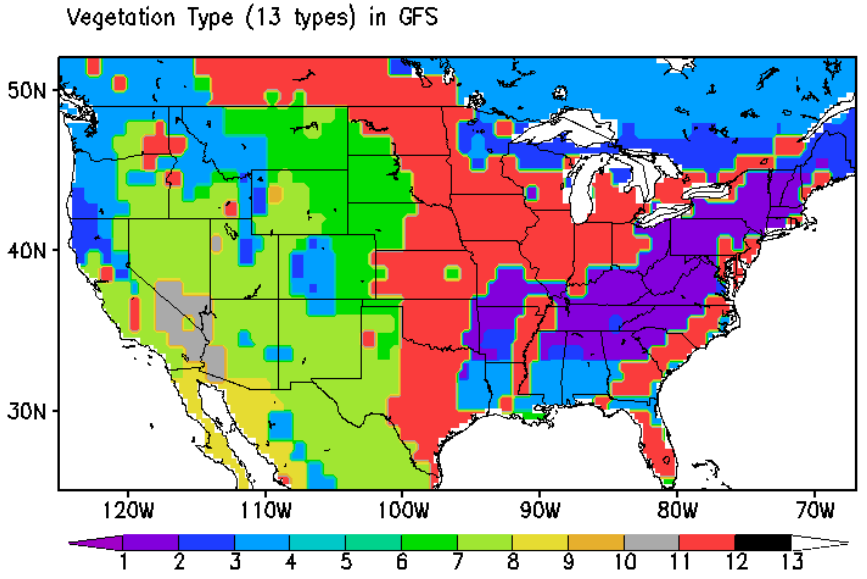
Comparison of LST: GFS, GFSX and VIIRS 20Z Aug 1, 2015





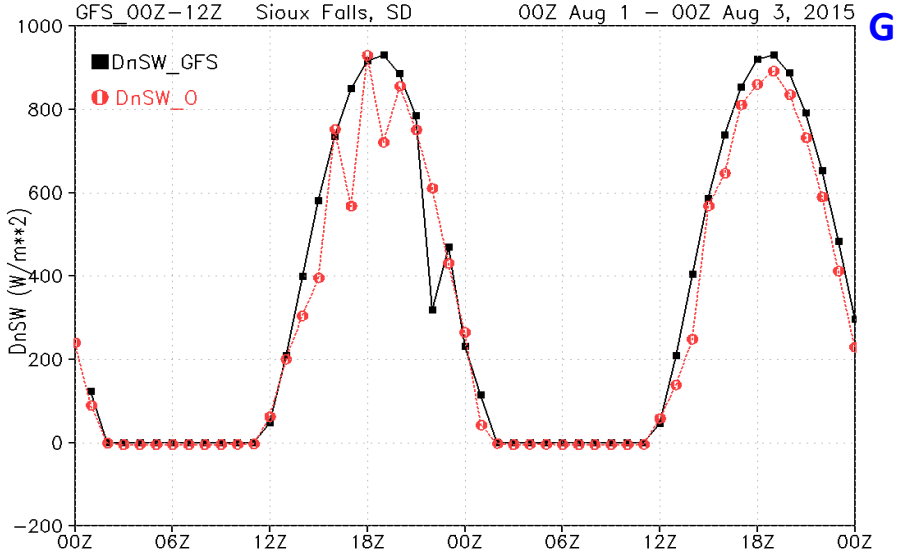
Zhen Song & Bob Yu



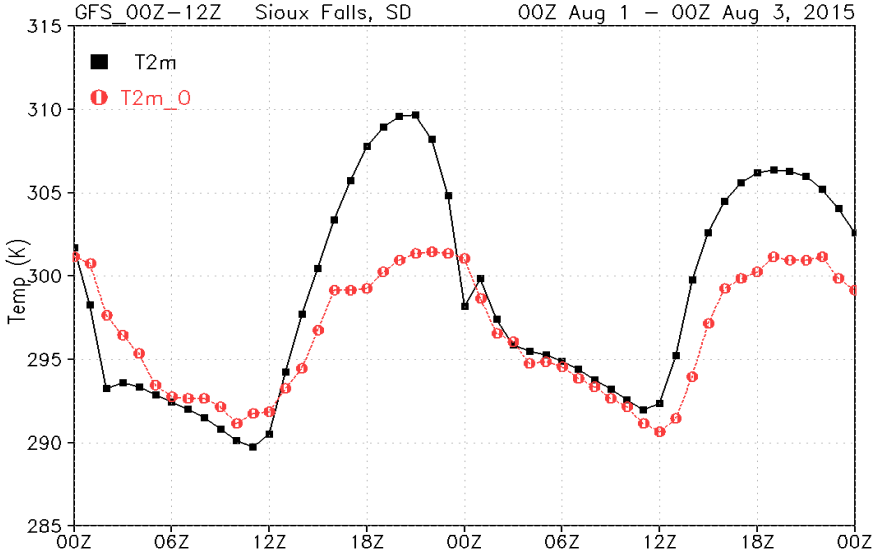


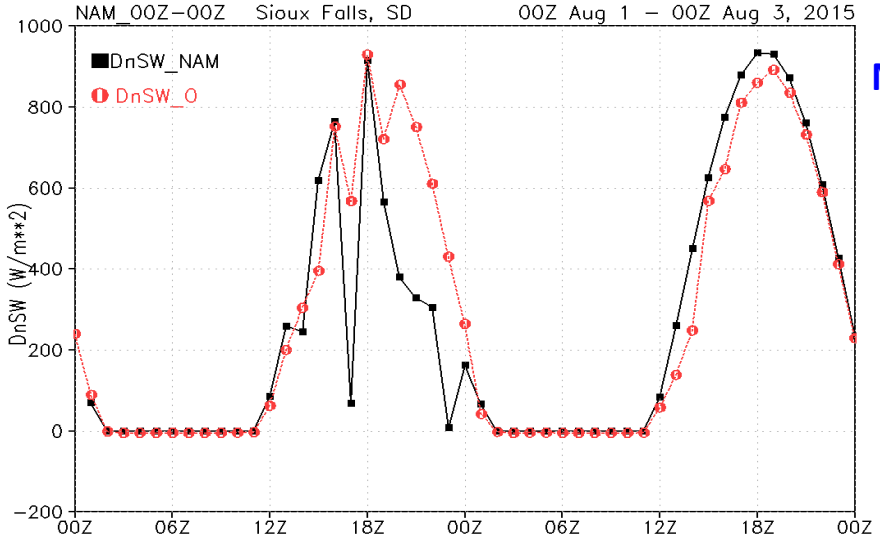
VIIRS LST VS Model LST

Verification of Swdn and T2m for GFS & NAM: 00Z Aug1-3, 2015

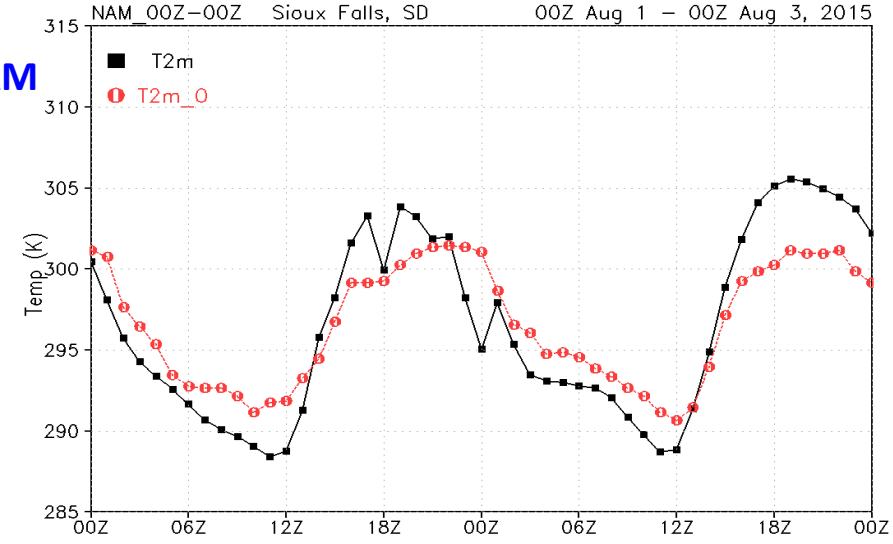


GFS





NAM



GVF milestones

- May 2015 – April, 2016: acquire VIIRS GVF data product from CLASS or NDE PE-1 distribution zone (√)
- May 2015 – April, 2016: acquire AVHRR derived GVF data product from CLASS (√)
- August 2015 – September, 2015: develop software application to ingest GVF datasets (AVHRR and VIIRS), perform statistical analyses and implement data display tools (√)
- October 2015 – March, 2016: perform statistical analysis to establish the relationship between GVF datasets (AVHRR and VIIRS) and the 5 year AVHRR derived monthly climatology currently used in NCEP models (√)
- March 2016 – April, 2016: summarize results (√)

LST milestones

- May – November, 2015: develop the methodology and software package to process the VIIRS granule LST data for gridded LST dataset that matches up all four model datasets; global gridded VIIRS LST files on each day in grib2 format at resolution of 0.036° (√)
- December, 2015 – May, 2016:
  - on the weekly basis, download all VIIRS granule data including all VIIRS granule-level temperature and geo-location data, and run the software package to produce the continuous global gridded VIIRS LST data at 0.036° resolution; time stamp of each VIIRS LST data is needed as attribute (√)
  - Develop software package that extract all the four model datasets that matches VIIRS LST at each grid, each time. (√)
- By the end of May 2016, generate **one year** global gridded daily VIIRS LST product at resolution of 0.036°; the match-up model data are ready for the comparison analyses (√)

Summary and conclusions

- VIIRS GVF and LST datasets have been produced to enable ingest into the NCEP land modeling suite
  - The VIIRS vs. AVHRR statistical analysis revealed the issue with the shift of the phenological signal; the issue has been addressed
  - Gridded LST data have been produced at two resolutions and work is ongoing towards an hourly gridded product
- Sensitivity of model runs to updated GVF has been demonstrated
  - Impact varies
  - Further test runs are being performed with updated VIIRS GVF data
- The value of the VIIRS LST product for model verification has been demonstrated