



EMC FY15Q1 Upgrade Review

GFS upgrade

**N
C
E
P**

Presented by:

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based on work done by Global Climate and Weather Modeling Branch



Charter Overview



- This upgrade is planned for November, 2014
- System description
 - This is a change to the GDAS and GFS.
- What's being changed in the system
 - Model
 - T1534 Semi-Lagrangian
 - Use of high resolution daily SST and sea ice analysis
 - Physics
 - Land Surface
 - Post Processor
 - Analysis upgrades
- Expected benefits to end users associated with upgrade
 - Major upgrade in global modeling capability.
 - Significant improvement in forecast skill
- This implementation will put GFS/GDAS into EE process.



Analysis Highlights

- Structure
 - T574 analysis for T1534 deterministic
 - Code optimization
- Observations
 - GPSRO enhancements – improve quality control
 - Updates to radiance assimilation
 - Assimilate SSM/IS UPP LAS and MetOp-B IASI radiances
 - CRTM v2.1.3
 - New enhanced radiance bias correction scheme
 - Additional satellite wind data – hourly GOES, EUMETSAT
- EnKF modifications
 - Stochastic physics in ensemble forecast
 - T574L64 EnKF ensembles



Model Highlights (1)

- T1534 Semi-Lagrangian (~13km)
- Use of high resolution daily SST and sea ice analysis
- High resolution until 10 days
- Dynamics and structure upgrades
 - Change from Lagrangian to Hermite interpolation in the vertical to reduce stratospheric temperature cold bias.
 - Restructured physics and dynamics restart fields and updated sigio library
 - Divergence damping in the stratosphere to reduce noise
 - Added a tracer fixer for maintaining global column ozone mass
 - Major effort to make code reproducible



Model Highlights (2)

- Physics upgrades
 - Radiation modifications -- McICA
 - Reduced drag coefficient at high wind speeds
 - Hybrid EDMF PBL scheme and TKE dissipative heating
 - Retuned ice and water cloud conversion rates, background diffusion of momentum and heat, orographic gravity-wave forcing and mountain block etc
 - Stationary convective gravity wave drag
 - Modified initialization to reduce a sharp decrease in cloud water in the first model time step
 - Correct a bug in the condensation calculation after the digital filter is applied



Model Highlights (3)

- Boundary condition input and output upgrades
 - Consistent diagnosis of snow accumulation in post and model
 - Compute and output frozen precipitation fraction
 - New blended snow analysis to reduce reliance on AFWA snow
 - Changes to treatment of lake ice to remove unfrozen lake in winter
 - Land Surface
 - Replace Bucket soil moisture climatology by CFS/GLDAS
 - Add the vegetation dependence to the ratio of the thermal and momentum roughness, Fixed a momentum roughness issue



Post - Processor Highlights

- Faster/less memory version
- .25 degree post file instead of master grib file (GRIB2)
- Accumulation bucket changed from 12 hour to 6 hour between day 8 and day 10
- Add user requested fields
 - frozen precipitation fraction
 - ozone at 150, 200, 250, 300, 350, and 400 mb,
 - 2m dew point,
 - wind chill and heat index,
 - instantaneous precipitation type
 - membrane SLP in GDAS pgb files
 - Improved icing algorithm in post
 - Higher precision rh
- BUFR station list to newer NAM/GFS list



Parallel Status

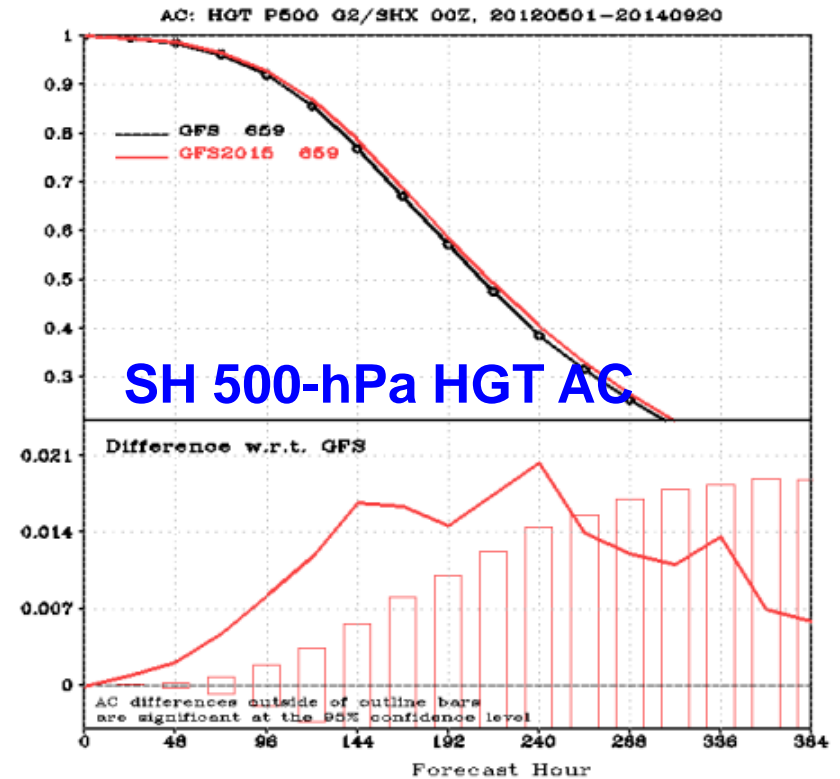
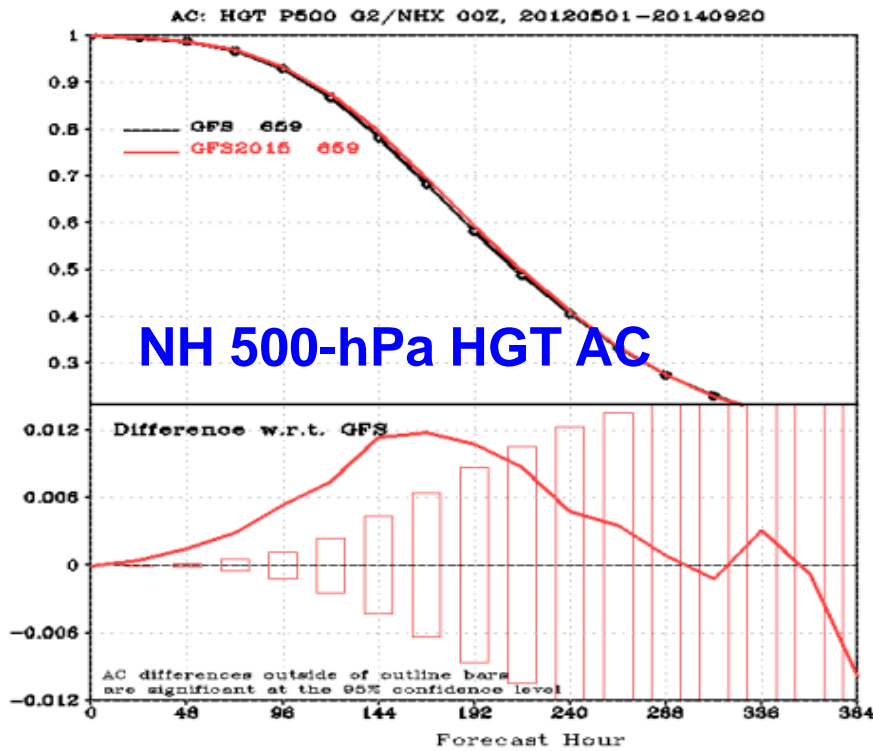


- All components of the system , including Storm-Relocation, OBSPROC, EMC-Surface, GSI, ENKF, GSM, Post-processing, were built in the EE structure, are frozen, and have been handed off to NCO for implementation.
- NCO is working on setting up a 30-day pre-implementation parallel, which will be run on the development machine.
- Parallels and verification pages
 - **Prhs14: 01/01/2014 ~ present** **running**
 - <http://www.emc.ncep.noaa.gov/gmb/wd20rt/vsdb/prhw14>
 - **Prhs13: 05/16/2013 ~ 12/31/2013** **completed**
 - <http://www.emc.ncep.noaa.gov/gmb/wd20rt/vsdb/prhs13>
 - **Prhs12: 05/01/2012 ~ 11/06/2012** **completed**
 - <http://www.emc.ncep.noaa.gov/gmb/wd20rt/vsdb/prhs12>
 - **Prhs11: 05/20/2011 ~ 12/31/2011** **completed (on Zeus)**
 - <http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/prhs11>
 - <http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/prhs11b/>
- merged 2012/2013/2014 <http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2015/>



Results – Merged 2012/2013/2014

- see <http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2015/> for more detail. Note that Hybrid ENKF 3D-VAR GSI was implemented into operation after May 22, 2012



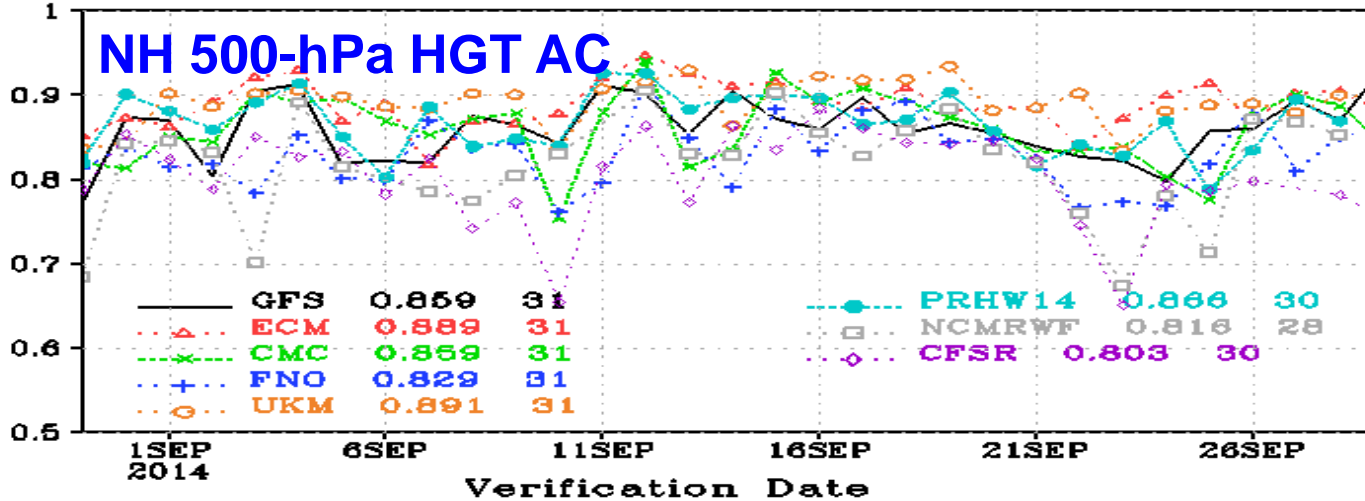
Link to scorecard

<http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2015/www/scorecard/mainindex.html>



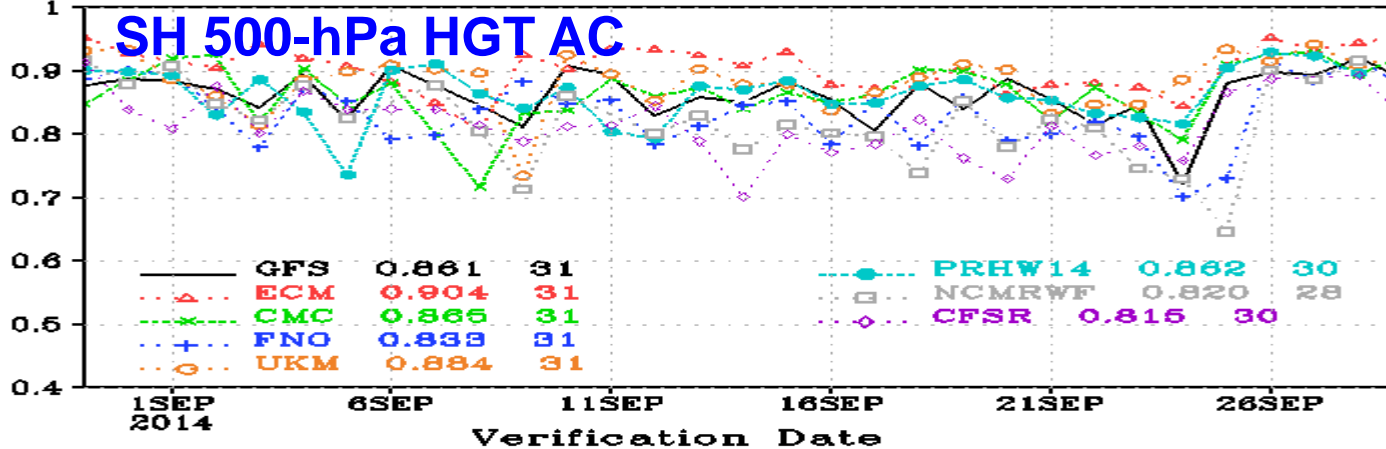
Real-Time Parallel in the past 31 Days

Anomaly Correl: HGT P500 G2/NHX 00Z, fh120



Prhw14 is
T1534
parallels

Anomaly Correl: HGT P500 G2/SHX 00Z, fh120

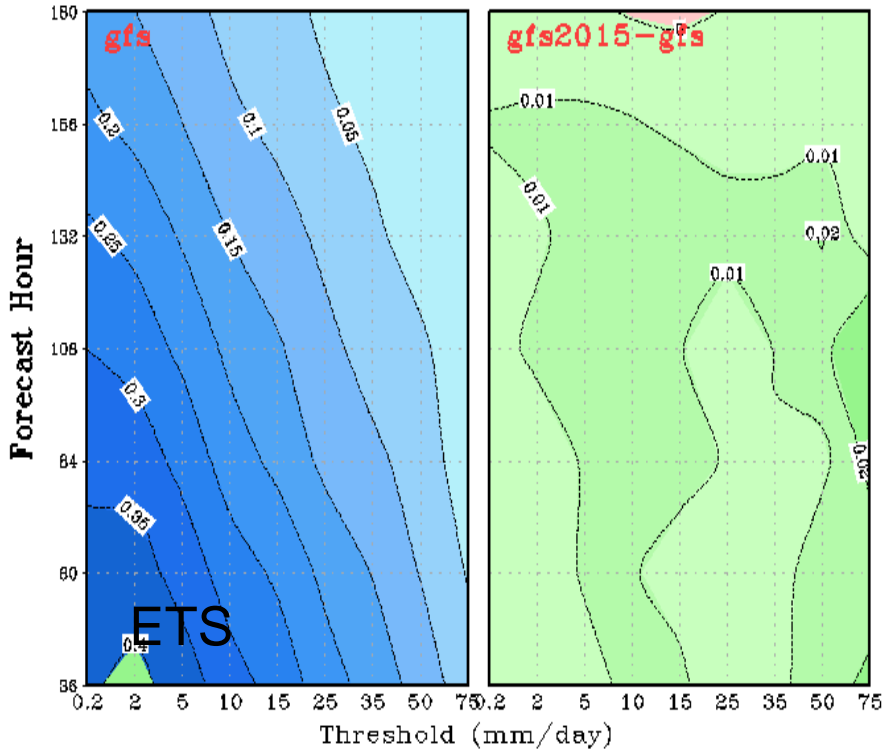




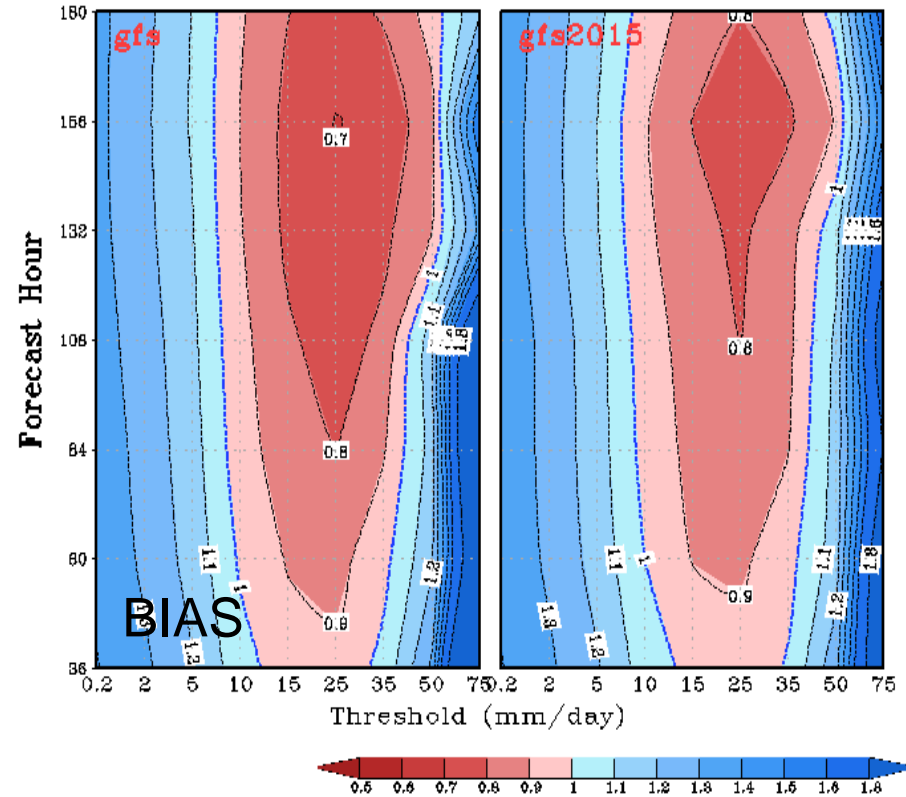
Precipitation Skill Scores, 00Z Cycle Merged 2012/2013/2014



CONUS Precipitation Equitable Threat Score
03may2012-20sep2014 00Z Cycle



CONUS Precipitation BIAS Score
03may2012-20sep2014 00Z Cycle



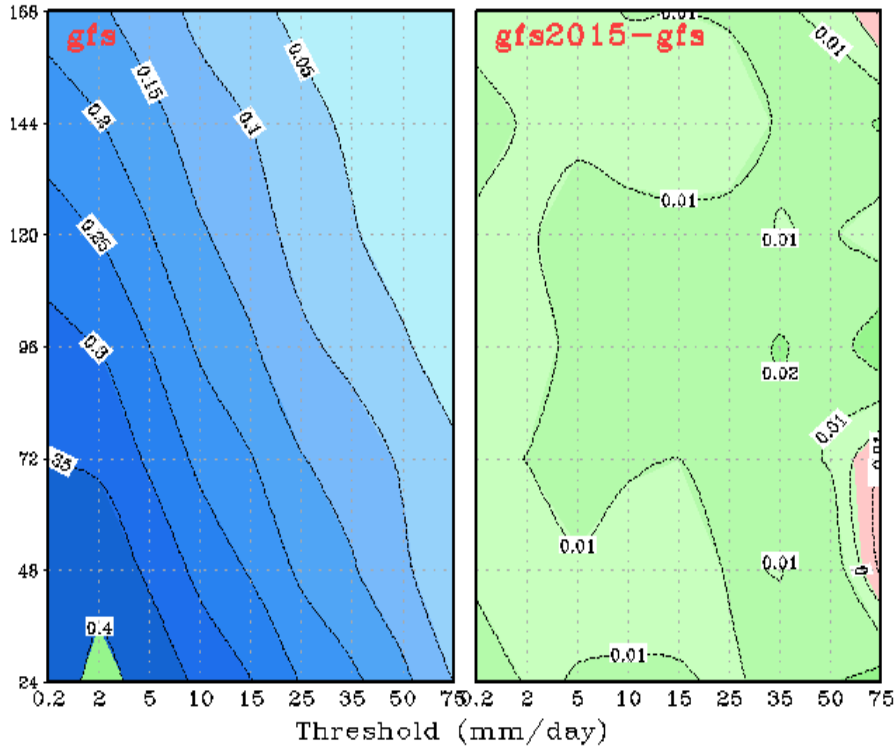
Improved ETS score and reduced forecast BIAS for all intensity and forecast lead time.



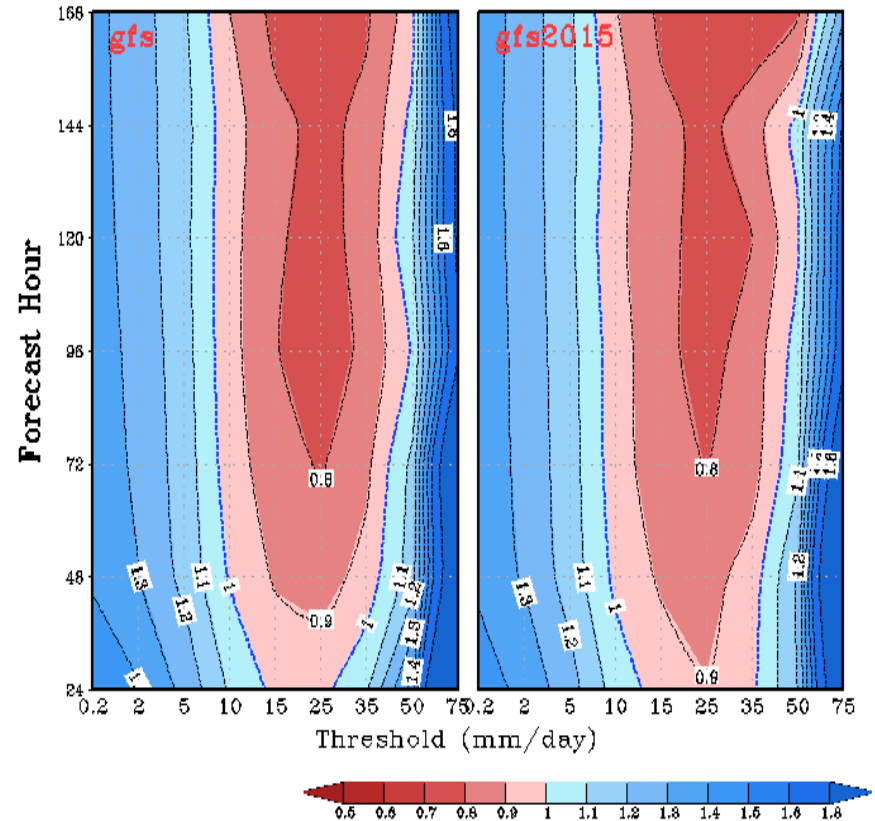
Precipitation Skill Scores, 12Z cycle Merged 2012/2013/2014



CONUS Precipitation Equitable Threat Score
03may2012-20sep2014 12Z Cycle



CONUS Precipitation BIAS Score
03may2012-20sep2014 12Z Cycle



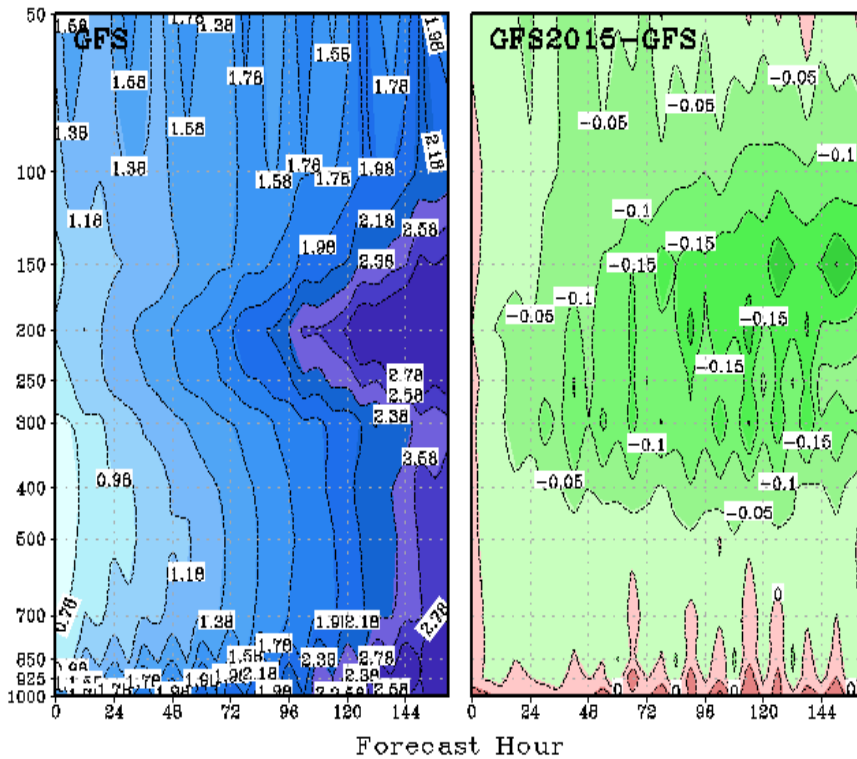
Improved ETS score and slightly reduced forecast BIAS for all intensity and forecast lead time.



Fit to RAOBS, RMSE Merged 2012/2013/2014

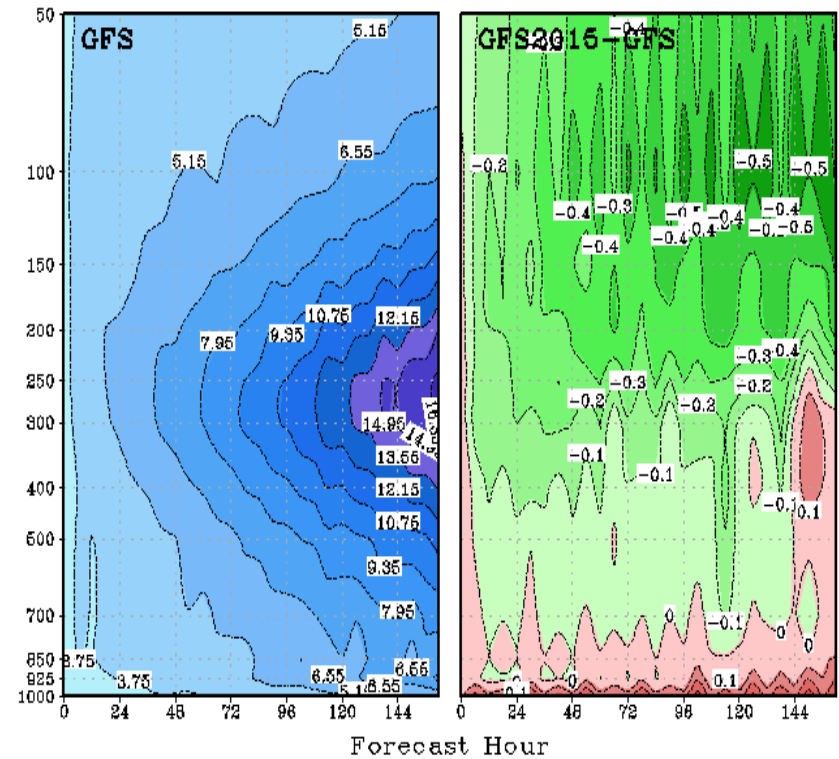
Global Mean Temperature RMSE

T (K) RMSE over Globe: fit to ADPUPA
00Z Cycle 20120510-20140920 Mean



Global Mean Wind RMSE

VWND (m/s) RMSE over Globe: fit to ADPUPA
00Z Cycle 20120510-20140920 Mean



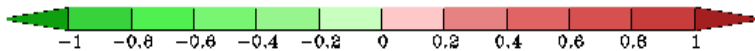
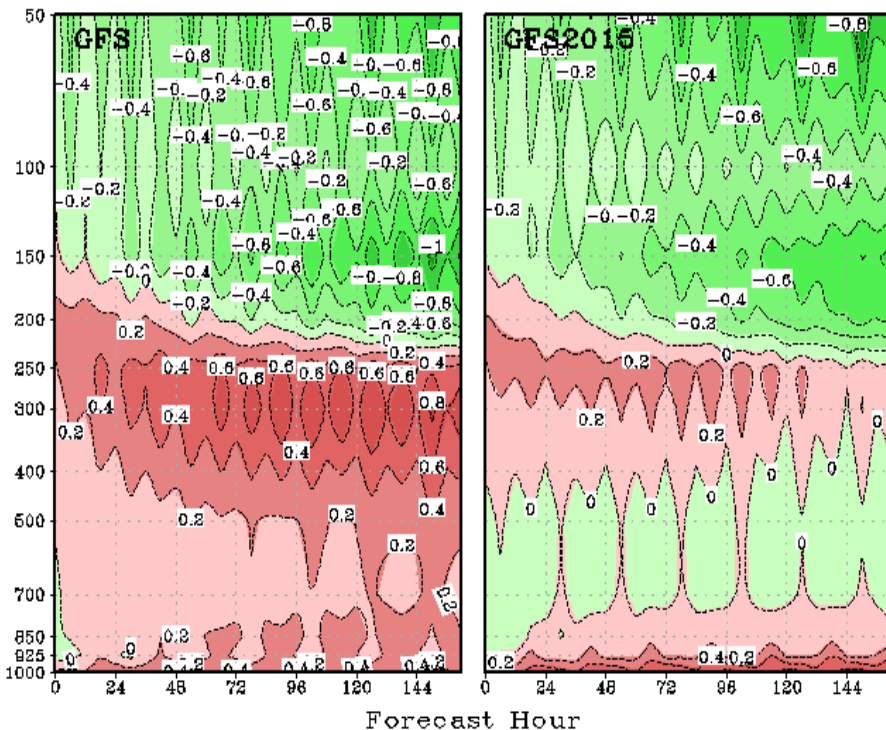


Fit to RAOBS, Bias Merged 2012/2013/2014



Global Mean Temperature Bias

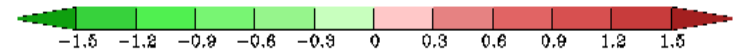
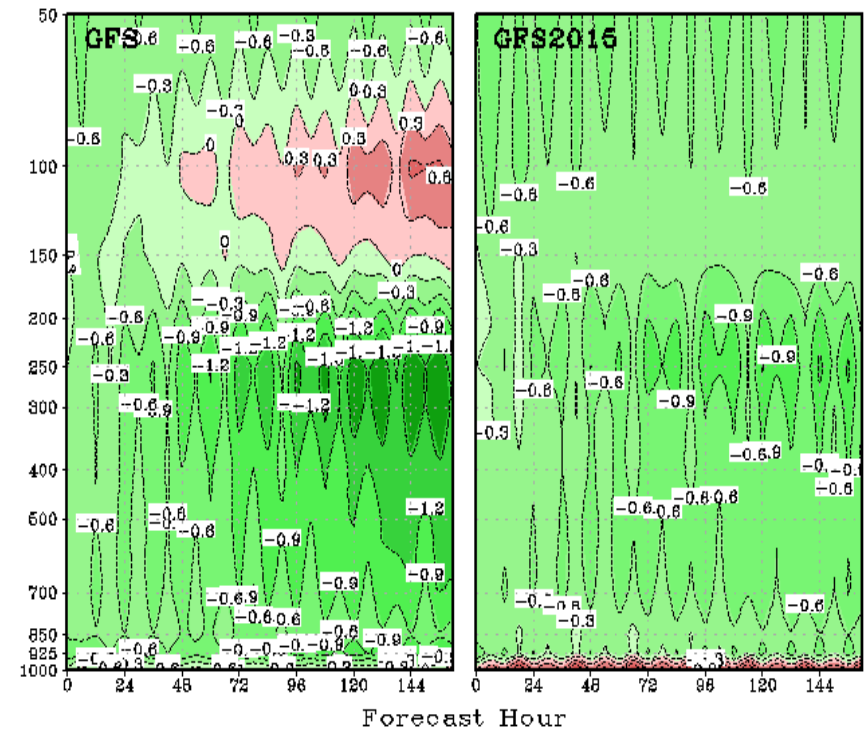
T (K) Bias over Globe: fit to ADPUPA
00Z Cycle 20120510-20140920 Mean



Reduced tropospheric warm bias,
increased near surface warm bias

Global Mean Wind Bias

VWND (m/s) Bias over Globe: fit to ADPUPA
00Z Cycle 20120510-20140920 Mean



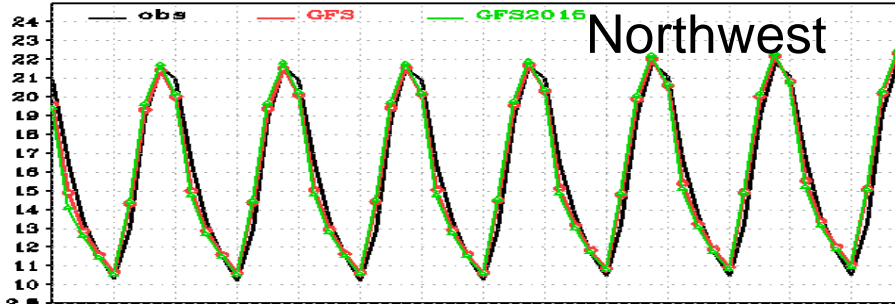
Strengthened tropospheric wind,
slightly weakened stratospheric wind



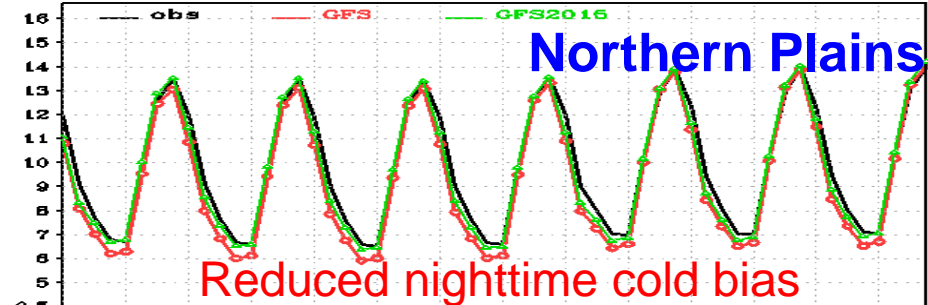
CONUS T2m, Fit to Sfc Obs Merged 2013/2014



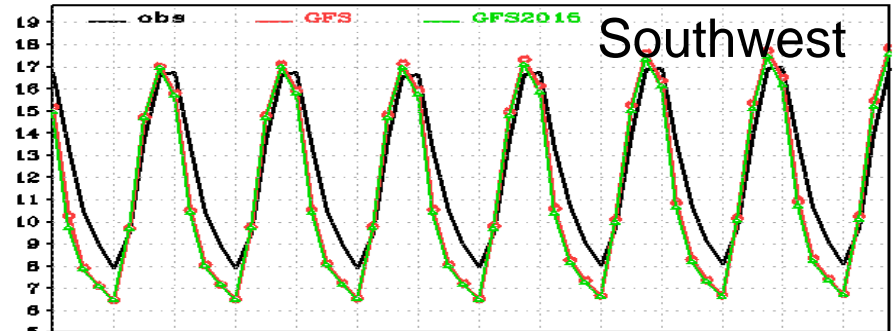
T SFC, CONUS Southwest, 00Z Cycle, 20130520-20140920 Mean



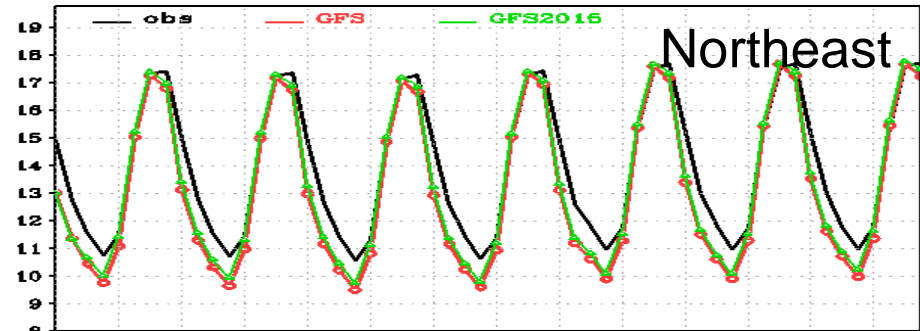
T SFC, N. Plains and Mid-West, 00Z Cycle, 20130520-20140920 Mean



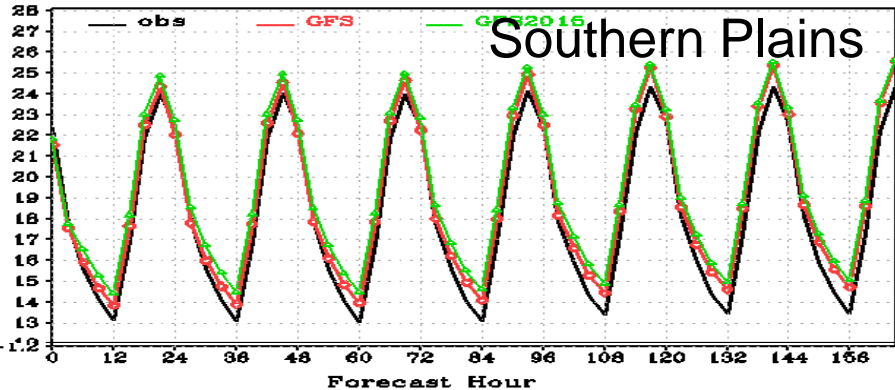
T SFC, CONUS Northwest, 00Z Cycle, 20130520-20140920 Mean



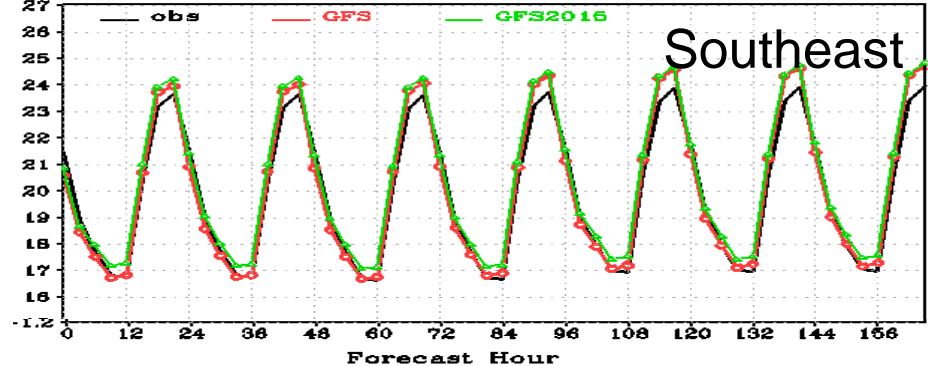
T SFC, CONUS Northeast, 00Z Cycle, 20130520-20140920 Mean



T SFC, S. Plains, 00Z Cycle, 20130520-20140920 Mean



T SFC, CONUS Southeast, 00Z Cycle, 20130520-20140920 Mean

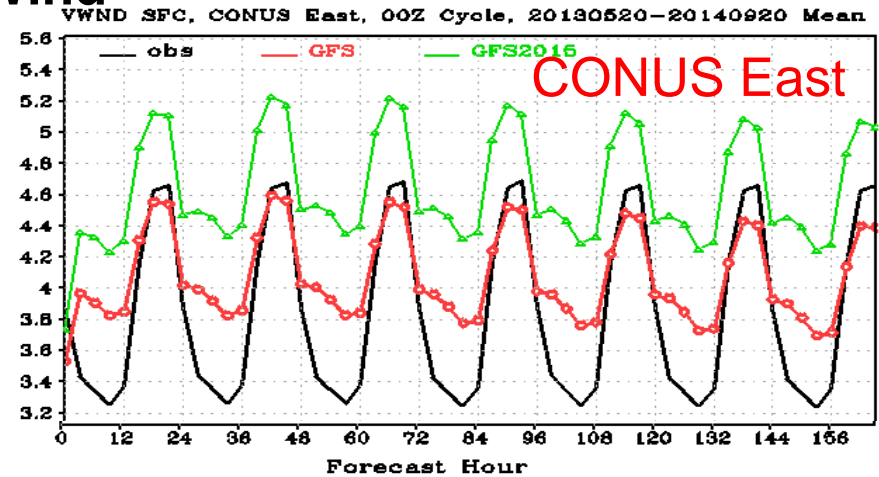
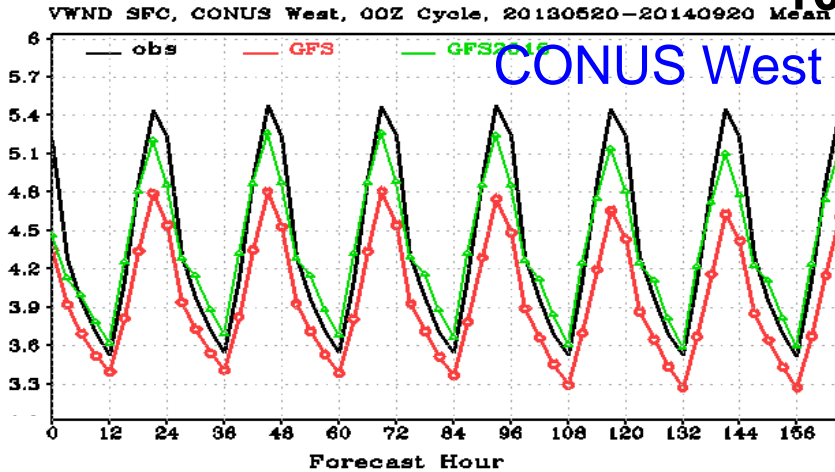




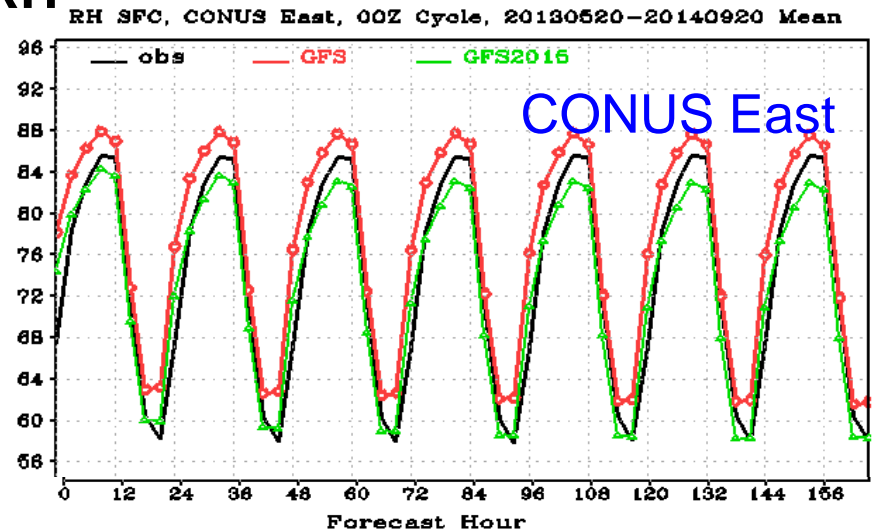
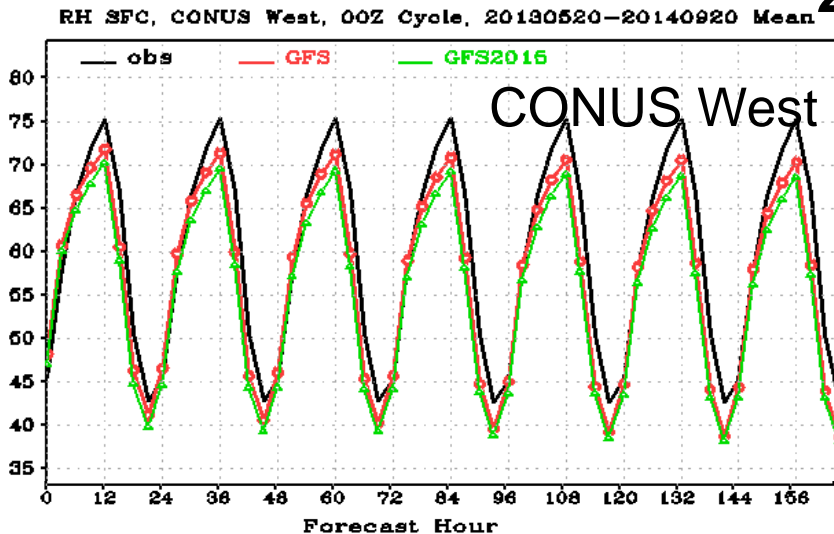
10-m Wind and 2m RH, Fit to Sfc Obs Merged 2013/2014



10m Wind



2m RH

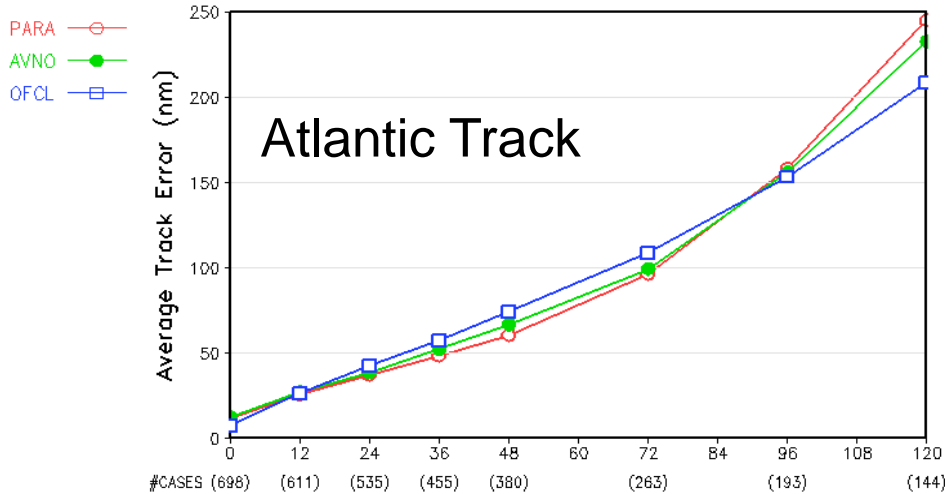




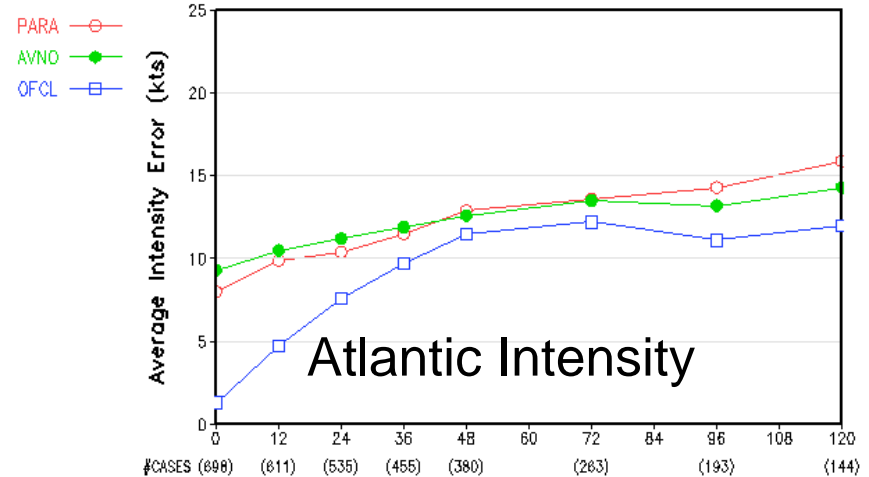
Hurricane Verification 2012/2013/2014



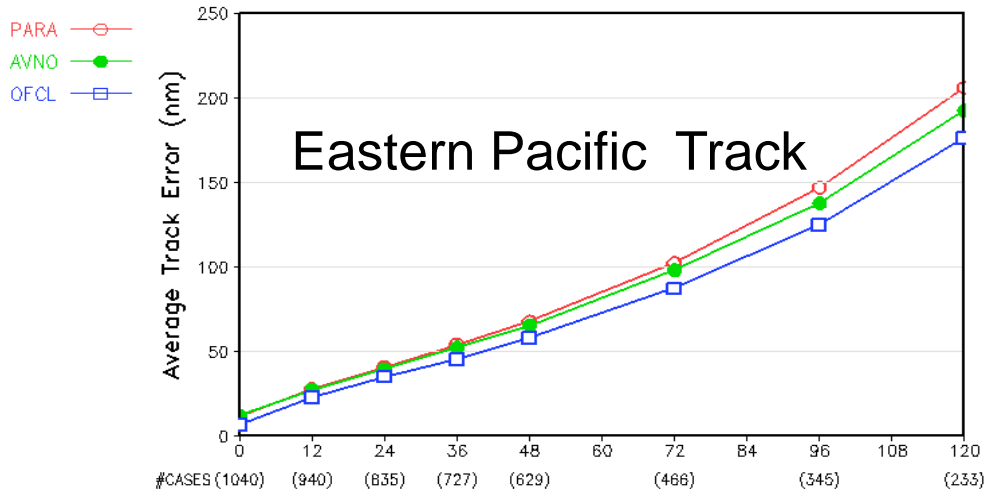
Hurricane Track Errors – Atlantic 20122014
20120501__20140920__4cyc



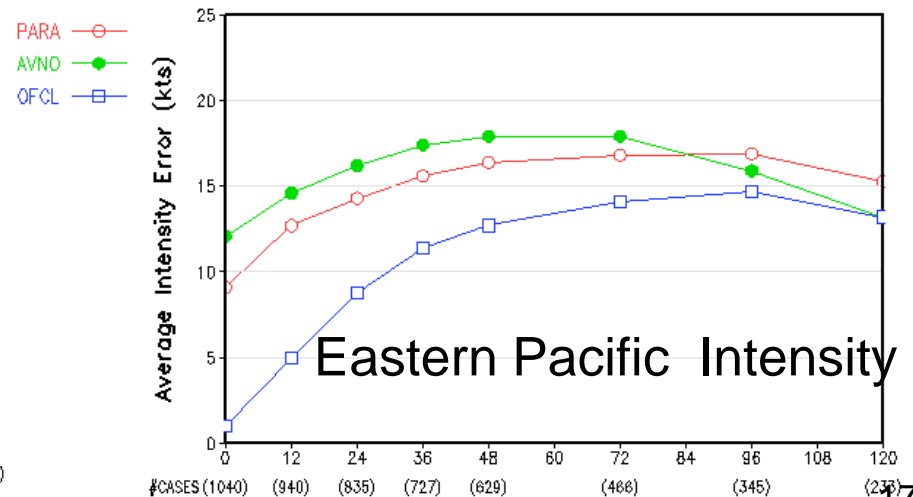
Hurricane Intensity Errors – Atlantic 20122014
20120501__20140920__4cyc



Hurricane Track Errors – East-Pacific 20122014
20120501__20140920__4cyc



Hurricane Intensity Errors – East-Pacific 20122014
20120501__20140920__4cyc

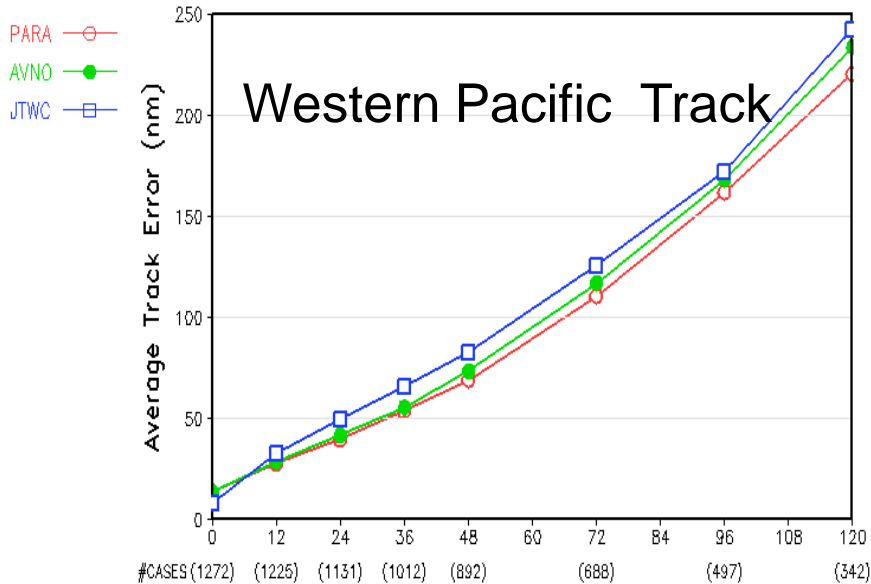




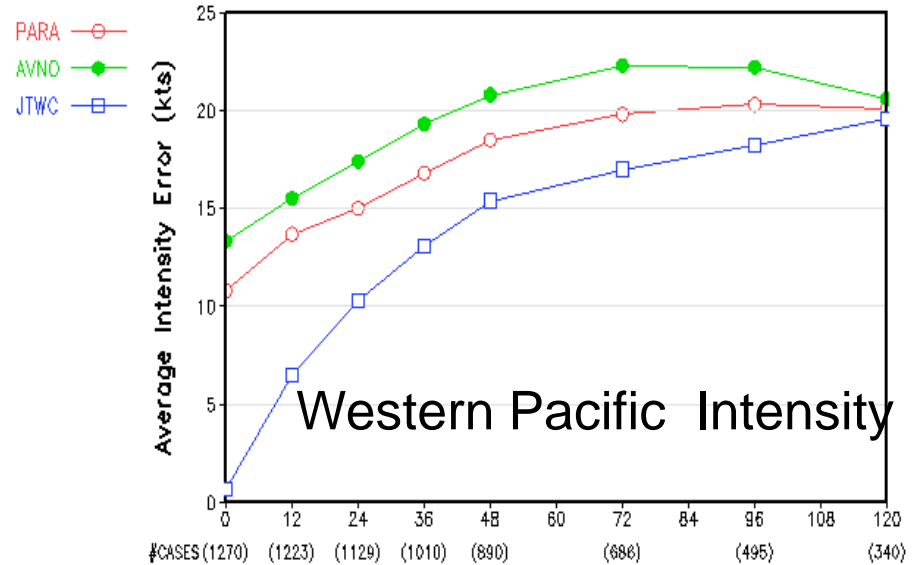
Hurricane Verification 2012/2013/2014



Hurricane Track Errors – West-Pacific 2012/2013/2014
20120501_20140920_4cyc



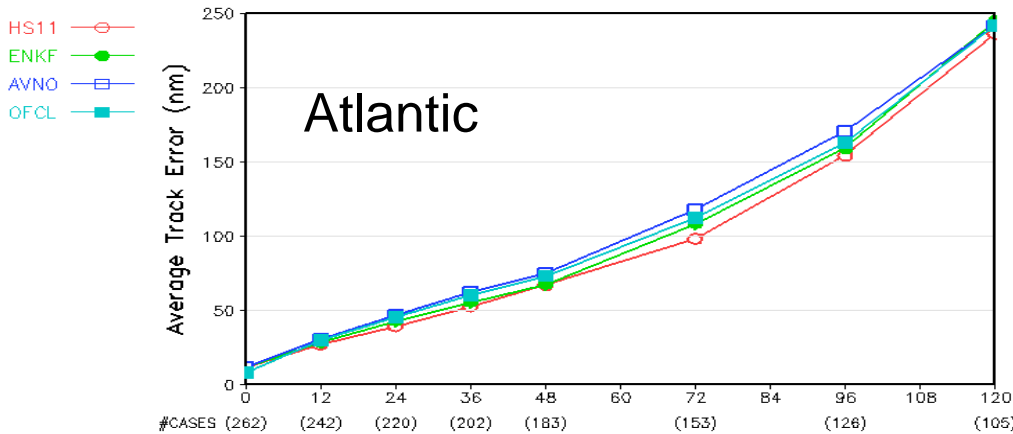
Hurricane Intensity Errors – West-Pacific 2012/2013/2014
20120501_20140920_4cyc





Hurricane Track Verification, 2011

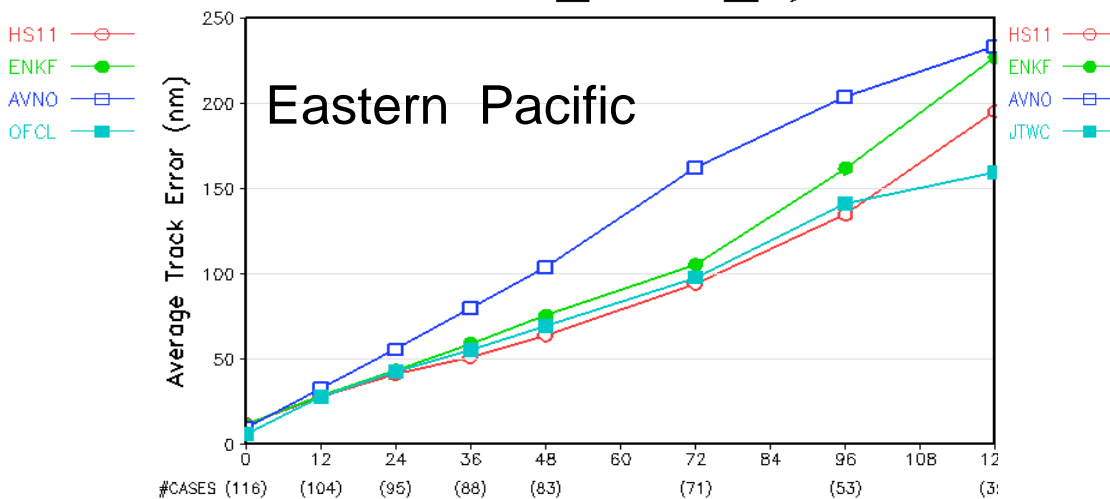
Hurricane Track Errors – Atlantic 2011
20110820_20111016_4cyc



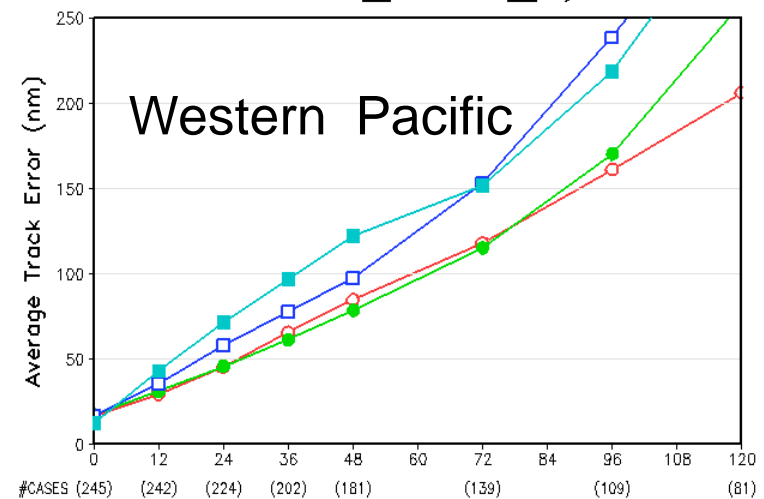
HS11: T1534 parallel
ENKF: T574 ENKF-3DVAR parallel

ENKF was run only for part of the 2011 hurricane season (08/20/2011 – 10/16/2011)

Hurricane Track Errors – East-Pacific 2011
20110820_20111016_4cyc



Hurricane Track Errors – West-Pacific 2011
20110820_20111016_4cyc





2012 Hurricane Sandy

Summary:

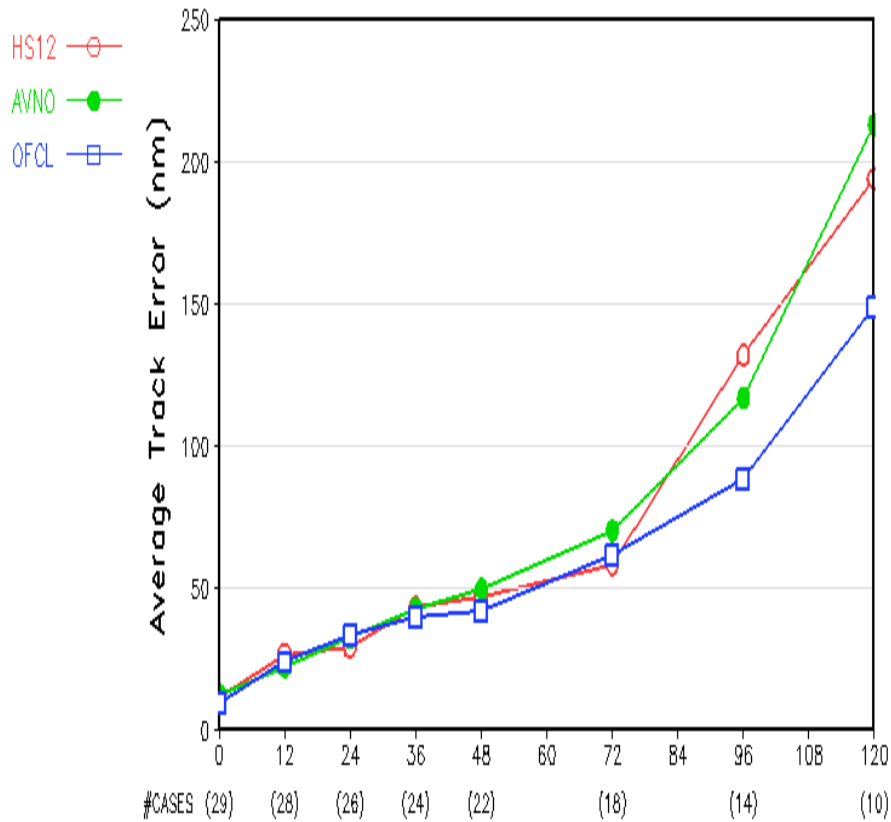
- At day 7, HS12 is significantly better than AVNO. HS12 showed the tendency to move Sandy northwestward.
- At day 6, HS12 is slightly better than AVNO, but the difference is small.
- At day-5 and day-4, the results are mixed. HS12 is better than AVNO for certain cycles but worse for other cycles.
- At day 3 and less, HS12 is much better than AVNO. HS12 forecast is as good as or slightly better than ECMWF forecast.
- **Overall, the forecast of hurricane Sandy's track is improved in the experimental T1534 semi-lag GFS in comparison with the operational T574 Eulerian GFS. The improvement is most significant for short-lead forecast within 72 hours. Long-lead 6 to 7-day forecasts showed improvement for certain cycles.**



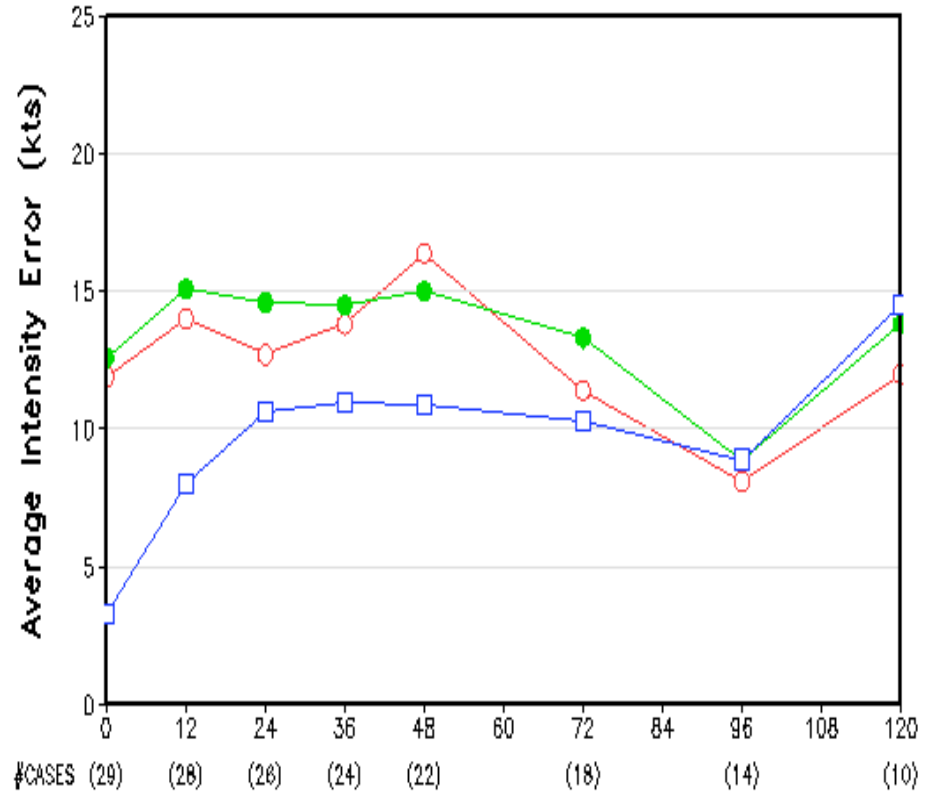
Mean Track and Intensity Errors 22 - 30 October 2012, 4 cycles/day



Hurricane Track Errors - Atlantic 2012
Sandy_20121022_20121030_4cyc



Hurricane Intensity Errors - Atlantic 2012
Sandy_20121022_20121030_4cyc

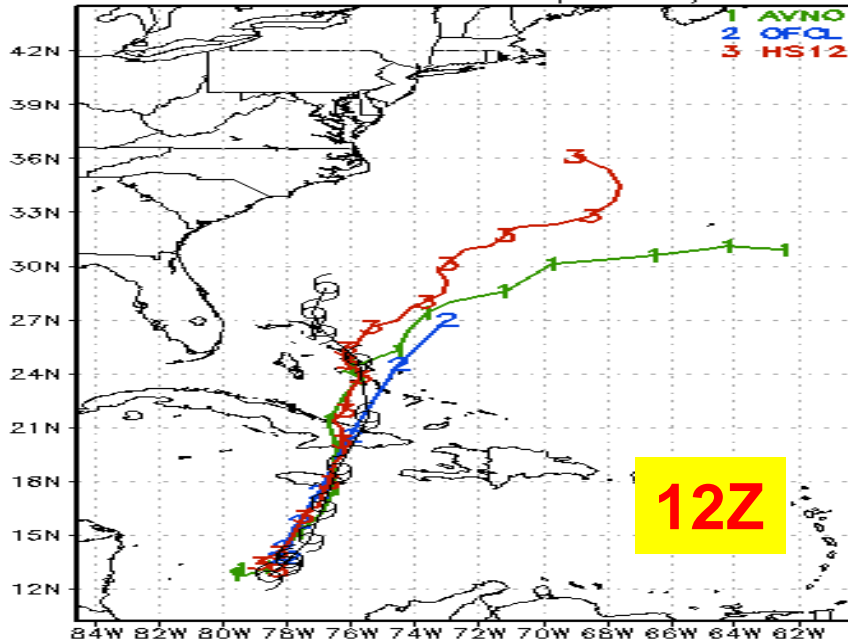




Tracks from Forecast Cycles 20121022: 12Z and 18Z 7 days before landfall

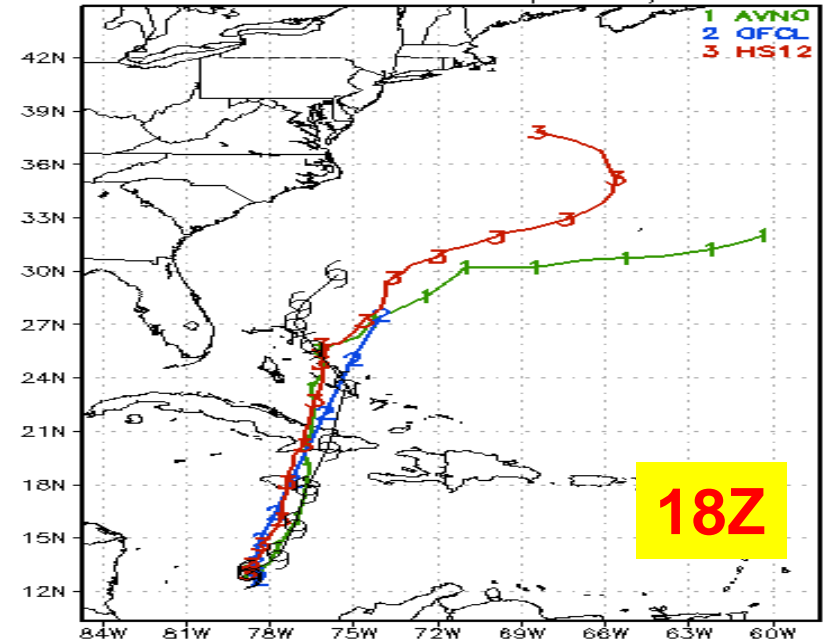


2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



Forecasts: Beginning 2012102212
Observed: Beginning 2012102212, every 12 hours

2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



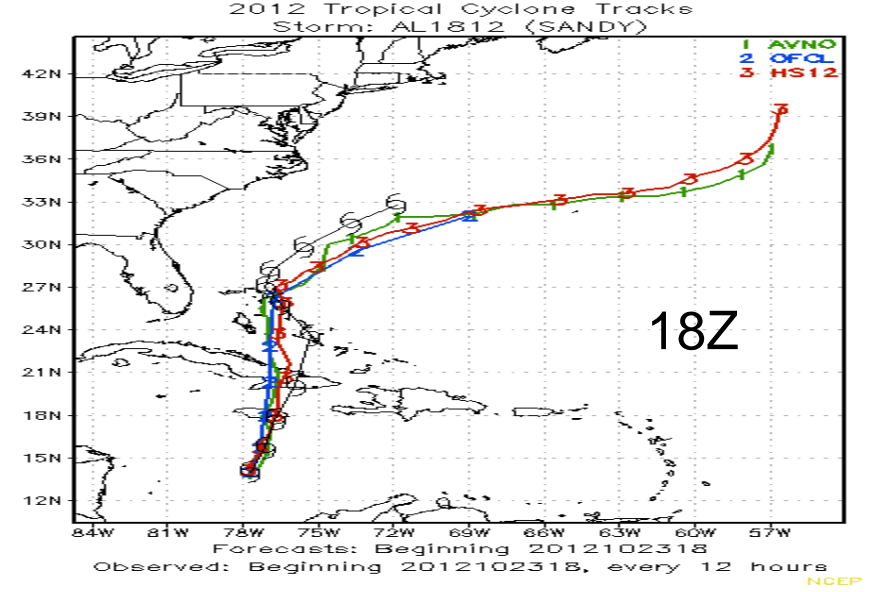
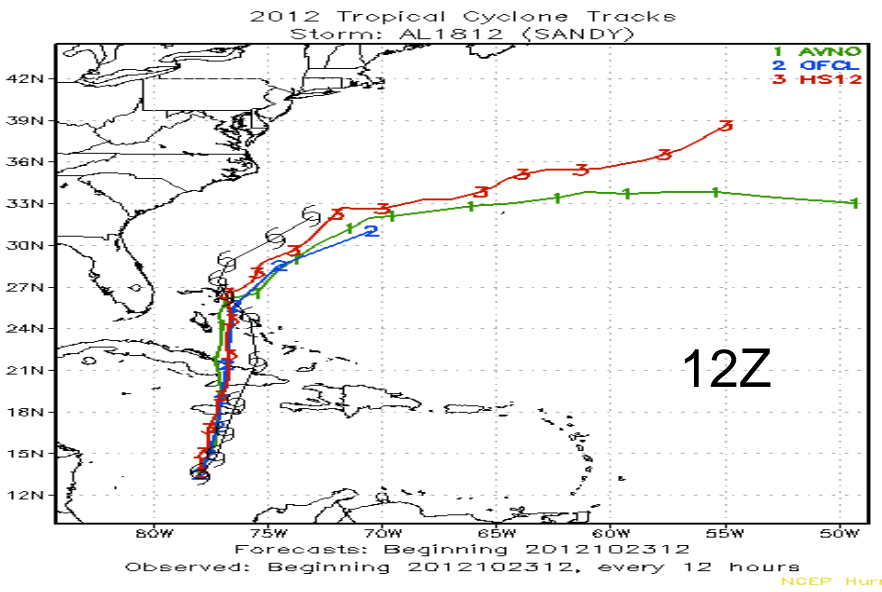
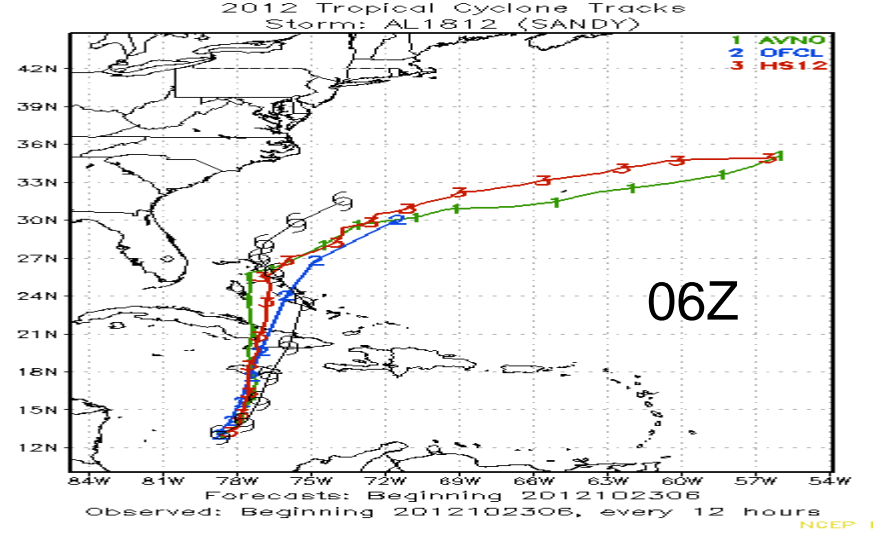
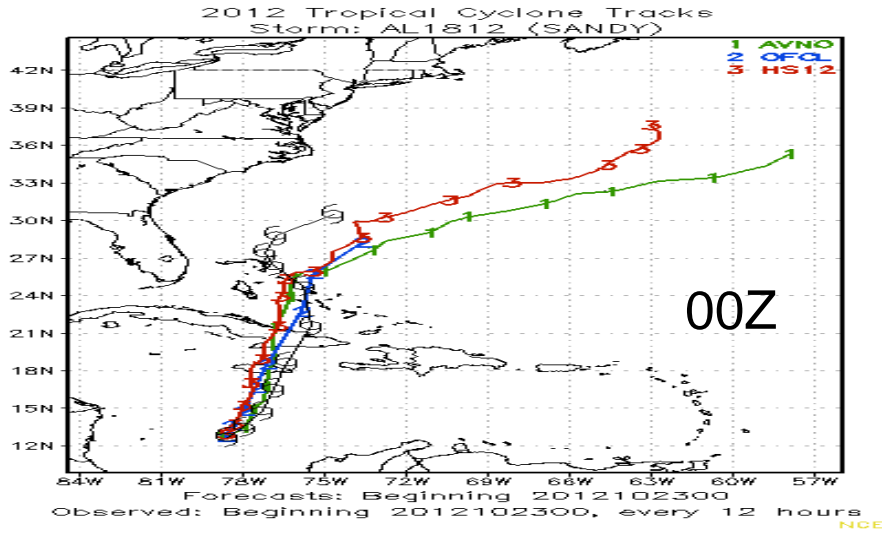
Forecasts: Beginning 2012102218
Observed: Beginning 2012102218, every 12 hours

NC



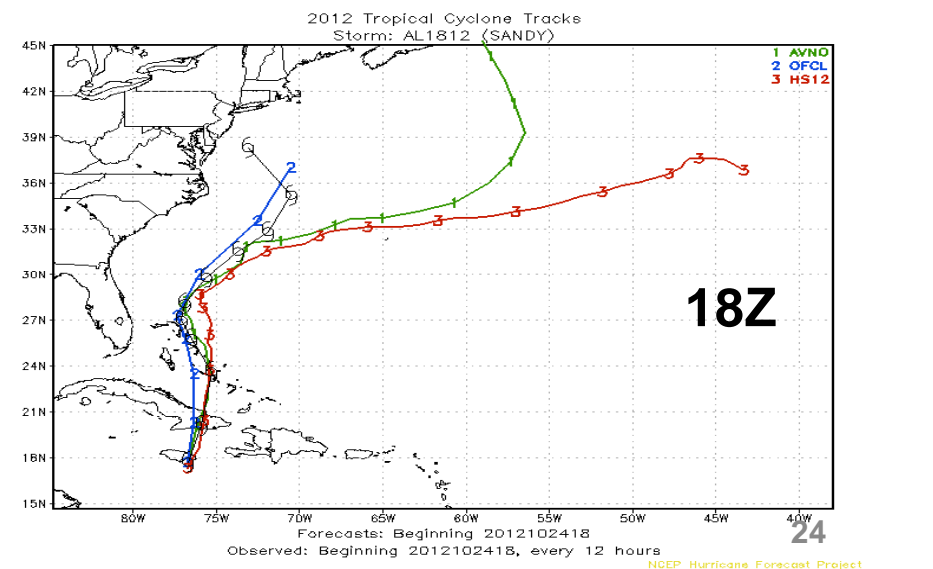
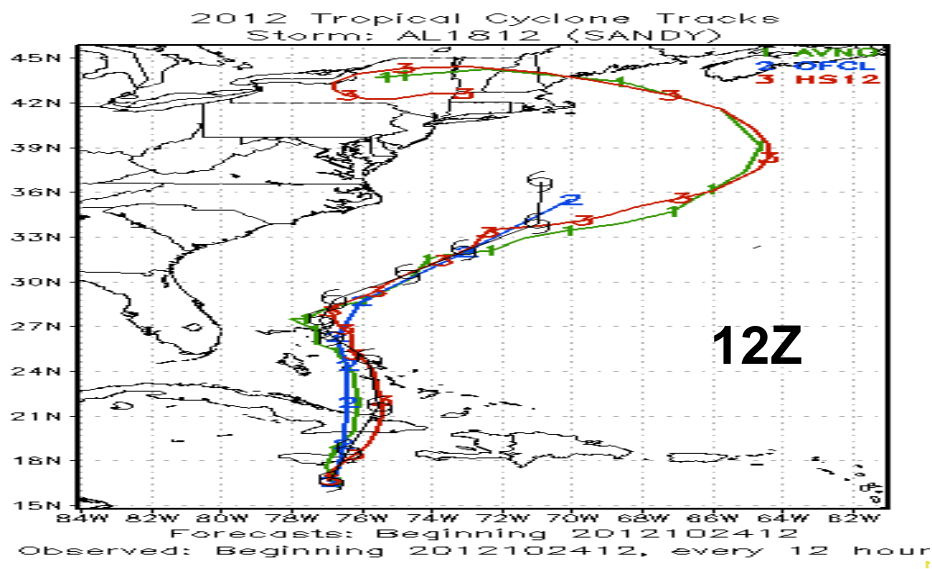
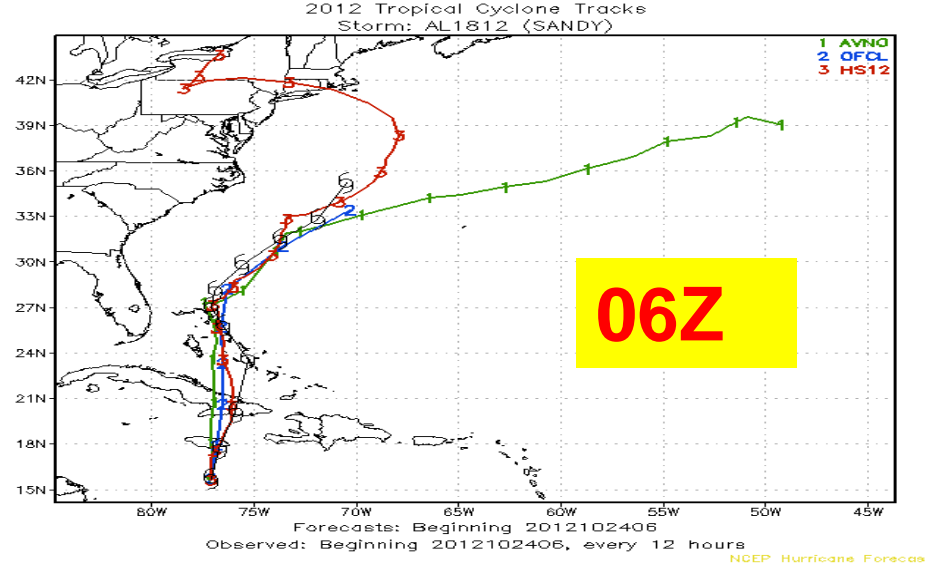
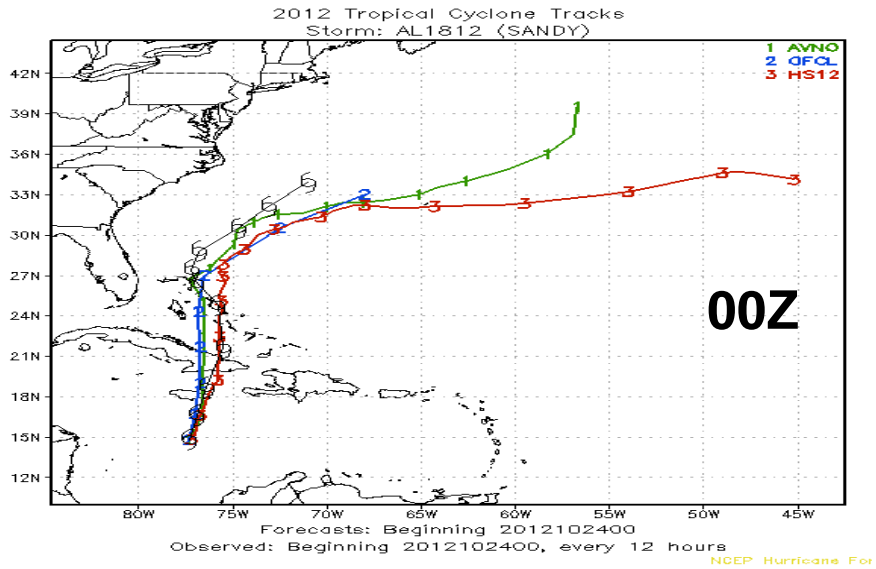
Tracks from 20121023: 00Z, 06Z, 12Z and 18Z Cycles

6 days before landfall



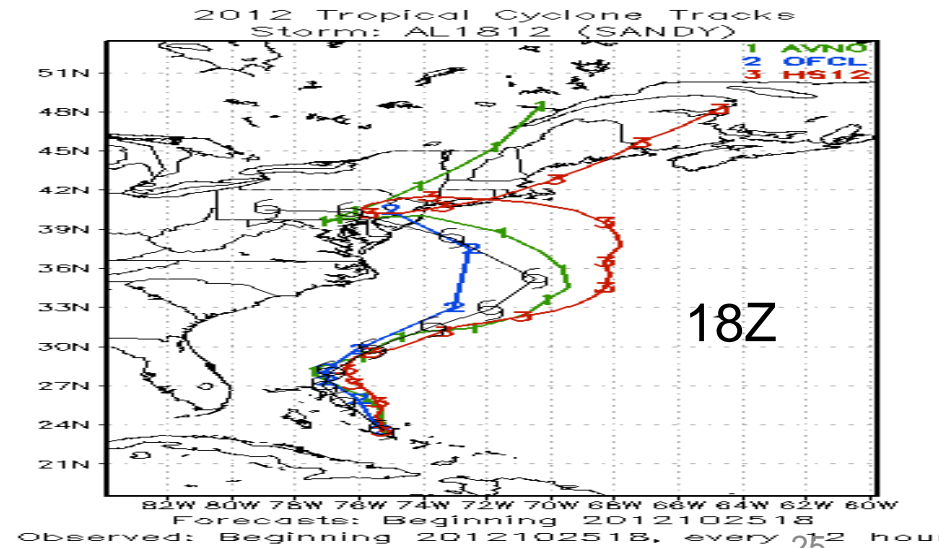
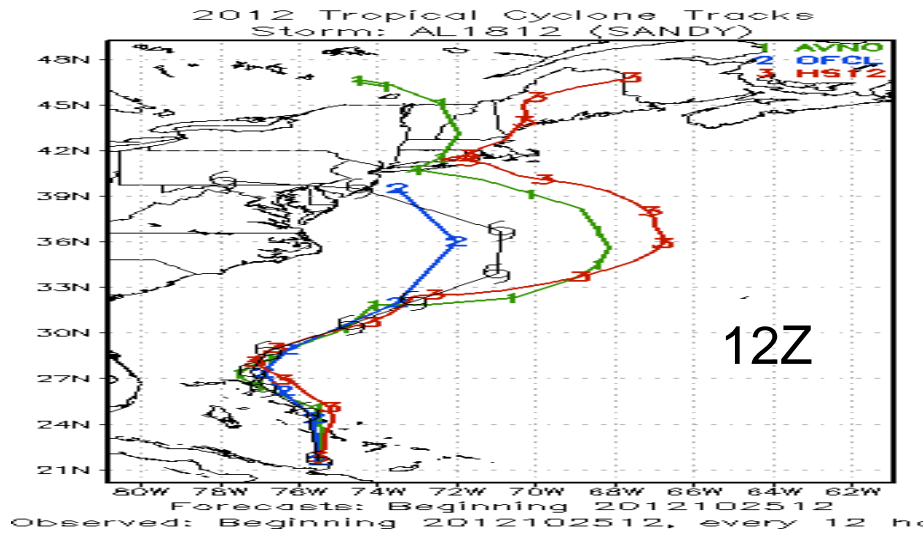
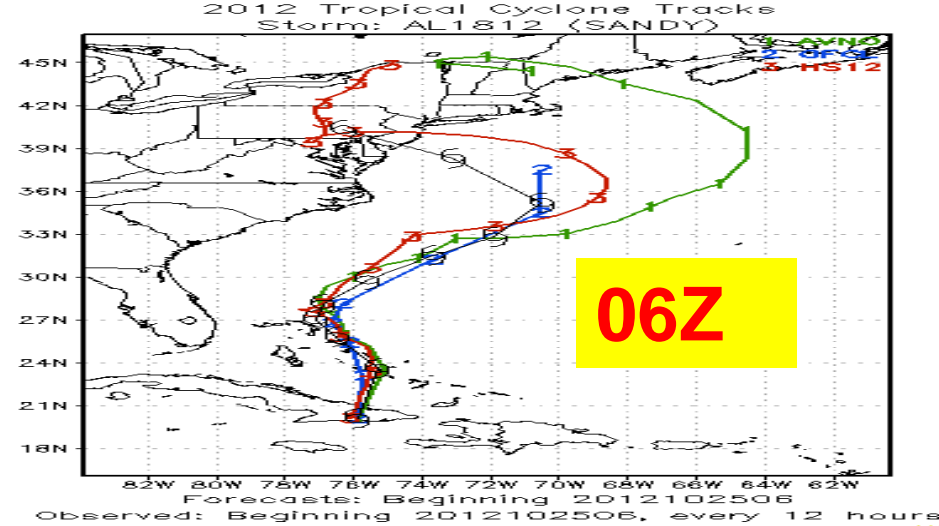
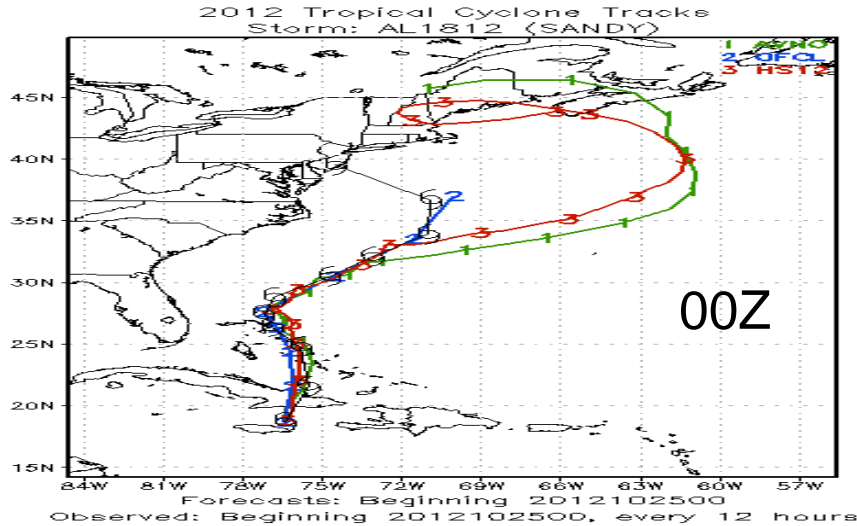


Tracks from 20121024: 00Z, 06Z, 12Z and 18Z Cycles 5 days before landfall





Tracks from 20121025: 00Z, 06Z, 12Z and 18Z Cycles 4 days before landfall

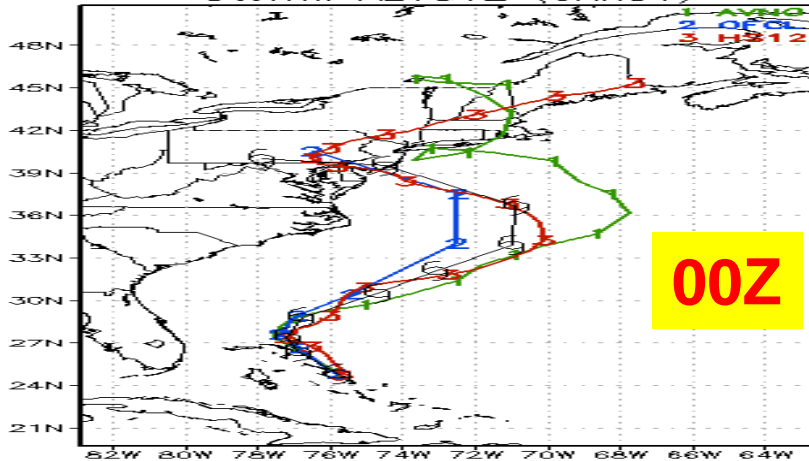




Tracks from 20121026: 00Z, 06Z, 12Z and 18Z Cycles 3 days before landfall

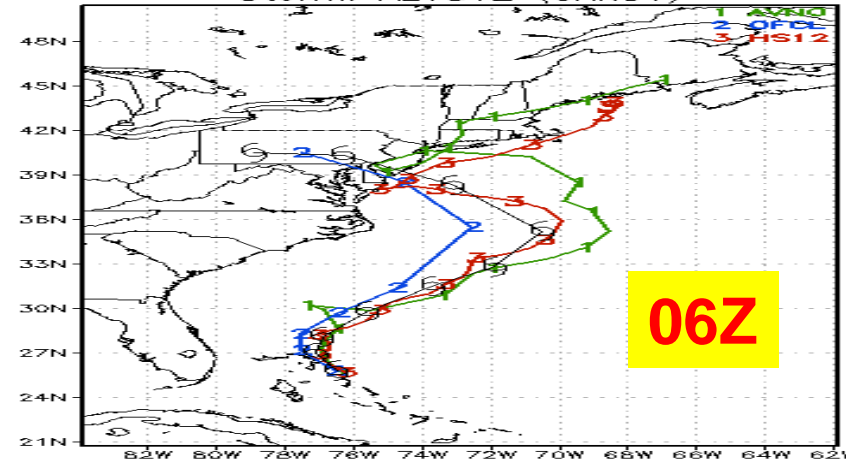


2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



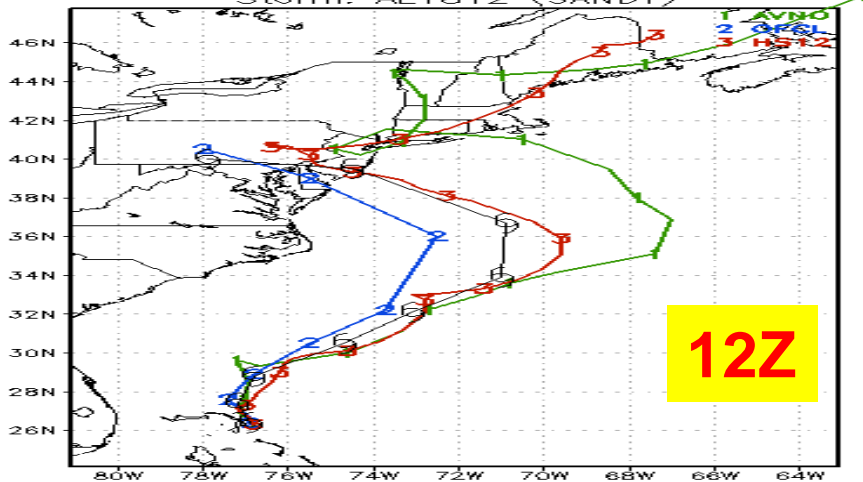
Forecast: Beginning 2012102600
Observed: Beginning 2012102600, every 12 h.

2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



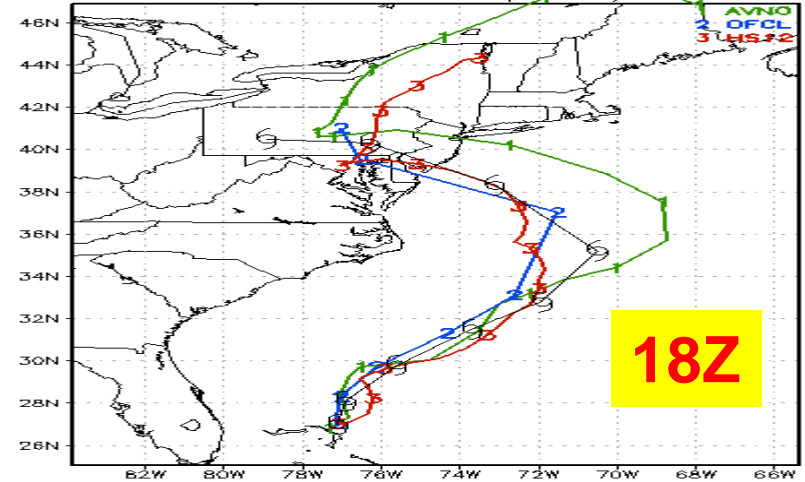
Forecast: Beginning 2012102606
Observed: Beginning 2012102606, every 12 hours

2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



Forecast: Beginning 2012102612
Observed: Beginning 2012102612, every 12 hours

2012 Tropical Cyclone Tracks
Storm: AL1812 (SANDY)



Forecast: Beginning 2012102618
Observed: Beginning 2012102618, every 12 hours

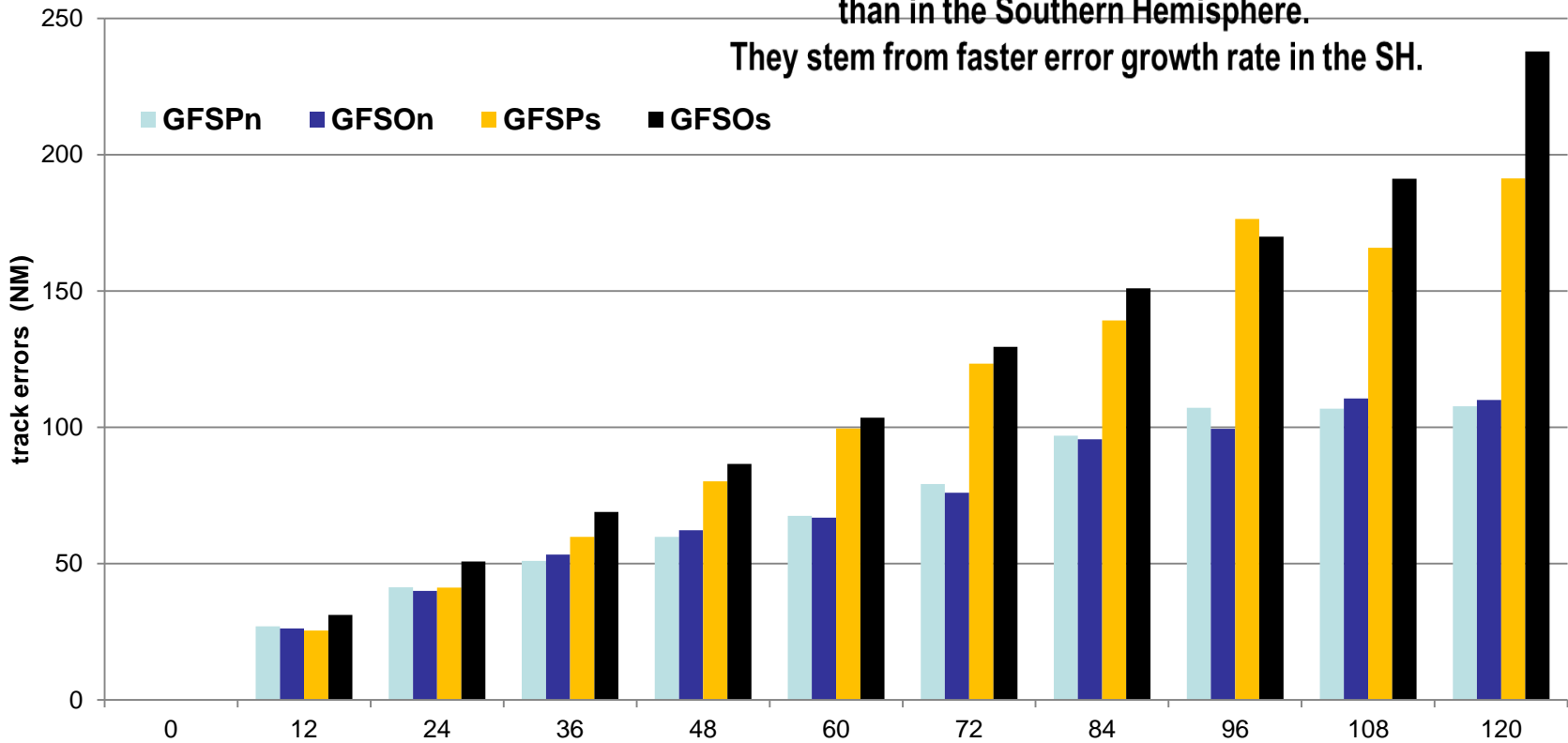


Extratropical Cyclone Track Errors (fcst cs analy) June-Aug 2014 (Lat > 20N/S)



Courtesy of Guang Ping Luo

Track errors in the Northern Hemisphere is much smaller than in the Southern Hemisphere.
They stem from faster error growth rate in the SH.



GFSPn (blue) – Parallel GFS (NH); GFSON (red) – Operations GFS (NH);
GFSPs (green) – Parallel GFS(SH); GFSOs (purple) – Operations GFS (SH).

fcst hr	0	12	24	36	48	60	72	84	96	108	120
NH cases	2145	1995	1752	1248	793	513	331	217	135	97	71
SH cases	1880	1742	1545	1014	564	309	157	79	43	19	8



Summary

- **All codes are now frozen, built in EE structure, and handed off to NCO for implementation.**
- Results are reasonable
 - Improved precipitation skill scores
 - Improved hurricane track in Atlantic and Western Pacific, but worsened in Eastern Pacific; Reduced intensity errors in all basins.
 - Reduced mid-latitude storm track errors.
 - Reduced global mean temperature bias in the upper troposphere; strengthened (improved) tropospheric winds but slightly weakened stratospheric winds.
 - Reduced nighttime 2m temperature cold bias over the Northern Great Plains. Large biases still exist in Northeast and Southwest.
 - improved 500-hPa HGT AC in both the Northern and Southern Hemispheres.



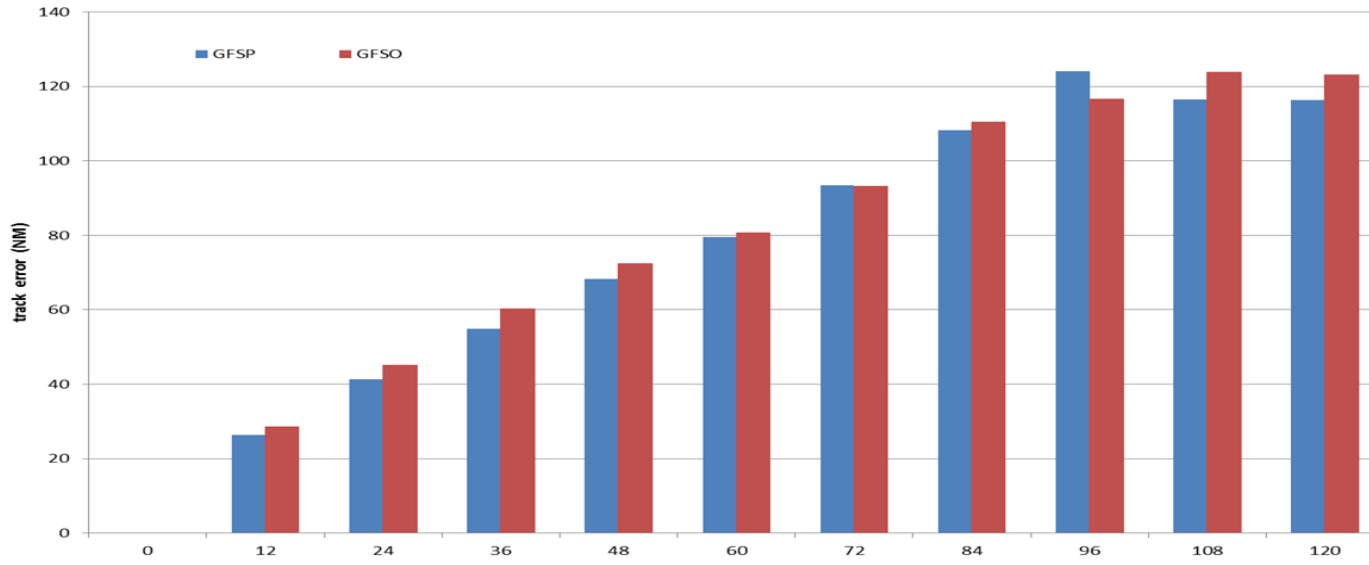
BACKUP SLIDES



Extratropical Cyclone Track Errors

Parallel GFS has consistent improvements over operations GFS in track errors except for 96hr forecasts

**Extratropical Cyclone Track Errors (fcst vs analy)
June-Aug 2014 (Lat > 20N/S)**

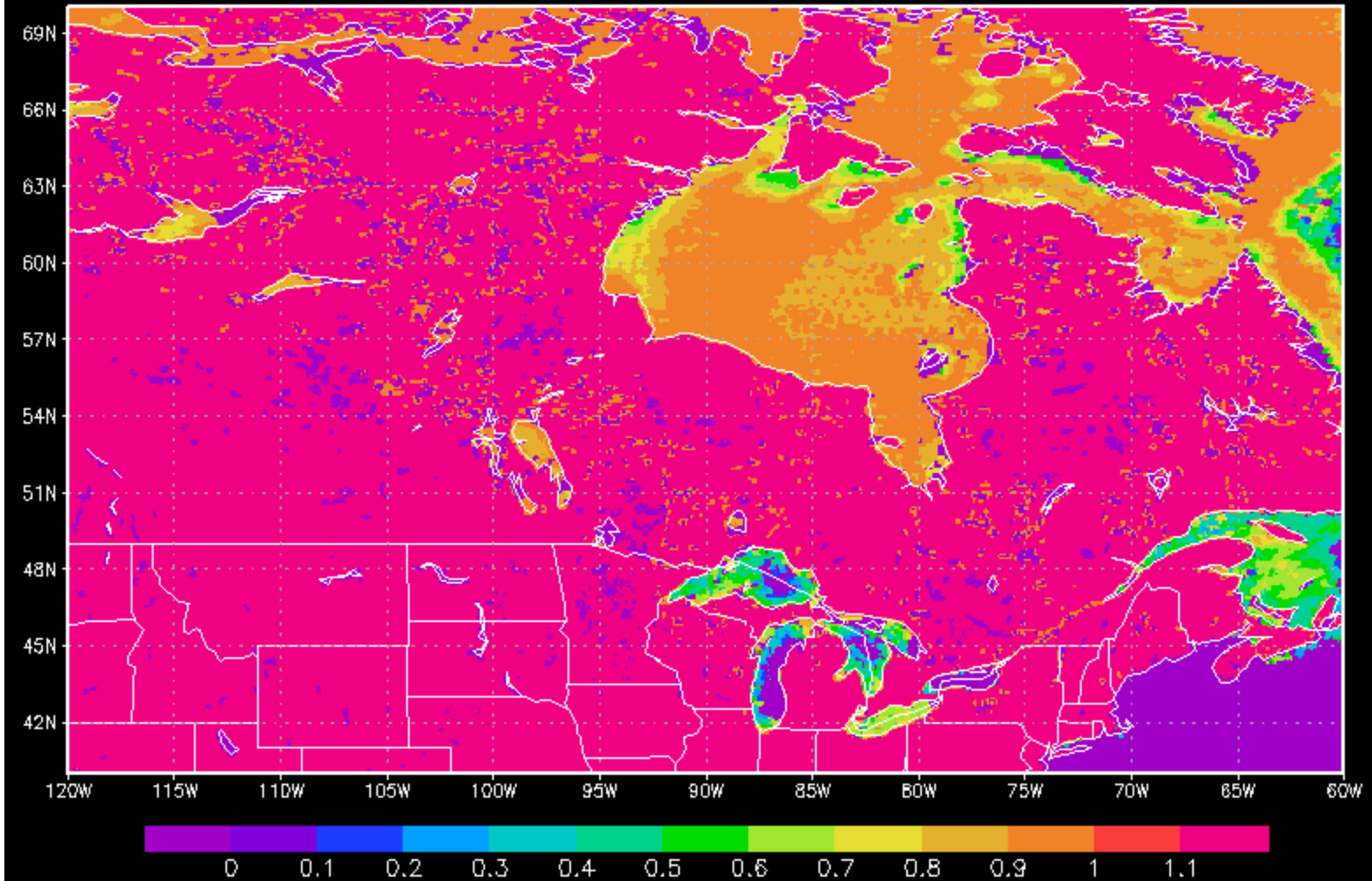


GFSP (blue) – Parallel GFS; GFSO (red) – Operations GFS
On average, 2.4 NM improvements in GFSP over GFSO.

Fcst hr	0	12	24	36	48	60	72	84	96	108	120
Cases	4025	3737	3297	2262	1357	822	488	296	178	116	79



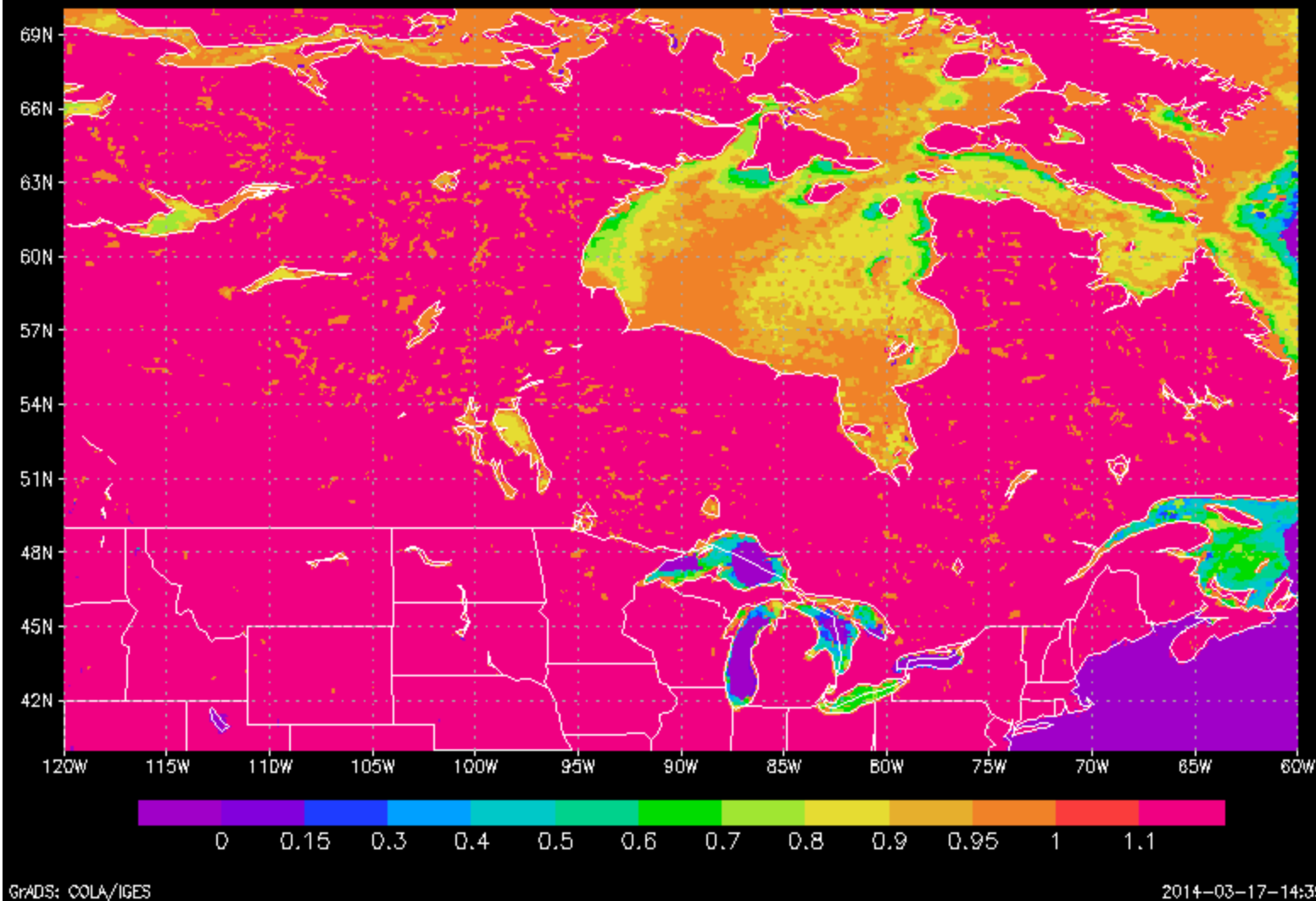
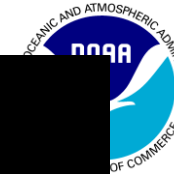
5-min data, with land area in red. Many open water lakes in Canada.



GrADS: COLA/IGES

2014-02-28-19:29

This is the updated blend. Note how more lakes are ice covered.



RED IS LAND



Updated condensation process at 1st timestep and after Digital Filter



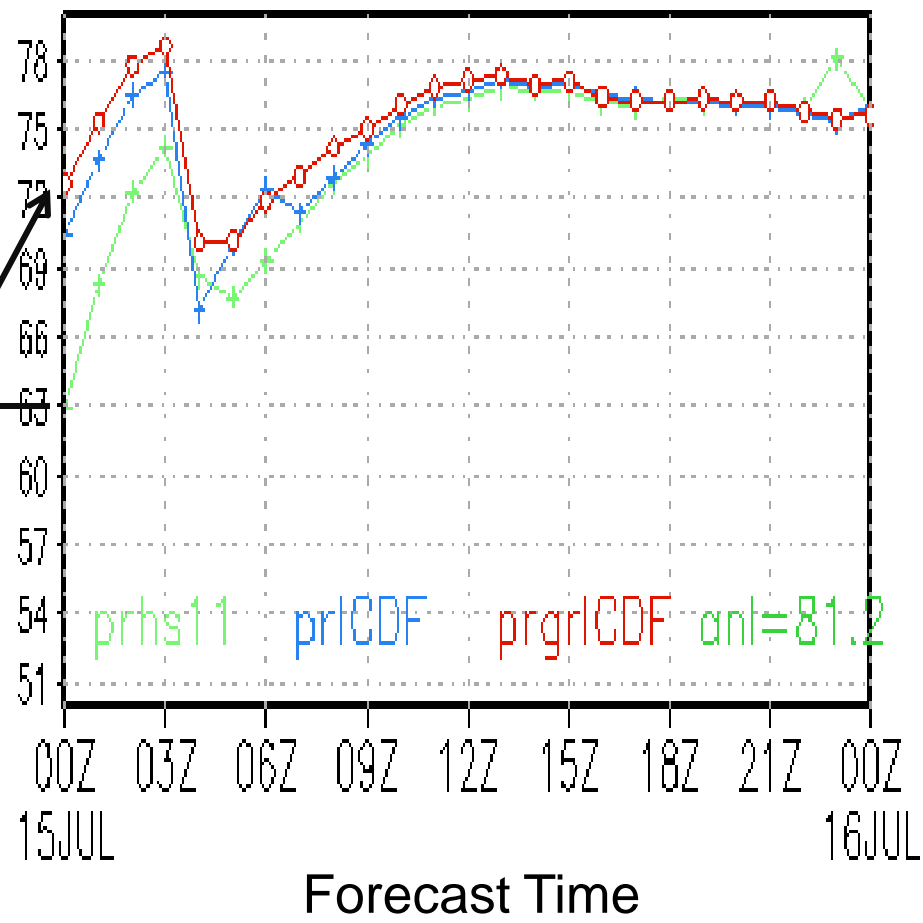
- **Old scheme**
 - Temperature and specific humidity tendencies are set to zero at 1st forecast timestep . No condensation occurs.
 - After calling digital filter incorrect values of temperature and humidity are used in condensation calculations
- **Updated scheme**
 - Initialize the temperature and specific humidity from the initial conditions passed into gloopr.
 - Effect of advection is included in the condensation.



Updated condensation process at 1st timestep and after Digital Filter



2011071500 cloud cond. path (g/m^2)



Increased cloud water by $\sim 10g/m^2$, getting closer to analysis value

Global Mean Cloud Water from a single forecast (IC 2011071500):

- Green: old scheme
- Blue: new scheme without advection
- Red: new scheme with advection, final version.



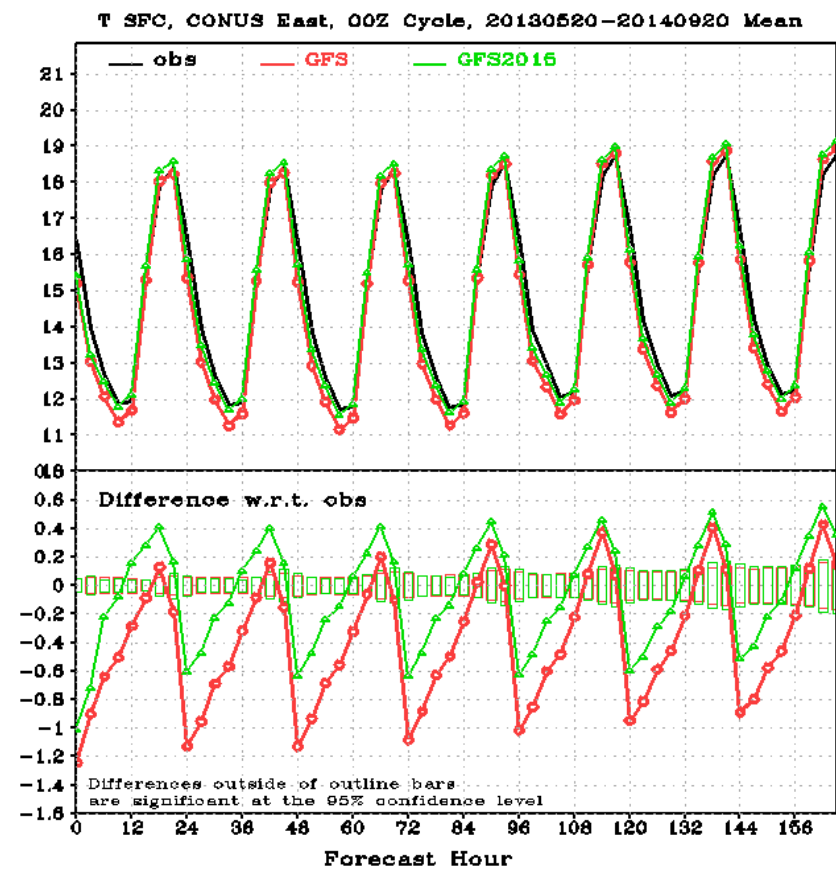
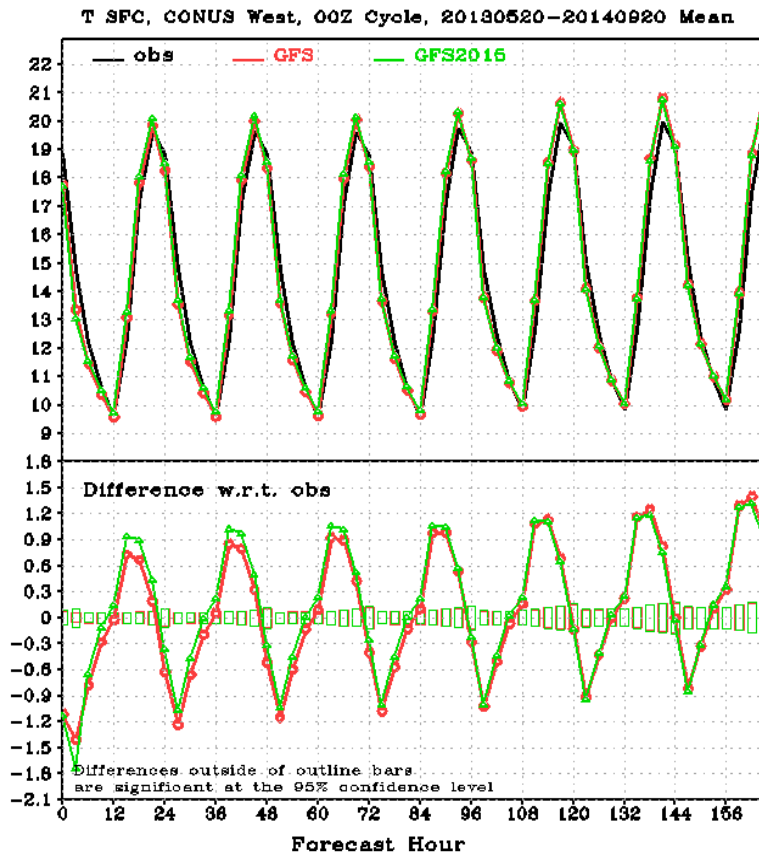
Fit to Surface Obs Merged 2013/2014



CONUS West

CONUS East

T2m



Reduced CONUS East nighttime cold bias