



Impact of New Terrain Data GMTED2010 on FV3GFS Forecast

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**Environmental Modeling Center
National Centers for Environmental Prediction**

GTOPO30 Data

- FV3GFS currently uses GTOPO30 terrain data.
 - Mapped to the cubed-sphere grid using Jordan's orography program.
 - https://svnemc.ncep.noaa.gov/fv3gfs/trunk/global_shared.v15.0.0/src/orog.fd
 - Separate data used for Antarctica – more on this later.
 - Radarsat Antarctic Mapping Project (RAMP) Digital Elevation Model - Liu, H. et al. (2001). A 1-km dataset.
 - GTOPO30 had several deficiencies (did not resolve large ice sheets).
- Global 30 arc-seconds (about 1 km).
 - But not really 30-sec everywhere.
- Created by USGS in 1996 from eight different sources.
 - No single, global source at the time.
- Quality varies from continent to continent (and even within continents).

GMTED2010 Data

- More accurate replacement for GTOPO30 data.
 - Created by USGS in 2010.
 - Primarily derived from NASA Shuttle Radar Topography Mission (SRTM) data.
- Three different resolutions – 30/15/7.5 arc second.
 - Corresponds to 1000/500/250 meters.
 - 30 arc-second data is global.
 - 15 and 7.5 arc-second versions have no data for Antarctica or Greenland.
 - I have only acquired the 30 and 15-second versions.
- For more details, see: <https://lta.cr.usgs.gov/GMTED2010>

NEMS FV3GFS Forecasts

- **Model:** NEMS FV3GFS + CAP + IPDv3 +NSST, non-hydrostatic, non-mono, 32-bit
- **Physics:** Q3FY17 NEMS GSM physics, including NSST model, updated convection, new high-resolution MODIS land datasets and a few other minor updates.
- **Initial Conditions:** NEMS GSM (global spectral model) ICs, converted to FV3 grid using CHGRES
- **Forecast Length:** 240 hours, 3-hourly output
- **Control:** FV3GFS C768 (~13km) L64 (top at ~0.4 hPa), prfv3l65

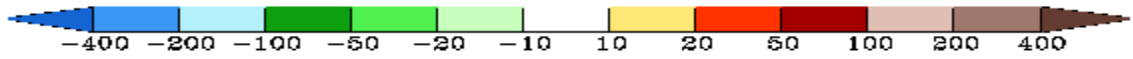
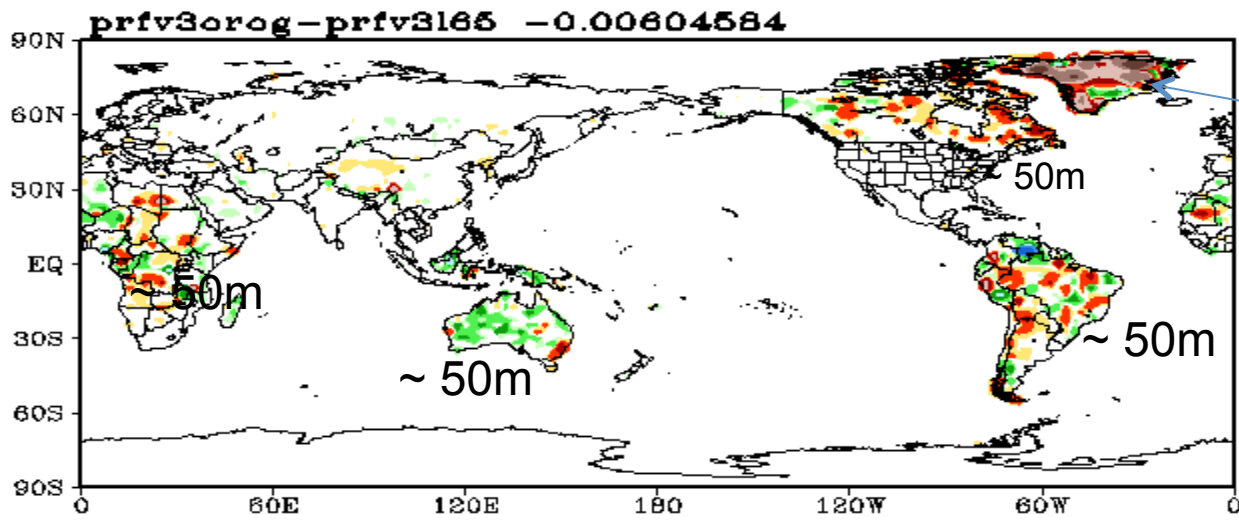
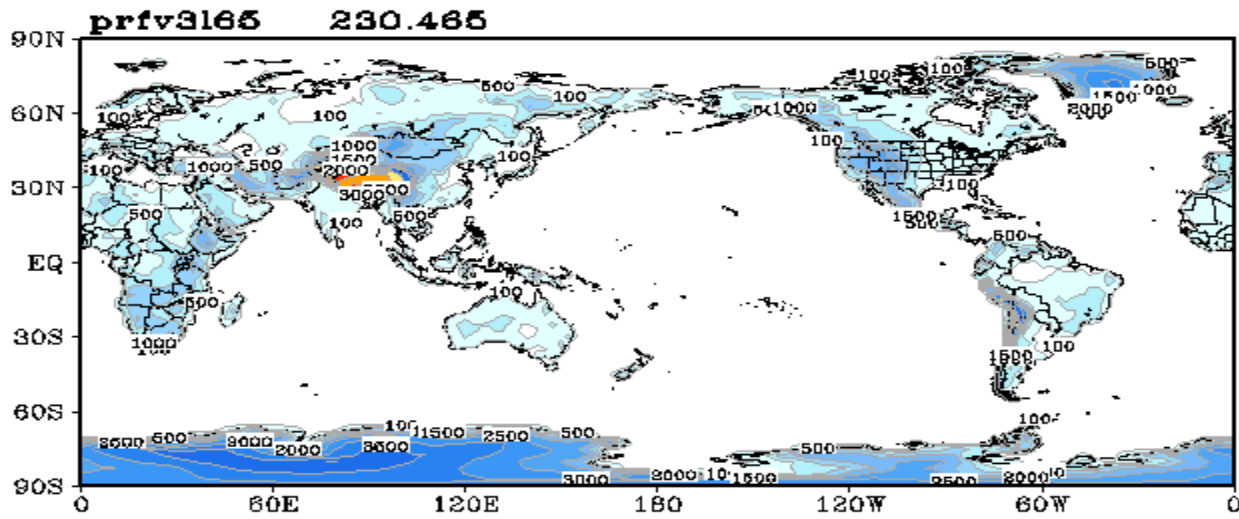
- **Experiment JJA 2016 (prfv3orog):** 01Jun2016 ~ 30Aug2016
 - http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/fv3orog_jja/

- **Experiment JFM 2017 (prfv3orog):** 03Jan2017 ~ 31Mar2017
 - http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/fv3orog_djf/

(C768, ~13km)

Surface Height

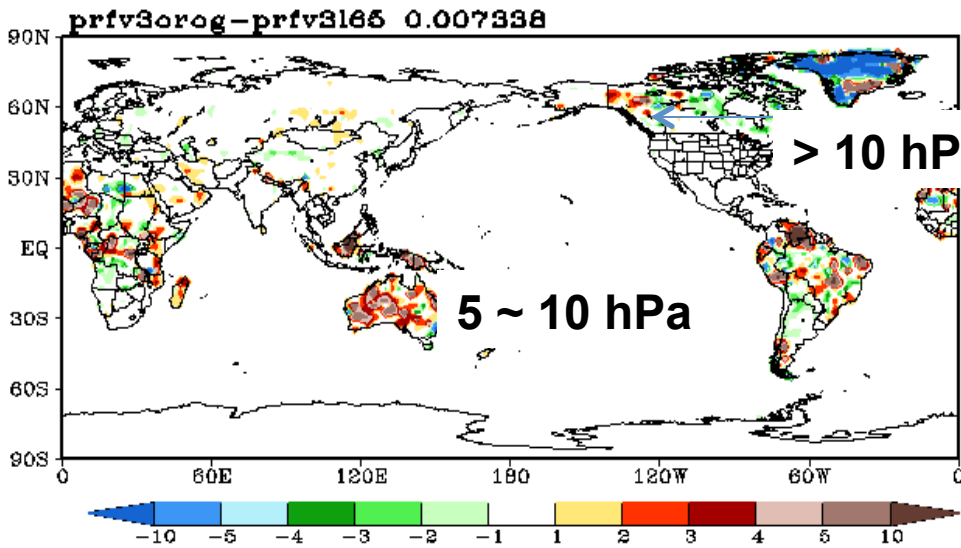
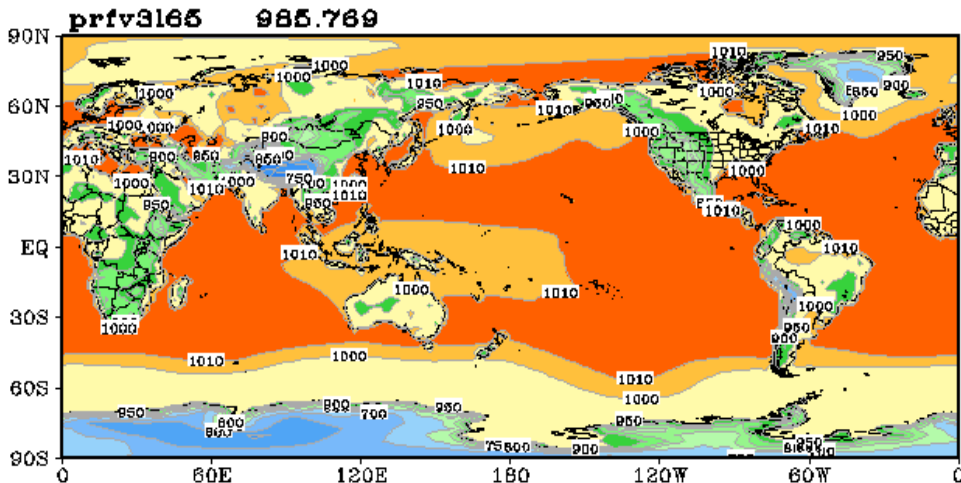
Surface Geopotential Height [gpm]
00Z-Cyc 15Jan2017-15Jan2017 Mean
(f120 f120 f120 f120) Post-Hour Average



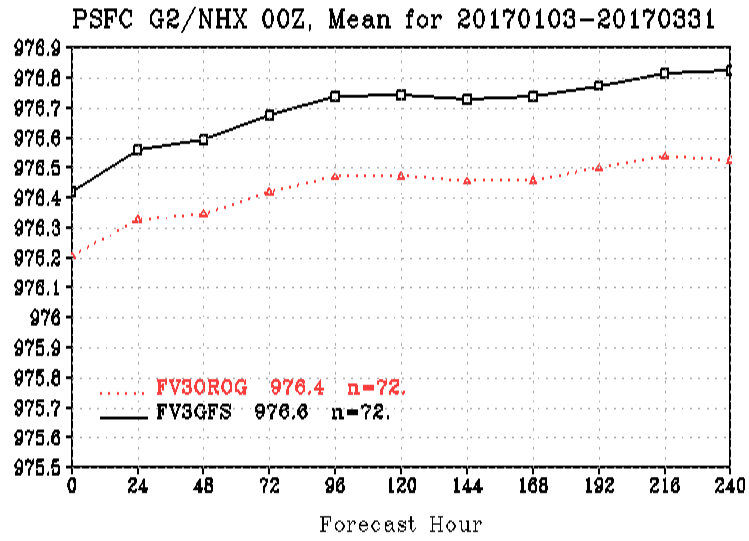
(C768, ~13km)

Surface Pressure

Surface Pressure [hPa]
00Z-Cyc 08Jan2017-02Feb2017 Mean
(f06 f12 f18 f24) Post-Hour Average



NH Psfc Mean

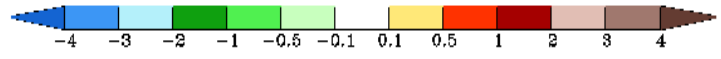
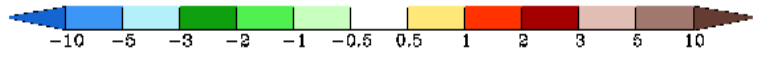
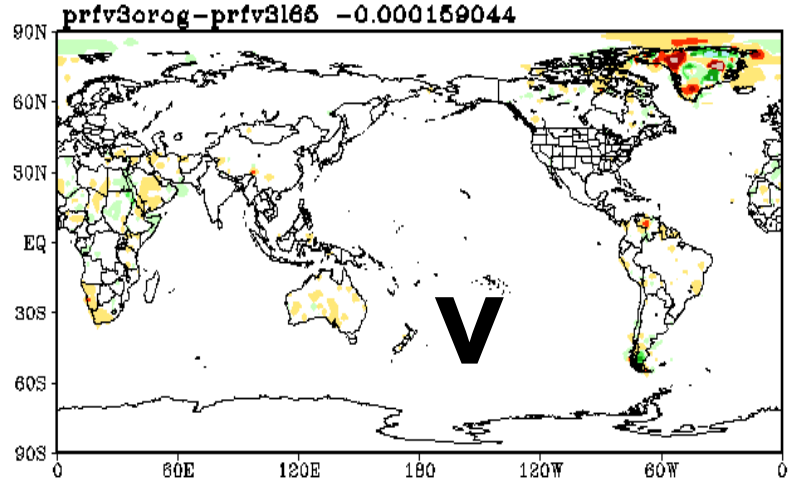
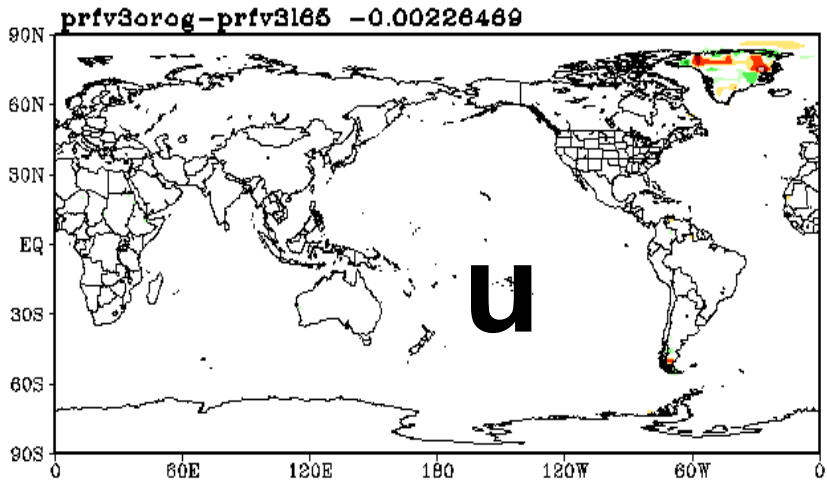
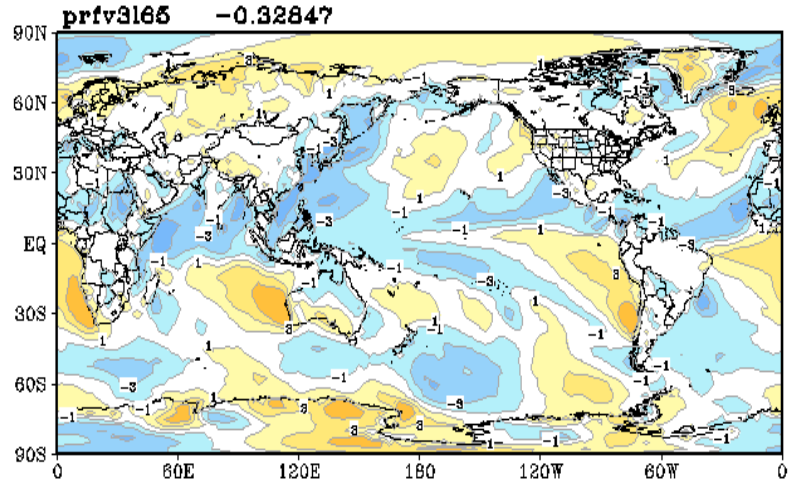
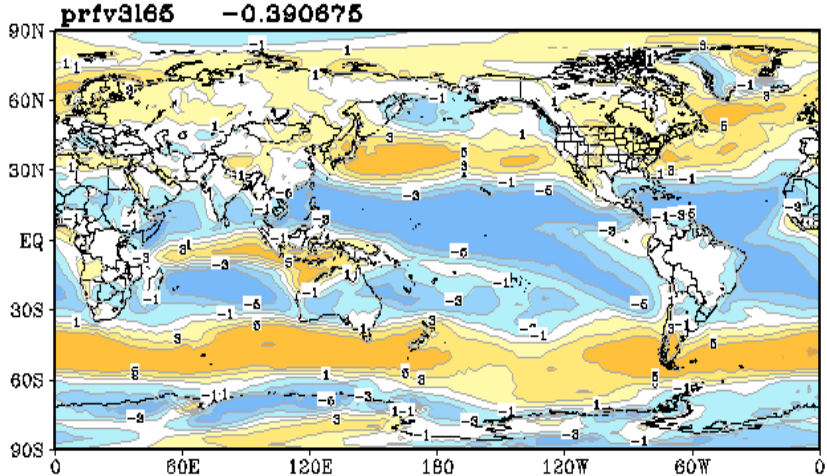


(C768, ~13km)

Surface 10-m Wind (1-dy fcst)

10m Above Ground Zonal Wind [m/s]
00Z-Cyc 09Jan2017-02Feb2017 Mean
(f06 f12 f18 f24) Post-Hour Average

10m Above Ground Meridional Wind [m/s]
00Z-Cyc 09Jan2017-02Feb2017 Mean
(f06 f12 f18 f24) Post-Hour Average

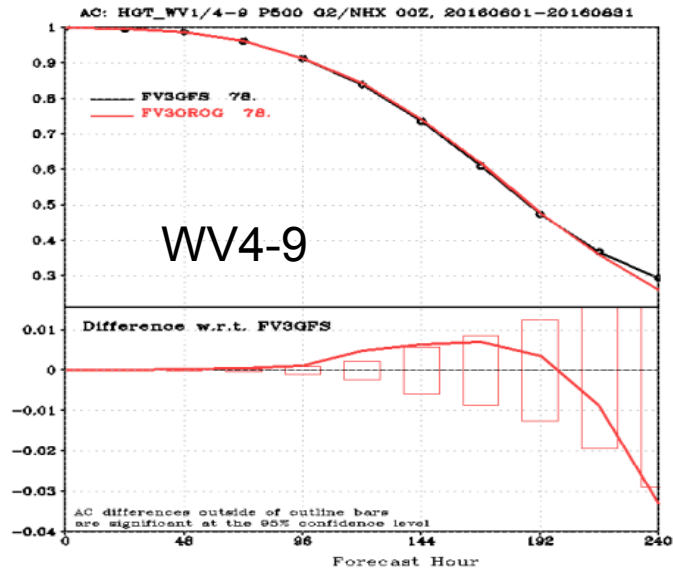
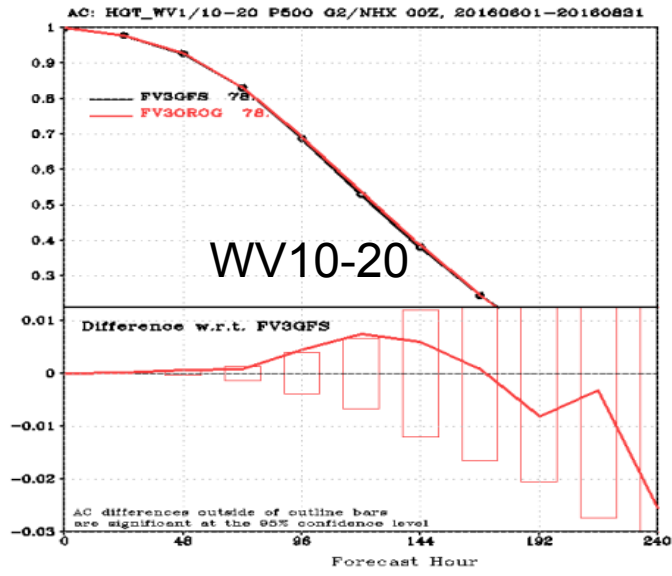
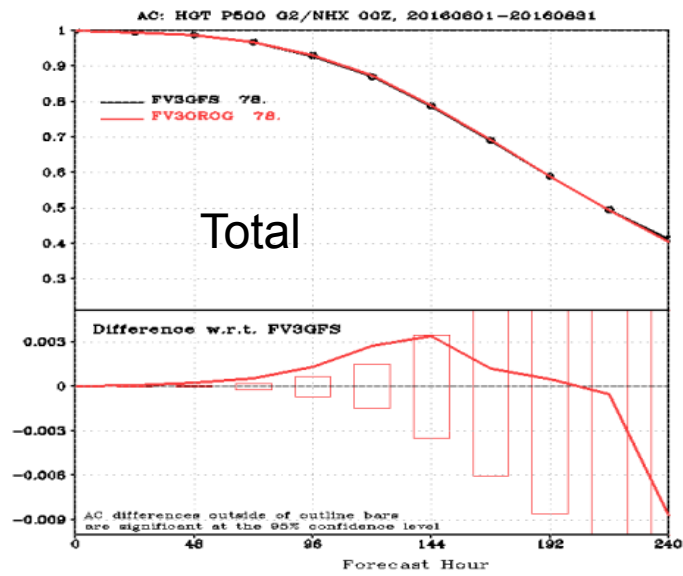
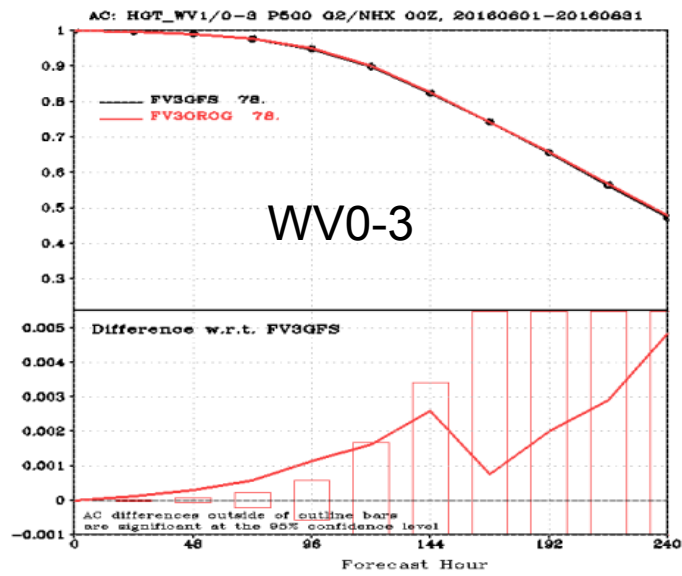


Skill Scores

JJA 2016

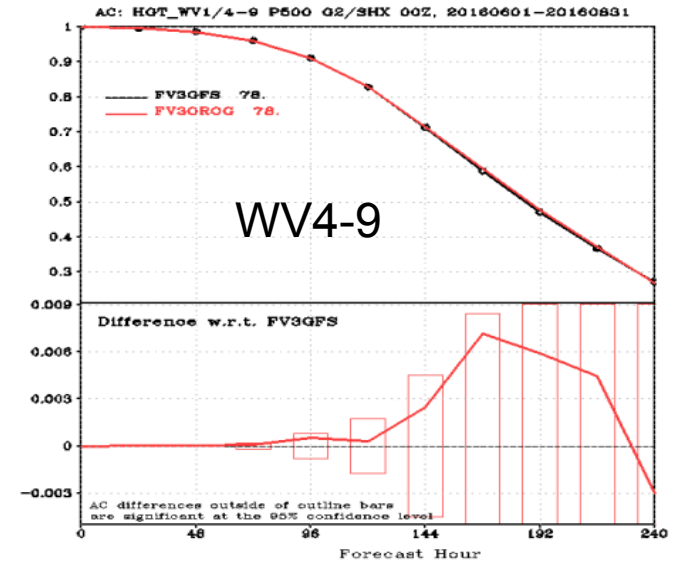
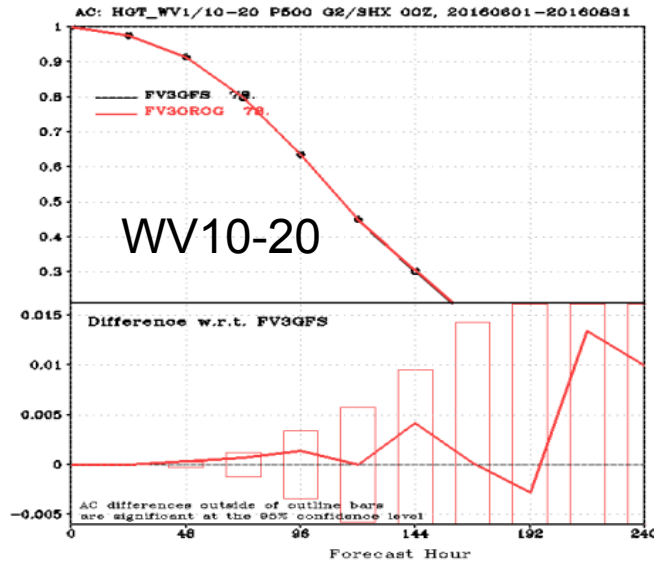
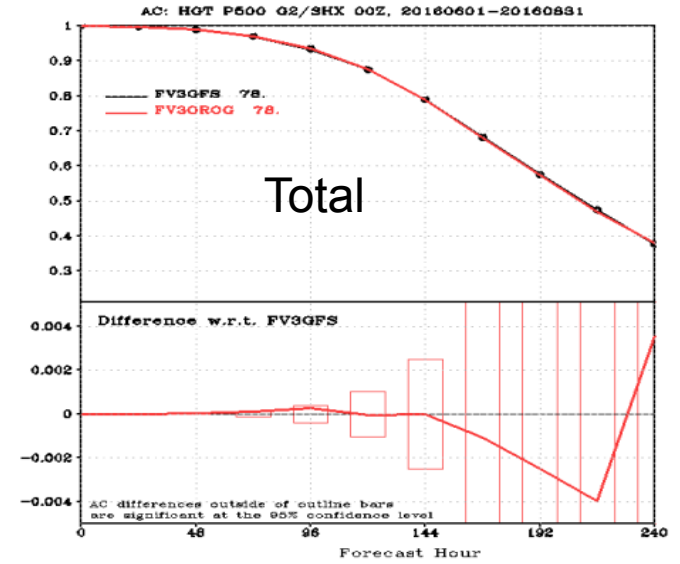
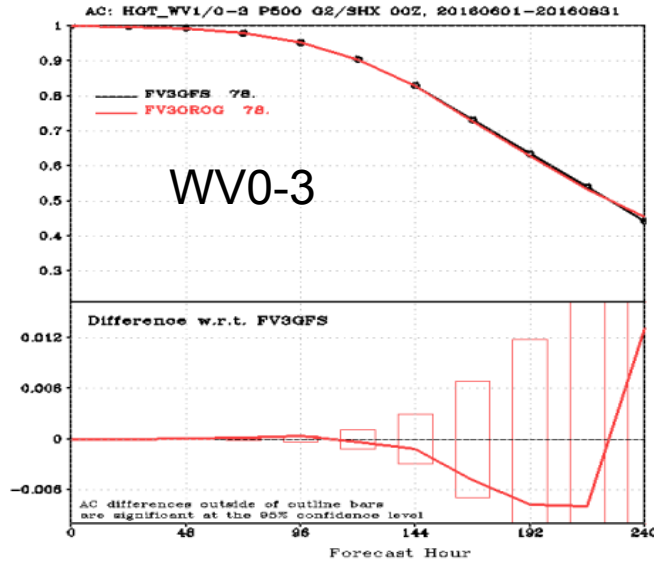
JJA 2016, NH 500-hPa HGT AC

slightly improved for all waves



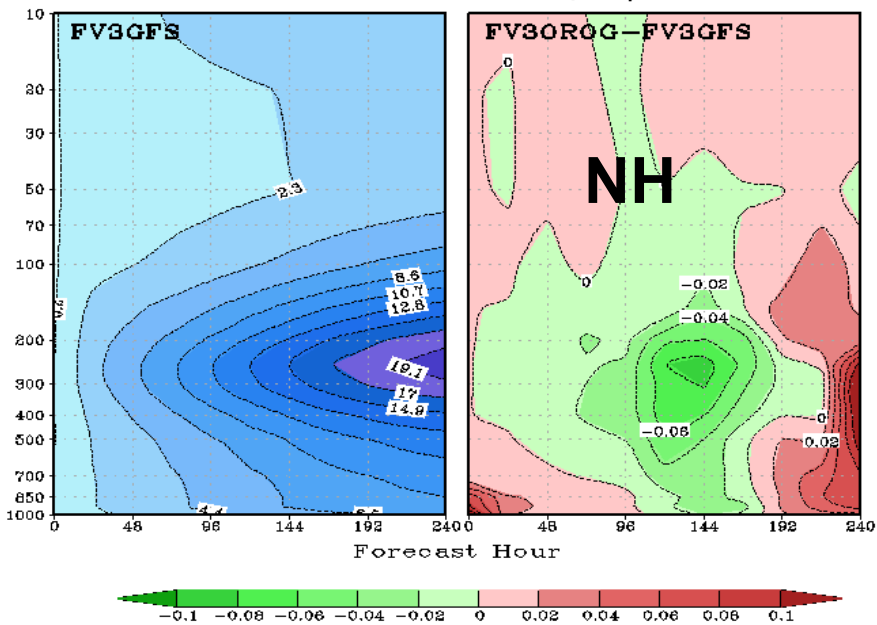
JJA2016, SH 500-hPa HGT AC

long waves
slightly
worse,
insignificant

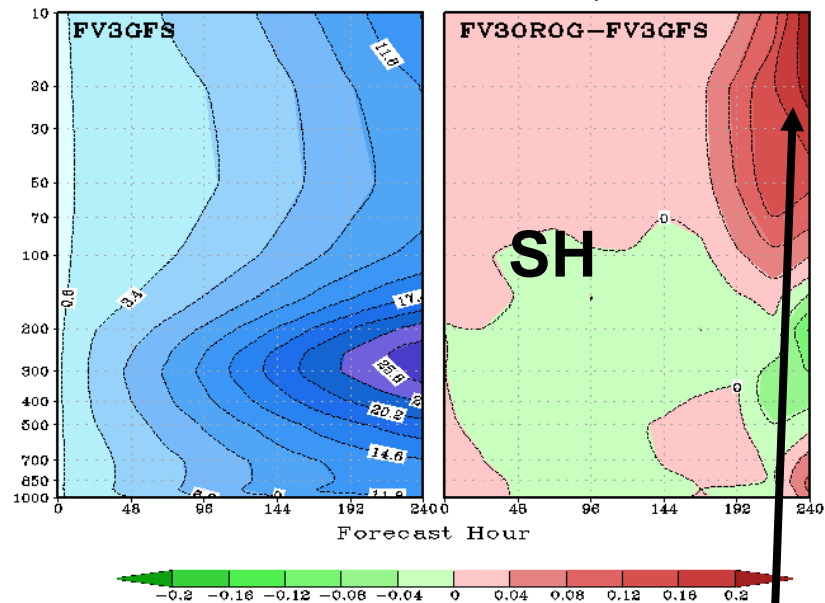


JJA2016, Winds RMSE

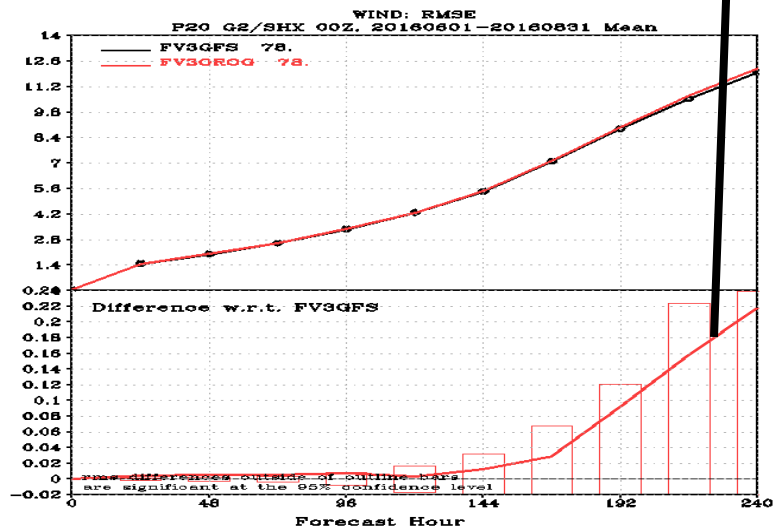
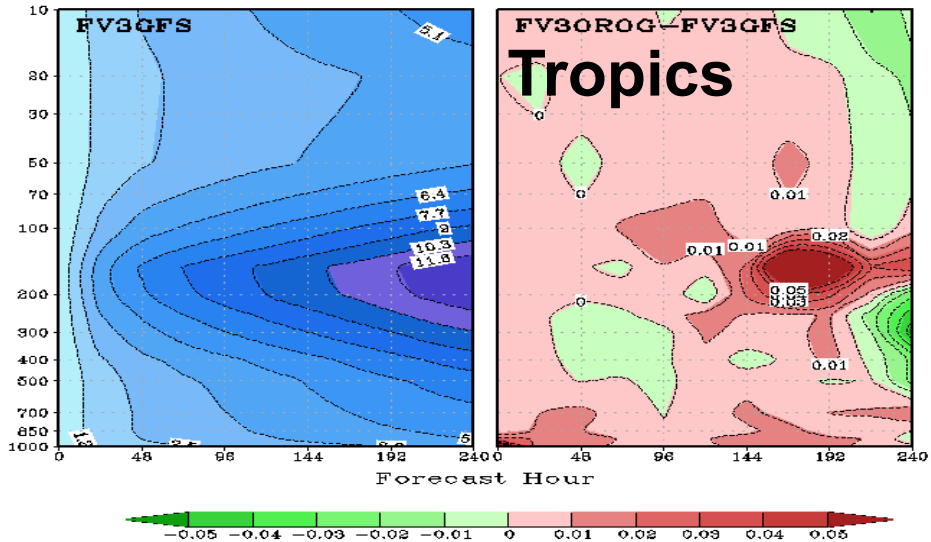
WIND: RMSE
20160601-20160831 Mean, G2/NHX 00Z



WIND: RMSE
20160601-20160831 Mean, G2/SHX 00Z

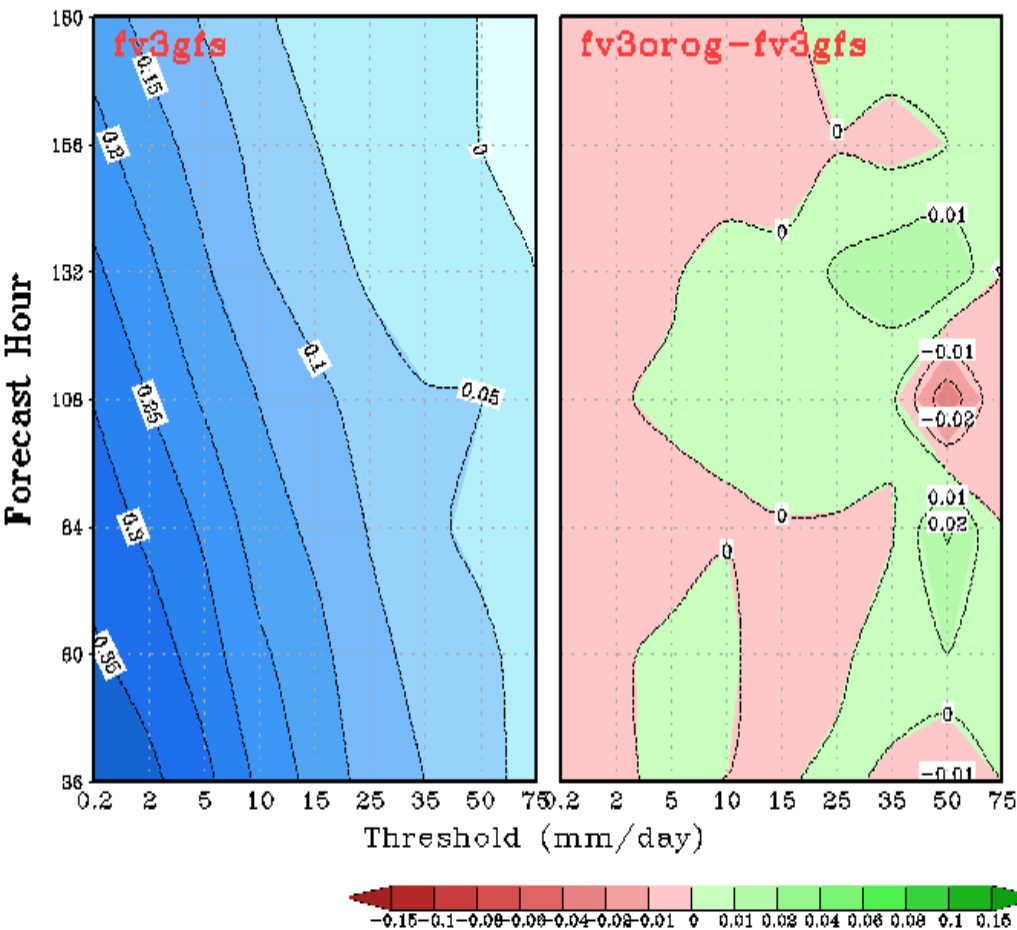


WIND: RMSE
20160601-20160831 Mean, G2/TRO 00Z

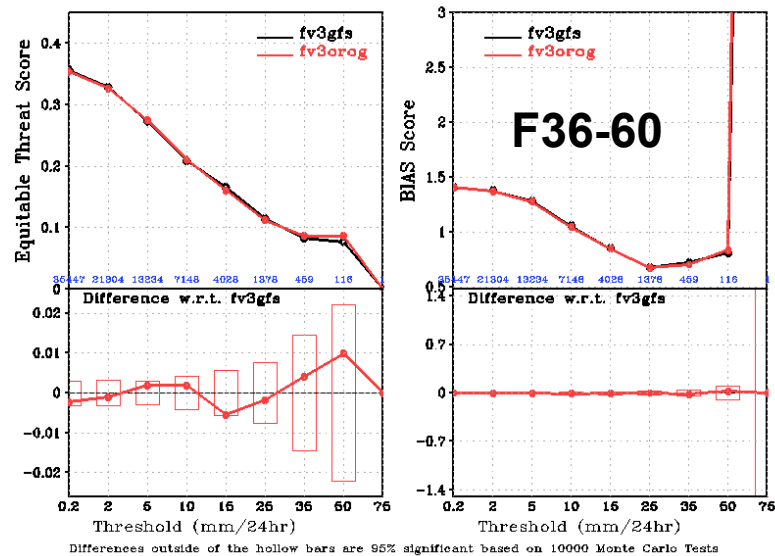


JJA2016, CONUS Precip ETS and BIAS scores

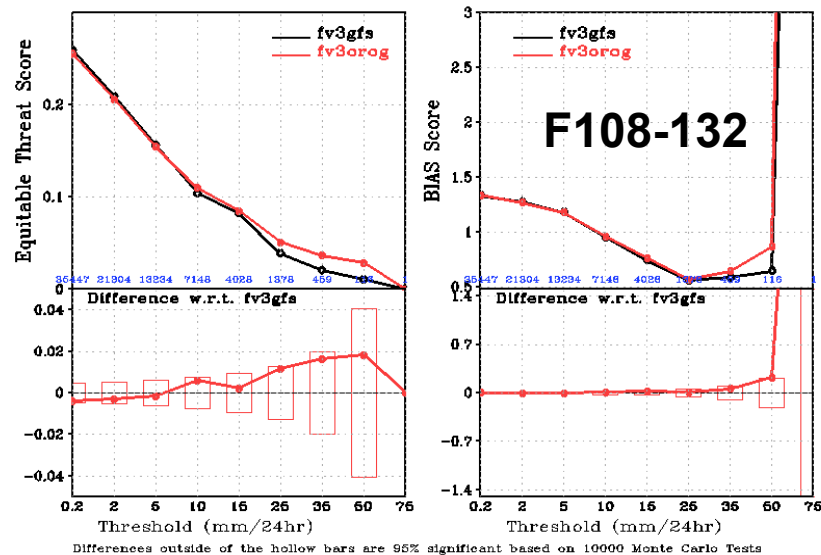
CONUS Precipitation Equitable Threat Score
01Jun2016-31Aug2016 00Z Cycle



CONUS Precip Skill Scores, f36-f60, 01Jun2016-31Aug2016 00Z Cycle



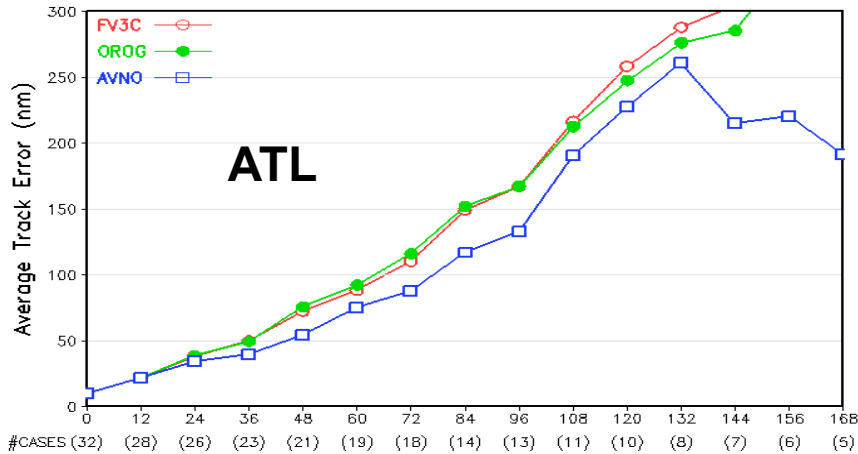
CONUS Precip Skill Scores, f108-f132, 01Jun2016-31Aug2016 00Z Cycle



JJA 2016 Hurricane Track

Red-cntl, Green-org, Blue-ops GFS

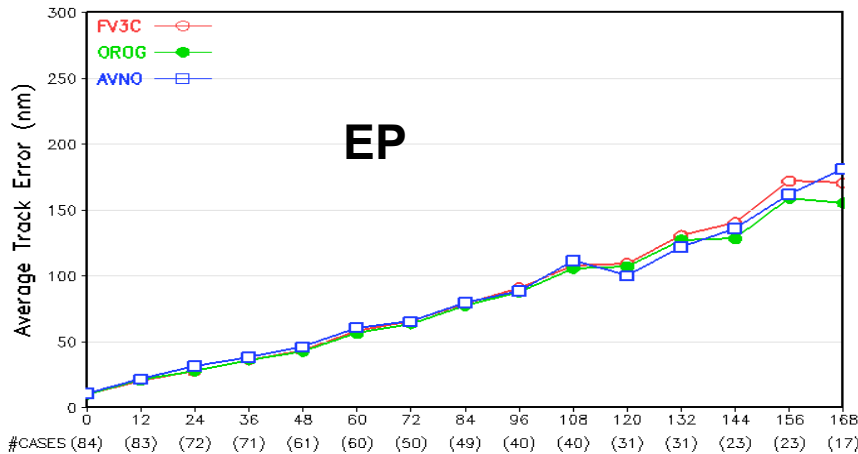
Hurricane Track Errors – Atlantic 2016
20160601__20160831__1cyc



Confidence Level (%) of Student-t Tests

FV3C_OROG	0	79	84	78	98	98	95	76	51	70	89	88	90	80	84
FV3C_AVNO	56	51	81	92	98	83	91	92	87	72	68	63	85	94	96
OROG_AVNO	56	54	82	91	99	91	95	93	87	88	81	57	78	87	86

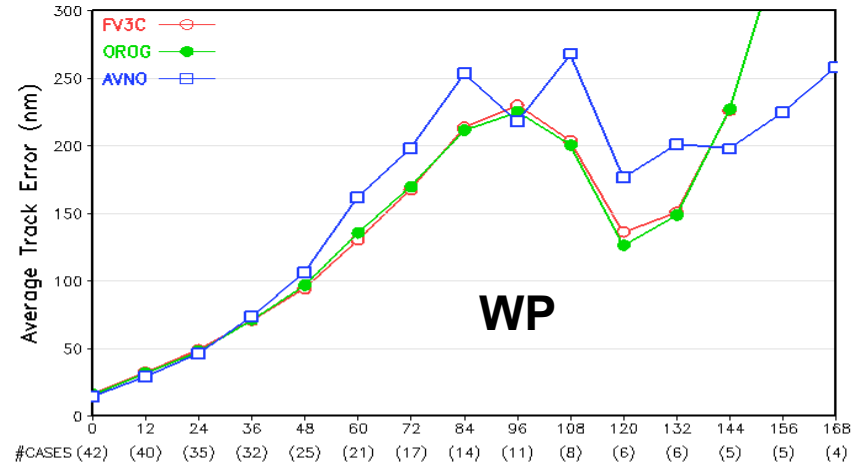
Hurricane Track Errors – East-Pacific 2016
20160601__20160831__1cyc



Confidence Level (%) of Student-t Tests

FV3C_OROG	92	80	51	57	78	98	87	77	98	91	87	90	99	99	98
FV3C_AVNO	80	69	89	74	77	71	50	53	58	59	80	74	58	65	64
OROG_AVNO	76	86	89	73	80	82	82	59	53	86	74	85	85	54	81

Hurricane Track Errors – West-Pacific 2016
20160601__20160831__1cyc



Confidence Level (%) of Student-t Tests

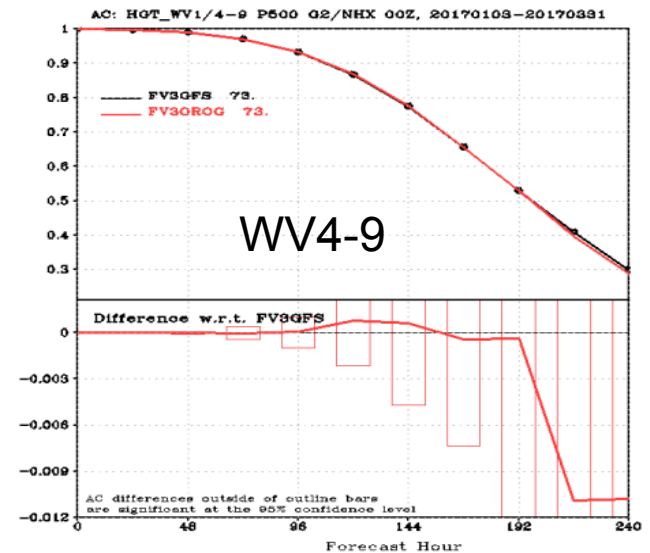
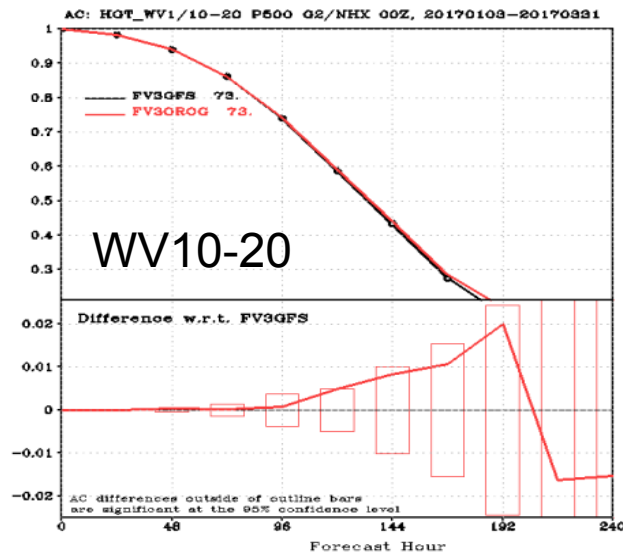
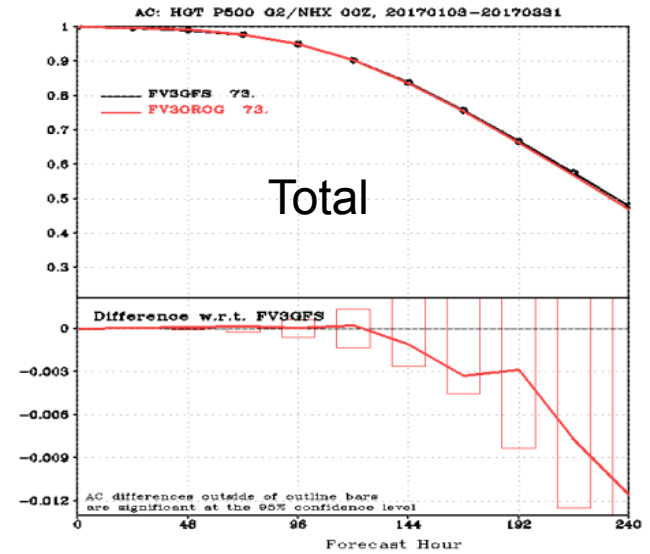
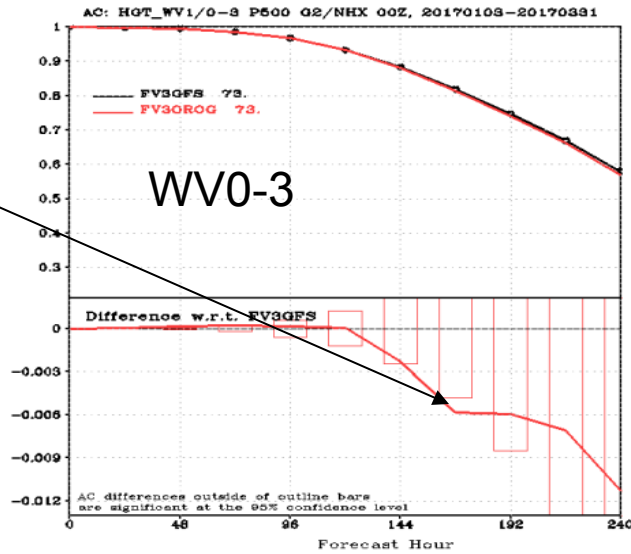
FV3C_OROG	83	91	91	88	88	99	76	68	70	84	95	82	58	67	78
FV3C_AVNO	93	84	67	61	81	95	94	90	65	88	78	77	83	99	99
OROG_AVNO	92	78	81	80	77	92	92	92	57	89	81	78	87	99	99

Skill Scores

JFM 2017

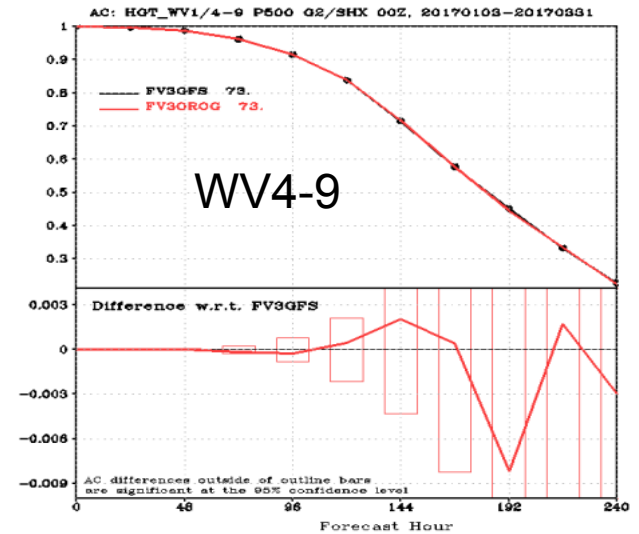
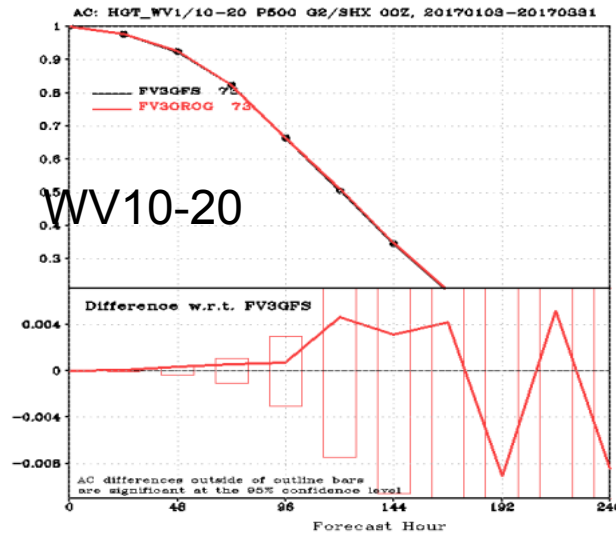
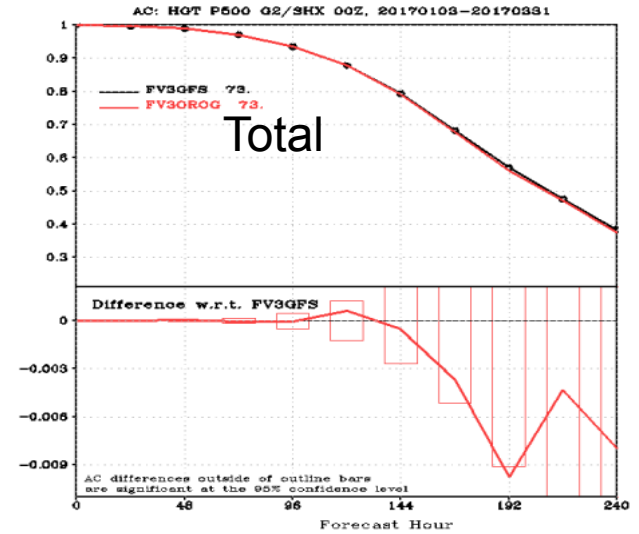
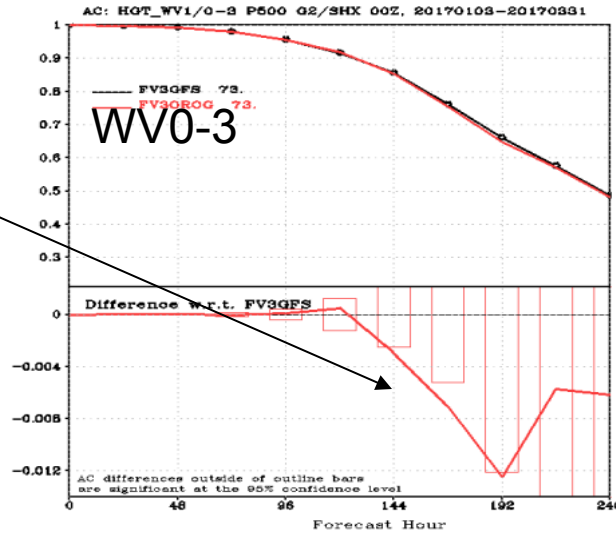
JFM2017, NH 500-hPa HGT AC

Long waves
(0-3) slightly
worse for
week2

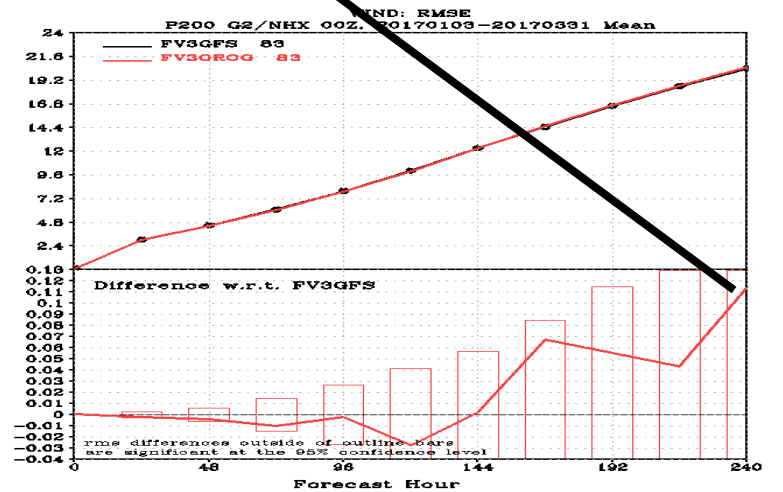
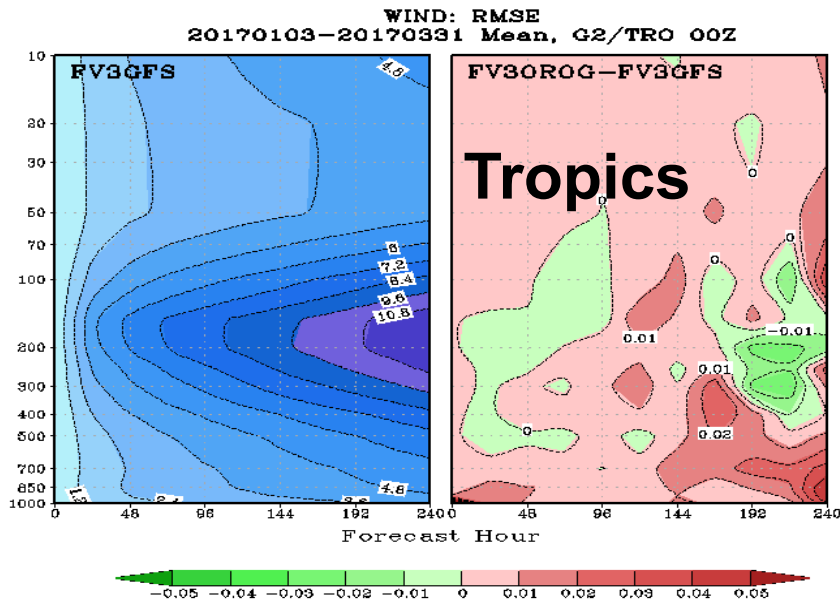
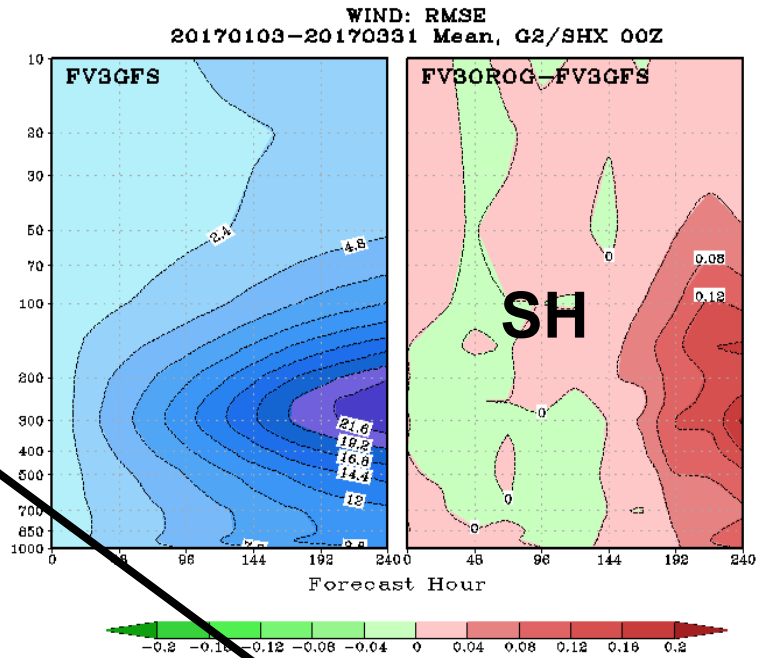
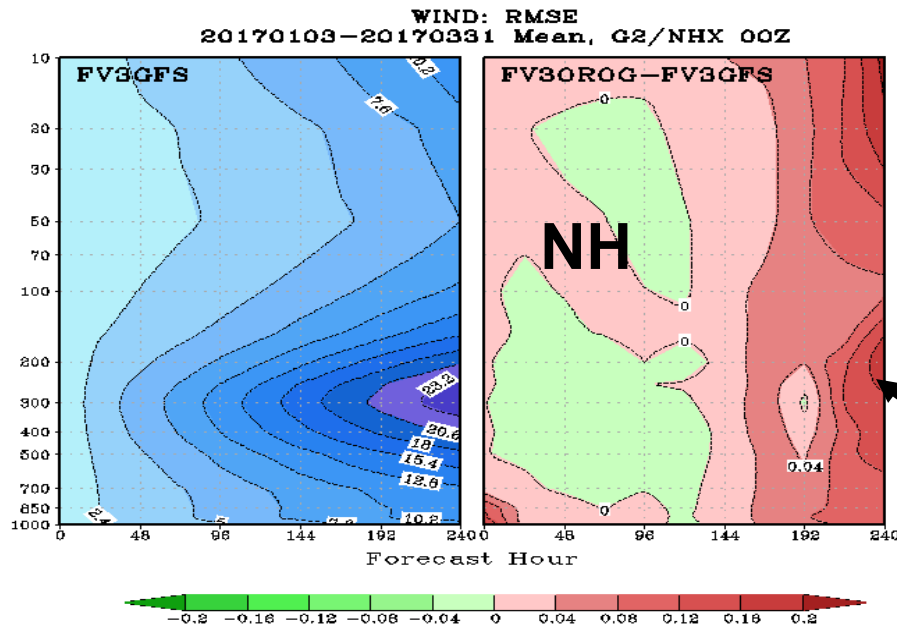


JFM2017, SH 500-hPa HGT AC

Long waves
(0-3) slightly
worse for
week2

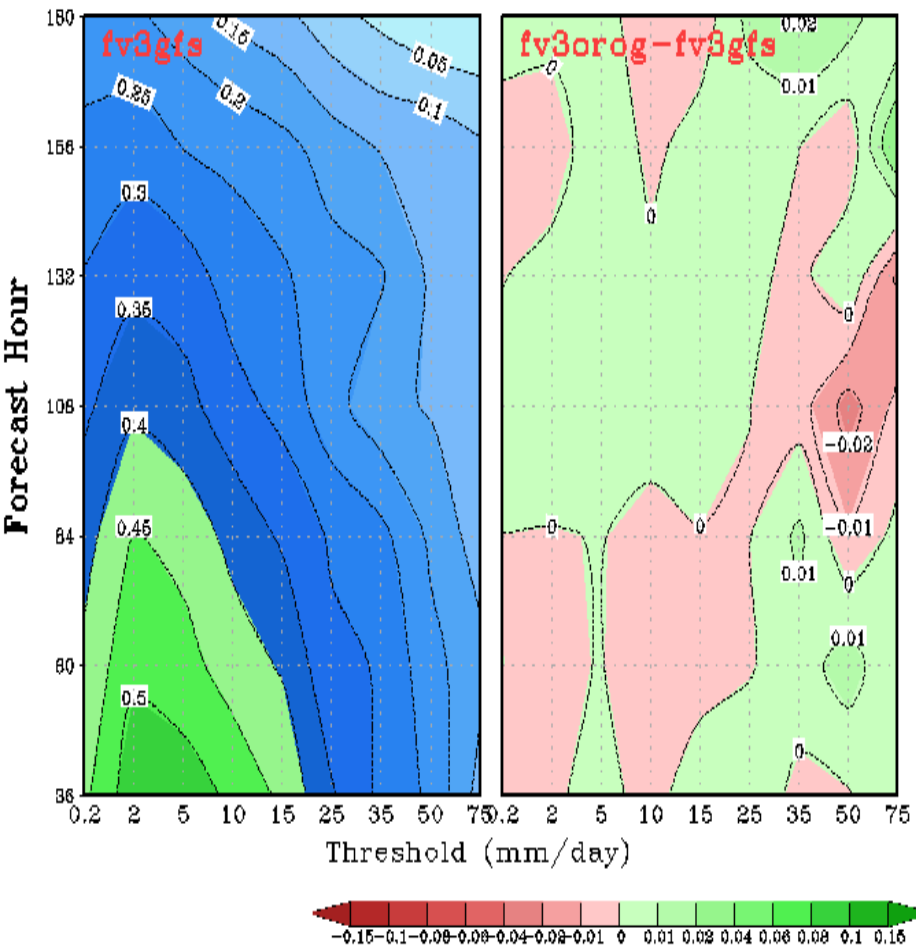


JFM2017, Winds RMSE

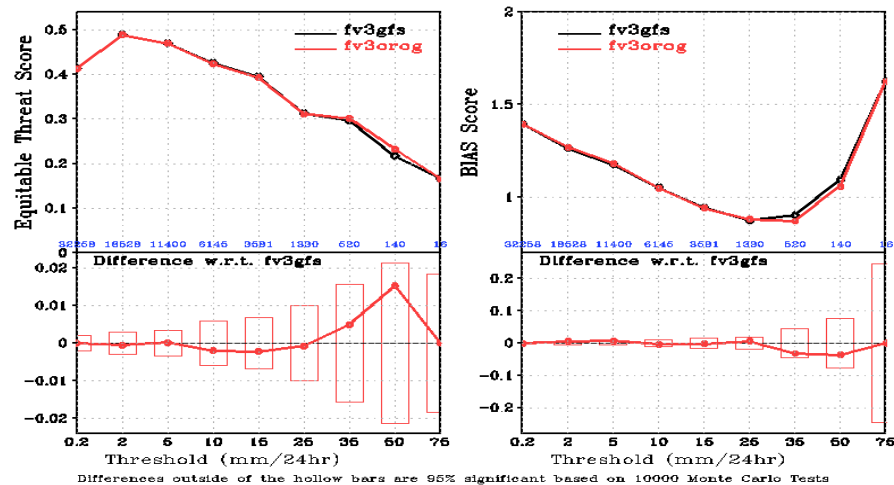


JFM2017, CONUS Precip ETS and BIAS scores

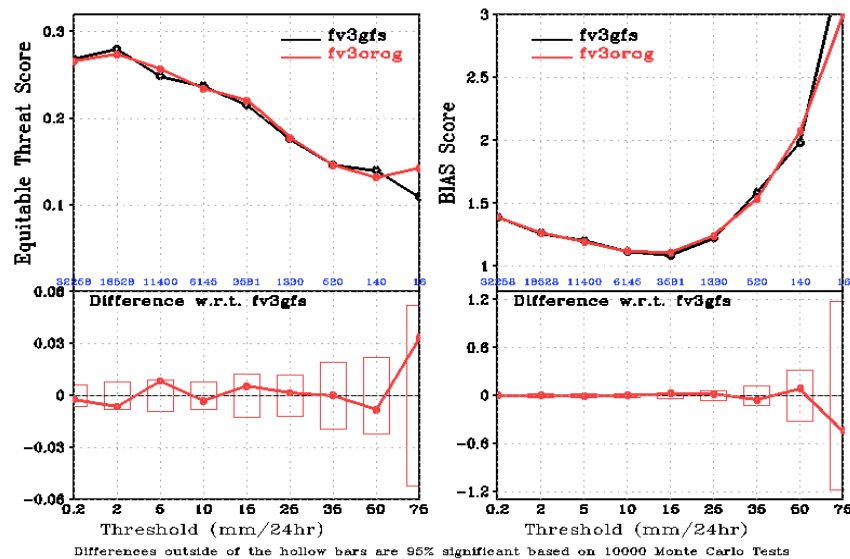
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CONUS Precip Skill Scores, f36-f60, 03Jan2017-31mar2017 00Z Cycle



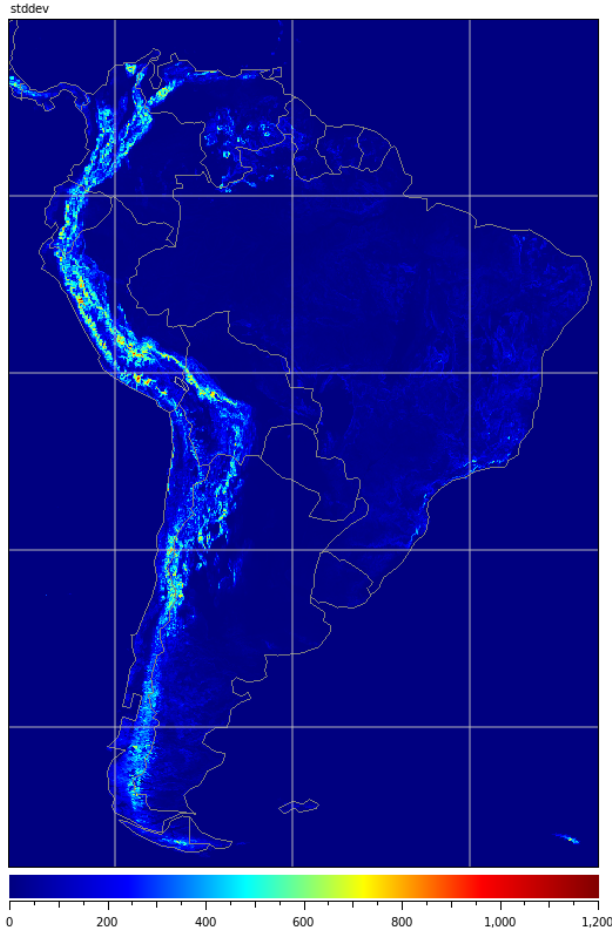
CONUS Precip Skill Scores, f132-f156, 03Jan2017-31mar2017 00Z Cycle



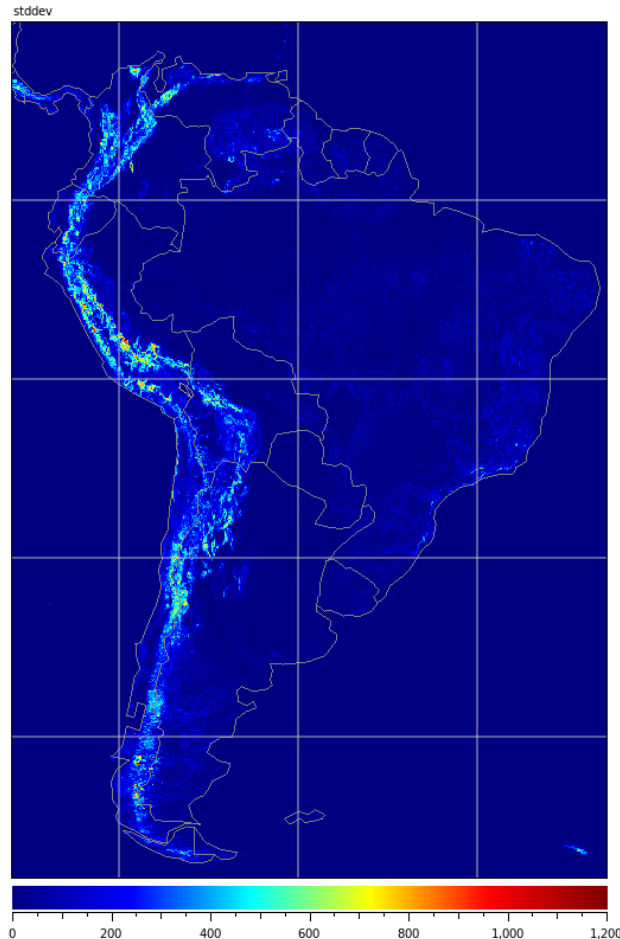
Tuning

Terrain Standard Deviation

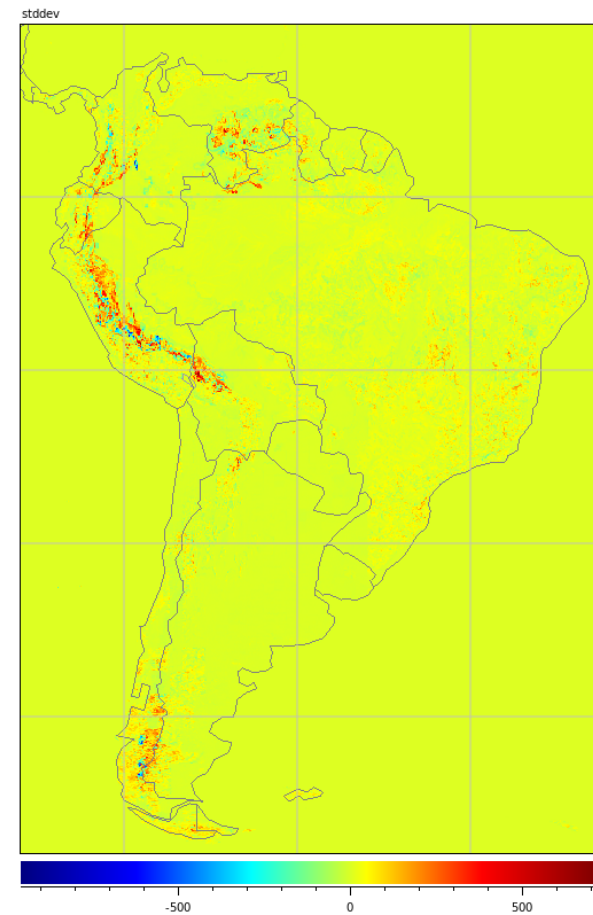
GMTED2010



GTOPO30



GMTED MINUS GTOPO



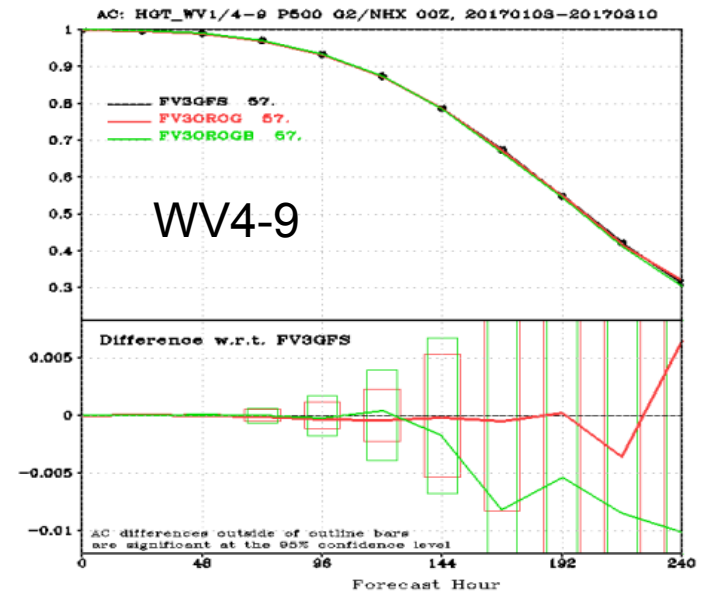
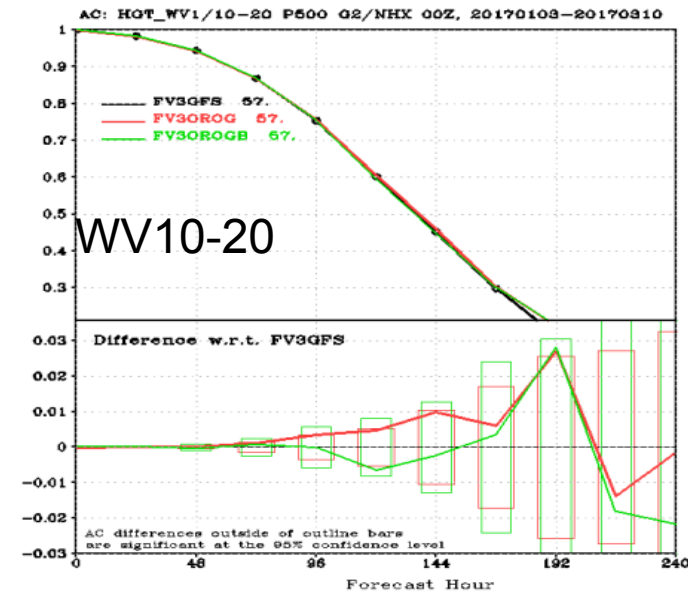
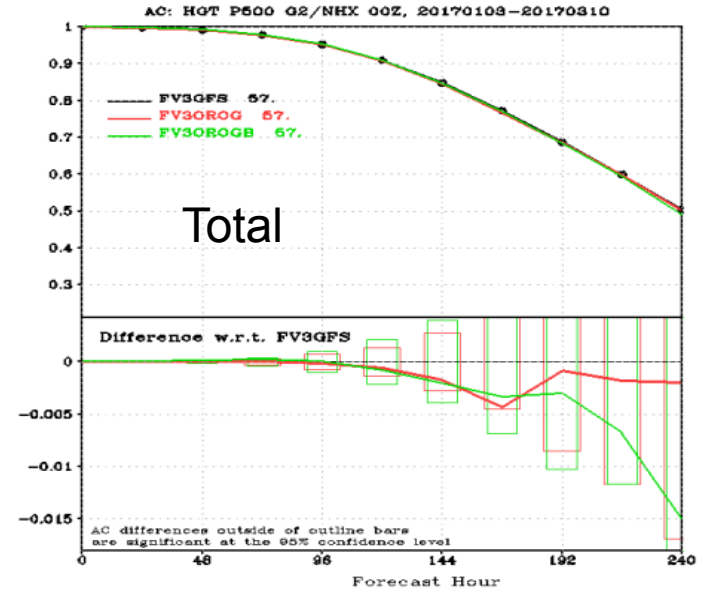
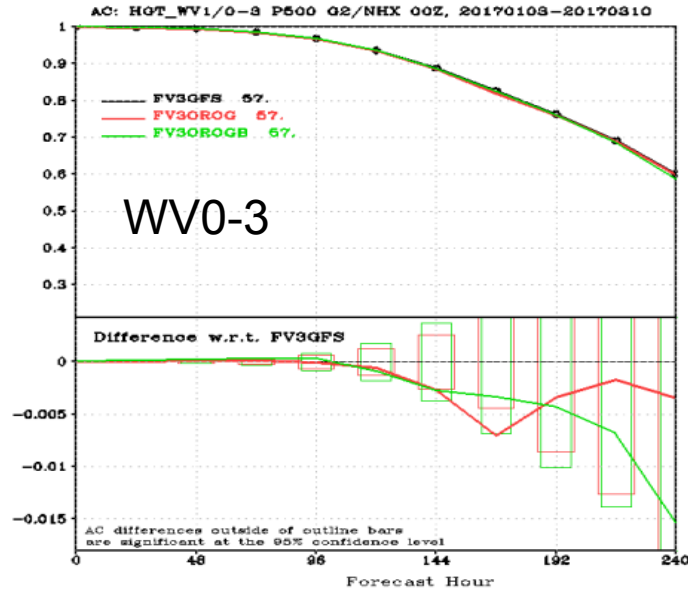
ORANGE/RED INDICATES TERRAIN MORE VARIABLE WITHIN GRID CELL.

mountain block and orographic gravity-wave drag vary with terrain characteristics.

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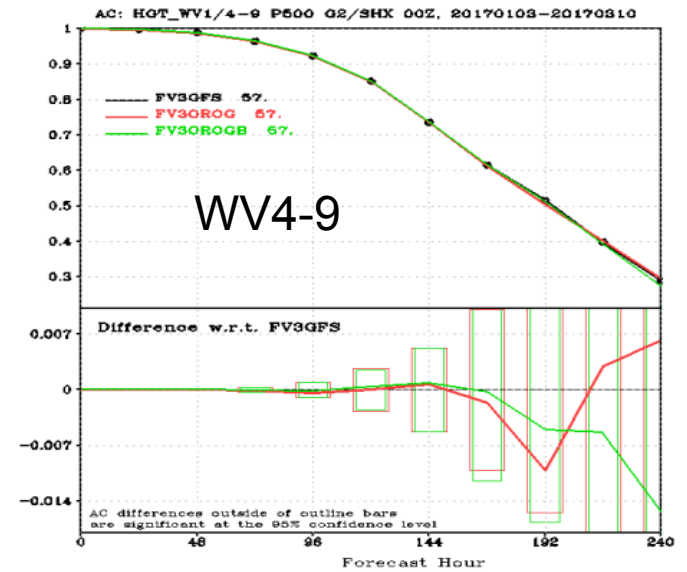
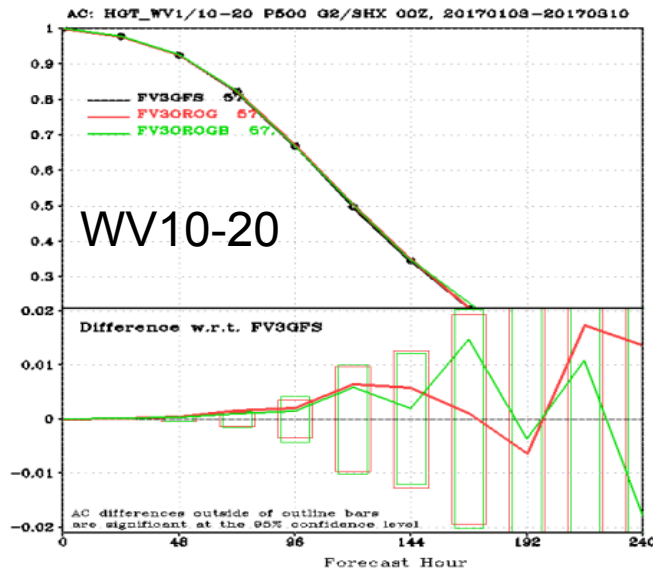
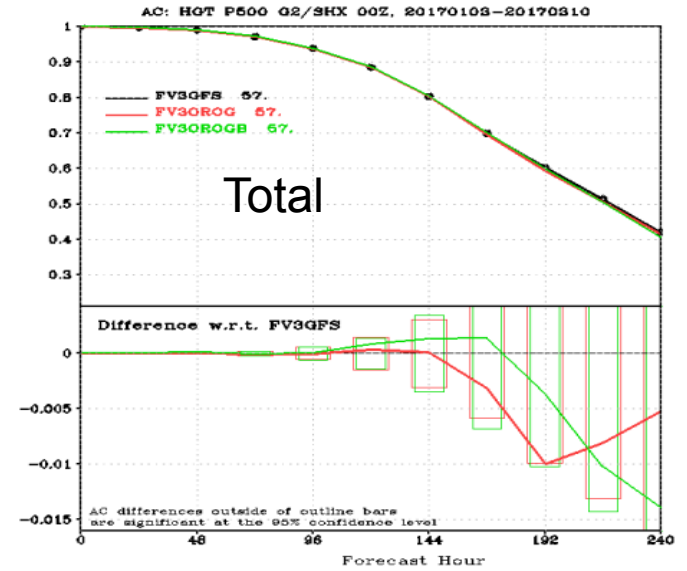
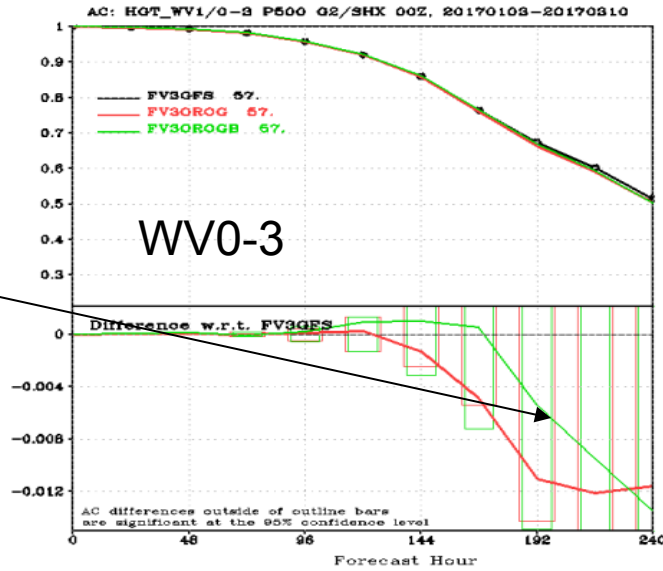
JF2017, NH 500-hPa HGT AC



No improvement

JF2017, SH 500-hPa HGT AC

Slightly
improvement



Summary

- The impact of the new terrain data on fv3GFS forecast is not always positive, but overall the impact is small.
- GMTED2000 terrain datasets for different fv3GFS resolutions will be created. They will be used to replace the old GTOPO30 in the coming weeks.
- The model will be further tuned in combination with other model upgrades to obtain the best possible forecast skills.