Comparison of GFS Forecasts with 32-bit and 64-bit Precision FV3 Dycore

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Weekly FV3GFS Technical Meeting
03/27/2017

Resolution, Physics Grid, and Run-time on Cray
10-d forecast, 6-hourly output, 3.75-minute time step
C768, 13km, 3,538,944 points

Hydro/ non-hydro	precision	threads	nodes	CPU (min/ 10day)
Non-hydro	32-bit	2	64	89
Non-hydro	64-bit	2	64	137
Non-hydro	64-bit	2	144	69
Non-hydro	64-bit	4 Hyper-Thread	64	135
hydro	64-bit	2	64	95
hydro	64-bit	2	144	51

T1534 NEMS GFS (~13 km, 3072x1536), 61 nodes, 73 minutes

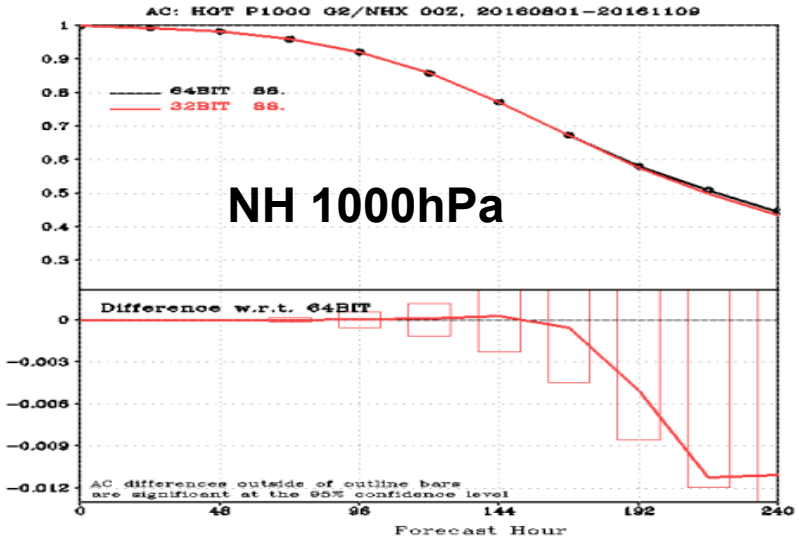
Purpose of this test:

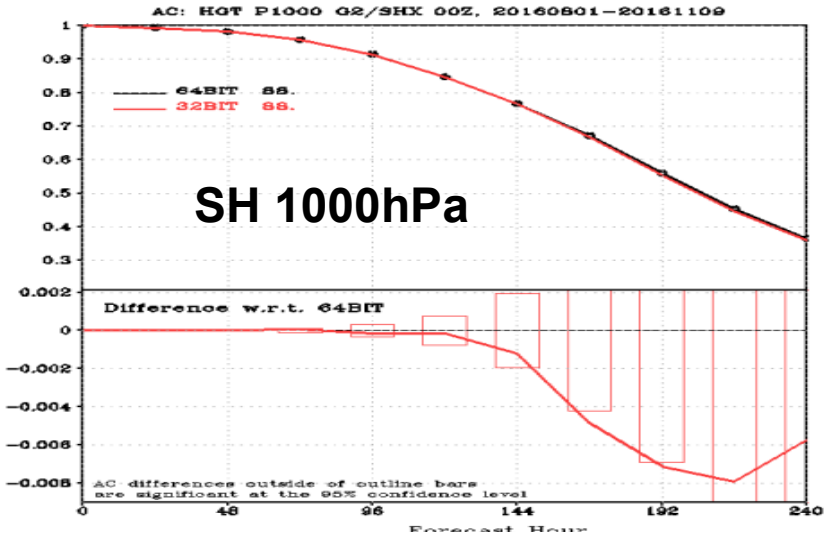
- **Running fv3gfs with 32-bit dycore is about 35% faster than with 64-bit dycore.**
- **Will forecast skills be adversely affected if 32-bit dycore is used?**
- **Physics is always run at 64-bit precision.**

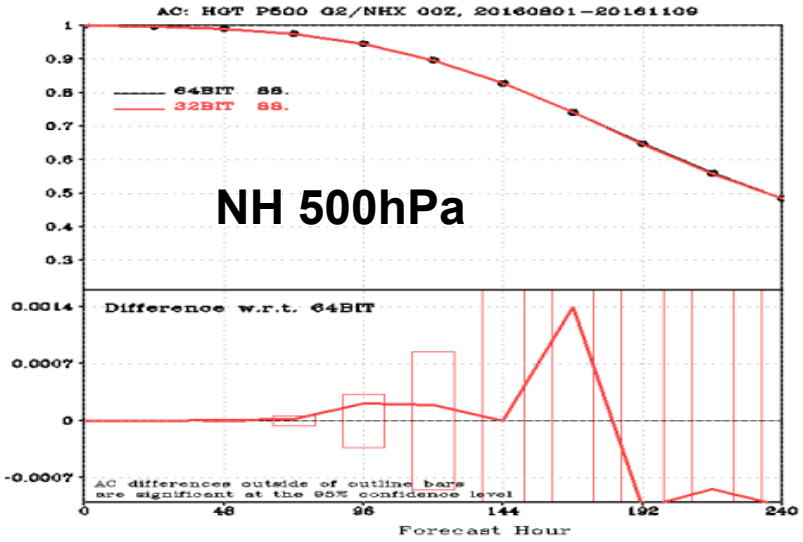
Two forecast experiments were carried out at C768 (~13km) resolution for Aug-Sep-Oct 2016. Both runs are L63 with model top at ~1.0 hPa.

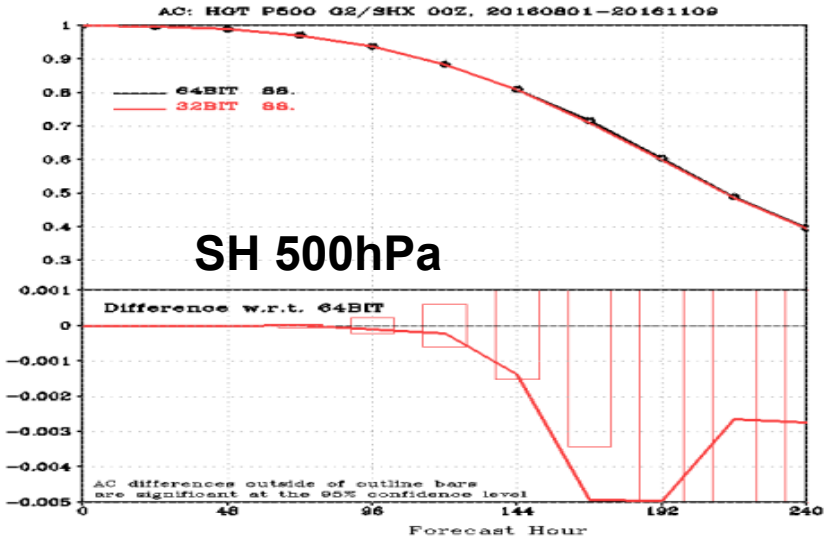
HGT AC

SH is significantly worse for medium-ranger forecast



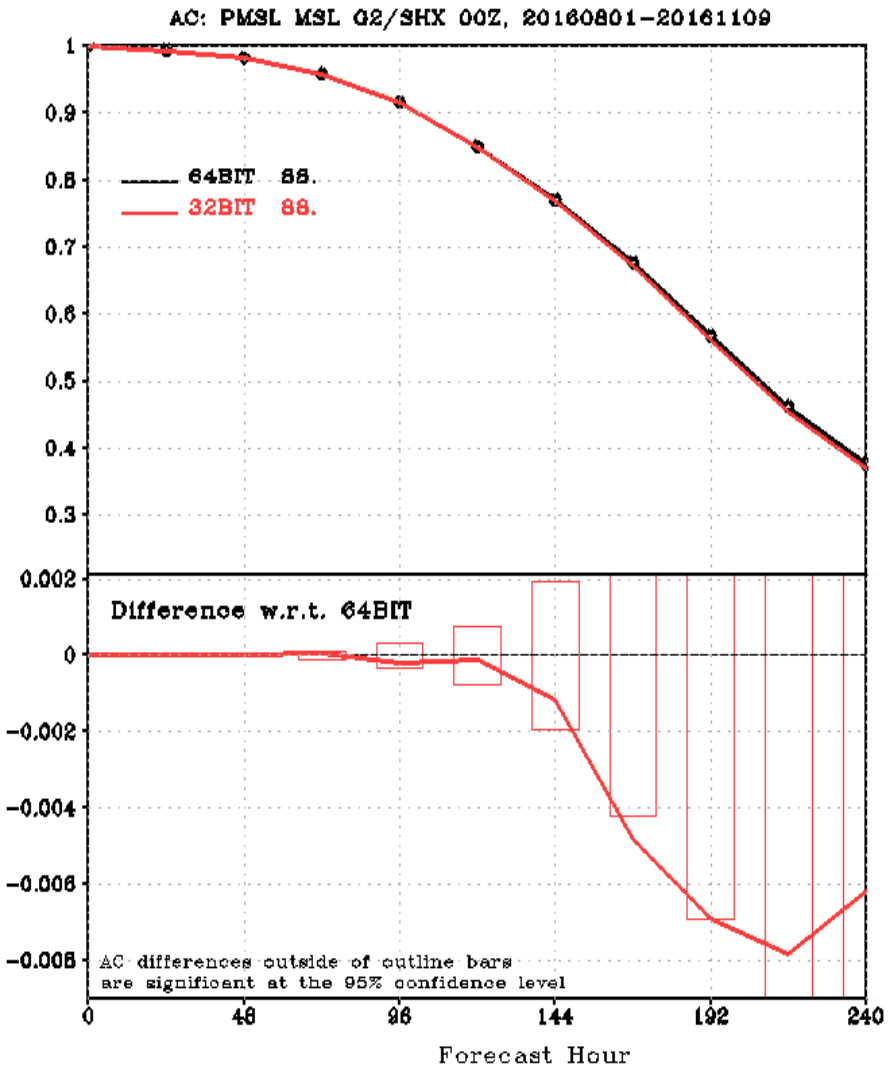


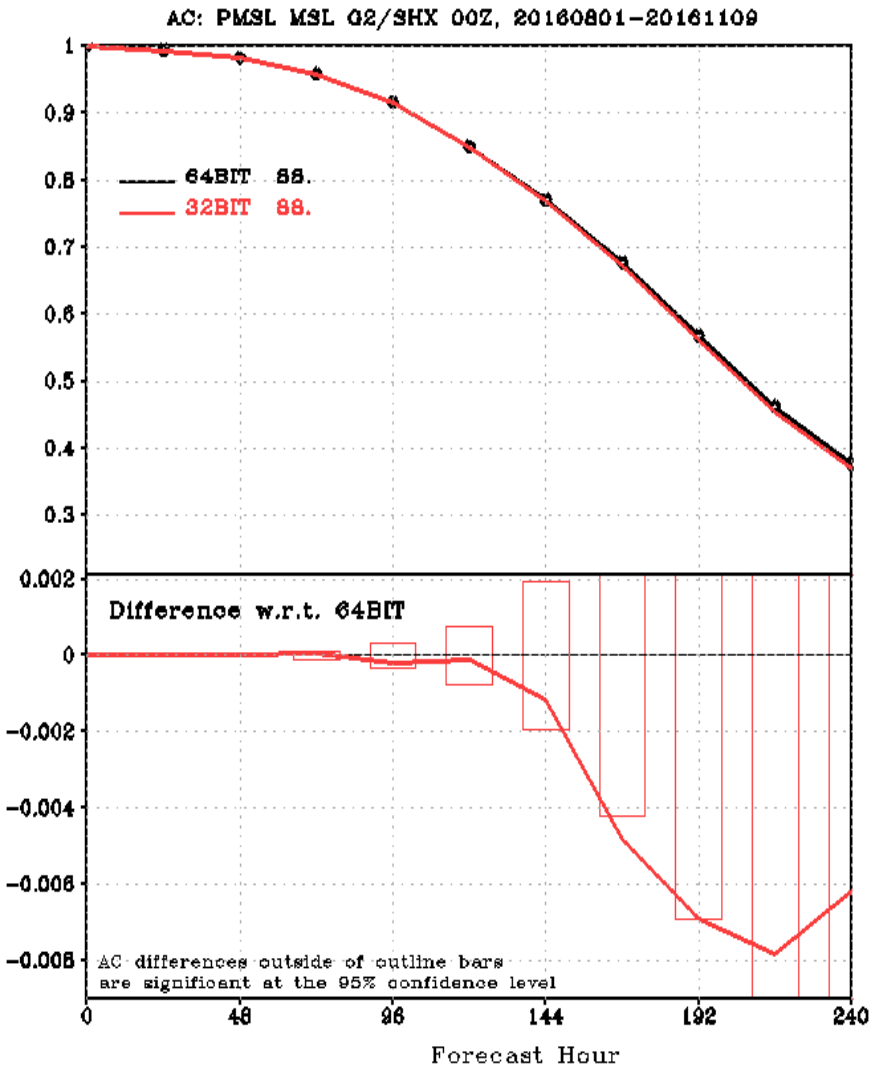




http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/32bit_64bit/

SLP AC


AC: PMSL MSL G2/SHX 00Z, 20160801-20161109
64BIT 88.
32BIT 88.
Difference w.r.t. 64BIT
AC differences outside of outline bars
are significant at the 95% confidence level
Forecast Hour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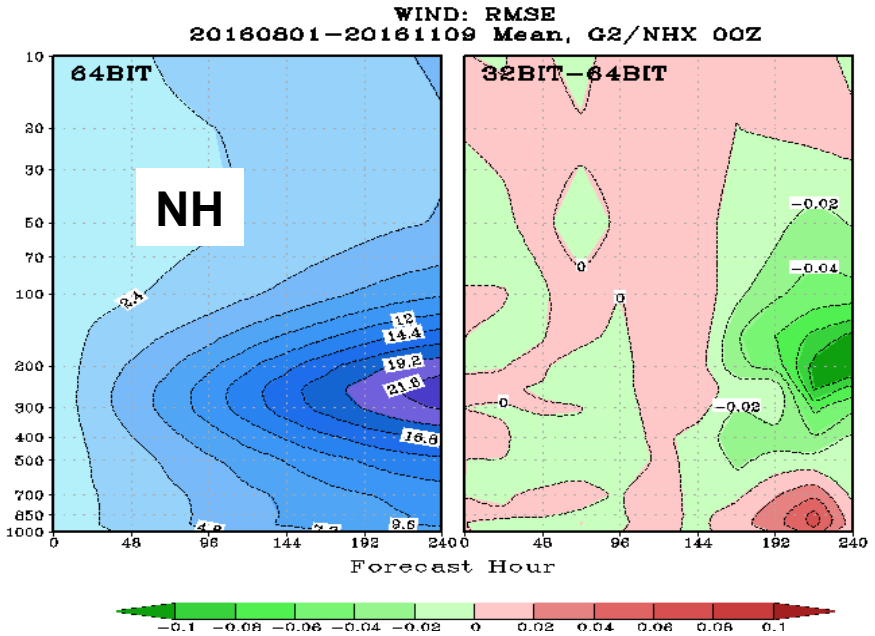
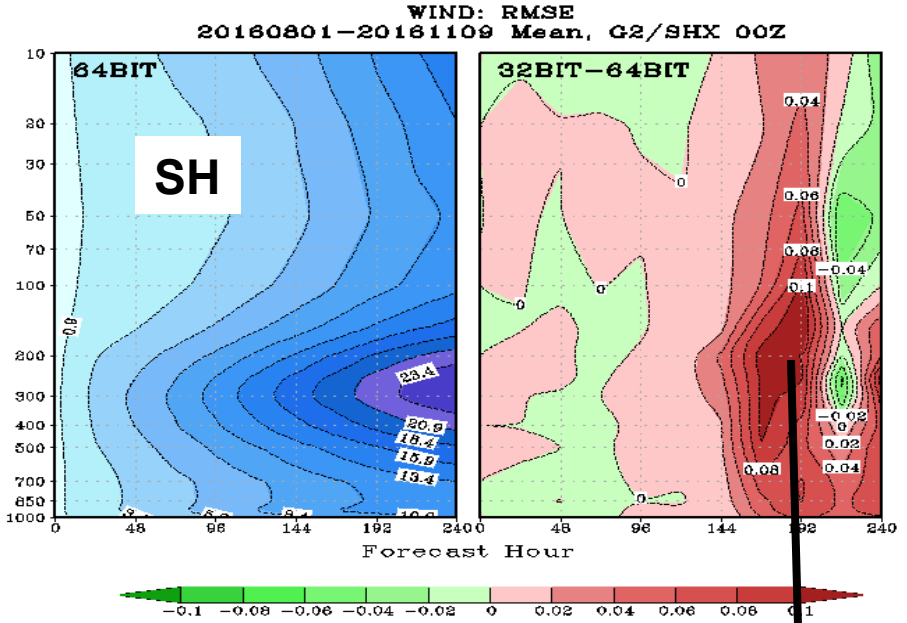
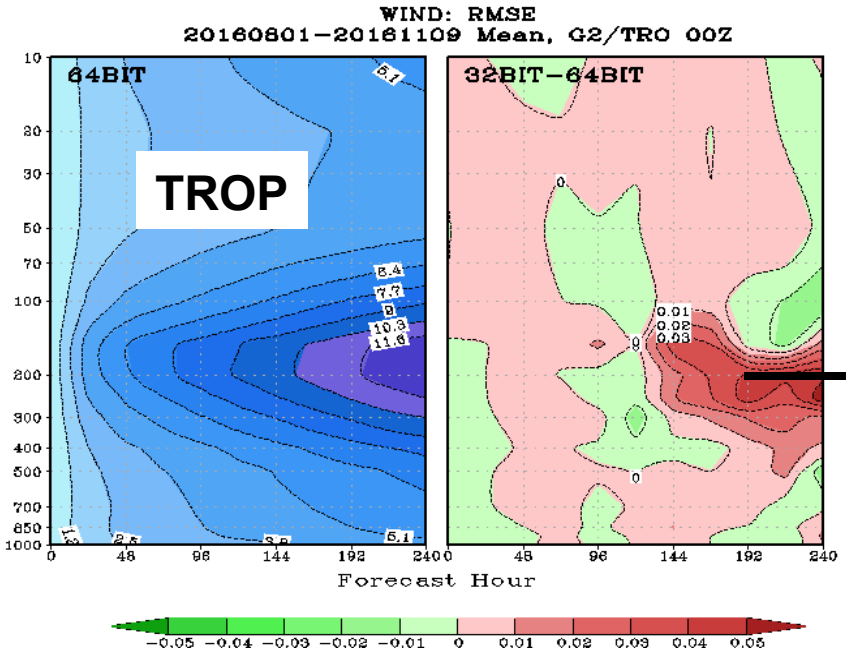
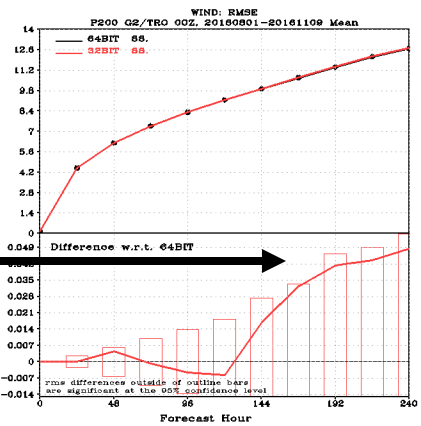
Vector Wind RMSE

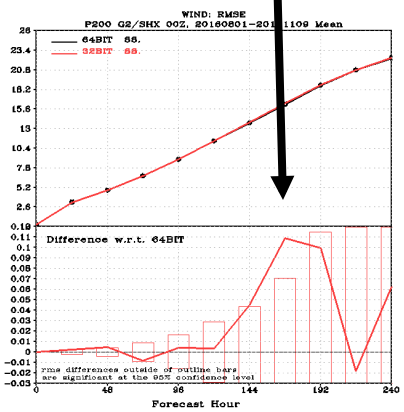
Worse near tropopause in SH and tropics





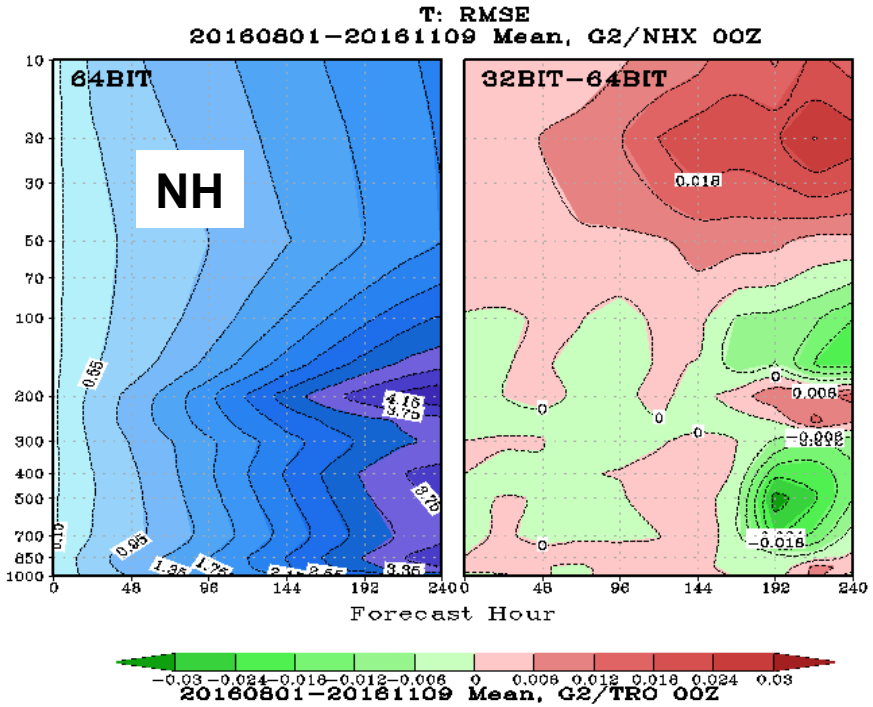


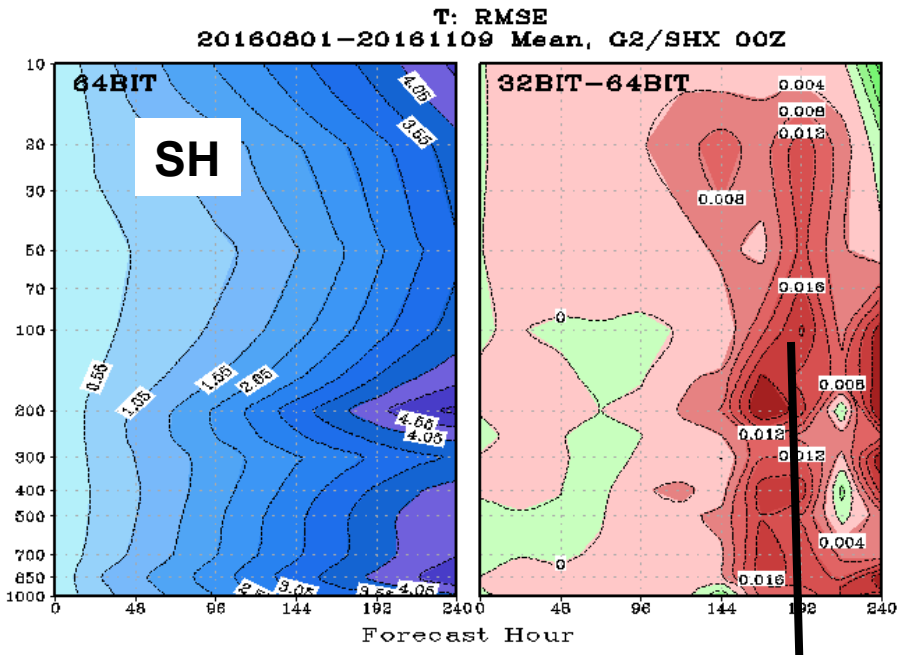


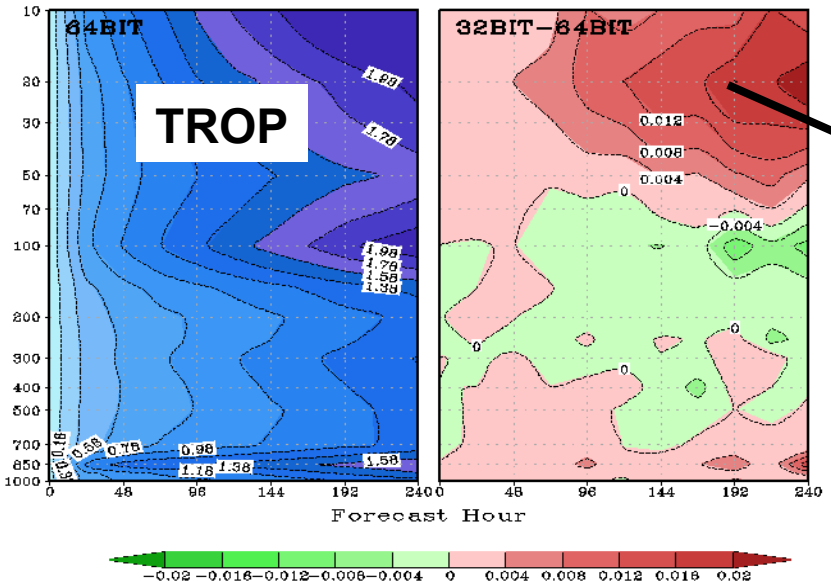


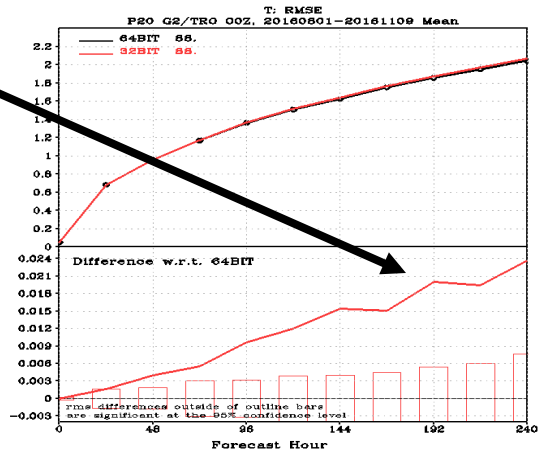
Temperature RMSE

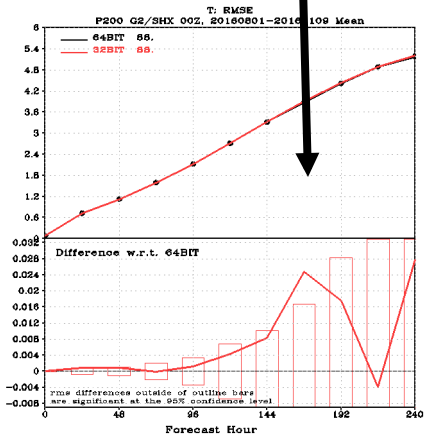
Worse in the stratosphere in NH and TROP, and worse in SH in both stratosphere and troposphere.





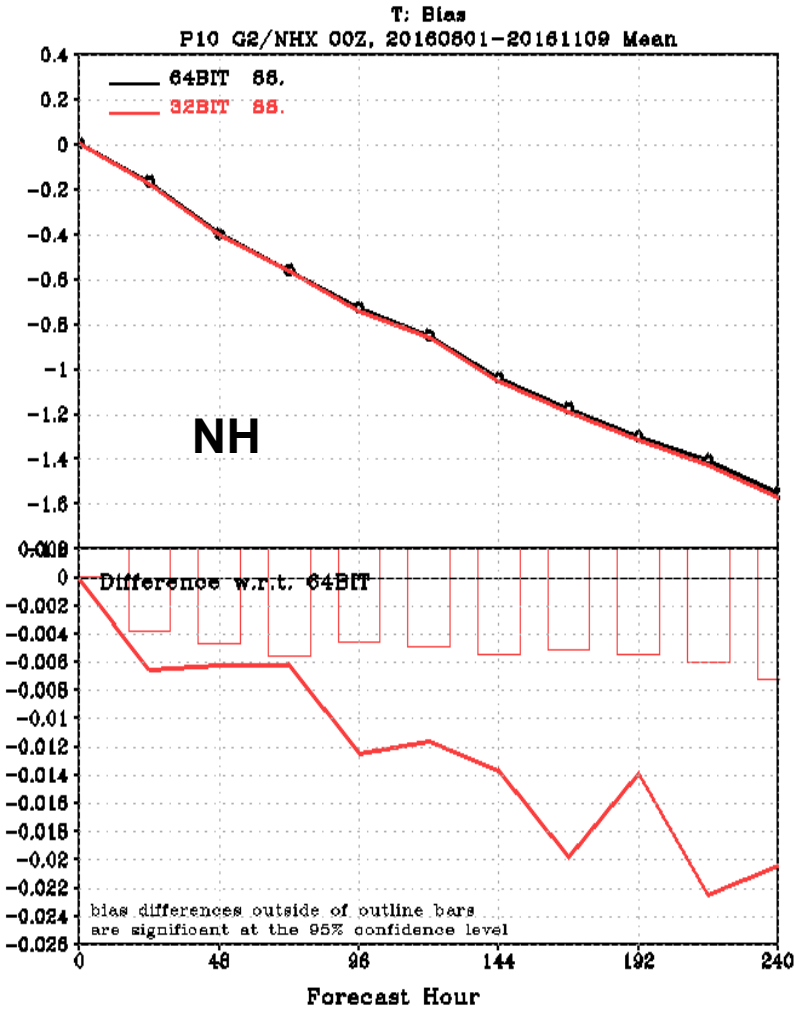


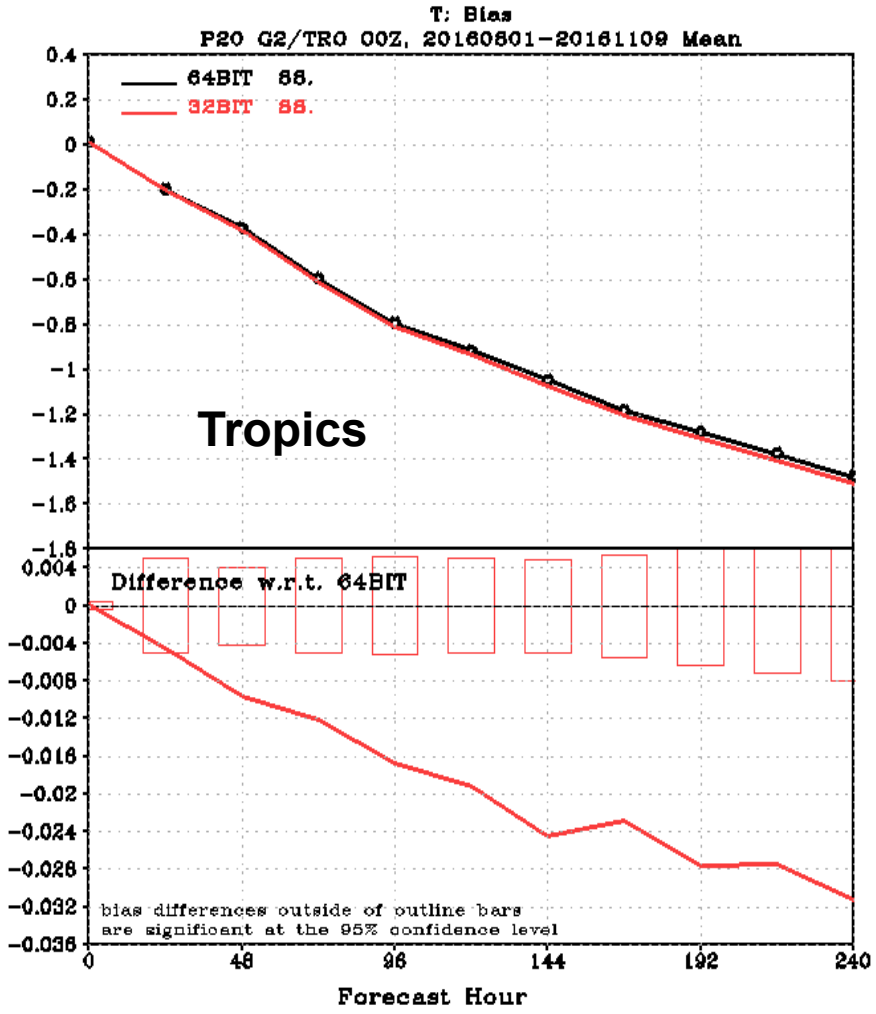




20hPa Temperature BIAS

32-bit run slightly colder than 64-bit run

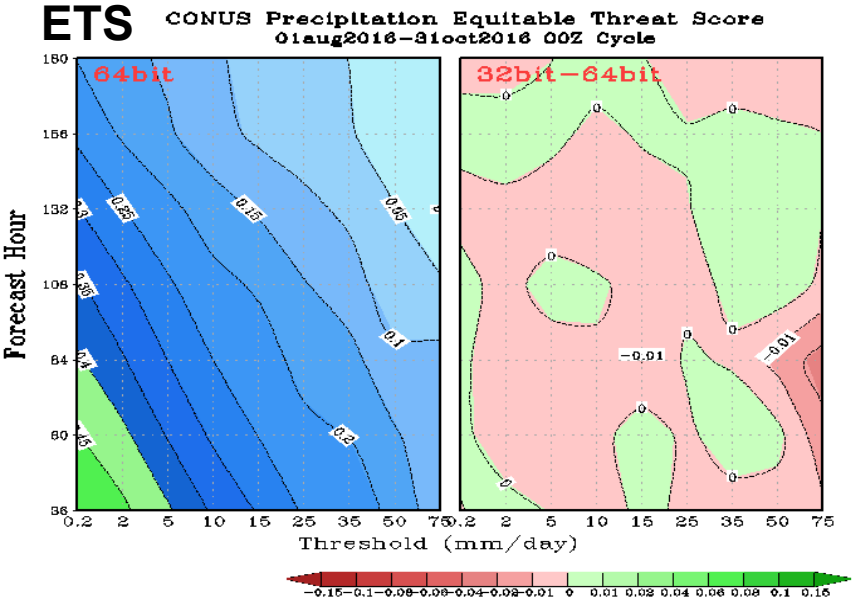


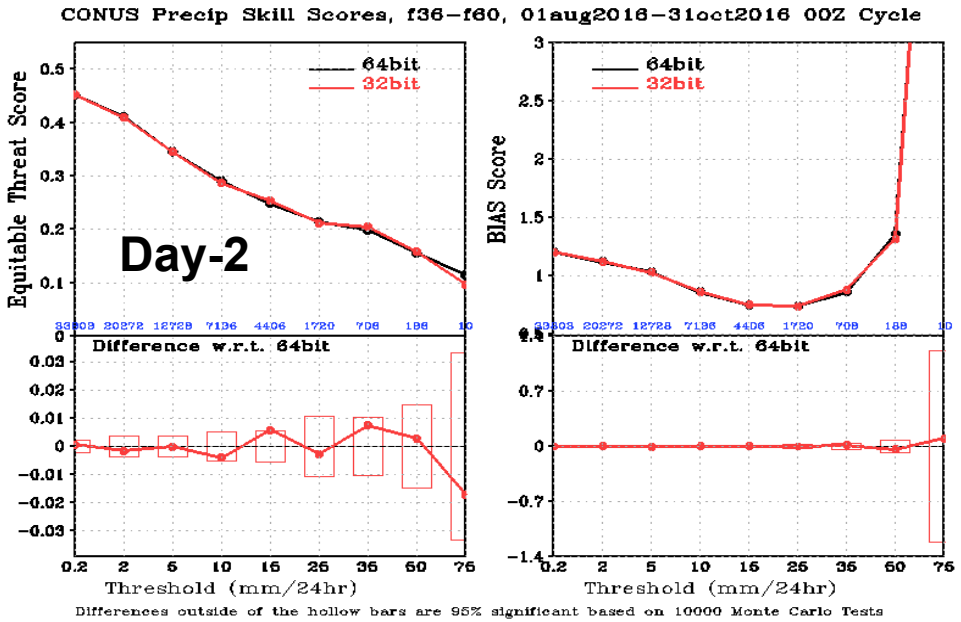


CONUS Precipitation Scores

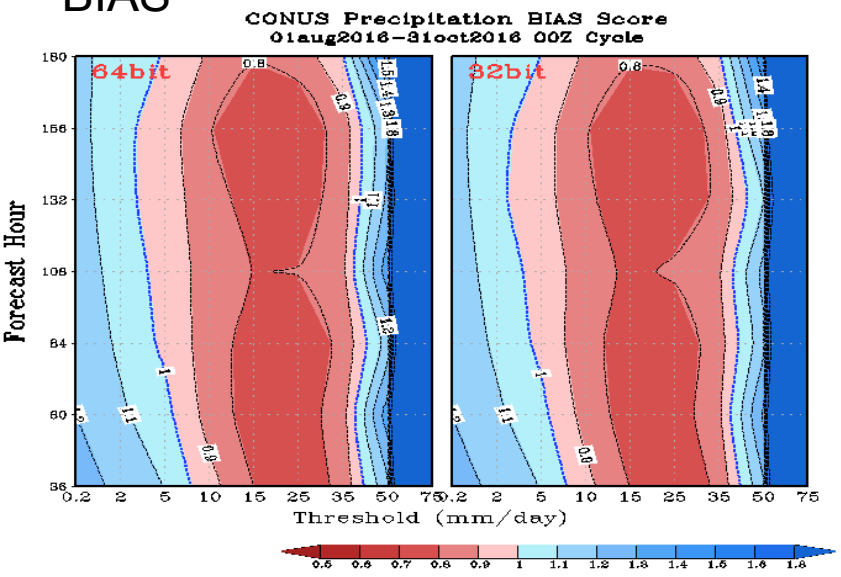
No impact

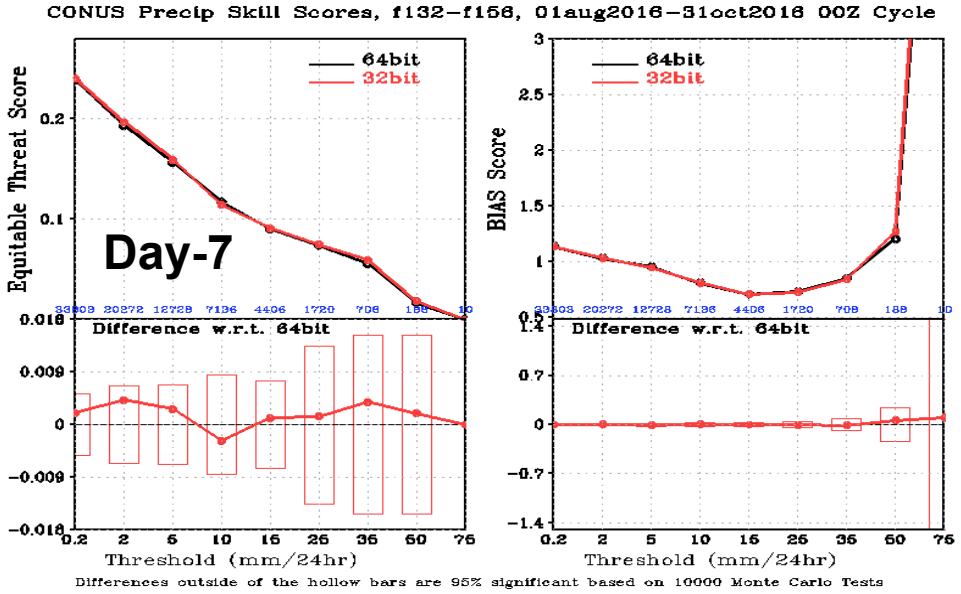
ETS



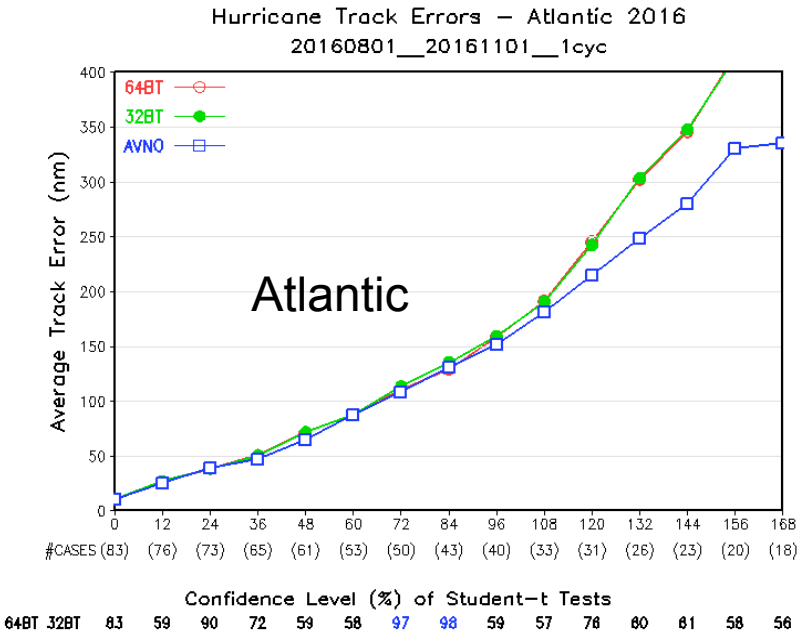


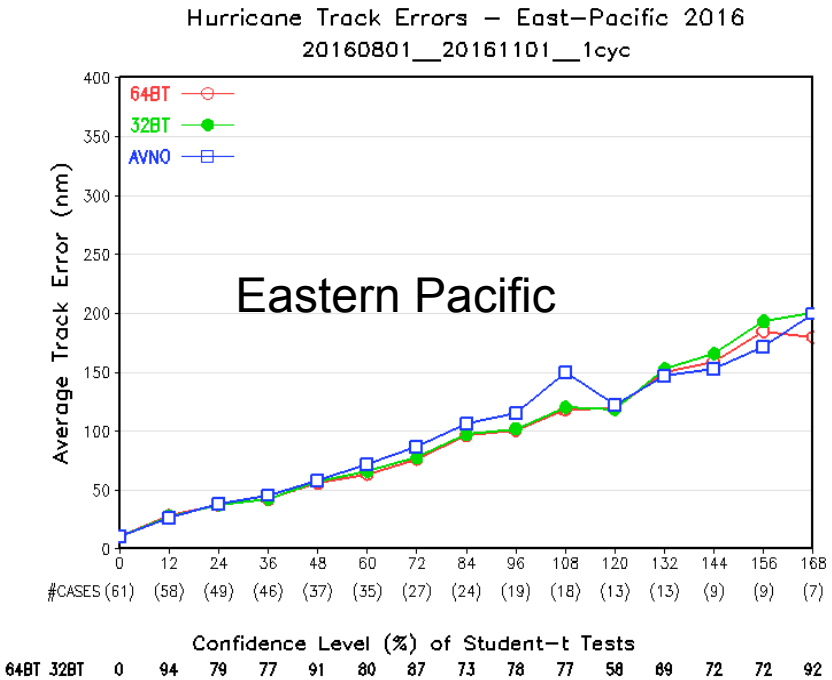
BIAS

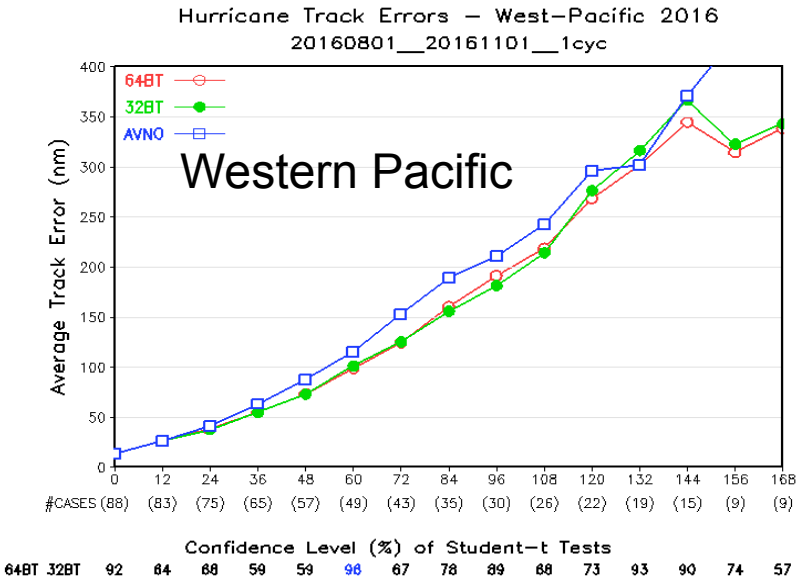




Hurricane Track







No impact

Summary
32-bit run against 64-bit run

- **Lower HGT AC at 1000hPa and 500hPa in SH**
- **Lower SLP AC in both NH and SH**
- **Higher wind RMSE near SH and Tropical tropopause**
- **Larger temperature RMSE (colder) in the NH and tropical stratosphere, and SH stratosphere and troposphere.**
- **No impact on CONUS precipitation ETS and Bias scores**
- **No impact on hurricane track error scores.**

Computing cost vs small gain of accuracy; probably need to run FV3GFS at different precision for different applications

Comparison of GFS Forecasts with 63 and 64 Model Vertical Layers

Pk=Ak+Bk*Ps

k	Ak	Bk
60	428.434	.00000000
61	318.266	.00000000
62	221.958	.00000000
63	137.790	.00000000
64	64.247	.00000000
~~65~~	~~.000~~	~~.00000000~~

63L FV3GFS

Top integer layer is at ~1.0 hPa

k	Ak	Bk
60	428.434	.00000000
61	318.266	.00000000
62	221.958	.00000000
63	137.790	.00000000
64	64.247	.00000000
65	10.000	.00000000
~~66~~	~~.000~~	~~.00000000~~

64L FV3GFS

Top integer layer is at ~0.37 hPa

Purpose of this test:

- **Setting the FV3GFS model top close to the current operational GFS model top simplifies the transition of data assimilation from GSM to FV3 dycore.**

- **Test if the forecast quality is acceptable if the model top is pushed up from 0.64 (~51 km) to 0.1 hPa (~65 km) without any other changes in model configuration**

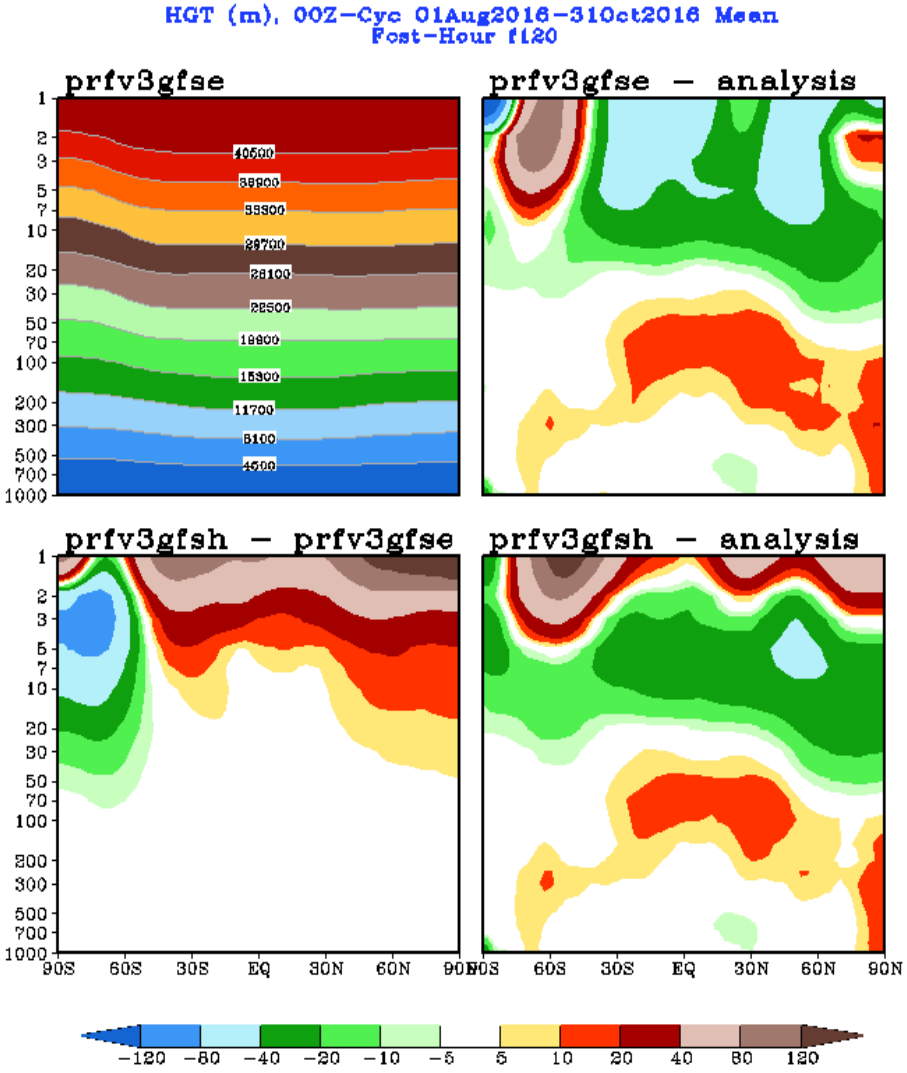
- **Two forecast experiments were carried out at C768 (~13km) resolution for Aug-Sep-Oct 2016, both with non-hydrostaitc and 32-bit dycore.**

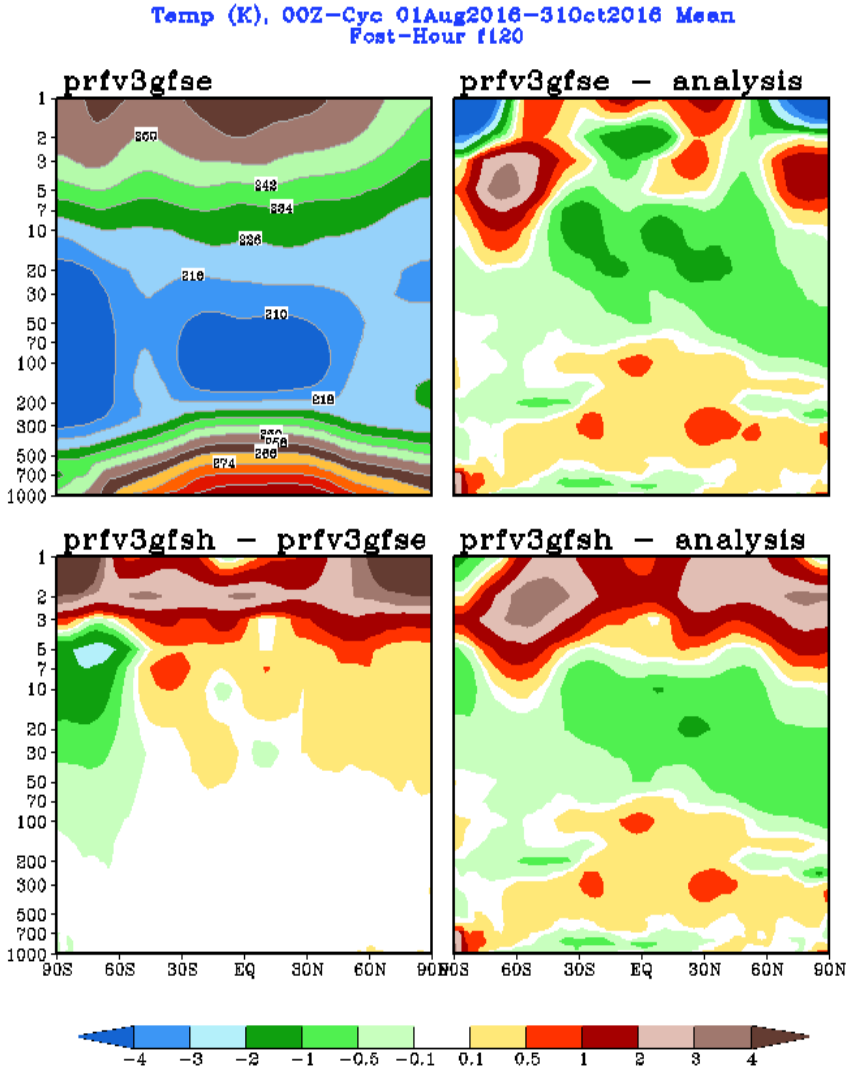
- **For the 64L run, time step was reduced by 50% to keep the model from blowing up due to computational instability.**

- ***Lucas Harris* provided a set of tunable parameters that may allow larger time steps to be used. DA group (Catherine Thomas) is testing 64L FV3GFS with these parameters.**

http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/63L_64L/

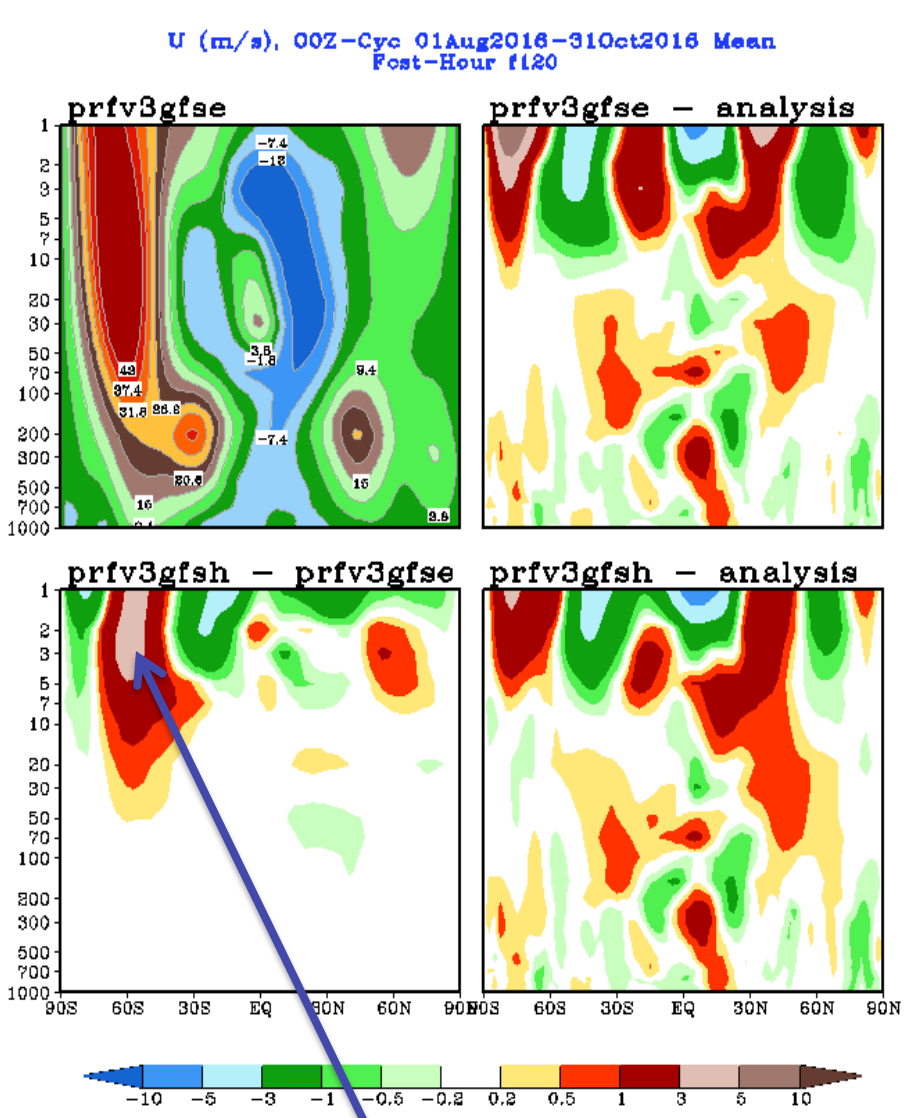
Zonal Mean Height and Temperature. 120-hr Fcst

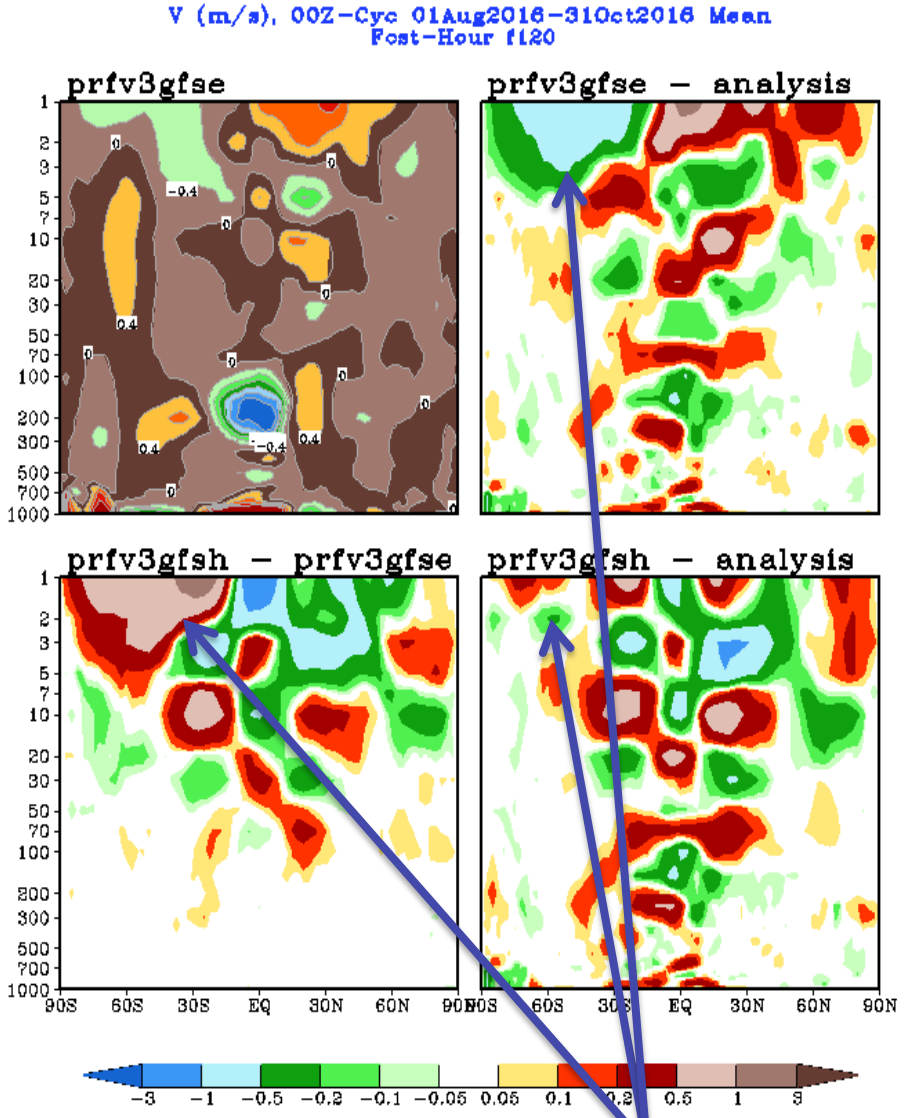




64L run is warmer than L63 run in upper stratosphere, and better matches analysis

Zonal Mean U and V. 120-hr Fcst

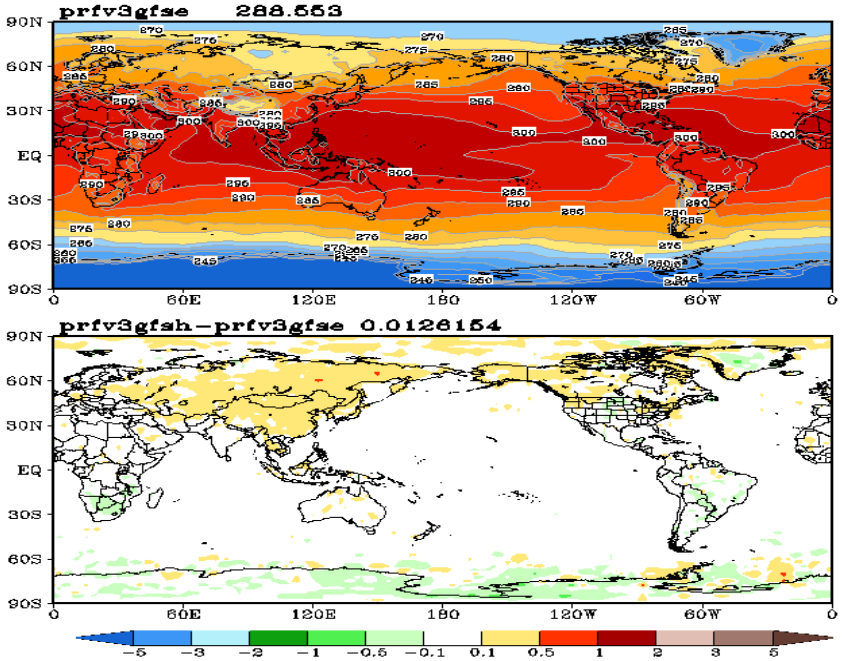




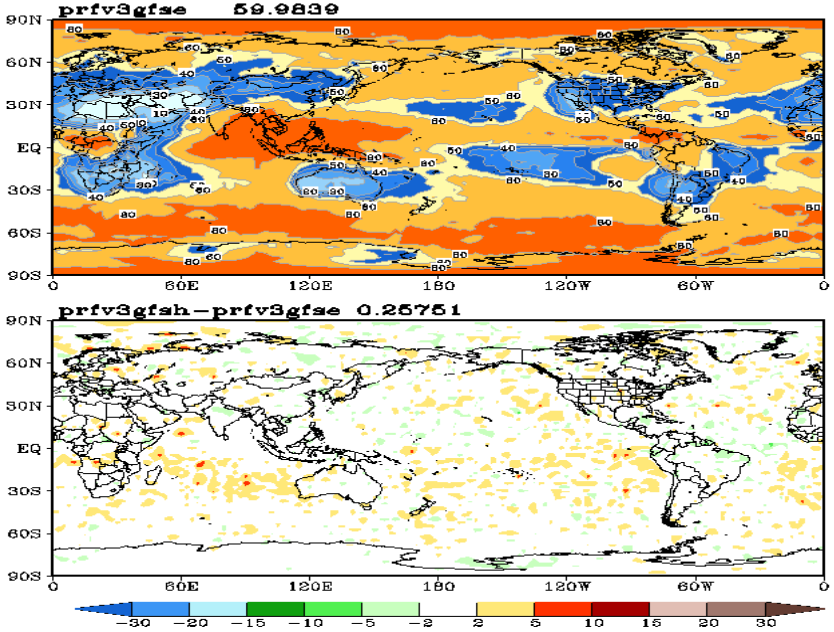
64L has stronger stratospheric polar night jet

64L has better pole-to-pole transport

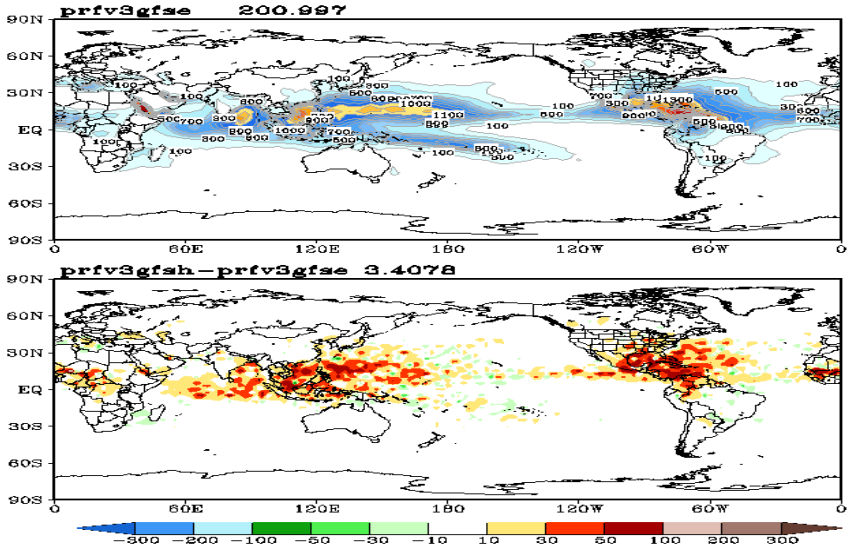
2m Above Ground Temperature [K]
00Z-Cyc 01Aug2018-31Oct2018 Mean
(f120 f120 f120 f120) Fcst-Hour Average



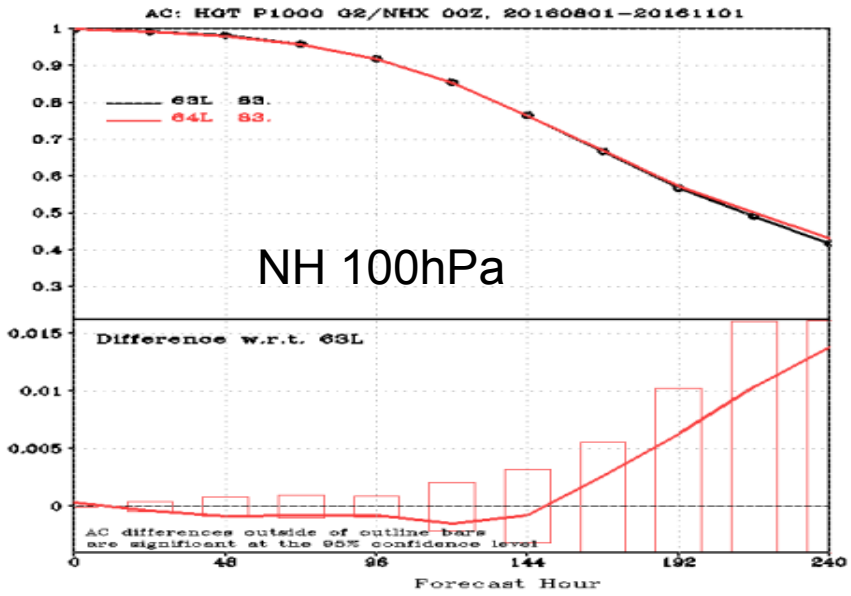
Atmos Column Total Cloud Cover [%]
00Z-Cyc 01Aug2018-31Oct2018 Mean
(f120 f120 f120 f120) Fcst-Hour Average

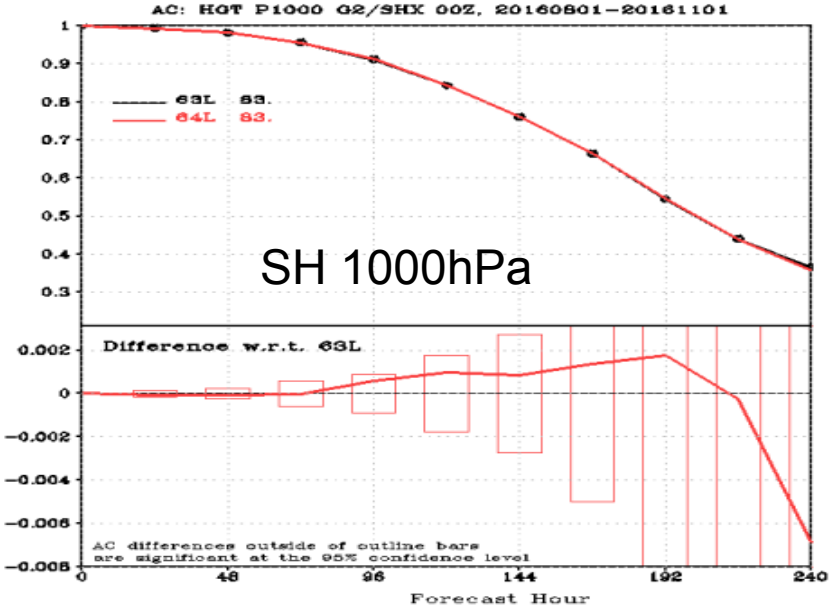


Surface Convective Avail Potential Energy [J/kg]
00Z-Cyc 01Aug2018-31Oct2018 Mean
(f120 f120 f120 f120) Fcst-Hour Average



HGT AC


AC: HGT P1000 G2/NHX 00Z, 20160801-20161101
63L 83.
64L 83.
NH 100hPa
Difference w.r.t. 63L
AC differences outside of outline bars are significant at the 95% confidence level
Forecast Hour


AC: HGT P1000 G2/SHX 00Z, 20160801-20161101
63L 83.
64L 83.
SH 1000hPa
Difference w.r.t. 63L
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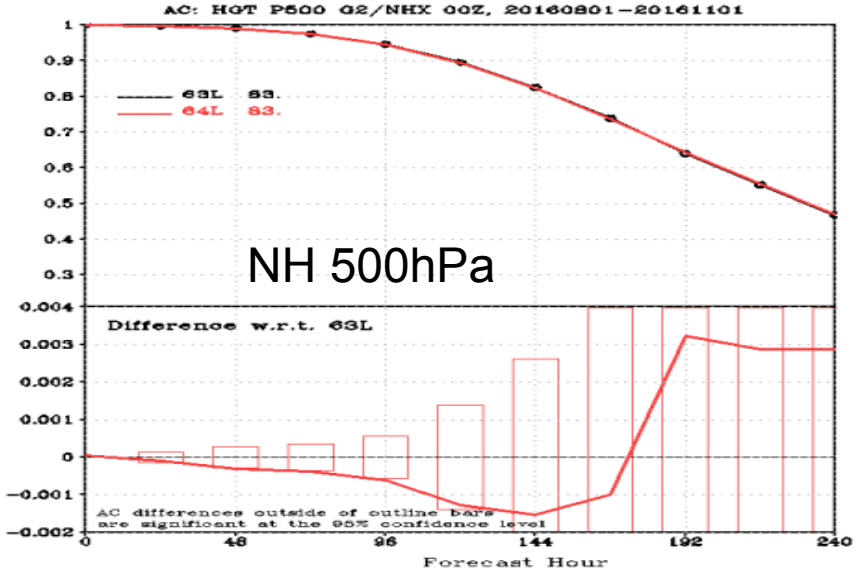
Forecast Hour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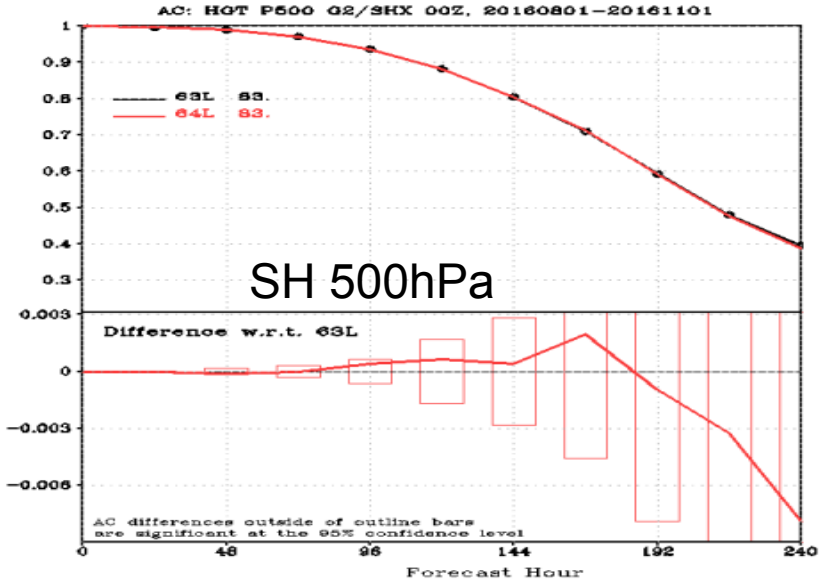
63L 83.
64L 83.
NH 500hPa
Difference w.r.t. 63L
AC differences outside of outline bars are significant at the 95% confidence level
Forecast Hour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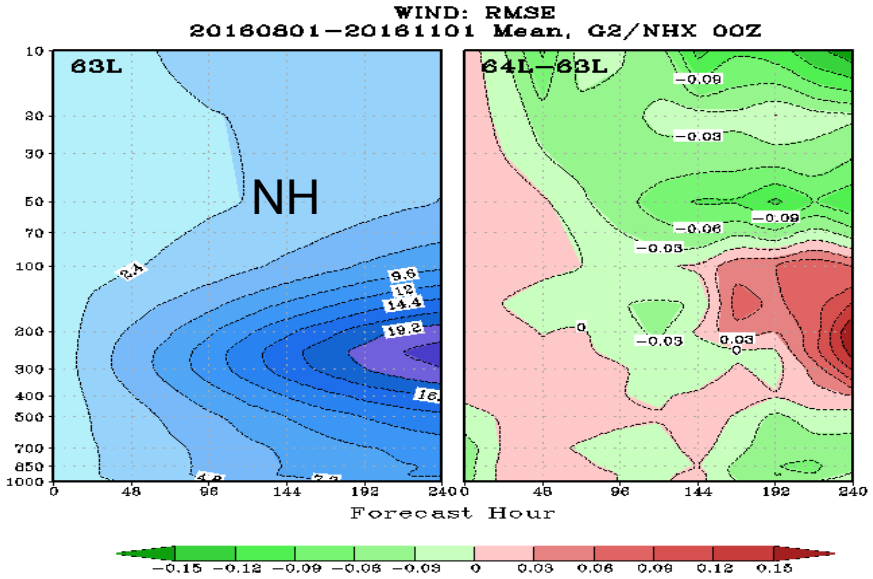
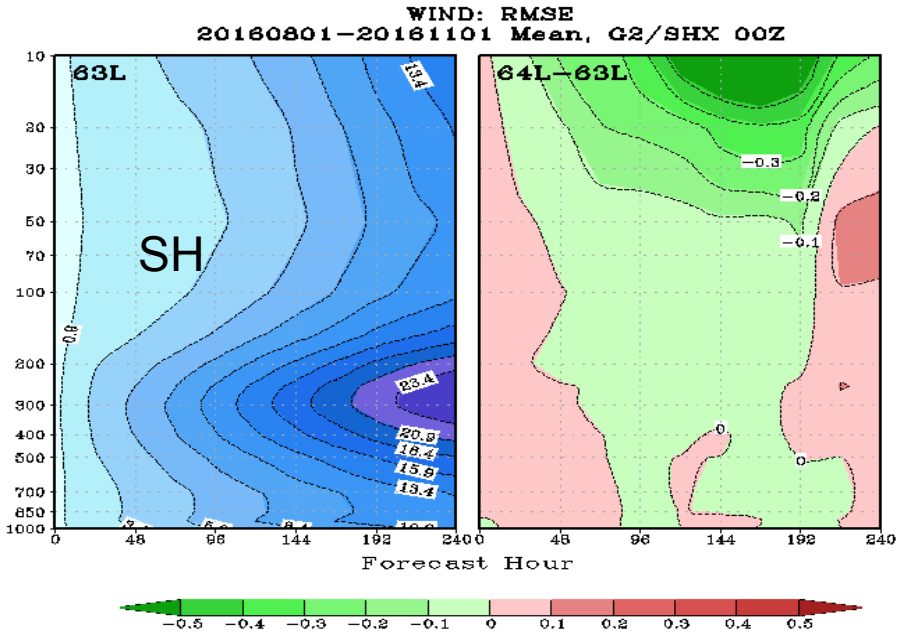
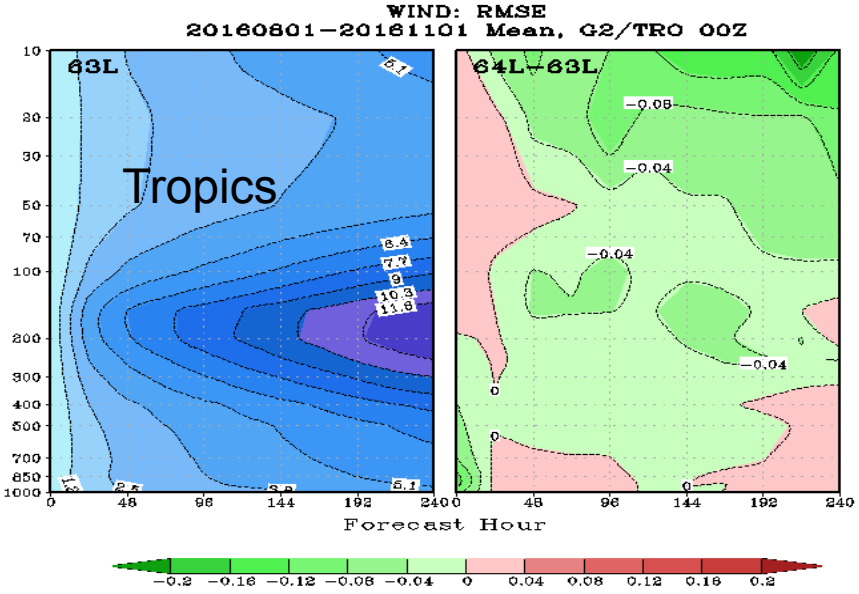
Forecast Hour

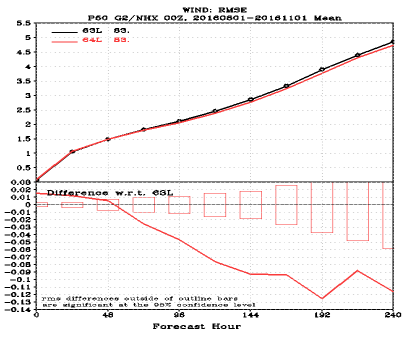
WIND RMSE

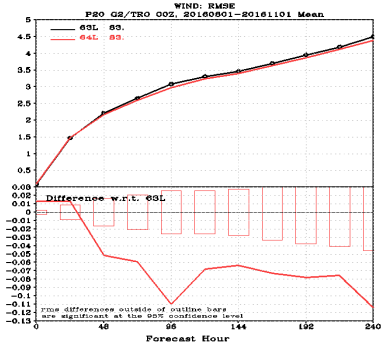




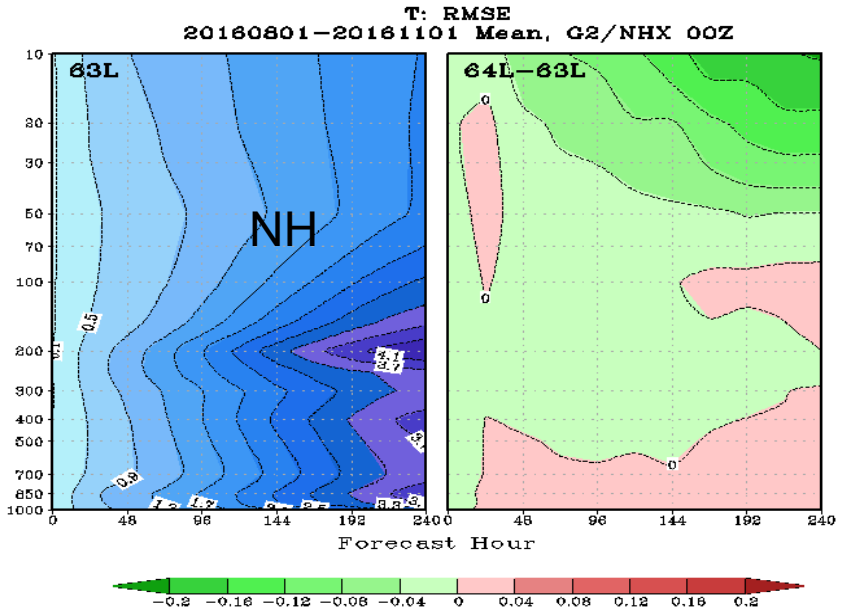


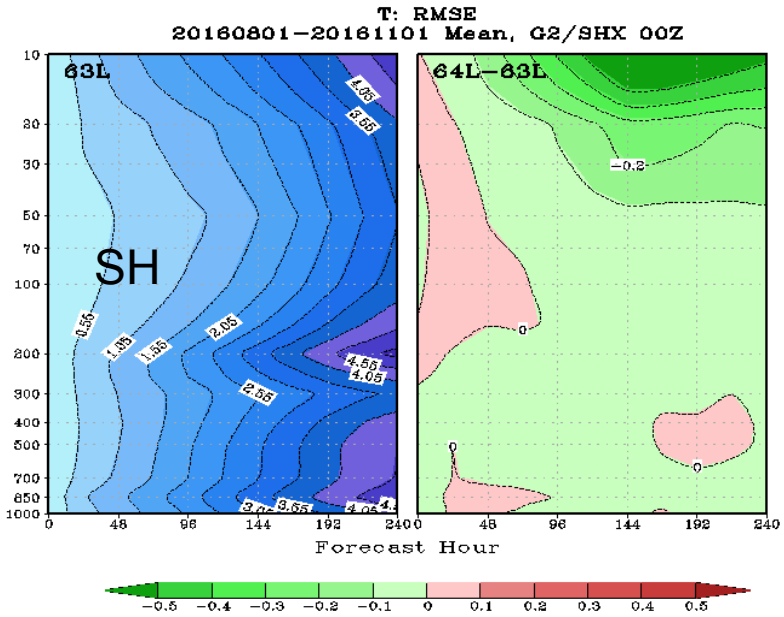
Extending model top significantly reduces wind RMSE in the stratosphere

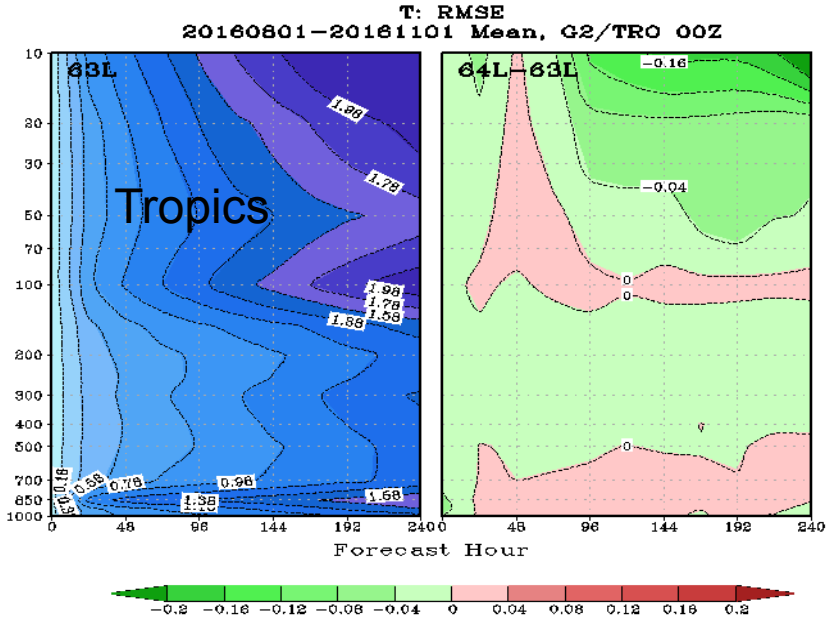




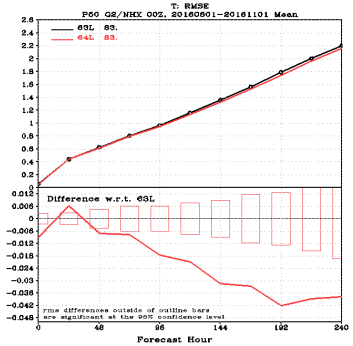
Temperature RMSE

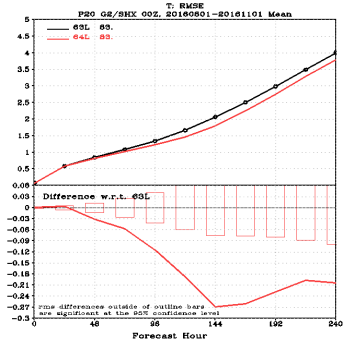






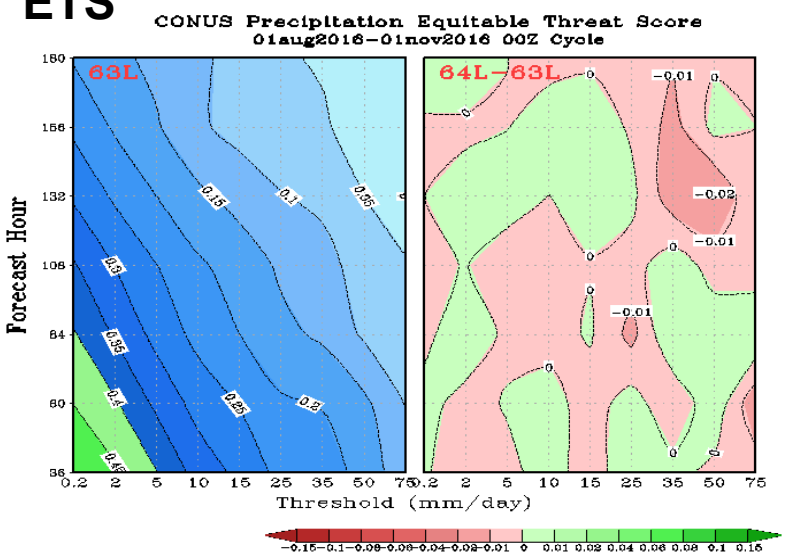
Extending model top significantly reduces temperature RMSE in the stratosphere

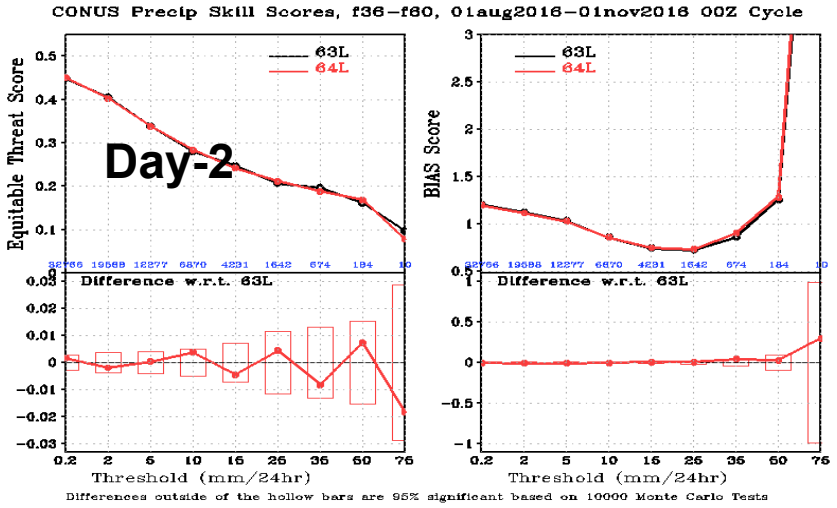




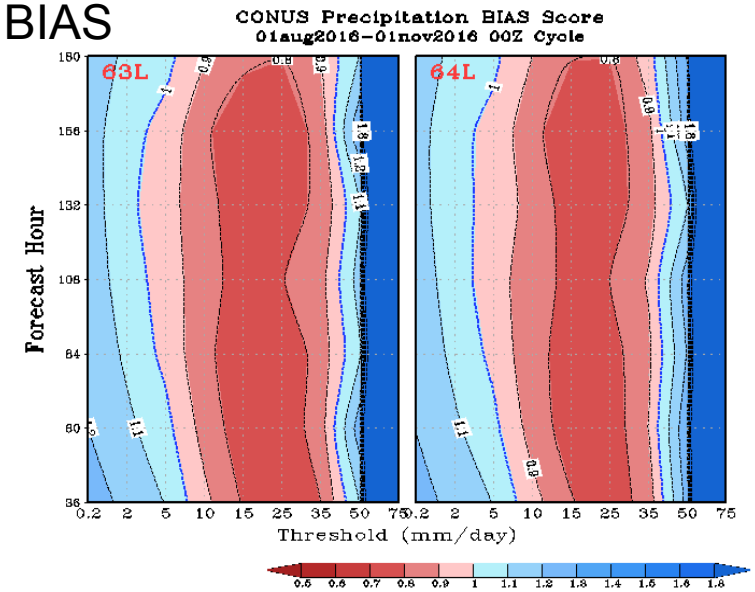
CONUS Precipitation Skill Scores – No Impact

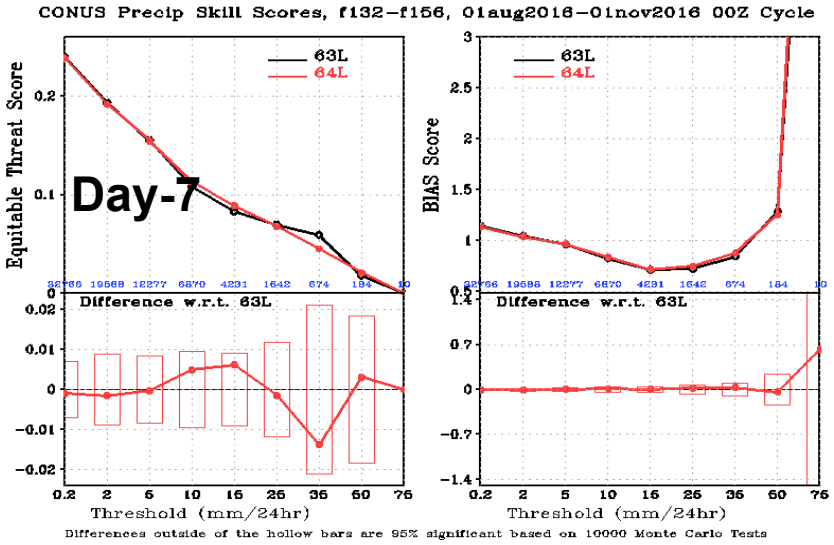
ETS



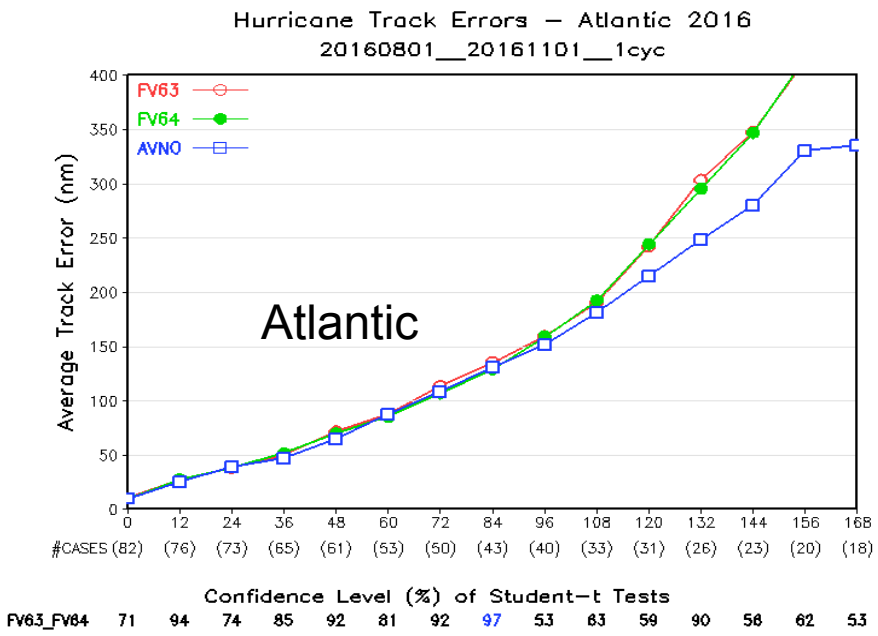


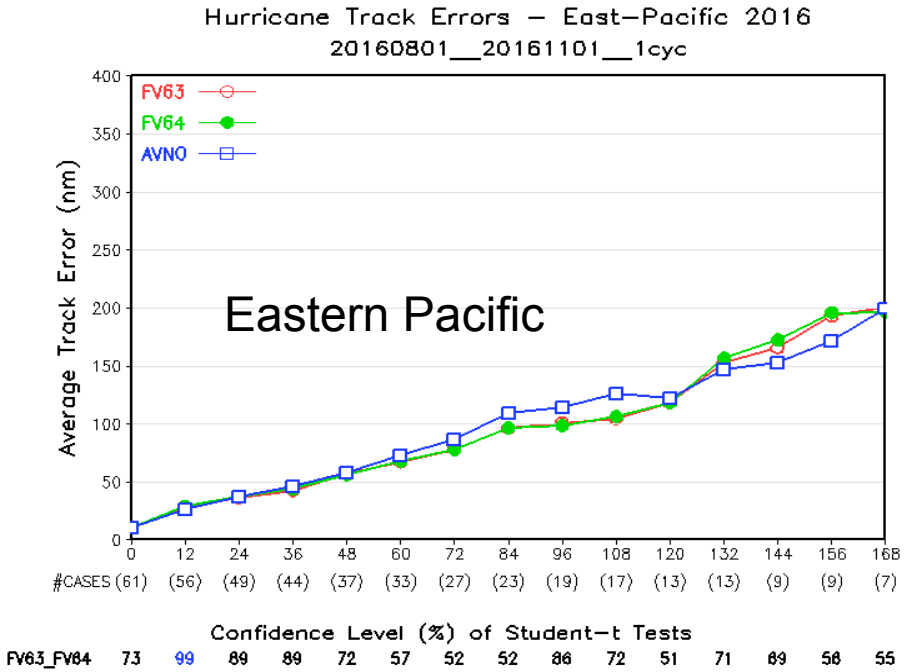
BIAS

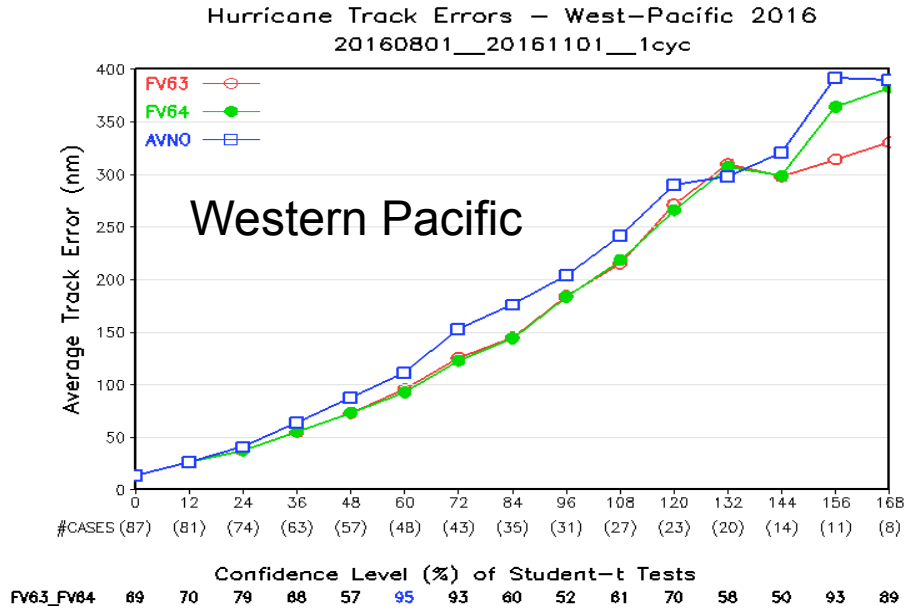




Hurricane Track







No impact

Summary
63L run against 64L run

- Reduced wind and temperature RMSE in the upper stratosphere
- Stronger polar night jets, and improved meridional wind in the stratosphere
- No significant impact on HGT AC at 500hPa and 1000hPa
- No significant impact on SLP AC
- No impact on CONUS precipitation ETS and Bias scores
- No impact on hurricane track error scores.

Need more tests to make the model run stably with longer time step