

# **Sensitivity of 63-Layer FV3GFS to Options of Vertical Coordinate**

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- **ncep\_plevels=T**: run fv3gfs with the current NCEP GFS 64-layer model vertical coordinate.
- **ncep\_plevels=F**: run fv3gfs with a coordinate coded within the model. It is slightly different from the GFS coordinate.
- **FV3GFS** was run with **ncep\_plevels=F** for the **NGGPS Phase-II** dycore comparison project.
- For consistency, data assimilation requires the use of current GFS coordinate. The purpose of this sensitivity test is to check if using current GFS coordinate will degrade the model forecast performance.
- Two forecast experiments were carried out with **ncep\_plevels=T** and **F**, respectively, for **Aug-Sep-Oct 2016**. Both were initialized with current operational GFS analyses.

$$P(k) = A(k) + B(k) * P_s$$

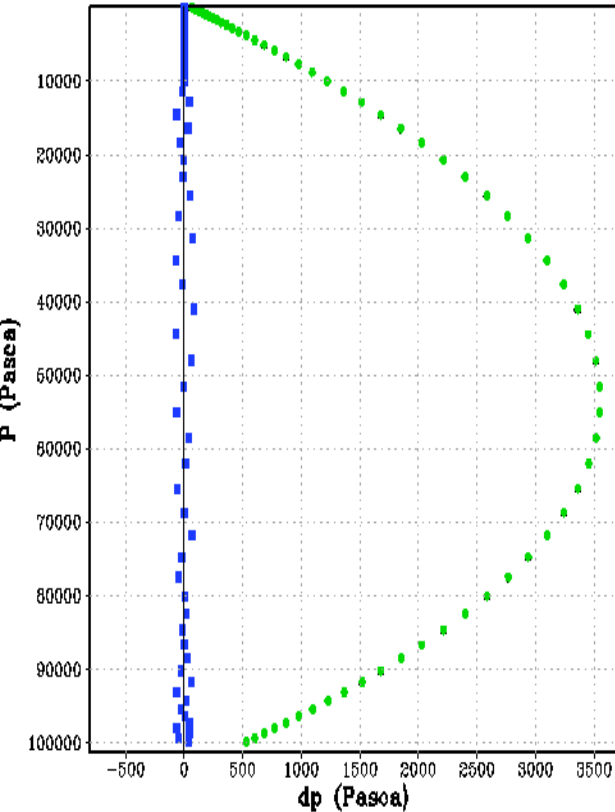
Black : GFS

Green: modified

Blue: diff

Vertical Profiles,  $P_{90}=100000\text{Pa}$

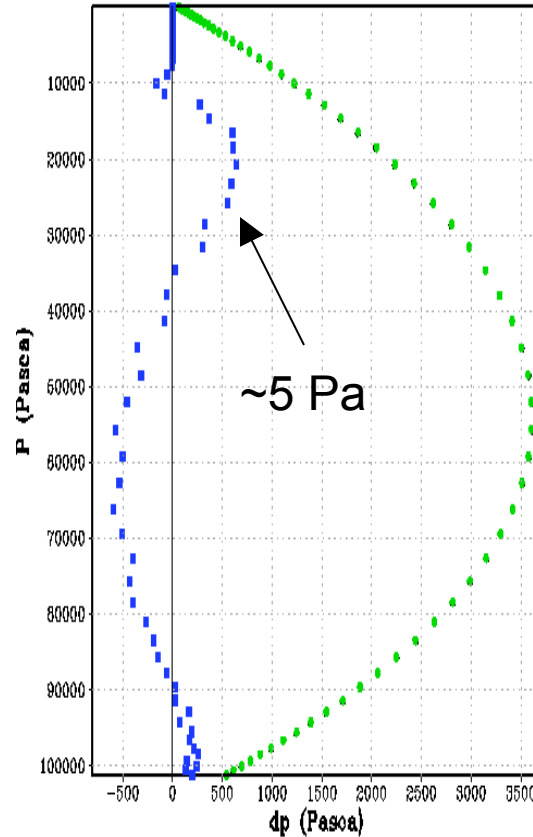
Black:GFS84; Green:GFDL84  
Blue: (GFDL-GFS)\*0.01



$P_s=100,000\text{ Pa}$

Vertical Profiles,  $P_{90}=101325\text{Pa}$

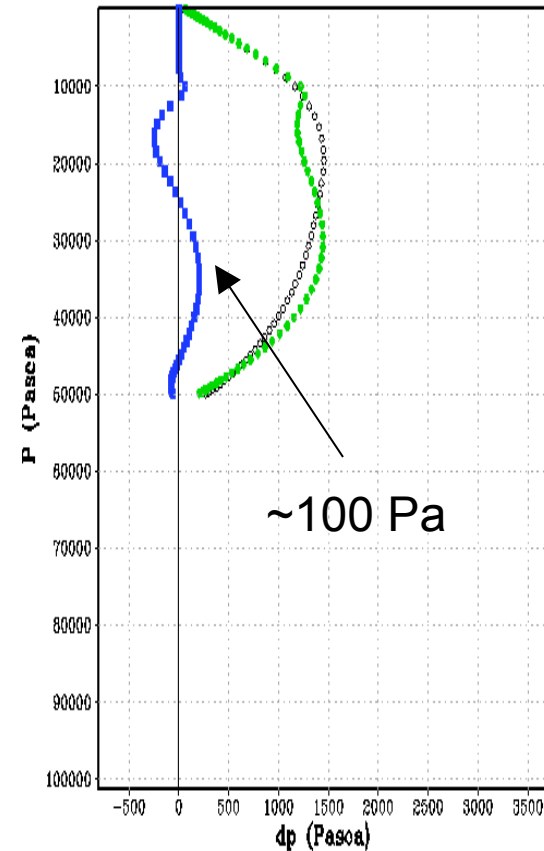
Black:GFS84; Green:GFDL84  
Blue: (GFDL-GFS)\*0.01



$P_s=101,325\text{ Pa}$

Vertical Profiles,  $P_{90}=50000\text{Pa}$

Black:GFS84; Green:GFDL84  
Blue: (GFDL-GFS)

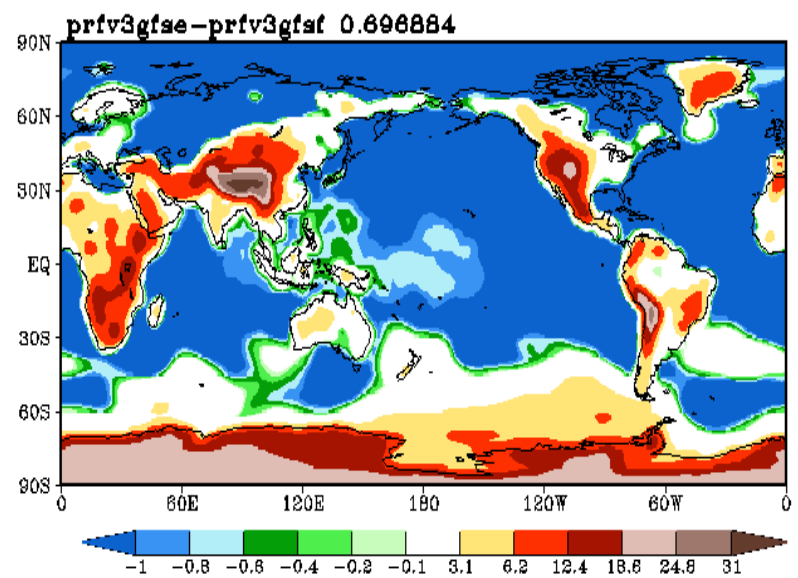
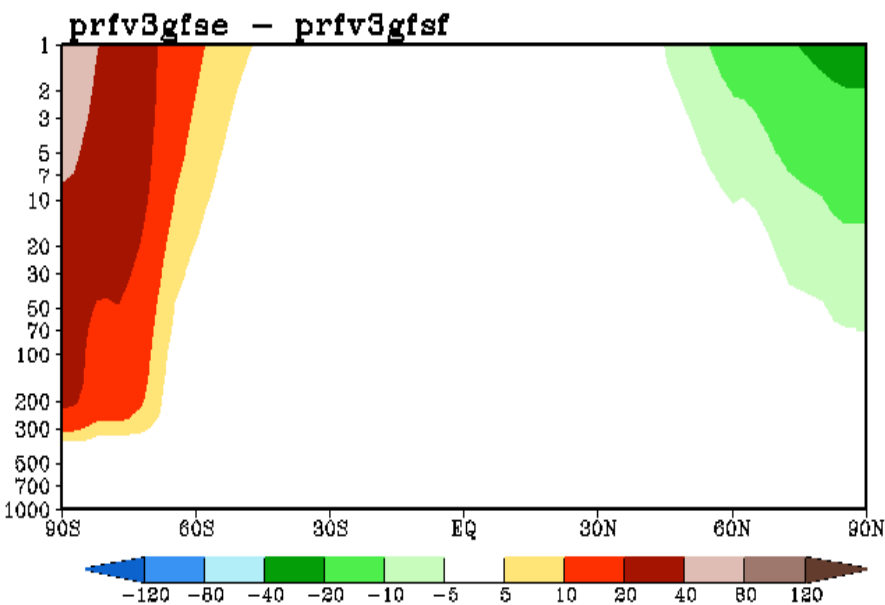
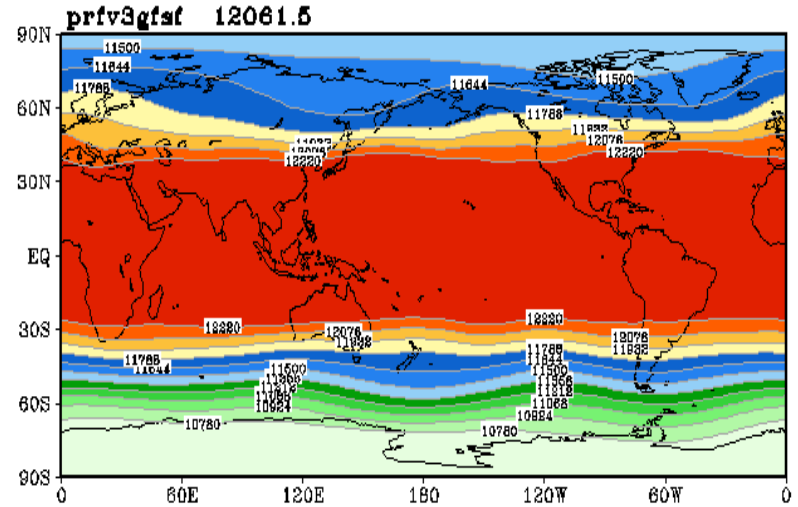
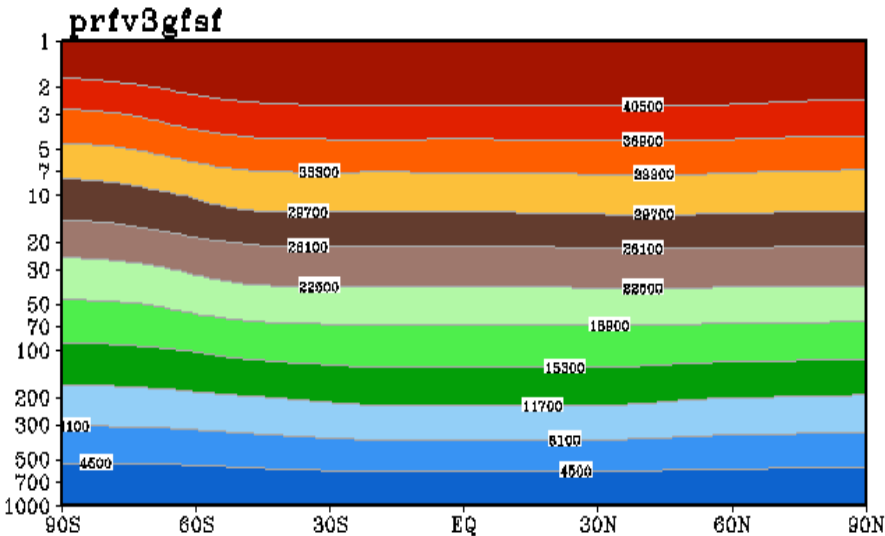


$P_s=50,000\text{ Pa}$

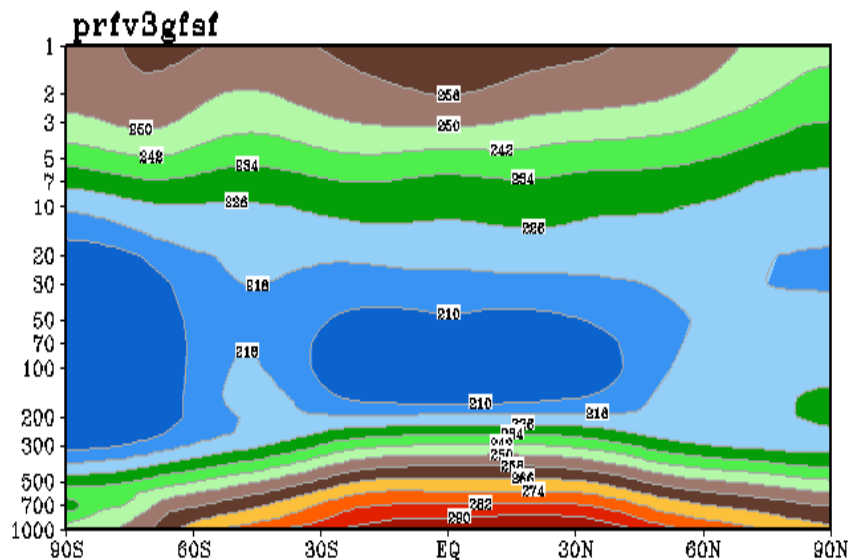
The difference between the two coordinates is small for  $P_s$  close to 1000 hPa, but increases over high terrains.

HGT (m), 00Z-Cyc 01Aug2016-31Oct2016 Mean  
(f102 f108 f114 f120) Post-Hour Average

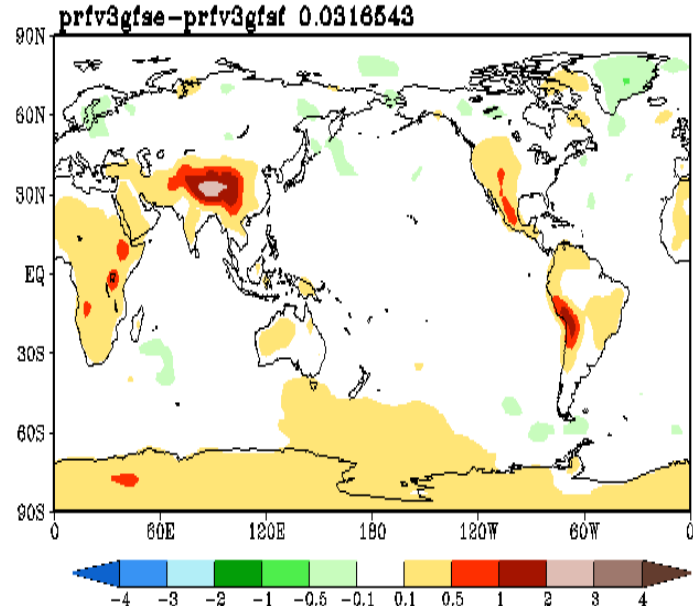
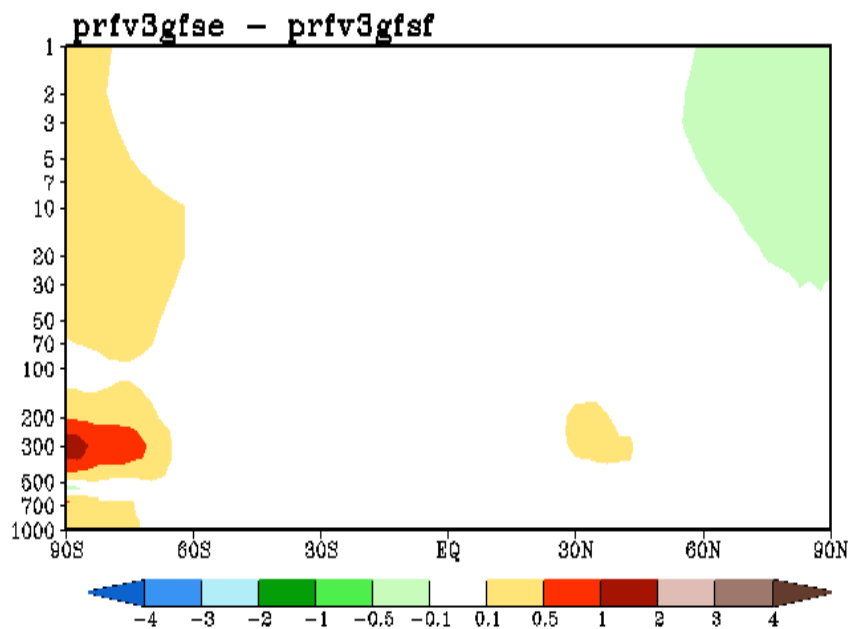
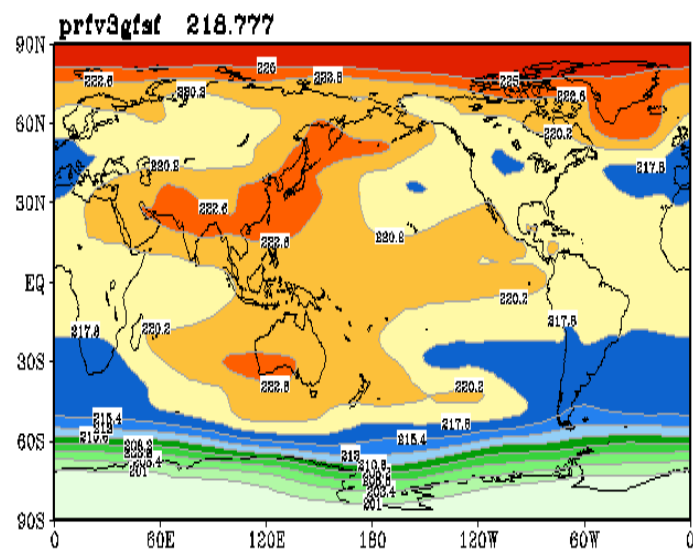
200hPa HGT (m), 00Z-Cyc 01Aug2016-31Oct2016 Mean  
(f102 f108 f114 f120) Post-Hour Average



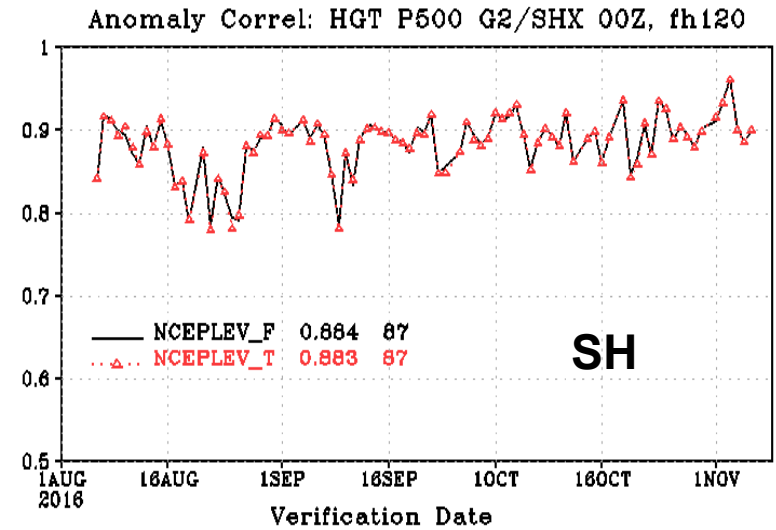
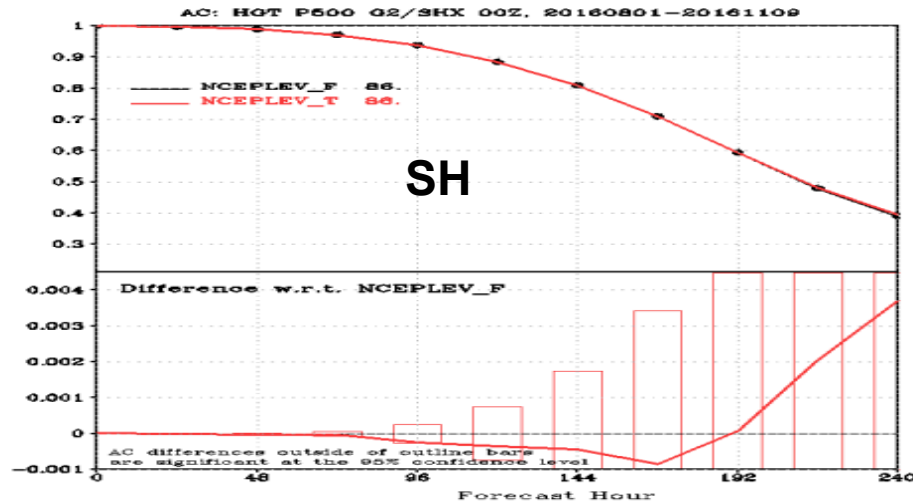
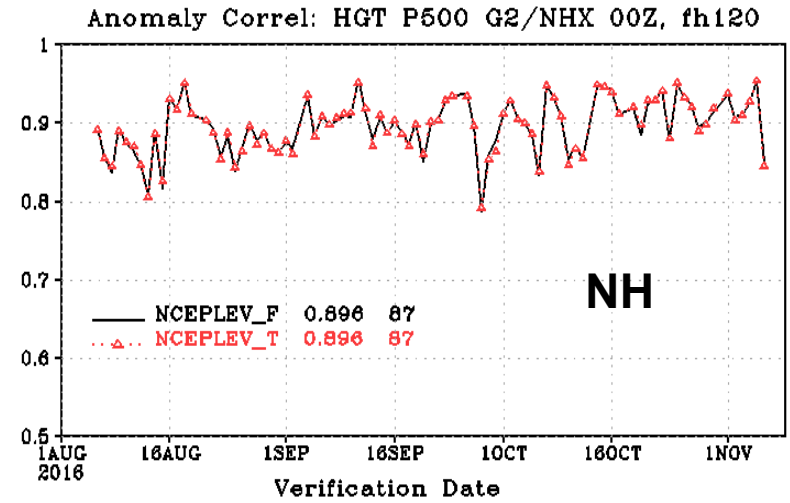
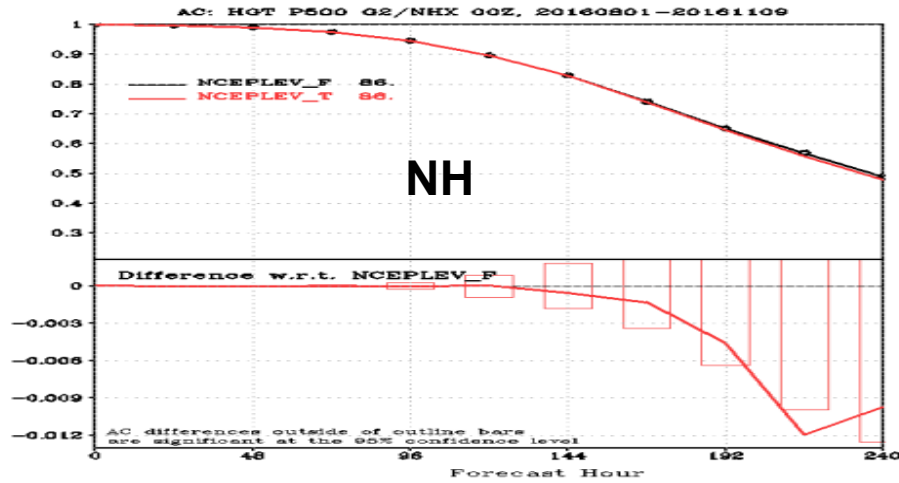
Temp (K), 00Z-Cyc 01Aug2016-31Oct2016 Mean  
(f102 f108 f114 f120) Post-Hour Average



200hPa Temp (K), 00Z-Cyc 01Aug2016-31Oct2016 Mean  
(f102 f108 f114 f120) Post-Hour Average

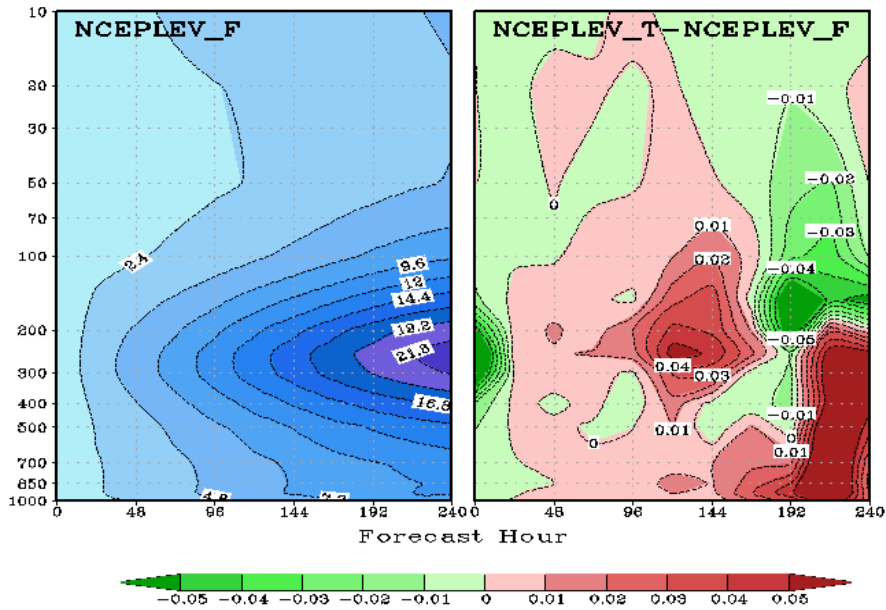


# 500-hPa HGT AC

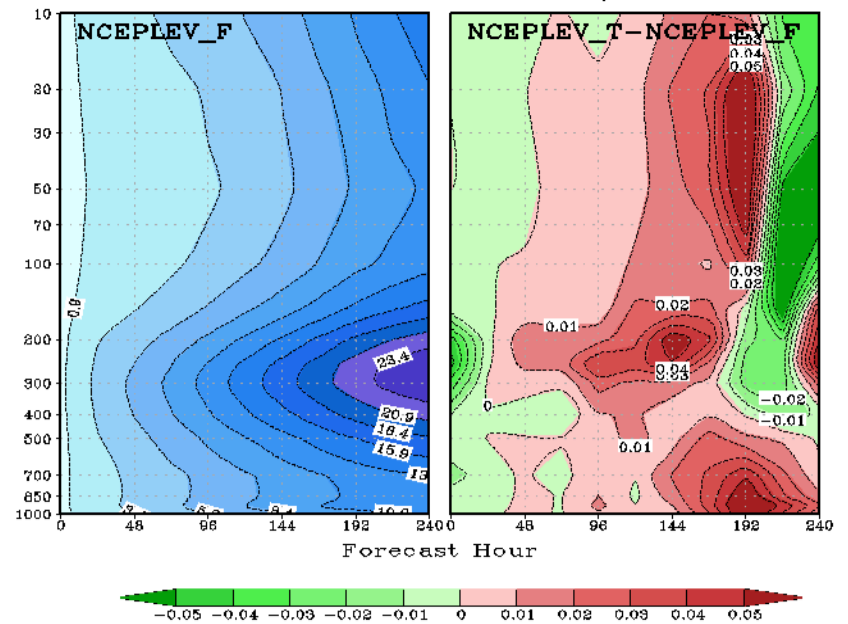


**ncep\_levles=T is slightly worse than ncep\_levles=F in both NH and SH.**

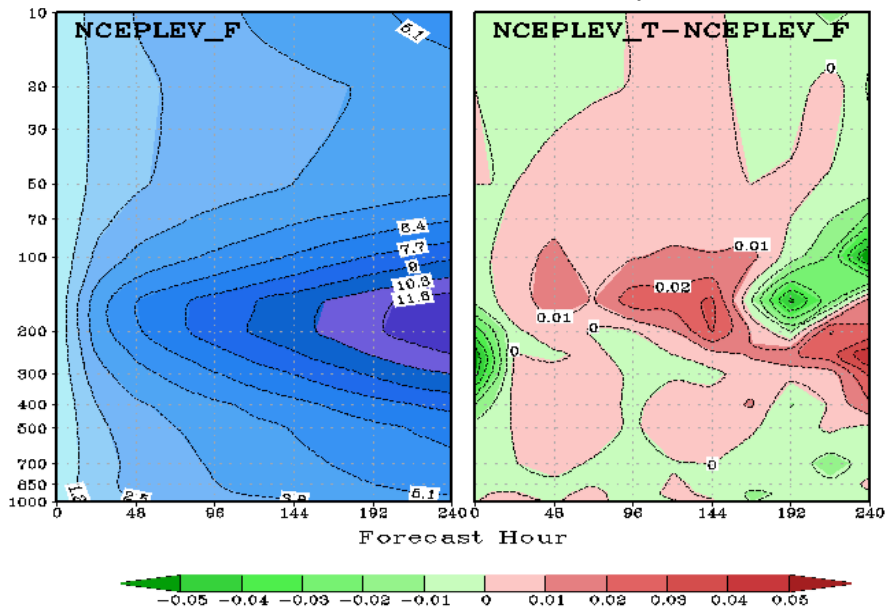
WIND: RMSE  
20160801-20161109 Mean, G2/NHX 00Z



WIND: RMSE  
20160801-20161109 Mean, G2/SHX 00Z

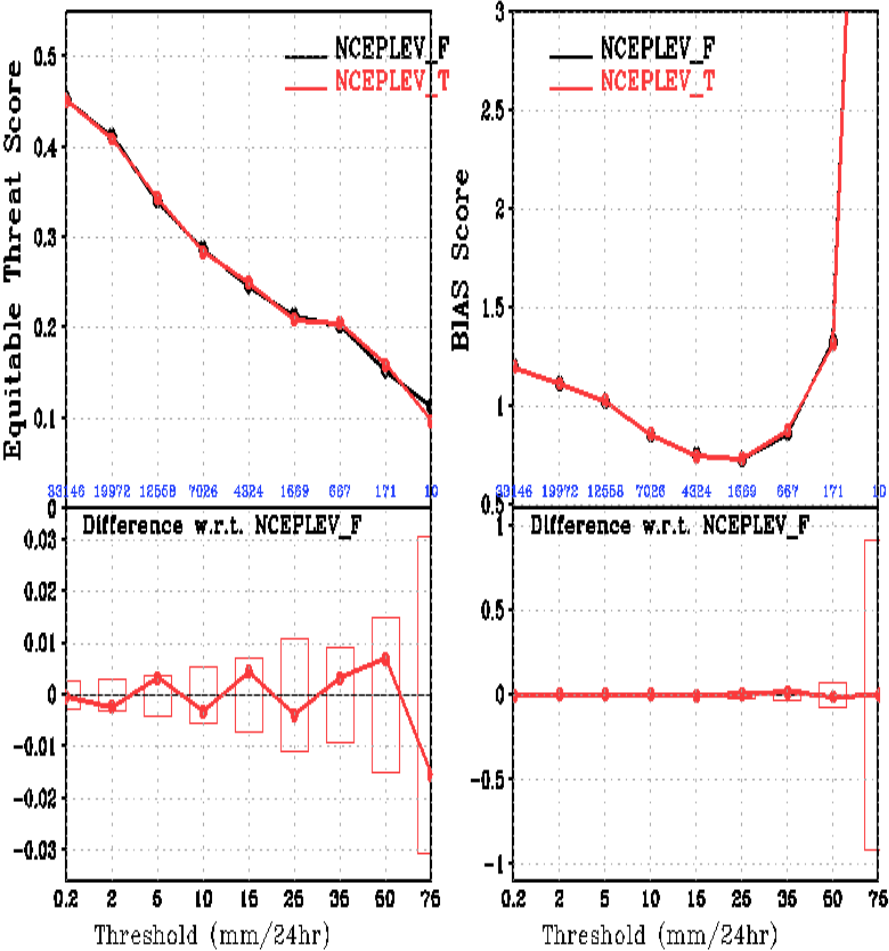


WIND: RMSE  
20160801-20161109 Mean, G2/TRO 00Z



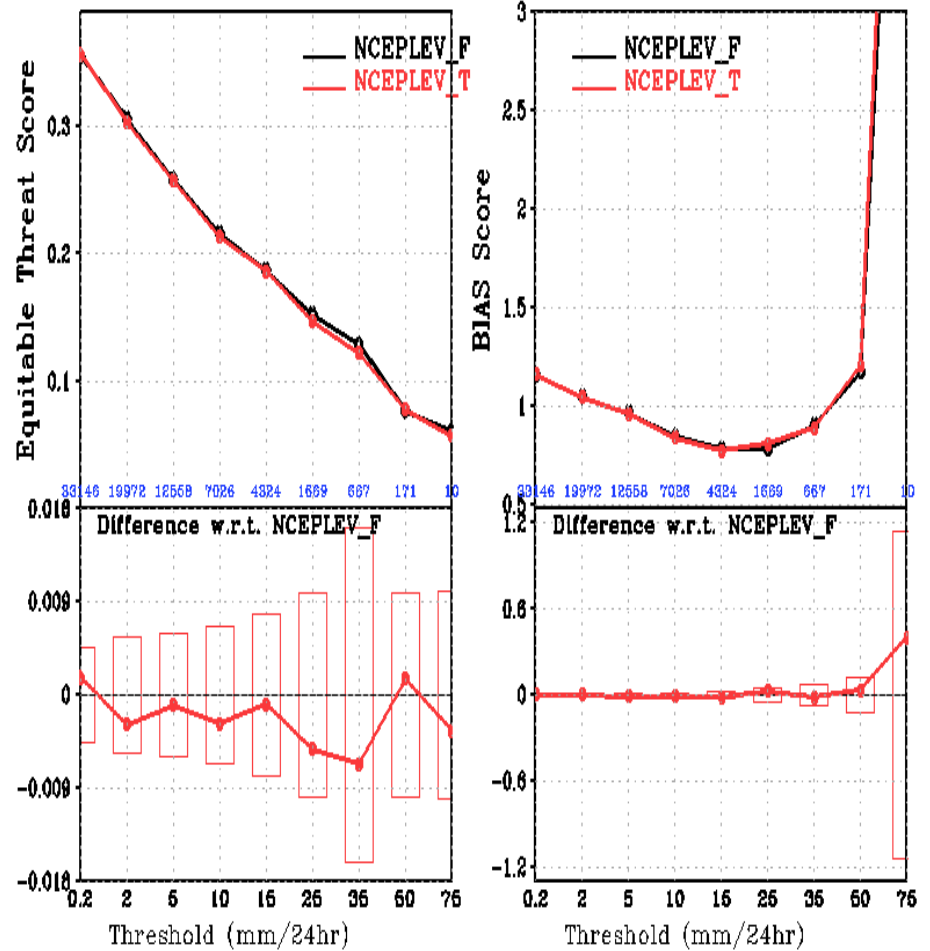
For wind RMSE, ncep\_plevles=T is slightly worse than ncep\_plevles=F in all regions (NH, SH and Tropics).

CONUS Precip Skill Scores, f36-f60, 01aug2016-31oct2016 00Z Cycle



Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

CONUS Precip Skill Scores, f84-f108, 01aug2016-31oct2016 00Z Cycle



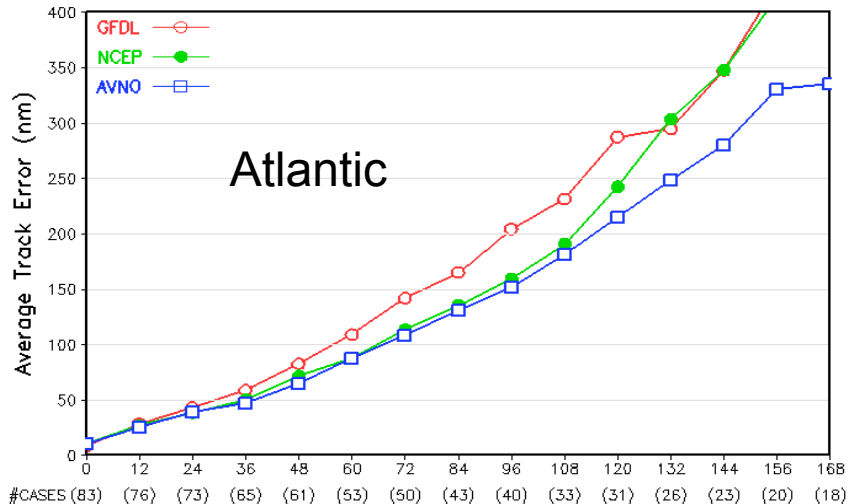
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

**No significant difference in precipitation ETS and Bias scores**



Hurricane Track Errors – Atlantic 2016

20160801\_\_20161101\_\_1cyc

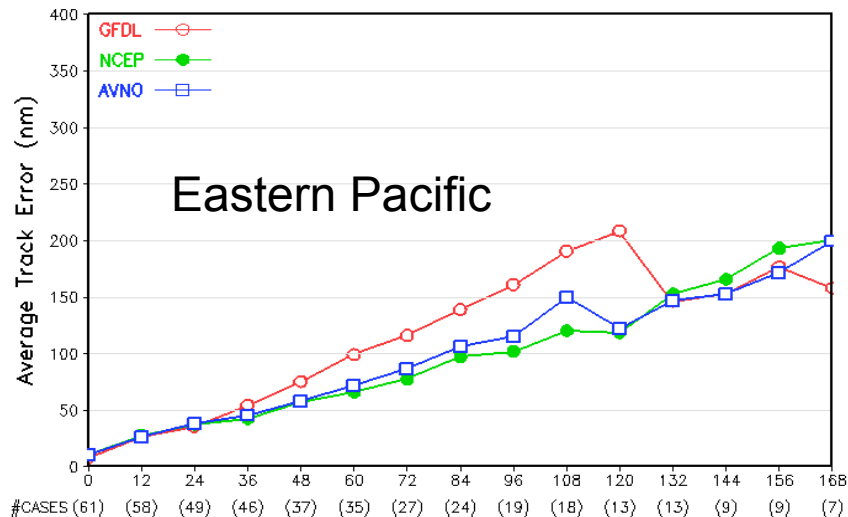


Confidence Level (%) of Student-t Tests

GFDL_NCEP	99	75	92	93	95	99	99	95	97	92	89	93	52	85	75
GFDL_AVNO	98	91	89	98	99	99	99	97	98	96	98	98	98	98	97
NCEP_AVNO	71	93	84	89	98	54	77	70	76	78	97	99	98	97	95

Hurricane Track Errors – East-Pacific 2016

20160801\_\_20161101\_\_1cyc

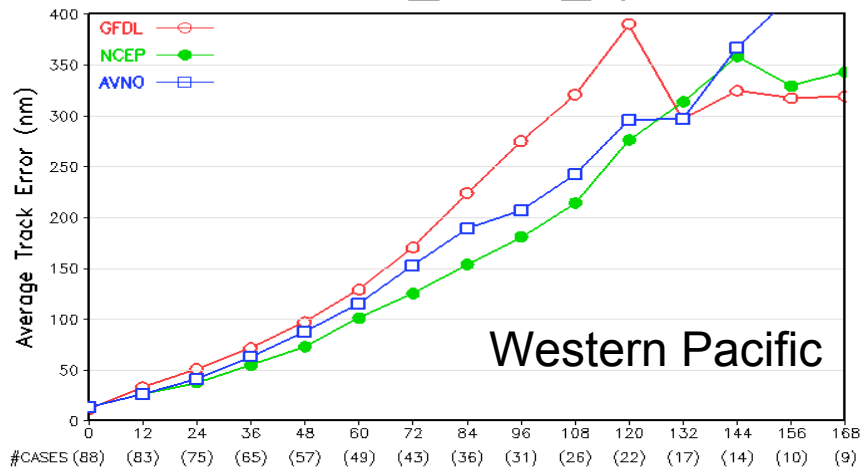


Confidence Level (%) of Student-t Tests

GFDL_NCEP	97	73	87	98	98	99	99	99	99	99	99	99	99	77	77	73	87
GFDL_AVNO	97	52	78	96	98	99	99	98	98	90	99	50	50	55	79		
NCEP_AVNO	51	93	89	91	59	91	96	88	89	97	81	64	89	74	50		

Hurricane Track Errors – West-Pacific 2016

20160801\_\_20161101\_\_1cyc



Confidence Level (%) of Student-t Tests

GFDL_NCEP	96	99	99	99	99	98	99	99	98	98	94	98	98	77	84
GFDL_AVNO	95	99	99	88	81	80	80	86	95	92	87	50	81	84	89
NCEP_AVNO	51	51	98	99	99	98	99	99	91	89	78	71	58	82	87

**Running with  
ncep\_levels=T  
improves hurricane  
track forecast in all  
three basins.**

		N. American					N. Hemisphere					S. Hemisphere					Tropics									
		Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	
Anomaly Correlation	Heights	250hPa	▲	▲				▲	▲					▲	▲											
		500hPa	▲	▲					▲	▲					▲	▲										
		700hPa	▼	▼					▼	▼					▼	▼										
		1000hPa	▼	▼					▼	▼					▼	▼										
		MSLP	▼	▼					▼	▼					▼	▼										
	Vector Wind	250hPa																								
		500hPa	▼	▼					▼	▼					▼	▼										
		850hPa																								
		250hPa	▲	▲					▲	▲					▲	▲										
		500hPa	▲	▲					▲	▲					▲	▲										
Temp	250hPa	▲	▲					▲	▲					▲	▲											
	500hPa	▲	▲					▲	▲					▲	▲											
	850hPa	▲	▲					▲	▲					▲	▲											
	MSLP	▼	▼					▼	▼					▼	▼											
	MSLP	▼	▼					▼	▼					▼	▼											
RMSE	Heights	10hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		20hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		50hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		100hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		200hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		500hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
		700hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	
		850hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	
		1000hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
		Vector Wind	10hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	20hPa		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	50hPa		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	100hPa		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	200hPa		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	Temp	10hPa																								
20hPa																										
50hPa																										
100hPa																										
200hPa		▲	▲					▲	▲					▲	▲											
Bias	Heights	10hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		20hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		50hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		100hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		200hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
	Wind Speed	10hPa																								
		20hPa																								
		50hPa																								
		100hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		200hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
Temp	10hPa																									
	20hPa																									
	50hPa																									
	100hPa																									
	200hPa	▲	▲					▲	▲					▲	▲											

Scorecard: overall difference is small

# Conclusion

- Using `ncep_plevels=T` slightly degrades AC and RMSE scores, but improves hurricane track forecasts. The overall differences are small between the two runs.
- It is recommend to use `ncep_plevles=T` to facilitate data assimilation applications.