



FV3GFS Workflow and Forecast-Only Experiments

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Acknowledgments: Contributions and /or insightful comments made by Rusty Benson, Jun Wang, George Gayno, Vijay Tallapragada, Shian-Jiann Lin, Lucas Harris, Jeff Whitaker, Philip Pegion, shrinivas Moorthi, Hui-ya Chuang, Rahul Mahajan, Dusan Jovic etc are gratefully acknowledged.

Outline

- Workflow and utilities
- Forecast-only experiment
- Hydrostatic vs non-Hydrostatic

Q3FY17 GFS Implementation Superstructure SVN Repository

https://svnemc.ncep.noaa.gov/projects/gfs/branches/gfs_q3fy17/

/gfs/branches/
gfs_q3fy17/
global_shared.v14.1.0
[Parent Directory]
[docs/](#)
[exec/](#)
[fix/](#)
[modulefiles/](#)
[parm/](#)
[scripts/](#)
[sorc/](#)
[ush/](#)

Revision 80517
/gfs/branches/gfs_q3fy17
[Parent Directory]
[gdas.v14.1.0/](#)
[gfs.v14.1.0/](#)
[gfs_workflow.v14.1.0/](#)
[global_shared.v14.1.0/](#)

/gfs/branches/gfs_q3fy17/
gfs_workflow.v14.1.0/para
[Parent Directory]
[bin/](#)
[exp/](#)
[jobs/](#)
[scripts/](#)
[ush/](#)
[util](#)

Revision 80517
/gfs/branches/gfs_q3fy17/
global_shared.v14.1.0/sorc
[Parent Directory]
[emcsfc_ice_blend.fd/](#)
[emcsfc_snow2mdl.fd/](#)
[gettrk.fd/](#)
[global_chgres.fd/](#)
[global_cycle.fd/](#)
[global_fcst.fd/](#)
[global_sfchdr.fd/](#)
[global_sighdr.fd/](#)
[gsi.fd/](#)
[ncep_post.fd/](#)
..... ~17 programs

Revision 80517
/gfs/branches/gfs_q3fy17/
gfs_workflow.v14.1.0/para/jobs
[Parent Directory]
[anal.sh](#)
[angu.sh](#)
[arch.sh](#)
[avrg.sh](#)
[copy.sh](#)
[d3dp.sh](#)
[dcop.sh](#)
[dump.sh](#)
[earc.sh](#)
[ecen.sh](#)
[echk.sh](#)
[efcs.sh](#)
[efmn.sh](#) ~30 jobs

The branches are set up to run on all NCEP production and development machines to support both operation and research development !

FV3GFS Superstructure SVN Repository

<https://svnemc.ncep.noaa.gov/projects/fv3gfs/>

[/bin/](#)
[exp/](#)
[exp_fv3gfs/](#)
[jobs/](#)
[scripts/](#)
[ush/](#)
[util/](#)



/fv3gfs/trunk

[gfs_workflow.v15.0.0/](#)

[global_shared.v15.0.0/](#)

[gdas.v15.0.0/](#)

[gfs.v15.0.0/](#)

[lib/](#)



[docs/](#)
[exec/](#)
[fix/](#)
[modulefiles/](#)
[parm/](#)
[scripts/](#)
[sorc/](#)
[ush/](#)

<https://svnemc.ncep.noaa.gov/projects/fv3/>

NEMS FV3
only contains forecast model source code

Currently managed by Jun Wang

New & Updated Source Code

(fv3gfs.fd moved to nems fv3)

fv3nc2nemsio.fd/
fre-nctools.fd
global_chgres.fd
orog.fd
regrid_nemsio.fd/

New USH Scripts

fv3gfs_driver_chgres.sh
fv3gfs_chgres.sh

fv3gfs_remap.sh
fv3gfs_remap_weights.sh

fv3gfs_nc2nemsio.sh
fv3gfs_regrid_nemsio.sh

fv3gfs_driver_grid.sh
fv3gfs_filter_topo.sh
fv3gfs_make_grid.sh*
fv3gfs_make_orog.sh*

New fcst script

exglobal_fcst_fv3gfs.sh.ecf

New parm/ parm_fv3diag

diag_table
diag_table_history
variable_table.txt

New fix fields

C1152/
C192/
C3072/
C384/
C48/
C768/
C96/

C768_grid.tile[1-6].nc
C768_grid_spec.tile[1-6].nc
C768_oro_data.tile[1-6].nc
C768_mosaic.nc

remap_weights_C768_0p125deg.nc
remap_weights_C768_0p25deg.nc
remap_weights_C768_0p5deg.nc
remap_weights_C768_1deg.nc

fv3_SCRIP_C768_GRIDSPEC_lon3072_lat1536.gaussian.bilinear.nc
fv3_SCRIP_C768_GRIDSPEC_lon3072_lat1536.gaussian.neareststd.nc

**Restructured and
simplified “jobs”
scripts**

Fcst.sh
Post.sh
Vrfy.sh
Arch.sh

New para_config structure ./exp_fv3gfs

para_config – master

(reduced from 2252 lines to 377 lines)

config.fcst
config.post
config.vrfy
config.arch

config.gsi **config.prep**
config.dump **config.nsst**

Does not use reconcile.sh

submit_fv3gfs.sh for running forecast-only experiment

Users can use this script to run forecast-only experiments.

It reads from /com dir or extracts from HPSS current operational GFS ICs, converts to FV3GFS cold start ICs, submits any given number of forecast-only runs at a time, runs post, vrfy and arch steps, and submits a batch job to wait for a few hours to submit next group for forecast-only runs. Currently the workflow is controlled by **psub** and **pend**.

para_config --master config

```
.....
Set up environment and running directories
.....
# -----
# settings that are used by more than one steps
# -----
gfs_cyc=1           # GFS cycles (00, 06, 12 and 18Z), defaults
to 1 (00Z) cycle
gdas_cyc=4          # number of GDAS cycles
fseg=1             # number of AM forecast segments for gfs
FHCYC=24           # Surface cycle calling interval

LEVS=64           # number of AM levels
CASE1=C192       # 1st segment resolution (0-240 hr)
CASE2=C192         # 2nd segment resolution (240-384 hr)
CASE_ENKF=C382     # ENKF resolution
CASE=$(eval echo \${CASE$nknd})
if [ $CSTEP = efmn -o $CSTEP = epos ]; then CASE=$CASE_ENKF; fi

case $CASE in
  C48) DELTIM=3600; layout_x=4 ; layout_y=8 ;;
  C96) DELTIM=1800; layout_x=4 ; layout_y=8 ;;
  C192) DELTIM=900 ; layout_x=4 ; layout_y=8 ;;
  C384) DELTIM=450 ; layout_x=4 ; layout_y=8 ;;
  C768) DELTIM=225 ; layout_x=8 ;
layout_y=16 ;;
  C1152) DELTIM=150 ; layout_x=8 ; layout_y=16 ;;
  C3072) DELTIM=90 ; layout_x=16 ; layout_y=32 ;;
  *) echo "grid $CASE not supported, exit"
  exit ;;
esac
.....
```

```
fmax1=240; ; fmax2=384
for cyc in 00 06 12 18; do
eval FHMAXFCST${cyc}GFS1=$fmax1
eval FHMAXFCST${cyc}GFS2=$fmax2 # maximum hour 2st segment
eval FHMAXFCST${cyc}GDAS=9 # maximum forecast hour for GDAS
eval FHOUTFCST${cyc}GFS1=6
eval FHOUTFCST${cyc}GFS2=12
eval FHOUTFCST${cyc}GDAS=1
eval FHZERFCST${cyc}GFS1=6
eval FHZERFCST${cyc}GFS2=12
eval FHZERFCST${cyc}GDAS=6
eval MFCST${cyc}GFS=$fseg #number of GFS forecast
segments
eval MFCST${cyc}GDAS=1 #number of GDAS forecast
segments
done
cdump=$(echo $CDUMP|tr '[a-z]' '[A-Z]')
FHMAX=$(eval echo \${FHMAXFCST$cycn$cdump$nknd})
FHOUT=$(eval echo \${FHOUTFCST$cycn$cdump$nknd})
FHZER=$(eval echo \${FHZERFCST$cycn$cdump$nknd})

#---if fdiag is given, it overwrites FHOUT
fh00=$(echo $DELTIM 3600|awk '{printf "%f",
$1/$2}')
fdiag="$fh00,6.,12.,18.,24.,30.,36.,....."

REMAP_GRID=latlon #gaussian or latlon for using
fregrid or regrid_nemsio for remapping
.....
```

Config.fcst

```
.....  
IC_DIR=/gpfs/hps/ptmp/$LOGNAME/FV3IC/ICs  
if [ $REMAP_GRID = latlon ]; then  
    DIAGTABLE=$BASE_GSM/parm/parm_fv3diag/diag_table  
else  
    DIAGTABLE=$BASE_GSM/parm/parm_fv3diag/diag_table_history  
fi  
  
npes=$(( ${layout_x} * ${layout_y} * 6 ))  
tasks=$npes                # number of PEs for 1st segment  
nth_f=2                    # number of threads for AM forecast  
npe_node_f=$pe_node       # number of pes per node for AM forecast  
task_per_node=$((npe_node_f/nth_f))  
  
MODE=64bit                # choices: 32bit, 64bit  
TYPE=nh                   # choices: nh, hydro  
HYPT=off                  # choices: on, off (controls hyperthreading)  
COMP="prod"               # choices: debug, repro, prod  
if [ ${HYPT} = on ]; then  
    export hyperthread=".true."  
    export j_opt="-j 2"  
else  
    export hyperthread=".false."  
    export j_opt="-j 1"  
fi  
FCSTEXEC=fv3_gfs_${TYPE}.${COMP}.${MODE}.x  
APRUN="aprun -n $tasks -N $task_per_node -d $nth_f $j_opt -cc depth"  
.....
```


Fcst.sh

```
....
set -a;. $CONFIG;set +a
echo "-----end of $CONFIG -----"
echo

export CKSH=${CKSH:-$(echo $CSTEP|cut -c-4)}
export CKND=${CKND:-$(echo $CSTEP|cut -c5-)}
export machine=${machine:-WCOSS_C}
machine=$(echo $machine|tr '[a-z]' '[A-Z]')
eval export DATA=$DATATMP
rm -rf $DATA||exit 1; mkdir -p $DATA||exit 1; cd $DATA||exit 1
chmod ${permission:-755} $DATA

#
export PBEG=${PBEG:-$SHDIR/pbeg}
export PEND=${PEND:-$SHDIR/pend}
export PERR=${PERR:-$SHDIR/perr}
export VERBOSE=YES

$FORECASTSH
rc=$?
if [[ $rc -ne 0 ]];then $PERR;exit 1;fi

if [ ${KEEPDATA:-NO} != YES ] ; then rm -rf $DATA ; fi
$PEND
```

Fcst.sh has been reduced from more than 1000 lines to 39 lines

It directly calls [exglobal_fcst_fv3gfs.sh.ecf](#), which can be used for operation.

Config.post

```
POSTSH=$BASEDIR/jobs/post.sh          #post workflow
NODES=4                                #number of nodes for all post jobs
if [ $CKND -eq 2 ]; then NODES=3 ; fi
POST_MEMORY=3072
```

#-----
#--use ESRL ESMF regrid tool to remap forecast 6-tile netcdf files to global Gaussian grids and to write output in nemsio format.

```
.....
REGRIDNEMSIOSH=$BASE_GSM/ush/
```

fv3gfs_regrid_nemsio.sh

#-----
#--use GFDL fregrid tool to remap forecast 6-tile netcdf files to global lat-lon grids but still in netcdf format, then use NC2NEMSIO to convert to nemsio.

```
...
REMAPSH=$BASE_GSM/ush/fv3gfs_remap.sh
```

```
#remap 6-tile output to global array in netcdf
REMAPEXE=$BASE_GSM/exec/fregrid_parallel
master_grid=0p25deg          #1deg 0p5deg 0p25deg 0p125deg
etc
.....
```

```
POSTJOB=$BASEDIR/jobs/JGFS_POST.sh
global_nceppost.sh and down-stream jobs
POSTGPPSH=$BASE_POST/ush/
```

global_nceppost.sh

```
POSTGPEXEC=$BASE_POST/exec/ncep_post
npe_node_po=6                #number of tasks per node for UPP
npe_po=$((NODES*npe_node_po)) #total number of tasks for UPP
NTHRPOST=1
APRUN_NP="aprun -n $npe_po -N $npe_node_po -j 1 -d $NTHRPOST -cc depth"
```

```
GFS_DOWNSTREAM=YES          #run downstream jobs
```

GFSDOWNSH=../gfs_downstream_nems.sh

GFSDWNSH=\$USHDIR/gfs_dwn_nems.sh

```
downset=1
npe_node_dwn=8              #number of tasks per node
npe_dwn=$((NODES*npe_node_dwn))
nthread_dwn=$((npe_node/npe_node_dwn))
APRUN_DWN="aprun -n $npe_dwn -N $npe_node_dwn -j 1 -d $nthread_dwn cfp"
```

```
.....
```

post.sh

```
set -a;. $CONFIG;set +a

export CKSH=$(echo $CSTEP|cut -c-4)
export CKND=$(echo $CSTEP|cut -c5-)
export machine=${machine:-WCOSS}
export machine=$(echo $machine|tr '[a-z]' '[A-Z]')
eval export DATA=$DATATMP
rm -rf $DATA||exit 1;mkdir -p $DATA||exit 1;cd $DATA||exit 1
chmod ${permission:-755} $DATA
#
export PBEG=${PBEG:-$SHDIR/pbeg}
export PEND=${PEND:-$SHDIR/pend}
export PERR=${PERR:-$SHDIR/perr}
$PBEG

if [ ${REMAP_GRID:-latlon} = latlon ]; then
echo
$REMAPSH                                #remap 6-tile output to global array in netcdf
if [[ $? -ne 0 ]];then $PERR;exit 1;fi

echo
$NC2NEMSIOSH                            #convert netcdf to nemsio
if [[ $? -ne 0 ]];then $PERR;exit 1;fi
else
echo
$REGRIDNEMSIOSH
if [[ $? -ne 0 ]];then $PERR;exit 1;fi ##use ESMF regrid to convert directly to gaussian grid
fi

echo
$POSTJJOB                                #converts nemsio to grib2 and run down-stream jobs
if [[ $? -ne 0 ]];then $PERR;exit 1;fi

.....
```

Post.sh has been reduced from **1089** lines to **~50** lines

It uses operational-like JGFS_POST.sh and exgfs_nceppost.sh.ecf.

Source code ncep_post.fd was updated to handle nemiso input on lat-lon grid, and for any model vertical layers.

NEMS GSM Input and Output

Initial Conditions:

gfnanl.gfs(gdas).\$cdate

sfnanl.gfs(gdas).\$cdate

Where

gfnanl – atmosphere states

sfnanl – land surface states

In binary nemsio format with meta data header, on model native grid

Forecast direct output:

gfnf\$fh.gfs(gdas).\$cdate

sfnanl\$fh.gfs(gdas).\$cdate

flnf\$fh.gfs(gdas).\$cdate

Where

fh is forecast hour; fln is flux variables such as radiation and precipitation etc

Also all in binary nemsio format, and on model native grid

NCEP Unified Post reads in model direct output, then 1) performs vertical interpolation to place variables on standard isobaric layers, 2) derives other output products, and 3) writes out grib2 products.

FV3GFS Input and Output

Cold RESTART

gfs_ctrl.nc sfc_ctrl.nc
gfs_data.tile\$n.nc
sfc_data.tile\$n.nc
Where n=1,2,...6

Created by CHGRES using
operational GFS IC as input

Warm RESTART

coupler.res fv_core.res.nc
fv_core.res.tile\$.nc
fv_srf_wnd.res.tile\$.nc
fv_tracer.res.tile\$.nc
sfc_data.tile\$.nc

Written out at the end of forecast

Forecast history: latlon=grid

\$cdate.atmos_4xdaily.tile\$.nc
\$cdate.nggps2d.tile\$.nc
\$cdate.nggps3d_4xdaily.tile\$.nc
atmos_static grid_spec

Written out at \$fdiag interval

Forecast history: latlon=gaussian

\$cdate.fv3_historyd.tile\$.nc
\$cdate.fv3_history2d.tile\$.nc

Written out at \$fdiag interval

```
#--if fdiag is given, it overwrites FHOUT  
fh00=$(echo $DELTIM 3600|awk '{printf "%f", $1/$2}')  
fdiag="$fh00,6.,12.,18.,24.,30.,36.,42.,48.,54.,60.,66.,72.,78.,84.,90.,96.,102.,108.,114.,120.,126.,132.,138.,144.,150.,  
156.,162.,168.,174.,180.,186.,192.,198.,204.,210.,216.,222.,228.,234.,240."  
NFCST=$(echo $fdiag |awk -F '[t,]' '{print NF}') ;#number of forecast output
```

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

FV3GFS is about 1.5 ~2 times slower than NEMS GFS

FV3GFS Forecast-only benchmark test

The version used for this test is the same as the one used for NGGPS dycore phase-II comparison, except for the following changes

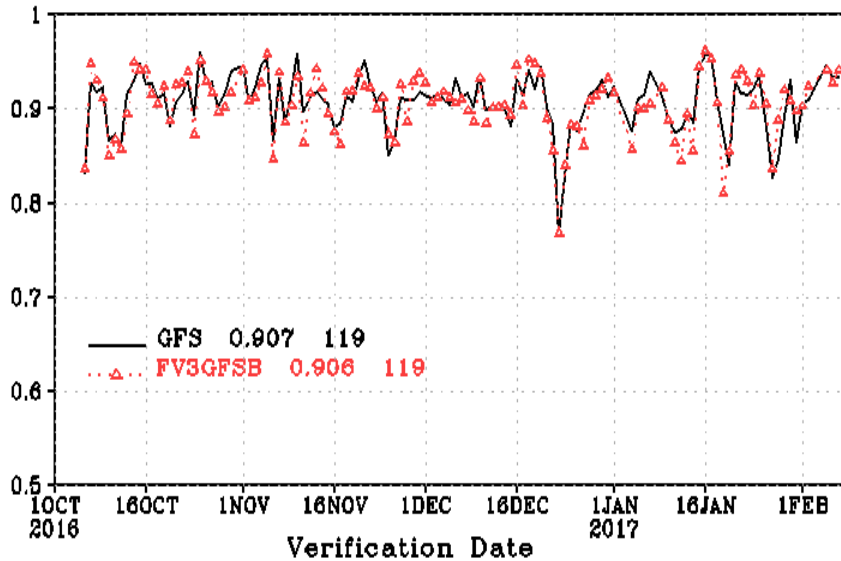
- **TKE dissipative heating:** F in fv3gfs, changed to T as in ops GFS
- **shallow convection:** F in fv3gfs, changed to T as in ops GFS
- **PBL scheme:** Moninq in fv3gfs, changed to hybrid EDMF as in ops GFS
- **sfc emmissivity:** black body (IEMS=0) in fv3gfs, changed to grey as in ops GFS.
- **mountain block and GWD:** 3.5,0.25 in fv3gfs, (2.0,0.25 in ops GFS)

Period: 20161001 ~ 20170208, initialized with current ops GFS ICs
Resolution: C768 (~13km), 64 Layer
Configuration: non-hydrostatic, 64-bit precision
CPU: on CRAY with 64 nodes takes ~13.7 minutes per day

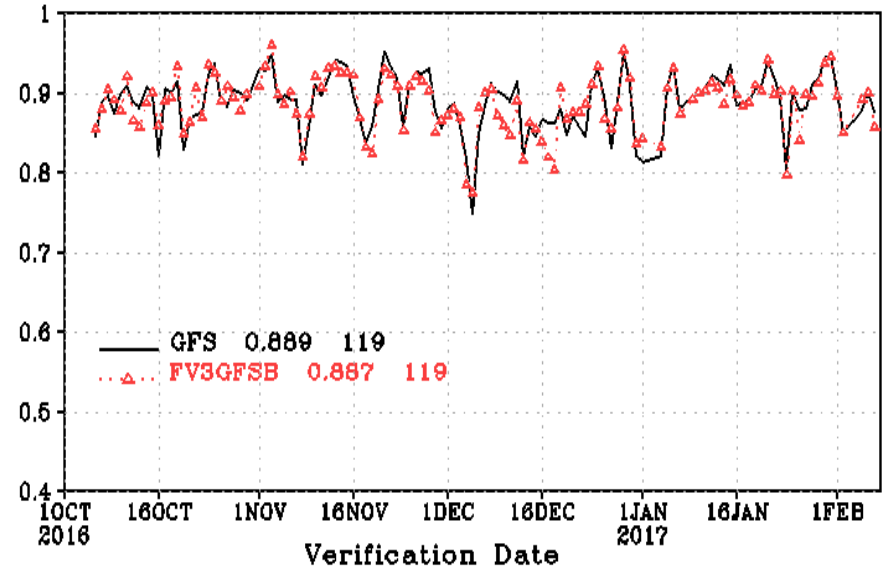
<http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/fv3gfsb/>

500hPa HGT AC

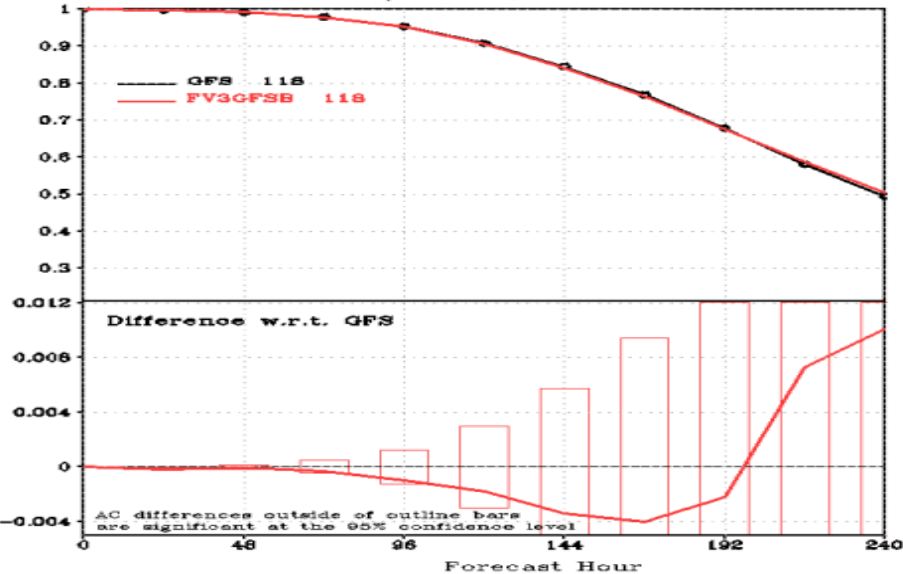
Anomaly Correl: HGT P500 G2/NHX 00Z, fh120



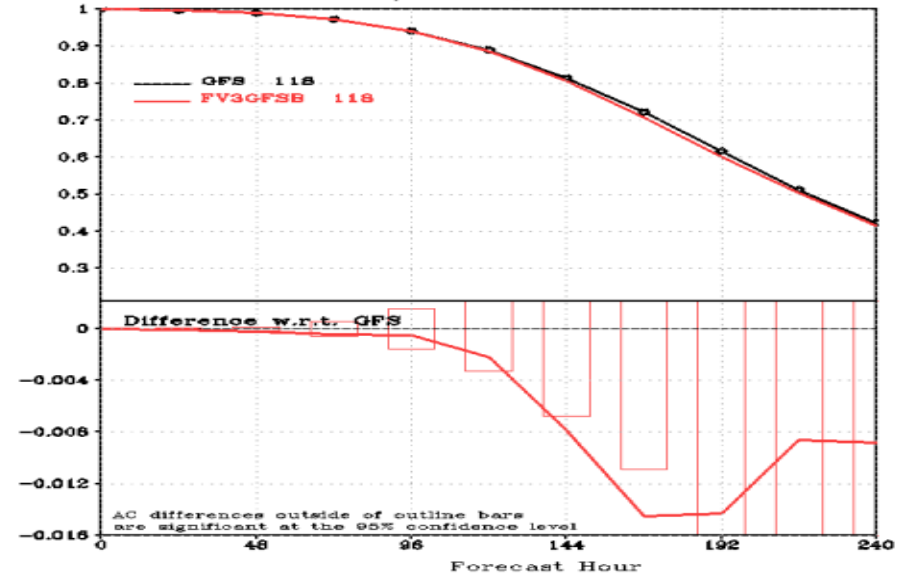
Anomaly Correl: HGT P500 G2/SHX 00Z, fh120



AC: HGT P500 G2/NHX 00Z, 20161001-20170208



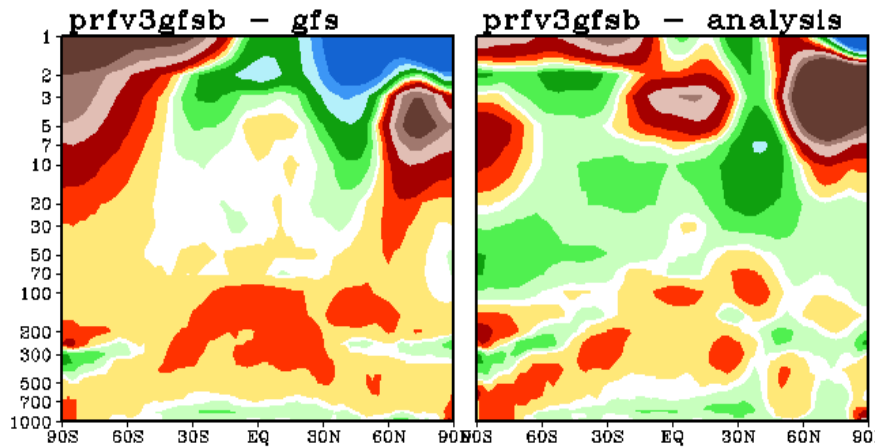
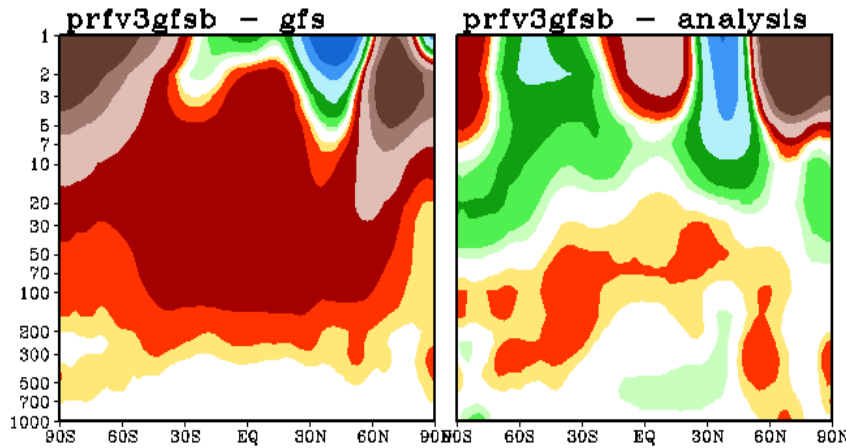
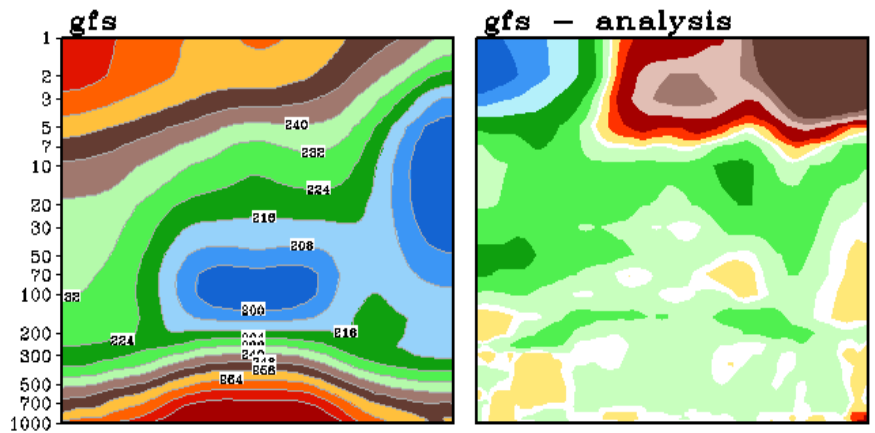
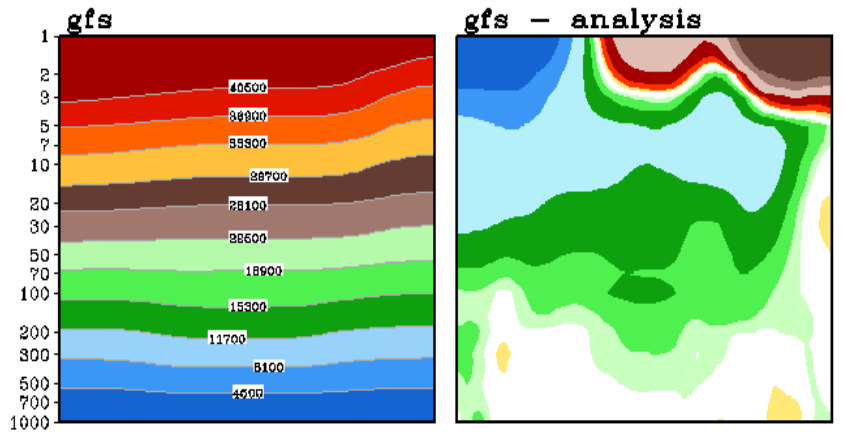
AC: HGT P500 G2/SHX 00Z, 20161001-20170208



Zonal Mean HGT and T, 120-hr forecast

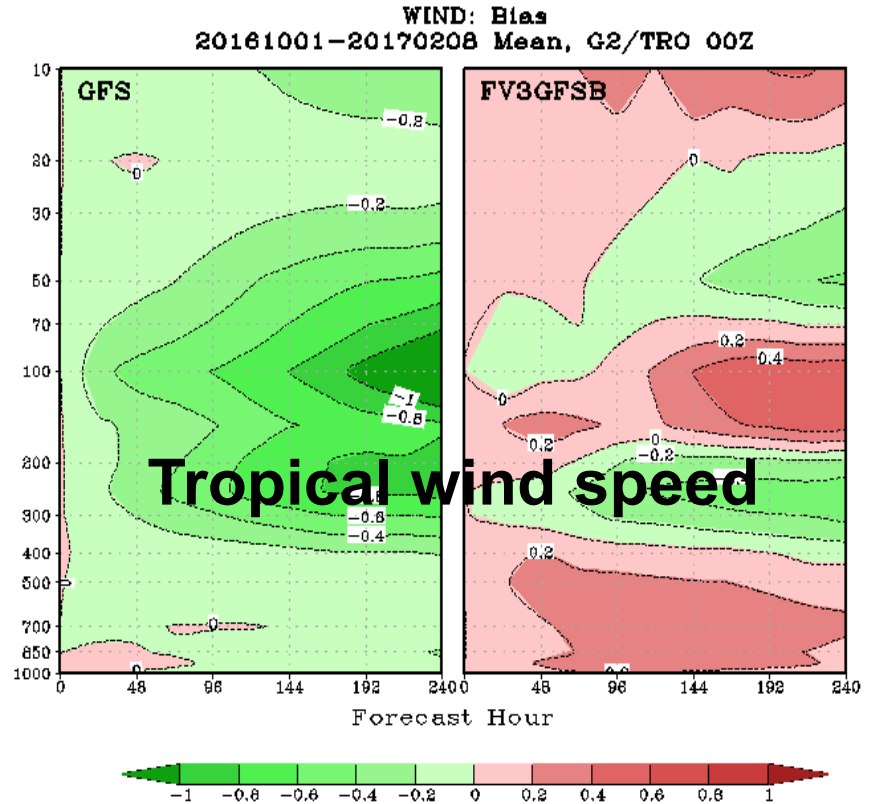
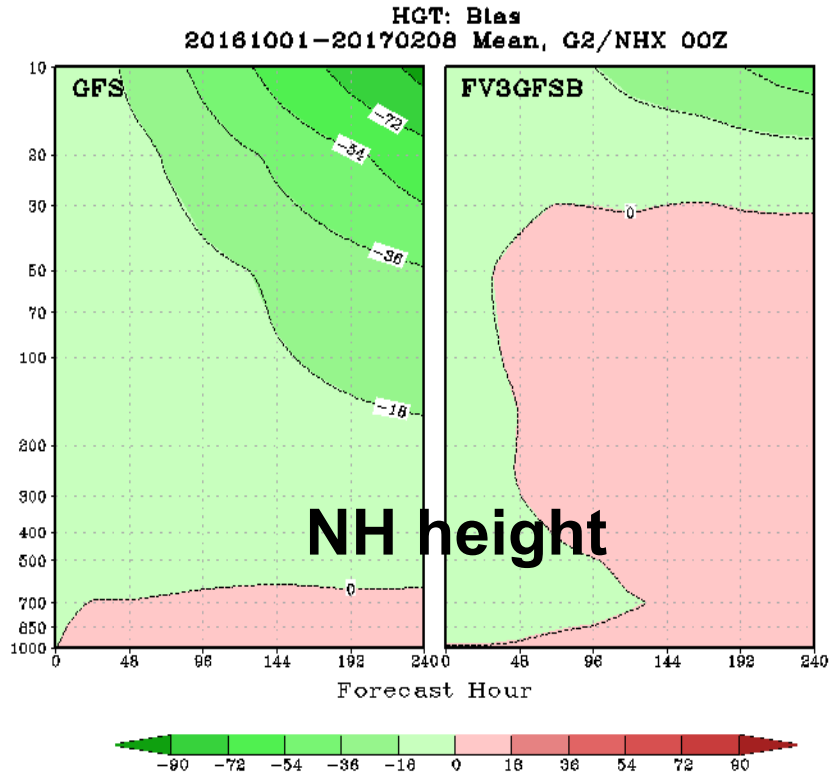
HGT (m), 00Z-Cyc 01Dec2016-29Dec2016 Mean
Post-Hour f120

Temp (K), 00Z-Cyc 01Dec2016-29Dec2016 Mean
Post-Hour f120

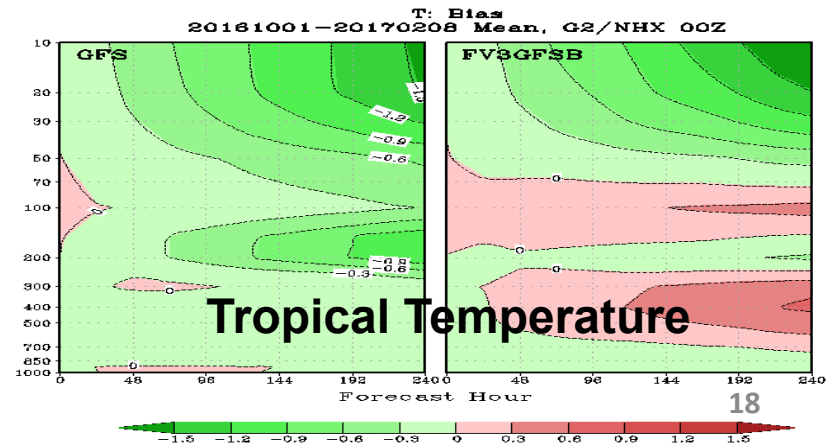


FV3GFS reduced stratospheric cold bias
Slightly too warm in the troposphere

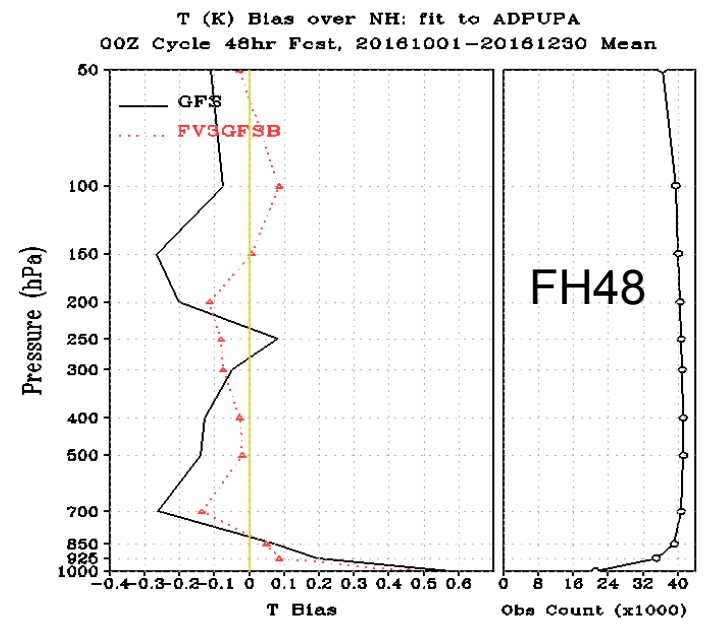
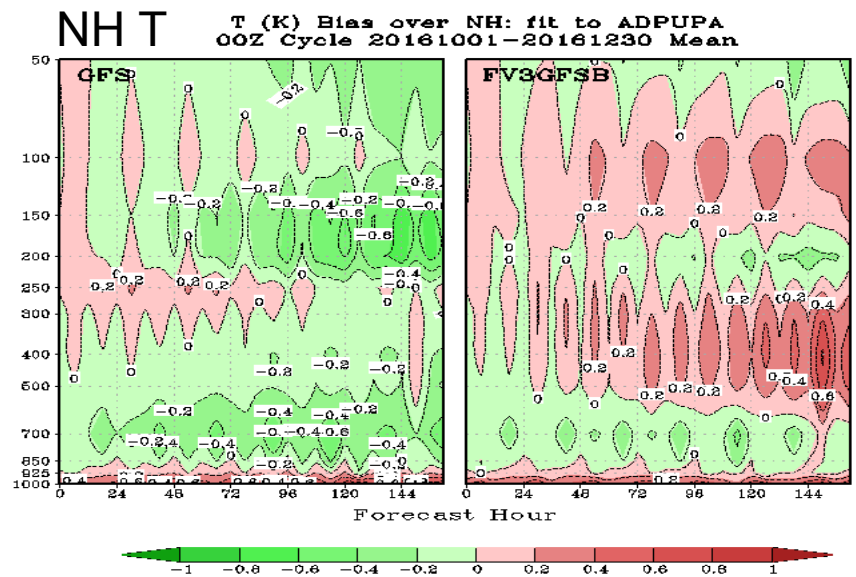
BIASES, verified against GFS analysis



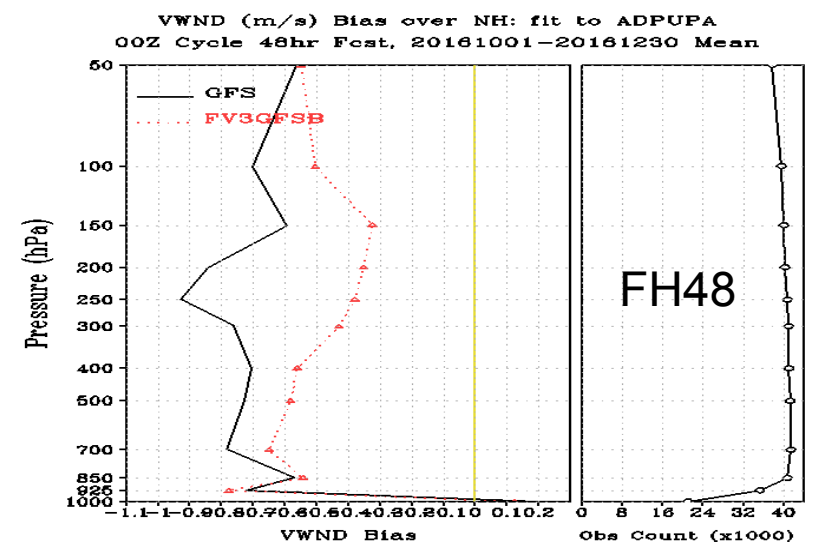
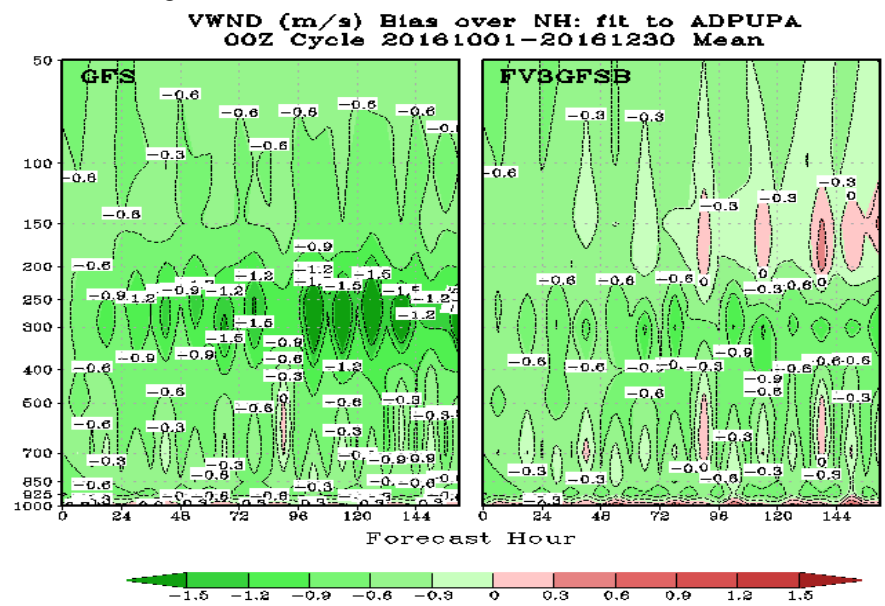
FV3GFS reduced cold bias in the stratosphere, and maintains better tropospheric jets.



Verified against ROBS, BIAS

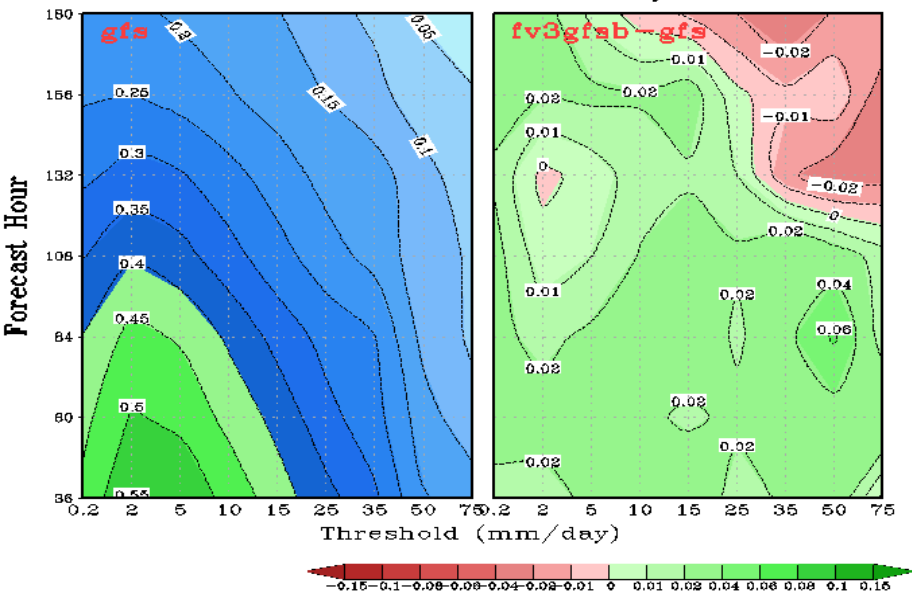


NH Wind

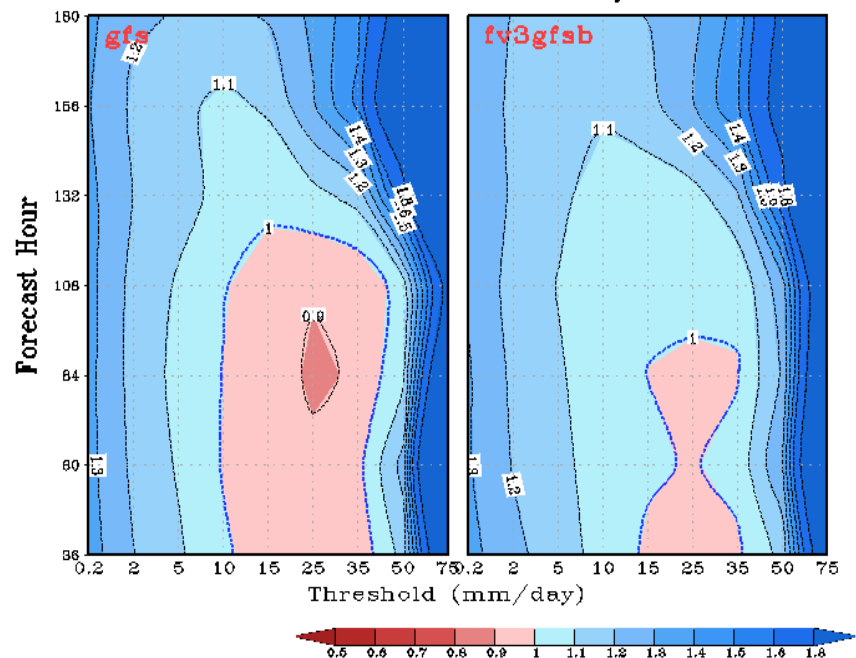


precipitation

CONUS Precipitation Equitable Threat Score
01oct2016-12feb2017 00Z Cycle

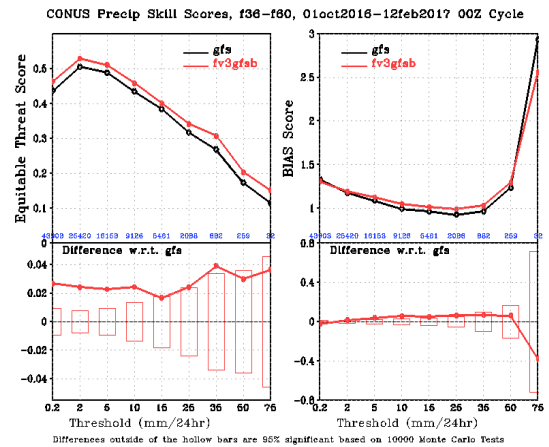


CONUS Precipitation BIAS Score
01oct2016-12feb2017 00Z Cycle



FV3GFS improved rainfall forecast skills

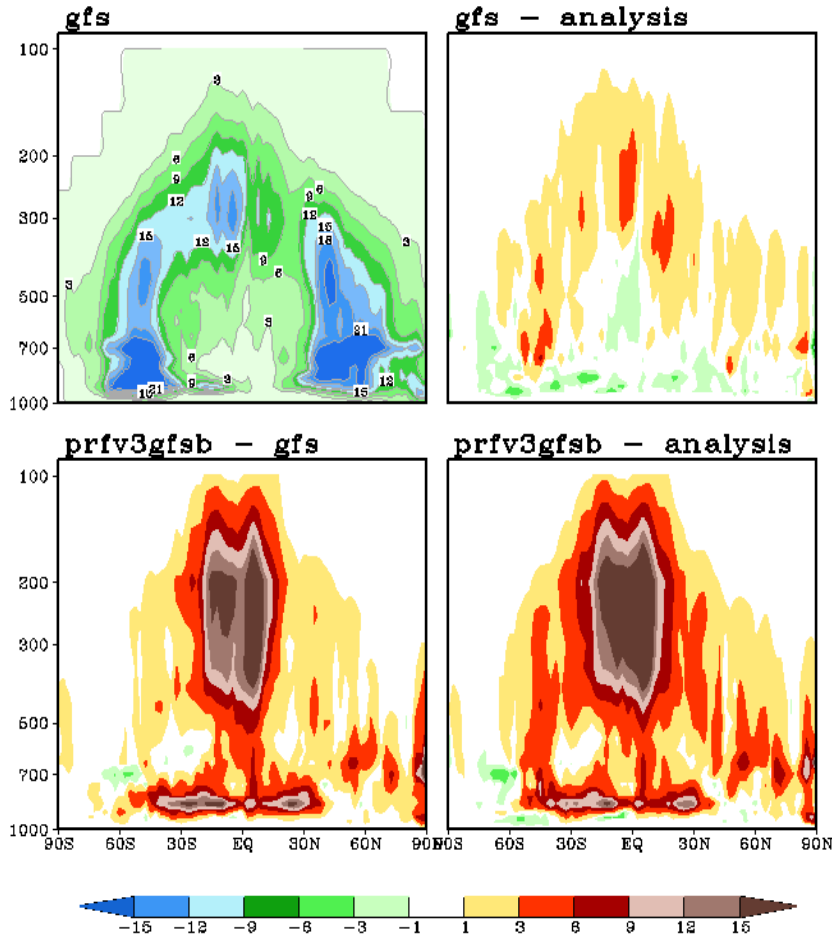
However: EMC physics developers recently reported that the deep convection scheme used in FV3GFS for phase-II dycore comparison is different from the one in the current operational GFS. The improvement in fv3gfs precipitation likely came from both the different convection scheme and new model dynamics.



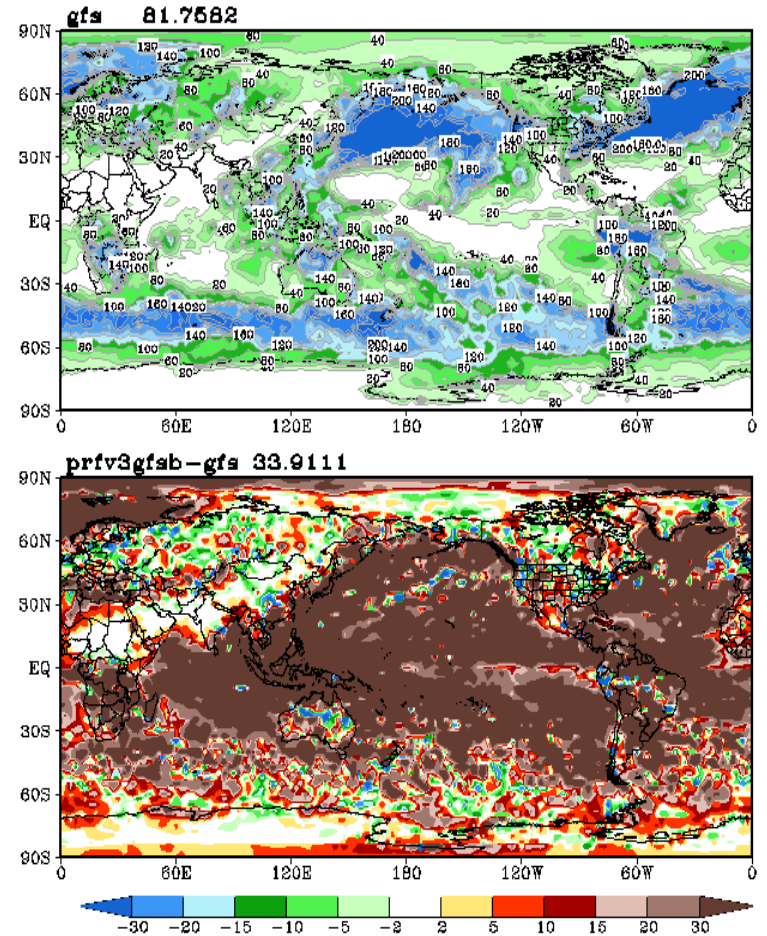
Need to use IPD v4.0 to establish a new benchmark

More cloud water

Cloud Water (ppmg), 00Z-Cyc 01Dec2016-29Dec2016 Mean
Post-Hour f120



Atmos Column Cloud Water [g/m²]
00Z-Cyc 01Dec2016-29Dec2016 Mean
(f102 f108 f114 f120) Post-Hour Average

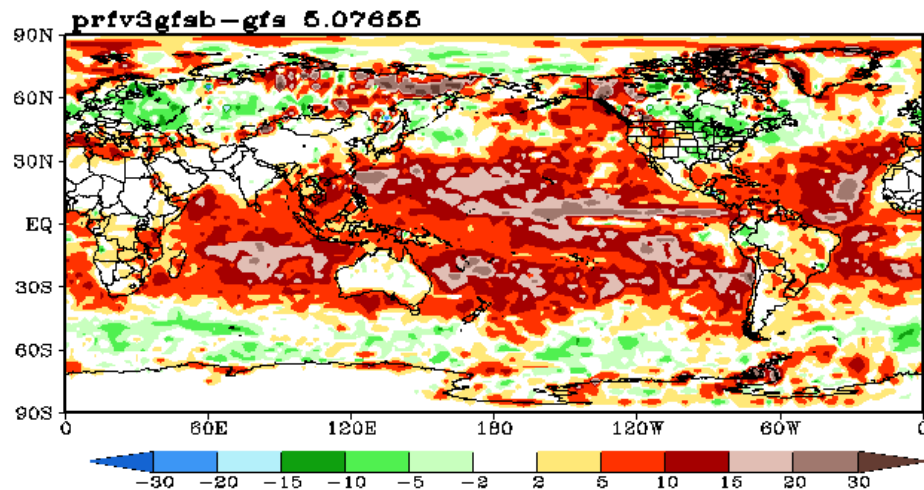
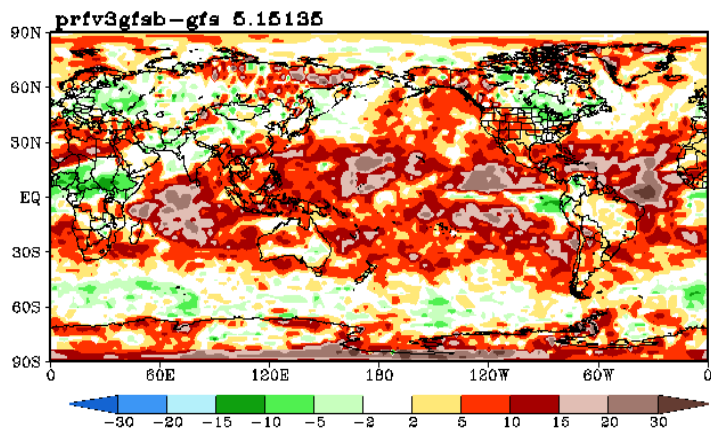
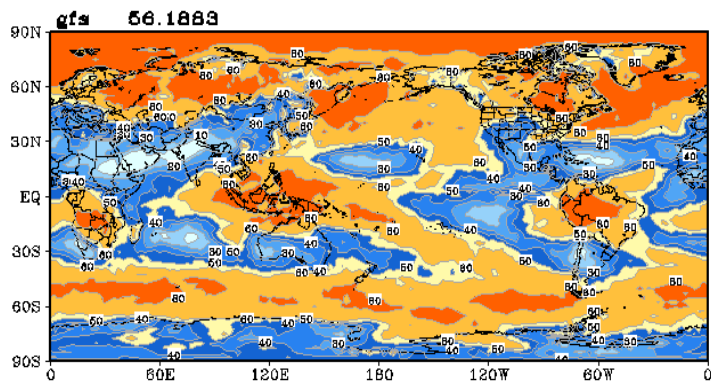


prautco(2) = (/1.0e-4, 1.0e-4/
psautco(2) = (/6.0e-4,3.0e-4/
Same as ops GFS

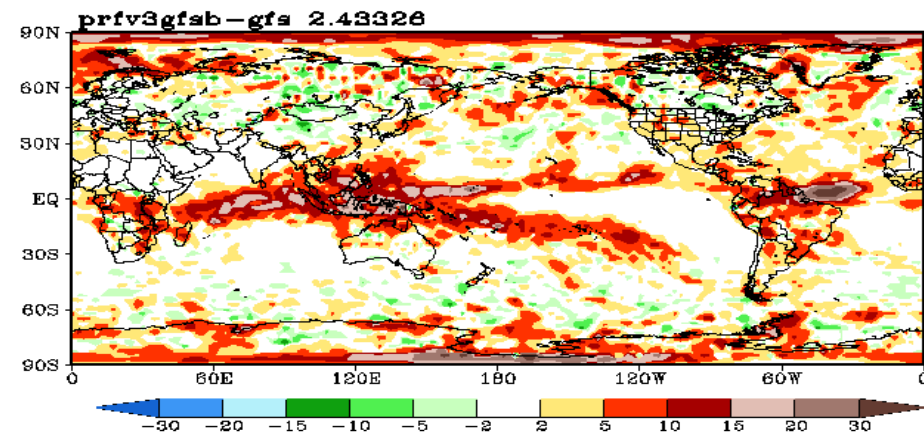
Clouds

total

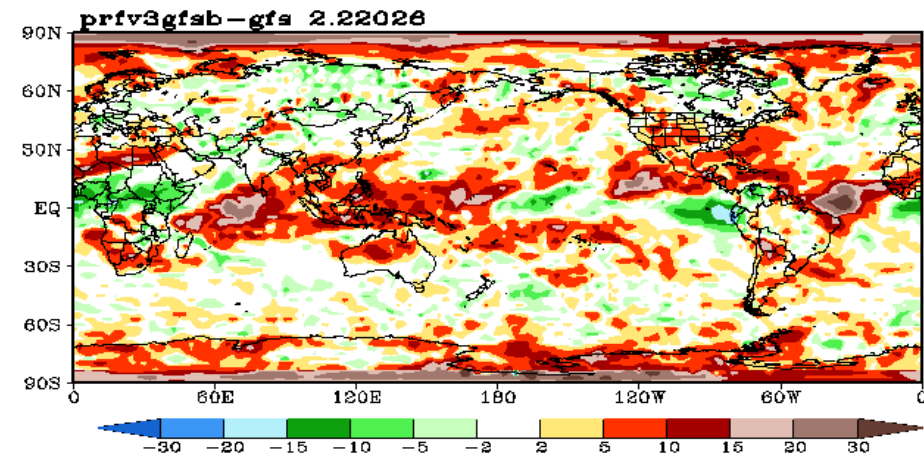
Atmos Column Total Cloud Cover [%]
00Z-Cyc 01Dec2016-29Dec2016 Mean
(f102 f108 f114 f120) Post-Hour Average



low



mid



high

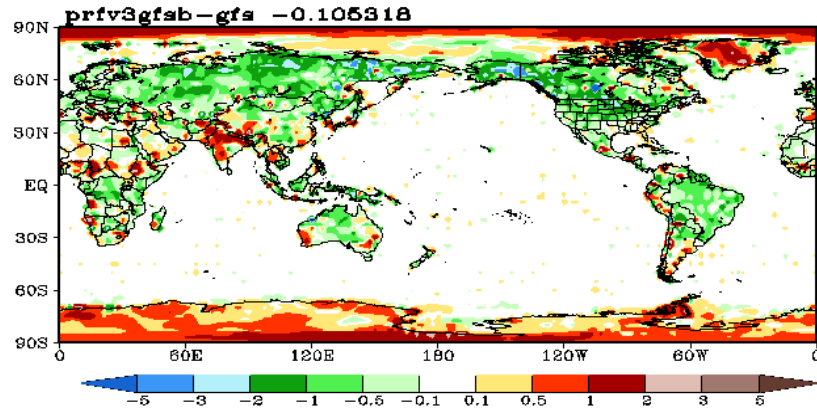
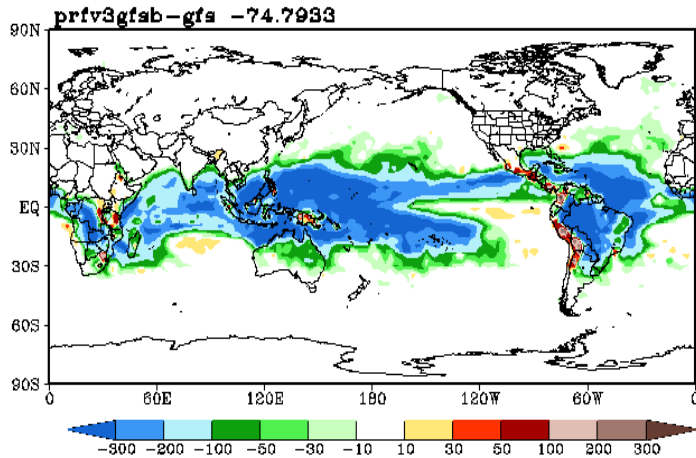
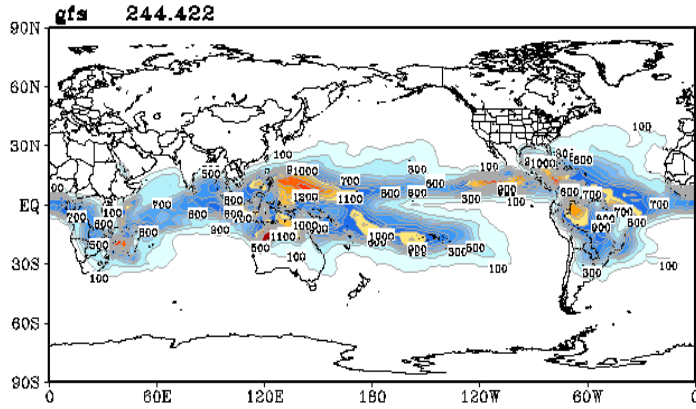
Xu-Randall Cloud cover scheme has been tuned. Even though cloud water increases, high cloud fraction remains almost unchanged

Much Smaller CAPE

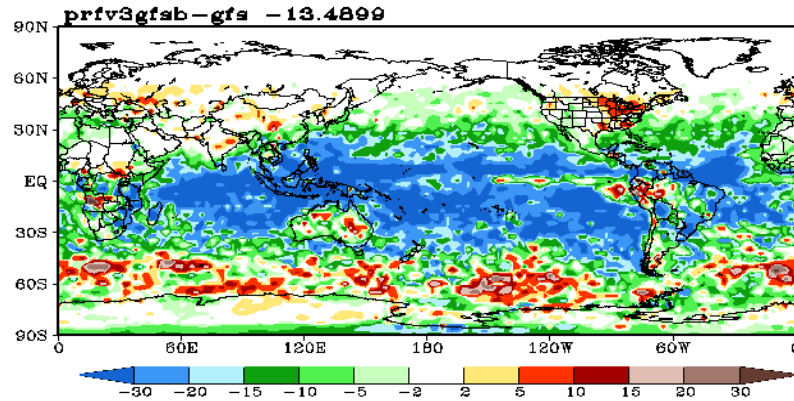
Larger LH

Smaller downward SW

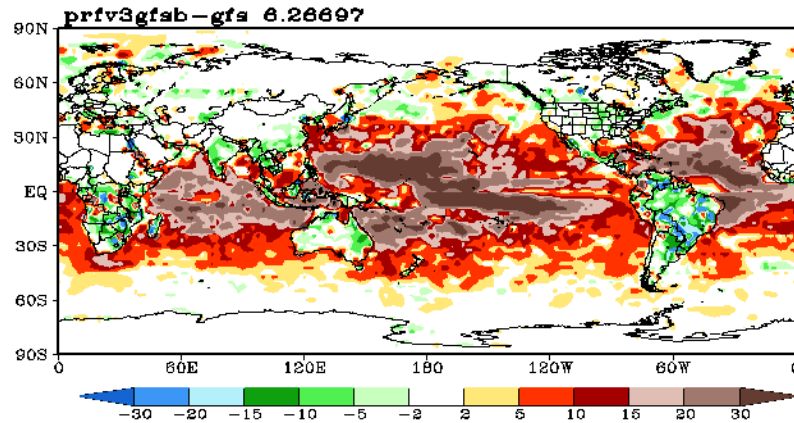
Surface Convective Avail Potential Energy [J/kg]
00Z-Cyc 01Dec2016-20Dec2016 Mean
(f102 f108 f114 f120) Post-Hour Average



Tskin



Sfc
down
SW



Sfc
Latent
heat
flux

Hydrostatic vs Non-hydrostatic

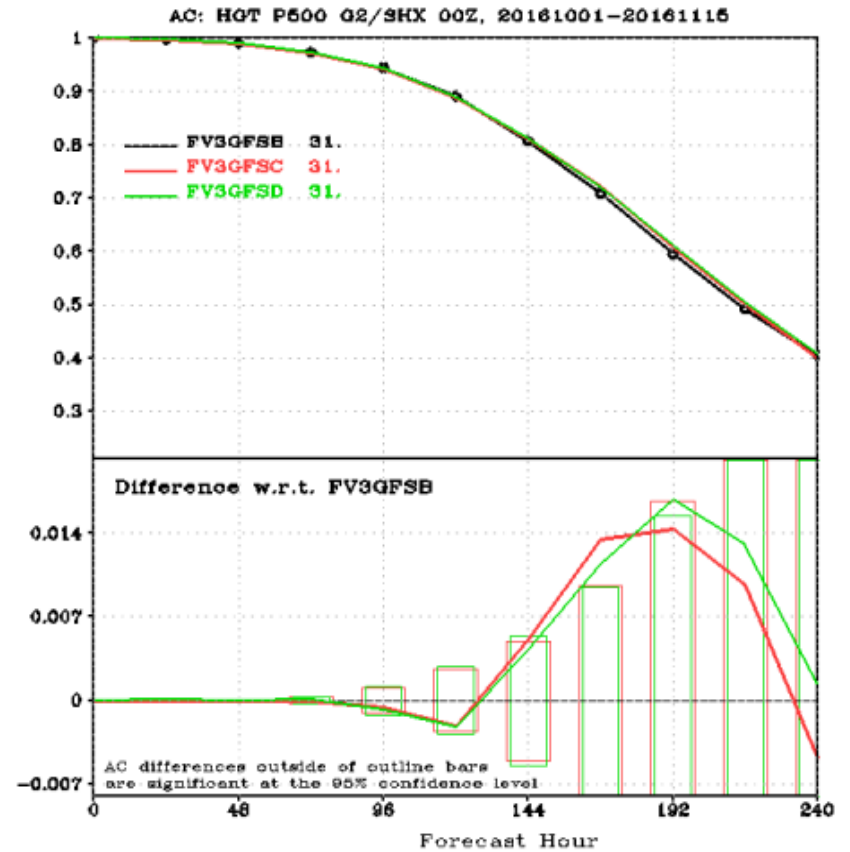
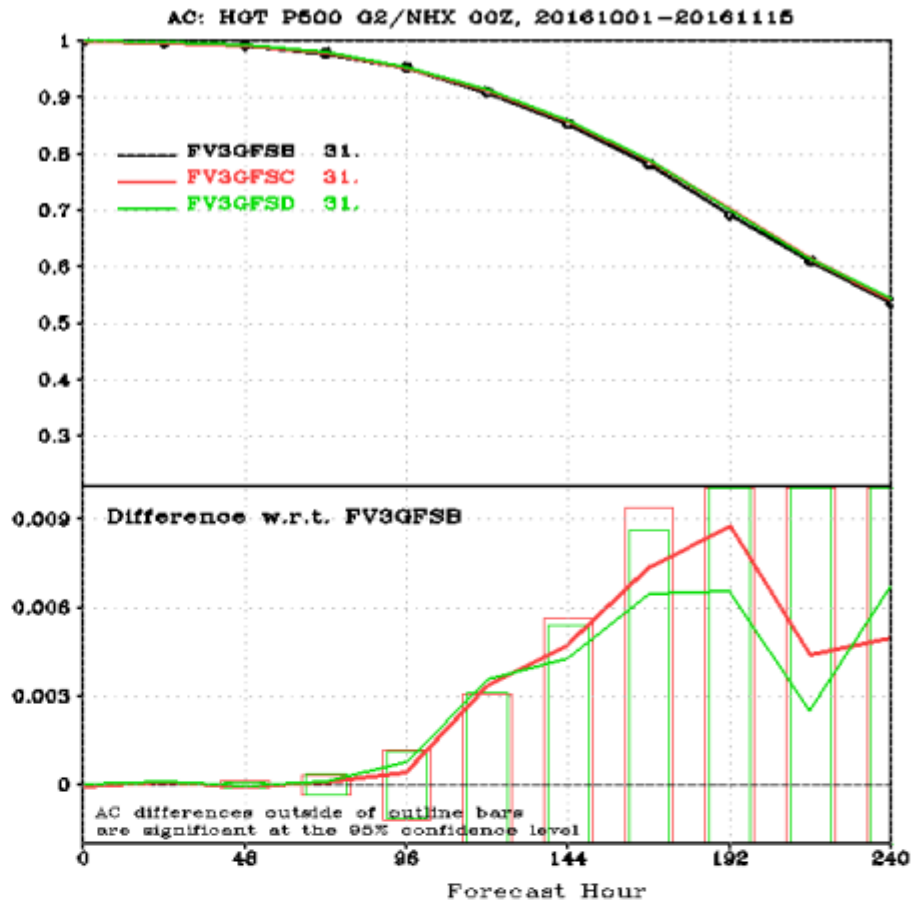
- Prfv3gfsb: non-hydrostatic, non-mono
- Prf3gfsc: hydrostatic, non-mono
- Prfv3gfsd: hydrostatic, mono

All ran at 64-bit, C768 resolution, with operational GFS ICs for the 01oct2016-06nov2016 period.

SJ-Lin and Lucas Harris:

- **Monotonic** Scheme -- is intrinsically diffusive to 2-delta waves. Needs explicit horizontal 4th-order **divergence** damping. No vorticity damping.
- **Non-monotonic** Scheme – applies no monotonicity constraint. Needs damping to **vorticity and momentum fluxes**.

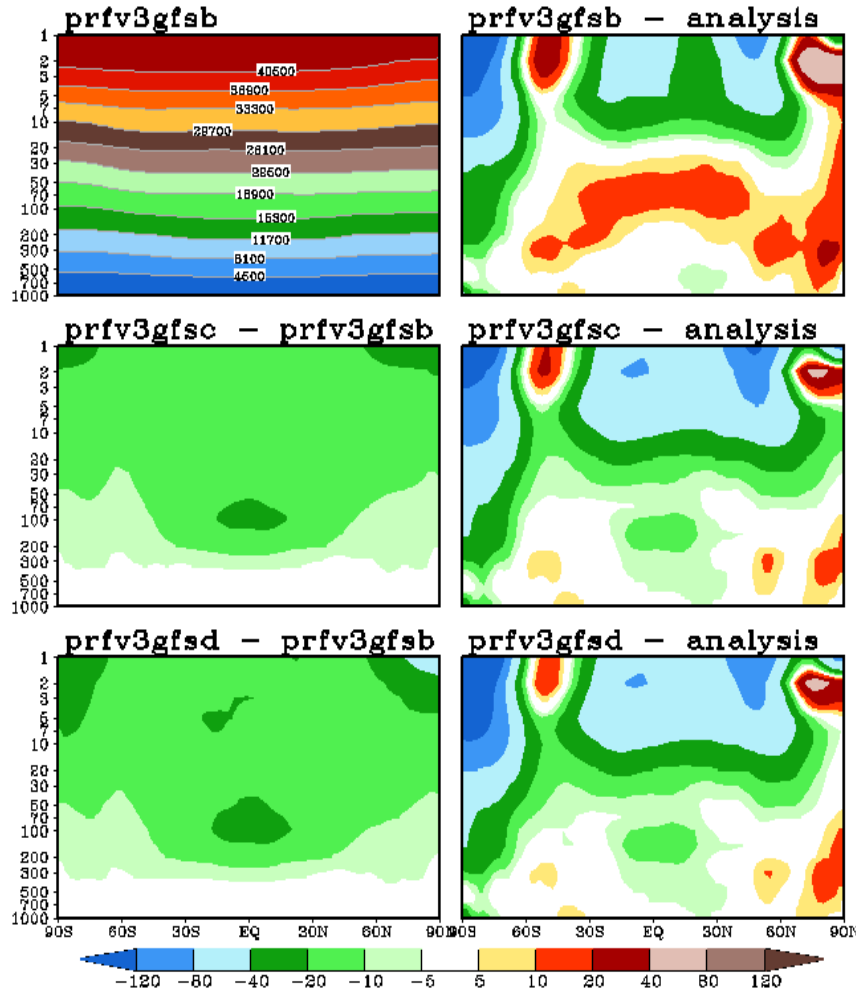
500hPa HGT AC



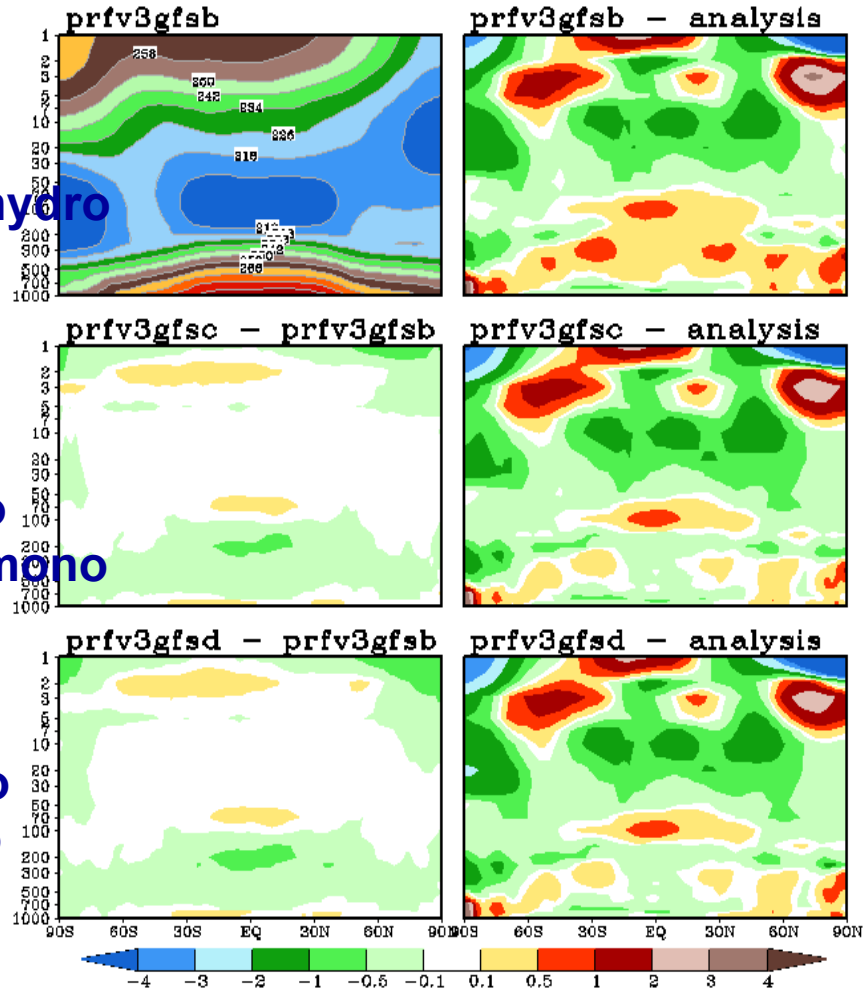
Hydro slightly better than non-hydro !

HGT (m), 00Z-Cyc 01Oct2016-31Oct2016 Mean
Post-Hour 1120

Temp (K), 00Z-Cyc 01Oct2016-31Oct2016 Mean
Post-Hour 1120



Non-hydro
mono

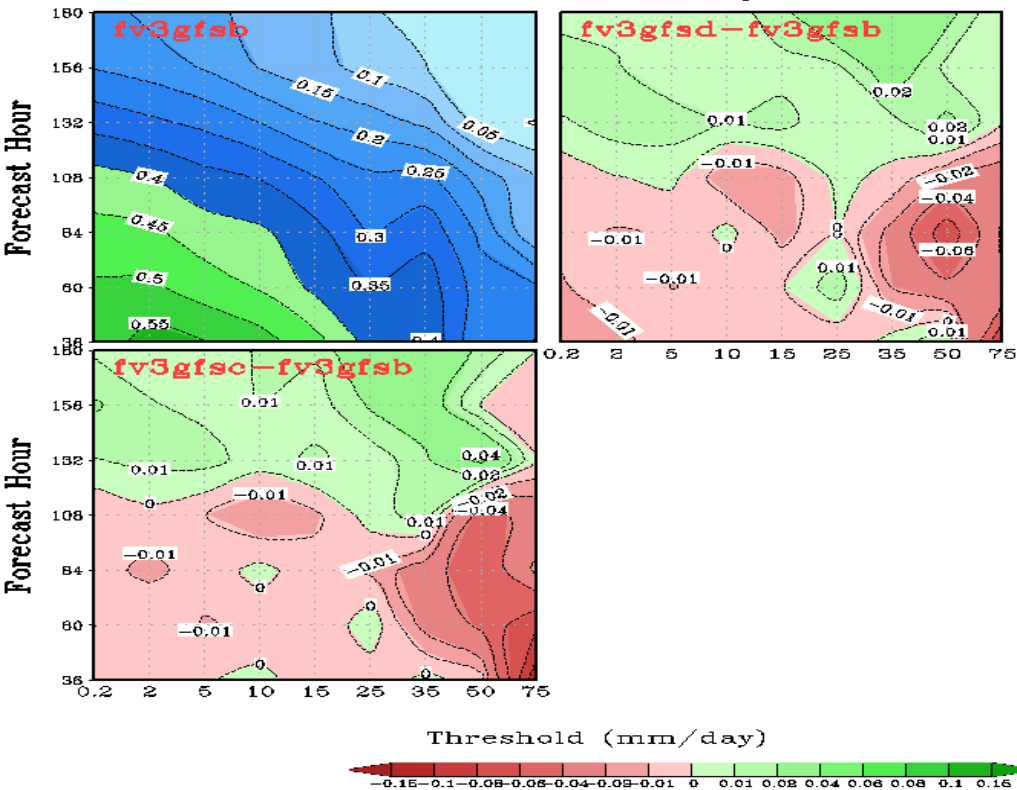


Hydro
Non-mono

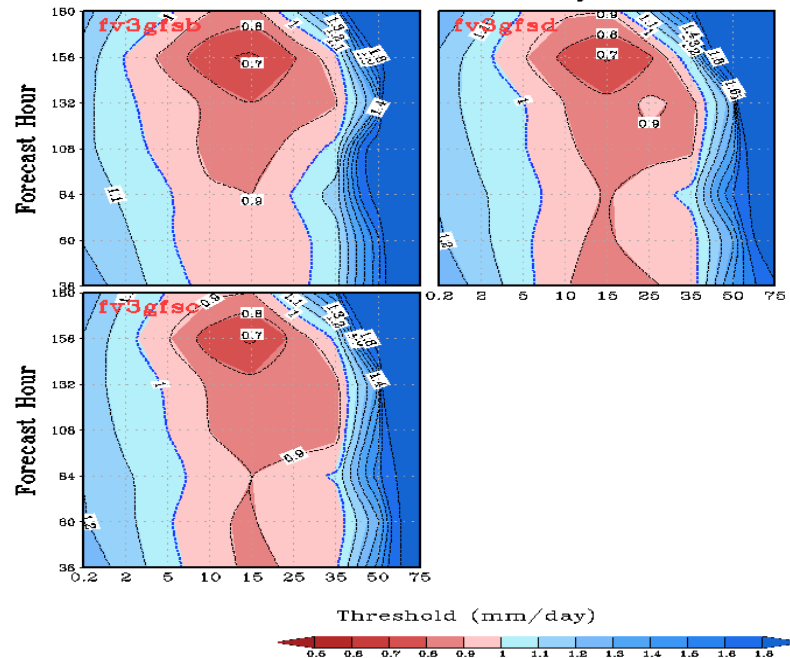
Hydro
mono

- Hydro is colder than non-hydro in the troposphere
- Difference in the stratosphere between hydro and non-hydro is small.
- Hydro is too cold near the tropopause, while non-hydro is too warm

CONUS Precipitation Equitable Threat Score
01oct2016-15nov2016 00Z Cycle

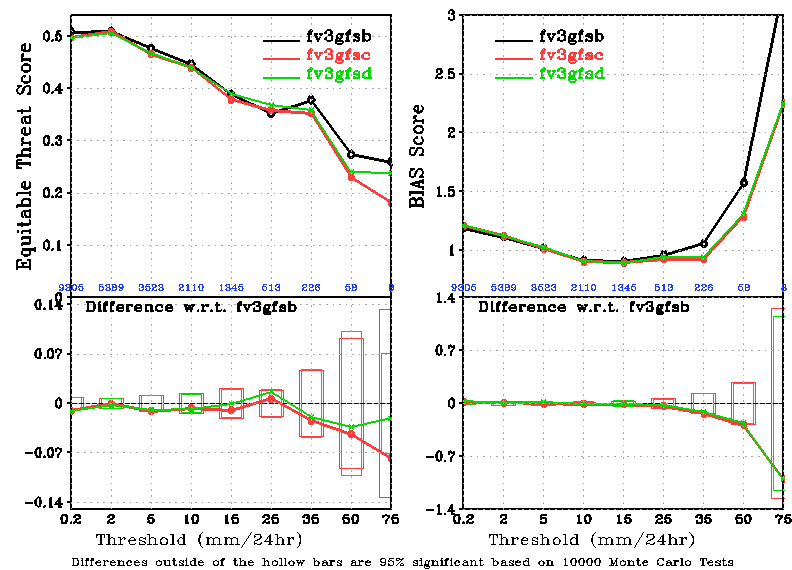


CONUS Precipitation BIAS Score
01oct2016-15nov2016 00Z Cycle



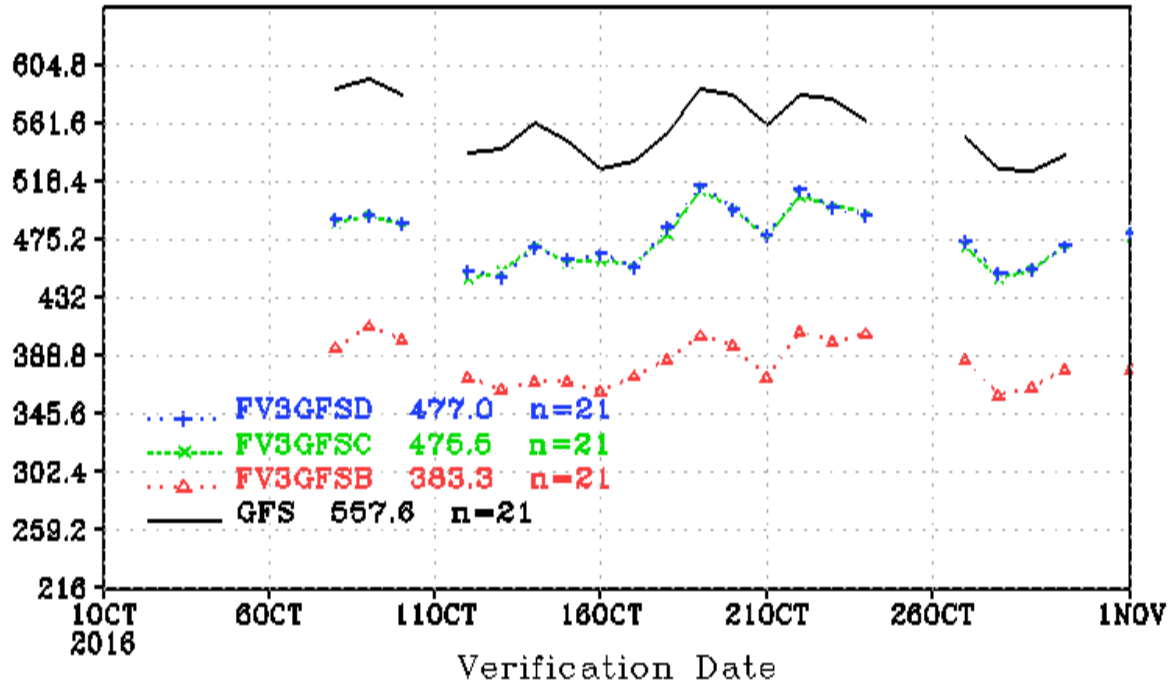
CONUS Precipitation Score:
Hydro is worse than non-hydro for short-range forecasts, but difference is insignificant. Need to test for summer, and with more samples

CONUS Precip Skill Scores, f36-f80, 01oct2016-15nov2016 00Z Cycle

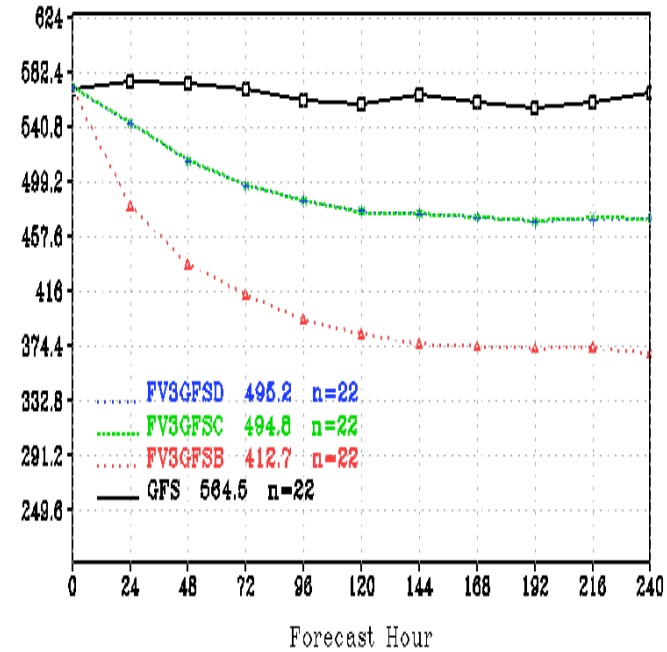


Tropical CAPE

CAPE G2/TRO 00Z, 20161001-20161101 fh120



CAPE G2/TRO 00Z, Mean for 20161001-20161101



- Non-hydro CAPE is ~35% less than that ops GFS CAPE
- Hydro CAPE is much larger than non-hydro CAPE

Concluding remarks

- Development of workflow scripts and utilities for **data assimilation** are still ongoing.
- A **new benchmark** needs to be established using IPD v4.0 and compared to Q3FY17 NEMS GFS.
- More sensitivity experiments need to be carried out to better understand the model behavior with different parameter options. Different applications (e.g. deterministic vs ensemble forecast) might require the use of different settings (e.g., 32-bit vs 64-bit; non-hydro vs hydro) to achieve **best computing efficiency and forecast performance**.
- Given that the model behaves quite differently between hydro and non-hydro, **ENKF and high-res deterministic** may have to be run with the same option.

THANK YOU

Resolution, Physics Grid, and Run-time on Cray

10-d forecast, 6-hourly output, non-hydrostatic, 3.75-minute time step,

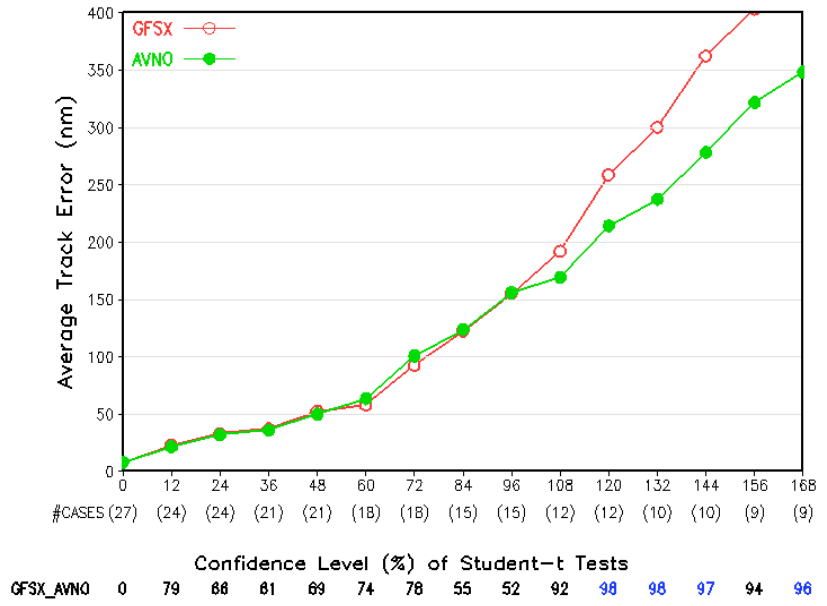
C#L63	Res	#Physics Grid (6xCxC)	Runtime (minutes) 2threads
C48	200km	13,824	32-bit, 16 nodes: 3.6
C96	100km	55,296	32-bit, 16 nodes: 7.2
C192	50km	221,184	32-bit, 16 nodes: 21.0
C384	25km	884,736	32-bit, 16 nodes: 75.7
C768	13km	3,538,944	32-bit 16 nodes: 323
C1152	8km	6,291,456	
C3072	3.5 km	9,830,400	

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

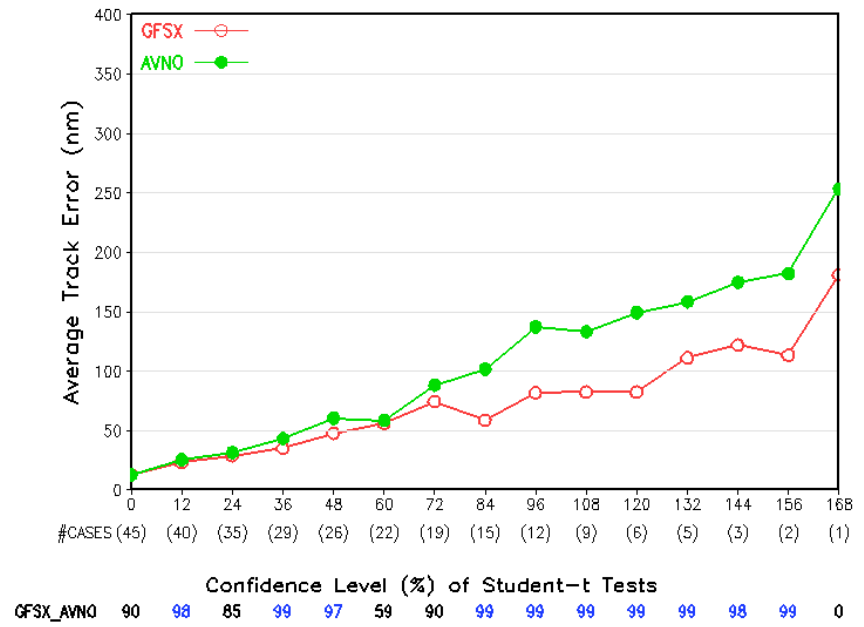
Thumb of rule : 10,000 / C# is grid size

Hurricane track

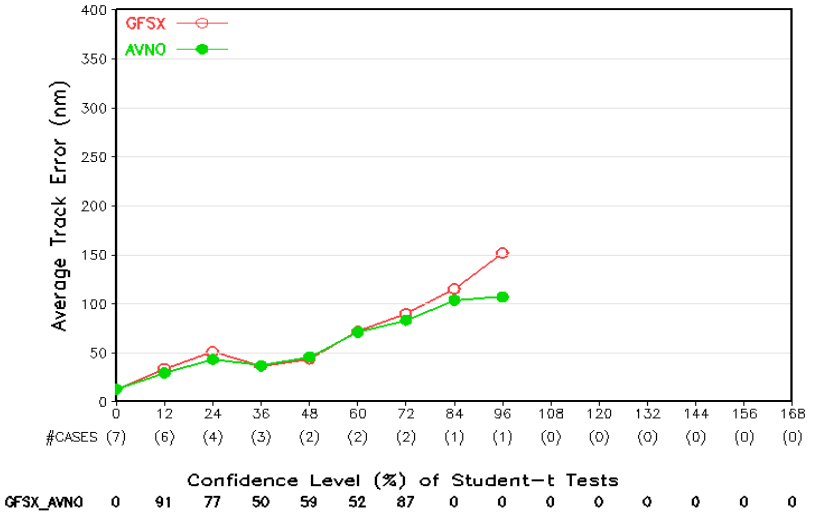
Hurricane Track Errors – Atlantic 2016
20161001__20161230__1cyc



Hurricane Track Errors – West-Pacific 2016
20161001__20161230__1cyc



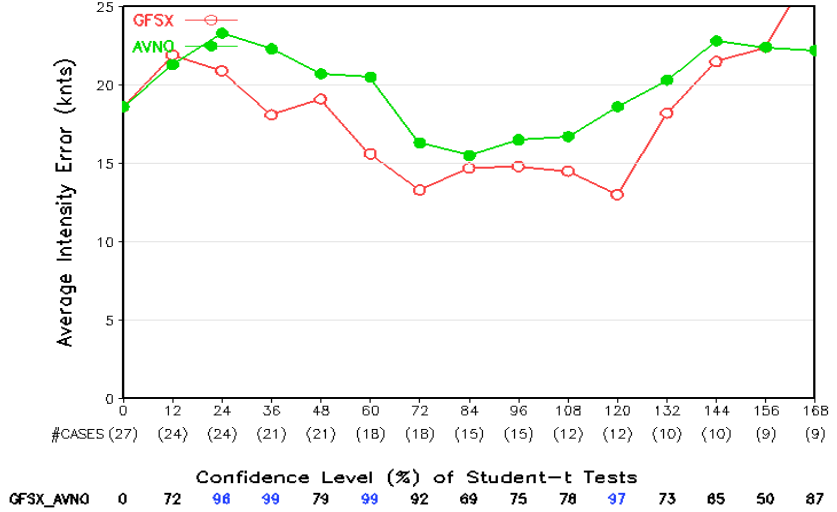
Hurricane Track Errors – East-Pacific 2016
20161001__20161230__1cyc



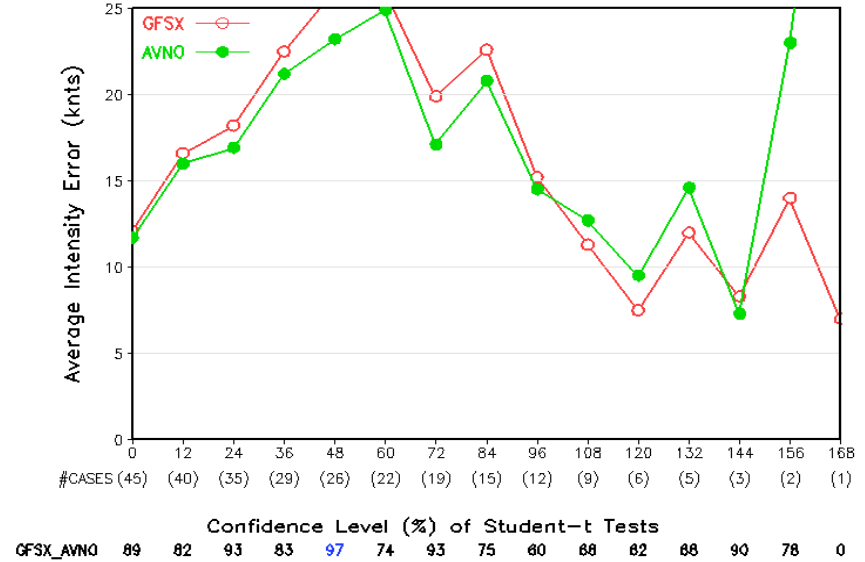
Limited sample size and only 00Z cycle !

Hurricane Intensity

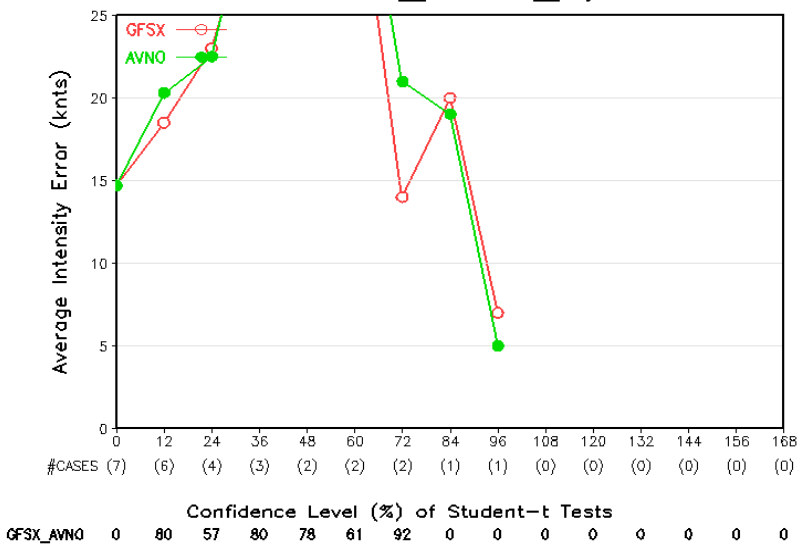
Hurricane Intensity Errors – Atlantic 2016
20161001_20161230_1cyc



Hurricane Intensity Errors – West-Pacific 2016
20161001_20161230_1cyc



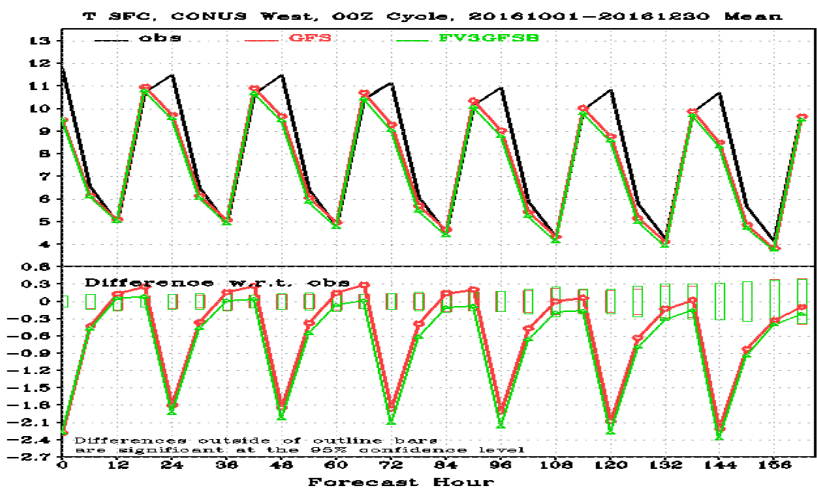
Hurricane Intensity Errors – East-Pacific 2016
20161001_20161230_1cyc



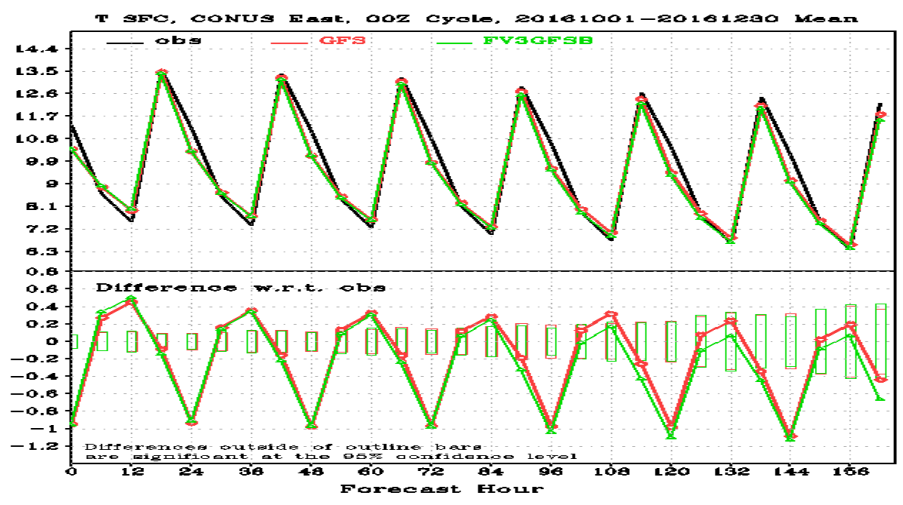
Limited sample size and only 00Z cycle !

Verified against Station Obs

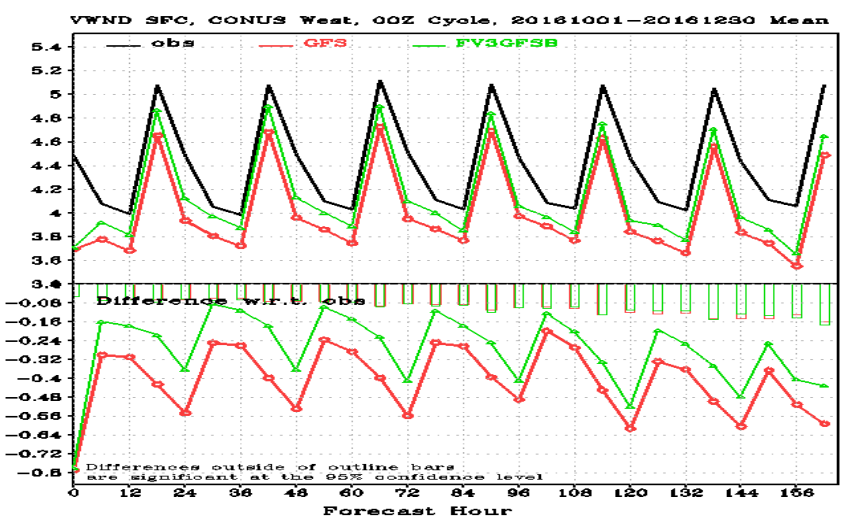
T2m, CONUS WEST



T2m, CONUS EAST



U10m, CONUS WEST



U10m, CONUS EAST

