EMC-NCO GFS.v16 Implementation Kick-off Meeting

Project Leads:	Fanglin Yang, Russ Treadon
Model:	Jongil Han, Jack Kain, Weizhong Zheng, George Gayno, Helin Wei, Ruiyu Sun, Moorthi Shrivinas, Anning Chen, Rongqian Yang, Xingren Wu, Xiaqiong Zhou, Valery Yudin, Youlong Xia, Jesse Meng, Henrique Alves, Roberto Padilla, Jessica Meixner, Ali Abdolali
Data Assimilation:	Jeff Whitaker, Catherine Thomas, Cory Martin, Wanshu Wu, Haixia Liu, Kristen Bathmann, Andrew Collard, Xu Li, Yanqiu Zhu, Xiujuan Su, Shelley Melchior, Sudhir Nadiga, Steve Stegall
Post & VV:	Hui-ya Chuang, Wen Meng, Boi Vuong, Mallory Row, Guang-Ping Lou, Yali Ma, Jiayi Peng, Deanna Spindler, Roberto Padilla, Geoffery Manikin, Alicia Bentley, Logan Dawson
Infrastructure :	Jun Wang, Kate Friedman, Mark Iredell, Hang Lei, Eric Rogers, George Vandenberghe, James Abeles, Gerhard Theurich, Edward Hartnett, Farida Adimi
Management:	Vijay Tallapragada, Arun Chawl, Jason Levit, Daryl Kleist, Jian-Wen Bao
NCO	Carissa Klemmer, Steven Earle, Anne Myckow, data-flow team

June 11, 2020

GDAS/GFS Version 16
Status as of May 27, 2020

Project Information & Highlights

Project Manager: Vijay Tallapragada

Leads: Fanglin Yang and Russ Treadon (EMC), Steven Earle (NCO)

Scope: Develop and incorporate new capabilities into the NCEP GFS with 13 km resolution and 127 levels, including advanced physics and DA system, including GLDAS in DA cycle, and coupling to a wave model. Additional capabilities from the NGGPS community will also be incorporated (project plan & charter)

Expected benefits: higher model vertical resolution, extended model domain up to the mesopause, improved model physics, advanced data assimilation, improved model forecast skills.

Dependencies: testing of NOAA MP, gravity-wave drag parameterization; wave coupling, and DA upgrade; Satisfactory evaluation by stakeholders and downstream products

Issues/Risks

Risk: Insufficient resources for carrying out 3 years of retrospective parallel runs mandated by NHC;

Mitigation: Reduce the length of retrospective parallels

Risk: Coupling to Waves doesn't fit into the operational run-time window

Mitigation: Reduce resolution of wave model or increase the efficiency of coupling or remove wave coupling from GFSv16

Schedule

Milestones & Deliverables	Date	Status
Freeze model code and data assimilation system	5/19/20	Complete
EMC/NCO EE2 kick off meeting	6/11/20	On track
PNS due to HQ	6/18/20	On track
Complete full retrospective/real time runs and evaluation	8/31/20	In progress
Complete Field evaluation & conduct CCB	9/25/20	In progress
Deliver Service Change Notice to NCO	9/16/20	planned
OD Brief and deliver final system code to NCO	10/9/20	planned
Start 30-day evaluation and IT testing	12/21/20	planned
Operational Implementation	2/3/21	planned

EMC | NCO | Blue text indicates changes from previous quarter

Resources

Staff: 3 Fed FTEs + 10 contractor FTEs; including Dev (FV3, physics, DA, post processing, V&V, and infrastructure)

Funding Source: STI/NGGPS

Compute: EMC Dev: (+100%)**; Parallels:** (+100%); **Ops**: 850 nodes HWM

Archive: Parallels: 5 PB HPSS for 3-year retros; **Ops**: 7 TB online and 1 TB HPSS per cycle

R Management Attention Required | Y Potential Management Attention Needed | G On Target

Link to Charter

Project Plan and Charter for

Global Forecast System (GFS) V16.0.0

Development and Transition to Operation

VERSION 1.0

08/26/2019

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
National Weather Service (NWS)
National Centers for Environmental Prediction (NCEP)
Environmental Modeling Center (EMC) &
NCEP Central Operations (NCO)

NCEP Project Plan and Charter	
Implementation of Global Forecast System Upgrades (GFSv16), Q2FY2021	
Effective Date: Date of last signature Responsible Organizations: NWS/NCEP/EMC & NCO	GFS V16.0.0 Plan v1.0

SIGNATURE PAGE

Concurred by:

Vijay Tallapgragada; EMC Modeling and Data Assimilation Branch Chief Date

Arun Chawla; EMC Engineering and Implementation Branch Chief
Date

Jason Levit; EMC Verification, Post-Processing & Product Generation Branch Chief
Date

Carissa Klemmer, NCO Implementation & Data Services Branch Chief Date

Approved by:

Brian Gross; EMC Director Date

Ben Kyger, NCO Director Date

Prepared by:

Vijay Tallapragada; EMC Modeling and Data Assimilation Branch Chief

Evolution of GFS vertical resolution

Mon	Year	Levels	Type	notes
Aug	1980	12	sigma	first GSM implementation
Apr	1985	18	sigma	
Aug	1993	28	sigma	first analytic formula
Jan	2000	42	sigma	first on IBM
Oct	2002	64	sigma	first time called ‘GFS’
May	2005	64	sigma	high res to 180 hours
May	2007	64	hybrid	Prognostic cloud
	2021	127	hybrid	FV3 dycore

14 years !

Changes in System Configuration

Model, Data Assimilation, Pre-processing, Post-Processing, Data Format, I/O, Libraries etc

GFS V16: Major Upgrades to Forecast Model

Model resolution:

Increased vertical resolution from 64 to 127 layers and raise model top from 54 km to 80 km

Physics updates

PBL/turbulence:	Replaced K-EDMF with sa-TKE-EDMF Revised background diffusivity as a stability dependent function
GWD:	Added a parameterization for subgrid scale nonstationary gravity-wave drag
Radiation:	Updated calculation of solar radiation absorption by water clouds; Updated cloud overlap assumptions.
Microphysics:	Updated GFDL microphysics scheme for computing ice cloud effective radius
Noah LSM:	Revised ground heat flux calculation over snow covered surface; Introduced vegetation impact on surface energy budget over urban area

Coupling to Wave

One-way coupling of atmospheric model with Global Wave Model (WaveWatch III)

Coupling to GLDAS

Spin up land states using CPC Gauge precipitation in the GDAS 00Z cycle

GFS V16: One-Way Coupling to WAVE

The operational Global Wave Deterministic (Multi_1) model will be replaced by the wave component coupled to the atmosphere in GFSv16

WAVE in GFSv16 will retain the following features from wave_multi_1:

- Global WAVEWATCH III model with two-way nested grid mosaic,
- 4 daily cycles,
- Ice concentrations from NCEP 1/12^{o} analysis.

The following features will be added or changed:

- New computational spatial grid mosaic,
  - Increase global core resolution from ½ to ⅙ degree in the Northern Hemisphere, and to ¼ degree in the Southern Hemisphere,
  - Increase Arctic polar stereographic grid resolution from 1**8 km to 9 km**.
  - The new grid mosaic will replace all Multi_1 4 and 10 arcmin grids.
- New RTOFS ocean surface current forcing up to 192h,
- Multi_1 9h hindcasts will be replaced by the wave step run within the GDAS cycle,
- Forecasts will be extended from 180 hr to 384 hr.

GFS V16: Major Upgrades to Data Assimilation

- **Local Ensemble Kalman Filter (LETKF)**
  with model space localization and linearized observation operator
  to replace the Ensemble Square Root Filter (EnSRF)

- **4-Dimensional Incremental Analysis Update (4D-IAU)**

- Turn on SKEB in EnKF forecasts
- Update variational QC
- Apply Hilbert curve to aircraft data
- Correlated observation error for CrIS over sea surfaces and IASI over sea and land
- Update aircraft bias correction with safeguard
- Assimilate AMSU-A channel 14 and ATMS channel 15 w/o bias correction
- Assimilate CSR data from ABI_G16, AHI_Himawari8, and SEVIRI_M08
- Assimilate AVHRR from NOAA-19 and Metop-B for NSST
- Use CRTM v2.3.0

I/O Change – Use NetCDF to replace nemsio

Size of current operational GFS (C768L64) nemsio files:

atmf	**16.8 GB**
sfc	**2.8 GB**

GFS.v16 (C768L127), if in nemsio format

atmf	**33.6 GB**
sfc	**5.6 GB**

A decision was made to write out GFS.v16 forecast history files (atmf and sfcf) in netCDF format with zlib compression. Parallel I/O was developed with updated netCDF and HDF libraries.

compression ratio:

Atmf 3d	**5x**	**(33.6 GB to 6.6 GB),**	**lossy compression**
sfc 2d	**2.5x**	**(2.8 GB to 1.1 GB),**	**lossless compression**

Pre-Processing Changes

obsproc_global.iss71402.supportGFSv16 was updated to process new satellite observations and work with model history files in netCDF format.

exglobal_dump.sh.ecf modified to generate BUFR dump files for the following data types:

- GOES-16, -17 Clear Sky Radiance data (gsrcsr)
- GOES-16 All Sky Radiance data (gsrasr)
- OMPS Limb Profiler (ompslp)
- Himawari-8 Clear Sky Radiance data (ahicsr)
- VIIRS SST (Clear Sky w/o Land Radiance data) from NPP & NOAA-20 (sstvcw)
- VIIRS SST (Probably Clear Sky w/o Land Radiance data) from NPP & NOAA-20 (sstvpw)
- LEO-GEO Satellite AMVs from UWisc (leogeo)

exglobal_dump.sh.ecf modified to remove legacy/obsolete bufr dump file processing:

- GOES-15 data
- Legacy VIIRS AMV data
- Obsolete EUMETSAT CrIS data (escris, escrsf)

`JGLOBAL_PREP` and **`exglobal_makeprepbufr.sh`**

- Updated to handle netcdf history filename patterns

Implementation will be coincident w/ GFSv16

Pre-Processing Changes

obsproc_prep.iss70457.netcdfhistory was updated to compile with parallel netCDF libs and to process model history files in netCDF format.

load_libs.rc

- uses w3emc_ver=2.4.0
- uses netcdf_ver=4.5.0
- Presently loads:
  - module use -a /usrx/local/nceplibs/dev/NCEPLIBS/modulefiles
  - module load w3emc_para/$w3emc_ver
  - module load hdf5_parallel/1.10.6
  - module load netcdf_parallel/4.7.4

Added ${NETCDF_LDFLAGS} to makefiles:

- prepobs_prepdata.fd
- prepobs_prevents.fd
- syndat_syndata.fd

Added new file: ush/getges_nc.sh

prepobs_makeprepbufr.sh

- Added new switch variable: NETCDF_IN
- Modified logic to react according to value of $NETCDF_IN

Implementation will be coincident w/ GFSv16

Pre-Processing Changes: WAVE

JWAVE_INIT job added: generates model definition files

JWAVE_PREP job: generates ice and RTOFS ocean current forcing

Requires CDO module

Upstream dependencies:

- NCEP 5 arcmin ice analysis (same as operational Multi_1)
- Requires RTOFS 3h netcdf files

All pre-processing wave jobs have been integrated to the GFS global-workflow.

Inline Post and Offline Post

- **Inline post** was introduced to GFS.v16
  - Inline post makes use of forecast data saved in memory for post processing, reduces I/O activity, and speeds up the entire forecast system.
  - A **Post library** was created using the offline post Fortran programs. It can be called by the Write Grid Component within the forecast model.
  - Since lossy compression is applied for writing out forecast history files, **inline post generates more accurate products** than the standalone offline post.

- **GFS.v15**
  - ALL master, flux, simulated satellite radiance, and GTG files are made by the offline post.

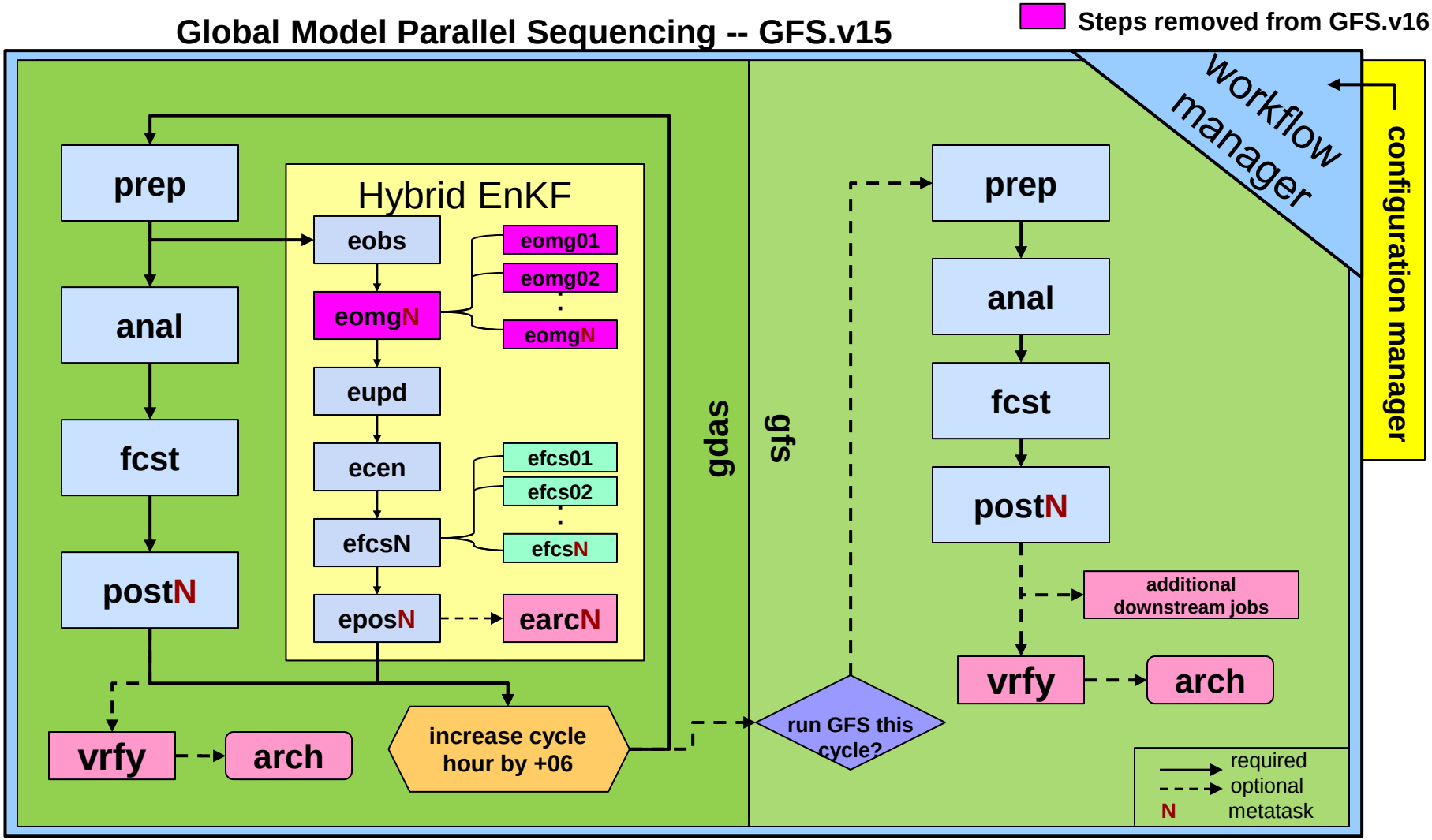
- **GFS.v16**
  - Master and flux files are produced by the inline post.
  - Simulated satellite radiance and WAFS files are still made by the offline post.

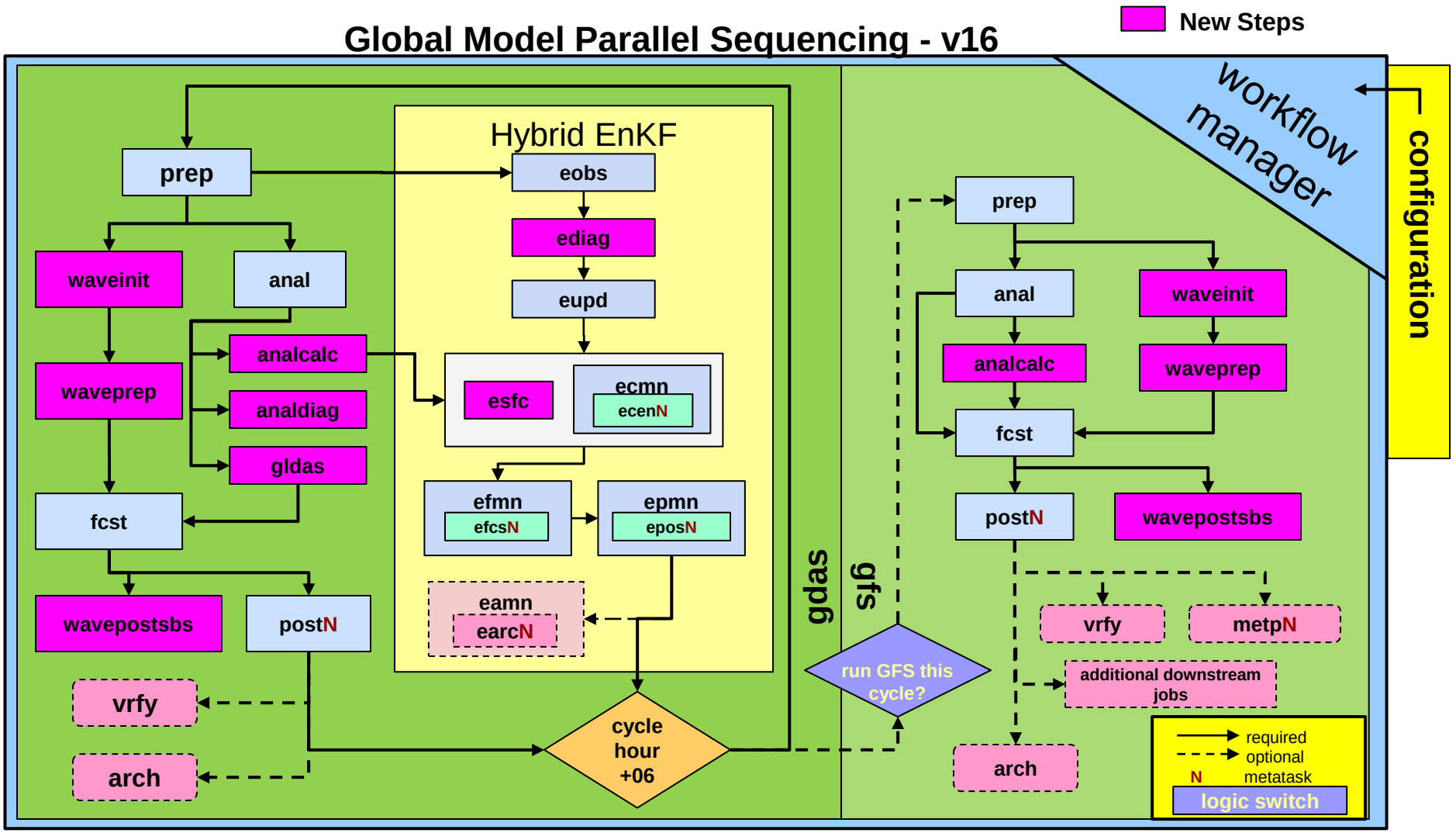
Libraries to be added and updated (link)

Library	Version	CDF target date
crtm	2.3.0	Delivered
w3emc	2.4.0	6/15/2020
post	8.0.9	6/15/2020
esmf	8.0.1	6/15/2020
netcdf	4.7.4	6/15/2020
netcdf-fortran	4.5.3	6/15/2020
hdf5	1.10.6	6/15/2020
bacio	2.0.3	6/15/2020
nemsio	2.2.4	6/15/2020
g2	3.2.0	6/15/2020
grib_util	1.2.0	6/15/2020
g2tmpl	1.6.0	Delivered
wgrib2	2.0.8	6/15/2020
CDO		

Dependency notes:

1. Many libraries must be built after netcdf/hdf5 dependency is.
2. Official release promised before 6/15 for netcdf-


Global Model Parallel Sequencing -- GFS.v15
Steps removed from GFS.v16
workflow manager
configuration manager
prep
anal
fcst
postN
vrfy
arch
Hybrid EnKF
eobs
eomgN
eomg01
eomg02
eomgN
eupd
ecen
efcsN
efcs01
efcs02
efcsN
eposN
earcN
increase cycle hour by +06
gdas
gfs
run GFS this cycle?
prep
anal
fcst
postN
additional downstream jobs
vrfy
arch
required
optional
N metatask


Global Model Parallel Sequencing - v16
New Steps
workflow manager
configuration
Hybrid EnKF
prep
eobs
ediag
eupd
waveinit
anal
analcalc
analdiag
gldas
waveprep
esfc
ecmn
ecenN
fcst
efmn
efcsN
epmn
eposN
eamn
earcN
wavepostsbs
postN
vrfy
arch
cycle hour +06
gdas
gfs
run GFS this cycle?
prep
anal
waveinit
analcalc
waveprep
fcst
postN
wavepostsbs
vrfy
metpN
additional downstream jobs
arch
required
optional
N metatask
logic switch

Changes in Products

Product Changes -- Atmosphere

- Unification: All isobaric state fields in pgrb2 files will have the same 41 levels at all forecast hours and analysis time
- New products:
  - **Add more pressure levels** (at 0.01, 0.02, 0.04, 0.07, 0.1, 0.2, 0.7 hPas) in the upper stratosphere and the mesosphere in pgrb2 files
  - Other **new products** include *ceiling, total column and low/mid/high cloud fractions, and radar reflectivity at 1 km/4 km and 1st/2nd model level above ground*.
- Replaced products:
  - *Replace filtered Shuell SLP with unfiltered one using same ID PRMSL*
  - *Replace legacy synthetic nadir GOES 12/13 with synthetic nadir ABI GOES-R products*
- Products moved to different files:
  - Isobaric SPFH moved from pgrb2b to pgrb2 files
  - GTG and Icing severity moved to new file gfs.tHHz.wafs_0p25.fFF.grib2
- Changes in Grib2 IDs:
  - low/middle/high cloud from TCDC to LCDC, MCDC, HCDC
  - Icing Severity parameter from 234 to 37, mnemonics from ICSEV to ICESEV

Product Changes -- Atmosphere (Cont'd)

- Delay in product delivery: synthetic GOES products
- Removed products:
  - Three legacy bulletins (navy bull, wintemv bull, gdas bull)
  - 5-wave height (5WAVH) in all GFS pgb files, AWIPS 20km grids (CONUS, Alaska, Puerto Rico, Pacific region) and AWIPS LAT/LON 1.0 degree grid
  - Lifted Index in GFS Flux files
  - SPFH at 16 levels from pgrb2b
  - A PNS on GFS V16 product removal has been sent out in April. No objection within 30 day period.
- Update to GFS Bufr sounding output
  - Increase vertical levels from 64 to 127
  - Remove terrain adjustments of temperature and SPFH profiles from station elevation
  - Sea-surface pressure is reduced from model surface height
  - Changed surface evaporation value and unit from watts/m^2 (surface latent heat net flux) to kg/m^2 (evaporation)

NEW Product -- Storm Genesis Verification

- The FSU storm genesis verification will be included in the existing storm track package ***ens_tracker.v1.1.20*** by adding one J-JOB (JGFS_FSU_GENESIS).

- It will be run 4 cycles per day with GFS 0.25-deg GRIB2 data up to 180 forecast hours.

- NHC forecasters will use this product (TC genesis tracking in Atlantic and Eastern Pacific) as their forecast guidances.

- The **pygrib** has already been installed on Dell/Cray machines, no other libs are needed.

Product Changes -- WAVE (relative to Multi_1)

Removed products (affects com, NOMADS, ftp and NOAAPORT)

- Full PNS: https://www.weather.gov/media/notification/pdf2/pns20-33multi_1_removal.pdf
  - All products from legacy grids awk, enp, wna, nww3, wam
  - Wave steepness files (wstp)
  - All 4-arcmin gridded data will be removed (ak_4m, at_4m, wc_4m)
  - Alaska ak_10m data (replaced by a full Arctic 9km dataset)
  - Binary forcing files will be removed
  - csv-bulletins (csbull) will be removed

Product Changes -- WAVE (relative to Multi_1)

Changes in products (affects com, NOMADS, ftp and NOAAPORT)

- New computational grid grib2 files
  - Northern hemisphere 0p16
    - Replaces global 30 arc min and all regional grids
  - Southern Hemisphere 0p25
    - Replaces global 30 arcmin
  - Arctic polar-stereographic 9km
    - Replaces Arctic 18km
  - New global extended 0p25
    - Replaces global extended 30 arcmin

Changes in the GDAS Data Volume Disseminated to NOMADS (per cycle)

https://ftp.ncep.noaa.gov/data/nccf/com/gfs/prod/gdas.PDY/CYC/

File type	GFS v15 (GB)	GFS v16 (GB)
pgrb2 at 0.25/0.5/1.0	3.4	4.6
flux	0.8	0.8
History files (atmf and sfcf)	86	42
others	4.8	2.6 + ??
Grand Total	95	50

We propose to add **RESTART** files to NOMADS:
./gdas.PDY/CYC/RESTART: 44GB

Analysis increments (Gdas.t00z.atmi003.nc, gdas.t00z.atmi009.nc, gdas.t00z.atminc.nc, gdas.t00z.dtfanl.nc): 16.2 GB

Total: ~ **110 GB**

Changes in GFS Data Volume Disseminated to NOMADS (per cycle)

https://ftp.ncep.noaa.gov/data/nccf/com/gfs/prod/gfs.PDY/CYC/

File type	GFS v15 (GB)	GFS v16 (GB)
pgrb2 at 0.25/0.5/1.0	84	116
pgrb2b at 0.25/0.5/1.0	60	53
Flux	46	47
bufr	1.3	1.4
History files (hourly, up to 24 hrs for atmf, and 12 hrs for sfcf)	**488**	**197**
wafs	n/a	0.341
others	1.7	??
Grand Total	**681**	**426**

We propose to add **RESTART** files to NOMADS: ./gfs.PDY/CYC/RESTART: 3.3 GB
Analysis increments (gfs.t00z.atmi003.nc, gfs.t00z.atmi009.nc, gfs.t00z.atminc.nc, gfs.t00z.dtfanl.nc): 16.2 GB

Total:
~ 445 GB

Changes in the WAVE_Multi_1 Data Volume Disseminated to NOMADS (per cycle)

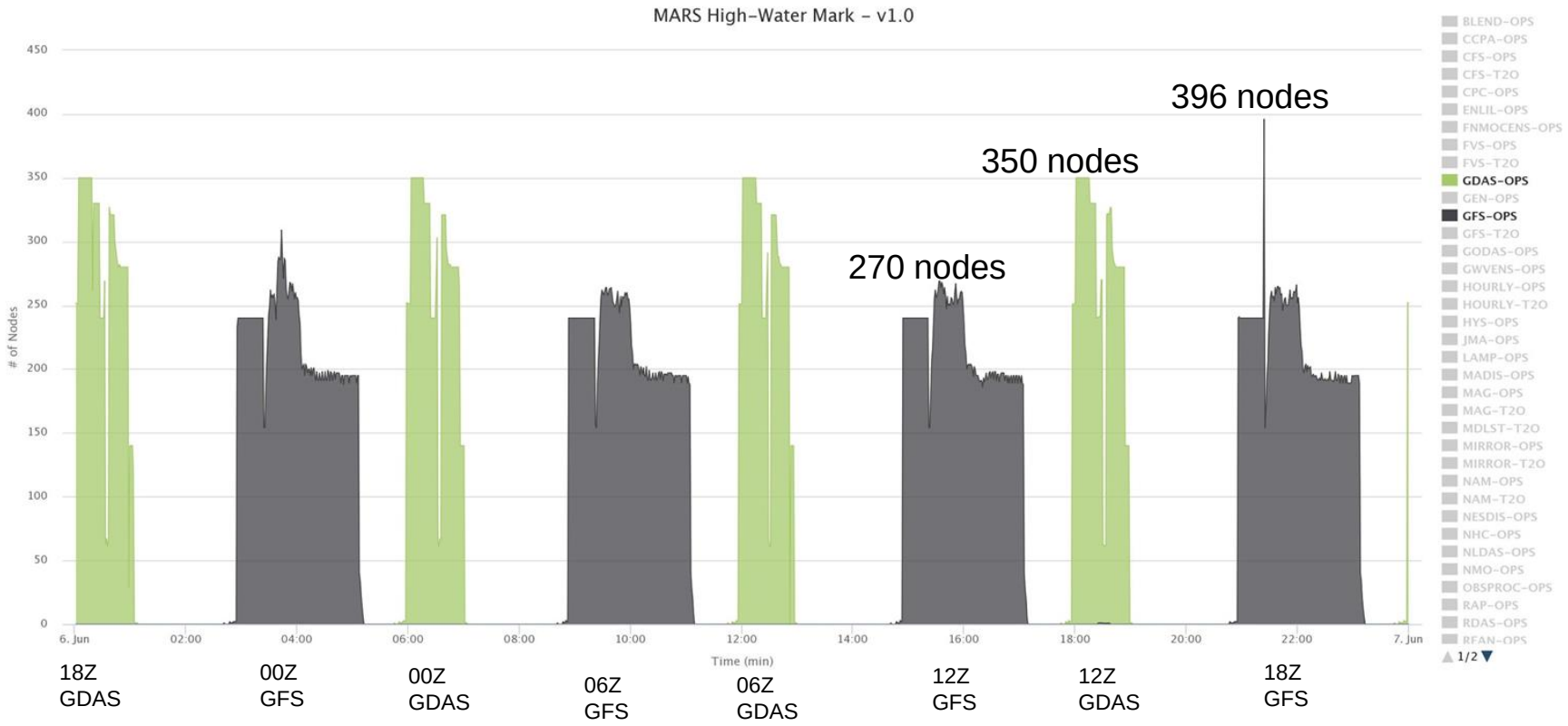
https://ftp.ncep.noaa.gov/data/nccf/com/wave/prod/multi_1.YYYYMMDDHH/

File type	**Operational Multi_1 (GB)**	**GFSv16-Wave (GB)**
grib2/grib2.idx	2.5	12
spec/bulls/compressed bulls	1.75	1
Removed files (see previous slides)	0.30	--

Computational Cost

Timing, Node Usage and Disk Space

High Watermark, GFS.v15 Operation, June 7, 2020



18Z GDAS

00Z GFS

00Z GDAS

06Z GFS

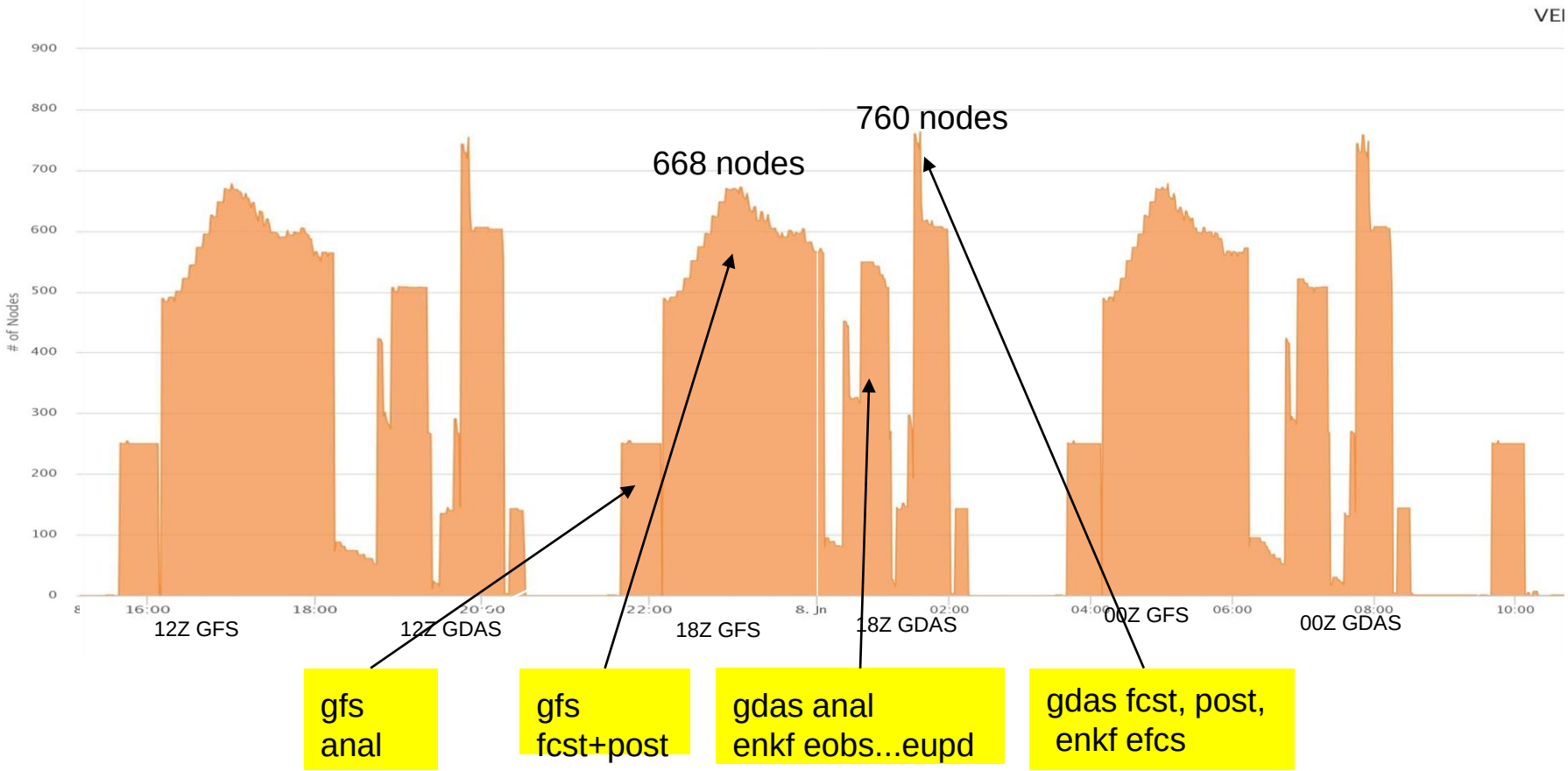
06Z GDAS

12Z GFS

12Z GDAS

18Z GFS

High Watermark, GFS.v16 Real-time Parallel, June 7-8, 2020



Computational Cost -- Timing and Node Usage

GFS	GFS v15 time (min)	GFS v15 nodes	GFS v16 time (min)	GFS v16 nodes
gfs_prep	3.5 - 3.8	1	6.1 - 6.8	1
gfs_analysis	**28.0 - 28.7**	**240**	**28.1 - 29.4**	**250**
gfs_analcalc	-na-	-na-	2.4 - 2.7	5
gfs_forecast_high	**100.8 - 103.4 (6.38 min/day)**	**148**	**122.8 - 124.2 (7.72 m/day)**	**484**
gfs_post_anl	1.6 - 1.7	6	4.7 - 4.9	7
gfs_post_f120	4.6 - 4.8	6	8.1 - 11.9*	7

* EMC parallel gfs_post_fXXX includes synthetic nadir GOES-R processing

Computational Cost -- Timing and Node Usage

GDAS	GFS v15 time (min)	GFS v15 nodes	GFS v16 time (min)	GFS v16 nodes
gdas_prep	3.8 - 3.9	1	6.5 - 6.8	1
gdas_analysis_high	**32.2 - 33.0**	**240**	**38.2 - 39.3**	**250**
gdas_analcalc	-na-	-na-	11.6 - 12.5	5
gdas_analdiag	-na-	-na-	4.4 - 5.1	4
gdas_gldas	-na-	-na-	6.0 - 6.7 (only 00Z)	4
gdas_forecast_high	**11.5 - 11.7**	**28**	**21.10- 21.5**	**119**
gdas_post_anl	1.4 - 1.6	6	5.3 - 6.1	7
gdas_post_f006	2.2 - 2.4	6	1.8 - 2.6	7

Computational Cost -- Timing and Node Usage

ENKF	GFS v15 time (min)	GFS v15 nodes	GFS v16 time (min)	GFS v16 nodes
enkf_select_obs	3.8 - 4.7	11	4.1 - 4.8	120
enkf_innovate_obs_XX	**13.9 - 14.6**	11 x 10 = 110	**-na-**	-na-
enkf_diag	-na-	-na-	3.6 - 4.0	2
enkf_update	**6.5 - 6.8**	**90**	**25.6 - 26.7**	**240**
enkf_inflate_recenter	4.1 - 4.2	20	-na-	-na-
enkf_recenter	-na-	-na-	3.8 - 4.9	40 x 3 = **120**
enkf_surface	-na-	-na-	2.2 - 2.6	3
enkf_fcst_XX	19.7 - 19.8	14 x 20 = 280	**28.5 - 31.5**	15 x 40 = **600**
enkf_post_fXXX	4.8 - 5.0	20 x 7 = 140	10.6 - 11.3	20 x 7 = 140

Computational Cost -- Timing and Node Usage

WAVES	wave_multi_1 time (min)	nodes	GFS v16 time (min)	nodes
gdas_waveinit	-na-	-na-	0.5 - 0.5	1
gdas_waveprep	-na-	-na-	1.5 - 1.7	5
gdas_wavepostsbs	-na-	-na-	14.2 - 14.4	10
gfs_waveinit	-na-	-na-	0.5 - 0.5	1
wave_prep/gfs_waveprep	1.7 - 2.0	1	1.6 - 1.9	5
wave_fcst/gfs_forecast_high	53.8 - 54	18	122.8 - 124.2	60 wave model
wave_post/gfs_wavepostsbs	15.2 - 15.7	12	204.6 - 209.1	10

For the wavepostsbs, current availability time for the 180h operational wave post products is **51 min** after the start of the fcst step. High watermark tests have 180h products from GFSv16-wave available **122 min** after the init of fcst step. To keep current delivery time, wavepostsbs job will require **2-3 times more** than current nodes. Inclusion of BC for downstream may require meta-tasks.

Computational Cost -- Timing and Node Usage

DOWNSTREAM	GFS v15 time (min)	GFS v15 nodes	GFS v16 time (min)	GFS v16 nodes
gfs_postsnd	52.5 - 53.9	3	26.7 - 28	8
gfs_gempak	17.5	2	25.17	2
gfs_awips_f120	2.2	1	2.3	1
gfs_wafs_grib2_0p25	n/a		15.4	1
gfs_wafs_blending_0p25	n/a		5.5	1

Delays in v16 with respect to v15

Based on timings from 2020060712 - 2020060806 cycles

- **gfs prep + anal + fcst**
  - **v15: 134.4 minutes**
  - **v16: 158.2 minutes (23.8 minutes longer, but still within 8 min/day)**
- **gdas 06, 12, 18Z**
  - **v15: prep + anal + fcst = 47.5**
  - **v16: prep + anal + fcst = 67.0 (19.5 minutes longer)**
- **gdas 00Z**
  - **v15: prep + anal + fcst = 48.3**
  - **v16: prep +anal + gldas + fcst = 72.3 (24 minutes longer)**
- **enkf**
  - **v15: eobs + eomg + eupd + ecen + efcs + epos = 53.2**
  - **v16: eobs + ediag + eupd + analdiag + ecen + efcs = 80.7 (27.5 minutes longer)**

COMROT Directory Structure

	GFS v15	GFS v16
gdas	gdas.$PDY/$cyc	gdas.$PDY/$cyc
enkf	enkfgdas.$PDY/$cyc	enkfgdas.$PDY/$cyc
gfs	gfs.$PDY/$cyc	gfs.$PDY/$cyc
waves	multi_1.$PDY	gdaswave.$PDY/$cyc gfswave.$PDY/$cyc rtofs.$PDY

Data Volume in COMROT (in TB, 4 cycles)

Daily totals (Tb)	**GFS v15**	**GFS v16**
gdas.$PDY/$cyc	1.25	0.92
enkfgdas.$PDY/$cyc	23.11	15.65
gfs.$PDY/$cyc	18.63	12.28
gdaswave.$PDY/$cyc	-na-	0.02
gfswave.$PDY/$cyc	0.02 (Multi-1)	0.04
rtofs.$PDY	-na-	0.02
TOTAL Daily Tb	**42.99**	**29.11**

The reduction resulted from the replacement of nemsio with compressed netDF for writing forecast history files

HPSS Archive for operation (GB/cycle), see details here

Daily totals (Tb)	GFS v15	GFS v16	notes
gdas	150	106	
enkfgdas & restart	840	1736	Increase due to IAU
enkfdgas history	1320	512	Reduction due to netCDF
gfs	813	512	Reduction due to netCDF
Multi_1 WAVE	16	60	Resolution, +GDAS, 7 → 16 day
TOTAL	**3139**	**2937**	

Notes:

- GFS v15
  - enkfgdas restart includes recentered increment at one time level.
- GFS v16
  - enkfgdas restart includes recentered increment at three time levels (IAU).
  - enkfgdas history includes original increment and forecast at three time levels

Upstream dependencies

- SSTOI
- SEAICE
- RadarL2
- RAW/SFCSHP
- RTOFS

Downstream dependencies on GDAS

- Q3FY20 - HMON v3.0
- Q3FY20 - URMA v2.8
- Q3FY20 - RAP v5.0
- Q3FY20 - HRRR v5.0
- Q4FY20 - HWRF v13.0
- Q4FY20 - GEFS v12.0
- Q1FY21 - RTOFS

Downstream dependencies on GFS

NHC Guidance
AMSU_ESTIMATION
LEOFS
NOSOFS
ETSS
Verification_grid2grid
NWM
UV Index
GFS-MOS
UKMET
MAG
CDAS2
RCDAS
Verification_grid2obs
ET TRACKER
Vessel IcingMODELS_REALTIME
SDMEDIT
CPCI
POES_PHYRET_SST
GEFS-legacy
HRRR
RAP
NWPS

NBM
Wave Multi 1
GRTOFS
HWRF
HMON
GEFS
HIRESW
Verification_precip
NGAC
HYSPLIT
TC TRACKER
obsproc_prep
NAM
RAW
SREF
ESTOFS_PAC
ESTOFS_ATL
ESTOFS_MIC
CFS CDAS
GLOBAL_FOG
rtgsst (low-res)
rtma/urma/pcpn

Downstream dependencies on WAVE

- Q3FY20 - NWPSv1.3.0
- Q4FY20 - HWRF v13.0
- Q4FY20 - MAG, RTMA/URMA

Bugzilla Status

ID	Summary	Status
892	Standard environment variables set below the j-job level	outstanding
893	Discrepancies between j-job and ex-script names	Updated j-job - **Resolved**
894	Unclear error message from gfs_analysis when missing a gdas atmf file	Include filename in run time printout (2019-09-11) - **Resolved**
861	Remove reference of maksynrc file in dcom in JGLOBAL_TROPCY_QC_RELOC job	**Resolved**
887	Floating point width exceeded in global_gsi.x printout	Problematic code removed (2019-09-11) - **Resolved**
216	need to remove all "GO TO" statement in GFS source codes	Incremental progress

Bugzilla Status

ID	Summary	Status
375	Update the global_extrkr.sh to create the storm directory if non-existence	**Resolved**
889	Subscript out of bounds in gfs_gempak_upapgif / rdbfmsua	**Resolved**
890	Character variable length exceeded in gfs_wafs_blending / wafs_blending	**Resolved**
891	Subscript out of bounds util/exec/webtitle	**Resolved**
895	Add all variables for new pressure levels	**Resolved**

Timeline for

EE2, Testing, Evaluation and Implementation

EE2 Evaluation

- **Assigned to Eric Rogers**
- **He wants to finish 1st evaluation by the end of July at the latest**
- **He will set up a EE2 refresher meeting with the GFS.v16 code managers in the next few weeks.**
- **EE2 Document**
- **EE2 Checklist Template**

GFS.v16 parallels, final decision made on 05/19/2020

Adjusted to meet the evaluation and testing timelines of NCAR GTG, MDL GFSMOS and HWRF

	Machine & Throughput	Period to be covered	Days Total (done by 06/10)	Projected completion Date	Notes
v16retro0e	Dell 3.5 (Prod) 7 cycles/day	03/1/19~ 05/30/19	92 (0)	July 30	If Dell 3.5 Prod is available by May 26
v16retro1e	Dell 3.5 7 cycles/day	06/1/19~ 08/31/19	92 (28)	July 20	MDL and NCAR need data for JJA 2019 by mid-July; HWRF test will start in June.
v16retro2e	Dell 3.0 4 cycles/day	09/1/19 ~ 11/30/19	91 (22)	August 31	
v16retro3e	HERA 7 cycles/day	12/01/19 ~ 03/31/20	121 (48)	To finish DJF by July 20, and entire stream by Aug 31	MDL and NCAR need data for DJF 2019/20 by mid-July
v16retro4e	Dell 3.5 7 cycles/day	04/01/19 ~ 05/18/20	48 (0)	August 31	To start after v16retro1e is completed.
v16rt3	Dell 3.0 Real-time	05/19/20 ~			

GFS V16 Implementation and Evaluation Schedule

- Real-time forecasts start: May 19, 2020
- Retrospective forecasts start: May 19, 2020

- EE2 Coordination meeting: 11 June 2020
- PNS sent to HQ: 18 June 2020
- Retrospective forecasts complete: August 31, 2020
- MEG Evaluation Kickoff webinar: July 23, 2020
- Field Evaluation: August 3, 2020 - September 25, 2020
- MEG Evaluation Briefing: September 24, 2020
- Field Recommendations due: September 28, 2020

- NCEP OD science brief: 6 Oct 2020
- Code Handoff to NCO: 9 Oct 2020
- SPA begins work: 12 Oct 2020
- NCO 30-day parallel: 21 Dec 2020
- NCO OD IT brief: 27 Jan 2021
- Implementation: 3 Feb 2021

VPPP branch GFS v16 Evaluation Plan

Thank You