

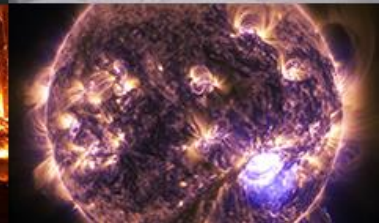
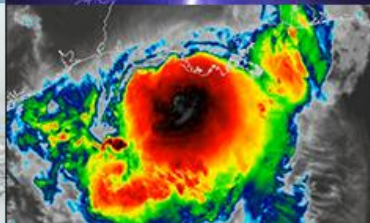


**NATIONAL
WEATHER
SERVICE**

NCEP/EMC Update for WGNE-36

November 4, 2021

Fanglin Yang, NOAA/NWS/NCEP/Environmental Modeling Center



First FV3-based GFS (version 15), Implemented in June 2019

GSM

Spectral
Gaussian
Hydrostatic
64-bit precision



Finite-volume
Cubed-Sphere
non-hydrostatic
32-bit precision

Physics still runs at 64-bit precision

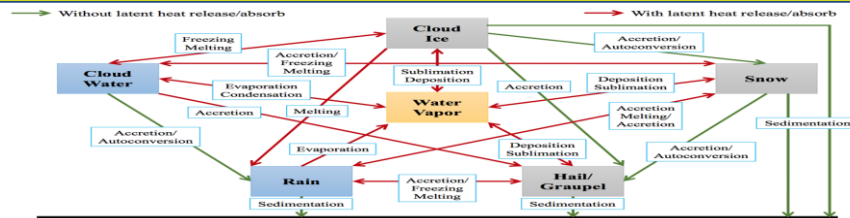
Zhao-Carr MP

Prognostic cloud species: one
total cloud water



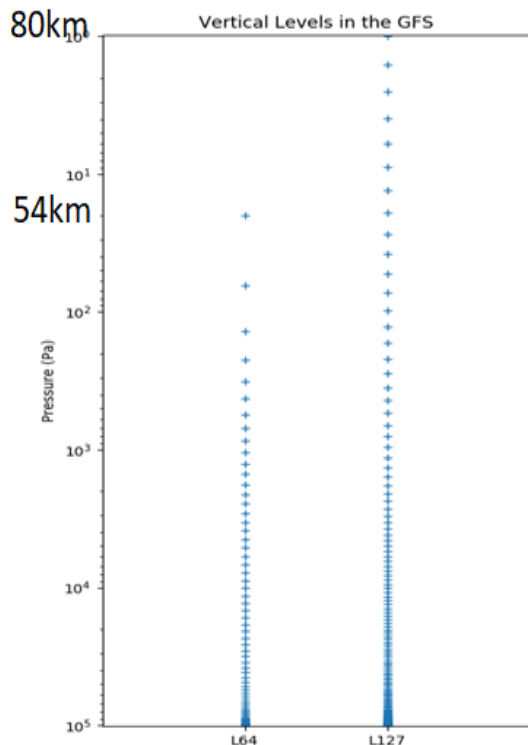
GFDL MP

Prognostics cloud species : five
Liquid, ice, snow, graupel, rain
more sophisticated cloud processes



GFS.v16: 127L Extending to the Mesopause

-- In operation since **March 21, 2021**



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 Model:

One-way coupling of atmospheric model with Global Wave Model (WaveWatch III, Multi_1)

Data Assimilation

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

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

Compressed NetCDF for I/O and Inline Post-Processing

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

compression ratio:

Atmf 3d	5x	(33.6 GB to 6.7 GB),	lossy compression
sfc 2d	2.5x	(2.8 GB to 1.1 GB),	lossless compression

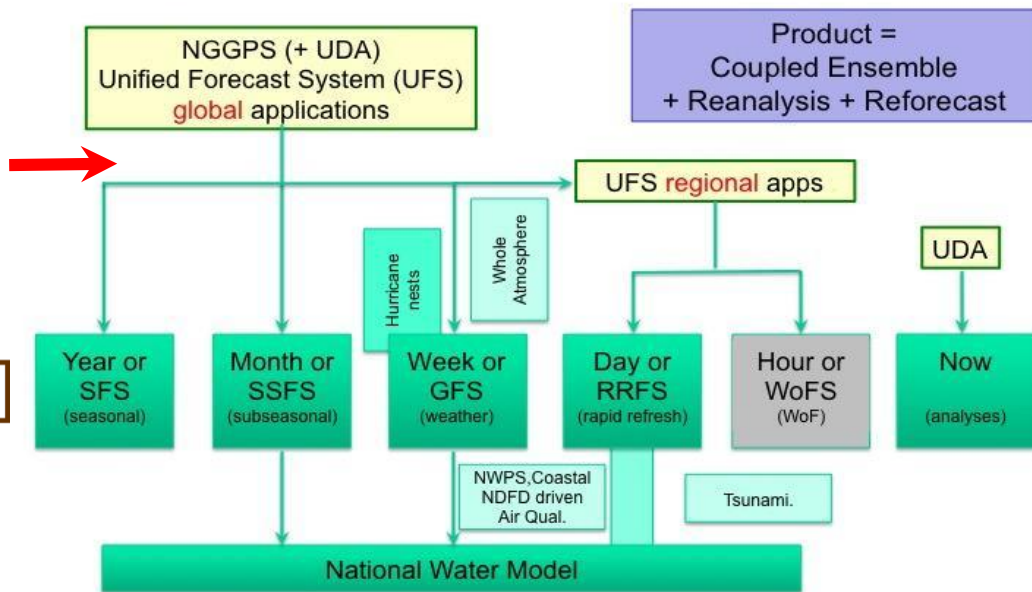
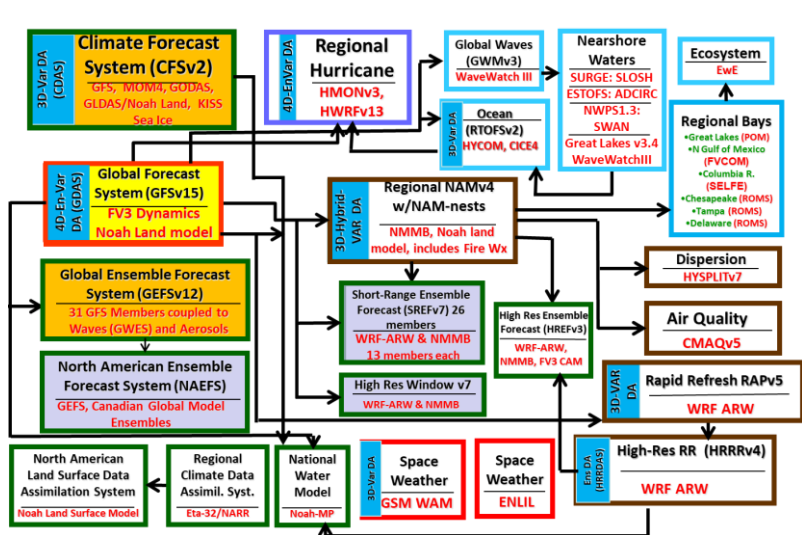
Inline post-processing (post library)

- makes use of forecast data saved in memory for post processing, *reduces I/O activity, and speeds up the entire forecast system*.
- Since lossy compression is applied for writing out forecast history files, *inline post generates more accurate products* than the standalone offline post.

First FV3-based GEFS (version 12)

Components	V11 (Dec. 2015)	V12 (Sept. 2020)
GFS Model	Semi-Lagrangian, 2015 version	FV3 (Finite-Vol Cubed-Sphere) GFSv15.1 version
Physics	GFSv13 package (Zhao-Carr MP)	GFSv15.1 package (GFDL MP)
Initial perturbations	EnKF f06	EnKF f06
Model uncertainty	STTP (Stoch. Total Tend. Pert)	5-scale SPPT and SKEB
Boundary forcing	SST - Climatology relaxation	NSST + 2-tiered SST
Tropical storm	Relocation for all members	No relocation
Horizontal Resolution	T _L 574 (34km)/T _L 382 (55km)	C384 (25km)
Vertical resolution	L64 (hybrid)	L64 (hybrid)
Daily frequency	00, 06, 12 and 18UTC	00, 06, 12 and 18UTC
Forecast length	16 days	16 days, 35 days (00UTC) - Support SubX
Members	Control + 20 pert members	Control + 30 pert members + 1 aerosol member
Output resolution	0.5° x 0.5°	0.25° x 0.25° and 0.5° x 0.5°
Output frequency	3hly for the first 8 days; 6hly for the rest	3hly for the first 10 days; 6hly for the rest
Reforecast	EMC offline – 20 years	30 years (1989-2018)
Implementation	December 2, 2015	September 2020

Target: Simplifying the NCEP Production Suite



UDA: Unified Data assimilation
 SFS: Seasonal Forecast System
 SSFS: Subseasonal Forecast System

GFS: Weather Forecast System
 RRFs: Rapid Refresh Forecast System
 WoFS: Warn on Forecast System



MRW/S2S Global Coupled Model Configuration

Targeted for 2024 implementation

Atmosphere

- FV3 dynamical core
- GFS Physics with GFDL microphysics
- CCM3 physics driver
- C768 (~13km), 127 levels

Ocean

- MOM6 Modular Ocean Model
- 1/4 degree tripolar grid, 75 hybrid levels
- OM4 Set up [[Adcroft, 2019](#)]

Waves

- WAVEWATCH III
- 1/2 degree regular lat/lon grid
- ST4 Physics [[Ardhuin, 2010](#)]

Ice

- CICE6 Los Alamos Sea Ice Model
- 1/4 degree tripolar grid (same as ocean)

Land

- Noah-MP

Atmosphere Composition

- GOCART

Mediator

- ESMF, NUOPC, CMEPS mediator

Physics Updates for GFS.v17 & GEFS.v13 -- Completed



	GFS.v16 (uncoupled)	GFS.v17/GEFS.v13 (coupled)
Cumulus Convection (Shallow & Deep)	sa-SAS	Positive definite mass flux scheme for tracer transport; cellular automaton stochastic convective organization; Improved CAPE
Surface Layer	GFS (Monin-Obukhov similarity theory)	Sea spray parameterization; many other improvements
PBL	sa-TKE-EDMF	Positive definite tracer advection; many other improvements
Orographic Gravity Wave Drag Small-scale gravity-wave drag (new) Turbulence Form drag (new)	Kim & Arakawa (1995)	uGWP.v1 Kim and Doyle (2005) Tsiringakis et al. (2017) Beljaars et al. (2004)
Non-orographic GWD	uGWP v0 (Yudin et al., 2020)	uGWP.v1 (Yudin et al., 2021)
Land	Noah LSM	NOAH MP and VIIRS veg type
Aerosol	OPAC (5 types, 5x5-deg resolution)	MERRA2

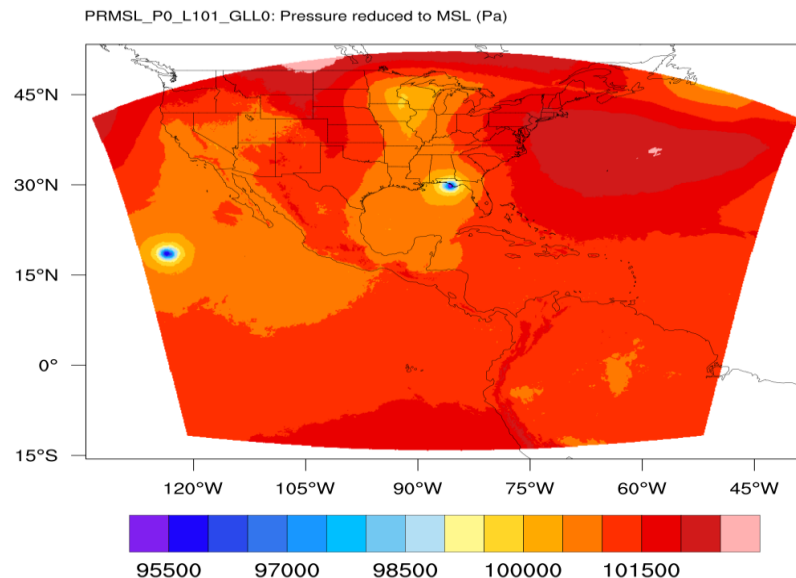
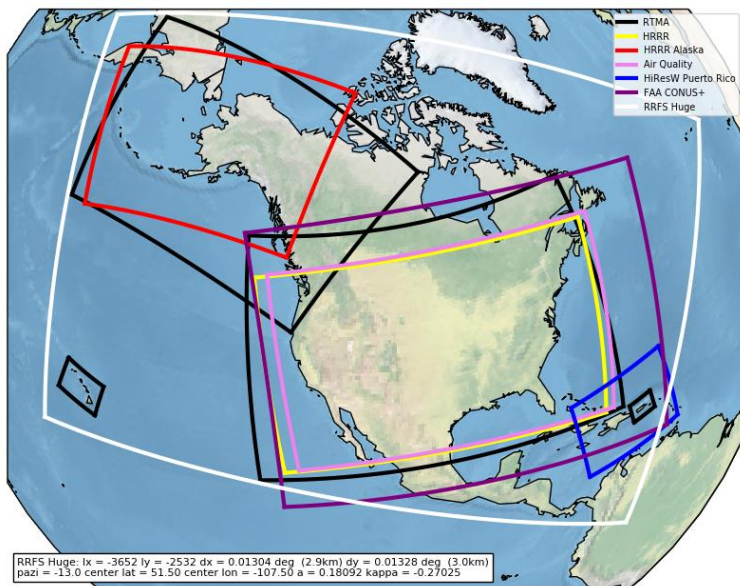
Physics Updates for GFS.v17 & GEFS.v13 -- Under Testing and Evaluation

	GFS.v16	GFS.v17/GEFS.v13
Microphysics	GFDL MP	Thompson MP (with optional interaction with MERRA2 aerosols)
Radiation (LW & SW)	RRTMG	RRTMGp
Lake (water)	NSST	FLAKE + NSST

SRW/CAM Regional Applications

Replacing NAM, RAP, HRRR etc with Rapid Refresh Forecast System (RRFS) Targeted for 2023/2024 implementation

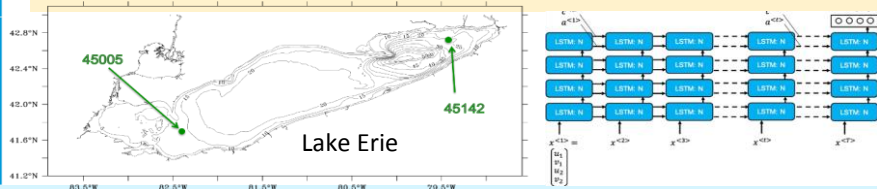
Replace HWRF and HMON with Hurricane Analysis and Forecast System (HAFS) Targeted for 2023 implementation



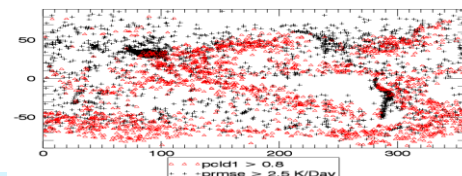
AI/ML Activities at NCEP/EMC

Observations	Data Assimilation	Forecast	Post/Product
Radiosonde observation Pre-processing	Physics Emulation (in particular for TL/AD in 4DVar Hybrids, Forecast Sensitivity, and FSOI)	Accelerated Tracer Transport	Wave Systems
Satellite Data Thinning	Improved Background Covariances	Atmospheric Chemistry Emulator	Rip Currents
Data Control Control		Physics Suite Emulation	Air Quality Bias Correction
		Radiation Parameterizations	Sub-Seasonal/ Seasonal forecast products
		Great Lake Wave Emulation	

Replacing WW3 in the Great Lakes with AI/ML



Radiation Emulation



Locations of higher NN HRLW errors (red triangles) and high cloudiness (black crosses)



Next Supercomputer WCOSS2, In Operation in 2022

Locations

- Manassas, VA
- Phoenix, AZ

Performance Requirements

- 99.9% Operational Use Time
- 99.0% On-time Product Generation
- 99.0% Development Use Time
- 99.0% System Availability

Configuration

- Cray EX system
- **12.1 PetaFlops**
- Multi-tiered storage
 - 2 flash filesystems each with...
 - 614 TB usable storage
 - 300 GB/s bandwidth
 - 2 HDD filesystems each with...
 - 12.5 PB usable storage
 - 200 GB/s bandwidth
 - Total aggregate - 26.2PB at 1TB/s
- Lustre parallel filesystem
- PBSpro workload manager
- Eclflow scheduler

- Compute nodes
 - **2,560 nodes (60 spare)**
 - 327,680 cores
 - **128 cores/node**
 - 1.3 PB of memory
 - 512 GB/node
- Pre/post-processing nodes
 - 132 nodes (4 spare)
 - 8,448 cores
 - 64 cores/node
 - 132 TB of memory
 - 1TB/node
- 200Gb/s Slingshot interconnect



Thanks You

