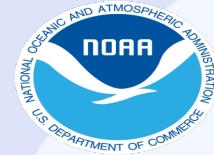




NGGPS



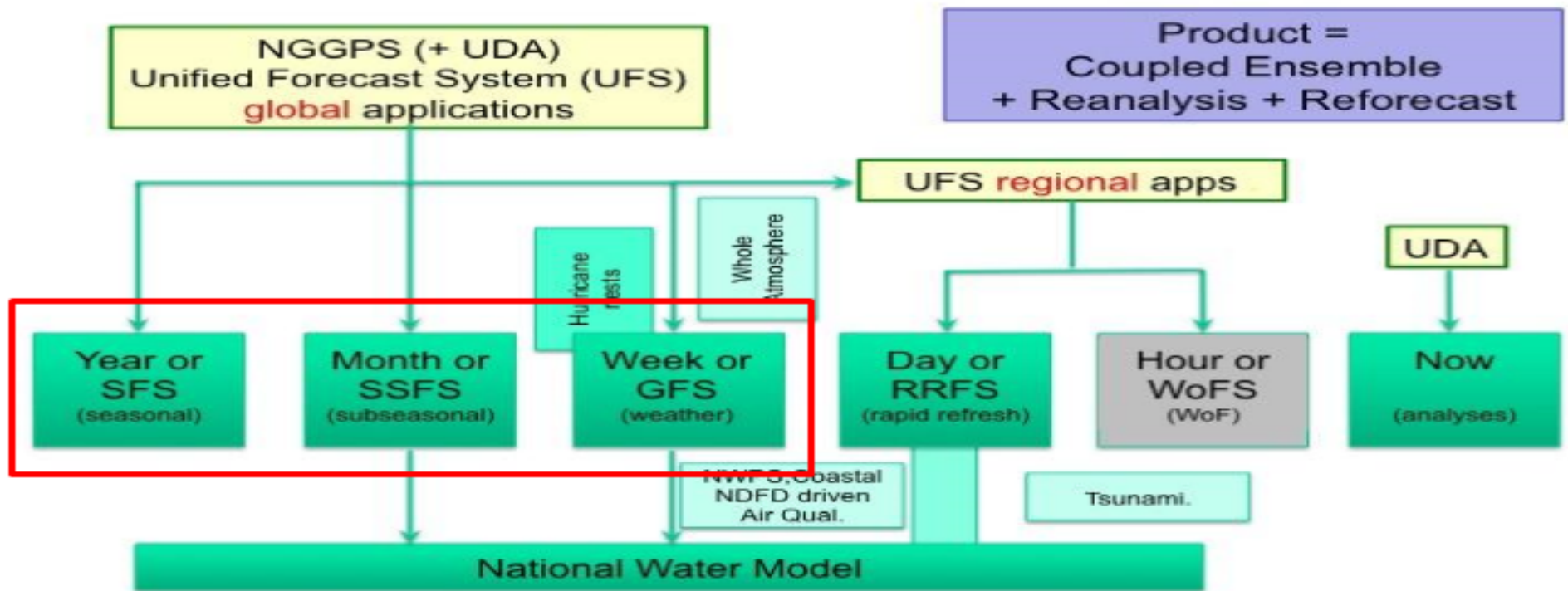
Unified Forecast System: Advancing NCEP Operational Global Modeling Systems for 2019 and Beyond

Vijay Tallapragada

*Chief, Modeling and Data Assimilation Branch
NOAA/NWS/NCEP/EMC*

**HFIP Annual Meeting
Miami, FL, Nov 4-6, 2019**

Moving Towards Unified Forecast System for NWS Operational Applications



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

GFS.v15.1 Transitioned to Operations on June 12, 2019*

Finite-Volume Cubed-Sphere Dynamical Core (FV3)

GFDL Microphysics Scheme with Multiple Prognostic Cloud Hydrometers

Configuration:

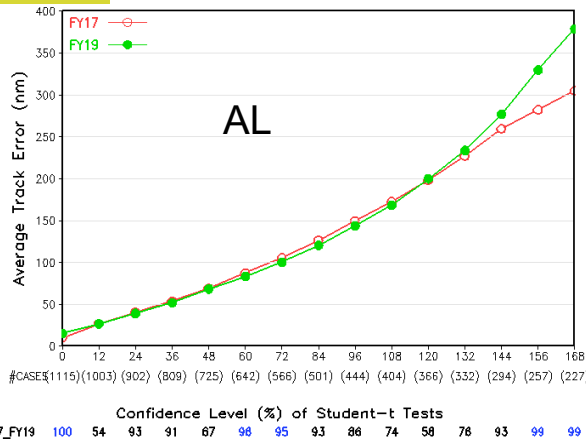
- **Resolution: C768L64 (~13km/64 Layers, 54km top at 0.2 hPa)**
- **Data Assimilation: C384 (~25km, 80 member ensemble, Advanced Stochastic Physics)**
- **Uniform resolution for all 16 days of forecast**
- **Dycore: FV3, non-hydrostatic, single precision**
- **Physics: GFS Physics + GFDL Cloud Microphysics, double precision**

** GFS v14 was run along with FV3 based GFSv15.1 through Sep. 30 before sunsetting from ops.*

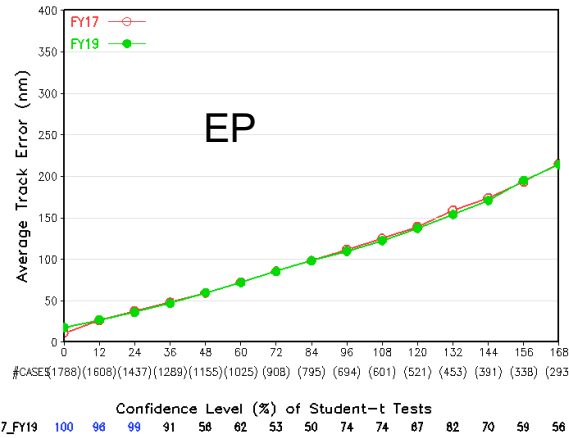
Operational GFS (v15) vs Legacy GFS (v14): Track and Intensity Errors for 2015-2018

Track

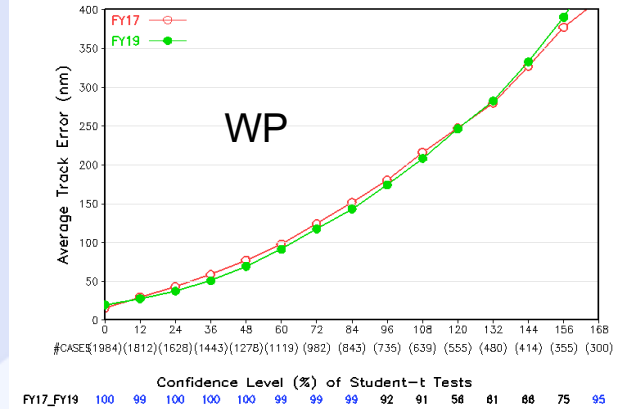
Hurricane Track Errors – Atlantic 20152018
20150601__20180919__4cyc



Hurricane Track Errors – East-Pacific 20152018
20150601__20180919__4cyc

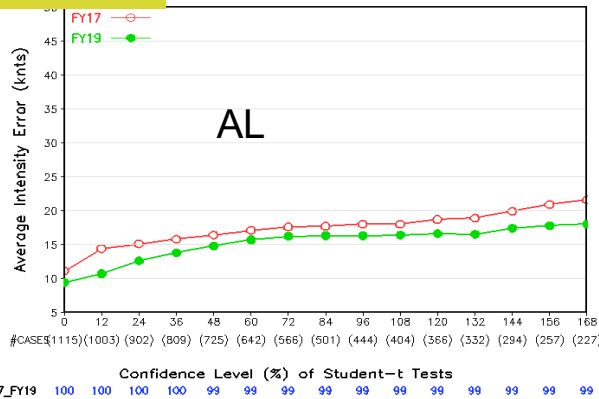


Hurricane Track Errors – West-Pacific 20152018
20150601__20180919__4cyc

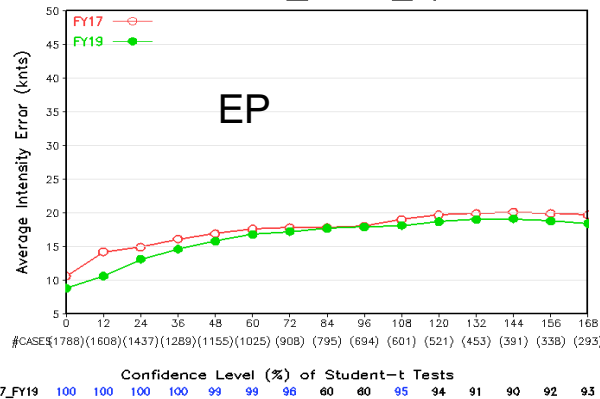


Intensity

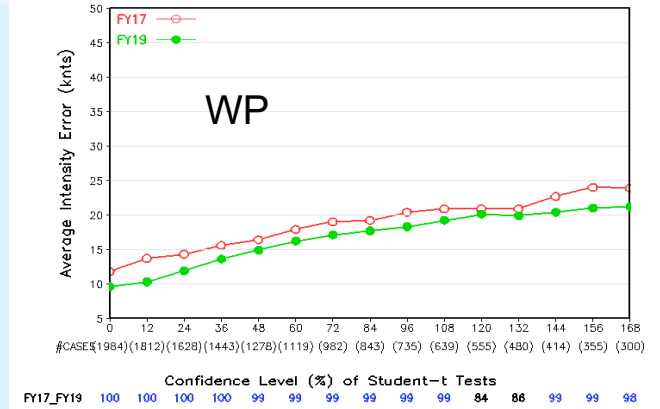
Hurricane Intensity Errors – Atlantic 20152018
20150601__20180919__4cyc



Hurricane Intensity Errors – East-Pacific 20152018
20150601__20180919__4cyc



Hurricane Intensity Errors – West-Pacific 20152018
20150601__20180919__4cyc



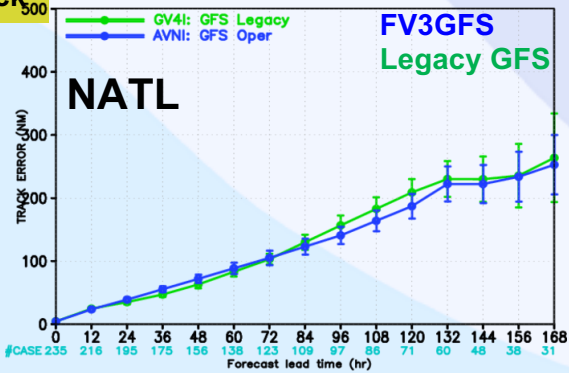


Operational GFS (v15) vs Legacy GFS (v14): Track and Intensity Errors for June-September 2019 (Interpolated)

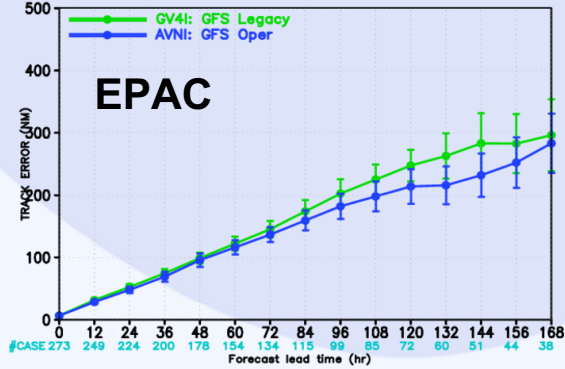


Track

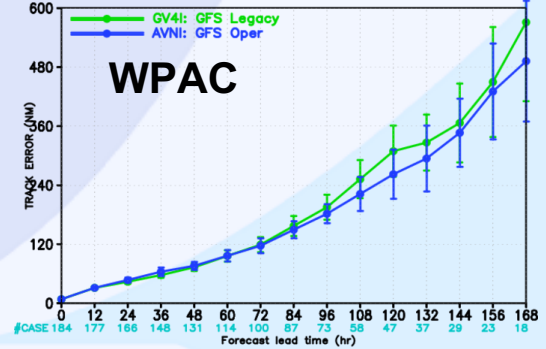
MODEL FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2019



MODEL FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR EASTERN PACIFIC BASIN 2019

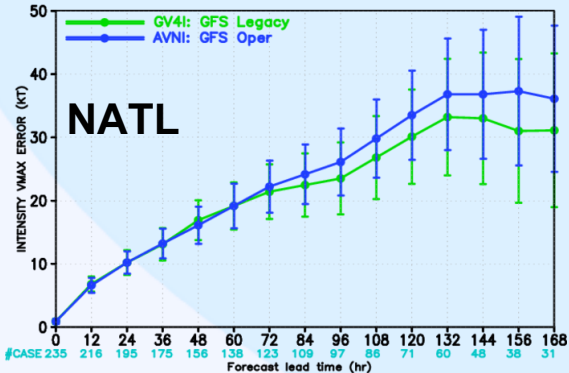


MODEL FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR WESTERN PACIFIC BASIN 2019

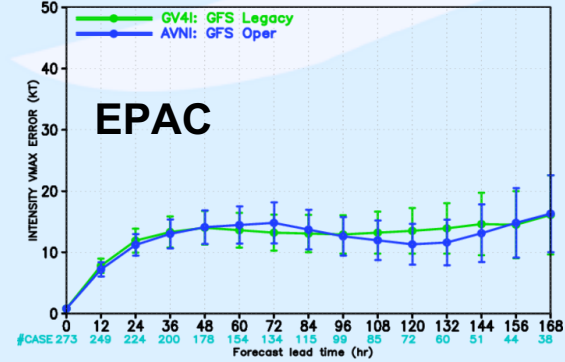


Intensity

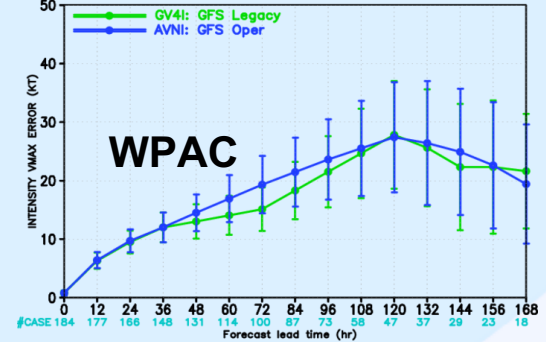
MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2019



MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR EASTERN PACIFIC BASIN 2019



MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR WESTERN PACIFIC BASIN 2019



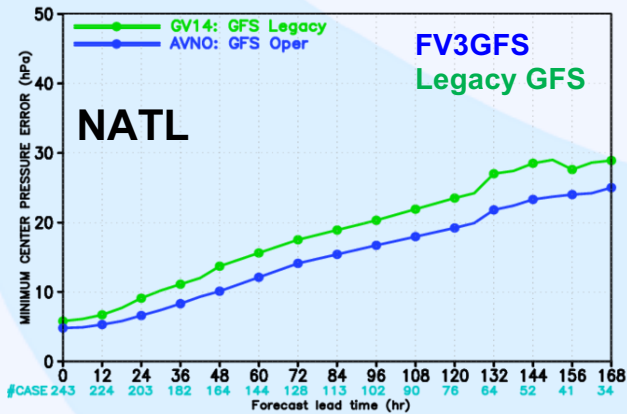


Operational GFS (v15) vs Legacy GFS (v14): MSLP Errors for June-September 2019

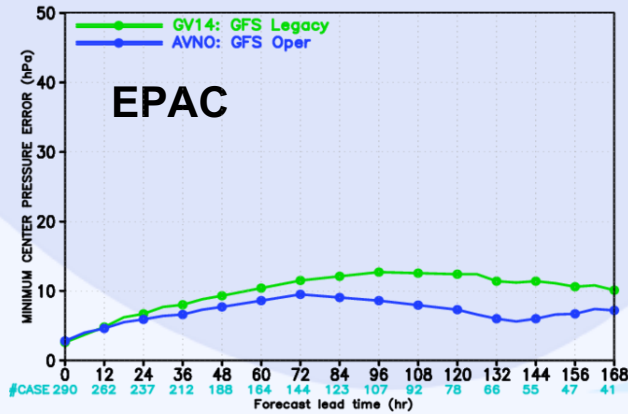


MSLP

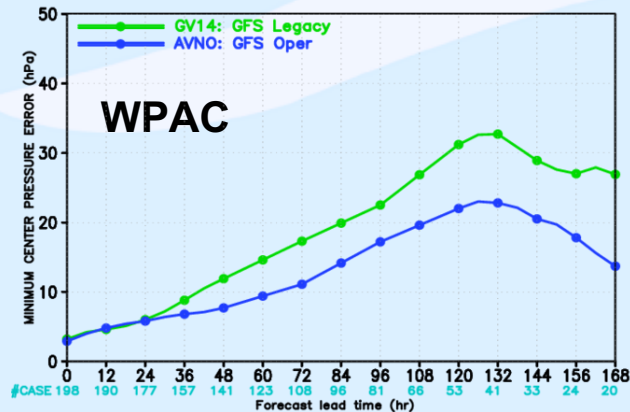
MODEL FORECAST – MINIMUM CENTER PRESSURE ERROR (hPa) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2019



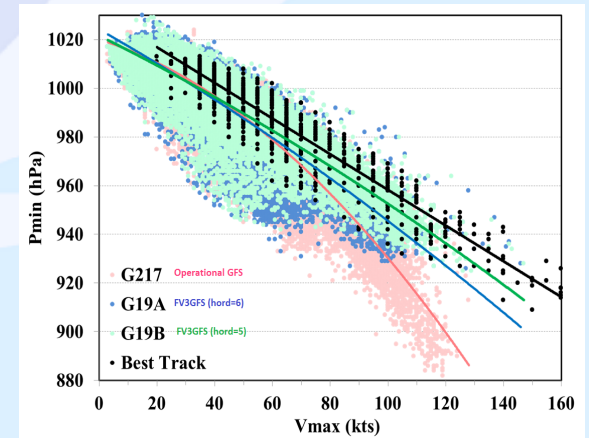
MODEL FORECAST – MINIMUM CENTER PRESSURE ERROR (hPa) STATISTICS
VERIFICATION FOR EASTERN PACIFIC BASIN 2019



MODEL FORECAST – MINIMUM CENTER PRESSURE ERROR (hPa) STATISTICS
VERIFICATION FOR WESTERN PACIFIC BASIN 2019



Better w-p relationship



GFS upgrades 2019-2021

GFSv15.1 (FV3GFS) became operational on June 12, 2019, providing guidance for most of the hurricane season along with old spectral GFS (GFSv14) through 30th September 2019.

GFSv15.1 has no TC Relocation (based on earlier study by Brennan et al., 2017)

There are noticeable differences in the GFSv15.1 model performance based on retrospective evaluation compared to real-time.

GFSv15.2 (with additional DA changes including data from GOES-17, METOP-C, KOMPSAT and additional buoys, and possibly COSMIC-2 when available) is scheduled for implementation on Nov. 6, 2019.

Next major GFS upgrade (GFSv16) planned for Q2FY21 before the next WCOSS moratorium starts in Jan 2021.

No model upgrades in 2021, next opportunity is on new WCOSS in 2022.

GFSv15.2: DA Upgrades in Nov. 2019

- **Assimilate GOES-17 AMVs**
- **Assimilate Metop-C AMSU and MHS**
- **Assimilate KOMPSAT-5 (GPS-RO)**
- **Assimilate buoyb sst data**
- **Assimilate VIIRS AMV data in the new format**
- **Improved GTG products for Aviation**
- **Improved land-sea mask for various products**
- **Add more bufr stations**
- **Merge Vessel Icing with UP**
- **Improved NSST to mitigate cold temperature biases over small lakes**

GFS V16: Major Upgrades to Deterministic Global Model

Model resolution:

- Increased vertical resolution from 64 to 127 vertical Levels and raise model top from 54 km to 80 km; ~~Increased horizontal resolution from 13 km to 10 km (depending on operational resources)~~

~~Dynamics: New advection algorithms from GFDL~~

Advanced physics chosen from Physics Test Plan:

- PBL/turbulence: K-EDMF => sa-TKE-EDMF
- ~~• Land surface: Noah => Noah-MP~~
- Gravity Wave Drag: => unified gravity-wave-drag
- Radiation: updates to cloud-overlap assumptions,
- Microphysics: Improvements to GFDL MP

Coupling to WaveWatchIII

- ~~• Two-way interactive~~ **One-way** coupling of atmospheric model with Global Wave Model (GWM)

Data Assimilation Upgrades:

- Local Ensemble Kalman Filter (LETKF), including early cycle updates in support of GEFS
- 4-Dimensional Incremental Analysis Update (4DIAU)
- Stochastic Kinetic Energy Backscatter (SKEB) based land surface perturbations
- Stratospheric humidity increments
- Improved Near Surface Sea Temperature (NSST) analysis
- Land Data Assimilation
- Shifting and Lagging Ensemble Members to expand ensemble size
- Improved cloud analysis
- Delz increments

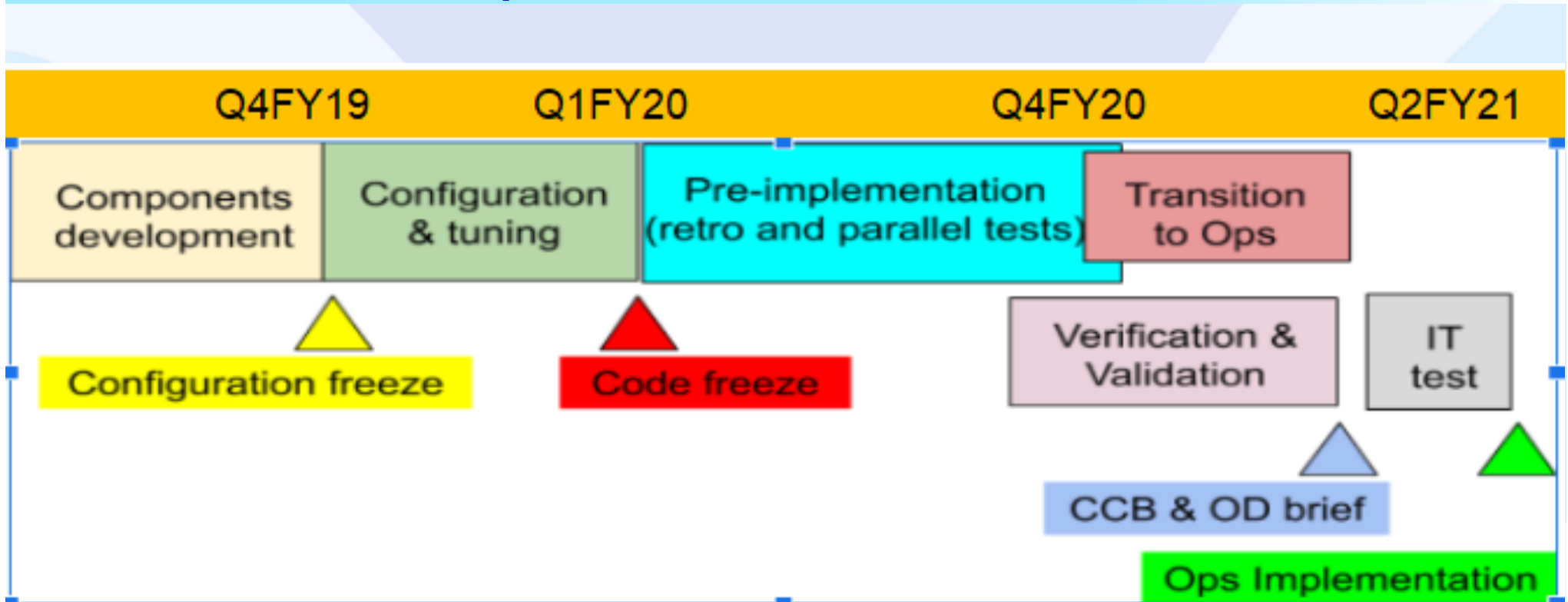
PHYSICS SUITES ASSESSED FOR POSSIBLE GFSv16 IMPLEMENTATION

	<u>Suite 1</u> <u>(GFS v15)</u>	<u>Suite 2</u>	<u>Suite 3</u>	<u>Suite 4</u>
Deep convection	sa-SAS	sa-SAS	sa-CS	sa/aa-GF
Shallow convection	sa-MF	sa-MF	sa-MF	MYNN-EDMF and sa GF
Microphysics	GFDL	GFDL	aa-MG3	aa-Thompson
PBL/Turbulence	K-EDMF	sa-TKE-EDMF	K-EDMF	MYNN-EDMF
Land Surface Model	Noah	Noah	Noah	RUC

Accelerate inclusion of RRTMG changes, UGWD, Noah-MP for GFSv16 prototype

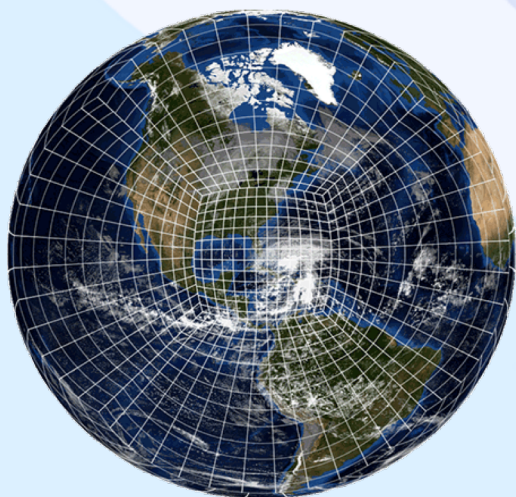
*sa = Scale-aware
*aa = aerosol aware

GFS V16 Implementation Schedule



Sub-Seasonal Forecast System (GEFS v12)

Global Ensemble Forecast System GEFS v12

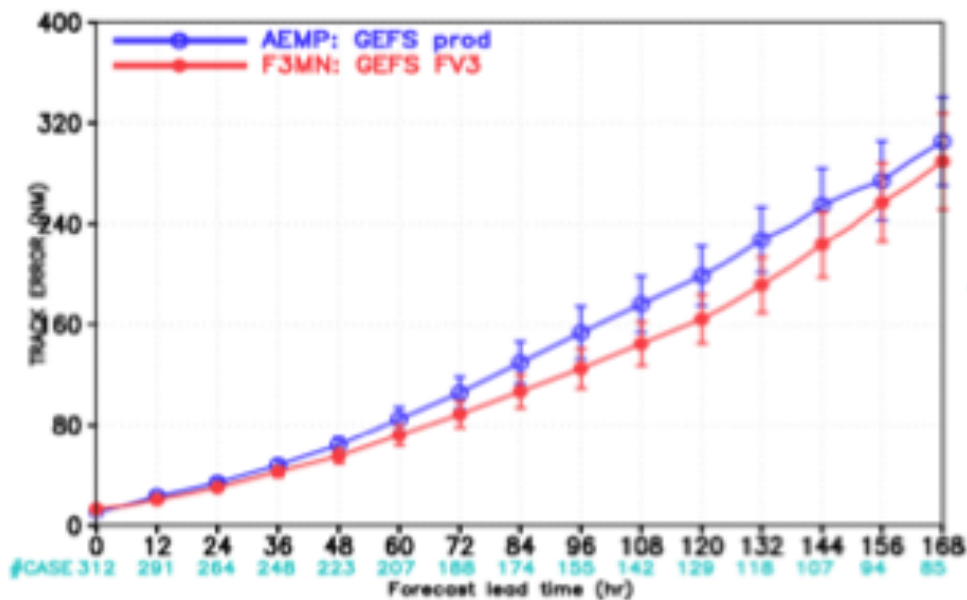


- Configuration
 - C384L64 (~25km); 35 days forecast
 - 31 members, 4 cycles/day
 - Coupling to waves and chemistry
- Q3FY18: Start to produce 20 years (1999-2018) reanalysis → completed
- Q1FY19: Start to produce 30 years (1989-2018) reforecast → 80% complete
- Q4FY19: Start to produce retrospective runs (2-years) → 70% complete
- Q2FY20: Start users evaluation
- **Q4FY20: Implement FV3GEFS operational version (v12)**

Tropical cyclone track forecast (2017 and 2018)

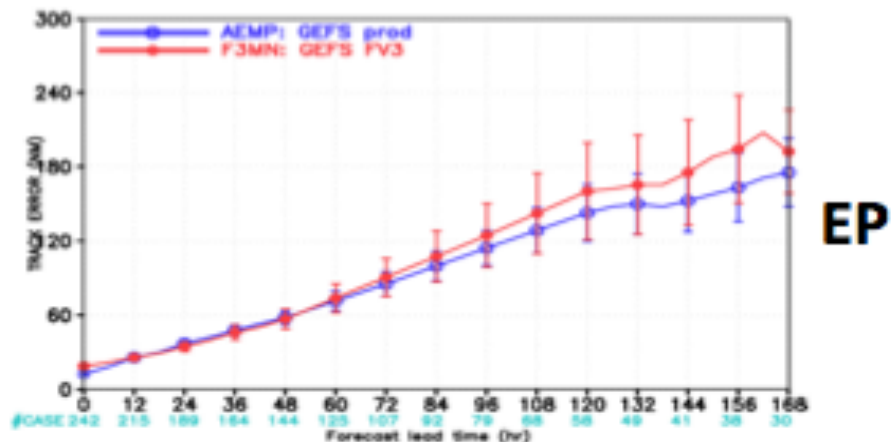
Atlantic

MODEL FORECAST – TRACK ERROR (NM) STATISTICS
GEFS prod/FV3 Atlantic 2017–2018



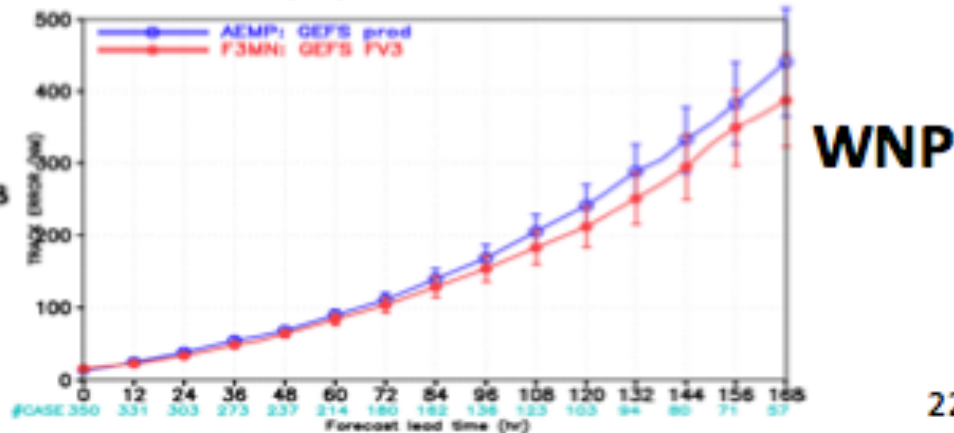
Retrospective forecasts for GEFSv12

MODEL FORECAST – TRACK ERROR (NM) STATISTICS
GEFS prod/FV3 East Pacific 2017–2018



EP

MODEL FORECAST – TRACK ERROR (NM) STATISTICS
GEFS prod/FV3 West Pacific 2017–2018

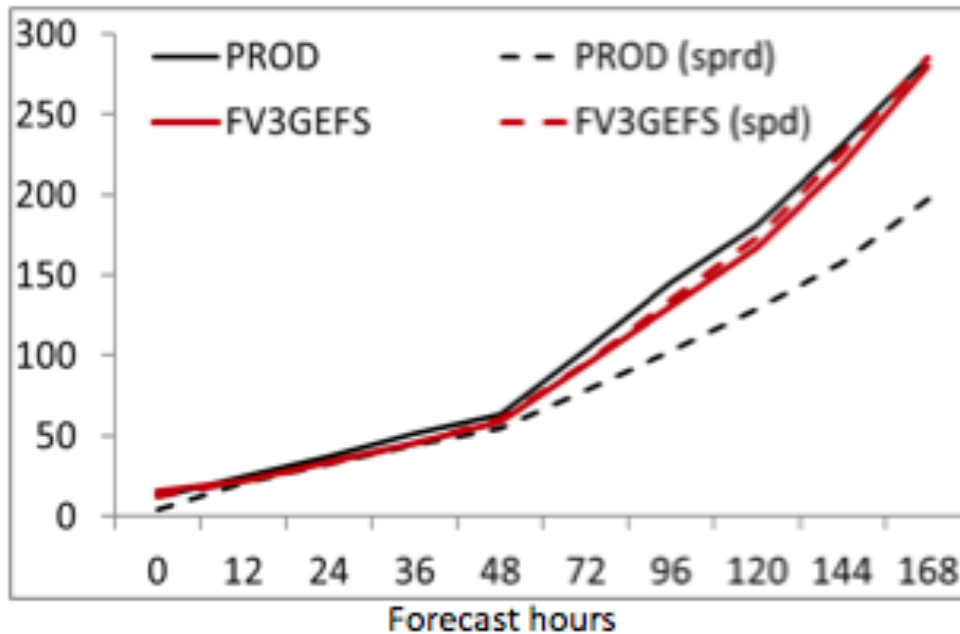


WNP

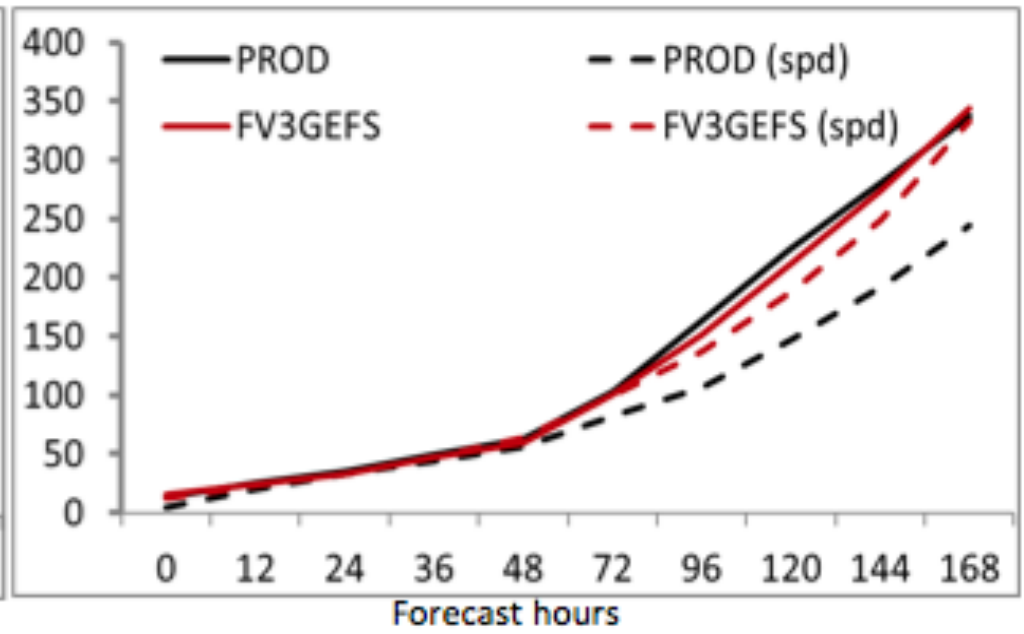


Track forecast error and spread (WNP/EP/ATL)

2017



2018

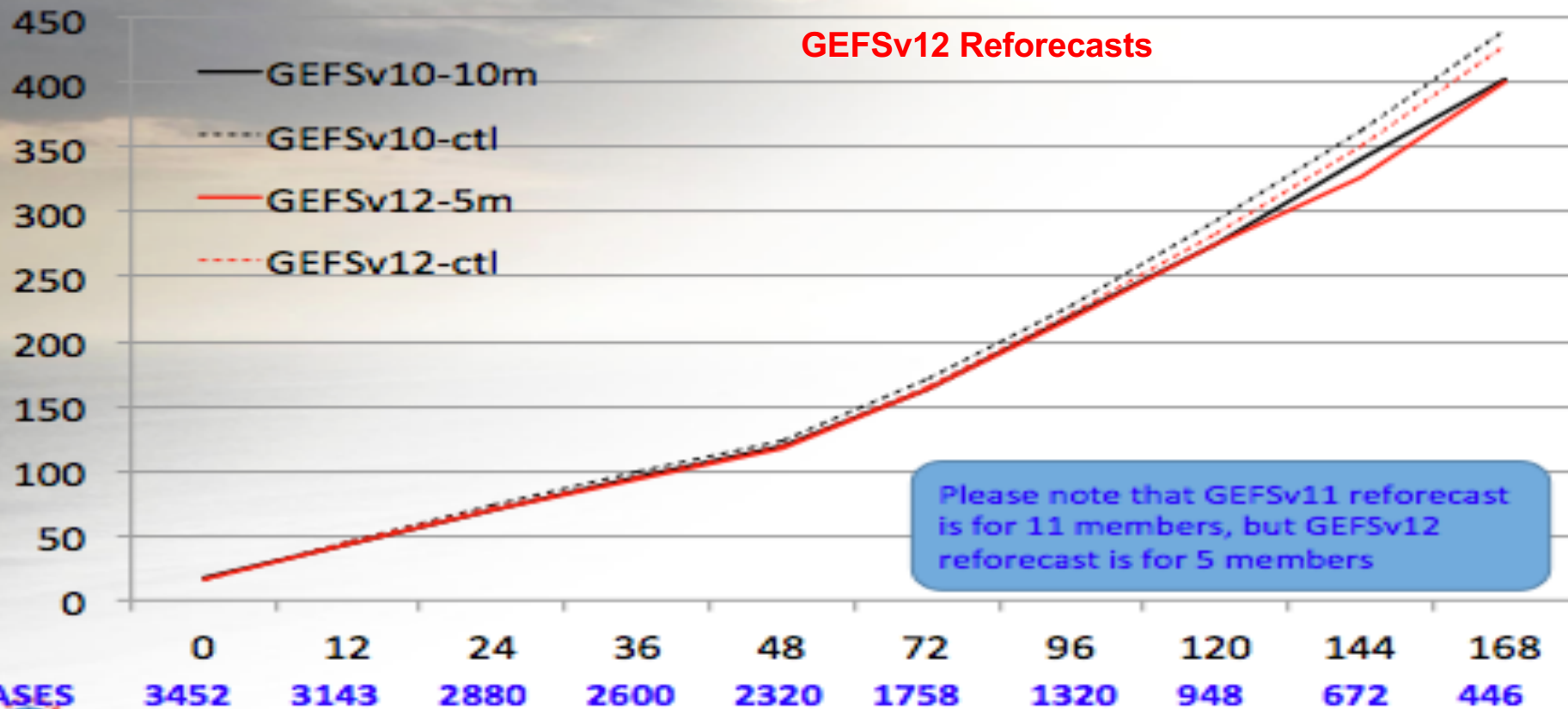


CASES 297 268 241 210 184 141 106 82 66 53 CASES 328 301 268 238 209 157 117 89 66 51

Retrospective forecasts for GEFSv12



TS track forecast errors (NM) for GEFSv12 11 years reforecasts (1989-1999)



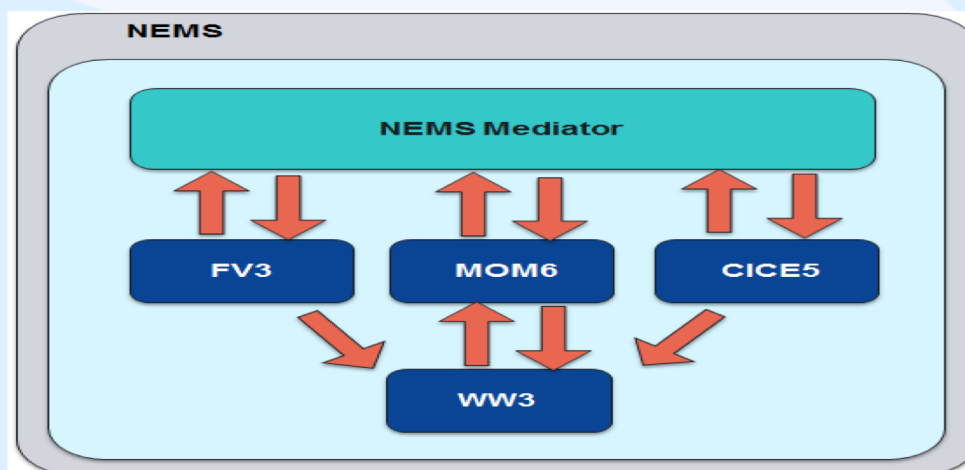
Coupled UFS Applications for sub-seasonal and seasonal predictions

GEFS (Ensemble) v13: First coupled system for sub-seasonal predictions

- FV3+MOM6+CICE5+WW3+GOCART Coupled Model
- Advanced Physics
- **FY23: Implement GEFS v13.0**
- **Combine with GFSv17**

Seasonal Forecast System (SFS v1.0/CFS v3)

- Fully coupled Unified Forecast System
- Seasonal ensemble forecasts with reanalysis and reforecasts
- Fully coupled DA
- **FY24: Implement SFS v1.0**



Plan for GFS.v17 and GEFS.v13

- × Coupled NWP
- × Merge GEFS with GFS
- × Use JEDI to replace GSI
- × Weakly coupled DA
- × Implementation in 2023



***A very ambitious plan
A steep mountain to climb***

Questions?

Thank You