Implementation Plans for FV3 based GFS and GEFS in NEMS

Status Update

TCORF/IHC, Miami, FL, 3/15/2017

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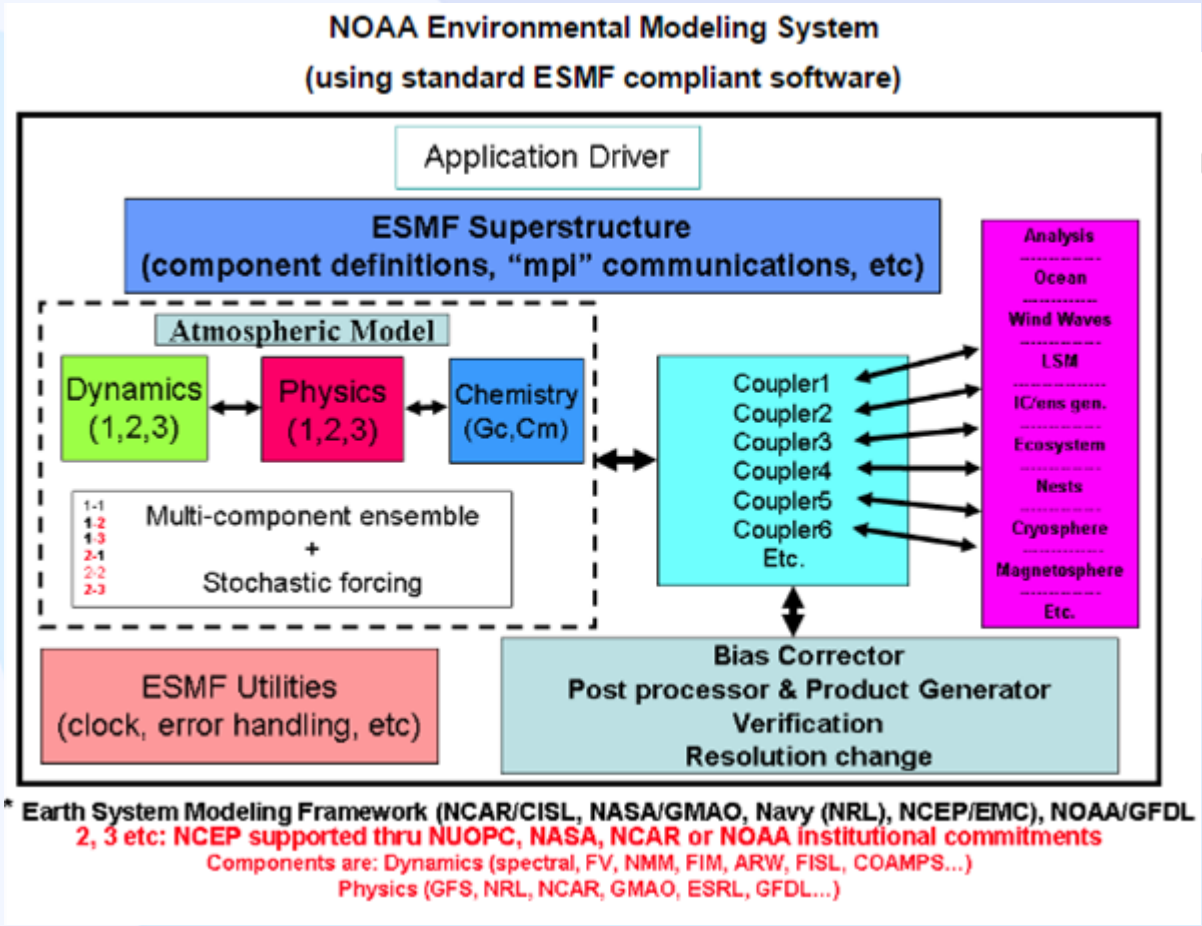
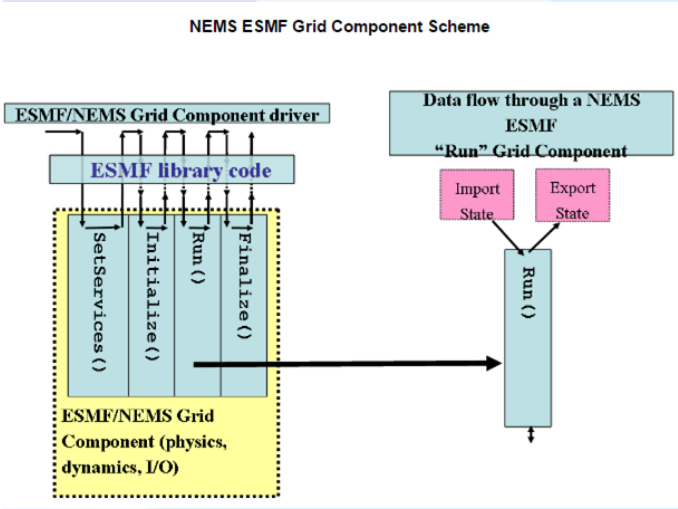
Unified Modeling Infrastructure using ESMF/NUOPC





Write component supports multiple I/O formats:

NEMSIO GRIB2 NETCDF

Many NCEP Global and Regional Modeling Applications migrated to NEMS superstructure

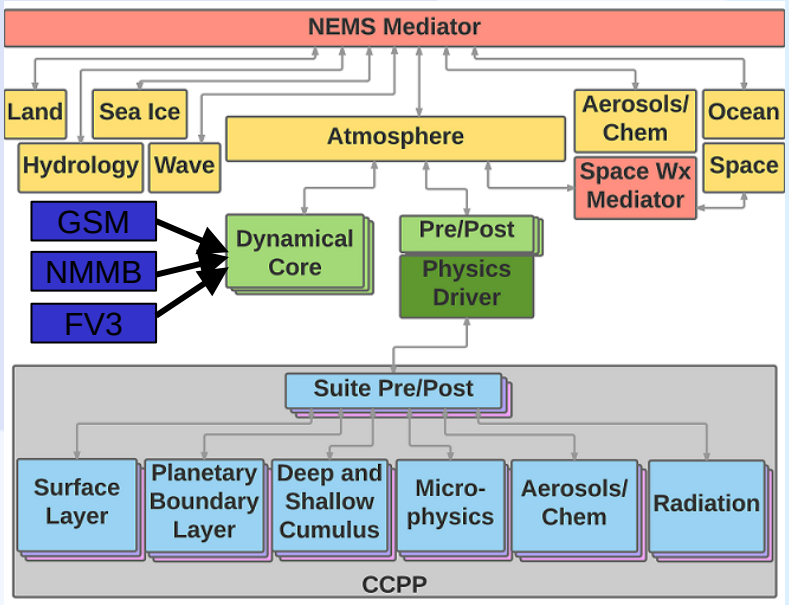
NAM NGAC GSM HMON FV3GFS UGCS

GDAS/GFS in NEMS

(*NOAA Environmental Modeling System)*

- Shared, portable, high performance software superstructure and infrastructure
- Common superstructure for all NCEP models.
- Modularize large pieces of the models
- Divide atmospheric models down into Dynamics and Physics components.
- Take history file I/O outside the science parts into a common Write component.
- Keep science code and parallelization codes same as before.

NEMS Component Schematic



Higly Efficient Infrastructure:

(Significant speed-up of NEMS GSM w/77 nodes)

- Use **gmalloc** library for better malloc/free performance (reduced runtime from **6400+ to 5700 seconds**)
- Recode the **I/O** for the quilts (reduced runtime from **5700 seconds to 5100+ seconds**)
- Replace ESMF DEGMM with **MKL DGEMM** (reduced runtime from **5100 seconds to 4300** seconds)

Major science issues addressed in Q3FY17 GFS Upgrades

Surface Parameters (Land Surface Upgrades):

- Cold temperature bias over snow
  - » Alaska, NW, NE
- Stable boundary
- Land-Atmosphere Decoupling
- Snow albedo too large

- **IGBP 20-type land classifications and STASGO 19 type soil classifications**
- **New MODIS-based snow free and max snow albedo**
- **Diurnal albedo treatment**
- **Unify snow cover and albedo between radiation driver and Noah LSM**
- **Fix excessive cooling of T2m during sunset**
- **Increase ground heat flux under the deep snow**

Precipitation (Convection Scheme Upgrades):

- "socialist" rain (too much drizzle)
- "popcorn" precip in western US
- convective fraction consistent w/resolution

Scale/aerosol-aware, parameterization
Decreased rain conversion rate above freezing level.
Update convective adjustment time in deep convection
Update cloud base mass flux in shallow convection scheme
Additional trigger based on CIN
Enhanced convective cloudiness

SST (Replace RTGSST with new NSST):

- Oceanic vertical temperature structure near surface due to the diurnal warming and sub-layer cooling physics processes

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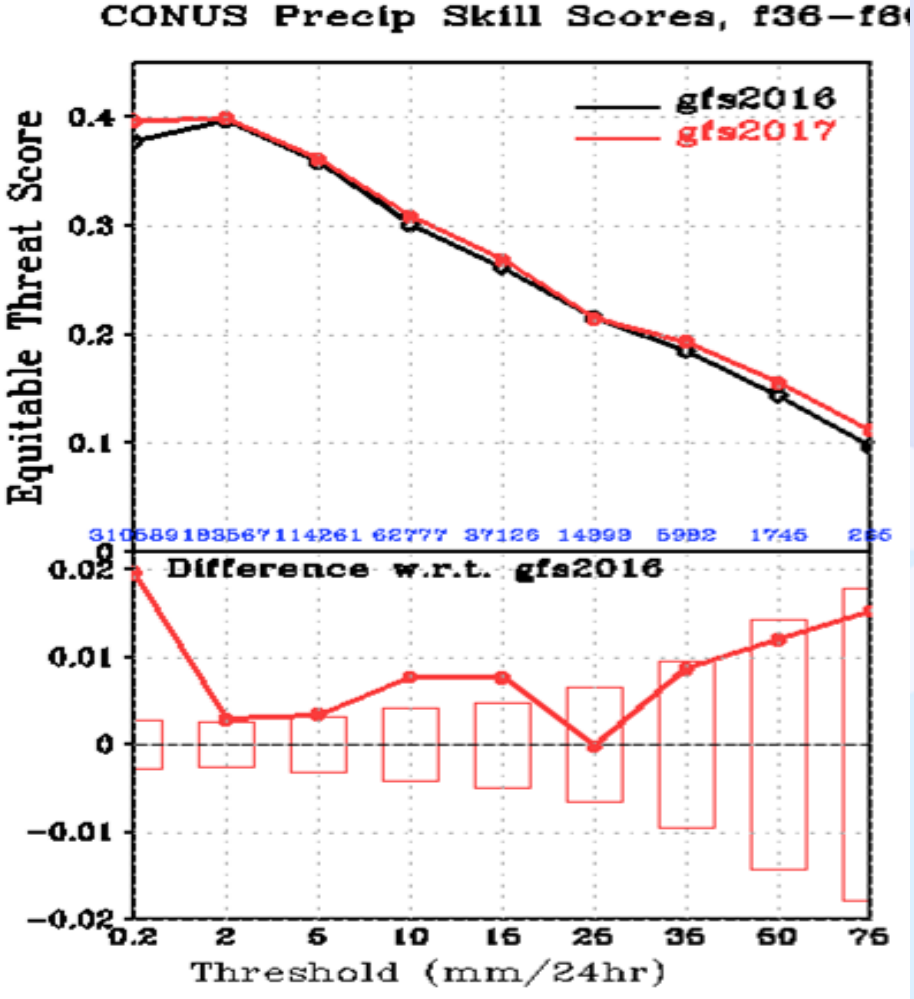
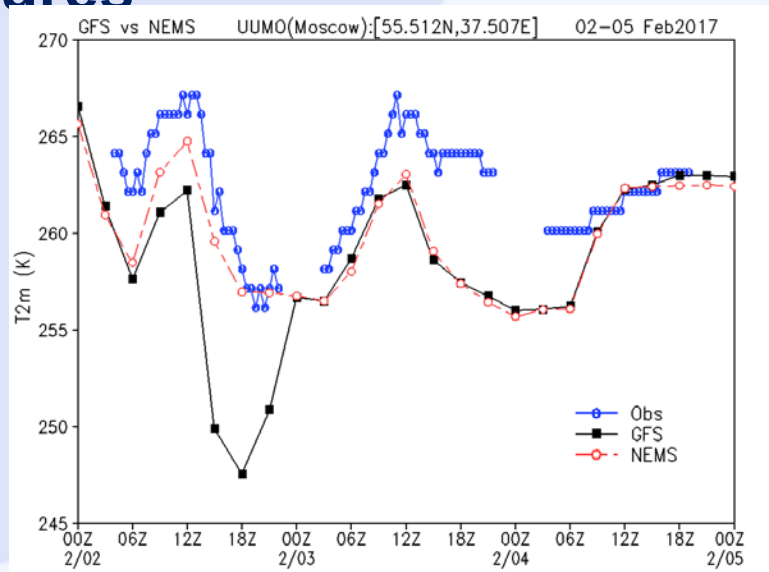
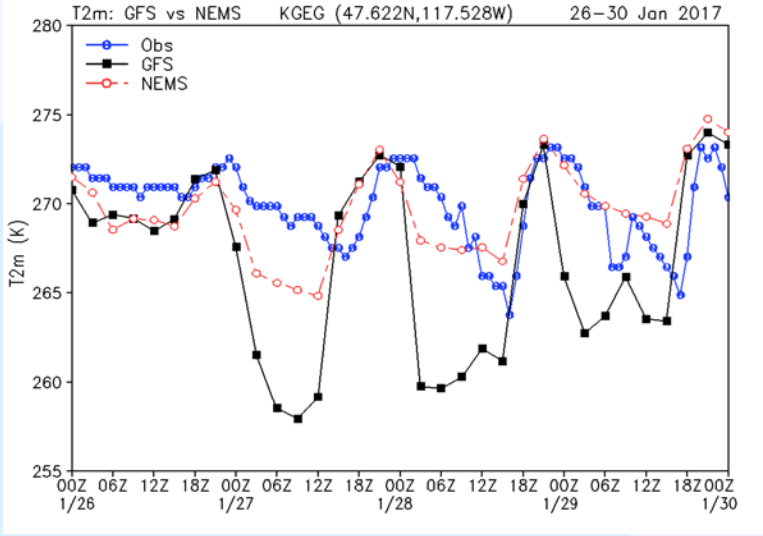
Significant improvement in CONUS Precip Skill Scores and 2m temperatures

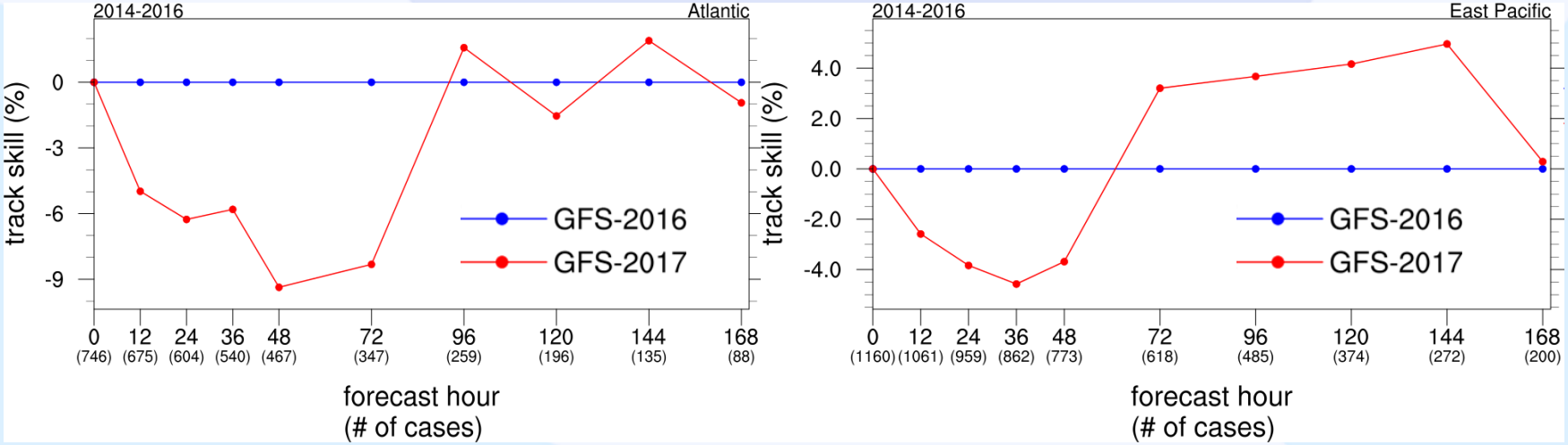




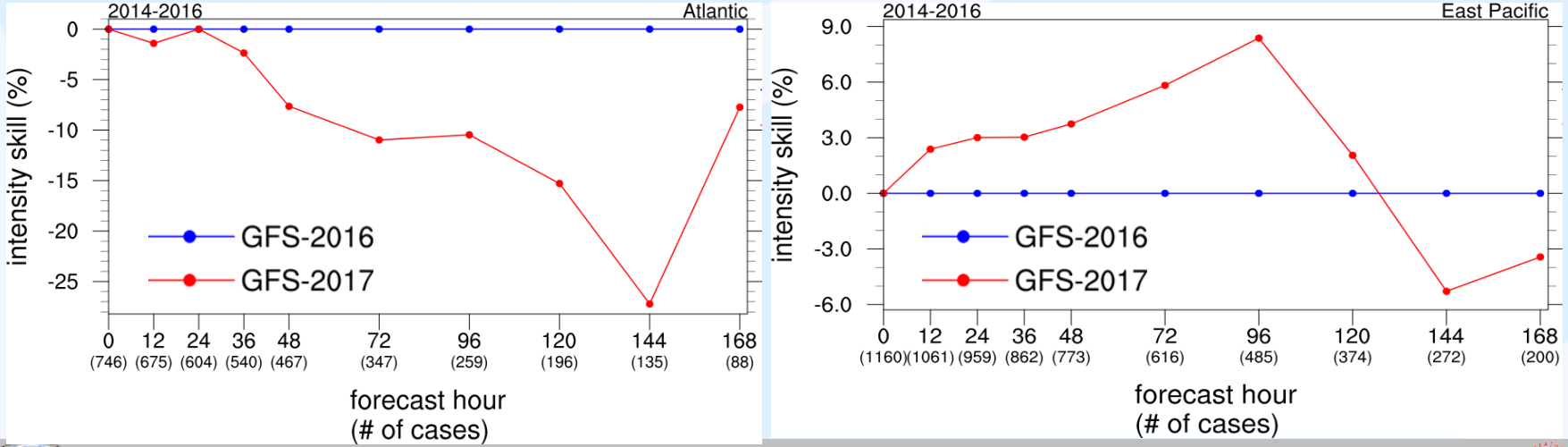


NHC Evaluation of Hurricane Forecasts

Skill relative to GFS-2016

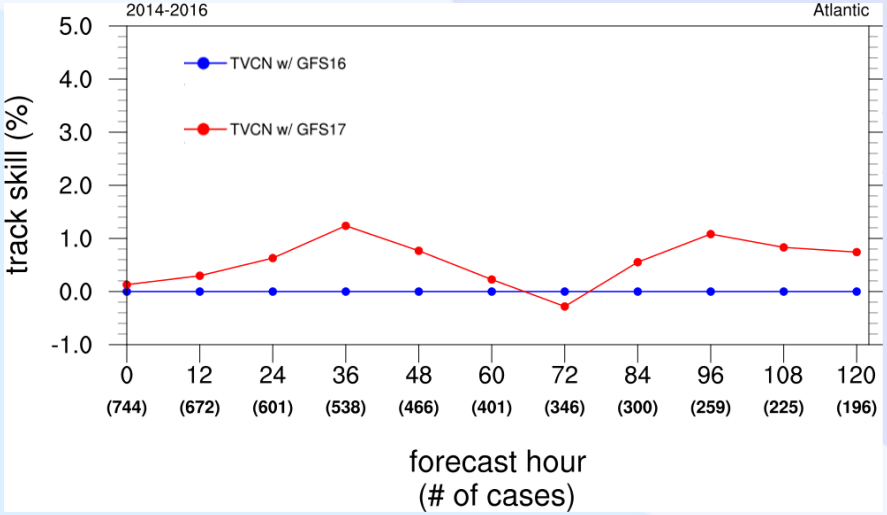


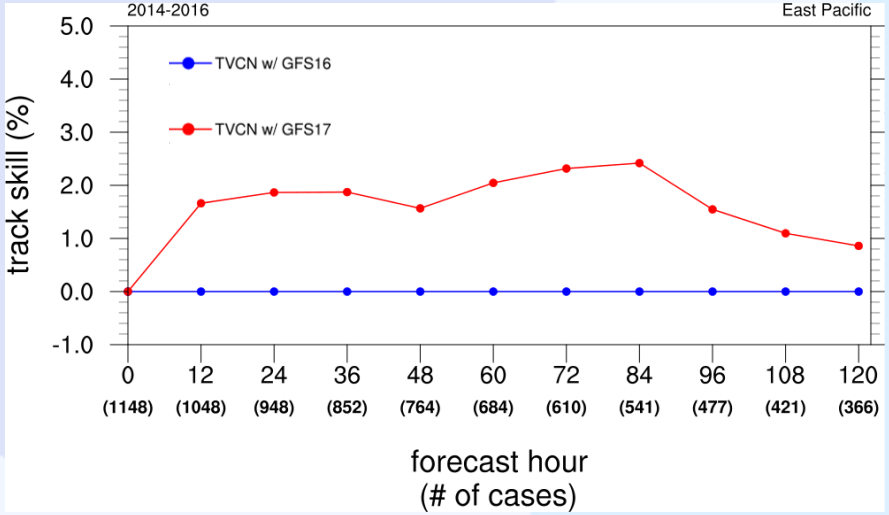
About 9-10% degradation in the Atlantic (48-72 hrs) & about 4% degradation in the East Pacific (24-48 hrs)

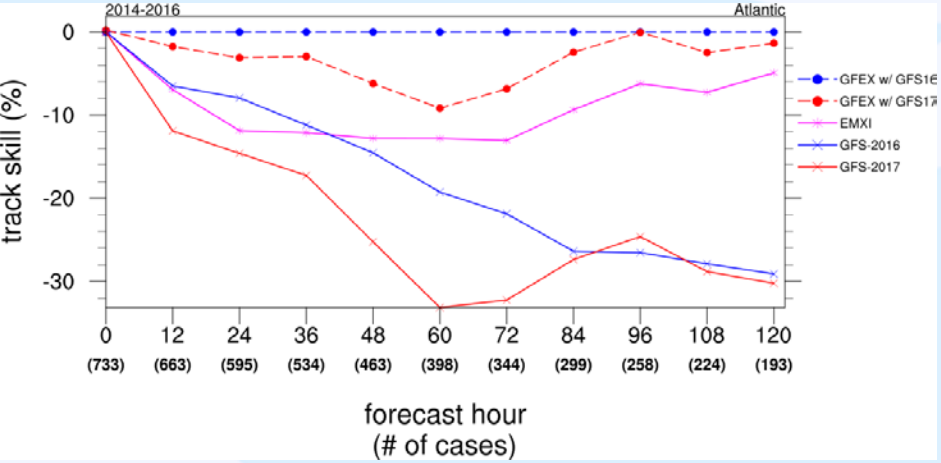


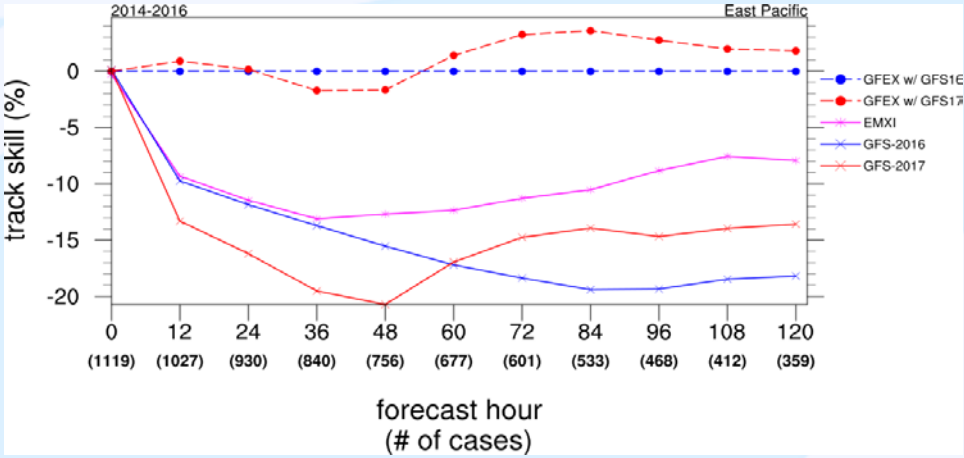
NHC Evaluation of Hurricane Forecasts

Skill relative to TVCN & GFEX





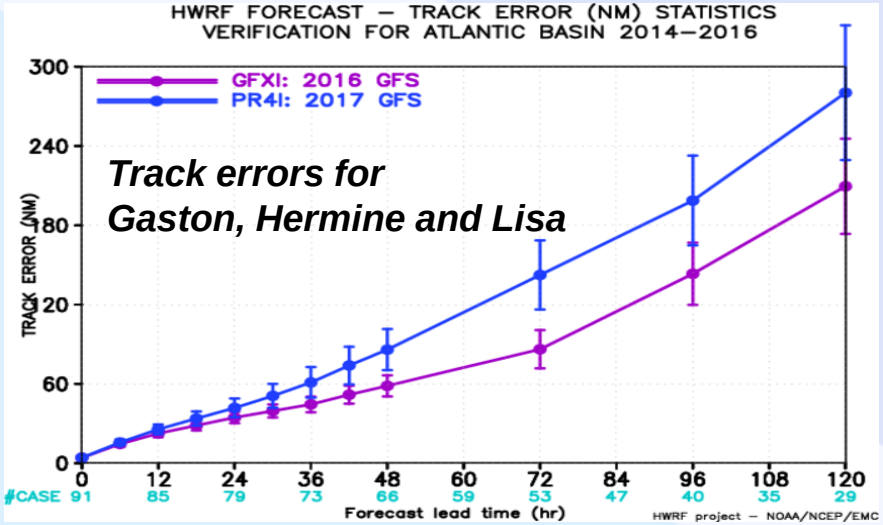


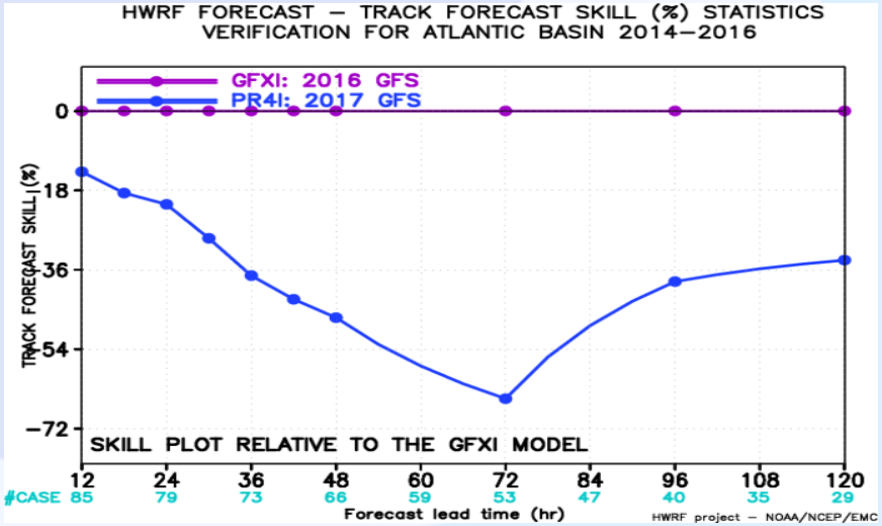


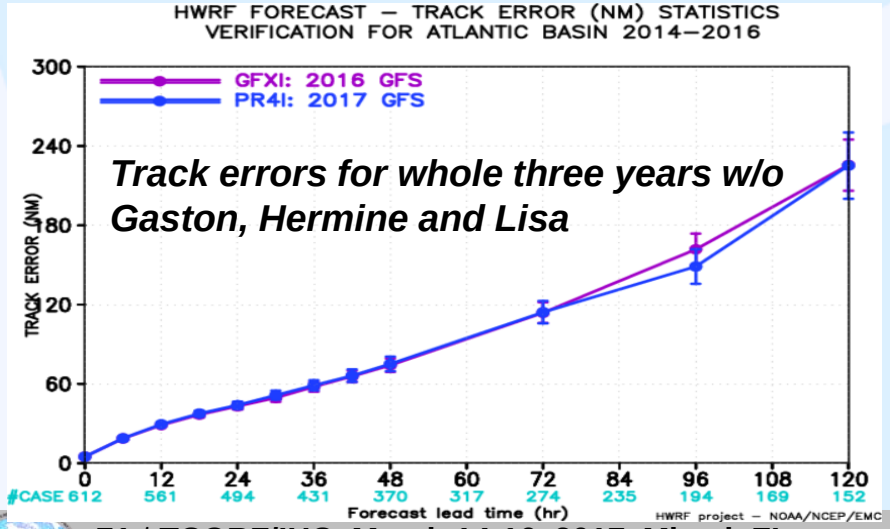
Improved skill w/TVCN, degraded with GFEX in ATL. Improved in EPAC

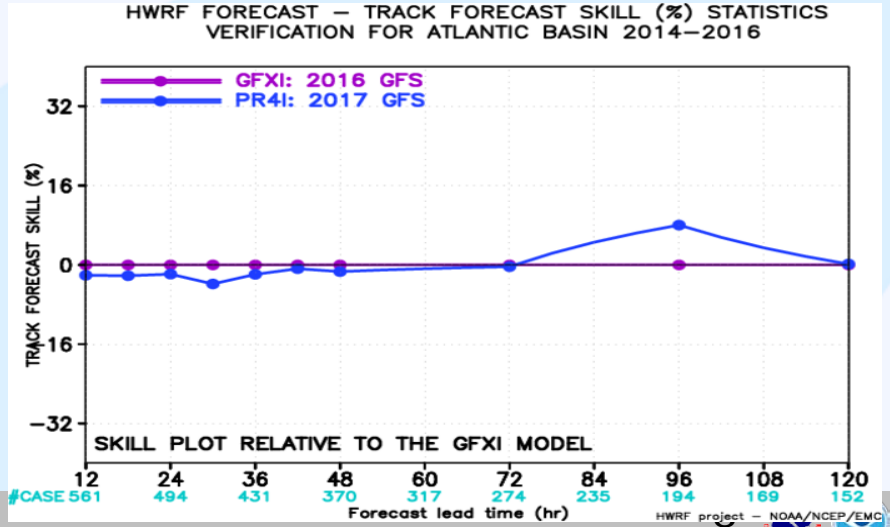
Further analysis of Hurricane Track performance in the Atlantic:

The three worst storms from 2016: Gaston, Hermine and Lisa

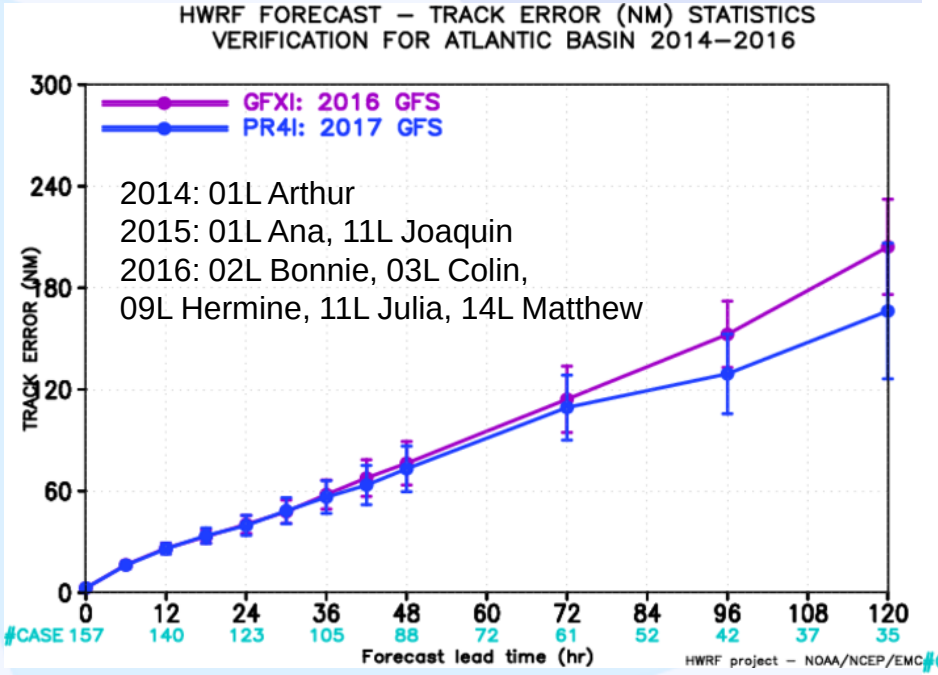


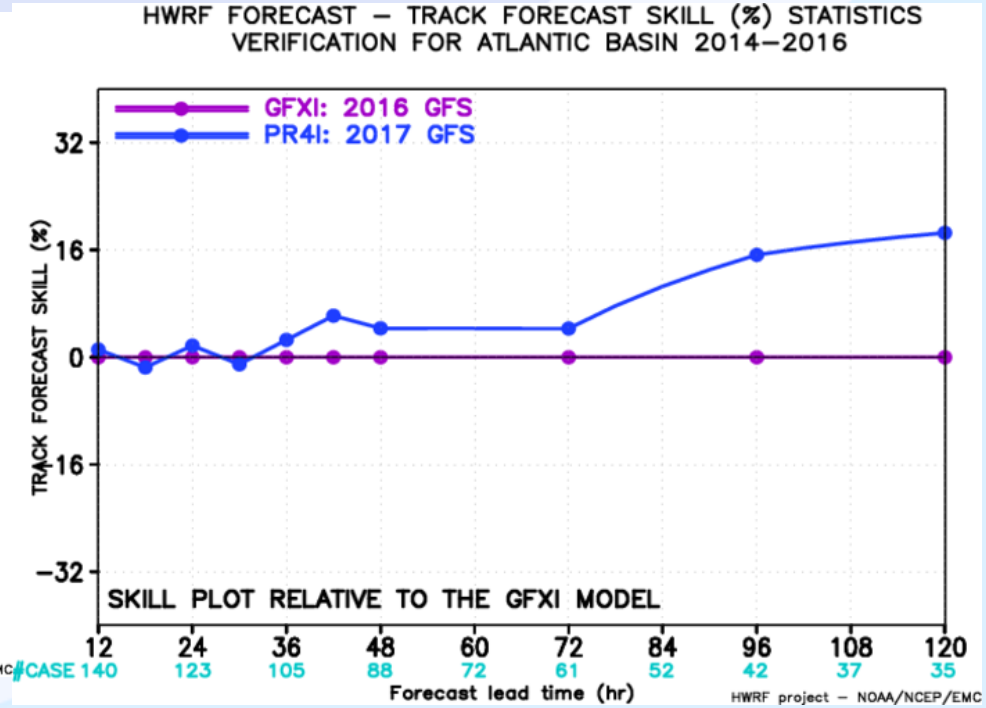




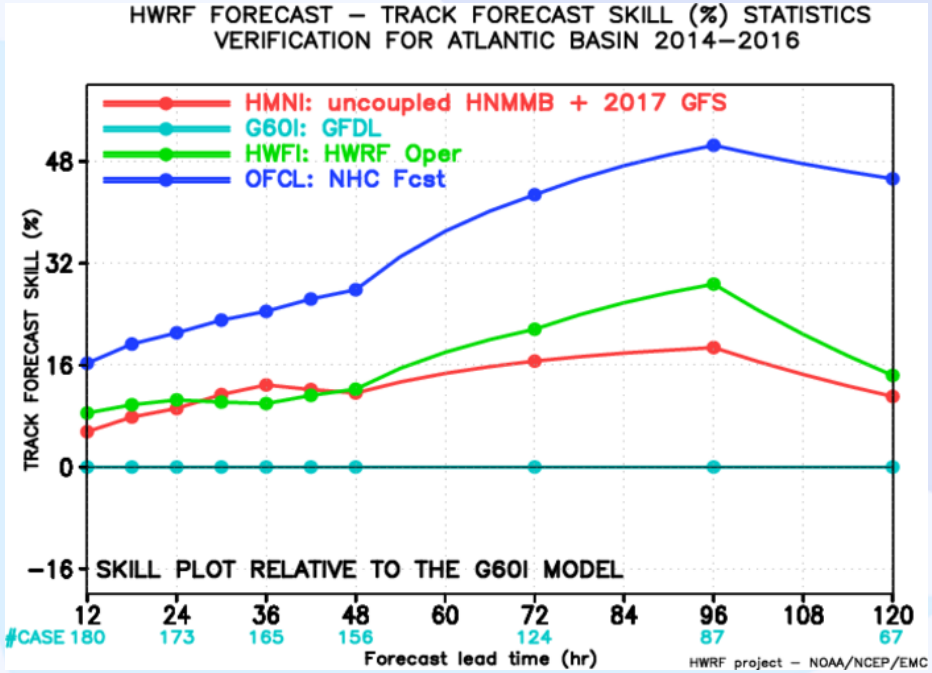


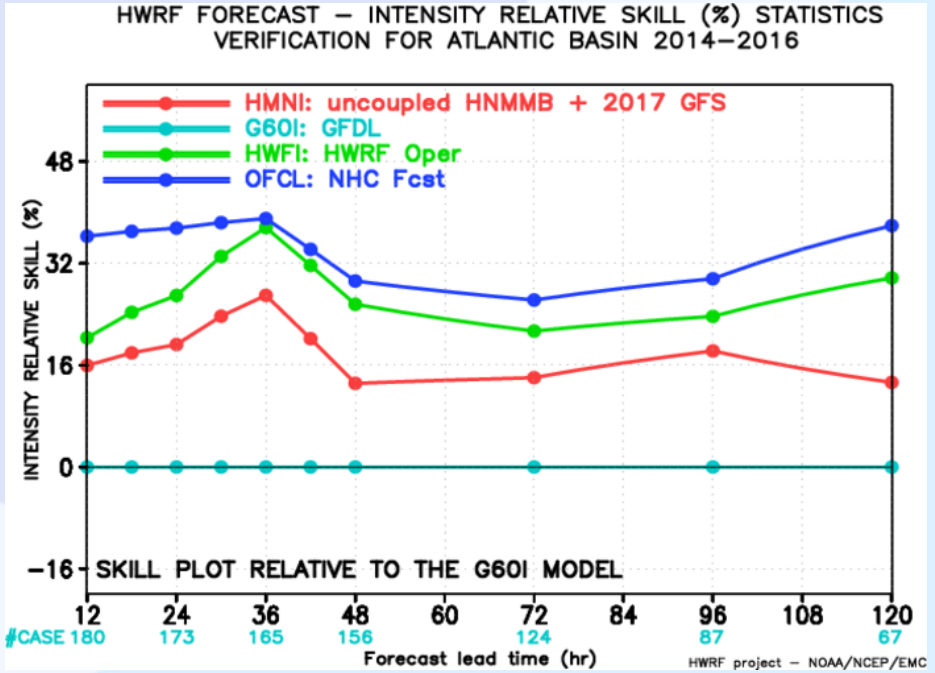
Track errors for US Landfalling Storms (including Joaquin), 2014-2016 ATL





Impact of 2017 GFS upgrade on HWRF and HMON (NATL)





- Compared to H216, H17B track forecasts remain neutral for the first 48hrs, but show improvement after that through day 5.
- HMON showed significant improvement over GFDL for both tracks and intensity.
- Impact of GFS 2017 on HWRF and HMON, if any, is positive, no apparent degradation for downstream hurricane and wave models, and other dependent models.

Endorsements from Stakeholders

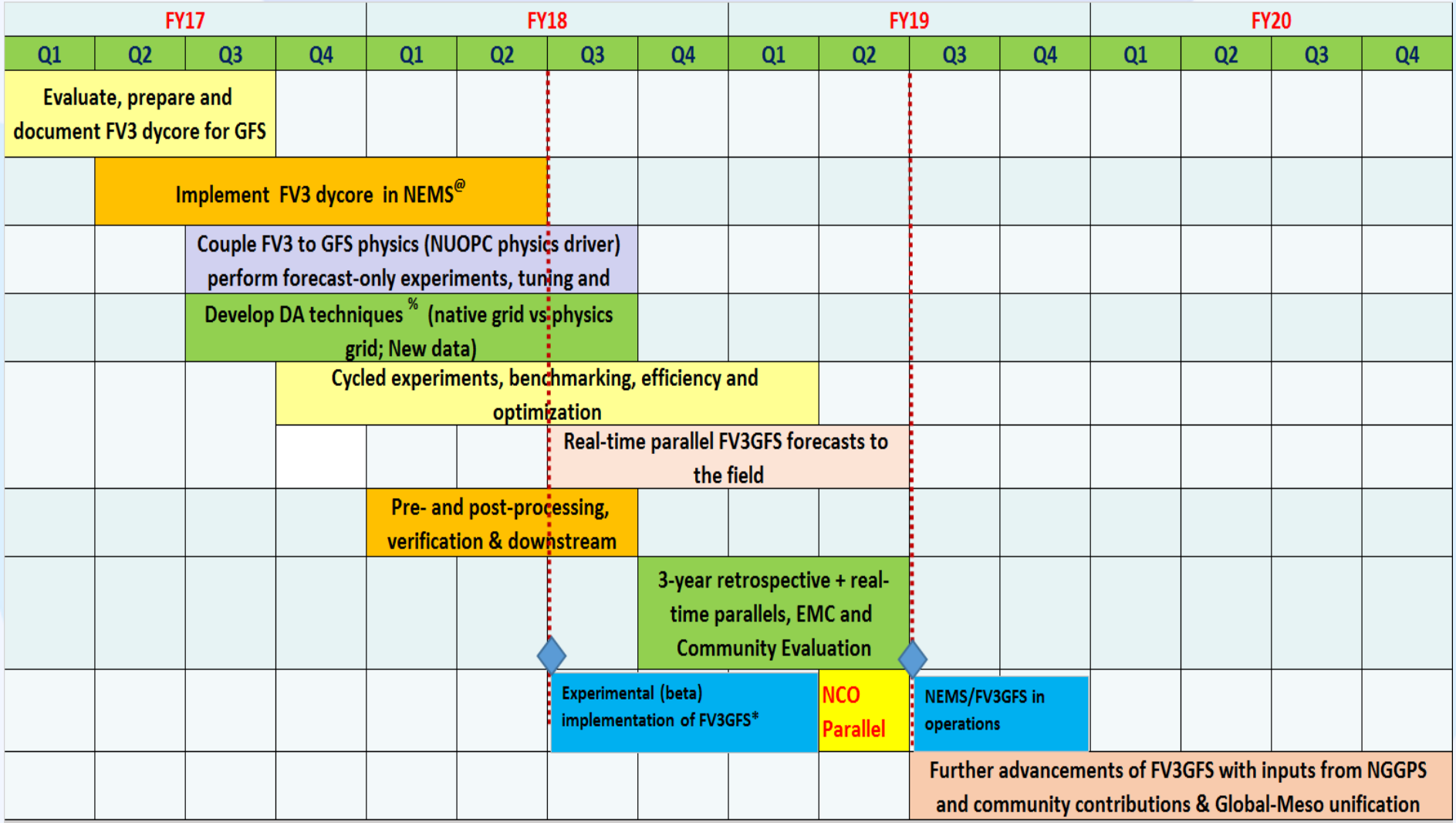
Region/Center	Recommendation	Remarks
Western Region	Implement	GFSX precip lighter in valleys
Central Region	Implement	No significant improvements nor detriments
Southern Region	Implement	GFSX slightly better Matthew,
Eastern Region	Implement	Some beneficial improvements and upgrades
Pacific Region	No evaluation	
Alaska Region	Implement	Forecast improvements largely neutral
WPC	Implement	Slight improvement, Better tropical convection S. America
NHC genesis	Oppose	9-10% less skill in track forecast at 48-72h in Atlantic Forecasts of tropical storm genesis improved
AWC	Implement	Significant improvements to tropical convection and ceiling and visibility over CONUS
CPC long range stratosphere	Implement	Stratospheric fields improved, slight improvement D+8, week 2
OPC	Implement	Small scale features improved; large scale features similar
SWPC	No evaluation	
MDL	Implement	see little to suggest any dramatic MOS impacts from implementing new GFS
OWP	Implement	Mixed results, extremely limited testing
SPC report	Implement	Slightly improved 2-m dew point and instability bias

NCEP Director approved the Q3FY17 upgrade package for implementation in June

Development & Implementation of Unified Modeling System at NCEP

NGGPS/FV3 based Global Model Unification for GFS & GEFS by FY19

Implementation Plan for FV3-GFS (FY2017-2019)



* Q3FY18 FV3GFS will be very similar to operational GFS being implemented in May 2017

'@ Q3FY19 FV3GFS target resolution is ~10km grid with 127 layers, extends up to 80 km.

'& Advanced physics: Scale-aware convection, SHOC PBL, Double-moment microphysics, Unified convective and orographic gravity wave drag etc

'% DA system will be @35 km 127 levels using 4d-Hybrid EnVAR

FV3 GFS Data Assimilation Plan

FY17				FY18				FY19				FY20			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		Adopt GDAS (4D Hybrid En-VAR) DA for FV3GFS													
Testing, Evaluation and Operational Implementation of new satellite datasets (GOES-16, JPSS, COSMIC-2 etc.)															
			Increase vertical resolution to 127 levels and increase GDAS resolution to 35 km												
					Incorporate JEDI Unified Forward Operator and Modular GSI infrastructure										
							Develop and implement DA on native cubed sphere grid								
										Further advancements of FV3GDAS Global-Meso-Marine unification (Unified DA Development)					

1 Jan 2017

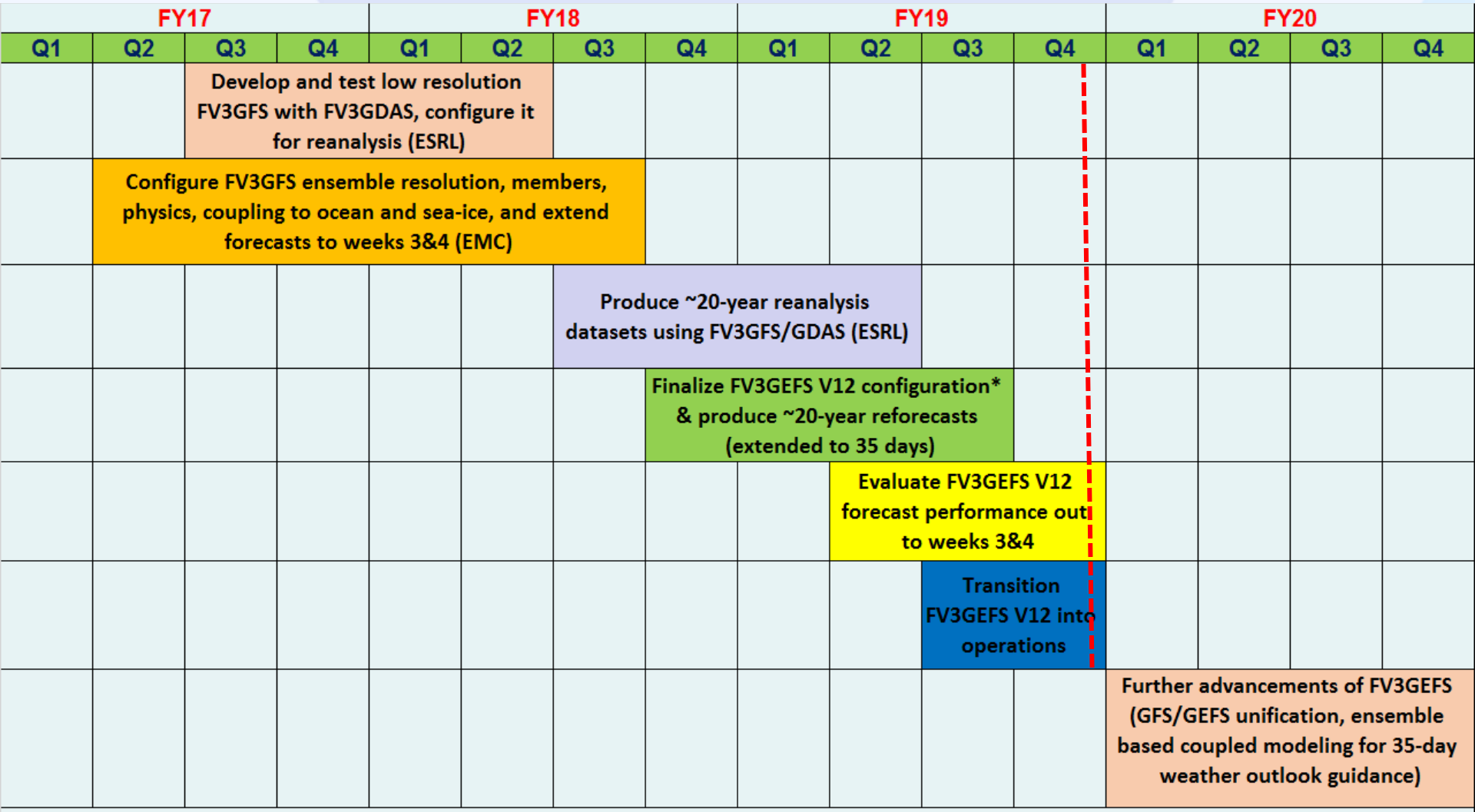
Physics: Two-Stream Strategy

NUOPC Physics Driver in NEMS using Community Common Physics Package (EMC, GFDL, ESRL, GMTB)

Physical Processes	Operational Physics (Evolved)	Advanced Physics* (CCPP)
Radiation	RRTMG	RRTMG (scale and aerosol aware, w/sub-grid scale clouds)
Penetrative convection and Shallow convection	SAS RAS	Scale-aware Chikira-Sugiyama & Arakawa-Wu; Grell-Freitas
Turbulent transport (PBL)	Hybrid EDMF	CS+SHOC (unified convection & turbulence)
Cloud microphysics	Zhao-Carr WSM-6	Double Moment scheme (Morrison, Thompson Barahona)
Gravity wave drag	Orographic GWD Stationary convective GWD	Unified representation of GWD
Ozone physics	NRL simplified scheme	Modified NRL scheme
Land surface model (LSM)	Noah	Noah and LIS
SST	Reynolds/RTG SST	NSST

Includes aerosol chemistry (NGAC) module

FV3 Global Ensemble Forecast System (GEFS) Plan With Reanalyses and Reforecasts (FY2017-2019)



* Proposed changes for GEFS V12: 1) Produce FV3 based reanalysis in FY18 using the same configuration as Q2FY18 FV3GFS (ESRL); 2) Reforecasts will be based on FV3GEFS configured with either coupled to Ocean and Sea-Ice models or use 2-Tier SST approach; and 3) FV3GEFS Reforecasts extended to 35 days to include weeks 3&4 guidance.

Stochastic Schemes for Atmosphere - Applied to GEFS experiments

Stochastic Kinetic Energy Backscatter (SKEB)

- Represents process absent from model
- Stream function is randomly perturbed to represent upscale kinetic energy transfer (Berner et al., 2009)

Stochastic Perturbed Physics Tendencies (SPPT) – (ECWMF tech memo 598)

- Designed to represent the structural uncertainty (or random errors) of parameterized physics
- Multiplicative noise used to perturb the total parameterized tendencies (Palmer et al., 2009)
- Biggest impact on tropic
- **5 scales, precipitation modification (ESRL/EMC – 2016)**

Stochastically-perturbed boundary layer HUMidity (SHUM)

- The same formula as SPPT
- Designed to represent influence of sub-grid scale humidity variability on the the triggering of convection (Tompkins and Berner 2008)
- Biggest impact on tropic
- **Implemented on NCEP DA, then testing for GEFS**

Progress on FV3GFS Development

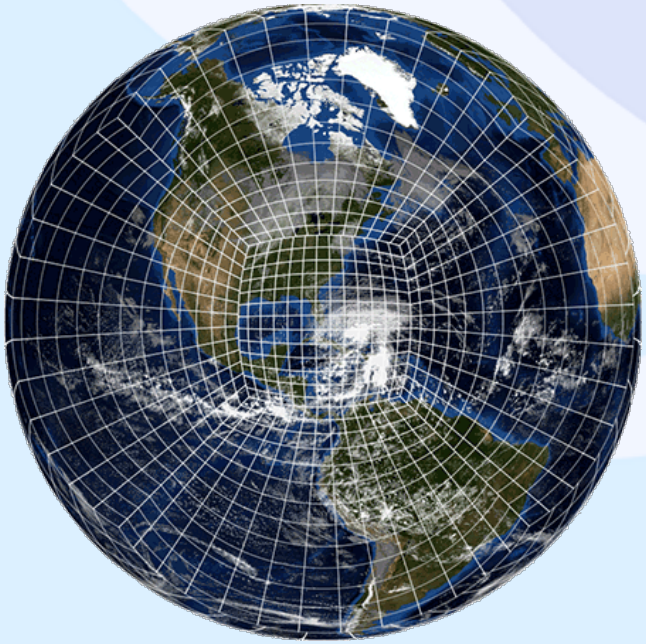
- **FV3GFS Superstructure is created on EMC subversion to manage the code and workflow repositories**
  - *ESRL, GFDL and EMC are currently primary developers*
- **FV3GFS Forecast only experiments run in real-time four times a day**
  - *Uses operational GFS IC and GFS Physics, results available online*
  - ***http://www.emc.ncep.noaa.gov/gmb/wx24fy/NGGPS/fv3gfsb/***
- **FV3GFS is now in NEMS**
  - *NEMS CAP is available for FV3GFS*
  - *Real-time experiments will switch to NEMS/FV3GFS by April 1, 2017*
  - *Interoperable Physics Driver (IPD V4.0) is delivered by GFDL*
  - *FV3GFS is coupled to CCPP style GFS Physics using IPD V4*
- **Data Assimilation for FV3 is progressing well**
  - *Stochastic Physics is implemented into FV3GFS*
  - *ESMF Regridding Tools are available in NEMS/FV3GFS*
  - *Cycled DA system is on target for experimentation by May 2017*

Real-time forecasts for March 2017 Northeast Snow Storm

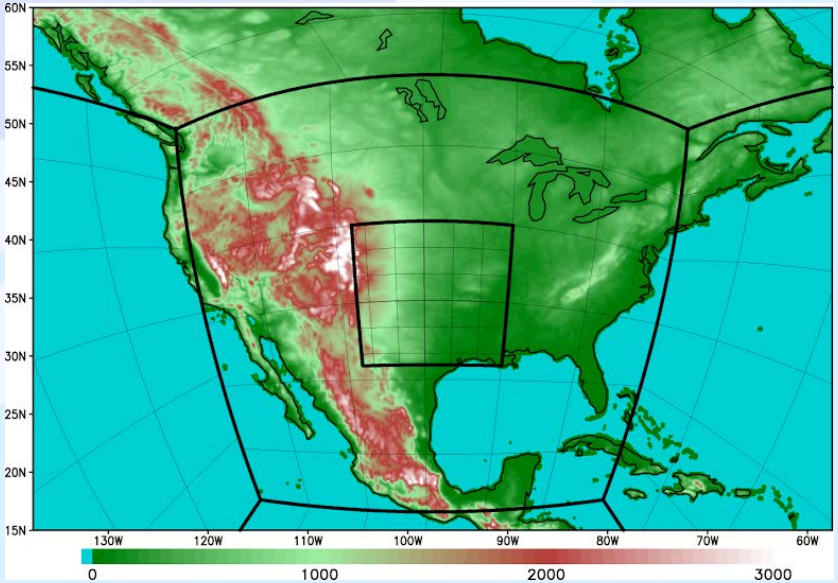
Grid refinement for higher-resolution (potential solution for hurricane forecasts)

FV^3 supports both stretching and nesting for grid refinement

Development of two-way interactive moving nests for FV^3 planned (AOML/GFDL/EMC Collaboration)

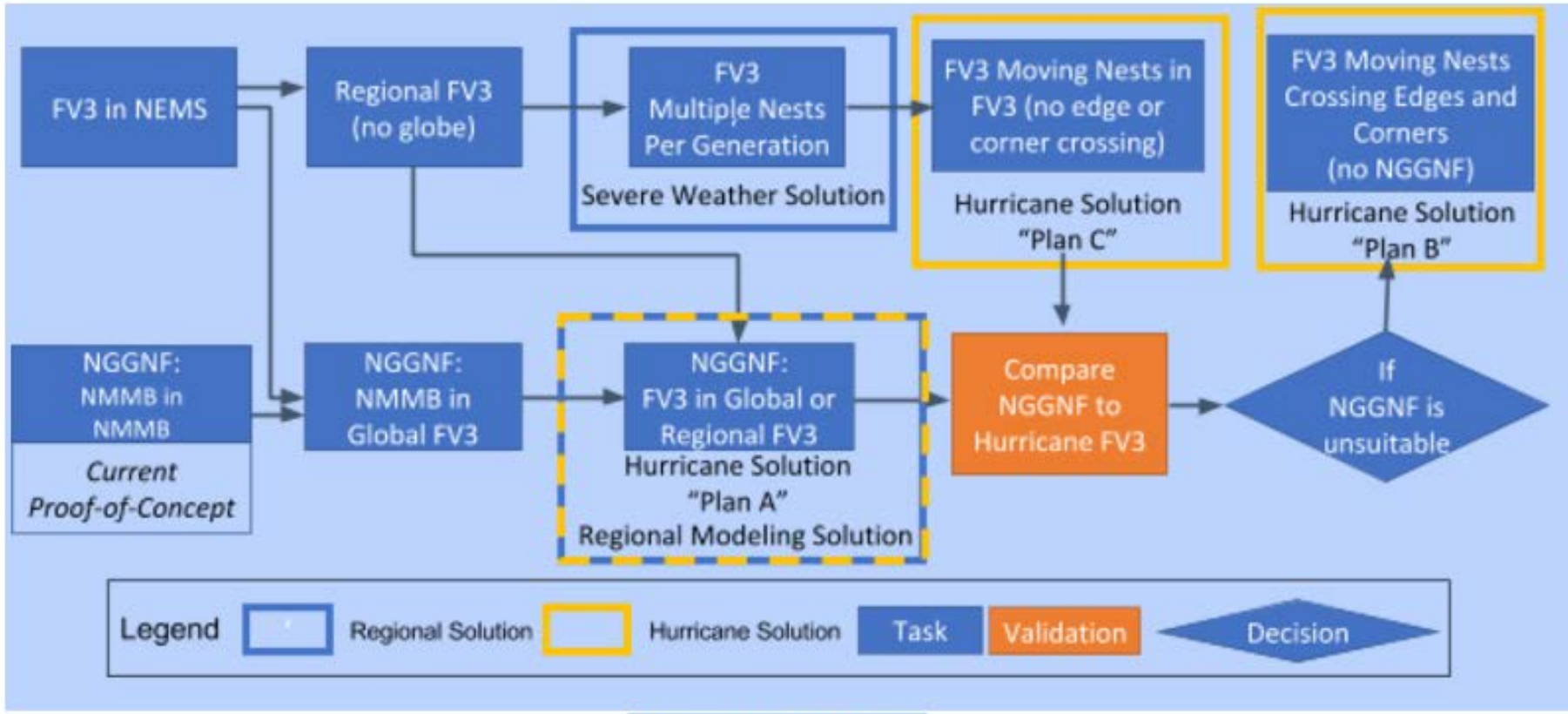


Grid stretching is simple and smooth



Grid nesting is efficient and flexible

Tropical Cyclone Forecasts in FV3



Development of next generation nesting techniques to address the tropical cyclone forecast problem within the global model

Strategic Implementation Plan for Unified Modeling

Strategic Vision for Evolution of NGGPS to a National Unified Modeling System

- Unified Modeling based on FV3 – Short term implementation plans through FY20
- Evidence based decision making process
- Community engagement from the beginning
- Working groups to meet at NCWCP during April 17-19, 2017 to draft SIP Draft V1
- Leading to more detailed Strategic Plan and Road Map being developed by NWS STI in collaboration with partners & community

Governance **System architecture** **Infrastructure** **Dynamics and Nesting (including hurricanes)** **Model physics**	**Data assimilation** **Ensembles** **Post Processing** **Verification & Validation** **Convective allowing models**

Questions?