NCEP Unified Forecast System: High-Resolution Global, Regional and Hurricane Modeling Capabilities using FV3 Dynamic Core

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Outline

FV3 Dynamic Core: Central component for NOAA's Next Gen. Prediction Systems

Progress on FV3GFS and FV3GDAS Developments and Results from Real-Time Experiments

FV3GEFS: Next Generation Global Ensemble System with extended predictions to Weeks 3&4

Dynamic Core for Regional Convective Allowing Modeling Applications and moving nests for hurricanes

Role of Community Engagement in the development of NOAA's Strategic Implementation Plan (0-3 years) and Roadmap (0-10 years)

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 met at NCWCP during April and August to draft SIP Draft V1, **first draft developed**
- EMC has developed internal **3-year Development and Implementation Plan** largely drawing from SIP
- Plan Leading to more detailed Strategic Plan and Road Map being developed by NWS STI in collaboration with partners & community
- Improved hurricane forecasts are front and foremost of the objectives of Unified Modeling implementation at NCEP. HFIP and NGGPS play a major role in carrying these plans forward.

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

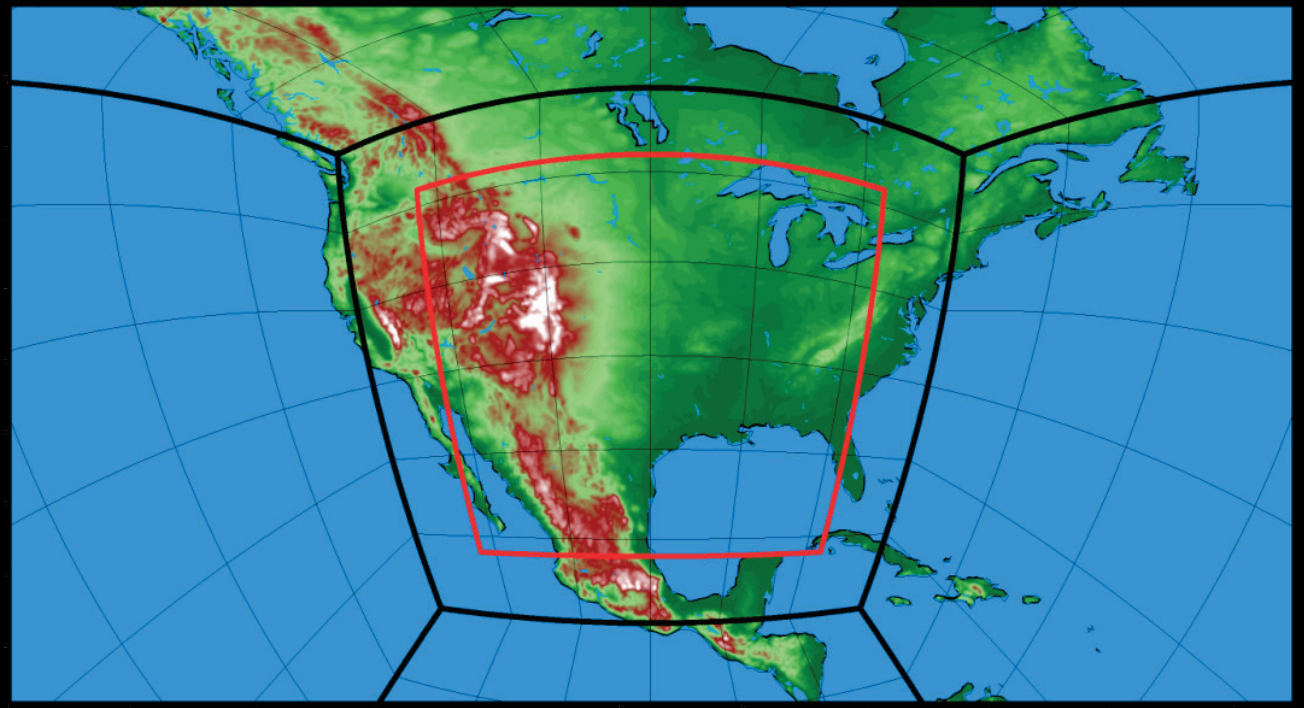
Achieving thunderstorm-resolving resolution “TODAY” in a unified meso-global prediction system

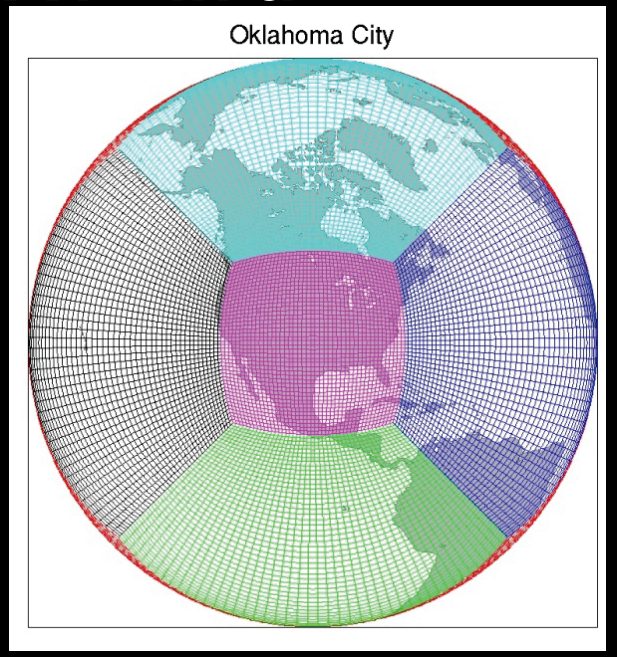
1) **Grid stretching (smooth variation of grid spacing)**

1) **2-way nesting (Harris and Lin 2014)**

FV3 is uniquely suitable for 2-way nesting, due to the application of two-time-level Finite-Volume transport scheme

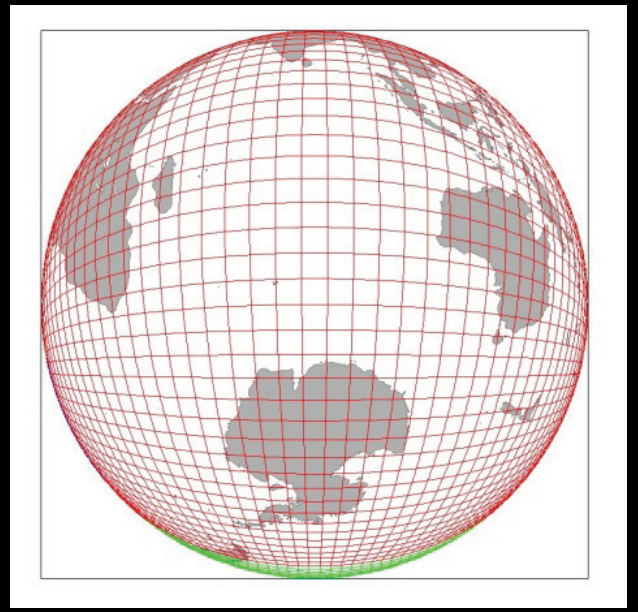
2) **Optimal combination of the “stretching” and “nesting”**



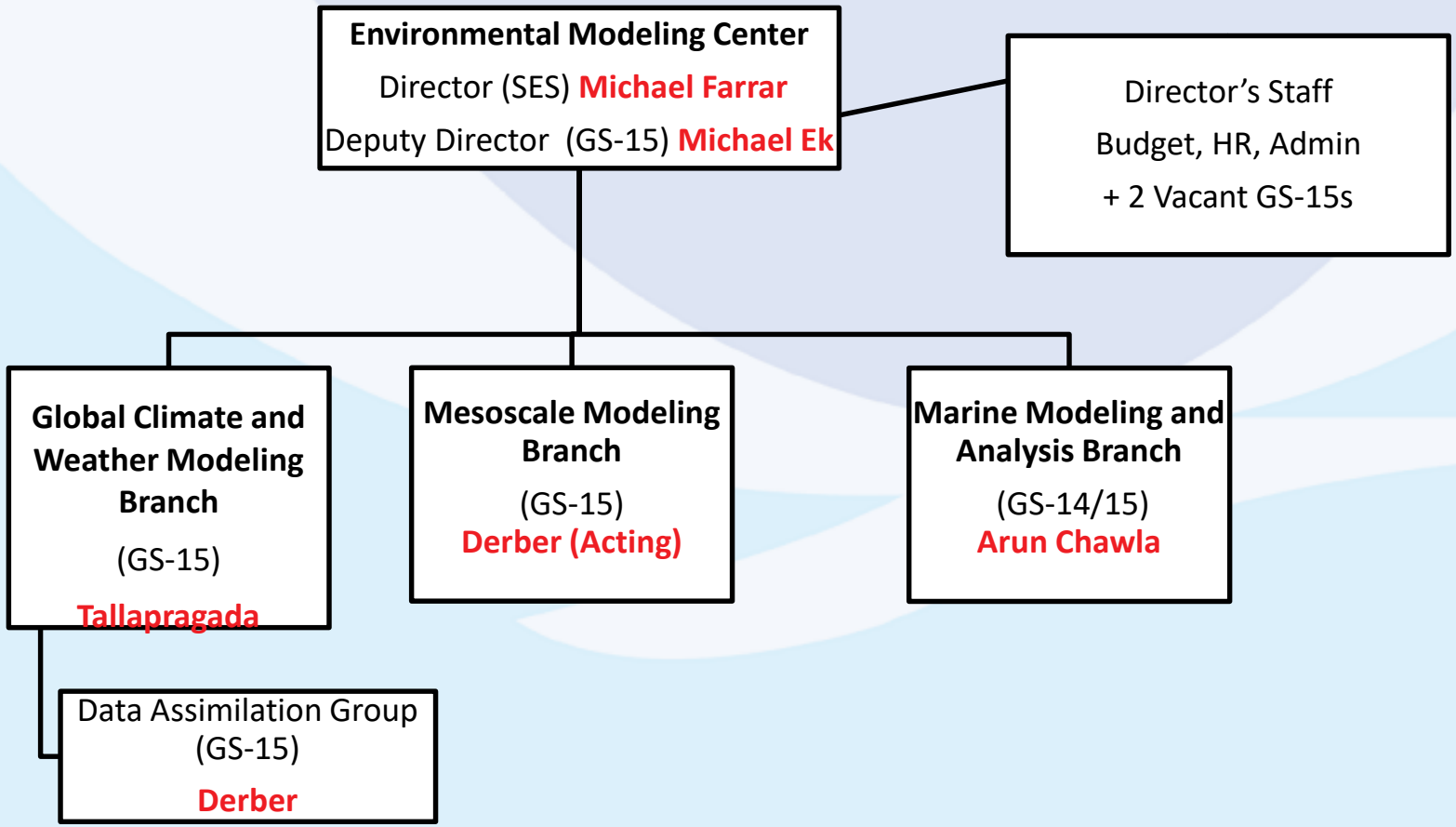


Example:

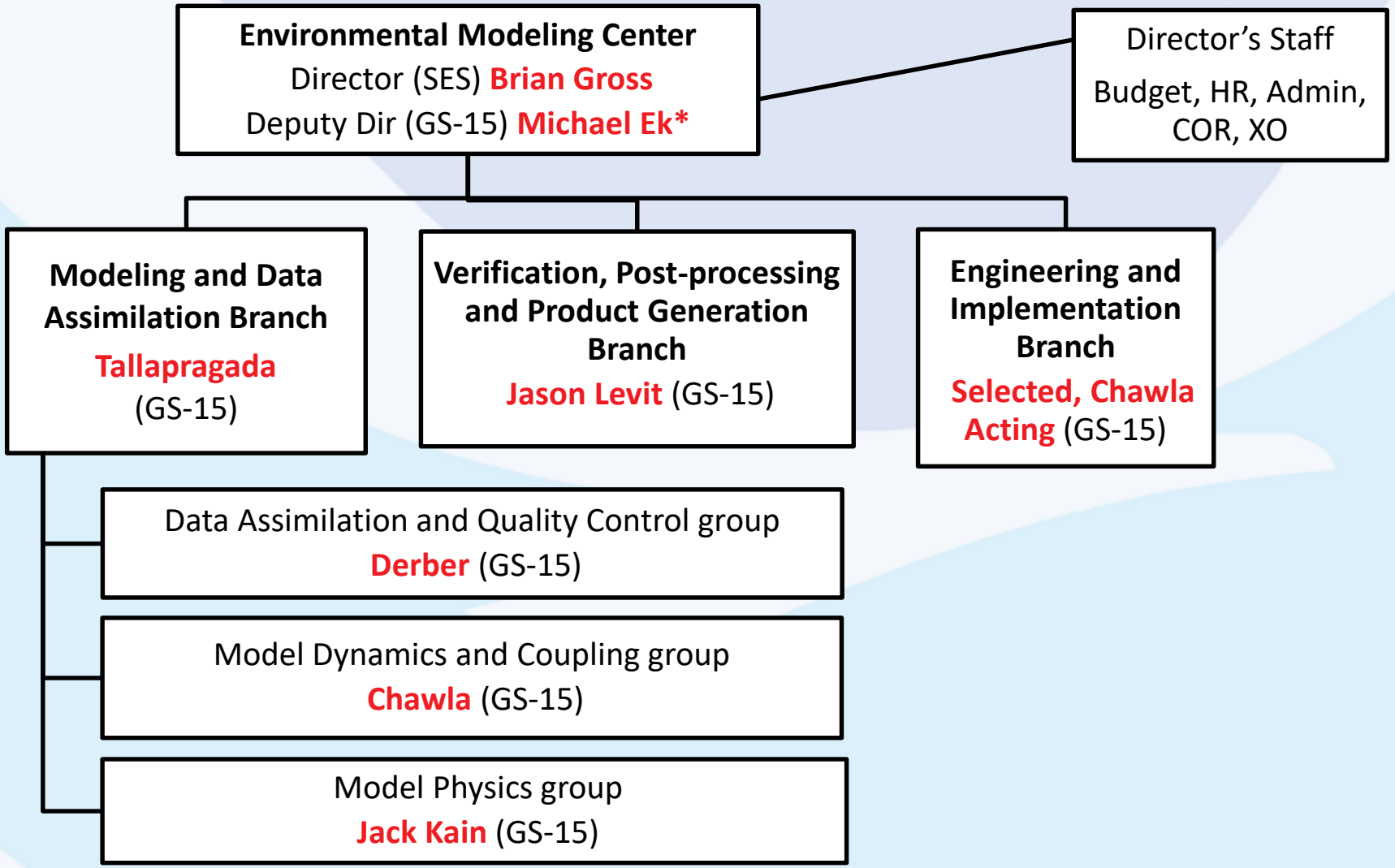
~ 3 km without the nest (black)
~ 1 km with a 2-way nest (red)



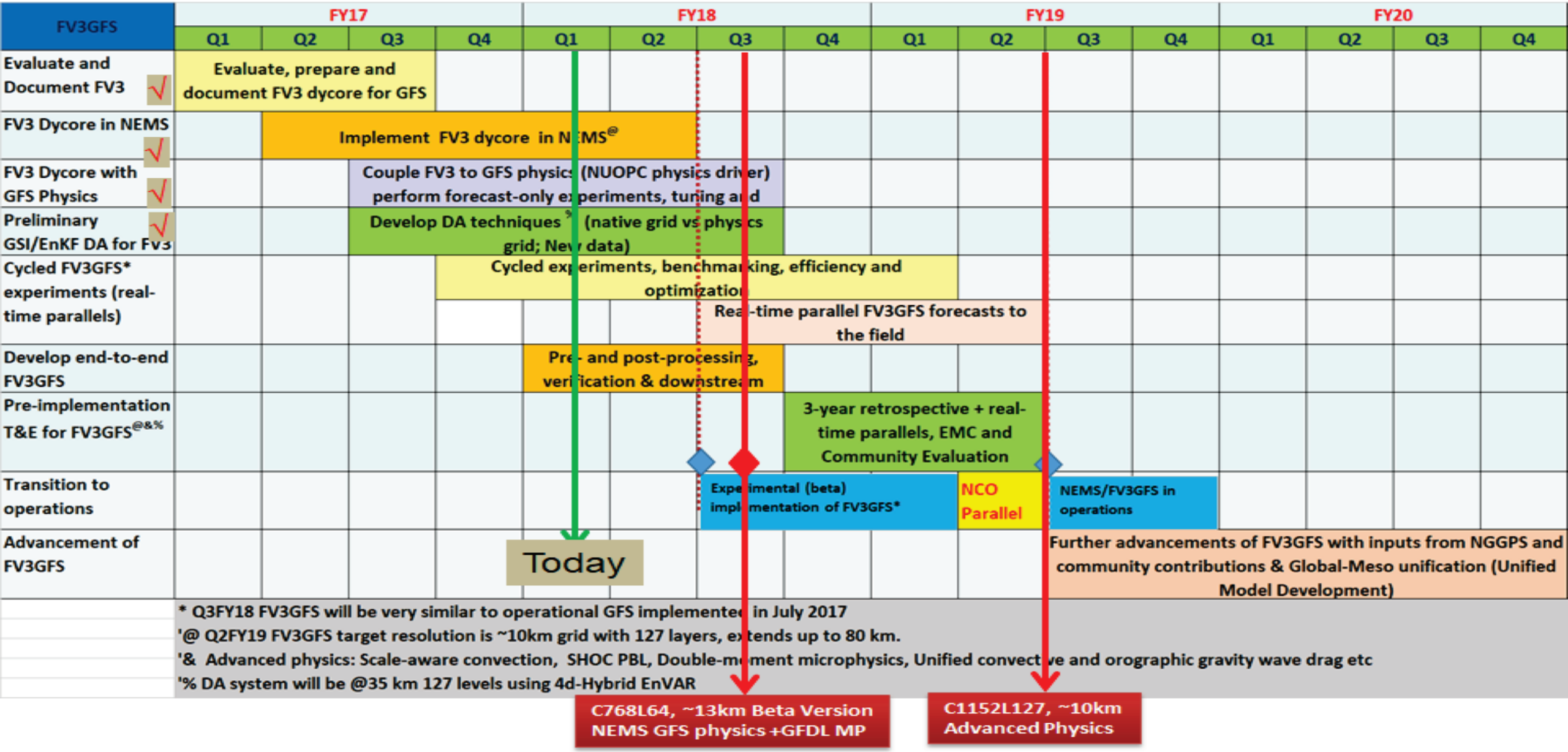
Org Chart: Before April 2017
Environmental Modeling Center (EMC)



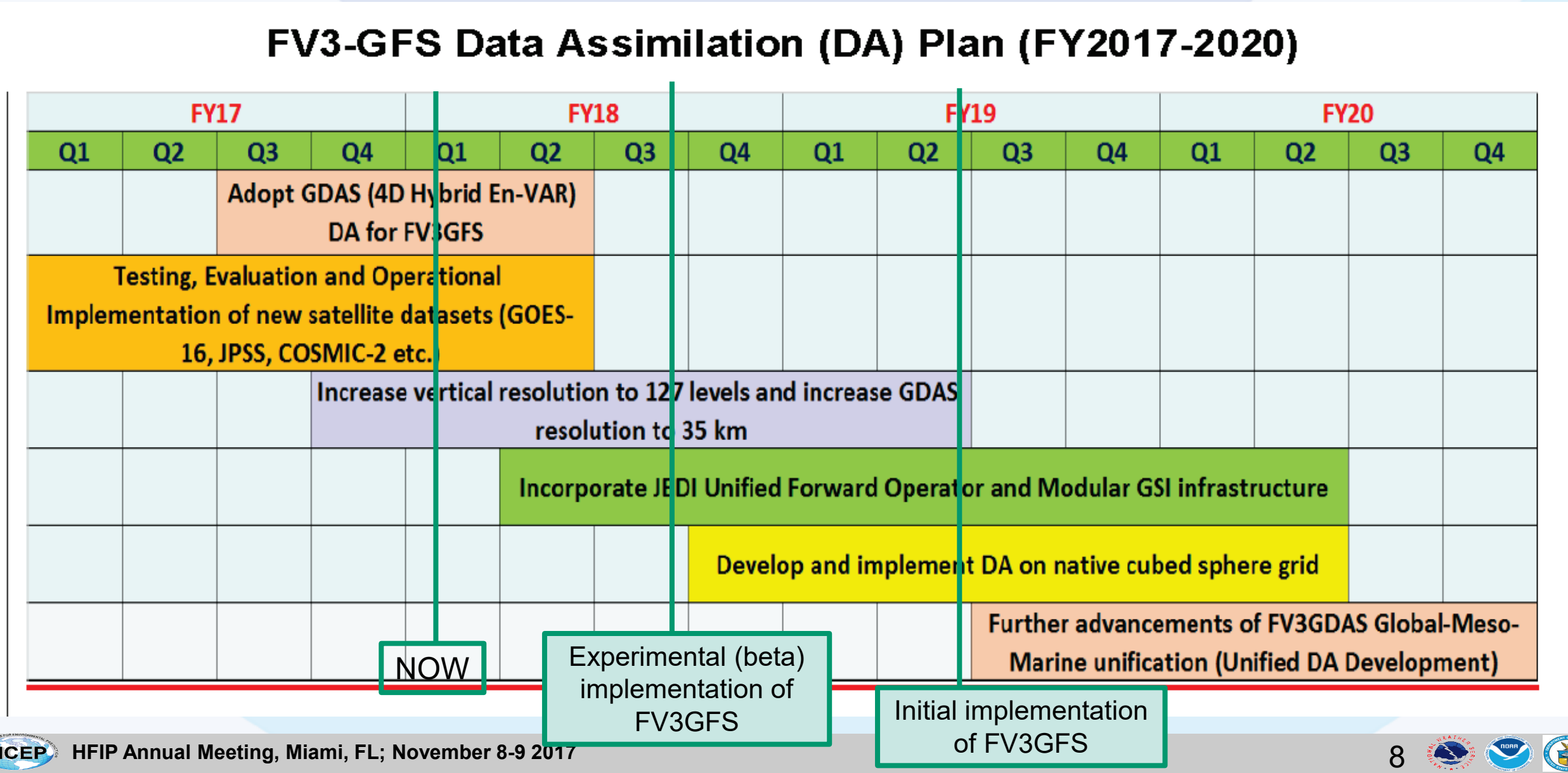
Org Chart (After April 2017)
Environmental Modeling Center (EMC)



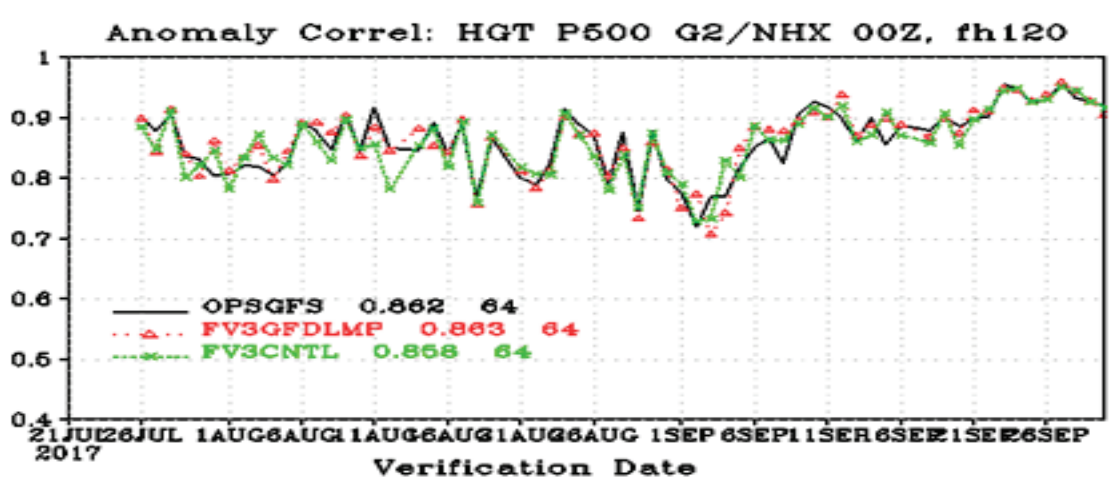
FV3GFS Implementation Plan

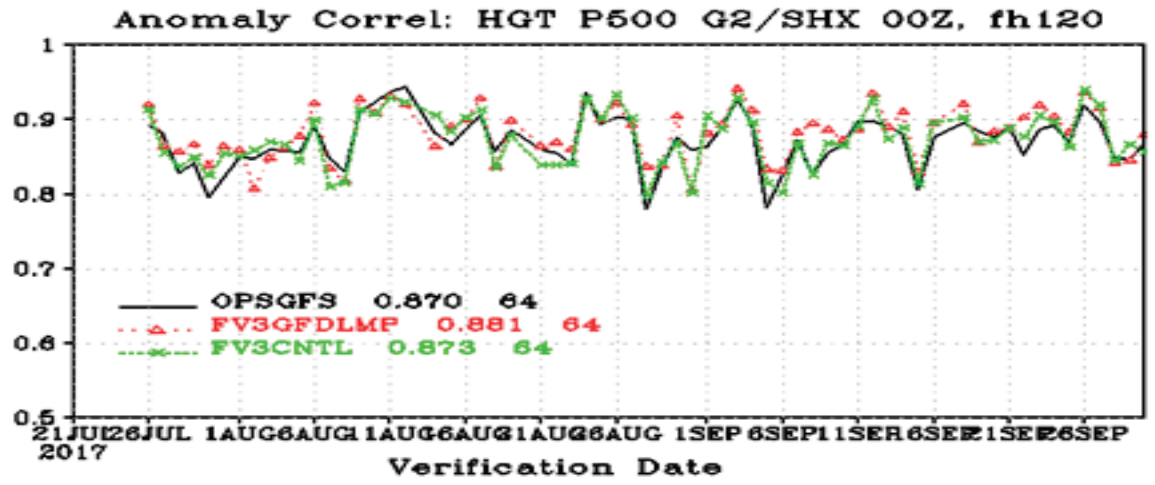


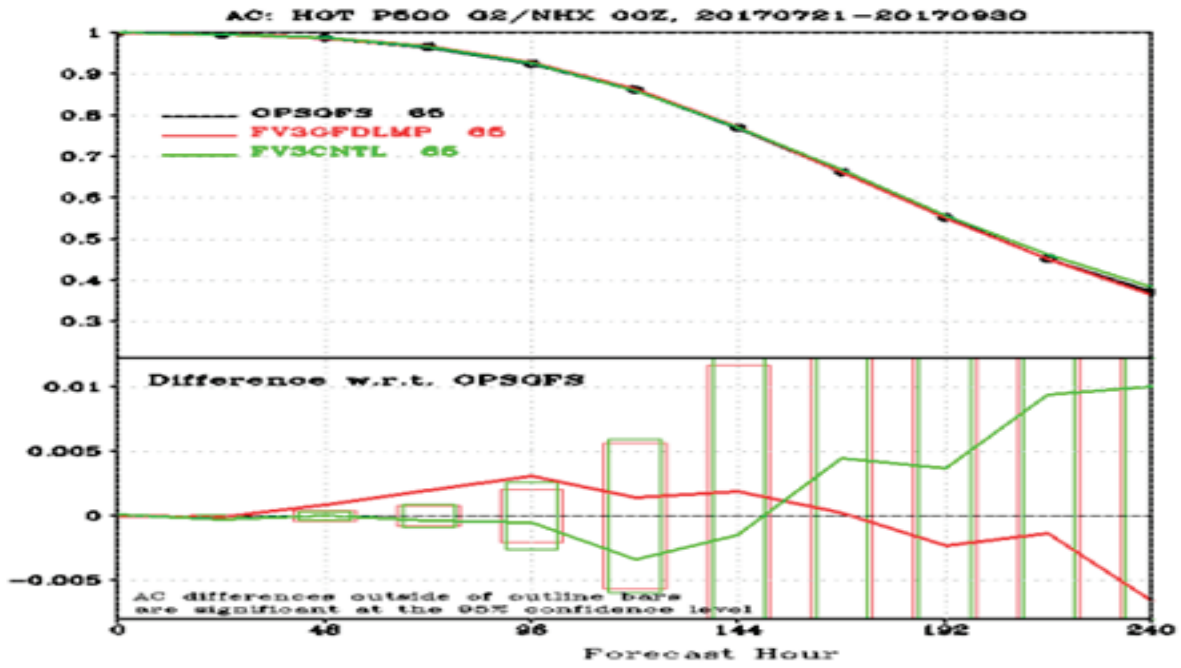
FV3 GFS DA Timeline

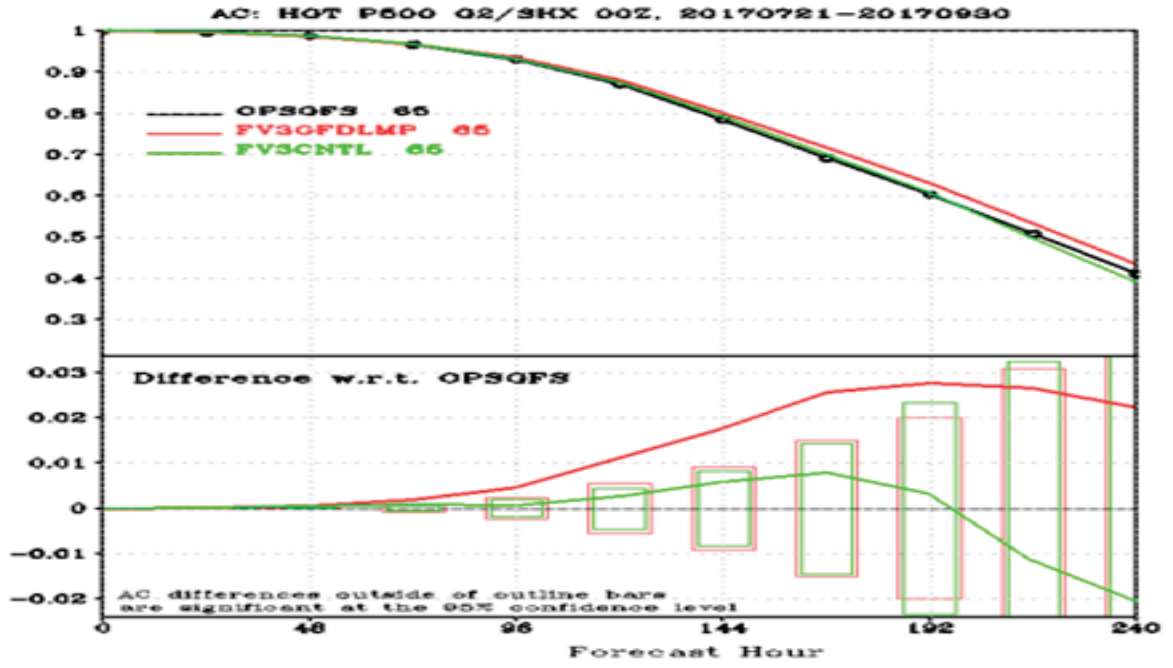


500mb HGT ACC

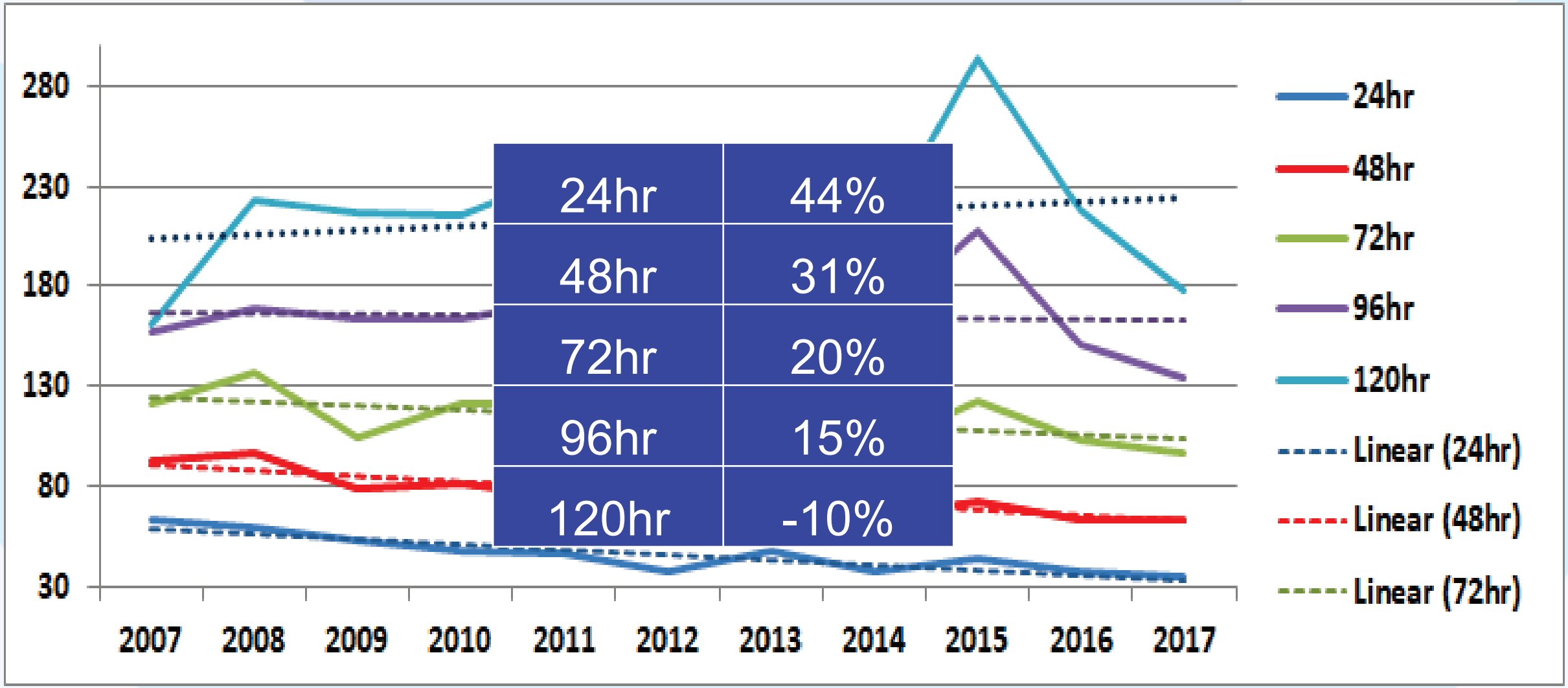








Atlantic 2007-2017 GFS TC track error



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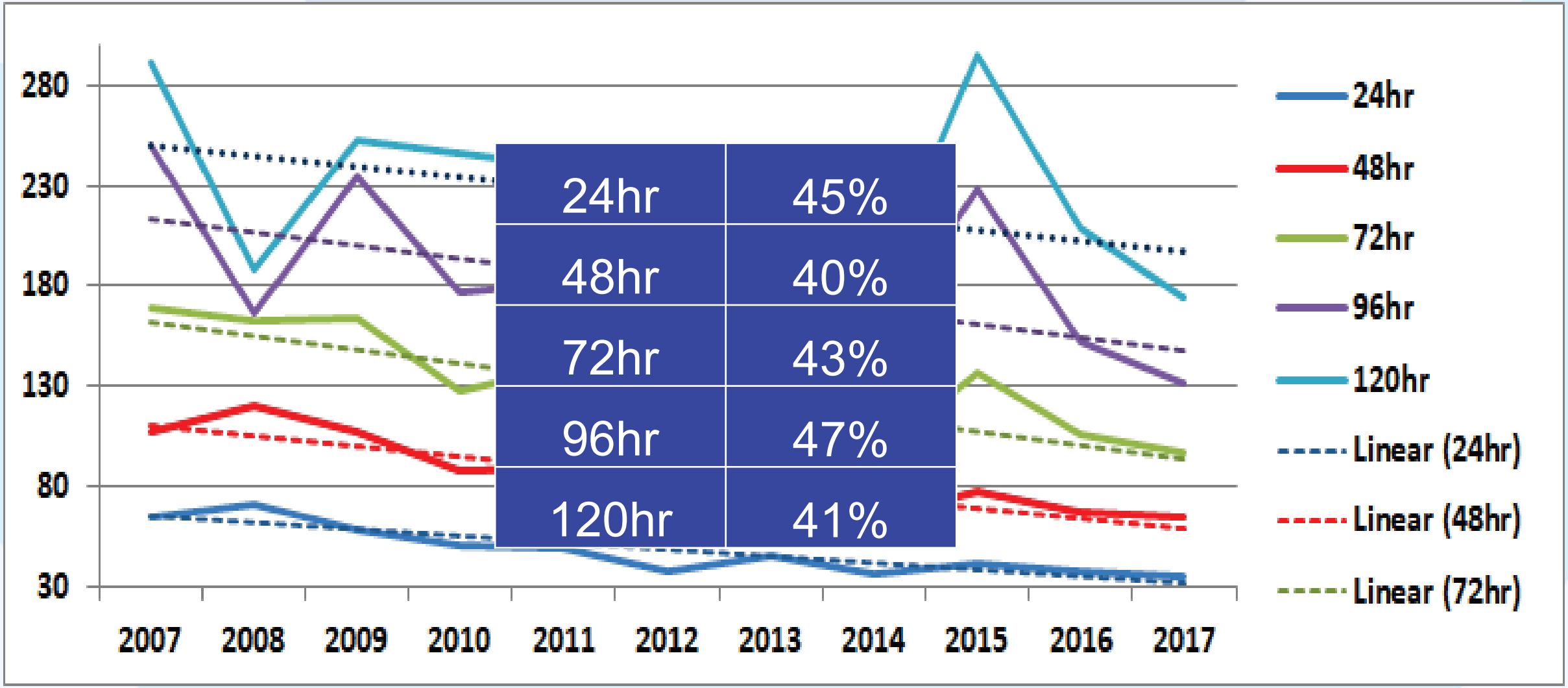
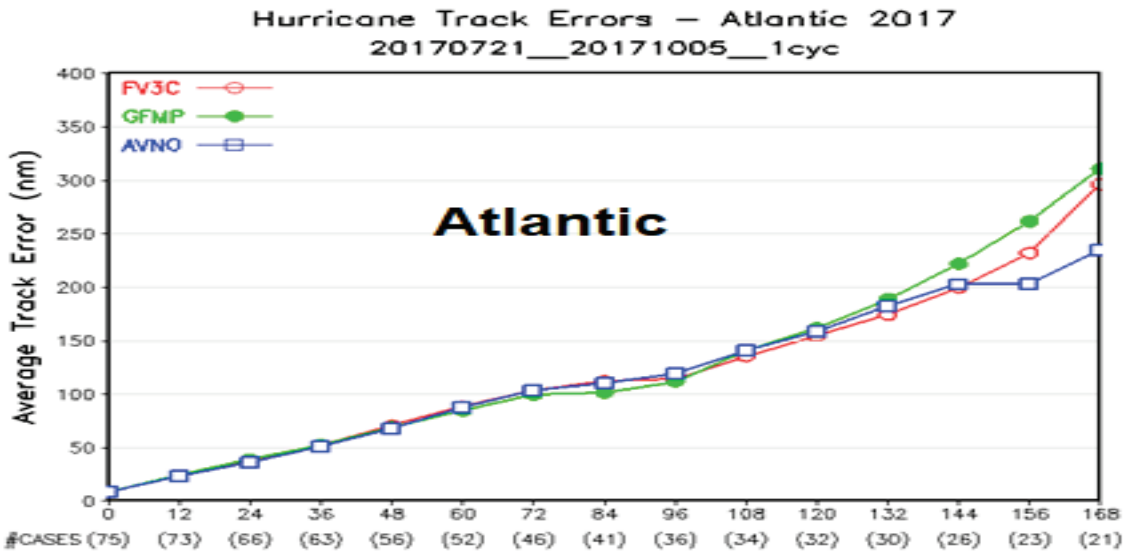
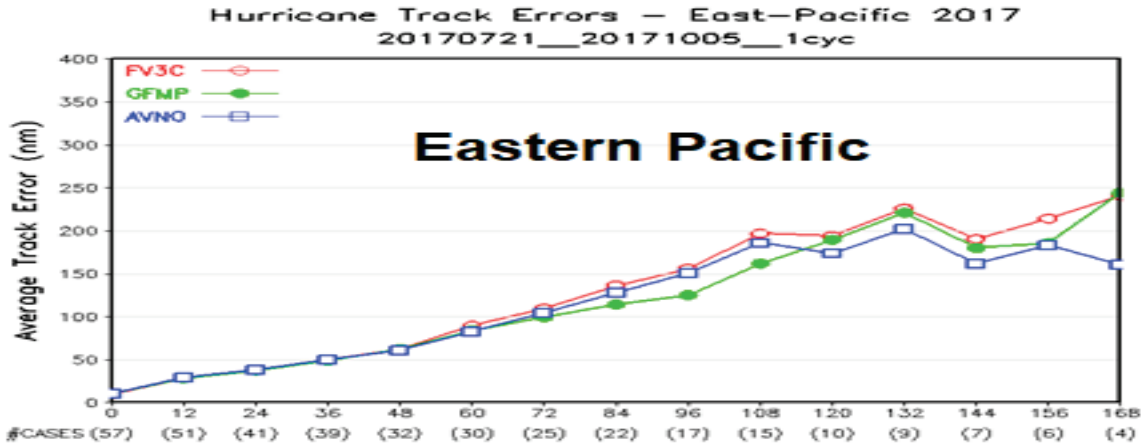


FV3GFS Hurricane Track Errors, July-September 2017



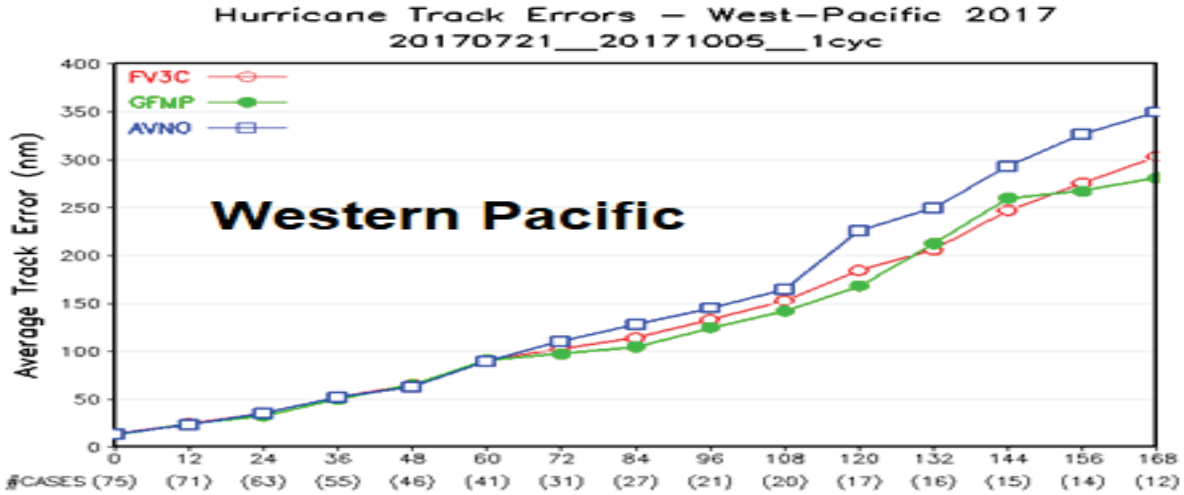
Confidence Level (%) of Student−t Tests

FV3C_GFMP	89	51	82	57	71	82	77	93	65	68	70	79	90	85	76
FV3C_AVNO	58	77	91	70	82	55	53	57	72	70	65	74	59	92	97
GFMP_AVNO	90	78	93	72	57	77	75	91	82	51	55	83	79	95	98



Confidence Level (%) of Student−t Tests

FV3C_GFMP	94	89	69	67	54	82	83	97	96	94	82	82	88	91	57
FV3C_AVNO	97	79	52	51	65	97	81	85	69	77	85	82	90	81	99
GFMP_AVNO	89	85	69	69	68	60	70	89	94	88	81	85	73	52	98



Confidence Level (%) of Student−t Tests

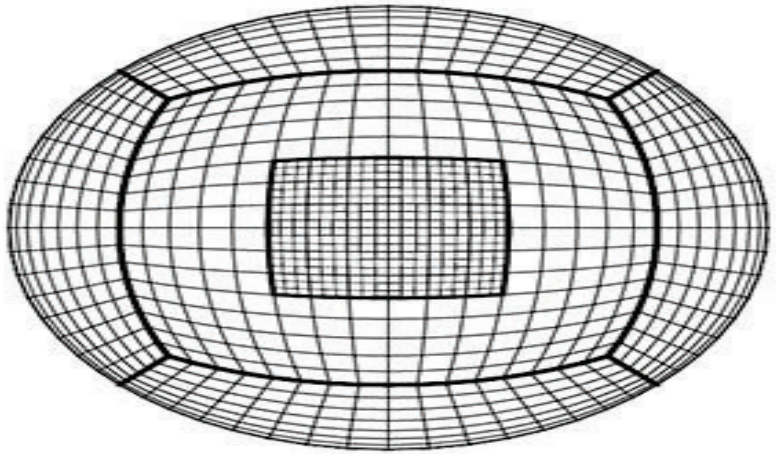
FV3C_GFMP	82	65	99	83	58	52	81	90	77	78	78	88	89	65	85
FV3C_AVNO	54	67	53	50	73	56	90	94	77	74	96	98	95	92	89
GFMP_AVNO	82	57	99	78	68	57	97	99	94	90	94	94	84	98	96

Proposed Plan for FV3-based GEFS v12 *(sub-seasonal ensemble system)* with reanalysis and reforecast

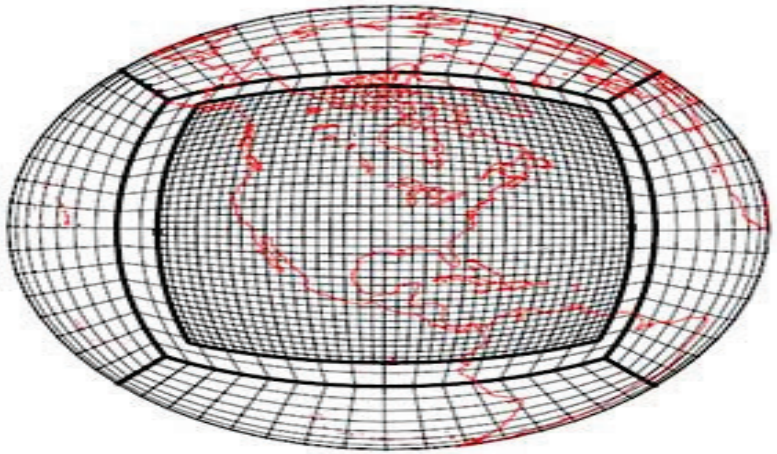
FY17				FY18				FY19				FY20			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		Develop and test low resolution FV3GFS with FV3GDAS, configure it for reanalysis (ESRL)													
	Configure FV3GFS ensemble resolution, members, physics, coupling to ocean and sea-ice, and extend forecasts to weeks 3&4 (EMC)														
						Produce ~20-year reanalysis datasets using FV3GFS/GDAS (ESRL)									
							Finalize FV3GEFS V12 configuration* & produce ~20-year reforecasts (extended to 35 days)								
									Evaluate FV3GEFS V12 forecast performance out to weeks 3&4						
										Transition FV3GEFS V12 into operations					
												Further advancements of FV3GEFS (GFS/GEFS unification, ensemble based coupled modeling for 35-day weather outlook guidance)			

* 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.

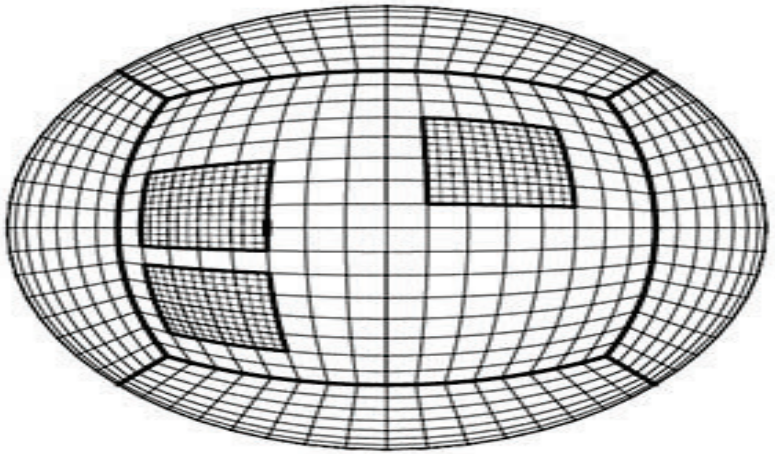
Tropical Cyclone Forecasts in FV3



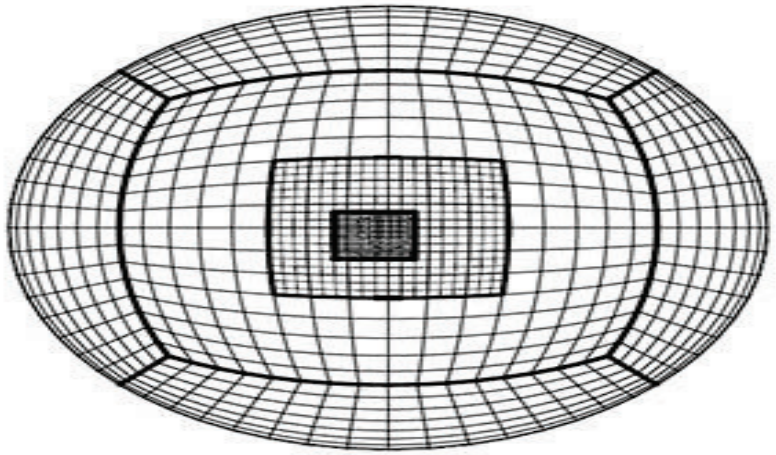
3:1 nested grid



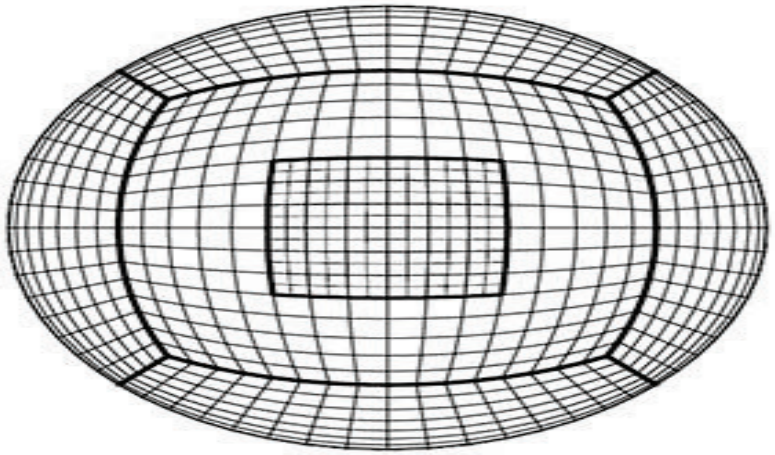
Large nest for RCMs



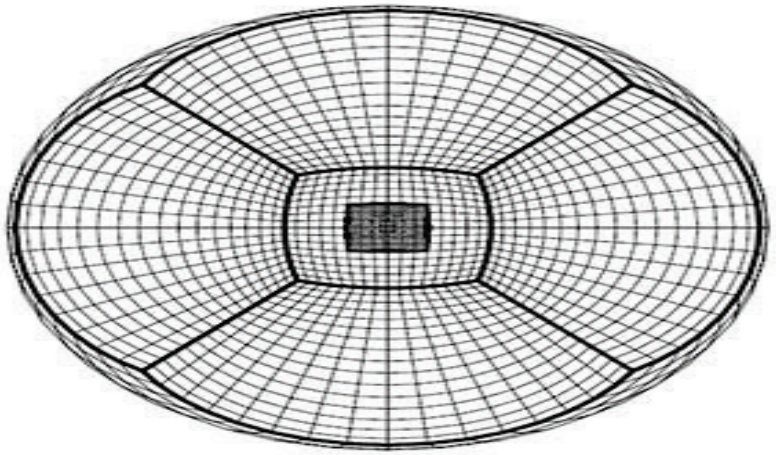
Multiple nests



Telescoping nests



2:1 nested grid

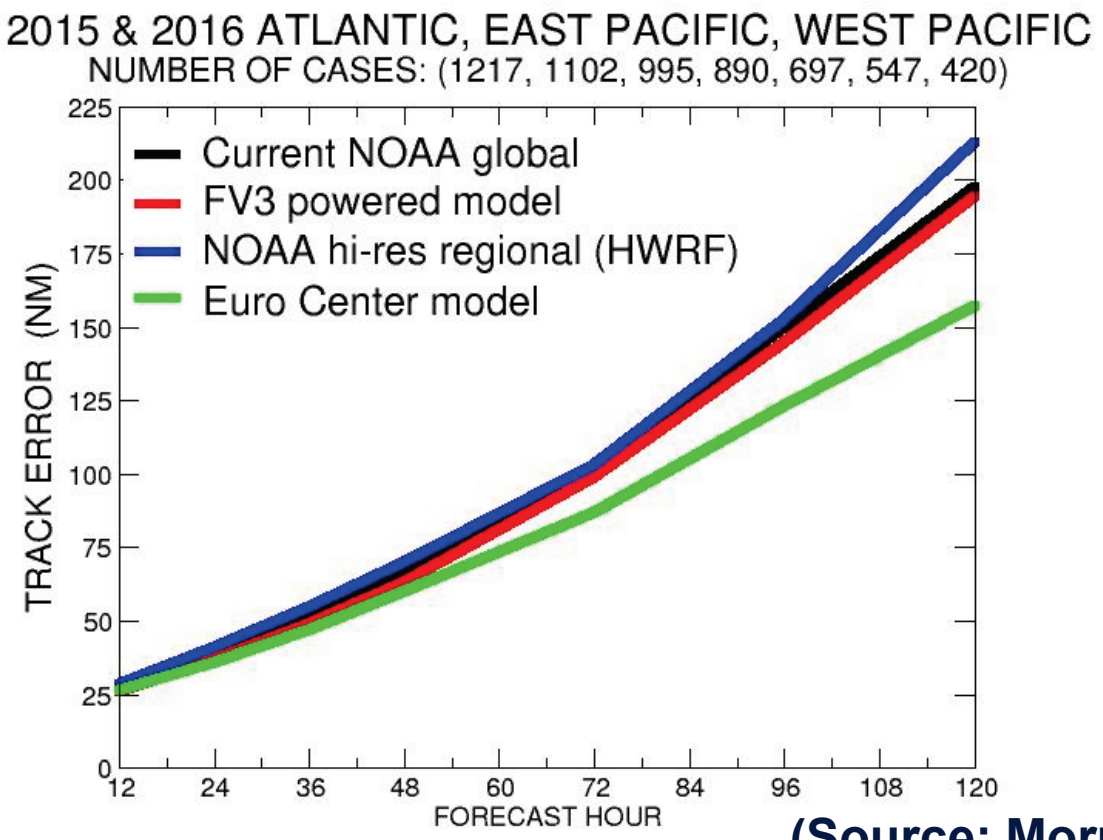


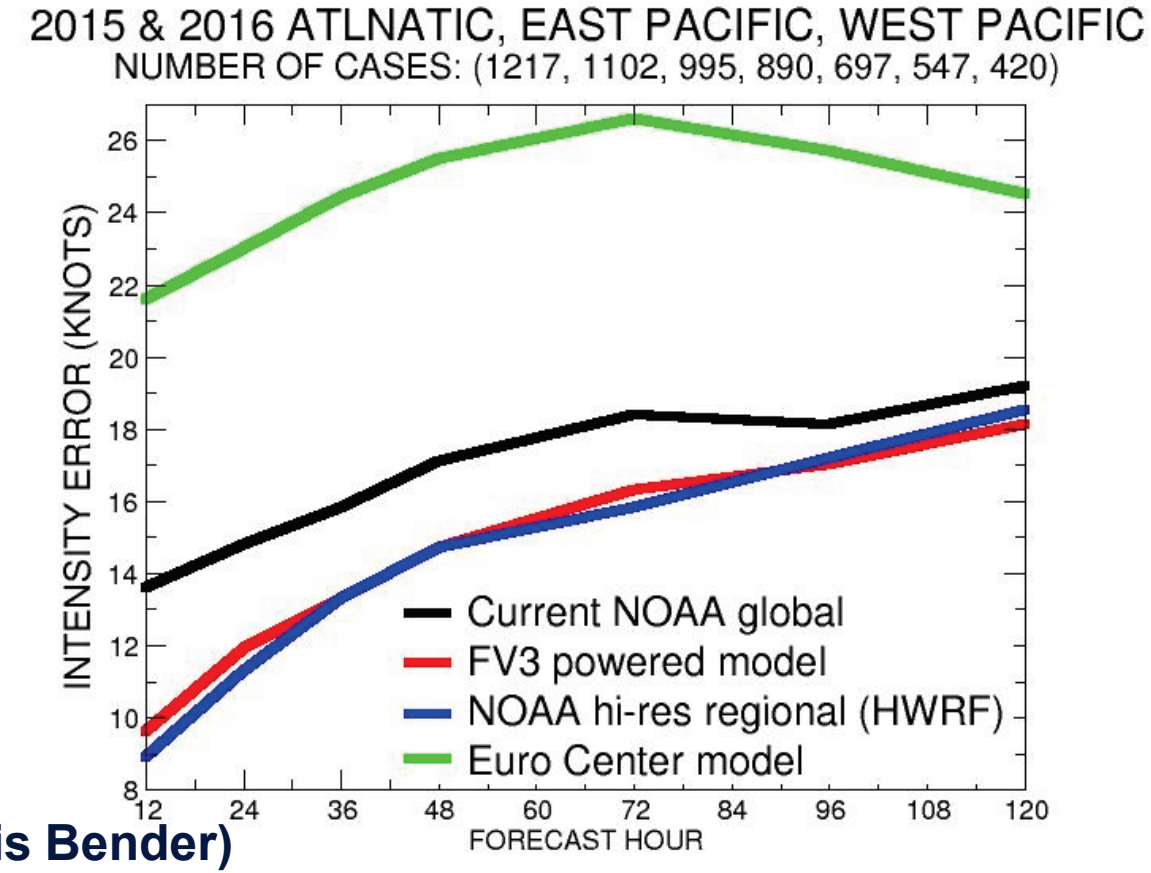
Nest in stretched grid

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

Statistics for 2-year period: 2015 & 2016

C768L63 (13-km) for all basins





(Source: Morris Bender)

Intensity skill is as good as HWRF

FV3GFS As a Community Model: Version 0 Code Release 05/15/17

- **Configuration**: **NEMS + FV3_CAP + FV3_Dycore + IPDv4 + GFS_Physics**

  Same model used for Phase-2 dycore comparison with upgrade of physics to Q3FY17 GFS configuration.
- **Resolution**: C96 (~100km), C384 (25km), C768 (~13km)
- **Build the model:** On WCOSS, THEIA and Jet, with pre-installed libraries and utilities.
- **Data**: Initial conditions for selected cases, and fixed fields
- **Release Date: May 15, 2017**
- **Method of Release: VLab GIT;** EMC Subversion
- **Running the model**: simple shell script and configuration files
- **Post Processing**: **Fregrid** and **Remap** tools to convert 6-tile model output to global lat-lon grid with user defined resolution

- **Next Public Version with Cycled DA capability to be released in January 2018**

NOAA Virtual Lab (VLab) to host FV3GFS Code Release & Git to host the repositories

- Access FV3GFS Project on VLab

https://vlab.ncep.noaa.gov/web/fv3gfs

- Code repositories set up on

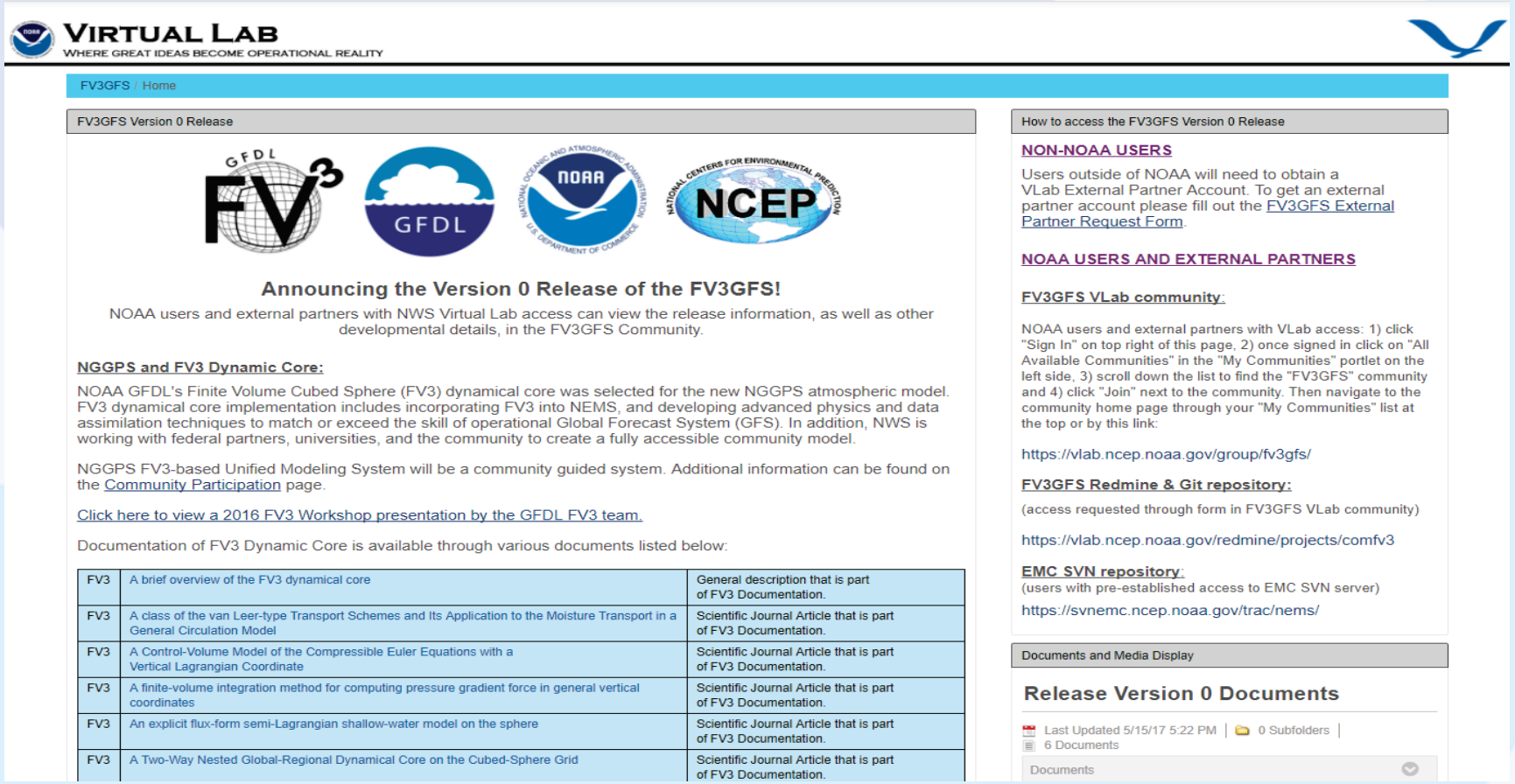
VLab GIT & EMC Subversion

- Community Wiki page, Forums and Developers Pages on VLab
- Case Studies:

Sept. 29, 2016 **Hurricane Matthew**
Jan. 18, 2016 **East Coast Blizzard**
Aug. 12, 2016 **Louisiana Flooding**

- Model Resolutions:

C96 (**~100km**), C382 (**~25km**) or C768 (**~13km**)



- Limited support from EMC to run FV3GFS forecast only experiments on WCOSS, Theia and Jet
- Unified Community Research and Operations Workflow (CROW) under development

Transition from SVN to VLAB/git for Code Management

Vlab and redmine for communication and collaboration

https://vlab.ncep.noaa.gov/group/fv3gfs/home

https://vlab.ncep.noaa.gov/redmine/projects/fv3gfs

Fully functional

Gerrit and Git repositories

ssh://vlab.ncep.noaa.gov:29418/fv3gfs	workflow
ssh://vlab.ncep.noaa.gov:29418/NEMSfv3gfs	fv3 compset
ssh://vlab.ncep.noaa.gov:29418/FV3	FV3 model code
ssh://vlab.ncep.noaa.gov:29418/NEMS	NEMS infrastructure

Fully functional

ssh://vlab.ncep.noaa.gov:29418/ProdGSI	Prod GSI
https://vlab.ncep.noaa.gov/redmine/projects/comgsi	Community GSI

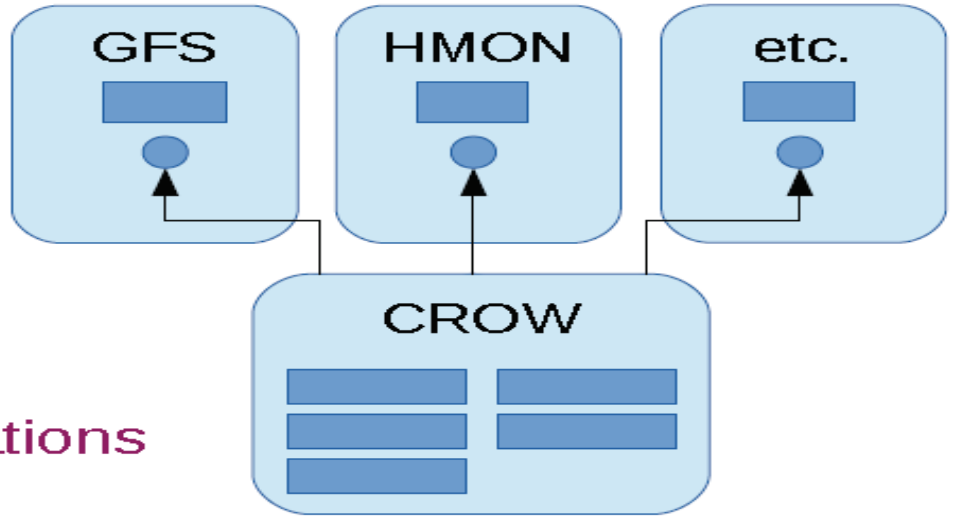
Fully functional

Unified Workflow for Research and Operations

CROW

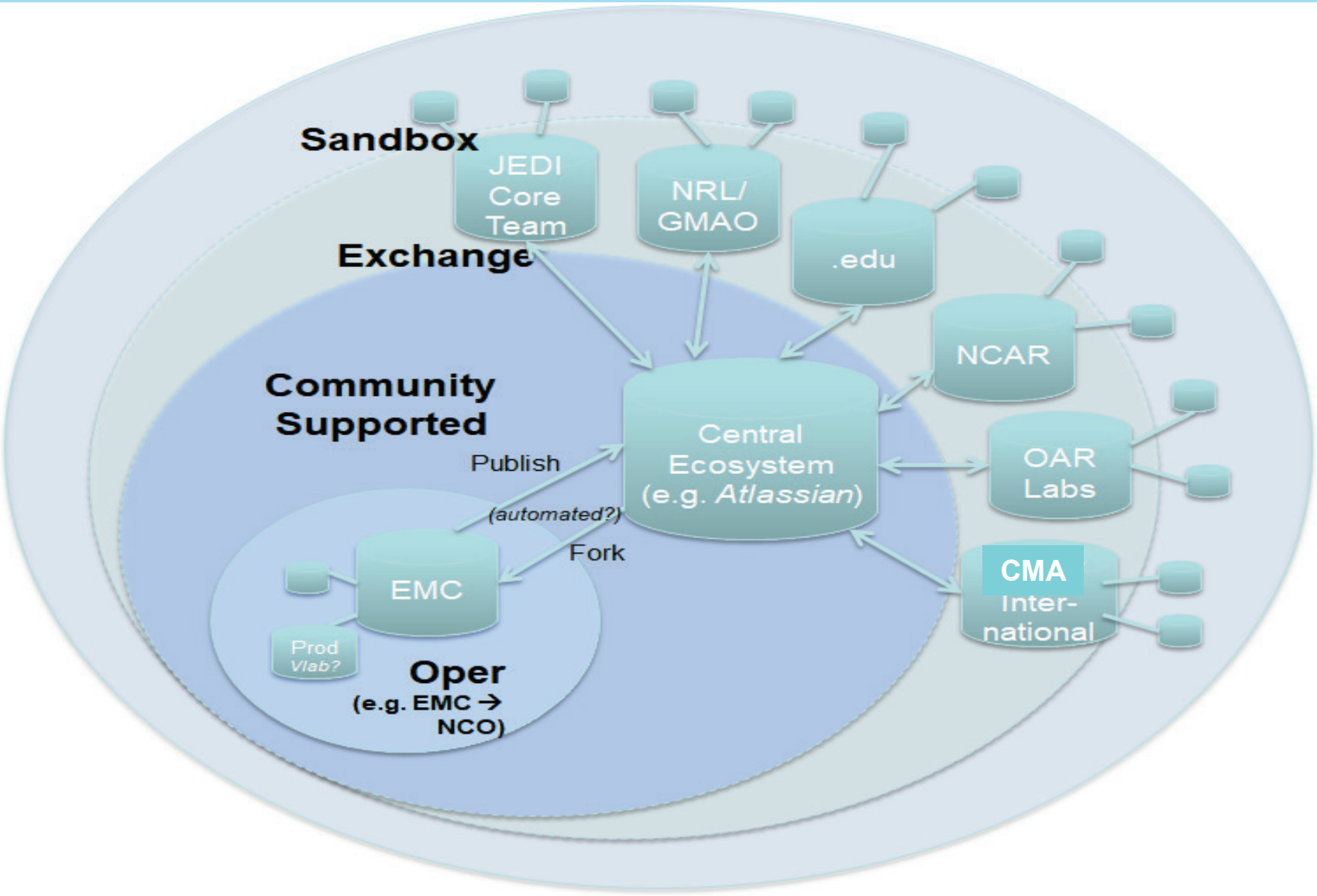
Common Research and Operational Workflow

Scope by ~12 months



- Integrated build & workflow system.
  - Umbrella build system
  - Unified workflow system
- For all use cases:
  - Production, Parallels, Research
  - Easy transition of code to and from operations
- System can be subsetted:
  - Researchers needs do not include DBNet, nor GFS faxes.
  - Production needs do not include scientific data visualization
- Initial target: FV3 Global Models (GFS, GDAS, GEFS)

Community Collaborations from NOAA Operations Point of view



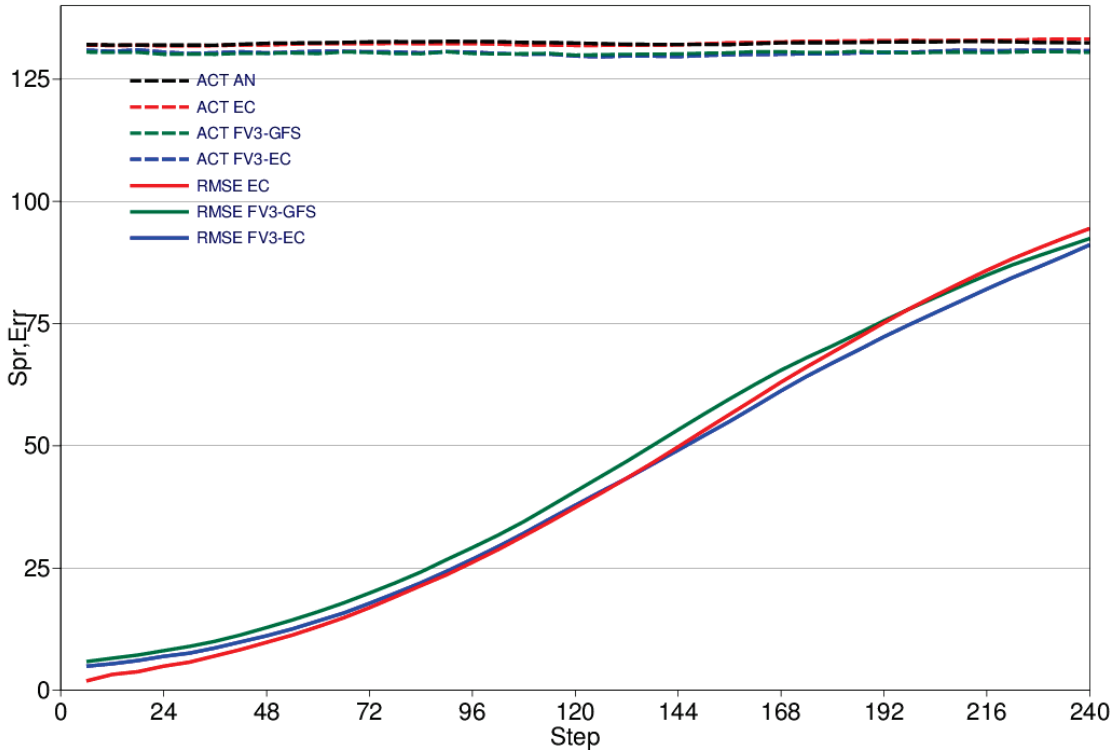
Ecosystem
= **collaborative environment**

- Code repo & Reviews *(Bitbucket)*
- Issue tracking *(JIRA)*
- Testing *(Bamboo)*
- Documentation *(Confluence)*
- Support *(JIRA Helpdesk)*
- Governance
  - Identify code utility
  - Define interfaces
  - Specify roles + authorities
  - Allocate resources

Aug 2015 – Aug 2016 (73 cases)

fvGFS with GFS IC – green
fvGFS with IFS IC - blue

RMSE and activity



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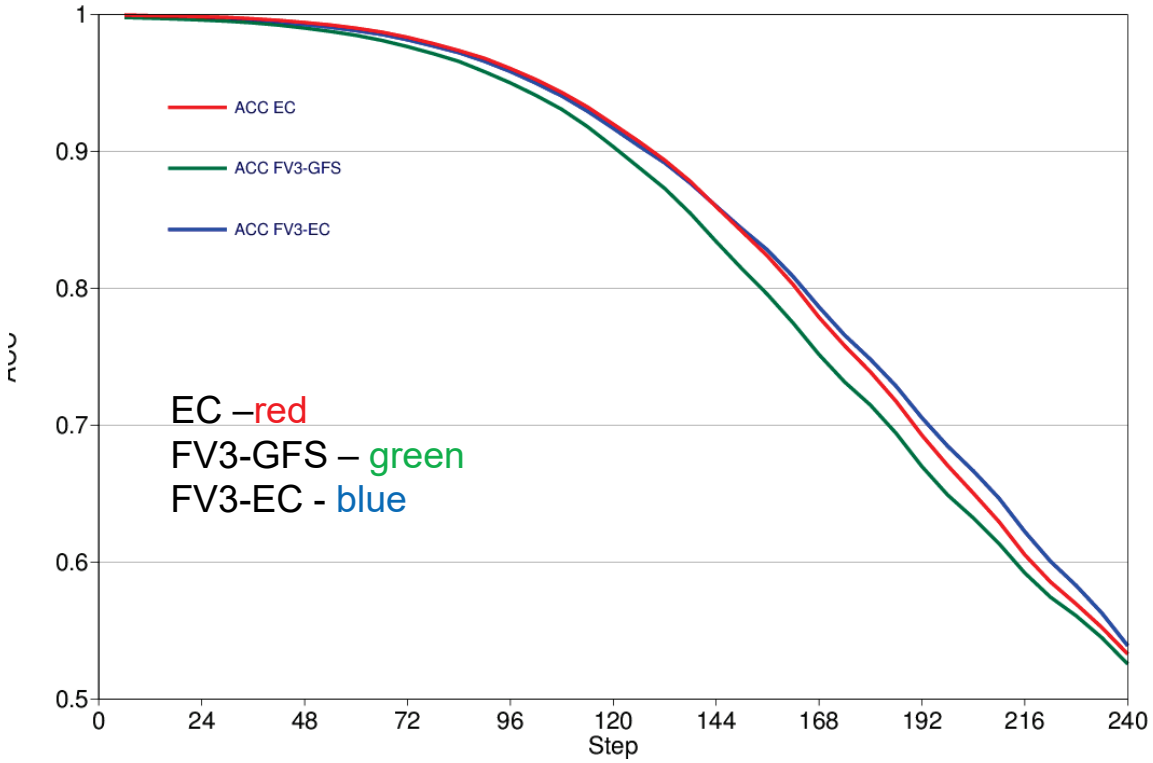

(Courtesy of Linus Magnusson, ECMWF)

A glimpse into the future of NWP

Global cloud-resolving prediction with FV3-powered NGGPS