

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

*Presentation at HFIP Annual Meeting, Miami, FL
November 8, 2017*

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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**

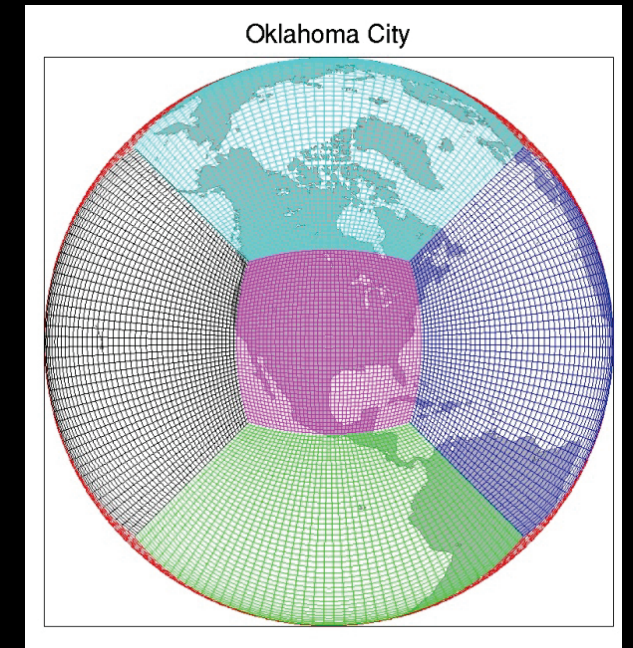
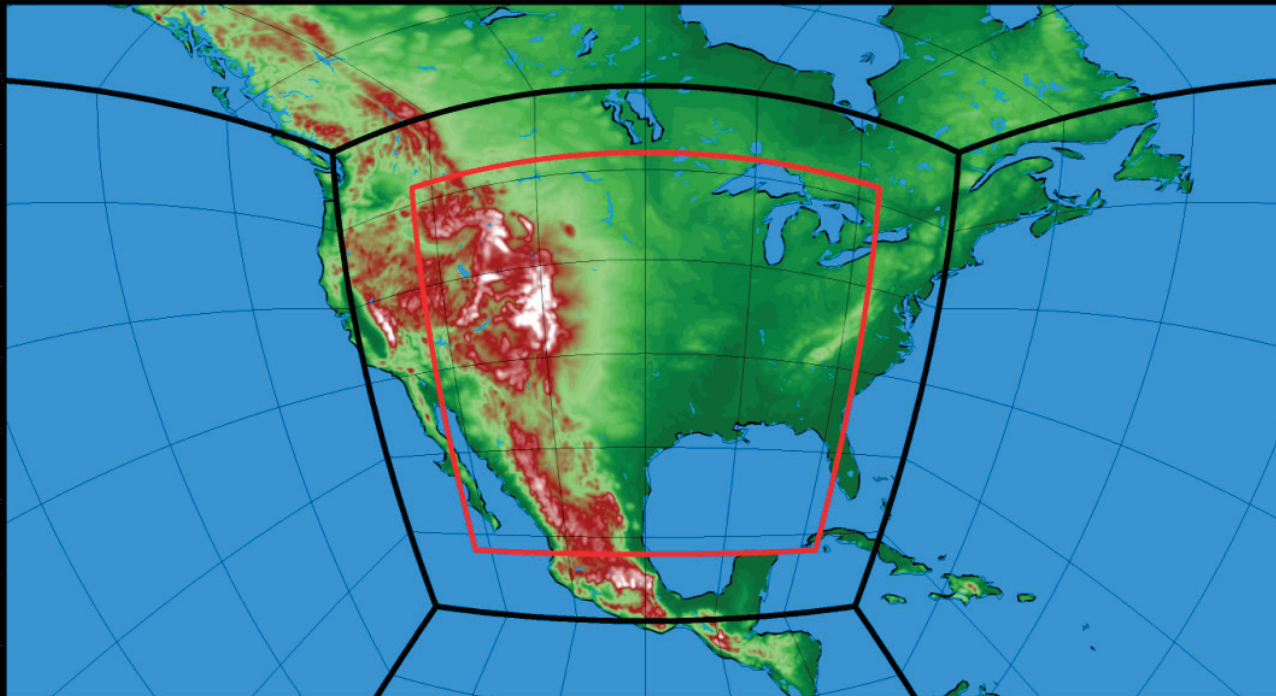
Achieving thunderstorm-resolving resolution “TODAY” in a unified meso-global prediction system

1) Grid stretching (smooth variation of grid spacing)

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

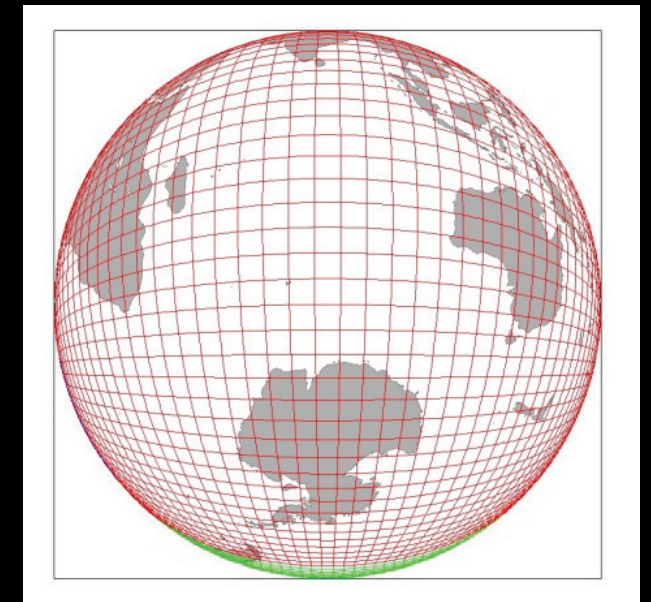
FV3 is uniquely suitable for 2-way nesting, due to the application of two-time-level Finite-Volume transport scheme

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



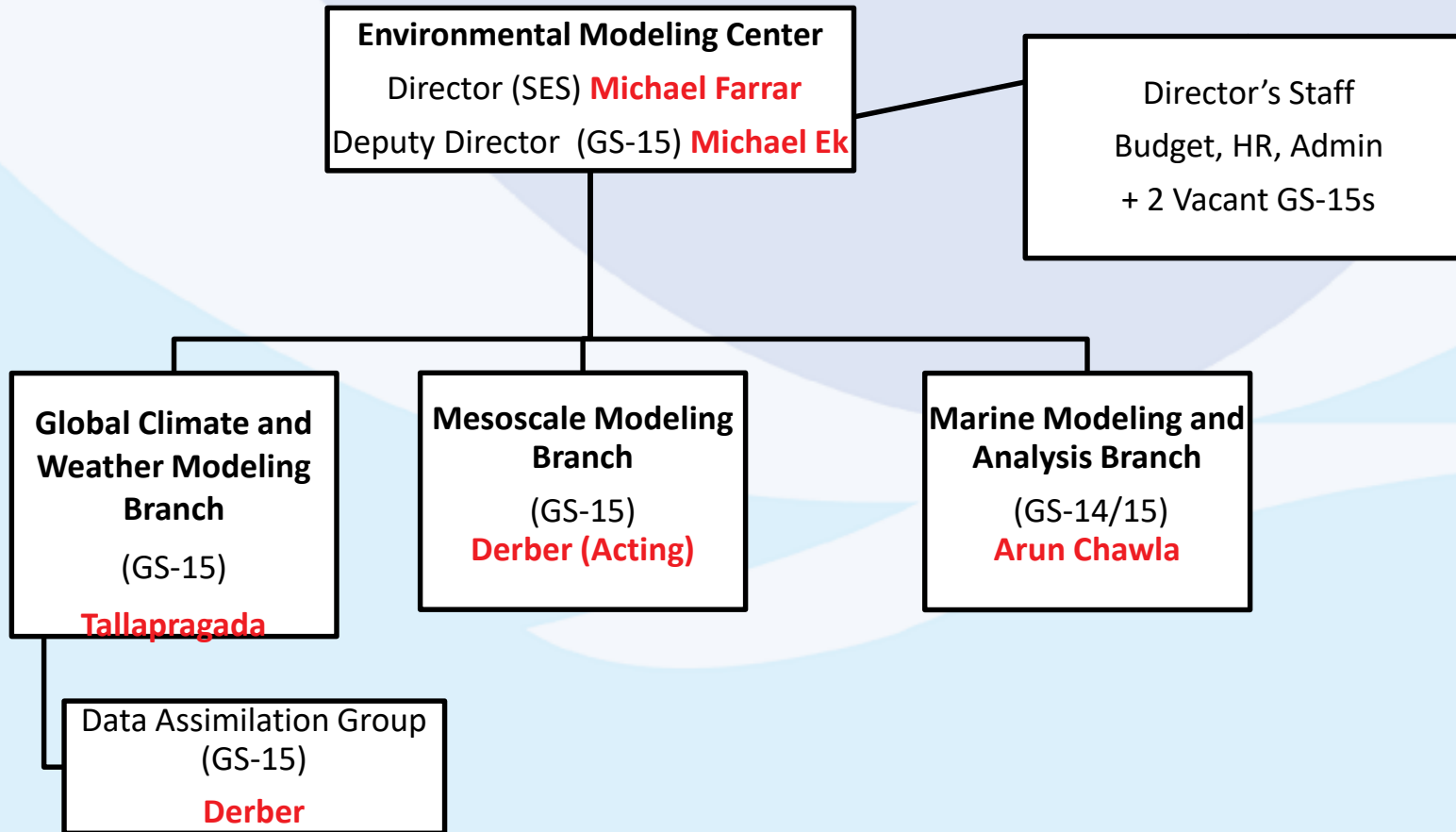
Example:

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



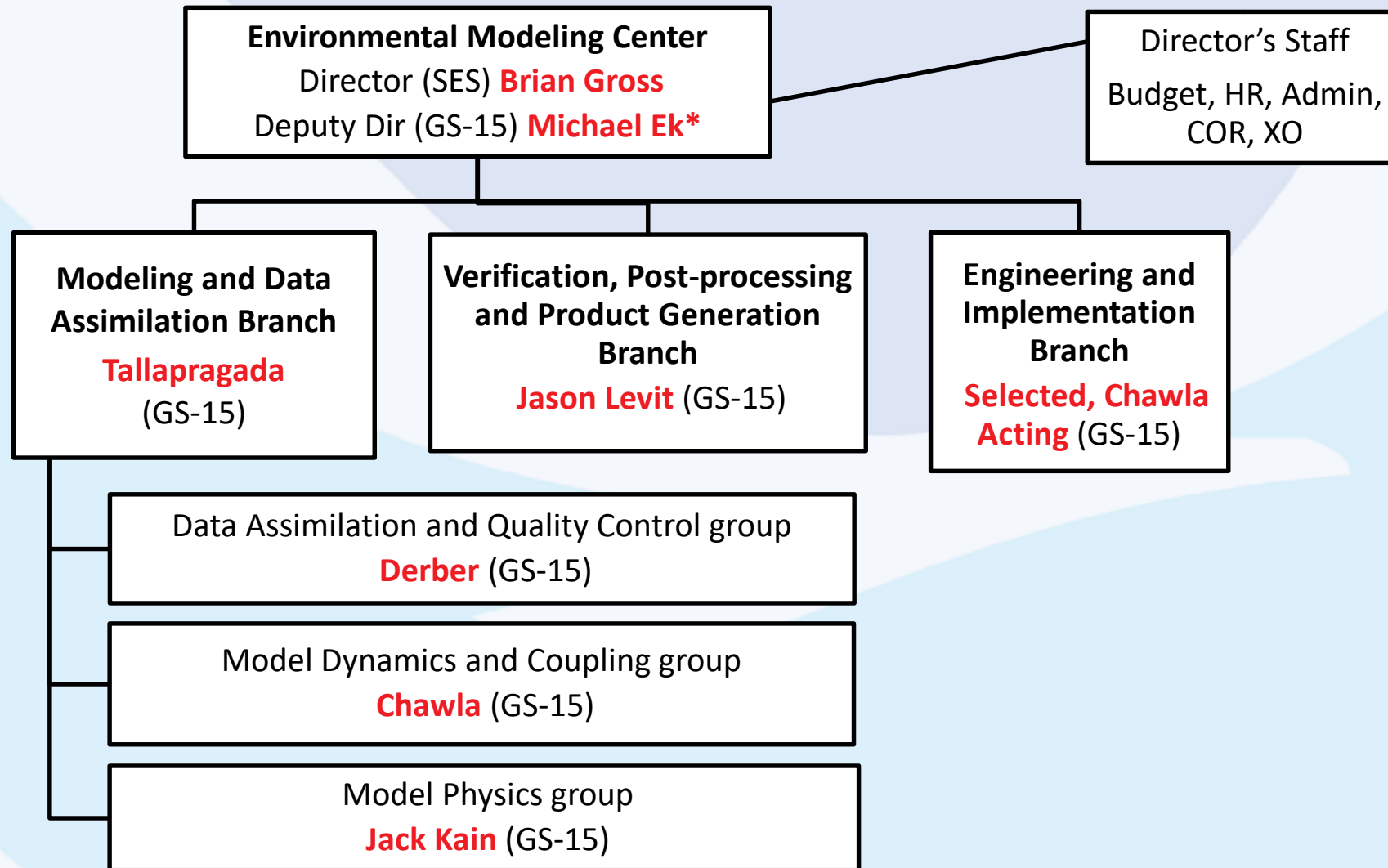
Org Chart: Before April 2017

Environmental Modeling Center (EMC)



Org Chart (After April 2017)

Environmental Modeling Center (EMC)



FV3GFS Implementation Plan

FV3GFS	FY17				FY18				FY19				FY20				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Evaluate and Document FV3 ✓	Evaluate, prepare and document FV3 dycore for GFS																
FV3 Dycore in NEMS ✓	Implement FV3 dycore in NEMS [@]																
FV3 Dycore with GFS Physics ✓			Couple FV3 to GFS physics (NUOPC physics driver) perform forecast-only experiments, tuning and														
Preliminary GSI/EnKF DA for Fv3 ✓			Develop DA techniques* (native grid vs physics grid; New data)														
Cycled FV3GFS* experiments (real-time parallels)			Cycled experiments, benchmarking, efficiency and optimization						Real-time parallel FV3GFS forecasts to the field								
Develop end-to-end FV3GFS				Pre- and post-processing, verification & downstream													
Pre-implementation T&E for FV3GFS ^{@&%}								3-year retrospective + real-time parallels, EMC and Community Evaluation									
Transition to operations								Experimental (beta) implementation of FV3GFS*		NCO Parallel		NEMS/FV3GFS in operations					
Advancement of FV3GFS												Further advancements of FV3GFS with inputs from NGGPS and community contributions & Global-Meso unification (Unified Model Development)					

* Q3FY18 FV3GFS will be very similar to operational GFS implemented in July 2017
[@] Q2FY19 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

C768L64, ~13km Beta Version
NEMS GFS physics +GFDL MP

C1152L127, ~10km
Advanced Physics

FV3 GFS DA Timeline

FV3-GFS Data Assimilation (DA) Plan (FY2017-2020)

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)					

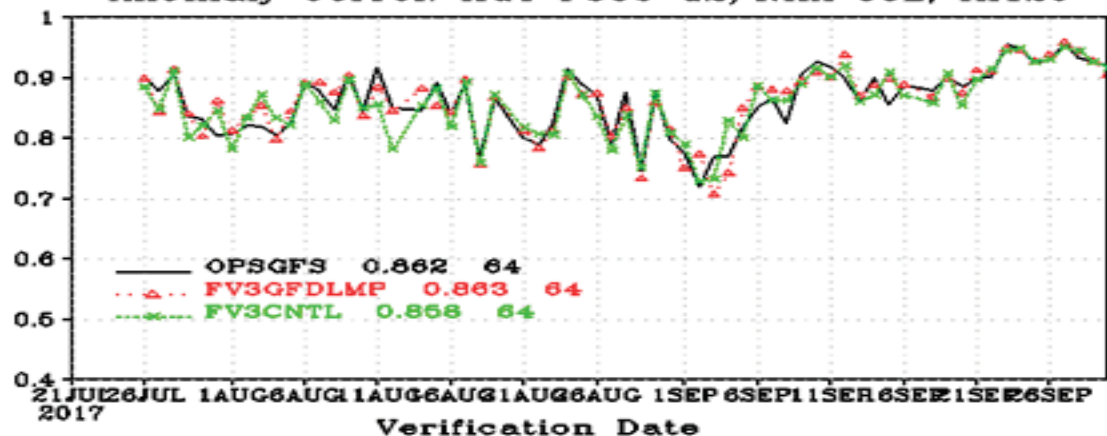
NOW

Experimental (beta)
implementation of
FV3GFS

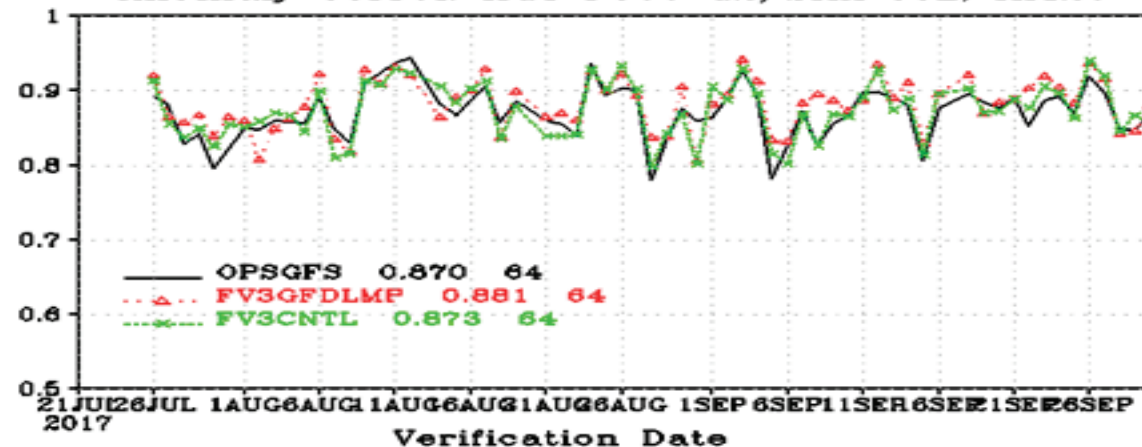
Initial implementation
of FV3GFS

500mb HGT ACC

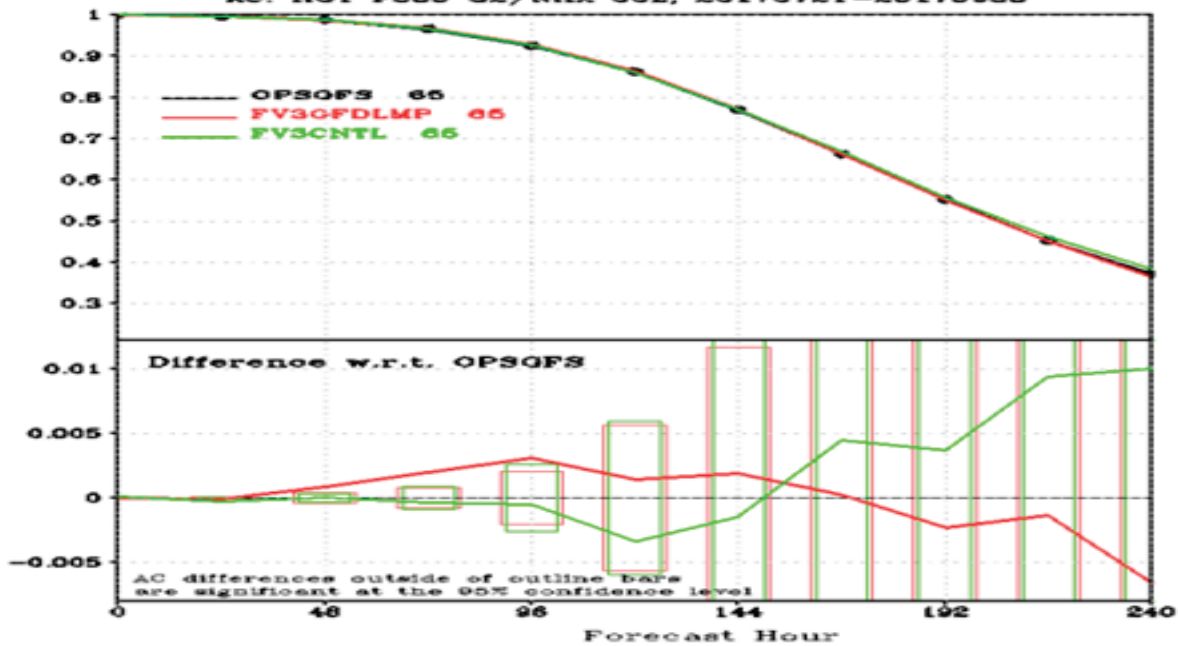
Anomaly Correl: HGT P500 G2/NHX 00Z, fh120



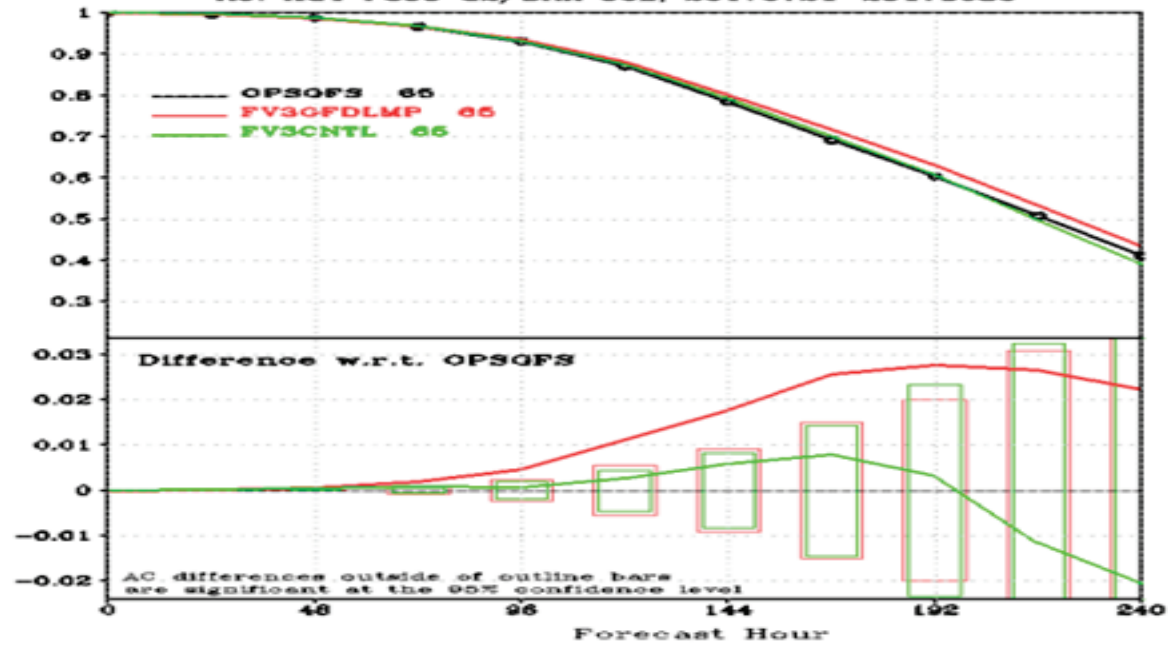
Anomaly Correl: HGT P500 G2/SHX 00Z, fh120



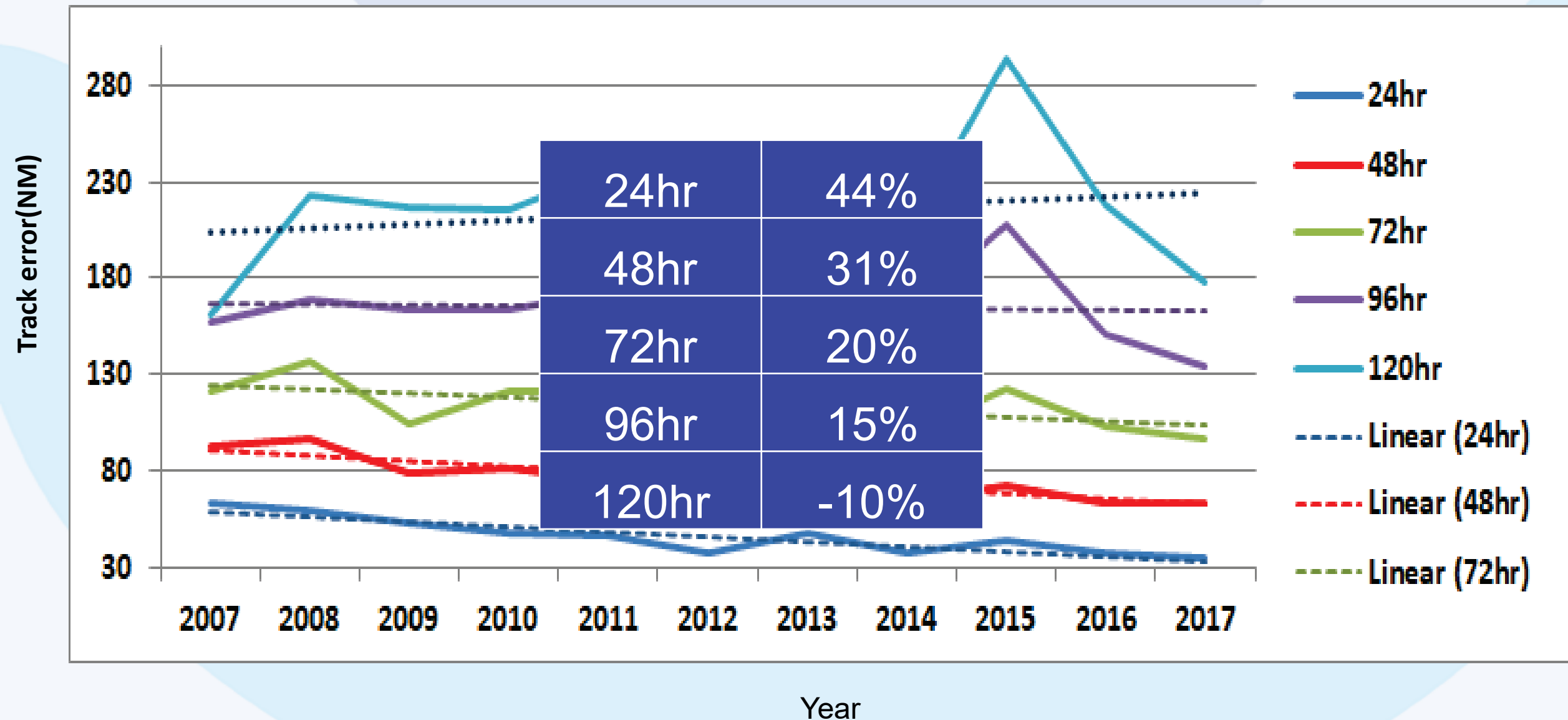
AC: HGT P500 G2/NHX 00Z, 20170721-20170930



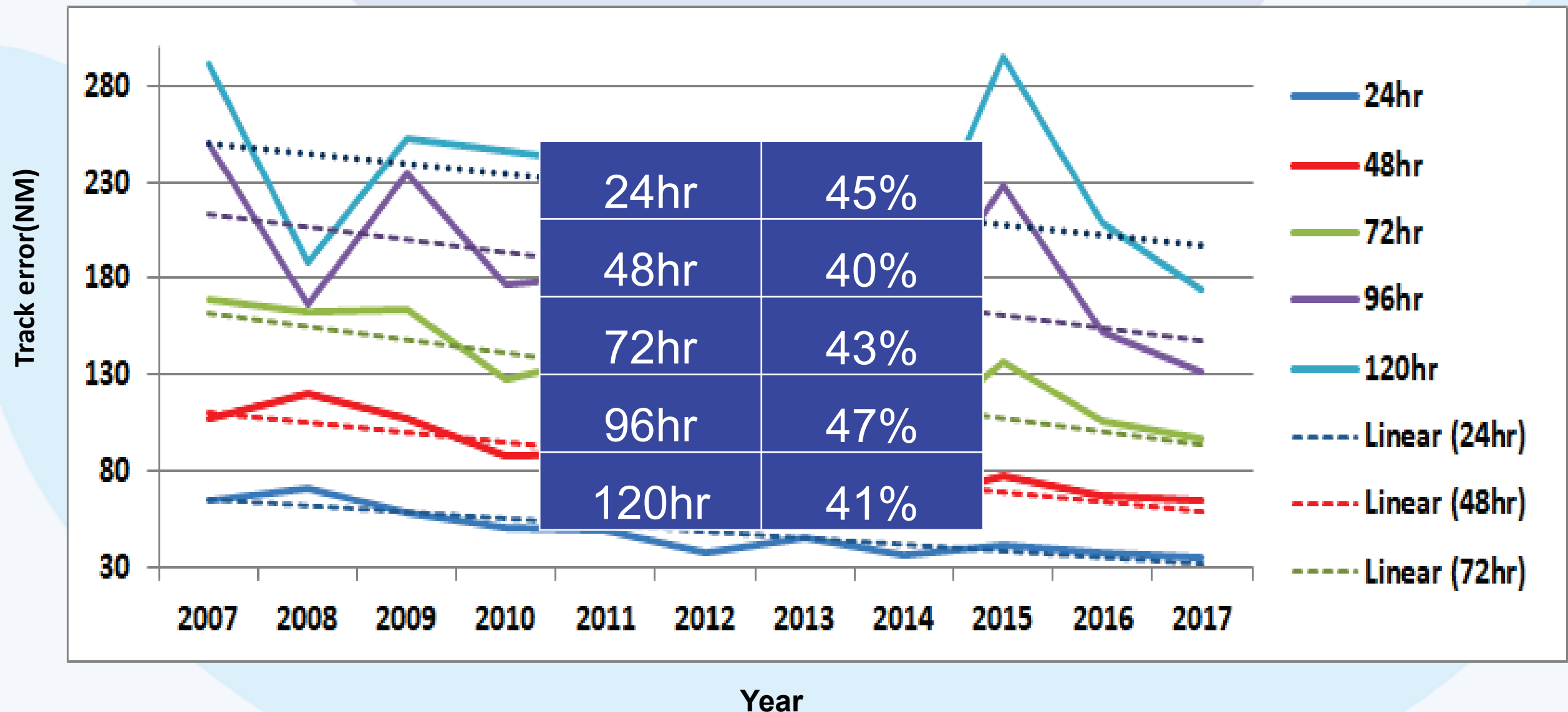
AC: HGT P500 G2/SHX 00Z, 20170721-20170930



Atlantic 2007-2017 GFS TC track error

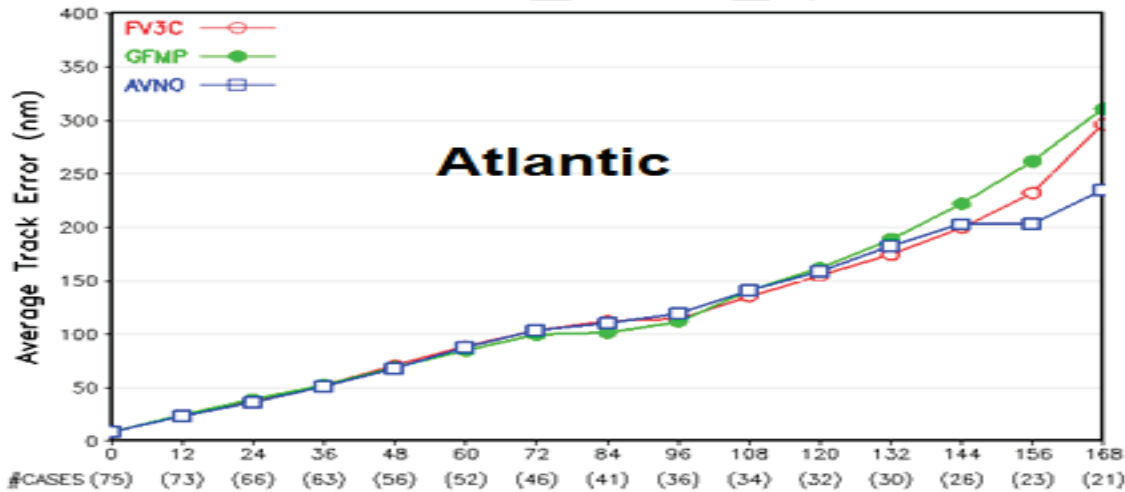


Atlantic 2007-2017 GEFS TC track error



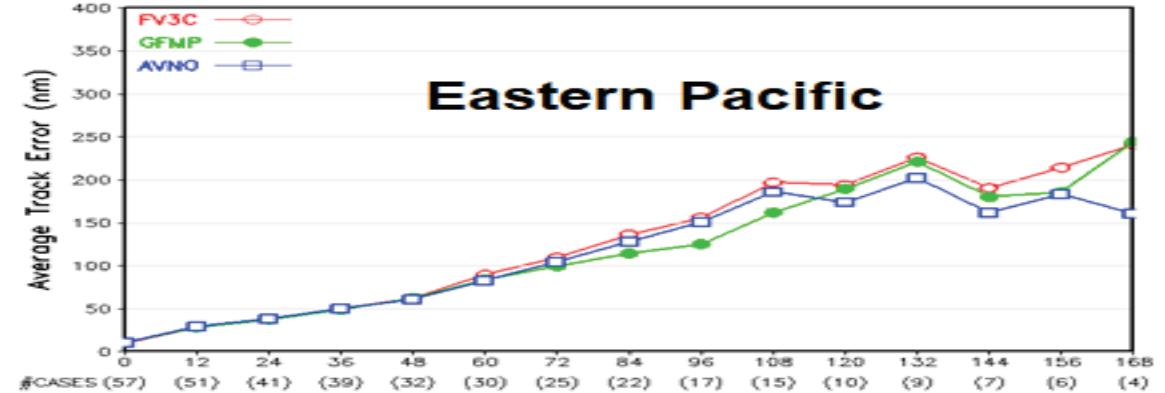
FV3GFS Hurricane Track Errors, July-September 2017

Hurricane Track Errors – Atlantic 2017
20170721_20171005_1cyc



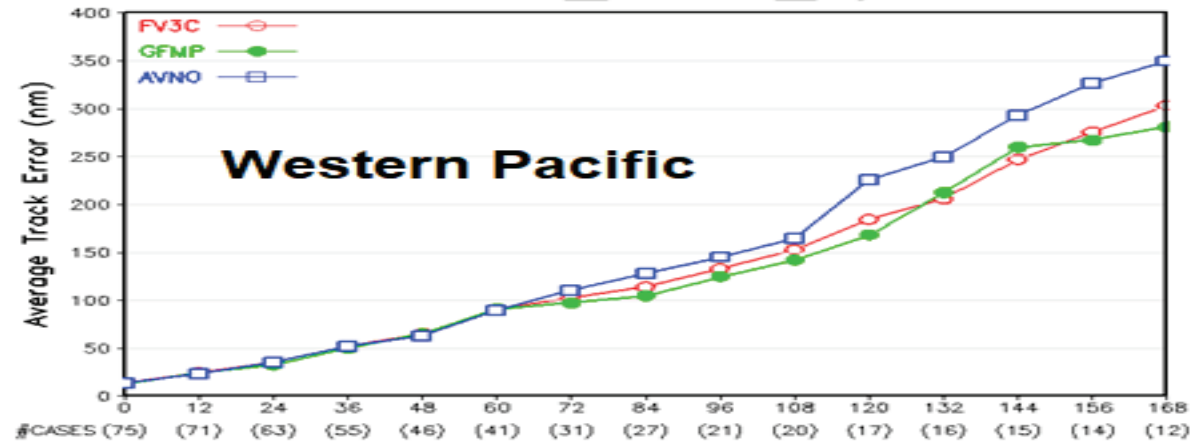
	(75)	(73)	(66)	(63)	(56)	(52)	(46)	(41)	(36)	(34)	(32)	(30)	(26)	(23)	(21)
FV3C_GFMP	89	51	62	57	71	82	77	93	65	68	70	79	90	85	76
FV3C_AVNO	58	77	91	70	82	55	53	57	72	70	65	74	59	92	97
GFMP_AVNO	90	78	93	72	57	77	75	91	82	51	55	83	79	95	98

Hurricane Track Errors – East-Pacific 2017
20170721_20171005_1cyc



	(57)	(51)	(41)	(39)	(32)	(30)	(25)	(22)	(17)	(15)	(10)	(9)	(7)	(6)	(4)
FV3C_GFMP	94	69	69	67	54	82	83	97	96	94	82	82	68	91	57
FV3C_AVNO	97	79	52	51	65	97	81	85	69	77	85	82	90	81	99
GFMP_AVNO	69	85	69	69	66	60	70	89	94	88	81	85	73	52	98

Hurricane Track Errors – West-Pacific 2017
20170721_20171005_1cyc



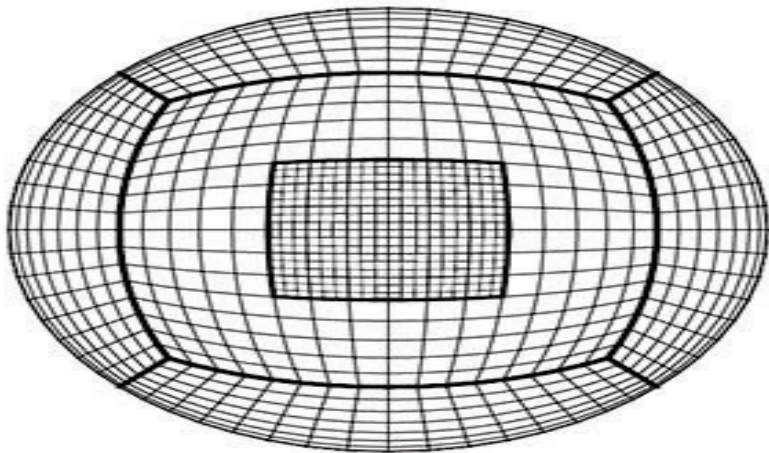
	(75)	(71)	(63)	(55)	(46)	(41)	(31)	(27)	(21)	(20)	(17)	(16)	(15)	(14)	(12)
FV3C_GFMP	82	65	99	83	58	52	81	90	77	78	78	68	69	65	85
FV3C_AVNO	54	67	53	50	73	56	90	94	77	74	96	98	95	92	89
GFMP_AVNO	62	57	99	78	68	57	97	99	94	90	94	94	84	96	96

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

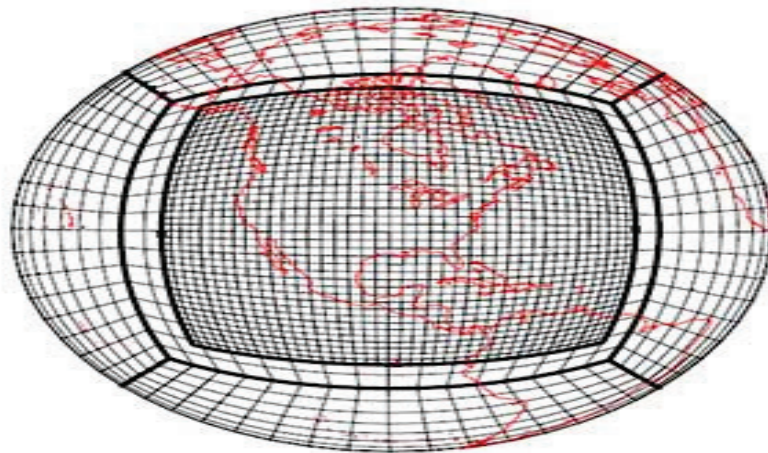
FY17				FY18				FY19				FY20			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		Develop and test low resolution FV3GFS with FV3GDAS, configure it for reanalysis (ESRL)													
Configure FV3GFS ensemble resolution, members, physics, coupling to ocean and sea-ice, and extend forecasts to weeks 3&4 (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.

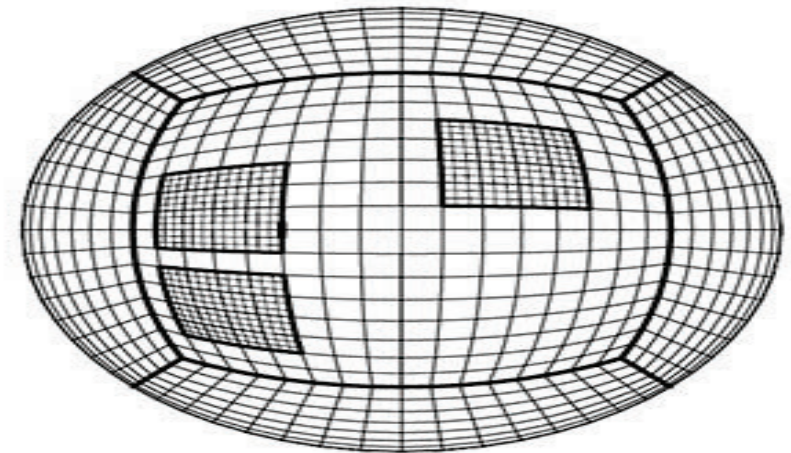
Tropical Cyclone Forecasts in FV3



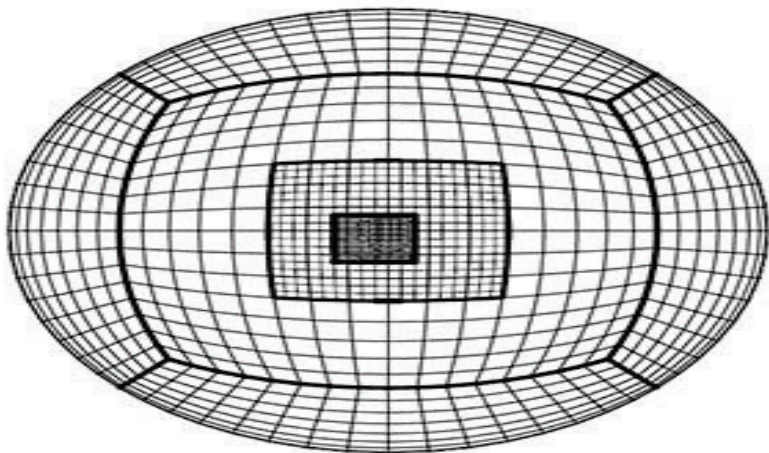
3:1 nested grid



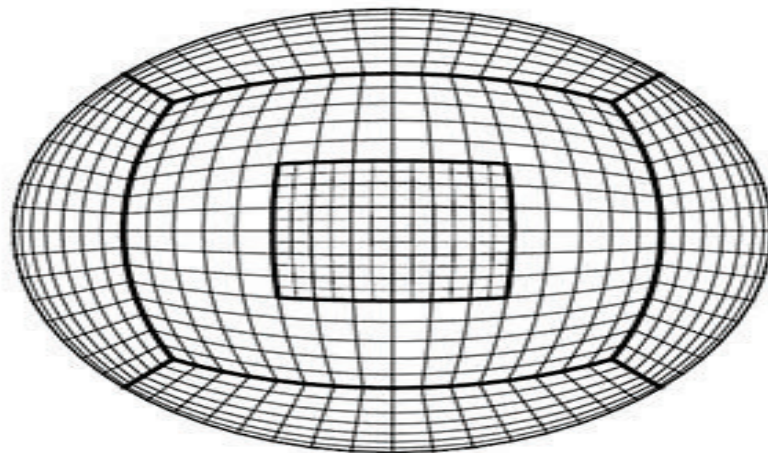
Large nest for RCMs



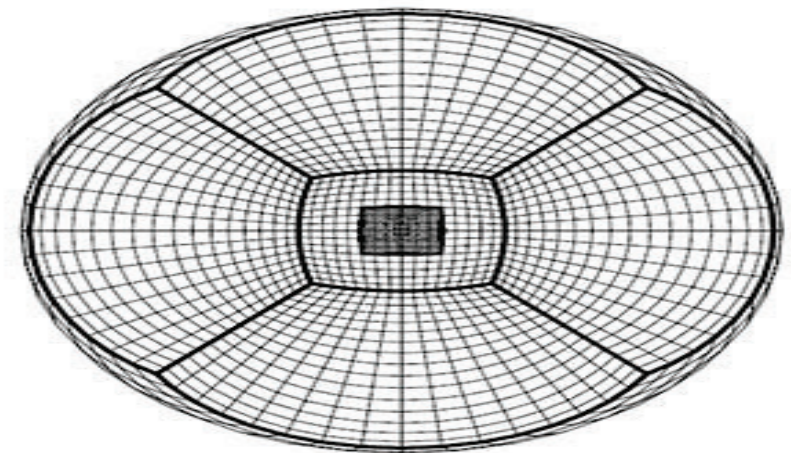
Multiple nests



Telescoping nests



2:1 nested grid



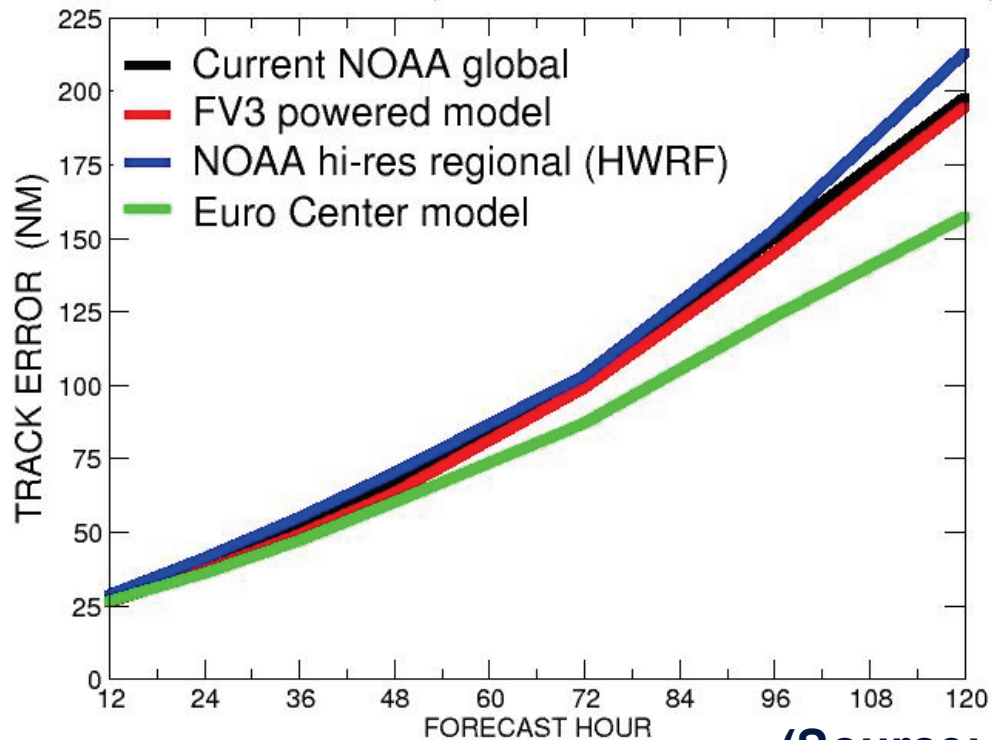
Nest in stretched grid

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

Statistics for 2-year period: 2015 & 2016

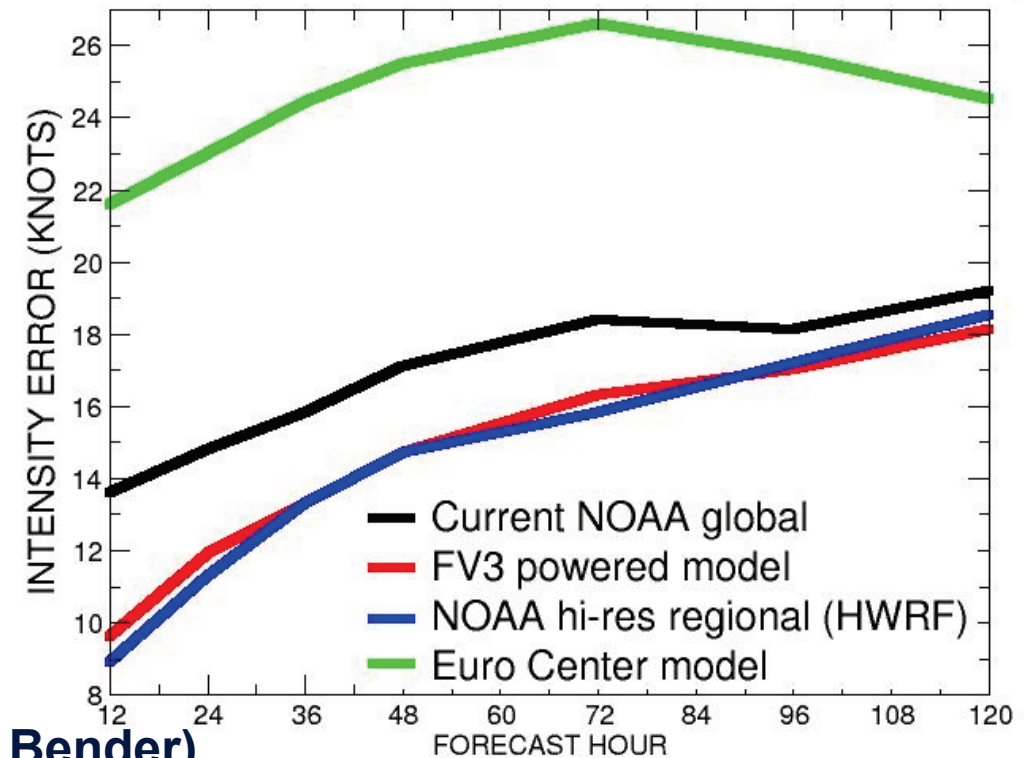
C768L63 (13-km) for all basins

2015 & 2016 ATLANTIC, EAST PACIFIC, WEST PACIFIC
NUMBER OF CASES: (1217, 1102, 995, 890, 697, 547, 420)



(Source: Morris Bender)

2015 & 2016 ATLANTIC, EAST PACIFIC, WEST PACIFIC
NUMBER OF CASES: (1217, 1102, 995, 890, 697, 547, 420)



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)

VIRTUAL LAB
WHERE GREAT IDEAS BECOME OPERATIONAL REALITY

FV3GFS / Home

FV3GFS Version 0 Release

Announcing the Version 0 Release of the FV3GFS!

NOAA users and external partners with NWS Virtual Lab access can view the release information, as well as other developmental details, in the FV3GFS Community.

NGGPS and FV3 Dynamic Core:

NOAA GFDL's Finite Volume Cubed Sphere (FV3) dynamical core was selected for the new NGGPS atmospheric model. FV3 dynamical core implementation includes incorporating FV3 into NEMS, and developing advanced physics and data assimilation techniques to match or exceed the skill of operational Global Forecast System (GFS). In addition, NWS is working with federal partners, universities, and the community to create a fully accessible community model.

NGGPS FV3-based Unified Modeling System will be a community guided system. Additional information can be found on the [Community Participation](#) page.

[Click here to view a 2016 FV3 Workshop presentation by the GFDL FV3 team.](#)

Documentation of FV3 Dynamic Core is available through various documents listed below:

FV3	A brief overview of the FV3 dynamical core	General description that is part of FV3 Documentation.
FV3	A class of the van Leer-type Transport Schemes and Its Application to the Moisture Transport in a General Circulation Model	Scientific Journal Article that is part of FV3 Documentation.
FV3	A Control-Volume Model of the Compressible Euler Equations with a Vertical Lagrangian Coordinate	Scientific Journal Article that is part of FV3 Documentation.
FV3	A finite-volume integration method for computing pressure gradient force in general vertical coordinates	Scientific Journal Article that is part of FV3 Documentation.
FV3	An explicit flux-form semi-Lagrangian shallow-water model on the sphere	Scientific Journal Article that is part of FV3 Documentation.
FV3	A Two-Way Nested Global-Regional Dynamical Core on the Cubed-Sphere Grid	Scientific Journal Article that is part of FV3 Documentation.

How to access the FV3GFS Version 0 Release

NON-NOAA USERS

Users outside of NOAA will need to obtain a VLab External Partner Account. To get an external partner account please fill out the [FV3GFS External Partner Request Form](#).

NOAA USERS AND EXTERNAL PARTNERS

FV3GFS VLab community:

NOAA users and external partners with VLab access: 1) click "Sign In" on top right of this page, 2) once signed in click on "All Available Communities" in the "My Communities" portlet on the left side, 3) scroll down the list to find the "FV3GFS" community and 4) click "Join" next to the community. Then navigate to the community home page through your "My Communities" list at the top or by this link:

<https://vlab.ncep.noaa.gov/group/fv3gfs/>

FV3GFS Redmine & Git repository:

(access requested through form in FV3GFS VLab community)

<https://vlab.ncep.noaa.gov/redmine/projects/comfv3>

EMC SVN repository:

(users with pre-established access to EMC SVN server)

<https://svnemc.ncep.noaa.gov/trac/nems/>

Documents and Media Display

Release Version 0 Documents

Last Updated 5/15/17 5:22 PM | 0 Subfolders | 6 Documents

Documents

- 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

Fully functional

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

ssh://vlab.ncep.noaa.gov:29418/ProdGSI

Prod GSI

Fully functional

<https://vlab.ncep.noaa.gov/redmine/projects/comgsi> Community GSI

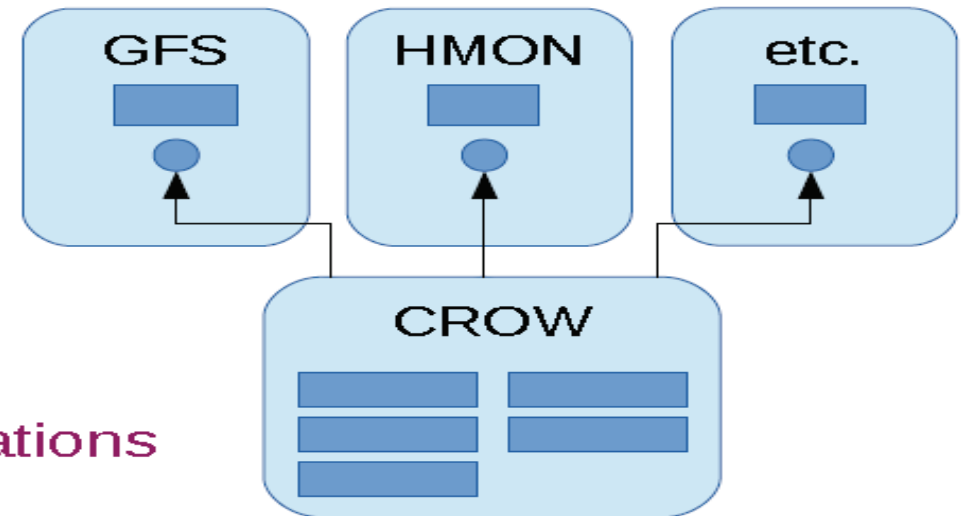
Unified Workflow for Research and Operations

CROW

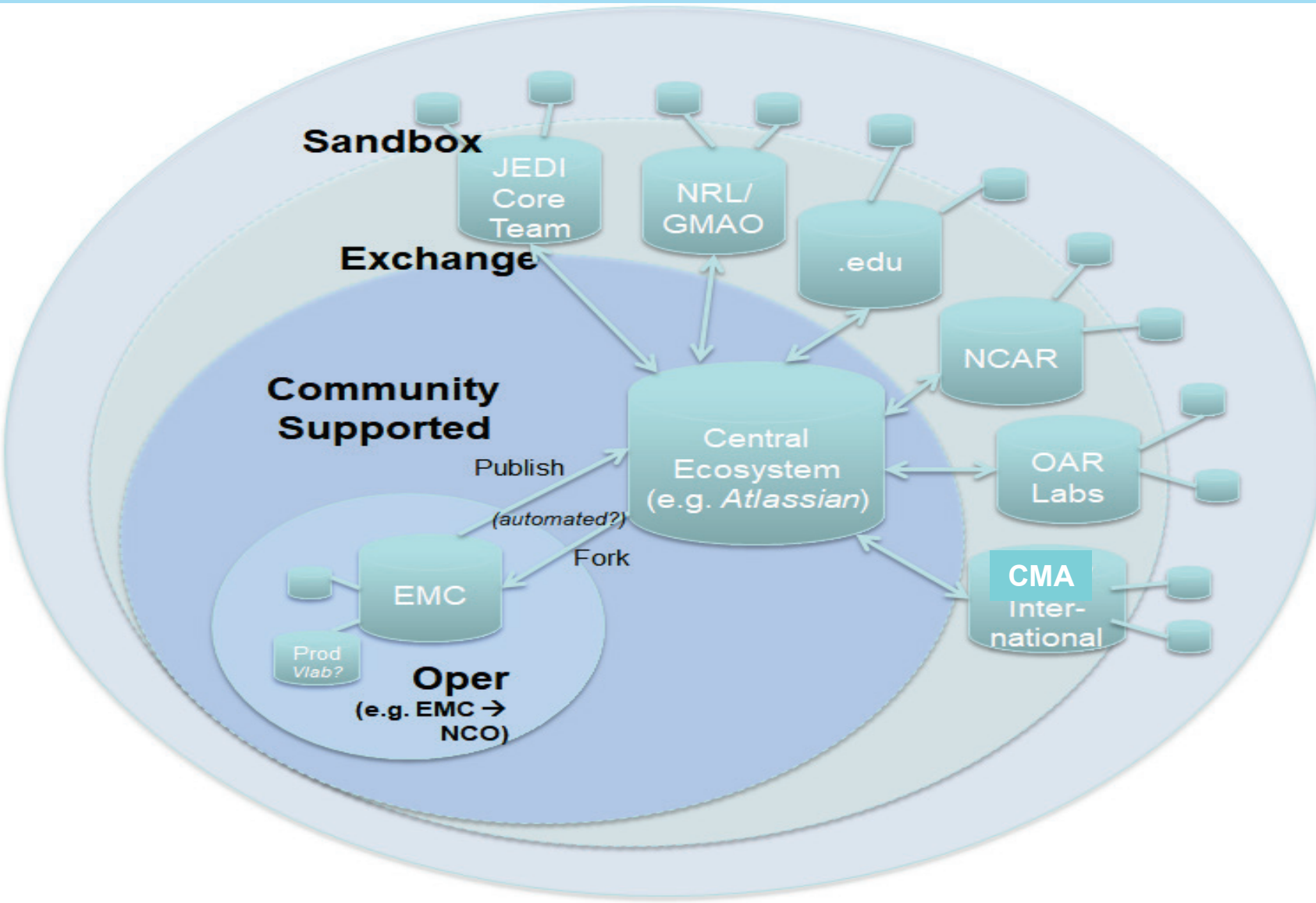
Common Research and Operational Workflow

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



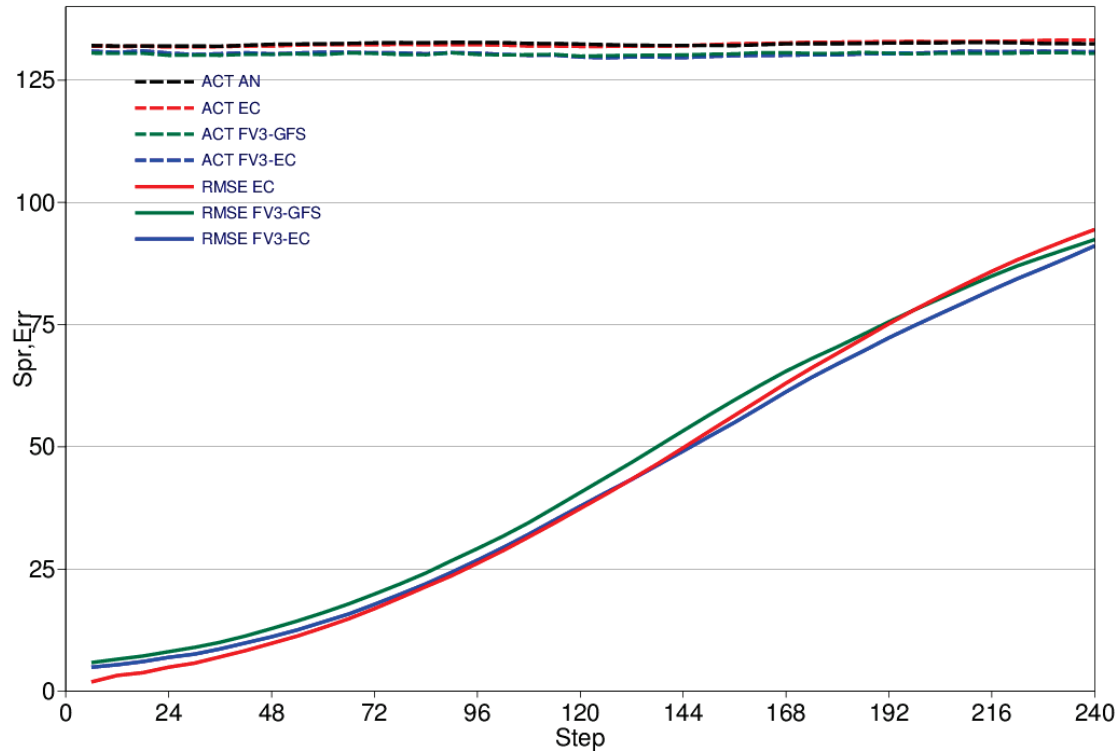
Ecosystem
= **collaborative environment**

- 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

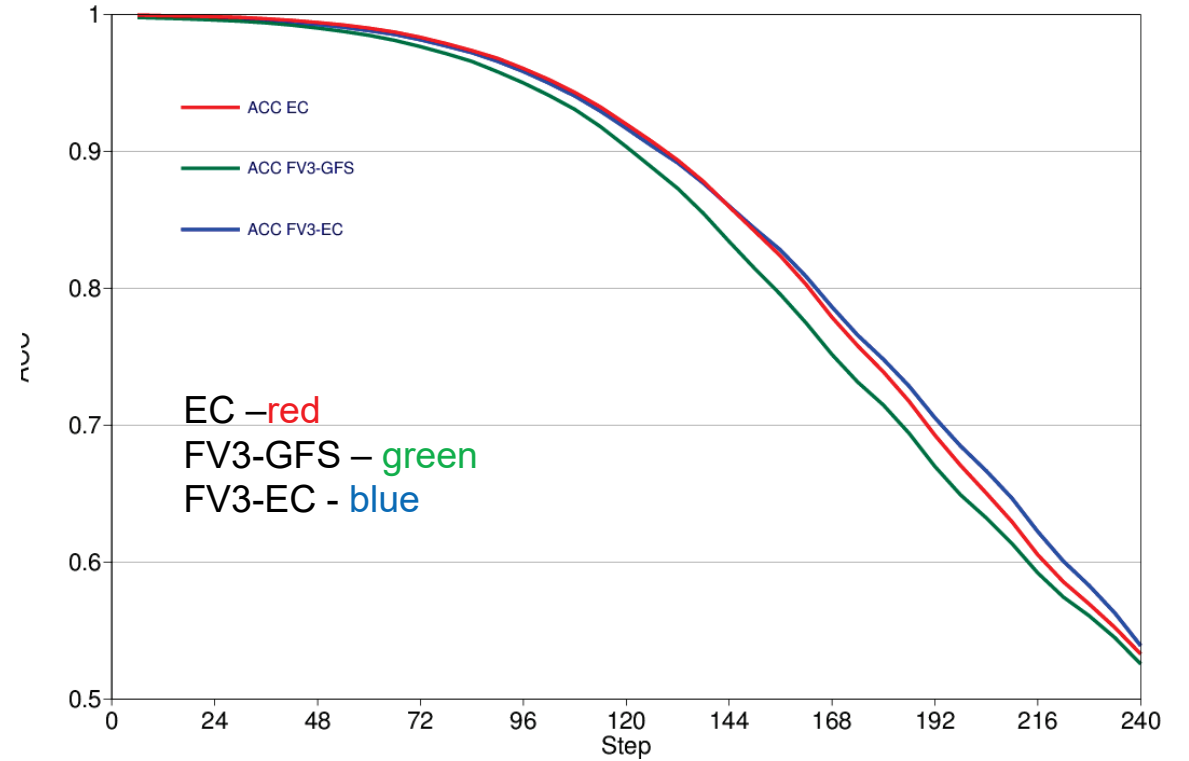
Aug 2015 – Aug 2016 (73 cases)

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

RMSE and activity



ACC



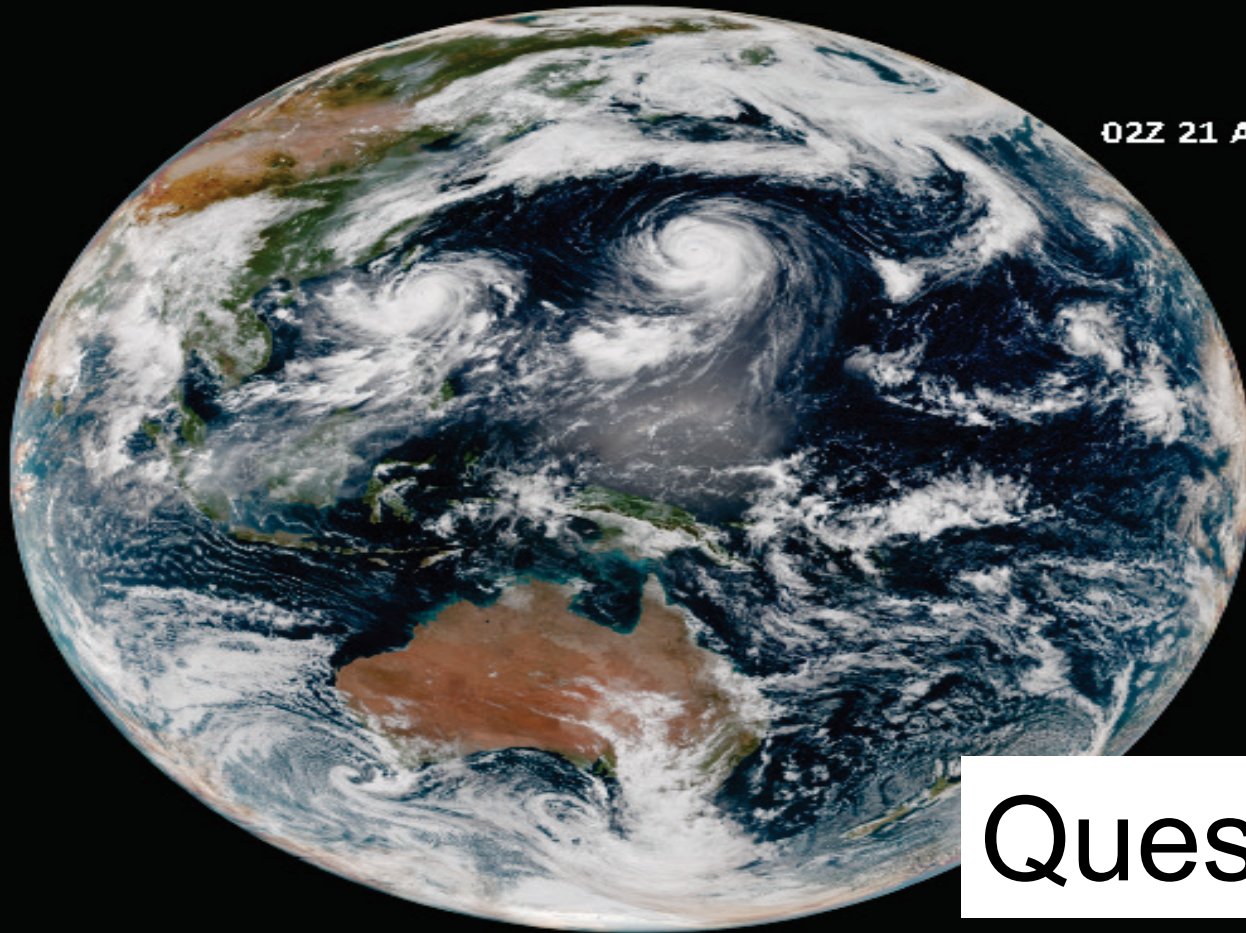
(Courtesy of Linus Magnusson, ECMWF)

A glimpse into the future of NWP

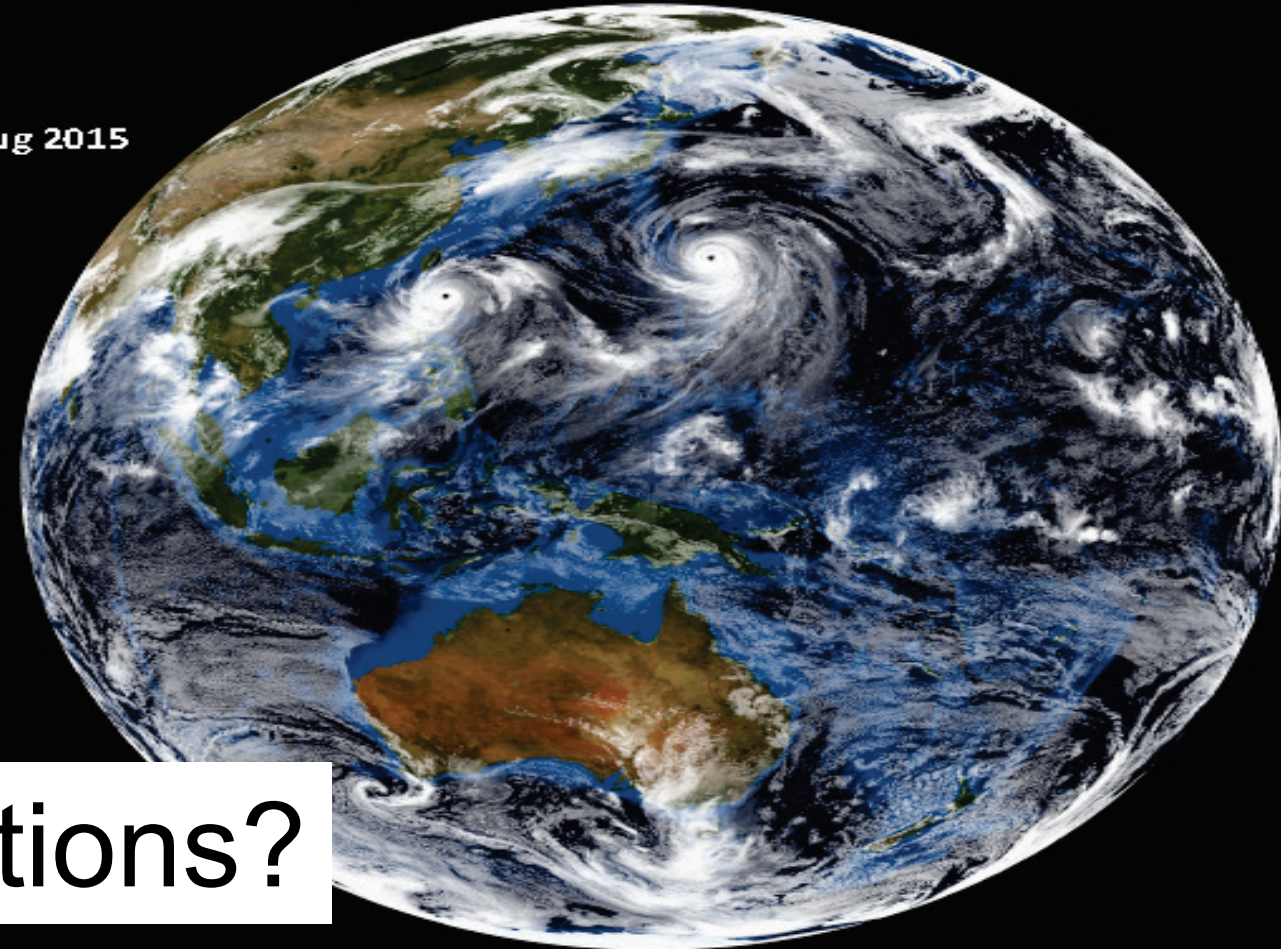
Global cloud-resolving prediction with FV3-powered NGGPS

Himawari Satellite

50-hour prediction (INIT: 00Z 19AUG 2015)



02Z 21 Aug 2015



Questions?

Courtesy: SJ Lin, GFDL

FV3 initialized with IFS IC (courtesy of Linus Magnusson, ECMWF)