NOAA's FV3 based Unified Modeling System Development Strategies

HFIP Annual Meeting, 8-9 Nov. 2017

NOAA's Modeling capabilities (Hurricane related)

- Global
  - GFS, GEFS
  - Global Wave (deterministic and ensembles)
  - RTOFS Global
- Regional
  - HWRF, HMON
  - Hurricane Wave & Storm surge models
  - Many high-resolution short-range regional prediction systems for CONUS and OCONUS
- Data Assimilation
  - Global Ensemble based 4D-EnVAR
  - Hurricane Data Assimilation System
  - Regional Data Assimilation Systems for NAM, HRRR, RTMA/URMA etc.

HWRF/HMON Development/Implementation Plans

2016	2017	2018	2019	2020

HWRF Operational Model Continues Followed by Ensembles

GFDL ——— HMON

10-member HWRF/ HMON Ensembles

NEMS Global Nests (NGGPS)

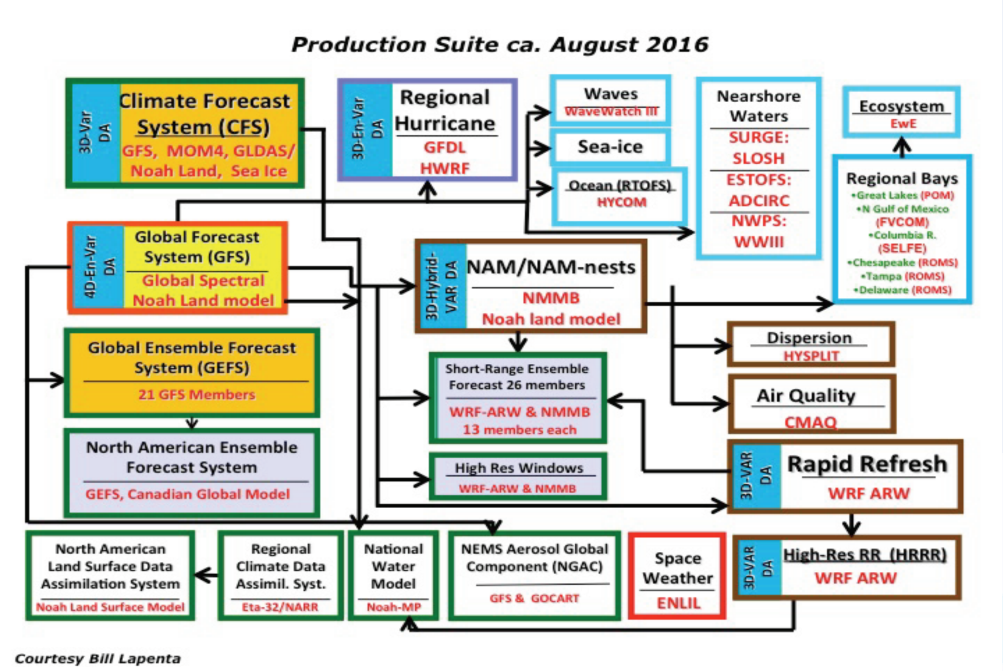
Basin-Scale HWRF/HMON/FV3——— Global/Tropical Domains

Hurricane Models take over Hurricane Wave Forecasts

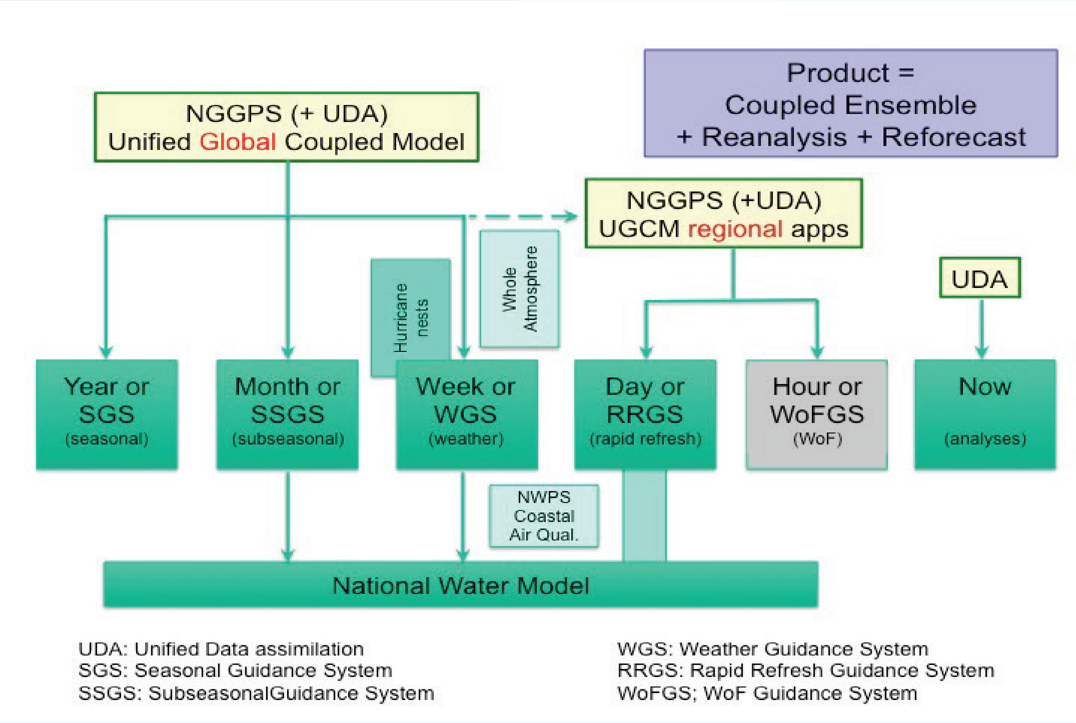
Implementation Plans for Global Forecast System (GFS V15) and Global Ensemble Forecast System (GEFS V12)

Timeline	FY17				FY18				FY19				FY20	
Component	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
FV3 GFS Beta (Experimental)	Evaluate, prepare and document FV3 dycore for GFS			Implement FV3 dycore in NEMS & coupled to GFS Physics Cycled FV3GFS experiments			Experimental (beta) implementation of FV3GFS							
Post-Processing, Downstream applications		Pre- and post-processing, verification & downstream												
FV3 GDAS	Preliminary GSI/EnKF DA for FV3; Assimilation of new satellite datasets (GOES-16, JPSS, COSMIC-2 etc.)				Cycled DA testing with advanced high-resolution configuration, tuning and optimization									
GFS 15.0 Implementation								retrospective + real-time parallels, evaluation and transition to operations			GFS V15 in operations			
FV3 GEFS Reanalysis	Develop and test low resolution FV3GFS with FV3GDAS, configure it for reanalysis (ESRL)				Produce ~20-year reanalysis datasets using FV3GFS/GDAS (ESRL)									
Ensemble configuration & Reforecasts	Configure FV3GFS ensemble resolution, members, physics, coupling to ocean and sea-ice, and extend forecasts to weeks 3&4 (EMC)						Finalize FV3GEFS V12 configuration* & produce ~20-year reforecasts (extended to 35 days)							
GEFS V12 implementation											Evaluate FV3GEFS V12 performance out to weeks 3&4		GEFS V12 in operations	

Strategic Vision & *Roadmap*

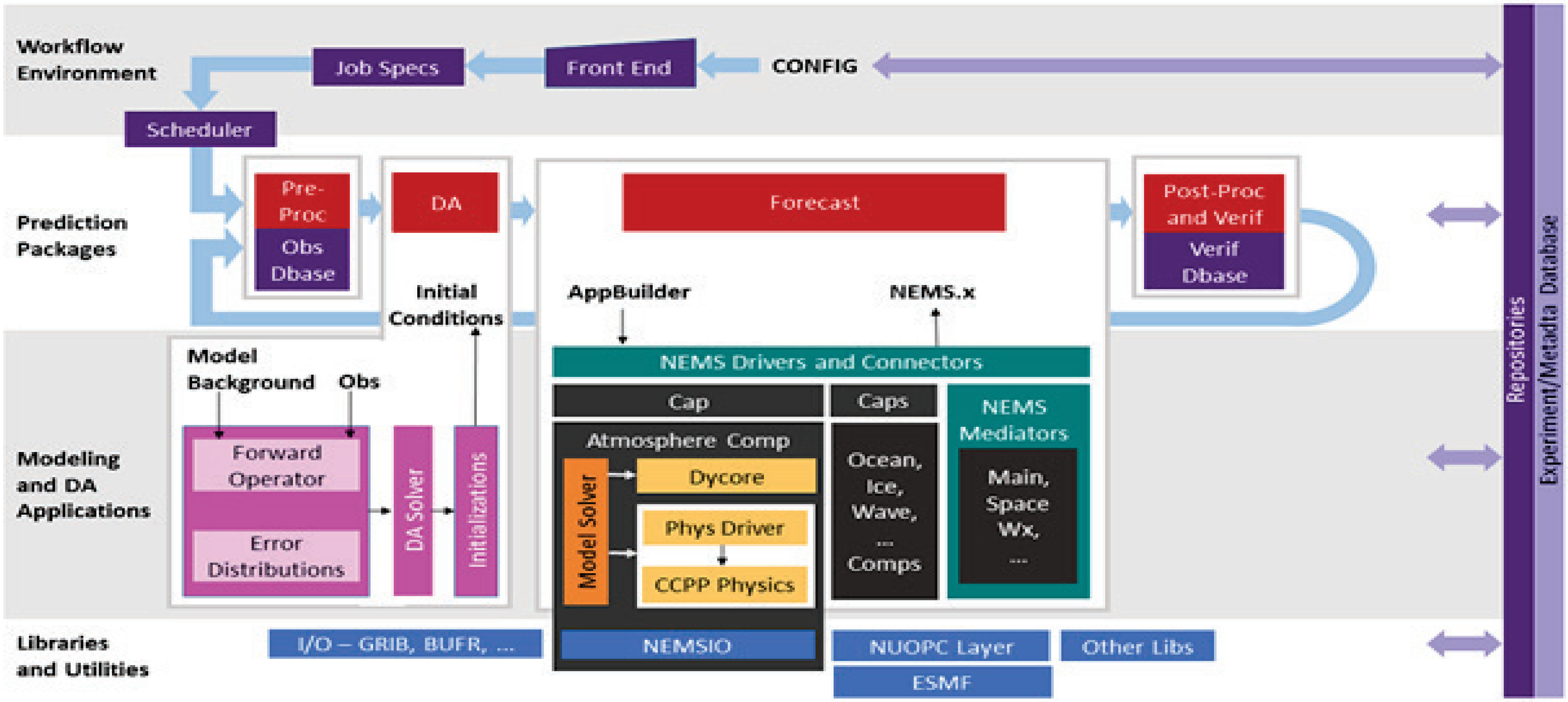


… we will move to a product based system that covers all present elements of the productions suite in a more systematic and efficient way



Starting from the quilt of models and products created by the implementing solutions rather than addressing requirements ….

Modern System Architecture

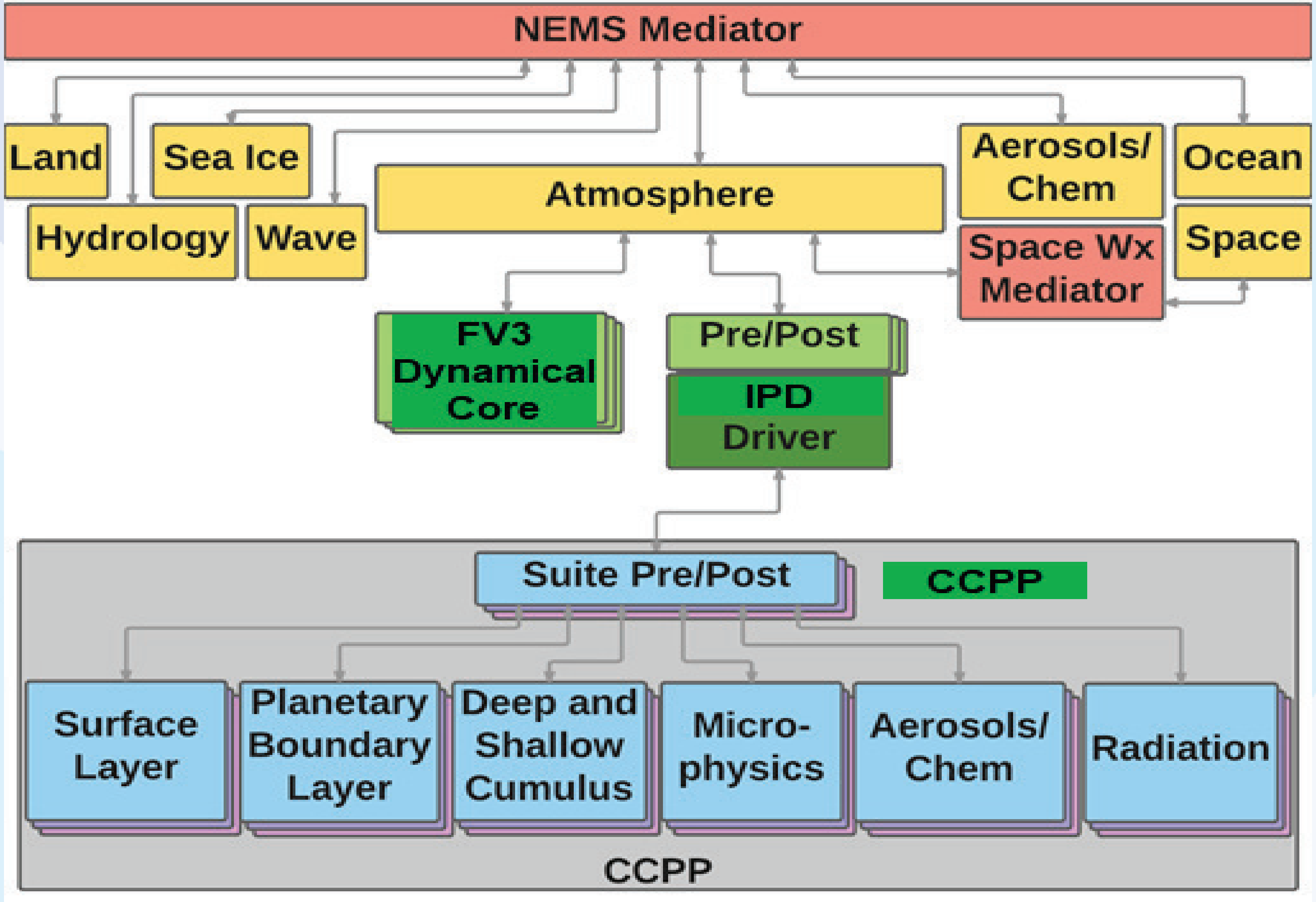


ESMF Based NEMS FV3GFS - Object Oriented Design

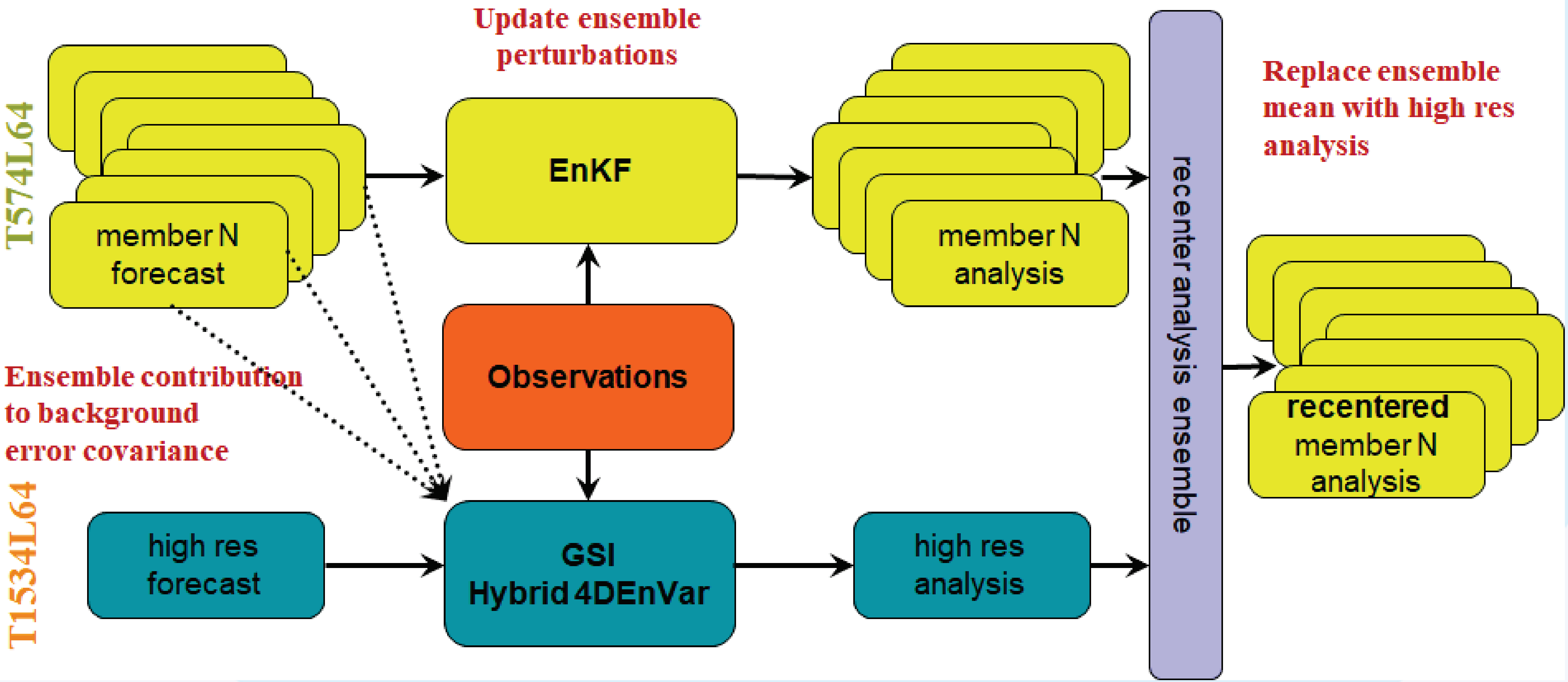
NEMS is based on ESMF and follows NUOPC convention

A numerical model in NEMS is represented by software and implemented as an ESMF grid component.

Each ESMF grid component has its own internal state with internal methods

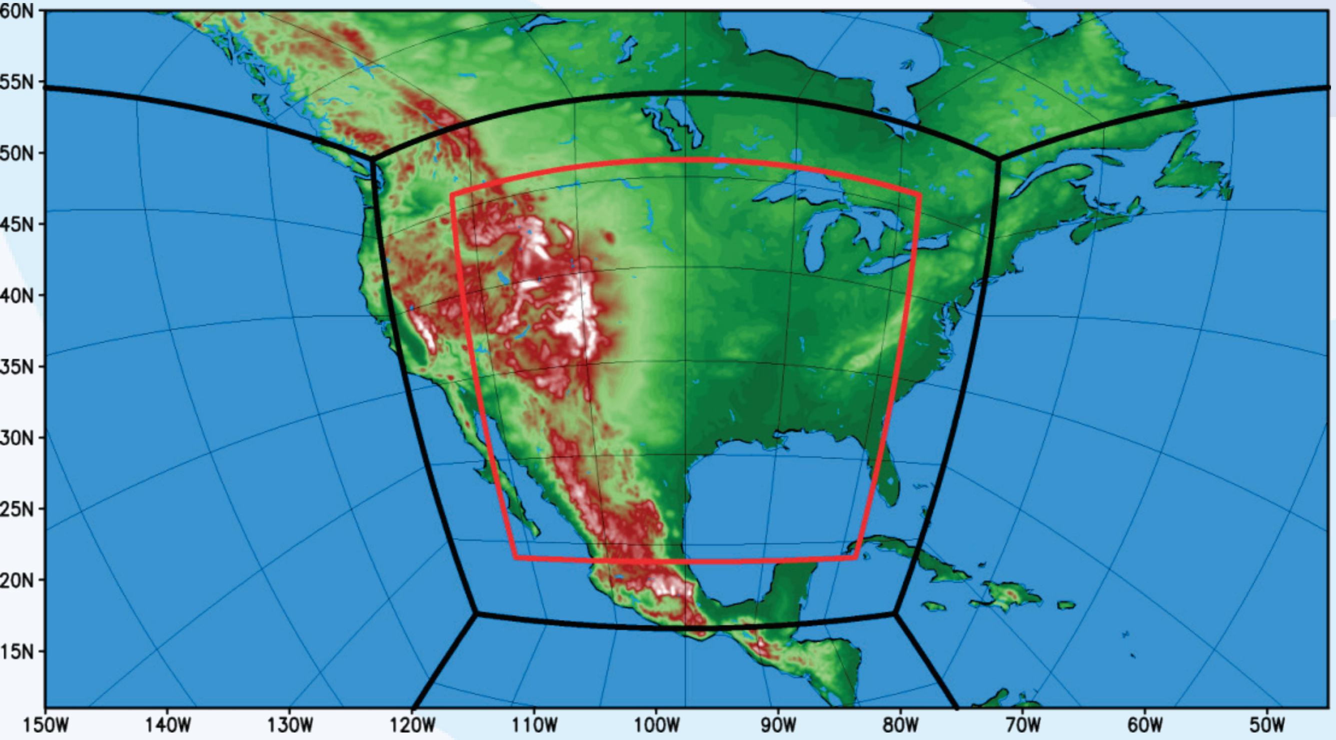


Current NCEP 4D-Hybrid DA System



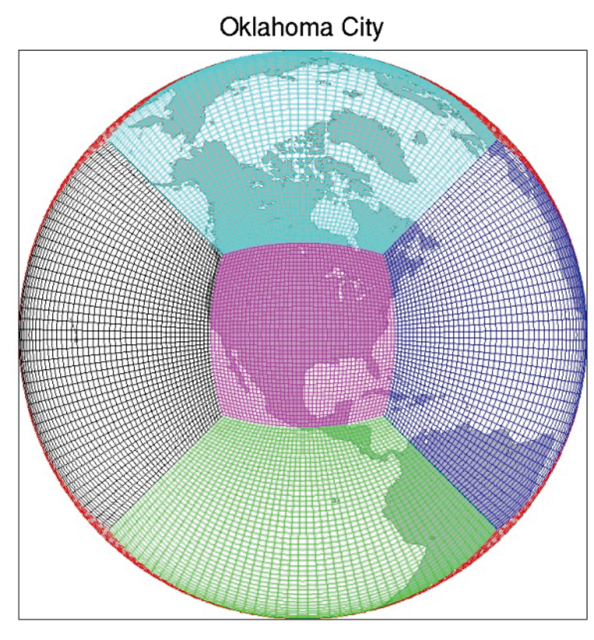
Achieving thunderstorm-resolving resolution "TODAY" in a unified meso-global prediction system

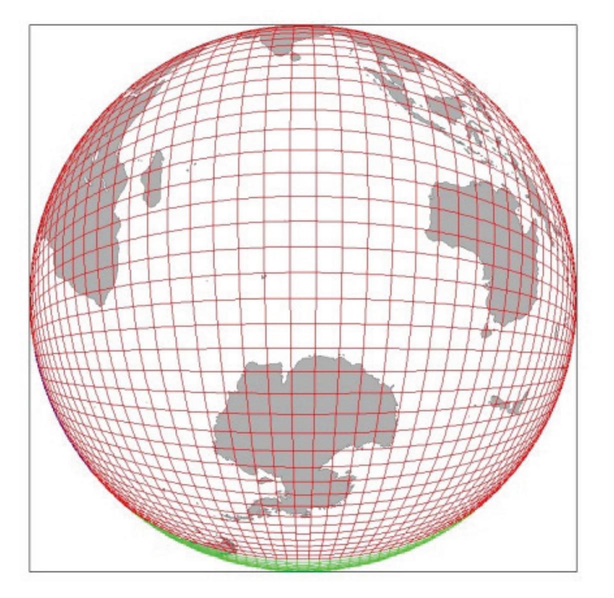
1) Grid stretching (smooth variation of grid spacing)
2) 2-way nesting (Harris and Lin 2014)
   FV3 is uniquely suitable for 2-way nesting, due to the application of two-time-level Finite-Volume transport scheme
3) Optimal combination of the "stretching" and "nesting"



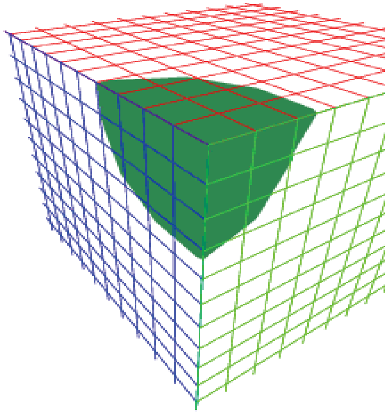
Example:

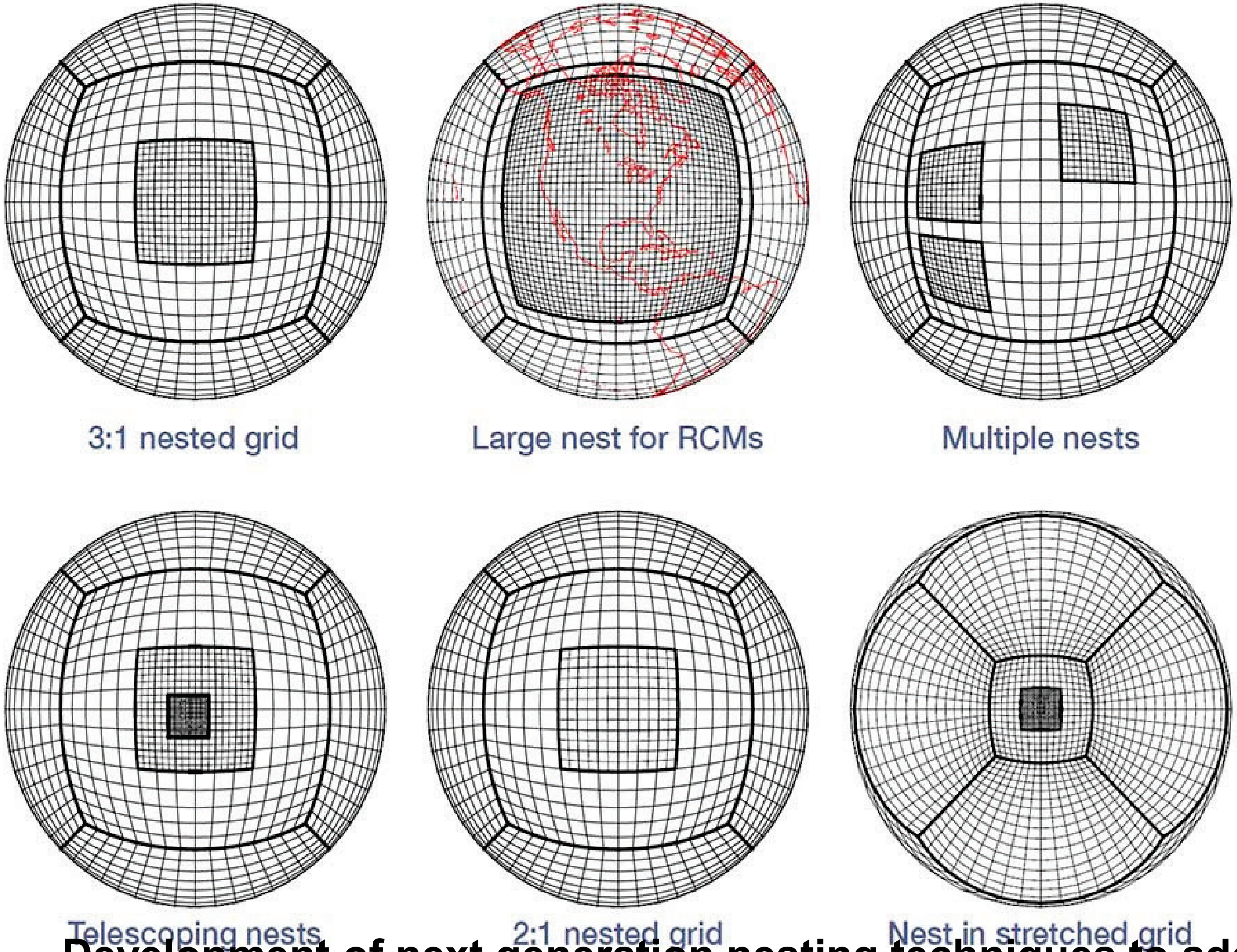
~ 3 km without the nest (black)
~ 1 km with a 2-way nest (red)

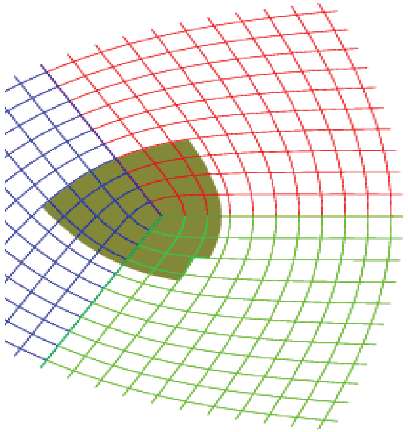




Tropical Cyclone Forecasts in FV3







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

Plans for Hurricane Nests in FV3 based models

SIP Draft Document has 3 special projects designated for developing regional and global hurricane nesting capabilities:

Stand-Alone Regional FV3 and Static High-Resolution Nests for Global FV3

Moving Nest for FV3 Hurricane Applications (AOML Approach)

FV3 based hurricane model developments: Moving nests and coupling to other earth system components (EMC approach)

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

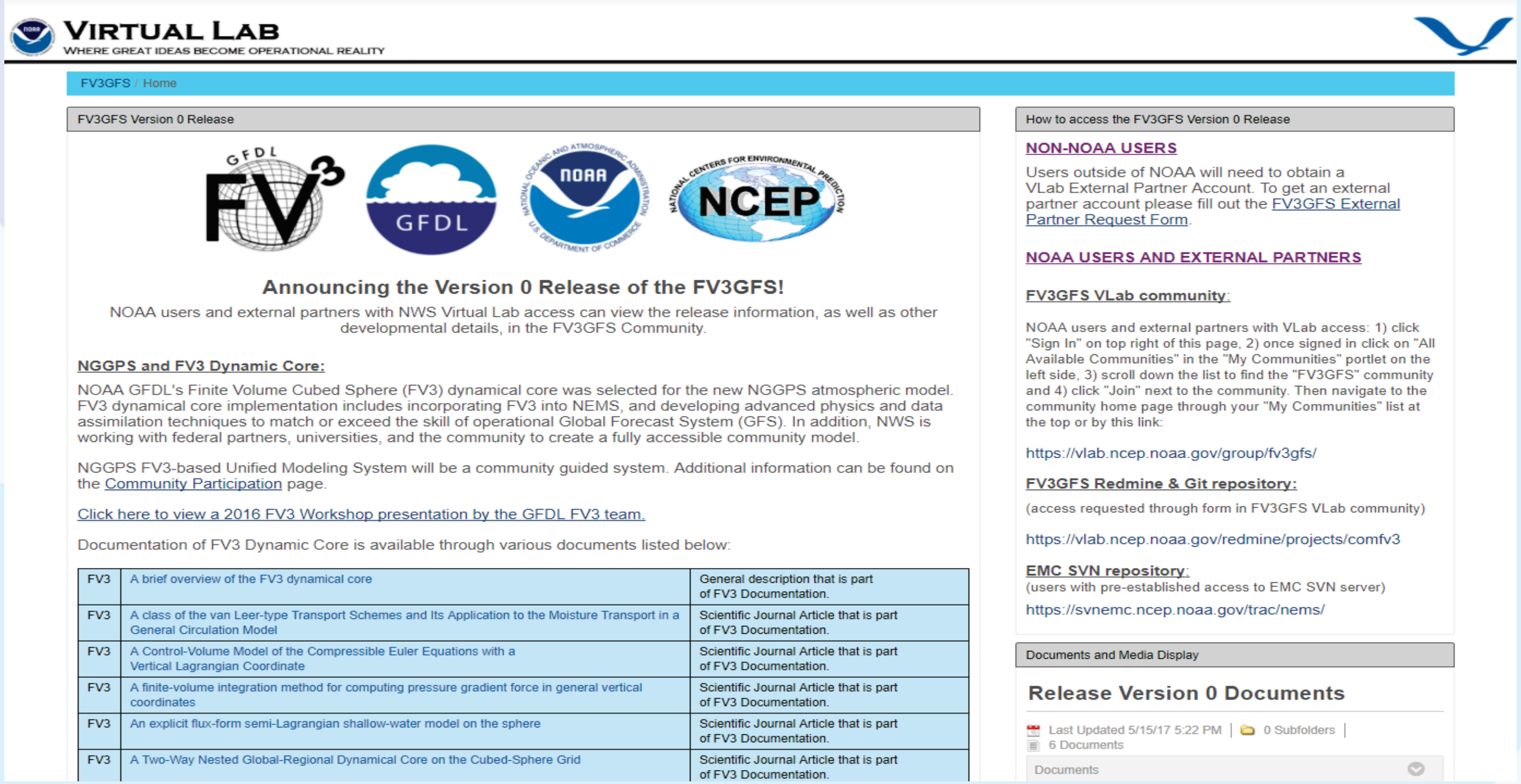
- Community Wiki page, Forums and Developers Pages on VLab

- 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

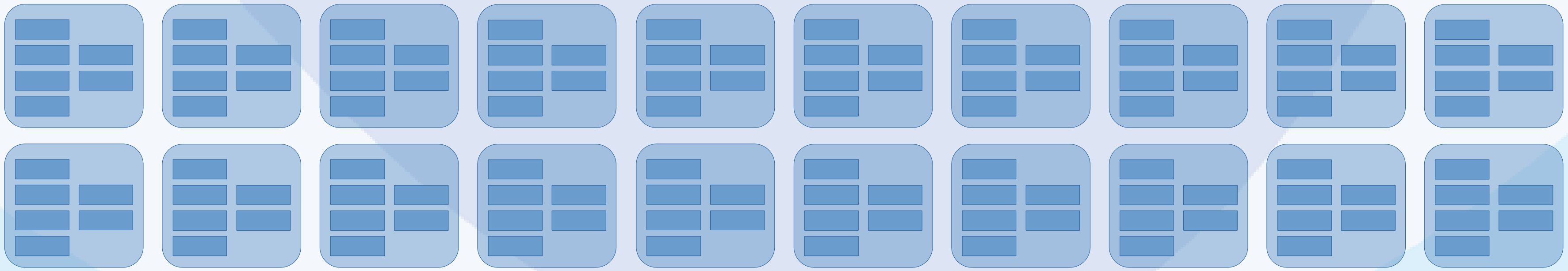
Release Version 0 Documents

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

CROW: Community Research and Operational Workflow



- Many workflows to learn, maintain, and support
  - High Training and support cost
  - Most researchers write and maintain workflows.

Scientists should be doing science not scripting.

- Different systems for NCO, R&D, community
  - Slower transition to and from operations

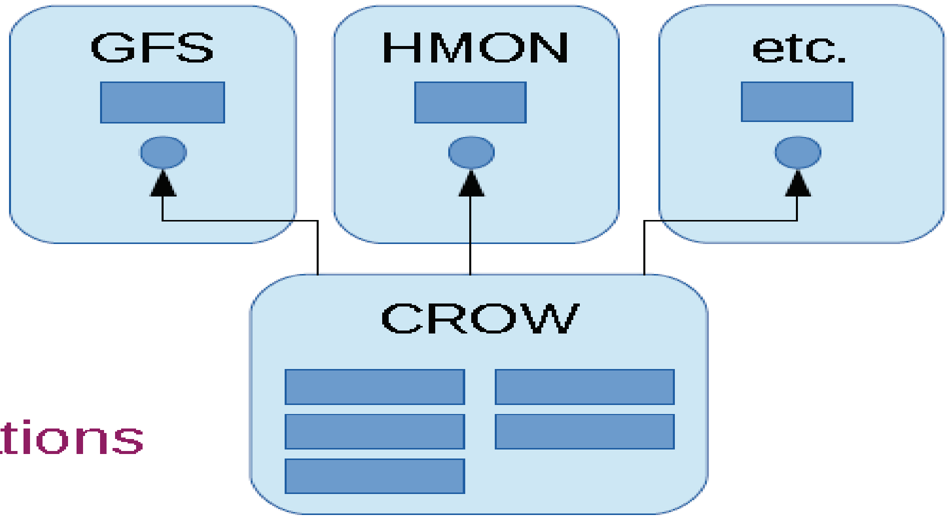
Unified Workflow for Research and Operations

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)



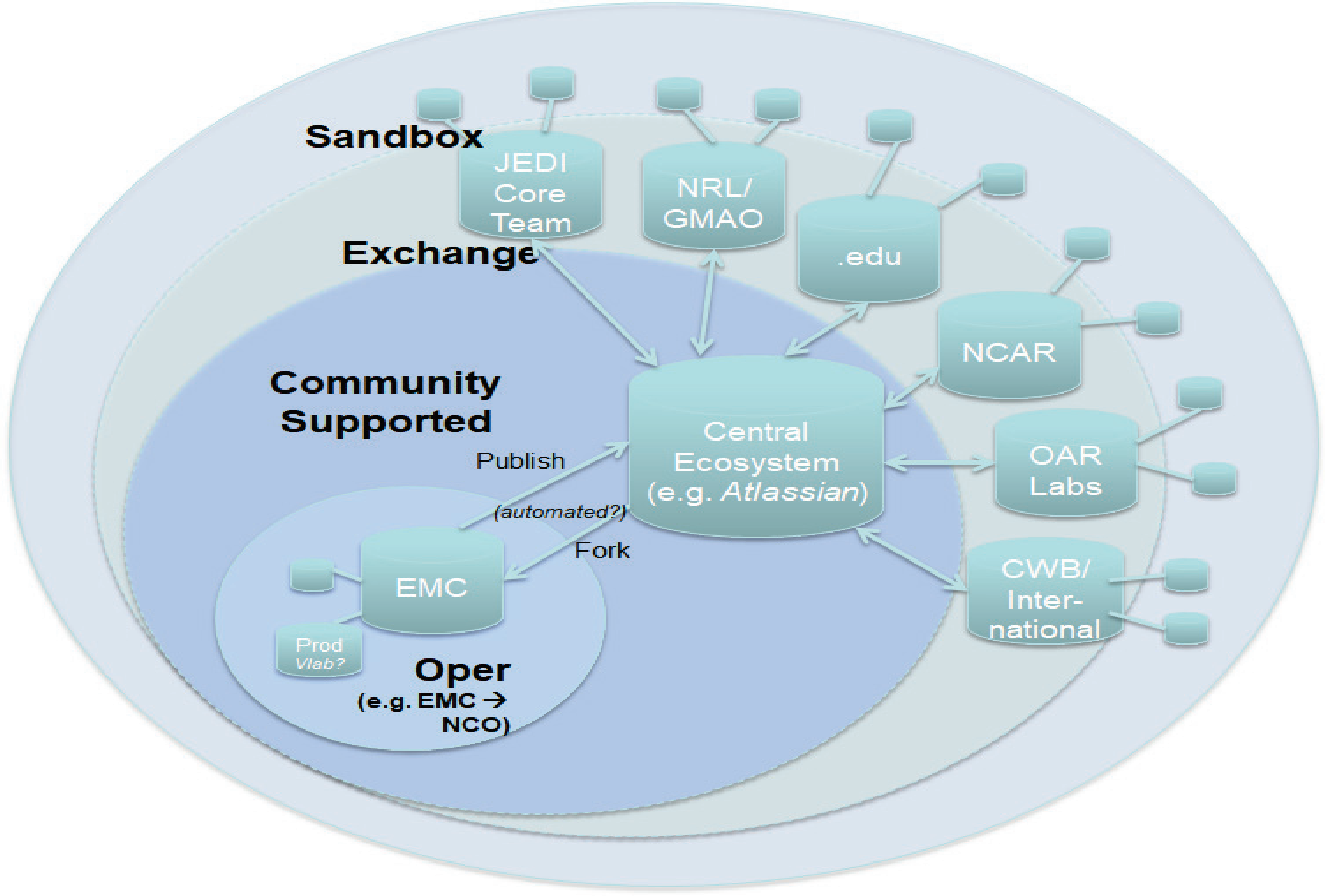
Strategic Implementation Plan for Unified Modeling

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

Community Collaborations from NOAA Operations Point of view



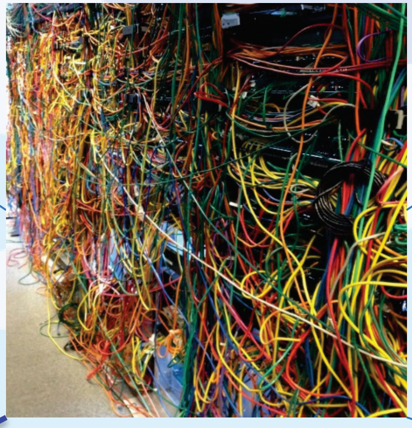
Ecosystem
= **collaborative environment**

- 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

Weather and Climate Operational Supercomputing System (WCOSS)

Phase 1: TIDE, GYRE, eddy

Phase 2: TIDE, GYRE, eddy



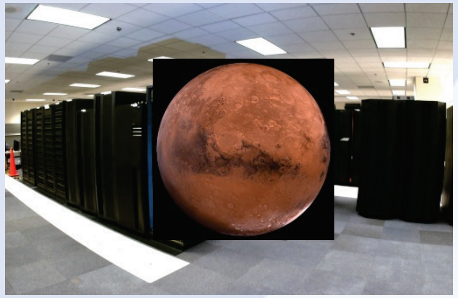
Phase 3: Mars, Venus, pluto

Task Order 4: LUNA, SURGE, hank

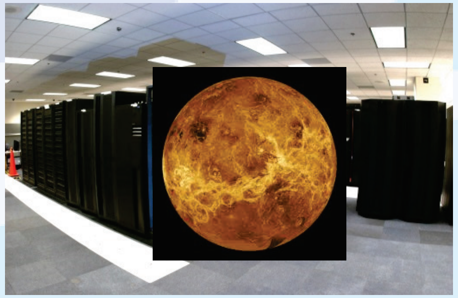
Dell Supercomputer Names

The winner is…

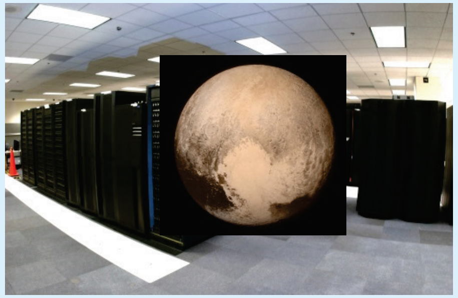
Reston: MARS



Orlando: VENUS



Test: PLUTO



Chris Magee and Jen Yang were responsible for this….

WCOSS Statistics

WCOSS Component	Compute nodes	Peak TFs	Processor Type	Storage	Cores/node	Memory/node
IBM - P1	640 / 504	149	Sandy Bridge	1.2 PB	16	64G
IBM - P2	1080	563	Ivy Bridge	2.0 PB	24	64G
Cray	2048	2,037	Haswell	3.5 PB	24	64G
DELL	**1212**	**1,400**	**Broadwell**	**5.4 PB***	**28**	**128G**

* Disk will be divided into 3 filesystems on Day 1

TOP 500 The List.

Rank	Site	System	Cores	Tflop/s
1	Wuxi, China	Sunway TaihuLight	10649600	125,435.9
4	DOE/Oak Ridge	Titan – Cray XK7	560640	27,112.5
11	UKMet	Cray – XC40	241920	8,128.5
25/26	ECMWF	Cray – XC40	126468	4,249.3
74	NOAA	Luna – Cray XC40	48960	2,036.7
75	NOAA	Surge – Cray XC40	48960	2,036.7
--	NOAA	Tide – IBM NeXtScale	25920	563
--	NOAA	Gyre – IBM NeXtScale	25920	563
83 *	NOAA	Mars – Dell	33936	1,400 *
84 *	NOAA	Venus – Dell	33936	1,400 *

If WCOSS was combined per site….

25/26 *	NOAA	WCOSS (per site)	116880	~ 4 Pflop/s

If all of WCOSS was combined….

11 *	NOAA	WCOSS (total)	233760	~ 8 Pflop/s