



The Unified Forecast System

Using community modeling to improve operations at NOAA

<https://ufscommunity.org/>

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About the UFS

Purpose

The Unified Forecast System (UFS) is a comprehensive, community-developed Earth modeling system, designed as both a research tool and as the basis for NOAA's operational forecasts.

Governance

Planning and evidence-based decision-making support improving research and operations transitions and community engagement.

Scope

UFS is configurable into multiple applications that span local to global domains and predictive time scales from less than an hour to more than a year.

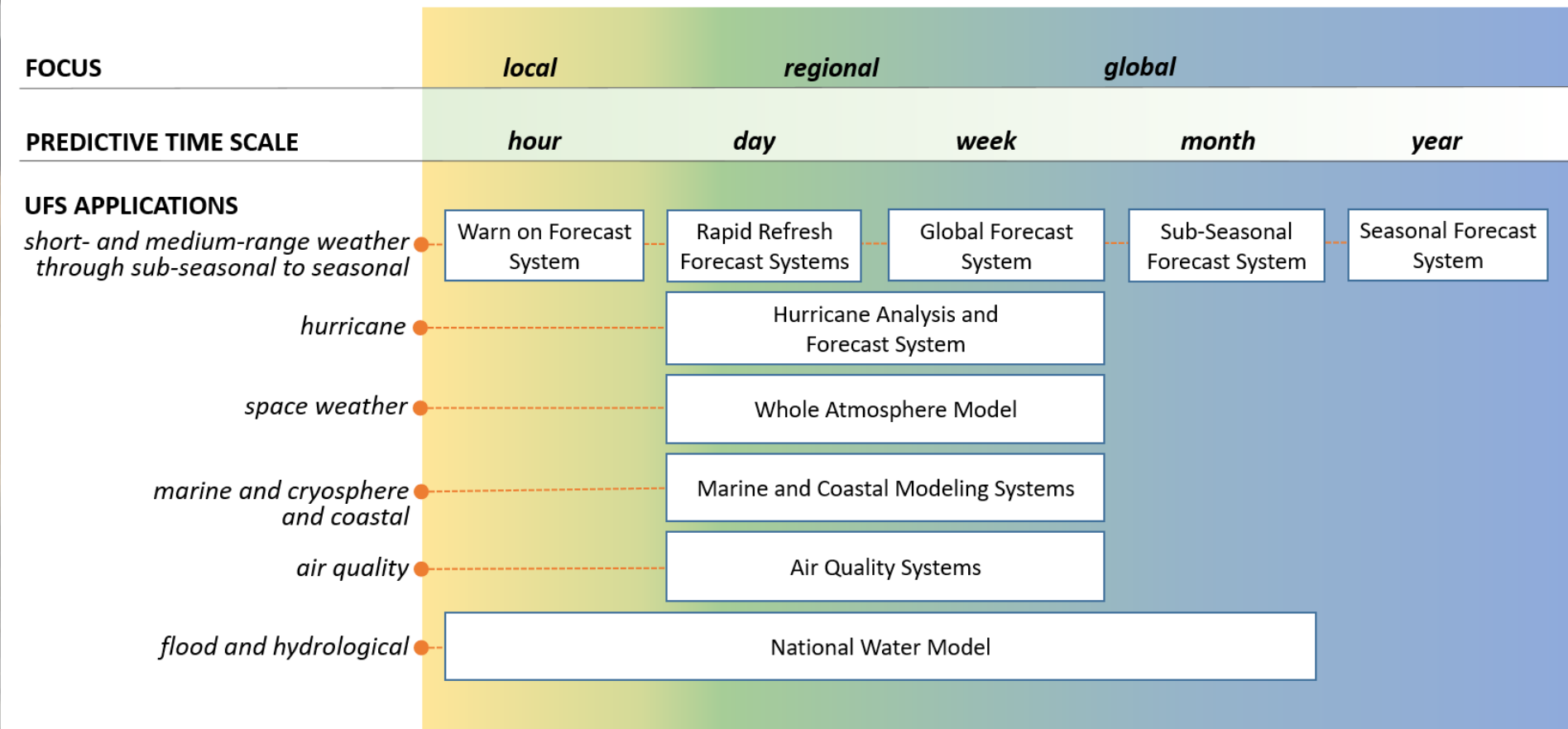
Design

UFS is a *unified* system because the applications within it share science components and software infrastructure

Impact

UFS is a **paradigm shift** that will enable NOAA to simplify the NCEP Production Suite, to accelerate use of leading research, and to produce more accurate forecasts for the U.S. and its partners.

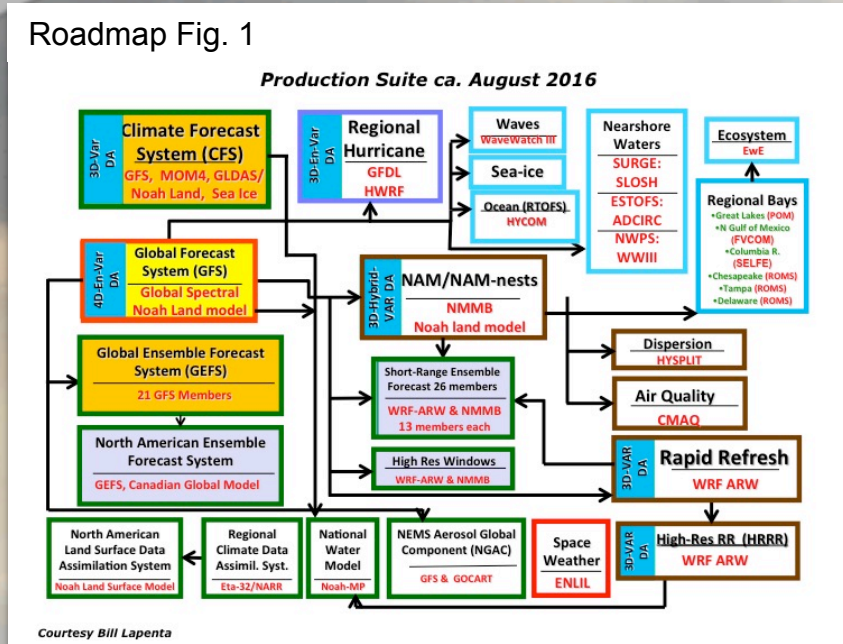
Scope of UFS (community)



UFS applications span predictive timescales (less than an hour to more than a year) and focus on multiple spatial scales (local to global).

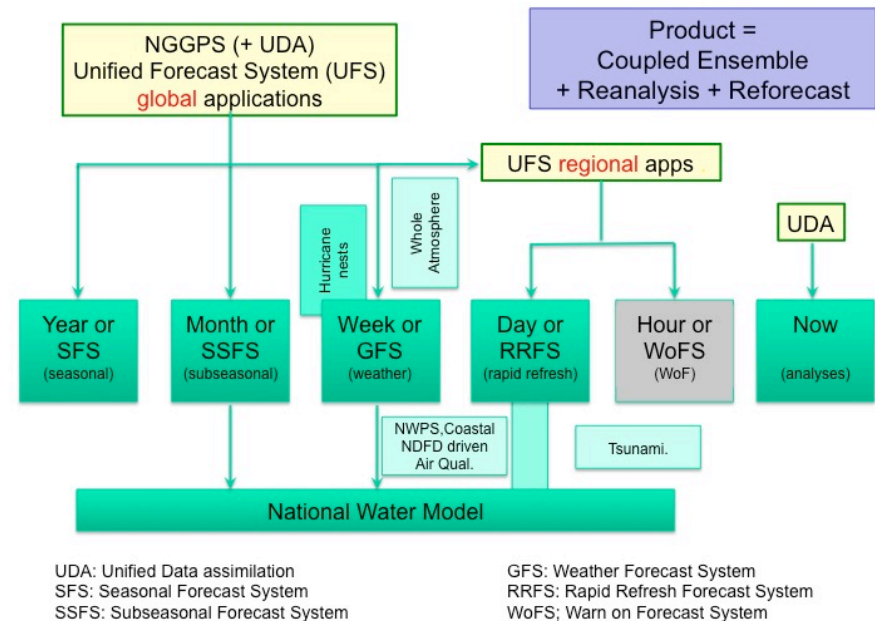
NOAA Production Suite

Roadmap Fig. 1



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

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



Roadmap Fig. 2

Simplify the Production Suite

NPS Modeling System	Current Version	Q1 FY 20	Q2 FY 20	Q3 FY 20	Q4 FY 20	Q1 FY 21	Q2 FY 21	Q3FY21 - Q2FY22 MORATORIUM	Q3 FY 22	Q4 FY 22	Q1 FY 23	Q2 FY 23	Q3 FY 23	Q4 FY 23	Q1 FY 24	Q2 FY 24	Q3 FY 24	Q4 FY 24	UFS Application
Global Weather & Global Analysis	GFS/ GDASv15						GFSv16												
Global Waves	GWMv3																		
Global Weather Ensembles	GEFSv11																		
Global Wave Ensembles	GWESv3																		
Global Aerosols	NGAC v2																		
Short-Range Regional Ensembles	SREFv7																		
Global Ocean & Sea-Ice	RTOFSv1.2						RTOFSv2												
Global Ocean Analysis	GODASv2																		
Seasonal Climate	CDAS/CFSv2																		
Regional Hurricane 1	HWRfv12						HWRfv13												
Regional Hurricane 2	HMONv2						HMONv3												
Regional High Resolution CAM 1	HiRes Window v7						HIRESWv8												
Regional High Resolution CAM 2	NAM nests/ Fire Wxv4																		
Regional High Resolution CAM 3	RAPv4/ HRRRv3						RAPv5/ HRRRv4												
Regional HiRes CAM Ensemble	HREFv2						HREFv3												
Regional Mesoscale Weather	NAMv4																		
Regional Air Quality	CMAQv5																		
Regional Surface Weather Analysis	RTMA/ URMA v2.7						RTMA/ URMA v2.8												
Atmospheric Transport & Dispersion	HySPLITv7																		
Coastal & Regional Waves	NWPSv1.2						NWPS v1.3												
Great Lakes	GLWUv3.4																		
Regional Hydrology	NWMv2						NWMv3												
Space Weather 1	WAM/IPEv1																		
Space Weather 2	ENLILv1																		

NCAR-NOAA Infrastructure MOA


- NCAR, NWS, and OAR Memorandum of Agreement focuses on synergistic development and use of infrastructure
- Builds on existing multi-agency community-developed infrastructure (NASA, Navy, NOAA, NSF, DOE...)
- UFS Working Groups are already engaged in all seven work areas specified by the MOA
- Finalized January, 2019


Dr. Antonio J. Busalacchi, President, NCAR Date: 10/5/18


Dr. Vanda Grubisic, Interim Director, NCAR Date: 10/31/18

FOR NOAA


Dr. Louis W. Uccellini, Assistant Administrator for Weather Services NOAA, and
Director, National Weather Service Date: 12/20/18


Mr. Craig McLean, Assistant Administrator, NOAA Oceanic and Atmospheric Research Date: 1/30/19 am

NCAR-NOAA Infrastructure MOA: Work Areas

1. Coupling components

New ESMF/NUOPC mediator (CMEPS/NEMS)

2. Interoperable atmospheric physics

CCPP & CPF frameworks

3. Community-friendly workflow

CIME - CROW unification, CIME Case Control System

4. Hierarchical model development capabilities

Extensions of CIME data models, unit, and system testing

5. Forecast Verification: Comparison to Observations

Extension of METplus

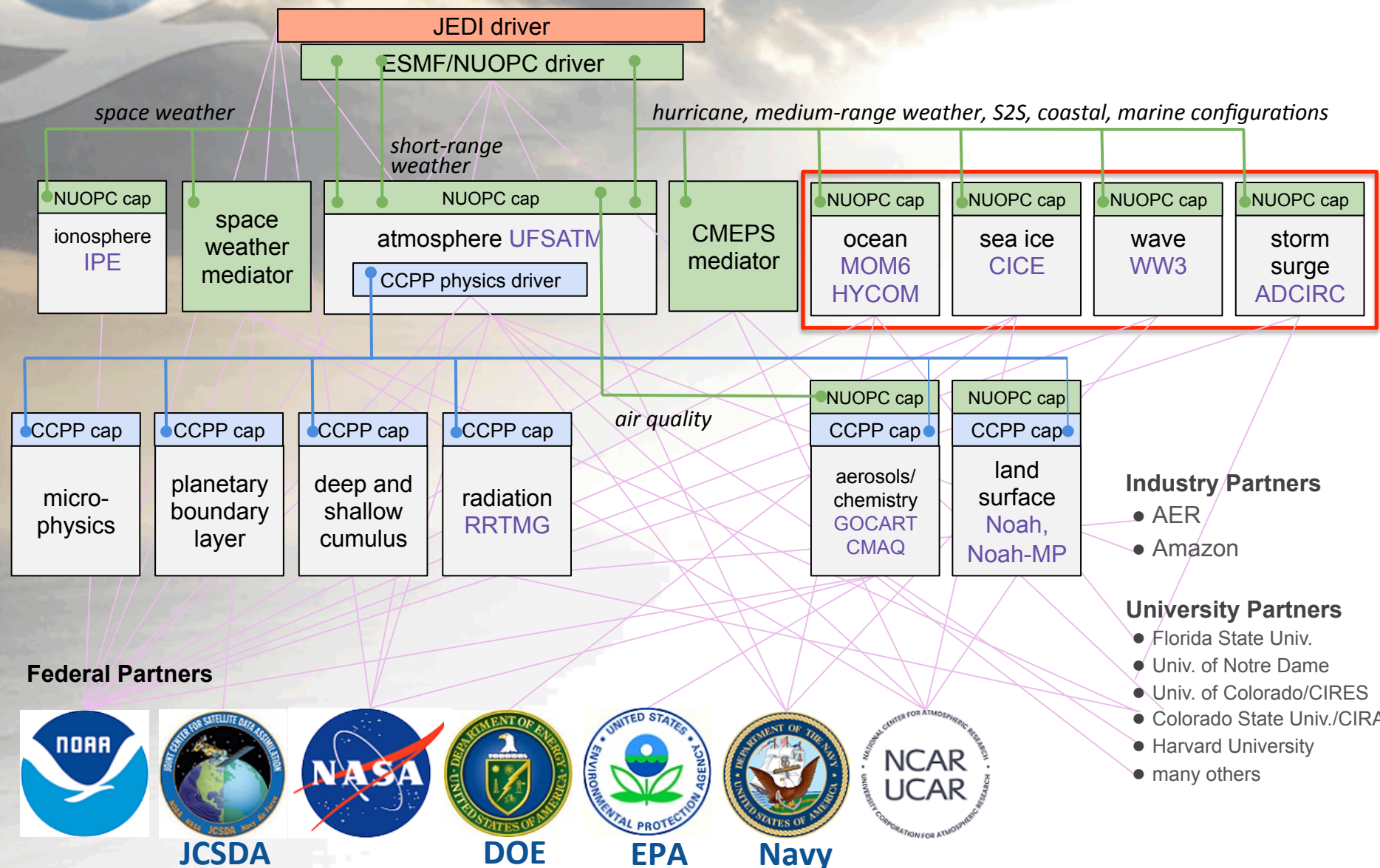
6. Software Repository Management

NCAR manage_externals tool

7. User / Developer Support

DTC and CESM Capabilities

UFS Model Components and Contributors



UFS Release Team

Release Team members: DTC, EMC, NCAR, and NOAA research labs (GSD, PSD, NSSL, GFDL)

Leads: Louisa Nance (DTC), Arun Chawla (EMC), and Mariana Vertenstein (NCAR)

Focus Teams

- Code
- Build
- Workflow
- Data pre-processing
- Testing
- Documentation
- Support

Other contributors: George Mason University / Center for Ocean-Land-Atmosphere Studies, CIRES

Release Strategy

- Incremental releases as new capabilities mature
- Initial release :
 - Medium Range Weather Application V1.0 March 11, 2020
 - ◆ FV3-atmosphere: 4 resolutions [C96 (~100km), C192 (~50km), C384 (~25km) and C768 (~13km)] & 64 vertical levels
 - ◆ Physics (using CCPP): GFS v15 (operational) or GFS v16 (developmental)
 - ◆ Pre- and Post-Processing
 - ◆ Initialization: GFS analyses after Jan 1, 2018
 - ◆ Community workflow: CIME (NCAR CESM)
- Subsequent releases will make available **standalone regional (late 2020)**, coupling (ocean, waves, ice) and data assimilation capabilities

Support Strategy

- Computer platforms: Linux & Mac for Intel & GNU compilers (NOAA Hera, NCAR Cheyenne, NSF Stampede and Mac laptops)
- Documentation: information on components, how to set up & run, how to commit changes back
- Online forum support: forums.ufscommunity.org, w/ topical sections & a centralized location for posting questions and exchange
- Training: DTC is working on plans for a MRW application webinar & tutorials covering multiple applications

1st UFS User Workshop, ~~Virtual~~ Boulder, July 27-30.

“Graduate Student Test”

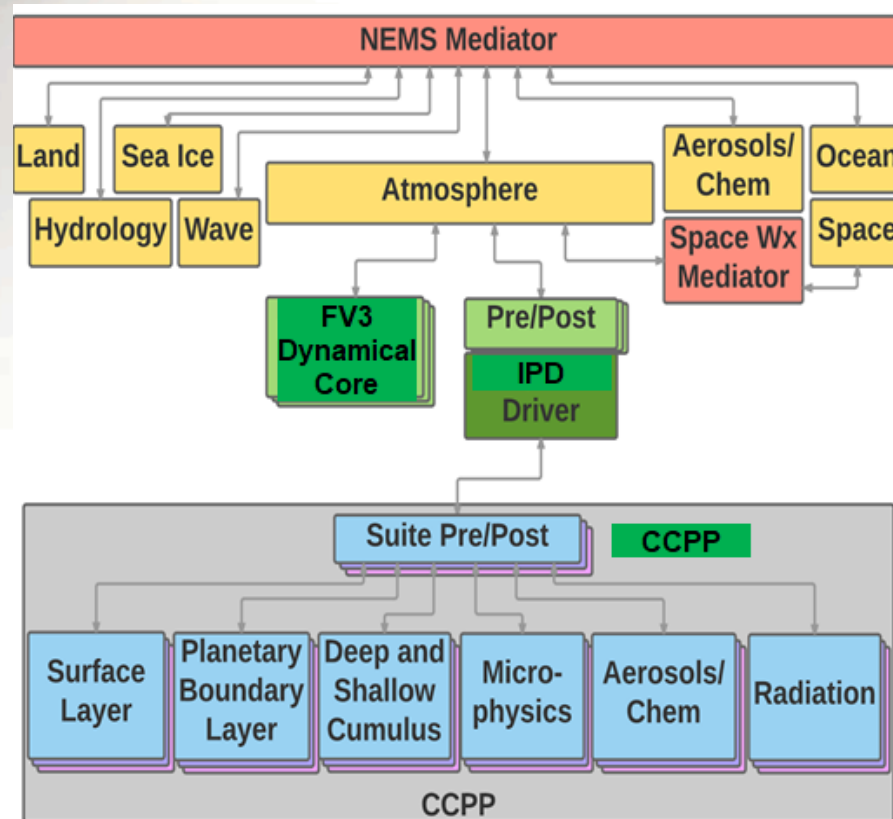
- Evaluators get and run the S2S application for 5 days
- Modify the code to increase the SST provided by the ocean by 2 deg C
- Rerun the application for 5 days with the modification
- Visually compare results
- ... **all within 6 hours** - then fill out a short questionnaire

Testers used research (NCAR, NSF XSEDE) computers.

The test is described here:

<https://github.com/ESCOMP/UFSCOMP/wiki/Milestone:-CMEPS-0.5-Appendix-Graduate-Student-Test-Evaluation-SST-Experiment>

- NWS UFS system consists of the following components (at the moment)
 - NEMS for infrastructure
 - FV3 dycore with Physics driver (IPD / CCPP)
 - MOM6 and HYCOM ocean models (ROMS, FVCOM)
 - ADCIRC storm surge model
 - WW3 wave model
 - CICE5 ice model
 - GOCART aerosol model
 - Noah MP land model
- Each component has its own authoritative repository. NEMS infrastructure allows flexibility to connect instantiations of the repositories together to create a coupled model.



Current Developments

Each of these is a working coupled application which is actively being tested

FV3 – WW3

Effects of waves on atmospheric stress at ocean surface

FV3 – CHEM

Atmosphere, aerosols interaction

ADCIRC – WW3

Wind wave and surge coupling
(COASTAL ACT)

MOM6 – CICE5

Ocean ice coupled model to look at polar dynamics and for developing a marine DA system

FV3 – MOM6 – CICE5

Coupled system for S2S scales (25 km atm, $\frac{1}{4}$ deg ocean and ice)

FV3 – MOM6 – CICE5 – WW3

S2S scales including Langmuir mixing (25 km atm, $\frac{1}{4}$ deg ocean and ice, $\frac{1}{2}$ deg waves)

Contributors

- NCEP

Bin Li, Jessica Meixner, Jiande Wang, Denise Worthen, Lydia Stefanova, Jun Wang, Samuel Trahan, Xingren Wu, Hyun Chul Lee, Todd Spindler, Shrinivas Moorthi, Suranjana Saha, Avichal Mehra, Robert Grumbine, Yuejian Zhu, Xiaqiong Zhou, Arun Chawla, Vijay Tallapragada

- ESRL

Shan Sun, Rainer Bleck, Benjamin W. Green, Ning Wang

- NESII

Tony Craig, Fei Liu, Cecelia DeLuca, Robert Oehmke, Gerhard Theurich

- GFDL

Rusty Benson, Brandon Reichl, Stephen M. Griffies, Robert Hallberg, Alistair Adcroft

- UCAR/NCAR

Mariana Vertenstein, Rocky Dunlap, Dave Bailey, Alper Altuntas, Gustavo Marques, Ufuk Turuncoglu

Benchmark Runs

A good test plan needs the following

- Include multiple important cases
- Short enough to be run multiple times

To test the Sub seasonal modeling system

- Initialize the model on the 1st and 15th of each month for 35 day runs
- Model components initialized independently
- Repeat for all months over a 7 year period (2011/2012 – 2017/2018)
- Covers important El Nino / La Nina years as well as years of very low ice
- Provides a large enough sample for statistically relevant metrics

Benchmark Overview

Model Resolution

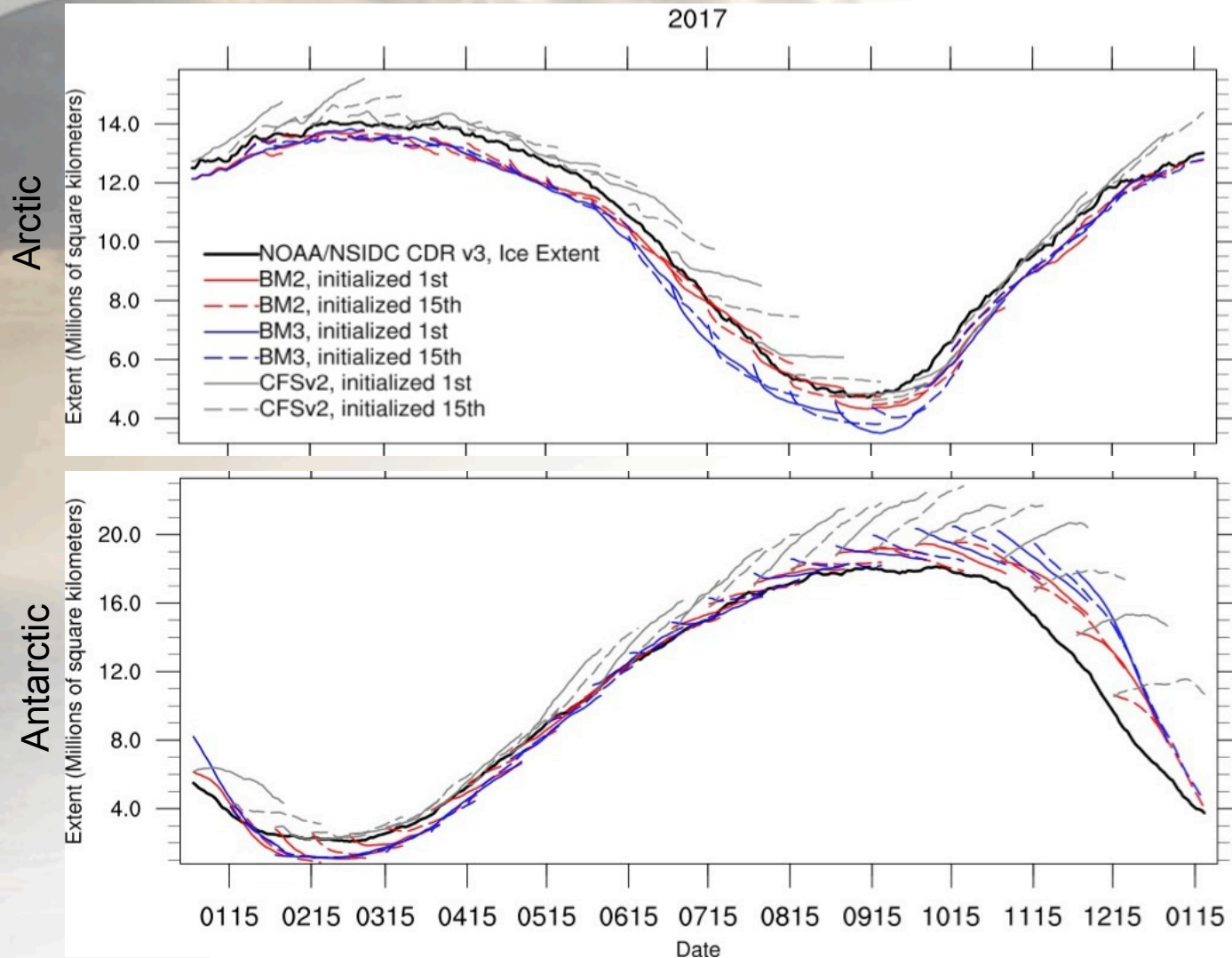
	FV3ATM	MOM6	CICE5	WW3
Resolution	C384 (~25km) 64 layers	¼ deg tripolar	¼ deg tripolar	½ deg regular lat/ lon

Initial Conditions

	FV3ATM	MOM6	CICE5	WW3
UFS_v1	CFSR	CFSR	CFSR	
UFS_v2	CFSR	CPC 3D Var	CFSR	
UFS_v3	CFSR	CPC 3D Var	CPC Ice Analysis	
UFS_v4	CFSR	CPC 3D Var	CPC Ice Analysis	Multi_1

Going from 4 to 8 benchmarks

Sea Ice Extent



Data Source : NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 3 (<https://nsidc.org/data/g02202/versions/3>)

EPIC

Earth Prediction Innovation Center

<https://owaq.noaa.gov/Programs/EPIC>



UFS Take Aways

UNIFIED not Unitary

- Better business model for research and operations
 - Operational models as world class research tools
 - Acceleration of transition of Research to Operations
 - ◆ Up to 5X speed up of R2O process
 - ◆ Adding to / improving existing operations = “free” O&M

Initial capabilities are available

- UFS MRW Application v 1.1.0, regional to follow

Buy in from community

- 50+ papers at AMS Annual Meeting in Boston
- 450+ attendees at for UFS Users Workshop

Questions?