Unified Environmental Modeling from research to operations

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In memoriam ….

Paul Wittmann

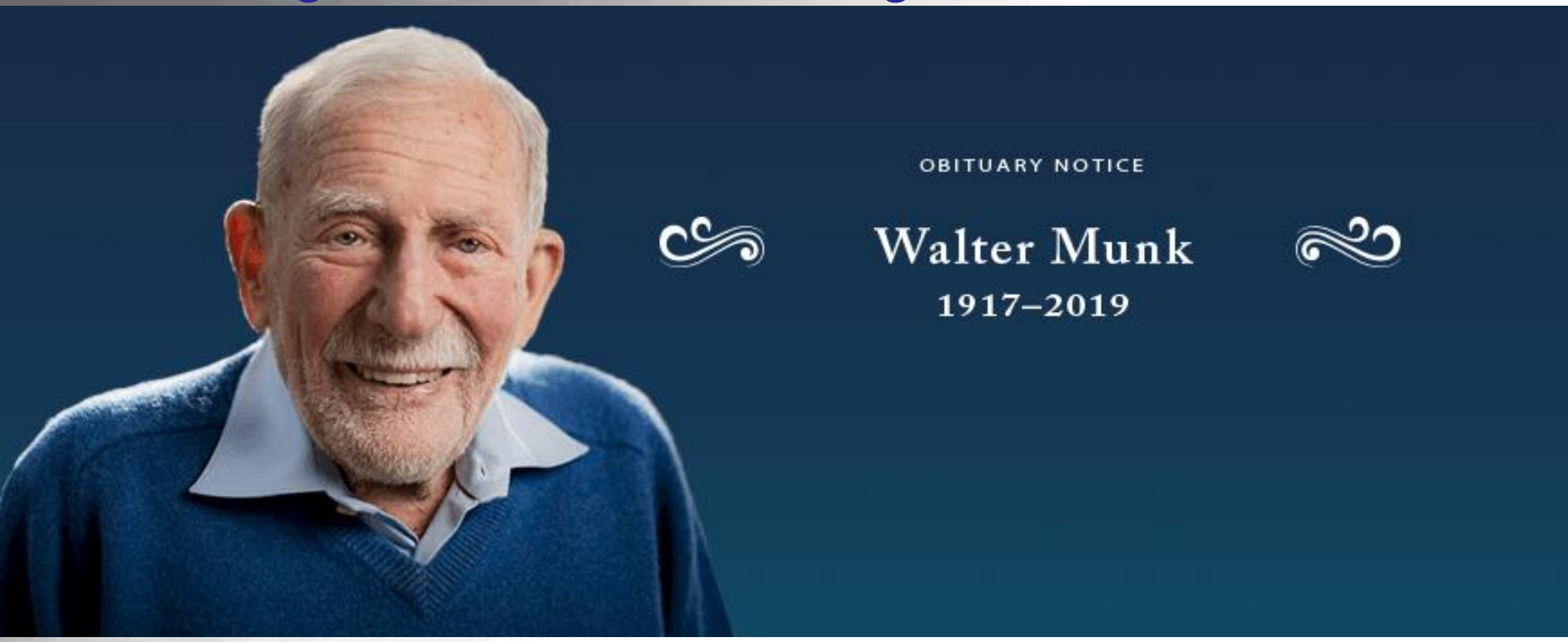
- April 22, 1956 - June 9, 2019
- Long time wave modeler at FNMOC
- First WAVEWATCH III adopter outside of NWS

Bill Lapenta

- Sept. 21, 1961 – Sept. 30, 2019
- NCEP director, advocate for community models in operations.
- Drowned at Duck is surf from Hurricane Lorenzo

In memoriam ….

Standing on the shoulders of giants …..



75 years since the D-day wave predictions.

Unified Forecast System (UFS)

UFS Steering Committee

Ricky Rood and Hendrik Tolman, co-chairs

https://ufscommunity.org/

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.

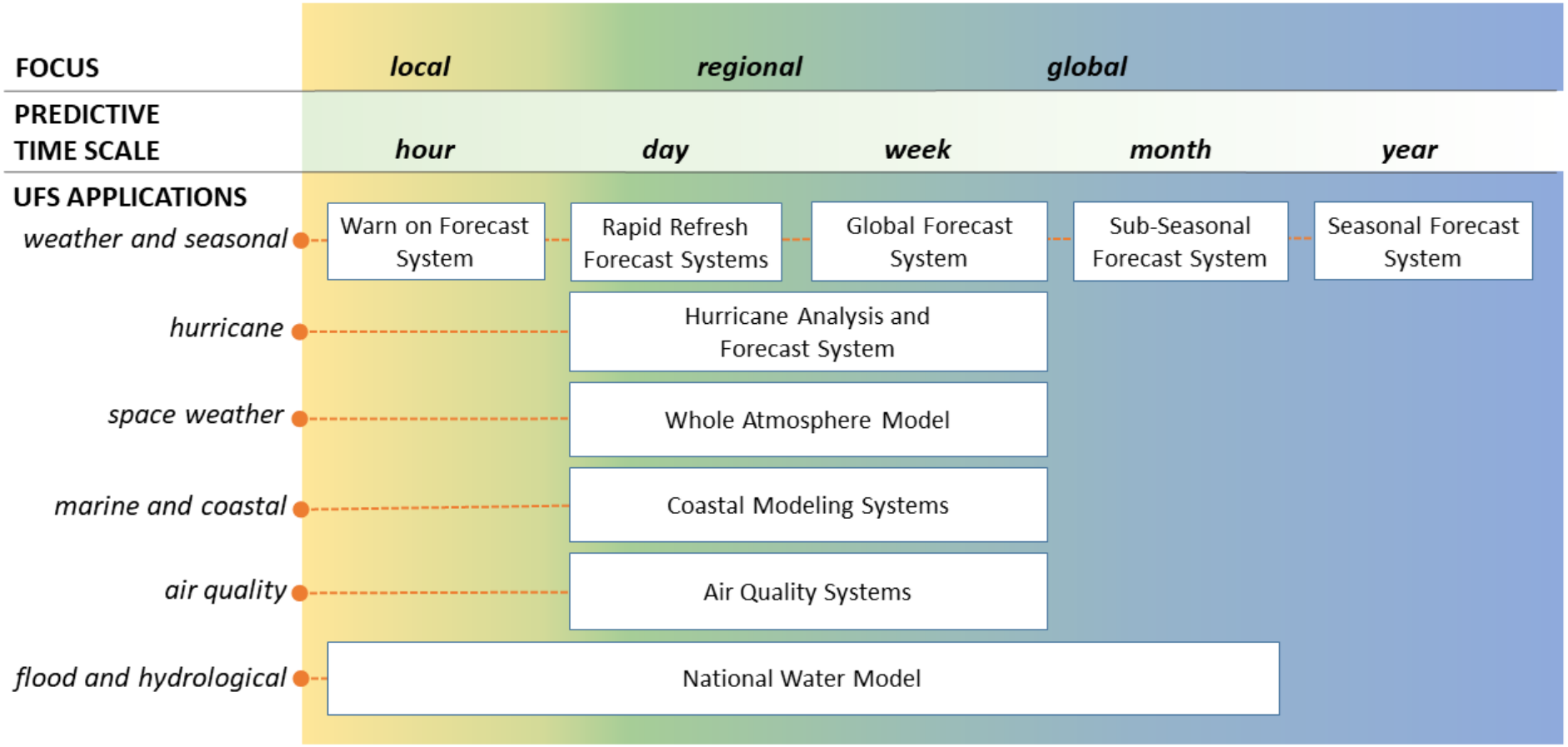
Governance Planning and evidence-based decision-making support improving research and operations transitions and community engagement.

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

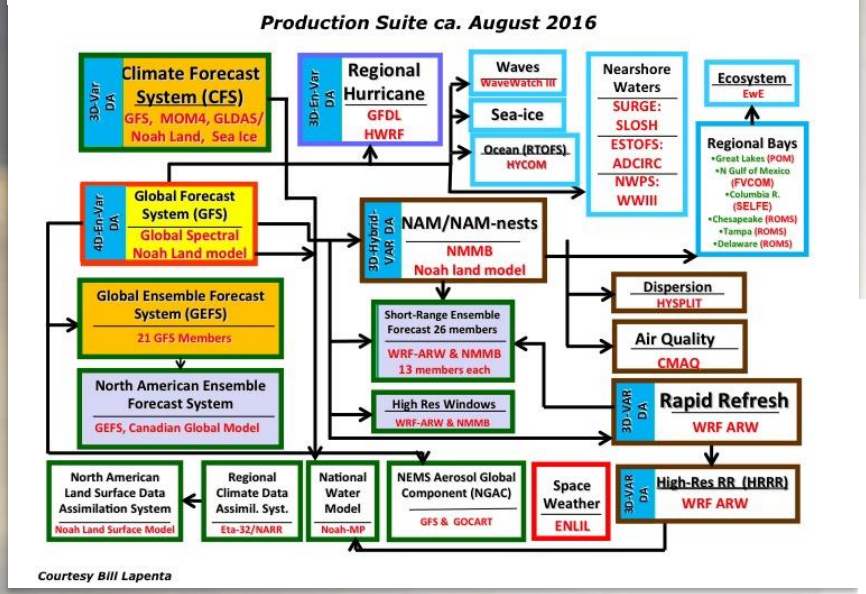
Impact UFS is a paradigm shift that will enable NOAA to simplify the NCEP Production Suite, to accelerate use of leading research, and to produce more accurate forecasts for the U.S. and its partners.

Scope of the UFS



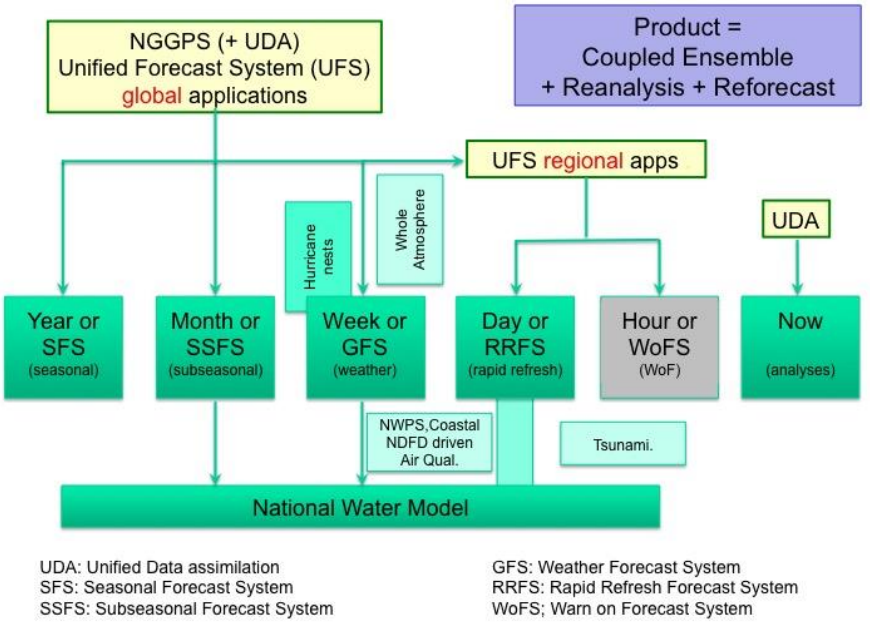
NOAA Production Suite

Roadmap Fig. 1



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

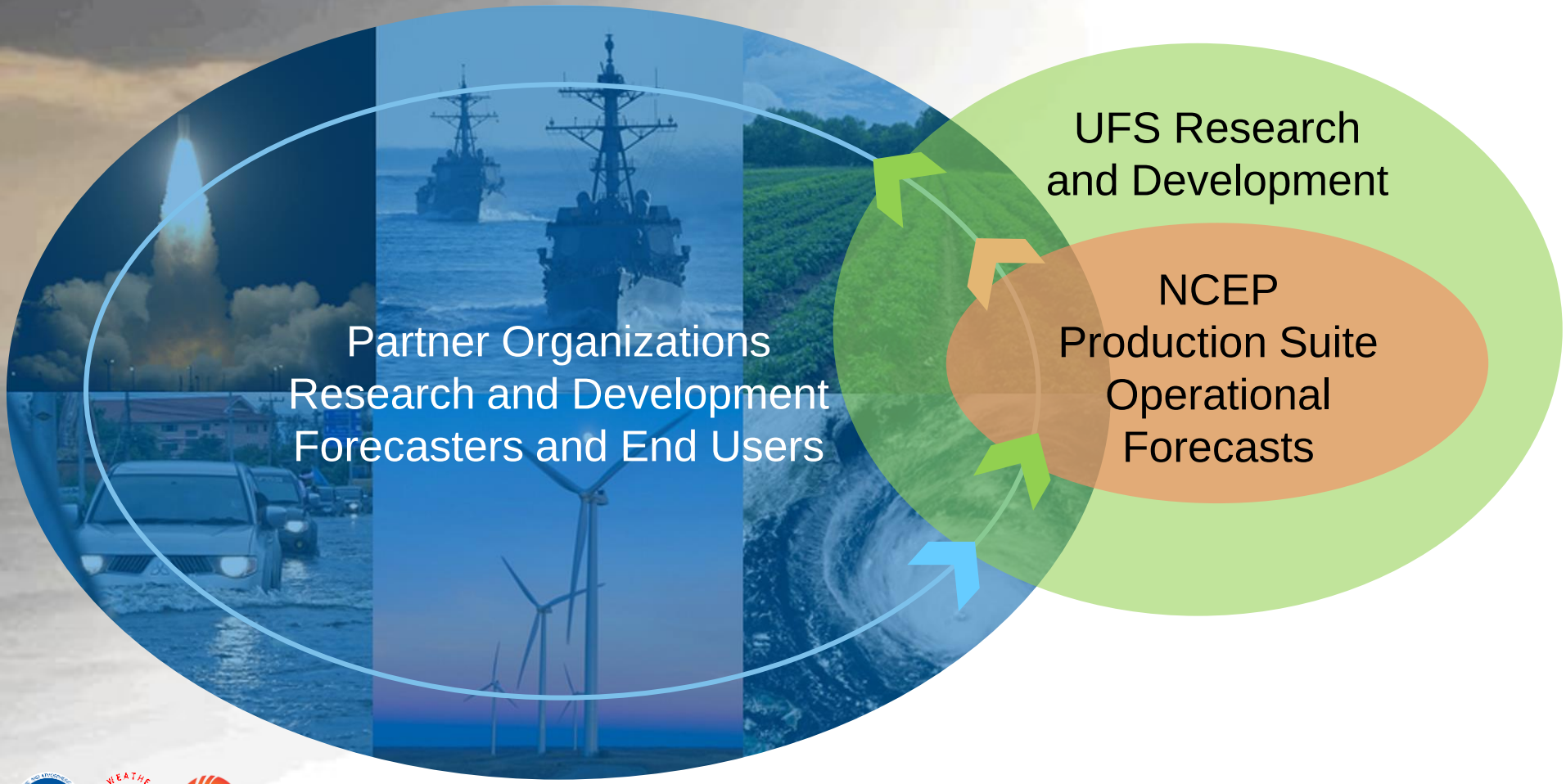
Starting from the quilt of models and products created by the implementing solutions rather than addressing requirements ….



Roadmap Fig. 2

Community-Based Development

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



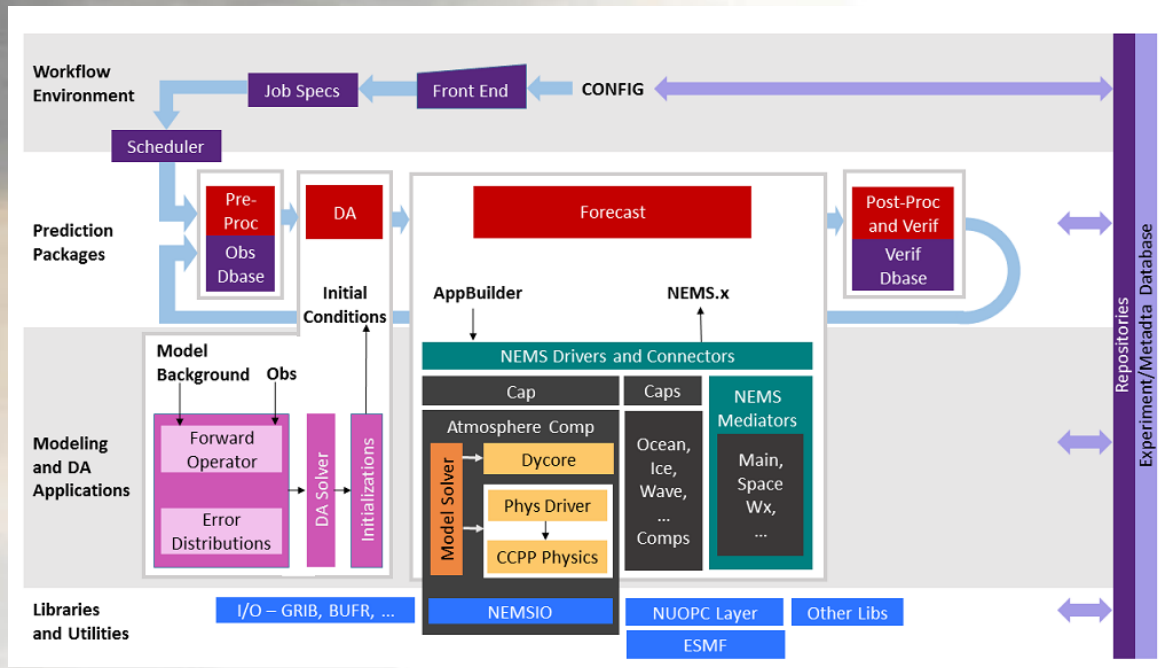
UFS System Architecture

Workflow

Prediction Packages

Modeling and DA Applications

Libraries and Utilities



Software engineering infrastructure: Repositories, Documentation

The Point: Complex system with differentiated functions. The functions are required to combine into end-to-end application systems. Requires data communication at the interfaces and communication among humans.

Governance

A work in progress …..

UFS Technical Oversight Board (TOB)

programmatic coordination, resource allocation

Program Offices: approval and resourcing of plans

reports to

generates SIP

UFS Steering Committee (UFS-SC)

Co-chairs:

STI Modeling Strategic Lead

External/Community Lead

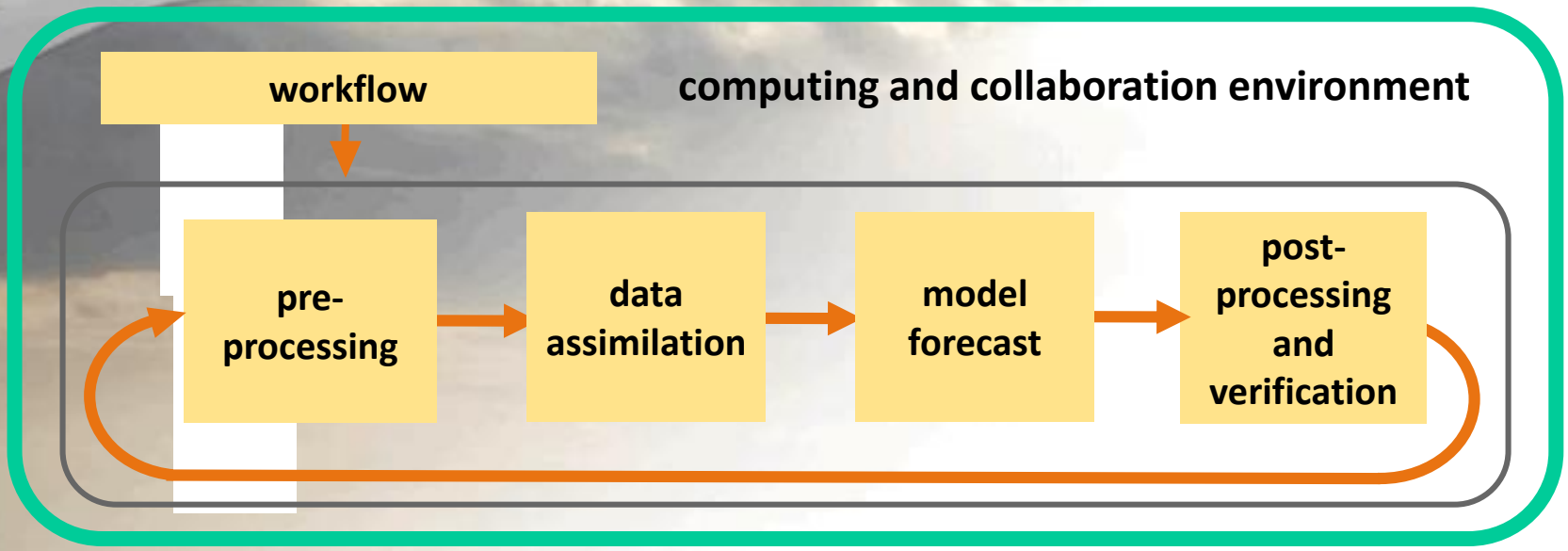
technical and scientific planning, review, and coordination

Strategic Implementation Plan Working Groups

- atm composition
- land
- comm & outreach
- marine
- data assimilation
- mesoscale
- dynamics and nesting
- physics
- ensemble development
- post-processing
- infrastructure
- system architecture
- verification & validation

Community is represented in every governance body

Parts of a UFS Application



Pre-processing and data assimilation	• Stages inputs, performs observation processing, and prepares an analysis
Model forecast	• Integrates the model or ensemble of models forward
Post-processing and verification	• Assesses skill and diagnoses deficiencies in the model by comparing to observations
Workflow	• Executes a specified sequence of jobs
Computing and collaboration environment	• May be different for research (experiment focus) and operations (forecast focus) • Provides actual or virtualized hardware, databases, and support

UFS Applications

- Medium-Range Weather (Weather) - Atmospheric behavior out to about two weeks
- Subseasonal-to-Seasonal (S2S) - Atmospheric and ocean behavior from about two weeks to about one year
- Hurricane - Hurricane track, intensity, and related effects out to about one week
- Short-Range Weather/Convection Allowing - Atmospheric behavior from less than an hour to several days
- Space Weather - Upper atmosphere geophysical activity and solar behavior out to about one month
- Marine and Cryosphere - Ocean and ice behavior out to about ten days
- Coastal - Storm surge and other coastal phenomena out to about one week
- Air Quality - Aerosol and atmospheric composition out to several days

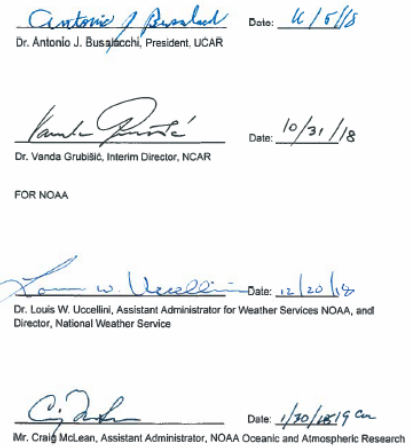
MoA areas of infrastructure

Memorandum of Agreement between NCAR, NWS and OAR on coupled model infrastructure

1) NEMS / CMEPS unification for inter-component coupling
2) CCPP / CPF unification for intra-component coupling
3) CIME – CROW unification for common workflow development
4) Unified testing to assure code is robust and performs as expected
5) Unified model validation through MET development and expansion to application for fully coupled systems
6) Github based repositories for all infrastructure
7) Modeling support; leveraging, creating if necessary, or adapting support capabilities at e.g. NCAR and DTC

MoA additional

- Additional principles
  - No (new) exchange of funding planned, leveraging existing funding of all parties
  - Building upon existing governance, expanding governance per component as needed
  - Five year life cycle, with option to renew
  - Signatories
    - Dr. Antonio Busalacchi, Director UCAR
    - Dr. Vanda Grubišić, Interim Dir. NCAR
    - Dr. Louis Uccellini, Director NWS
    - Mr. Craig MacLean, AA OAR


Date: 11/5/18
Dr. Antonio J. Busalacchi, President, UCAR

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

FOR NOAA

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

Date: 1/30/18 19
Mr. Craig McLean, Assistant Administrator, NOAA Oceanic and Atmospheric Research

Practical Progress

GFS-v15 based on FV3 dycore is considered first practical instantiation of UFS

- Supported code release in Github ca. December.

More than weather: Coupled model prototypes

- Working prototypes, good enough quality for R&D
- Targeting S2S and Seasonal Implementations
- Codes successfully transitioned to NFS computers

Contributors (coupling)

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*

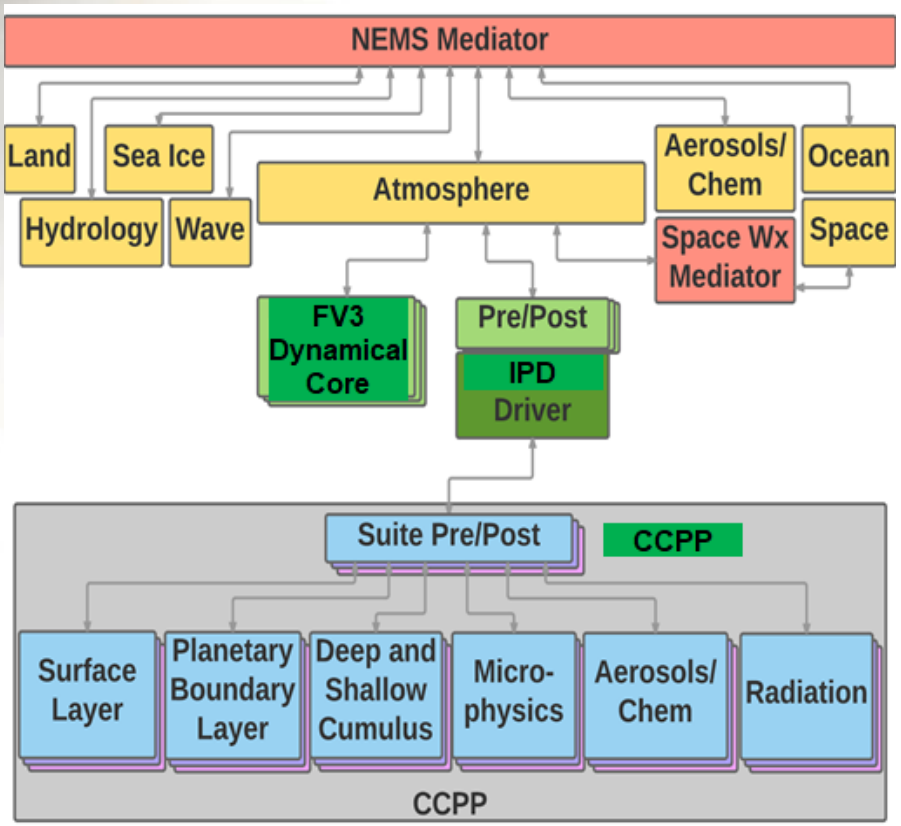
GFDL

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

UCAR/NCAR

- *Mariana Vertenstein, Rocky Dunlap, Dave Bailey*

- NWS UFS system consists of the following components (at the moment)
  - NEMS for infrastructure
  - FV3 dycore with Physics driver (IPD / CCPP)
  - MOM6 ocean model (S2S scales)
  - HYCOM ocean model (weather scales)
  - 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, ¼ deg ocean and ice)

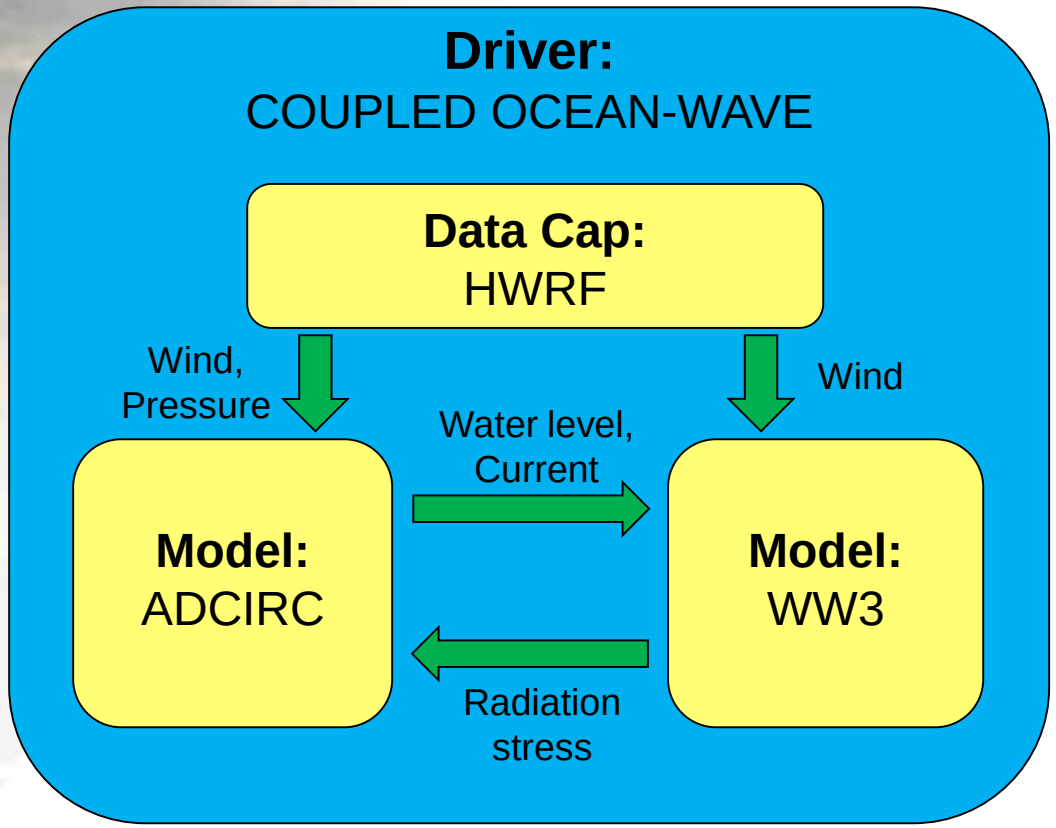
FV3 – MOM6 – CICE5 – WW3
S2S scales including Langmuir mixing (25 km atm, ¼ deg ocean and ice, ½ deg waves)

Wave - Surge Coupling

Courtesy: Arun Chawla

COASTAL Act

- NOS / EMC Collaboration
- Wave model updated
  - ➤ implicit propagation
  - ➤ domain decomposition
- Wave cap updated to handle unstructured grids
- NUOPC cap for ADCIRC (NOS)
- Verified import and export fields between wave and surge models

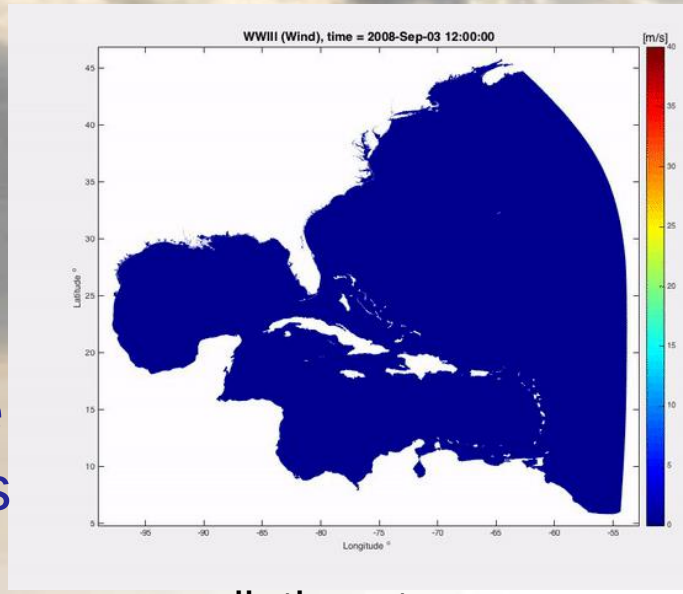


ESMF	“Language”
NUOPC	“Dictionary”
NEMS	“Book”

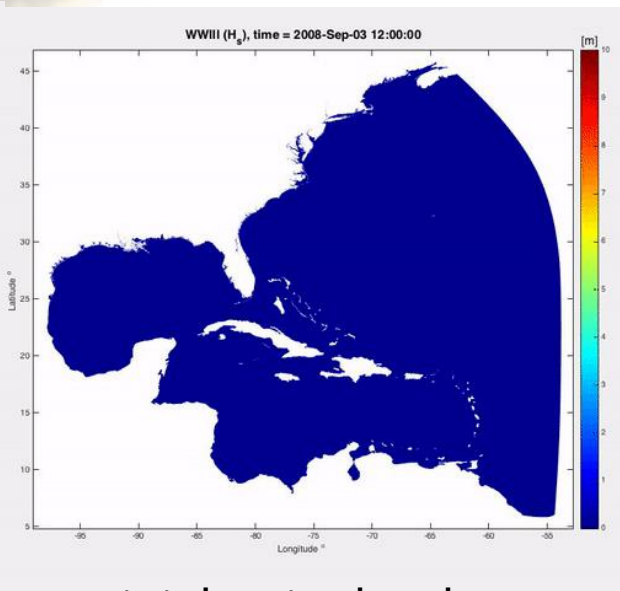
See paper E2 for most recent results and a comprehensive overview of this project

See papers JJ1 and JJ3 for next step: total coastal water = surge + river + rain

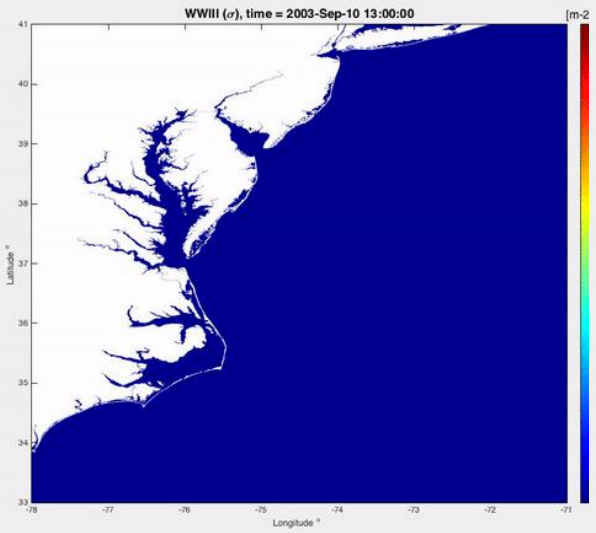
wind speed



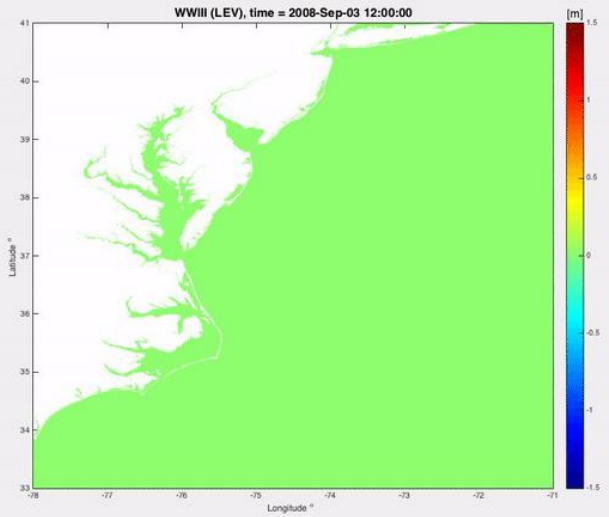
sig. wave height



radiation stresses



total water level



Take aways for UFS ….

Evolving set of activities on science, unification, community building, and capacity building

- Need: UFS to emerge as the focus of NOAA modeling: Shared understanding, investment, strategic focus

Governance is active and evolving

- Need: Alignment of resources of tasks with the goals of simplification, community building, scientific excellence, and managed interfaces between R&O

Research and Operations Transitions

- Need: Planning and implementation of end-to-end system. Balanced investment in end-to-end system

Earth Prediction Innovation Center (EPIC)


Thank You!