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# The NOAA Environmental Modeling System (NEMS)

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**Eugene Mirvis**

**RAL/NCAR**



# Presentation Outline

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## ➤ NCEP/EMC Mission

## ➤ Motivation for NEMS

## ➤ NEMS Description

## ➤ Example Applications

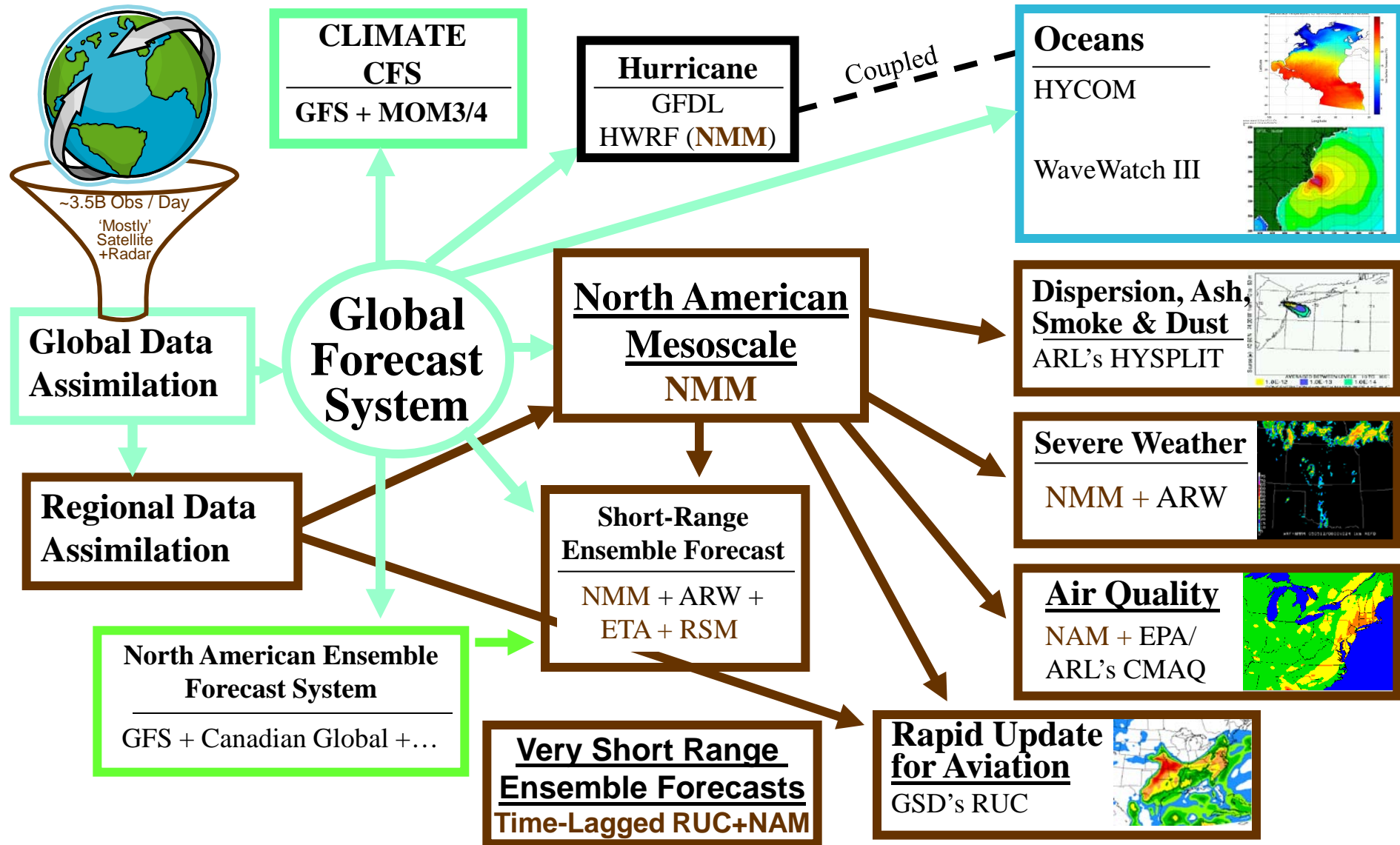
- North American Mesoscale (NAM) Forecast System
- Moving Nests (NMMB global + Regional)
- Global Aerosols (GFS and GOCART)

## ➤ Future Plans





# Linkage of Model Systems Within Production Suite

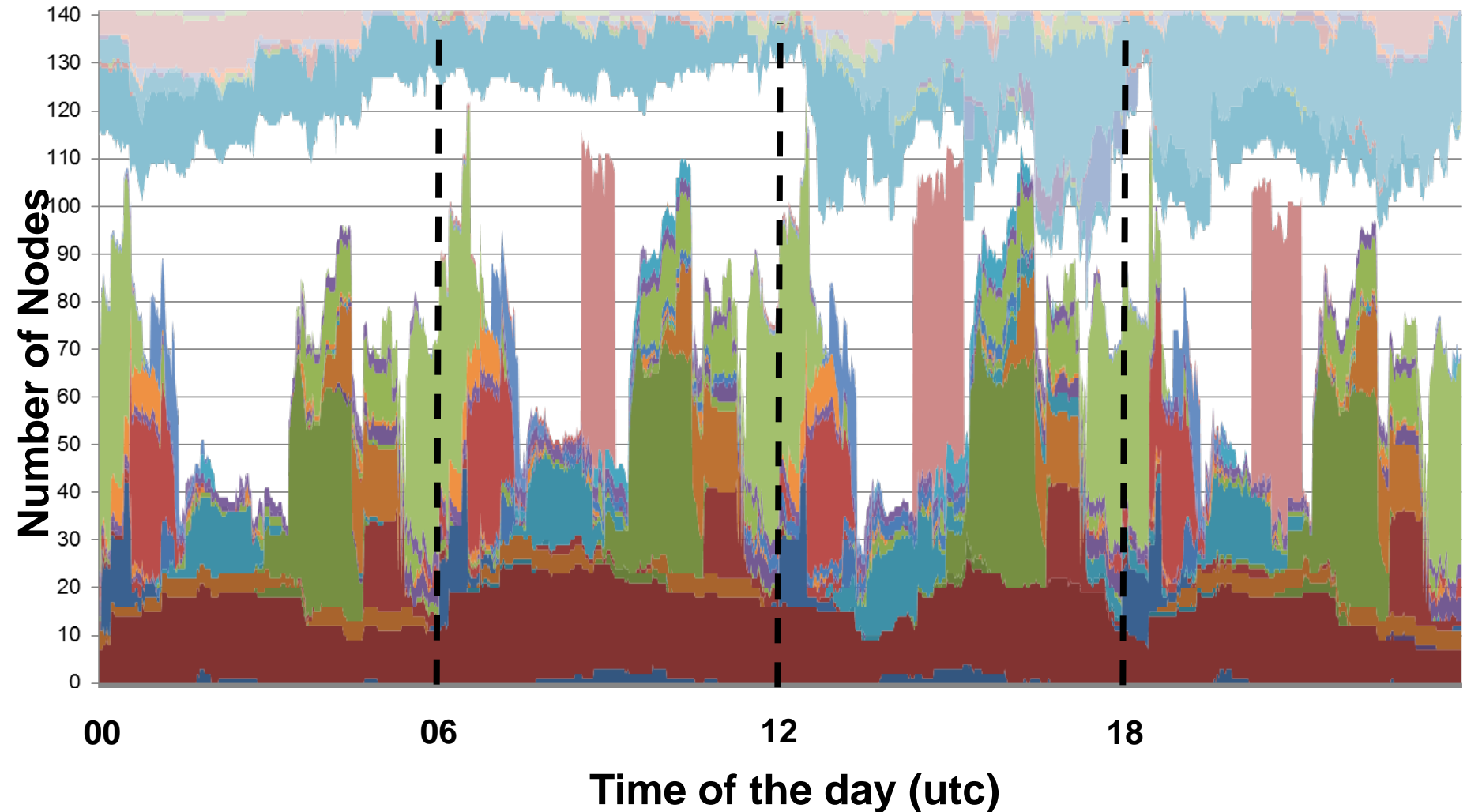




# Production Suite on Supercomputer



9 May 2011





# NEMS Incorporates the Earth System Modeling Framework



## Earth System Modeling Framework

### Motivation

#### **In climate research and numerical weather prediction..**

increased emphasis on detailed representation of individual physical processes; requires many teams of specialists to contribute components to an overall modeling system

#### **In computing technology...**

increase in hardware and software complexity in high-performance computing, as we shift toward the use of scalable computing architectures

#### **In software ...**

emergence of frameworks to promote code reuse and interoperability

The ESMF is a focused community effort to tame the complexity of models and the computing environment. It leverages, unifies and extends existing software frameworks, creating new opportunities for scientific contribution and collaboration.



# Motivation for the Development of NEMS



- **Develop a common superstructure for NCEP Production Suite components**
- **Reduce overhead costs and provide a flexible infrastructure in the operational environment**
  - **Concurrent nests**
  - **NAM executed concurrent with GFS**
  - **Stochastic ensemble generation**
  - **Coupled atmosphere/ocean/land/icesystems becoming a NOAA requirement**
- **Modularize large pieces of the systems with ESMF components and interfaces—concurrent execution**
- **NOAA contribution to the National Unified Operational Prediction Capability (NUOPC) with Navy and Air Force**



# System Characteristics

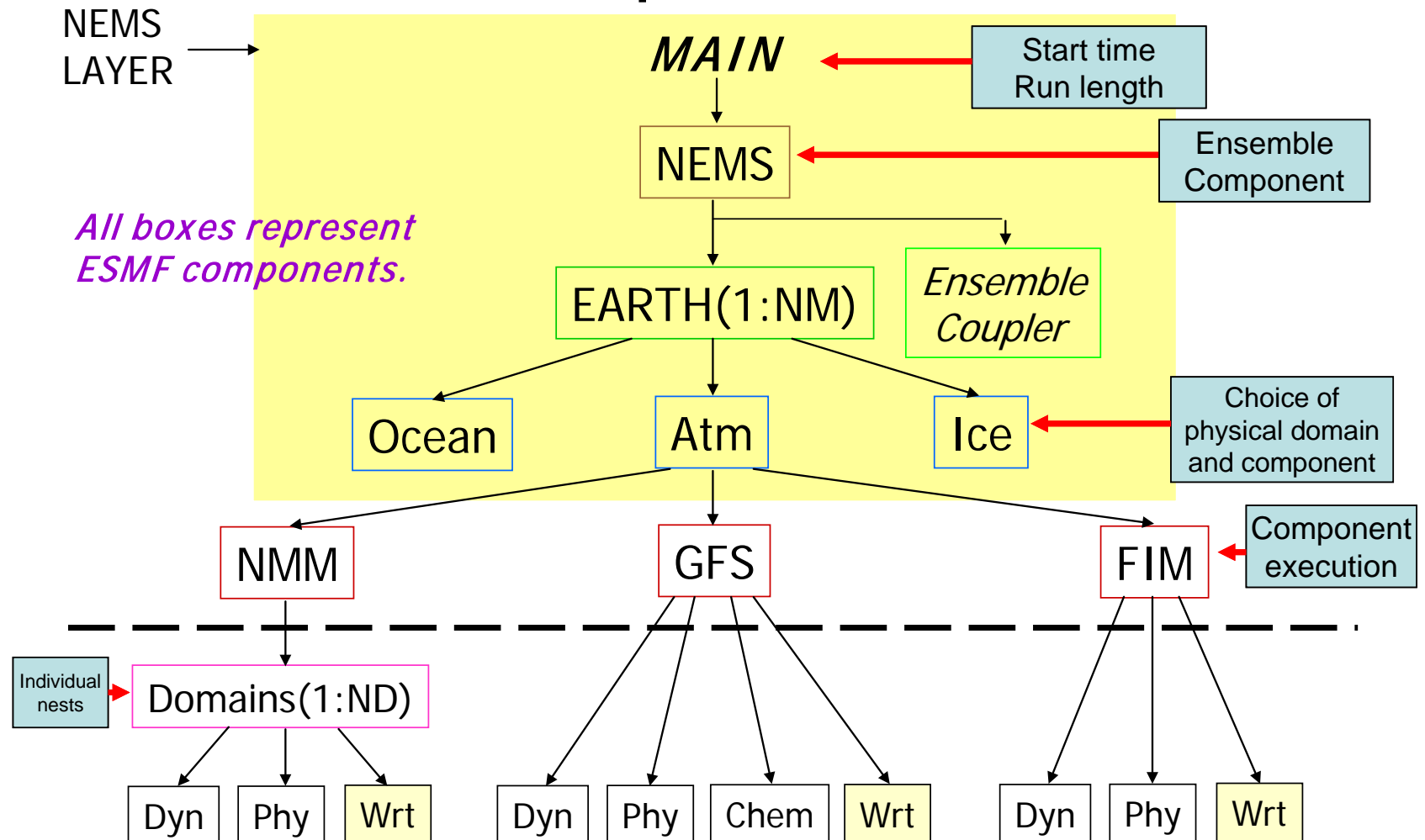
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- **Divide atmospheric models down into Dynamics and Physics components but no further**
- **Take history file I/O outside the science parts and into a common Write component**
- **Keep science code and parallelization code in the respective models the same as before**
- **Follows NUOPC defined standards and protocols**
- **Eventual support to community through Developmental Test Center (DTC)**

<http://www.emc.ncep.noaa.gov/NEMS/>



# NEMS Component Structure



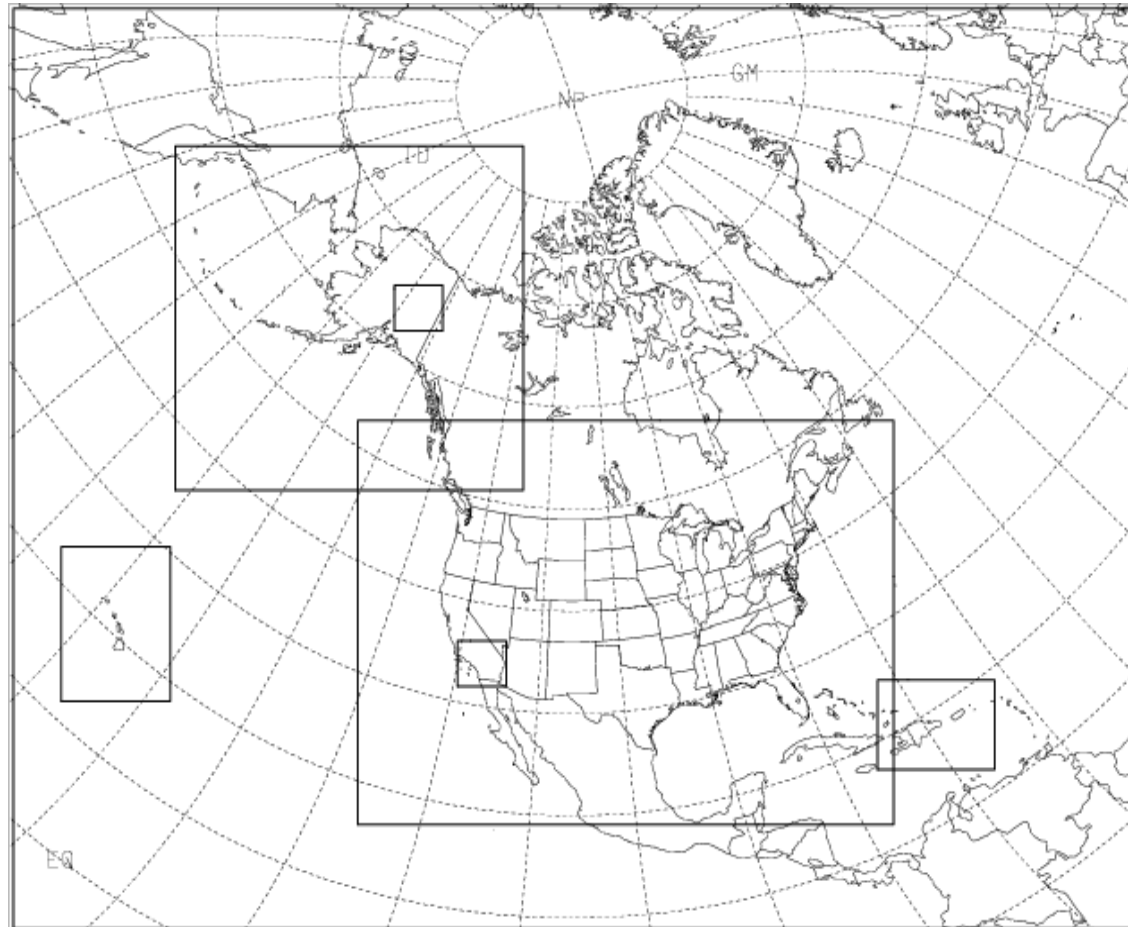
*Below the dashed line the source codes are organized by the model developers.*



# First Operational Implementation with the NAM in Aug 2011



- 12 km NAM will still run to 84 hr
- Fixed domain nests run to 60 hr
  - 4 km CONUS
  - 6 km Alaska
  - 3 km HI & PR
- Single locatable 1.33 km (CONUS) or 1.5 km (Alaska) nest to 36hr
- Nests
  - Static, 1-way
  - Boundaries from parent every timestep
  - Nest is “grid-associated” with parent (same orientation w.r.t. earth)
  - Moving nests and 2-way interaction under development





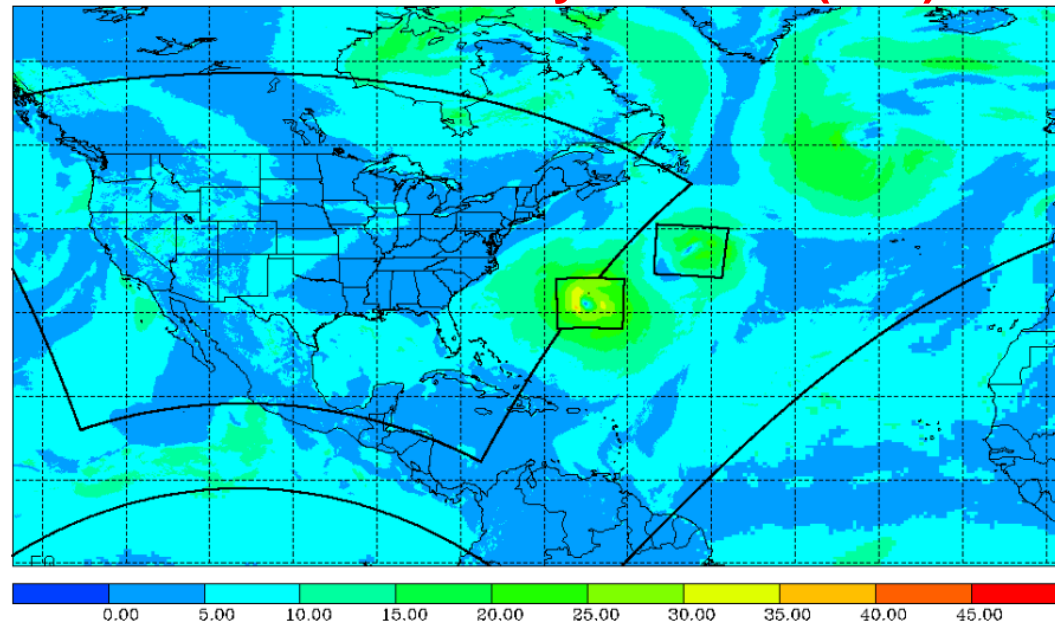
# Future Plans for NEMS at NCEP

## Global, CONUS & Hurricane



**84-hour forecasts from 12Z 17 Sep 2010**  
**Lowest model layer winds (m/s).**

[Internet Link](#)  
[Local link](#)



- **Global NMM-B in the outermost domain**
- **NAM/NMM-B inside the global domain**
- **CONUS nest inside the NAM**
- **Moving nests of Hurricanes Igor and Julia**
- **Configuration within a single executable**



# Future Plans for NEMS at NCEP

## Global, CONUS & Hurricane



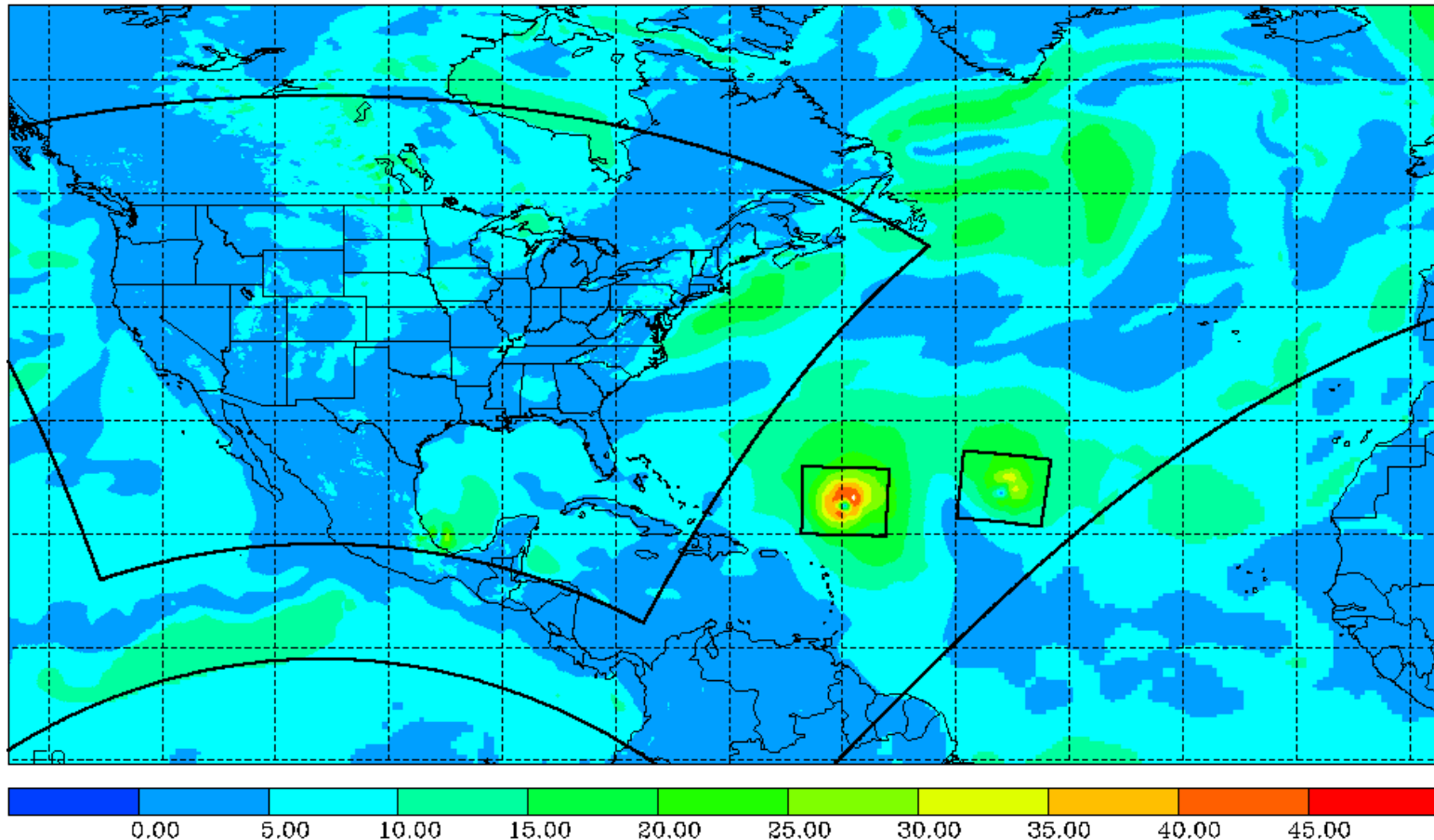
**84-hour forecasts from 12Z 17 Sep 2010**  
**Lowest model layer winds (m/s).**

[Internet Link](#)

[Local link](#)

wind

20100917 12h 00m 0.00s



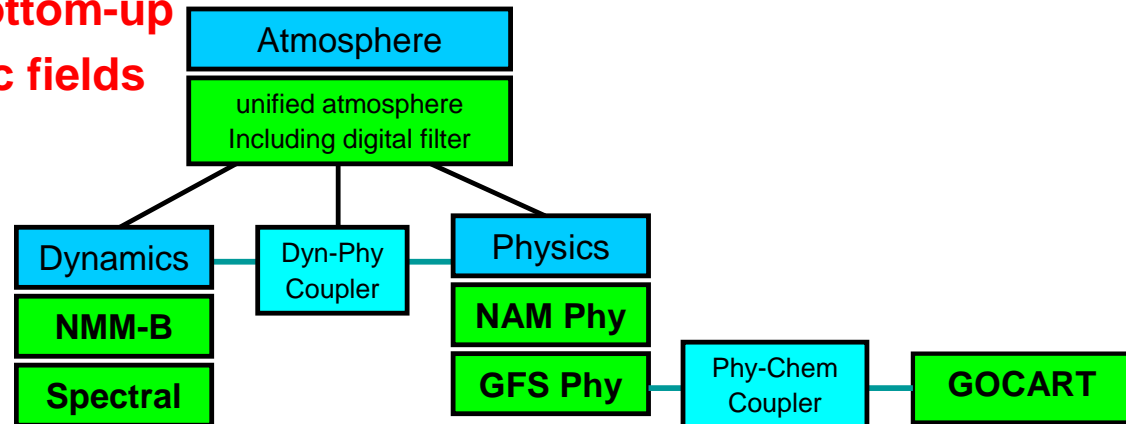
staggering H



# NEMS GFS Aerosol Component (NGAC)



- Dynamics, physics and chemistry run on the same grid in the same decomposition
- GOCART does not own aerosol tracers (i.e, do not allocate aerosol tracer fields)
- **PHY2CHEM coupler component** transfers/converts data from PYHS to GOCART import state
  - Convert units (e.g., precip rate, surface roughness)
  - Calculations (e.g., soil wetness, tropopause pressure, relative humidity, air density, geopotential height)
  - Flip the vertical index for 3D fields from bottom-up to top-down
- **CHEM2PHY coupler component** transfers data from GOCART to PHYS
  - Flip vertical index back to bottom-up
  - Update 2d aerosol diagnostic fields



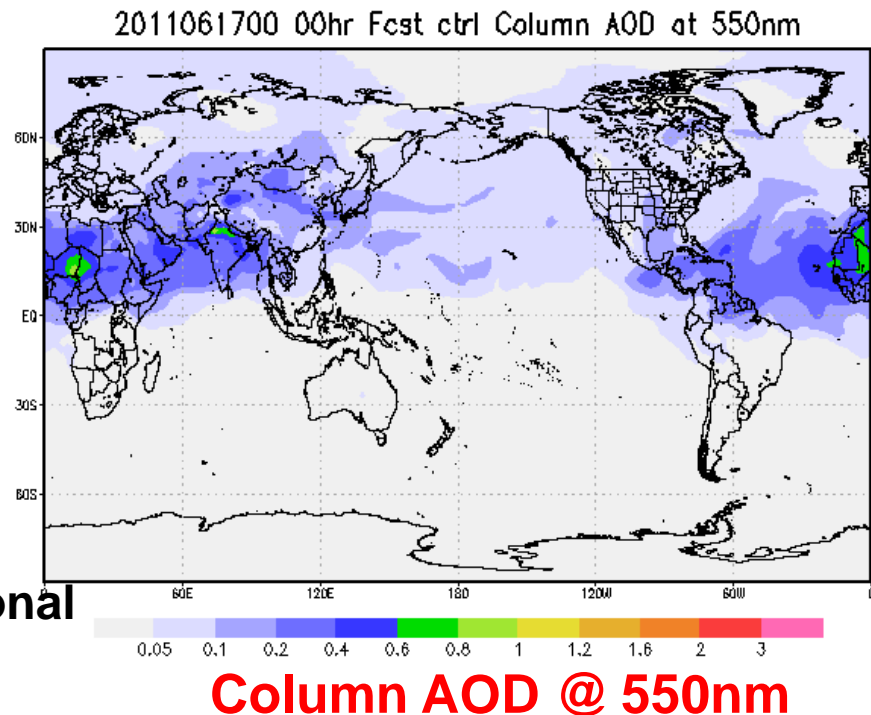


# NEMS GFS Aerosol Component Configuration



## Experimental (non-operational)

- Executable compiled from NEMS trunk code repository
- 120-hr dust-only forecast
- Once per day (00Z)
- 3-hourly products: 3d distribution of dust aerosols (5 bins from 0.1 – 10  $\mu\text{m}$ )
- Automatic output archive, post processing and web update since June 11, 2011
- Same physics and dynamics as operational GFS with the following exceptions:
  - Lower resolution (T126 L64)
  - Use RAS with convective transport and tracer scavenging
  - Aerosol-radiation feedback is turned off





# Future Plans

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## ➤ **NEMS will include the following components by the end of FY11**

- **GFS**
- **GEFS**
- **Unified Postprocessor**
- **FIM**
- **Multi-model ensemble capability**
- **GRIB2 output**

## • **FY12 and beyond**

- **NMM nested in GFS**
- **Moving nests**
- **Coupled ocean-atmosphere**
- **Tiled land model**
- **netCDF output**
- **ARW**







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NOAA Environmental Modeling System



For the past several years, a common modeling framework called the NOAA Environmental Modeling System (NEMS) has been in development to streamline the interaction of analysis, forecast, and post-processing systems within NCEP. The NEMS architecture is based on the Earth System Modeling Framework (ESMF). This marks the first general use of ESMF within NCEP.

NEMS is a shared, portable, high performance software superstructure and infrastructure for use in operational prediction models at the National Centers for Environmental Prediction (NCEP). It is also part of the National Unified Operational Prediction Capability (NUOPC) with Navy and the Air Force, and will eventually provide support to the community through the Developmental Test Center (DTC). Currently, the Global Forecast System (GFS), the Global Ensemble Forecast System (GEFS), and the B-grid version of the Nonhydrostatic Multiscale Model (NMM-B) are placed together within NEMS.

Because NEMS is still in development, this website will evolve as NEMS evolves. Please be patient with our construction.

[Current Implementation Plans](#)  
2011 Implementation - NMM-B with nests  
2012 Implementation - NEMS GFS Aerosol Component (NGAC)

[NEMS Delivery Plans](#)

National Weather Service • Since 1870

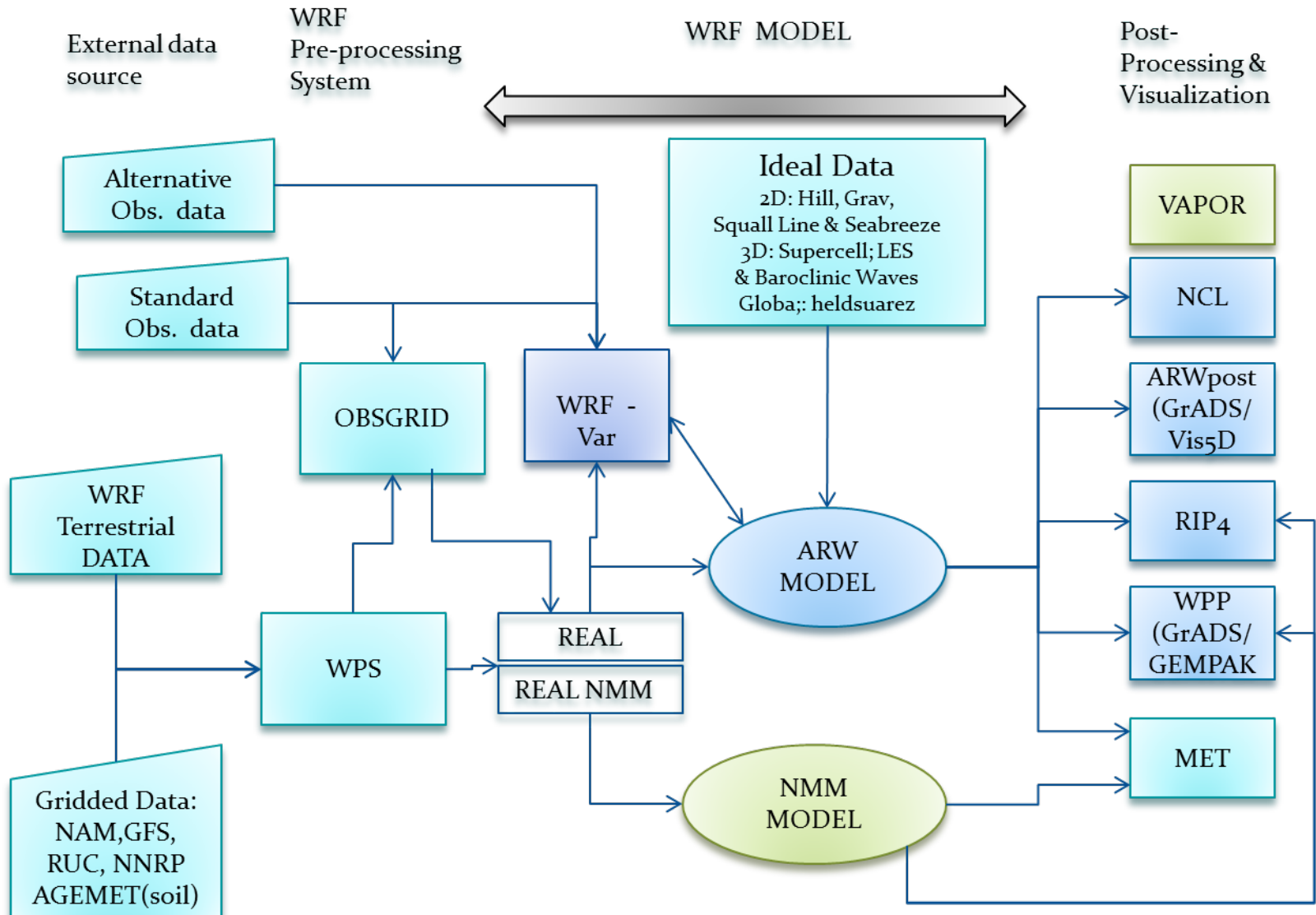
First NEMS Tutorial planned for Summer 2013



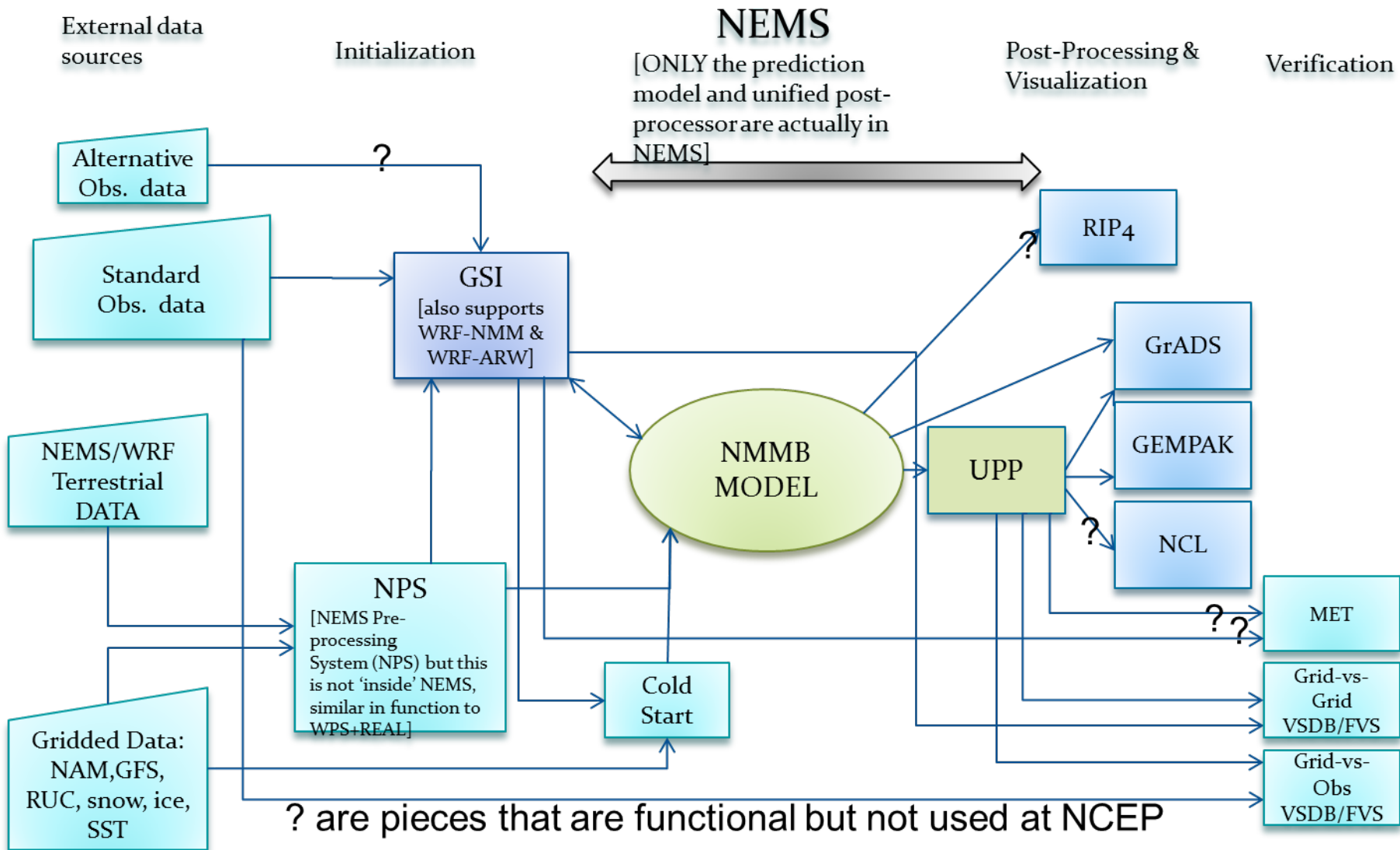


# Backup Slides

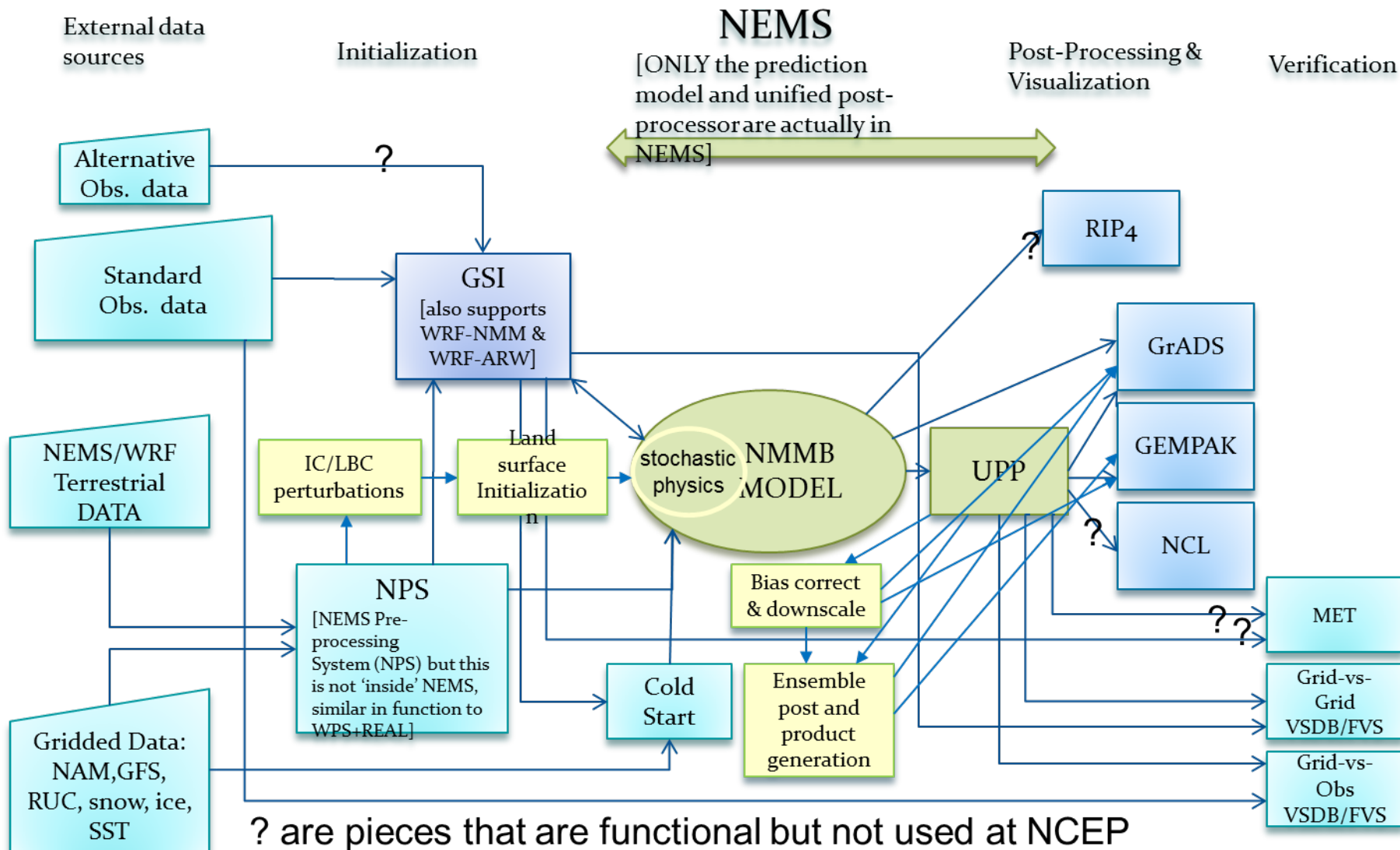
# Program Flow:: WRF/DTC/DET



# NCEP Version of Program Flow



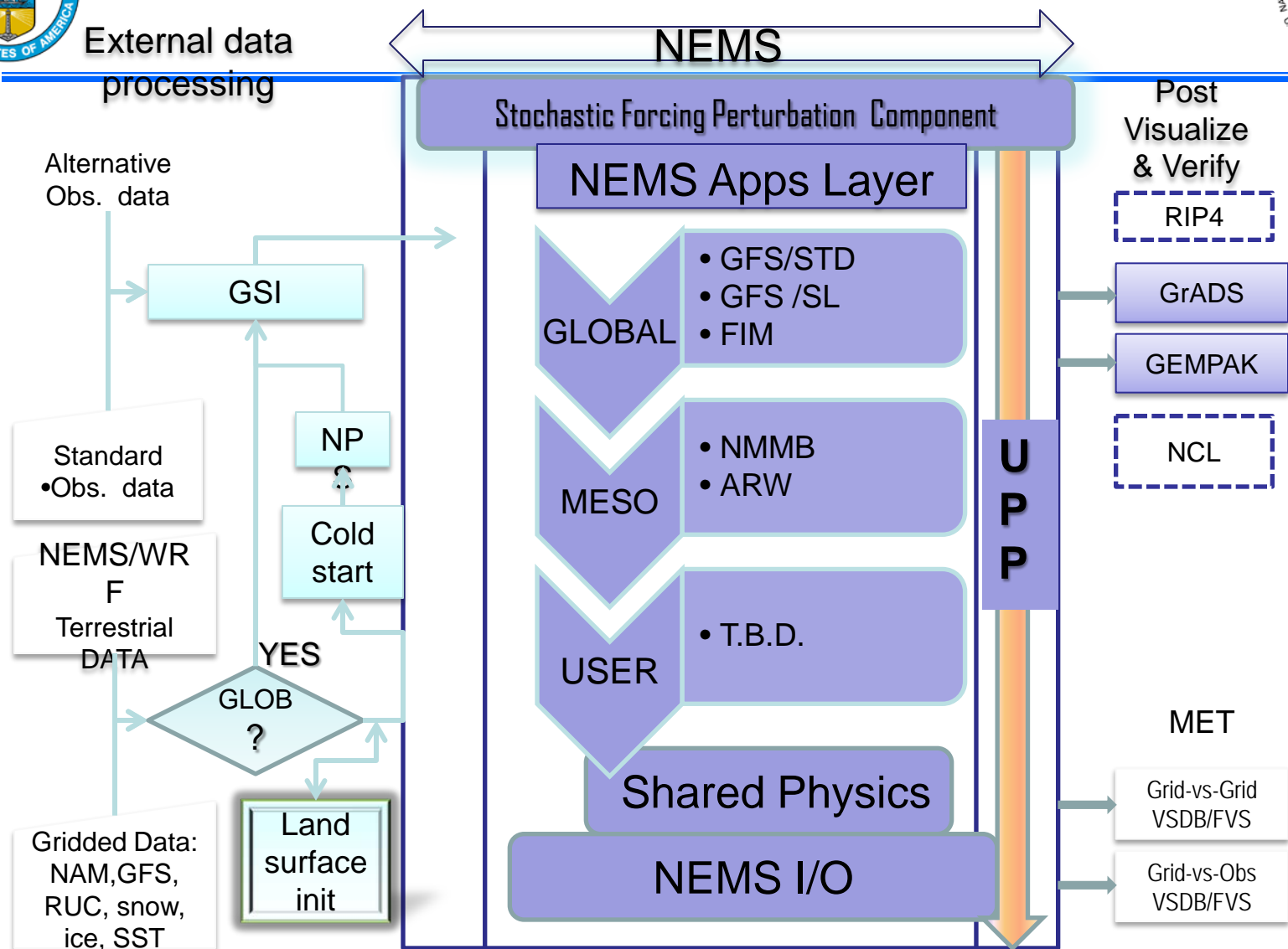
# WF:: NCEP SREF Version SREF



? are pieces that are functional but not used at NCEP



# NEMS WORKFLOW



[ ] not used at NCEP



# NCEP NEMS ENSEMBLE WORKFLOW

