NCEP/EMC overview

operations, gaps and requirements

Hendrik L. Tolman
NOAA / NWS / NCEP
Environmental Modeling Center

Hendrik.Tolman@NOAA.gov

Content

The suite in 2 minutes

Emerging requirements

Forces driving unification of the model suite

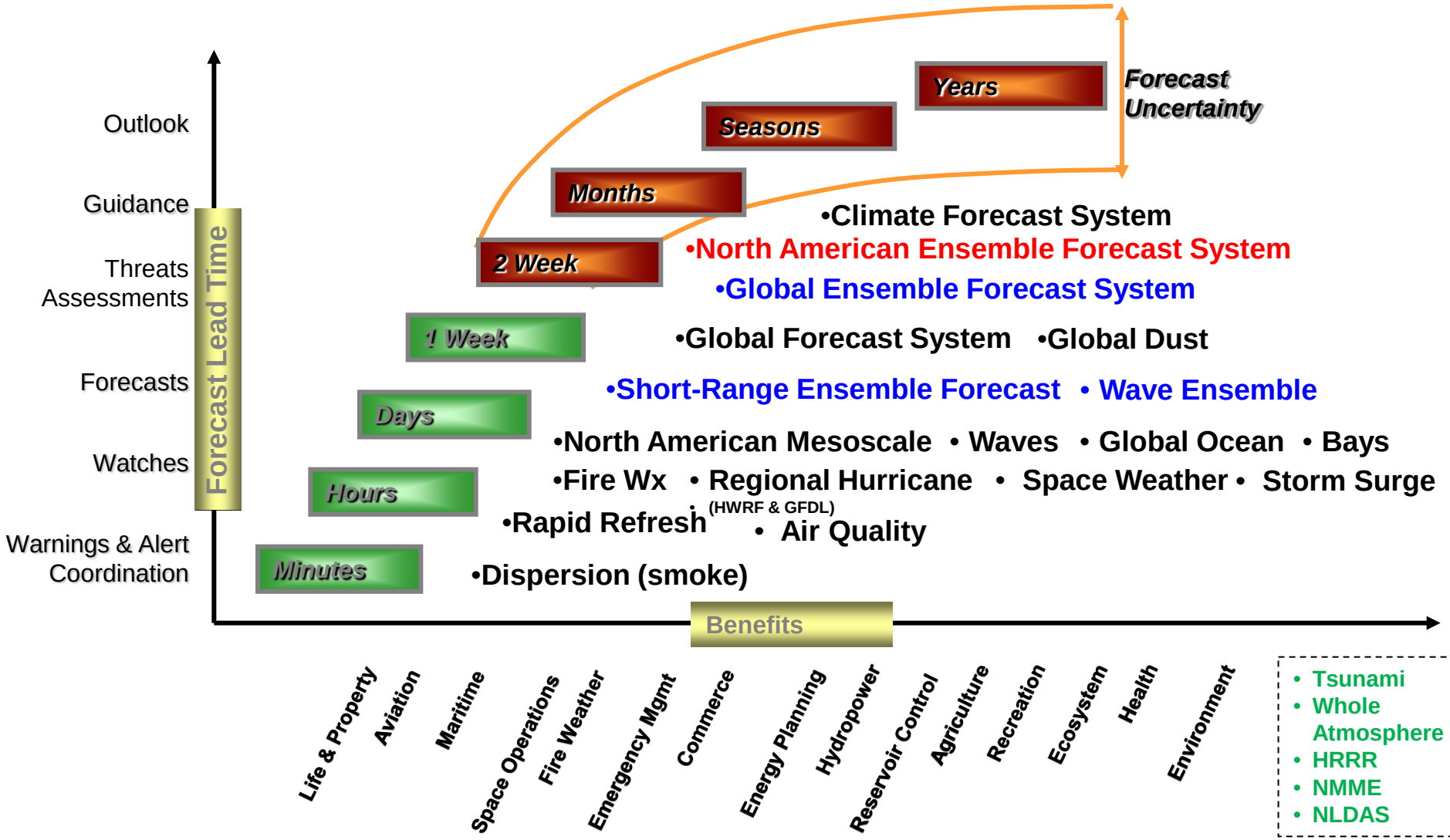
- UMAC (UCACN model advisory committee)
  - ➢ High-level plans for simplified production suite
- NGGPS (Next Generation Global Prediction System)
  - ➢ Unified Global Coupled Model

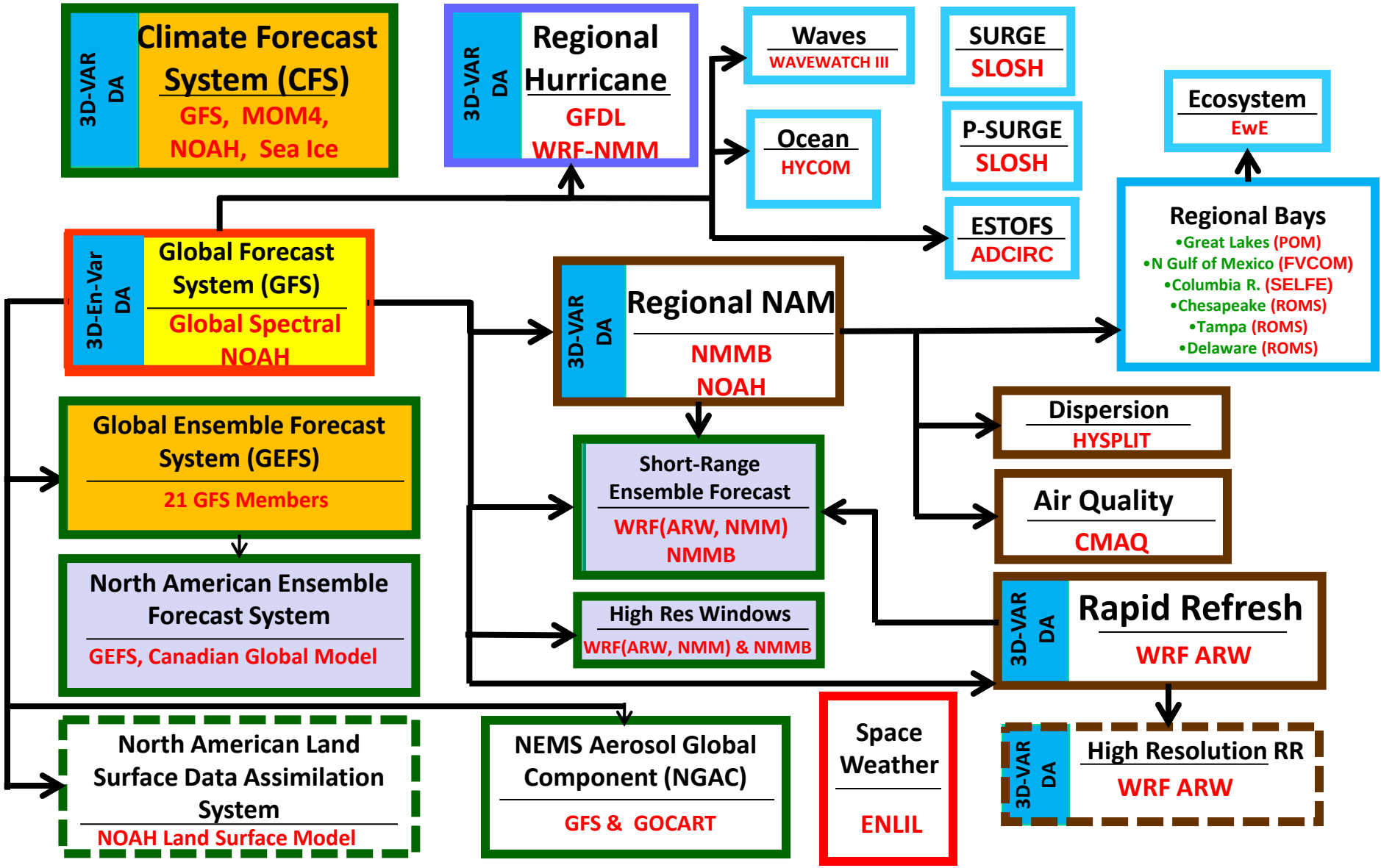
What does this mean for CTB?

Model suite in 2 minutes

Present state and emerging requirements

Seamless Suite, spanning weather and climate





Production suite ca. January 2014

Emerging requirements

Weather Ready Nation.

- Products.
- Social science.
- High impact events.

Weather to climate—seamless suite of guidance and products.

- Week 3-4.
- Systematic reforecast need.
  - ➢ Forecast uncertainty.
  - ➢ Calibration of outlook products.
  - ➢ Validation / Decision Support.

Range of products beyond weather:

- Land, ice, ocean, waves, aerosols, (ecosystems, space weather).
- Water cycle, National Water Center (NWC).

Driving Forces: UMAC

High-level plans for simplified production suite

Basic issues / UMAC

Some key findings of UMAC* :

- Simplify / unify model suite.
- Lack of requirements process.
- Better process to identify development paths.
  - “end-to-end” management of implementations.
- Evidence driven decision.
  - No more predetermined (relative) compute resources for individual applications (our previous “jigsaw puzzle”)

The production suite has evolved as a set of solutions for (ill-defined) requirements, instead of a set of products serving well defined requirements.

* UCACN Model Advisory Committee

https://www.earthsystemcog.org/projects/umac_model_advisory

Basic issues / UMAC

Moving away from implementing solutions:

- Need better NWS requirements process.
- Map requirements to products (not models).
- Target model development to better serve requirements.
- Business case is integral part of decisions:
  - ➢ Unified model with concentrated effort, versus
  - ➢ models tailored to selected requirements.

Additional considerations

- Coupled modeling needs to be considered in this context.
- Focus on predictability and outlook products requires systematic ensemble / reanalysis (retrospective) / reforecast approach.

Basic approach : atmosphere

Start with weather side:

- We are NWS !

Starting with products:

- What forecast time ranges.
- which reasonably imply
  - ➢ Run cadences.
  - ➢ Update cycles.
- Not so clear:
  - ➢ Resolutions.
  - ➢ Data Assimilation.
  - ➢ Reforecast / reanalysis / retrospectives
- Need to map requirements to forecast ranges.

Possible Approach			
Range	Target	Cadence	Means
year	Seasonal	?	9-15mo
month	S2S	6-24h	35-45d
week	Actionable weather	6h	3-16d
day	Convection resolving	1h	18-36h
hour	Warn On Forecast *	5-15 ‘	3-6h
now	Analyses **	?	now

* FACETs

** Separating from DA for models

Basic approach : coupling

This is not just a science problem

- Requirements for additional, traditionally downstream products.
- '"One-way" model coupling versus downstream model:
  - Increases forcing resolution of downstream models while reducing I/O needed to force models.
  - Creates a better integrated test environment for holistic evaluation of model upgrades.
  - Less implementations.
  - Creates environment for investigating benefits of two-way coupling. Enables two-way coupling if science proves benefit.

Negative aspects of coupling:

- More complex implementations.
- Less flexibility to tailor products.
- Produce "too much" compared to tailored products (forecast range).

Basic approach : coupling

Many potentially coupled model components already have products in the production suite :

- Where no products exists, science suggests benefit of coupling.
- For the hourly forecast range, all still TBD.
- DA is also moving (internationally) to coupling.
- Space weather making its way into operations.
- Ecosystems (marine) being considered (not in table).

Subsystem	Year	Month	Week	Day	Hour
Land / hydro	Y	Y	Y	S	?
Ocean / coast	Y	Y	Y	S/R	?
Ice	Y	Y	S	?	?
Waves	S	Y	Y	Y	?
Aerosols	S	S	Y	Y	?
Space weather	?	?	Y	?	?

Y: present product
S: science benefit
R: unmet requirement
?: TBD

Basic approach : coupling “now”

CFS	Influencing						
	Atmos.	Land / hydro	Ocean / coast	ice	waves	Aerosols	Space W.
Atmos.		yes	yes	yes	yes	yes	yes
Land/hydro	yes		inflow	yes	inundation		
Ocean/coast	yes	inundation		yes	WCI	climate	
Ice	yes		yes		yes		
Waves	fluxes		WCI	yes			
Aerosols	climate						yes
Space W.	yes					yes	

Green boxes:	light:	tradition 1-wy downstream coupling
	dark:	two-way coupling in selected operations.
Grey boxes:	fixed data, not dynamic coupling	
Black text:	presently in place.	
Red text:	science has shown impact	

Unifying model suite (atmosphere view)

Range	Year	Month	Week	Day	Hour	Now
Target	Seasonal outlook	S2S outlook	Actionable weather	Convection resolving	Warn On Forecast	Analyses / nowcast
Present models	CFS	CFS (GEFS extension)	GFS, GEFS, NAM, SREF, RAP, hurricane	HRRR, NAM nest, HiresW		RTMA, URMA, blend
Cadence	? (is 6h)	24h (is 6h)	6h	1h	5-15'	?
Range	9-15mo global	35-45d global	3-16d global (?)	18-36h regional (?)	3-6h ? regional	0 regional (?)
Updates	4y	2y	1y	1y	1y	6 mo
Reanal.	1979-now	20-25y	3y	?	?	
Where	?	WCOSS	WCOSS	WCOSS	?	WCOSS

- Ensemble based DA for all ranges (day and hour TBD).
- All global applications from single unified modeling system.
- Global / regional unification ?

- Present NPS elements not fitting in this layout:
  - Space weather (WAM-IPE / Geospace).
  - Hurricane models (GFDL / HWRF).

Driving Forces: NGGPS

High-level plans for simplified production suite

NGGPS

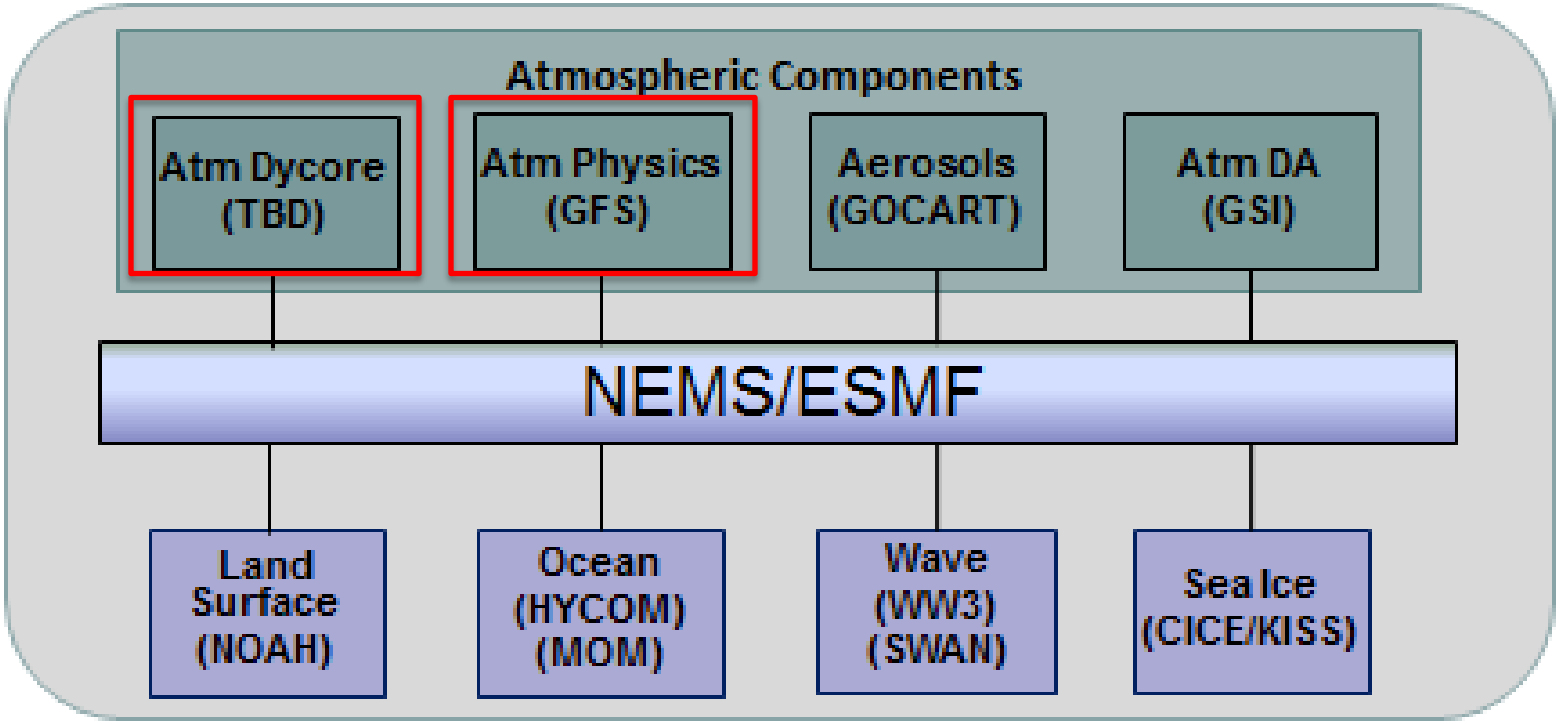
(Next Generation Global Prediction System)

NWS R2O funding and NGGPS projects.

- For first time NWS is funding agency.
  - Fund gaps in operations.
  - Project based funding for strategic development.
    - Within US government.
    - Academia, with NWS partners / champions.
  - Test beds for R2O.

- Key element in NGGPS
  - Next generation Dycore Selection.
  - Unified physics interface, focus on physics.
  - Model Coupling
    - Started with Climate Forecast System
    - Arctic modeling

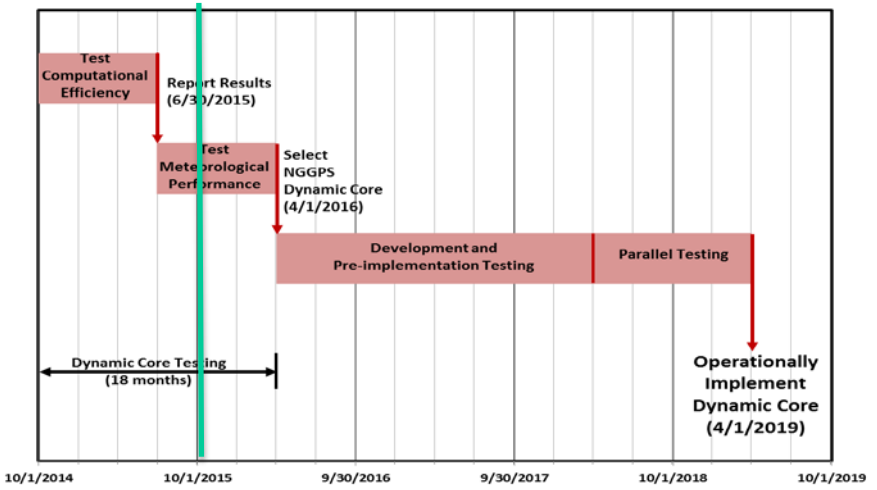
NGGPS and NEMS / ESMF



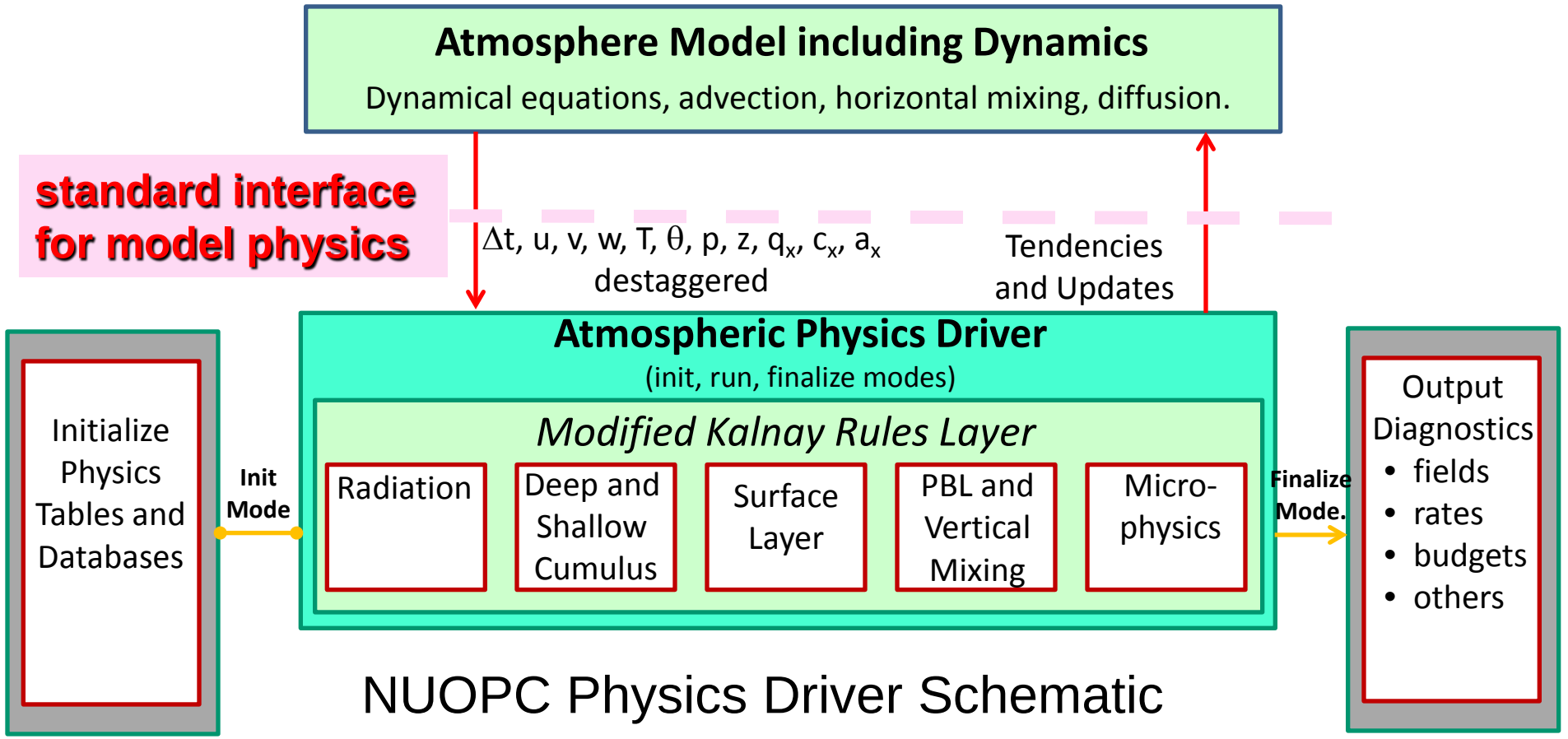
Modular modeling, using ESMF to modularize elements
in fully coupled unified global model
(+ *ionosphere , ecosystems , ……*)

NGGPS dycore

- Selecting a new dynamic core for global model to serve the NWS for the coming decades.
  - Architecture suitable for future compute environments.
  - Non-hydrostatic to allow for future convection-resolving global models.
- 18 month process to down-select candidate cores.
- 5 year plan to replace operations.
- Core → NEMS → applications.
  - ~~GSM-NH (EMC)~~
  - MPAS (NCAR)
  - FV3 (GFDL)
  - ~~NIM (ESRL)~~
  - ~~NEPTUNE (NRL)~~
  - ~~NMMB-UJ (EMC)~~



NGGPS physics



NUOPC Physics Driver Schematic

Version 1.0 delivered June 2015

COUPLED DA PROOF OF CONCEPT

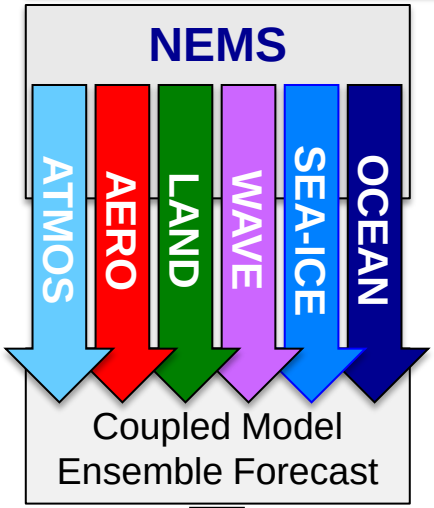
Moving toward coupled DA concept.

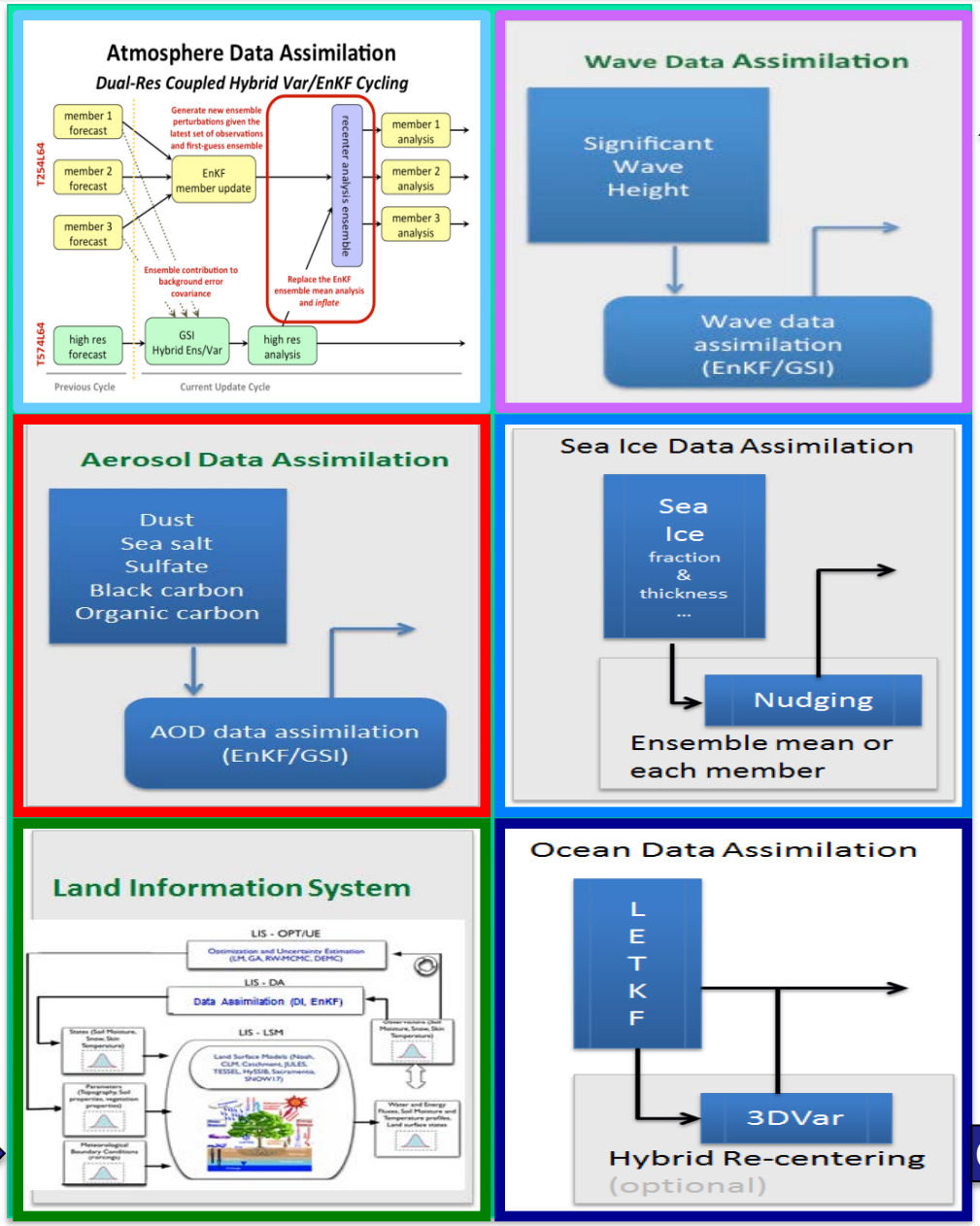
- Atmosphere: Hybrid 4D-EnVAR approach using a 80-member coupled forecast and analysis ensemble, with Semi-lagrangian dynamics, and 128 levels in the vertical hybrid sigma/pressure coordinates.
- Ocean/Seaice: GFDL MOM5.1/MOM6-SIS and/or HYCOM-CICE for the ocean and sea-ice coupling, using the NEMS coupler.
- Aerosols: Inline GOCART for aerosol coupling.
- Waves: Inline WAVEWATCH III for wave coupling.
- Land: Inline Noah Land Model for land coupling.

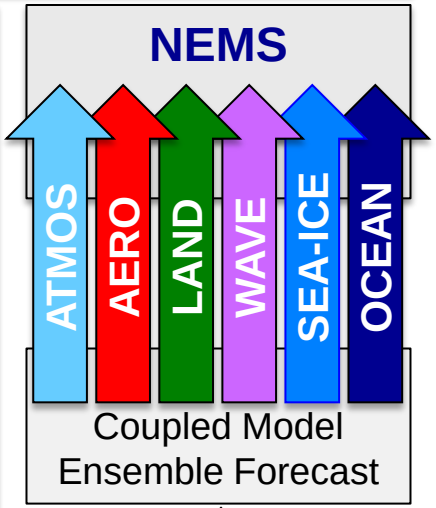
International community going here too

- E.G. CAWCR meeting November 2015.

NCEP Coupled Hybrid Data Assimilation and Forecast System







Coupled Ensemble Forecast (N members)

Ensemble Analysis (N Members)

INPUT

OUTPUT

What does this mean for CTB

CTB

Starting coupled modeling work in NGGPS

- Focus on demonstration for coupled modeling
- Stating from CFS-v2.
- Initial funding from NGGPS.
- Needs to transition to climate funding for CFS development.

Focal points for development

- Enhancing coupled modeling and DA
- Transition to new dycore
  - ➢ Creating sustainable development environment
- Main progress expected with physics
  - ➢ Per component (e.g., boundary layer)
  - ➢ With coupling (e.g., land / hydro issues)


Thank You!