Short to medium range coupled modeling at the US National Weather Service;

moving toward unified modeling approaches

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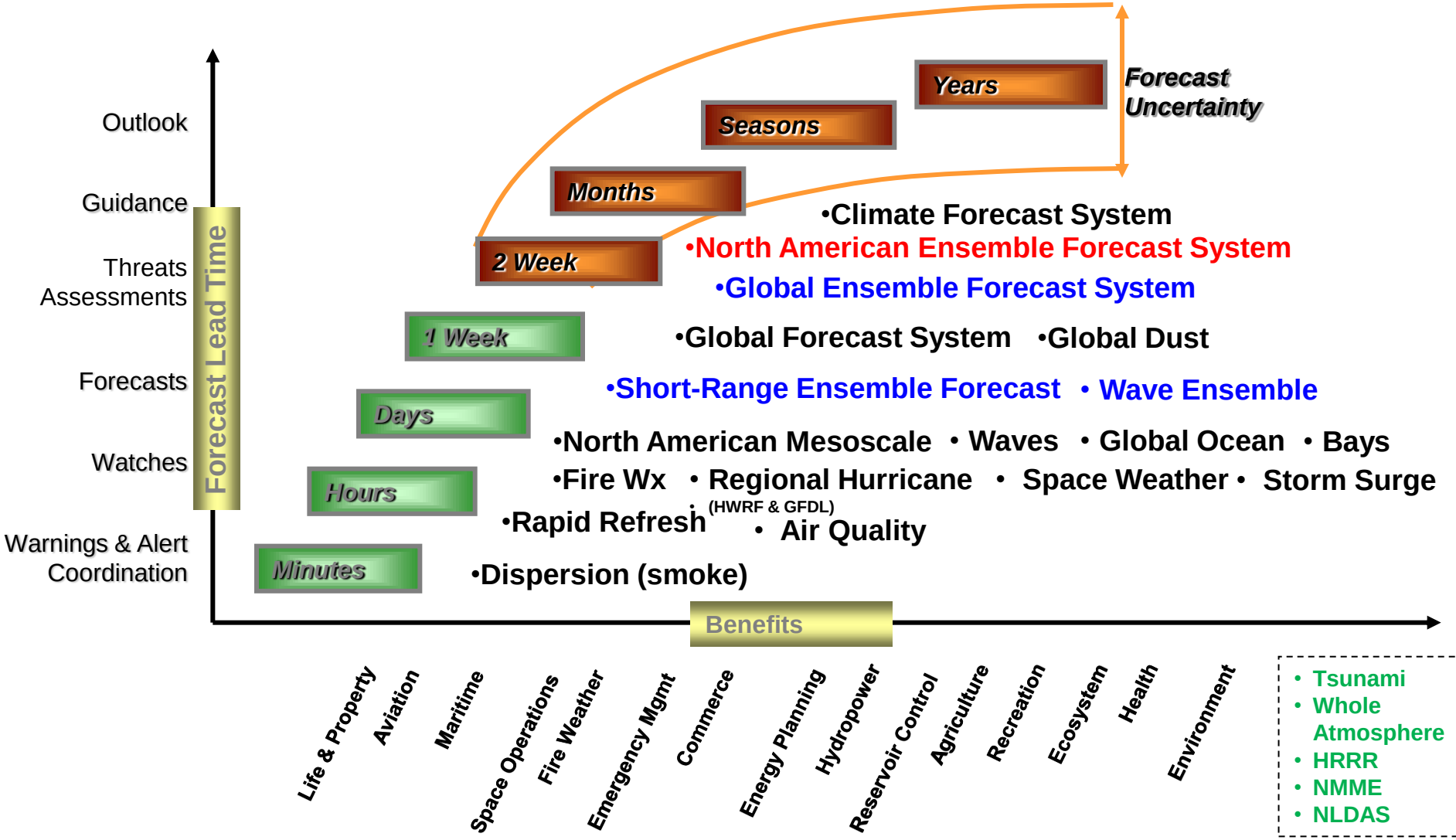
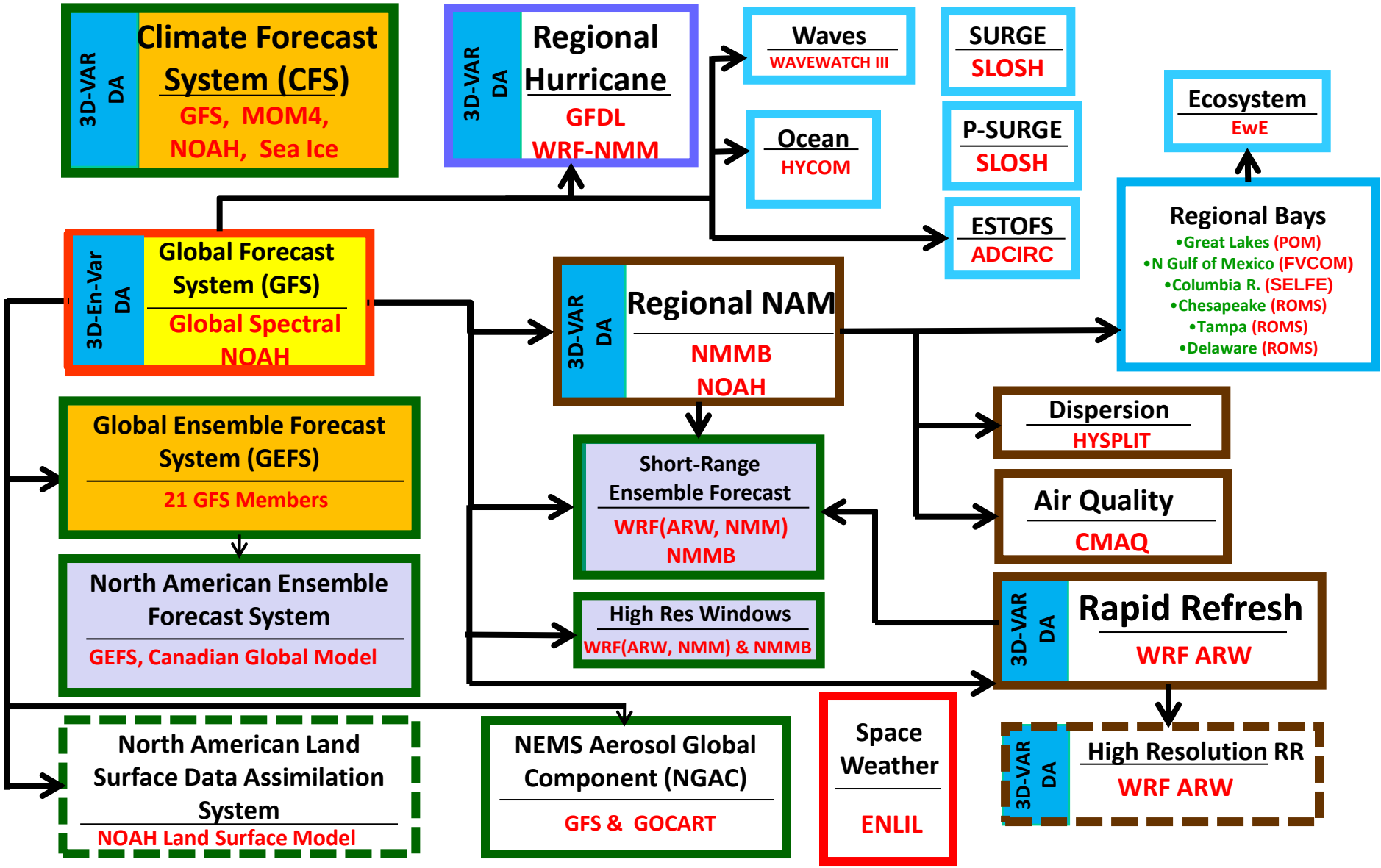
Content

- The suite in 2 minutes
- Emerging requirements
- Forces driving unification of the model suite
  - UMAC (UCACN model advisory committee)
  - NGGPS (Next Generation Global Prediction System)

- What does this mean for our production suite?
  - High-level plans for simplified production suite
  - Unified Global Coupled Model
  - Dynamic cores
  - Physics
  - Data Assimilation

Seamless Suite, spanning weather and climate





Production suite ca. January 2014

Emerging requirements

- Weather Ready Nation. (Talk on Tuesday)
  - Products.
  - Social science.
- High impact events. (Talk on Tuesday)
- Weather to climate—seamless suite of guidance and products.
  - Week 3-4.
  - Systematic reforecast need.
    - Forecast uncertainty.
    - Calibration of outlook products.
- Range of products beyond weather:
  - Land, ice, ocean, waves, aerosols, (ecosystems, space weather).
  - Water cycle, National Water Center (NWC).

UMAC

- UCACN Model Advisory Board
  - Review production suite (August 2015)
    - Strategic level.
    - Team from academia, stakeholders / contributors heard, but not on the panel itself.

- Some key findings:
  - 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”).

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

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

Production suite

- We have tended to *implement solutions* rather than *satisfy requirements*.
- Moving away from this:
  - Need better NWS requirements process.
  - Map requirements to products (not models).
  - Target model development better to 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.

What could this mean for weather products ?

Range	Year	Month	Week	Day	Hour
Target	Seasonal outlook	S2S outlook	Medium range weather	Convection resolving	Warn On Forecast
Present models	CFS	“GEFS”	GFS / NAM / SREF / RAP / HWRF	HRRR / NAM nest / HiresW	none
Cadence	??? (is 6h)	6-24h (is 6h)	6h	1h	5-15m
Range	9-15 mo global	35-45d global	Up to 10d global (?)	18-24h regional	3h ? regional
Updates	4y	2y	1y	1y	1y
Reanalysis	1979-present	20-25y	3y	???	???
Where	???	WCOSS	WCOSS	WCOSS	???

- Ensemble based DA for all ranges (day and hour TBD).
- Unified global model with applications for ranges.
- Global / regional unification ?
- Target R&D resources to move here(critical science questions).
- Hurricanes & Space weather need to find place in layout.
- Map to requirements to set metrics.

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 modeling systems implementations.
  - Less flexibility to tailor products.

Coupling

- The table below identifies which of the potentially coupled model components already have products or in the production suite corresponding to the five forecast ranges.
  - Where no products exists, science may indicate benefit of coupling.
  - For the hourly forecast range, all still TBD.

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	?

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

Coupling

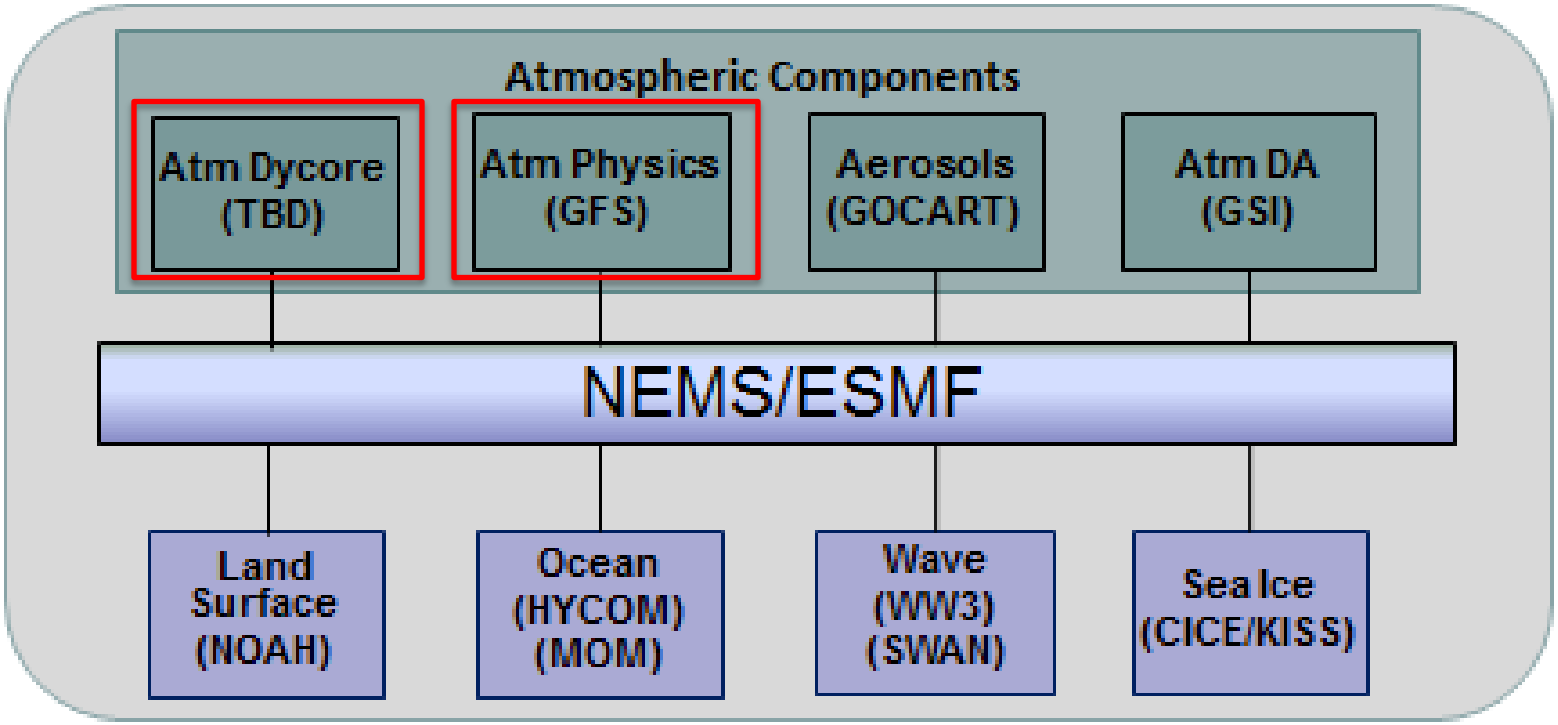
	Influencing					
	Atmos.	Land / hydro	Ocean / coast	ice	waves	Aerosols
Atmos.		yes	yes	yes	yes	yes
Land/hydro	yes		inflow	yes	inundation	
Ocean/coast	yes	inundation		yes	WCI	climate
Ice	yes		yes		yes	
Waves	fluxes		WCI	yes		
Aerosols	climate					

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	

Back to NGGPS

HOW TO GET THERE

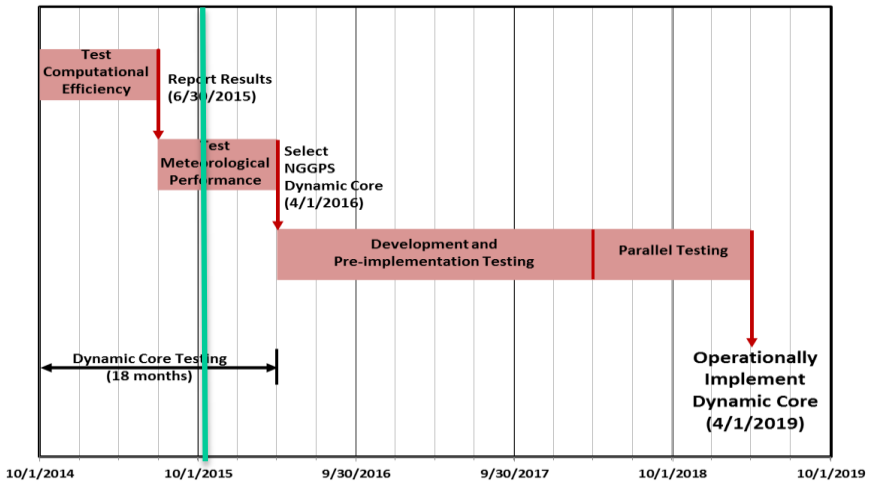
NGGPS and NEMS / ESMF



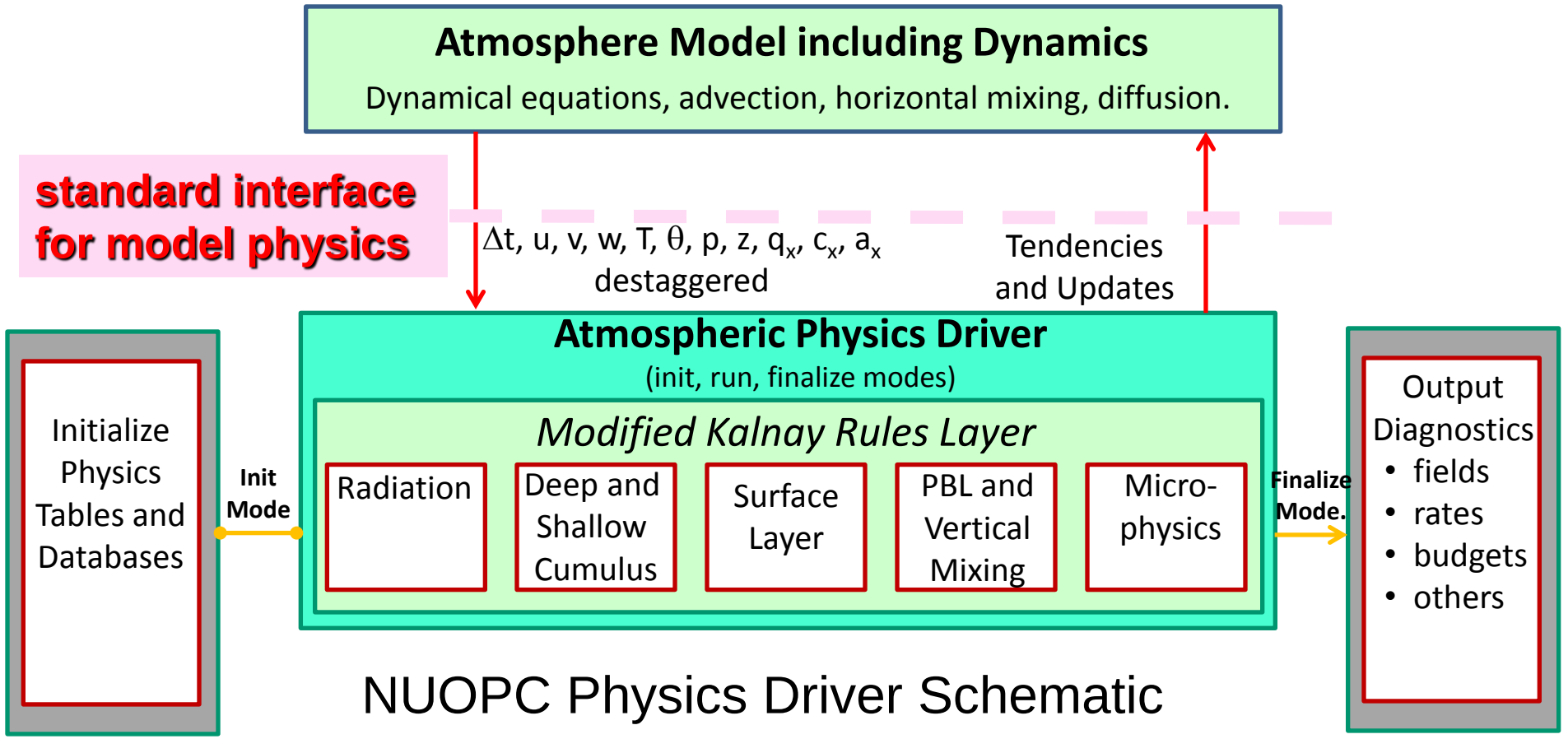
Modular modeling, using ESMF to modularize elements
in fully coupled unified global model
(+ *ionosphere , ecosystems , ……*)

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



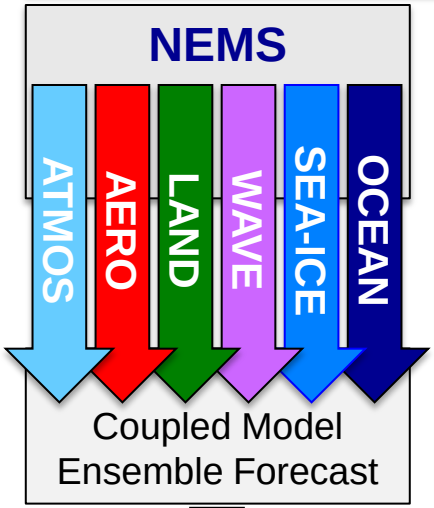
NUOPC Physics Driver Schematic

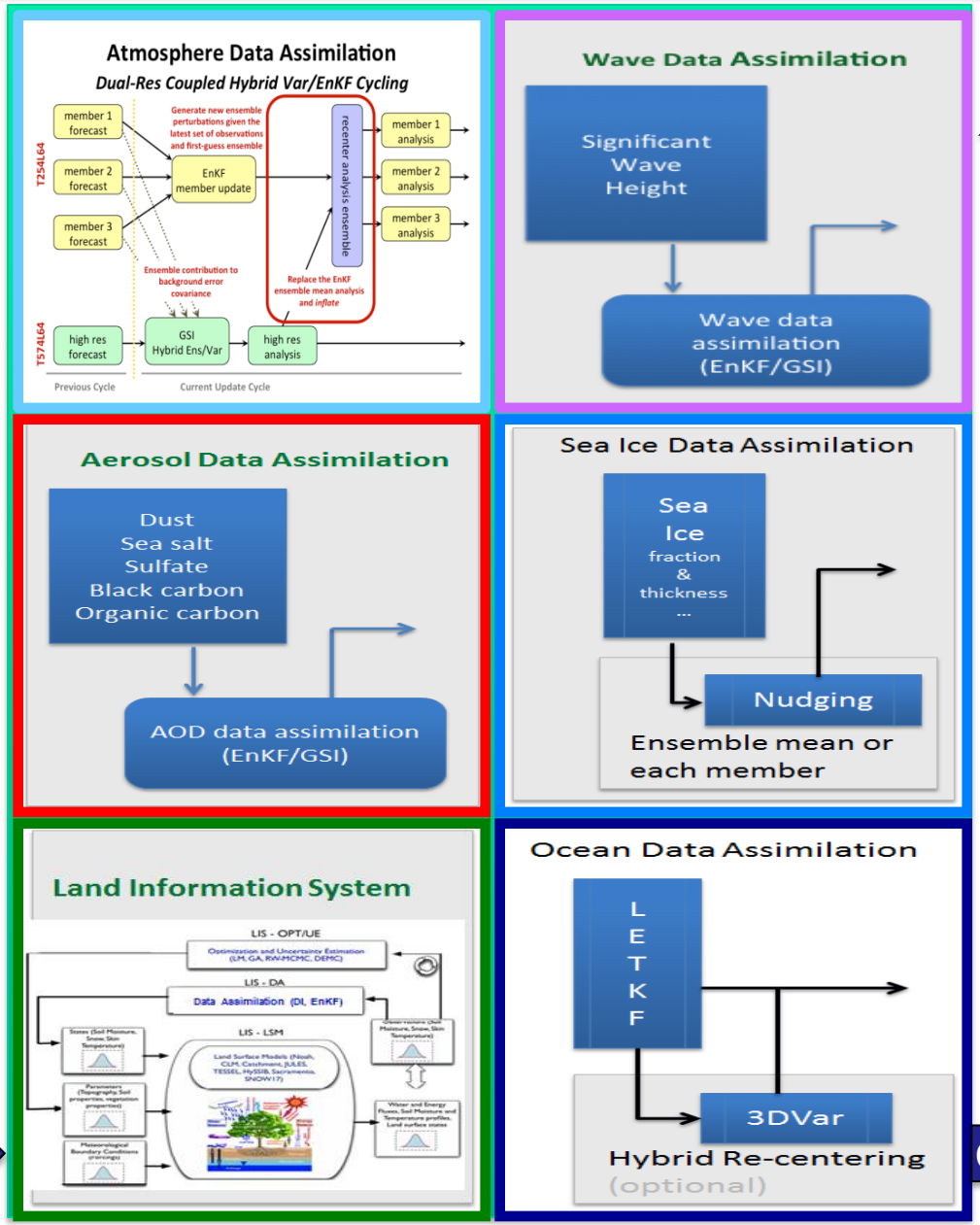
Version 1.0 delivered June 2015

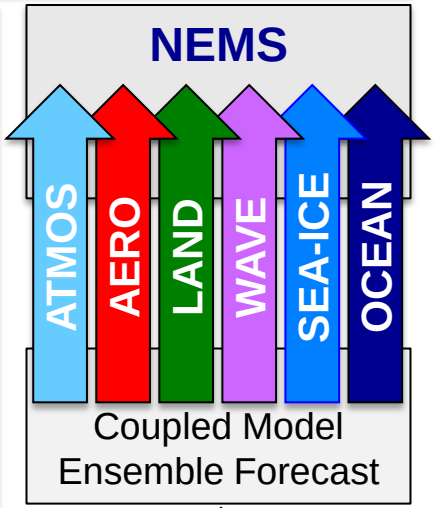
COUPLED DA PROOF OF CONCEPT

- 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.

NCEP Coupled Hybrid Data Assimilation and Forecast System







Coupled Ensemble Forecast (N members)

Ensemble Analysis (N Members)

INPUT

OUTPUT


Thank You!