NGGPS
Software Architecture and Engineering

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Overview

This will be short, much in other presentations

Base effort:
- NEMS: software architecture
- Unification: suite architecture

Bigger picture:
- NITE
- Validation and Verification
NGGPS and NEMS / ESMF

Modular modeling, using ESMF to modularize elements in fully coupled unified global model

(+ ionosphere, ecosystems, …..)
NGGPS physics

Atmosphere Model including Dynamics
Dynamical equations, advection, horizontal mixing, diffusion.

\[ \Delta t, u, v, w, T, \theta, p, z, q_x, c_x, a_x \]
destaggered

Tendencies and Updates

Atmospheric Physics Driver
(init, run, finalize modes)

Modified Kalnay Rules Layer
Radiation Deep and Shallow Cumulus Surface Layer PBL and Vertical Mixing Microphysics

Output Diagnostics
• fields
• rates
• budgets
• others

NUOPC Physics Driver Schematic

Version 1.0 delivered June 2015
NEMS / progress

Deliveries by Cecilia

- Training at EMC
- Starting to run models / debug

Issues:

- How to get off dual development paths
- Revisit path of NEMS development
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

<table>
<thead>
<tr>
<th>Range</th>
<th>Target</th>
<th>Cadence</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>Seasonal</td>
<td>?</td>
<td>9-15mo</td>
</tr>
<tr>
<td>month</td>
<td>S2S</td>
<td>6-24h</td>
<td>35-45d</td>
</tr>
<tr>
<td>week</td>
<td>Actionable weather</td>
<td>6h</td>
<td>3-16d</td>
</tr>
<tr>
<td>day</td>
<td>Convection resolving</td>
<td>1h</td>
<td>18-36h</td>
</tr>
<tr>
<td>hour</td>
<td>Warn On Forecast *</td>
<td>5-15 '</td>
<td>3-6h</td>
</tr>
<tr>
<td>now</td>
<td>Analyses **</td>
<td>?</td>
<td>now</td>
</tr>
</tbody>
</table>

* 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).

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Year</th>
<th>Month</th>
<th>Week</th>
<th>Day</th>
<th>Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land / hydro</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td>?</td>
</tr>
<tr>
<td>Ocean / coast</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>S/R</td>
<td>?</td>
</tr>
<tr>
<td>Ice</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Waves</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Aerosols</td>
<td>S</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>?</td>
</tr>
<tr>
<td>Space weather</td>
<td>?</td>
<td>?</td>
<td>Y</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

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

DA is critical!
Unifying on GSI and ensemble hybrid 4DVAR.

Global focus:
- Is a single DA system for all global models feasible?
  - Freeze or update DA for climate applications.
- Where do we go with coupling.

Regional focus:
- We do want to unify, but how feasible is this?
- Great progress with convection resolving, but
- not yet at the science level achieved at global scales.
  - Ensemble based convection resolving DA ….
  - WoF, many efforts, no real link to production suite yet.
### Unification, the atmosphere

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

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

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

NGGPS Unified Global Coupled Model

- **“GFS”**
  - Actionable weather
  - Week 1 through 4-6

- **“GEFS”**
  - Seasonal & annual

- **“CFS”**
  - Update cycle

<table>
<thead>
<tr>
<th>1 y</th>
<th>2 y</th>
<th>4 y</th>
<th>Update cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 y</td>
<td>20-25 y</td>
<td>1979- present</td>
<td>Reanalysis</td>
</tr>
<tr>
<td>6h</td>
<td>6-24h</td>
<td>??</td>
<td>cycling</td>
</tr>
<tr>
<td>WCOSS</td>
<td>WCOSS</td>
<td>WCOSS ?</td>
<td>where</td>
</tr>
</tbody>
</table>

Application = Ensemble + Reanalysis + Reforecast
Unified Mesoscale?

Not quite part of NGGPS yet, but:

EMS / ESRL / NSSL discussion on going forward with mesoscale models:

Discussion not yet mature but,

- Need to do mesoscale core comparison, as soon as the NGGPS global dycore has been selected
Other

NITE: create common run time environment:
- Design by DTC
- Work on development starting at EMC

Validation and verification:
- Key to have community package for efficient community modeling and R2O.
- Focus on MET.
Thank You!