Overarching System Team

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NOAA Environmental Software Infrastructure and Interoperability (NESII)
NOAA ESRL/University of Colorado

HIWPP/NGGPS Program Meeting
February 10, 2016

Objectives

1. Provide a portable, high performance, **unified software infrastructure** for use in operational prediction models at NCEP.
2. Coordinate and provide to NCEP a document on **code, [data, and documentation] management** for NEMS-based modeling applications and suites.
3. **Promote communication** and coordinated software development across the NGGPS teams and related efforts at EMC and NOAA.

Unified Software Infrastructure
Coupled NEMS Deliveries

Milestones

Define and deliver a sequence of increasingly capable coupled modeling applications

- Delivery schedule for NEMS applications: https://docs.google.com/spreadsheets/d/1RS-fTBYnfSIWrJYfalD2lAI-bUOGM0frNPEMIO_ND28/edit#gid=0

Applications and activities include (but are not limited to):

- **Unified Global Coupled System (UGCS) – Seasonal Scale**
- **Regional-Hydrology**
- Whole Atmosphere Model – Ionosphere Plasmasphere Electrodynamics Integration
- Unified Global Coupled System – Weather Scale (HYCOM integration)

Unified Software Infrastructure
UGCS-Seasonal 0.2

Milestone

- atm: GSM, ocean: MOM5, sea ice: CICE, coupler: NEMS mediator
- Technically valid 3-way interaction, capable of 9 month run
- Target September 2015

Status/Deliveries

- Running 15 days with full set of three-way exchange fields
- Testing 30 day runs but need restart to go longer
- Waiting on:
  Investigation of GSM memory growth every 6th timestep/hour
  GSM version which has a restart capability
  Cold start implementation sequence (NESII and EMC)
- Anticipating February 2016 delivery if GSM issues are resolved

Unified Software Infrastructure
UGCS-Seasonal 0.2

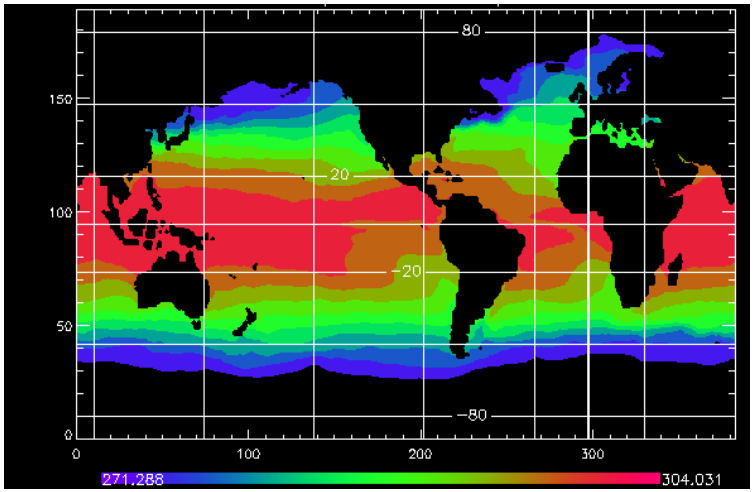
Lead and Collaborators

- Collaboration of NESII team (Fei Liu, Gerhard Theurich, Anthony Craig, Cecelia DeLuca, others), EMC (Xingren Wu, Jiande Wang, Bin Li, Mark Iredell, Suru Saha, Patrick Tripp, others), NCAR (David Bailey), COLA (Larry Marx, Jim Kinter), GFDL (Niki Zadeh), many others
- NESII organizes weekly calls with about 50 on distribution, high attendance

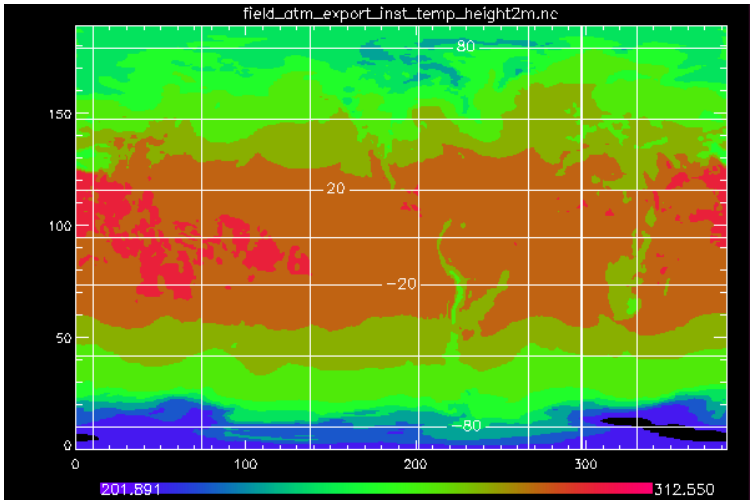
Unified Software Infrastructure

UGCS-Seasonal 0.2

SST (K)



2m air temperature (K)



Sample results at 15 days

GSM: T126
MOM5 and CICE: 0.5 degree
with 0.25 degree tropics

Unified Software Infrastructure
Regional-Hydro 0.2

Milestone

- atm: GSM, ocean: MOM5, sea ice: CICE, land: LIS/Noah, hydro: WRF-Hydro, coupler: NEMS mediator
- Technically valid 5-way interaction
- Target December 2015

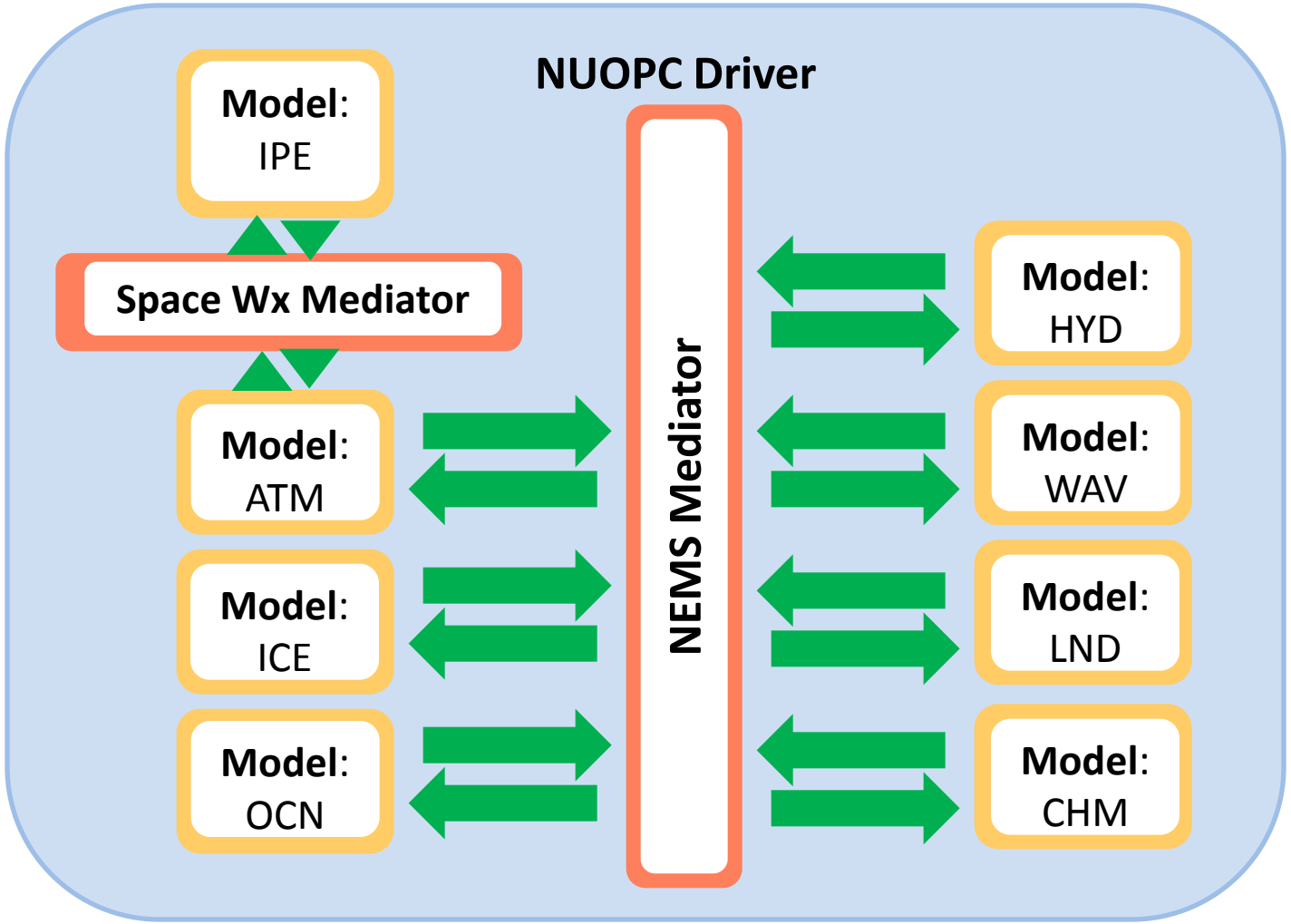
Status/Deliveries

- Delivery within the next week – release page: http://cog-esgf.esrl.noaa.gov/projects/couplednems/regional02

Lead and Collaborators

- Collaboration of NESII team (Rocky Dunlap, Dan Rosen, others), EMC (Jairui Dong, Mike Ek, others), NCAR (David Gochis, Wei Yu), NASA GSFC (Sujay Kumar, Jim Geiger), GLERL (Drew Gronewald), Navy (Sue Chen)
- NESII organizes weekly calls with about 20 on distribution

Components in NEMS



Additional activities include space weather, wave, and aer/chem integration, with application milestones for each of these later in 2016.

Unified Software Infrastructure
Software Training

Milestone

- Provide an initial NUOPC/NEMS training offering in collaboration, target December 2015

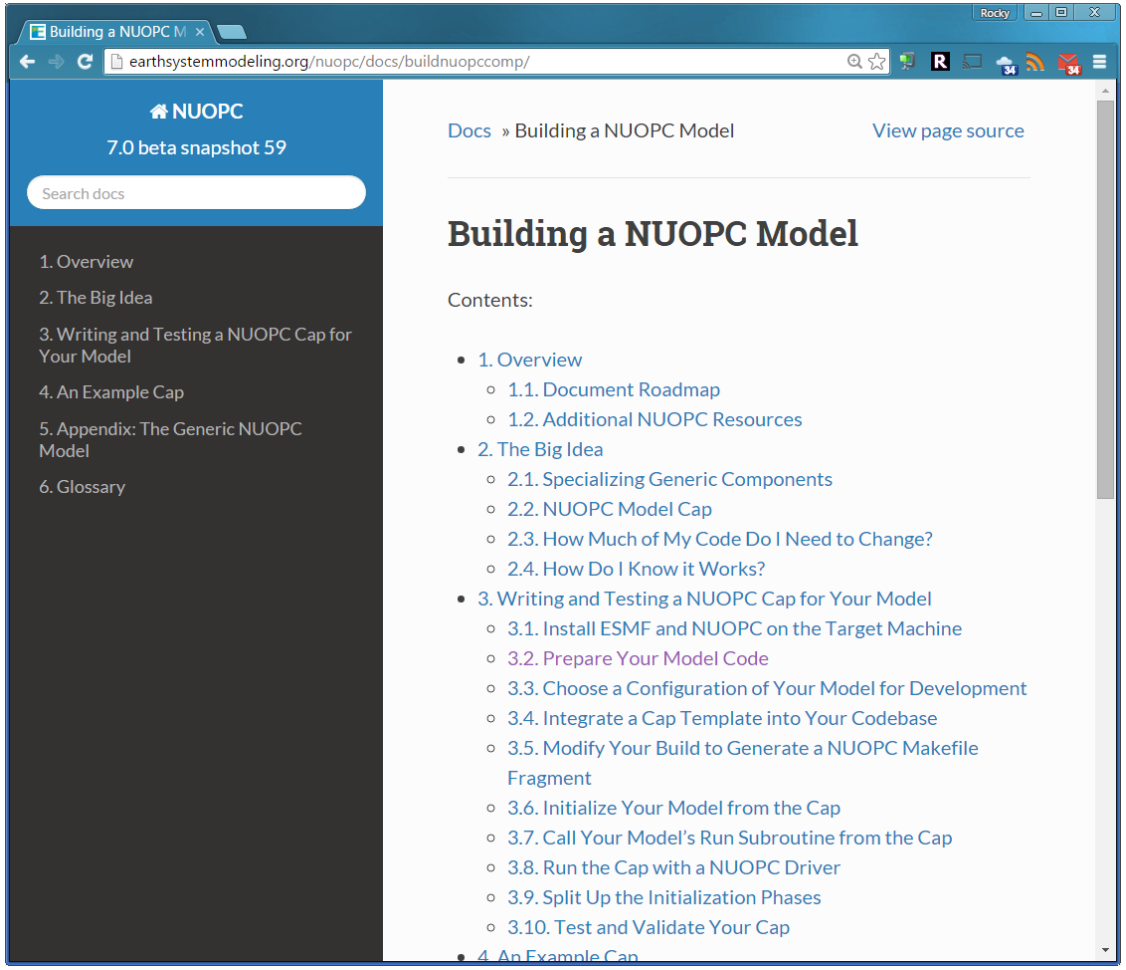
Deliveries

- Developed one-day basic training course: http://cog-esgf.esrl.noaa.gov/site_media/projects/couplednems/training_1601_emc_final.pptx
- Training courses at EMC on November 12-13, 2015 (8 trainees), January 28, 2016 (15 trainees), and January 29, 2016 (15 trainees)
- Additional courses will be provided as needed, along with sessions on more specialized topics

Leads and Collaborators

- Fei Liu (NRL) and Rocky Dunlap (NOAA NESII) were instructors
- Suru Saha coordinated at EMC; EMC management provided input on the class structure and curriculum

Unified Software Infrastructure
Software Training



- Delivery of guide on how to adapt a model component for NUOPC interfaces, November 2015: http://earthsystemmodeling.org/nuopc/docs/buildnuopccomp/

Unified Software Infrastructure
Code and Repository Management

Milestones

Complete draft of code management document in September 2015

Deliveries

- Completed draft code management document and extended it to include documentation and data management sections https://docs.google.com/document/d/1bjnyJpJ7T3XeW3zCnhRLTL5a3m4_3XIAUeThUPWD9Tg/edit#heading=h.ku78qulk21xh
- Plan to disseminate more broadly across NGGPS in the next month

Leads and Collaborators

Contributors/reviewers include DTC (Bernadet, Carson), ESRL (DeLuca, Theurich, Liu), EMC (Iredell, Tolman, Saha), NCAR CESM (Large, Vertenstein), VLab (Sperow), COLA (Kinter, Marx)

Unified Software Infrastructure
Code and Repository Management

Code, Data, and Documentation Management for NEMS Modeling Applications and Suites

Table of Contents (sample topics)

Unified Software Infrastructure
Communication and Coordination

Milestones

- Communication and coordination across NGGPS as needed

Status/Deliveries

- Initiated documentation survey and gap analysis: https://docs.google.com/spreadsheets/d/1CLT66uzJrjrsY-um0jB5hU-Gfeh3_VCIJDA4-Ibmu5s/edit#gid=0
- Logical counterpart to development of documentation policies in the Code, Data, and Documentation Management Document

Leads and Collaborators

Organized mainly by DTC (Bernadet) and NESII (DeLuca, Liu); others from EMC, ESRL and elsewhere have been contributing ideas and information

Unified Software Infrastructure
Communication and Coordination

Milestones

- Communication and coordination across NGGPS as needed

Status/Deliveries

Initiated mailing lists (thanks to Steve Warren):

nws.nems.application.leads.all.hands@noaa.gov
nws.nems.component.leads.all.hands@noaa.gov
nws.nggps.teams.leadership.all.hands@noaa.gov

New request: ALL NGGPS

Rationale

- Effective, broad communication pathways are needed for coordination
- Need to easily and consistently communicate with people in specific roles (e.g. model component leads, NGGPS team leads)

Unified Software Infrastructure
Communication and Coordination

Milestones

- EMC would benefit from formation of NEMS "Change Review Board," populated with NEMS application leads
- Goal is to manage shared technical resources effectively in the delivery of NGGPS and other milestones

Status/Deliveries

- Completed draft terms of reference
- Tentative first meeting on February 16 – waiting on EMC to complete scheduling

Lead and Collaborations

- EMC management leads, NESII support

Summary

Major Accomplishment

- Physically reasonable 15+ day runs of coupled atmosphere-ocean-ice system – many issues remain, and in-depth analysis of behavior has not really begun

Priority Focus Effort for FY2016

- Training at EMC; support for delivery of applications

Most Important Issue or Coordination Need

- Need for community support and analysis of the coupled system – for operational workflows and research workflows
- Believe this would benefit from discussion including EMC, DTC, CESM, COLA, and NESII
- Proposed “CIME” pilot with NCAR is important in this respect– leverages existing coupled system research workflow and components

Unified Software Infrastructure
Strategic Motivation for CIME Pilot

- CESM already includes the 7+ components that NEMS anticipates integrating, plus the target dynamical cores (finite volume and MPAS). There is tremendous expertise in CGD in having spent decades in making that very complex coupled system work.
- NEMS applications will need a community-friendly environment for coupled model development. That requires the kinds of many-component coupled model management tools that CESM has developed over decades. It seems advantageous to leverage what has already proven valuable, accessible, and familiar to a broad coupled modeling community.
- It will benefit NEMS application developers (and collaborators such as DTC) to have a standing relationship with scientists with established expertise in many-component coupled model development, evaluation, and governance.

Unified Software Infrastructure
Community Mediator - CIME Pilot Project

- CIME (Common Infrastructure for Modeling the Earth) is a github community repository for storing infrastructure software
- Created by the CESM team but not specific to CESM software
- Pilot would store the NEMS mediator in CIME, where it can be treated like other community-developed components
  - NEMS components can be run within research workflows, with access to tests and diagnostics
  - NEMS mediator can be scrutinized by coupling experts and tested with a variety of community components
  - NUOPC interfaces provide a link back to operational systems
- Issues with license and access requirements must be addressed

Overarching System Team

Cecelia DeLuca *ESRL/CIRES/NESII*

Ligia Bernadet *NCAR DTC*

Anthony Craig *contracting for NESII*

Jim Doyle *NRL MRY*

Mark Iredell *NCEP EMC*

John Michalakes *NOAA NWS*

Gerhard Theurich *Fei Liu NRL/NESII*

Mariana Vertenstein *NCAR CGD/CESM*

Valbona Kunkel *NCEP EMC*

Patrick Tripp *NCEP EMC*

In coordination with

+ EMC and external model component leads

+ modeling application leads, including NGGPS science/product lead

Supplementary Material

NEMS Basics

- The NOAA Environmental Modeling System (NEMS) is infrastructure for building coupled modeling systems
  - Examples of other coupled modeling systems: UK Met Office Unified Model, Community Earth System Model (CESM)
- NEMS is associated with a collection of model components
- External model components have a primary repository that is not at EMC
- In general, model components exchange data using the main NEMS mediator – often called a "coupler“
- Custom NEMS mediators are being built for special interactions, such as optimized 3D coupling of the upper atmosphere to the ionosphere

Introduction to NEMS:
http://cog-esgf.esrl.noaa.gov/projects/couplednems/introduction

NEMS Modeling Applications

- NEMS can be assembled into a number of different modeling applications, each associated with:
  - a purpose, such as seasonal forecasting
  - a set of model components
  - a set of parameters that represents a range of supported options, including grids and resolutions
- Different NEMS modeling applications can have different types and numbers of model components
- The same physical domain may be represented by different model components in different modeling modeling applications:
  - For example, in some NEMS modeling applications the ocean component may be HYCOM and in others it may be MOM5

Spreadsheet of NEMS modeling applications:
https://docs.google.com/spreadsheets/d/1RS-fTBYnfSIWrJYfalD2lAI-bUOGM0frNPEMIO_ND28/edit#gid=0

NEMS Infrastructure

- NEMS is built using Earth System Modeling Framework (ESMF) infrastructure software, which provides:
  - generation and application of interpolation weights, time management classes, and other utilities
  - data structures for representing fields, grids, and model components in a standard way
- The National Unified Operational Prediction Capability (NUOPC) Layer increases interoperability by adding behavioral rules to ESMF, including:
  - a standard way of representing build dependencies
  - a standard syntax for initialization and run phases
- NUOPC wrappers or "caps" contain translations of native data structures (e.g. grids, field data, time quantities) into ESMF data structures.

ESMF site: https://www.earthsystemcog.org/projects/esmf/
NUOPC Layer site: https://www.earthsystemcog.org/projects/nuopc/
Performance reports: https://www.earthsystemcog.org/projects/esmf/performance