Primary Agenda Item: Reactions to Outreach to SIP Working Groups (Taking on Kinter’s charge that UFS – SC should describe r2o process)

r2o = research to operations

1) see minutes for discussion of UFS – SC role


2) Collection of materials on r2o

2.1) During meeting

2.1.1) NAO (NOAA Administrative Order) 216 – 105 B: POLICY ON RESEARCH AND DEVELOPMENT TRANSITIONS

Web: http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/216-105B.html


Handbook for NAO216 – 105 B

Rood comment: If you look through the NOAA Policy, above, then there are definitions that are worth noting. A major point of the Policy is the need for a Transition Plan. It does not precisely codify the plan. There is reference to the Frascati Manual, which is a huge international standards document on R&D. Perhaps of interest to scholars of R&D and its transition to products.


2.1.2) EMC – NCO Testing and Handoff (link) (contact Arun Chawla) & below

The Environmental Equivalence 2 (EE2) Consolidated Document outlines the technical process for numerical modeling\* systems transition from research to operations in the National Centers for Environmental Prediction (NCEP) Operational Production Suite. This EE2 process document is an upgrade to the original EE1 process (see appendix) and was developed between the Development Organizations (hereby referred to as DevOrg) that are responsible to provide the model upgrades (EMC, NOS, MDL etc) and NCEP Central Operations (NCO), considering input
from both development and operational perspectives and personnel, as well as NCEP partners and stakeholders within the National Weather Service (NWS).

A. Elements of Structure
B. Elements of Testing
C. Elements of Integration


Rood comment: This document focuses primarily on the transition of a candidate for operations to NOAA’s operational environment. There are major sections on code management and repositories, testing and computational environment, and integration of the modeling system with other aspects of the workflow. There are important elements in this document, and if it informed the stream from research to a model that is a candidate for operations, then that would be a good thing.

- There is a need to define Environmental Equivalence.
- The document/protocol can be revisited and revised.

2.2) SIP Community Contributions

2.2.1) From Neil Jacobs

At the AMS Community Meeting, August 2018, Boulder Colorado, Neil Jacobs gave a talk on accelerating the r2o process. The powerpoint can be found at this link.

https://umich.box.com/s/d0yzkbyslip7vigsbrimawez5tiocvle

Here are the words from one of the slides:

Formalizing the R2O funnel

- Follow SIP strategy, but build on momentum and speed up process
- Initial baseline requirements with operations in mind (gates and transitions)
- Problems should be suggested (versus tasks)
- Objective evaluation process to transition though gates
- UMAC: evidence-based decisions
- Parallel production environment (possibly many)
- Academia and labs (community)
- Software engineers brought in at initial stages
- EMC involved throughout the process (avoid forklift approach)

2.2.2) From Ligia Bernardet

Also, on the theme of R2O, DTC publishes a quarterly newsletter called Transitions (link). This newsletter is not solely about DTC, as it covers various aspects of R2O in NWP. Writers in recent issues include several non-DTC folks, such as Georg Grell (GSD), Russ Schumaker (CSU), Bill Gallus (Uni Iowa), EMC folks, Paula Davidson (NOAA Testbeds coordinator) etc.

https://dtcenter.org/newsletter/
Community Support and transition of Research to Operations for the Hurricane Weather Research and Forecasting Model, Bernardet et al., BAMS, 2015  (link)

HWRF r2o path on Developers site:
https://dtcenter.org/HurrWRF/developers/index.php

2.2.3) From Cecelia Deluca: (This includes response to Mike Ek in 2.2.3, below)

This is a belated response to the UFS-SC questions about WG activities related to R2O, from the perspective of the UFS System Architecture Working Group (SAWG). I'm a co-chair along with Jim Kinter.

To answer the UFS-SC question about whether any WGs have R2O in their charge: Yes, the SAWG does - from the terms of reference:

"To provide [...] prioritized recommendations for the advancement of a system architecture that meets operational needs as well as enables and encourages collaboration with external model development partners and the broader research community."

Below is a specific example in response to the UFS-SC request for efforts that already exist that are working on improving the R2O process. This example is a UFS partnership with the research community on a shared community coupler.

This work is important because it means that the research community and operational communities can work together on the same versions of shared components and integration software. It enables both sides to leverage each other's advances and to align training programs. It also opens the door to creating user-friendly workflows for operational codes that are proven and familiar to many from community models.

The evolution of this idea can be traced through UFS documents. The SAWG delivered an initial report in March 2017:


The report articulates a vision for modeling supportive of R2O that is:
- unified by a common infrastructure shared and co-developed by the community.
- able to leverage science expertise from the broader community, and in particular science expertise related to system integration from places like NCAR and GFDL (a little on how this relates to hierarchical model development at the end of this mail).

Among the SAWG report recommendations is that UFS share a community coupler with other organizations:

"The SAWG recommends that NOAA, NCAR and partner organizations work toward supporting NEMS or similar infrastructure code (coupler, driver, etc.) as community software. A key opportunity is to explore the possibility of leveraging established CESM training programs and outreach in support of the EMC unified modeling system. This opportunity will require an understanding of the roles to be adopted by GFDL and CESM, and coordination between the CESM project and the Global Model Test Bed, which is offering a community interface to atmospheric model physics."
The recommendation in the SAWG report was made more concrete in the System Architecture section of the UFS Strategic Implementation Plan (SIP), through milestones representing steps in the development of a community coupler usable by UFS.

A number of these SIP milestones have already been met. Over the last year, the NEMS (EMC) coupler was generalized by a collaboration that includes NCAR, GFDL, and EMC, and the result is called CMEPS (Community Mediator for Earth Prediction Systems). There was a June 2018 milestone that demonstrated CMEPS running an all-active CESM configuration, using development versions of CESM components and validating against the previous CESM coupler:

https://github.com/ESCOMP/UFSCOMP/wiki/Milestone:-CMEPS-0.2

This milestone is both a technical demonstration of the community coupler and a prototype that shows how UFS could be set up in a community-friendly workflow, how data inputs and some baselines for simple verification could be provided as part of the workflow, and how a set of prescribed data components might be included with UFS for testing and scientific experimentation. All of these features of the infrastructure are conducive to R2O.

R2O is also enhanced by having UFS rely on science components from the research community. UFS shares multiple model components (such as MOM6, CICE5, WW3) with CESM, which creates opportunities for direct code and knowledge transfers with this community modeling effort. The underlying ESMF/NUOPC framework for CMEPS means that NASA and Navy components are compatible with the architecture as well, and the unique expertise from those agencies can be leveraged.

The next SIP milestone will demonstrate use of CMEPS with UFS components.

The community coupler is just one part of the UFS infrastructure that SAWG members are working on. Some of the people central to the coupler work are also engaged in development of the atmospheric physics driver as part of NCAR's "single track" initiative. That overlap is helping to make sure that both of these critical elements will work together, and with the Common Community Physics Package being led by GMTB.

Briefly, back to hierarchical model development (HMD). From a software perspective, I think forms of HMD have been used for many years within groups like CESM and GFDL for testing, component integration, and scientific experimentation (e.g. data components, modular workflows). The example of the community coupler shows how HMD-relevant infrastructure can be brought into UFS through research partnerships.

On the science side, it's interesting to look at the perspectives represented in the GFDL workshop on HMD in 2016 (https://www.wcrp-climate.org/gc-model-hierarchies-home). Others are the experts, but what I see is that simplifying a model in order to advance understanding can require considerable insight and experience, even more so when considering coupled modeling. It's also evident that there is no single understanding or representation of a scientific hierarchy - it can mean many things to many people. This may be especially true in a modeling system like UFS that will support multiple applications.

2.2.4) Mike Ek provided several documents with this email description: (Documents linked at end of email.)

Ricky (et al.)

I believe that you might find this material interesting since it’s relevant to what we’re trying to do via our work here at NCAR, the SIP WGs at EMC/with partners, and across NOAA in general with connections to the broader Research-to-Operations-to-Research (R2O2R) community. I was motivated to write this R2O2R doc (attached--1 page) because there was a UCAR reporters briefing in Boulder on 1 June where one of the questions was: "What the US needs to do to close the forecasting gap with Europe". (Since this was a UCAR briefing, I also provided some NCAR-specific examples in my doc, where the NCAR
Research Applications Laboratory (RAL) / Joint Numerical Testbed (JNT) and the NCAR-NOAA Developmental Testbed Center (DTC) are leading this "hierarchical model development" approach, working with the R2O2R community. I shared this with Jim Hurrell (NCAR director), Bill Mahoney (RAL director), and Louisa Nance (DTC acting director and RAL/JNT science deputy) prior to the reporters briefing since I was out of town.

I've been working on this topic of improving R2O2R with Xubin Zeng (Univ. Arizona), Alan Betts (Atmospheric Research, Vermont), Paul Dirmeyer (George Mason Univ.), Joe Santanello (NASA Goddard), and others. The outgrowth of this is my 1-page R2O2R doc attached here. Alan's comments in this regard are, as usual, quite insightful (also attached --2 pages). Xubin and I are drafting a related R2O2R "white paper" (I guess you'd call it) --initially something for a (WCRP) "GEWEX News" article. I also shared this with others, e.g. Chris Davis (MMM director), Daryl Kleist (EMC), Tom Auligne (JCSDA), Cliff Mass (Univ. Wash.), as well as some in the AMS Forecast Improvement Group (I'm on FIG now) since it's quite relevant, and await more detailed responses.

At EMC, there's a strategic implementation plan (SIP; attached) for HMD that Jack Kain (EMC modeling physics group leader) has embraced as a good method to effectively test and improve model physics in the weather and seasonal prediction models that are part of EMC's mission. This HMD SIP ties into/leverages DTC's GMTB capabilities here at NCAR and NOAA/ESRL, in collaboration with EMC and the weather and earth system research and operational communities. (Aside: NCAR itself is working on the infrastructure to connect/test the various ESM components on both weather and climate time scales, where those two time scales meet at S2S. Relevant to this longer time scale, and because of the positive benefit in predictability, Canada implemented a coupled modeling system for medium-range forecasts in early Nov 2017, ECMWF did more recently this year, and UKMO will sometime this year; the Koreans are exploring coupled modeling for the medium-range in their new global prediction system that is being developed under their "KIAPS" project. Correctly predicting ocean and land states (and the stratosphere to be complete) are necessary for predictability on a broad range of time scales.)

The next attachment is a powerpoint about hierarchical model development (HMD) that shows some concrete examples of "looking under the hood" (at the model physics). Slides 1-5 are HMD background/pre-amble. Slides 6-9 are those examples, that is, evaluation of sub-components (for the calculation of surface fluxes) and component(s) (land model, and single column model, SCM), i.e. some of the more focused model physics parameterization testing that I have experience with. Of course, at NCAR, NCEP/EMC and other Met offices, research centers, and within academia, there's A LOT of material on regional, global, S2S, and longer-term climate testing/evaluation covering the more complex/coupled HMD steps. The steps between sub-components/components/SCM --and-- regional/global/S2S/climate include limited-area models (e.g. LES and high-res NWP) to study e.g. inherently 3-D convective systems, and a 2-D HMD step that was suggested by Paul Dirmeyer. Slides 10-11 list some examples of other likely tools and then provide a summary. The key to making the HMD approach successful (i.e. to make the R2O2R process more efficient and speed it up) is to effectively connect all the HMD steps via a fully integrated model development software framework. This concept was discussed in the talk by Mariana Vertenstein (NCAR/CGD) on Monday afternoon of the WRF workshop at NCAR this week. Setting up all these HMD steps is one of the goals of the DTC/GMTB project, working In collaboration with many R2O2R partners. This is just a working doc to show with some examples that we're moving beyond the "idea stage" for the various steps in HMD.

Christian Jakob had a couple of his interesting articles (2 short position papers, really--both attached) that I believe are relevant to the HMD approach of more thorough, comprehensive and sustainable earth system model development. Christian is from Monash University (Australia) and is the former co-chair for the WCRP Modelling Advisory Council (https://www.wcrp-climate.org/wmac-overview); he actively supports a HMD philosophy. He is more climate-focused, but what he discusses is still quite applicable for NWP/S2S as well, as he says. His papers (not too many pages to read):

#1. "Accelerating Progress in Global Atmospheric Model Development through Improved Parameterizations: Challenges, Opportunities, and Strategies"
BAMS July 2010, 7 pages
Summary: "To address long-standing systematic errors, the community needs to improve the diagnosis of key processes contributing to these errors and it needs more model developers." Note that Figure 1 is related to this theme of a HMD approach, and attempts to make the R2O2R model development process more efficient and effective.

#2. "Going back to basics"

An excerpt:
"Accelerating progress will require building a stronger connection between the application-driven and process-driven approaches to model development. This can be achieved through the development of more insightful model diagnosis and evaluation techniques, which confront the model errors by identifying the key regimes or phenomena contributing to them. Those regimes and phenomena can then be used to provide focus to the process studies that drive model improvement. This increases the probability that improvements in a model’s process representation will actually improve its performance when it is applied for its purpose."

I spoke to Christian recently and he said "Yes, the sad news is that those statements were made in my paper in 2010 and nothing has changed." I suggested that via the HMD approach we are employing, the Global Model Test Bed collaboration between NCAR, NOAA/ESRL, NCEP/EMC and the research community more generally, can help us move in the right direction.

BTW, it’s important to point out that Julia Slingo (UKMO, ret.) led the recent review of the WCRP program where it was suggested that there should be better connections between WCRP (i.e. climate) and WWRP (i.e. weather), and that there should be a strong effort in "back to basics" in observing, understanding processes, and model development.

Comments/input/questions most welcome!

Many thanks,
--
Mike Ek

1) Mike Ek on Making Research - Operations transitions more efficient (link) & https://www.earthsystemcog.org/site_media/projects/ufs-sc/Improving-R2O2R-M.Ek-01JUN2018.pdf

2) Alan Betts comments on Mike Ek on Making Research - Operations transitions more efficient (link) & https://www.earthsystemcog.org/site_media/projects/ufs-sc/CommentsTo-Mike_Ek-2018June5-from-AKBetts.pdf

3) 3-year FY18-20 EMC Implementation Plan (link) & https://www.earthsystemcog.org/site_media/projects/ufs-sc/EMC-SIB-HMD-v2.1.pdf

4) Mike Ek presentation on hierarchical model development, verification & validation, and role in transition from research to operations (link) & https://www.earthsystemcog.org/site_media/projects/ufs-sc/HMD-steps-examples-v3d.pdf

5) Accelerating Progress in Global Atmospheric Model Development through Improved Parameterizations: Challenges, Opportunities, and Strategies Challenges, Opportunities, and Strategies
by Christian Jakob
https://doi.org/10.1175/2009BAMS2898.1
2.2.5) From Ricky Rood: Material on Technical Readiness Level from Community Governance Working Group

**Relationship between Community and Operations**: Dave McCarren


In this presentation Dave introduces the concept of Technical Readiness Levels (TRL).

Turns out NOAA does, in fact, have their version of Technical Readiness Levels.

- **NOAA Technical Readiness Levels**

In 2005, Robert Ferraro and Richard Rood worked on some TRLs just for models: Model Maturity Levels. That draft document is here.

- **Model Maturity Levels: DRAFT**

Here is some background on TRLs from NASA

- NASA Technical Readiness Levels 1

- NASA Technical Readiness Levels 2

- Demystifying Technical Readiness Levels
  [https://www.nasa.gov/topics/aeronautics/features/trl_demystified.html](https://www.nasa.gov/topics/aeronautics/features/trl_demystified.html)

2.3) From web search

2.3.1) BRIDGING RESEARCH TO OPERATIONS TRANSITIONS Status and Plans of Community GSI (Bulletin AMS article describing a case study)

2.3.2) Uccellini description of NCEP’s Research to Operations Transition