Unified Forecast System - Steering Committee (UFS-SC) Meeting
20 July 2018
Telecon - 11:00 AM - 12:00 PM EDT

Attendees:

Ricky Rood (Co-Chair) U. Michigan
Adam Clark NOAA NWS/NSSL
Bhavana Rakesh NOAA NWS/OSTI
Bill Putman NASA/GMAO
Brian Colle Stonybrook
Brian Gross NOAA NWS/EMC
Cecelia DeLuca CIRES; NOAA ESRL
Daryl Kleist NOAA NWS/EMC
Georg Grell DTC/ESRL/GSD
Gerhard Theurich Navy NRL/NESII
Ivanka Stajner NOAA NWS/EMC
Jeff Craven NOAA NWS/MDL
Jeff Whitaker NOAA ESRL/PSD
Jim Doyle Navy NRL
John Michalakes UCAR/NRL
Rahul Mahajan NOAA NWS/EMC
Sheema Lett NOAA NWS/OSTI
Sherrie Morris NOAA NWS/OSTI
Tara Jensen NCAR/RAL
Timothy Schneider NOAA NWS/OSTI
Tom Hamill NOAA ESRL/PSD
Vijay Tallapragada NOAA NWS/EMC

Summary:

The following topics were the proposed agenda items for the meeting:
- What is status of current data assimilation?
- What is the scientific plan for data assimilation?
  - Coupled Data Assimilation
  - Requirements for coupled model to support assimilation development
- What are the highest risks and the risk management strategies?
- How are the interests of all applications and all members of community being considered?

Administrative Highlights:
- SC co-chair is working on the first draft of R2O description and will continue to flush it out with the comments provided by Brian Gross.
- The agenda for the UFS-SC call/meeting on 7/27/18 will be reserved for the final preparations for SIP meeting that will occur the week of 8/1/18-8/3/18.
- UFS-SC co-chair requested team members who are reading the meeting minutes to provide their feedback if they have corrections or notice that something has not been captured by Bhavana Rakesh.

**Data Assimilation Discussion:**
Daryl Kleist presented Data Assimilation Discussion. It was highlighted that the SIP meeting will have a 2 hrs session on DA.

Overview of the current status of current DA was presented. The highlights are listed below
- NCEP has leveraged single data assimilation code for all atmospheric model applications
- GSI includes community engagement and support. It was noted that O2R has had more success that R2O. The biggest challenge has been getting feedback from larger community.
- Ensembles and hybrids are state-of-the science and operations for global NWP at most centers

-Background slide 4D hybrids information was presented
- Adjoint based 4DVar is active in navy; ECMWF uses Ensemble based hybrid 4DVar. There is research to be done.

**NCEP prefers hybrid 4D ensemble var**
- Technical challenges
  - Hybrid 4DEnVar is 2-3% worse than hybrid 4DVar, but much cheaper (order of magnitude) in terms of computational resources
  - Gap between blue and red curve (slide #7), the 4dvar out performs 4denvar
  - We should keep some sort of intercomparison of Hybrid 4D Var and Hybrid Ensemble 4DVar for the next 5 years
  - Question: development-wise, developing ensemble system is easier than 4Dvar, what are your thoughts? Met-Office dev cost is just maintenance of adjoint system.
  - Running ensemble for Hybrid EnVar is computationally expensive
  - Question was raised if having GSI scaling issue motivated EMC to run more ensembles instead of 4DVar? Were there any computational tradeoffs? This question was addressed by saying that running 100% ensemble (pure EnKF) was considered. EMC knows what the bottleneck is in GSI. But they haven’t been able to address the issue because of resource constraints.
  - GSI has 3D localization. That could be a factor in the performance of GSI

**Scientific plan for DA - where do we want to head?**
- Challenges for the path ahead have been identified and are listed below
  - Coupled assimilation across earth system
  - Multi-scale assimilation across temporal and spatial scales
- Increase in volume of observations and
- Increase in types of observations
- Representation of system uncertainty and model error including for the coupled system
- Scalability
- IO and regridding

Discussing the above in detail
- GSI re-engineering is already underway. However it is going to be difficult to get something flexible to work for non-atmospheric components using GSI. JEDI is the preferred path for all earth system components.
- Mature DA for each component is required to perform any meaningful DA

Vision
- Start with ensemble-based or hybrid “weakly coupled” assimilation system - leverage state-of-science for each component; explore coupled variances through coupled ensemble forecasts
- Investment in coupled observation operators - some observations have value for more than one component, for example fluxes at the interfaces
- Additional research into coupling strategies - weakly, quasi-strongly, or strongly coupled. For aerosols and chemistry, pursuing atmospheric DA path is preferred.
- Algorithm testing - standard 4DVar difficult without TL/AD of fully coupled model
- How to deal with differing temporal/spatial scales of components. Alternate cycling could be an option.
- Given results by UKMO, draft a test plan for our own inter-comparison between hybrid ensemble Var and hybrid 4DVar
  - Continue to invest in improvement of 4DEnVar as it is operational
- Notion of native-grid DA is a bit of a red herring. - model equivalents are more important from native, full resolution perspective. However compromises are made all over the place and it may or may not make sense for full resolution, native-grid solver. UFS-SC co-chair questioned if it needs to be done in observation space? By native grid it is meant FV3GFS. Important to develop native grid forward operators for observations. The response was it is not critical to focus on developing native grid solver
- In terms of observations
  - New observations including those from non traditional sources - rvt, crowd-sourced, cell-phone etc. How do we deal with quality/quantity of these data? More measurements of fluxes at the interfaces.
  - Need to do a better job of extraction of info from observations such as satellite observations
  - Leveraging stuff from data analytics research such as machine learning and AI.
  - Brian Gross mentioned - one of the real challenges where private satellites have instruments with 1-1.5 year life span, and we don’t have a procedure to do cal/val for these sensors, and it is difficult getting cheap satellite data into operations.
- Pressure to address key info in above bullet by data providers
- Research and strategic plan for improving operational DA capabilities in 5-10 year timeframe.
  - Careful consideration to HPC aspects
  - Leveraging data analytics
  - Alternate cycling strategies including overlapping windows
  - ‘In-core’ data assimilation
  - Non-gaussian, nonlinear errors
  - Bridging very short time scales to S2S scales
- Requirements for coupled model to support DA development
  - Robust, stable and efficient
  - Need to be able to characterize uncertainties for all components.
  - Have a separate interface for DA, not just physics.
  - Comment - interfaces wrt to coupled da system aspect
  - Ability to do adjoint on coupled system has implications on the system development.
  - Coupling of the component codes and da codes needs to be looked at closely
  - With regard to 5-10 year DA plan - as a strategic and implementation plan - how much should be strategy and how much should be tactical implementation? Post processing is extremely tactical with no thought for a 5-year vision. Do we really want 5-year plan for all components of NGPPS system? What we put into IP is a subset of long term strategic plan
- Risks and management strategies
  - Schedule : if JEDI milestones are not aligned with implementation schedules, either implementation or leveraging of JEDI will be delayed
    - Mitigation - continue to develop GSI for targeted projects/applications
  - Transition - if well defined, specific, incremental improvements cannot be identified, operational innovation will be delayed. Co-development is a risk
    - Mitigation - build agreed upon requirements document and ‘transition plan’. Leverage components of existing systems like GSI, where possible
  - Operational viability - if JEDI/OOPS cannot meet operational requirements, NOAA cannot efficiently leverage JEDI developments
    - Mitigation - transition plan. Investments in co-development to keep things on track for operational viability
  - Spin-up - if new system has too steep of a learning curve, operational improvements may be be delayed with respect to agile code development
    - Mitigation - regular training and communication
  - Funding /resources - if additional resources are not provided to emc to transition to jedi, implementation will be delayed
    - Mitigation - reallocation of internal resources
  - Physical location - if JEDI core team remains remote from EMC customers/partners, implementation maybe delayed due to communication issues
- Mitigation - regular conf calls. Liaison position at each location
- Authority/accountability - if JEDI is not focused on specific operational outcomes as described by customer/partners, development efforts may fracture
  - Mitigation - leveraging common resources such as hurricane supplemental. Co-development strategy. Greater involvement from working staff from ESRL, EMC, GMAO, etc. Co-author 5-10+ yr strategic research plan for DA
- How are the interests of application and community being served?
  - What has been done?
    - Gathering i/p and requirements at series of DA workshops
    - Engagement through other working groups that are non-atmospheric side

RR question - Will GSI be used for ocean and ice? Answered- It will not be used for oceans and ice. Targeting use of JEDI for these components.

Thoughts on moving toward high resolution - what are the demands/problems associated with it? Answered - “scary”. Because we will inherit several problems including high-frequency updates, representativeness, multi-scale interactions, ensemble strategies, code scalability, new data streams (e.g. radar), and HPC resource constraints.