Report on ensemble related developments that will have an impact on future operation implementations

An ensemble design workshop took place at ESRL/GSD in Boulder on July 24-25. The focus of the workshop was on the next generation High-Resolution Rapid Refresh Ensemble and its design. The workshop attendees were from various organizations including NOAA laboratories, NCAR, and the research community. In the two-day workshop, different approaches and corresponding results were discussed. A general summary and overall recommendations are provided below.

**Overall Recommendations**

**Storm Scale Ensemble of Opportunity (SSEO)**

* SSEO should be operationalized at NCEP
* Ensemble should be ~O(10) in size, split between ARW and NMMB cores
* Committee should be formed from model developers and users (SPC, NWS) to specify each core’s characteristics for the ensemble membership and to standardize how models are run

**High-Resolution Rapid Refresh Ensemble (HRRE)/High Resolution Ensemble Forecasts (HREF)**

* Multiple core (ARW and NMMB) can be used as an initial implementation without ensemble data assimilation for next several years
* An ensemble data assimilation system will require a single core in order to facilitate model improvement and the ensemble data assimilation.
* Not clear which core will eventually be used for 3 km (ARW, NMMB, or new NGGPS core?)
* Not clear when HREF ensemble DA can be implemented at NCEP due to resources (GSD thinks ~2-3 years, EMC thinks ~5-6 years)

**Additional Recommendations**

* EMC suggested that another workshop be held to define forecast metrics for SSEO, HRRRe, and HREF systems to evaluate system performance
* The community would benefit from a far more COORDINATED effort to identify ways to determine best practices for ensembles and ensemble DA. This is probably a critical issue to push over the next 2-3 years.

**Science Summary**

**Model**

* Reduction of model errors should be the highest priority of model developers over the next few years, particularly focused on PBL.
* Model improvements are likely to come from running single physics systems that are continuously cycled. Multi-core, multi-physics (and multi-background ICs) systems are designed to increase ensemble spread also hide model biases making it very difficult to detect and correct model errors.
* Need to understand biases in storm-motion in ensemble-based DA systems over next year.
* 1 km grid will be needed to predict evolution of individual storms.

**Forecast & Verification**

* For SSEO-type applications (12-36 hour forecasts), neighborhood methods appear to provide useful information for probabilistic forecasts for severe weather threats
* Object-based methods will be useful for forecasts attempt to verify individual convective systems or large cells.
* Need to focus efforts on what is wrong with SSEO-type applications (what is the low-hanging fruit) to help focus model improvements.

In addition, recently NCEP director Bill Lapenta requested a formation of the Modeling Advisory Committee (UMAC) to provide a comprehensive, technical review of the exiting NCEP Prediction Suite and strategy for future improvements. The UMAC report is under development and it will have a significant impact on the future of the operational suite. Below are some public record links providing more details:

* + <https://www.earthsystemcog.org/projects/umac_model_advisory/>
  + [All UMAC Presentations](https://www.earthsystemcog.org/projects/umac_model_advisory/resources/)
  + [Model Glossary](https://www.earthsystemcog.org/projects/umac_model_advisory/Model_Glossary)