Precipitation Prediction Grand Challenge Strategic Plan Review

A collaboration between Working Groups of NOAA's Science Advisory Board:
Climate Working Group and the
Environmental Information Services Working Group
Submitted August 24, 2020 to NOAA's Science Advisory Board

NOAA's draft Precipitation Prediction Grand Challenge Strategic Plan establishes an excellent framework for our nation to increase its precipitation prediction skill through the development and application of a fully-coupled Earth system prediction model. Building on the thought and foresight reflected in the Strategic Plan, this review offers one Grand Recommendation and five additional Recommendations that, together, form six opportunities for enhancing clarity and content and thus increasing scientific and organizational success.

Grand Recommendation. Emphasize the **grand** in the plan: What is the biggest push that will make the biggest difference?

Consider emphasizing the three top outcomes that NOAA and partners can produce right now to improve, even if they are expensive or difficult. For each, clarify: Why now? How will NOAA know the time is right? To align resources, especially time and money, NOAA and partners must be able to emphasize and support those three top outcomes in scientific, policy, and budget conversations.

Recommendation #1. Structure the strategic plan for R2O2R, from the identification of needs in science of prediction and predictability, to the co-development of products to service.

By re-aligning the structure of the document to the standard process steps—beginning with observations and ending with developing products for users—the document will encourage focus on all of the parts of the process that NOAA and partners control and require.

Recommendation #2. Explain the specific sources (decisions, observations, processes, etc.) of the substantial improvement (or the lack thereof) in precipitation prediction from the last 20 years, especially lessons learned from observations, modeling, and prediction.

Precipitation prediction has been a challenge for every weather and climate prediction center in the world, including NOAA, so learning the lessons from history is critical.

- What are the explanatory factors for those historical improvements? In what ways can those be leveraged for additional improvements? In what ways are they now interacting with, or counteracting, additional improvements?

- What were the primary reasons for the substantial improvement in the skill score between 2003-2011 (based on Figure 1 in the Report), and why have skill scores decreased since then?
- Does research suggest the changes in prediction skill are caused by model and data assimilation revisions, observations systems, or predictability of the system itself over time? It is possible that improvements in skill are being obscured by the differences in the observational target itself.

Recommendation #3. Explain the specific sources that will lead to substantial improvement in precipitation prediction over the next 20 years.

Consider enhancing the integration between Subseasonal-to-Seasonal (S2S) and Seasonal-to-Decadal (S2D) research and prediction efforts; integrating interdisciplinary observations from the root zone to the entire tropospheric column; including the "storm lifecycle" time scale; and, related, enhancing the action to bridge the gaps between short-term numerical weather prediction (NWP) model forecasting and data-driven nowcasting (see also Action 5.2). In addition, field campaigns and/or sustained measurements at a few sites will improve understanding of precipitation processes, address decision maker needs, and test the Unified Forecast System's treatment of the precipitation processes in a coupled system. This could be accomplished by coordinating the existing observational capabilities in collaboration with other agencies such as the Department of Energy and the National Aeronautics and Space Administration.

Recommendation #4. Highlight clear, quantitative goals and **connect** those to the improvements distinguished in Recommendation #3.

As with the Grand Recommendation, to show the biggest push that will make the biggest difference, the PPGC should show the clear, quantitative goals that connect to the biggest improvements. For example:

- If the precipitation predictions are intended to beat the European Centre for Medium-Range Weather Forecasts, on which metrics and over what period of time?
- How might NOAA measure the amount of learning about sources of predictability as researchers integrate precipitation datasets?
- What is the feasibility of the goal to improve the skill of precipitation forecasts from 15 or 30% per decade to 30 or 50% per decade? What is the baseline skill score that will be used to determine percent improvement? Consider taking the average historical peak performance (with the skill score of approximately 20 in Figure 1) as the baseline for 30% and 50% improvement, respectively.

Consider also connecting each objective and action to a key question and/or guiding principle and adding a crosswalk to other NOAA initiatives (e.g., the Earth Prediction

Innovation Center), thus developing a stronger foundation for the subsequent implementation plan.

Recommendation #5. Delineate the role of the community (different NOAA line offices, NOAA Cooperative Institutes, academia, private sector, states, and other federal agencies) and how NOAA and partners will work together to achieve these outcomes.

This Strategic Plan demands an "all hands on deck" approach which, in turn, requires extensive coordination between and among NOAA and partners. The roles of entities within NOAA (e.g., Cooperative Institutes, Regional Integrated Sciences and Assessments, labs, etc.) should be defined and partners should be more clearly described. Additionally, clearly characterize community engagement: What is the role of the community and how will it evolve? Which structures already exist and which need building to scale, inventing, or reimagining? Relative to the earlier comment about creating a crosswalk, how do engagement opportunities under initiatives like Earth Prediction Innovation Center and the "NOAA Citizen Science Strategy: Applying the Power of the Crowd" affect the strategic plan?

Comment #1. Highlight the mechanism of integrating precipitation process datasets (including clouds and precipitation rate), seamless approaches to understand and model the processes behind precipitation predictability from weather to decadal scales, and establish traceability of error sources to evaluate improvements in precipitation prediction skill.

It may be worthwhile to develop unified precipitation datasets as common standards for NWP model calibration, validation, and performance tuning. Precipitation datasets based on rain gauges (on the surface), Doppler radar precipitation retrieval (above ground and to top of troposphere), and satellite retrieval (for certain atmospheric levels depending on remote sensing channels used) have different characteristics. The modeled precipitation, however, though not necessarily matching reality, could still be sound within the particular modeling system context. Model performance may be tuned (thus interpreted) differently, depending on which set of metrics the model is driven towards.

Assimilating satellite-based radiance (and retrieved products) has clearly improved global model forecasts, most notably for the southern hemisphere, for the past two decades. Today, there are more observation data, and more expected in future, as heterogeneous platforms grow in type and observations, that NWP models can use in future operations. Unified datasets for model verification, tuning, and for operational data assimilation are desirable and can be coordinated/leveraged with the ground system products from NOAA's enterprise-level efforts such as the NOAA Satellite Observing System Architecture.

Comment #2. Clarify the focus of the plan to exclude or include precipitation prediction improvement over the ocean.

Whether intentional or not, the Strategic Plan appears to have an underlying focus only on precipitation forecast improvement over land and coastal areas where most of social-economic gains and losses are reported and ground-truthing is more feasible. If precipitation over ocean is not the focus of the grand challenge, consider clarifying this at the outset and acknowledging other major efforts (e.g., the Hurricane Forecast Improvement Program) that are already improving hurricane forecasts, including hurricane intensity that closely relates to precipitation over land. Then, emphasize improving land-atmosphere coupling and/or ocean-coastal-land-atmosphere coupling with additional focused resources. Especially in Action 3.3, this could include identifying and experimenting on a number of community-agreed domains for research and development.

Conclusion. With acknowledgements to NOAA, the Weather, Water, and Climate Board, and each contributor to the Strategic Plan, this document is so well conceived that this review offers modest recommendations. As Working Groups of NOAA's Science Advisory Board, the Climate Working Group (CWG) and the Environmental Information Services Working Group (EISWG) are grateful for the review opportunity and look forward to engaging again.

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