NWS Product Improvements and Uncertainty Recommendations

- NWS Wind Predictions: Provide limited uncertainty information
- Ensemble "spaghetti" diagrams
- Finding: A number of methods for generating initial ensembles are being explored in the research and operational communities. In addition, ensemble-based data assimilation approaches are proving beneficial, especially at the mesoscale. **Recommendation 3.1: As the GMB and the MMB of the EMC continue to develop their ensemble forecasting systems, they should evaluate the full range of approaches to the generation of initial ensembles and apply the most beneficial approach. The EMC should focus on exploring the utility of ensemble-based data assimilation approaches (and extensions) to couple ensemble generation and data assimilation at both the global and the mesoscale levels.**
- Finding: There is a range of approaches to help account for model inadequacy in ensemble forecasting. So far, NCEP has explored varying physics parameterizations, multimodel initial conditions, and stochastic methods. **Recommendation 3.2: The NCEP should complete a comprehensive evaluation to determine the value of multiple dynamical cores and models, in comparison to other methods, as sources of useful diversity in the ensemble simulations.**
- Finding: The spatial resolution of the MMB SREF ensemble system is too coarse to resolve important mesoscale features. Moving to a finer resolution is computationally more expensive, but necessary to simulate key mesoscale features. **Recommendation 3.3: The NCEP should (a) reprioritize or acquire additional computing resources so that the SREF system can be run at greater resolution or (b) rethink current resource use by applying smaller domains for the ensemble system or by releasing time on the deterministic runs by using smaller nested domains.**
- Finding: An easily accessible observation and forecast archive is a crucial part of all post-processing or verification of forecasts. **Recommendation 3.4: The NOAA NOMADS should be maintained and extended to include (a) long-term archives of the global and regional ensemble forecasting systems ant their native resolution, and (b) reforecast datasets to facilitate post-processing.**
- Finding: Reforecast data provide the information needed to post-process forecasts in the context of many different applications (e.g. MOS, hydrology, seasonal forecasts). NWS provides only limited reforecast information for some models and time periods. In addition, post-processing systems need to change each time the numerical model changes. The facilitate adaptation of applications and understanding of forecast performance, reforecast information is needed for all models and lead times whenever a significant change is made to an operational model. **Recommendation 3.5: NCEP, in collaboration with appropriate NOAA offices, should identify the length of reforecast product necessary for time scales and forecast of interest and produce a reforecast product each time significant changes are made to a modeling/forecasting system.**
- Finding: A database such as the NDGD would provide a wealth of information for the NWS forecaster and academic researcher and provide a basis for significant added value by the private sector, catalyzing economic activity. In addition, there is a strong complementarity between the NDGD and NOMADS. **Recommendation 3.6: Efforts**

on the proposed NDGD should be accelerated and coordinated with those on the NOAA NOMADS (recommendation 3.4).

- Finding: In many cases the CPC's monthly and seasonal forecasts have little skill, especially at long lead times. Other forecasting groups, such as the International Research Institute, only provide forecasts out to 6 months due to the limited –or negative –skill for longer projections. **Recommendation 3.10: The CPC should examine whether it is appropriate to distribute forecasts with little skill and whether projections should be limited to shorter time lengths. Information about prediction skill should be more readily available to users.**
- Finding: The transition for deterministic to probabilistic/ensemble hydrologic forecasting over broad time and small spatial scales will require a number of steps. **Recommendation 3.12: The OHD should implement operational hydrology databases that span a large range of scales in space and time. The contribution of remotely sensed and onsite data and the associated error measures to the production of such databases should be delineated.**
- Finding: Blending of short-term predictions with longer-term predictions to force hydrologic models is particularly difficult. This is an area in which hydrologists, as weather and climate forecast users, can provide significant input to meteorologists. **Recommendation 3.14: The OHD should develop methods for seamlessly blending short-term (weather) with longer-term (climate) ensemble predictions of meteorological forcing within the operational ensemble stream-flow predication system. This will require NCEP model output downscaling and bias adjustment, and real-time data availability.**
- Finding: Verification drives forecast system development and affects the use of forecast information. **Recommendation 3.15: NWS should expand its verification systems for ensemble and other forecasts and make more explicit its choice of verification measures and rationale for those choices. Diagnostic and new verification approaches should be employed, and the verification should incorporate statistical standards such as stratification into homogeneous subgroups and estimation of uncertainty in verification measures. Verification information should be kept up to date and be easily accessible through the Web.**
- Finding: The public weather forecasts from the IFPS and distributed as the NDFD are one of NWS's primary forecast products. **Recommendation 4.1: The NWS should expedite development of the IFPS toward a system that can access, produce, and communicate uncertainty guidance for most forecast parameters. Such a revised system should be able to access deterministic and ensemble prediction systems, historical error statistics, and statistically post-processed forecast information (e.g. MOS) to allow production of uncertainty information with varying levels of subjective and objective contributions. The system should be capable of preparing probabilistic products to communicate probability density functions an other types of uncertainty information (e.g., probability of temperature less than freezing or wind speed greater than 26 knots).**
- Finding: AFDs are popular NWS products that were designed as technical discussions to enhance collaboration among NWS offices and to convey uncertainty to a specialized audience. AFDs are now routinely accessed by broad user community and could be even more widely read and utilized if they were written for the even larger

nonspecialist audience. **Recommendation 4.2: The NWS should release the AFD only in layperson English to facilitate its broad use and understanding. For more sophisticated users, NWS could provide more detailed technical information linked to the AFD.**

- Finding: The graphics conveying monthly and seasonal outlooks are difficult for many users to understand and do not convey all the information (both graphical and tabular) that is available or needed. Exceedance probability distributions provide the most complete information about the climate probabilities at particular locations. These distributions do not rely on pre-specified categories or definitions of "normals." Overall, more research is needed regarding user needs for these graphical and tabular formats, as well as more forecaster-user interactions to provide two-way feedback on this and other products. **Recommendation 4.3: The CPC should provide full Exceedance probability distributions of the projected monthly and seasonal temperature and precipitation values in both graphical and tabular forms. A straightforward graphical presentation of this information should be developed that is understandable to relevant user groups.**
- Findings: A variety of products is needed to communicate uncertainty to a broad range of users. Consistency of language, icons, and graphical representations of uncertainty among all these products is critical for the effective communication of uncertainty information. A necessary first step toward ensuring consistency is understanding users' interpretations. **Recommendation 4.4: To ensure consistency in the communication of uncertainty information and user comprehension, NWS should more fully study and standardize uncertainty terms, icons, and other communications methods through all pathways of forecast dissemination.**
- Findings: The official NWS process for developing new products does not formally engage the user throughout the product development process. Rather, it seeks feedback when the product already has gained significant momentum. Moreover, the feedback obtained often fails to rigorously and comprehensively evaluate the product's effectiveness. **Recommendation 4.5: NWS should extend NWS Directive 10-102 to require collaboration with users on product development throughout the development process. Moreover, users' comprehension and interpretation of products should be formally evaluated at several stages during the product development process.**