**Development of a Seasonal Severe Weather Outlook**

Recent tornado outbreaks over the U.S. have caused devastating societal impacts with significant loss of life and property, prompting the need to identify and understand long-term climate signals that may provide seasonal predictability for intense tornado outbreaks over the U.S. Over the past few years, a series of workshops designed to advance this goal were held, with the 3rd held in College Park in early 2015 including participants from various NOAA/NCEP and NOAA/OAR centers (SPC, CPC, and AOML), NOAA's Climate Program Office, and the academic research community. While a key outcome was that different outlooks should be developed as a function of varying lead-times, this report will focus only on the development of a seasonal outlook. Other recommendations from this workshop were that an experimental seasonal severe weather outlook be issued for spring 2016, and that research activities for improving such an outlook continue to be supported.

At this time, expectations are that an experimental seasonal severe weather outlook will be an activity forecast aggregated for March, April, May, and June (MAMJ) and will be issued on the Friday prior to the beginning of March. However, the CPC lead employee responsible for this task unexpectedly departed for a job with a non-profit, and CPC is currently working on assigning this task to others on staff. In the short run, the current plan will be to have folks familiar with the seasonal outlooks assume responsibility for working with outside partners and contributors to issue this experimental outlook internally in February, 2016. Long term, it’s possible that the lead of the product is not currently on staff and will be not be on staff until after we’re able to fill the vacancy.

Given that the first release of this product is still months away, the final format of the outlook is still under discussion. CPC is leaning toward a more regional approach, while some of our partners are favoring an outlook similar to the Atlantic and Pacific Hurricane Outlooks, which only give an assessment of likely activity over a large domain.

The plans to create the outlook and to facilitate discussion of relevant tools and information, will include teleconferences to be held in early February 2016 to familiarize and educate the group with the various tools and information, with a second telecom to be held on the Thursday prior to March 1 to discuss the latest scientific information and develop a consensus for the creation of the seasonal severe weather outlook map. The experimental consensus outlook map will be issued in conjunction with a forecast discussion one day later.

Some key decisions about the outlook have been made. First, the outlook will focus only on tornadoes (F1-F5) and large hail, and not damaging winds or F0 tornadoes. Trends in the observations of F0 tornadoes make it particularly challenging to develop an unbiased tornado count climatology. The outlook will be similar to other CPC climate outlooks in that it will be a comparison to a calculated climatology (i.e. above-normal or below-normal). Finally, the current thinking is that this outlook will characterize the season as being in the upper/ lower quartile, with the near-average category encompassing 50% of the total, which is different from other CPC outlooks that divide the distribution into terciles.

Tool development to date has largely focused on links between seasonal activity of severe weather and the transitional phases of the El Niño / Southern Oscillation (ENSO) phenomena. A number of recently published papers (e. g., Allen et. al, 2015; Lee et. al, 2013; Weaver et. al, 2012) have discussed the role that ENSO plays in producing an environment that may be favorable or hostile to the development of severe weather. Results indicate that El Niño acts to make the environment over the Plains less conducive to severe weather during the spring, but increases the likelihood of severe weather in the Southeast during the winter. Conversely more tornado and hail events occur across the central U. S. during La Nina events. These changes in statistics are also borne out in shifts in atmospheric variables such as low-level winds and stability parameters like the lifted index.

Given the strong El Niño currently underway in the tropical Pacific, it’s likely that the experimental seasonal severe weather outlook that will be developed in February 2016 will rely heavily on these relationships. Assuming this event persists into early spring, the ENSO state will be one factor used to predict changes in tornado and hail frequency during spring 2016.

Ongoing research at the Cooperative Institute of Marine and Atmospheric Science (CIMAS) will also contribute to the outlook. The main goals of this research is to: (1) implement scientific development activities within CPC to explore long term climate signals of importance to seasonal severe weather, (2) evaluate seasonal forecast skill of severe weather parameters in the NCEP Climate Forecast System version 2 (CFSv2), and (3) develop a dynamical-statistical hybrid prediction system (modeled after a successful tool used in support of the seasonal hurricane outlooks) in support of the seasonal severe weather outlook.

Another potential tool will be based on forecasts from the North American Multi-Model Ensemble (NMME) system. The development of this tool will include evaluating the skill of the NMME system for predicting various ENSO indices including the Trans-Niño index, as well as the onset, decay, transition (El Niño to La Niña or La Niño to El Niño) and resurgent (El Niño to El Niño or La Niña to La Niña) phases. This will be followed by the construction of proxy tornado indices using the NMME analysis, based on forecasts of cape and shear. The skill of these proxy indices will then be examined hopefully leading to a proto-type seasonal outlook tool for US tornado outbreaks based on the NMME system.

An attempt to employ a Bayesian network for predicting the probability distribution of the monthly or seasonal tornado frequency based on output from the CFSv2 models was pursued for several months at CPC but did not produce promising results and was abandoned. The contractor working on this task left CPC in February and our primary focus now is on supporting development of the tools at CIMAS, which show more promise.

A critical aspect to the success of this project is to nurture shared activities among the NOAA/NCEP centers (i.e., CPC and SPC), NOAA/OAR labs (i.e., NSSL and AOML) and the academic research community. Given that gaps remain in understanding the climate and severe weather linkage and developing applied forecasting techniques, it is necessary that both basic and applied research continues in earnest, focusing on statistical and dynamical modeling, improved diagnostic understanding, and applied research on methods to blend models into useful guidance products.

Allen, J. T., M. K. Tippett, and A. H. Sobel (2015), Influence of the El Nino/Southern Oscillation on tornado and hail frequency in the United States., Nature Geosci., 8, 278–283

Lee, S.-K., R. Atlas, D. B. Enfield, C. Wang and H. Liu (2013), Is there an optimal ENSO pattern that enhances large-scale atmospheric processes conducive to major tornado outbreaks in the U.S., J. Clim., 26, 1626-1642

Weaver, S. J., S. Baxter, and A. Kumar (2012), Climatic role of North American low-level jets on U.S. regional tornado activity., J. Clim., 25, 6666 - 6683.