CSTAR Progress Report for period of work 11/1/2013 – 4/30/2013

Project Title: Integration of Forecast Sensitivity into the NWS Forecasting Process to Improve Predictability of High-impact Weather
University Partner: Texas Tech University (TTU)
PIs: Brian Ancell and Christopher Weiss

Work Performed: This last 6 months of the project has focused on 1) preparing further experimentation based on results found up to this point regarding targeting, verification, and sensitivity associated with the Texas Tech EnKF system, and 2) transitioning forecast products found to provide value into real-time Texas Tech EnKF operations. Specifically, the work performed has been as follows:

- Further progress on the use of ensemble sensitivity analysis applied to convection has been made. Recent effort has focused on appropriately choosing the response function to highlight specifically the forecast aspect we wish to address. Such a task in non-trivial since forecast convection is highly variable and sensitive to model and assimilation parameters. Furthermore, a complete assessment is underway regarding estimated target forecast value, involving a temporal and spatial comparison of impacts throughout the forecast window and across the entire three-dimensional domain. This investigation is meant to provide guidance on what lead times are likely to be effective target times for severe convection in the South Plains. In preparation for potential field observation targeting tests, a test launch of a mobile radiosonde unit was successful in the Lubbock, TX area. Further field operations are being planned for the near future in order to test the impacts of actual observations in targeted areas, an approach that is unable to occur by only considering routine observations.
- Continued verification of the operational WRF deterministic and ensemble systems has progressed. This verification effort has made clear the need to create an adaptive ensemble system that varies in time the bias removal scheme, the specific set of model physics, and the data assimilation parameters. In other words, an ensemble system with a constant set of parameters will produce degraded forecasts compared with system that can vary its parameters based on the current conditions. Along these lines, verification (both traditional and object-oriented) has begun on the DART assimilation parameters toward understanding such optimal settings for the Texas Tech WRF ensemble. Biases are well known through the years of system operation, and bias removal schemes are currently being implemented toward adding value to probabilistic guidance. This idea of an adaptive ensemble is a primary focus for the next TTU CSTAR project, which has already been awarded.
- The development of ensemble best member techniques on synoptic scales has been completed (see publication #1 below); members closest to the mean with regard to specific cyclone events have been shown to provide the best forecasts. Work is underway to identify in real time such members when mid-latitude cyclones are present in the forecast, providing a "best guess" from the ensemble that provides more realistic predictions than the smoothed-out mean forecast for high-impact forecasts. This is especially helpful with regard to severe convection,

and similar techniques evaluating the closest member based on simulated reflectivity will also be compared to that using the synoptic-scale approach.

- Real time operation has continued of both the TTU Weather Research and Forecasting (WRF) EnKF assimilation/forecasting system (12km/4km) and the WRF deterministic forecasting system (12km/3km). Operational forecast products from both systems continue to be made available online to participating NWS WFOs and the SPC at the following websites: http://www.atmo.ttu.edu/bancell/real_time_ENS/ttuenshome.php (EnKF) and http://www.atmo.ttu.edu/bancell/real_time_WRF/ttuwrfhome.php (deterministic). Continued interaction with NWS personnel (particularly at the Lubbock, TX WFO) based on the exposure of products from the real time systems to forecasters has continued through this period of work. In addition, parallelization of the real-time forecast sensitivity code has continued, and is planned to allow sensitivity-based products to be more feasible operationally for a larger number of NWS offices and the SPC.

Synergistic Activities Performed with NOAA: Activity in direct collaboration with NWS personnel continued during this period of work:

- Informal collaboration with participating NWS forecast offices has occurred smoothing the transition of the upgraded TTU deterministic and ensemble prediction systems into NWS operations
- Plans have been made with SPC personnel for four TTU researchers to participate in the 2014 Hazardous Weather Testbed (HWT) Spring Experiment. This collaboration is planned to provide TTU researchers with an understanding of the TTU EnKF forecast and sensitivity products that might provide operational value to severe storm forecasting at the SPC and participating WFOs.

Presentations Supported by Project: The following presentations were given during this period of work in association with this project:

1) "**Improving the Ensemble Predictability of High-Impact Events Using Forecast Sensitivity**", Brian C. Ancell, American Meteorological Society 26th Conference on Weather Analysis and Forecasting / 22nd Conference on Numerical Weather Prediction, Atlanta, GA, February 2-6, 2014.
2) "**Performance and Verification Results of a Cycled WRF/DART Multiscale Ensemble System at Texas Tech University**", Anthony E. Reinhart and Brian C. Ancell, American Meteorological Society 26th Conference on Weather Analysis and Forecasting / 22nd Conference on Numerical Weather Prediction, Atlanta, GA, February 2-6, 2014.
3) "**Application of Mesoscale Ensemble-based Sensitivity Analysis to Observation Targeting**", Aaron J. Hill, Christopher C. Weiss, and Brian C. Ancell, American Meteorological Society 26th Conference on Weather Analysis and Forecasting / 22nd Conference on Numerical Weather Prediction, Atlanta, GA, February 2-6, 2014.

Publications Supported by Project: The following publication activity occurred during this period of work in association with this project:

1) Ancell, B.C., 2013: **Nonlinear Characteristics of Ensemble Perturbation Evolution and their Application to Forecasting High-impact Events**. *Weather and Forecasting*, Volume 28, Issue 6, pages 1353-1365.
2) Bednarczyk, C.N. and B.C. Ancell, 2014: **Ensemble Sensitivity Analysis applied to a Southern Plains Convective Event**. Submitted to *Monthly Weather Review*, American Meteorological Society, in review.

Graduate Student Involvement: Two graduate students have been supported through the CSTAR project during this period of work:

1) **Aaron Hill**, M.S. student - Ensemble sensitivity and observation targeting.
2) **Brock Burghardt**, Ph.D. student - Object-oriented verification, adaptive ensembles, ensemble sensitivity.

In addition, other graduate students have contributed work toward project goals with no cost to the project:

1) **Anthony Reinhart**, Ph.D. student - Deterministic and probabilistic verification.

Upcoming Period of Work: TTU received a no-cost extension to continue the research and research-to-operations tasks developed during the final stages of the project. These tasks include:

- Finish the investigation of the initial observation targeting fields to provide a foundation for extending to other cases and potential real-time use
- Apply ensemble sensitivity to a large number of cases (~10 events) to understand the differences in the features that influence the predictability of convection/convective initiation among different events
- Implement the operational tools discovered to have forecast value (ensemble best member generation, ensemble sensitivity) in real time and make available to the NWS
- Continue the verification efforts for different system parameters toward development of an adaptive ensemble
- Continue development of real-time TTU prediction system products based on subjective feedback from participating NWS offices and experience at the HWT Spring Experiment

It should be noted that many of these planned tasks overlap with the goals of the next TTU CSTAR project, which has already been awarded by NOAA and begins this year.