Scientific Progress Report on

Improving Prediction of Severe Winds, Convection and Heavy Precipitation in the Southeastern United States

to the

National Oceanic and Atmospheric Administration
Collaborative Science, Technology & Applied Research Program (CSTAR)
Award Number NA10NWS4680007

For the period 1 November 2013 through 30 April 2014

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May 2014

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A. Project Schedule

All of the MS students who have been supported on this project have now successfully completed and defended their MS theses: Keith Sherburn, Jordan Dale, and Jason Davis. PhD student Bryce Tyner did not receive CSTAR support during the reporting period, but has made progress with earlier work that was supported by CSTAR. In order to allow time for the maturation of R2O materials, development of journal articles, and other dissemination of results, we requested, and are currently working in a 1-year no-cost extension. This effectively extends our collaboration beyond the original project ending date, and provides flexibility in project completion. Recall that the primary research areas include: Inland wind prediction during landfalling tropical cyclones (TCs), severe high-shear, low-CAPE convection (HSLC), and inland precipitation accompanying landfalling TCs.

This report is organized as follows: First, a technical summary of activity during the reporting period for the three project areas is provided in Section B. Section C presents a list of additional accomplishments and activities that do not fit within the technical summaries. Finally, Section D supplies a concise summary of accomplishments and deliverables from the reporting period.

B. Research Activity, 1 November 2013 – 30 April 2014

1.) Inland wind

Investigating tropical cyclone sustained wind speed and gust forecasts in the study region was the primary focus for graduate student Bryce Tyner. The results of the work aimed at improving tropical cyclone sustained wind speed and gust forecasts in the study region were summarized in a paper submitted to Weather and Forecasting in October, 2013 (Tyner et al. 2014 – see references). The paper has since then been revised, following the constructive comments of three anonymous reviewers. The revised manuscript was submitted to the editor in April, 2014. Some key earlier results include:

- Tropical cyclones making landfall in the southeastern US often undergo a period rapid decay in terms of sustained wind speeds. The period of rapid decay typically depends on the angle of storm approach with respect to the coastline. The decay occurs over a period much smaller than the 12-24 hourly temporal resolution of the NHC wind forecast data. The linear assumption used in the TCMWindTool to create hourly grids likely results in significant error in wind speeds that should be accounted for.

- The NDFD verification using both the observations from the CRONOS data network and the H*Wind surface analyses suggest a general over prediction in sustained wind speeds for much of the study region. Forecasters are encouraged to consider using larger land reduction factors in the TCMWindTool and to collaborate among Weather Forecasting Offices (WFOs) on these land reduction factors to improve the sustained wind speed forecasts for future TCs.

- Gust factors are highly variable at lower sustained wind speeds. The variability in the gust factors significantly decreases as the sustained wind speeds increase; furthermore, these gust factors nearly asymptotically decay to values near 1.1-1.2 for sustained wind speeds above 40 knots. Although there was no general conclusive bias in gust factors based on wind direction, locations near the immediate coastline displayed lower gust factors when the flow was from the maritime environment. Forecasters should consider the sustained wind speed, wind direction, boundary layer stability, and local topographic effects when choosing a gust factor to create wind gust forecasts.

The newly developed WindReductionFactor and GustFactor grids have been developed and distributed to the local Weather Forecasting Offices of Raleigh, Wilmington, and Morehead City. The tools will be tested during the 2014 tropical cyclone season before distribution to other Weather Forecasting Offices in future seasons. These new fields are designed to improve forecast continuity between forecasters and among neighboring WFOs, and provide a more efficient process to create wind and wind gust grids.

The motion to include the climatologically-based bias correction, known as the Modified Rankine Error Function (MREF), into the TCMWindTool was approved at the December 2013 NOAA Hurricane Meeting. The MREF has been coded and will be tested by participants from WFOs Raleigh, Wilmington, Newport, Wakefield, Charleston, and Miami.

As a follow up to the C* tropical cyclone wind work, the characteristics of the landfalling hurricane boundary layer have been examined using the Weather Research and Forecasting (WRF) Model. The work is supported by National Science Foundation Grant ATM-0847323. Since version 3 of WRF, a large-eddy-simulation (LES) option has been available for the planetary boundary layer. Select simulations were conducted for Irene (2011) using two popular planetary boundary layer schemes in the mesoscale domains: the Yonsei University (YSU) non-local scheme and the Mellor-Yamada-Janjic (MYJ) local scheme. The preliminary results of the work suggest the simulation conducted using the YSU scheme produced a stronger tropical cyclone, likely attributed to the presence of localized strong areas of convection from the outer rain bands of the tropical cyclone. An examination of the boundary layers within the LES domains showed the presence of large-eddy circulations (LECs) within the eyewall. The LECs were limited in vertical extent to the top of the boundary layer. The horizontal sizes of the LECs were different between the simulations, with the LECs in the MYJ simulation having a broader range of sizes than in the YSU simulation. The preliminary results suggest the characteristics of the simulated hurricane boundary layer within the LES domain are sensitive to the planetary boundary layer scheme chosen for the outer domains. Further sensitivity studies will continue to examine the characteristics of these simulated LECs in the boundary layer.

2.) High-shear low-CAPE (HSLC) severe weather climatologies (Davis, Sherburn, Parker)

During the reporting period, the main items specifically linked to this award were primarily aimed at dissemination of results. Major highlights include the final acceptance of two journal papers in Weather and Forecasting, the delivery of a widely-attended NWS webinar, and expansion of the suite of quasi-operational real-time HSLC products.

Davis, J. M., and M. D. Parker, 2014: Radar climatology of tornadic and non-tornadic vortices in high shear, low CAPE environments in the mid-Atlantic and southeastern U.S. Wea. Forecasting, accepted in final form, April 2014. *In press.*
http://journals.ametsoc.org/doi/abs/10.1175/WAF-D-13-00127.1

Sherburn, K. D., and M. D. Parker, 2014: Climatology and ingredients of significant severe convection in high shear, low CAPE environments. Wea. Forecasting, accepted in final form, April 2014. *In press.*
http://journals.ametsoc.org/doi/abs/10.1175/WAF-D-13-00041.1

NC State real-time HSLC SHERB plots were updated and expanded this spring. Some of the improvements include the addition of the SHERBE, the SHERBS3 is now only shaded where MUCAPE>0 J/kg and/or MULI < +6 K, and RAP data have been extended to 12 hours. GFS/NAM imagery is available at 3 hour intervals through 36 hours, then 6 hour intervals through 84 hours.

Real-time RAP – http://storms.meas.ncsu.edu/users/mdparker/rap
Real-time NAM – http://storms.meas.ncsu.edu/users/mdparker/nam
Real-time GFS – http://storms.meas.ncsu.edu/users/mdparker/gfs

Additionally, there have been continued discussions with SPC about implementation of the SHERB parameter into their produce suite. These discussions include several phone calls and face-to-face meetings, along with numerous emails.

Jason Davis and Keith Sherburn delivered an additional webinar presentation entitled "Improving the Forecasting of Severe Weather in High Shear, Low CAPE Environments" on April 15, 2014. This presentation was attended by 29 different NWS offices. The presentation materials including a recording of the webinar, a PDF of the presentation, and the PowerPoint slides with speaker notes. See:
https://cimmse.wordpress.com/2014/05/06/%ef%bb%bfmaterials-from-the-spring-2014-cstar-high-shear-low-cape-research-to-operations-webinar-are-now-available/

Several additional HSLC case studies discussed by regional WFOs on the CIMMSE blog
https://cimmse.wordpress.com/2014/03/15/interesting-test-for-the-sherb-sunday-in-southern-ga/
https://cimmse.wordpress.com/2014/02/21/severe-weather-possible-in-a-borderline-high-shear-low-cape-environment-today/
https://cimmse.wordpress.com/2013/11/05/halloween-night-hslc-tornadic-qlcs-a-sherb-success/

3.) Tropical Cyclone QPF (Dale and Lackmann)

Investigation of precipitation patterns accompanying landfalling tropical cyclones was the research focus for graduate student Jordan Dale. Jordan defended his thesis in July, 2013. The primary case study and model experiments focused on Tropical Storm Ernesto (2006), based on input from a number of NWS collaborators. This case featured a predecessor rain event (PRE) in addition to heavy rainfall along the track of the system.

During the reporting period, Jordan presented his work at the AMS Annual Meeting in Atlanta within the 26th Conference on Weather Analysis and Forecasting/ 22nd Conference on Numerical Weather Prediction:

The Role of Hurricane Ernesto (2006) in a Predecessor Rainfall Event, **Jordan Dale**, North Carolina State University, Raleigh, NC; and G. M. Lackmann, AMS Annual Meeting, Atlanta, GA; **26th Conference on Weather Analysis and Forecasting / 22nd Conference on Numerical Weather Prediction**

A journal article presenting these findings is in preparation for submission to the journal Weather and Forecasting during summer, 2014.

C. Other Project Highlights

- Former CSTAR student, Jason Davis accepted a position at the NWS Birmingham, AL as a meteorological intern.
- The CIMMSE blog was developed to share applied research findings, training materials, and unique meteorological events that impact the Southeast and Mid-Atlantic region. Most of the posts have focused on topics relating to current and past CSTAR projects. The blog has hosted 289 posts in 17 categories with over 35,000 views.

References:

Davis, J. and M. D. Parker, 2014: Radar climatology of tornadic and non-tornadic vortices in high-shear, low-CAPE environments in the Mid-Atlantic and Southeast. *Wea. Forecasting*, In press.

Sherburn, K.D., and M.D. Parker, 2014: Climatology and ingredients of significant severe convection in high shear, low CAPE environments. *Wea. Forecasting*, In press.

Tyner, Bryce, P. A. Aiyyer, J. Blaes, and D. R. Hawkins, 2014: An Examination of Wind Decay, Sustained Wind Speed Forecasts, and Gust Factors for Recent Tropical Cyclones in the Mid-Atlantic Region of the United States. *Wea. Forecasting*, revision submitted April 2014.