The Collaborative Science, Technology, and Applied Research (CSTAR) Program

Development of Improved Diagnostics, Numerical Models, and Situational Awareness of High-Impact Cyclones and Convective Weather Events

University: University at Albany

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1. SUMMARY OF STUDENT RESEARCH ACTIVITIES

a) Forecast and model diagnostics for severe convective weather events in complex terrain

Graduate student: William Flamholtz
PI and co-PIs: Brian Tang, Lance Bosart, and Kristen Corbosiero
NWS focal points: Thomas Wasula (ALY), Michael Evans (ALY), and Matthew Kramar (PIT)

Research summary:

Increased low-level shear due to terrain channeling may play a role in organizing convection in major Northeast U.S. valleys (e.g., Lapenta et al. 2005; Bosart et al. 2006; Katona et al. 2016). William Flamholtz utilized the WRF model with HRRR-like physics to conduct simulations that examined the role of terrain-channeled flow on convective evolution. These simulations are based off the 13–14 August 2016 severe weather event in the Northeast U.S.. Wind profiles were obtained from a location within the Hudson Valley from two parent WRF simulations, one with realistic terrain (T) and one without terrain (NT). We define the wind profile from the T simulation as "channeled" (C), and the wind profile from the NT simulation as "nonchanneled" (NC). The winds in the 0–1-km layer were retained for each profile. Above 1 km, the average of the two wind profiles was used in both the C and NC profiles. Additional wind profiles were created by scaling the C and NC winds by factors of 1.25 (e.g., C-1.25) and 1.5 (e.g., C-1.5) to increase the shear, while keeping the same overall shape of the hodograph (Fig.1). In total, six wind profiles were created.

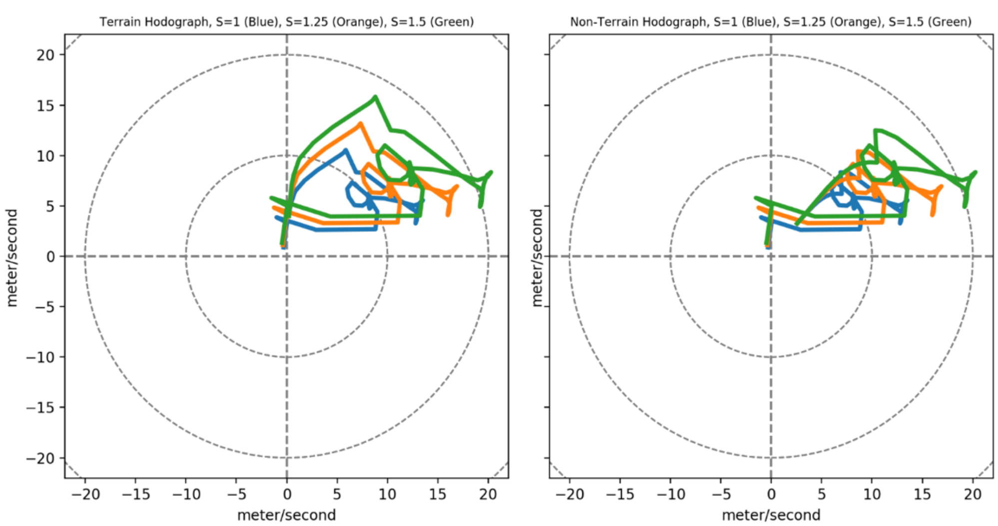

Figure 1: *Channeled (C; left) and nonchanneled (NC; right) hodographs. Different colors represent wind profiles multiplied by scale factors: 1.0 (blue), 1.25 (orange), and 1.5 (green).*

These six wind profiles served as initial conditions for six idealized WRF simulations with homogeneous initial conditions. The simulations are run at 1-km resolution. The thermodynamic profiles for all simulations are based off a representative Albany, NY sounding from the aforementioned case. Convection is initiated with a warm bubble.

Interesting differences arise between the C and NC simulations. All simulations develop a convective line three hours into the simulation. All C simulations maintain more vigorous convection along the leading edge of the cold pool, however, compared to the NC simulations

(Fig. 2). This difference is likely due to a better balance between cold-pool propagation and environmental, low-level shear in the C simulations, consistent with RKW Theory (Rotunno et al. 1988). Additionally, the C-1.5 simulation exhibits a quasilinear convective structure, with kinks within the central and southern parts of the reflectivity field. These kinks are associated with locally higher low-level vertical vorticity of ~ 0.003 s^{-1} (not shown). In contrast, the convection is tilted back into the cold pool more strongly in the NC simulations, demonstrating a less optimal state for maintenance of severe convection. As a result, there is generally lower reflectivity in the NC simulations compared to the C simulations.

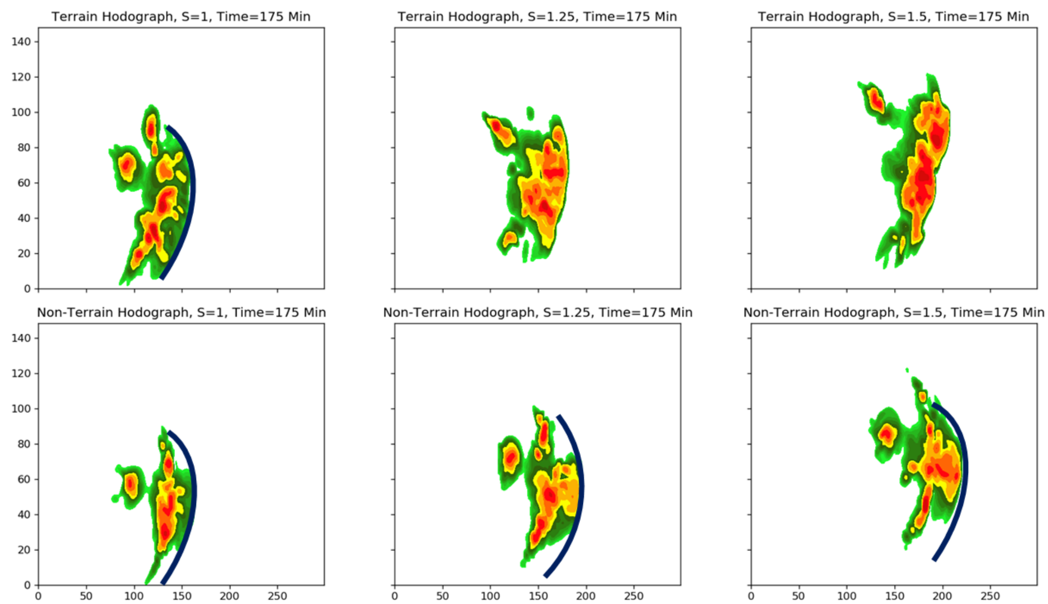

Figure 2: *Radar reflectivity for C-1.0, C-1.25, and C-1.5 (top row, left to right); NC-1.0, NC-1.25, and NC-1.5 (bottom row, left to right) simulations at 175 min. Navy blue curved lines represent approximate location for the front edge of the cold pool in select simulations.*

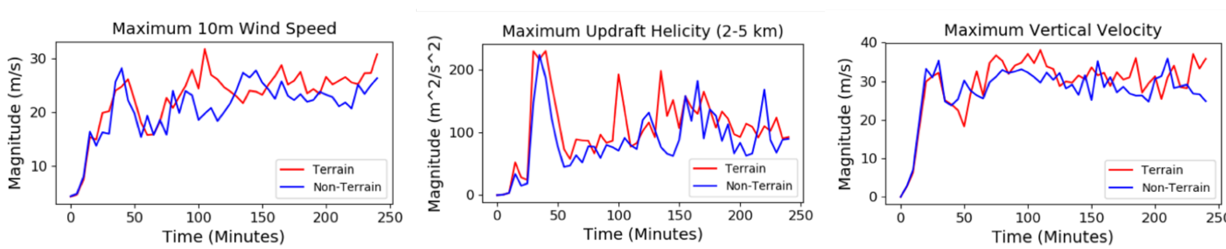

Figure 3: *Time series of the maximum 10-m wind speed (left), maximum 2–5-km updraft helicity (center), and maximum vertical velocity (right) for the C-1.5 (red) and NC-1.5 (blue) simulations.*

The maximum updraft helicity, 10-m wind speed, and vertical velocity were used to assess the storm intensity evolution in the C and NC simulations. The C-1.0 and N-1.0 simulations did not have significant differences, using the Student's t-test (not shown). Both simulations produced severe wind winds at the surface, consistent with the large number of wind damage reports observed in the 13–14 August 2016 event. A similar result was obtained when comparing the C-1.25 and N-1.25 simulations. The storm intensity metrics were statistically significantly different between the C-1.5 and NC-1.5 simulations (Fig. 3). The C-1.5 simulation (red line) had a maximum 10-m wind speed exceeding 30 m s^{-1}, which is indicative of the likelihood for such storms to produce significant severe wind. The results of these simulations might indicate that increases in low-level shear and helicity due to terrain channeling may be more important in high-CAPE, moderate/high-shear environments versus high-CAPE, low-shear environments.

During the next six months, we will continue to refine the idealized modeling framework to analyze a greater variety of environments (e.g., lower CAPE) and convective storm modes (e.g., supercells). The goal will be to supply forecasters with information and conceptual models about in what environmental conditions (e.g., CAPE and shear combinations), and potential scenarios, terrain-channeling can enhance the risk of severe weather above the background risk.

In a complementary project, co-PI Brian Tang and R2O Specialist Ross Lazear worked with an undergraduate student, Luke LeBel, to conduct a 1-km resolution WRF simulation of the 31 May 1998 Mechanicville, NY supercell and tornado (LaPenta et al. 2005). The focus of the investigation was on the formation and maintenance of a mesoscale boundary on the western edge of the Hudson Valley. The western side of the boundary was characterized by surface southwesterly winds, warmer temperatures, and lower dew points. The east side of the boundary was characterized by surface southerly winds (channeled flow up the Hudson Valley), cooler temperatures, and higher dew points. There was an axis of higher CAPE along the boundary. There were extreme values of the significant tornado parameter (> 5) on the east side of the boundary, indicative of a very favorable environment for tornadoes.

A simulated supercell that closely followed the track and timing of the actual Mechanicville, NY supercell was examined. As the supercell crossed the boundary, there was a substantial increase in low-level relative vorticity (Fig. 4) and a warming of the rear-flank downdraft air. These two factors are associated with an increased likelihood of tornadogenesis. Future work will look at trajectories in this simulation, particularly those on either side of the boundary and in the vicinity of the supercell. We will look at other, similar cases to assess if such boundaries are common in severe weather events in the region.

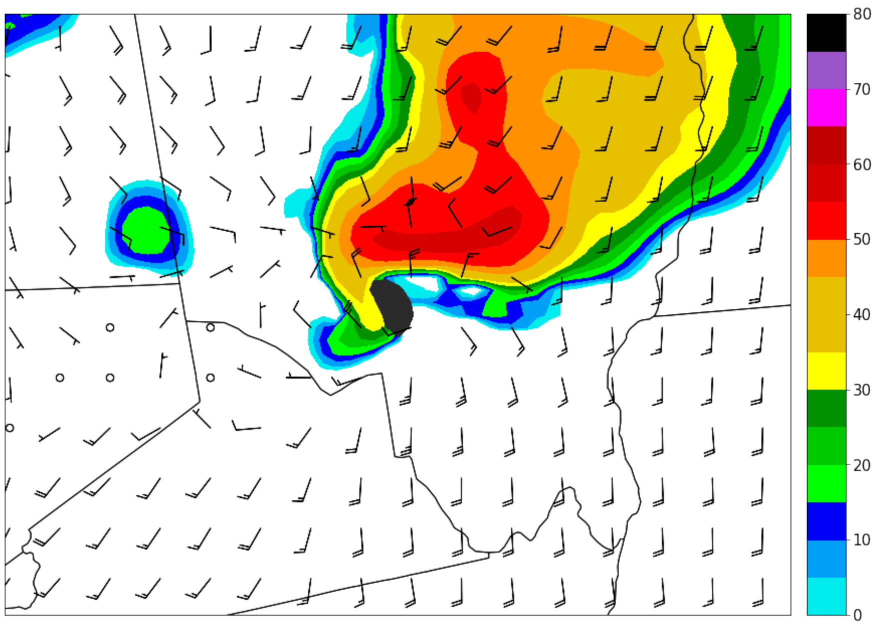

Figure 4: *Radar reflectivity (dBZ), 1-km absolute vorticity > 0.01 s^{-1} (black fill), and 10-m winds (barbs) for a WRF simulation of the Mechanicville, NY supercell.*

NWS Interactions:

William Flamholtz presented a research update to NWS Focal Points at the Spring CSTAR Meeting on 15 May 2018, coincidentally during a severe weather outbreak in the Northeast U.S.. The NWS Focal Points provided feedback on how the research may aid them in improving situational awareness and forecasts of severe convection in complex terrain. In particular, Mike Evans stated that it would be useful for William to come up with a conceptual model for environment(s) that are favorable for strong-terrain influences versus a different conceptual model for environment(s) that are not as favorable. There was also discussion of the WRF simulation setup and other events that would be useful to examine. The discussion continued after the CSTAR meeting through e-mail in order to guide future directions for the research to make it more operationally relevant, in addition to addressing basic scientific questions about convective behavior in channeled flow.

William Flamholtz, Luke LeBel, Brian Tang, and Ross Lazear also had discussions with NWS forecasters at the 29th AMS Severe Local Storms Conference in Stowe, VT in October. William and Luke both received questions and feedback about their research, which have helped to generate more ideas and guide future research.

References:

Bosart, L., A. Seimon, K. LaPenta, and M. Dickinson, 2006: Supercell tornadogenesis over complex terrain: The Great Barrington, Massachusetts, tornado on 29 May 1995. *Wea. Forecasting*, **21**, 897–922.

Katona, B., P. Markowski, C. Alexander, and S. Benjamin, 2016: The Influence of topography on convective storm environments in the eastern United States as deduced from the HRRR. *Wea. Forecasting*, **31**, 1481–1490.

LaPenta, K., L. Bosart, T. Galarneau, and M. Dickinson, 2005: A multiscale examination of the 31 May 1998 Mechanicville, New York, tornado. *Wea. Forecasting*, **20**, 494–516.

Rotunno, R., J. Klemp, and M. Weisman, 1988: A theory for strong, long-lived squall lines. *J. Atmos. Sci.*, **45**, 463–485.

b) High-resolution numerical forecasts of lake-effect snowstorms: model performance, physics sensitivities, and synoptic predictability

Graduate student: Massey Bartolini

PIs and co-PIs: Justin Minder, Daniel Keyser, and Ryan Torn

NWS focal points: Joseph Villani (ALY) and David Zaff (BUF)

Research summary:

Research has continued to focus on the model physics uncertainties within the microphysics (MP) and planetary boundary layer/surface layer (PBL/SL) parameterization schemes. During June 2018, Massey Bartolini, the graduate student assigned to this project, traveled to Boulder, CO, for three weeks to attend the NCAR Advanced Study Program (ASP) Summer Colloquium focused on comparing modeled and observed cloud properties, and to present project updates to the ESRL–HRRR development team and to Craig Schwartz (NCAR). Massey and Justin also presented results from model physics evaluations to the ESRL HRRR team and scientists from NOAA Great Lakes Environmental Research Lab (GLERL) during a conference call in August. Results were also presented at several local, national, and international meetings, as listed below.

As introduced in previous reports, we have continued analyzing a suite of HRRR-like WRF simulations of OWLeS IOP2b. The previous report described our efforts to characterize the bulk differences in precipitation types and cloud liquid water path (CLWP) between members of a microphysics ensemble, and verify the WRF output against ground-based radar and radiometer observations. More recently, additional analyses have compared airborne in situ measurements of precipitation particle size distributions (PSDs) against model-derived PSDs from the control HRRR-like WRF simulation using Thompson aerosol-aware microphysics. Massey learned how to compute the model PSDs for a project during the ASP Summer Colloquium.

Results of the PSD comparisons show that the control simulation has adequate concentrations of small particles, but under-predicts the number of larger particles greater than 2–3 mm during most of the flight legs (Fig. 5). Within the microphysics scheme, the errors in the PSD translate to an under-prediction of the large particles' mass and fall velocities, which allows the hydrometeors to travel further downwind of Lake Ontario. By adjusting the PSD equation in the model to be more representative of the observations, the resulting sensitivity experiment increases liquid equivalent precipitation amounts by 5–10 mm on the windward side of the Tug Hill Plateau and reduces precipitation on the leeward side. This reduces the model's low windward precipitation bias relative to surface snow measurements and radar-derived precipitation estimates. Additional sensitivity experiments are ongoing to continue exploring PSD sensitivity and snow crystal habit assumptions within the Thompson scheme.

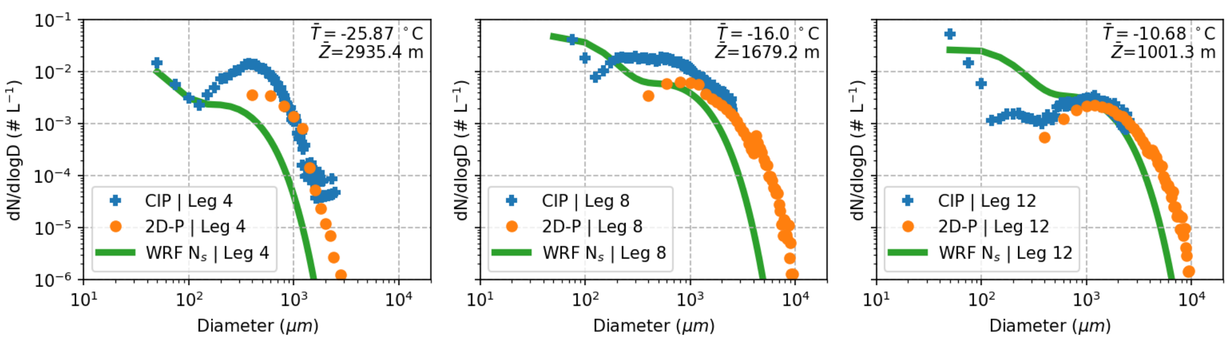

Figure 5: *Snow-band average particle size distributions along three University of Wyoming King Air (UWKA) flight legs during OWLeS IOP2b, from a wing-mounted Cloud Imaging Probe (CIP, blue plus signs) and 2D-Precipitation probe (2D-P, orange circles) and model-derived PSDs from the WRF control simulation with Thompson aerosol-aware microphysics (green line). WRF output from the nearest model time step is interpolated to the same location and altitude as the UWKA flight legs, with leg-average temperature and altitude indicated at the upper right corner of each panel.*

In the previous report, preliminary PBL/SL research was introduced for three case studies over Lakes Ontario, Erie, and Superior. Since then, we have run additional PBL/SL ensemble members for the Lake Ontario case (OWLeS IOP2b) and for the Lake Superior case (11 February 2016). Comparisons between the ten-member ensembles show a large range in sensible and latent heat flux amounts, as expected. Verification against the Great Lakes Evaporation Network lighthouse lake-air turbulent flux measurements indicates the highest-flux schemes such as the Quasi-Normal Scale Elimination (QNSE), Asymmetric Convective Model (ACM), and sometimes Mellor-Yamada-Janjic (MYJ), have unrealistically large sensible and latent heat fluxes, while other schemes, such as the MYNN scheme used in the HRRR, have reasonable representations of the fluxes. These differences in fluxes lead to large differences in predicted snowfall. Sensitivity experiments for both case studies indicate that the QNSE SL scheme can be tuned to resemble lower-flux ensemble members by changing the Prandtl number and friction velocity threshold used in the over-water roughness calculation.

During the next six months, we will work to complete our remaining sensitivity experiments with the Thompson MP scheme, and analyses for both the MP and PBL/SL results. During early 2019 we will submit two manuscripts, one for each of our MP and PBL/SL research topics, for publication in AMS journals. Massey will present some of our MP results from OWLeS IOP2b at the AMS Annual Meeting in Phoenix, AZ, during January 2019. We will summarize operationally relevant aspects of our results to share with forecasters through VLab and will continue to communicate with the ESRL HRRR development team.

c) Applying forecast track and intensity diagnostics to high-impact Northeast winter storms

Graduate student: Tomer Burg
PI and co-PIs: Andrea Lang, Ryan Torn, and Kristen Corbosiero
NWS focal points: Neil Stuart (ALY), Joseph Dellicarpini (BOX), and Justin Arnott (GYX)

Research summary:

The goal of this project is to identify and quantify any systematic biases with forecasts of high-impact Northeast U.S. winter cyclones to improve situational awareness during the forecast process. Over the six-month reporting period, work consisted of (a) refining the objective cyclone identification and tracking algorithm to capture the array of cyclone lifecycles, and (b) creating composites of cases categorized by forecast bias. In evaluating the cyclone identification methodology, it was determined that using a hybrid of 925-hPa vorticity averaged over a 700-km radius and 925-hPa geopotential height minima as metrics to identify Northeast U.S. winter storms was the most reliable for tracking cyclones in both the reanalysis and reforecast data. The previous iteration of the cyclone tracking algorithm was 850-hPa area-averaged vorticity based. Our analysis showed that the previous algorithm missed numerous fast moving, developing cyclones off the coast of the Northeast. These missed cyclones had a closed surface low but lack of a height minimum at 850-hPa in early stages of the cyclones' life cycles; thus, the old tracking algorithm missed these developing cyclones and greatly reduced the sample size. Applying the new tracking algorithm increased the number of cases from 308 to 516, out of a set of 601 preliminary identified potential cases from the Sprenger et al. (2017) cyclone track dataset following the methodology described in prior CSTAR reports. The track density of all the identified cases is shown in Figure 6.

The new version of the cyclone identification and tracking algorithm was applied to the GEFS Reforecast data corresponding to zero- to five-day lead times for the 516 cases identified. Figure 7 shows an example of the new track output for the 1993 Superstorm using the Reforecast ensemble forecast initialized at a 126-h forecast lead time, representing the five-day lead time. Using the newly available climatology, the calculations that were done in the previous CSTAR report including left vs. right of track biases were redone with the new set of cases. Using the 40˚N/70˚W benchmark as the verification location, short-forecast lead times, particularly prior to 60 h, exhibited a slight left of track (LOT) bias, but a prominent slow bias. Figure 8 depicts the along vs. across track bias for forecast hour 48 showing the slow bias.

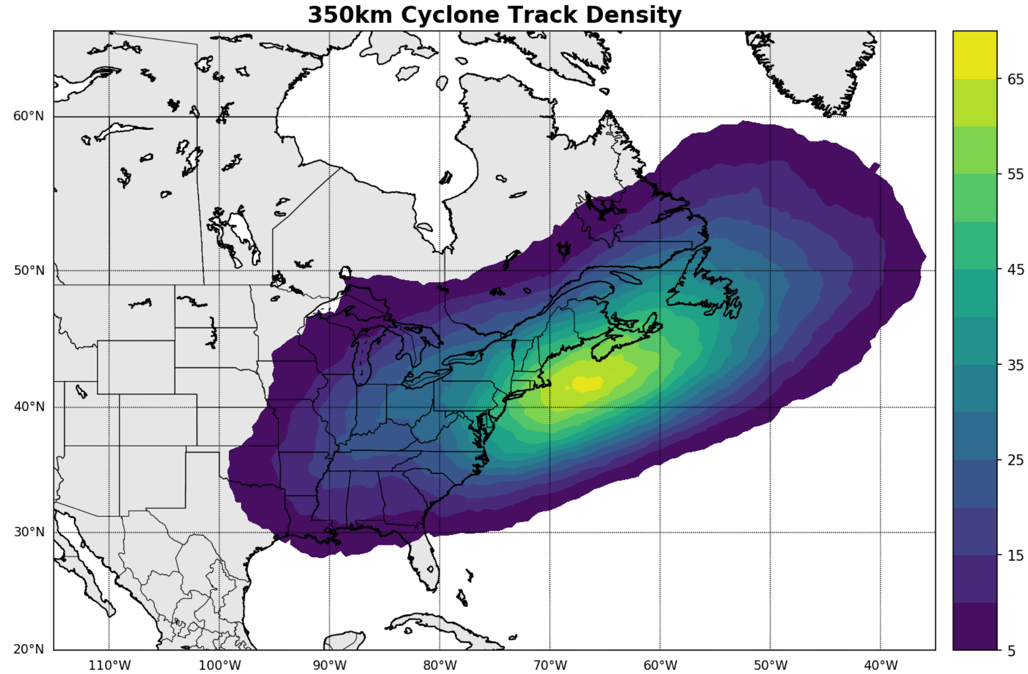

Figure 6: *350-km track density plot for all 516 cases that were identified. The values are normalized relative to the total number of cases, and range from 0 to 100% of all cases within a 350-km radius of any given point.*

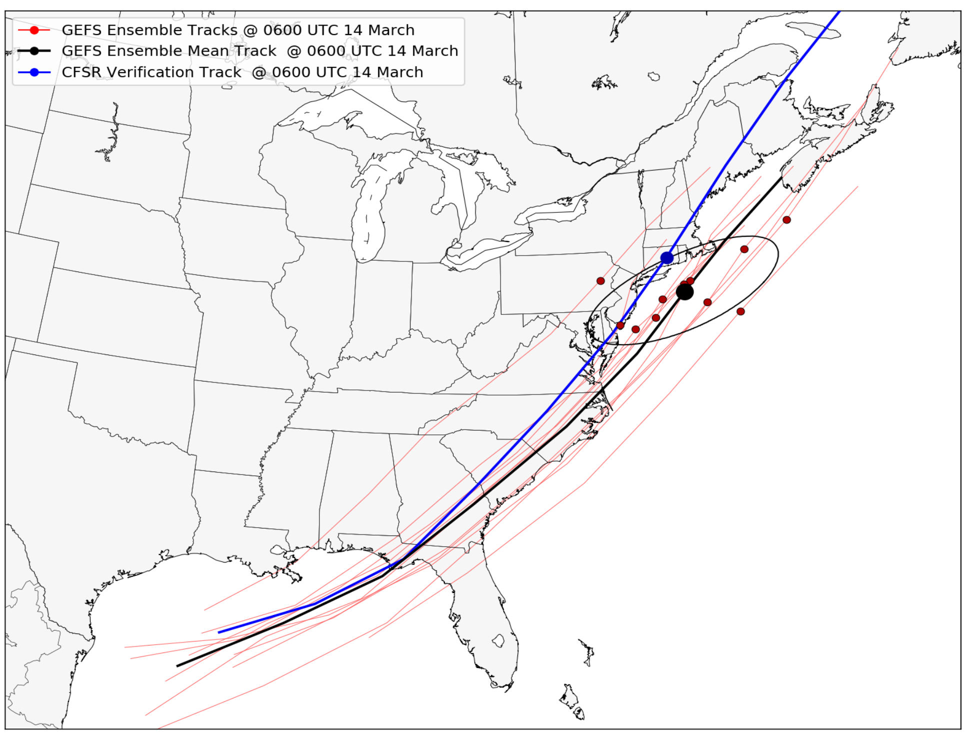

Figure 7: *Example of the tracking algorithm applied to the GEFS Reforecast ensembles initialized 0000 UTC 9 March 1993 for the 13–14 March 1993 cyclone. Ensemble tracks are in red, ensemble mean track is in black, and CFSR verification is in blue, with positions valid at 0600 UTC 14 March. The ensemble spread ellipse following the methodology of Hamill et al. (2011) is denoted by the black ellipse.*

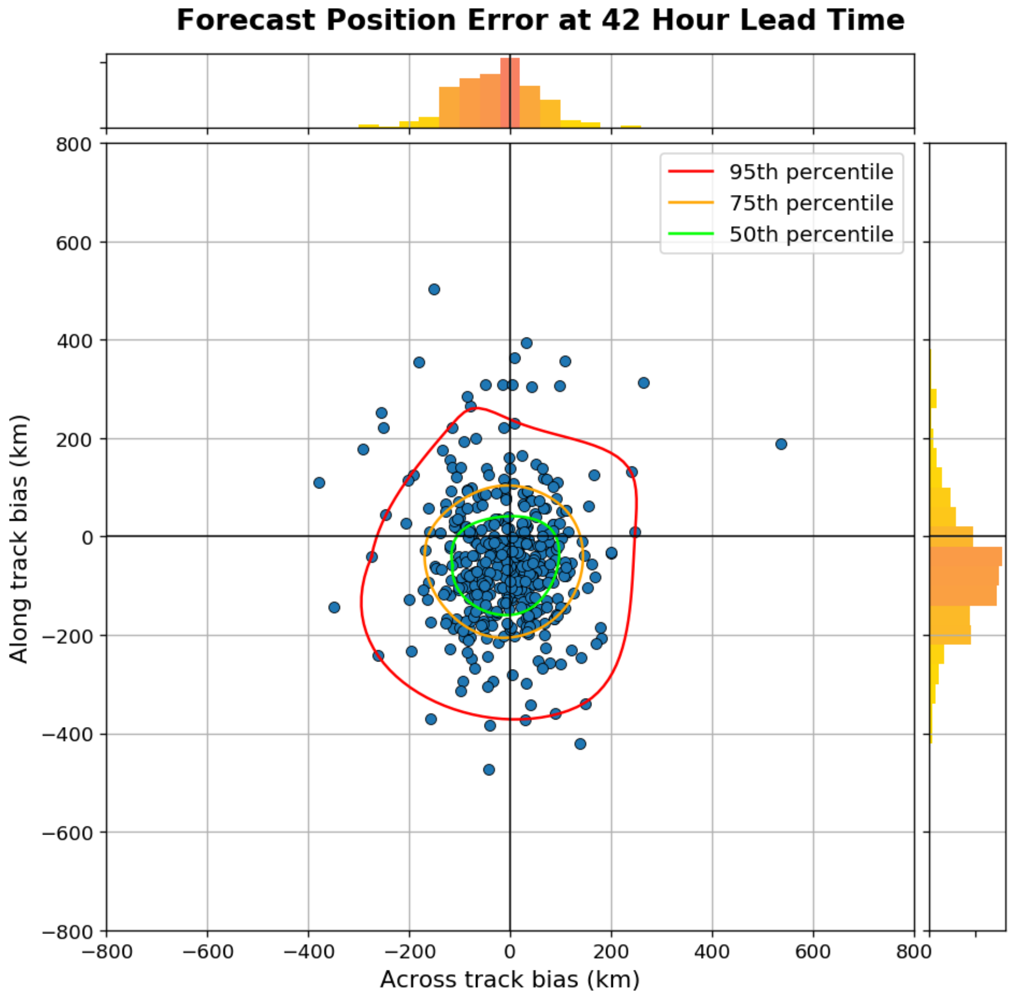

Figure 8: *A two-dimensional plot of the along- and across-track errors for the ensemble means of all cases with seven or more ensemble members. The origin point is the location of verification and the storm motion vector is pointing up. Histograms on the top and right sides represent the fraction of all cases that are located within the 50-km bin and color-coded by the number of cases in each bin, where a higher number corresponds to a darker color.*

Composite were created for groups of cyclones showing LOT and right of track (ROT) biases. To be added to the LOT or ROT groups, cases had to meet the following criteria: a bias greater than 50 km in the same direction at both two-day and three-day lead times, as well as exhibit the bias for 12 consecutive hours surrounding the time the cyclone was closest to the benchmark (to ensure spatial and temporal consistency of the bias). Cases that tracked within 250 km of the benchmark were retained, as to avoid significant smoothing of the composites due to spatial variability of the observed cyclones. This approach yielded 19 cases for a LOT bias and 24 cases for a ROT bias. The relative lack of cases meeting the criteria suggests that most cases do not have a consistent bias across medium-range forecast lead times. For cases that do have a bias, Figure 9 illustrates the difference between the 500-hPa fields of the LOT and ROT cases at the time they tracked closest to the benchmark. The results suggest that cases with a ROT bias tend to have a more amplified meridional flow, likely associated with cyclones originating at a more equatorward latitude. The hypothesis is that these cases tend to advect more

Gulf of Mexico moisture poleward, leading to stronger diabatic amplification of the downstream ridge. This hypothesis is currently under investigation.

Ongoing work involves creating additional composite groups for various error and bias types, such as intensity errors, ensemble spread relative to climatology, and whether variability for a given case is along or across track dominant. Some work has additionally been done to create an interactive website to display past cases and ensemble data for those cases, as a tool that can be referenced by forecasters in the R2O stage. Tomer Burg, the graduate student working on this project, additionally met with his NWS Focal Point Neil Stuart prior to the end of the six-month period to discuss the latest research findings, including the modifications made to the tracking algorithm, to ensure that the changes made to the algorithm can be viewed as useful from an operational forecaster's perspective.

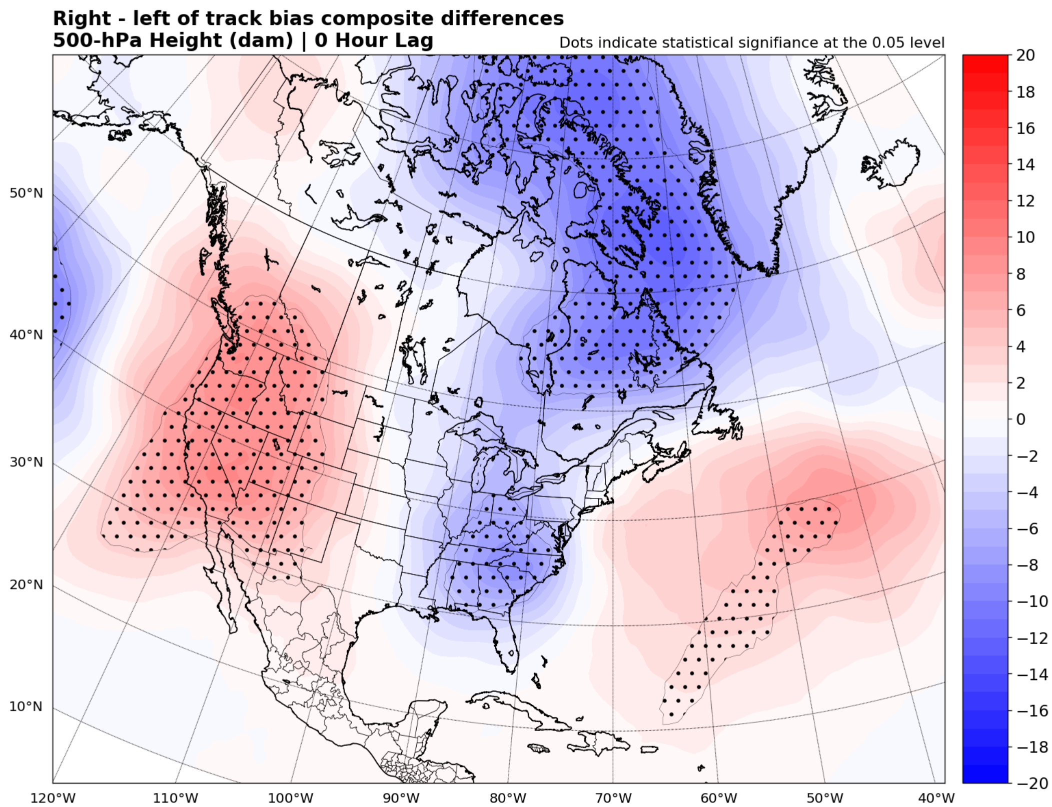

Figure 9: *Difference between ROT minus LOT bias cases for 500-hPa geopotential height (dam), with statistical significance at the 0.05 level dotted.*

References:

Hamill, T. M., J. S. Whitaker, M. Fiorino, and S. G. Benjamin, 2011: Global ensemble predictions of 2009's tropical cyclones initialized with an ensemble Kalman filter. *Mon. Wea. Rev.*, **139**, 668–688.

Sprenger, M., G. Fragkoulidis, H. Binder, M. Croci-Maspoli, P. Graf, C.M. Grams, P. Knippertz, E. Madonna, S. Schemm, B. Škerlak, and H. Wernli, 2017: Global climatologies of Eulerian and Langrangian flow features based on ERA-Interim. *Bull. Amer. Meteor. Soc.,* **98**, 1739–1748.

2. CSTAR VI PROJECT THESES, PRESENTATIONS, AND PUBLICATIONS

a) Theses completed

None

b) Presentations

Minder, J. R., and W. M. Bartolini, 2018: Characterizing and constraining uncertainties in convection permitting simulations lake-effect snowfall associated with parameterization of surface fluxes. Poster presentation at the *8th GEWEX Open Science Conference*, 8 May, Canmore, Alberta, Canada.

Burg, T., A. L. Lang, K. L. Corbosiero, and R. D. Torn, 2018: Applying forecast track diagnostics in high-impact Northeast winter storms: Climatology and case analysis. Oral presentation at the *29th Conference on Weather Analysis and Forecasting/25th Conference on Numerical Weather Prediction*, 4 June, Denver, CO.

Bartolini, W. M., J. R. Minder, C. S. Schwartz, D. Keyser, and R. D. Torn: Multiscale frontal circulations during the 6–8 January 2014 lake-effect snow event: Understanding their superposition and predictability using convection-permitting ensemble forecasts. Poster presentation at the *29th Conference on Weather Analysis and Forecasting/25th Conference on Numerical Weather Prediction,* 5 June, Denver, CO.

Minder, J. R., and W. M. Bartolini, 2018: Convection-permitting simulations lake-effect snowfall response to climate change: Understanding and constraining uncertainties associated with surface and boundary layer turbulence. Oral presentation at the *GEWEX Convection-Permitting Climate Modeling Workshop II,* 5 September, National Center for Atmospheric Research, Boulder, CO.

Minder, J. R., and W. M. Bartolini, 2018: Convection-permitting simulations lake-effect snowfall response to climate change: Understanding and constraining uncertainties associated with surface and boundary layer turbulence. Oral presentation *GEWEX Convection-Permitting Climate Modeling Workshop II,* 5 September, National Center for Atmospheric Research, Boulder, CO.

Frugis, B. J., 2018: Using specific differential phase to predict significant severe thunderstorm wind damage across the Northeastern United States. Poster presentation at the *29th AMS Severe Local Storms Conference*, 22 October, Stowe, VT.

Wasula, T. A., and B. J. Frugis, 2018: Albany forecast area significant hail climatology and case studies. Poster presentation at the *29th AMS Severe Local Storms Conference*, 22 October, Stowe, VT.

Flamholtz, W., B. Tang, and L. Bosart, 2018: Evaluating the effects of terrain-channeled, low-level flow on convective organization. Oral presentation at the *29th AMS Severe Local Storms Conference*, 23 October, Stowe, VT.

LeBel, L., B. Tang, and R. Lazear, 2018: Examining terrain effects on the 31 May 1998 Mechanicville, New York supercell and tornado. Poster presentation at the *29th AMS Severe Local Storms Conference*, 23 October, Stowe, VT.

Wasula, T. A., B. J. Frugis, and M. S. Evans, 2018: A multiscale analysis of the 18 May 2017 severe weather event across eastern New York and western New England. Poster presentation at the *29th AMS Severe Local Storms Conference*, 25 October, Stowe, VT.

c) Refereed publications

None

3. RESEARCH TO OPERATIONS

Updates to the Albany CSTAR Virtual Lab (VLab) community page are ongoing. After the page was made public, pages and subpages were organized, and some unused pages were removed in order to make the page more easily readable, and operationally relevant products more accessible.

As has been produced for CSTAR V, work was begun on developing quick references for earlier CSTAR research, especially those projects where conceptual models and/or operational guidelines were produced. The first CSTAR projects to be added to the page and linked to with keywords via the AWIPS Interactive Reference (AIR) tool are:

- *Cool-season high wind events in the Northeast U.S.*
- *Precipitation distribution in cool-season 500-hPa cutoffs in the Northeast U.S.*
- *Predecessor rain events in advance of tropical cyclones*
- *Synoptic and mesoscale patterns associated with ice storms in the Northeast U.S.*

Lastly, CSTAR VI students are producing webpages with tools and products that can be used operationally, and a new tab (*Web Tools*) will be created on the VLab to link to these pages.

4. NWS PERSPECTIVE ON CSTAR VI PROGRESS *(Michael Evans, SOO WFO ALY)*

Progress continues on the initiative to migrate Albany CSTAR training materials and research findings to NOAA's VLab in order to facilitate increased research to operations for our projects. Ross Lazear is working with our information technology officer Vasil Koleci on the CSTAR VLab page. This page now contains reports and Masters theses, as well as cold-season and warm-season quick reference graphics. Links to recorded training will also be added to the page in 2019. Reference material from the research is also available to forecasters via the AWIPS Interactive Reference Tool. This tool allows operational forecasters to access VLab material with a mouse click on a product legend.

Research continues on the three Major Projects of CSTAR VI, including Tomer Burg's work on track and intensity errors in major Northeast U.S. winter storms. NWS Focal Points for this project are Neil Stuart from NWS Albany, Joe Dellicarpini from NWS Taunton, and Justin Arnott from NWS Grey. The goal of this research is to compare observed low pressure tracks to GEFS forecast tracks for a large number of storms, in an effort to identify patterns that may help forecasters to better utilize the ensemble data to determine the most likely storm tracks within ensemble track envelopes. Tomer is working on a diagnostic tool that will aid forecasters with this effort.

In addition to the results reported upon above, Tomer has developed plots of track biases in ensemble forecasts at lead times of 0–120 ho and has some preliminary findings with the mean positions and biases, but more research is needed to be sure the conclusions are scientifically valid. Tomer showed Mike Evans histograms and centroid relative plots of track errors in ensemble members at various forecast times, showing varying errors at various lead times. He also showed spaghetti plots of ensemble track errors at different lead times for various historical storms, showing how biases vary with differing lead times. Future plans are to create trend plots for various lead times to determine if there are consistent spatial and temporal biases from long-term to short-term lead times. Once the analyses are complete, Tomer will be consulting with Neil Stuart, Joe Dellicarpini, Justin Arnott, and other NWS personnel on what results would be useful for operational forecasters.

During a 17 October meeting with Neil Stuart, he told Tomer that graphics of biases at different time steps and conceptual models at different forecast times are helpful. Tomer envisions R2O while doing his research and many of his draft graphics are in formats intended for operational applications. Neil also told him that conceptual models and graphics at standard heights are most useful for operational applications and that has always been an important consideration during his research.

The second Major Project is work by Massey Bartolini on the predictability and variability of lake-effect snow bands. Massey is looking at how well high-resolution models simulate severe lake-effect storms. In particular, he is investigating model physics sensitivity, multi-scale predictability, and ultimately model performance. He is using the extensive observational datasets gathered during OWLeS.

Joe Villani was able to meet with Massey on 21 June 2018 to discuss his project and familiarize him with lake effect snow forecast methodologies in the Albany forecast area. As part of the project, Joe will be conducting a local study with regards to hi-resolution model output (from the 3 km NAM and HRRR) and inland extent of lake effect snow bands. This would be an extension of his prior lake effect snow research mentioned in the Future Work section of the NWA JOM paper, *https://member.nwas.org/sites/default/files/nwa_pubs/2017-JOM5.pdf*. This project will utilize a new capability in the GAZPACHO program (upcoming build November 2018) that will allow for comparison of hi-resolution model data to observed snowfall. Over the same time frame for an event, the program will compare the observed snowfall analysis to the positive snow depth change in the 3 km NAM and HRRR. This project will begin during the upcoming 2018–2019 snowfall season.

The final Major Project of CSTAR VI is work examining severe convection in complex terrain, started by Pamela Eck and continued by Will Flamholtz. The NWS Focal Points are Tom Wasula, Michael Evans, and Matt Kramar. Kat Hawley from NESDIS is also working with Will on the project and supplied some satellite imagery to William for a case that he is working on.

Mike Evans and Tom Wasula have met with Will to discuss potential operational benefits and applications to his research. After Will's presentation at our May CSTAR meeting, Mike submitted a review of Will's work to Will and his advisors, from an operational perspective, including some thoughts on how the work could apply to operations. Mike's thoughts were that a good outcome of this research would be if conceptual models or synoptic patterns could be identified that are favorable vs. unfavorable for strong topographic influences on convection. If the cases examined in the research could ultimately be divided into a large-terrain-effect case data set and a small terrain-effect data set, synoptic pattern differences between these data sets could be examined to give forecasters an idea of what to look for when trying to identify cases that will be particularly susceptible to topographic influences.

Kat has also been in contact with Will a few times to discuss the project. Kat was unable to attend the CSTAR meeting; however, she was able to review Will's presentation. She noted that both the NT and T runs of the WRF did a poor job simulating the convection that developed over New England for his case, which was possibly in association with a back-door cold front. She wondered whether that had an impact on the rest of the simulation. Kat also believes that expanding the study to several cases to compare and contrast terrain effects will ultimately be required for this study to be useful operationally.

5. STATUS OF "SNYDER PLAN V" PROJECTS *(Michael Evans and focal points)*

Work continues on the Collaborative and Associate Projects of CSTAR VI, details of which are presented below. Six NWS offices are participating in this work.

CSTAR VI Collaborating and Associate Projects

1. Assessment of polygon-based lake effect warnings

Team lead: Jon Hitchcock (BUF)

Dave Zaff at WFO Buffalo (BUF) is leading the effort to expand polygon-based warnings for lake effect snow to other sites within the National Weather Service. Dave has worked with Jeff Waldstreicher at Eastern Region Headquarters, Jared Klein at WFO Binghamton (BGM), and Michael Evans at WFO Albany (ALY) to develop an experiment where BGM and ALY will begin issuing polygons this winter in collaboration with WFO BUF. This effort will ultimately become part of a nation-wide National Weather Service effort to increase collaboration of issuance of high-impact weather information across multiple forecast offices. In addition, verification of polygons will continue this winter, with verification efforts beginning at ALY, as well as continuing at BUF.

2. Expansion of Buffalo high wind study and decision aide to other offices

Team lead: Shawn Smith (BUF)

Work associated with this study was completed and an Eastern Region Technical Attachment was published based on this work in 2017:

Smith, S. 2017: High wind events in western New York: An expanded study and development of potential impact tables. *Eastern Region Technical Attachment*.

3. Improving forecasts of snow along the west-facing slopes of the Appalachians

Team lead: Matt Kramer (PIT)

Work has not yet begun on this project.

4. Integrating advanced boundary layer physics and theory into operations

Team lead: Ian Lee (DTX)

Nothing new to report.

5. Heat waves/extreme heat events in the Northeast United States

Team leads: Neil Stuart and Kevin Lipton (ALY)

a. The apparent temperature threshold for Heat Advisories in upstate New York changed from 100°F to 95°F during the summer of 2018. This change was accomplished through the research collaboration between the NY State Department of Health and NWS Albany, NY under the NASA ROSES grant.

b. The NYSDOH is continuing to redesign their interactive map of counties with links to the nearest 10 cooling centers from where a person clicks on the map. They intend to include multi page analyses showing the vulnerability of various demographics on GIS based maps. The NWS will be listed as a resource and links to NWS heat information will be provided. New fact sheets will be available along with the cooling center links.
c. The NYSDOH submitted a paper to the journal "Environmental Health" with Neil and Steve as coauthors. It is titled, "Estimating policy-relevant health effects of ambient heat exposures using spatially contiguous remote sensing reanalysis data".
d. The NYSDOH began a study on the health effects of extreme precipitation. This is an extension of the satellite temperature study. They are consulting us on how best to use the satellite data to evaluate extreme precipitation. They are determining whether there is a correlation between satellite and airport data. They may look into adding radar data or multi sensor data for their analyses. Winter is a challenge, especially with snow measurement and conversions of snow to liquid equivalent.
e. The NYSDOH will be analyzing the 90th percentile of the maximum rainfall for each day and each month. They will eventually try to relate extreme precipitation with health issues similar to the temperature studies. They will also consult the Northeast Regional Climate Center for their methodology in past studies of the 90th percentile for precipitation in some of their past studies.
f. Dr. Shao Lin and her colleagues at the UAlbany School of Public Health published a paper to the October 2018 volume of the journal "Science in the Total Environment" with Neil, Steve, and Kevin as coauthors. The title is, "Does wind chill temperature better predict the risk of cardiovascular disease than temperature only in cold seasons?".
g. Dr. Shao Lin also has sent a draft proposal for a new National Institute of Health research grant to assess how multi-weather factors or large temperature variation and air pollution jointly affect human health. Neil, Steve and Kevin would act as consultants providing weather data and analysis if this proposed research grant becomes funded. The Atmospheric Science Research Center and the NY State Department of Health are also included in this proposed research grant.
h. Kevin Lipton and Neil Stuart attended a NIHHIS workshop, which was held in Westborough, MA to discuss heat health decision-making in the Northeast U.S. The workshop was organized by Hunter Jones from the NOAA Climate Program Office and Ellen Mecray, the NOAA Eastern Region Climate Services Director. It was very unique in that it brought together a wide variety of agencies and professions, including doctors, big city health department officials, an athletic race director, a graduate student in the Environmental Health and Engineering Dept. at Johns Hopkins University, the Northeast Regional Climate Center in Ithaca, NY, NWS Forecast Office personnel from both Norton, MA and Albany, NY, among others. Besides providing the opportunity to network and learn from heat health experts in New England, a main goal of the workshop was to improve understanding of New England's most heat-vulnerable populations, interventions needed to be taken to reduce their risk, and how best to implement these. We broke into groups and attempted to develop "decision calendars", which give a timeline for actions taken years before an event all the way up to the immediate actual heat wave.

i. Kevin Lipton has proposed a workshop or seminar on extreme heat in 2019. This would be a collaboration with the UAlbany Departments of Atmospheric Science and the School of Public Health and Public Policy. Local media and other NWS offices in the region would also participate. This possible workshop or seminar is in the very early planning stages.

6. Develop methods/best practices for development of conceptualized models for (parameter) use by operational forecasters using previous event analysis/reanalysis

Team lead: Alan Cope (PHL)

Nothing new to report.

7. Development of IFR climatologies for inland TAF sites

Team lead: Joseph Dellicarpini (BOX)

Discontinued due to short-staffing and other commitments.

8. Development of improved WSR-88D warning criteria using dual polarization datasets

Team leads: Tom Wasula and Brain Frugis (ALY)

a. Tom attended and presented at the 15 May 2018 CSTAR meeting that was held at the NWS conference room. The title of his talk was, "Albany forecast area significant hail climatology and case studies". Brian Frugis was a co-author. Results from the initial study showed that the Albany forecast area has only 59 significant hail reports (2" or greater in diameter hail stones) from 1950 to March 2018. Columbia County had the most reports with eight and Albany was second with seven reports. Two counties in the forecast area have never had a report (Hamilton and Schoharie Counties). Thirty-four out of the 59 reports (57.6%) were 2" diameter or hen egg/lime size. The greatest number of significant hail events happened in June with 25, and 68% occurred in May and June (40 reports). All the events happened in May to September. Incredibly, there has been a dramatic increase in reports since 2000, with 76% (45) of the reports occurring the past few decades, which may be attributed to increased number of spotters, social media, and advanced technology. Composites of 20 cases/events days with the NCEP/NCAR reanalysis data from 2000–2017 showed a strong, negatively-tilted trough over the Great Lakes Region and Northeast with a dual low-pressure system over the Mid-Atlantic Coast and Great Lakes Region with a strong upward velocity maximum over the Northeast. The significant severe weather events of 1, 8, and 9 June 2011 were also briefly reviewed where 13 significant hail reports occurred. A common theme was thick CAPE, strong deep shear of ≥40 kt, and steep mid-level lapse rates or elevated mixed layers. There have been 16 significant hail reports in the dual-polarization era at KENX from May 2012 to the present.
b. Tom gave a poster presentation at the *29th AMS Severe Local Storms Conference* in Stowe, VT (22–26 October 2018) entitled, "A multiscale analysis of the 18 May 2017 severe weather event across eastern New York and western New England". Brian Frugis and Mike Evans were co-authors. New York State Mesonet data and performance of the High Resolution Ensemble Forecast (HREF) Versions 1 and 2 are used in the analysis. Some initial results in terms of this case include: 1) an anomalously warm air mass was in place with temperatures and heights aloft a few standard deviations above normal; 2)

moderate instability and 0–6-km bulk shear of 40 kt or greater supported discrete mini-supercells evolving into QLCS and finally a squall line; 3) extreme DCAPE coupled with steep low-level lapse rates (inverted-V signature) supported a fairly widespread and significant damaging wind threat; 4) mid-level lapse rates were also impressive with an elevated mixed layer in the 1800 UTC KALB sounding; 4) elevated reflectivity cores (application of the 1" hail study results), ZDR arches, and KDP spikes or collapsing KDP columns helped with warning decision making for severe hail, damaging winds, and the Queensbury–Kingsbury macroburst; 5) the NYS Mesonet was very helpful with warning decision making and verification; and, 6) the 1200 UTC HREF v2 did fairly well over the Albany forecast area with looking at the neighborhood or smoothed probabilities 1-km probability of reflectivity > 40 d BZ and the 2–5-km max updraft helicity > 25 $m^2 s^{-2}$.

c. Tom gave a second poster presentation at the *29th AMS Severe Local Storms Conference* entitled, "Albany forecast area significant hail climatology and case studies". Brian Frugis was a co-author. The main results reported are summarized in (a) above. One additional item completed for the poster was an extensive KALY observational sounding analysis on all the hail event days (32 days). KALY soundings were analyzed and key parameters were used to make box and whisker diagrams. The parameters examined were CAPE (MLCAPE or SBCAPE), 0–6-km shear, wet bulb zero heights, equilibrium levels (EL), and 700–500-hPa lapse rates. The CAPE showed a range of variability with a medium value of a 1041 J/kg, with the 0–6-km shear having a median value of 41 kt, the wet-bulb zero heights median value around 11.5 kft AGL, the EL median value of 11,458 ft, and the 700–500-hPa lapse rates were a little low at 6.0^{0}C/km. The 75th percentile 700–500-hPa lapse rate was 6.5^{0}C/km and the 90th percentile was 7.0^{0}C/km. This result may need to be further analyzed by looking at a steeper layer, 850–500 hPa, or proximity soundings.

9. Assessing the relationship between flash flooding verification and values of instantaneous precipitation rate (DPR)

Team lead: Ian Lee (DTX)

Due to time constraints, this project has been discontinued.

10. Explore and assess use of MRMS in warning operations

Team lead: Ian Lee (DTX)

Ian is currently involved in writing a journal article based on research on this topic while he was stationed at Miami. He has collected 50 cases for additional examination from southeast Michigan.

11. Verification of gridded ceiling and visibility forecasts at Taunton, MA

Team lead: Joseph Dellicarpini (BOX)

Nothing new to report.

12. Expanding Decision Support Services

Team lead: Brian Montgomery (ALY)

The main accomplishment in this area was the rollout of national IDSS training in September. The plan moving forward is to continue to evolve our decision support services independently from the CSTAR program.

13. A climatology of damaging QLCS storms that produce mesovortices

Team lead: Matt Kramer (PIT)

Nothing to report at this time.

14. Expressing uncertainty with lake-effect snow in the ER probabilistic snow project

Team lead: Matt Kramer (PIT)

Work has not yet begun on this project.

15. An expanded analysis of BUFKIT methodologies to forecast wind and wind gust speed for the upper Ohio River Valley

Team lead: Matt Kramer (PIT)

Nothing new to report at this time.

16. R2O and CSTAR project support by UAlbany undergraduate interns

Team lead: Vasil Koleci and Michael Evans (ALY)

Ross Lazear and Vasil Koleci continue to work on the VLab page, which will act to transition findings related to the CSTAR research to operations. All past CSTAR thesis and some conceptual models have been added to the page. Recorded training based on CSTAR research will be added in 2019. The AWIPS Interactive Tool has been setup with CSTAR projects that have been uploaded to VLab.

17. A study of severe thunderstorm winds

Team lead: Brian Frugis (ALY)

Brian Frugis has been working on a project to use the dual-pol radar product Specific Differential Phase (KDP) to help improve warning guidance for significant severe thunderstorms. Over the past six months, he reanalyzed the 46 cases of significant severe thunderstorm wind damage across the Albany area from 2012 to 2017. Brian went back to examine data at the time of significant damage, as well one and two radar scans before damage occurred. When doing this, he found high values of KDP aloft have a tendency to lower towards the surface by the time of damage. While this technique seems best when used with supercells, it also does have some utility for squall line events as well. The depth of the mixing layer was shown to not have a strong influence if high KDP cores are able to make it to the surface, although low-level lapse rates were typical rather steep within the mixed layer. WFO Albany staff has been examining KDP during warning operations over the past severe weather season. The staff has mentioned to Brian on several occasions that this methodology has been helpful in anticipating wind damage.

Brian presented these findings at the *29th AMS Severe Local Storms Conference* in Stowe, VT in poster format on 22 October 2018. Feedback was positive. In addition, he has written these finds into a draft paper for publication, which is undergoing local review and will be sent to ER SSD shortly.

6. COMPUTER AND TECHNOLOGY TRANSFER ISSUES *(David Knight)*

Computing infrastructure continues to play an important and integral part in this collaborative effort. Students are exposed to NWS facilities and software, and NWS staff has access to capabilities not available in the local office. Both groups benefit from this interaction and sharing of facilities. Several Linux workstations and PCs are available for use by CSTAR participants. Approximately 9 TB of disk space on the UAlbany Department of Atmospheric and Environmental Sciences (DAES) servers is dedicated to storing CSTAR related data and software. This disk space is available on all DAES workstations and provides a central location where both UAlbany and NWS personnel can store, process, and exchange large datasets. Each CSTAR student has a PC or Mac laptop, which enables them to take familiar computers with them when visiting NWS staff, and provides them ready access to the DAES UNIX machines. CSTAR Email lists originally created on the DAES computers at the beginning of the project have been superseded by the "map" list (*map@listserv.albany.edu*). The "map" list reaches a much larger audience (out of 821 members, more than ¼ are from NOAA), allowing discussion of CSTAR related research among many more people.

NWS Albany staff took the lead in maintaining content for the CSTAR webpage at *http://cstar.cestm.albany.edu*. The web page provides an additional mechanism for exchanging information and ideas. The NWS also runs a CSTAR forum and discussion group at *http://infolist.nws.noaa.gov/read/?forum=cstar_ne*. The DAES web server (*http://www.albany.edu/atmos*) and ftp server (*ftp://ftp.atmos.albany.edu*) are being used to facilitate exchange of large datasets between CSTAR collaborators. The DAES computing resources are available for CSTAR related research including a Linux server (with 32 CPUs and 256 GB RAM) and two large network attached disk storage arrays (85 TB total usable space). While CSTAR money was not used for this, and the machines were not bought specifically for CSTAR use, they nonetheless directly benefit the CSTAR research by providing much faster servers for computation and storage space for commonly used datasets. A Linux server (Peebles) with 48 cores, and 128 GB RAM, dedicated to CSTAR computations was recently purchased. This computer will facilitate increasingly complicated computations.

In addition to DAES, and NWS computing facilities, the formal CSTAR collaborative grant effort has allowed access to University Research Information Technology (RIT) services. In particular, NWS ALY is using the RIT 144 CPU Linux cluster for WRF model simulations. This computing facility allows them to perform computations not possible at the local office. The facility is used to generate additional members for the collaborative ensemble, and to generate higher resolution runs for research purposes. So far this facility has been made available at no cost to the CSTAR project. The RIT group has also made an additional 10 TB of disk space available for CSTAR data storage.

7. CSTAR PROJECT RESEARCH IN NWS AFDs

Saturday 11 August 2018

CSTAR research on warm-season flooding events was cited in the long-term section of the NWS ALY AFD.

FXUS61 KALY 110842
AFDALY

Area Forecast Discussion
National Weather Service Albany NY
442 AM EST Sat Aug 11 2018

.LONG TERM /TUESDAY THROUGH FRIDAY/...
The period starts out Tuesday with a cut-off low pressure system centered over PA and southern NY. ECMWF/GFS in good agreement indicating our region to be under the influence of a moist diffluent/southerly flow just downstream of the core of the upper low for much of Tuesday. **Pattern recognition points to a flash flood threat based on previous CSTAR research.** Forecast PWAT anomalies in the +1 to +2 STDEV range along with potential for embedded slow- moving convection within widespread rain shields. Main challenge will be narrowing in on which locations will be most susceptible. For now will mention likely pops, with locally heavy rainfall possible across the entire area. Chances for showers/thunder with embedded heavy rainfall should continue into Tuesday evening, as the upper low slowly pushes eastward across the region. The center of the upper low should be east of our region by Wednesday morning.

LONG TERM...JPV

Tuesday 9 October 2018

CSTAR research on predecessor rain events (PREs) was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 092030
AFDALY

Area Forecast Discussion
National Weather Service Albany NY
430 PM EDT Tue Oct 9 2018

.SHORT TERM /6 AM WEDNESDAY MORNING THROUGH THURSDAY NIGHT/...
Thu-Thu night...The greatest impact period for heavy rain will be Thursday as the cold front approaches from the Great Lakes Region, Ohio Valley, and Mid Atlantic Region. A low-level southwesterly jet will continue to focus some heavy rain showers with PWATS in the 1.66-2.0" range. The synoptic lift will increase as the H850/H925 low-level theta-e ridge will be over the forecast area in the late morning into the early to mid afternoon. The QG Lift or synoptic forcing increases ahead of the front with some upper level divergence. The better jet streak looks like it will lag upstream of the region over the over the central and eastern Great Lakes Region. **The better focus for the right entrance region of the H250 jet streak of 125+ knots remains a bit out of phase from the low-level theta-ridge and anomalous PWAT air for a classic Predecessor Rain Event or PRE documented in the CSTAR research.** A rain axis well northeast of Michael is possible, but the placement and amounts of QPF are still uncertain. The latest NAM was the most aggressive with 1-3" of rainfall from southern VT, the Berkshires southwest through the Taconics, mid Hudson Valley, and the eastern Catskills. The GFS has the heavier rain amounts from the Capital Region/Mohawk Valley northward with 1-1.5+ inches. The 12Z ECMWF has a general half an inch to an inch for Thu-Thu night. We believe a widespread rainfall is possible with bands of heavier showers and isolated thunderstorms due to small amounts of instability in place. We are not confident for the potential of widespread flooding yet, and we are forecasting about three quarters of an inch to an inch and an inch and third of rainfall through THU night. The high PWAT values may favor localized rainfall rates on an inch or so an hour in a few spots.

SHORT TERM...Wasula