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

Improving Analyses, Numerical Models, and Situational Awareness of High-Impact Severe Convective and Mixed-Phase Precipitation Events in Complex Terrain

University: University at Albany

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1. SUMMARY OF STUDENT RESEARCH ACTIVITIES

a) Near-freezing winter precipitation type in complex terrain

Graduate student: Matthew Seymour
PI and co-PIs: Justin Minder, Nick Bassill, Robert Fovell, Andrea Lang
NWS focal points: Michael Evans (ALY) and Frank Nocera (BOX)

Research summary:

During the reporting period Mr. Seymour continued his academic progress towards his MS degree, taking a full load of graduate coursework and research. He continued to build skills needed to conduct WRF simulations and analyze radar, sounding, and New York State Mesonet (NYSM) datasets. He simulated two case studies using WRF in a HRRR-like configuration.

The first case simulated was a difficult rain vs. snow precipitation type forecast on 5 April 2019. The simulations included sensitivity experiments involving alterations of the PBL schemes. The results of this research, including comparisons to sounding and Mesonet observations, was presented at the Northeastern Storm Conference on 7 March 2020.

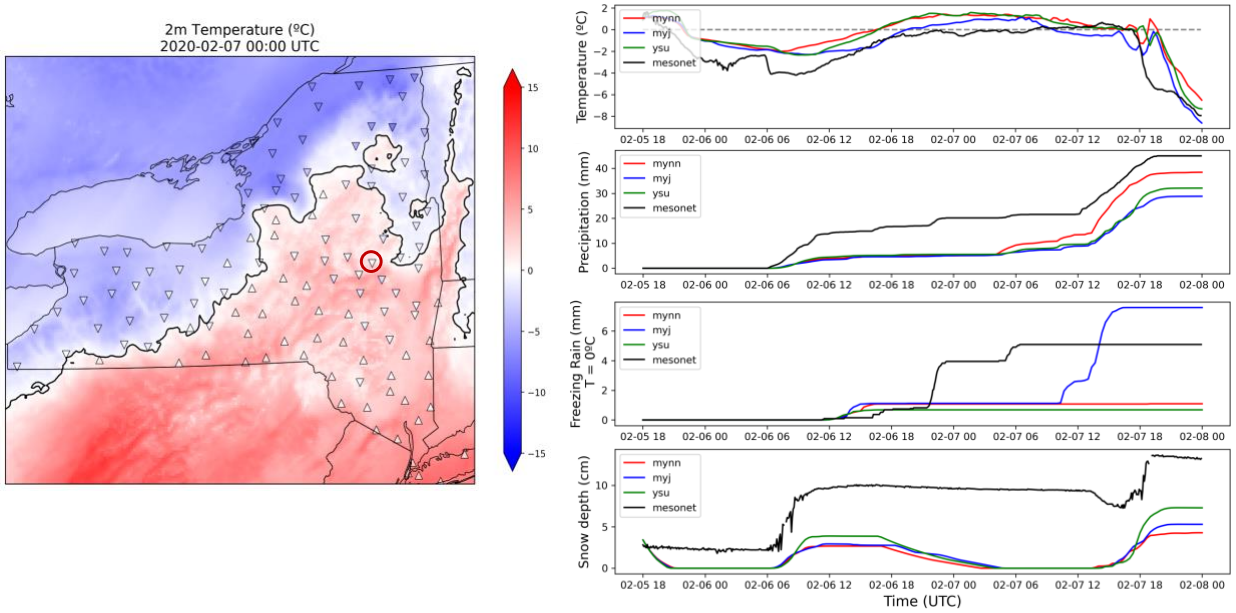

Figure 1. *Model comparison with NYSM observations for 6–7 February 2020 event. Left panels show 2-m temperature at 0000 UTC 7 February 2020 from HRRR-like WRF-MYNN control simulation (shading) and NYSM station observations (colored triangles). The simulated zero-degree Celsius isotherm is shown (bold line) and stations above/below zero-degrees Celsius are denoted with upward/downward pointing triangles. Right panels show time series from the JOHN NYSM station (indicated with red circle on left panel and three WRF simulations using different PBL schemes (MYNN, MYJ, YSU). Individual panels show 2-m temperature, total liquid-equivalent precipitation accumulation, freezing rain accumulation (diagnosed based on sub-freezing 2-m temperatures), and snow depth. The time corresponding to the panel on the left is highlighted in red.*

The second case was a long-duration event, with multiple precipitation types, on 6–7 February 2020. The simulations of this case included sensitivity experiments altering the PBL and microphysics (MP) schemes. As an illustrative example, Figure 1 shows select comparisons of simulations and New York State Mesonet observations from this event. The simulations exhibited substantial warm biases throughout most of the event and large portions of New York State (Fig. 1 left and top-right). These warm biases were associated with errors in the thermodynamic profile (not shown), excessive snow melt, and errors in surface precipitation type (Fig. 1 right). Ongoing analysis of this case study include diagnosing the contributions of errors in PBL mixing, synoptic evolution, land surface initialization/simulation, diabatic feedbacks, and surface fluxes in contributing to precipitation type errors. Results from this work will be presented at the National Weather Association (NWA) annual meeting in September 2020 (likely in virtual format).

Over the next six months, research activities will involve conducting and analyzing further PBL, MP, and initial/boundary condition experiments, as described in the proposal. Work will also begin on conducting stochastic physics perturbation (SPP) experiments. Results will be presented at the UAlbany New York State Mesonet Forum in the fall, the NWA annual meeting in September, and Northeast Regional Operational Workshop in November. There is uncertainty regarding our proposed plans to conduct field observations during winter precipitation events in winter 2020–2021, due to the ongoing COVID-19. We are monitoring the situation and will move forward with these efforts if we can do so safely and effectively, given public health guidance and university policies.

NWS Interactions:

During January 2020, Mr. Seymour met with Mike Evans of the National Weather Service in Albany, NY, discussed the NWS role in the project, and received additional feedback on how to proceed with selecting winter weather events to study.

b) Severe convection in complex terrain and across severe-weather environments

Graduate student: Brennan Stutsrim
PIs and co-PIs: Brian Tang and Robert Fovell
NWS focal points: Thomas Wasula (ALY) and Joe Dellicarpini (BOX)

Research summary:

Graduate student Brennan Stutsrim, co-PI Brian Tang, and co-PI Robert Fovell continued work on this component of the CSTAR project. After completing an initial synoptic and mesoscale analysis of several severe weather cases from August 2019, we focused on cases that exhibited convective mode changes and back building within the Hudson Valley. Our goal is to better understand the interaction between complex topographic features and the mesoscale environment that may have played a role in the convective evolution and associated hazards.

We examined the 21 August 2019 case in more detail, in which the convective mode changed from discrete to multicellular, as convection moved from the Catskill Mountains into the Hudson Valley. In the Hudson Valley, the convection back built, producing locally heavy rainfall and areas of flash flooding.

Brennan used a HRRR-like configuration of the WRF model initialized with HRRR analyses to simulate this event (Figure 2). Different combinations of horizontal resolutions, initialization times, and microphysics parameterizations were tested to arrive at a simulation that best represented the actual convective evolution on 21 August 2019.

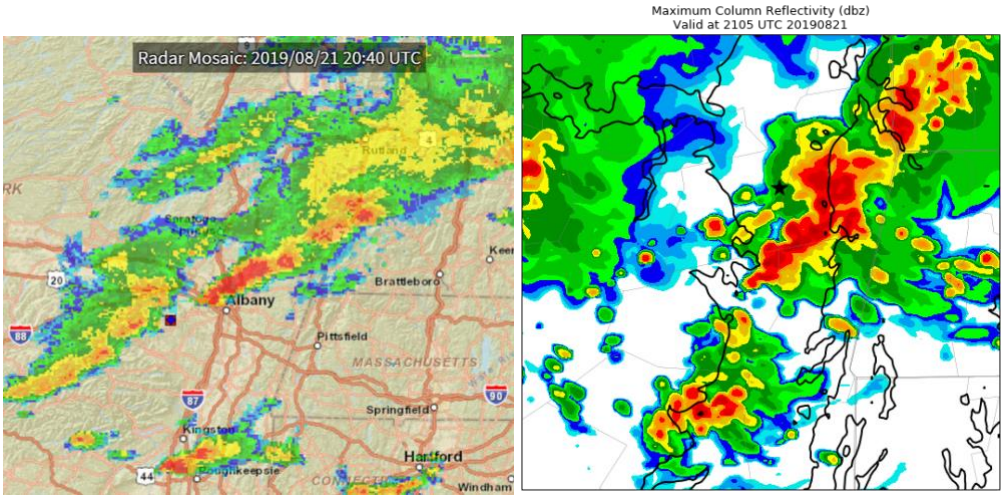

Figure 2. *Composite radar reflectivity (left) at 2040 UTC 21 August 2019. Simulated maximum column reflectivity at 2105 UTC 21 August 2019 and 225-m terrain contour (black outline), which roughly outlines the Hudson and Mohawk valleys. The black star denotes Albany, NY.*

Brennan analyzed a number of fields to better understand local environmental controls on the convective evolution, including the equivalent potential temperature, convective available potential energy (CAPE), and vertical wind shear. We compared our findings to those of Schumacher and Johnson (2005), who studied extreme rain producing mesoscale convective systems (MCS) in the Midwest and Great Plains. The mechanisms responsible for the back-building behavior on 21 August had similarities to mechanisms responsible for back-building MCSs in the Midwest. In both cases, the back building occurred along the cold side of a pre-existing outflow boundary. The leading edge of the outflow boundary was well defined (as given by the potential temperature gradient), as the boundary moved southward. High equivalent potential temperature (high-CAPE) air was advected by a low-level wind maximum (terrain-channeled) northward towards the boundary. This air lifted over the boundary, initiating new convective cells (Figure 3). The precipitation associated with these new cells created evaporatively cooled air, which helped sustain the outflow boundary and initiation of new convection.

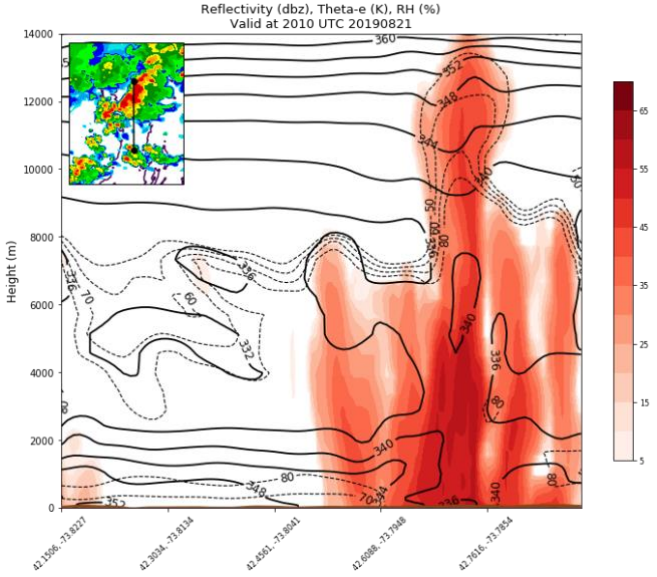

Figure 3. *Cross section of simulated reflectivity (red shading), equivalent potential temperature (solid lines), and relative humidity (dashed lines) at 2010 UTC 21 August 2019 from the WRF simulation. The inset shows the maximum column reflectivity and cross section location.*

Brennan also identified more cases with a similar convective evolution to the 21 August 2019 case. To identify cases, Brennan searched for days that had severe thunderstorm and flash flood warnings in the Capital District of the Hudson Valley, using the Iowa State University NWS Warning Archive. On 26 July 2008, discrete convection moved from the Catskill Mountains into the Hudson Valley, where it changed to a multicellular mode, similar to 21 August 2019. However, in this case, little to no back building occurred southward. These two cases have a similar synoptic environment, so they will serve as a potentially useful comparison in future simulations. Additionally, future work may use semi-idealized simulations to investigate hypotheses related to the moisture field and advection.

NWS Interactions:

Brennan met with the NWS focal points in January 2020, during which he presented his initial analyses of the cases from August 2019. There was then a discussion with NWS SOOs and forecasters from WFOs ALY and BOX about what challenges they face in forecasting convective mode and how this CSTAR project could help improve their forecasting capabilities. NWS forecasters stated that their most challenging forecasts come from environments with high CAPE and low shear. In terms of forecasting convection, they often use the HREF to assess the mode and convective initiation. Forecasters also stated that conceptual models, flow charts, and rules of thumb can be very helpful in short-term forecasting of convective mode and evolution. This input will be used to motivate and guide future research directions for this project.

Brennan presented his findings from the 21 August 2019 case to NWS staff from WFOs ALY and BTV at the Interior Northeast NWS Spring Science Webinar in May 2020. It was suggested that Brennan try to find a null case to analyze and compare to the 21 August 2019 case.

Brennan plans to meet with the NWS focal points during summer 2020 to discuss research progress and plans.

References:

Schumacher, R. S., and R. Johnson, 2005: Organization and environmental properties of extreme-rain-producing mesoscale convective systems. *Mon. Wea. Rev.*, **133**, 961–976.

c) Data fusion applications to assess forecast uncertainty and improve analyses

Graduate student: Brian Filipiak
PI and co-PIs: Kristen Corbosiero, Nick Bassill, Andrea Lang, and Ross Lazear
NWS focal points: Christina Speciale (ALY) and Neil Stuart (ALY)

Research summary:

During the six-month reporting period, the PI and co-PIs continued to prepare to begin our data fusion research. First, we recruited a graduate student, Brian Filipiak, who graduated from The University of Rochester in May. Brian's technical and computing skillset are ideal to perform the machine learning research and analysis we plan to perform. Brian will join the group in August 2020. Second, we continued to archive high-resolution numerical model output from convection-permitting models such as the operational HRRR and 3-km NAM. Thus far, we have collected nearly two years of hourly, HRRR-model output and 15 months of 3-km NAM output. Third, in collaboration with NWS Albany, we have added to our list of topographically-influenced mixed-phase precipitation events for New York State and surrounding regions. Finally, we have begun to examine utilizing NYS Mesonet observations for the purposes of evaluating high-resolution model

forecasts for mixed precipitation events, as an initial means to assess potential model bias for key events. We anticipate that Brian will start with this project when he joins the group at the end of the summer.

2. CSTAR VII PROJECT THESES, PRESENTATIONS, AND PUBLICATIONS

(For a complete list of UAlbany–NWS Albany CSTAR project publications, please see *http://www.atmos.albany.edu/facstaff/kristen/CSTAR/CSTAR_CumulativePublications.pdf*.)

a) Theses completed

None

b) Presentations

Seymour, M. , 2020: An evaluation of WRF parameterizations on terrain impacts of an April 2019 New York winter precipitation event. *45th Annual Northeastern Storm Conference*, 7 March, Saratoga Springs, NY.

Stutsrim, B., R. Fovell, B. Tang, T. Wasula, and J. Dellicarpini, 2020: Modeling convective mode changes in complex terrain in the northeast U.S. *45th Northeastern Storm Conference*, 7 March, Saratoga Springs, NY.

c) Refereed publications

Loeffler, S. D., M. R. Kumjian, M. Jurewicz, and M. M. French, 2020: Differentiating between tornadic and nontornadic supercells using polarimetric radar signatures of hydrometeor size sorting. *Geophys. Res. Lett.*, **47**, e2020GL088242.

3. RESEARCH TO OPERATIONS

Updates to the Albany CSTAR Virtual Lab (VLab) community page are ongoing, with traffic to the page monitored using Google Analytics.

With recent CSTAR M.S. students having recently completed their degrees, Massey Bartolini's and Tomer Burg's theses have been to VLab. Additionally, after consultation with National Weather Service (NWS) focal points, both students' operationally relevant quick references were added to the VLab:

- Massey Bartolini created a table documenting differences in simulated lake-effect snow band intensity, position, and graupel content using a variety of microphysics and boundary layer parameterization schemes.
- Tomer Burg created a phase-space and conceptual diagrams showing along- and across-track biases for Northeast cyclone tracks from the GEFS.

Keywords for both quick references allow this work to be accessed using the AWIPS Interactive Reference (AIR) utility.

Ross Lazear will be meeting with CSTAR students Matthew Seymour and Brennan Stutsrim to develop operationally relevant quick references as they make progress on their research.

Finally, the agenda and preprints for the Northeast Regional Operational Workshops dating back to 2000 have begun to be added to the VLab.

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 contains CSTAR reports, Master's theses, and web tools derived from previous and ongoing projects. In addition, cold-season and warm-season quick reference graphics and links to recorded training are on the page, along with a link to previous NROW presentations. Reference material from the research is also available to forecasters via the AWIPS Interactive Reference Tool.

Research has begun on the three major projects of CSTAR VII. Students for two of the projects were selected in 2019, and NWS Focal Points have met with these students and shared their ideas for how the projects can move forward, and how results from the projects could best benefit National Weather Service operations. A student for the third project was more recently selected, and communication between that student and the associated NWS focal points has not yet occurred.

In regard to Major Project #1, Mike Evans met with CSTAR student Matt Seymour in January 2020 to show how NWS operations are conducted during winter weather events. They discussed that the NWS typically is challenged by two very distinct types of event. One event is associated with significant amounts of mid-tropospheric warm air advection with a warm nose aloft that frequently results in freezing rain and sleet along with snow and rain. The second type of event is associated with cold air aloft, but marginal boundary layer conditions that produce rain or wet snow, often with large elevation effects.

During the meeting, Mike showed Matt how gridded forecasts are produced, and how forecasters use smart tools and model blends to produce precipitation type forecasts. The smart tools use a combination of critical temperatures, a top-down methodology, and output from other algorithms to produce precipitation type forecasts. The gridded forecasts are then used to create winter weather headlines and briefings to critical partners, focusing on impacts and timing of snow and ice. It was also emphasized that production of detailed short-range forecasts of factors such as snowfall rates and precipitation type via social media platforms are becoming an increasingly important component of our operations. These forecasts typically focus on the 1 to 6-h time frame.

Issues and challenges for NWS forecasters regarding winter precipitation type range from the medium range (days 2 to 4) through the near term (hours 1 through 6). Modeling issues that we continue to see include problems with temperature forecasts in the boundary layer, short-range forecasting of bands of heavy precipitation and the resultant cooling that affect precipitation type forecast, and forecasts of elevated warm layers. Effects of elevation and topography also remain a challenge. For example, questions remain on what storms will have large vs. small elevation impacts and how good are models at depicting those effects.

After this meeting, NWS focal points Mike Evans and Frank Nocera have shared several case studies with Matt, including the 15 November 2018 surprise heavy snow event in the big cities of the northeast U.S., the 6–7 February 2020 and 29–30 December 2019 mixed precipitation events, and a spring wet snow event on 9 May 2020.

There remain many forecast challenges associated with winter weather events associated with marginal, near freezing temperatures and the impacts of terrain on these types of events. We have discussed some of these challenges with Matt. Some topics that could be explored related to the forecasting and modelling of these events include:

- Identifying and quantifying model errors and biases. Models are always changing but some problems with the models seem to persist, especially related to low-level temperature forecasts.
- Examining the utility of precipitation type algorithms and methods such as top down and Bourgouin.
- Evaluating the utility of blended and ensemble approaches for precipitation type forecasts, vs. single deterministic model approaches.
- Developing methods for identifying the potential for enhanced precipitation resulting in cooling and changes in precipitation type.
- Developing conceptual models for different types of topographic impacts: patterns associated with high elevation ice storms, large-elevation impacts on snow amounts ("elevation storms"), and patterns associated with "surprise" lower elevation heavy, wet snowstorms. Also, development of conceptual models for "front-end thump" storms associated with warm-air advection.

For Major Project #2, Tom met with student Brennan Stutsrim on 22 January 2020 and led a conference call with Joe Dellicarpini and Hayden Frank at WFO BOX, and Dr. Tang and Dr. Fovell. Brennan gave an overview of his research so far and discussed the 21 August 2019 severe weather case. Some initial conclusions from the 21 August 2019 severe weather case from Brennan's work:

- Forecasting changes in convective mode can be challenging due to small lead times and necessity for high resolution observations and/or modeling
- Mesoscale phenomena such as terrain channeling in Hudson Valley and blocking on western Taconics may create small areas of favorable conditions for convection
- Discrete convection moving through the area may become more intense, organize and change convective mode

Tom, Joe, and Hayden were able to provide some additional cases for Brennan after the meeting. Tom also brought the SPC HREF's archive to Brennan's attention with all the CAM's on there. Tom also gave a short presentation entitled: "What Works for Operational Meteorologists" on putting CSTAR results into operations. The quickest three avenues lately are: Conceptual Models, Flow Charts and Rules of Thumb; however, teletraining sessions/short PowerPoints, short papers, and journal articles are also encouraged but may take a little more time.

A major initiative for the NWS Albany office related to forecasts of severe convection continues to be the production of forecasts with enhanced temporal and spatial detail in short time ranges, from 0 to 6 hours. The idea is to fill in the gap of forecast information available to our partners and the public during the time period between when watches are issued, and when warnings are issued. Improvements in our ability to enhance these forecasts will result from an increased emphasis on meso-analysis as well as improvements in short-range, high resolution modelling. One NWS-supported effort to improve high-resolution modeling of severe convection is the "warn-on-forecast" initiative, which is being developed at the National Severe Storms Lab. NWS Albany sees the work being done in this project as complementary to the broader NWS-supported warn-on-forecast initiative. Similar to the warn-on-forecast work, this project will focus on accurate, high-resolution modelling of short-term convective threats, however this project will

concentrate on the modelling of events local to our area, and in particular on the impact of our unique topography on the evolution of these events. Results from the modeling studies in this project should help us to develop some conceptual models on how our topography impacts the evolution of convection in our area, which will help us to produce more accurate short-term forecasts. In addition, access to output from model forecasts from the UAlbany system in real-time would also help us to produce more accurate forecasts and warnings.

Finally, for Major Project #3, work with the student has not yet begun on this project as the student was just selected this spring, and interactions have been restricted due to the COVID-19 pandemic. Accurate predictions of high-impact weather in the short range requires that forecasters be well-versed in mesoscale analysis. A robust mesoanalysis requires that forecasters have access to a wide-ranging suite of observational data, and that forecasters understand which types of data are most important to evaluate in order to accurately assess high-impact weather potential. This project has the potential to help our operations by making a wide-range of observational data available to our forecasters. In addition, results from this study should help our forecasters learn which types of data are most important to evaluate, and how uncertainties in certain observational data sets could potentially translate into uncertainties in resulting weather outcomes and impacts. Ultimately, direct output from an application produced by UAlbany could help forecasters to not only assess which observational variables are most important, but to compare the values of those observed variables to values in models to help determine the likelihood of various model forecast outcomes. The result of this will be improved communication with weather-sensitive partners on the range of possible impacts that they may experience.

5. COLLABORATIVE AND ASSOCIATE PROJECTS *(Michael Evans and focal points)*

The eight collaborative projects associated with CSTAR VII are listed below, along with updates on progress from June through November 2019.

1. Improvement of tornado detection and lead time

Team lead: Joe Dellicarpini (BOX) and Christina Speciale (ALY)

Joe and Christina have planned a conference call on15 June to lay out a game plan for the project. A list of cases has been developed from the Boston and Albany forecast areas with additional cases being continuously added from this year's severe weather season, which has already included a few tornado events. Dave Radell and Da'Vel Johnson from OKX will also join the call, with the hopes that they will provide additional cases for the study. Mike Evans has been looking at the utility of applying "confidence builders" and "nudgers" from the NWS Central Region Tornado Warning Improvement Project, into the tornado warning process for the Northeast CONUS, and he will also show some of this at the meeting in June. Mike may present some of this material at a National Weather Service "storm of the month" virtual presentation later this summer.

2. Warm season QPF challenges: identifying when model precipitation, areal coverage, location and maximum amounts will be skillful

Team lead: Justin Arnot (GYX)

Warm season QPF has long been identified as one of the greatest challenges for operational model guidance. Frequently, the areal extent of high QPF amounts is too great with the threat of flooding overestimated. This project seeks to determine how forecasters can

optimally interact with warm season model QPF. Specifically, when are QPF forecasts skillful and what aspects of them are of the greatest benefit to the operational meteorologist? This will be done both in a deterministic and ensemble/probabilistic framework.

A request for project volunteers was made and a team of eight project scientists, including representation from three WFOs (CAR, BOX, GYX) was assembled with a kickoff meeting in February. Since then a project outline and plan has been finalized with three sub-teams working on the data-gathering portion of the project.

Team 1 is tasked with identifying significant observed warm season QPF events during the past five years (2015–2019). Team 2 is tasked with identifying high-resolution ensemble forecasts of significant warm season QPF events (either NCAR ensemble or HREF ensemble) during this same period. Team 3 is tasked with identifying NWS headlines for warm season QPF events during the same period.

Once the data gathering portion of the study is complete (goal: warm season 2020), the group will cross reference ensemble forecasts with observations and NWS headlines to examine the skill of high resolution ensembles in anticipating significant warm season QPF events with the goal of then providing forecasters insight into how best to interact with this tool when developing watch/warning products for warm season QPF. The goal is to have preliminary results ready for the 2021 warm season.

3. Recent dual-polarization radar techniques to support severe weather operations

Team lead: Mike Jurewicz (CTP)

The main goal of this project is to identify at least three to five of the latest, emerging severe weather techniques utilizing dual-polarization radar fields and then synthesize the results into one location/project, featuring short write-ups/conceptual models that could be quickly referenced in an operational setting. Since such results often are not brought into operations (simply remain in the literature) and dual-polarization techniques remain generally under-utilized, this is a worthwhile endeavor. Since many of the below noted topics are already published in some form, will be shortly, and/or are active topics of research, this should aid the process of creating handy reference material.

So far, candidates for inclusion are: 1) Using size sorting signals to differentiate between tornadic and non-tornadic supercells; 2) Using Zdr and Kdp columns to provide advanced notice of downburst development; 3) Anticipating Storms Producing Large Accumulations of Small Hail (SPLASH); 4) Using dual-polarization parameters to help infer the thermodynamic environment within the rear flank downdraft; 5) Work done by several UAlbany CSTAR collaborators/NWS Albany forecasters using Zdr columns and other dual-pol fields to help identify large/severe criteria hail; and, possibly 6) Some of the latest research results connected with using CC for Tornadic Debris Signatures (TDS).

Results from research on using Zdr / Kdp separations in the tornado warning process was published (*https://doi.org/10.1029/2020GL088242*). We are mulling over the idea of a follow-up submission to WAF.

4. Using GLM lightning data in operations for severe weather forecasting and enhanced DSS

Team leads: Jared Klein (BGM) and Mike Jurewicz (CTP)

Since December 2019, we have searched for emerging research which makes use of GLM data both for severe weather interrogation and for lightning anticipation in support of IDSS efforts for outdoor events featuring large gatherings. We are in the process of gathering/incorporating the latest results within this topic in order to narrow our focus and methodology going forward.

5. Using GAZPACHO to verify high-resolution model snowfall forecasts from 2017–2019

Team leads: Joe Villani and Mike Evans (ALY)

During the past six months, we ran the GAZPACHO program based on 13 events from the 2018–19 winter season verifying NDFD, HRRR and NAMNest snowfall error (using positive snow depth change) for each event and created error maps using ArcGIS stratified by selected environmental parameters: 0–1-km/925-mb wind direction, 0–1-km wind speed, surface temp, 950–850-mb lapse rate, Froude number, and elevation ratio. A UAlbany student volunteer assisted with the calculations for the parameters. Observed composite snowfall maps were also created based on the parameters.

We replicated the methodology to create error maps (using GAZPACHO and ArcGIS) from all combined events in the 2017–18 and 2018–19 winter seasons. A total of 25 events are now part of the database.

Our future work is to perform calculations for parameters based on the 2019–20 winter season, then compute snowfall error for NDFD, HRRR and NAMNest for 12 additional events using GAZPACHO, as well as observed composite snowfall maps based on the selected environmental parameters.

Our final goal is to create error maps stratified by each environmental parameter using GAZPACHO and ArcGIS for the 37 combined events from the 2017–18, 2018–19 and 2019–20 winter seasons. These results should help forecasters to better understand the strengths and limitations of model forecast snowfall patterns in areas of complex terrain in the northeast U.S.

6. Examination of significant hail events: expand the project across the Northeast U.S.

Team lead: Tom Wasula (ALY)

Limited work has been done on this project over the past six months. The ALY WFO climatology has not changed with a total of 65 significant hail reports (2” or greater in diameter hail stones) from 1950 to May 2020. I continue to work on a NYS Climatology and adjacent New England State Climatologies from the database work SUNYA student, Justin Templer, did in the spring of 2019. He gathered all the reports for NY, MA, and VT from NCEI and placed them in a spreadsheet.

7. The role of the strength of large-scale low-level forcing on severe weather event magnitudes

Team leads: Neil Stuart (ALY) and Joe Cebulko (National Water Center)

Nothing new to report.

8. Use of collapsing specific differential phase columns to predict significant severe thunderstorm wind damage across the Northeast United States
Team lead: Joe Cebulko (National Water Center)

Nothing new to report.

6. CSTAR PROJECT RESEARCH IN NWS AFDs

Monday 16 December 2019

CSTAR research on mesoscale snowbands was cited in the near-term section of the NWS ALY AFD.

FXUS61 KALY 162105
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
405 PM EST Mon Dec 16 2019

.NEAR TERM /THROUGH TUESDAY/...
The trough sweeps eastward tonight into Tuesday with the northern stream flow becoming more amplified ahead of a digging, robust upper low. This process will allow the upper jet to become more anticycloncially curved with a strong equatorward jet entrance region becoming positioned over the area by late tonight. Models are now in fairly good agreement with the track of the surface low ahead of the southern stream trough, tracking from the central Appalachians offshore of southern New England. Combined with large- scale ascent from the jet entrance region, the isentropic lift ahead of the approaching wave will allow snow to spread into the region gradually from south to north 03-12Z. Good sloped 850 to 700 mb frontogenesis will coincide with the onset of the snow, which could come down moderately to locally heavily south of Albany between 06-12Z. **The pattern is reminiscent of the laterally translating snowband composite in CSTAR research, but the bands will likely not be moving very quickly.** HREF mean suggests snowfall rates of 0.50-0.75 inches per hour are likely with this activity, with low probability of brief 1 inch per hour rates. Warming aloft will allow the snow to turn to sleet and freezing rain from south to north after about 09Z. Current expectations are for the mixing line to remain south of the Capital District. Temperatures aloft warm such that a period of freezing rain is likely across southern portions of Dutchess and Litchfield Counties, with a good cold air drainage signal replenishing the cold air near the surface.

NEAR TERM...Thompson

Tuesday 31 December 2019

CSTAR research on the inland extent of lake-effect snowbands was cited in the near-term section

of the NWS ALY AFD.

FXUS61 KALY 311945
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
245 PM EST Tue Dec 31 2019

.NEAR TERM /THROUGH WEDNESDAY/...
As of 230 PM EST...Rather impressive upper low was crossing Lake Ontario with comma tail approaching the I81 corridor. Showers and squalls are accompanying the cold front where some in-cloud lightning has been detected via the NLDN. However, downstream lapse rates and minimal CAPE are forecast to weaken a bit so upstream line should weaken a bit and break up as suggested by the HRRR/NAM3km hires reflectivity. We have already issued an SPS to highlight the potential for snow squalls through this evening. In the wake of fropa, combination of cold advection (H850 temperatures only drop back to around -10C) and tight gradient should allow for brisk conditions across most of the region. Some upslope snow showers are expected as the attention will be downwind of Lake Ontario. Lake Ontario temperatures were near 42F (6C) and delta t/s climbing toward the mid teens for conditional lake instability. A fairly uniform wind flow should allow for bands of snow to make it inland into portions of the Dacks. **Inland penetration per CSTAR research suggests the lake band snow can move inland with excess of 100+ miles overnight and New Years Day morning.** Previous forecast had a winter weather advisory for lake effect snow and per the new guidance and overview, we will not make changes at this time. Generally 3-7" of snow expected through New Years Day as we watch one more short wave swing southeast across the state. This will likely disrupt the band into multi bands and reduce inland extent.

NEAR TERM...BGM

Wednesday 1 January 2020

CSTAR research on mesoscale snowbands was cited in the near-term section of the NWS ALY AFD.

FXUS61 KALY 010922
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
422 AM EST Wed Jan 1 2020

.NEAR TERM /UNTIL 6 PM THIS EVENING/...

The low and mid level flow will likely veer more to a northwesterly trajectory, as the some narrow multibands may materialize by the mid to late pm, and the lake inland extent will shrink based on the cool season CSTAR research. A light to moderate accumulation is likely and we increased totals west of Indian Lake only slightly into the 3 to 8 inch range.

NEAR TERM...Wasula

Friday 3 January 2020

CSTAR research on Mohawk–Hudson convergence was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 030929
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
429 AM EST Fri Jan 3 2020

.SHORT TERM /6 PM THIS EVENING THROUGH SUNDAY/...
Saturday Night...The mid and upper trough becomes negatively tilted and the secondary low goes through cyclogenesis near Cape Cod and then lifts into the Gulf of Maine. Dynamical cooling and colder air being wrapped into the system will generate a period of snow. **We will have to monitor for some potential Mohawk-Hudson Convergence snowfall for the Capital District into the northern Taconics which is well documented in the cool CSTAR research.** We have light snow accums in the valley areas including Albany with an inch or less, except the upper Hudson corridor near KGFL and the western Mohawk Valley where 1-3" is possible. The higher totals of 2-5" or so could be over the southern Greens, southern Adirondacks, and portions of the northern Berkshires. We may need advisories for some of the higher terrain later. Some orographic enhancement due to westerly upslope flow is possible for the southern Greens, Taconics, and Berkshires in the deformation zone of the system. It will become windier with brisk northwest winds. Lows will fall back into the 20s with some teens over the western Adirondacks and southern Greens.

SHORT TERM...Wasula

Wednesday 15 January 2020

CSTAR research on local terrain effects in winter storms was cited in the long-term section of the NWS ALY AFD.

FXUS61 KALY 152347
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
647 PM EST Wed Jan 15 2020

.LONG TERM /SATURDAY THROUGH WEDNESDAY/...
Then as that aforementioned upper jet moves across the Ohio Valley, left exit region dynamics will further enhance lift across the central and northern part of our region. This in turn also further enhances the warm advection from the south for a wintry mixture to develop from south to north. While difficult to ascertain where that line will develop, trends favor just south and east of Albany Saturday evening which will cut down on snowfall accumulations. **Furthermore, per CSTAR research, these miller-type `B` systems tend to favor upslope areas of the Dacks and southern Greens with a precip diminishing into the Capital Region due to downsloping from the Catskills.** So this places higher accumulation totals for those terrain areas and a reduction in overall accumulations from the Capital Region and points to the south and southeast.

LONG TERM...BGM

Wednesday 15 January 2020

CSTAR research on mesoscale snowbands was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 162116
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
416 PM EST Thu Jan 16 2020

.SHORT TERM /6 AM FRIDAY MORNING THROUGH SATURDAY NIGHT/...
A fast moving storm with favorable jet dynamics will bring a widespread moderate to heavy snowfall to the region. A cold airmass will be place across the region ahead of this storm. There will be impressive insentropic lift with strong frontogenetical forcing. **CSTAR research indicates banding will be possible.** Laterally translately bands occur with strong warm air advection and the low approaching from the west. Overrunning warm air advection snow will quickly spread across the area early Saturday afternoon. Once it starts expect it come down heavy with snowfall rates of 1 to 2 inches an hour. The bulk of the snow is expected to fall between noon and midnight. The highest snowfall amounts are expected across the southern Adirondacks, lake George Saratoga Region, Berkshires and southern Vermont where 7+ inches are expected.

SHORT TERM...IAA

Friday 14 February 2020

CSTAR research on flow-dependent snowfall totals was cited in the long-term section of the NWS ALY AFD.

FXUS61 KALY 142031
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
331 PM EST Fri Feb 14 2020

.LONG TERM /MONDAY NIGHT THROUGH FRIDAY/...
Isentropic lift and warm thermal advection will result in a period of light snow overspreading the region Tuesday morning. As per previous excellent forecast discussions, the degree of warm advection will result in a transition toward rain/snow mix and periods of rain during the afternoon hours along and south of I90 and south of KGFL. **Southwest flow regime per CSTAR research would favor the Dacks and southern Greens with higher QPF and perhaps higher snowfall amounts.**

LONG TERM...BGM

Wednesday 26 February 2020

CSTAR research on the inland extent of lake-effect snowbands was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 261008
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
508 AM EST Wed Feb 26 2020

.SHORT TERM /6 PM THIS EVENING THROUGH FRIDAY/...
Lake-effect will be developing behind the departing storm as well for Thursday afternoon into Thursday evening, as temps aloft rapidly cool. 850 hpa temps will be -15 to around -20 C and lake surface temps remain about +5 C. The cutoff upper level low will only slowly be moving across Ontario and Quebec, and there will be a persistent westerly flow at low to mid levels. The flow will be across multiple Great Lakes, with a single long-lake axis parallel band off Lake Ontario. **Local CSTAR research would suggest a band of this setup should have a fairly far inland extent, especially considering the abundant moisture and strong winds in place.** It should be fairly steady state band as well, with the development expected by Thursday afternoon and it looks

to impact the western and central Adirondacks through at least Friday. Single point totals look to easily be 1 to 2 feet, and its not out of the question for even higher totals near Old Forge-Inlet based off latest guidance.

SHORT TERM...Frugis

Sunday 22 March 2020

CSTAR research on transition season snow events was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 221044
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
644 AM EDT Sun Mar 22 2020

.SHORT TERM /6 PM THIS EVENING THROUGH MONDAY NIGHT/...
Mon-Mon Night...Transitional season storms are always challenging as shown in recent cool season CSTAR research, as this one has a chance to produce light to moderate snow accumulations in many locations, and possibly heavy amounts in the Berkshires northward into southern VT, and also in the eastern Catskills.

SHORT TERM...Wasula

Monday 23 March 2020

CSTAR research on mesoscale snowbands was cited in the short-term section of the NWS ALY AFD.

FXUS61 KALY 231048
AFDALY

AREA FORECAST DISCUSSION
National Weather Service Albany NY
648 AM EDT Mon Mar 23 2020

.SHORT TERM /6 PM THIS EVENING THROUGH TUESDAY NIGHT/...
Tonight...Our forecast continues to favor a consensus of the NAM/ECMWF and 00Z HREFS. There are indications the H700 circulation may close off briefly over southeast New England

between 00Z-03Z TUE. The short-waves finally phase with the coastal low sliding northeast toward Cape Cod. The mid and upper level deformation zone strengthens with decent low to mid level frontogenesis from the Capital Region south and east. The H850 0C isotherm may briefly reach the I-90 corridor around 03Z. **We will have to monitor if a pivoting pcpn or mesoscale snow band forms per the recent cool season CSTAR research.** We are expecting a transition to snow everywhere at night and it could accumulate quick at a half an inch to an inch and hour especially the grassy and untreated surfaces. Expecting 1-3" in the Capital District, 1-2" in the Mid Hudson valley, and Litchfield County with 1-4" in Washington Co.

SHORT TERM...Wasula