# Better Use of Ensembles in the Forecast Process: Scenario-Based Tools for Predictability Studies and Hazardous Weather Communication

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## 1. Background

Our project addresses CSTAR objectives to: "Improving the lead-time and accuracy of forecasts and warnings for high impact weather -- Improving the use of ensemble predictions systems in order to enable more effective forecaster assessment of uncertainty"; "Improving Impact-Based Decision Support Services"; and "Improving water resource information (precipitation) for decision support and situational awareness" Our focus area is the Eastern U.S. for high impact weather during the cool season; however, our approach can be expanded to other parts of the country and phenomena. The primary goals are: (1) To extend our newly developed fuzzy clustering approach to high impact weather events including precipitation, freezing level (2-m temperature), and 10-m wind for days 1-7 using the short-range and global ensembles; (2) Expand our new spread-anomaly ensemble tool; (3) Use these tools to verify these phenomena in the ensembles and understand the large-scale flows attached to the less predictable events; and (4) Integrate the Alan Alda Center for Communicating Science (www.aldacenter.org) into our CSTAR to help forecasters better communicate probabilistic information through a series of three workshops, some of which involving stakeholders.

## 2. Scientific Objectives and Accomplishments

During the past six months we focused on further testing of the fuzzy clustering approach. The existing version online (http://breezy.somas.stonybrook.edu/CSTAR/Ensemble_Sensitivity/FC_Main.html) has focused the clusters around sea level pressure using GEFS, CMC, and EC – 90 members). As noted and described in the the last report the CSTAR student got the clustering to work for 6-h accumulated precipitation and the 0C line. We have also used the clusters to evaluate operational ensembles, and those results are in the following recent Zheng et al. (2019) publication:

Zheng, M., E. Chang, and B.A. Colle: 2019: Evaluation of a multi-model ensemble for extratropical cyclones using a fuzzy clustering approach. *Wea. Forecasting,* **147***,* 1967-1987.

During the past 6 months we also conducted our 1st workshop on effective communication, with ~15 forecasters and the Alan Alda Center for Communicating Science at Stony Brook University.

*a. Ensemble Tools*

For the freezing line approach, the 2-m temperatures larger than 0C are set to 1, while temperatures < 0C are set to zero. The ensemble mean and spread are calculated and then the two leading EOFs, which are then used to obtain the clusters in the PC1 and PC2 space. During these last 6 months we tested other cases, such as the 24 December 2010 coastal storm event (around hour 36). Figure 1 shows the ensemble spread used to make the clusters, and Fig. 2 shows the two leading EOF patterns used to make the clusters in Fig. 3. One thing we learned in our testing

is to make the domain relatively small, so it focusses the statistics in the area of interest, rather than other remote temperature gradients. Once we have the clusters, we can plot the cluster 0C line positions (Fig. 4) and the precipitation for separate groups. These are the graphics that will be operational on the web page.
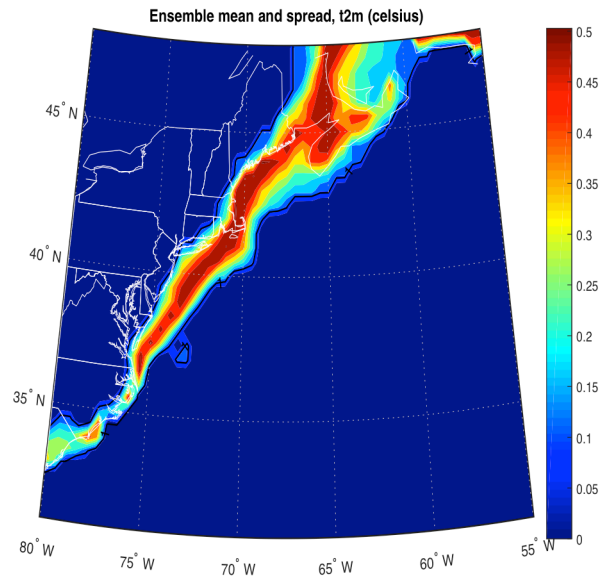


*Figure 1. Shading is ensemble spread of transformed T925 temperature to highlight variation in 0C line for hour 36 forecast initialized at 0000 UTC 24 December 2010.*
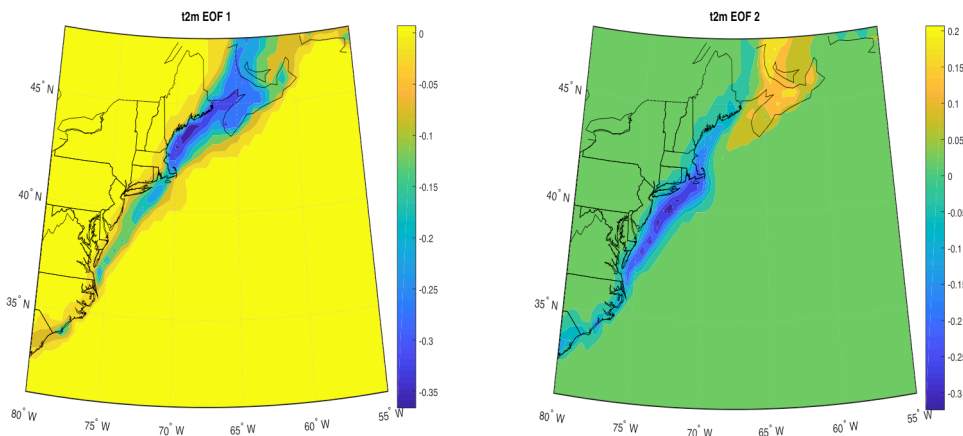


*Figure 2. EOF1 and EOF2 for the variance in Fig1. Explaining 27% and 14% of the variance, respectively.*
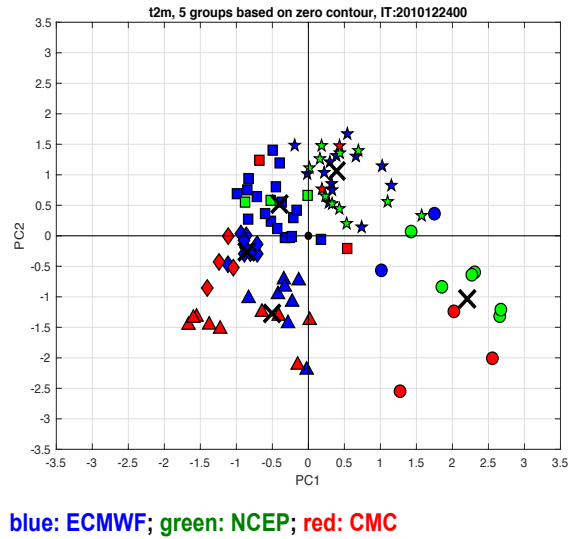
3

# 5 Clusters (X) on PC1-2 Phase Space

**t2m, 5 groups based on zero contour, IT:2010122400**



**blue: ECMWF; green: NCEP; red: CMC**

*Figure 3. The 5 clusters on the PC1-PC2 phase space at hour 36.*

# Five  0C Clusters, Cyclone Positions, and Model Breakdown

**t2m, zero lines of group means, IT:2010122400**



ensemble mean (black)
group1(red): ECMWF 8 NCEP 0 CMC 9
group2(blue): ECMWF 2 NCEP 6 CMC 3
group3(green): ECMWF 13 NCEP 11 CMC 2
group4(cyan): ECMWF 9 NCEP 0 CMC 4
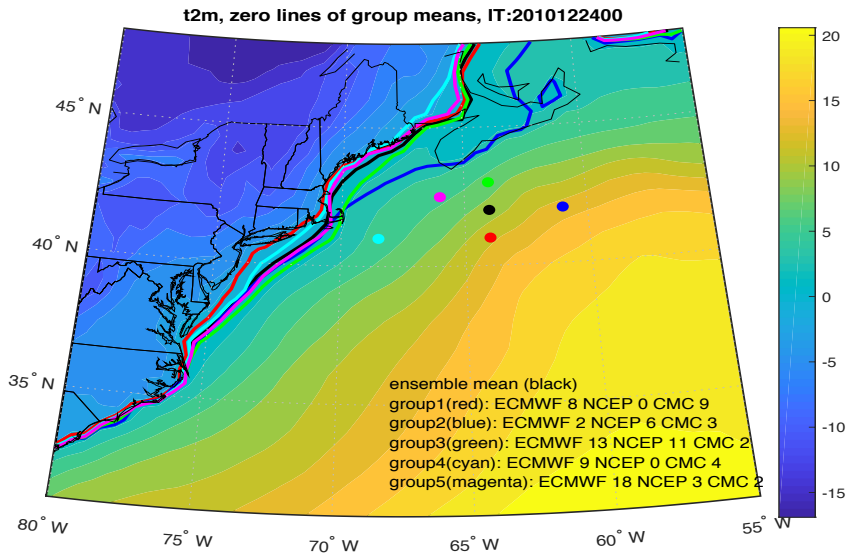group5(magenta): ECMWF 18 NCEP 3 CMC 2

*Figure 4. The 0 C lines for the 5 cluster means as well as the model breakdown numbers per cluster (group) and the cluster cyclone positions.*
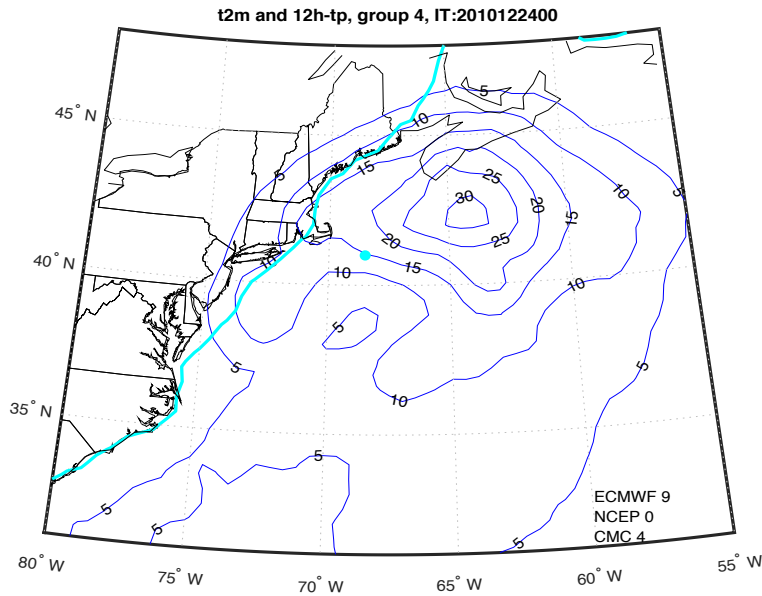
*Figure 5. Sample 12-h mean precipitation for group 1 of the 0C temperature clusters.*

## b. *Communication Uncertainty Workshop*

The first CSTAR Communication Workshop was held from 4-5 March 2019, involving 14 forecasters from NWS Eastern Region, Northeast River Forecast Center, and Weather Prediction Center. Table 1 highlights the agenda of the meeting. The workshop began with welcomes and a discussion of the communication challenges for forecasting. The forecasters discussed some recent challenging forecast events as part of the homework assignment. The activities the rest of the day focused on how to better distill a message and communicate things in a more concise way. For example, one exercise focused on communicating anything to do with weather in 1-minute, then the time allowed was reduced to 30 seconds, 15 seconds, and then 7 seconds. This forced participates to focus on the most important parts of their message.

During day2 participates gave 3-minute weather briefings using just 1-2 slides and the information they were taught in day1. The Alan Alda staff provided constructive feedback on their presentations and slides. Common issues were putting too much information or too many weather hazards on a slide, such that the message was lost. The oral presentation should also have a sense of urgency and clear statements of why it is important to the user. Figure 6 shows a few photos from the event. The "Recent Interactions" section below has the evaluations from the workshop and comments from the forecasters.

*Table 1. 4-5 March workshop agenda.*

## DAY 1

| | |
|---|---|
| 8:30-9:00am | Check-in & Registration<br>All participants: Endeavor 120 |
| 9:00-10:00am<br>Workshop | Welcome to the Alda Center's Science Communication<br><br>- Communication challenges for forecasting, messaging probabilistic information, and communication with various audiences<br>- The science of science communication<br>- Examples of recent events<br>All participants: Endeavor 120 |
| 10:00am-12:30pm | See and Be Seen<br>Improvisation-based activities to help you focus on and connect with your audience.<br>All participants: Endeavor 120 |
| 12:30-1:30pm | Lunch |
| 1:30-2:00pm | Designing a Vivid Message Part I<br><br>All participants: Endeavor |
| 2:00-3:00 | Designing a Vivid Message Part II<br>Group A: Okubo<br>Group B: EN 113 |
| 3:00-3:15pm | Break |
| 3:15-5:15pm | Just a Minute (JAM) Session (Groups of 8)<br><br>Practice talking about your work in clear, vivid and concise ways.<br><br>Group A: Okubo<br>Group B: EN 113 |
| 5:15-5:30pm | Reflection Routine & Wrap Up<br>All participants: Room |

## DAY 2

| | |
|---|---|
| 9:00-10:00am | Talking to Challenging Audience and Listening |

All participants: Endeavor 120

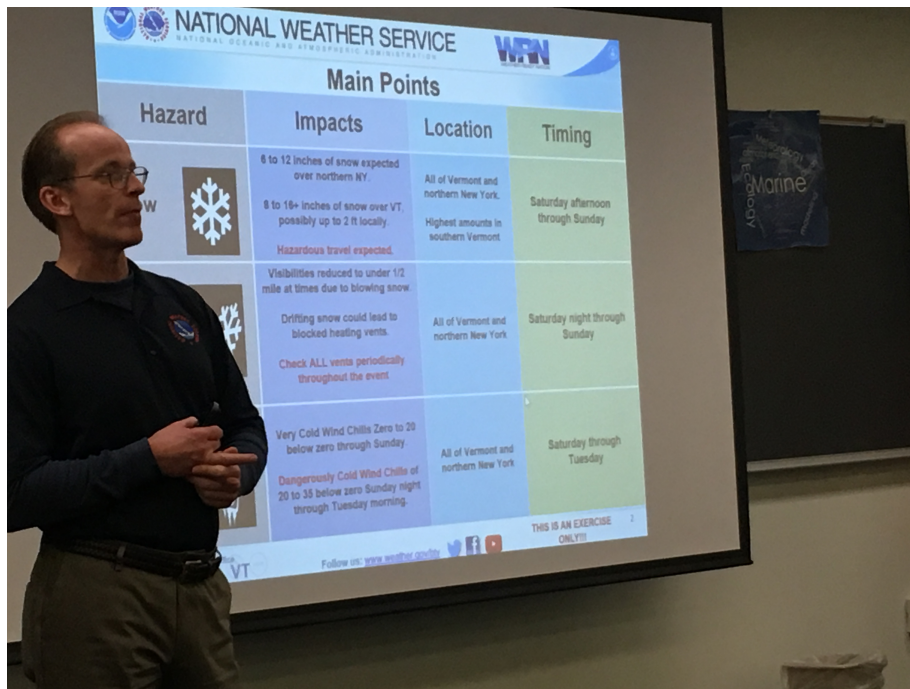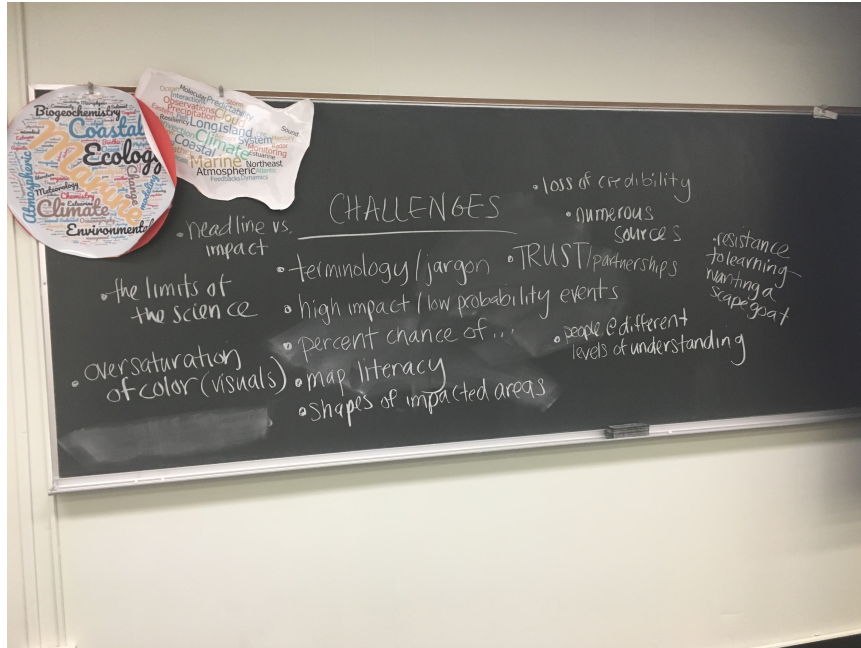| | |
|---|---|
| 10:00-12:45pm | Practice 3-minute Briefings |
| | Participants will practice and receive feedback presenting on a hazardous weather event |
| 12:45-1:00pm | Celebrating the Journey |

*Figure 6. Photos from the 4-5 March Communication Workshop.*

### 3. Recent Interaction with Operational CSTAR Partners

*a. Ensemble Tools*

We have been preparing for our cluster tools to be used operationally for this upcoming cool season by doing the following:

1. We have updated the CSTAR web page to include the 6- and 12-h precipitation clusters as well as the 925 hPa freezing line clusters.
2. We shared the code for these clusters with EMC so they can run in real-time using the NCEP, CMC, and EC ensembles (90 total members). After the images are generated at EMC they are ftp'd back to Stony Brook to be displayed on a password-protected webpage.
3. We iterated with EMC on debugging the cluster code to run as fast as possible on their computers.
4. We added a floater domain to each of the clusters, which allows the user to select the region of interest using a Google map interface.

WPC implemented our clustering approaches for their 2018-2019 Winter Weather Experiment (WWE). The last report (January 2019) highlighted some examples from their internal cluster page. We have shared the precipitation and 0C cluster codes to hopefully be included in their 2019-2020 Winter Experiment.

*b. Communication Uncertainty Workshop*

Through discussion and improvisation exercises the 4-5 March 2019 workshop discussed some of the challenges in forecasting high impact winter storm events, which laid out the motivation and foundation for the subsequent messaging and engagement exercises. This was done by introducing participants to general principles in how to craft short, clear, conversational statements, find common ground, engage your audience, and speak at different levels of complexity for different audiences without jargon or "dumbing it down." The second day allowed forecasters to practice and get feedback in the presentation of a given hazardous weather event in the context of the uncertainties associated with the range of high-impact scenarios.

Overall, the workshop was a huge success, and the forecasters really enjoyed it and learned a lot. Figure 7 shows the summary statistics on the feedback for the workshop. The results only include those who filled out both the pre- and post-workshop surveys (n=7), with poor = 0, and excellent = 4. The average participate thought he/she had good communication skills and approaches before the workshop, but they felt the workshop was excellent in improving their communication skills. The overall rating of the workshop was ***excellent***.

# STONY BROOK CSTAR
**MARCH 4, 2019: CLIENT REPORT**

Alan Alda Center
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## Summary

Workshop participants included 18 junior-level, mid-level, and senior-level faculty, of which 12 completed the pre-questionnaire, 10 completed the post-questionnaire, and 7 completed both the pre- and post-questionnaires.

## Quantitative Results

Paired samples t-tests determined significant increases in several science communication skills following the workshop compared to before the workshop.

Participants reported increases in their abilities to connect and relate to their audience, successfully identify and achieve a communication goal, and use narrative as a communication tool.

| Competency (n=7) | Pre-Survey | Post-Survey | t-value | p-value |
|---|---|---|---|---|
| Using appropriate analogies | 3.14 | 4.00 | 2.52 | < .05 |
| Successfully identifying an appropriate goal(s) for a particular interaction | 3.00 | 4.00 | 2.65 | < .05 |
| Successfully achieving a goal for a particular interaction | 3.14 | 4.14 | 3.24 | < .05 |
| Identifying and drawing on my experience to relate to others | 3.00 | 3.86 | 3.29 | < .05 |
| Using story/narrative to share my research | 3.00 | 4.14 | 4.38 | < .01 |

## Qualitative Results

A thematic analysis of qualitative results revealed several takeaways from the workshop. Participants reported the importance of:

- Knowing your audience and tailoring your message to fit their needs and interests.
- Keeping your communication goal in mind
- Developing empathy for your audience.
- Keeping slides simple so it is still possible to interact with the audience.
- Using language and techniques that encourage the audience to take action.

## Overall Results

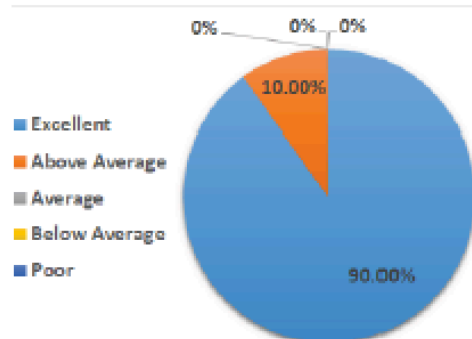**Overall, how would you rate the workshop?**



- Excellent
- Above Average
- Average
- Below Average
- Poor

0% — 0% — 0%
10.00%
90.00%

*Fig. 1: Overall Workshop Rating*

## Demographics

| | |
|---|---|
| *Broad Field/Discipline | n = 10 |
| Geosciences | 8 |
| Other | 2 |
| **Career Level** | n = 10 |
| Junior (e.g. post-doc; assistant prof.) | 2 |
| Mid-career (e.g. associate professor) | 3 |
| Senior (e.g. professor, administrator) | 5 |
| **Gender** | n = 10 |
| Male | 8 |
| Female | 2 |
| *Race/Ethnicity | n = 10 |
| White/Caucasian | 10 |

* indicates select all that apply

Additional forecaster feedback about the workshop was sent to NWS Eastern Region.

Note that the feedback below comes from participants from *several* different professional perspectives.

**1) One of our own goals of the workshop was to have the participants follow up *with their staff* to incorporate what was learned at the workshop.**

Warning Coordination Meteorologist at the forecast office in Binghamton, NY

*We are have 2 of our forecasters doing emergency operations center (EOC) exercises to prepare them to be deployment ready. They both have to do stand-up briefings and I plan to incorporate a lot of what we were taught to prep them.*

**2) Examples of immediate application of workshop objectives**

Warning Coordination Meteorologist at the forecast office in Newport/Morehead City, NC

*During the workshop we had to do the 1-minute on whatever we wanted to talk about weather-wise. Then they made us cut it down to 30 seconds, then 15 seconds, then 7 seconds. I always wanted our office to do hurricane forums in the community where we educated the public beyond the traditional hurricane awareness week. I felt we did a ton of hurricane talks but usually the audience was the same emergency managers and public officials every year. I had this idea coming up to Stony Brook and wanted to do it this spring given what we went through with Hurricane Florence. Well during the class I tested it out on my partner. Through the workshop I saw that you really only need 15 to 30 seconds to get out main points if you work hard. So we put it to the test and made this video, totally inspired by what I learned at Stony Brook.*

*https://www.youtube.com/watch?v=zCl99rJQ5r4*

Forecaster at the Weather Prediction Center at the NWS headquarters

*This past week I gave a presentation at the NWS Winter Program Meeting and I tried to incorporate as much as I could from the workshop. I started the talk off engaging the audience with two quick "raise your hands questions" keeping in mind the audience was a mix of meteorologists and non-meteorologists. I was pleasantly surprised to see the whole audience raise a hand during one of the questions and I really felt they were more engaged after that. I also tried to incorporate the materials to keep the presentation focused on the core goals I set out to achieve beforehand. I definitely felt my presentation was more focused than similar talks I have given before incorporating the lessons learned from the workshop.*

**3) Incorporation into the NWS Eastern Region Decision Support Services (DSS) Roadshows**

Meteorologist-in-Charge at the forecast office in Buffalo, NY

*I'm presenting the 'Just a Minute' (JAM) tool at the ERH DSS Roadshows -- we did it in Charleston, SC, and Blacksburg, VA. It has gotten excellent reviews. And considering I'm the one trying to explain it, that's pretty good.*

## 4. Products and Presentations

*a. Ensemble Spread Tool*

A web page has been developed the past year for the spread anomaly tool (*(http://blue.somas.stonybrook.edu/ssa/ssa.html)*). The code has been shared with NCEP-WPC and it is on github, so the output can eventually be combined with the Situational Awareness Table (SAT) online for forecasters. The webpage is currently down while the machine is being upgraded during the summer season.

*b. Fuzzy Clustering and other Ensemble Tool*

The fuzzy clustering and other ensembles tools (ensemble sensitivity, wave packets, cyclone tracks, etc) are currently maintained and accessible from our CSTAR page:

http://breezy.somas.stonybrook.edu/CSTAR/Models.html

*c. Theses, Papers, and Presentations*

*Formal papers published or in preparation:*

Zheng, M., E. Chang, and B.A. Colle: 2019: Evaluation of a multi-model ensemble for extratropical cyclones using a fuzzy clustering approach. *Wea. Forecasting,* **147***,* 1967-1987.

Wirth, V., M. Riemer, E. K. M. Chang, and O. Martius, 2018: Rossby wave packets on the mid-latitude Rossby waveguide, *Mon. Wea. Rev.*, **146**, 1965-2001.

Mandelbaum T., B.A. Colle, 2019: Assessing the spread-error relationship for East Coast winter storms. To be submitted to *Wea. Forecasting*.

Zheng, M., Chang, E.K., & Colle, B. A., 2019: Impacts of upper level Rossby wave packets on medium-range forecast errors and uncertainties. In preparation.

Zheng, et al, 2019: Ensemble sensitivity of U.S. East Coast winter storms: the multi-model climatology and paths of forecast uncertainty in medium range. In preparation.

*Presentation at 25th Northeast Regional Operational Workshop , Albany NY (7-8 November 2018)*

Brian Colle, "CSTAR Update: Better Use of Ensembles in the Forecast Process: Scenario-Based Tools for Predictability Studies and Hazardous Weather Communication."

*Presentation at 25th Conference on Numerical Weather Prediction, Denver CO (4-7 June 2018)*

Taylor Mandelbaum, Brian Colle, and Trevor Alcott: "Assessing the Spread/Error Relationship for East Coast Winter Cyclones."


*d. Stony Brook CSTAR graduates (alum)/students:*

*David Stark (M.S., 2012) – NWS General Forecaster at Upton, NY*

*Matthew Souders (M.S., 2013) –Weather Analytics, New Hampshire*

*Michael Layer (M.S., 2014) – Weatherworks, Hackettstown, NJ*

*Michael Erickson (Ph.D., 2015) – NOAA Contractor (Weather Prediction Center)*

*Minghua Zheng (Ph.D. -2016, Post-doc at Scripps)*

*Nathan Korfe (M.S. 2016) – Research Meteorologist at WindLogics, MN)*

*Taylor Mandelbaum (M.S. 2018)—Meteorologist and Data Analyst at NY Power Authority*

*Rui Zhang – current Ph.D. CSTAR student*


*d. CSTAR Group Meetings and List Serve*

There are over 50 participants on the list serve: cstar_stony_brook@infolist.nws.noaa.gov.

## 5. Problems and Difficulties

The 4-5 March workshop was rescheduled twice because of hurricane Florence in the September 2018, and in January 2019 because of the government shutdown. As a result, we are at least 6 months behind with the final two workshops planned for this project. We plan to have a no cost extension to makeup these efforts.