University: College of Charleston

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Partners or Cooperative Project: Partners

Project Title: Developing a Forecast Tool Based on a Climatology of Coastal Flooding along the South Carolina and Georgia Coast

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SECTION 1: Summary of Project Objectives and Accomplishments

1.1 Overview of progress

As detailed in the proposal (which will not be repeated in depth here), this project involves the use of climatic data to develop forecast tools that may aid in predicting coastal flooding. The first task involved assembling the student team. We first recruited the primary student, Joey Coz, who is a masters student that will be using this project as the basis for his thesis. Joey has completed grouping the events by type and has made composite plots for the different types, and also separated the raw tidal anomalies into event type and created new scatter plots. Some sample results are shown below.

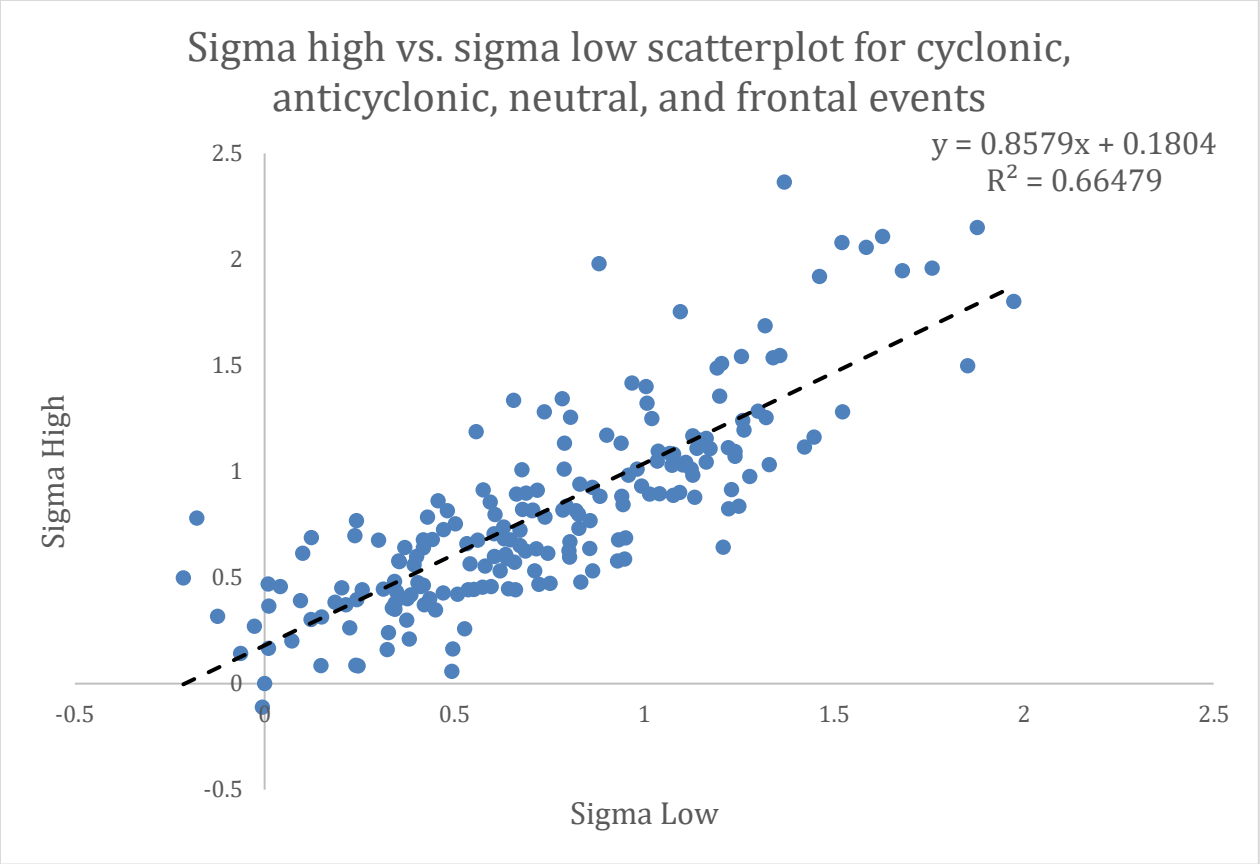

Figure 1: the sigma high vs. sigma low scatterplot for all event types excluding tropical. Tropical events are considered special flooding events that are more easily forecasted and thus are excluded from many of the tables and figures created for the final report. This scatterplot can be used to predict sigma high based on previous sigma low. When all categories are combined into one, the following outliers were created

Date	**Category**
10/15/02	Cyclonic
5/4/13	Cyclonic
3/7/14	Cyclonic
10/5/14	Cyclonic
5/31/96	Anticyclonic
9/12/06	Anticyclonic
12/14/08	Anticyclonic
9/8/06	Neutral
7/14/14	Neutral

Table 1: Table 1 represents the outlier events as predicted by Minitab software using the fits and diagnostics for unusual observations function of the regression analysis.

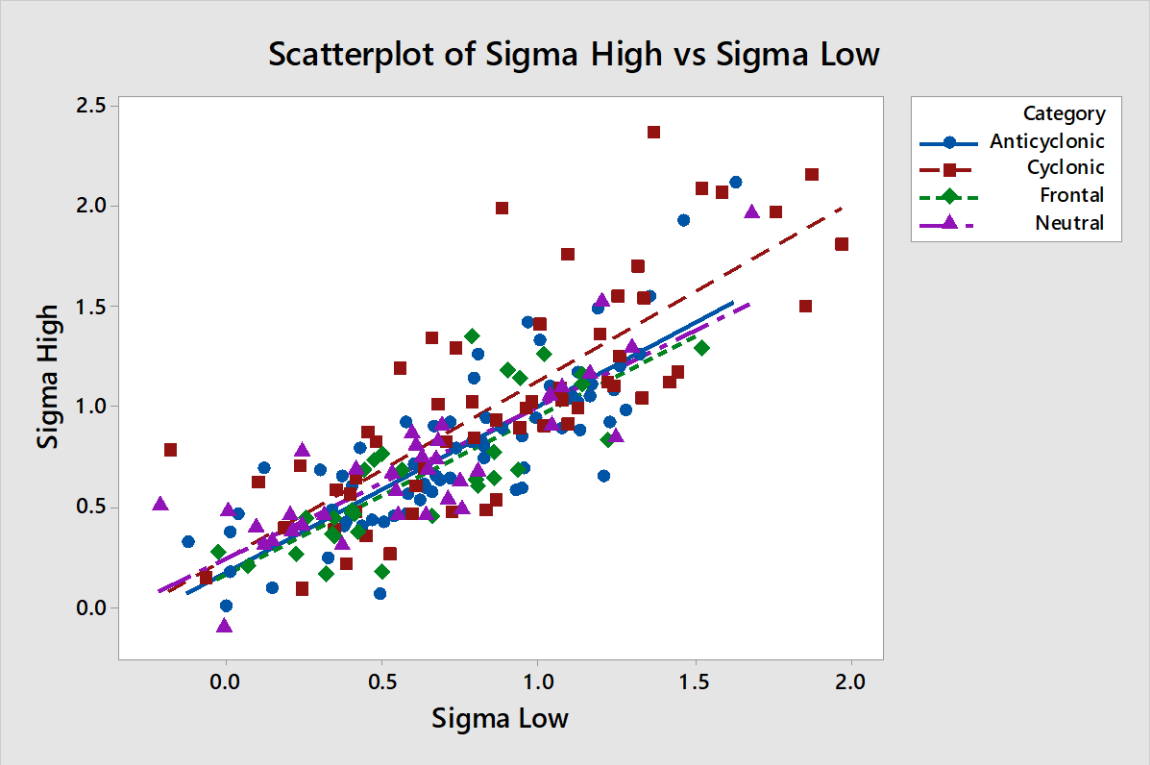

Figure 2: A regression analysis of sigma high vs. sigma low. This model considers events as separate types. Figure was created using Minitab software. Running this model produced six additional outliers (see table 2).

Date	**Category**
1/24/00 (10:42)	Cyclonic
3/20/01	Cyclonic
2/27/05	Cyclonic
9/25/08	Cyclonic
10/7/98	Anticyclonic
10/24/08	Anticyclonic

Table 2: Table 2 represents the additional outlier events created by the Minitab software's fits and diagnostics for unusual observations function of regression analysis when events are divided into their categories.

Figures which only account for one event type are important for forecasters because they will have less noise and influence from the other events types. When forecasting sigma high based on sigma low, it will be very common to know which event type the forecaster will be working with. Figures 3, 4, 5, and 6 represent the scatterplots for sigma high vs. sigma low for each event type as considered as separate categories. Within these figures, the 95% confidence intervals (CI) and the 95% prediction intervals (PI) are also represented.

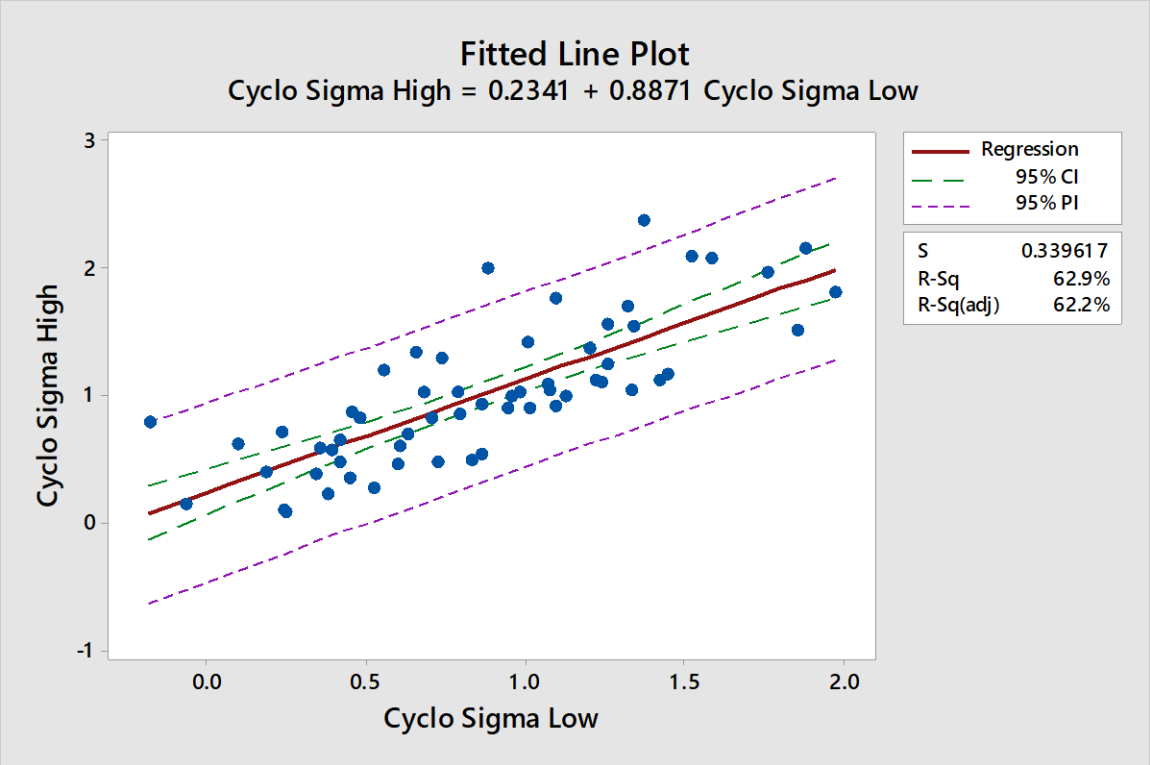

Figure 3: the sigma high vs. sigma low scatterplot for the cyclonic events only. This figure was created using Minitab software's regression analysis function.

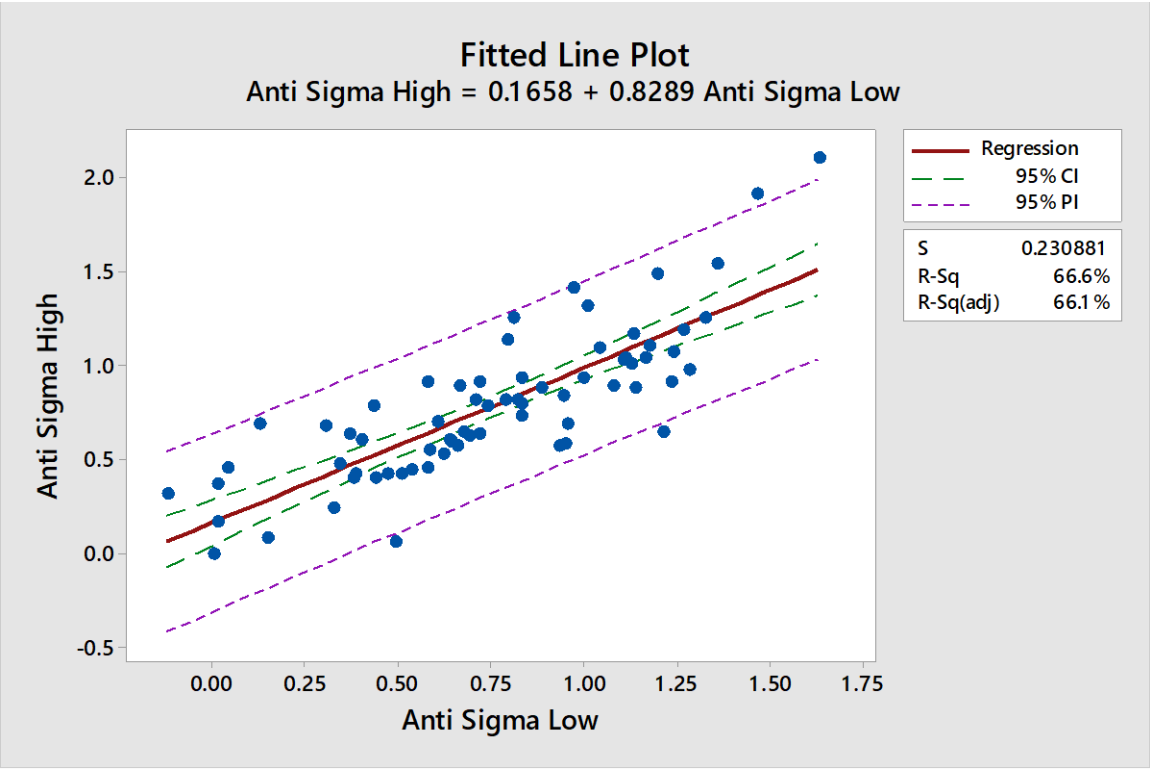

Figure 4: the sigma high vs. sigma low scatterplot for the anticyclonic events only. This figure was created using Minitab software's regression analysis function.

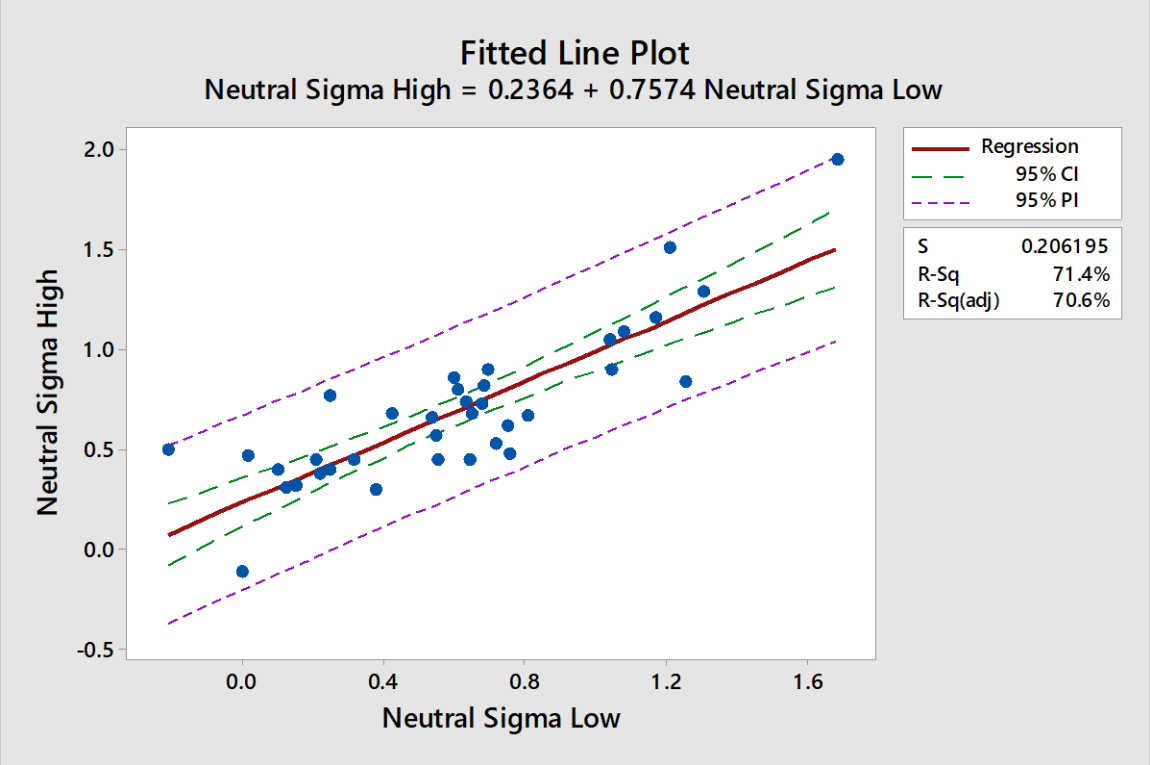

Figure 5: the sigma high vs. sigma low scatterplot for the neutral events only. This figure was created using Minitab software's regression analysis function.

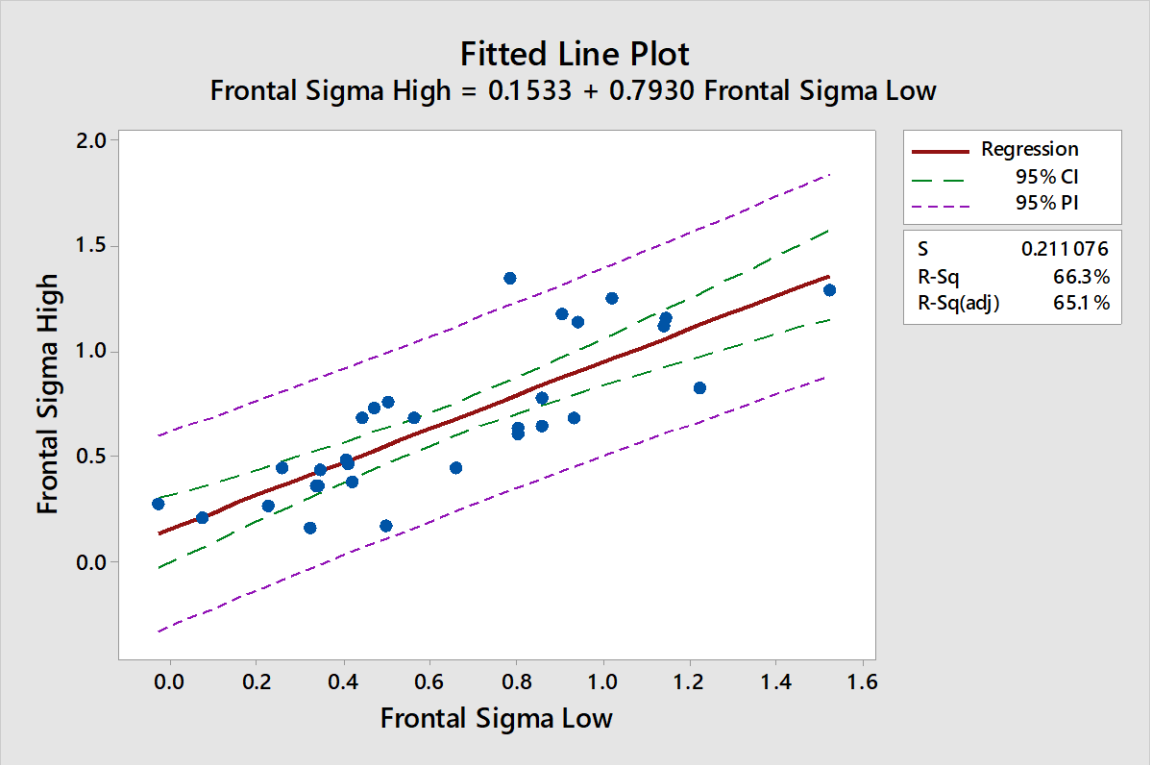

Figure 6: the sigma high vs. sigma low scatterplot for the frontal events only. This figure was created using Minitab software's regression analysis function.

Joey has also completed his thesis proposal, which formalized his thesis and has been approved. Seven undergraduates have been recruited to assist in this project, Aaron Neuhauser, William Pickren, Christian Hawkins, Tyniyah Goodlett, Madeline Rogers, Tommy Huggins and Mikel Hannah-Harding. They will assist with statistical analysis and interpretation.

1.2 Division of tasks between PIs

The NWS PI has been the primary contact for Joey, providing detailed assistance with the specific tasks listed above. The NWS PI also serves as a committee member on the thesis committee. The university PI has been primarily responsible for recruiting students, assisting students with understanding the overarching goals and objectives of the research, creating and managing coursework for the students (thesis for graduate students, independent study for undergraduate students), and managing the grant. Both PIs have prepared conference abstracts and assisted students in preparing their own conference abstracts.

SECTION 2: Direct and Related Project Accomplishments and Findings

2.1 University perspective

Eight students participated in this project. Specifically one graduate student (Joey Coz) and seven undergraduate students (Aaron Neuhauser, William Pickren, Christian Hawkins, Tyniyah Goodlett, Madeline Rogers, Tommy Huggins and Mikel Hannah-Harding). The graduate student

does not receive college credit until Fall 2017 when the thesis is defended. Each of the undergraduate students has already received college credit for their participation in the research. Specifically, William Pickren, Tommy Huggins, Madeline Rogers, Christian Hawkins, Aaron Neuhauser, Tyniyah Goodlett and Mikel Hannah-Harding were enrolled in an independent study Physics and Astronomy course (in other words, a separate course was created for each of these students, where the academic PI was the instructor and guided the student research during the term). Seven sections of PHYS390 (for varying credit of one to three hours each), six sections of PHYS397 (zero credit hours but appears on the transcript) and one section of ENVT350 (environmental studies). Each of the students prepared a final report at the end of their course that summarized what they learned and problems they encountered.

Specifically, here are the courses developed for the students involved in this COMET research:
Fall 2015:
PHYS390, Aaron Neuhauser, 1 credit hour
PHYS390, Christian Hawkins, 2 credit hours
Spring 2016:
PHYS390, William Pickren, 3 credit hours
PHYS397, Aaron Neuhauser, 0 credit hours (appears on transcript, but no tuition!)
Summer 2016:
PHYS397, Aaron Neuhauser, 0 credit hours (appears on transcript, but no tuition!)
Fall 2016:
PHYS397, Aaron Neuhauser, 0 credit hours (appears on transcript, but no tuition!)
PHYS397, Christian Hawkins, 0 credit hours (appears on transcript, but no tuition!)
Spring 2017:
ENVT350, William Pickren, 3 credit hours
PHYS390, Tyniyah Goodlett, 2 credit hours
PHYS390, Mikel Hannah-Harding, 2 credit hours
PHYS390, Tommy Huggins, 3 credit hours
PHYS397, Christian Hawkins, 0 credit hours (appears on transcript, but no tuition!)
PHYS399, Aaron Neuhauser, 3 credit hours
Summer 2017:
PHYS390, Madeline Rogers, 1 credit hour
PHYS397, Aaron Neuhauser, 0 credit hour (appears on transcript, but no tuition!)
Fall 2017:
EVSS690, Joey Coz, 6 credit hours

The University PI and one graduate student attended the 2016 Carolina Climate Resiliency Conference, held in Charlotte, NC, Sept. 12-14, 2016. The University PI, the NWS PI and three undergraduate students attended the 2017 Palmetto Chapter of the AMS annual meeting, held in Columbia, SC, March 2, 2017.

2.2 NWS perspective

Frank Alsheimer has hosted the graduate student at the NWS office on several occasions and shown him the operations. He also met repeatedly with the graduate student, either in person or via webcast. He also served as contact points for undergraduate students desiring further

research opportunities. These students spend time as volunteers at the NWS office learning about its operations, as well as understanding the process of transitioning research into operations to fulfill the Weather Ready Nation vision of the NWS.

SECTION 3: Summary of Benefits

3.1 University Partner Perspective

In 2016 the College of Charleston received final approval upgrading the meteorology program to fully meet AMS and Federal Civil Service curriculum requirements. This is the only such program in the state of South Carolina. A close collaboration with the SC NWS offices is essential for providing students insight into operational forecasting and jobs. The COMET connection is central to this collaboration and will pay great dividends to both the NWS within South Carolina and also to the meteorology program at the College of Charleston.

Also, many undergraduate and graduate students are getting valuable research experience, as well as a deep understanding of the difficult issues the NWS faces in trying to present the risks associated with coastal flooding to the public. Additionally, sixteen College of Charleston special topics research courses have been created as part of the students' educational experience. These courses will appear on the students' transcripts, which will enhance their employment possibilities in the future. NWS personnel also have served as contacts and mentors for the undergraduate and graduate students.

This project also has created a bridge between the College of Charleston and the City of Charleston. Coastal flooding is a tremendous problem for residents here and a headache for the city police and policy makers. This bridge will be beneficial to both the College and the City.

3.2 Operational Partner Perspective

One of the premier benefits for WFO Charleston to date has been the continued interaction with College of Charleston students on the project, as discussed in the section above. This allows the exchange of ideas between the field forecasters and the students during visits to the office as well as volunteer tours of duty. Additionally, contact with students has led to research projects for credit.

This particular project has also lead to an increased awareness in some city leaders of the problem the city of Charleston will be facing in the future as tides continue to rise. This awareness has come from the PIs and the students reaching out to the city emergency manager for some of the preliminary comments on the effort from a public policy point of view.

Further, it increases the visibility of the NWS to students as a viable career path. The students learn the potential benefits of working for NOAA/NWS after graduation.

SECTION 4: PRESENTATIONS AND PUBLICATIONS

Five presentations were made of prior or existing COMET research while this grant was in effect, and three manuscripts describing prior COMET research are in preparation and will be submitted soon (appropriate citation of COMET funding is or was noted in each abstract and manuscript).

Conference Abstracts:

Caulder, A.C., B. L. Lindner, and P. J. Mohlin, Forming a basis for mesoscale sea fog forecasting in the Charleston-Savannah area (abstract), Proceedings Volume, 22nd Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p.4, 2016.

Coz, J., B.L. Lindner, F.Alsheimer, S. Carr, D. Warheit and H. Lipinski, A coastal flood climatology for the Lowcountry, 2nd Carolinas Climate Resilience Conference Proceedings Volume, pp. 32-33, University of South Carolina Dept. of Geography, Columbia SC, 2016.

Lindner, B.L., J. Johnson, S. Duke and F. Alsheimer, Communicating the risk of tropical storm surge to the public in Charleston, SC, 2nd Carolinas Climate Resilience Conference Proceedings Volume, pp. 43-44, University of South Carolina Dept. of Geography, Columbia SC, 2016.

Lindner, B. L., A.M. Neuhauser, C. Hawkins, W. Pickren, B. T. Huggins, T. Goodlett and M. Hannah-Harding, A deeper look at the climatology of hurricanes and tropical storms in Charleston (abstract), Proceedings Volume, 23rd Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p. 5, 2017.

Neuhauser, A.M., P. Mohlin and B. L. Lindner, Beta testing of a sea fog prediction technique (abstract), Proceedings Volume, 23rd Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p. 5, 2017.

Journal Articles:

Lindner, B.L., J. Johnson, F. Alsheimer, S. Duke and G.D. Miller, Increasing Awareness of the Threat of Hurricane Storm Tide Using an Interactive, Web-based, Visualization Approach, Weather, Climate and Society, under review.

Lindner, B.L., F. Alsheimer and J. Johnson, Assessing improvement in the public's understanding of the risks due to hurricane storm surge through the use of a surge visualization model, Weather, Climate and Society, under review.

Lindner, B.L., C. Hawkins and A. Neuhauser, Climatology and variability of tropical cyclones impacting Charleston, SC, J. Coastal Res., under review.

SECTION 5: Summary of Problems Encountered

5.1 University PI perspective

The primary problem encountered has been the shortened timeframe within which to do the research (due to the constraint that UCAR funding was scheduled to expire, our grant timeframe

was cut to just 9 months). This problem was resolved as COMET staff helped us obtain a no-cost extension. This provided adequate time to complete the project.

The other related problem has been the delays in getting the graduate student going on this research and thesis proposal. It is not unusual for students to take a relaxed approach to initiating paperwork and research, but given the tight timeframe for this grant, it potentially caused some problems. However, this problem was also resolved with the no-cost extension.

5.2 NWS PI perspective

No significant problems have been encountered. There was a bit of a delay in the progress in May due to the student's end of semester needs, but that has since started to catch back up. When meeting in person has not been possible, we have held webinars to bridge the gap to some extent.

Additionally, the NWS PI received a new appointment in the Columbia SC office, which has made in person meetings more challenging. However, the new office is only 100 miles away, so in person meetings can still be held, thesis defense meetings will still be possible, and webinars, email and other electronic communication have made the new location virtually problem-free.