University: College of Charleston

Name of University Researcher Preparing Report: B. Lee Lindner

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Partners or Cooperative Project: Partners

Project Title: Evaluating the efficacy of Internet-based hurricane surge forecasts

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SECTION 1: Summary of Project Objectives

As detailed in the proposal (which will not be repeated in depth here), this project consists of two main parts. The first part involves the completion of the interactive Internet-based hurricane surge simulation computer model. Specifically, this involves connecting the multiple databases assembled under previous COMET grants to the Internet display system. The second part involves having many test subjects use the model and then having their hurricane understanding probed with a survey to examine how well their understanding has improved (if at all).

SECTION 2: Project Accomplishments and Findings

Nine students participated in this project. Specifically two graduate students (Janet Johnson and Stephen Duke) have worked on GIS and HTML computer programming of the model for the entire term of the project. Six undergraduate students (Cory Barton, Jessica Darone, Austin Garland, Laura Mudge, Liah Wallace, and Daniel Johnson) and one high school student (Carter Rhea) did data collection and database manipulation for various semesters during the project. Specifically, the undergraduate and high school students gathered additional data points (in addition to the approximately 2000 data points at locations throughout the tri-county area) and provided new data for some of the previous data points that were determined to be in error. Each data point consists of a photograph of a landmark, GPS measurements of exact latitude and longitude, scales within the photograph, general descriptions, time and date. The data collection phase of this project is now virtually completed.

The primary accomplishment thus far has been the ongoing model development by the graduate students (who received the lion's share of the funding). When this project began, we had developed a preliminary working map with a few datapoints connected to it to demonstrate its effectiveness. When we began to flesh out the model during this project, it became apparent our approach was not going to work on the full scale, and the graduate students have taken an entirely new approach to the computer model. Progress has been slow, as several technical

problems have cropped up, but there only remain a couple of technical problems to resolve before this new approach will be ready for full-scale development and implementation. We are hopeful that within a matter of weeks we will have a working prototype model.

Another primary accomplishment has been the development of two surveys that will be administered to gauge the effectiveness of the web site in conveying the threat of storm surge to the public. One survey will be administered online to participants before they are allowed access to the model. This survey will collect basic demographic data as well as determine the current knowledge of each participant of the underlying physics and risks associated with surge. The second survey will be administered online to participants immediately after they have explored the model. This survey will repeat some of the questions probing surge understanding, to search for improvement, as well as ask questions of any confusion or misunderstanding that resulted, or any flaws discovered, or any difficulties in using the model.

The Principal Investigators (both academic and forecasting) have been supervising the overall work, as well as presenting preliminary COMET results at the American Geophysical Union Ocean Sciences Meeting, held in Orlando, Fla., in March 2008; the Interdepartmental Hurricane Conference, held in Charleston, SC in March 2008; the 28th AMS conference on hurricanes and tropical meteorology, held in Orlando, Fla. in April 2008; the AMS/NWA regional conference on the inland impacts of tropical cyclones, held in Atlanta, GA in June 2009; and 29th AMS Conference on Hurricanes and Tropical Meteorology, held in Tucson, Arizona in May 2010 (the first and fourth conference presentation was delivered by the academic PI while the remaining presentations were by the forecasting PI or our other NWS collaborator Bob Bright; details on the abstracts are given below). The academic PI has also worked with college webmasters to resolve security issues that were hampering model development. The academic PI also recruited and managed the students, and was also responsible for the budget. The forecasting PI has also been assisting the students with understanding the hurricane warning suite issued by the local forecasting office and also with answering technical questions regarding hurricane surge modeling.

2.2 Related Accomplishments

Each of the undergraduate students received college credit for their participation in the research. Specifically, Laura Mudge, Liah Wallace and Jessica Darone all were enrolled in independent study Environmental Studies courses, numbered ENVT350 (in other words, a separate course was created for each of these students, where the academic PI was the instructor and guided the students research during the term). Daniel Johnson, Cory Barton and Austin Garland were enrolled in independent study Physics courses, numbered PHYS390 or PHYS 399 (again, three separate courses were created where the academic PI was the instructor). Each of the students prepared a final report at the end of their course that summarized what they learned and problems they encountered.

Additionally, the academic PI taught a Environmental-Studies special-topics course titled “Katrina” (ENVT 395) in Spring 2008, with over 30 students enrolled. The academic PI taught a Freshman-Seminar special-topics course titled “Perspectives on Katrina” (FYSM 154) in Fall 2009, with over 20 students enrolled. In both courses, the academic PI spent half the term discussing the physics of hurricanes, and had various guest speakers come in the second half of

the term and describe Katrina from their perspective. The forecasting PI gave one lecture in both courses, where he explained how the National Weather Service forecasts hurricanes, how the local office deals with issuing these forecasts, and how the local office interacts with state and local officials as well as other NWS offices.

The above-mentioned lectures in ENVT 395 and FYSM 154 by the forecasting PI was well received by the students. All of the students were very curious about how the NWS forecasts hurricanes, issues forecasts and deals with local officials. Several students in the class were meteorology students, and quizzed the forecasting PI repeatedly about NWS jobs and lifestyle. Additionally, both Robert Bright and Frank Alsheimer have also served as contact points for undergraduate students desiring further research opportunities. A couple of the students actually spent time as volunteers at the NWS office learning about its operations.

SECTION 3: Benefits and Lessons Learned: 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.

This project has also helped the WFO staff understand that GIS-based and web-based technologies and delivery systems will become a larger part of operations going forward.

Preliminary concepts on technique and display have already been discussed with the South Carolina Emergency Management community. The availability of additional tools to get the public to evacuate during the threat of hurricane landfall has become even more critical in light of the devastation in storm-surge prone areas from both Hurricane Katrina (2005) and Hurricane Ike (2008). The results of the research will be incorporated into the significant hurricane outreach efforts by the NWS Charleston WFO.

SECTION 4: Benefits and Lessons Learned: University Partner Perspective

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 hurricanes to the public. Additionally, eight 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. This project was central in the development of the special topics courses 'Katrina' and 'Perspectives on Katrina'. Not only was the topic clearly linked to our research, but the forecast partners' guest lecture tied in directly as well. Over 50 students were enrolled in these courses, and their appreciation for the NWS mission is immeasurable. NWS personnel also have served as contacts and mentors for the graduate students.

The GPS mapping software that we had proposed using did not connect to the various databases that we had assembled. This required us to develop new mapping software. Also, we ran into various technical issues, including new security requirements campus-wide. Various new software packages were purchased, that required additional time to understand. All these technical problems resulted in taking far more time to complete the model than we had originally anticipated. Regardless, these problems have been mostly resolved and we believe we are very

near to having a completed model. Note that all the graduate students are now working full-time jobs, and basically work on the model in their spare time (thus, additional delay). However, we felt it better to continue using graduate students familiar with the research than start with new students.

SECTION 5: PRESENTATIONS AND PUBLICATIONS

Five presentations were made of COMET research while this grant was in effect, and six abstracts were published (appropriate citation of COMET funding was noted in each). Note that the fifth abstract presented results from our prior COMET grant, while the others all dealt with the current grant. Also, an additional presentation will be made this coming May, along with another abstract publication (approximate citation below). Copies of all these abstracts are attached, except for the one to be published this May.

Lindner, B.L., J. Johnson, D. Timmons, G. Miller, R. Evsich and F. Alsheimer, Conveying forecasts of tropical-cyclone-generated surge to the public with an interactive, internet-based surge model (abstract), 2008 Ocean Sciences Meeting Proceedings Volume, http://www.sgmeet.com/aslo/orlando2008/viewabstract2.asp?AbstractID=368 2008.

Bright, R. J., F. Alsheimer, B. L. Lindner, G. Miller, D. Timmons, and J. Johnson, An interactive internet-based tropical cyclone storm surge display for Charleston, South Carolina (abstract), 28th Conference on Hurricanes and Tropical Meteorology, http://ams.confex.com/ams/28HURR/techprogram/paper_74476.htm, 2008.

Alsheimer, F., R.J. Bright, B. L. Lindner, G. Miller, D. Timmons, and J. Johnson, An interactive website designed to enhance public understanding of storm surge and National Weather Service tropical products, 2008 Interdepartmental Hurricane Conference proceedings volume, 2008.

Bright, R. J., F. Alsheimer, B. L. Lindner, G. Miller, D. Timmons, and J. Johnson, An interactive internet-based tropical cyclone storm surge display for Charleston, South Carolina, 28th Conference on Hurricanes and Tropical Meteorology, http://ams.confex.com/ams/pdfpapers/137579.pdf, American Meteorological Society, Boston, 2008.

Alsheimer, F., J. Jelsema, B. L. Lindner, J. Johnson, D. Timmons, and T. Rolfson, A synoptic climatology of high impact events in the county warning area of the National Weather Service forecast office in Charleston, South Carolina, 25th conference on severe local storms, 7 p., American Meteorological Society, Boston, 2008.

Lindner, B.L., J. Johnson, D. Timmons, G. Miller, R. Evsich, F. Alsheimer and R. Bright, Modeling the inland impact of tropical cyclone surge, AMS/NWA Metro Atlanta Chapter presents inland impacts of tropical cyclones, p. 26, 2009.

Alsheimer, F., B. L. Lindner, R. Bright, J. Johnson and S. Duke, An effort to increase storm surge threat awareness for the Charleston, SC area using a web-based visualization tool and associated survey, 29th Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, Boston, 2010.

Additionally, we wished to note that over the past decade we have published 24 abstracts and one journal article that presented research funded by the five COMET partners grants we have received. Many of these were published AFTER the final reports were due to

COMET, and thus we wished to take a moment to list them all for your records. We can provide copies of any or all of these presentations and publications if requested.

COMET Grants:

DOC/NOAA/NWS via the UCAR (University Corporation for Atmospheric Research) COMET (Cooperative Program for Operational Meteorology, Education and Training) NWS (National Weather Service) Partners Project Outreach Program, entitled "Forecasting the Development and Movement of the Sea Breeze and its Effect on Severe Weather", $5,250 over 1 year, June 1998- May 1999, grant number NA67WD0097 (Subaward number UCAR-S98-94731).

DOC/NOAA/NWS via the UCAR COMET NWS Partners Project Outreach Program, entitled "Improving Hurricane Warning Effectiveness", $8,007 over 1 year, June 2000 – May 2001, grant number NA97WD0082 (Subaward number UCAR-S00-22461).

DOC/NOAA/NWS via the UCAR COMET NWS Partners Project Outreach Program, entitled "Interactive Hurricane Surge Depictions", $8,966 over 2.5 years, March 2005 – August 2007, grant number NA17WD2383 (Subaward number UCAR-S05-52253).

DOC/NOAA/NWS via the UCAR COMET NWS Partners Project Outreach Program, entitled "A Synoptic Climatology for High Impact Events in Southern South Carolina and Northeast Coastal Georgia", $8,580 over 1 year, Aug. 2006 – July 2007, grant number NA17WD2383 (Subaward number UCAR-S06-58397).

DOC/NOAA/NWS via the UCAR COMET NWS Partners Project Outreach Program, entitled "Evaluating the efficacy of an internet-based hurricane surge model", $8,799 over 1 year, June 1 2008 – Dec. 31 2009, grant number NA (Subaward number UCAR-S08-68867)

Abstracts:

Frysinger, J.R., J. Chenault, B.L. Lindner and S. Brueske, Sea Temperature Monitoring with a Portable Weather Station near Charleston, SC (abstract), Proceedings Volume, Fifth Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p. 13, 1999.

Frysinger, J.R., S.L. Brueske and B.L. Lindner, Prediction and Characterization of Sea Breezes in Coastal South Carolina (abstract), http://www.confex2.com/ams/cpp3/index.htm, 1999.

Frysinger, J.R., S.L. Brueske and B.L. Lindner, Prediction and Characterization of Sea Breezes in Coastal South Carolina, Proceedings Volume, Third Conference on Coastal Atmospheric and Oceanic Prediction and Processes, pp. 27-32, 1999.

Frysinger, J.R., B.L. Lindner and S.L. Brueske, Statistical modeling of Sea Breezes (abstract), Proceedings Volume, Fourth Annual Fall Meeting Southern Atlantic Coast Section of the American Association of Physics Teachers, p. 4-5, 1999.

Chenault, J., S.L. Brueske and B.L. Lindner, Investigation of tornadic storms on 15 April, 1999, in eastern Georgia (abstract), Bulletin of the South Carolina Academy of Science, 62, 52, 2000.

Harper K. and B. L. Lindner, Site Specific Storm Surge Model (abstract), Proceedings Volume, Ninth Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p.4, 2003.

Brisacher S. and B. L. Lindner, A New Twist on Teaching Teachers: Helping Broadcasters Convey the Physics Behind Hurricane Warnings (abstract), Proceedings Volume, Ninth Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p.5, 2003

Harper, K. and B. L. Lindner, Site Specific Storm Surge Model (abstract), Proceedings of the fifteenth annual College of Charleston Research Poster Session, http: //www.cofc.edu/~physics/poster_03/, 2003.

Brisacher, S. and B. L. Lindner, A New Twist on Teaching Teachers: Helping Broadcasters Convey the Physics behind Hurricane Warnings (abstract), Proceedings of the fifteenth annual College of Charleston Research Poster Session, http: //www.cofc.edu/~physics/poster_03/, 2003.

Lindner, B. L., Improving the effectiveness of inland warnings and watches (abstract), Proceedings of the Mid-Atlantic Regional Conference on the Inland Effects of Tropical Weather Systems, Raleigh, NC, http://www.nc-climate.ncsu.edu/ams/conference/agenda/, 2003.

Lindner, B. L., C. Cockcroft and S. Brueske, Enhancing the efficacy of hurricane advisories (abstract), 26th Conference on Hurricanes and Tropical Meteorology, http://ams.confex.com/ams/26HURR/techprogram/paper_74476.htm, 2004.

Lindner, B. L., C. Cockcroft and S. Brueske, Enhancing the efficacy of hurricane advisories, 26th Conference on Hurricanes and Tropical Meteorology, pp. 427-428, American Meteorological Society, Boston, 2004.

Lindner, B. L., S. Perkins, L. Germanow, R. Evsich, K. Steele, T. Kent, F. Alsheimer and R. Bright, Visualizing Hurricane Surge (abstract), Proceedings Volume, Eleventh Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p.9, 2005.

Lindner, B.L., D. St. Jean, C. Cockcroft, and S. Brueske, Predictions of storm surge flooding with the use of hurricane climatology (abstract), 15th Conference on Applied Climatology, http://ams.confex.com/ams/15AppClimate/techprogram/paper_90600.htm , 2005.

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Lindner, B.L., D. Timmons, J. Johnson, F. Alsheimer and R. Bright, A Prototype Next Generation Hurricane Storm Surge Warning System (abstract), Proceedings Volume, 12th Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, p. 8, 2006

Lindner, B.L., R. Evsich, D. Timmons, J. Johnson, and F. Alsheimer, On the display of hurricane surge (abstract), Proceedings Volume, 13th Mini-technical conference of the Palmetto Chapter of the American Meteorological Society, 1 p., 2007

Lindner, B.L., J. Johnson, D. Timmons, G. Miller, R. Evsich and F. Alsheimer, Conveying forecasts of tropical-cyclone-generated surge to the public with an interactive, internet-based surge model (abstract), 2008 Ocean Sciences Meeting Proceedings Volume, http://www.sgmeet.com/aslo/orlando2008/viewabstract2.asp?AbstractID=368 2008.

Bright, R. J., F. Alsheimer, B. L. Lindner, G. Miller, D. Timmons, and J. Johnson, An interactive internet-based tropical cyclone storm surge display for Charleston, South Carolina

(abstract), 28th Conference on Hurricanes and Tropical Meteorology, http://ams.confex.com/ams/28HURR/techprogram/paper_74476.htm, 2008.

Alsheimer, F., R.J. Bright, B. L. Lindner, G. Miller, D. Timmons, and J. Johnson, An interactive website designed to enhance public understanding of storm surge and National Weather Service tropical products, 2008 Interdepartmental Hurricane Conference proceedings volume, 2008.

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Paper:

Frysinger, J.R., B. L. Lindner and S.L. Brueske, A statistical sea-breeze prediction model for Charleston, South Carolina, Weather and Forecasting, 18, 614-625, 2003.

SECTION 6: Summary of University/Operational Partner Interactions and Roles

Both Partners were integrally involved in project design, proposal writing, project administration, report preparation and presentation of results at conferences. Both Partners met several times in person to discuss this project, but primarily communicated via email. The University PI was solely responsible for funds disbursement and curriculum design for research and lecture courses. The Operational PI was solely responsible for meeting students when they toured NWS facilities and mentoring students who sought out advice about NWS or similar careers.