

Expert Panel Assessment of Coastal Hazard Mapping in the Southeastern U.S.: Results from the *First Cullowhee Coastal Conference July 23-24, 2007*

I. ABSTRACT

An expert panel of coastal scientists and engineers was convened in July 2007 for a workshop to assess the state of coastal hazard mapping in the southeastern US, and identify research needed to improve coastal hazard assessments. Over the last 20-30 years, scientists and engineers have built a general understanding of storm processes and coastal responses, as well as quantitative models that estimate specific characteristics of storm surge and surface waves. This work has led to a clear, although qualitative, enumeration of the geomorphological factors that govern the intensity of coastal storm hazards. Such factors include coastal elevation, dune height and volume, vegetation type and density, proximity to inlets or other channels, gross coastal geomorphology, and nearshore bathymetric control. This scientific understanding has been translated into conceptual and numerical models that describe the susceptibility of coastal areas to hurricane impact, flooding, storm surge, wave attack, and erosion. Controls on the spatial (both alongshore and cross shore) and temporal distribution of storm energy are complex, and the above factors interact in ways that may be impossible to understand or predict. Existing methods used for defining and mapping coastal hazards typically achieve substantial agreement on the end members—extremely low and extremely high hazard—but do not show concurrence of boundaries between intermediate hazard definitions. The First Cullowhee Coastal Conference aimed to identify areas of consensus and discordance among practitioners of coastal storm hazard assessment and hazard mapping. Recommendations were sought regarding the types of data and techniques needed to fill the gap in our present understanding of coastal storm response to landfalling tropical cyclones in the southeastern U.S.

II. INTRODUCTION

The Program for the Study of Developed Shorelines (PSDS) together with the United States Geological Survey (USGS) and the National Climate Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) hosted a two-day workshop held July 23-24, 2007 on the campus of Western Carolina University. Twenty coastal scientists and engineers (Appendix I) from across the country came together to assess the capabilities of and needs for coastal hazard mapping related to tropical storms in the southeastern U.S..

The *a priori* stated goals of the meeting were:

- a. To summarize the data available for assessing, mapping, and modeling coastal hazards.
- b. To evaluate the methods used for assessing, mapping, and modeling coastal hazards.
- c. To compare method outcomes and discussions of successes and failures.
- d. To itemize the data and techniques presently missing or lacking, but needed to improve existing hazard assessment, mapping, and storm surge modeling.

In order to make the discussion more concrete and manageable, workshop participants agreed to focus spatially on the southeastern U.S. coastline, both Atlantic and Gulf of Mexico (Appendix II), and temporally over the next 10 years. A further procedural constraint was to focus the discussion and recommendations only on the effects of tropical cyclones (i.e. hurricanes). Thus the specific suite of recommendations are intended strictly for application along the southeastern U.S., and are considered not fully transmissible to other regions of the country without further modification or consideration of other processes such as regional geologic framework. A final decision was made to focus exclusively on the physical nature of coastal storm hazards. Issues of vulnerability, development, socioeconomics, and populations at risk were expressly not addressed. The primary objective of the meeting was to address the topic, "***The state of the science for assessing and mapping coastal storm hazards.***" In other words, what information and/or techniques are presently available to identify and assess the most hazardous stretches of coastline in the southeastern United States in terms of impacts from tropical cyclones? A secondary objective was to identify additional or new information/techniques that will be needed in order to successfully assess coastal hazards in this region over the next decade.

III. WORKSHOP DETAILS

This workshop grew, in part, out of a town-hall-style meeting that followed the topical session, "**Identifying Our Most Vulnerable Shorelines: Science and Policy**" held during the Geological Society of America (GSA) meeting in October 2006. This session itself was in many ways a response to the effects of the 2005 hurricane season, particularly hurricanes Katrina and Rita and their impact on the Southeastern coast. One vivid example and hot-button topic during the GSA discussion was the fact that the western end of Dauphin Island, Alabama, was inundated and severely damaged by hurricane Katrina - the fourth such occurrence in the last 30 years. Dauphin Island was seen as a clear indication that the scientific community needs a more effective way to address the issue of coastal storm hazards (Young and Bush, 2006; Sallenger et al., 2006; and Sallenger et al., 2007). The ***First Cullowhee Coastal Conference***, therefore, sought to address the questions that arose from the GSA session, namely--**How does the scientific community presently assess and map coastal hazards, and how in the future should we assess and map parts of the coast that are more hazardous than others?**

Workshop participants represented a cross-section of expertise including geologists, engineers, oceanographers, numerical modelers, and climatologists. Attendees came from the ranks of academia, government agencies, and the private sector. For a complete list of attendees and affiliations see Appendix I. The meeting did not examine issues of planning, risk assessment, or coastal management; but specifically addressed the scientific aspects of our current understanding of coastal hazards.

The meeting was organized into a 2-day, two-phase schedule. Day one involved individual presentations on previous or ongoing research approaches geared towards assessing coastal hazards. During day two, attendees engaged in an open forum

discussion with the aims of: 1) exploring the present state of the field and 2) establishing a series of consensus-based recommendations for future research needs.

IV. COASTAL HAZARDS DISCUSSION

The following represents key points discussed during the workshop. A comprehensive treatment of coastal hazards was deemed beyond both the scope of the meeting and this report.

Data

Several important existing datasets for characterizing tropical storm meteorology, intensity, and frequency were identified and discussed including:

1. HURDAT
2. Satellite observations
3. H*Wind
4. Wave Buoy network

HURDAT-- The National Weather Service and the National Hurricane Center's official hurricane database for the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, including those that have made landfall in the United States, is currently being updated, see Landsea et al. (2004).

Satellite Observations--The National Oceanographic Data Center (NODC) is a national repository and dissemination facility for global oceanographic data that acquires and preserves a historical record of the Earth's changing environment to be used for operational applications and ocean climate research. See <http://www.nodc.noaa.gov/>. See also other NOAA sites including NOAA Satellite Services Division <http://www.ssd.noaa.gov/> and NOAA's National Environmental Satellite, Data, and Information Service at <http://www.nesdis.noaa.gov/>

H*Wind is a NOAA Hurricane Research Division project to develop an objective analysis of the distribution of surface wind speeds in a hurricane. See Powell, et al. (1998). See http://www.aoml.noaa.gov/hrd/data_sub/wind.html.

Wave Buoy network – The National Data Buoy Center (NDBC), part of the National Weather Service (NWS), designs, develops, operates, and maintains a network of data collecting buoys and coastal stations. Access via <http://www.ndbc.noaa.gov/>.

Another useful and complementary approach to traditional storm hazard characterization discussed during the workshop was the Joint Probability Method or JPM. For discussions of applications of the Joint Probability Method to coastal issues see, for example, Ferro (2007), Resio et al., (2006), Schmalz (1983), or Scheffner et al., (1996).

Processes & Hazards

The following processes (listed alphabetically) were identified as having critical importance to the site-specific impact of a storm:

1. Erosion
2. Flooding
3. Inlet formation/migration
4. Overwash
5. Precipitation
6. Subsidence
7. Surge
8. Waves
9. Wind

Spatiotemporal Factors

In addition to the above-mentioned processes, the following factors (in no particular order) were considered to play an important role in the modification of hazards, in as much as their spatiotemporal variation would affect--either positively or negatively--a given process (as an example, a well-vegetated, tall, wide dune system formed in the early Holocene would likely reduce the hazard associated with processes such as surge, overwash, flooding and erosion, while the existence of an inlet - current or historic - would likely increase the impacts of these processes):

1. Elevation
2. Dune Morphology
3. Shoreline type
4. Vegetation
5. Tide
6. Nearshore bathymetry/roughness
7. Geology

V. CHALLENGES AND RECOMMENDATIONS

The panel concluded that, at present, the coastal research community lacks the requisite observations needed for either the full assessment of storm impacts, or for the validation of storm hazard models. An expert panel approach was utilized in order to arrive at group consensus, resulting in the following data recommendations (Actions deemed most critical or most severely lacking are shown in bold):

Recommendation 1: Improve hazard mapping to communicate risk

In order to achieve this goal the following actions are advocated:

- 1) Develop and execute collaborative mapping initiatives for hazard mapping with partnerships amongst federal, state, private, and academic participants**

2) Conduct research especially aimed at data/observation needs and techniques related to the following high-priority topics:

- **Geology (e.g. characterization of the surficial and underlying geological framework)**
- **Inundation (field verification of elevation and velocity of maximum inundation as well as inundation time series)**
- ***In situ* hydrodynamic measurements, including surge level, water velocity, and wave characteristics**
- Water level
- Seamless topography/bathymetry
- Wind field
- Precipitation
- Dune height
- Island width
- Dune/Vegetation Quality Index
- Cross-island elevation
- Built environment
- Marine buoys
- Imagery (Aerial photography, beach cameras, multispectral land cover, airborne LIDAR)
- Paleotempestology
- Radar/CODAR
- Seafloor classification
- Benchmarks/geodetic control

Recommendation 2: Communicate hazards and risk to decision makers and the public

In order to achieve **recommendation** 2, the panel suggested a set of specific tropical cyclone hazard assessment approaches. Following the discussion of existing and needed data and techniques, the panel discussed a set of complimentary quantitative approaches for assessing tropical cyclone hazards along the southeastern US Coastline:

- 1) Using one or more appropriate models, apply design storm parameters every 50km along the coast to evaluate the resulting storm impacts, thus controlling for storm forcing conditions and thereby highlighting the differences in spatial factors, and
- 2) Evaluate storm frequency and other climatologic and geologic data that make one site more or less vulnerable than another (assessing susceptibility) utilizing techniques such as joint probability method and other statistical approaches.

This suite of analyses would help determine the most hazardous sites in a given region (Analysis 1) as well as the most vulnerable (Analysis 2). The resulting analysis could then form the basis of a public debate regarding local, regional, and national coastal management policies and highlight coastal areas requiring the greatest attention/study.

VI. CONCLUSIONS

The clearest and most consistent consensus to emerge from the *First Cullowhee Coastal Conference* was a need for better direct observations of coastal storm processes and resulting impacts. Of particular importance is the need for *in situ* instrument arrays capable of measuring and recording a temporal series of storm inundation over a meaningful spatial domain (i.e. 10s-100s of kilometers). A second need is the validation of storm surge models using better quantitative time-series observations of surge and inundation.

It was also generally held that longstanding reductionist geometric models (e.g. the Bruun rule) that have commonly been adopted by various agencies and other groups for coastal hazard assessment efforts oversimplify key physical and geological processes. Due to these limitations, such models should not be relied upon as the sole predictor of the potential for future erosion. Instead, efforts should be promoted to develop, test, and validate rigorous physics-based numerical models in conjunction with acquisition of the requisite *in situ* field observations listed previously.

Finally, participants noted the need for additional technological development and utilization on both the observational and modeling fronts, and recommended that continued and additional research efforts should be initiated with a goal of developing a unified framework for coastal hazard mapping and modeling.

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Appendix I: Meeting Attendees and Affiliations

Mark Borrelli- National Park Service

Brian Blanton- University of North Carolina at Chapel Hill

David Bush- State University of West Georgia

Andy Coburn- PSDS Western Carolina University

Bill Dally- Surfbreak Engineering Inc.

Mike Fenster- Randolph Macon College

Chip Fletcher- University of Hawaii

Jim Fox- University of North Carolina at Asheville

Paul Gayes- Coastal Carolina University

Dave Levinson- NOAA National Climatic Data Center

Chris Macon- USACE *Joint Airborne Lidar Bathymetry Technical Center of Expertise*

John Marra- NOAA IDEA Center

Len Pietrafesa- North Carolina State University

Nathaniel Plant- Naval Research Laboratory

Donald T. Resio, USACE Coastal and Hydraulics Lab

Abby Sallenger- USGS Center for Coastal & Watershed Studies

Michael Squires- NOAA National Climatic Data Center

Rob Thieler- USGS Center for Coastal and Marine Geology

Gabriel Toro- Risk Engineering Inc.

Art Trembanis- University of Delaware

Rob Young- PSDS Western Carolina University

Appendix II: Location Map

Map of the southeastern U.S.A

