SMART RIVER & DAM SECURITY
TRANSCRIPT FROM LEN PIETRAFESA, SECRETARY

I **Minutes from 06 February 2019 Taken by John Cleveland**

- a General Livingston called meeting to order.
- b General Livingston asked members to review previous meeting minutes and approve. So approved.
- c General Livingston asked members to review roster, provide phone numbers and indicate whether they will attend the February 8 Commission meeting.
- d General Livingston asked members to review email input of various members during the week of 31 January – 6 February.
- e General Livingston asked if there are other members that we should bring in. Suggestions included the Army Corps of Engineers and the SC Geologic Survey.
- f General Livingston turned discussion toward taking inventory of modeling currently available on inland waters.
- g Myra Reece brought up the Lumber River Basin Flood Analysis and Mitigation Strategies Study;
- h Dr. Chaudry brought up USC-funded study of floods.
- i Dr. Allen: Surface Water Availability Model and CHEOPS – Computer Hydro Electric Operations and Planning Software.
- j General Livingston: priority is to pull together modeling in one place.
- k Sel Hemingway: Lots of groups with data, no one putting it together.
- l Discussion about Interagency Data Collection
  - i. Objectives
    - a Find out who is modeling;
    - b Coordinate modeling;
    - c Predictive modeling = saving money and lives.
- m Discussion about dams
  - i Dam modeling must be interactive during event itself, adjust as situation develops
  - ii No accurate measurement of sediment
  - iii Lower ponds and bodies of water during these events
  - iv Coordinate w/ farmers to use irrigation pumps
  - v Dam Classifications – Class 1, 2, 3 – establish list of critical regulated dams.
- n Sel Hemingway moves discussion toward organizational issues
- o Sel moves to bifurcate committee into two subcommittees: 1) smart river; and 2) dam security. Motion carried.
- p Chairs:
  - i Sub-Committee: (2), Dam Security: Myra Reece
  - ii Sub-Committee: (1) Smart Rivers: Len Pietrafesa
- q Short-Term Goals
  - i Inventory of modeling
  - ii Inventory of data
  - iii Establish list of projects that can improve river flow
  - iv Analyze critically regulated dam

- r Long-Term Goals
    - i Education
    - ii New Flood Control Structures
    - iii Gap Analysis
    - iv Public Policy Changes
- s General Livingston:
    1. Send email for what subcommittee you want to serve on.
    2. Comfortable w/ meeting on a monthly basis? YES.
    3. Next meeting: 6 March – 12:00 – 2:00. Wade Hampton Governor's Conference Room.
- t Adjourn

II Minutes from 08 February 2019 taken by Len Pietrafesa

1 Bob Livingston reported out on the meeting of the 6^{th}. Bob's words are given in quotes below:

- a. "The Task Force has been split into Two Groups: Rivers and Tributaries and Dams"
- b. "March 06 is the next Face-to-Face Meeting"
- c. "Need to get an inventory of model systems from Global to Local"
- d. "Have to marry the various Datums"
- e. "The present situation is woefully short on Tidal Modeling"
- f. "What will it take to predict with a high degree of accuracy"
- g. "Canals?"
- h. "Effects of Man-made structures, particularly in smaller rivers"
- i. "Need to co-ordinate with Dam Owners"
- j. "Need to co-ordinate across State lines"
- k. "Small to large Dams"
- l. "How do these affect water flows in the rivers?"
- m. "Looking at future flood control structures"

III A Thought Piece - Report of Sub-Committee (1) Smart Rivers and Responses to

A **Data Sources for Data Assimilation, Modeling, Validation and Artificial Intelligence (AI), including, but not limited to: NOAA, USGS, NASA, Euro-Met and Non- Federal Assets:**

1 Lidar Topography and Bathymetry Data
2 NWS Ground Station Moisture data;
3 NWS Snowfall data;
4 NWS - WSD Radar data;
5 NOS Coastal Water Level data;
6 NDBC Marine Buoy data;
7 NESDIS IOOS data;
8 NOAA Earth System Research Lab/Global Systems Division (ERSL/GSD) MRMS Rainfall Estimate Output, which is "operational";
9 High Resolution Rapid Refresh (and RAP) model(s) (together as MRMS, HRRR-RAP);
10 NESDIS Satellite data;
11 USGS River Flow data;
12 CCU and FAU SEA EcoNET (NOAA sponsored NOAA MESO) data;
13 NESDIS, NASA and EuroMet SAR Data and Imagery.
14 For the Record: The NOAA –NREL WRF Atmospheric Forecast Model has Datum built into it; so this is not an issue for interactively coupled model system

B Numerical Models which could apply to SC Flooding; some positively, some not:

1. NOAA - SLOSH is a 2-D vertically averaged linearized numerical model, which solves the Shallow Water Equations. It does not contain physically consistent bottom boundary conditions nor fluid mechanically correct inundation (wetting) or retreat (drying) boundary conditions. All water level observations, including SLOSH storm surge heights, are referenced as height above a vertical datum. A vertical datum is an established surface that serves as a reference to measure or model heights and depths. Currently, the SLOSH model utilizes the National Geodetic Vertical Datum of 1929 (NGVD29) and the North American Vertical Datum of 1988 (NAVD88). All basins in the contiguous U.S. have been updated to NAVD88. SLOSH does not contain interactively coupled waves and is not interactively coupled with the atmosphere. It cannot produce accurate prognostic results but can be run quickly as its physics is simply formulated.
2. ACE - ADCIRC is a 2-D vertically averaged numerical model, which solves the Shallow Water Equations. It does not contain physically consistent bottom boundary conditions nor fluid mechanically correct inundation (wetting) or retreat (drying) boundary conditions. ADCIRC does not contain interactively coupled waves and is not interactively coupled with the atmosphere. It cannot produce accurate prognostic results, but can be run quickly as its physics is simply formulated.
3. POM is a 3-D primitive Navier-Stokes equations model that has realistic boundary conditions and inundation and retreat schemes. It has been interactively coupled with waves and the atmosphere. It is quite accurate and can be coupled to waves, the atmosphere and rivers.
4. ROMS is a next-generation POM and has more plug-in capabilities with Ecological modules and hydrologic modules. It is very versatile and is quite accurate and can be coupled to waves, the atmosphere and rivers, etc..
5. EFDC is a primitive equation code, like POM. Very good.
6. FVCOM is a volume preserving primitive equation code. Very good.
7. The hydrologic model WRF-HYDRO (Gochis et al. 2016) is a model that simulates a wide range of hydrologic processes that cover a complete water cycle including rainfall, soil moisture, evaporation, infiltration and exfiltration, subsurface flow base flow, one and two spatial dimensional (1D and 2D) river channel flow, etc. The model is employed as the basis for the U.S. National Water Model (NWM) and includes a land-surface-model.
8. The hydraulic model HEC-RAS. It is necessary to couple a hydraulic model to simulate 1D and 2D freshwater flooding because WRF-HYDRO does not. We will use the HEC-RAS model which has been developed by the U.S. Army Corps of Engineers (USACE) and models the hydraulics of water flow through natural rivers and other channels.
9. For SC numerical modeling of flooding, what is required is an Interactively- Coupled Numerical Model System. The interactively- coupled numerical system, shown in Figure 1 below, is based on model elements that have been applied widely for coastal ocean and coastal environment modeling and forecasting. Fortunately, a recent break-through development has implemented a prototype river-ocean interaction process. The modeling suite includes the following components shown in Figure 1 (with peer literature references).
   a. The atmospheric component is the Weather Research and Forecasting (WRF) (Skamarock et al. 2005). The WRF model, developed by NCAR and the NWS, is a numerical weather prediction and simulation non-hydrostatic primitive equation model with comprehensive atmospheric physics parameterization schemes. WRF is used by the NWS and worldwide to simulate and forecast nearly the full suite range of weather events including hurricanes and severe rainfall events;
   b. The oceanic component is the Regional Ocean Modeling System (ROMS) (Shchepetkin and McWilliams 2005). ROMS solves 3-D primitive equations and is used widely to study how a given region of the ocean estuaries respond to physical forcing, such as strong winds. ROMS is a free-surface model and is suitable for simulating Sea Level Rise and hurricane caused storm surge

and inundation. ROMS can be interactively coupled to the SWAN waves model and the WRF atmospheric model;

c WWIII is a NOAA linear wave model. It can be run quickly but lacks complete physics;

d SWAN (Booij, 2012) is an ONR - Navy wave model with wave breaking mechanisms and dissipation. SWAN is the most widely used computer model to compute irregular waves in coastal environments, based on deep water wave conditions, wind, bottom topography, currents and tides (deep and shallow water). SWAN explicitly accounts for all relevant processes of propagation, generation by wind, interactions between the waves and decay by breaking and bottom friction. It has been shown in peer-reviewed publications that waves create and exacerbate coastal and inland flooding. Further, it has been shown that simply adding waves to current model output is not fluid mechanically correct. Rather, via US Navy ONR sponsored research, it was shown definitively that interactively coupled wave-current interactions and modeling get the flooding models correct, that is the results agree with the validation data. Charleston was one of the validation sites studied;

e The hydrologic model WRF-HYDRO (Gochis et al. 2016) is a model that simulates a wide range of hydrologic processes that cover a complete water cycle including rainfall, soil moisture, evaporation, infiltration and exfiltration, subsurface flow base flow, one and two spatial dimensional (1D and 2D) river channel flow, etc. The model is employed as the basis for the U.S. National Water Model (NWM) and includes a land-surface-model;

f The hydraulic model HEC-RAS. It is necessary to couple a hydraulic model to simulate 1D and 2D freshwater flooding because WRF-HYDRO does not. We will use the HEC-RAS model which has been developed by the U.S. Army Corps of Engineers (and models the hydraulics of water flow through natural rivers.

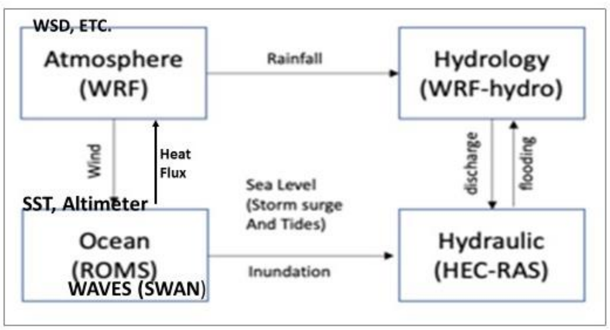

Figure 1 Diagram of the coupled model system

g All monitored data (see Section III a) can be assimilated in real-time into the Interactively – Coupled Model System shown in Figure 1.

h Ensembles or multiple runs of the model system starting 72 hours (6 days) out from an incoming or oncoming storm event produces the best results. Ensembles need to be produced at 24 hour for 6 and 5 days prior, then every 12 hours for 4 and 3 days prior and then every 6 hours for 2 and 1 day and 12 hours prior;

i Real-Time observational data, such as Sea Level, Radar, etc. must be used to Initialize the Model Runs and for Data Assimilation.

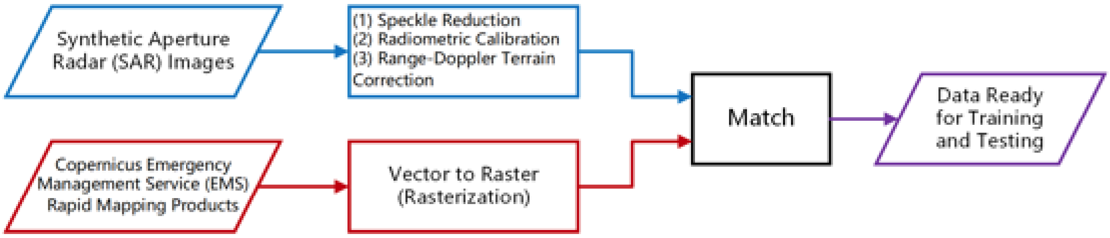

Figure 2 Flowchart of the preprocessing

C **The AI-based DCNN Remote Sensing Processing and Validation Methodology.**

a The first part of an inundation area mapping framework is data preprocessing. The aims of the data preprocessing are radiometric calibration and geometric correction. After the data preprocessing, one must select the features within a SAR image that can be matched with known ground truth from Copernicus EMS rapid mapping products to train and validate the developed algorithm. The flowchart of the data preprocessing is shown in Figure 2. It is worth mentioning that, if the matched scene with the Copernicus EMS rapid mapping product is covered by two or more SAR images, image mosaicking is also performed;

b The AI-DCNN framework is shown in Figure 3. The DCNN integrates the multi-dimension information in a unified framework, and provides an end-to-end classification solution. The most prominent classification features are not pre-designed by humans but rather are learned from the data. The AI-DCNN design performs pixel-level classification. After the DCNN method generate flood extend mapping, a high-resolution topography data set can be used for each domain to get the floodwater depth mapping.

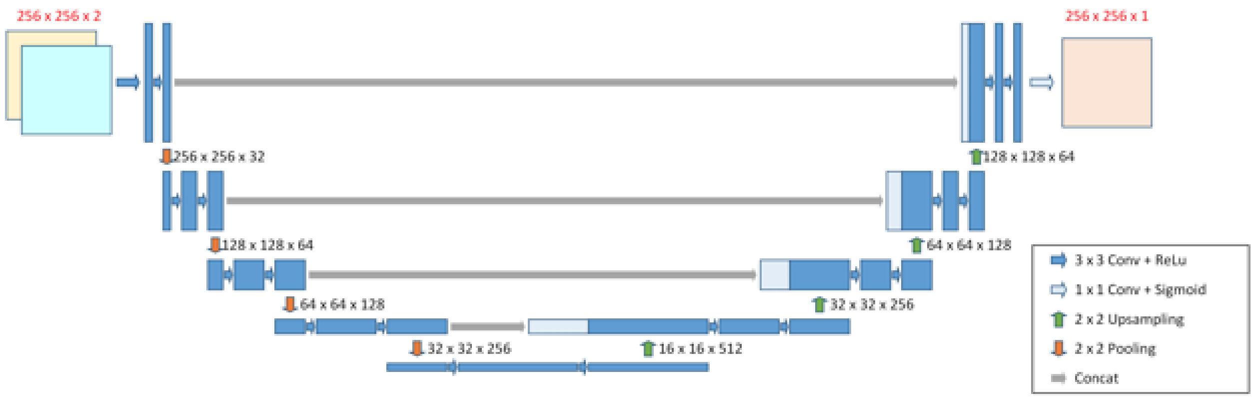

Figure 3 Flowchart of the DCNN design

D **Public Health**

1. A very important factor comprises the Public Health of SC residents and visitors, both physical and mental. In the grand scheme, this is an incredibly important factor, as both human and ecological health impacts can be short term and very long-lived and must be studied as a core component of this Task Force.

2. Given item D and the members of the Task Force, I reached out to Dr. John Yanessa, Associate Professor of Public Health, CCU, and he provided the following: 1) "Dear Len, I agree with you, this is a very important health issue. Horry County, and the Conway-Myrtle Beach area in SC were deeply impacted by the recent storms and massive flooding. I will be happy to assist with public health information as you need it. I wanted to initially provide you a broad overview of *some* of the public health concerns after a natural disaster that includes flooding. I am not sure as to the specific outcomes you need, but am happy to

advise. 2) Loss of Structures/Built Environment: Personal injuries related to structures may occur as individuals attempt to remove themselves, their families, or possessions from danger. There is also potential for injuries when people return to their homes and businesses and begin to assess personal damage. These injuries can occur from entering unstable buildings, or unintended contact with electrical power cables. 3) Increase in Infectious Disease: When there is flooding, there is potential for increased fecal- oral transmission of disease. As waters rise, it is common for sewers to flood, and the contents to be strewn throughout areas where there is standing, or slow moving water. Once the storm passes, the standing water remains. Bacteria, Viruses, and other organisms proliferate exponentially. As the waters slowly recede, large areas can remain so contaminated they are unsafe for human habitation. Contact with contaminated surfaces can cause disease outbreaks. For example, this is an ongoing issue in the Conway park by the Waccamaw River. It is costly for DHEC to perform the necessary soil testing and surface cleaning needed for humans to re- enter the contaminated areas. An additional specific interest to the Carolinas is the environmental impact from the flooding of Hog farms. There have been published studies (case-control studies, cross-sectional surveys, outbreak investigations etc.) that have reported post-flood increases in infectious diseases. In rural areas, the population may not have access to clean water and sanitation. This rural isolation intensifies the dangers for infectious disease, and may force relocation of effected families for an extended period of time. 3) Mental Health Issues: Less discussed (but as important) are the mental health issues related to flooding from disasters. It is perhaps easiest for me to quote the World Health Organization. It recognizes that the mental health consequences of floods "have not been fully addressed by those in the field of disaster preparedness or service delivery," although it is generally accepted that natural disasters, such as earthquakes, floods, and hurricanes, "take a heavy toll on the mental health of the people involved… Most often we see an increase in the incidence of anxiety and depression";

3. I have invited John to join the Smart River Sub-Committee.

E **The Applications**

Forecasting of Flooding by depth, location, time and persistence, 5-days, 4- days, 3-days, 2-days, 1-day prior to an incoming event and during an event

6-hourly Communication of the visualized numerical model output on a CCU Web-Site

F The SC Watersheds and major highways through SC Watersheds

Figure 1. The eight surface-water basins to be modeled in South Carolina.

Figure 4 SC Watersheds

Figure 5 SC Rivers and Lakes

Figure 6 SC Major Highways and Rivers