Forecast Predictions of Winds, Waves and Storm Surge during Hurricane Arthur (2014)

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Outline

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- ➢ **Sharing forecast guidance in NC**
- ➢ **Providing forecast guidance in other formats**
- ➢ **Introducing *Kalpana***

PART 2 : Forecast predictions during Arthur (2014)
- ➢ **Influence of track uncertainty on ASGS results**
- ➢ **Evolution of water levels**
- ➢ **Sensitivity of maximum surge to track**

PART 3 : More about *Kalpana* – A visualization tool
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General summary

PART 1: Real-time storm surge forecasting in NC

➤ Atlantic hurricanes pose a severe threat to North Carolina (NC) every year

➤ Hazel (1954), Fran (1996), Floyd (1999), Isabel (2003) and Irene (2011) are historical hurricanes that have severely affected NC coastal communities

➤ NC coastline characterized by a unique network of barrier islands, sounds, bays and estuaries
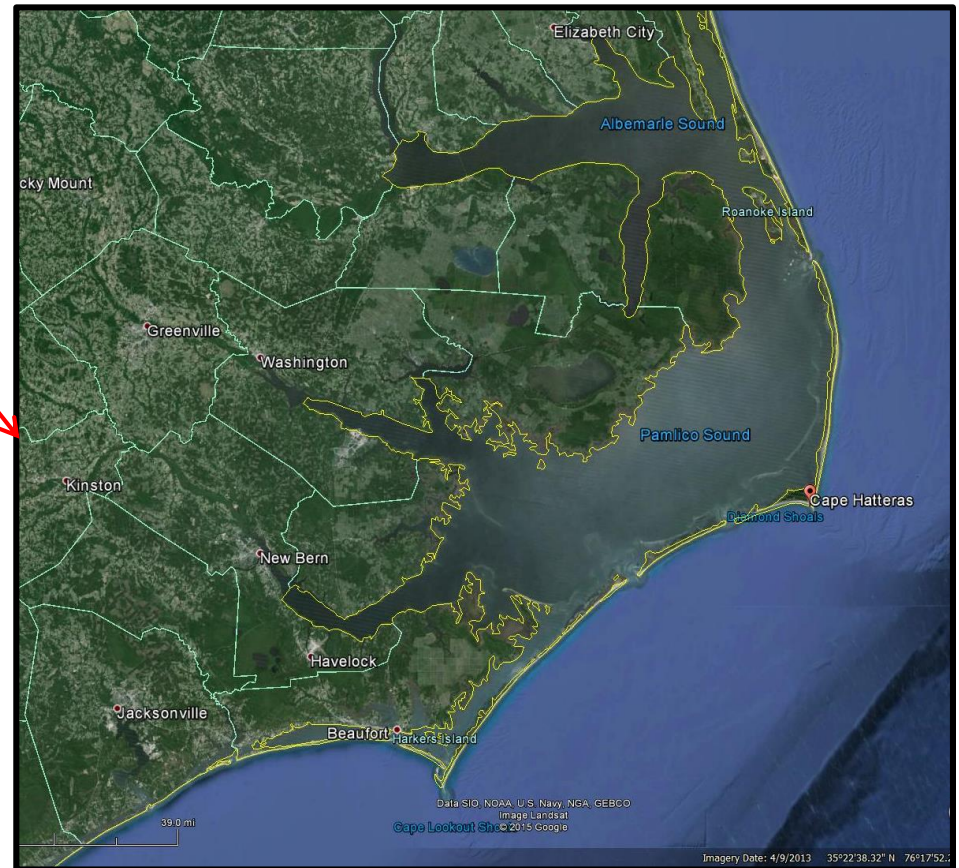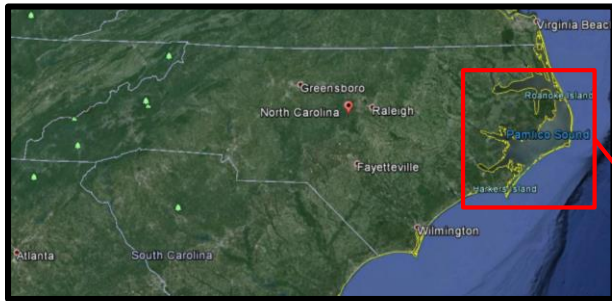
PART 1: Real-time storm surge forecasting in NC

Review of ADCIRC Surge Guidance System (ASGS)

➢ ADCIRC Surge Guidance System (ASGS) – software that automates storm surge and wave forecasting during a hurricane event

➢ Key features:

  ➢ Initiates ADCIRC+SWAN simulations in real time

  ➢ Receives meteorological input from NHC advisories issued during the event

  ➢ Constructs asymmetric hurricane wind field using parametric Holland wind model (1980)

  ➢ Forecast guidance archived and distributed in different formats

➢ ASGS Development Teams

  ➢ University of North Carolina at Chapel Hill

    ➢ Provide forecasts for Carolina and surrounding states via Google Maps application (nc-cera.renci.org)

  ➢ Louisiana State University

    ➢ Provide forecasts for Lousiana and northern Gulf States via Google Maps application (cera.cct.lsu.edu)

  ➢ University of Texas at Austin

    ➢ Provide forecasts for storms impacting Texas coastline; partnerships with Texas State Operations Center

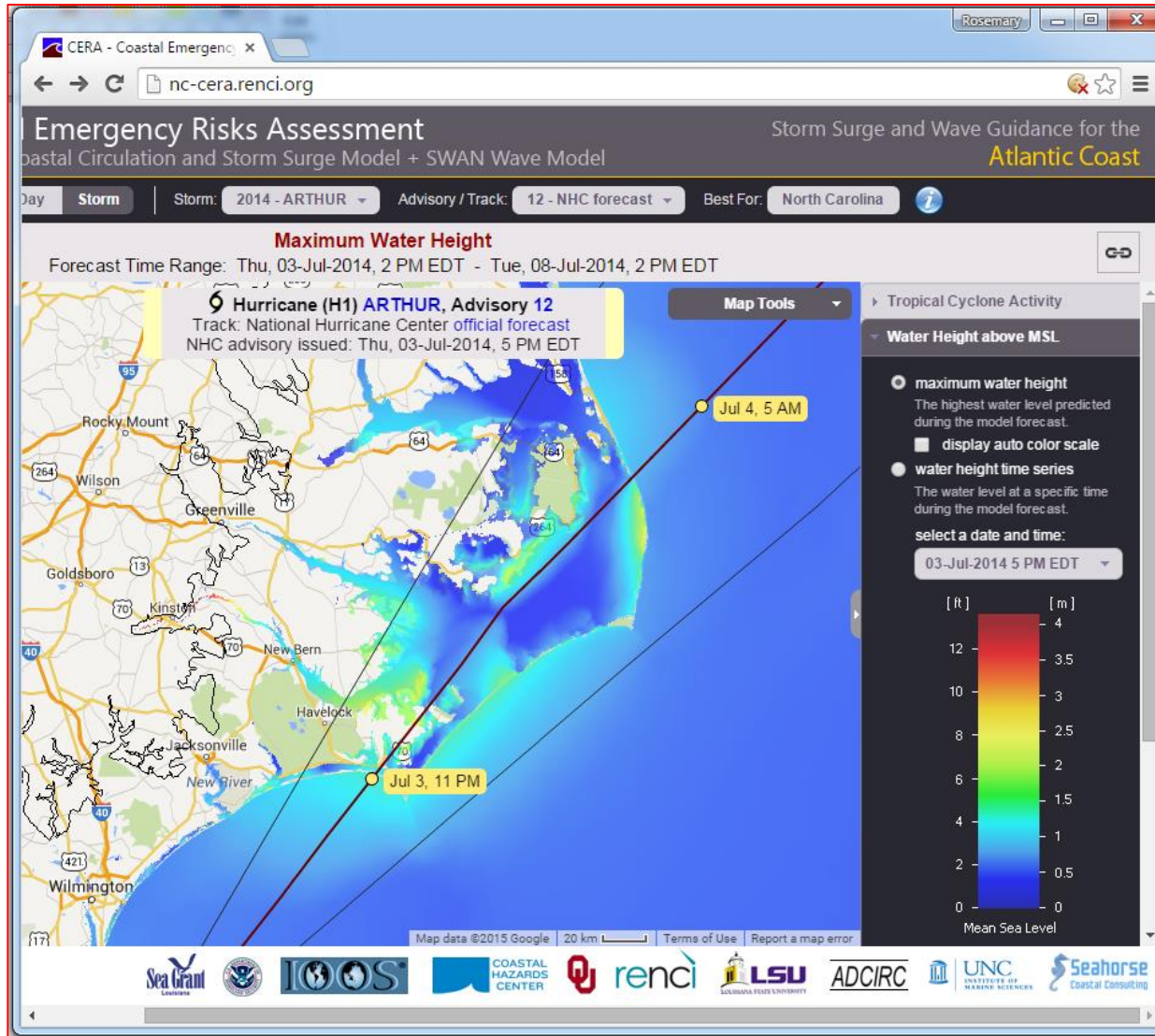# PART 1: Real-time storm surge forecasting in NC

Sharing forecasting guidance in NC

Interactive guidance offered via Google Maps by Coastal Emergency Risks Assessment (CERA) Team

- ➢ ASGS results provided as geo referenced raster images
- ➢ Shared via web portal - nc-cera.renci.org
- ➢ Can view real-time and historical storm results as time series or maxima
- ➢ Select layers for:
  - ➢ Water Levels (above MSL or above ground)
  - ➢ Waves (significant heights, peak periods)
  - ➢ Wind Speeds
  - ➢ Hydrographs at NOAA/NOS gage stations

PART 1: Real-time storm surge forecasting in NC

During Arthur (2014): nc-cera.renci.org

PART 1: Real-time storm surge forecasting in NC

Providing forecast guidance in other formats

Visualization of ADCIRC outputs in vector based formats:
- Polygon-based formats:
  - Shapefiles and ancillary files for GIS
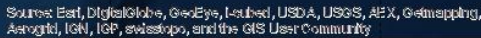 - KML files for Google Earth

Advantages of proposed formats:
- Easy to store and visualize large amount of data in a geographical information system
- These files can be overlaid with other spatial data (such as road networks, evacuation routes, locations of emergency shelters etc.)
  - May be useful for emergency managers

We developed a Python-based script to convert ADCIRC+SWAN output to these formats
- Part of NC Sea Grant project to expand forecast guidance to end users
- Based on older scripts from Brian Blanton and Rick Luettich
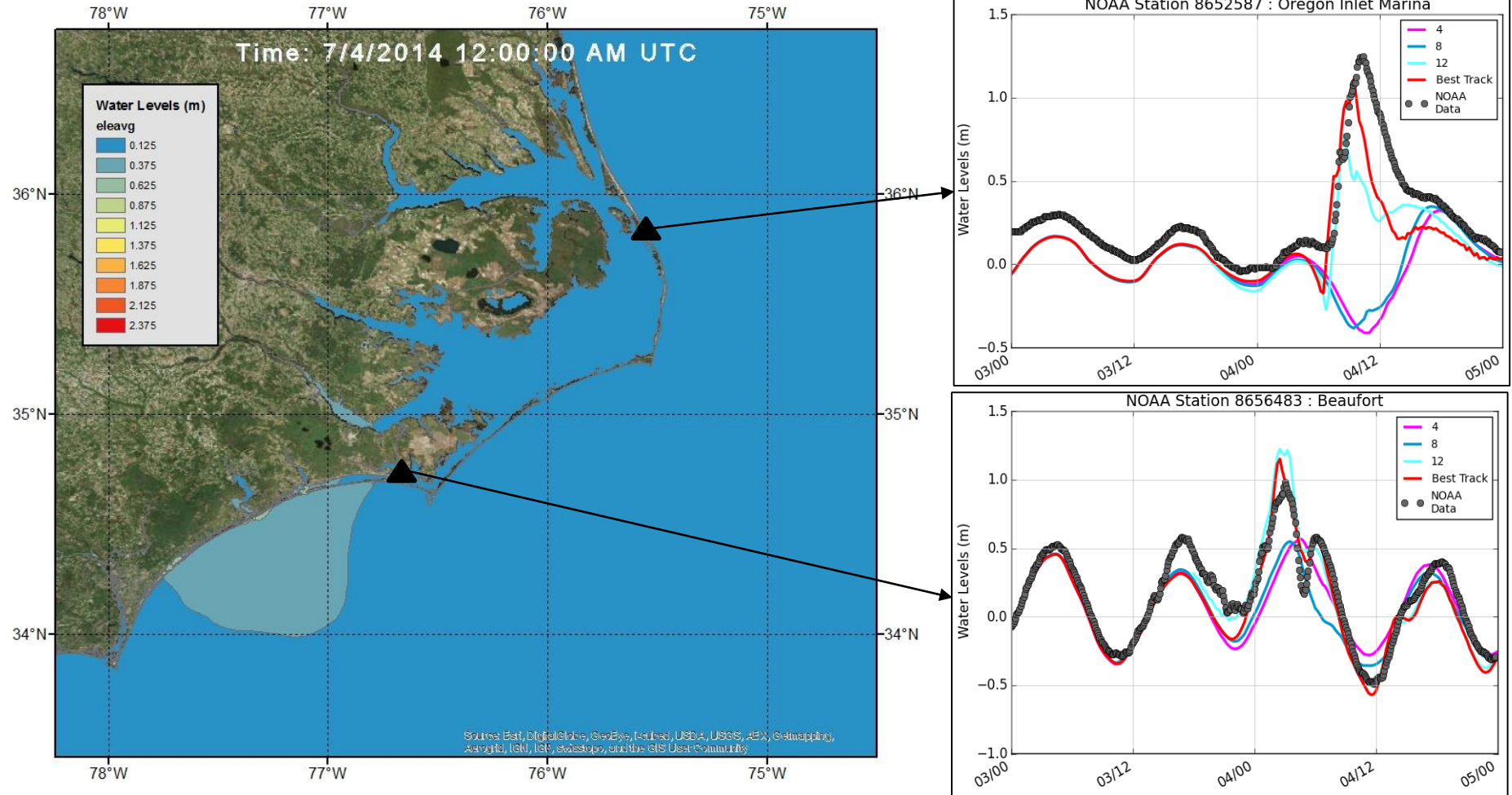- Expanded to consider time series information, KML formats

PART 1: Real-time storm surge forecasting in NC

Introducing *Kalpana*

Our Python-based script is called *Kalpana*

- ➢ Visualizes guidance in GIS and Google Earth formats
- ➢ Tested with the forecast predictions for Arthur (2014):

PART 2: Forecast predictions during Arthur (2014)
Influence of track uncertainty on ASGS results

Legend:
- Wind and Waves
- Wind and Water Level
- Wind Only
- Wave Only
- Water Level Only
- Advisory 4
- Advisory 8
- Advisory 12
- Best Track

Lines show tracks for advisories:
— 04 (issued 54hr before landfall) — 08 (30 hr) — 12 (6 hr) — Best Track (post-storm)

PART 2: Forecast predictions during Arthur (2014)
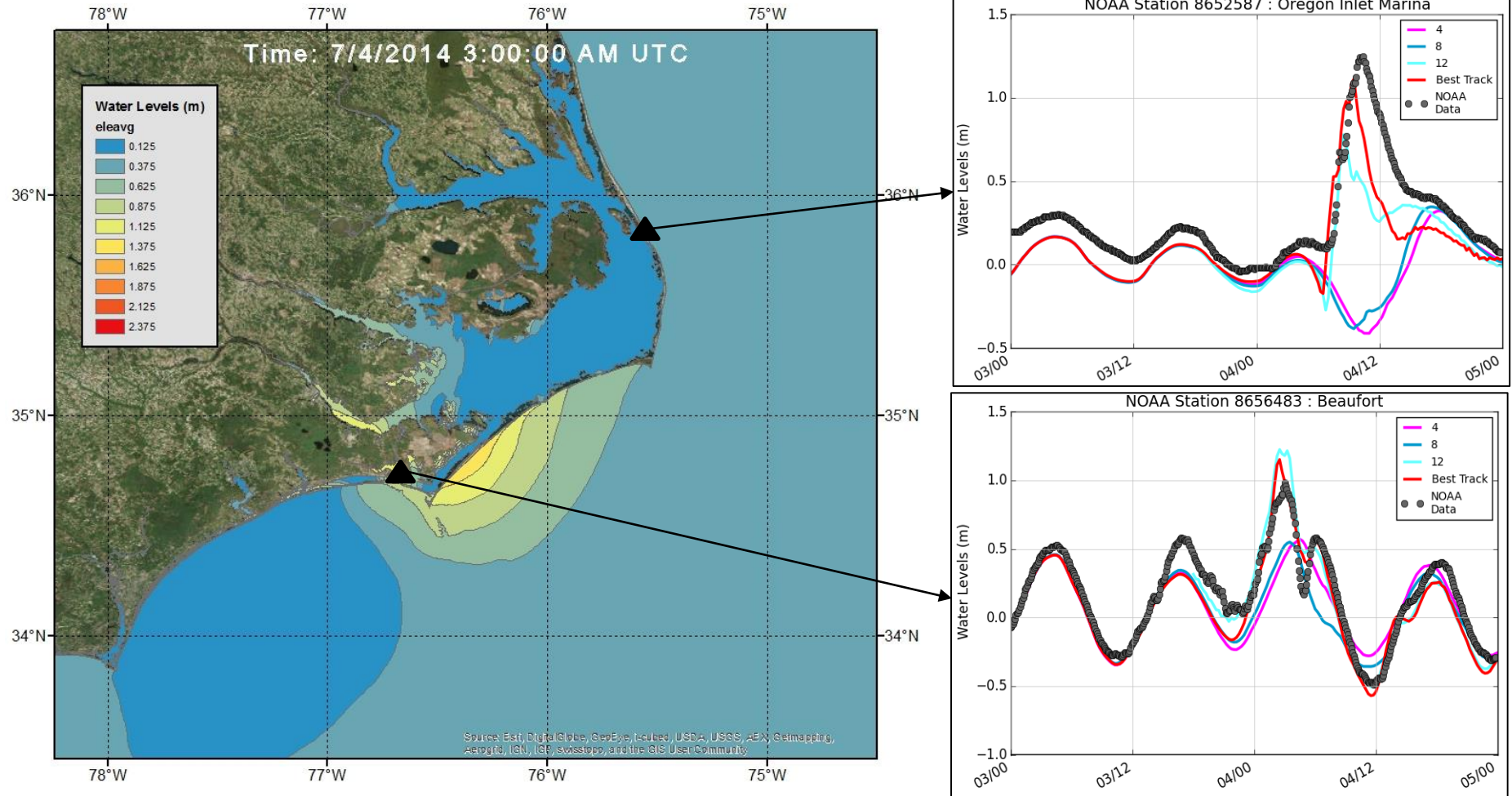
Evolution of water levels

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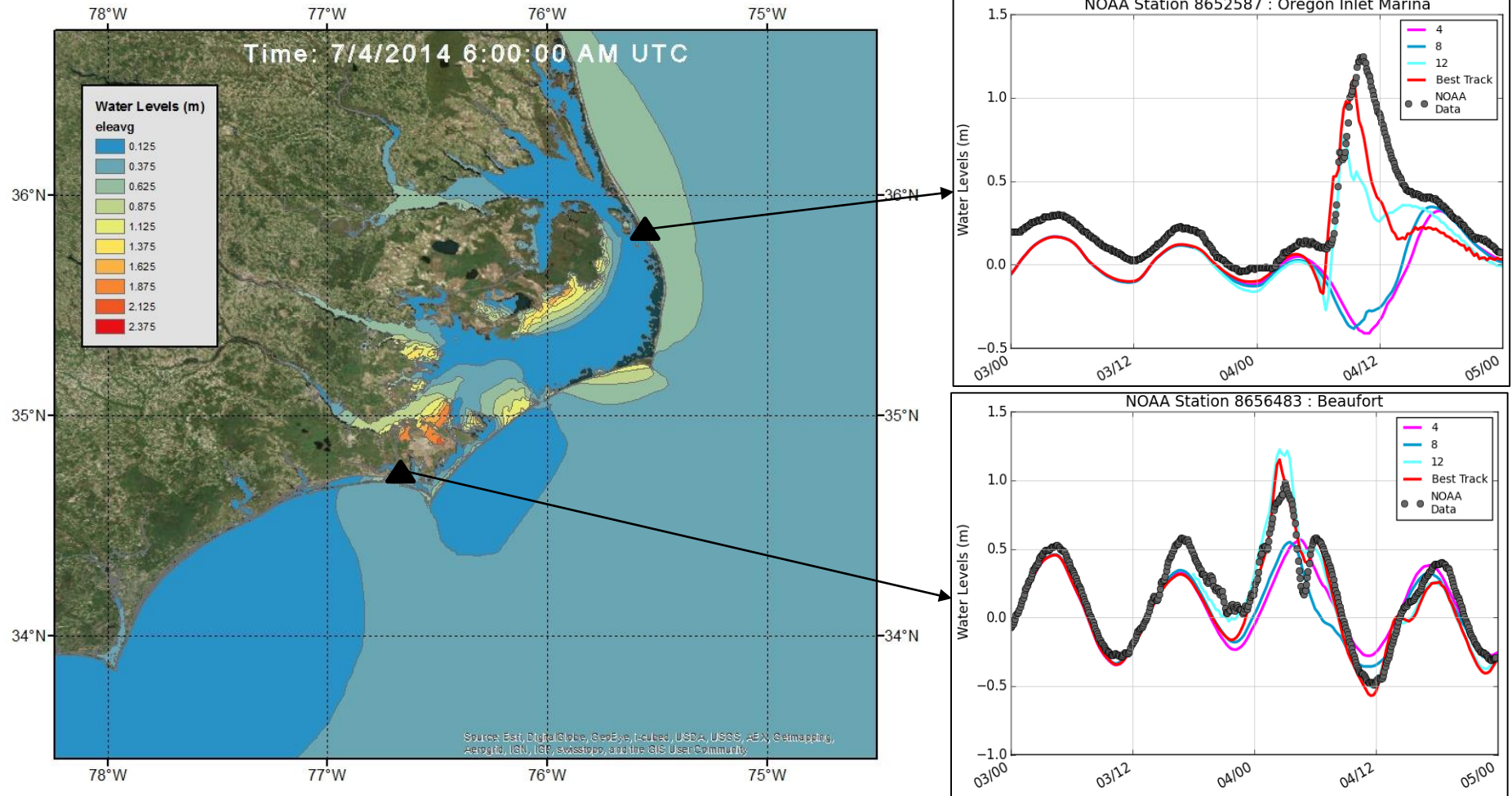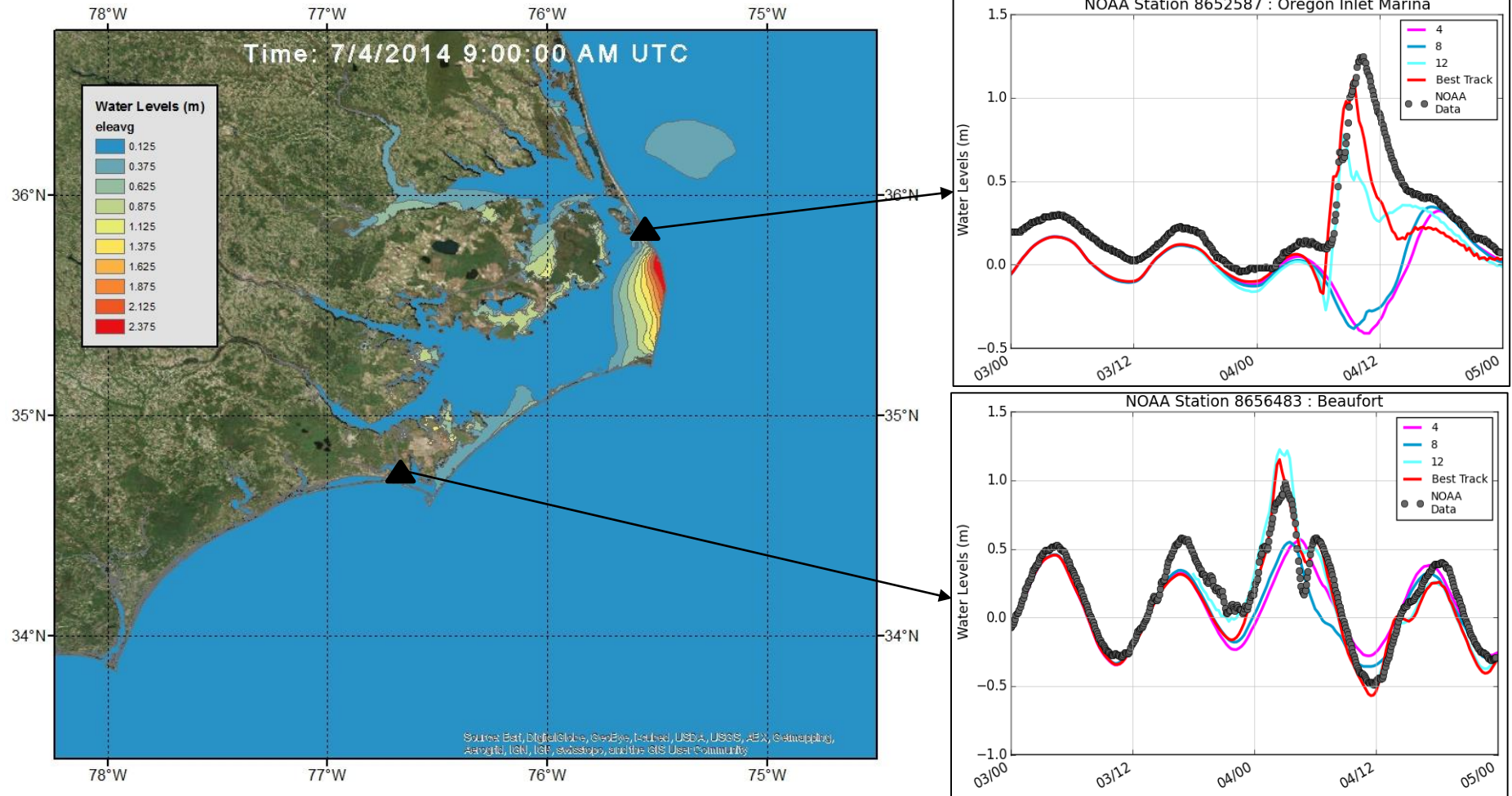
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PART 2: Forecast predictions during Arthur (2014)

Evolution of water levels

Time: 7/4/2014 6:00:00 AM UTC

Water Levels (m)
eleavg
- 0.125
- 0.375
- 0.625
- 0.875
- 1.125
- 1.375
- 1.625
- 1.875
- 2.125
- 2.375

NOAA Station 8652587 : Oregon Inlet Marina
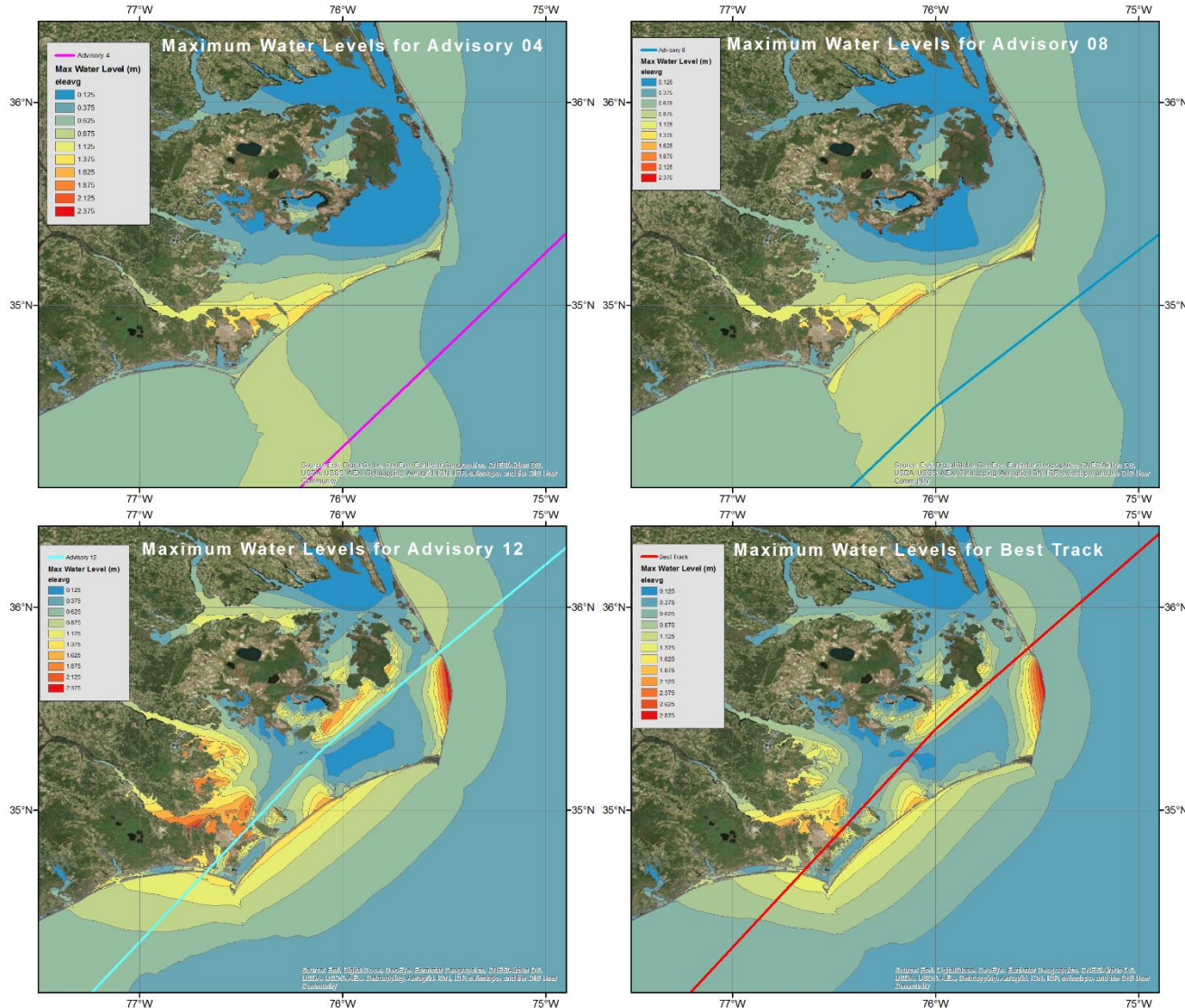
NOAA Station 8656483 : Beaufort

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PART 2: Forecast predictions during Arthur (2014)

Evolution of water levels

PART 2: Forecast predictions during Arthur (2014)

Sensitivity of maximum surge to track

PART 3 : More about Kalpana – A visualization tool

Key features

Kalpana has been developed with a range of capabilities:

- Utilizes specialized Python libraries to convert ADCIRC outputs(water levels, wind speeds, wave height, mean wave period, peak wave period, etc.) to shape files and KMZ file formats compatible with ArcGIS and Google Earth respectively

    - Python is usually available in most Linux clusters on which ADCIRC runs
    - Libraries are free and relatively easy to download and install – we can help you with their installation

- Identifies polygons from the user-defined contour levels

- Can work with single time step or full time series ADCIRC output data

- Quick generation of visualization products

- To be distributed as an open source code which work in Windows and Linux platforms

- Incorporated into ASGS by Jason Fleming in January 2015

PART 3 : More about Kalpana – A visualization tool

Procedure

Kalpana visualizes forecast guidance in the following steps:

1. Accept user input
   ➤ netCDF ADCIRC output file, geometry type, number of contour levels etc

2. Read mesh and variable data from the ADCIRC output file (using *netCDF4* library)

3. Contour ADCIRC variable data (using *matplotlib* library) into user-defined contour levels for each time step

4. Contour information is extracted as *shapely* polygon objects, processed and stored as outer and inner polygons
   ➤ Received help from Carola Kaiser at LSU for processing the polygons and removing errors in polygon geometry
   ➤ Multi-geometry objects are used for KMZ files

5. Polygons are written into the corresponding shapefile or KMZ files using *fiona* or *simplekml* library respectively

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PART 3 : More about Kalpana – A visualization tool

Demonstration of visualization products created by Kalpana

PART 3 : More about Kalpana – A visualization tool

Future work

➤ Currently KML creation implemented in Kalpana has been specialized for the NC coast - need to extend this capability to general conditions

➤ KML creation for time series ADCIRC output data is to be explored

➤ Collecting feedback from emergency managers and other end users about the visualization products and incorporate their suggestions for further improvements

To obtain a copy of Kalpana please contact me at: *rcyriac@ncsu.edu*

General summary

➢ Real Time forecasting for NC coast implemented through ASGS and CERA Web-based guidance - nc-cera.renci.org

➢ ASGS forecast system gave realistic predictions during Arthur but displayed sensitivity to the track uncertainties

➢ Introduced new Python based visualization tool – Kalpana, that converts ADCIRC outputs to GIS and KML based formats
  ➢ Tested during 2014 Atlantic hurricane season

THANK YOU!
Contact me at : rcyriac@ncsu.edu