Impact of storm events on density stratification in the Pamlico and Albemarle Estuarine System

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1. Introduction and Background

Motivation:

- Albemarle - Pamlico Estuary System (APES) is heavily influenced by storms
- Density stratification is altered; can have impacts on ecosystem

Purpose:

- Investigate density alterations due to storm events
- Create model using ADCIRC (ADvanced CIRCulation model)

Usual density distribution:

- Fresh water located near river mouths
- Brackish river in Pamlico Sound
- Majority of Albemarle Sound is fresh

Storm event used:

- Hurricane Irene
- Occurred in August 2011
- Landfall on August 27
- Shore parallel storm
- Winds up to 34.42 m/s

Figure 1: The area of study is APES in North Carolina. The brown border shown depicts the area that the ADCIRC mesh encompasses. Red line is Hurricane Irene's path through area.

How do storm events alter the density stratification during the storm and how long does it take to regulate?

2. Methods

3D ADCIRC with forcings:

- Tidal Forcing - from tidal constituents
- Atmospheric Forcing - NOAA best track file
- Riverine Forcing - USGS stream gauges
- Density Forcing - SalWise

SalWise:

- Developed by University of North Carolina - Dr. Niels Lindquist and Dr. Stephen Fegley
- Over 1,980,000 records
- From 1945 - 2014

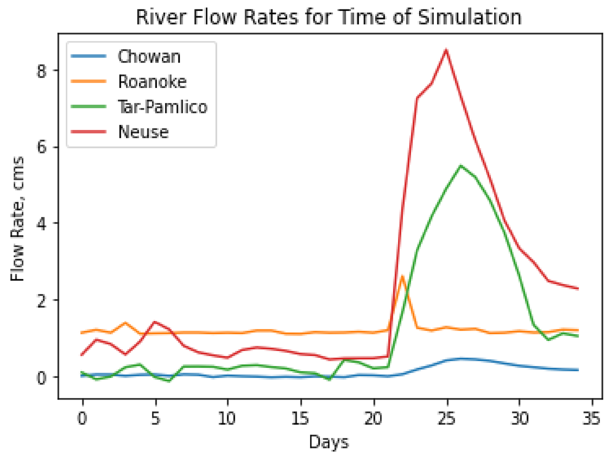


Figure 2: The flow rates for the four major rivers. The x-axis is the day of the simulation and the y-axis is the flow rates.

Density input development:

1. Select SalWise data
2. Develop equally sized bins of area
3. Group data by bins
4. Assign mean values to each bin
5. Use GRASS (Geographic Resources Analysis Support System) GIS to create surfaces from mean values
6. Interpolate onto ADCIRC Mesh

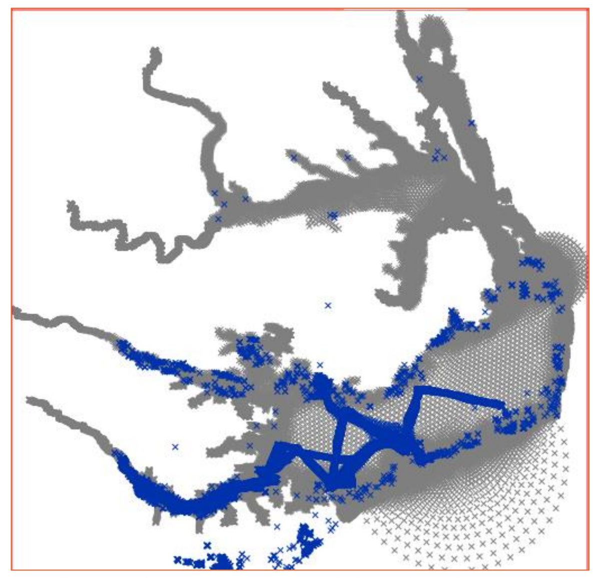


Figure 3: An example of SalWise Data from step 1. Surface measurements for the month of August. Grey is ADCIRC mesh, blue is SalWise points.

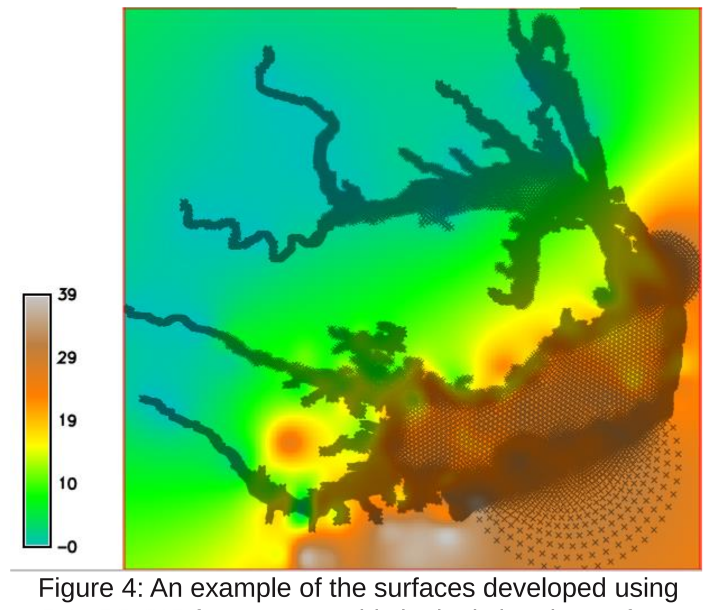


Figure 4: An example of the surfaces developed using GRASS GIS from step 5. This is depicting the surface salinities as the color range. Orange is saline and the blue is fresh. The grey-black X's are the ADCIRC mesh.

Timeline of Simulation:

- 8/06 – 8/16: Diagnostic: Tides
- 8/16 – 8/21: Prognostic: Tides, Rivers, Density
- 8/21 – 8/29: Prognostic: Tides, Rivers, Density, Atmospheric
- 8/29 – 9/5: Prognostic: Tides, Rivers, Density

4. Conclusions

During storm:

- Albemarle Sound experiences brackish water (up to 14 ppt) intrusions during storm
- Pamlico Sound inflow of fresh water at beginning
- Tar-Pamlico River has 56 km brackish water intrusion
- Neuse River experiences 47 km brackish water intrusion
- Roanoke Island becomes brackish

After storm:

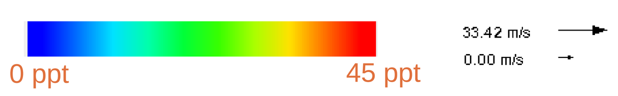
- Reduction of length of brackish intrusions in Neuse River and Tar-Pamlico River
- Large fresher water inflow from Albemarle Sound

Future work:

- Inclusion of heat flux forcing
- Increase after storm simulation
- More intensive analysis of results
- Different storm events

3. Results

Figure 5: Surface salinity values and Wind Vectors



8/16 00:00 UTC — 8/21 00:00 UTC — 8/27 00:00 UTC — 8/29 00:00 UTC — 8/31 12:00 UTC — 9/5 00:00 UTC

a. Density Spin Up Start

- Albemarle Sound: approx. avg. 3 ppt
- Pamlico Sound: approx. avg. 21 ppt
- Roanoke Island surrounded by 12 ppt - 16 ppt

b. Beginning of Storm Simulation

- Winds blowing Southwest, small magnitudes
- Albemarle Sound: < 6 ppt, approx.19 km long intrusion
- Pamlico Sound: ranges 14 ppt near rivers, 25 ppt near ocean, avg. 20 ppt middle

c. Storm Making Landfall

- Winds blowing Southwest - West, max speed 23 m/s
- Albemarle Sound: 7.5 ppt - 14 ppt inflow
- Brackish approx. 47 km into Neuse River
- Brackish approx. 56 km into Tar-Pamlico River
- Roanoke Island brackish

d. Storm Leaving Area

- Winds are Northeastern, max speed 6.7 m/s
- Avg. of 21 ppt around Roanoke Island
- Reduction brackish Tar-Pamlico River (approx. 44 km)
- Reduction brackish Neuse River (approx. 43 km)

e. 3.5 Days After Storm

- Fresh water replacing brackish in Albemarle Sound
- Reduction brackish Tar-Pamlico River (approx. 41 km)
- Reduction brackish Neuse River (38 km)

f. 7 Days After Storm

- Fresh water surrounding Roanoke Island (avg. 12 ppt)
- Reduction brackish Tar-Pamlico River (approx. 38 km)
- Reduction brackish Neuse River (31 km)
- Fresher water from Albemarle Sound (approx. 37 km)