Impact of Ocean Observations on Hurricane Irene and Hurricane Sandy Forecasts

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Background

• Hurricane intensity prediction remains key area of research (e.g. Bender and Ginis, 2000)
• Measurements of upper ocean limited (Emanuel, 2003)
• **Hurricanes Irene (2011) and Sandy (2012)** are key events to study coastal ocean mixing and feedback onto hurricane intensity
• Unique coastal ocean observations collected before, during and after both storms
Hurricane Irene (2011)
Challenges in Predicting the Intensity of Storms

Scientists say that it is much easier to accurately predict what path a hurricane will take.

By HENRY FOUNTAIN
Published: August 27, 2011
Even coupled models (e.g. HWRF) overpredicted Irene.

Could the ocean be a major player?
Cape Cod to Cape Hatteras

1000 km

CT RI MA

10 States

Regional Association – 2004
Regional Coastal Ocean Observing System – 2007

CODAR L-Band X-Band Gliders Forecasts

Rutgers University

Jersey Roots, Global Reach
New MARACOOS De-clouded SST Composite

1. De-cloud 1-km resolution AVHRR data using various temperature and near IR thresholds
2. 3-day *coldest* dark pixel composite of de-clouded AVHRR scans
3. Then, coldest pixel composite with SPoRT SST to fill in remaining cloudy gaps
4. Result: high resolution in space and time, resolves cold wake
But when did the 6-8°C surface cooling occur? And what did subsurface mixing look like?
Did forecast models resolve surface cooling correctly?
HWRF, GFDL SST during Irene

Courtesy of CSU/CIRA
Model Setup

- Weather Research and Forecasting (WRF) model, Advanced Research core (ARW) (Michalakes et al., 2001)
- **Horizontal Resolution**: 6km
- **Vertical Resolution**: 50 levels, focused near surface
- **Lateral B.C.**: NAM 12km / GFS 0.5 degree
- **Microphysics**: Thompson (6-class with graupel)
- **Planetary Boundary Layer (PBL) scheme**: Mellor-Yamada-Janjic (MYJ)
- **Land surface model**: Noah Land Surface Model
- **Longwave radiation**: Rapid Radiative Transfer Model (RRTM-G)
- **Shortwave radiation**: RRTM-G
- **Bottom B.C. (Sea Surface Temperature, SST)**: Variant
Hurricane Irene SST Sensitivity Hindcast

- Using observed variations in SST reduced modeled intensity of Irene—in some cases by 15 knots—to more closely match NHC best track and available obs.
- 1D ocean mixed-layer model in Advanced Hurricane WRF only slightly decreased errors
- Fully coupled atmosphere-ocean models even overpredicted intensity → critical need for correct ocean simulation of coastal mixing, esp. bottom boundary layer

<table>
<thead>
<tr>
<th>Maximum Wind Speed Skill Score</th>
<th>Official Forecast</th>
<th>Warm SST Hindcast</th>
<th>Warm SST + OML Model Hindcast</th>
<th>Cold SST Hindcast</th>
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<tr>
<td>RMS Error (knots)</td>
<td>9.43</td>
<td>7.13</td>
<td>7.09</td>
<td>3.61</td>
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Hurricane Sandy (2012)
Sandy intensity predictions can be improved...
Post-Hurricane Sandy Sea Surface Temperatures (°C)

Persistent clouds post-Sandy prevented clear satellite view...
Hurricane Sandy Hindcast: Intensity

Maximum Sustained 10m Wind Speed (kts)

- NHC Best Track
- NHC Forecast
- Warm SST
- Cold SST
- GFS
- NAM

Day/Time (UTC)

- 28/1200
- 28/1800
- 29/0000
- 29/0600
- 29/1200
- 29/1800
- 30/0000
• What caused acceleration toward landfall? Phasing?
• Could accurate acceleration improve intensity forecast 6-12 hours prior to landfall?
• Hindcasts are being ingested into storm surge models to improve sea level prediction

![Maximum Sustained 10m Wind Speed (kts)](chart)

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- NHC Best Track
- NHC Forecast
- Warm SST
- Cold SST
- GFS
- NAM

Ocean waves kick up near hurricane (Elvis Amodeo/AP Photo)
Conclusions

• **Hurricanes Irene (2011) and Sandy (2012)** key events to study coastal ocean mixing during tropical/subtropical storms

• Unique coastal ocean observations (satellite, glider) collected before, during and after both storms

• Data used to improve hindcast intensity (Irene) and speed (Sandy) and storm surge (Sandy)

• Next steps:
  - *Predict* storm mixing (Irene) with accurate ocean model
  - Investigate why acceleration was underpredicted (Sandy)
  - Provide storm surge model with better wind fields (Sandy)
References


Gemmill, William, Bert Katz and Xu Li, 2007: Daily Real-Time Global Sea Surface Temperature - High Resolution Analysis at NOAA/NCEP. NOAA / NWS / NCEP / MMAB Office Note Nr. 260, 39 pp


MARACOOS Network Observations: Hurricane Irene

2011-08-27 09:36 - 2011-08-29 00:00 UTC

**Thermocline Depth**

**Surface Temp**

**Max S.D. w' Depth**

**Max S.D. w'**

**Glider RU16**

Wind Vectors: 2011-08-27 - 2011-08-29 UTC

NDBC Winds

Bottom Orbital Velocities: 2011-08-27 - 2011-08-29 UTC

NDBC Waves

Bottom Orbital Velocity

Currents: 2011-08-27 11:00 - 2011-08-29 00:00 GMT

Glider, CODAR & Calculated Bottom Currents
RU-COOL De-clouding Thresholds

• Visible and near IR thresholds empirically derived by season and location

• E.g. Mid-Atlantic Bight, summer/fall:
  – <10°C removed (cloud)
  – near IR albedo >2.3% removed (clouds)
  – Other tests on changes (within ~3km X 3km grid boxes) of SST (1°C) and near IR albedo (0.15%)
WARM: RTG+SPoRT(8/27)  
Init: 2011-08-27_00:00:00

27/1200 → 28/0600

RTG, SPoRT(9/06)+AVHRR(8/31) init: 2011-08-28_06:00:00

28/0600 → 29/0600