Progress in AXCTD/AXCP Sampling Strategies Since 2010: Ocean Profiling

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Permanent Installation on P-3
In 2011 Working With AOC

AXBT RX Units

Mark 21 Processors

Marantz 560 Units for Storage

LM Mark 10a RX Unit (200 kHz Bandwidth)
## Summary of Flights Since 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th># Flights</th>
<th>AXBT</th>
<th>AXCTD</th>
<th>AXCP</th>
<th>Total Ocean</th>
<th>GPS-DS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>DwH</td>
<td>9</td>
<td>363/405</td>
<td>35/41</td>
<td>74/142</td>
<td>472/588</td>
<td>67/77</td>
</tr>
<tr>
<td></td>
<td>Bonnie</td>
<td>1</td>
<td>33/35</td>
<td>–</td>
<td>–</td>
<td>33/35</td>
<td>2/2</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>1</td>
<td>6/6</td>
<td>–</td>
<td>5/6</td>
<td>11/12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Matthew</td>
<td>2</td>
<td>88/92</td>
<td>37/40</td>
<td>5/10</td>
<td>130/142</td>
<td>27/27</td>
</tr>
<tr>
<td>2011</td>
<td>Pre-season</td>
<td>3</td>
<td>47/50</td>
<td>41/41</td>
<td>32/51</td>
<td>120/142</td>
<td>37/38</td>
</tr>
<tr>
<td>2012</td>
<td>Isaac</td>
<td>6</td>
<td>107/121</td>
<td>53/56</td>
<td>27/41</td>
<td>187/218</td>
<td>153/158</td>
</tr>
<tr>
<td>2013</td>
<td>Pre-season</td>
<td>1</td>
<td>32/34</td>
<td>15/15</td>
<td>1/12</td>
<td>48/61</td>
<td>15/15</td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>1/11</td>
<td>1/11</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
<td><strong>676/743</strong></td>
<td><strong>181/193</strong></td>
<td><strong>145/273</strong></td>
<td><strong>1002/1209</strong></td>
<td><strong>301/317</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Success</strong></td>
<td></td>
<td><strong>91%</strong></td>
<td><strong>93%</strong></td>
<td><strong>53%</strong></td>
<td><strong>83%</strong></td>
<td><strong>95%</strong></td>
</tr>
</tbody>
</table>
Low success rates of AXCPs (60% versus 90%) during DWH. Air-Cannon Test (simulates terminal fall speeds) by vendor revealed:

- High Success at 90 to 100 ft/sec
- Low Success at 115 to 120 ft/sec

Discovered faulty parachutes:

- July 2012 Chutes replaced in 80 units to decrease terminal fall speeds
- Agar replaced (surrounds sensor)
- Tension on lanyard checked.

A test flight on P-3 in 15 Aug 2012 to assess.
Upper: adjusted surface winds (10-m) at NOAA Data Buoy 42040 located ~55 km NE of DWH-Red lines depict day of the flights.

Lower: atmospheric boundary layer winds from GPS sonde and ocean currents from an AXCP (stick plots) colored to depict equivalent potential temperature (K) and ocean temperature (C).
AXBT Versus AXCP and AXCTD
Water Mass Characteristics: T-S, Buoyancy and Current Profiles in Thermostad Region Due South of DWH
Assimilation of T(z) Into HYCOM
(Analysis Courtesy of G. Halliwell)

**Temperature Between 30 and 300 m**
- **Bias (°C)**
  - P-3 profiles assimilated
  - P-3 profiles denied

**RMS Error (°C)**
- WP-3D Flight Days (2010)

**26°N Section, 21 May 2010, P-3 Profiles Denied**

**26°N Section, 21 May 2010, P-3 Profiles Assimilated**
### Isaac Flight Summary

- 58 AXBTs deployed in other 3 in-storm flights (97%)
- 218 Ocean probes
- overall success: 88% during six flights

*Below are the T/S curves from XCTDs prior, during and after Isaac.*
Contrasting ocean response in oceanic geostrophic features.

Contrasting distribution of $\theta_E$ as a function of underlying oceanic features.
Contrasting upwelling (dashed contours) and downwelling (solid contours) regimes developed inside the region of cyclonic curl of the wind stress.

- \( h_{20_{\text{pre}}} \) is from SMARTS (25 Aug)
- \( h_{20_{\text{in}}} \) is from in situ P-3 data (28 Aug)
- \( \tau \) is from Hwind (1030z, 28 Aug)

Vertical velocity associated with isopycnal displacements are a function both the geostrophic current vorticity and the curl of the wind stress (Stern, 1965; Jaimes and Shay 2009; Jaimes et al. 2011):

\[
w = \frac{K \times \tau}{\rho_0 f^2} \cdot \nabla \left( \frac{\partial v_g}{\partial x} - \frac{\partial u_g}{\partial y} \right)
\]

(contours)
Upwelling/Downwelling Inside the Region of Cyclonic Wind Stress

In-storm data is from the 28 August morning flight (during intensification to hurricane level)
Deployed 11 AXCPs (10 Surface housings recovered):
• Mesh over wire spool was displaced-inducing wire problems;
• Cracking of the shell housing XCP sensor; and
• Pins holding probe in place punctured surface canister (water leak).
Sample strategies with deeper profiles for Loop Current/Eddy regimes. Ocean cannot be ignored in the western parts of the basin—an integral part of RI/RW—that has been shown (e.g., Katrina/Rita).

Targeted ocean profiles to improve the ocean/coupled models. Data sets to resolve mixing and (3-D) upwelling issues that cool the ocean mixed layer (AND SSTs that affect Enthalpy Fluxes!). Adding EM/APEX floats this summer to platform mix.

Approach compliments AXBT Demonstration Project from C-130s.

Re-engineering AXCP (needed for transports/shears). Digital TSK AXCTD performance has been exceptional ~94%!

Effectively assimilate 3-D data into the models to better understand oceanic impact on hurricane intensity changes.