Measuring Ocean Effects From Hurricane Michael

Air deploying APEX-EM floats into the path of hurricane Michael to better understand and predict major weather events

Teledyne Webb Research

Vehicles

Product:
APEX EM Profiling Float

Application:
Study of hurricanes in the Gulf of Mexico

Customer:
University of Miami Rosenstiel School of Marine and Atmospheric Science

Background:

Dynamical coupled models to better understand and predict major weather events and climate events, such as hurricanes, require ever more precise ocean and atmospheric data. This includes the measurement of ocean current velocity, temperature and salinity throughout a water column, both before, during and after hurricanes pass over a body of water, such as in the Gulf of Mexico. The autonomous drifting 'Electromagnetic Profiling' float (APEX-EM) is perfectly suited for such a role. For example, the APEX-EM can precisely measure water column current velocity by using motionally-induced electric fields, which are themselves generated by ocean currents moving through the Earth's magnetic field. Other sensors to measure properties such as pressure, temperature & salinity are also included on an APEX-EM. And finally, APEX-EM floats can be dropped by parachute from aircraft, which can be crucial if they are to be deployed at short notice ahead of moving storms.

In June 2014, several APEX-EM floats were acquired by the Ocean Sciences Department at the University of Miami's Rosenstiel School of Marine & Atmospheric Science (UM). These floats were then put into storage, awaiting a suitable event such as a hurricane. Crucially, the floats were configured to be 'deployment ready' so that they could be rapidly loaded onto an aircraft, and dropped by parachute in front of an approaching hurricane, with very little notice.

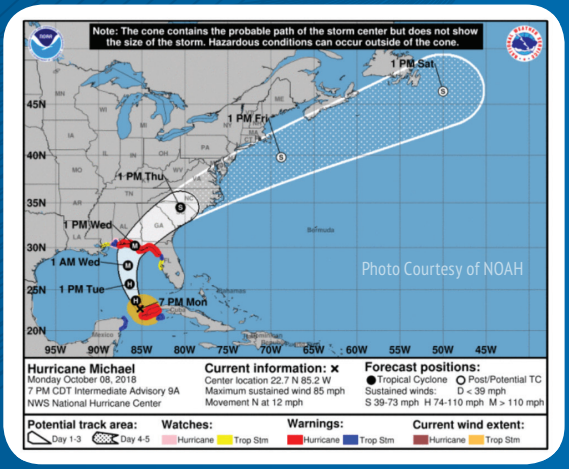

Figure 1
Hurricane Michael's projected path

Figure 2
Typical float deployment from an aircraft.

Preparing for Hurricane Michael:

In early October, 2018, hurricane Michael entered the Gulf of Mexico basin. This provided an ideal opportunity to deploy several of the University of Miami APEX-EM floats and Scripps Institution of Oceanography (SIO) satellite track drifters right into the path of the hurricane. The team carrying out this role was comprised of Professor Lynn (Nick) Shay, Ms Jodi Brewster and Dr. Benjamin Jaimes de la Cruz, and Mr. Joshua Wadler (PhD Student) at UM and Professor Luca Centurioni from SIO. As summarized by Professor Shay: "We have a warmer ocean, a warmer atmosphere and all those things come together to increase the probability of a storm like Michael happening. That's our scientific understanding. We don't have much more depth than that."

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Data hosting for all data transmitted from the deployed floats was provided by Teledyne Marine, as well as other technical support. In addition, several APEX-EM profiling simulations were conducted before the deployment. This helped determine how mission parameters should be set, since required mission characteristics varied depending on whether the APEX-EM float was in a pre-storm, in-storm or post-storm state. For example, floats were to be deployed in an area of the Gulf about 12 hours before the hurricane came through (ie. pre-storm). During this period, the requirement was for floats to continually descend and ascend between the surface & a depth of 800 m. However, when the hurricane arrived (ie. in-storm), the requirement was for floats to descend and ascend between a depth of 30 and 300m, avoiding the surface entirely while still being able to acquire data in the upper ocean and through the entrainment zone where vigorous mixing is known to occur which causes the mixed layer to cool and deepen. Finally, when the hurricane passed (ie. post-storm), the requirement was for floats to continually descend and ascend between the surface and 500 m. This post-storm behavior was designed to sync the floats into a ¼ 'inertial period' for that latitude, to resolve near-inertial wave wake in the current profiles. These near-inertial motions are central to vertical mixing processes due to their enhanced shears.

Finally, an energy analysis was performed to calculate the expected lifetime of the APEX-EM floats, given their original battery load and the final mission characteristics.

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Deployment:

Once hurricane Michael entered the Gulf of Mexico basin, the decision to deploy three APEX-EM floats left very little time for float preparation or testing. Considering that the floats had been in storage since June 2014 (ie. over three years prior), this was a concern. However, given the limited availability of aircraft to deploy the floats, the decision was made to go ahead.

Deployment would not have been possible without the support of the 'National Oceanic & Atmospheric Administration' (NOAA); the 'Chief, Aerial Reconnaissance Coordination, All Hurricanes' unit (CARCAH), and the USAF 53rd 'Weather Reconnaissance Squadron' (Hurricane Hunters). The USAF 53rd agreed to air-deploy the EM-APEX floats and several ocean 'drifters' from SIO, into the path of hurricane Michael. These drifters measured key surface processes such as winds, barometric pressure and sea surface temperatures. Air deployment was from a USAF WC-130J out of the Keesler Air Force base, which are modified for the specific purpose of collecting weather information in hurricanes.

EM-APEX floats were air-dropped by parachute, inside 12" diameter cardboard cylinders. Each cylinder was split in half along the long axis & secured together by tape which dissolves in water. This protected the float during impact with the water surface, and allowed the cylinder to open & discharge the float a short time after landing in water. Deployment of all EM-APEX floats went smoothly, and about 12 hours before the hurricane arrived, as planned in the approximate area where Michael intensified to a category 3 level.

As part of the deployment strategy, oceanographic and atmospheric expendables were deployed on several in-storm missions from the NOAA WP-3D Orion aircraft as well as a post-storm flight over the area where the APEX-EM floats were actively sampling.

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Figure 3
APEX descent with canopy

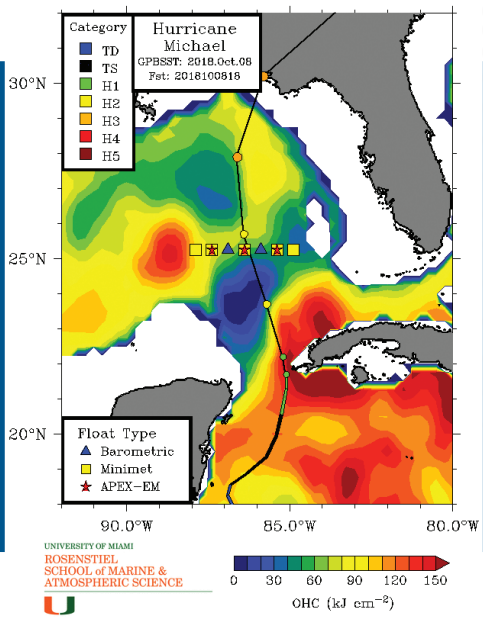

Figure 4
Hurricane Michael's final path through the Gulf of Mexico, showing the deployment points for APEX-EM floats as well as Barometric & Minimet surface drifters. The hurricane category reading can be seen to change as it passes over the Gulf. GPBSST indicates the 'Geo-Polar Blended Sea Surface Temperature' measurement, while OHC is the 'Oceanic Heat Content', generated by combining data from several satellites.

Early Results:

Subsequent to the initial deployment, pre-storm data started being transmitted from the EM-APEX floats to the data-server at Teledyne Marine. These data were constantly available to the team at the UM, and indicated that the floats were performing as intended. Only one sensor-related issue was initially seen, although it was determined that this was due to the EM electrodes drying out slightly over their three years in storage. As predicted, this issue quickly corrected itself once the electrodes were exposed to the sea water.

The required pre, in and post-storm mission characteristics were executed correctly, ensuring that none of the EM-APEX floats were exposed to surface conditions during hurricane Michael. Also, when on the surface, data continued to be transmitted from the floats and received by the Teledyne data-server, providing the opportunity to better understand, and predict, the characteristics of a major hurricane as well as the oceanic response. By around six days after the storm had passed over, the EM-APEX floats had provided over 600 profiles of data, while the drifters continue to sample surface conditions. As Professor Shay noted: "A lot of meteorologists believe it's only atmospheric effects during rapid intensity change, but there's a whole group of us who believe you have to understand what lies beneath as the hurricane interacts with the ocean."

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