Enhancing Coastal and Ocean Observing and Innovation: OAR and IOOS

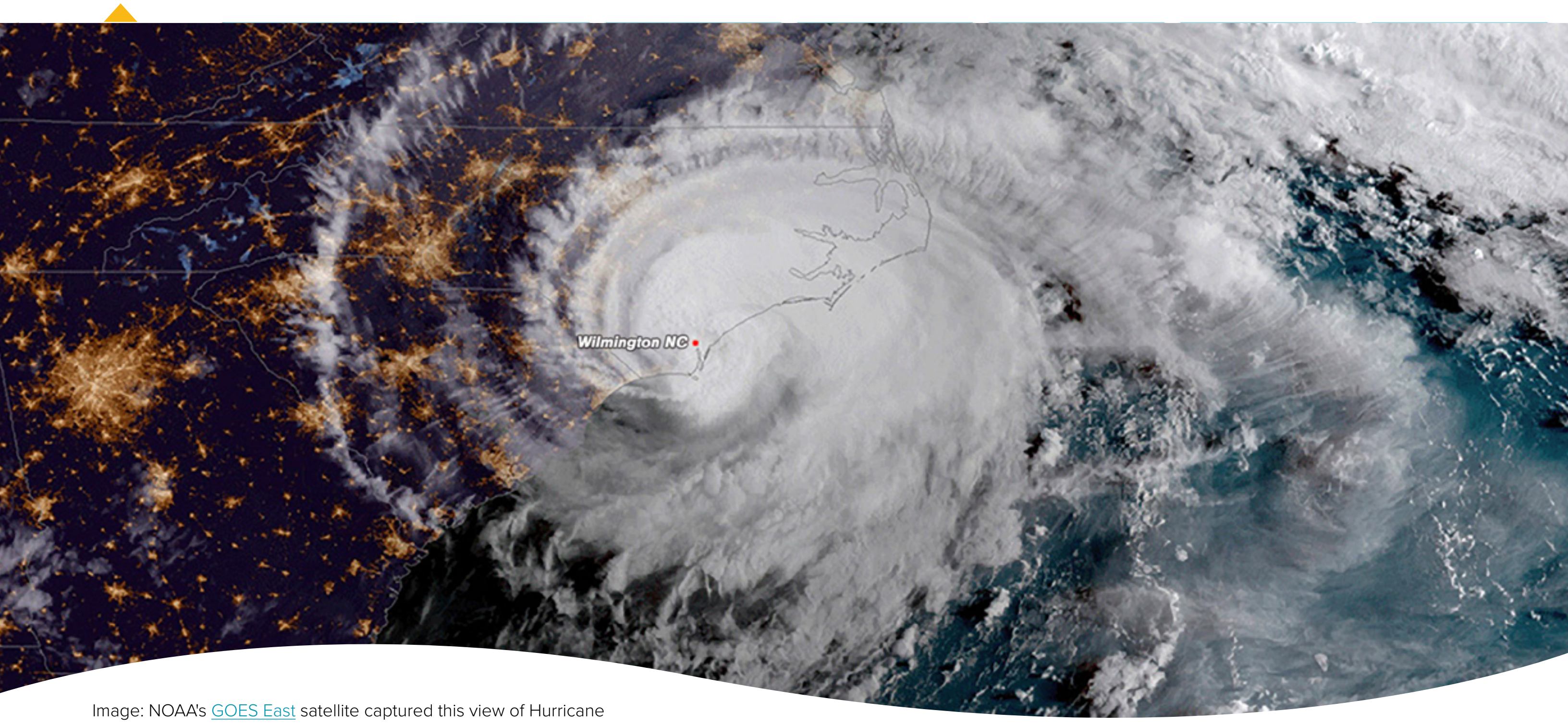

Image: NOAA's GOES East satellite captured this view of Hurricane Florence shortly after the storm made landfall near Wrightsville Beach, N.C. on Friday, Sept. 14, 2018.; Source

Hurricane Intensity Forecasting

OVERVIEW

Several key ocean features have been linked to intensification or weakening of hurricanes. Some of these features can be detected from satellite altimetry, which provides information about the location of major ocean currents and eddy fields because upper temperature and salinity structure can be assessed as a first order with broadscale temperature and salinity observations from Argo floats. However, ocean-atmosphere models fall short of correctly representing these features—in particular, their ocean thermal/salinity (T/S) characteristics—if only altimetry and Argo float observations are used. Underwater gliders and floats can successfully fill this deficiency to efficiently help represent the mixed layer, barrier layers, subsurface cool pool of waters, and horizontal gradients of mesoscale features within ocean models. These two platforms provide targeted observations, gliders by continuously observing T/S in areas where other profile observations are not available and where hurricanes intensify/weaken, and Air Launched Autonomous Micro Observer (ALAMO) floats by opportunistically targeting areas in front of hurricanes from planes.

Argo Float: A freely-drifting profiling device deployed in front of storms that provides global and regional ocean observations.

ALAMO Float: A smaller, freely-drifting, air-deployed profiling float deployed through a chute on a plane that provides global and regional ocean observations.

Underwater Glider: An autonomous underwater vehicle well-suited for safely collecting data in remote or challenging oceanic locations.

Observing Systems Simulations (OSSE): A modeling experiment used to evaluate the value of an observing system when actual observational data are not available.

OPPORTUNITY

As part of Congressional Supplemental funding, Integrated Ocean Observing System (IOOS) and Oceanic and Atmospheric Research's (OAR) Atlantic Oceanographic and Meteorological Laboratory (AOML) initiated a joint effort in 2014 to monitor these ocean features in two regions: the Caribbean Sea-tropical Atlantic Ocean and the Mid Atlantic Bight. Subsequently, other regions and partners have joined this effort to include the Gulf of Mexico and South Atlantic Bight, two areas where these ocean features have also been linked to hurricane intensity changes. These observations are being used in data impact studies performed by AOML, IOOS, and the Environmental Modeling Center (EMC) and have shown that underwater glider and (Argo core and ALAMO) float ocean profile of T/S observations in the upper ocean (500m), combined with satellite observations, are the most effective in representing the ocean conditions within operational ocean models.

Modeling studies carried out as part of OAR and IOOS-coordinated ocean glider operations show that these glider and float observations lead to improved representation of the ocean in numerical models, which in many cases result in a reduction of hurricane intensity forecast errors within NOAA experimental ocean-atmosphere forecast models. These proof of concept studies show that: 1) the use of satellite observations and products serve to define the spatial extent of mesoscale features (mainly altimetry data) and barrier layers (mainly ocean color and sea surface salinity); 2) Argo floats serve to correct large scale temperature and salinity biases; and 3) surface and subsurface T/S observations from gliders and ALAMO floats serve to correctly represent the vertical T/S structure of the ocean features linked to intensity changes in hurricanes. In turn, the improved representation of the ocean in numerical models result in a reduction of hurricane intensity forecast errors within NOAA experimental ocean-atmosphere forecast models.

The 2020 Atlantic hurricane season had the highest number of recorded named hurricanes as well as the largest number of ocean observations capturing changes of ocean feature properties. Glider and ALAMO observations were conducted as part of the NOAA Hurricane Field Program and coordinated through tight collaboration between AOML, Global Ocean Monitoring (GOMO) and IOOS (National Ocean Service, NOS). Glider operations, including efforts by the United States Navy and academic institutions, had more than 40 missions with gliders deployed along fixed or predetermined transects forming a picket fence, and collected approximately 180,000 profiles of temperature and salinity in the four regions. Results obtained by IOOS and OAR from 2020 and previous seasons indicate the potential to routinely improve hurricane forecasting based on correctly representing the upper (500m) ocean. Based on these findings and on Observing Systems Simulations (OSSEs), a minimal configuration of integrated ocean observations conducted by gliders, ALAMO and core Argo floats are hypothesized to be able to provide routine and targeted monitoring with a combination of different sampling strategies to benefit hurricane intensity forecasting.

In addition, OAR and IOOS have experience and expertise to operate the following observing platforms. Although promising, these have not yet been evaluated through data-impact studies and require testing and assessments to evaluate their impact within numerical forecast models.

- Atmospheric observations in the ocean-atmosphere boundary layer obtained from air-deployed probes during hurricane missions.
- Atmospheric pressure and wave spectra measurements from surface drifters.
- Collocated ocean-atmospheric observations by specialized saildrones.

GOMO (OAR) led meetings and a workshop in January 2021 for the potential planning of a field campaign during the 2022 Atlantic hurricane season: This field campaign is expected to include a suite of (mostly) ocean observations, using current and new technology (e.g., autonomous sailing drones) geared towards understanding ocean-atmospheric interaction during high wind events, with the goal of improving hurricane intensity forecasts. It will be the first of such experiments ever proposed.

NEXT

OAR and IOOS partnership work and next actions:

- Monitor routine baseline of ocean features and upper ocean conditions using probed and effective observing platforms (gliders, Argo and ALAMO floats) for hurricane intensity forecasting in four regions: tropical Atlantic Ocean-Caribbean Sea; Gulf of Mexico; South Atlantic Bight; and Mid-Atlantic Bight.
- Use NOAA experimental and operational models to determine an optimized integrated observing design for the baseline and enhanced monitoring.
- Improve observing and modeling efforts to better understand ocean and ocean/atmosphere processes and their relevance to ocean/hurricane forecasts.
- Enhance current technologies and develop new innovative technologies for ocean monitoring during hurricane events by OAR engineering groups and private industry.
- Work with the National Weather Service (NWS) towards the design, implementation, and maintenance of an integrated ocean and atmospheric observing system for hurricane intensity forecasts.

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