MATURE STAGE EXPERIMENT
Science Description

Experiment/Module: Eye-Eyewall Mixing

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Requirements: Categories 4–5

Plain Language Description: Small features in the eyes and eyewalls of very intense tropical cyclones have been hypothesized to increase the amount of energy available for hurricane intensification, or to be responsible for damaging surface wind at landfall or intense turbulence features impacting flight operations. However, the structures of these features, especially the temperature and humidity structures, have never been documented.

Mature Stage Science Objective(s) Addressed:

1) Collect observations targeted at better understanding internal processes contributing to mature hurricane structure and intensity change [APHEX Goals 1, 3].

2) Test new (or improved) technologies with the potential to fill gaps, both spatially and temporally, in the existing suite of airborne measurements in mature hurricanes. These measurements include improved three-dimensional representation of the hurricane wind field, more spatially dense thermodynamic sampling of the boundary layer, and more accurate measurements of ocean surface winds and underlying oceanic conditions [APHEX Goal 2]

Motivation and Background: Eyewall miso- and mesovortices have been hypothesized to mix high-entropy air from the eye into the eyewall, thus increasing the amount of energy available to the hurricane. They may also produce very high wind-speed signatures at the surface leading to small regions of extreme damage at landfall. Features widely described as eyewall mesovortices have been seen in satellite imagery within the eyes of strong TCs, in radar reflectivity signatures (Hurricane Fabian), from above during aircraft penetrations (Hurricanes Hugo, Erin, and Felix). Extreme miso-scale features have been seen at the surface in damage surveys (Hurricane Andrew), and in dropwindsonde data within and above the boundary layer; such features are also noted in large-eddy simulations. Meso-scale vortical features have never been observed, though miso-scale features in eyewalls of intense TCs are regularly seen. We do not know whether these features ultimately impact intensity changes. Observations within the eye and eyewall can allow for the study of these features and improve knowledge of intensity changes in very strong TCs.

Goal(s): To continue to add to the dataset of dropwindsonde sequences in the eyewalls of intense tropical cyclones in the hopes of finding cases in which multiple instruments sample individual small-scale features.

Hypotheses: Meso- and miso-scale features play an important role in TC intensity change.

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Objectives: To obtain multiple-dropwindsonde (2-8) sequences in the eyewalls of intense tropical cyclones.

Aircraft Pattern/Module Descriptions (see *Flight Pattern* document for more detailed information): This module occurs during the eyewall penetration. During the penetration, up to eight dropwindsondes will be released across the radius of maximum wind speed to try to obtain kinematic and thermodynamic observations in a single small-scale feature. Depending on the characteristics and width of the eyewall, the instruments may be released nearly simultaneously or up to 30 s from each other. The goal is to have the second-outermost dropwindsonde to be coincident with the flight-level radius of maximum wind speed, and the second-innermost dropwindsonde to be coincident with the surface radius of maximum wind speed.

Links to Other Mature Stage Experiments/Modules: This can be coordinated with any other mature-stage experiment or module. The multi-sonde sequence in the eyewall is the same as that in the Multi-Lidar Observations of Tropical Cyclone Inflow module.

Analysis Strategy: The data will be examined to look for individual meso- or miso-scale features at the eye-eyewall interface and characterize their structure and for other evidence of eye-eyewall mixing. Analyses with an advanced data assimilation system may also be conducted when one becomes available.

References:

Aberson, S. D., J. A. Zhang, and K. Nuñez Ocasio, 2017: An extreme event in the eyewall of Hurricane Felix on 2 September 2007. Mon. Wea. Rev., 145, 2083–2092.

Marks, F.D., P.G. Black, M.T. Montgomery, and R.W. Burpee. Structure of the eye and eyewall of Hurricane Hugo (1989). Mon. Wea. Rev., 136, 1237–1259.

Rogers, R. F., S. Aberson, M. M. Bell, D. J. Cecil, J. D. Doyle, T. B. Kimberlain, J. Morgerman, L. K. Shay, and C. Velden, 2017: Re-writing the tropical record books: The extraordinary intensification of Hurricane Patricia (2015). Bull. Amer. Met. Soc., 98, 2091-2112.

Stern, D. P., G. H. Bryan, and S. D. Aberson, 2016: Extreme low-level updrafts and wind speeds measured by dropsondes in tropical cyclones. Mon. Wea. Rev., 144, 2177– 2204.