

# 2021 NOAA/AOML/HRD Hurricane Field Program - APHEX

## OCEAN SURVEY EXPERIMENT *Flight Pattern Description*

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**Experiment/Module:** Ocean Survey Experiment

**Investigator(s):** Jun Zhang (PI), Joseph Cione, Nick Shay (RSMAS), Benjamin Jaimes (RSMAS), Joshua Wadler, Sue Chen (NRL), James Doyle (NRL), James Cummings (NRL), Johna Rudzin (NRL), Yi Jin (NRL), Elizabeth Sanabia (USNA), Luca Centurioni (SIO), Theresa Paluszkiwicz (OOC, LLC), Steven Jayne (WHOI), Rick Lumpkin, Gustavo Goni, Gregory Foltz, Francis Bringas, Matthieu Le Hénaff, and Lew Gramer

**Requirements:** No requirements: flown at any stage of the TC lifecycle

### **Ocean Observing Science Objective(s) Addressed:**

- 1) Collect datasets that can be used to improve the understanding of intensity change processes, as well as the initialization and evaluation of 3-D numerical models, particularly for TCs experiencing moderate vertical wind shear [*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 early stage TCs. These measurements include improved three-dimensional representation of the TC wind field, more spatially dense thermodynamic sampling of the boundary layer, and more accurate measurements of ocean surface winds [*APHEX Goal 2*].
- 3) Collect temporal and spatially coincident ocean, wave, and atmosphere observations during the pre-, during, and post-storm phases in order to better address hypotheses related to the ocean and wave boundary layer's role in energy exchange and intensification, evaluate the efficacy of new observing platforms such as wave drifters and Alamo profiling floats, and support data assimilation [*APHEX Goals 1, 3*].

### **P-3 Pattern #1: Ocean Survey (Pre-storm)**

**What to Target:** Region before storm passage based NHC's best track

**When to Target:** 24-48 hours prior to forecast arrival of the TC over the operating area

**Pattern:** Lawnmower, as in Fig. OC-1

**Flight altitude:** 6–8 kft preferable (Launched through free-fall chute)

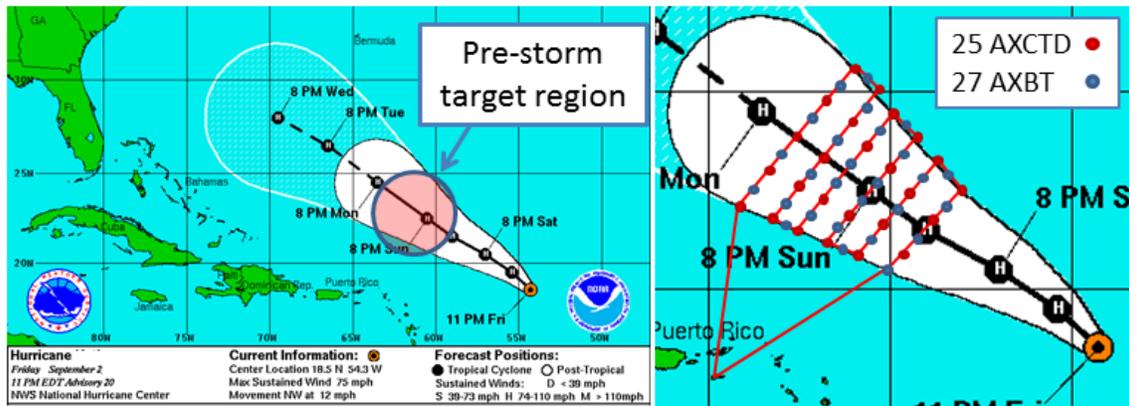
**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 5 h

**Expendable distribution:** 50–60 aircraft ocean expendables (AXBTS/AXCTDs) spaced approximately 0.5 deg. apart. AXCP probes may be included if significant gradients (and thus currents) are expected to be observed. A transect of 6-10 A-Sized DWSTM wave drifters to establish a wave field.

**Instrumentation Notes:** Use straight flight legs as safety permits

OCEAN SURVEY EXPERIMENT  
*Flight Pattern Description*



**P-3 Pattern #2: Ocean Survey (In-storm)**

**What to Target:** Sample the same area as pre-storm, include front quadrants, *core*, and *wake region* of a TC

**When to Target:** No constraint

**Pattern:** Standard Rotated Figure-4, as in Fig. OC-2

**Flight altitude:** 10 kft preferable

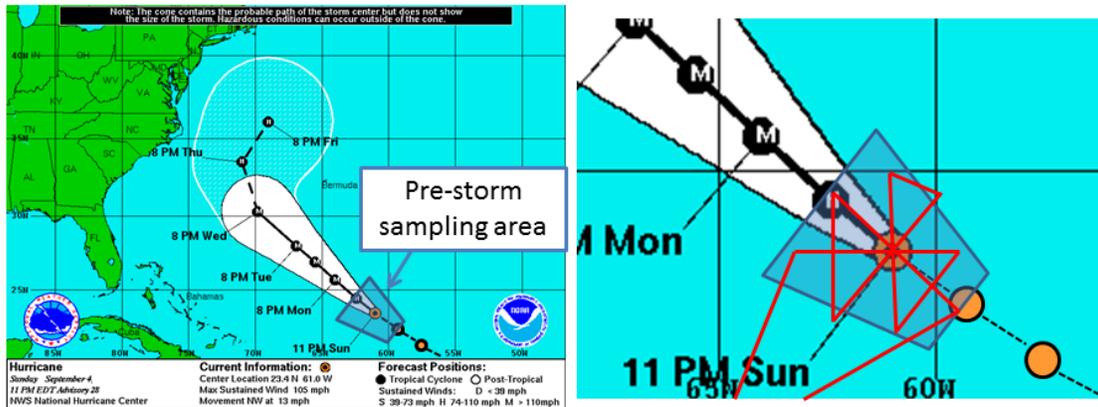
**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 5 h

**Expendable distribution:** 20–30 AXBTs, 4–8 A-Sized DWSTM wave drifters, distributed into the 4 quadrants of the storm to determine building wave state, in combination with dropwindsonde measurements.

**Instrumentation Notes:** Use straight flight legs as safety permits. Preferably flown with the WSRA.

OCEAN SURVEY EXPERIMENT  
*Flight Pattern Description*



*Figure OC-2: Left: NHC official forecast track at time of in-storm mission, with pre-storm sampled region highlighted. Right: P-3 in-storm flight pattern centered on storm and over previously sampled ocean area. Typical pattern is expected to be a Rotated Fig-4.*

**P-3 Pattern #3: Ocean Survey (Post-storm)**

**What to Target:** Sample the same *pre-storm* region, with slight pattern adjustments made based on the known storm track

**When to Target:** 24-48h Post storm

**Pattern:** Lawnmower, as in Fig. OC-3

**Flight altitude:** 6-8 kft preferable (launched through free fall chute)

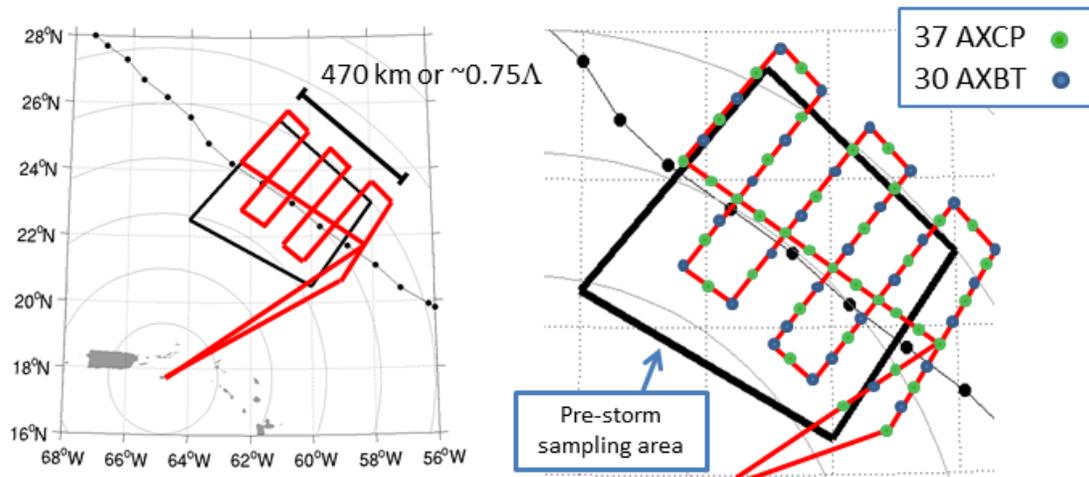
**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 5 h

**Expendable distribution:** 60–70 aircraft ocean expendables (AXBTs/AXCPs and 6-10 A-Sized DWSTM wave drifters).

**Instrumentation Notes:** None

OCEAN SURVEY EXPERIMENT  
*Flight Pattern Description*



**Figure OC-3:** Left: Post-storm ocean sampling flight pattern (red line), over previously sampled area (black box). In this example, the pattern extends around 470 km in the along-track dimension, or around 0.75 of a near-inertial wavelength. Right: Flight pattern with expandable drop locations, consisting of a combination of AXCP and AXBT probes.

**P-3 Pattern #4: Ocean Survey (Loop Current, Pre- and Post-storm)**

**What to Target:** Sample the loop current and associated eddy field (Gulf of Mexico warm eddy)

**When to Target:** Pre- (1–3 days prior to storm passage over the loop current) and post-storm (over same area as pre-storm survey, 1–3 days after storm passage)

**Pattern:** As in Fig. OC-4

**Flight altitude:** 6–8 kft preferable (launched via free-fall chute)

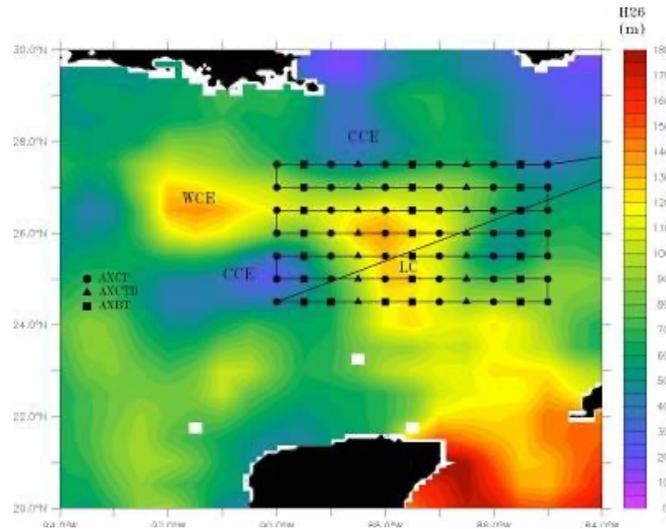
**Leg length or radii:** 250 n mi

**Estimated in-pattern flight duration:** ~ 8 h

**Expendable distribution:** a total of 60–80 aircraft ocean expendables (AXBTs, AXCPs, and AXCTDs, and 6-10 A-Sized DWSTM wave drifters)

**Instrumentation Notes:** Use straight flight legs as safety permits

OCEAN SURVEY EXPERIMENT  
*Flight Pattern Description*



*Figure OC-4: Typical pre- or post-storm pattern with ocean expendable deployment locations relative to the Loop Current. Specific patterns will be adjusted based on actual and forecasted storm tracks and Loop Current locations. Missions generally are expected to originate and terminate at AOC.*

**P-3 Pattern #5: Ocean Survey (Loop Current, In-storm)**

**What to Target:** Sample the *core region* of a TC and loop current eddy field

**When to Target:** In storm, no constraint

**Pattern:** Standard Rotated Figure-4, as in Fig. OC-2

**Flight altitude:** 6-8 kft (Launched via free-fall chute)

**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 4 h 45 min for Figure-4 + Rotated Figure-4 (45 n mi legs)

**Expendable distribution:** A total of 40 aircraft ocean expendables (AXBTs, AXCPs, and AXCTDs, and 6-10 A-Sized DWSTM wave drifters)

**Instrumentation Notes:** Use straight flight legs as safety permits.

**P-3 Pattern # 6: Ocean Survey (Float and Drifter)**

**What to Target:** Sample the core region of a TC

**When to Target:** 24-48h in storm, no constraint

OCEAN SURVEY EXPERIMENT  
*Flight Pattern Description*

**Pattern:** As in Fig. OC-6

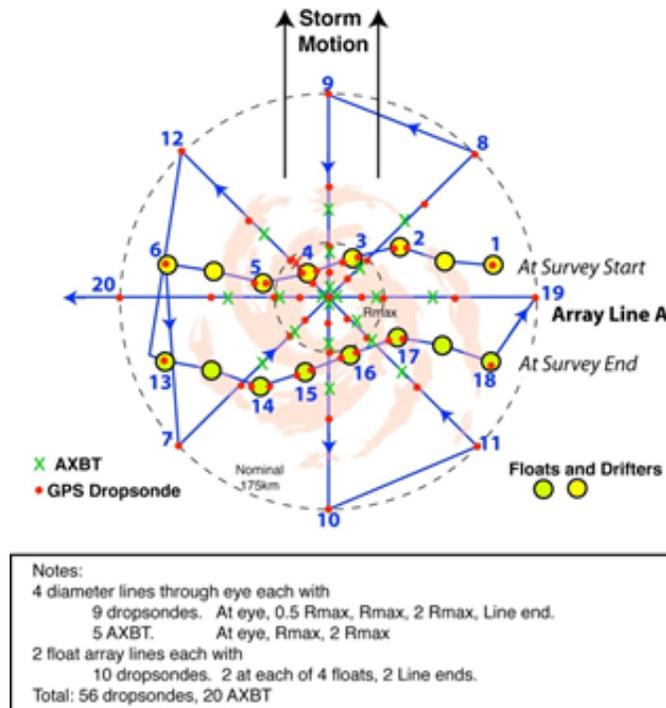
**Flight altitude:** 10–12 kft preferable

**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 4 h 45 min for Figure-4 + Rotated Figure-4 (45 n mi legs)

**Expendable distribution:** 56 sondes and 20 AXBTs

**Instrumentation Notes:** Use straight flight legs as safety permits



**Figure OC-6:** P-3 pattern over float and drifter array. The array has been distorted since its deployment on the previous day and moves relative to the storm during the survey. The pattern includes two legs along the array (waypoints 1–6 and 13–18) and an 8 radial line survey. Dropsondes are deployed along all legs, with double deployments at the floats. AXBTs are deployed in the storm core.

**P-3 Pattern # 7: Ocean Survey (Glider coordination)**

**What to Target:** Sample the *core region* of a TC

**When to Target:** In storm, no constraint. Standard Figure-4 or Rotated Figure-4 pattern with radial leg or downwind leg overpass the location of gliders.

# 2021 NOAA/AOML/HRD Hurricane Field Program - APHEX

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**Pattern:** An example of the flight pattern is shown in Fig. OC-7. This flight pattern was tested in Hurricane Dorian (2019).

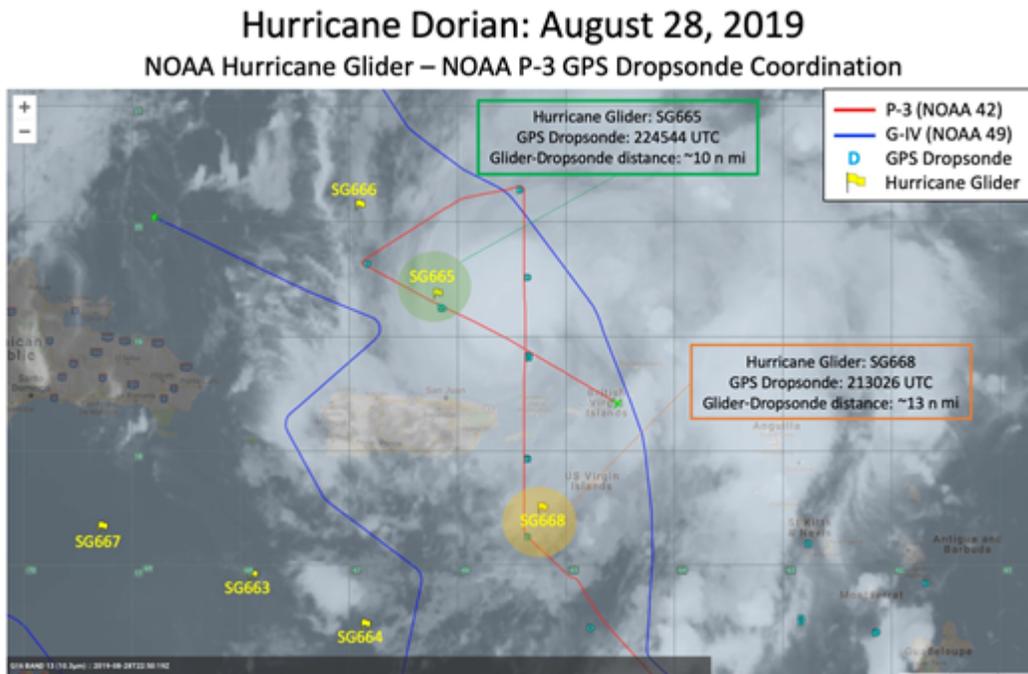
**Flight altitude:** 10–12 kft preferable

**Leg length or radii:** 105 n mi

**Estimated in-pattern flight duration:** ~ 4 h 45 min for Figure-4 + Rotated Figure-4 (45 n mi legs)

**Expendable distribution:** 12 dropsondes and 4 aircraft ocean expendables with the option for additional A-Sized DWSTM wave drifters if indicated.

**Instrumentation Notes:** Use straight flight legs as safety permits



**Figure OC-7:** P-3 pattern over gliders. Dropsondes are deployed along all legs, with deployments at the locations of gliders. AXBTs are deployed at glider locations.