2021 NOAA/AOML/HRD Hurricane Field Program - APHEX

END STAGE EXPERIMENT
Flight Pattern Description

Experiment/Module: Tropical Cyclones at Landfall

Investigator(s): Investigator(s): John Kaplan, Peter Dodge, Ghassan Alaka, Heather Holbach, Jun Zhang, Frank Marks, Michael Biggerstaff (University of Oklahoma), John Schroeder (Texas Tech University), Forrest Masters (University of Florida), Kevin Knupp (University of Alabama at Huntsville), David Nolan (University of Miami)

Requirements: TC making landfall, approaching the coastline, undergoing rapid weakening, or extratropical transition

End Stage Science Objective(s) Addressed:

1) Collect observations targeted at better understanding changes TCs undergo at landfall. Objectives include validation of surface wind speed estimates and model forecasts, understanding factors that modulate intensity changes near and after landfall, and to understand processes that lead to tornadoes in outer rainbands [*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 landfalling TCs, rapidly weakening TCs, and TCs undergoing extratropical transition. 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*].

P-3 Pattern #1: Landfall (Offshore Intense Convection)

What to Target: An intense rain band > 150 n mi (280 km) from the center of either a tropical storm or hurricane that is forecast to make landfall along the U.S coastline

When to Target: This module should be performed within ~12–24 h of the time of landfall

Pattern: Break-away/non-standard (see Fig. EN-1 and description below):

Fig. EN-1 shows a sample Offshore Intense Convection flight pattern near the Carolina coast. The P-3 should (safety permitting) cross the target band 10-15 n mi (20–25 km) downwind of the intense convective cells and then proceed to 15 n mi (25 km) outside the rain band axis all the while maintaining a ~5 n mi (10 km) separation from the outer edge of the band. The aircraft then turns upwind and proceeds along a straight track parallel to the band axis. When the P-3 is 10-15 n mi (20–25 km) upwind of the target cells, the aircraft turns and proceeds along a track orthogonal to the band axis until the P-3 is 15 n mi (25 km) inside the rain band then turns downwind and flies parallel to the rain band axis while maintaining a ~5 n mi (10 km) separation from the edge of the rain band for safety.

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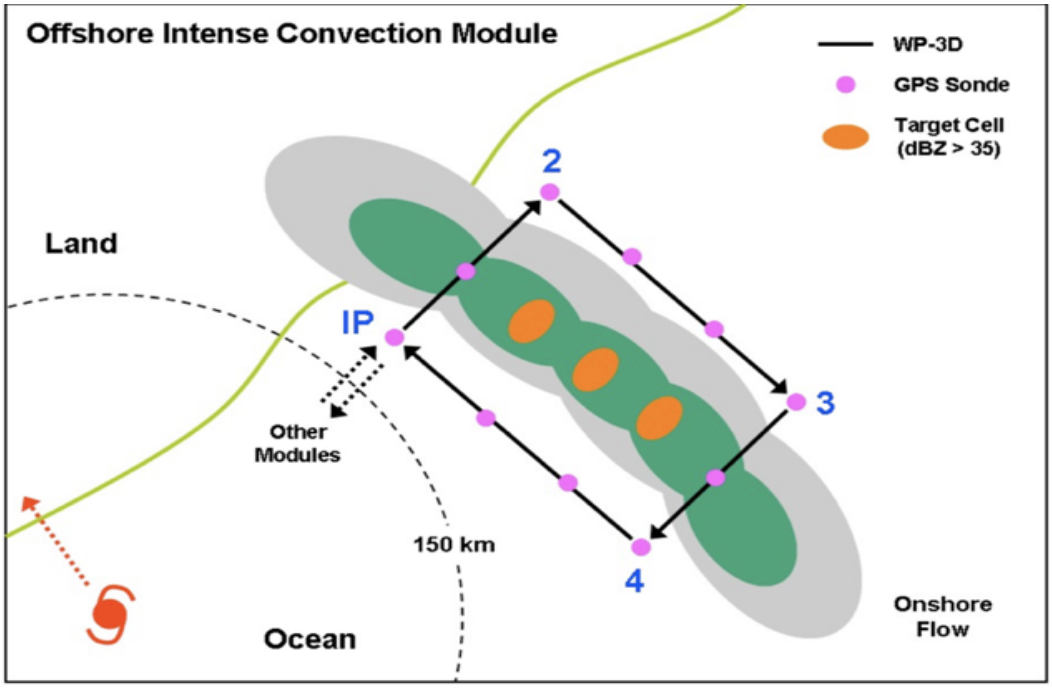

Figure EN-1. *Offshore Intense convection module*

Flight altitude: 10 kft or higher radar altitude

Leg lengths: ≥40 n mi (75 km) for each parallel leg

Estimated in-pattern flight duration: 1–2 h

Expendable distribution: Deploy dropwindsondes at the start or end points of each leg, at the band axis crossing points, and at 10-15 n mi (20–25 km) intervals along each leg parallel to the band. At least 2 dropwindsondes should be deployed on either side of the convection and at least 1 dropwindsonde should be deployed each time the band-axis is crossed (for a minimum of 6 dropwindsondes).

Instrumentation Notes: The Tail Doppler radar should be turned on and scanning normally. The Lower Fuselage radar (MMR) should operate in HWX mode to collect both reflectivity and Doppler velocity. Aircraft should avoid penetration of intense reflectivity regions (particularly over or near land). AXBTs may be released at the discretion of the LPS but are not a requirement. Dropsondes should be transmitted to GTS.

P-3 Pattern #2: Landfall (Coastal Survey)

What to Target: A tropical storm or hurricane that is forecast to make landfall along the U.S coastline

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When to Target: This module should be performed within ~6 h of the time of landfall

Pattern: Break-away/non-standard (see Fig. EN-2 below and description below):
Fig. EN-2 shows a sample Coastal Survey pattern for a hurricane landfall near Melbourne, Florida. The P-3 would fly parallel but ~20-25 n mi (40-45 km) offshore so that the SFMR and WSRA, if available, footprints are out of the surf zone. The second pass should be parallel and just offshore ~ 5 n mi (10 km) from the coast or as close to the coastline as safety permits. Finally, a short leg from the coastline spiraling towards the storm center could be flown provided that time and safety permitted. If mobile radars are deployed, legs should be adjusted so airborne radar data and sondes can be released in the surface dual Doppler lobes (typically ~30-40 km from radar location) when precipitation is present. If other mobile surface observing teams are deployed, dropsondes should be released as close to their locations as possible. This pattern can also be flown prior to the eyewall coming ashore. Coordination with Synthetic Aperture Radar (SAR) satellite overpasses is also desirable, when possible.

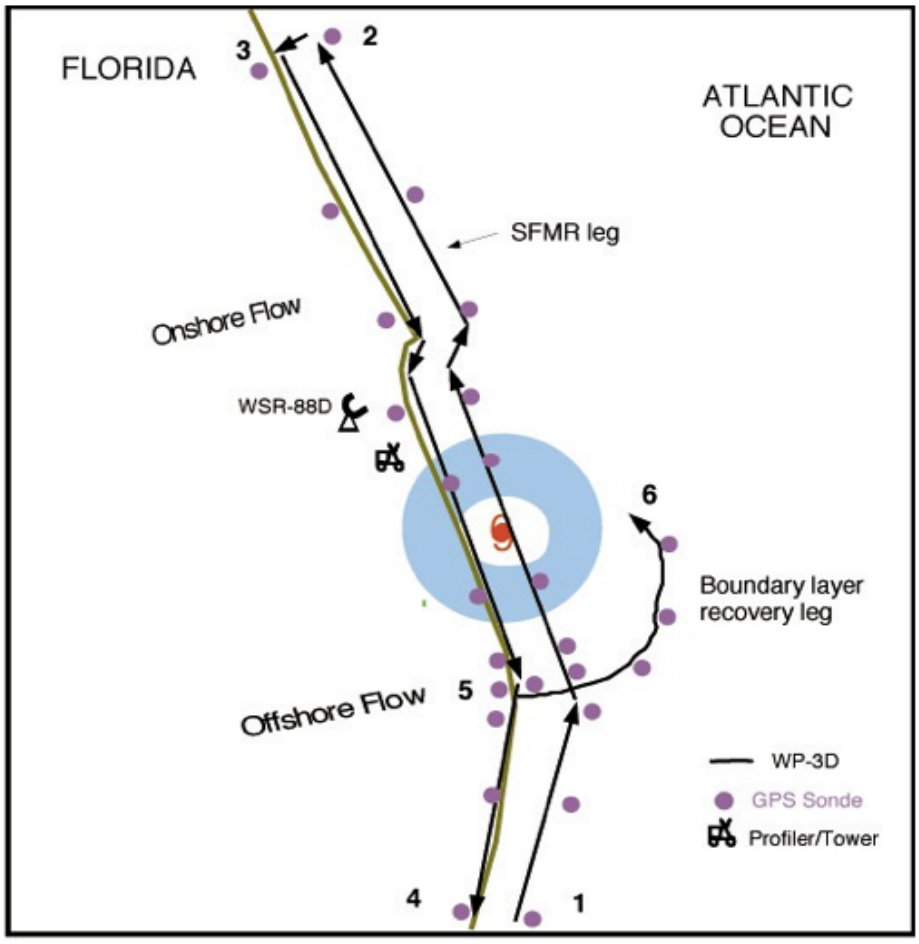

Figure EN-2. *Coastal Survey module*

Flight altitude: ~10 kft (radar altitude preferred).

Leg lengths: ~150 n mi (275 km) for each parallel leg

Estimated in-pattern flight duration: ~2 h

Expendable distribution: Dropwindsondes at the RMW as well as up to four additional drops equally spaced on each side of the storm along both the near shore and offshore legs. One or two drops could be made (at the LPS's discretion) along the leg spiraling toward the center provided that it is flown. If surface towers or portable mesonet stations are present, adjust drops to be upwind of the surface sites.

Instrumentation Notes: The Tail Doppler radar should be turned on and scanning normally. The Lower Fuselage radar (MMR) should be in HWX mode if conditions permit. Aircraft should avoid penetration of intense reflectivity regions (particularly those overland). SFMR and WSRA, if available, should be operating normally. AXBTs are not required but may be dropped at LPS discretion. Dropsondes should be transmitted to GTS.

P-3 Pattern #3: Landfall (SFMR Coastal)

What to Target: A tropical storm or hurricane that is forecast to make landfall in a region with varying bathymetry near the coastline

When to Target: This module should be performed when sustained winds are greater than 30 kt in the region of interest

Pattern: Break-away/non-standard (see Fig. EN-3 and description below):

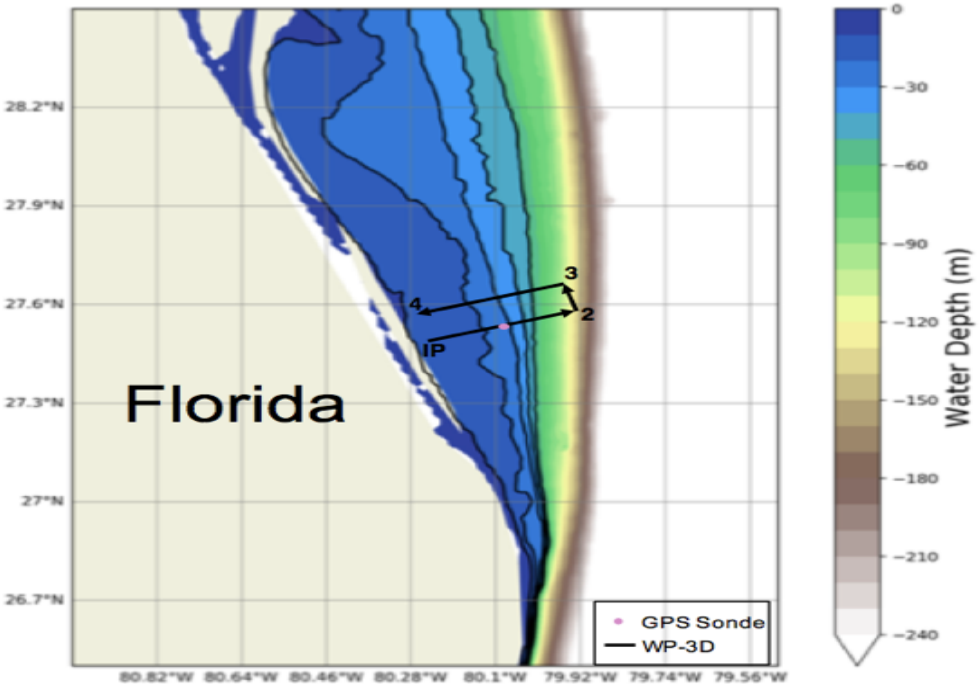

Figure EN-3. *SFMR coastal module*

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The P-3 would fly perpendicular to the coastline, across the bathymetry gradient, in a region with near constant surface winds. After flying away from the coast for about 27 n mi (50 km), the P-3 would turn downwind and then back towards the coast repeating a similar line as the first leg. This pattern can also be flown in reverse with the first leg flying towards the coast. Ideal to have the WSRA collecting surface wave spectra data as well.

Flight altitude: Can be performed at any radar altitude between 5 kft to 12 kft. Aircraft should maintain a constant altitude and attitude throughout the module.

Leg lengths: ~13-27 n mi (25–50 km)

Estimated in-pattern flight duration: ~30–45 min

Expendable distribution: Dropsonde at middle of first leg. If winds appear to vary over the leg, then an additional dropwindsonde may be necessary. No AXBTs are required, but could be helpful if available. If desired, the AXBT would be released with the dropsonde. Dropsondes should be transmitted to GTS.

Instrumentation Notes: SFMR should be operating normally. Preferable to also have the WSRA collecting surface wave data. Tail and Lower fuselage radars should also be operated normally, with the lower fuselage (MMR) in HWX mode if conditions permit.