MATURE STAGE EXPERIMENT
Flight Pattern Description

Experiment/Module: Distribution of Hazardous Winds

Investigator(s): Heather Holbach (PI) and Kelly Ryan (Co-PI)

Requirements: Categories 2–5

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) Collect observations targeted at better understanding the response of mature hurricanes to their changing environment, including changes in vertical wind shear, moisture and underlying oceanic conditions [*APHEX Goals 1, 3*].

P-3 Pattern #1

What to Target: Tropical cyclone inner and outer core along ordinals (NE, SE, SW, NW)

When to Target: Tropical cyclones greater than Category-1 strength and have asymmetric surface wind distributions (may or may not correlate with distribution of convection).

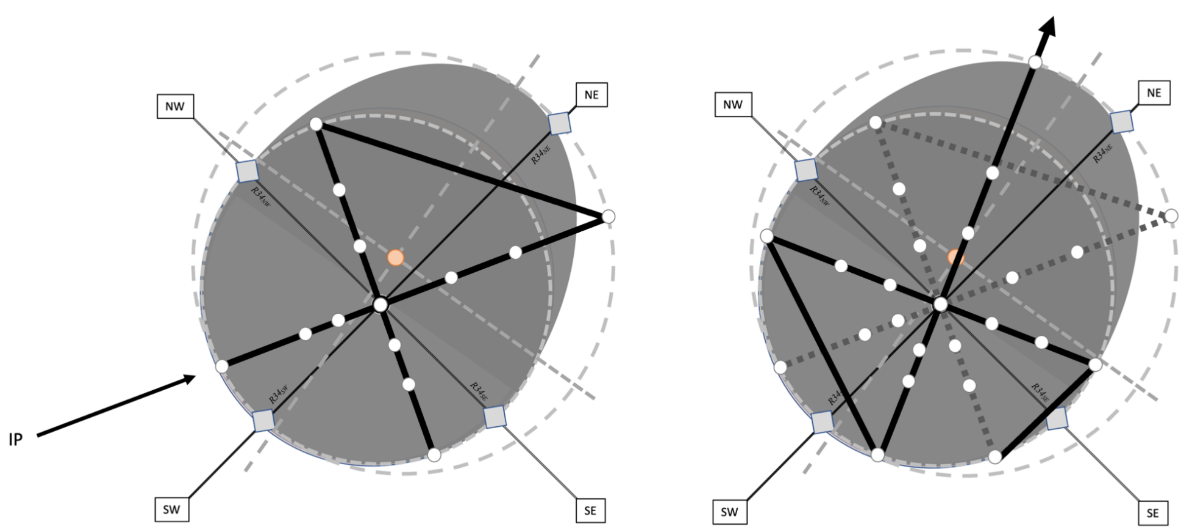

Figure 1. Initial skewed Figure-4 (left) and second skewed Figure-4 after rotation (right). White dots indicate potential dropsonde deployment locations at quadrant-defined significant radii when necessary to verify instrument-derived surface wind speeds. The gray shaded region defines the estimated asymmetric wind distribution (see Science Document, Figure 1) with its associated center (orange dot), and gray diamonds indicate reported quadrant wind radii.

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Pattern: Begin with a modified Figure-4 initially oriented 20 degrees clockwise from ordinal direction axes and where radial leg lengths are defined using NHC-reported quadrant 34-knot wind radii. Following a 40-degree rotation, a second modified Figure-4 is performed with leg lengths defined by updated quadrant wind information from the first Figure-4. If the first skewed Figure-4 does not align within 20 degrees of the estimated skew direction, the second skewed Figure-4 should align along the ordinals (NE, SE, SW, NW) or the approximate azimuth of anticipated maximum extent (see Figure 1 in Science Document).

Flight altitude: 700mb or 850 mb pressure altitude preferred, 8-12 kft acceptable

Leg length or radii: Dependent on the extent of the 34-knot wind radii in each quadrant. Typical axisymmetric 34-knot wind radii can range from 25 to 375 n mi in the North Atlantic basin, with a median value of 110 n mi.

Estimated in-pattern flight duration: ~5 hours, depends on size and asymmetry of outer core wind field

Expendable distribution: Dropsondes deployed near significant wind radii (R64, R50, R34) in coordination with remotely sensed observations along these axes aim to reduce the uncertainty in quadrant radii information. Additional dropsondes may be necessary along the downwind legs to obtain adequate azimuthal coverage in the outer core.

Instrumentation Notes: Coordinate with all available wind observing platforms. Wave information from the WSRA or KaIA would also be useful for hazard assessment.

P-3 Pattern #2

What to Target: Tropical cyclone inner and outer core oriented along the axis of greatest extent of 64-, 50-, or 34-knot winds.

When to Target: Tropical cyclones greater than Category-1 strength and have asymmetric surface wind distributions (may or may not correlate with distribution of convection). If targeting 34-knot wind distribution, at least one NOAA P-3 or AF C-130 mission must be flown prior to performing this pattern to ensure best estimate of quadrant radii information. Storms expected to experience large gradients in environmental conditions are of particular interest as these are known to cause substantial asymmetries in the overall extent of hazardous winds.

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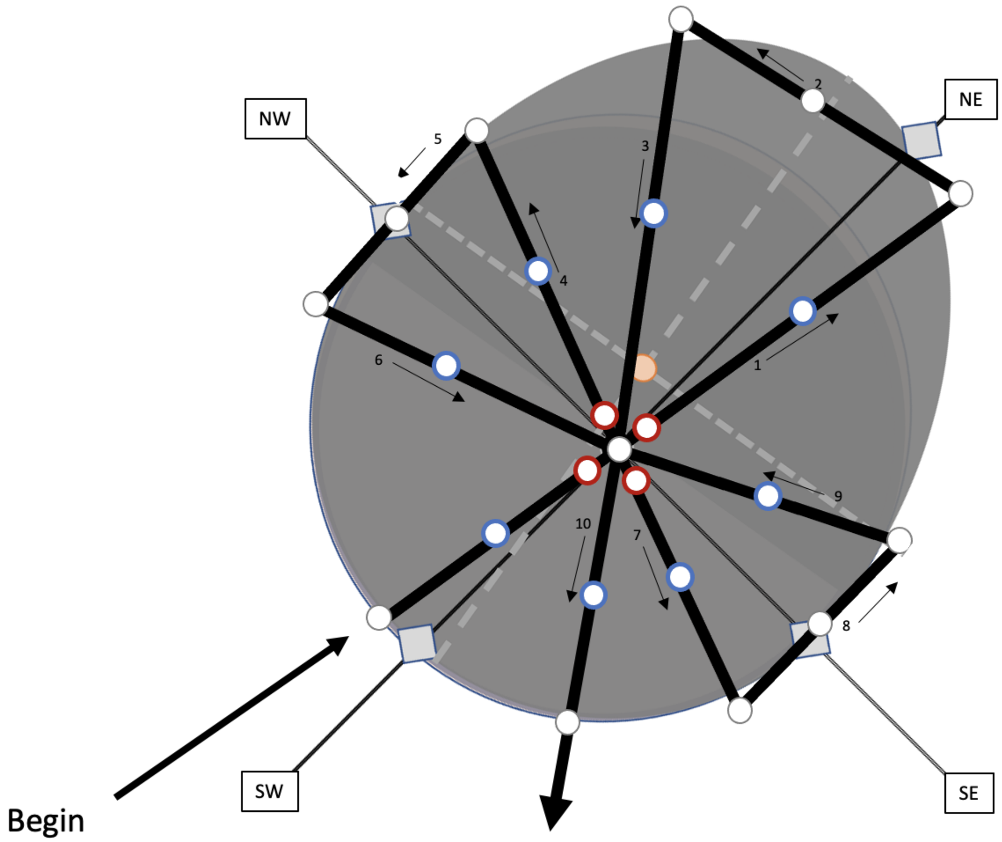

Figure 2. Windmill flight pattern (black lines) along major and minor axes (dashed gray lines) of an asymmetric distribution (gray shaded area) estimated using reported 34-knot wind radii in each quadrant (gray diamonds). The aircraft begins on the azimuth 20 degrees clockwise of the 34-knot wind distribution skew direction and samples each quadrant's gale-force extent. Dropsondes should be deployed at endpoints (white dots), mid-points (white/blue dots), and maximum wind radii (white/red dots) in each quadrant.

Pattern: Begin with a transect oriented 20 degrees clockwise from <u>wind distribution skew azimuth</u> (see Figure 2). A 40-degree downwind rotation is made at the end of the first outbound radial leg, followed by an inbound leg where radial leg lengths are defined using NHC-reported quadrant 34-knot wind radii. This completes one blade of the windmill. Two more blades oriented perpendicularly complete the pattern and the final outbound leg occurs in the IP quadrant.

Flight altitude: 700mb or 850mb pressure altitude, 8-12 kft

Leg length or radii: Dependent on the extent of the 64-, 50-, or 34-knot winds in each quadrant. Typical axisymmetric 64-knot (50-knot) wind radii can range from 10 (10) to 125 (255) n mi in the North Atlantic basin, with a median value of 45 (70) n mi.

Estimated in-pattern flight duration: 3-5 hours, depending on the size and asymmetry of wind distribution and choice of significant radius (34-, 50-, or 64-knot winds).

Expendable distribution: The maximum wind in each quadrant will be used to determine radial dropsonde locations for each fan, where "mid-points" are defined as the significant radius closest to half of its quadrant's maximum wind; at least 1 additional dropsonde should be deployed during downwind legs.

Instrumentation Notes: Coordinate with all available wind observing platforms. Wave information from the WSRA or KaIA would also be useful for hazard assessment.

P-3 Pattern #3

What to Target: Tropical cyclone inner and outer core

When to Target: Tropical cyclones greater than category 1 strength and have asymmetric surface wind distributions (may or may not correlate with distribution of convection). Smaller TC's will allow more time for better azimuthal coverage of wind measurements.

Pattern: An initial modified figure-4 with quadrant-dependent leg lengths is performed, followed by a downwind leg 40 degrees counter-clockwise and inbound leg. This part of the pattern uses quadrant radii of 34-knot winds.

Once in the center, instead of continuing along the azimuth, turn outward along distribution skew direction (as in Pattern 2 but for radius of 50-knot winds) to begin the first spoke. Once surface wind speeds decrease by half from quadrant maximum, or when is safe, the P-3 should turn around and head inbound on the same azimuth. This should be repeated for 2-4 additional spokes to sample the quadrant counterclockwise of calculated skew direction every 20, 30, or 45 degrees depending on the size of the storm. The exit azimuth can be chosen to gain additional azimuthal coverage in the less observed quadrants or to revisit azimuths with inconsistent data among instrumentation or known changes in structure during flight.

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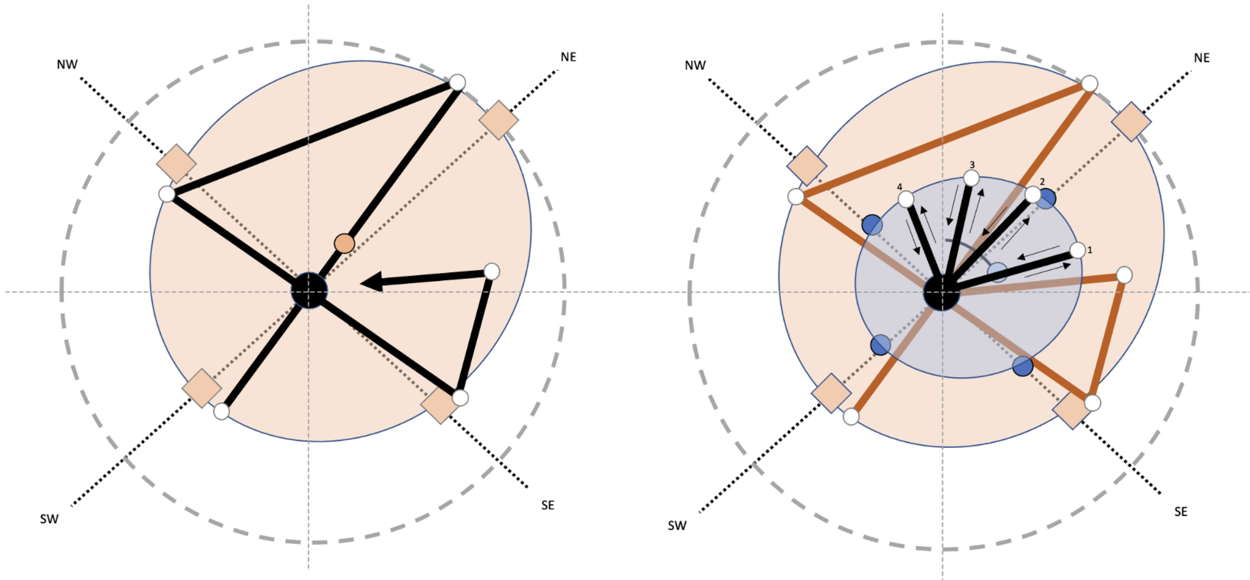

Figure 3. Spoked Figure-4 broken up into (a) Figure-4, where the distribution shape (orange shaded area) is dependent on the 34-knot wind distribution center (orange dot) and orange diamonds indicate 34-knot wind radii in each quadrant, and (b) radial spokes, which depend on the distribution (blue shaded area) of the significant wind radii closest to half the observed TC intensity (50-knot radii for most TCs, blue dots). Dropsondes should be deployed at endpoints (white dots) and mid-points (not shown) of each radial.

Flight altitude: 700 mb or 850 mb pressure altitude preferred, 8-12 kft acceptable

Leg length or radii: Based on radius of 50-knot winds in each quadrant (through category 3) and radius of 64-knot winds (category 4 or higher). Typical axisymmetric 64-knot (50-knot) wind radii can range from 10 (10) to 125 (255) n mi in the North Atlantic basin, with a median value of 45 (70) n mi.

Estimated in-pattern flight duration: 4-5 hours, depends on size and asymmetry of wind field

Expendable distribution: Dropsondes will be deployed at typical end- and mid-points during the Figure-4, and at the endpoints at mid-points of each spoke. Additional dropsondes may be necessary along downwind legs to obtain adequate azimuthal coverage.

Instrumentation Notes: Coordinate with all available wind observing platforms. Wave information from the WSRA or KaIA would also be useful for hazard assessment.