EARLY STAGE EXPERIMENT
Flight Pattern Description

Experiment/Module: Impact of Targeted Observations on Forecasts (ITOFS) Experiment

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

Early Stage 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*].

P-3 Pattern #1

What to Target: Sample the core and surrounding environment of the TC or pre-genesis invest. Sampling strategies will be determined using real-time targeting guidance derived from the ECMWF, GEFS, NRL, HAFS models, as well as COAMPS-TC adjoint sensitivity.

When to Target: Sample when model targeting guidance indicates viable targets (Fig. 1) that could positively impact forecasts of TC (or pre-genesis invest) track, intensity and/or structure. Any intensity TC (or invest); no land restrictions; no specific take-off time requirements; missions can be once every 12 or 24 h. If possible, this P-3 module should be conducted in coordination with G-IV Pattern 1.

Pattern: For invests, any standard pattern that provides symmetric coverage (e.g., Lawnmower, Square Spiral, Figure-4, Rotated Figure-4, Butterfly). For TCs, fly any standard pattern that provides symmetric coverage (e.g., Figure-4, Rotated Figure-4, Butterfly, P-3 Circumnavigation).

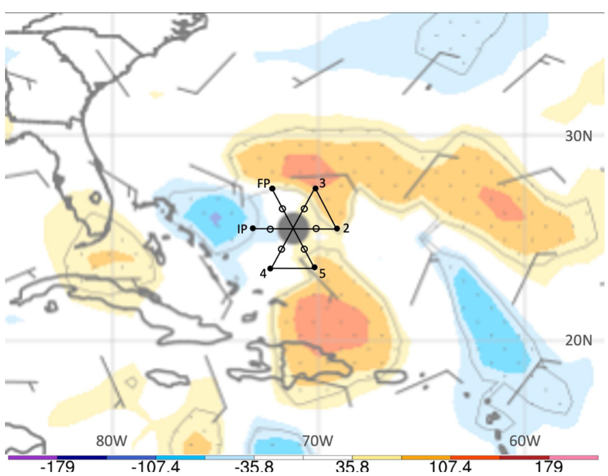

Figure 1. P-3 Synoptic Flow pattern for a TC mission flown on 29 Aug 00 UTC designed to impact the forecast for 31 Aug 00 UTC. The plot shows hypothetical reductions in ECMWF position variance due to assimilating GPS dropsonde data at each location. Warmer and cooler colors denote areas where GPS dropsonde data could most effectively reduce variance amongst the ensemble members. A butterfly pattern with 125-n mi (230-km) legs and endpoint (solid circles) & midpoint (open circles) GPS dropsonde locations are overlaid.

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Flight altitude: 10–12 kft pressure altitude (radar altitude is acceptable) in the inner core and as high as possible in the near environment [≥~80 n mi (150 km)] to provide better vertical sampling by GPS dropsondes that are deployed. If the P-3 is coordinated with the G-IV, P-3 altitudes greater than 10–12 kft may not be necessary.

Leg length or radii: Standard leg lengths of 105 n mi (200 km) in TCs, but legs should be extended to reach the radius of 34-kt winds whenever possible [R~125 n mi (230 km) for Atlantic hurricanes]. Sampling at these larger radii can also be completed during ferries to/from the storm.

Estimated in-pattern flight duration: ~2.0–6.0 h

Expendable distribution: Standard (10–20 dropsondes), although fewer may be used. Additional dropsondes are desirable in regions with large thermodynamic gradients or regions of downdrafts. AXBTs are not a mission requirement.

Instrumentation Notes: Use TDR defaults. GPS dropsondes should be quality controlled and transmitted to the GTS in real-time. Use straight flight legs as safety permits.

G-IV Pattern #1

What to Target: Sample the near and peripheral environments of the TC or pre-genesis invest. If the P-3 is not available, the G-IV could also overfly or circumnavigate as closely as possible, the TC core or pre-genesis invest. Sampling strategies will be determined using real-time targeting guidance derived from the ECMWF, GEFS, NRL, HAFS models, as well as COAMPS-TC adjoint sensitivity.

When to Target: Sample when model-targeting guidance indicates viable targets (Fig. 2) that could positively impact forecasts of TC (or pre-genesis invest) track, intensity and/or structure. Any strength TC (or pre-genesis invest); no land restrictions; no specific take-off time requirements; missions can be once every 12 or 24 h. If possible, this G-IV pattern should be conducted in coordination with P-3 Pattern 1. It is also desirable to coordinate potential G-IV flight targets with NHC. A high-priority scenario would include flying a series of G-IV Synoptic Flow missions for a TC or pre-genesis invest that has a reasonable chance of being tasked by NHC to fly operational Synoptic Surveillance missions. In this scenario, a combination of Synoptic Flow and Synoptic Surveillance missions could provide an extended period with continuity in observations where data is being regularly assimilated into forecast models for several days.

Pattern: Variable from storm to storm, dictated by regions that are identified using model targeting techniques. The over-storm or near-storm portion of the pattern could incorporate the following patterns: Figure-4, Rotated Figure-4, Butterfly, Lawnmower, G-IV Circumnavigation, G-IV Star pattern, or G-IV Star with Circumnavigation. In order to maintain consistency with NOAA NHC operational Synoptic Surveillance missions, an outer circumnavigation at R=180 n mi (335 km) should be flown. If time and conditions permit, a second inner circumnavigation is also desirable. This inner radius should be the smaller of the following two radii:

1. 90 n mi (165 km), the standard inner radius used by NHC

2. NHC's analyzed R34 winds multiplied by 1.5 (addresses storms with small R34 winds). For reference, an observed value of R34 for a small Atlantic hurricane is 50 n mi (90 km), equating to a G-IV inner circumnavigation radius of ~75 n mi (~140 km).

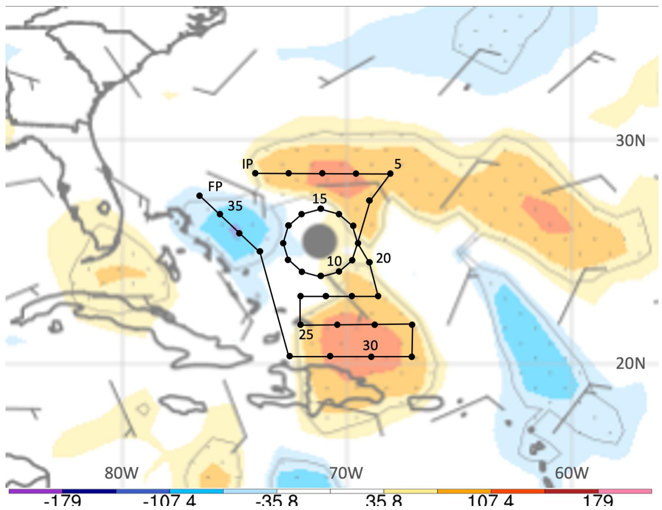

Figure 2. G-IV Synoptic Flow pattern for a mission flown in a TC on 29 Aug 0000 UTC designed to impact the forecast for 31 Aug 0000 UTC. The plot shows hypothetical reductions in ECMWF position variance due to assimilating GPS dropsonde data at each horizontal location. Warmer and cooler colors denote areas where GPS dropsonde data could most effectively reduce variance amongst the ensemble members. A circumnavigation with a radius of 90 n mi (165 km) is indicated in the pattern and GPS dropsonde locations (solid circles) are overlaid.

Flight altitude: 40–45 kft or as high as possible to provide better vertical sampling by dropsondes that are deployed.

Leg length or radii: Standard leg lengths for over-storm patterns. For near-storm patterns, inner points and optional inner circumnavigation, radii should be as close to the edge of the inner core convection as possible. This distance will be dictated by safety considerations, will typically range from ~60–90 n mi (110-165 km), and will require coordination between the HRD LPS and G-IV Flight Director. A radius of 180 n mi (335 km) is desirable for the outer circumnavigation.

Estimated in-pattern flight duration: ~2.5–7.5 h

Expendable distribution: Standard in the pre-invest/TC inner core. For the near and far environments, ~1.5–2 degree spacing in quiescent regions and oversampling (~1–2 degree spacing) in model-indicated target areas.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits. All GPS dropsonde data should be transmitted to the Global Telecommunication System (GTS) in real-time to ensure availability for assimilation into forecast models.

G-IV Pattern #2

What to Target: Sample the near-TC (or invest) and joint environment of a non-priority TC (or invest) interacting with a priority TC (or invest) that exhibits high uncertainty in track or intensity forecasts.

When to Target: Sample when 2 or more TCs (invests) are interacting with each other and are located less than ~15 degrees from one another; if the second P3 is used, this distance is less of a constraint. Any strength TC (or invest); no land restrictions; no specific take-off time requirements; missions can be once every 12 or 24 h. This G-IV module must be conducted in coordination with symmetric G-IV and P-3 sampling of the priority TC (such as during standard operationally tasked missions) and is designed as an add-on to G-IV Pattern 1 (Fig. 3). *Optimal, but not required:* Perform when priority TC is within 5 degrees of the CONUS such that some of the expected sensitive regions are sampled through land-based methods.

Pattern: Depending on both TCs and distance between them, this module consists of two parts that can occur in either order, or individually based on available time. One part samples the near-storm environment of the non-priority TC using a circumnavigation as close to inner core convection as possible; the other part samples the shared environment of the interacting TCs using straight paths oriented approximately perpendicular to the path connecting their centers (Fig. 3). These regions may also coincide with areas identified using model targeting techniques for G-IV Pattern 1. For 24-h missions, the second P-3 can be used instead and can include other symmetric flight patterns (e.g., rotated figure-4, butterfly) to capture the non-priority TC vortex structure.

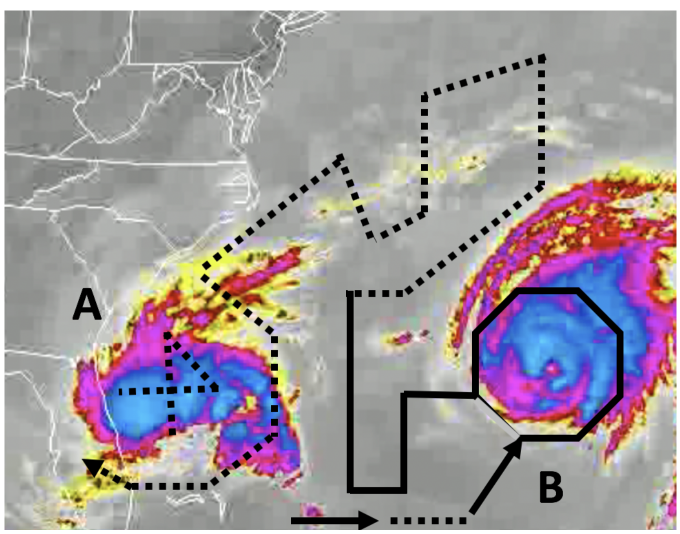

Figure 3. Example flight plan for a 3-hour G-IV Pattern 2 (solid), representing the two part module focused on non-priority TC (B), and where dotted lines represent potential coordinated paths for G-IV Pattern 1 and P-3 inner-core, which focus on priority TC (A).

Flight altitude: 40–45 kft or as high as possible to provide better vertical sampling by dropsondes that are deployed.

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Leg length or radii: For near-storm G-IV circumnavigation, radii should be as close to the edge of the inner-core convection as possible. This distance will be dictated by safety considerations, typically range from ~60–90 n mi (110-165 km), and will require coordination between the HRD LPS and G-IV Flight Director. If the second P-3 is used, legs must extend outward to 105 n mi (195 km) or out to a minimum of 90 n mi (165 km).

Estimated in-pattern flight duration: ~2–4 h

Expendable distribution: 8 azimuthally equidistant GPS dropsondes for circumnavigation, and ~1.5–2 degree spacing in common environment region between TCs (unless otherwise indicated by G-IV Pattern 1). If the P-3 is used, release dropsondes at all end points and include at least 1 center dropsonde; GPS dropsondes at the midpoints/RMW can be added on a case-by-case basis.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits. All GPS dropsonde data should be transmitted to the Global Telecommunication System (GTS) in real-time to ensure availability for assimilation into forecast models.