EARLY STAGE EXPERIMENT
Pattern and Module Descriptions

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Requirements: TD, TS, Category 1

SCIENCE OBJECTIVE #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*
[Analysis of Intensity Change Processes Experiment, AIPEX]

P-3 Pattern #1: AIPEX

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

When to Target: Every 12 h [*optimal*] or every 24 h [*minimal*], preferably in coordination with a corresponding G-IV mission (**G-IV Pattern #1: AIPEX** or **G-IV Pattern #2: AIPEX**)

Pattern: Standard Rotated Figure-4

Flight altitude: [*optimal*] 10–12 kft (5 kft is minimum altitude for dropsonde launches)

Leg length or radii: 105 n mi

Estimated in-pattern flight duration: ~ 5 h

Expendable distribution: [*optimal*] (up to 28 dropsondes total) Modify standard by moving the mid-point dropsonde to half the radius of innermost G-IV radii. AXBTs preferably paired with dropsondes at mid- and turn points and center. If radius of maximum wind (RMW) is significantly different (> 10 n mi) from any of the standard dropsonde locations, release dropsonde there, and also release dropsonde at 1.5 x RMW, subject to same constraint regarding proximity to standard dropsonde locations. No AXBTs need to be coordinated with these RMW-based drops.

[*minimal*] (10–12 dropsondes total) Modify standard as stated in [*optimal*], keeping only midpoint drops, as well as center drops on the first and last pass. AXBTs preferably paired with dropsondes at midpoints and center.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits. Inbound-outbound passes should be uninterrupted. DWL should be downward looking, 20° off nadir.

P-3 Pattern #2: AIPEX

What to Target: Sample the inner core and near environment regions of a TC when the *inner core precipitation distribution is asymmetric and when the G-IV is not available for coordination*

When to Target: Every 12 h [*optimal*] or every 24 h [*minimal*]

Pattern:

[*optimal*] P-3 Circumnavigation with Rotated Figure-4 (*modified* from the *standard*)

[*minimal*] P-3 Circumnavigation with single Figure-4 (*standard*)
Note: The circumnavigation can be adjusted for hazard avoidance; e.g., if pattern in downshear hemisphere is not possible, the circumnavigation can be abbreviated to the upshear hemisphere with a pass over the center (see example below in Fig. ES-1):

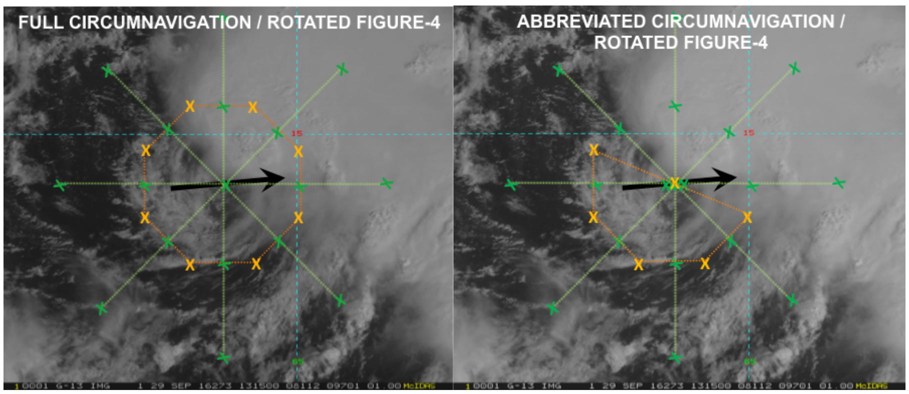

Figure ES-1. *Standard Rotated Figure-4 pattern dropsonde locations (green 'x') with full circumnavigation (orange 'x') (left panel), and with partial circumnavigation (right panel)*

Flight altitude: Figure-4: [*optimal*] 10–12 kft (5 kft is minimum altitude for dropsonde launches). Circumnavigation: As high as possible [*optimal*] above 25 kft [*minimal*]

Leg length or radii: 105 n mi (leg length). Radius of circumnavigation is preferably as close to the inner-core precipitation shield as safety allows.

Estimated in-pattern flight duration: [*optimal*] Circumnavigation with rotated Figure-4, ~6 h; [*minimal*] Circumnavigation with single Figure-4, ~ 4 h

Expendable distribution: [*optimal*] Use the standard for P-3 circumnavigation (8 dropsondes), as well as for rotated Figure-4 (20 dropsondes, 28 total with circumnavigation) or single Figure-4 (10 dropsondes, 18 total with circumnavigation). AXBTs preferably paired with dropsondes at mid- and turn points and center.

[*minimal*] Use the standard for P-3 circumnavigation (8 dropsondes), and modify standard Figure-4 by keeping only turn point drops, as well as center drops on the first and last pass (for rotated Figure-4, 10 dropsondes, 18 total with circumnavigation; for single Figure-4, 6 dropsondes, 14 total with circumnavigation). AXBTs preferably paired with dropsondes at turn points and center.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits. Inbound-outbound passes should be uninterrupted. DWL should be downward looking, 20° off nadir.

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G-IV Pattern #1: AIPEX

What to Target: Sample the environment and near environment of the TC

When to Target: Every 12 h [*optimal*] or every 24 h [*minimal*], preferably in coordination with a corresponding P-3 mission (**P-3 Pattern #1: AIPEX**)

Pattern: Standard G-IV Circumnavigation (octagon [*optimal*], hexagon [*minimal*]). Should be storm centered and oriented such that the left and right of shear semicircles are sampled equally by dropsondes.

Flight altitude: 40–45 kft

Leg length or radii: 200 n mi (370 km), 120 n mi (222 km), and 60 n mi (111 km) (radii)**.** The innermost radii can be adjusted outward if necessitated by hazard avoidance (outer two radii rings should be similarly adjusted, if time allows).

Estimated in-pattern flight duration: ~ 5–6 h

Expendable distribution: Dropsonde at each turn point; 24 in total (octagon) [*optimal*], or 18 in total (hexagon) [*minimal*]

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits.

G-IV Pattern #2: AIPEX

What to Target: Sample the surrounding environment of the TC

When to Target: Every 12 h [*optimal*] or every 24 h [*minimal*]

Pattern: G-IV Star (with circumnavigation if no coordination with P-3)

Flight altitude: 40–45 kft

Leg length or radii: 210 n mi (388 km) outer, 90 n mi (167 km) inner radii (*standard*). Depending on the time of day, aircraft duration limitations, and safety considerations, the lengths of the inner (outer) points could be shortened (extended) if an opportunity to sample a diurnal pulse presents itself (see TC Diurnal Cycle Experiment).

Estimated in-pattern flight duration: ~ 4 h (~ 5 h with circumnavigation)

Expendable distribution: Dropsonde at each turn point; 13 dropsondes total (20 with circumnavigation)

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits.

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SCIENCE OBJECTIVE #2: *Obtain a quantitative description of the kinematic and thermodynamic structure and evolution of intense convective systems (convective bursts) and the nearby environment to examine their role in TC intensity change*
[Convective Burst Structure and Evolution Module, CBM]

P-3 Module #1: CBM

What to Target: An area of vigorous, deep convection occurring within the circulation of a tropical cyclone (TC)

When to Target: When deep convection is identified either by radar or satellite during the execution of a survey pattern at or near the radius of maximum wind (RMW) of a tropical depression, tropical storm, or Category 1 hurricane. Particular attention should be paid when a developing area of deep convection can be detected on the downshear (shear direction inferred by real-time SHIPS analyses) side of the storm.

Pattern: Series of inbound/outbound radial penetrations / bowtie pattern (Fig. ES-2)

Repeated sampling can allow for a following of the burst around the storm, or if the burst remains confined downshear.

- Repeat penetrations as long as time permits within the 1–2 h window
- When a high-altitude aircraft is present, efforts should be made to coordinate the pattern with the high-altitude aircraft, so that the two aircraft are as close to vertically stacked as possible.

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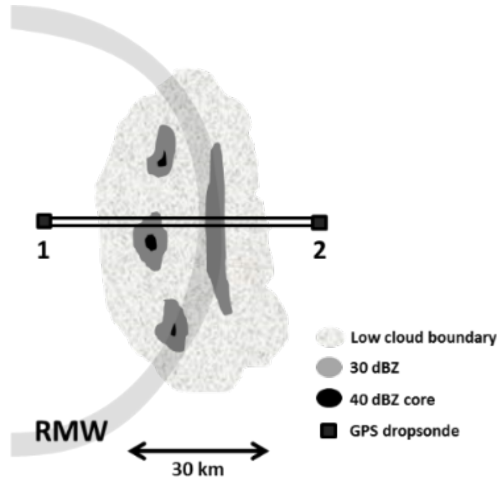
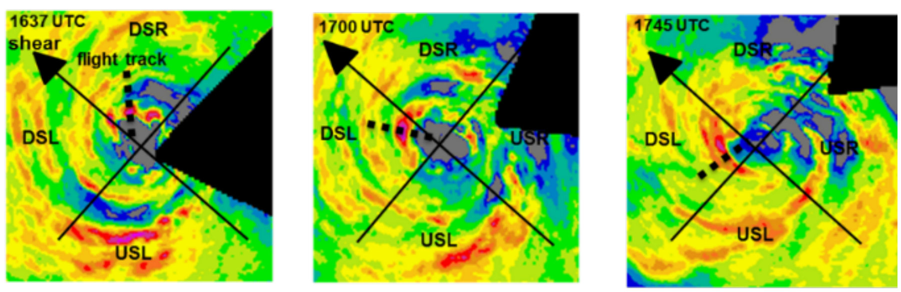


(a)



(b)

Figure ES-2. *P-3 Convective burst module: (a) Radial penetrations / bowtie pattern. Black square denote locations of GPS dropsondes from P-3. This pattern should be repeated multiple times as time allows, following the CB around the storm or remains confined downshear. (b) Example of sampling strategy following CBs around the storm, beginning downshear right (DSR) and into the upshear quadrants. Each radial pass is separated by ~30 minutes.*

Flight altitude: A constant altitude of 10–12 kft (radar or pressure altitude) is preferable

Leg length or radii: Variable depending on size of CB, but should extend at least 10 n mi inside and 10 n mi outside radar-defined edges of CB

Estimated in-pattern flight duration: ~1–2 h added to the mission

Expendable distribution: Dropsondes at turn points. No more than 15 dropsondes needed for this module. No AXBTs required.

Instrumentation Notes: Every effort made to fly the aircraft level for optimal Doppler radar sampling

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SCIENCE OBJECTIVE #3: *Improve our understanding of the physical processes responsible for the formation and evolution of arc clouds, as well as their impacts on TC structure and intensity in the short-term* (Arc Cloud Module)

P-3 Module #1: Arc Cloud

What to Target: Large arc cloud features (100's of km in length) emanating from the periphery of TCs

When to Target: There are optimal times of day when large arc clouds occur and therefore preferred times of day for conducting this module. Arc clouds are linked to the position of radially propagating TC diurnal pulses that pass through areas of dry mid-level air (≤ 45 mm Total Precipitable Water [TPW]) and therefore will tend to occur from ~0400–1200 LST in the approximate radial operating area of the P-3.

Pattern: Transect orthogonal to the radially propagating arc cloud

Flight altitude: 10–12 kft, or as high as possible to provide better vertical sampling of arc clouds by GPS dropsondes that are deployed

Leg length or radii: Variable depending on the location of the arc cloud, but a transect through the arc cloud should be made that spans from the convective area where the arc cloud originated to at least 20 km beyond the leading edge of the arc cloud.

Estimated in-pattern flight duration: ~30–60 min added to the mission

Expendable distribution: GPS dropsonde spacing should be ~10 n mi (20 km) [reduced to ~5 n mi (~10 km) spacing closer (10 n mi [20 km]) to the arc cloud] and the transect can be made inbound (sampling in front of, across, and behind the arc cloud) or outbound (sampling behind, across, and then ahead of the arc cloud) relative to the convective core region of the AEW/TC.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits.

G-IV Module #1: Arc Cloud

What to Target: Large arc cloud features (100's of km in length) emanating from the periphery of TCs

When to Target: There are optimal times of day when large arc clouds occur and therefore preferred times of day for conducting this module. Arc clouds are linked to the position of radially propagating TC diurnal pulses that pass through areas of dry mid-level air (≤ 45 mm TPW) and therefore will tend to occur from ~0400–1500 LST in the approximate radial operating area of the G-IV.

Pattern: Arc cloud transect

Flight altitude: 41–45 kft, or as high as possible to provide better vertical sampling of arc clouds by GPS dropsondes that are deployed

Leg length or radii: Variable depending on the location of the arc cloud, but a transect through the arc cloud should be made that spans from the convective area where the arc cloud originated to at least 30 n mi (50 km) beyond the leading edge of the arc cloud.

Estimated in-pattern flight duration: ~30 min added to the mission

Expendable distribution: GPS dropsonde spacing should be ~20 n mi (~35 km) and the transect can be made inbound (sampling in front of, across, and behind the arc cloud) or outbound (sampling behind, across, and then ahead of the arc cloud) relative to the convective core region of the AEW/TC.

Instrumentation Notes: Use TDR defaults. Use straight flight legs as safety permits.