2023 APHEX HFP Kickoff Meeting

Jason Dunion[1] – HFP Director
Heather Holbach[2] – HFP Deputy Director
Rob Rogers[3] – HFP Science Director

1 University of Miami/CIMAS - NOAA/AOML/Hurricane Research Division
2 Florida State University - Northern Gulf Institute
3 NOAA/AOML/Hurricane Research Division

2023 APHEX Hurricane Field Program

Agenda

1. 2023 APHEX HFP overview
2. COVID-19 Update
3. Health & Safety
4. Operations & Logistics
5. Expendables & Instrumentation
6. Planned Collaborations with ONR
7. HFP Experiments & Modules

2023 APHEX HFP Overview

2023 APHEX Hurricane Field Program

NOAA APHEX Partnership: HRD, AOC, NHC, EMC, NESDIS

2023 Collaboration: Office of Naval Research MAGPIE Program

<u>Goal 1:</u> Collect **observations** that span the TC life cycle in a variety of environments for **model initialization and evaluation**

<u>Goal 2:</u> Develop and refine **measurement strategies and technologies** that provide improved real-time analysis of TC intensity, structure, environment, and hazard assessment

<u>Goal 3:</u> Improve the **understanding of physical processes** that affect TC formation, intensity change, structure, and associated hazards

COVID-19 Update

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COVID-19 Update

Visiting AOC and/or Joining Aircraft Flight Crews*

- Shelter-in-place protocols & COVID-19 testing no longer required

- HRDers (Feds, CIMAS, & NGI)
  1) Fill out AOC's acknowledgment and waiver form (watch for an email from Jason)
     - HRDers only need to submit this form to AOC once for 2023 (watch for an email from Shirley)
     - Training requirements (NAO 209-124, NOAA Aviation Safety Policy)#
       a) NOAA E-Learning courses:
          - Aviation Policy and Procedures
          - Aviation Safety & Survival
       b) Safety videos
          - Surviving on Open Water
          - Survival Medicine
       c) Water Ditching, Safety & Survival (classroom & pool training that is required every 5 yrs)

** As of June 12, 2023, OMAO/AOC COVID-19 protocols are identical to 2022 protocols*

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COVID-19 Update

Visiting AOC and/or Joining Aircraft Flight Crews (Cont'd)

- HRDers (Feds & CIMAS) Cont'd
  2) Fill out AOC's visitor clearance form (watch for an email from Jason)
     - This form is for entry to AOC and/or joining NOAA aircraft missions
     - Current OMOA/AOC vaccination requirements:
       - ≥2 weeks after receipt of the second dose in a 2-dose series (Pfizer and Moderna) or…
       - ≥2 weeks after receipt of the single dose of the Janssen vaccine.
       - …and have been boosted
     - Once you've been cleared, you don't need to complete this form again unless:
       - 1) You have COVID-19 symptoms or
       - 2) You come into contact with someone with COVID-19

Health & Safety

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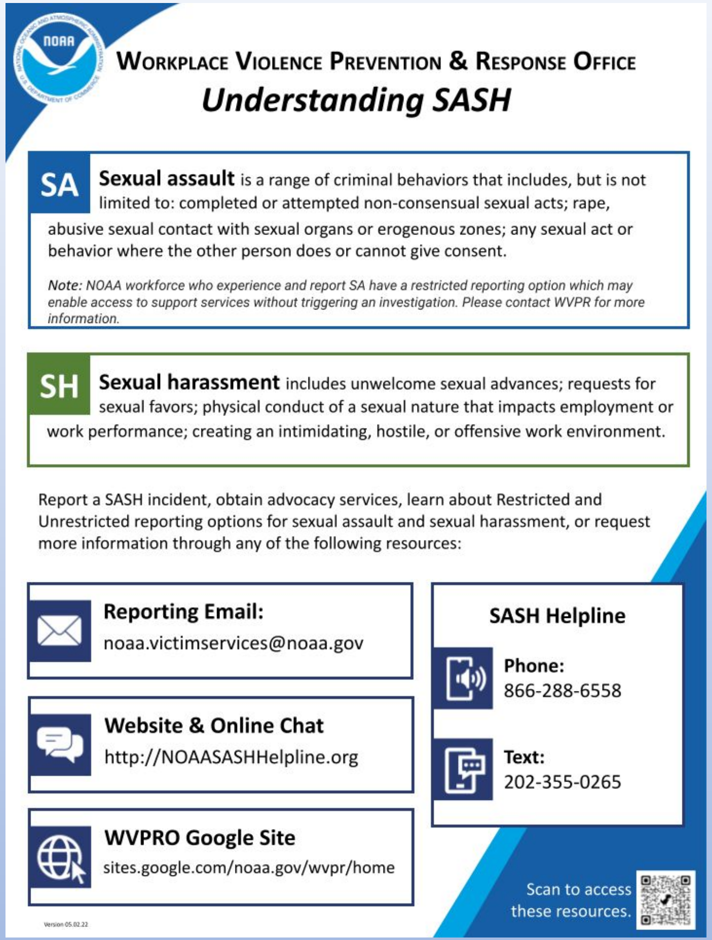
Health & Safety



Workplace Violence Prevention & Response Office

Understanding SASH

SA **Sexual assault** is a range of criminal behaviors that includes, but is not limited to: completed or attempted non-consensual sexual acts; rape, abusive sexual contact with sexual organs or erogenous zones; any sexual act or behavior where the other person does or cannot give consent.

Note: NOAA workforce who experience and report SA have a restricted reporting option which may enable access to support services without triggering an investigation. Please contact WVPR for more information.

SH **Sexual harassment** includes unwelcome sexual advances; requests for sexual favors; physical conduct of a sexual nature that impacts employment or work performance; creating an intimidating, hostile, or offensive work environment.

Report a SASH incident, obtain advocacy services, learn about Restricted and Unrestricted reporting options for sexual assault and sexual harassment, or request more information through any of the following resources:

Reporting Email:
noaa.victimservices@noaa.gov

Website & Online Chat
http://NOAASASHHelpline.org

WVPRO Google Site
sites.google.com/noaa.gov/wvpr/home

SASH Helpline

Phone:
866-288-6558

Text:
202-355-0265

Scan to access these resources.

Version 05.02.22

- Data gathering is the HFP's ultimate goal, but the paramount concern is the safety and health (including mental health) of those individuals doing the work
- Health & Safety link has information on:
    - *Workplace Violence Prevention and Response*
    - *Behavioral Health and Wellness,*
    - *Employee Assistance Programs (NOAA, UM, MSU)*
    - *The Fieldwork Initiative to Stop Sexualized Trauma*
    - *Towards Sexual Literacy in Fieldwork Training*

- New for 2023 -> Code of Conduct
    - Sets minimum expectations for personal and professional behavior
    - Specifies consequences for violating the code

Data Management

2023 APHEX Hurricane Field Program

Data Management

Data Management

- Main Document in the HFP Plan
- Data Product List and contacts is provided in the HFPP
- Focus on providing mission info and data to the HRD HFP Data Page as soon as possible after a storm sequence
- Like last season, we'll maintain a Google Sheet inventory of mission info and data acquisition

Data Products List

INSTRUMENTS	INVESTIGATORS
Tail Doppler radar (TDR)	John Gamache (john.gamache@noaa.gov) Paul Reasor (paul.reasor@noaa.gov)
Multi-Mode Radar (MMR)	John Gamache (john.gamache@noaa.gov) Paul Reasor (paul.reasor@noaa.gov)
Stepped Frequency Microwave Radiometer (SFMR)	Heather Holbach (heather.holbach@noaa.gov)
Cloud Physics Probes	Robert Black (Robert.a.black@noaa.gov)
Imaging Wind and Rain Airborne Profiler (IWRAP)	Paul Chang (paul.s.chang@noaa.gov)
Wide Swath Radar Altimeter (WSRA)	Heather Holbach (heather.holbach@noaa.gov) Ivan Popstefanija (popstefanija@prosensing.com)
W-Band radar	Elizabeth Thompson (elizabeth.thompson@noaa.gov)
Airborne Radio Occultation (ARO) System	Jennifer Hause (jhaase@ucsd.edu)
Airborne Doppler Lidar (ADL)	Zhien Wang (zhien.wang@lasp.colorado.edu)
PLATFORMS	**INVESTIGATORS**
P-3 and G-IV Flight-level	Neal Dorst (neal.m.dorst@noaa.gov)
GPS Dropwindsonde	Kathryn Sellwood (Kathryn.sellwood@noaa.gov)
Airborne eXpendable BathyThermograph (AXBT)	Nick Shay (nshay@miami.edu) Jun Zhang (jun.zhang@noaa.gov)
OBSERVATIONAL PRODUCTS	**INVESTIGATORS**
HEDAS Pre-processing	Altug Aksoy (altug.aksoy@noaa.gov)
Center Fixes / Tracks (2-min)	Neal Dorst (neal.m.dorst@noaa.gov)
INFORMATIONAL	**INVESTIGATORS**
Flight Logs (e.g., LPS, Radar, Dropsonde, Boundary Layer)	Neal Dorst (neal.m.dorst@noaa.gov)
MODEL PRODUCTS	**INVESTIGATORS**
Basin-scale HWRF	Ghassan Alaka (ghassan.alaka@noaa.gov)
Hurricane Analysis and Forecast System (HAFS)	Andrew Hazelton (andrew.hazelton@noaa.gov)
HWRF Hurricane Ensemble Data Assimilation Scheme (HEDAS)	Sim Aberson (sim.aberson@noaa.gov) Altug Aksoy (altug.aksoy@noaa.gov)

2023 APHEX Hurricane Field Program

Data Management

HFP Data

- AOC will ensure that all data is transferred to AOC ground servers after missions
    - HRDers no longer need to take an external hard drive on missions
    - Aspen output should be copied (not moved) to the “FRD” folder periodically during missions
    - At end of mission: move all Aspen output to a mission ID folder and kept on the aircraft computer
    - Auto Qced AXBT data will be transferred to AOC ground servers in near real-time
- For any data downloaded by HRDers while onboard the aircraft, options include:
    - Upload data to the Google Drive for scanning
    - Upload data to the AOML FTP (for smaller data transfers) - no scanning done
    - Download data to a USB then upload to Google drive via GFE (gov’t issued laptops/equipment)
        - *Use McAfee to scan the USB stick before using and after loading data*

Operations & Logistics

2023 APHEX Hurricane Field Program

Operations and Logistics

Aircraft

- N42 (Aug 1), N43 (June 1), and N49 (June 1) all available this season
- Potential Deployment Sites: Aruba, Bermuda, Barbados, Cabo Verde, Liberia Costa Rica, St. Croix
- Twice daily P-3 and G-IV missions possible
- HRD will continue to take advantage of "flights of opportunity" during operationally tasked missions
- G-IV takeoff times for NHC Synoptic Surveillance: 1730/0530 UTC (adjustable for research)
- P-3 take-off times for EMC: timed for roughly symmetric patterns (timewise) around the synoptic time (00 and 12 UTC) >> ~0400L & 1600L (adjusted for ferry times & time zone)

HRD Crewing

- 1-2 onboard scientists to support P-3 missions (up to 1 for G-IV research)
- HRD crewing will be a combination of onboard and ground-based (LPS, radar, Aspen-TAG)
    - *If you're interested in training for a crew duty contact Jason, Heather, & Rob*
- HRD aircraft scientific crews will consist of HRD Fed & HRD CI scientists
- Visiting scientists & observers when seats are available

2023 APHEX Hurricane Field Program

Operations and Logistics

FY22 P-3 OAR/NESDIS/NWS Flight Hours

Aircraft	Research (OAR)	Research (NESDIS)	NWS
P-3s	100	27	241
G-IV	92	-	89

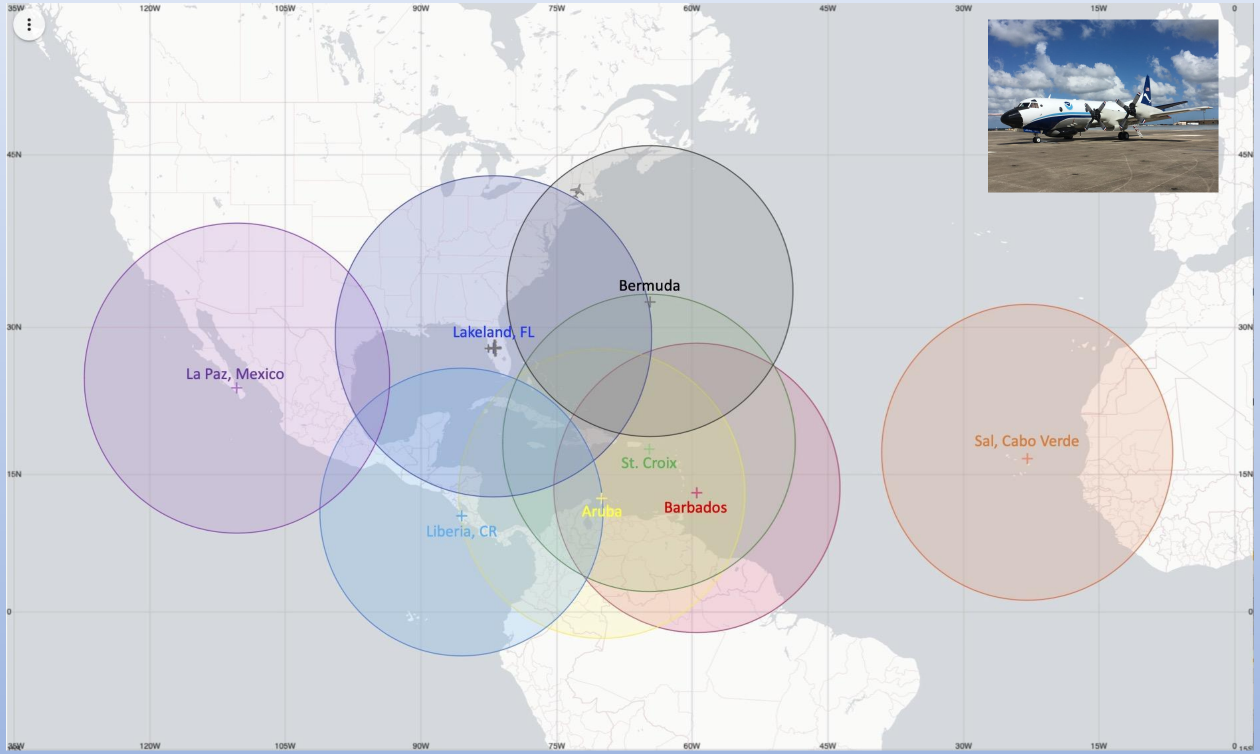
Aircraft Status

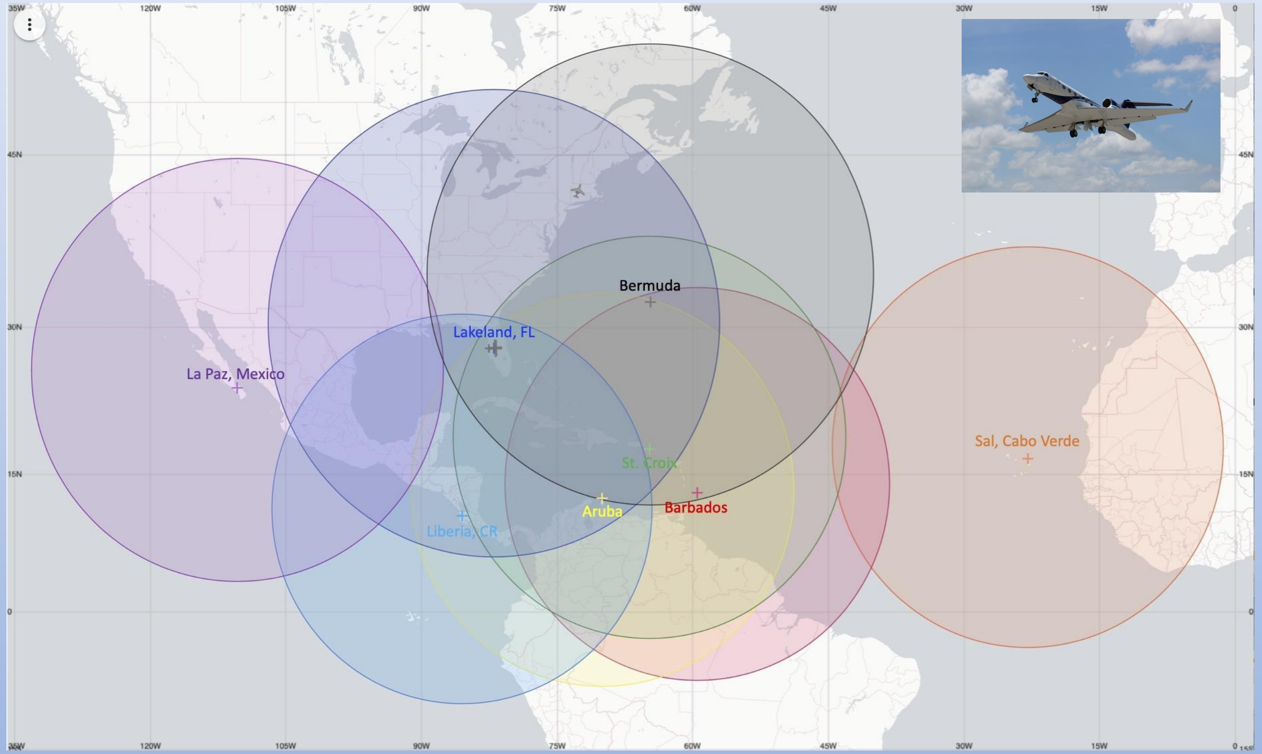
- N42 (P-3)
  - *Currently in scheduled Scheduled Depot Level Maintenance (SDLM) maintenance*
  - *Planned to be "hurricane ready" 1 Aug*
- N43 (P-3)
  - *Nearly "hurricane ready" as of 12 June*
- N49 (G-IV)
  - *Nearly "hurricane ready" as of 12 June*

2023 APHEX Hurricane Field Program

Operations and Logistics

Primary Atlantic Operating Bases and Ranges (2-h on-station time)





2023 APHEX Hurricane Field Program

Operations and Logistics

Daily Schedule

- 0900 EDT (1300 UTC): Conference call with APHEX participants & collaborators (if needed)
- 0920 EDT (1320 UTC): NHC-EMC-HRD coordination call for operations & logistics (if needed)
- 1000 EDT (1400 UTC): HRD-ONR MAGPIE coordination call (if needed)
- 1230-1300 EDT (1630-1700 UTC): HRD Map Discussion
- 1300 EDT (1700 UTC): Go/No-go coordination with NOAA AOC

HRD Map Discussion

- Weekdays, 1230-1300 EDT (1630-1700 UTC), 17 July – 20 October
- Hybrid format (in-person & GotoMeeting remote participation)
- Contact Jason D. if you'd like to lead or co-lead a week of map discussions
- HRD Map Discussion Links (HRD Google Drive Folder):
  - Hurricane Field Program >> 2023 >> Map Discussion Links
  - Contact Sim A. if you have a link that you'd like added to the links document

2023 APHEX Hurricane Field Program

Operations and Logistics

Mission Monitoring and Communication

- NASA MTS will serve as our primary tool for monitoring and coordinating missions
  - MTS training: Date & time TBD
  - Contact Jason D. if you're interested in getting a MTS account
- Google Meet will be used again this year by ground-based crew
  - Limited participation (ground-based LPS, radar scientist, Aspen-TAG scientist)
  - Science PIs will also be invited/encouraged to join if he/she has an experiment/module being flown
- Mission Flight Logs
  - Will be used again this summer by ground-based LPSs to document the mission in real-time
  - Mission log docs will be used for each mission to help standardize HRD's mission summaries
  - *HRD >> Hurricane Field Program >> 2023 >> Mission Reports/Data*

2023 APHEX Hurricane Field Program

Operations and Logistics

Administrative / Travel

- Federal Employees
  - Emy Rodriguez will be HRD's main POC for HFP Fed travel this summer (Roberta will be Emy's back-up after 21 Aug)
  - Counter Threat Awareness Training (CTAT): available through the CLC (see next slide)
    - *Required for personnel traveling internationally for less than a cumulative 90 days for the calendar year*
    - *Requires ~5 hr to complete; certificate is valid for 6 years*
    - *You are not required to take the new CTAT training until the expiration of your current HTSOS certification*
    - *Check with Emy if you need to confirm certification*
  - FTE Travel Requirements
    - *Federal official passport required for international travel (personal passports are prohibited)*
    - *HRD Travel Request form is still required and must be approved by Frank or Shirley before Emy can initiate travel*
    - *Link to NOAA Travel Policy: https://www.corporateservices.noaa.gov/~finance/Travel_policy.html*
  - Federal Passports
    - *HFP participants can hold their official passport during the 2023 hurricane season*
    - *Contact Jason if you would like to hold onto your Federal passport for the season*
  - Complete 2023 Requirements for Driving AOML Government Vehicles
    - Google Drive: *HRD >> Hurricane Field Program >> 2023 >> AOML GOVs*
  - Inform Shirley and Jason of completion of Online Aviation Safety Training & Videos

2023 APHEX Hurricane Field Program

Operations and Logistics

Administrative / Travel

- CIMAS Employees
  - Must complete travel request forms prior to traveling
    - COVID-19 Protocols no longer required when requesting travel
    - Confirm with Jason (Heather and Rob as back-ups) which grant to charge your travel to
    - The CIMAS travel form was recently updated (see 9 June email from Nathalia Bahamon)
      - *Send the form to Carmen Rifa at CIMAS with a CC to your NOAA advisor*
      - *The CIMAS Director will only approve travel if the advisor is CCed*
  - Please ensure that your passport has not expired or is not about to expire
  - Complete 2023 Requirements for Driving AOML Government Vehicles
    - Google Drive: *HRD >> Hurricane Field Program >> 2023 >> AOML GOVs*
  - Inform Shirley and Jason of completion of Online Aviation Safety Training & Videos

2023 APHEX Hurricane Field Program

Operations and Logistics

To Participate in the HFP:

- CTAT Foreign Travel Course (Feds) >> see NOAA CLC site
  - https://doc.csod.com/client/doc/default.aspx
- Safety Training (Feds & HRD CI Employees)
  - See Shirley's email from 12 June: **due 14 July**
  - Aviation Safety Trainings (3 videos on AOC's Google site)
    - *Aviation Policy & Procedures, Aviation Safety & Survival, Aviation Health*
  - Aviation Safety Videos (2):
    - *Surviving on Open Water*
    - *Survival Medicine (our favorite one!)*
- CLC certificates are sometimes not appearing on CLC transcripts
  - As a back-up, save a screenshot of your quiz score/completion certification and submit to Shirley
- Trained for one or more roles to perform HRD Science Crew duties (Feds & HRD CI Employees)
  - Lead Project Scientist (Ground and/or onboard)
  - Dropsonde Scientist (Ground <TBD> and/or onboard)
  - Radar Scientist (Ground and/or onboard)

2023 APHEX Hurricane Field Program

Operations and Logistics

HFP Trainings

- Ground-based and onboard crews
    - Radar (Ground, Invited): TBD
    - Radar (Airborne): TBD
    - ASPEN (Airborne): 13 & 14 June
    - ASPEN (TAG): TAG readiness for 2023 still TBD
    - LPS (Ground & Airborne, Invited): TBD
- Mission monitoring tools
    - NASA Mission Tools Suite (MTS): TBD

2023 APHEX Hurricane Field Program

Operations & Logistics

External Communication

- HRD will be working with AOML's Comms Team (Laura Chaibongsai & UM intern Marike Pinsonneault)
- HRD blog: https://noaahrd.wordpress.com/
- HRD webpage: http://www.aoml.noaa.gov/hrd/
- Facebook: https://www.facebook.com/noaahrd/
- Twitter:
  - AOML: https://twitter.com/NOAA_AOML?s=20
  - HRD https://twitter.com/HRD_AOML_NOAA

Internal Communication

- Daily Plan of the Day email: when operations are ongoing
  - aircraft status, potential targets, deployment logistics, travel
- Daily map discussions (M-F)

Expendables & Instrumentation

2023 APHEX Hurricane Field Program

Expendables & Instrumentation

2023 P-3 OAR/NESDIS/NWS Expendables (**recoverable*)

Expendable	Research (OAR)	Research (NESDIS)	Research (ONR)	Research (JPSS)	Research (GOMO)	Research (NASA)	NWS
GPS Dropsondes	362	3	253	110	45	50	1157
IR Dropsondes	110	-	-	-	-	-	-
AXBTs	96 UM/HRD	-	72	-	-	-	-
CADs (BTs)	451	-	-	-	-	-	-
sUAS Altius-600	5-6	-	-	-	-	-	-
sUAS Blackswift	7-8	-	-	-	-	-	
Skyfora Streamsondes	30-40						
MicroSWIFT wave buoys	TBD	-	-	-	-	-	-
Hurricane Gliders*	Pre-deployed 8 NATL, 1 Carib, 1 near DR, 2 near PR (Navy)	-	-	-	-	-	-
Saildrones*	Pre-deployed: *8 NATL, 1 Carib, 1 Gmex*	-	-	-	-	-	-

2023 APHEX Hurricane Field Program

Expendables & Instrumentation

2023 Aircraft Instrumentation

Instrument	Aircraft	Measurements
Flight-Level Measurements	N42, N43, N49	Position, altitude, PT, moisture, winds (40 Hz & 1 Hz)
Tail Doppler Radar (TDR)	N42, N43, N49	Reflectivity, 3-D winds (~0-15 km)
Multi-Model Radar (MMR)	N42, N43	X-band horizontal-scanning pulse Doppler radar
Stepped Frequency Microwave Radiometer	N42, N43	Surface wind speed, rain rate
Cloud Microphysics: Cloud Combination Probe (CCP), Precipitation Imaging Probe (PIP), Cloud and Aerosol Spectrometer (CAS)	N43	Aerosol, cloud hydrometeor, & precipitation size distributions: CCP (2-1550 µm), PIP (100 µm-6.4 mm), CAS (0.63-100 µm)

2023 APHEX Hurricane Field Program

Expendables & Instrumentation

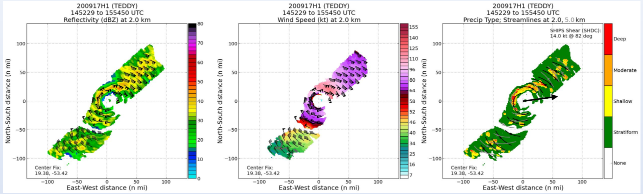
2023 Aircraft Instrumentation (cont'd)

Instrument	Aircraft	Measurements
Imaging Wind and Rain Airborne Profiler (IWRAP)	N42	Doppler velocity and reflectivity profiles in precipitation and surface backscatter (scatterometry)
KaIA	N42	Significant wave height, mean squared slope, relative ocean height, & wind speed at low wind speeds, precip profiles at ka- and ku-band
Wide Swath Radar Altimeter (WSRA)	N43	Significant wave height and directional wave spectra
W-Band radar	N43	clouds, precipitation, sea spray, very small water droplets of fog or mist, vertical air motion, rain rate
Airborne Radio Occultation (ARO) System	N43?, N49	Vertical profiles of T & moisture below the aircraft
Airborne Wind Lidar (AWL)	N43 (possible camera port install TBD)	3-D winds below flight level

2023 Hurricane Field Program-APHEX

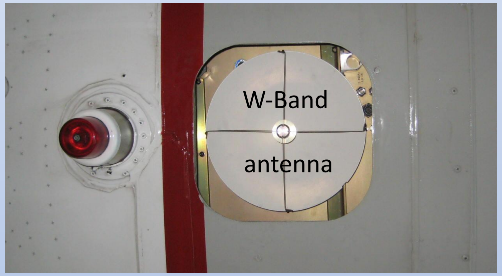
Instrumentation

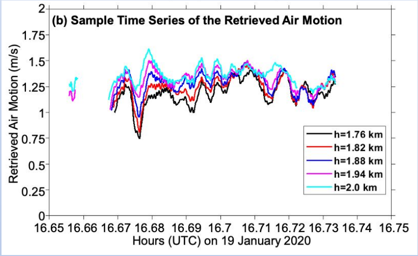
Tail Doppler Radar (TDR): N42, N43, N49



- Measurements: reflectivity, 3-D winds (~0-15 km)
- Why fly TDR?: real-time TDR data is assimilated into forecast models (e.g., HAFS & HWRF) & used by forecasters at NHC

W-Band Radar (cloud to light precip radar): P-3 (N43)





- Measurements (95 GHz/3.17 mm): clouds, precipitation, sea spray, very small water droplets of fog or mist, vertical air motion, rain rate
- Why fly W-BAND?: study the lowest levels of the marine boundary layer above the ocean where the P-3s do not normally fly

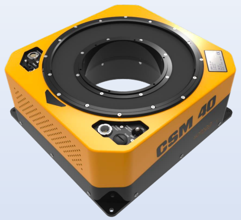
Wide Swath Radar Altimeter (WSRA): P-3 (N43)

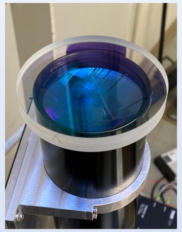
- Measurements: wave height and sea state characteristics below the aircraft
- Why fly WSRA?: provide data that supports NOAA TAFB High Seas Forecasts, calibrate ocean wave models, & provide observations that are required in the NOAA Hurricane Operations Plan (NHOP)

2023 Hurricane Field Program-APHEX

Instrumentation

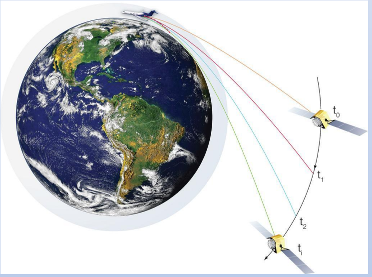
Airborne Doppler Lidar (ADL): P-3 (N43) - AOC exploring install feasibility





- Measurements: 3-D profiles of winds (flight level to surface)
- Why fly ADL?: ADL data can help us better sample the TC near environment (R~ ≥80 n mi) and capture the radius of 34 and 50 kt winds in TCs.

Airborne Radio Occultation (ARO) System: P-3 (N43) and/or G-IV



- Measurements: vertical profiles of temperature & moisture below the aircraft (using GNSS/GPS satellite signals)
- Why fly ARO?: obtain continuous 3-D temperature & moisture profiles to study the TC environment and how it affects TC structure and intensity

Cloud Microphysics Probes (CDP, CIP, PIP, CAS): P-3 (N43)

- Measurements: images and particle size distributions of cloud, aerosol, and precipitation particle (0.63-100 µm)
- Why fly cloud microphysics probes?: Improve our understanding of how rain droplets, ice, and snow particles are vertically distributed in TCs and how accurately they are represented in forecast models.

2023 Hurricane Field Program-APHEX

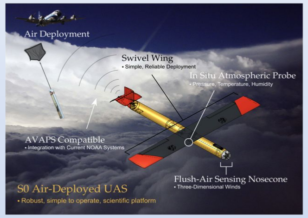
Instrumentation

P-3 deployed sUAS (Altius-600 & Black Swift S0): P-3 (N43)

- Measurements: 3-D profiles of pressure, temperature, moisture, and winds (flight level to surface)
- Why fly sUAS?: sample the lowest and most dangerous regions of TCs to improve basic understanding and enhance forecaster situational awareness.

Altius-600

- wingspan: 8 ft 4”
- gross weight: 23-27 lbs
- cruising speed: 55 KIAS
- Endurance: ~4 hr

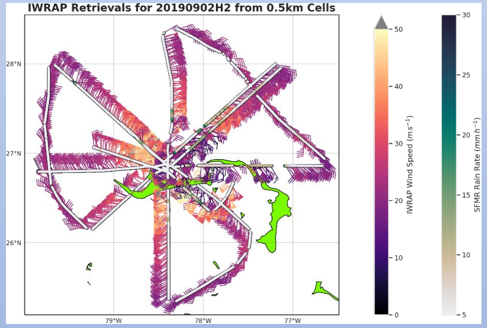


Black Swift S0

- wingspan: 4 ft 7”
- gross weight: 3 lbs
- cruising speed: 33 KIAS
- Endurance: ~1.5 hr

Imaging Wind and Rain Airborne Profiler (IWRAP): P-3 (N42)

- Measurements: C-band and Ku-band profiles of volume reflectivity and Doppler velocity of precipitation from just below the P-3 to just above the ocean surface, & ocean surface backscatter
- Why fly IWRAP?: improve our understanding of microwave retrievals of the ocean surface and atmospheric wind fields, and to evaluate new remote sensing techniques/technologies.

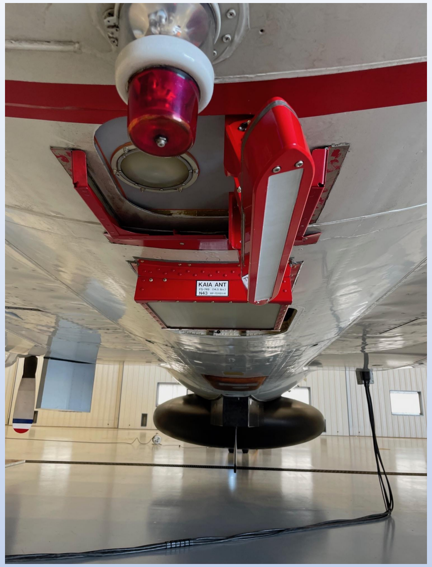


2023 Hurricane Field Program-APHEX

Instrumentation

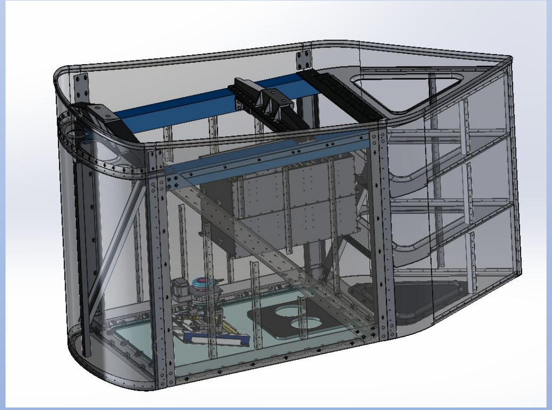
Ka-band Interferometric Altimeter (KaIA) + Ku-band: P-3 (N42)

- Measurements: significant wave height (SWH), mean squared slope (MSS), relative ocean height, & wind speed at low wind speeds, precipitation profiles at ka- and ku-band
- Off-angle ka-band fan-beam: surface NRCS measurements
- Why fly KaIA?: provide data that supports NOAA TAFB High Seas Forecasts & provide observations that are required in the NOAA NHOP. The precipitation profiles (new) will help separate wind and rain signals and improve our understanding of surface wind measurements (i.e., SFMR)



Ka-band Conically Scanning Radar (ARCoS) in AWHIP (wing pod)

- Measurements: Doppler velocity and reflectivity profiles in precipitation and surface backscatter (scatterometry) – Rain and Winds
- Why fly ARCoS?: Demonstrate ka-band scatterometry wind retrievals and ka-band Doppler wind and reflectivity profiles. Demonstrate instrumentation in a P-3 wing pod which provides risk reduction for the P-3 to C-130 platform transition. Primary calibration and validation instrument for Tomorrow.io's Pathfinder satellite missions.



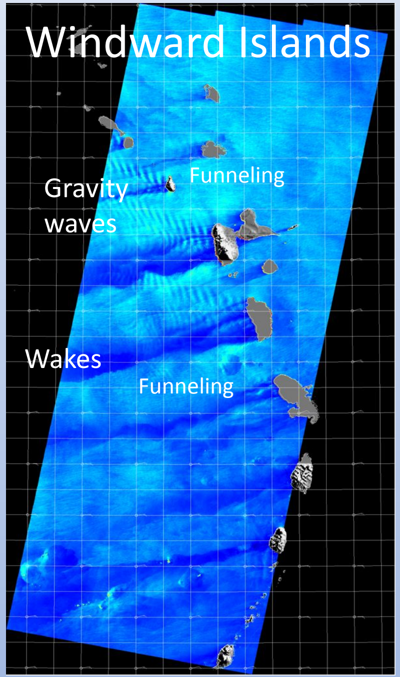
Planned Collaborations with ONR

2023 APHEX Hurricane Field Program

Planned Collaborations with ONR

ONR MAGPIE: mid July – late Aug 2023

- Main Objective (campaign year-1)
  - Study how the boundary layer (lowest ~1,500 ft of the atm) evolves over time in different environments
  - NOAA-ONR collaboration
- Deployment & Operating Area
  - Barbados
  - Flights focused east of Barbados in the central North Atlantic
- Aircraft
  - ONR: NPS Twin Otter DH-6
    - *FL: ~<10 kft; Normal Ops: <3 kft, Max: ~20 kft*
    - *Duration ~5 hr, usually within ~40-100 n mi of Barbados*
  - NOAA: P-3 & possibly NOAA G-IV
    - *Possible P-3 stacked overflight of the NPS Twin Otter*
- Synergy with NOAA APHEX
  - TC genesis (tropical waves, Saharan Air Layer, marine boundary layer)

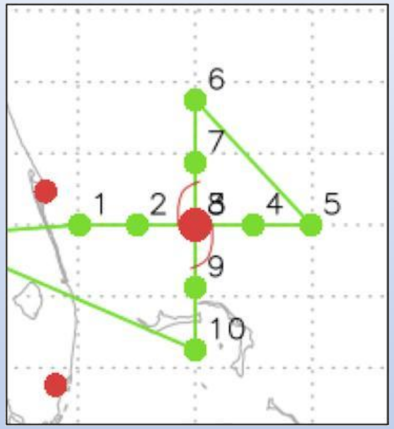


HFP Experiments & Modules

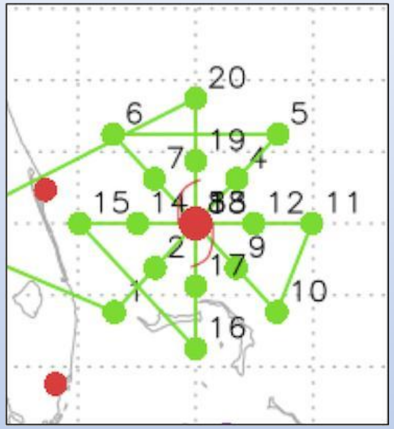
2023 APHEX Hurricane Field Program

Standard P-3 & G-IV Flight Patterns

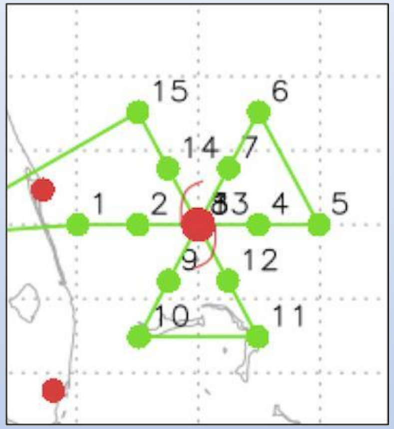
Figure-4
(P-3)



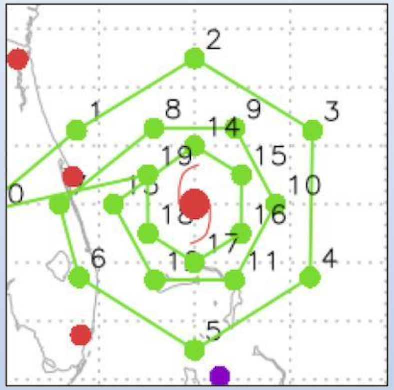
Rotated Figure-4
(P-3)



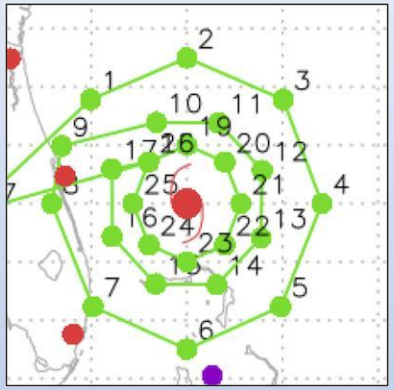
Butterfly
(P-3)



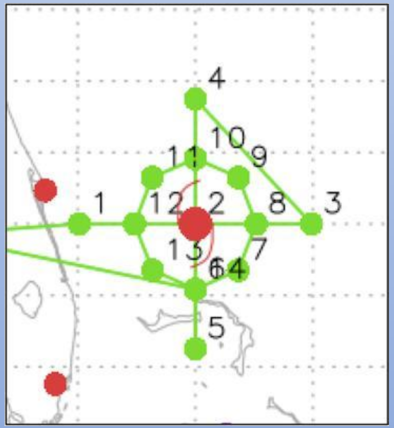
Circumnavigated Hexagon
(G-IV)



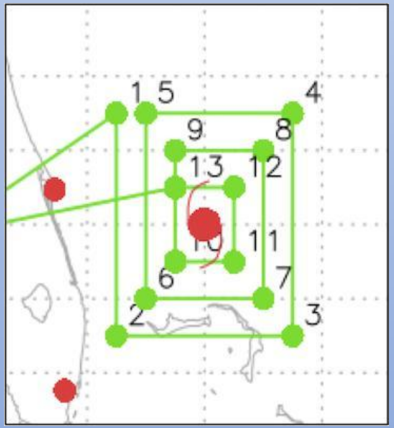
Circumnavigated Octagon
(G-IV)



Circumnav + Figure 4
(P-3)



Square Spiral
(P-3 & G-IV)



Lawn Mower
(P-3 & G-IV)

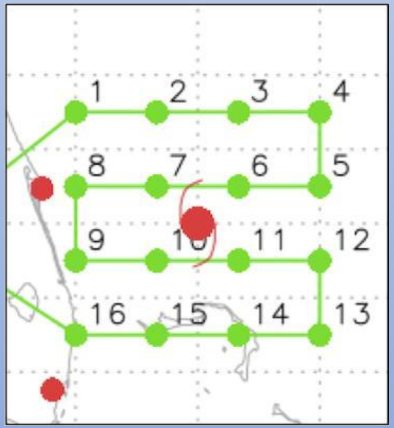
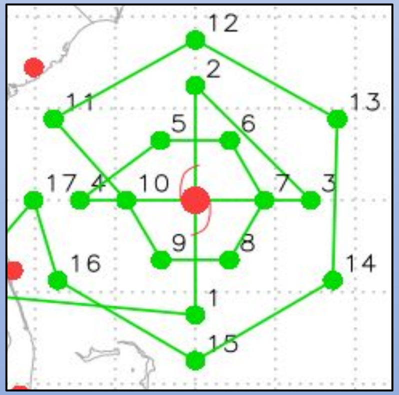
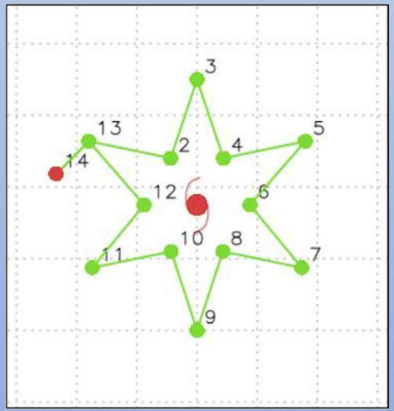


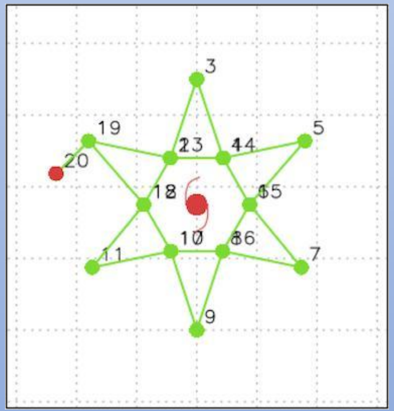
Figure-4 with Double Circumnav
(G-IV)



Star 1
(G-IV)



Star 2
(G-IV)



2023 APHEX Hurricane Field Program

Experiments & Modules

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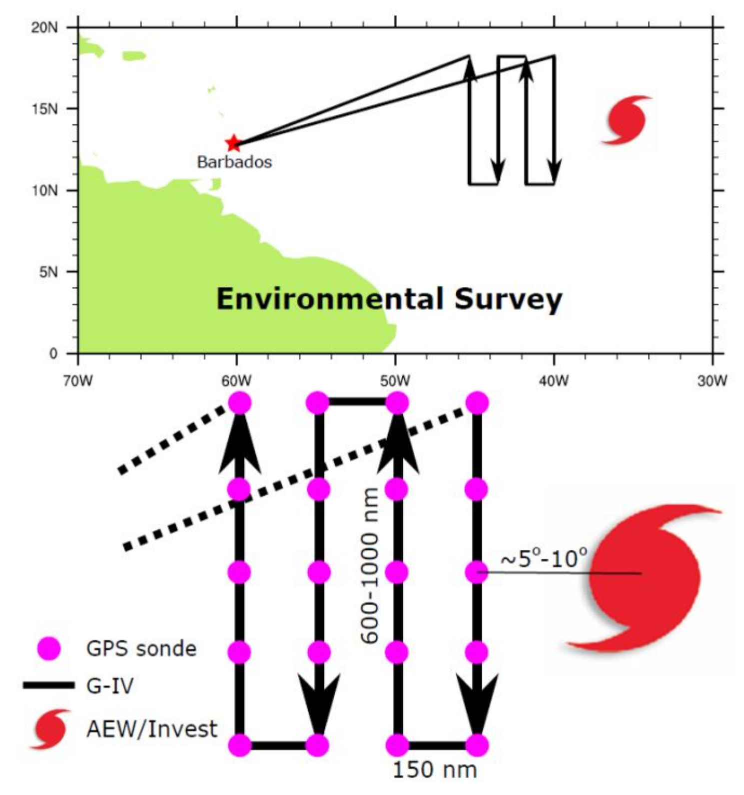
2023 APHEX HFP: Genesis Stage

Favorable Air Mass (FAM)

SCIENCE TEAM: Ghassan Alaka, Jason Dunion, Rob Rogers, Sharan Majumdar,
Alexis Wilson, Quinton Lawton, Alan Brammer, Chris Thorncroft

- To **investigate the favorability in both dynamics** (e.g., vertical wind shear) and **thermodynamics** (e.g., moisture, relative humidity) **for tropical cyclogenesis** in the environment near a pre-tropical depression, especially in the **environmental air mass surrounding and ahead** (**downstream**) of the pre-TD
- **Consecutive missions** are recommended to observe the **evolution** of the observations over time and how that pertains to the (non-)development of a pre-TD



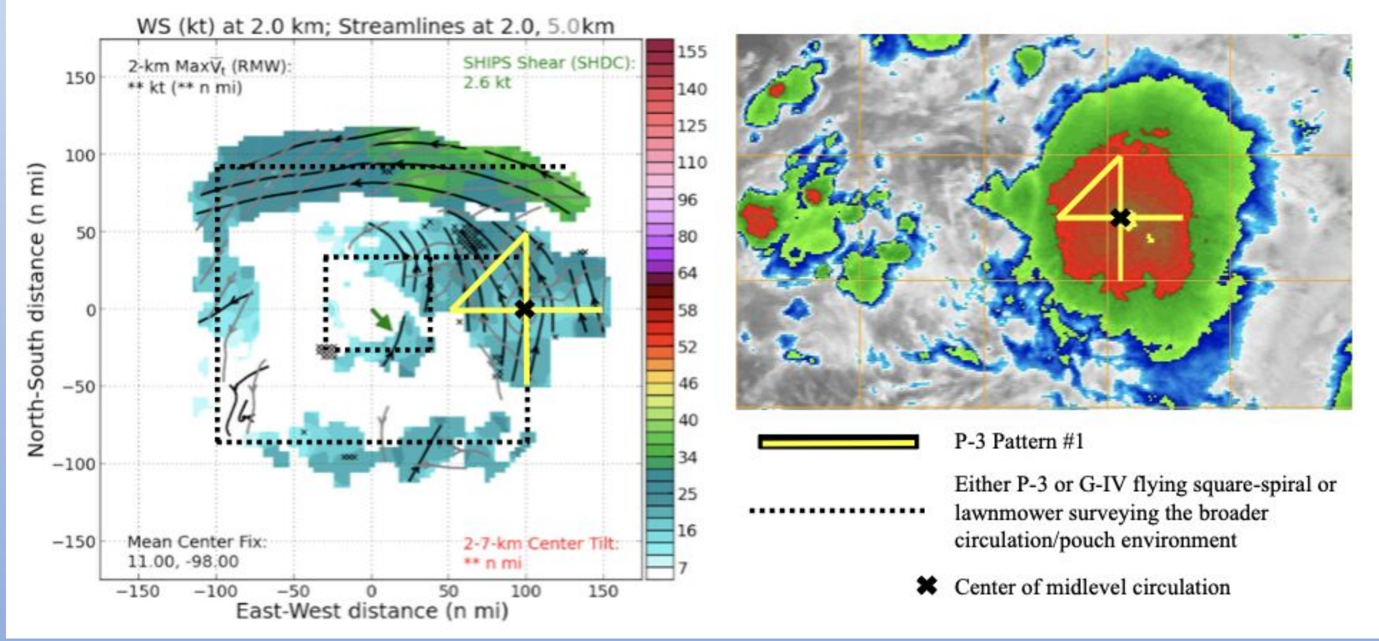
- Adaptable to both the G-IV (preferred) and the P-3s
- Twice-a-day missions preferred
- *Potential opportunity to collaborate with ITOFS-East and MAGPIE*

2023 APHEX HFP: Genesis Stage

PREFORM (PREcipitation during Formation and Observing its Response across Multiple scales)

SCIENCE TEAM: Rob Rogers, Ghassan Alaka, Jason Dunion, Michael Fischer, Paul Reasor,
Jun Zhang, Sharan Majumdar, Alexis Wilson, Quinton Lawton, Xiaomin Chen

- Measure the **relative contributions of various precipitation modes** (e.g., deep convection, moderately deep convection, stratiform) to the total precipitating area
- **Quantify the moisture and relative humidity** characteristics of the circulation, **relate those to precipitation** characteristics, and **measure their evolutions** over multiple days
- Identify the **location, strength, and origins of circulations** from the low to middle troposphere, and **relate changes to the precipitation** observed



- Ideally 2 aircraft (adaptable for both P-3 and G-IV): one samples the *environment (wave)* and one focused on the *convective systems*
- Twice-a-day missions preferred
- *Collaborative with ITOFS-East and MAGPIE*

Example strategy adapted to pre-Sergio (2018) in the EPAC

2023 APHEX Hurricane Field Program

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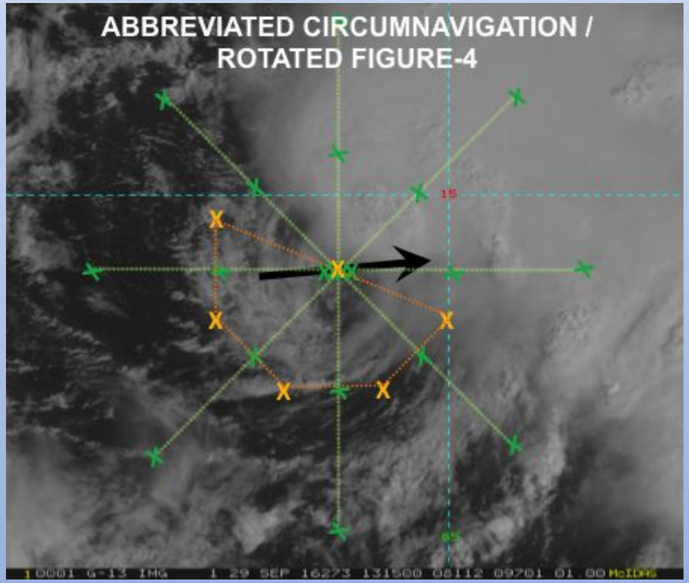
2023 HFP-APHEX: Early Stage

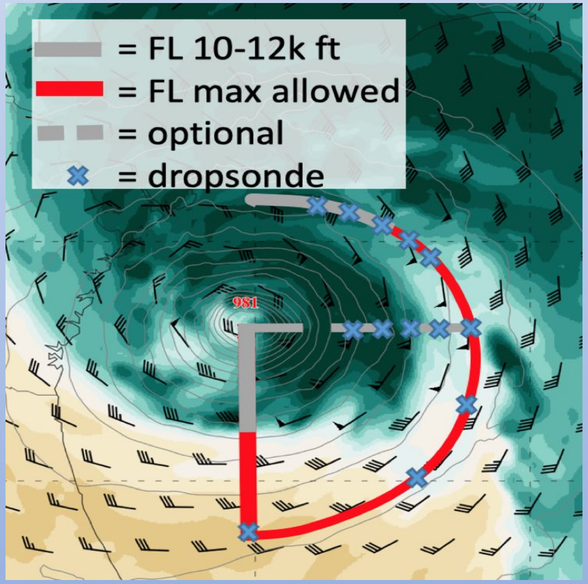
AIPEX (Analysis of Intensity Change Processes EXperiment)

Science Team:Rogers, Alaka, Alvey, Cione, Dunion, Fischer, Holbach, Reasor, J. Zhang, Alland, Chen, Judt, Rios-Berrios, Josh Wadler, Doyle, Stern, Finnochio, Majumdar, Nolan, Wimmers, Fuchs-Stone, Raymond, Tang, Bryan, Bell, Foster

- Collect aircraft observations that will allow us to **characterize the precipitation and vortex-scale kinematic and thermodynamic structures** of TCs experiencing **moderate vertical shear**
- Understanding the **reasons behind these structures**, particularly greater **azimuthal coverage of precipitation**, associated **lateral ventilation**, and **boundary layer ventilation and recovery**
- Greater understanding of the **physical processes that govern whether TCs will intensify**, (especially those that undergo **RI**) in this type of environment



Upshear circumnavigation module



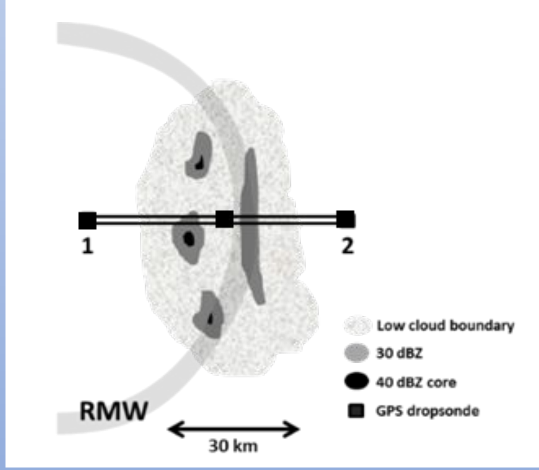
Dry-air entrainment module

2023 HFP-APHEX: Early Stage

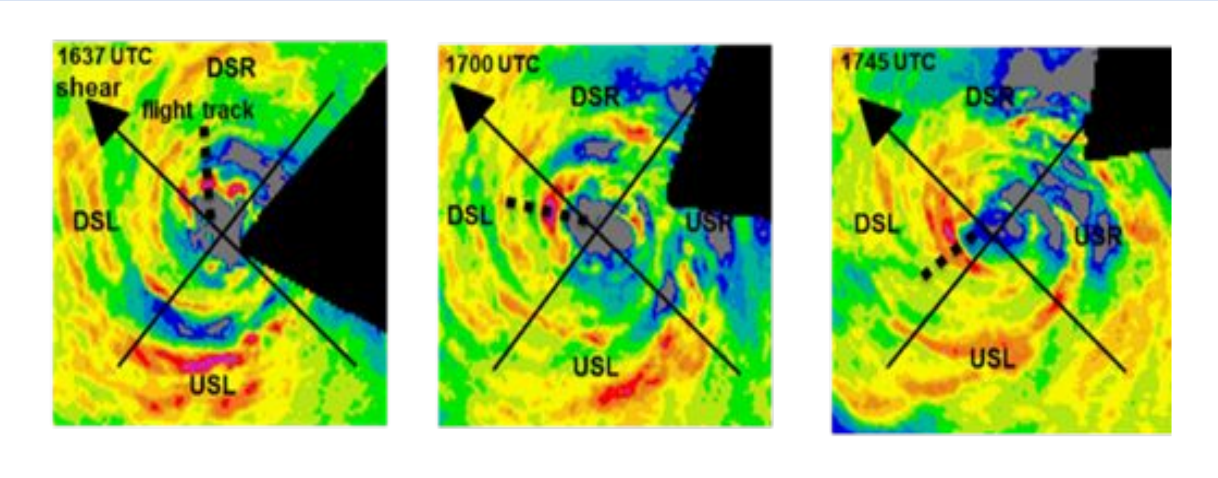
Convective Burst Structure and Evolution Module (CBM)

Science Team:Rob Rogers (PI), Trey Alvey, Josh Wadler, Robert Black, Josh Wadler, Hua Leighton, Xuejin Zhang, Michael Bell (CSU), Anthony Didlake (PSU), Jim Doyle (NRL), Dan Stern (NRL), Ralph Foster (UW)

- 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
- Repeatedly sample the kinematic and reflectivity structure and evolution of individual convective bursts and their associated precipitation structures using airborne Doppler radar
- Follow CBs as they translate azimuthally downwind in a shear-relative framework (where relevant)
- Optimal additional measurements include:
  - Deep-layer measurements of temperature and humidity in the local environment of the CBs from high-altitude aircraft will provide the thermodynamic context within the mid-and lower troposphere
  - Measurements of sea-surface temperature and subsurface temperature profiles from ocean probes and/or IR dropsondes will provide context on the surface boundary



Sampling schematic of CB



Example pattern following CB during translation upshear

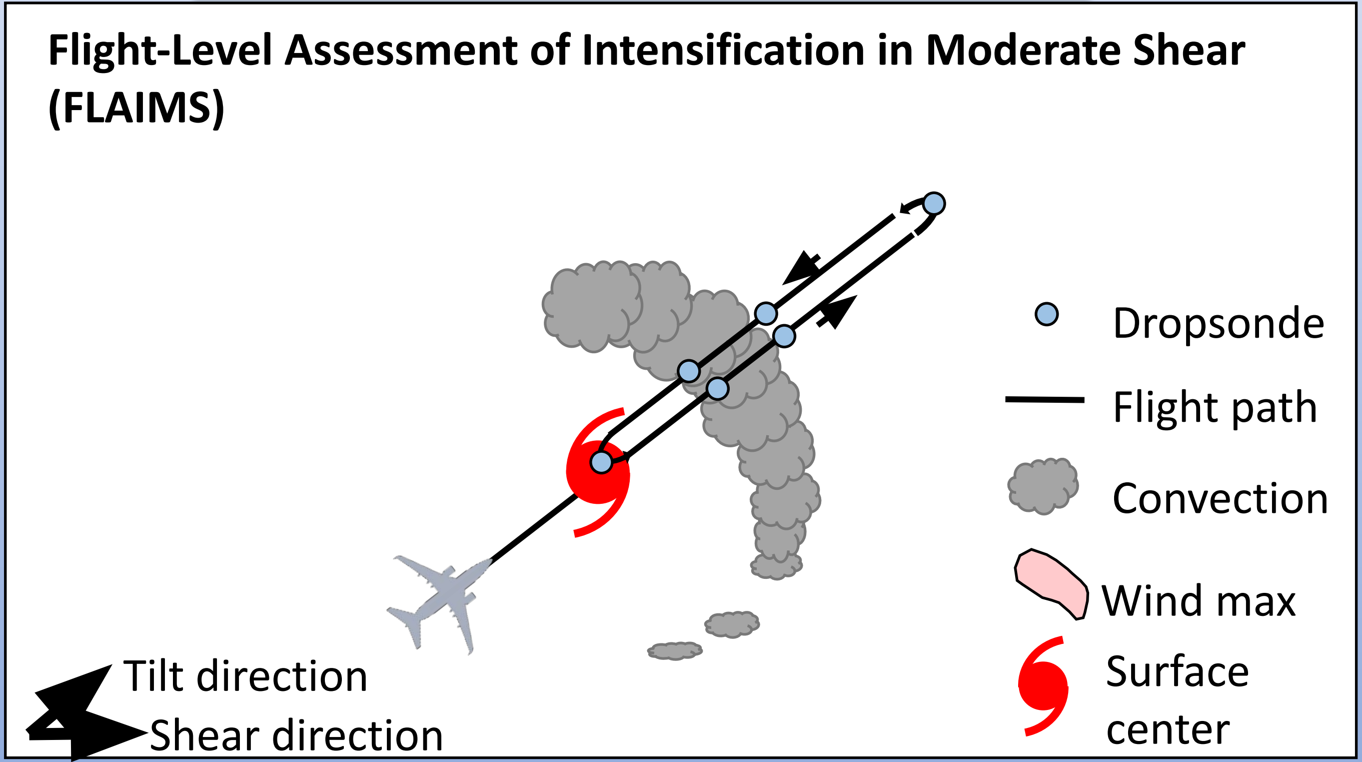
2023 APHEX HFP: Early Stage

FLAIMS (Flight-Level Assessment of Intensification in Moderate Shear)

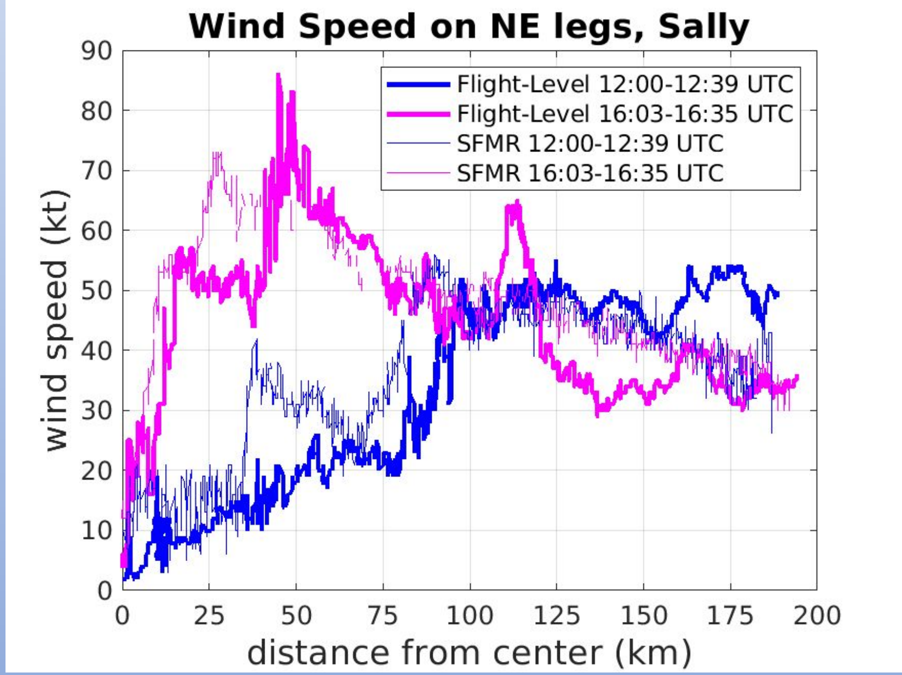
Science Team: Rob Rogers, Dan Stern, Pete Finocchio, Jim Doyle, Trey Alvey, Michael Fischer

- Repeatedly sample the region of maximum wind speed for weak, but intensifying TCs, in order to assess the temporal evolution of both the wind and precipitation fields.
- Intensification in shear is often highly asymmetric, and conventional survey patterns are unable to adequately capture the kinematic and convective changes associated with this intensification, which can occur suddenly.

FLAIMS Pattern #1



Only 2 legs through max wind, 4 h apart



2023 APHEX HFP: Early Stage

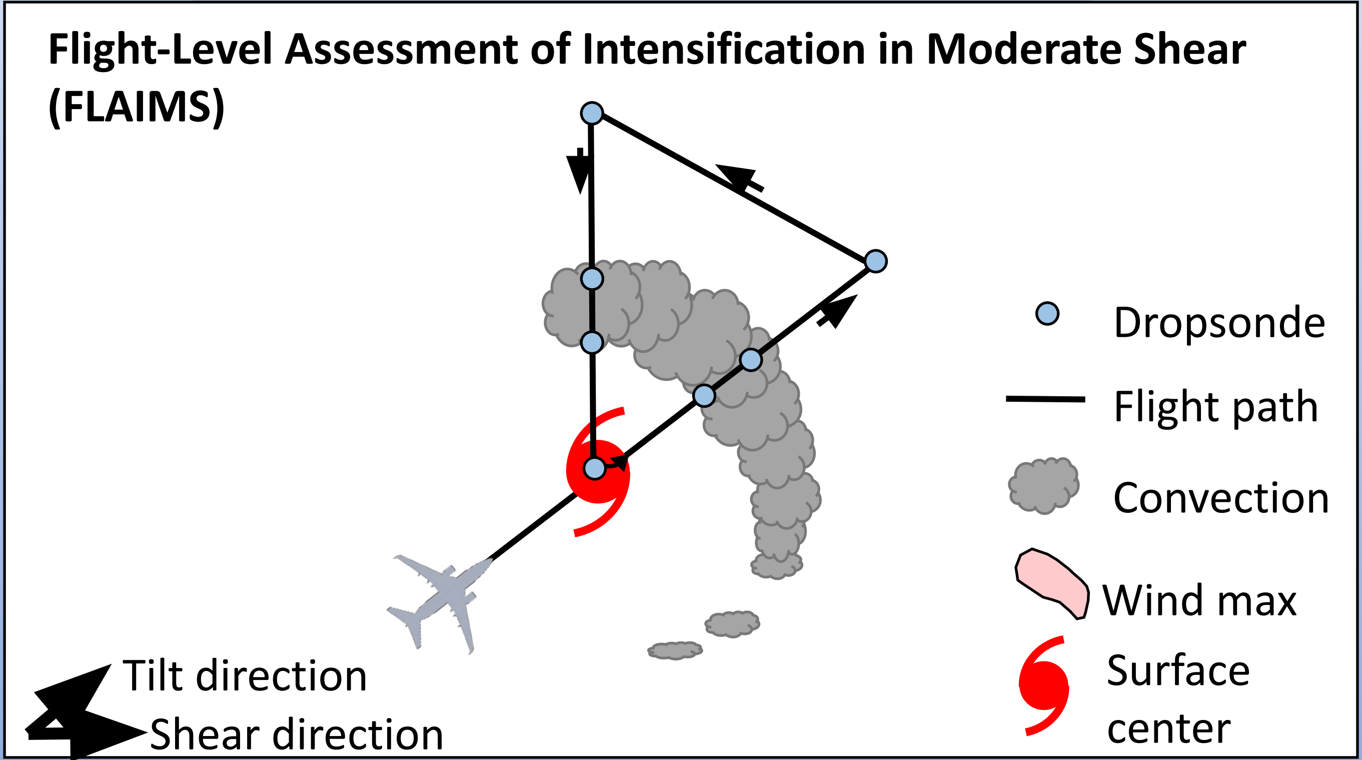
FLAIMS (Flight-Level Assessment of Intensification in Moderate Shear)

Science Team: Rob Rogers, Dan Stern, Pete Finocchio, Jim Doyle, Trey Alvey, Michael Fischer

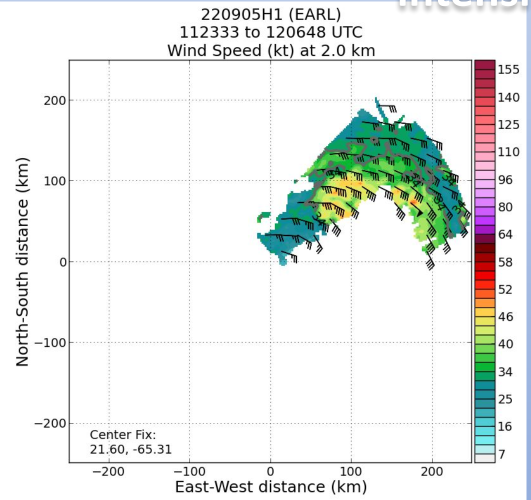
- FLAIMS was flown during 9 missions into 4 storms in 2022, including Hurricane Earl (below right).

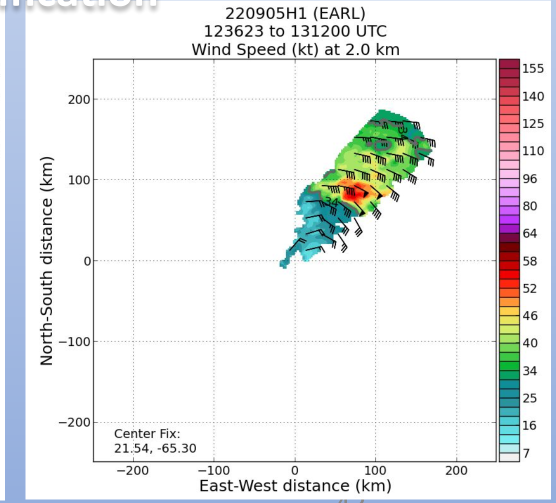
- In order to modestly lengthen the time between repeated legs, a triangular flight pattern (below left) can be utilized as an alternative to the single-azimuth legs of the original FLAIMS pattern.

FLAIMS Pattern #2



3 NE legs in 1.5 h, capturing Earl's intensification



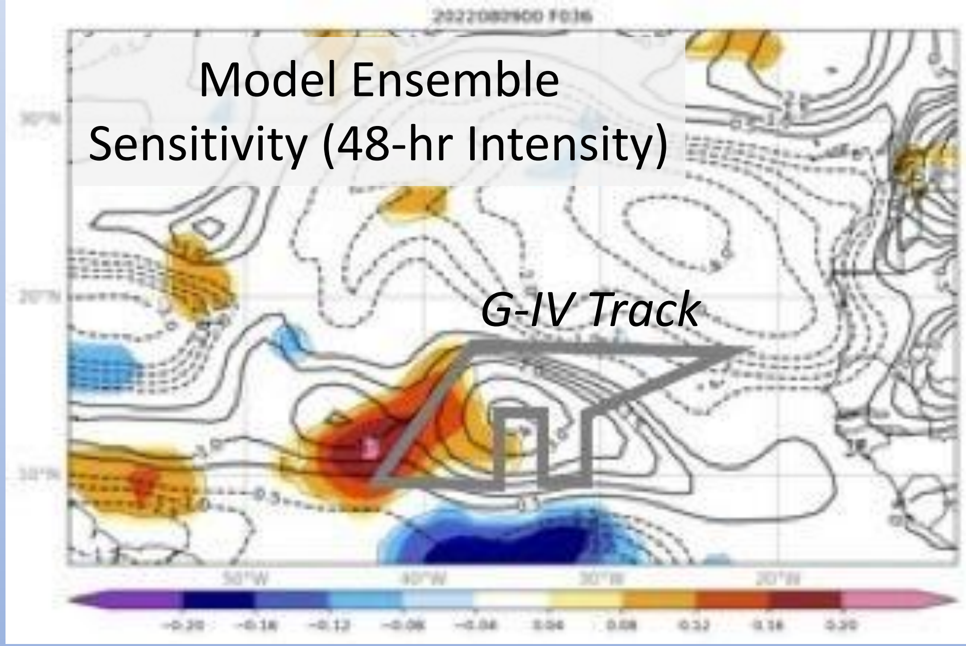


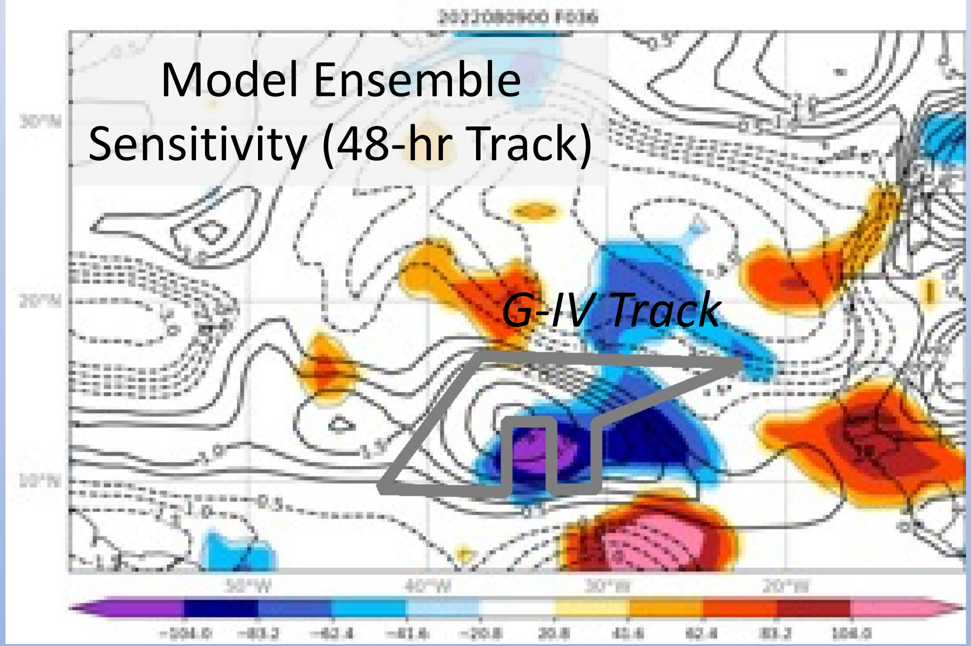
2023 APHEX HFP: Early Stage

Impact of Targeted Observations on Forecasts (ITOFS) Experiment

Jason Dunion (Co-PI), Sim Aberson (Co-PI), Jason Sippel, Ryan Torn (Univ at Albany- SUNY), Jim Doyle (NRL-Monterey), Kelly Ryan (CIMAS), Eric Blake (NWS/NHC), Mike Brennan (NWS/NHC), Chris Landsea (NWS/TAFB)

Goal: Identify when and where we should target aircraft observations to help improve model forecasts of TC track, intensity, structure, and precipitation. Test advanced guidance techniques from models and new areas of operation (e.g., Cabo Verde) that could enhance NHC's G-IV Synoptic Surveillance missions.





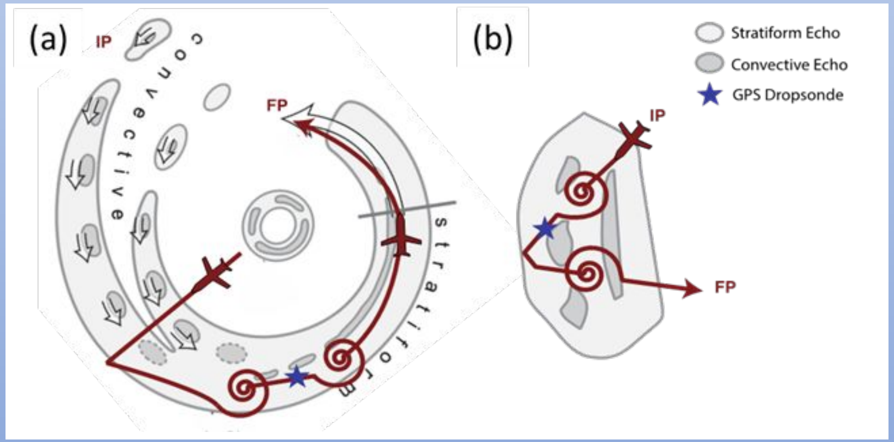
G-IV ITOFS mission 20220810N1 (AL97, Cabo Verde). Model ensemble locations with warm & cool shading indicate areas where dropsonde sampling could improve the 48-hr model track & intensity forecasts for ECMWF.

2023 HFP-APHEX: Early Stage

Stratiform Spiral Module (SSM)

Science Team: Rob Rogers (PI), Trey Alvey, Robert Black, Josh Wadler, Hua Leighton, Xuejin Zhang, Michael Bell (CSU), Anthony Didlake (PSU), Jim Doyle (NRL), Dan Stern (NRL)

- Obtain a quantitative description of the distribution of liquid and frozen hydrometeors in stratiform precipitation to better understand the processes that govern these distributions and how they are represented in numerical models.
- Precipitation probe measurements of stratiform regions in TCs can also help improve retrievals of stratiform microphysical properties by polarimetric radar.
- Spiral ascents/descents in stratiform regions of deep convection at radii outside the RMW will provide microphysical measurements from in situ probes, including how the microphysics vary in a shear-relative framework
- Optimal additional measurements include:
  - Deep-layer measurements of temperature and humidity in the local environment of the stratiform precipitation from high-altitude aircraft will provide the thermodynamic context within the mid-and lower troposphere
  - Measurements of sea-surface temperature and subsurface temperature profiles from ocean probes and/or IR dropsondes will provide context on the surface boundary



(a) Example spiral ascent and descent in stratiform portion of primary rainband. (b) Example spiral ascent and descent in isolated CB during stratiform transition.

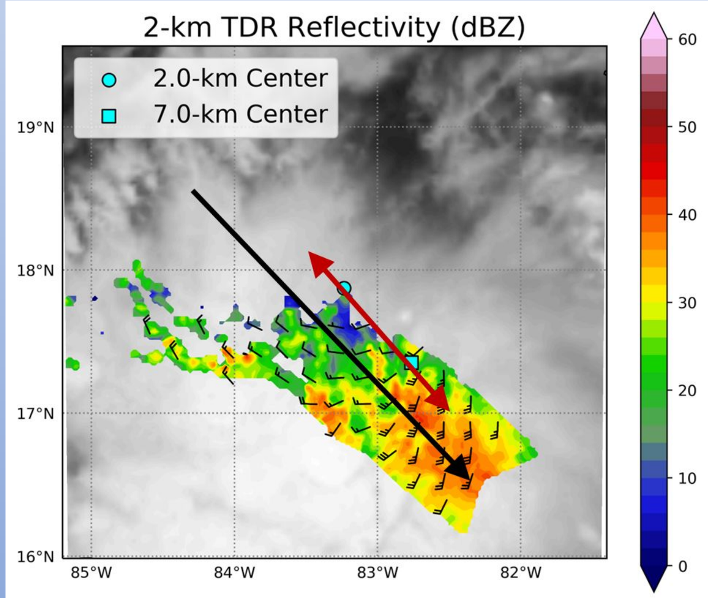
2023 APHEX HFP: Early Stage

Vortex Alignment Module (VAM)

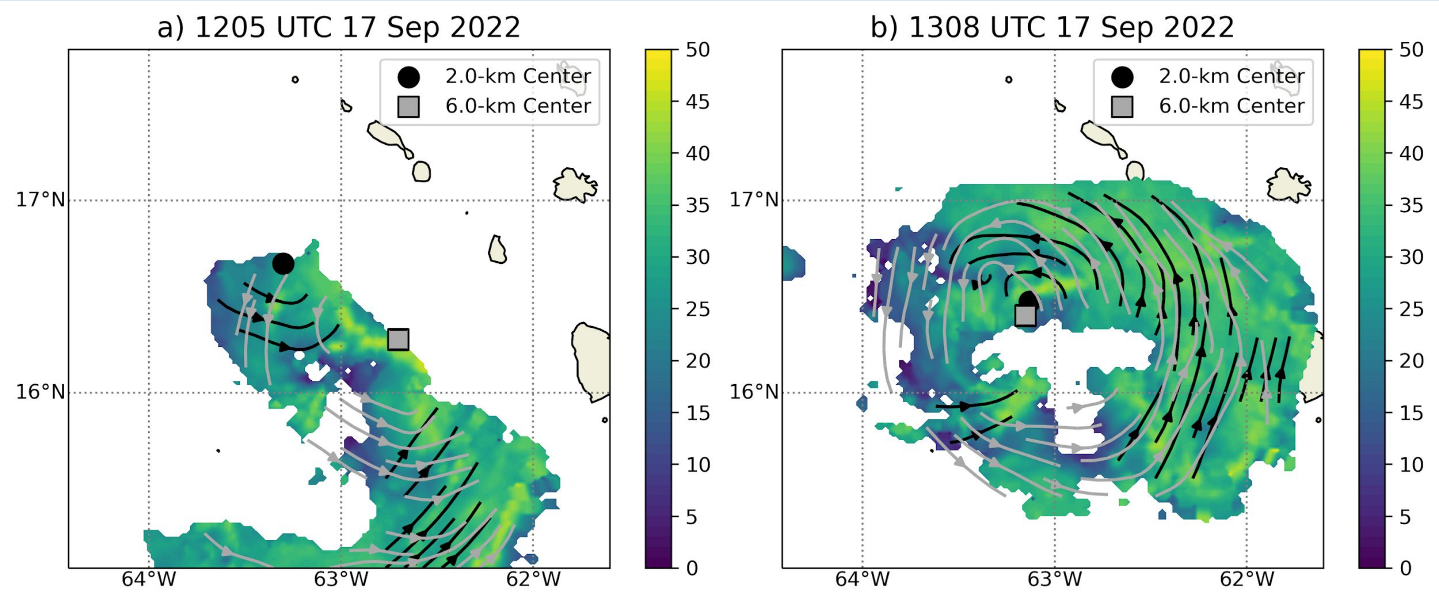
Science Team: Michael Fischer, Trey Alvey, Rob Rogers, Jason Dunion, Paul Reasor, David Nolan, Daniel Stern, Zeljka Stone, David Raymond, Stipo Sentic, David Schecter, Rosimar Rios-Berrios

- TC intensity change in early-stage TCs is strongly related to the vortex misalignment structure
- Through what physical processes is vortex alignment achieved?
- The goal is to collect observations of the evolution of the **TC vortex misalignment and precipitation structures** at a **greater temporal resolution than that achieved from standard flight patterns**
- Fly repeated legs between the low-level (e.g., 2-km) and mid-level (e.g., 6-km) TC centers
    - Be sure to fly ~25 nmi past each center to ensure TDR observations are collected!

Example of the sampling strategy:



Example of a VAM flown into Fiona (2022); Reflectivity (dBZ) is shaded:



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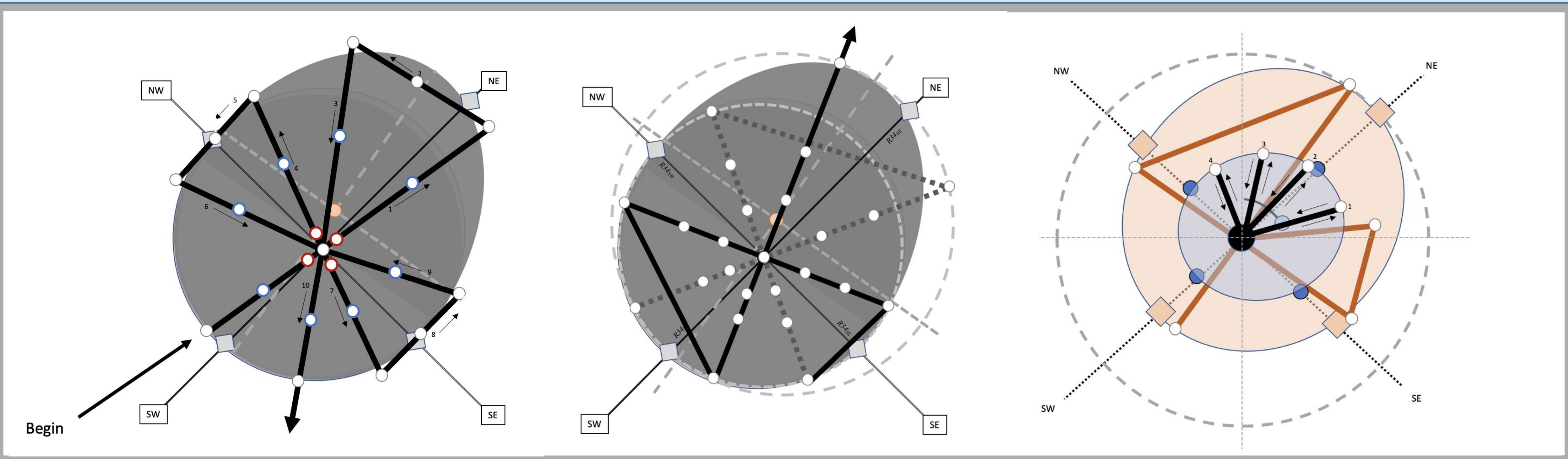
2023 APHEX HFP: Mature Stage

<< Distribution of Hazardous Winds>>

Science Team: << Kelly Ryan and Heather Holbach >>

Objective: Address issues related to the uncertainty of TC surface wind distribution by optimizing azimuthal coverage

- **Spatially (horizontal):** How well do quadrant wind radii represent the asymmetry of hazardous winds?
- **Temporally**: How well do quadrant wind radii capture changes in surface wind distribution within the forecast time window?
- **Spatially (vertical):** How might wind reduction values from flight level depend on azimuthal and radial wind structure?



Pre-flight: Use NHC-reported wind radii to asymmetrically scale radial **leg lengths** and estimate **azimuths** of greatest skew

Mid-flight: Adjust radial legs to **maximize azimuthal coverage in the outer core**; deploy additional sondes when wind reduction values exceed expected values

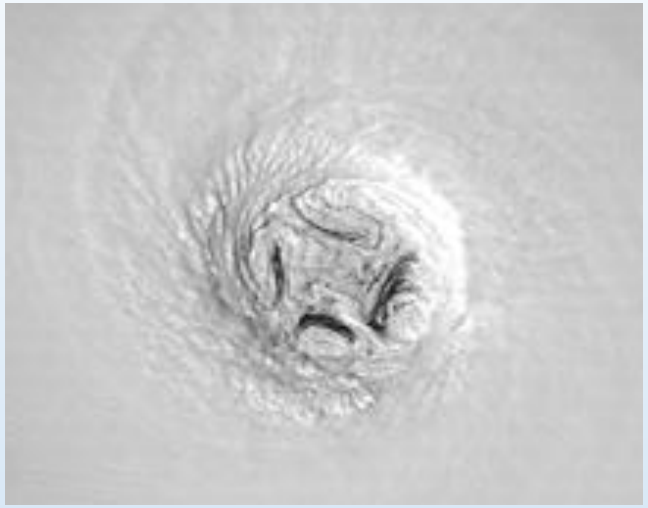
Post-flight: Data collected will be used to **refine assumptions asymmetrically**, investigate asymmetries in the boundary layer as they relate to **wind and wave hazards**, and expose potential **boundary layer biases** in numerical weather and climate models

2023 HFP-APHEX: Mature Stage

Eye-Eyewall Mixing

Science Team: Sim Aberson, Joe Cione, Josh Wadler, Jun Zhang

Hurricane Isabel

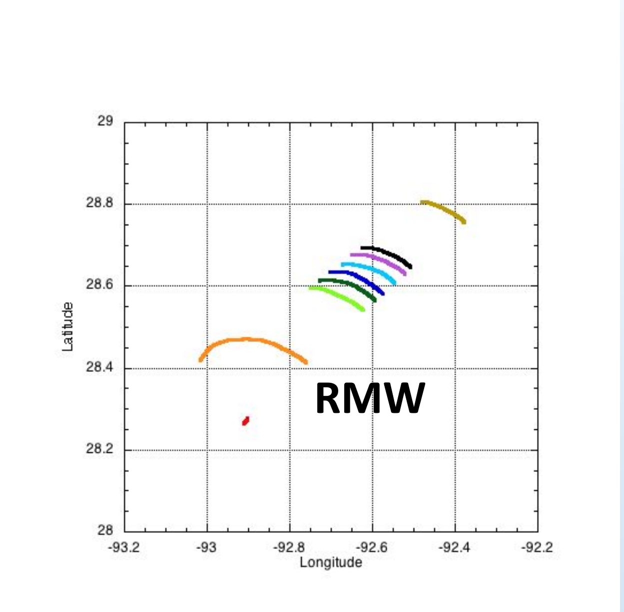


We continue to have no direct evidence of meso-cyclones in the eye and eyewall
What are these features?

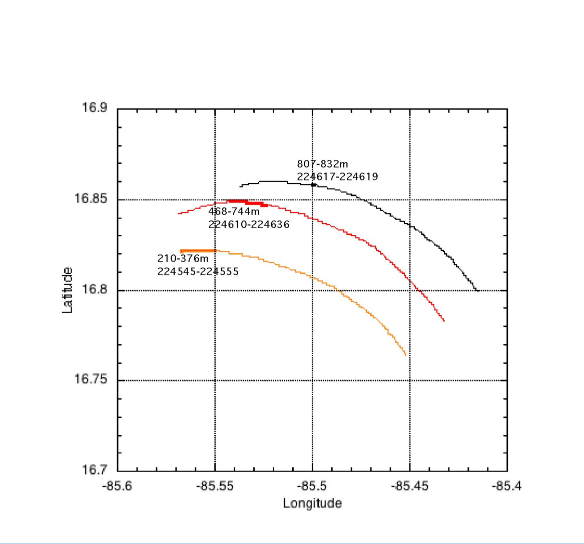
What are their thermodynamic and kinematic properties?

Are they important for intensity change, or do they have no impact besides flight safety?

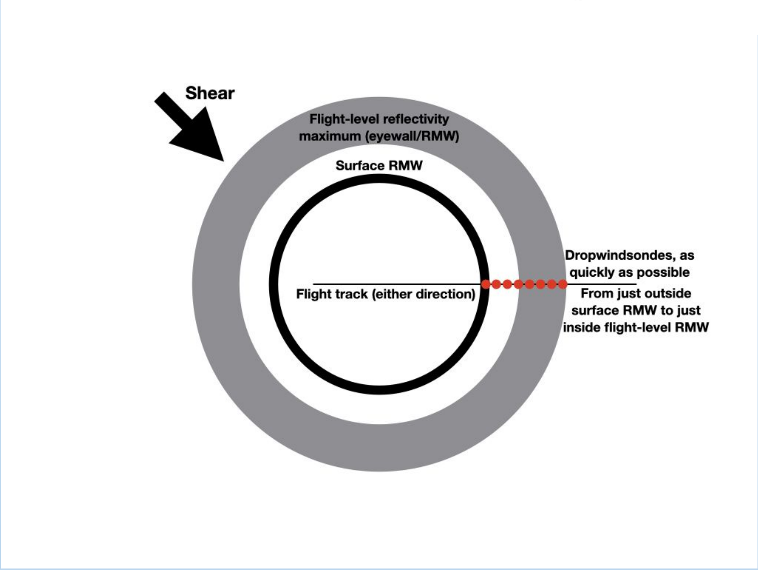
Hurricane Laura



Hurricane Mitch



1. **Surround RMW with sondes**
2. **Fly circle inside eye timed for DA system cycling (based on Fabian results (6-min or 10-min circles).**

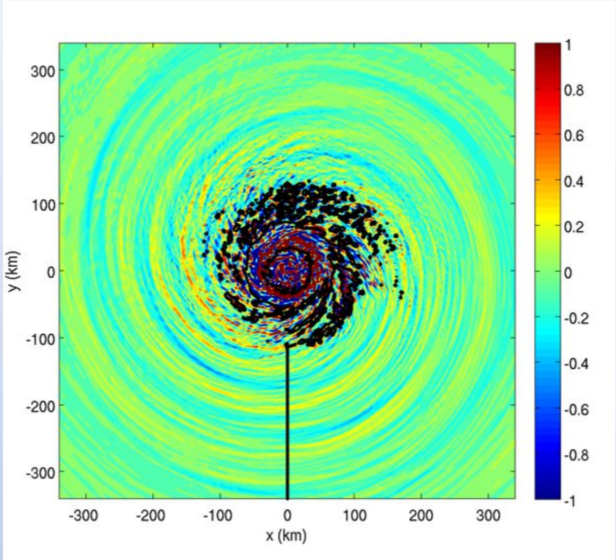


UAS data!

2023 APHEX HFP: Mature Stage

Gravity Wave Module

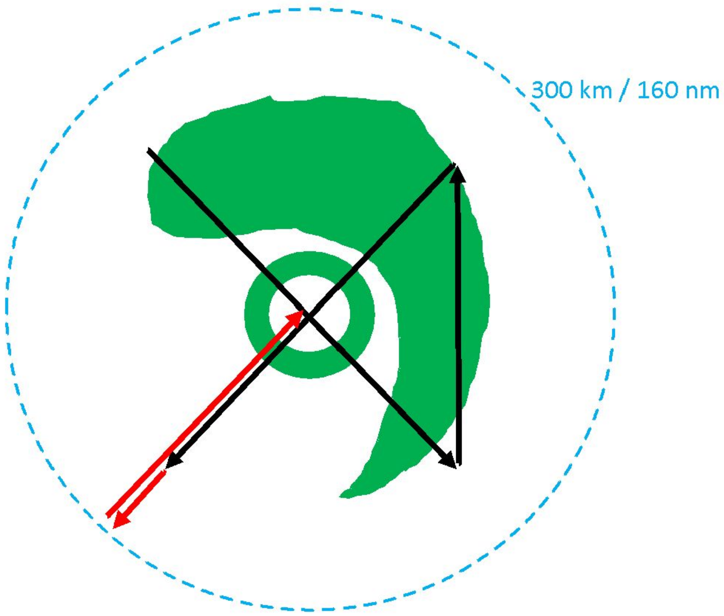
Jun Zhang (PI), David Nolan (Co-PI)

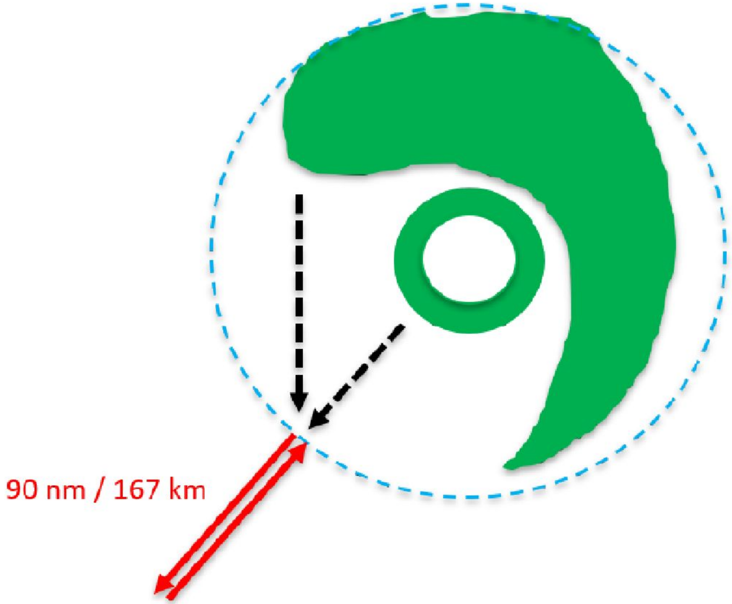


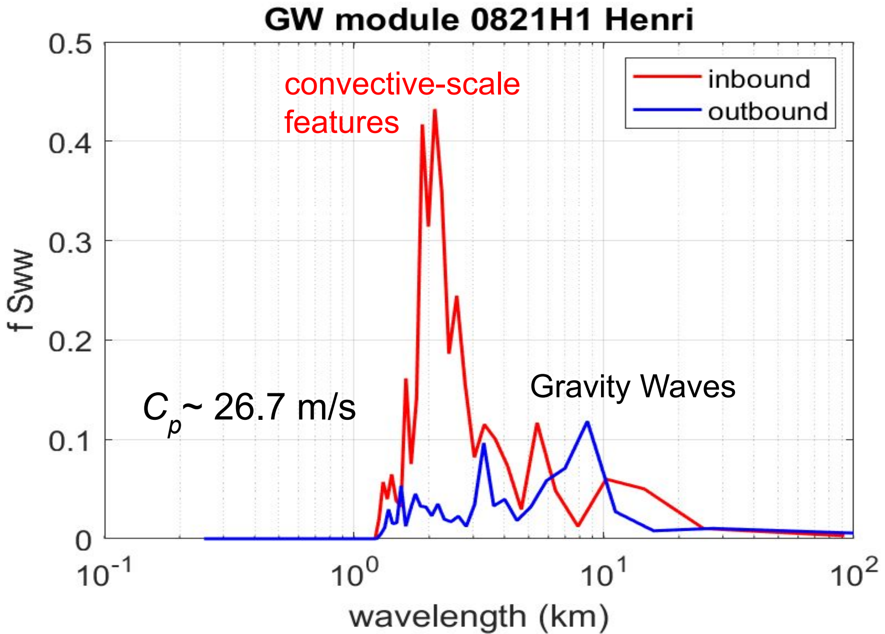
- Collect observations for improving our understanding of the characteristics of gravity waves in mature-stage hurricanes.
- Quantify how the characteristics of these waves are related to hurricane intensity and intensity change.
  - Fly back and forth across individual waves so that both their wavelength (λ) and phase speed (C_p) can be measured.

$$C_p = S \times (\lambda_o - \lambda_i) / (\lambda_o + \lambda_i)$$

S – true air speed







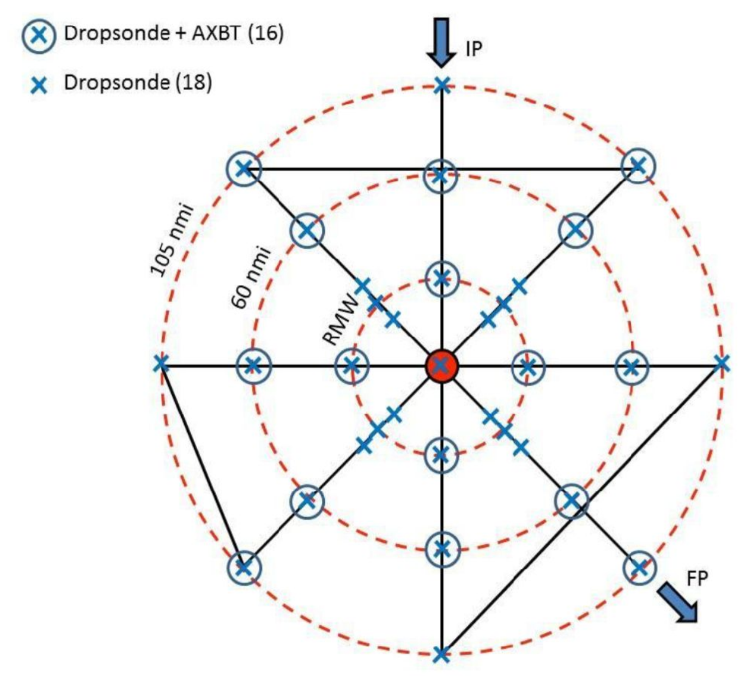
2023 APHEX HFP: Mature Stage

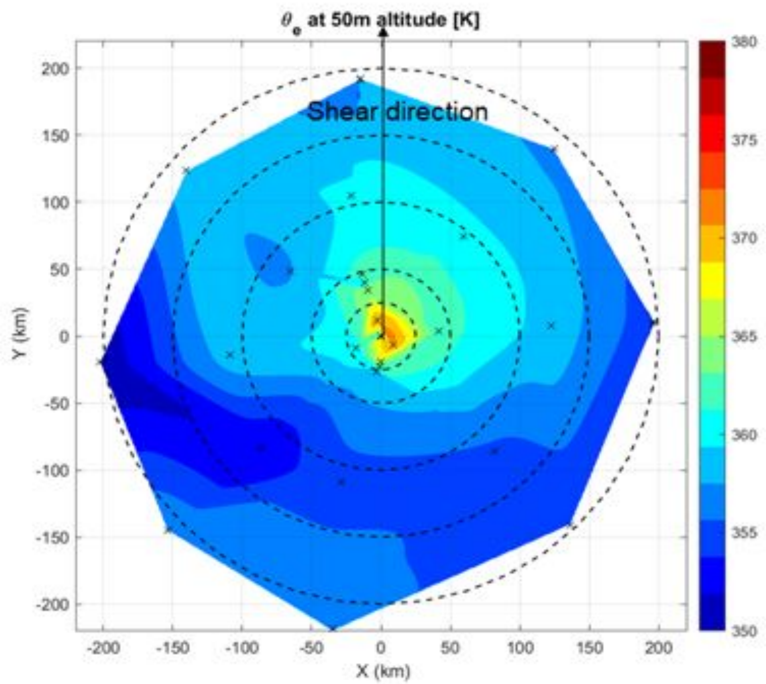
Hurricane Boundary Layer Module

Science Team: Jun Zhang (PI), Jason Dunion, Joseph Cione, Robert Rogers, Frank Marks, Andrew Hazelton, Jonathan Zawislak, Gregory Foltz, Daniel Stern, James Doyle, Sue Chen, Yi Jin, Nick Shay, Benjamin Jaimes, Elizabeth Sanabia, Ping Zhu, Xiaomin Chen, Brian Tang, Robert Fovell, Zhien Wang, Michael Bell, Ralph Foster, Joshua Wadler, Johna Rudzin, George Bryan, Rosimar Rios-Berrios, Falko Judt, Cheyenne Stienbarger, Emily Smith

Goal: Better understand details of boundary layer structure and evolution before and during hurricane intensification.

1) How are boundary-layer inflow and thermodynamic fields related before TC intensification?
2) How do boundary layer height scales evolve before and during TC intensification?
3) How might environmental shear modulate the boundary layer asymmetry during TC intensity change?
4) What is the role of boundary layer recovery in TC intensity change in shear?
5) What is the relative importance of boundary layer recovery for TCs near landfall compared to over ocean?





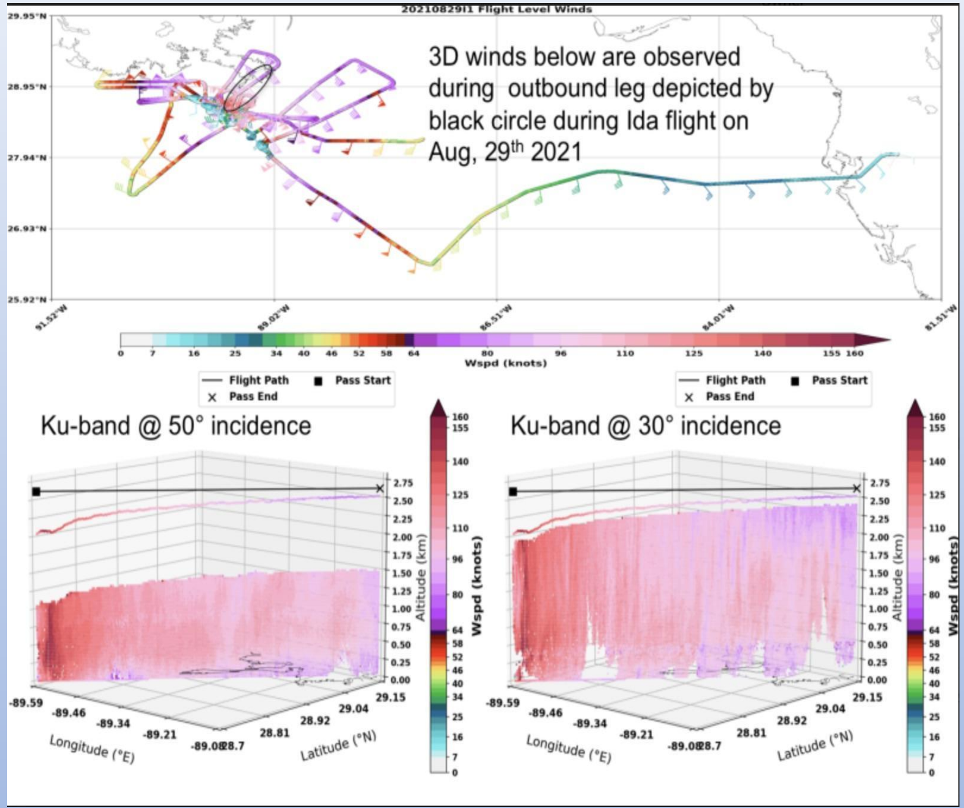
2023 APHEX HFP: Mature Stage

NESDIS Ocean Winds Module

Science Team: Paul Chang, Zorana Jelenak, Joe Sapp, Brad Isom, Clayton Bjorland, Jim Carswell, Ricky Roy, Sim Aberson

Module Goals

- Provide real-time atmospheric wind profiles, surface wind fields and SWH data to NHC, AOML and EMC
- Connect flight level winds to surface winds via IWRAP wind profiles to update existing parameterization assumptions
- Characterize impacts of intense wind, rain and wave fields on passive and active microwave measurements
- Characterize the importance of fine spatial resolution measurements in understanding changes in storm intensity
- Calibrate/validate satellites (Tomorrow.io Pathfinder, Oceansat3, AMSR2, ASCAT, SMAP, SAR)
- Characterize SFMR errors and develop improvements
    - WPO proposal NOAA-OAR-WPO-2023-2007516
- Coordinate with the CHAOS HFP module (overfly drifters, saildrones, etc.)



Data Collection

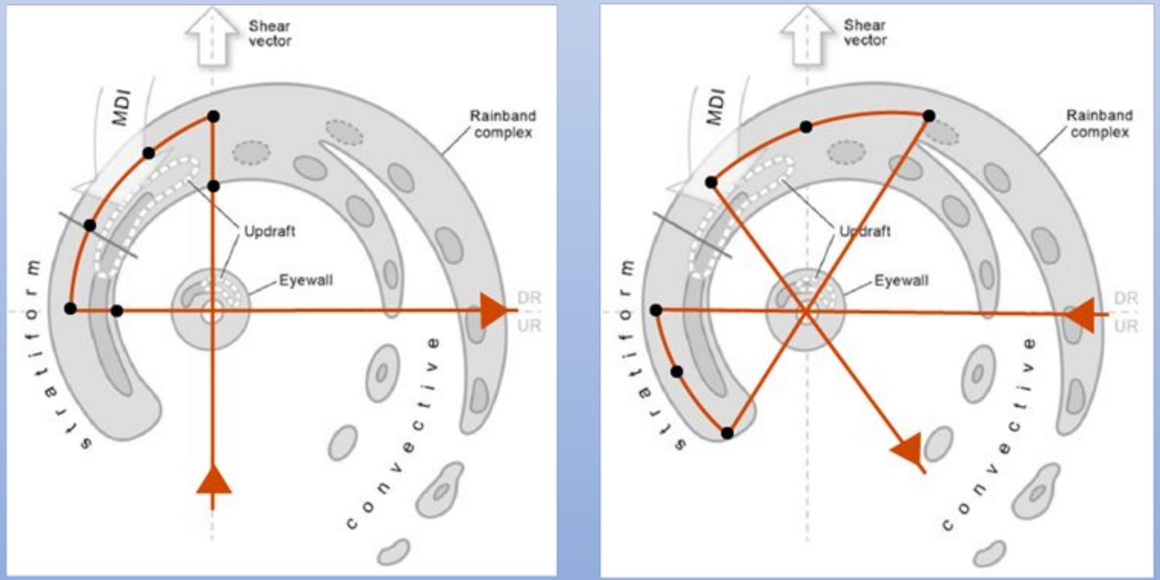
- Instrumentation: IWRAP, KaIA, SFMR and ARCoS
- Nominally radar altitude (10 Kft or below) and level flight at 210 kts IAS
- For under flights with Tomorrow.io satellites may want as altitudes high as possible
- For invest flights would desire at least one pass at 5K ft or higher to collect IWRAP surface wind vectors to investigate close surface circulation detection
- Opportunity to have a follow the leader flight with N43 (w-band and WSRA) desired

2023 HFP-APHEX: Mature Stage

Rainband and Secondary Eyewall Formation (SEF) Module

Science Team: Rob Rogers (PI), Michael Fischer, Anthony Didlake (PSU), Michael Bell (CSU), Anthony Wimmers (UWisc), Jim Doyle (NRL), Dan Stern (NRL)

- Improve understanding of the dynamic and microphysical processes of the rainband complex and its role in secondary eyewall formation
- Sample the wind and precipitation structures of both convective and stratiform regions of the rainband complex in varied storms across varied shear and moisture environments.
- Sample the microphysics of the convective-to-stratiform transition and the downwind stratiform regions of the rainband complex (when combined with Stratiform Spiral Module)
- Validate key features linked with different hypotheses of rainband-vortex interaction (e.g., sampling along the mesoscale descending inflow (MDI), generally located downshear left) and secondary eyewall formation

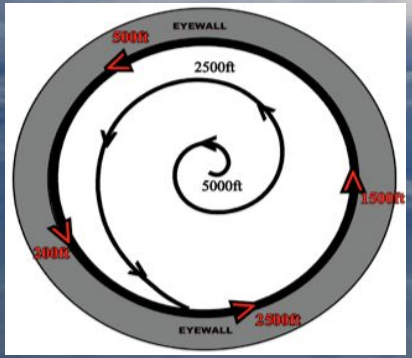


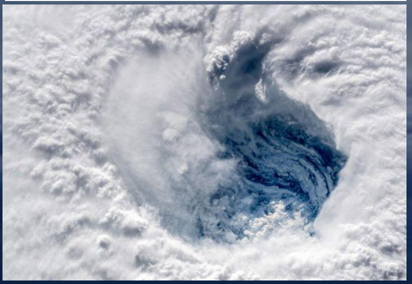
Rainband Complex modules in Figure-4 (left) and Butterfly (right) survey patterns. Target the stratiform and transition regions of a mature rainband complex. The downwind straight legs of a regular survey pattern are replaced with along-band curved legs, and the radial leg lengths are adjusted to meet the endpoints of the module leg. The "optimal" dropsonde (black dots) strategy is in the left panel, and the "acceptable" dropsonde strategy is in the right panel, for each RCM

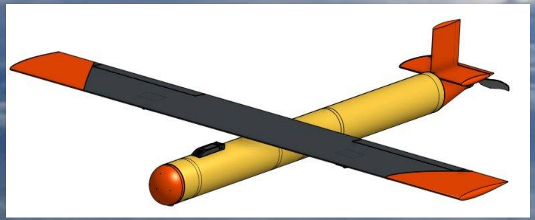
2023 HFP-APHEX: Mature Stage

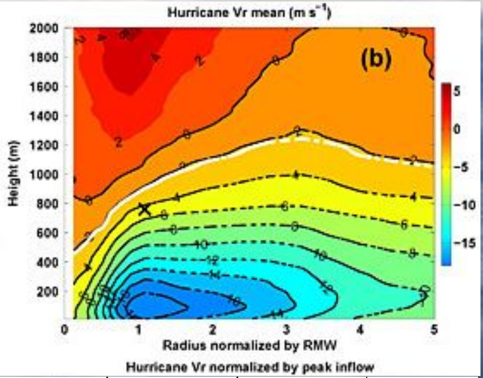
RESEARCH IN COORDINATION WITH OPERATIONS
SMALL UNMANNED AIRCRAFT VEHICLE EXPERIMENT
(RICO SUAVE)

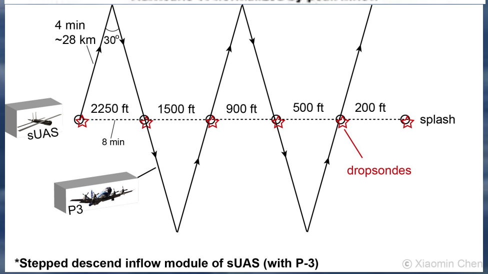
Science Team: Joseph J. Cione, Jun Zhang, Josh Wadler, George Bryan (NCAR), Ron Dobosy (NOAA/ARL-ret), Frank Marks, Altug Aksoy, Jason Sippel, Kelly Ryan (CIMAS), Brittany Dahl, Josh Alland (NCAR), Rosimar Rios-Berrios (NCAR), Xioamin Chen (UA), Chris Rozoff (NCAR), Eric Hendricks (NCAR), Falko Judt (NCAR), Jonathan Vigh (NCAR), Ed Dumas (ARL), Guo Lin (HRD Post Doc)











Plain Language Description: This experiment uses small drones, instead of manned aircraft, to sample the lowest and most dangerous regions of the tropical cyclone. It is believed that observations from these unique platforms will improve basic understanding and enhance forecaster situational awareness. Detailed analyses of data collected from these small drones also have the potential to improve the physics of computer models that predict changes in storm intensity.

2023 APHEX HFP: Mature Stage

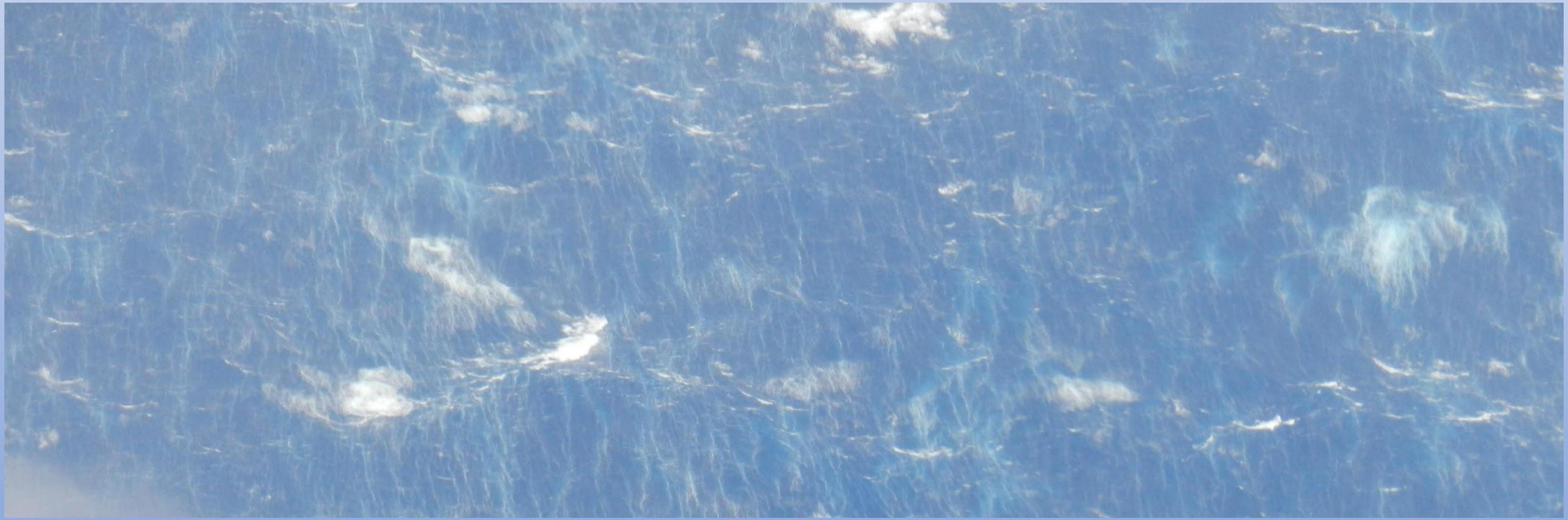
Surface Wind and Wave Validation Module

Science Team: Heather Holbach, Ivan PopStefanija (ProSensing Inc.), Mark Bourassa (FSU), and Ralph Foster (UW-APL)

Motivation: Observations of surface wind speed and wave fields in TCs are extremely important for producing accurate analyses and forecasts of the hazards associated with a TC.

Goals: To collect data with the NOAA P-3 aircraft to:

1. Improve wind speed and rain rate estimates from the SFMR
2. Understand how wind speed observations from the SFMR, flight-level winds, dropsondes, and TDR should be averaged and adjusted to statistically consistent 1-minute mean winds
3. Validate WSRA wave data and map the extent of 8 ft seas

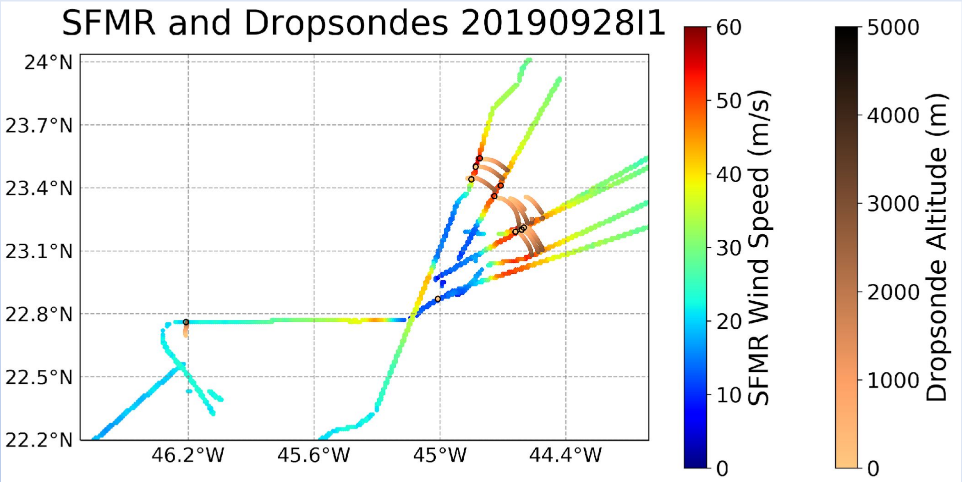


2023 APHEX HFP: Mature Stage

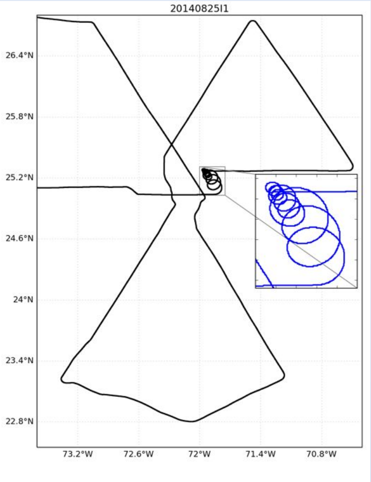
Surface Wind and Wave Validation Module

Science Team: Heather Holbach, Ivan PopStefanija (ProSensing Inc.), Mark Bourassa (FSU), and Ralph Foster (UW-APL)

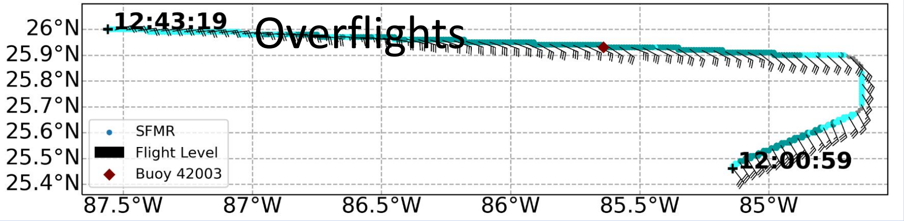
Dropsonde Overflights



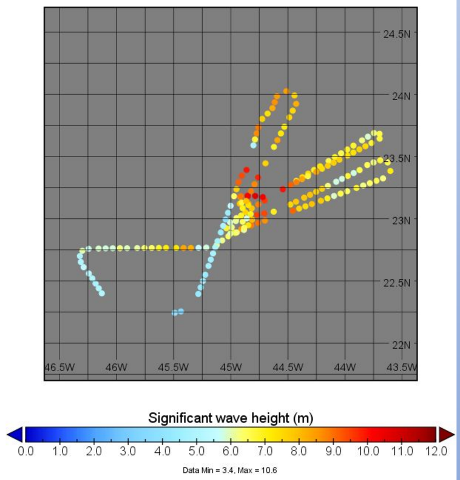
SFMR High-Incidence Angle



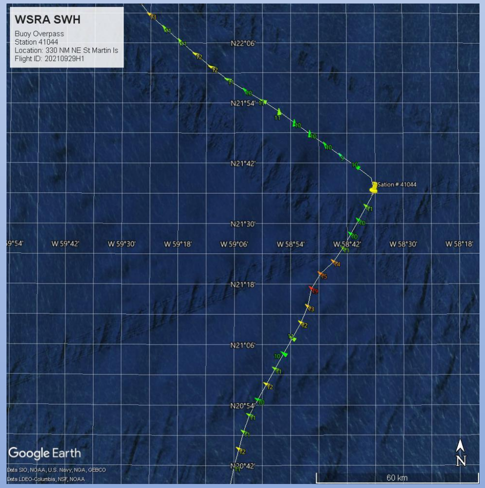
Wind Buoy Overflights



High Seas



Wave Buoy Overflights



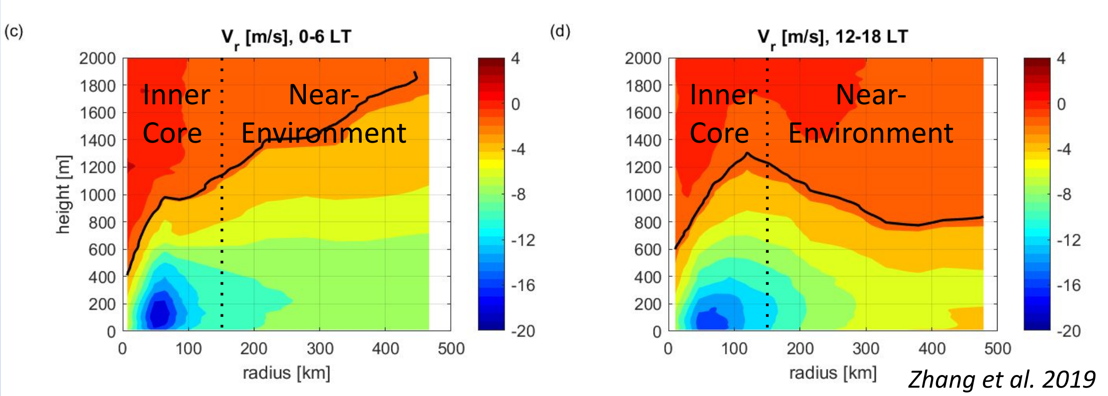
2023 APHEX HFP: Mature Stage

Tropical Cyclone Diurnal Cycle Module

Jason Dunion (PI), Jun Zhang (Co-PI), John Knaff (NESDIS/STAR-CIRA/CSU), Chris Slocum (NESDIS/STAR-CIRA/CSU)

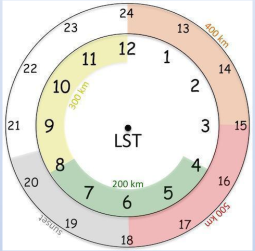
Goal: Improve our understanding of how day-night fluctuations in radiation affect the intensity and structure of hurricanes, particularly the flow of air into the storm at the lowest levels above the ocean.

Night (0-6 LT) Day (12-18 LT)

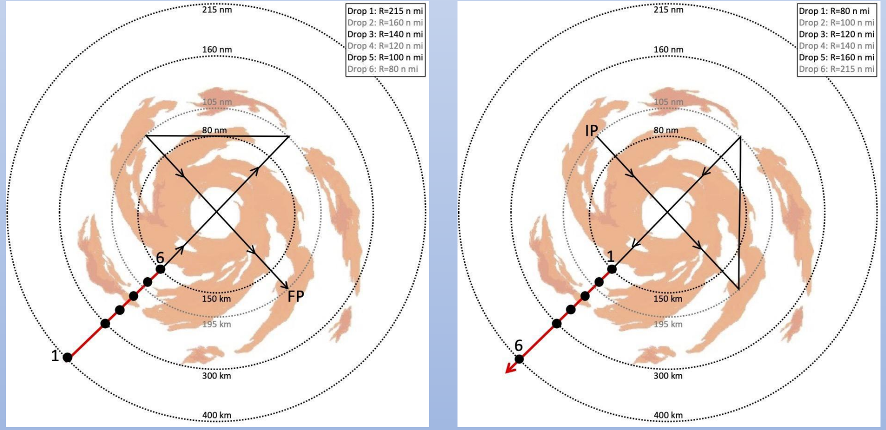


Inner Core: Stronger inflow | Weaker inflow

Near Envir: Stronger, deeper inflow | Weaker, shallower inflow



TCDC clock that estimates the radial location of TC diurnal pulses/waves propagating away from the storm.



Dropsondes launched either (left) inbound (R=215-80 n mi) or (right) outbound (R=80-215-80 n mi) to (from) the storm. Outermost drop inside primary rainband then spacing is ~20 n mi

2023 APHEX HFP: Mature Stage

TDR Analysis Evaluation Module

Science Team: Paul Reasor and John Gamache

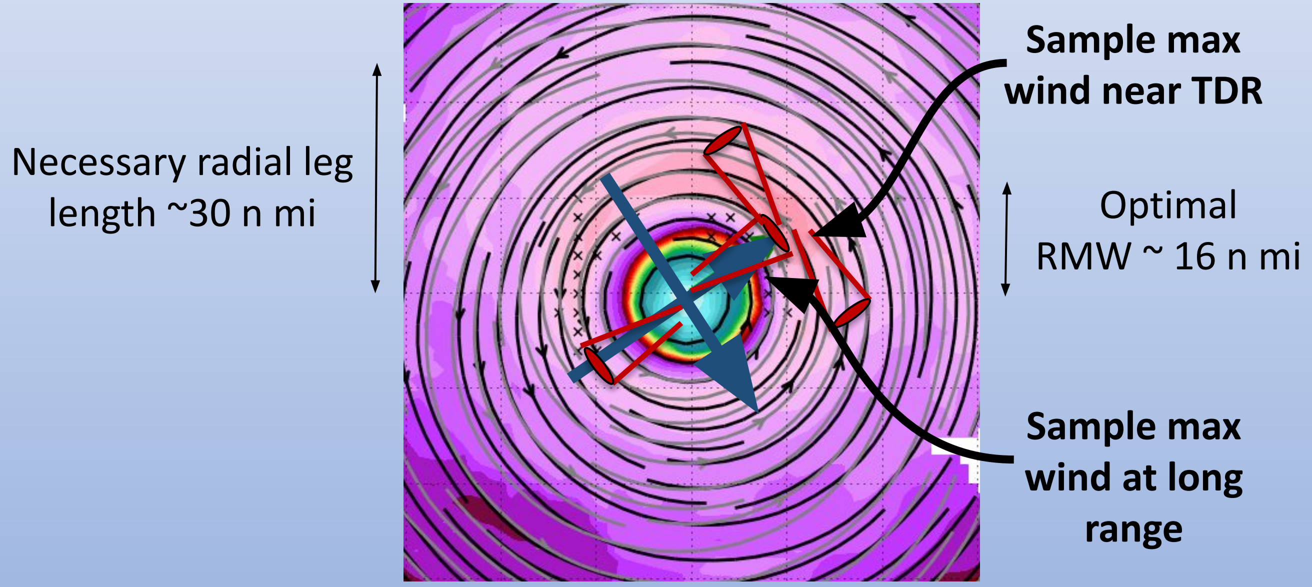
Module Goals

- Quantify **sensitivity** of TDR-derived **peak wind speed estimates**
- Quantify **robustness** of **3-D TDR wind retrievals**
- **Verify** reflectivity **calibration corrections**

Data Collection

Reflectivity and **velocity** from **two TDRs** along **orthogonal** flight tracks

- P-3s as **close vertically** as operationally permitted
- **Simultaneous** eyewall measurements
- **Near-simultaneous** overlapping radar swaths
- Straight and level (no center hunting)



2023 APHEX HFP: Mature Stage

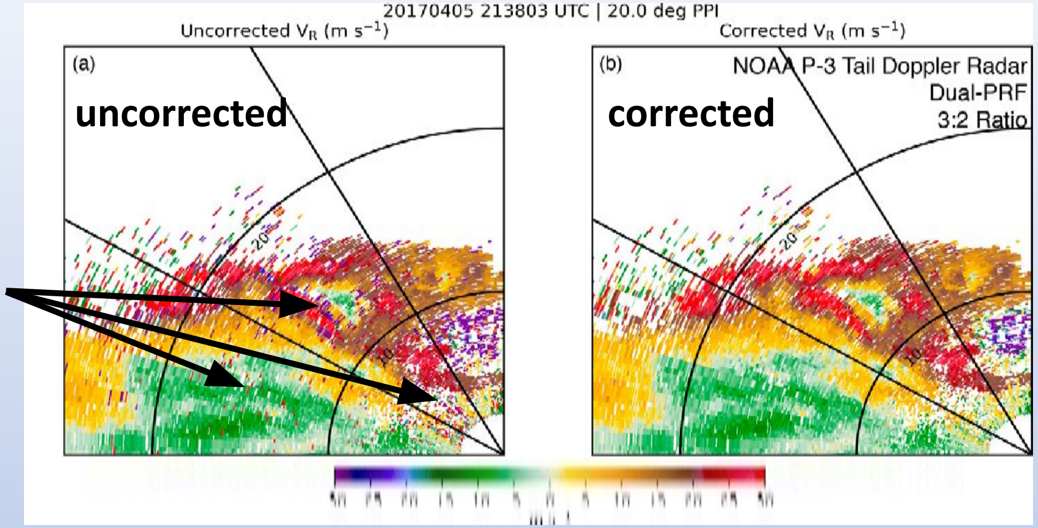
TDR Dual-PRF in Hurricanes Module

Science Team: Paul Reasor and John Gamache

Module Goals

- Assess **benefit of extending TDR Nyquist range** using dual-PRF*
- Test **method for correcting dual-PRF errors** in hurricane context
- Further develop **next-generation automated TDR QC** approach

*PRF = Pulse Repetition Frequency



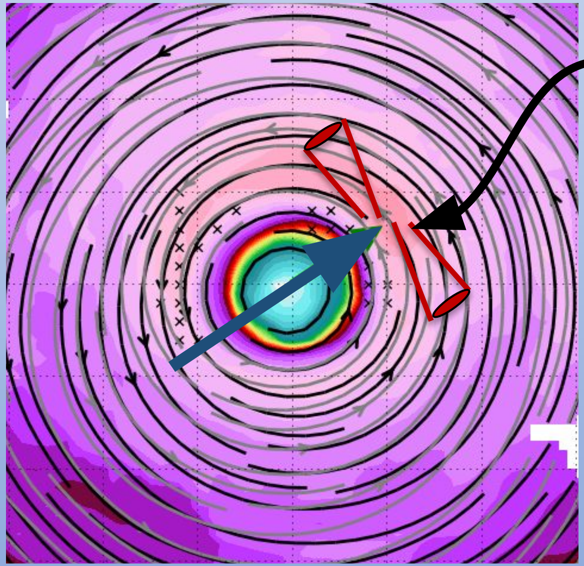
from Alford et al. (2022)

Data Collection

TDR **velocity** from eyewall transect

- Operate TDR with **3:2 PRF ratio** (2775/1850 Hz)
- Extends Nyquist velocity from 22 to **44 m/s**
- Compare with single-PRF transects from flight

Necessary radial leg length 40-50 n mi



Sample high-shear eyewall region

Optimal RMW < 27 n mi

2023 APHEX Hurricane Field Program

Experiments & Modules

GENESIS STAGE (2)
Favorable Air Mass (FAM) Experiment
Precipitation during Formation and Observing its Response across Multiple Scales (PREFORM)

MATURE STAGE (11)
Distribution of Hazardous Winds
Eye-Eyewall Mixing
Gravity Wave
Hurricane Boundary Layer
NESDIS Ocean Winds, Waves, & Precipitation
Rainband Complex Module (RCM)
Research In Coordination with Operations Small Unmanned Aircraft Vehicle Experiment (RICO SUAVE)
Surface Wind and Wave Validation
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TDR Dual-PRF in Hurricanes

EARLY STAGE (6)
Analysis of Intensification Processes Experiment (AIPEX)
Convective Burst Structure and Evolution Module (CBM)
Flight-Level Assessment of Intensification in Mod. Shear (FLAIMS)
Impact of Targeted Observations on Forecasts (ITOFS)
Stratiform Spiral Module (SSM)
Vortex Alignment Module (VAM)

END STAGE (2)
Extratropical Transition
Tropical Cyclones at Landfall Experiment

OCEAN OBSERVING (2)
Ocean Survey Experiment
Coordinated Hurricane Atmosphere-Ocean Sampling (CHAOS)

SATELLITE VALIDATION (2)
Evaluation of the Tropical Transition Envir. using Satellite Soundings
NASA TROPICS Satellite Validation Module

2023 HFP-APHEX: End Stage

Extratropical Transition

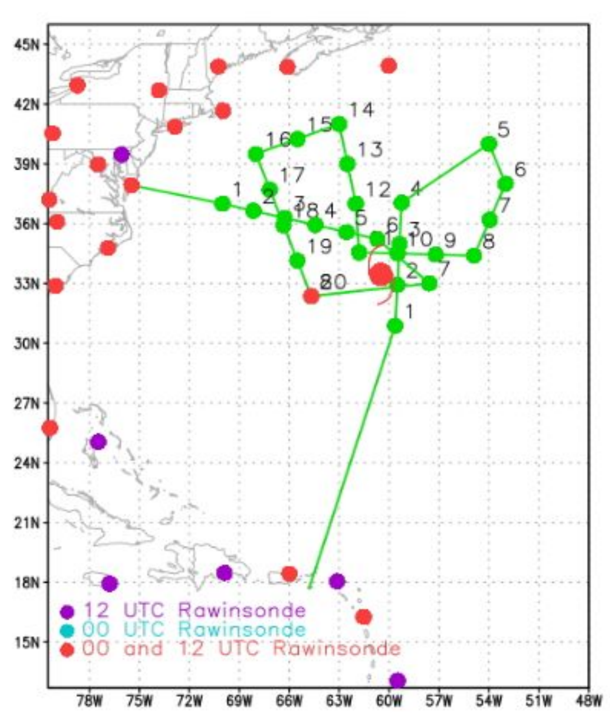
Science Team: Aberson

Target: mature hurricane entering the midlatitudes that has not recently encountered land.

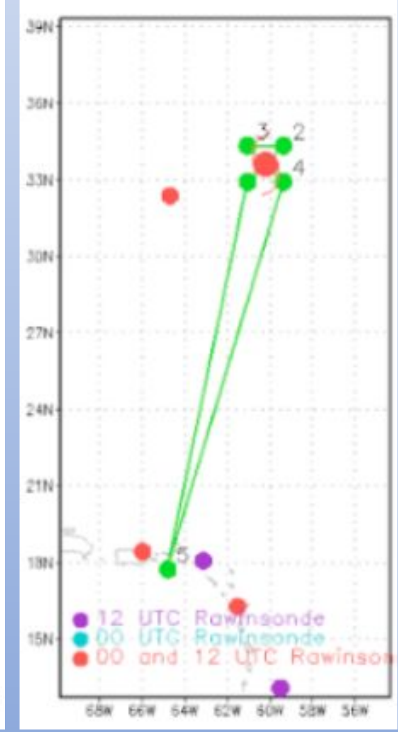
P-3: Sample the system with at least a figure-4 pattern.
G-IV: Sample the system with a figure-4 pattern (not necessarily all together), plus the interface between the system and the environmental flow.

Sample every 12 h from the time it begins the transition to an extratropical cyclone to the time it is out of range of the aircraft, or the system dissipates or makes landfall.

G-IV



P-3



2023 APHEX HFP: End Stage

Tropical Cyclones at Landfall

Science Team: Heather Holbach, John Kaplan, Jun Zhang, Ghassan Alaka, Frank Marks, Lew Gramer, George Alvey, Forrest Masters (University of Florida), Michael Biggerstaff (University of Oklahoma), David Nolan (University of Miami), Xiaomin Chen (University of Alabama in Huntsville), Johna Rudzin (Mississippi State University), and John Schroeder (Texas Tech University)

This year's experiment is dedicated in memory of our dear friend and colleague, Peter Dodge

Goals: Utilize P-3 aircraft and land-based mobile research teams to collect thermodynamic and kinematic observations in landfalling tropical cyclones (TCs) to:

1. Reduce uncertainty in SFMR wind speed estimates and improve PBL parameterizations in coastal regions.
2. Investigate factors that influence wind gust and sustained wind magnitude and TC size near the time of landfall.
3. Improve our understanding of the mechanisms that modulate mesovortices and tornadoes, especially in TC rainbands.
4. Evaluate the impact of coastal oceanic conditions on TC intensity and structure.

2023 HFP-APHEX: End Stage

Tropical Cyclones at Landfall

P-3 Flight Patterns

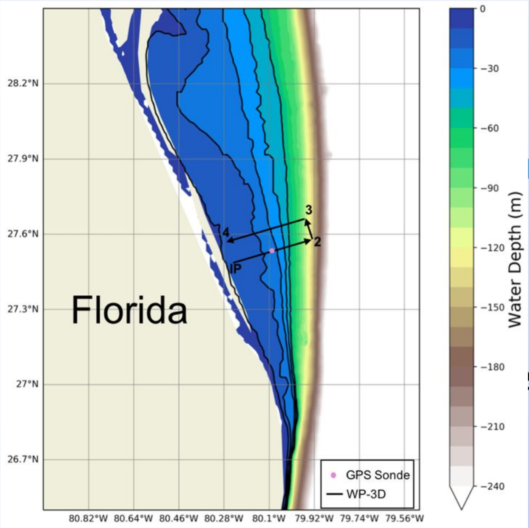
SFMR Coastal

Flight level: > 5-12 kft

Timing: Winds are > 50 kt

Length: ~30-45 min

*Coordinate with landfall teams



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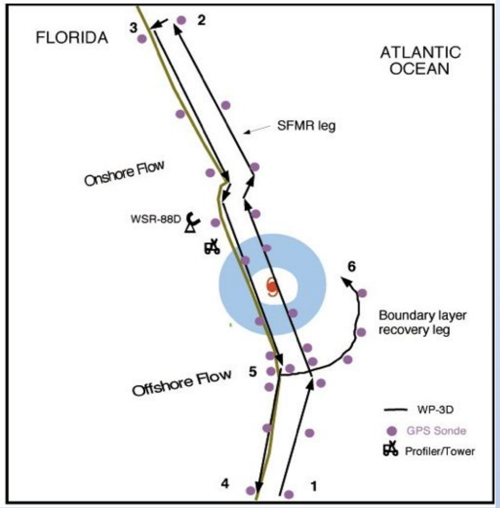
Flight level: ~10 kft

<6 h from landfall

~2-3 h

with landfall teams

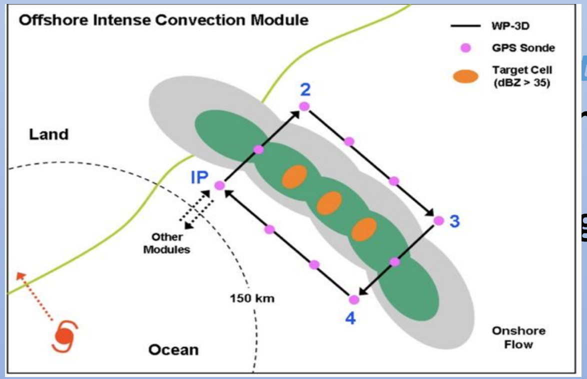


Offshore Intense Convection

Flight level: > 10kft

Timing: 12-24 h from landfall

Length: ~1-2 h

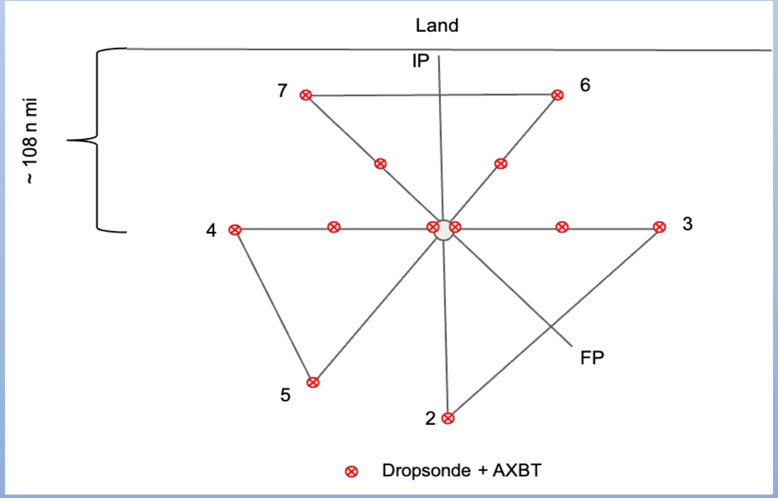


tal Air-Sea Interaction

nt level: 8-10 kft

Timing: < 200 km of land

gth: ~5 h



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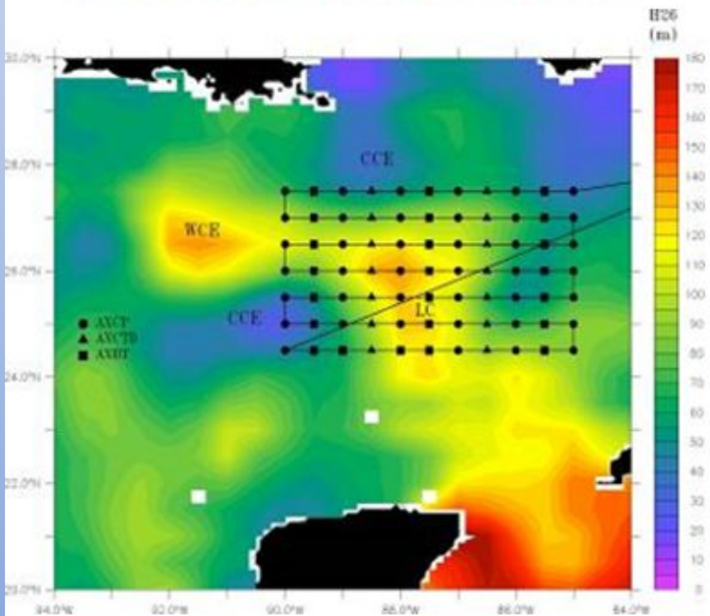
2023 APHEX HFP: Ocean Observing

Ocean Survey

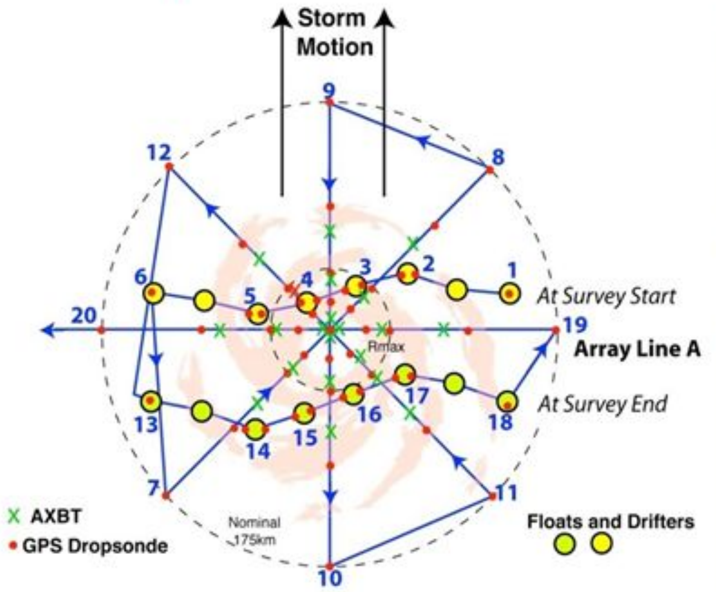
Science Team: Jun Zhang (PI), Nick Shay, Joseph Cione, Frank Marks, Sue Chen, Benjamin Jaimes, Joshua Wadler, Elizabeth Sanabia, Johna Rudzin, Lew Gramer, Heather Holbach, Rick Lumpkin, Gregory Foltz, Gustavo Goni, Hyun-Sook Kim, Matthieu Le Henaff, James Doyle, James Cummings, Luca Centurioni, Theresa Paluszkiewicz, Steven Jayne, Chidong Zhang, Dongxiao Zhang, Christian Meinig, Cheyenne Stienbarger, Emily Smith

- Collect observations targeted at better understanding the response of hurricanes to changes in underlying ocean conditions.
- 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.
- Use observational data collected in this experiment to evaluate and improve hurricane model physics related to air-sea interaction and support data assimilation.

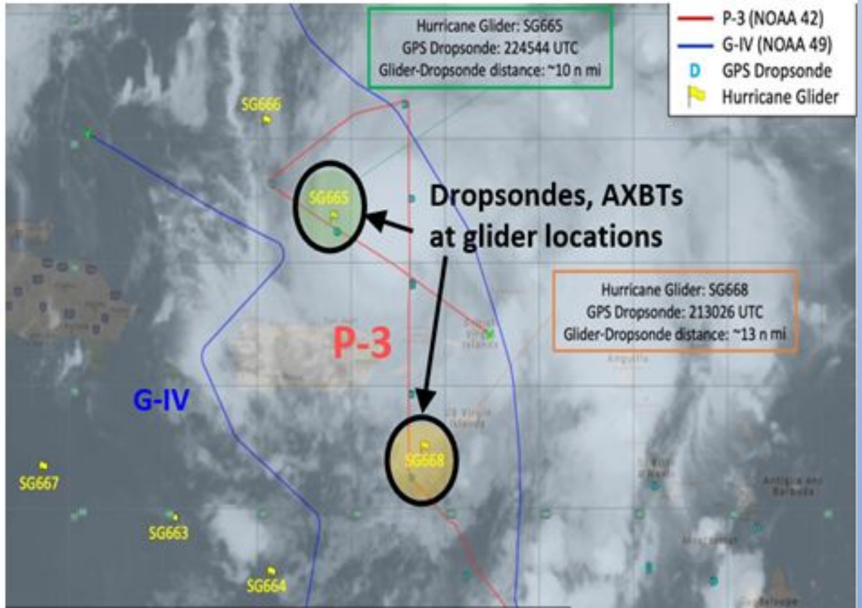
Pre- and post- storm P3 pattern



In-storm P3 pattern over drifters and floats



P3 over underwater Gliders



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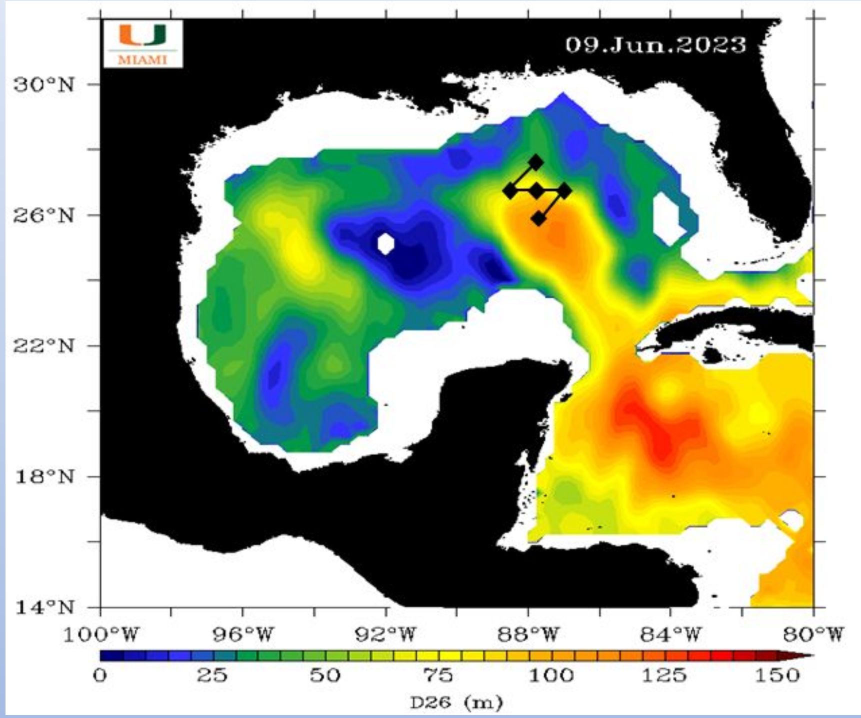
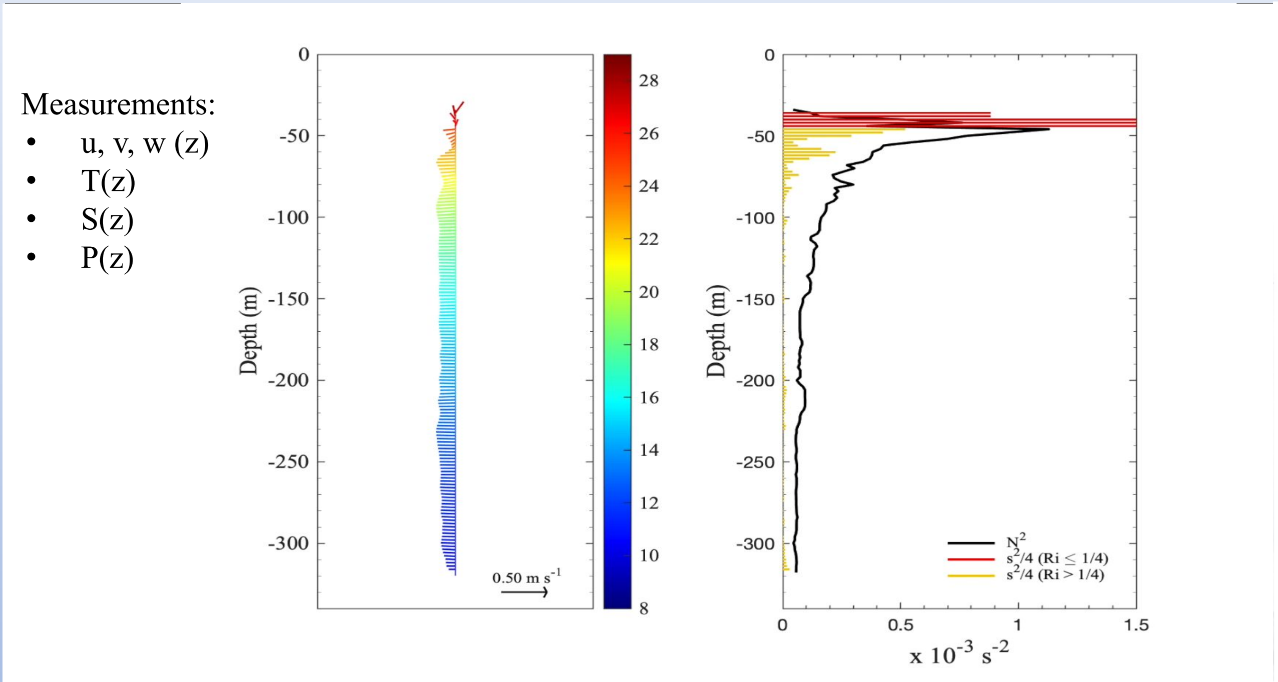




APEX-EM Float Deployments in Warm Eddy by 53rd Wx Squadron During Hurricane

- Warm eddy detachment/ reattachment similar to Eddy Franklin (2010).
- Deployed from the WC-130s with drifters and Alamos?
- Complemented by WP-3D expendables.
- Ship-board deployments of gliders/drifters as part of NAS UGOS-3 MASTR in NW Caribbean Sea in Sept.
- Sampling rates (hours to days) and depths (0-2000m) varied for **adaptive sampli**ng to measure ocean structure.
- Programmed to sample to 300 m at ~1-1.5 h intervals via mission downloads through remote sensing in yo-yo mode.
- Monitoring of data and float position via uploads through IR.
- Other modes include i) **park and profile** at specific depth and ii) **continuous mode.**
- Working with engineers at Teledyne Webb.

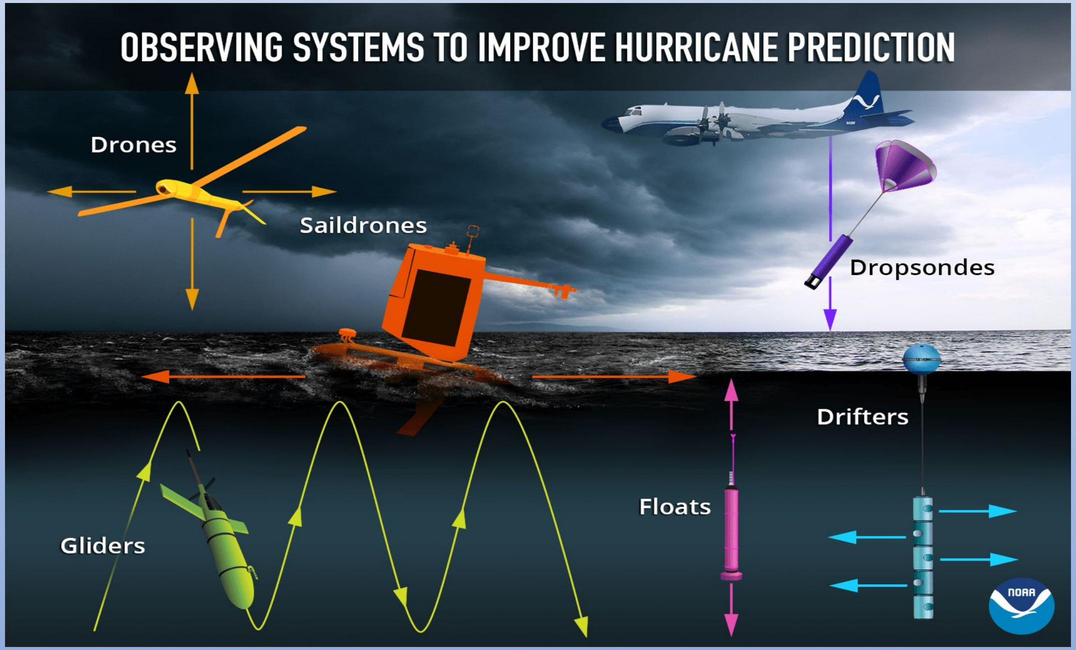
2023 APHEX HFP: Ocean Observing

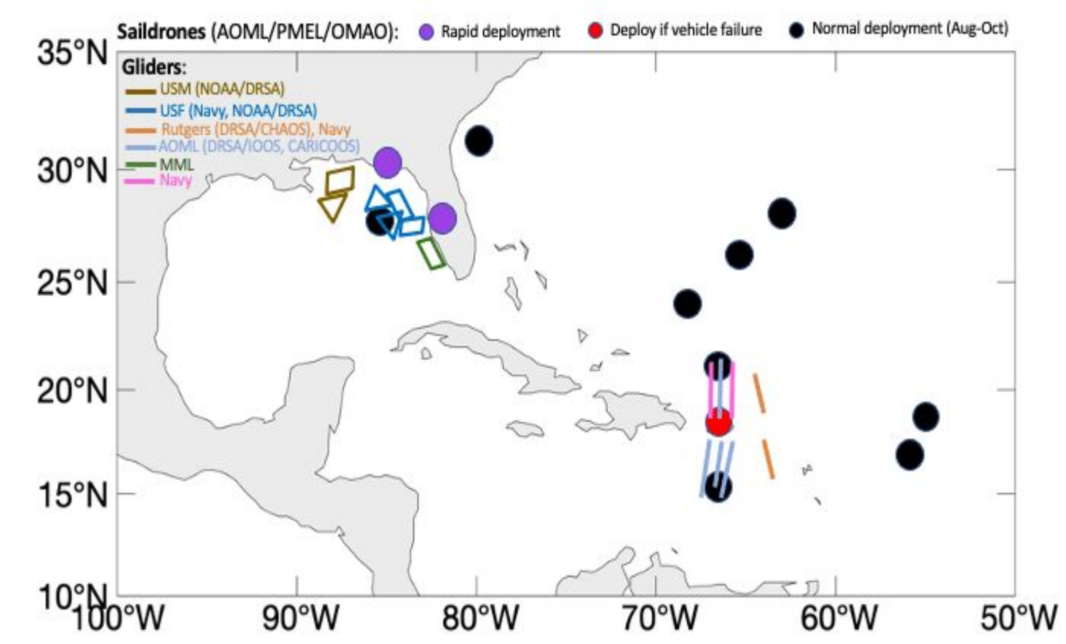
CHAOS: Coordinated Hurricane Atmosphere-Ocean Sampling

Science Team: J., Zhang, J. Wadler, J. Rudzin, J. Cione, N. Shay, C. Zhang, G. Foltz, S. Howden, K. Martin, T. Miles, G. Goni, K. Bailey, S. Jayne, A. Gonzalez, P. Robbins, P. Chang, Z. Jelenak, J. Sapp, L. Centurioni, M. Schonau, H-S Kim, M. Le Henaff, H.S. Kang L. Gramer, C. Stienbarger

Goal: deploy and operate a coordinated suite of ocean-atmosphere observing instruments and facilitate colocated observations of the air-sea transition zone.

- Improving observations of essential ocean features and ocean representation in coupled models
- Elucidating upper ocean and lower atmosphere processes that impact TC intensity through new and established observing systems





Credit: NOAA PMEL

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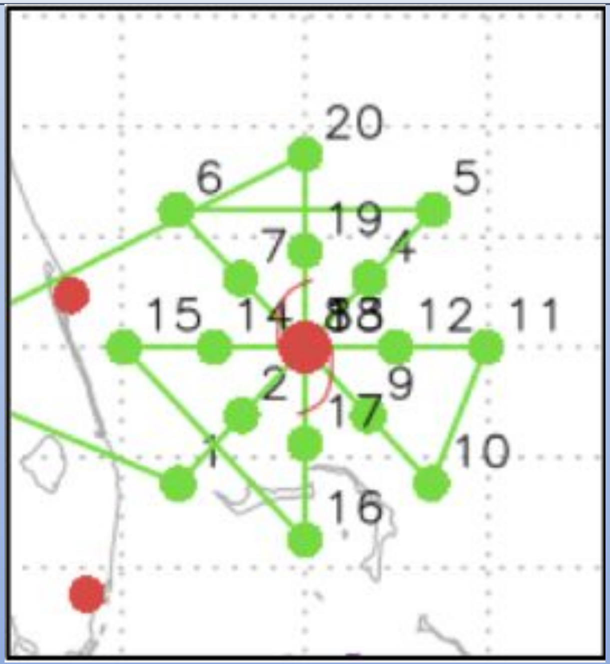
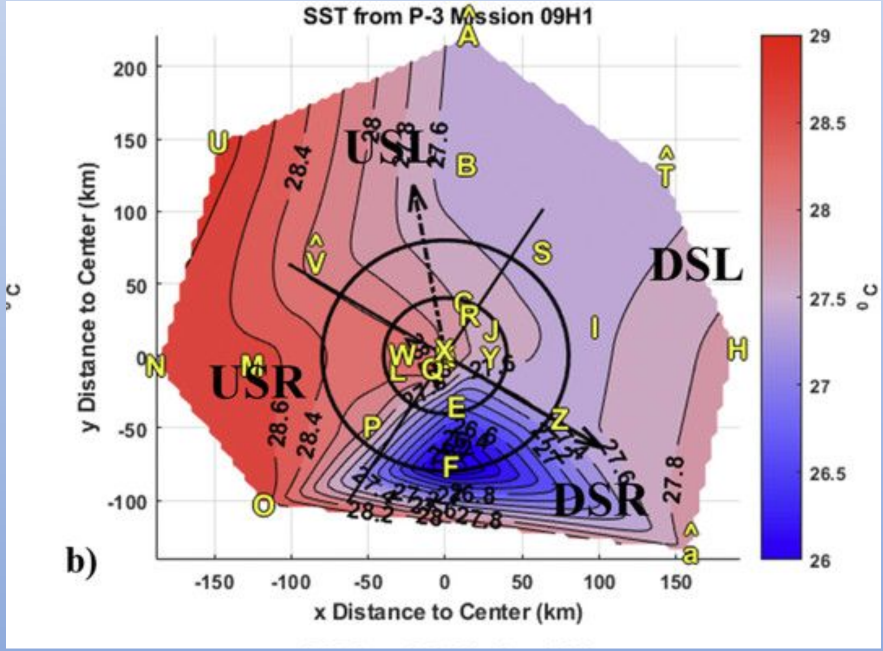
Goal: deploy and operate a coordinated suite of ocean-atmosphere observing instruments and facilitate colocated observations of the air-sea transition zone.

- Successful implementation of this module incorporates long-duration ocean instruments (e.g., Saildrones/Gliders), expendables launched via USAF C-130 (APEX-EM floss), and expendables launched via P-3 (sUAS, AXBTs)
- In-storm patterns can be any standard P-3 pattern. Ideally the legs will be orientated to allow for overflight of ocean instruments for co-located measurements





- Ideally target ocean features to understand their effects on the atmospheric boundary layer (image from Wadler et al. 2021 which looked at the effect of a cold eddy on Hurricane Michael in 2018

2023 APHEX Hurricane Field Program

Experiments & Modules

GENESIS STAGE (2)
Favorable Air Mass (FAM) Experiment
Precipitation during Formation and Observing its Response across Multiple Scales (PREFORM)

MATURE STAGE (11)
Distribution of Hazardous Winds
Eye-Eyewall Mixing
Gravity Wave
Hurricane Boundary Layer
NESDIS Ocean Winds, Waves, & Precipitation
Rainband Complex Module (RCM)
Research In Coordination with Operations Small Unmanned Aircraft Vehicle Experiment (RICO SUAVE)
Surface Wind and Wave Validation
Tropical Cyclone Diurnal Cycle
TDR Analysis Evaluation
TDR Dual-PRF in Hurricanes

EARLY STAGE (6)
Analysis of Intensification Processes Experiment (AIPEX)
Convective Burst Structure and Evolution Module (CBM)
Flight-Level Assessment of Intensification in Mod. Shear (FLAIMS)
Impact of Targeted Observations on Forecasts (ITOFS)
Stratiform Spiral Module (SSM)
Vortex Alignment Module (VAM)

END STAGE (2)
Extratropical Transition
Tropical Cyclones at Landfall Experiment

OCEAN OBSERVING (2)
Ocean Survey Experiment
Coordinated Hurricane Atmosphere-Ocean Sampling (CHAOS)

SATELLITE VALIDATION (2)
Evaluation of the Tropical Transition Envir. using Satellite Soundings
NASA TROPICS Satellite Validation Module

2023 APHEX HFP: Satellite Validation

Evaluation of the tropical transition environment using satellite soundings

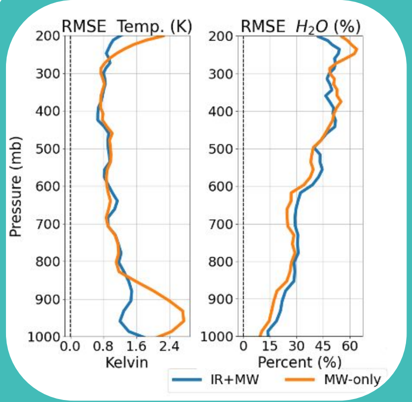
Science Team: Jason Dunion (HRD), Rebekah Esmaili (STC/JPSS), Michael Folmer (NWS/OPC)

1

Motivation

NUCAPS[1] is a satellite sounding retrieval that provides timely, global observations in clear to partly cloudy scenes which can help forecasters monitor tropical cyclones in remote regions.

2



Background

We previously found good statistical agreement with dropsondes.

NUCAPS infrared and microwave (IR+MW) temperature profiles had a 1 K RMSE[2] and a 1.7 km vertical resolution from 600-1000 mb.[3]

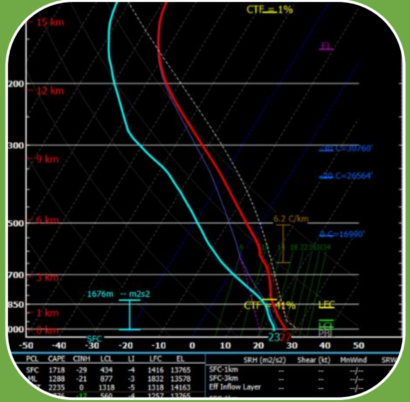
3

Science Objectives

Investigate if NUCAPS can anticipate extratropical/tropical transition by examining the atmospheric column composition and thermodynamics.

Validate NUCAPS thermodynamic structure with coincident (< 1hr, < 5km) dropsondes.

4



Operational Objectives

Provide NUCAPS using timely data delivery in forecaster-friendly software tools (e.g., plan view maps, Skew-T profiles, web tools, SHARPpy, AWIPS-II) to campaign organizers, collaborators.

[1]NOAA-Unique Combined Atmospheric Processing System [2]Root mean square error [3]Esmaili et al., 2022 (in review)

2023 APHEX HFP: Satellite Validation

TROPICS Satellite Validation

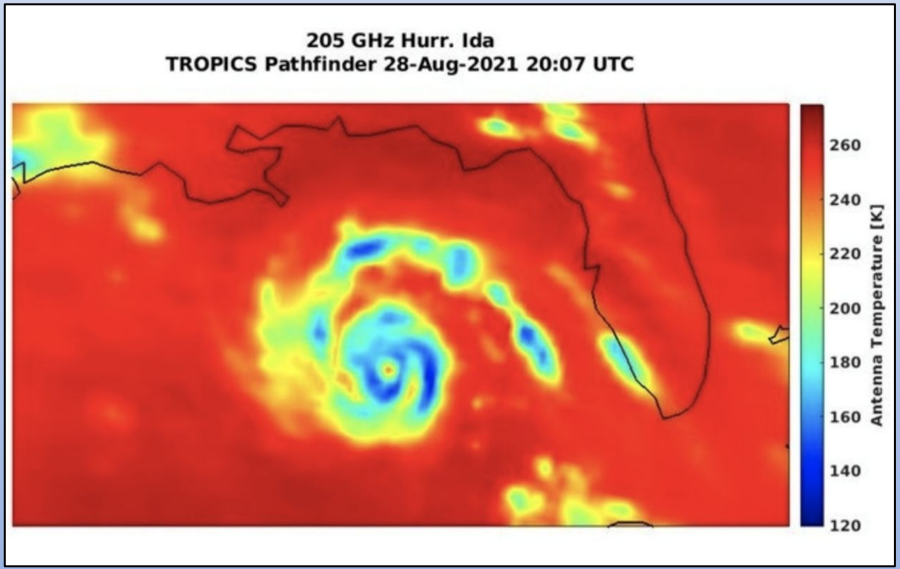
Science Team: Brittany Dahl (co-PI), Jason Dunion (co-PI), Rob Rogers (co-PI), Trey Alvey, and Bill Blackwell (MIT/LL)

Description

The TROPICS satellite mission will deliver unprecedented rapid-update microwave measurements over the tropics that can be used to observe the mesoscale and synoptic-scale evolution of mesoscale and synoptic-scale precipitation and thermodynamic structure of tropical cyclones (TCs). Temperature, moisture, and precipitation measurements from TROPICS will be calibrated and validated by comparing them to observations from NOAA P-3 and G-IV that are coordinated in space and time with satellite overpasses.

Objectives

1. Collect GPS dropsonde and TDR data in a variety of tropical environments using NOAA P-3 and G-IV.
2. Coordinate GPS dropsonde locations with TROPICS satellite overpasses in time (within 30 min) and space (within 750 km of satellite nadir).
3. Evaluate and potentially enhance the impact of TROPICS data on regional numerical prediction of TCs.



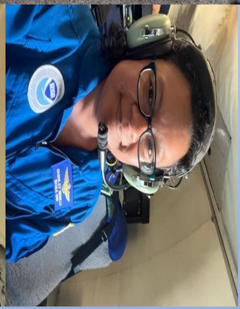




Questions?





Copies of the 2023 HFP Kickoff and today’s chat log can be found on the HRD Google Drive folder
HRD >> Hurricane Field Program >> 2023 >> Presentations >> HFP Kickoff