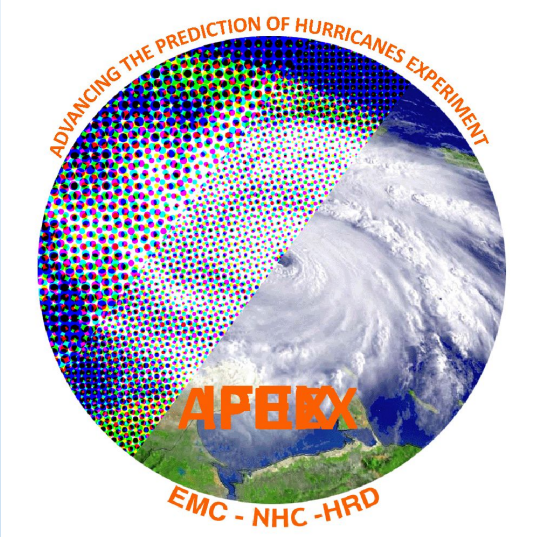
NOAA's APHEX Hurricane Field Program: 2021 Highlights & Plans for 2022

Jason Dunion[1] – HFP Director
Jon Zawislak[1] - HFP Deputy Director

1 University of Miami/CIMAS - NOAA/AOML/Hurricane Research Division

2021 Hurricane Field Program-APHEX



Advancing the Prediction of Hurricanes EXperiment (APHEX)

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

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

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

2021 Hurricane Field Program-APHEX

2021 Season by the Numbers

2021 Atlantic Hurricane Season

by the numbers

21
Named Storms
Average is 14

Ana
Bill
Claudette
Danny
Elsa
Fred
Grace
Henri
Ida
Kate
Julian
Larry
Mindy
Nicholas
Odette
Peter
Rose
Sam
Teresa
Victor
Wanda

7
Hurricanes
Average is 7

4
Major Hurricanes
Average is 3

8
Storms made U.S. landfall

NOAA Hurricane Hunters

467
P-3 & G-IV flight hours

52
Operational (39) & research (13) missions

146
Tail Doppler radar analyses transmitted

Aircraft-Deployed Instruments

1324
GPS dropsondes

131
Airborne eXpendable BathyThermographs (AXBTS)

8
ALAMO Floats (AOML/PhOD & Navy)

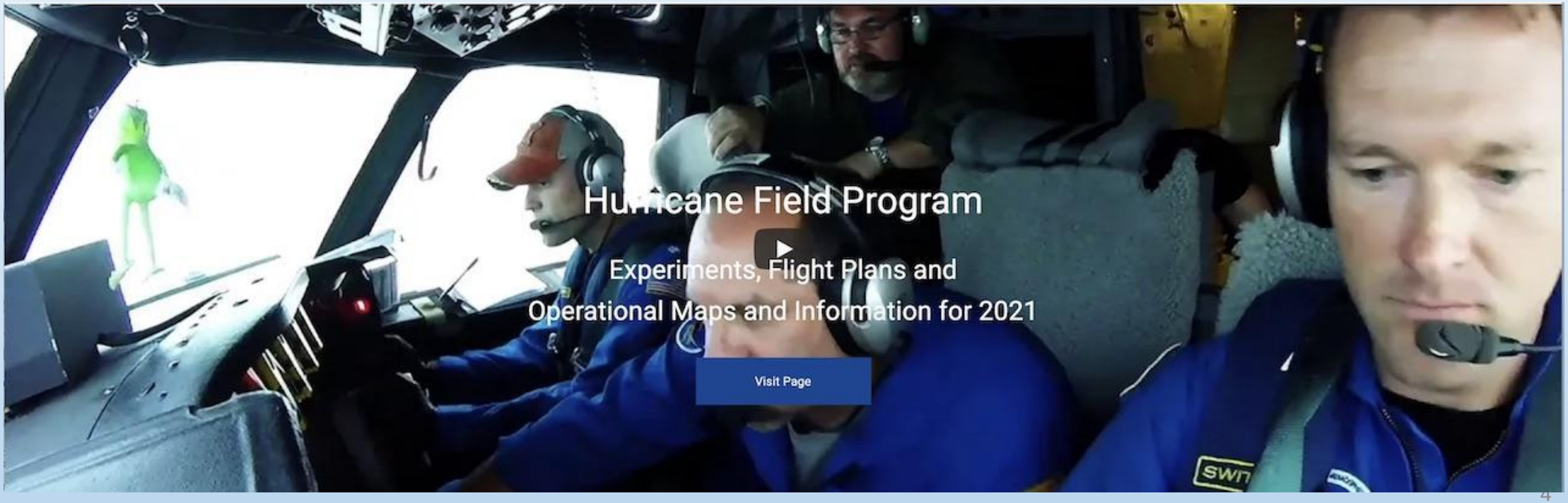
2021 Hurricane Field Program-APHEX

Hurricane Field Program Plan:

https://www.aoml.noaa.gov/2021-hurricane-field-program/

…and Hurricane Field Program Data Page:

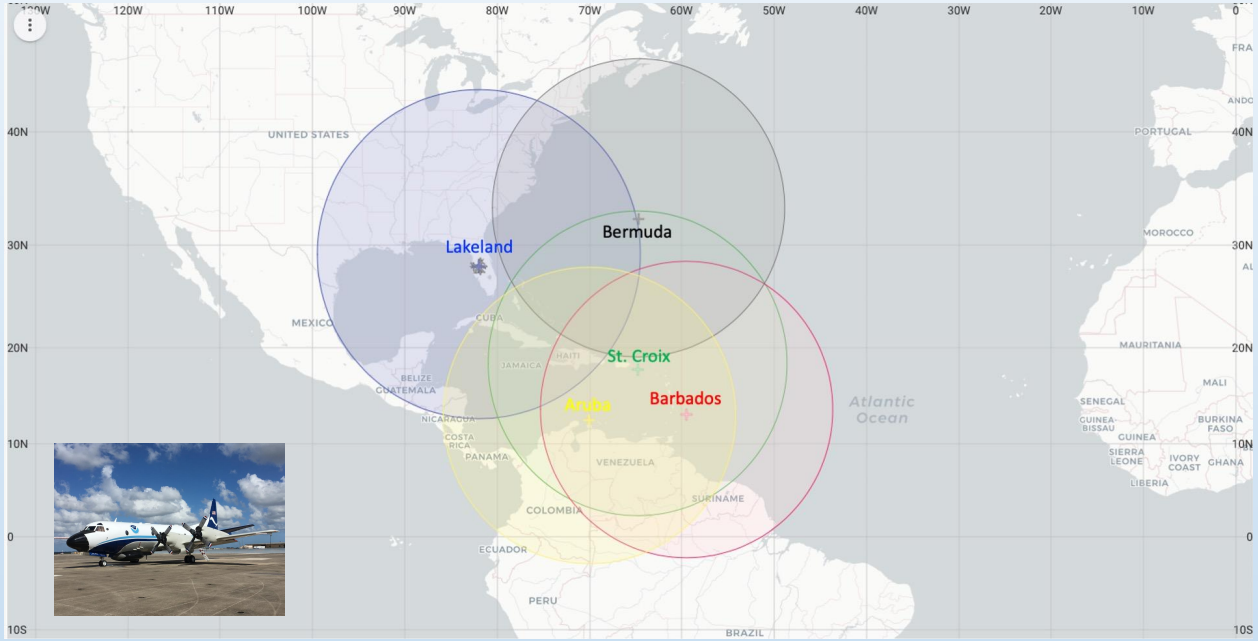
https://www.aoml.noaa.gov/2021-hurricane-field-program-data/

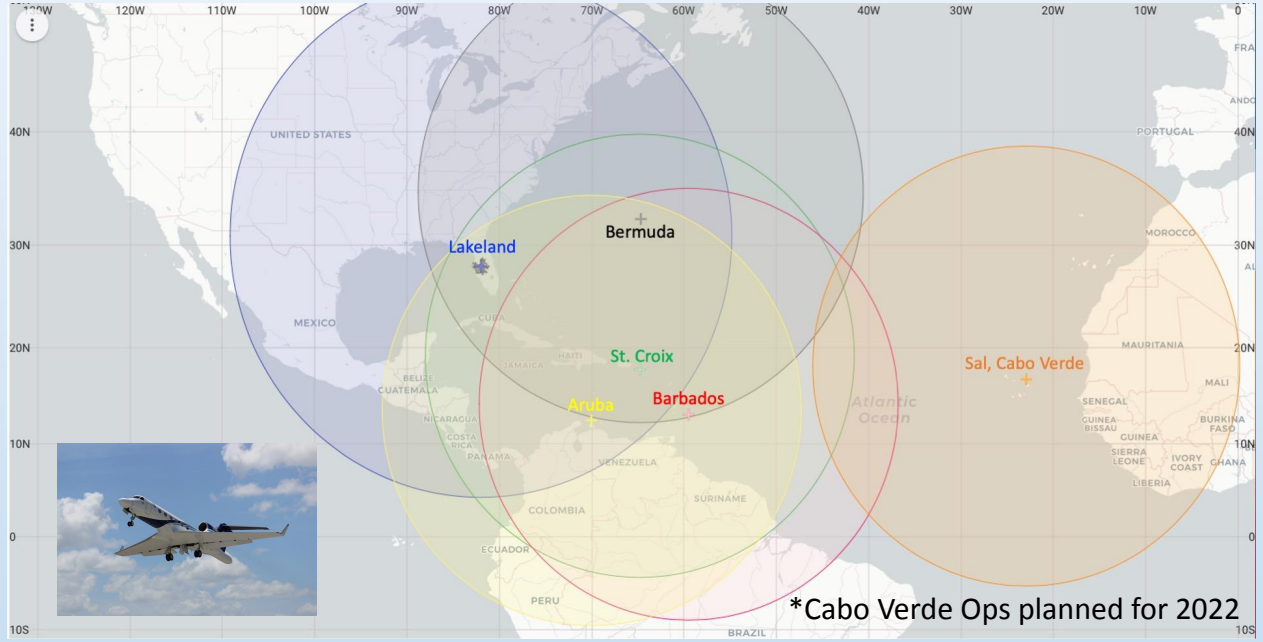


2021 Hurricane Field Program-APHEX

Operations & Logistics

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





*Cabo Verde Ops planned for 2022

2021 Hurricane Field Program-APHEX

HFP Experiments and Modules

GENESIS STAGE

Favorable Air Mass (FAM) Experiment

Precipitation during Formation and Observing its Response across Multiple Scales (PREFORM)

MATURE STAGE

Eye-Eyewall Mixing Module

Gravity Wave Module

NESDIS Ocean Winds

Rainband Complex Module (RCM)

Research In Coordination with Operations Small Unmanned Aircraft Vehicle Experiment (RICO SUAVE)

Surface Wind and Wave Validation Module

Tropical Cyclone Diurnal Cycle Experiment

EARLY STAGE

Analysis of Intensification Processes Experiment (AIPEX)

Convective Burst Structure and Evolution Module (CBM)

Hurricane Boundary Layer Module

Impact of Targeted Observations on Forecasts (ITOFS)

Stratiform Spiral Module (SSM)

END STAGE

Tropical Cyclones at Landfall Experiment

OCEAN OBSERVING

Ocean Survey Experiment

Sustained and Targeted Ocean Observations

SATELLITE VALIDATION

ADM-Aeolus Satellite Validation Module

NESDIS JPSS Satellite Validation Experiment

NASA TROPICS Satellite Validation Module

2021 Hurricane Field Program-APHEX

HFP Experiments and Modules (~85% conducted)

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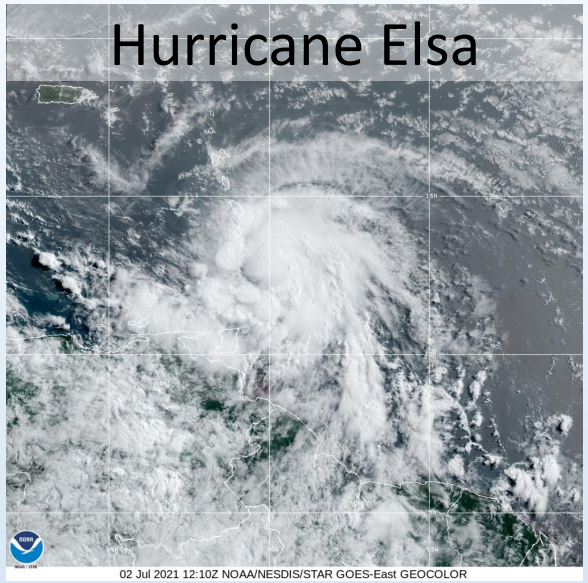
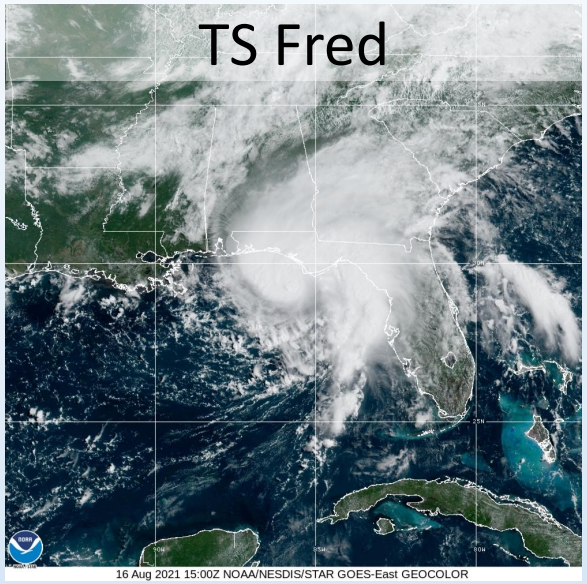
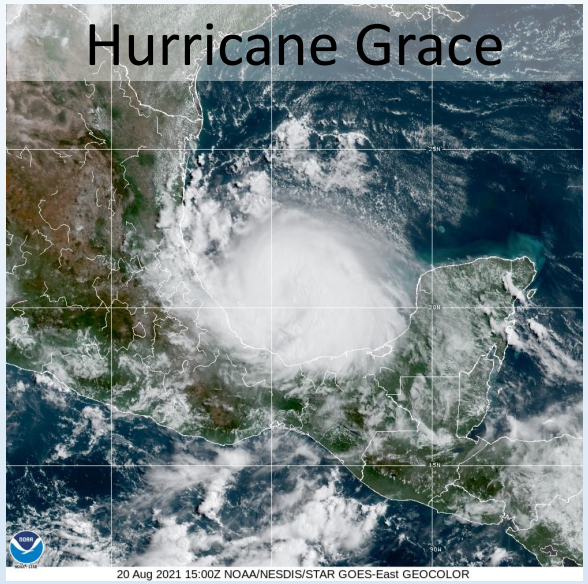
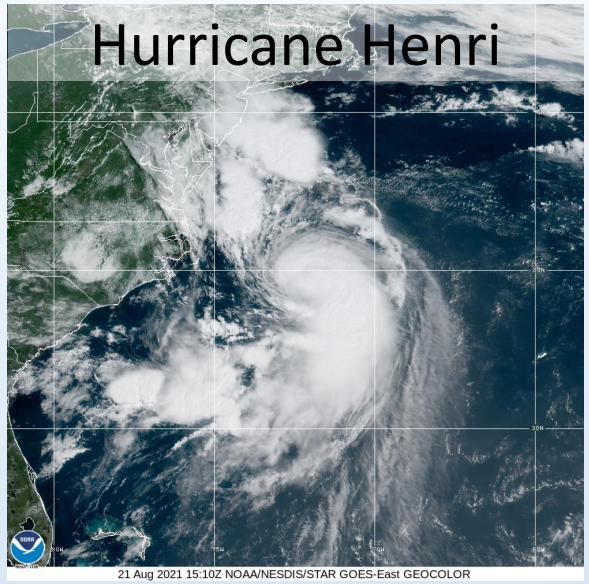
2021 Hurricane Field Program-APHEX

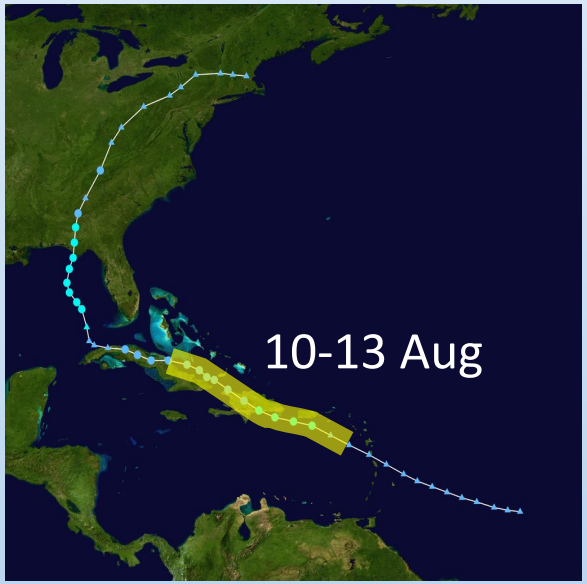
Atlantic Missions Overview

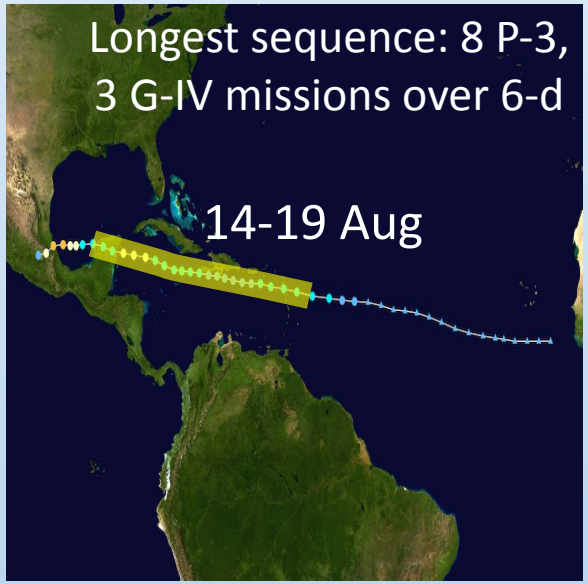


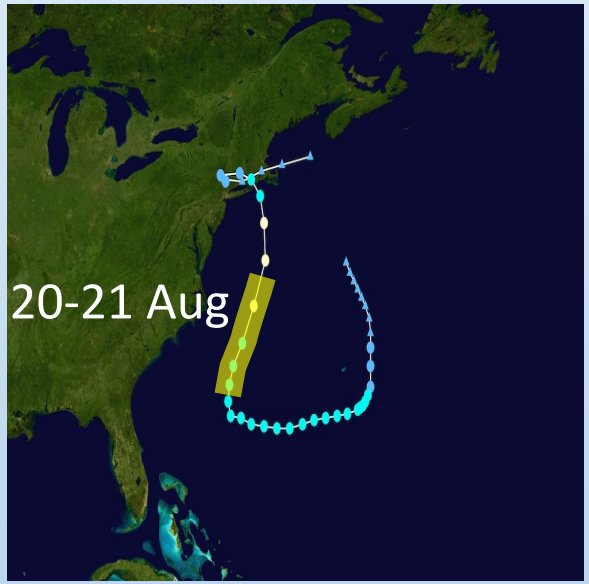






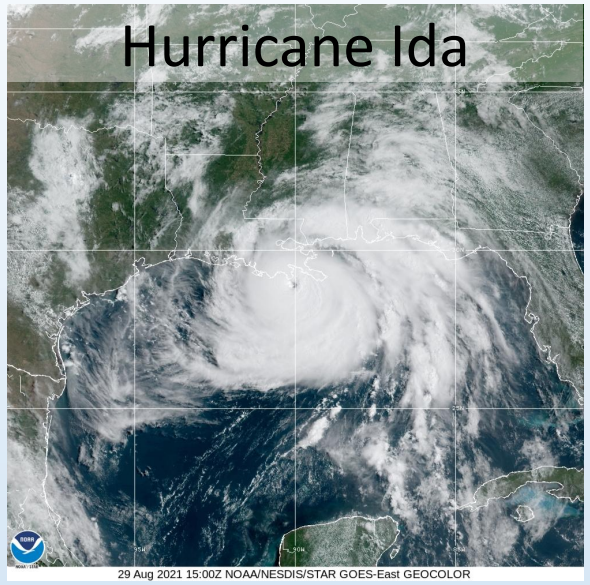


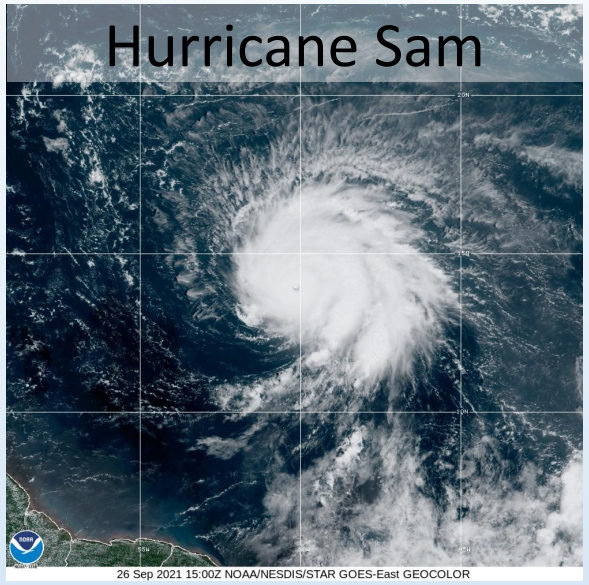


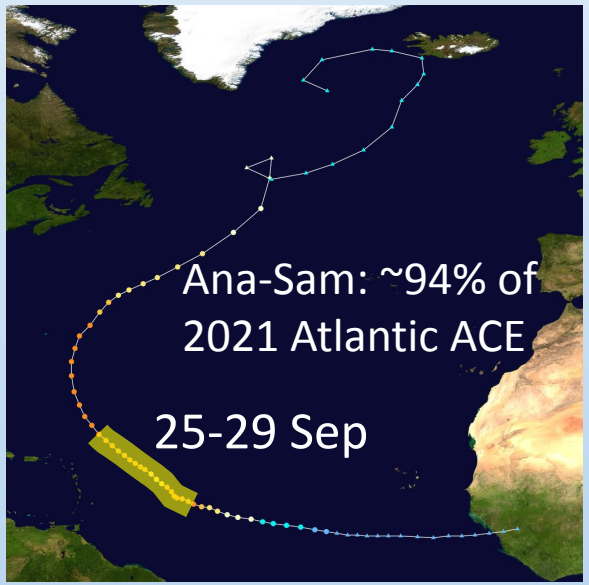


2021 Hurricane Field Program-APHEX

Atlantic Missions Overview

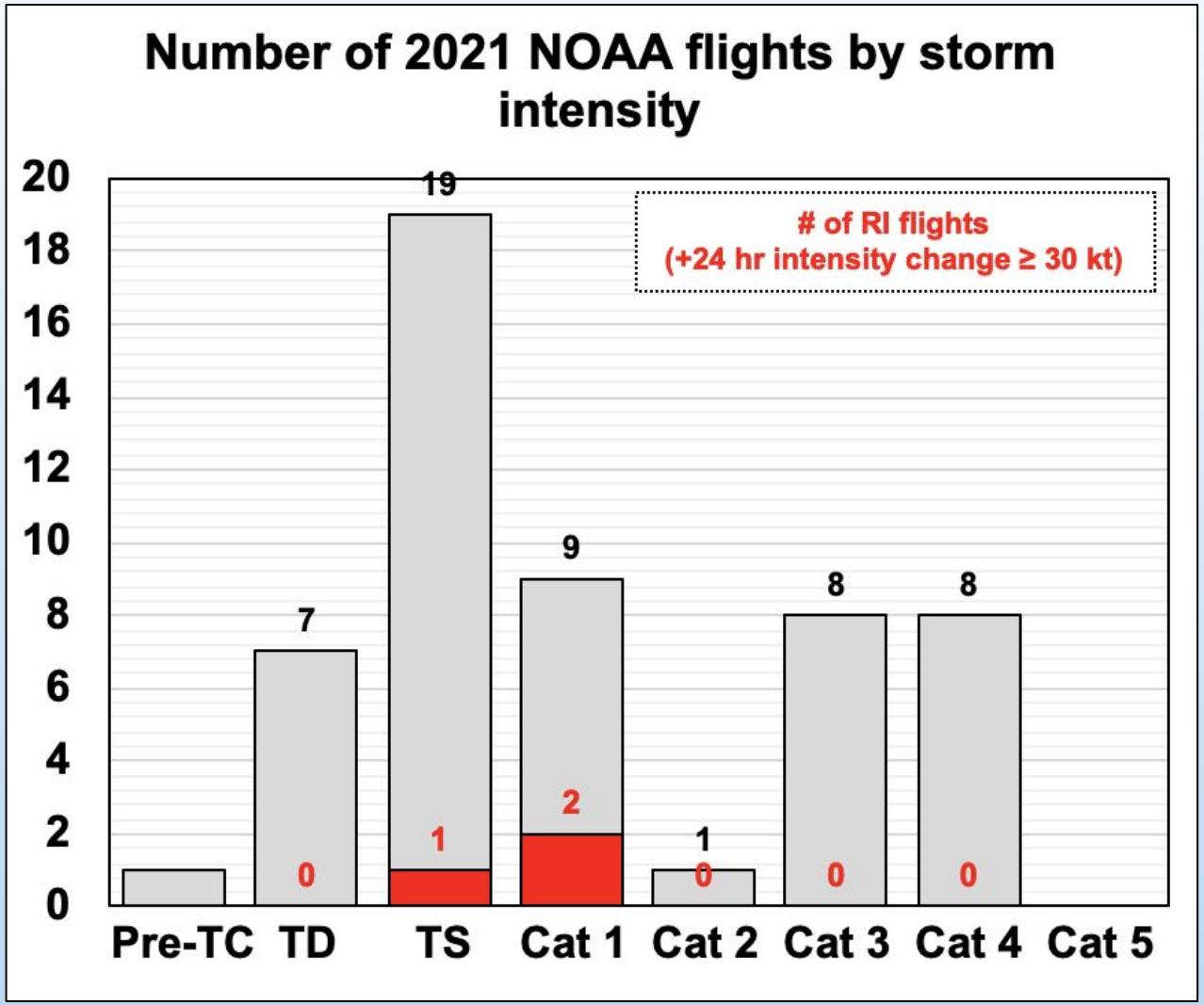






2021 Hurricane Field Program-APHEX

Atlantic Missions Overview



P-3 Highlights:

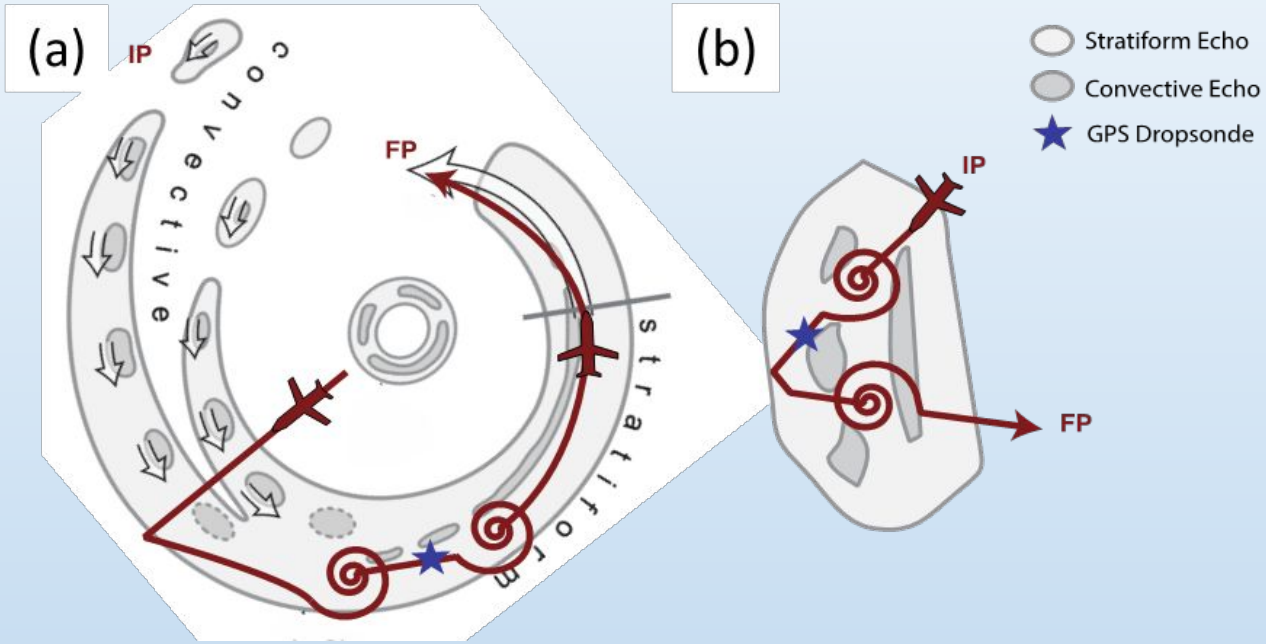
- **50%** of flights flown at **TS intensity or less**
- Only 3 missions with subsequent periods of **RI**

Stratiform Spiral Module (SSM): Early Stage

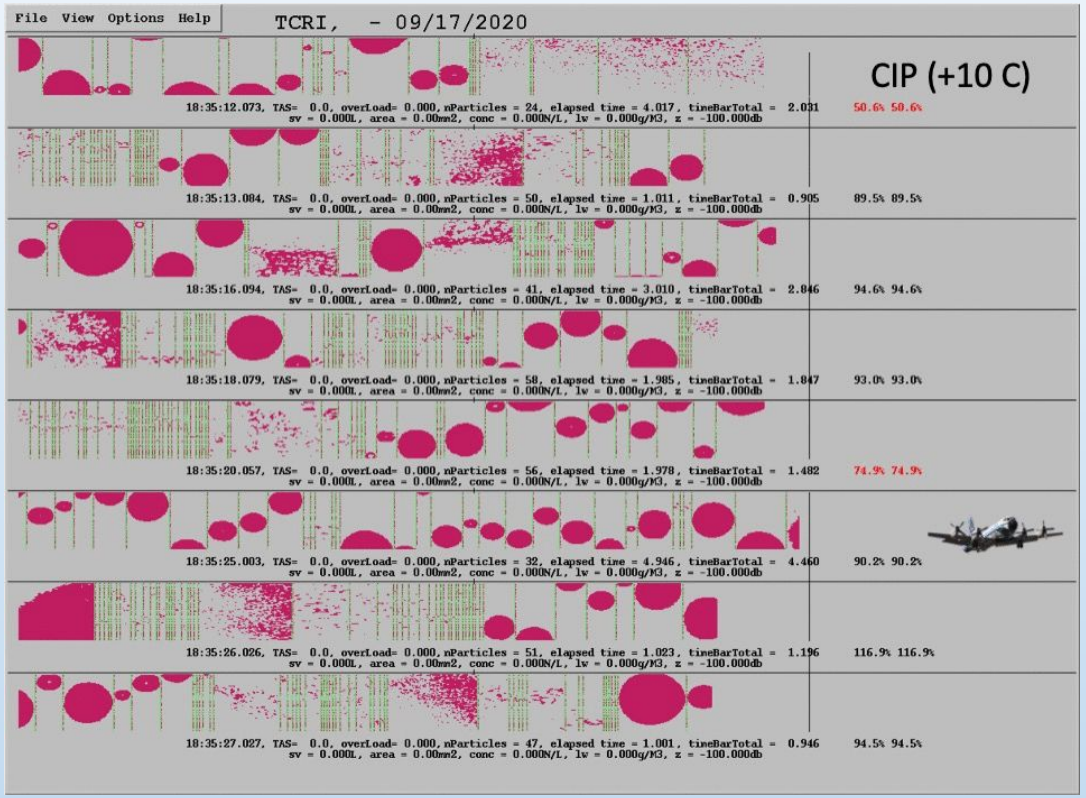
Aircraft: *NOAA P-3s*

Data: *distributions of hydrometeors >> 5 probes sampling from 0.63 um – 6.4 mm*

Goal: *sample distributions and variability of cloud & rain droplets and ice & snow particles in TCs*



P-3 Stratiform Spiral module: a spiral ascent and descent in the stratiform portion of a primary rainband is shown in (a).

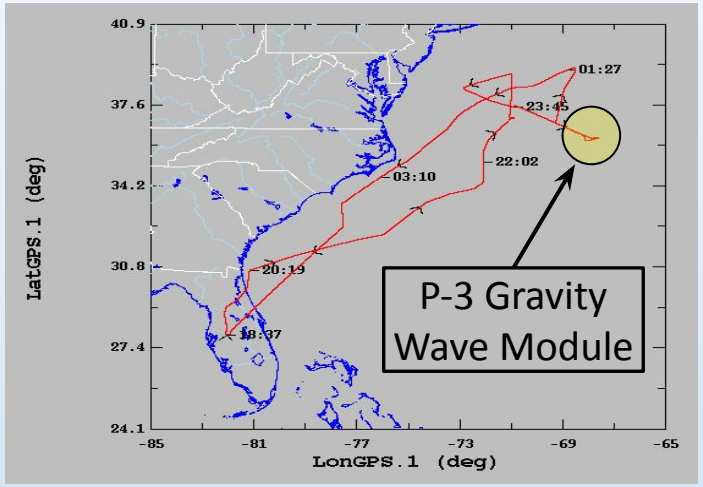


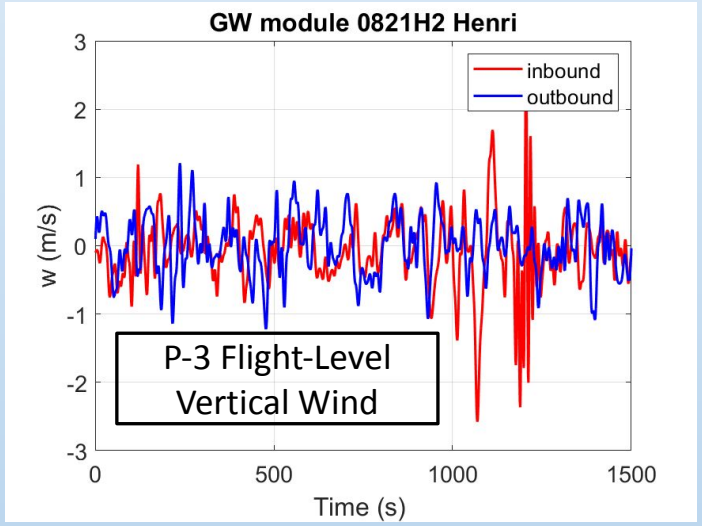
Cloud Imaging Probe (CIP) measurements of rain droplets, ice crystals, and snow. Hydrometeors transition from water to ice as the P-3 flies through and above the freezing level.

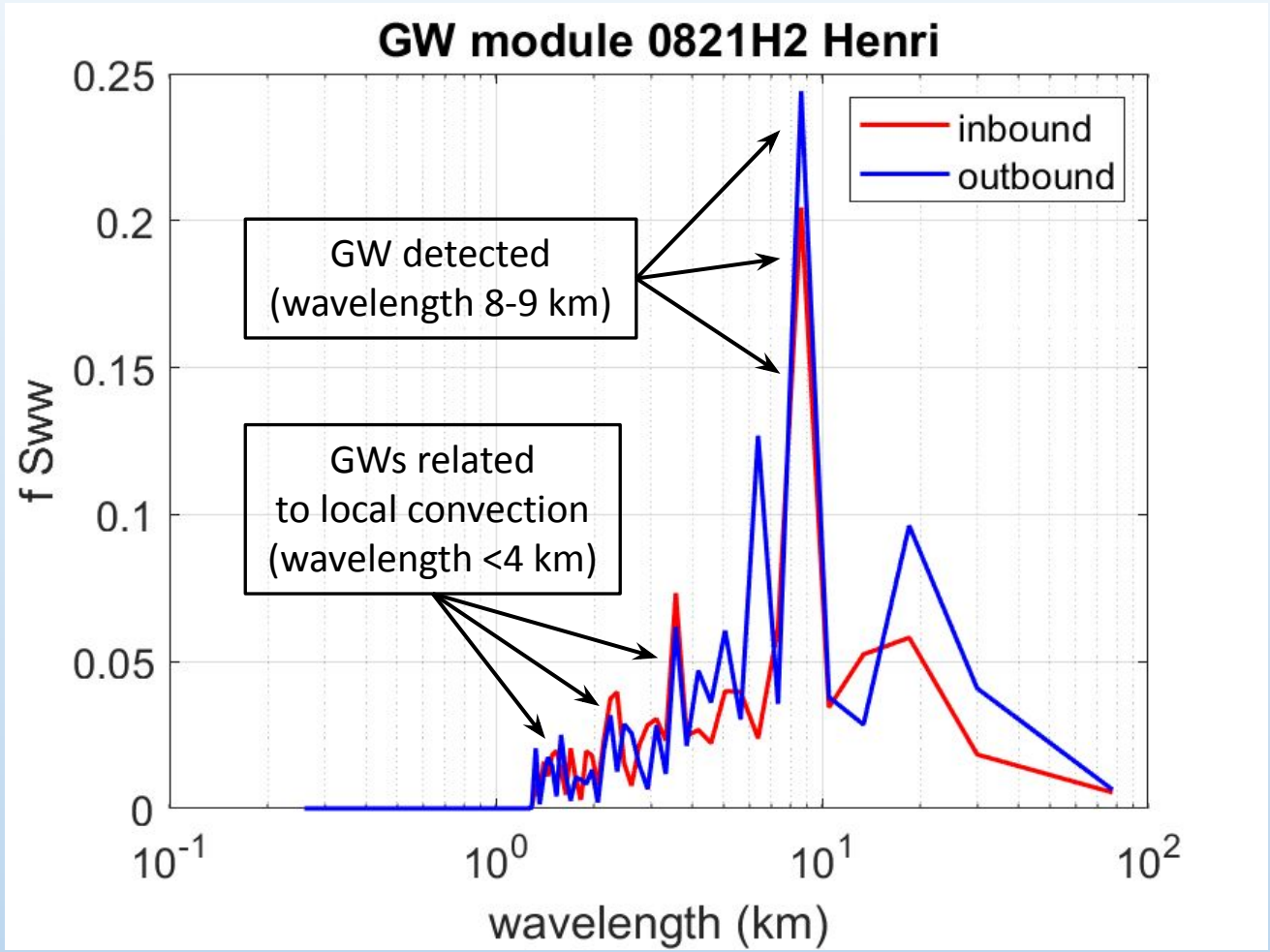
Gravity Wave Module: Mature Stage

Aircraft: *NOAA P-3s*

Goal: *use P-3 flight-level data to examine GWs in early-stage TCs and how they relate to TC intensity*







Jun Zhang (UM/CIMAS – AOML/HRD), Dave Nolan (UM)

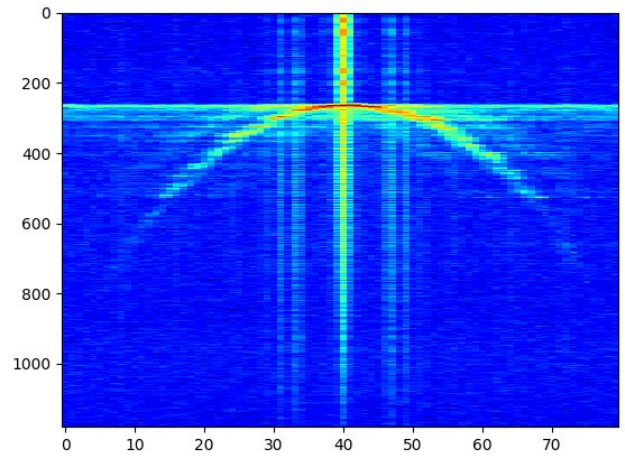
Surface Wind and Wave Validation Module: Mature Stage

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

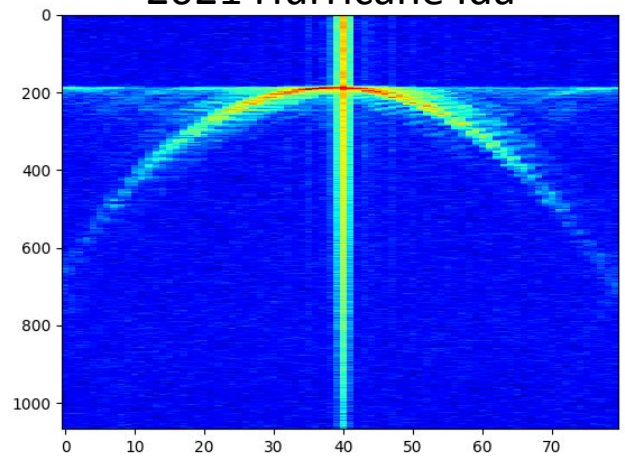
Data: significant wave height, ocean directional wave spectra, & rain rate

2021 upgrade to 12-year old hardware & server software >> "cleaner" radar returns

2019 Hurricane Lorenzo

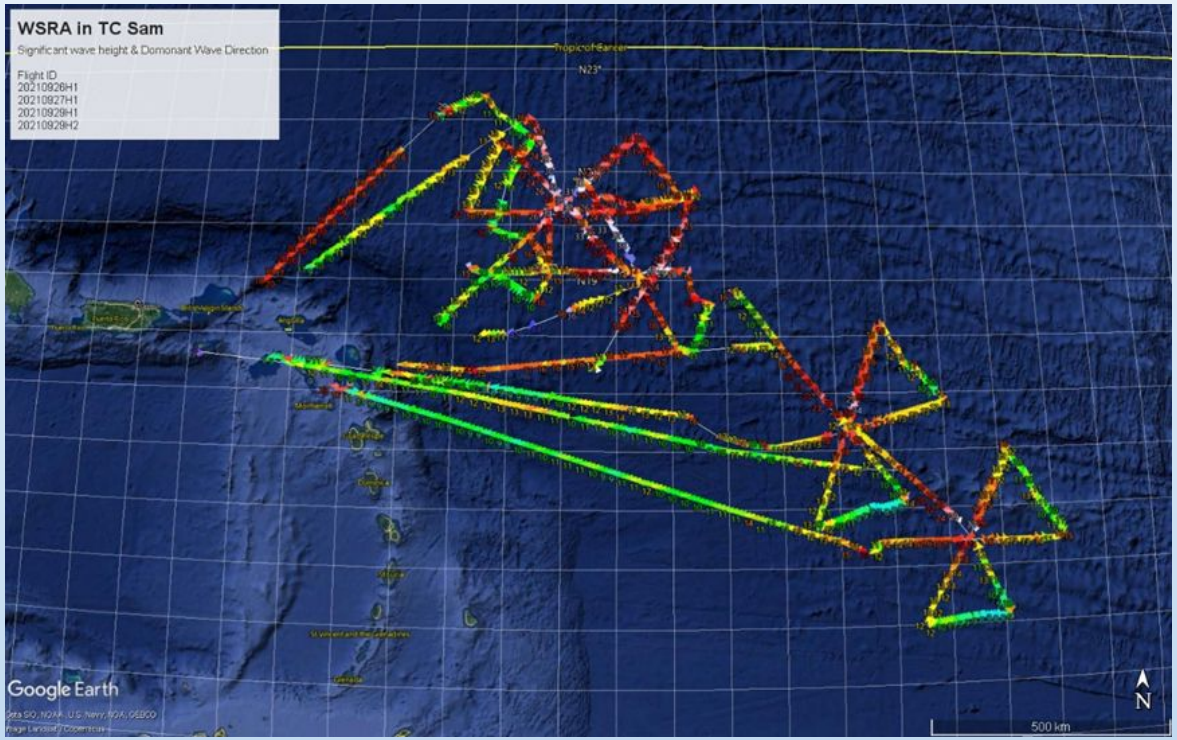


2021 Hurricane Ida



2021 Hurricane Sam

Real-time P-3 SWH data provided to NHC



Ivan PopStefanija (ProSensing)

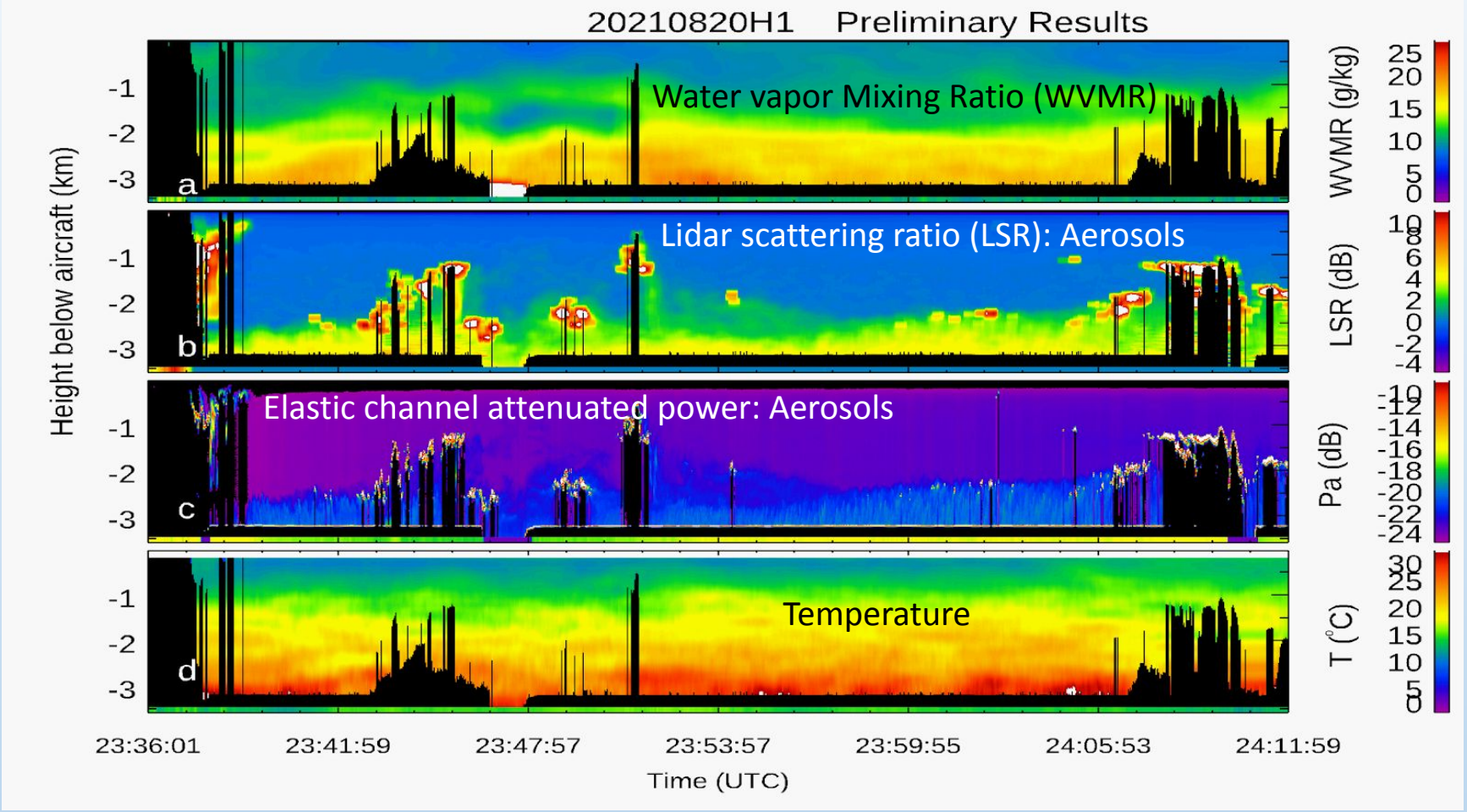
Compact Rotational Raman Lidar (CRL)

Aircraft: NOAA P-3

Data: *3-D temperature, water vapor, clouds, & aerosols below flight level (nadir)*

Resolution: *45 m vertical, 100-1000 m horizontal*

2021 Hurricane Henri



Zhien Wang (U Colorado Boulder)

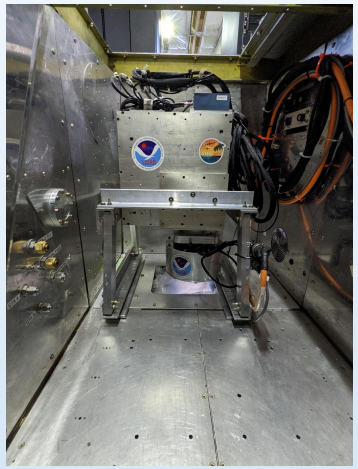
Micro-Pulse Doppler (MicroDop) Lidar, NOAA/CSL

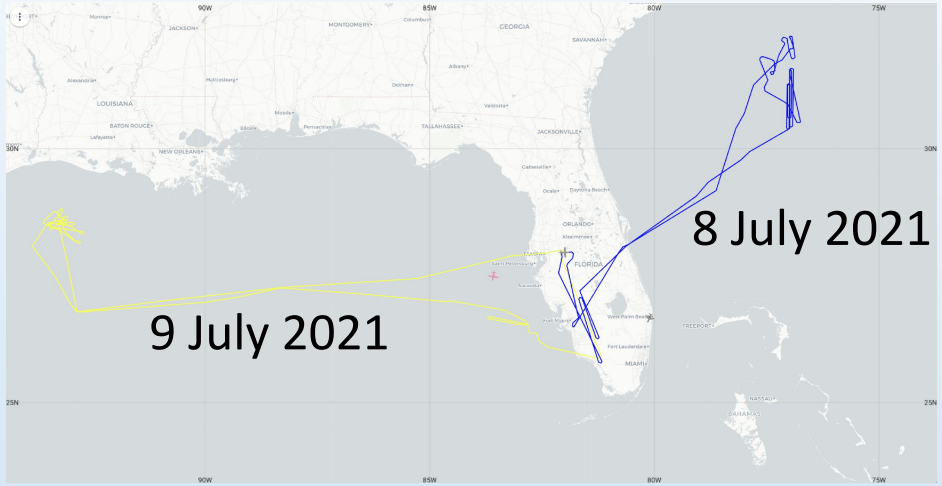
Aircraft: NOAA P-3s (N43)

Data: *3-D winds & aerosol backscatter below flight level*

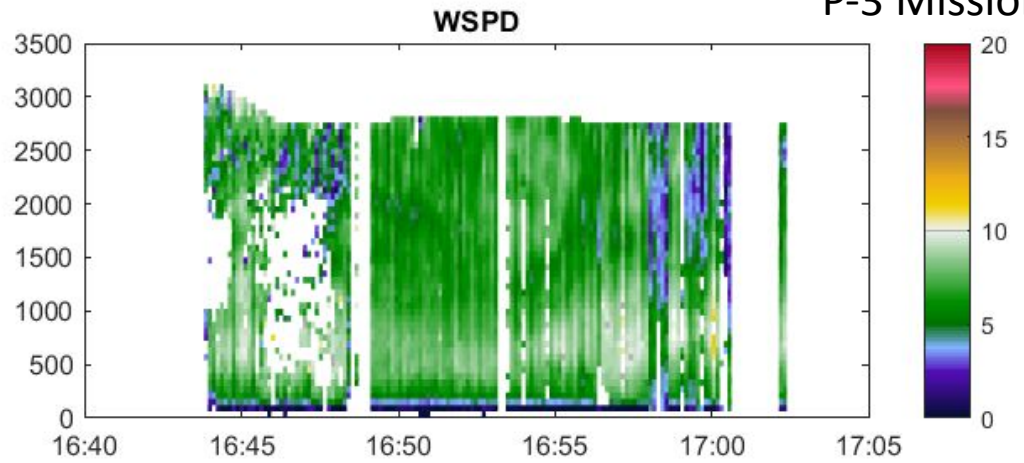
Goal: demonstrate future potential for P-3 MicroDop measurements in the TC environment

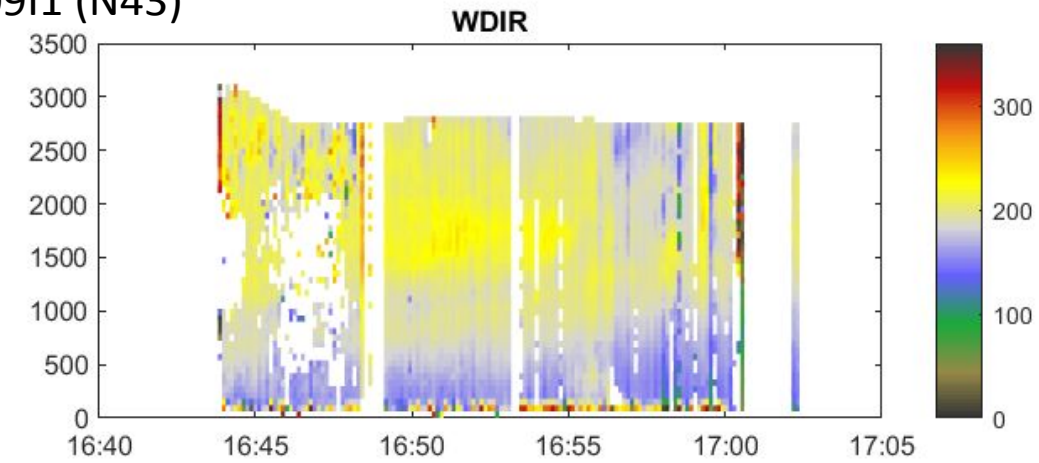
MicroDop Lidar installation on NOAA-43 (P-3)





P-3 Mission 20210709I1 (N43)





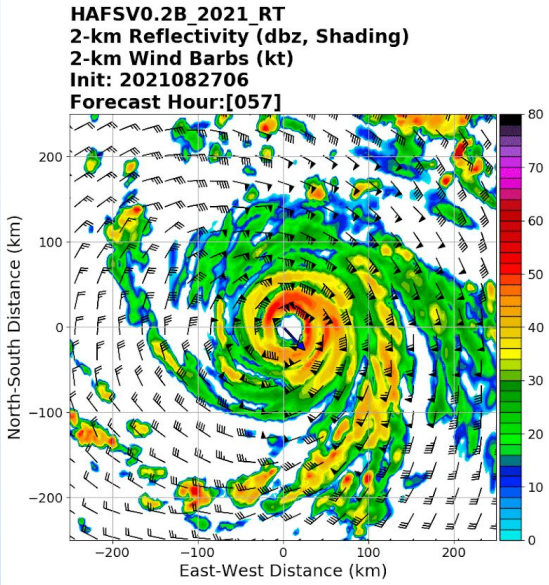
Alan Brewer (NOAA/CSL)

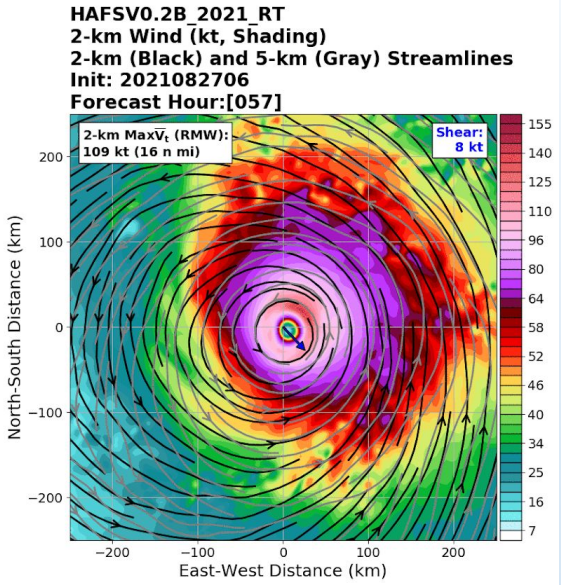
Tail Doppler Radar – Hurricane Ida Model Evaluation

Aircraft: NOAA P-3s, G-IV

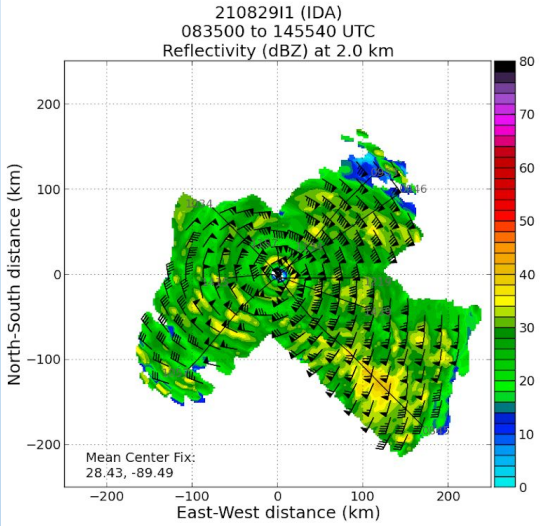
2 km Reflectivity | 2 km Winds

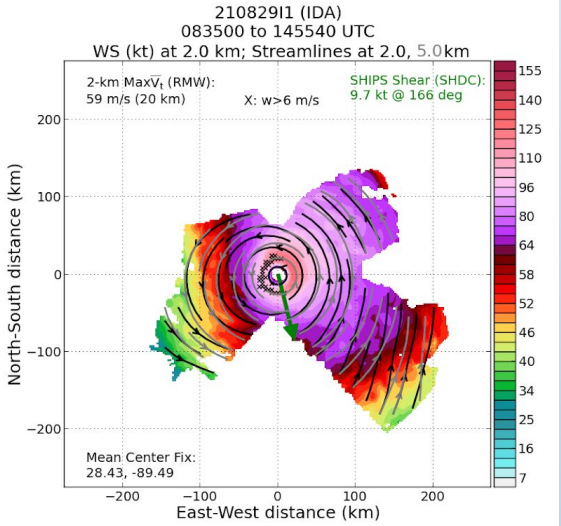
HAFS-B





P-3 TDR





27 August: Flights 1 & 2

- Initial wind + precipitation field >> asymmetric
- HAFS-B represented this well
- Vortex was interacting with Cuba

28 August: Flights 3 & 4

- Precipitation and wind field >> more symmetric
- Inner core was becoming more compact
- HAFS-B reproduced these structures well
- TC becoming primed for RI

29 August: Flight 5

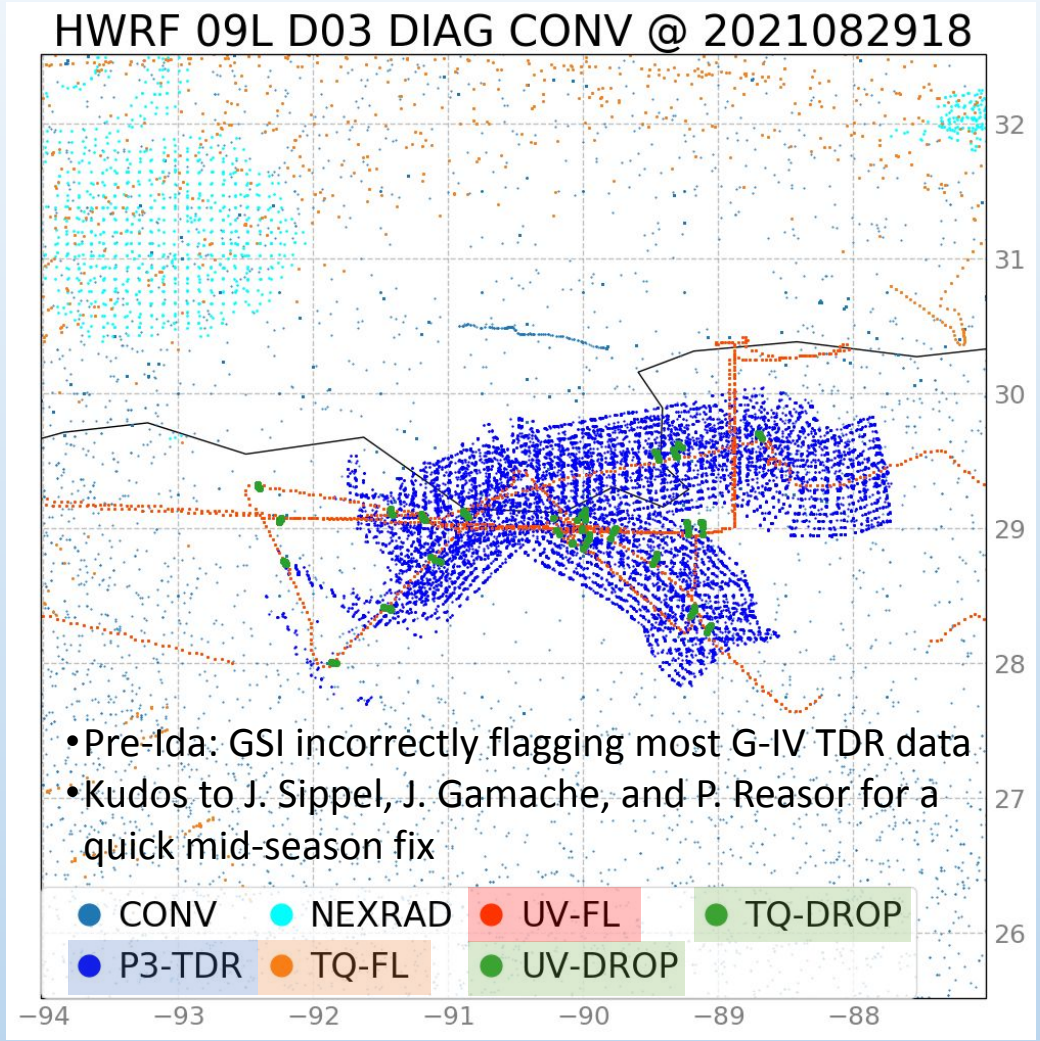
- Extreme wind field post-RI
- Strongest winds in the NE quadrant
- HAFS-B eye >> too large (common model issue)

Andy Hazelton (UM/CIMAS – AOML/HRD)

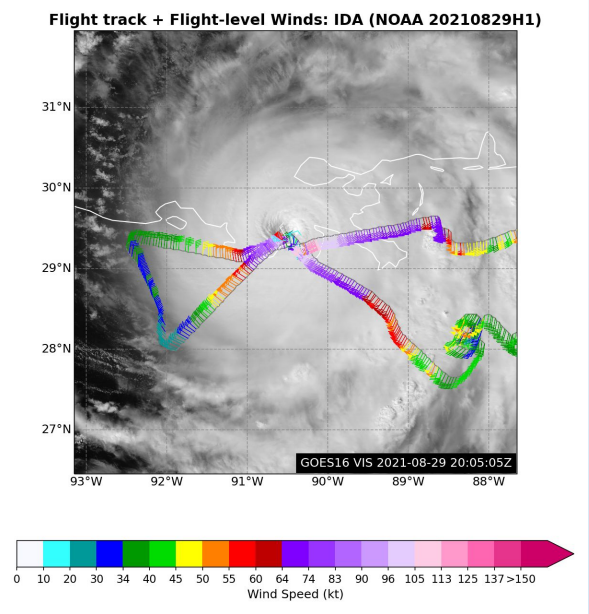
Real-Time Model Assimilation of NOAA Aircraft Data

Observations Assimilated into HWRF

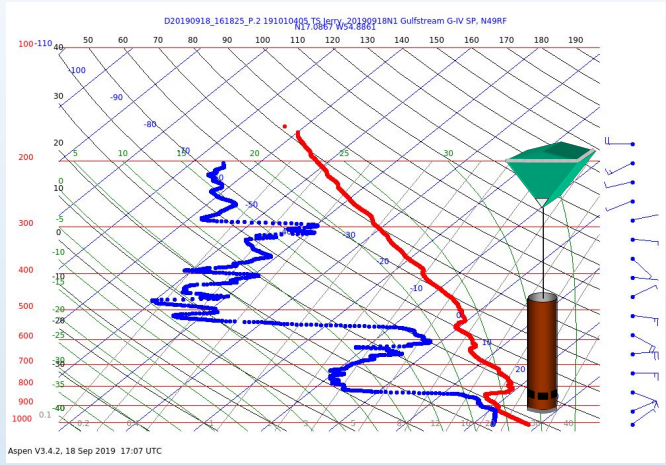
Hurricane Ida: 29 Aug 2021, 18 UTC



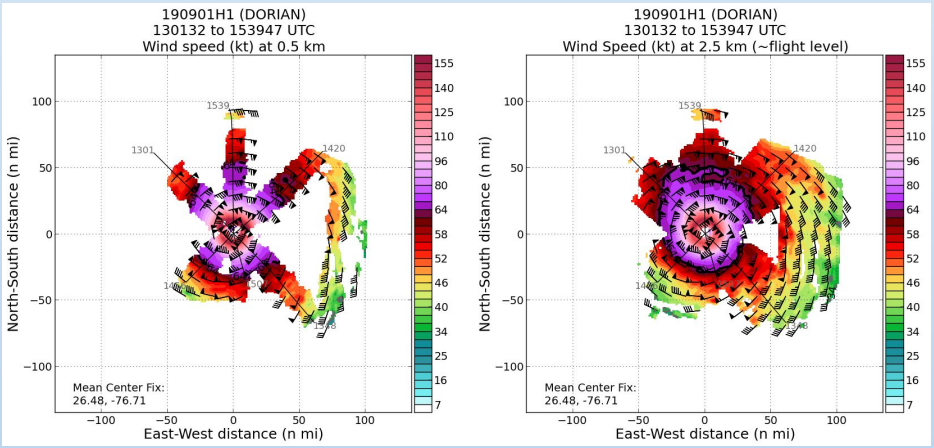
Flight-Level Data



GPS Dropsonde Data



P-3 Tail Doppler Radar (Radial Data)



2022 Hurricane Field Program-APHEX

HRD APHEX Collaborations & Research Priorities

- HFP Plan (Experiments & Modules)
  - Genesis Stage - Early Stage - Mature Stage – End Stage – Ocean Observing – Satellite Validation
- HFP High Priorities:
  1) ONR Tropical Cyclone Rapid Intensification (**TCRI**): July - Nov 2022
     - *Explore the prediction of rapid intensification in TCs (campaign year-3)*
  2) NOAA Impact of Targeted Observations on Forecasts (**ITOFS-East Atlantic**): July-Sep 2022 (Cabo Verde)
     - *TC genesis & ensemble-based targeted observations to improve TC forecasts*
  3) NASA Convective Processes Experiment (**CPEX**): Sep 2022 (DC-8 in Cabo Verde)
     - *Tropical convection, SAL, ITCZ, WAM, AEWs, & the AEJ; Aeolus-ADM satellite validation*
  4) Research In Coordination with Operations Small Uncrewed Air Vehicle Exp (**RICO SUAVE**): July-Nov 2022
     - *Clear air testing in the late spring; HFP missions this summer (P-3-deployed)*
  ~~5) APHEX-West: 1 P-3 deployed to WPAC; study precipitation processes; NSF, ONR, Asia partners~~
- 2022 HRD APHEX HFP Plan
  - Call for submissions March 2nd
  - HFP Plan release: May 2022 on the AOML/HRD website

Questions?