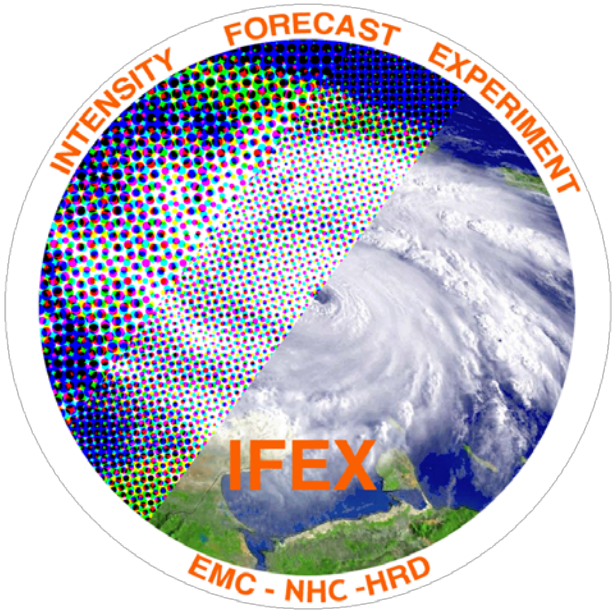
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

HFIP Biweekly Meeting

Jon Zawislak – HFP Director



Overview of HFP-IFEX

IFEX GOALS

- **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 technologies that provide improved real-time monitoring of TC intensity, structure, and environment;

- **Goal 3**: Improve understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle

- **Goal 4:** Transition concepts borne from basic research [G #3], model improvements [G #1], and instrumentation [G #2], to operations

Collaborative effort between research (AOML/HRD and Academia) and operations (EMC, NHC, CPHC, NESDIS)

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

2018 HFP-IFEX Experiments

Genesis Stage
Ghassan Alaka and Jon Zawislak

Early Stage
Rob Rogers and Jon Zawislak

Mature Stage
Paul Reasor and Jason Dunion

End Stage
Sim Aberson and John Kaplan

Synoptic Flow
Jason Dunion and Sim Aberson

Ocean Survey
Jun Zhang and Nick Shay

SFMR
Heather Holbach

Tail Doppler Radar (TDR)
Paul Reasor and John Gamache

Instrumentation

- **Tail Doppler radar, TDR** [P-3 and G-IV]
  - **Transmit data in real-time to EMC and AWIPS-II from both aircraft**
  - Wind and reflectivity analyses produced in real-time
- **Lower fuselage, LF** [P-3]
  - **Multi-mode Radar (MMR)**
- **Stepped Frequency Microwave Radiometer, SFMR** [P-3 and G-IV]
  - **2nd SFMR on-board to begin the season (H-pol, V-pol)**
- **Doppler Wind LIDAR, DWL** [P-3]
  - First half of season with WSRA

Instrumentation

- **Imaging Wind and Rain Airborne Profiler, IWRAP** [P-3]
  - Second half of season
- **Wide Swath Radar Altimeter, WSRA** [P-3]
  - First half of the season with DWL
- **Compact rotational Raman LIDAR, CRL** [P-3]
  - Fine-scale temperature, water vapor, and aerosol measurements within 2 km below the aircraft
  - Clear of clouds, but possible in rain
- **Coyote** [P-3]
  - **Possible activity this season**

Genesis Stage Experiment

Science Objectives and Goals

1. ***Precipitation Mode (PMODE):*** To investigate the **precipitation modes** that are prevalent during the genesis stage and the response of the vortex to that precipitation organization [*IFEX Goal 3*]

2. ***Pouch:*** To investigate the **importance of the pouch**, including the shear sheath, which tends to indicate a tropical storm, and its **relationship to a low-level circulation and organized deep convection** with the pouch [*IFEX Goal 3*]

3. ***Favorable Air Mass (FAM):*** To investigate the **favorability in both dynamics (e.g., vertical wind shear) and thermodynamics (e.g., moisture)** for tropical cyclogenesis in the environment near a pre-TD, especially the **downstream environment** [*IFEX Goal 3*]

Science Objectives and Goals

1. ***Analysis of Intensity Change Processes Experiment, AIPEX:*** 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** [*IFEX Goals 1, 3*]

2. ***Convective Burst Structure and Evolution Module, CBM:*** 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 [*IFEX Goals 1, 3*]
3. ***Arc Cloud Module:*** 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 [*IFEX Goals 1, 3*]

Mature Stage Experiment

Science Objectives and Goals

1. ***Internal Processes***: Collect observations targeted at better understanding ***internal processes*** **contributing to mature hurricane structure and intensity change**. These processes include mixing between the eye and eyewall, secondary eyewall formation, the TC diurnal cycle, and gravity waves that emanate from the TC inner core [IFEX Goal 3]

2. ***Environment Interaction***: Collect observations targeted at **better understanding the response of mature hurricanes to their changing environment**, including changes in vertical wind shear and underlying oceanic conditions [IFEX Goal 3]

3. ***New Observing Systems (NOS)***: Test **new (or improved) technologies with the potential to fill gaps, both spatially and temporally, in the existing suite of airborne measurements in mature hurricanes**. These measurements include improved three-dimensional representation of the hurricane wind field, more spatially dense thermodynamic sampling of the boundary layer, and more accurate measurements of ocean surface winds [IFEX Goal 2]

Synoptic Flow Experiment

Science Objectives and Goals

Investigate **new strategies for optimizing the use of aircraft observations** to improve numerical forecasts of TC track, intensity, and structure [IFEX Goal 1]

Hypotheses

New, more **advanced targeting techniques that optimize aircraft sampling of the TC environment** can improve numerical forecasts of TC track, intensity, and structure, and could potentially be transitioned to operations

Ocean Survey Experiment

Science Objectives and Goals

1. ***TC-Ocean Interaction***: Obtain **observations on TC-Ocean interaction to improve flux parameterizations and to test coupled TC models** [*IFEX Goals 1, 3*]

- Measure the two-dimensional SST cooling, air temperature, humidity and wind fields beneath the storm and thereby deduce the effect of the ocean cooling on ocean enthalpy flux to the storm;
- Measure the three-dimensional temperature, salinity and velocity structure of the ocean beneath the storm and use this to deduce the mechanisms and entrainment rates (shear-induced) of ocean cooling;
- Conduct these measurements at several stages along the storm evolution therefore investigating the role of pre-existing ocean variability;
- Use observational data collected in this experiment to assess the accuracy of the oceanic component of the coupled hurricane model system.

SFMR Experiment

Science Objectives and Goals

1. ***SFMR High-incidence Angle Measurements (HiSFMR)*:** Collect high-incidence angle (off-nadir) SFMR data in regions with different wind speeds (≥ 15 m/s), rain rates, storm relative quadrants, and radii from the storm center [*IFEX Goal 2*]

   ➢ Goal: Obtain **SFMR measurements when the aircraft exceeds the current pitch** and/or roll thresholds. These measurements will also aid the continued development of HiRAD.

2. ***G-IV SFMR Validation*:** Sample the wind speed and rain rate from the G-IV SFMR in coordination with the P-3 SFMR [*IFEX Goal 2*]

   ➢ Goal: Develop a **modified algorithm to obtain wind speed and rain rate measurements from the G-IV SFMR**

TDR Experiment

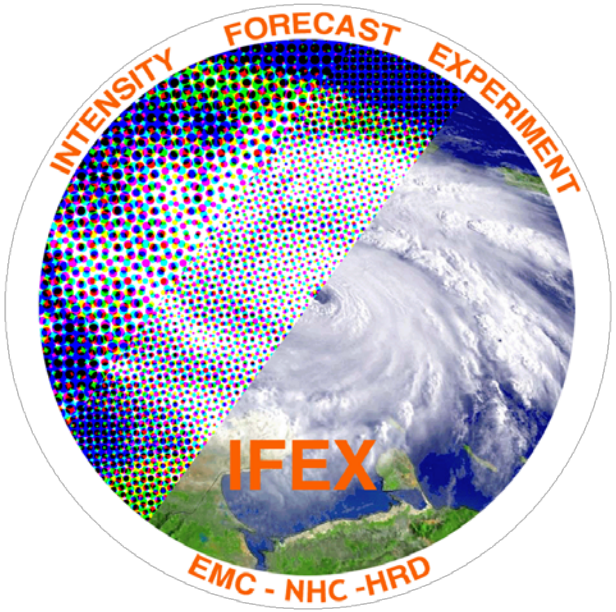
Science Objectives and Goals

1. ***Tail Doppler Radar, TDR*: Gather airborne Tail Doppler Radar wind measurements that permit an accurate initialization of HWRF, and also provide three-dimensional wind analyses for forecasters** [*IFEX Goals 1, 3*]

- [EMC] **Obtain the 3-D wind field from airborne Doppler data** every 6 h to provide an initialization of HWRF through assimilation every 6 h
- Maximum possible rotation of missions is two per day or every 12 h
- Organizing tropical depression or weak tropical storm, to increase the observations available in these systems (preference for azimuthal coverage)
- In hurricanes, wavenumber-0 and -1 (out to largest radius possible)
- Dropsondes should be deployed during radial penetrations
- **Transmit G-IV data in real-time possible this season (INE correction)**
- **Production of real-time wind and reflectivity analyses**

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL03/Chris



2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)
AL03/Chris

July 9-10

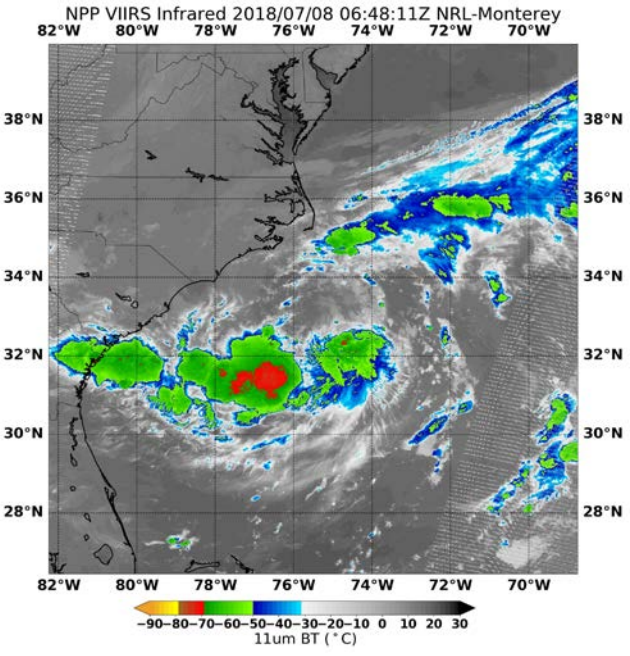
4 EMC-tasked Missions

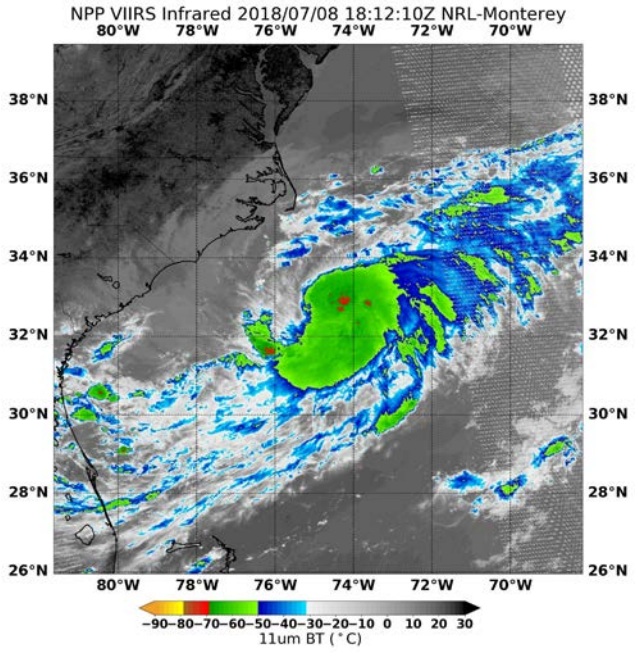
30 P-3 Flight Hours

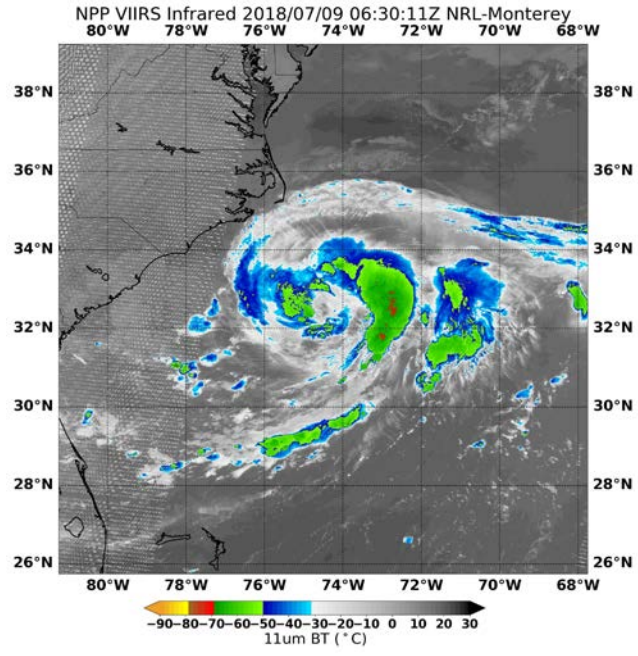
55 Drops

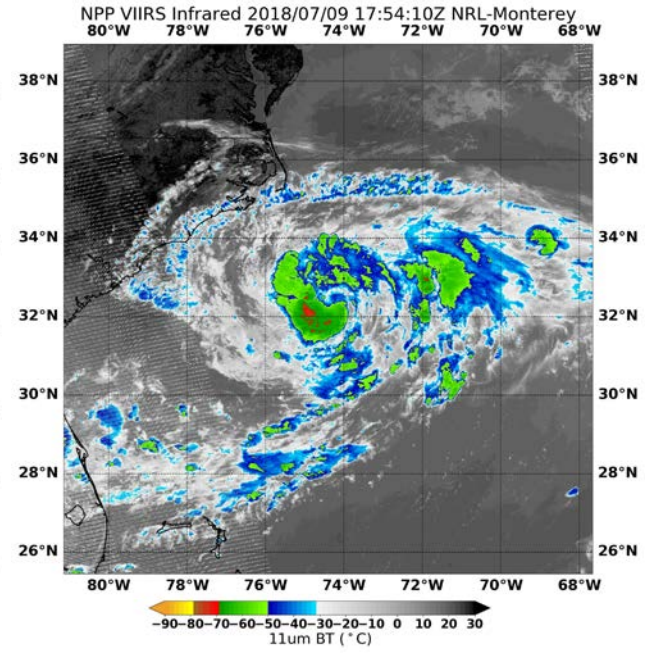
- EMC-tasked data collection targeting 00 UTC and 12 UTC HWRF cycles
- Test assimilation after H218 implementation
- TD 3 / Tropical Storm Chris as it was slowly intensifying off the coast of the Carolinas
- Shakedown for the season

- 180708H1
- 180708H2
- 180709H1
- 180709H2









AL03/Chris

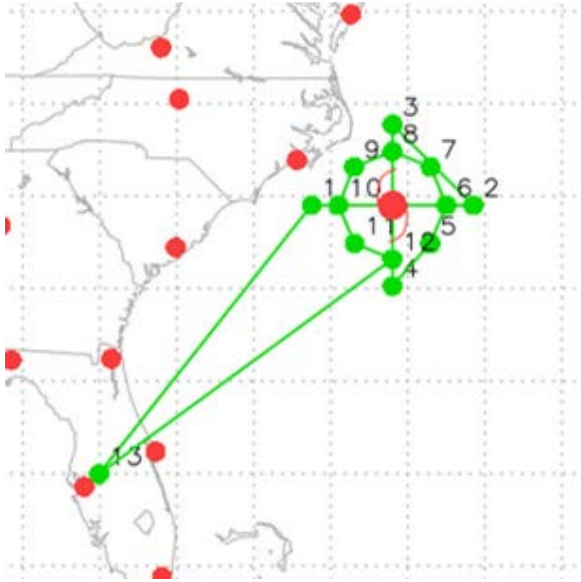
Mission Highlights:

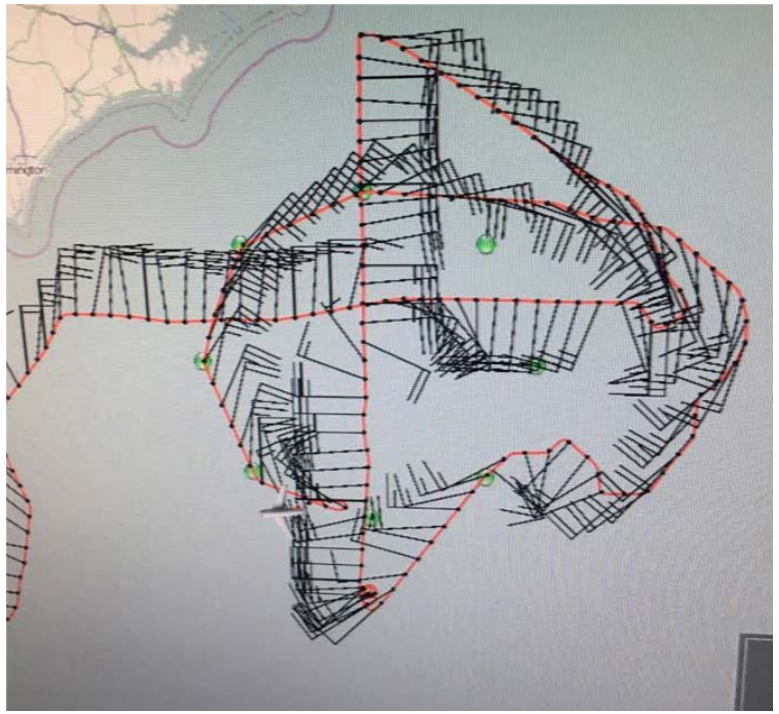
- All **TDR data transmitted successfully to EMC / visualized in AWIPS-II at NHC**
- No DWL; WSRA collected on each mission, though hardware difficulties led to some outages on 180709H1 and 180709H2
- Progress was made on the implementation of new Multi-mode Radar (MMR) (replacement for the lower fuselage)
- **Research-worthy case within the "Early Stage Experiment", Objective #1: AIPEX**
- ***Partial high-altitude circumnavigation*** accomplished, some of it in precipitation
- ***Slowly intensifying storm in moderate shear*** (no motion to worry about!)

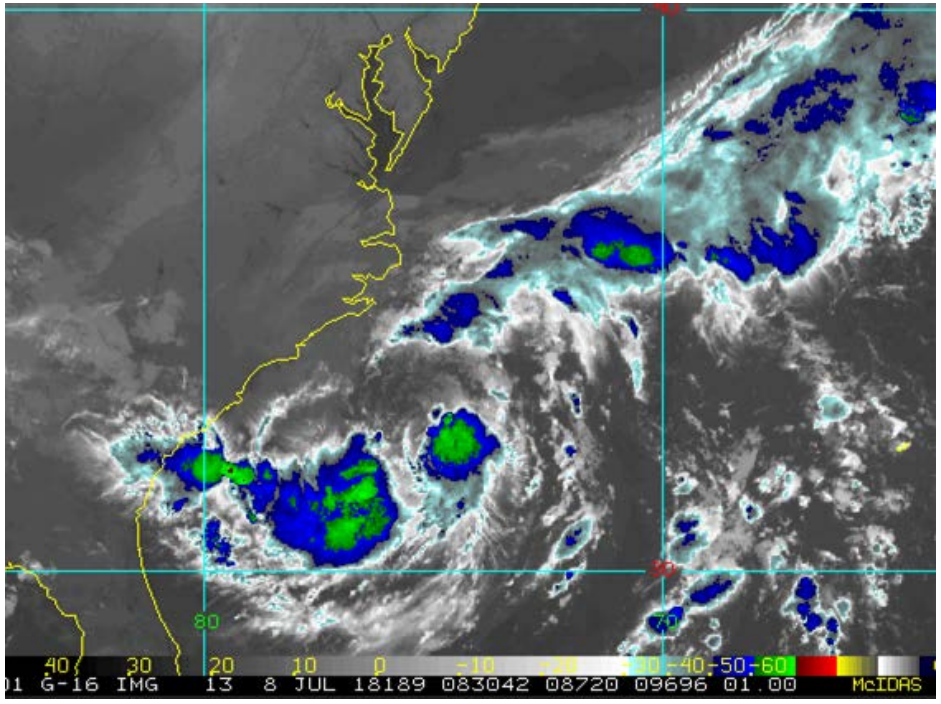
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL03/Chris

Mission 1: 20180708H1 (EMC Tasked / Early Stage Experiment)



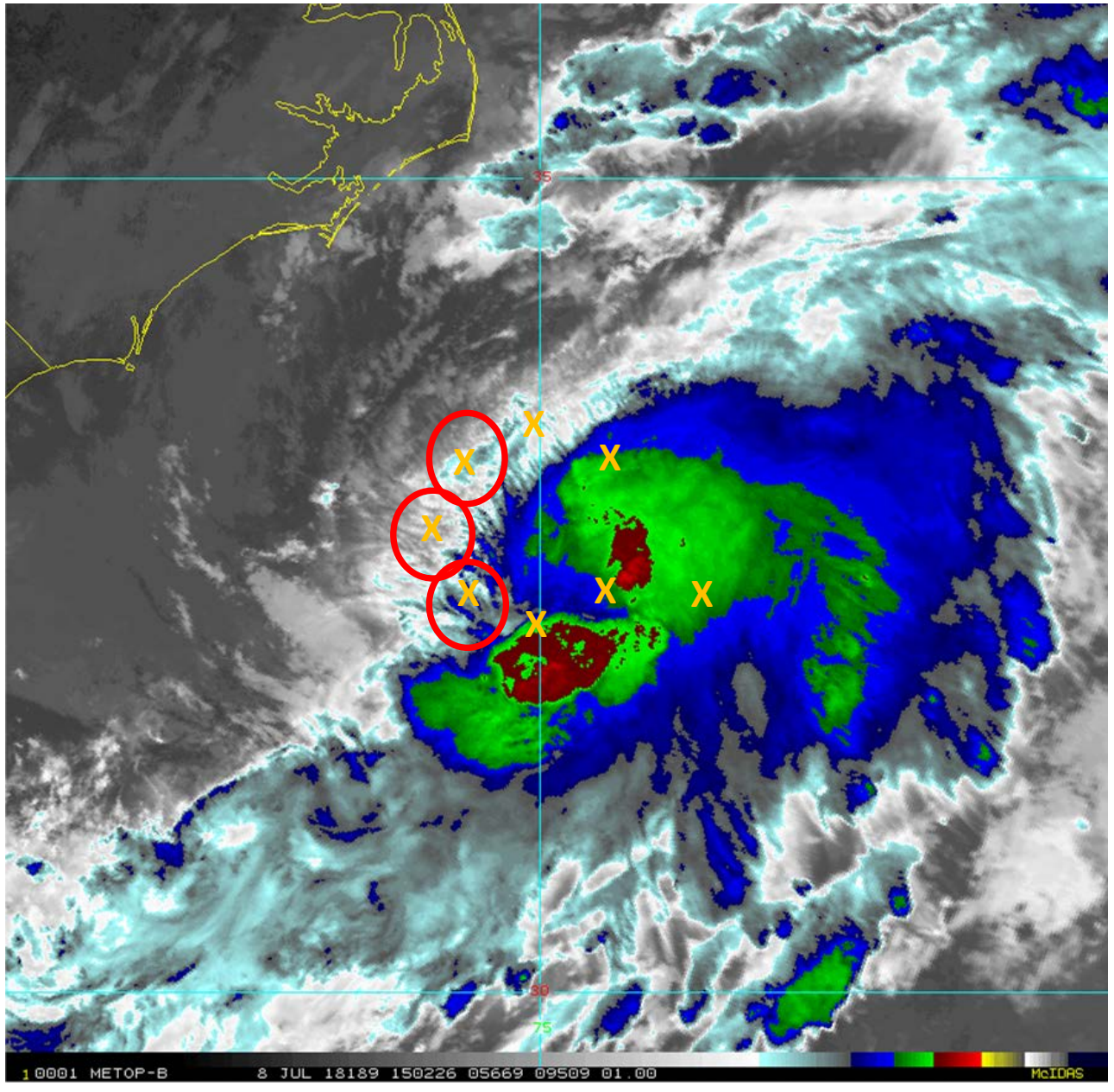


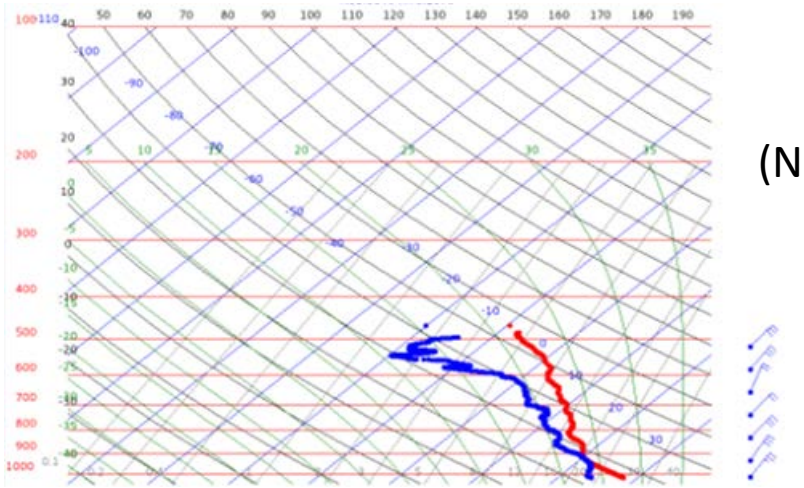


Storm is experiencing moderate vertical wind shear

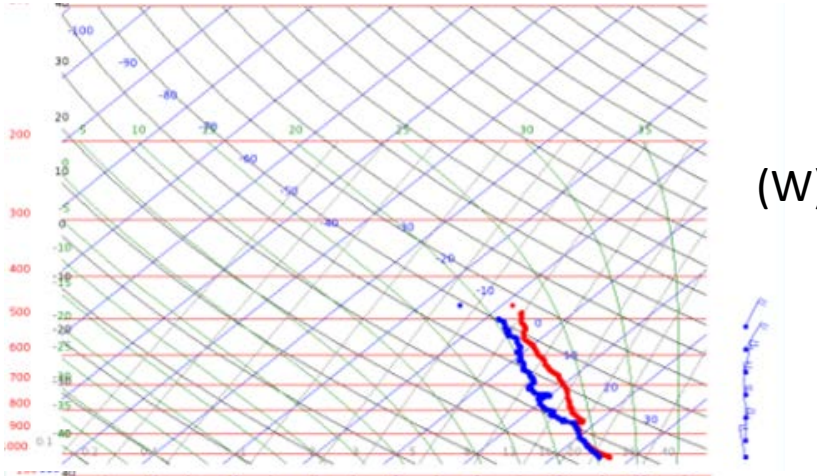
Flight pattern plan: Figure-4 @ 8kft with endpoints and 1 center sonde followed by **circumnavigation @ 20kft with sondes every 45° (storm relative) along 70 nautical mi. radius**

Latest TC specs at takeoff time
(TEAL): Vmax: 40 kts; **Motion: 0 kts**
SHIPS VWS: 15 kts @ 327

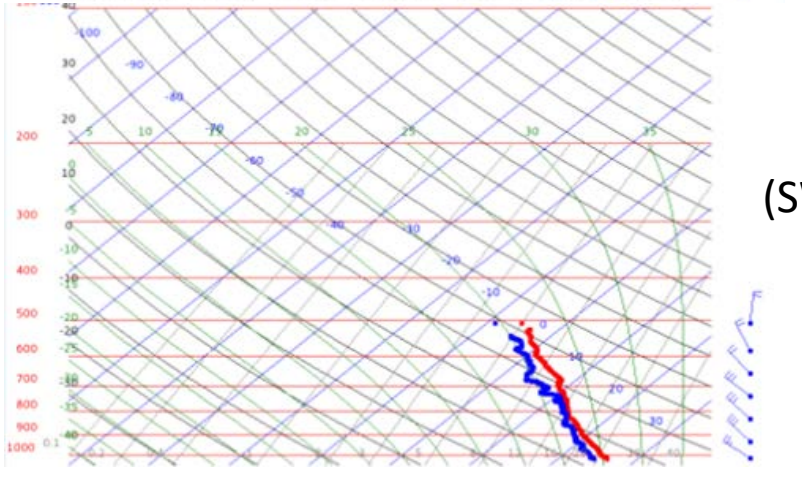




(NW) 1456 UTC



(W) 1506 UTC



(SW) 1516 UTC

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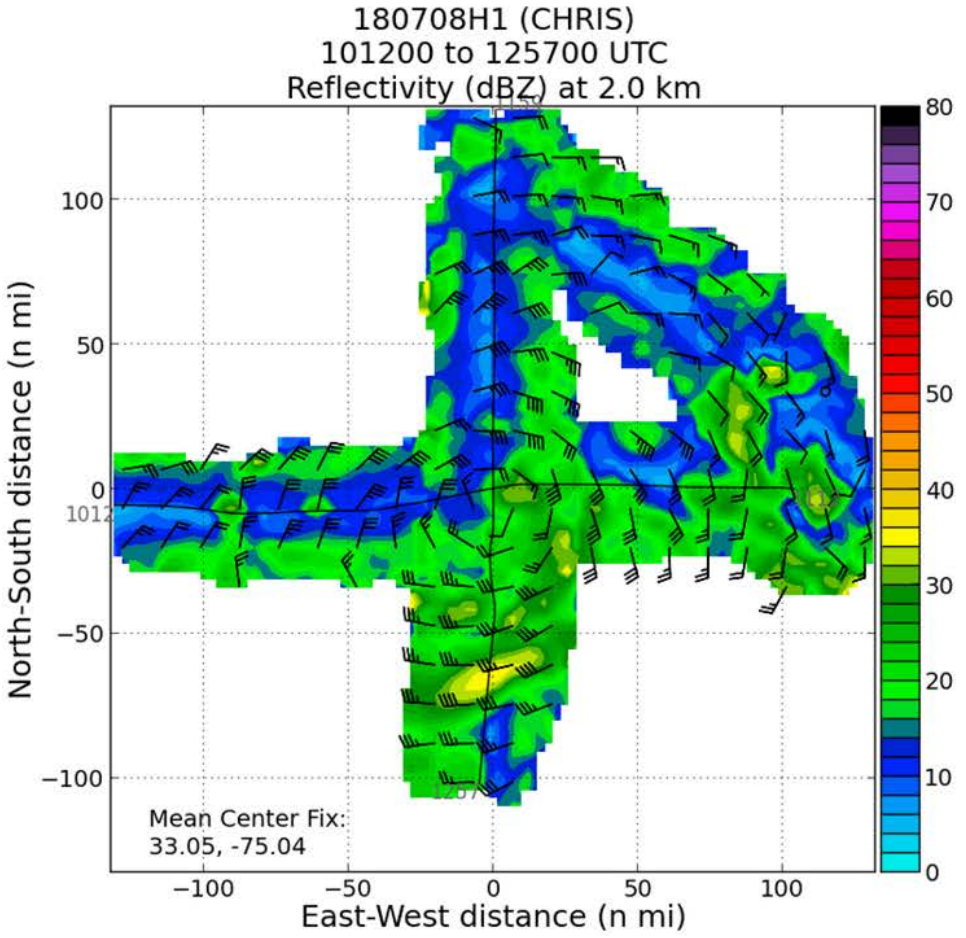
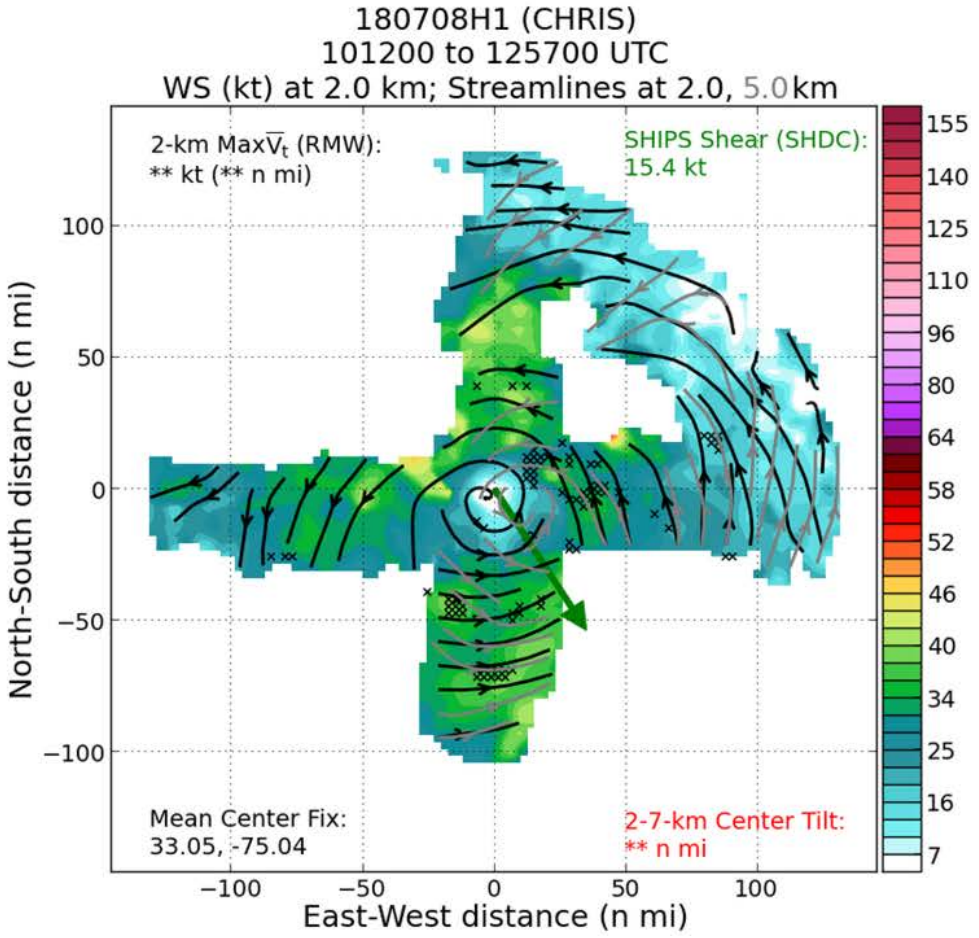
Intensity Forecast Experiment (IFEX)

AL03/Chris

Mission 1: 20180708H1 (EMC Tasked / Early Stage Experiment)

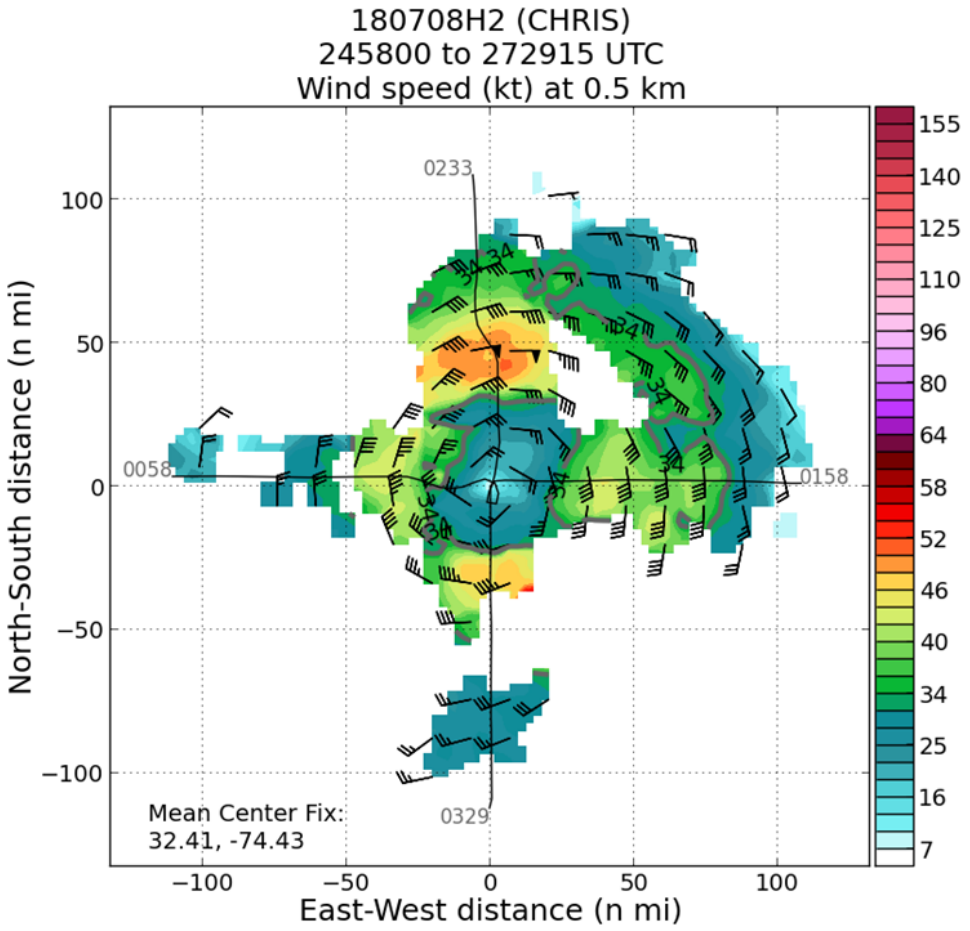


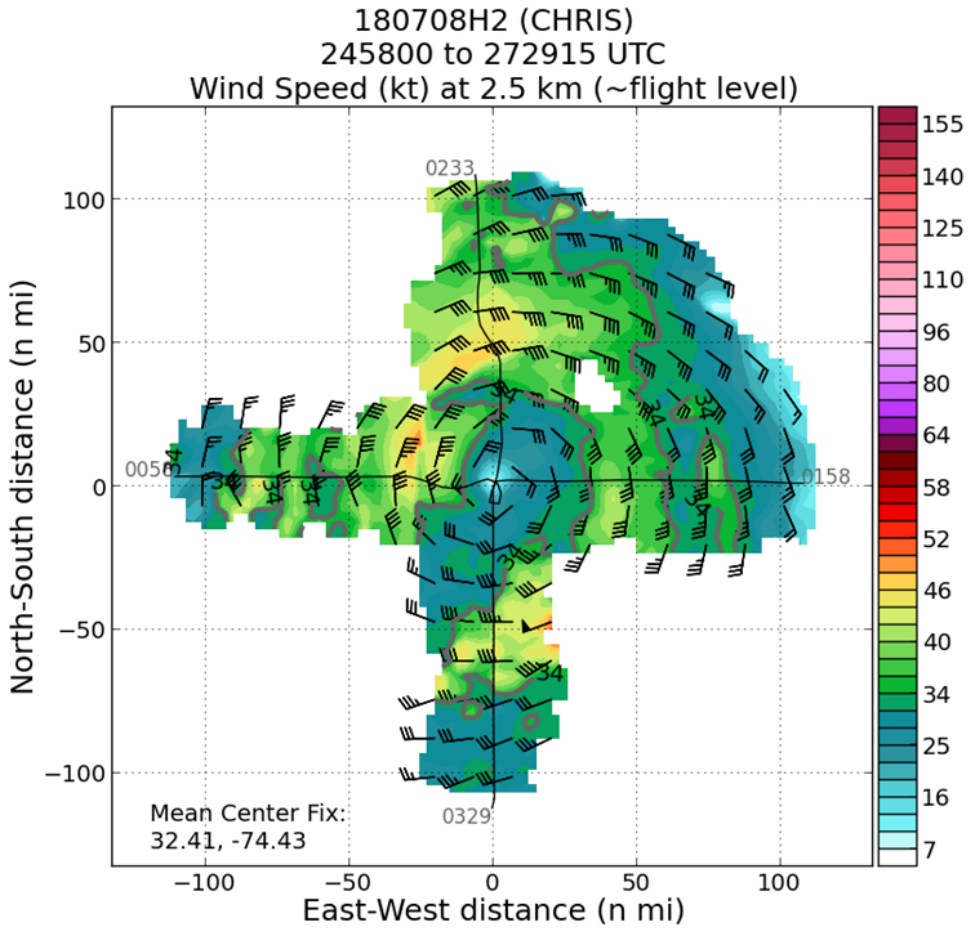


2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL03/Chris

Mission 2: 20180708H2 (EMC Tasked / Early Stage Experiment)

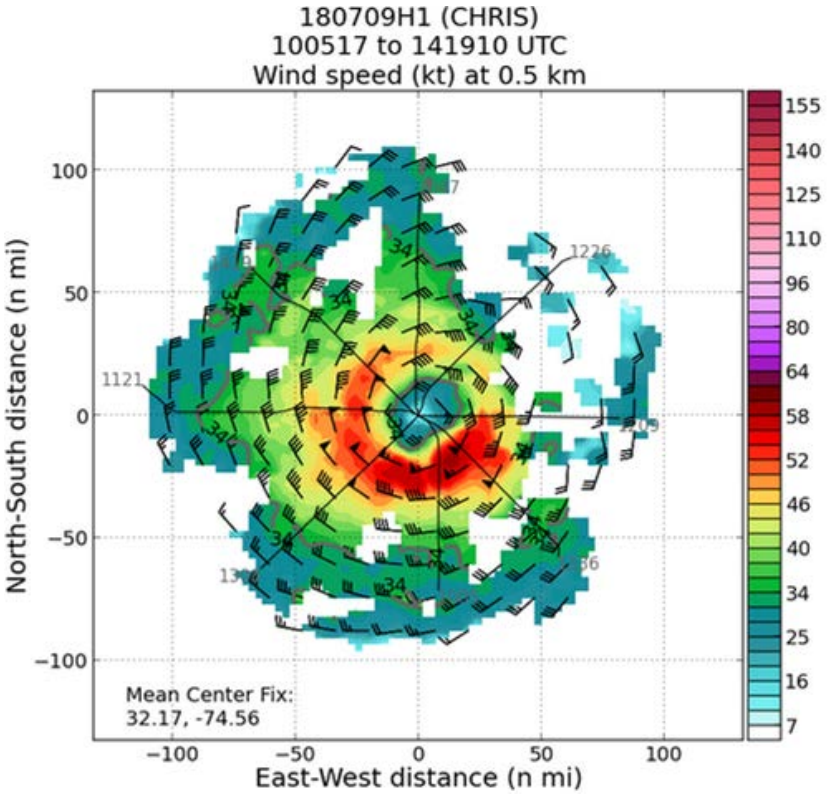


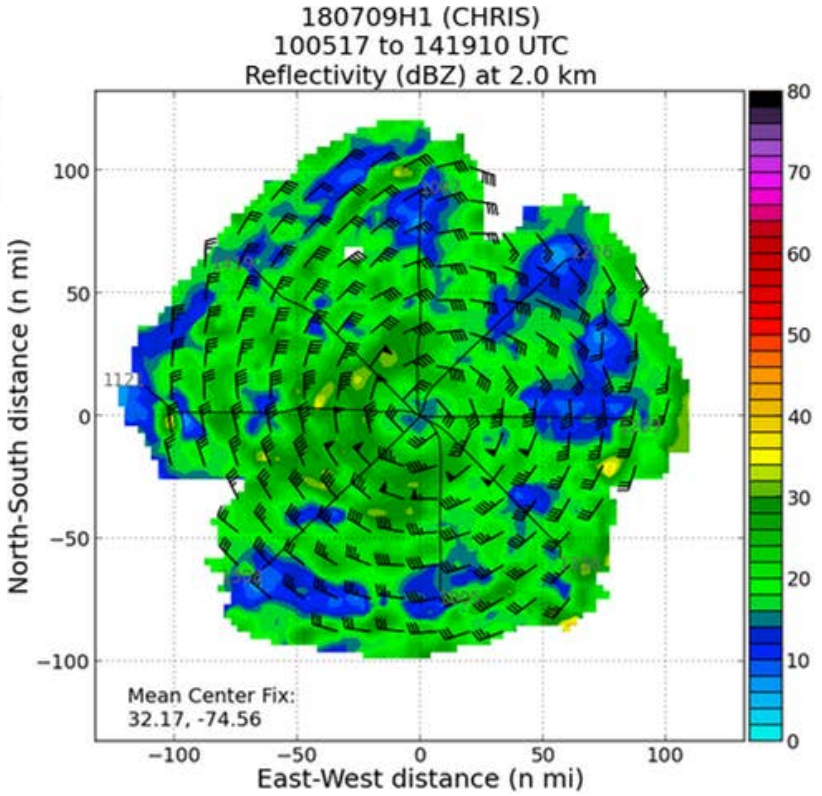


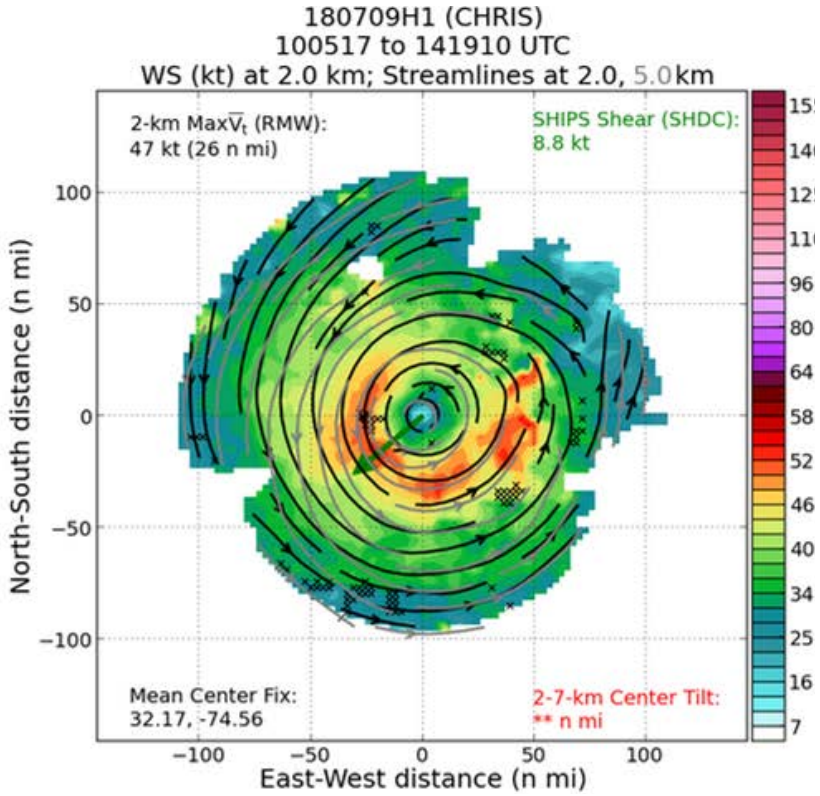
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL03/Chris

Mission 3: 20180709H1 (EMC Tasked / Early Stage Experiment)



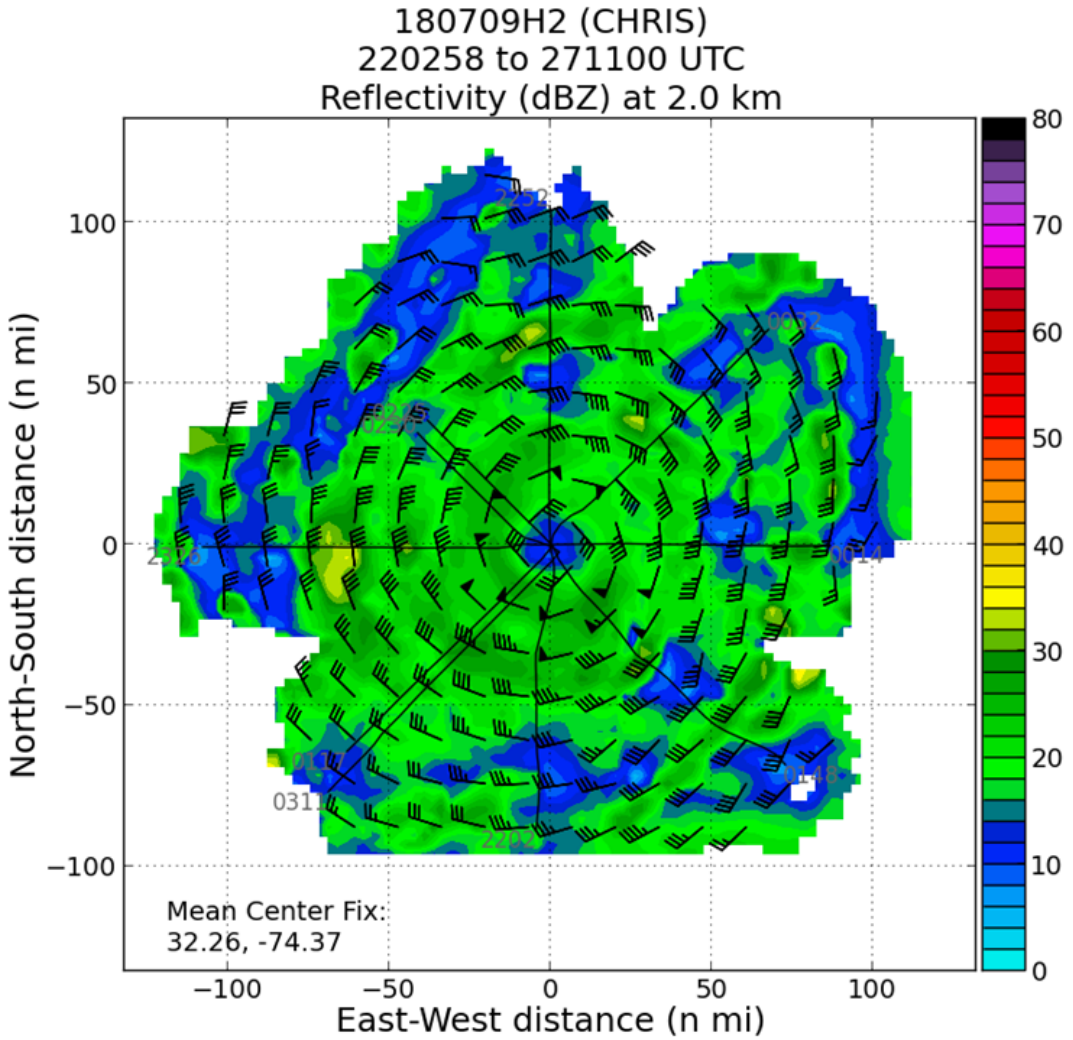


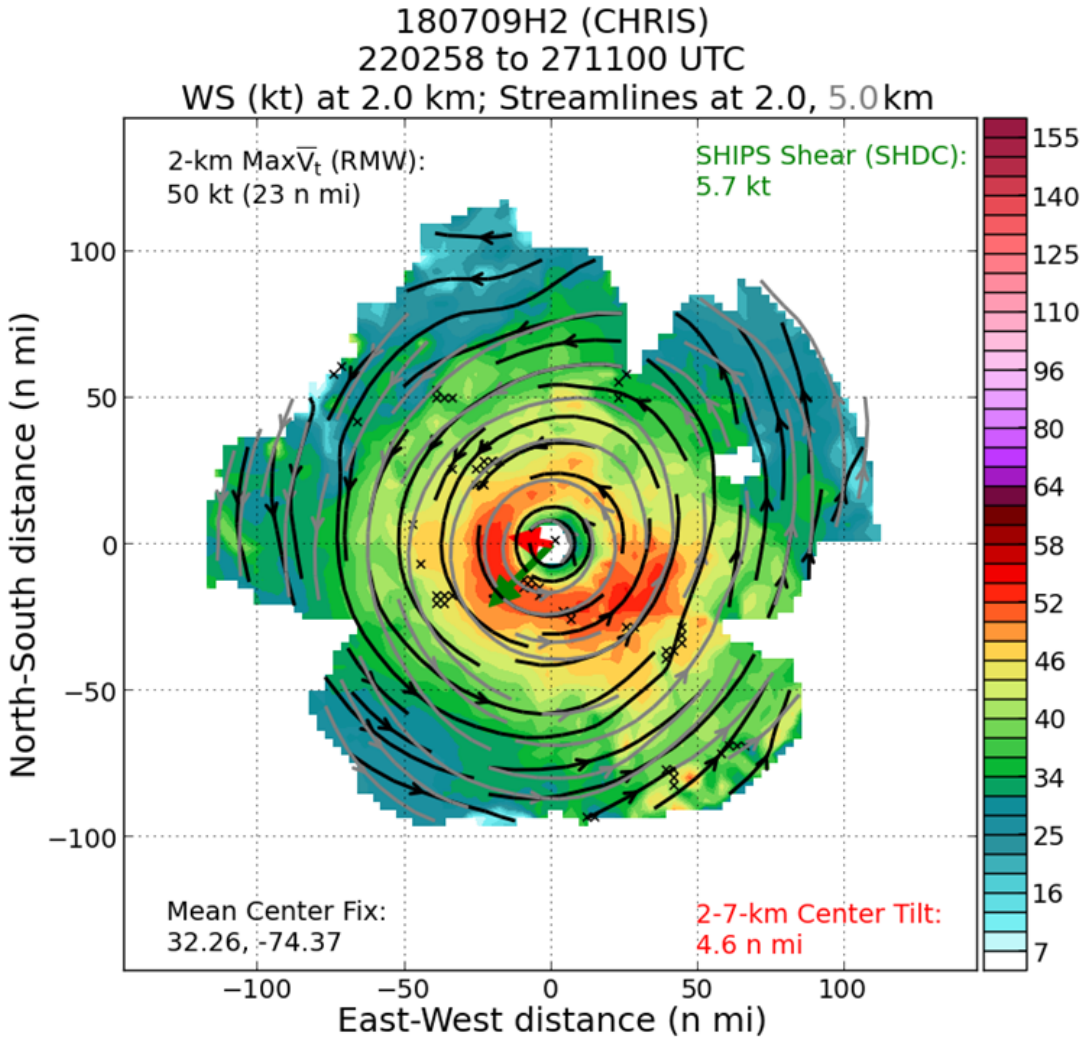


2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL03/Chris

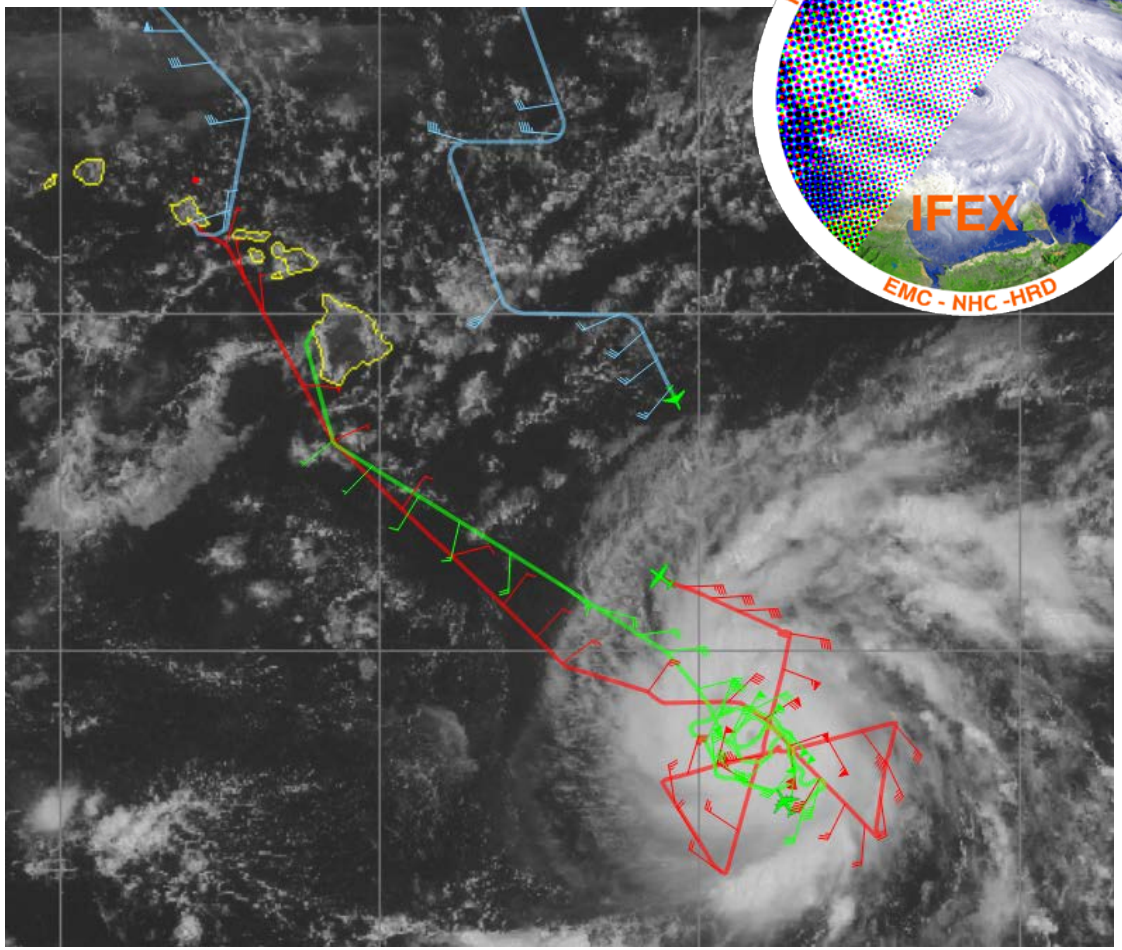
Mission 4: 20180709H2 (EMC Tasked / Early Stage Experiment)





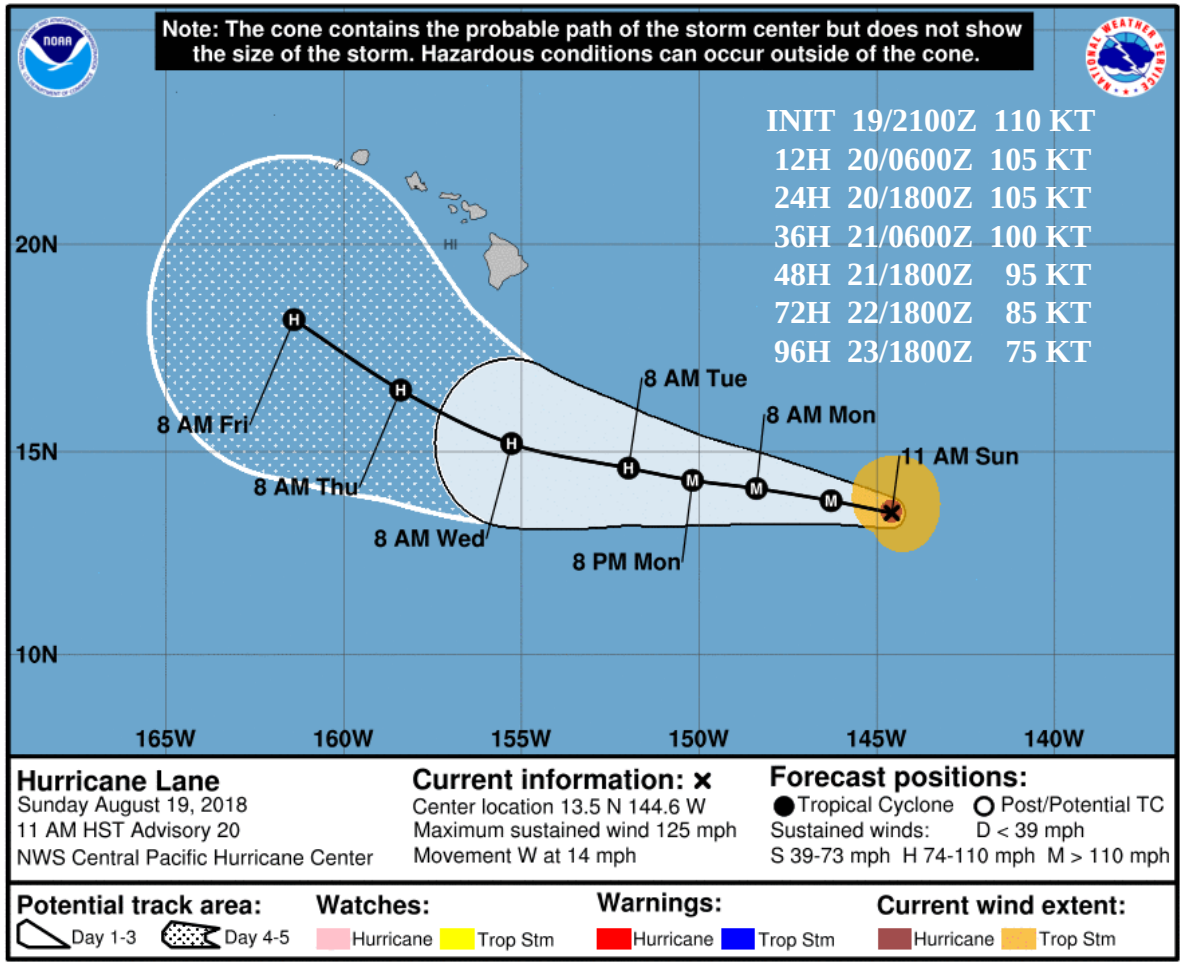
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

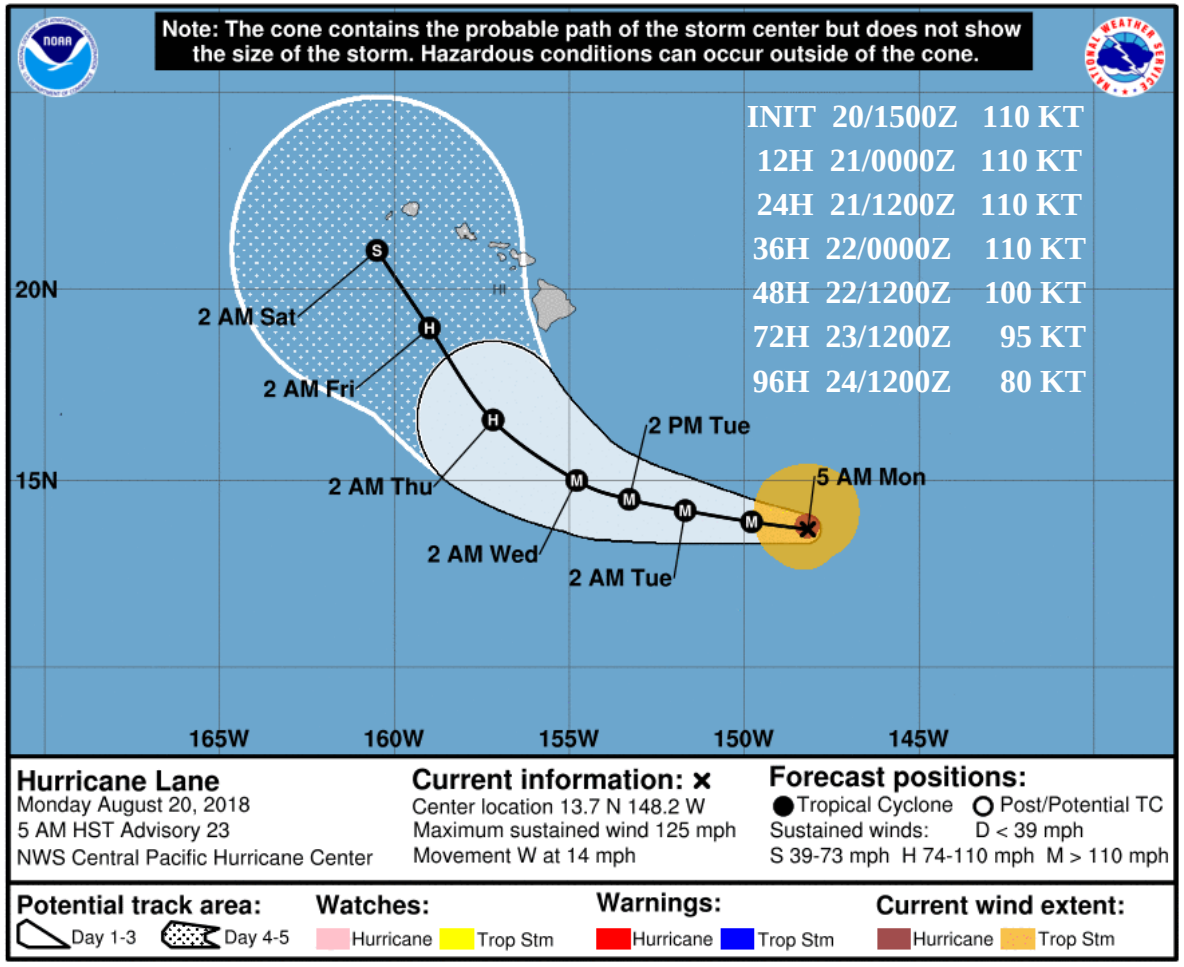
EP14/Lane



2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

EP14/Lane



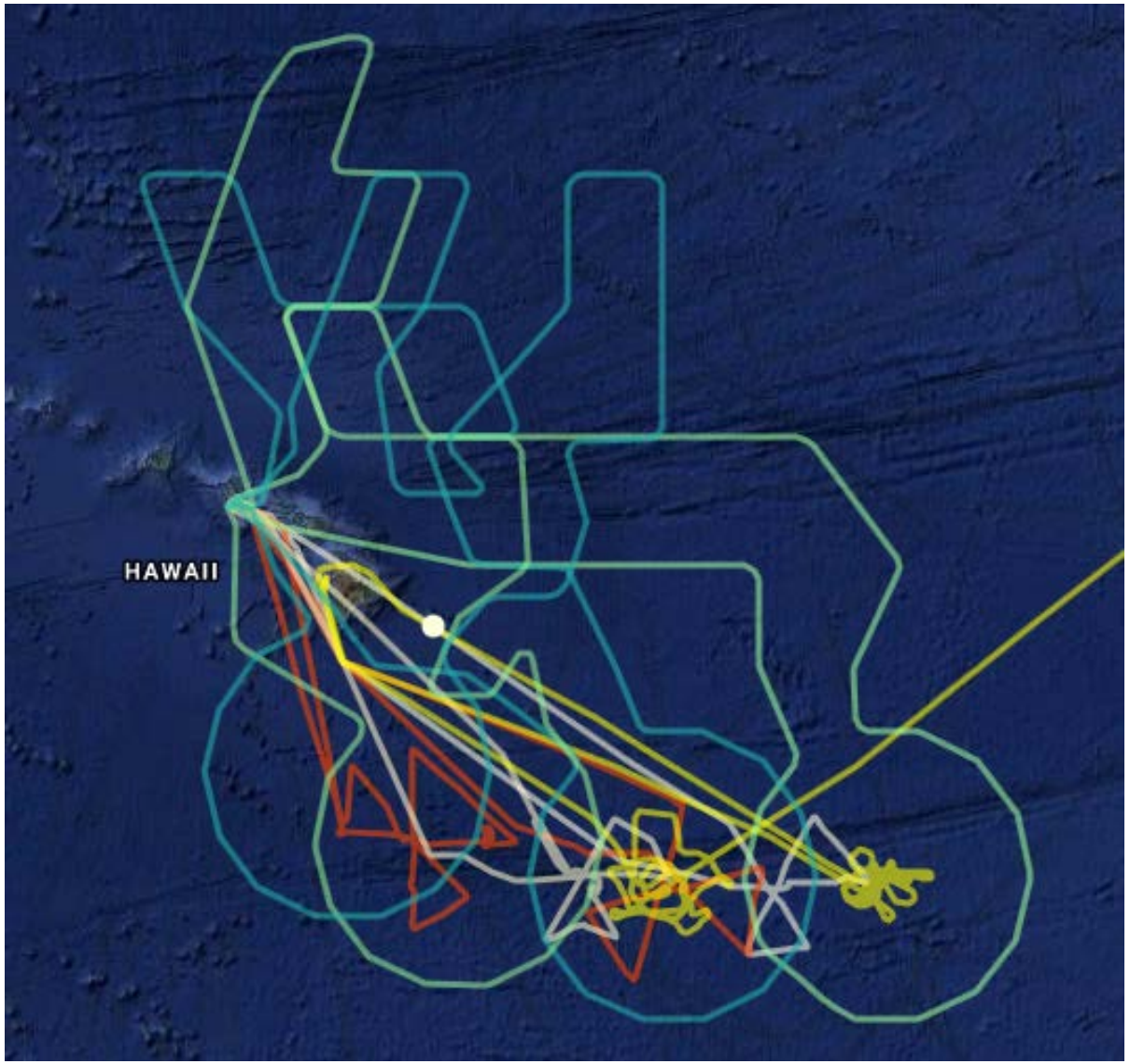


EP14/Lane

Purpose:

- **EMC-tasked P-3 data collection** targeting 06 and 18 UTC HWRF cycles
- G-IV tasked by CPHC for synoptic surveillance targeting 00 UTC
- Final **opportunity for Doppler Wind Lidar (DWL) and Wide-swath Radar Altimeter (WSRA) data collection** this season
- Transmission of DWL processed data off the P-3
- **Collect SFMR data at high incidence angles -- with 2nd down-looking SFMR**
- **Demonstrate P-3 data capabilities for CPHC -- AWIPS II**
- **Accomplish aspects of the "Mature Stage Experiment: Objective #1 (Internal Processes)"**

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)
EP14/Lane



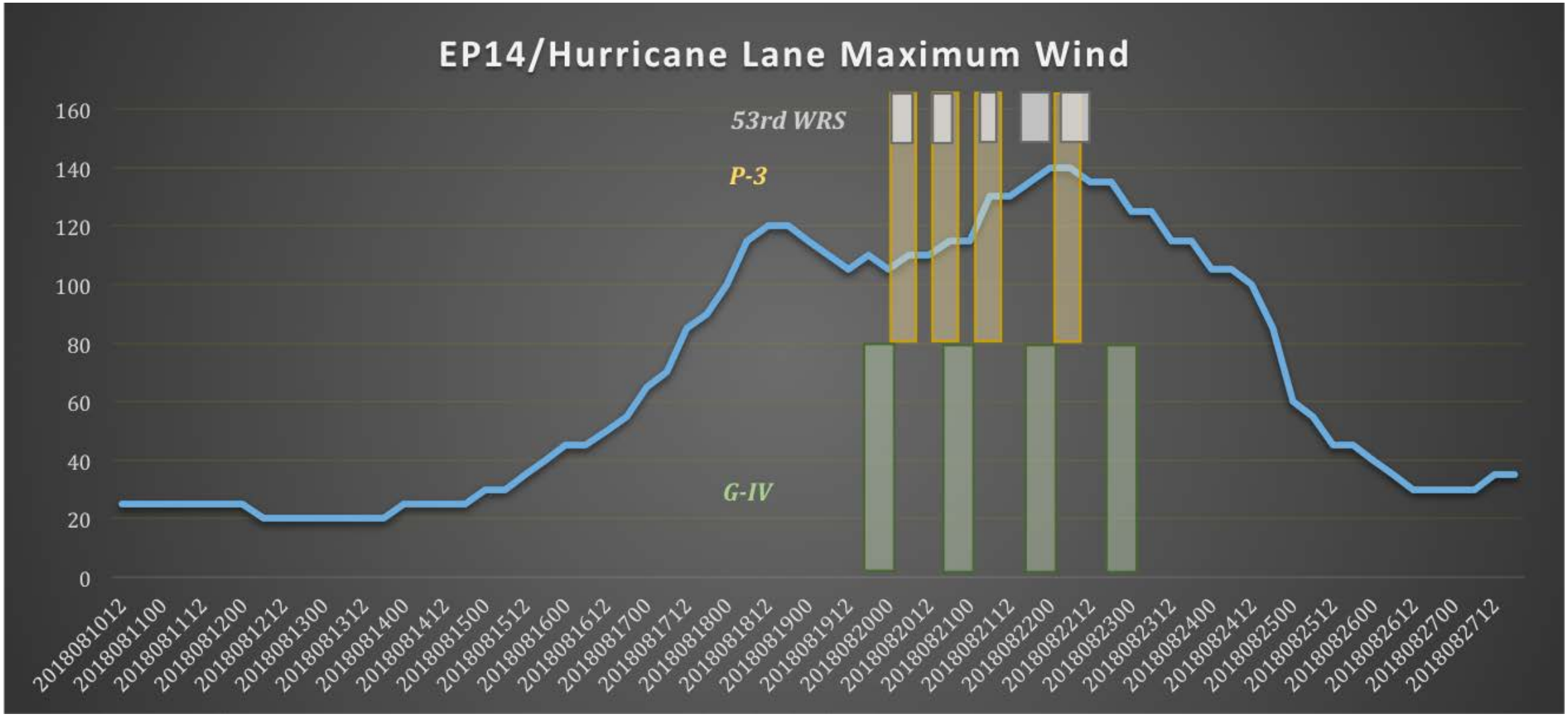
P-3

- ➔ **4 EMC-tasked Missions**
  - **20180820H1 0200 UTC (4 PM HST/10 PM EDT)**
  - **20180820H2 1400 UTC (4 AM HST/10 AM EDT)**
  - **20180821H1 0200 UTC (4 PM HST/10 PM EDT)**
  - **20180822H1 0200 UTC (4 PM HST/10 PM EDT)**
- ➔ 60 Flight Hours
  (27 h LAL-HNL-LAL, 33 h Operations)
- ➔ 77 Drops / 19 AXBTs

G-IV

- ➔ **4 CPHC-tasked Synoptic Surveillance Missions**
  - **20180819N1 1730 UTC (7:30 AM HST/1:30 PM EDT)**
  - **20180820N1 1730 UTC (7:30 AM HST/1:30 PM EDT)**
  - **20180821N1 1730 UTC (7:30 AM HST/1:30 PM EDT)**
  - **20180822N1 1730 UTC (7:30 AM HST/1:30 PM EDT)**
- ➔ 53 Flight Hours
  (20 h LAL-HNL-LAL, 33 h Operations)
- ➔ 119 Drops

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)
EP14/Lane



EP14/Lane

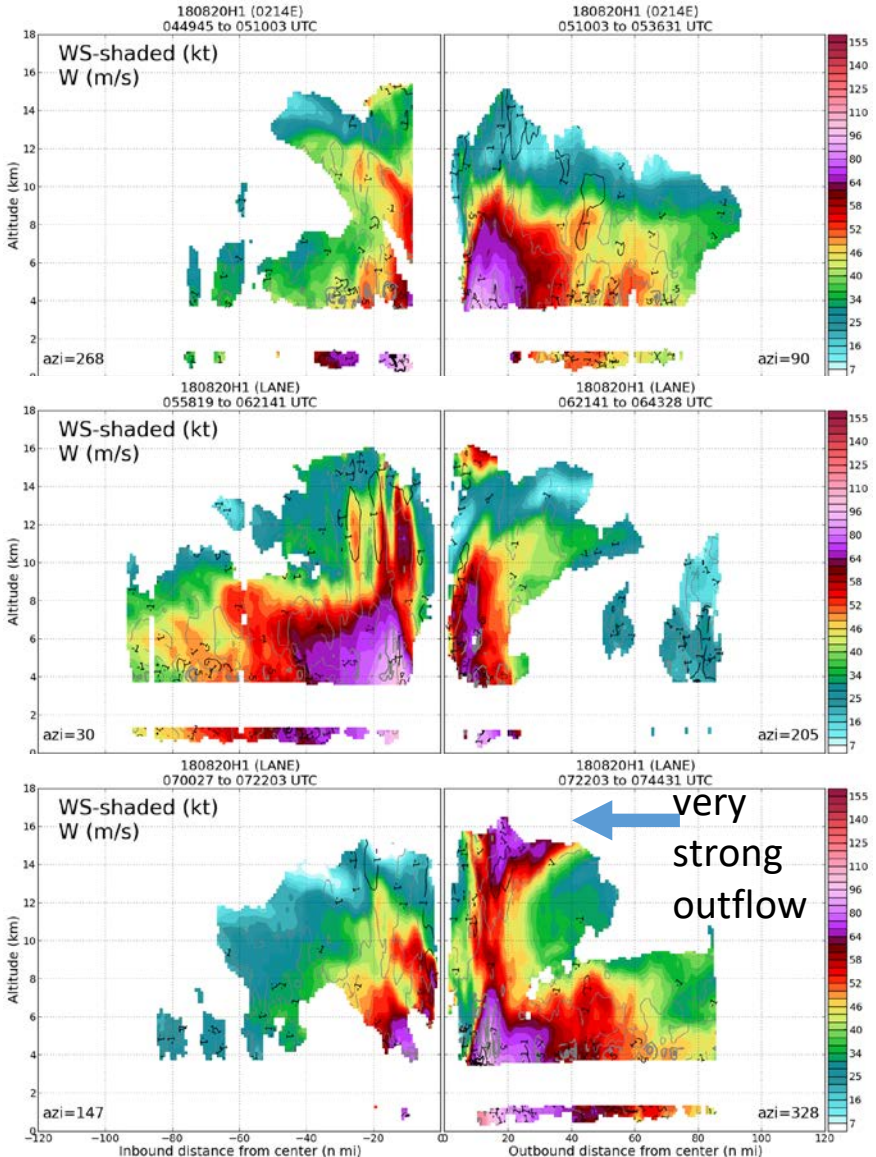
Mission Highlights:

- First NOAA P-3 mission to fly a Central Pacific storm
- First all female HRD Science Crew on a Hurricane Hunter mission
- Real-time availability of P-3 data in AWIPS II, available at CPHC
- Generally successful data collection with TDR, DWL, WSRA (except for last mission), and 2nd down-looking SFMR
- Multiple SFMR High Incidence Angle modules flown
- Transmission of DWL processed data to the ground
- Generally research-worthy case within the “Mature Stage Experiment”, Objective #1: Internal Processes -- RI of an already major hurricane

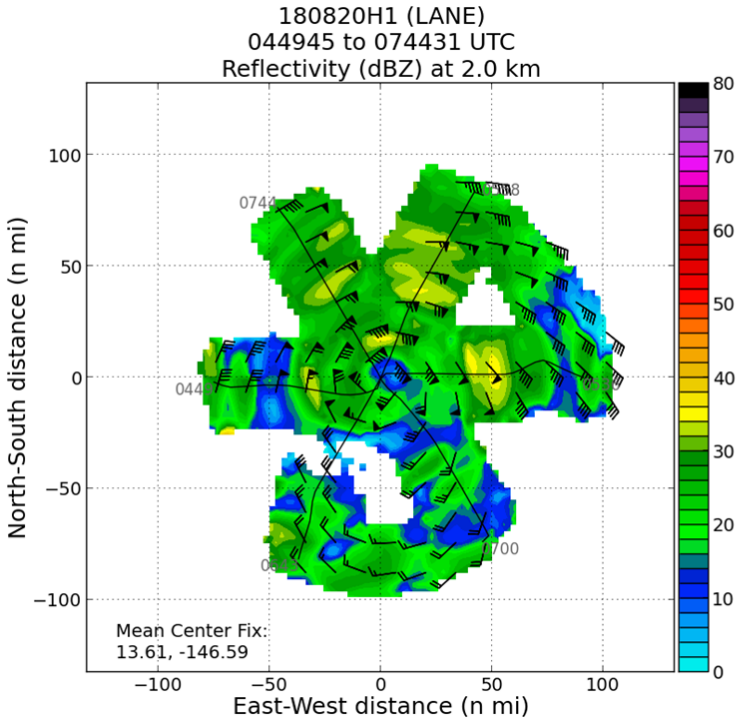
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

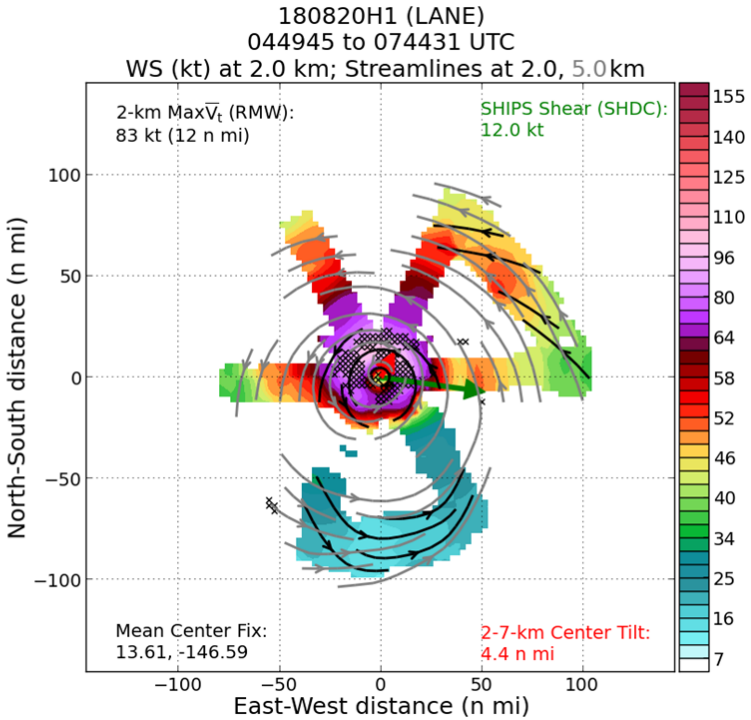
EP14/Lane

Mission 1: 20180820H1 (EMC Tasked / Mature Stage Experiment)



very strong outflow





Even though at 100 kt, asymmetric wind field, very weak on south side with no convection

2018 NOAA/AOML/HRD Hurricane Field Program
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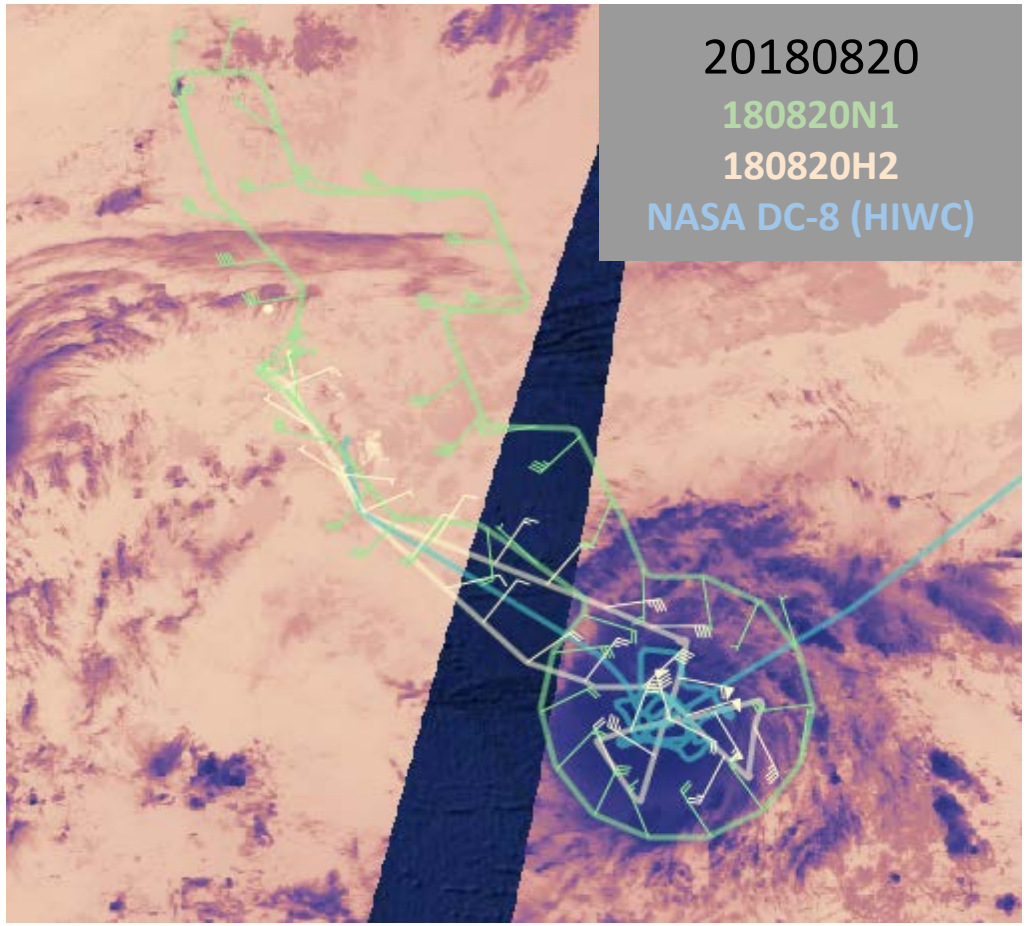
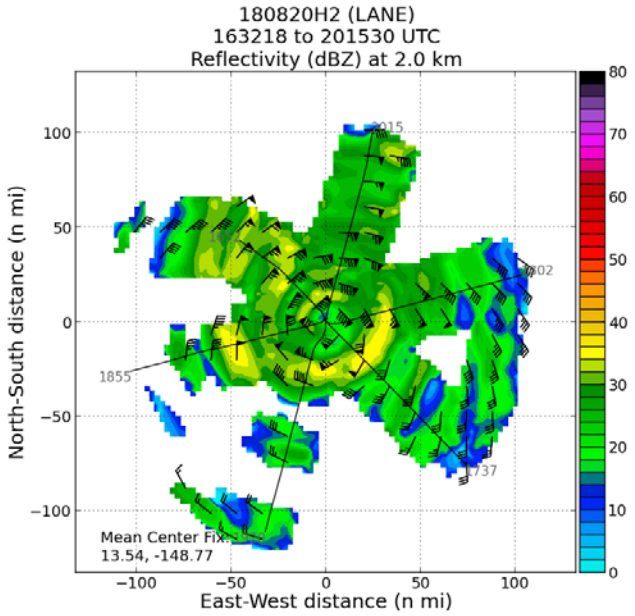
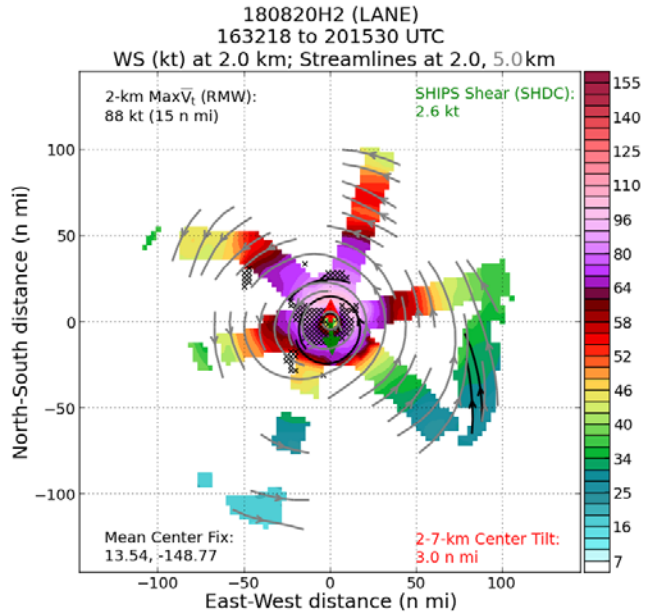
EP14/Lane



Mission 2: 20180820H2 (EMC Tasked / Mature Stage Experiment)





- "Onset" of subsequent rapid intensification that will be observed in the next mission
- Improving symmetry on the south side of the storm
- SHIPS shear is becoming quite low (<5 kt)

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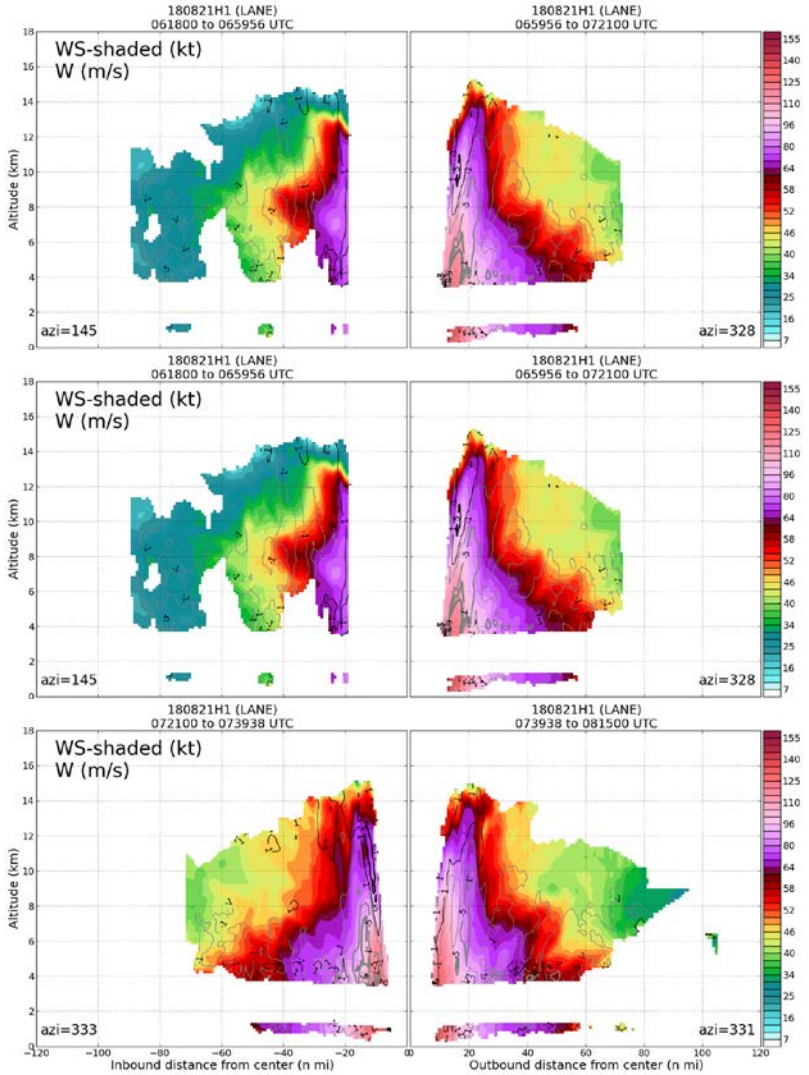
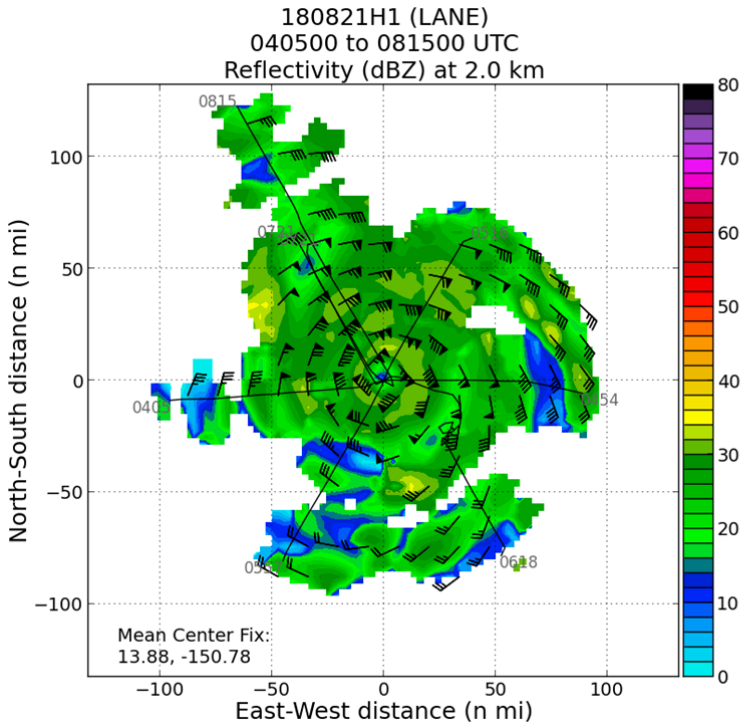
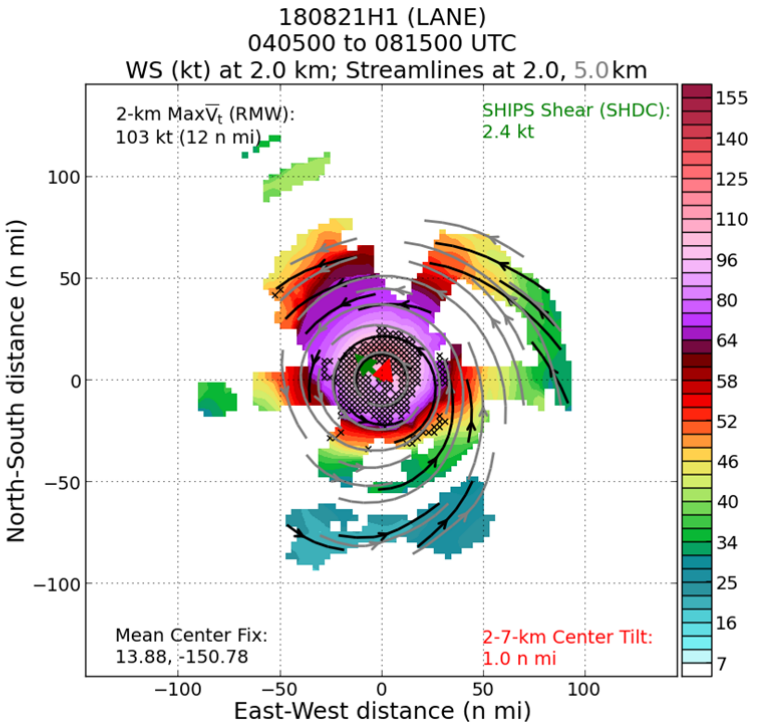
Intensity Forecast Experiment (IFEX)

EP14/Lane

Mission 3: 20180821H1 (EMC Tasked / Mature Stage Experiment)





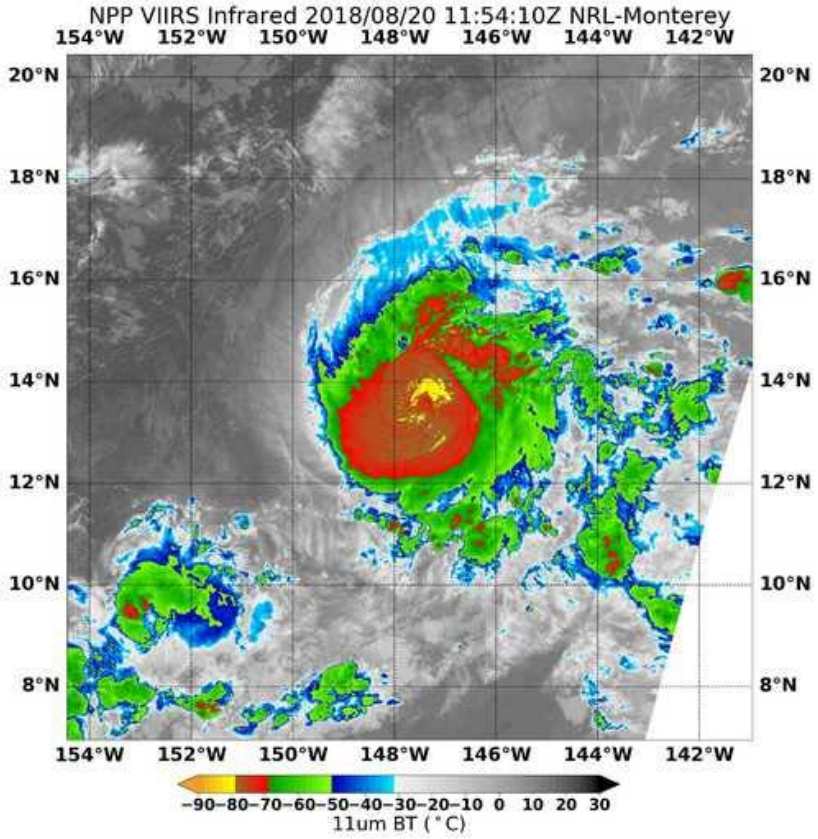


- Rapid intensification is ongoing
- Approaching 140 kt by the end of the mission

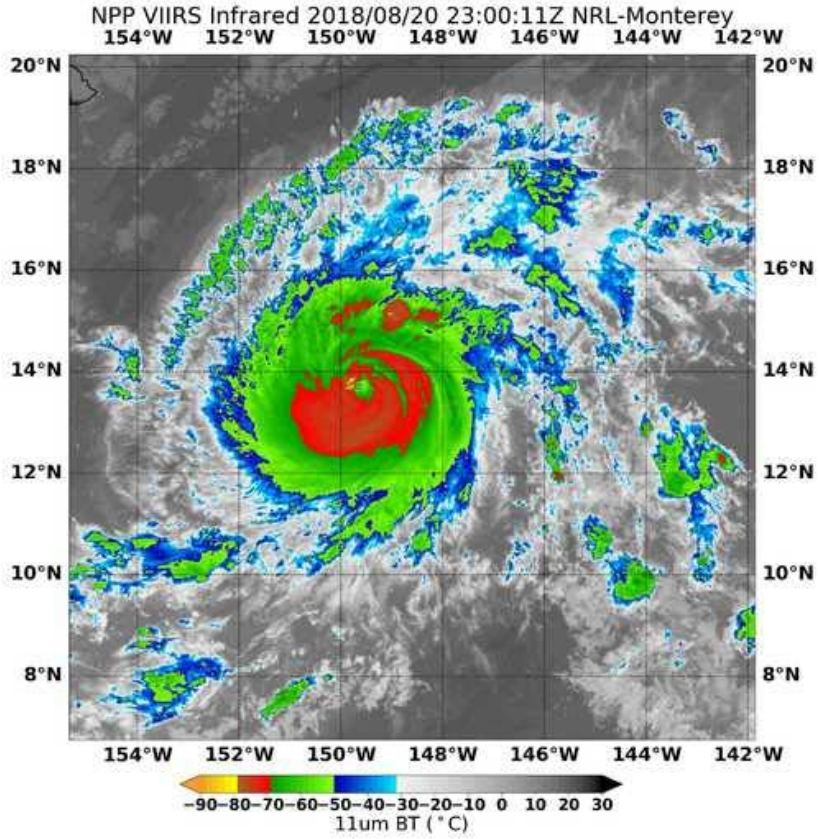
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

EP14/Lane

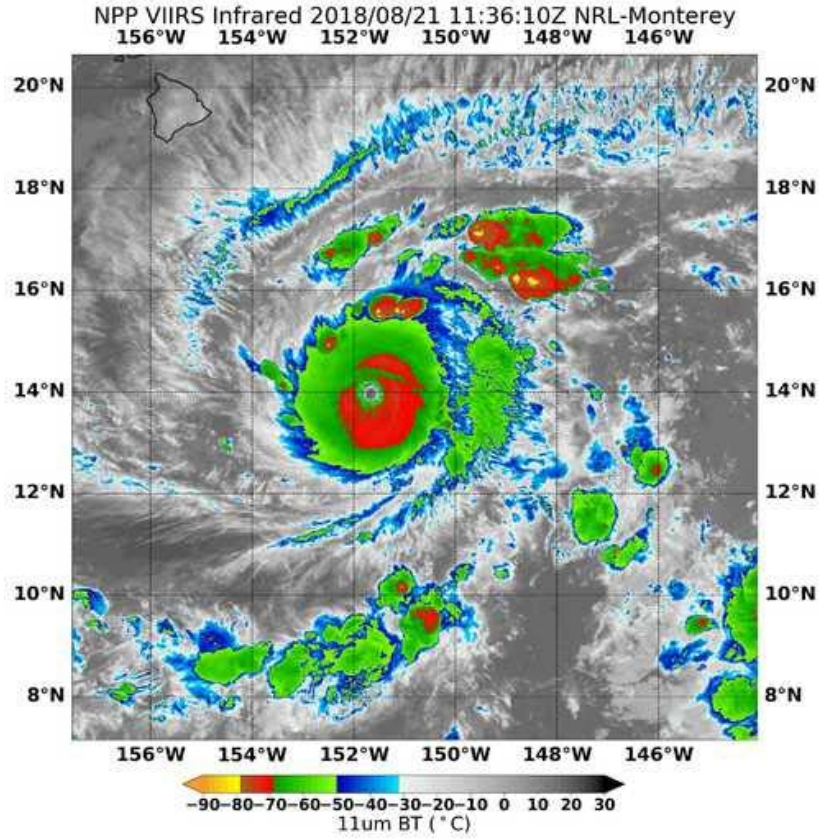
In between 180820H1 and 180820H2



In between 180820H2 and 180821H1



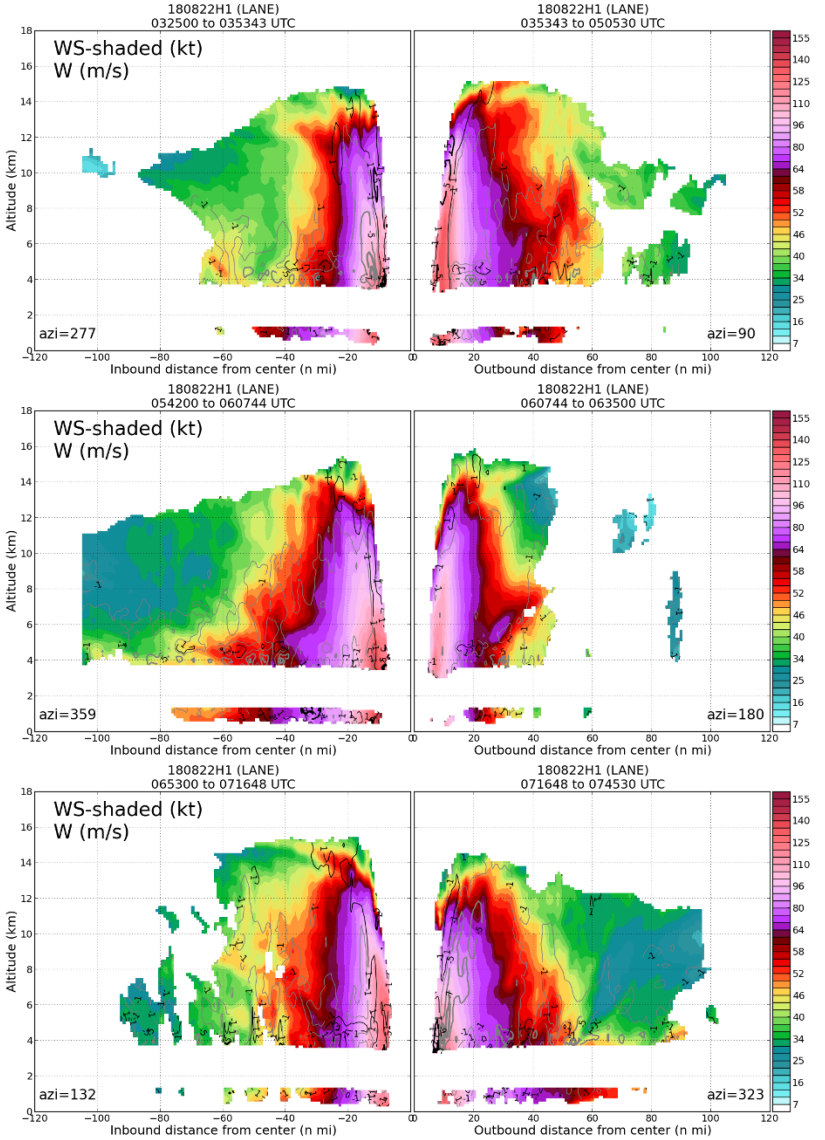
After 180821H1



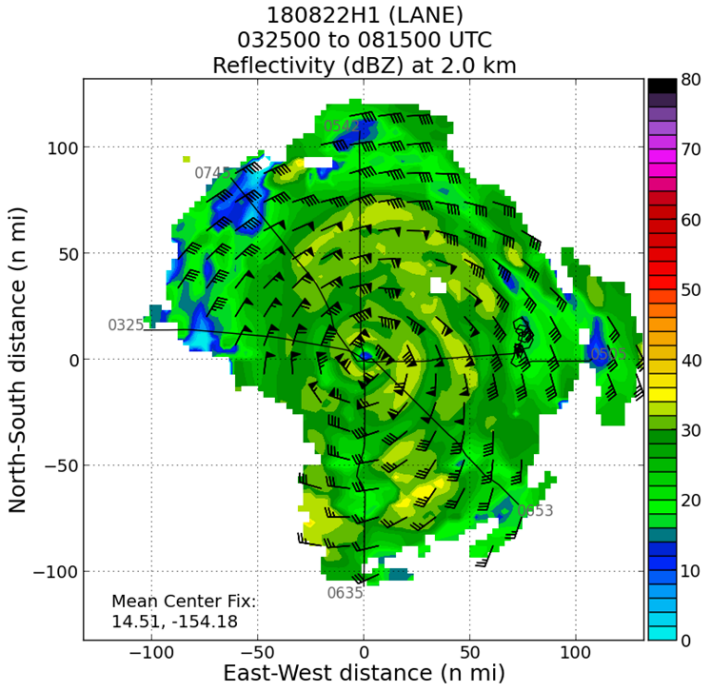
Mature stage rapid intensification event, 100 kt to 140 kt (compared to Early Stage)

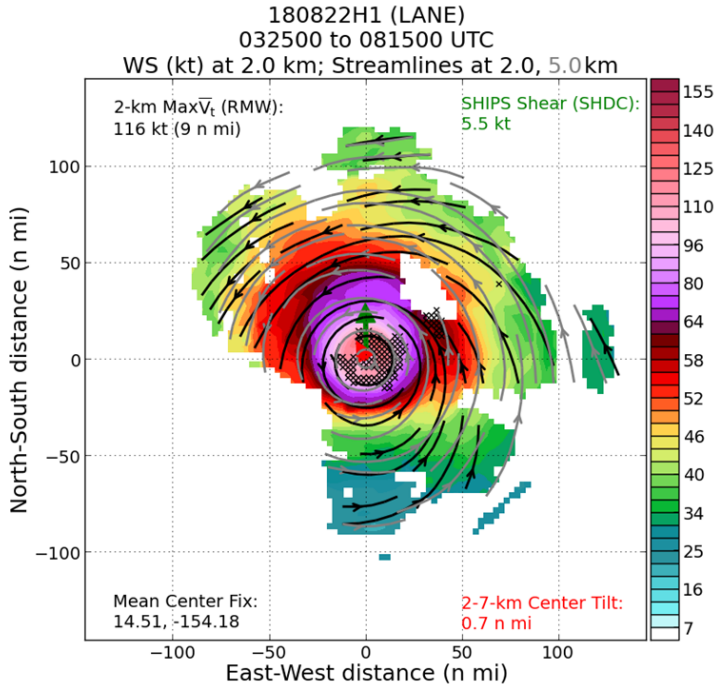
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

EP14/Lane



Mission 4: 20180822H1 (EMC Tasked / Mature Stage Experiment)

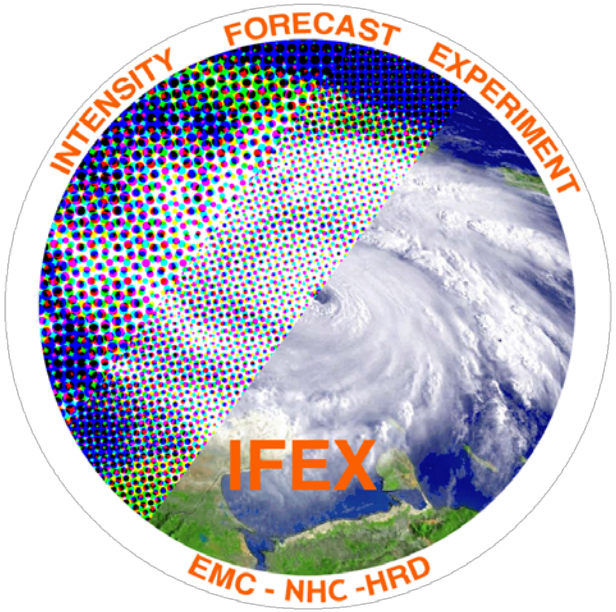




- Category 5, 140 kt

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

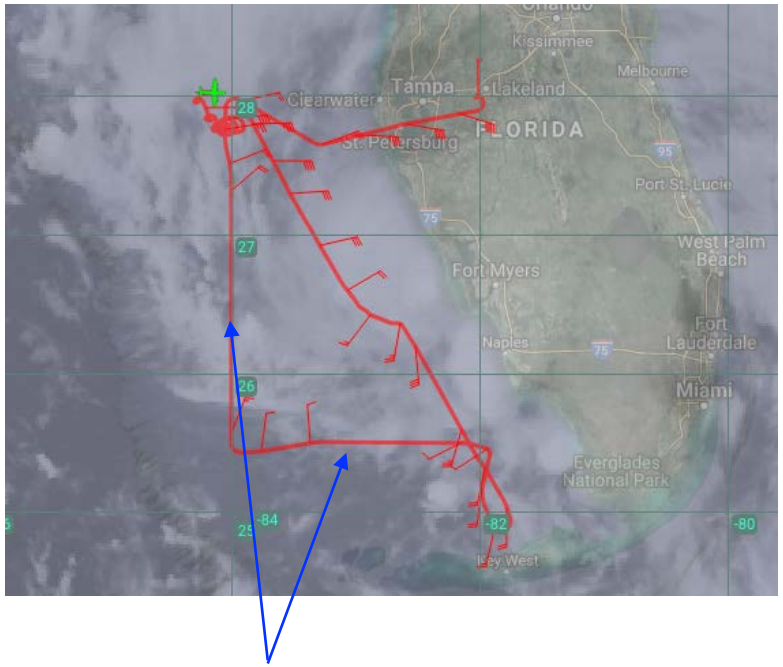
AL07/Gordon



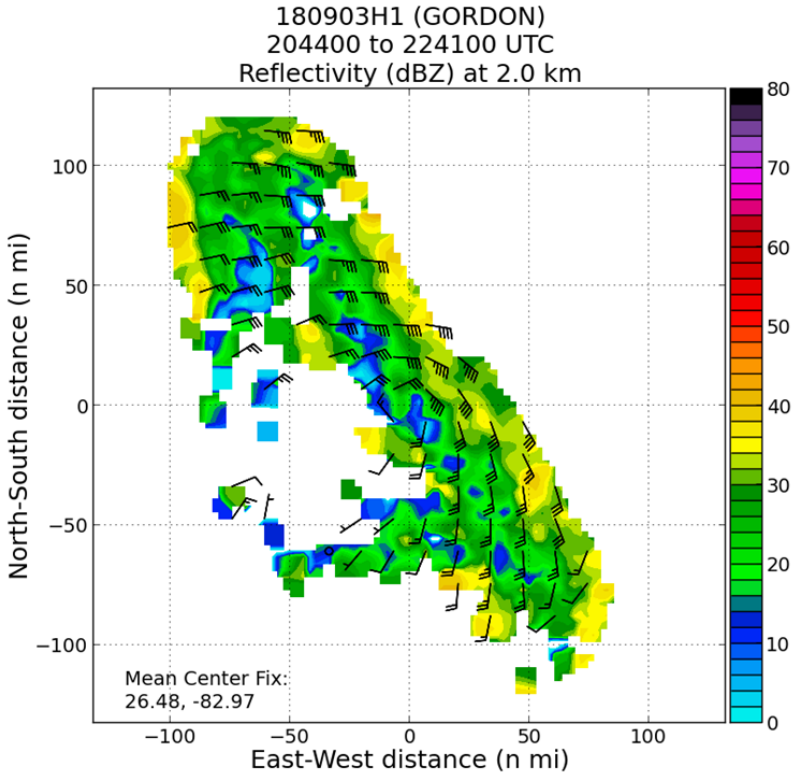
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL07/Gordon

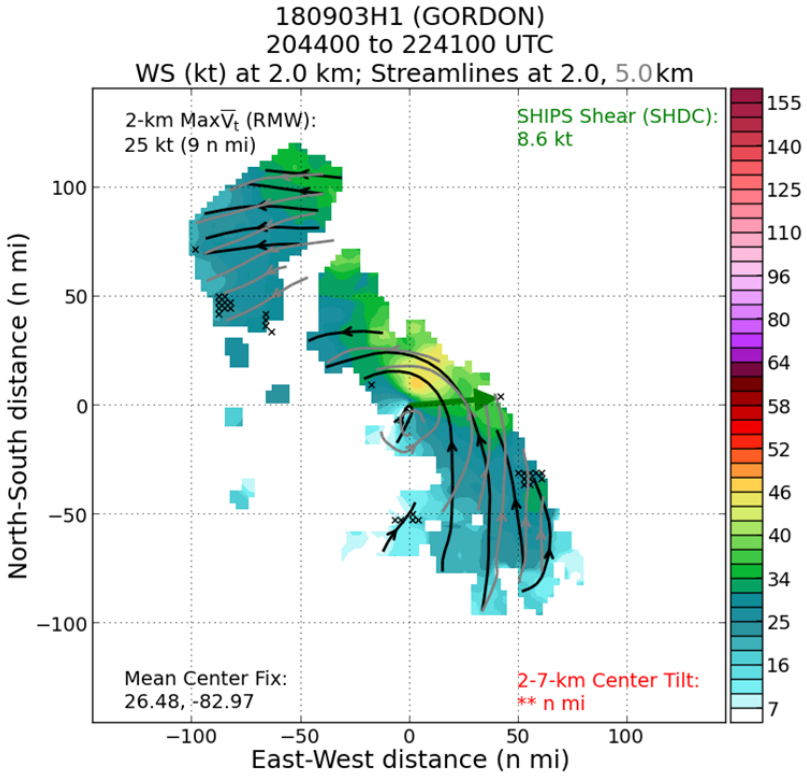
Mission 1: 20180903H1 (EMC Tasked / Early Stage Experiment)



2nd “high altitude” circumnavigation of the season with dropsondes every 1°



Mission aborted due to mechanical issue

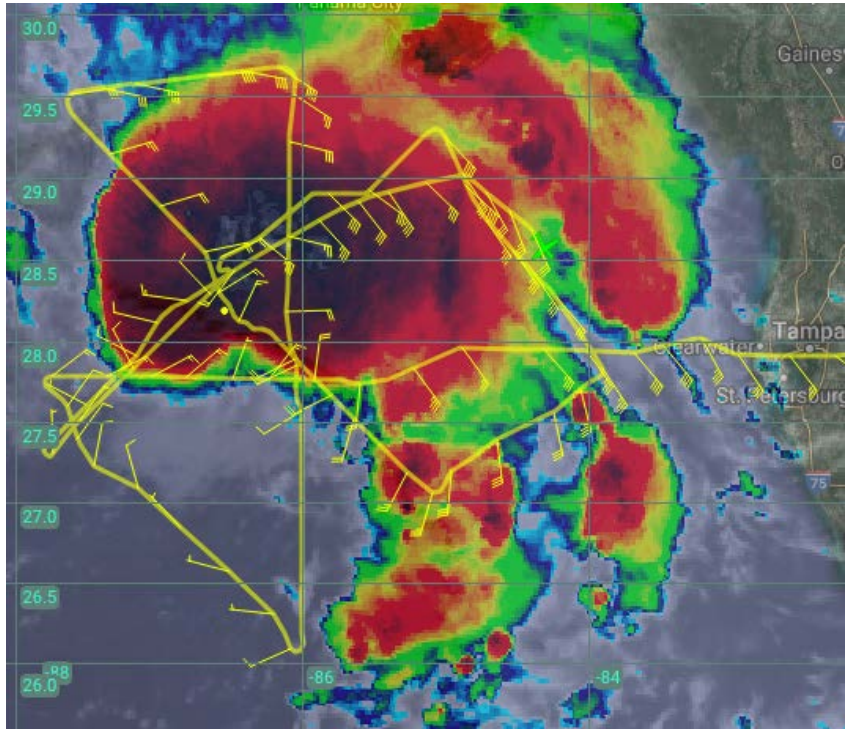


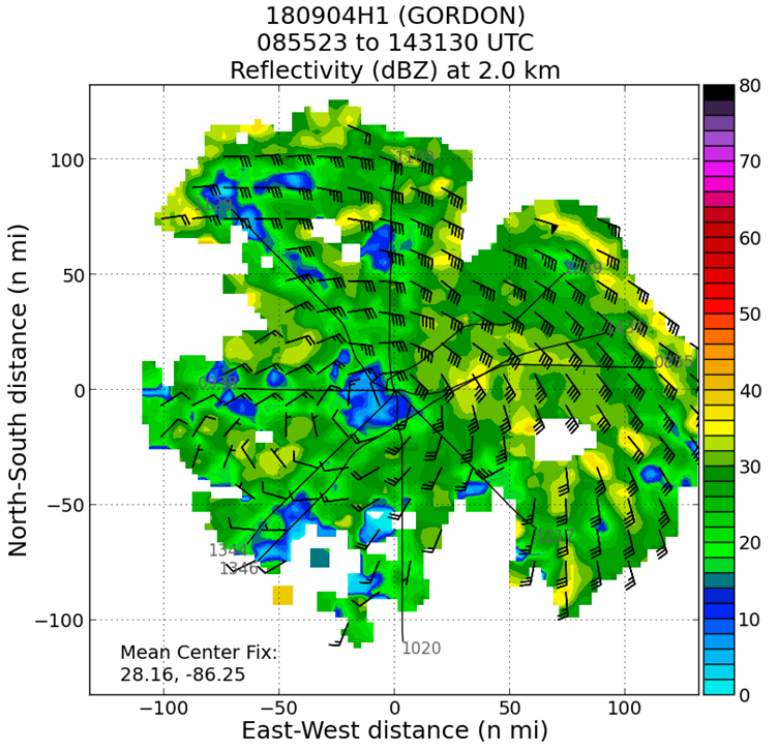
Accomplished SFMR High Incidence Angle Module

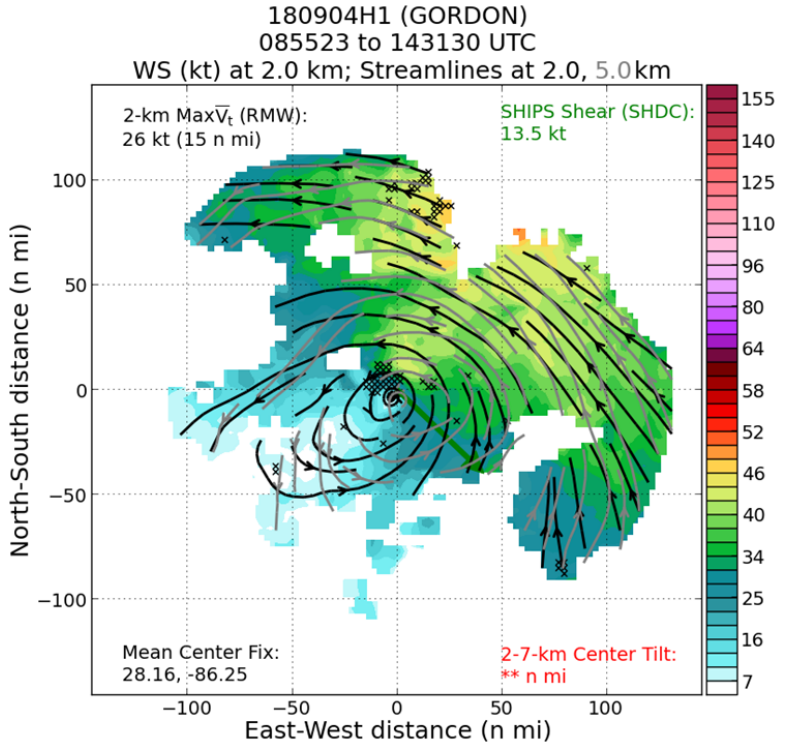
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL07/Gordon

Mission 2: 20180904H1 (EMC Tasked / Early Stage Experiment)



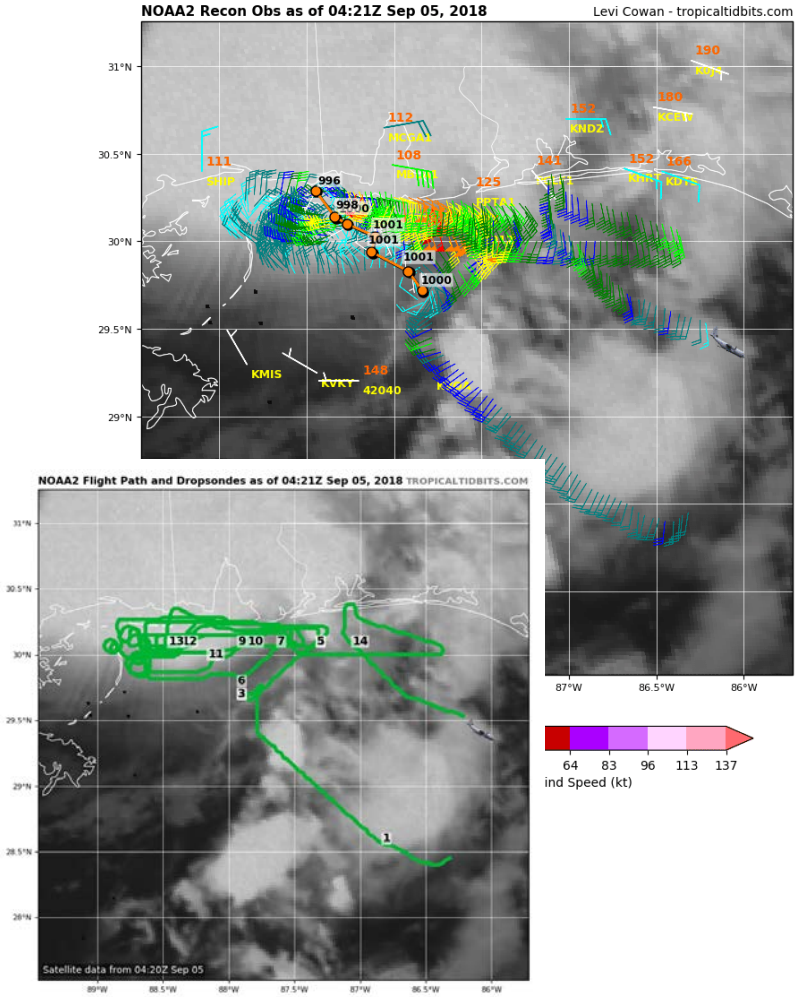


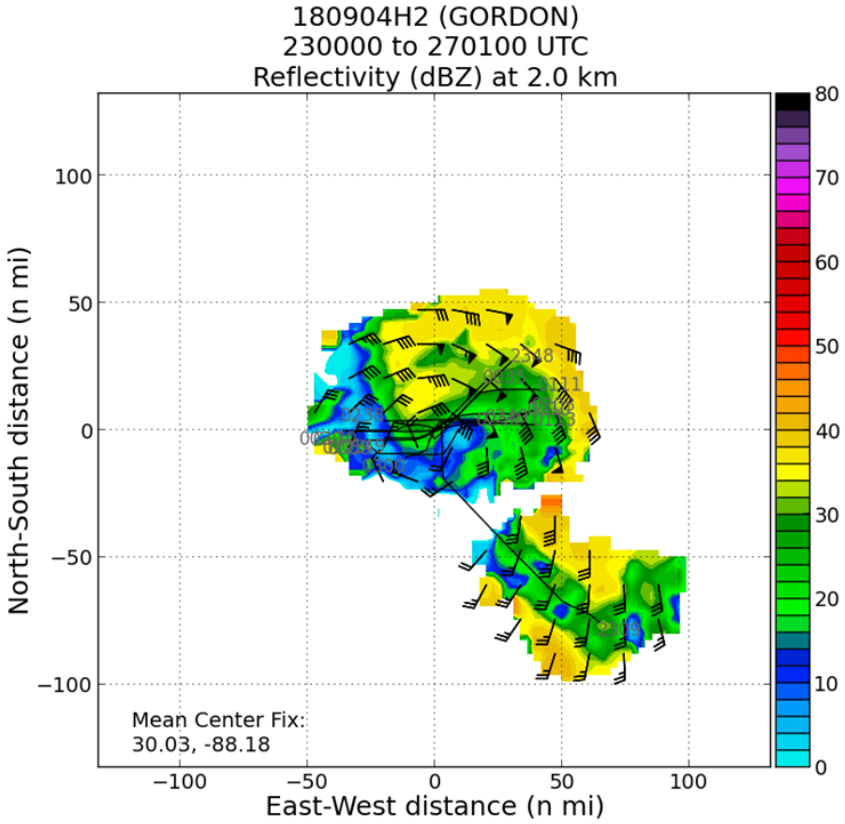


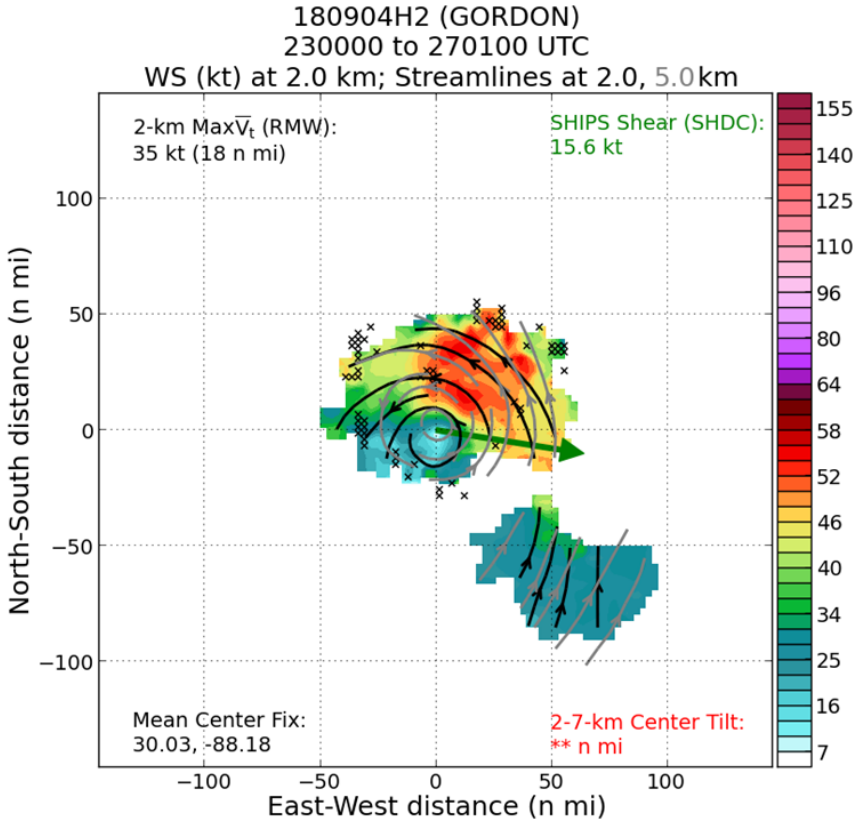
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL07/Gordon

Mission 3: 20180904H2 (NHC Tasked Reconnaissance)

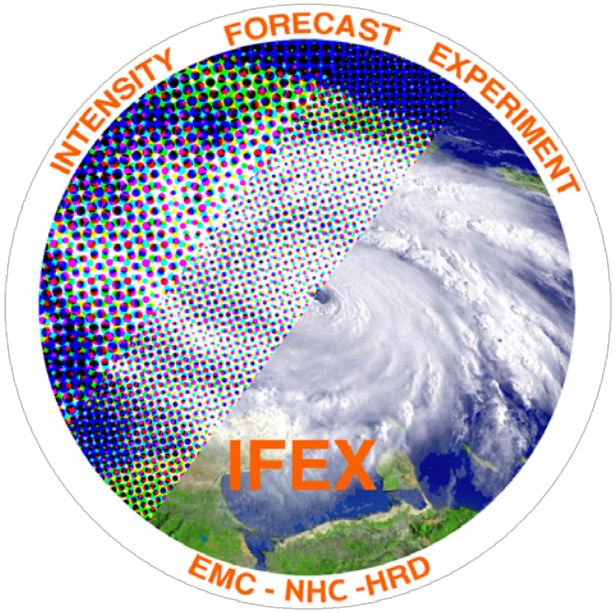






2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

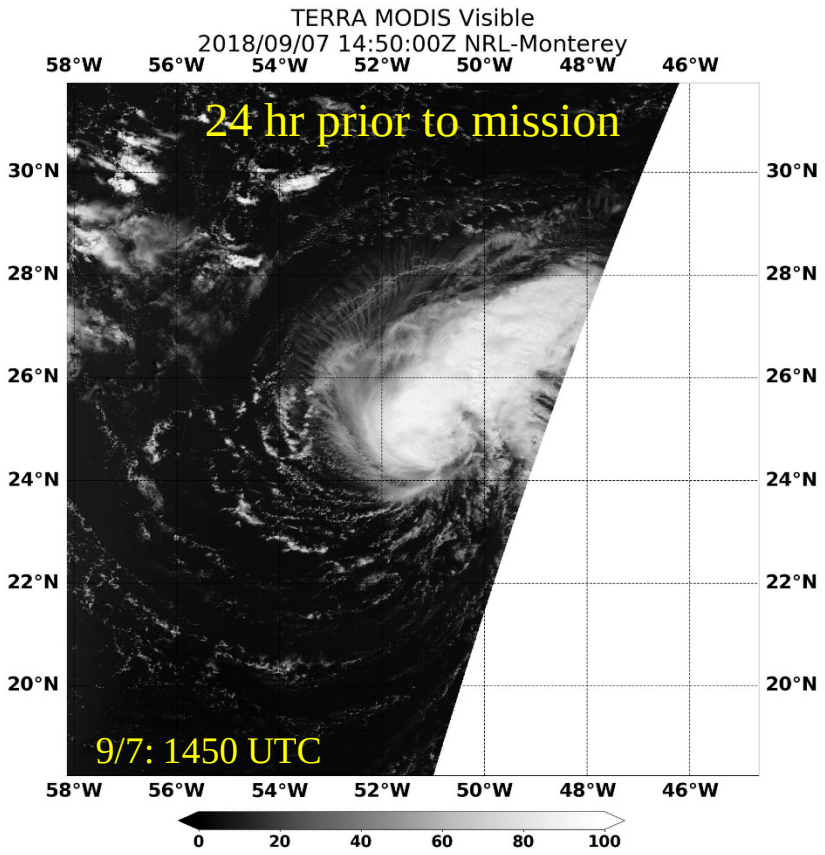
AL06/Florence



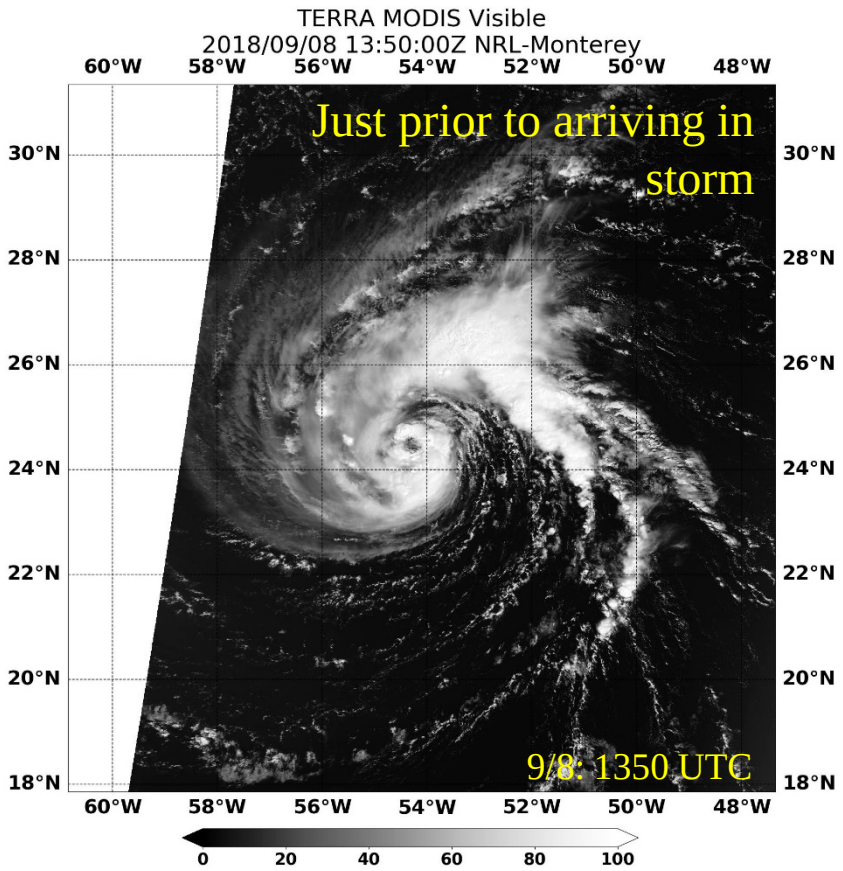
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 1: 20180908H1/2 (Research, Early Stage Experiment / Ocean Winds)



Florence had previously been a Category 4 storm, but since weakened and increased in asymmetry due to vertical wind shear

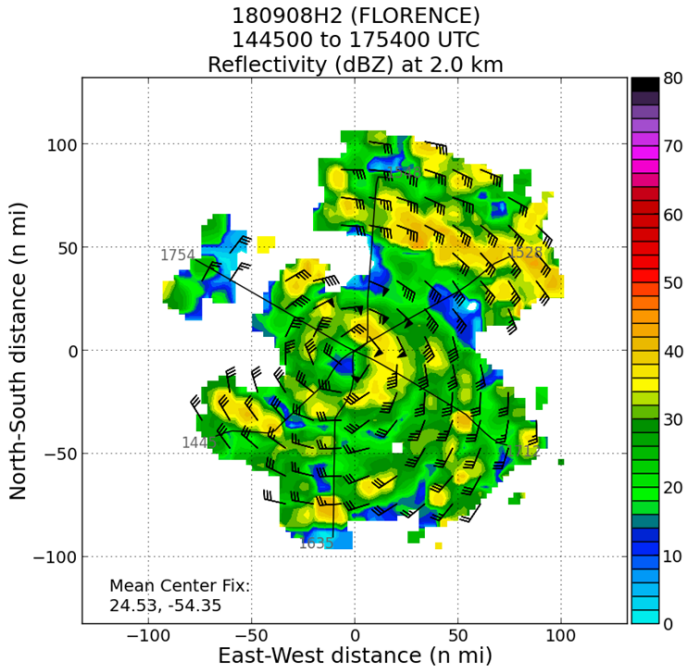


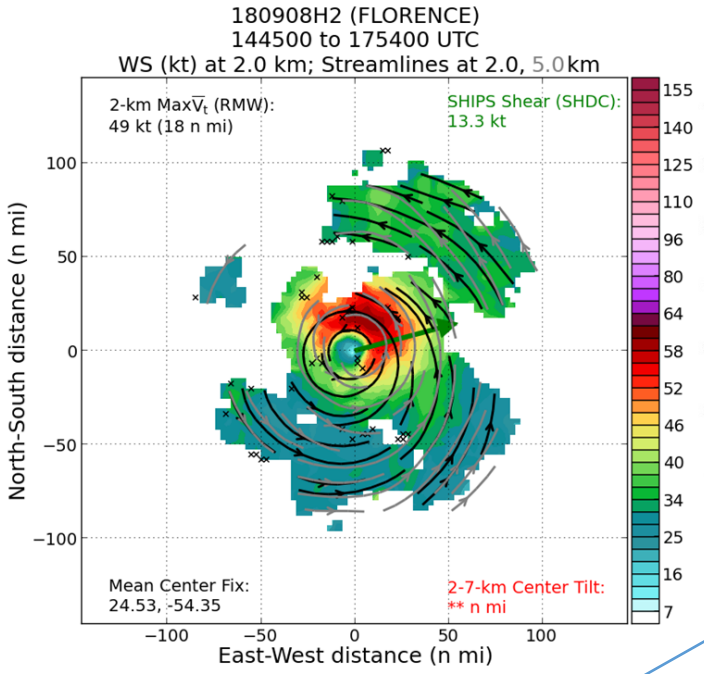
During this first mission, symmetry in the storm was certainly improving, but dry slot present, which could have been preventing intensification

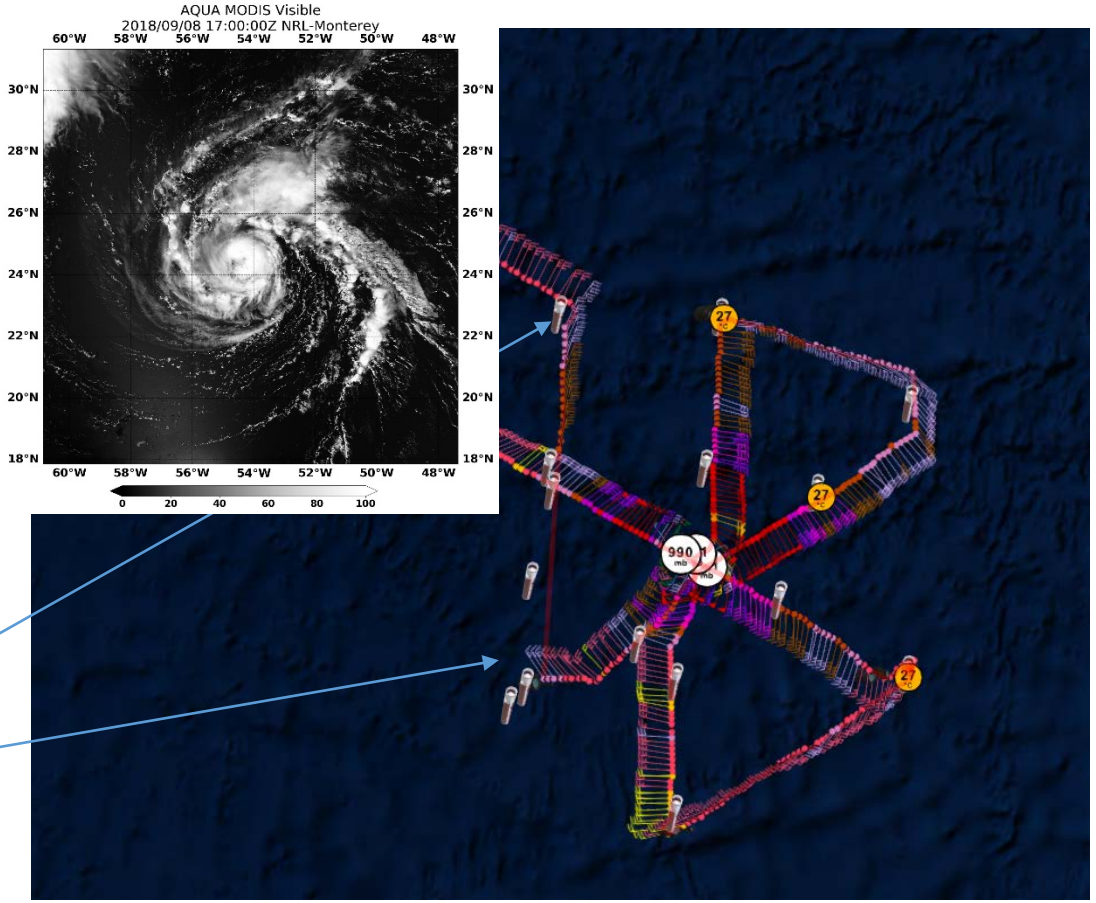
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 1: 20180908H1/2 (Research, Early Stage Experiment / Ocean Winds)





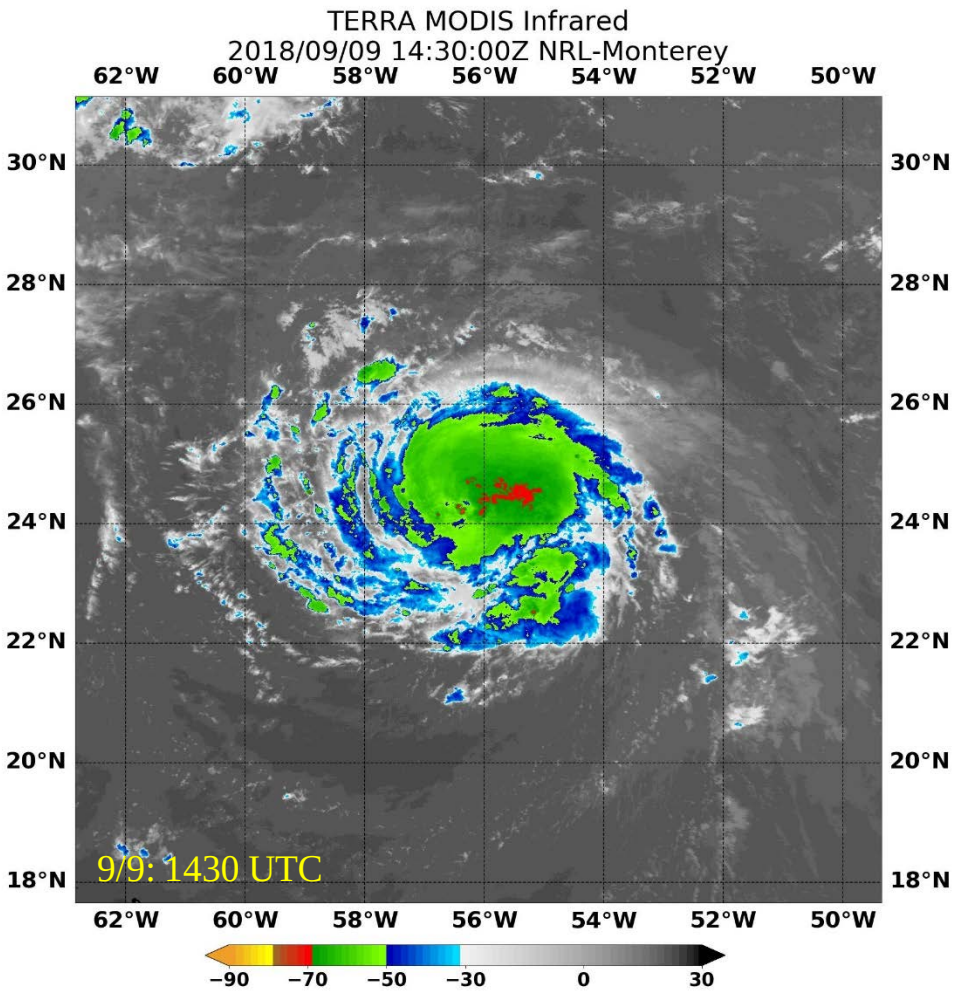


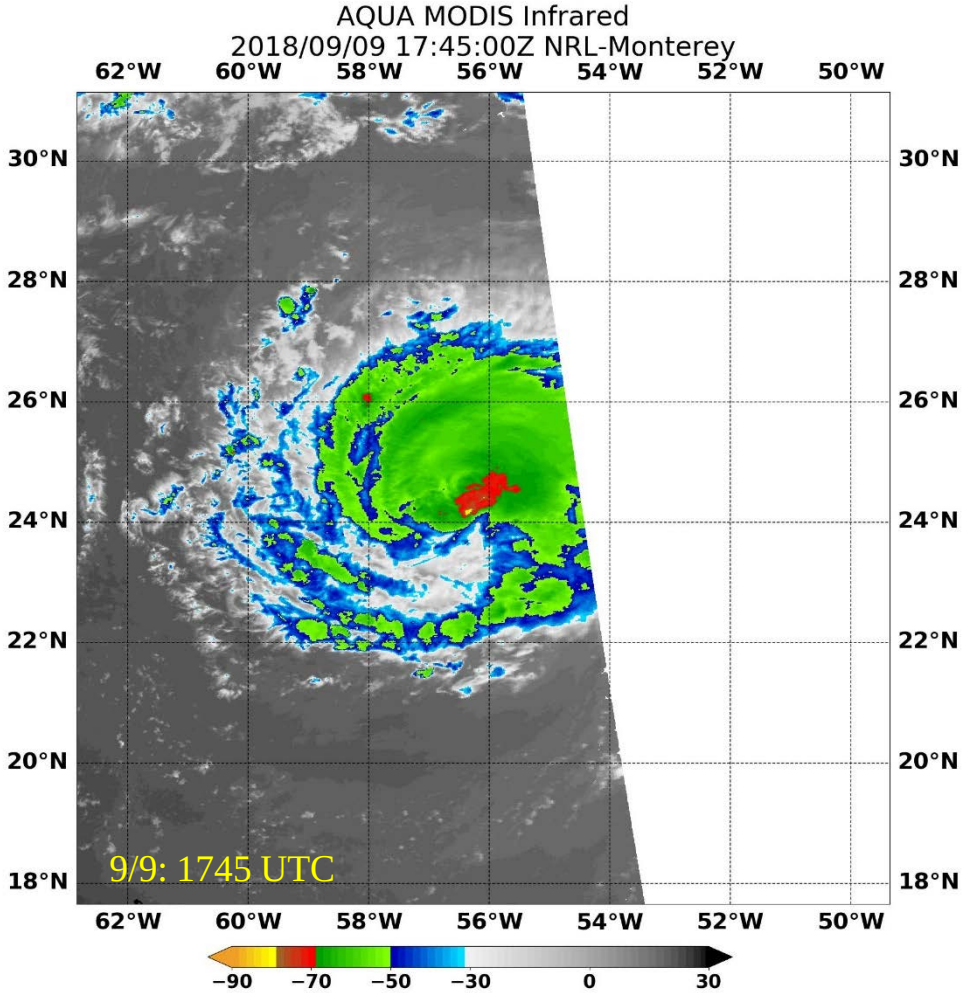
- Intensity remained near 60 kt
- Attempt a partial circumnavigation at 20 kft
- Butterfly with midpoint/endpoint/center sondes
- Released 8 AXBTs to sample ocean-atmos. surface fluxes
- Align first SW -> NE leg for CYGNSS underflight

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 2: 20180909H1 (Research, Early Stage Experiment / Ocean Winds)

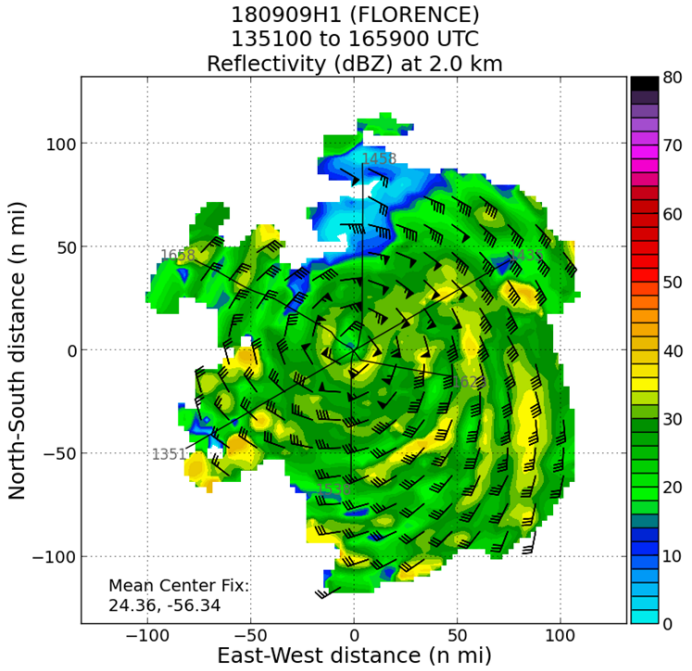


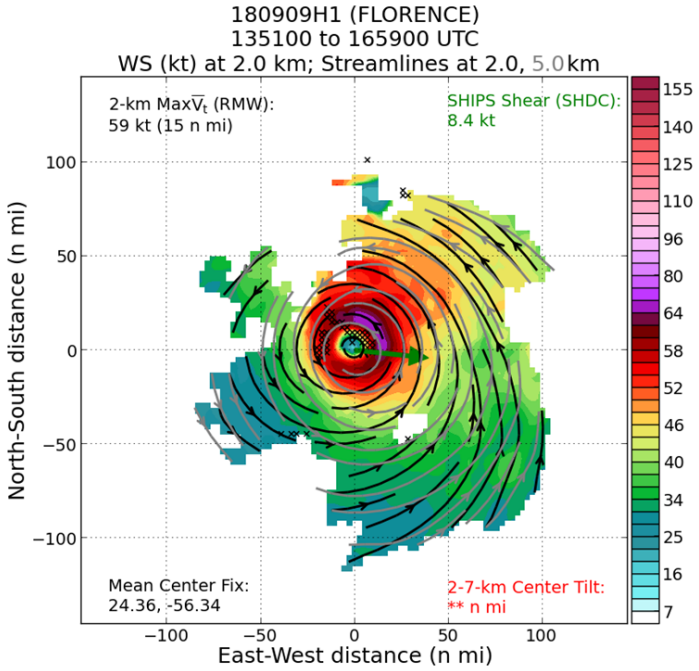


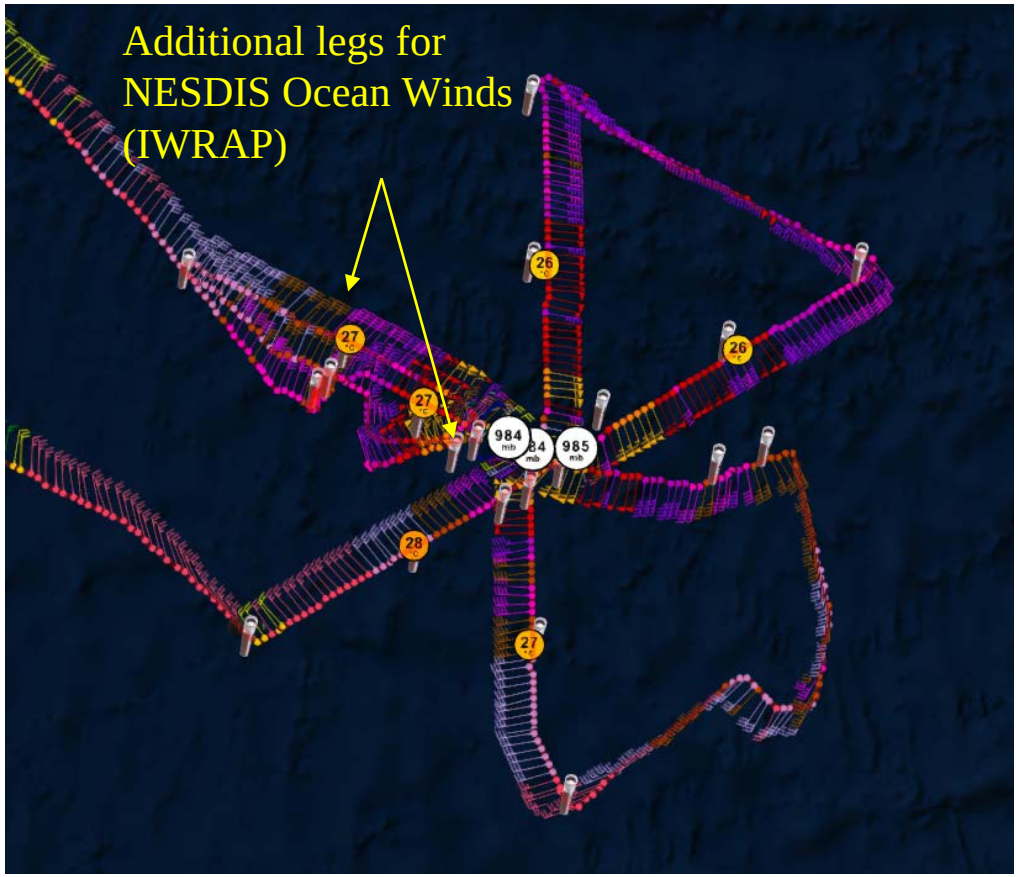
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 2: 20180909H1 (Research, Early Stage Experiment / Ocean Winds)





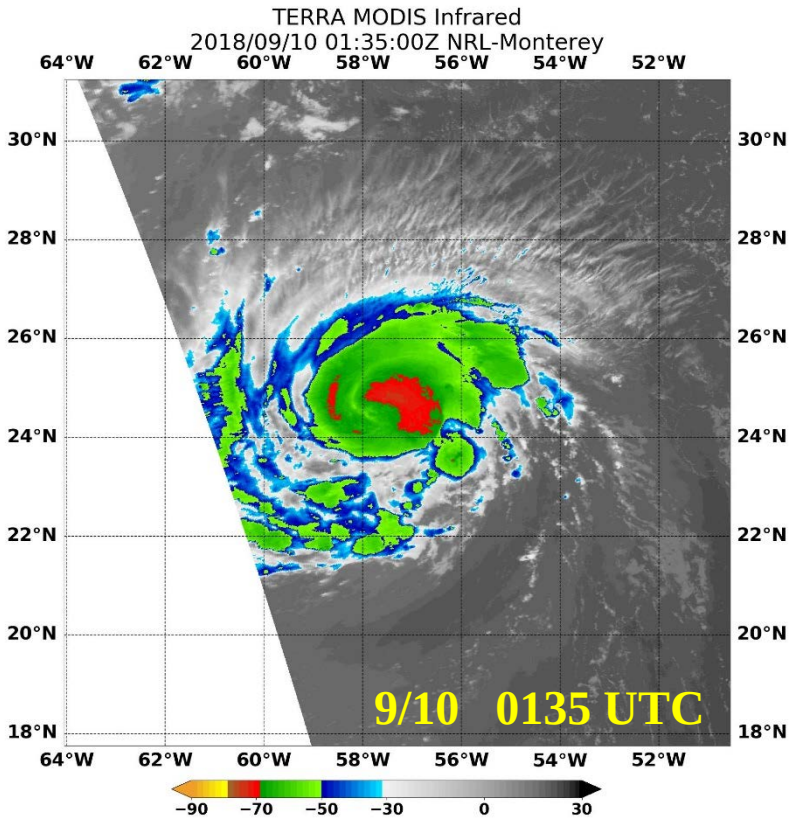


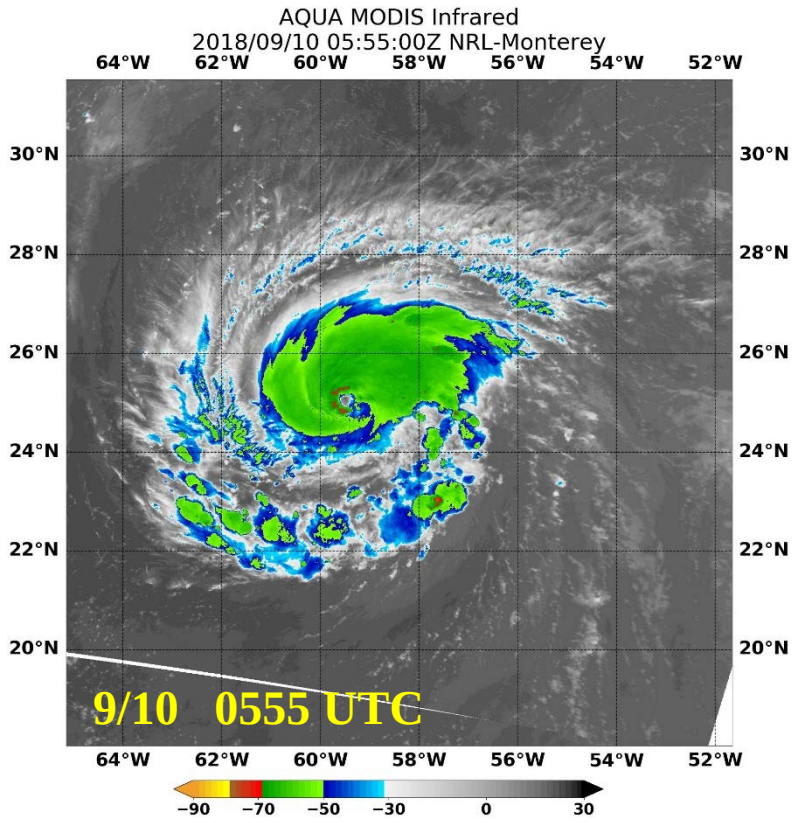
- Intensity remained near 65-70 kt
- Onset of subsequent RI period
- Butterfly with midpoint/endpoint/center sondes
- Released 8 AXBTs to sample ocean-atmos. surface fluxes
- Align first SW -> NE leg for CYGNSS underflight

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 3: 20180910H1 (Research, Mature Stage Experiment / Ocean Winds)



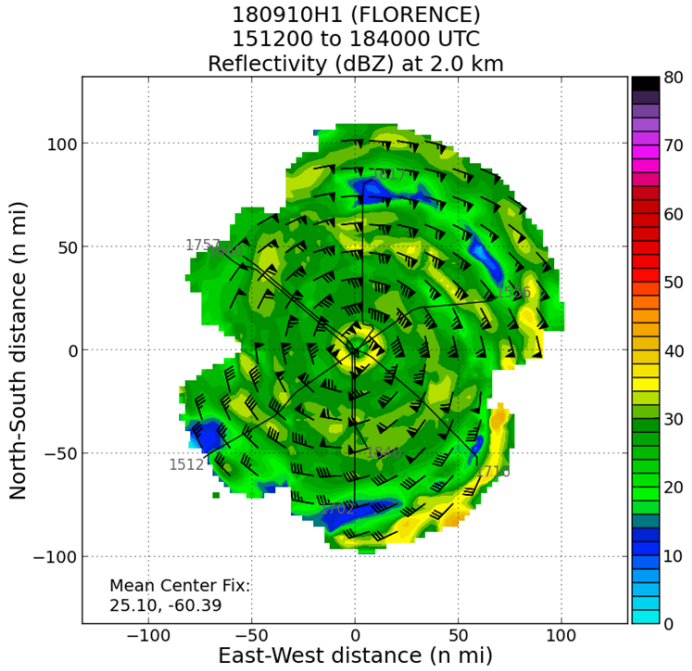


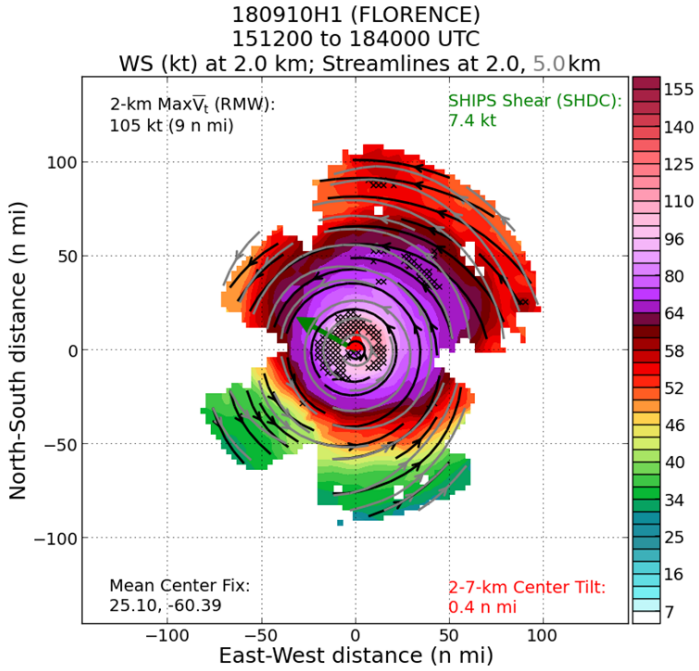
In the ~12-18 hours leading up this mission, Hurricane Florence rapidly intensified from 70 kt to 115 kt

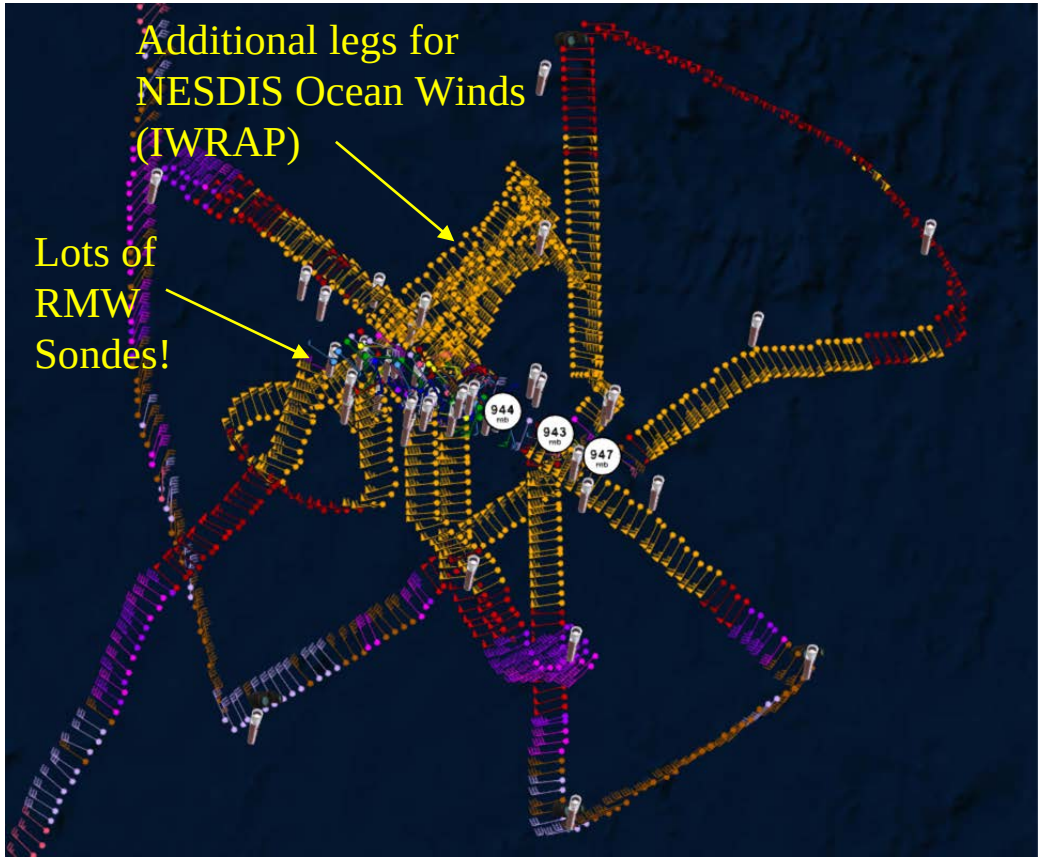
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 3: 20180910H1 (Research, Mature Stage Experiment / Ocean Winds)





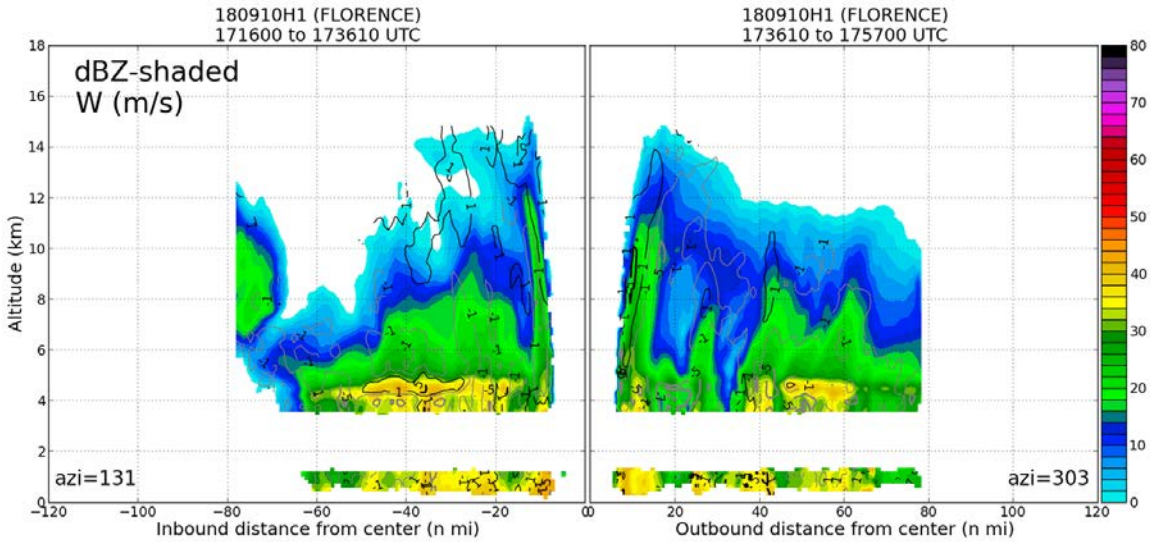


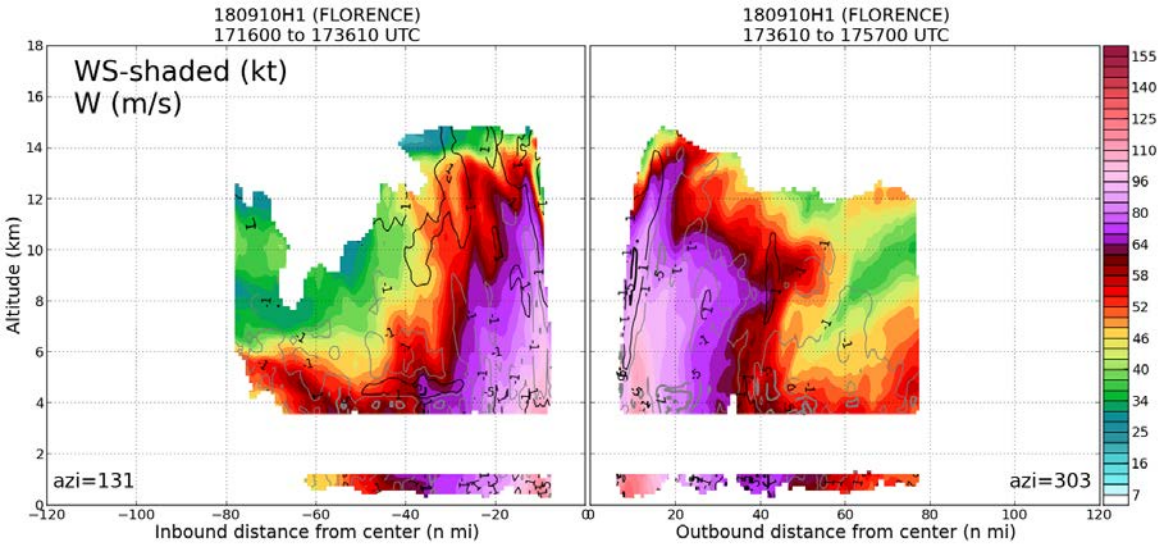
- Intensity remained near 120 kt
- Conclusion of RI period / possible beginning of SEF
- Butterfly with midpoint/endpoint/center sondes
- Released 4 AXBTs to sample ocean-atmos. surface fluxes
- Align first SW -> NE leg for CYGNSS underflight

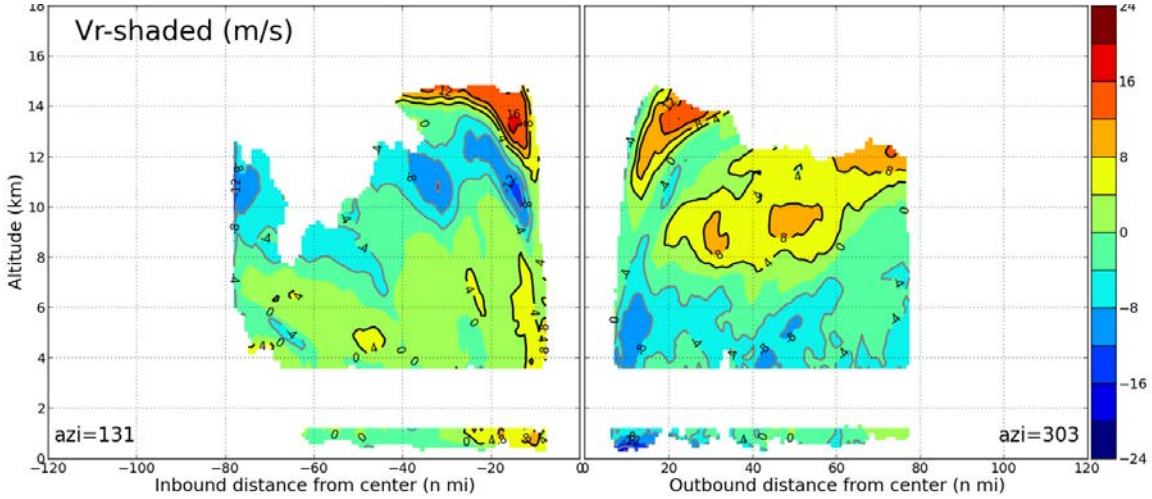
2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL06/Florence

Mission 3: 20180910H1 (Research, Mature Stage Experiment / Ocean Winds)





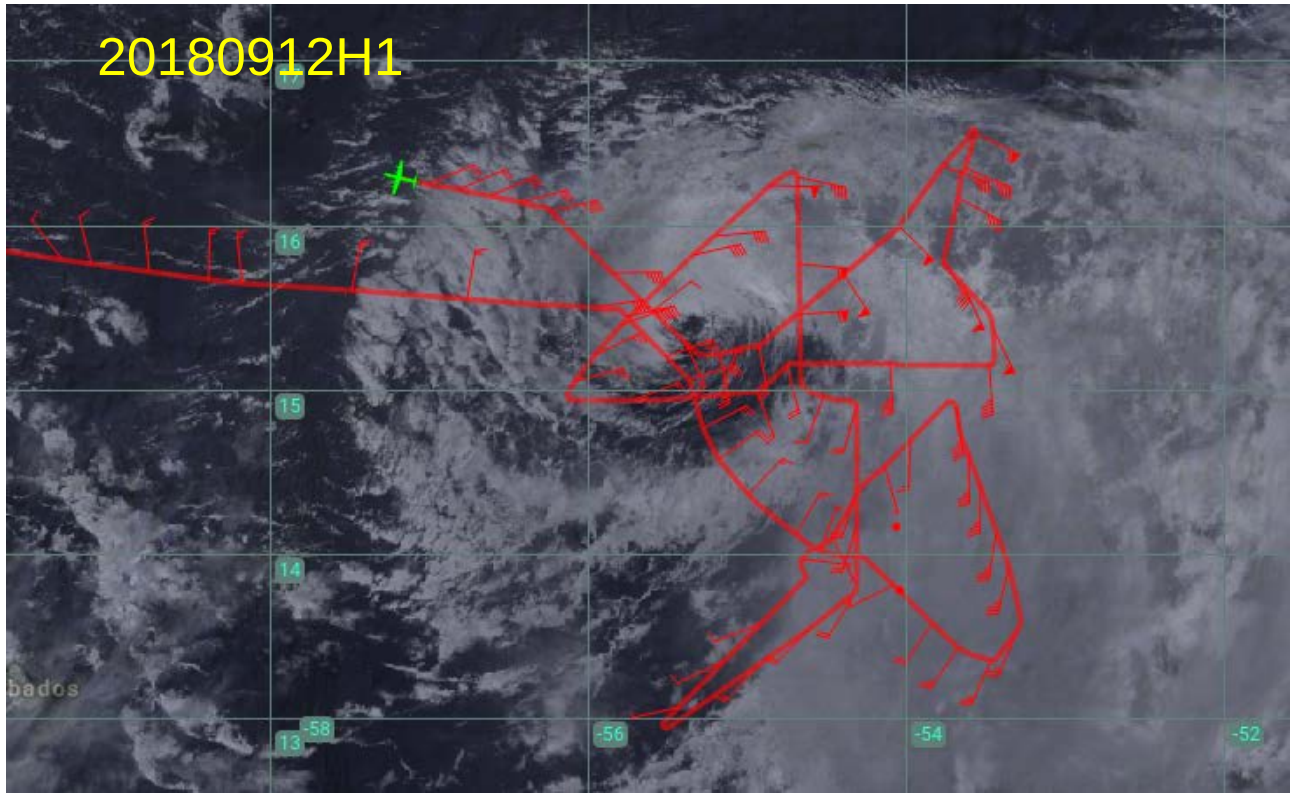


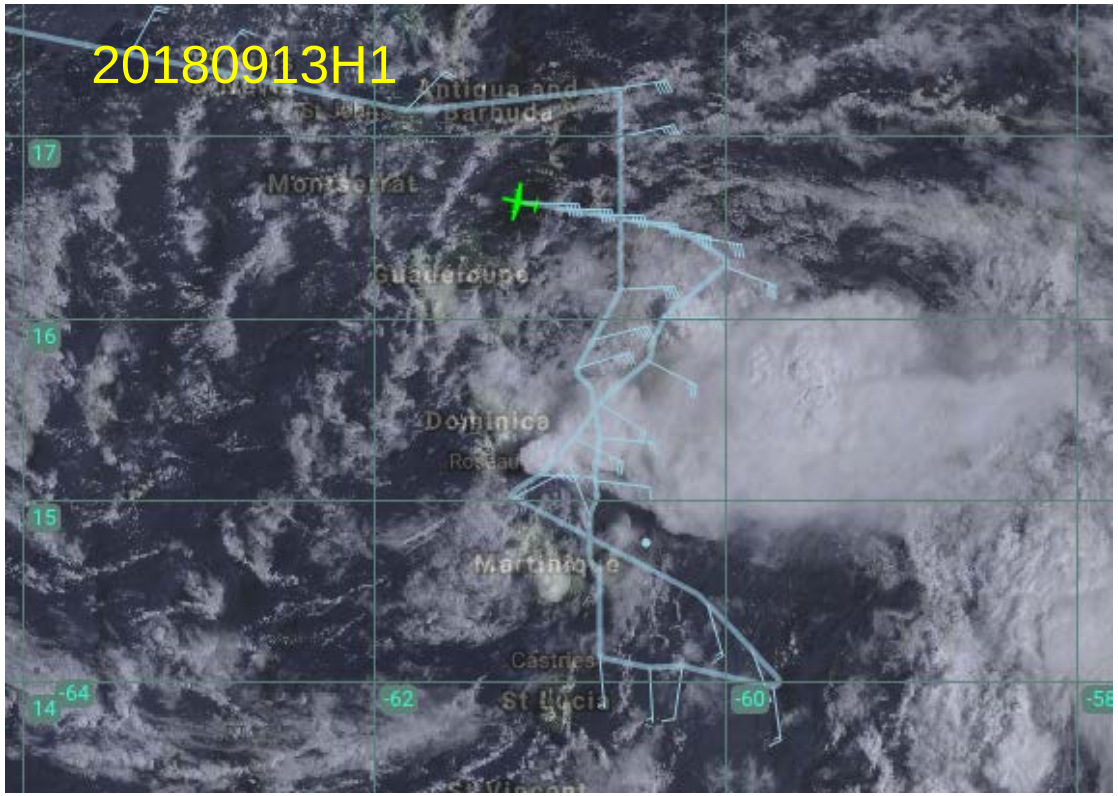
Near real-time analyses of the 3-D structure of precipitation and wind

Higher resolution profile analyses through each transect of the storm

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

AL09/Isaac





NHC-tasked reconnaissance missions out of St. Croix / Lakeland

Low-level circulation exposed, little convective coverage, weakening from tropical storm to open wave

2018 NOAA/AOML/HRD Hurricane Field Program
Intensity Forecast Experiment (IFEX)

- **Research to operations**
  - AWIPS-II development to view P-3 data (Tail Doppler radar, dropsonde, and flight level) and G-IV (Tail Doppler radar, dropsonde)
  - EMC assimilation of Doppler velocity from both P-3 *and G-IV*, complete suite of P-3/G-IV data
  - BUFR formatted dropsondes transmitted off the airplane
  - Inner circumnavigation on G-IV (90 nmi) for the first time around Florence
- **Science**
  - Early and Mature Stage science accomplished
  - Successful high altitude circumnavigations with the P-3
  - Focus on upshear properties
  - Hope to accomplish Genesis Stage Experiment objectives
  - JPSS NUCAPS validation work with the G-IV upcoming
- **Model Evaluation**
  - Sampled a variety of intensities, full 3-D measurements