

Low Altitude UAS Missions into Major Hurricane Maria (2017)



Joseph J. Cione^{1,3}

NOAA Acknowledgments: *Office of Oceanic and Atmospheric Research
Office of Marine and Aviation Operations
Aircraft Operations Center*

The Coyote UAS Scientific Team:

George Bryan³, Altug Aksoy¹, Kelly Ryan¹, Brittany Dahl^{1,5}, Jun Zhang^{1,5}, Ronald Dobosy⁴, Gijs de Boer², Edward Dumas⁴, Chris Fairall², Aaron Farber⁶, George Halliwell¹, Heather Holbach¹, Evan Kalina⁷, Bradley Kent⁸, Temple Lee⁴, Frank Marks¹, Chris Trout⁸, Rani Wiggins¹, Jonathan Zawislak^{1,5}, Michael Buban⁴

¹NOAA/AOML/HRD, ²NOAA/ESRL/PSD, ³NCAR, ⁴NOAA/ARL/ATDD, ⁵Univ. Miami/CIMAS,
⁶Latitude Engineering, ⁷NOAA/DTC/CIRES, ⁸Raytheon Corp.

IHC/TCORF Annual Meeting
Thursday 15th 2018
Miami, Florida

Observational Team Objective:

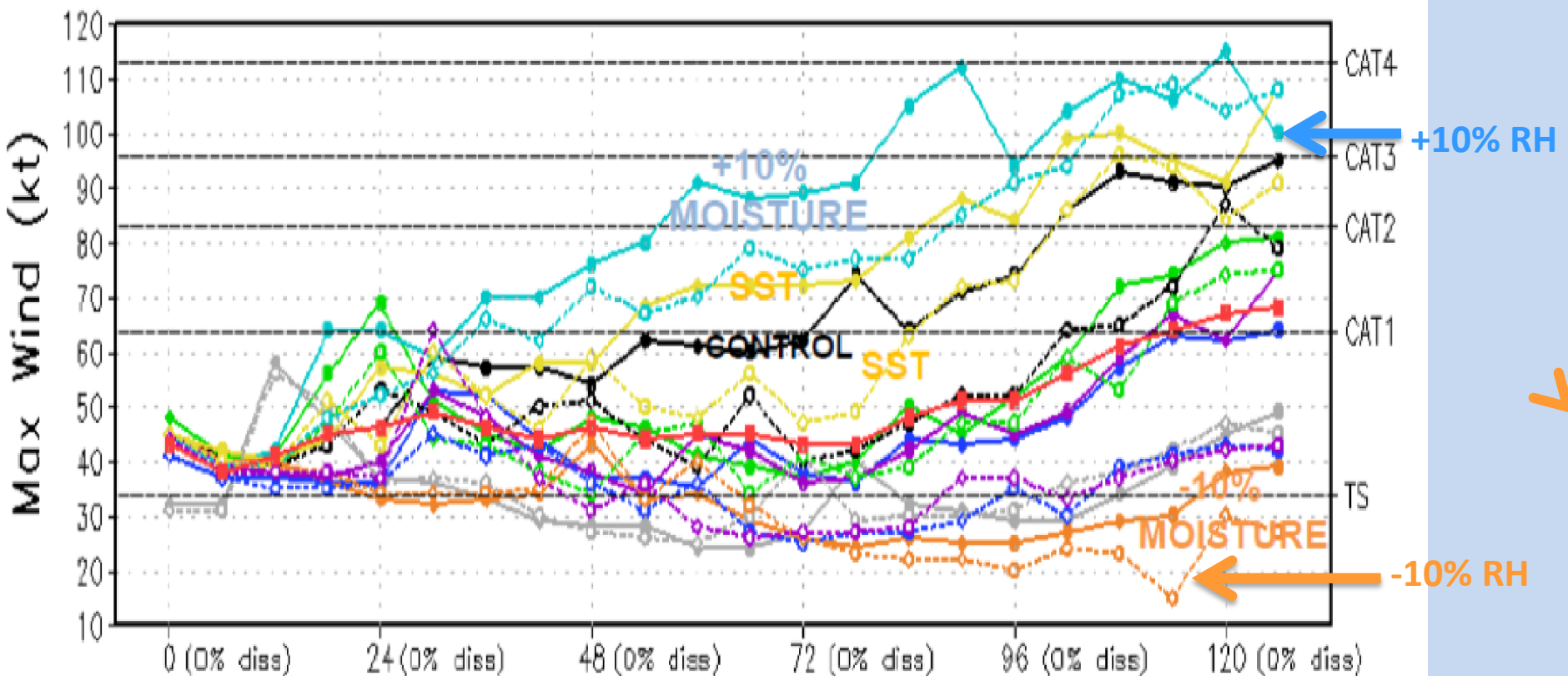
Leverage key attributes of NOAA's existing Hurricane Hunter P-3 aircraft to develop emerging unmanned technologies designed to enhanced data coverage of the critically important, yet sparsely-sampled tropical cyclone boundary layer environment.

End goal:

Through enhanced observation...improve basic understanding, operational situational awareness and ultimately, hurricane intensity forecast performance.

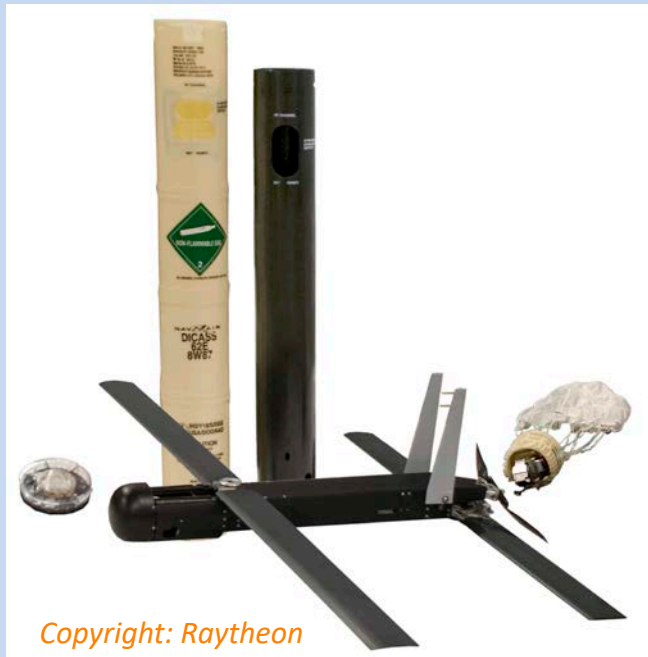
Model Extreme Sensitivity to Small Differences in boundary layer moisture as it relates to forecasts for hurricane intensity...

GFDL Ensemble Forecast for ERNEST005L: Maximum Wind
Initial time: 00Z04AUG2012

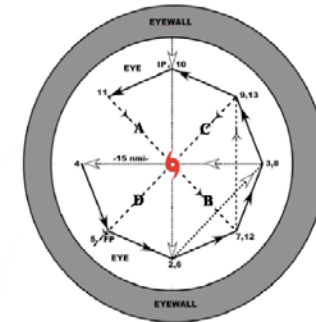


Coyote UAS: A new tool to help us better understand, evaluate and ultimately improve future forecasts of intensity change...

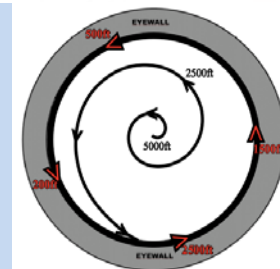
Flight patterns



Coyote UAS - P3 Mature Hurricane Eye Module

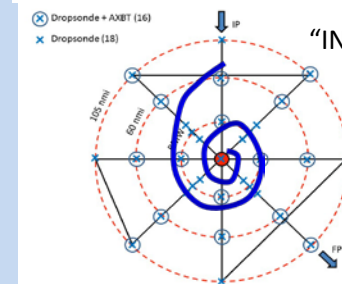


P-3 FLIGHT PATTERN

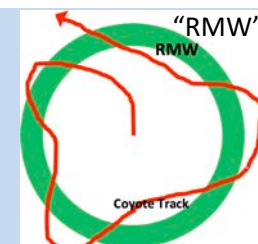


"EYEWALL"

COYOTE UAS
FLIGHT PATTERN



"INFLOW"



"RMW"

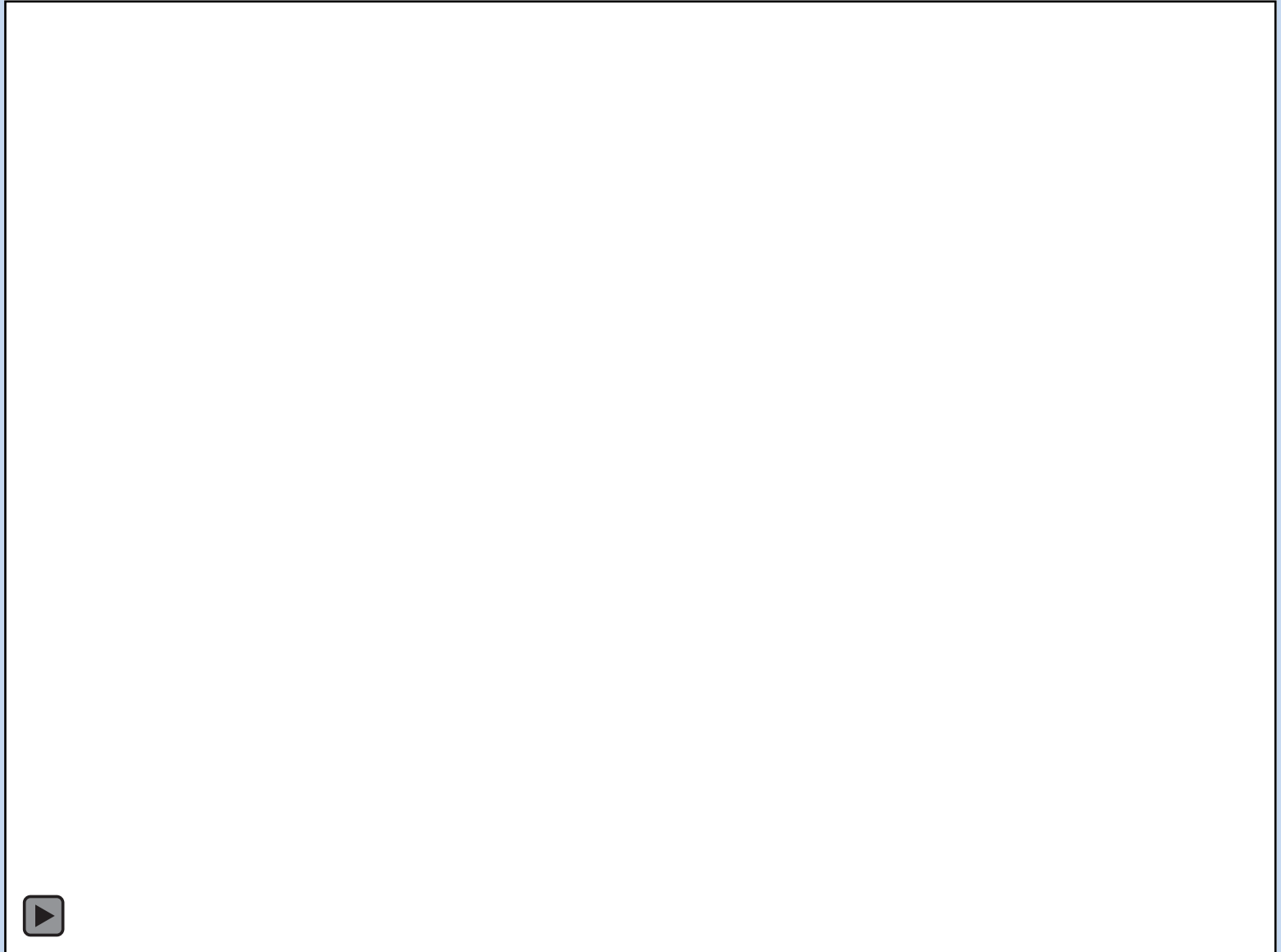
Coyote Track

For more details on the specifications of the data collected by Coyote see: [Cione et al. 2016 \(Earth and Space Science\)](#)
DOI: [10.1002/2016EA00018](#)

Coyote UAS – Deployment Sequences



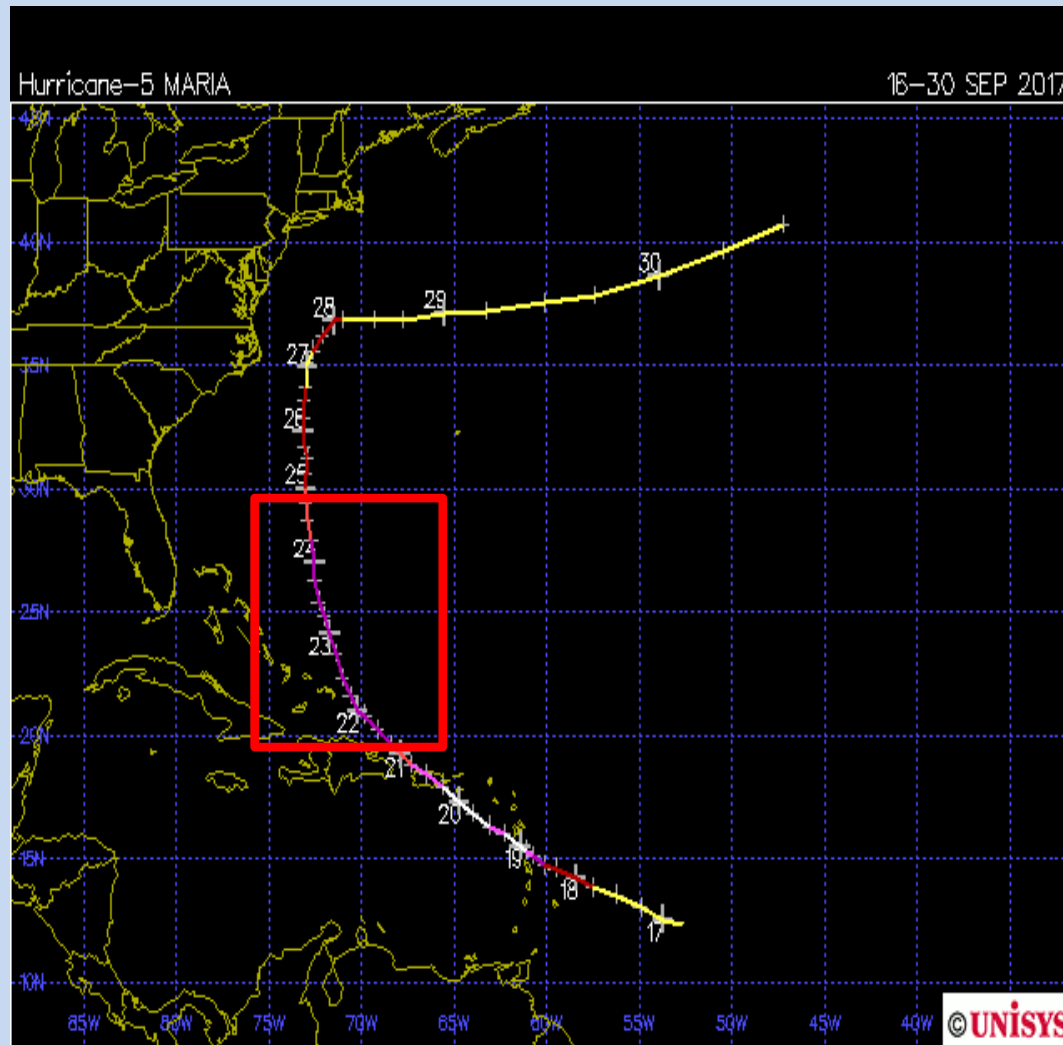
Coyote UAV – Deployment Sequences



Hurricane Maria

22-24 Sep 2017

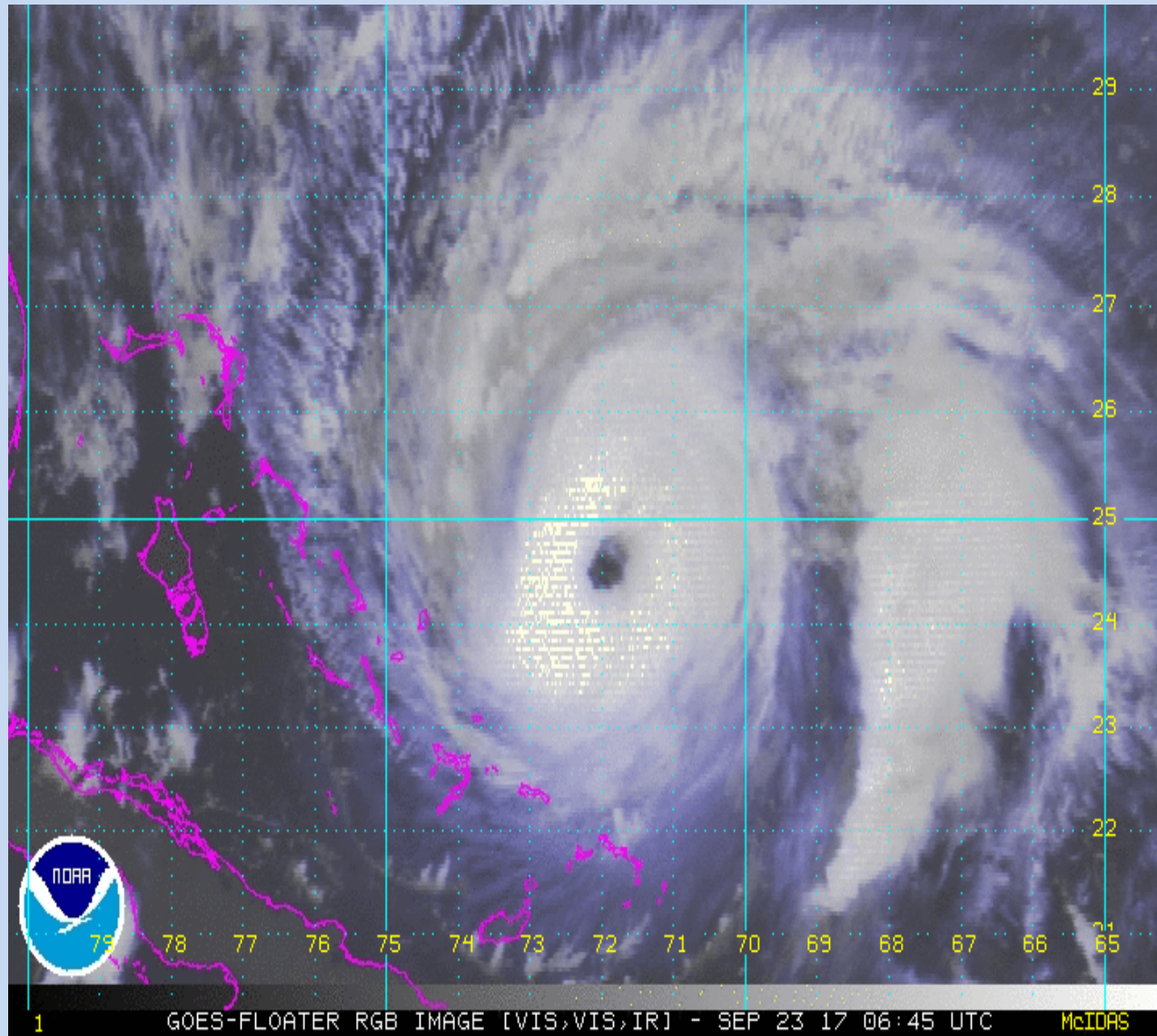
Approx. Category 3: Min pressure ≈ 950 mb; Max 10-m wind speed ≈ 100 kt



Hurricane Maria

22-24 Sep 2017

Approx. Category 3: Min pressure ≈ 950 mb; Max 10-m wind speed ≈ 100 kt



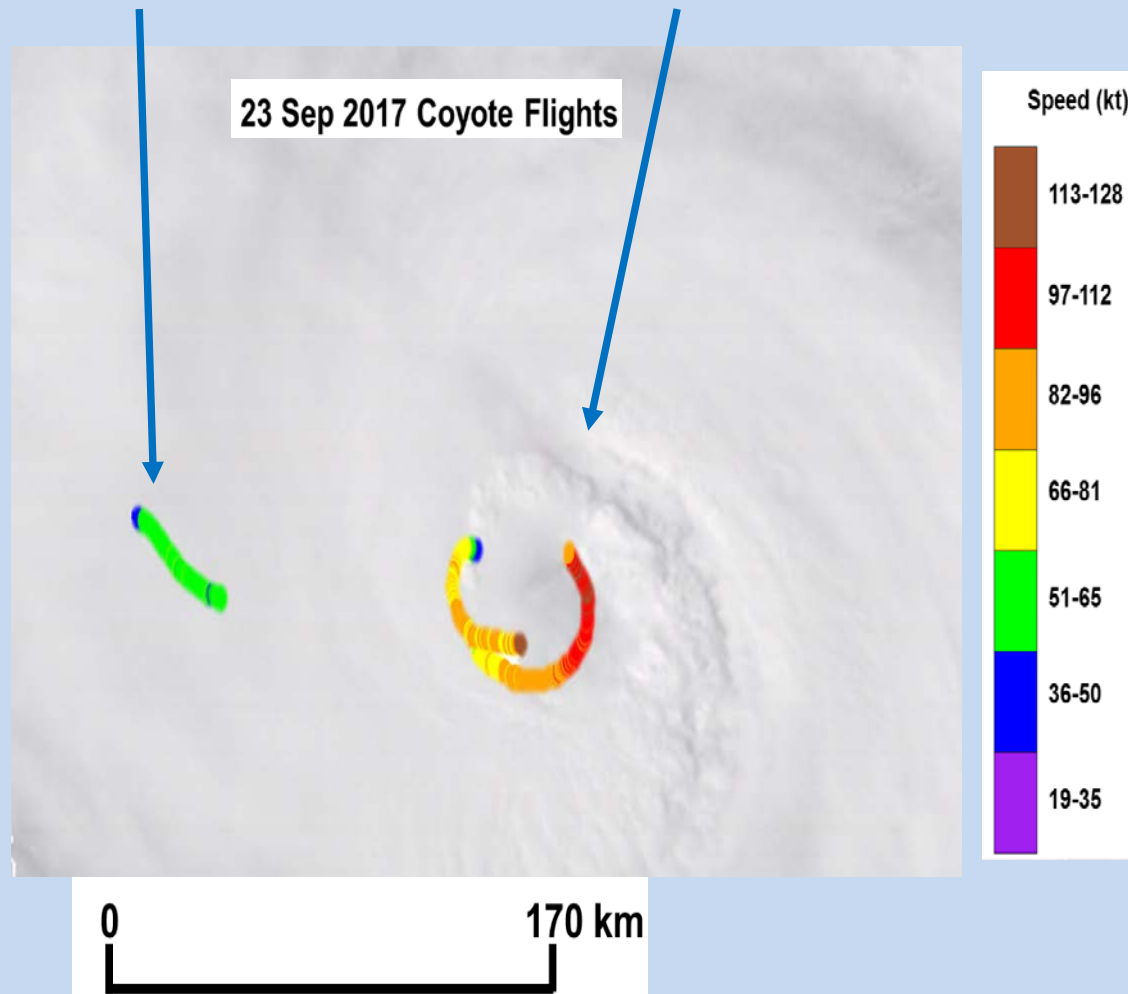
Unique Observational Data in Hurricanes

Fundamental Research:

Measurements of turbulent fluxes, eddy dissipation rate, etc, in hurricane boundary layer; structure of turbulence

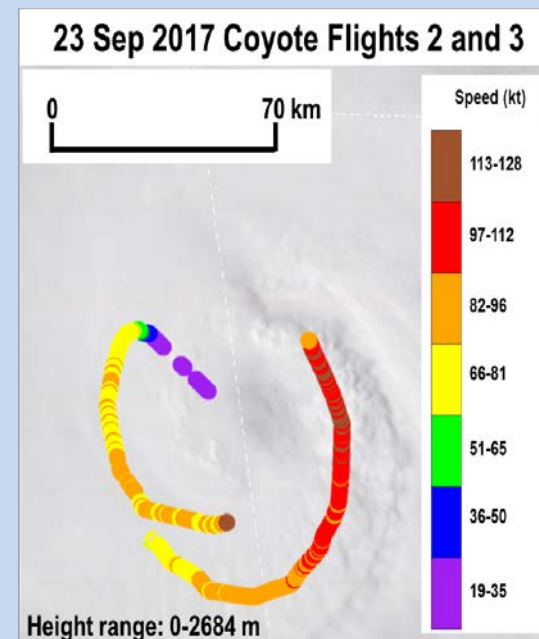
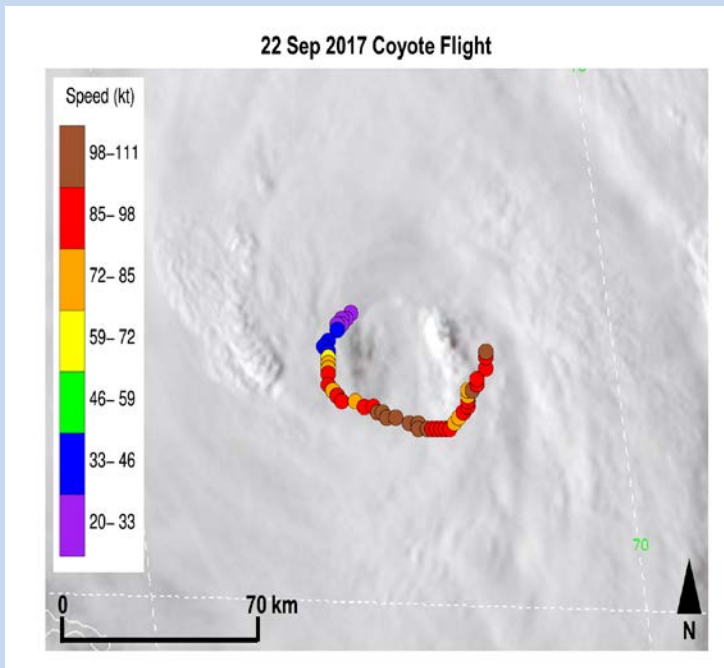
Reconnaissance:

e.g., locate and measure maximum wind speeds



Summary of Coyote Flights in Hurricane Maria

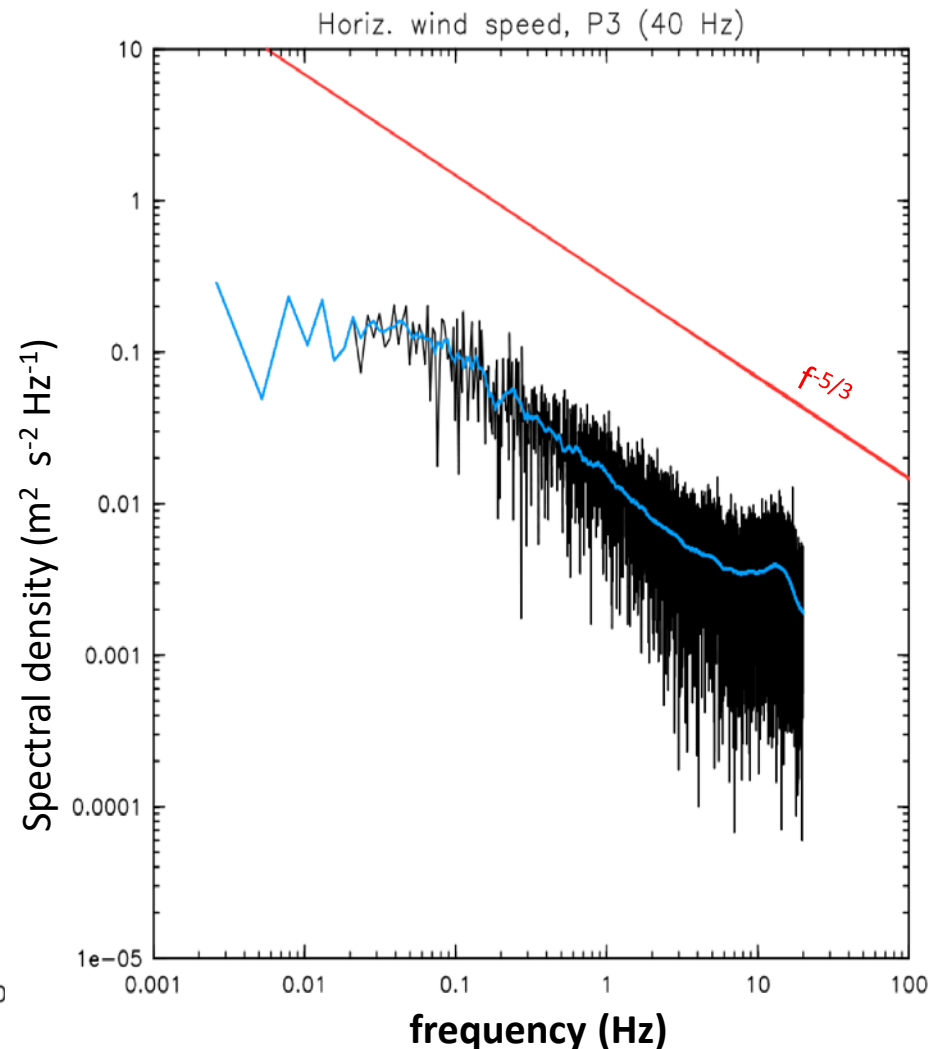
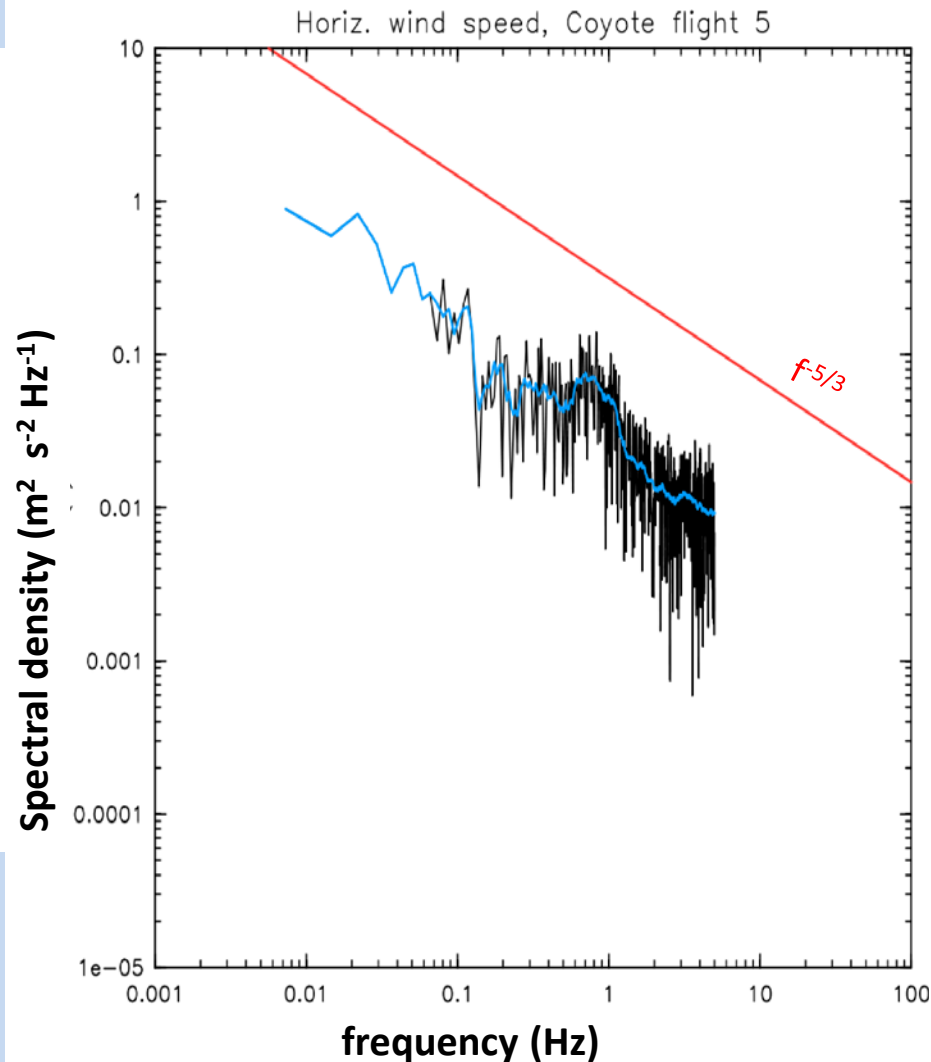
- 6 total flights on 22-24 September
 - 3 “eyewall” modules: searching for flight level max winds
 - 1 “inflow” module: boundary-layer obs. (eddy dissipation)
 - 2 “glider” flights: gradual descent (issues with engine initiation)
- Longest flight: 43 minutes
- Max wind speed: 64 m/s at 340 m ASL



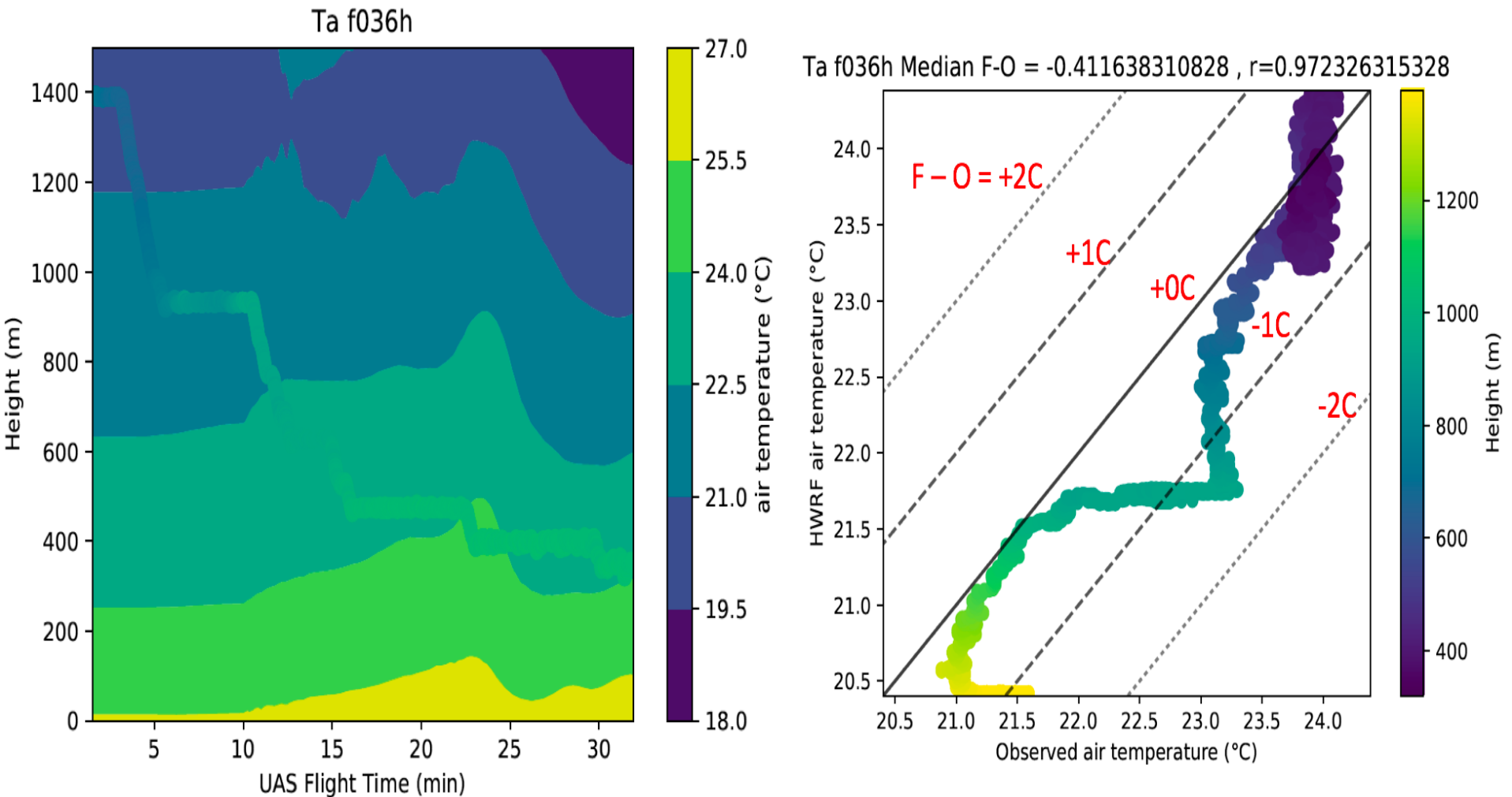
Turbulence Studies (Foci 1): Comparison of Velocity spectra from Coyote and P3

Coyote (Hurr. Maria 2017): ≈ 10 Hz

P3 (CBLAST, Hurr. Isabel, 2003): 40 Hz



Operational Numerical Model Evaluation (Foci 2): Evaluation of Physical Parameterization Schemes in NWP Models (HWRF)



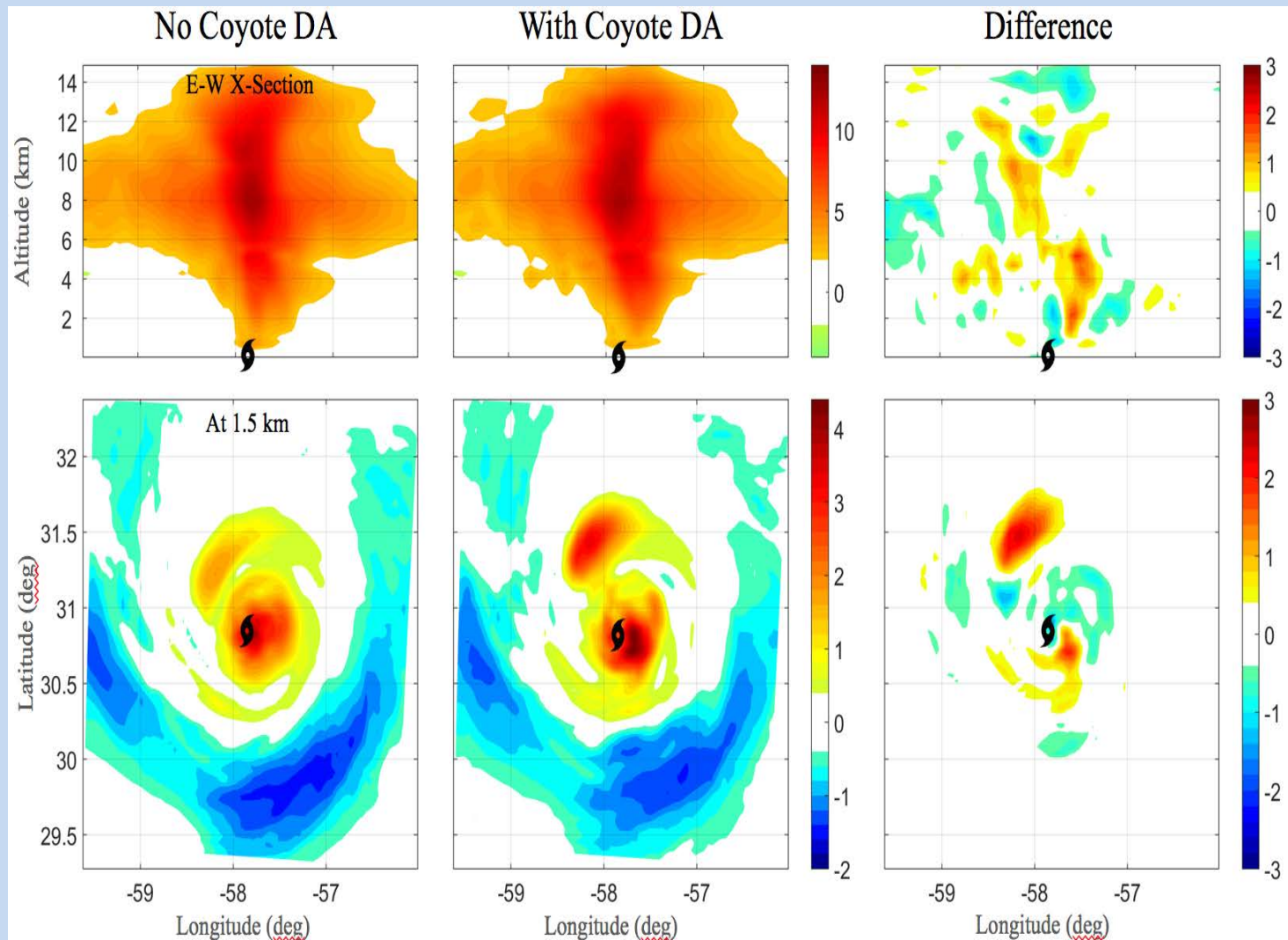
Sep 23, 36-h forecast: Model BL generally cooler than Coyote data

OSE/OSSE (Foci 3)

Impact of Coyote Data on Numerical Weather Prediction (NWP)

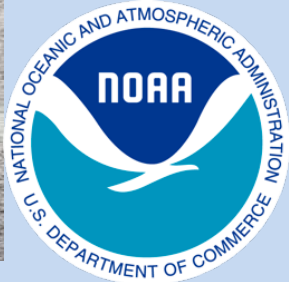
Coyote Mission on 16 September (Eduoard, 2014)

Comparison of Temperature Perturbation (K)

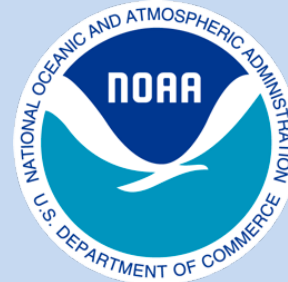


Altug Aksoy, NOAA/AOML/HRD

Raytheon Coyote Drone



Summary



• Why Coyote UAS Data collected in Hurricane Maria are special...

- 1st Successful 3 day deployment of a small UAS into a Major Hurricane (repeatability)
- Highest UAS-measured wind speed in a tropical cyclone (64 m/s at 340 m ASL)
- Record UAS endurance in a hurricane eyewall environment (42 minutes)
- High-frequency wind measurements collected at low altitudes (up to 10 Hz)
- Continuous thermodynamic and kinematic data collected in the hurricane eyewall (at controlled flight level altitudes as low as 120m)
- UAS data transmitted in real time to NHC each day (and noted in NHC discussions on 9/22 and 9/23)

These type of highly unique data have the potential to significantly enhance physical understanding of a rarely observed region of the storm, improve operational situational awareness and provide valuable insights related to (coupled) model evaluation and improvement...

• Future operations:

- Improve/expand existing METOC payload
- Incorporate a turbulence/gust probe?
- Refine flight patterns, based on lessons learned from 2017
- Working with the 53rd, AOC and Raytheon, conduct a C-130/Coyote Demo at Avon park, FL (5/18?)