Evaluating the Impact of Hurricane Observations from the Unmanned Coyote Aircraft in Observing System Simulation Experiments

Altug Aksoy[1,2]

Joe Cione[2,3], Brittany Dahl[1,2], Hui Christophersen[1,2], Robert Atlas[4]

[1] Cooperative Institute for Marine and Atmospheric Studies, University of Miami – Miami, Florida
[2] Hurricane Research Division, NOAA/AOML – Miami, Florida
[3] Physical Sciences Division, NOAA/ESRL – Boulder, Colorado
[4] Atlantic Oceanographic and Meteorological Laboratory, NOAA – Miami, Florida

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NOAA Hurricane Forecast Improvement Project (HFIP)

Coyote Unmanned Aircraft System

A New Tool to Better Observe Tropical Cyclones

The NOAA P-3 Aircraft Typically Penetrates Tropical Cyclones and Collects Data with a Suite of Instruments

The Dropsonde System is Designed to Measure the Vertical Variations in the Atmosphere

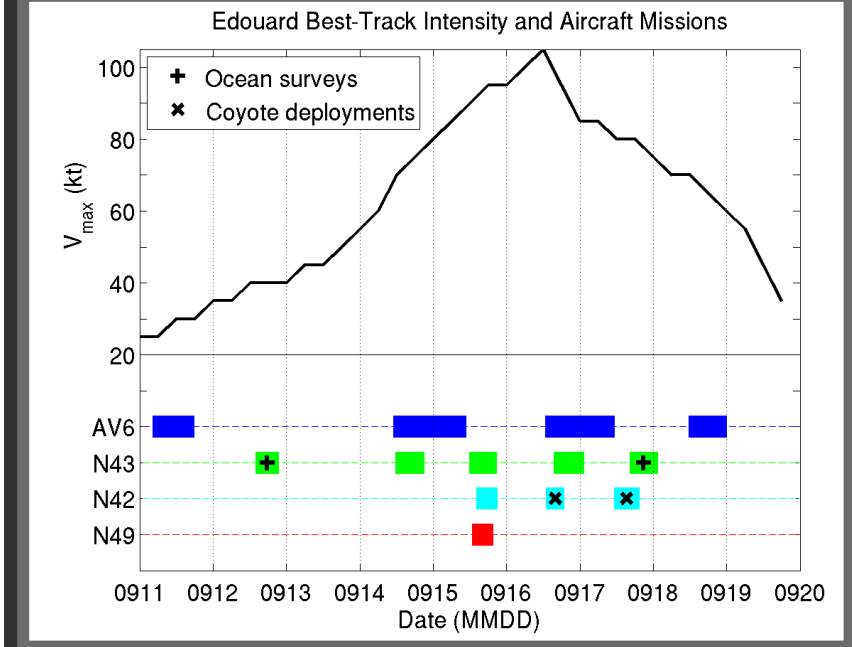
The Coyote is a Small Aircraft that Uses the Dropsonde Deployment System and Sensor Suite and is Capable of Remaining Airborne for ~1 h or Longer

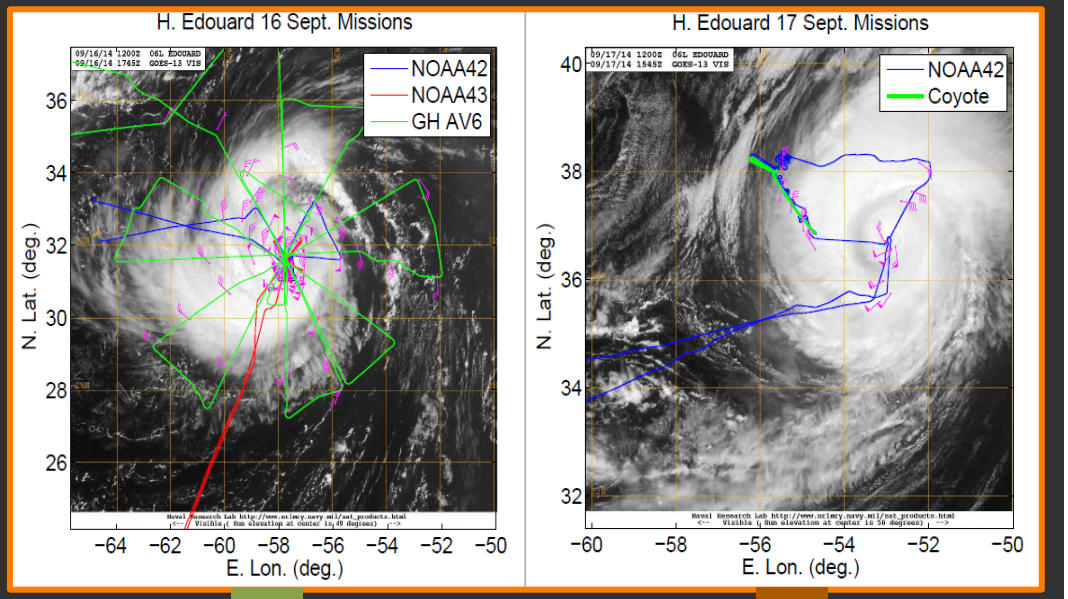
Hurricane Edouard (2014) Aircraft Missions

Coordination of Multiple Aircraft and Coyote Missions

Multiple Aircraft Conducted Successful Missions:

- NASA Global Hawk (AV6)
- NOAA P-3 (N42/N43) and G-IV (N49)
- Ocean Surveys (+)
- Coyote UAS Missions (x)





1

16 September 2014 1432Z
Eye/Eyewall Sampling
28-minute Mission
Min. Altitude 896 m
Max. Wind Speed 100 kt

2

17 September 2014 1507Z
Inflow Channel Sampling
68-minute Mission
Min. Altitude 400 m
Max. Wind Speed 53 kt

Hurricane Edouard (2014) Aircraft Missions

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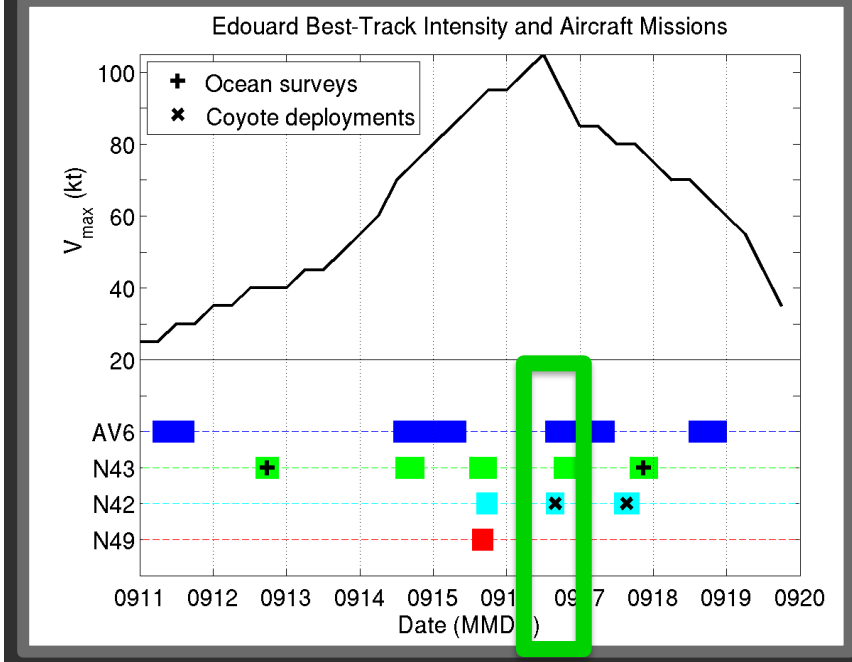

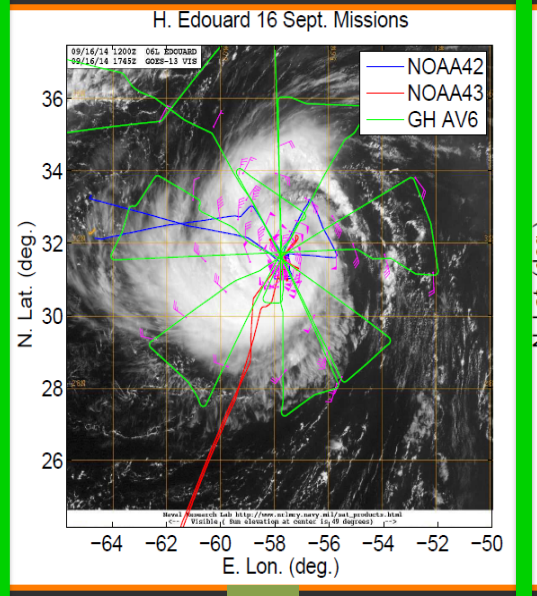

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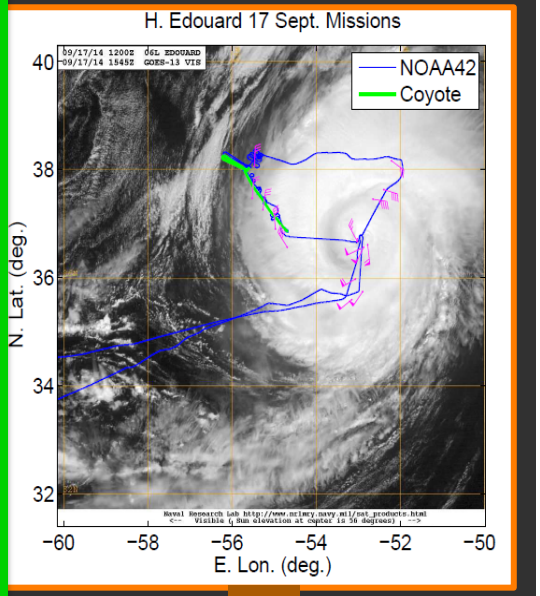

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Inflow Channel Sampling
68-minute Mission
Min. Altitude 400 m
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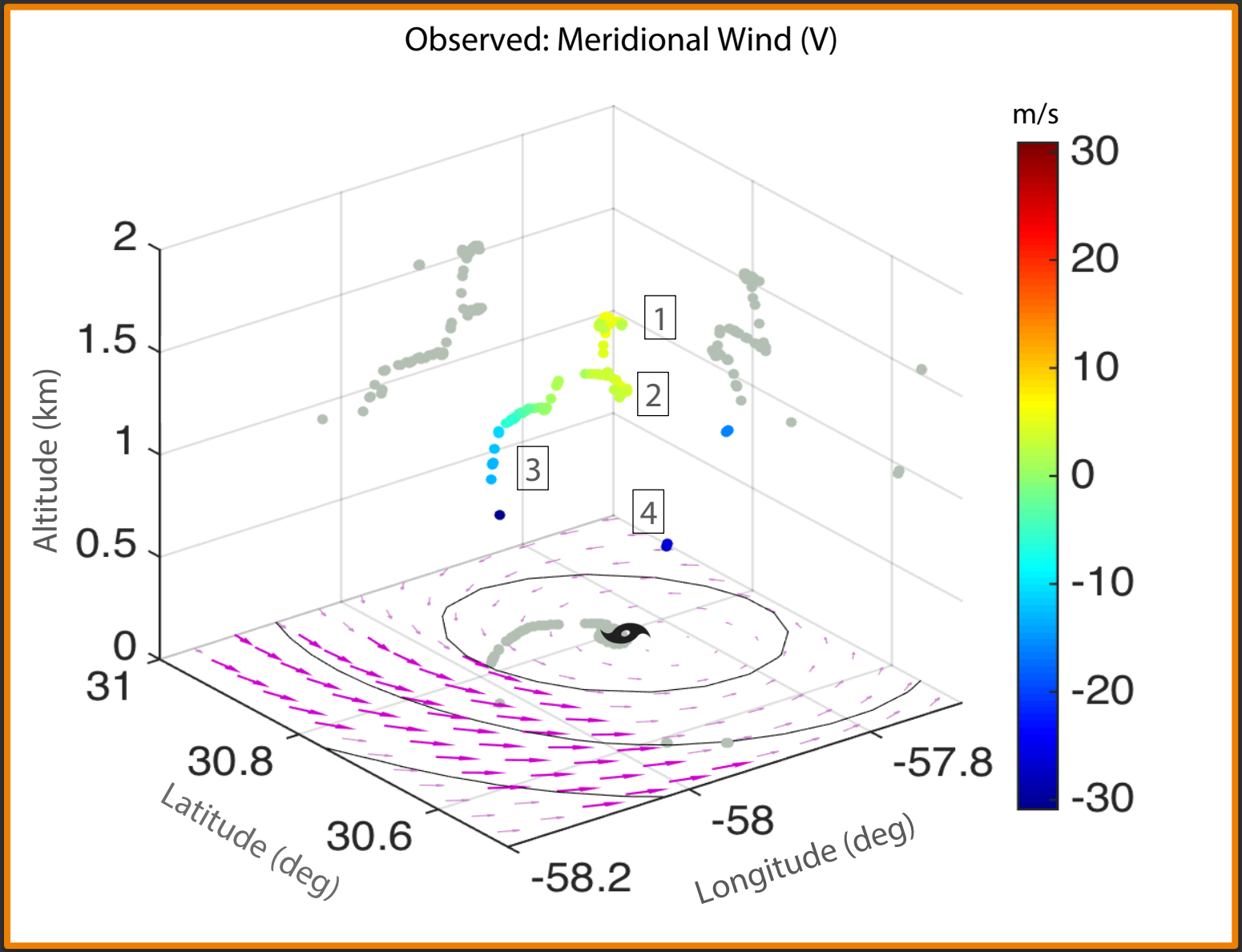
Can we repeat the findings of the real-data experiment and expand on it in an OSSE?

Altug.Aksoy@noaa.gov

Coyote Mission on 16 September

Closer Look at What Was Observed



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Coyote Mission on 16 September

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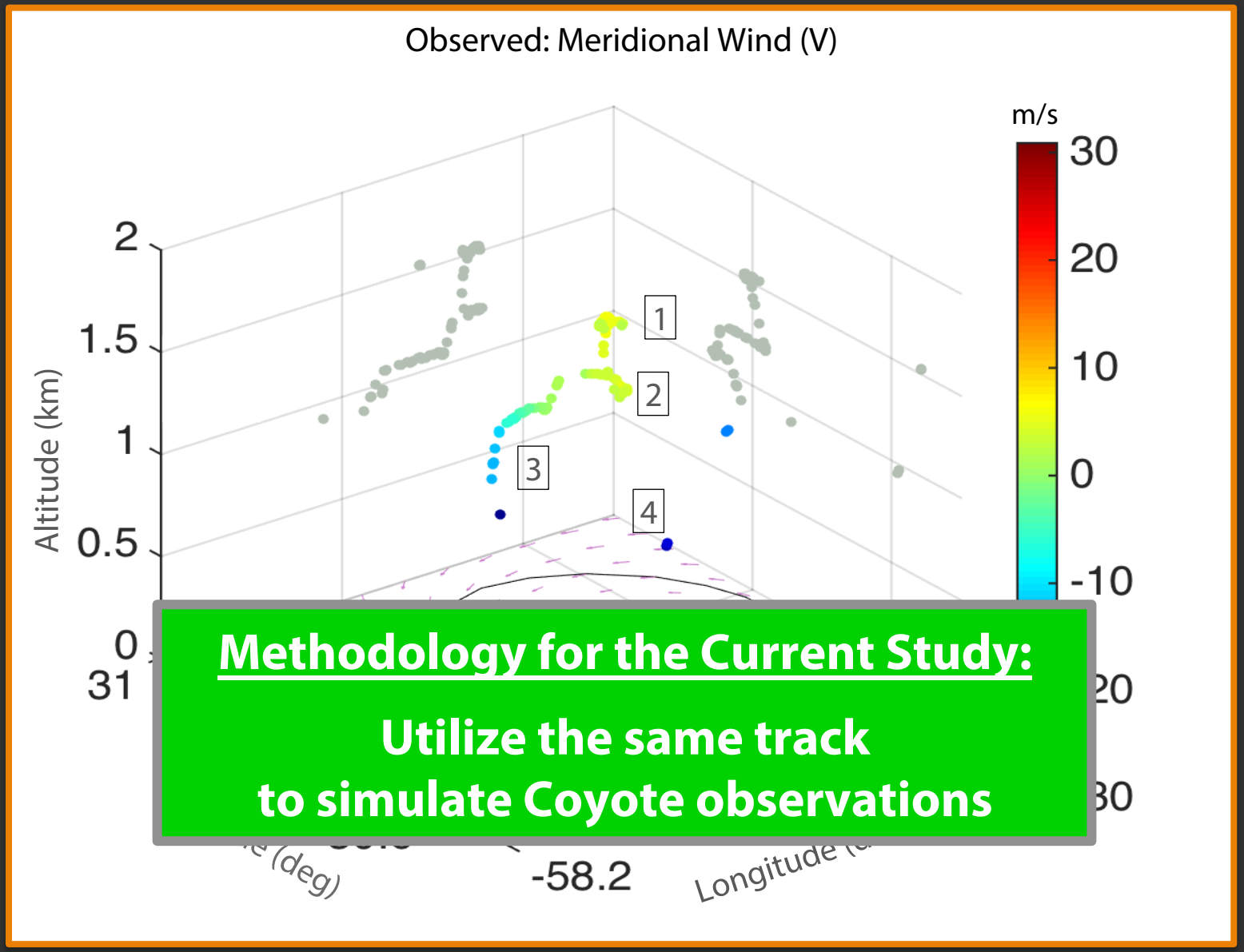
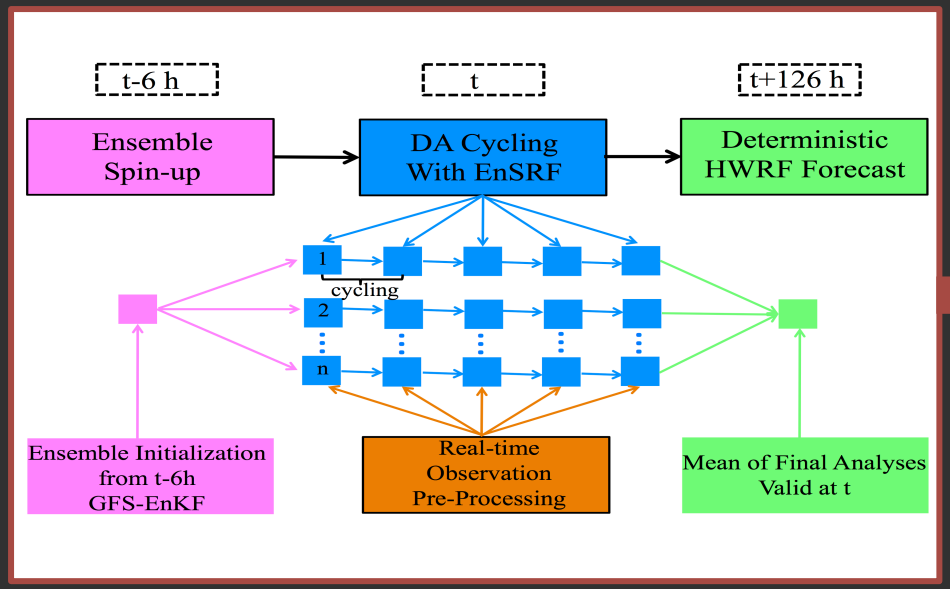


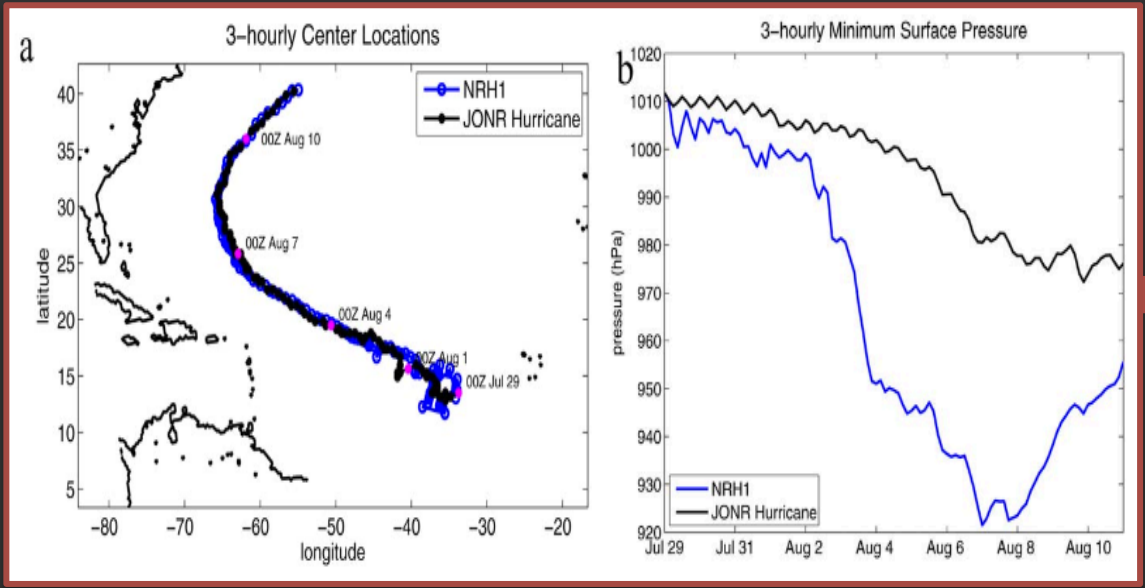
OSSE Experimental Setup

Data Assimilation System and Nature Run



HEDAS Characteristics

- Focus on tropical cyclone inner-core data assimilation for high-resolution vortex initialization
- Uses the ensemble square-root Kalman filter (Whitaker and Hamill 2002)
- Storm-relative observation processing capability (Aksoy 2013)

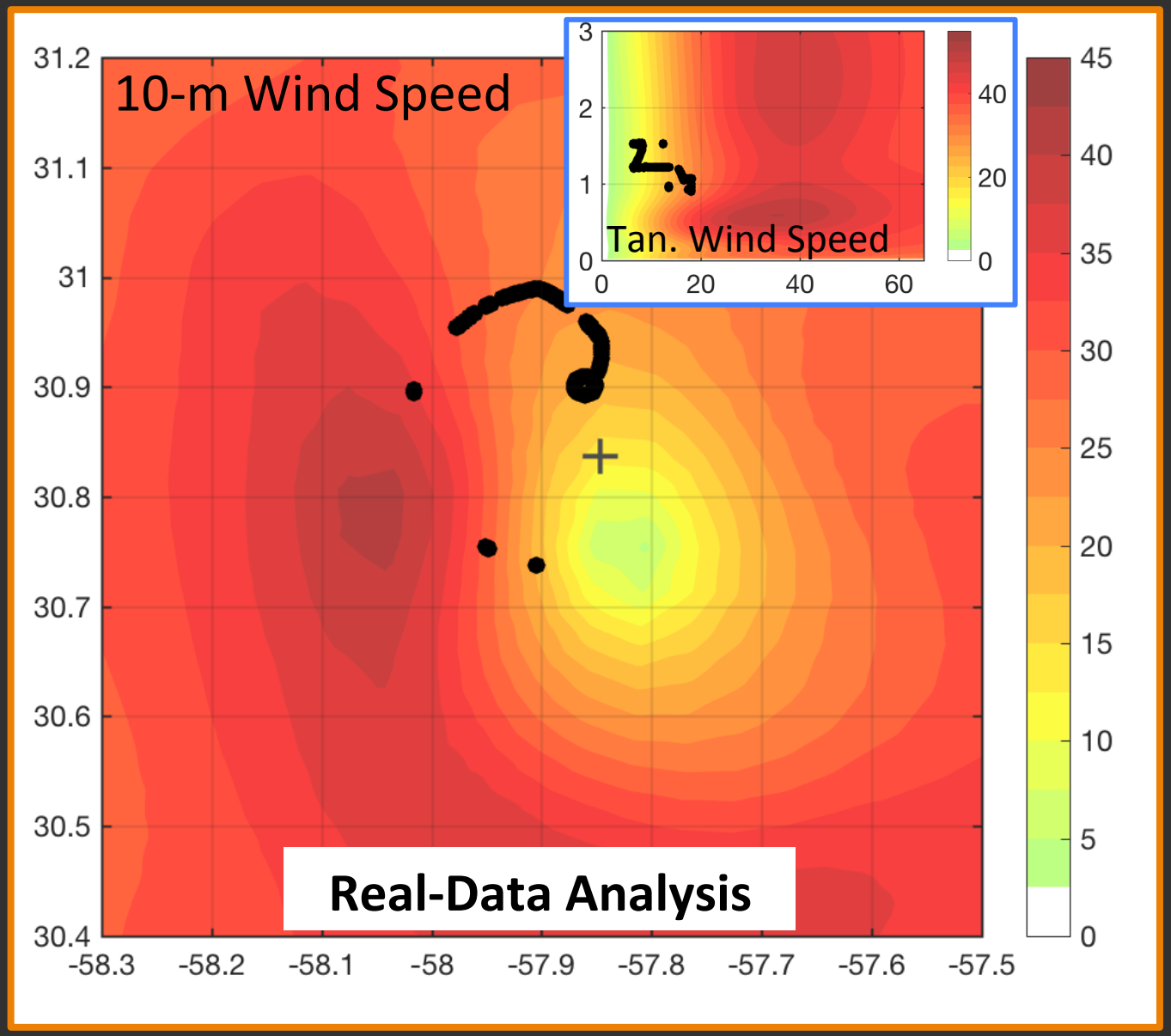


Nature Run Characteristics

- From Nolan et al. (JAMES 2013)
- High-resolution (27/9/3/1 km) hurricane simulation with WRF-ARW
- Embedded in and nudged toward an ECMWF T511 nature run

Simulating Coyote Observations for OSSEs

Question: What If We Observed the Nature Run Same As Real Data?



Actual Edouard (2014)
16 September
Observations

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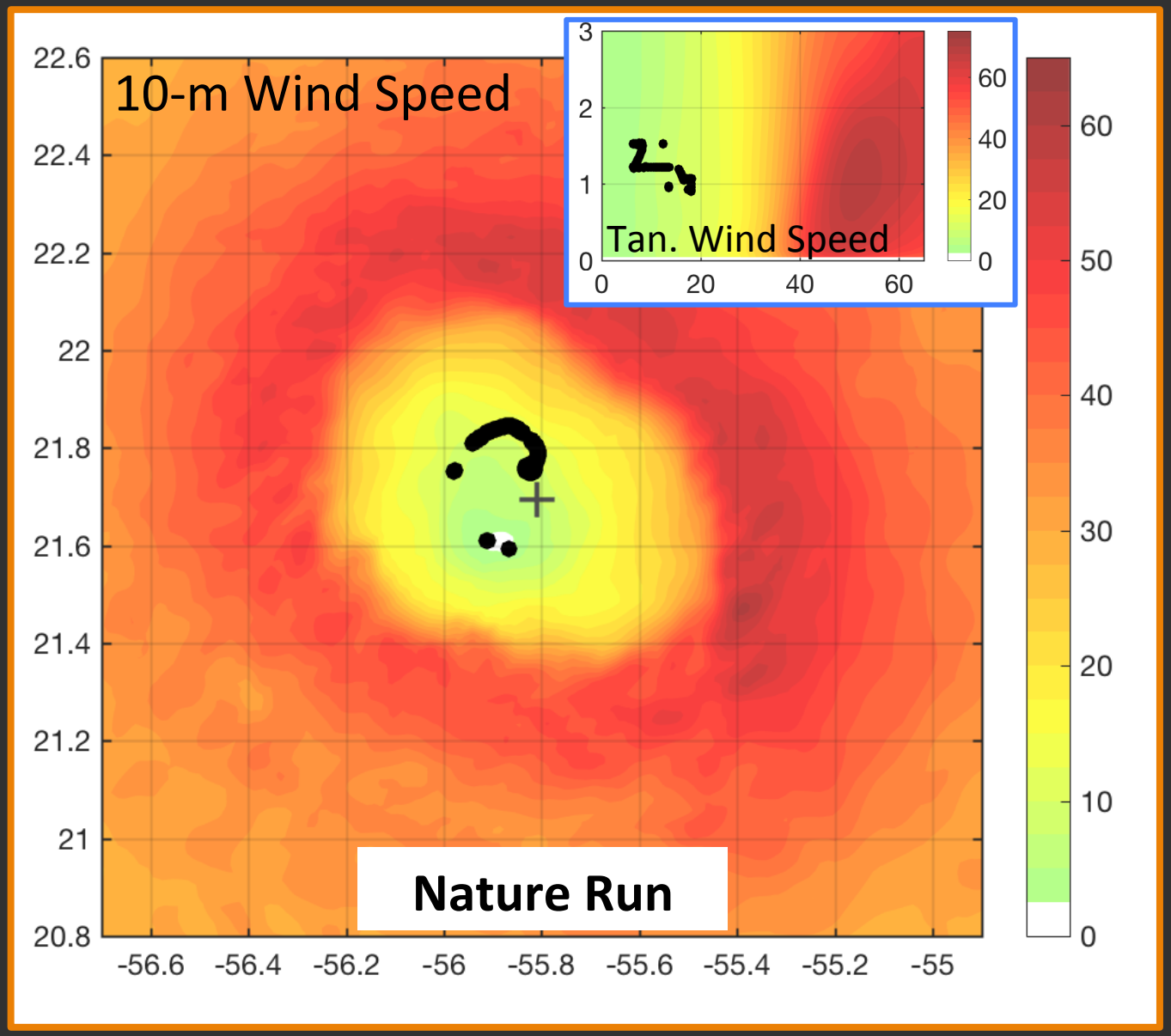

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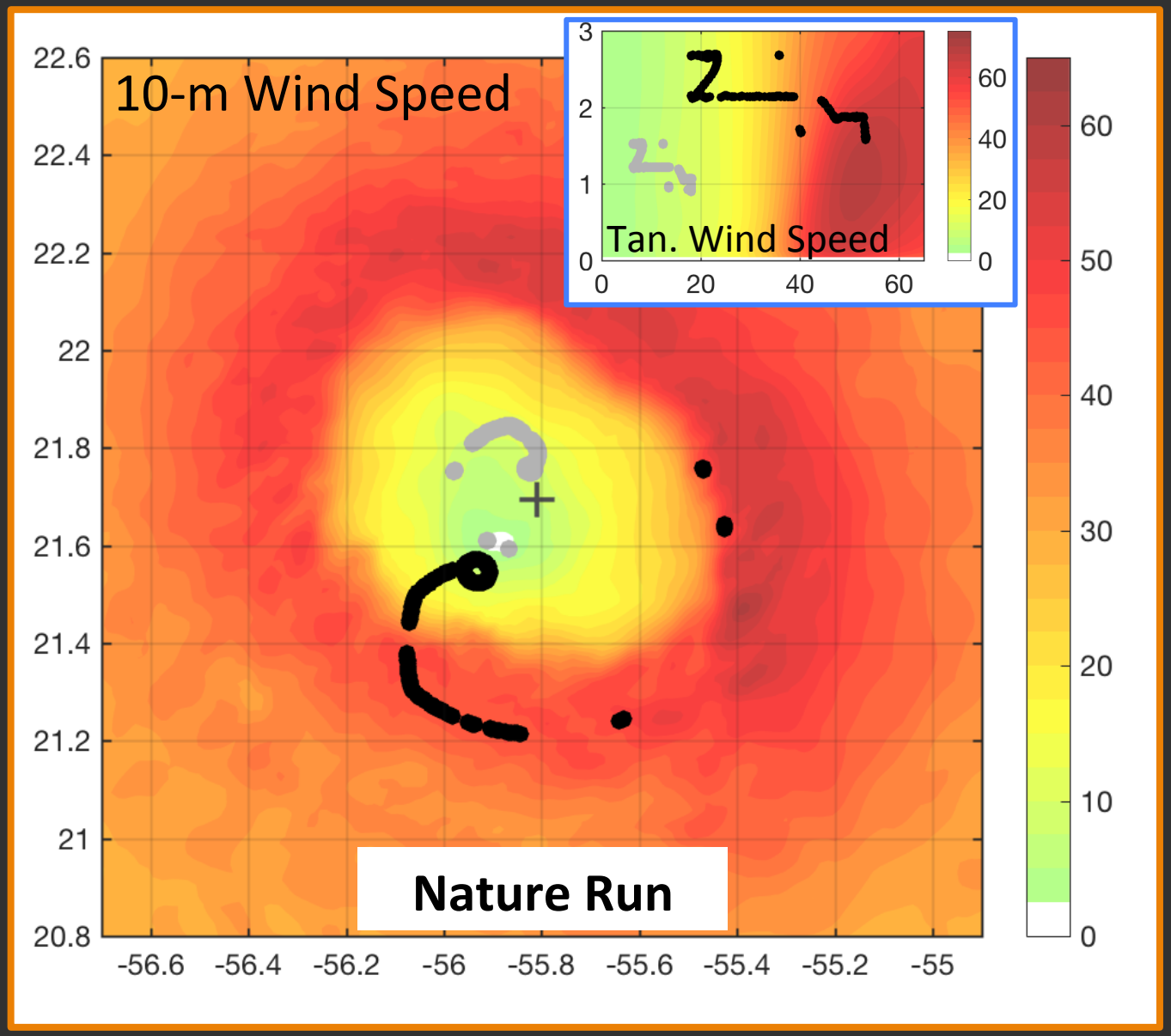

Actual Edouard (2014)
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1 Observations Rotated & Expanded to Match Nature Run

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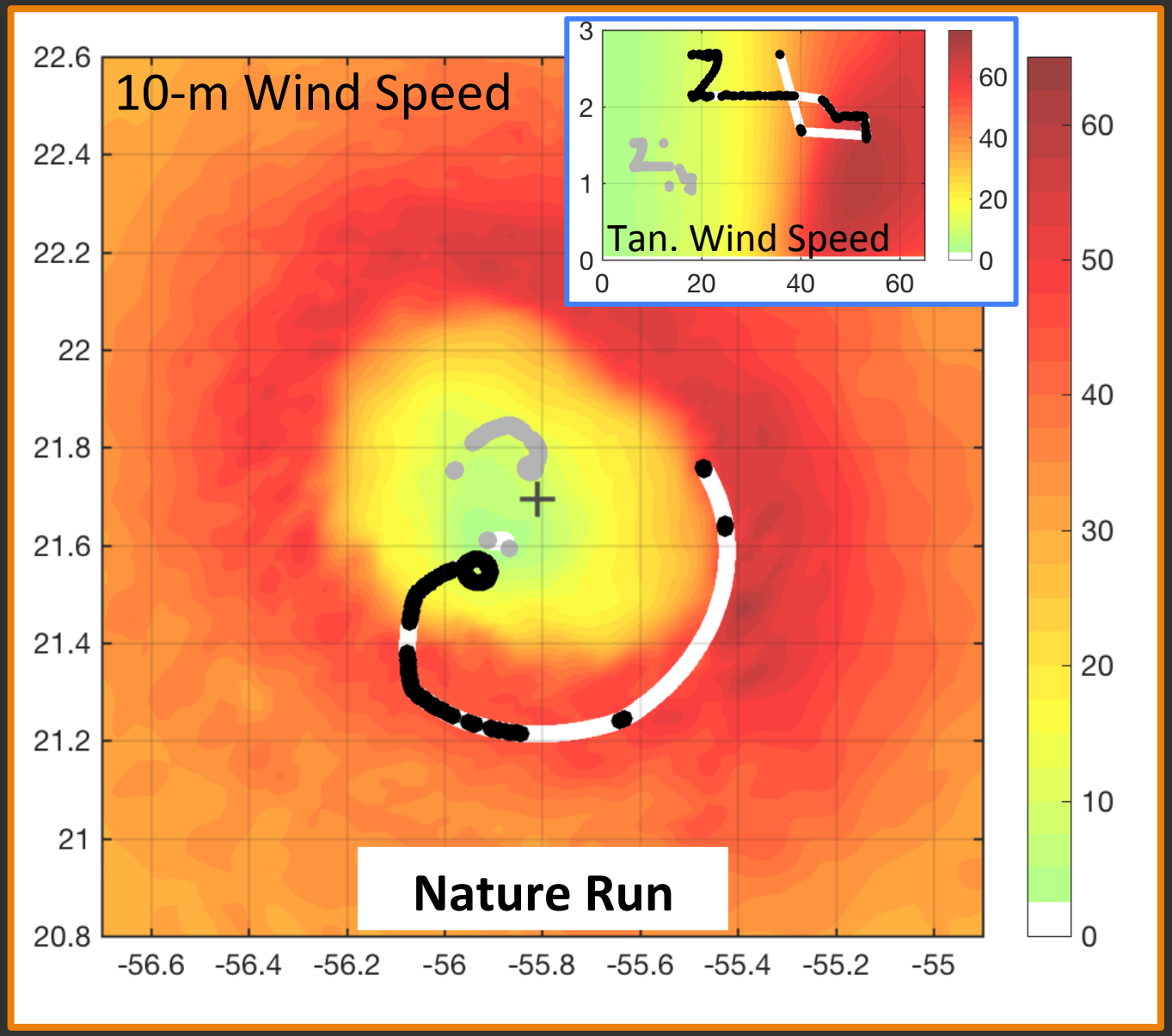

Actual Edouard (2014) 16 September Observations

1 Observations Rotated & Expanded to Match Nature Run

2 Observations Interpolated (1-sec) to Fill In Gaps

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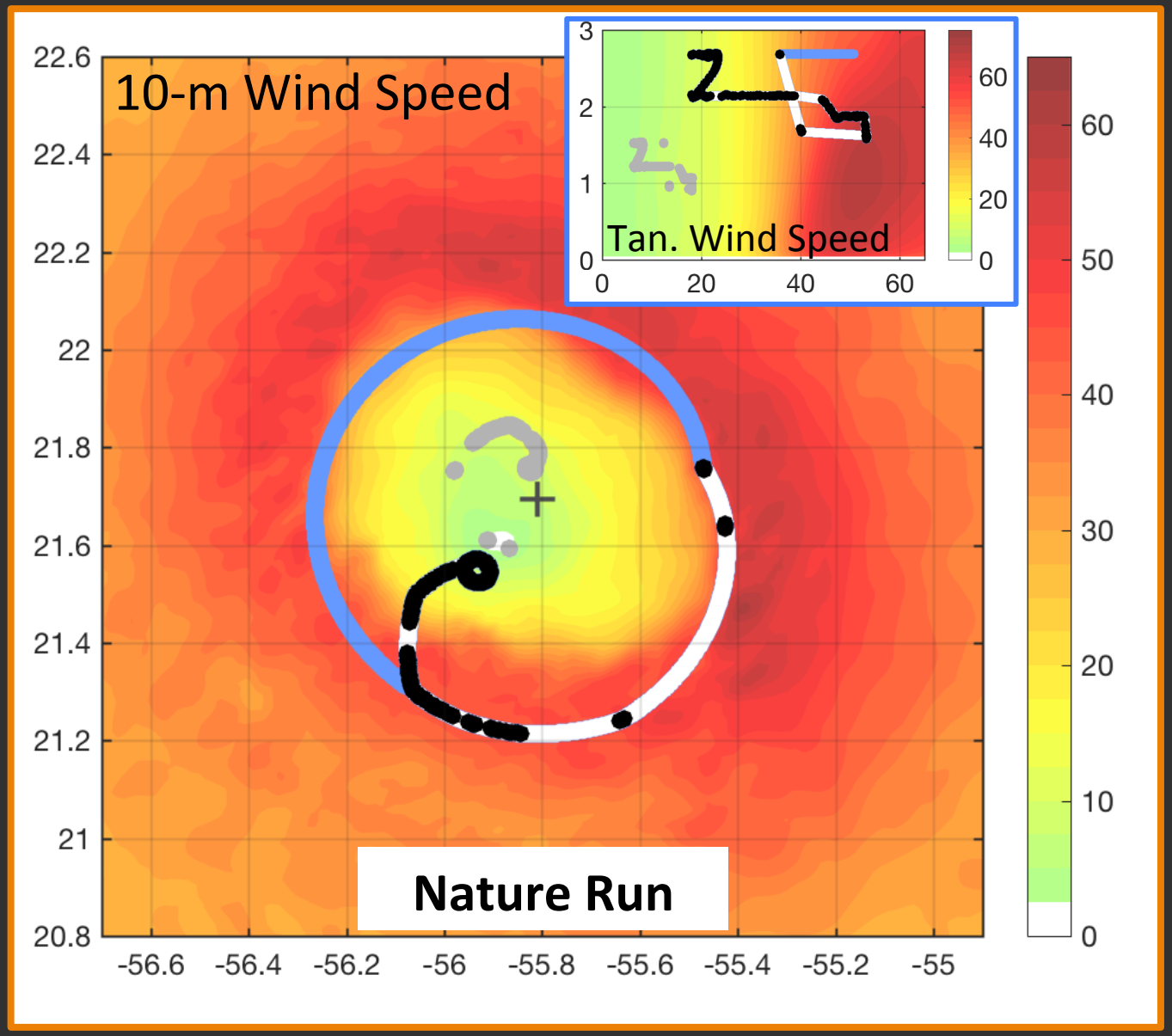

Actual Edouard (2014) 16 September Observations

1 Observations Rotated & Expanded to Match Nature Run

2 Observations Interpolated (1-sec) to Fill In Gaps

3 Observations Extrapolated (1-sec) to Complete Circle

Simulating Coyote Observations for OSSEs

Comparison to Other Data Types Simulated

Tail Radar	Dropsonde	Flight Level	SFMR	Coyote
23,600	1,650	1,100	350	--
23,650	1,650	1,100	350	1,400
23,900	1,650	1,100	350	4,800
23,900	1,650	1,100	350	9,500

Control:

Only NOAA P-3 Data

1 +

Coyote

Original (Rotated)

2 +

Coyote

Interpolated

3 +

Coyote

Extrapolated

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Control:

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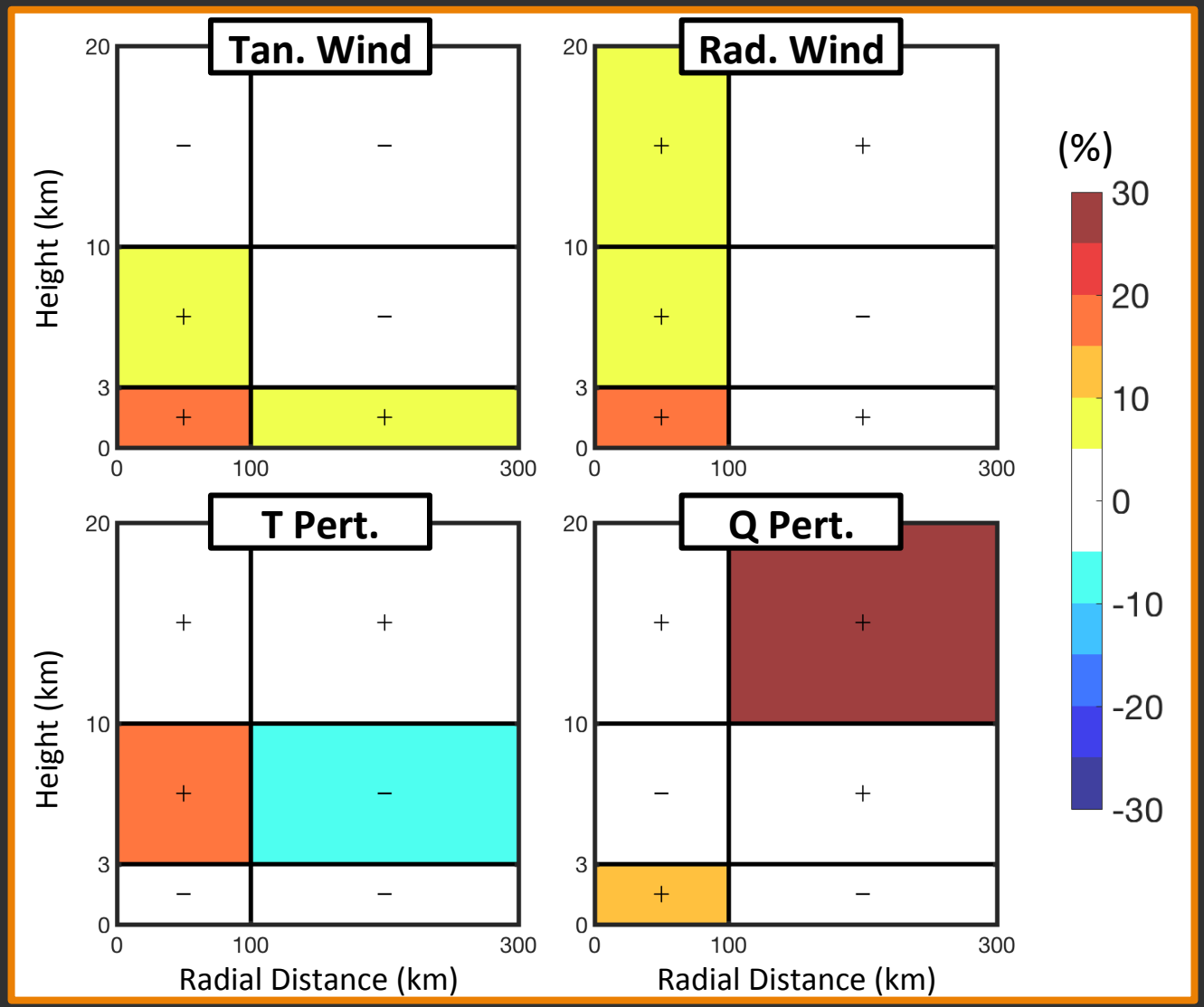
3 + Coyote Extrapolated

Results: Impact on Hurricane Structure

Comparison to the Nature Run

Incremental Improvement (%) in Total Error



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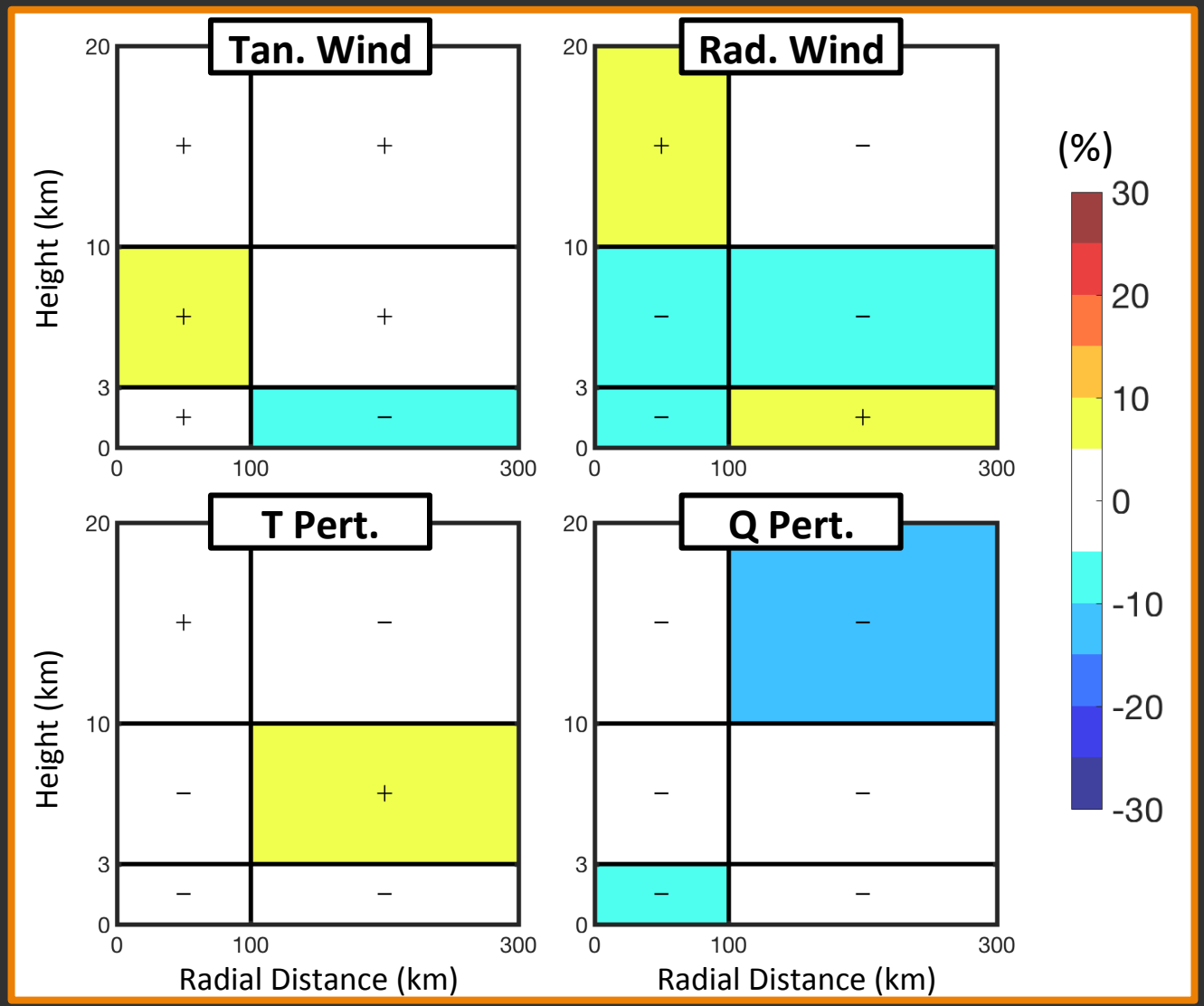

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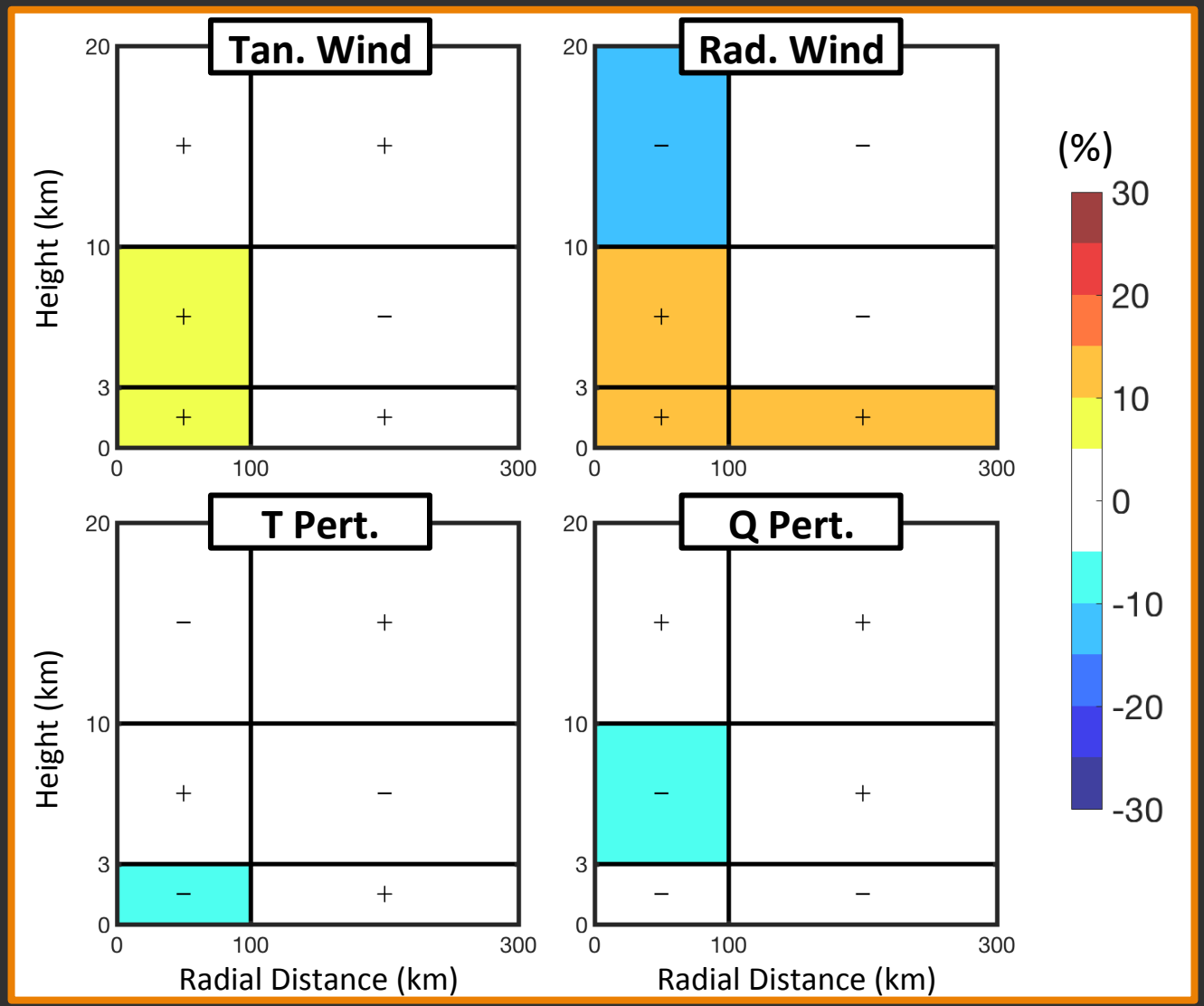

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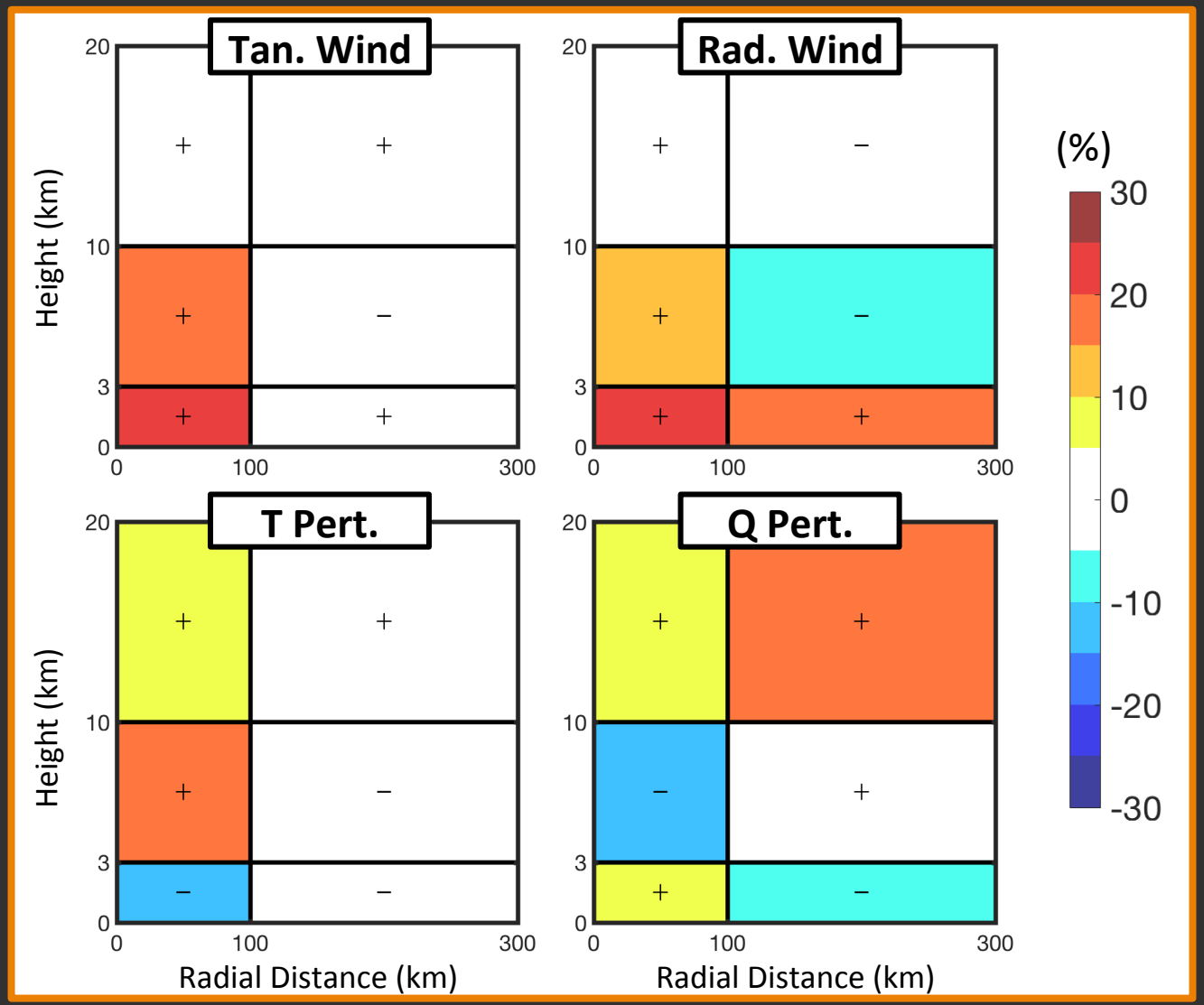

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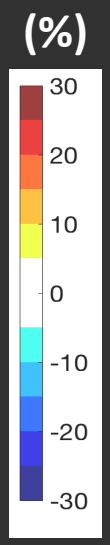
Simulating Coyote Observations for OSSEs

Comparison to the Nature Run

Improvement in Error (Experiment − Nature Run)			
Position	**MSLP**	**Max. Wind**	**RMW**
-1.4 km (-8%)	+1.4 hPa (+6%)	+1.5 m/s (+7%)	+5 km (+24%)



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\+

Coyote Extrapolated

Simulating Coyote Observations for OSSEs

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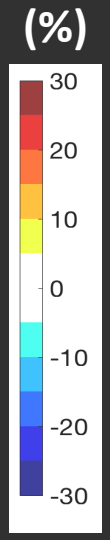
Very Comparable to the Real-Data Experiment



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3 + Coyote Extrapolated

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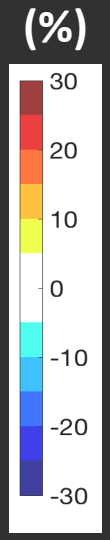

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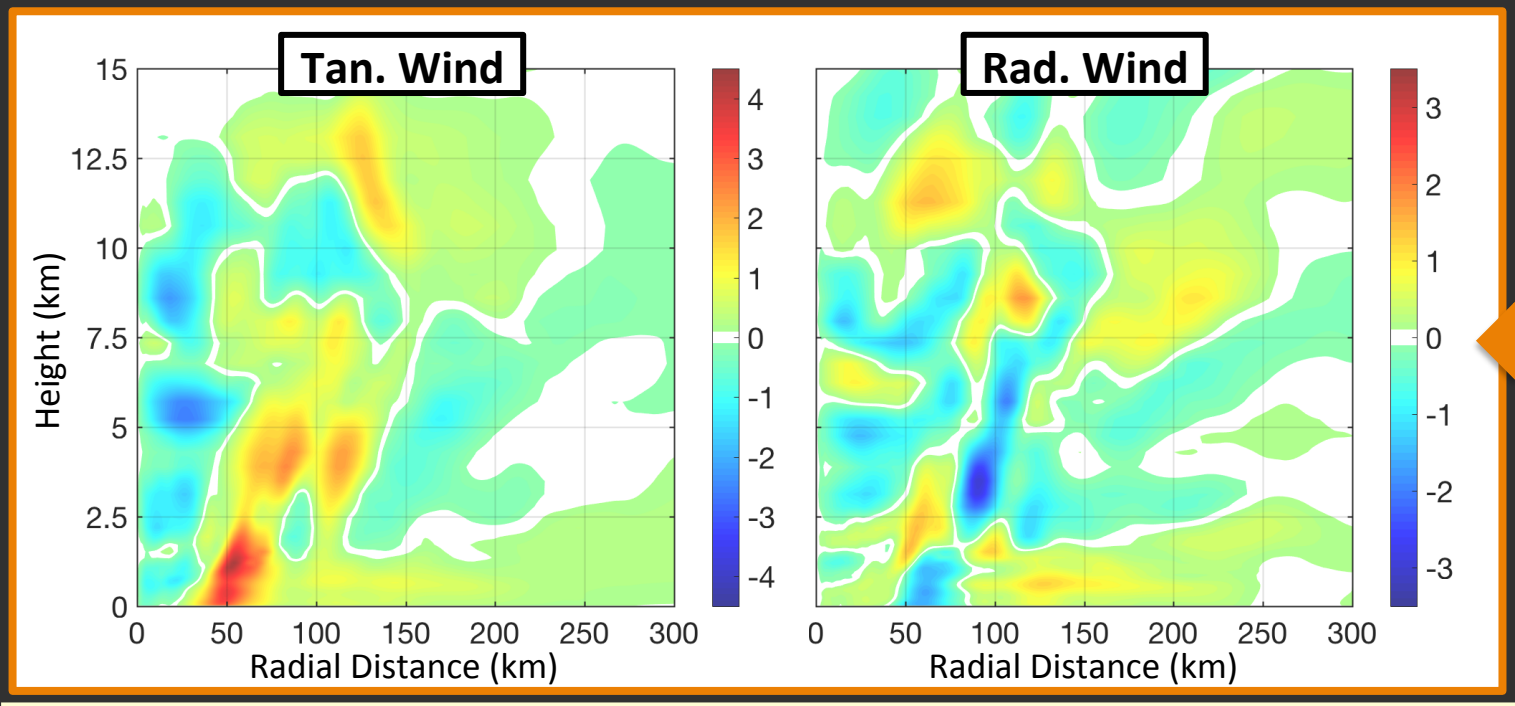

Exp 3 minus Control

Altug.Aksoy@noaa.gov

Simulating Coyote Observations for OSSEs

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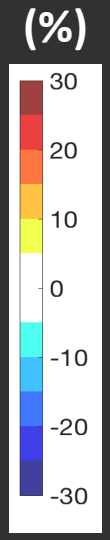

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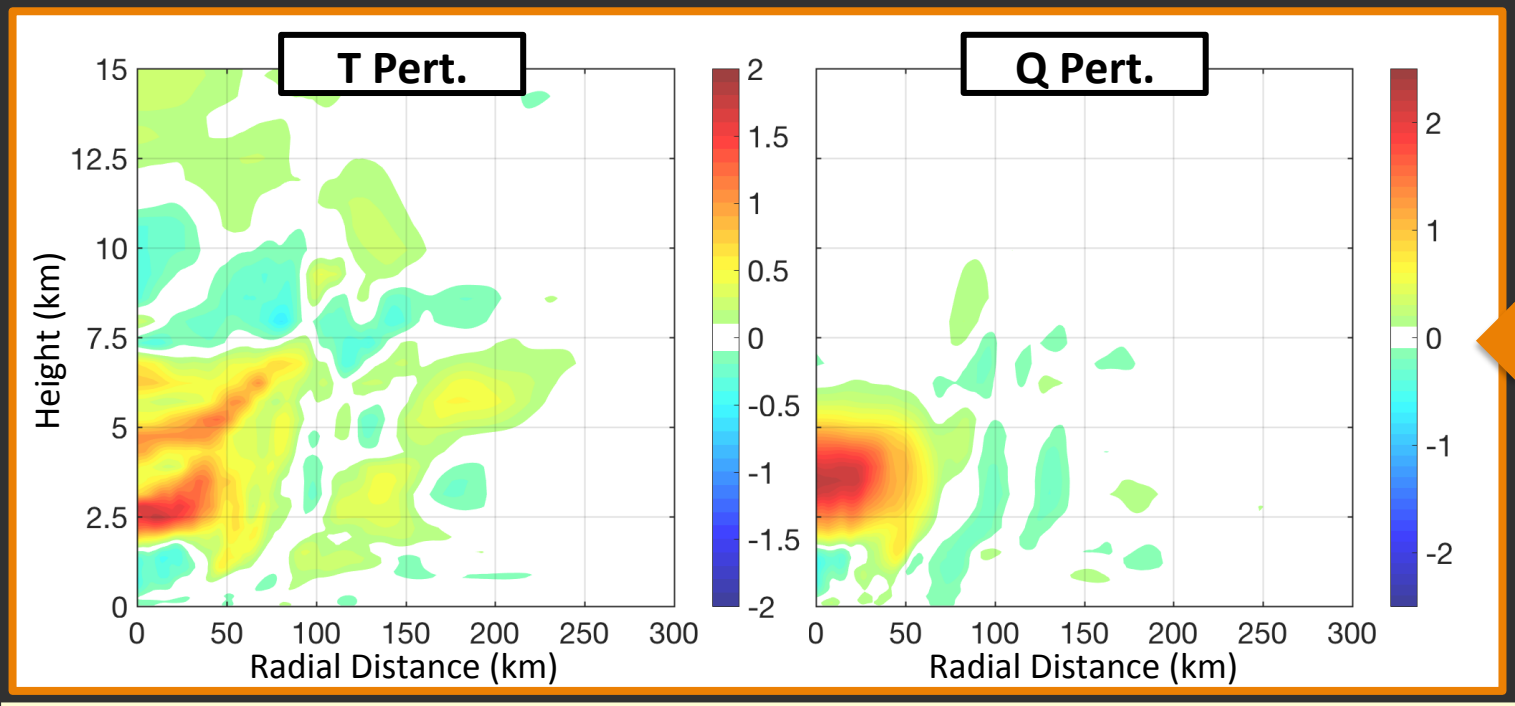

Exp 3 minus Control

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Summary

1. Successful simulation and assimilation of Coyote UAS observations
   - This Phase-1 OSSE confirms the findings of the real-data study
2. Small but consistent & meaningful improvements in the kinematic and thermodynamic structures
   - Mostly in the low-to-mid levels
   - Mostly near the inner core
3. Further optimization in DA may be necessary as # of dense Coyote UAS observations increase in a localized region of the vortex
4. Further research will investigate ways to improve sampling strategies with the Coyote UAS
   - Where in the vortex?
   - Sampling rate vs sampling duration
   - Possibility of simultaneous sampling by multiple aircraft