

Extreme Winds Observed by Saildrones and the Need for Collaboration with the Satellite Community

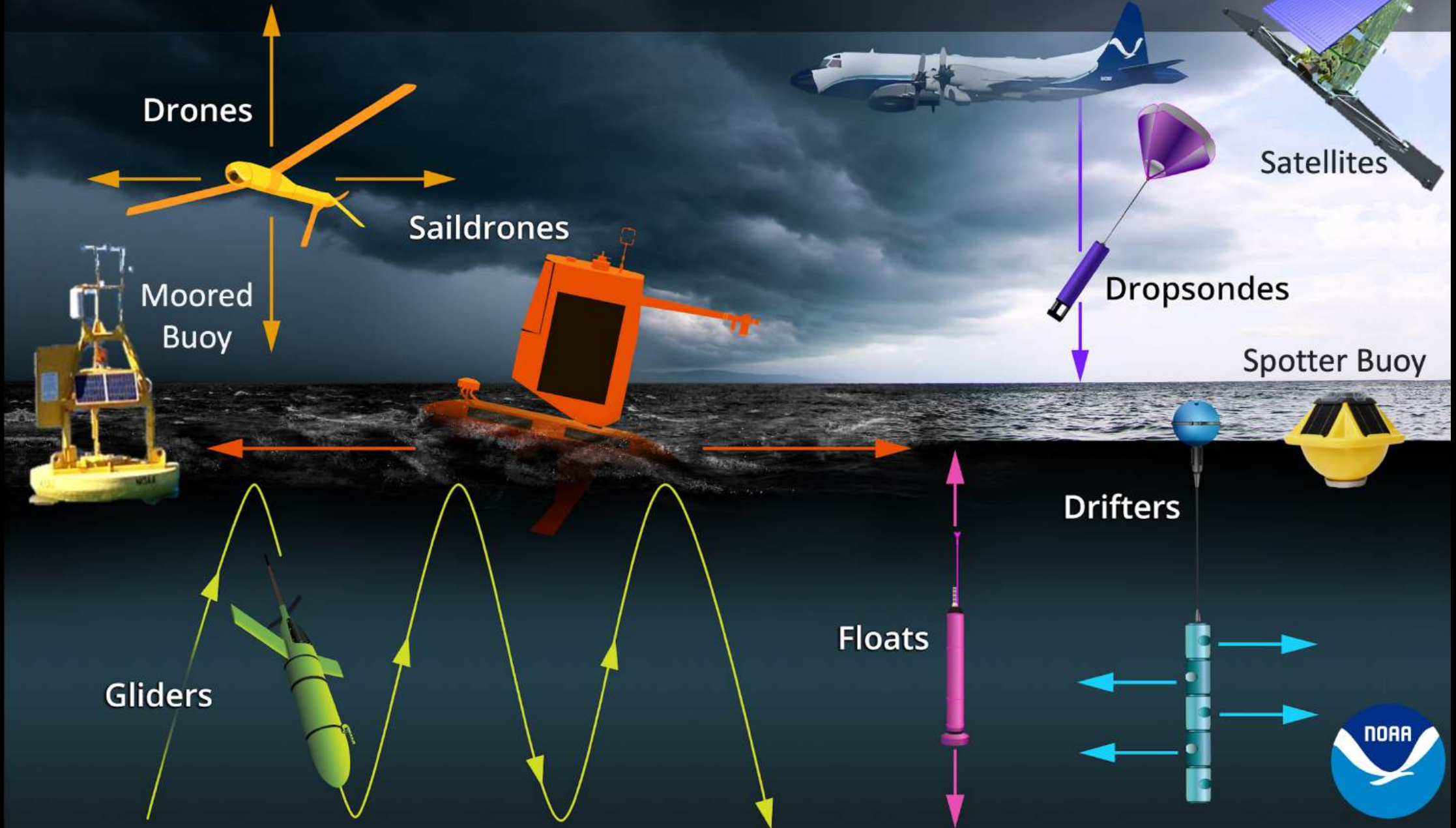


Saildrone Funding from NOAA/OMAO/UxS

Additional Support: NOAA/OAR/GOMO

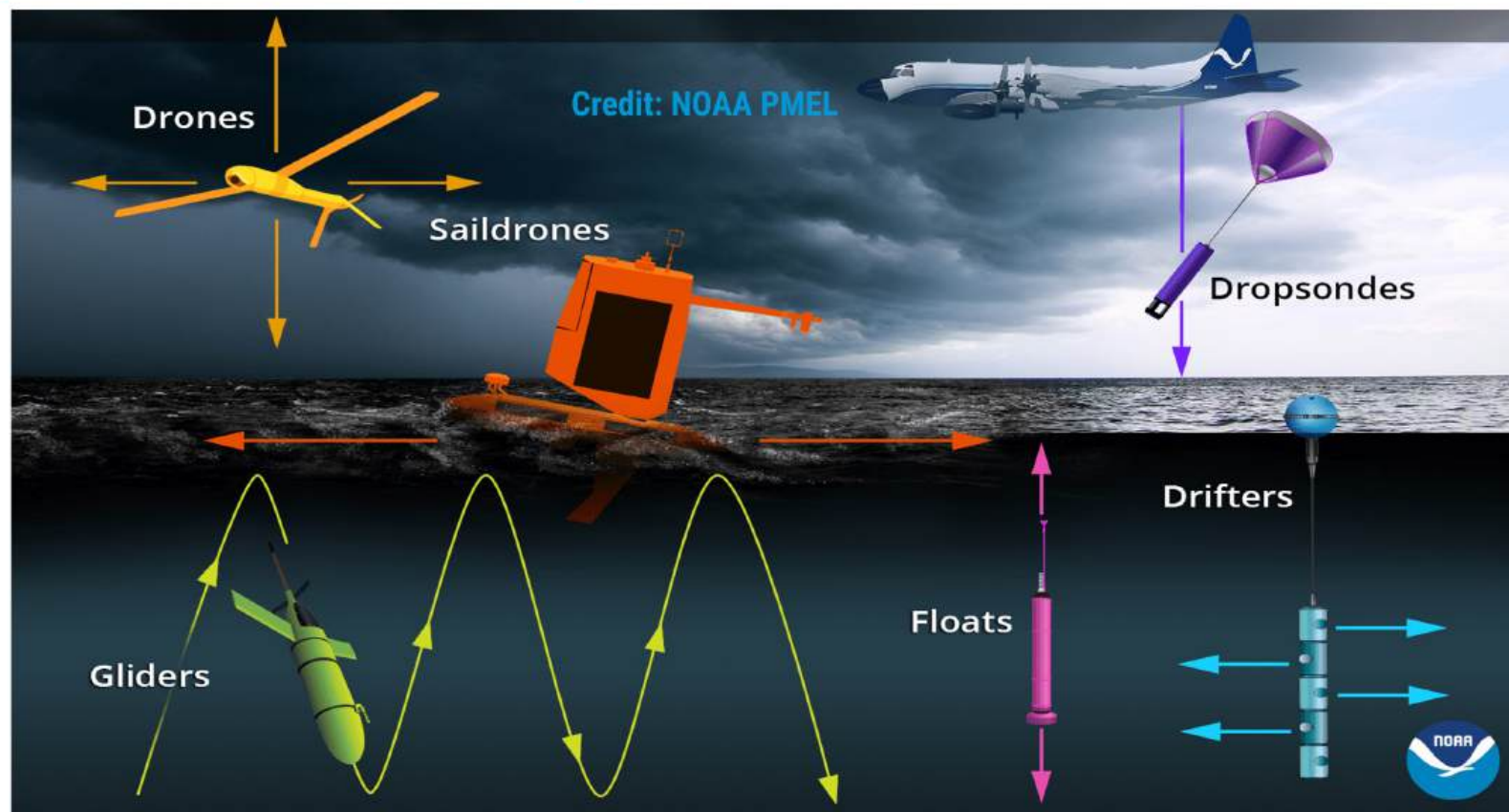
NOAA/AOML & PMEL, and Saildrone Inc.

OBSERVING SYSTEMS TO IMPROVE HURRICANE PREDICTION





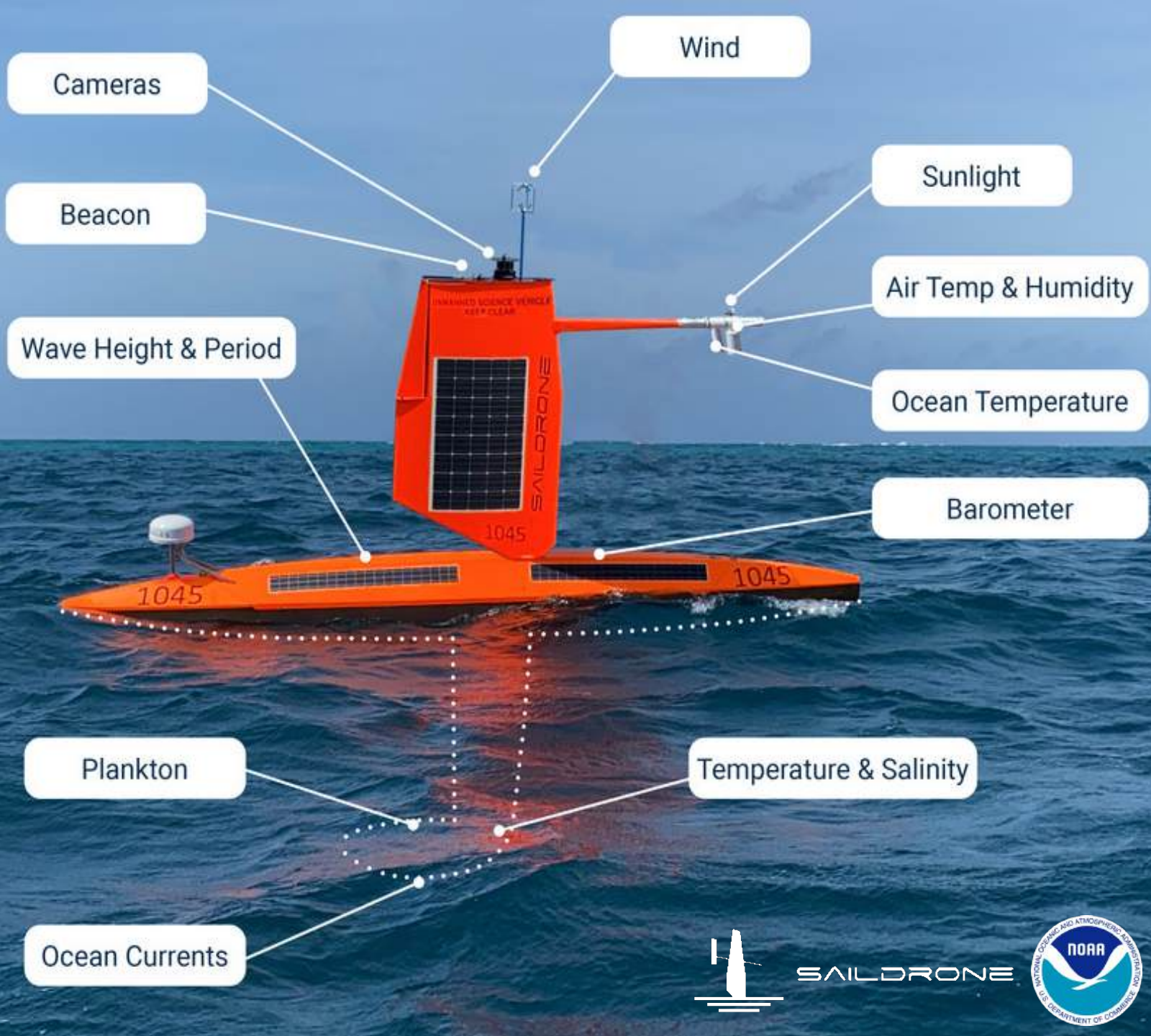
CHAOS: Coordinated Hurricane Atmosphere-Ocean Sampling



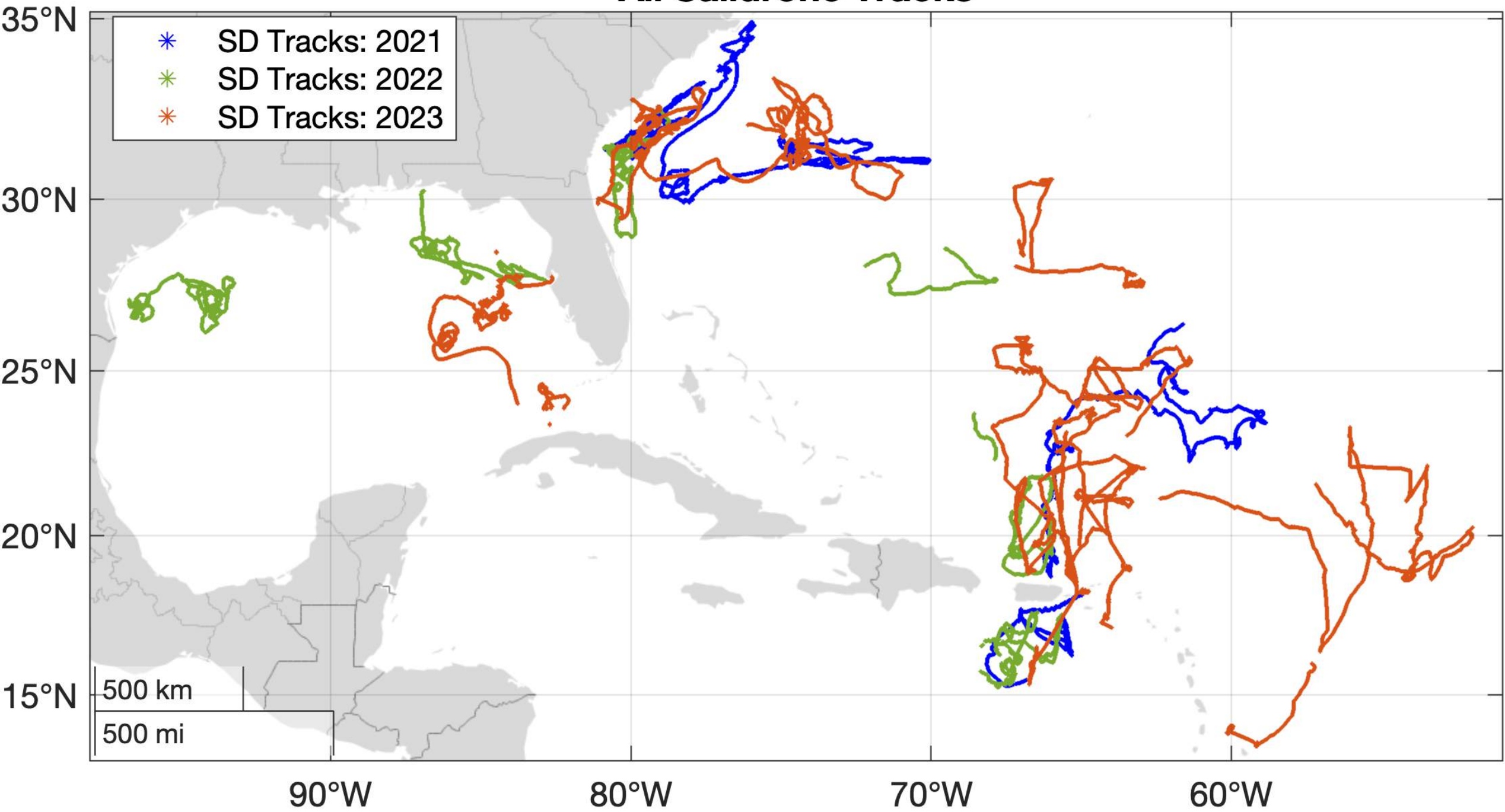
Science Team: J., Zhang, J. Wadler, J. Rudzin, J. Cione, N. Shay, C. Zhang, G. Foltz, L. Looney, S. Howden, K. Martin, T. Miles, K. Bailey, S. Jayne, A. Gonzalez, P. Robbins, P. Chang, Z. Jelenak, J. Sapp, L. Centurioni, M. Schonau, H-S Kim, M. Le Henaff, H.S. Kang, L. Gramer, C. Stienbarger

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

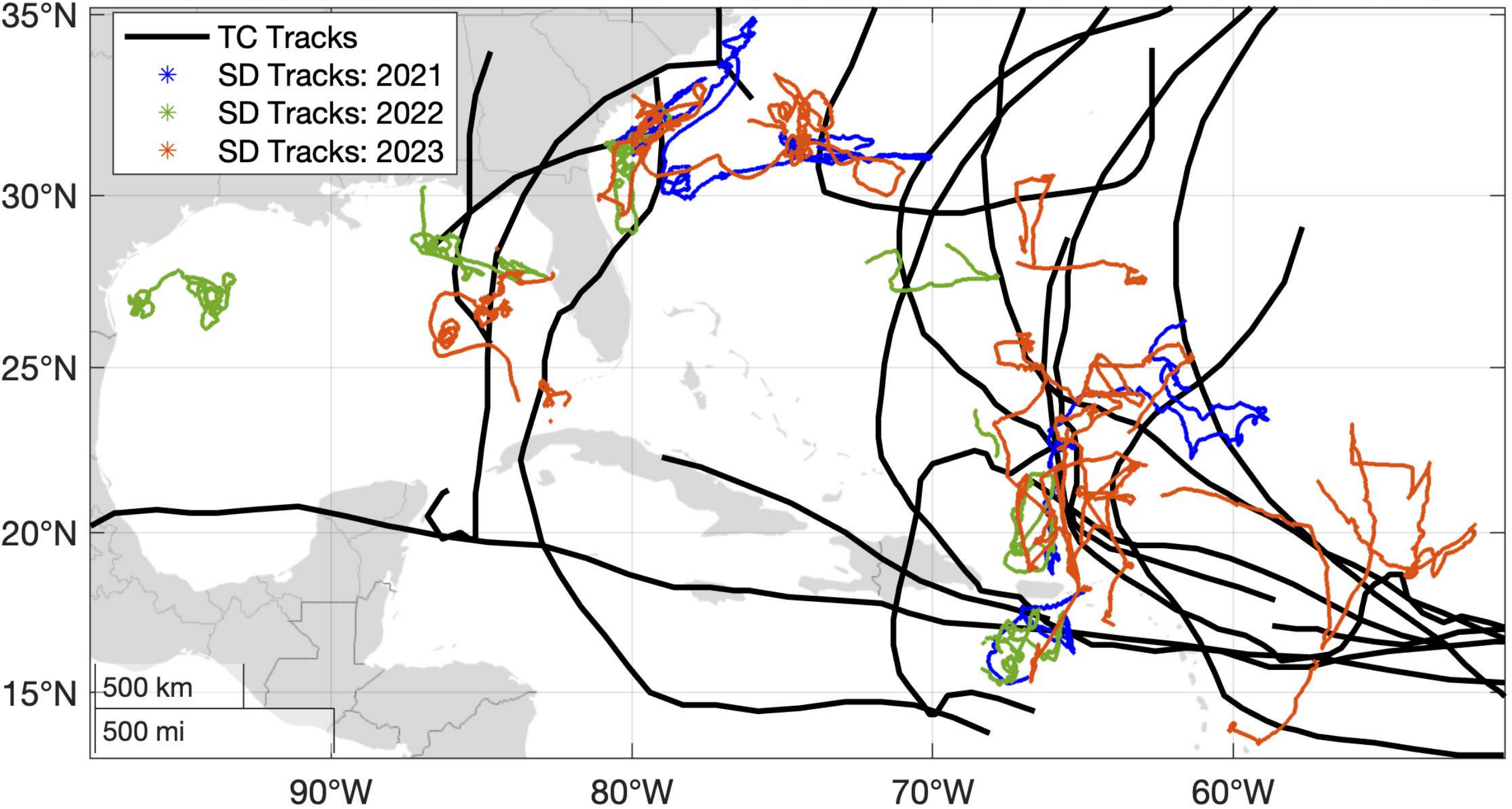
- Improving observations of essential ocean features and ocean representation in coupled models
- Elucidating upper ocean and lower atmosphere processes that impact TC intensity through new and established observing systems



All Sairdrone Tracks

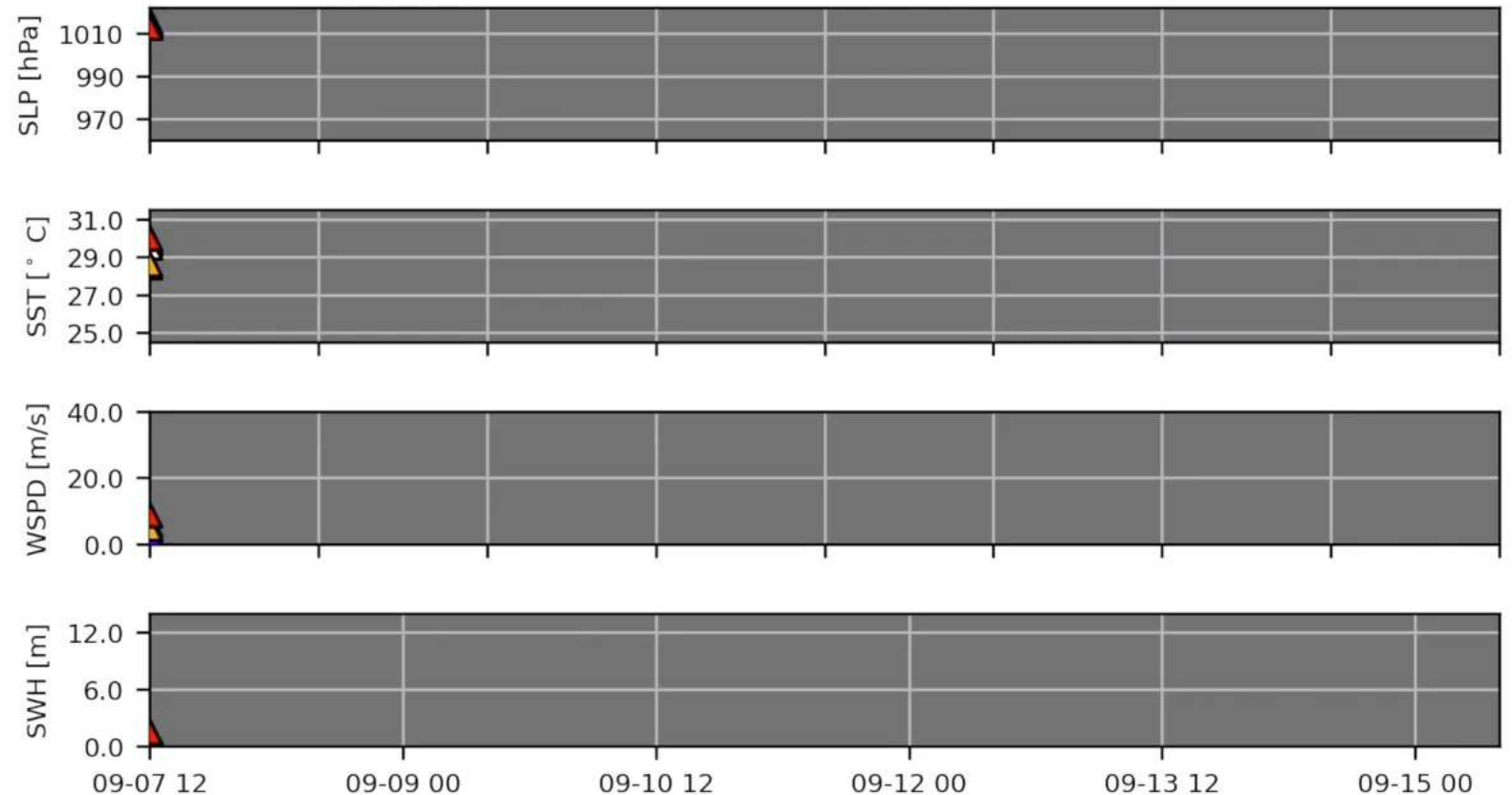
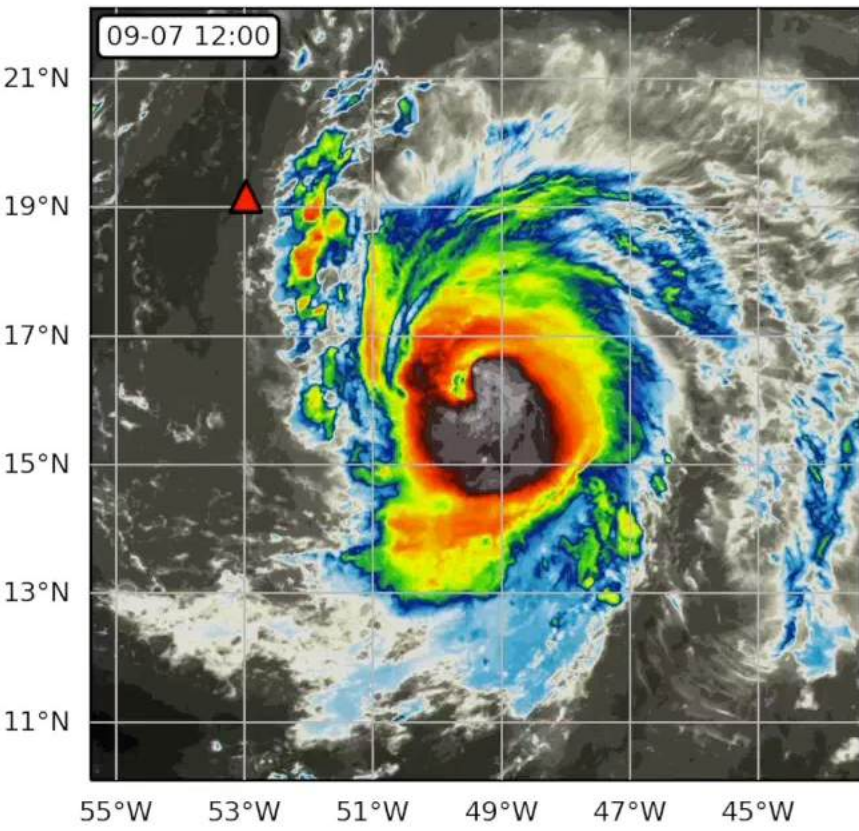
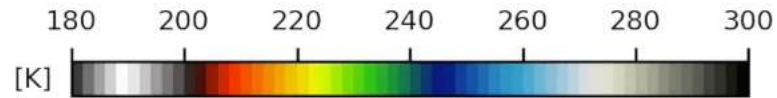


TC Tracks for TCs Within 250 km of a Saildrone with All Saildrone Tracks

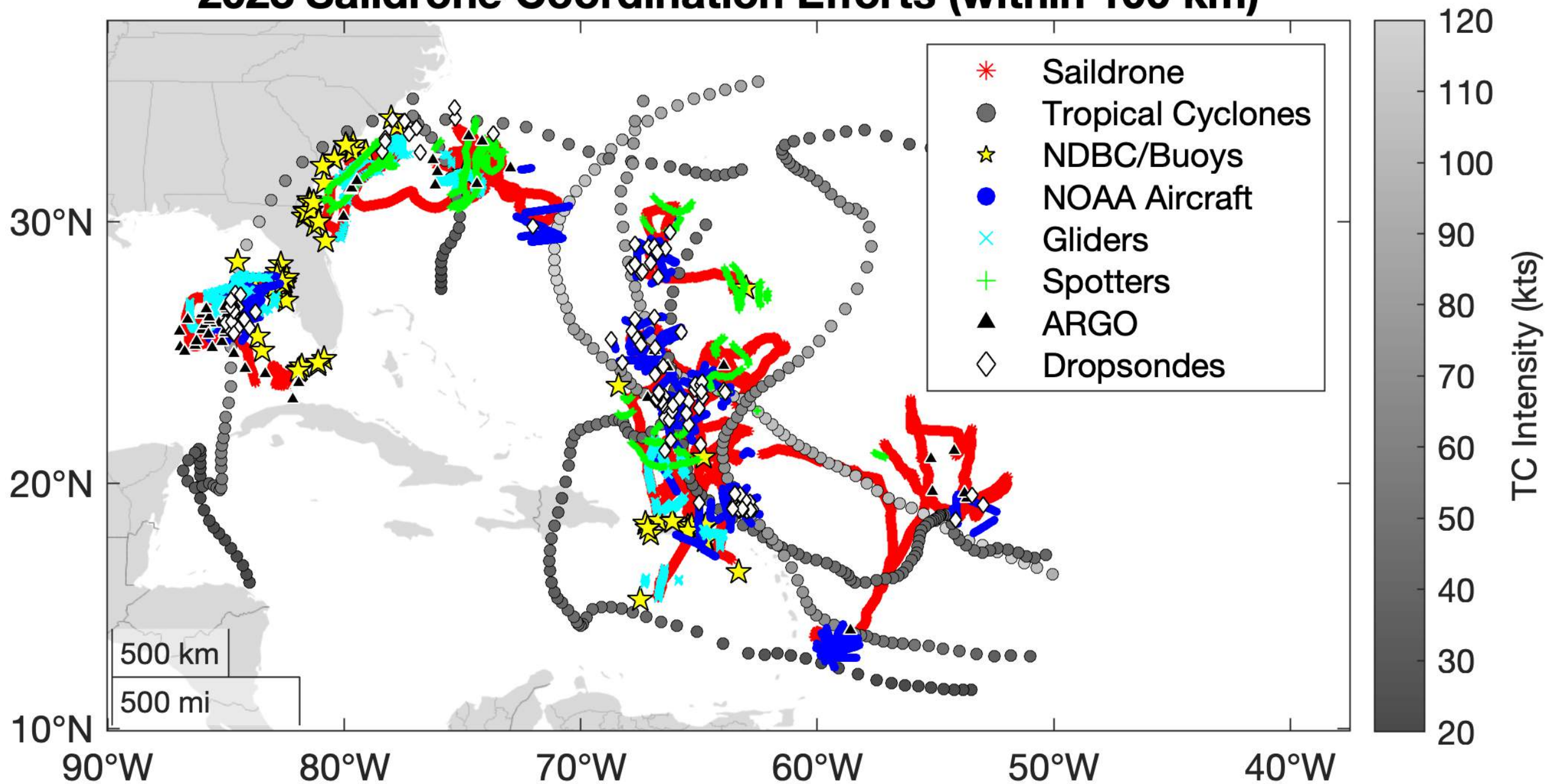


Initial Motivation: Do we trust the measurements?

Yes! Still need to show it, especially in extremes (HU Lee below)

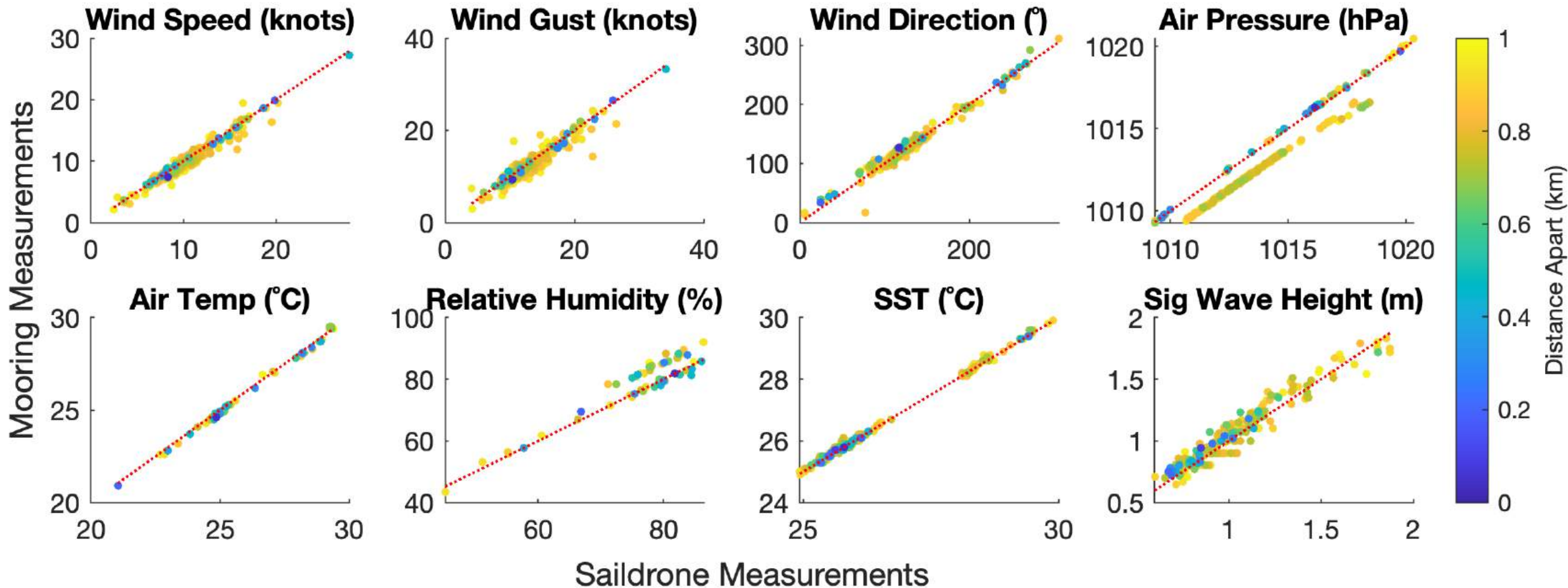


2023 Sairdrone Coordination Efforts (within 100 km)



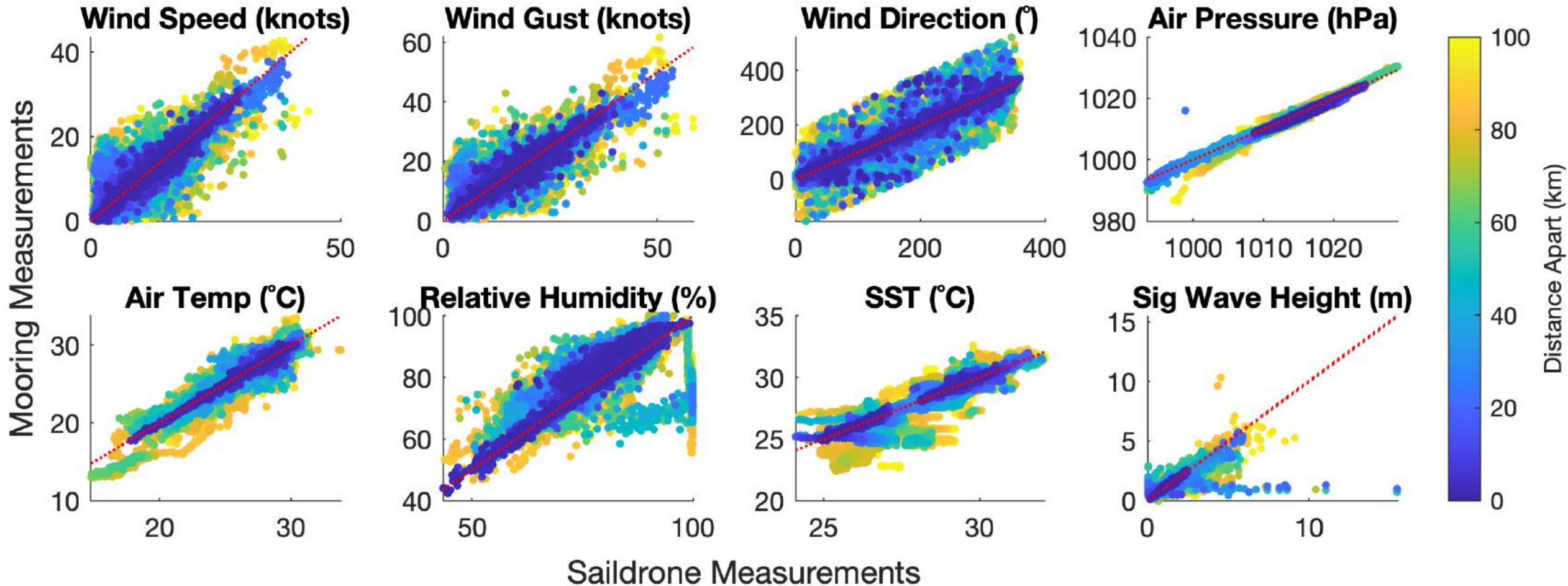
Challenge: How close is needed to compare? 1 km? Limits data...

Comparing Saldrone to Mooring Measurements: Within 1 km



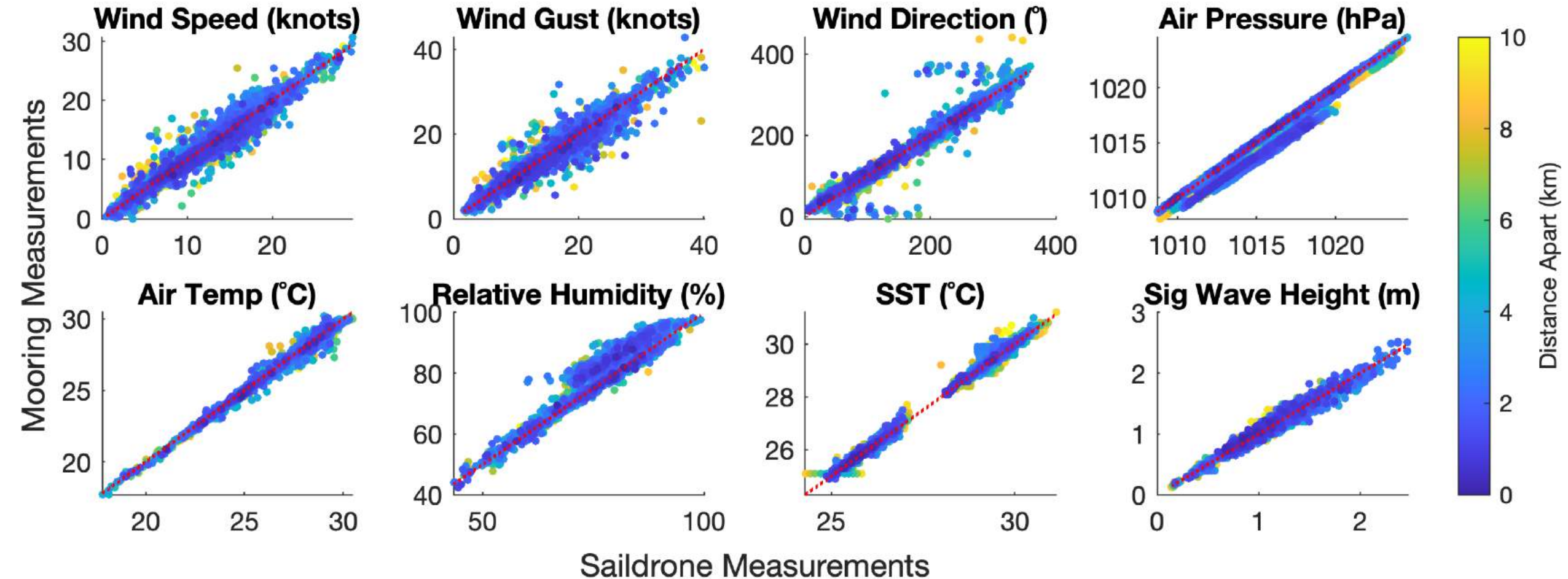
Challenge: How close is needed to compare? 100 km? Too far apart...

Comparing Saildrone to Mooring Measurements: Within 100 km



Challenge: How close is needed to compare? 10 km? Maybe?

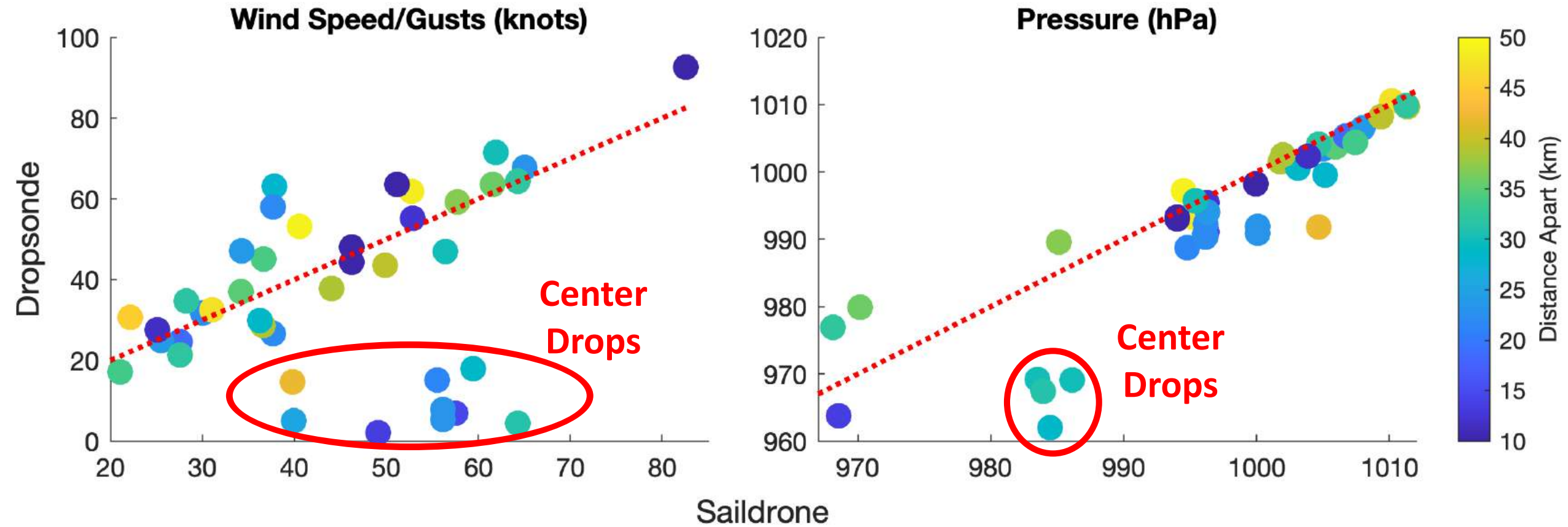
Comparing Saildrone to Mooring Measurements: Within 10 km



2021 - 2023: 44 Dropsondes within 50 km

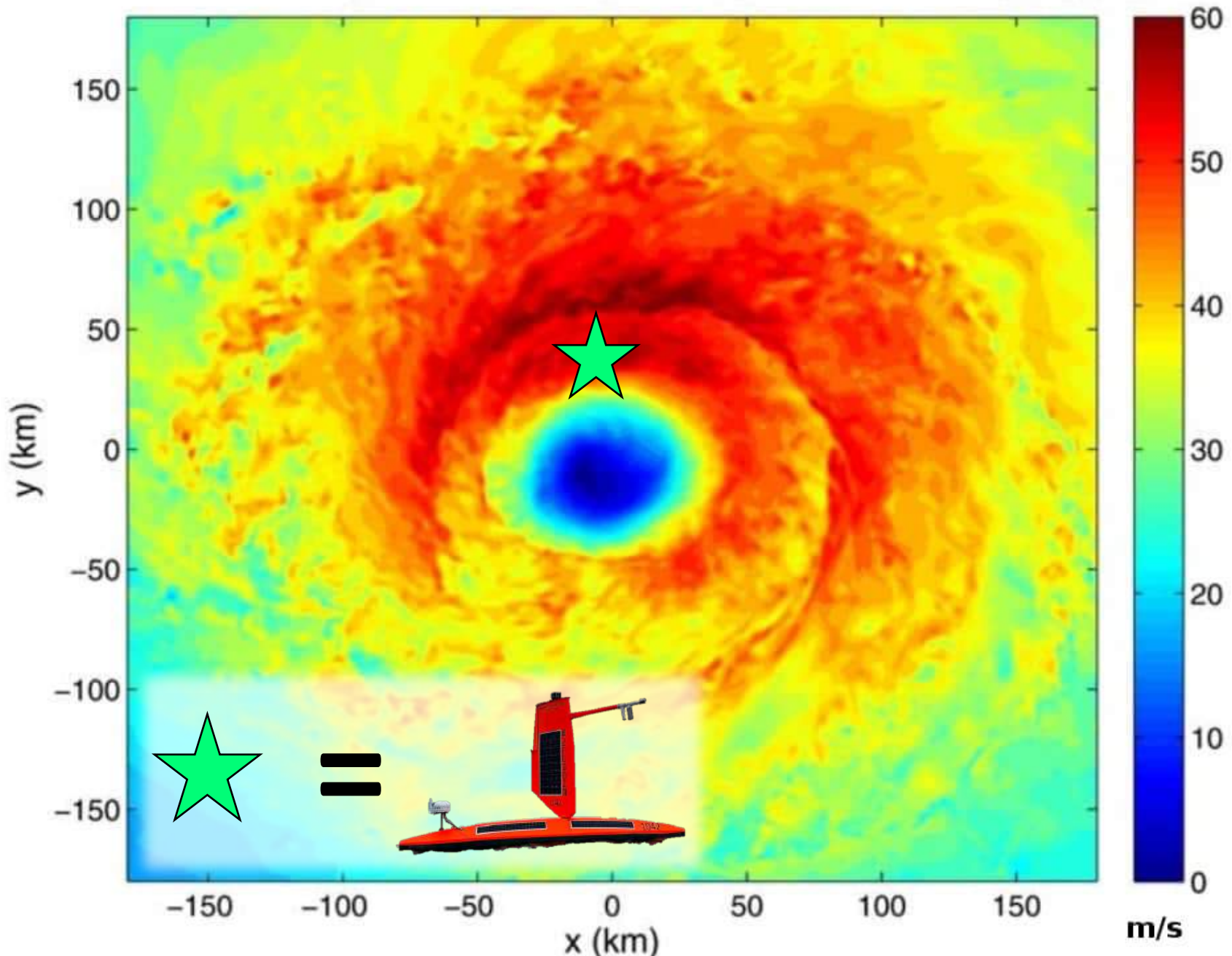
Most (37) were in 2023

Comparing Saildrone and Dropsonde Data within 50 km separation



Need for TC Relative Position

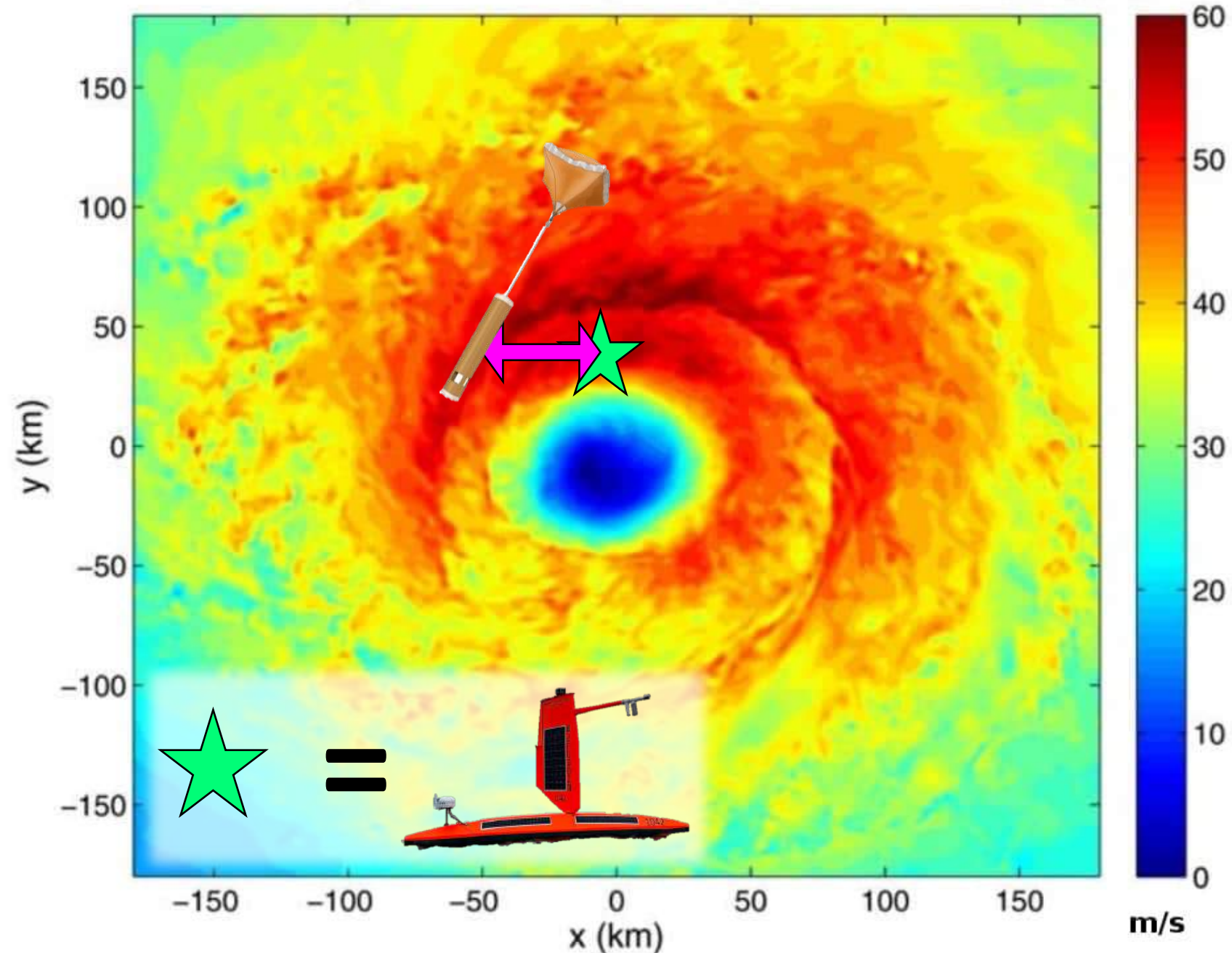
Wind Speed from a High-resolution Hurricane Model



Need for TC Relative Position

Example 1: Dropsonde
Same Distance to Center
(tangential to the winds)
→ Not Bad

Wind Speed from a High-resolution Hurricane Model

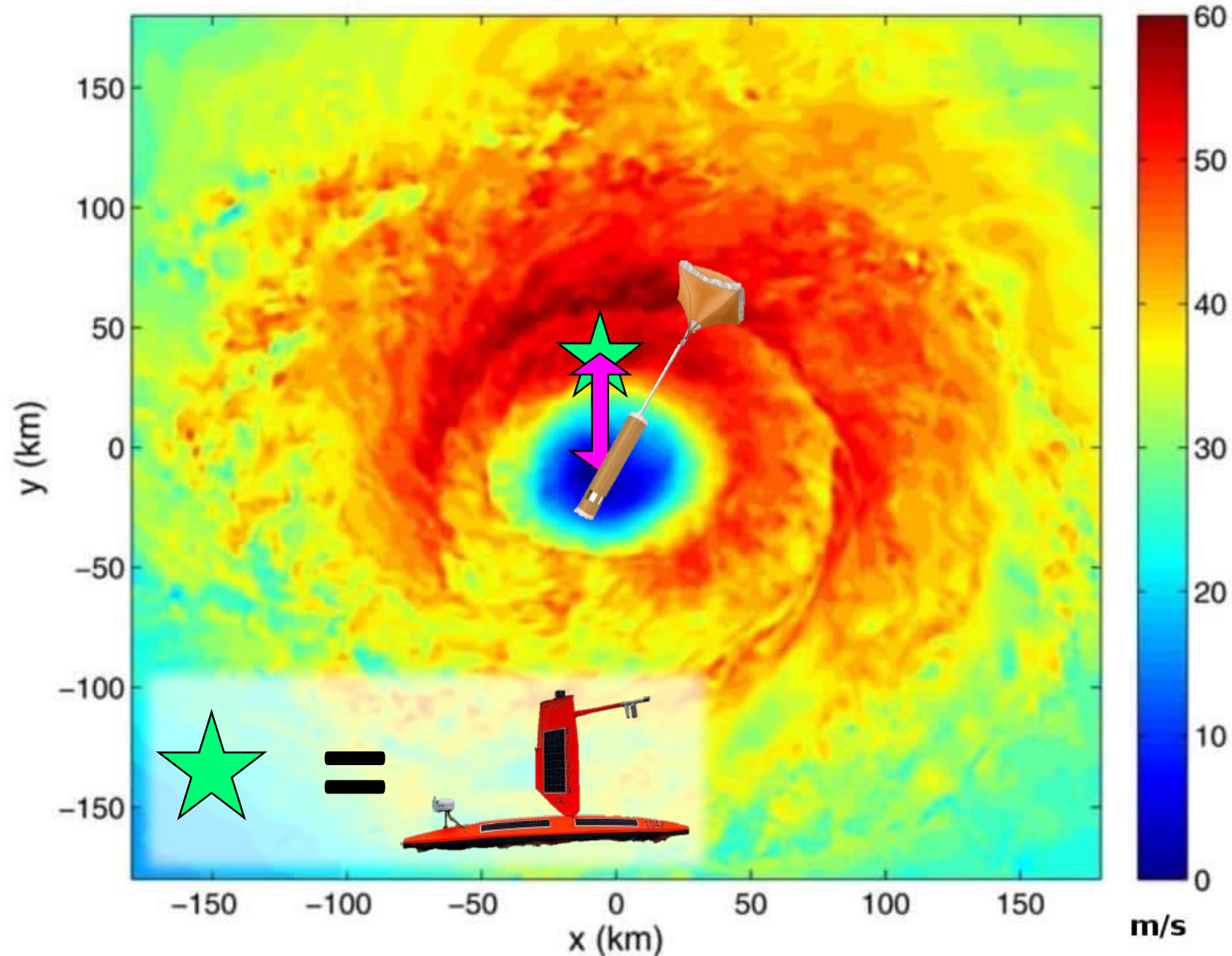


Need for TC Relative Position

Example 1: Dropsonde
Same Distance to Center
(tangential to the winds)
→ Not Bad

Example 2: Dropsonde
Max Distance to Center
(Orthogonal to the winds)
→ Very Bad

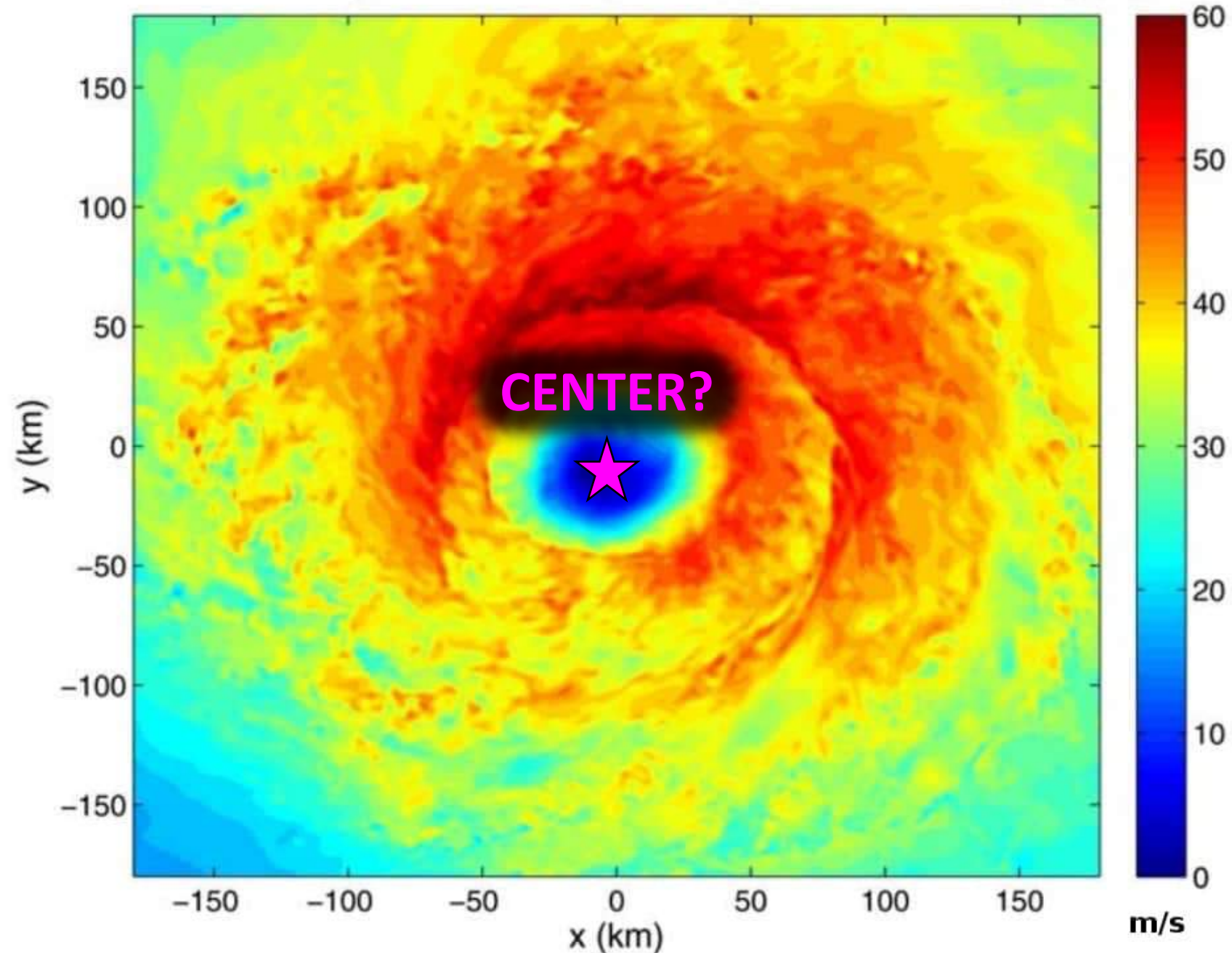
Wind Speed from a High-resolution Hurricane Model



Need for TC Relative Position

New Challenge: *Where
even is the center?!*

Wind Speed from a High-resolution Hurricane Model



Need for TC Relative Position

New Challenge: *Where
even is the center?!*

Example 1: Different
ways at $z = 2$ km

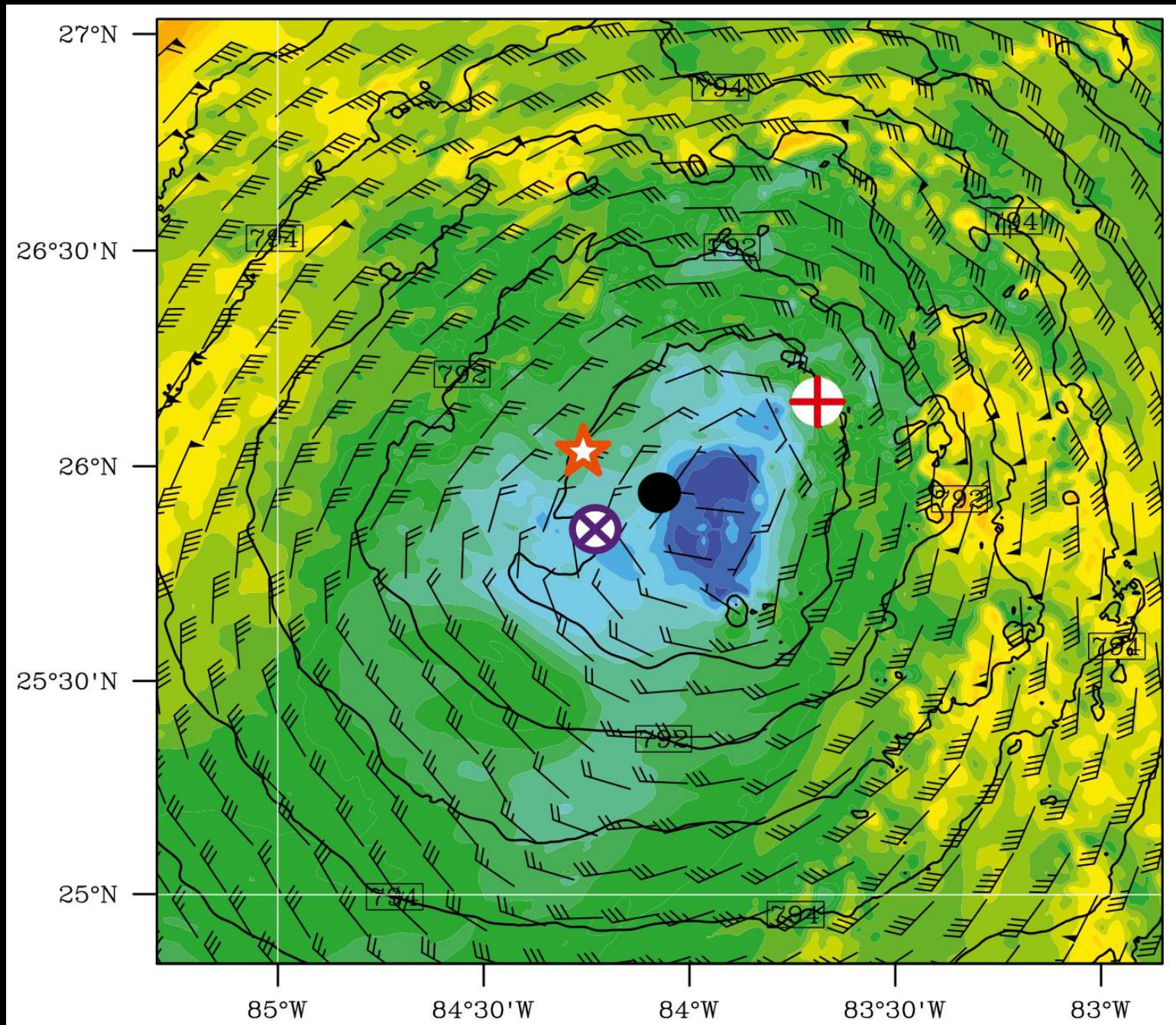


Figure from Nguyen et al., 2014

Need for TC Relative Position

New Challenge: *Where
even is the center?!*

Example 1: Different
ways at $z = 2$ km

Example 2: Different
ways at $z = 8$ km

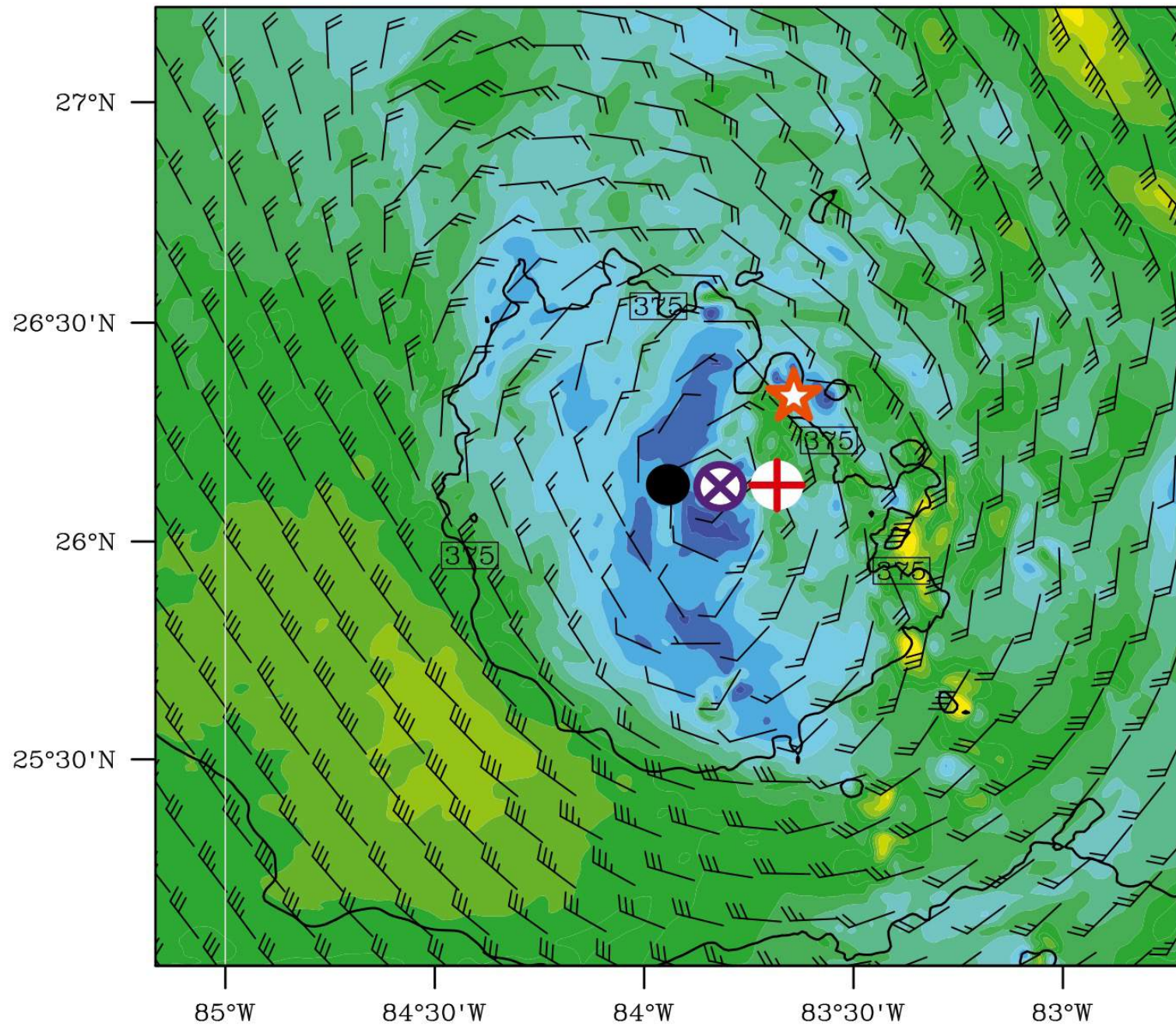


Figure from Nguyen et al., 2014

Need for TC Relative Position

New Challenge: *Where
even is the center?!*

Example 1: Different
ways at $z = 2$ km

Example 2: Different
ways at $z = 0$ km

CHALLENGE

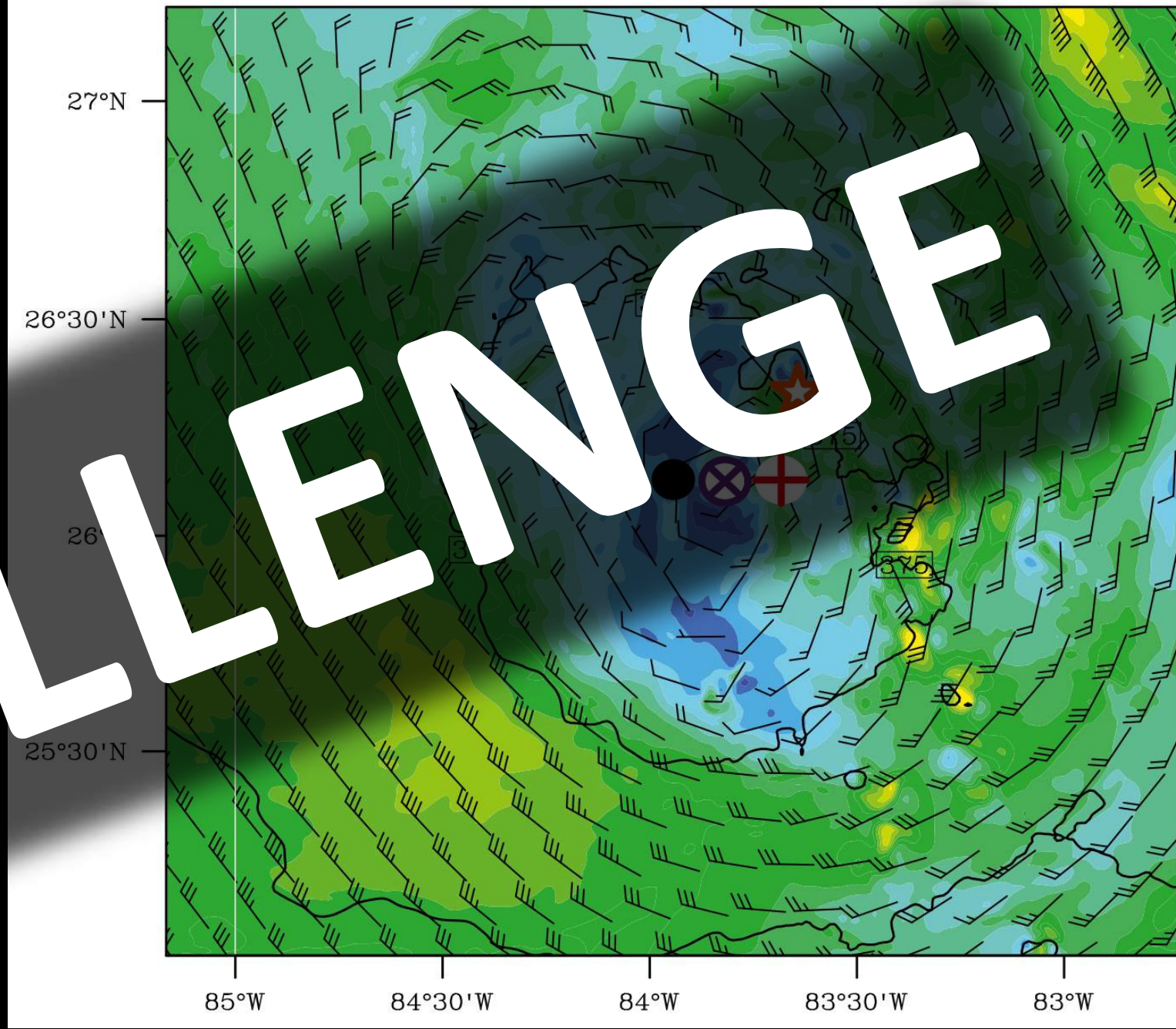
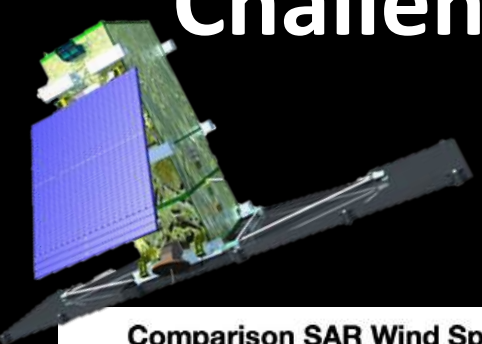
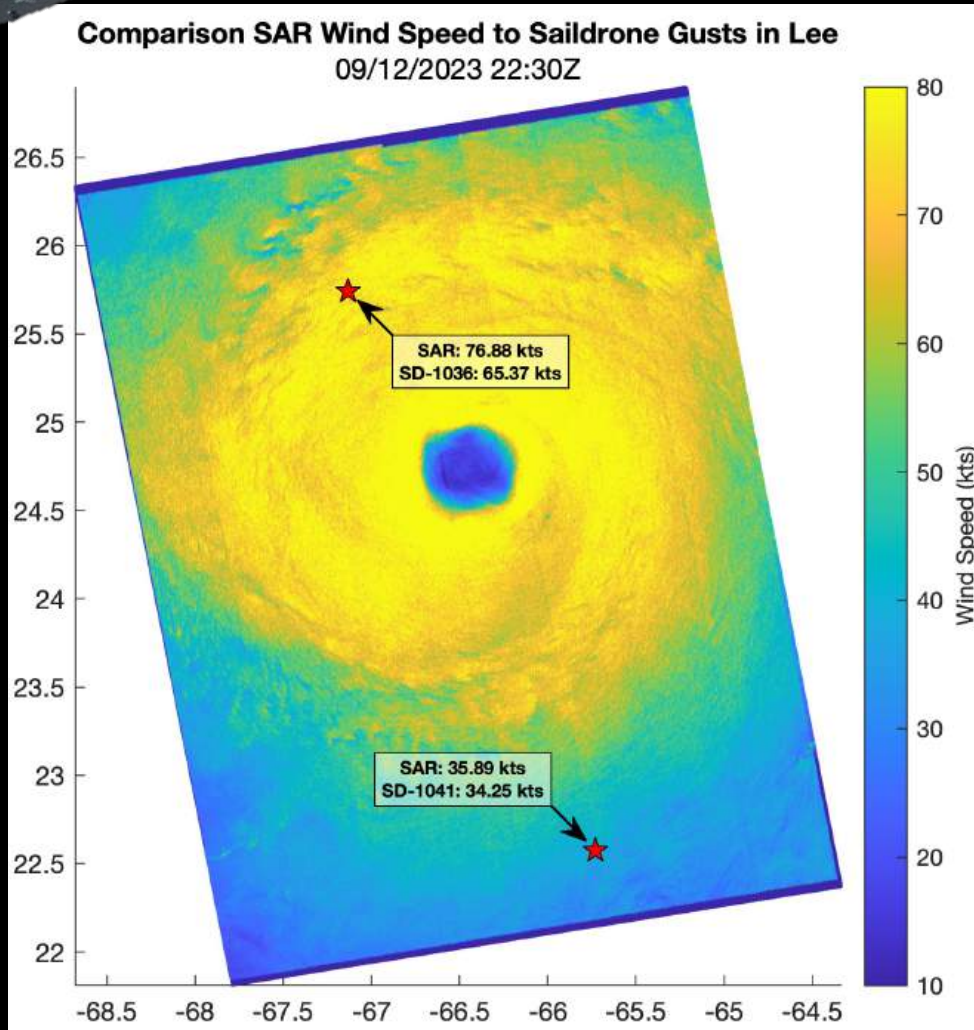


Figure from Nguyen et al., 2014

Challenge: How to directly compare remotely sensed

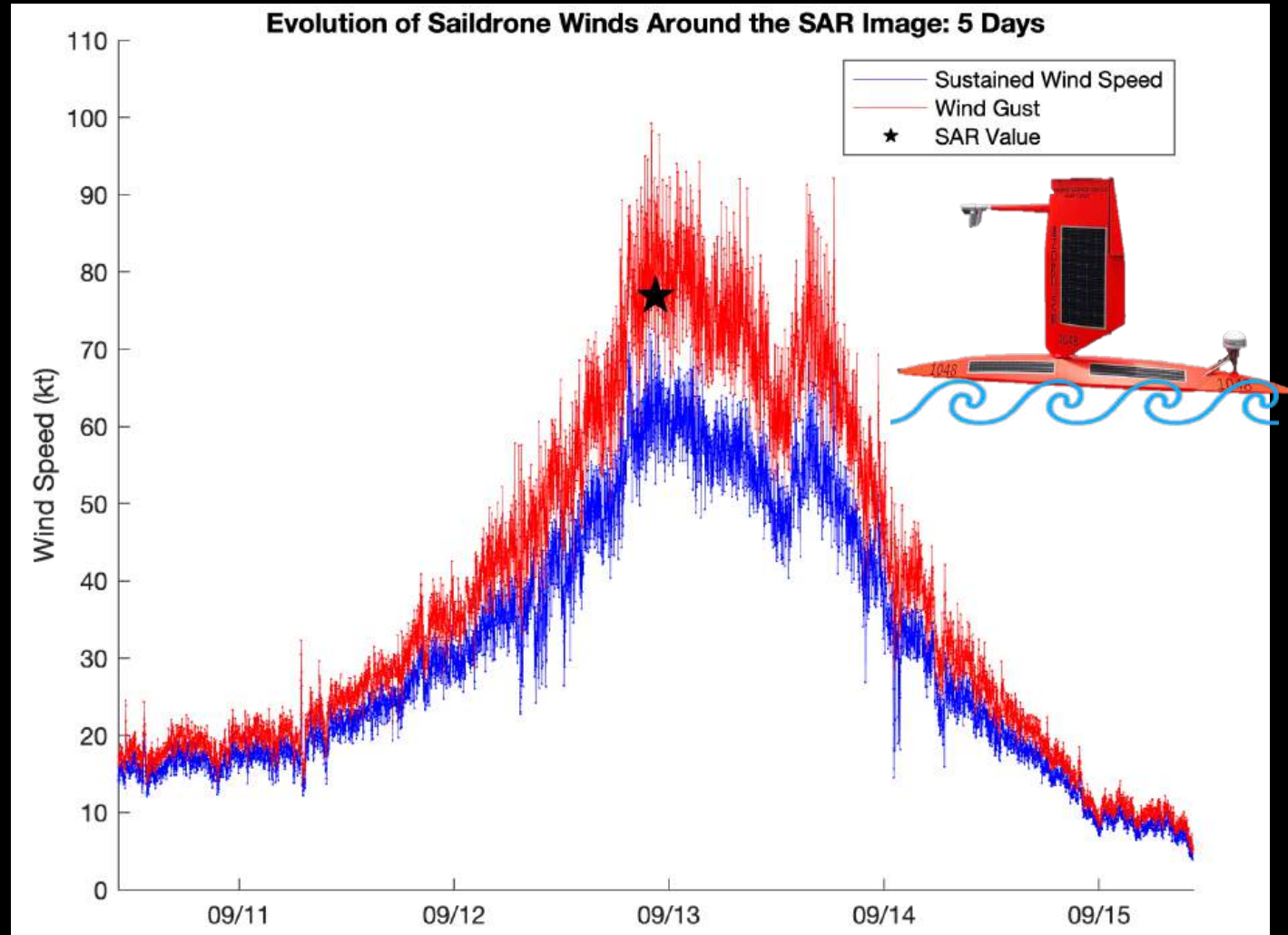
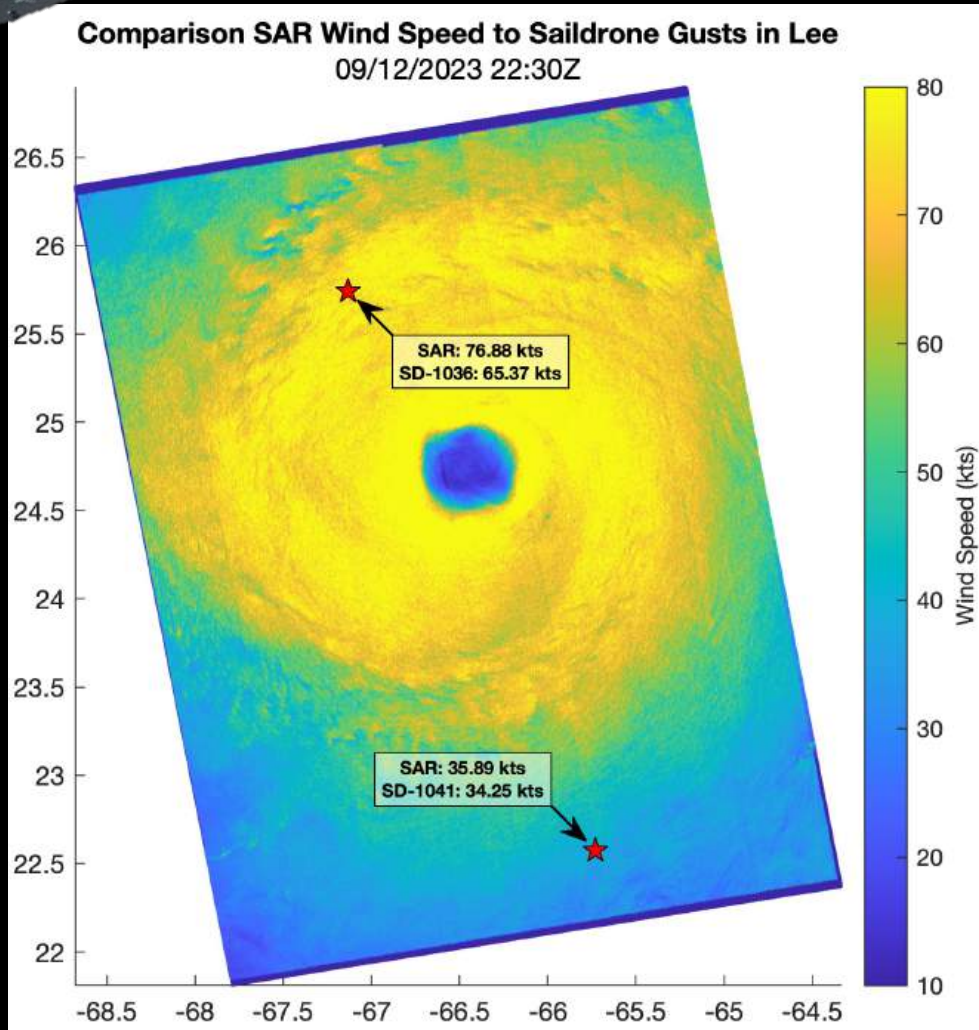
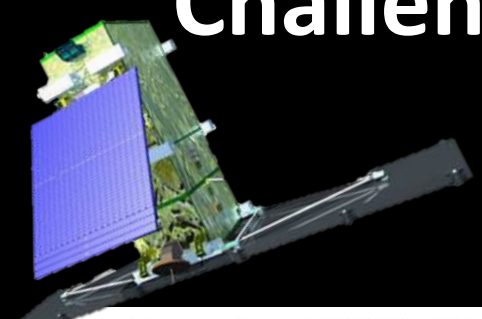


Spatial



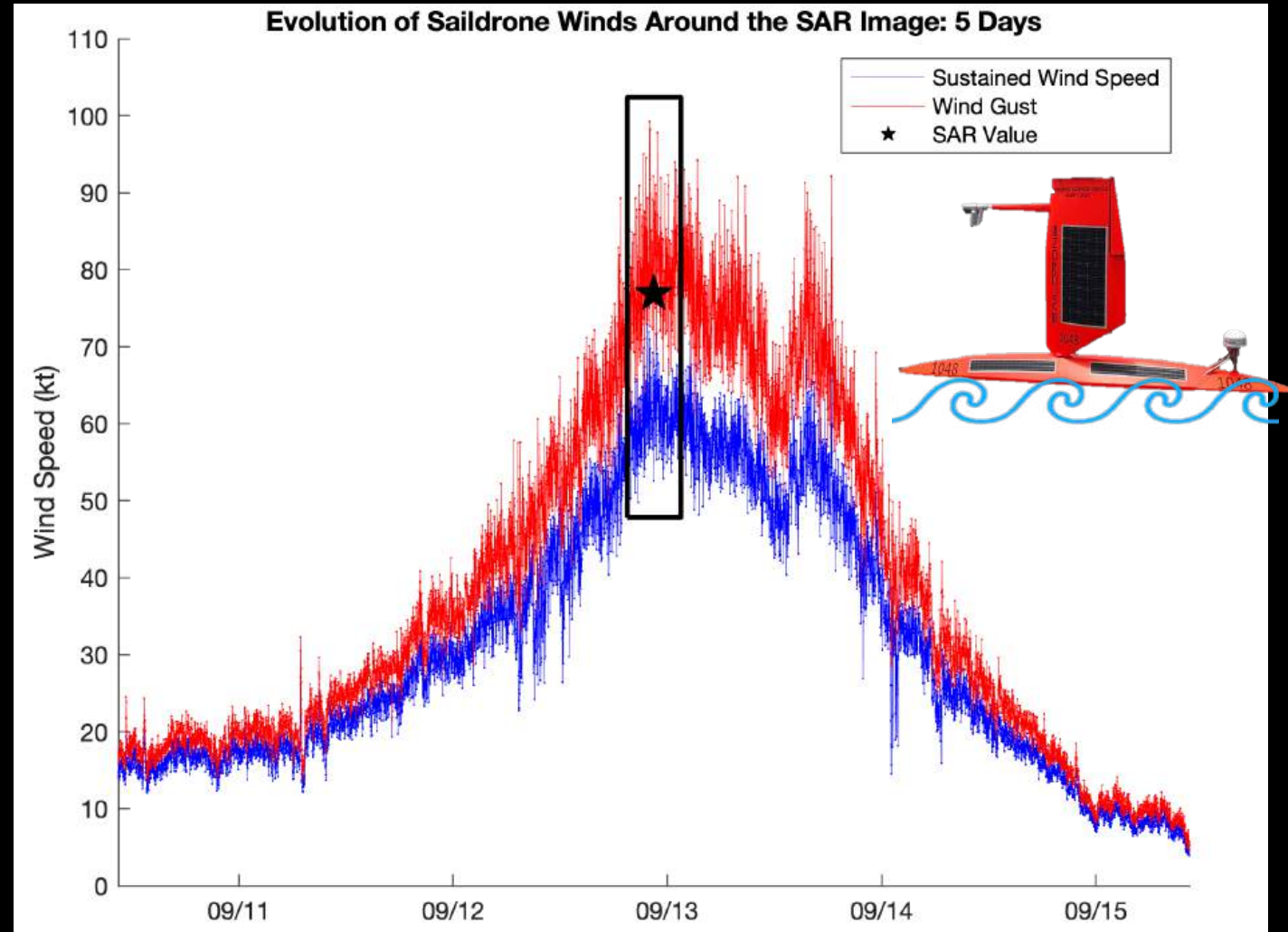
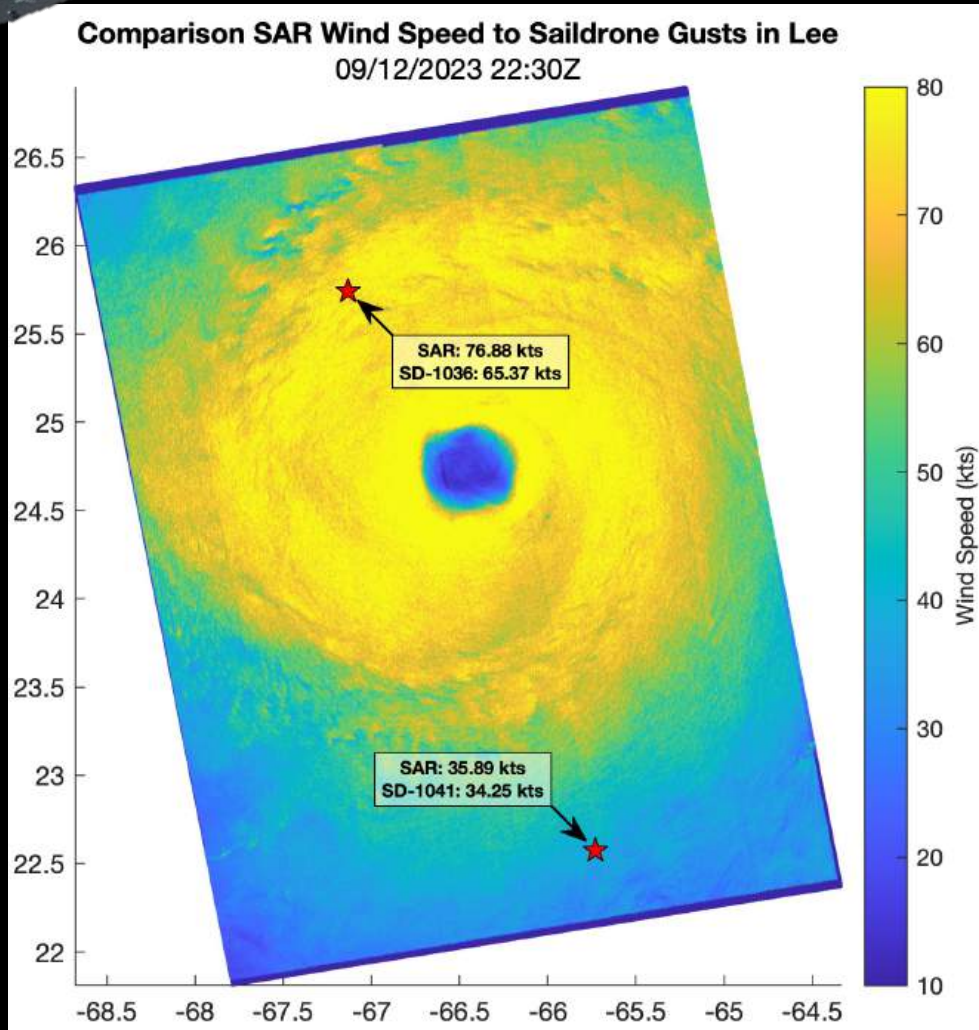
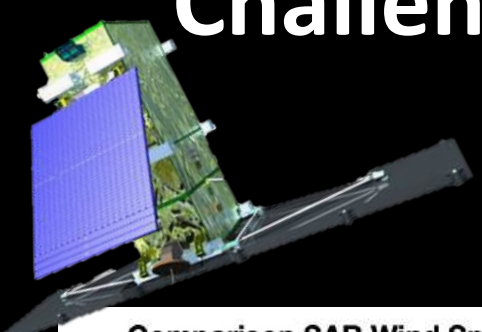
Challenge: How to directly compare remotely sensed vs in situ observations?

Spatial vs Temporal Resolution

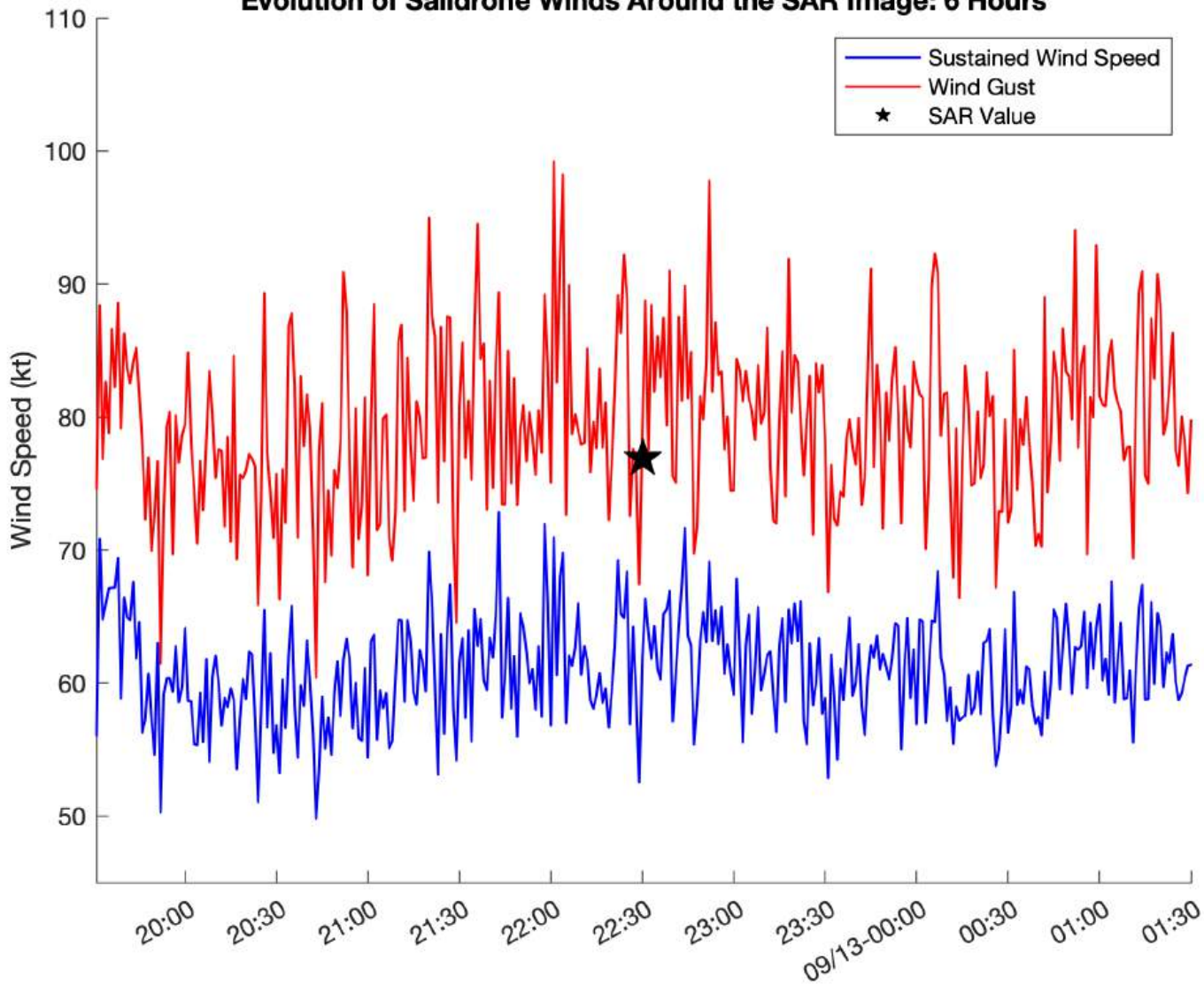


Challenge: How to directly compare remotely sensed vs in situ observations?

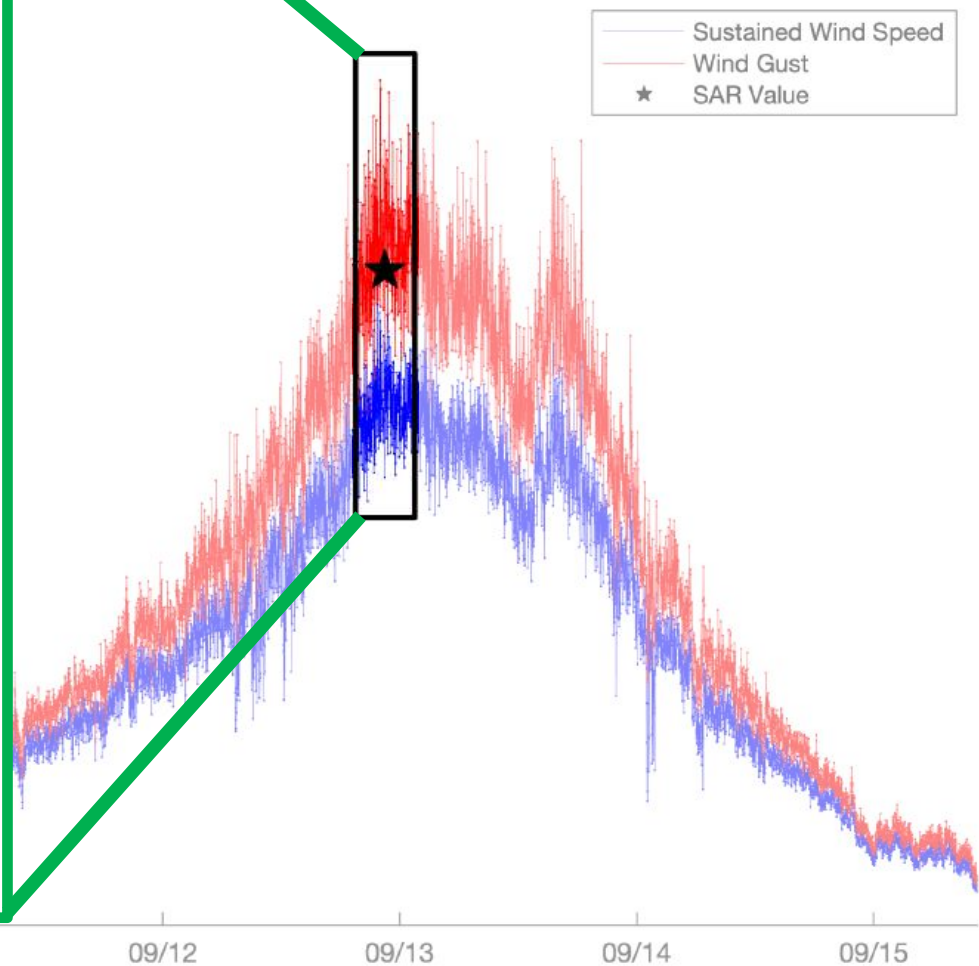
Spatial vs Temporal Resolution



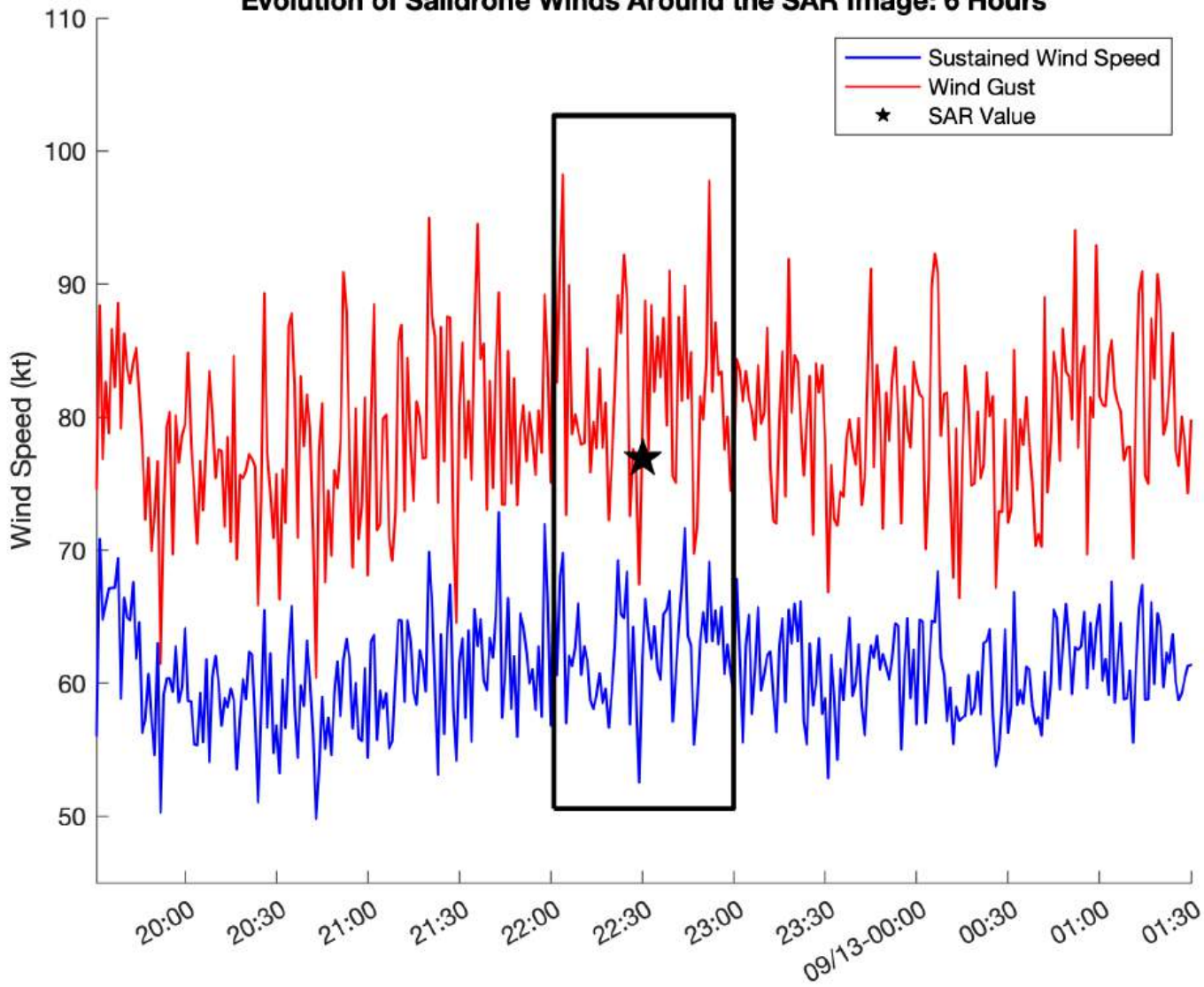
Evolution of Sairdron Winds Around the SAR Image: 6 Hours



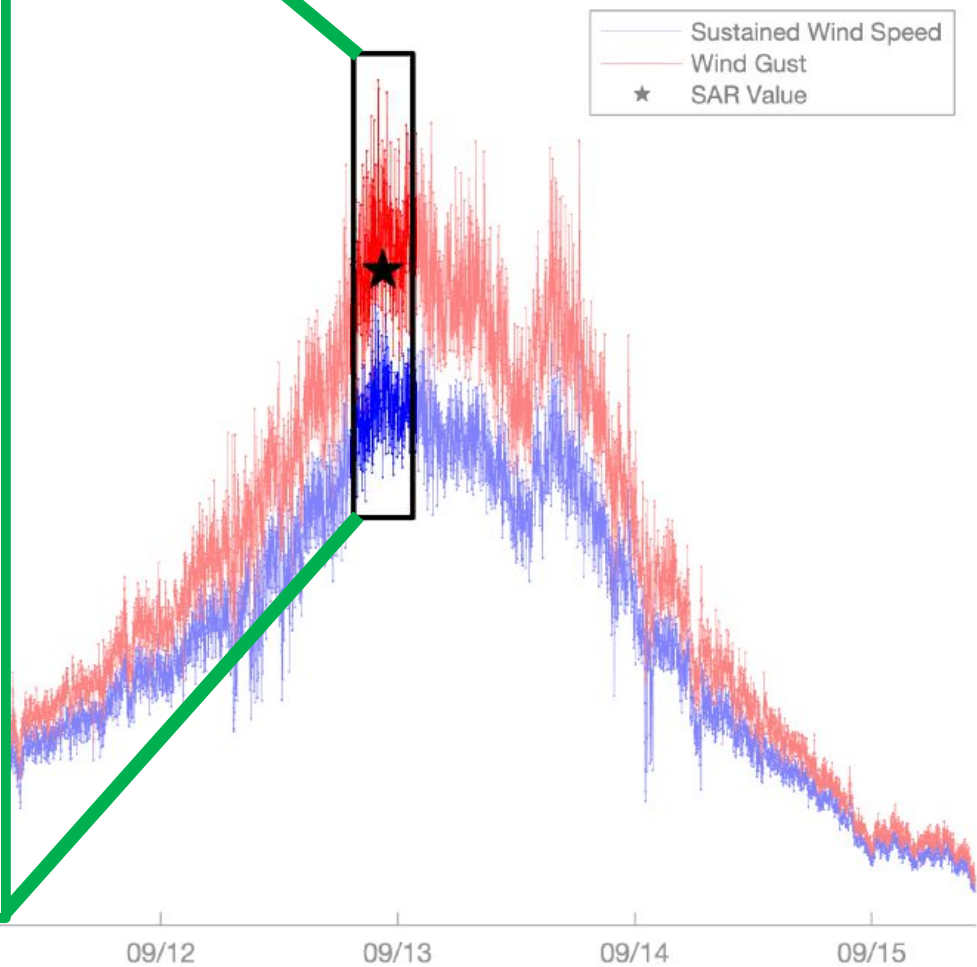
Evolution of Sairdron Winds Around the SAR Image: 5 Days



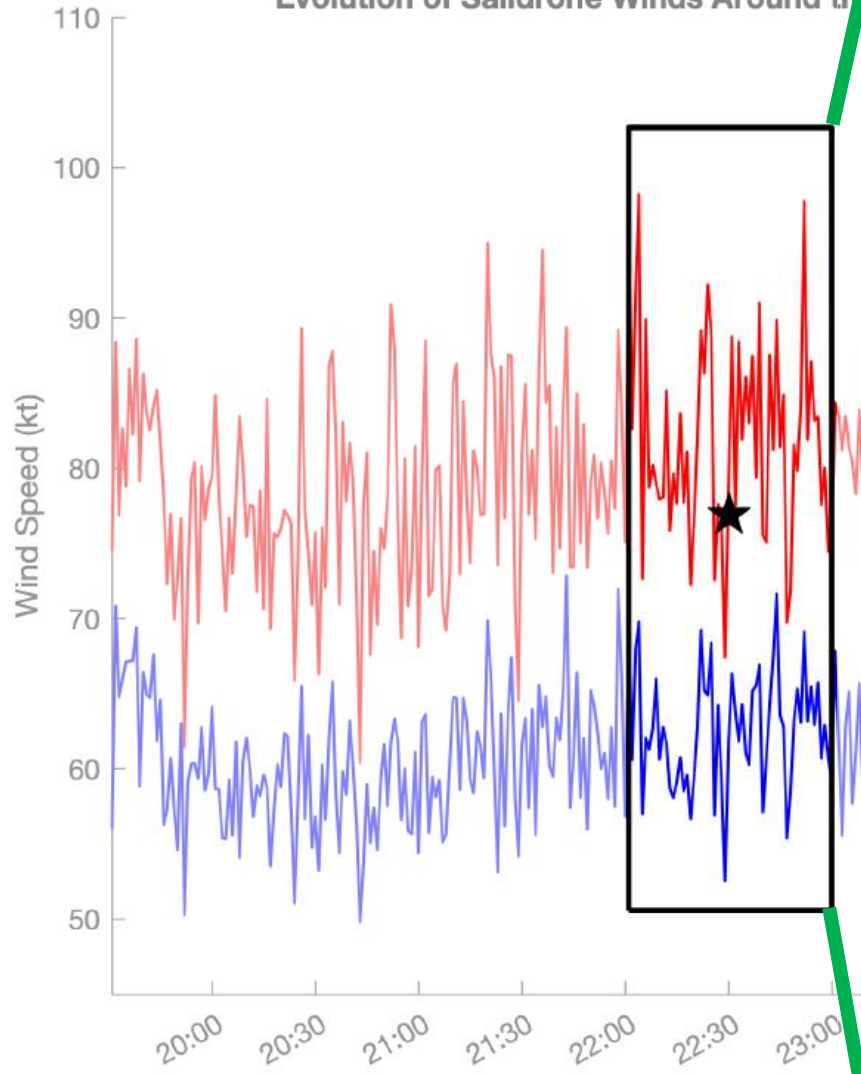
Evolution of Sairdron Winds Around the SAR Image: 6 Hours



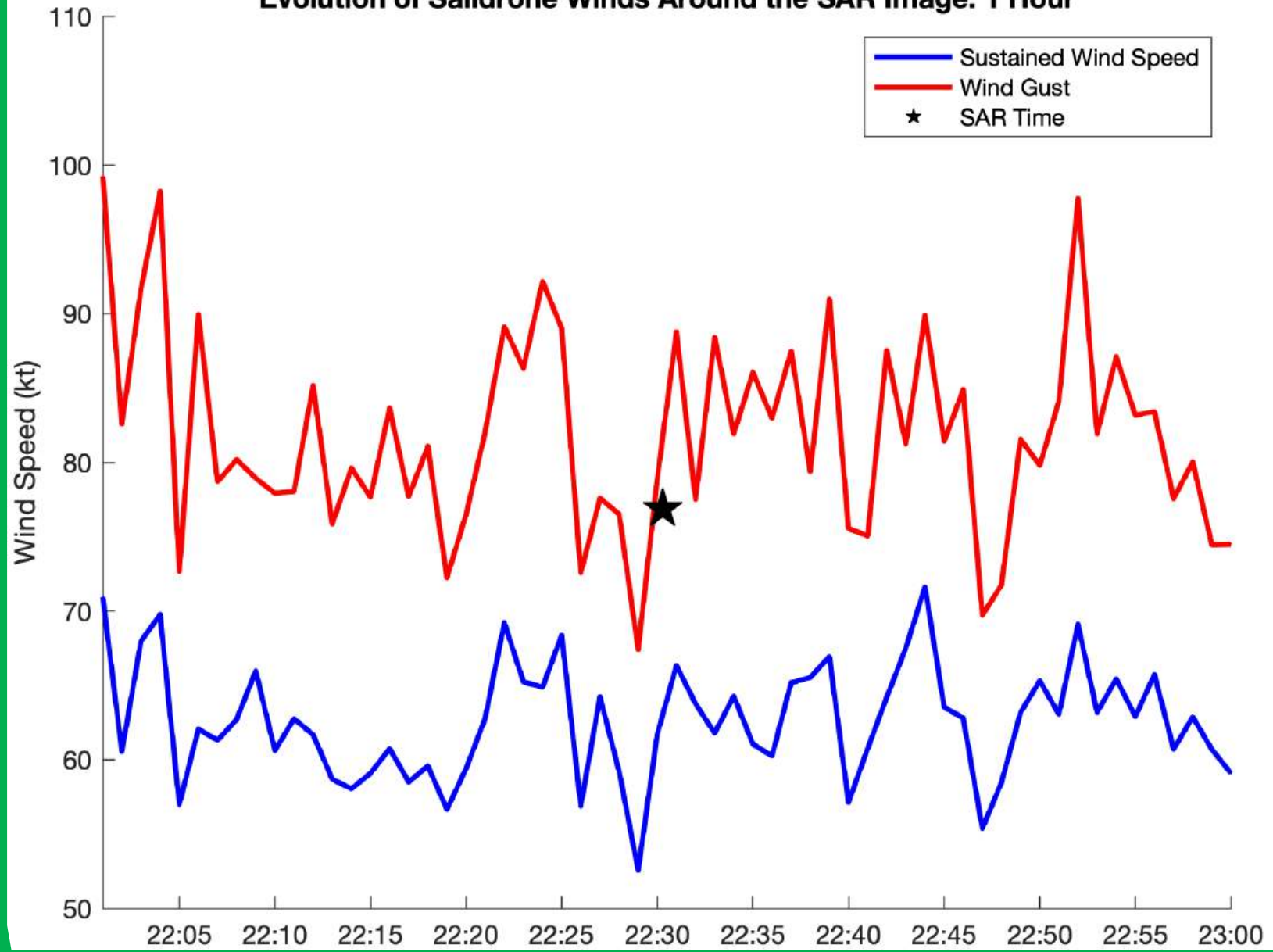
Evolution of Sairdron Winds Around the SAR Image: 5 Days



Evolution of Sairdrone Winds Around the SAR Image

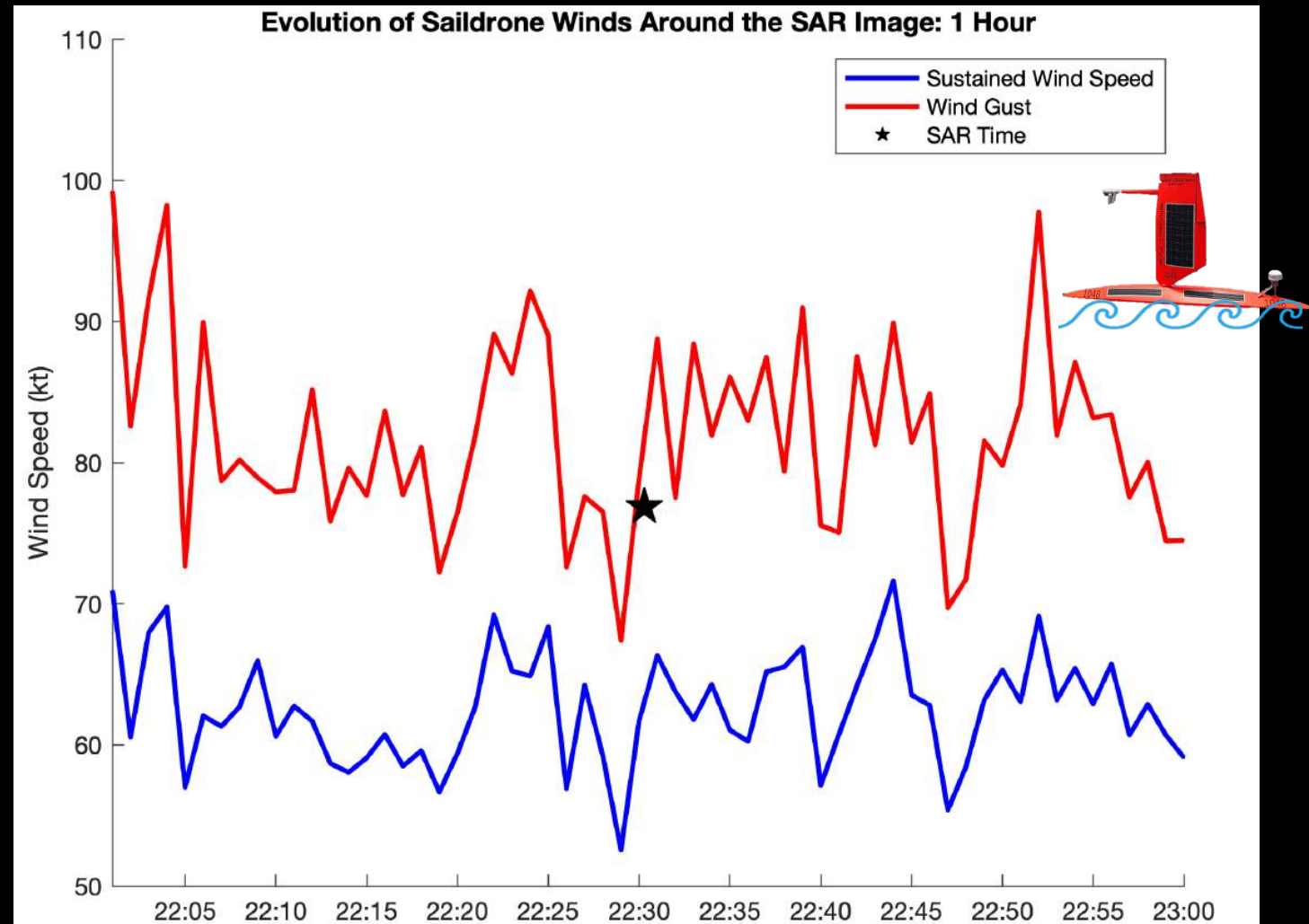
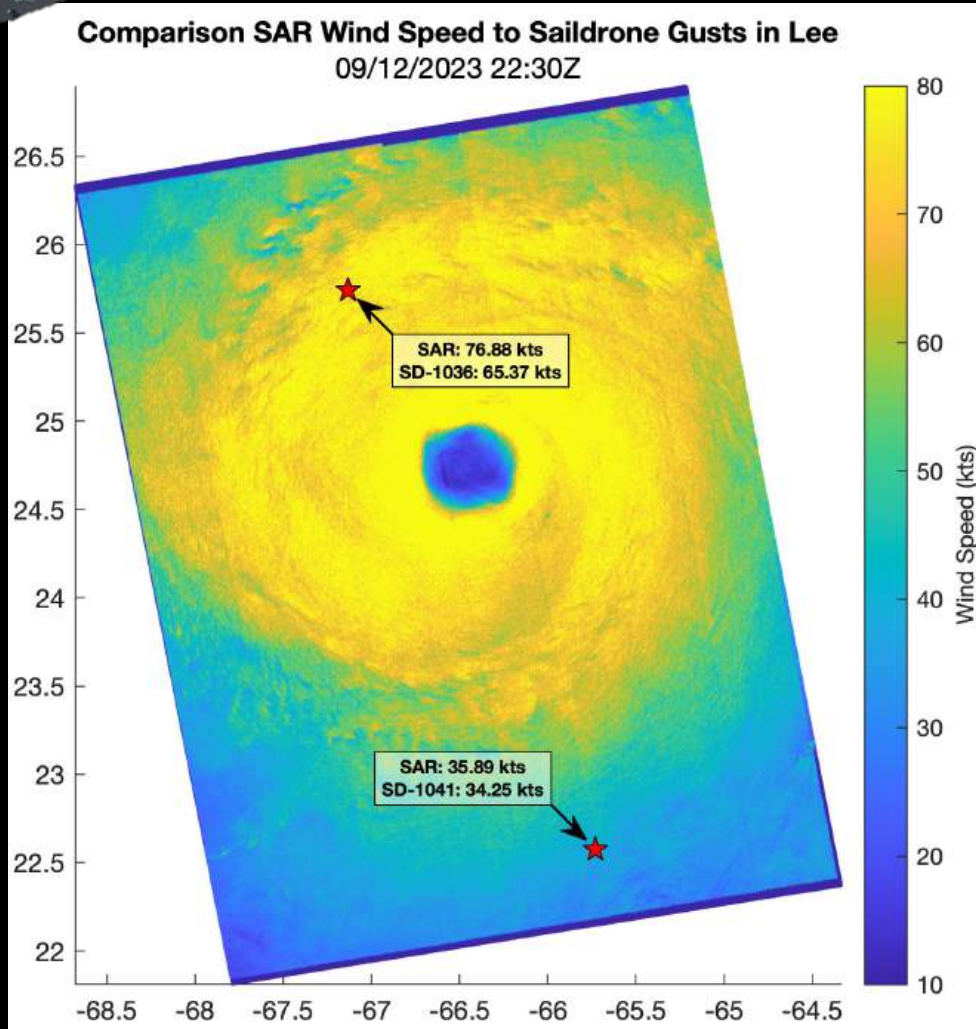
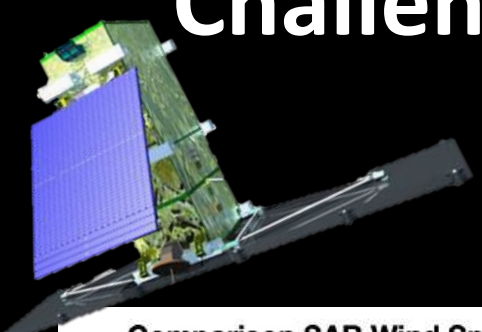


Evolution of Sairdrone Winds Around the SAR Image: 1 Hour



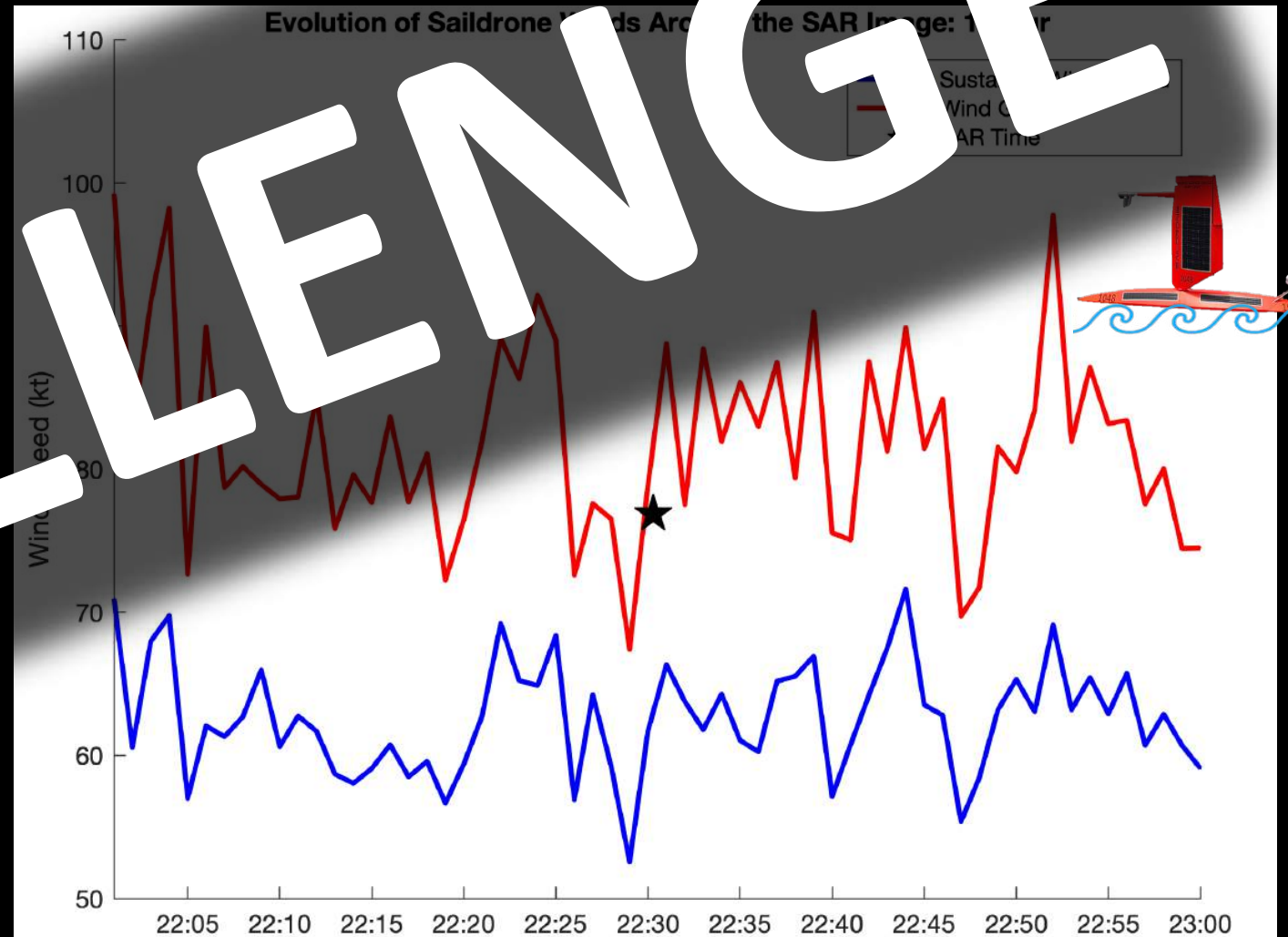
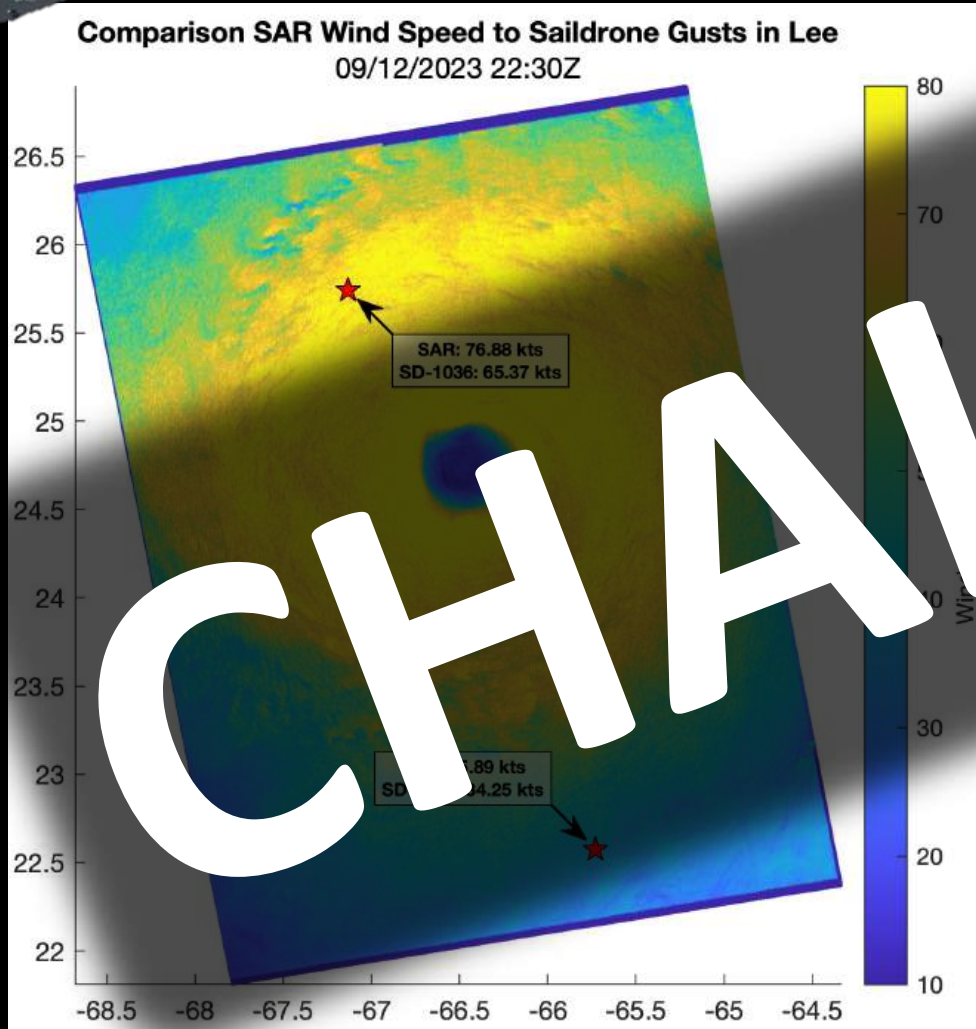
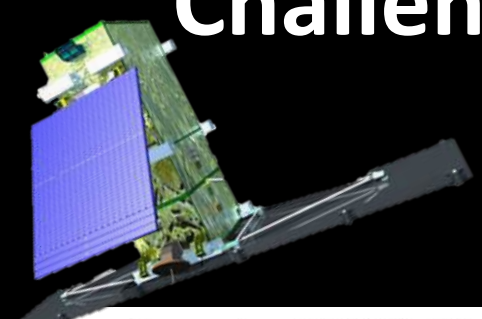
Challenge: How to directly compare remotely sensed vs in situ observations?

Spatial vs Temporal Resolution

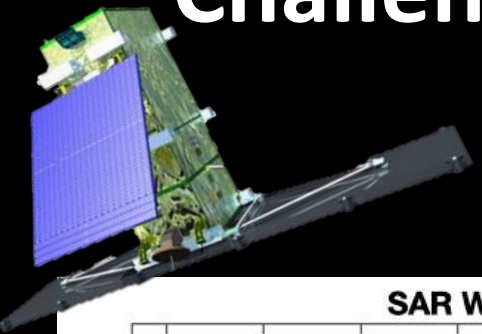


Challenge: How to directly compare remotely sensed vs in situ observations?

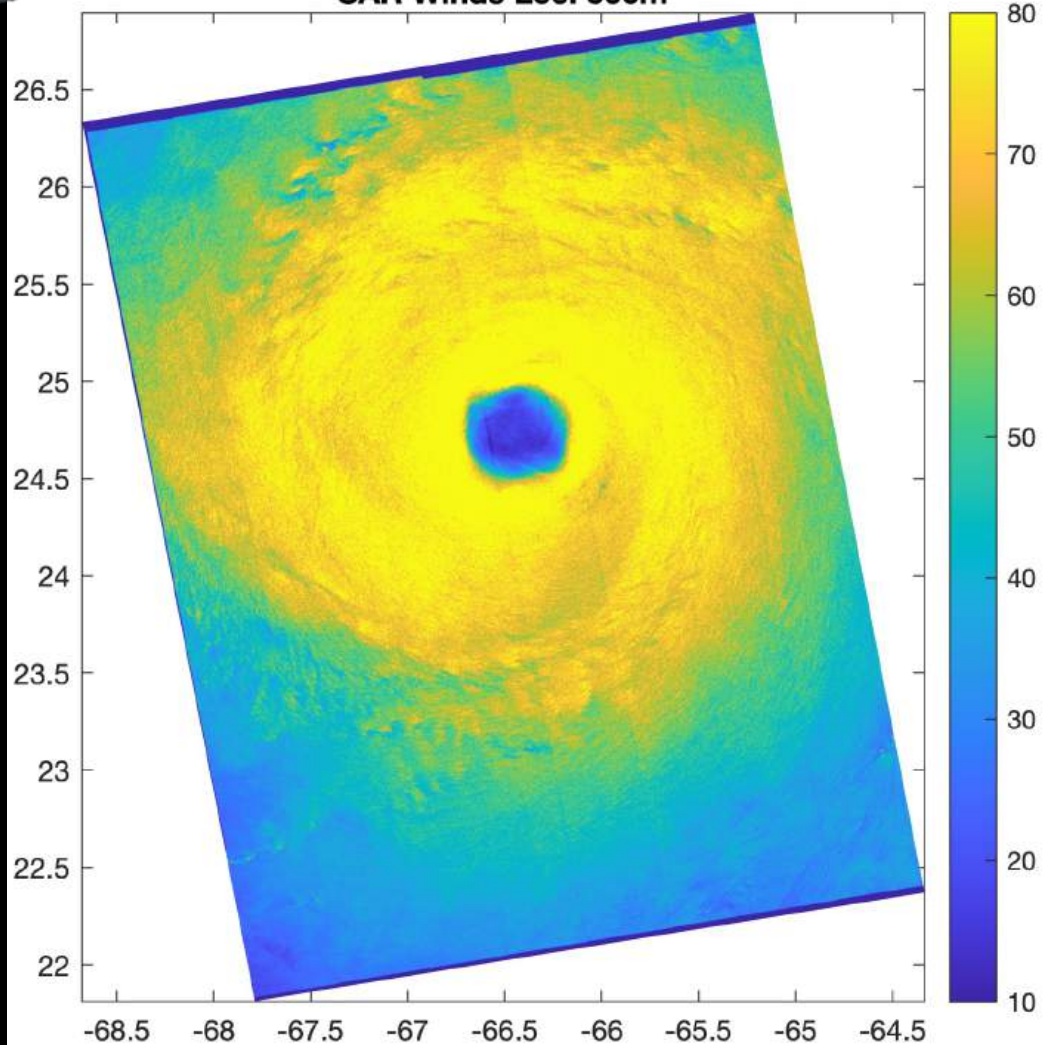
Spatial vs Temporal Resolution



Challenge: How to directly compare remotely sensed vs in situ observations? Spatial vs Temporal Resolution

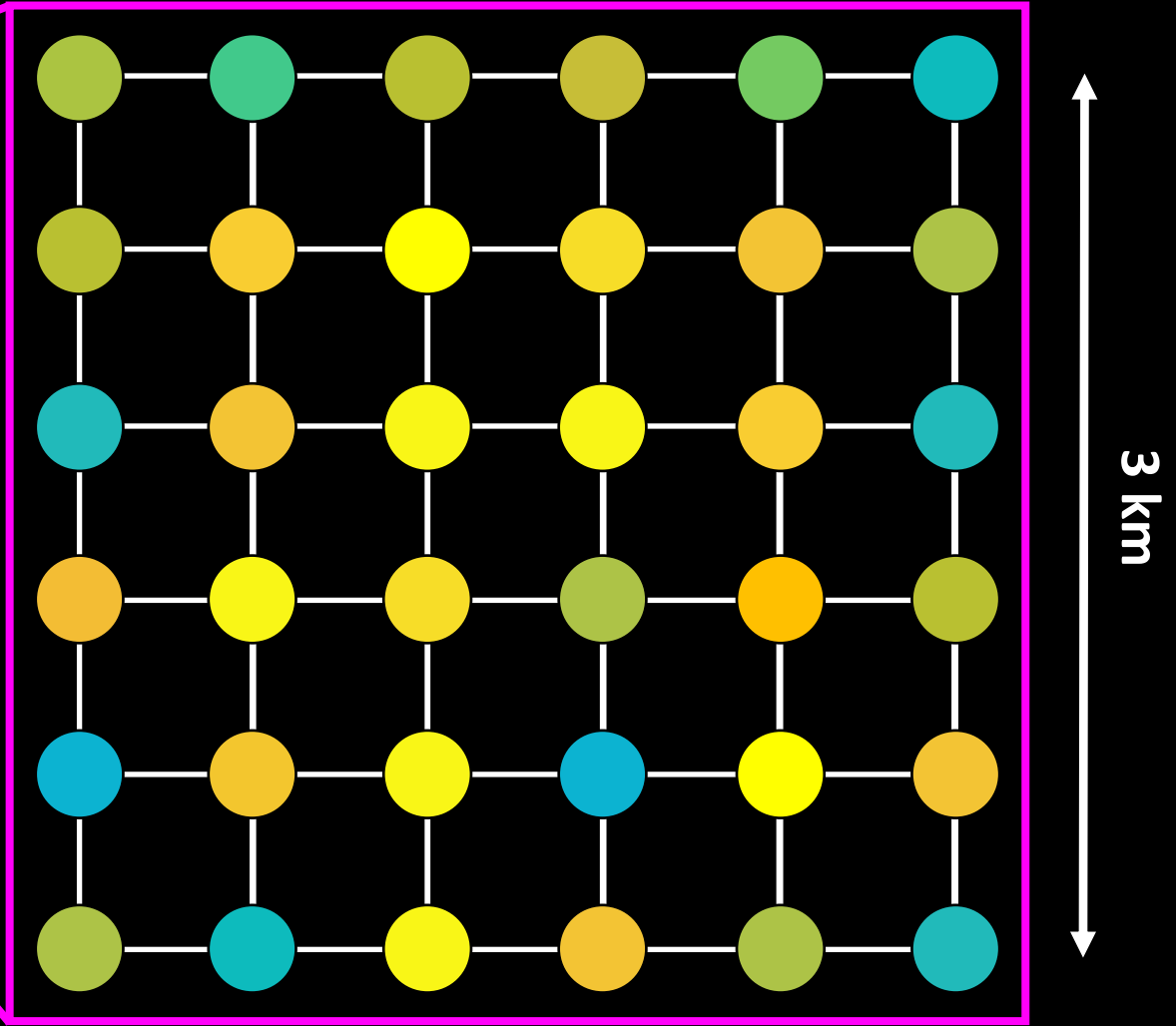
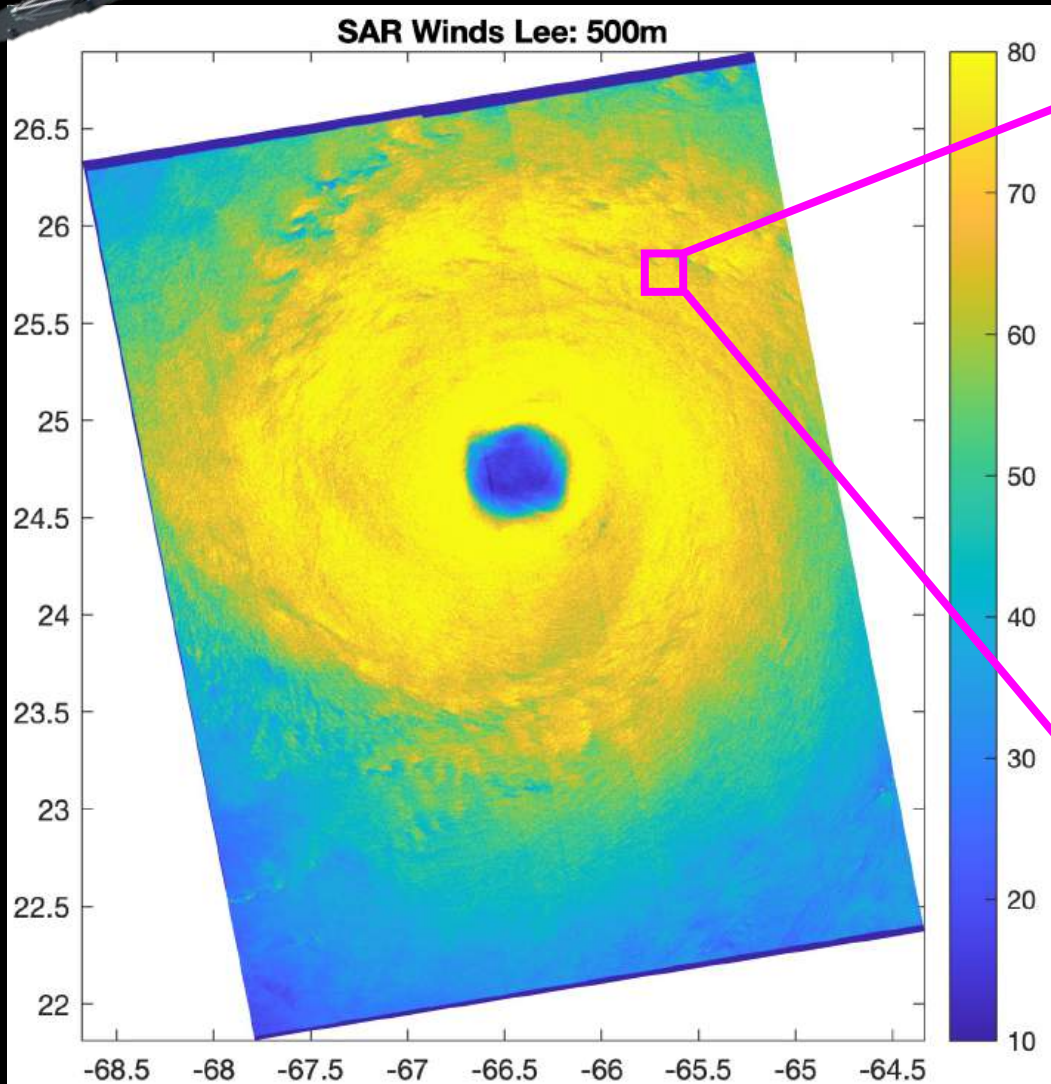
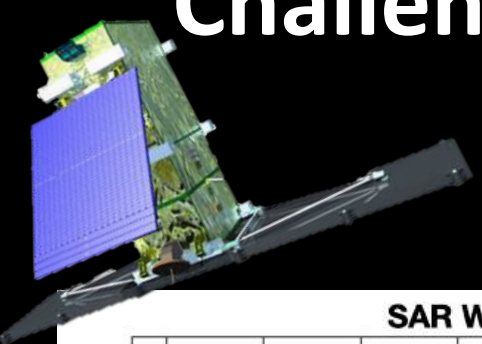


SAR Winds Lee: 500m



Challenge: How to directly compare remotely sensed vs in situ observations?

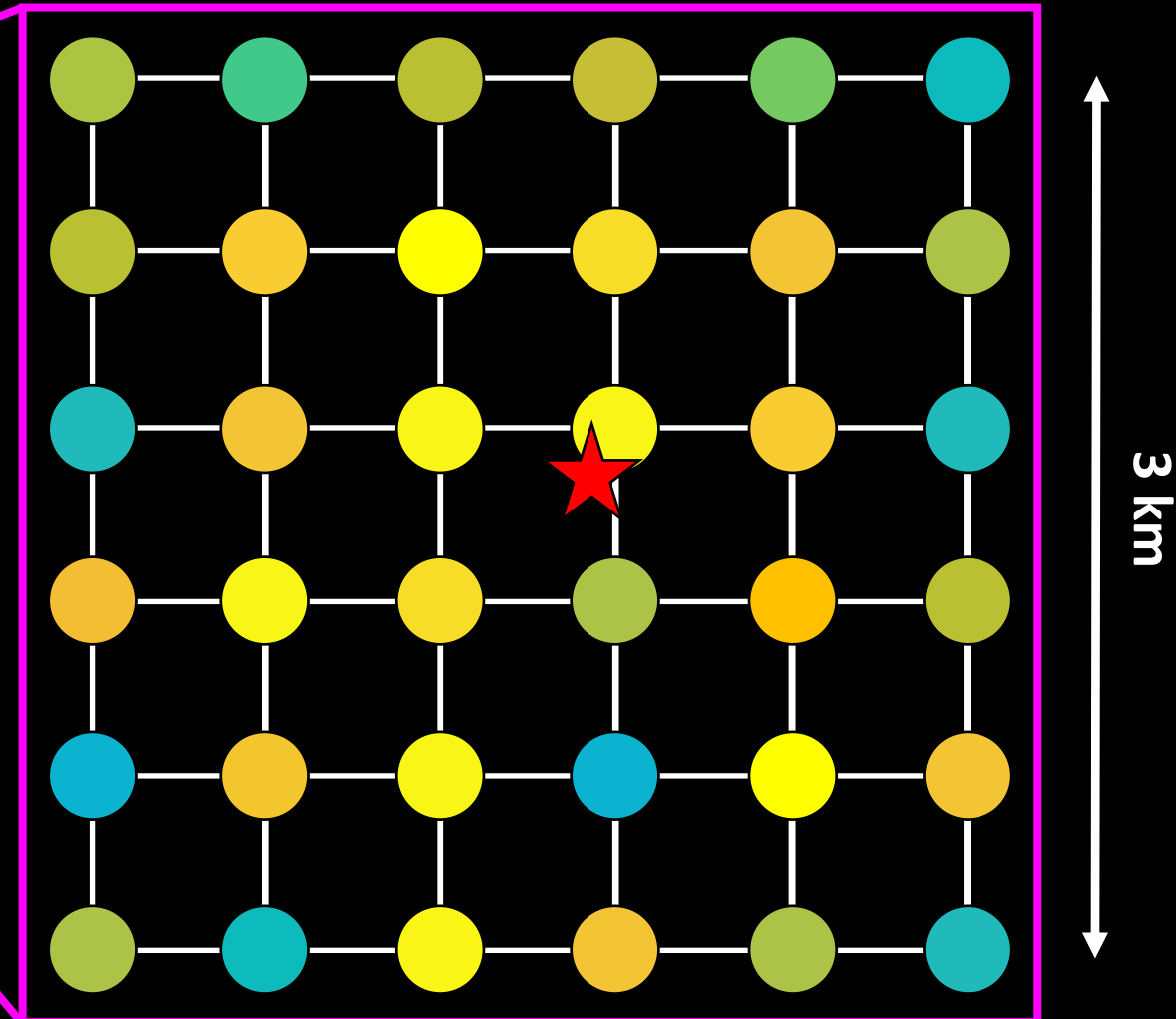
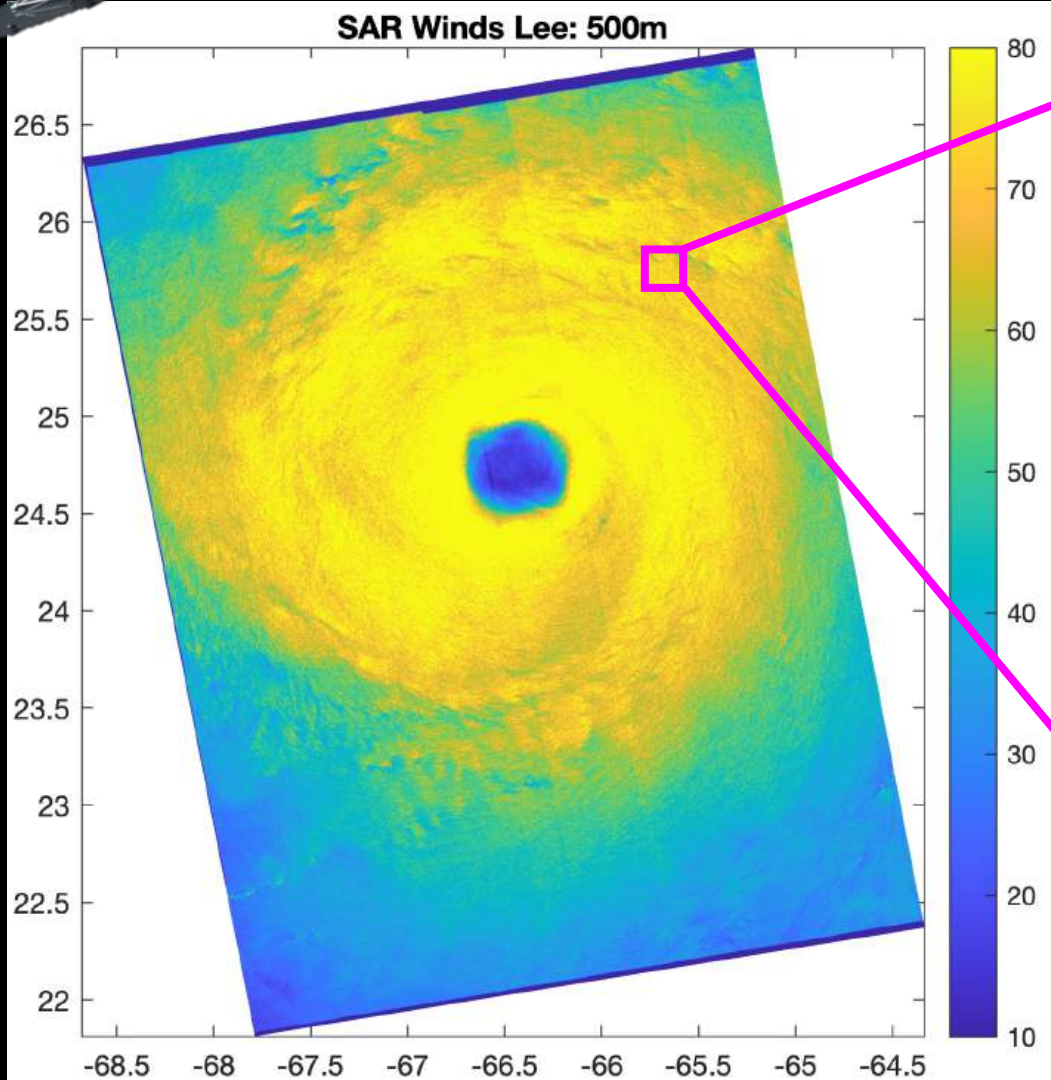
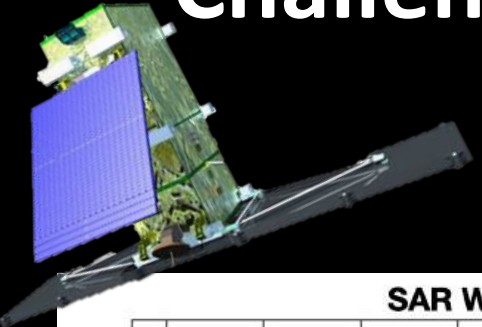
Spatial vs Temporal Resolution



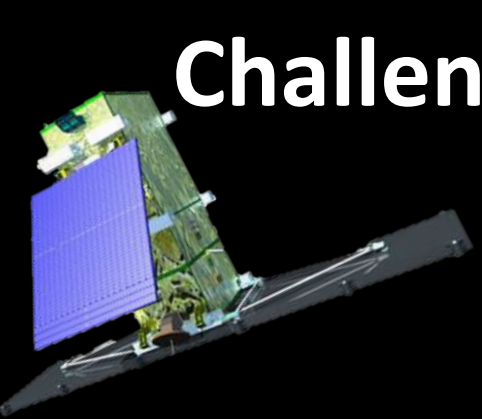
* Not real example shown

Challenge: How to directly compare remotely sensed vs in situ observations?

Spatial vs Temporal Resolution

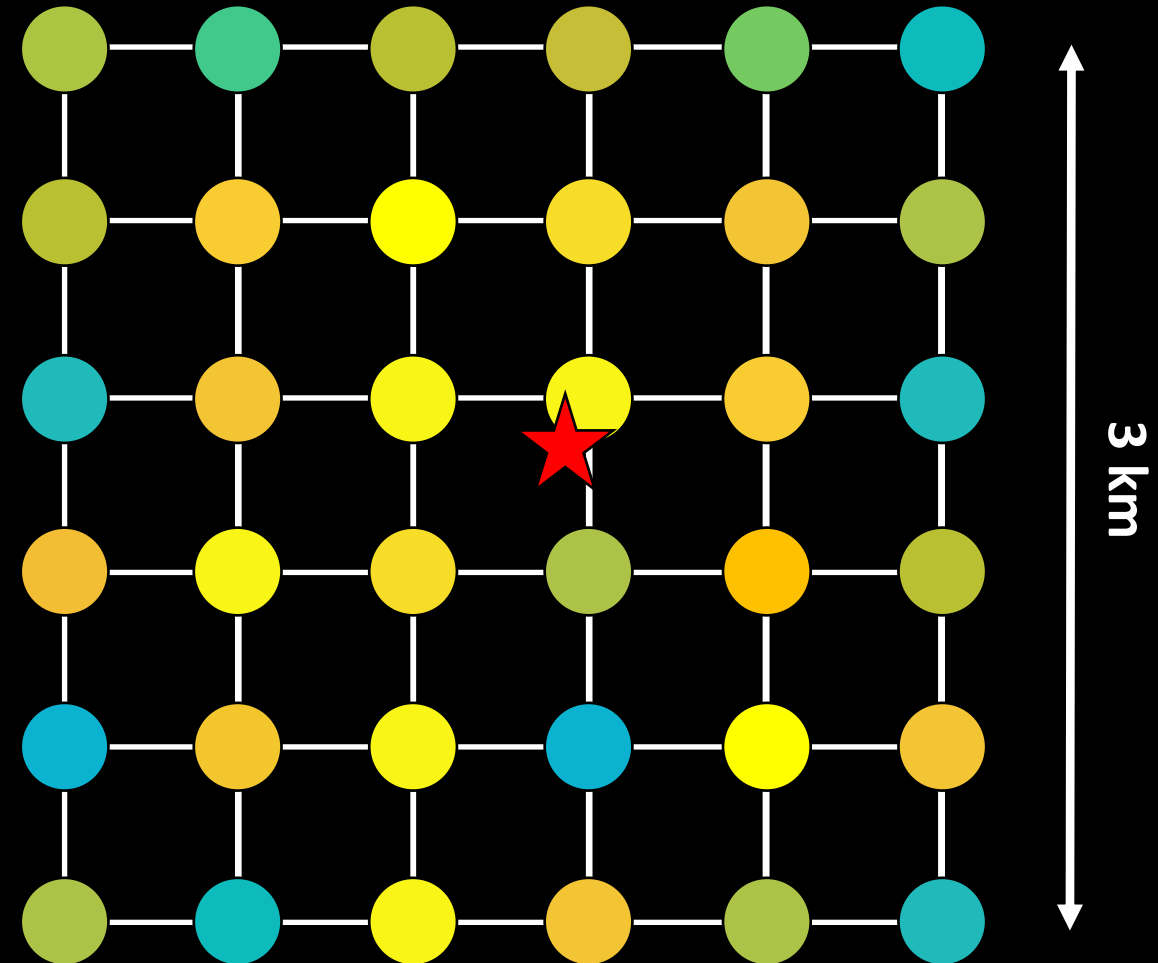


* Not real example shown

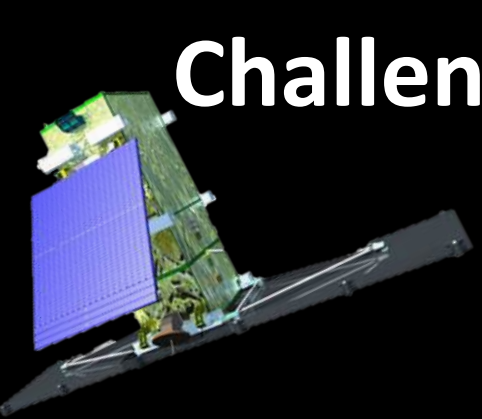


Challenge: How to directly compare remotely sensed vs in situ observations? Spatial vs Temporal Resolution

What do we compare?



* Not real example shown

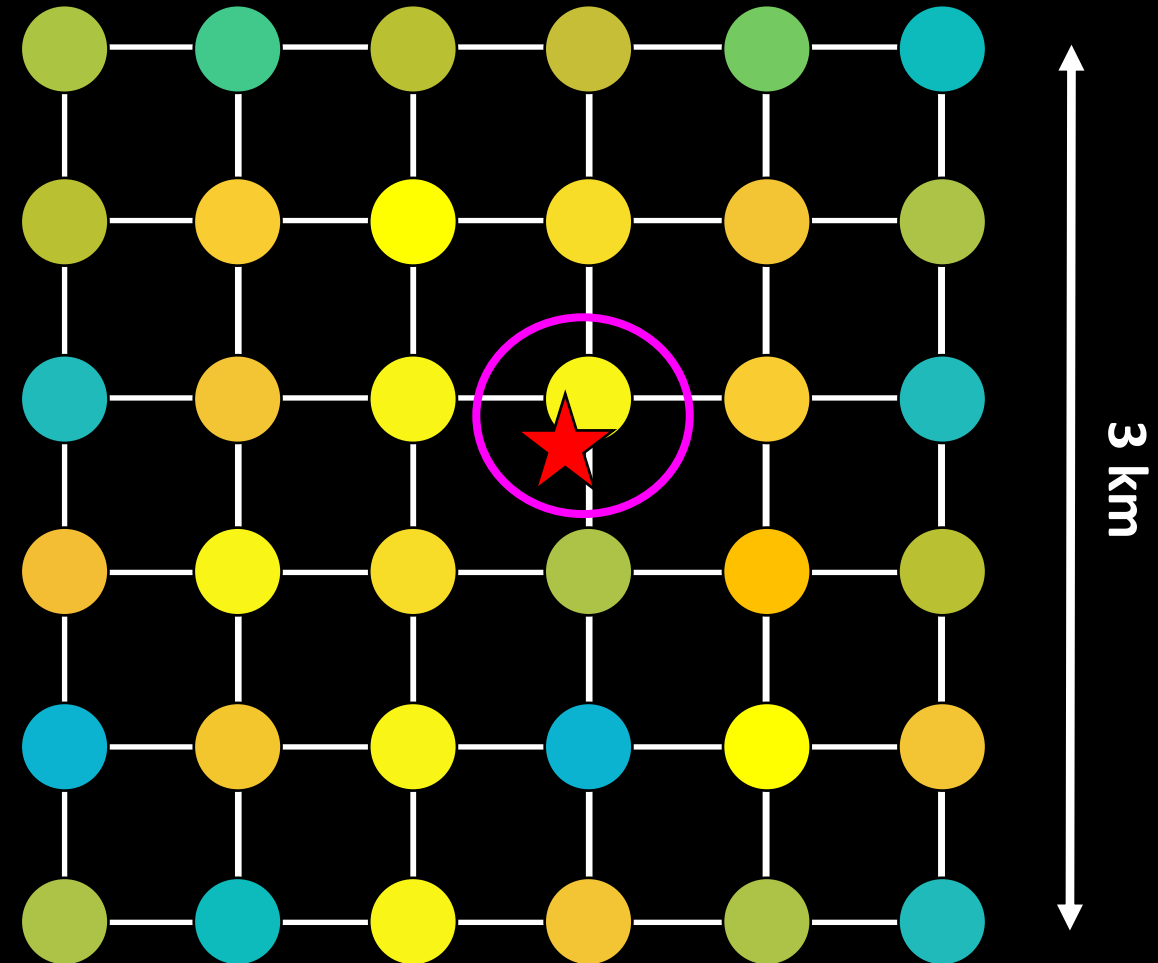


Challenge: How to directly compare remotely sensed vs in situ observations?

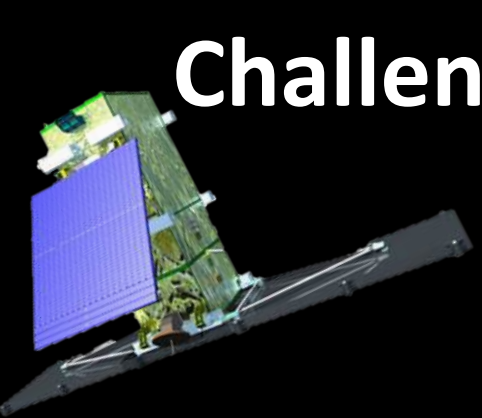
Spatial vs Temporal Resolution

What do we compare?

- Closest Point?



* Not real example shown

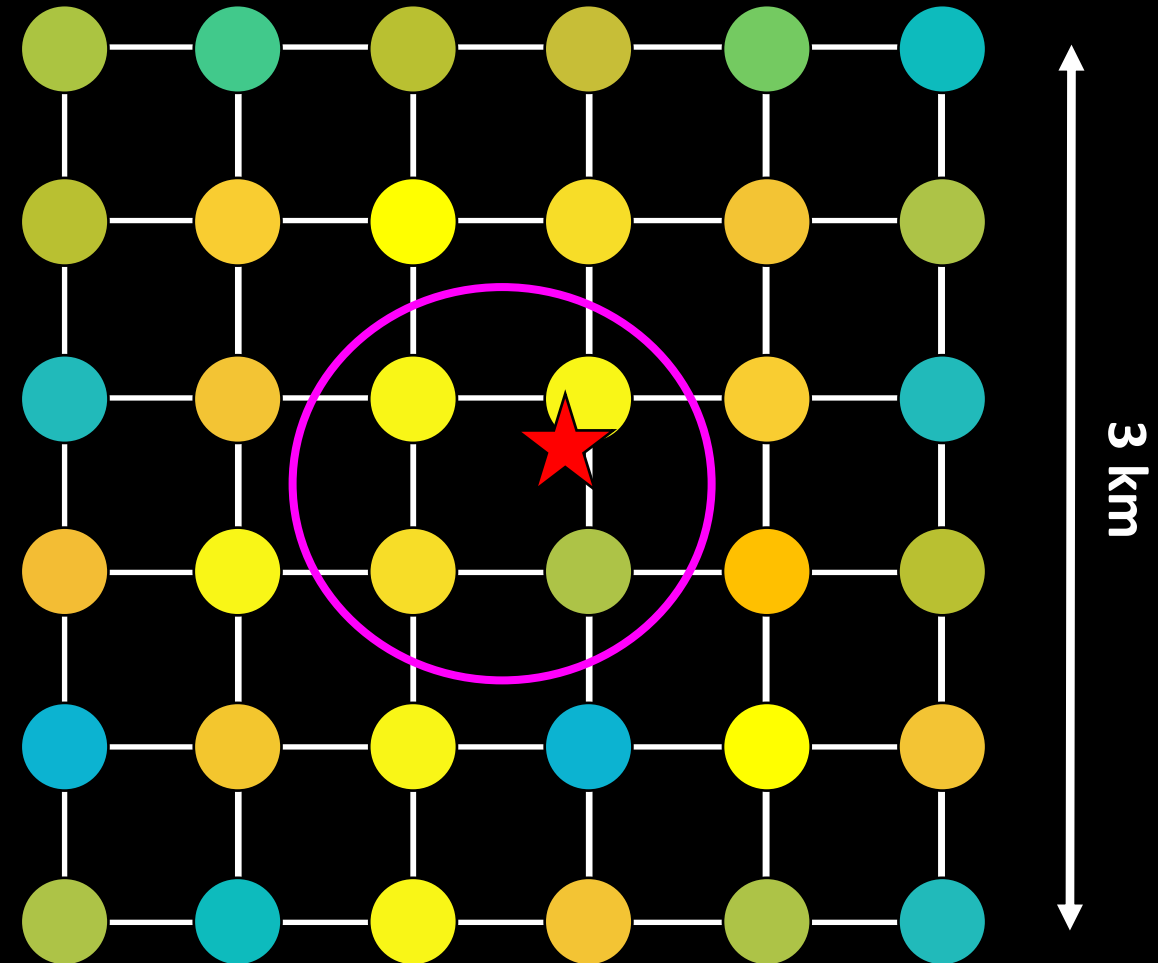


Challenge: How to directly compare remotely sensed vs in situ observations?

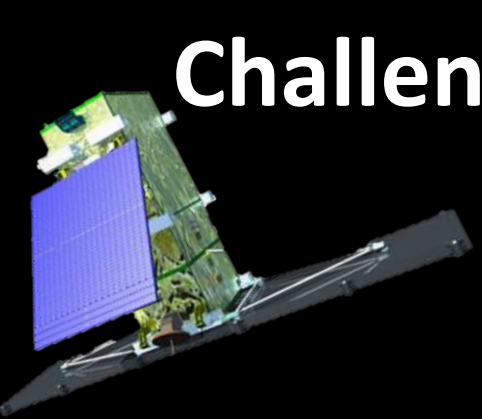
Spatial vs Temporal Resolution

What do we compare?

- Closest Point?
- Average within 500 m?
- Max within 500 m?



* Not real example shown

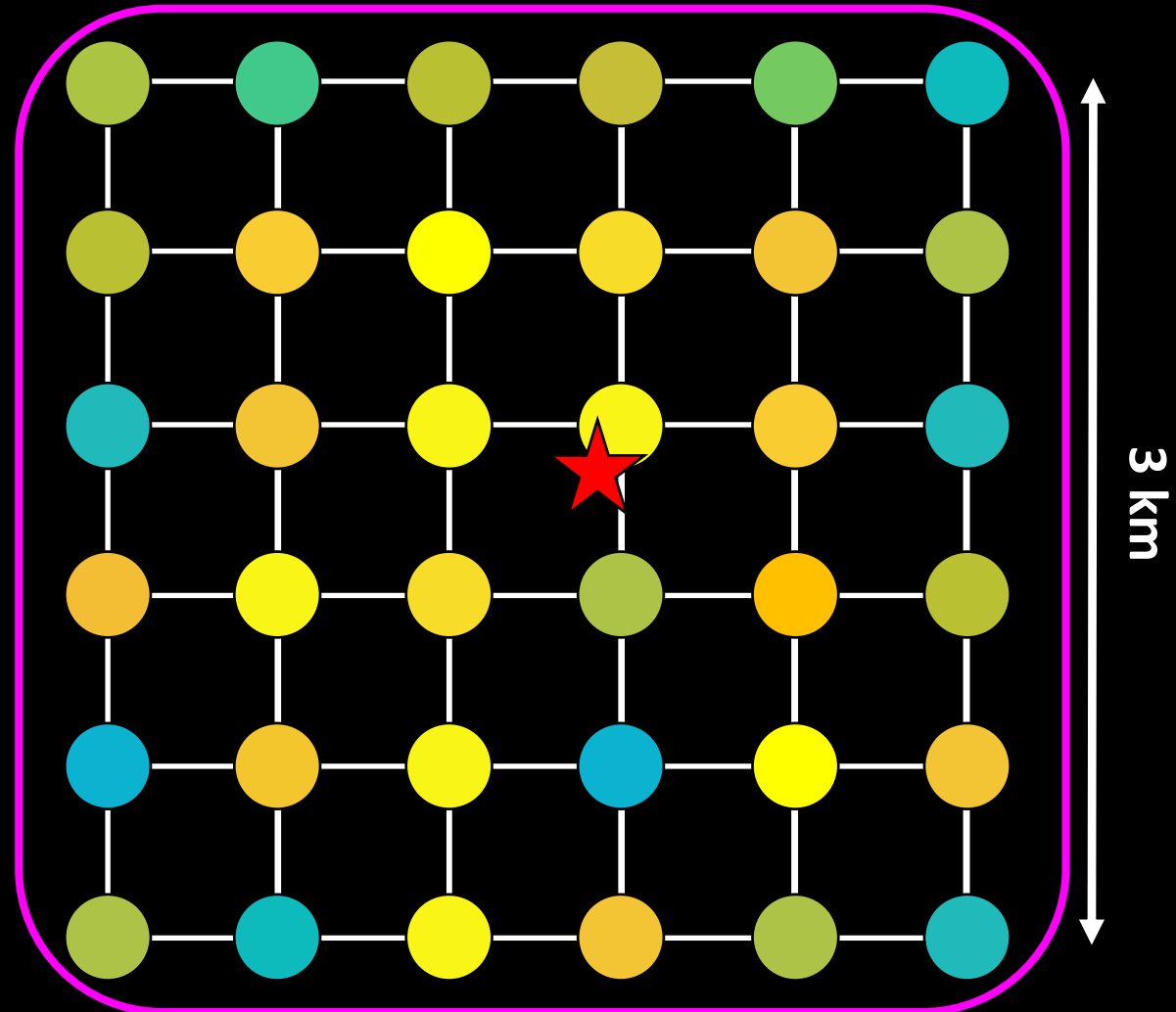


Challenge: How to directly compare remotely sensed vs in situ observations?

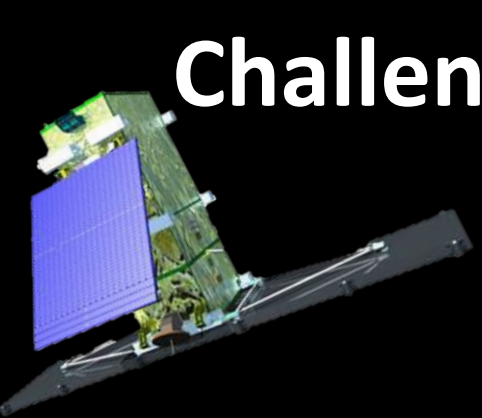
Spatial vs Temporal Resolution

What do we compare?

- Closest Point?
- Average within 500 m?
- Max within 500 m?
- Average within 3 km?
- Max within 3 km?



* Not real example shown



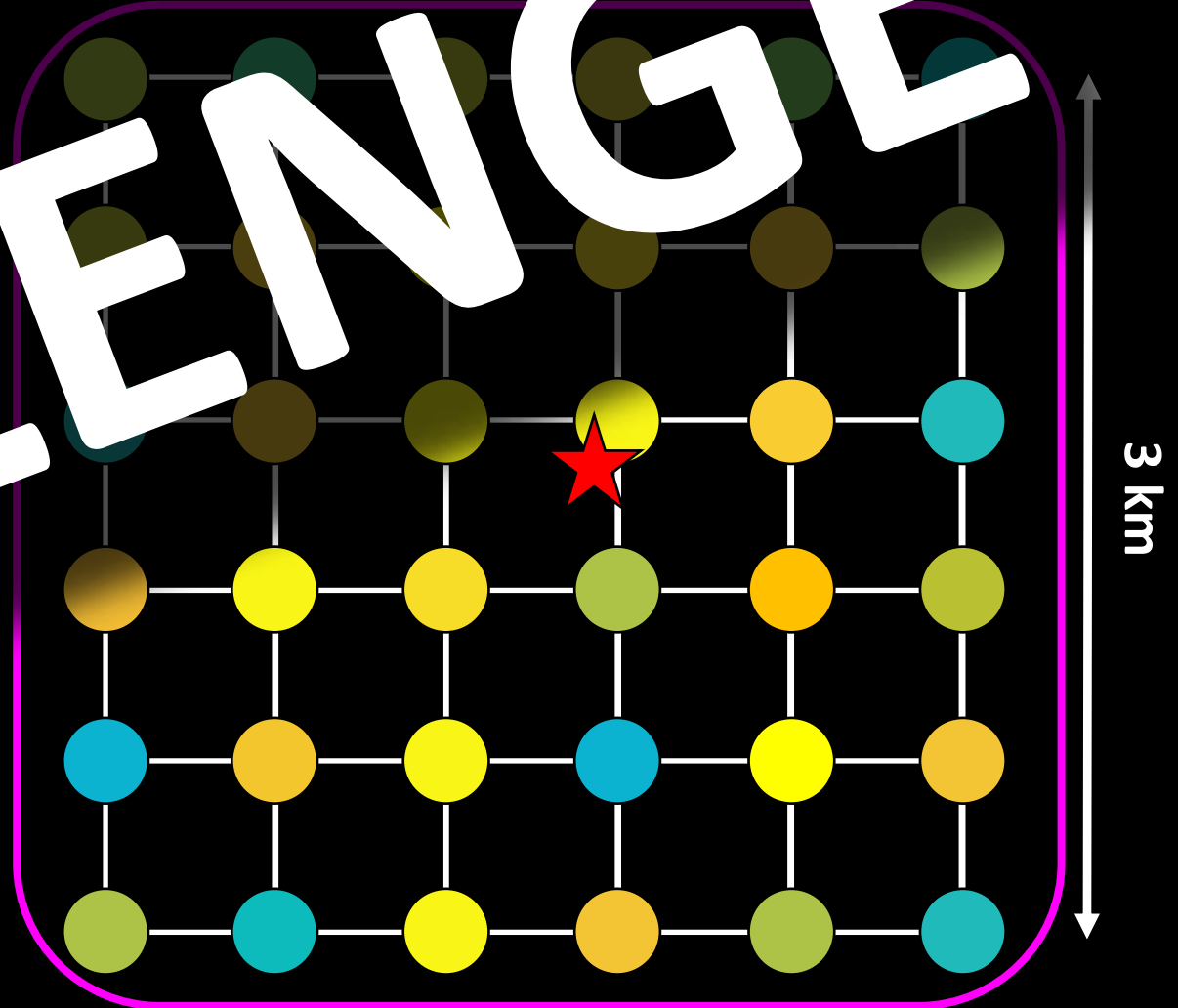
Challenge: How to directly compare remotely sensed vs in situ observations?

Spatial vs Temporal Resolution

What do we compare?

- Closest Point?
- Average within 500 m?
- Max within 500 m?
- Average within 3 km?
- Max within 3 km?

CHALLENGE

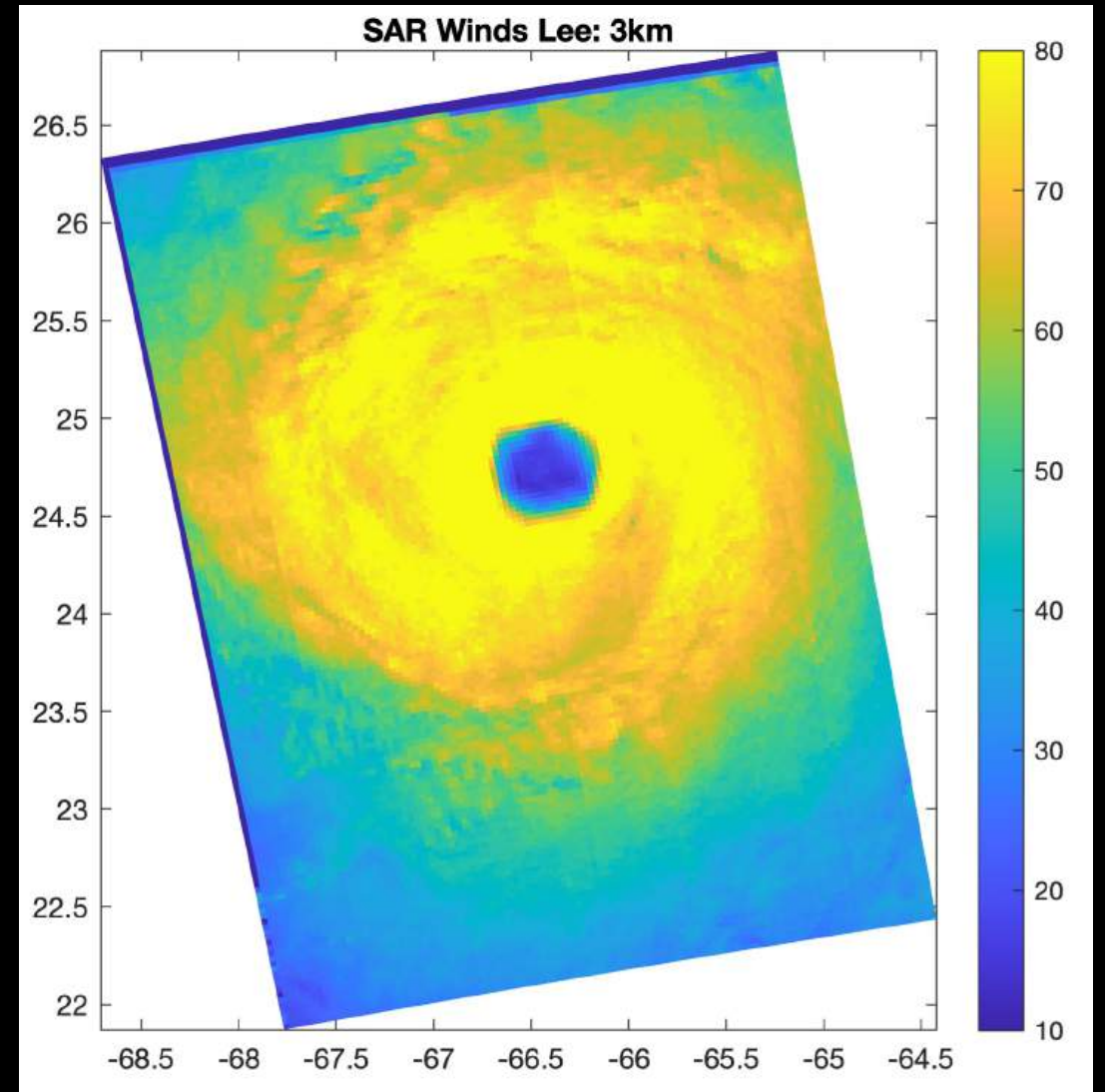
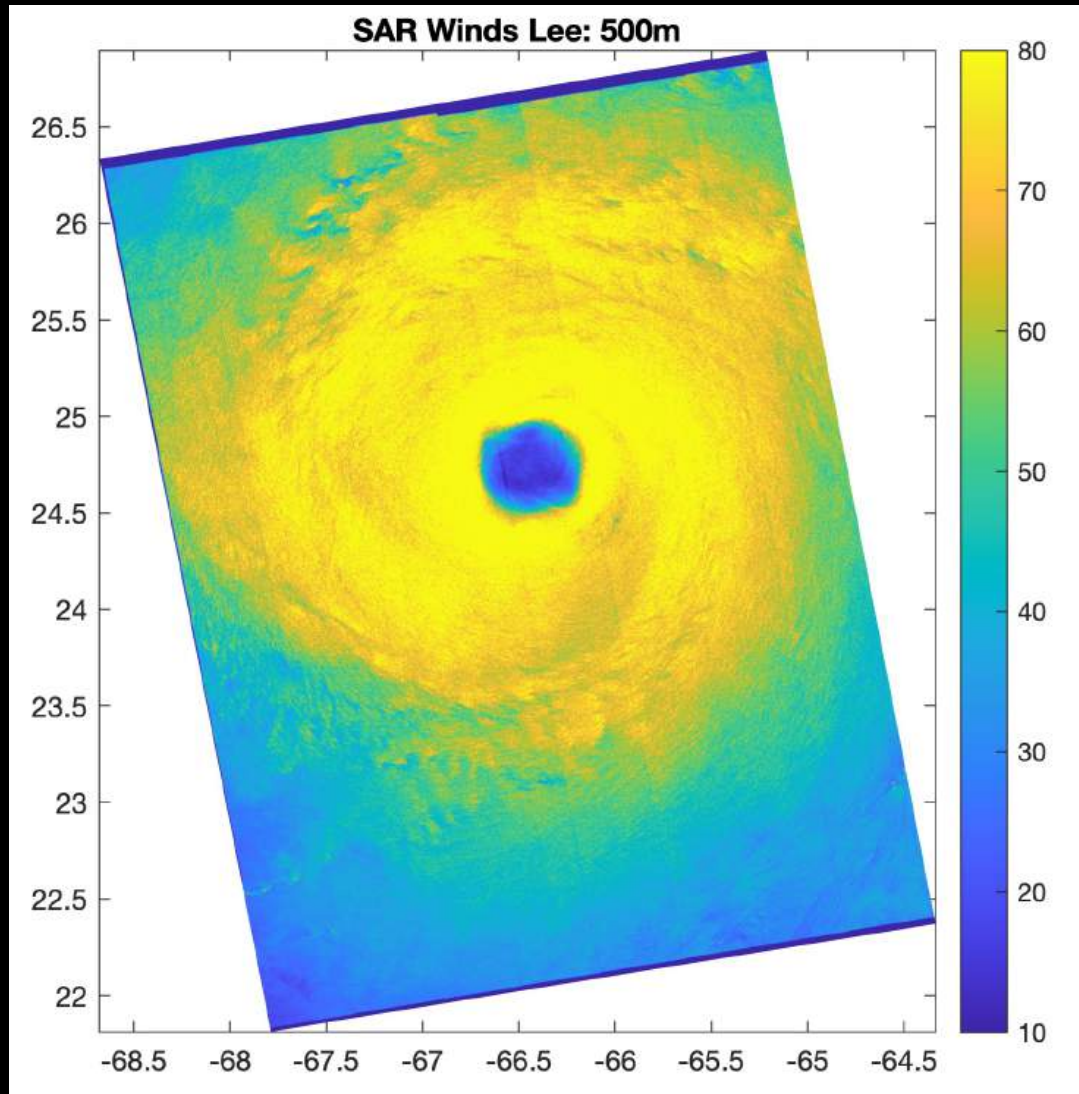


* Not real example shown

SAR: Different Resolutions

500 m: Gusts?

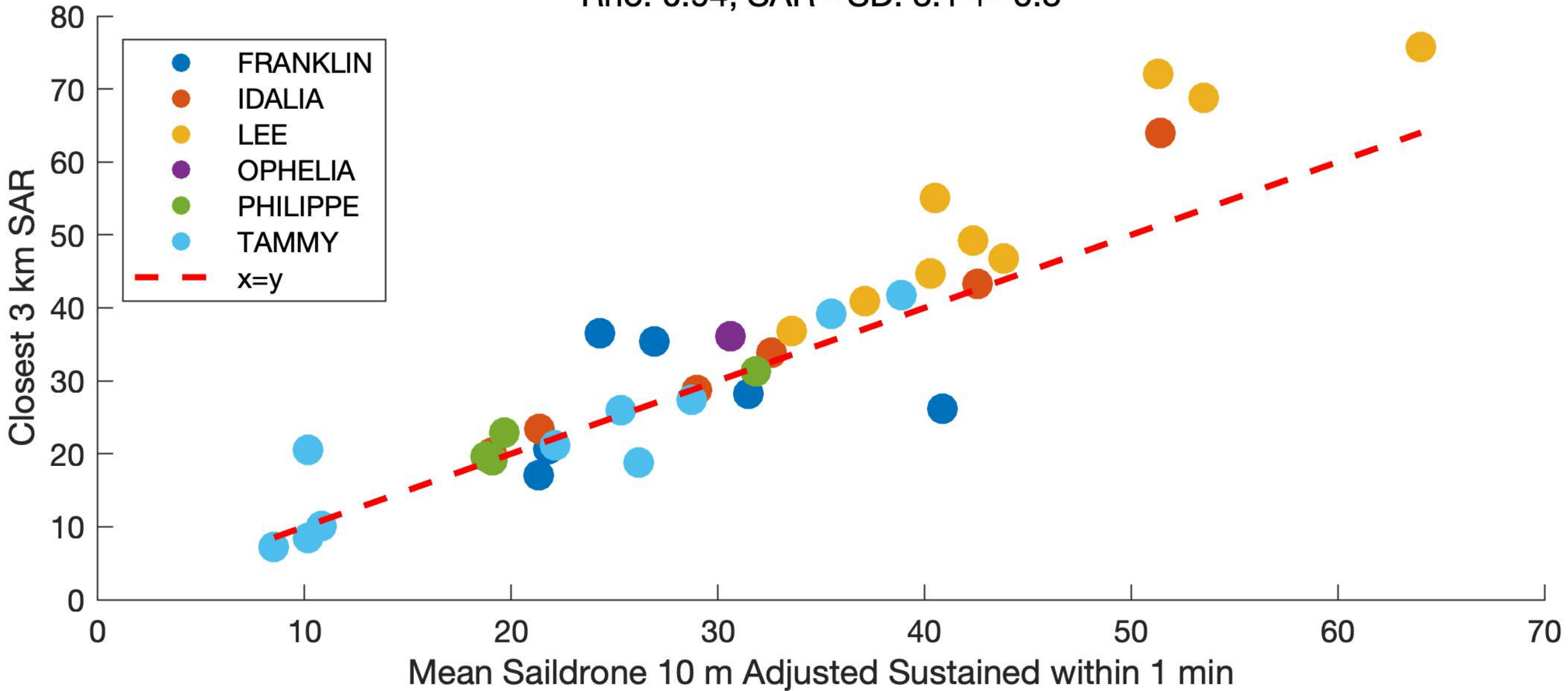
3 km: Sustained?



2023 Satellite Comparison: SAR

Comparison of SAR vs Saildrone Sustained (Knots)

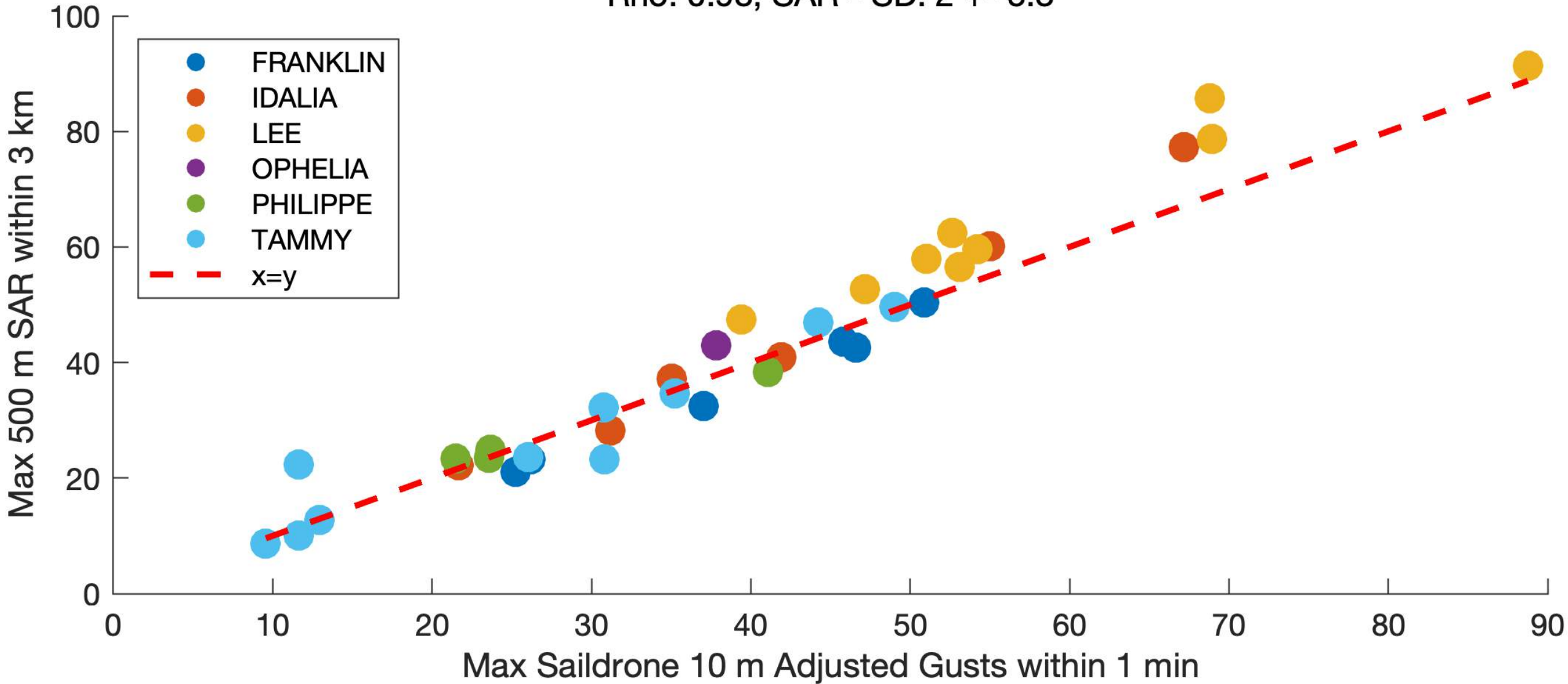
Rho: 0.94, SAR - SD: 3.1 +/- 6.8



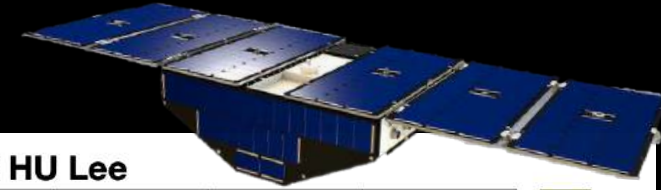
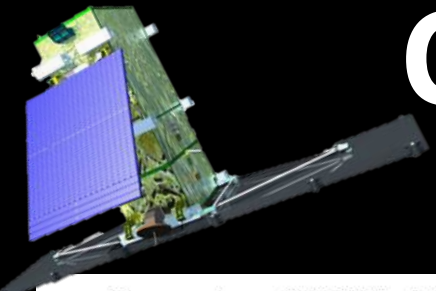
2023 Satellite Comparison: SAR

Comparison of SAR vs Sairdrone Gusts (Knots)

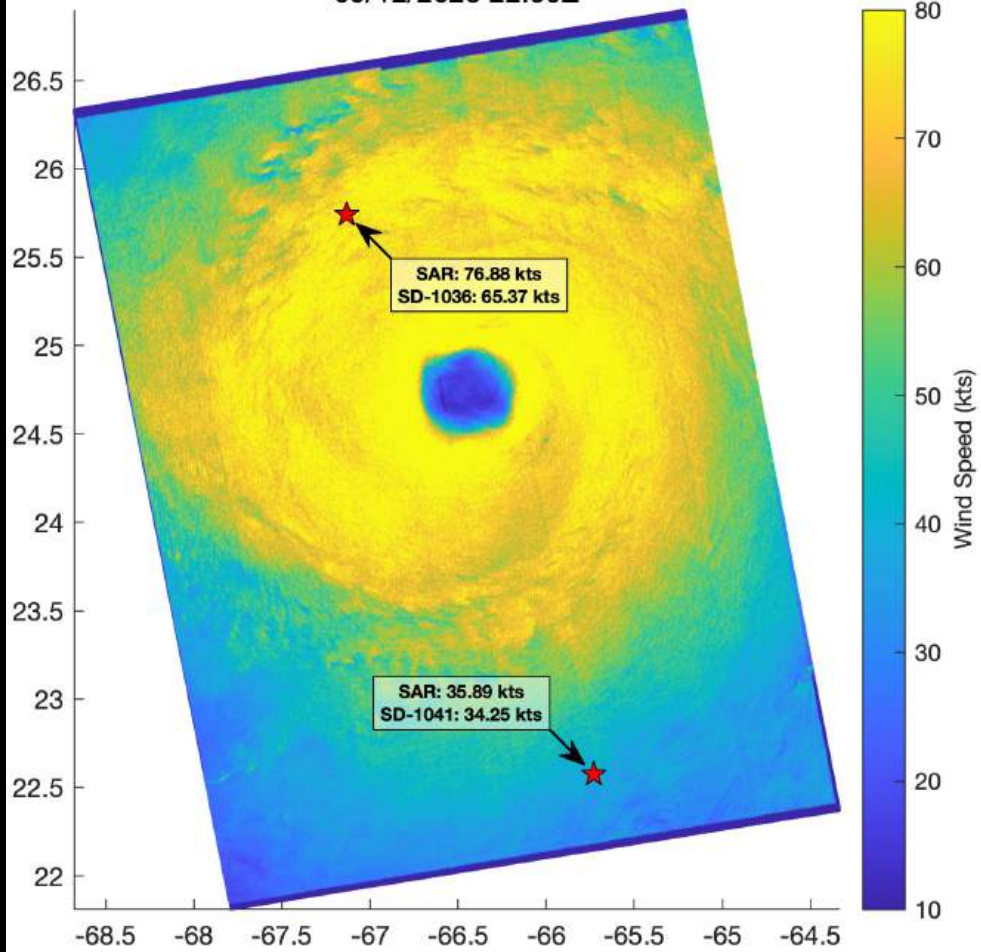
Rho: 0.98, SAR - SD: 2 +- 5.3



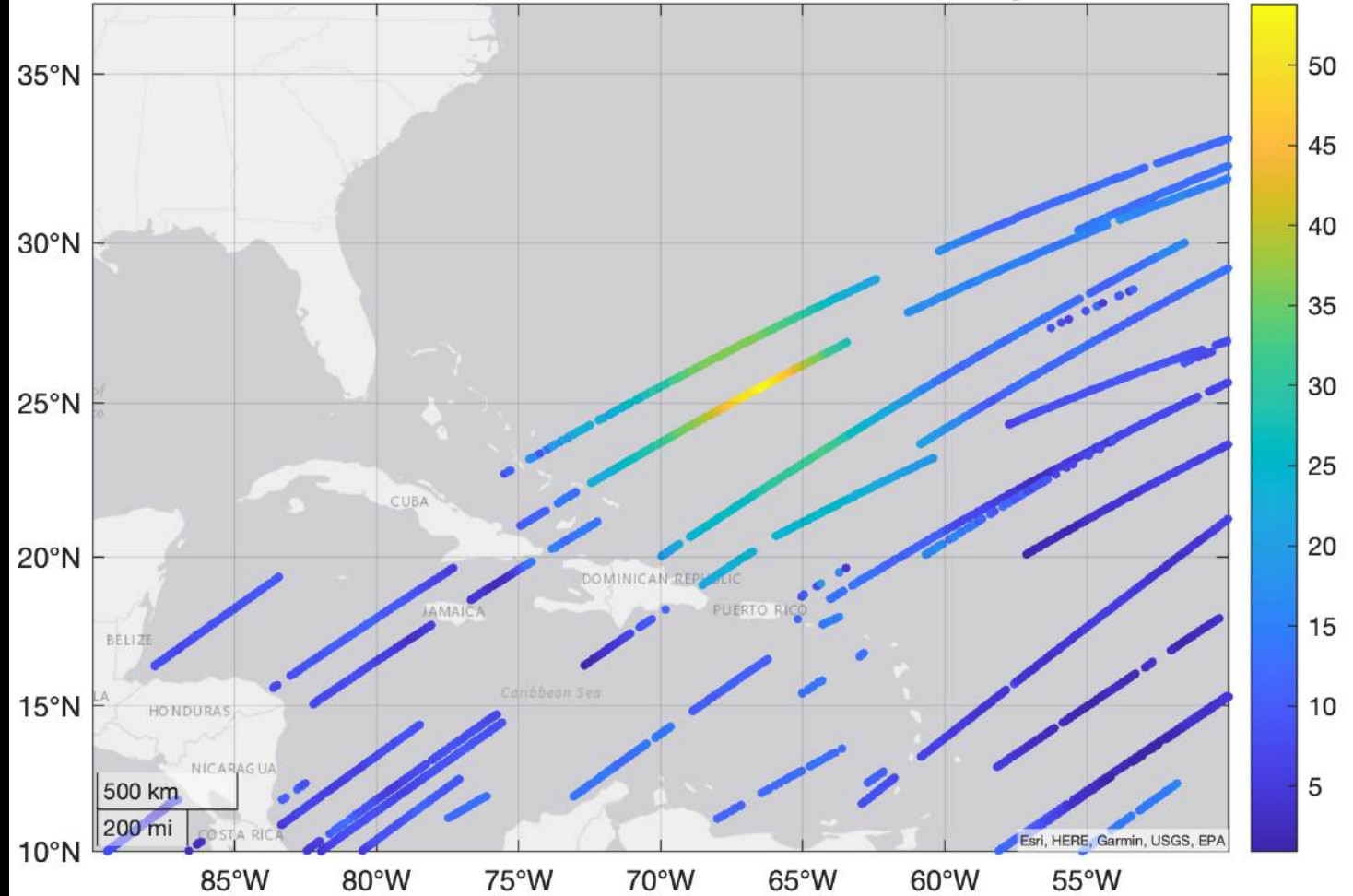
CYGNSS: Limited Time/Space



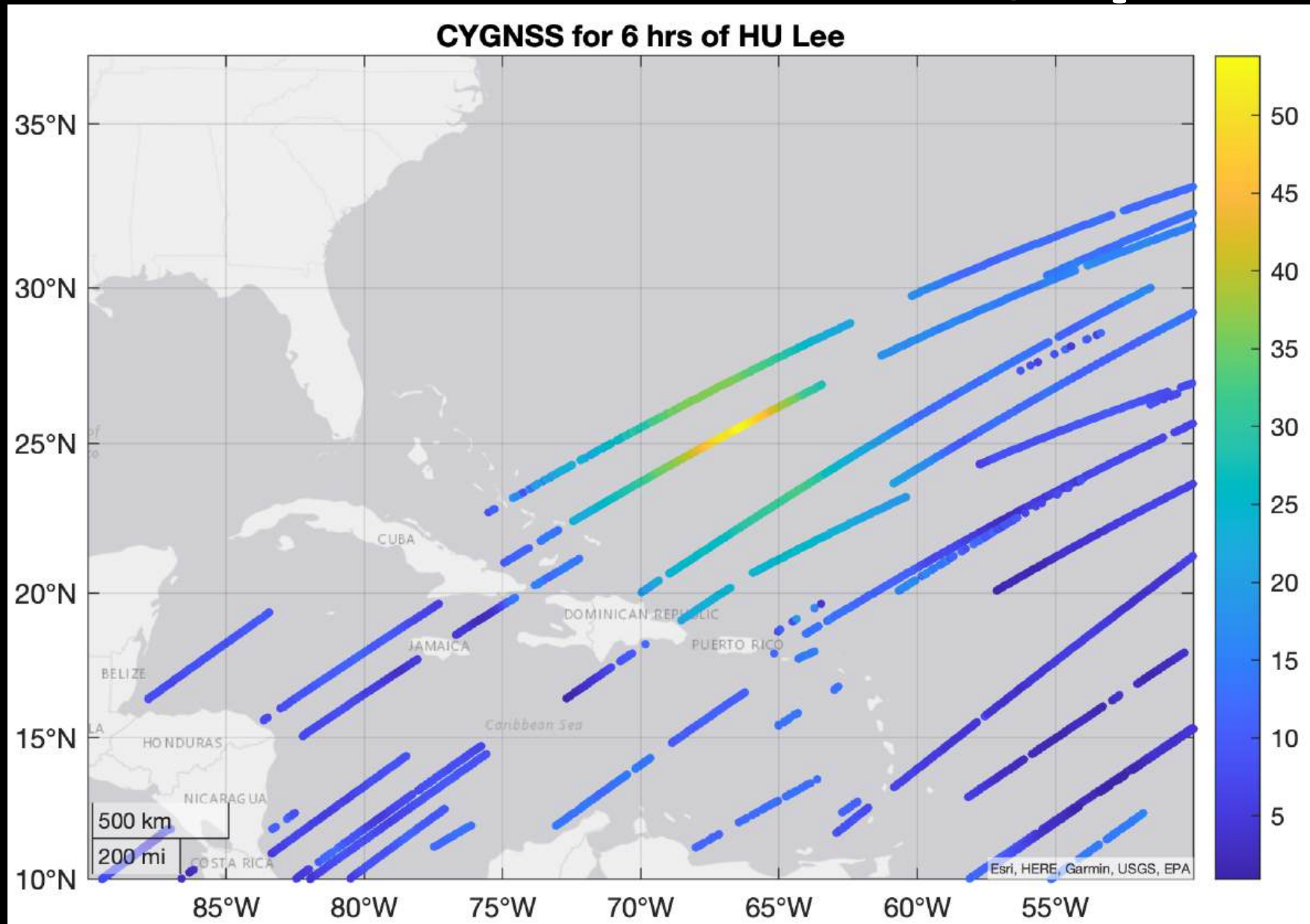
Comparison SAR Wind Speed to Saildrone Gusts in Lee
09/12/2023 22:30Z



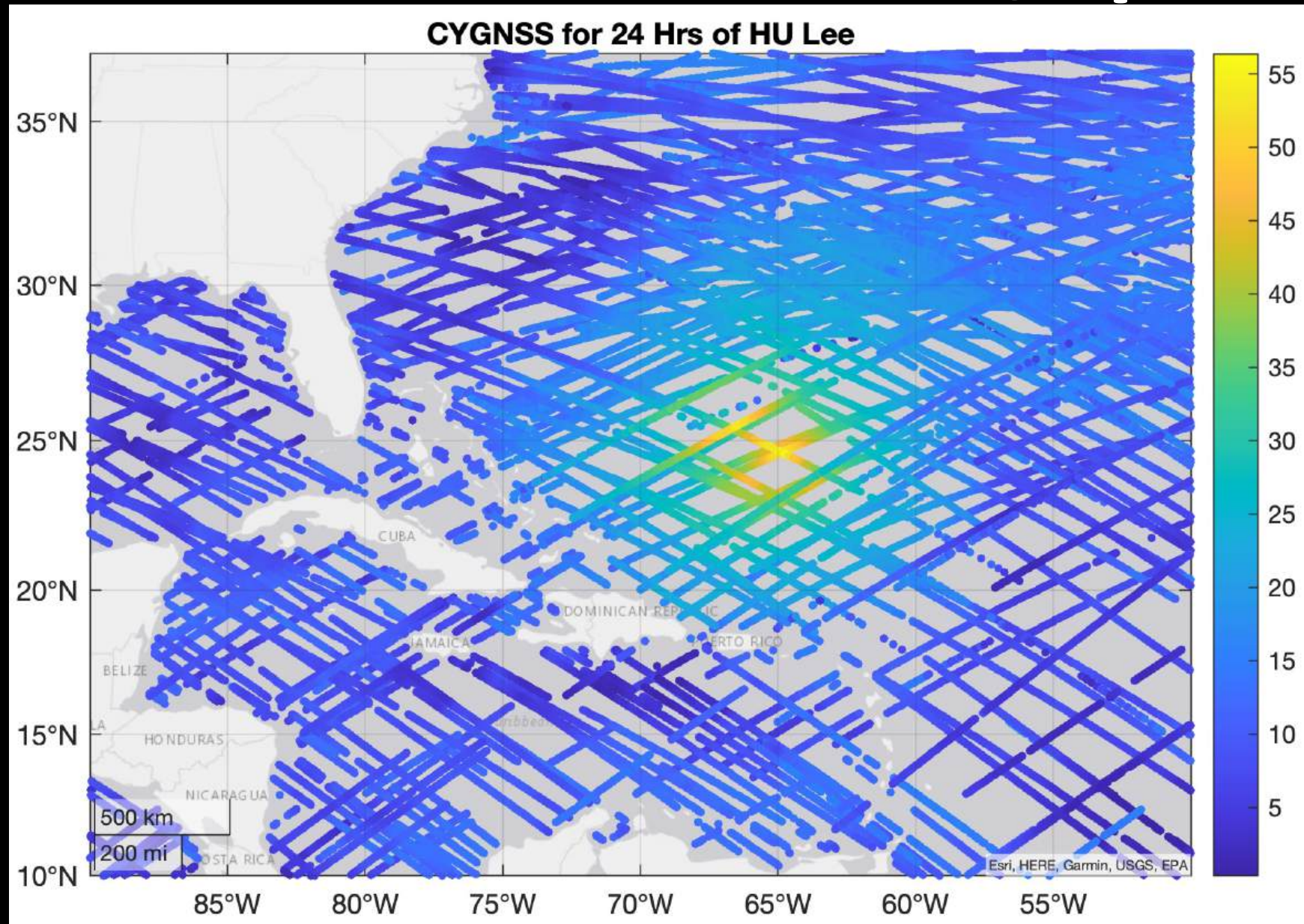
CYGNSS for 6 hrs of HU Lee



CYGNSS: Limited Time/Space

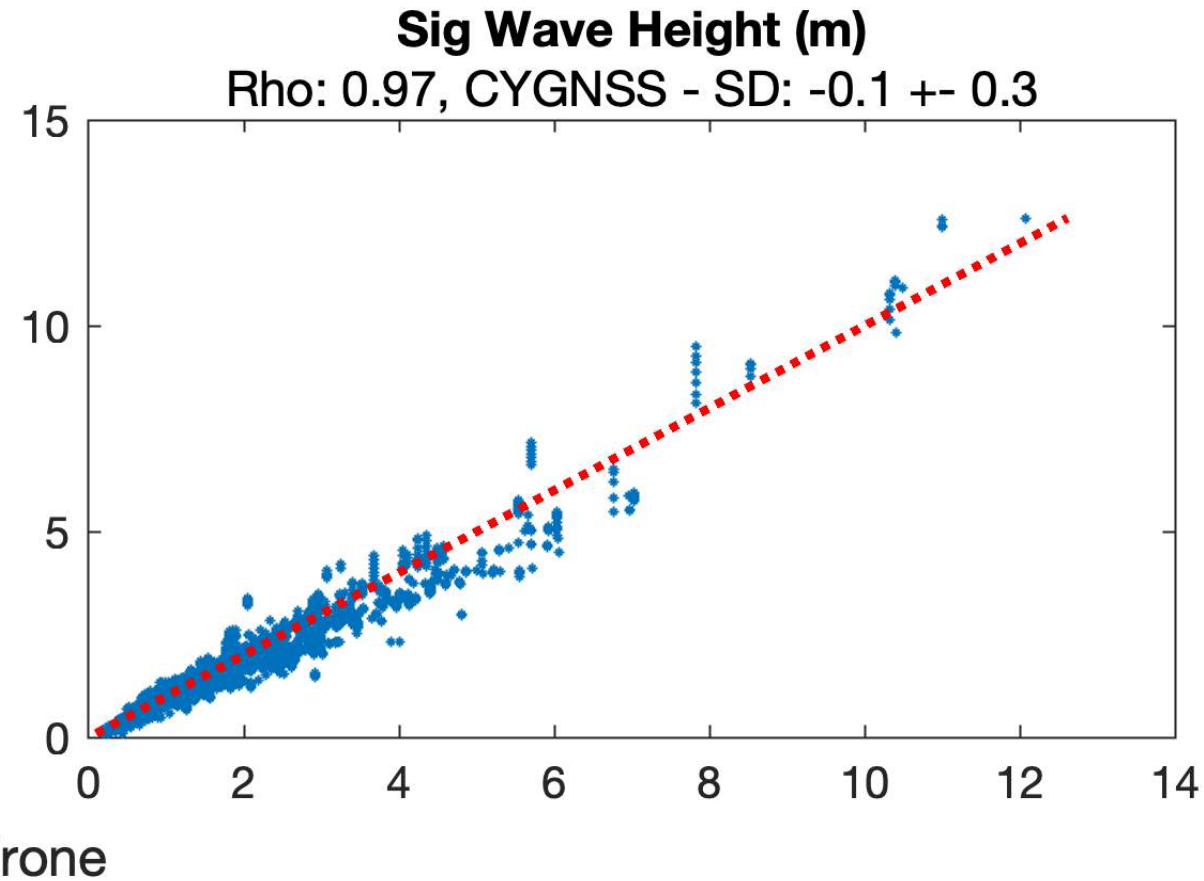
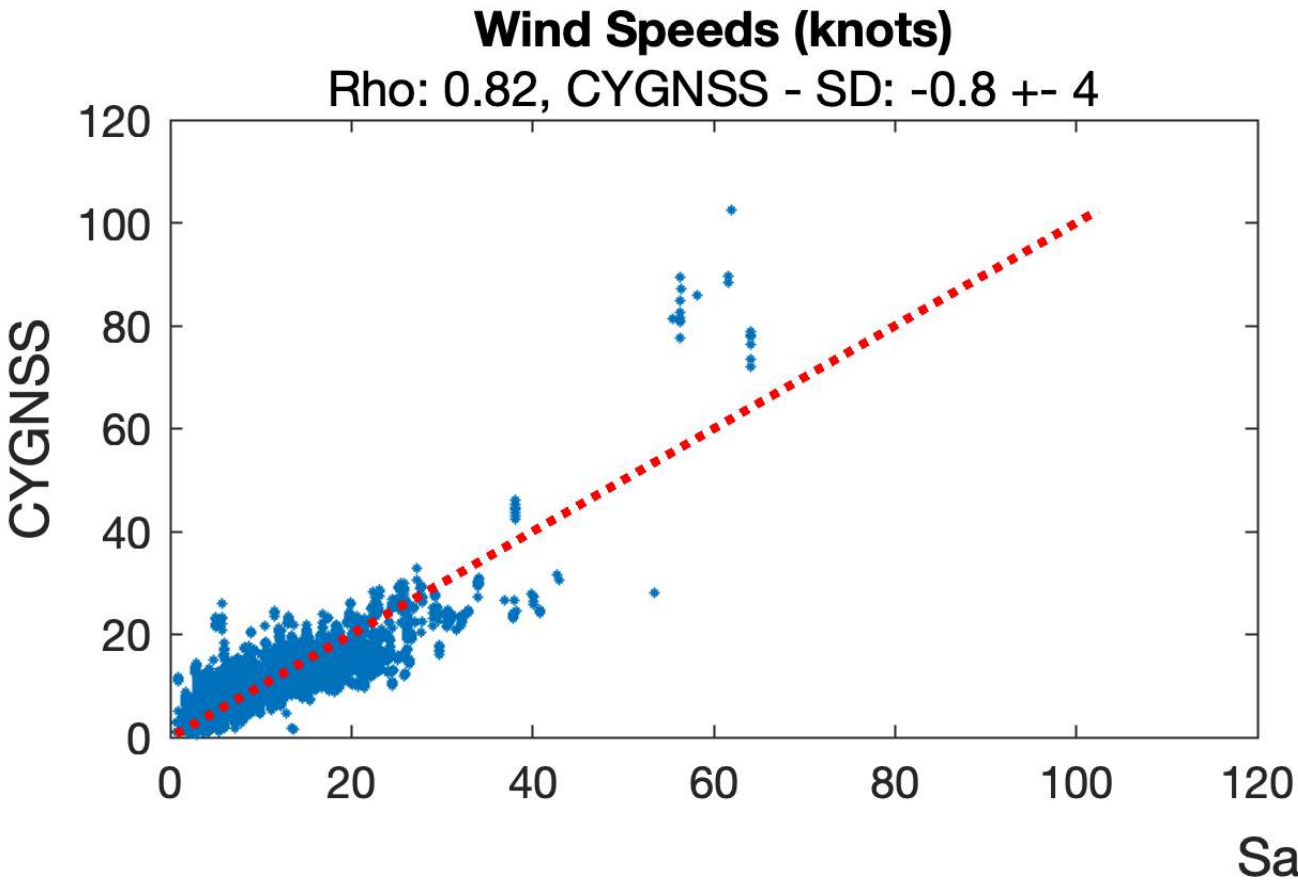


CYGNSS: Limited Time/Space

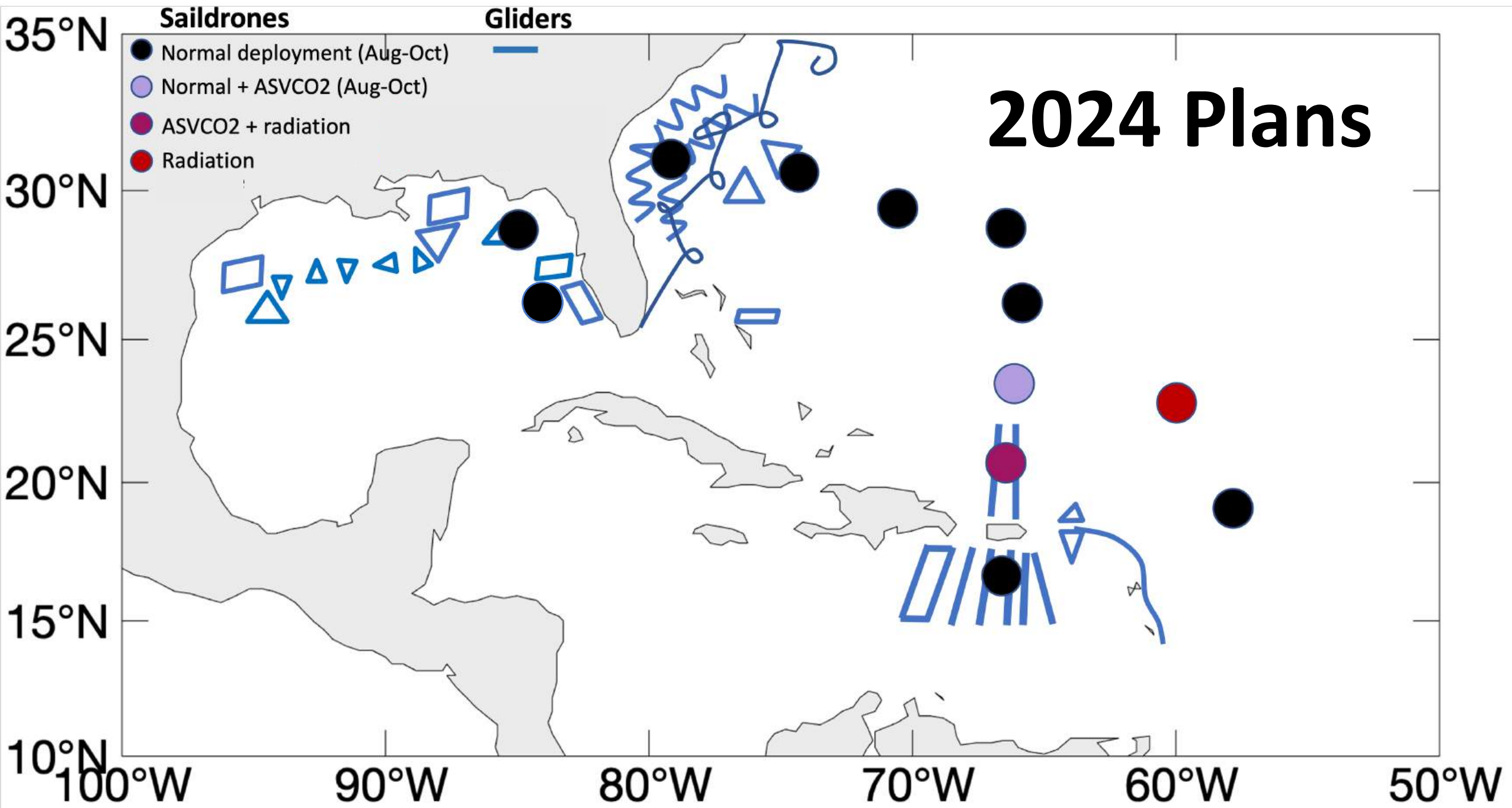


2023 Satellite Comparison: CYGNSS

Comparing Saildrone and CYGNSS Measurements



**Note Average Saildrone 20 min Sustained within 25 km &
CYGNSS FDS < 34 kts, YSLF >=34 kts
& NO QC on CYGNSS*



Incredible footage captured by Saldrone Explorer SD 1078
in the Atlantic Ocean during Hurricane Fiona Sept. 22, 2022

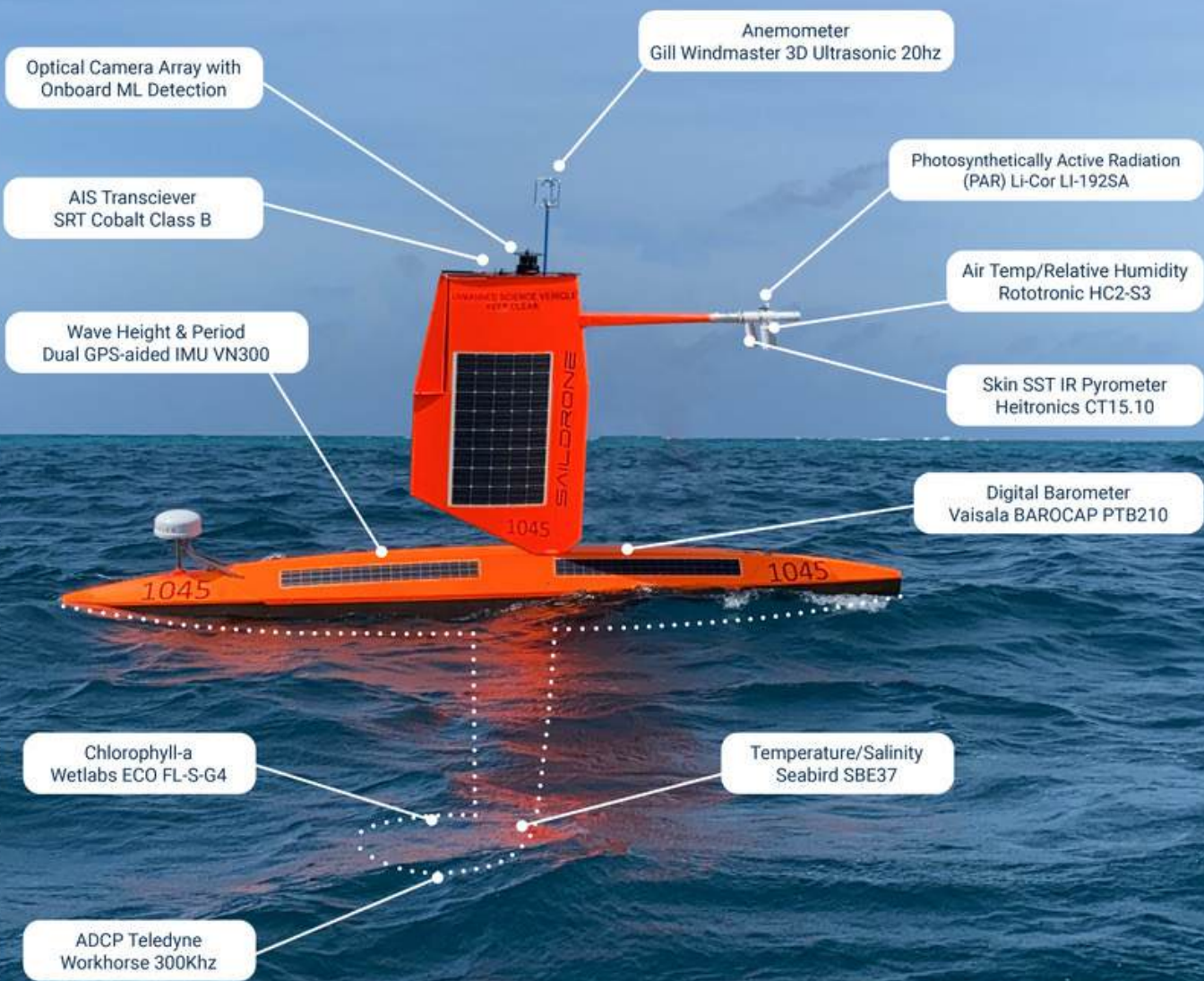


SALDRONE



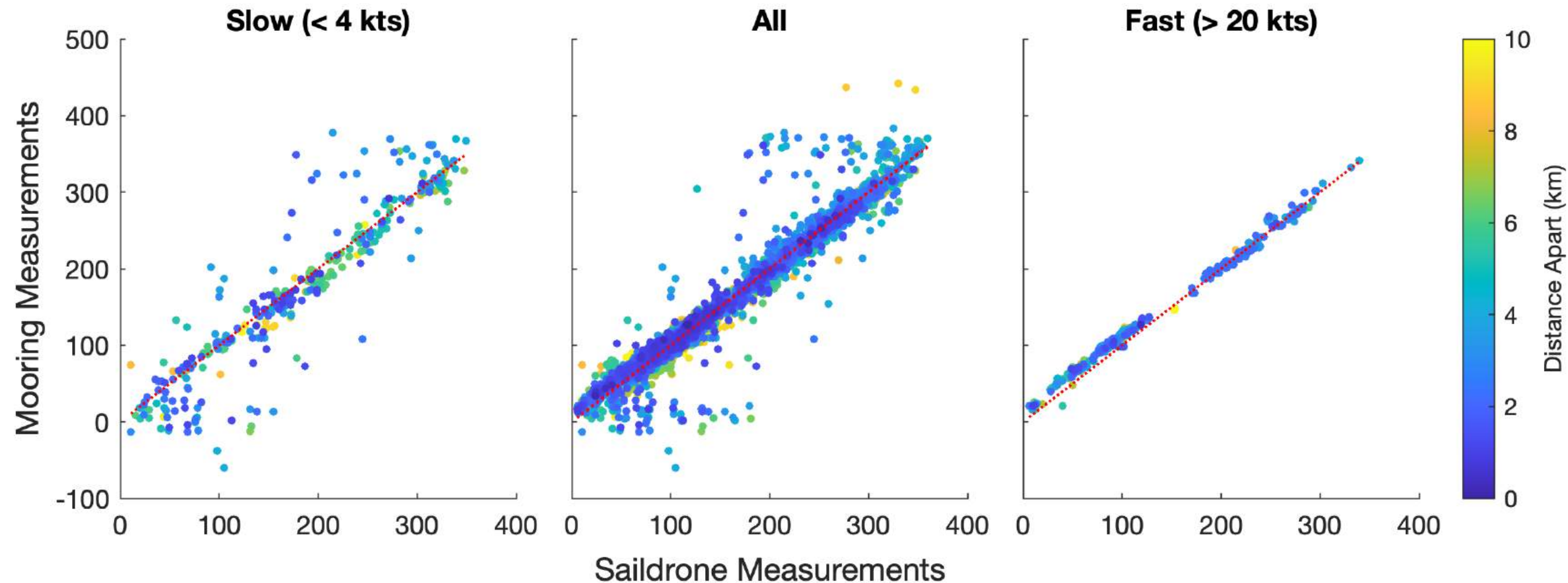
Questions?

Email: lev.looney@noaa.gov



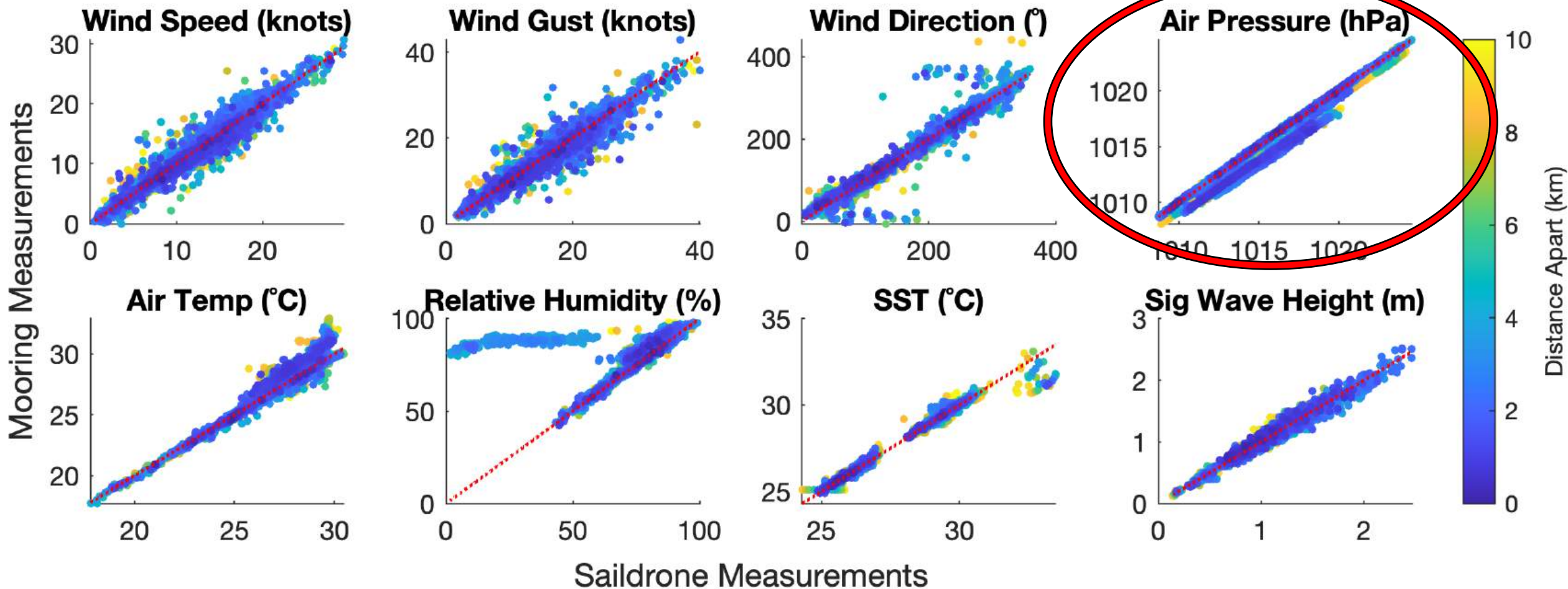
Wind Direction Differences for Slow and Fast Sustained Winds: Remove Winds Below 4 knots

Comparing Saildrone to Mooring Wind Directions: Within 10 km

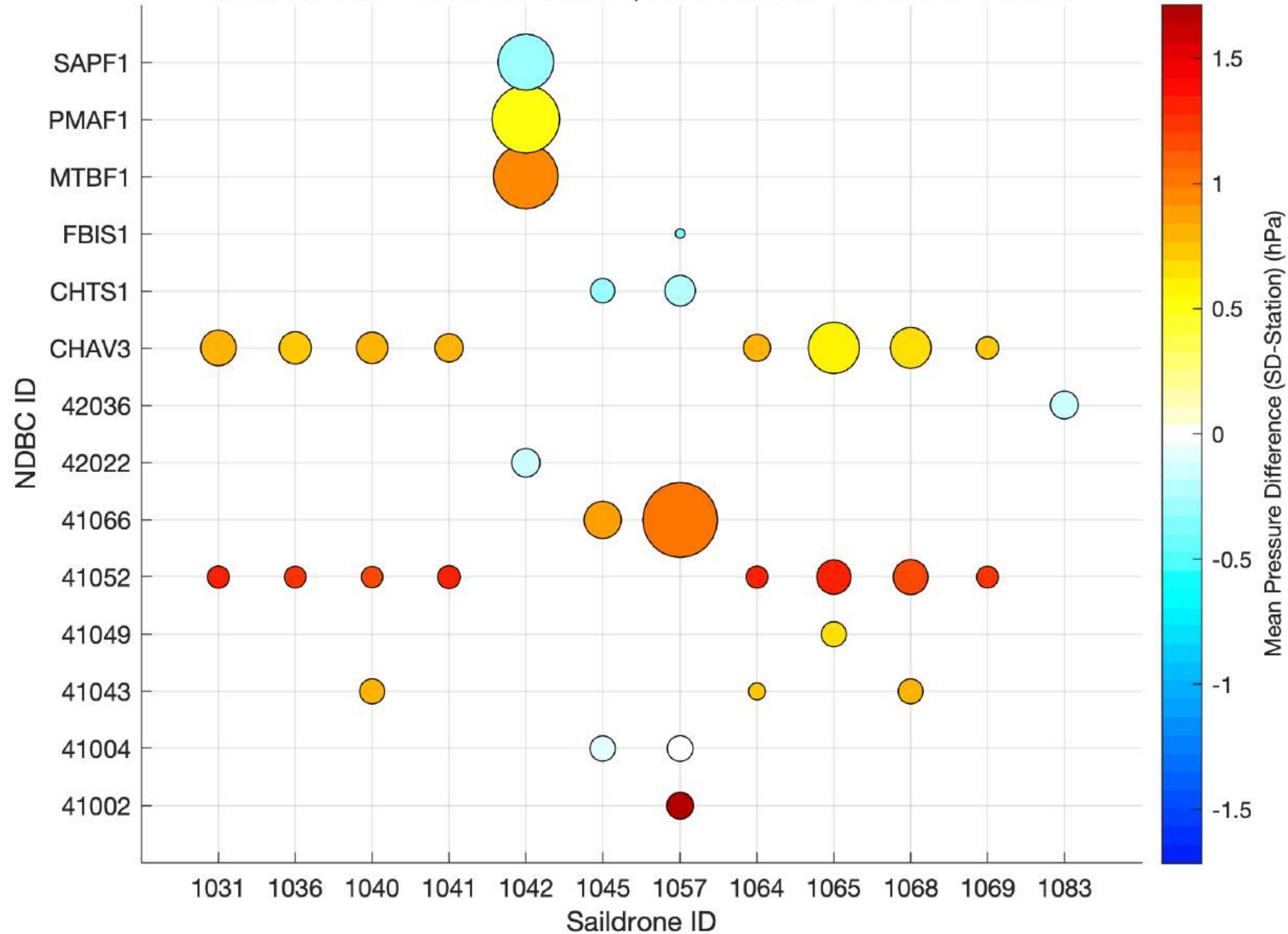


Area of Possible Concern: Air Pressure

Comparing Saldrone to Mooring Measurements: Within 10 km



Pressure Difference based on SD and Station ID: Within 10 km
Color is Mean Pressure Difference, Size is STD of Pressure Difference



Pressure

Constant color across rows

- Not biased across saildrones

Variable in each column

- Biased across moorings

Pressure Comparison: 2023

Further confirms saildrone values

Comparing Saildrone Pressure to Other Platforms: Within 10 km

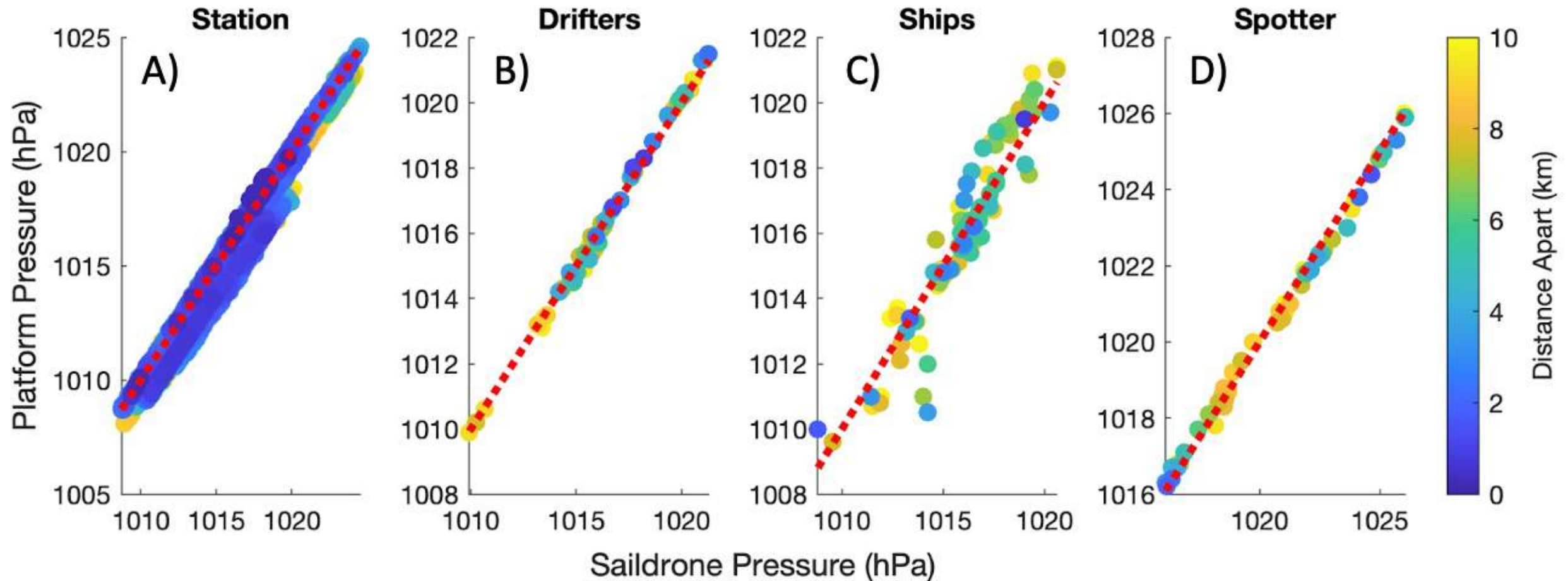
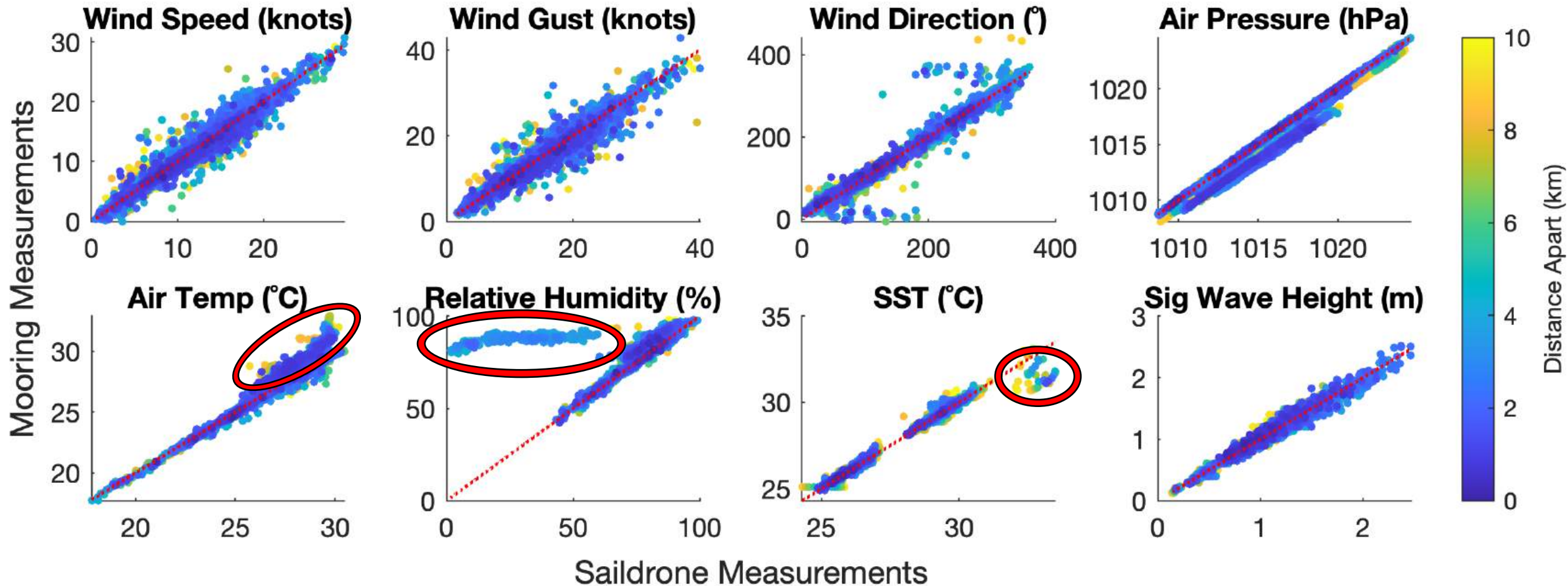


Table 1: Statistics of pressure data comparisons between saildrones and other co-located platforms at 10 and 25 km maximum separation

Max Separation Distance	Mean Difference (\pm standard deviation)	Correlation Coefficient (P Value)	Unique other Platform	Unique SDs	Unique Total Pairs	Total Comparable Data Points	Notes/Data Frequency
NDBC-hosted Stations							
10 km	0.83 \pm 0.66	0.97 (-inf)	14	12	33	11,964	10 minutes
25 km	0.77 \pm 0.53	0.98 (-inf)	21	12	46	24,568	
Drifters							
10 km	0.01 \pm 0.19	1.0 (1e-67)	6	5	6	56	Hourly
25 km	0.07 \pm 0.25	1.0 (1e-251)	8	7	9	219	
Ships							
10 km	-0.02 \pm 0.96	0.94 (1e-42)	31	11	35	87	Typically hourly, semi-random
25 km	0.09 \pm 1.23	0.93 (1e-175)	68	12	107	415	
Spotters							
10 km	0.07 \pm 0.23	1.0 (1e-66)	1	1	1	54	Hourly
25 km	-0.02 \pm 0.28	1.0 (-inf)	1	1	1	268	

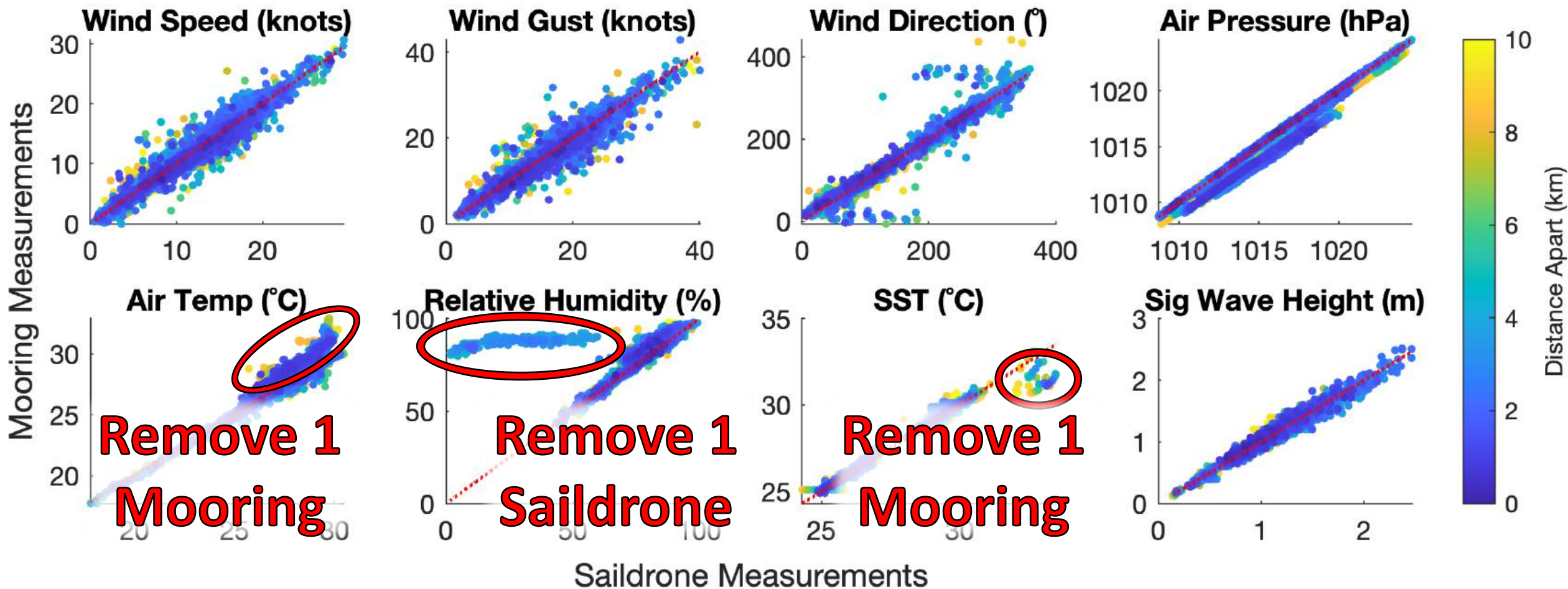
Other Areas of Possible Concern

Comparing Saldrone to Mooring Measurements: Within 10 km



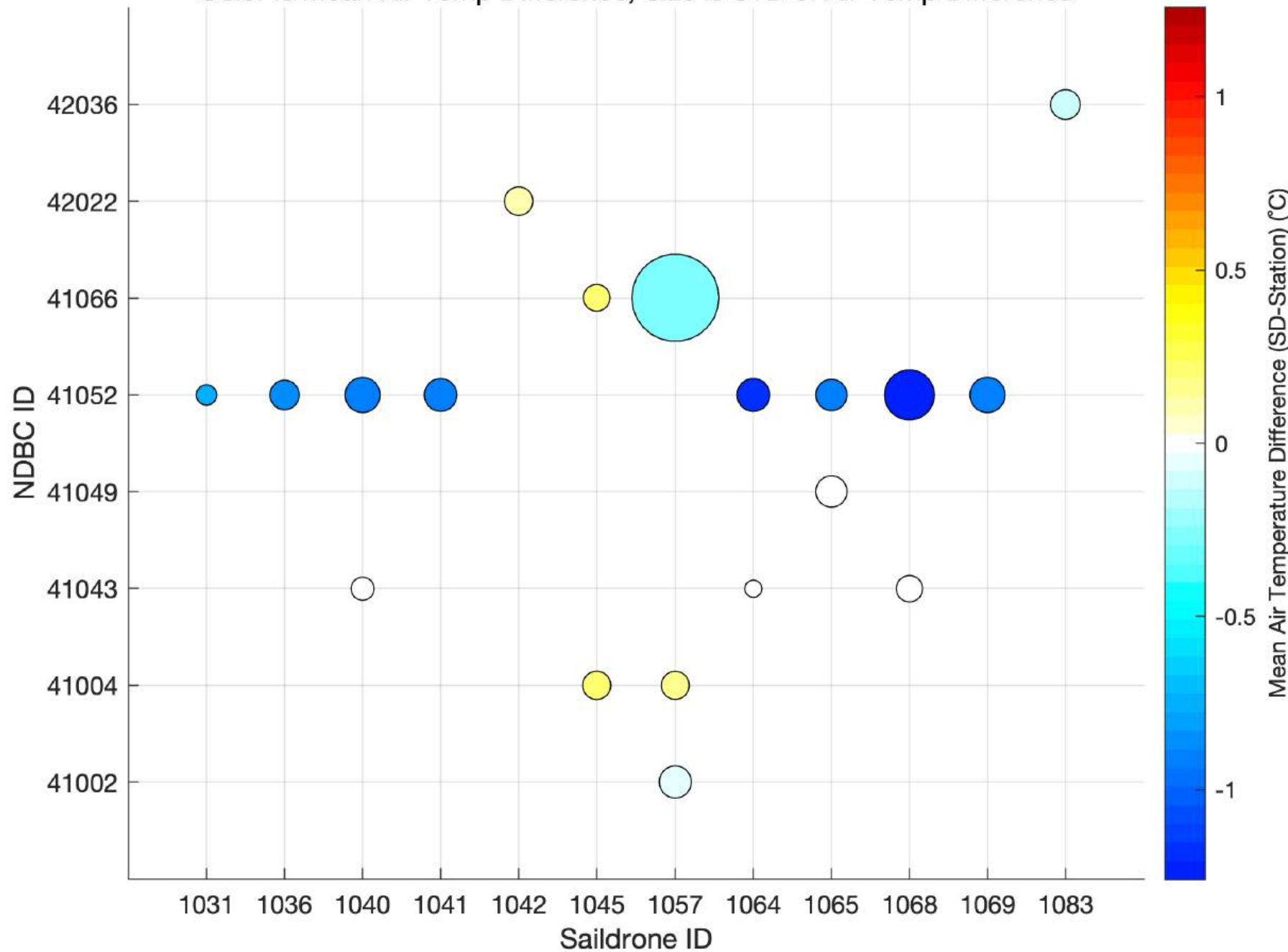
Other Areas of Possible Concern

Comparing Sailandrone to Mooring Measurements: Within 10 km



Air Temperature Difference based on SD and Station ID: Within 10 km

Color is Mean Air Temp Difference, Size is STD of Air Temp Difference

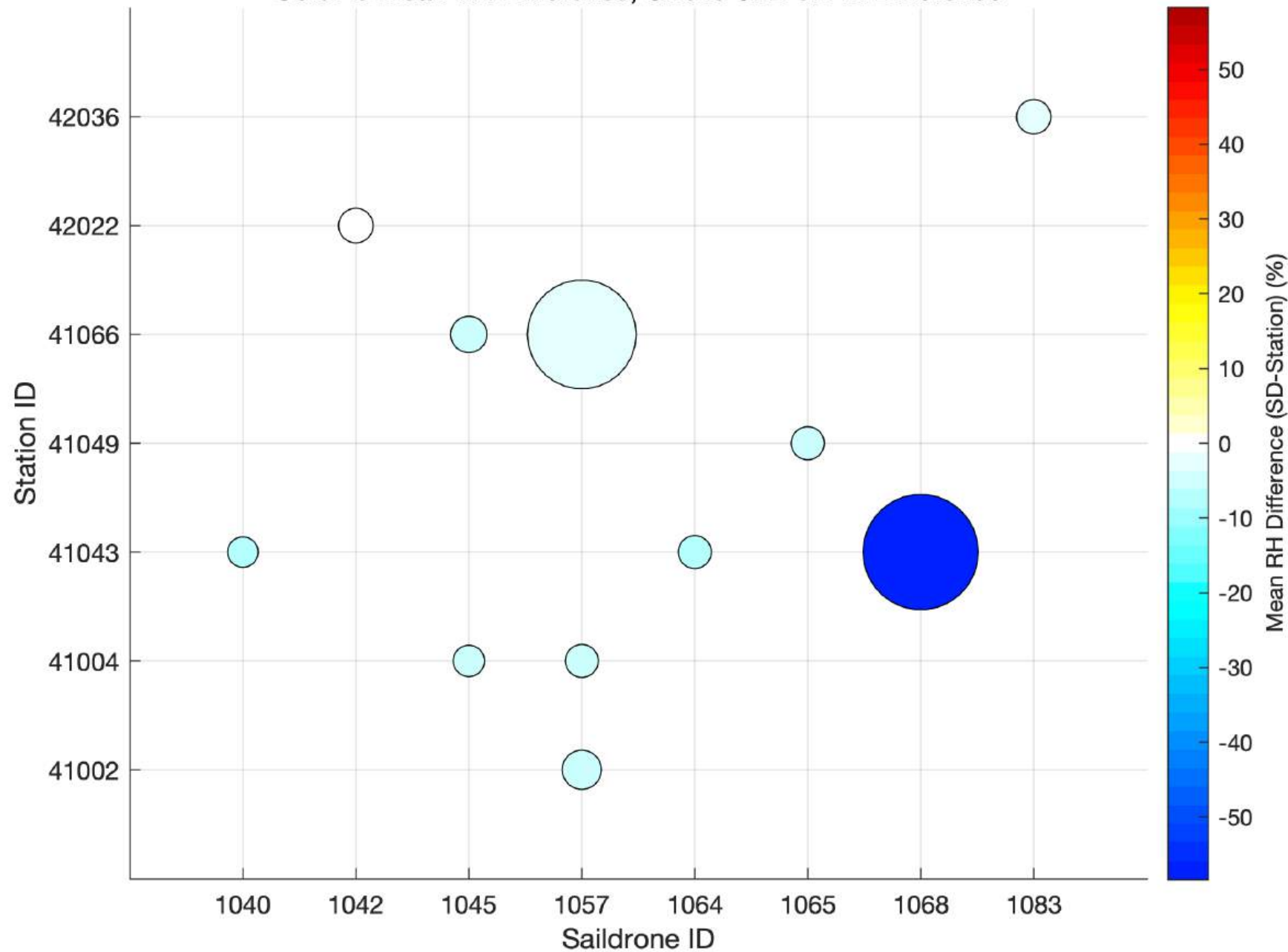


Air Temp

- Issue is with 41052
- Remove that mooring

Relative Humidity (RH) Difference based on SD and Station ID: Within 10 km

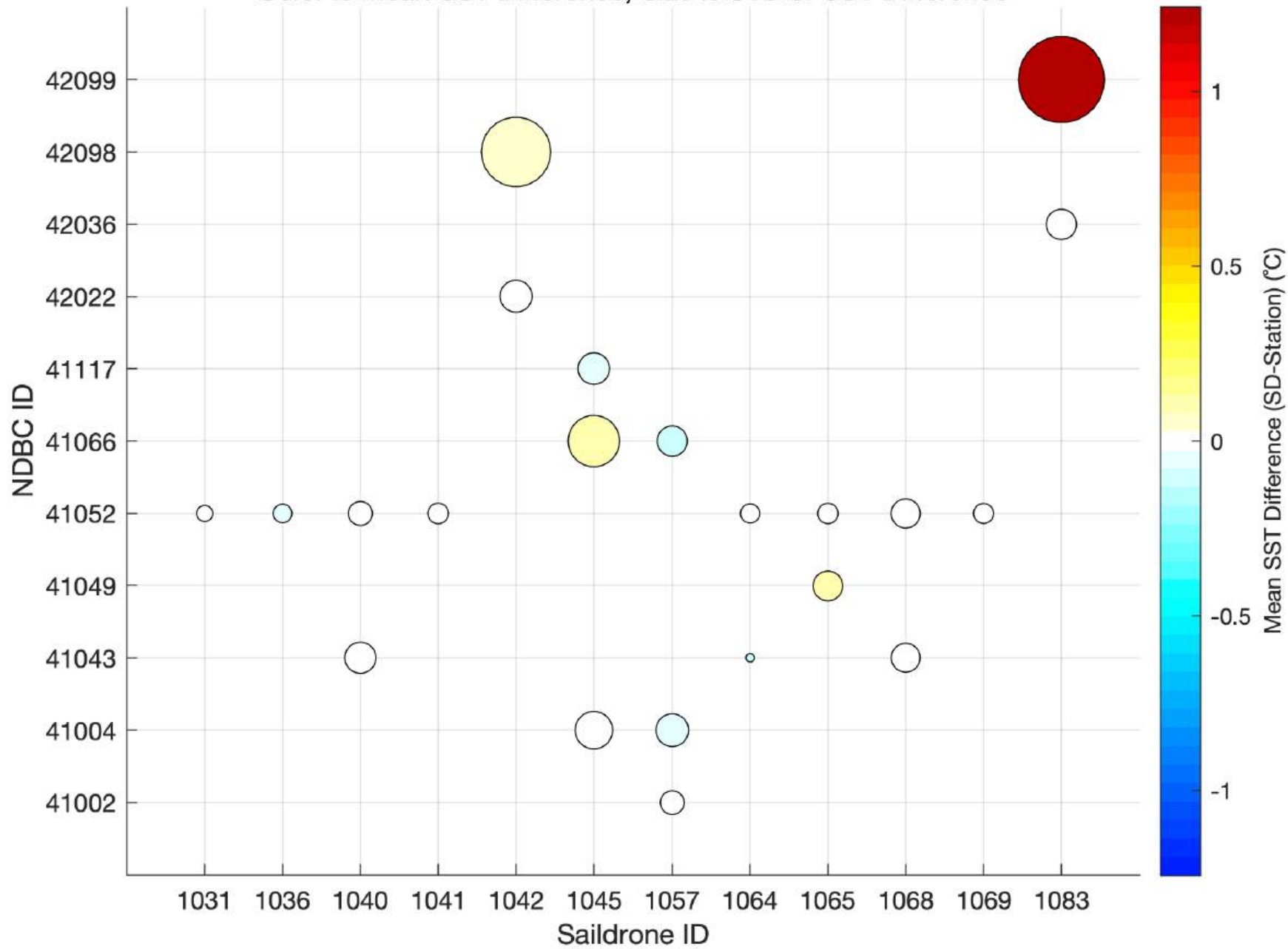
Color is Mean RH Difference, Size is STD of RH Difference



Relative Humidity

- Issue is with SD- 1068
- Remove that saildrone

SST Difference based on SD and Station ID: Within 10 km
Color is Mean SST Difference, Size is STD of SST Difference



SST

- Issue is with 42099
- Remove that mooring

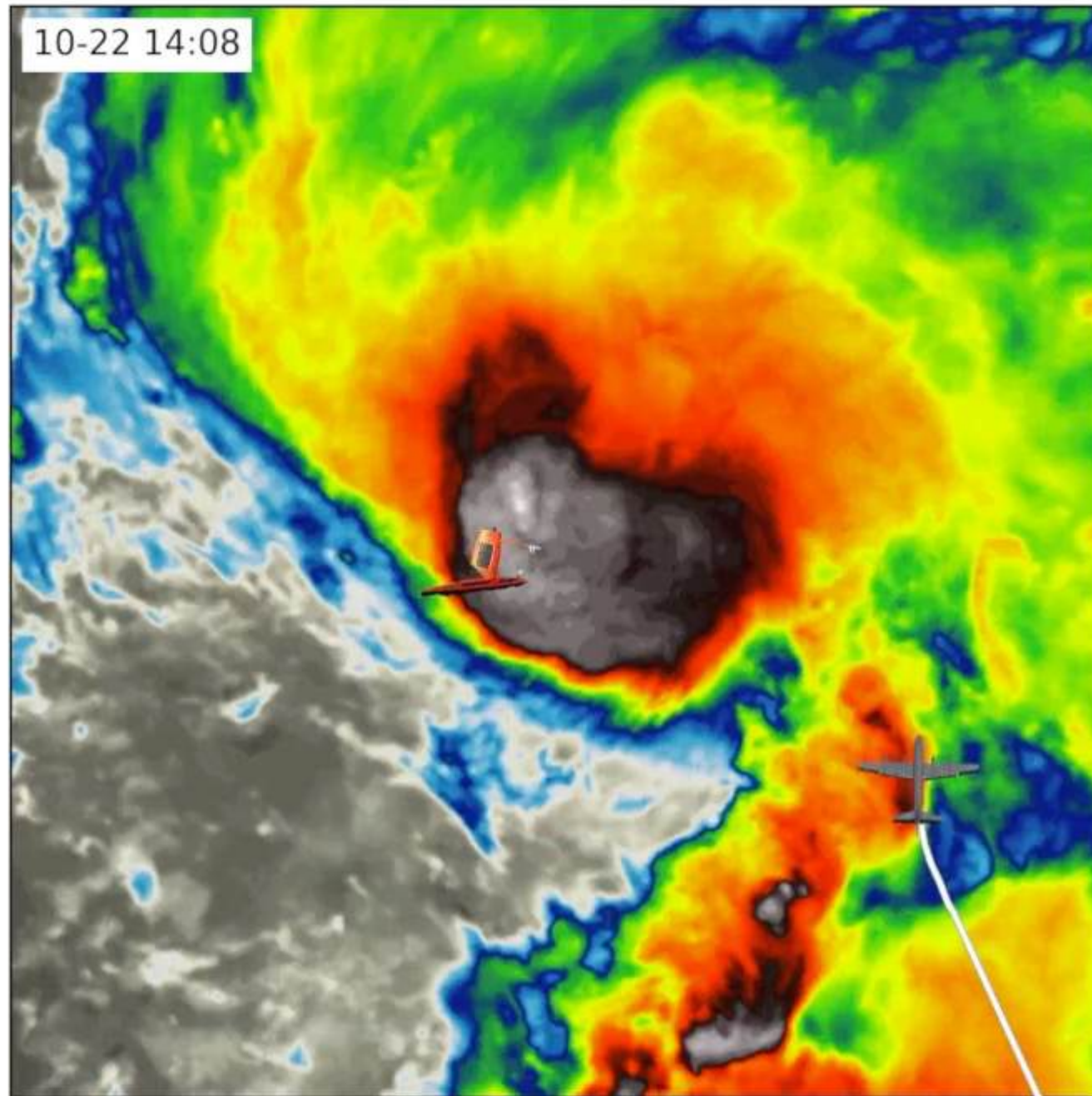
10-22 14:08

20.5°N

19.5°N

18.5°N

17.5°N



64.5°W

63.5°W

62.5°W

61.5°W

Altius

Coordination

- Altius launched nearby SD
 - Within 20km from launch spiraling down to 2k ft
 - Within 35km for entire flight

Animation Credit: Edoardo Mazza

NHC Operational Advisories:

DISCUSSION AND OUTLOOK

At 800 AM AST (1200 UTC), the center of Tropical Storm Philippe was located by an Air Force Reserve Hurricane Hunter aircraft near latitude 24.9 North, longitude 66.3 West. Philippe is moving toward the north near 10 mph (17 km/h). This general motion with an increase in forward speed is expected through Saturday. On the forecast track, the center of Philippe will pass near Bermuda on Friday, and approach eastern New England and Atlantic Canada on Saturday.

Maximum sustained winds are near 45 mph (75 km/h) with higher gusts based on aircraft reconnaissance and Saildrone data.

Additional gradual strengthening is forecast during the next few days. Philippe is forecast to become a post-tropical cyclone on Saturday as it approaches Atlantic Canada and New England.

Tropical-storm-force winds extend outward up to 230 miles (370 km) to the east of the center. Saildrone SD-1041, located about 100 miles (160 km) east-southeast of Philippe's center, recently measured a sustained wind of 40 mph (64 km/h) and a gust to 47 mph (76 km/h).

- Saildrone Data Cited in 20 Separate Advisories
 - 5 TCs: Idalia (1), Lee (7), Ophelia (3), Philippe (7), Tammy (2)
 - 9 Different NHC Specialists cited SDs
- Utilized Winds, Pressures, Wave Heights, SST
- Peak info data goes out 1-hr before in email