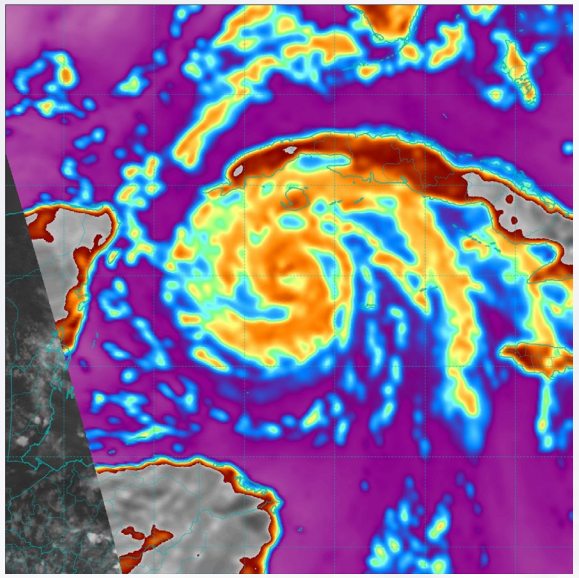
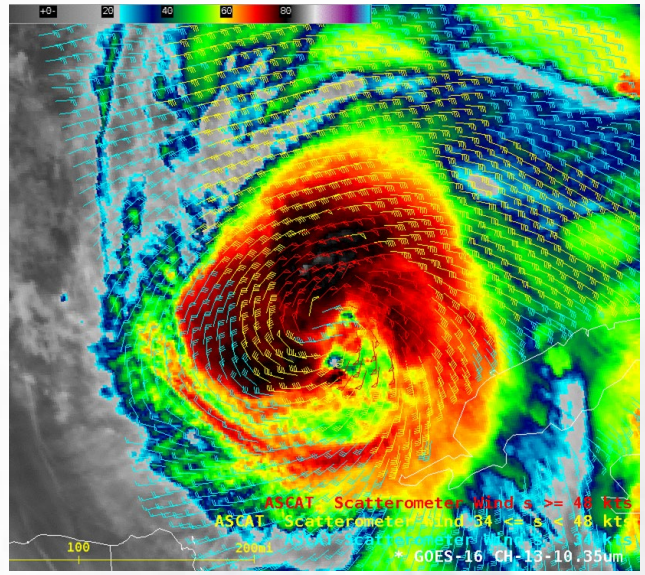
Interpretation of Microwave Imagery and Scatterometry





Brad Reinhart

National Hurricane Center

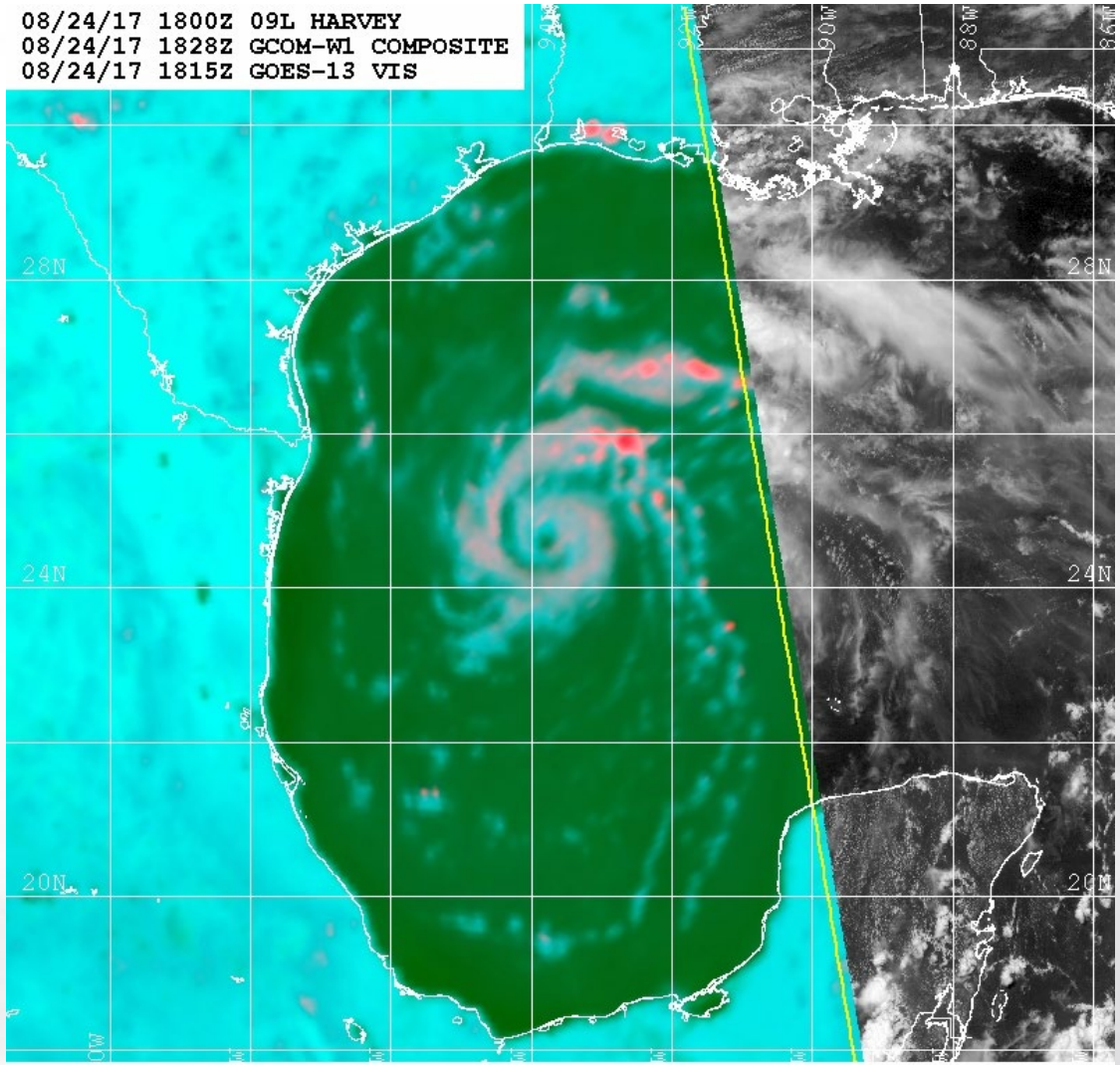
2024 WMO RA-IV Workshop on Hurricane Forecasting and Warning

Why use microwave imagery?

0

It has higher resolution than other satellites and therefore you can see more detail	0%
Microwave imagery shows features of the storm you can't see in other satellite imagery	0%
It provides a better estimate of cloud-top temperatures than infrared	0%
What is microwave imagery? Why would I use my kitchen microwave to see tropical cyclones?	0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**



Advantages of Microwave Imagery for TC Analysis

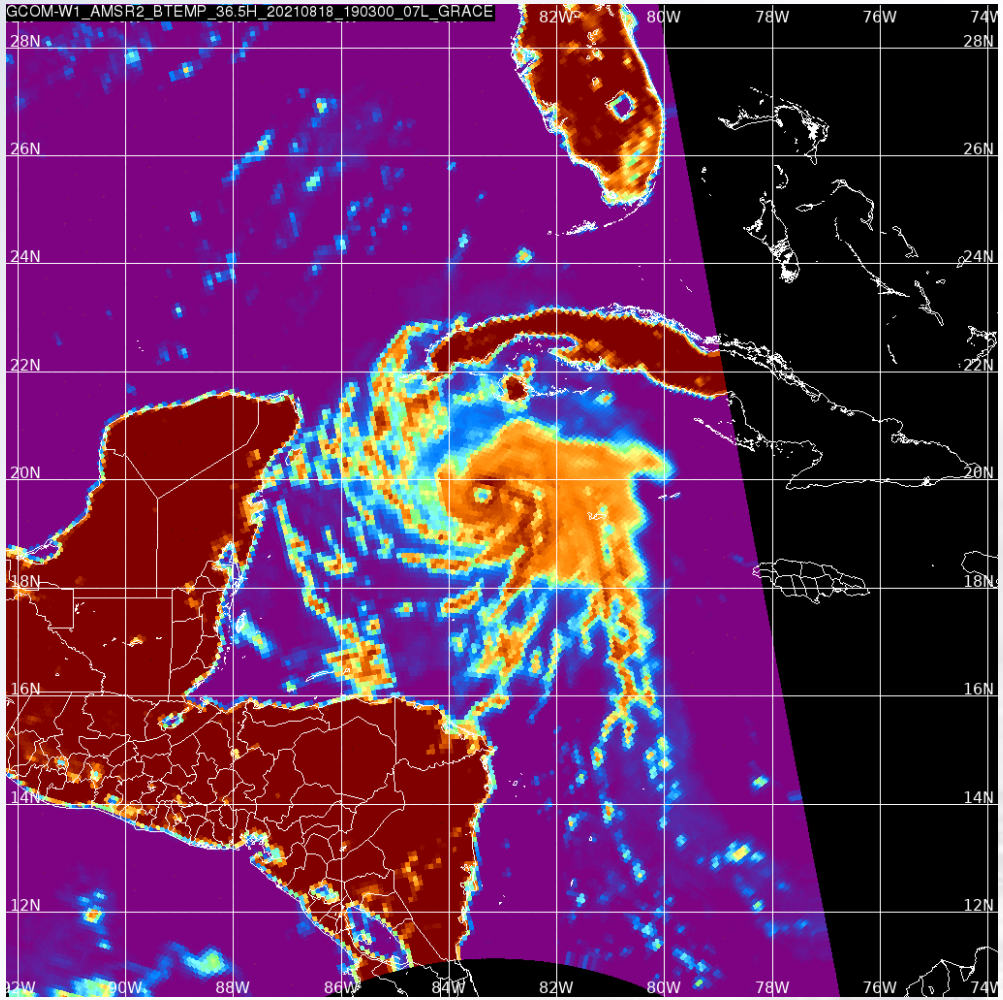
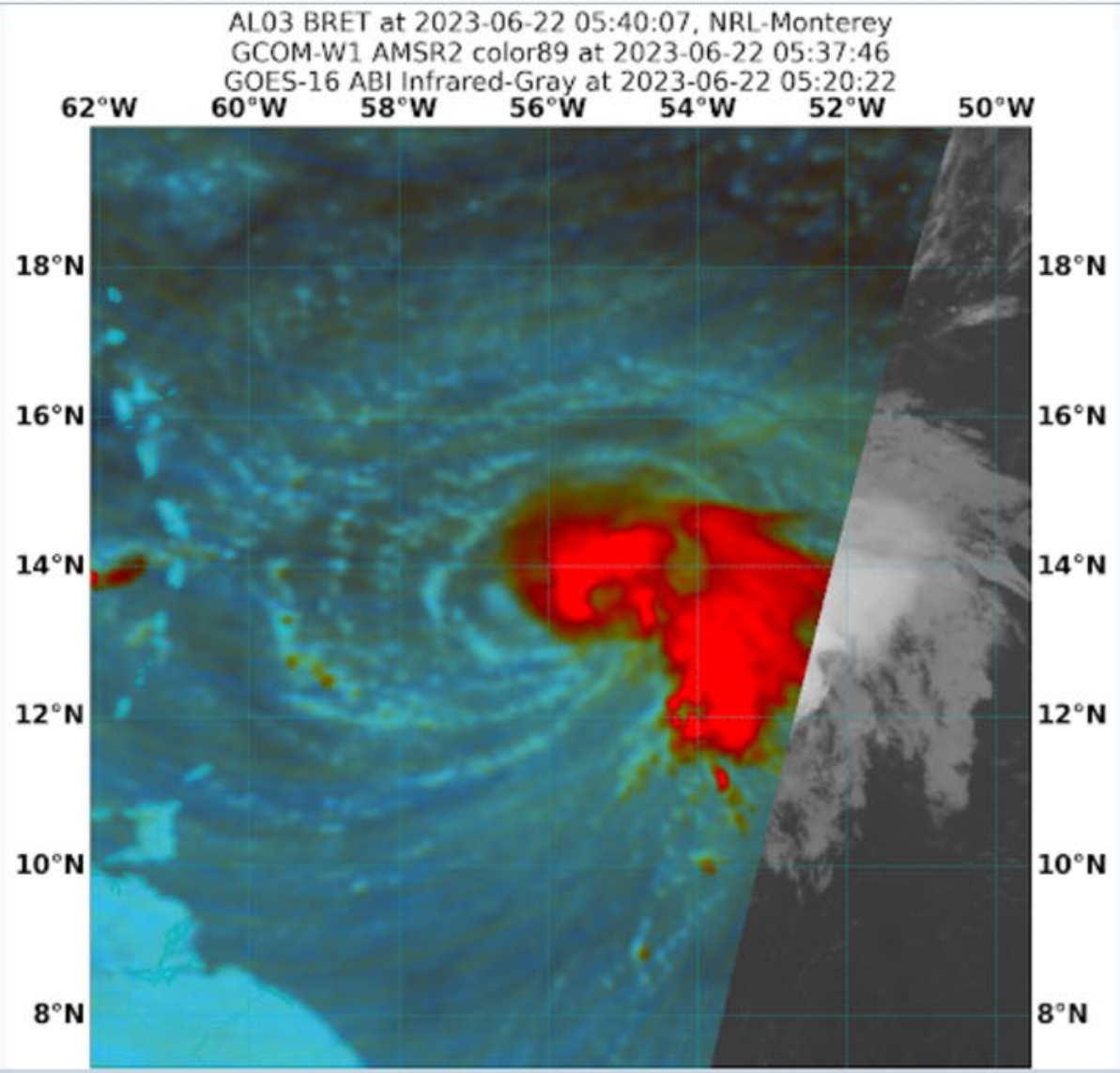


Image courtesy CIMSS Satellite Blog

- Identification of circulation center (critical step in initiating TC advisories)
- Assess the position of TCs in difficult situations (especially in early stages of development and at night)
- View convective rain bands that are directly related to TC intensification
- Monitoring structural changes such as eyewall replacement cycles

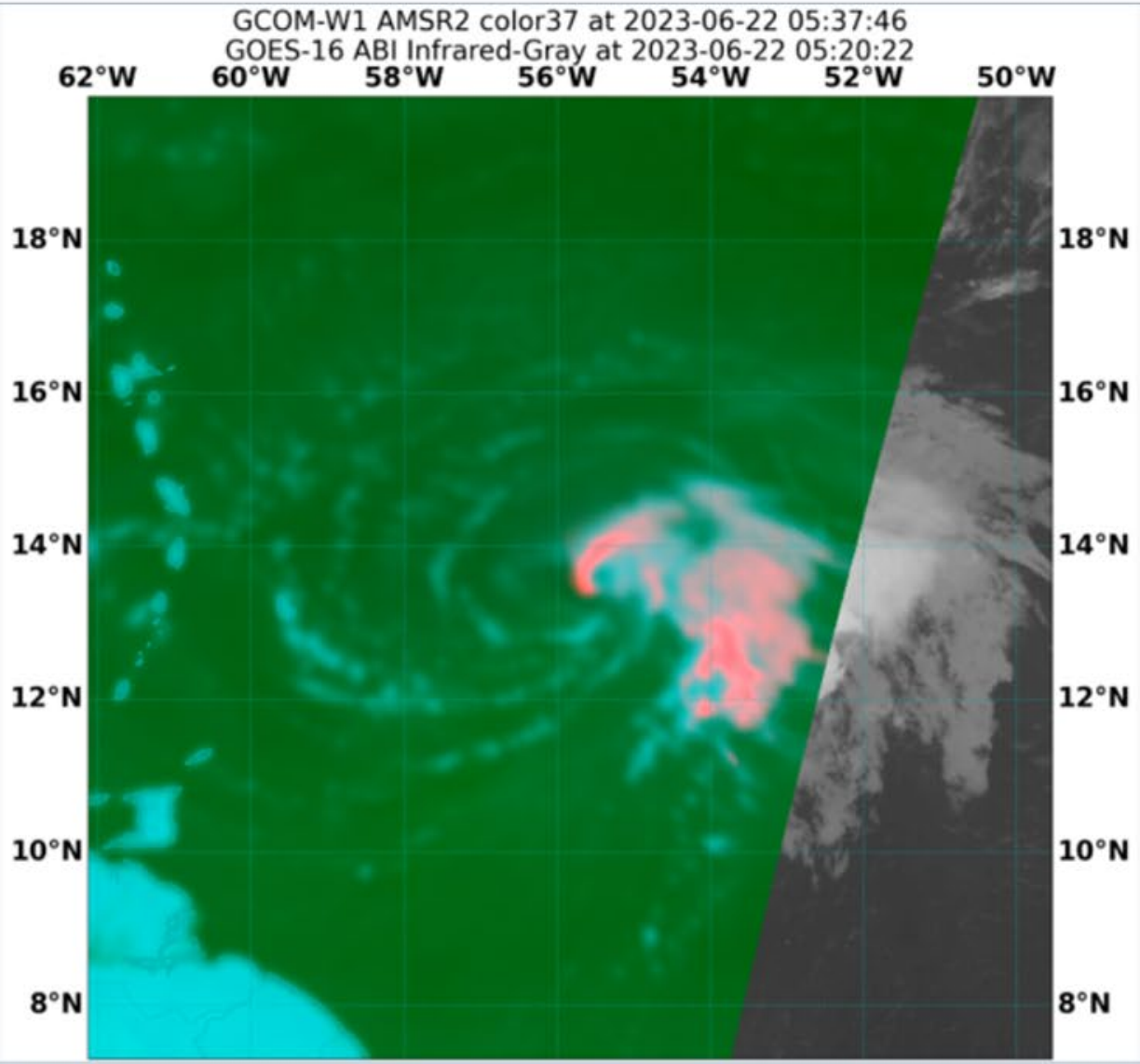
Identify the center of circulation in the 89 GHz microwave imagery of this TC. Select a location.

0



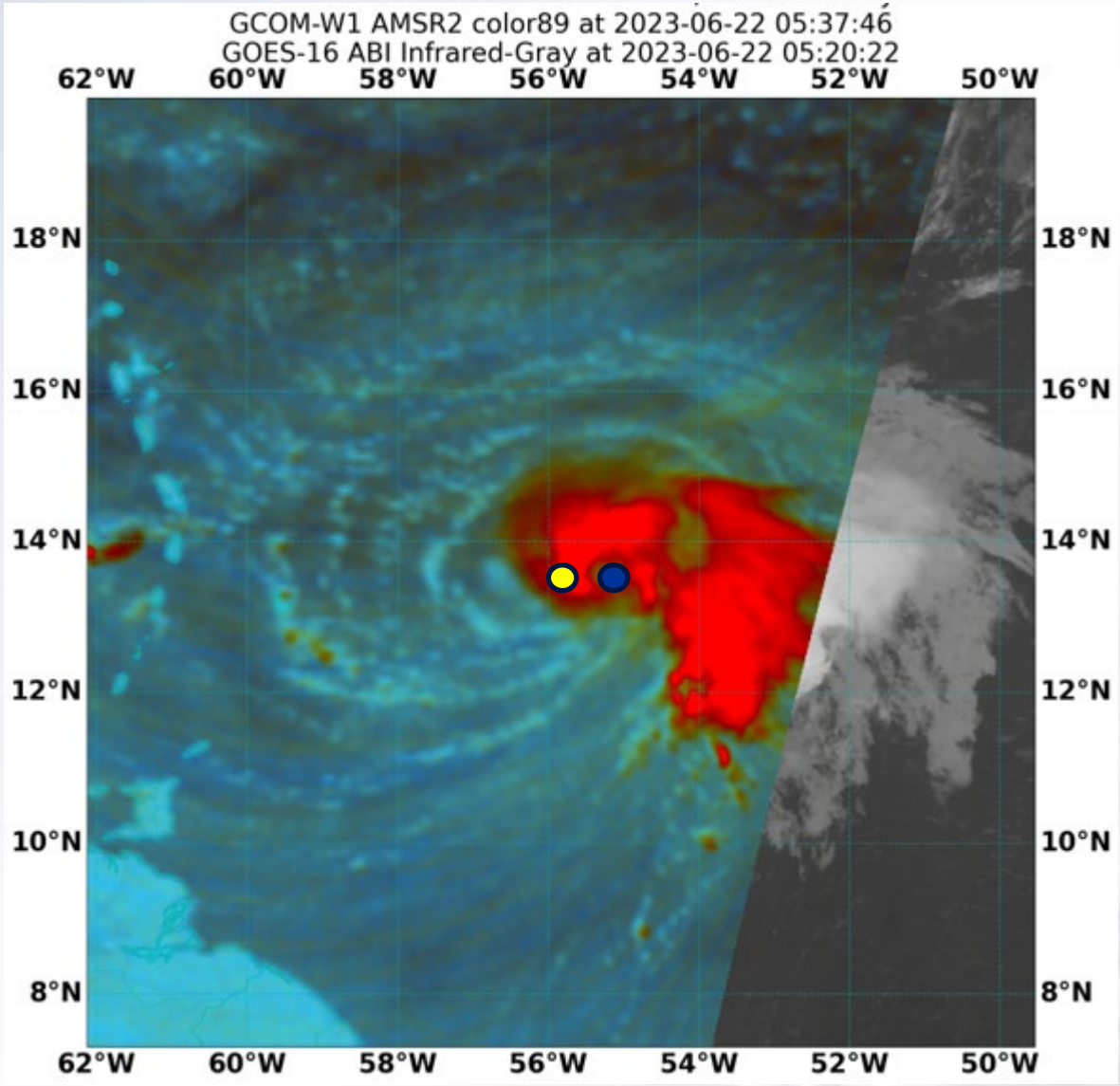
Identify the center of circulation in the 37 GHz microwave imagery of this TC. Select a location.

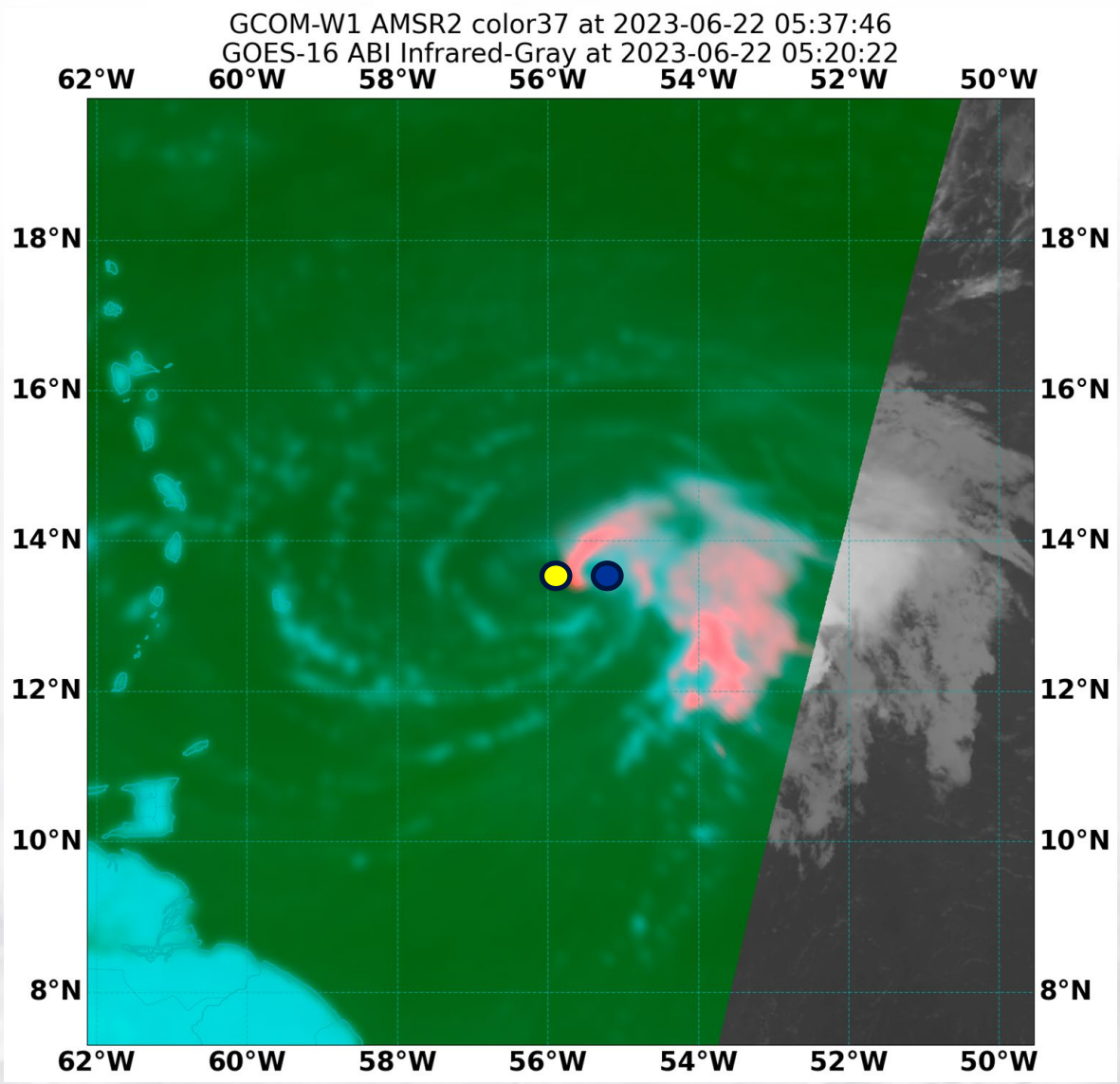
0



Yellow: Center based on 37 GHz imagery

Blue: Center based on 89 GHz imagery





Why do you think there is a difference between the center locations in the two images?

0

The two frequencies show different levels of the atmosphere and the storm is sheared

0%

The eye feature in the 89 GHz imagery is misleading and does not represent a center of circulation

0%

There is an error with the imagery in one of the frequencies

0%

85/89/91-GHz Imagery Interpretation

- Imagery can reveal internal storm structure
- Better for locating TC centers than conventional visible and infrared, but you cannot always see the low-level circulation
- Land appears warm relative to water surfaces
- Deep convection appears cold (due to scattering by large ice crystals)
- Offers higher spatial resolution than imagery at lower microwave frequencies

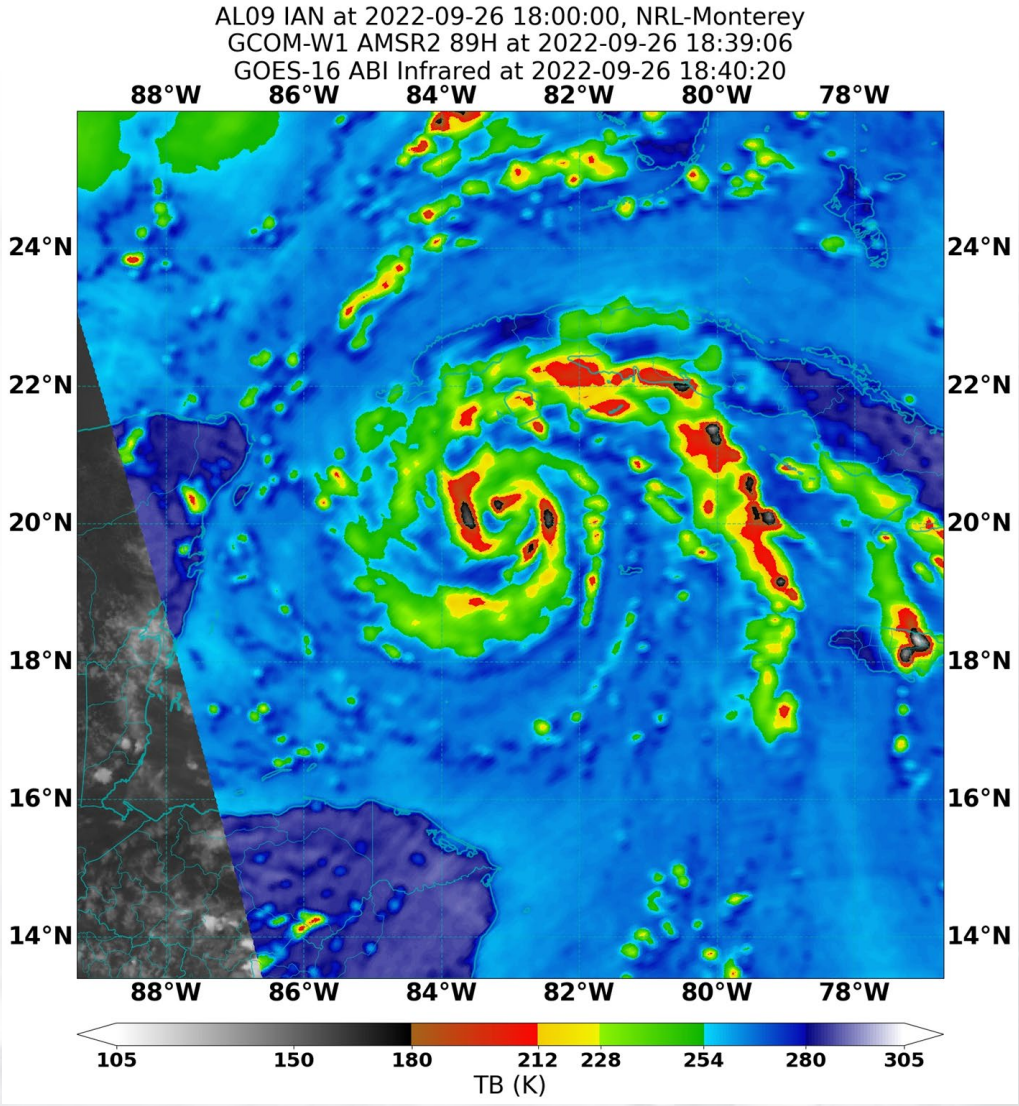


Image courtesy Navy/NRL

37-GHz Imagery Interpretation

- Imagery reveals the low-level cloud features and storm structure
- Can help identify cirrus-covered eyes and give a ‘true’ low-level center (instead of a mid- to upper-level center as in 85-91 GHz imagery)
- Precipitating clouds and land appear warm
- Sea surface appears cold

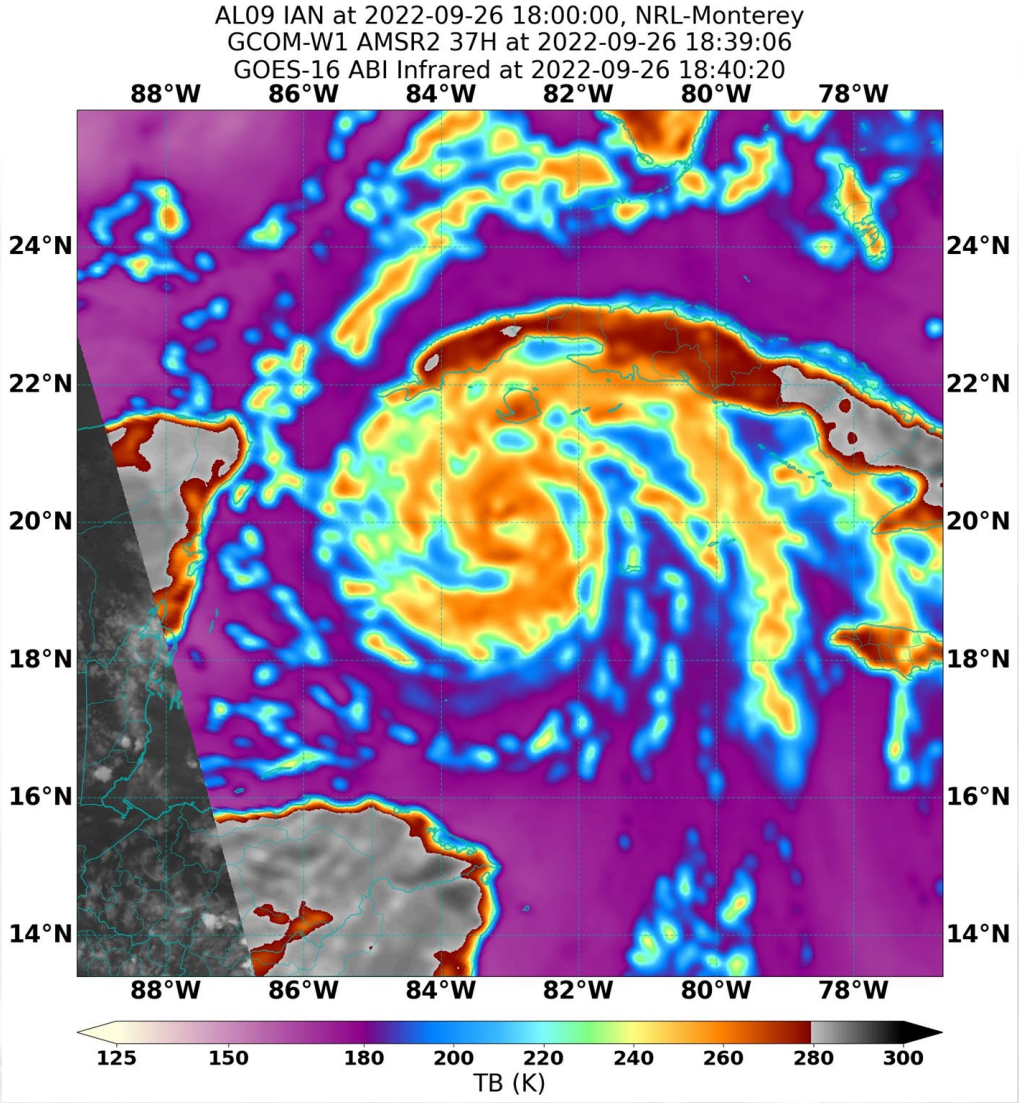
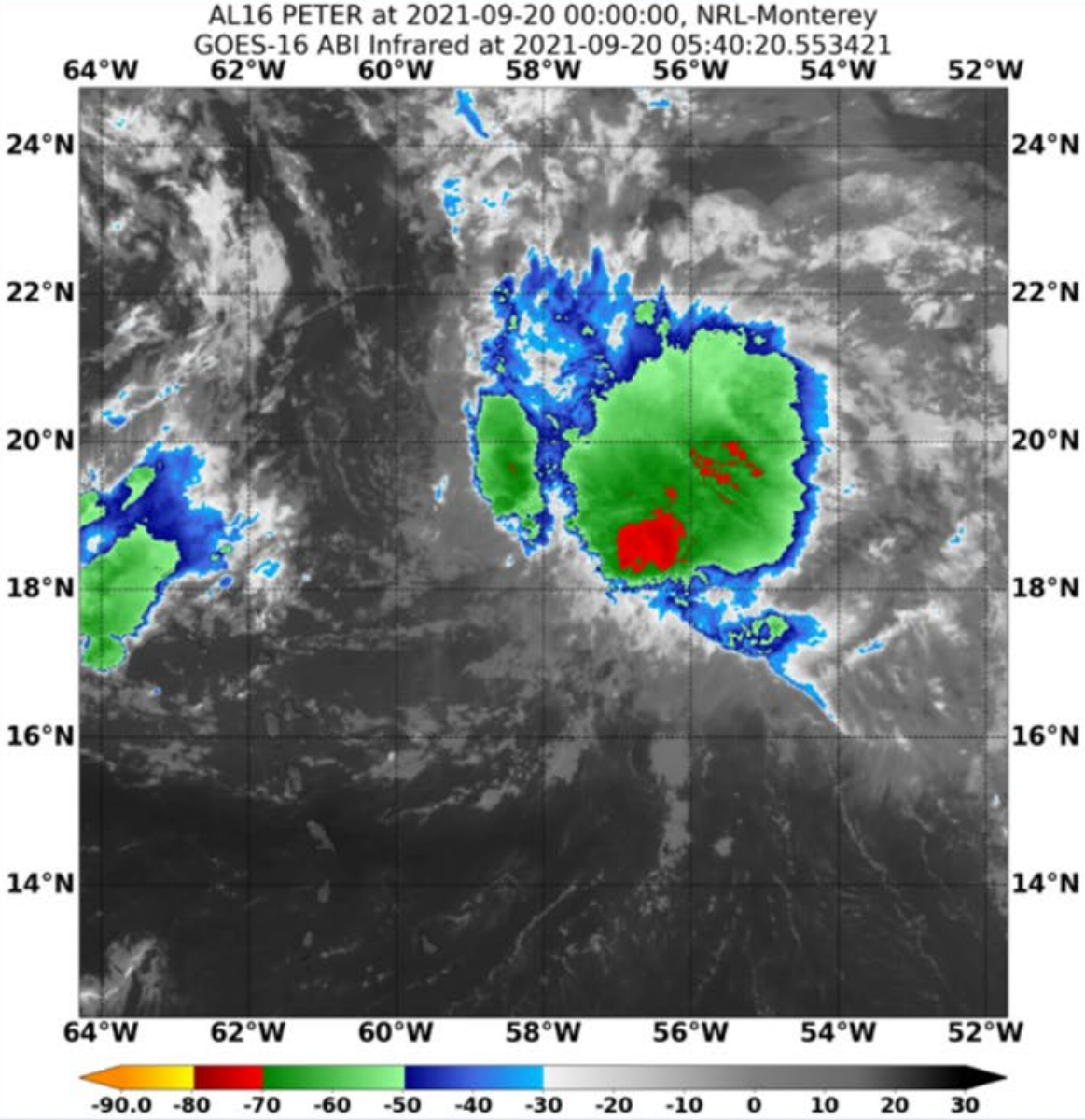


Image courtesy Navy/NRL

Identify the center of circulation in the IR imagery of TD Peter. Select a location.

0



There was a recent AMSR2 overpass. Would you use a microwave channel to help you locate the center? If so, which one?

0

I am happy with the location I obtained using IR

0%

37 GHz

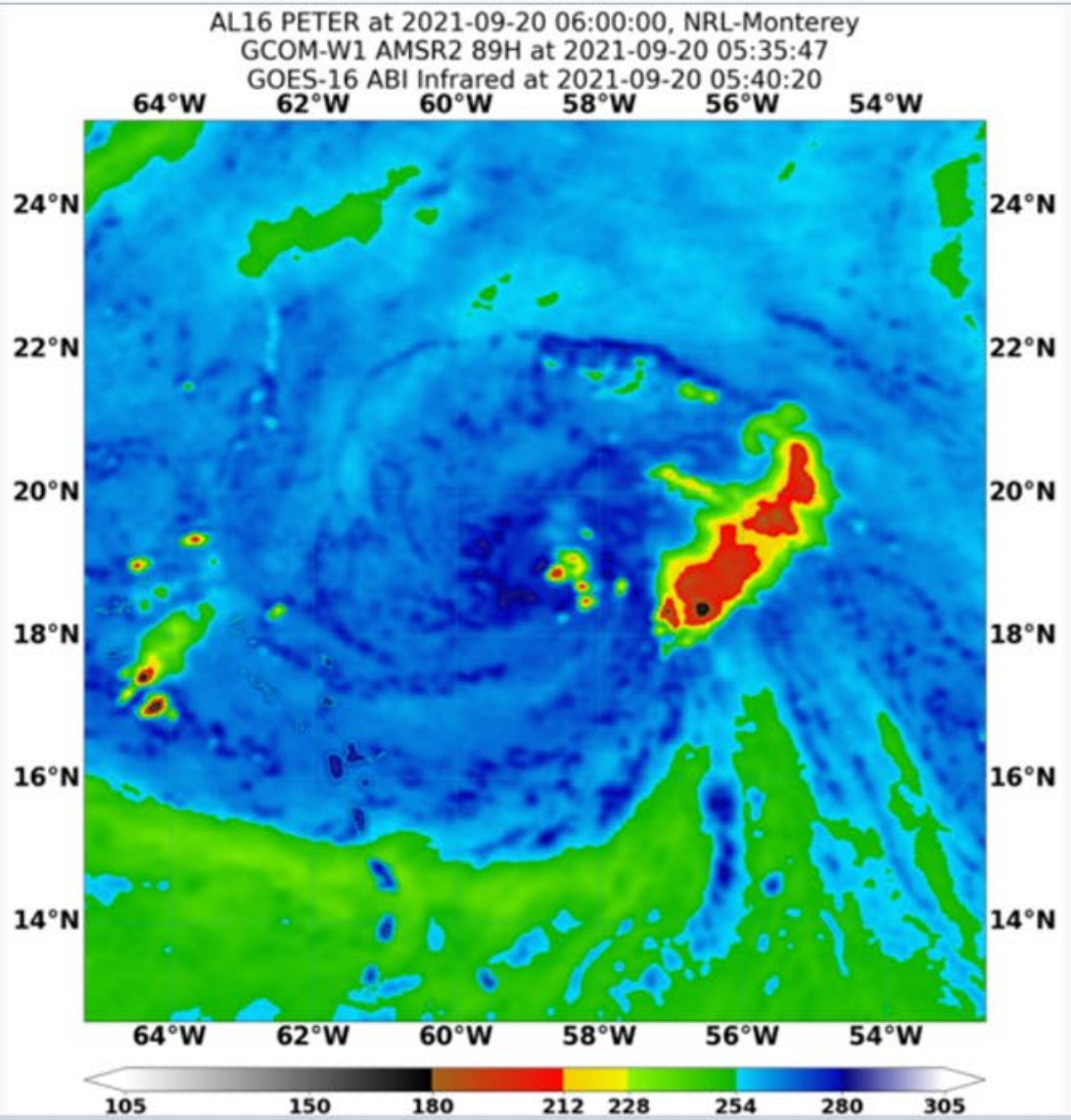
0%

89 GHz

0%

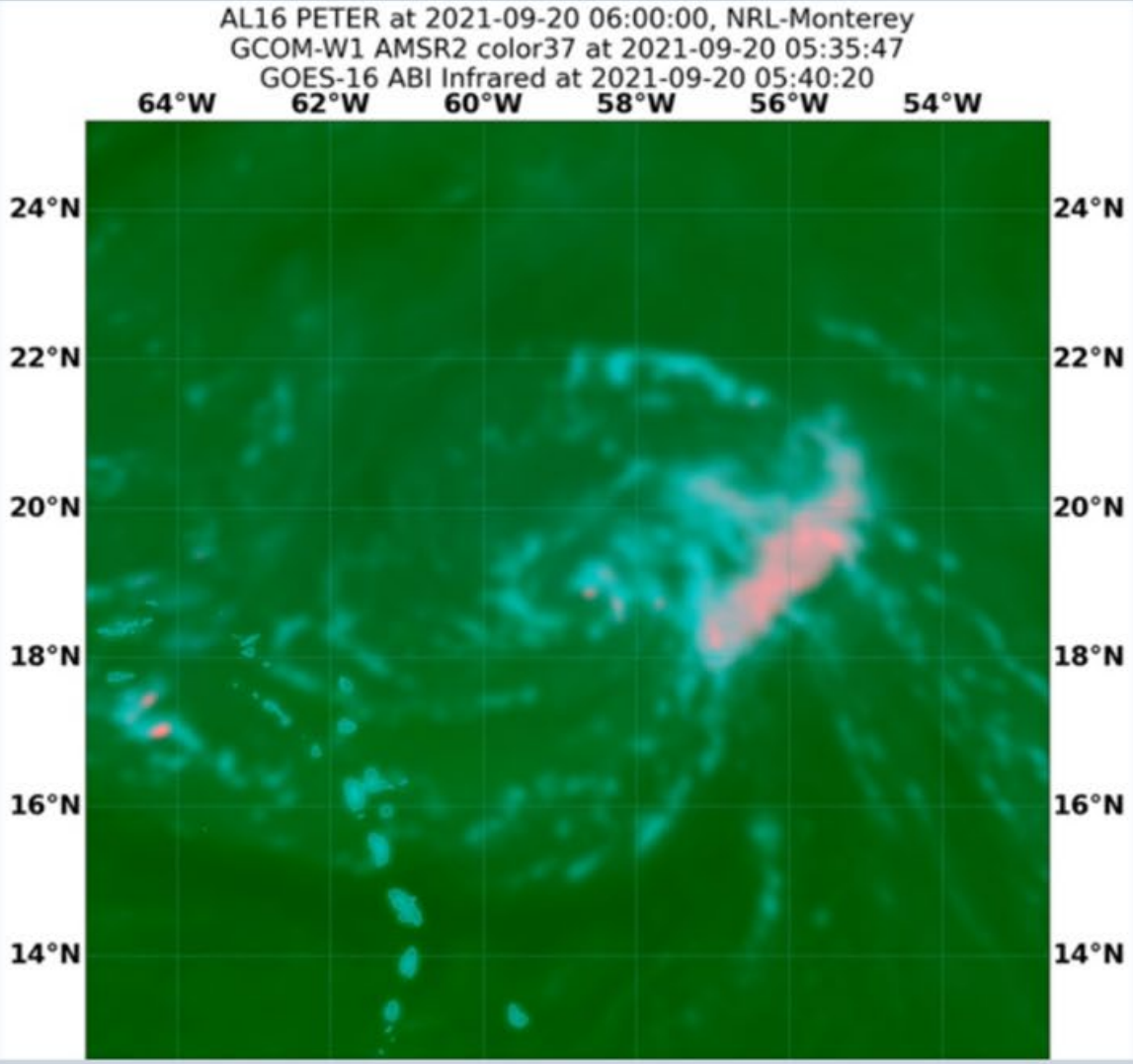
Identify the center of circulation in the 89 GHz microwave imagery of TD Peter. Select a location.

0

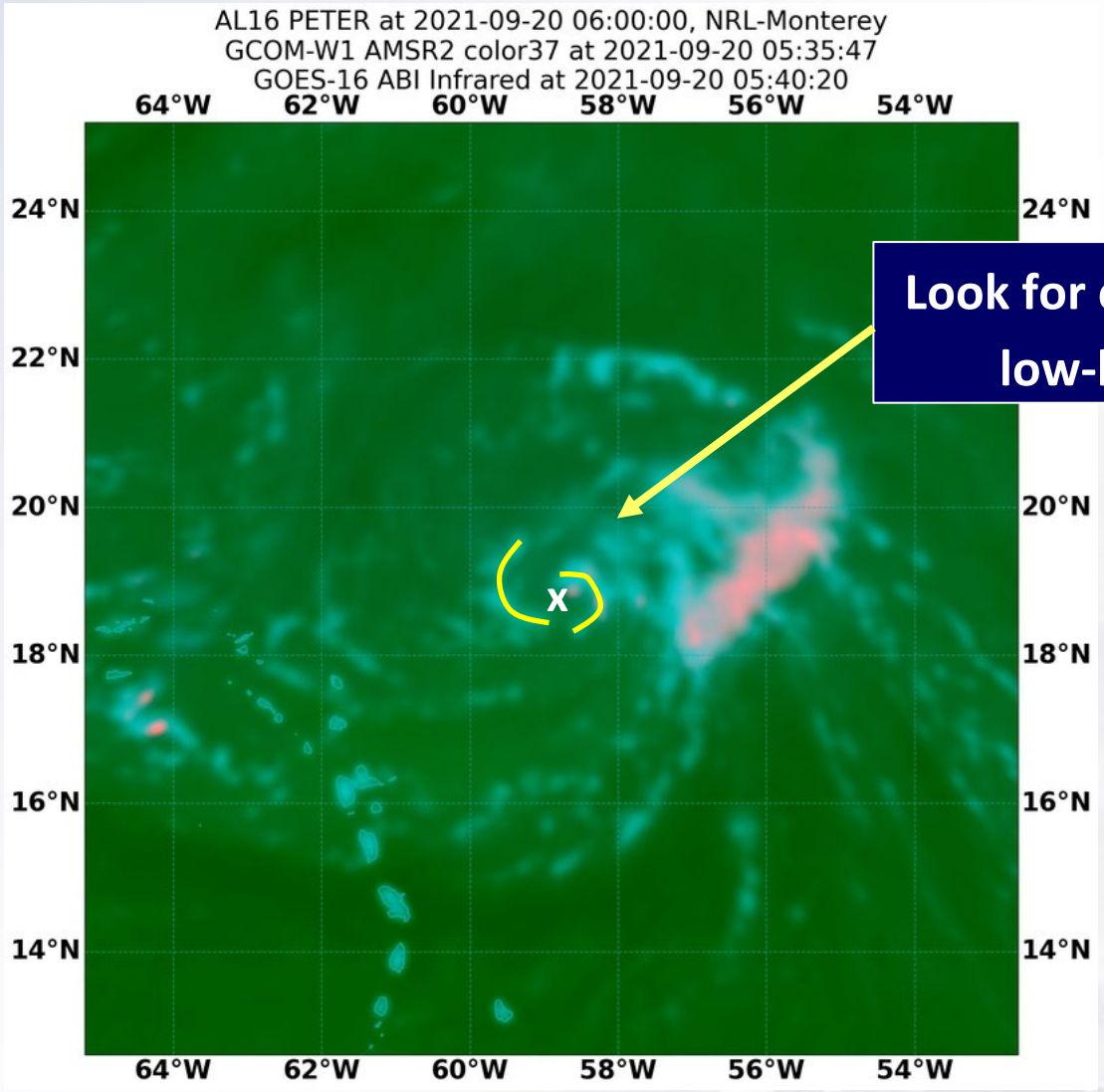


Identify the center of circulation in the 37 GHz microwave imagery of TD Peter. Select a location.

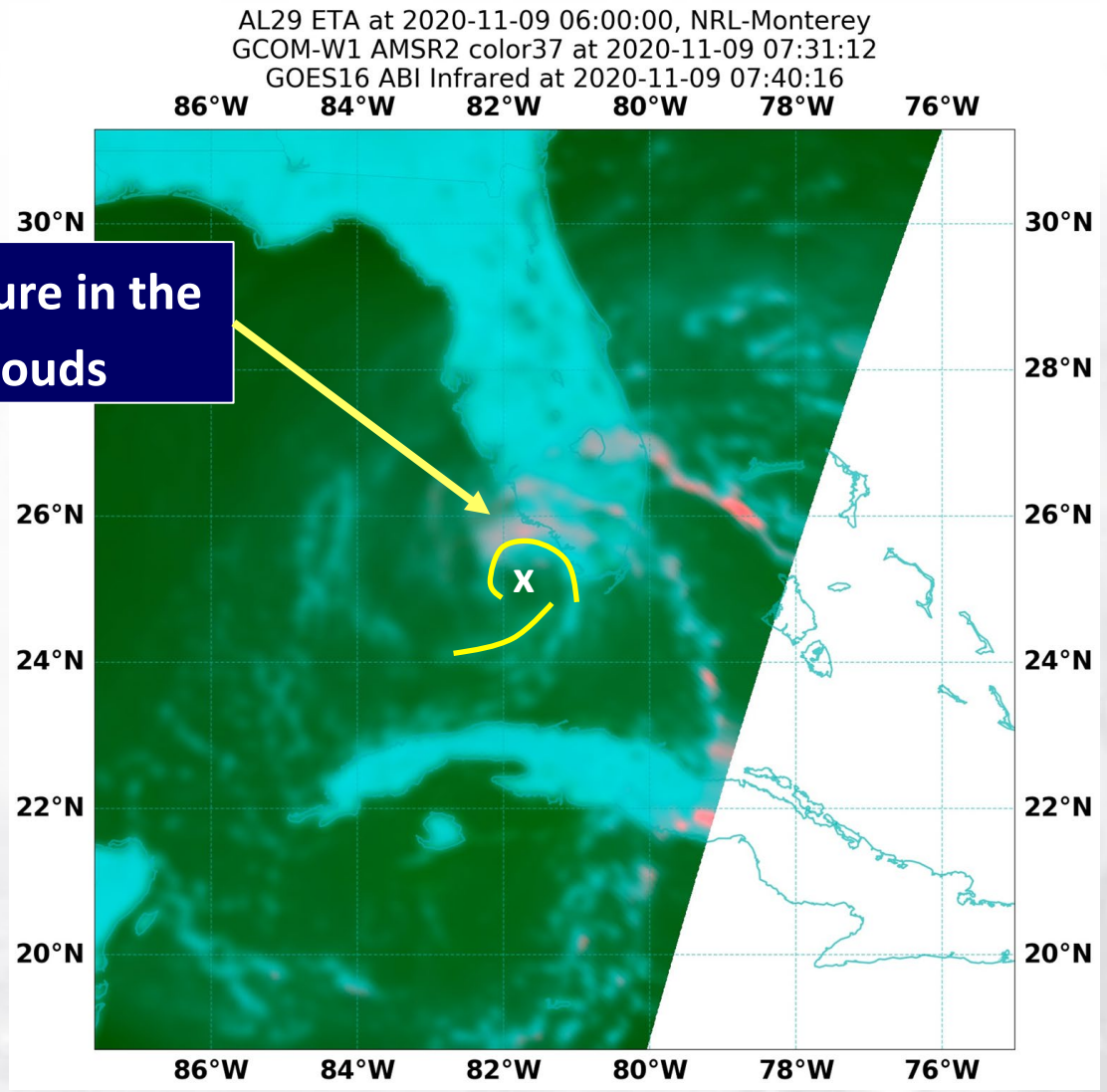
0



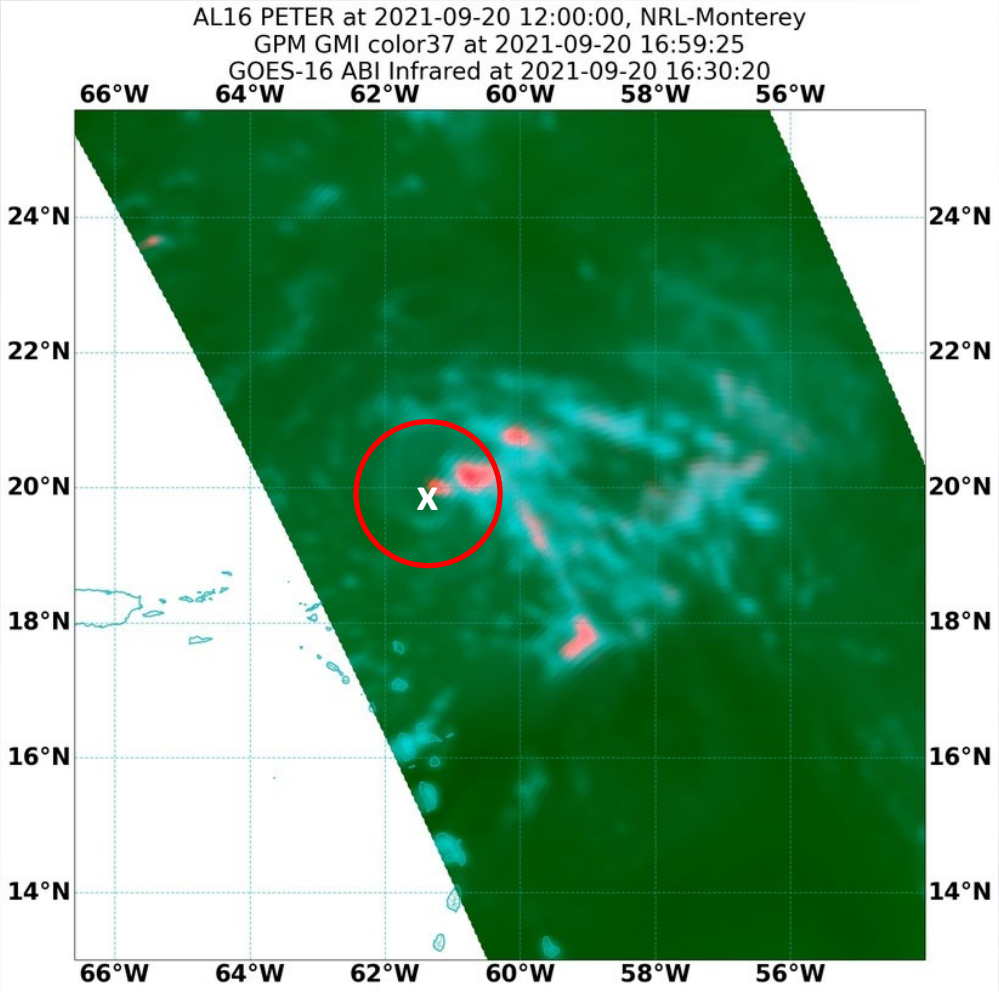
Locating the TC Center

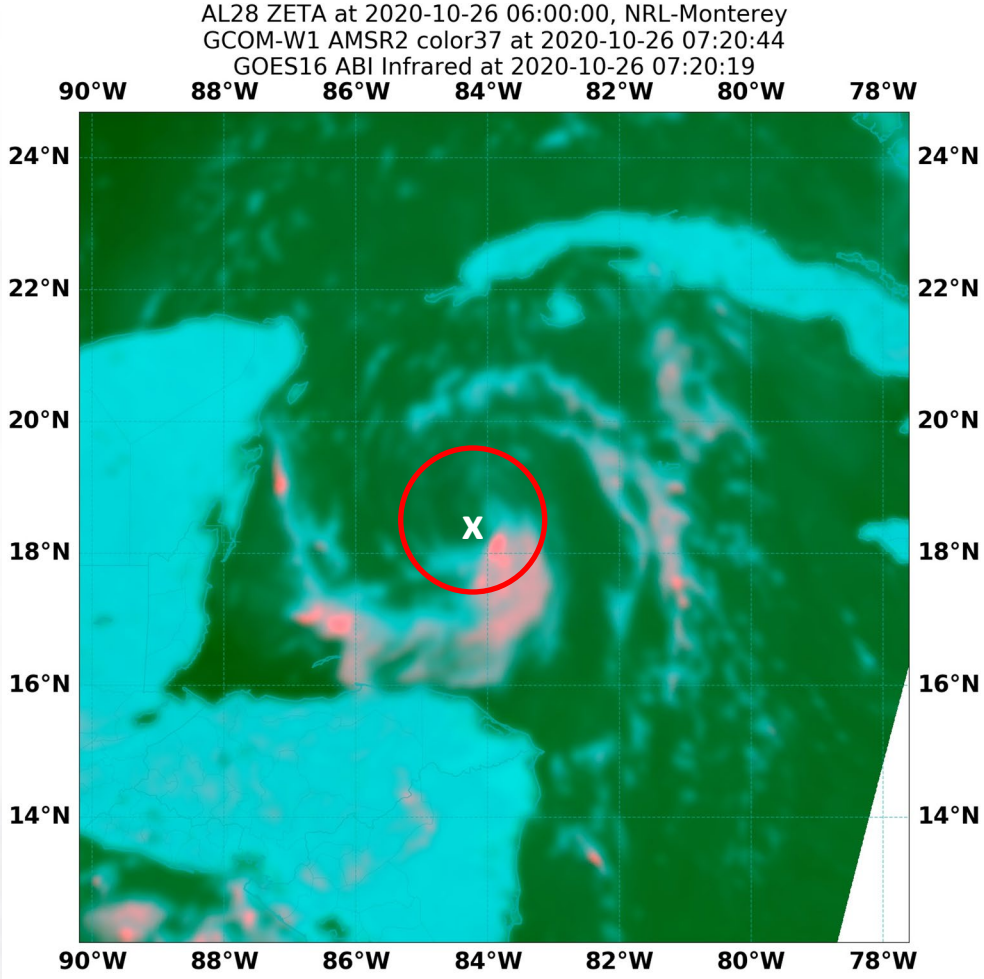


Look for curvature in the low-level clouds



Locating the TC Center





You are monitoring a hurricane and notice the storm's satellite appearance is quickly changing. Then, you receive a new microwave image of the storm. What will this newly-received microwave image depict?

0

The current structure of the hurricane

0%

The structure of the hurricane at the time of the last GOES scan

0%

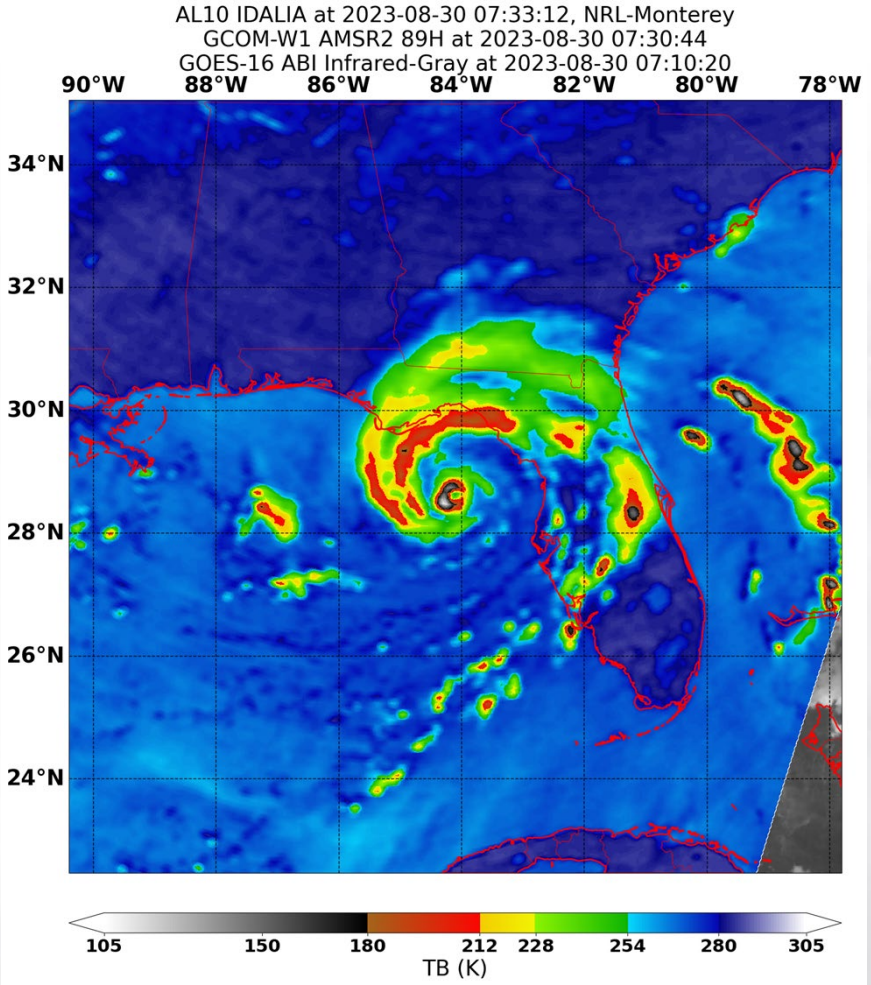
The structure of the hurricane a couple of hours ago

0%

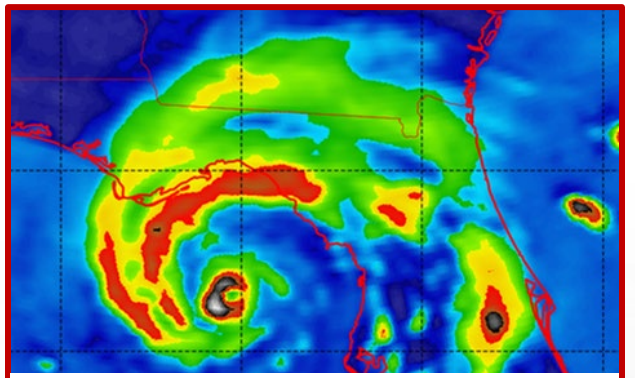
The structure of the hurricane yesterday

0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**



By the time you receive microwave data, the image is a couple of hours old.



0730 UTC AMSR2 89 GHz

0630 UTC

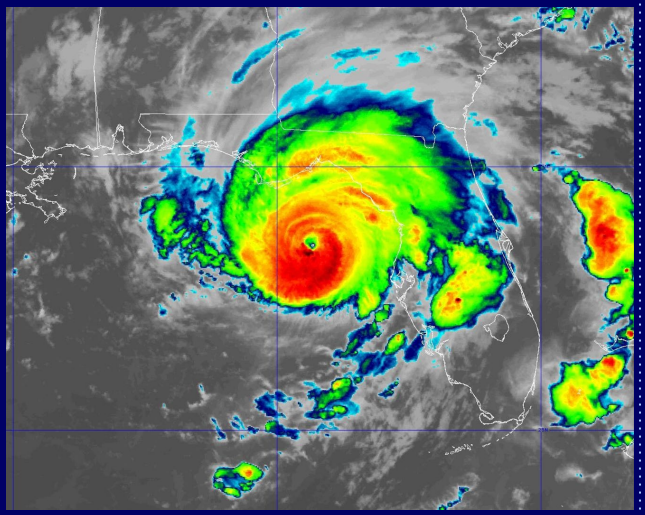
0730 UTC

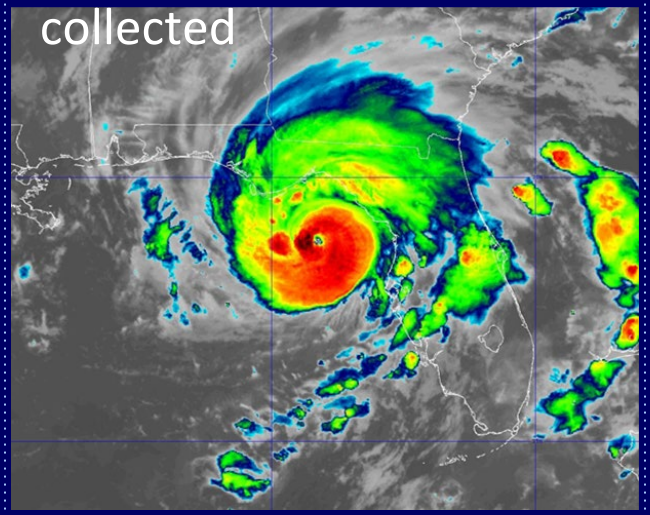
0830 UTC

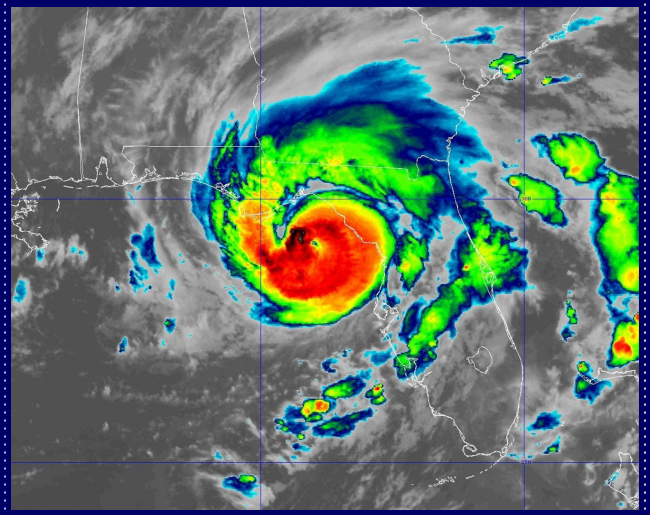
0930 UTC

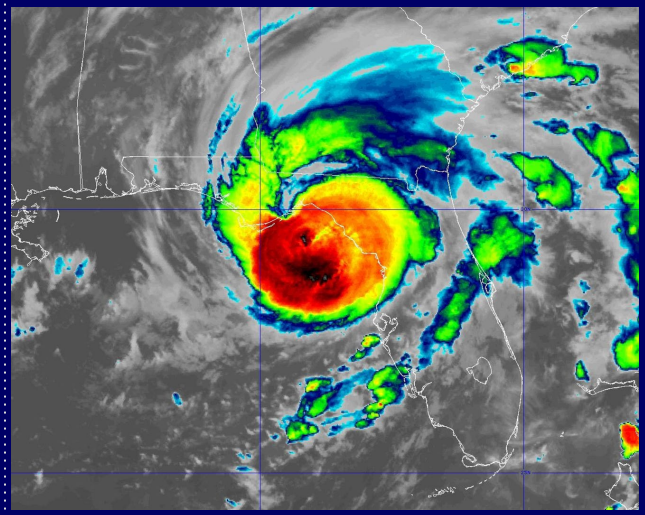
Microwave data collected

Microwave image received









Data Latency and Timeliness

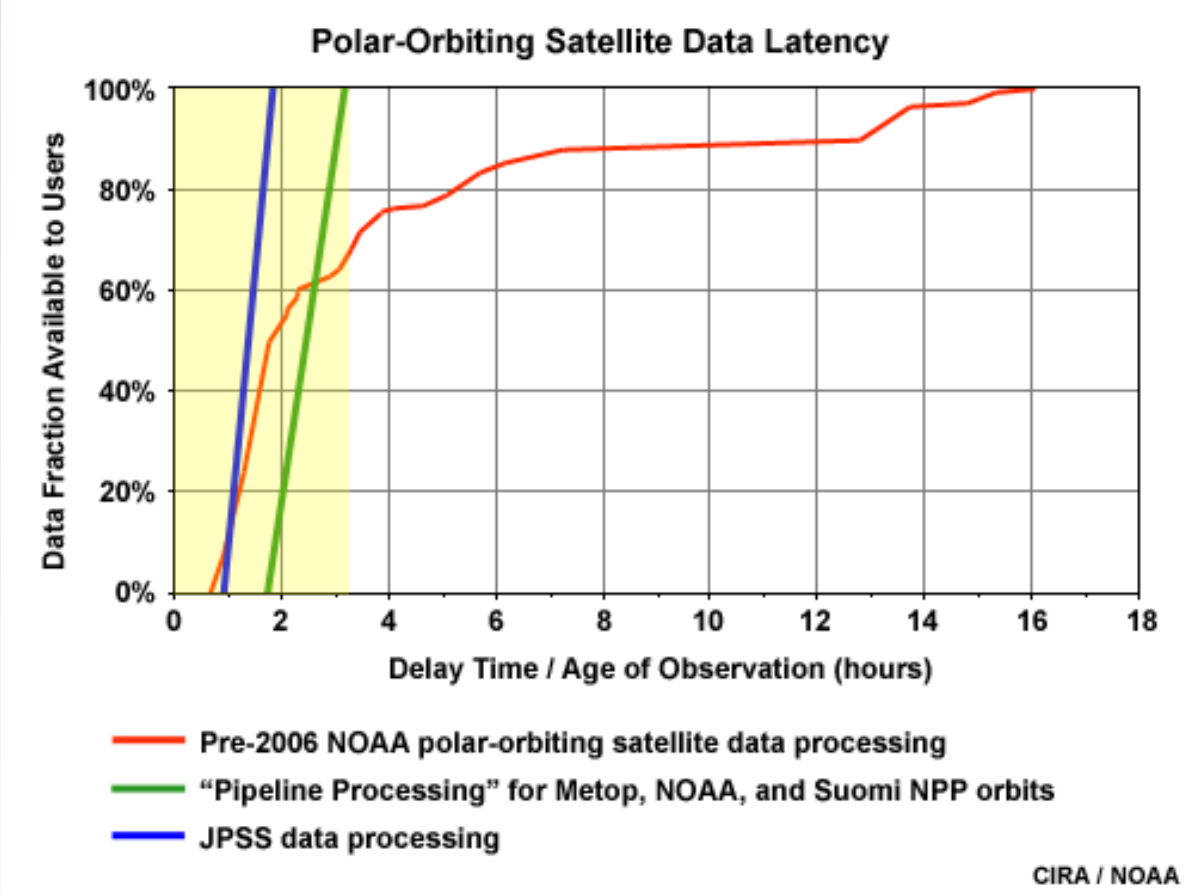


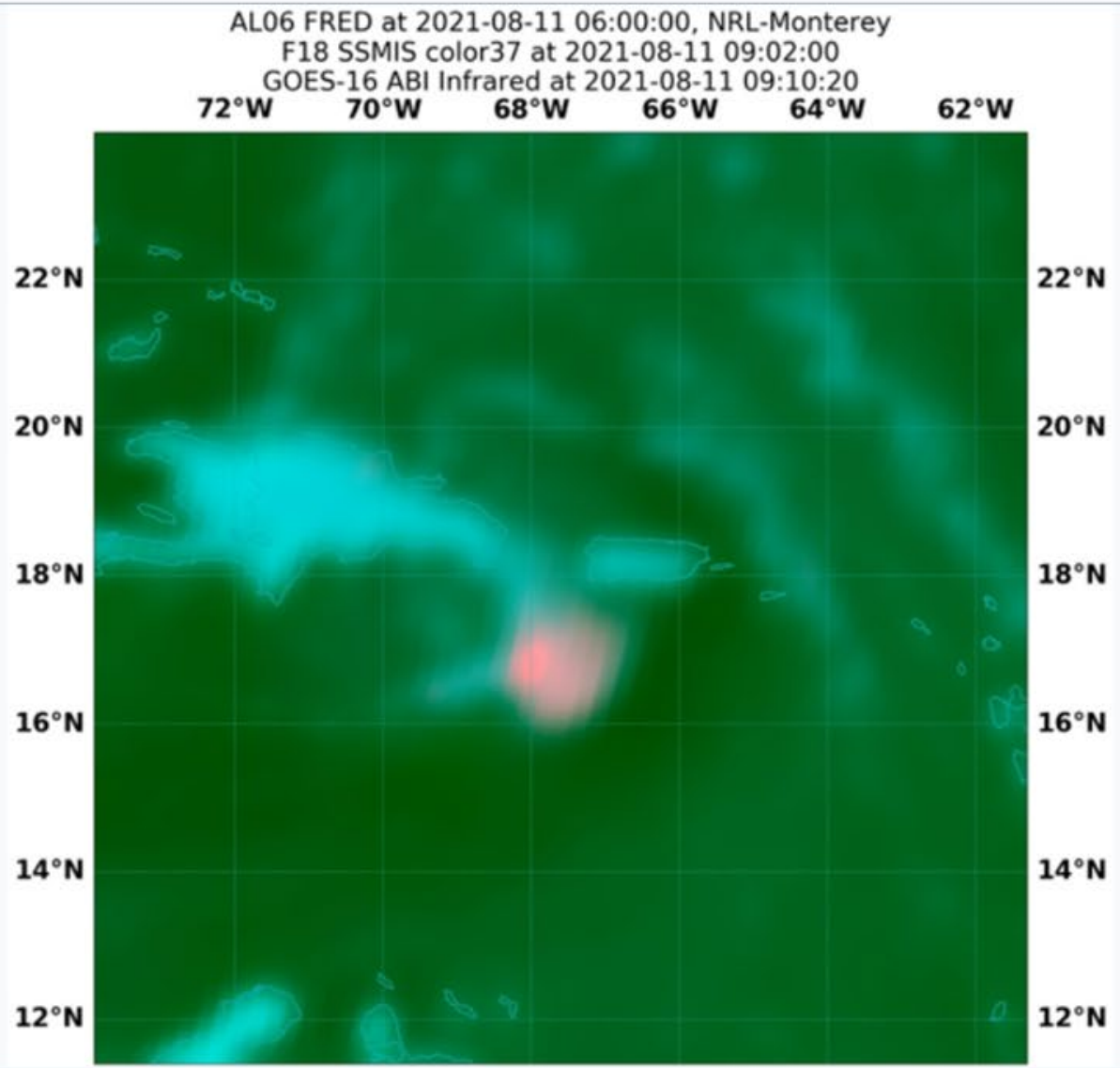
Image courtesy COMET

Why is there a delay in receiving the data?

- Low Earth orbit satellites are not continuously in view of data receiving stations.
- They can only download data when in range of those stations.
- This leads to a delay in data transmission and processing up to a couple of hours.

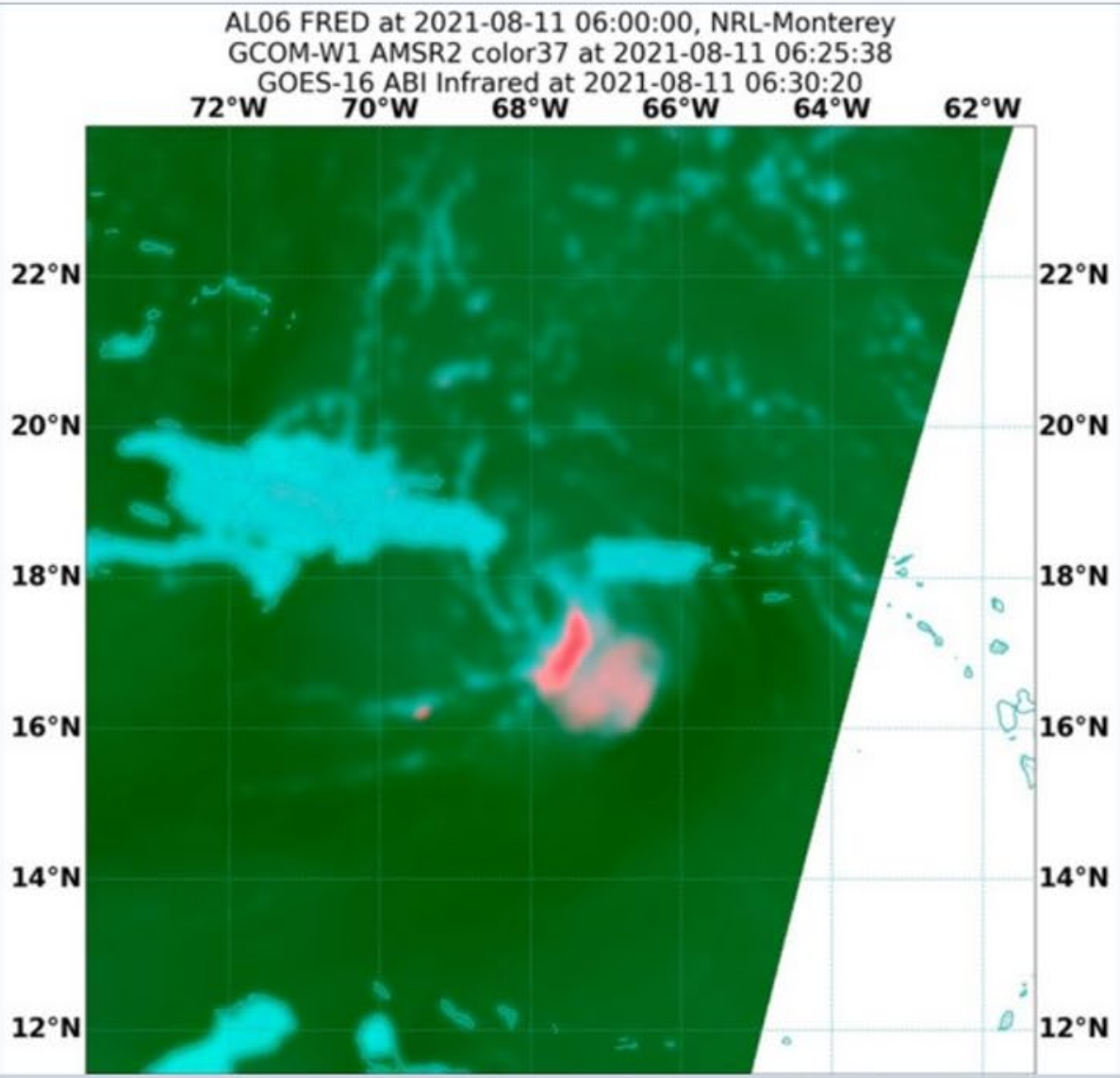
Identify the center of circulation in the 37 GHz SSMIS microwave imagery of TS Bret. Select a location.

0

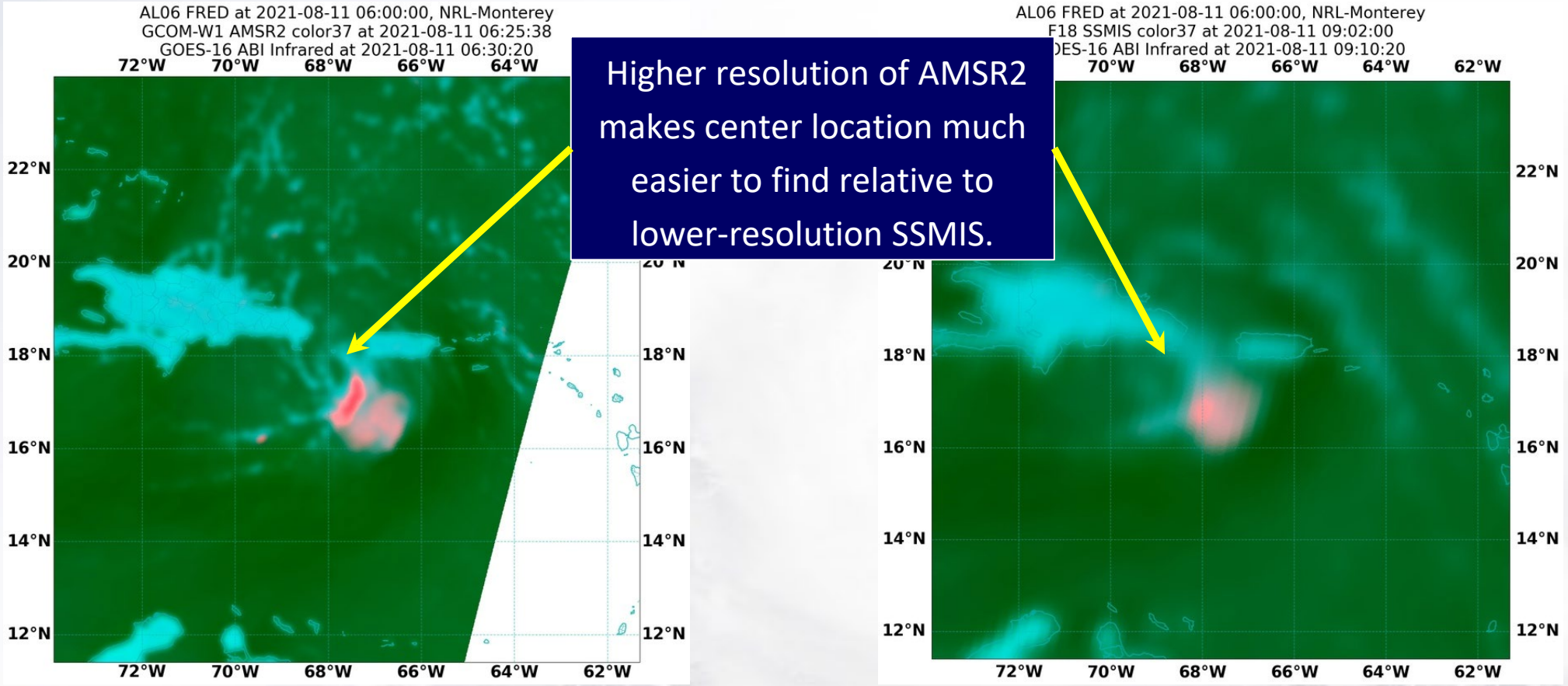


Identify the center of circulation in the 37 GHz AMSR2 microwave imagery of TS Bret. Select a location.

0



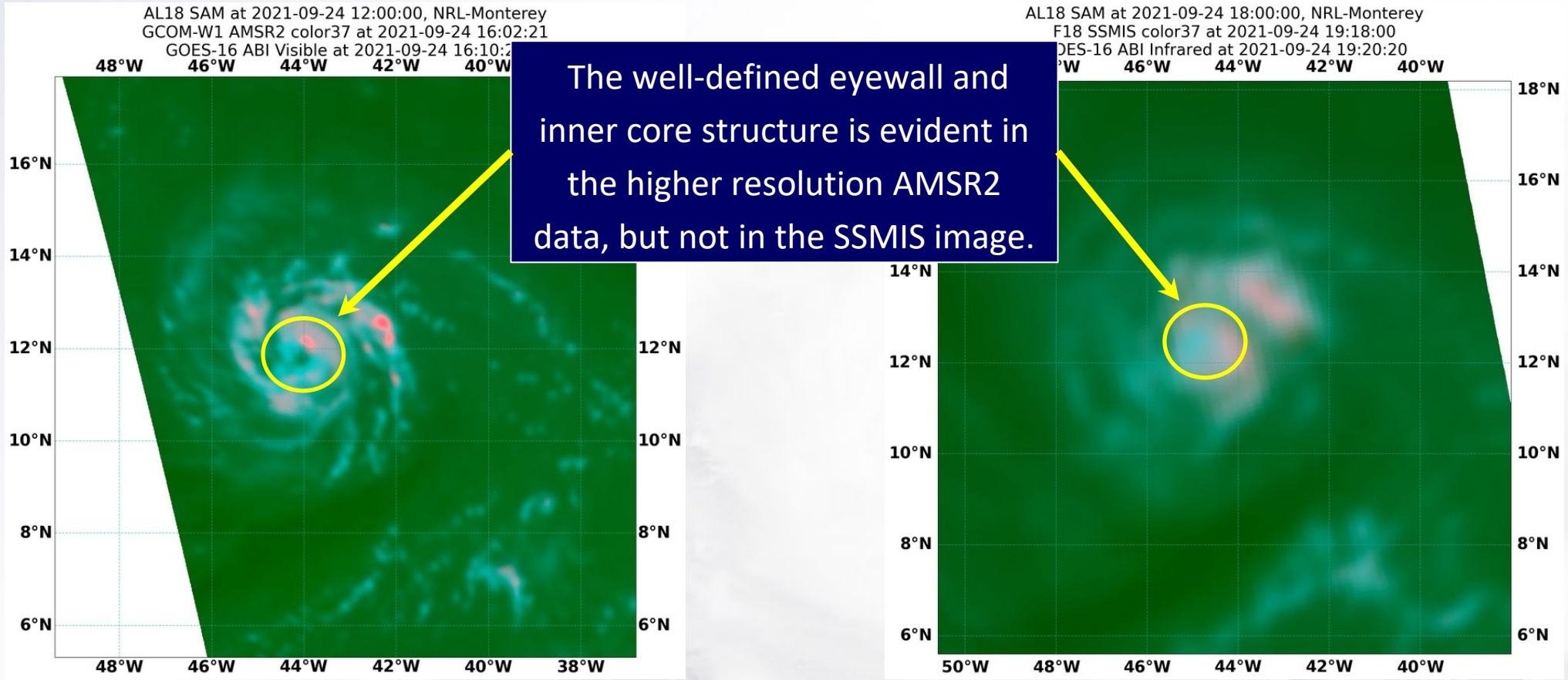
Resolution Limitations



Comparison of 37-GHz color composite imagery over Tropical Storm Fred from AMSR2 (left) and SSMIS (right) at 0625 UTC and 0902 UTC 11 August 2021, respectively.

Images courtesy Navy/NRL

Resolution Limitations



Comparison of 37-GHz color composite imagery over Hurricane Sam from AMSR2 (left) and SSMIS (right) at 1602 UTC and 1918 UTC 24 September 2021, respectively.

Images courtesy Navy/NRL

Scatterometry Basics

What is a scatterometer?

- Microwave radar located aboard polar-orbiting (LEO) satellites
- The instrument actively transmits energy toward the Earth's surface and measures the energy reflected back to it.
- How does this information help us as tropical cyclone forecasters?

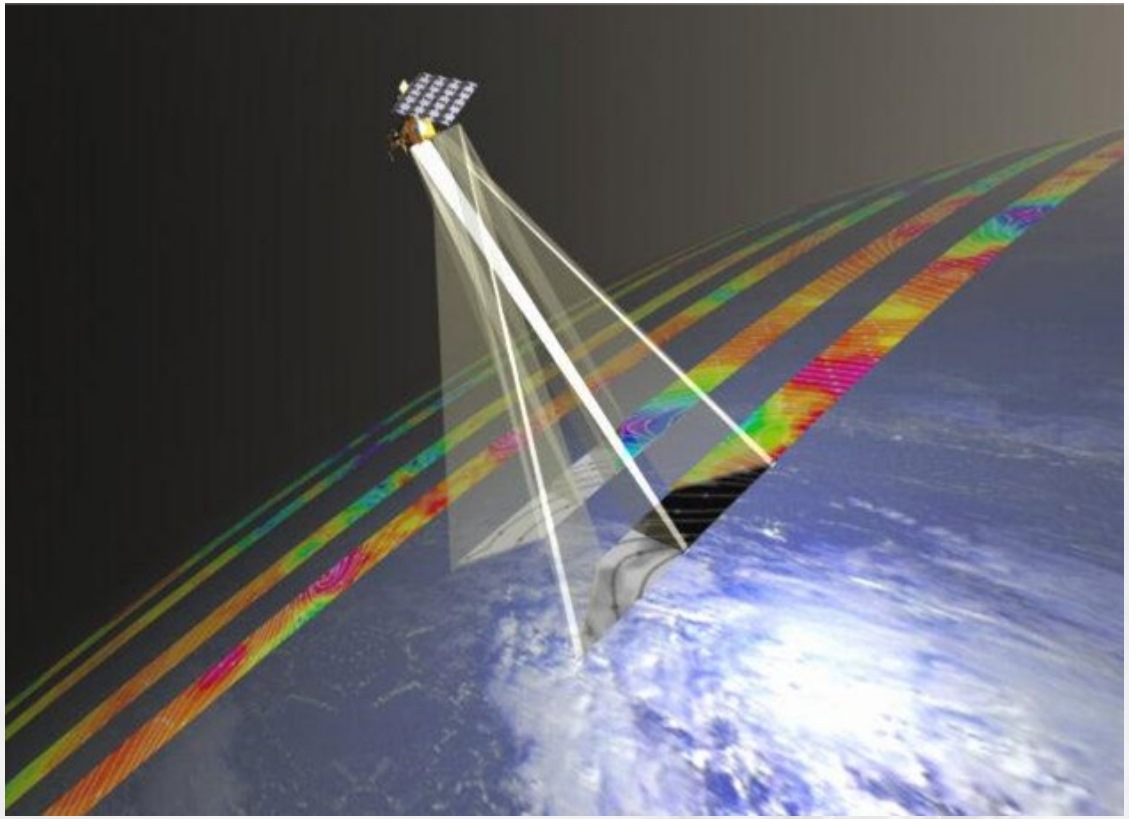


Image courtesy EUMETSAT

Scatterometry Basics

- Microwave energy is sensitive to small-scale roughness of the ocean surface that is generated by surface winds.
- By viewing the same patch of ocean from several angles, it is possible to derive wind speed and direction.

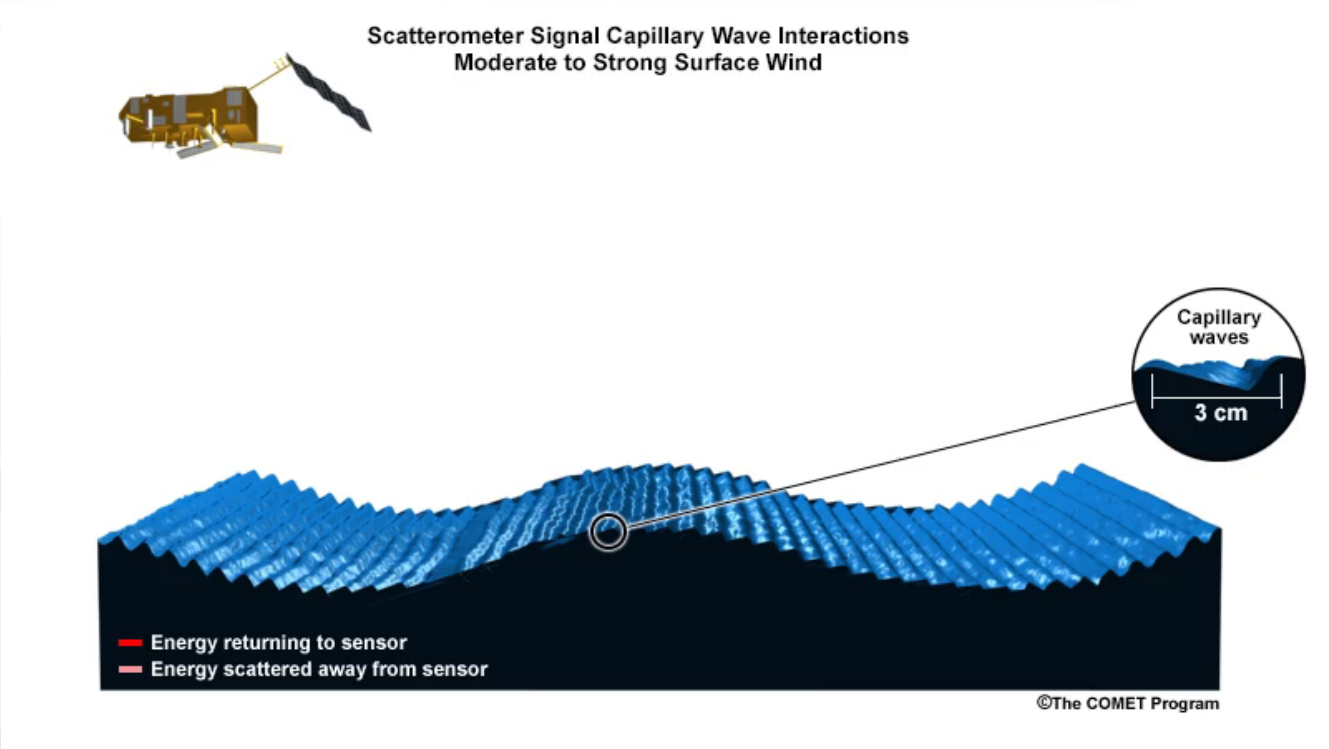


Image courtesy COMET

Using the scatterometer data, what is the maximum wind speed of TC Grace?

0

45 kt

0%

55 kt

0%

65 kt

0%

75 kt

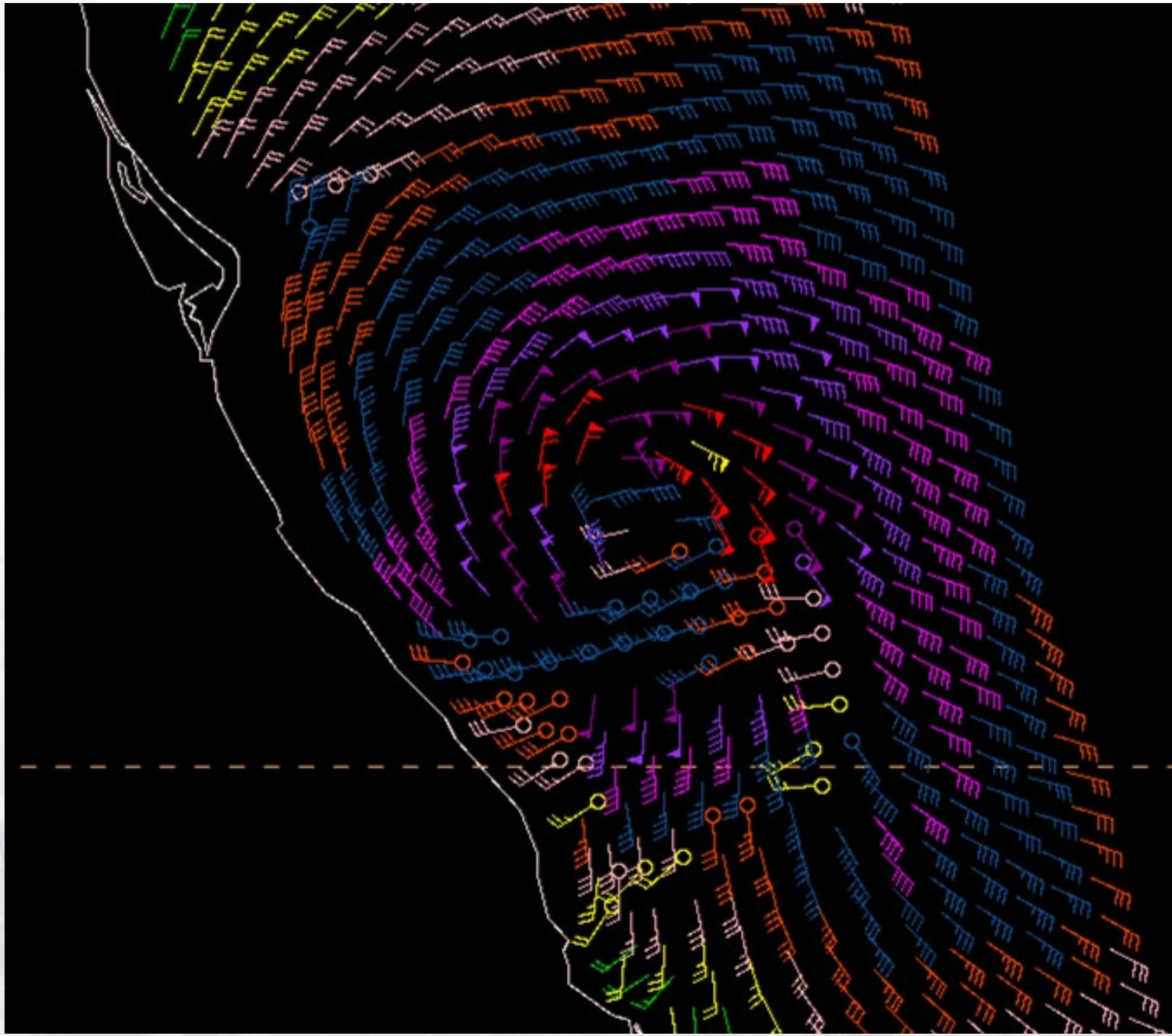
0%

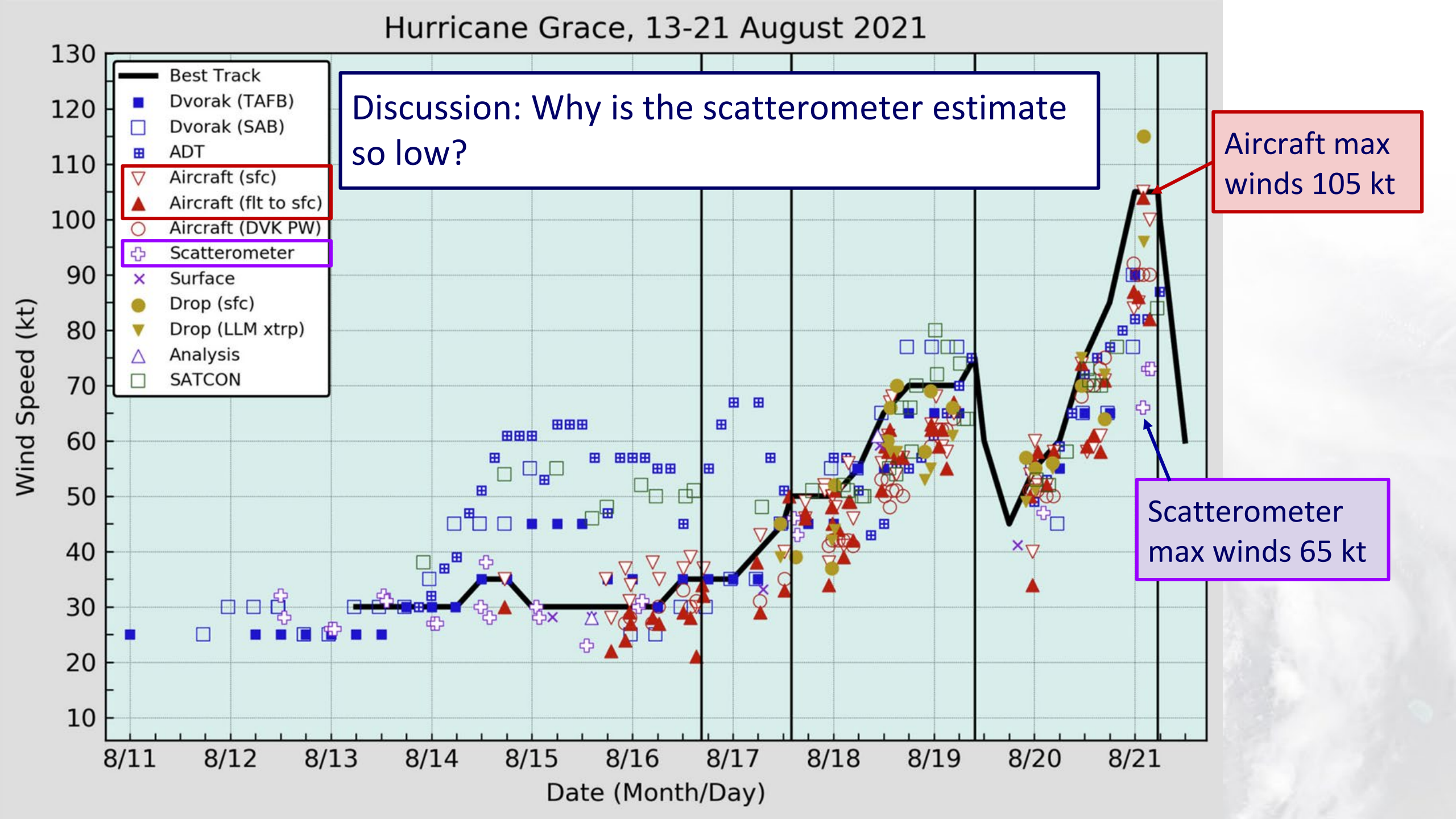
105 kt

0%

Need more data

0%




Hurricane Grace, 13-21 August 2021
Best Track
Dvorak (TAFB)
Dvorak (SAB)
ADT
Aircraft (sfc)
Aircraft (flt to sfc)
Aircraft (DVK PW)
Scatterometer
Surface
Drop (sfc)
Drop (LLM xtrp)
Analysis
SATCON
Discussion: Why is the scatterometer estimate so low?
Aircraft max winds 105 kt
Scatterometer max winds 65 kt
Wind Speed (kt)
Date (Month/Day)
130
120
110
100
90
80
70
60
50
40
30
20
10
8/11
8/12
8/13
8/14
8/15
8/16
8/17
8/18
8/19
8/20
8/21

Why is the scatterometer estimate much lower than the peak winds sampled by the aircraft?

0

Overpass of the scatterometer is not at exactly the same time

0%

The scatterometer has low spatial resolution

0%

Estimating winds using scatterometry always yields underestimates

0%

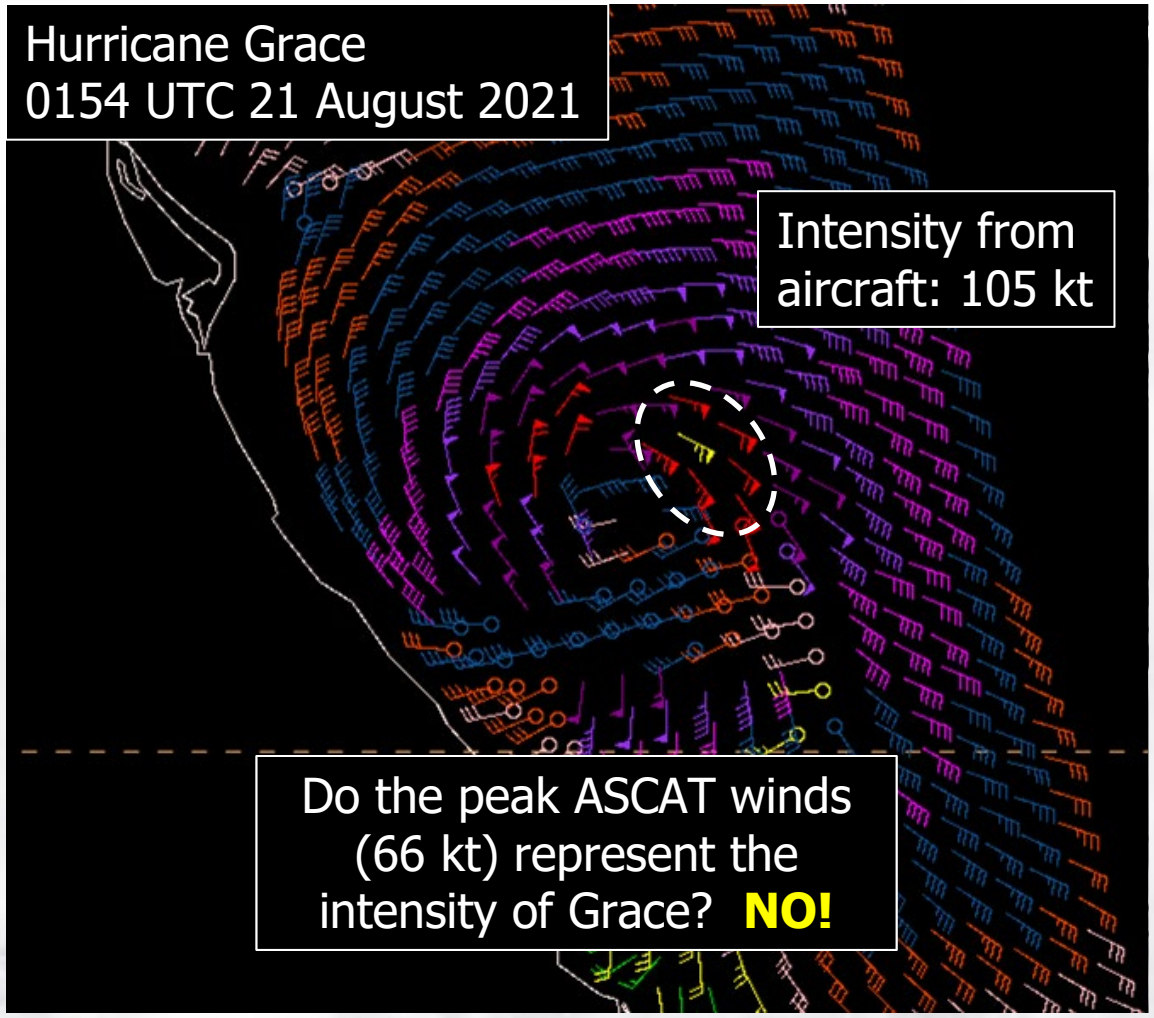
Scatterometry is not measuring winds at the surface

0%

TC Applications: Intensity Analysis

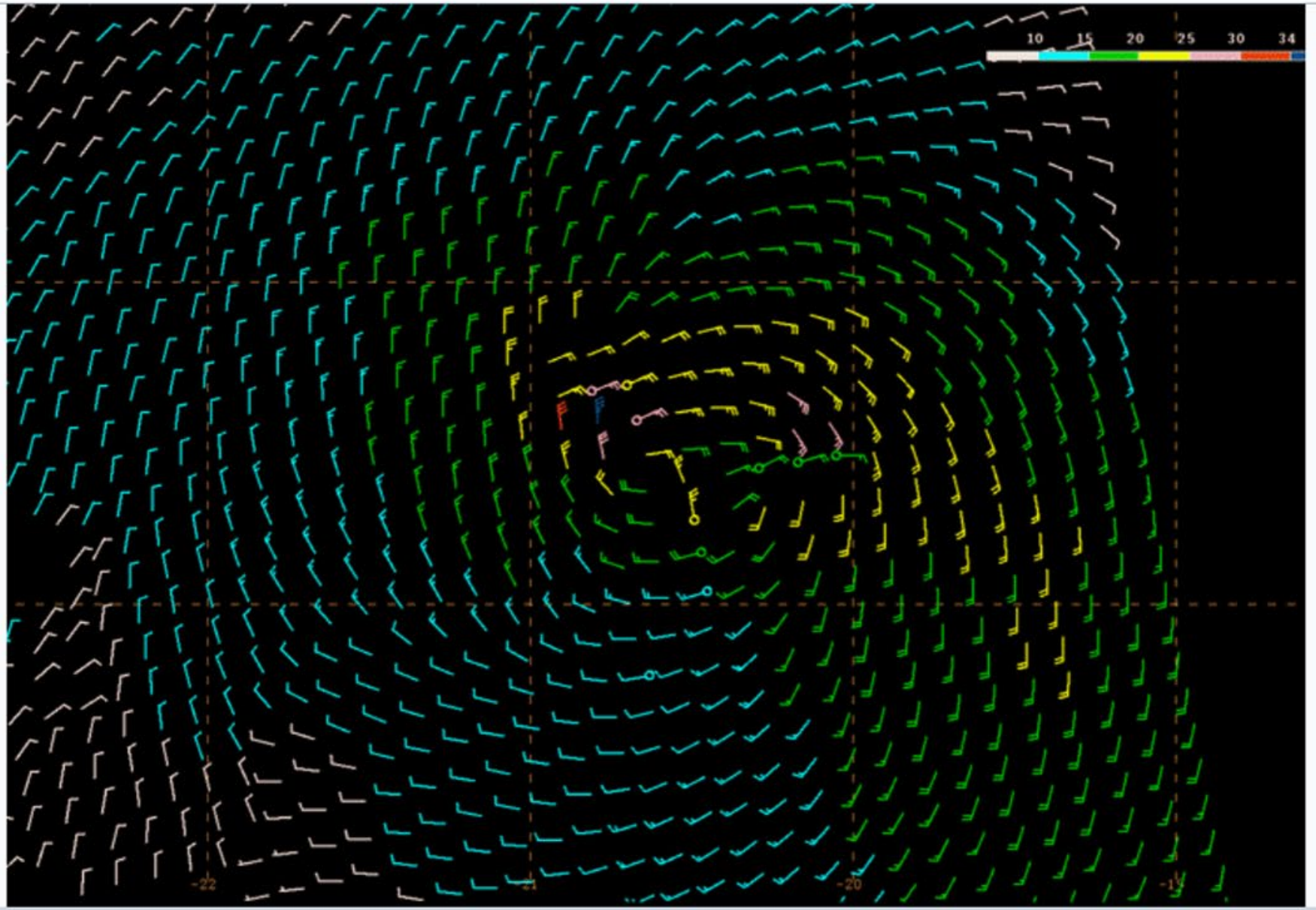
- Remember: Scatterometer winds **cannot** be used to determine the peak intensity of hurricanes or stronger tropical storms.

- The data can still provide us with valuable information about the low-level wind field.
  - Center fix (w/ambiguities)
  - Radius of maximum wind
  - 34, 50-kt wind radii

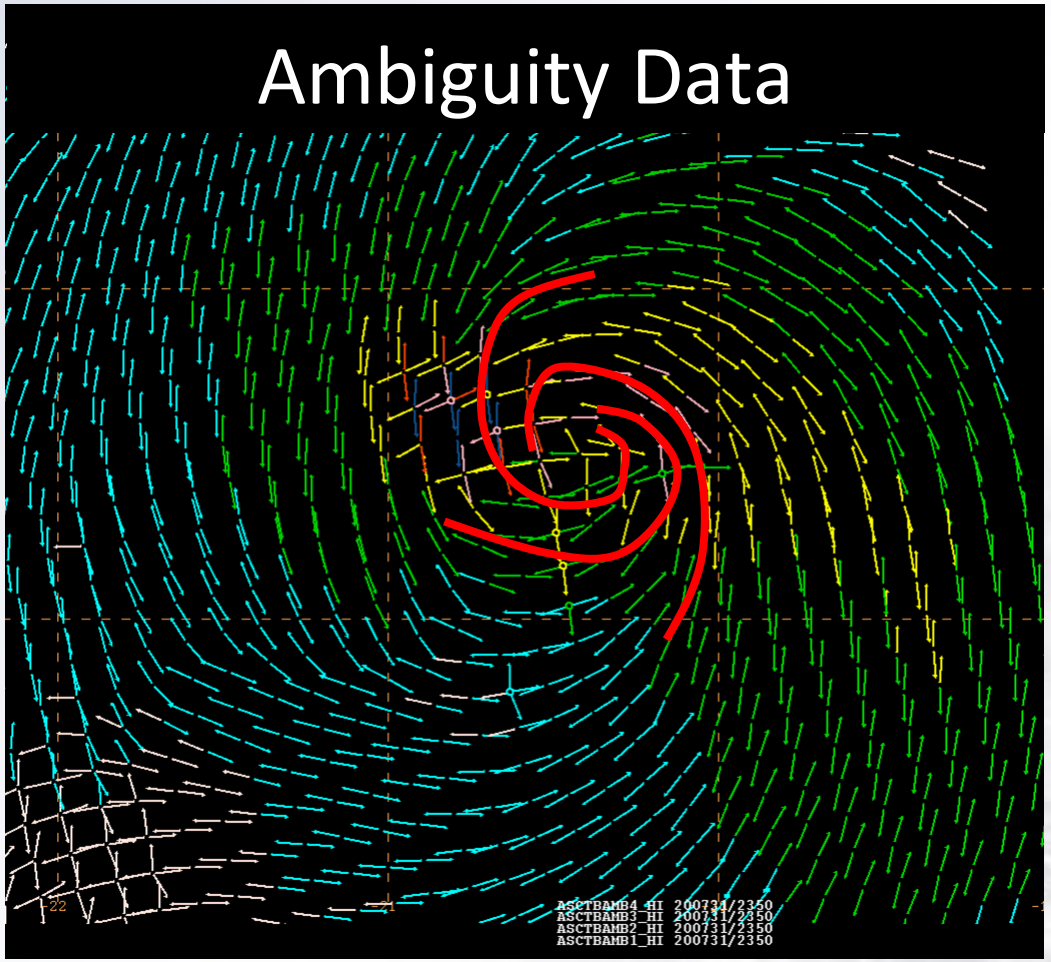


Identify the center of circulation in the scatterometer image of this TC. Select a location.

0



Directional Ambiguities



- The wind direction estimation process does not always yield the most realistic or correct solution
- ASCAT ambiguities show other possible wind direction solutions
- These ambiguities can be used to help determine the most likely wind directions and improve the center fix for developing TCs

Scatterometer Limitations

- Gaps over the tropics reduce spatial data coverage, and data swaths may completely miss TCs
- Spatial sampling/resolution does not allow for detection of peak winds in hurricanes or strong tropical storms
- Uncertainties in derived wind direction (directional ambiguity)

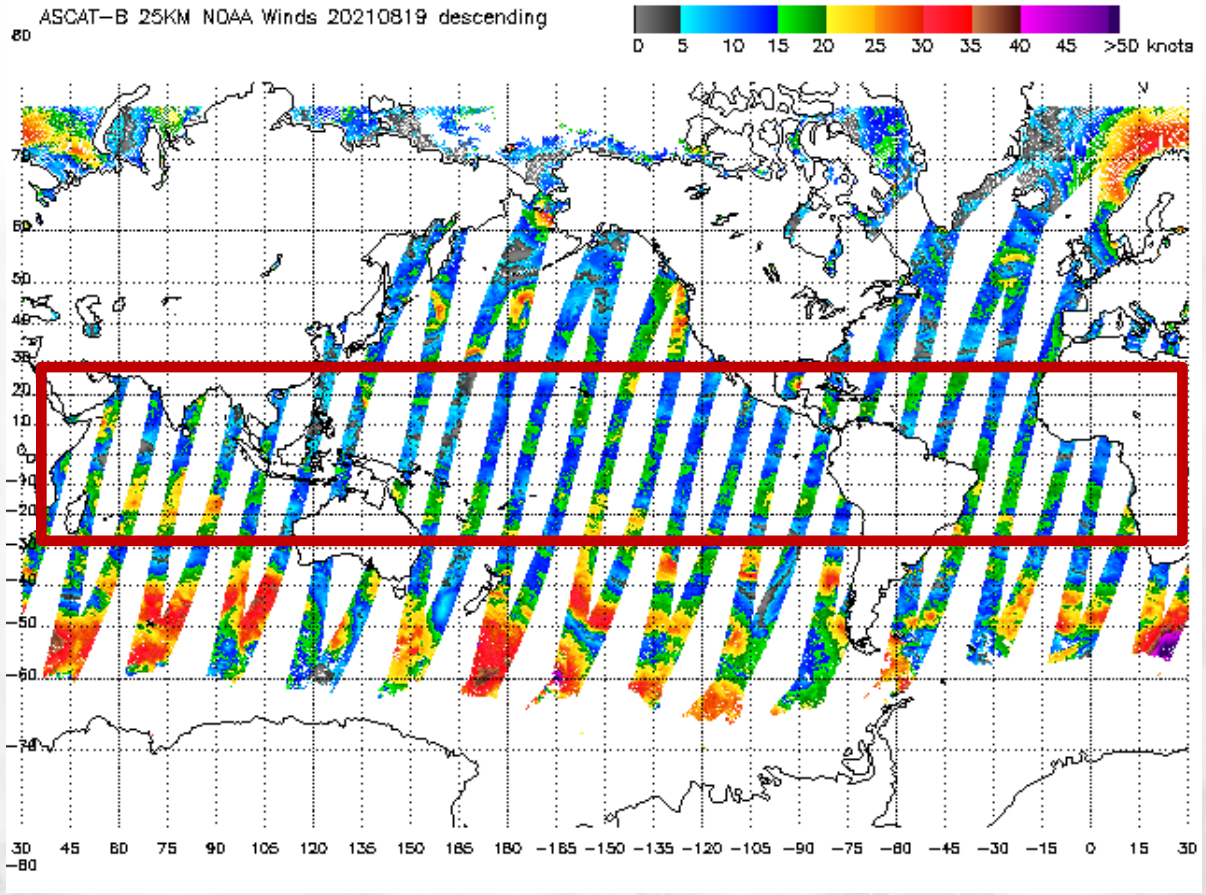
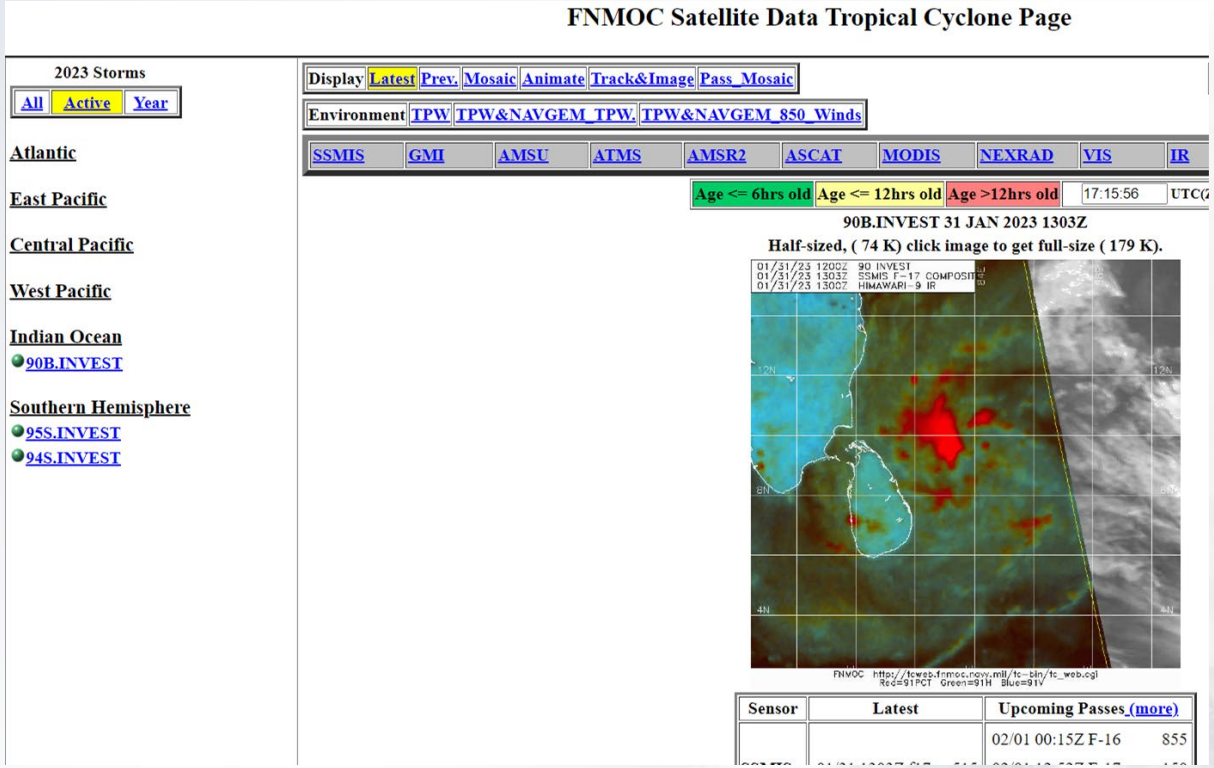


Image courtesy NOAA/NESDIS

Accessing Microwave Imagery

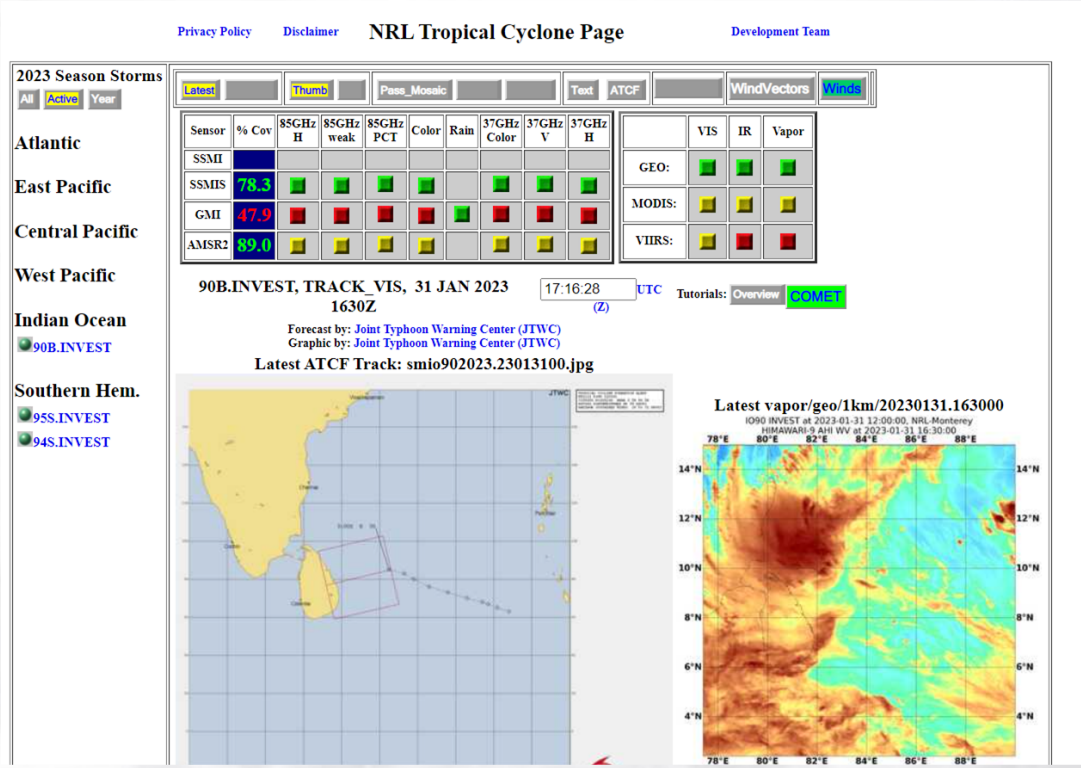
FNMOC Tropical Cyclone Webpage

https://www.fnmoc.navy.mil/tcweb/cgi-bin/tc_home.cgi



NRL Tropical Cyclone Webpage

https://www.nrlmry.navy.mil/TC.html

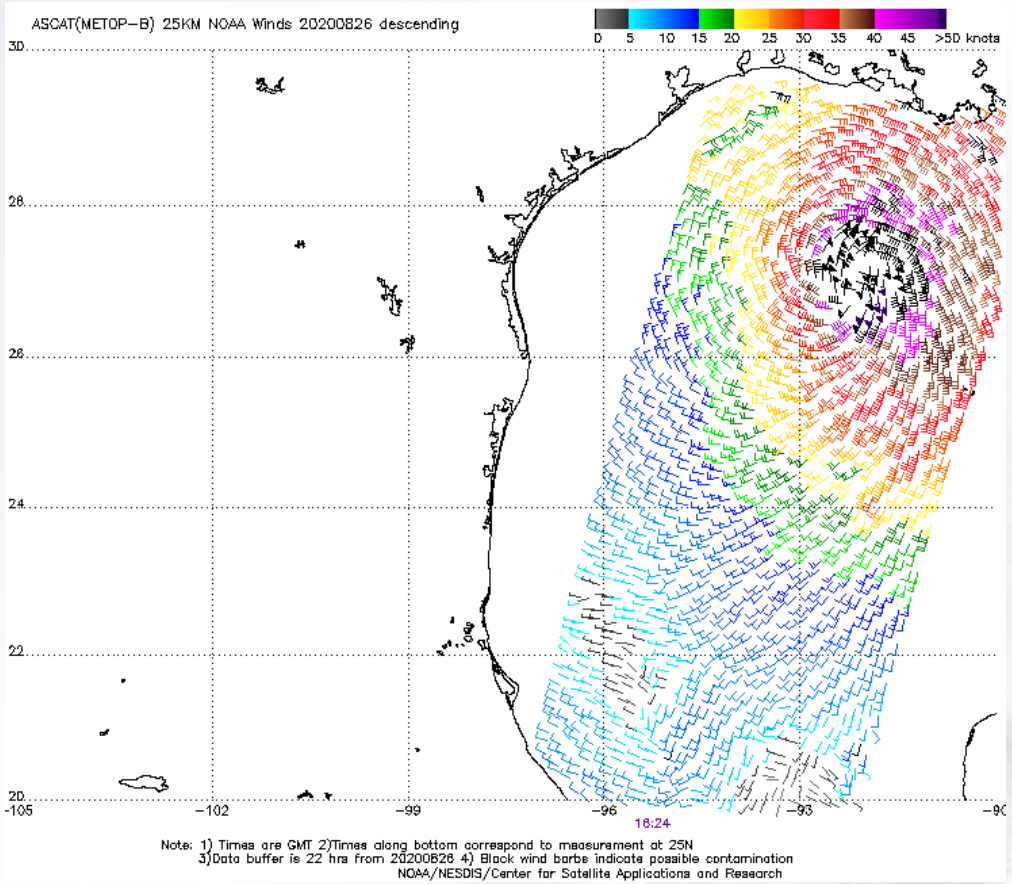


Accessing Scatterometer Data

NOAA/NESDIS

https://manati.star.nesdis.noaa.gov/

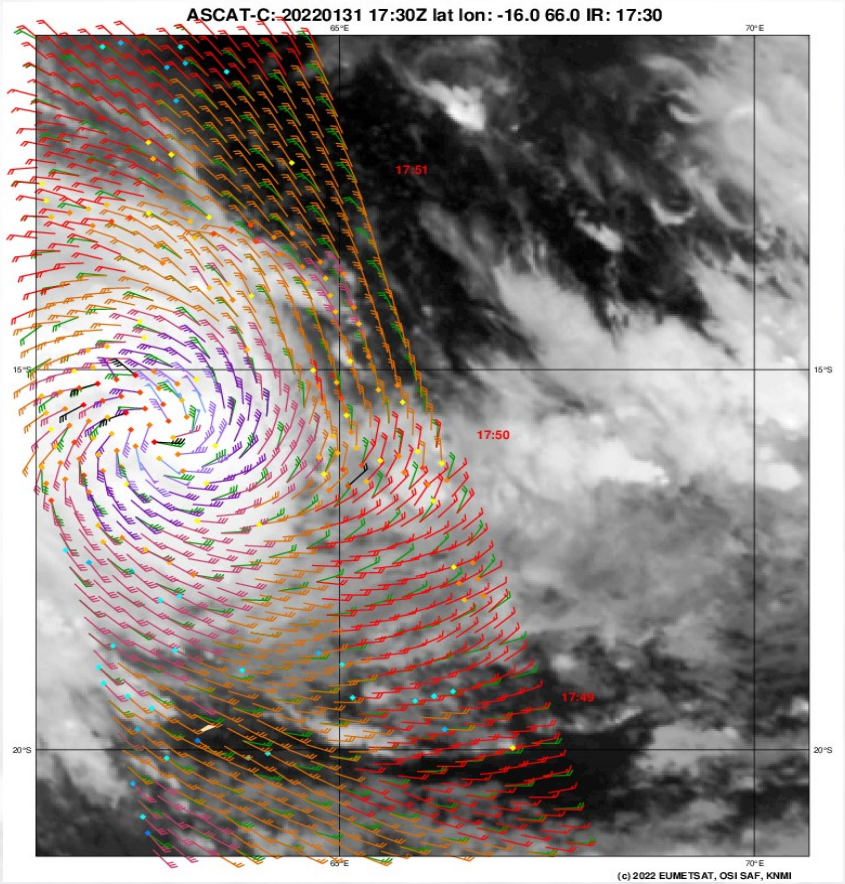
(25- and 50-km ASCAT wind vector products)



KNMI/EUMETSAT

https://scatterometer.knmi.nl/tile_prod

(Includes other international data products)



Key Points

- Microwave imagery can be used to identify various features that might be a challenge to see in other satellite imagery
  - 37 GHz and 85-91 GHz show storm structure at different levels
  - Use 37 GHz to identify low-level circulation center
  - Data is received 1-3 hours after it is collected, and the poor resolution of some satellites can make data interpretation difficult

- Scatterometer data can be used to help identify the center of circulation and assess the low-level wind field of TCs
  - Scatterometer winds are derived; it is not a direct measurement of surface winds
  - Estimating peak wind speeds using scatterometry will yield underestimates due to the low spatial resolution of the instrument