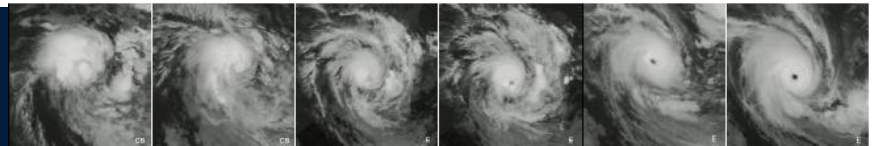
Tropical Cyclones: Positioning

Objectives:

- Techniques in positioning
- Microwave interpretation



Joe Courtney

Tropical Cyclone Positioning

From Dvorak (1985):

> "The cloud system center is defined as the focal point of all the curved lines or bands of the cloud system. It can also be thought of as the point toward which the curved lines merge or spiral."

Centre not always obvious, especially at night.

Tropical Cyclone Positioning

USE **ALL** SOURCES OF INFORMATION

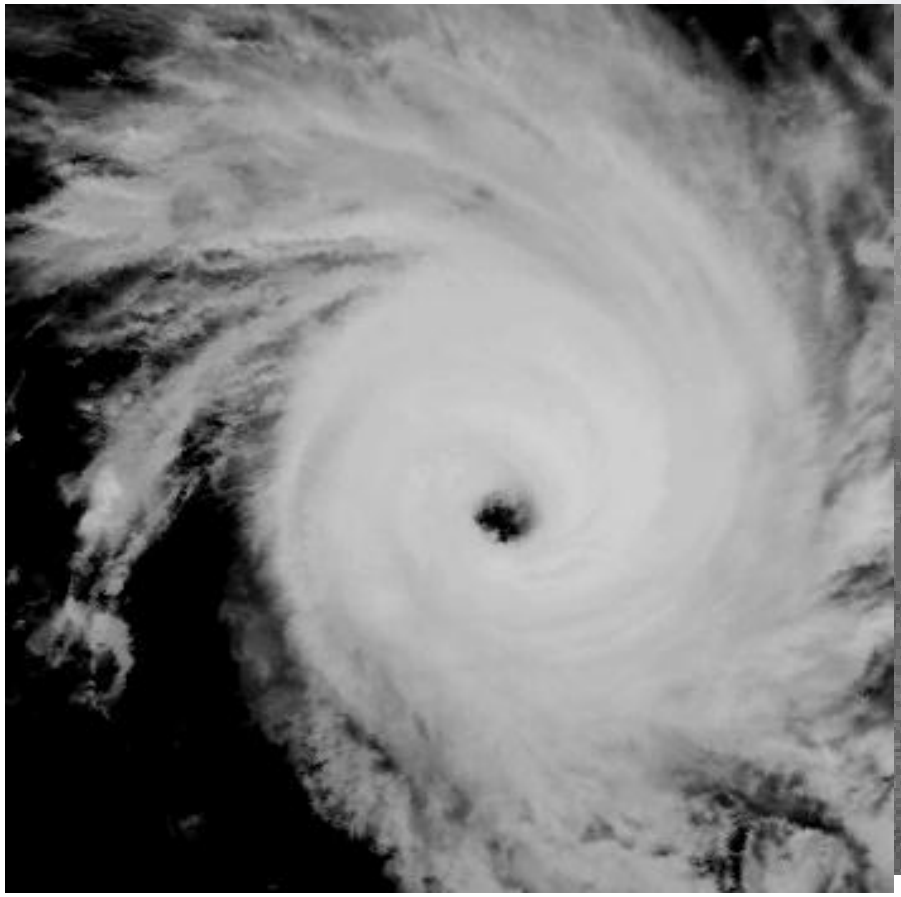
Radar, Microwave, AScat, Surface Observations …

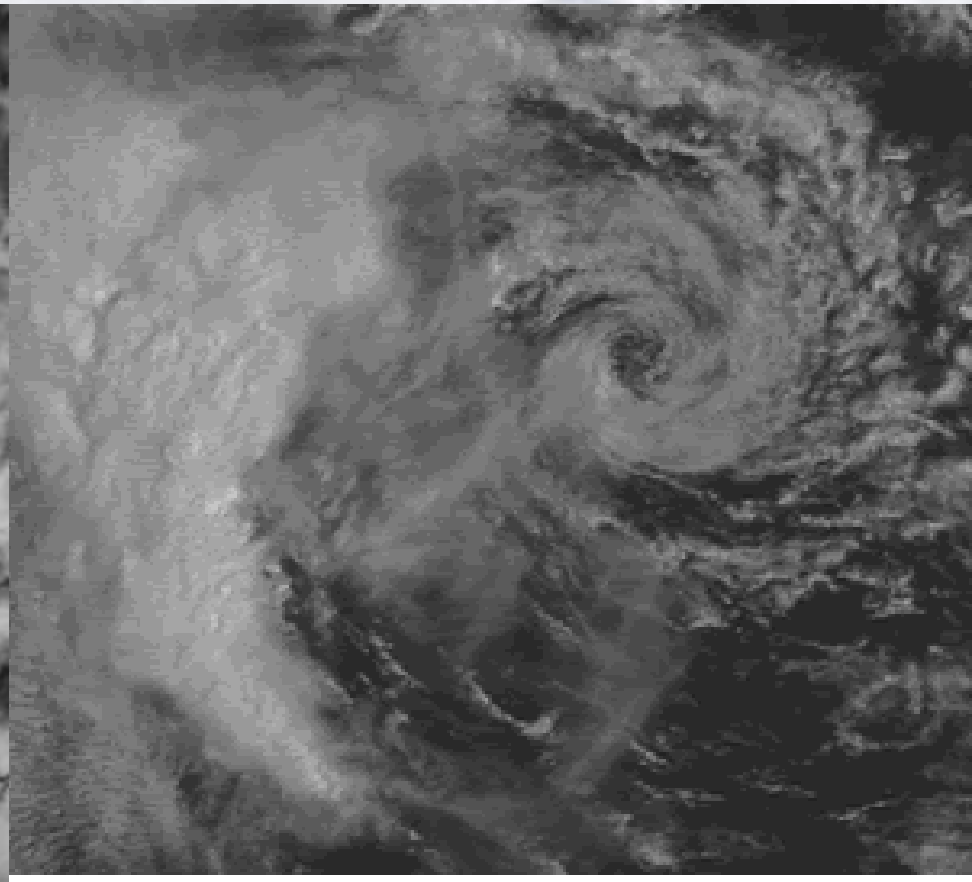
Maintain track continuity, Find LOW level circulation (LLCC)

Locating the centre by IR/VIS

- Partially exposed LLCC
- Cloud minimum wedge
- Cirrus outflow
- Circle method
- Conservative feature
- Animation
- Extrapolation

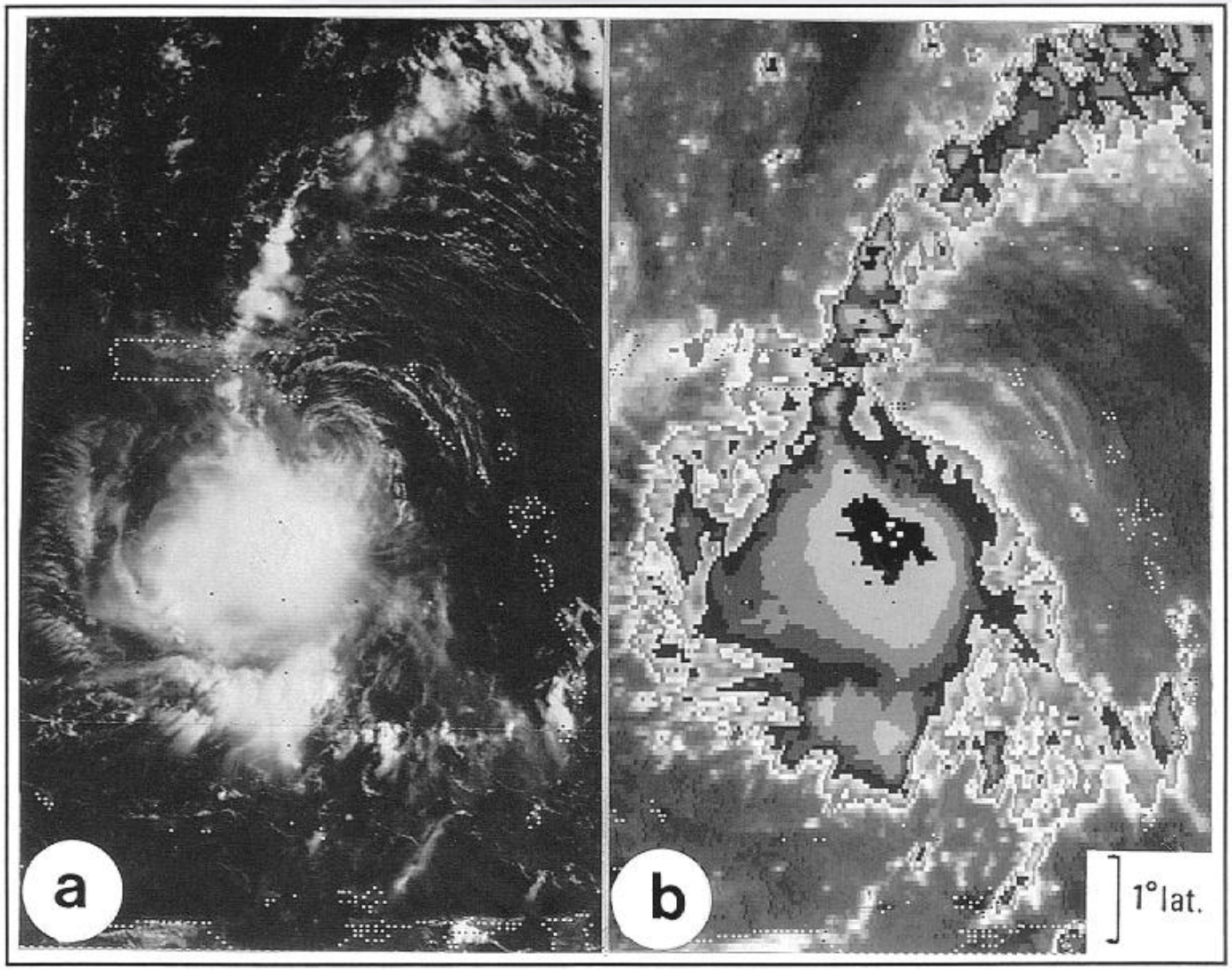
Exposed Low Level Circulation Centre (LLCC)





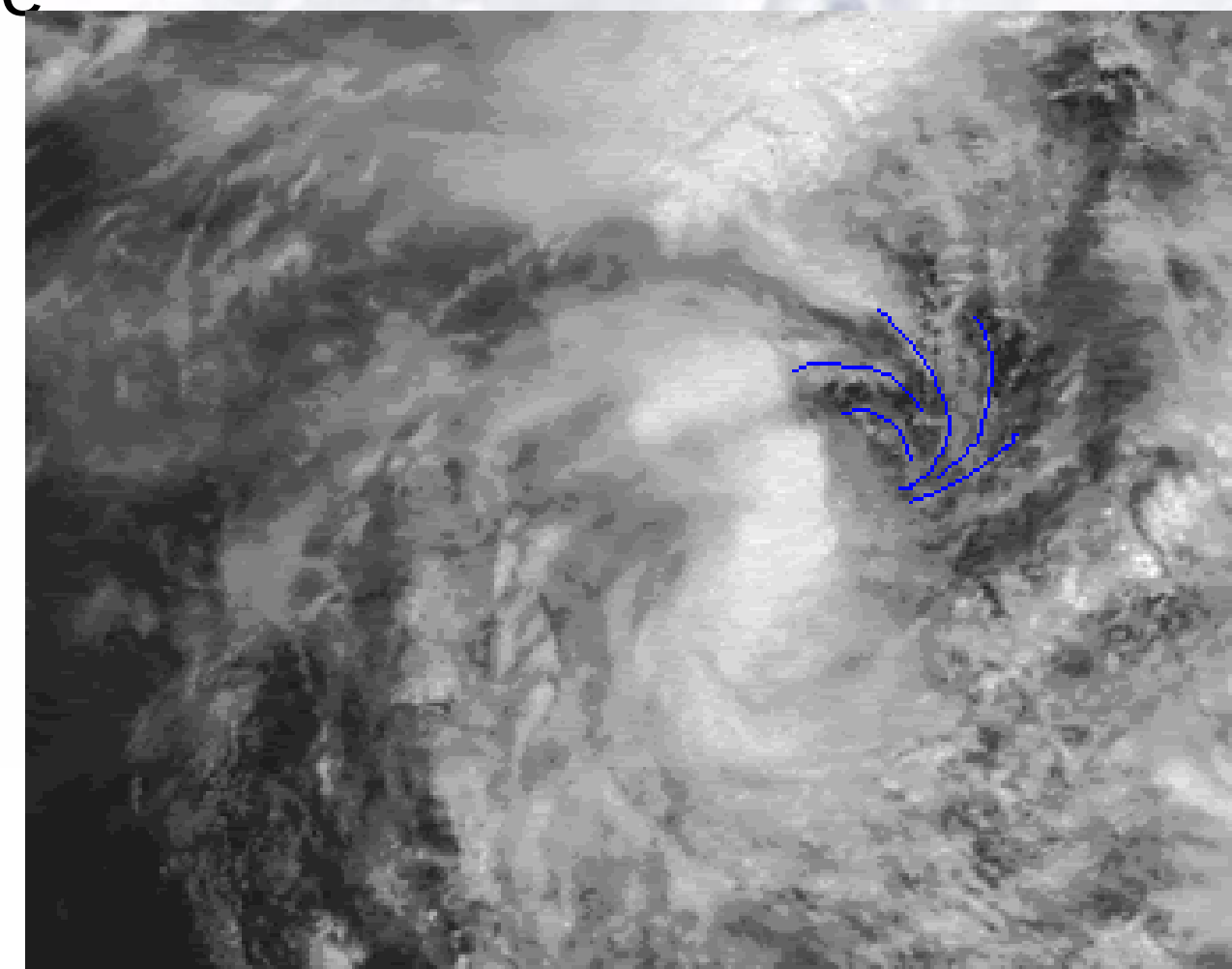
Exposed Low Level Circulation Centre (LLCC)

VIS Vs IR



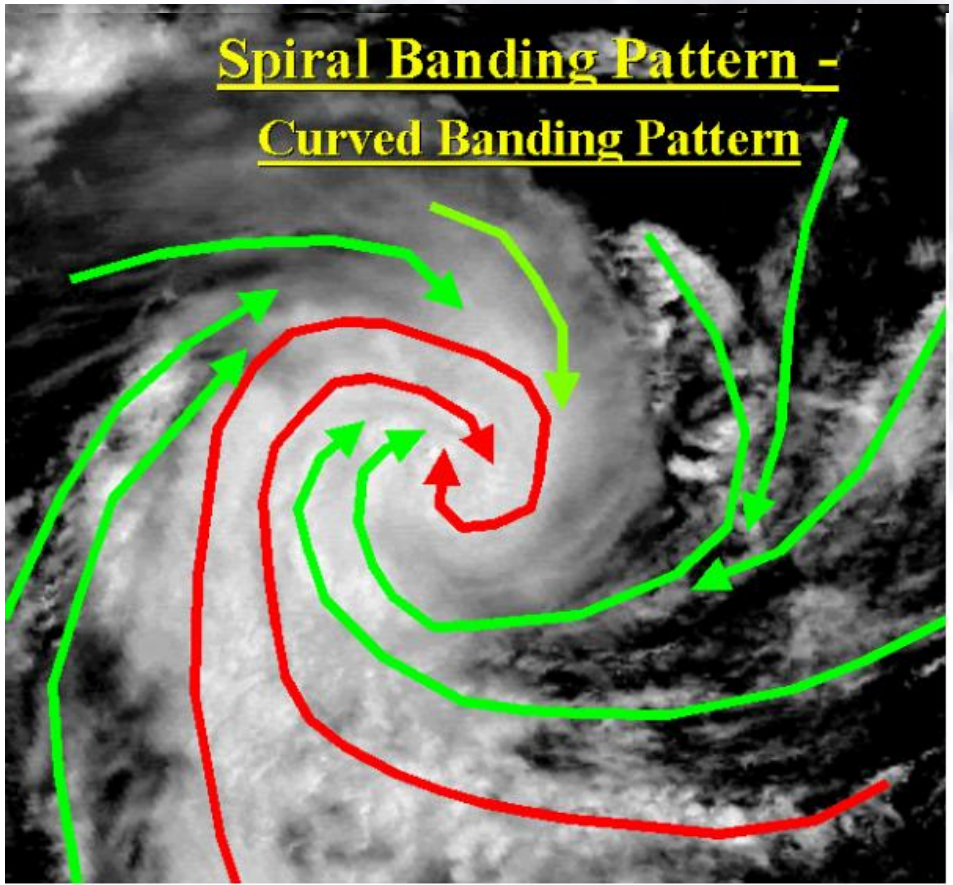
Exposed Low Level Circulation Centre (LLCC)

Partial Exposure



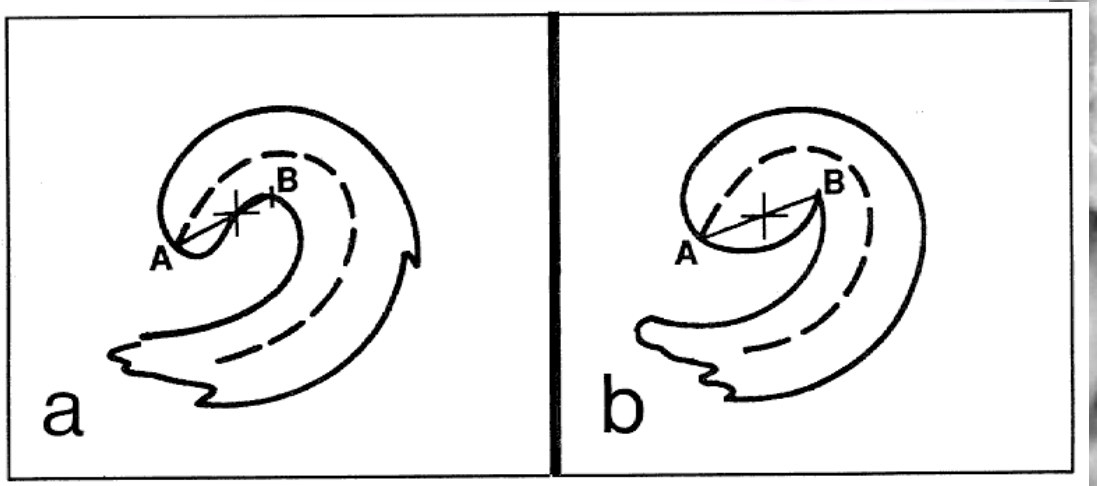
Southern Hemisphere Example

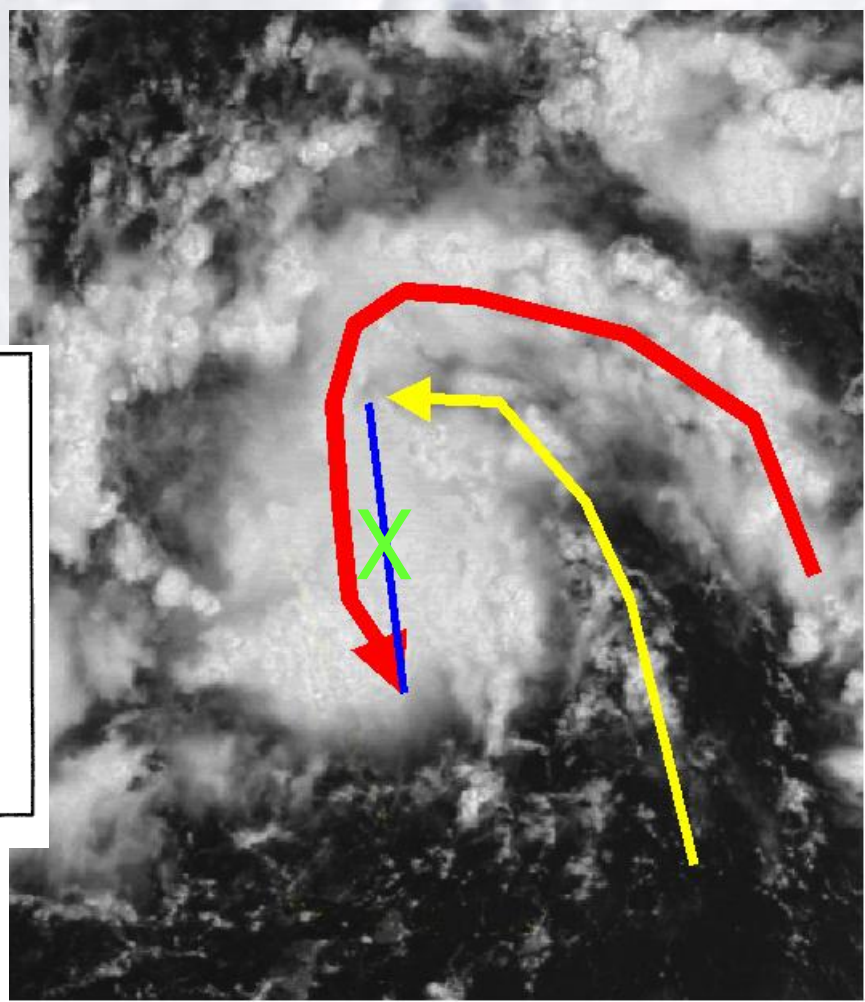
Following the cloud line or band curvature



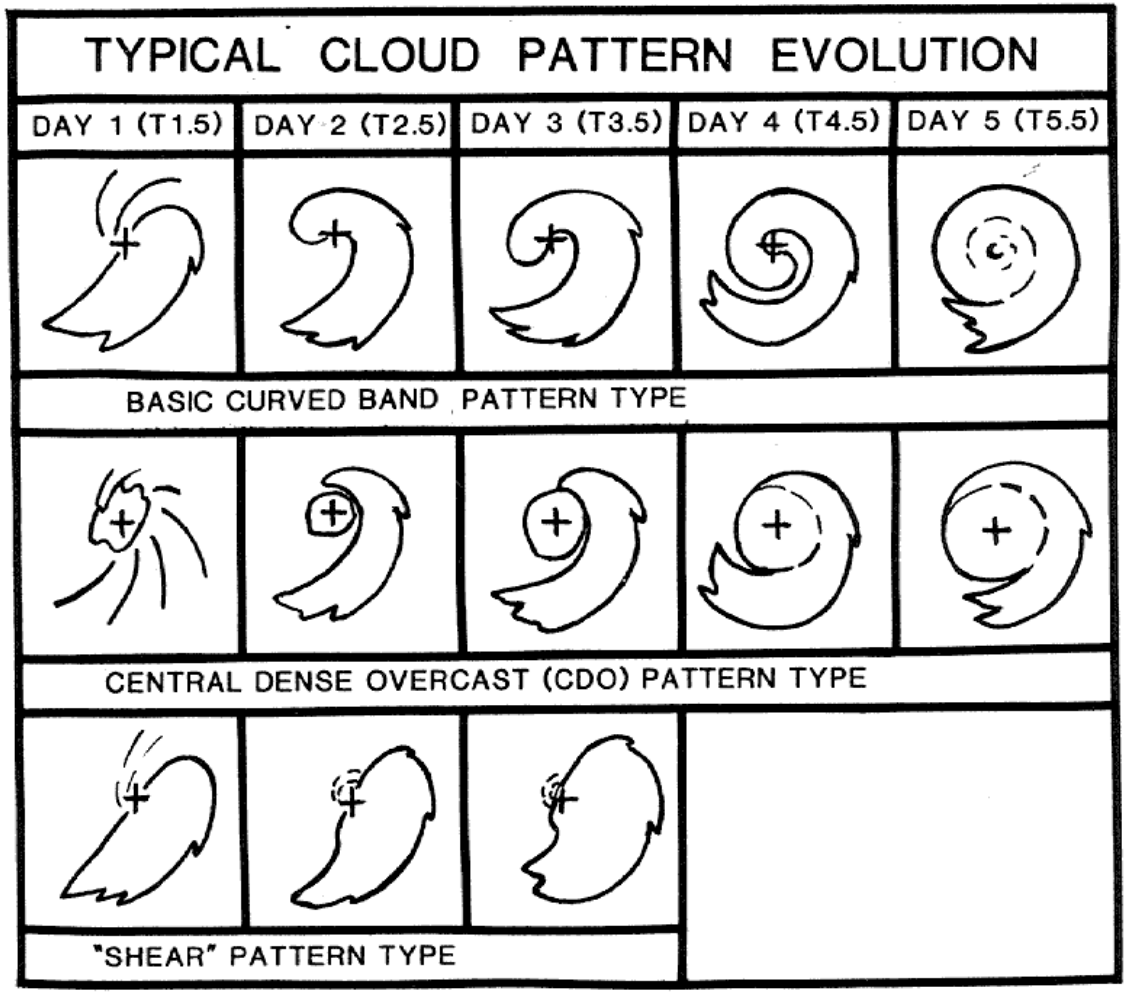
Southern Hemisphere Example

Cloud Minimum Wedge



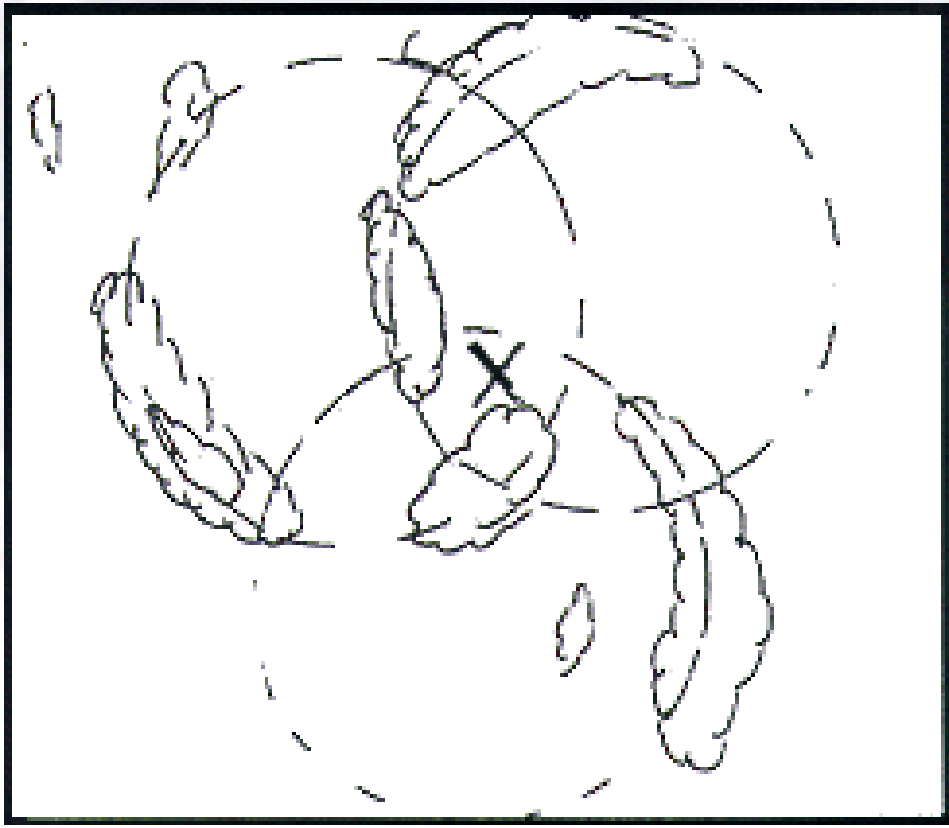


Modelled Cloud Centre



Circle method

- To be used with weak or very broad systems.
- Use all available curvature to find centre.
- Where most circles meet, indicates most likely LLCC.



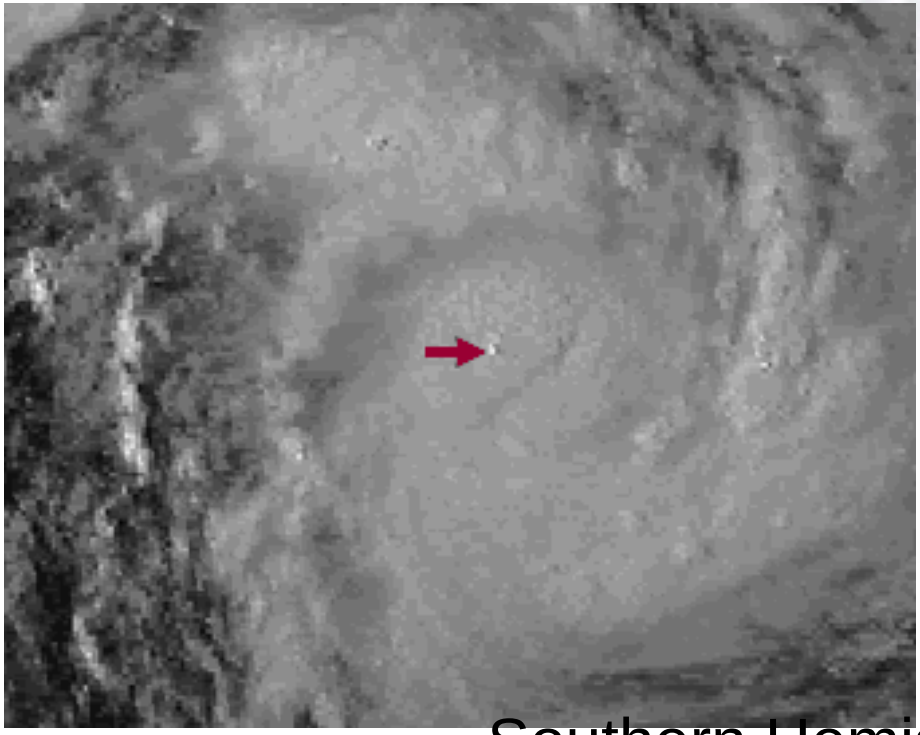
- Covered Centre

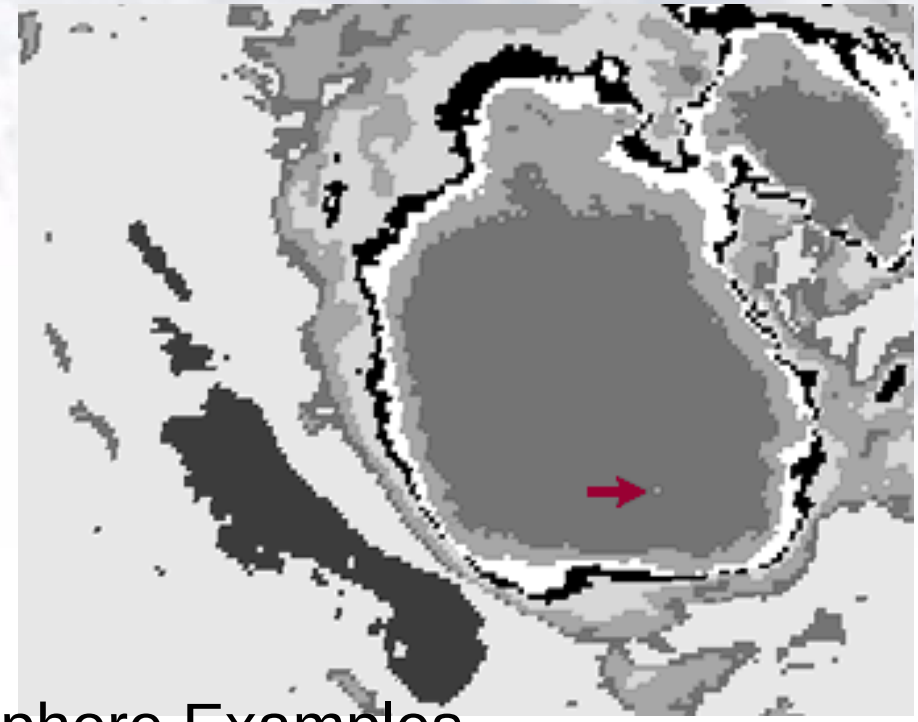
Central Dense Overcast

Embedded Centre

Overshooting Tops

Warm spots



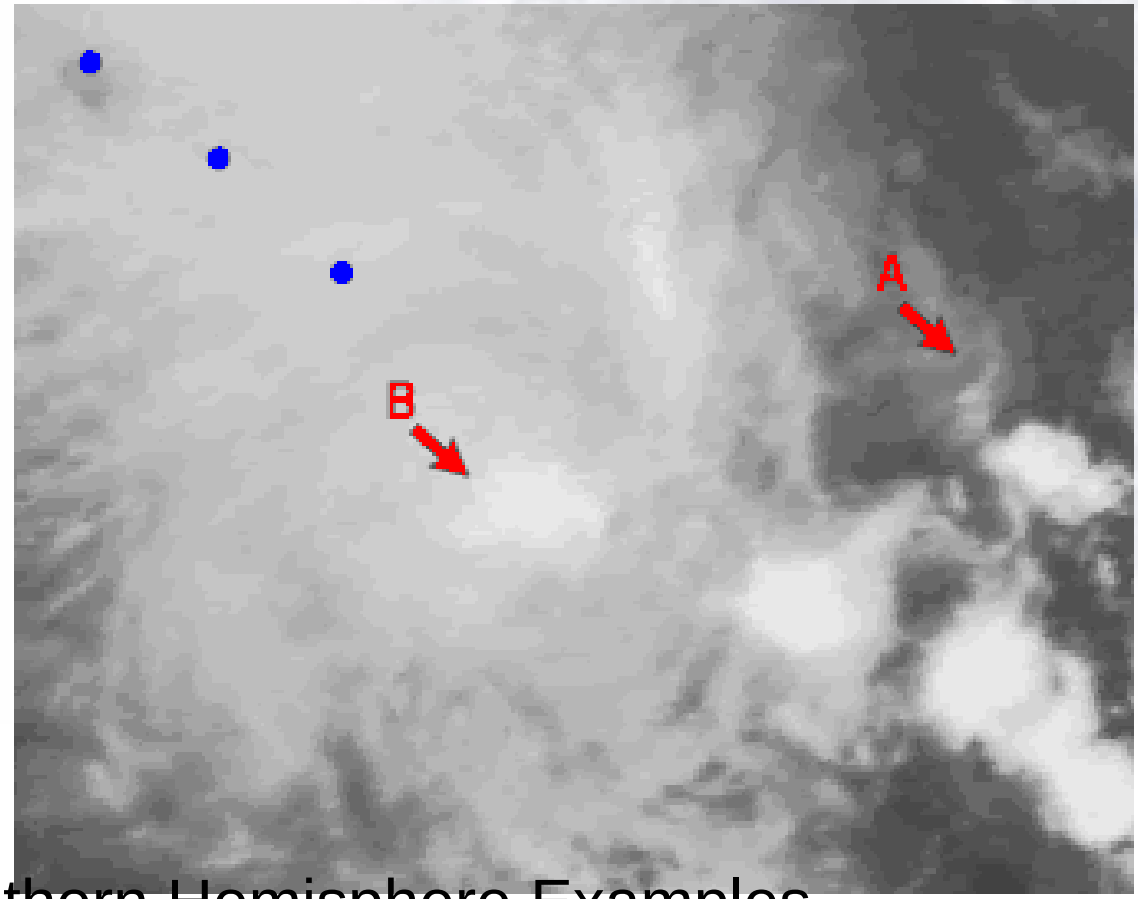


Southern Hemisphere Examples

Principles of the Dvorak Method

Locating the centre

- Compare Centre location with forecast

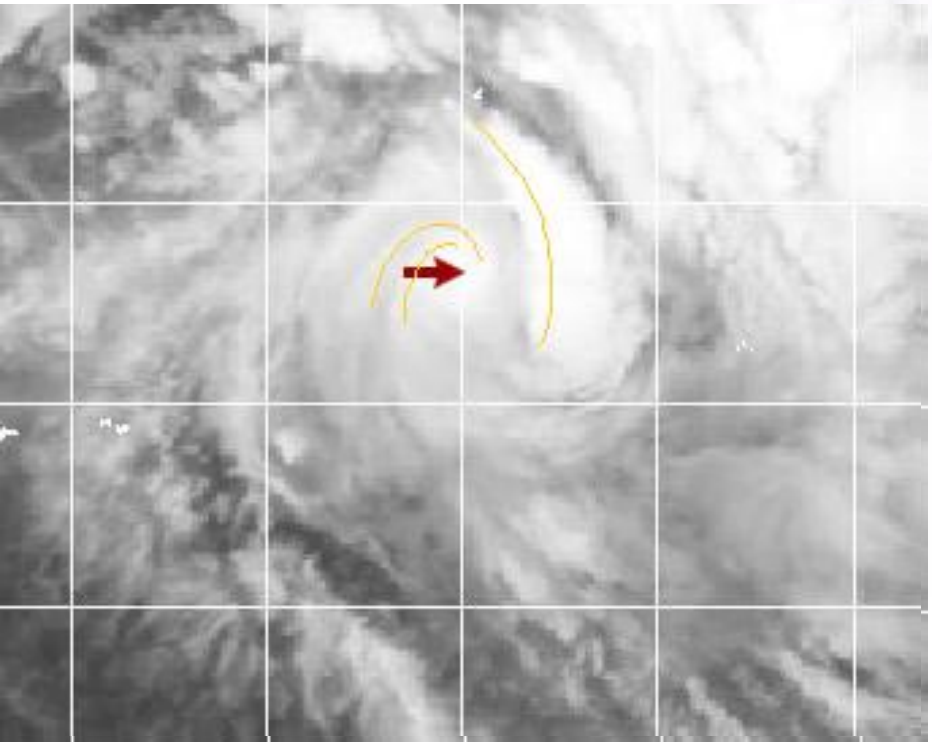


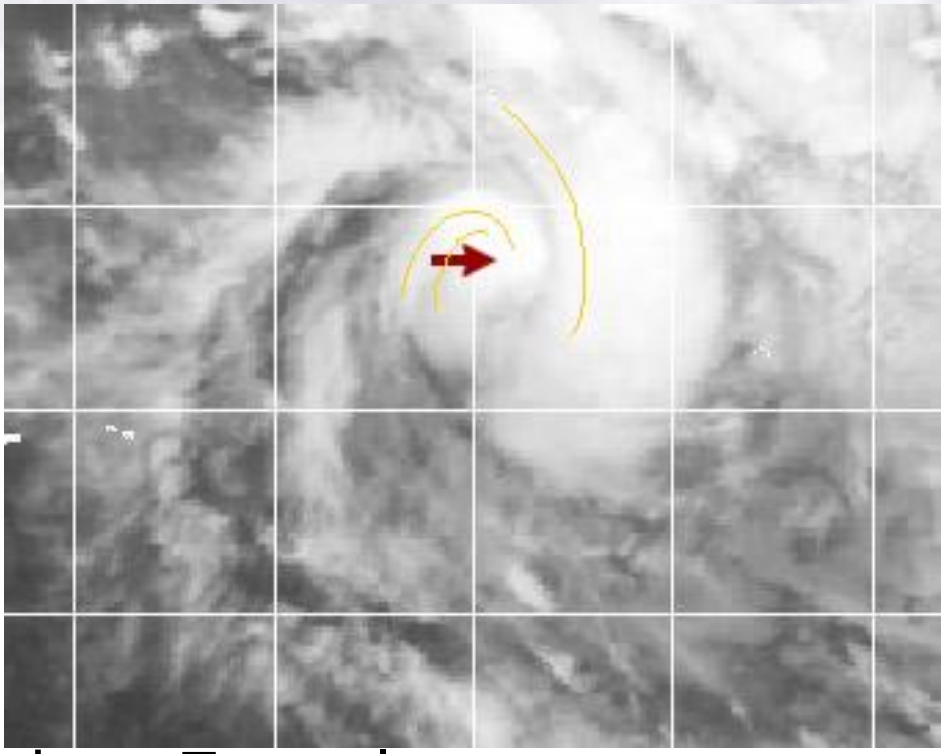
Southern Hemisphere Examples

Compare Centre location with previous location

(Use animation)

three hours later





Southern Hemisphere Examples

Microwave Imagery Interpretation

Why Microwave?

Satellites and access

Features of 37 and 85 frequencies

How to use both

XX Intensity

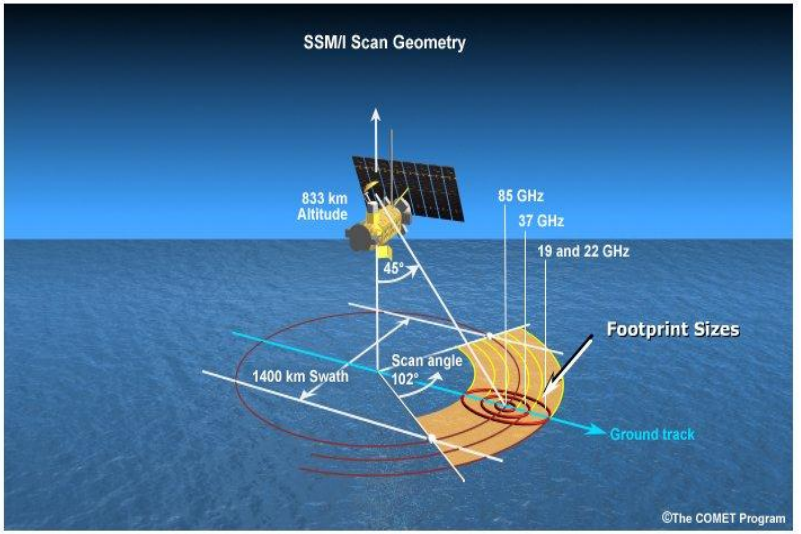
COMET microwave training

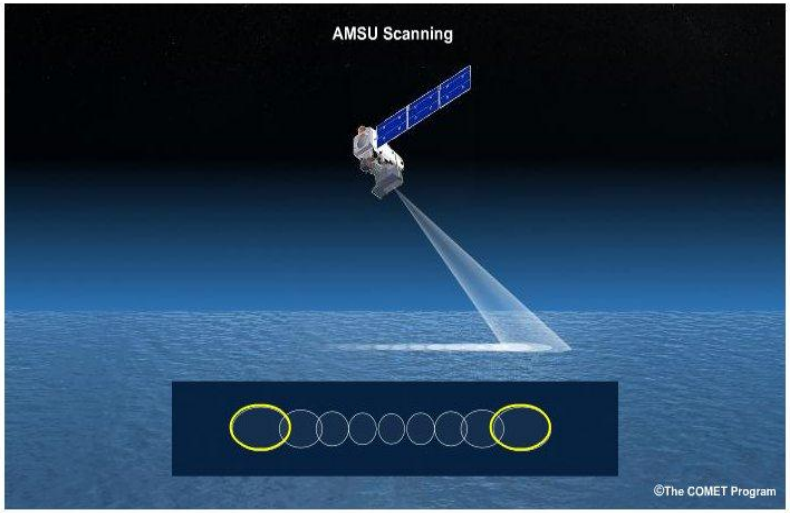
www.meted.ucar.edu

Acknowledgements: Roger Edson

The Satellites

- Polar Orbiting Conical Scanner
  - SSMI
  - SSMIS
  - AMSRE
  - TMI (TRMM)
- cross track AMSU
- Conical scanning produces narrower scan widths but maintains footprint resolution across the entire scan
- Cross-track scanners have wider scan swaths, but resolution degrades toward the edge of scan

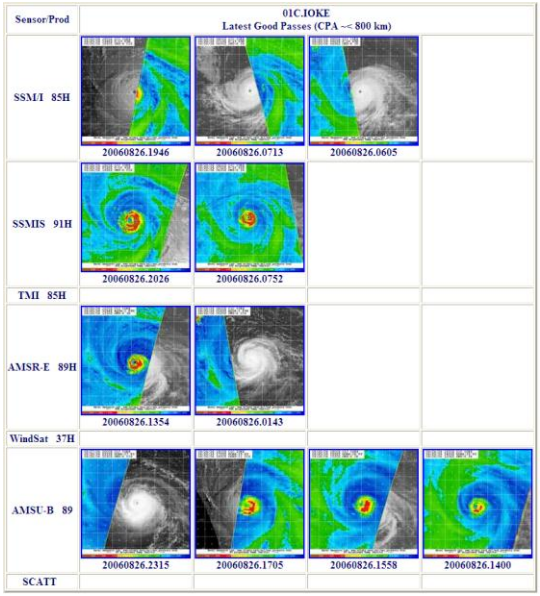




NRL web pages

	VIS	IR	IR-BD	Multi Sens.	85GHz H	85GHz weak	85GHz PCT	Color	Rain	Wind	37GHz Color	37GHz V	37GHz H	SSM/I Vapor	Scatt
SSMI:															
SSMIS:															
TMI:															
AMSRE:															
WINDSAT:															
AMSUB:															

<= 6 hrs. old, <= 12 hrs. old, > 12 hrs.



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

Alternate Page at FNMOC

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

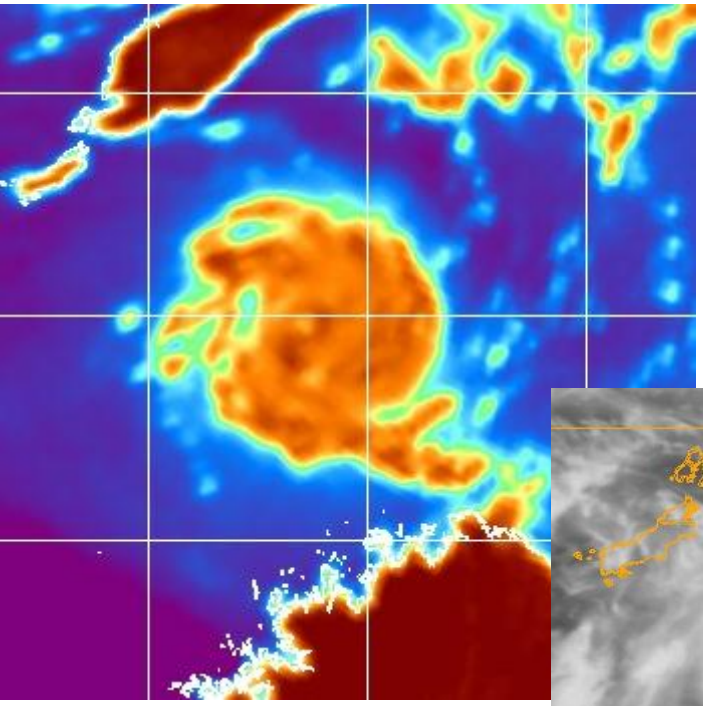
FNMOC Satellite Data Tropical Cyclone Page

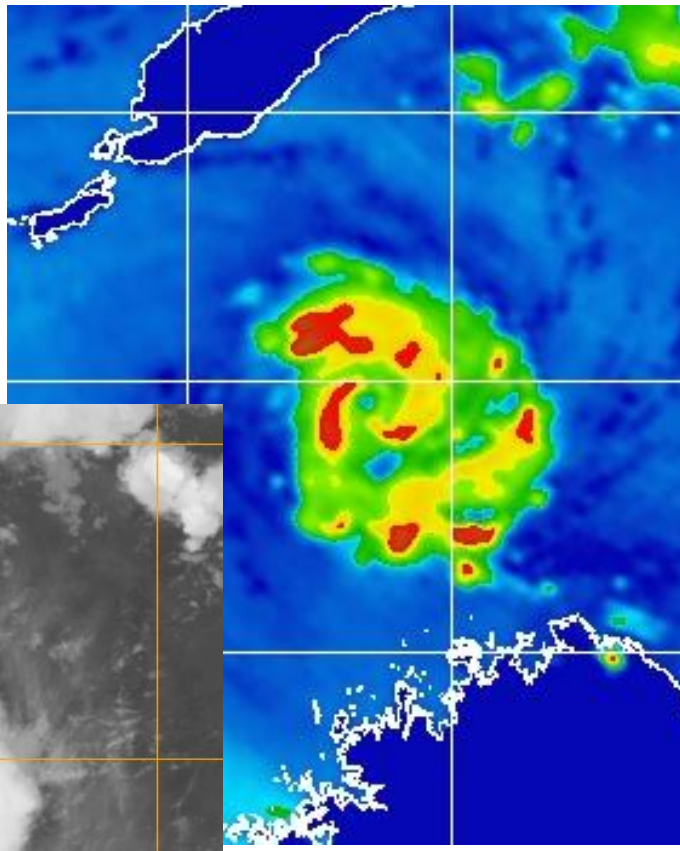
Display Latest Prev. | Warn: Text Track ATCF | 1_km: Track&Image VIS IR | Info: General Tutorial Disclaimer

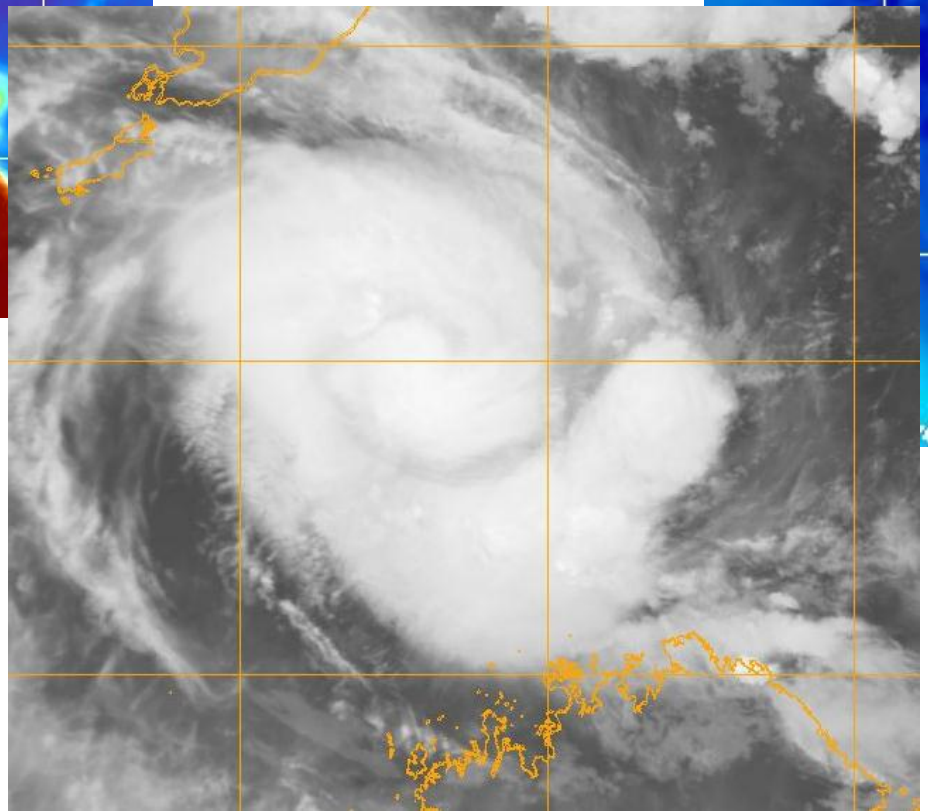
SSMI	VIS	IR	IR-BD	4Panel	85H	85HWeak	85PCT	85Color	Rain	Wind	37H	37V	37Color	37PCT	Vapo
TMI	VIS	IR	IR-BD	4Panel	85H	85V	85PCT	85Color	Rain	Wind	37H	37V	37Color	37PCT	Wate
AMSU					89H			89Color	Rain						
QuikScat	NCEP	FNMOC	Ambig												
AMSR-E	VIS	IR	IR-BD	4Panel	89H		89PCT	89Color			36H	36V	36Color		
SSMIS	VIS	IR	IR-BD	4Panel	91H	91HWeak	91PCT	91Color	Rain	Wind	37H	37V	37Color	37PCT	Vapo
WindSat									Ambig	Wind	37H	37V	37Color	37PCT	

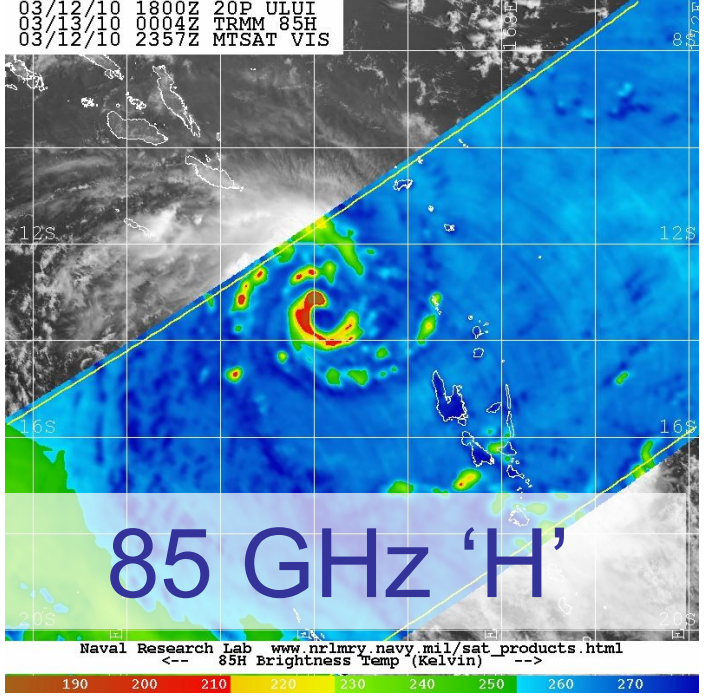
GREEN <= 6 hrs. old; Orange <= 12 hrs. old; RED > 12 hrs. old

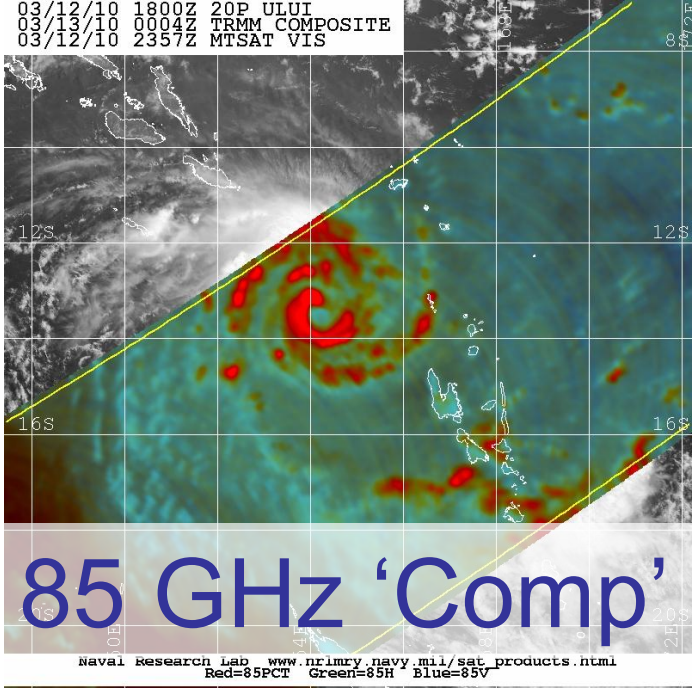
Three views of *Errol*

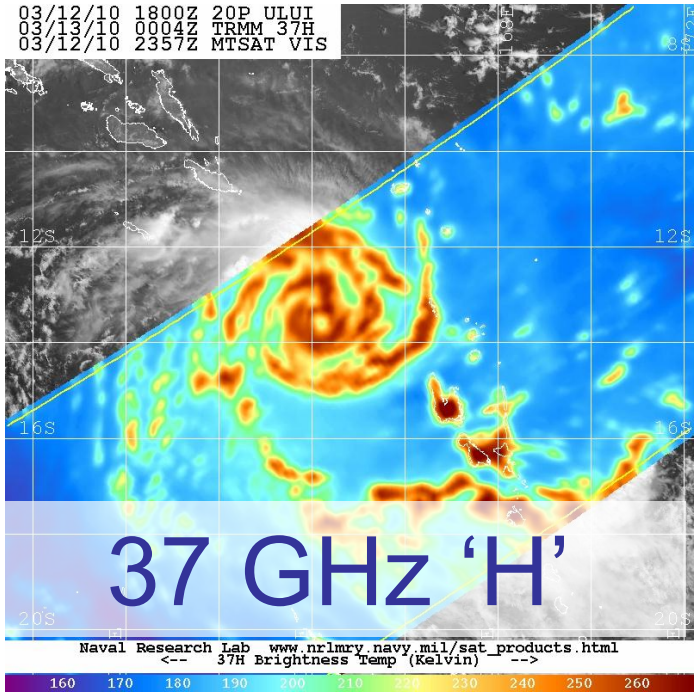


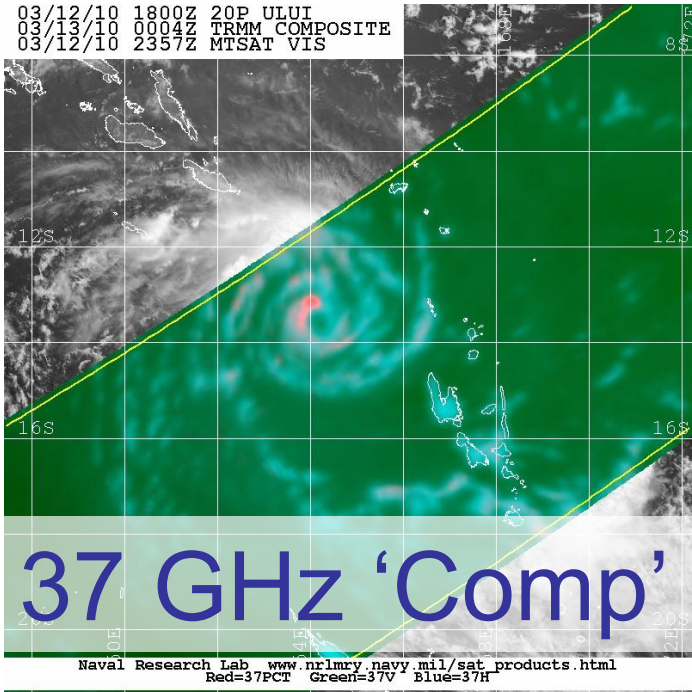





03/12/10 1800Z 20P ULUI
03/13/10 0004Z TRMM 85H
03/12/10 2357Z MTSAT VIS
85 GHz 'H'
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 85H Brightness Temp (Kelvin) -->
190 200 210 220 230 240 250 260 270


03/12/10 1800Z 20P ULUI
03/13/10 0004Z TRMM COMPOSITE
03/12/10 2357Z MTSAT VIS
85 GHz 'Comp'
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
Red=85PCT Green=85H Blue=85V


03/12/10 1800Z 20P ULUI
03/13/10 0004Z TRMM 37H
03/12/10 2357Z MTSAT VIS
37 GHz 'H'
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->
160 170 180 190 200 210 220 230 240 250 260

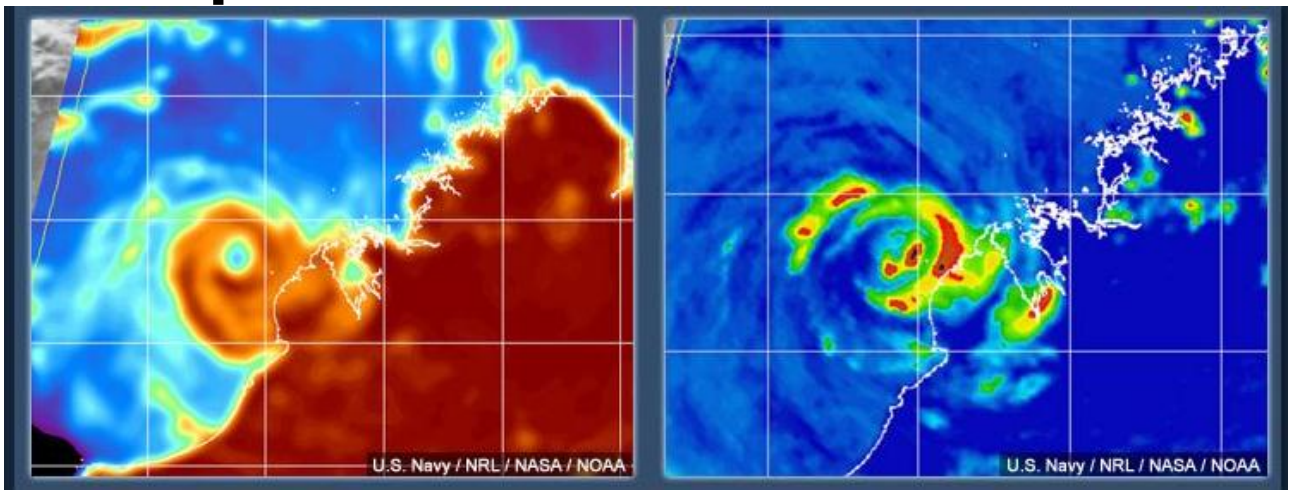

03/12/10 1800Z 20P ULUI
03/13/10 0004Z TRMM COMPOSITE
03/12/10 2357Z MTSAT VIS
37 GHz 'Comp'
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
Red=37PCT Green=37V Blue=37H

37 Vs 85 GHz

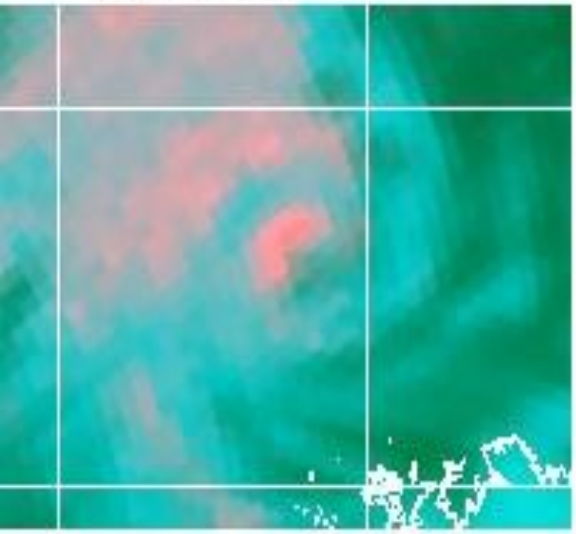
- **37 GHz shows region of low-level clouds/rain and so clearly shows low-level circulation but doesn't distinguish deep convection from rain.**

- **85-91GHz better shows deep convection but can not always see low-level circulation.**

  Use 'colour' enhancement to resolve ambiguity between deep convection and clear ocean surface.



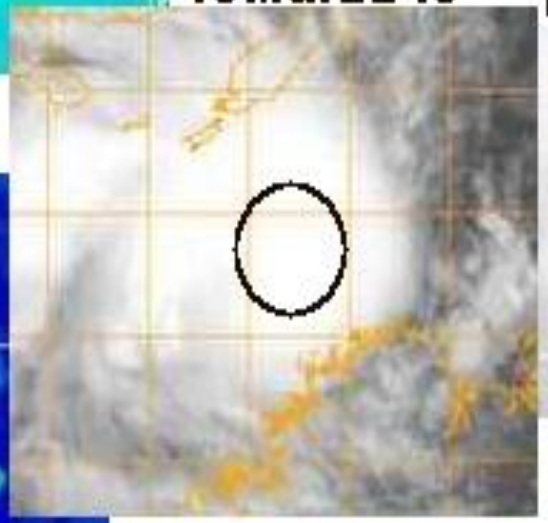
TRMM 37color
19Mar0605



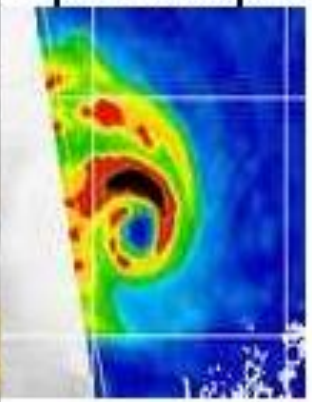
AMSRE 36color
19Mar1641
Confirmed Eye Development

Progression of Tropical Cyclone Fay (18S) in Microwave Imagery

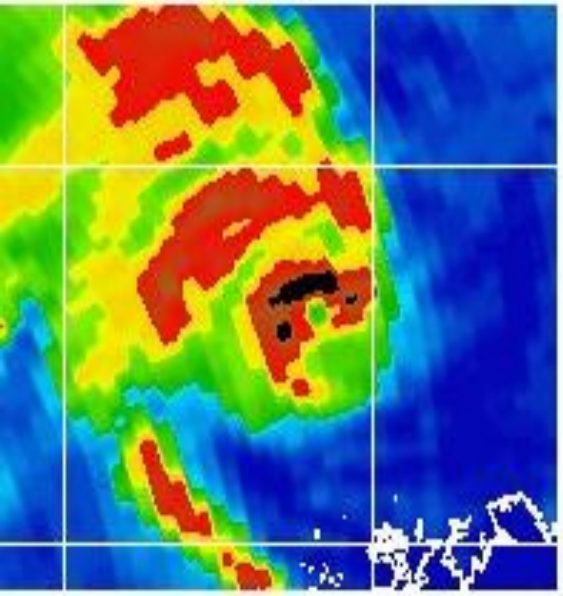
IR Image
19Mar2249



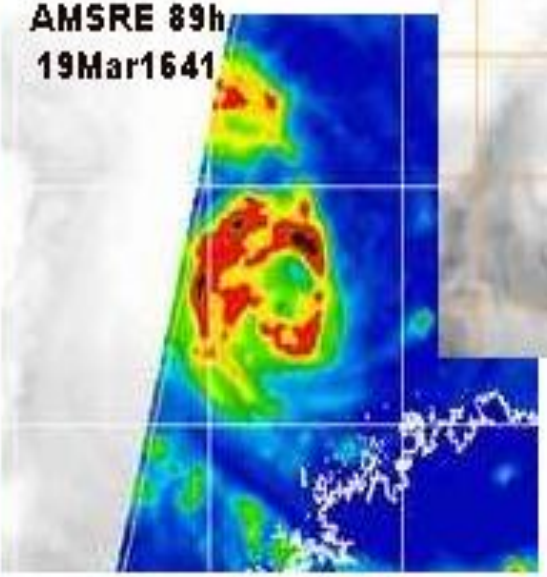
AMSRE 85h
20Mar0413
"Rapid Development"



TRMM 85h
19Mar0605

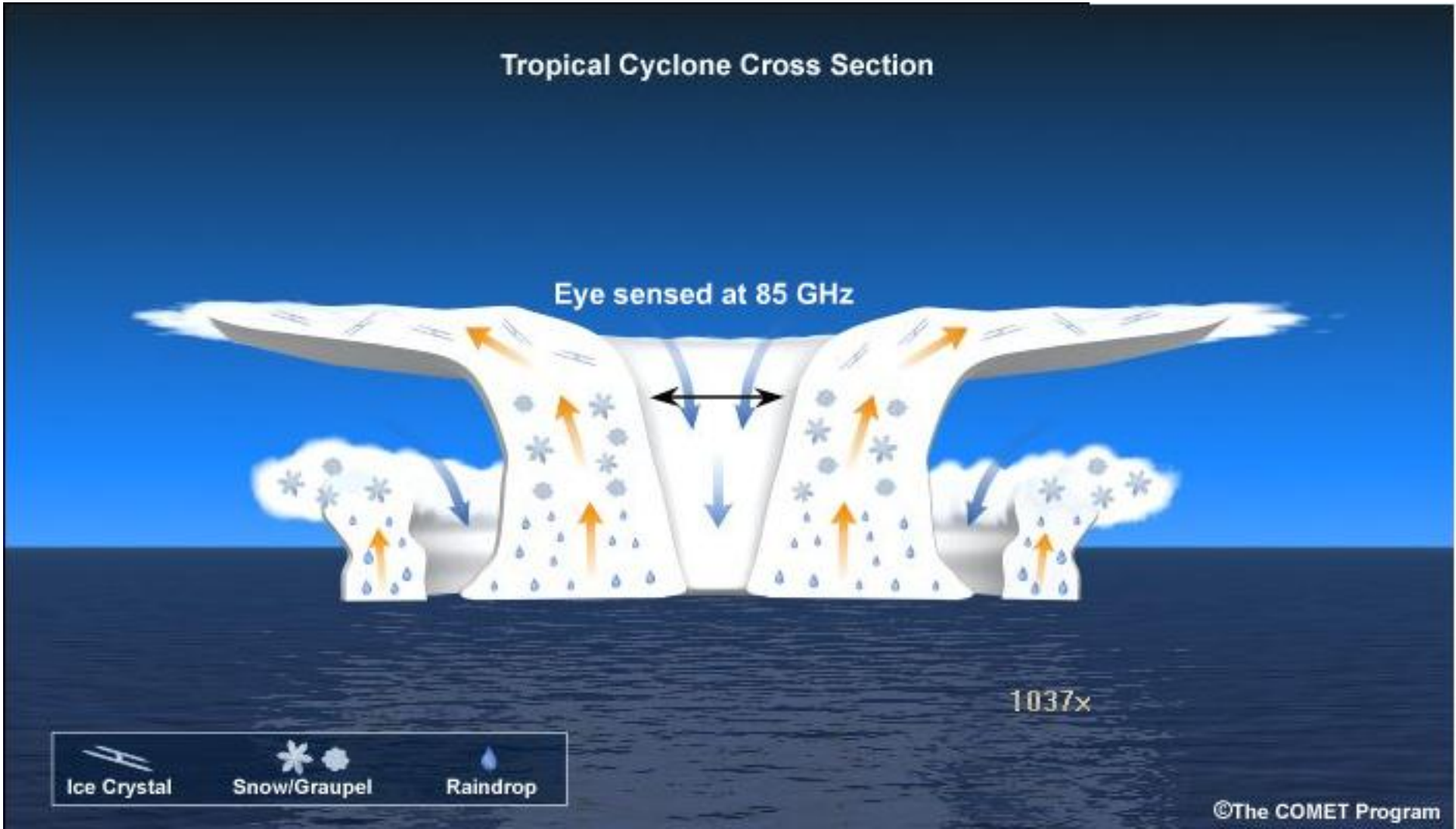


AMSRE 89h
19Mar1641

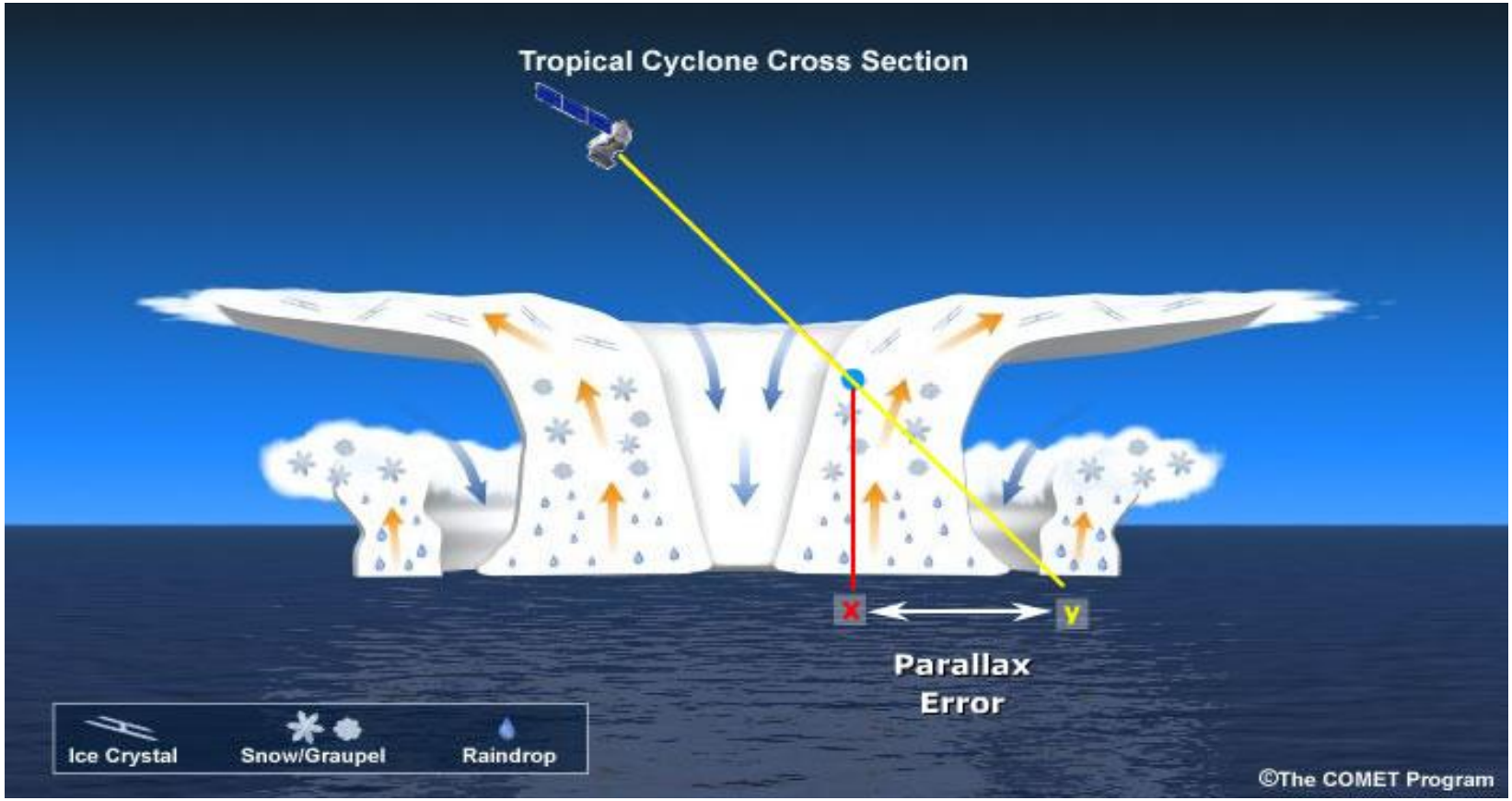


37 Vs 85 GHz

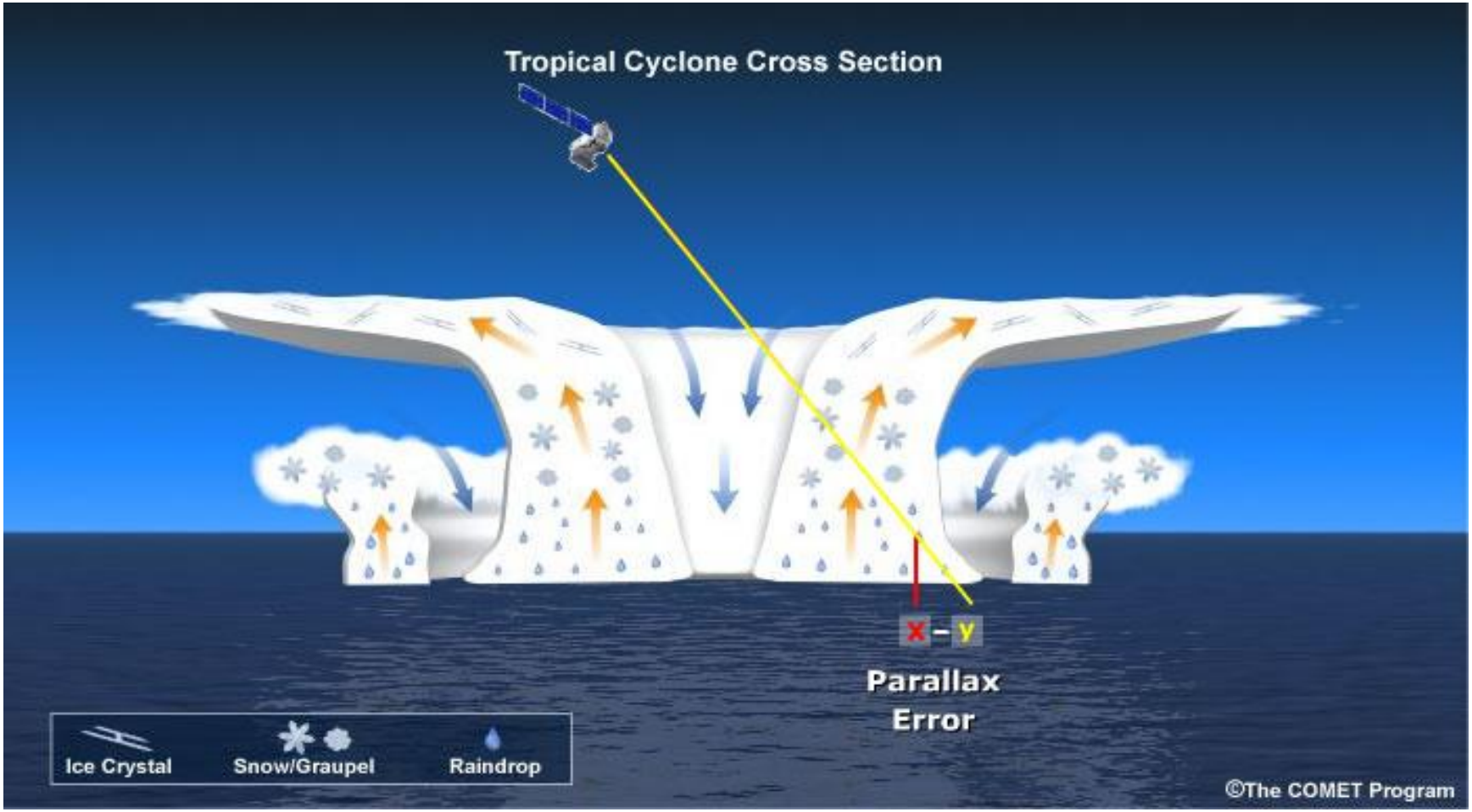
- **Eye looks bigger on 85 GHz because 85GHz represents conditions higher in the storm.**



Parallax at 85-91 GHz



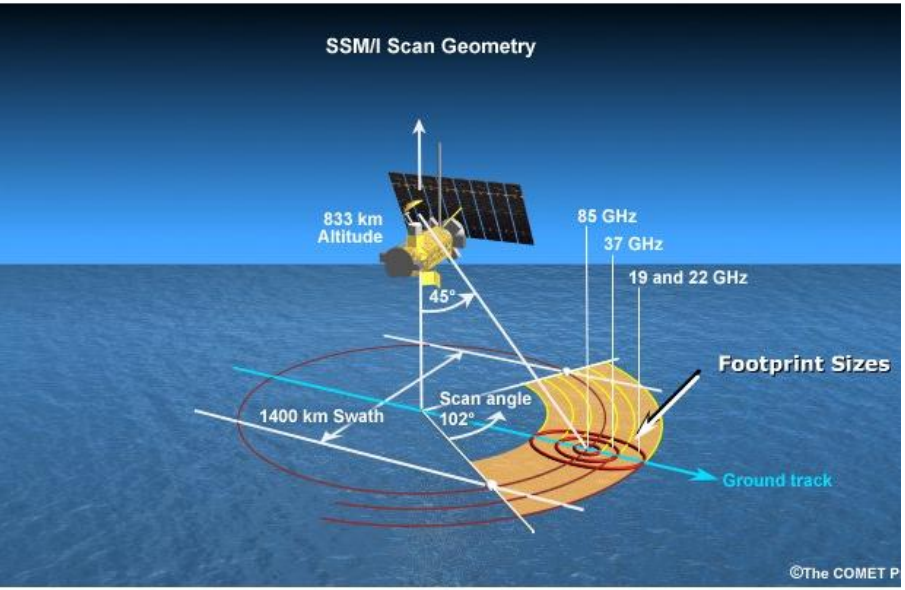
Parallax at 37 GHz

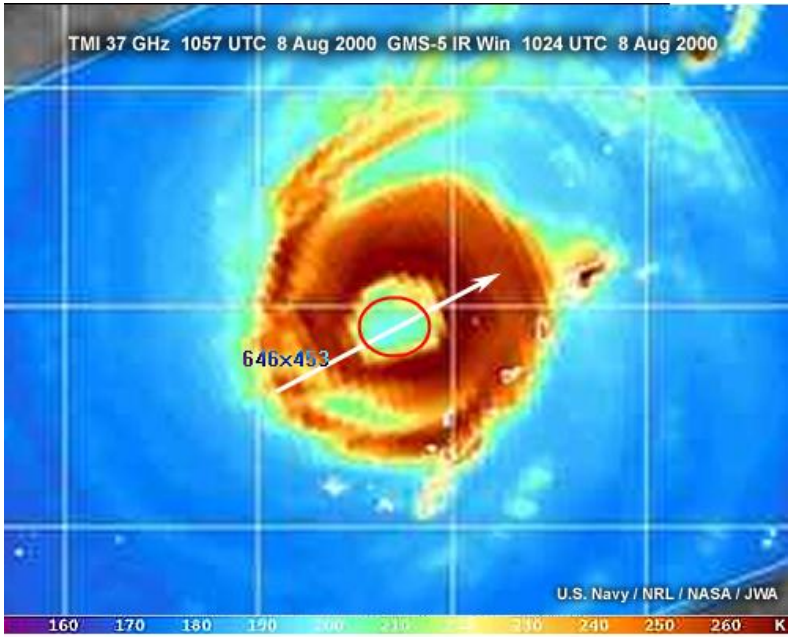


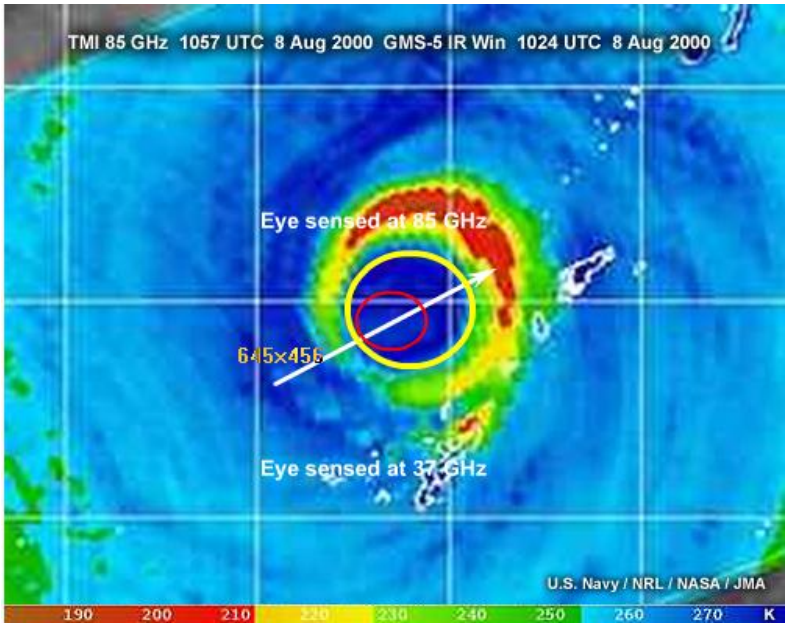
37 Vs 85 GHz - Parallax

- **Parallax error:**
- **37 GHz 5 km or less**

- **85 GHz - 10-20 km**

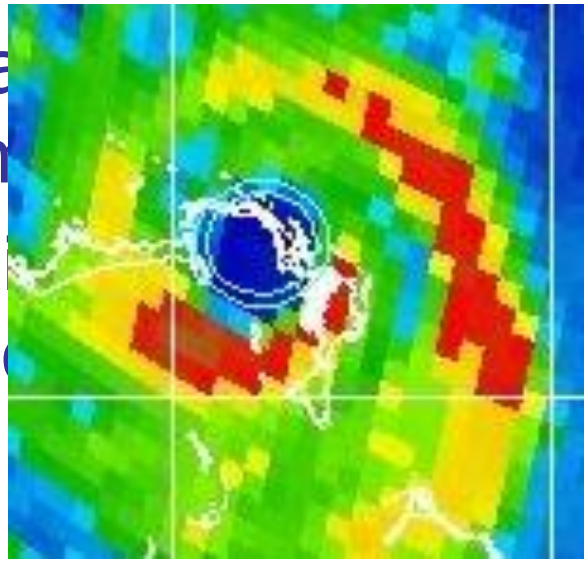


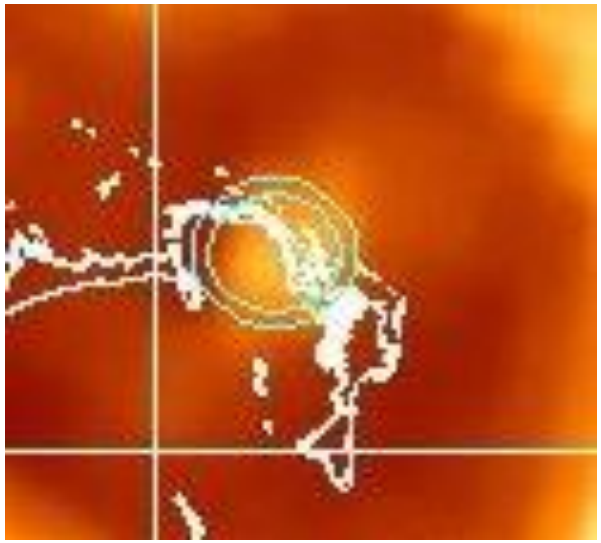


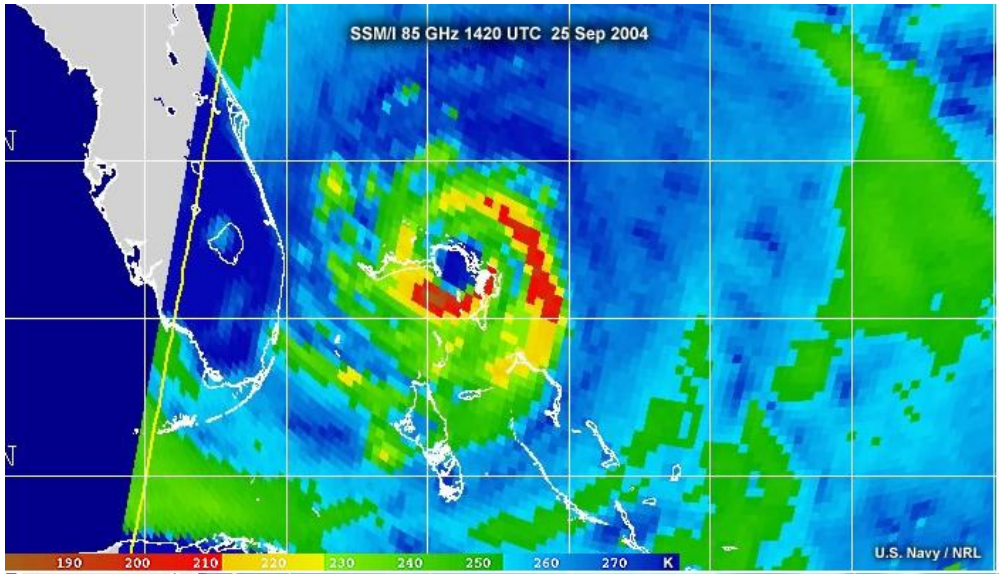


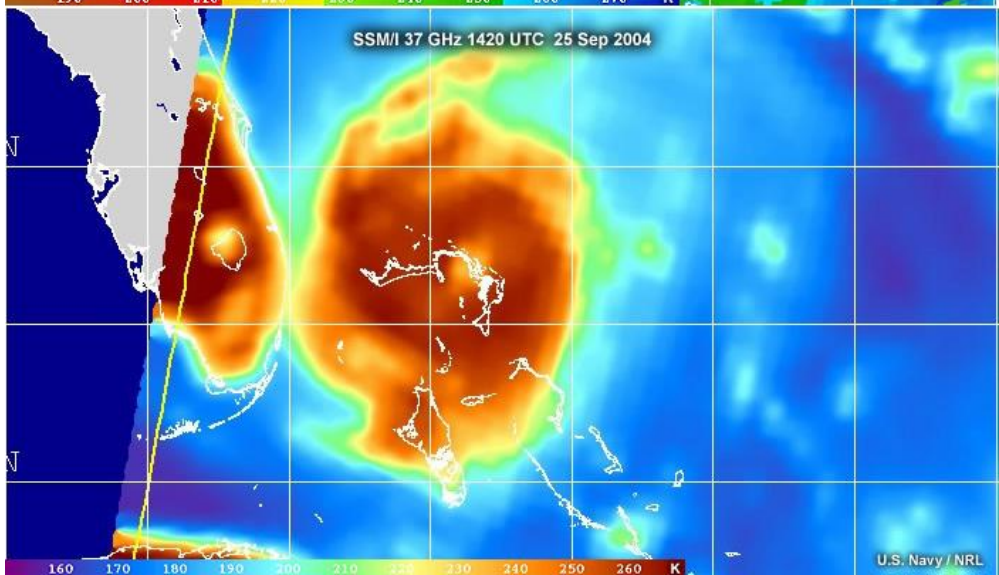
37 Vs 85 GHz Pongsona

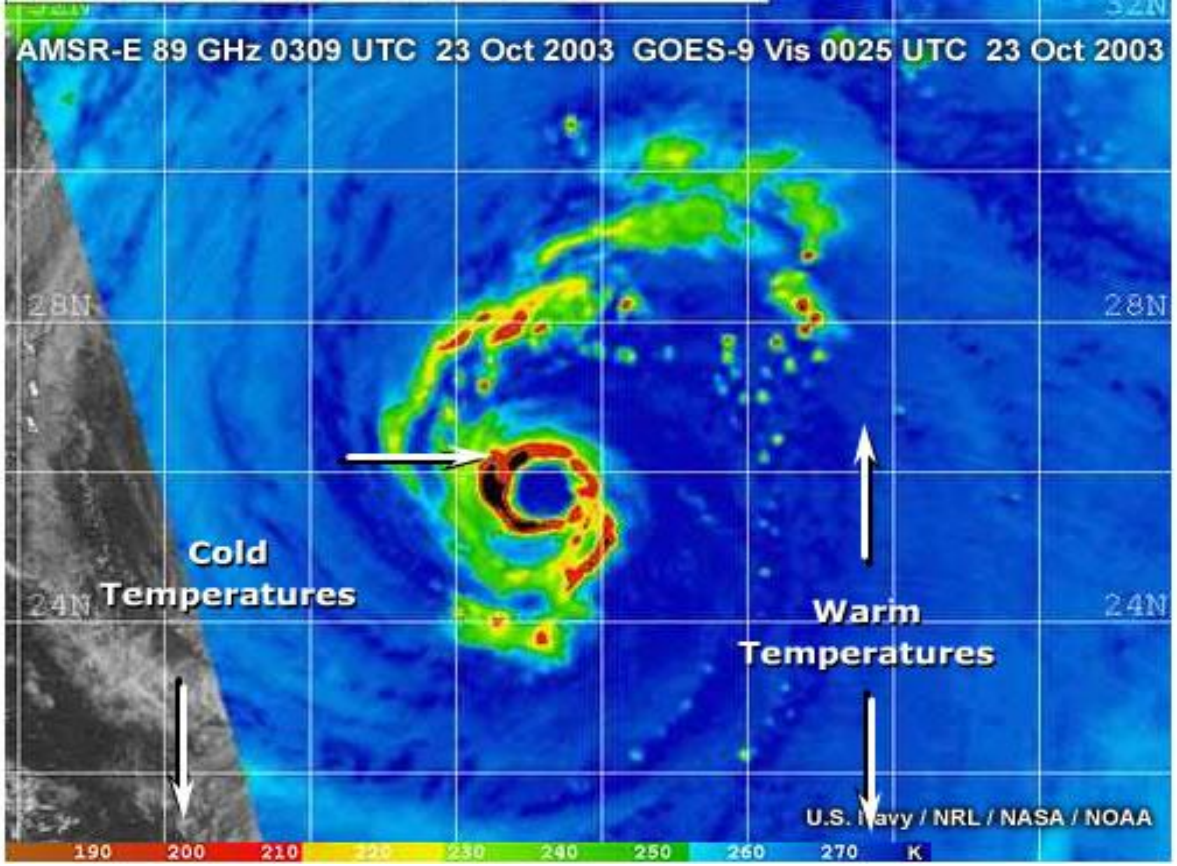
- Wha
  dian
- Rad
  Win



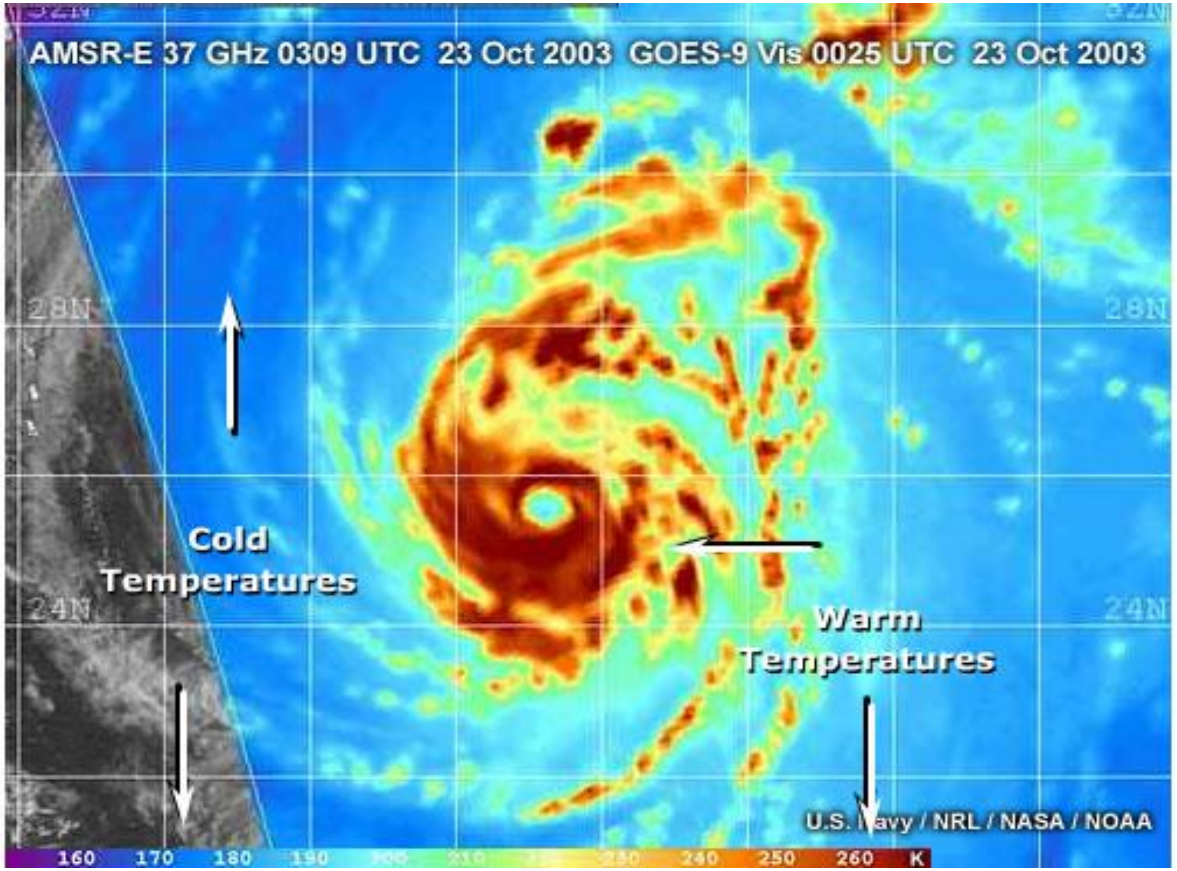








85 GHz image colour scale: blue is warm and red is cold
COLDER temperatures of deep convection at mid levels is RED
WARMER ocean background in BLUE

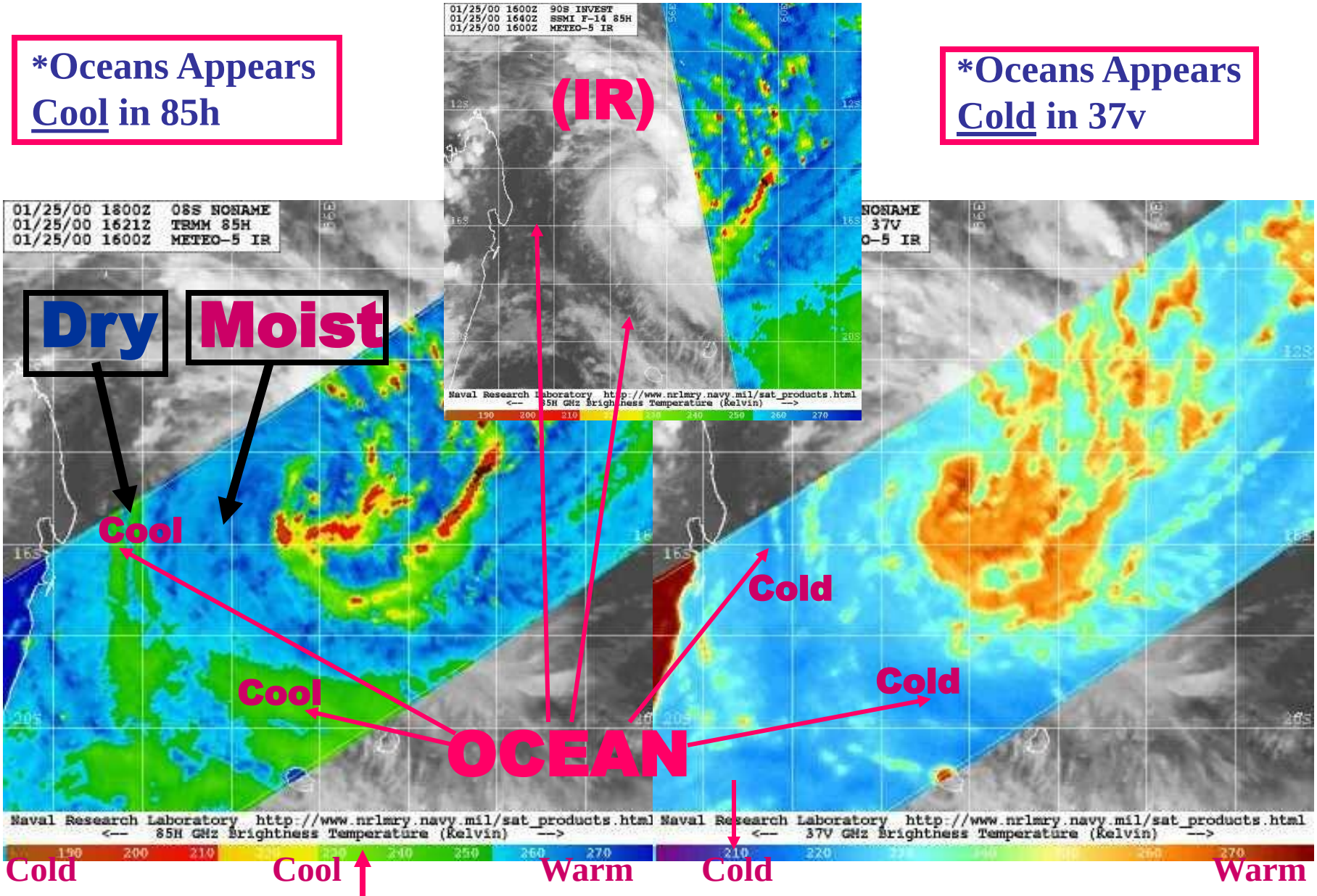


37 GHz image colour scale: red is warm and blue is cold
WARM temperatures of rain at low levels is RED
COOLER ocean background in BLUE
precipitation in both instances, but the primary mechanism for sensing the precipitation is different.

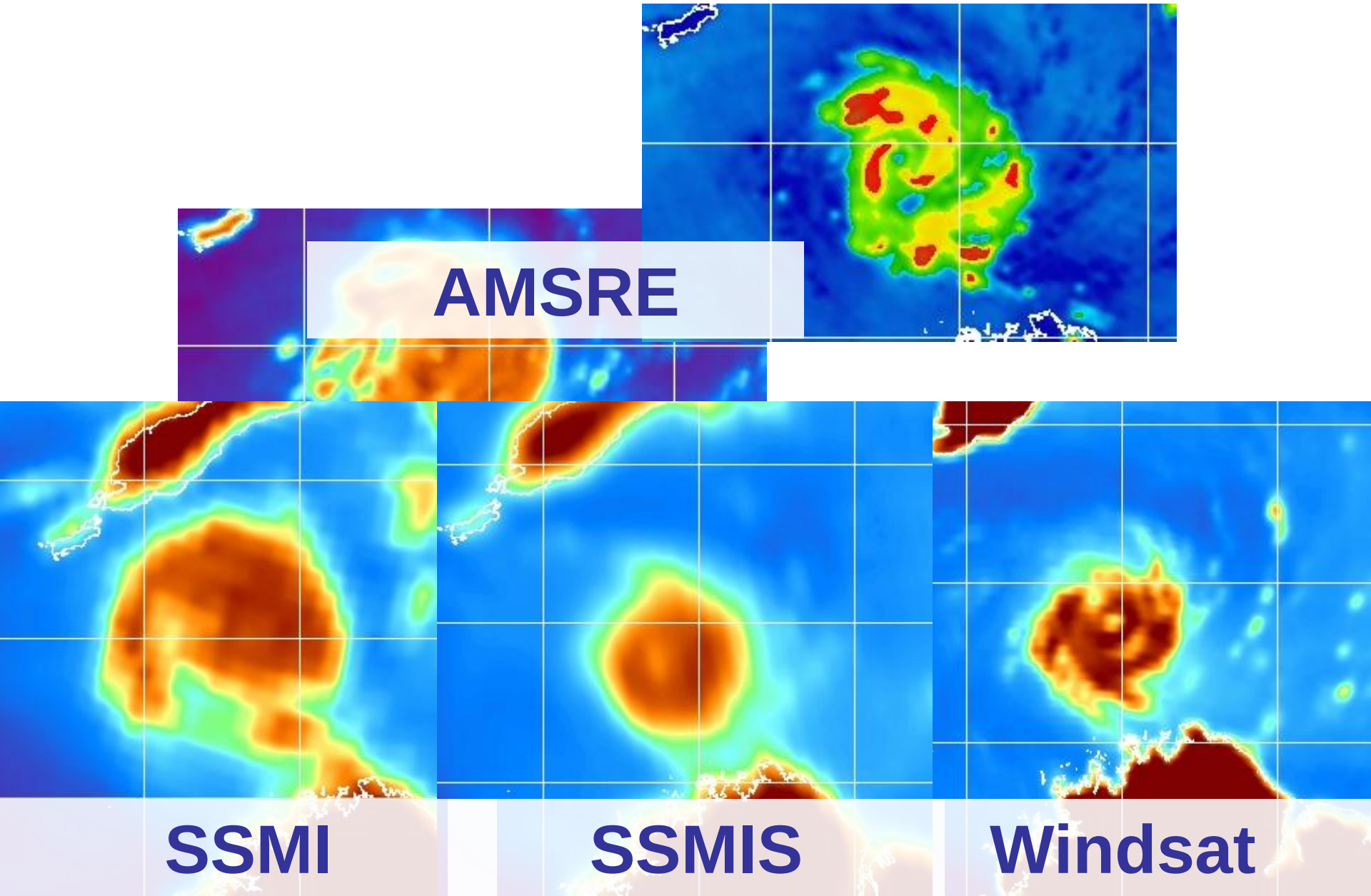
Microwave Imagery
Viewing Interpretation--*Oceans*

*Oceans Appears Cool in 85h

*Oceans Appears Cold in 37v



Resolution differences: 85 better than 37; sensor variations



85-91GHz

At 85 GHz, energy emitted from the ocean surface is rapidly depleted in lower to middle portions of convective clouds due to scattering by water drops and large ice particles

- **Advantages at 85-91 GHz:**
  - **Can penetrate cirrus canopies and reveal internal storm structure relative to storm center**
  - **Distinguishes deep (cold) convection (heavy precipitation) from lightly-raining (warm) low cloud features**
  - **Identifies cirrus-covered eyes**
  - **Offers higher spatial resolution than imagery at lower microwave frequencies**
  - **Complements geostationary imagery for optimal analysis**
- **Limitations at 85-91 GHz:**
  - **Is able to distinguish deep convection, but can not always see low-level circulations when associated primarily with low-level water clouds**
  - **Cold ocean may look like deep convection**
  - **Needs a color enhancement technique to help resolve ambiguity between deep convection and clear ocean surface**
  - **Potential parallax errors when viewing deep convection (10-20 km)**
  - **Saturates (no detail) in storm cores, misses structures**
  - **Not available on WindSat**
- **Should be used in combination with 37 GHz imagery for difficult cases**

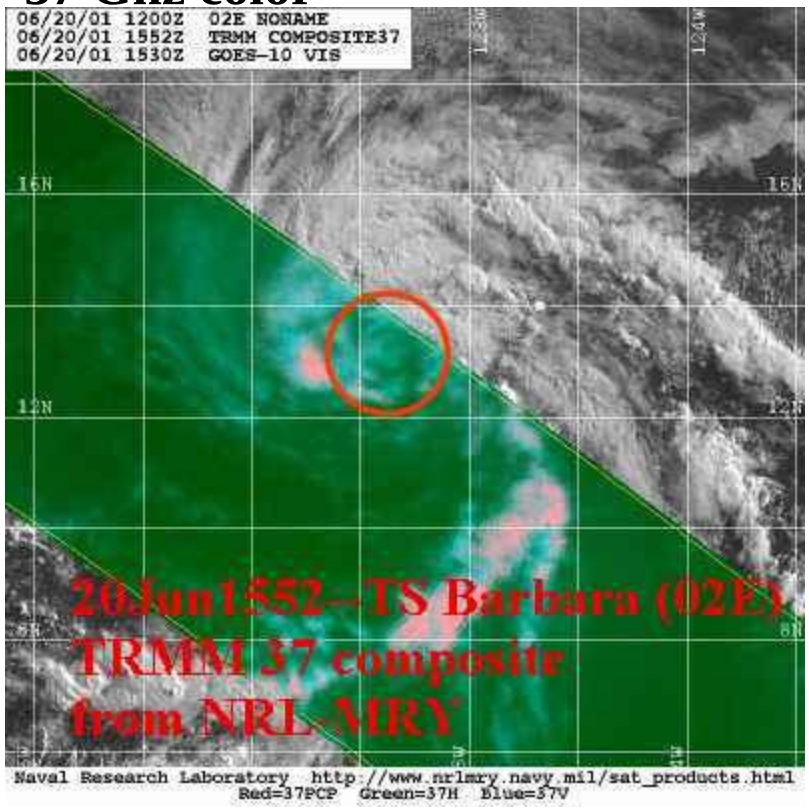
37GHz

At 37 GHz, abundant energy emitted by water droplets lower in the convective cloud is largely unaffected by ice particles higher in the cloud

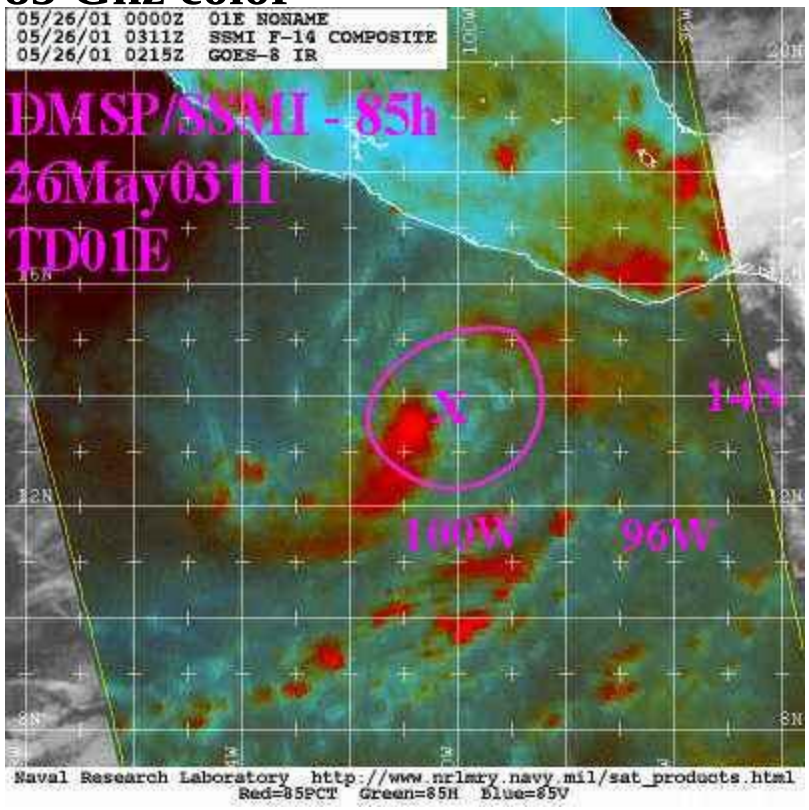
- **Advantages at 37 GHz:**
  - **Identifies cirrus-covered eyes**
  - **Resolves detail within the storm core missed by 85-91 GHz, sometimes sees eyes missed by 85-91 GHz**
  - **Shows regions of low-level clouds/rain**
  - **Small parallax error compared to 85-91 GHz**
- **Limitations at 37 GHz:**
  - **With deep convection not distinguished well from low cloud bands, tropical cyclone eyes are sometimes poorly defined**
  - **Suffers from poor spatial resolution on SSM/I and SSMIS**
  - **Spatial resolution is improved on TMI, AMSR-E, and NPOESS CMIS**
  - **Not available on AMSU-B or NPP/NPOESS ATMS**
- **Should be used in combination with 85 GHz imagery, especially for difficult cases**

Positioning in Microwave Imagery

37 Ghz color

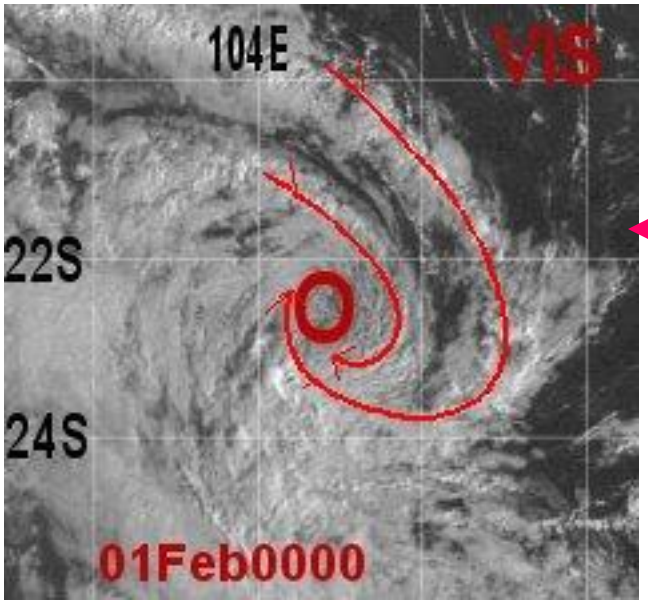


85 Ghz color

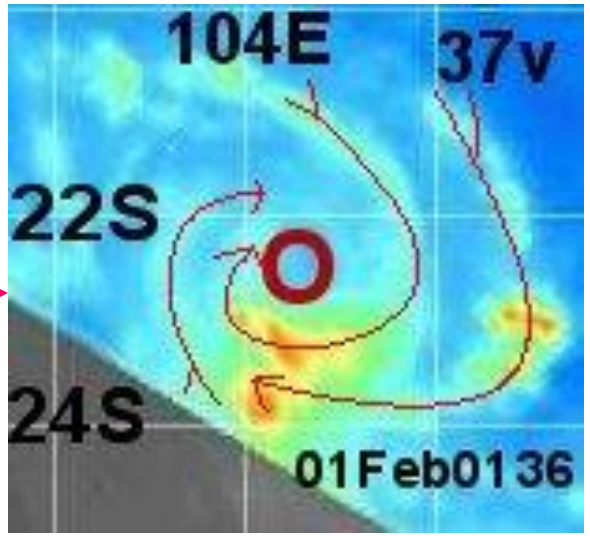


Try to position in the <u>rain-free dry</u> area—out of the convection

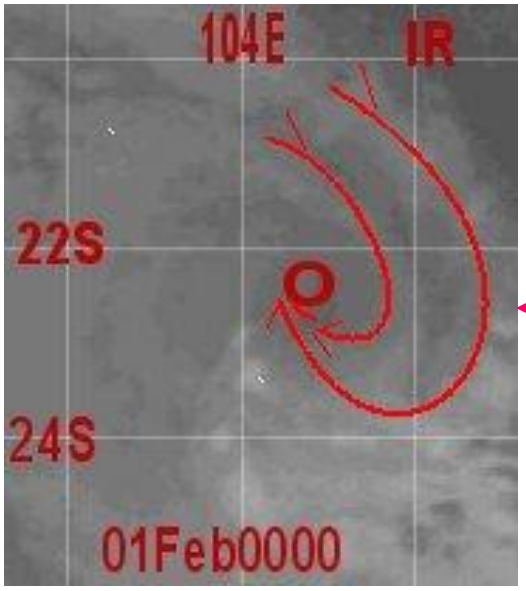
POSITIONING



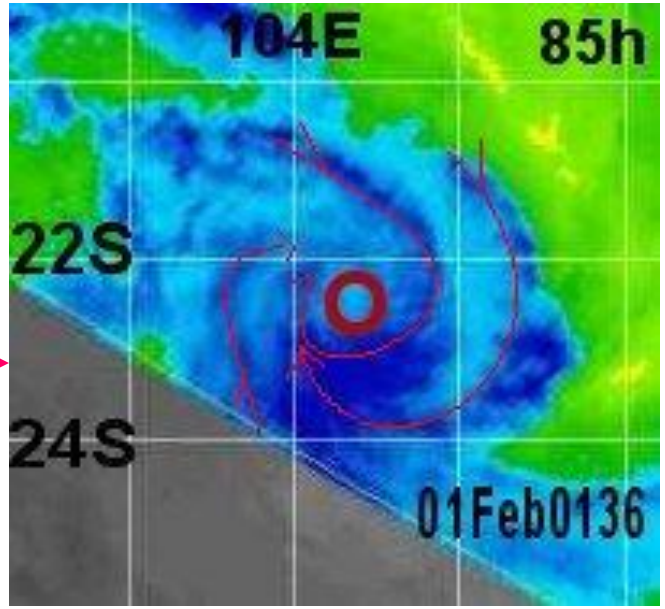
In Visible, easy to follow cloud lines



In 37GHz, look for warmer color rain band, in NRL depiction, light green

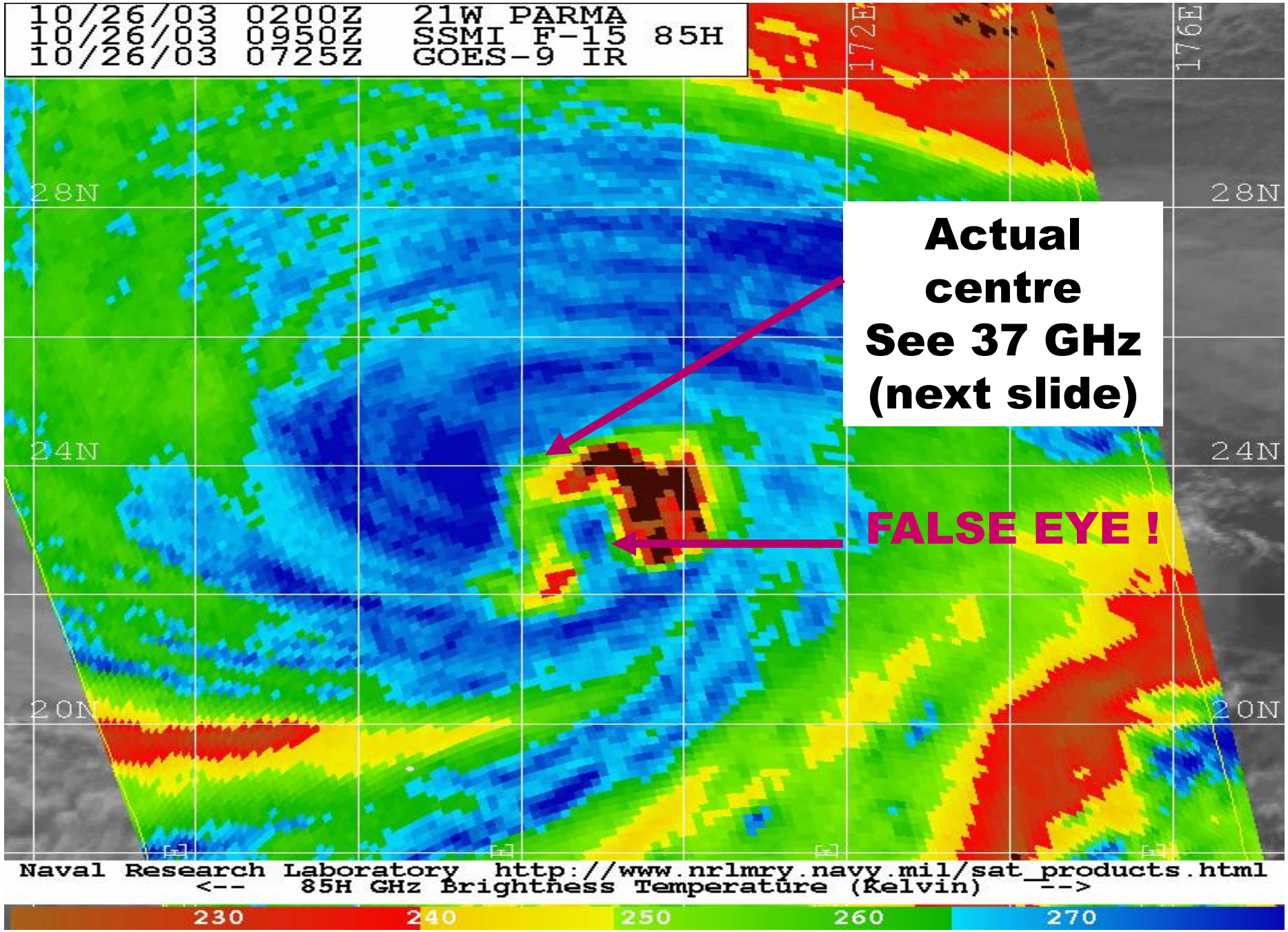


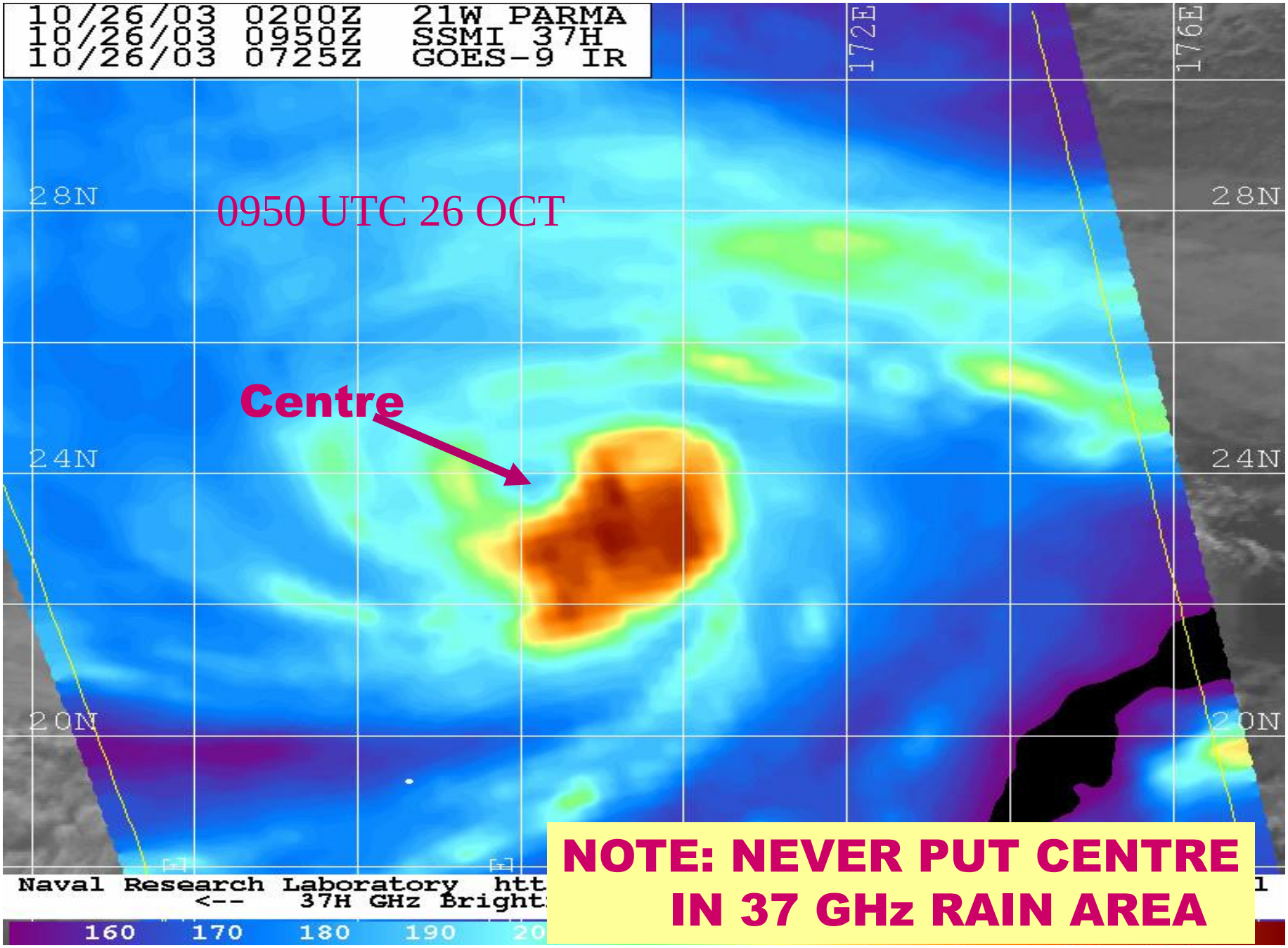
In IR imagery, difficult to follow low level clouds, but easier to see deep cloud bands

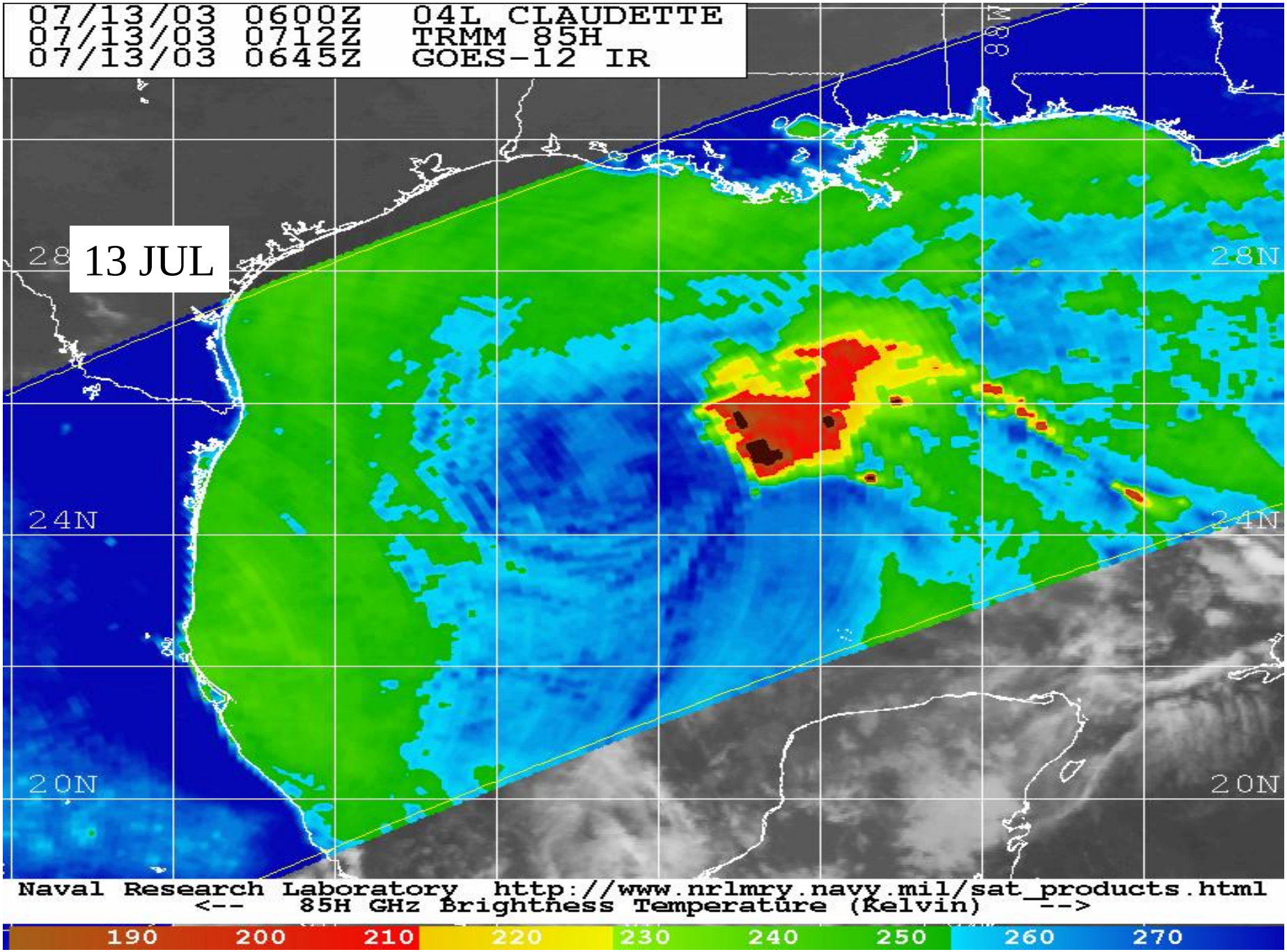


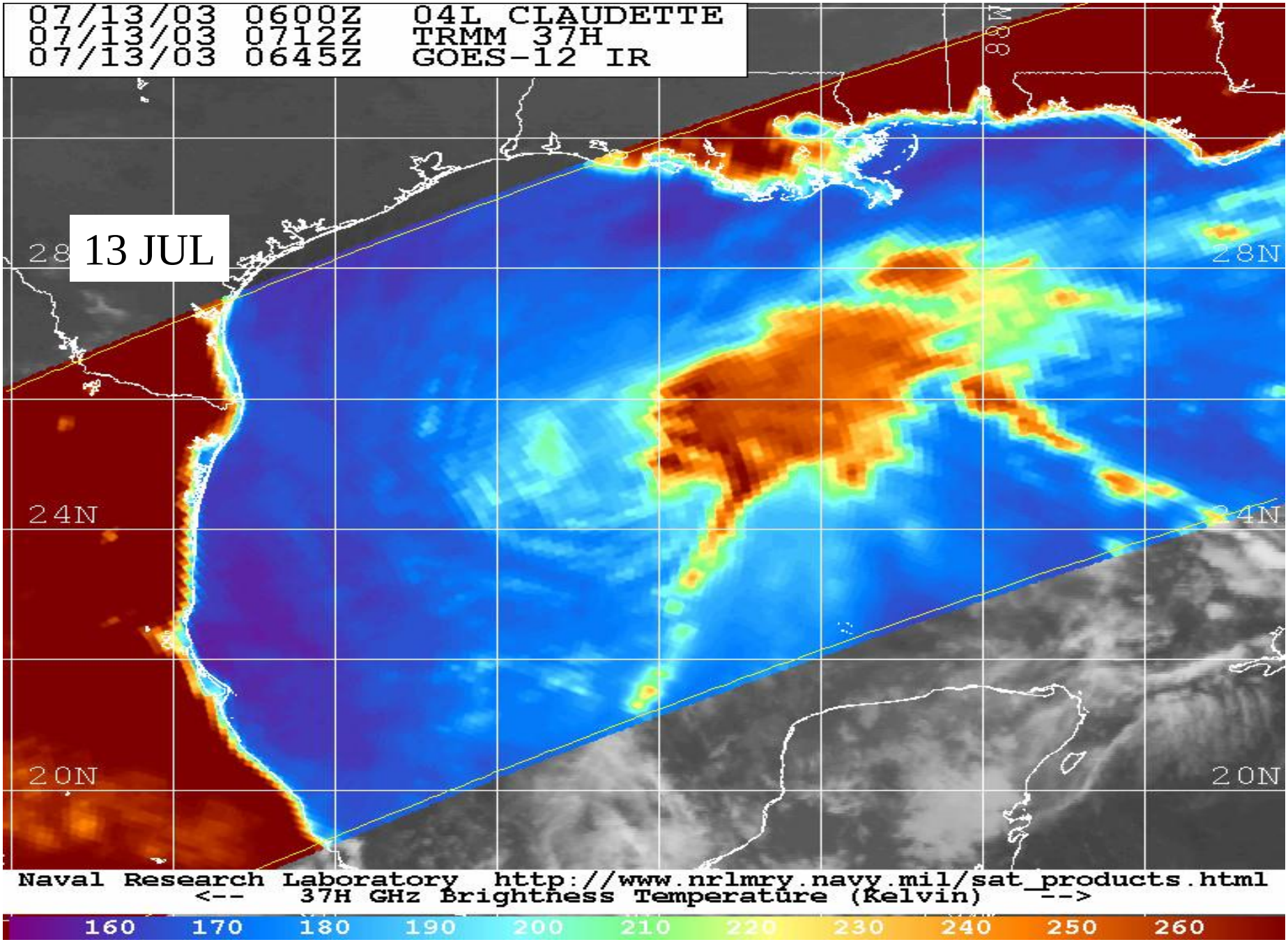
In 85GHz, look for warmer color rain band, in NRL depiction, deep blue

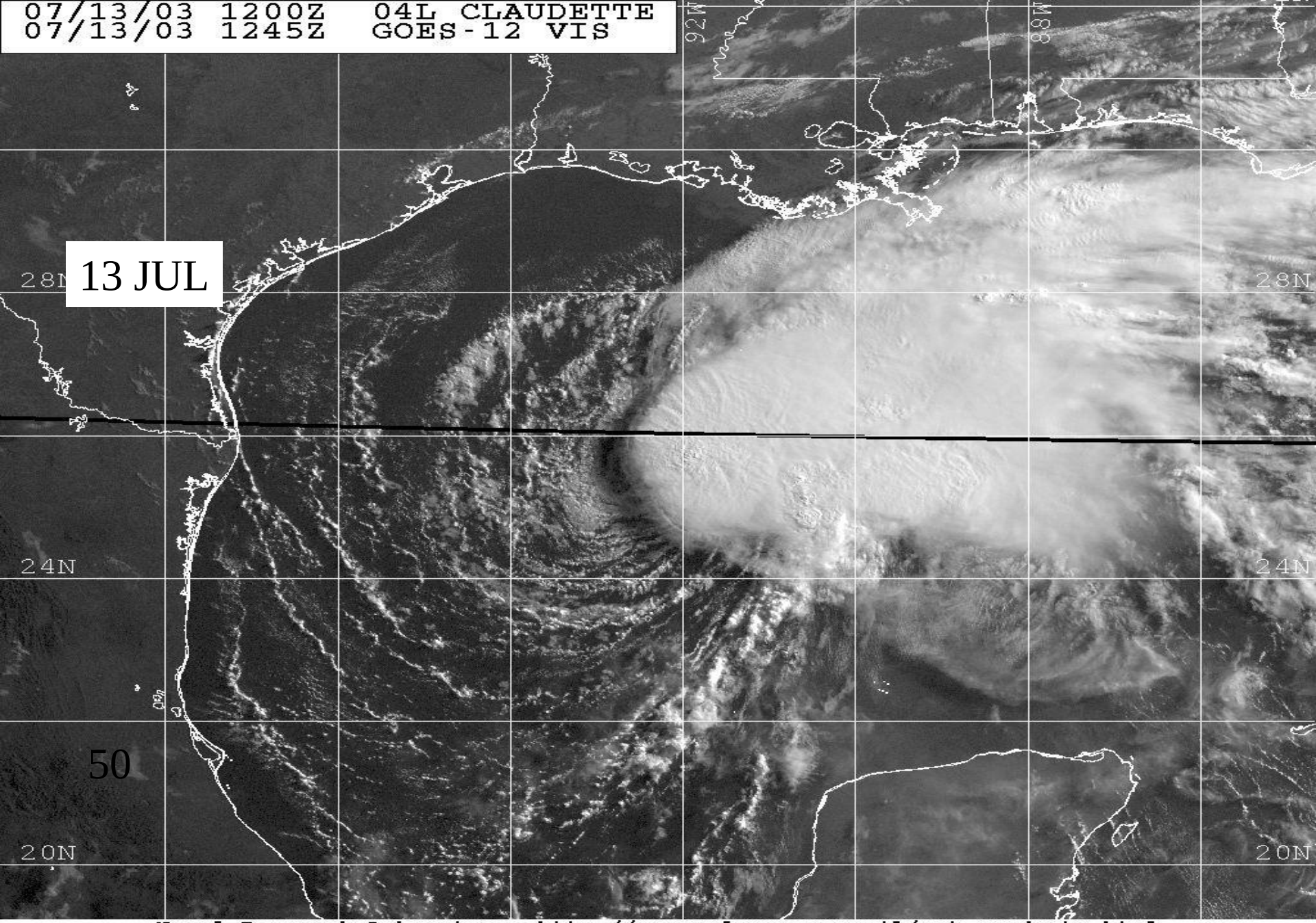

10/26/03 0200Z 21W PARMA
10/26/03 1301Z GOES-9 IR
168E
176E
176W
32N
32N
1200 UTC 26 OCT
WHERE IS THE CENTRE?
24N
24N
16N
16N
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20


10/26/03 0200Z 21W PARMA
10/26/03 0950Z SSMI F-15 85H
10/26/03 0725Z GOES-9 IR
172E
176E
28N
24N
20N
Actual centre See 37 GHz (next slide)
FALSE EYE !
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- 85H GHz Brightness Temperature (Kelvin) -->
230
240
250
260
270

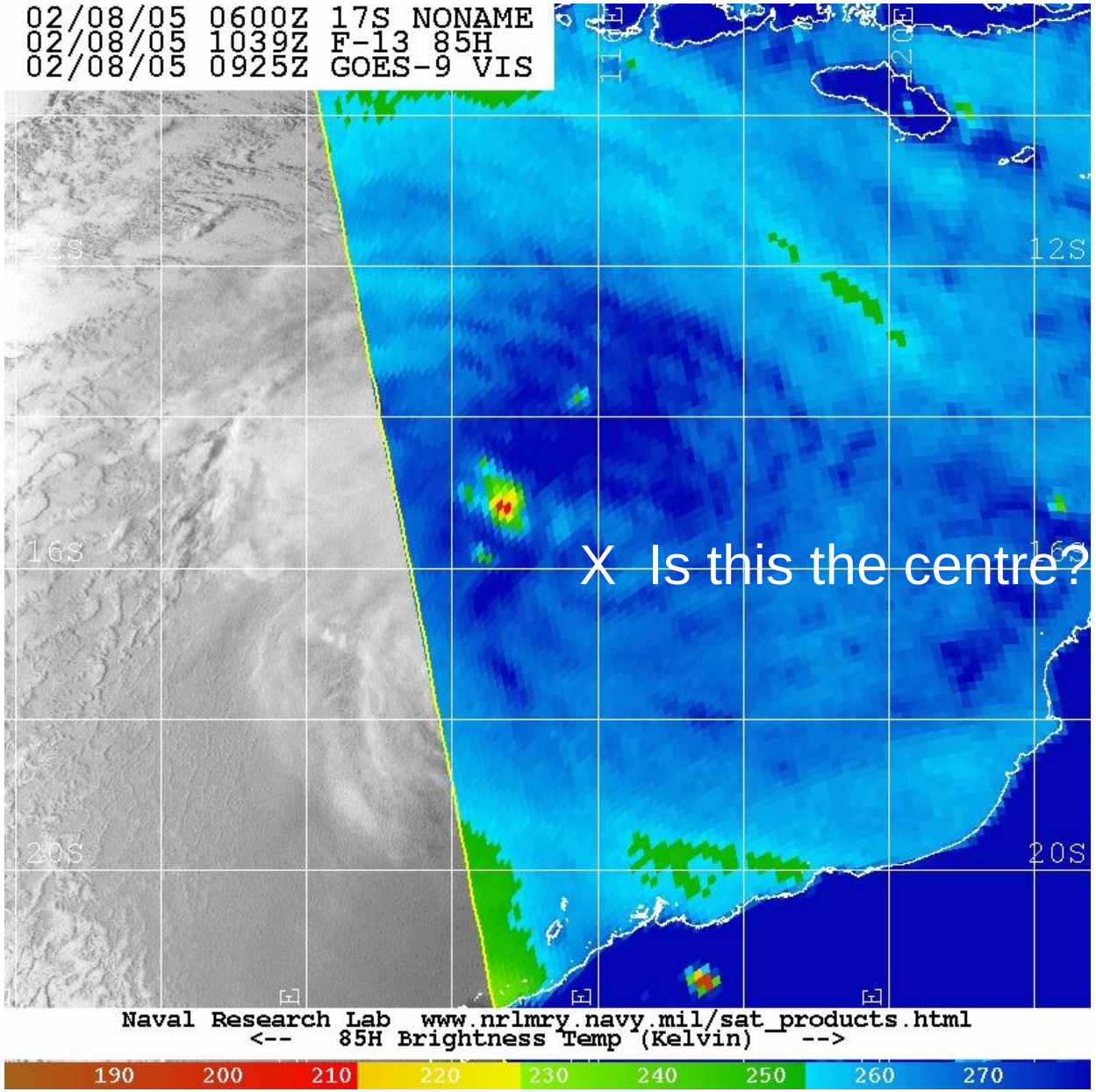

10/26/03 0200Z 21W PARMA
10/26/03 0950Z SSMI 37H
10/26/03 0725Z GOES-9 IR
172E
176E
28N
24N
20N
0950 UTC 26 OCT
Centre
Naval Research Laboratory htt
<-- 37H GHz Bright
160 170 180 190
NOTE: NEVER PUT CENTRE
IN 37 GHz RAIN AREA

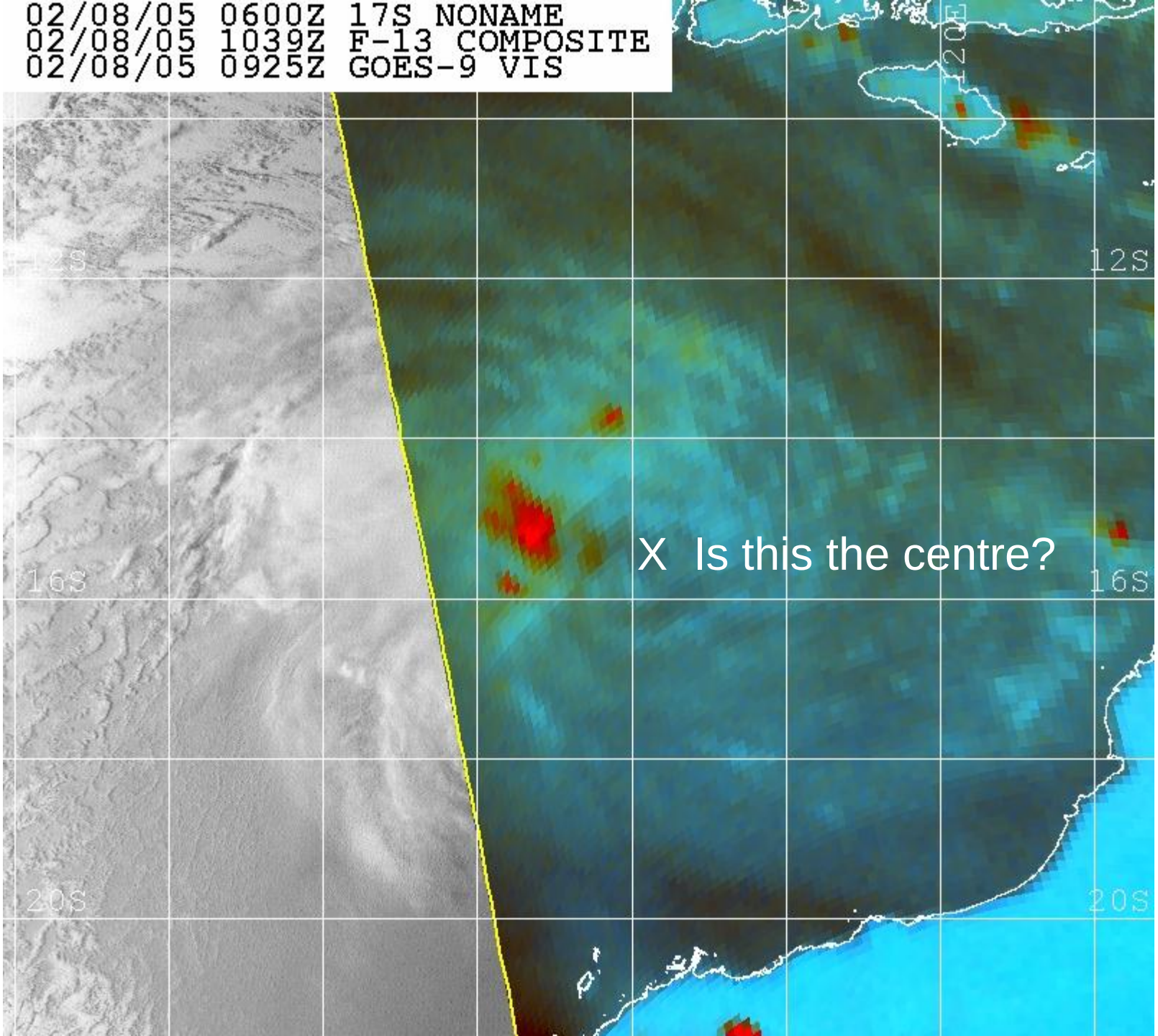

07/13/03 0600Z 04L CLAUDETTE
07/13/03 0712Z TRMM 85H
07/13/03 0645Z GOES-12 IR
13 JUL
28N
24N
20N
88W
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- 85H GHz Brightness Temperature (Kelvin) -->
190 200 210 220 230 240 250 260 270

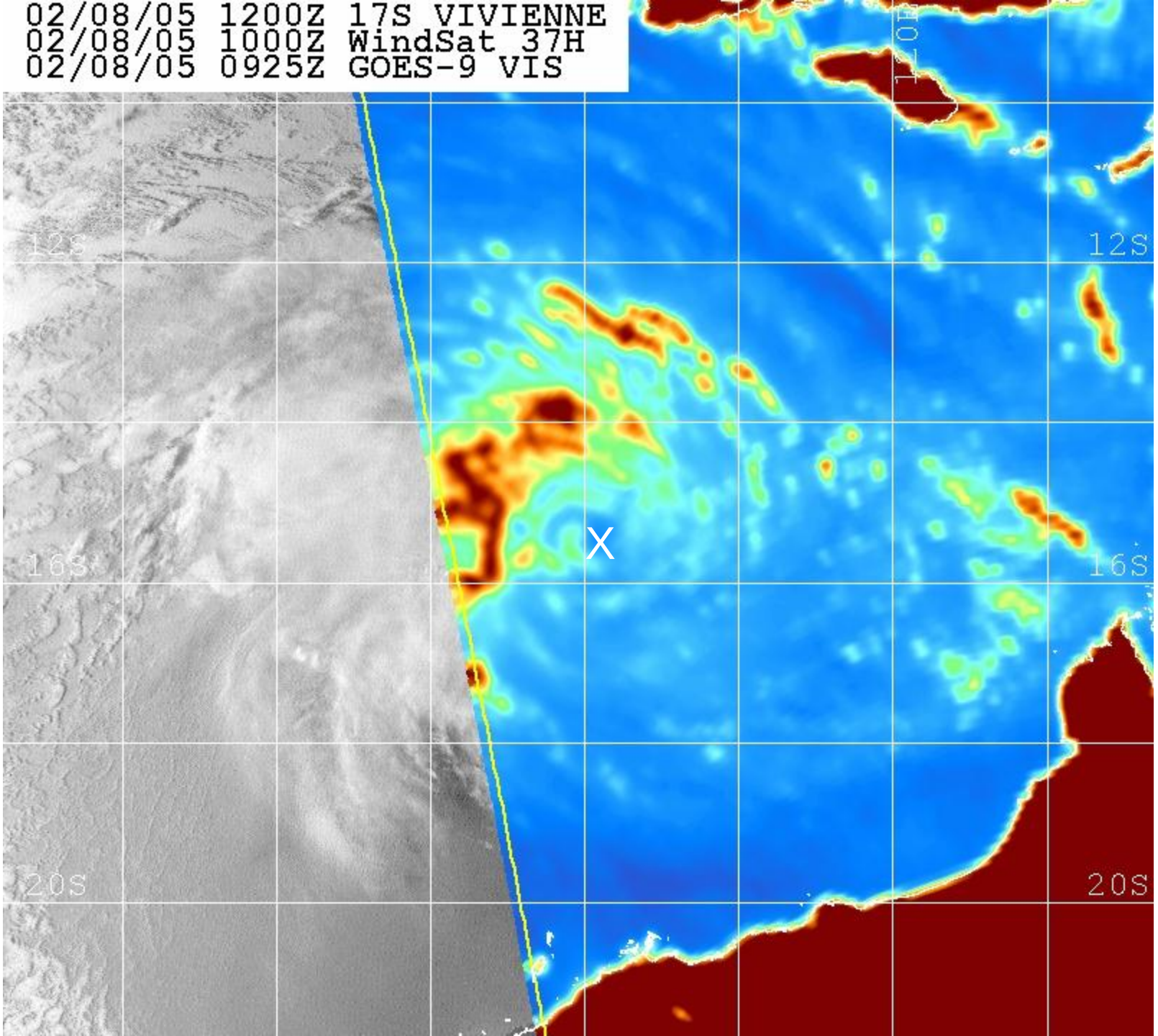

07/13/03 0600Z 04L CLAUDETTE
07/13/03 0712Z TRMM 37H
07/13/03 0645Z GOES-12 IR
13 JUL
28N
24N
20N
88W
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- 37H GHz Brightness Temperature (Kelvin) -->
160 170 180 190 200 210 220 230 240 250 260


07/13/03 1200Z 04L CLAUDETTE
07/13/03 1245Z GOES-12 VIS
92W
88W
28N
28N
24N
24N
20N
20N
13 JUL
50
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 17 degrees) -->

Apparent eye (dark spot) close to 16S 116E ?




02/08/05 0600Z 17S NONAME
02/08/05 1039Z F-13 COMPOSITE
02/08/05 0925Z GOES-9 VIS
X Is this the centre?
12S
16S
20S


02/08/05 1200Z 17S VIVIENNE
02/08/05 1000Z WindSat 37H
02/08/05 0925Z GOES-9 VIS
12S
16S
20S

Summary

- There are different techniques used to find the centre: use all available and the best;
- Microwave images:
  - 37GHz low level – generally best for positioning
  - 85-91GHz highlights convection in mid-levels

http://www.wa.bom.gov.au/sect_info/sevwx/tc/microwave/viewer/index.php

Quiz

1. The 85GHz microwave imagery has higher resolution than the 37GHz microwave imagery.

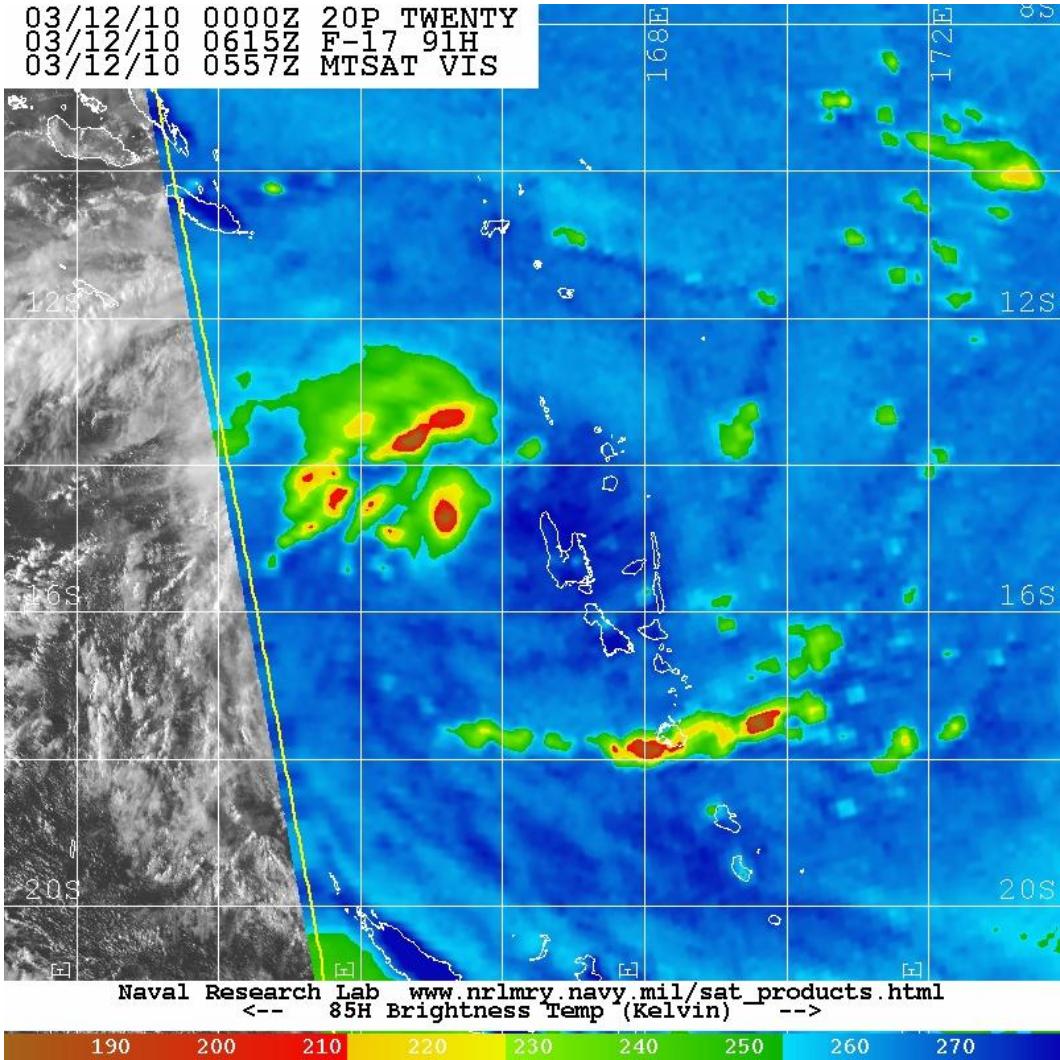
So the 85 GHz imagery is superior in locating the centre of a Tropical Cyclone.”

True or False ?

Quiz

2. Which type of microwave image is this?

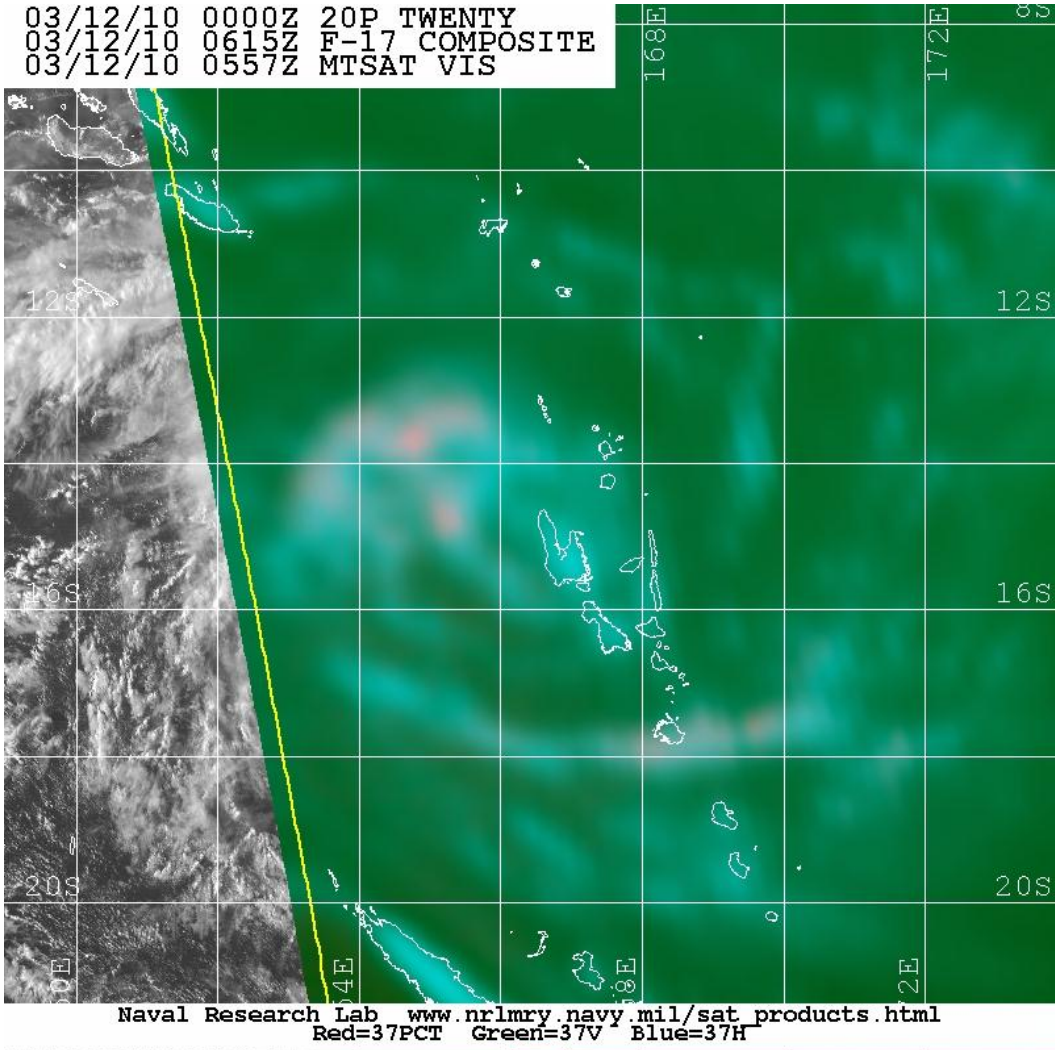
a. 37GHz H
b. 37GHz col comp
c. 85GHz H
d. 85GHz col comp



Quiz

3. Which type of microwave image is this?

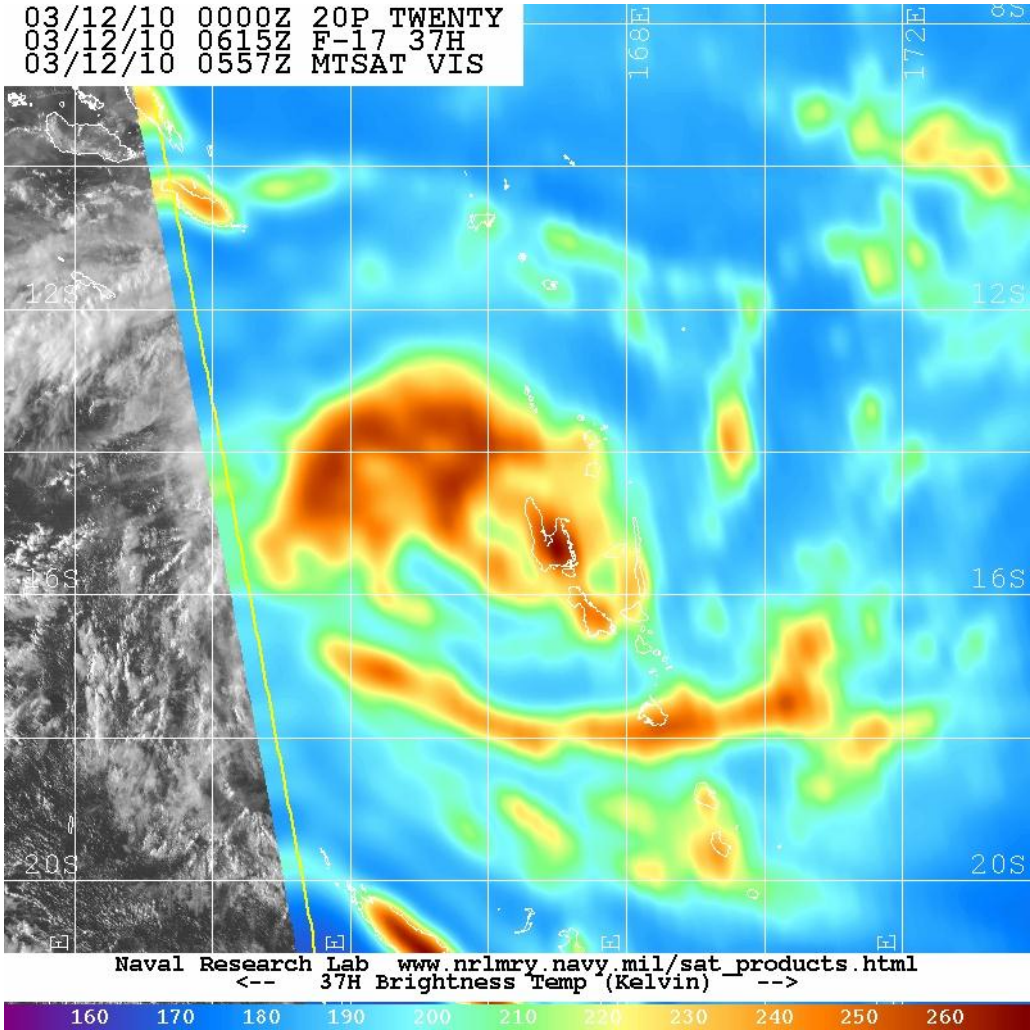
a. 37GHz H
b. 37GHz col comp
c. 85GHz H
d. 85GHz col comp



Quiz

4. Which type of microwave image is this?

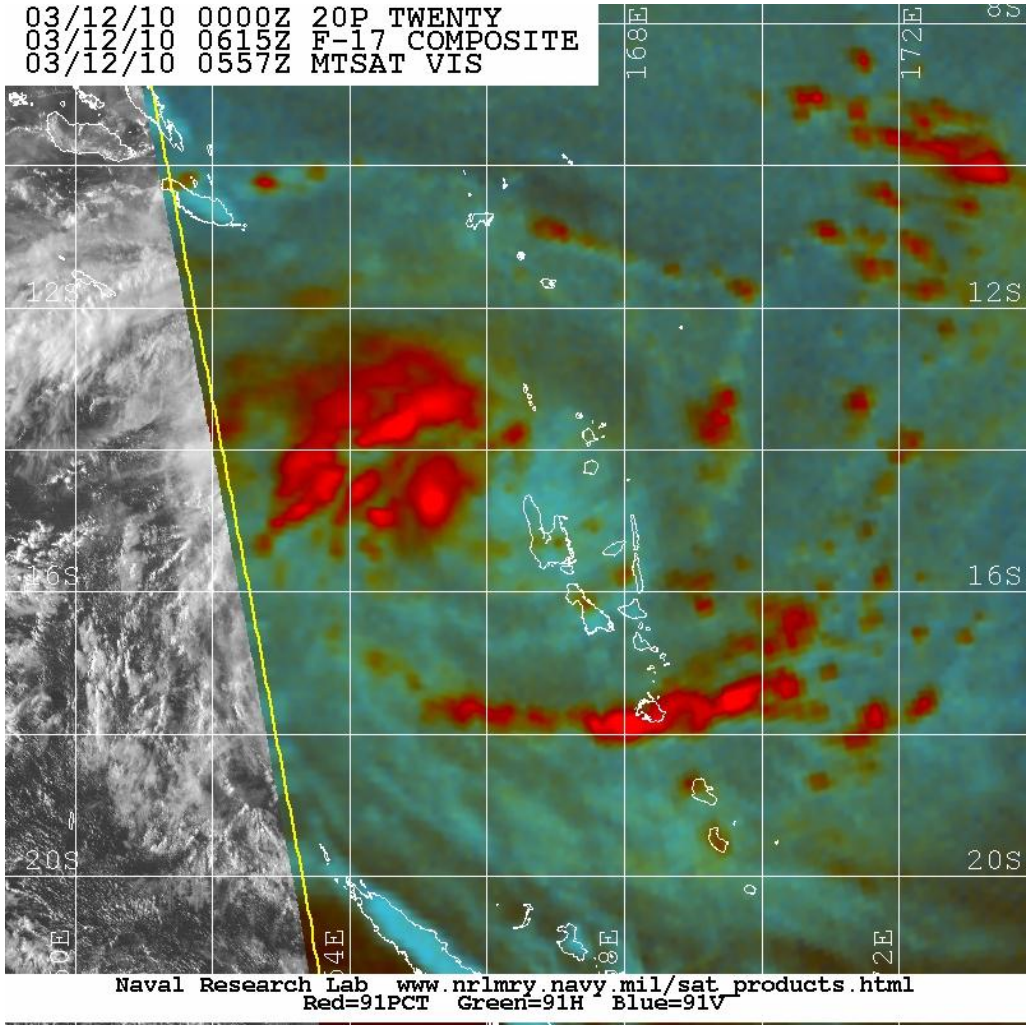
a. 37GHz H
b. 37GHz col comp
c. 85GHz H
d. 85GHz col comp



Quiz

5. Which type of microwave image is this?

a. 37GHz H
b. 37GHz col comp
c. 85GHz H
d. 85GHz col comp



Quiz

6. Which of these are NOT microwave sensors?

a. SSMI
b. SSMIS
c. AMSU
d. AMSRE
e. TMI
f. None of the above