

Satellite-Based Analysis in Tropical Cyclone Forecasting

Uses of Dvorak, Microwave and Scatterometer

by

Roger T. Edson
Science and Operations Officer
NOAA/NWS WFO Guam, USA

UN/ESCAP/WMO Typhoon Committee
8th IWS/2nd TRCG Forum
2 – 6 December 2013
Macao Science Center, Macao, China

Satellite-based Analysis of Tropical Cyclone

Outside of the Atlantic Basin:

(No aircraft reconnaissance)

Primary means of evaluating tropical cyclones

- Synoptic data (scarce)
- Radar (localized)

(still)

Dominated by visual and infrared satellite imagery

Outline of Talk

What do you need from Satellite reconnaissance?

--Position

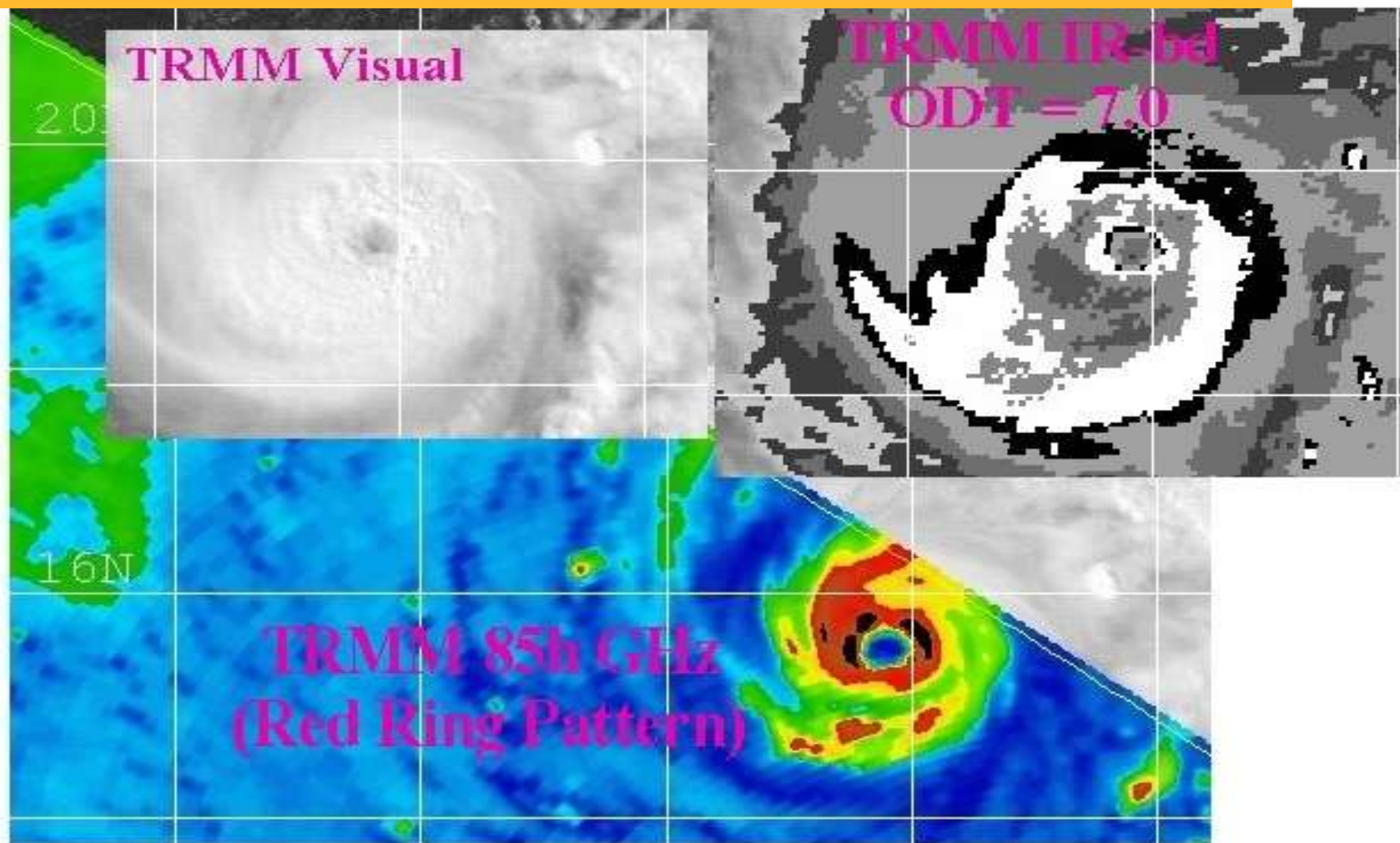
--Intensity/Change of Intensity

--Structure

--Genesis (plus dissipation)

**Need for more than one technique (e.g. IR Dvorak) to do a good analysis

Three views of Super Typhoon Podul 125–140kts



Traditional Satellite Imagery

**Use of Dvorak Satellite Intensity Technique (Infrared and Visual)

- **Visual (higher resolution and animation)**
 - Is the low level visible, obscured by clouds?
 - Eye or overshooting tops near an apparent center
 - Watch out for mid-trop circulations and outflow boundaries
- **Infrared (24hr view, Temp at the top)**
 - Good for well developed systems (no shear)
 - Very difficult in early stages, shear, multi-vortices , heavy mid-upper level clouds, etc etc etc.

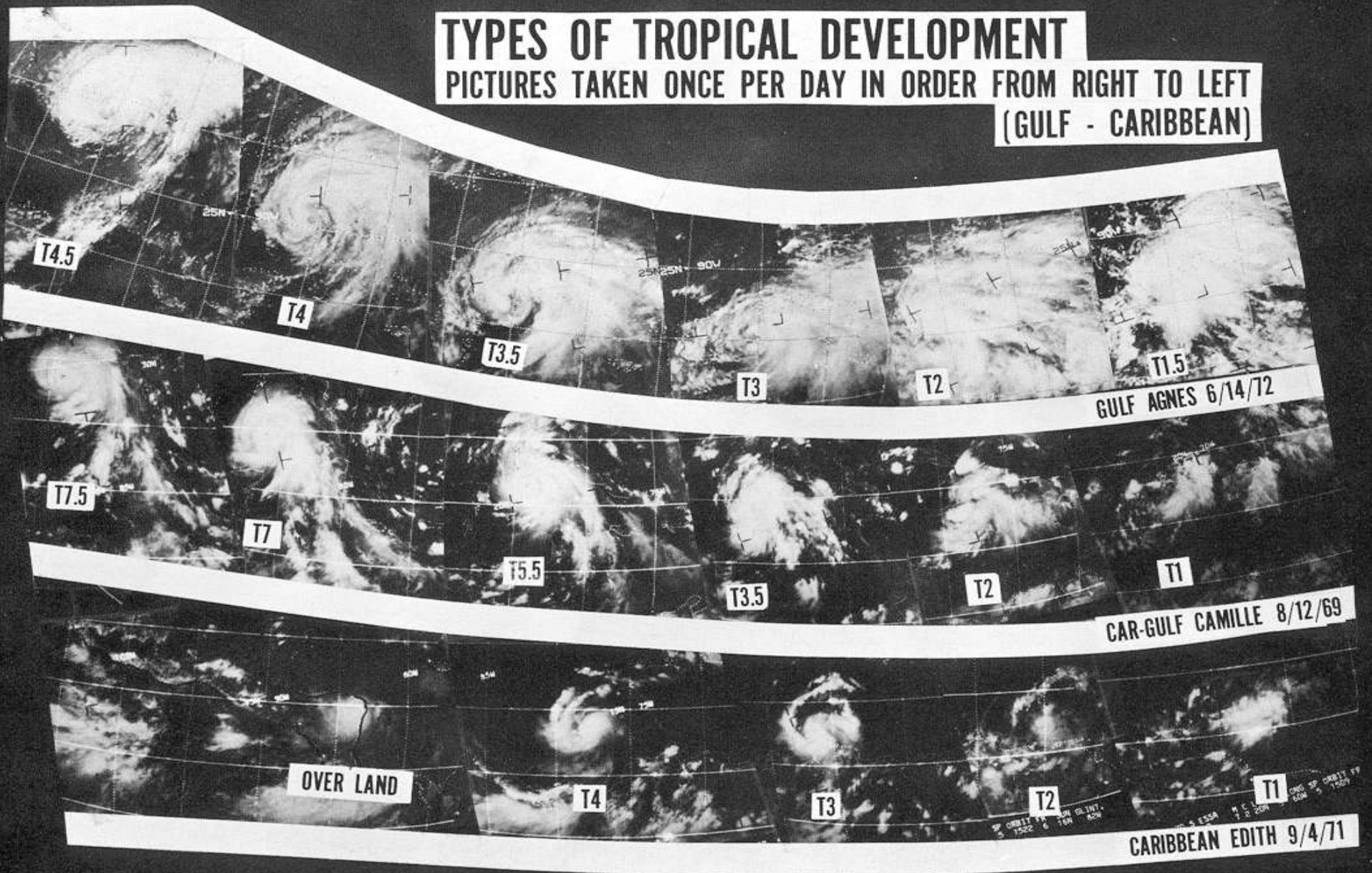
What is the Dvorak Technique?

- A statistical method for estimating the intensity of tropical cyclones from satellite imagery
 - Can use both Infrared and Visible imagery (maybe MI and SCAT can help)
 - Based on a “measurement” of the cyclone’s convective cloud pattern and a set of rules
- **This technique DOMINATES all others for identifying TC intensity (primarily the IR) in the TC Warning Centers**






















Dvorak Cloud Patterns

TYPES OF TROPICAL DEVELOPMENT

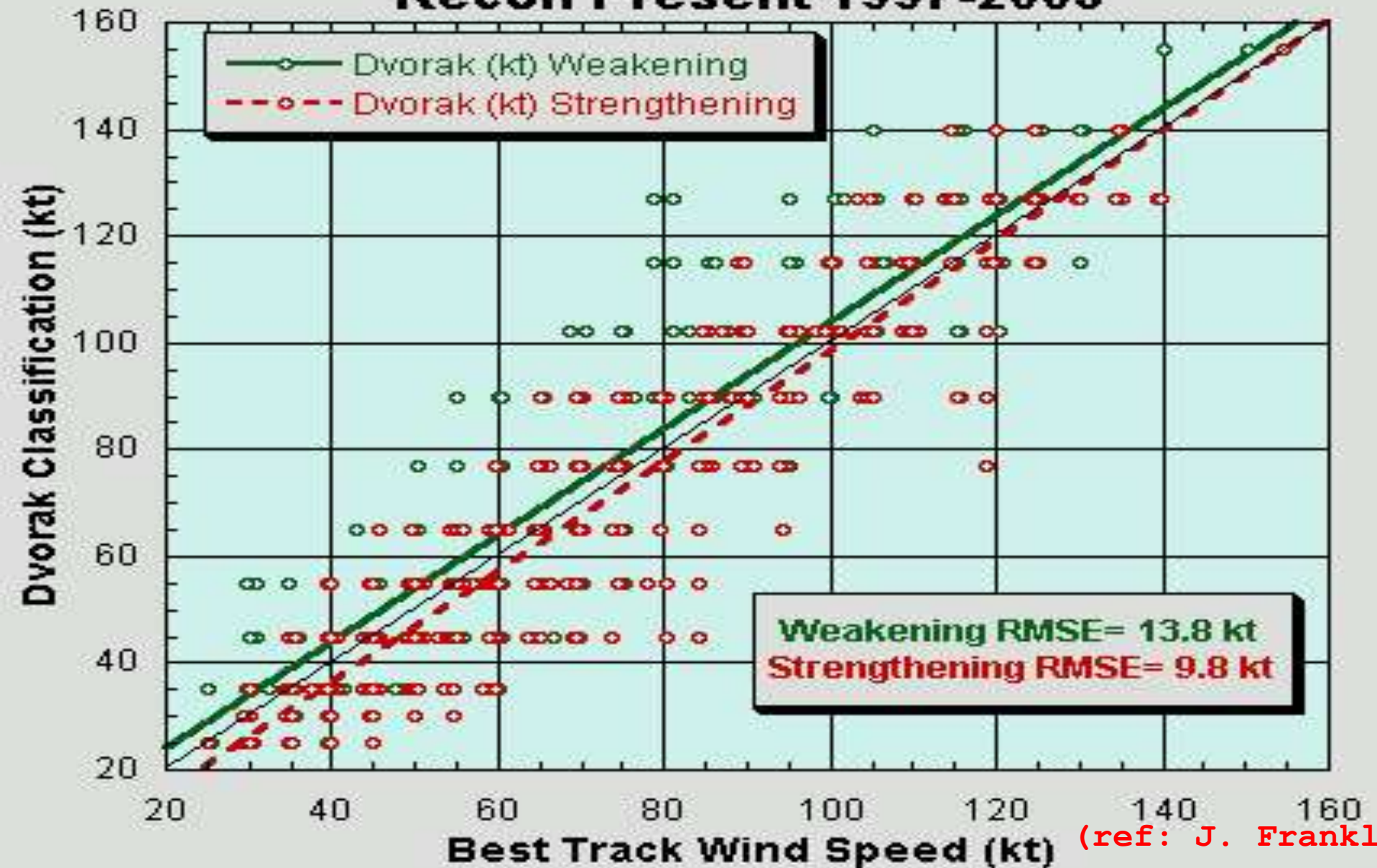
PICTURES TAKEN ONCE PER DAY IN ORDER FROM RIGHT TO LEFT
(GULF - CARIBBEAN)



Dvorak Technique Cloud Patterns

DEVELOPMENTAL PATTERN TYPES	PRE STORM	TROPICAL STORM		HURRICANE PATTERN TYPES		
		(Minimal)	(Strong)	(Minimal)	(Strong)	(Super)
	T1.5 ±.5	T2.5	T3.5	T4.5	T5.5	T6.5 - T8
CURVED BAND PRIMARY PATTERN TYPE						
CURVED BAND EIR ONLY						
CDO PATTERN TYPE VIS ONLY						
SHEAR PATTERN TYPE						

Dvorak MSSW Estimates versus Best Track Data when Recon Present 1997-2003



Chip Guard's Summary of Why Dvorak Works
Contains the basic ingredients to 'make' a Tropical Cyclone

- **VORTICITY**
- **SHEAR**
- **CONVECTIVE VIGOR**

Dvorak Technique (problem areas)

- From the late 70s
- Updates still based on initial premise
- Primary tool for intensity, outside of aircraft reconnaissance
- Often little ground truth to 'correct'
- Many documented situations where Dvorak is suspect

THE DVORAK TECHNIQUE

(Is there room for improvement?)

- Visual technique developed in mid 1970s
- IR technique developed in late 70s/ early 80s
 - Animation not part of technique—but since adapted for better positioning
 - Not designed for 'midget-type' TCs, 'Truck Tire eyes,
 - Not designed for TCs originating as monsoon depressions (i.e. large trough in sheared environment), ST & ET systems
 - Only "sees" clouds
 - Becoming 'automated', but still takes a real long time to learn to do well
 - Embedded IR procedure has very large variability
- Ref: 2006 BAMS article, AMS Tropical Conf proceedings

Dvorak Technique

- Even when technique 'works', many errors
 - Easy to do, but difficult to do correctly
 - Many times junior forecaster/analyst (with little extensive experience...NEED 2 seasons, minimum)
 - Use of spiral band curvature over used (easy)
 - TC Forecaster is often not the satellite analyst
 - Requires communication and questioning for Forecaster to understand the difficulty
 - What is the forecaster's experience with Dvorak?



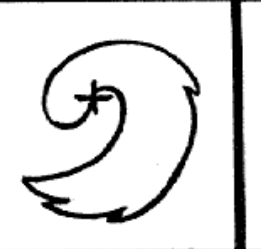
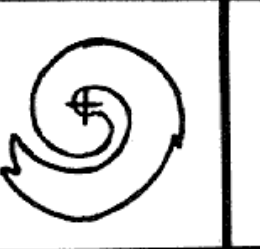



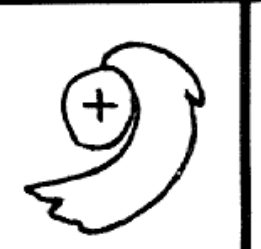





Positioning Difficulties (#1)

Cloud System Center

SBC

CDO

Shear

TYPICAL CLOUD PATTERN EVOLUTION				
DAY 1 (T1.5)	DAY 2 (T2.5)	DAY 3 (T3.5)	DAY 4 (T4.5)	DAY 5 (T5.5)
				
BASIC CURVED BAND PATTERN TYPE				
				
CENTRAL DENSE OVERCAST (CDO) PATTERN TYPE				
				
"SHEAR" PATTERN TYPE				

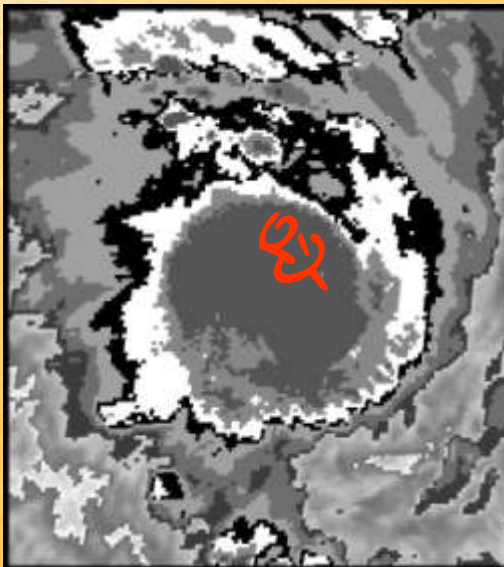
Positioning Difficulties

Embedded Center

(Difficult) -

IR

- Look for a warm spot.
- Look toward the edge with the tightest temperature gradient.



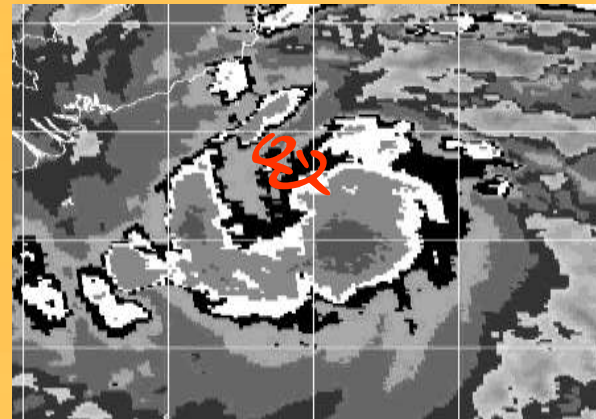
Spiral-Band Curvature IR

or Vis

(Often

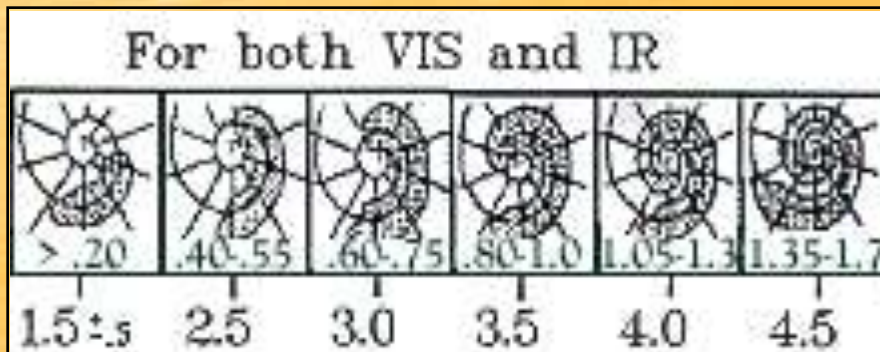
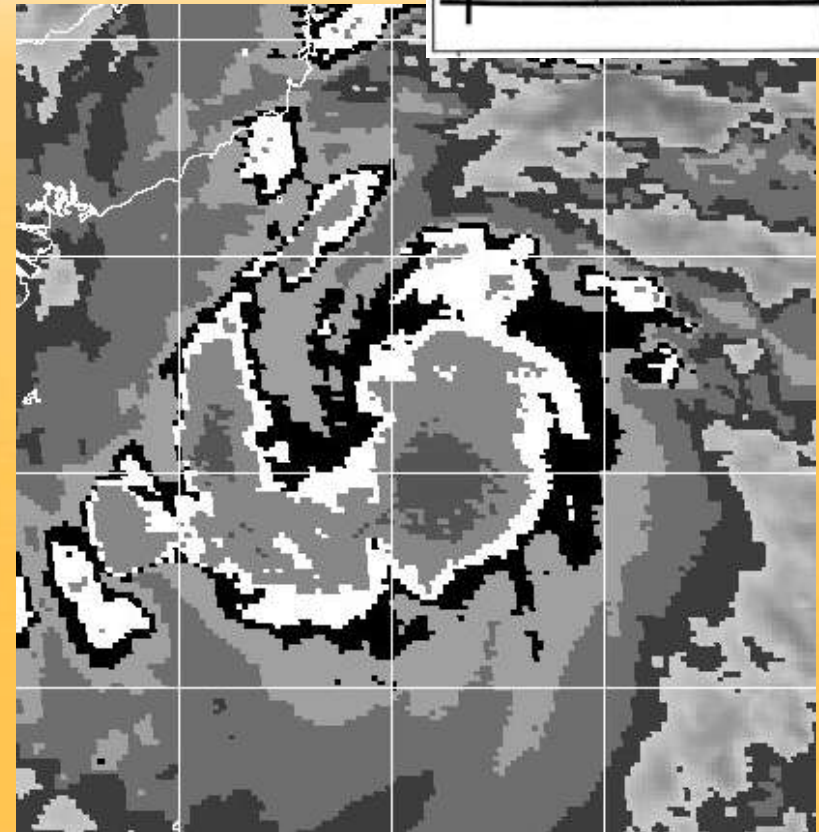
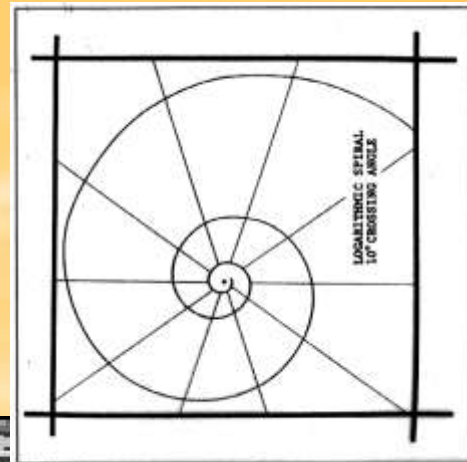
Difficult)

- Use the LOG10 spiral overlay.
- Place it so the curve lies as close as possible to the connective bands.
- Follow the curve to the center.



Too much Spiral Band Curvature (SBC)

- Use a LOG10 spiral overlay.
- The spiral should lie along the axis of the of the band, and roughly parallel the inside edge of the band.
- Measure the arc length.



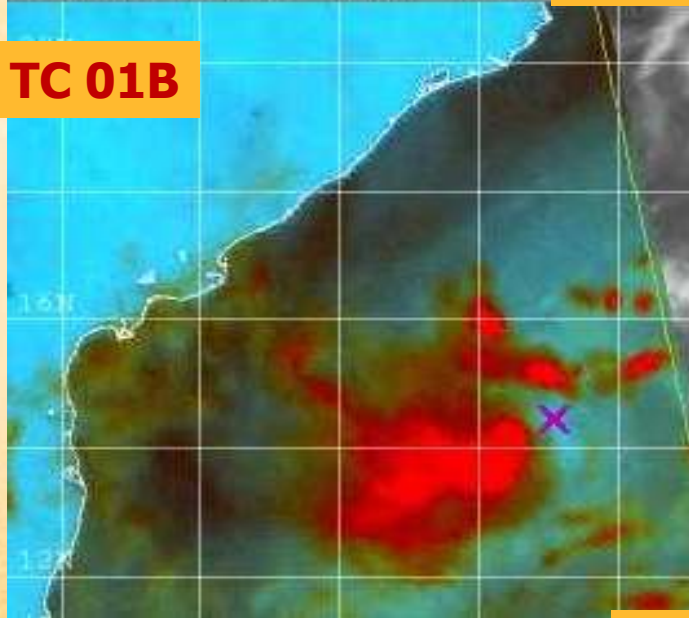
Do you remember this embedded IR Techniques (use with MI Multi-Coverage)

05/15/03 1200Z 01 NONAME
05/15/03 1418Z SSMI F-14 CC
05/15/03 1400Z METEO-5 IR

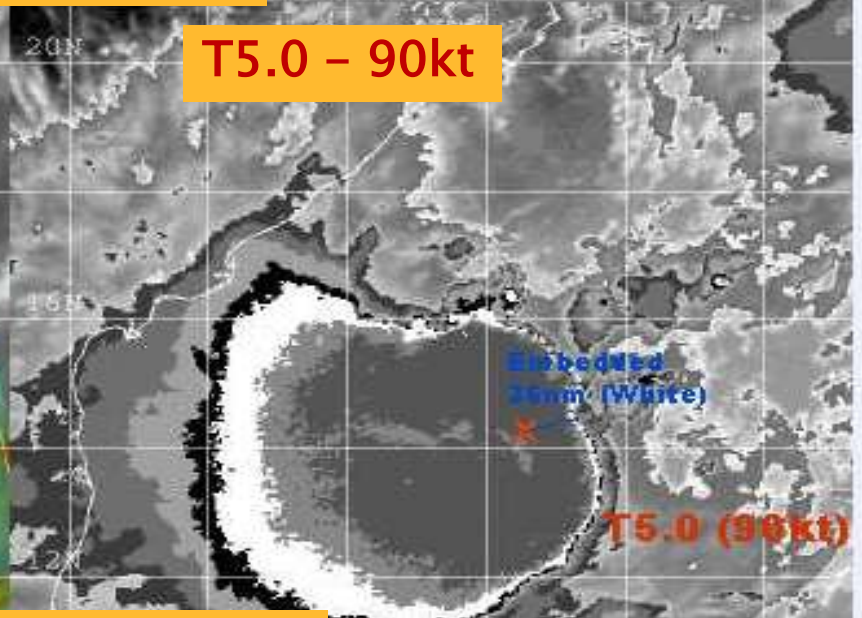
15 May 1418Z

01 NONAME
SSMI F-14 overpass
METEO-5 IR

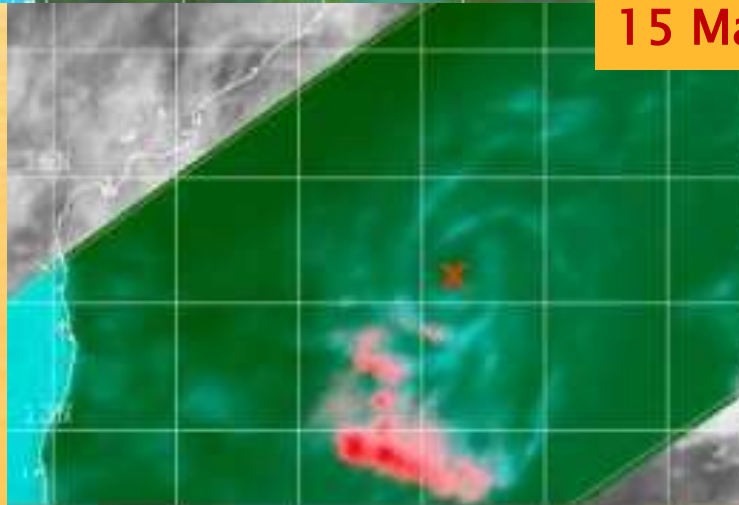
TC 01B



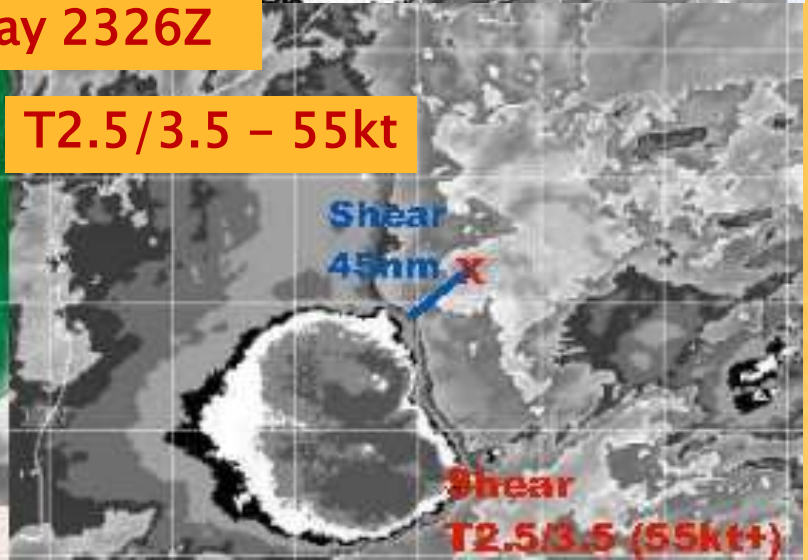
T5.0 - 90kt



15 May 2326Z



T2.5/3.5 - 55kt



Comparison between JTWC and JMA (non-agreement between TC centers)

- 1' vs. 10'
- Modification to high end scale (based on an observation study by Koba, et al. 1991)
- See T# correspondence (however, satellite interpretation of definition of T# is the same)

Comparison of Dvorak Intensities JTWC vs. JMA

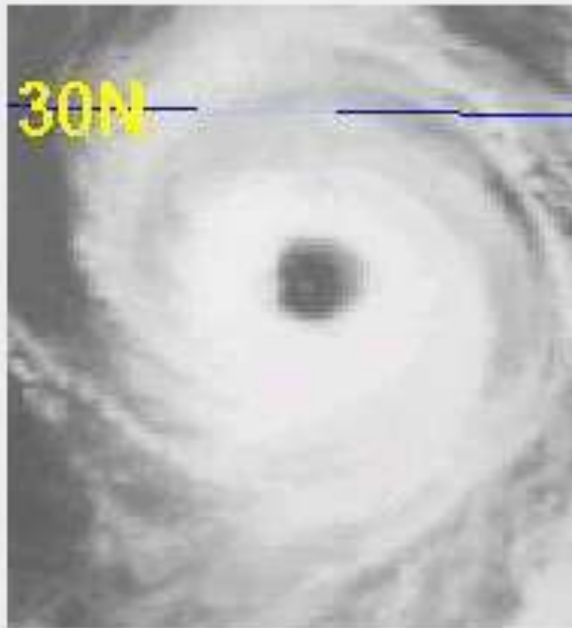
(Conversion to 10' to 1')

T Number	JTWC (1min)	JMA (10min)	→ 10' to 1'
2	30	30	33.6
2.5	35	35	39.2
3	45	45	50.4
3.5	55	55	61.6
4	65	65	72.8
4.5	77	70	78.4
5	90	77	86.2
5.5	102	85	95.2
6	115	93	104.7
6.5	127	100	112.0
7	140	107	119.8
7.5	155	115	128.8
8	170	122	136.6

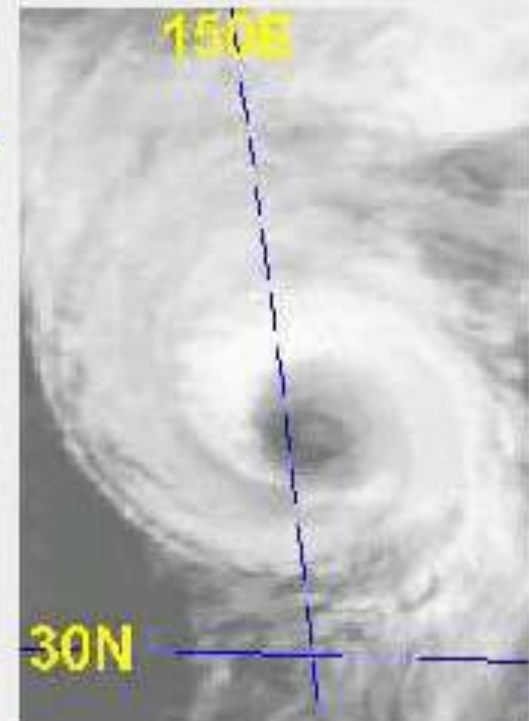
Mark Lander's 'Truck' Tires



06 AUG 0230Z

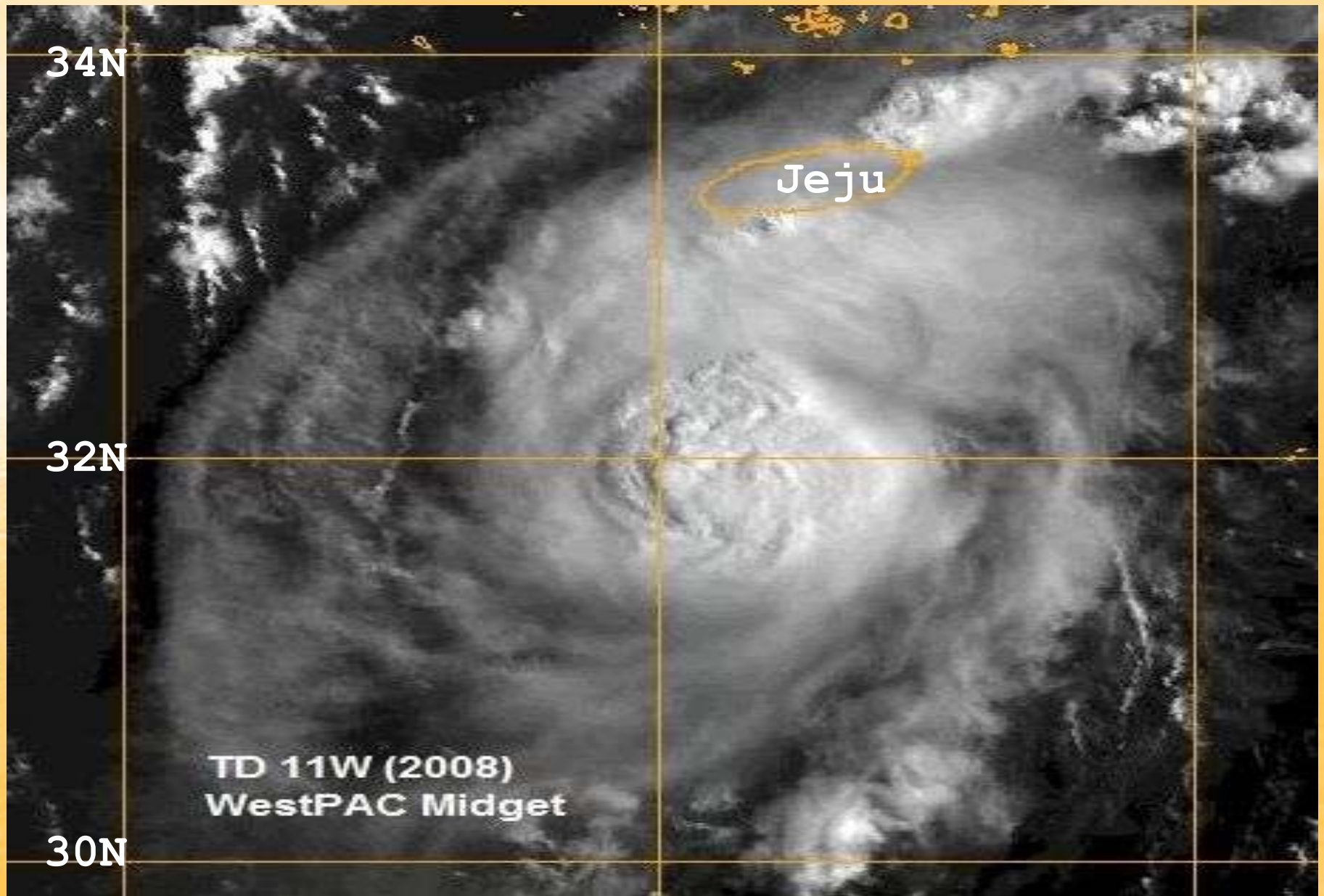


07 AUG 0130Z



08 AUG 0130Z

Midgets



Eye-Wall Replacement Cycle

12hr Trend of Hurricane Katrina (85h and IRbd)
~28/12Z to 29/00Z

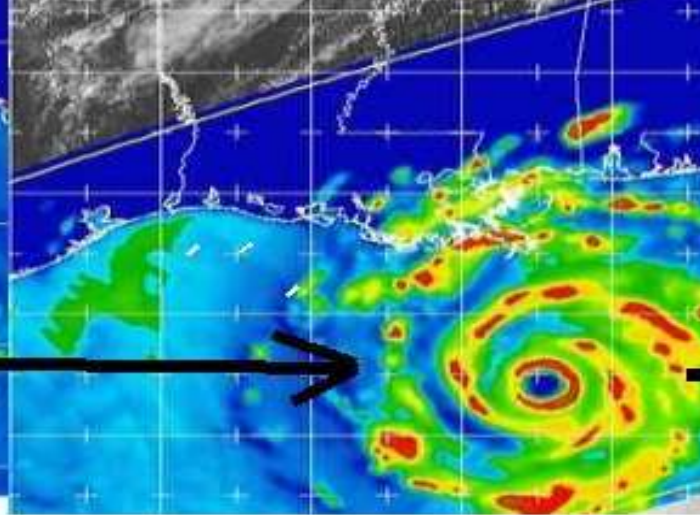
Weakening

Last 3hrs

1200Z 12L KATRINA
1244Z F-13 85H
1245Z GOES-12 VIS

29/05 0000Z 12L KATRINA
28/05 2133Z TRMM 85H
28/05 2015Z GOES-12 VIS

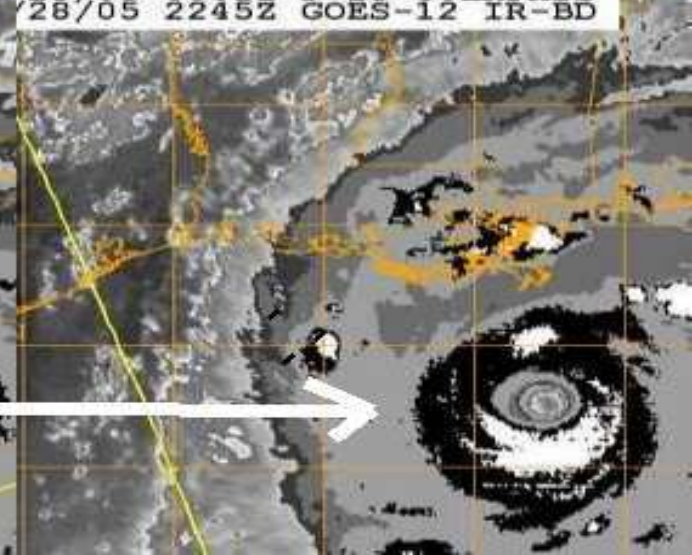
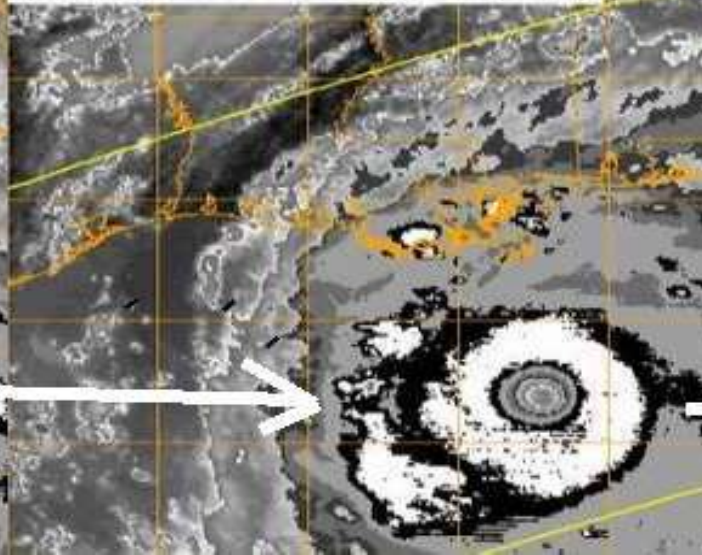
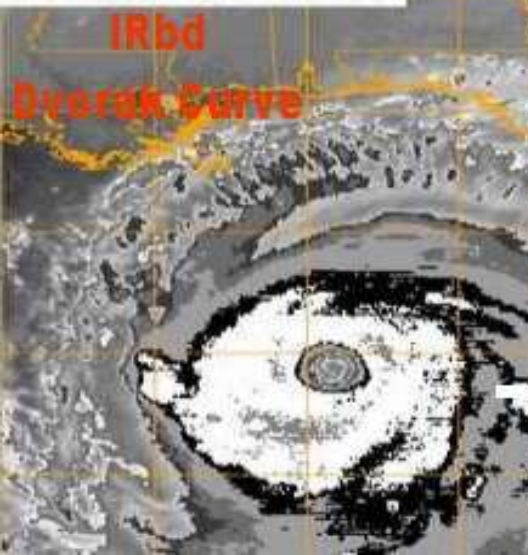
29/05 0001Z 12L KATRINA
28/05 0001Z F-13 85H
28/05 2245Z GOES-12 VIS



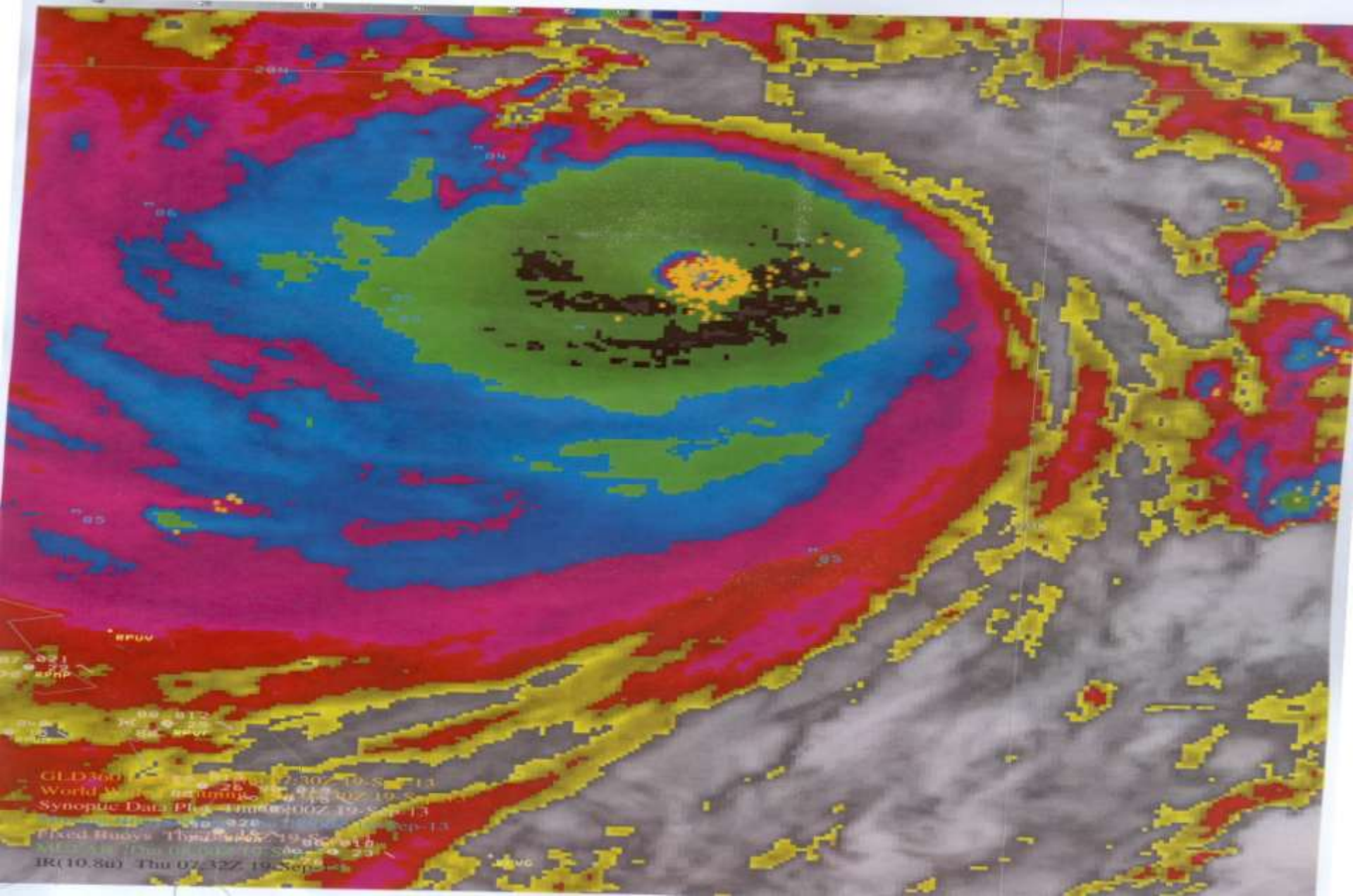
00Z 12L KATRINA
044Z F-13 OVERPASS
15Z GOES-12 IR-BD

29/05 0000Z 12L KATRINA
28/05 2133Z TRMM OVERPASS
28/05 2015Z GOES-12 IR-BD

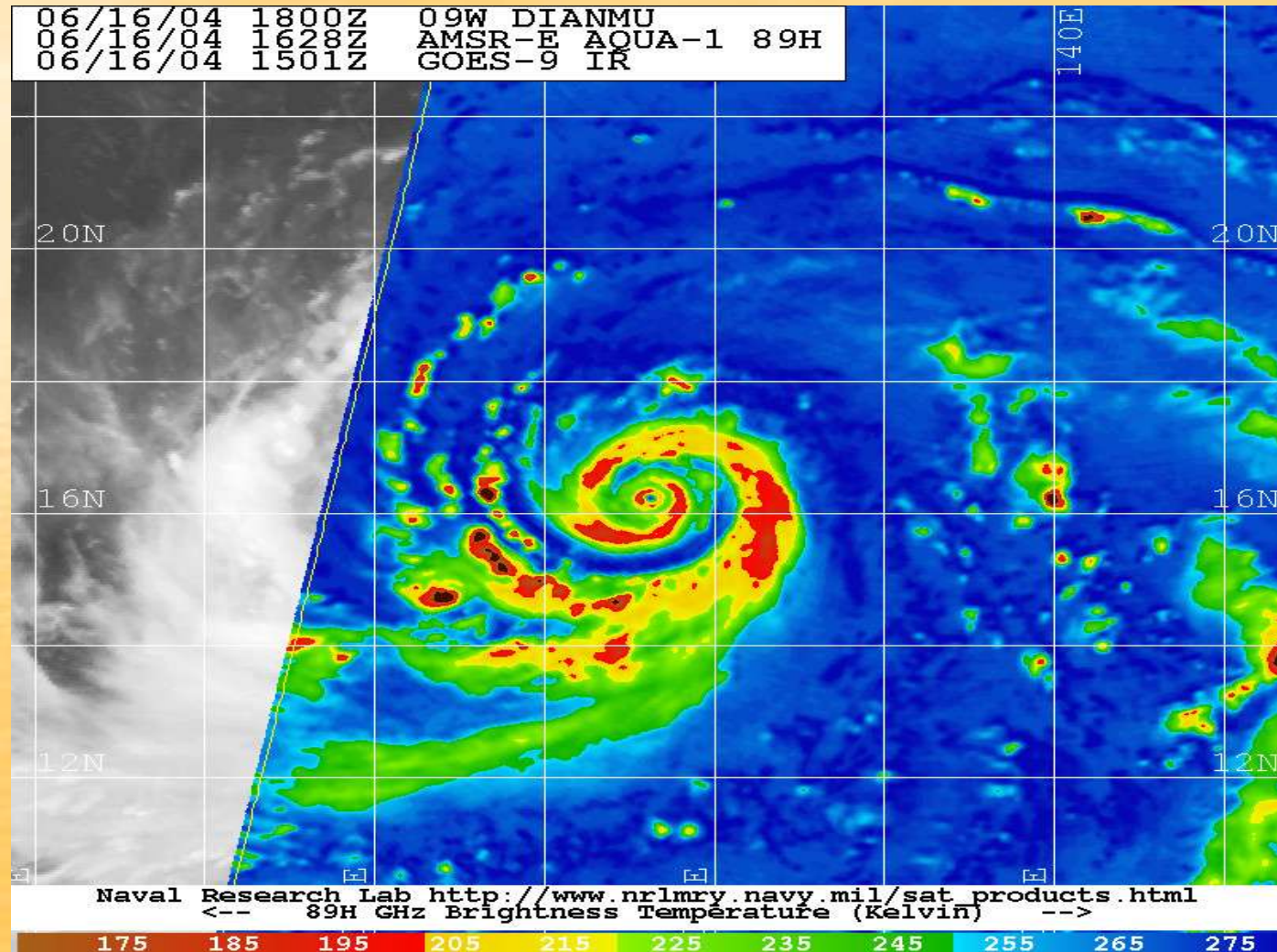
29/05 0000Z 12L KATRINA
28/05 0001Z F-13 OVERPASS
28/05 2245Z GOES-12 IR-BD



TY Usagi Rapidly Intensifying (RI) Lightning in Eye-Wall



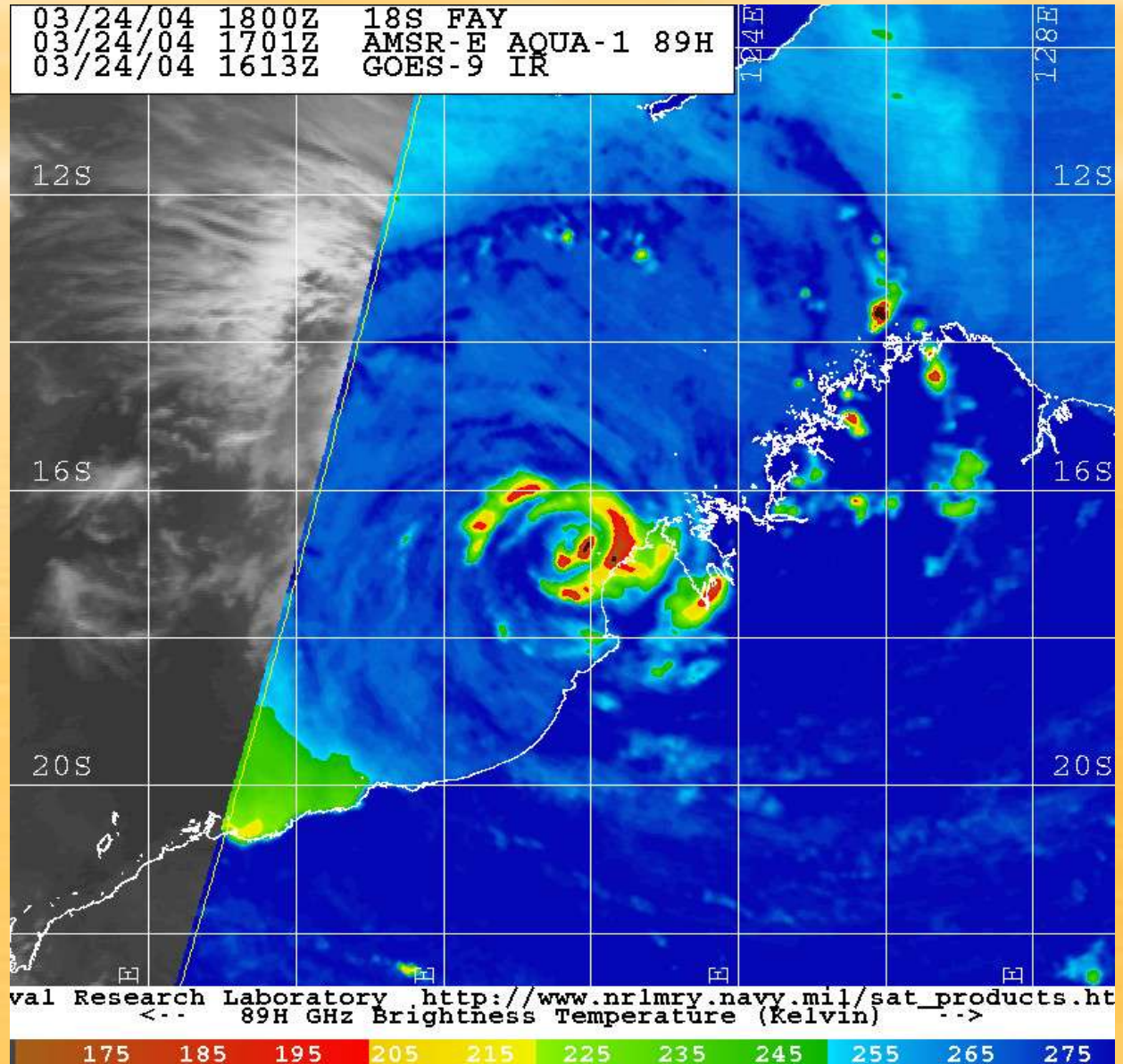
Perhaps we need to (finally) add a Microwave Procedure?



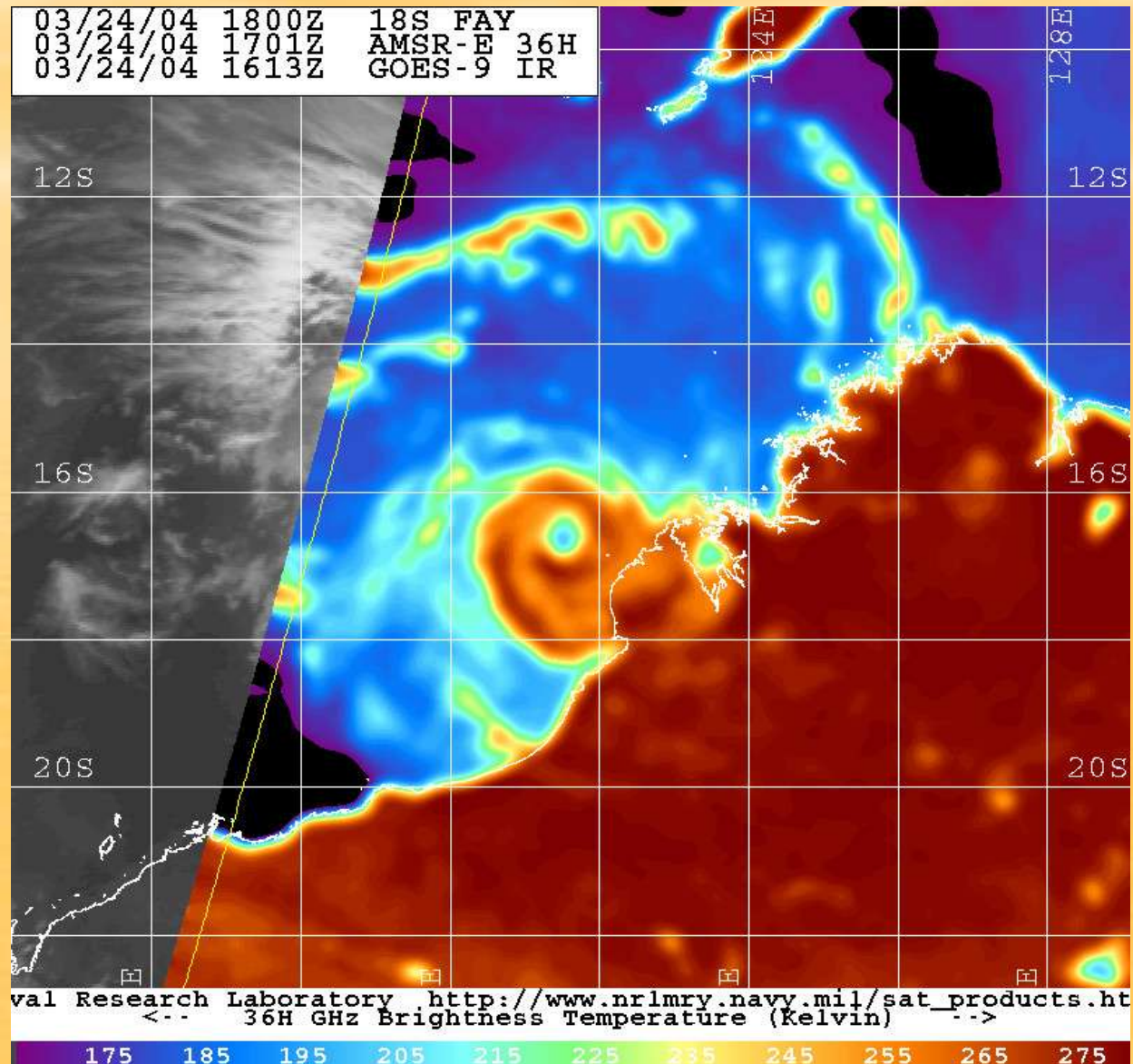
ADVANTAGES OF USING 85 GHz AND 37 GHz Microwave Imagery

- 'Sees' through clouds
- Positioning of TCs in difficult situations (especially in EARLY stages of development)
- View of convective rain bands is more DIRECTLY related to intensification of the TC
- Less delay in seeing *changes* in intensification
- Lower altitude of TRMM/WindSAT has increased resolution in BOTH 85 and 37 GHz
- Can (should be) still use in conjunction with existing techniques (e.g. IR Dvorak and Scatterometer data)

Some times the 87 GHz Imagery is not enough: Where's the Eye of the Storm?



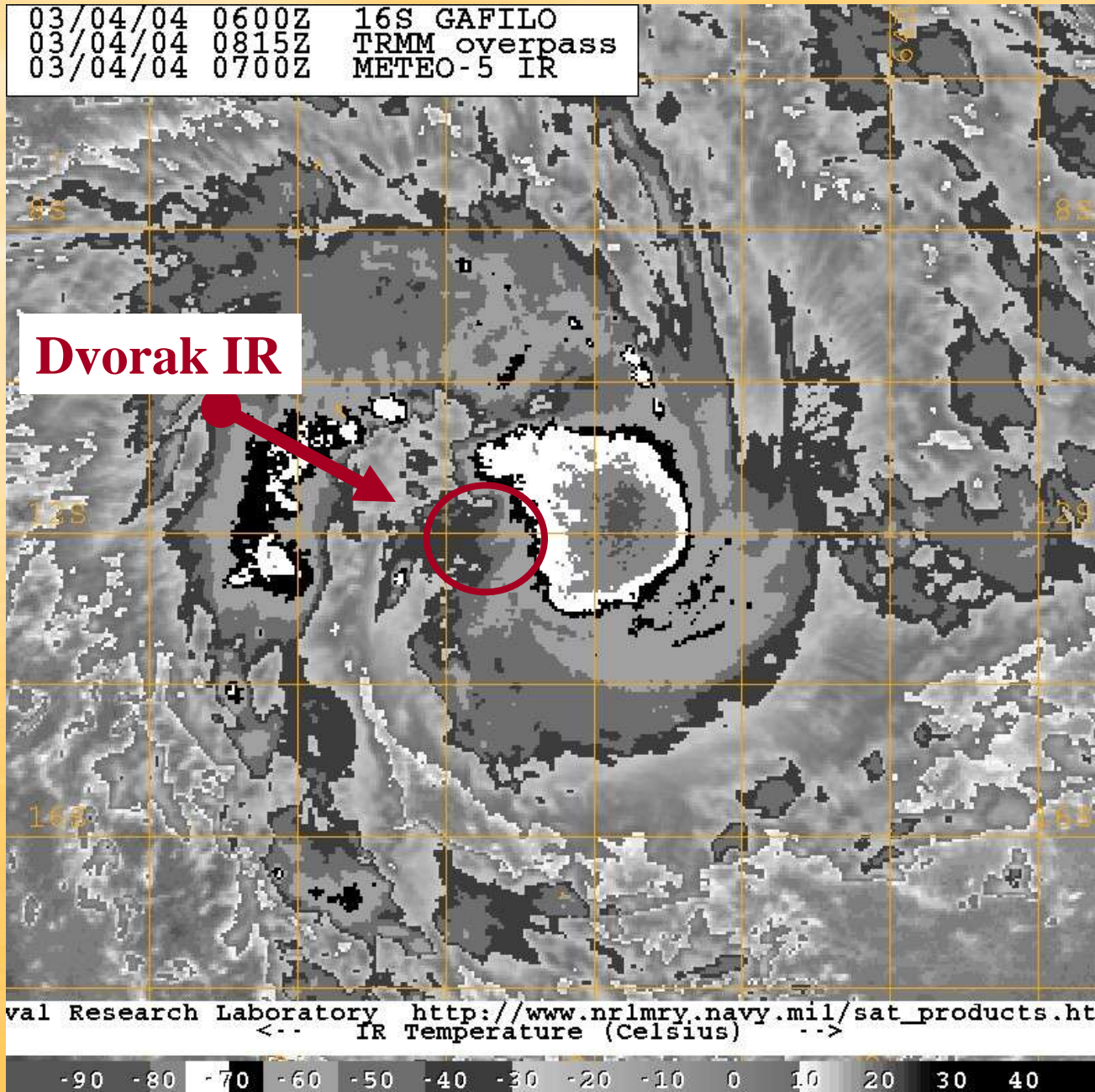
Another case for Using the 37 GHz: Eye Revealed



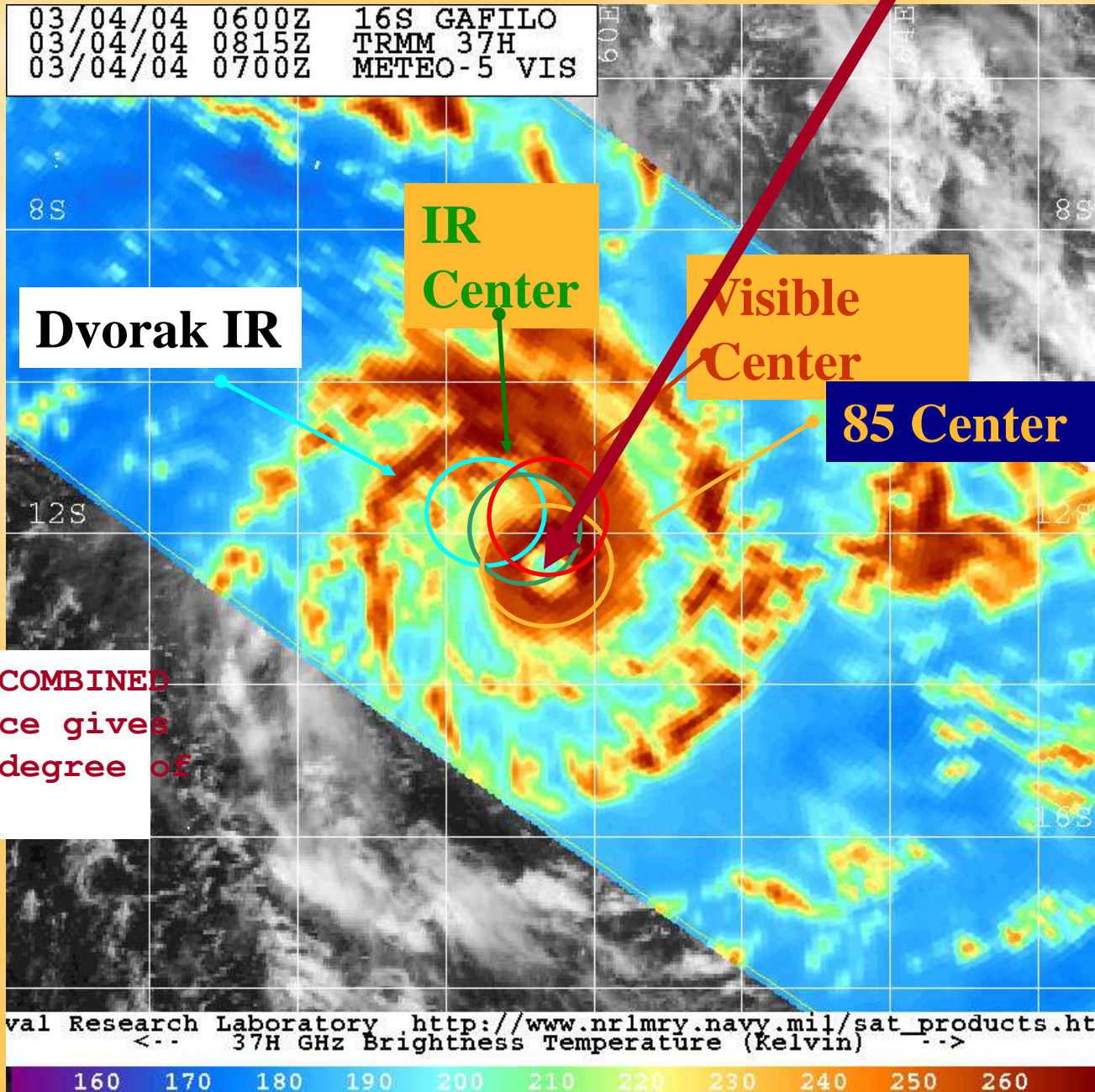
Use of Microwave and Dvorak

- Positioning is often superior to Vis/IR
- Problems
 - Frequency of passes (and correspondence to other data)
 - Resolution
 - Some interpretation
 - (still) No current intensity technique (partial by CIMSS, Univ of Wisconsin)

Where's the Center? Need help for Dvorak IR



Now, where's the Center? TMI 37 GHz**



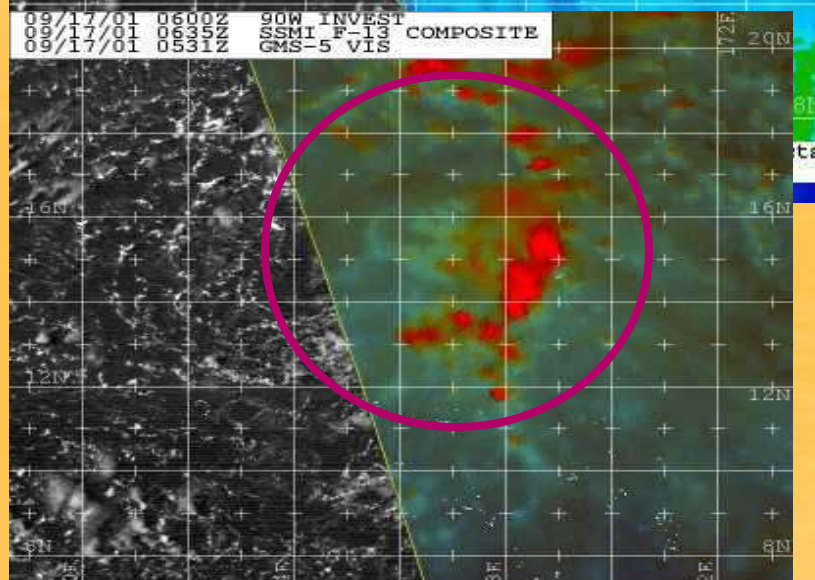
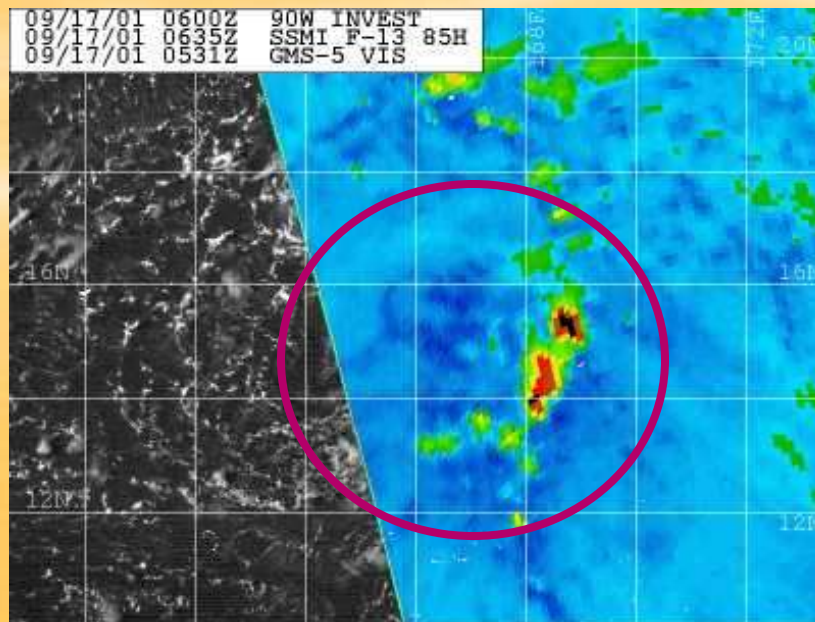
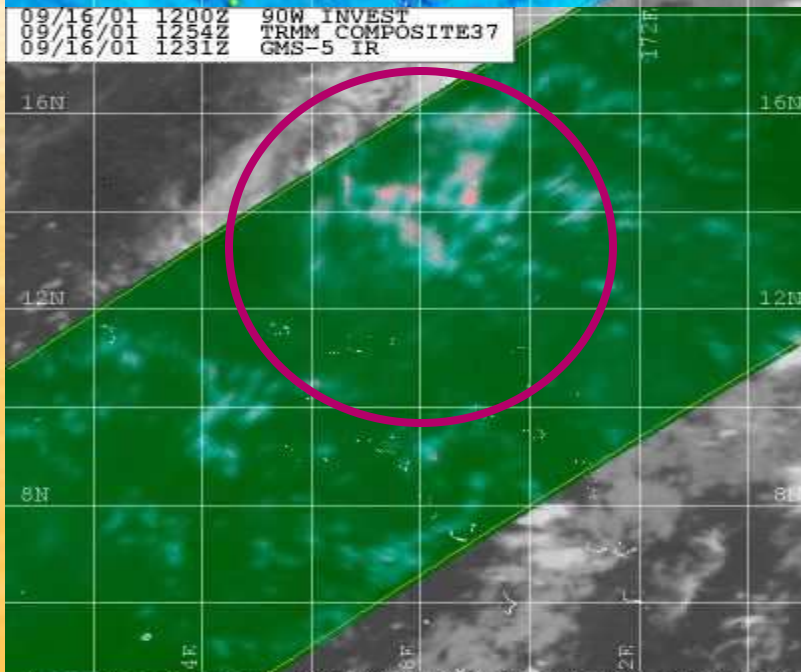
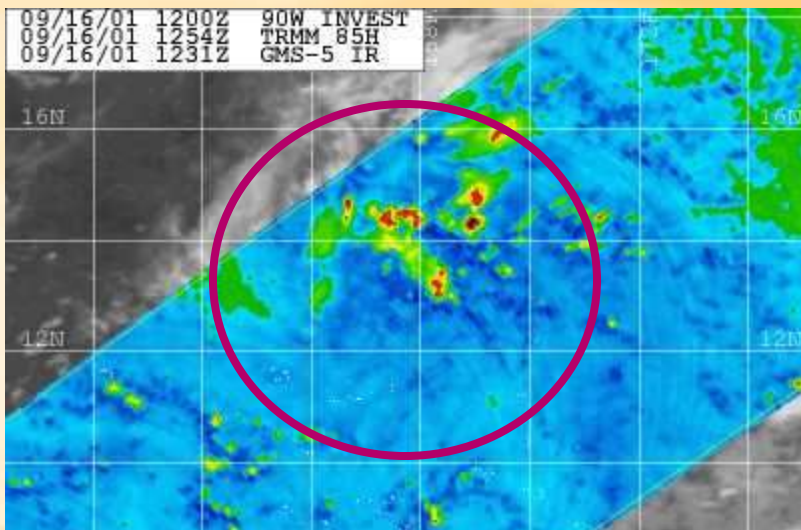
Comparison of Dvorak patterns with first 3 MI Stages in a TC Life Cycle

DEVELOPMENTAL PATTERN TYPES	MI Stages					
	1	2	3	←	→	
	PRE STORM	TROPICAL STORM		HURRICANE PATTERN TYPES		
		(Minimal)	(Strong)	(Minimal)	(Strong)	(Super)
	T1.5 T2.5	T2.5	T3.5	T4.5	T5.5	T6.5 T8
CURVED BAND PRIMARY PATTERN TYPE						
CURVED BAND EIR ONLY						
CDO PATTERN TYPE VIS ONLY						
SHEAR PATTERN TYPE						

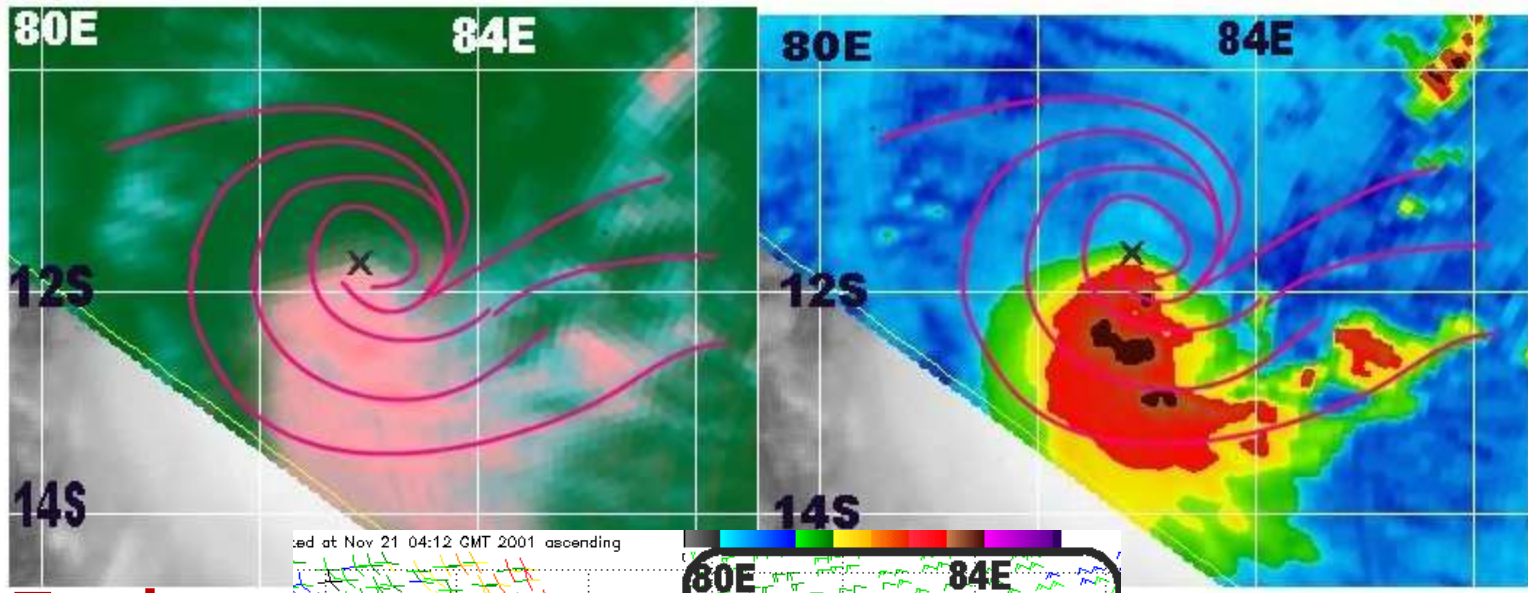
(Pre-Typhoon Francesco ≤ 25 kts)

16 Sep 1200 - 2 days before

17 Sep 0600 - 1 day before

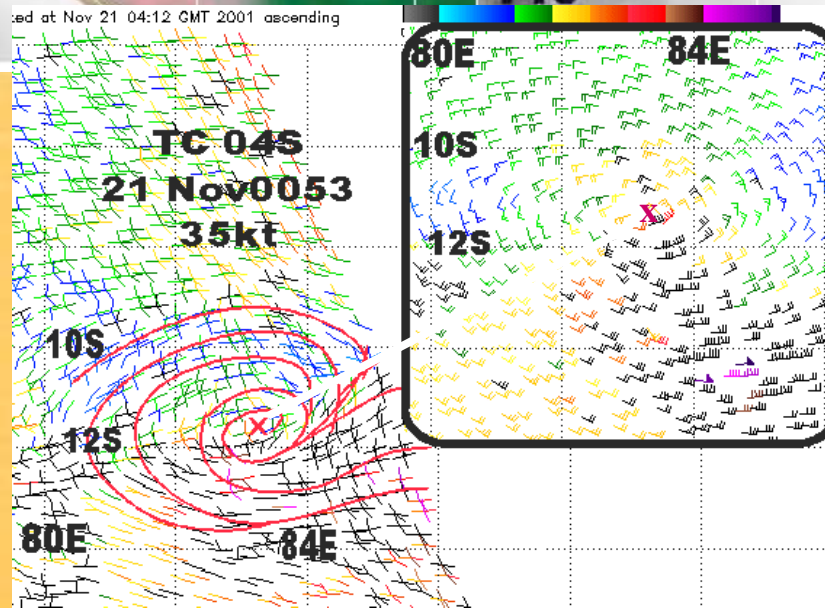


Stage 2 – Shear pattern (35kts)



37color

85h



QuikSCAT
Ambiguity

Each system may require
a varied set of microwave
imagery to best bring
out the best features

Tropical Storm Erin (06L) 45kts-- Stage 2 03Sep1200

TRMM/MI 37Ghz-Composite (Low-level enhanced)

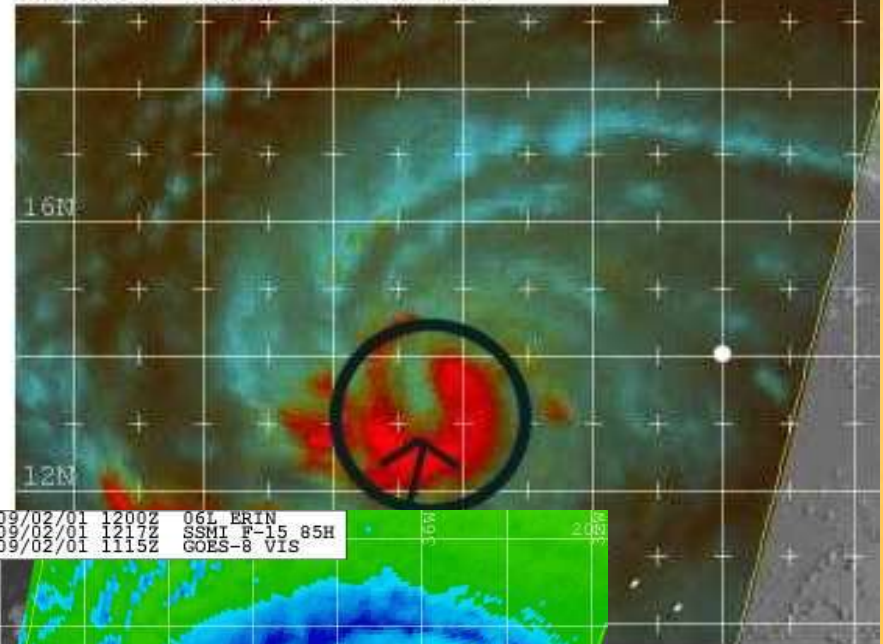
09/02/01 1200Z 06L ERIN
09/02/01 1012Z TRMM COMPOSITE37
09/02/01 0945Z GOES-8 VIS



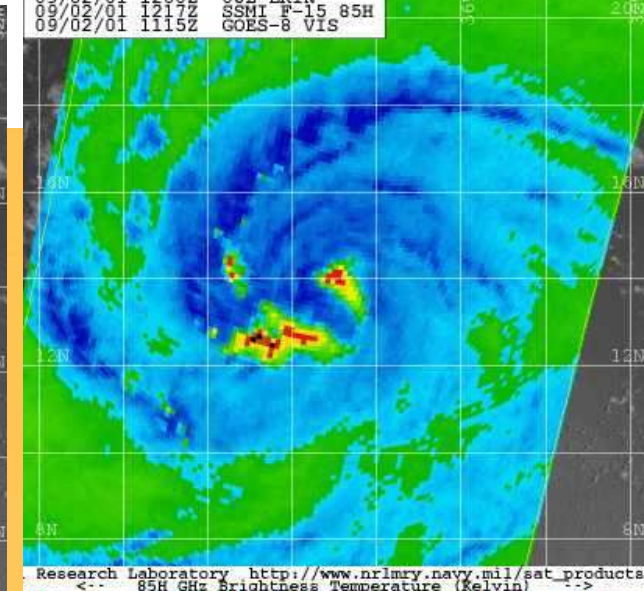
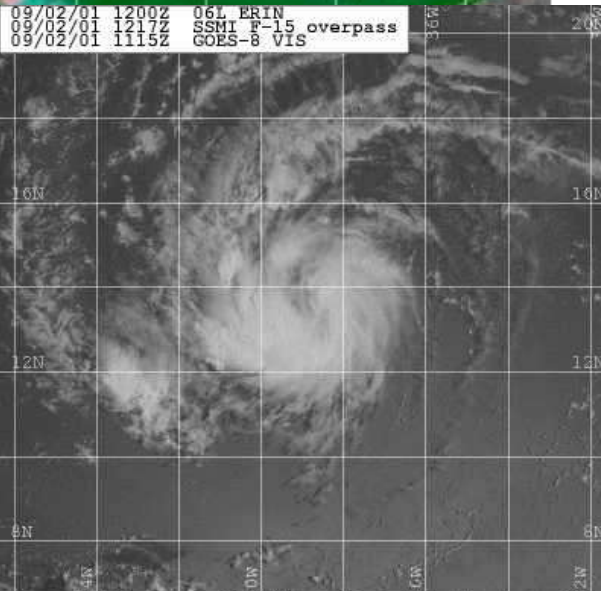
09/02/01 1200Z 06L ERIN
09/02/01 1217Z SSMI F-15 overpass
09/02/01 1115Z GOES-8 VIS

SSM/I 85Ghz-Composite (Low-level enhanced)

09/02/01 0600Z 06L ERIN
09/02/01 0855Z SSMI F-13 COMPOSITE
09/02/01 0945Z GOES-8 VIS



09/02/01 1200Z 06L ERIN
09/02/01 1217Z SSMI F-15 85H
09/02/01 1115Z GOES-8 VIS



Research Laboratory http://www.nrlmry.navy.mil/sat_products
85H GHz Brightness Temperature (Kelvin)

Research Laboratory http://www.nrlmry.navy.mil/sat_products

Possible ways to Supplement the Dvorak Analysis with Microwave Imagery

– Provide for an integrated positioning technique

(spiral band curvature and shear)

- Precision in use of embedded IR technique

- TC life cycle supplement (in MI)

- Early genesis identification (pre-T#1)

- Identifying both potential 'rapid' and 'delayed' intensification scenarios ('MET')

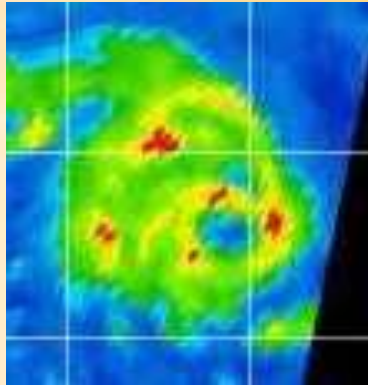
- Identification of 'peaking' and 'MET' changes

- Intensities during Extratropical Transition and dissipation scenarios

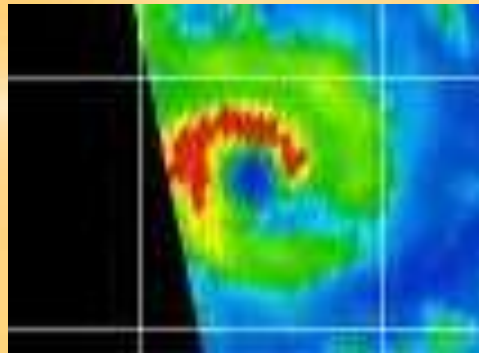
- Integration with 'other' techniques, including use of AMSU, Scatterometer, AODT, etc..

EVALUATIONS OF CAT5/SUPER TYPHOONS (85h)

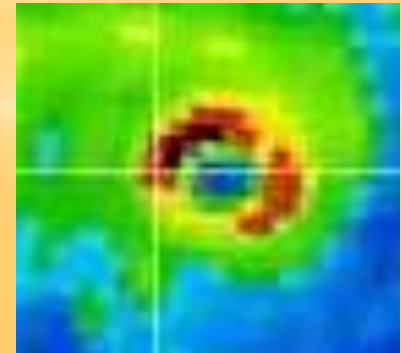
VIEWS: Time changes in red inner eyes



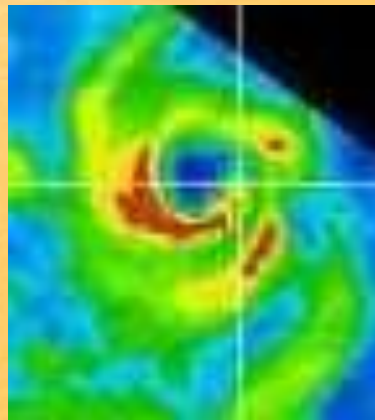
TC Susan 70kt -26hr



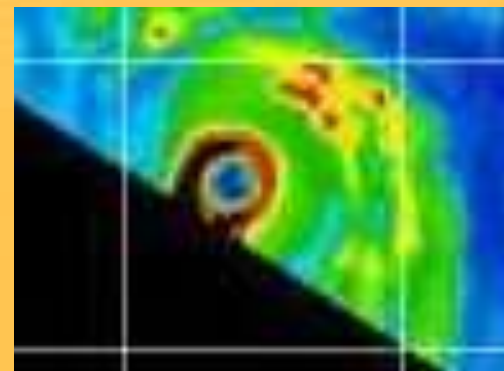
TC Susan 95kt -13hr



TC Susan 120kt -06hr



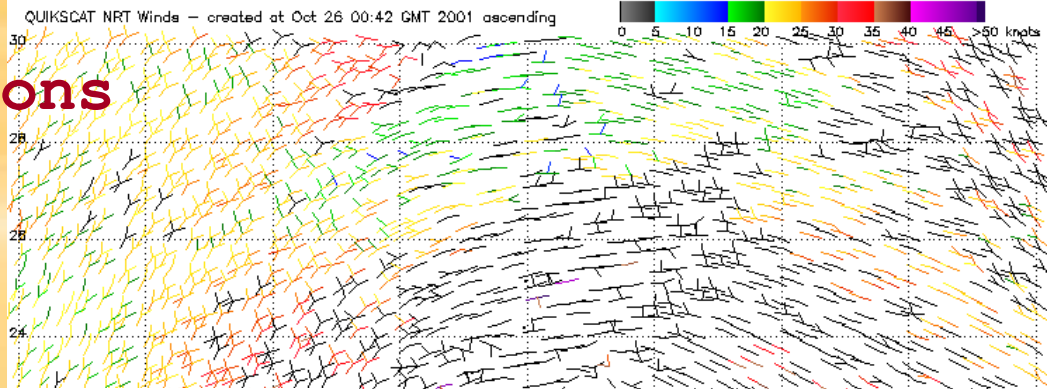
STY Zeb 95kt -24hr



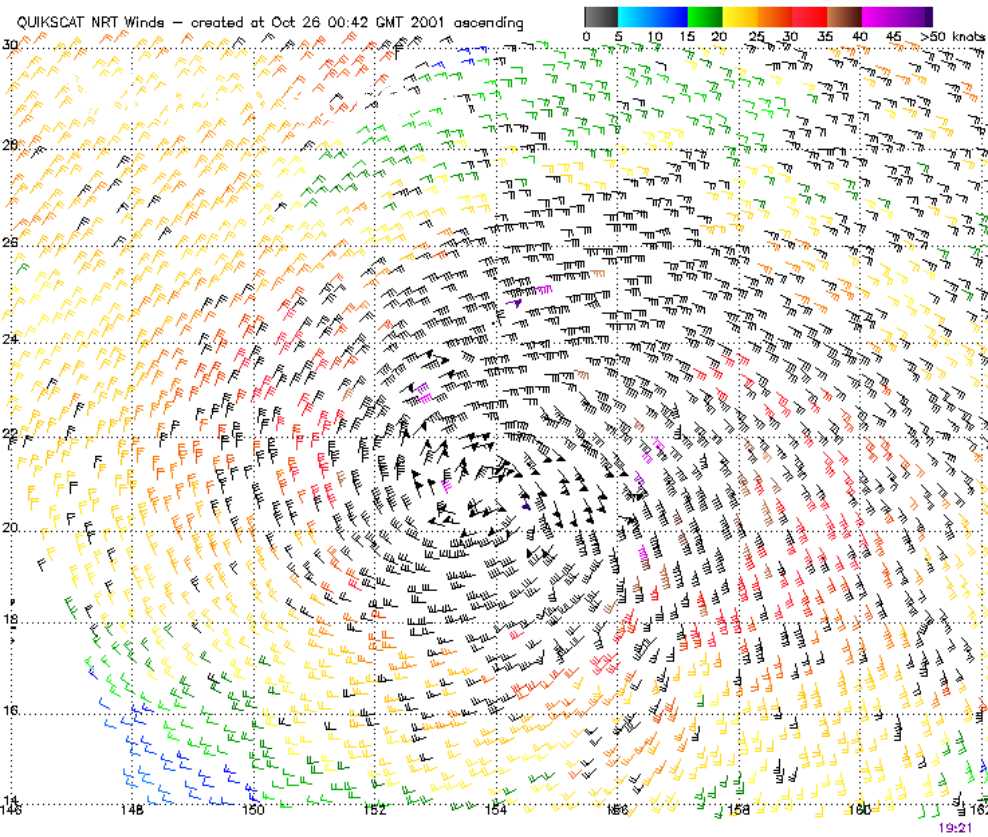
STY Zeb 140kt -00hr

3-views of Scatterometer

Ambiguity Solutions

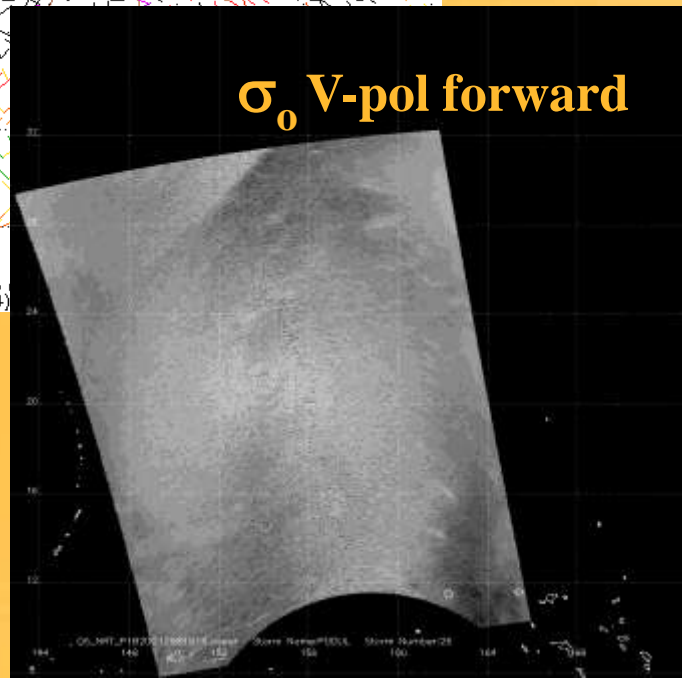


Wind Vectors



NRCS

σ_0 V-pol forward



Note: 1) Times are GMT 2) Black bars indicate possible rain contamination
3) Data buffer is Oct 26 00:42 GMT 2001-22 hrs 4) Data pass times at bottom of image

Scatterometer Platforms



	ASCAT Metop A: 2006-	OSCAT Oceansat-2: 2009-	QuikSCAT 1999 - 2009
Frequency	5.3 GHz (C)	13.5 GHz (Ku)	13.4 GHz (Ku)
Geometry	6 Fan Beams	2 Rotating Pencil	2 Rotating Pencil
Polarization	VV	HH inner / VV outer	HH inner / VV outer
Altitude	817 km	720 km	803 km
Sun-Sync Orbit / Repeat	101 min / 29 days	99 min / 2 days	101 min / 4 days
Incidence Angles	25° – 53° 34° – 64°	49° / 57°	46° / 54°
Swath	550km 700km-gap 550km	1400 km / 1836 km	1400 km / 1800 km
to Launch	**Metop B: 2012	Oceansat-2: 2016	?



Scatterometer Sites NOAA/NESDIS

<http://manati.star.nesdis.noaa.gov/datasets/OSCATData.php>



STAR Center for Satellite Application and Research

National Environmental Satellite, Data, and Information Service (NESDIS)

Ocean Surface Winds Team

OSCAT

NOAA | NESDIS | STAR | SOCD

[OSWT Home](#) | [Product Description](#) | [Data Products](#) | [Research](#) | [Contact Us](#)

► [OSWT Home](#)

► [Product Description](#)

► [Data Products](#)

- [QuikSCAT/SeaWinds](#)
- [OSCAT >>](#)
- [ASCAT \(METOP-A\)](#)
- [ASCAT \(METOP-B\)](#)
- [WindSAT](#)
- [ERS-2](#)
- [SSM/I](#)

Data from Satellite/Instruments: [Oceansat-2](#)

Additional Products

Year

Month

Day

Global(80N80S-180E180W)

[Get Images](#)

- NOAA Wind Vectors 10x15 (25KM)
- NOAA Wind Vectors 20x30 (25KM)
- NOAA Wind Vectors 10x15 (12KM)
- Global Directional Ambiguity 10x15 (25KM)
- Global Directional Ambiguity 20x30 (25KM)
- Ice
- Storm
- Sea Level Pressure

Ascending Pass



STAR Center for Satellite Application and Research

National Environmental Satellite, Data, and Information Service (NESDIS)

Ocean Surface Winds Team

ASCAT A or B

NOAA | NESDIS | STAR | SOCD

[OSWT Home](#) | [Product Description](#) | [Data Products](#) | [Research](#) | [Contact](#)

► [OSWT Home](#)

► [Product Description](#)

► [Data Products](#)

- [QuikSCAT/SeaWinds](#)
- [OSCAT](#)
- [ASCAT \(METOP-A\) >>](#)
- [ASCAT \(METOP-B\)](#)
- [WindSAT](#)
- [ERS-2](#)
- [SSM/I](#)

► [Research](#)

► [Contact Us](#)

This web site is not supported on a 24x7 basis and should not be considered operational.

Data from Satellite/Instruments: [Advanced Scatterometer \(ASCAT METOP-A\)](#)

Additional Products

Year

Month

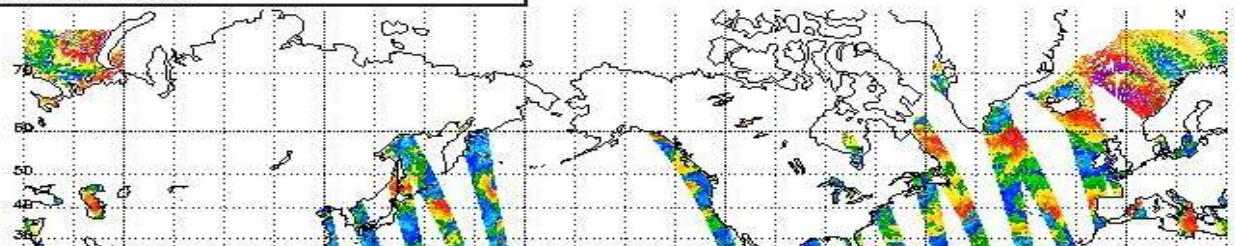
Day

Global(80N80S-180E180W)

[Get Images](#)

- NOAA wind vectors 10x15 (25KM)
- NOAA wind vectors 20x30 (50KM)
- NOAA Directional Ambiguity
- Storm
- Ultra High Resolution Winds (Gulf of Mexico)
- Ice
- Sea Level Pressure

Ascending Pass



Scatterometer Sites NOAA/NESDIS

Storm Pages (ASCAT and OSCAT)



STAR Center for Satellite
Application and Research

National Environmental Satellite, Data, and Information Service (NESDIS)

Ocean Surface Winds Team

NOAA | NESDIS | STAR | SOCD

OSWT Home | Product Description | Data Products | Research | Contact US

▸ OSWT Home

▸ Product Description

▸ Data Products

- QuikSCAT/SeaWinds
- OSCAT >>
- ASCAT (METOP-A)
- ASCAT (METOP-B)
- WindSAT
- ERS-2
- SSM/I

▸ Research

▸ Contact Us

This web site is not supported on a 24x7 basis and should not be considered operational.

Enter search term(s)

Go

This site only All of NOAA

[Advanced Search](#)

Data from Satellite/Instruments: Oceansat-2

Additional Products

Year

Storm_ID:

Storm

2013

HAIYAN

Get Images

- Atlantic ocean
- Eastern pacific
- Western pacific
- Central pacific
- Northern pacific
- Indian ocean
- Southern Hemisphere

Wind Vector Images:

[HAIYAN 13110402 31 as HAIYAN 13110402 31 ds](#)
[HAIYAN 13110408 31 as HAIYAN 13110408 31 ds](#)

Ambiguity Images:

[HAIYAN 13110402 31 as HAIYAN 13110402 31 ds](#)
[HAIYAN 13110408 31 as HAIYAN 13110408 31 ds](#)

NRCS Images:

[201311040338.S1L1B2013308 21791 21792.h5.avewr](#) [HAIYAN 31W 20133080044.avewr](#)

BYU Hires Images:

[201311040338.S1L1B2013308 21791 21792.h5.avewr](#) [HAIYAN 31W 20133080044.WRave3 map](#)

Scatterometer Sites: KNMI

http://www.knmi.nl/scatterometer/ascat_osi_25_prod/ascat_app.cgi



Ocean and Sea Ice SAF
Wind Processing Centre

[GO TO
OSI SAF CENTRAL
WEB SITE](#)

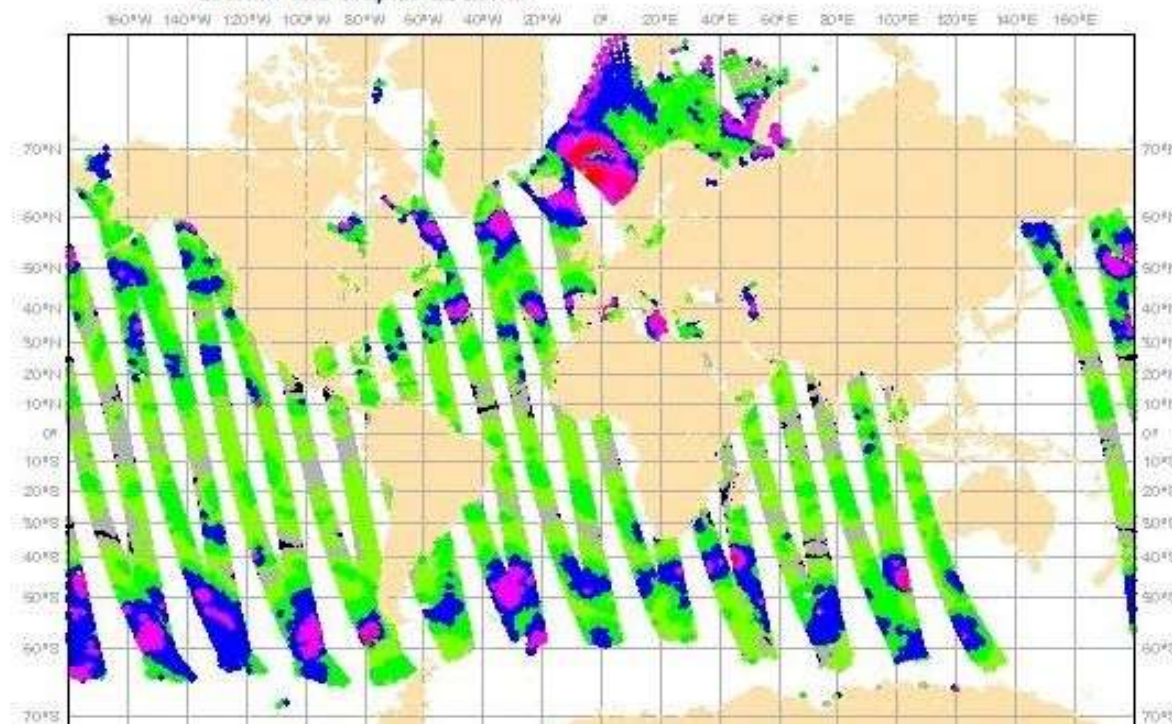
Updated @ 2013-12-01 12:33 utc

OSI SAF ASCAT-A 12.5-km product

ASCAT12, status: operational

Ascending passes

Click in the map to zoom in



Select view

- Monitoring information
- Buoy validations
- Ice maps
- Data from previous day

Background information

- Modifications/anomalies
- Description of plots
- Access to products
- Acknowledgements
- ASCAT Product User Manual
- ASCAT 12.5-km Validation report
- Home OSI SAF Wind Centre

OSI SAF Wind Products

- ASCAT-A 25-km winds
Operational status
- ASCAT-A Coastal winds
Pre-operational status
- ASCAT-B 25-km winds
Operational status
- ASCAT-B Coastal winds
Pre-operational status
- Oceansat-2 50-km winds
Operational status
- QuikSCAT winds
Discontinued status

Uses of Scatterometer data over Tropical Cyclones (GOALS)

- **Positioning and Motion**
- **Minimum (at least) maximum wind**
- **Structure and Structure Change (Wind Radii)**
- **Genesis and (Surface) Genesis processes**
- **Extratropical Transition and Dissipation**

high conf



high conf

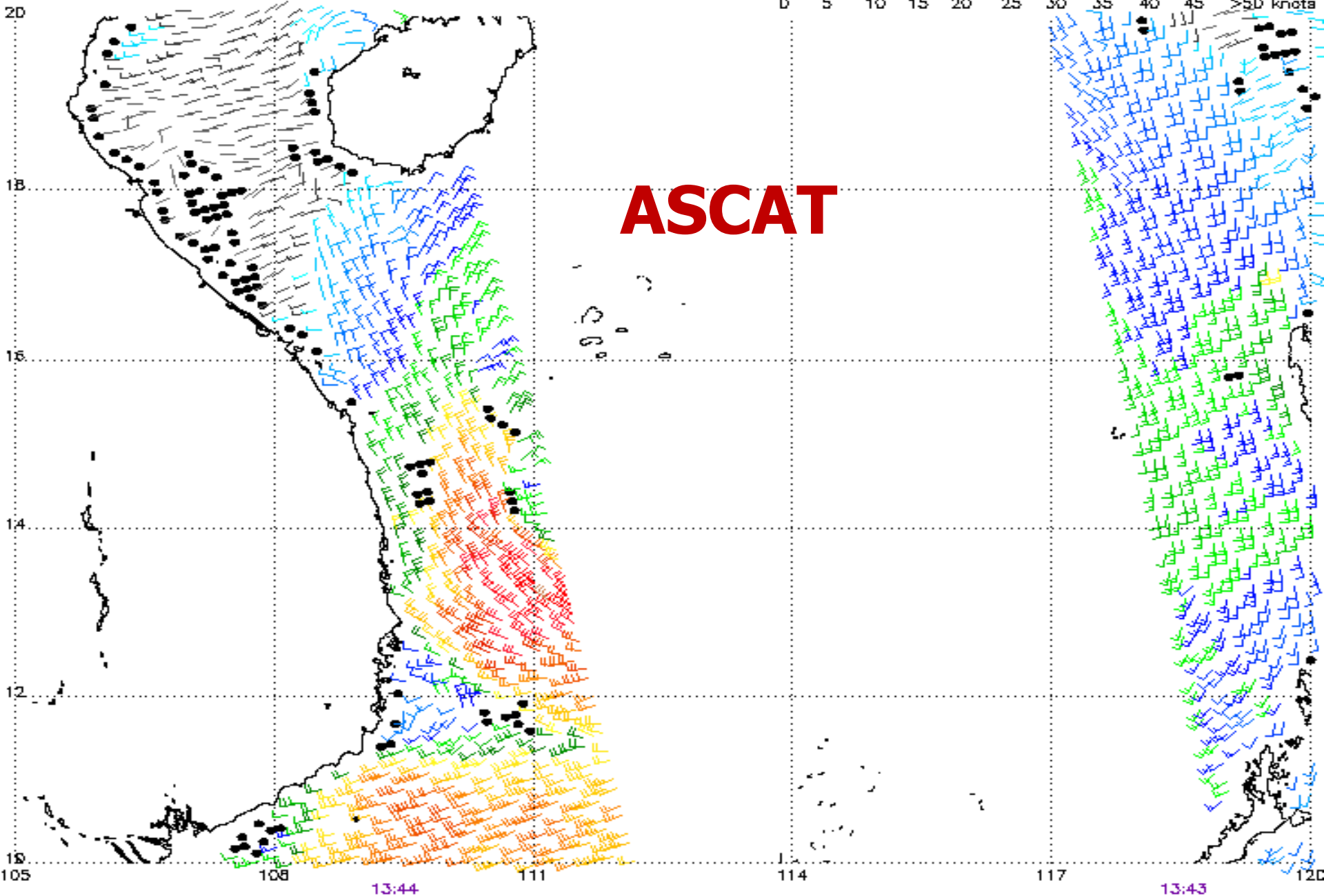
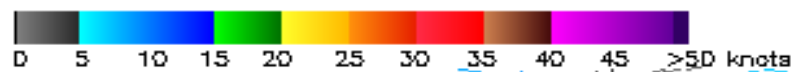
mod conf

Ambiguity Format



3.8 160.4

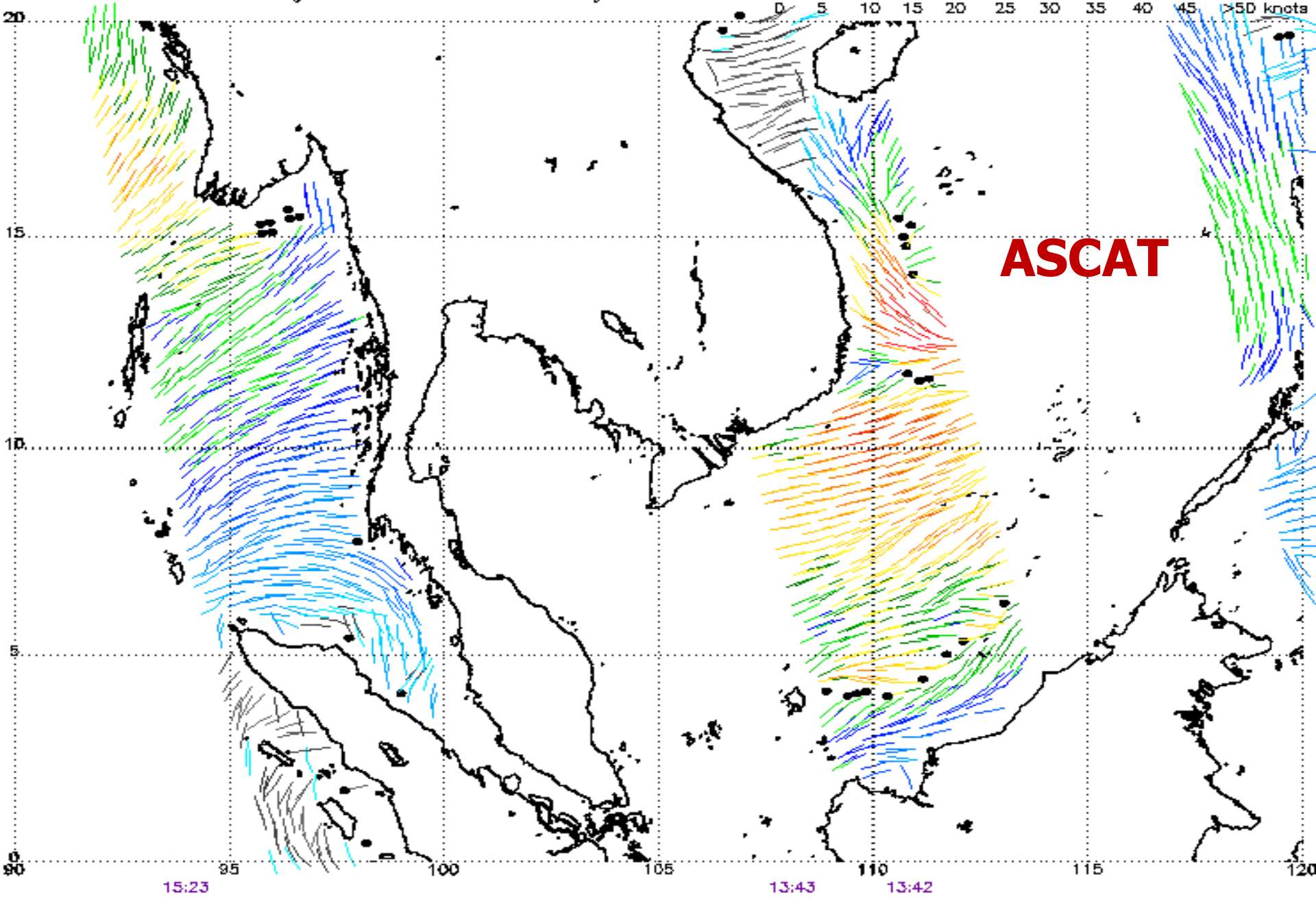
neutral conf



13:44

13:43

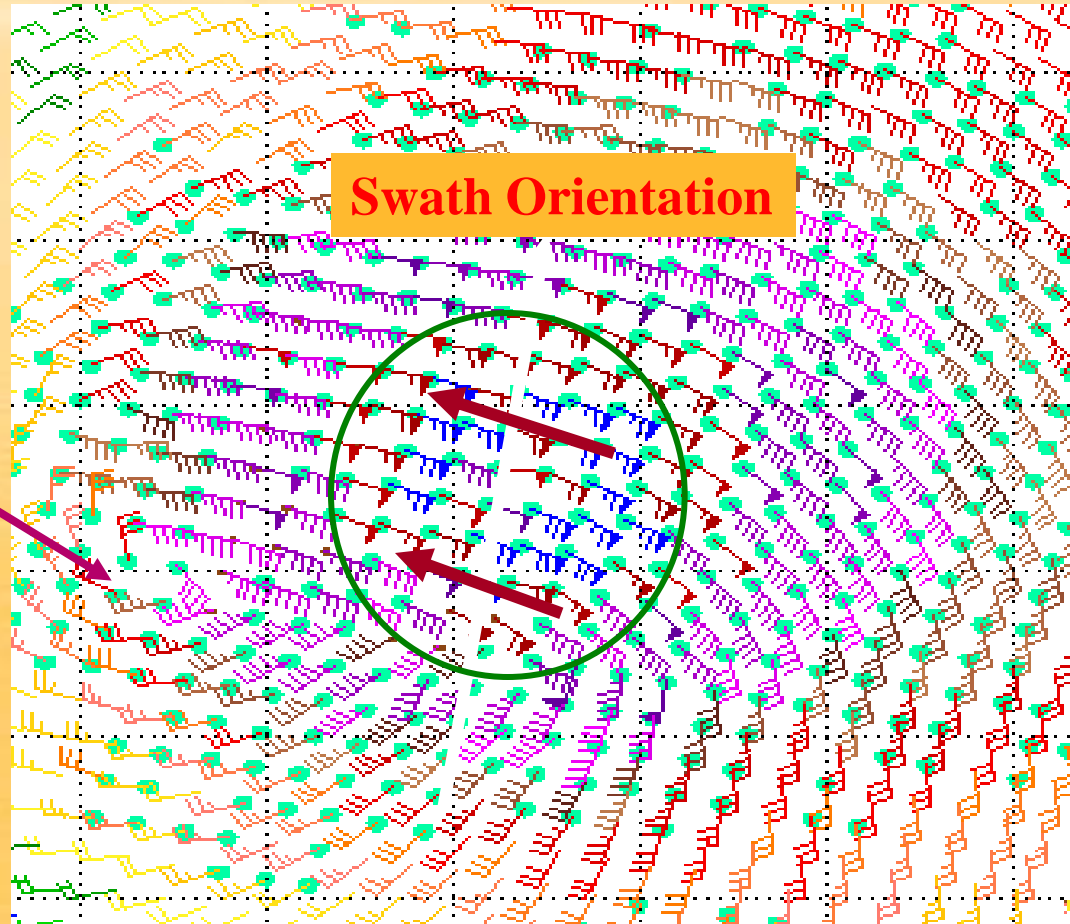
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 15N
 3) Data buffer is 22 hrs from Aug 4 04:10 UTC 2007 4) Black circles indicate possible contamination
 NOAA/NESDIS/Office of Research and Applications



Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 10N
3) Data buffer is 22 hrs from Aug 4 04:03 UTC 2007 4) Black circles indicate possible contamination
NOAA/NESDIS/Office of Research and Applications

RAIN EFFECTS-Direction selection problem (Rain Blocks--Perpendicular to Swath)

The “Rain Block”



Bad direction *selection*—Speeds are ‘good’.

Watch
out for
“False
Center”!

Ascending Swath

σ_0 v-pol (forward)

STY Podul (26W)

25 Oct 1921Z

Psn: 21N 153.8E

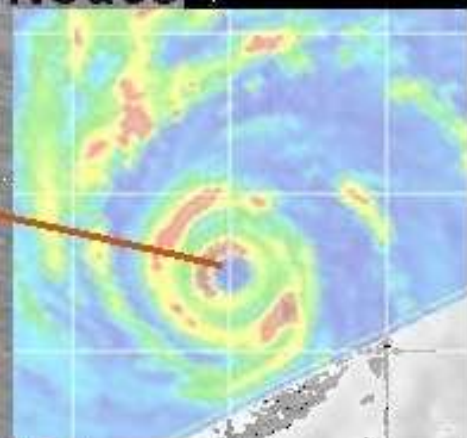
est Int: 140kt

Center dark spot

Along-track Bright Nodes

Cross-track Dark Band

Swath Scan



28

24

20

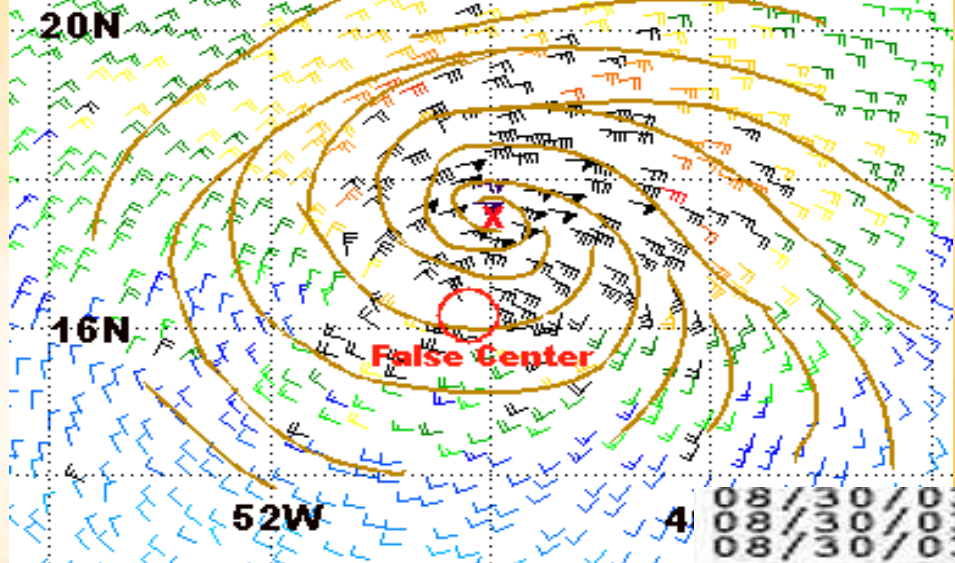
16

12

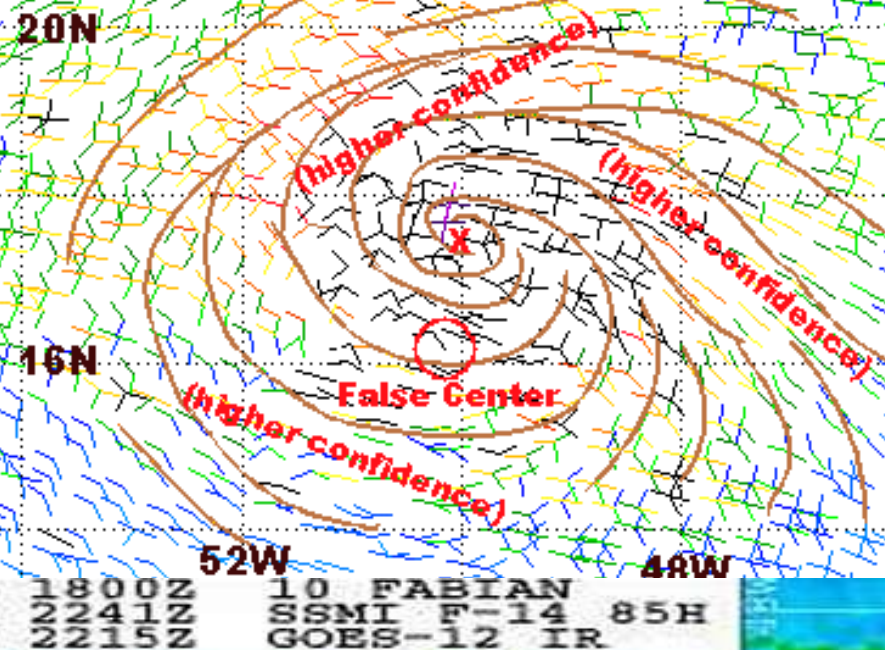
QuikSCAT - NRT/NOAA

30 Aug 2126

Hurricane Fabian (~105kt)



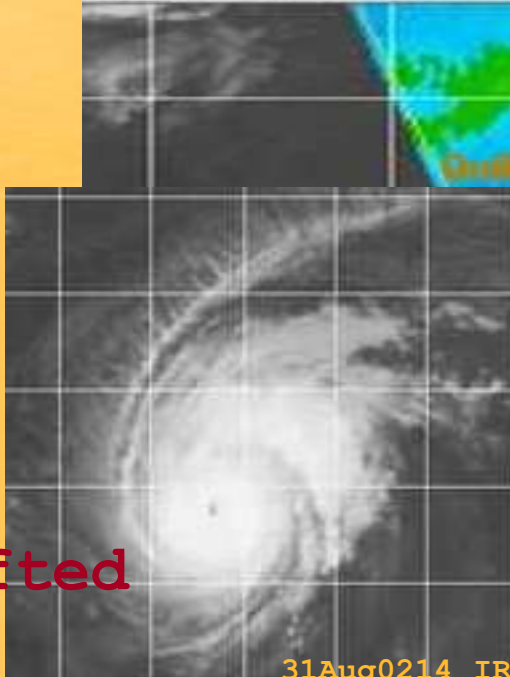
QuikSCAT - NRT Ambiguities



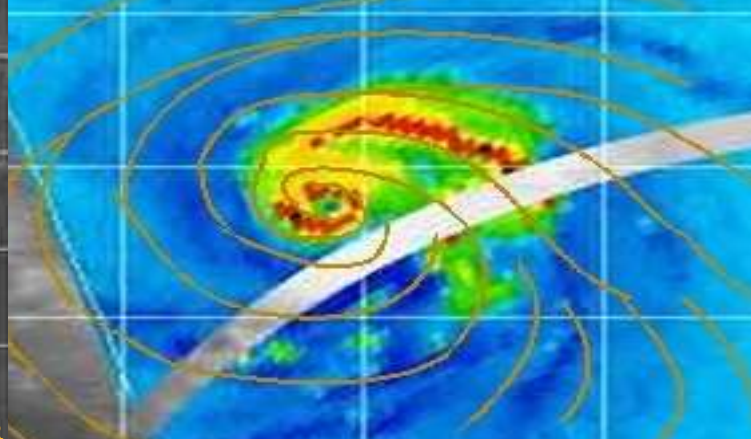
08/30/03	1800Z	10 FABIAN
08/30/03	2241Z	SSMI F-14 85H
08/30/03	2215Z	GOES-12 IR

Hur Fabian
 (10 L)
 ~17.5N 49.9W
 105kt

Streamlines shifted
 westward



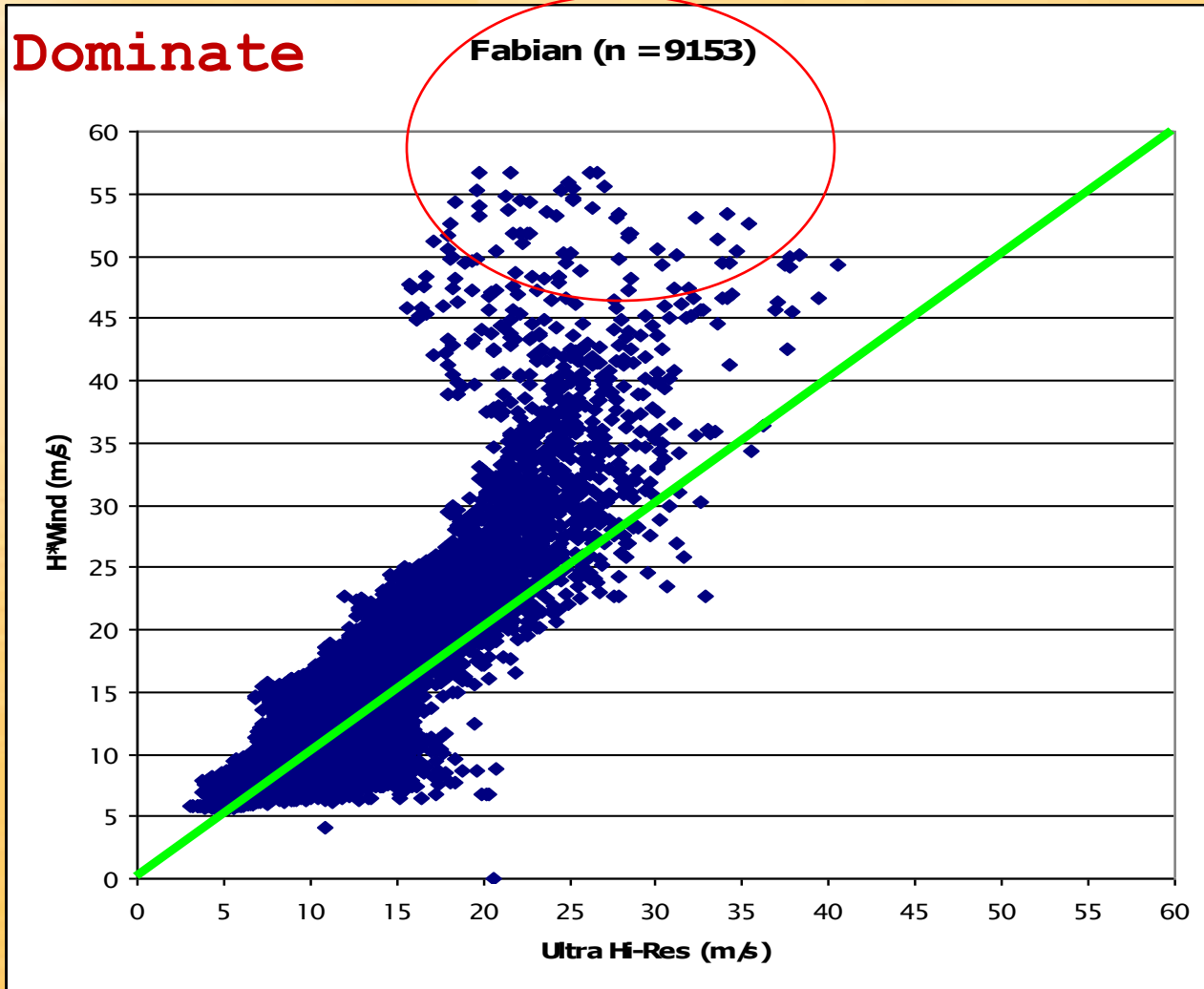
85h SSMI
 QuikSCAT Streamlines (see ambiguity plot)
 (shifted westward for ~1hr. msg)



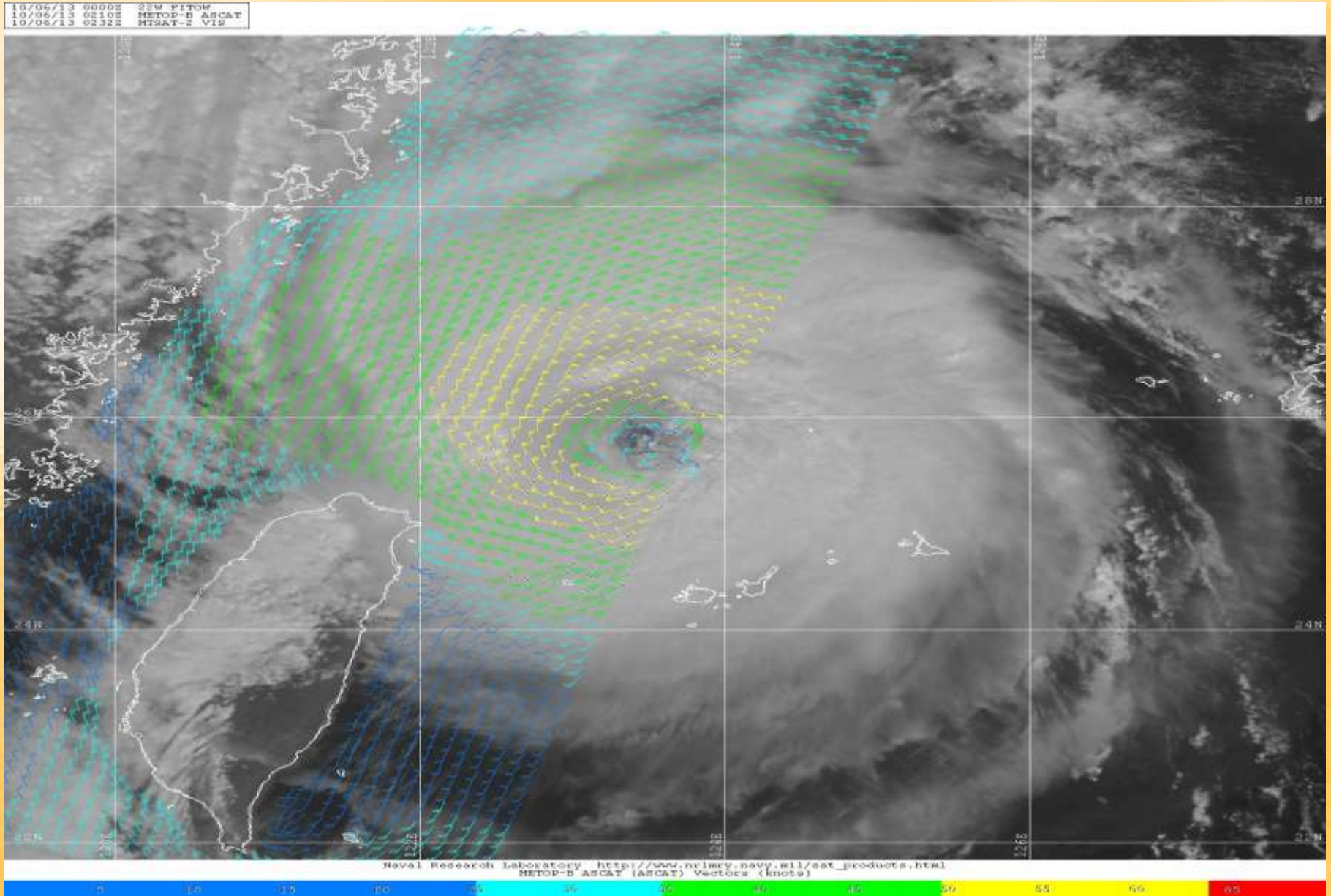
31Aug0214 IR

Doesn't the scatterometer always read to high?

NO! Attenuation and Resolution Dominate



Structure—ASCAT-B

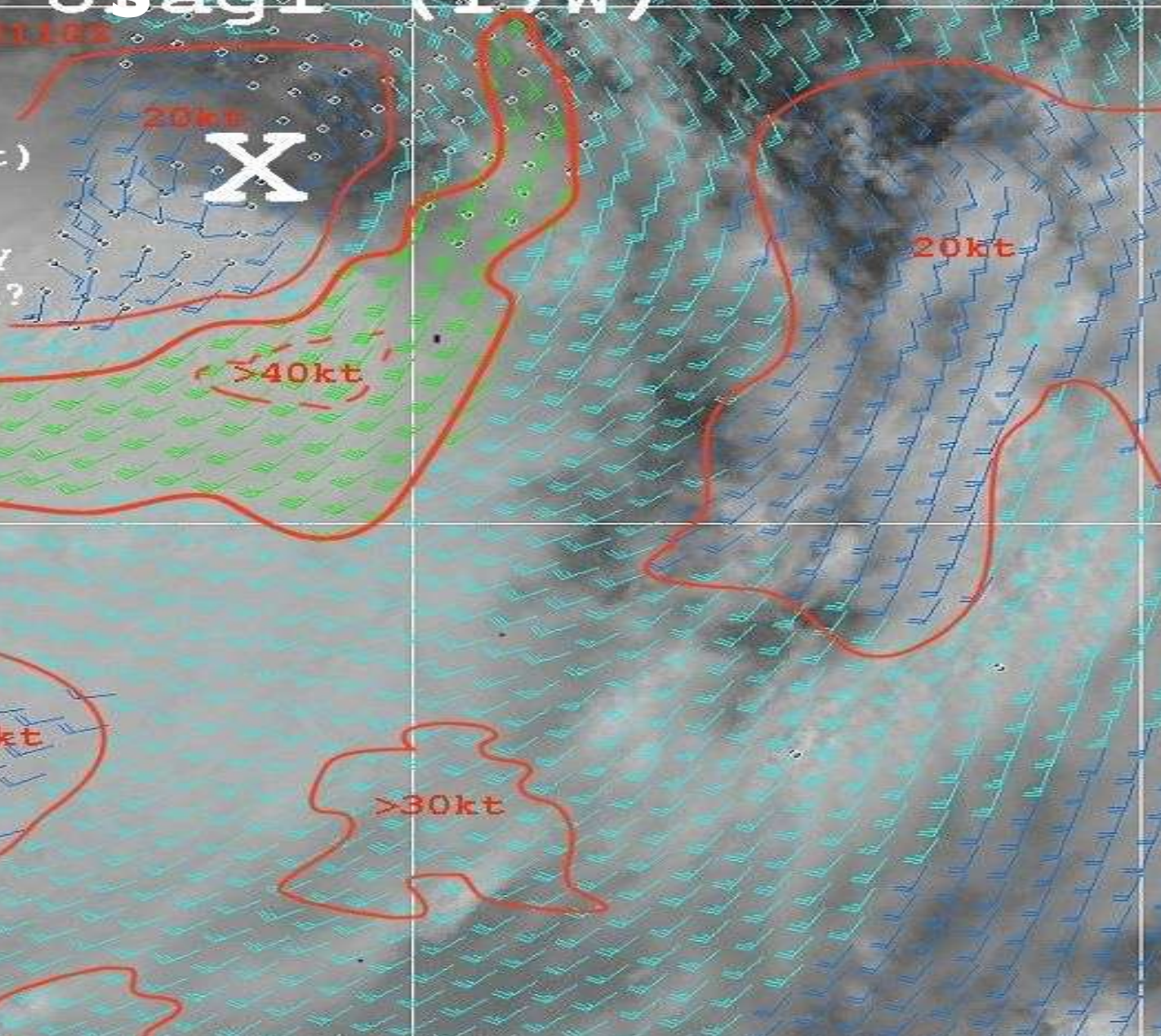


TS Usagi (17W)

0000Z at 17/0110Z

Dvorak
~T2.0 (30kt)

What intensity
do you go with?



>35kt
>40kt
>35kt

20kt

>30kt

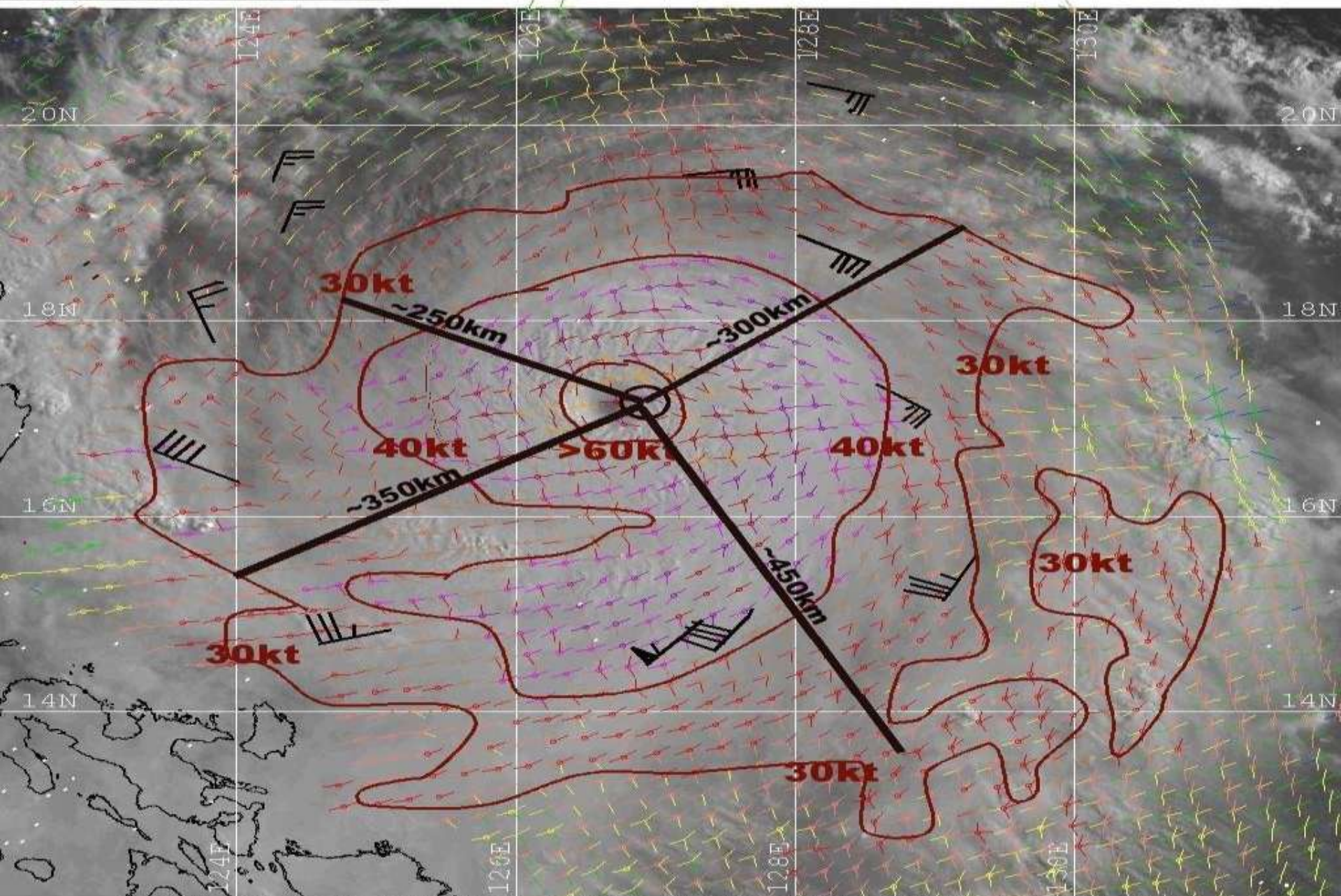
>30kt
~area of ship report
(35kt-4m seas)

00E

02E

04E

088/15/07 1800NN
088/15/07 2230NN
09W SEPAT
QuikScat
CMS-1000 cat
VIS

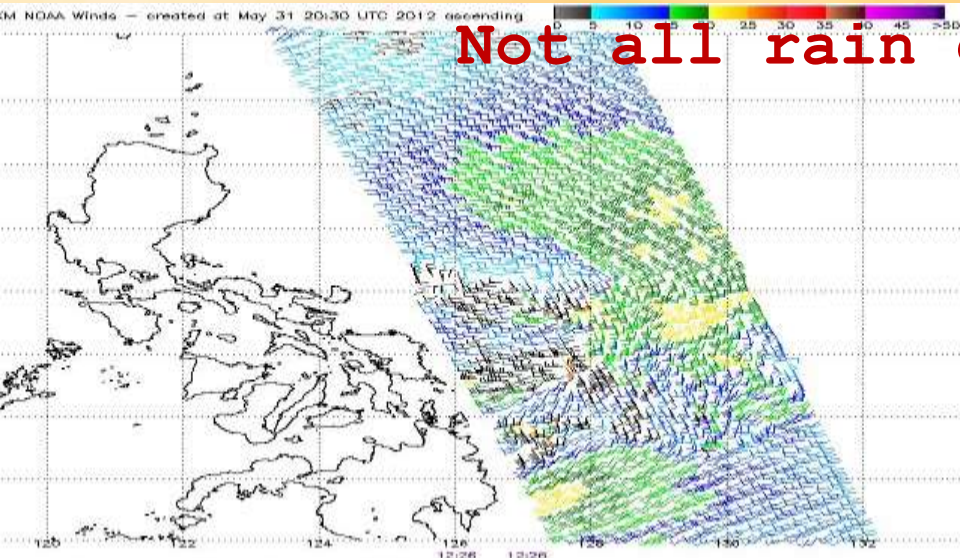


Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
QuikScat (FNMOC_AMB) Vectors (Knots)

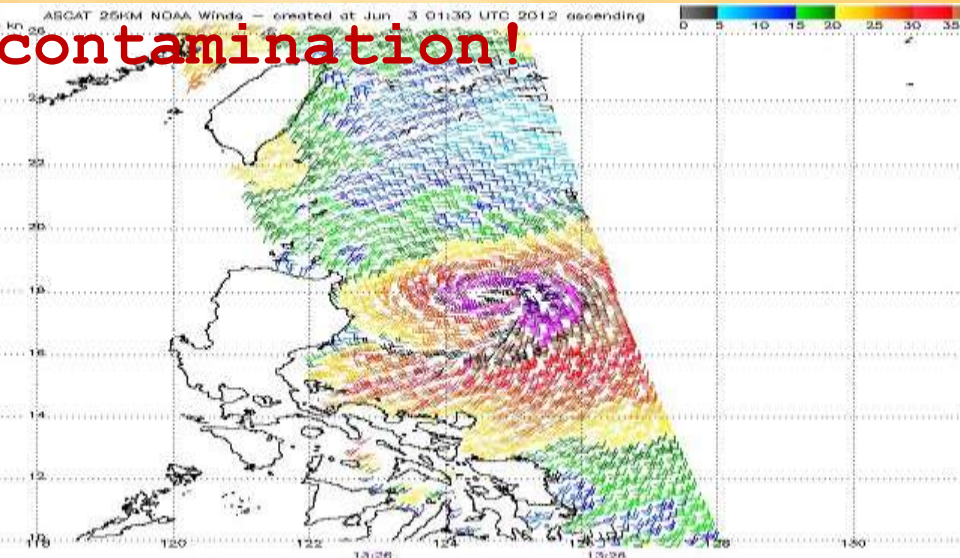


Scatterometer shows development just like the IR

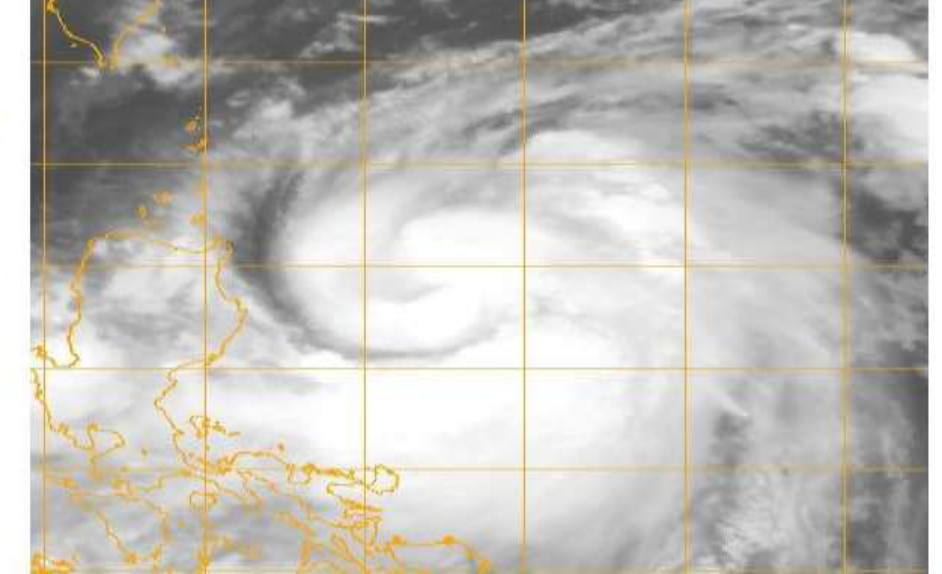
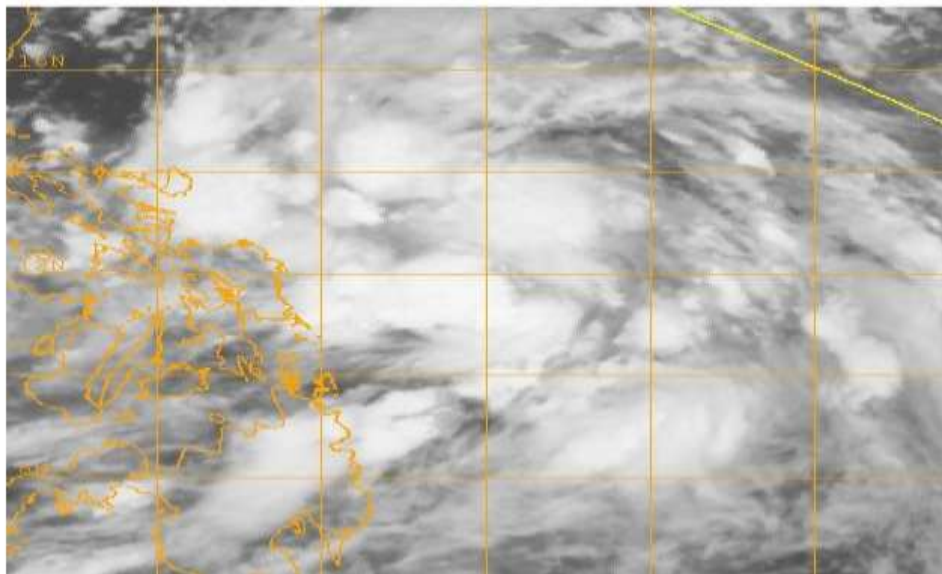
Not all rain contamination!



Storm number: 04 Storm name: FOUR
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 14N
3) Data buffer is 22 hrs from May 31 20:30 UTC 2012 4) Black Circles indicate possible contamination



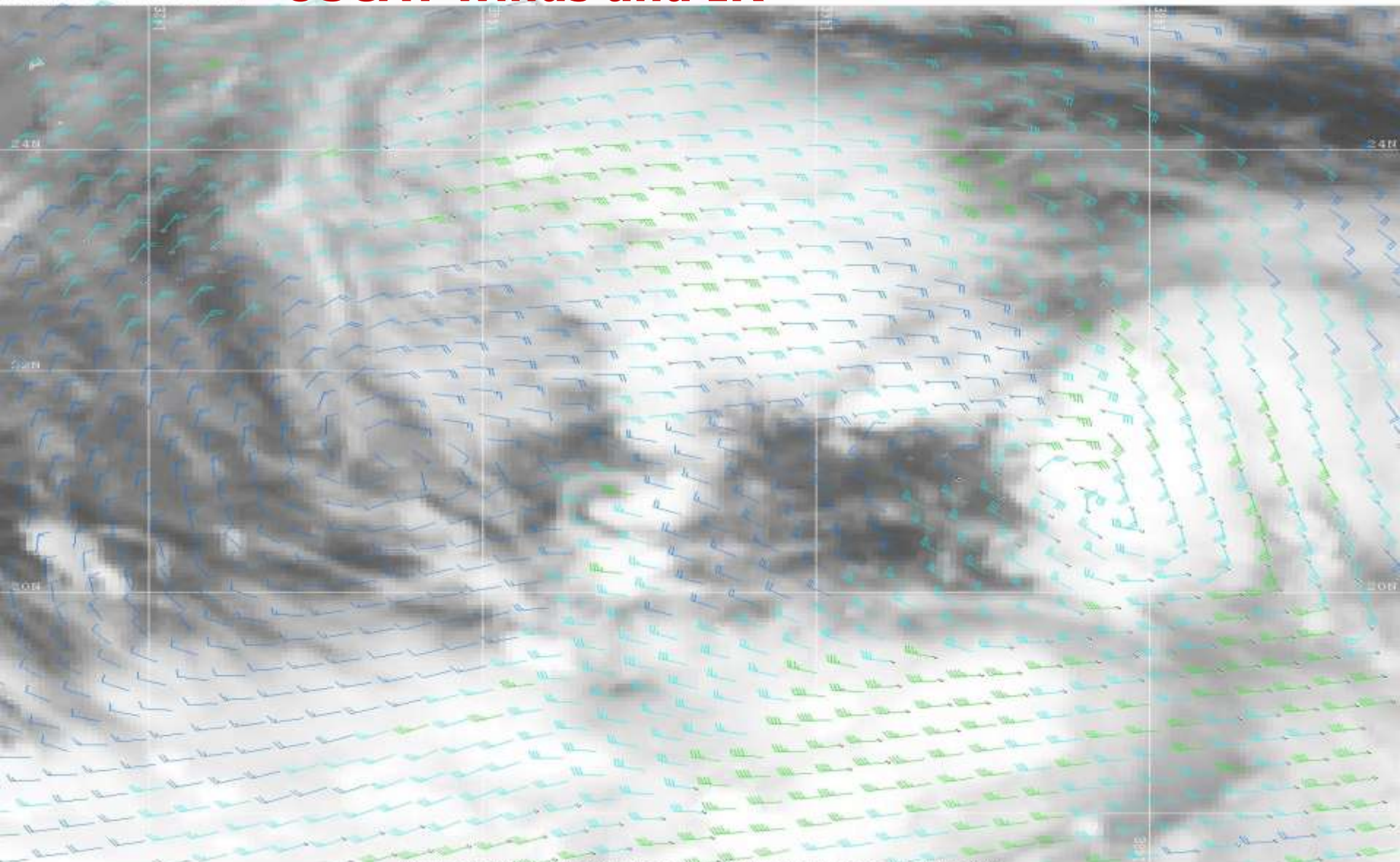
Storm number: 04 Storm name: MAWAR
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 18N
3) Data buffer is 22 hrs from Jun 3 01:30 UTC 2012 4) Black Circles indicate possible contamination



TD developing from Monsoon Circulation 16W (Man-yi)

OSCAT winds and IR

09/12/13	1200Z	16W SIXTEEN
09/12/13	1405Z	OSCAT
09/12/13	1401Z	MTSAT-2 IR

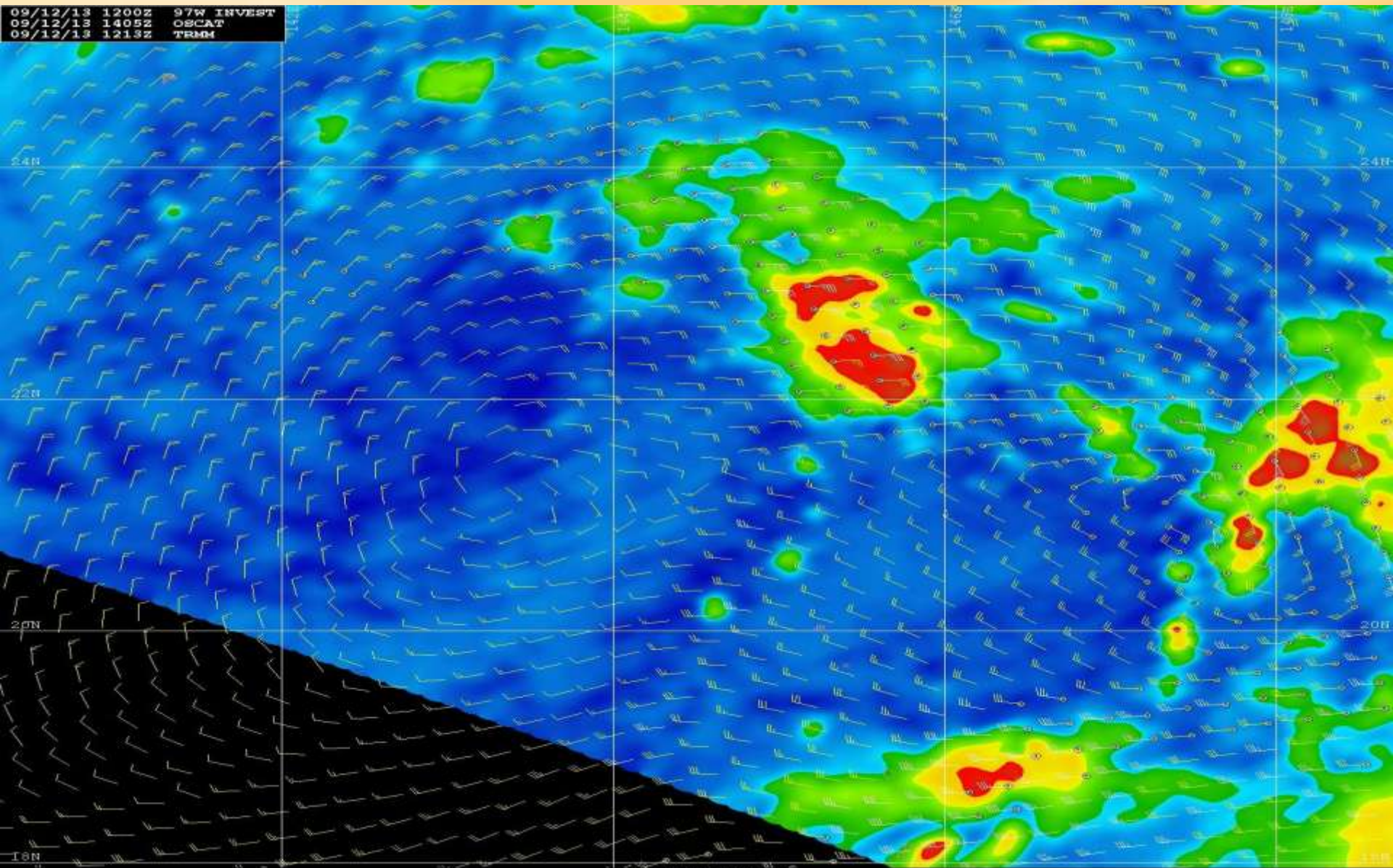


Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
OSCAT (OSCAT) Vectors (knots)



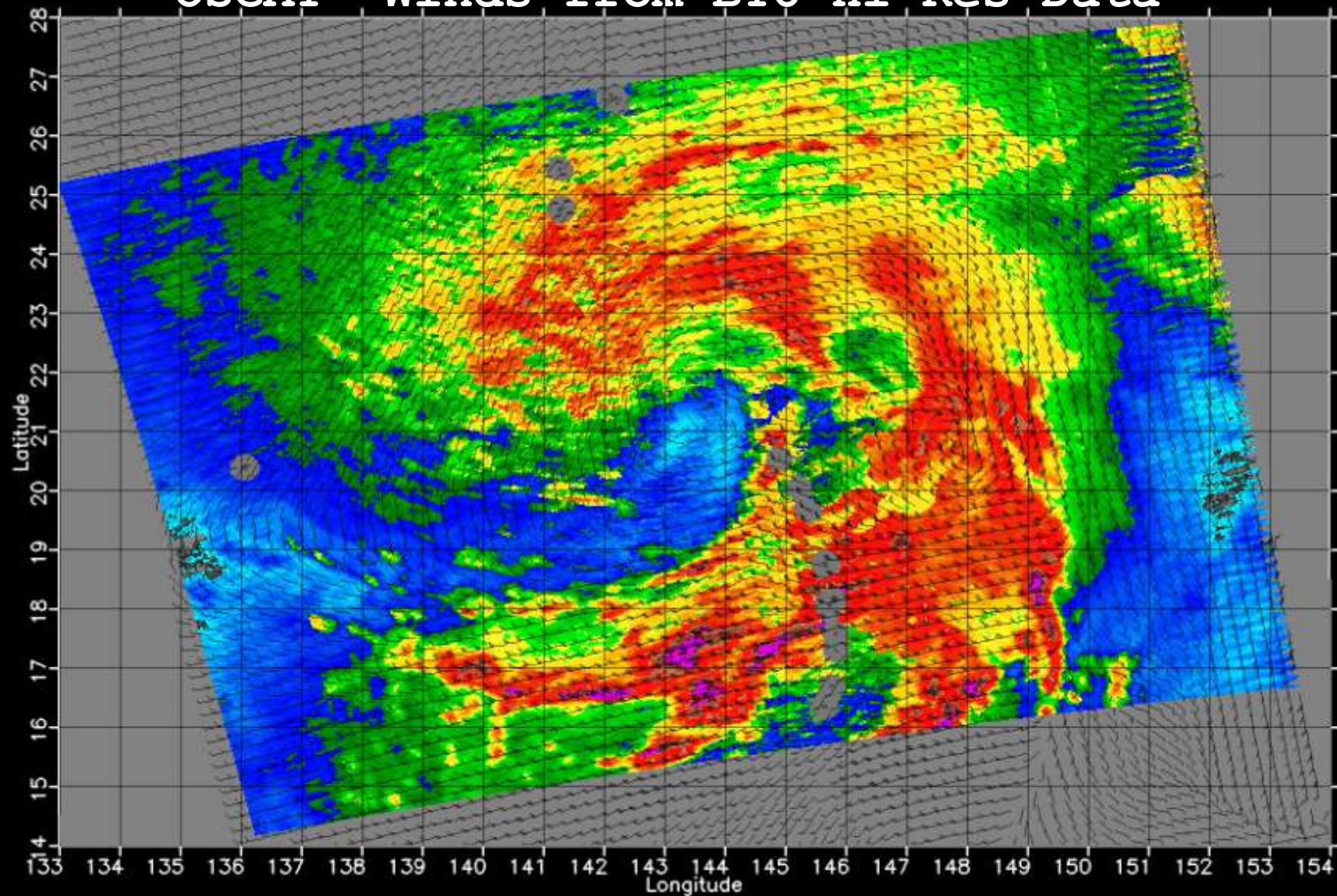
TD developing from Monsoon Circulation 16W (Man-yi)

OSCAT winds and TRMM 85h



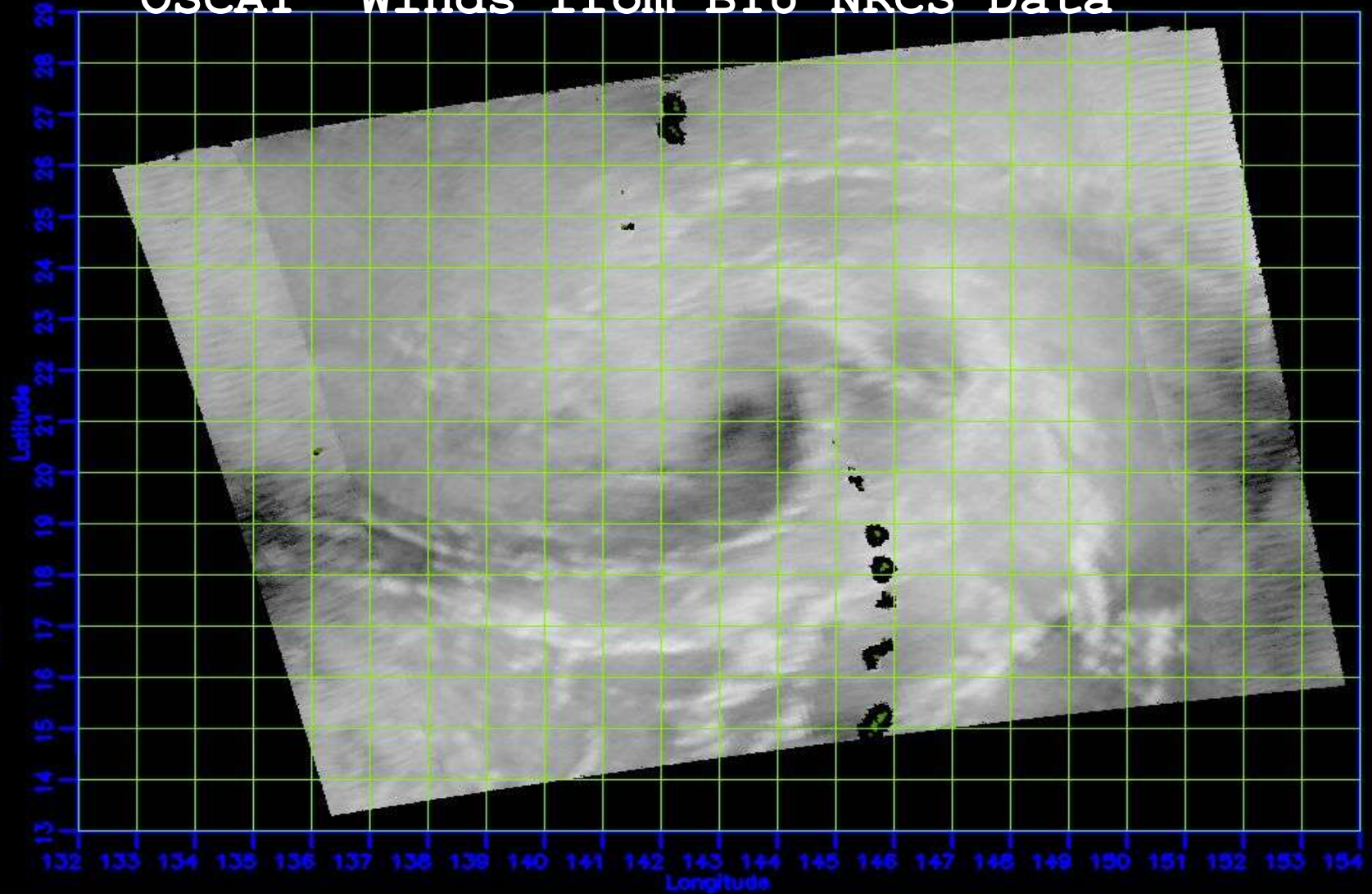
TD developing from Monsoon Circulation 16W (Man-yi)

OSCAT Winds from BYU Hi-Res Data



TD developing from Monsoon Circulation 16W (Man-yi)

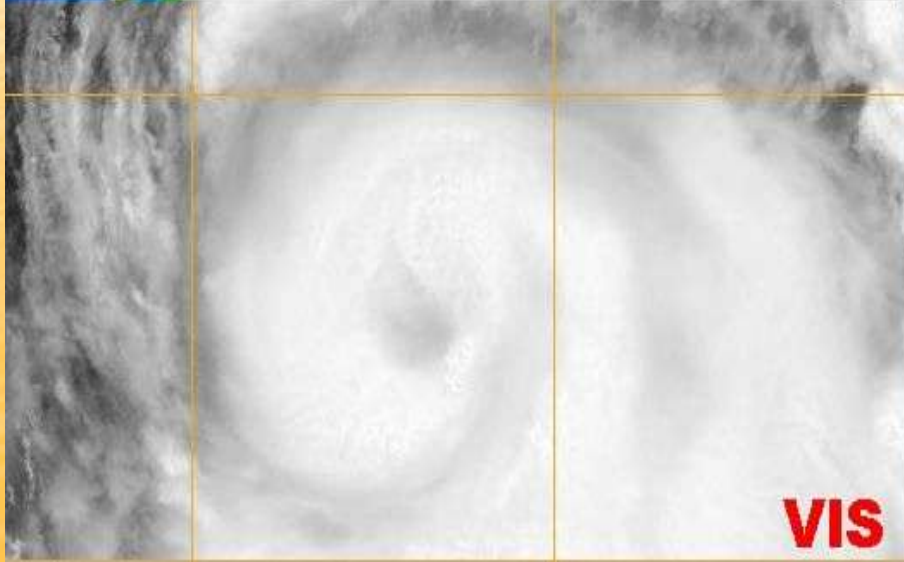
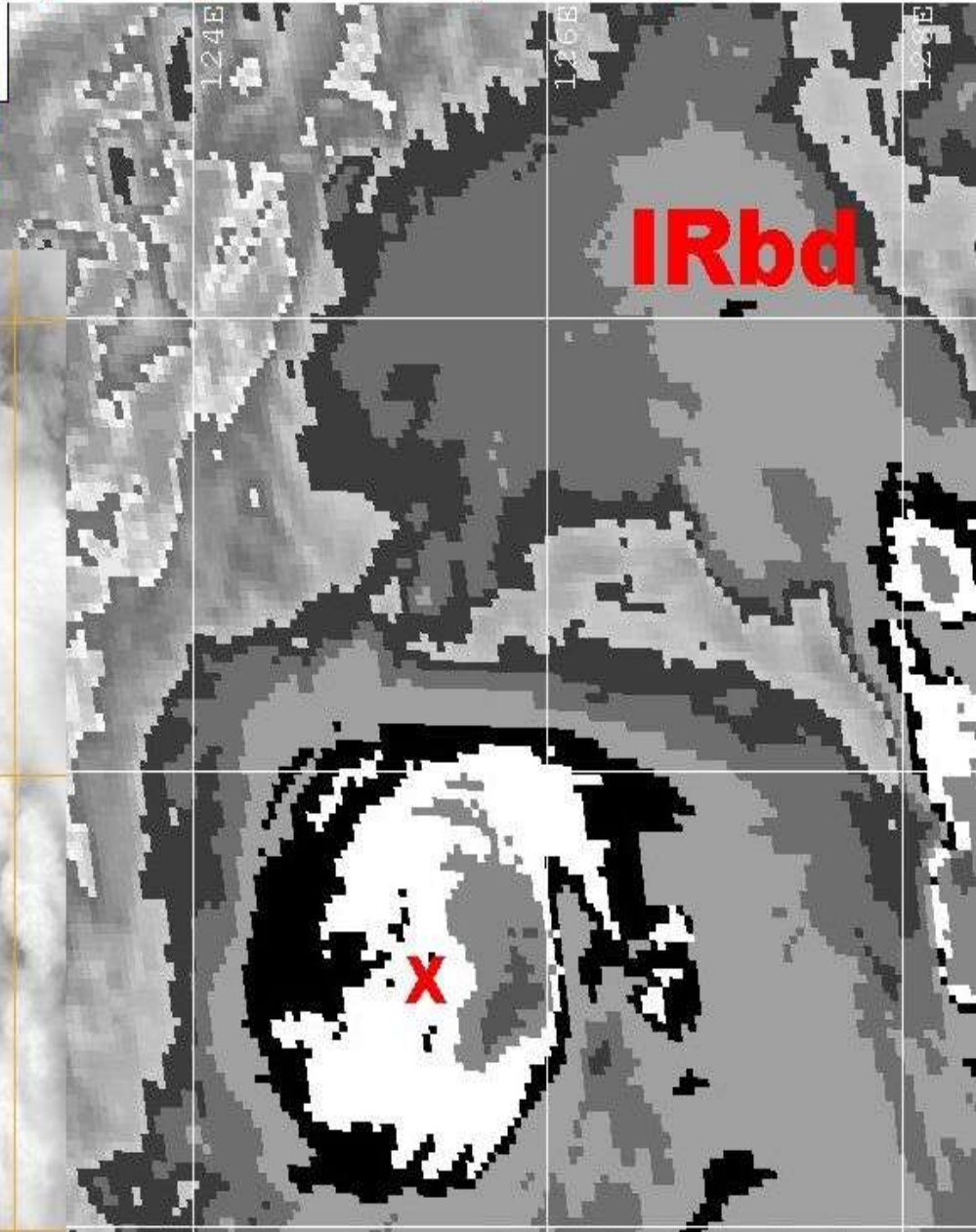
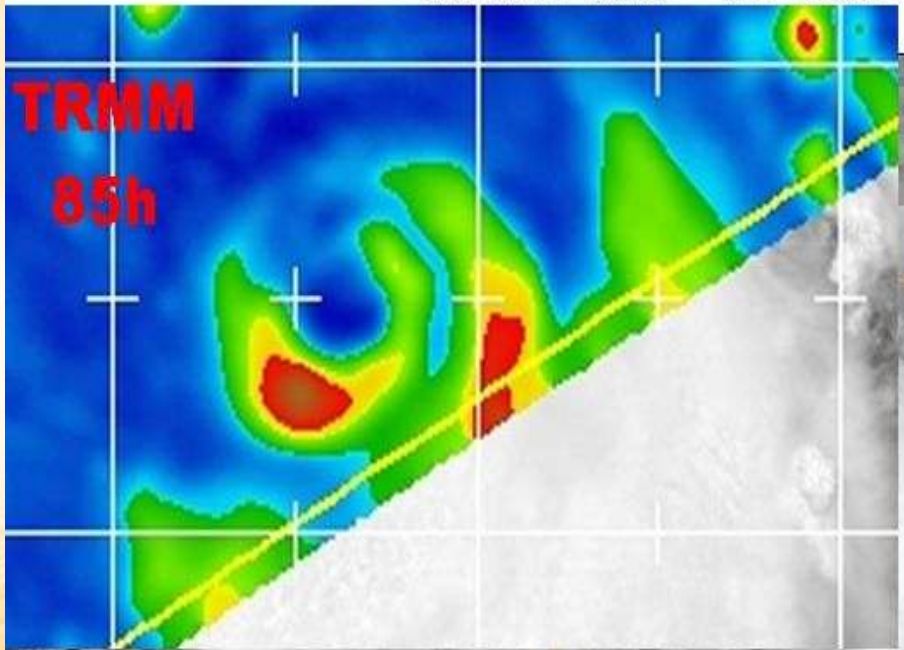
OSCAT Winds from BYU NRCS Data



File: S1L1B2013255_21030_21031.h5
BYU OSCAT UHR Mean Sigma-0

Three Views of Typhoon Mawar (04W) (STS 1203, Mawar)---90kt (1min) or 55kt (10min)

06/03/12 0000Z 04W MAWAR



Typhoon Tembin (15W) Comparisons

29 August 2012

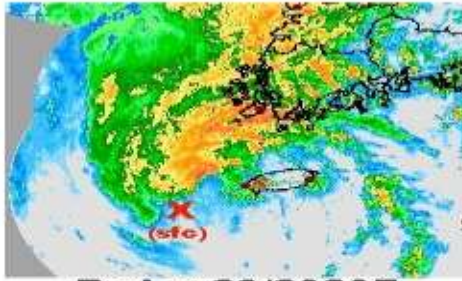
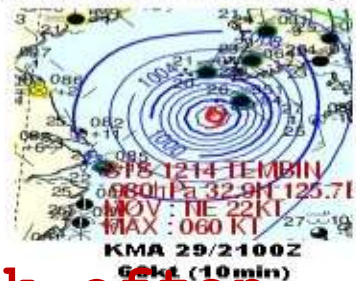
STS 1214 (TEMBIN)
Issued at 21:50 UTC, 29 August 2012

JMA

Analyses at 20:21 UTC	
Scale	-
Intensity	-
Center position	100°25'(32.4°) E125°40'(125.7°)
Direction and speed of movement	NNE 30km/h(18kt)
Central pressure	980hPa
Maximum wind speed near the center	30m/s(60kt) 60kt (10min)
Maximum wind gust speed	45m/s(95kt)

- Scat Winds in Rain (ASCAT or OSCAT)
- LOW Bias (when actual winds > ~25-30kt)
- More reliable when not cross track (rain bias direction)
- More reliable/confident with consistent pattern

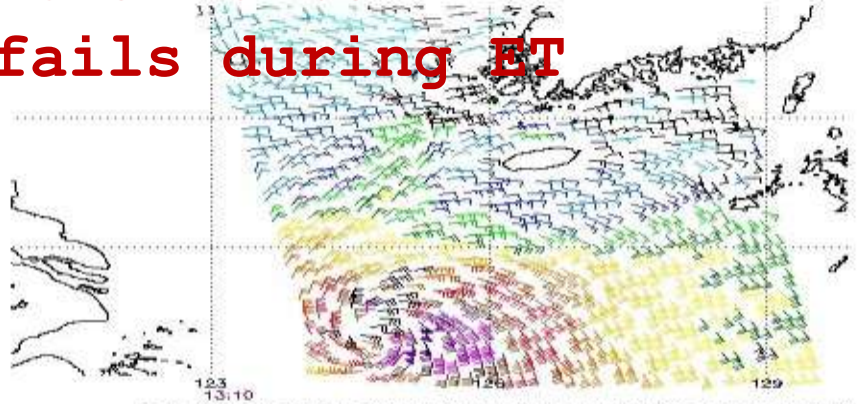
- Dvorak in Shear/Ext ra4 tropical Transition
- Often not representative (non-tropical pattern)
- Does not account for accelerated forward speed
- Often weakens too quickly (when under 100kt)



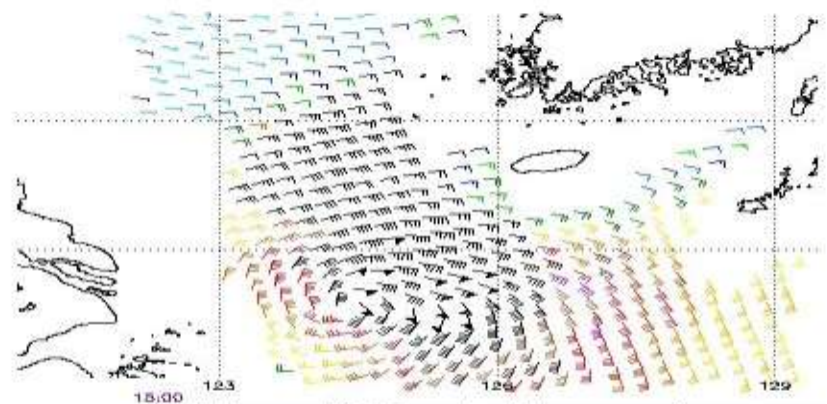
JTWC
45kt

WTFN31 PGTW 292100
MSGID/GENADMIN/JOINT TYPHOON WCEN/PEARL HARBOR HI//
SUBJ/TROPICAL CYCLONE WARNING//
FMCS/
1. TROPICAL STORM 15W (TEMBIN) WARNING NR 044
01 ACTIVE TROPICAL CYCLONE IN NORTHESTPAC
02 WINDS BASED ON ONE-MINUTE AVERAGE
03 RADIUS VALID OVER OPEN WATER ONLY
04
05 WARNING POSITION:
291000Z --- NEAR 22.4N 125.3E
06 CURRENT EAST SIX HOURS - 01S DEGREES AT 20 KT
07 POSITION ACCURATE TO WITHIN 025 NM
08 POSITION BASED ON CENTER LOCATED BY SATELLITE
09 PRESENT WIND DISTRIBUTION:
10 MAX SUSTAINED WINDS - 045 KT, GUSTS 055 KT

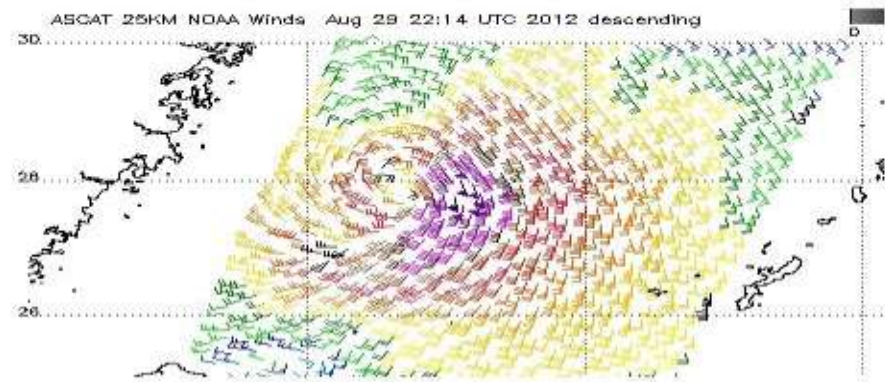
Dvorak often fails during ET



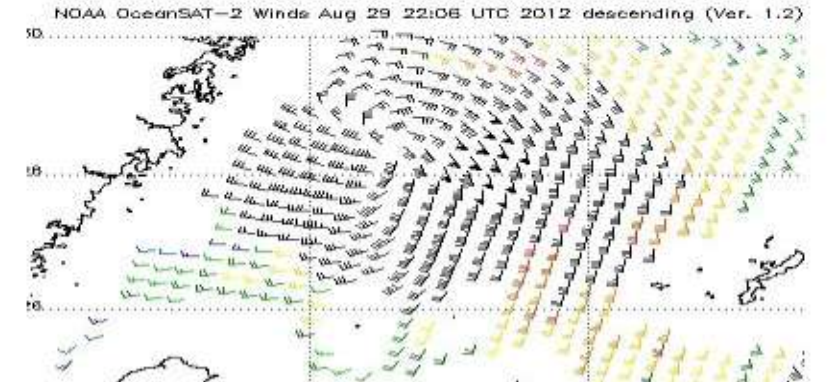
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 3) Data buffer is 22 km from Aug 29 22:14 UTC 2012 4) Black circles 1
ASCAT 29Aug 1310Z



Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 3) Data buffer is 22 km from Aug 29 22:06 UTC 2012 4) Black circles 1
OSCAT 29Aug 1500Z



ASCAT 29Aug 0154Z



OSCAT 29Aug 0357Z

TC Centers and TC Forecasters

IR Dvorak CANNOT (should not) work by itself

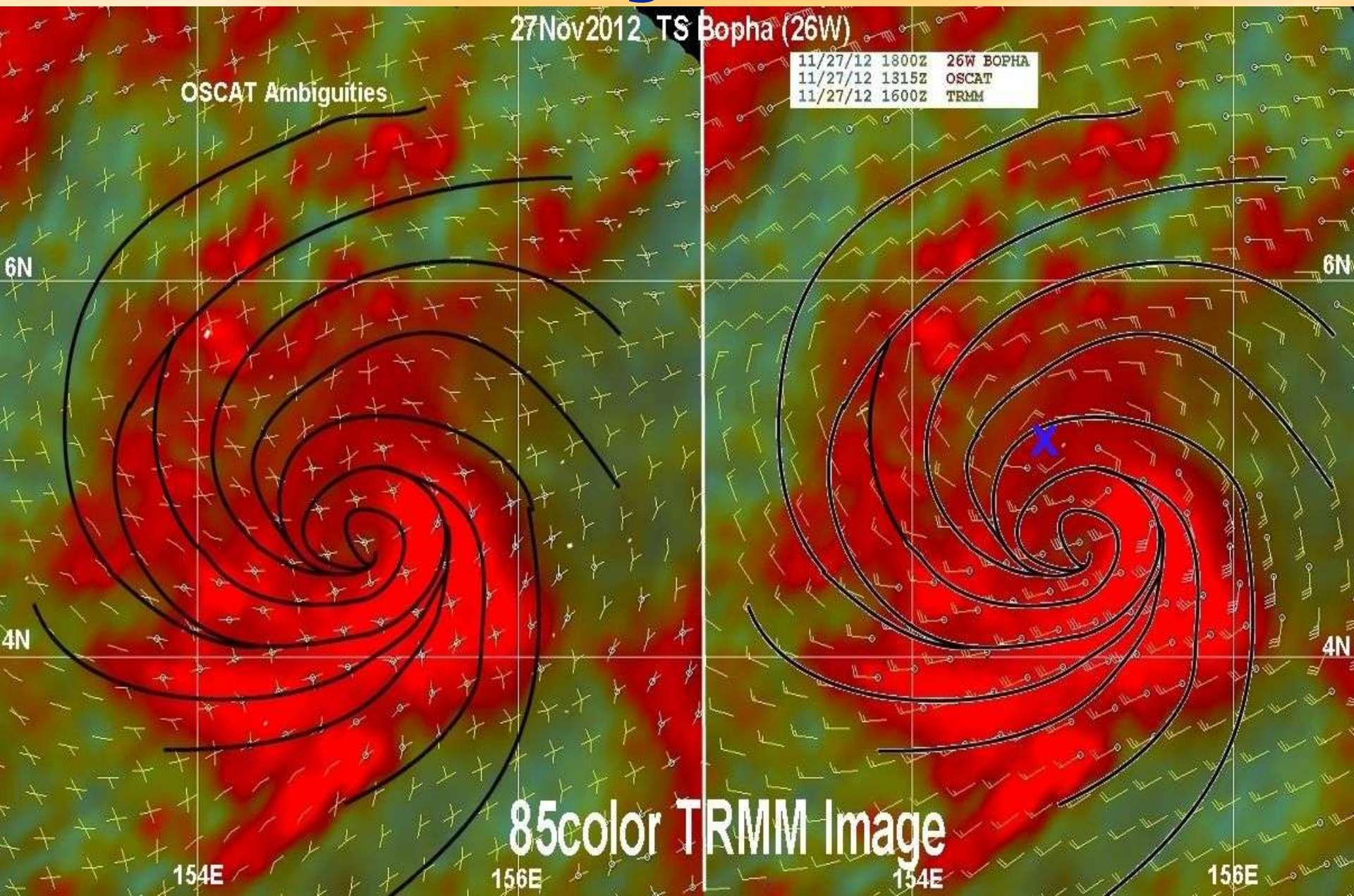
Only an integrated/combined satellite analysis will improve TC Analysis (and Forecasting)

Now is the time: Don't be 'low' and 'slow'

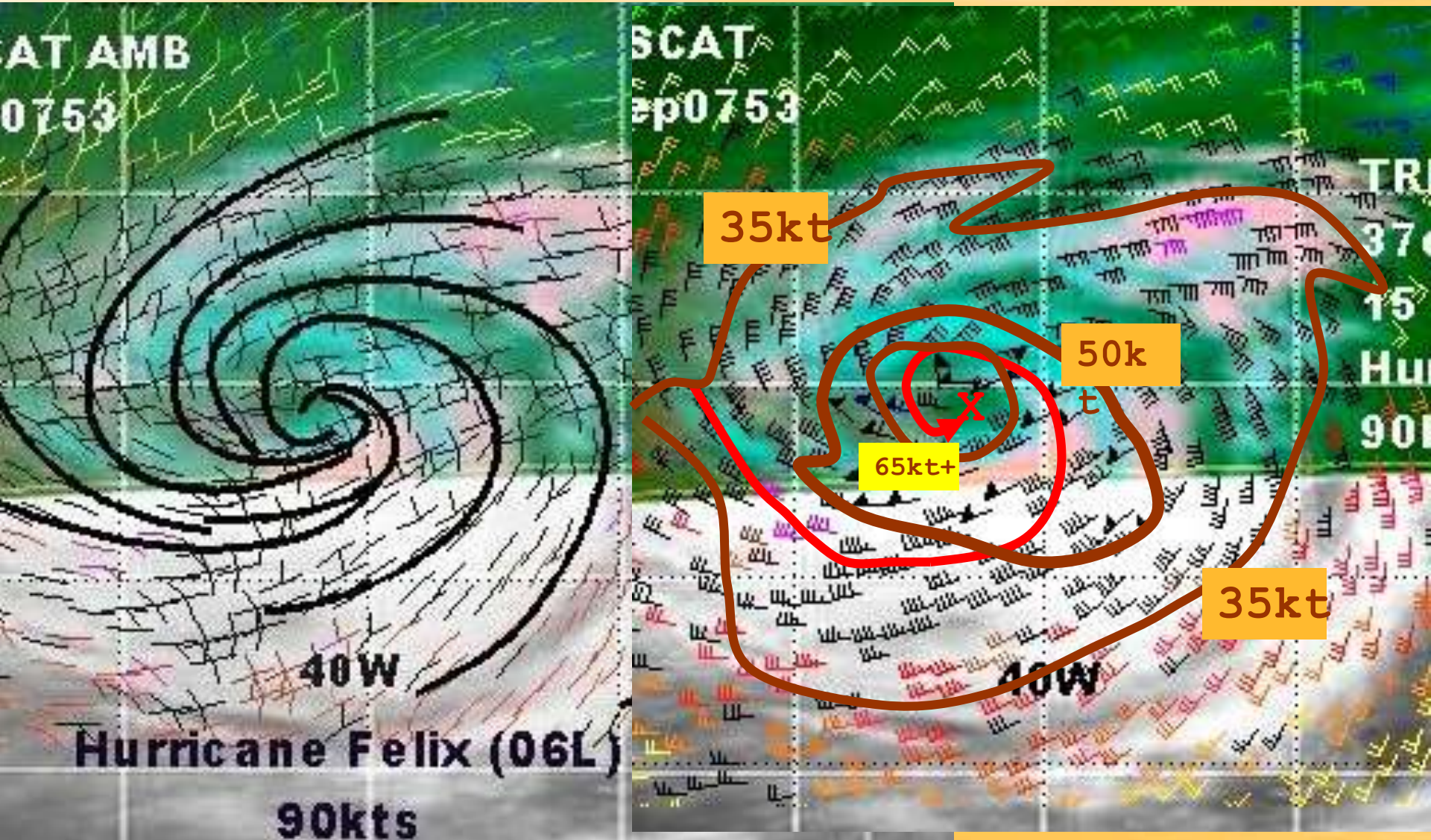
Questions?

EXTRA Slides for Reference

Positioning and Structure



Overlay QuikSCAT winds and ambiguities over MI - 37Ghz imagery



Advantages of 85 GHz

1. Identify peripheral low-level cloud bands, giving information about center of circulation.
2. Distinguish deep (cold) convection (heavy precipitation) from lightly-raining (warm) low cloud features.
3. Identify cirrus-covered eyes.
4. High Spatial Resolution

Limitations of 85 GHz

1. Cold Ocean may “look like” deep convection:
Use 85 GHz Color Composite as a correction.
2. Parallax Error (10-20 km).
3. Saturates (no detail) in storm cores, misses structure.

Advantages of 37 GHz

1. Identify cirrus-covered eyes.
2. Resolve detail within the storm core missed by 85 GHz, sometimes can see eyes missed by 85 GHz.
3. Shows regions of low-level clouds/rain.
4. Little Parallax error compared to 85 GHz.

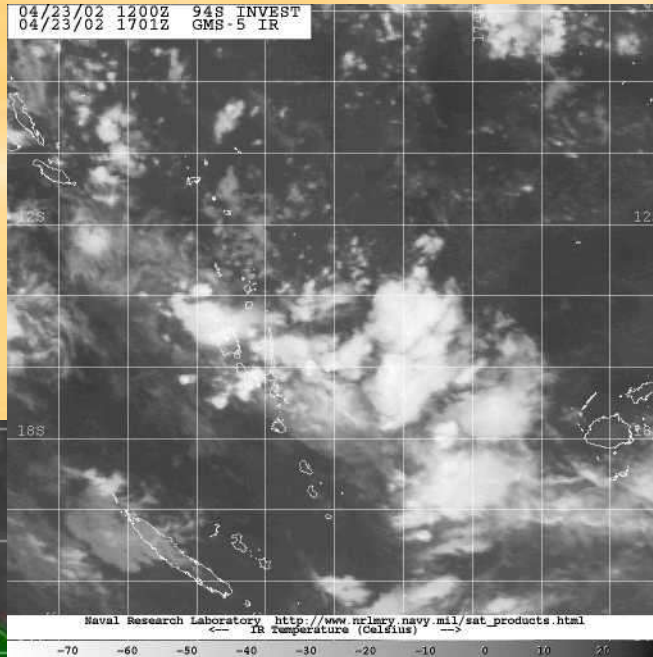
Limitations of 37 GHz

1. Does not show distinguish convection from low clouds bands. Eyes are sometimes poorly defined or not detectable. False eyes are common*.
2. Suffers from poor spatial resolution on SSM/I, SSM/IS, better on TMI, WindSAT and AMSR-E
3. Not available on AMSU-B

Tropical Cyclone Lifecycle in Microwave Imagery

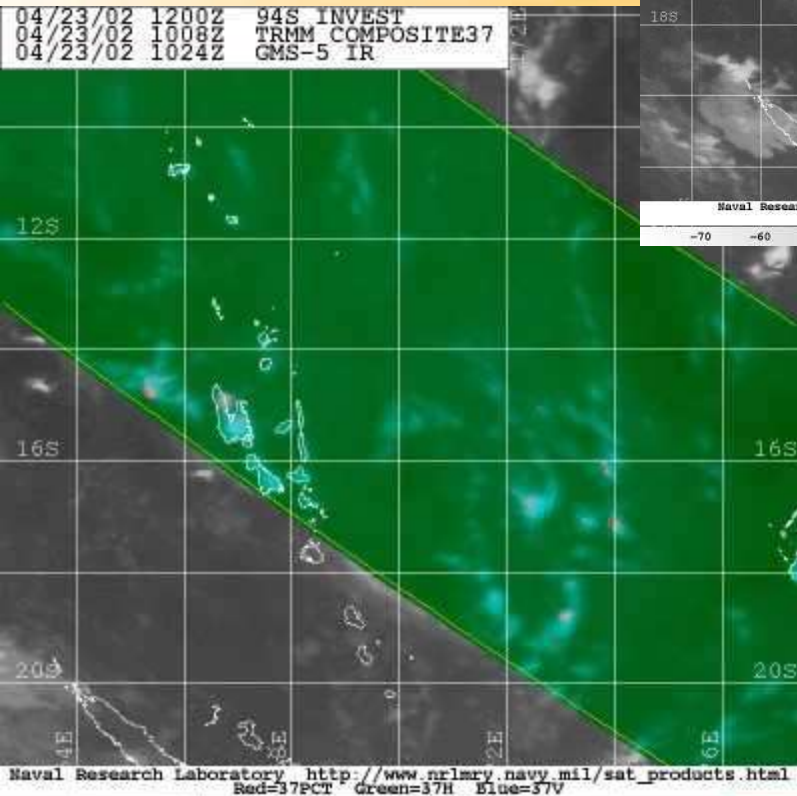
- I. TC Genesis Stage ~25-30kt**
- II. Early Intensification and Development ~30-45kt**
- III. Continued Intensification and Mature Stage**
- IV. Peaking and Initial Weakening Stage**
- V. Dissipation and Extratropical Transition**

The Beginning?...no classification

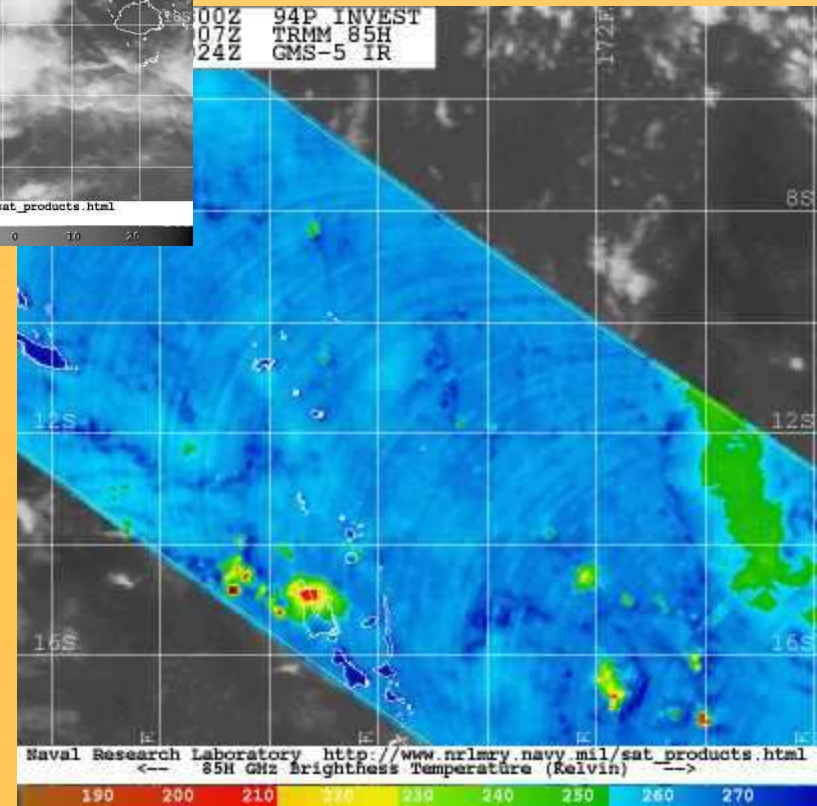


IR

TRMM 37 color



TRMM 85h



Pattern 'C': LLCC present and convection < 250 K forms hooks, claws or broken rings: AVG INTENSITY = 57 kts

(From Cock et al.)

SATELLITE: f13 97 08 01 2054Z 85 GHZ H
WARNING: TINA (12) 970801 1800 14.1N 133.1E
NRL Monterey Code 7541

CLAWS

SATELLITE: f14 97 08 21 2331Z 85 GHZ H (Bright
WARNING: AMBER (18) 970822 0000 14.4N 131.9E
NRL Monterey Code 7541

HOOKS

SATELLITE: f14 97 10 22 0027Z 85 GHZ H (Brightness Temperature)
WARNING: IVAN (27) 971021 1800 20.3N 125.6E
NRL Monterey Code 7541

BKN RINGS

