Current Methods of Tropical Cyclone Analysis using Microwave Imagery and Data

(Why Can't Operational Forecasters Supplement this into the Dvorak Technique?)

by

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

31st Conference on Hurricane and Tropical Meteorology
American Meteorological Society
31 March – 4 April 2014
San Diego, California

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)

(and so, still!)
**Dominated by visual and infrared satellite imagery
AND the (IR) Dvorak Technique that is over 30 years old**

Outline of Talk

Where can Dvorak be supplemented with Microwave Data

(from Peter Black, "Roger, It has already been done"

Roger, "Uh? Then why do operational agencies have such different positions and intensities and make so many 'mistakes'")

--Position

-- Genesis (plus dissipation)

--Intensity/Change of Intensity

--Structure and Structure Change

p.s. See Anthony Salemi and Mike Turk's work 9C.5**

Reasons for non-use of these data in operational setting

- Timing of Availability
- Failure to go back and 're-best track'
- Too many tasks
- Not working as a 'team' with the forecaster/analyst (afraid to offer something different: culture???)
- NOT advocated and championed by experienced Middle Mangers (OJT)

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)
- **However, (except for the intensities of high-end TCs) this is NOT the primary reason for the differences**

Comparison of Dvorak Intensities JTWC vs. JMA

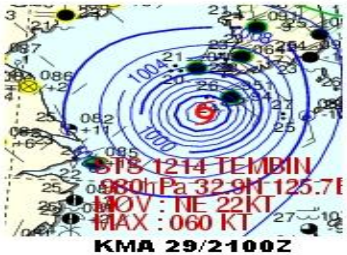
(Conversion to 1')

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

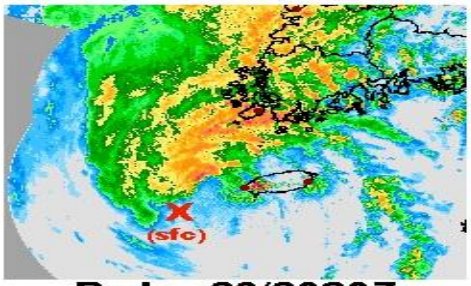
Typhoon Tembin (15W) Comparisons
29 August 2012

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



KMA 29/2100Z
60kt (10min)



Radar 29/2030Z

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

<Analyses at 29/21 UTC>	
Scale	-
Intensity	-
Center position	N32°25'(32.4°)
	E125°40'(125.7°)
Direction and speed of movement	NNE 30km/h(15kt)
Central pressure	980hPa
Maximum wind speed near the center	30m/s(60kt) **60kt (10min)**
Maximum wind gust speed	45m/s(85kt)

WTPN31 PGTW 292100
MSGID/GENADMIN/JOINT TYPHOON WRNCEN PEARL HARBOR HI//
SUBJ/TROPICAL CYCLONE WARNING//
RMKS/
1. TROPICAL STORM 15W (TEMBIN) WARNING NR 044
01 ACTIVE TROPICAL CYCLONE IN NORTHWESTPAC
MAX SUSTAINED WINDS BASED ON ONE-MINUTE AVERAGE
WIND RADII VALID OVER OPEN WATER ONLY

WARNING POSITION:
291800Z --- NEAR 32.4N 125.3E
MOVEMENT PAST SIX HOURS - 015 DEGREES AT 20 KTS
POSITION ACCURATE TO WITHIN 035 NM
POSITION BASED ON CENTER LOCATED BY SATELLITE
PRESENT WIND DISTRIBUTION:
MAX SUSTAINED WINDS - 045 KT, GUSTS 055 KT

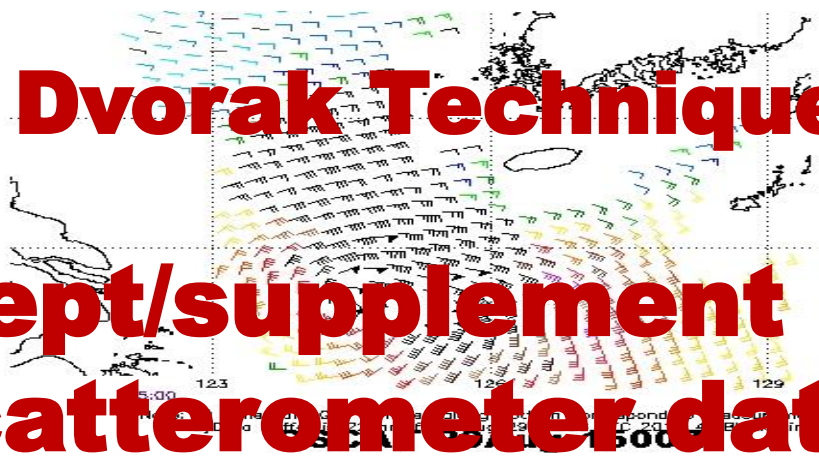
JTWC **45kt (1min)**

-Break Down of the Dvorak Technique

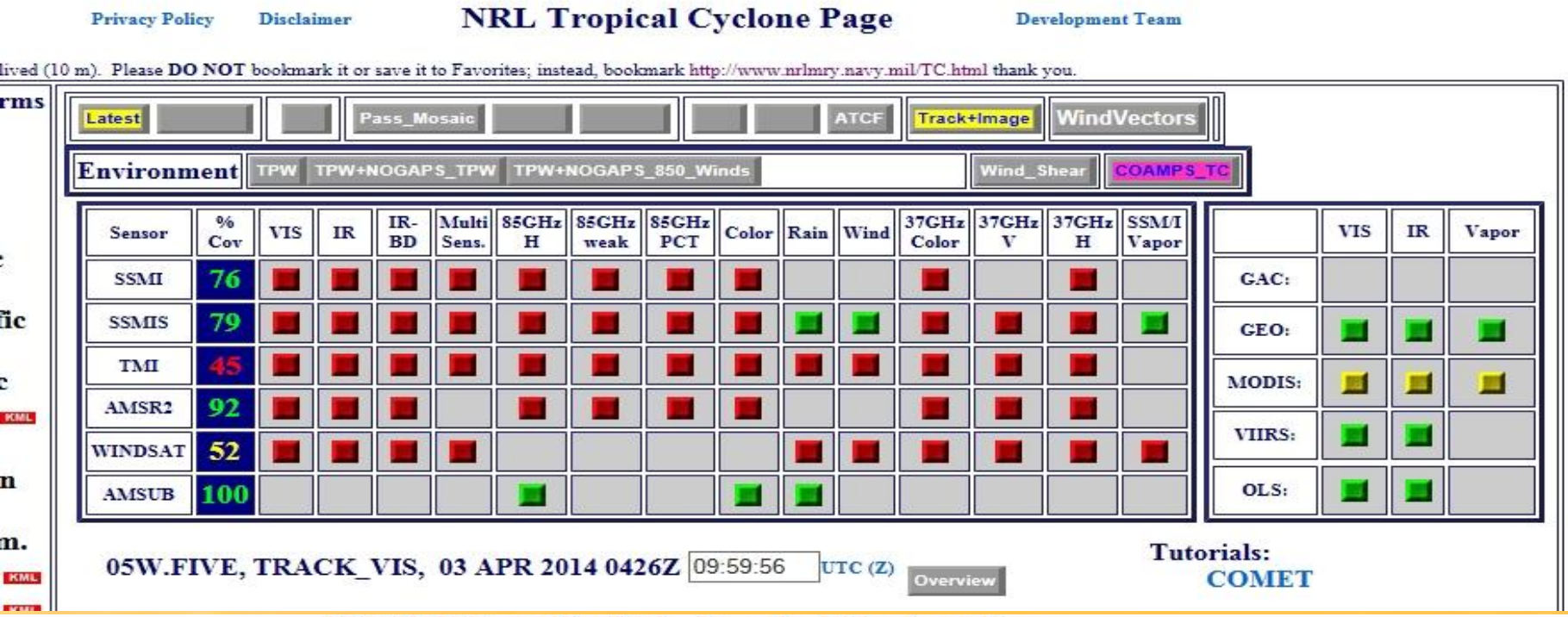
-Unwilling to accept/supplement (even repetitive) scatterometer data

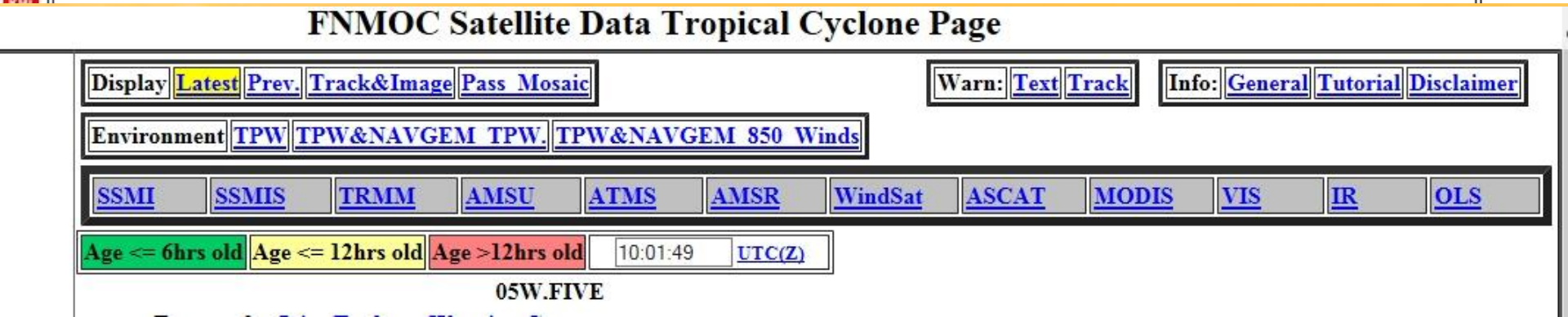
-(clearly not a 1' to 10' scenario)


ASCAT 29Aug 0154Z


OSCAT 29Aug 0357Z

Many MI instruments (and many coming on line)





Possible ways to Supplement the Dvorak Analysis with Microwave Imagery

(this is not the first time that I presented this)

- Provide for an integrated positioning technique (spiral band curvature and shear)—Don't need automated techniques
- Precision in use of embedded IR technique (MI eye)
- TC life cycle supplement (in MI)—PATTERN T#
- Early genesis identification (pre-T#1)
- Identifying both potential 'rapid' and 'delayed' intensification scenarios ('MET'), Use of PLUS/MINUS
- Identification of 'peaking' and 'MET' changes MINUS
- Intensities during Extratropical Transition and dissipation scenarios (MUST use other data)
- Integration with 'other' techniques, including use of AMSU, Scatterometer, AODT, SATCON,etc..

Positioning

- STILL using (1) IR

(2) "Multi-spectral" (IR/VIS)

Really should mean, "MULTI-spectral": IR/VIS/MI/SCAT! (animated)

(Even Archer method goes back and finds the highest confident fix!)

Simple Rules: STOP using (only) IR…SYSTEMATIC POSITIONING

- Meteorological Training (automated techniques be aware)!!!

-- MUST position in the surface trough (light wind and cyclonic curvature…NOT in the strong winds, may look for weakening tendency of winds, though): MI and Scatterometer, VIS animation

-- Avoid putting UNDER the convection

(Low pressure falls within the warming subsidence in-between CBs)

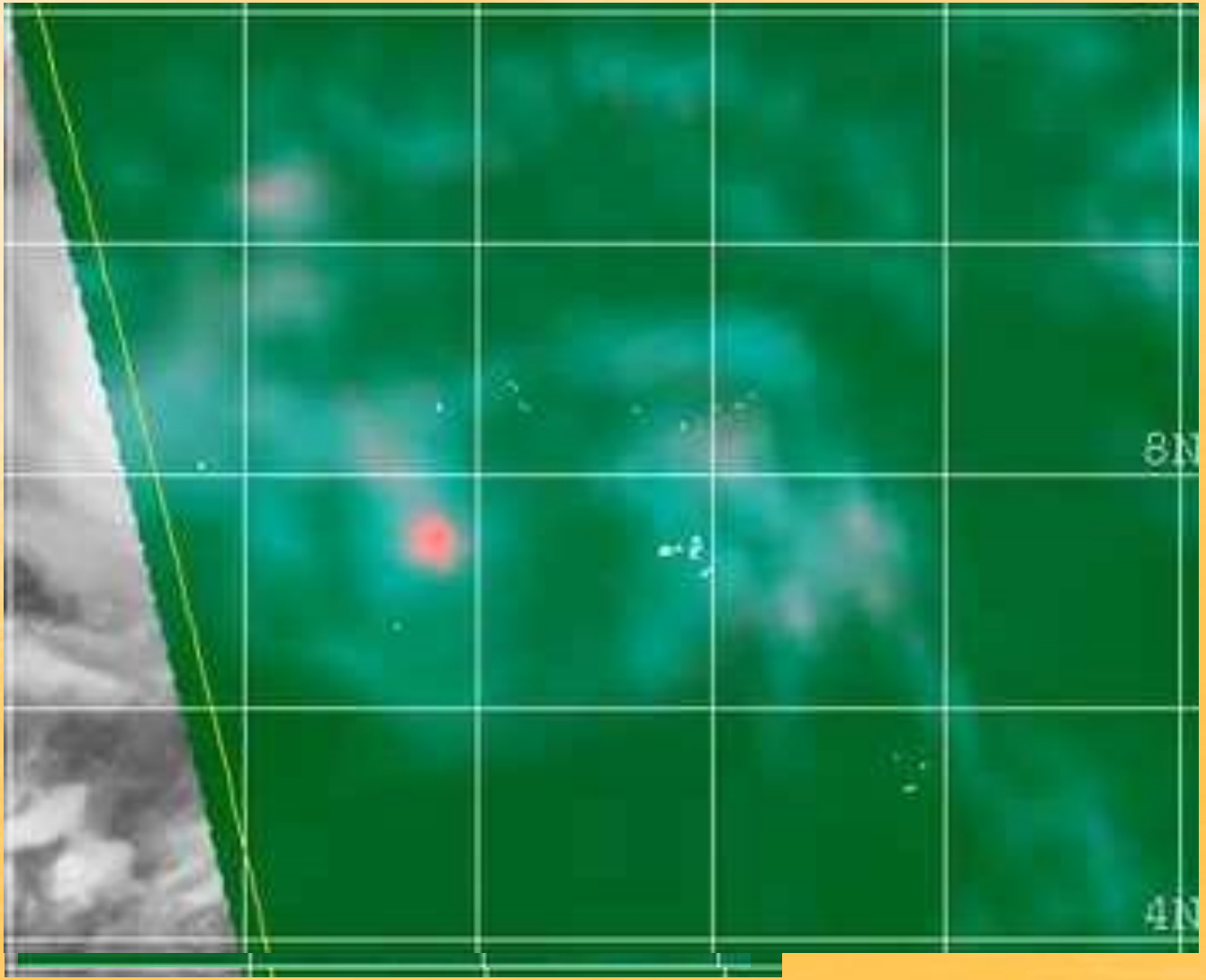
-- Keep your eye on the surface center

-- (Don't be swayed by mid-atmospheric 'twirls' in the vorticity)

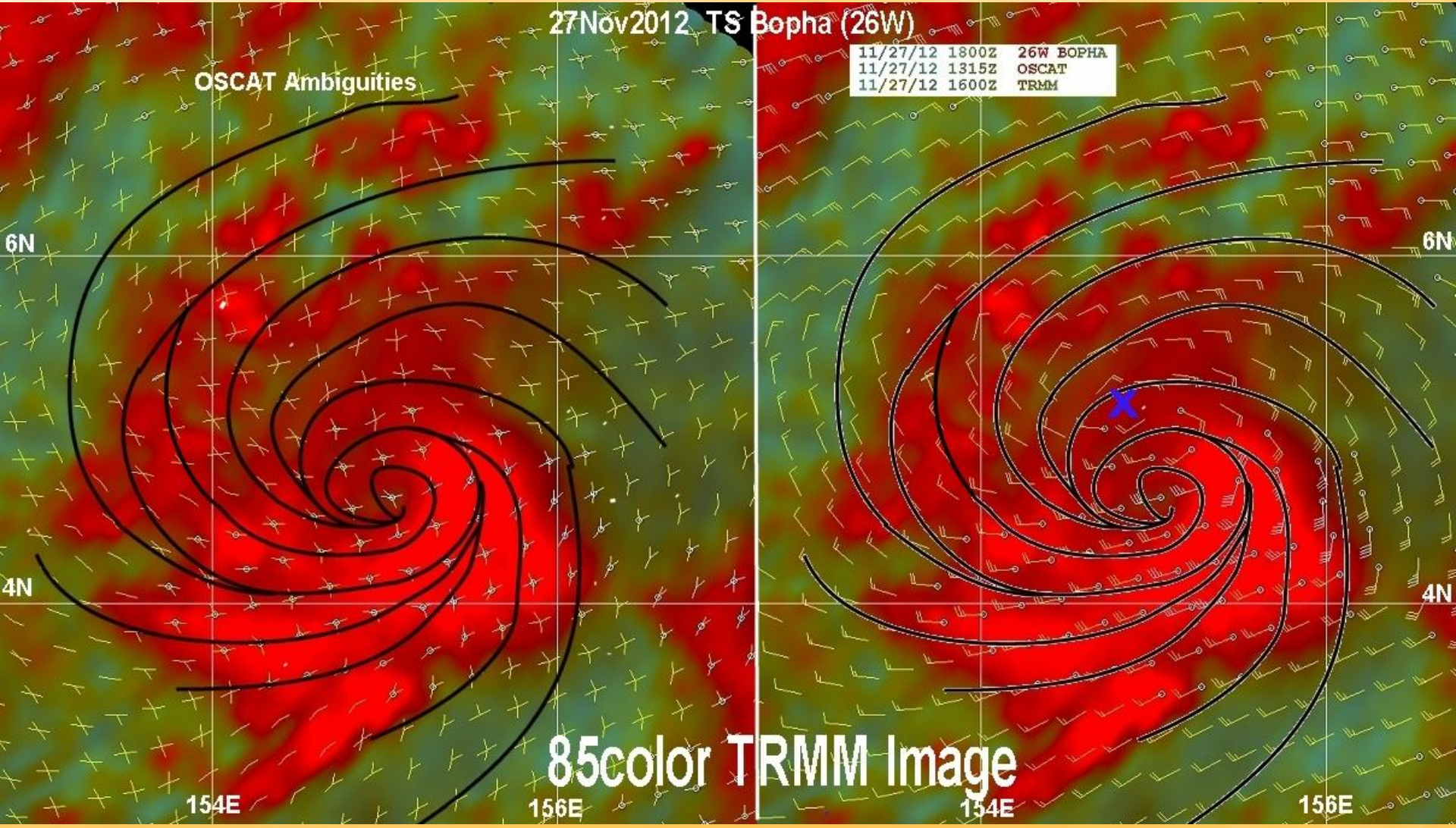
Animated 36Ghz Imagery

(Tropical Depression Sudal – 4 April 2004)

Where do you look for the center?



Combine MI with Scatterometer

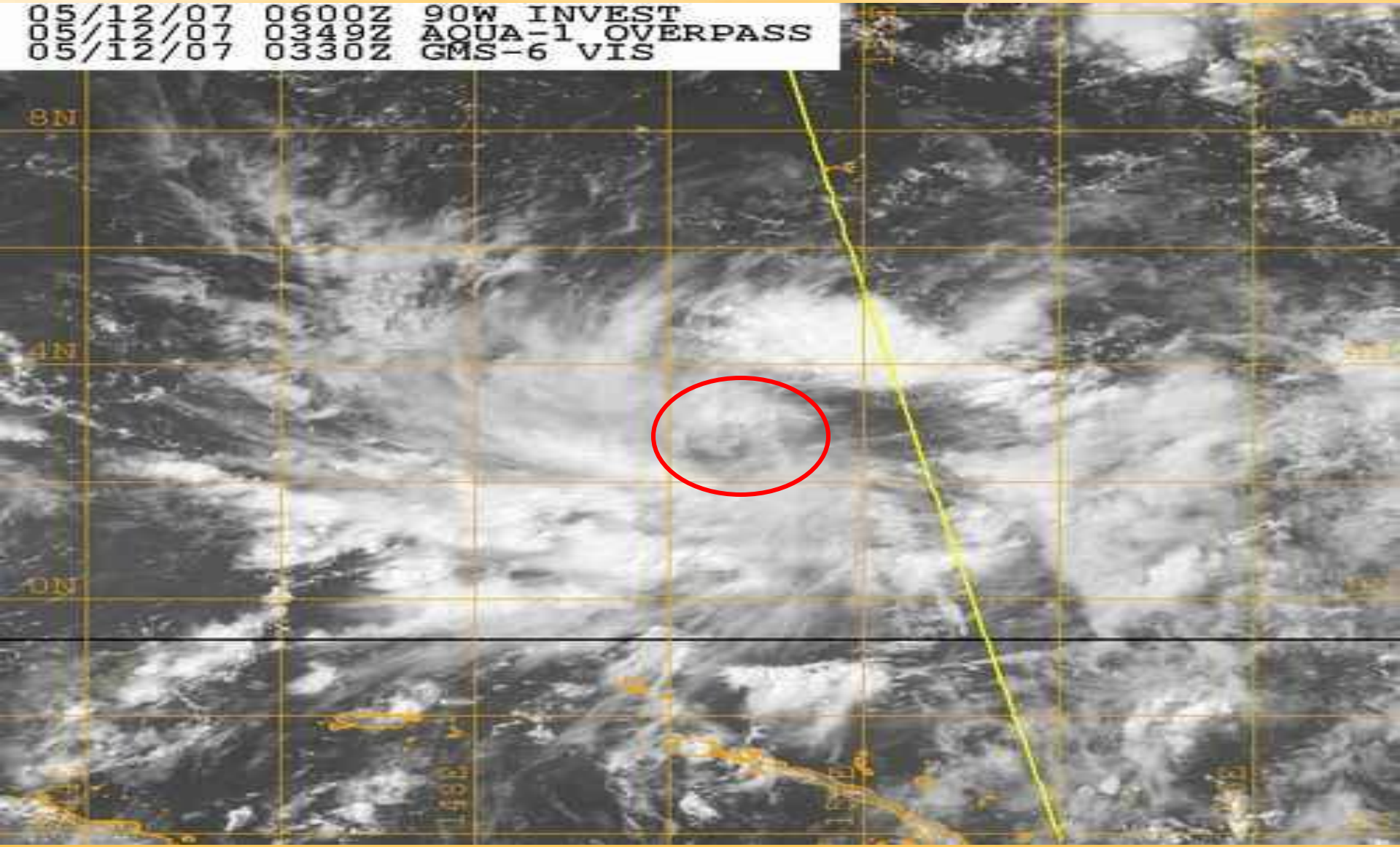


Rules for using Scatterometer Data

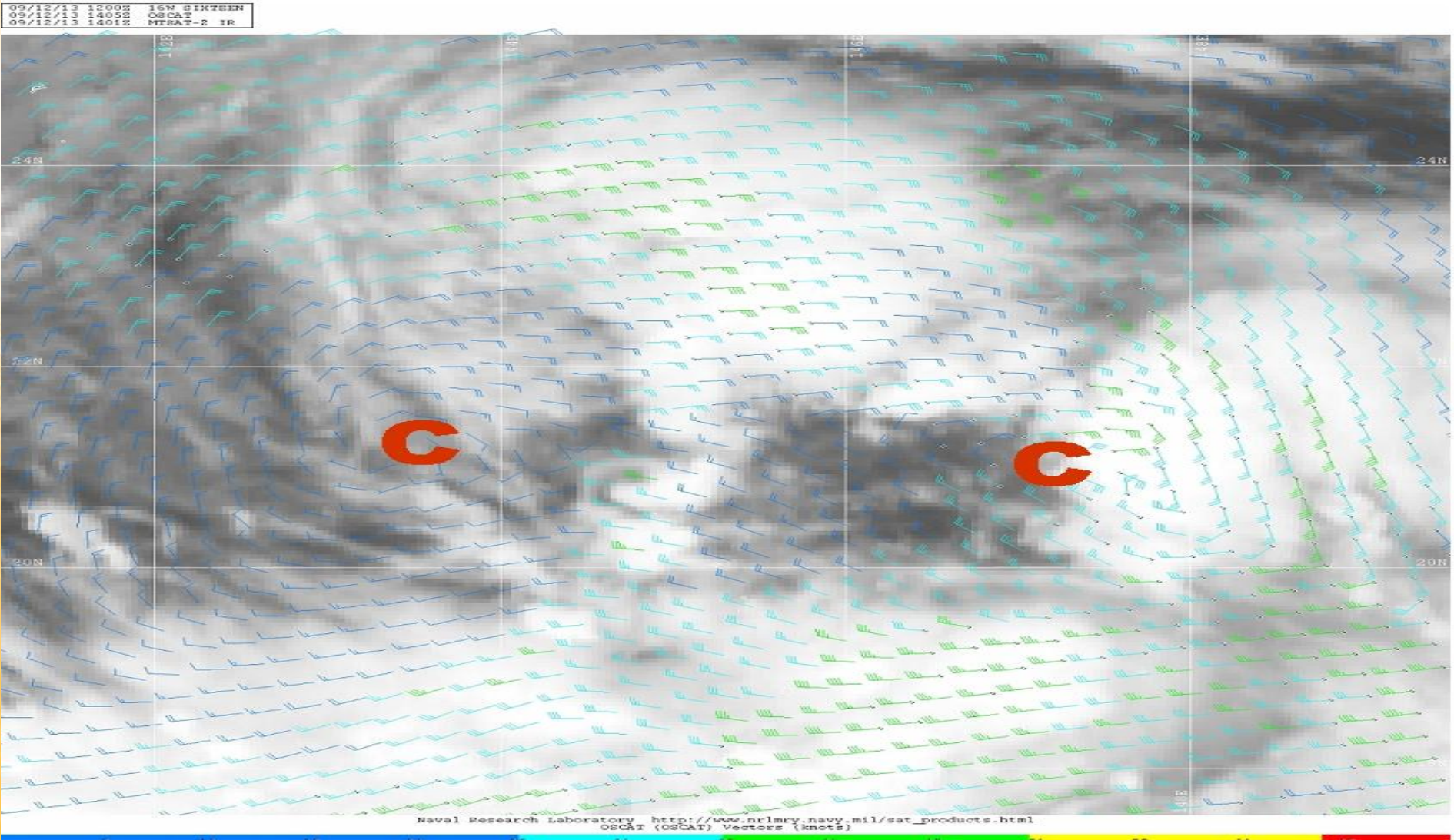
TC Genesis

- Position the center in the low wind/light rain region
- Look along trough axis and examine ambiguities
- Place along (meridianal) axis closest to strongest wind gradient and curvature
- In NRCS, look for broad 'dark' area
- Must coincide with other data (expect one (1) center…and if 'others' must be also in trough axis)

Pre-Typhoon Yutu South of Chuuk
('Typical TC Genesis')

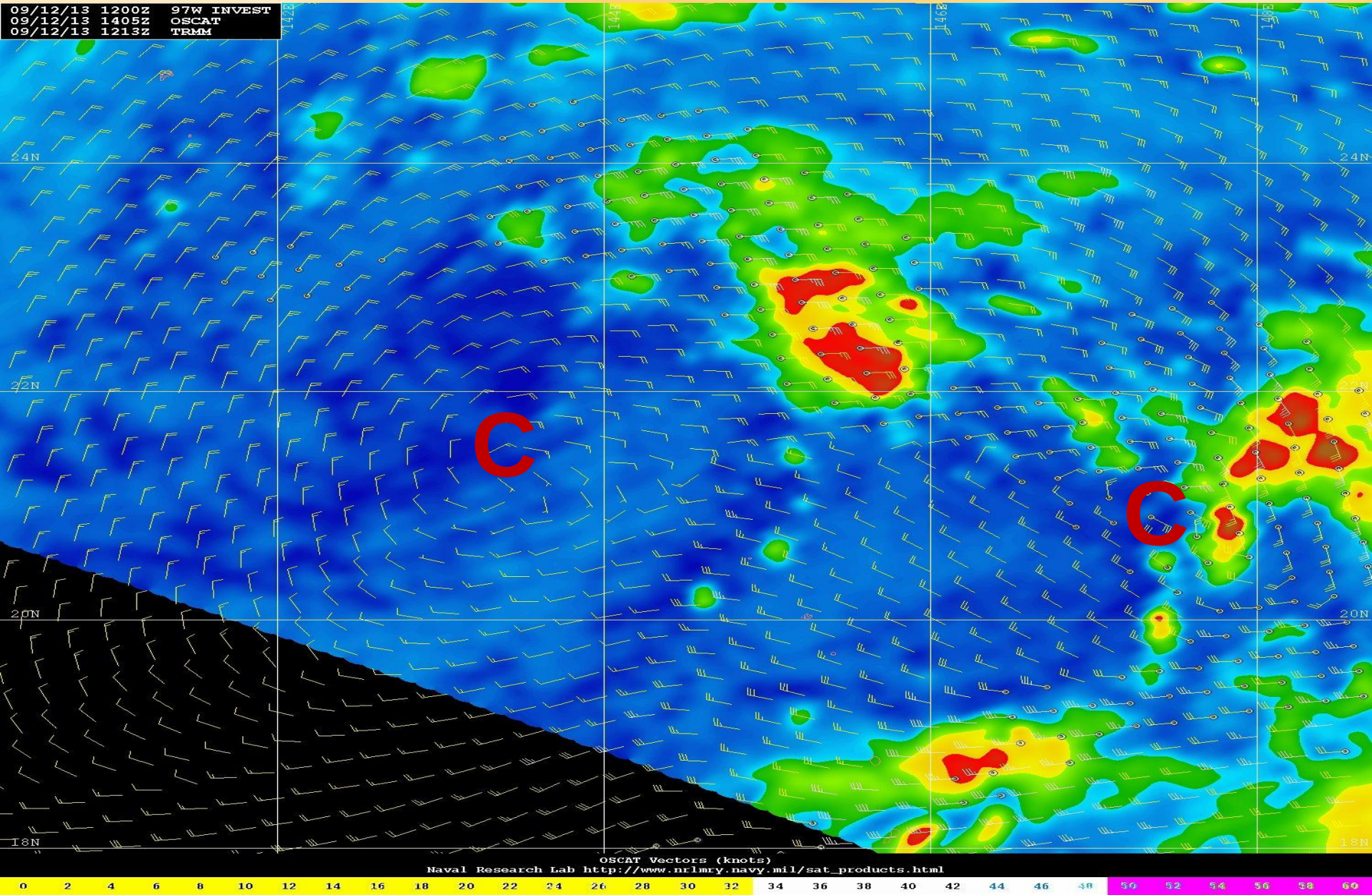


Finding Centers and Development in a Monsoon Gyre

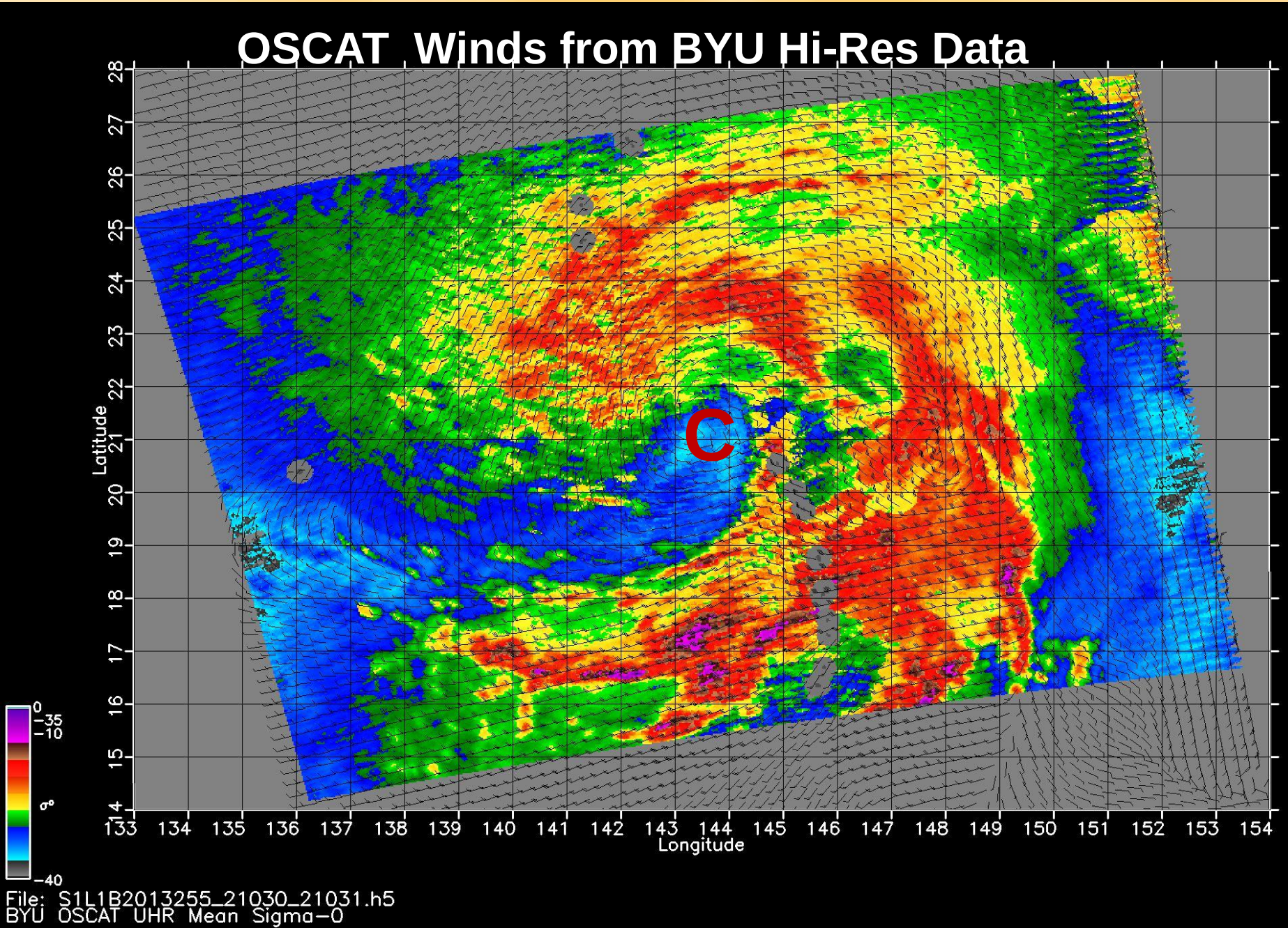


TD developing from Monsoon Circulation 16W (Man-yi)

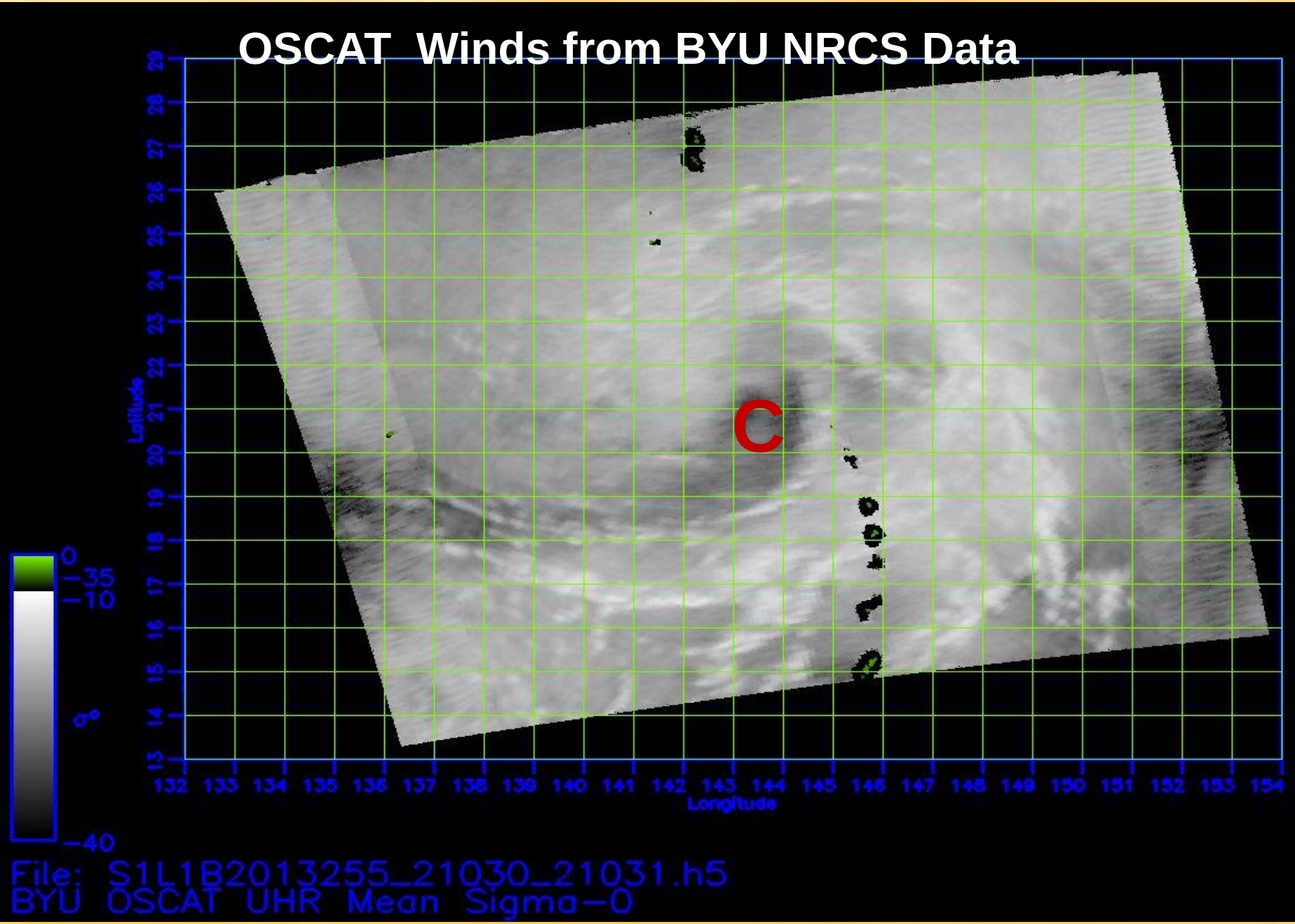
Scatterometer Winds and TRMM 85h



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



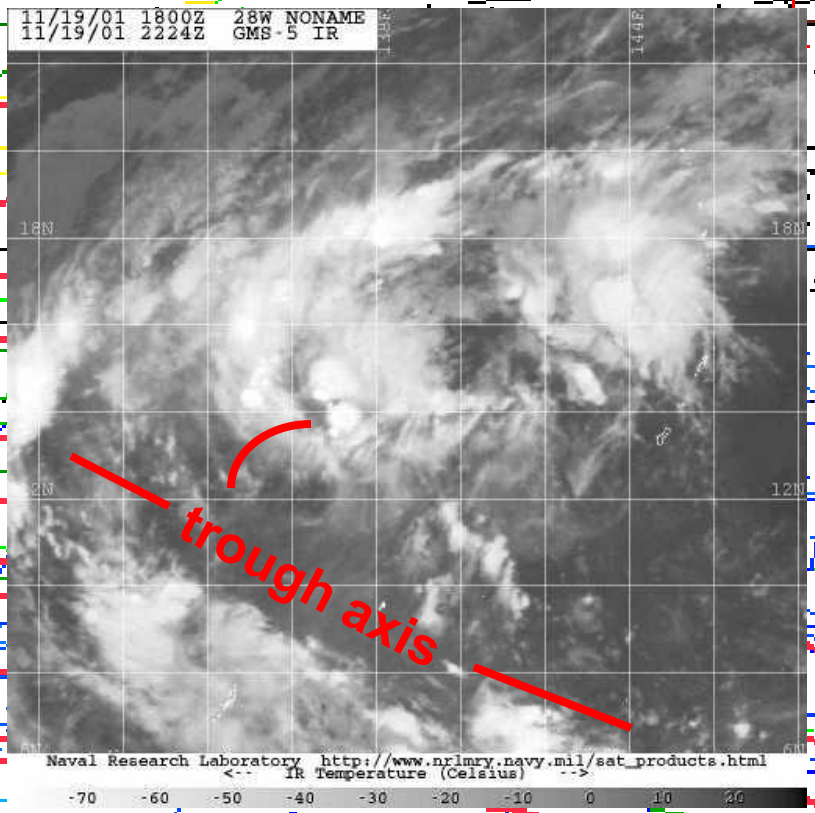
TD developing from Monsoon Circulation 16W (Man-yi)



SCAT Anomaly Solutions

19Nov 2023Z TS 28W

PSN
13.9N 136.7E



Strong Wind region

Light Wind region

14N

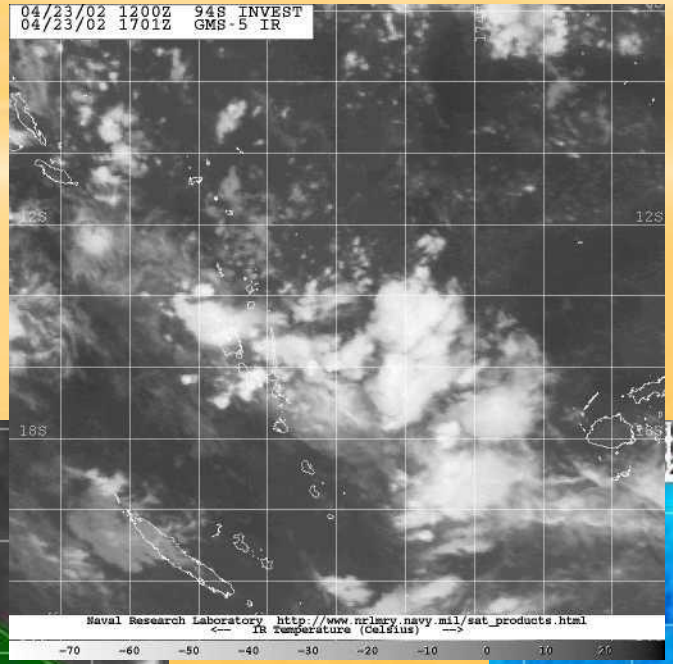
12N

136

138

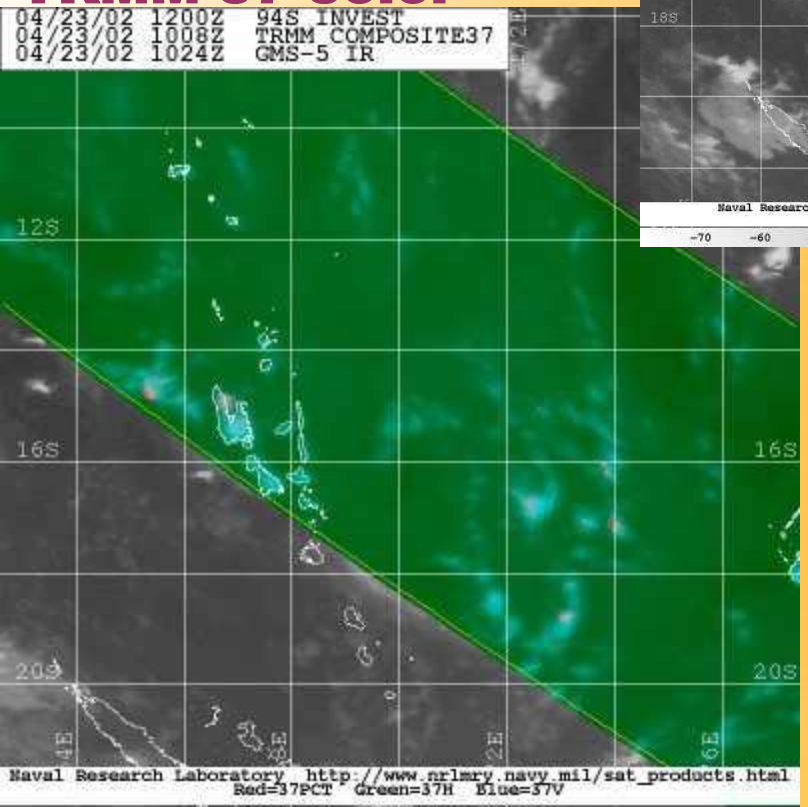
140

Pre-Genesis….No Surface Moistening

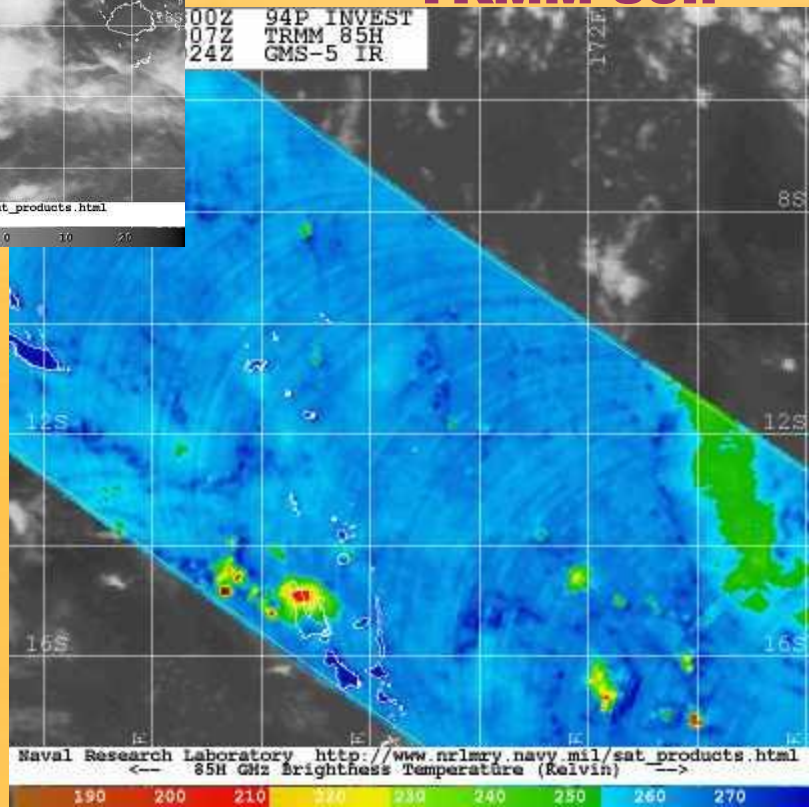


IR

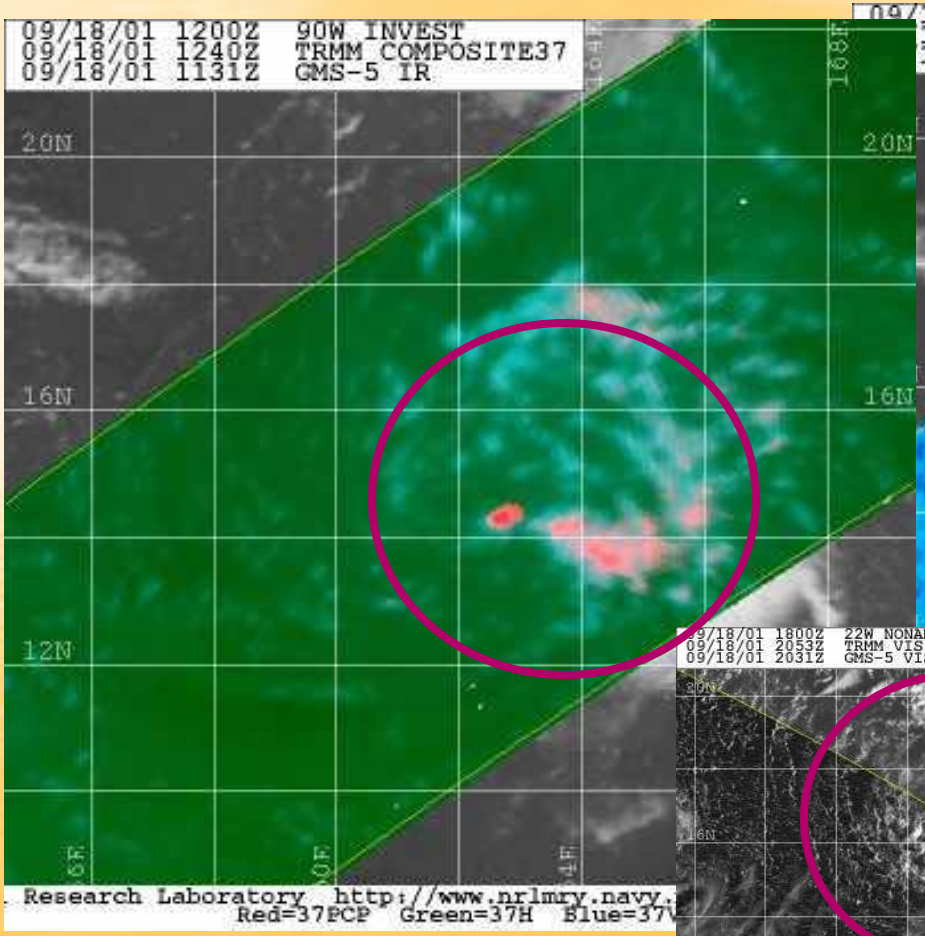
TRMM 37 color

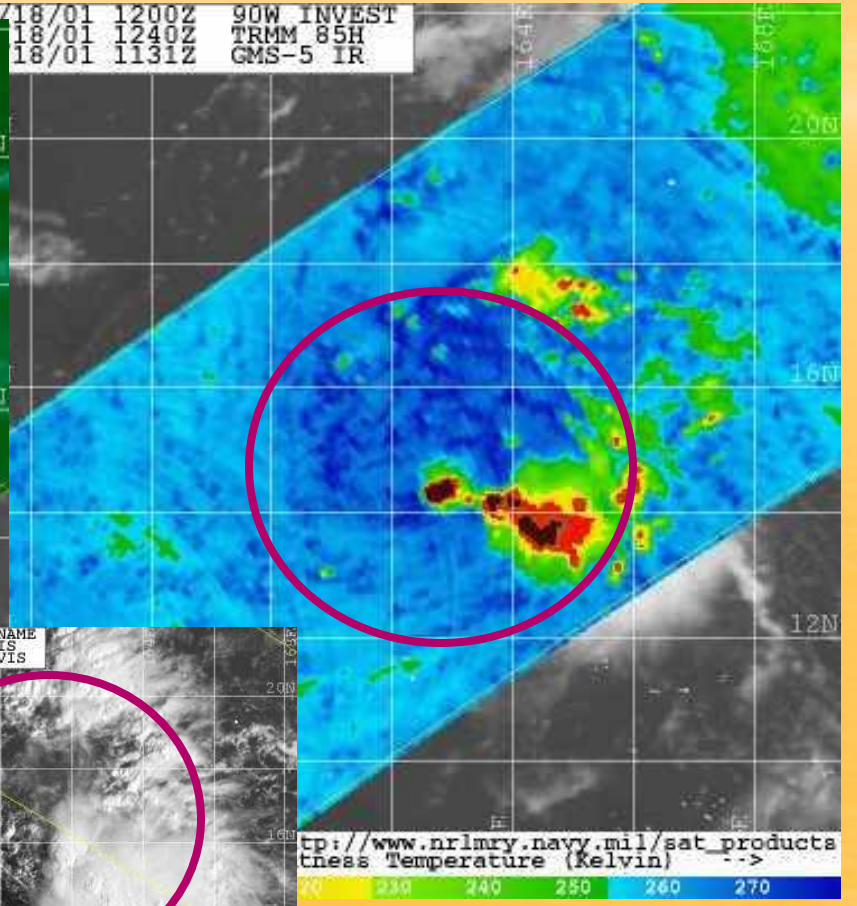


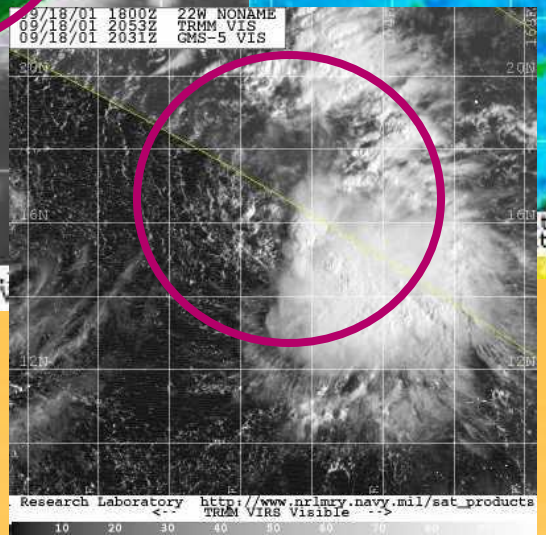
TRMM 85h



Surface Moistening (Pre-Typhoon Francesco)
Microwave 85 and 37GHz





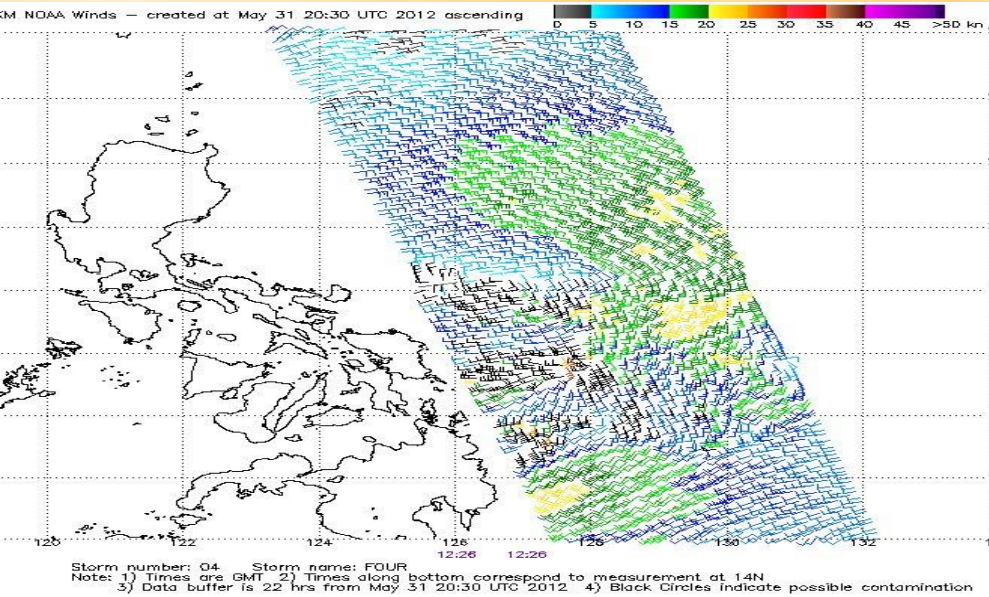


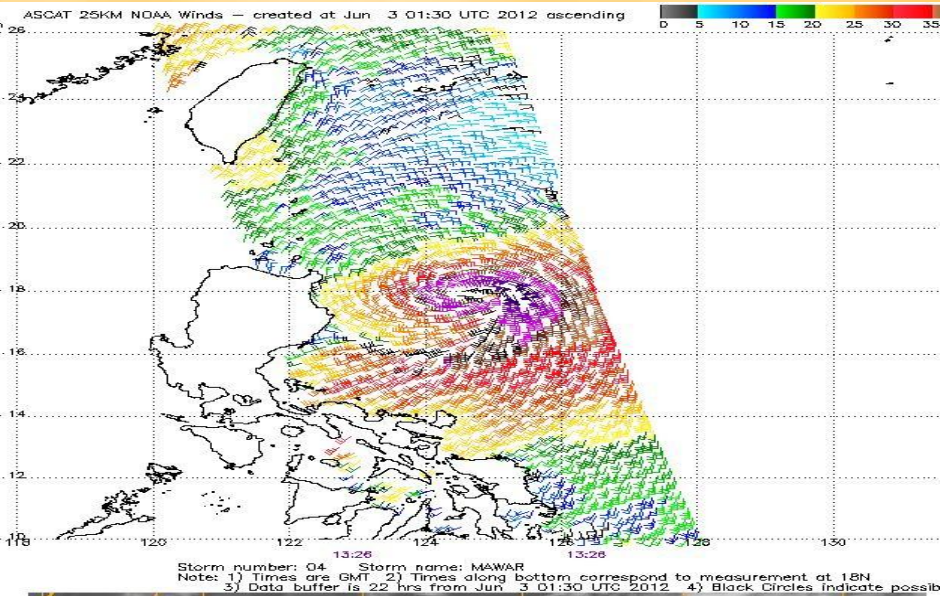
You can see the low Level CU line in the MI

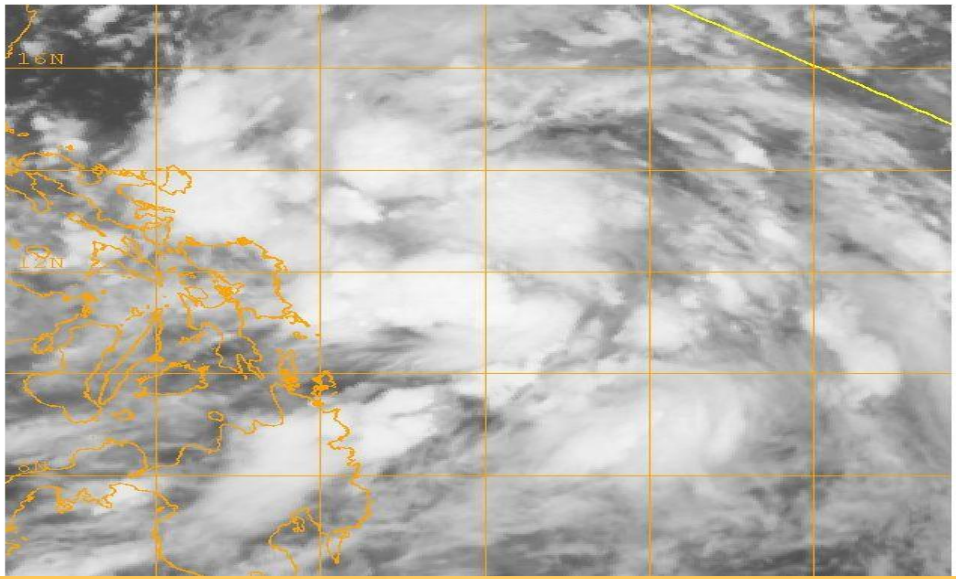
through the cirrus

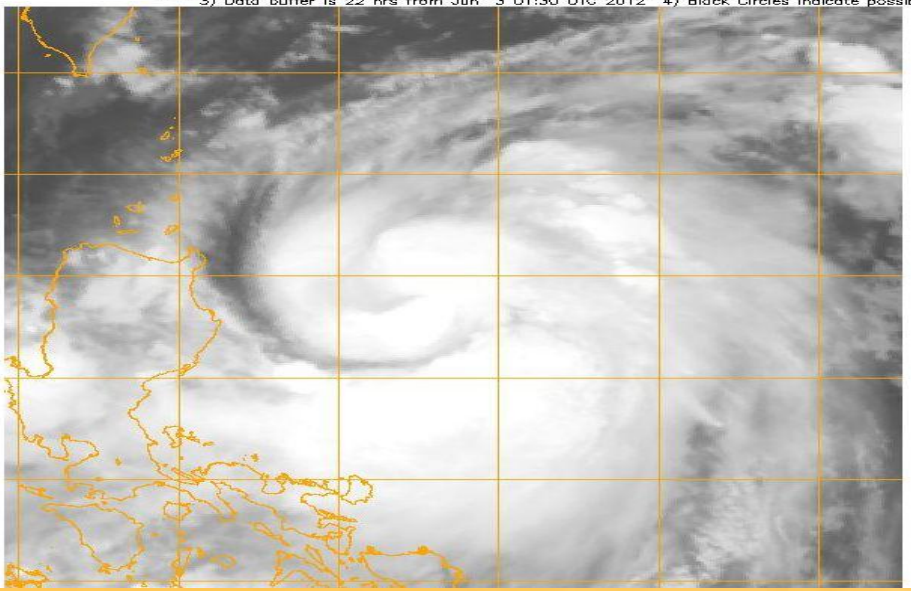
Scatterometer shows development just like the IR

Not all rain contamination!

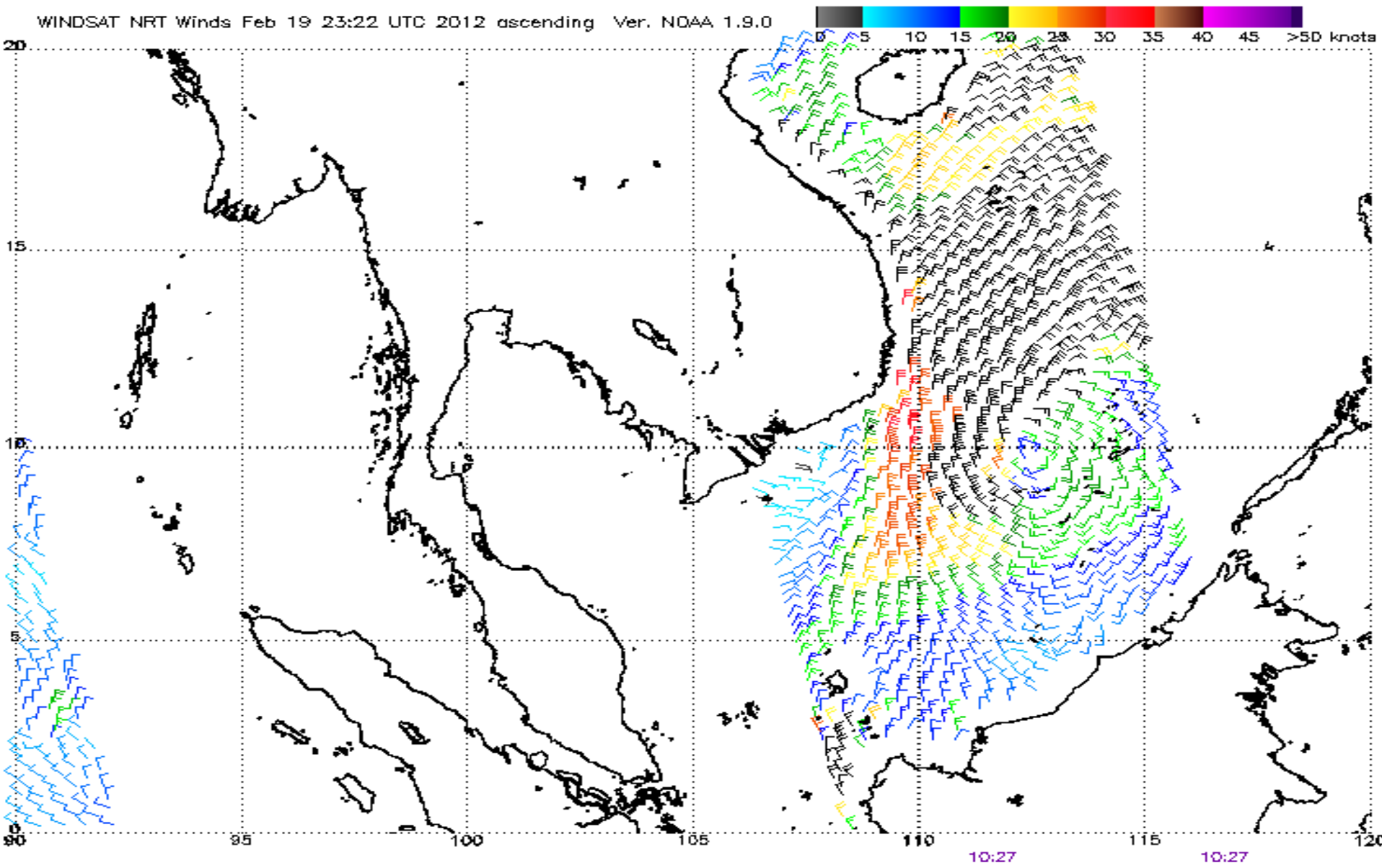


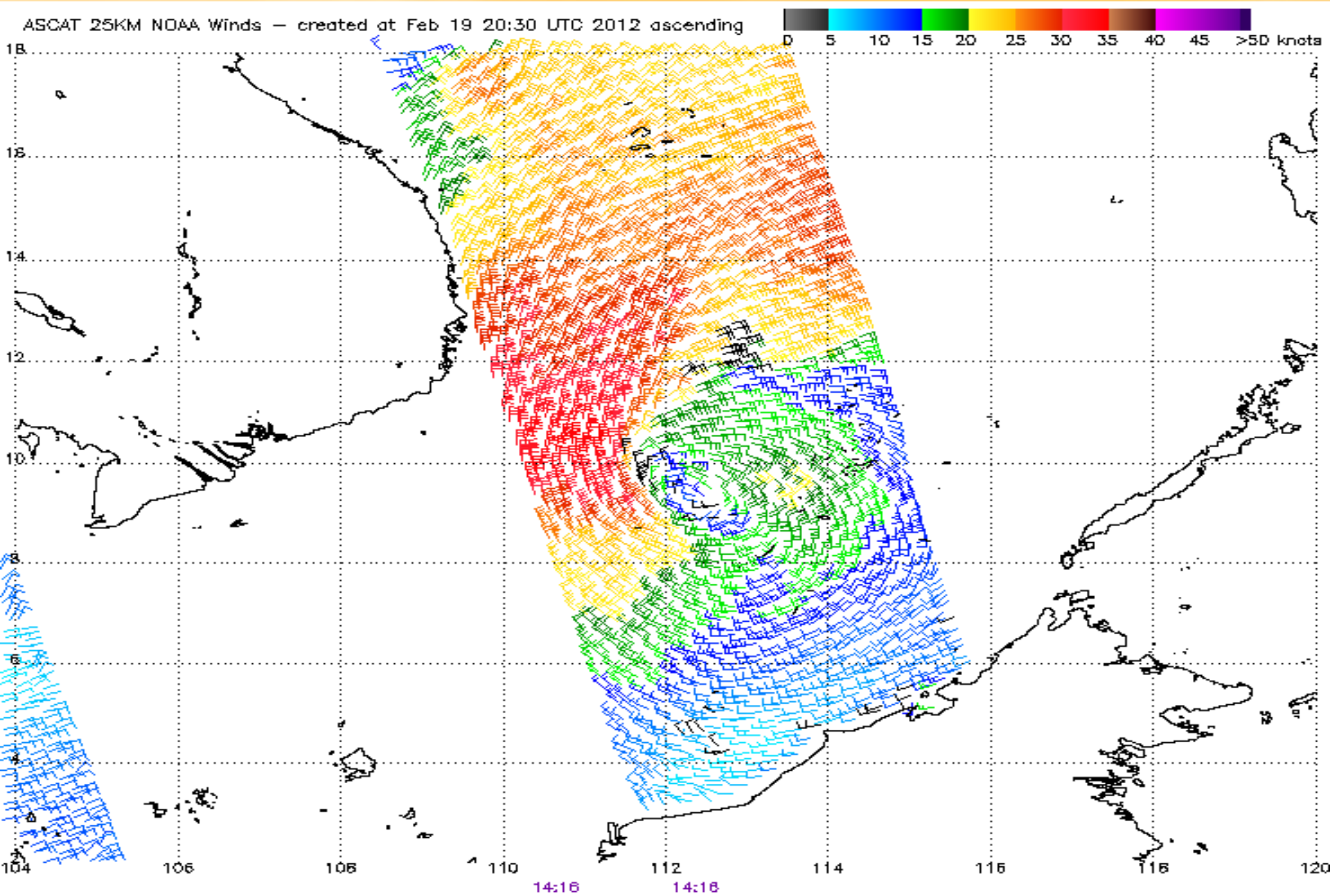






Structure and Pre-existing Wind Field



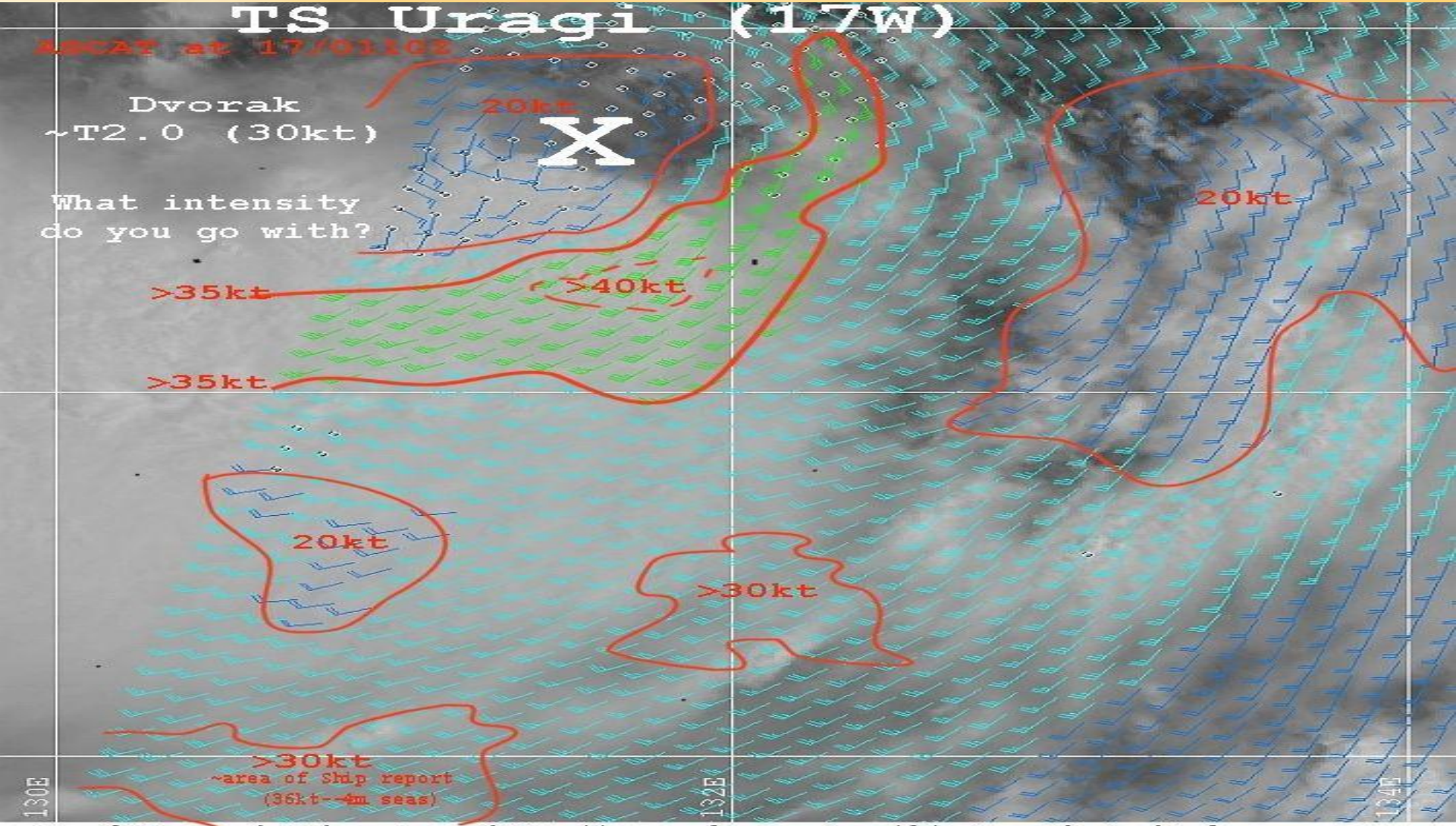


Storm number: 01 Storm name: ONE
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 10N
3) Data buffer is 22 hrs from Feb 19 20:30 UTC 2012 4) Black Circles indicate possible contamination

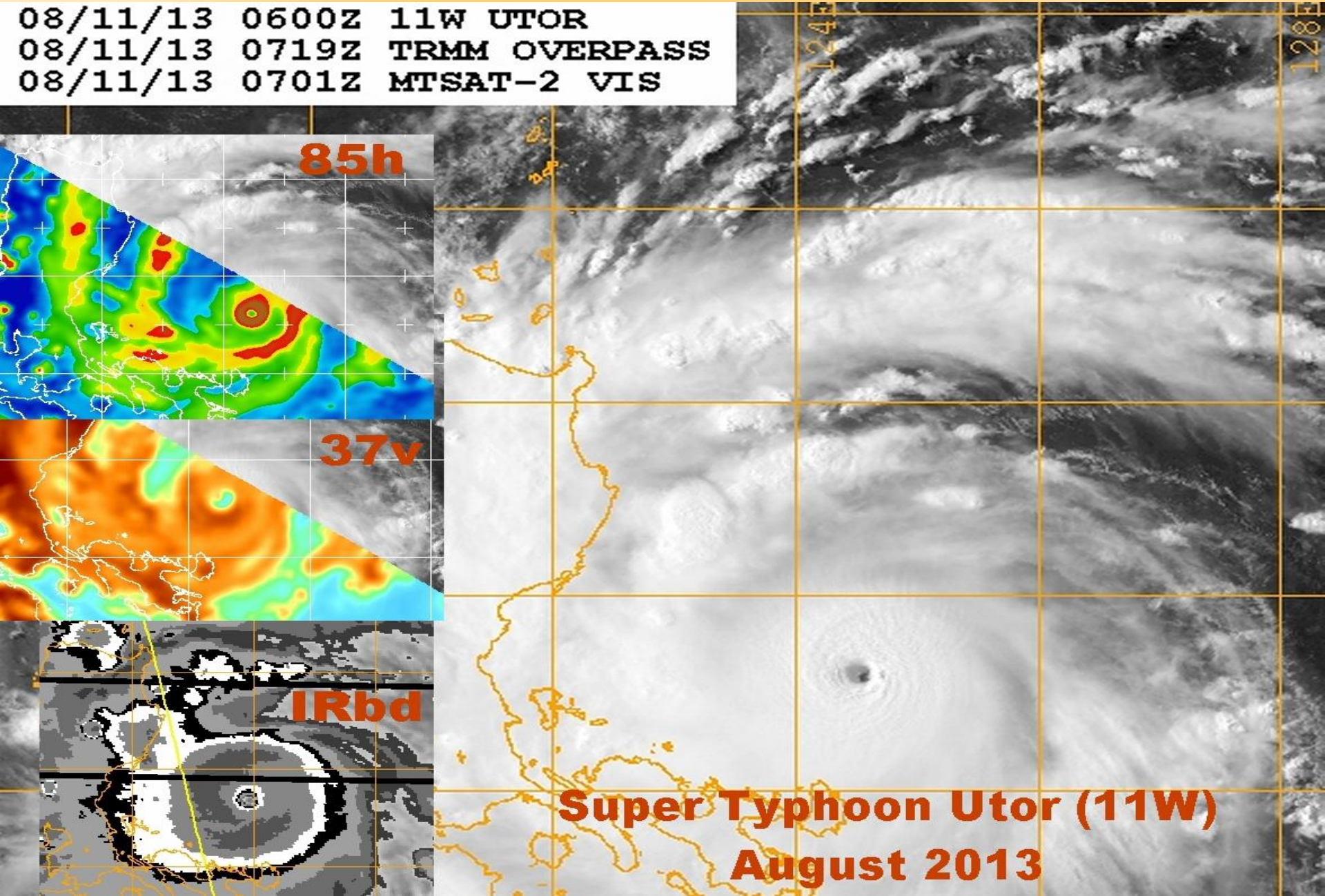
How to handle pre-existing wind field

-Describe it in the warning as ‘away from the center’

-- Expect some influence once wrap-around occurs



Intensification



Tropical Cyclone Lifecycle in Microwave Imagery (Pattern MI T#)

I. TC Genesis Stage ~25-30kt

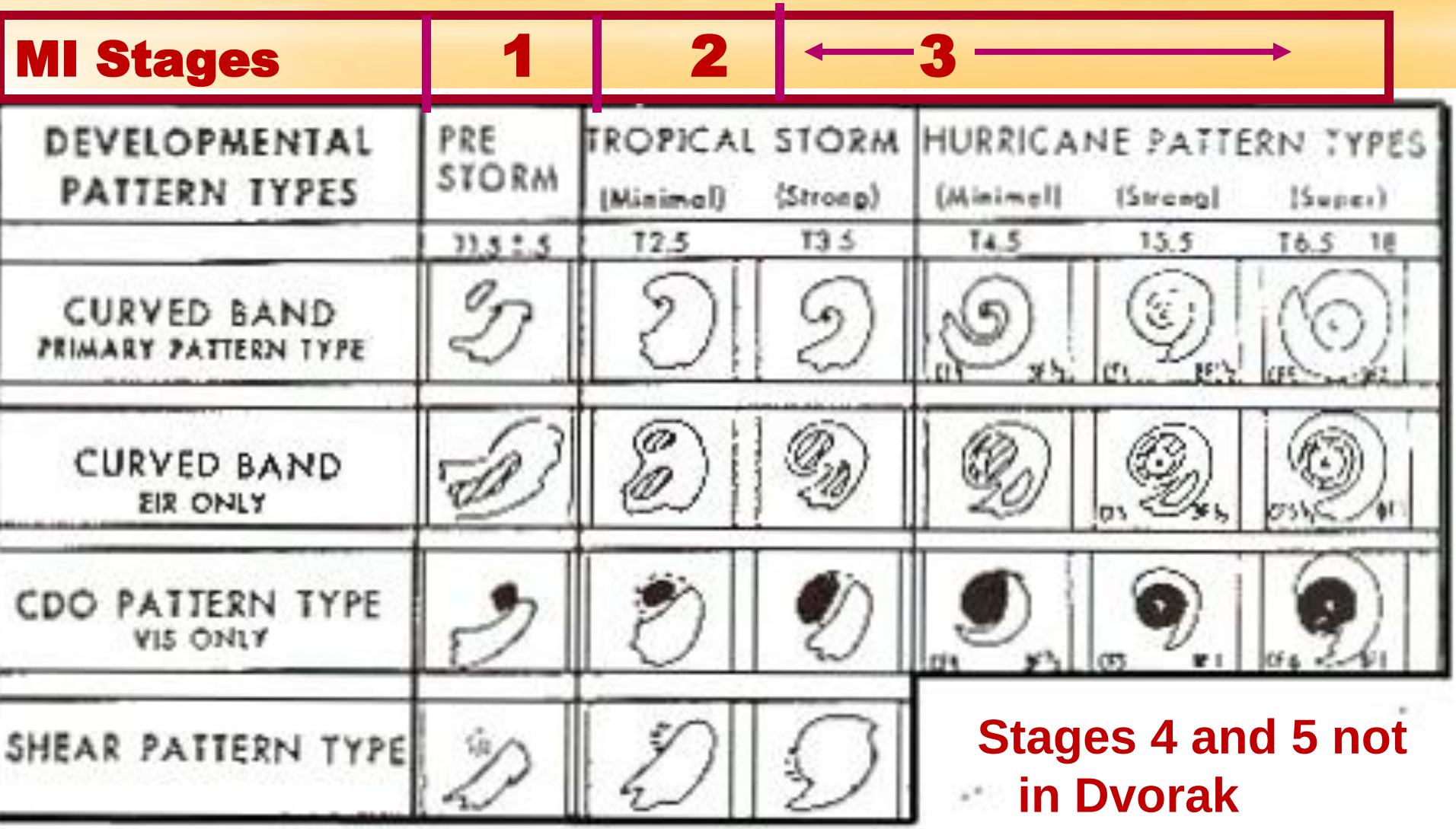
II. Early Intensification and Development~30-45kt

III. Continued Intensification and Mature Stage

IV. Peaking and Initial Weakening Stage

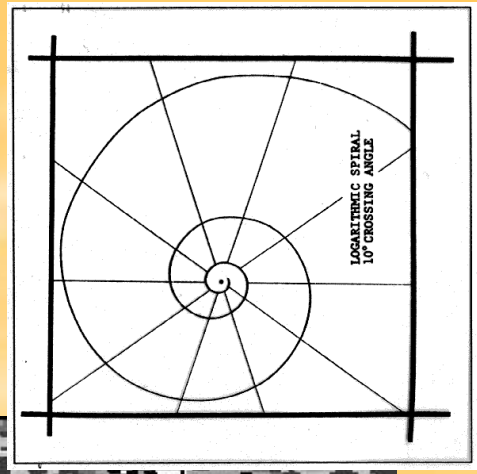
V. Dissipation and Extratropical Transition

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

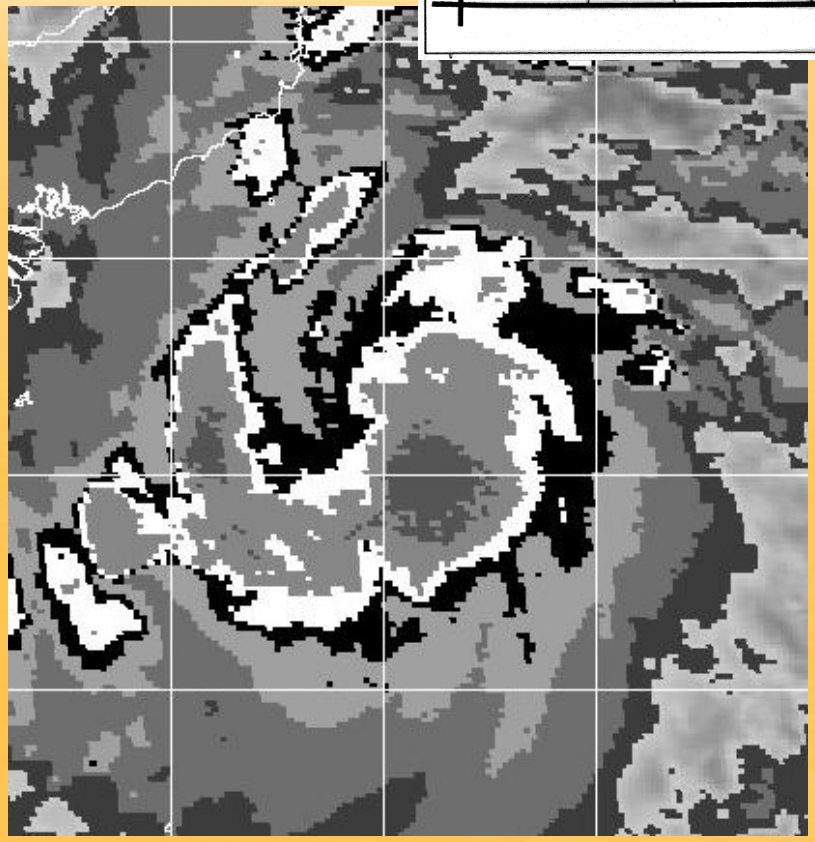


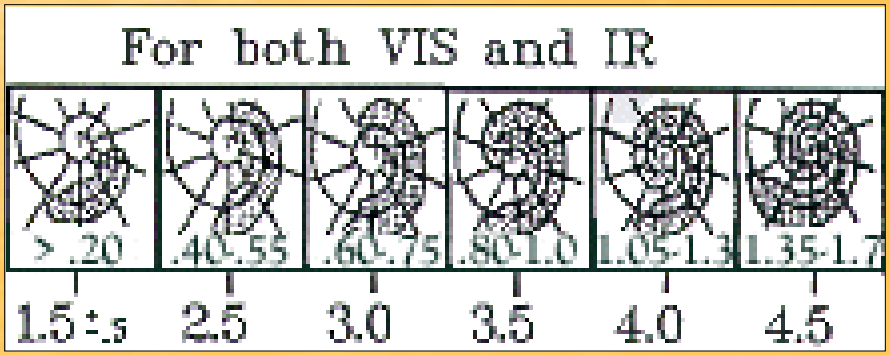
Stages 4 and 5 not in Dvorak

Too much Spiral Band Curvature (SBC)

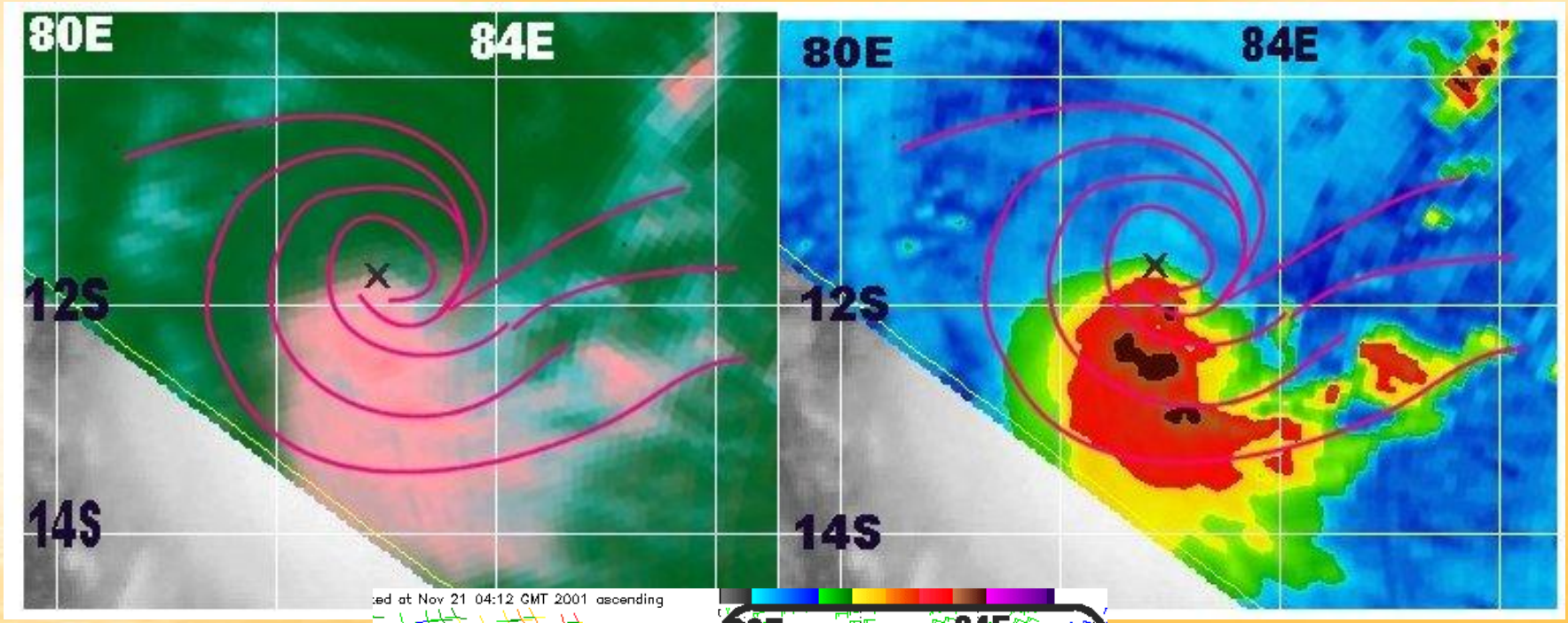


We should be able to improve on this part of the Dvorak Technique

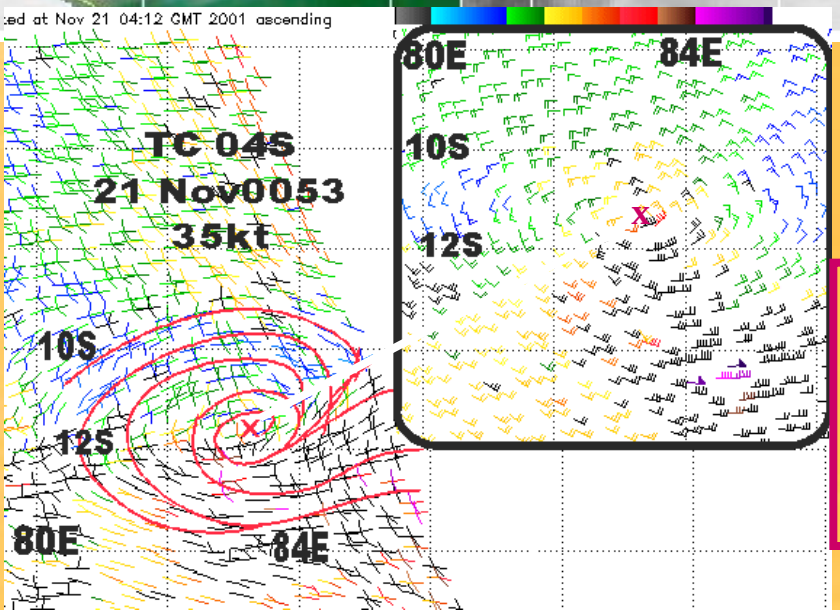




Stage 2 – Shear pattern (35kts)



37color



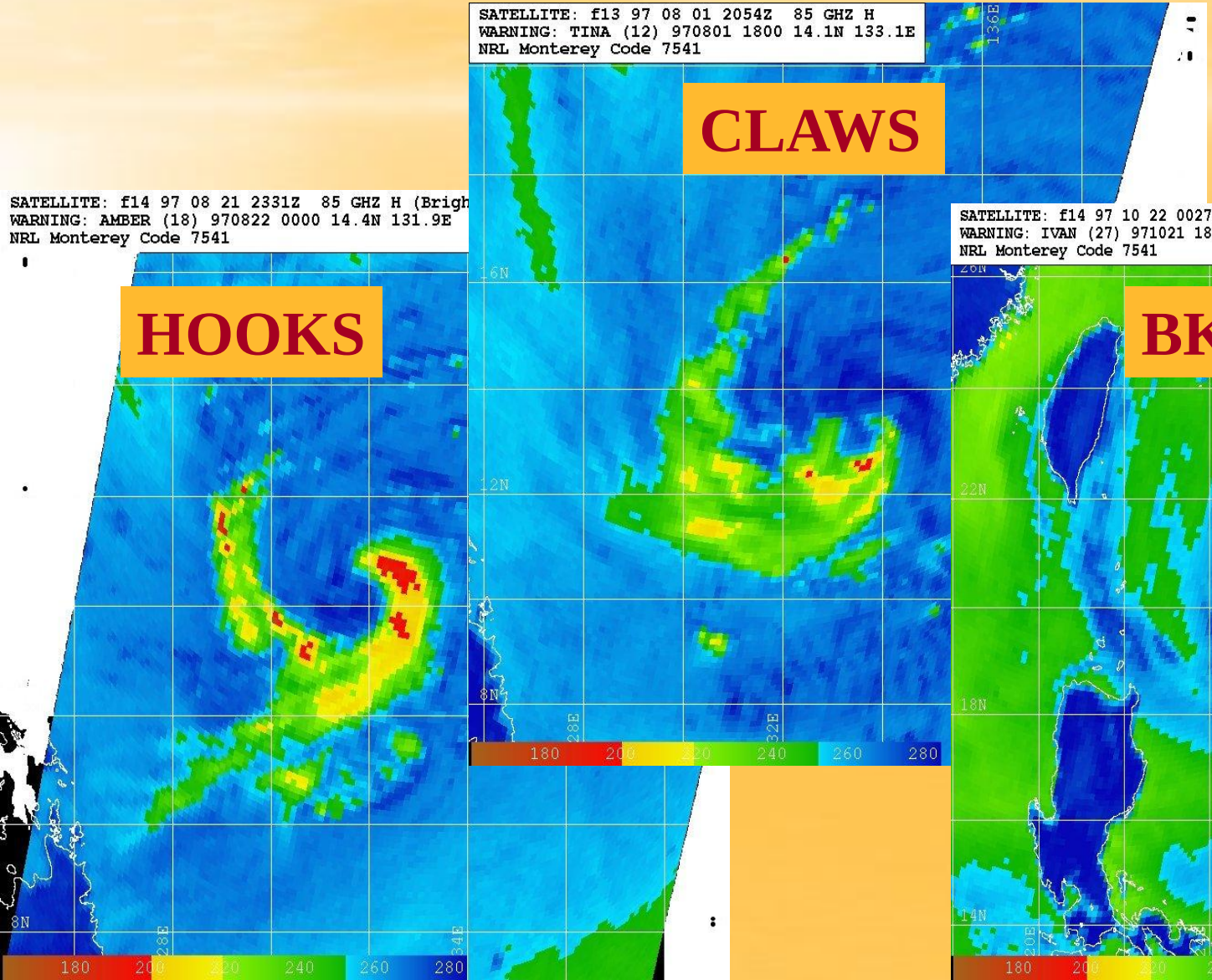
85h

Scatt Ambiguity

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

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

****there may be many other quantitative measurements****

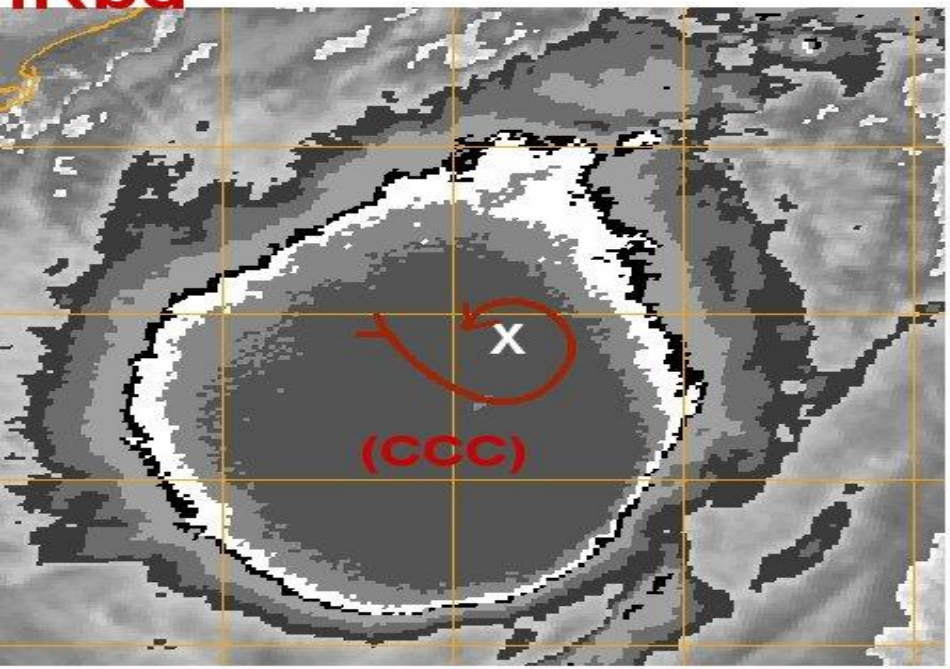


(From Cock et al.)

Identifying CCC Pattern with MI data

Review of a 'Hot Tower' under a Central Cold Cover (CCC) Burst
Tropical Cyclone Lehar (05B), 27 Nov 2013 ~0230 UTC

IRbd



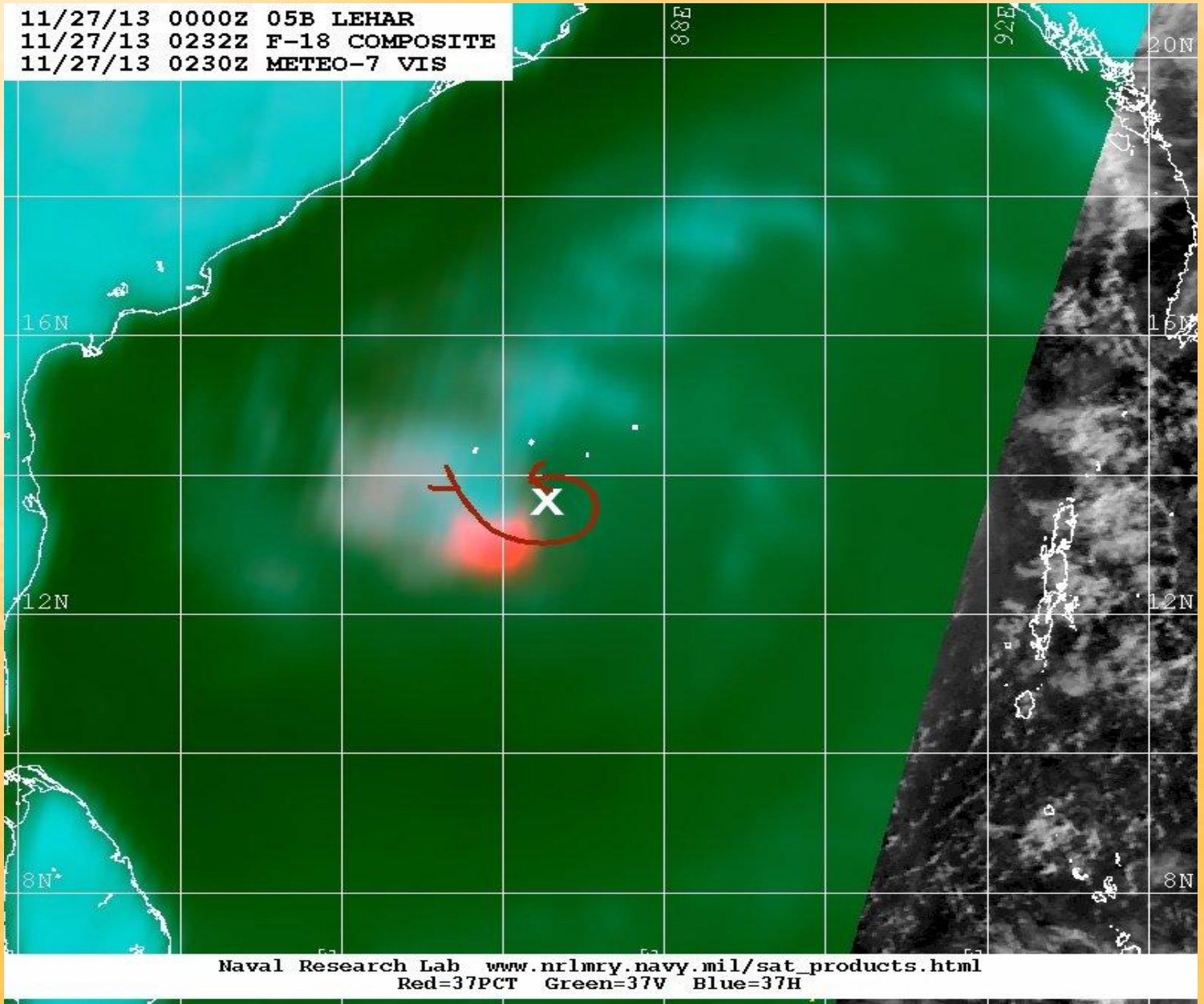
Note: CCC usually occur at T3.5 (55kt) and under the Dvorak technique, this is a (temporary) arrested development, or a 'hold' on a T# per day. Quite often itensification occurs within 12 hours at a equal or greater rate of intensification.

Visual

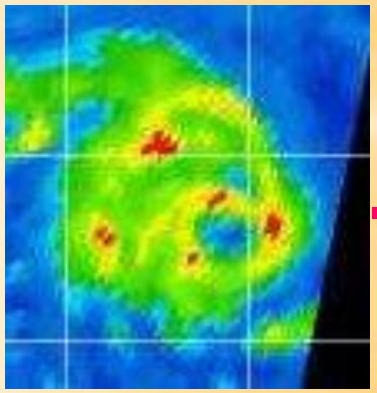
SSMIS 91h

SSMIS 36color

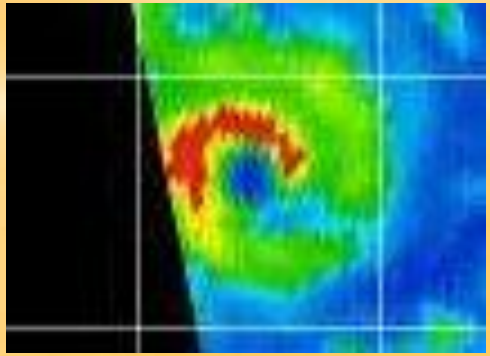
Nice View in the 37Ghz Imagery



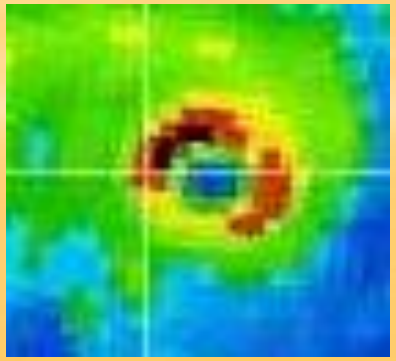
EVALUATIONS OF CAT5/SUPER TYPHOONS (85h)
VIEWS: Time changes in red inner eyes



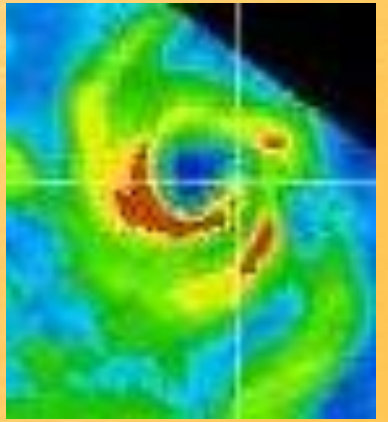
TC Susan 70kt -26hr



TC Susan 95kt -13hr



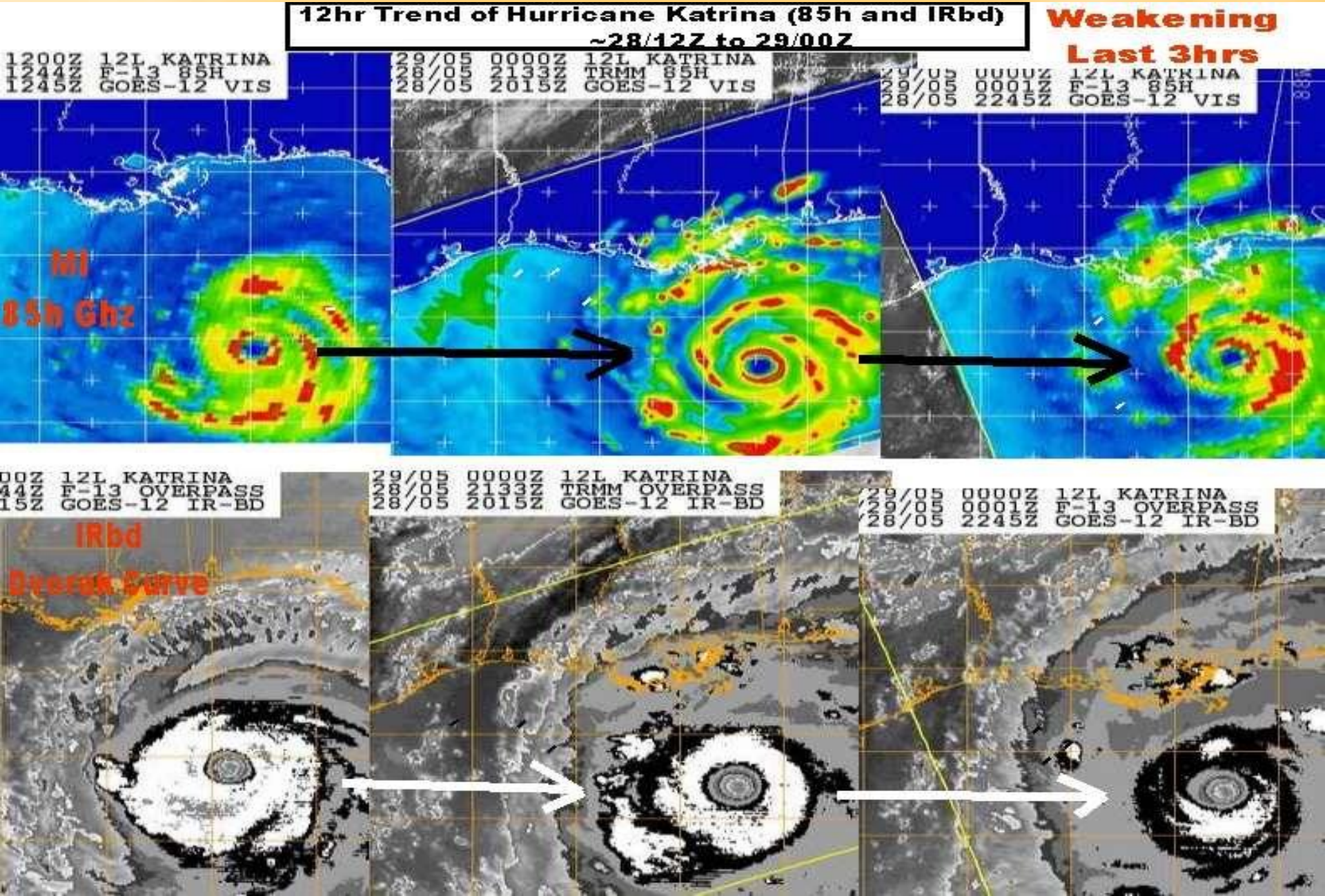
TC Susan 120kt -06hr



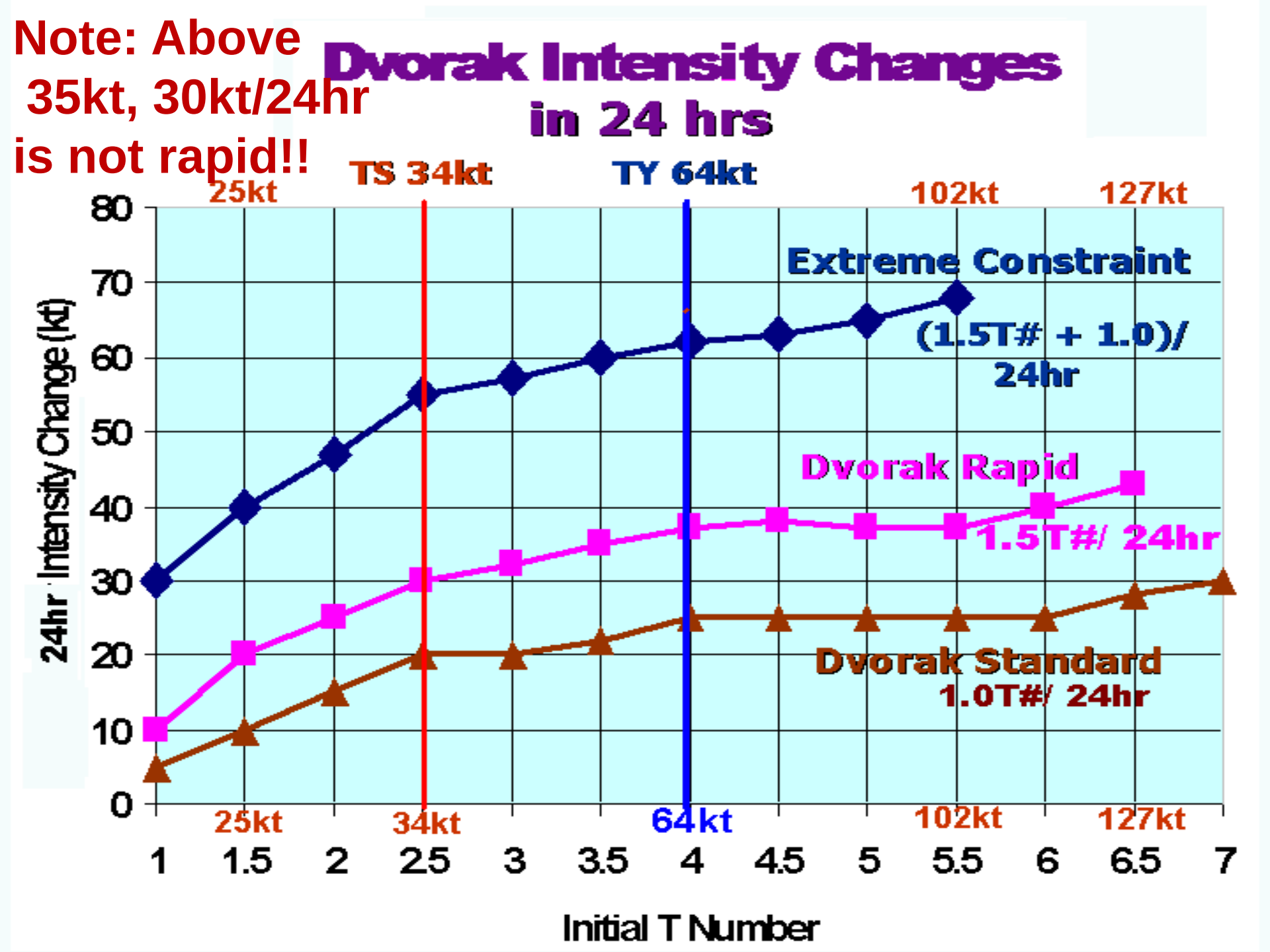
STY Zeb 95kt -24hr

STY Zeb 140kt -00hr

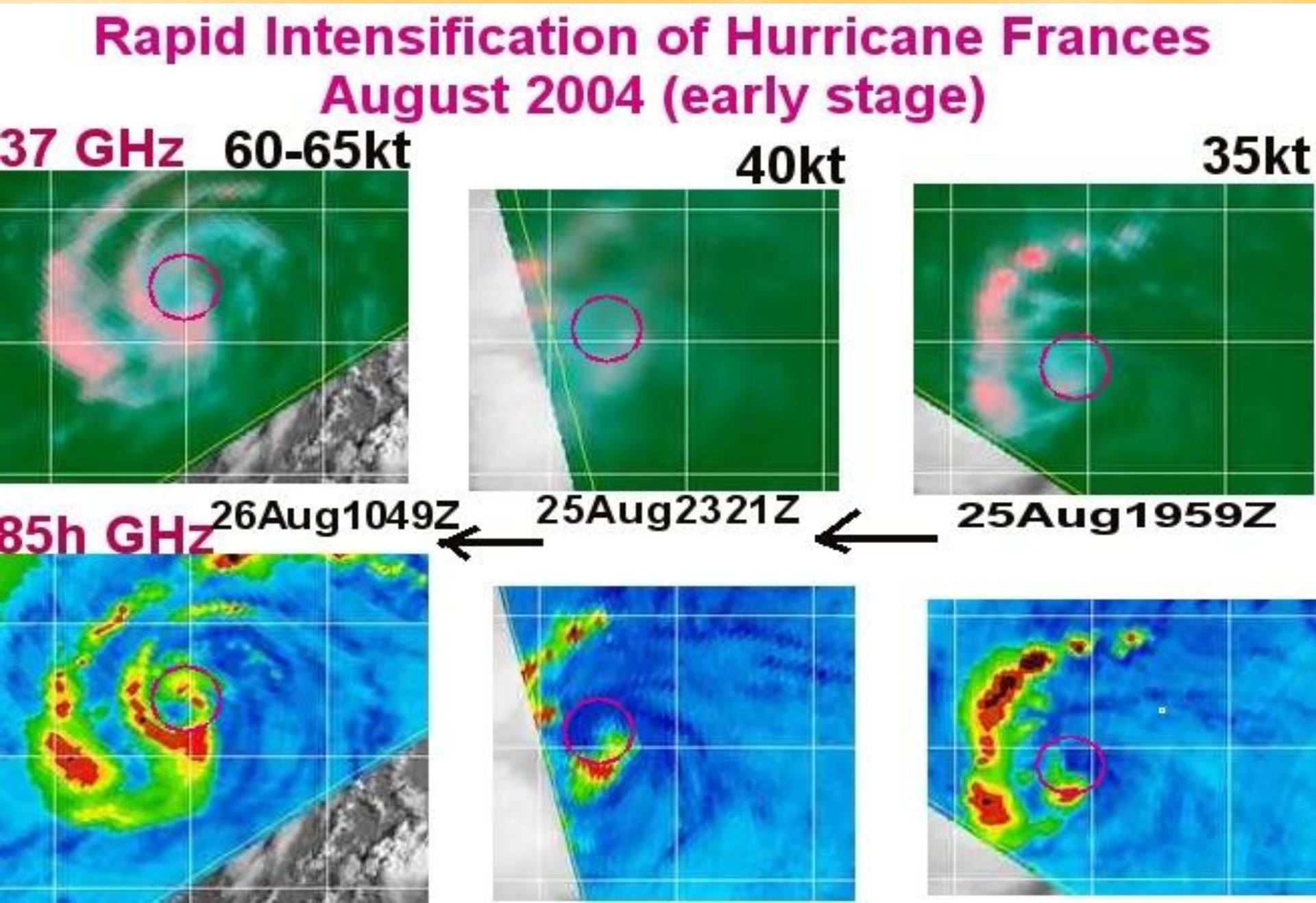
Eye-Wall Replacement Cycle



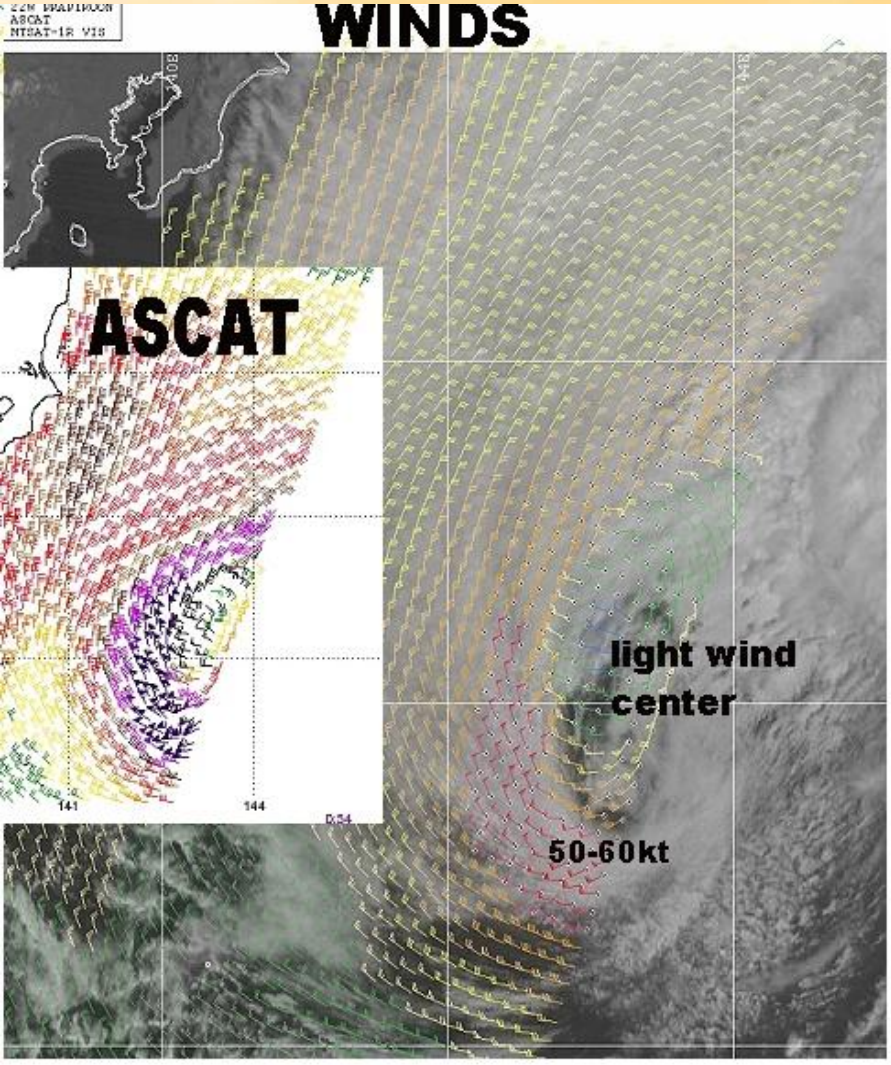
Note: Above 35kt, 30kt/24hr is not rapid!!

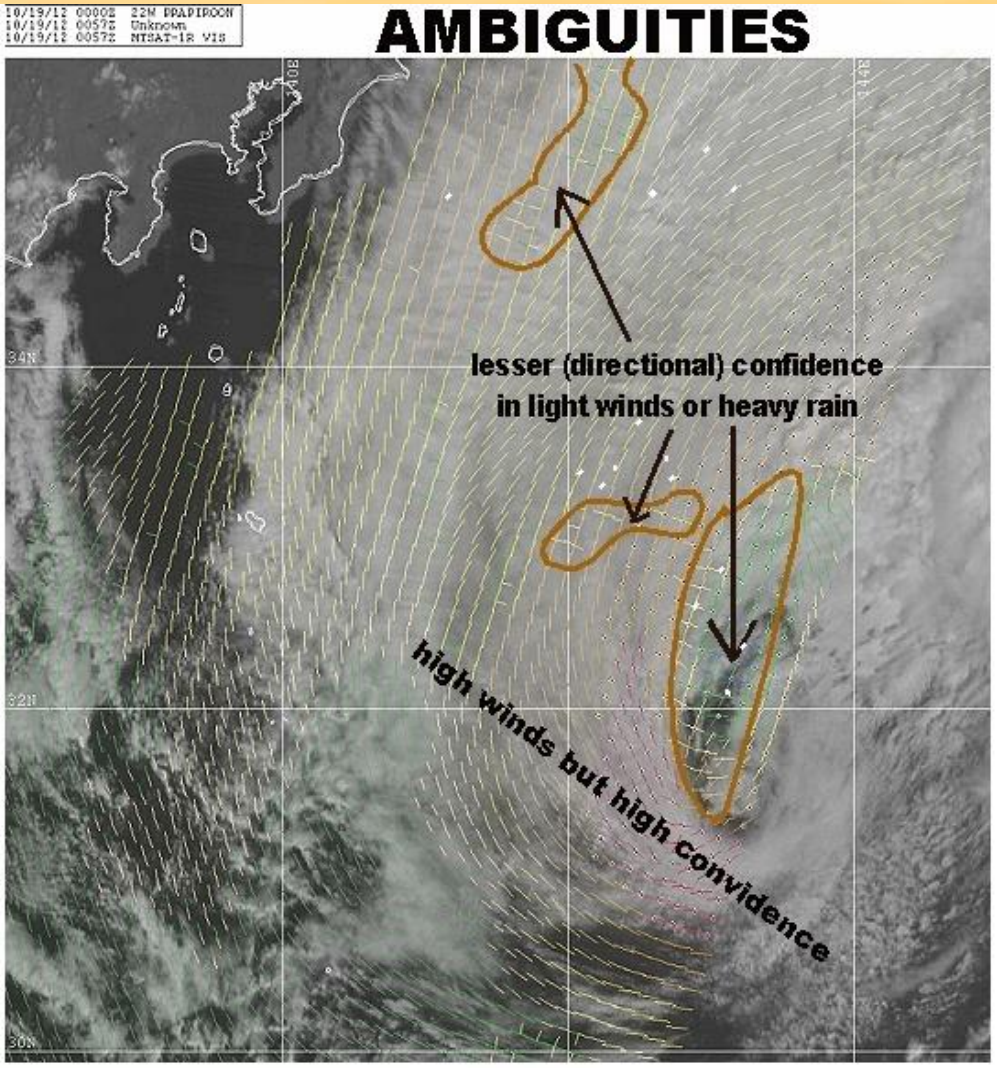


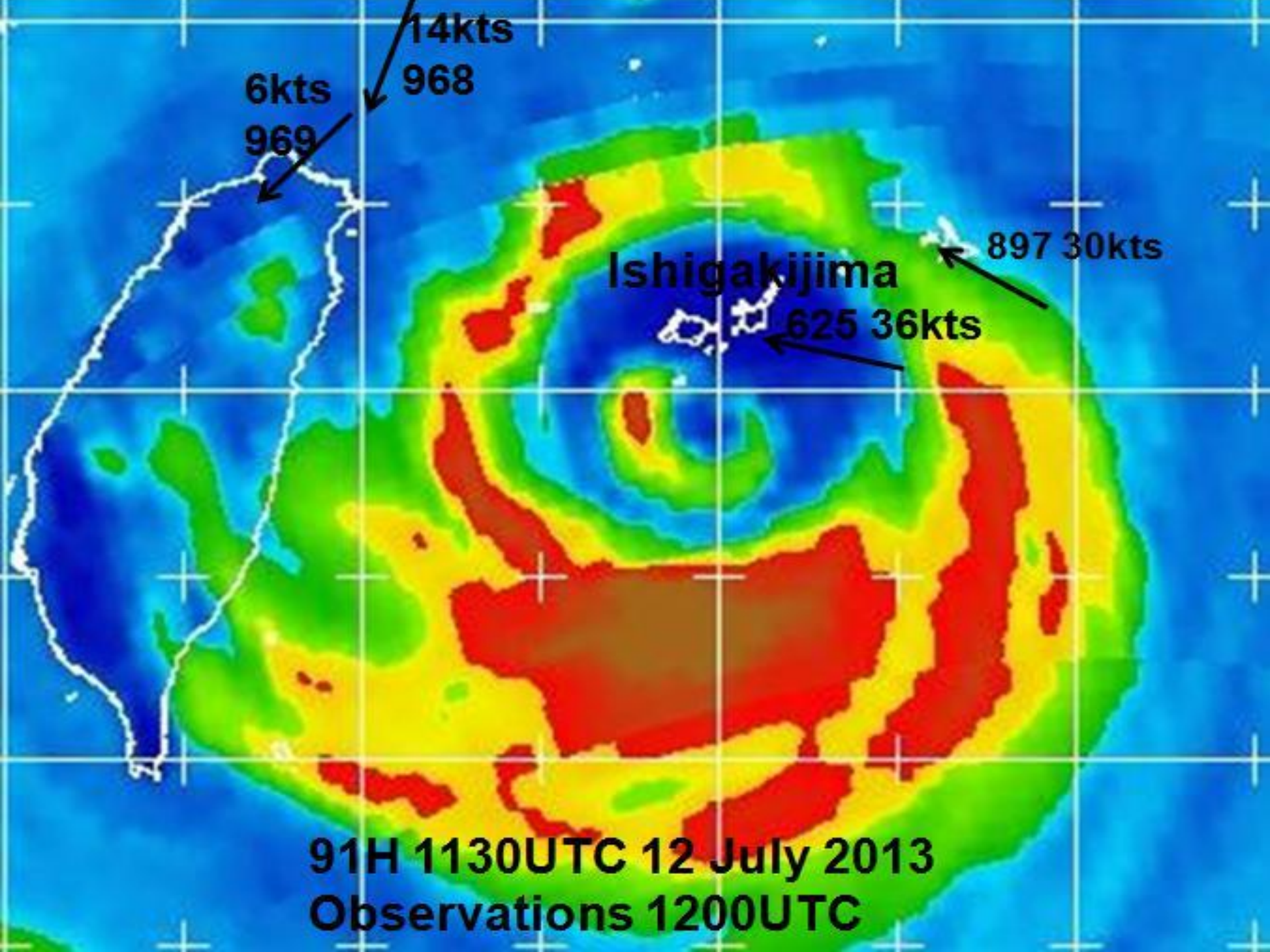
Examples of TC Rapid Intensification - Early

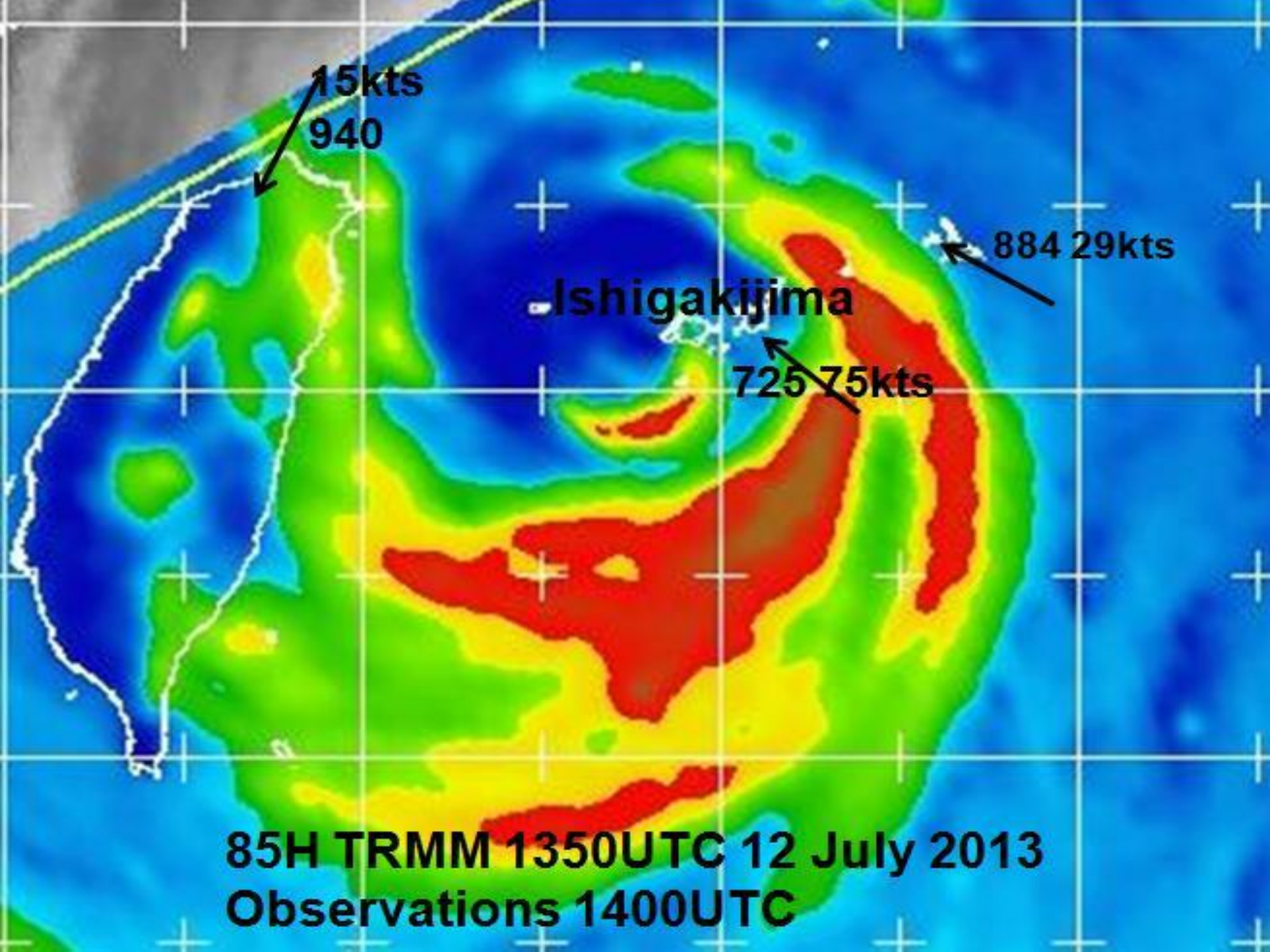


ASCAT and Extra-Tropical Transition
Winds 'ok' 50-60kts






14kts
968
6kts
969
897 30kts
Ishigakijima
625 36kts
91H 1130UTC 12 July 2013
Observations 1200UTC


15kts
940
884 29kts
Ishigakijima
725 75kts
85H TRMM 1350UTC 12 July 2013
Observations 1400UTC

BTW: Critical Need for WMO to require reporting of ‘peak wind’ since the last reporting time!

TC Centers and TC Forecasters

IR Dvorak CANNOT (should not) work by itself

Initial Stages should be 'modernized'

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

Now is the time!

Questions?