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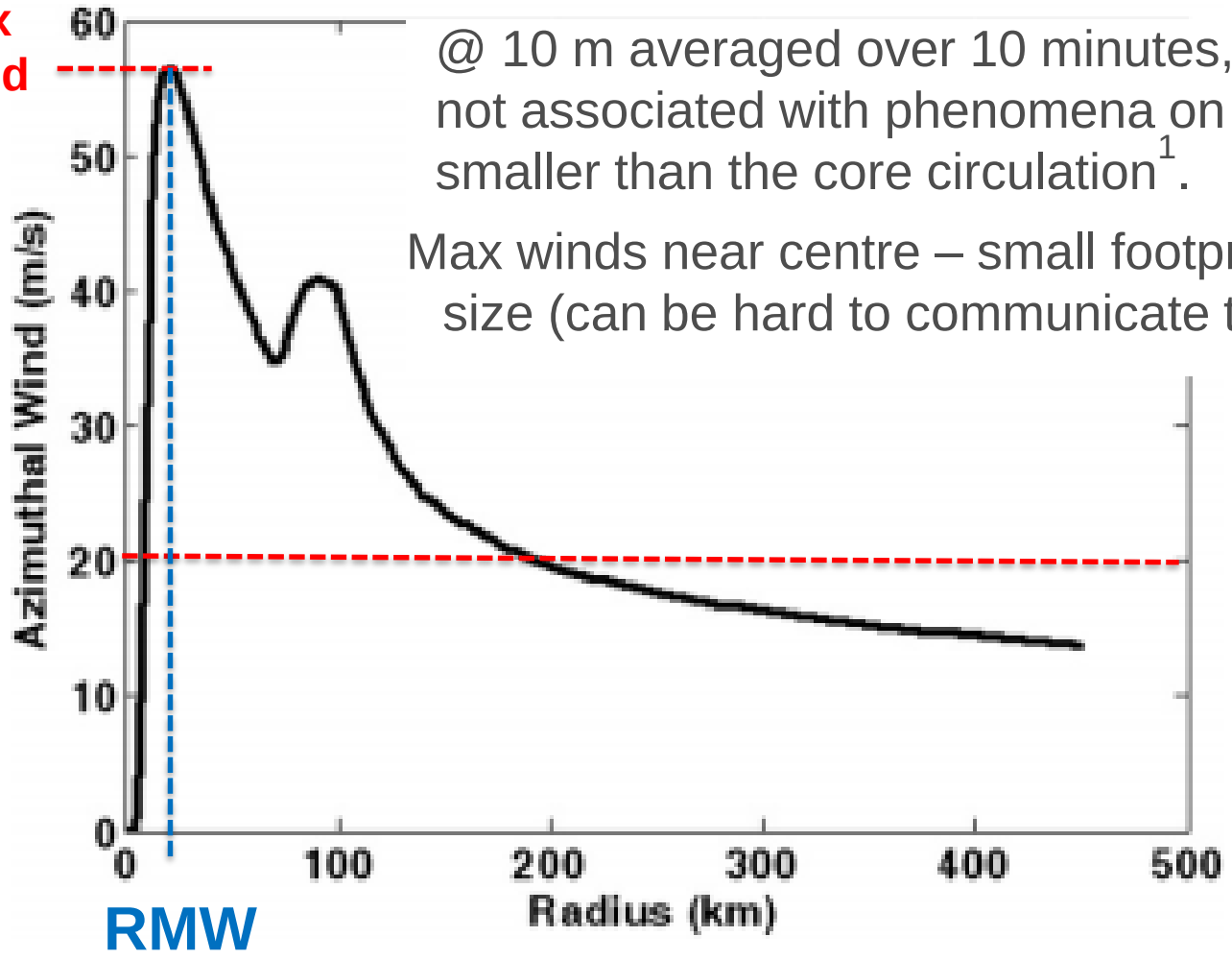
TC Intensity analysis - maximum wind speed estimate



@ 10 m averaged over 10 minutes, not associated with phenomena on a scale significantly smaller than the core circulation[1].

Max winds near centre – small footprint compared to TC size (can be hard to communicate this issue)

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TCs fluctuate intensity

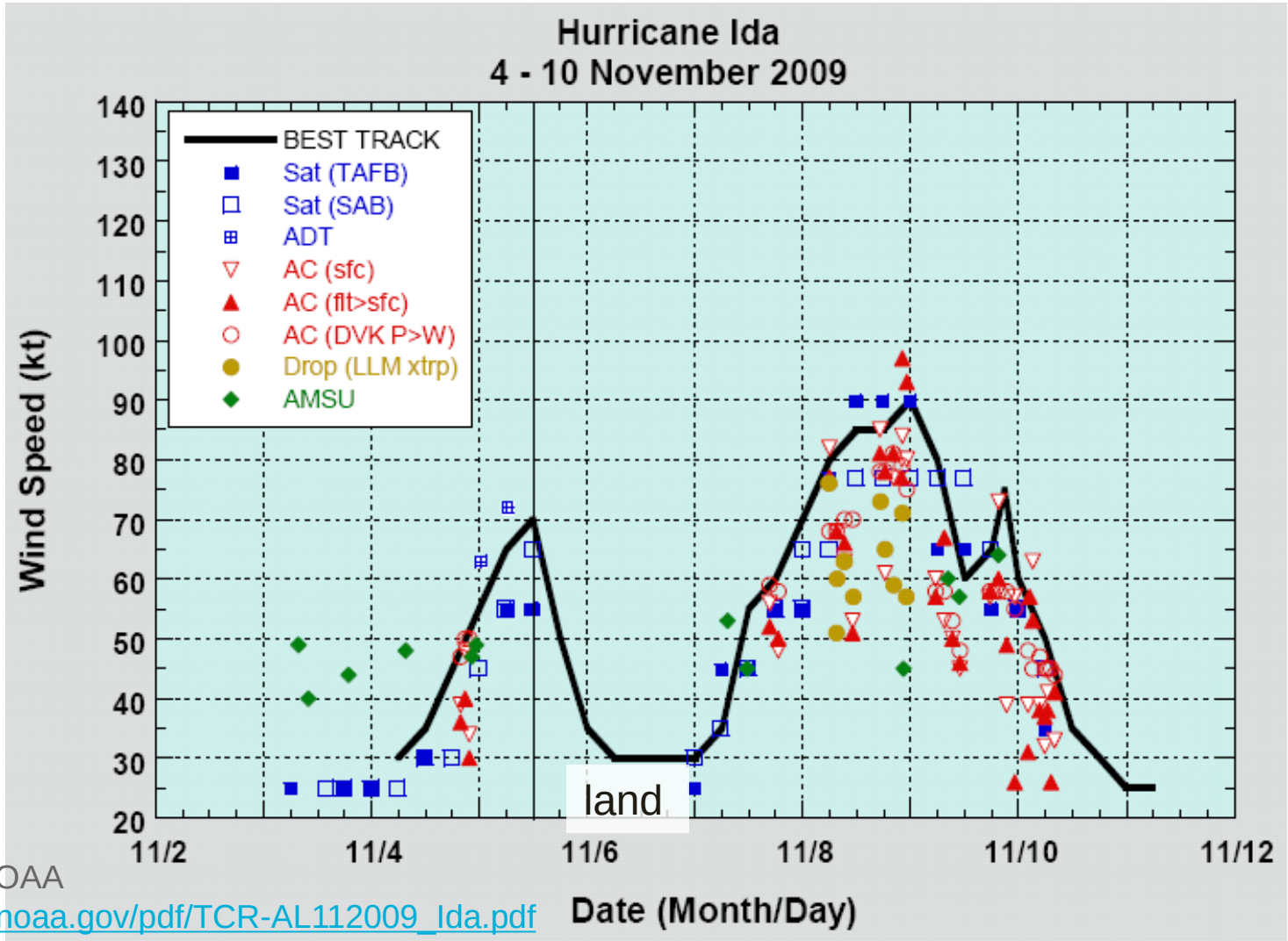

Image: NHC, NOAA
http://www.nhc.noaa.gov/pdf/TCR-AL112009_Ida.pdf

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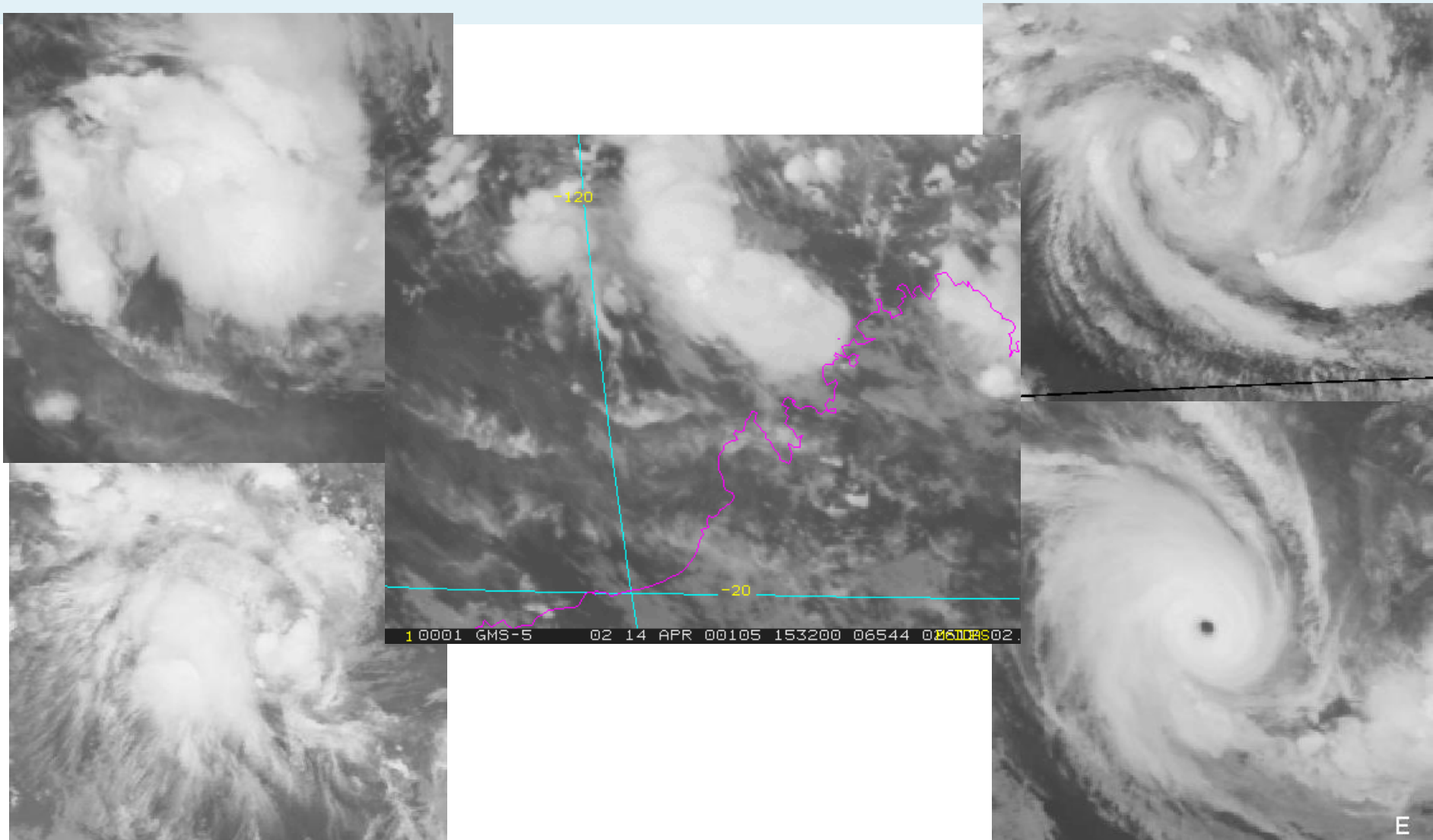
What is the intensity of these TCs?



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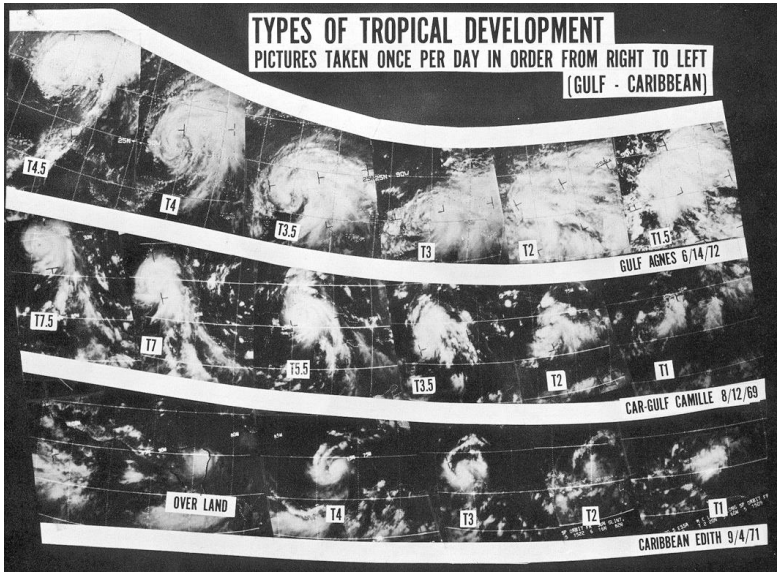
Part A. Intro to the Dvorak Technique

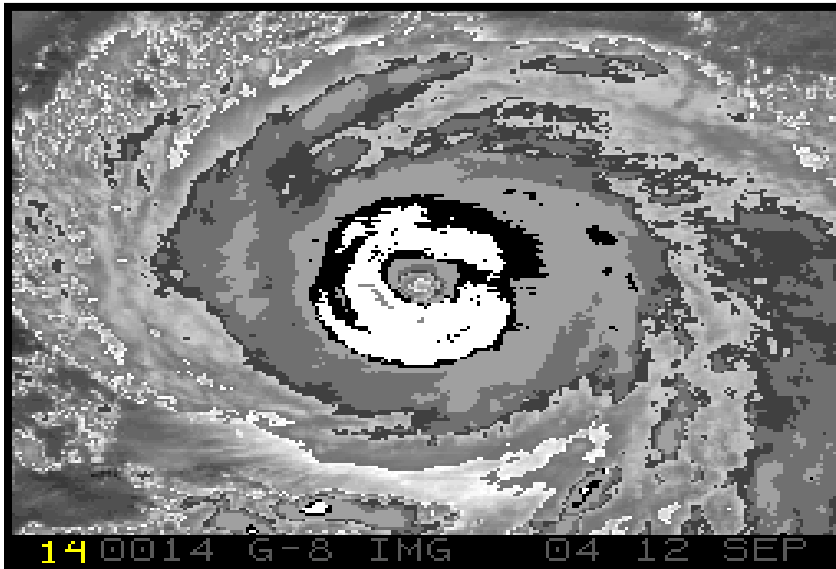
Empirical pattern technique to estimate intensity

Still the most robust technique available after 40+yrs

Comparison of agencies shows variations in the application of the technique (IWSAT 2011, 2016) – can we do better?

Ongoing debates regarding calibration with better data





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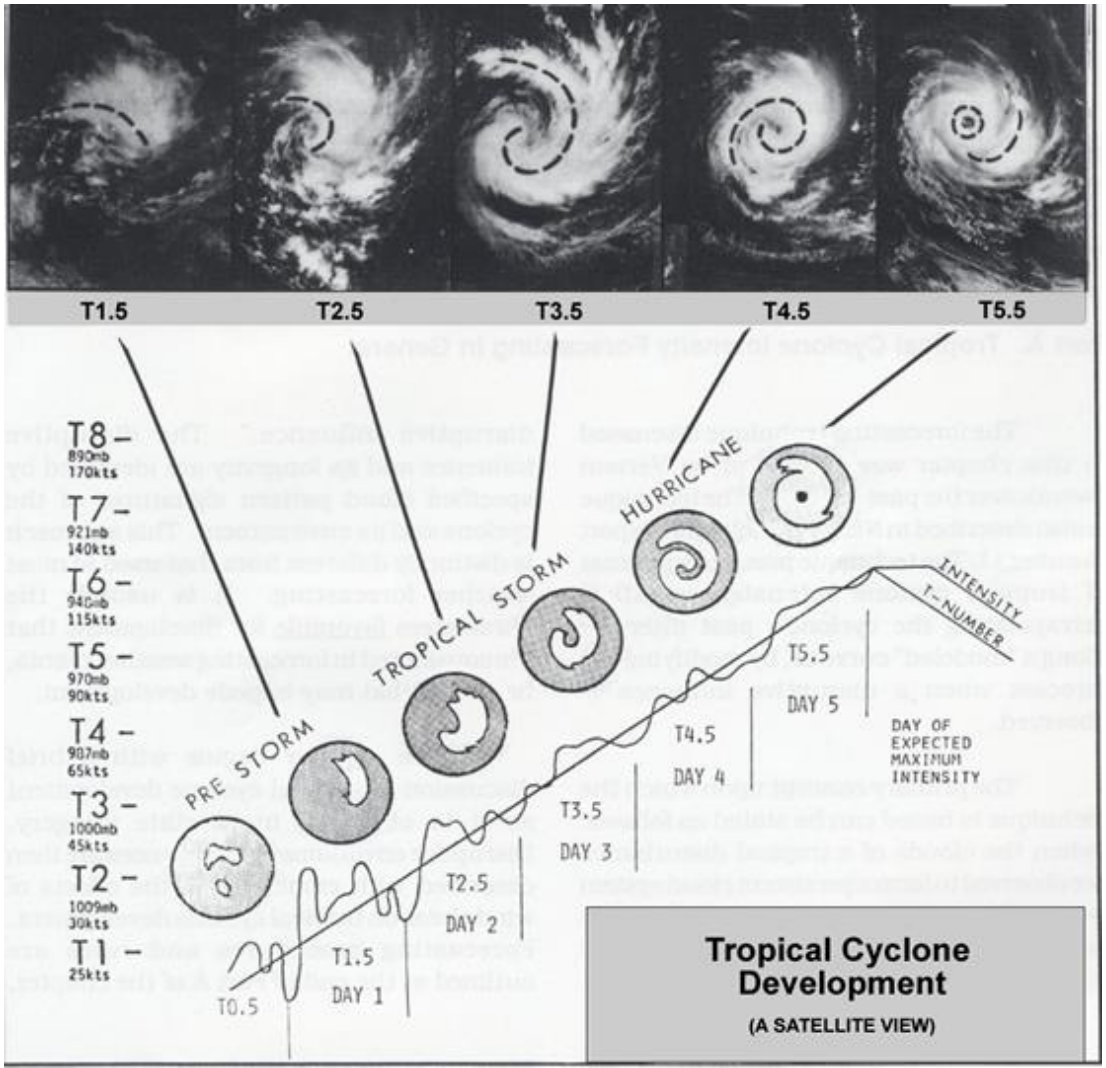
The Dvorak Technique: pattern matching to known intensity changes

More info:

[VLAB Dvorak resources]

[Isobar intensity exercises]

[WMO/NHC Dvorak]



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Sources of Dvorak information
(in addition to ADT)

NOAA Satellite Analysis Branch: http://www.ssd.noaa.gov/PS/TROP/tdpositions.html

JTWC: http://www.usno.navy.mil/JTWC/

Last Update Tue Jul 25 03:50:01 UTC 2017

Users are reminded that the posted SSD position and intensity may differ fror
For official information:

National Hurricane Center (NHC)
Central Pacific Hurricane Center (CPHC)
Joint Typhoon Warning Center in Honolulu (JTWC)

Archives: (2017-2018 S-HEM Season), 2017, 2016, 2015, 2014, 2013, 2012, 201

Most Recent Positions Regardless of Basin:

DATE/TIME	LAT	LON	CLASSIFICATION	STORM
25/0230 UTC	25.7N	157.0E	T4.5/4.5	NORU -- *West Pacifi*
25/0230 UTC	32.8N	155.9E	T2.0/2.5	KULAP -- *West Pacific*
25/0230 UTC	17.3N	108.1E	T3.0/3.0	SONCA -- *West Pacific*
25/0000 UTC	14.6N	134.5W	T2.5/2.5	GREG -- *East Pacific*
25/0000 UTC	15.1N	118.0W	T3.5/4.0	IRWIN -- *East Pacific*

```
TPPN10 PGTW 250249

A. TYPHOON 07W (NORU)

B. 25/0230Z

C. 25.72N

D. 156.99E

E. THREE/HMWRI8

F. T5.0/5.0/D0.5/24HRS  STT: D0.5/03HRS

G. IR/EIR/VIS/MSI

H. REMARKS: 11A/PBO RAGGED EYE/ANMTN. OW EYE SURROUNDED BY LG
YIELDS AN E# AND DT (NO EYE ADJUSTMENT) OF 5.0. MET AND PT
YIELD 5.0. DBO DT.

I. ADDITIONAL POSITIONS: NONE
```

LOWE

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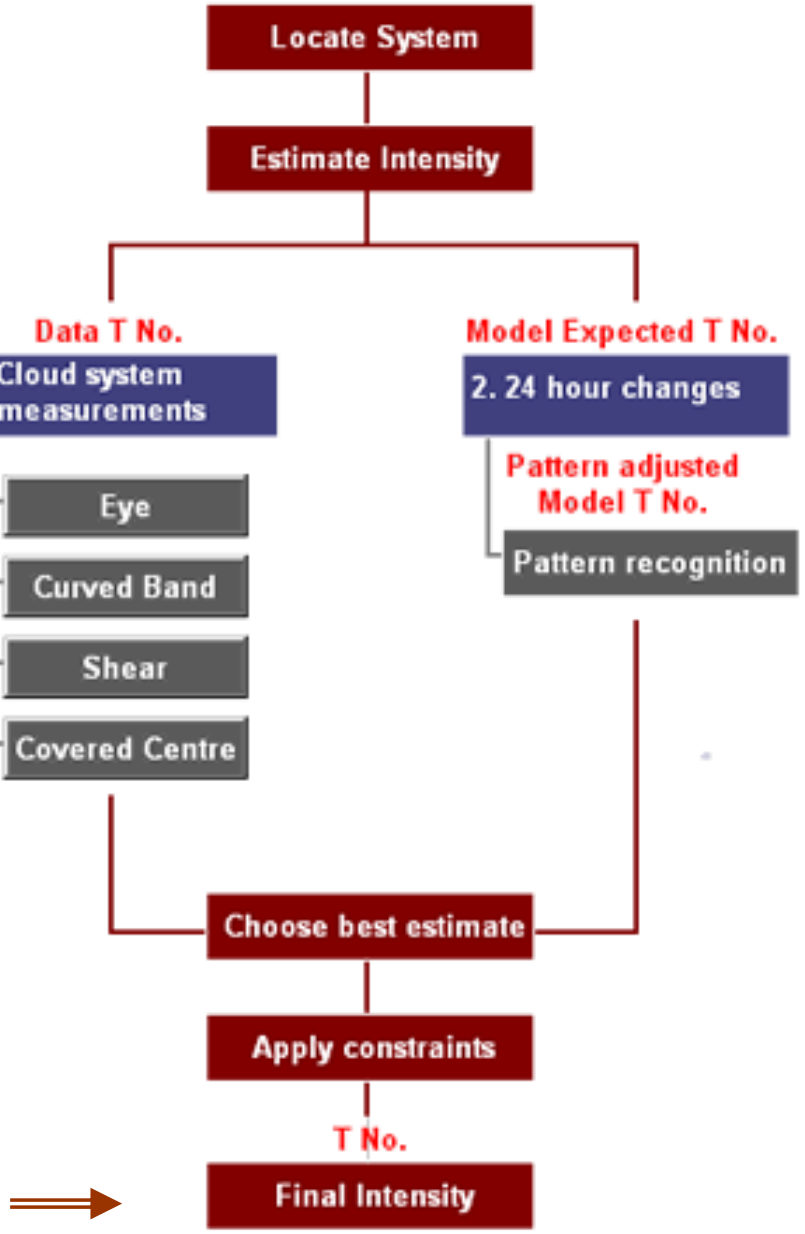

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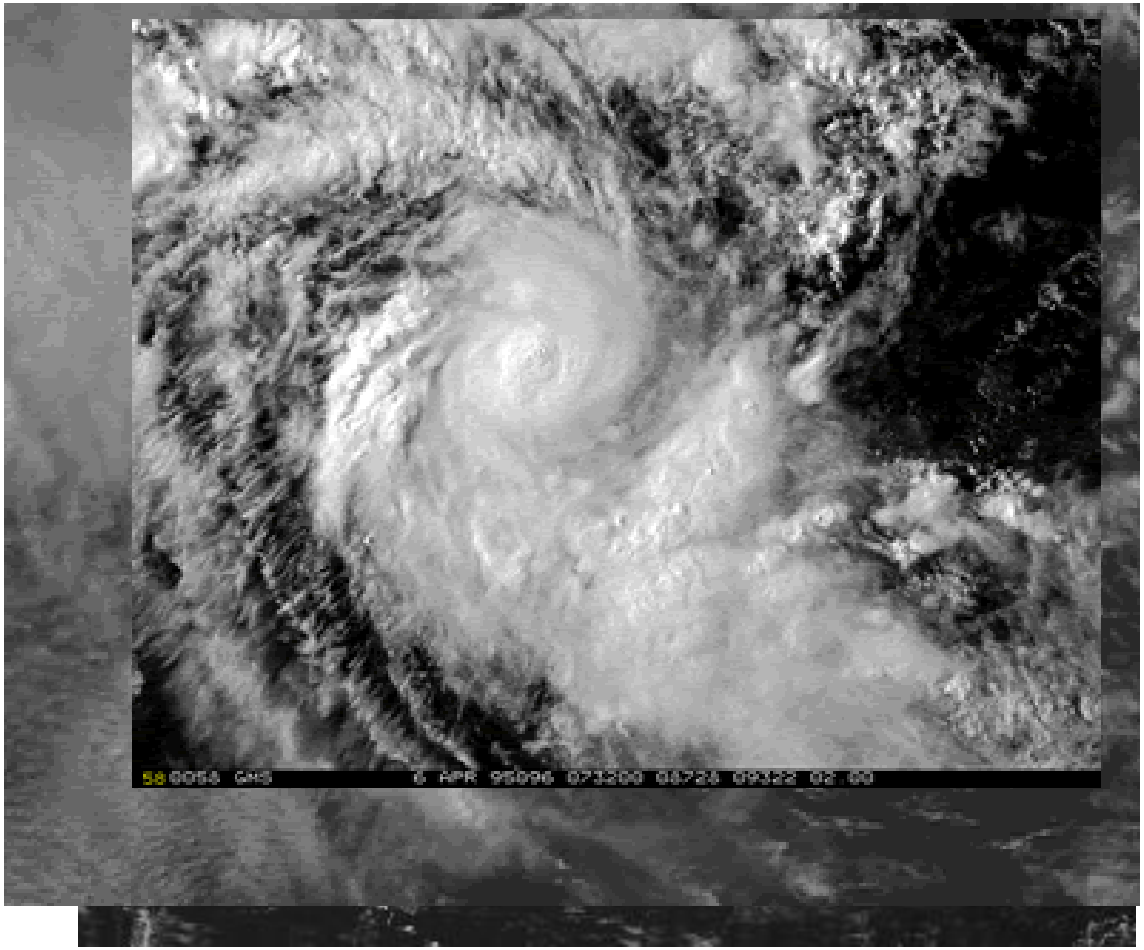
Pattern Types

- Eye
- Curved Band
- Shear
- Covered



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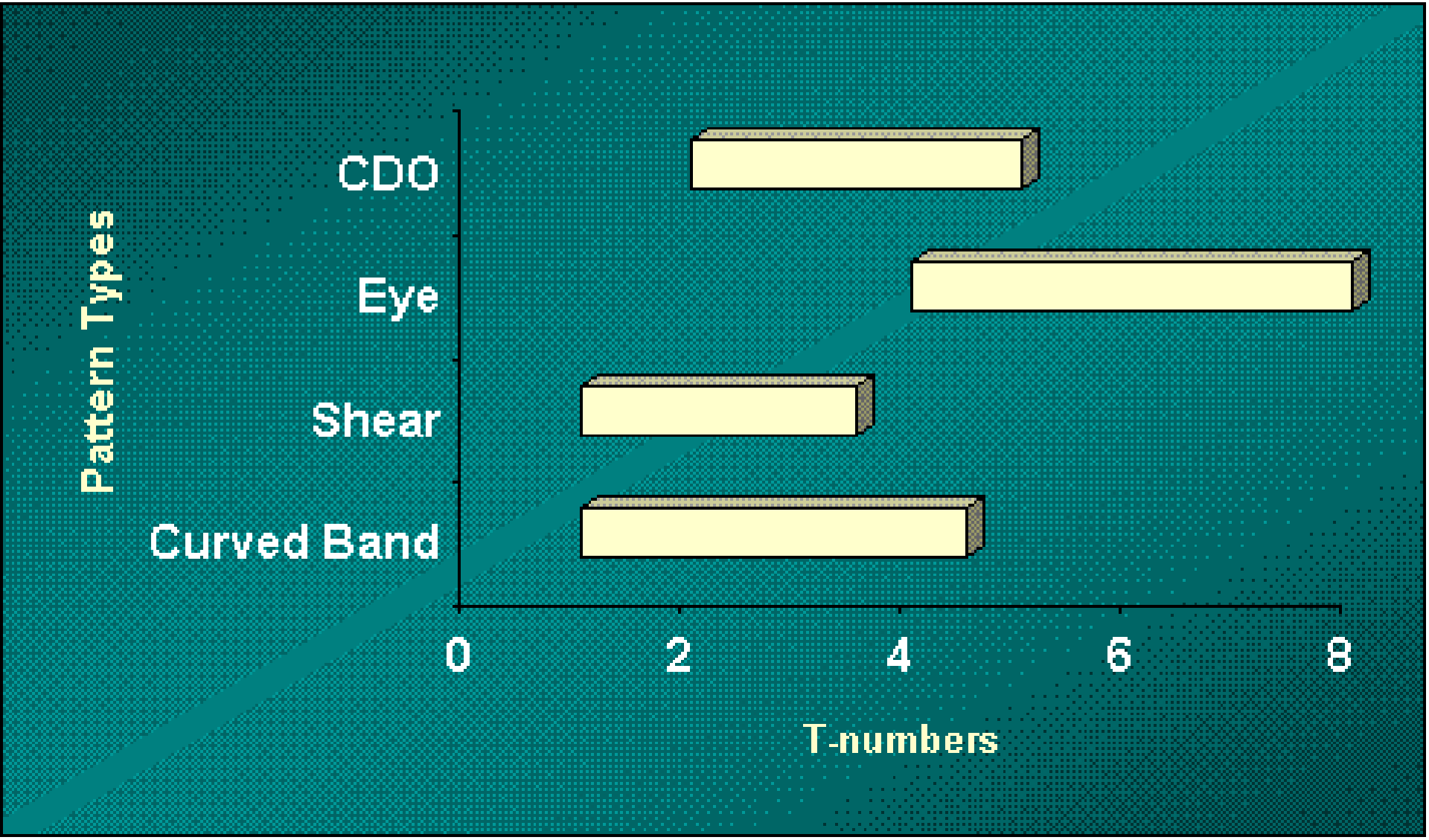
Patterns and intensities

Intensity schematic



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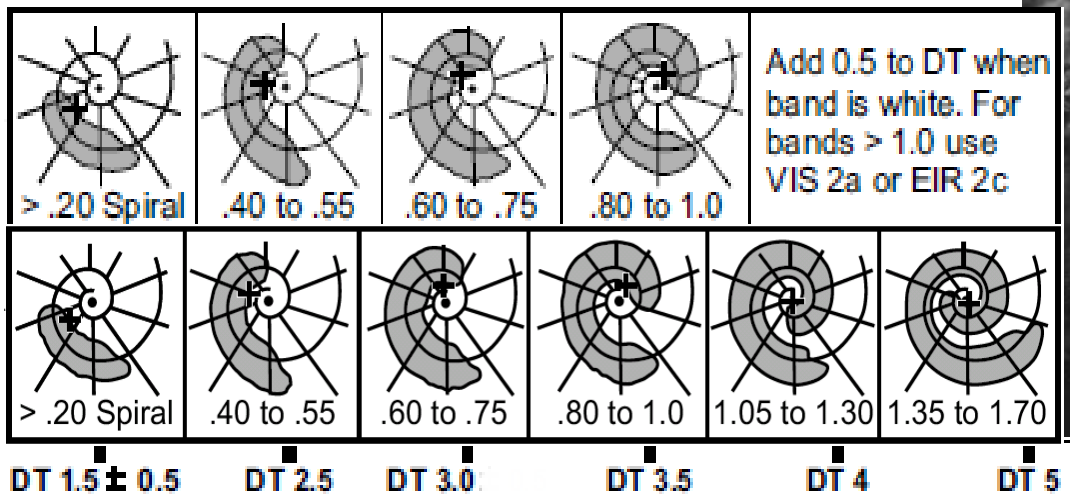
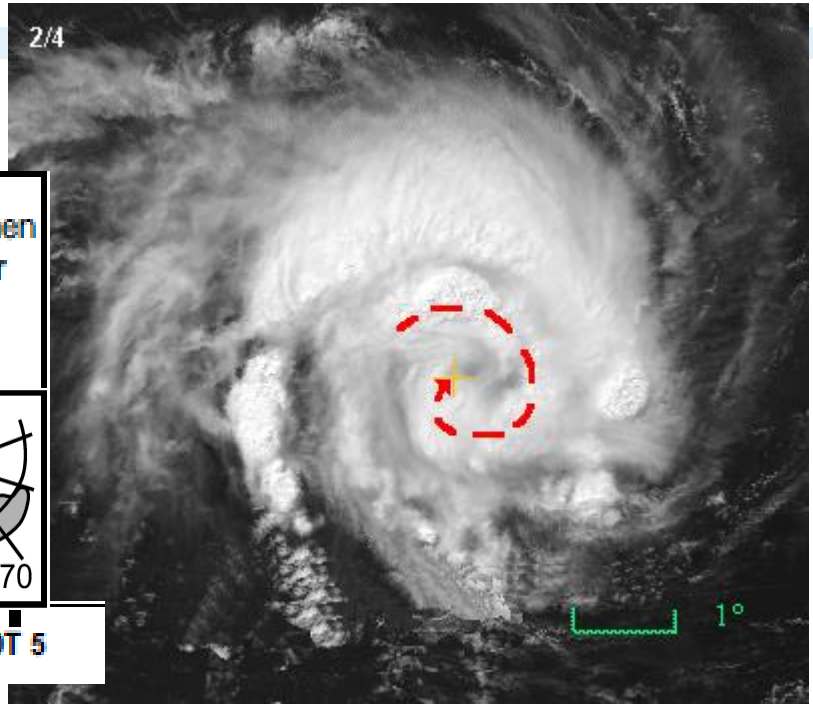
STEP 2A Curved bands





Method: Measure the curvature of the band

Physical principle: the “wrap-aroundness” or tightness of the convective bands indicates the vorticity associated with the system.

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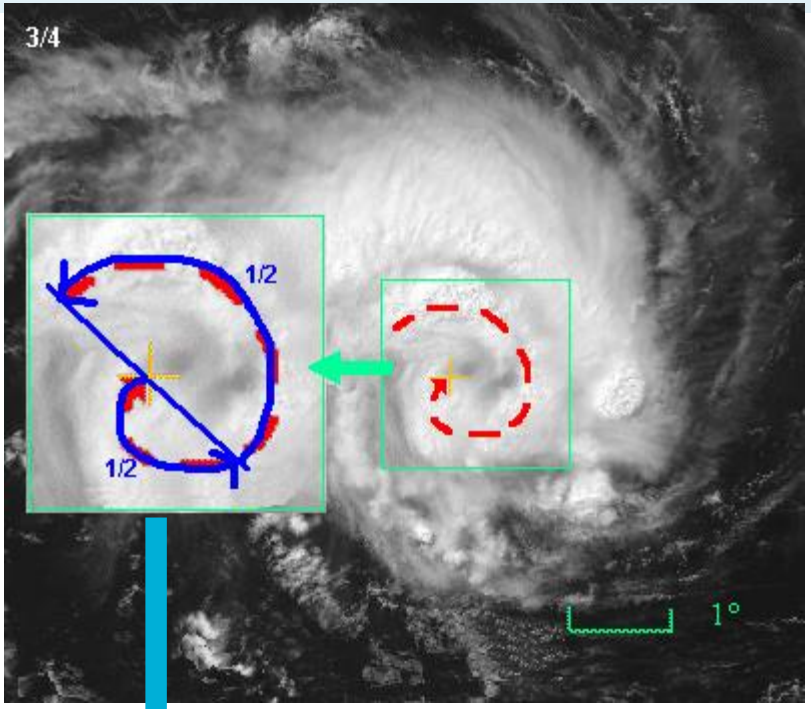
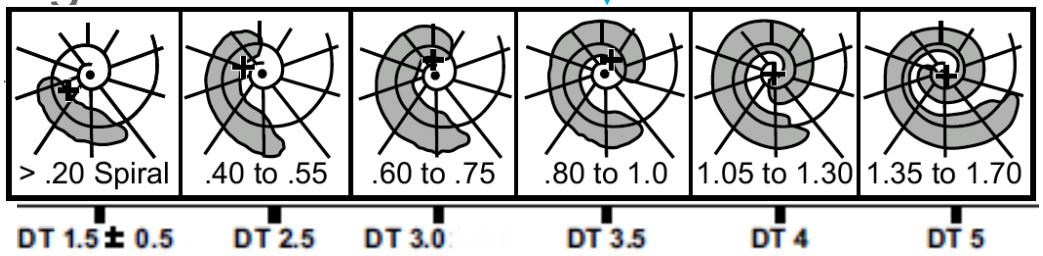
STEP 2A Curved bands

- Define axis of band (subjective):
  parallel the inside edge of band
  tightest inner curvature
  follow convection not cirrus
  small breaks allowed
  vis easier than ir
- Match with Log10 spiral overlay
- Measure the arc length.





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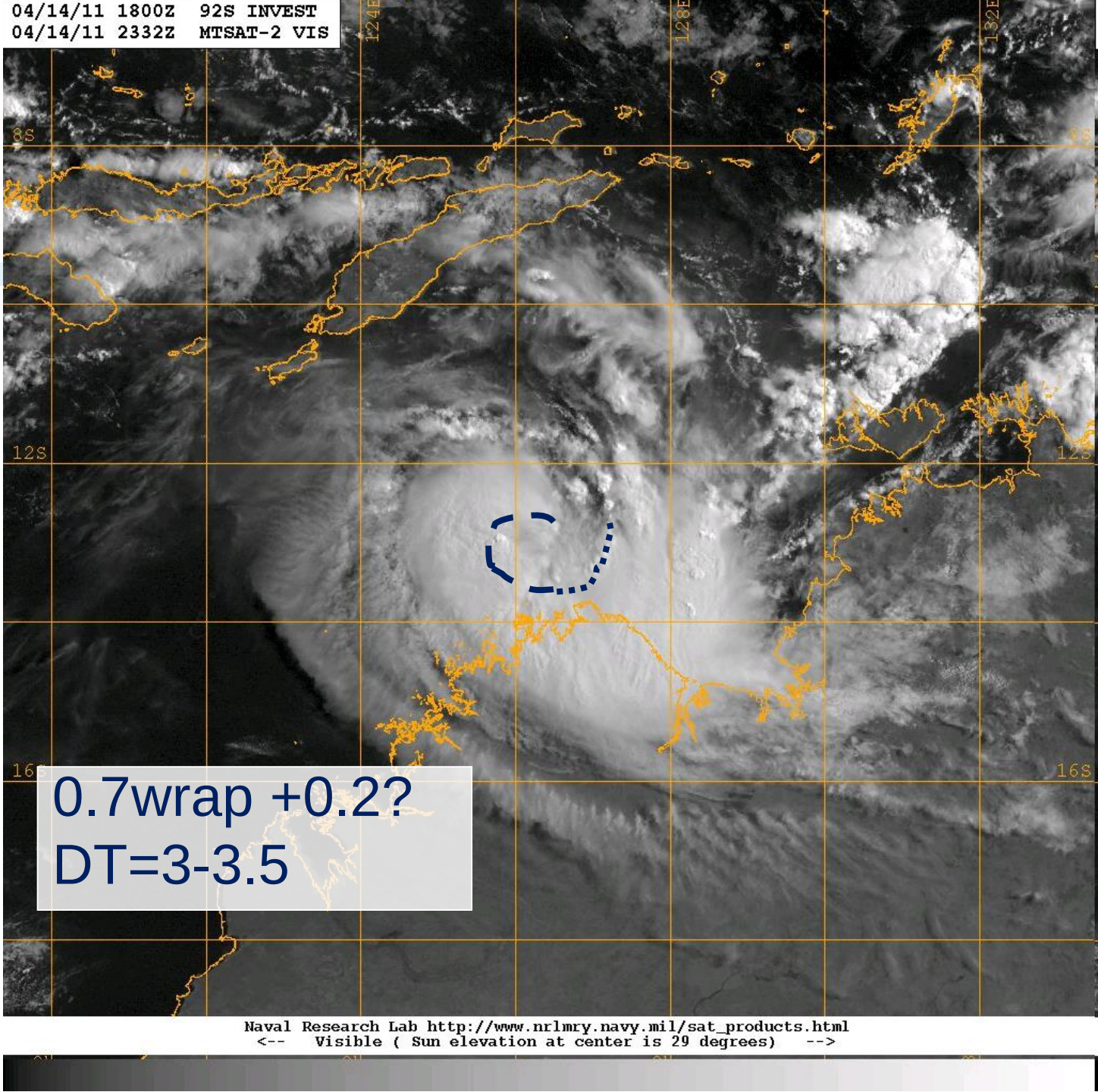
Errol

WARNING:

Southern

Hemisphere



Errol

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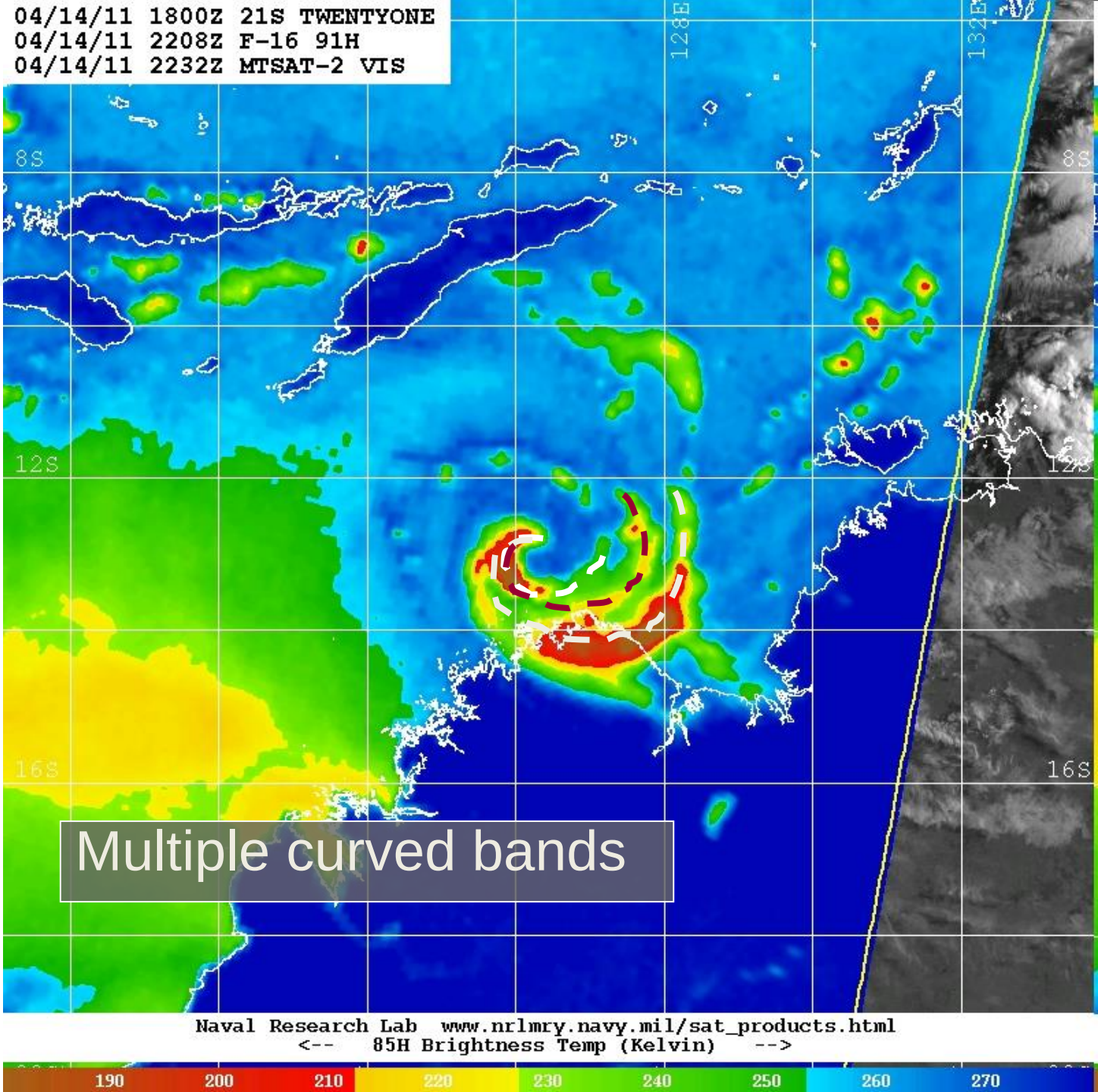

Curved Band pattern: Errol

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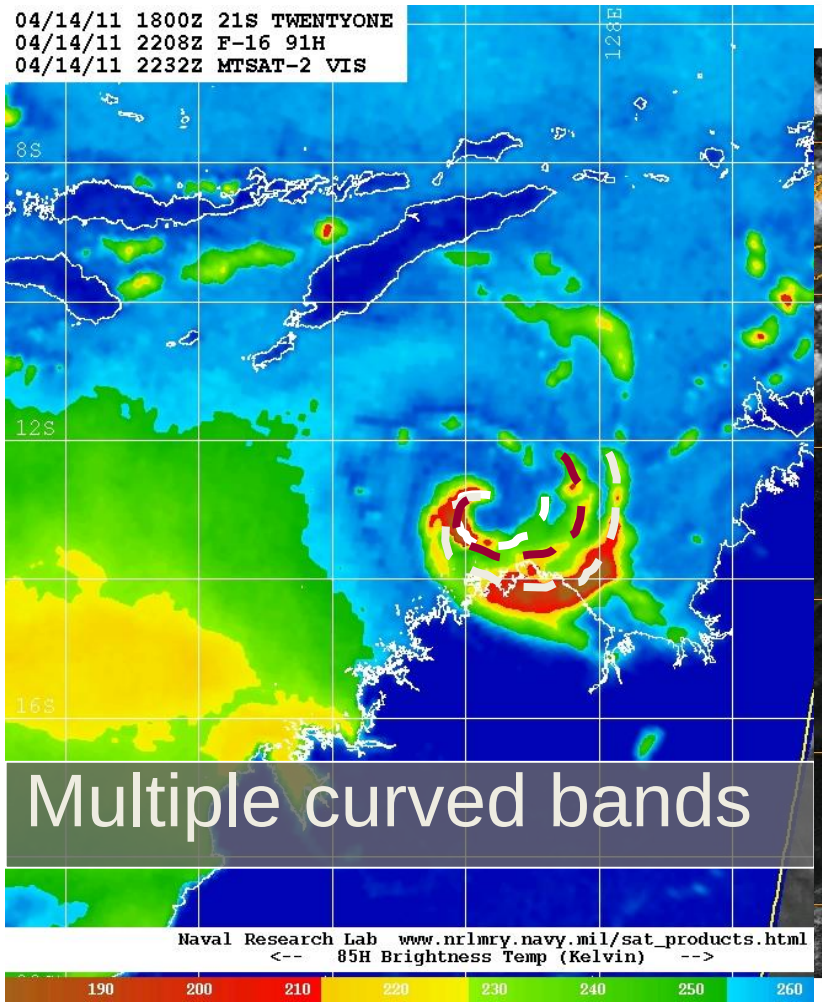

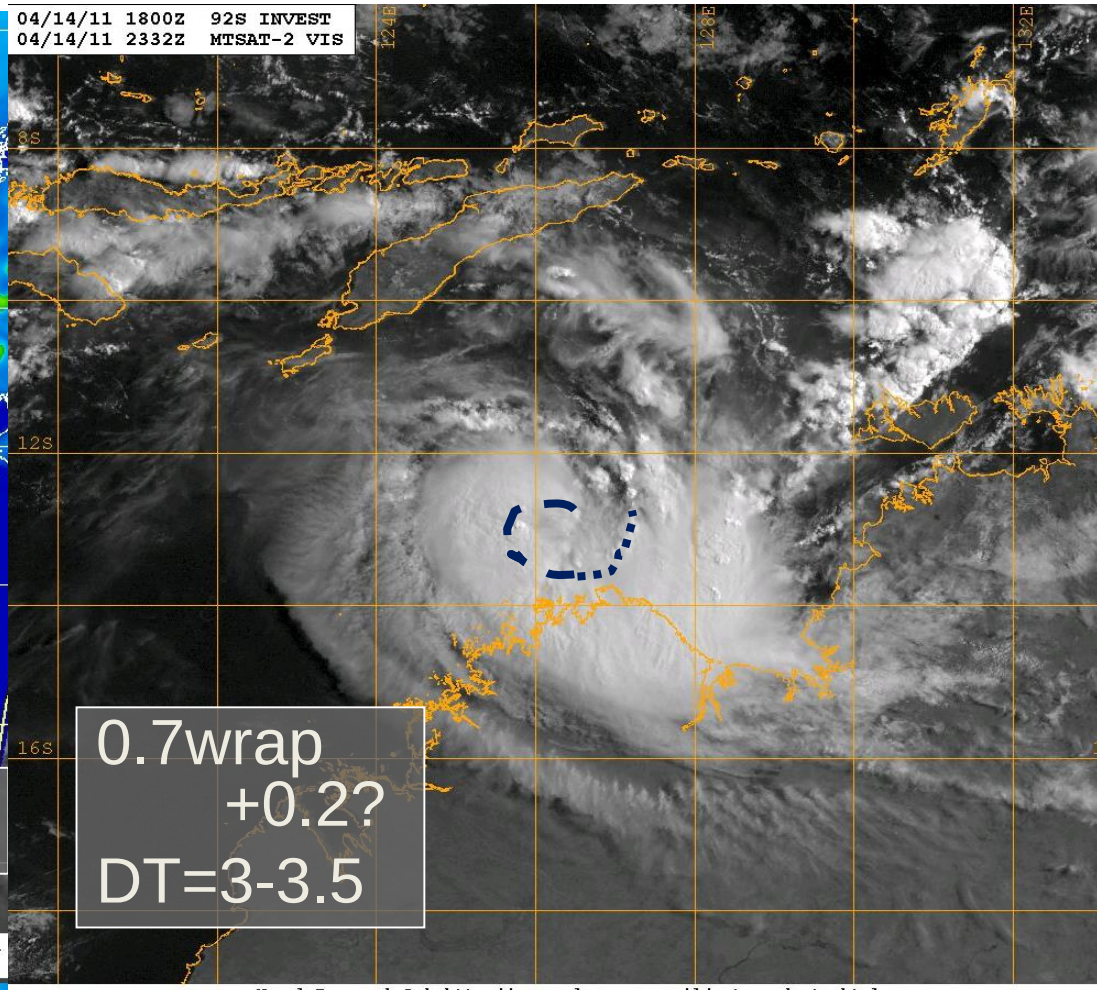

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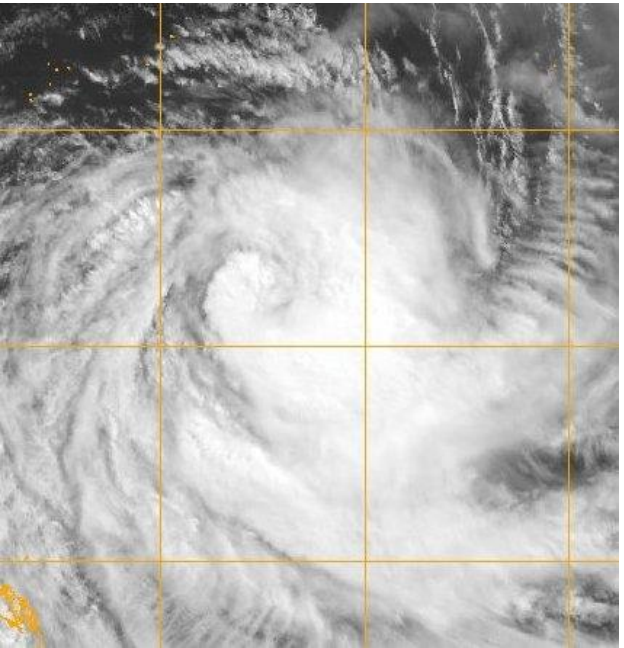
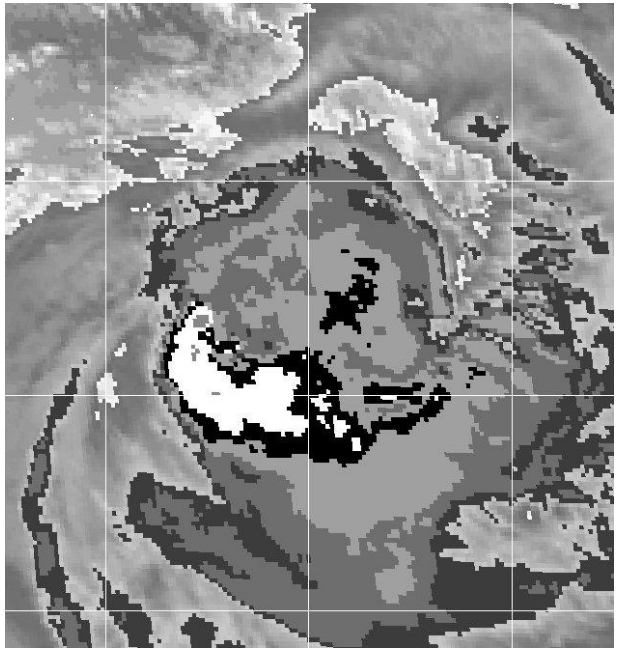
STEP 2A Curved bands

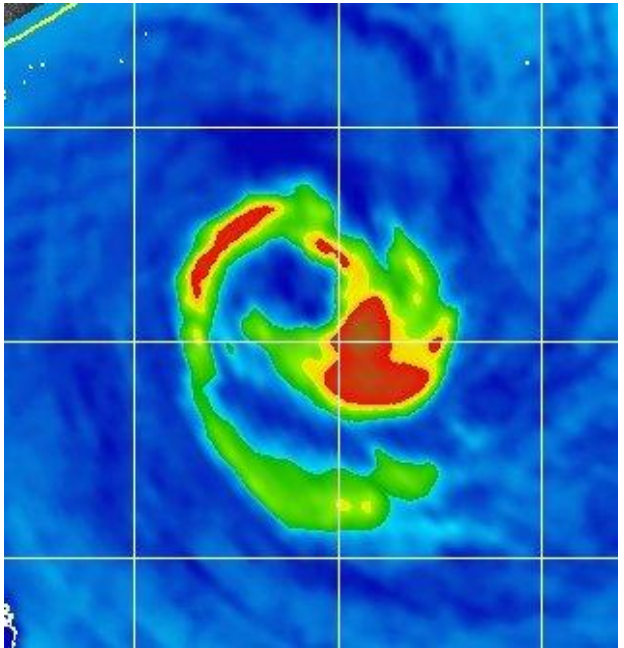
Convection is easiest to visualise in 85-91GHz microwave

But can apply this to improve discerning curvature in Vis

IR is typically more difficult to define curved band (SH example)







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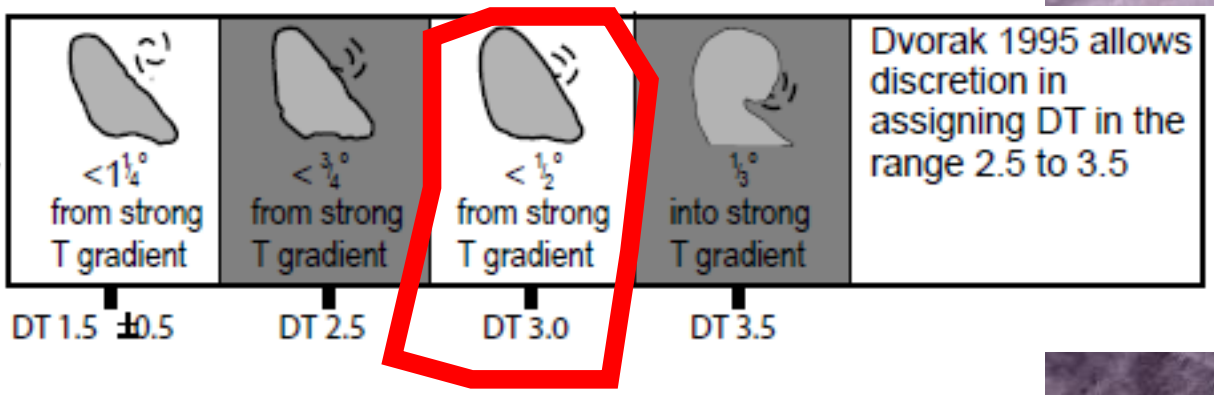
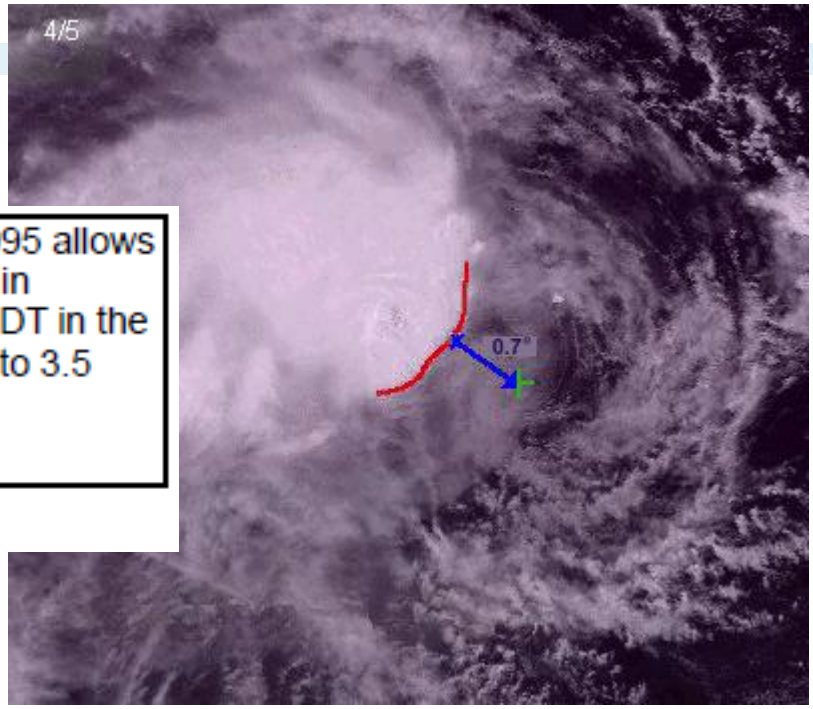
Step 2B Shear pattern





Method: Measure the distance form the low level centre to the edge of the “dense overcast”

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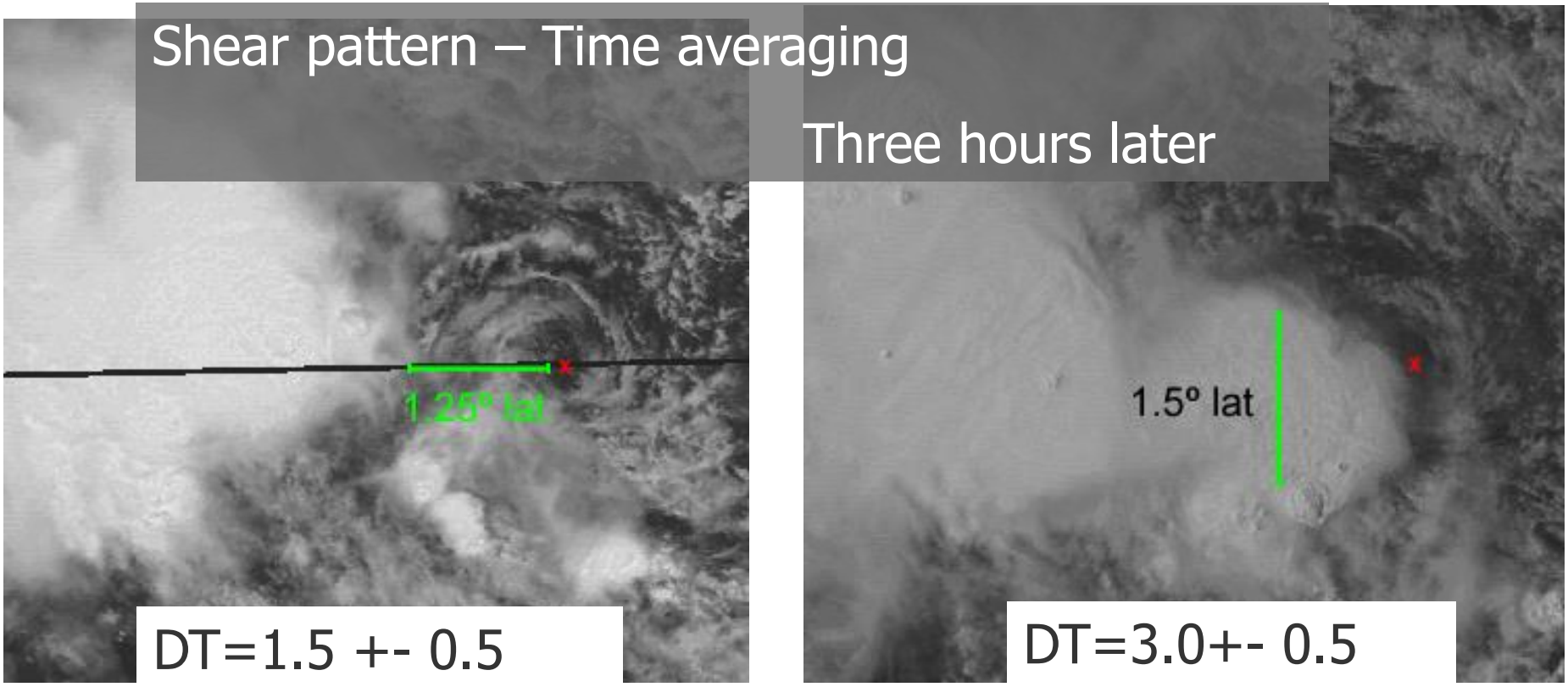
Step 2B Shear pattern

Size of dense overcast>1.5˚

Low level cloud definition (circular)

Distance LLCC to dense overcast or strong T gradient (IR)



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The enhanced IR scale (EIR)

kafj

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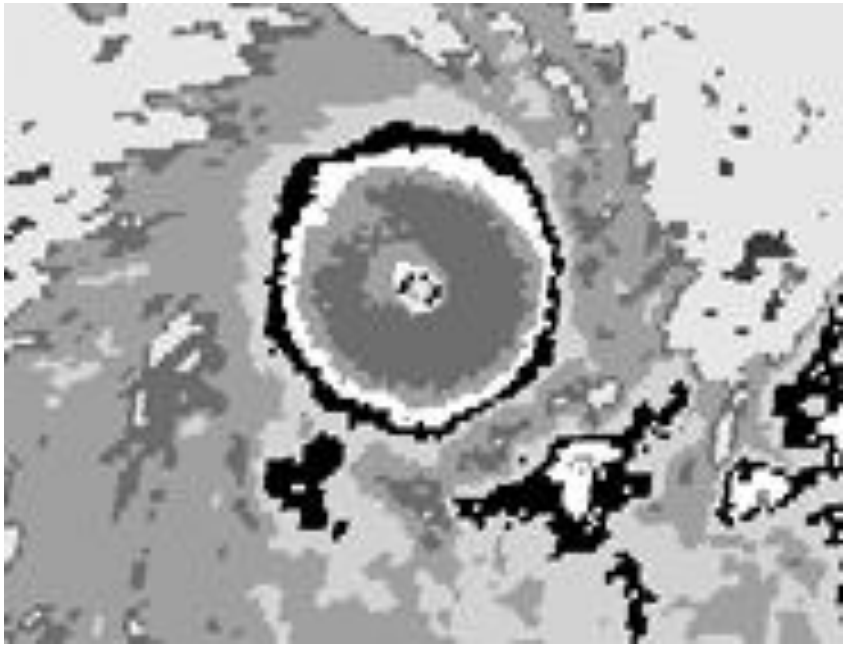
STEP 2C Eye patterns (EIR)

Method: Measure the warmest brightness temperature in the eye and the coldest surrounding temperature in the deep convection.



Physical principle: strength of the thermal contrast between the eye and the surrounding convection indicates strength of the system

STEP 2C Eye patterns (EIR)

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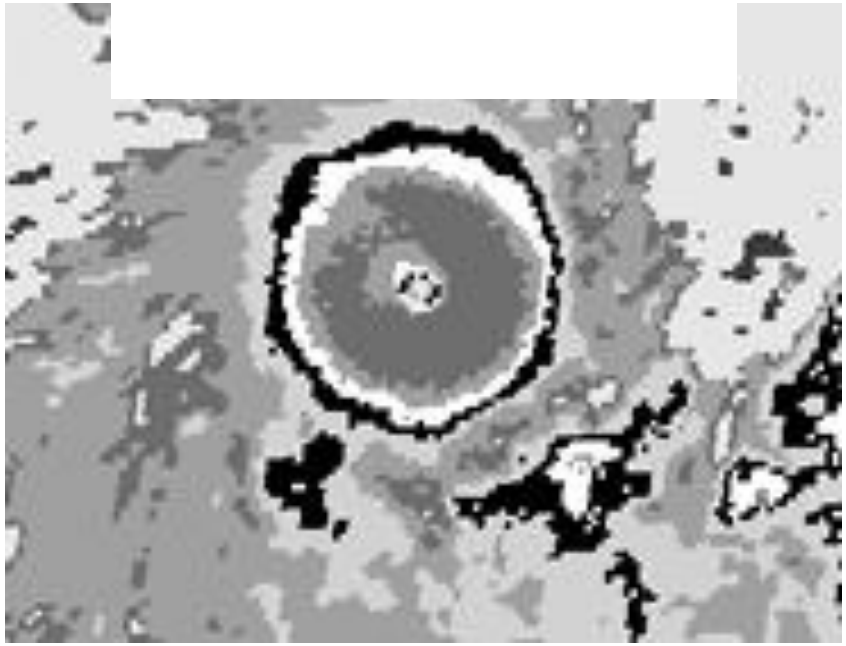
Abbrev-iation	Grey Shade BD Curve	Temperature Range (°C)	Temperature Range (°K)
WMG	Warm Medium Grey	> +9°C	> 282
OW	Off White	+9 to -30°C	243 - 282
DG	Dark Grey	-30 to -41°C	232 - 242
MG	Medium Grey	-42 to -53°C	220 - 231
LG	Light Grey	-54 to -63°C	210 - 219
B	Black	-64 to -69°C	204 - 209
W	White	-70 to -75°C	198 - 203
CMG	Cold Medium Grey	-76 to -80°C	193 - 197
CDG	Cold Dark Grey	⩽ -81°C	⩽192



24h ago was the T number > T2 ?

NO → Step 2a or Step 4

YES

E-no: Eye number

Minimal width	>= 0.5	>= 0.5	>= 0.5	>= 0.4	>= 0.4	>= 0.3	>= 0.3
Surrounding colour	CMG	W	B	LG	MG	DG	OW
E	6.5	6.0	5.5	5.0	4.5	4.5	4.0

E-adj: Eye number adjustment

EYE TEMPERATURE

SURROUND RING TEMP	WMG	OW	DG	MG	LG	B	W
OW	0	-0.5					
DG	0	0	-0.5				
MG	0	0	-0.5	-0.5			
LG	+0.5	0	0	-0.5	-0.5		
B	+1.0	+0.5	0	0	-0.5	-0.5	
W	+1.0	+0.5	+0.5	0	0	-1.0	-1.0
CMG	+1.0	+0.5	+0.5	0	0	-0.5	-1.0

E-no + E-adj = CF

Is CF < MET ?

NO → DT = CF

YES

Addition of the band structure

BF

DT = CF + BF

STEP 2C Eye patterns (EIR)

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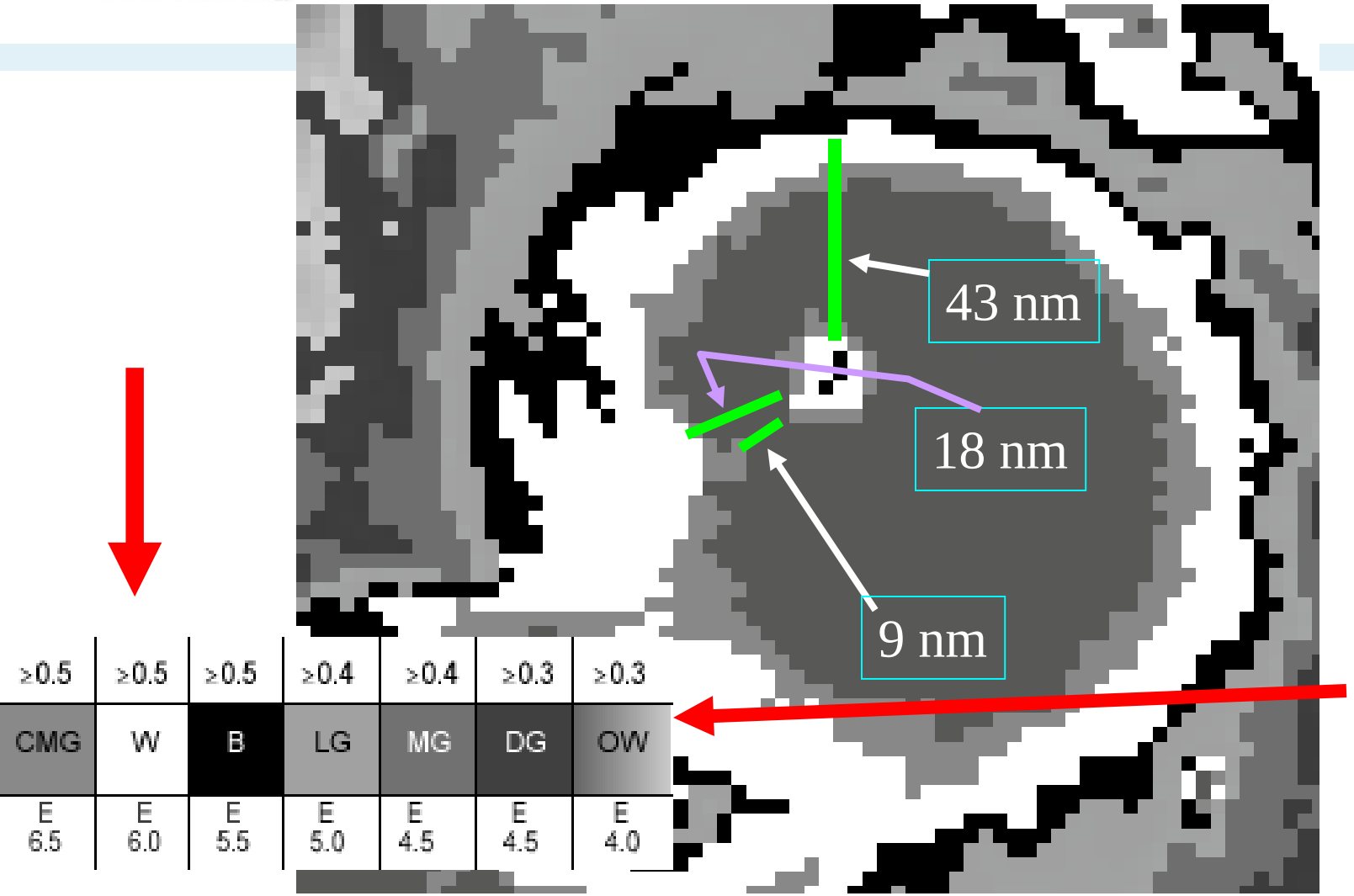

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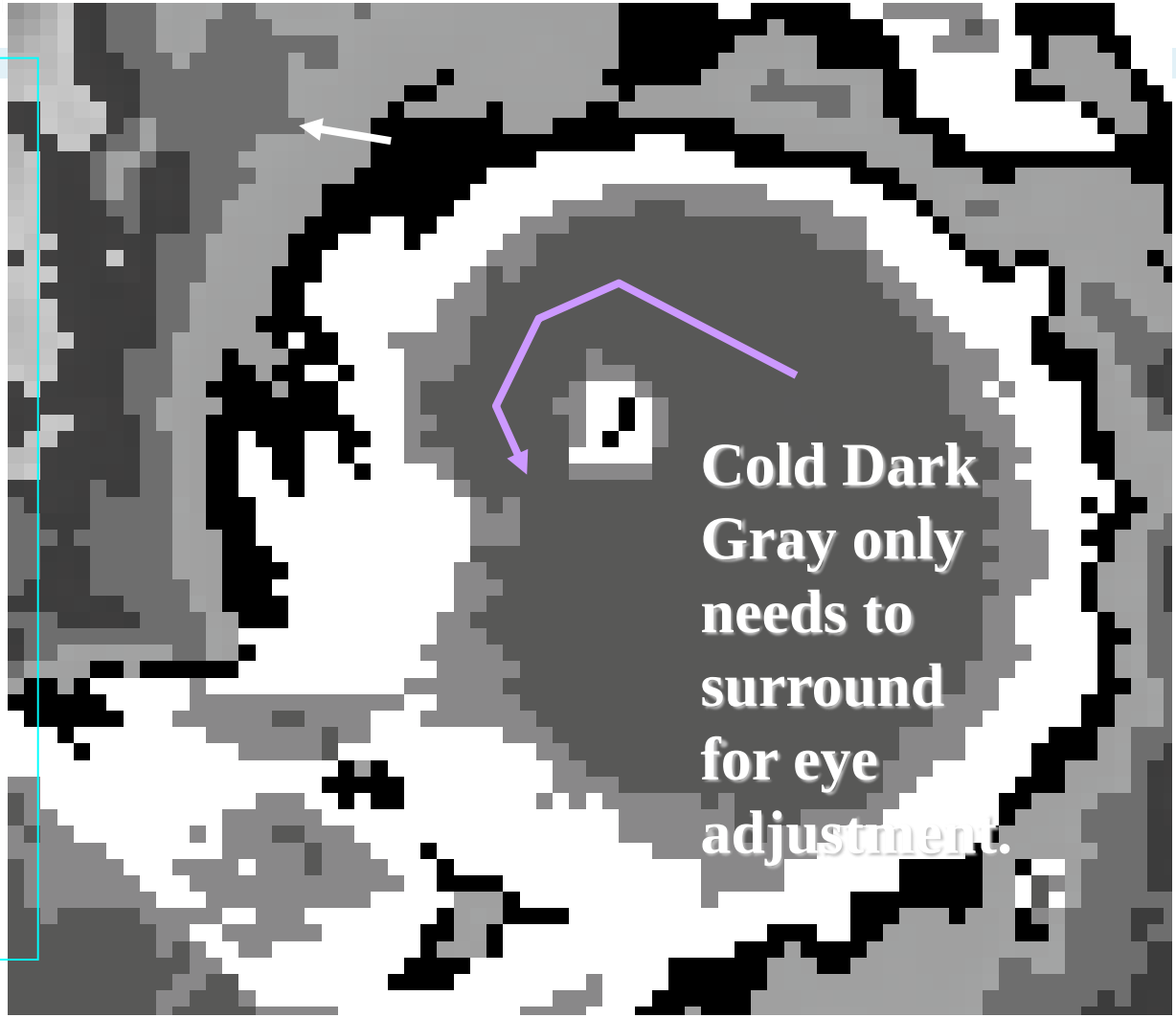
STEP 2C Eye patterns (EIR)

Here, *distance doesn't matter.*
Use the Cold Dark Gray (CDG) for the surrounding ring temp.
Use **Black** for the eye.



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STEP 2C Eye patterns (EIR)

EYE TEMPERATURE

SURROUND RING TEMP	WMG	OW	DG	MG	LG	B	W
OW	0	-0.5					
DG	0	0	-0.5				
MG	0	0	-0.5	-0.5			
LG	+0.5	0	0	-0.5	-0.5		
B	+1.0	+0.5	0	0	-0.5	-0.5	
W	+1.0	+0.5	+0.5	0	0	-1.0	-1.0
CMG	+1.0	+0.5	+0.5	0	0	-0.5	-1.0

So, for a **Black** eye and **CMG** surround ring temperature, the eye adjustment is **-0.5**

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STEP 2C Eye patterns (EIR)

E# = **6.0**

Eye adj= **-0.5**

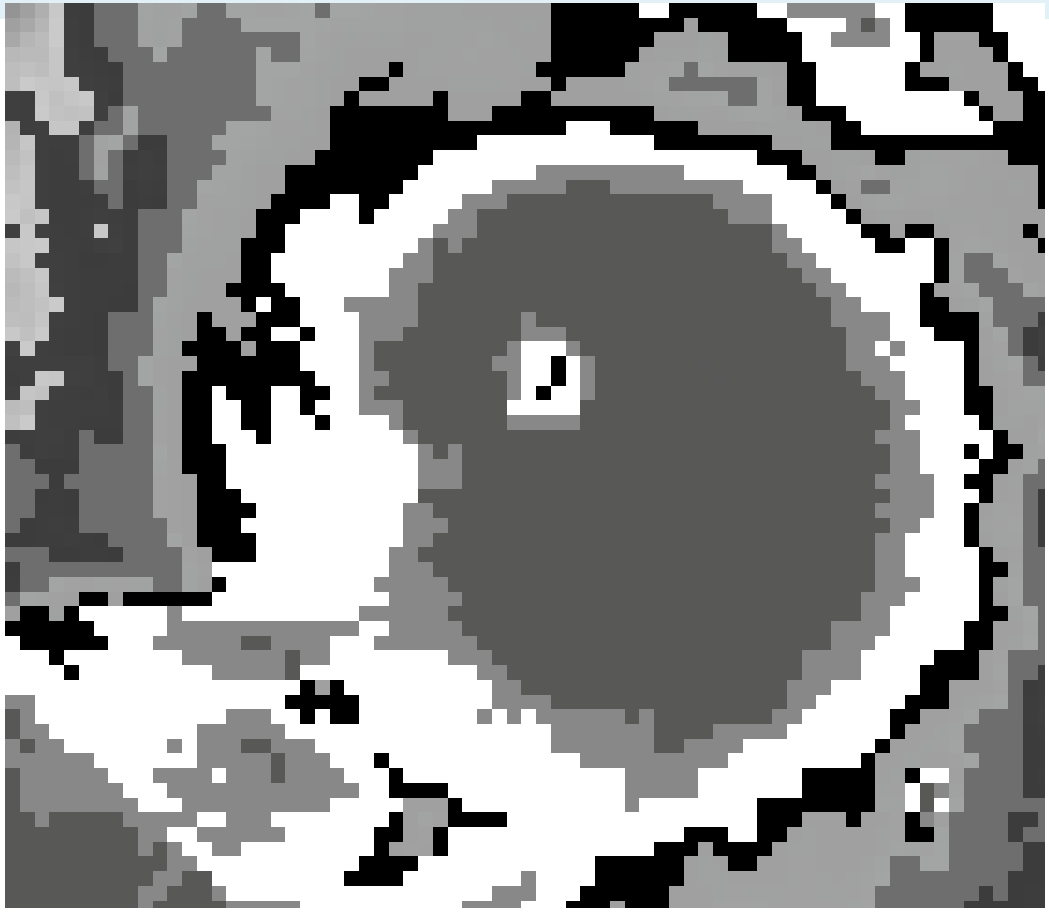
(don't forget minus!)

CENTRAL FEATURE (CF):

CF = E# + Eye adj

Here,

CF=6.0 +(-0.5)=**5.5**



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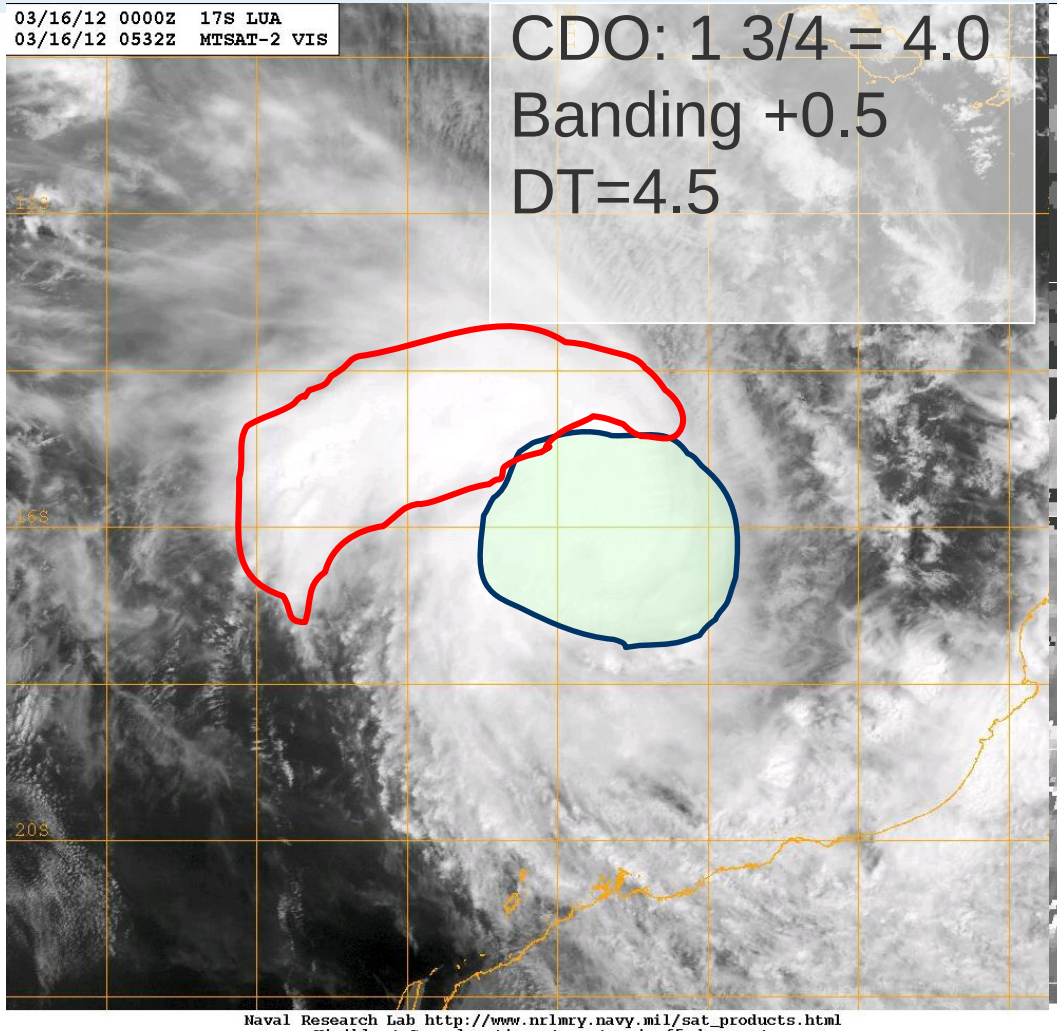
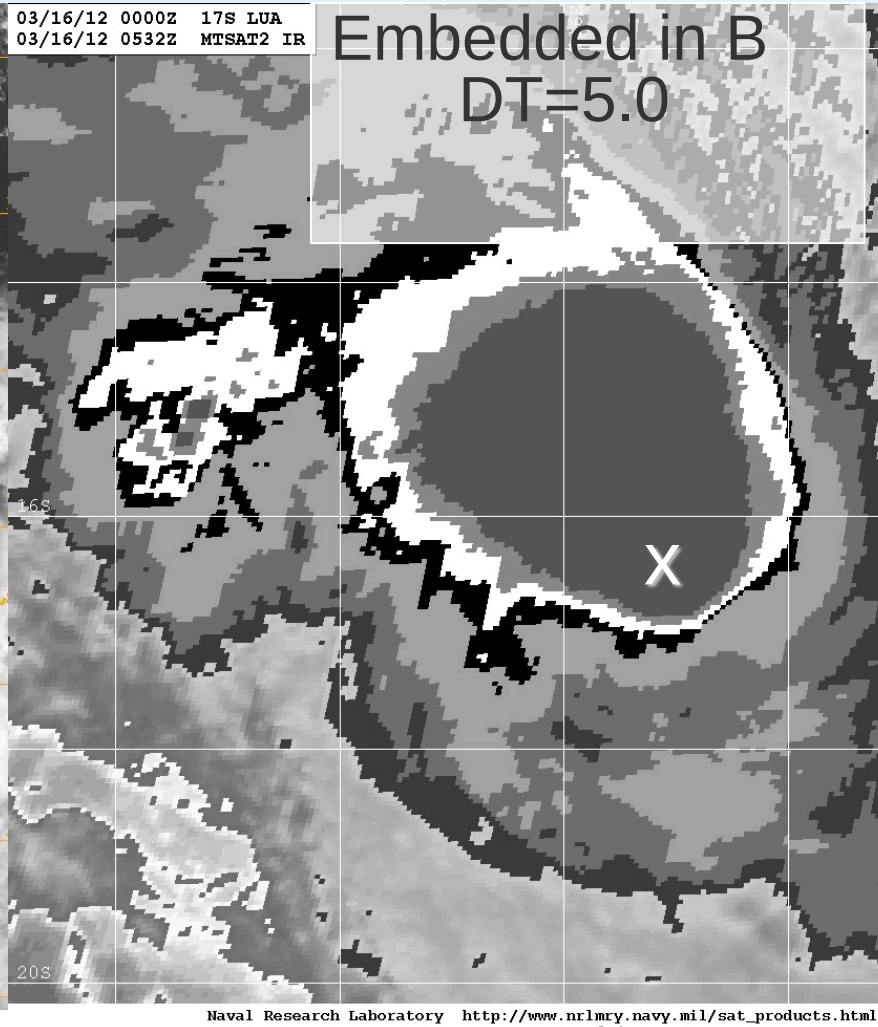
STEP 2C Covered Centre patterns





Review: What patterns are these?

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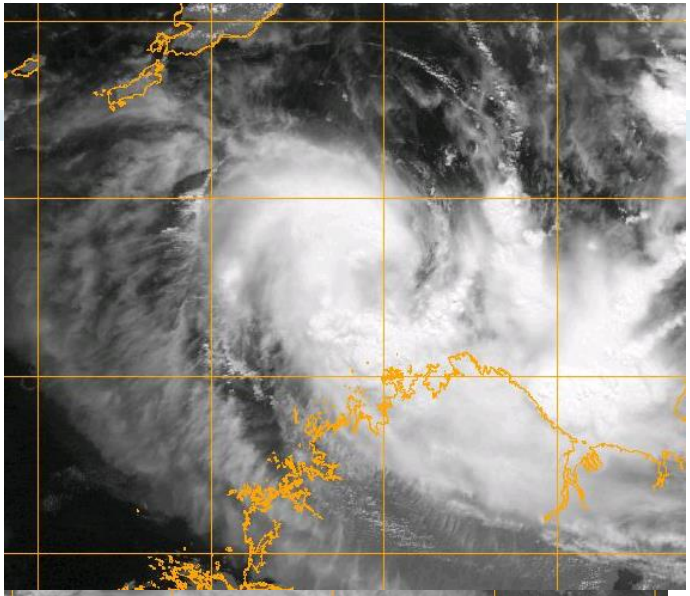

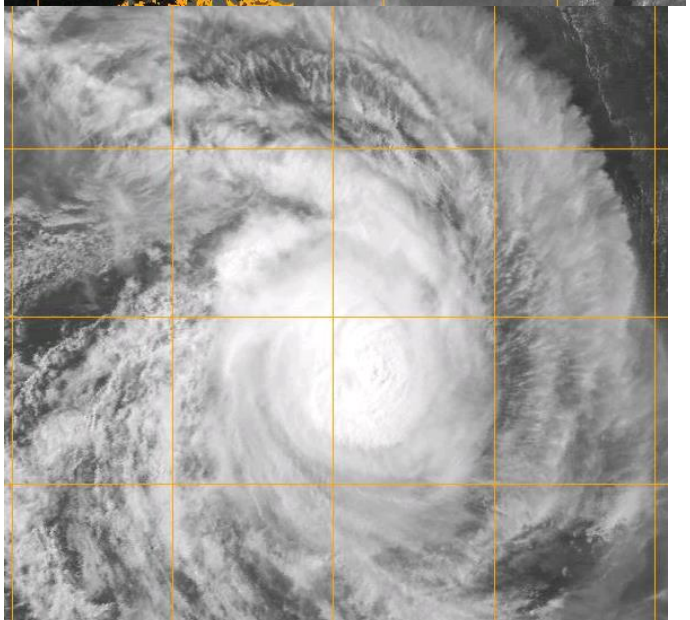

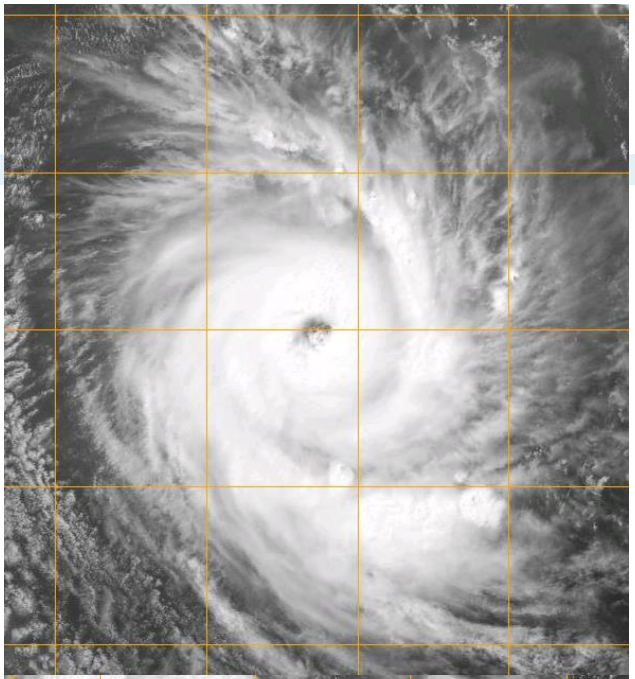

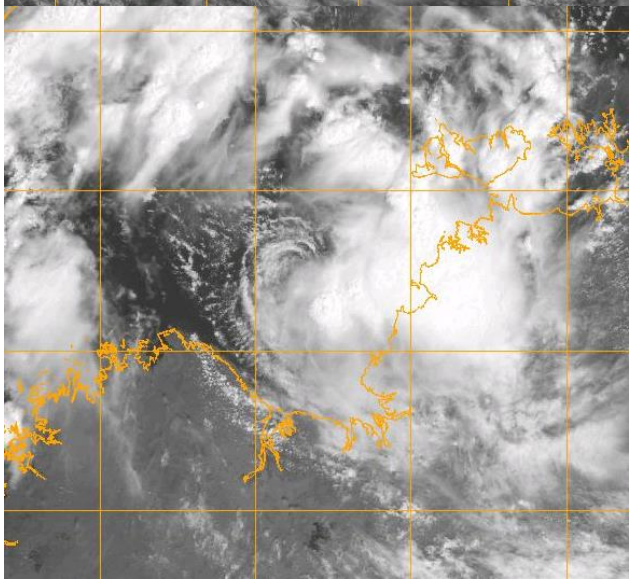

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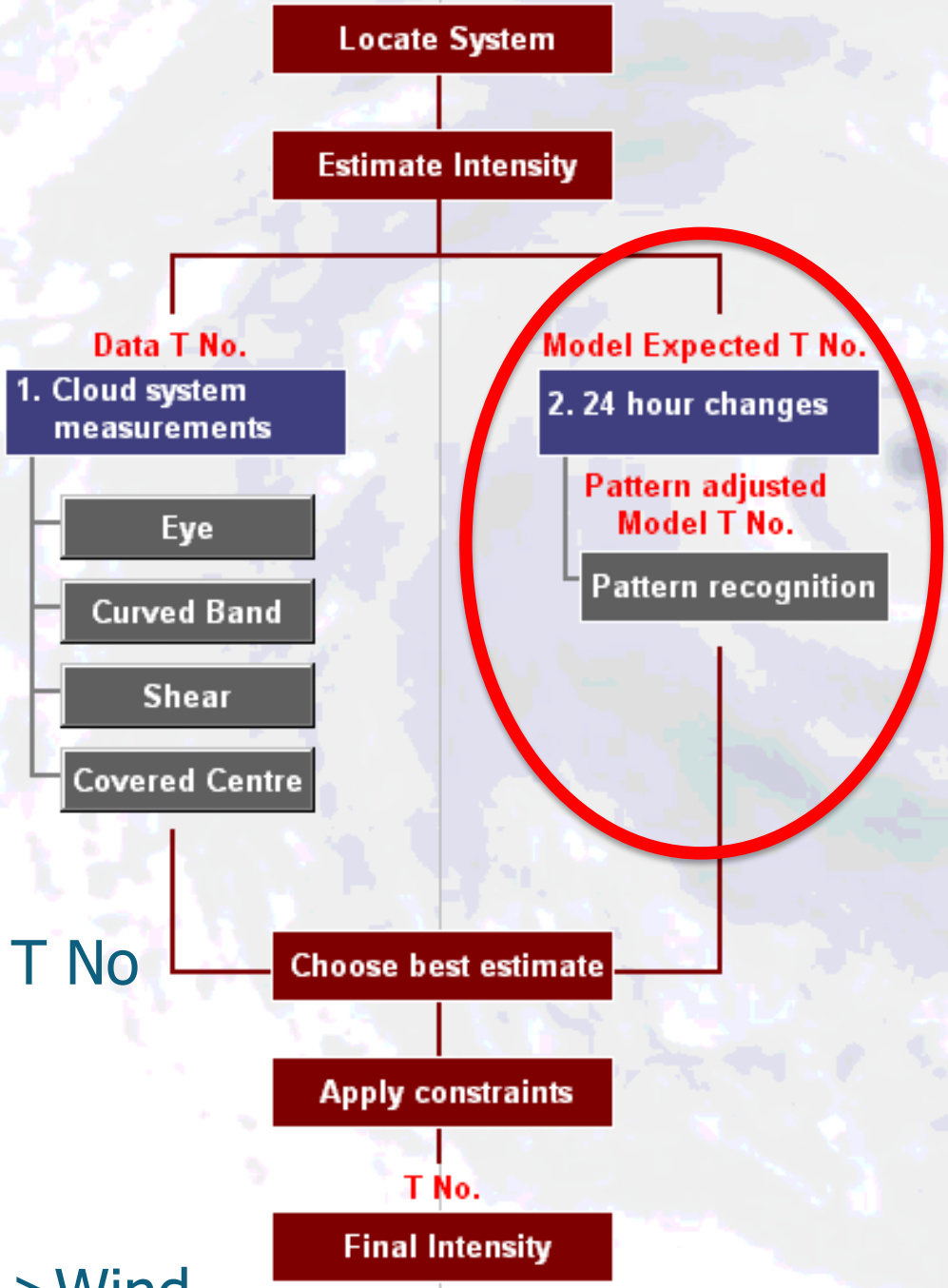

DT = Data T Number

MET = Model Expected T No

PT = Pattern T No

FT = Final T No

CI = Current Intensity>>Wind

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STEPS 4-5 MET 24-hour change

- Compare current image to image 24 hours ago.
- Are cloud features better defined, same or worse.
  - If better, the trend is Developed (D)
  - If the same, the trend is Same (S)
  - If worse, the trend is Weakened (W)

STEP 5 MET = Model Expected T number

Adjust FT
- - Slow (± .5)
- Normal (± 1.0)
- \+ Rapid (± 1.5)

- Assumes you are routinely doing Dvorak intensity estimates - can't do a ***"one-timer"***!

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The Dvorak 'model'
24h Trend

Developing	Weakening	Steady
Increasing convection or colder cloud tops near centre	Decreased convection or warmer cloud tops near centre	No noticeable 24h change
Increased curved banding	Decreased curve banding	Mixed - developing & weakening signs
Eye forms or becomes more distinct or warmer	Eye disappears or becomes less distinct or cooler	
Increased curvature of low clouds near centre	Decreased curvature of low clouds near centre	
Exposed centre closer to convection	Exposed centre further from convection or covered centre becomes exposed	

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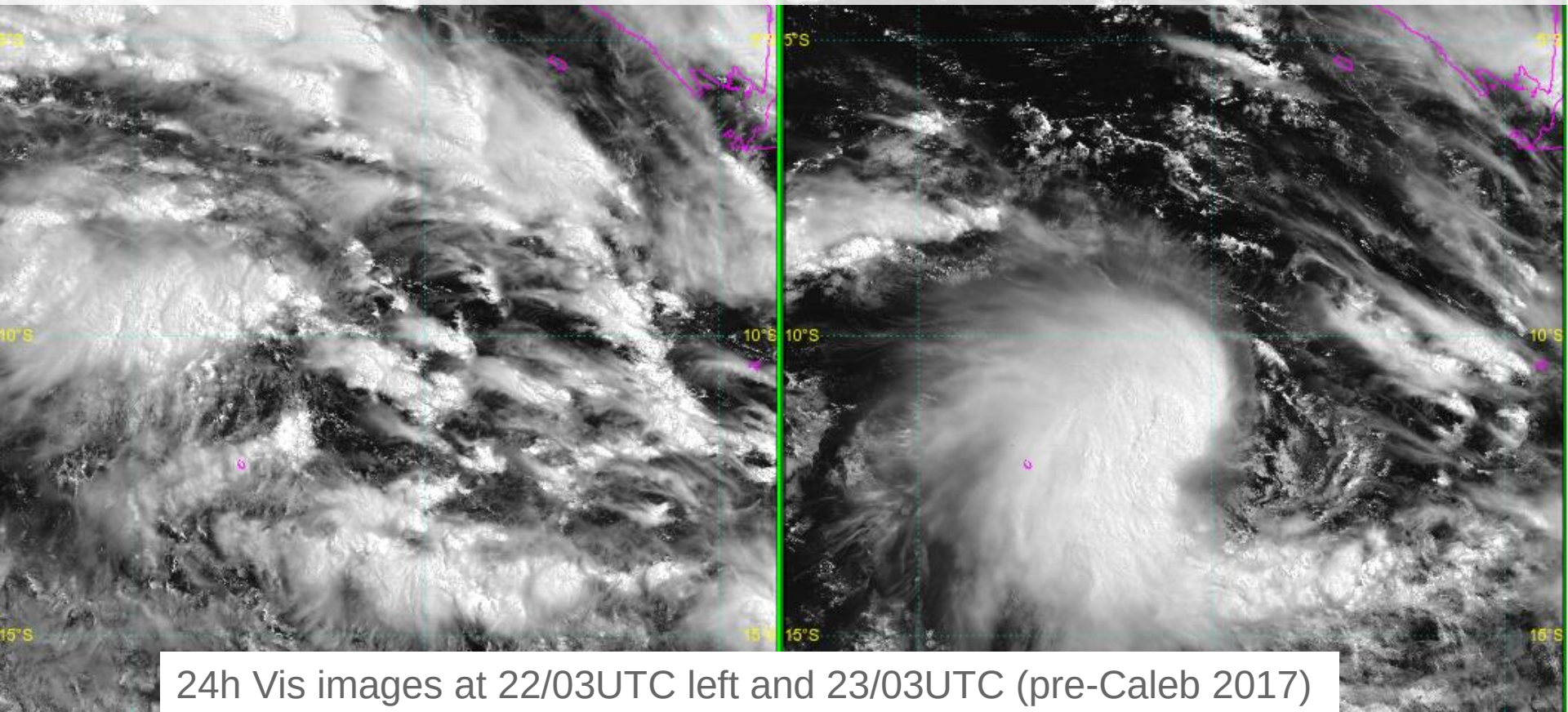
The Dvorak 'model'
24h comparison
Developing/Steady/Weakening
Rapid '+' Vs slight '-'

Considerations: increase and organisation of convection banding, cloud top temps; eye; centre near convection



24h Vis images at 22/03UTC left and 23/03UTC (pre-Caleb 2017)

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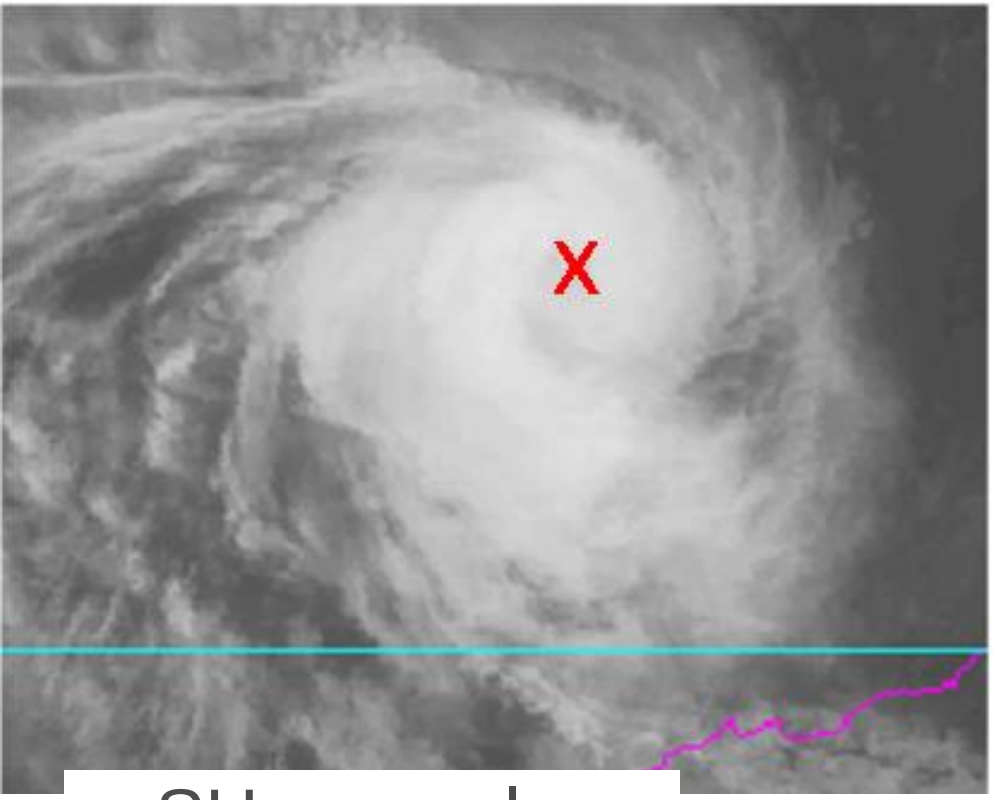
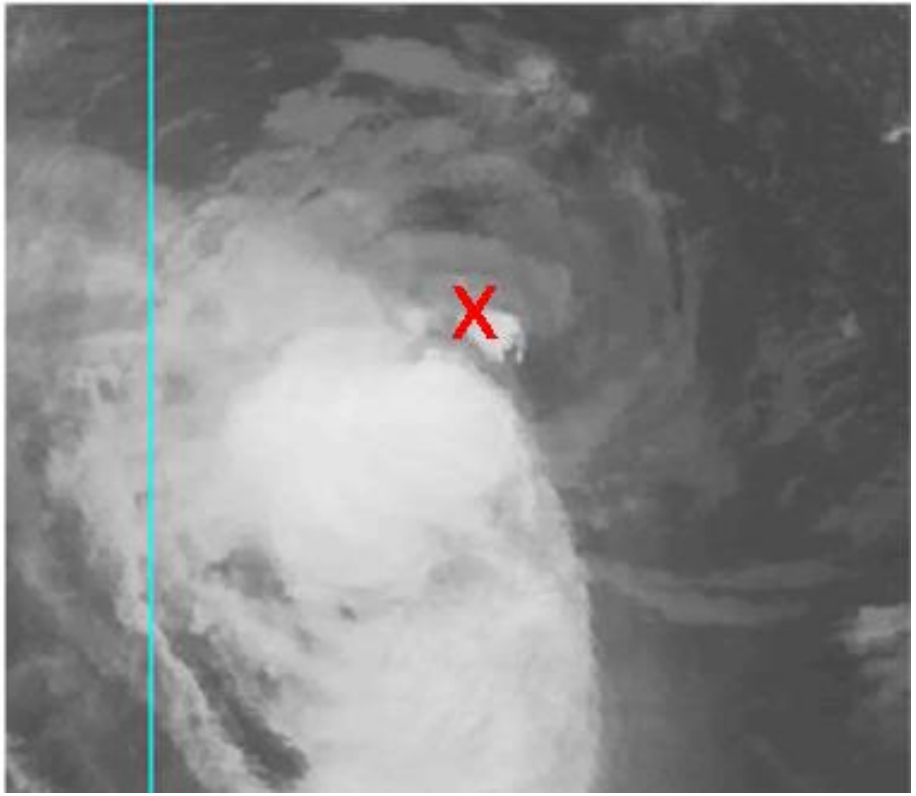
Step 6 Pattern T no. or Adjusted MET

24h changes what is the trend for these D/S/W +/- ?

Yesterday **Current**





SH example

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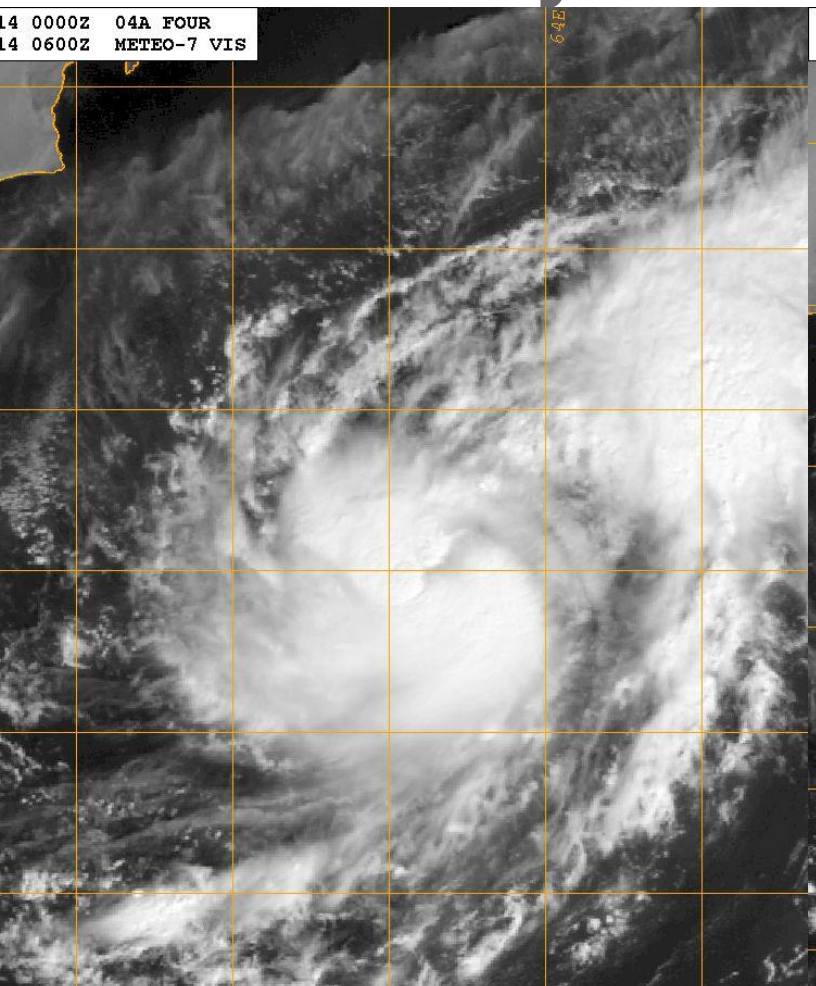
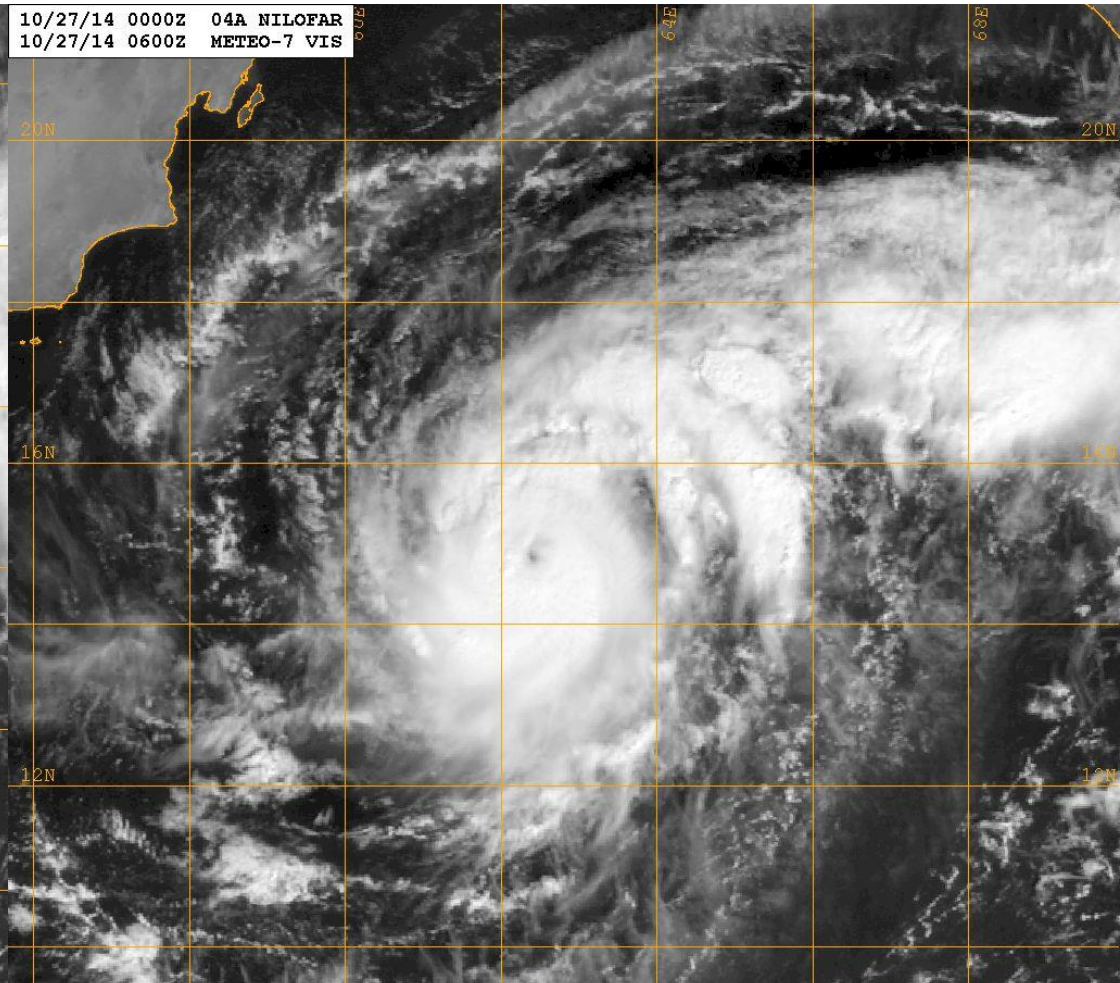
Step 6 Pattern T no. or Adjusted MET

24h changes what is the trend for these D/S/W +/- ?

Yesterday



Current (Nilofar)



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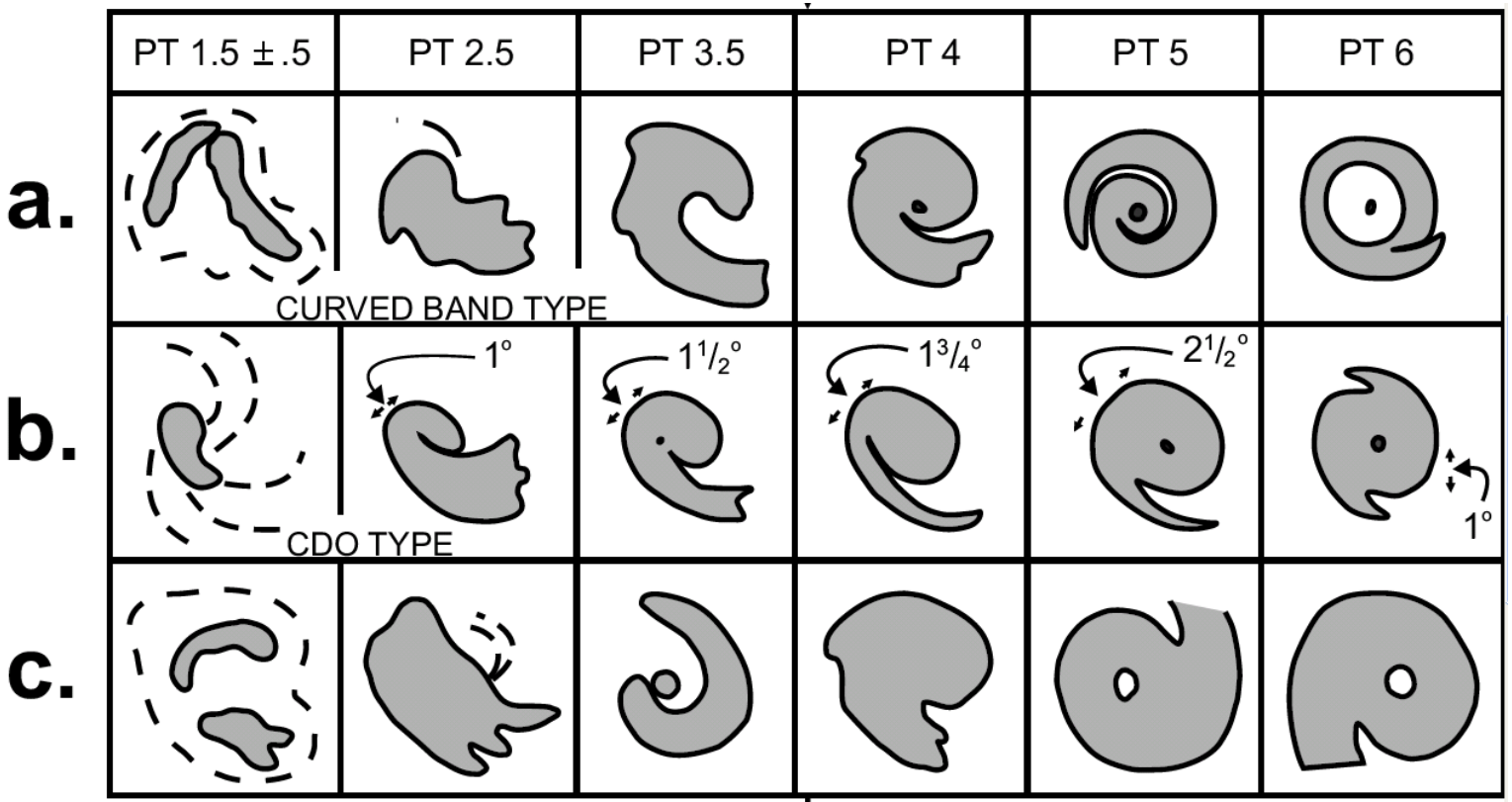
Step 6 Pattern T no. or Adjusted MET

Select the pattern in the diagram that best matches your storm picture – within one column of the MET (adjust MET by no more than 0.5 **SUBJECTIVE**



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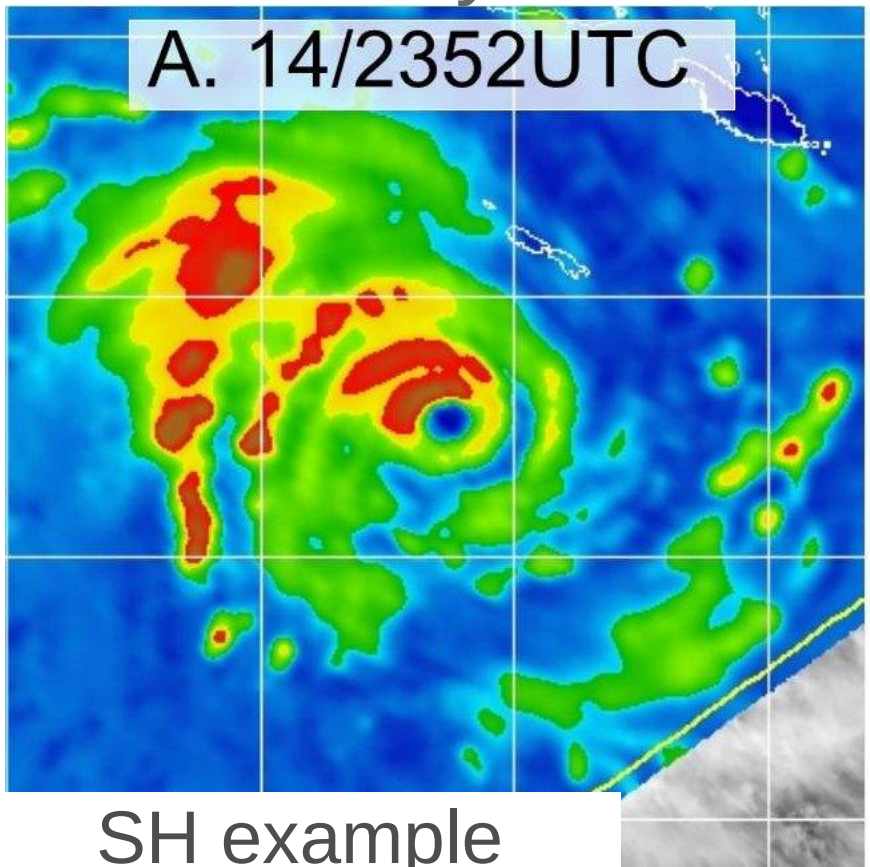
Step 6 Pattern T no. or Adjusted MET

Can we use microwave to help?

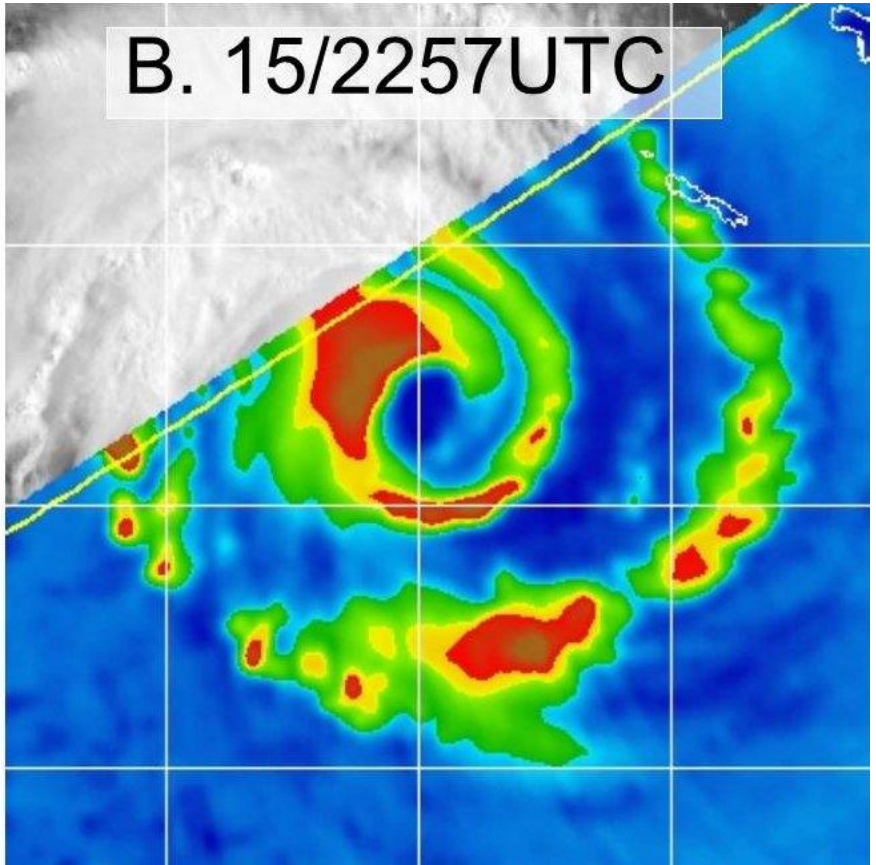
24h changes what is the trend for these D/S/W +/- ?

Yesterday



SH example

Current



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Steps 7 -10

STEP 7 Choosing the best estimate – the Final T-no

More objective →

- Use DT when cloud features are “clear cut”
- Otherwise use MET (possibly adjusted by “Pattern T-no)

And then...STEP 8 Constraints RULES, RULES, RULES

STEP 9 The Current Intensity - Maximum Wind

STEP 10 Forecast Intensity (FI)

Coding FT/CI/Trend/Period eg T3.0/4.0/W1.5 24HRS

Filling Out The Worksheet

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Australia uses xls version

		Step 1			Step 2A, 2B		Step 2C - EYE			Step 2D	Step 2E	DT Computation			AVG	Step 3	Step 4	Step 5	Step 6	Steps 7,8	Step 9	Step 10	Step 11	
Date	Time UTC	Position Lat. (S)	Lon. (E)	IR/VIS	Curved band CB Help	Shear Patt Shear Help	Embdd. Dist.	Surr. Temp	Eno+Eadj=CF Eno	Eadj	CDO Size (CF)	Embdd Cntr. Temp. (CF)	CF + BF = DT CF	BF	DT	DT 3 hours	CCC Use	Trend 24 hr	MET	PAT	FT Use Rules	CI	FI Number		Re
	0430			IR				B	5.5	0*					5.5										*DG/W would give +0.5 but considered elon
19/02/15	0530	20.5	150.9	IR				B	5.5	0.5	OW/W				6.0	5.5		D+	4.5	5.0	5.0	5.0		JC	Clear eye but constrained for development T
				Vis			0.8		5.0						5.0										
	0830			IR				W	6.0	0.5	OW/W				6.5										
	0930			IR				LG	5.0	0.5	OW/W				5.5										
	1030			IR				LG+	5.0	0.5-1	OW-CMG/W-CMG				5.5-6										
	1130	20.8	150.5	IR				B	5.5	0.5	OW/W				6.0	6.0		D+	5.0	5.5	6.0	6.0		JC	DT 3h ave could be 5.5-6 but biased to 6 giv
	1230			IR				W	6.0	0.5	OW/W				6.5										just white surround
	1330			IR				W	6.0	1.0	CMG/W				7.0										
	1430			IR				B	5.5	1.0	CMG/W				6.5										
	1530			IR				B	5.5	1.0	CMG/W				6.5										Black surround, as white is marginally less
	1630			IR				B	5.5	1.0					6.5										
	1730	21.7	150.7	IR				B	5.5	1.0					6.5	6.5		D+	5.0	5.5	6.5	6.5		JC	consistent eye adjustment of 1 to keep DT a
	1830			IR				B	5.5	1.0	CMG/B		6.5		6.5	6.5									
	1930			IR				LG	5.0	1.0	(CMG/W)		6.0		6.0	6.3									
	2030	22.1	150.7	IR				LG	5.0	1.0	CMG/B		6.0		6.0	6.2		D+	5.0	5.5	6.0	6.5		JC	black surround now under 30nm width on e
	2130			IR				LG	5.0	1.0	CMG/B		6.0		6.0	6.0									Black surround continues to shrink
	2230			IR				LG	5.0	0.5	OW/B		5.5		5.5	5.8									
	2330	22.7	150.7	IR				LG	5.0	0.5	OW/B		5.5		5.5	5.7		D+	5.0	5.5	5.5	6.0		JC	Core of storm now entirely over land, so win
20/02/15	0030			IR				LG	5.0	0.0	DG/B		5.0		5.0	5.3									

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CI to wind (to pressure)

Last step to convert to wind

CI	10 min mean winds		Gusts		Severity Category	Comments
	km/h	knots	km/h	knots		
1.0	35	20	80	45	Tropical Low	
1.5	45	25	80	45		
2.0	45	25	80	45		
2.5	55	30	80	45		
3.0	65	35	90	50	Category 1	**Damaging** gusts 90-124km/h **Gale force** mean 34-47 knots
3.0	75	40	100	55		
3.0	85	45	120	65		
3.5	95	50	130	70	Category 2	**Destructive** gusts 125-164km/h **Storm force** mean 48-63 knots
4.0	100	55	140	75		
4.0	110	60	155	85		
4.5	120	65	170	90	Category 3	Gusts 165-224 km/h Mean 64-85 knots **Very Destructive** gusts >164km/h **Hurricane force** mean > 63 knots
4.5	130	70	185	100		
4.5	140	75	195	105		
5.0	150	80	205	110		
5.0	155	85	220	120		
5.5	165	90	230	125	Category 4	Gusts 225-279 km/h Mean 86-107 knots
5.5	175	95	250	135		
6.0	185	100	260	140		
6.0	195	105	275	150		
6.5	205	110	285	155	Category 5	Gusts >279 km/h Mean ≥108 knots
6.5	215	115	295	160		
7.0	220	120	315	170		
7.0	230	125	325	175		
7.5	240	130	345	185		
7.5	250	135	350	190		
7.5	270	145	380	205		
8.0	280	150	390	210		

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Questions

True or False

1. *Curved band patterns are easier on IR imagery than Vis imagery?*
2. *Eye patterns are more accurate on EIR than on Vis imagery.*

3. *Shear patterns are appropriate for TCs for the range*

   a. 25-50kn b. 30-65kn c. 50-85kn d. 25-85kn

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Where is the curved band here?

more difficult!

Multiples

Ranges

Changes from hour to hour >> loop