On the rapid intensification (and weakening) of Tropical Cyclones Vernon and Charlotte

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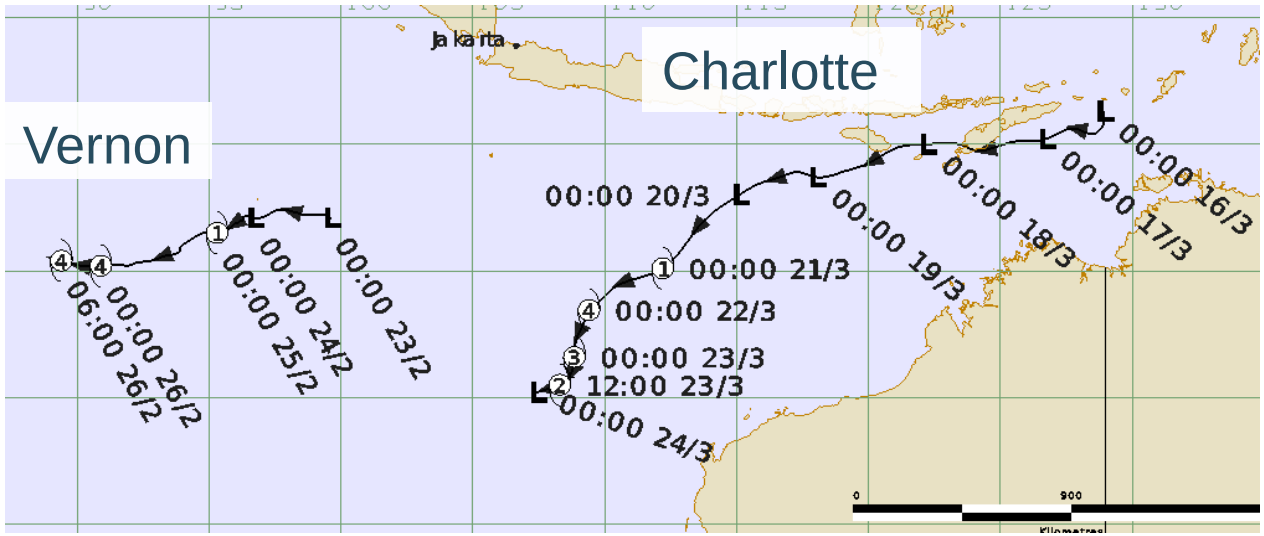
Joe Courtney VLAB 29 March 2022

Rapid Intensity change remains a major forecasting challenge

Highlight satellite signatures of recent events

30kn/24h



Socrative: socrative.com
Login as student
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(anonymous)

Acknowledgements:

CIMSS: https://tropic.ssec.wisc.edu/tropic.php
NRL https://www.nrlmry.navy.mil/tc-bin/tc_home2.cgi
NOAA https://manati.star.nesdis.noaa.gov/datasets/ASCATData.php
CIRA https://rammb-data.cira.colostate.edu/tc_realtime/

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Which of these is MOST important for RI for a circulation at 35-55kn intensity?

SOCRATIVE QUESTION

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A. Increasing low level inflow

B. Increasing upper-level outflow

C. Low wind shear

D. Moistening of low-mid levels

E. Warm ocean temperatures

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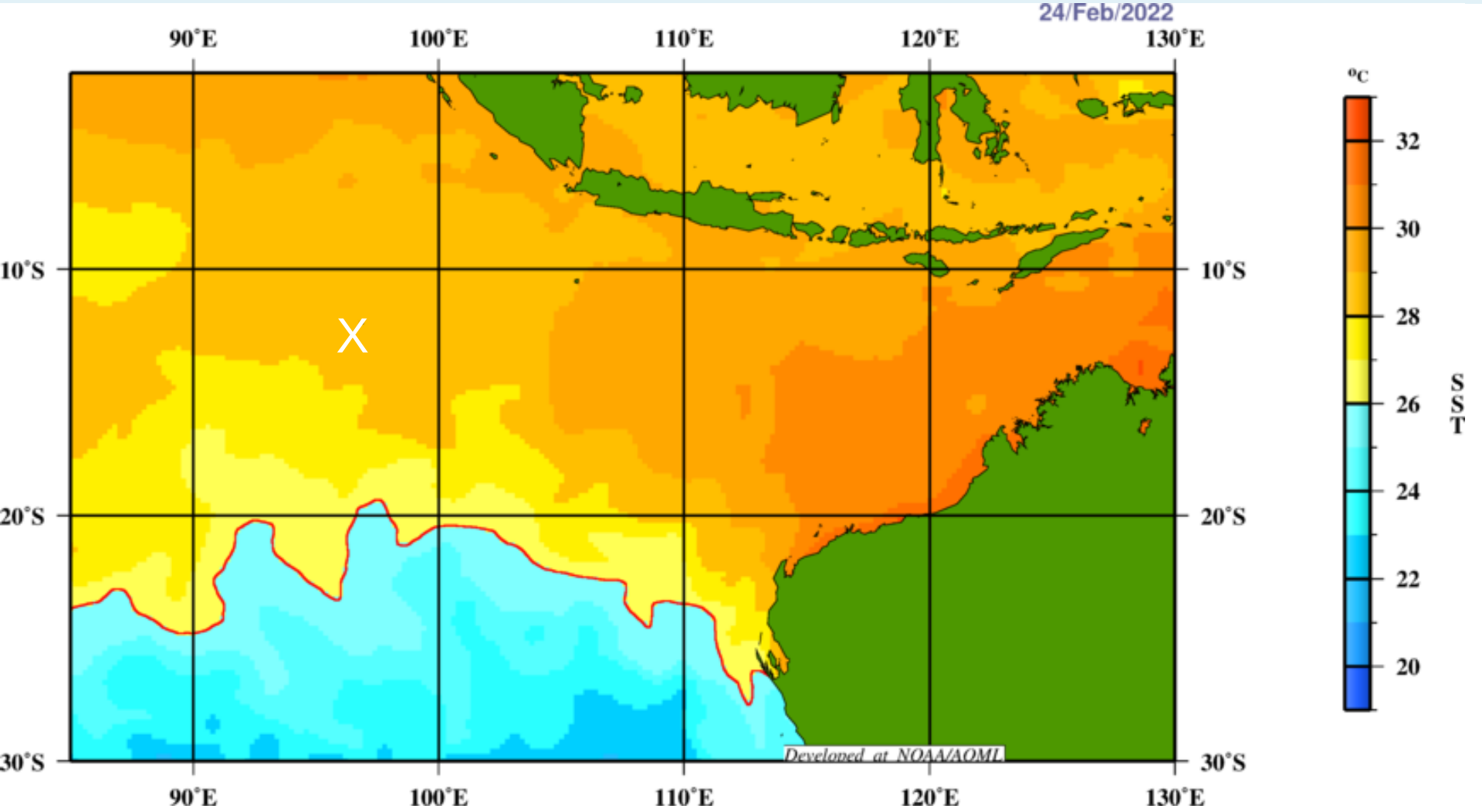
SST for Vernon
Feb >28C

https://www.aoml.noaa.gov/phod/dataphod1/work/HHP/NEW/2022055ausst.png



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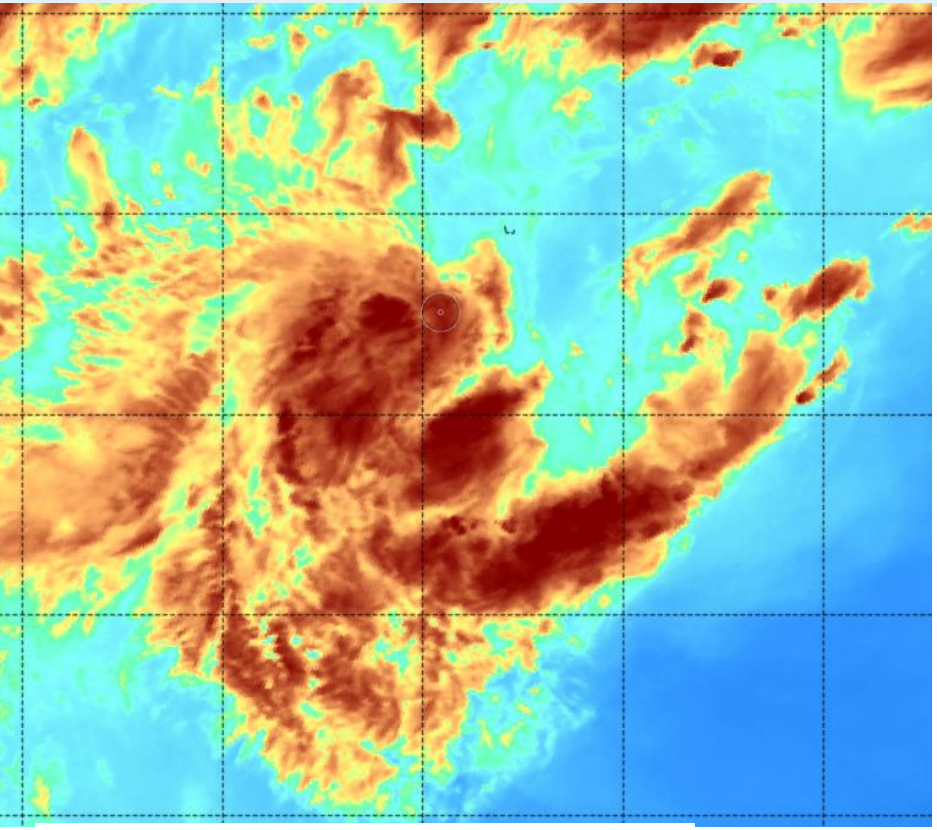
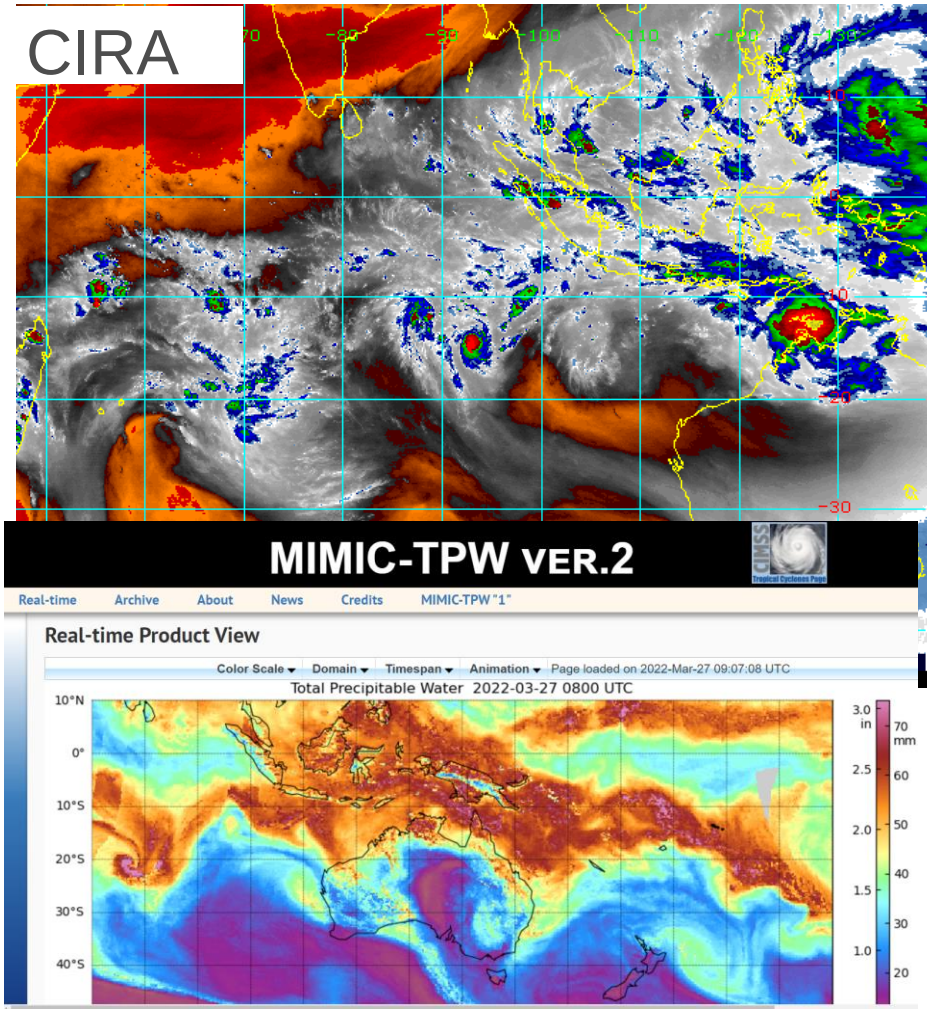
Deep moisture ?
WV and TPW



WV 24/12UTC (NRL)



http://tropic.ssec.wisc.edu/real-time/mtpw2/product.php?color_type=tpw_nrl_colors&prod=ausf&timespan=24hrs&anim=html5

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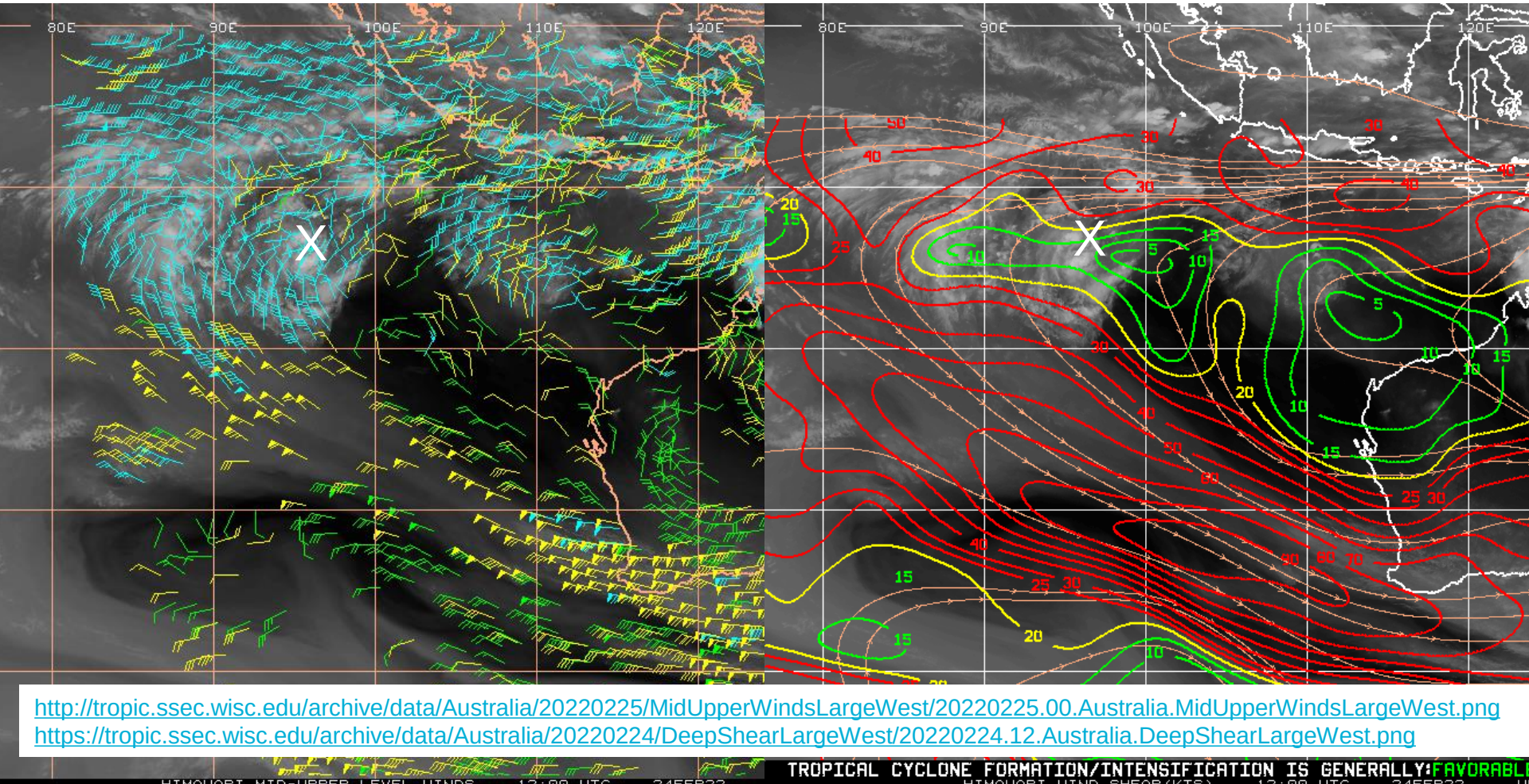
Shear and Upper winds 24/12UTC

Strong poleward outflow, moderate (15-20kn) easterly shear



http://tropic.ssec.wisc.edu/archive/data/Australia/20220225/MidUpperWindsLargeWest/20220225.00.Australia.MidUpperWindsLargeWest.png
https://tropic.ssec.wisc.edu/archive/data/Australia/20220224/DeepShearLargeWest/20220224.12.Australia.DeepShearLargeWest.png

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Size: True or False?

SOCRATIVE QUESTION

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A smaller system is more likely to rapidly intensify (or weaken) than a larger system

TC Vernon 24/12UTC

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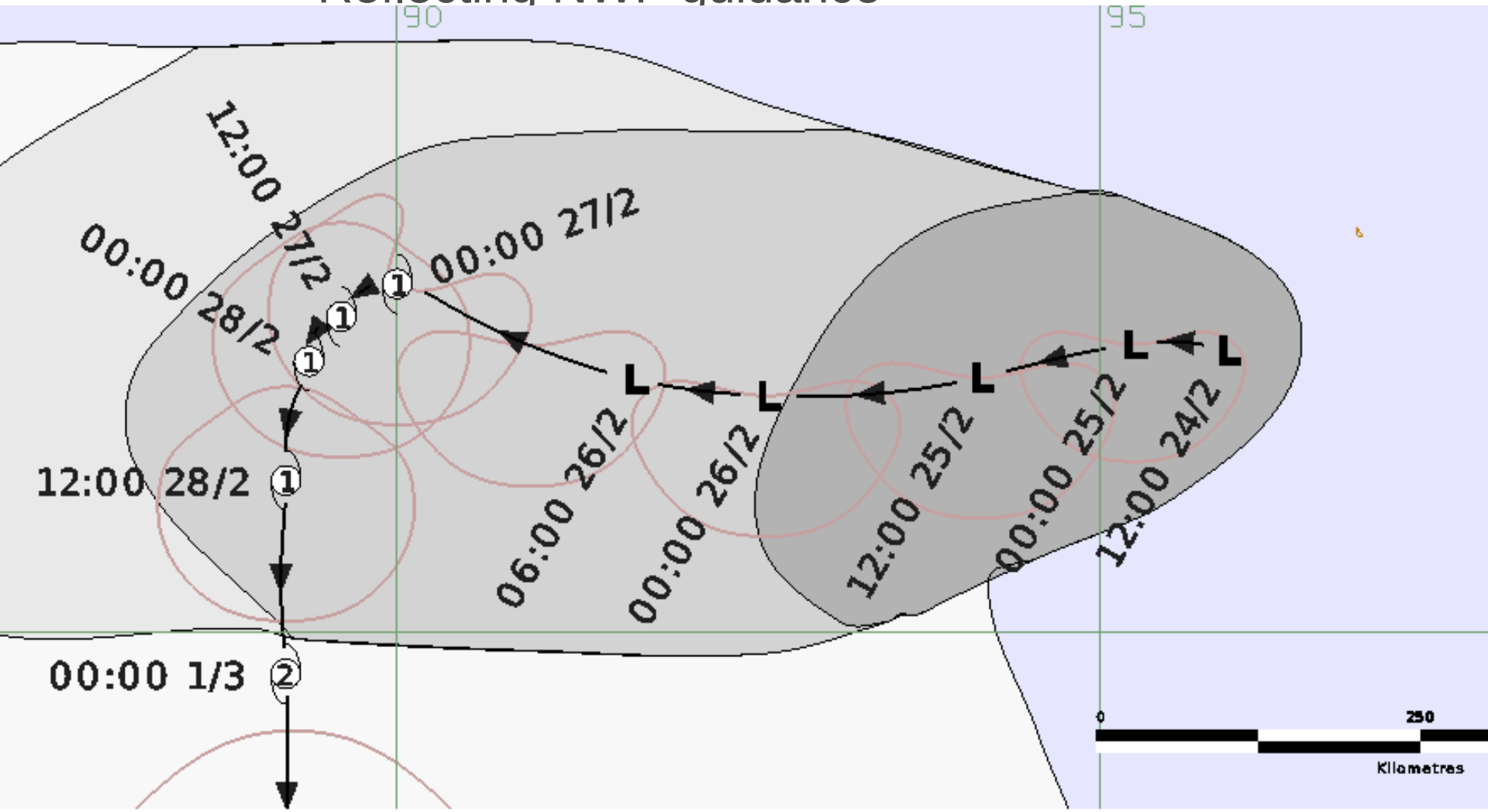
Forecast: gales on southern side but not a TC until +54h at 26/18UTC before 90E

Reflecting NWP guidance



Vernon intensification IR 24/08 to 25/20UTC

Australian Government
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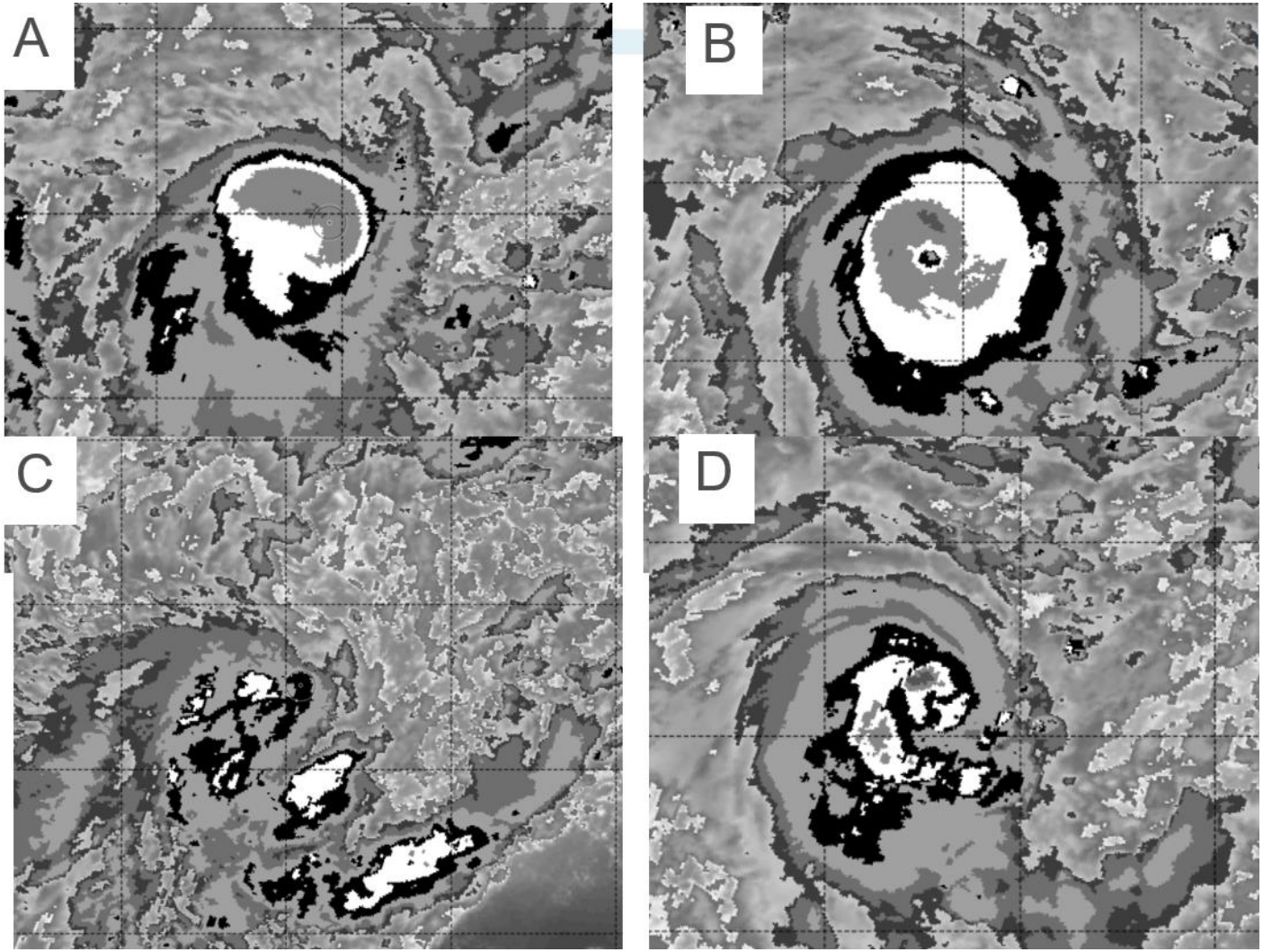
What is the order of intensification: weakest to strongest?

SOCRATIVE QUESTION



Vernon intensification IR 24/08 to 25/20UTC

Australian Government
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What is the order of intensification: weakest to strongest?

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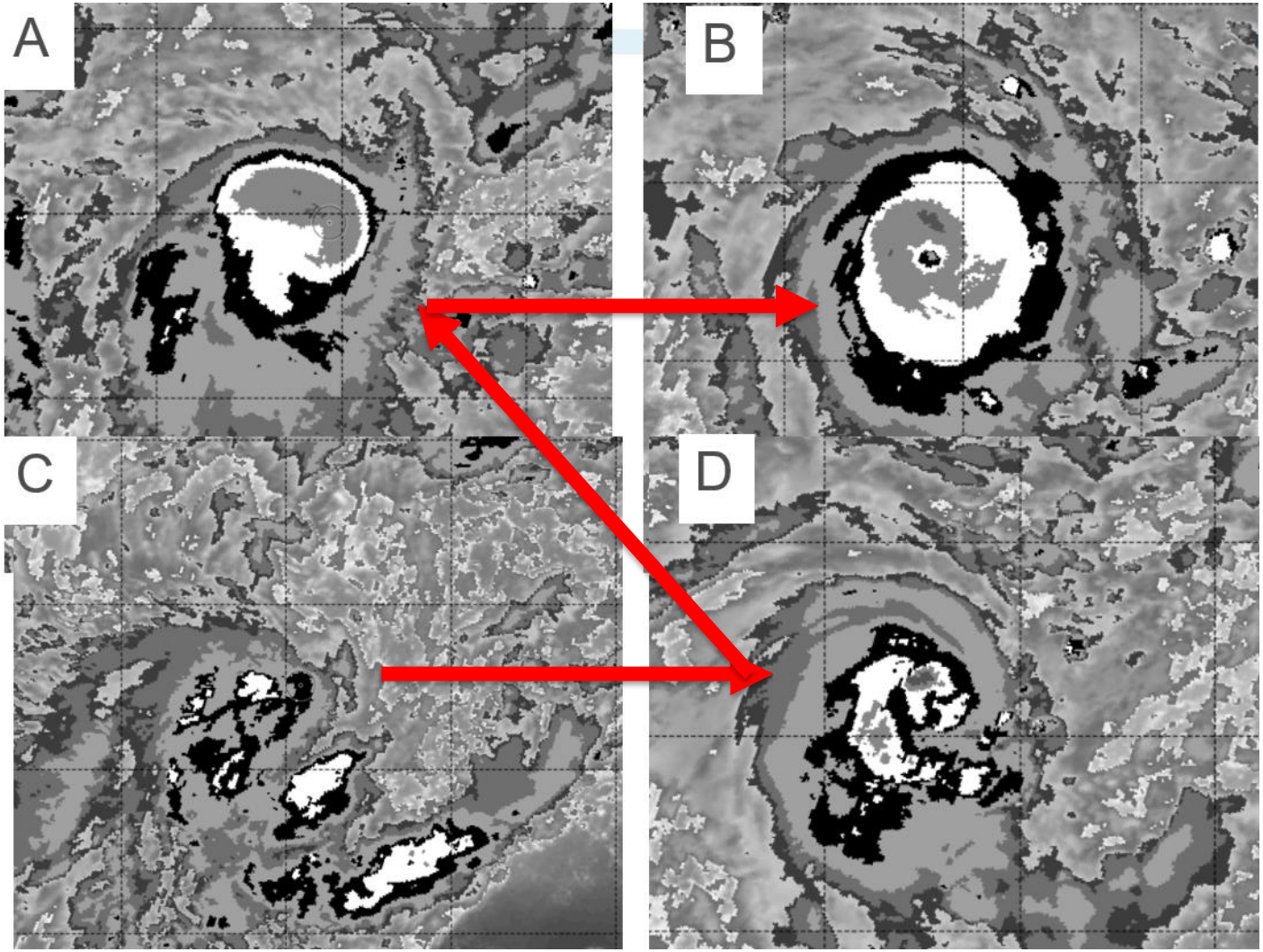

Vernon intensification

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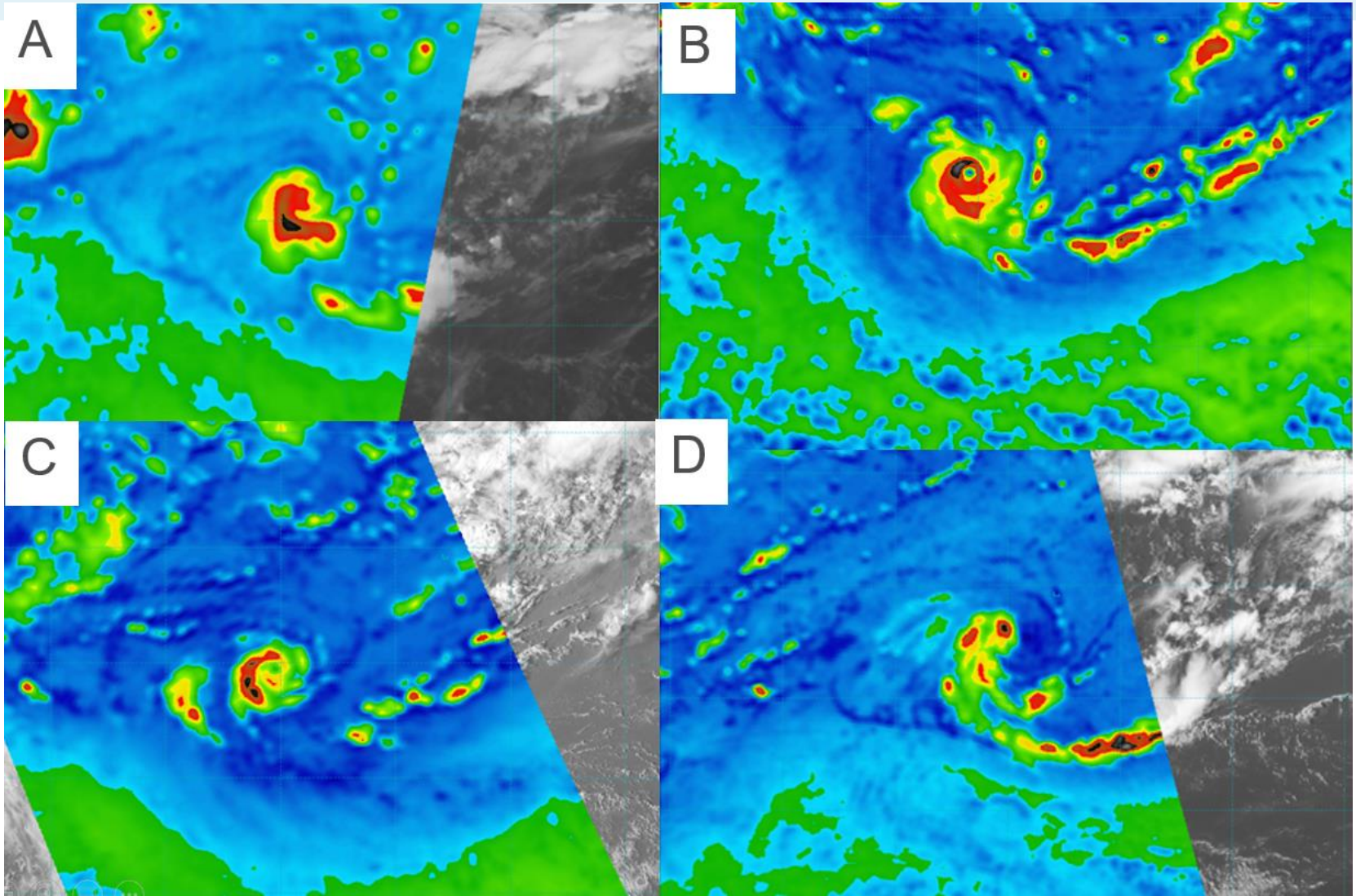
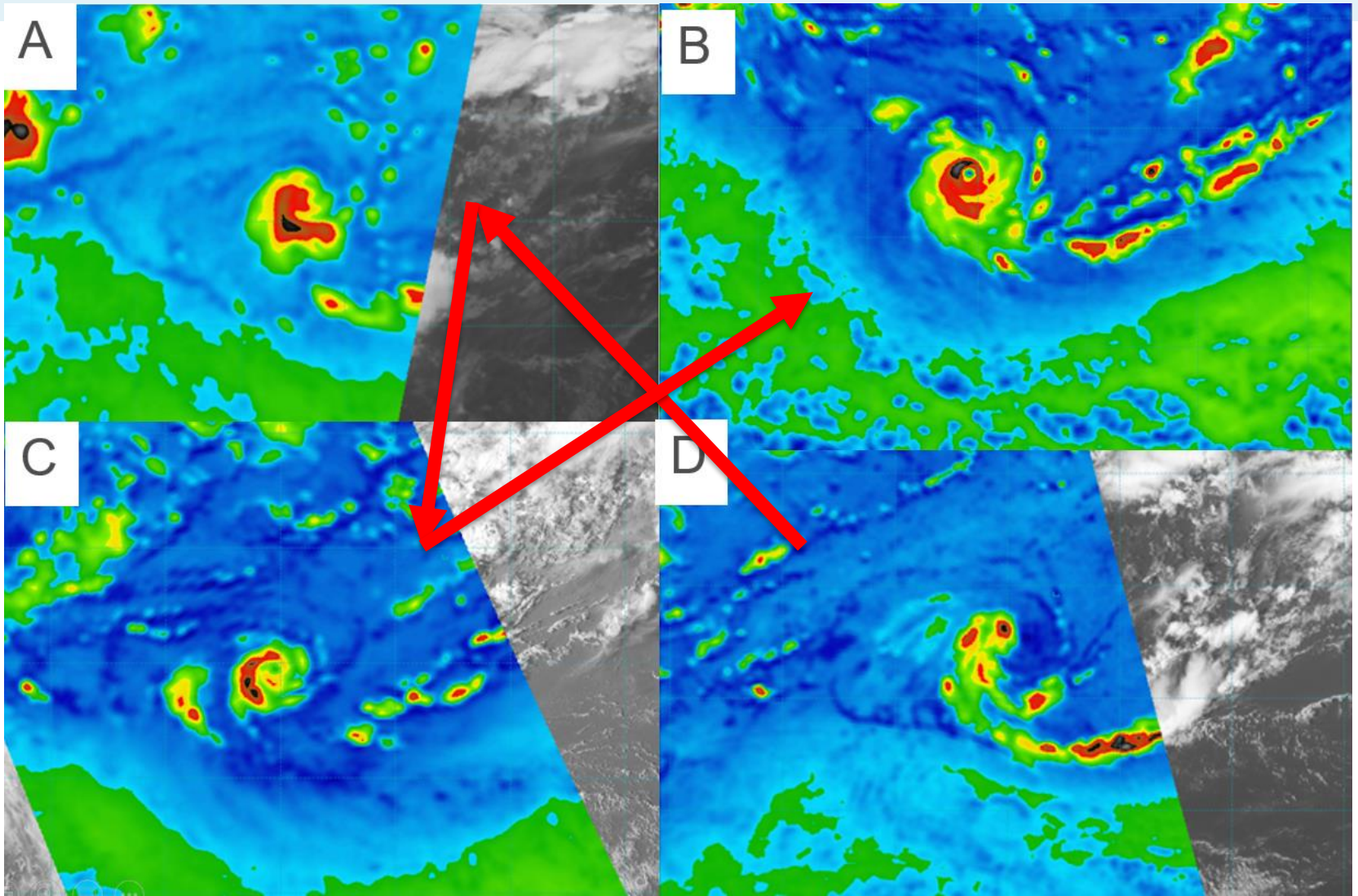
SOCRATIVE QUESTION



Vernon intensification

What is the order of intensification: weakest to strongest?

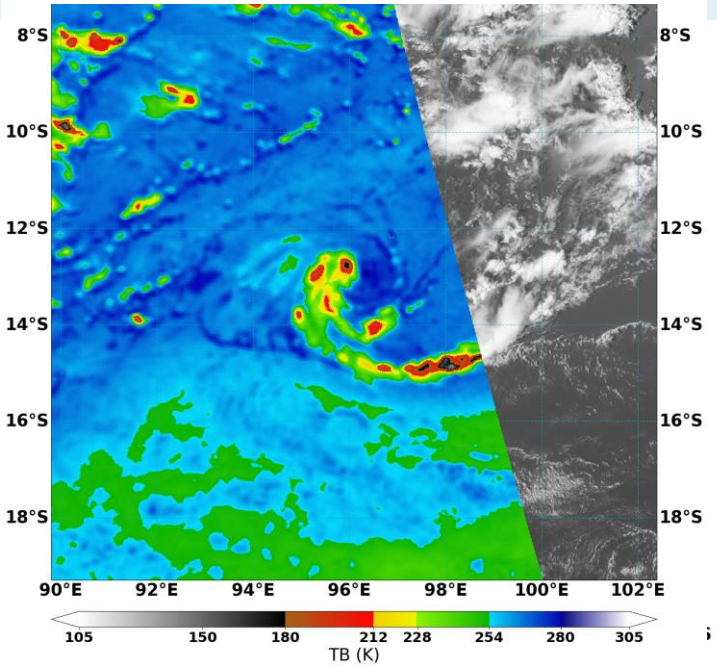
D – A – C - B



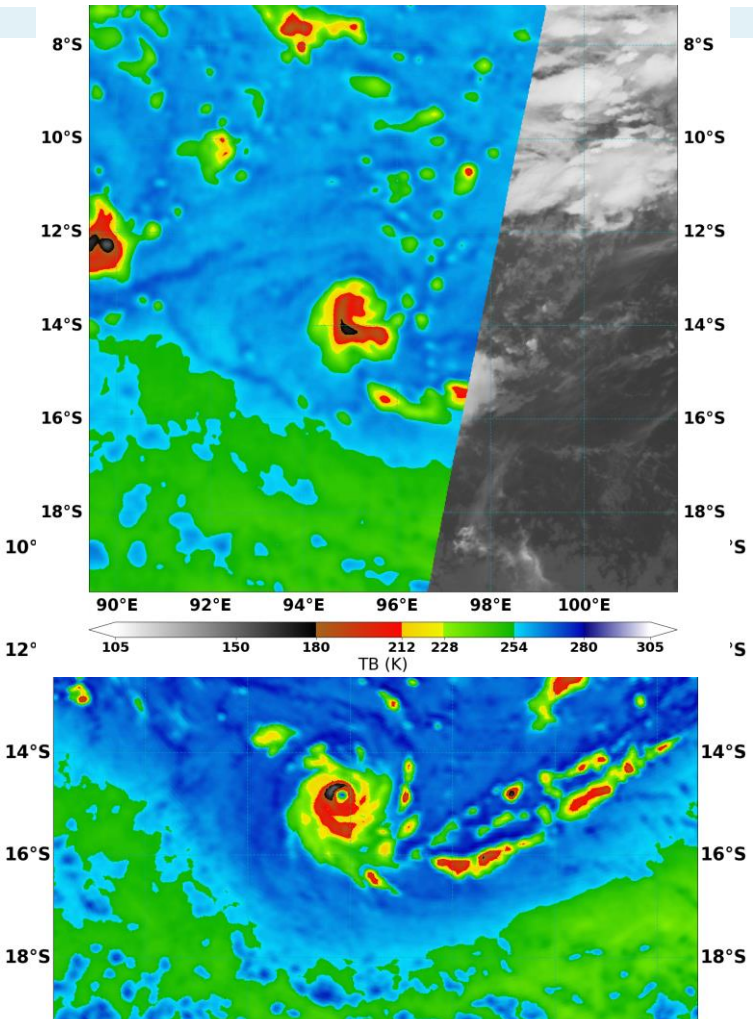
Microwave series: 24/07 to 26/19UTC

Australian Government

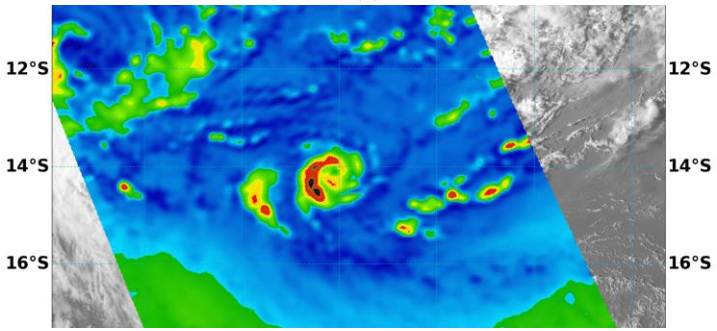
AMSR2 24/0735UTC



SSMIS 24/2235UTC



GMI 25/0948UTC



AMSR2 25/1909UTC

TC Vernon 24 Feb 2022

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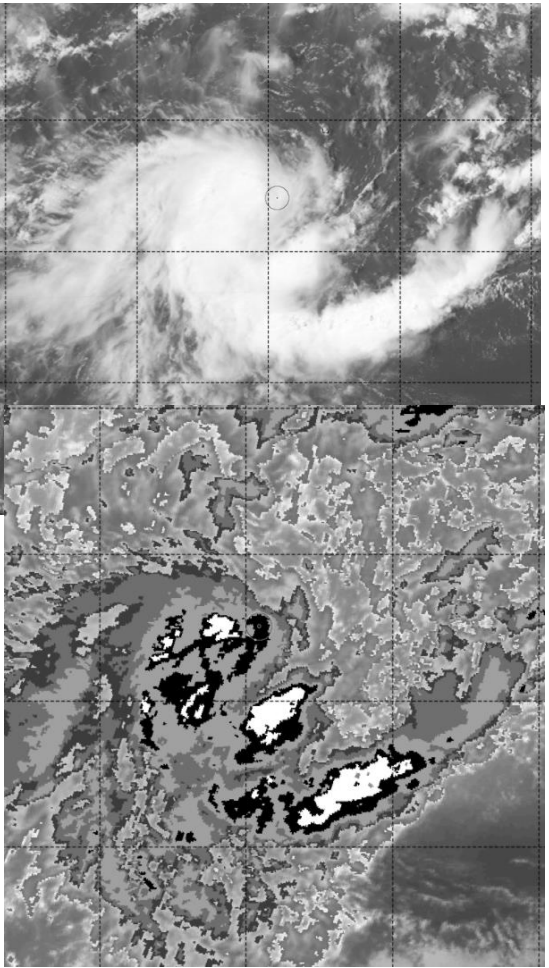
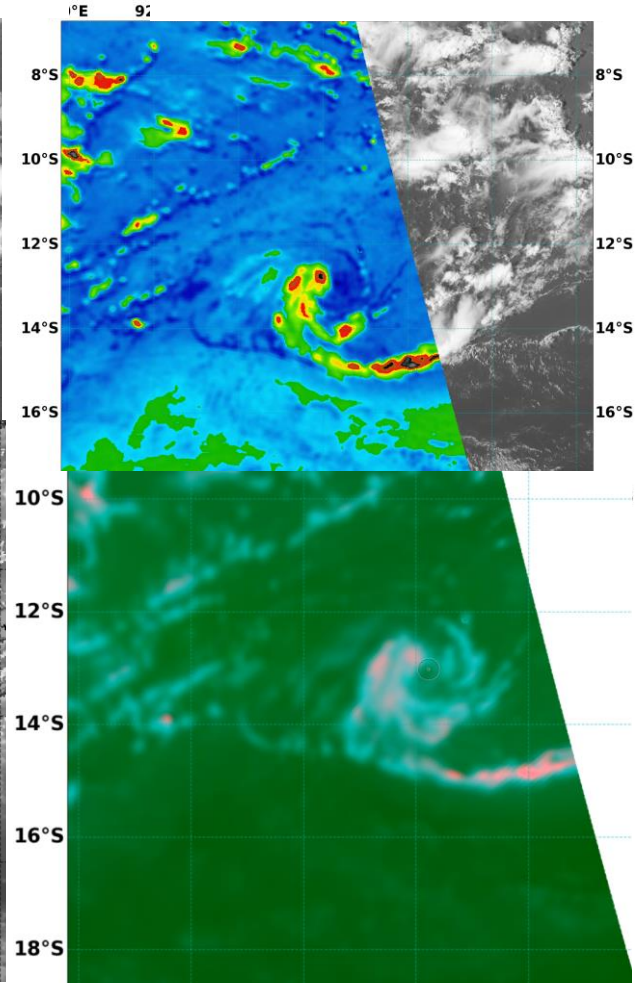
What should we look at for the intensity forecast?

13S 96E

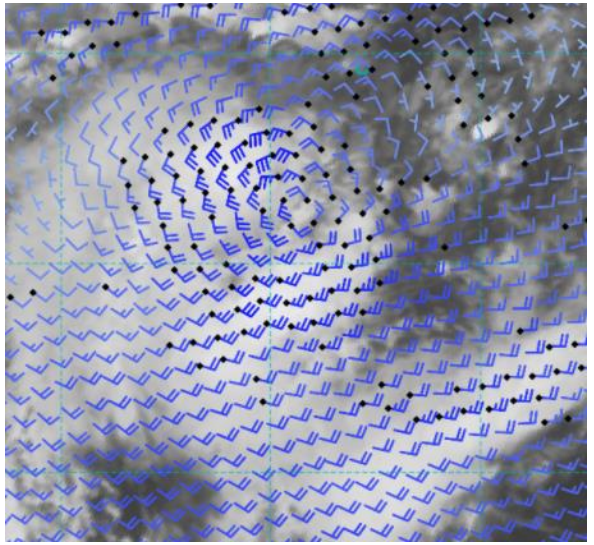
Vis & IR 0735UTC



SH AMSR2 0735UTC



HSCAT 1200UTC



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TC Vernon
Intensification satellite signatures?

Greater organization and involvement of deep convection near centre (inc. 37GHz LLCC organization)

Increase in curved banding

Appearance of an eye

Colder cloud tops (IR) on deep convection near centre

Decrease in IR T gradient on upshear side – developing convection upshear – WV warming upshear*

References:

a. Dvorak Technique D patterns and D+

b. *Rylglicki RI in mod shear: extending convection to upshear and deflection of upper winds and decreasing wind shear

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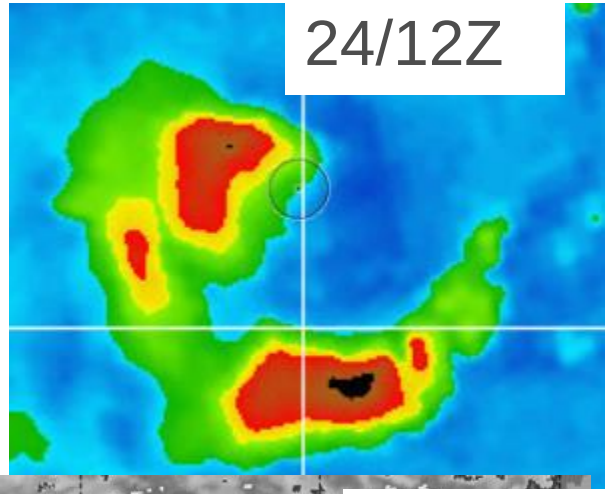
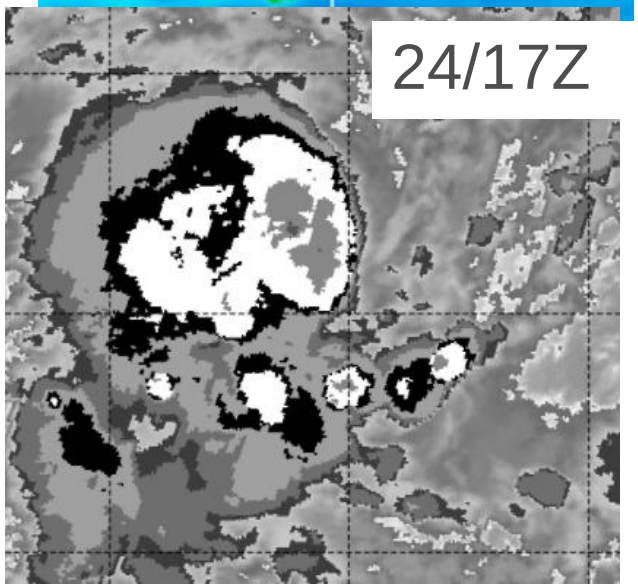
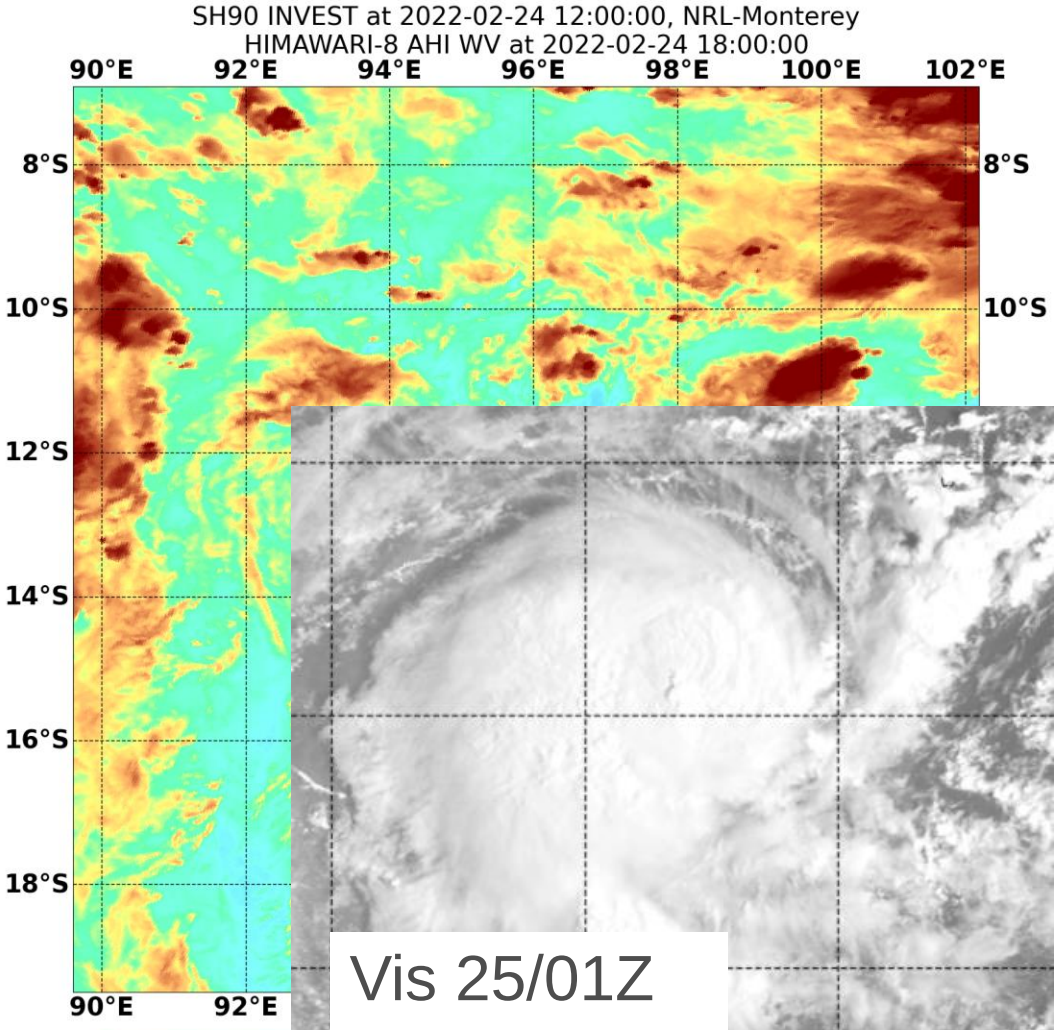
24 to 25 change against upper winds

Fights against upper E/NE flow







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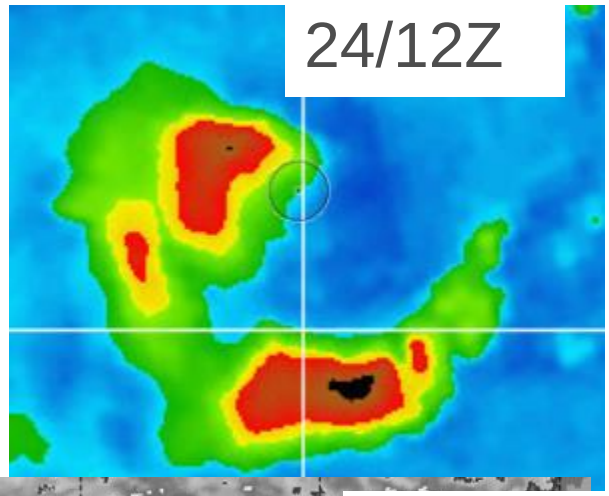
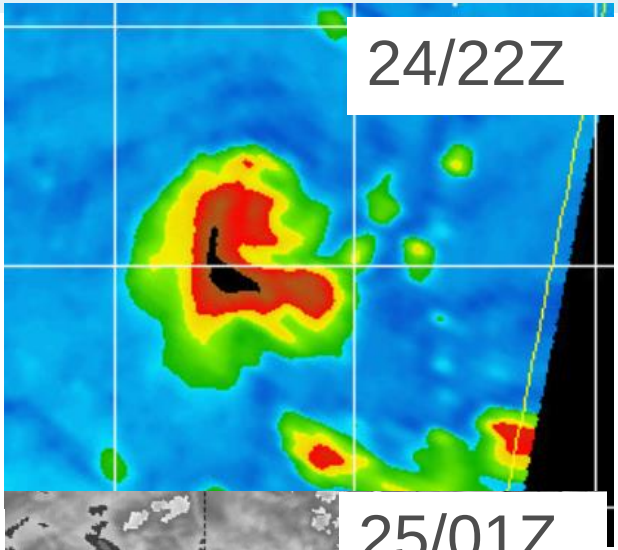
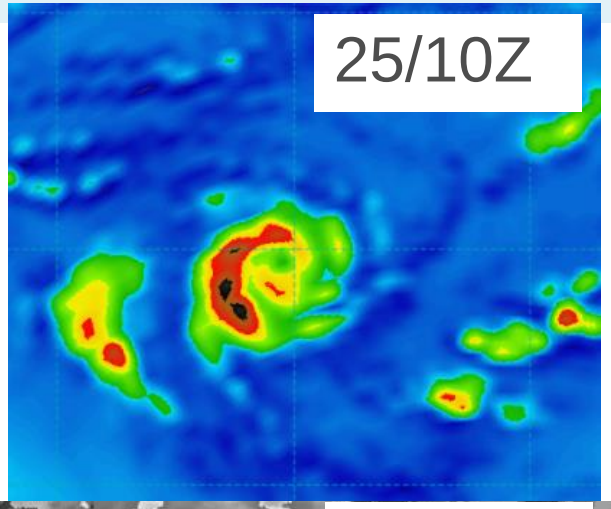
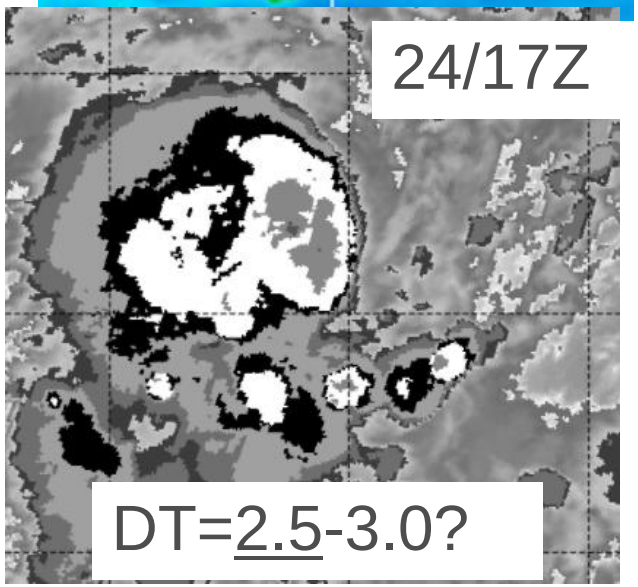
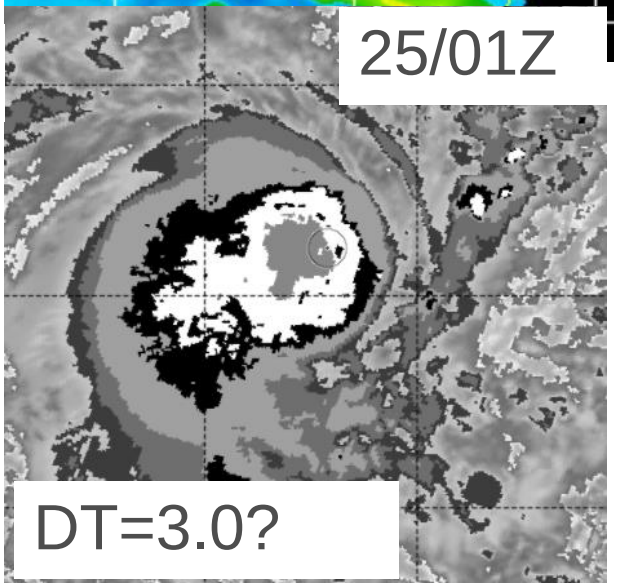
24 to 25 change against upper winds

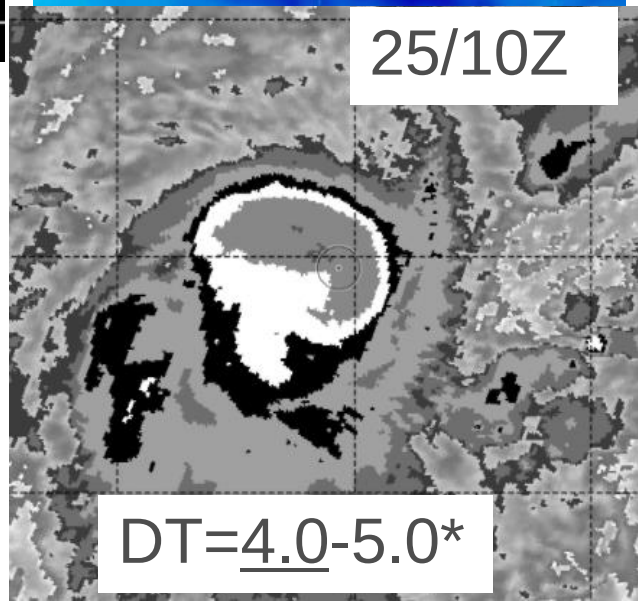












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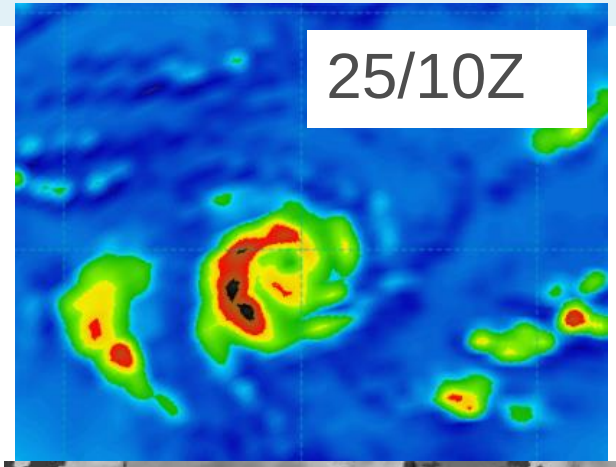
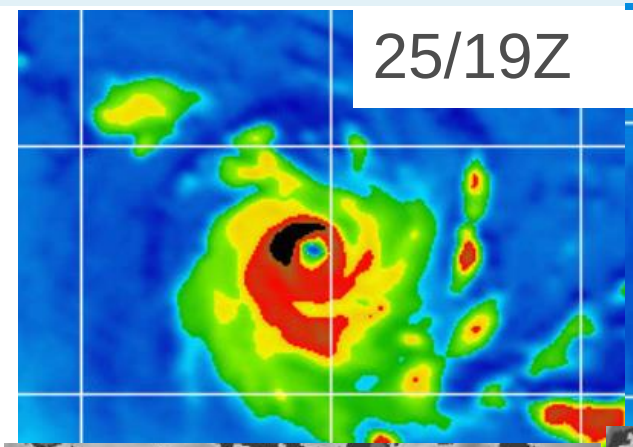
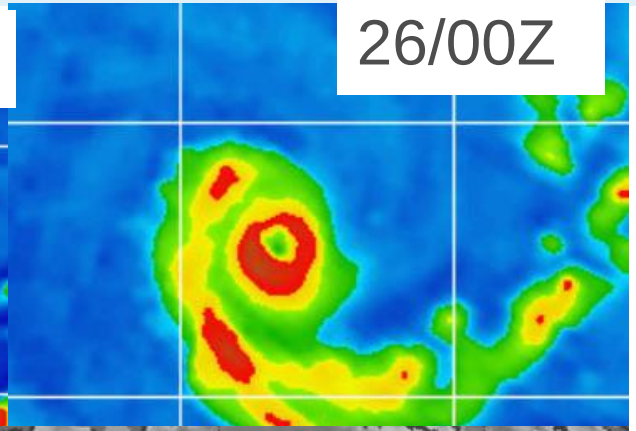
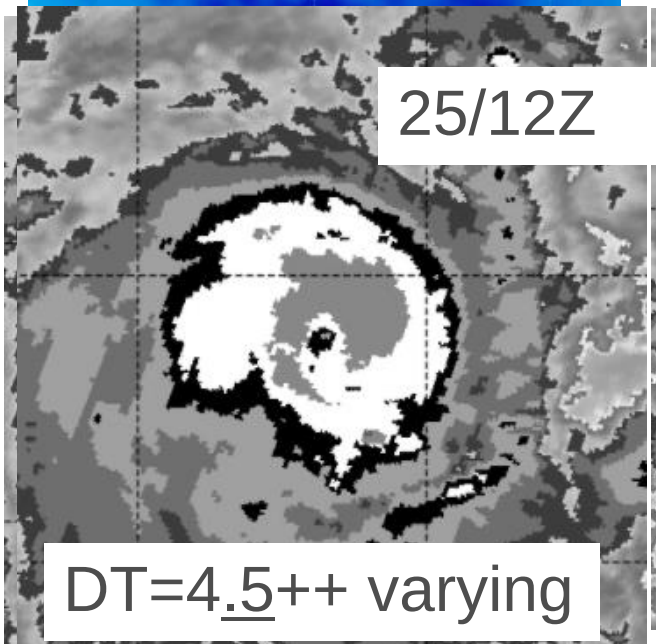
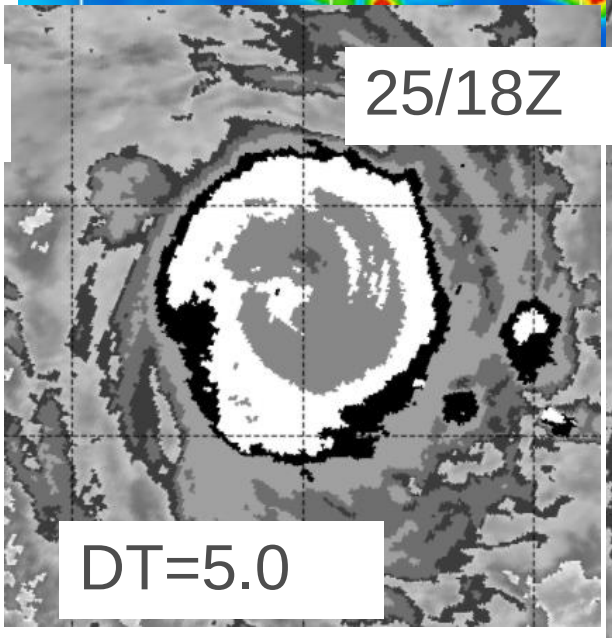
25-26 Feb eye pattern

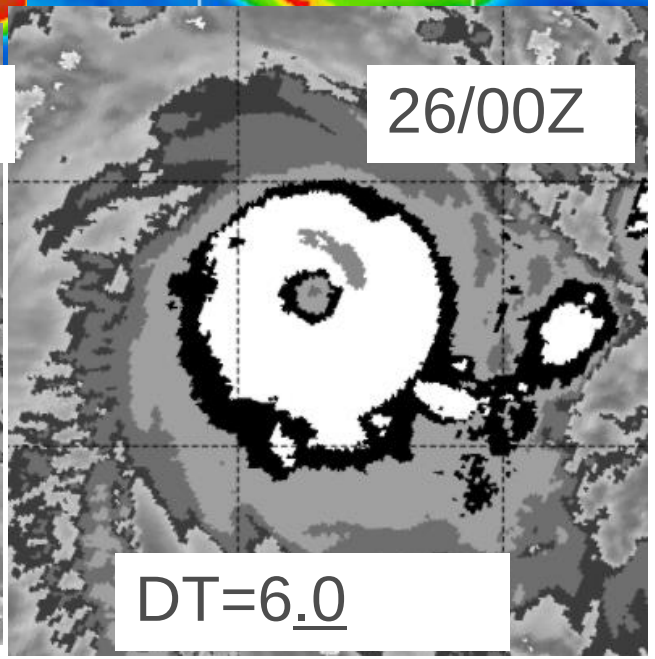












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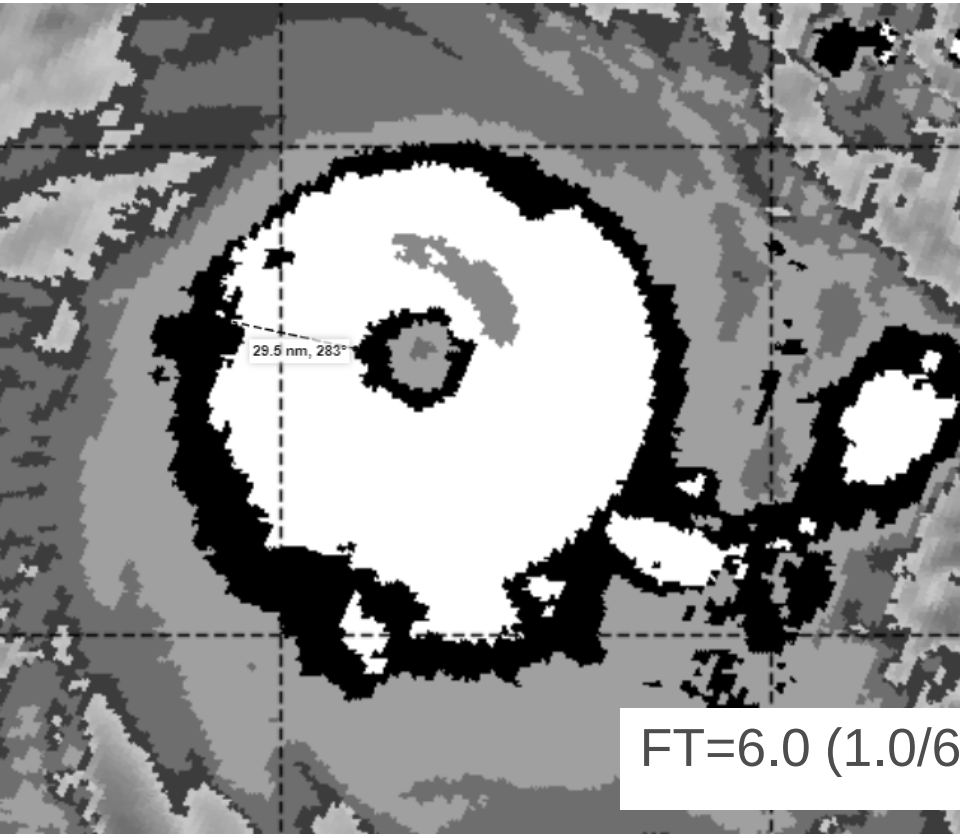
Dvorak 26/00Z
inheriting 25/18 CI=5.0

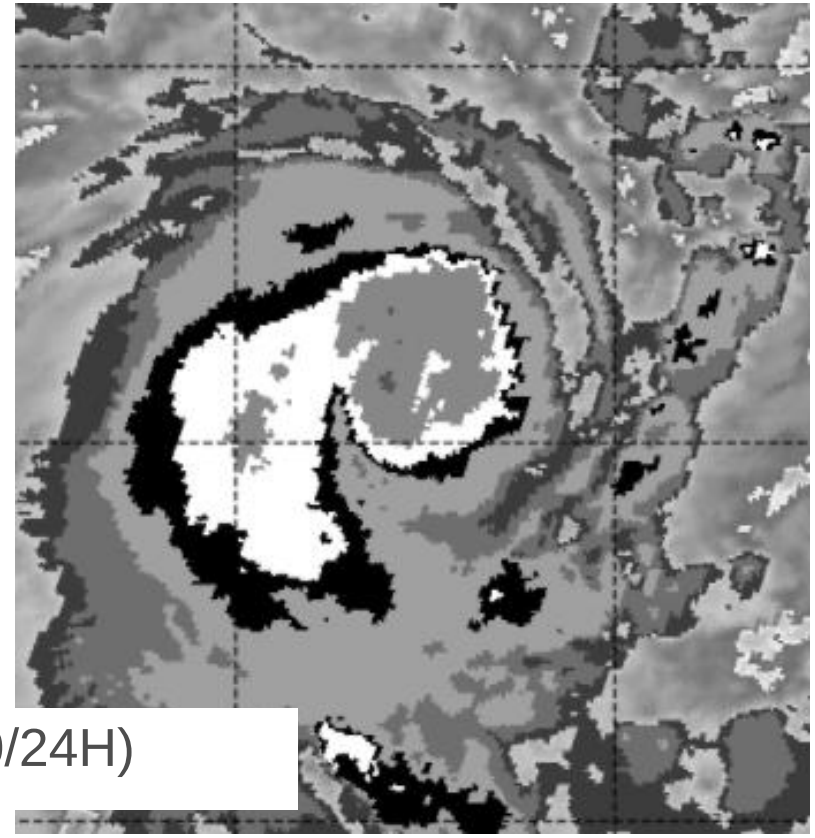
Eye B surround 5.5 DG/W +0.5 DT=6.0

Or W surround MG/W DT=6.0

24h change D+ 3.0 +1.5 =4.5

Pat adj. +0.5 so MET=5.0





FT=6.0 (1.0/6h; 3.0/24H)

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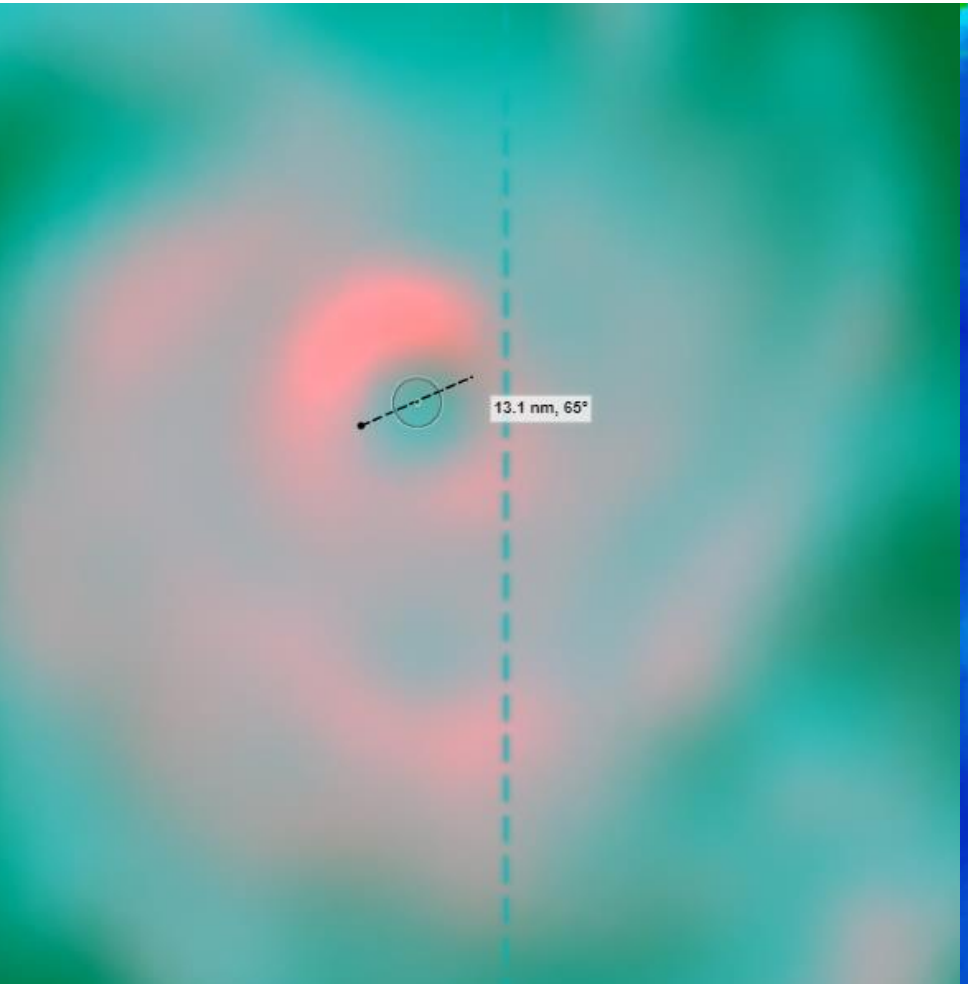
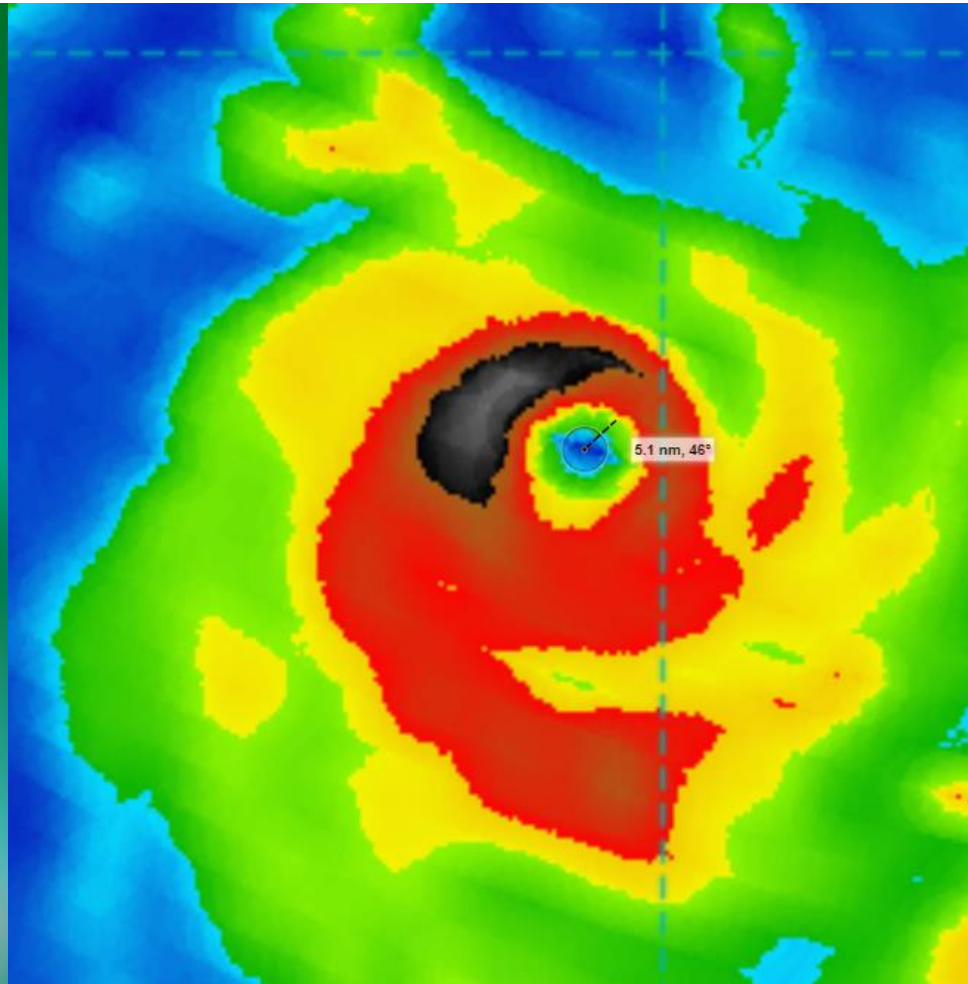
RMW =5-7nm
AMSR2 at 25/1909UTC
Detection of max winds? Dvorak?

37GHz



89GHz



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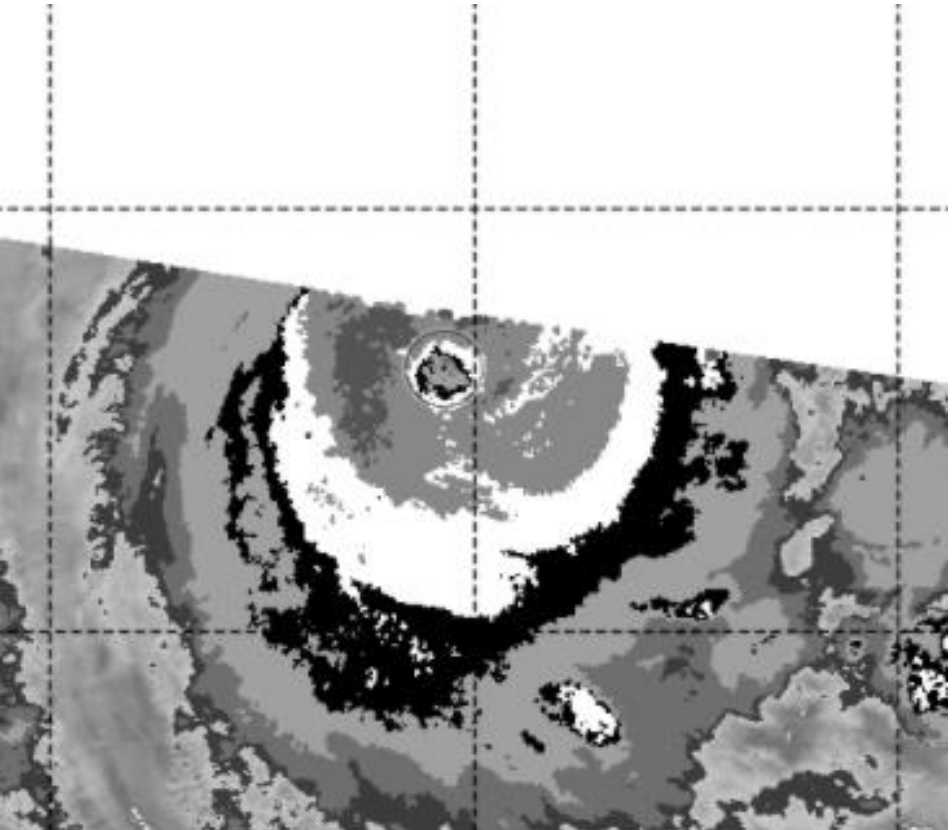
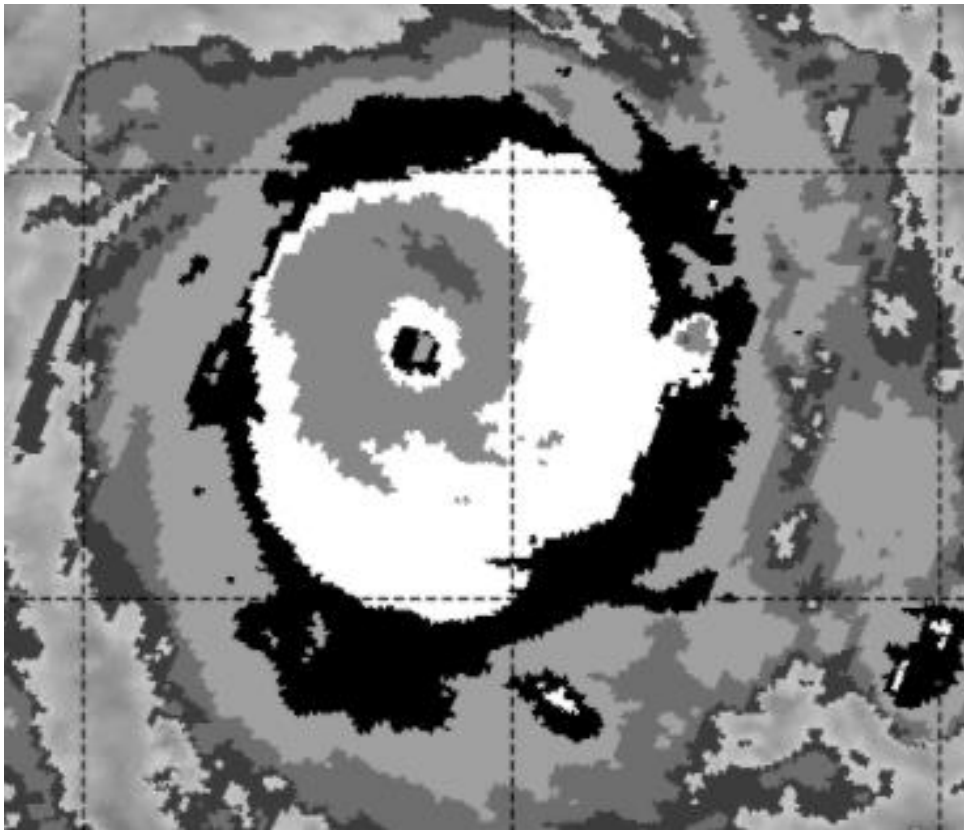
Dvorak 25/1915Z
Himawari (parallax) Vs polar orbiting

Modis-Aqua EIR at 25/1915UTC



H8 EIR at 25/1920UTC



Scatterometry/Radiometry 25 Feb

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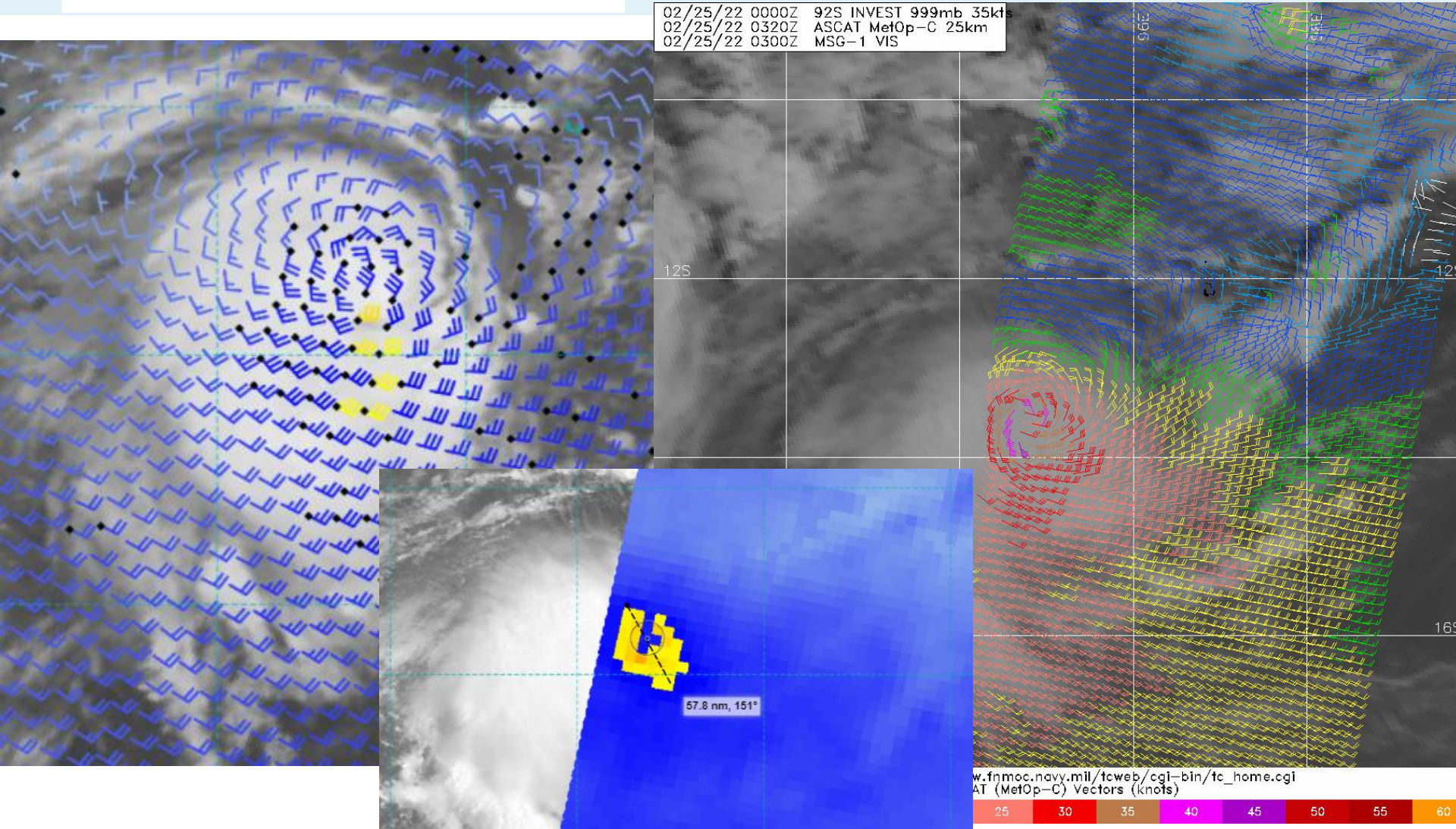
HY2B 24/2327UTC

ASCAT-C 25/0320UTC



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Scatterometry/Radiometry 25 Feb

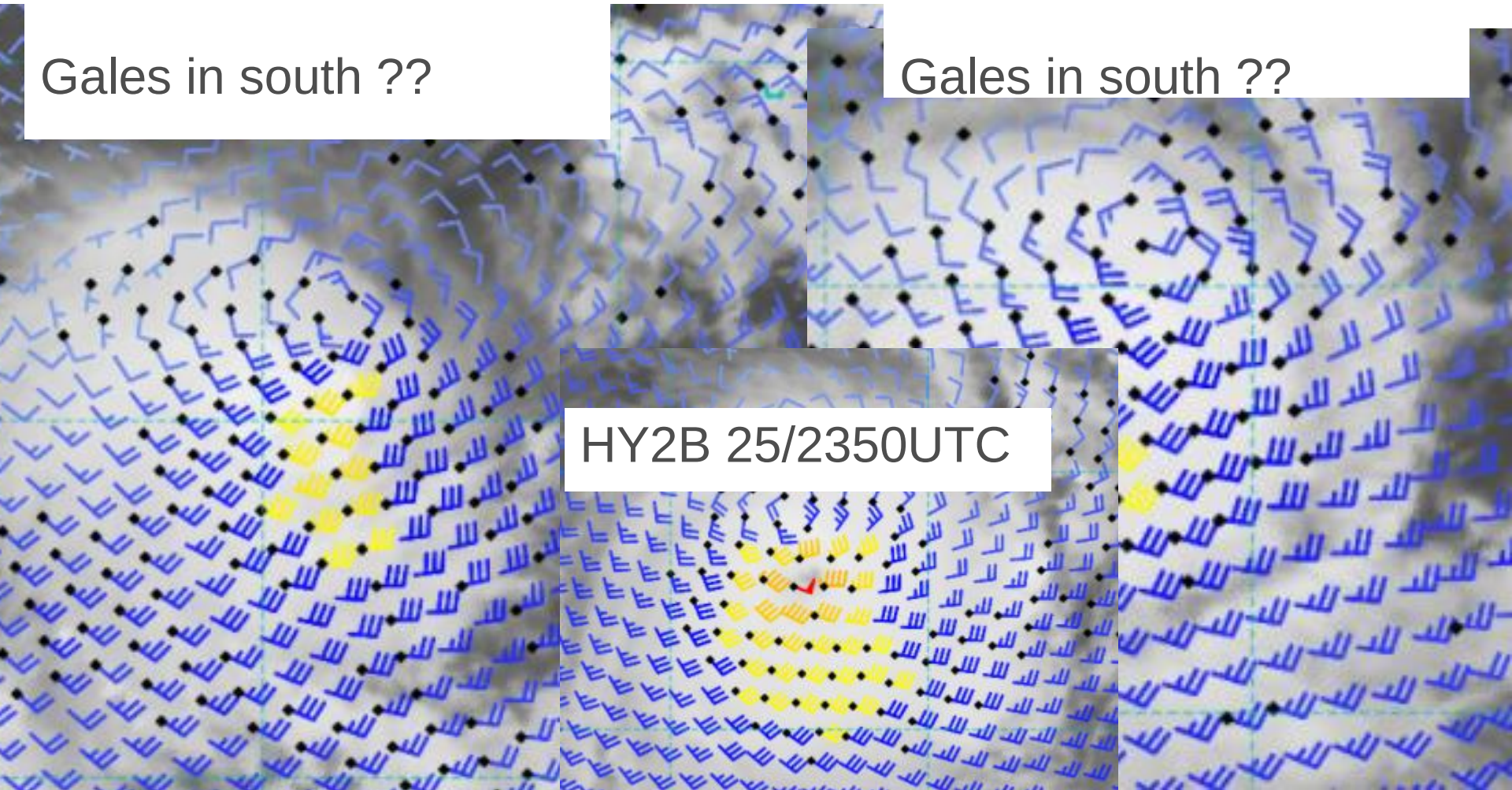
WHAT IS WRONG WITH THIS?

HY2C 25/0651UTC

Gales in south ??

HY2B 25/1222UTC

Gales in south ??



HY2B 25/2350UTC

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Scatterometry/Radiometry 24 Feb

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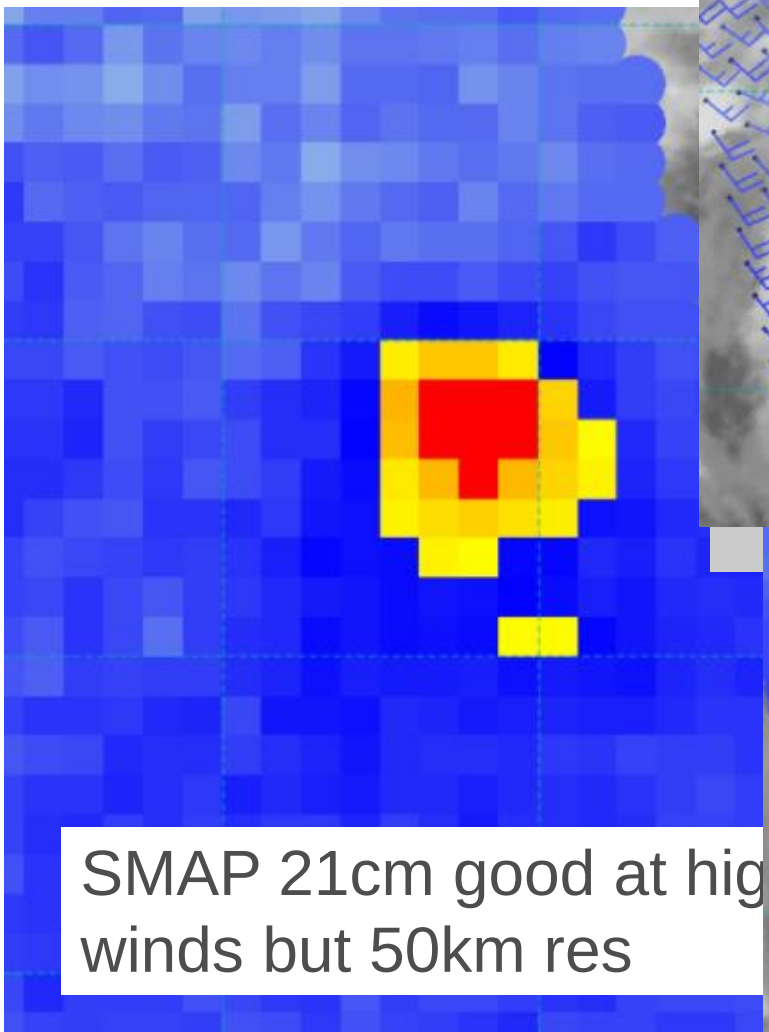
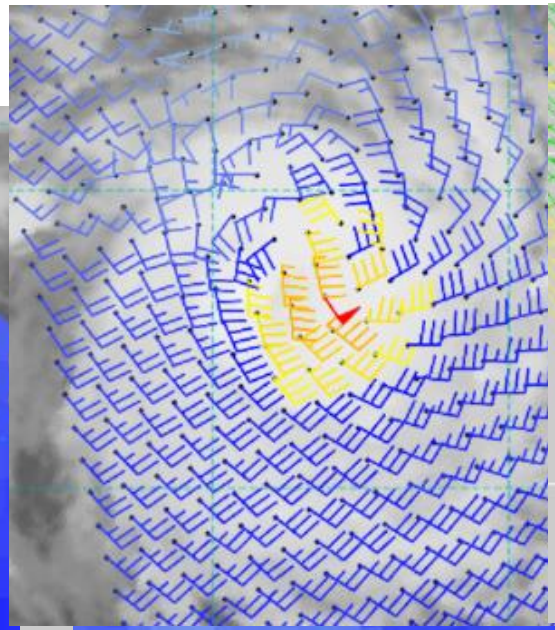
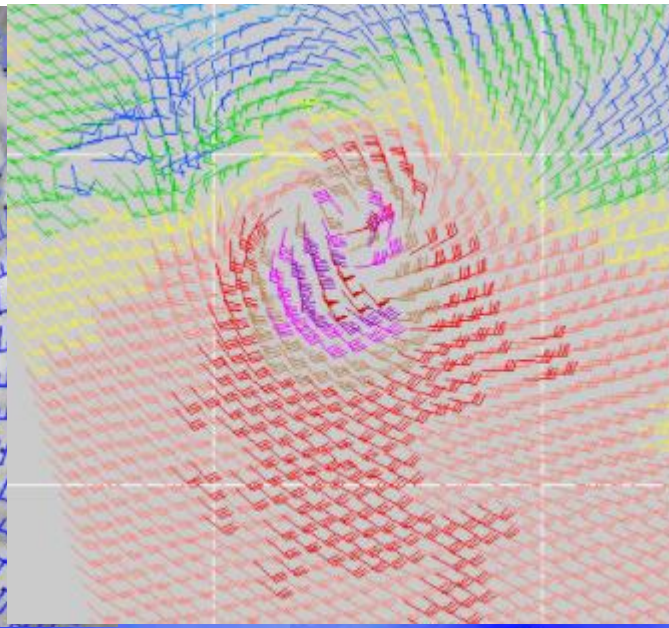
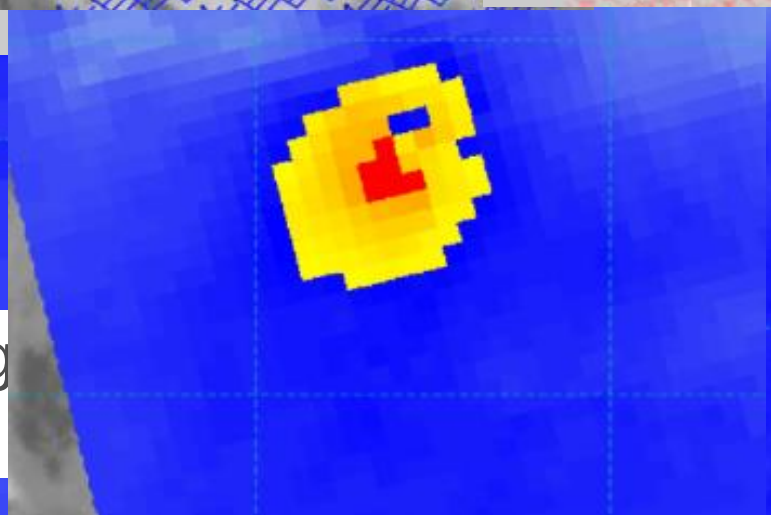
ASCATC 25/1551UTC

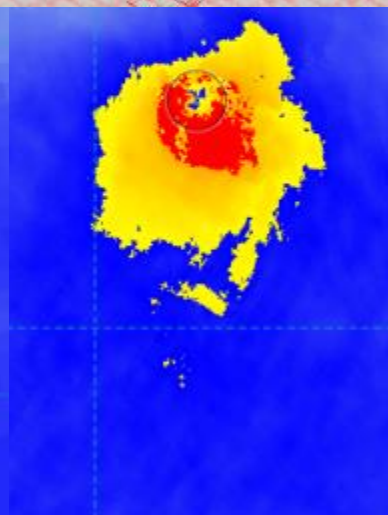
SMAP 25/1204UTC











SMAP 21cm good at hig
winds but 50km res

ASCAT-C 25/1551: Hires

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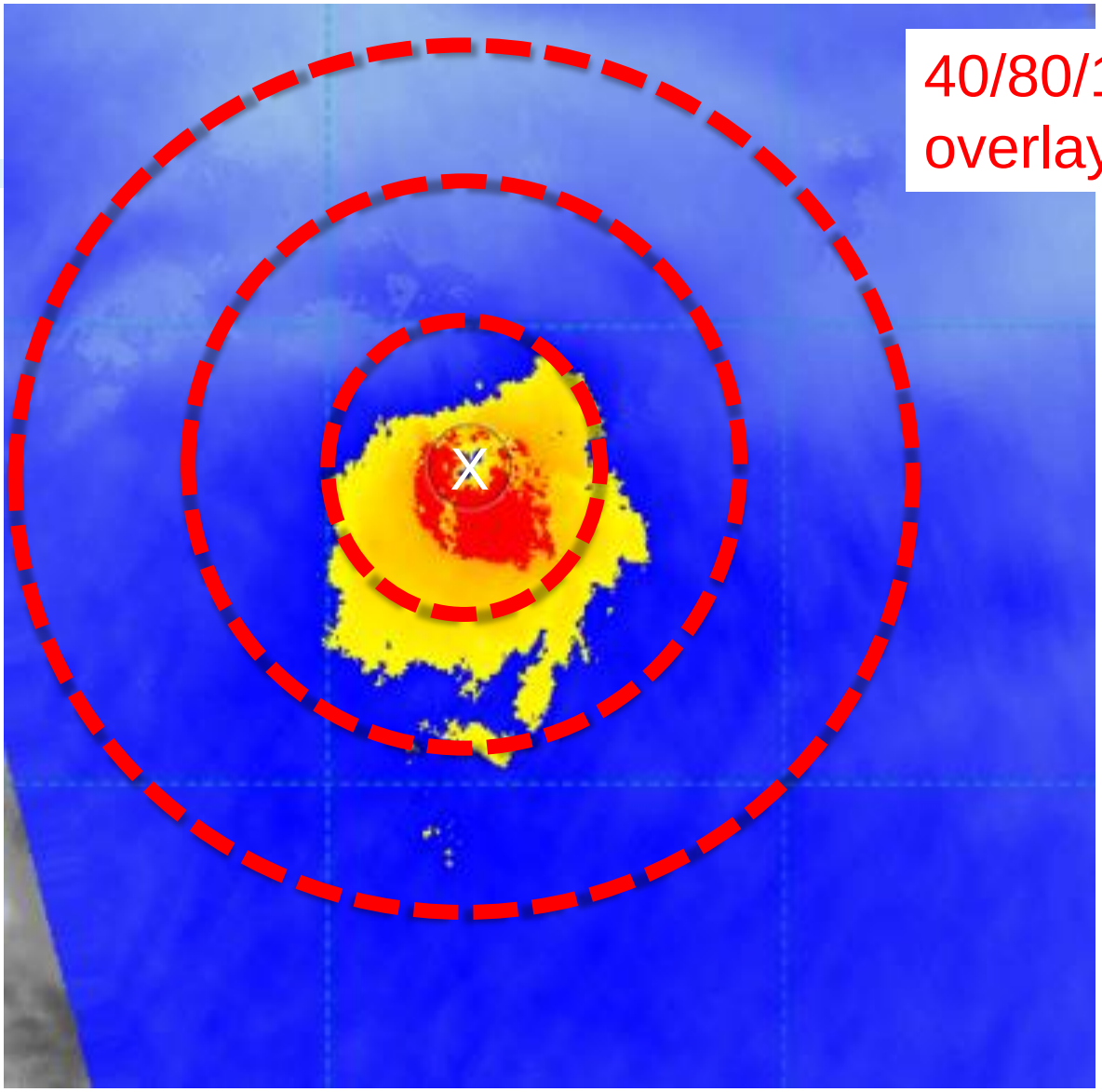
Bureau of Meteorology

R34:
40/60/60/30

What %? SE



Scatterometry/Radiometry 24 Feb

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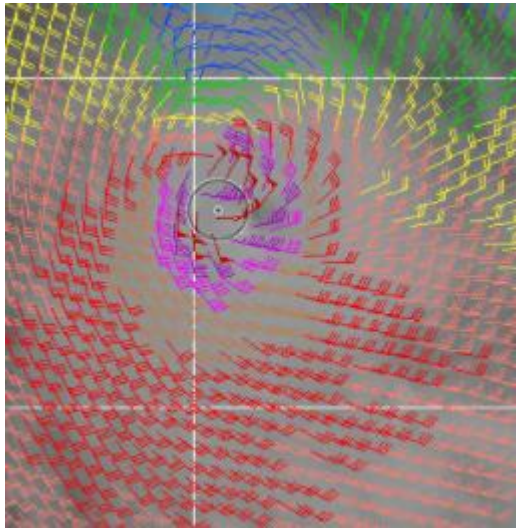
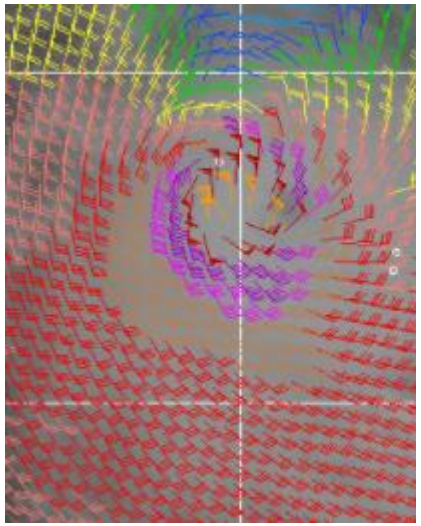
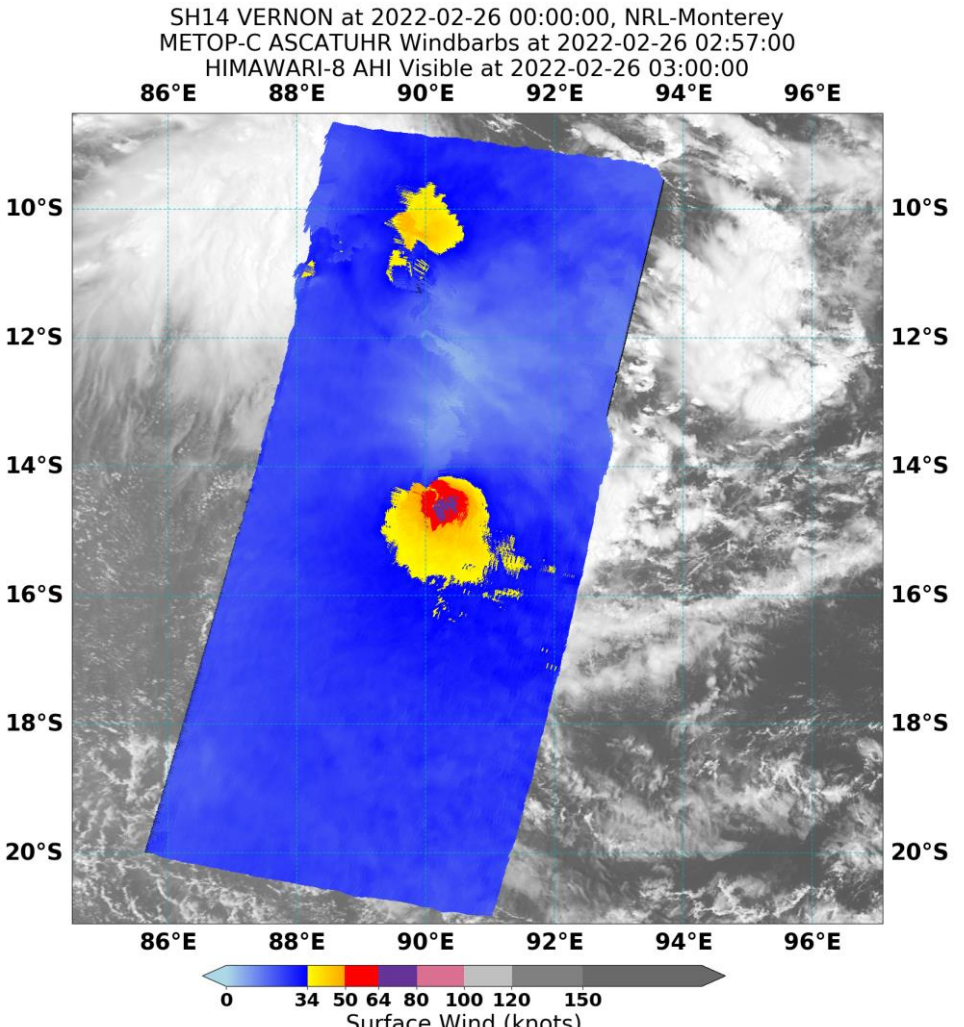
ASCAT-C 26/0301UTC



ASCAT-B 26/0348UTC





ASCATC UHR winds >64k

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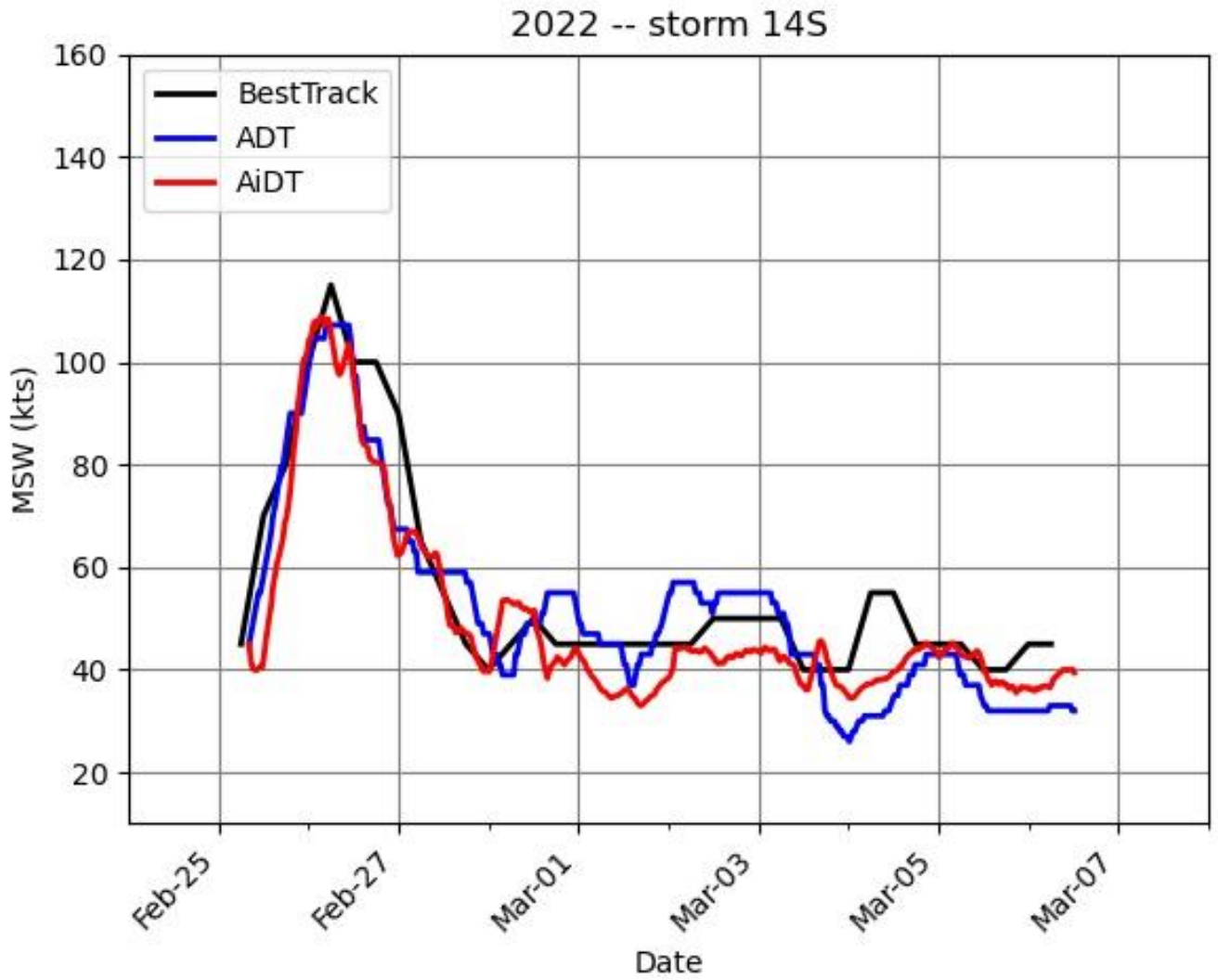
AiDT

Late initiation, rapid intensification and weakening 25 to 26 Feb



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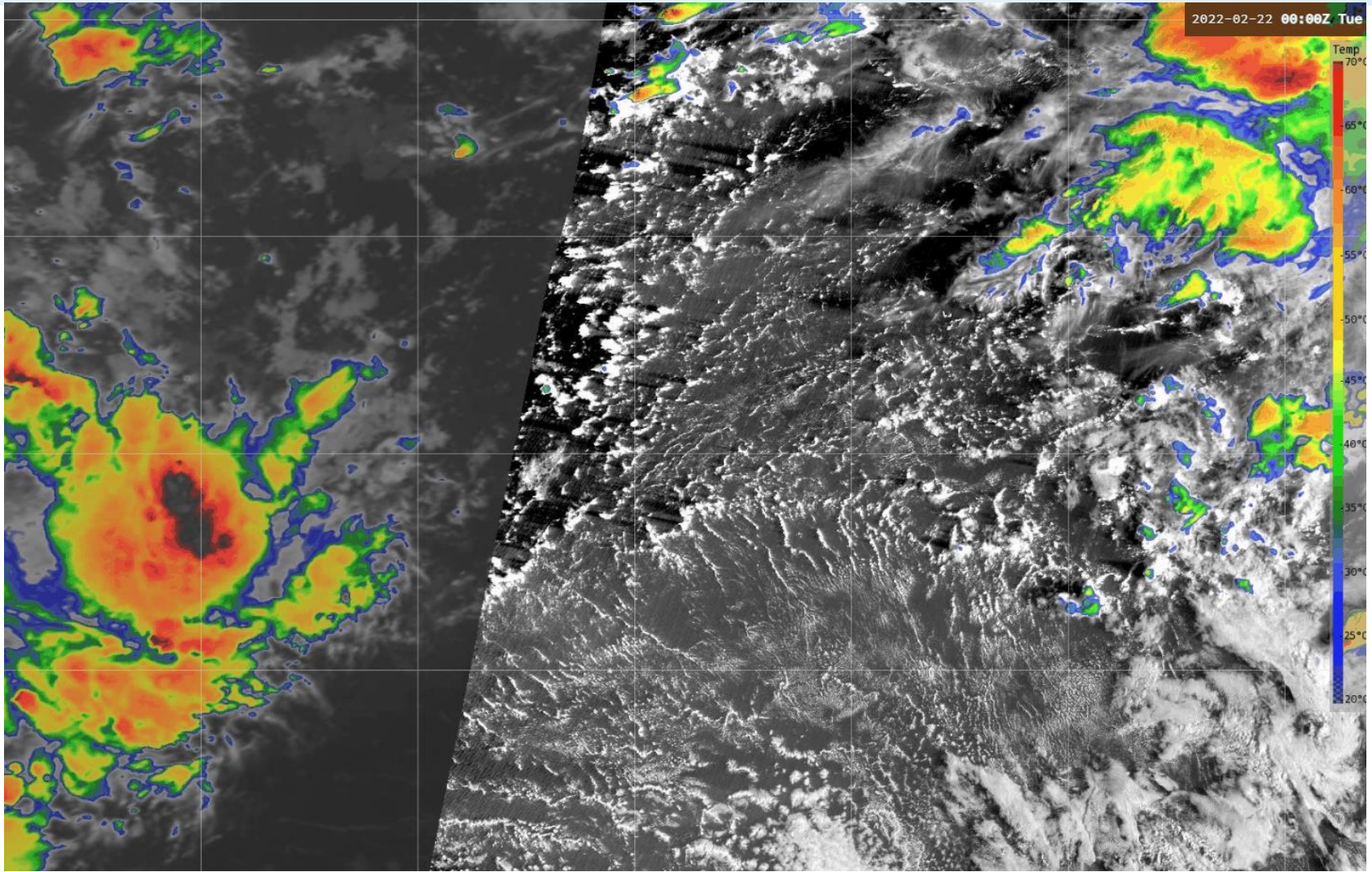
Vernon 22U 2021/22

Vis hourly loop 22-28 February 2022



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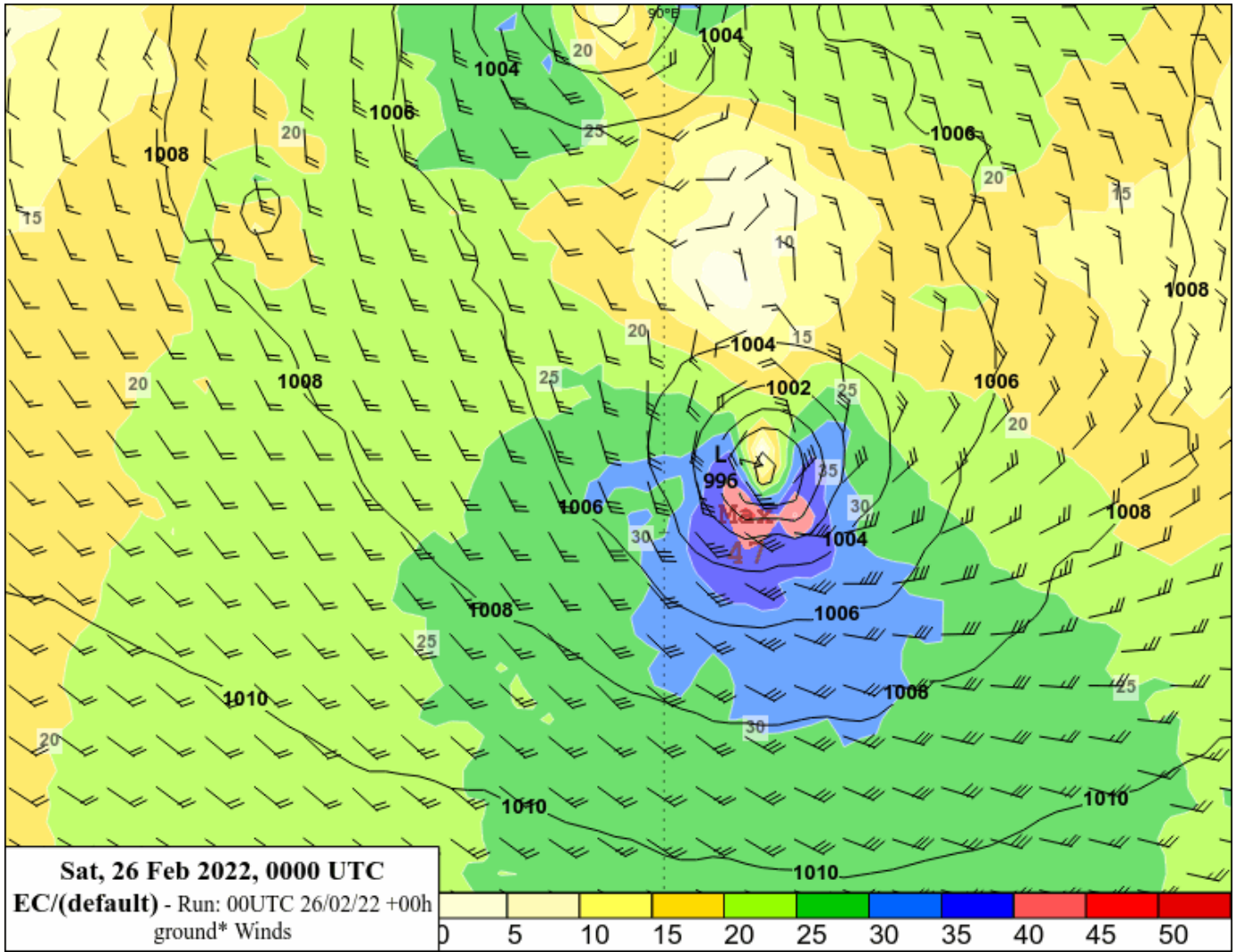
Vernon-25U merger by EC

Run 00UTC 26 Feb 0-36h



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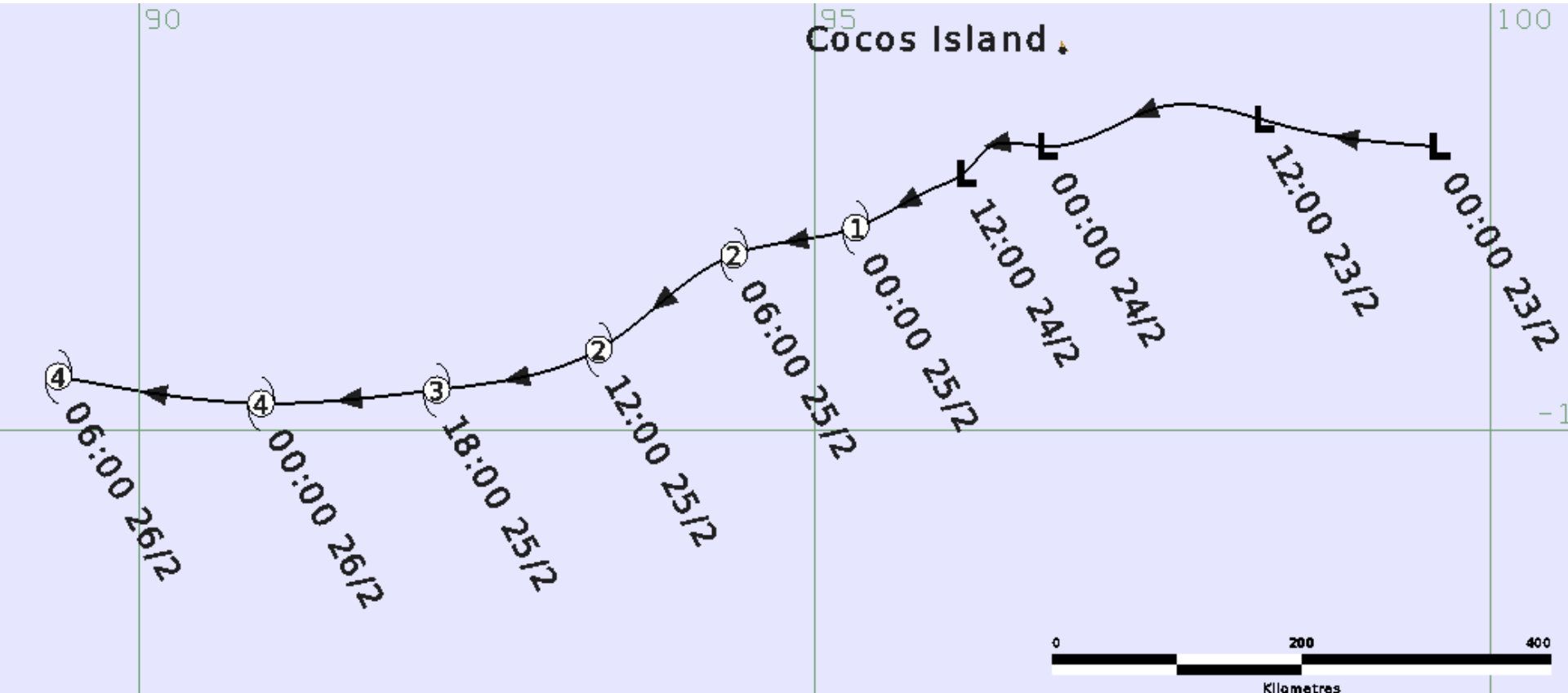
Bureau of Meteorology

TC Vernon Feb 2022

Developed rapidly 40-100kn/24h 25-26 March then weakened 26-27 March

Small system that overcame moderate shear (Ryglicki RI work)



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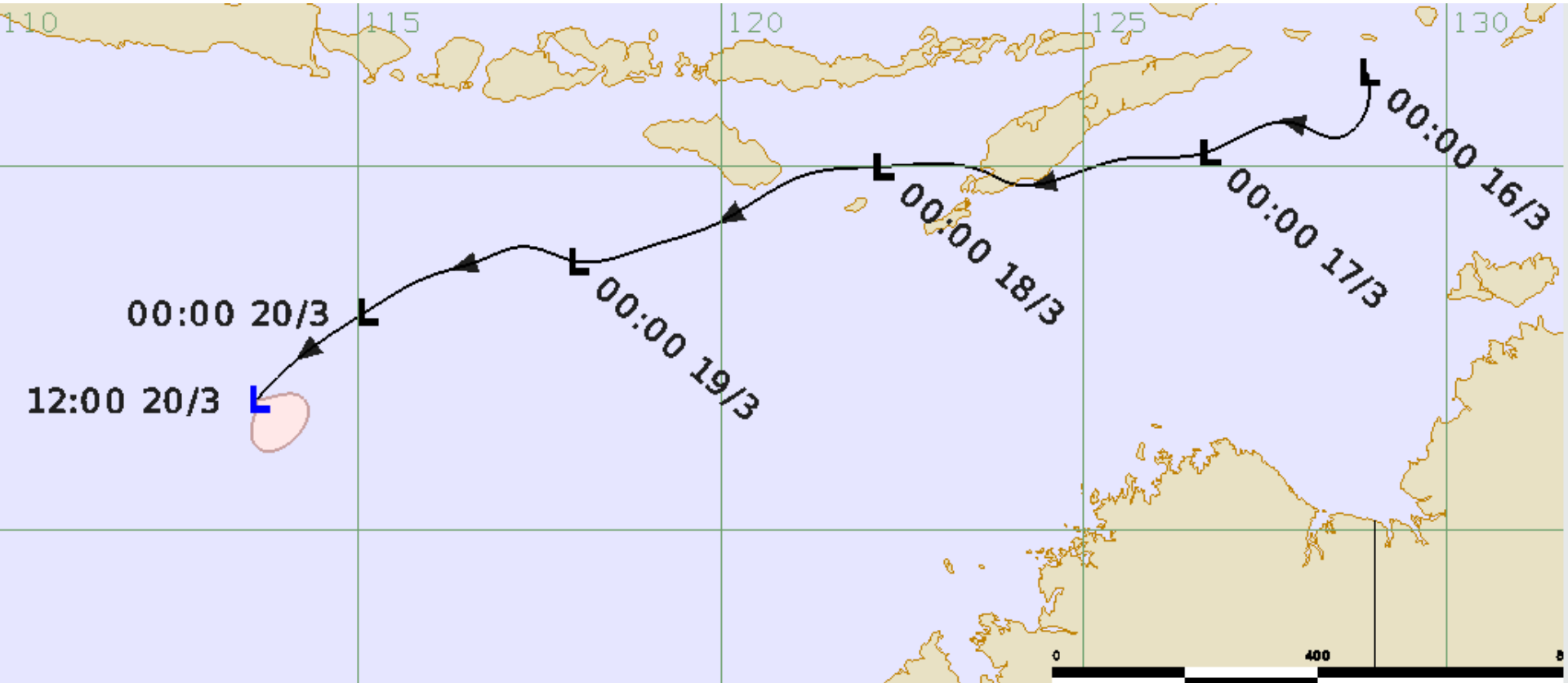
Bureau of Meteorology

Pre-TC Charlotte 12UTC 20 March 2022

Been under easterly shear restricting development but has developed in past 24h over open waters
Varying NWP guidance on intensity



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Charlotte to 20/12UTC

IR hourly loop 19/11-20/12UTC March 2022

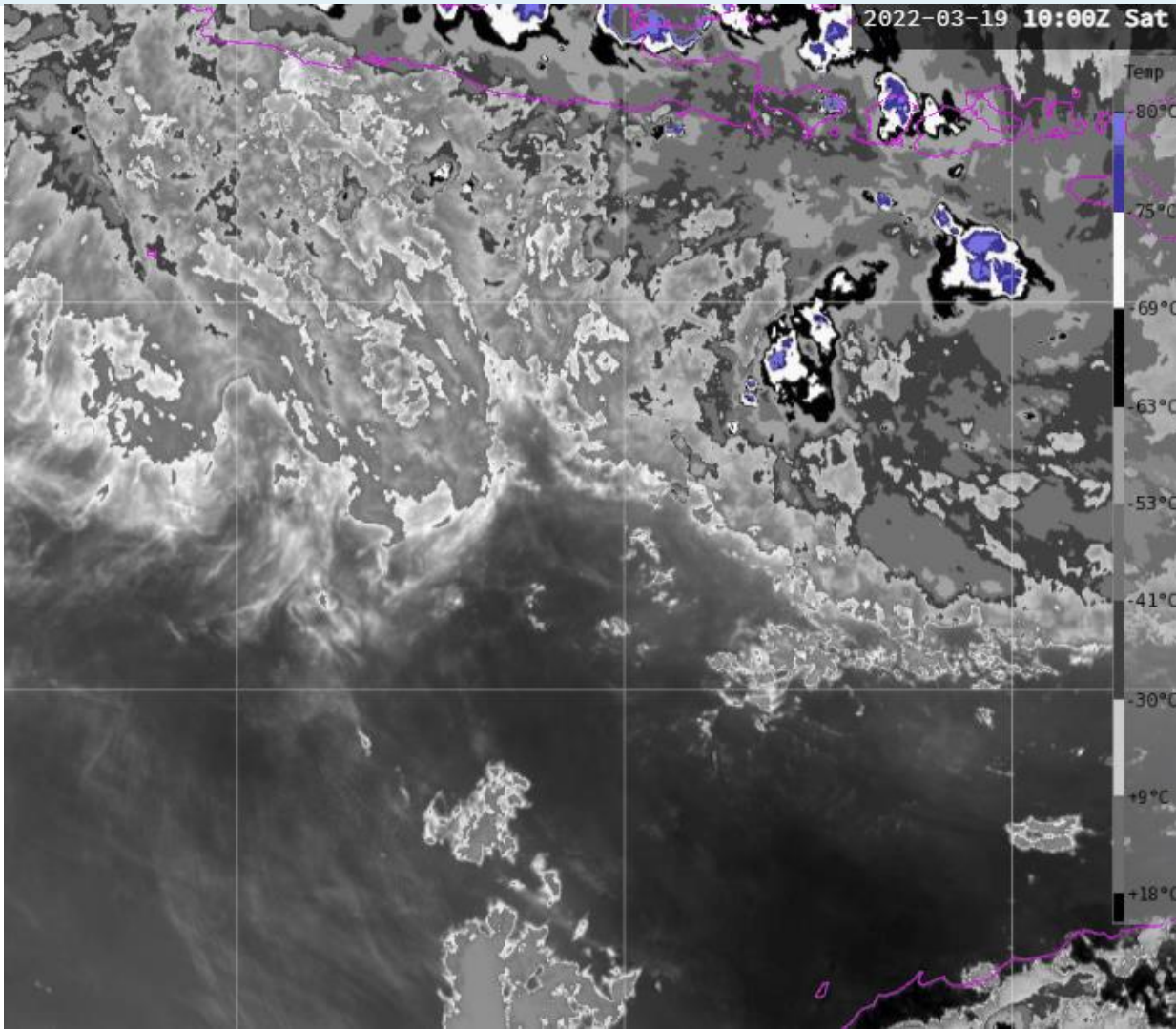
Developing?

Curved banding?

More convection?

Eye?

Development through diurnal min?



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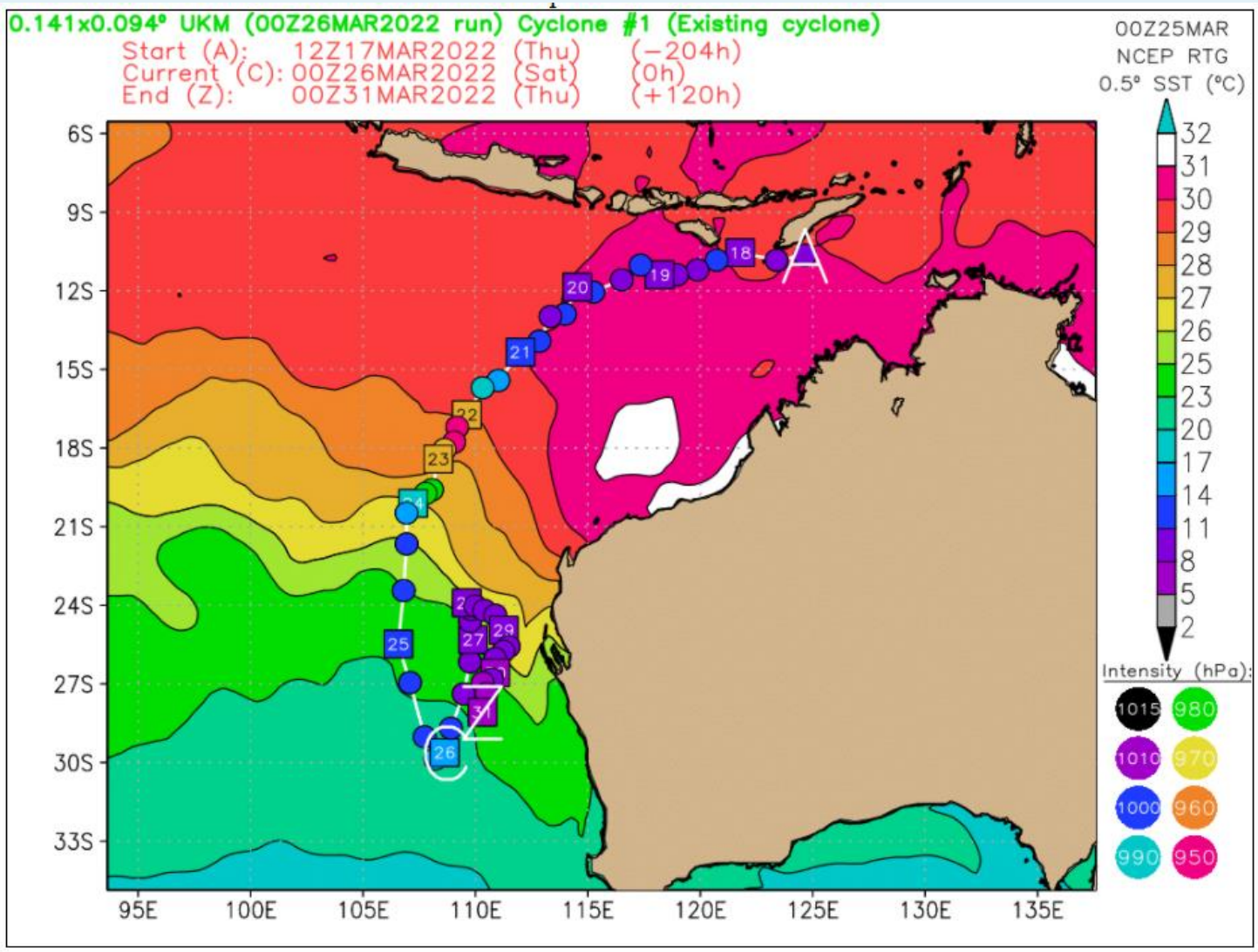
SST for Charlotte
20-22 March >29C

http://moe.met.fsu.edu/cyclonephase/ukm/fcst/archive/22032600/1.html



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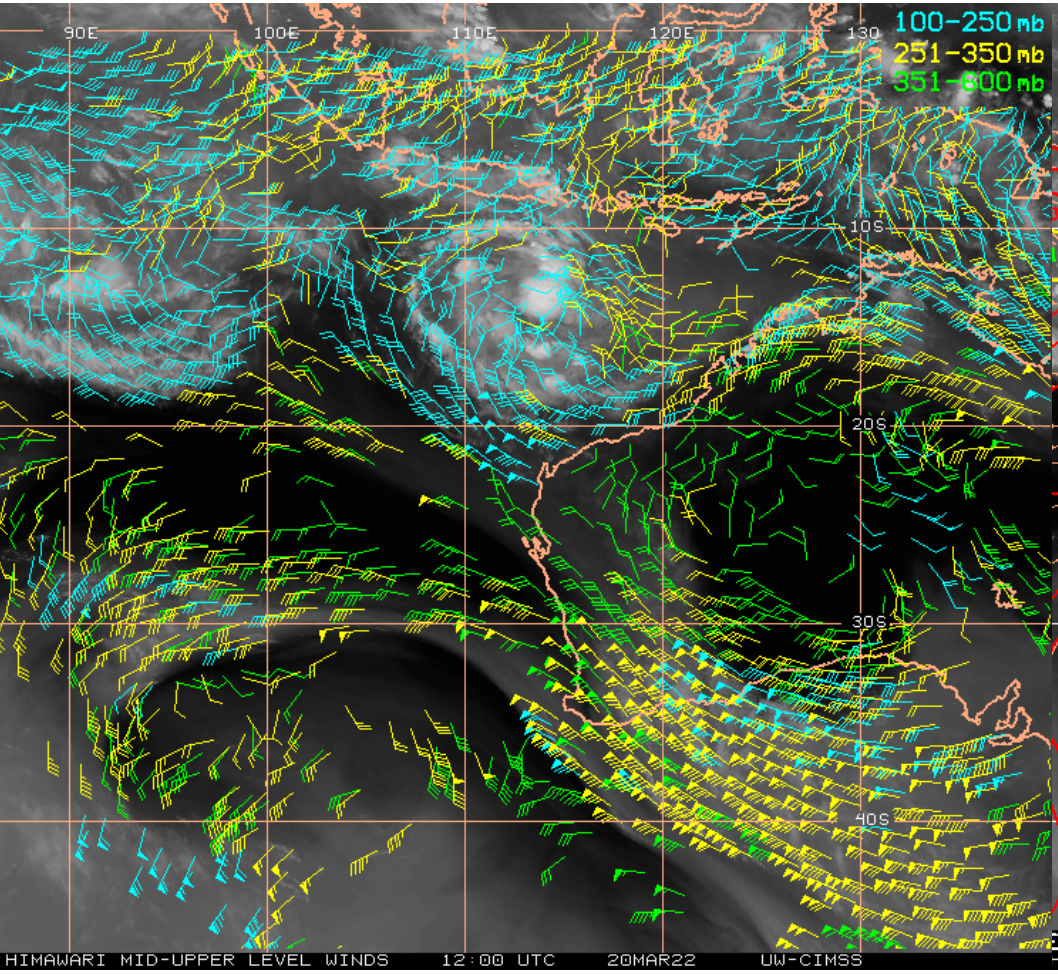
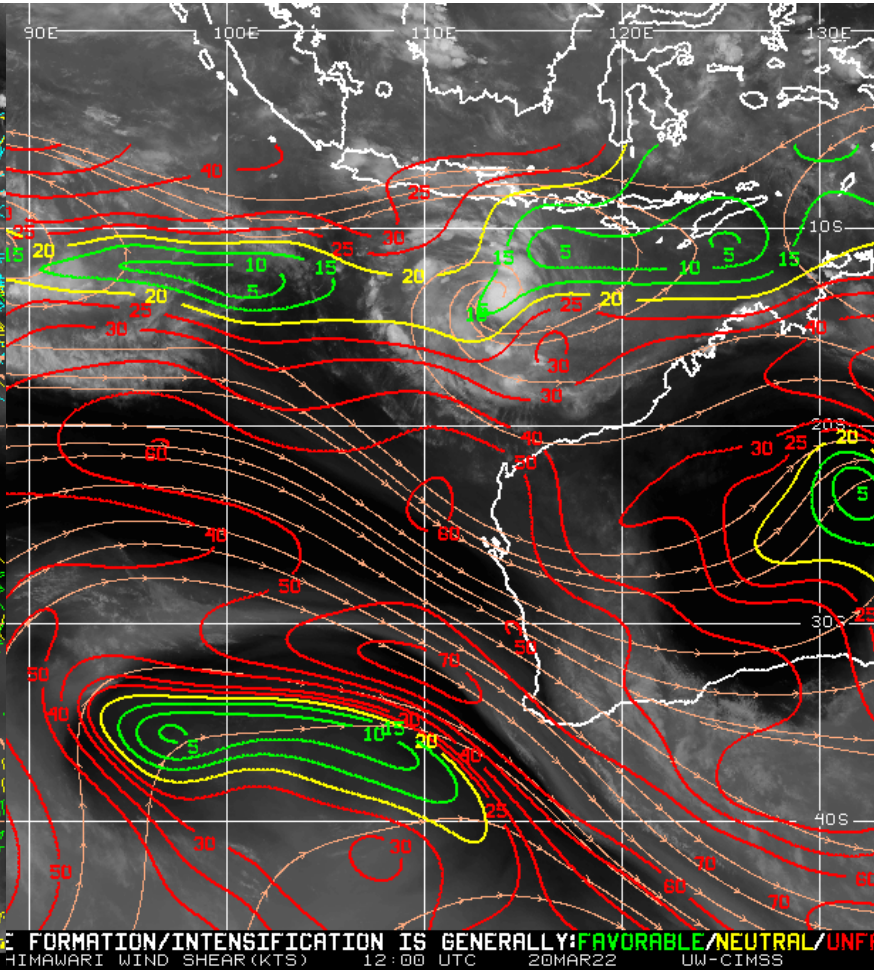
Shear and Upper winds 20/12UTC

Strong poleward outflow, Easterly shear now low





https://tropic.ssec.wisc.edu/archive/data/Australia/20220320/MidUpperWindsLargeWest/20220320.12.Australia.MidUpperWindsLargeWest.png
https://tropic.ssec.wisc.edu/archive/data/Australia/20220320/DeepShearLargeWest/20220320.12.Australia.DeepShearLargeWest.png

TC Charlotte 20/12UTC

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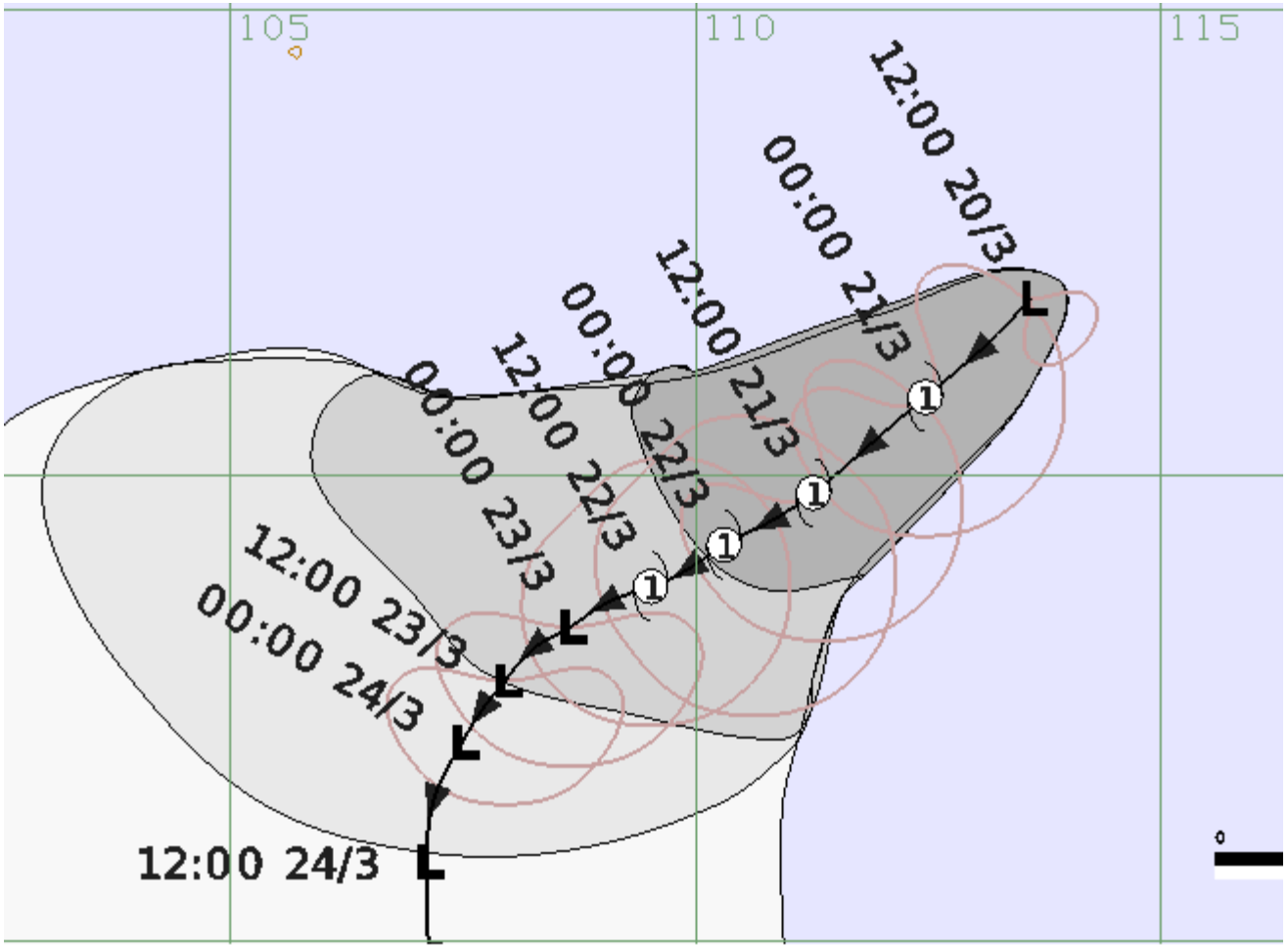
Forecast: TC in +12h but not further intensification

Reflecting NWP guidance (EC weak but others stronger)



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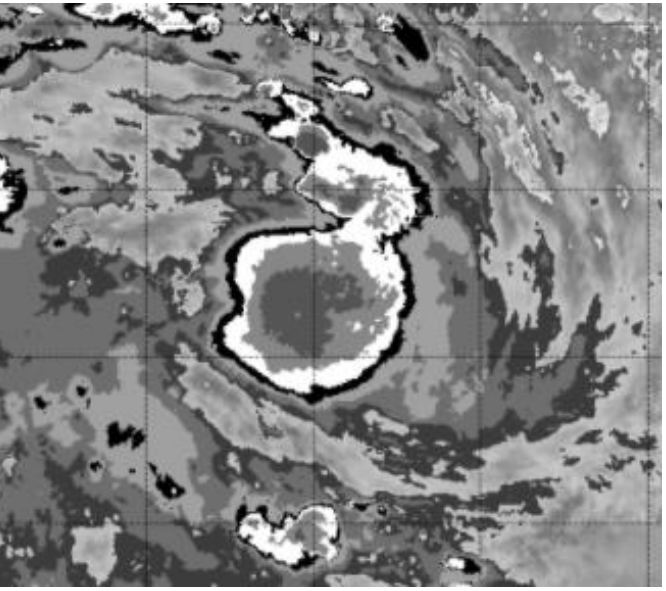
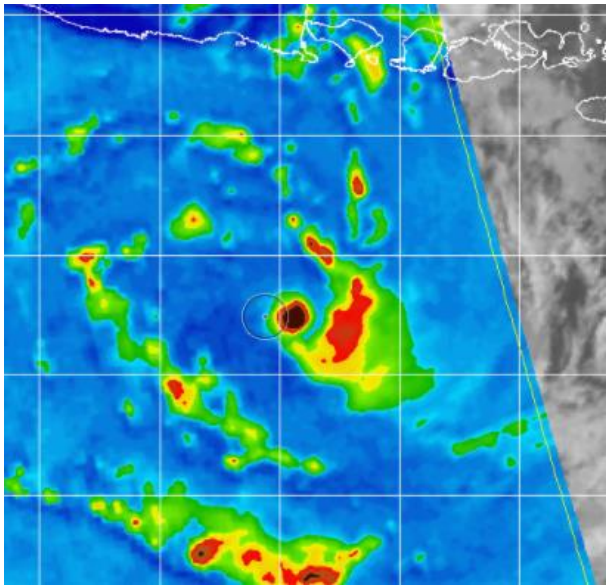
Pre-Charlotte 20/12UTC

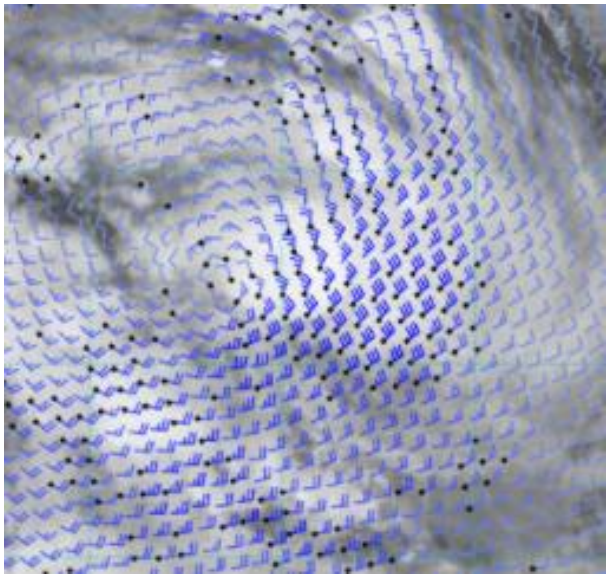
EIR 20/12UTC



SSMIS 0935UTC



HY2B 1031UTC



Dvorak: curvature? Can't use embedded centre; X shear pattern

Adj MET 2.5 (+1.5/24h)

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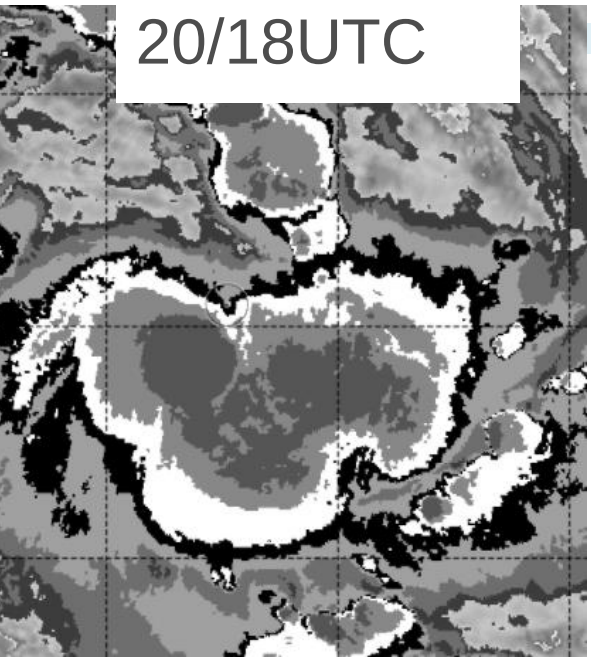
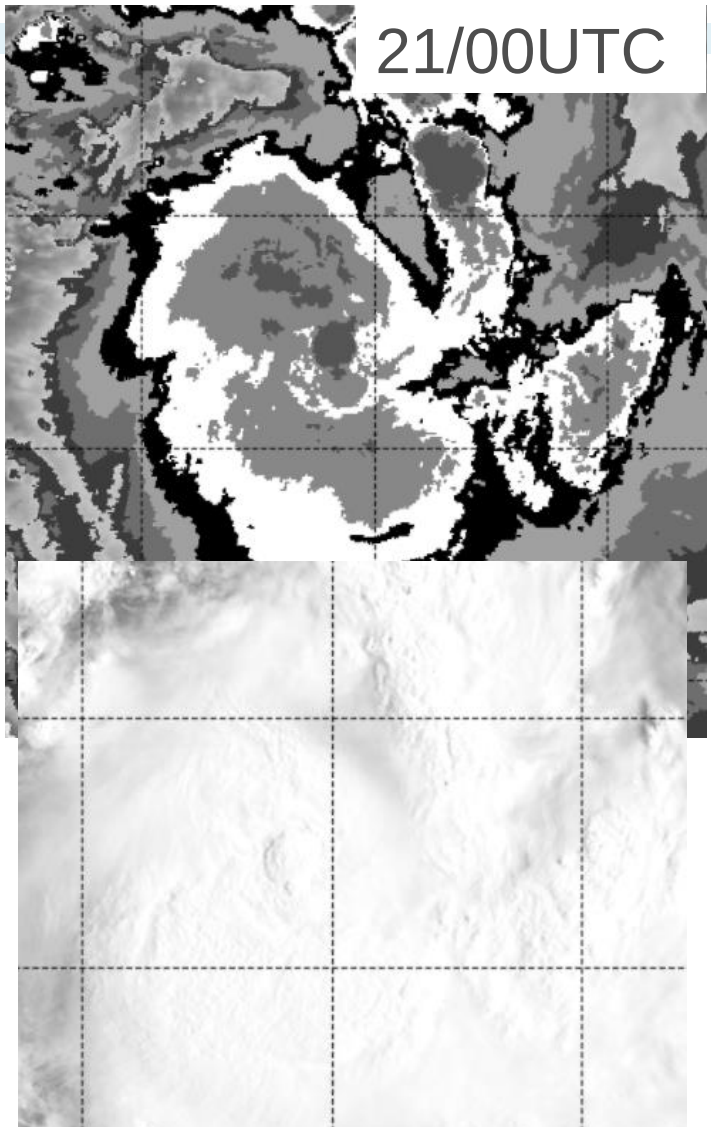
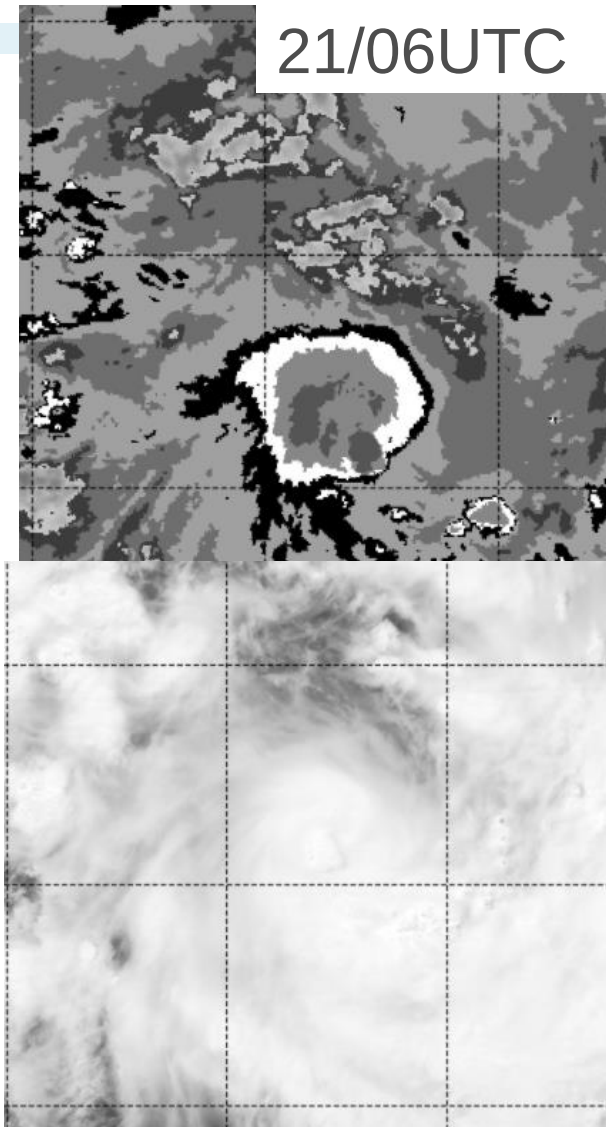
IR 6h series 20/18 to 22/06UTC







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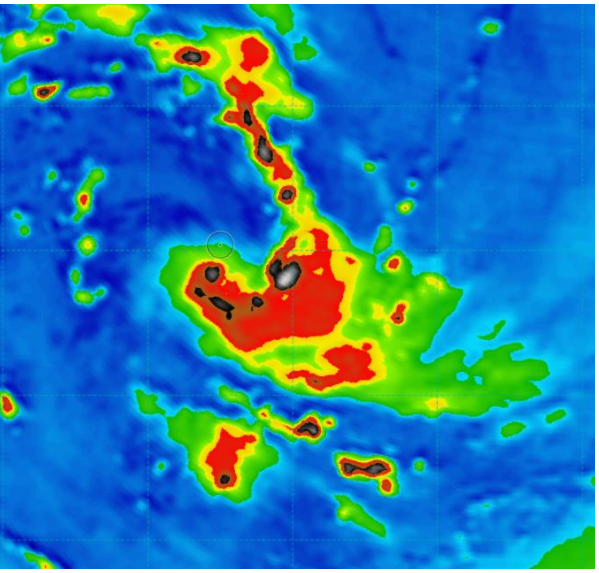
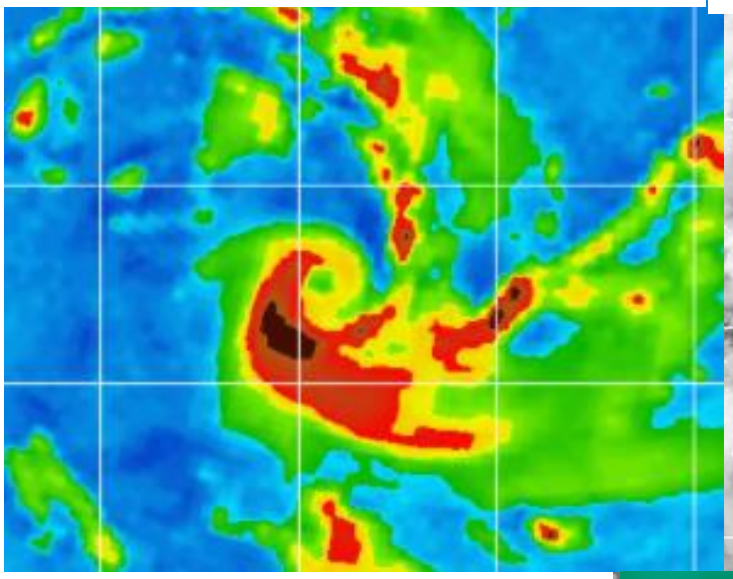
Microwave series 20/18 to 21/06UTC

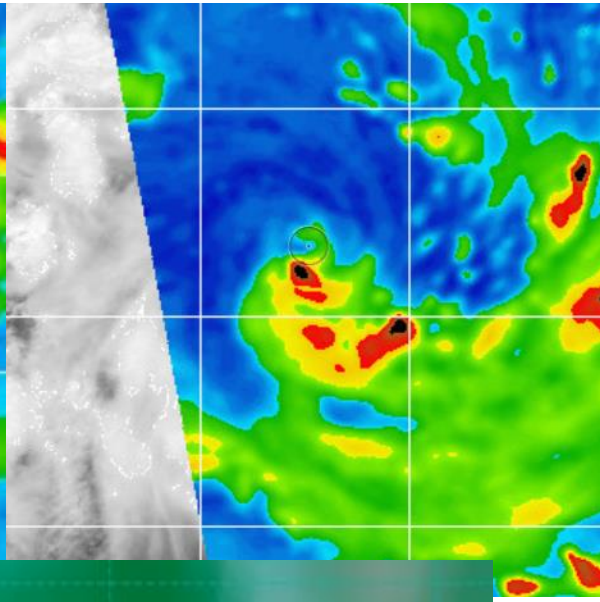
AMSR2 20/1736UTC



SSMIS 20/2250UTC



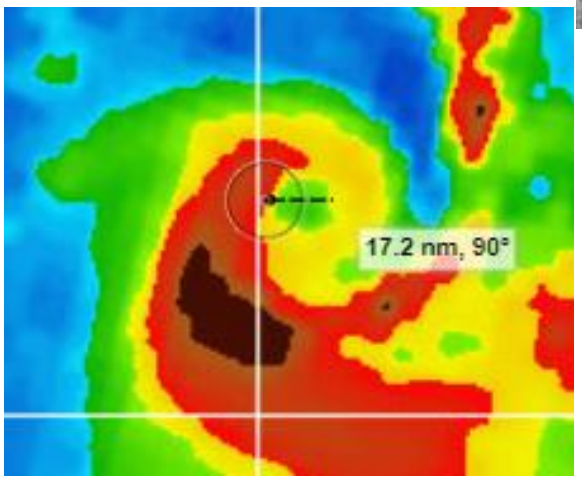
SSMIS 21/0552UTC

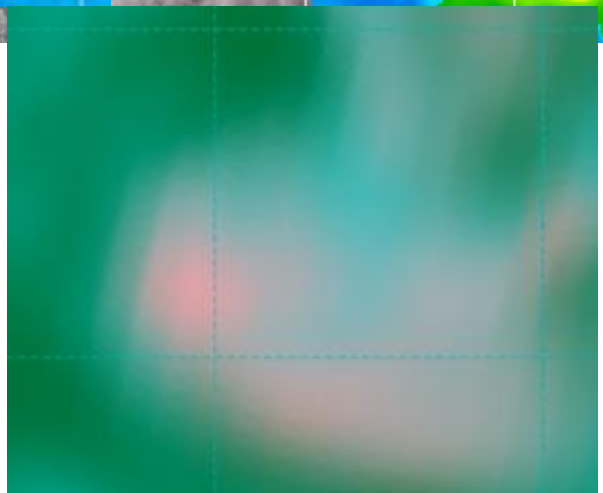


Small inner core

RMW<10nm

Detect Vm?





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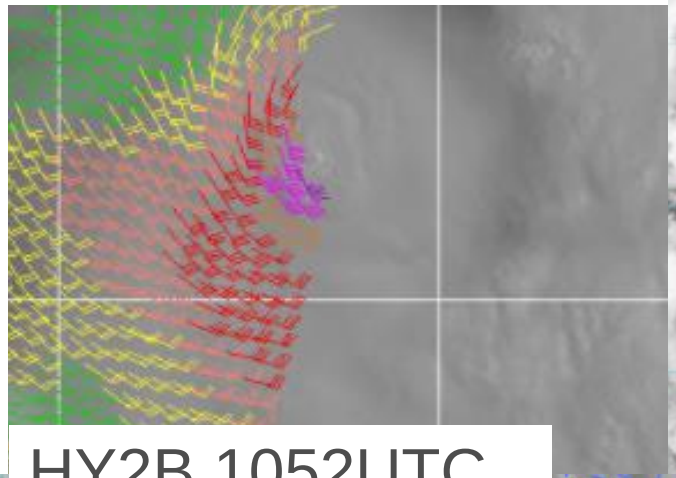
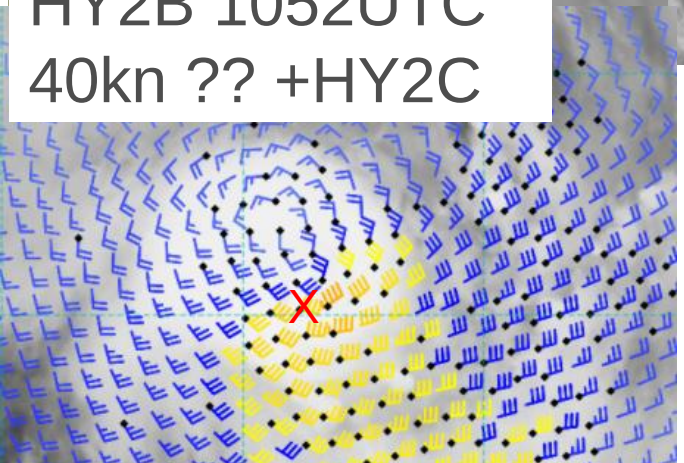
Scatterometry/Radiometry 21 Mar

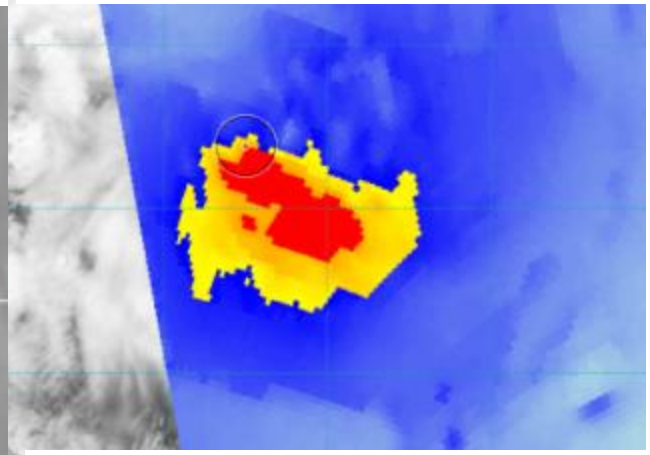
ASCATC 0144UTC
45kn



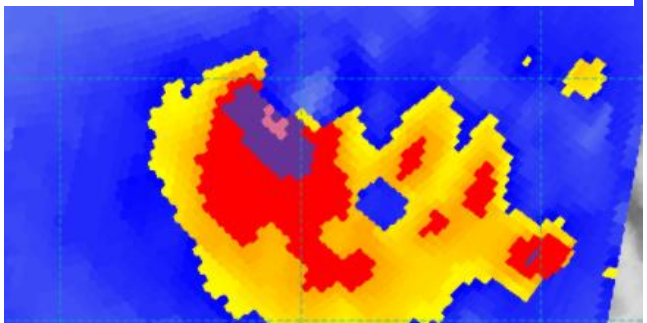
HY2B 1052UTC
40kn ?? +HY2C



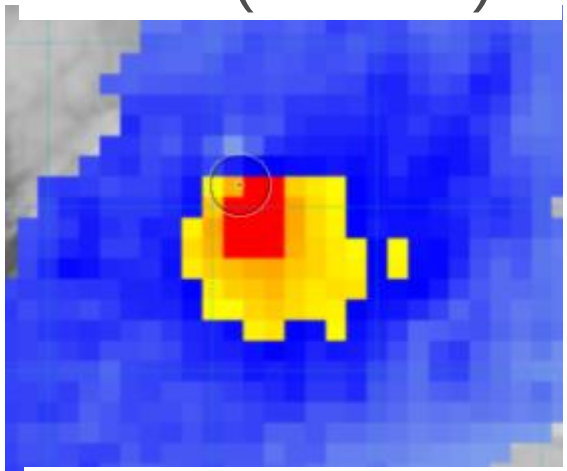
AMSR2 0550UTC
>50kn



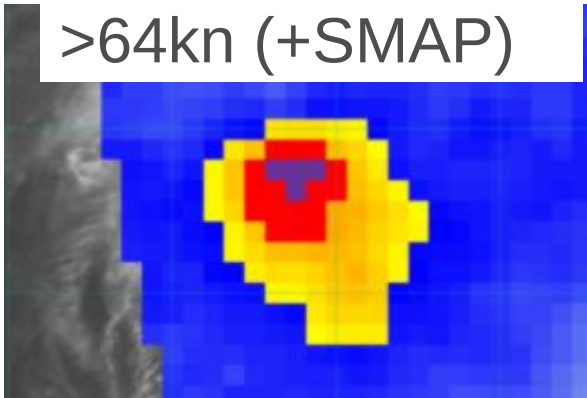
AMSR2 1820UTC
>80kn



SMOS 1021UTC
>50kn (+SMAP)



SMOS 2244UTC
>64kn (+SMAP)



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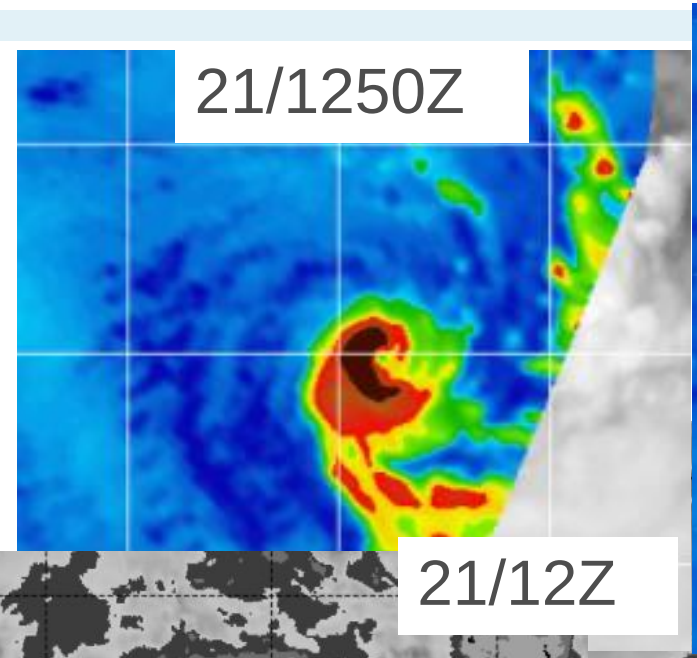
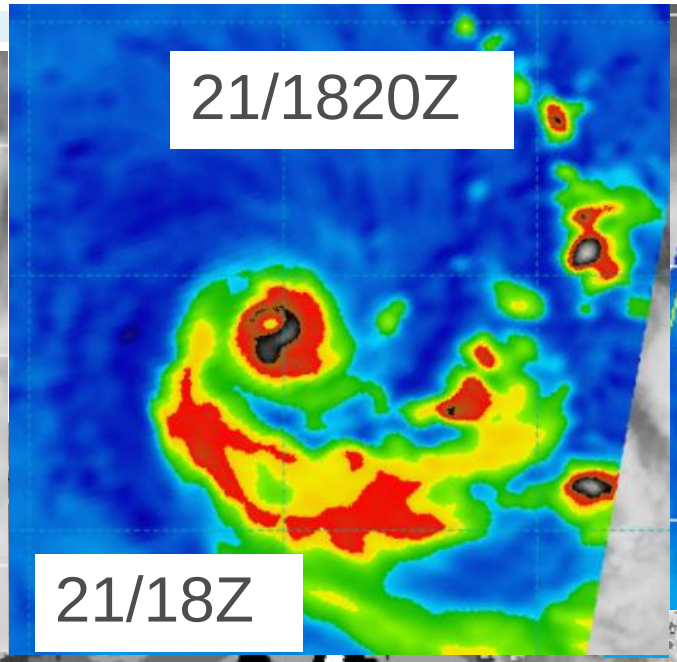
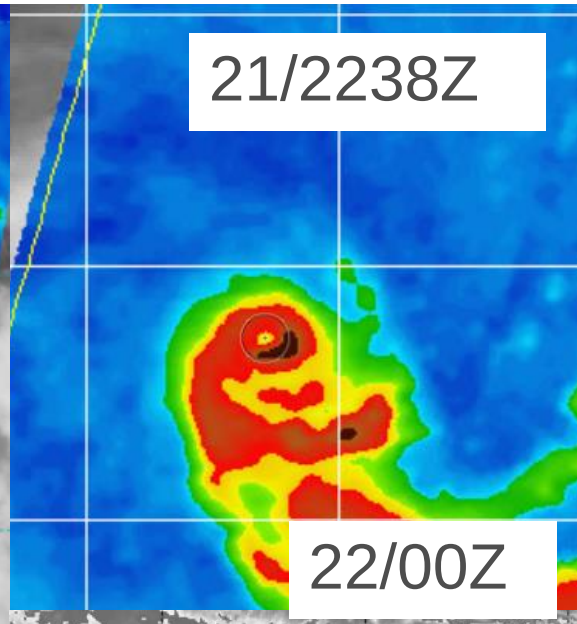
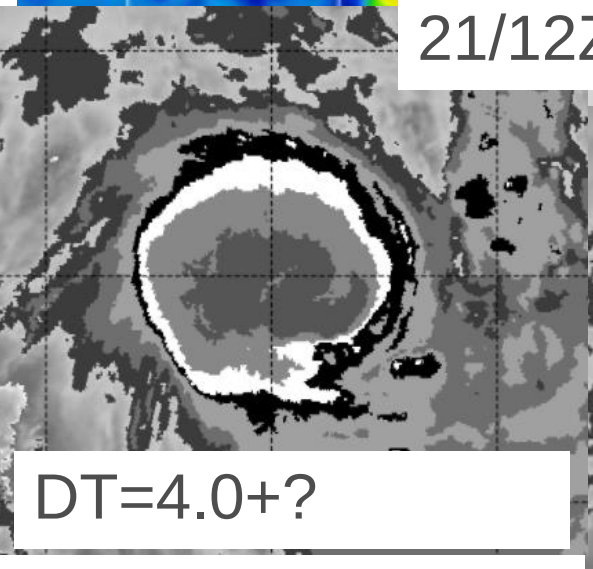
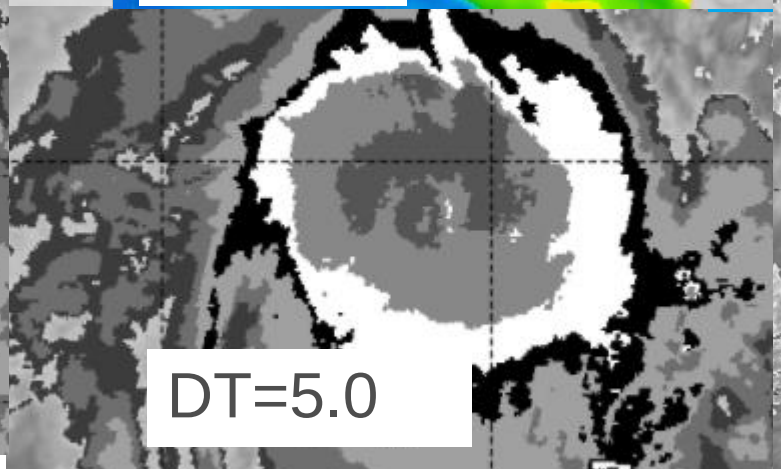
21 Feb eye pattern?
Vmax=90kn (CI=5.5)

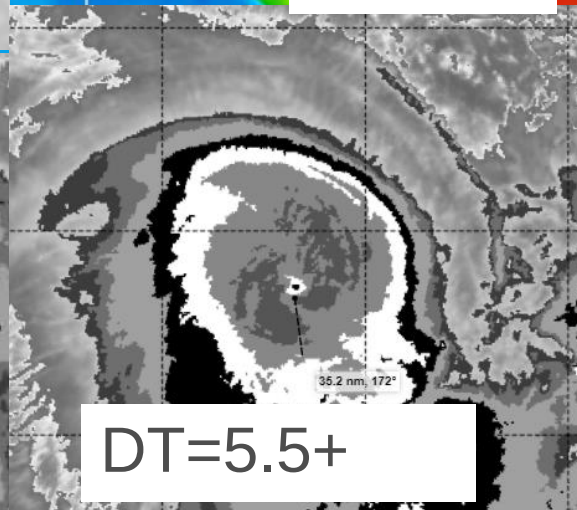












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Objective guidance: no CIMSS ADT/SATCON/AiDT available NESDIS ADT underestimate

22/00UTC CI=4.8 but when eye pattern detected raw T no. =6.4

Small systems!!!

2022MAR21	120000	4.3	981.8	72.2	4.3	4.3	3.2	MW	ON	OFF	OFF	-68.61	-65.42	UNIFRM	N/A	20.1	-15.80	-110.80	FCST	HIM-8 38.9
2022MAR21	123000	4.4	980.0	74.6	4.4	4.4	3.2	MW	ON	OFF	OFF	-68.61	-64.19	UNIFRM	N/A	20.1	-15.84	-110.76	FCST	HIM-8 38.9
2022MAR21	130000	4.4	980.0	74.6	4.4	4.4	3.3	MW	ON	OFF	OFF	-76.16	-69.55	UNIFRM	N/A	20.1	-15.86	-110.42	FCST	HIM-8 39.3
2022MAR21	133000	4.4	980.0	74.6	4.4	4.4	3.3	MW	ON	OFF	OFF	-72.60	-68.31	UNIFRM	N/A	20.1	-15.91	-110.37	FCST	HIM-8 39.3
2022MAR21	140000	4.4	980.0	74.6	4.4	4.4	3.3	MW	ON	OFF	OFF	-78.01	-68.47	UNIFRM	N/A	20.1	-15.95	-110.33	FCST	HIM-8 39.4
2022MAR21	143000	4.4	980.0	74.6	4.4	4.4	3.3	MW	ON	OFF	OFF	-77.64	-68.71	UNIFRM	N/A	20.1	-16.00	-110.29	FCST	HIM-8 39.5
2022MAR21	150000	4.5	978.2	77.0	4.5	4.5	3.4	MW	ON	OFF	OFF	-75.69	-68.08	UNIFRM	N/A	20.1	-16.04	-110.24	FCST	HIM-8 39.5
2022MAR21	153000	4.5	978.2	77.0	4.5	4.5	3.4	MW	ON	OFF	OFF	-74.98	-69.06	UNIFRM	N/A	20.1	-16.09	-110.20	FCST	HIM-8 39.6
2022MAR21	160000	4.5	978.2	77.0	4.5	4.5	3.5	MW	ON	OFF	OFF	-73.49	-70.15	UNIFRM	N/A	20.1	-16.13	-110.16	FCST	HIM-8 39.7
2022MAR21	163000	4.5	978.1	77.0	4.5	4.5	3.5	MW	ON	OFF	OFF	-74.98	-71.15	UNIFRM	N/A	20.1	-16.18	-110.12	FCST	HIM-8 39.7
2022MAR21	170000	4.5	978.1	77.0	4.5	4.5	3.6	MW	ON	OFF	OFF	-76.04	-74.44	UNIFRM	N/A	20.1	-16.22	-110.08	FCST	HIM-8 39.8
2022MAR21	173000	4.6	976.2	79.6	4.6	4.6	3.7	MW	ON	OFF	OFF	-76.29	-75.44	UNIFRM	N/A	20.1	-16.26	-110.04	FCST	HIM-8 39.8
2022MAR21	180000	4.6	976.2	79.6	4.6	4.6	3.8	MW	ON	OFF	OFF	-74.98	-75.59	UNIFRM	N/A	20.1	-16.35	-109.84	SPRL	HIM-8 40.1
2022MAR21	183000	4.6	976.2	79.6	4.6	4.6	3.9	MW	ON	OFF	OFF	-73.15	-75.92	UNIFRM	N/A	20.1	-16.39	-109.70	SPRL	HIM-8 40.2
2022MAR21	190000	4.6	974.2	79.6	4.6	4.6	3.9	MW	ON	OFF	OFF	-72.82	-76.14	UNIFRM	N/A	20.1	-16.28	-109.62	SPRL	HIM-8 40.3
2022MAR21	193000	4.6	974.1	79.6	4.6	4.6	3.9	MW	HOLD	OFF	OFF	-71.09	-76.36	UNIFRM	N/A	20.1	-16.41	-109.58	SPRL	HIM-8 40.4
2022MAR21	200000	4.6	974.2	79.6	4.6	4.6	3.8	MW	HOLD	OFF	OFF	-69.32	-76.33	UNIFRM	N/A	20.1	-16.34	-109.65	SPRL	HIM-8 40.3
2022MAR21	203000	4.6	974.1	79.6	4.6	4.6	3.8	MW	HOLD	OFF	OFF	-64.97	-75.66	UNIFRM	N/A	20.1	-16.47	-109.71	SPRL	HIM-8 40.3
2022MAR21	213000	4.6	974.1	79.6	4.6	4.6	6.4	MW	HOLD	OFF	OFF	-25.09	-77.58	EYE/P	-99 IR	16.1	-16.42	-109.53	SPRL	HIM-8 40.4
2022MAR21	220000	4.6	974.1	79.6	4.6	4.6	[illegible]	MW	HOLD	OFF	OFF	-62.55	-77.37	[illegible]	N/A	16.1	-16.55	-109.49	SPRL	HIM-8 40.5
2022MAR21	223000	4.6	974.1	79.6	4.6	4.6	6.4	MW	HOLD	OFF	OFF	-27.67	-77.75	EYE/P	-99 IR	16.1	-16.57	-109.45	SPRL	HIM-8 40.6
2022MAR21	230000	4.6	974.1	79.6	4.6	4.6	6.4	MW	HOLD	OFF	OFF	-27.34	-77.69	EYE/P	-99 IR	24.9	-16.60	-109.41	SPRL	HIM-8 40.6
2022MAR21	233000	4.8	970.2	84.8	4.8	5.0	6.3	MW	AdjEnd	OFF	OFF	-28.17	-77.28	EYE/P	-99 IR	24.9	-16.62	-109.48	SPRL	HIM-8 40.6
2022MAR22	000000	4.8	970.2	84.8	4.7	4.1	[illegible]	NO	LIMIT	ON	OFF	-68.61	-77.00	[illegible]	N/A	24.9	-16.55	-109.33	SPRL	HIM-8 40.7
[illegible]																				

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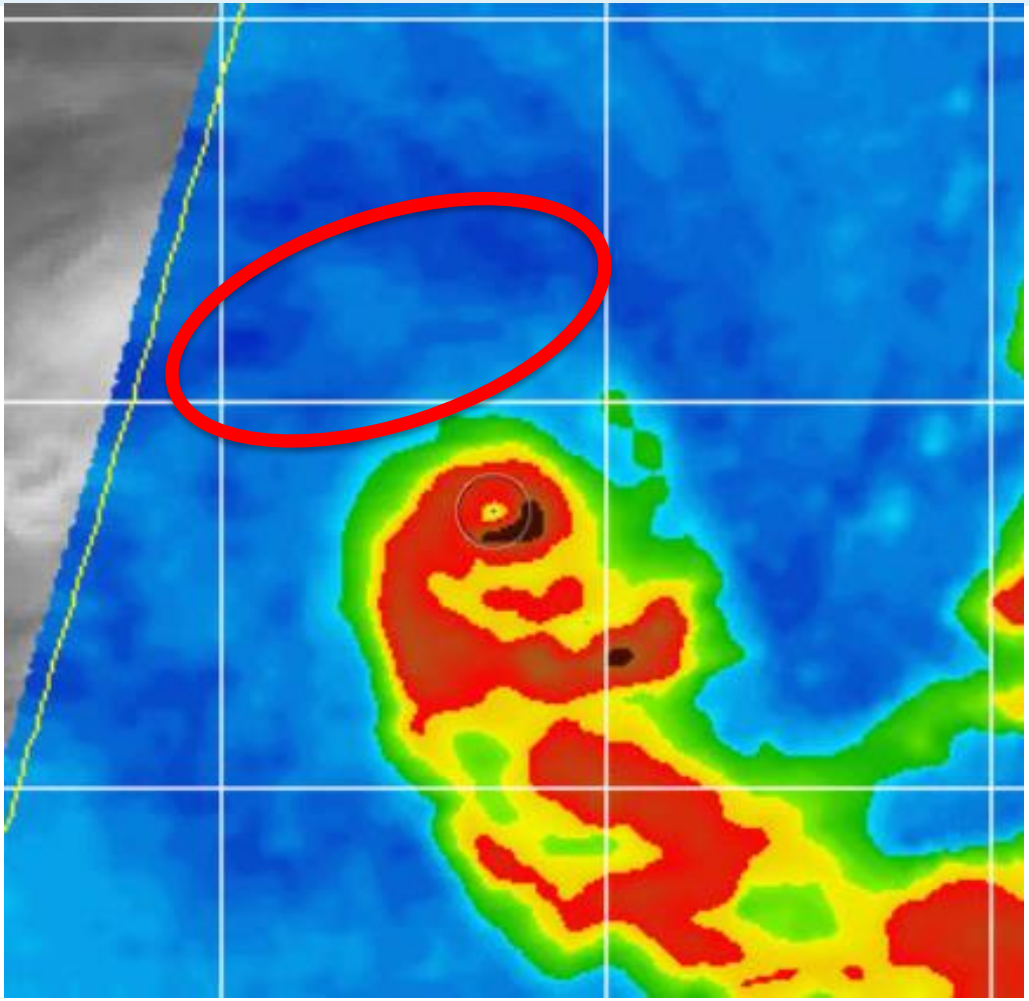
Charlotte part 2

What does this mean?



Shear and Upper winds 22/18UTC

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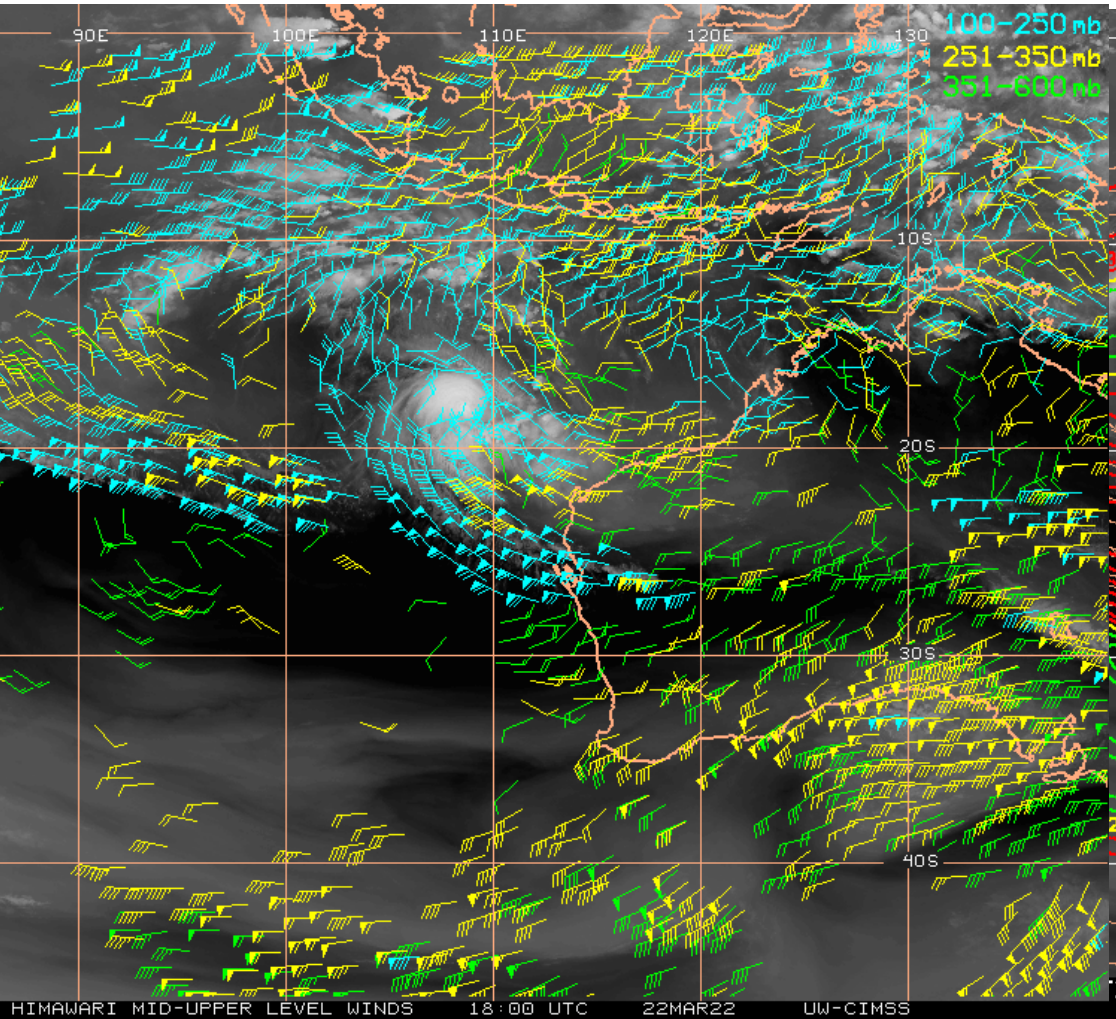
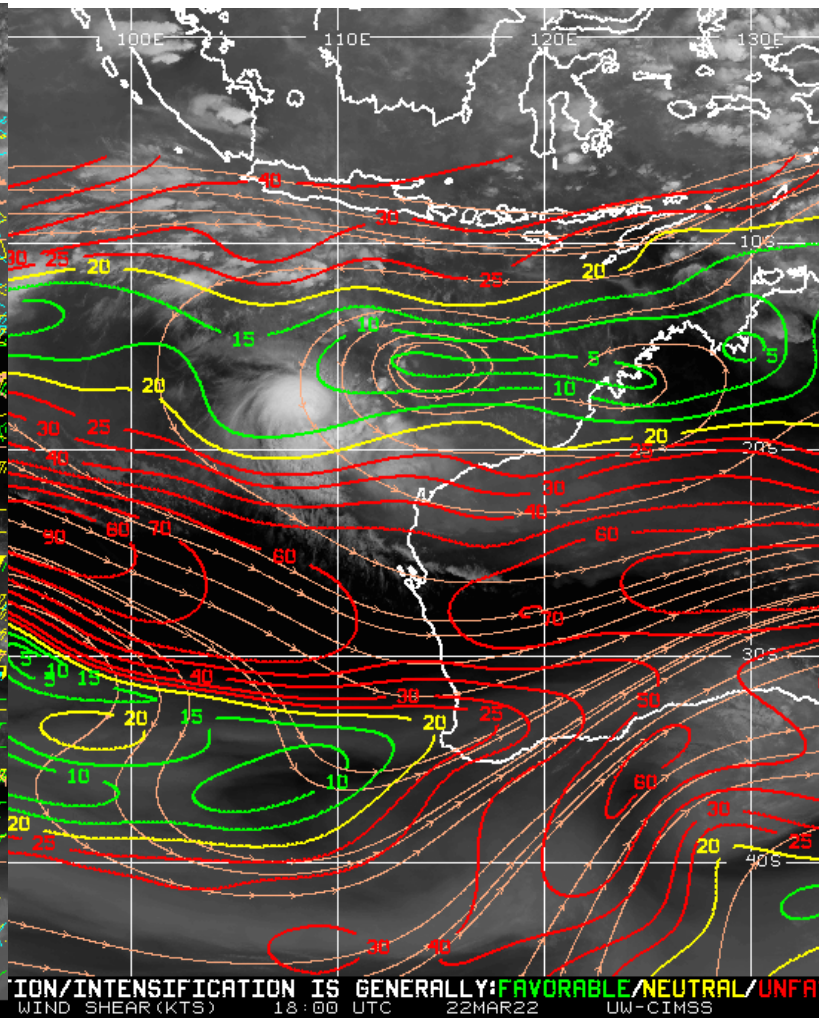
Strong poleward outflow;
15kn northerly shear - what will this do?





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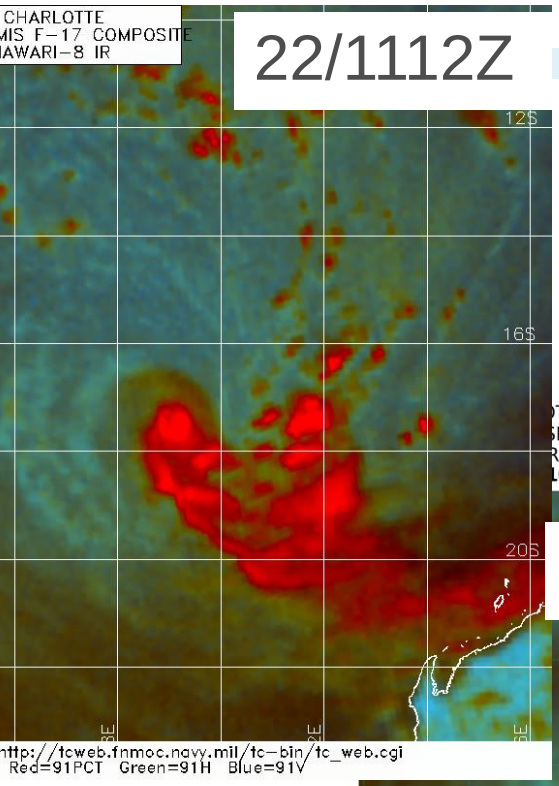
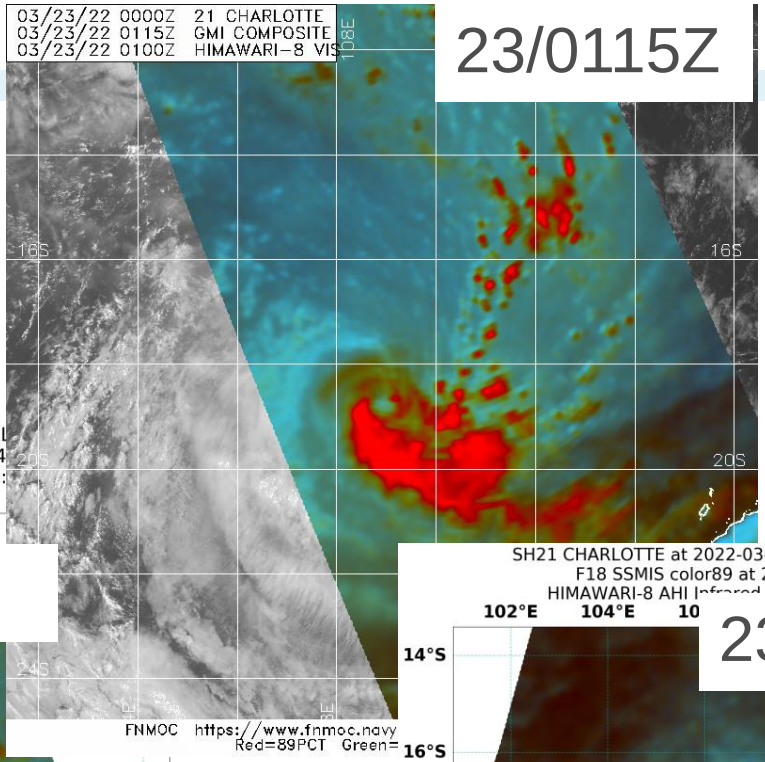
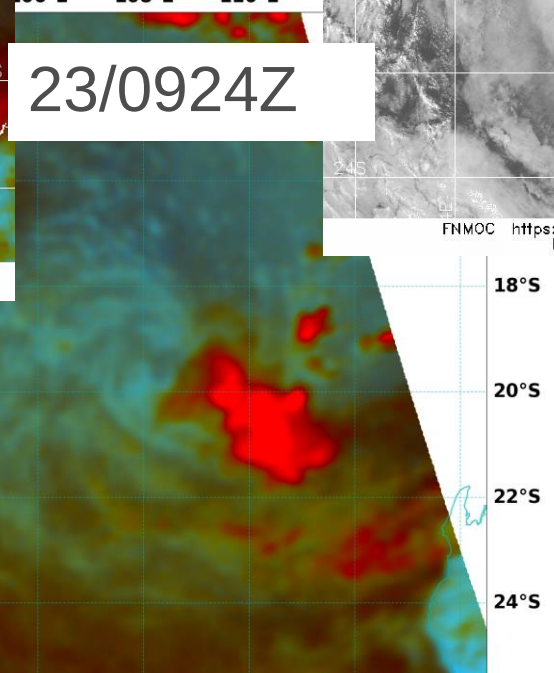
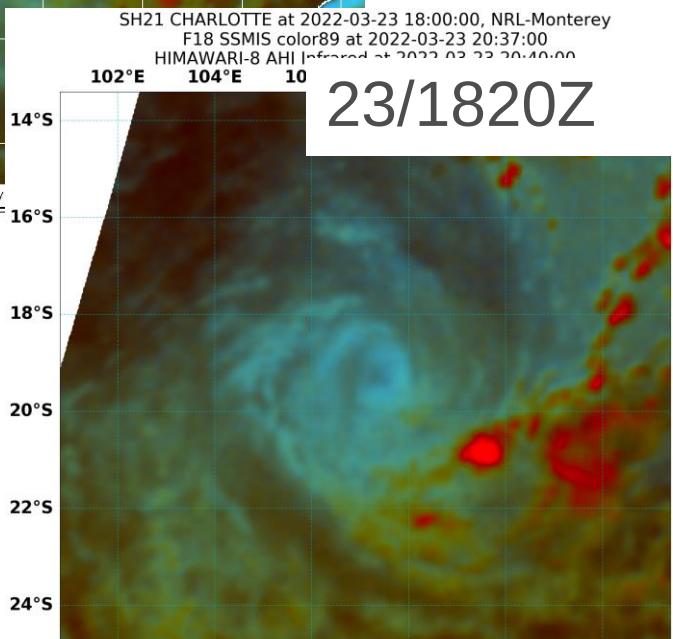
22-23 Feb weakening









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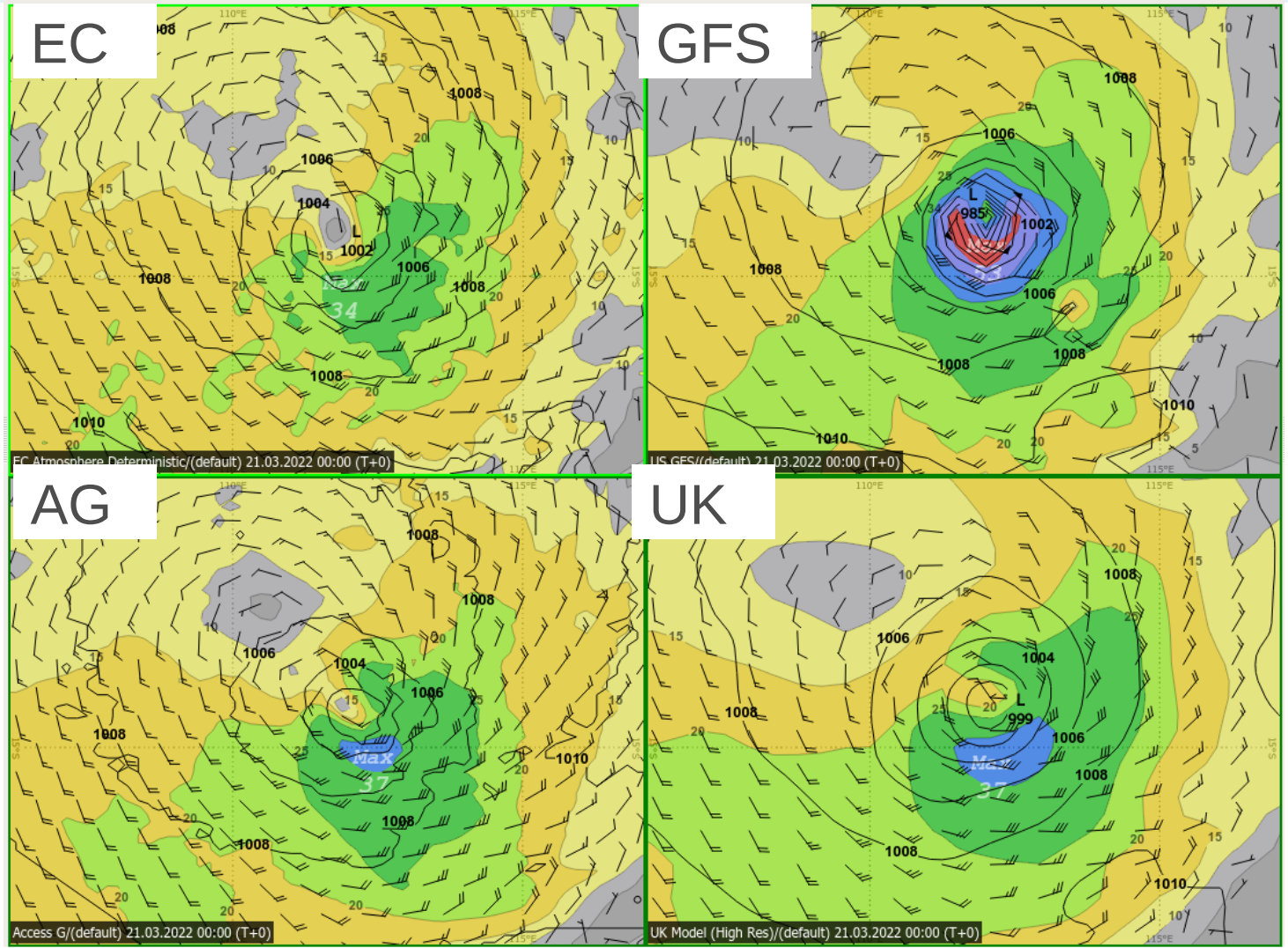
Performance: ECMWF under-estimate 21/00UTC analysis Vm=45kn Forecast varying



Australian Government
Bureau of Meteorology

Summary: Intensification challenges
Vernon 40-100kn/24h
Charlotte 45-90kn/24h

RI literature identifies 50-60kn as onset time but small systems onset in Australian region typically onset 30-45kn when NWP including objective guidance either not available or varying;

Forecasting 'reluctance' to forecast RI prior to TC forming – experience of many non-developers when environments are not that different;

Recognising satellite signals important – use all the information!

Small systems 'fragile' – subtle environmental changes can have a big impact – e.g. Charlotte weakening under 15kn shear

NWP guidance still struggling with these types of systems