The Bureau of Meteorology

12th Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-12)

Satellite applications for Tropical Cyclone Analysis

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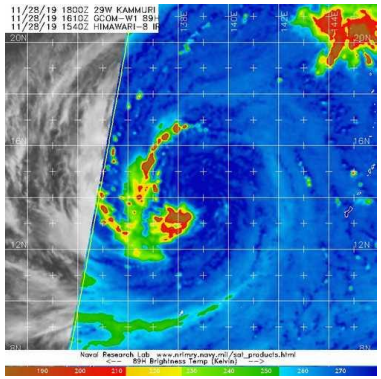
14 November 2022

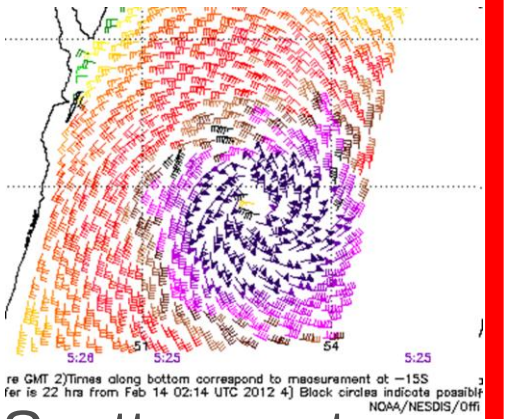
Socrative: socrative.com Student Login

Room: cyclone2022

The analysis challenge



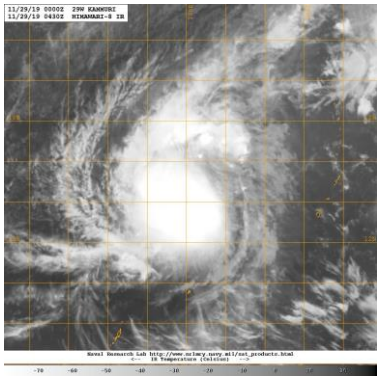
Microwave



Scatterometers
radiometers

radar

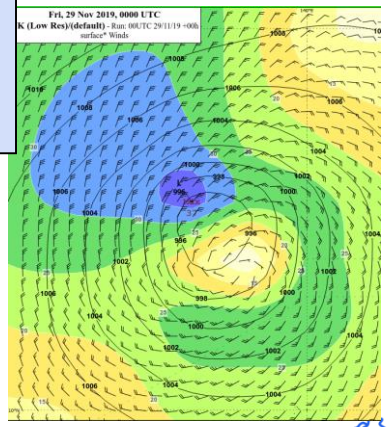
objective
algorithms



Geo
IR/Vis

Analysis
Posn/intensity/structure
[prcp, environment…]

Observations
(sfc/aircraft…)



NWP

Satellites and sensors: used at the Bureau for example but very similar to other TC warning centres

Satellite/sensor	Source	Software	Use	Comments
Geostationary Himawari IR/Vis/WV/RGB/TPW	JMA-BoM CIMSS TPW	BoM platform ('panther') Vis. Weather	Routine RGB occasional	Rapid Scan mode on demand
Scat – ASCAT, others	NOAA STAR NRL/FNMOC	NOAA STAR Internal BoM Vis. Weather KNMI (HY-2B/C)	Routine	Heavily used for developing cases.
SMAP/SMOS	NRL/FNMOC	Internal BoM	Routine	
SAR	NOAA	NOAA	Routine	Hi res but infrequent
AMSR-2	NRL/FNMOC	Internal BoM	Routine	Recently upgraded
Microwave 37; 85-91GHz	NRL/FNMOC CIMSS MIMIC	Internal BoM display CIMSS web	Routine Frequent	Good for positioning and intensity changes

Satellite-based techniques

Technique	Source	Use	Comments
Subjective Dvorak	BoM SAB/JTWC	Routine (3-6h) Comparison	Publish results on Tech Bulletin
ADT	CIMSS NESDIS	Routine	Used for trends; comparison with subjective.
SATCON	CIMSS	Routine	Typically in close agreement
AI: Deep-NET; RI	CIMSS	Test	Evaluation mode
AMV (winds); shear; divergence	CIMSS	Routine	Rapid-scan for sfc winds.
MPERC	NOAA	Occasional	Detecting ERC onset
ARCHER	NRL/FNMOC	Occasional	Only for check of ASCAT pos.
Multi-platform winds	CIRA	Occasional	Less use now with preference to ASCAT/AMSR2/SMAP/SMOS/SAR

QUESTION 1. Positioning

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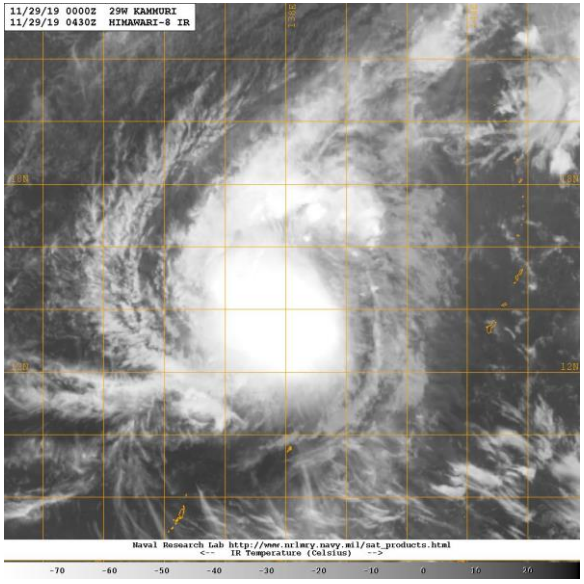
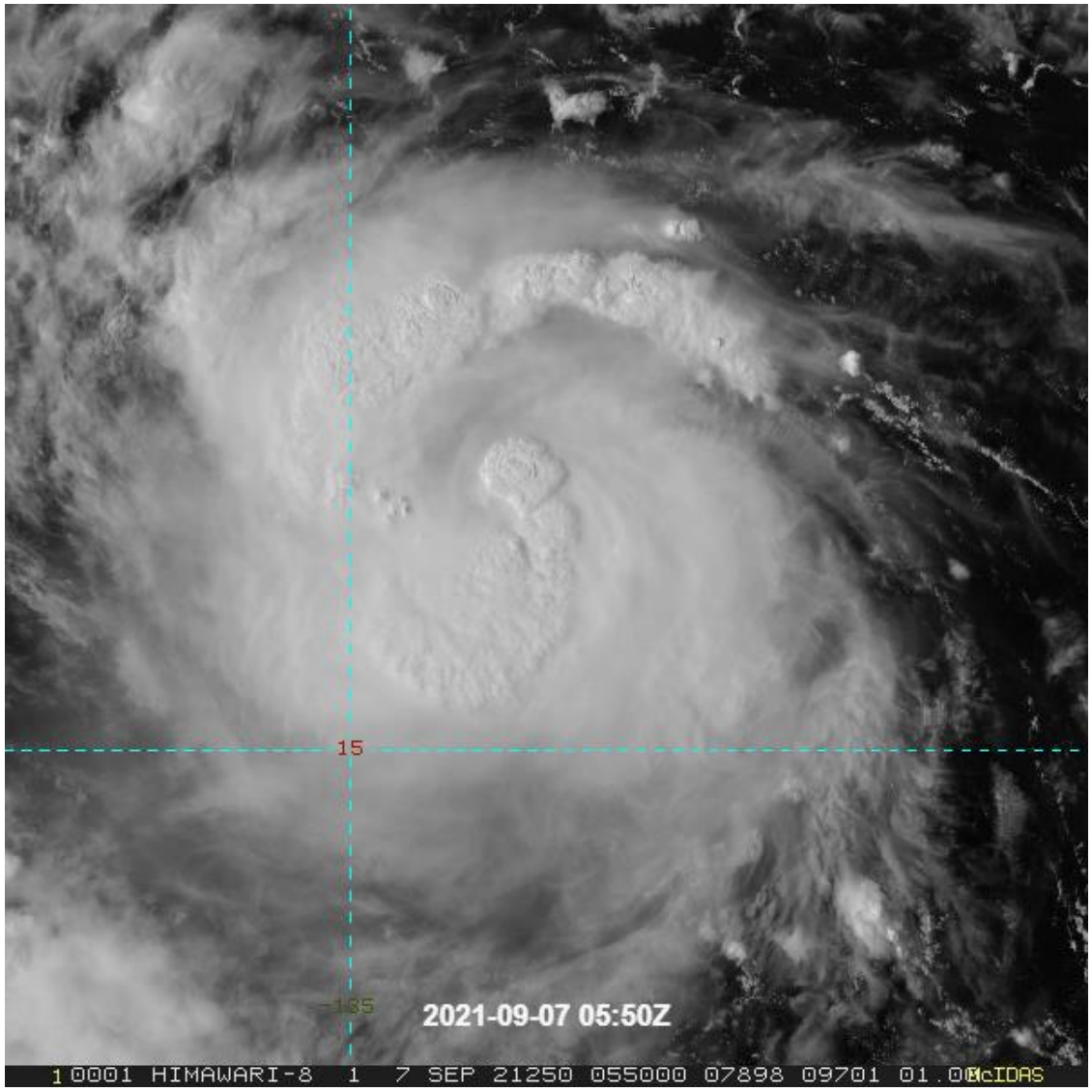
Which of these is useful for finding the centre of a TC?

A. IR
B. Vis
C. Microwave (37 and/or 85-91GHz)
D. Scatterometers (e.g. ASCAT)
E. Radiometers (e.g SMAP/SMOS/AMSR2)
F. All of the above
G. Unsure

Conventional Vis loop





CIRA https://rammb-data.cira.colostate.edu/tc_realtime/loop.asp?product=1kmsrvis&storm_identifier=wp192021&starting_image=2021wp19_1kmsrvis_202109070550.gif&ending

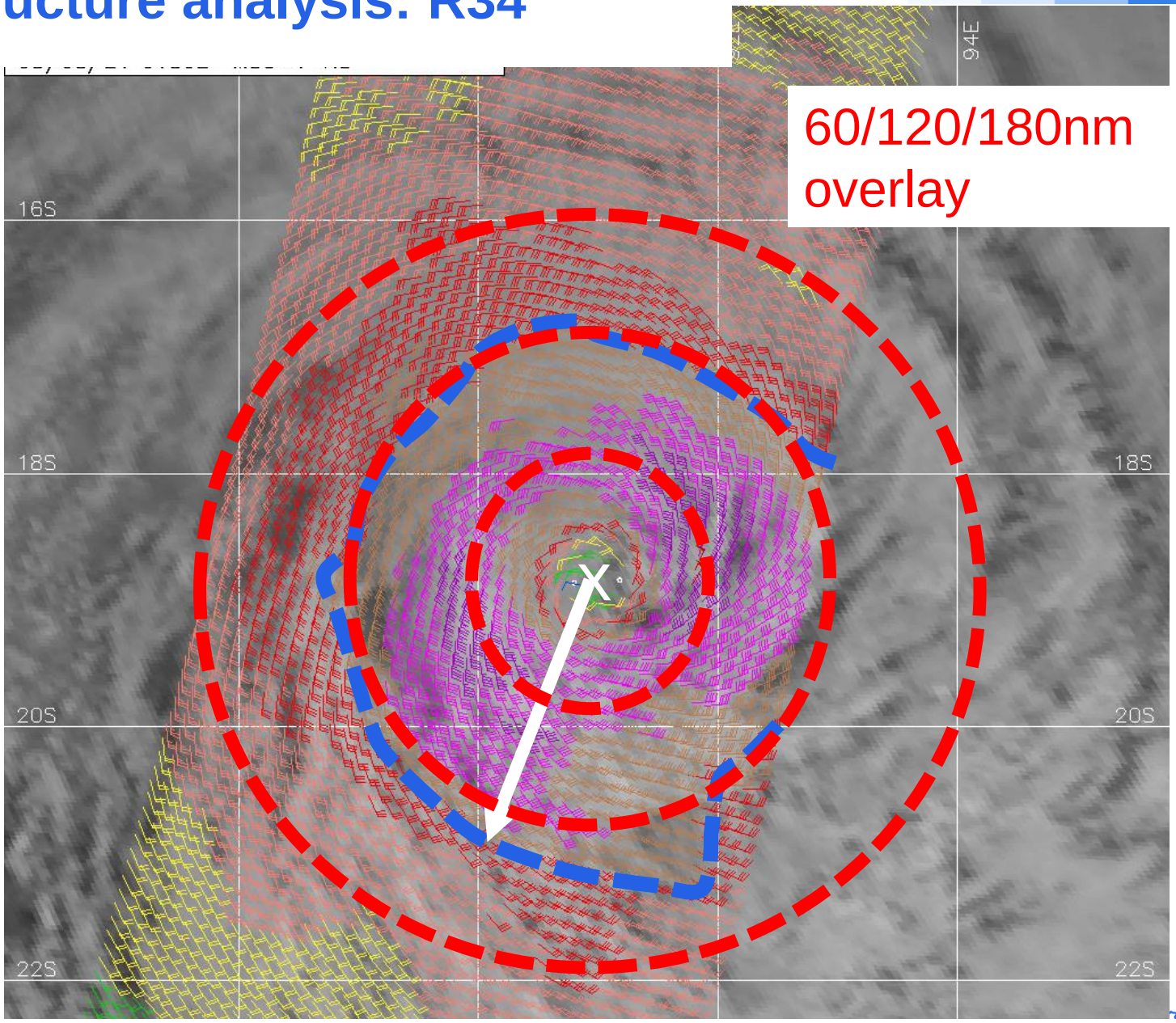
QUESTION 2. Structure

socrative.com Room: CYCLONE2022

When available which is best for determining the gale radii?

A. IR
B. Vis
C. Microwave 37 and/or 85-91GHz
D. ASCAT winds
E. SMAP/SMOS/AMSR2 winds
F. NWP surface winds
G. Unsure

Structure analysis: R34



Marian: ASCAT-A 0142Z 3 March 2021 courtesy NRL

Passive and Active instruments for measuring radiation

Scatterometry: https://learn.bom.gov.au/course/view.php?id=701 key: scatterometer
Microwave: https://learn.bom.gov.au/course/view.php?id=727 key: microwave

Passive Instruments:

– Receive radiation leaving the earth-atmosphere system

– Measure solar radiation reflected by land & atmosphere targets (visible light)

– Measure emitted and scattered IR radiation

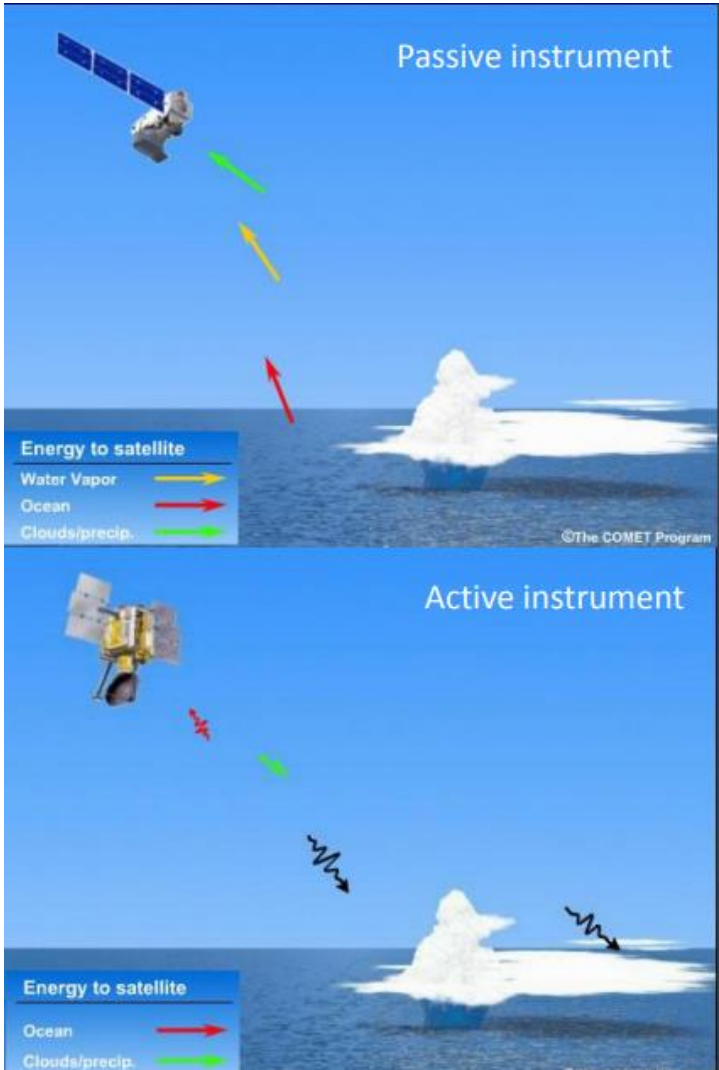
– Measure microwave radiation emission, scattering (ice); emission/absorption (liquid water in clouds) directly related to brightness Temperature

Active Instruments:

– Send out pulses of radiation, usually at microwave frequencies

– Measure radiation returned to the sensor

– eg: radars; scatterometers



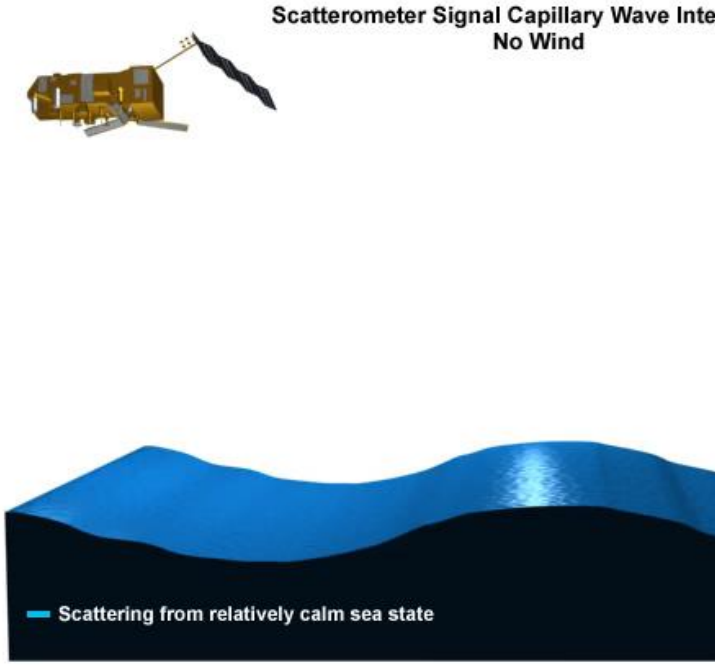
Scatterometry theory

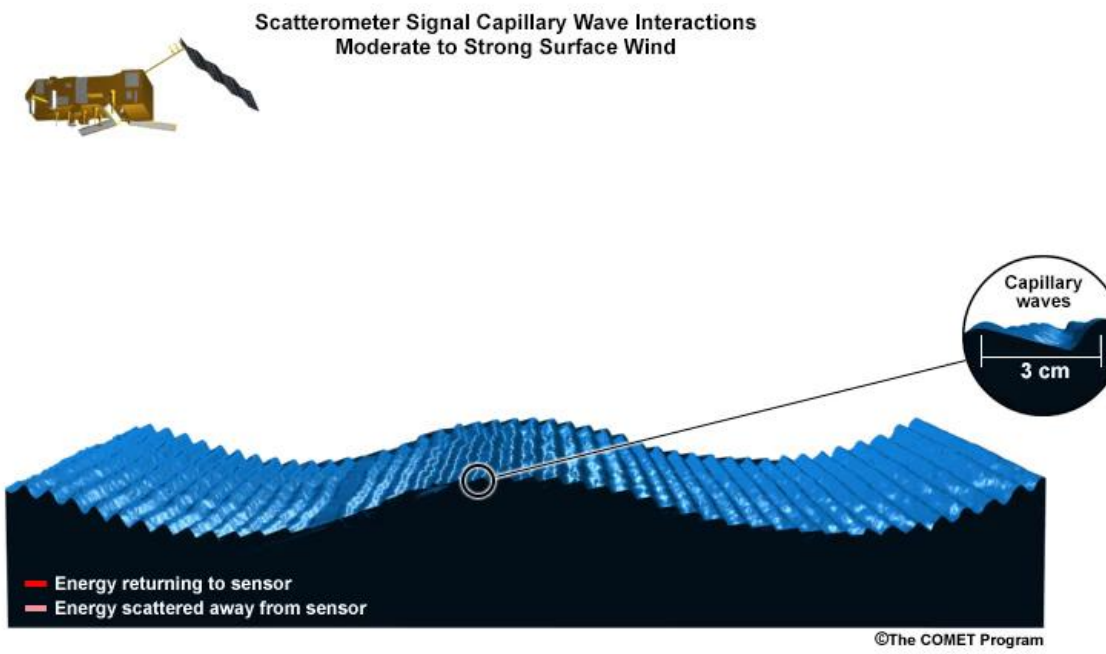
https://learn.bom.gov.au/course/view.php?id=701

active sensors measure backscatter

Bragg scattering

- Sensors emit microwave energy and measure return signal
- Small (2-4cm) capillary waves correspond to wind speed
- Bragg scattering: energy at similar wavelengths scattered





Credit: COMET https://www.meted.ucar.edu/training_module.php?id=1093#.XElBfteWa71

Scatterometers and Radiometers

ASCAT: on METOP-B and C satellites (R.I.P. 'A

see:http://manati.orbit.nesdis.noaa.gov/datasets/ASCATData.php/

Excellent for R34 and winds to ~50kn

Lack of coverage in the tropics an issue

Others: HY2B/HY2C/CFOSAT +

SAR: high quality but narrow and infrequent

AMSR-2 (R): ok for high winds; good for R34

SMAP/SMOS (R): good for high winds and R34

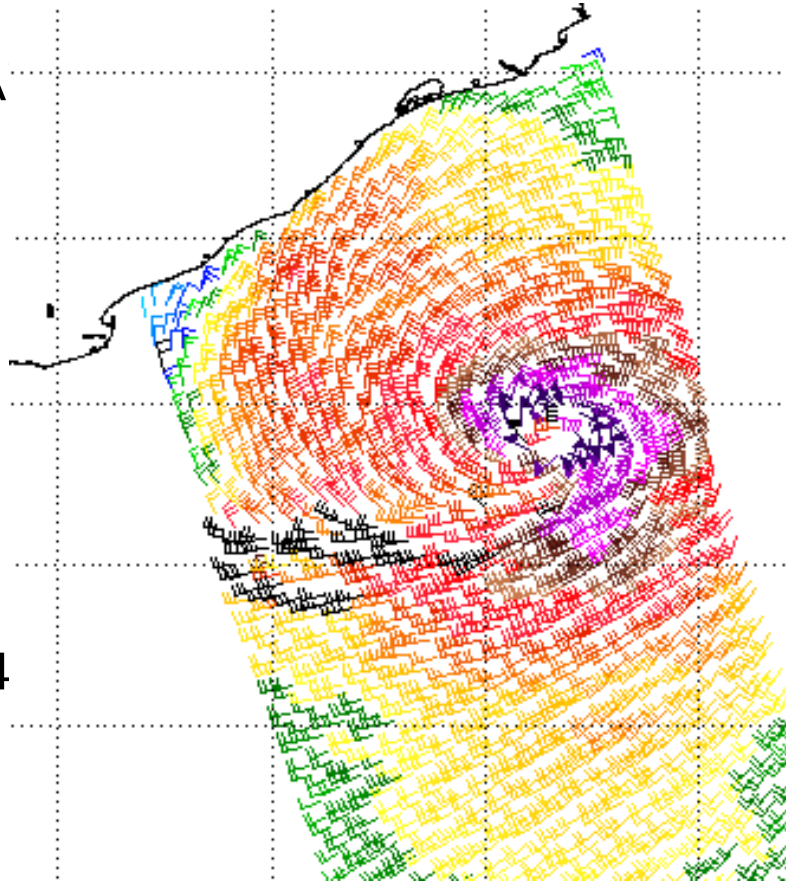
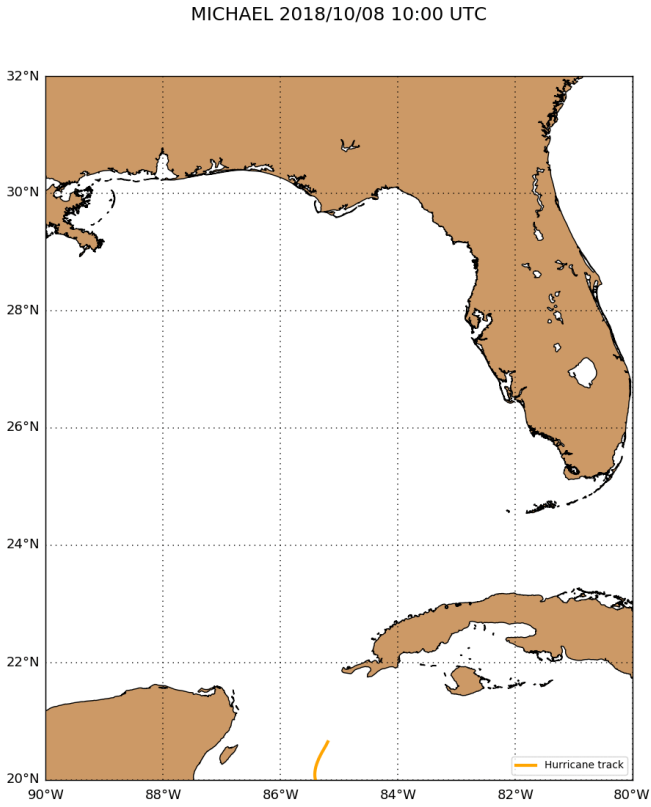


Image: http://manati.orbit.nesdis.noaa.gov/datasets/ASCATData.php

FY-3E and 4E but I can't see operational data

Synthetic Aperture Radar (SAR) measures high winds but limited availability

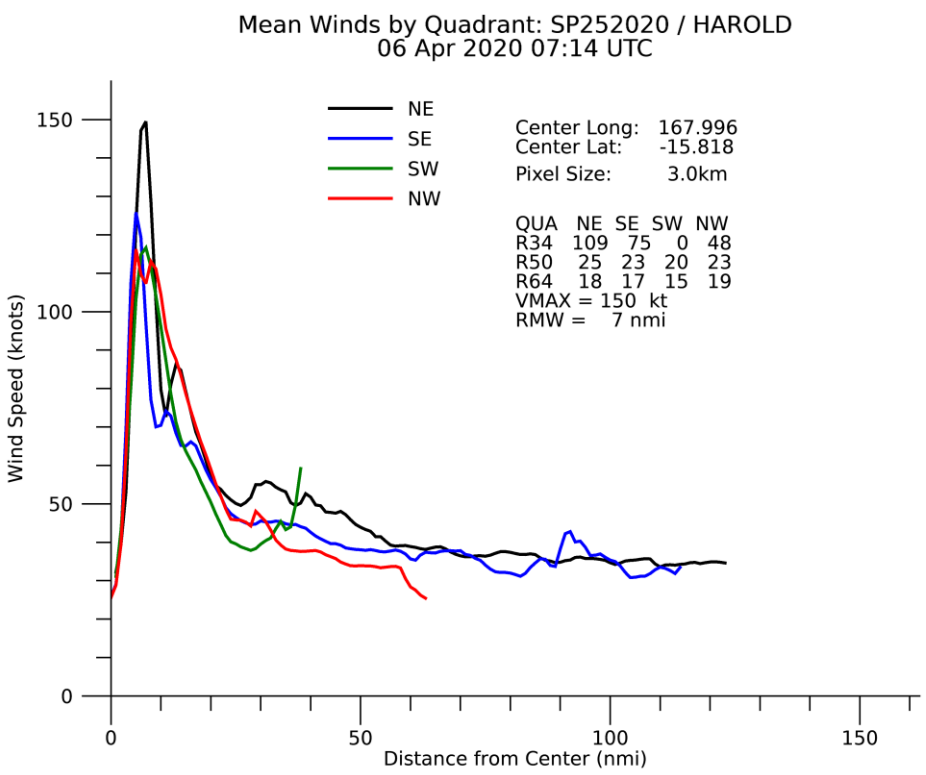
- Dual Pol. (co and cross polarization)
- Satellites: Sentinel-1 A (EUMETSAT) RIP 1B; 1C coming
- Radarsat-2 and now RCM (Canada)
- Others: Gaofeng-3 (China); Radar Constellation
- Mission (RCM) (Canada); ALOS-2 (Japan); +commercial.
- Channel: 1.4 GHz (C-Band)
- Coverage: 400km swathe
- Resolution: <150m; shown as ~3km average
- Issue: availability! requires scheduling so for strong TCs

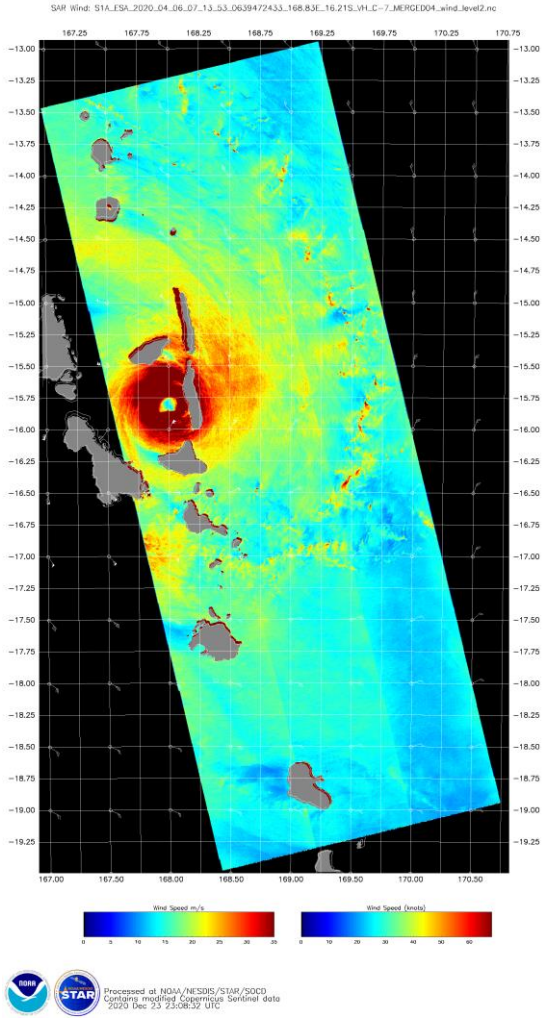


Availability:
US NOAA STAR: https://www.ospo.noaa.gov/Products/ocean/sar/
TC viewer: https://www.star.nesdis.noaa.gov/socd/mecb/sar/AKDEMO_products/APL_winds/tropical/index.html
European portal: https://eoda.cls.fr/client/oceano/
More information: Detailed presentation (127MB) by Alexis Mouche from IFREMER (France)
https://drive.google.com/file/d/1yi1sdfspM22N2TzgOrqSoy-BtOFEiR_Z/view?usp=sharing

SAR: NOAA STAR TC viewer

https://www.star.nesdis.noaa.gov/socd/mecb/sar/AKDEMO_products/APL_winds/tropical/index.html





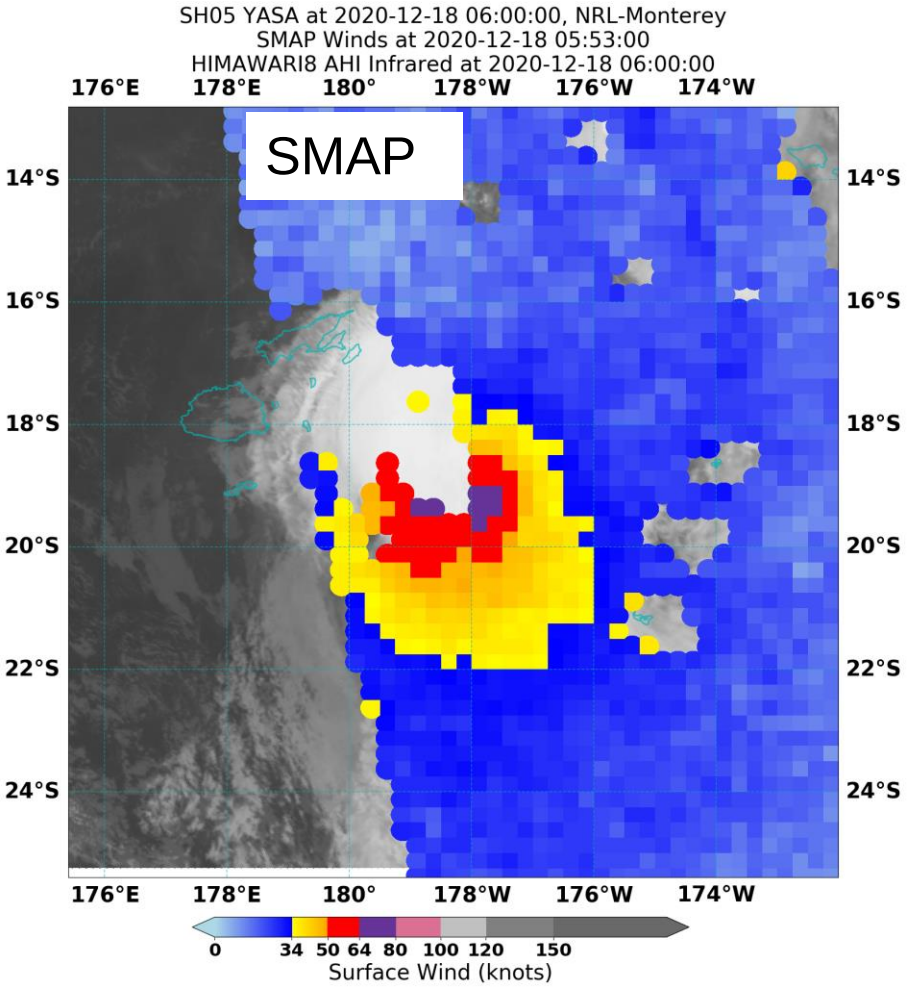
Also NRL page

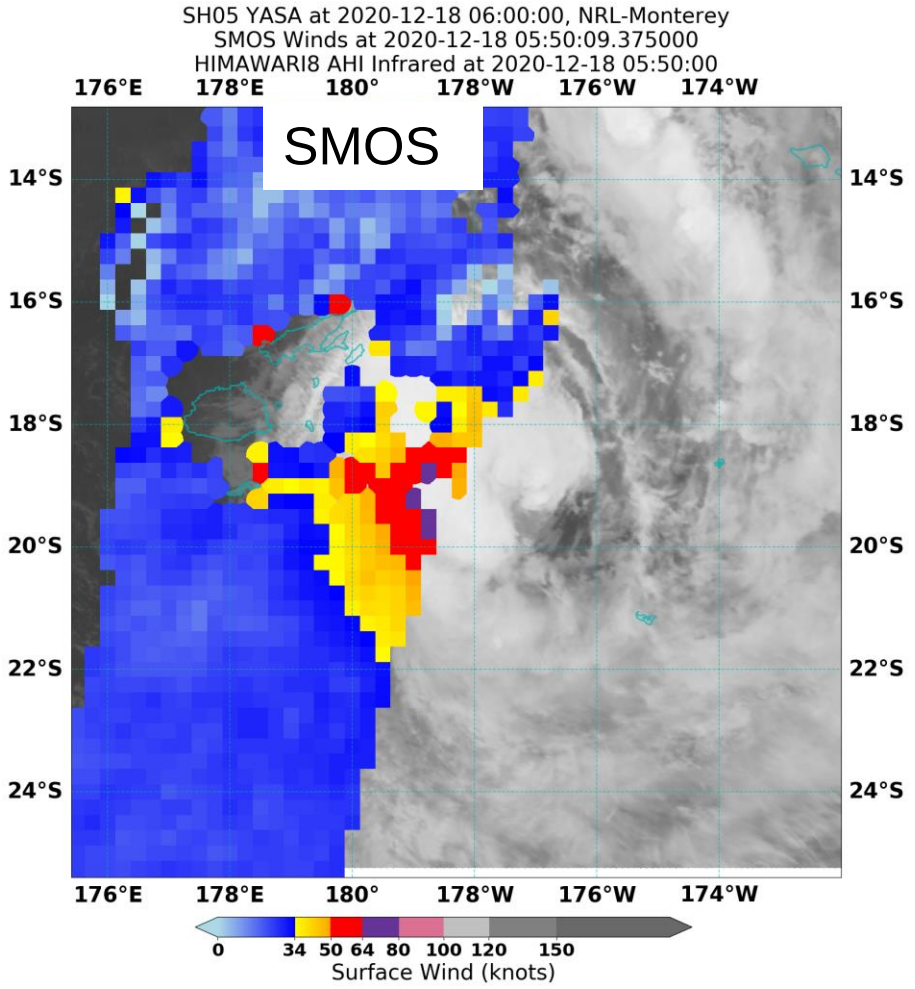
European portal: https://eoda.cls.fr/client/oceano/

More information: Presentation (127MB) by Alexis Mouche from IFREMER (France)
https://drive.google.com/file/d/1yi1sdfspM22N2TzgOrqSoy-BtOFEiR_Z/view?usp=sharing

SMAP and SMOS Radiometer

1. NRL: https://www.nrlmry.navy.mil/tc-bin/tc_home2.cgi
2. NOAA: https://manati.star.nesdis.noaa.gov/datasets/SMAPData.php





Examples: Yasa 18 December 2020 courtesy NRL

AMSR2 Radiometer

Satellite: GCOM (2012)

Channel: 6.9; 10.7 (+36.5) GHz

Coverage: 1450km (wider than ASCAT)

Two passes per day

TC applications: wind radii and intensity

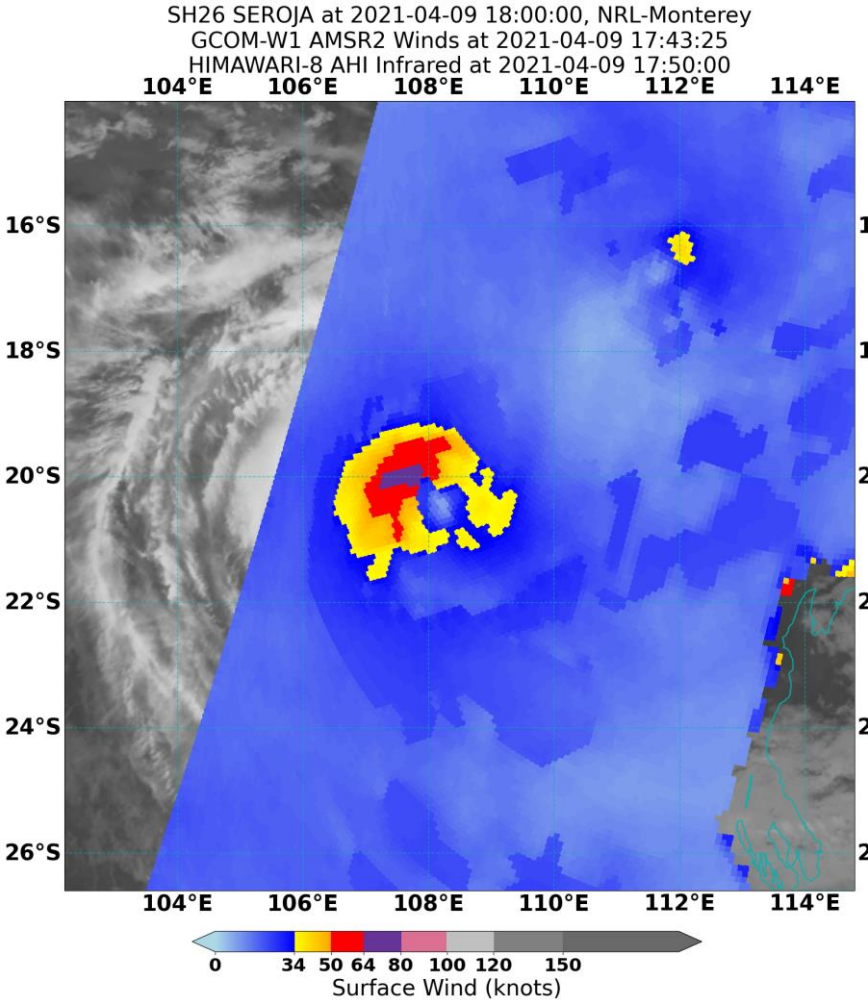
NEW: Recent solutions to overcome heavy rainfall contamination
https://www.mdpi.com/2072-4292/13/9/1641/htm

Speed only; not for near land.

Availability for operational use:

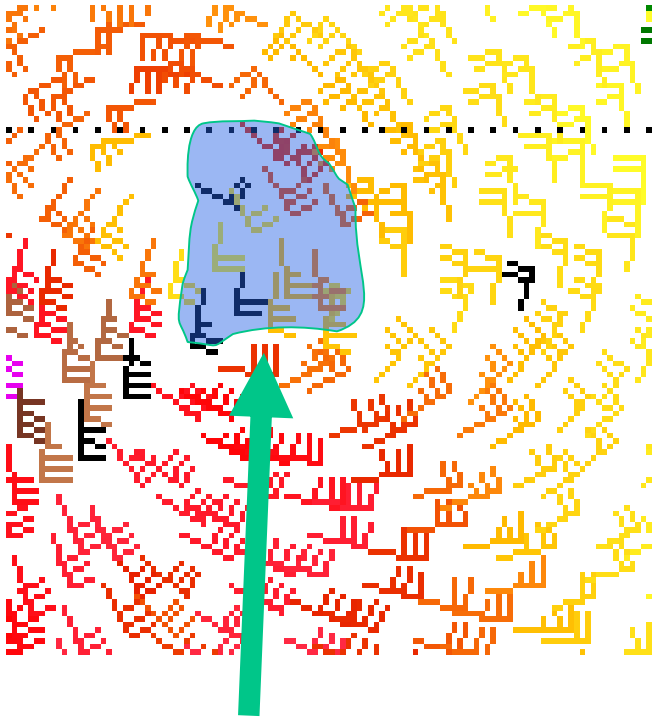
NRL: https://www.nrlmry.navy.mil/tc-bin/tc_home2.cgi

backup NOAA:
https://manati.star.nesdis.noaa.gov/datasets/GCOM2Data.php



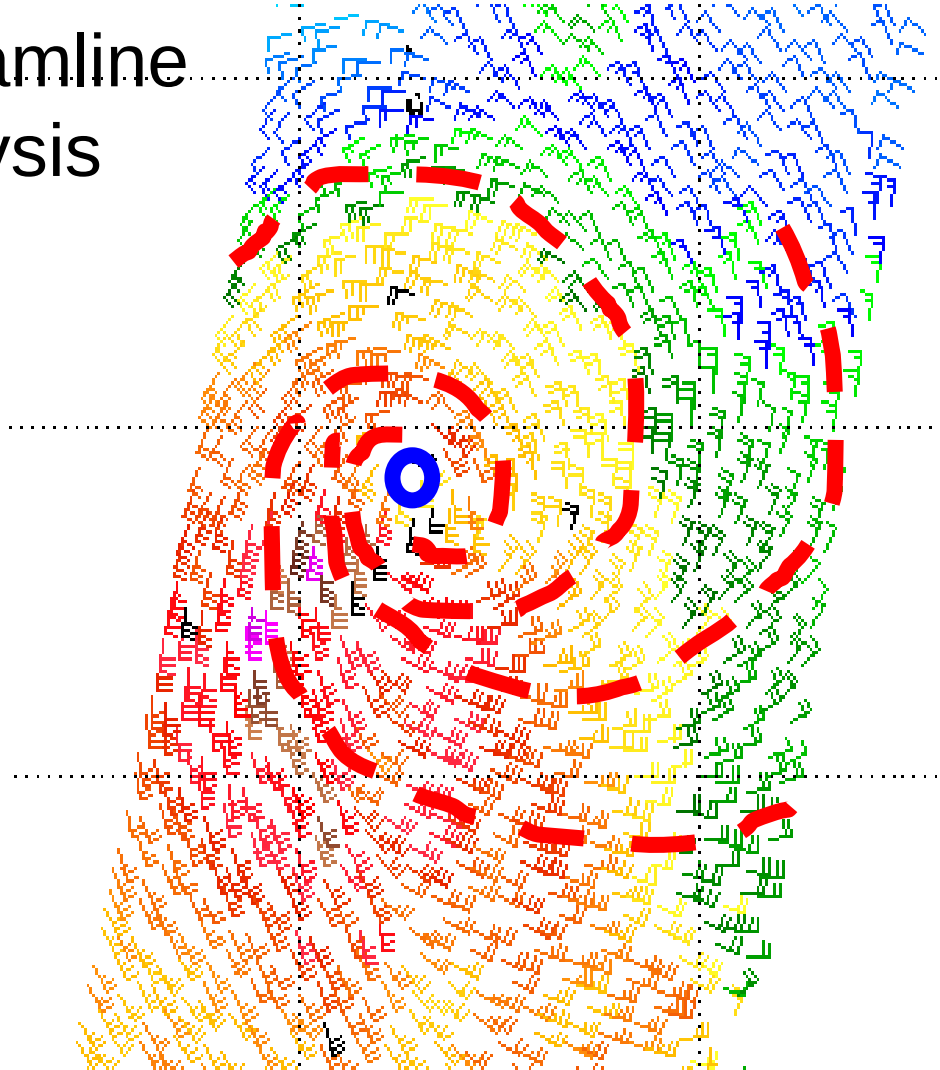
Example: Seroja April 2021 courtesy NRL

ASCAT positioning



Wrong direction

Streamline analysis



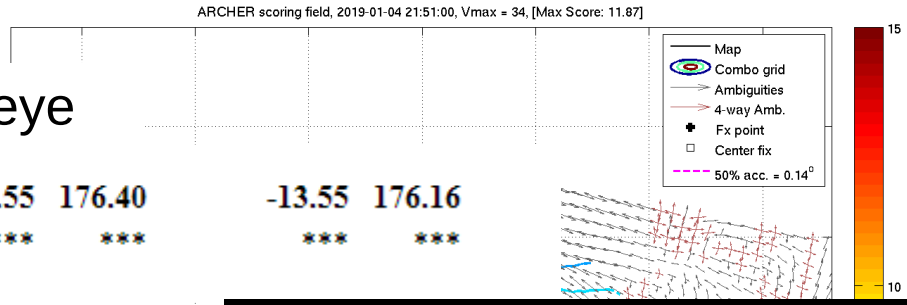
Southern Hemisphere example

ASCAT positioning: ARCHER

http://tropic.ssec.wisc.edu/real-time/archerOnline/web/index.shtml

Automatic and usually better than human eye

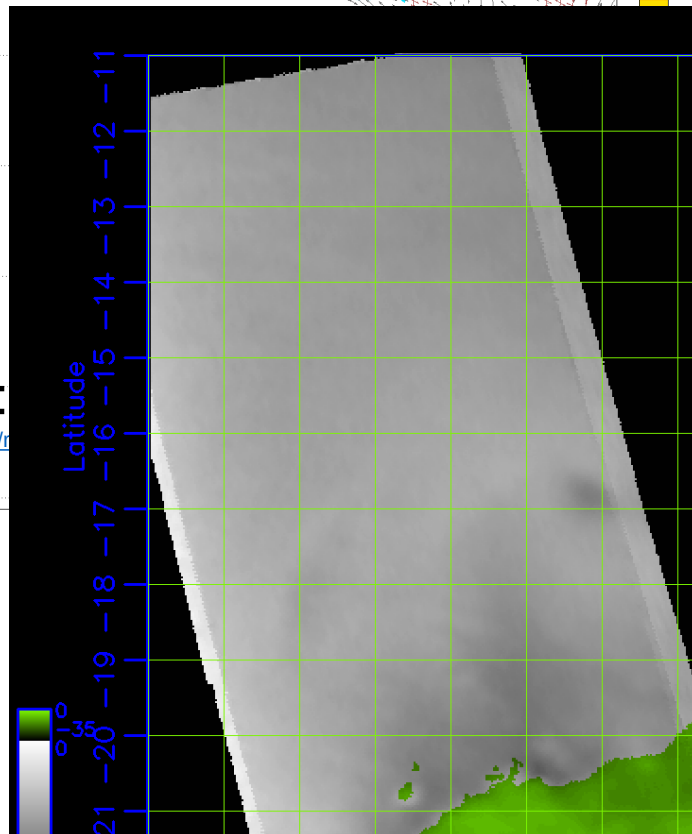
20190104 21:51:00 *	Metop-B	ASCAT	33.6	-13.55	176.40	-13.55	176.16
20190104 20:42:00	Metop-A	ASCAT	35.5	***	***	***	***



NRCS: scalar wind display can be the clearest indication of centre fix in the light wind area

Mona 09P:

http://tropic.ssec.wisc.edu/r



NRCS from NOAA 'manati' web page:

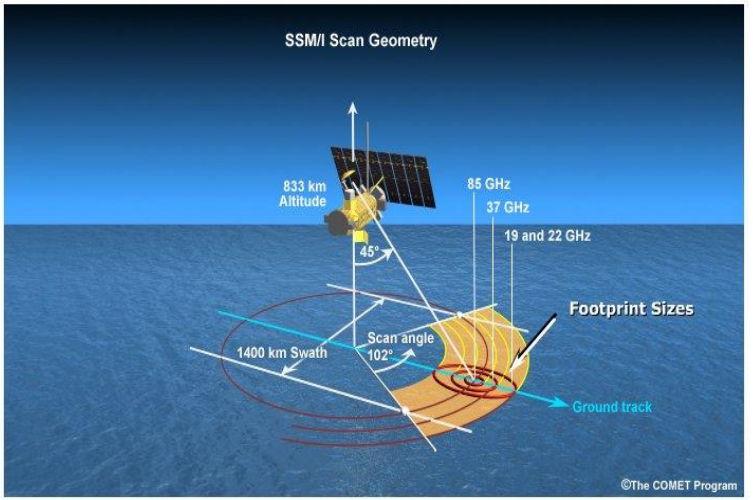
via 'storm' option

eg : Riley Jan 2019: NRCS better than Archer

Microwave: sensors

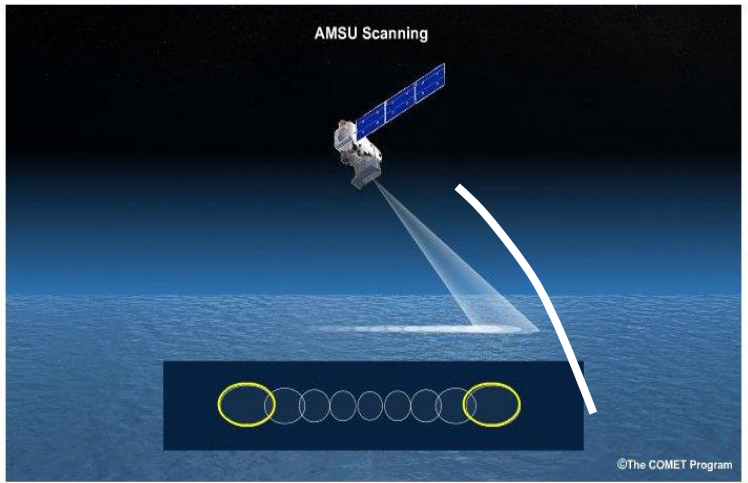
Passive sensing up–radiation from ocean/clouds in 19-24, 37, 85-91GHz ranges

- Polar Orbiting Conical Scanner
  SSMIS, GMI, AMSR2,
  X RIP: SSMI, TMI, Windsat
- narrow scan widths but maintains footprint resolution across the entire scan
- 85GHz higher res than 37GHz



- Cross track ATMS (NPP)/MHS (88GHz)
  previous AMSU

wider scan swaths but resolution degrades toward the edge of scan

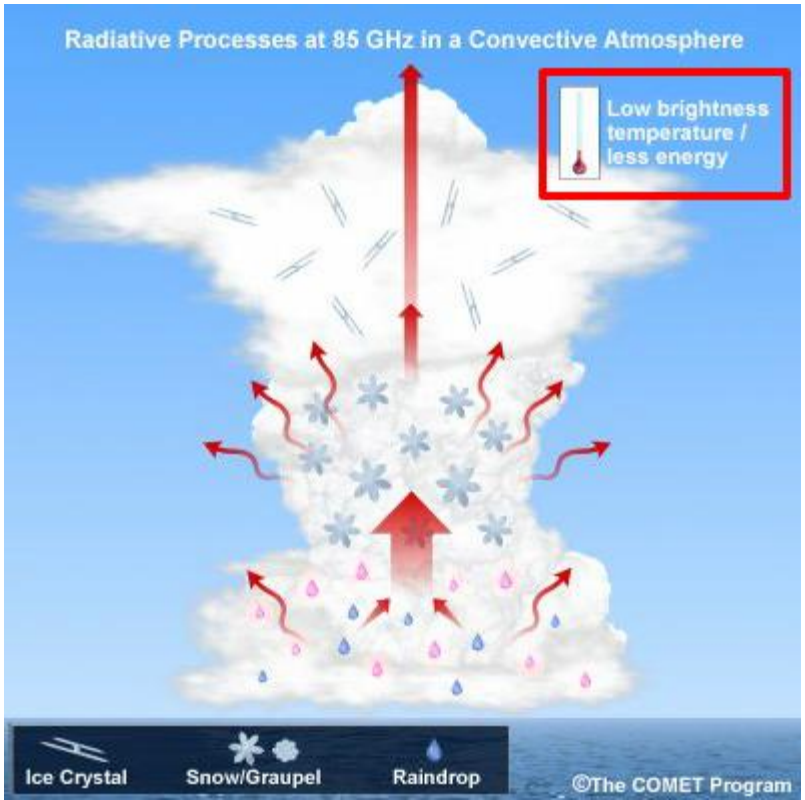


FY-3E and 4E but I can't see operational data

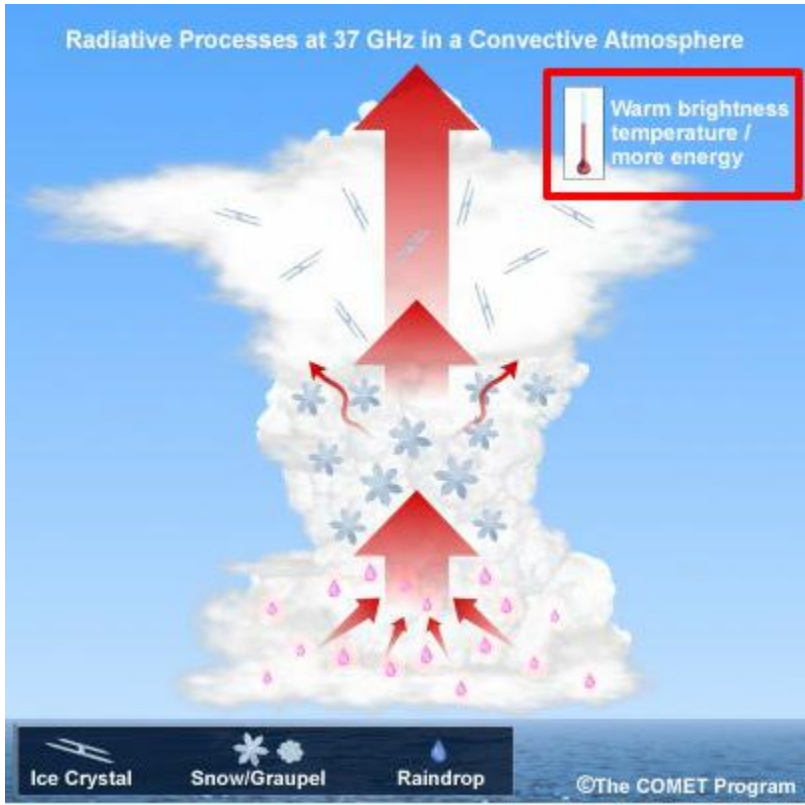
Background: 37-85 GHz differences

"37 lower number lower down"

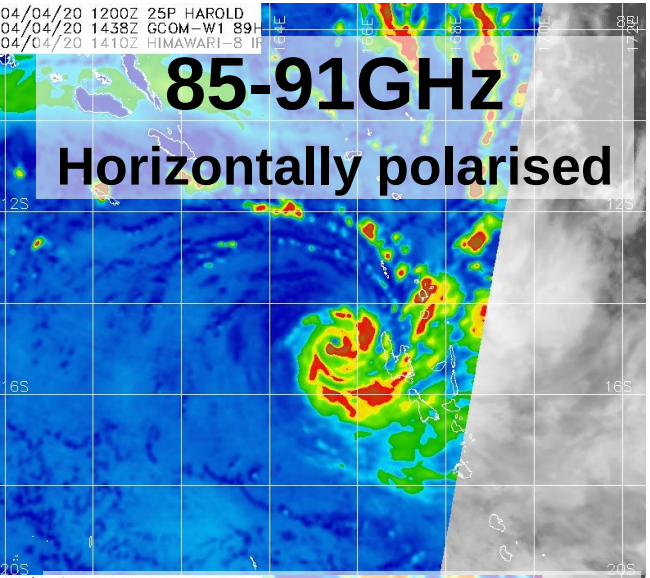
85GHz from ocean is absorbed & scattered by water droplets and further scattered by large water droplets and hail higher up in deep convection leading to low brightness temperatures.

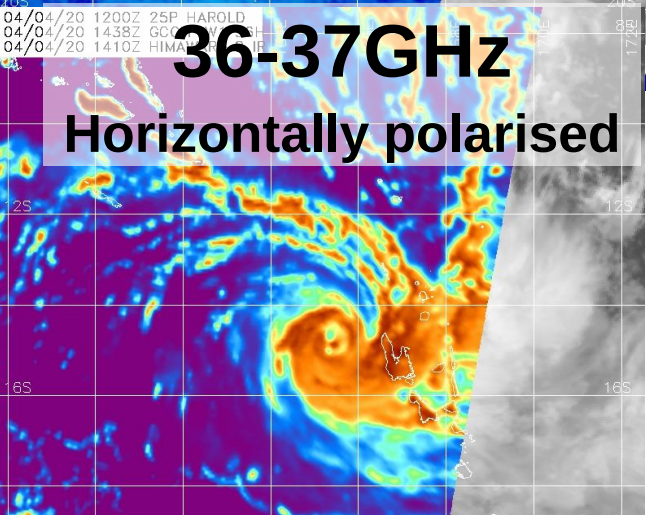


37GHz from ocean is absorbed by cloud/ rain droplets – the radiated energy is NOT affected by large water droplets and hail higher up in deep convection leading to high brightness temperatures.

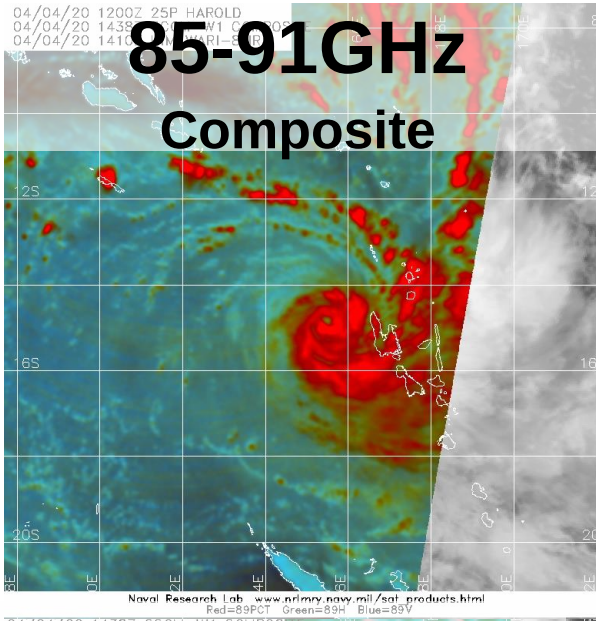


Different presentations
Polarizations and composites



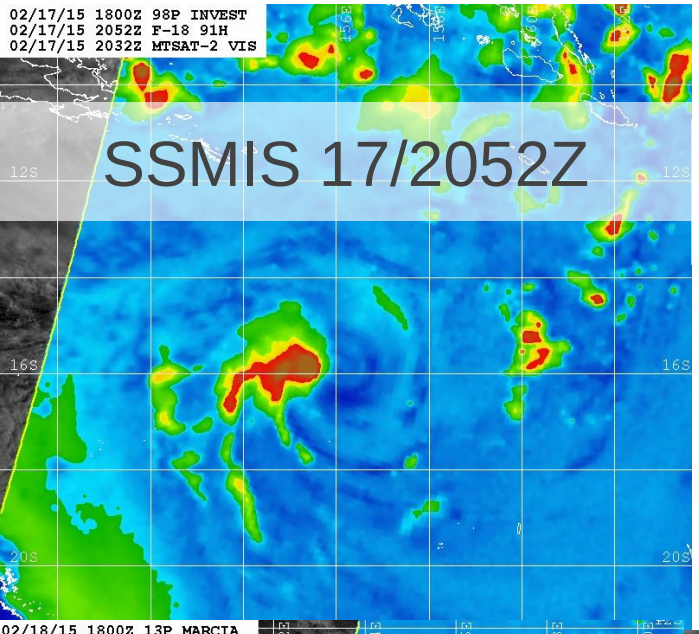


'color' Composite view combines horizontal and vertical polarisation and PCT so can 'correct' for known weaknesses to allow detection of lower clouds and so useful for positioning

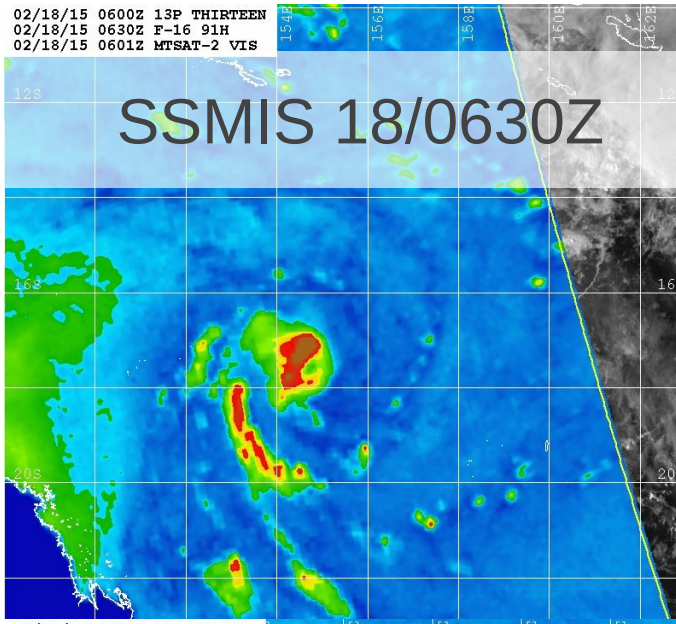


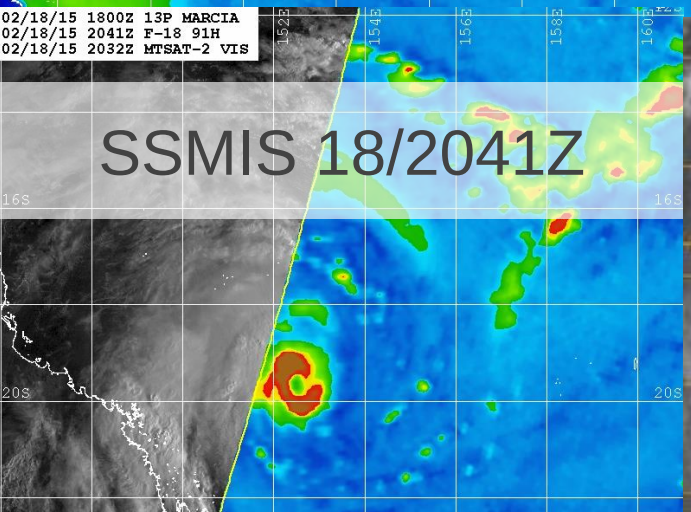
Example: Harold 2020 (SPac)

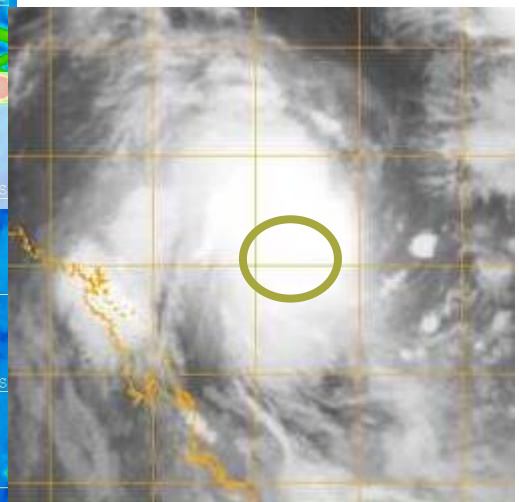
Microwave can be very important to indicate intensity changes
TC Marcia Rapid Intensification

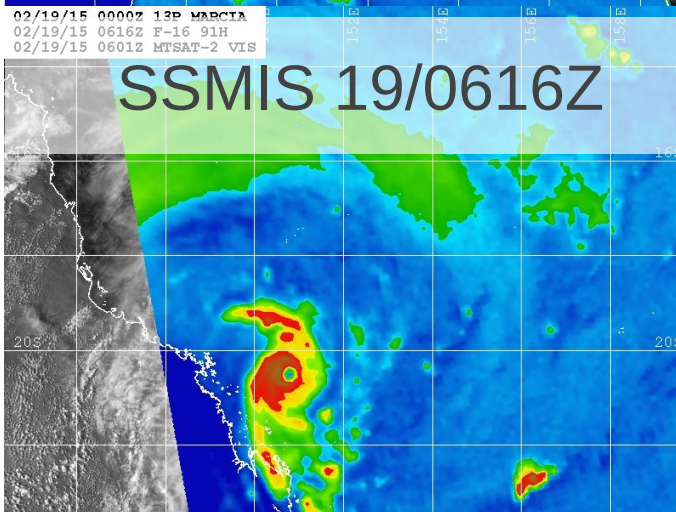


91GHz SSMIS over 34h







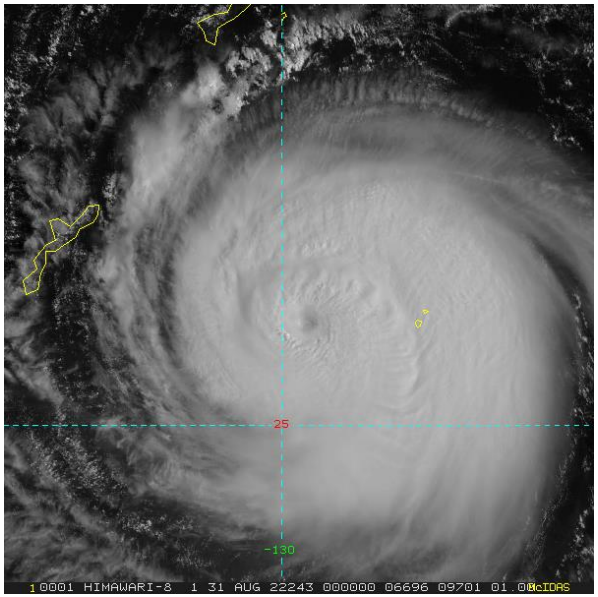


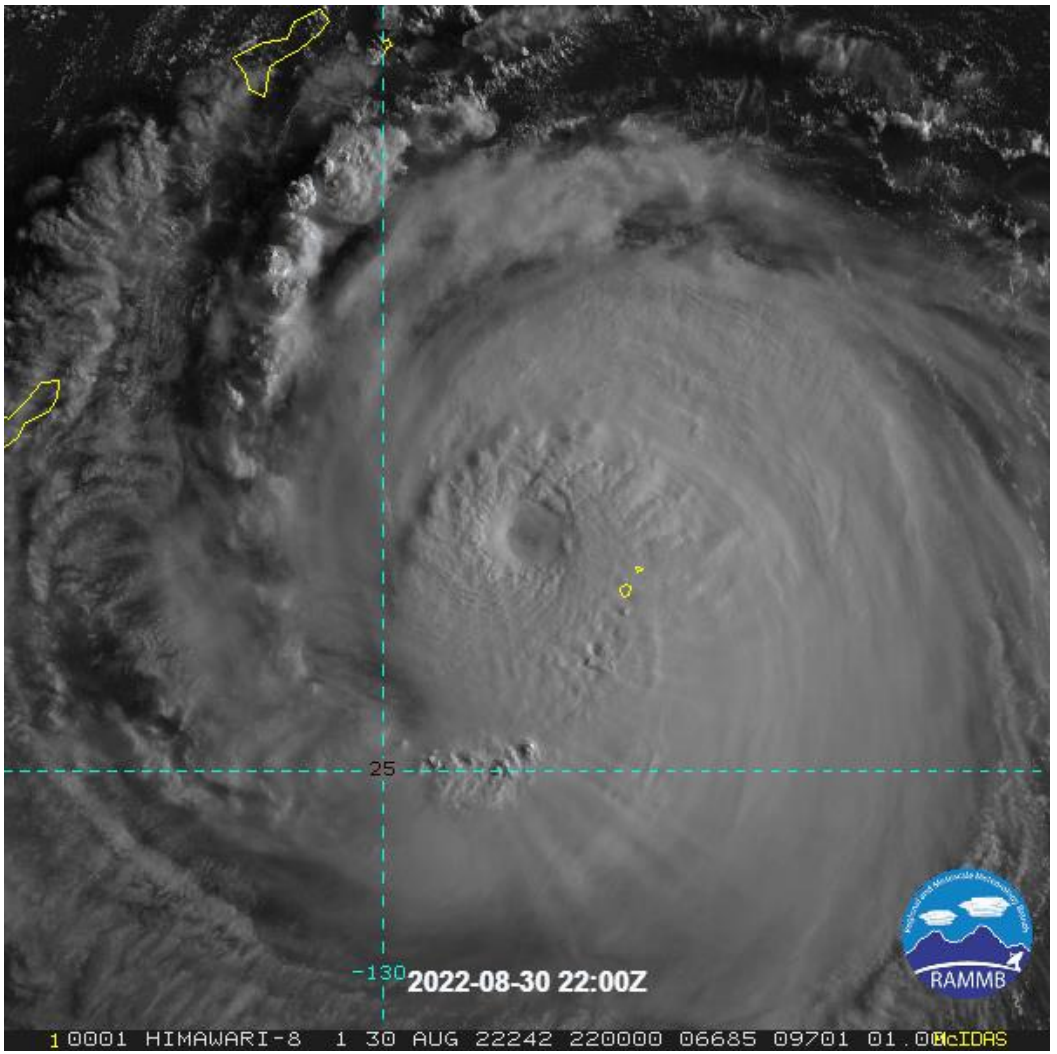
Typhoon Hinnamnor exercise: Analysis at 00 UTC 31 August 2022

1. H8: Vis and IR: Dvorak
2. Microwave patterns
3. ADT and SATCON
4. Scatterometry and Radiometers
5. SAR

1. 00UTC 31 August
Conventional Vis loop (22-00UTC)

- Position is easy with an eye!
- Eye is moderately well defined

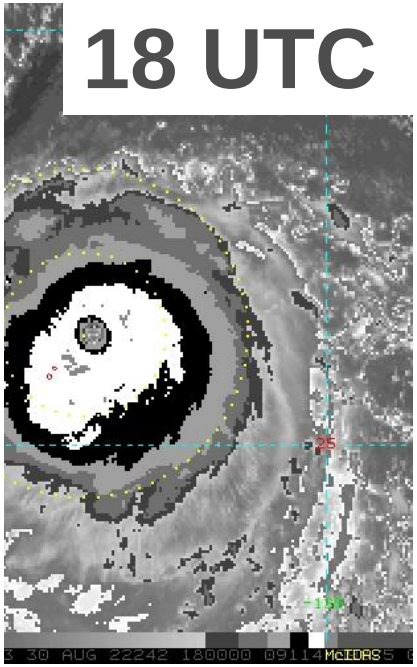


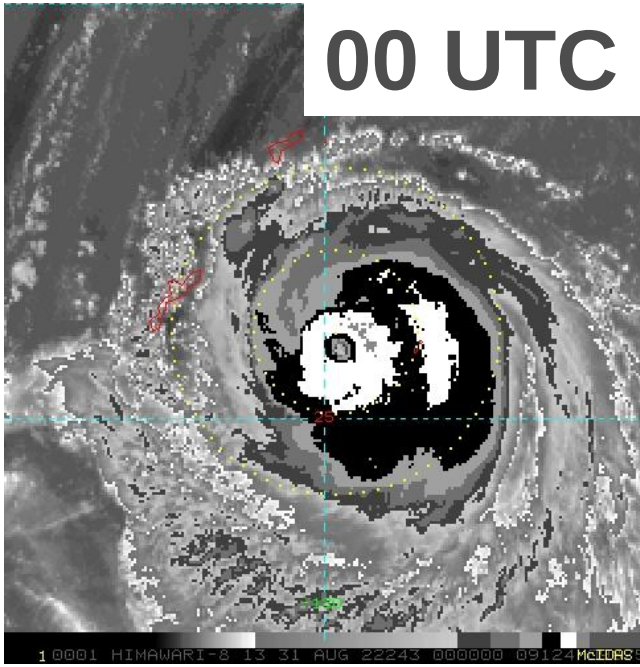


CIRA https://rammb-data.cira.colostate.edu/tc_realtime/loop.asp?product=1kmsrvis&storm_identifier=wp122022&starting_image=2022wp12_1kmsrvis_202208302200.gif&ending

1.1 Dvorak estimate?
Previous at 30/18UTC SAB FT/CI= 6.5

```
TXPQ25 KNES 301805
TCSWNP

A.  12W (HINNAMNOR)

B.  30/1730Z

C.  26.3N

D.  132.0E

E.  ONE/HIMAWARI-8

F.  T6.5/6.5

G.  IR/EIR/SWIR

H.  REMARKS...WMG EYE SURROUNDED BY WHITE BUT EMBEDDED IN B YIELDS A
DT OF 6.5 AFTER ADDING 1.0 FOR THE EYE ADJUSTMENT. THE MET AND PT ARE
6.5 BASED ON A SLOW DEVELOPMENT TREND OVER THE PAST 24 HOURS. THE FT IS
BASED ON THE DT.

I.  ADDL POSITIONS

    NIL


...COVERDALE
```





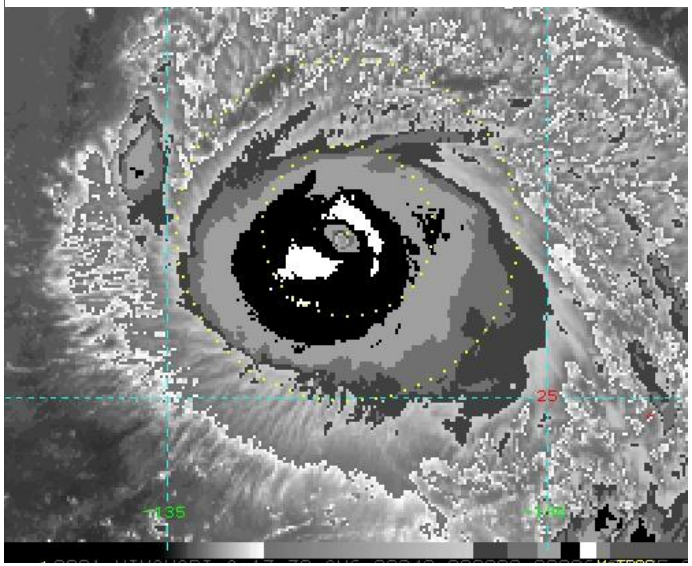
SAB analysis:
https://www.ssd.noaa.gov/PS/TROP/DATA/2022/bulletins/wpac/20220830233012W.html
CIRA https://rammb-data.cira.colostate.edu/tc_realtime/products/storms/2022wp12/4kmsrbdc/2022wp12_4kmsrbdc_202208301800.jpg

1.1 Dvorak estimate?

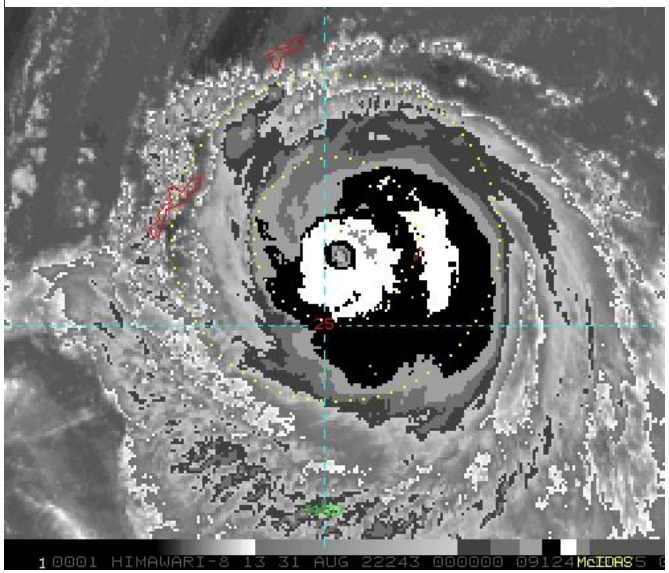
DT=6.5 based on eye pattern

24h old FT=5.0; Change D so MET=5.0+1.0=6.0 adj.= 0.0
FT and CI=6.5 =>Vm ~ 110-120kn (10min)

5.0 at 30/00UTC



31/00UTC



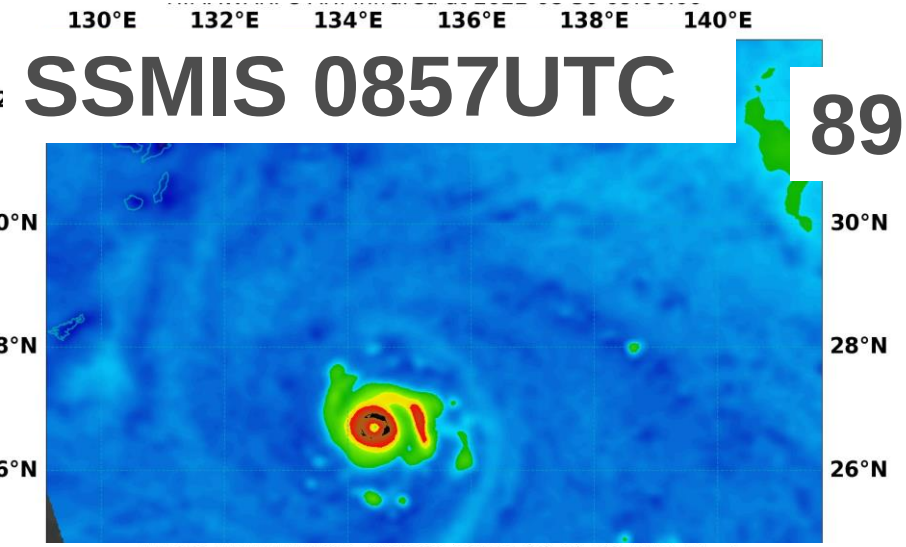
CIRA: https://rammb-data.cira.colostate.edu/tc_realtime/products/storms/2022wp12/4kmsrbdc/2022wp12_4kmsrbdc_202208310000.jpg

2. Microwave patterns:

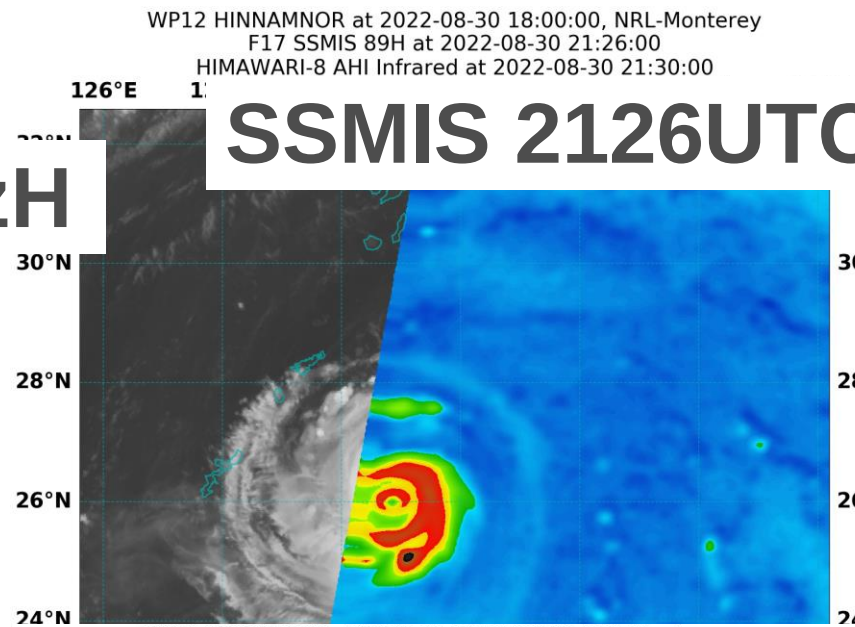
- What does this indicate?

SSMIS 0857UTC

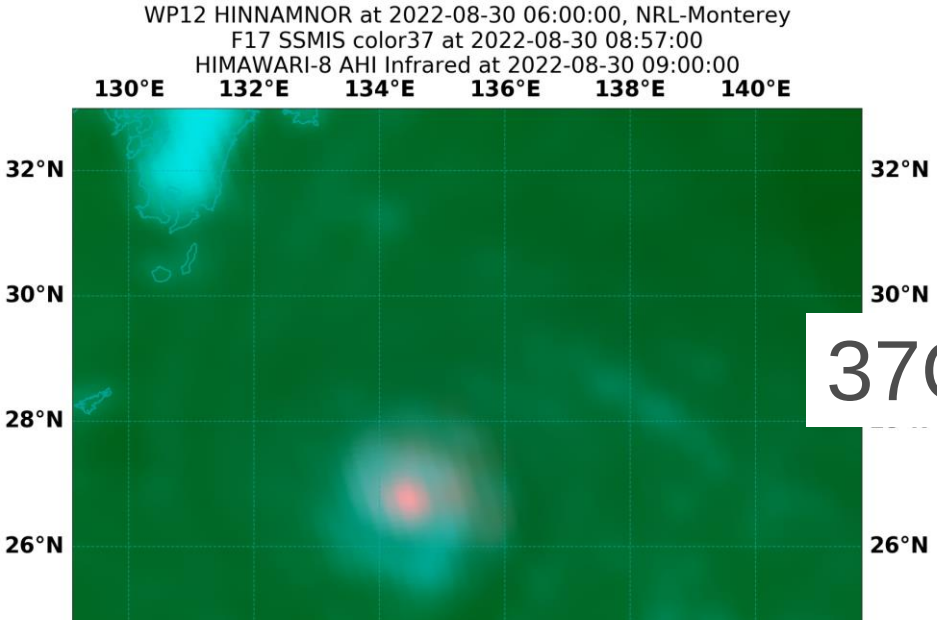
89GHzH

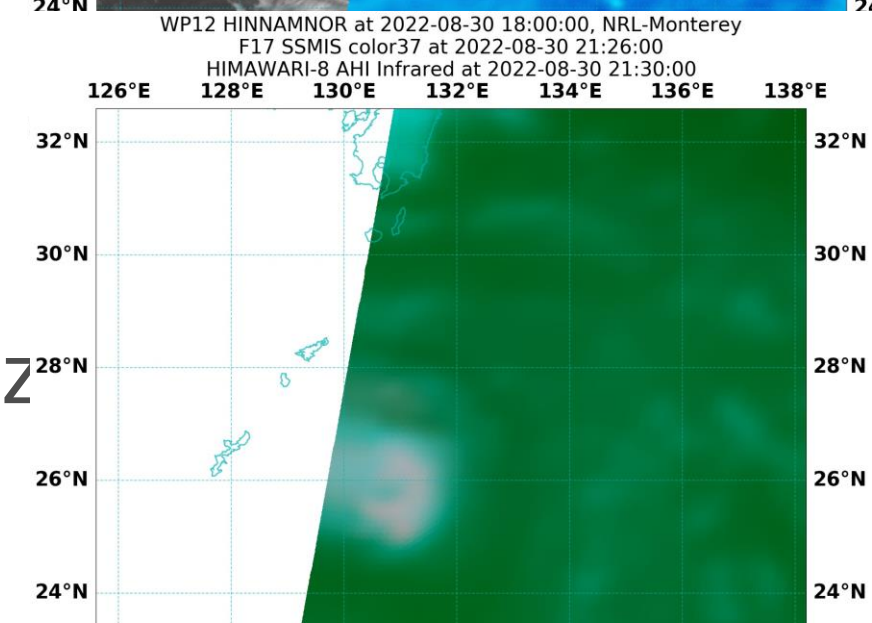


SSMIS 2126UTC

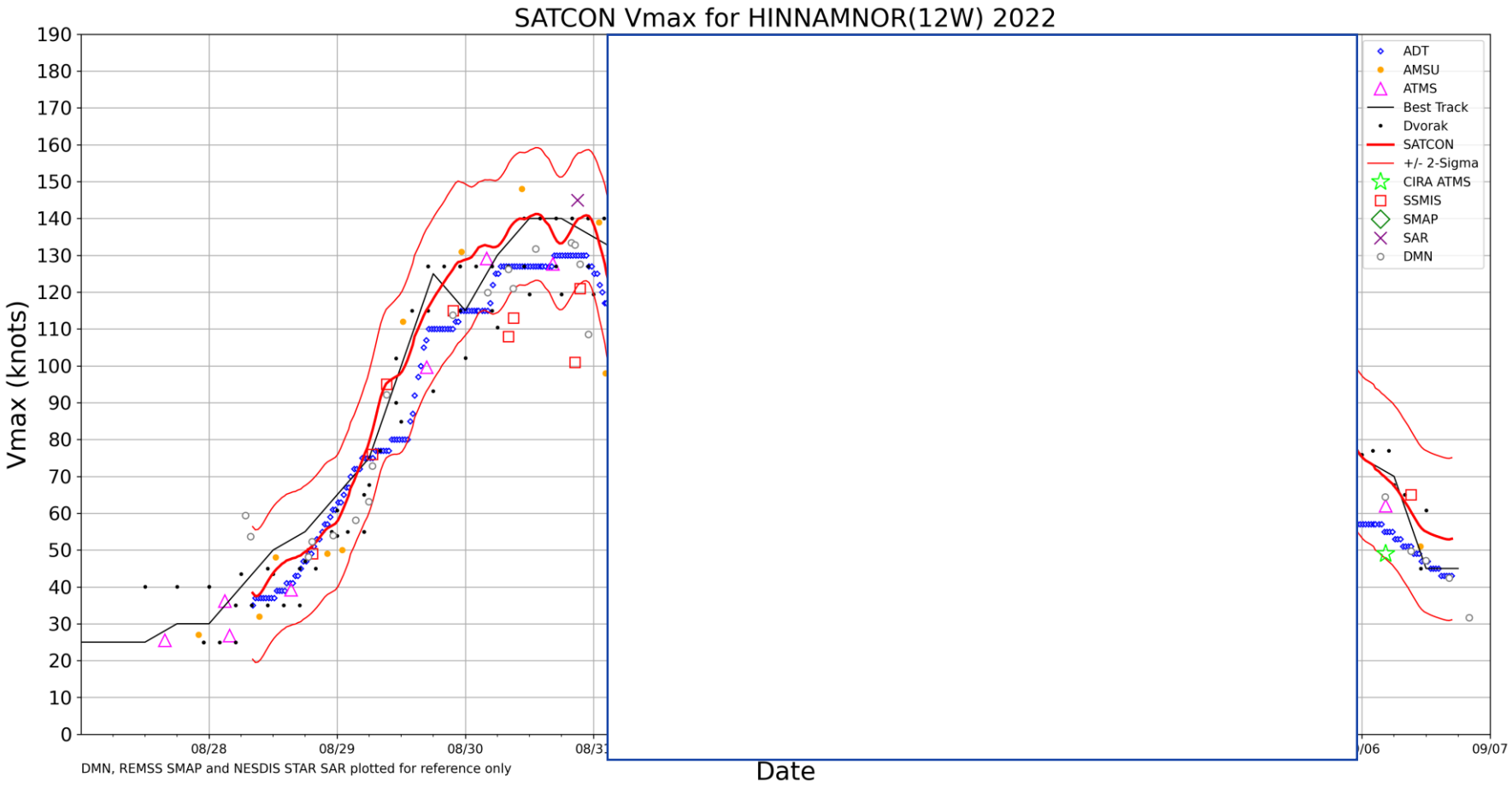


37GHz



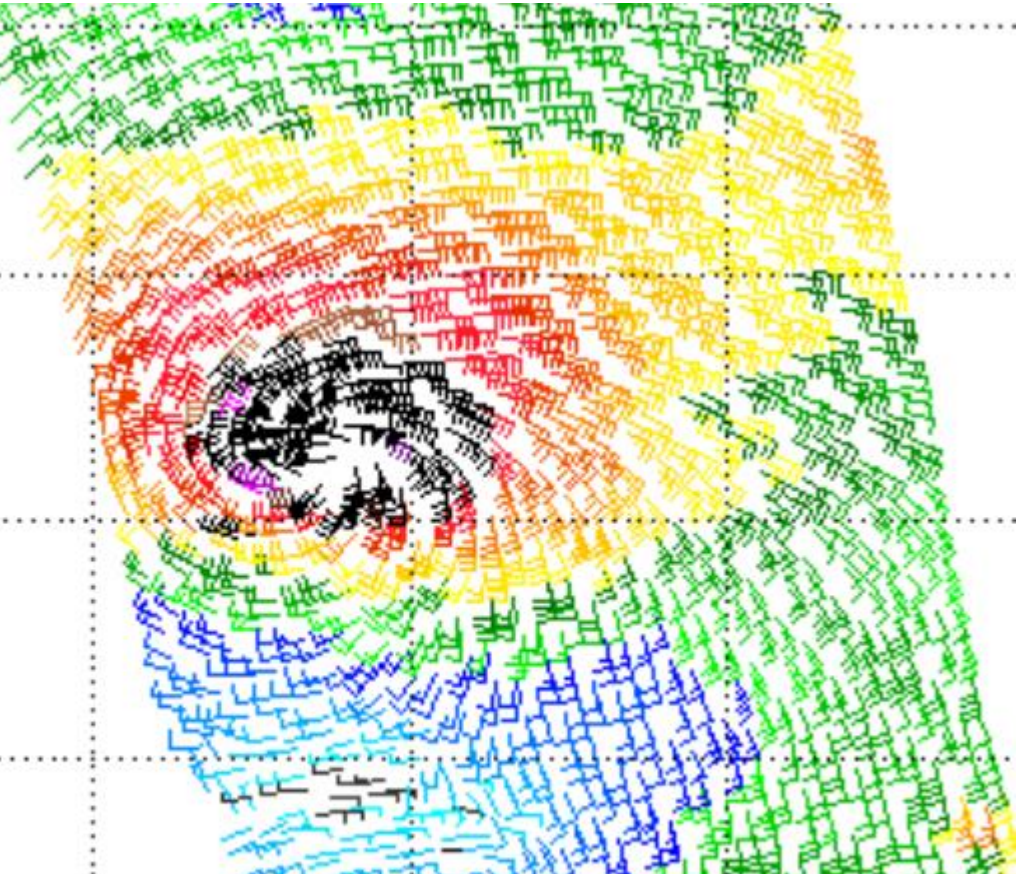


3. SATCON 140kn 1min (~125kn 10min)
ADT CI=6.5 (CIMSS) 125kn (1min) 115kn (10min)

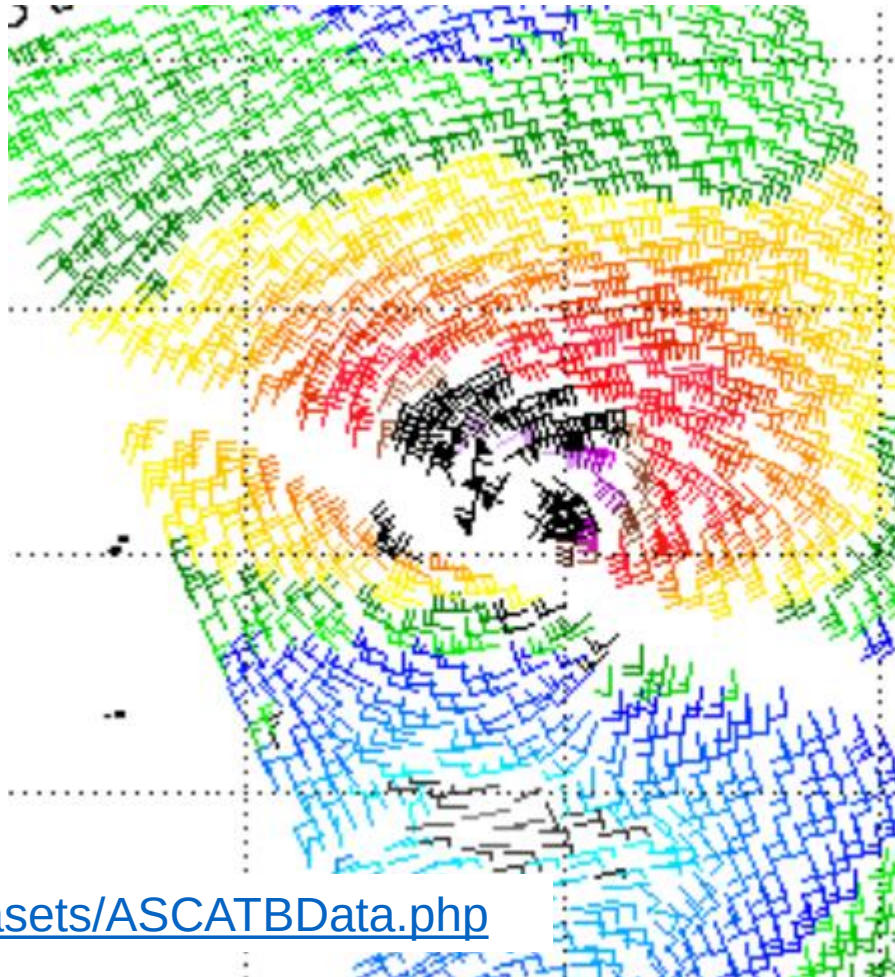


4. ASCAT ~65kn Useful?

ASCAT-B 30/1239UTC



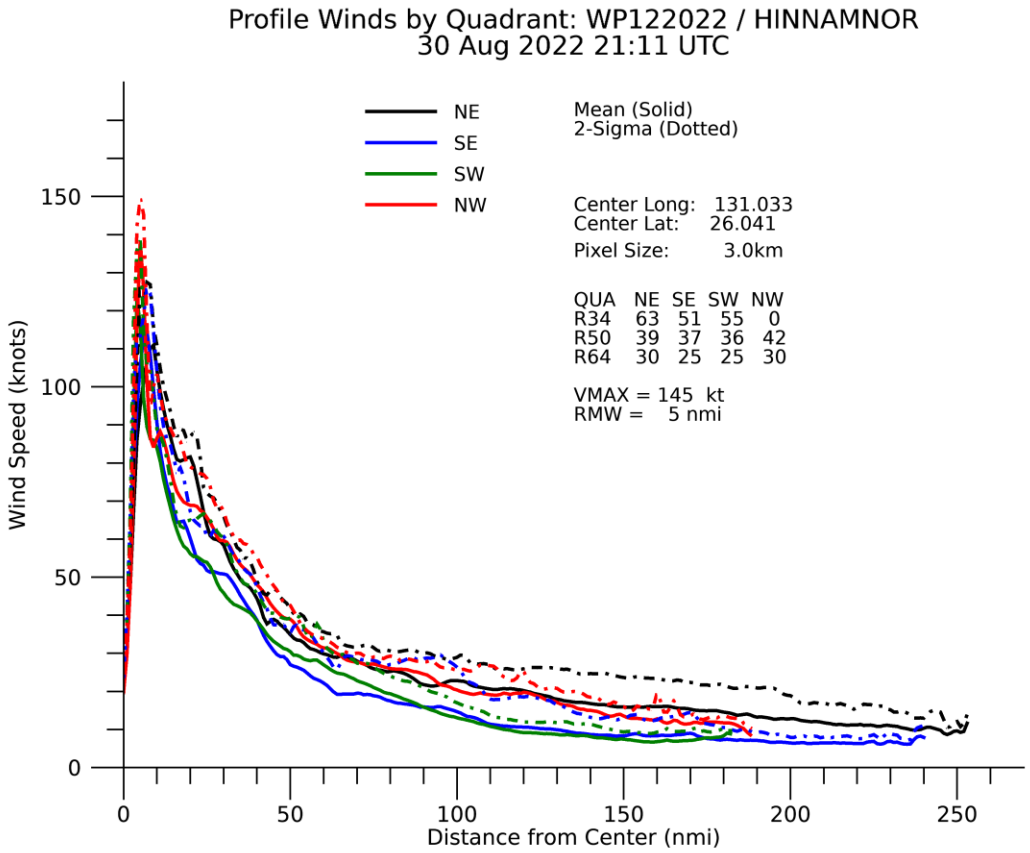
ASCAT-C 30/1151UTC

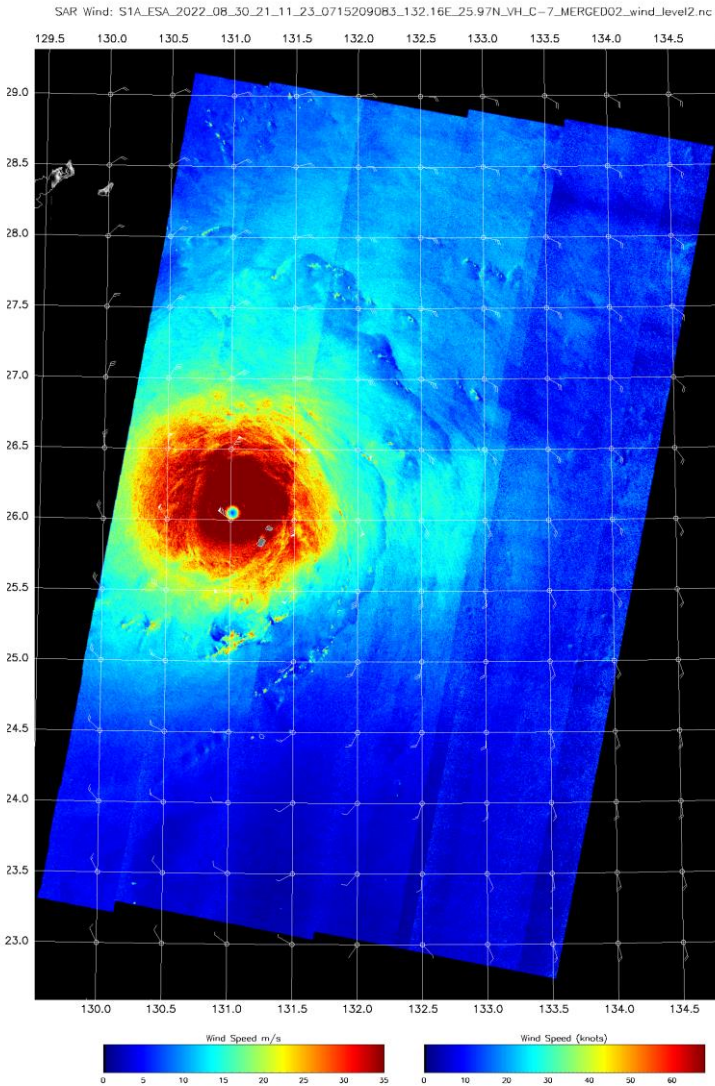


NOAA: https://manati.star.nesdis.noaa.gov/datasets/ASCATBData.php

5. SAR: 145kn (~1-3min) – 125-140kn representative?

https://www.star.nesdis.noaa.gov/socd/mecb/sar/AKDEMO_products/APL_winds/tropical/index.html





Also NRL page

European portal: https://eoda.cls.fr/client/oceano/

More information: Presentation (127MB) by Alexis Mouche fr

https://drive.google.com/file/d/1yi1sdfspM22N2TzgOrq

Summary: making sense of different inputs

Question 3 What is your intensity of Hinnamnor at 00UTC 31 August?

- Dvorak 110-120kn
- Microwave: ERC (lower?)
- SATCON 125kn
- ADT 115 kn
- ASCAT 65 kn
- SAR 125-140kn

a. 65kn
b. 105kn
c. 120kn
d. 145kn
e. unsure

socrative.com **Room: CYCLONE2022**

The Bureau of Meteorology

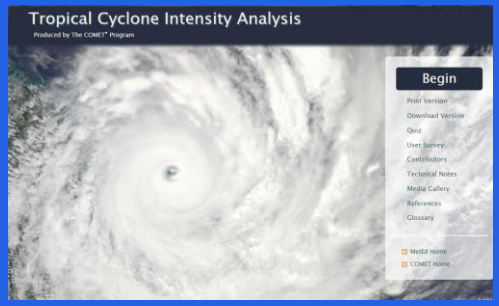
Thank you.
Questions?

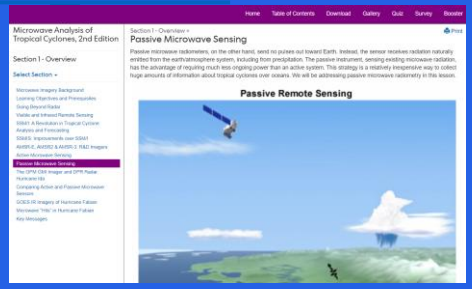
Joe Courtney, Australian Bureau of Meteorology

Resources:

COMET: Tropical Cyclone Intensity analysis
https://www.meted.ucar.edu/bom/tropical_intensity/index.htm

Microwave Analysis of Tropical Cyclones 2nd edition.
https://www.meted.ucar.edu/satmet/microwave_topics/tc_analysis_v2/navmenu.php?tab=1&page=9-0-0&type=flash



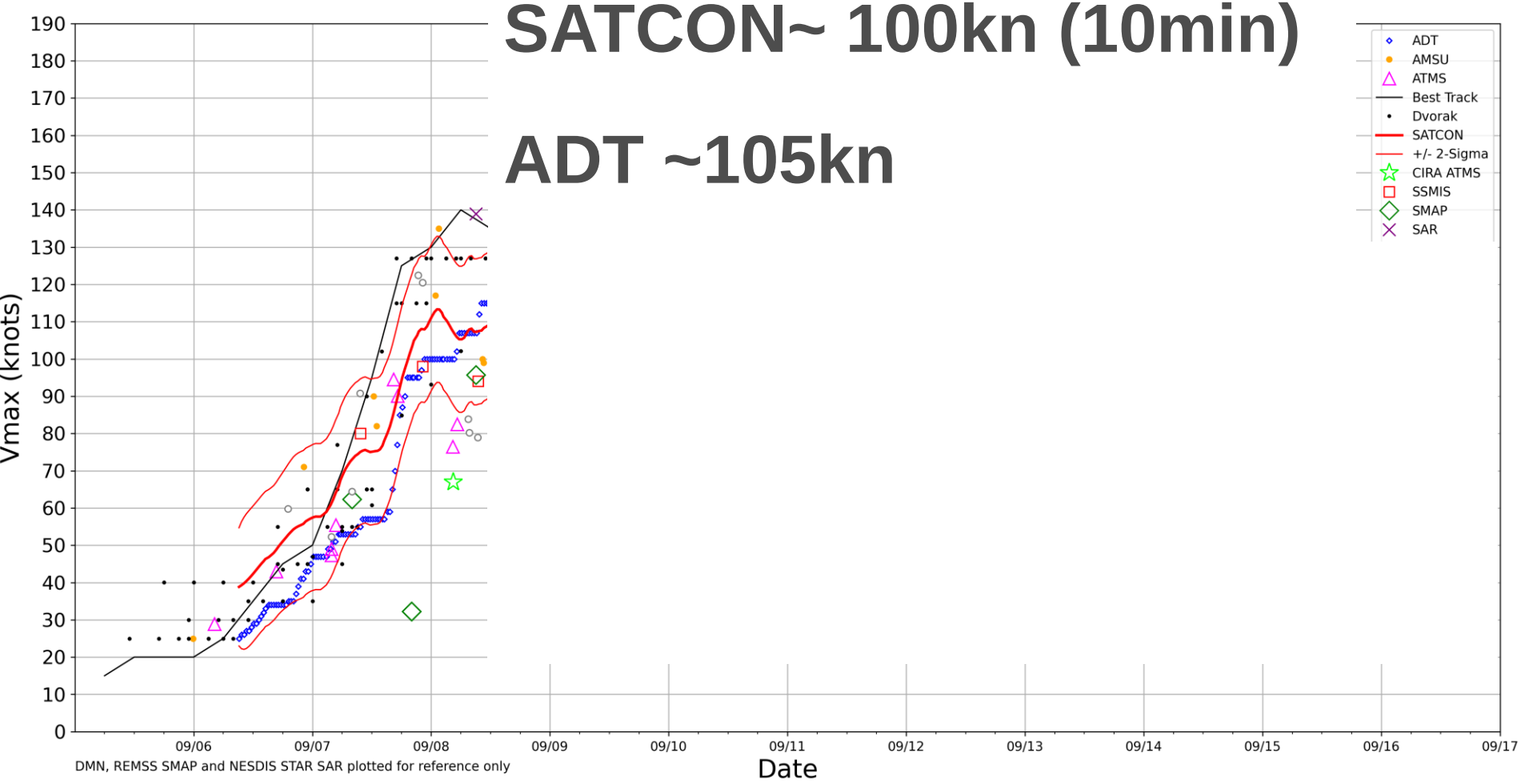


CIMSS intensity

- click to edit Master text

SATCON~ 100kn (10min)

ADT ~105kn



CIMSS http://tropic.ssec.wisc.edu/real-time/satcon/202119W_wind_dmn.png

Section heading
Arial Bold 30pt

Subheading Arial 20pt

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Title of presentation

Subheading

Presenter name

Replace the image by right-clicking on it and choosing ‘Change picture’. You may have to resize/crop the image to fit the layout.
Recommended image size 12.7 x 19.05cm.

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The Bureau of Meteorology

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Subheading

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Subheading

Section heading to go here

Subheading

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Icons

Forecast

Flood

Warning

Agriculture

Temperature

Wind

Slide heading, Arial Bold 25pt

Heading	Heading	Heading	Heading	Heading	Total
Body	100%	$200 000	100%	$200 000	$400 000
Body	90%	$300 000	90%	$300 000	$600 000
Body	**80%**	**$500 000**	**190%**	**$500 000**	**$1 000 000**
Body	70%	$60 000	70%	$60 000	$120 000
Body	60%	$800 000	60%	$800 000	$1 600 000
Body	50%	$400 000	50%	$400 000	$800 000
Body	40%	$250 000	40%	$250 000	$500 000
Body	30%	$30 000	30%	$30 000	$60 000
Body	**550%**	**$2 980 000**	**550%**	**$2 980 000**	**$4 960 000**

Add descriptive alt-text to the table – right click on the table and select ‘Edit Alt Text’, then follow the instructions in the panel.

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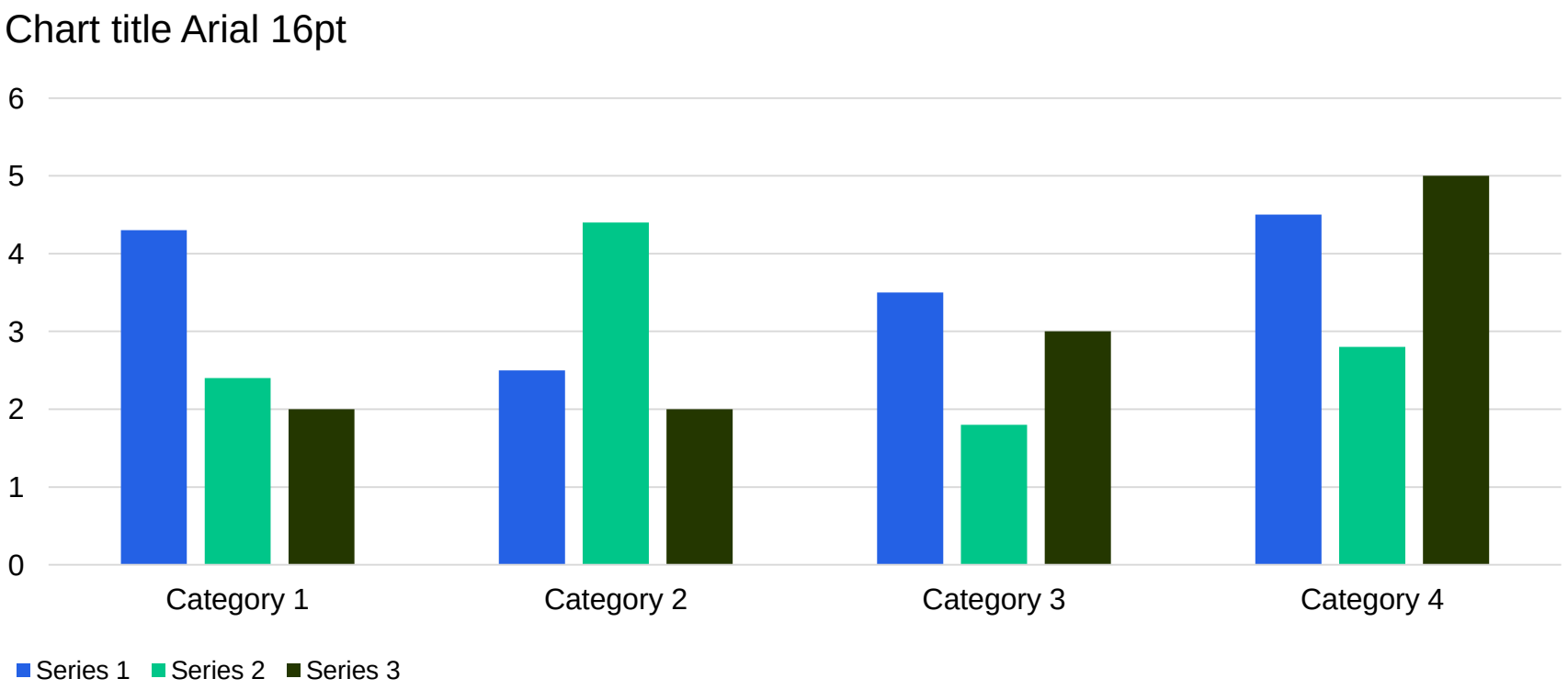
Subtitle Arial 20pt



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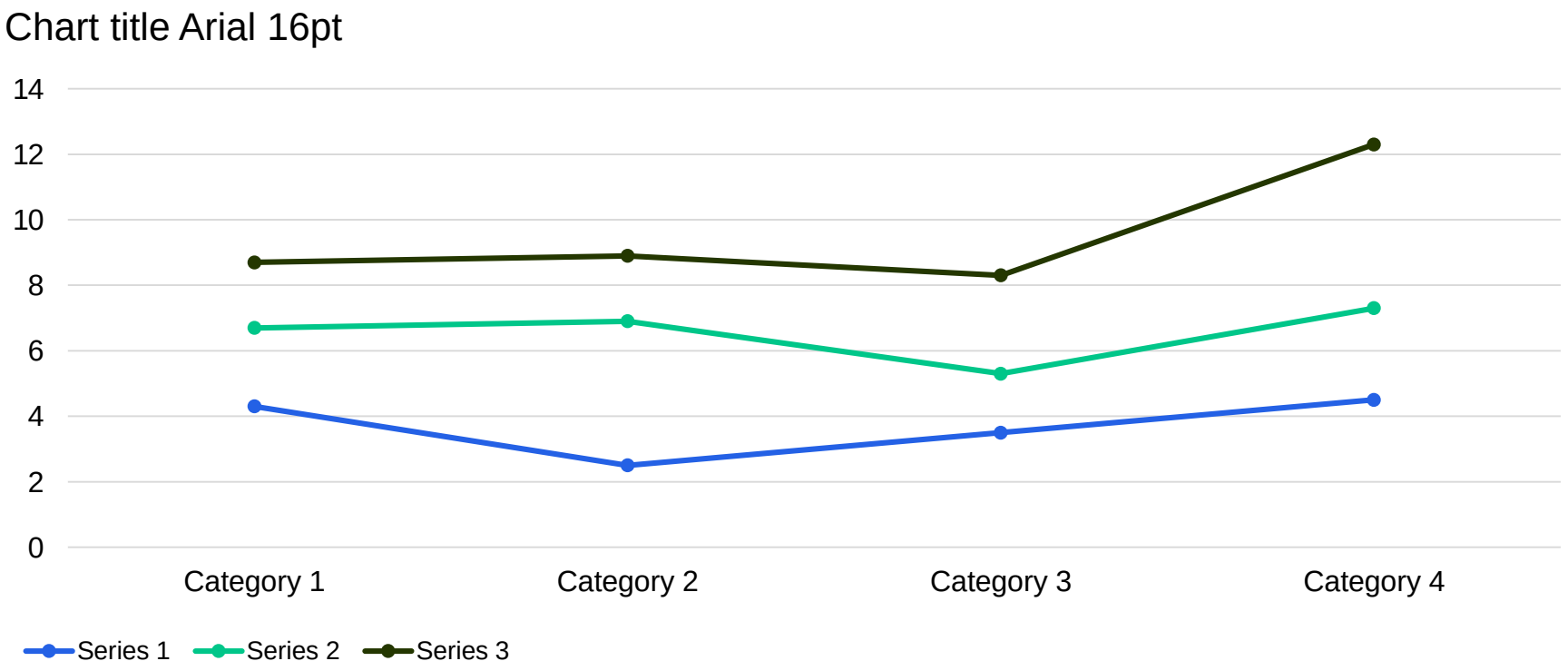

Add descriptive alt-text to the graph – right click on the table and select ‘Edit Alt Text’, then follow the instructions in the panel.

Slide heading, Arial Bold 25pt

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- Body

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- Text can be split over two columns if needed.
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