Objective guidance for intensity and structure analysis : Microwave, SATCON, scatterometers, ...

Sébastien Langlade Tarik Kriat

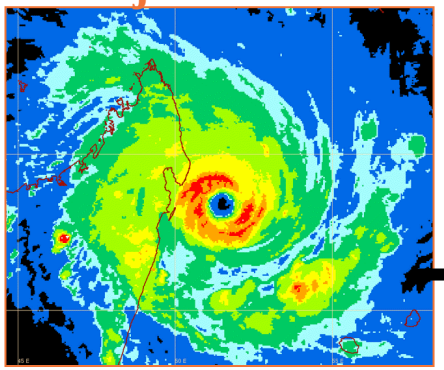
RA I WMO training course on tropical cyclones 2021

Intensity / Structure assessment : Overview

1. Microwave data
2. Objective Satellite guidance
3. Remote sensing of strong / extreme winds

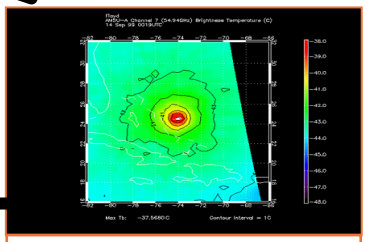
TC intensity / structure analysis in TC forecasting: an expertise

Subj. DVORAK



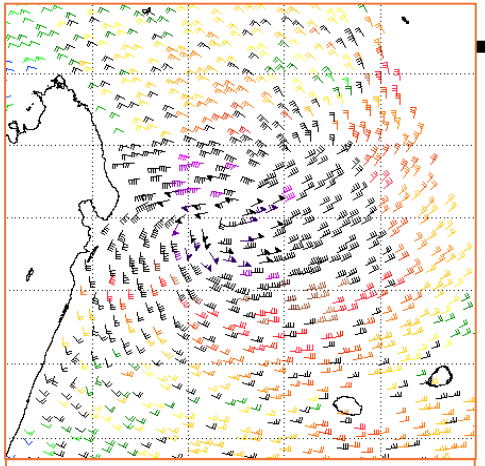
ADT

SATCON

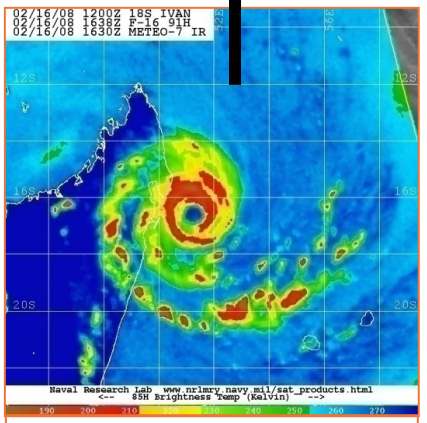


AMSU, ATMS, SSMI/S

TC intensity and structure analysis



ASCAT, SCATSAT, SMAP, (SAR)



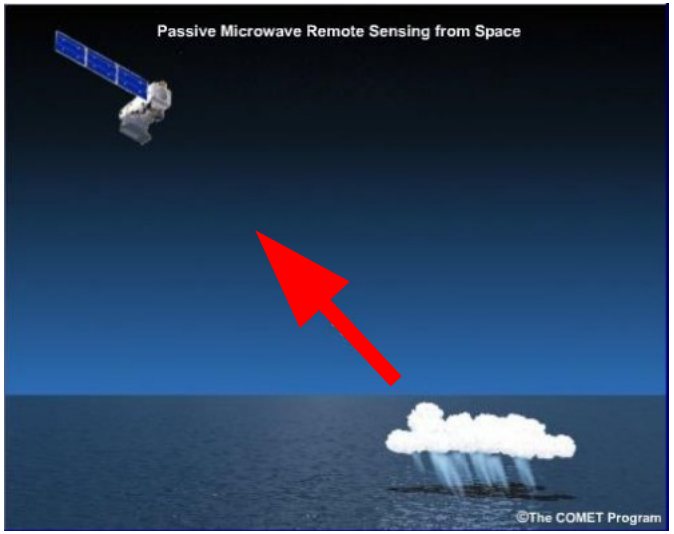
MICRO-ONDES

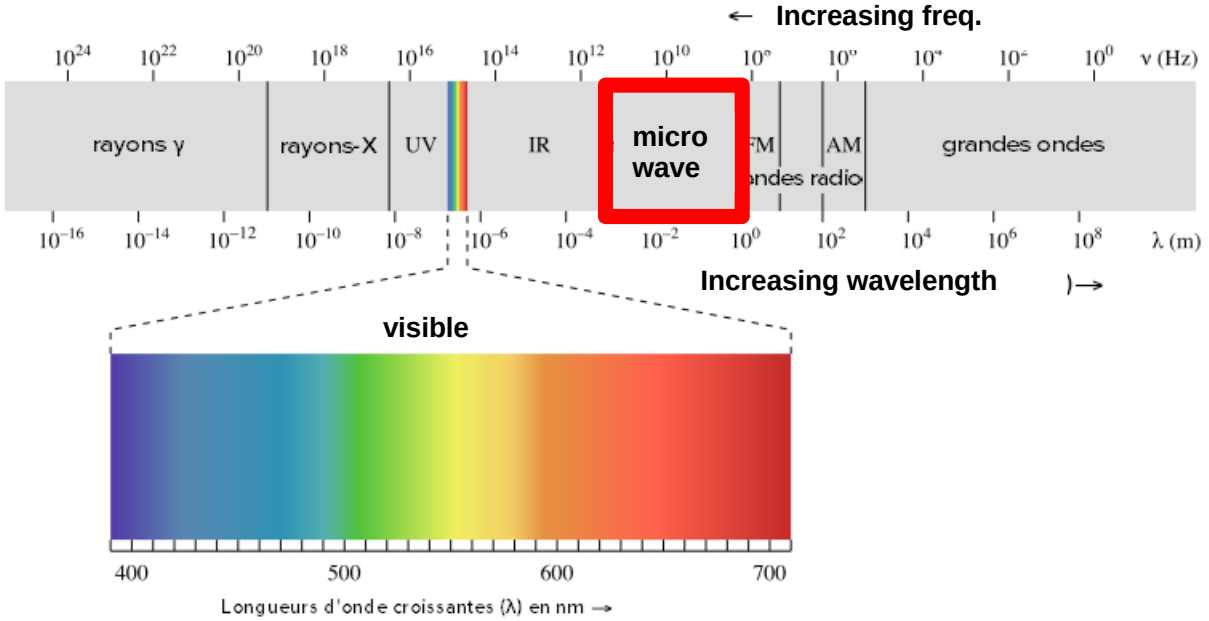
Surf. OBS

Intensity / Structure assessment : Overview

1. **Microwave data**
2. **Objective Satellite guidance**
3. **Remote sensing of strong / extreme winds**

Passive micro-wave imagery





- Passive microwave imagers measure the radiation emitted in the 5-200 GHz microwave range.
- A brightness temperature (Tb) is measured which allows to quantify the radiative processes and the associated hydrometeors:

- Scattering / graupeln

- Emission / Absorption / liquid cloud water and water drops

Passive micro-wave imagery

- Advantages:

  - see through cirrus clouds

  - detection in almost all atmospheric conditions

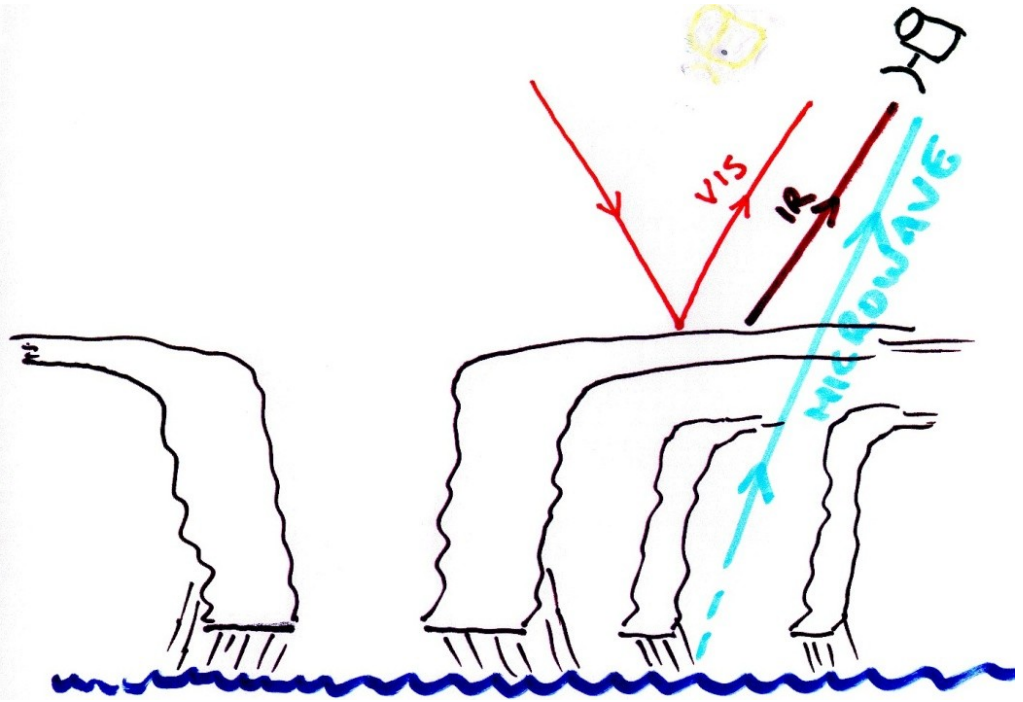
- Disadvantages

  - Wavelength + long than VIS or IR

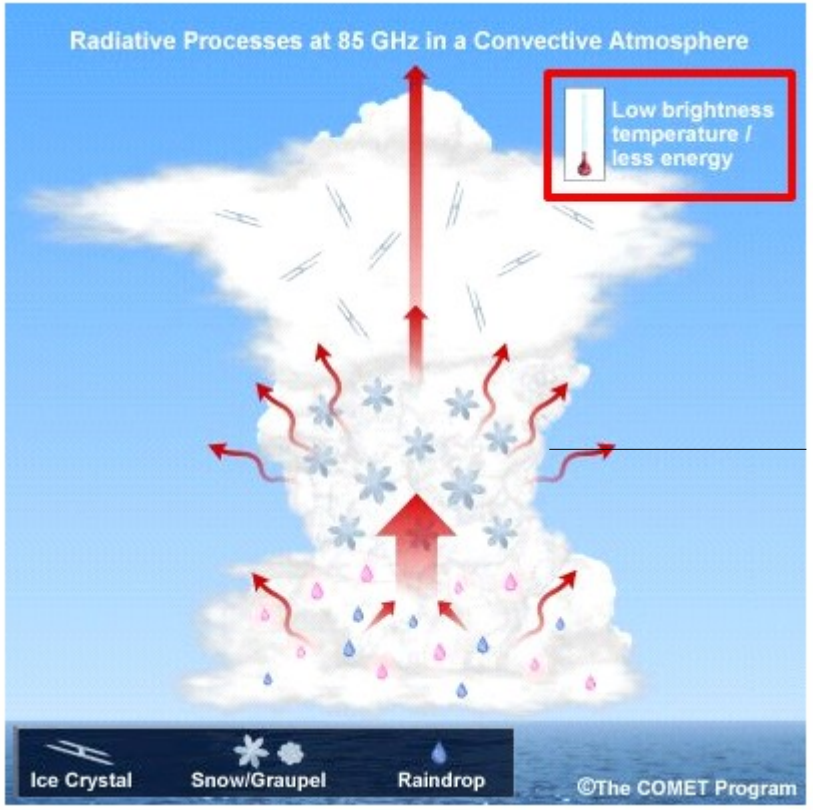
  → less energy and less good resolution

  → Only on scrollers

  → More complex interpretation.



Passive micro-wave imagery



- 85GHz :

  - The signal is amplified in the presence of liquid drops

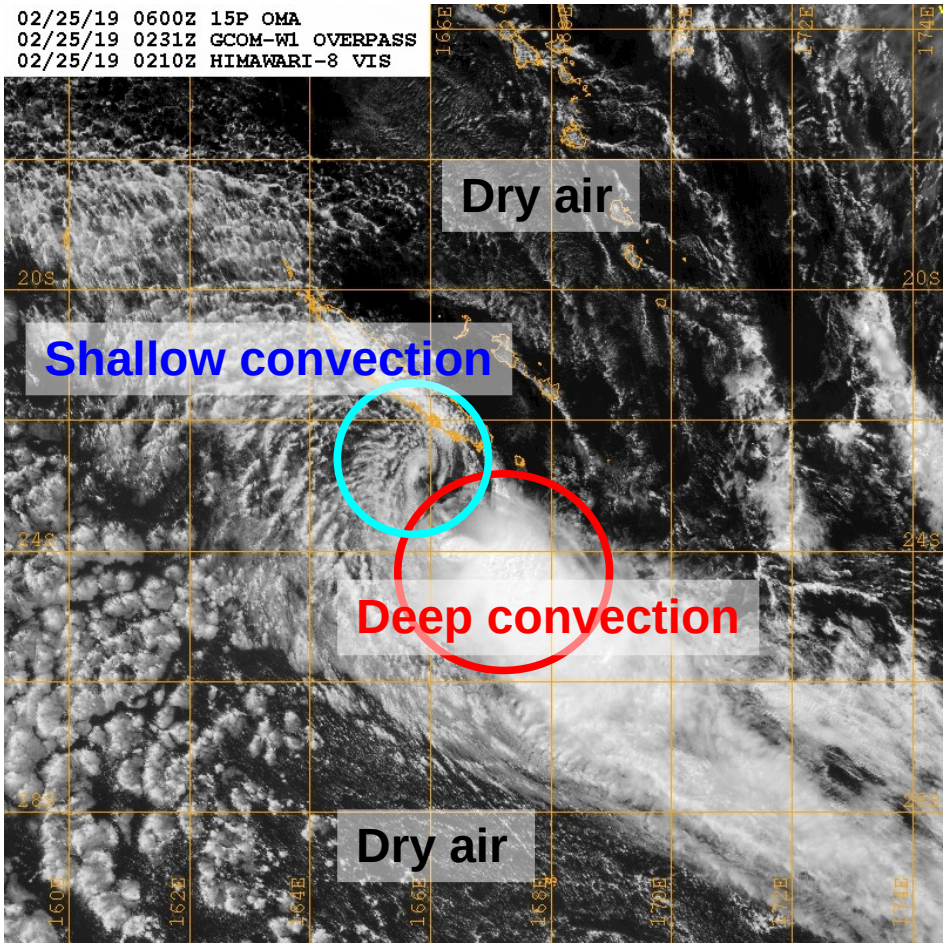
  - Scattering by icy particles

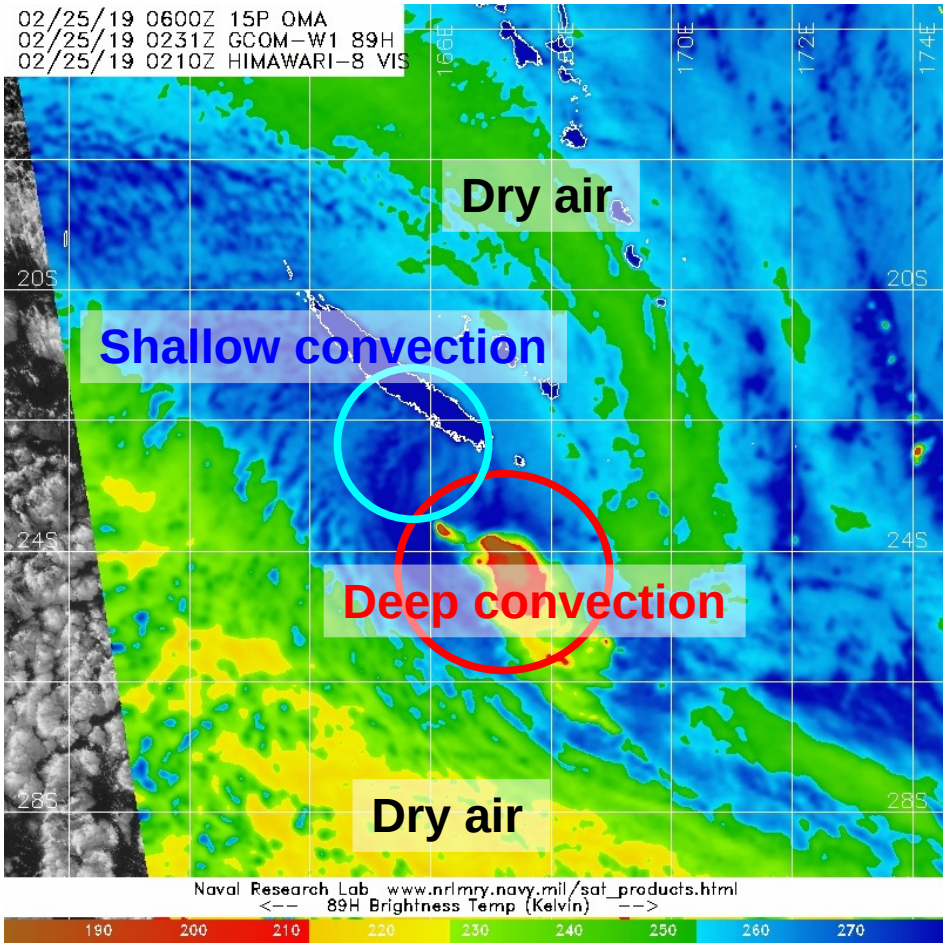
  - Deep convection associated with low Tb

  - Weak convection associated with high Tb

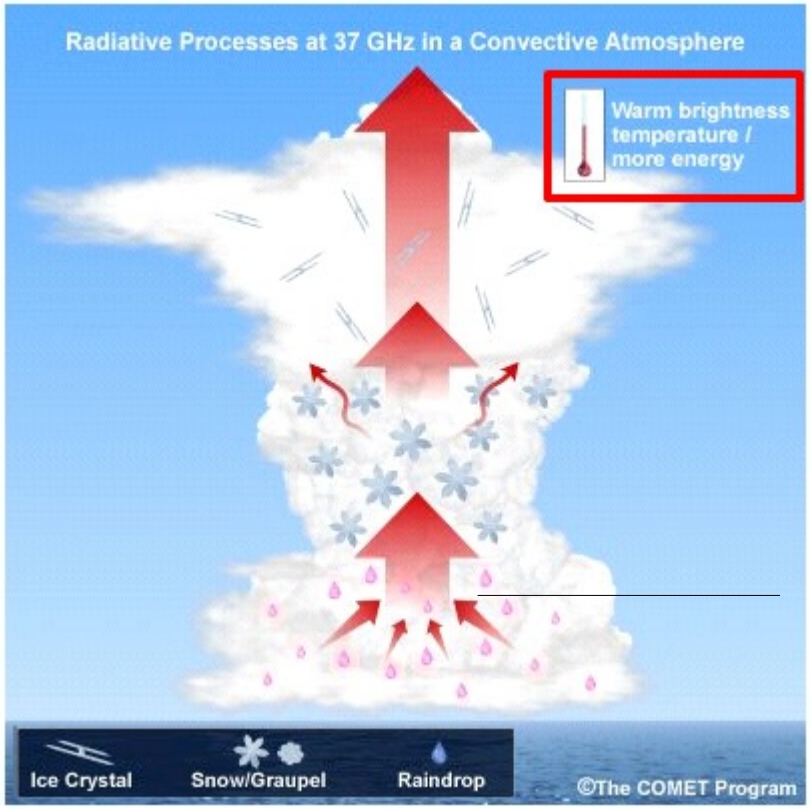
Passive micro-wave imagery

- 85GHz :





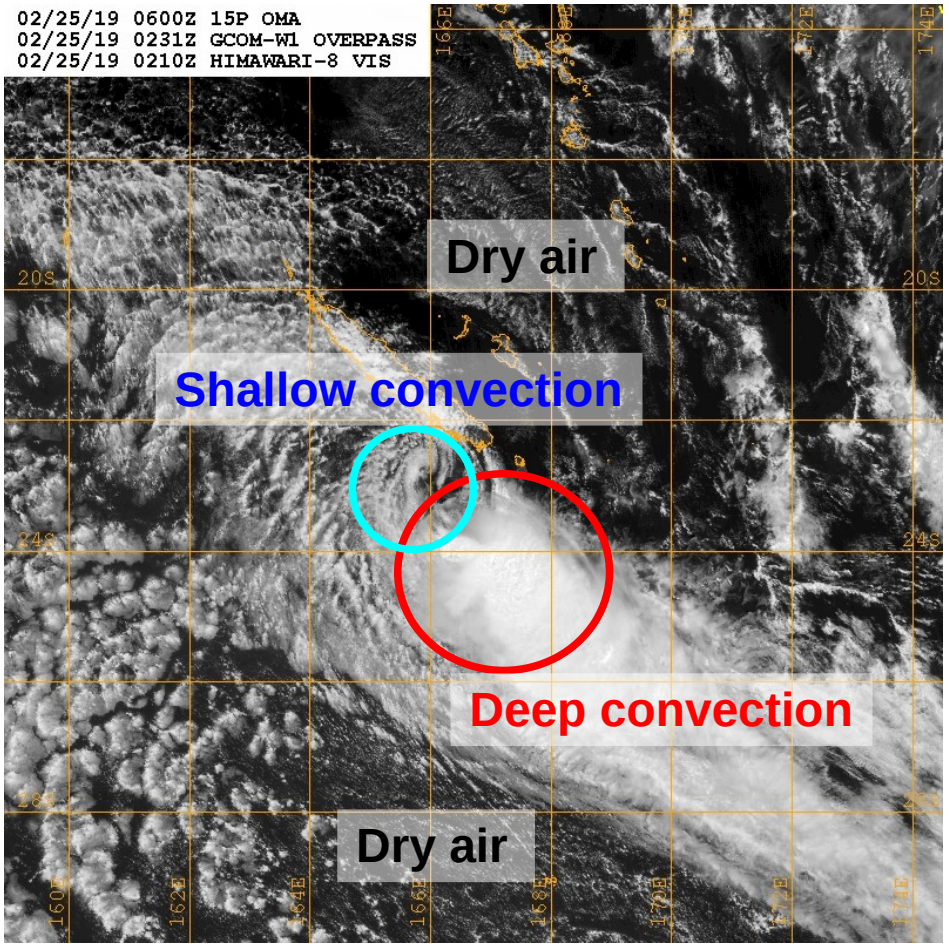
Passive micro-wave imagery

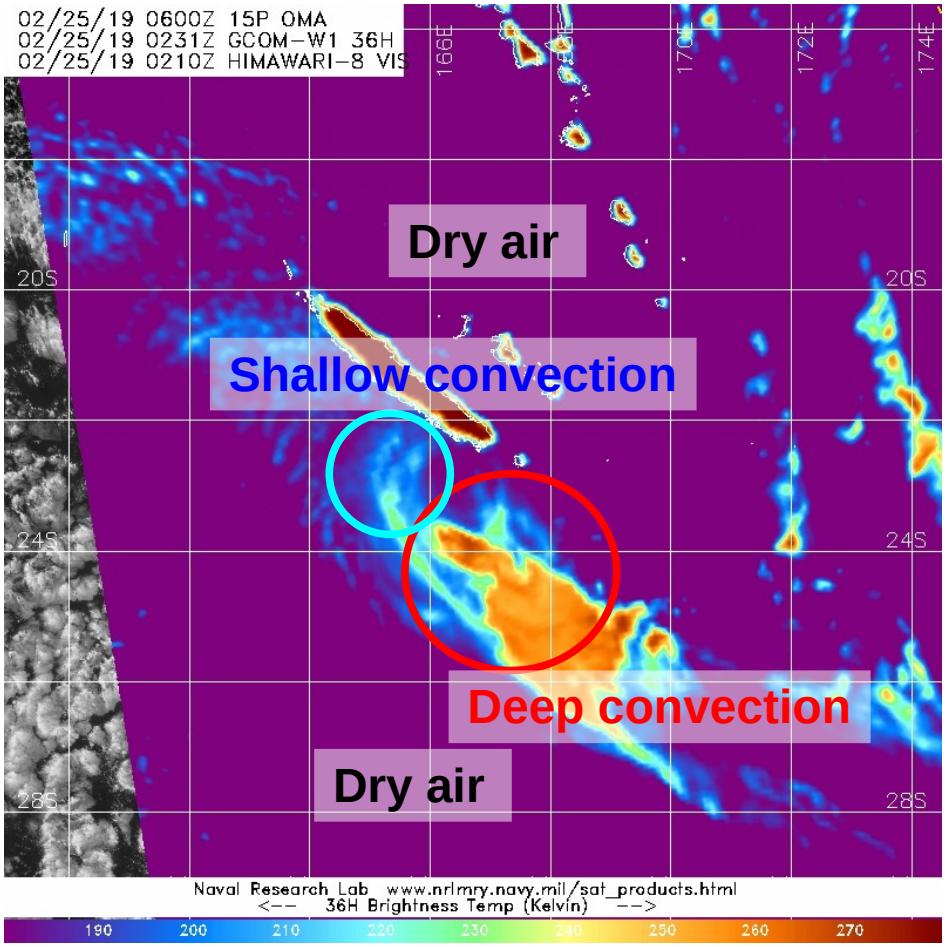


- 37GHz :
  - The signal is amplified by the liquid drops
  - No scattering by ice particles
  - Heavy rain associated with high Tb
  - Light rain associated with low Tb

Passive micro-wave imagery

- 37GHz :

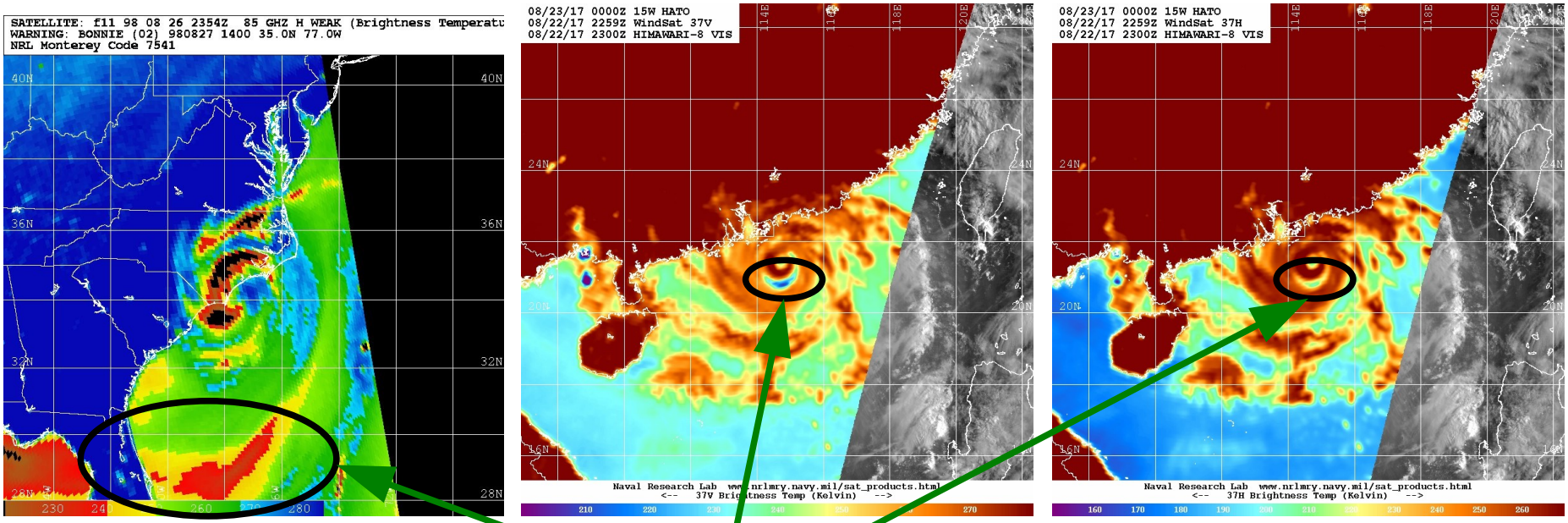




Passive micro-wave imagery

- Different products available on the NRL/FNMOC :
  - Polarised products :

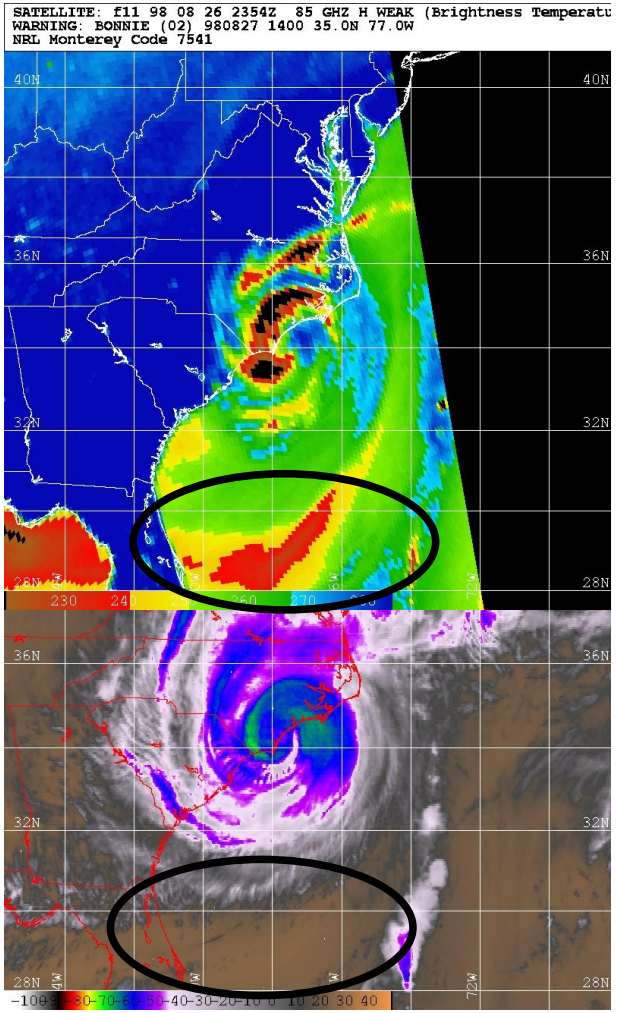
89h/89weak **37v** **37h**



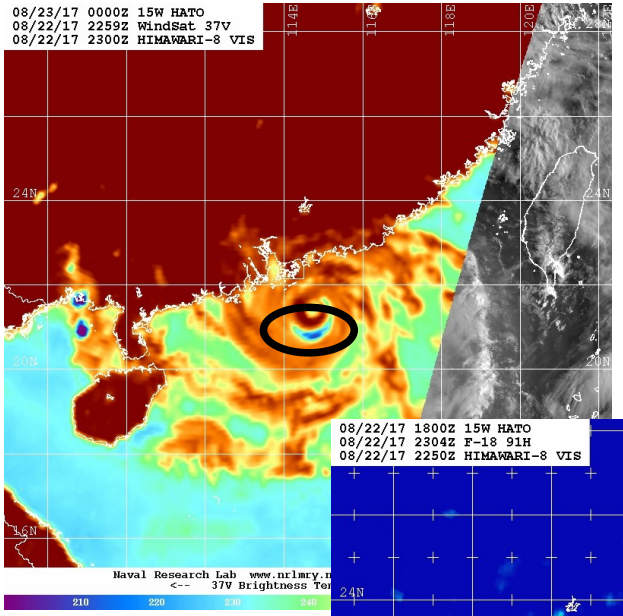
  - But some biases :

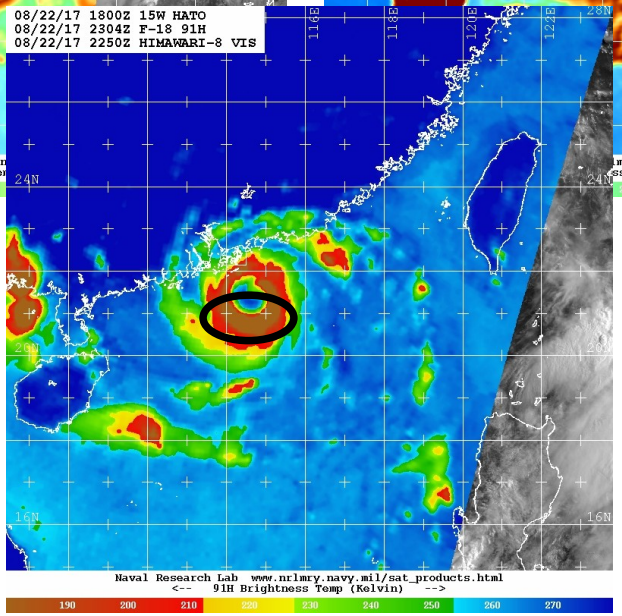
Passive micro-wave imagery

89h/89weak

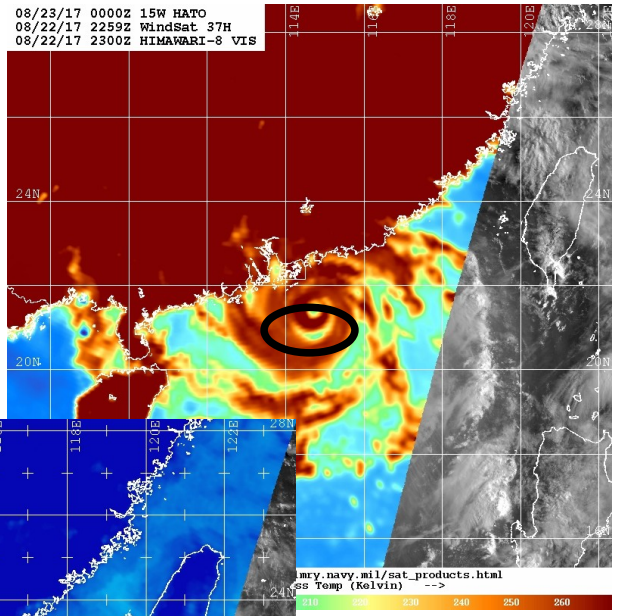


37v





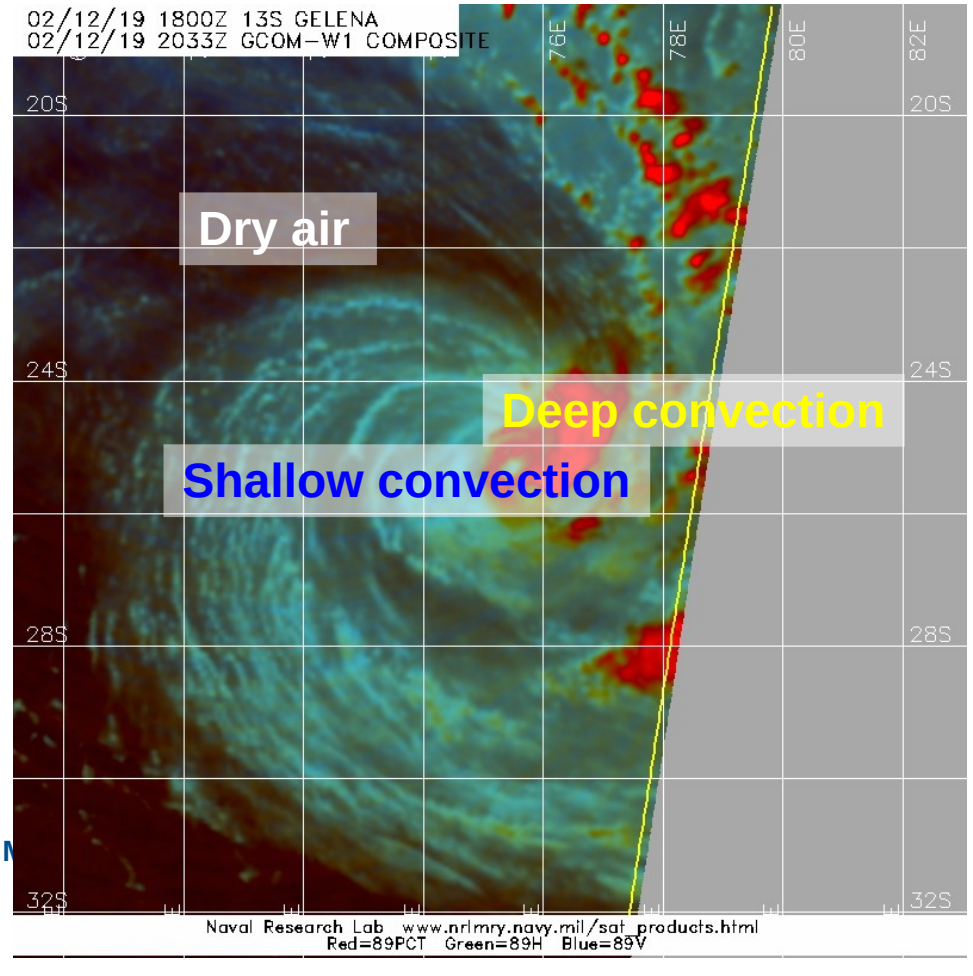
37h



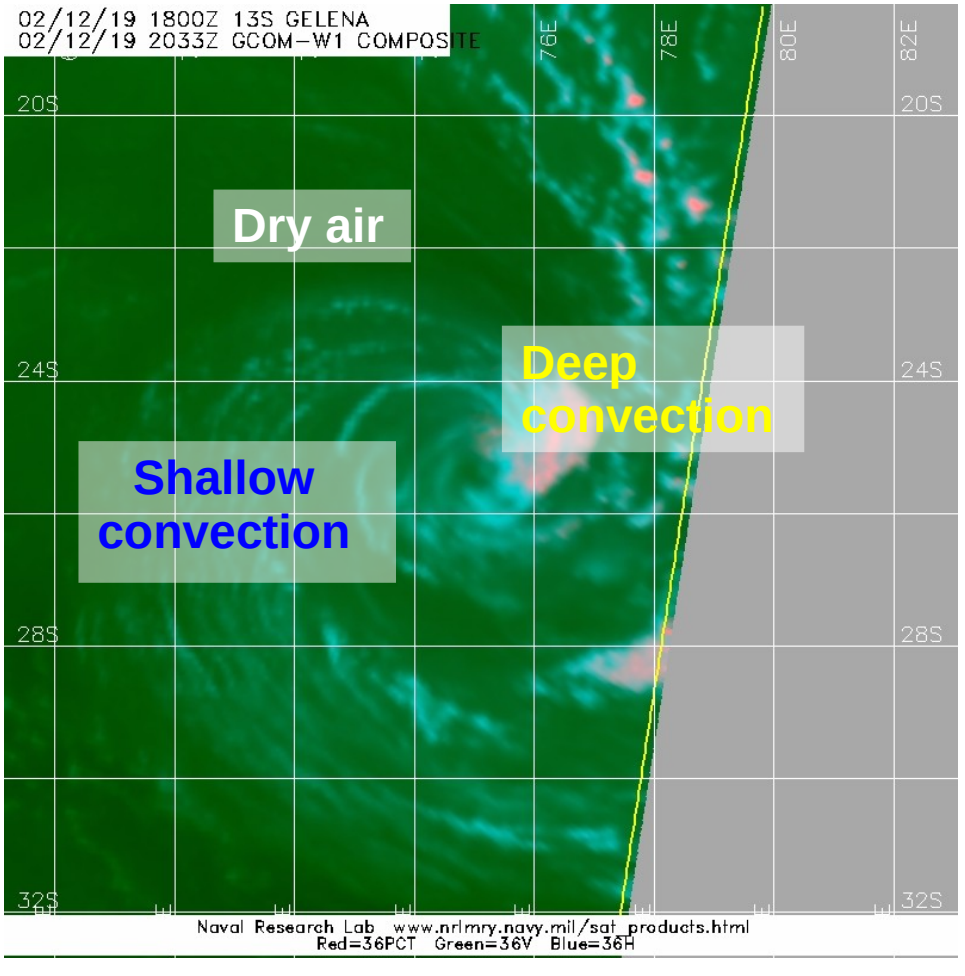
Passive micro-wave imagery

- Different products available on the NRL/FNMOC :
  - Composites (most used) :

Color

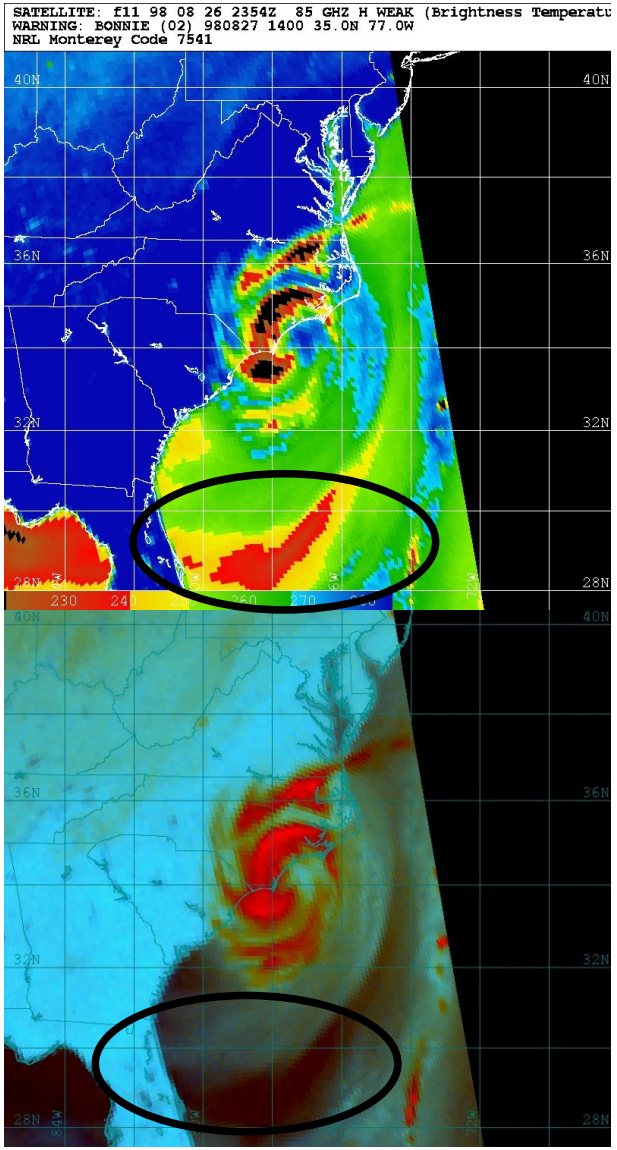


37Color

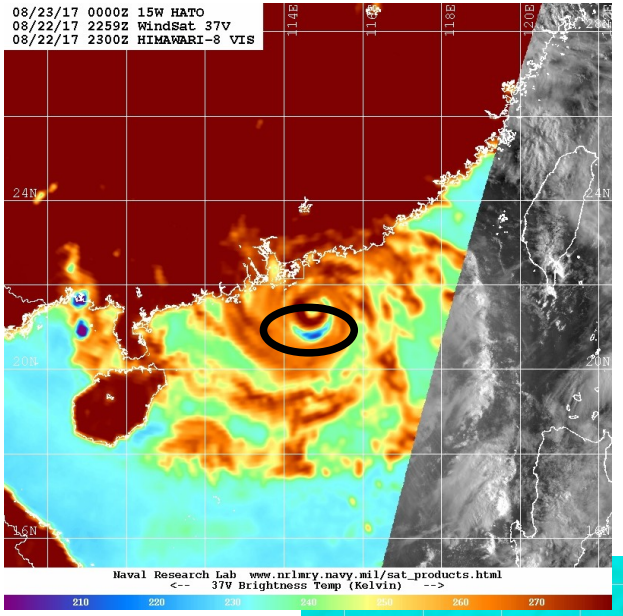


Passive micro-wave imagery

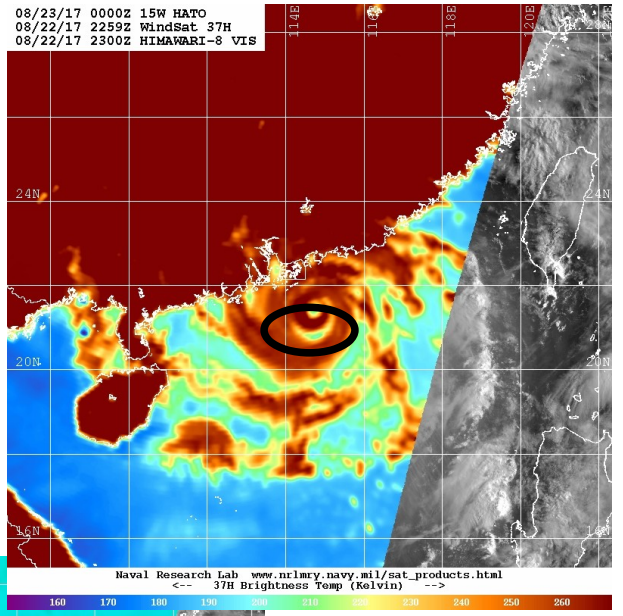
89h/89weak



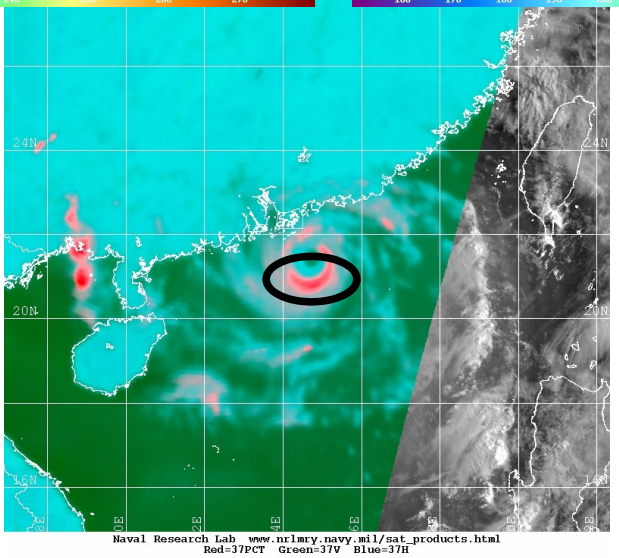
37v



37h



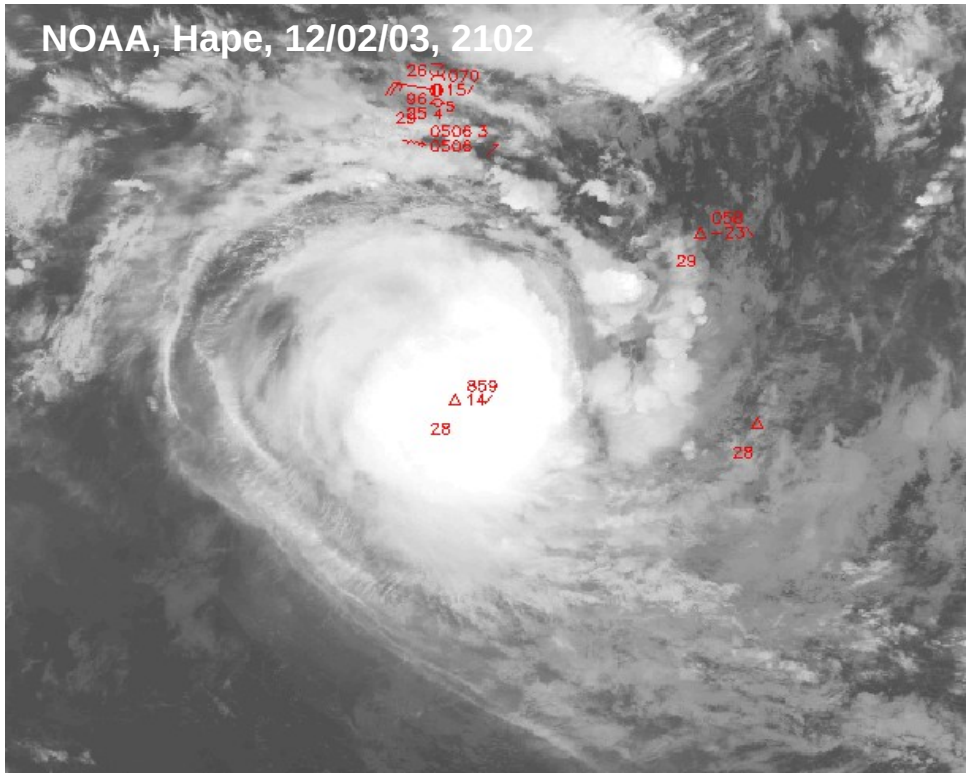
Color

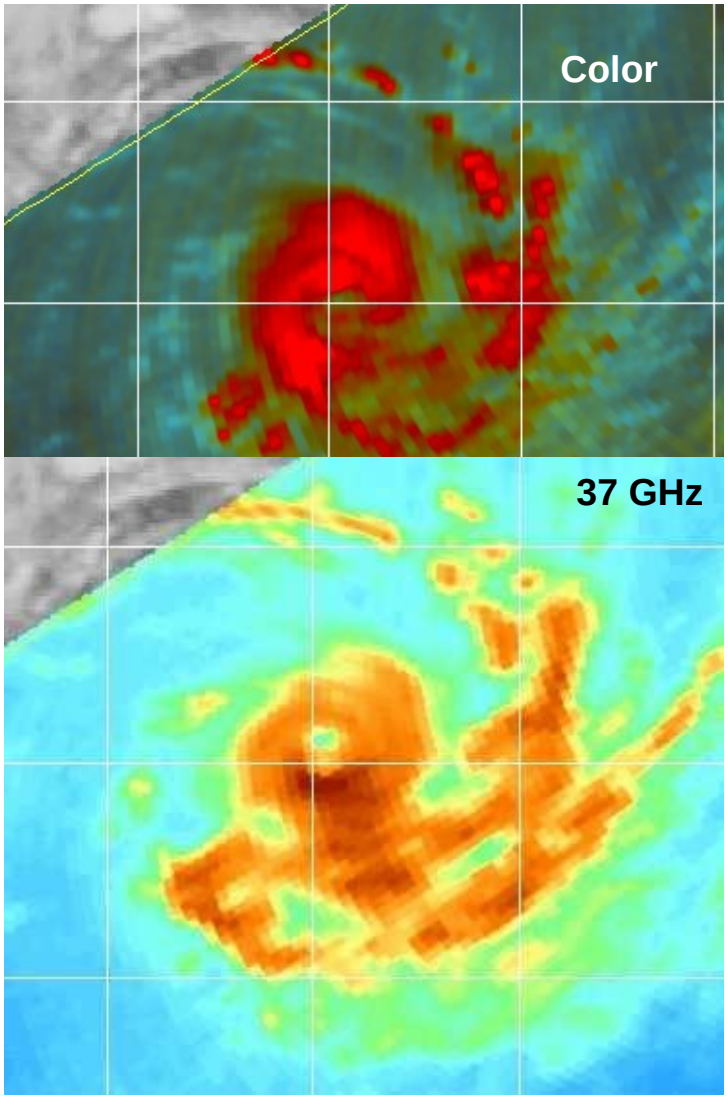


37Color

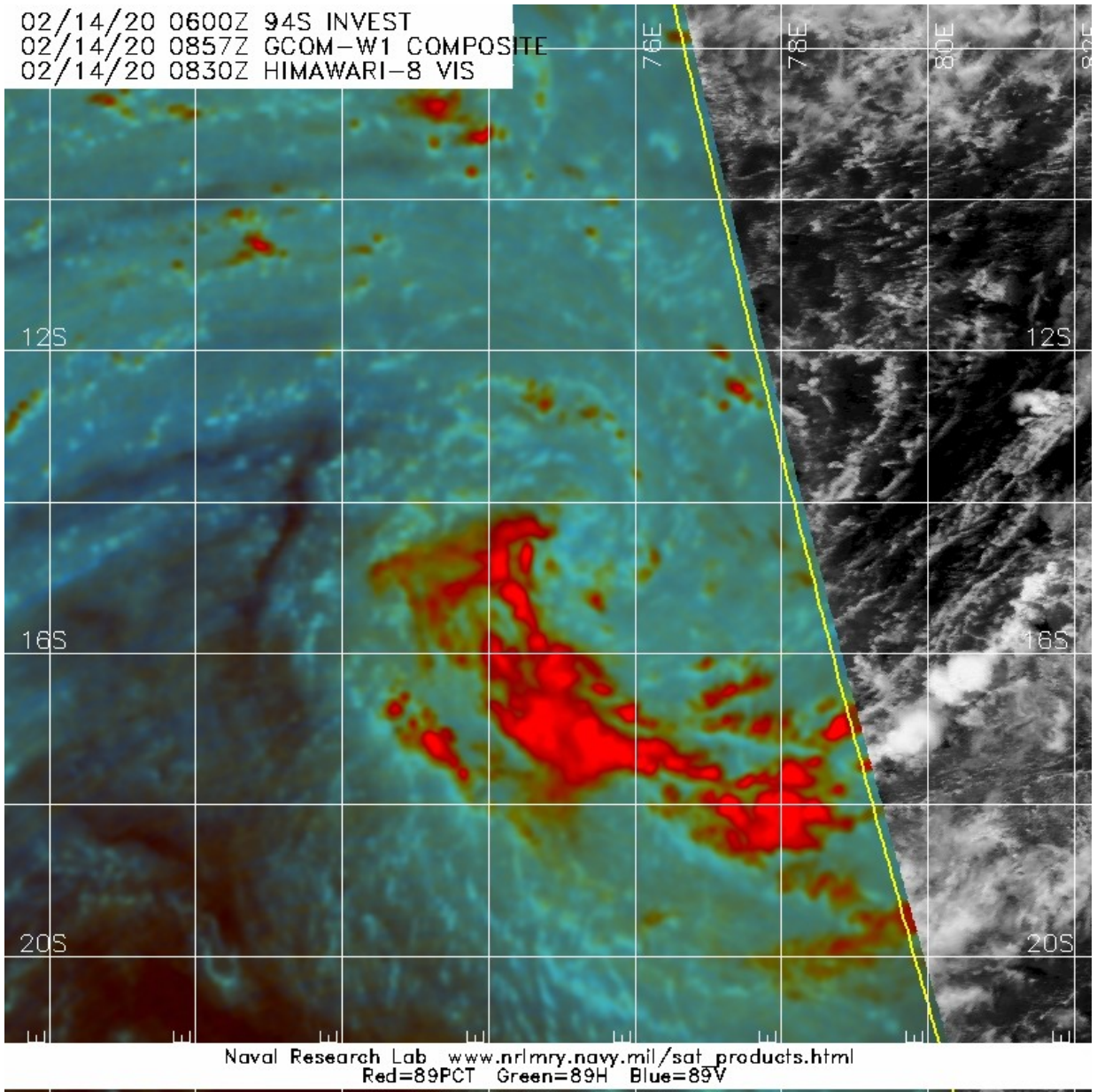
Passive micro-wave imagery

- Essential tool to locate the center precisely:
  - CDO/sheared cloud pattern
  - At the beginning/end of TC lifecyle





Passive micro-wave imagery

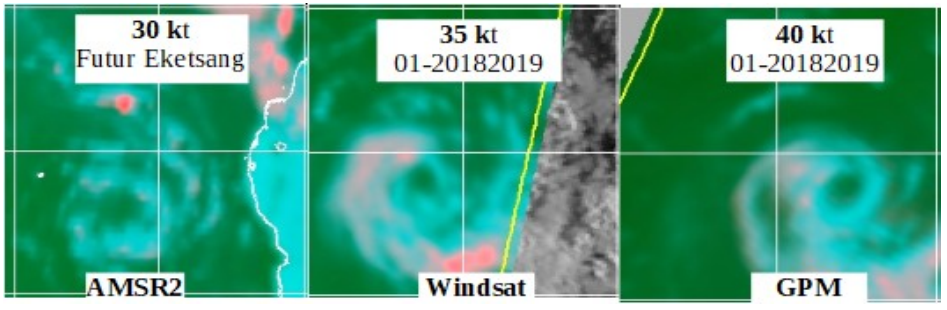


Where is the center ?

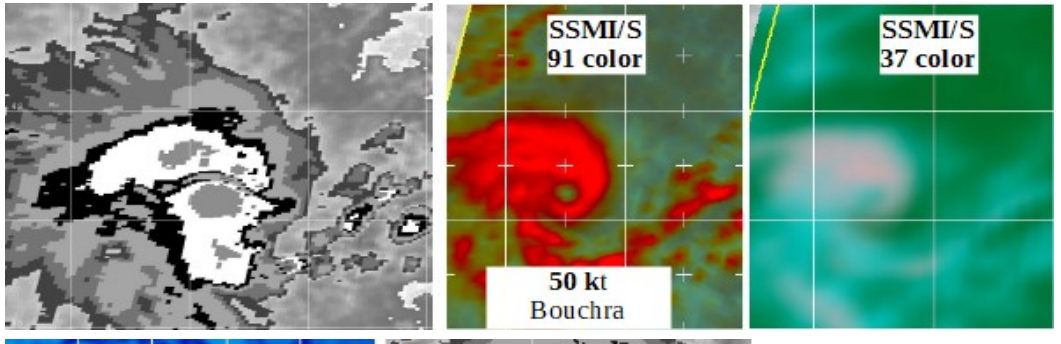
Early stage of Gabekile (février 2020)

Passive micro-wave imagery

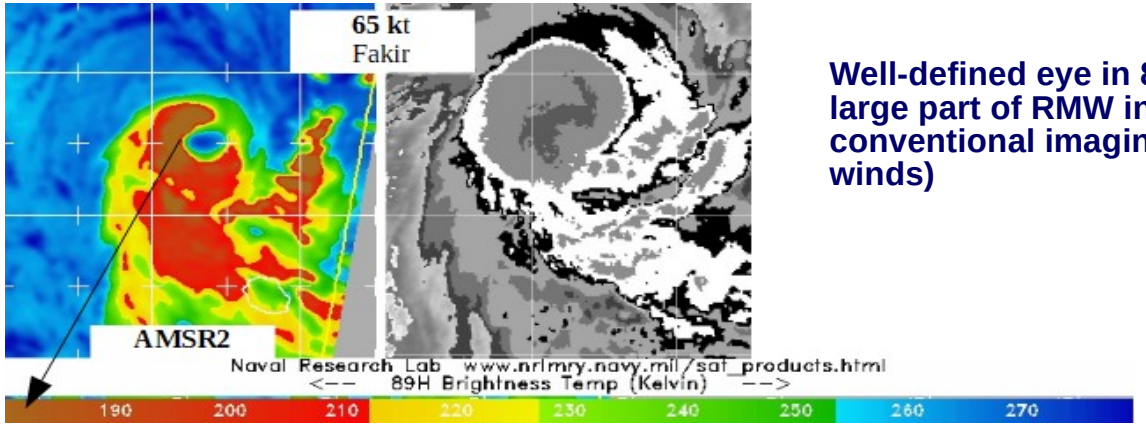
- Witness the inner-core structuring and intensification : :



Well-defined eye in 37 GHz / No eye in 85 GHz / No eye in conventional imaging → MTS (gale force winds)



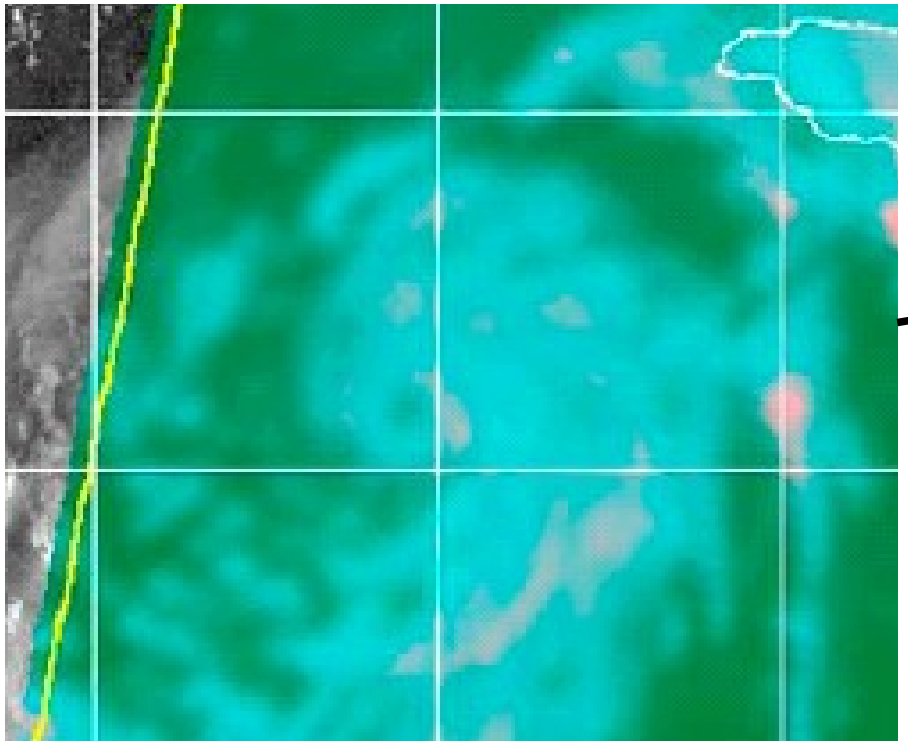
Well-defined eye in 85 GHz / vertical alignment / No eye in conventional imaging → STS (storm force winds)

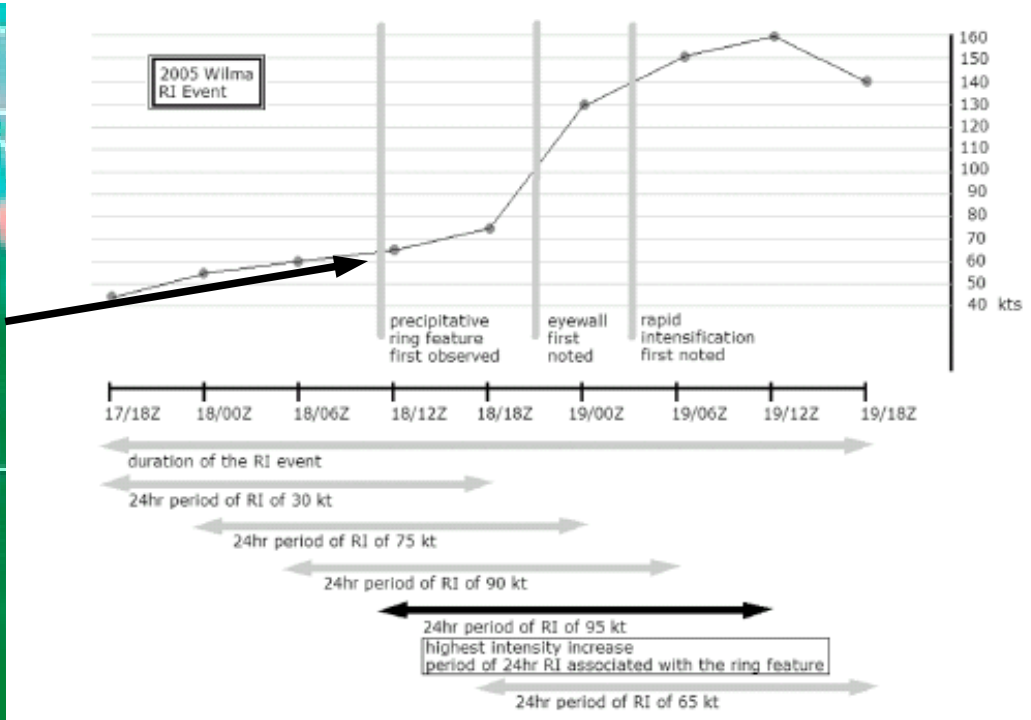


Well-defined eye in 85 GHz / Very low Tb on large part of RMW in 85 H / No eye in conventional imaging → TC (hurricane force winds)

Passive micro-wave imagery

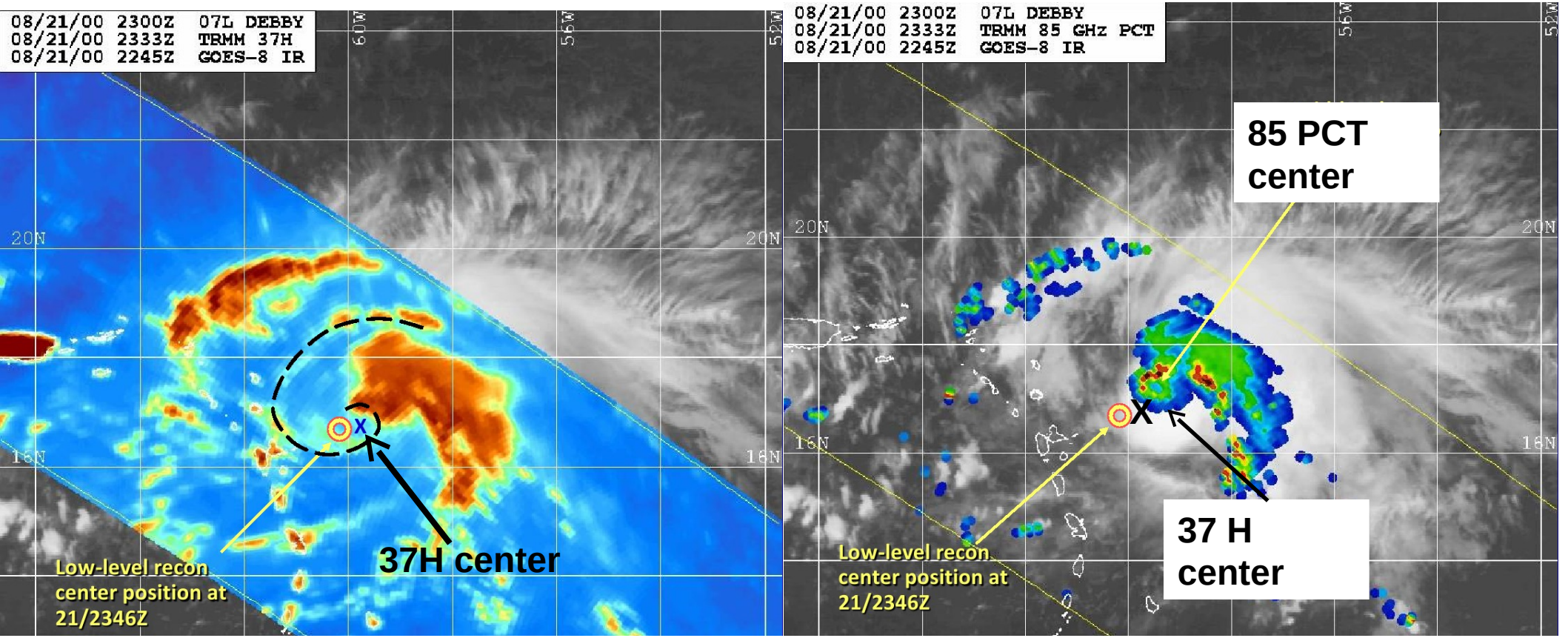
- Rapid intensification predictor (Cyan ring)
  - Kieper (2012): risk of rapid intensification within 24 hours





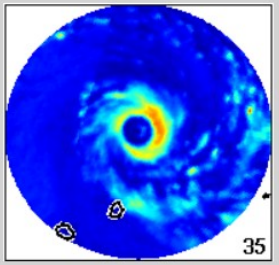
Passive micro-wave imagery

- Revealing the tilt of the cyclonic vortex in a sheared environment.

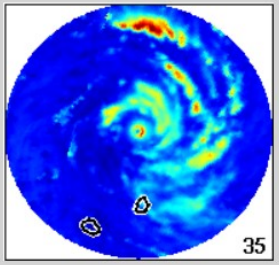


Passive micro-wave imagery

- MIMIC-TC :
  - Morphing animation of 89GHz data:
    - Bansi 2015



2015-01-14 00:00 -- 2015-01-15 00:00 [Animated GIF] [JAVA]



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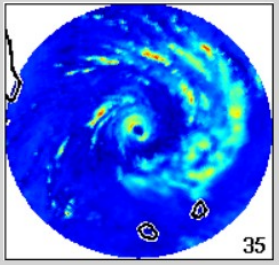


2015-01-12 00:00 -- 2015-01-13 00:00 [Animated GIF] [JAVA]

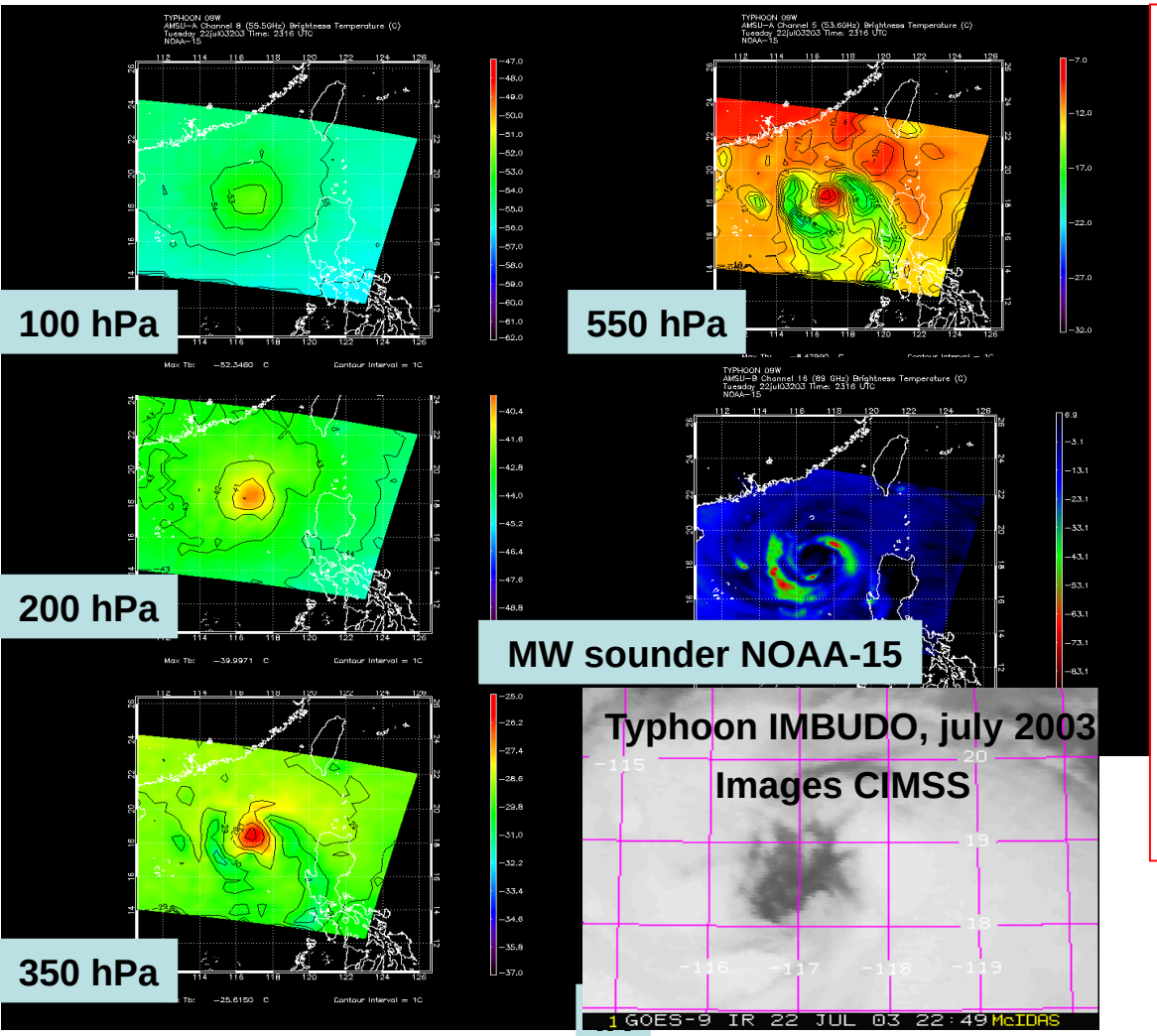
Intensity / Structure assessment : Overview

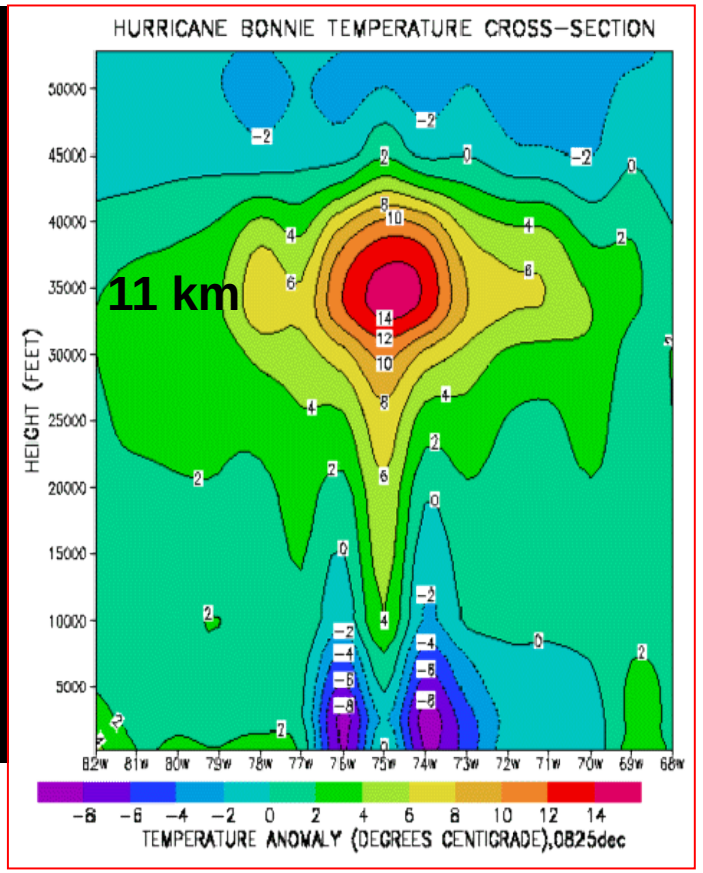
1. Microwave data
2. Objective Satellite guidance
3. Remote sensing of strong / extreme winds

Microwave sounders

- AMSU, ATMS, SSMIS :

  An objective way to estimate the intensity of a system based on the magnitude of the warm core as seen by a sounder

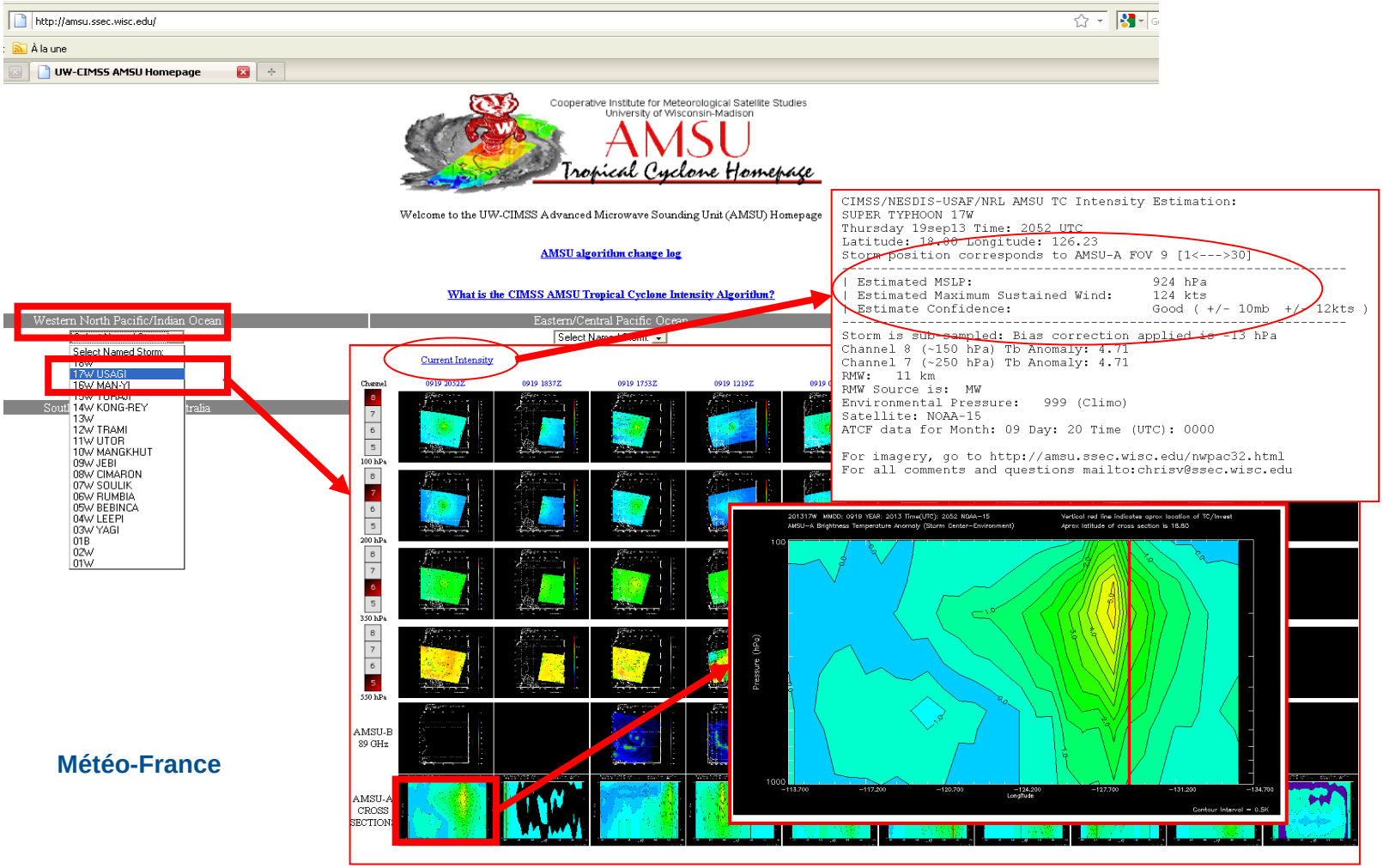




Microwave sounders

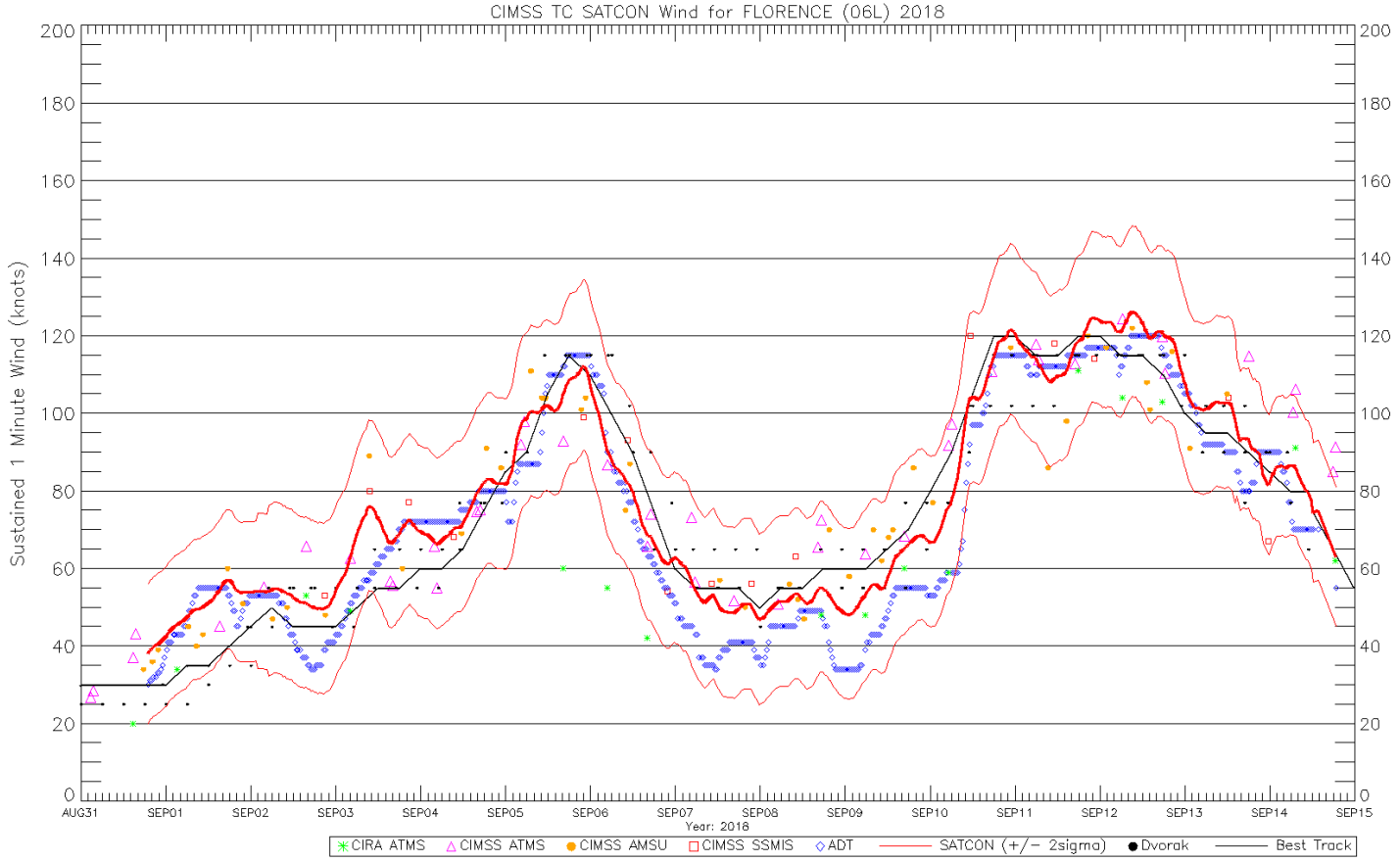
- AMSU :

  2 institutes develop operational algorithms : CIMSS, CIRA



Weighted consensus of objective satellite estimates

- SATCON : **SAT**ellite **CON**sensus → estimates of TC Vmax/MSLP
  - Calibrated consensus of several objective intensity estimators: ADT (automatic Dvorak) & Probes (AMSU, SSMIS, ATMS)
  - Optimized for cloud configuration / TC life cycle



Weighted consensus of objective satellite estimates

- SATCON : SATellite CONsensus
  - Better scores than its components (2006-2015)

N = 4097	CIMSS AMSU	CIMSS ADT	SSMIS/ ATMS	SATCON
BIAS	-3.9	-1.6	-2.2	-0.2
AVG ERROR	9.7	10.0	8.6	7.2
RMSE	12.5	12.8	11.2	9.1

Intensity / Structure assessment : Overview

1. Microwave data
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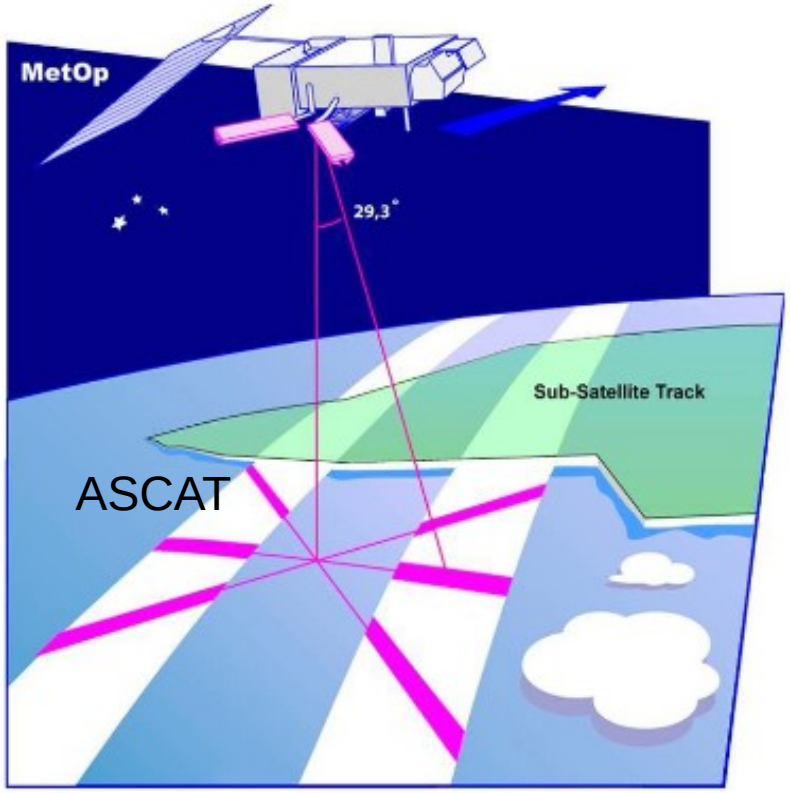
3. Remote sensing of strong / extreme winds

Remote sensing of strong / extreme winds

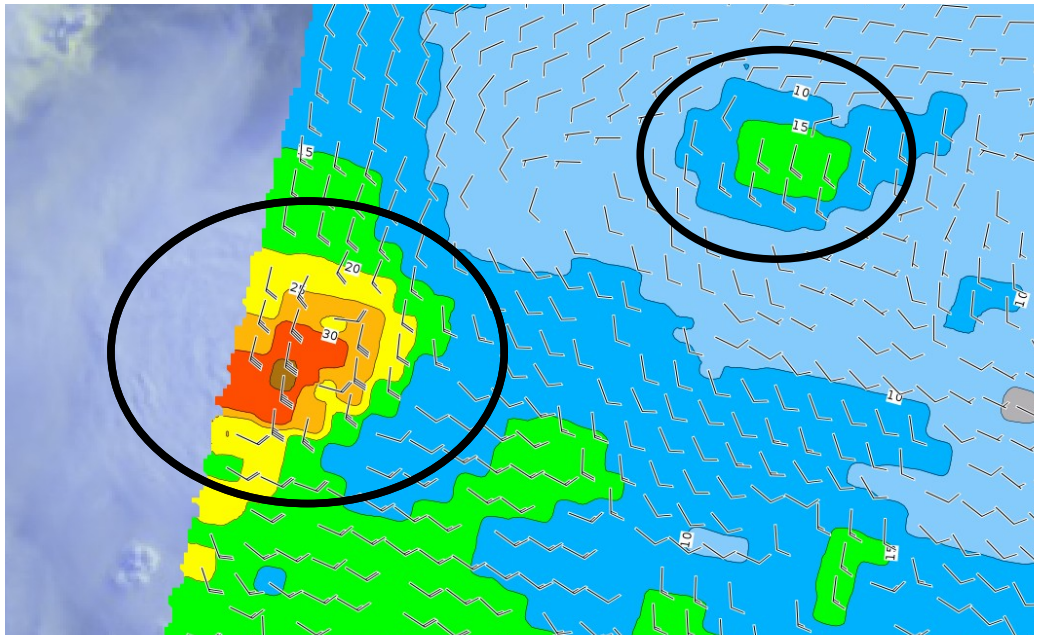
- Principle :

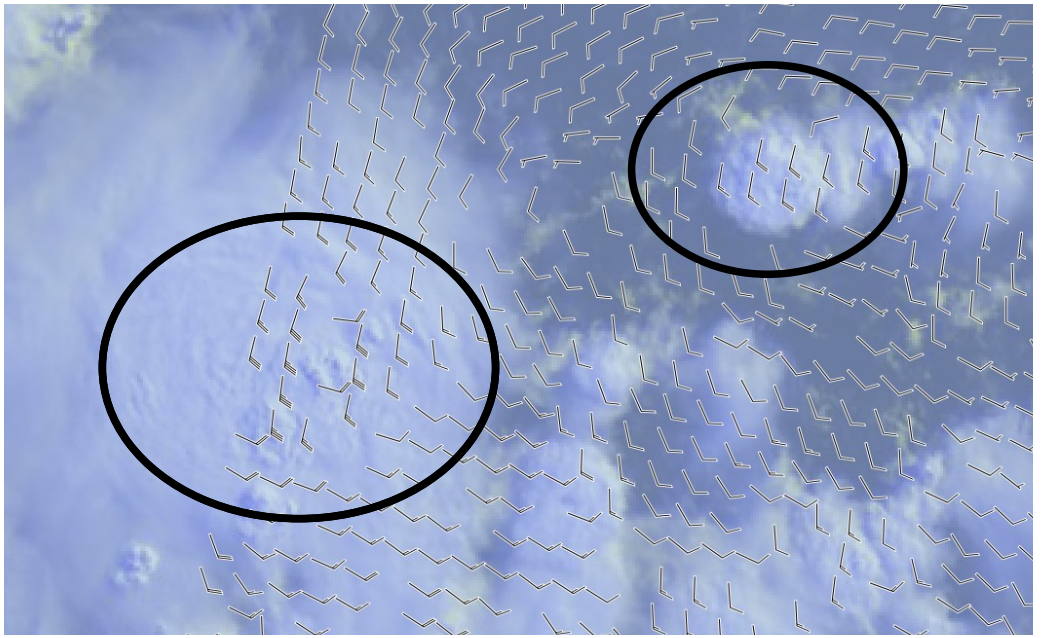


- Diffusiometer: microwave radar measuring the signal backscattered by capillary and gravity waves on the sea surface
- The analysis of the signal backscattered by the same ocean surface seen from different angles by the satellite allows to calculate the strength and direction of the wind.
- The measurement is disturbed by any phenomenon that destroys the capillary waves: rain, very weak or very strong winds.
- Wind direction ambiguity: removed with model data

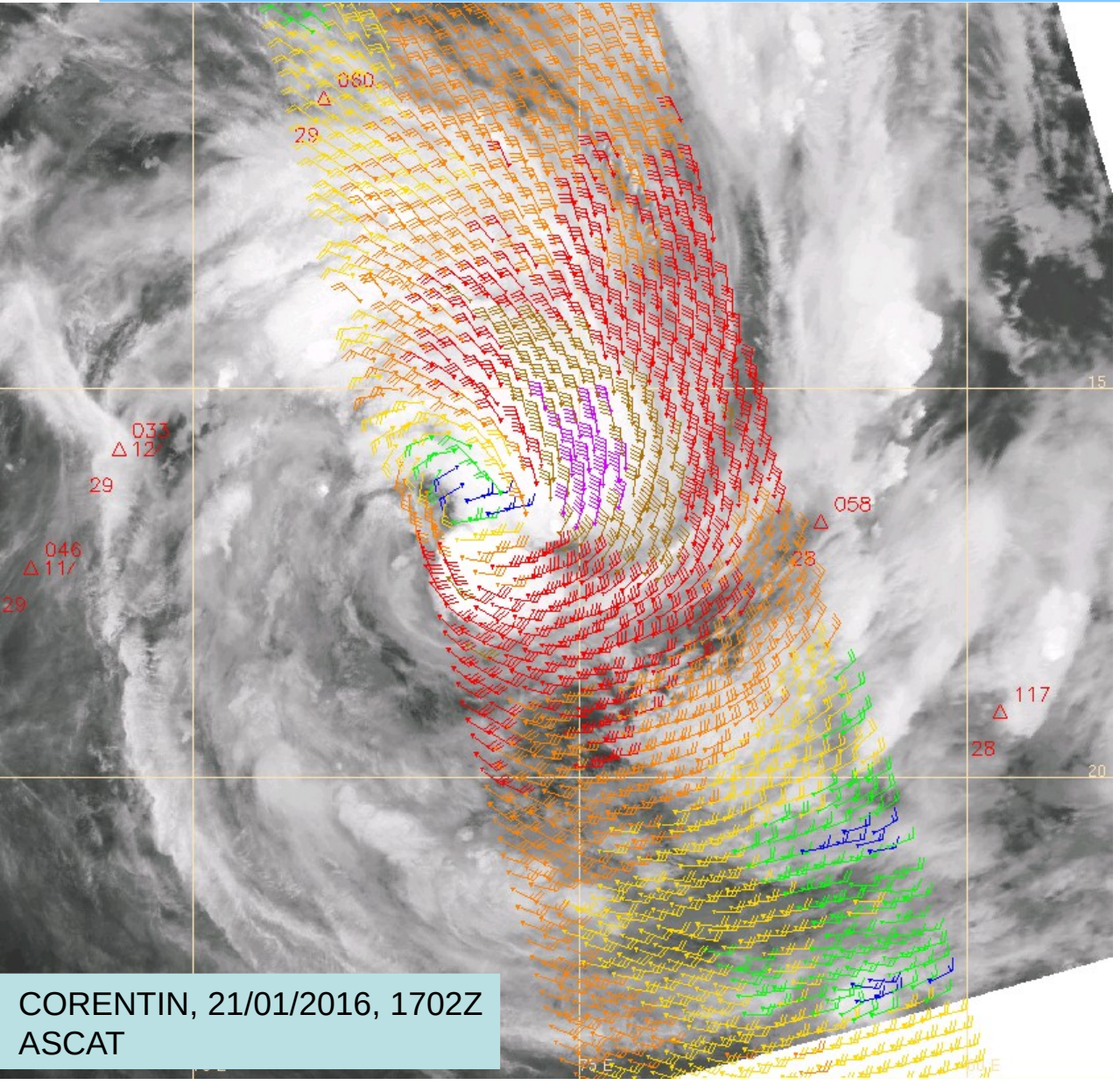
Remote sensing of strong / extreme winds

Example of the influence of heavy rainfall in light wind conditions → erroneous measurements





Remote sensing of strong / extreme winds



CORENTIN, 21/01/2016, 1702Z
ASCAT

- ASCAT A, B and C (Metop - EU)
Best resolution at 12.5 km
Passage ~06Z and ~18Z
→ **ASCAT-A discontinued on 15/11/21**

- HSCAT 2B, 2C - (HY 2B, 2C - CHINA)
Best resolution at 25 km
Status : development
Passage to ~00Z ~12Z

<u>Interest in cyclone monitoring :</u>

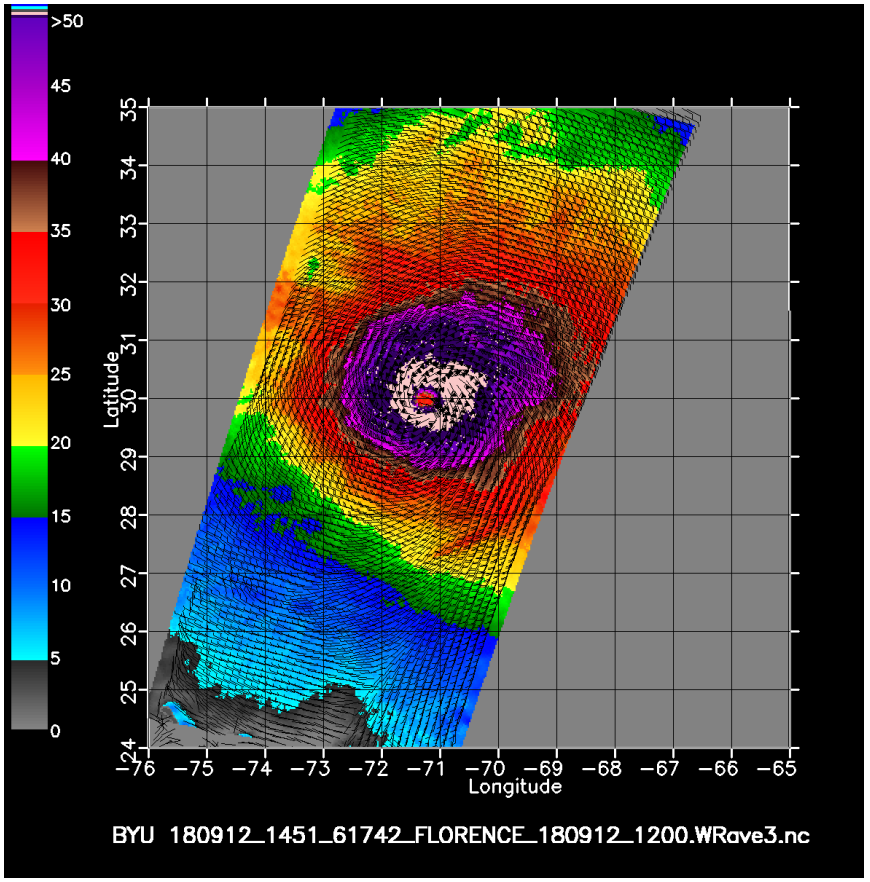
- Center fixing

- Intensity (range: 20 → 40 kt, can be used to assess the existence of storms or even hurricanes winds), but **beware resolution regards to system size**

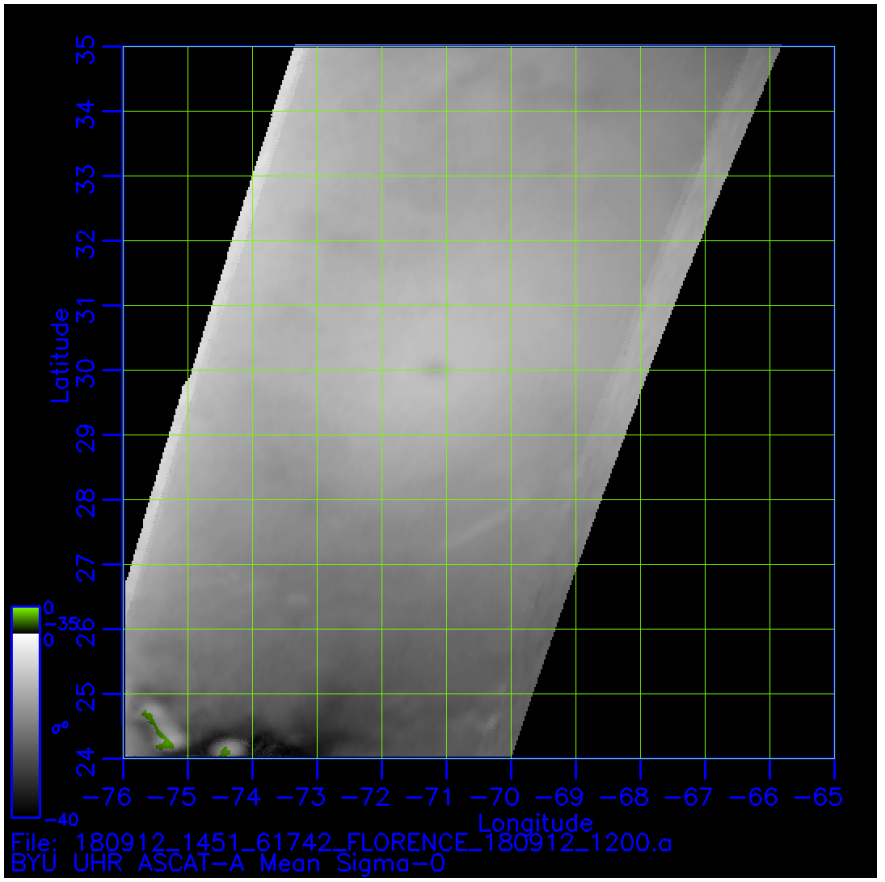
- Winds radii assessment (near gale, gale, ~ storm force winds)

Remote sensing of strong / extreme winds

- Manati : High resolution product based on backscattered signal (windspeed retriaval)

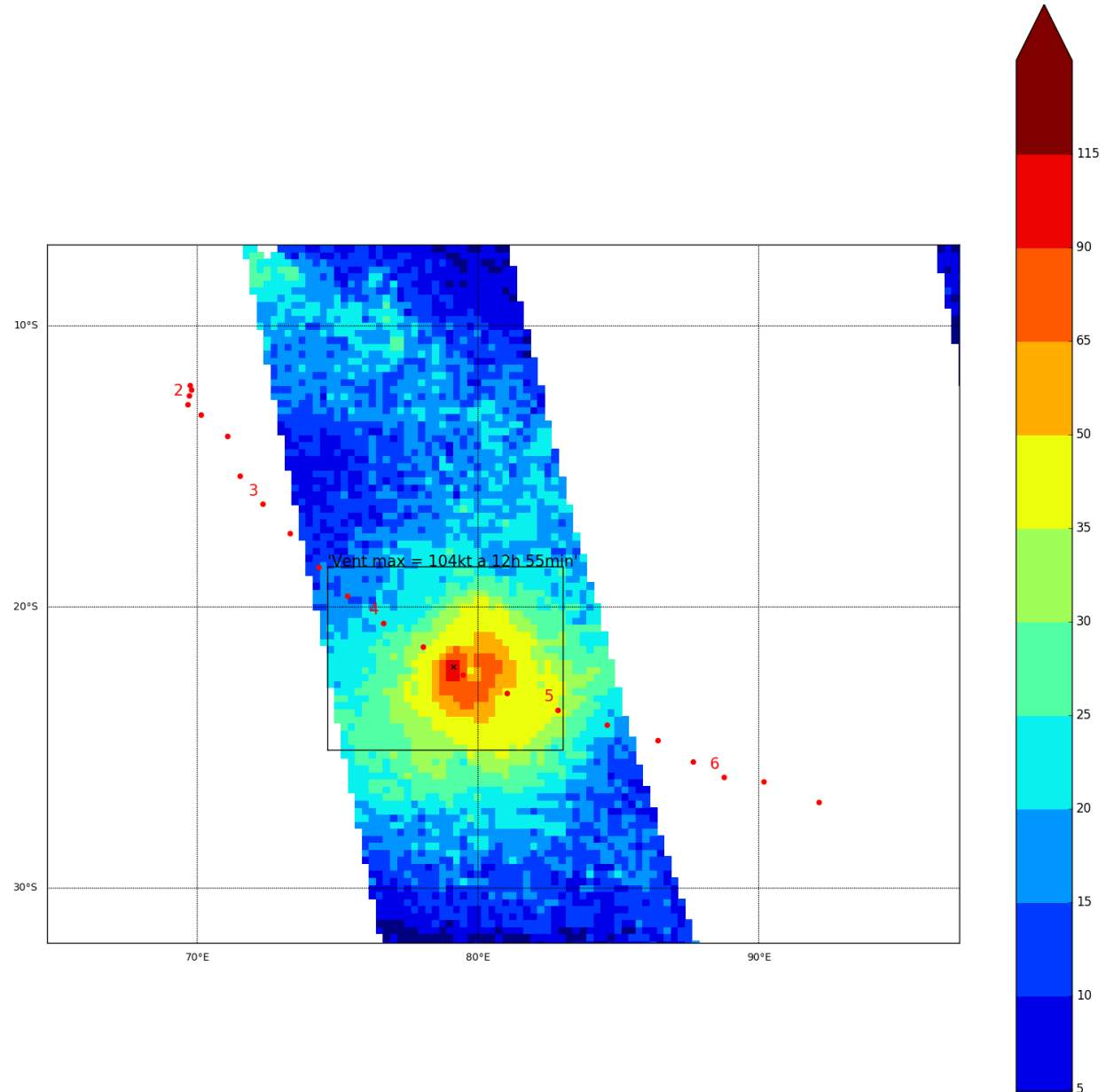


BYU Florence (12/09 1451Z)



NRCS Florence (12/09 1451Z)

Remote sensing of strong / extreme winds SMOS/SMAP (Soil Moisture Active Passive)

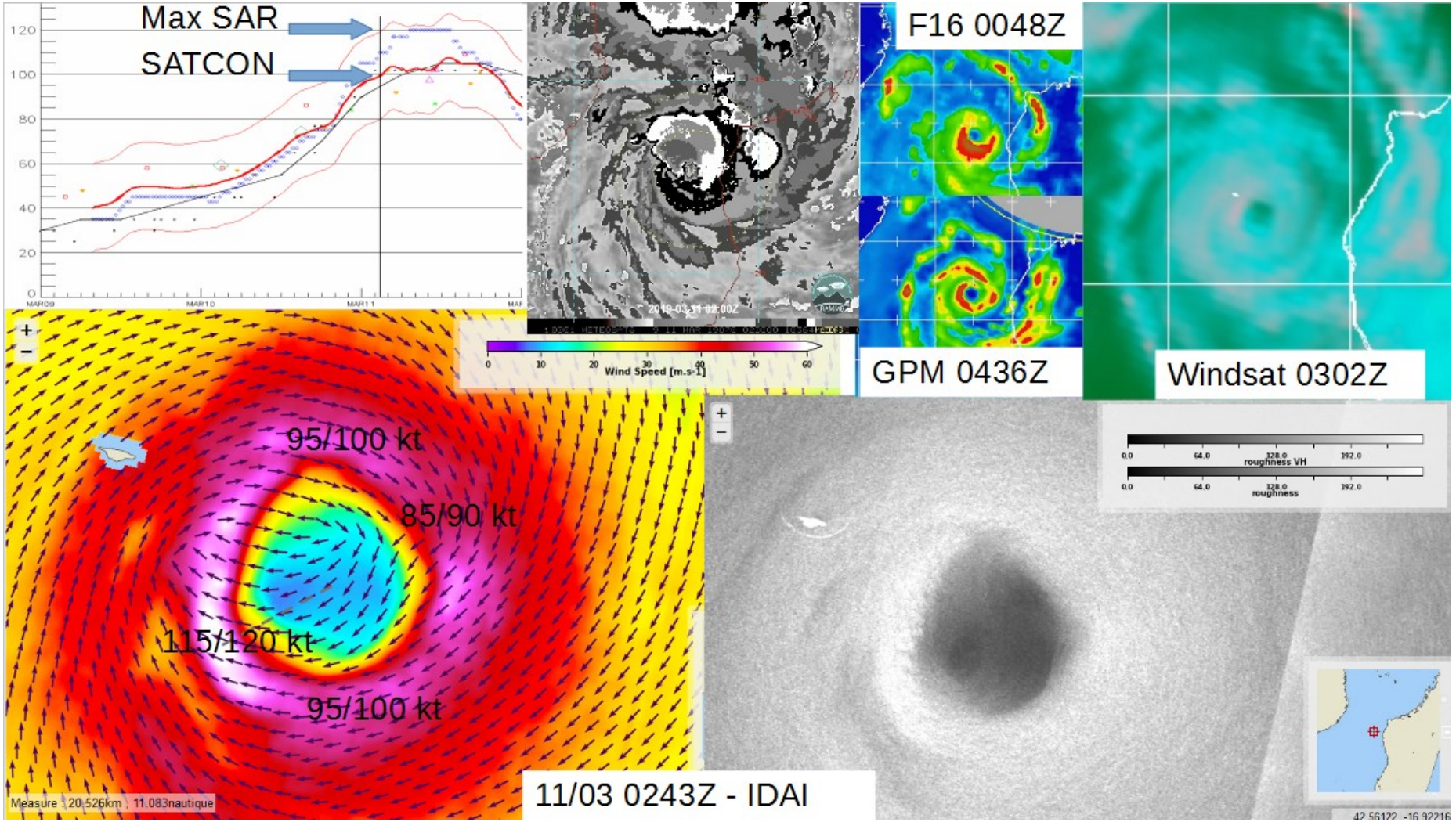


➔ Passive low freq microwave radiometer sensitive to very high winds while being less affected by rain

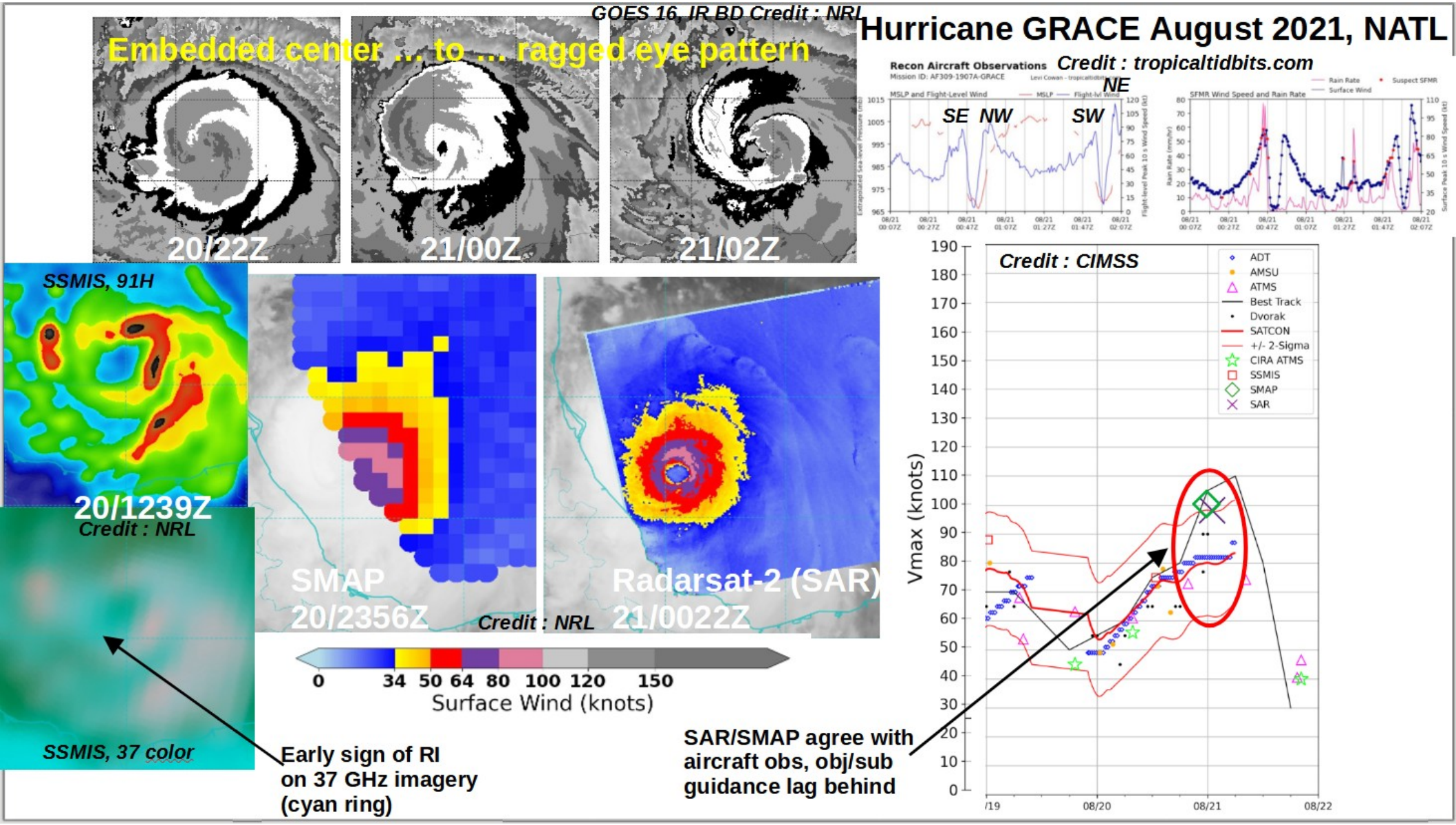
➔ Loose resolution (~40 km) but calibration to be able to estimate winds over 100 kt ...

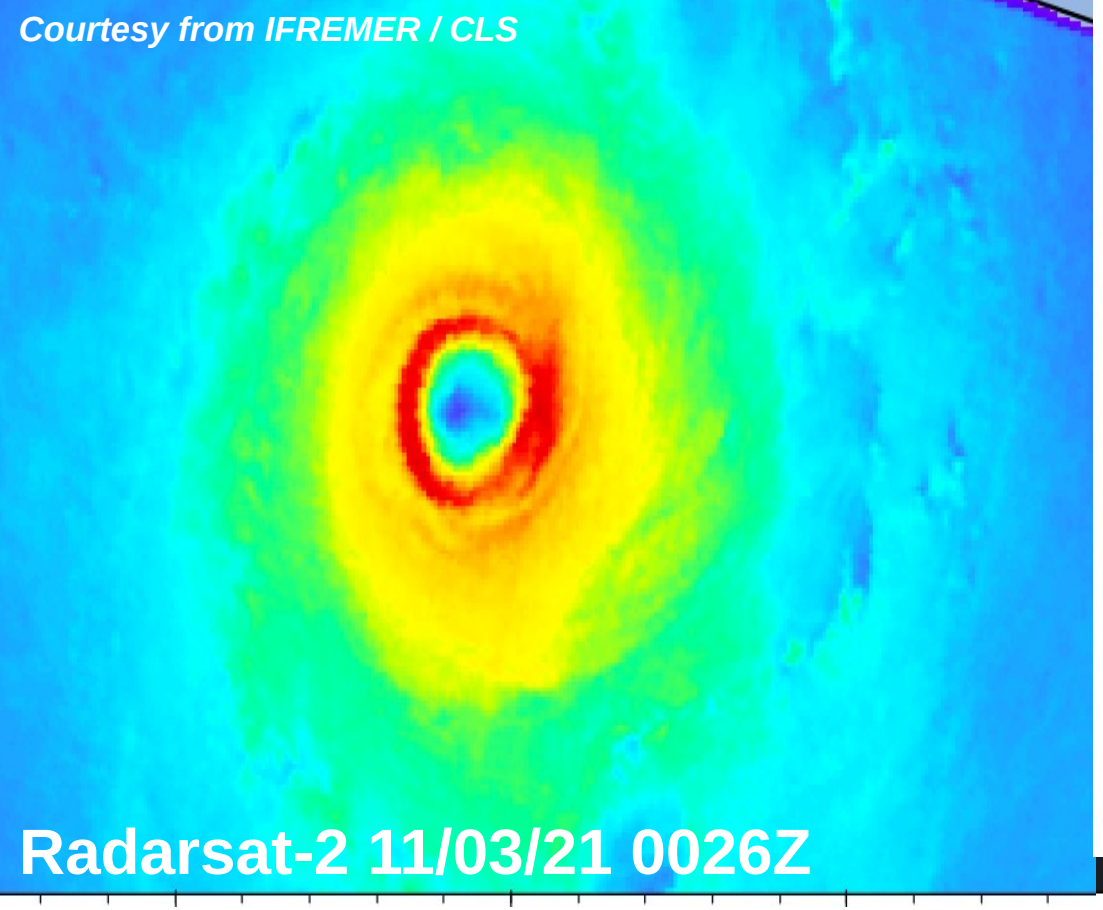
➔ Several hours between the satellite pass and the availability of wind products ...

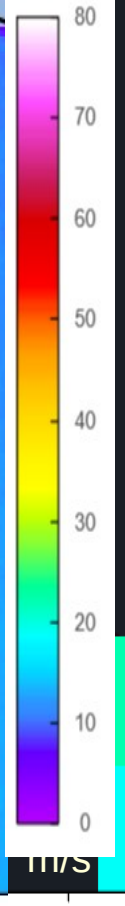
Remote sensing of strong / extreme winds
SAR (Synthetic Aperture Radar) = Ascat HD

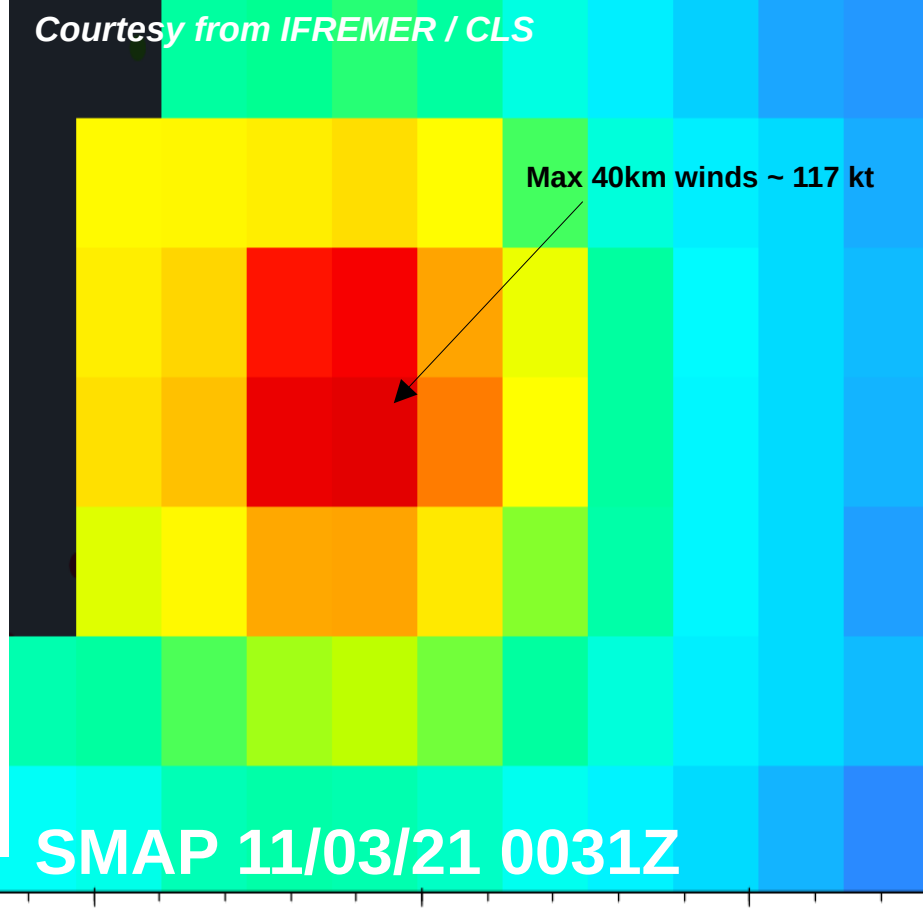


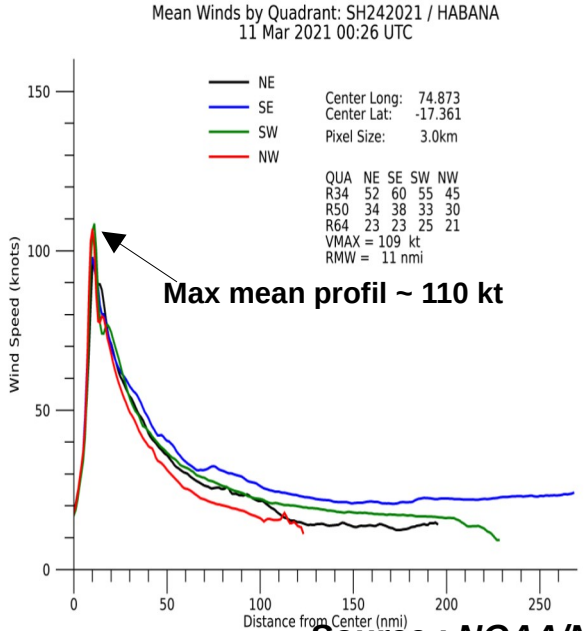
Remote sensing of strong / extreme winds
SAR (Synthetic Aperture Radar) = Ascat HD

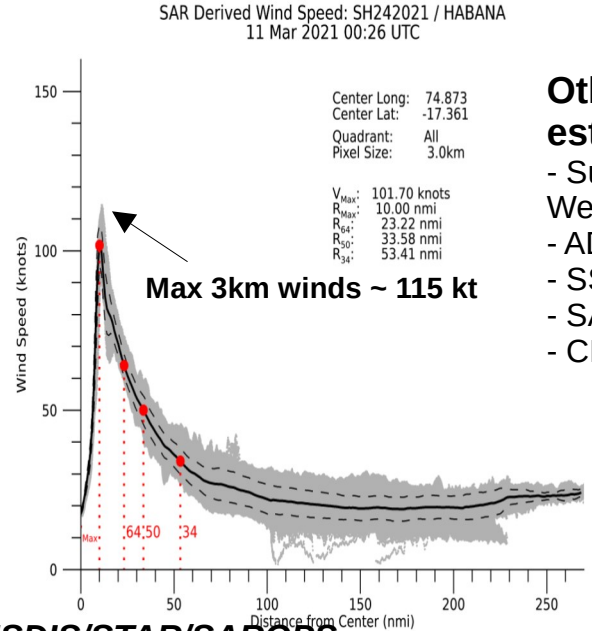












Other aids near 11/00Z for TC HABANA intensity estimate :

- Subj Dvorak : Ci from 6.5 (**127 kt** 1') to 7.0 (**140 kt** 1')
Weakening trend (FT FMEE 6.0 / PGTW 6.5)
- ADT ~ **120/125 kt** (1')
- SSMIS / AMSU (shortly after) : resp. **130+ kt** (1') / **110/115 kt** (1')
- SATCON ~ **120/125 kt** (1')
- CIMSS ATMS (shortly before) : **115/125 kt** (1')

Source : NOAA/NESDIS/STAR/SAROPS

Courtesy from IFREMER / CLS

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Max 40km winds ~ 117 kt

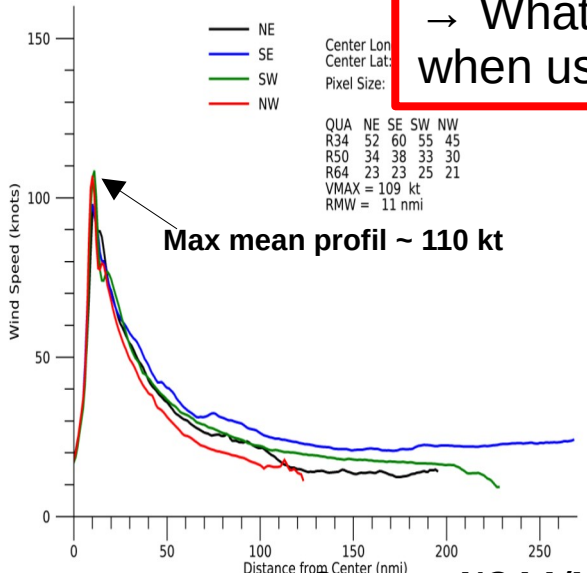
Remote sensing of extreme winds conditions era has begun ….This is great news ! ... **BUT** some open questions remains :

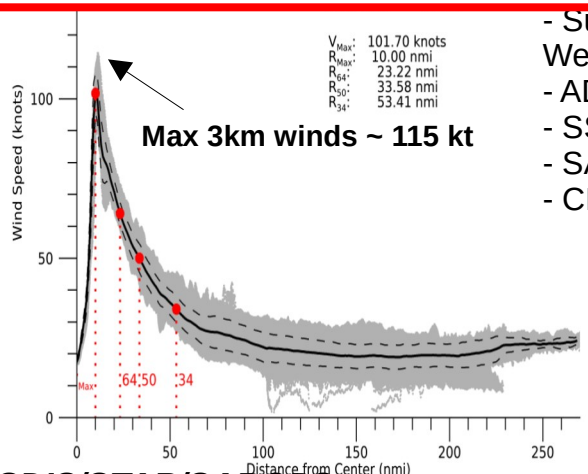
→ Estimation of error bars due to calibration/measure issues

→ How do we define the intensity of a TC in the sense of a best-track (6 hrs sampling) ?

→ What is the appropriate way to deal with wind averaging period when using SMAP/SMOS/SAR winds ?

Radarsat-2 1





Source : NOAA/NESDIS/STAR/SAROPS

ntensity

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TC intensity / structure analysis in TC forecasting: an expertise