A Need to start using an Integrated Method of Tropical Analysis using Microwave Imagery and Data with the Current Dvorak Intensity Analysis

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BASIC PROBLEM: for Tropical Cyclone Satellite Analysis

(All) Operational Centers still primarily dependent upon the 35-year old IR Dvorak technique (if no aircraft available)… ***especially for intensity estimations.***

Need to integrate near real-time MI and Scatterometer data (to at least supplement the existing techniques)!

Often I see this (but disagree with either the position or the T#---somehow I feel that no one looked at a recent MI or Scat pass):

"THE CURRENT INTENSITY IS ASSESSED AT 35 KNOTS BASED ON RECENT DVORAK ESTIMATES OF T2.5 (35 KNOTS) FROM ALL AGENCIES"

Or this:

ASCAT PASSES FROM LAST NIGHT AT 0905 UTC AND THIS MORNING AT 2047 UTC SHOWED *RAIN-FLAGGED* WINDS IN EXCESS OF 50 KT IN THE SOUTHERN SEMICIRCLE. GIVEN ITS HISTORY OF STRONGER THAN EXPECTED WINDS ...THE OFFICIAL INTENSITY WILL BE CONSERVATIVELY INCREASED TO 50 KT.

Why aren't the TC Operational Centers (truly) using the new Data?

Discussion:

- Concerns about the existing Dvorak Intensity technique (many have discussed this already)
- Typical problems/weaknesses in current analysis
- Can microwave help…integrating with Microwave Imagery and Scatterometer Data? (*Why do we not have a new technique by now*?)
- <u>What are the operational center's concerns to this question</u>?? (4 Points)

Dvorak Concern: Frequently there is a 'disagreement' between agencies evaluating the same system (Goal: +/- ½ T#)

Point #1: Many errors in Dvorak because of:

Incorrect positioning (Mostly fixable)

During initial/genesis state
During intensification stage when center is obscured

**** This point can be answered by going back and using the best (most reliable) position/sensor and then updating to the current time period. ****

Data Types Available

Visual	**High Resolution , Can see the low-level cloud lines, especially in animation**
Infrared	**Easy to see deep convection, 24hr view**
MI (85GHz)	**Deep rain bands and lower atmosphere moisture**
MI (37GHz)	**Early, less developed rain bands, compare with scatterometer**
Scatterometer	**Surface wind field and characteristics (must use ambiguities!)**

New RGB Products **Perhaps can simulate what the MI 'sees' (Himawari-8/GOES-R)**

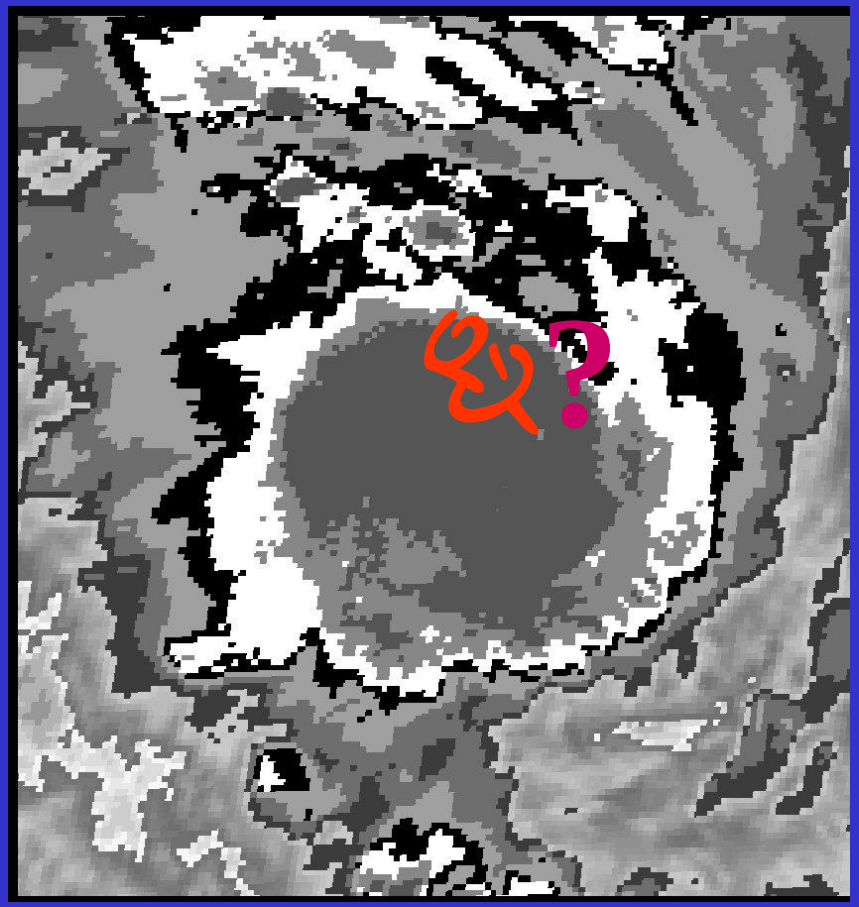
- **Higher space/time resolution (with animation)**
- **New sensor frequencies (to better see low level CU)**

EMBEDDED/COVERED CENTER

Worst Case Scenario T3.0/T3.5 (45-55kt) –- until Eye Appears

- ***** Subject to the most errors in positioning and intensity estimate***

MUST go back and use BEST possible position, possibly from MI or Scatterometer!



Remember, Dvorak technique assumes you know where the center is. Therefore, what we need:

1) **A sensor or method that best sees the Low Level Clouds (MI, Scat, last Vis).**

2) **Use the best position available since the last analysis (then move forward and update to the current time)**

Dominance of Geostationary Imagery

The numerous 'Red' geostationary fixes can easily dominate in best-tracking determination. The 'Blue' MI and Scatterometer fixes (triangles, squares and diamonds are related to PCN) will have less influence even if more accurate.

*** Often, nothing is done to 'correct' positions, since ALL fixes are in a row!**

*** Working Best Tracks and Post-analysis Best Tracks MUST use data with the best quality and not the best quantity!**

Point 2a: Dvorak Intensification Estimates (fixable)

- Start too late (genesis) (‘low and slow’)
- Use of spiral band curvature, when should be using shear, maybe embedded or eye
- Failing to see the ‘peaking time’ (or RI)…and (failing to) use PLUS or MINUS annotations
- Not using high-res visual imagery when available (maybe new satellite technology will help, here)
- Failing to go back or to re-examine 24-hr analysis (afraid this might ‘offend’ your co-worker)

Point 2b: Failing to recognize situations where Dvorak does not work (ADT will 'probably' not help, either):

(*here, a new technique or procedure is needed*)

- Pin-hole eyes
- Very small and very large circulations
- "Truck Tires"
- Extratropical transition
- Sudden shear with an existing (high) wind pattern in monsoon or strong trades
- Eye wall Replacement Cycle (ERC)

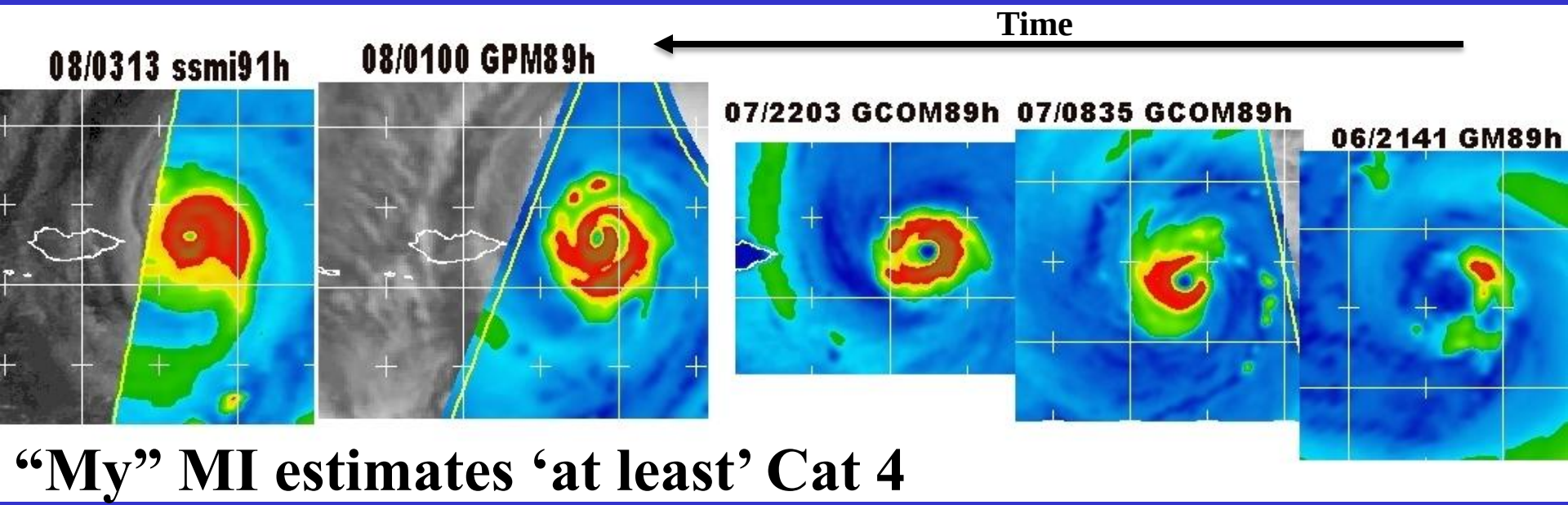
We need to use the sensor or method that best identifies the *changes* in the location of Rain and Wind in a TC (intensification)

We 'Understand' Microwave Imagery— Why aren't we using it in real time??

- 'Sees' through clouds
- Able to position TCs in difficult situations (especially in EARLY (and LATE) stages of development)
- View of convective rain bands is more DIRECTLY related to intensity of the TC
- Much better than IR showing eye-wall intensifying/weakening trend
- 37GHz is able to examine clouds and moisture closer to the surface than 85GHz (or IR)

A better method to identify RI

Tropical Cyclone Megh (05A) Approaching Socotra Is.

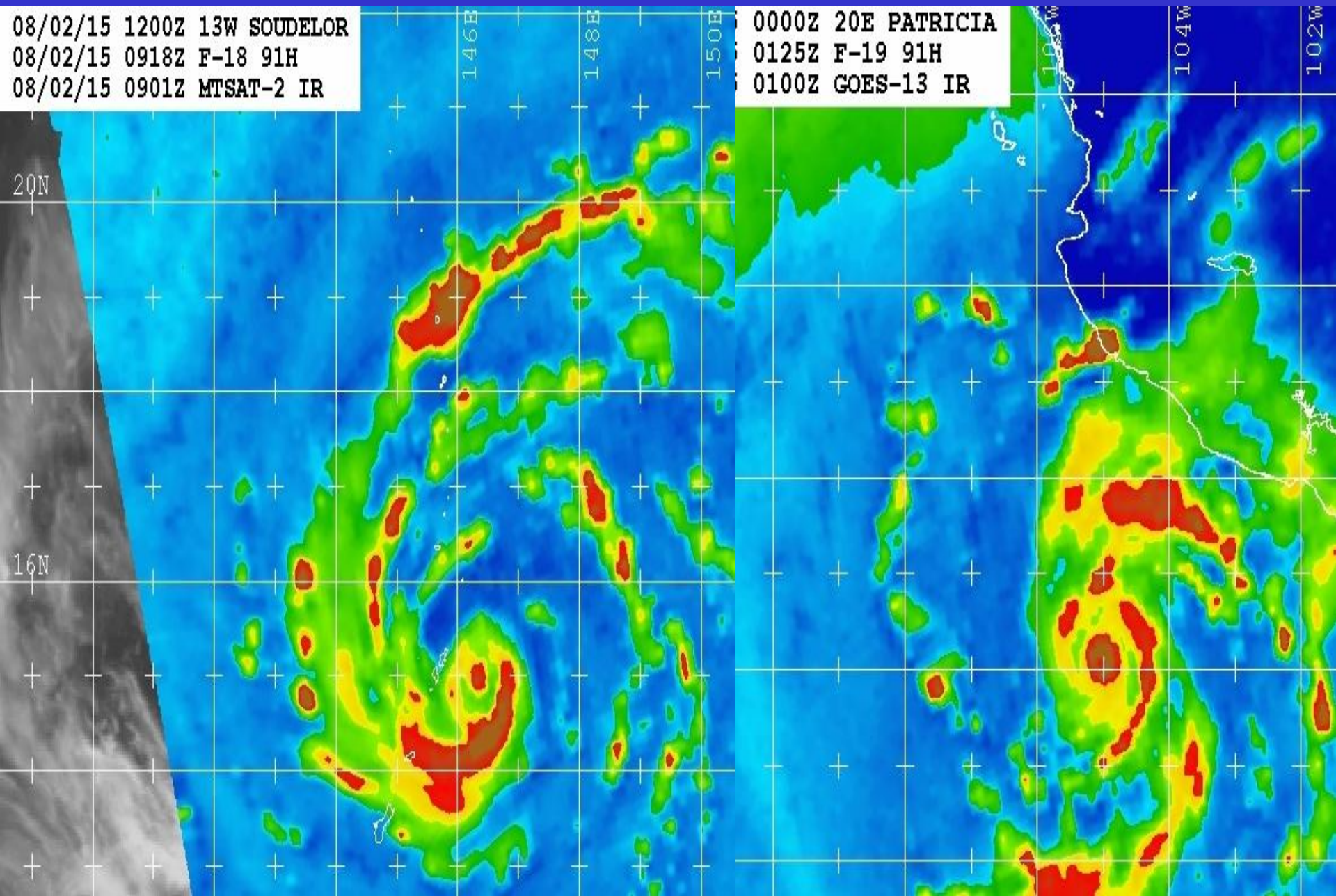


“My” MI estimates ‘at least’ Cat 4

Some agency estimates as low as 70 knots…

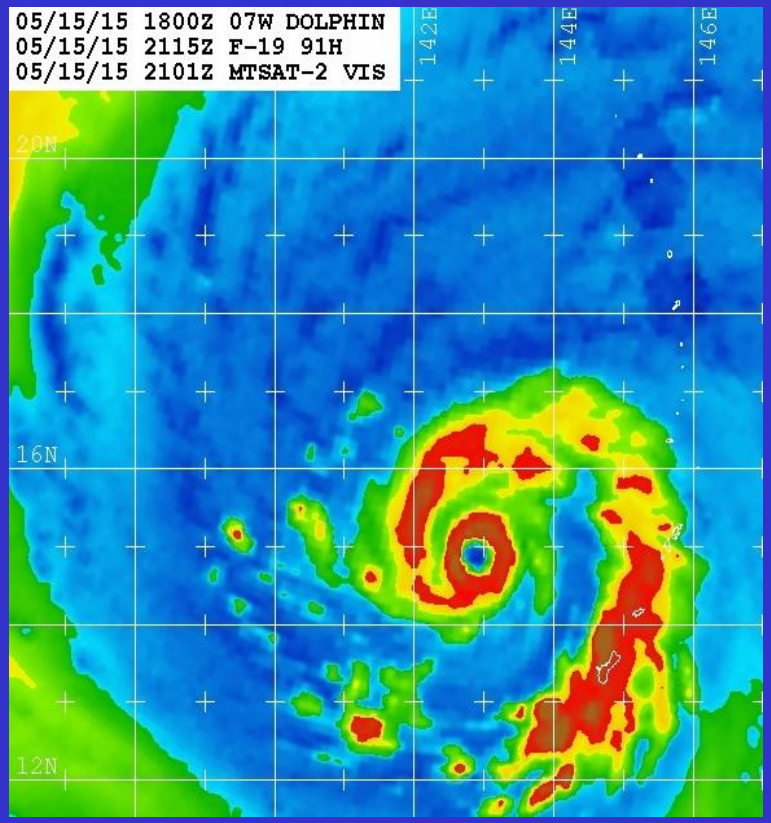
The Dvorak method needs to reflect this intensification!

Examples of tiny but intense ‘pinhole’ eyes



Peaking Tendency
(Dvorak does not tell you this!)

15May 2115Z



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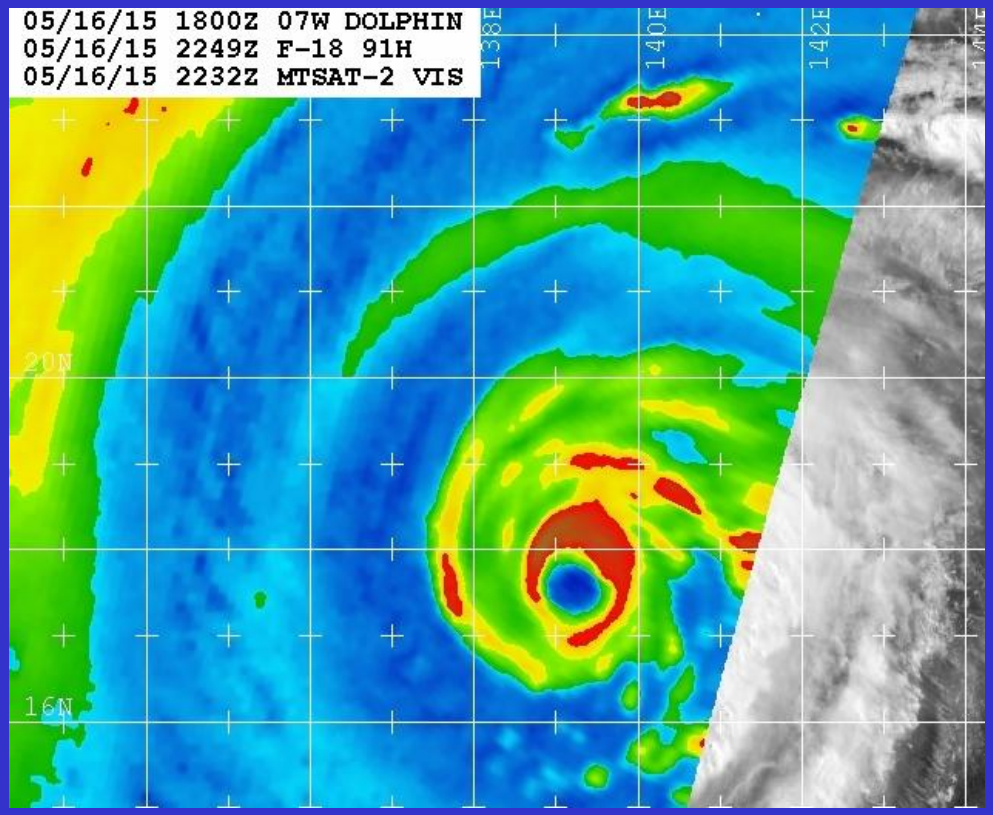


Why is the forecast for continued intensification?

Possible ways to Supplement the Dvorak Analysis with Microwave Imagery (Suggestions)

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

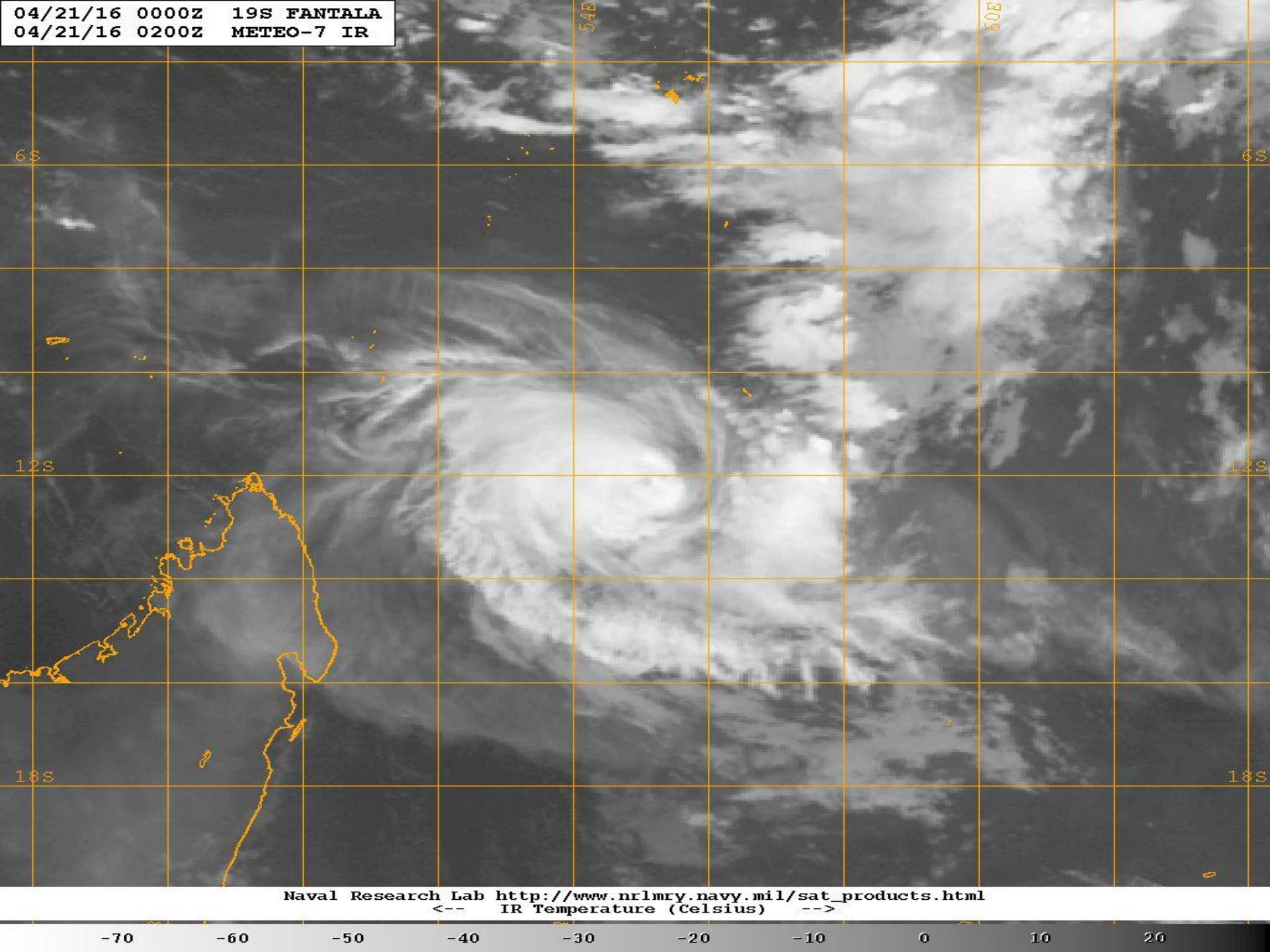
Point 3: Typical 'reasons' why MI data is <u>not</u> being used in real time:

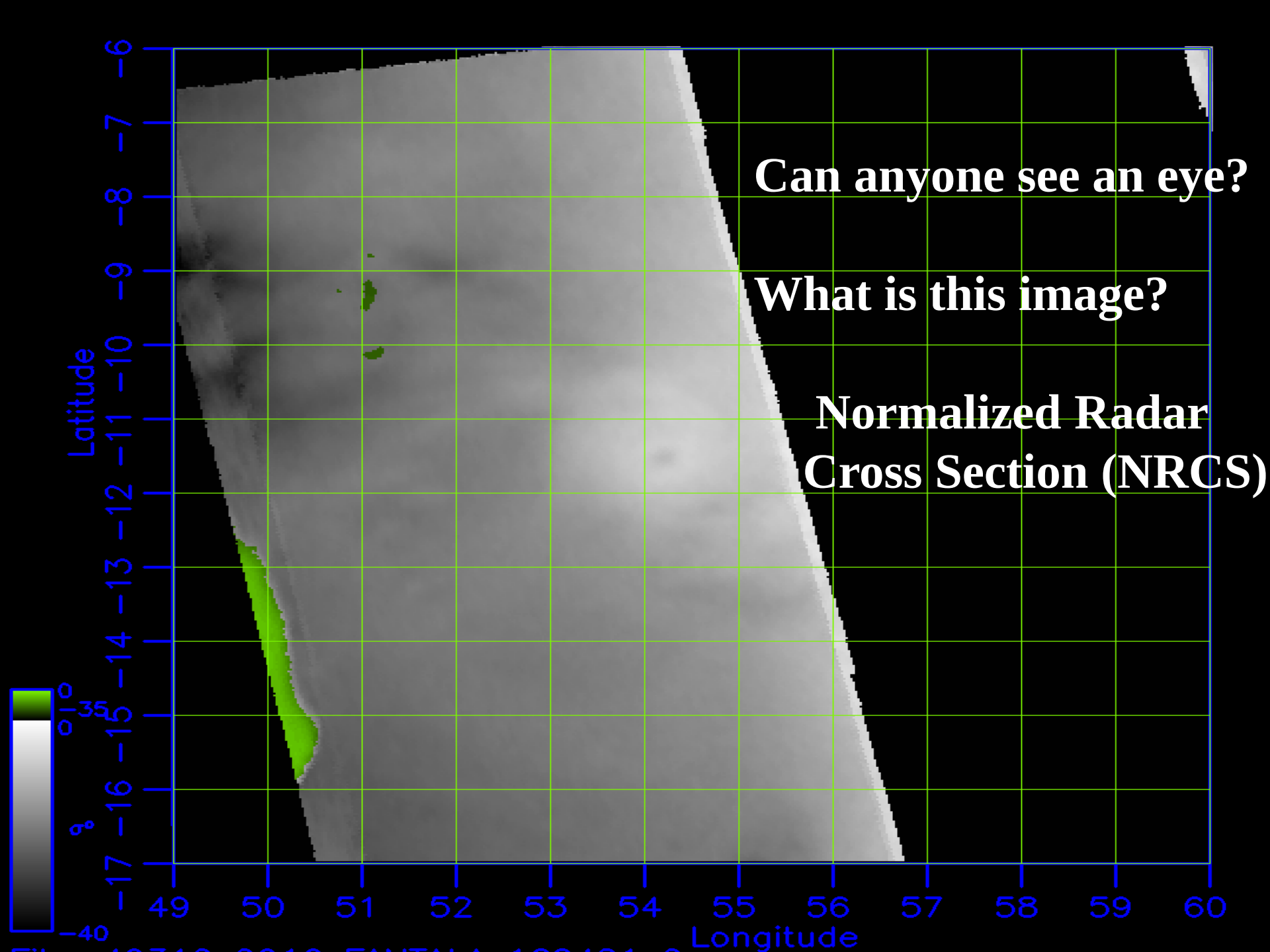
- Not all sites are accessible to all Countries
- Some agencies 'require' their own gridding or calibration
- Unhappy with coverage or timeliness (*forget to use as a 'best position/intensity known' since last pass*)
- Unfamiliar with characteristics of various sensors
- Lack of using multiple frequencies for a particular pass (no time!—*but isn't it worth it…don't we wait for an aircraft fix*?)
- Like to be able to integrate easier with other data
- Do not know how to combine with Dvorak technique
- New training required!

How about using Scatterometer in the real time analysis?

Goal of Scatterometer Data for TC Analysis (recap)

- Positioning and Motion
- Minimum (at least) maximum wind
- Structure and Structure Change (Wind Radii)
- Radius of Maximum Winds (RMW)…new!
- Genesis and (Surface) Genesis processes
- Extratropical Transition and Dissipation


04/21/16 0000Z 19S FANTALA
04/21/16 0200Z METEO-7 IR
54E
60E
6S
12S
18S
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20


Can anyone see an eye?
What is this image?
Normalized Radar Cross Section (NRCS)
Latitude
Longitude
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
49
50
51
52
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56
57
58
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60
0
-35
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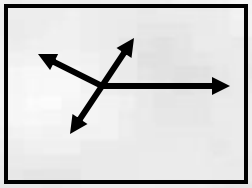
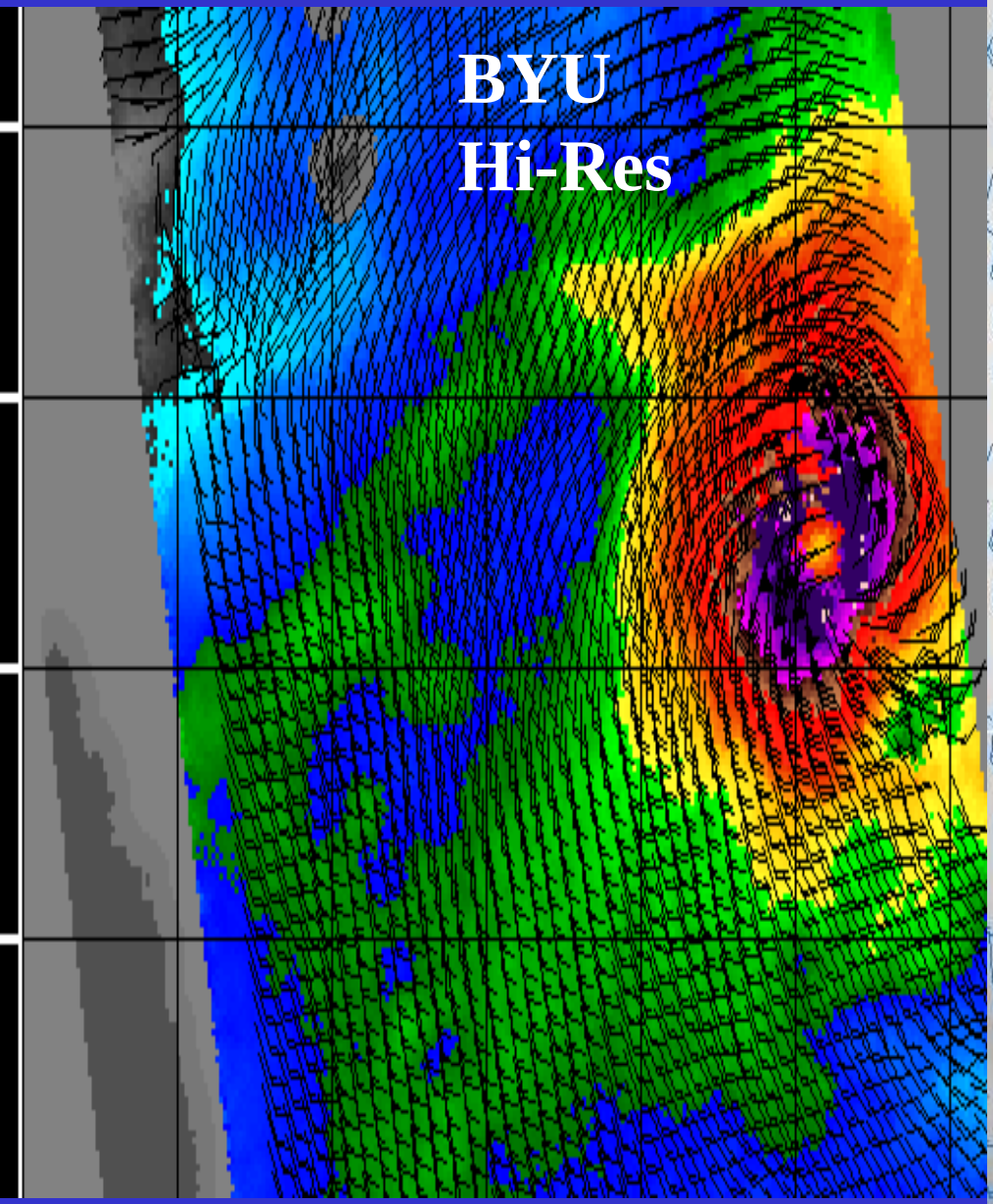
dB

ASCAT Ambiguities



<u>Ambiguity plotting convention</u>: 1-4 possible wind directions are plotted from the center of the wind vector cell (wvc) OUTWARDS and towards the direction of the flow (this is opposite of conventional meteorological wind vector plotting routines).

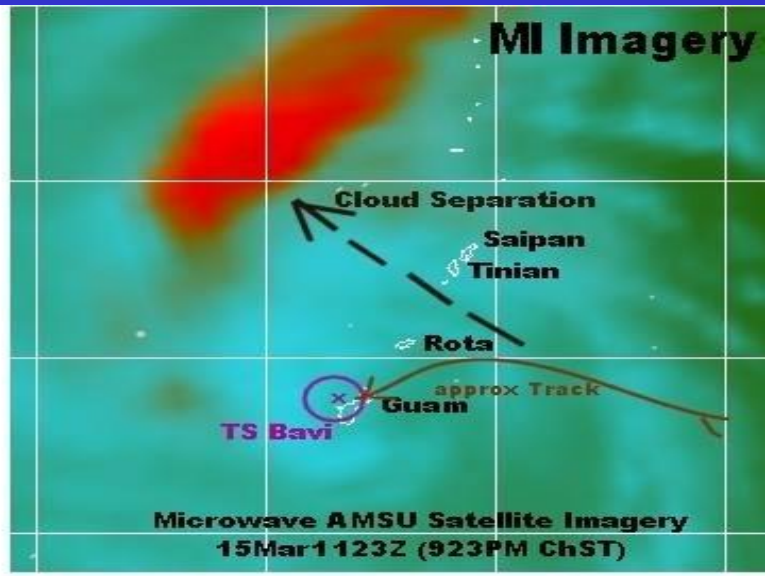


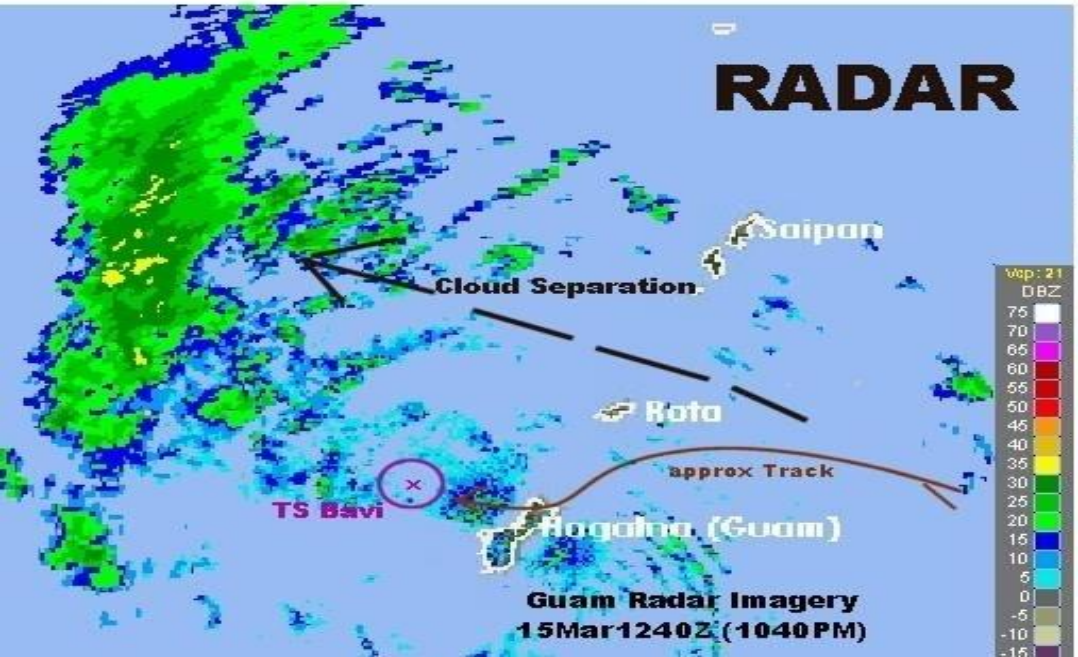
Standard ASCAT Wind Solutions… NWP assisted

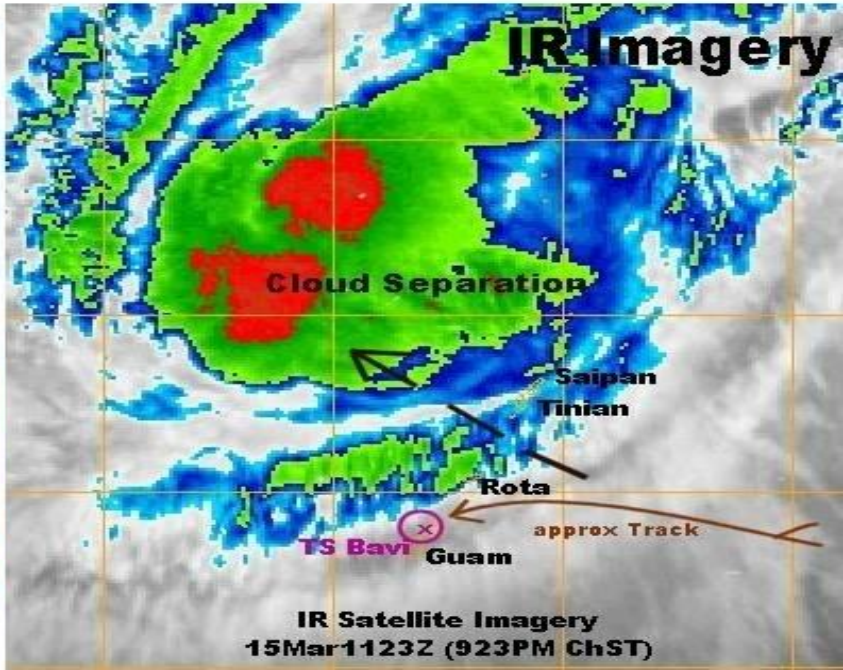
Case Example: TS Bavi

Movement and Cloud Separation of Tropical Storm Bavi (03W) on March 15, 2015

Wind Gusts (at time of separation)
Up to ~70mph at Saipan and Tinian
Up to ~50mph at Rota and Guam





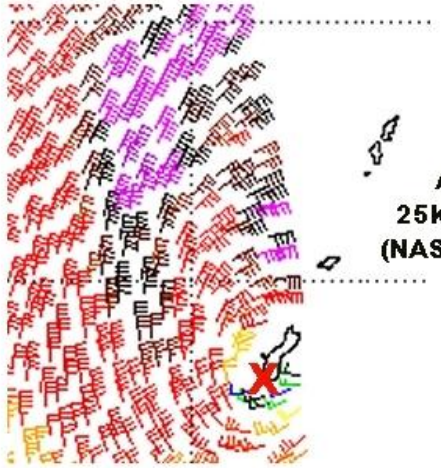


ASCAT Scatterometer View of Tropical Storm Bavi (03W)
Passage through the Marianas
15 March 2015

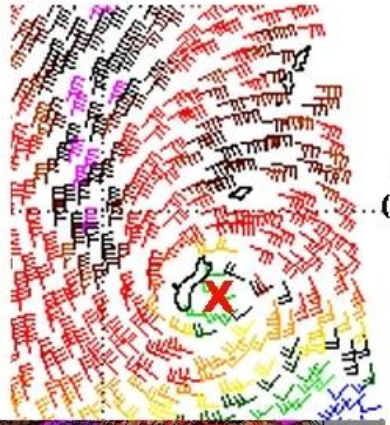
15Mar1216Z

15Mar1124Z

15Mar0018Z



ASCAT
25km Vector
(NASA/NESDIS)



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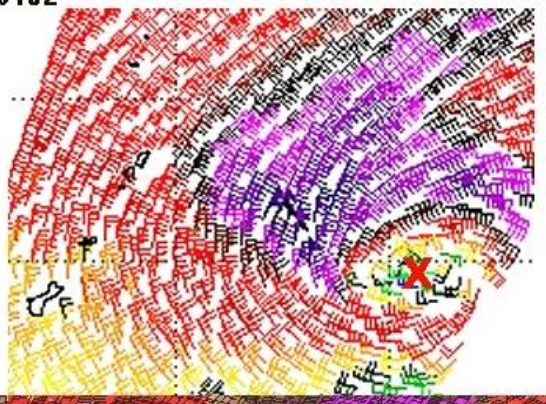
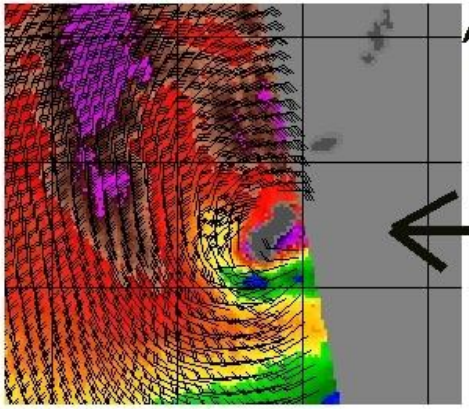
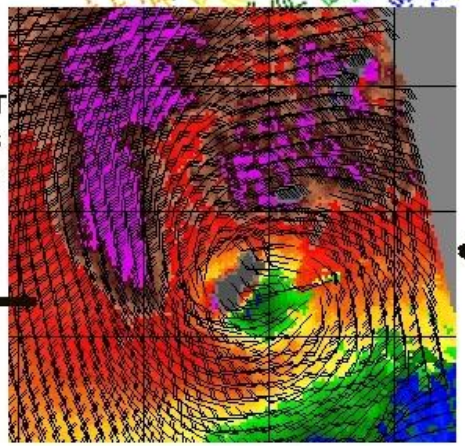




ASCAT
HiRes
(BYU)



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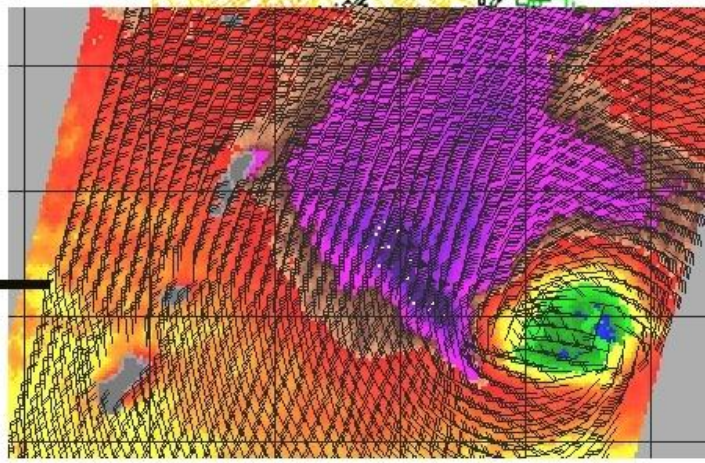
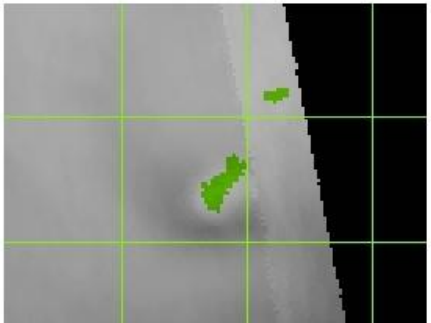
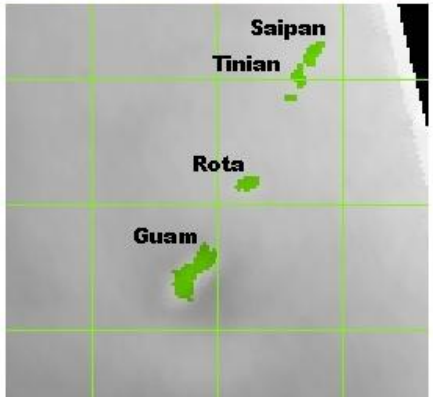




(NRCS)



(NRCS)

Method of obtaining RMW with Scatterometer

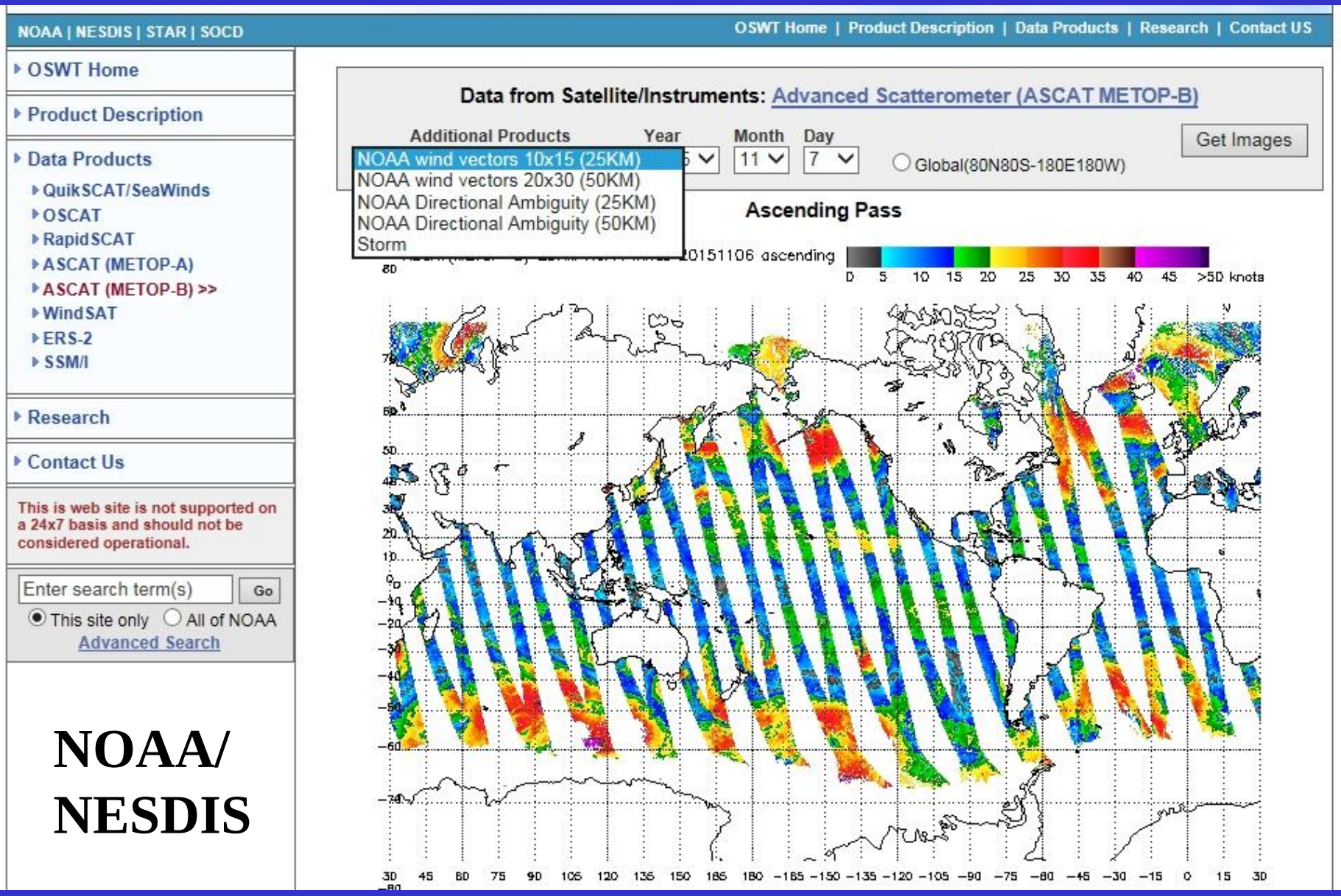
And…almost exact positioning!!

Point 4a: Common misconceptions or knowledge of using Scatterometer

- Importance of knowing ‘where the center CANNOT be located’
- Importance of knowing the difference of good ‘outer winds’ as well as acknowledging good (at least this high…if not more) wind speeds into the center
- Not familiar with the EASE of using to find the center, almost exactly in some cases

Point #4b: Problems with routinely using Scatterometer data

- Not familiar with characteristics scat data (good and difficult points…and how to overcome)
- Too afraid of using in rain!
- Not routinely available on your site
- Importance of using ambiguity data
- Unfamiliarity of high resolution display and NRCS products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Additional Products
Year
Month
Day
NOAA wind vectors 10x15 (25KM)
NOAA wind vectors 20x30 (50KM)
NOAA Directional Ambiguity (25KM)
NOAA Directional Ambiguity (50KM)
Storm
11
7
Global(80N80S-180E180W)
Get Images
Ascending Pass
20151106 ascending
0 5 10 15 20 25 30 35 40 45 >50 knots

NOAA/ NESDIS

STAR Center for Satellite Application and Research

National Environmental Satellite, Data, and Information Service (NESDIS)

Ocean Surface Winds Team

Storm Folder

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  - ASCAT (METOP-B) >>
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Data from Satellite/Instruments: Advanced Scatterometer (ASCAT METOP-B)

Additional Products: Storm | Year: 2015 | Storm_ID: FIVE | Get Images

( ) Atlantic ocean
( ) Eastern pacific
( ) Western pacific
( ) Central pacific
(•) Indian ocean
( ) Southern Hemisphere

Wind Vector Images:

FIVE_15110507_05_as FIVE_15110507_05_ds
FIVE_15110513_05_as FIVE_15110513_05_ds

Ambiguity Images:

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25Km Wind Vector Images:

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FIVE_15110513_05_as FIVE_15110513_05_ds

NRCS Images:

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16246_FIVE_151105_0600.avewr
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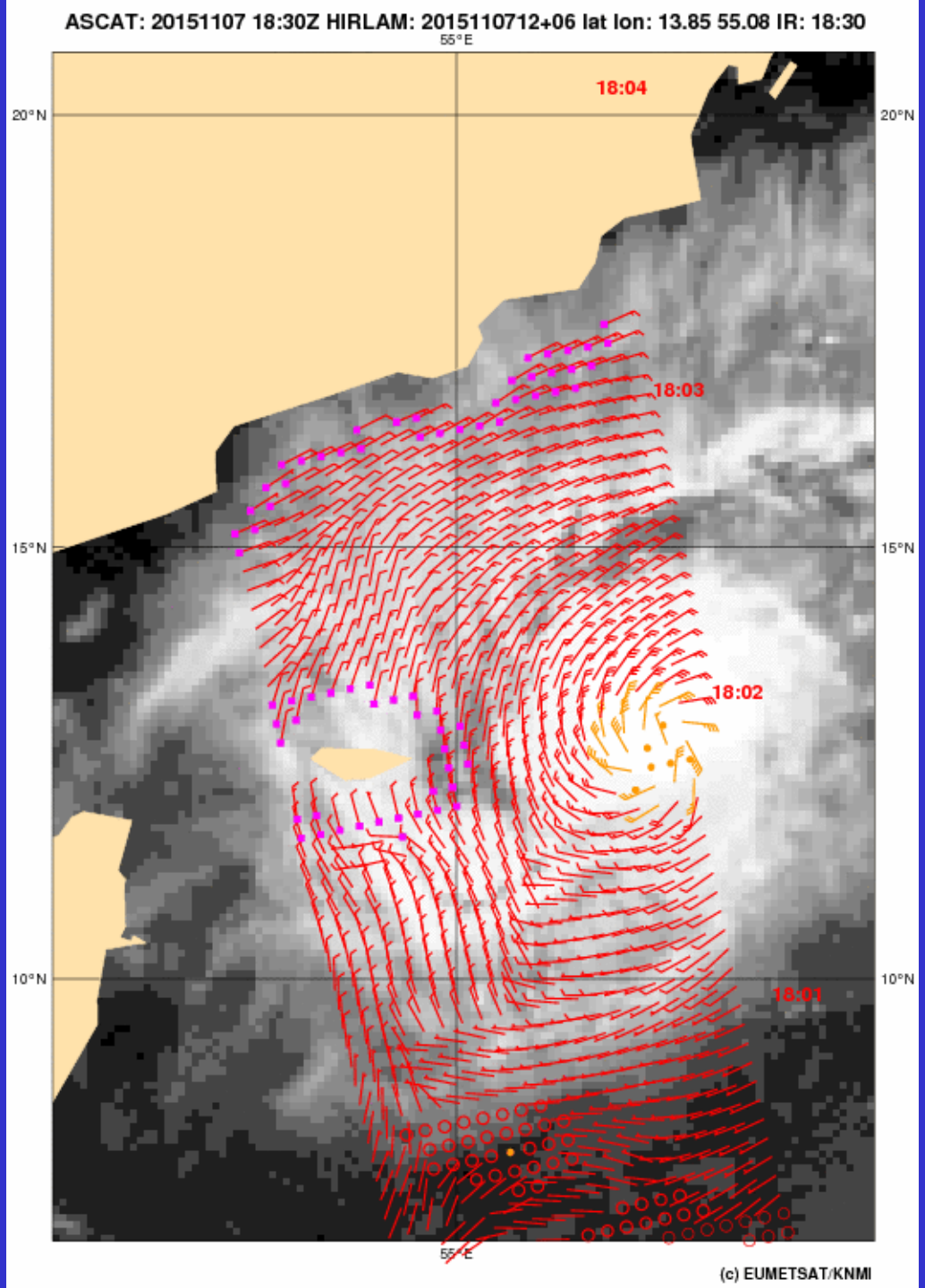
KNMI site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55°E
20°N
15°N
10°N
18:04
18:03
18:02
18:01
(c) EUMETSAT/KNMI

This is much better:

THE INITIAL INTENSITY HAS BEEN INCREASED TO 65 KNOTS BASED ON ASSESSMENT OF DVORAK INTENSITY ESTIMATES OF T4.0 (65 KNOTS) FROM ALL FIXING AGENCIES AND IS SUPPORTED BY THE IMPROVING STRUCTURE AND THE DEVELOPING MICROWAVE EYE FEATURE.

Or this:

A recent ASCAT pass revealed maximum winds of about 50 kt, so the initial intensity has been increased accordingly. The scatterometer data also provided a better estimate of the size of the tropical cyclone wind field, and the tropical-storm-force wind radii have been adjusted outward.

Or this:

A WELL PLACED 2049 UTC ASCAT PASS SHOWED A SWATH OF 50 KT WINDS WITHIN THE SOUTHEAST AND SOUTHWEST QUADRANTS. ALL WIND RADII WERE ADJUSTED FOR THIS ADVISORY BASED ON THIS ASCAT PASS. SUBJECTIVE DVORAK SATELLITE INTENSITY ESTIMATES...HEAVILY WEIGHTED ON ORGANIZATION OF DEEP CONVECTION...WERE NOTICEABLY LOWER THAN INTENSITY DEPICTED IN ASCAT AT 3.0...45 KT... FROM ALL THREE SATELLITE CENTERS. ASCAT IS MOST COMPELLING HERE...AND THE INITIAL PALI INTENSITY FOR THIS ADVISORY WILL BE MAINTAINED AT 55 KT.

Conclusion: Need for Centers and middle managers/mentors to emphasize these NEW techniques into OPERATIONS (Forecasters AND Satellite Analyst)

- Hybrid Dvorak can be easily adapted
- **Previous (and current) attempts to use MI or Scatterometer data via automation (neural networks, etc.) not very successful: trust Human Eye (perhaps this 'takes work'…*solution not always easy*)!**
- NEED to develop techniques for operational people to more easily obtain and view and interrogate the data (to avoid spending precious time 'looking')
- **Finally…remember your last 'good' analysis point!**

Questions?

Reasons for Flagging data

- 2DVAR spacial consistency (closeness to NWP and closeness to neighboring wvc)
- Too close to land and/or ice
- Wind less than 3 m/s or greater than 30 m/s
- Noisy signal, bad calculation, etc…
- MLE (maximum likelihood estimation) variational control
  - (Solution EXISTS…but was not what was expected as compared to closeness to the neighboring wvc)
  - May occur in rapidly changing environment with respect to the size of the wvc (winds in a TC may qualify; so may an area around a strong frontal zone, or any high gradient synoptic/mesoscale feature)
  - May occur in rain…but difficult to 'reject' the data outright, without examining the data