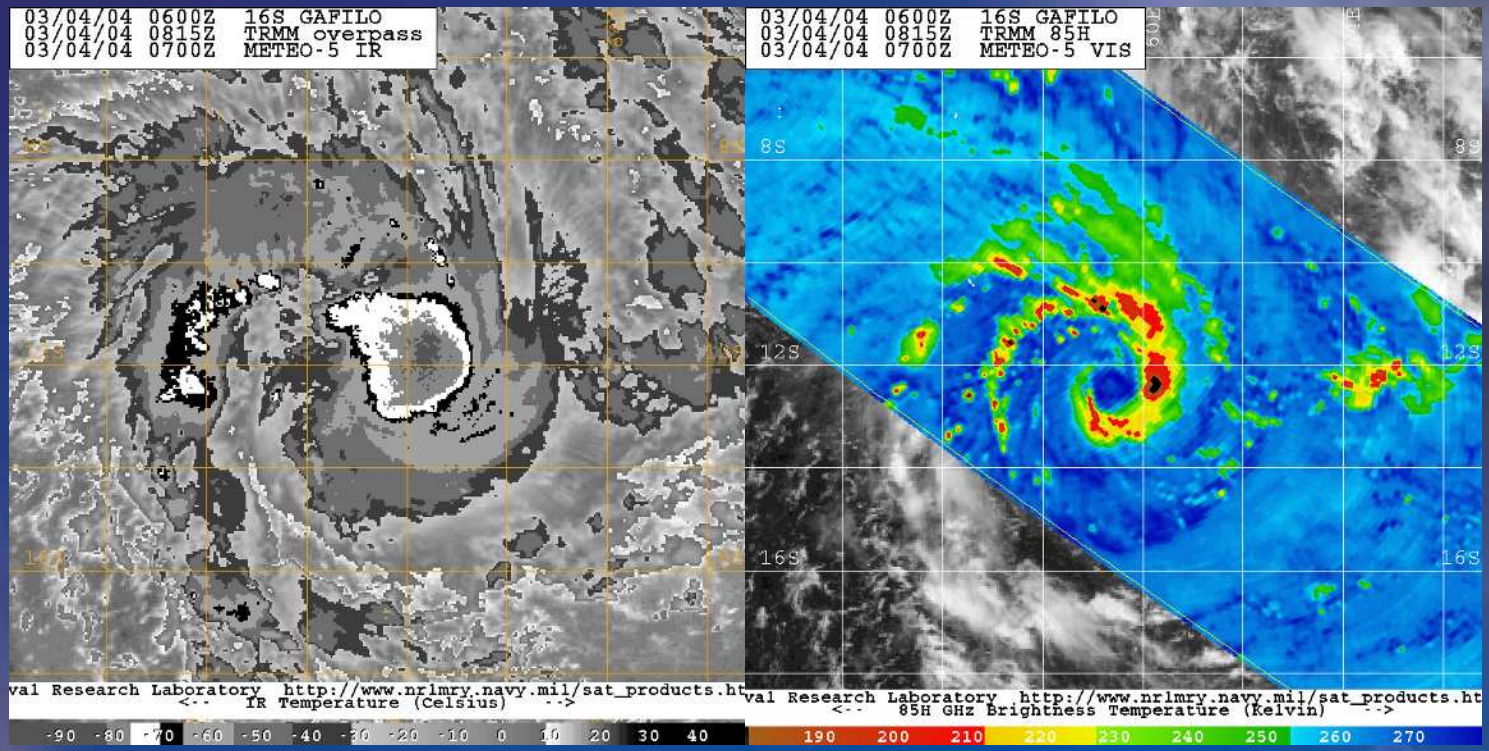
Passive Microwave Data Tools



Derek Wroe
Hurricane Specialist
Central Pacific Hurricane Center

Acknowledgements:
Naval Research Laboratory
Chris Velden, Cooperative Institute for Meteorological Satellite Studies
Derrick Heardon, Cooperative Institute for Meteorological Satellite Studies

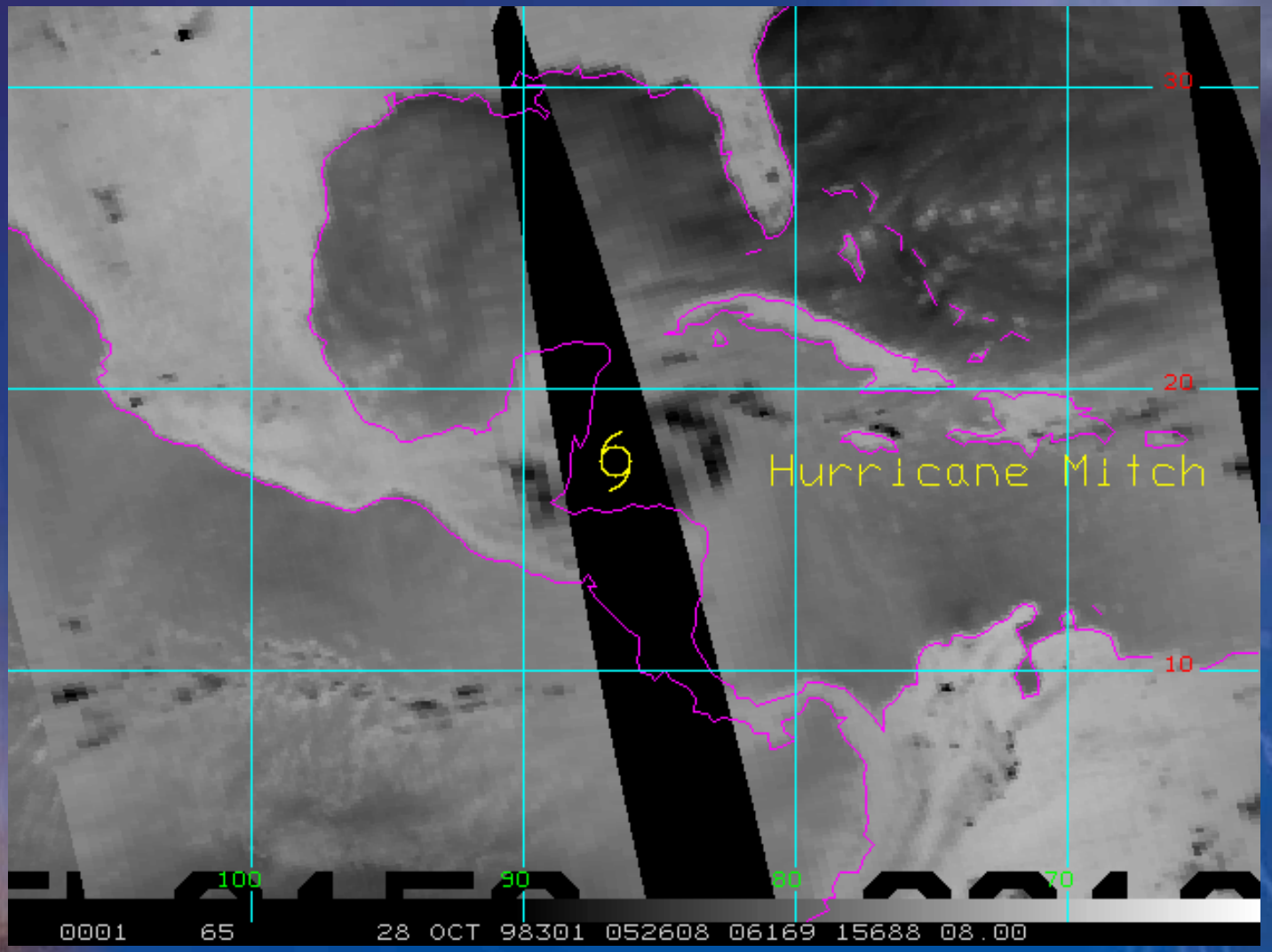
Agenda

- Microwave imagery interpretation review
- CIMSS & CIRA AMSU Intensity Algorithm
- CIMSS Satellite Consensus (SATCON)

Passive Microwave Data

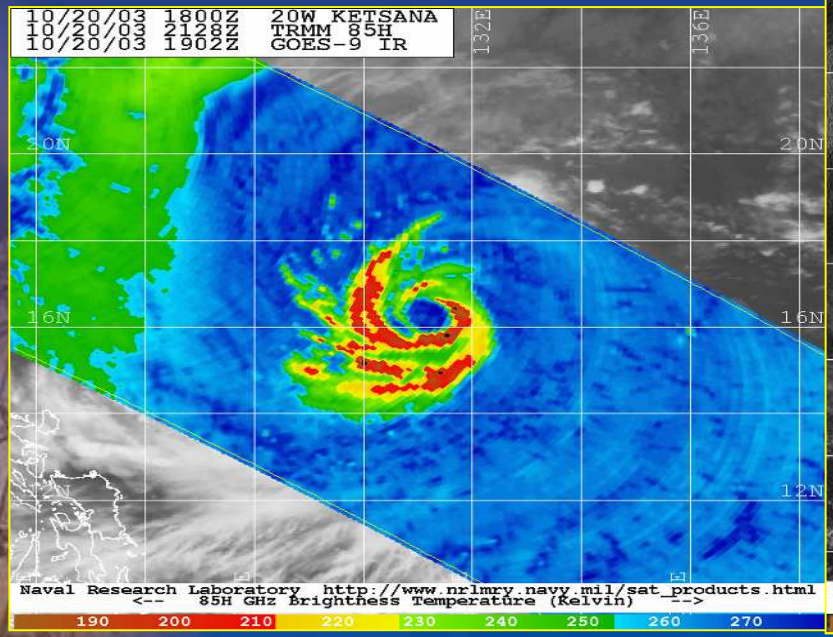
- Tropical cyclone (TC) monitoring requires the use of multiple satellites and sensors to accurately assess TC location and intensity.
- Geostationary satellite data provide the bulk of TC information, but upper-level cloud obscurations limit these important data.
- Passive microwave data and imagery from polar orbiting satellites can provide key storm structural details and offset many of the VIS/IR spectral problems.
- The ability to view storm rainbands, eyewalls, impacts of shear, and exposed low-level circulations, whether it is day or night, makes passive microwave data a significant tool for the satellite analyst.

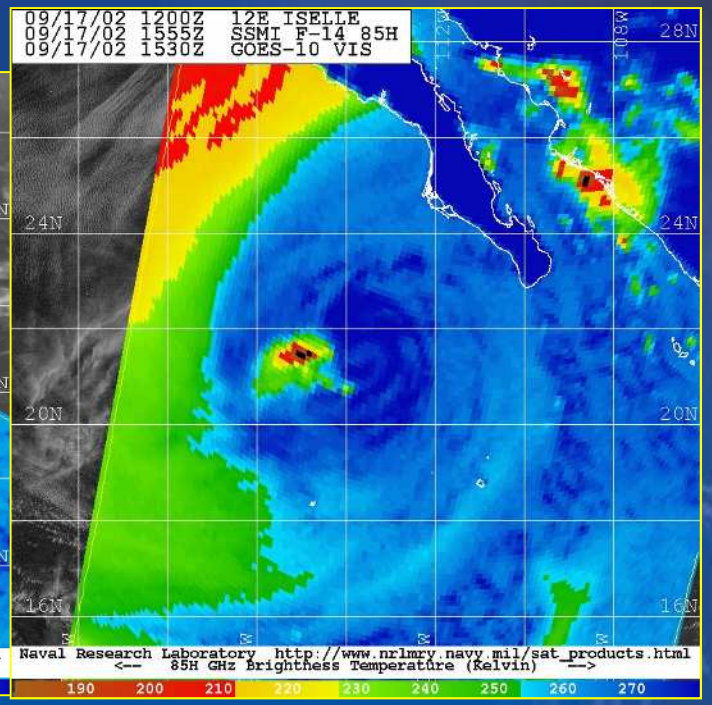
Passive Microwave Data
Temporal & Spatial Issues



Microwave Review: 85-89GHz

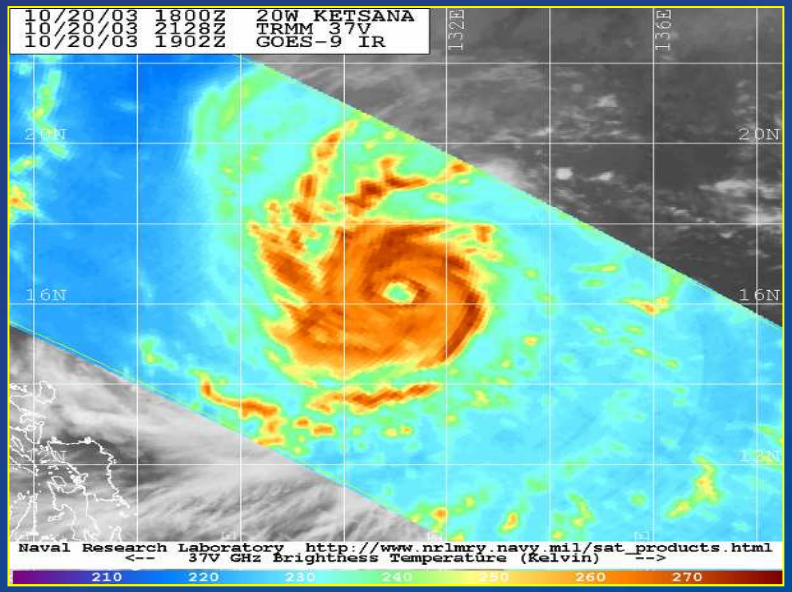
- TC core and rainbands in 85 - 89 GHz channels marked by dramatically **lowered** equivalent blackbody brightness temperatures (Tb) caused by scattering from precipitation-size **ice hydrometeors**
  - **Cold:** High portions of deep convection (ice!)
  - **Warm:** Low cloud fields





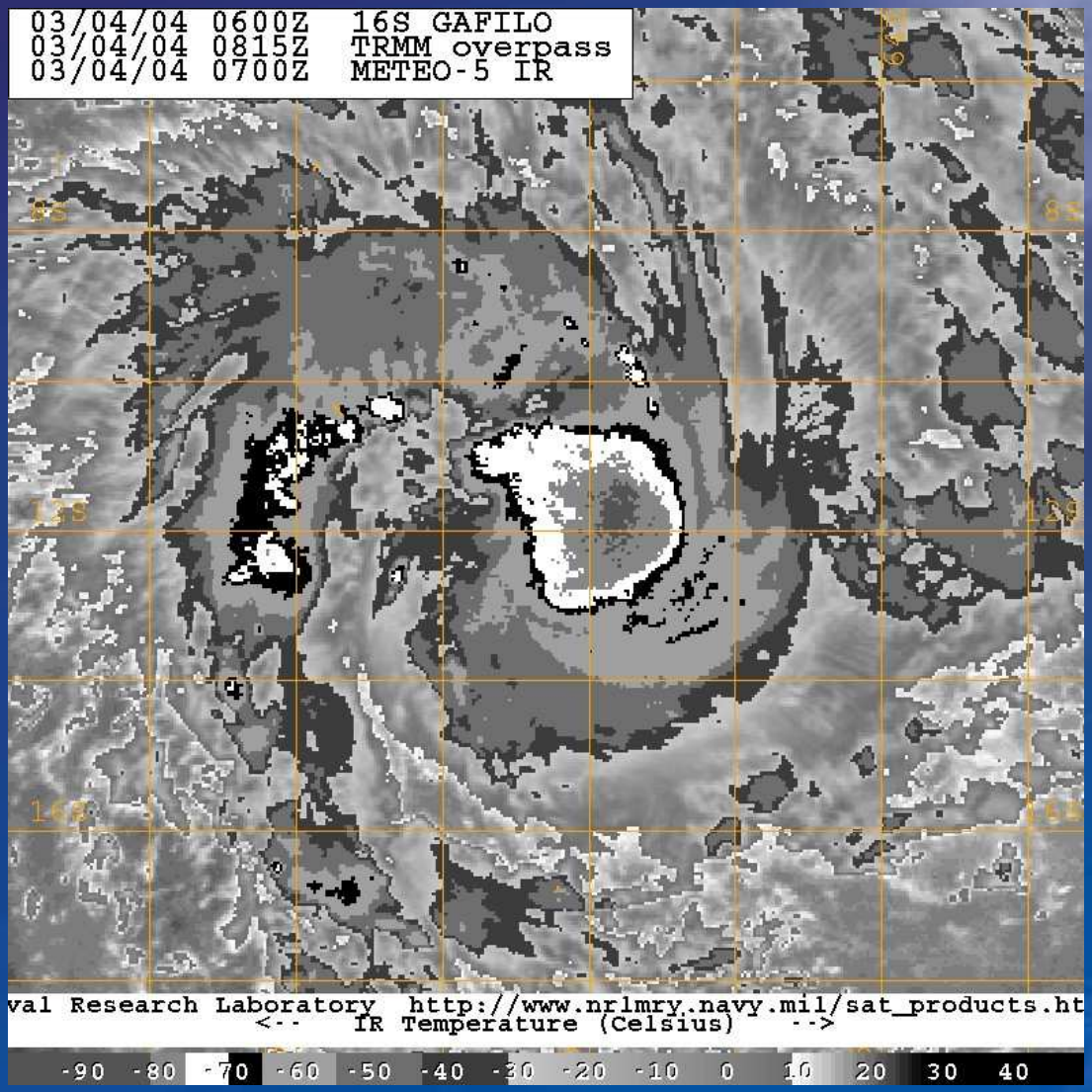
Microwave Review: 36-37GHz

- TC core and rainbands in 36 - 37 GHz channels marked by elevated Tb caused by absorption from mainly **liquid water**
  - **Warm:** Rain at low levels

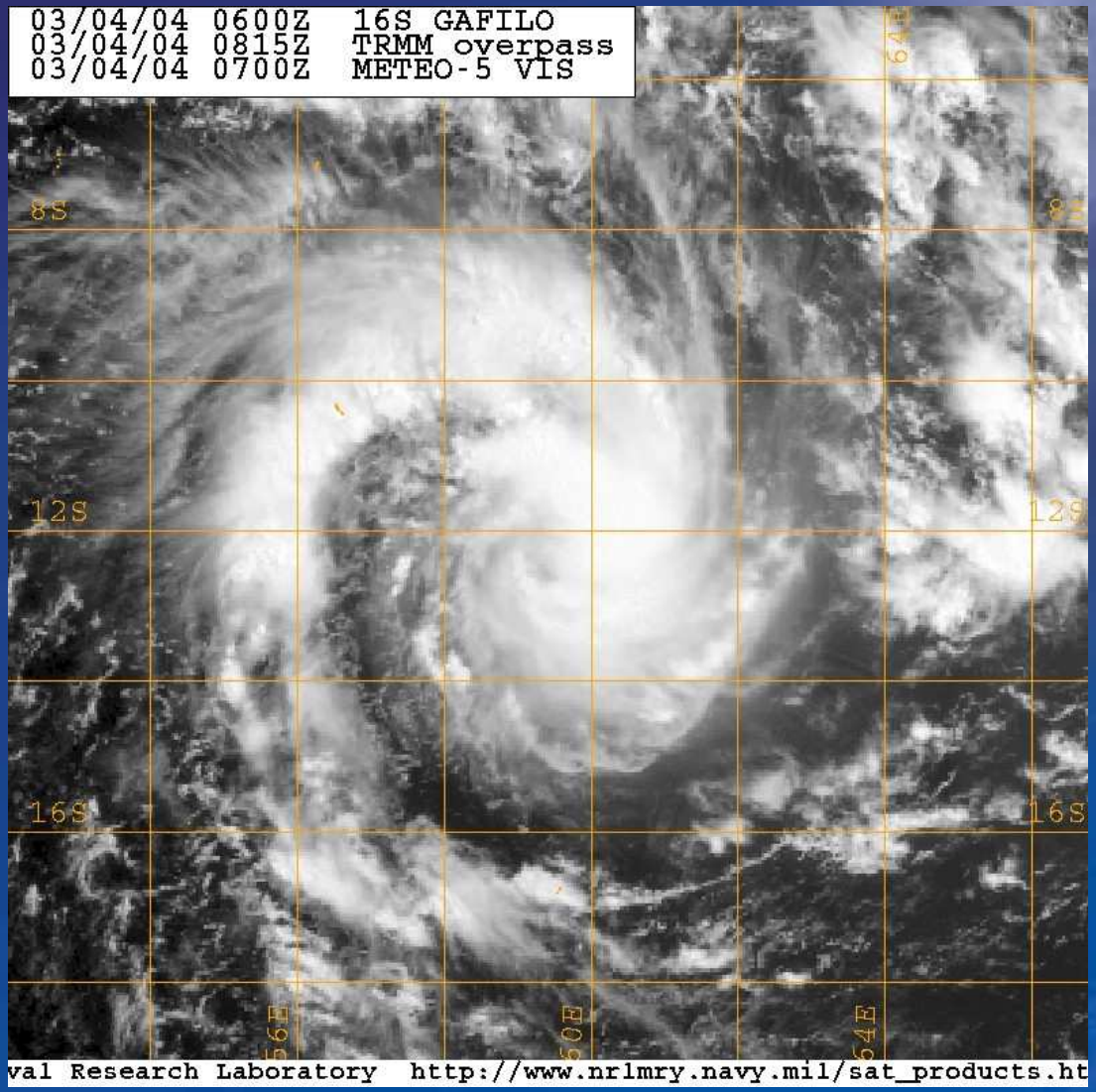


  - Note: Eye often smaller than in 85 - 89 GHz

Center Finding



Center Finding



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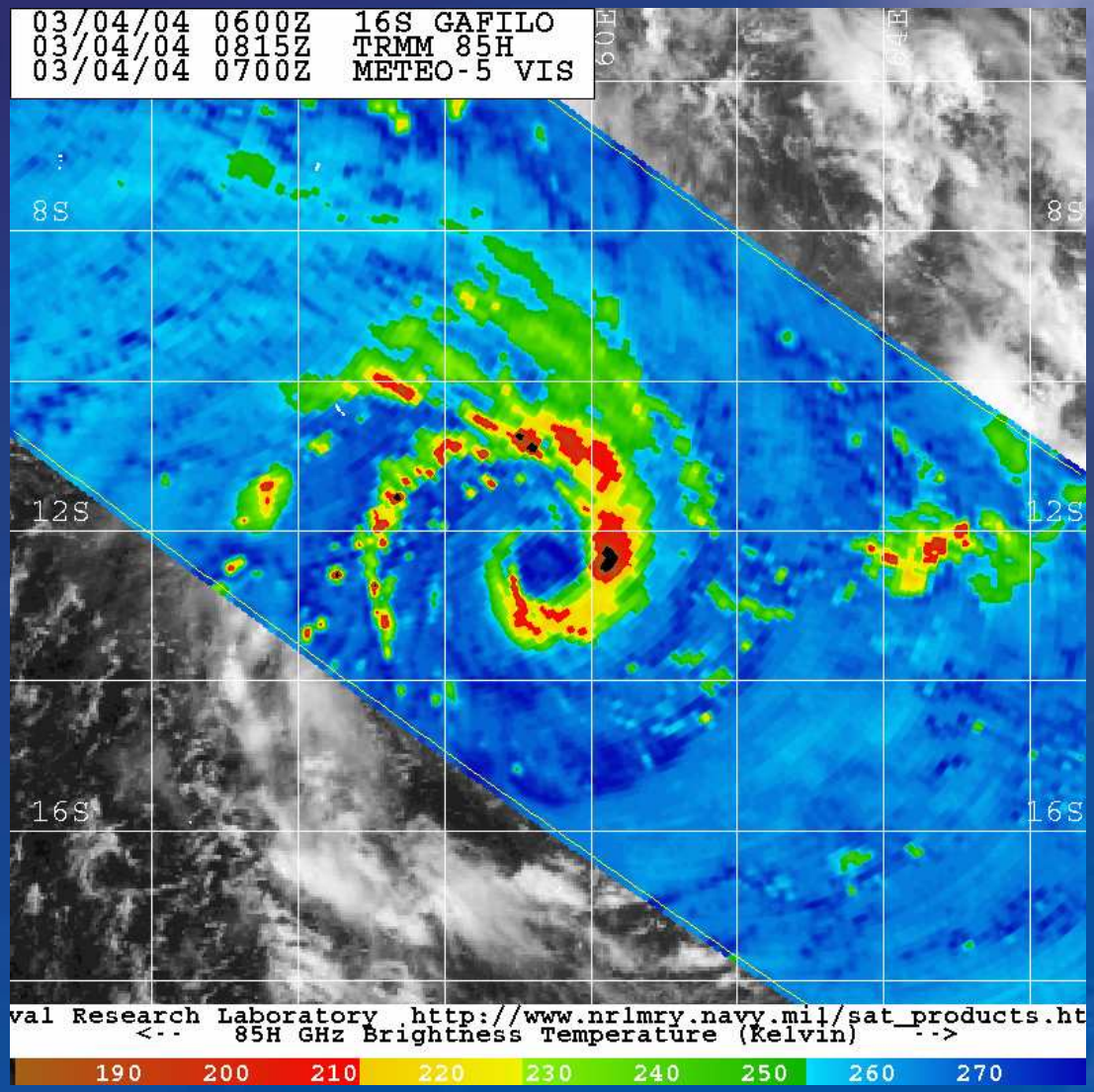

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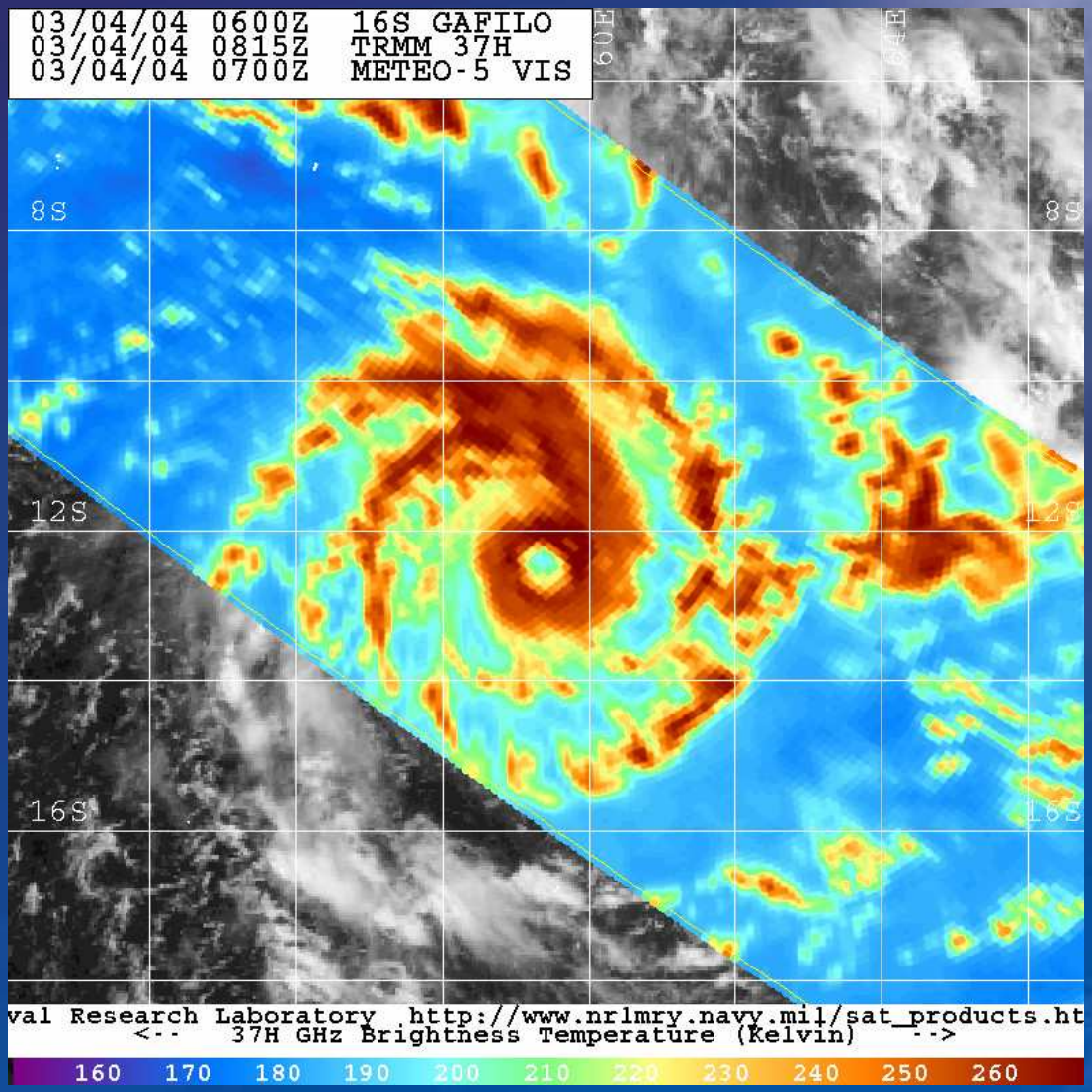
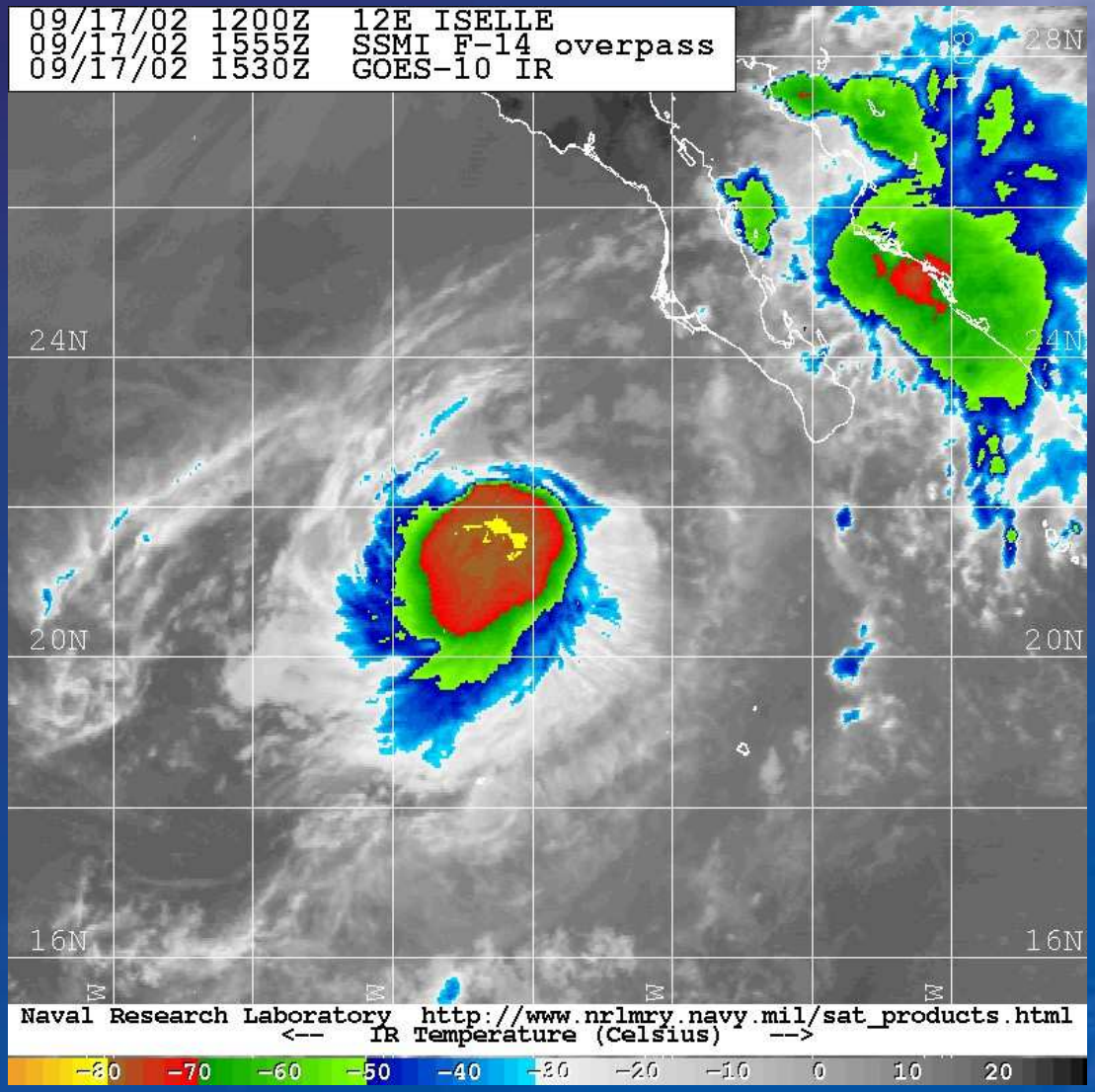
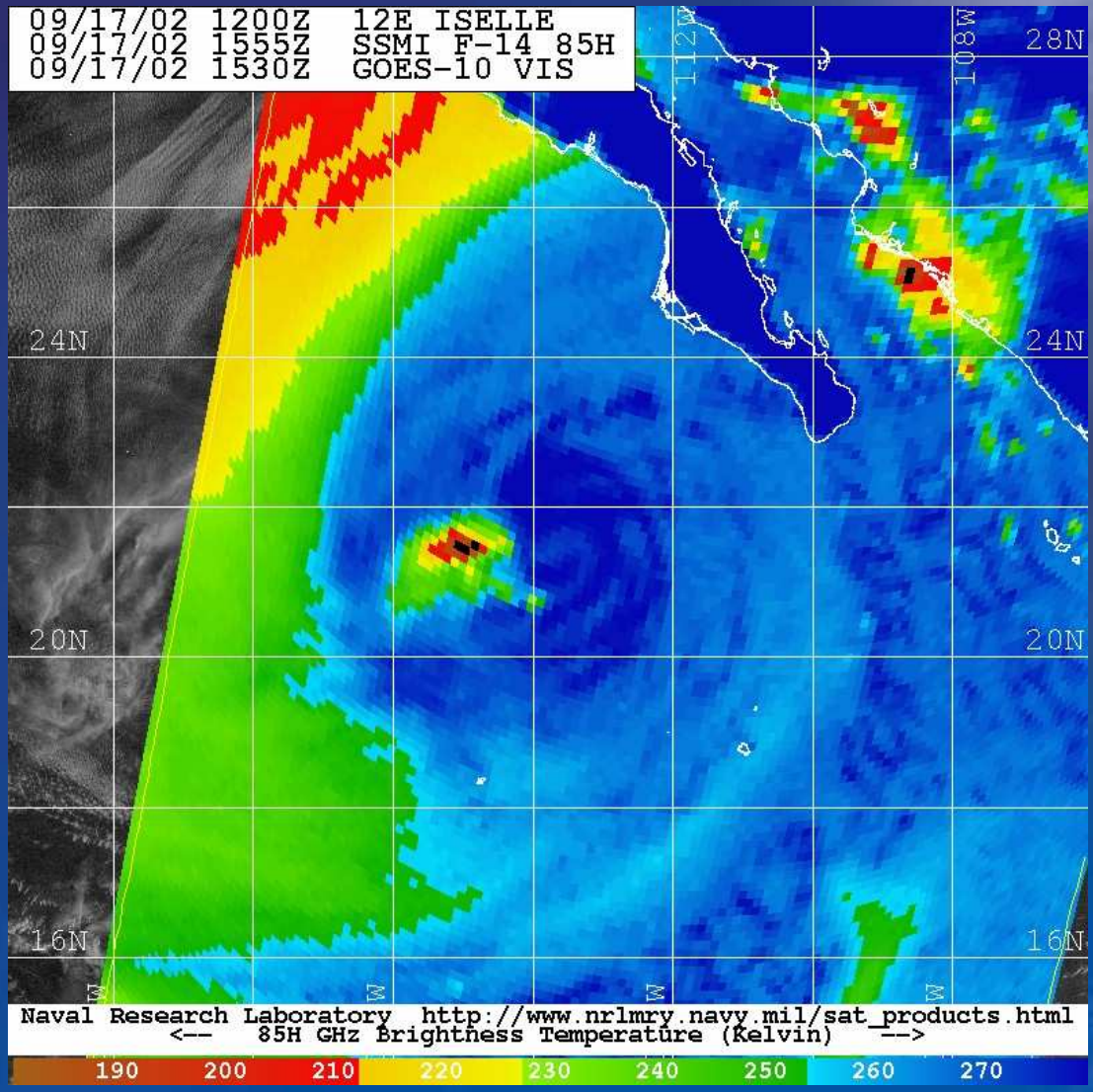


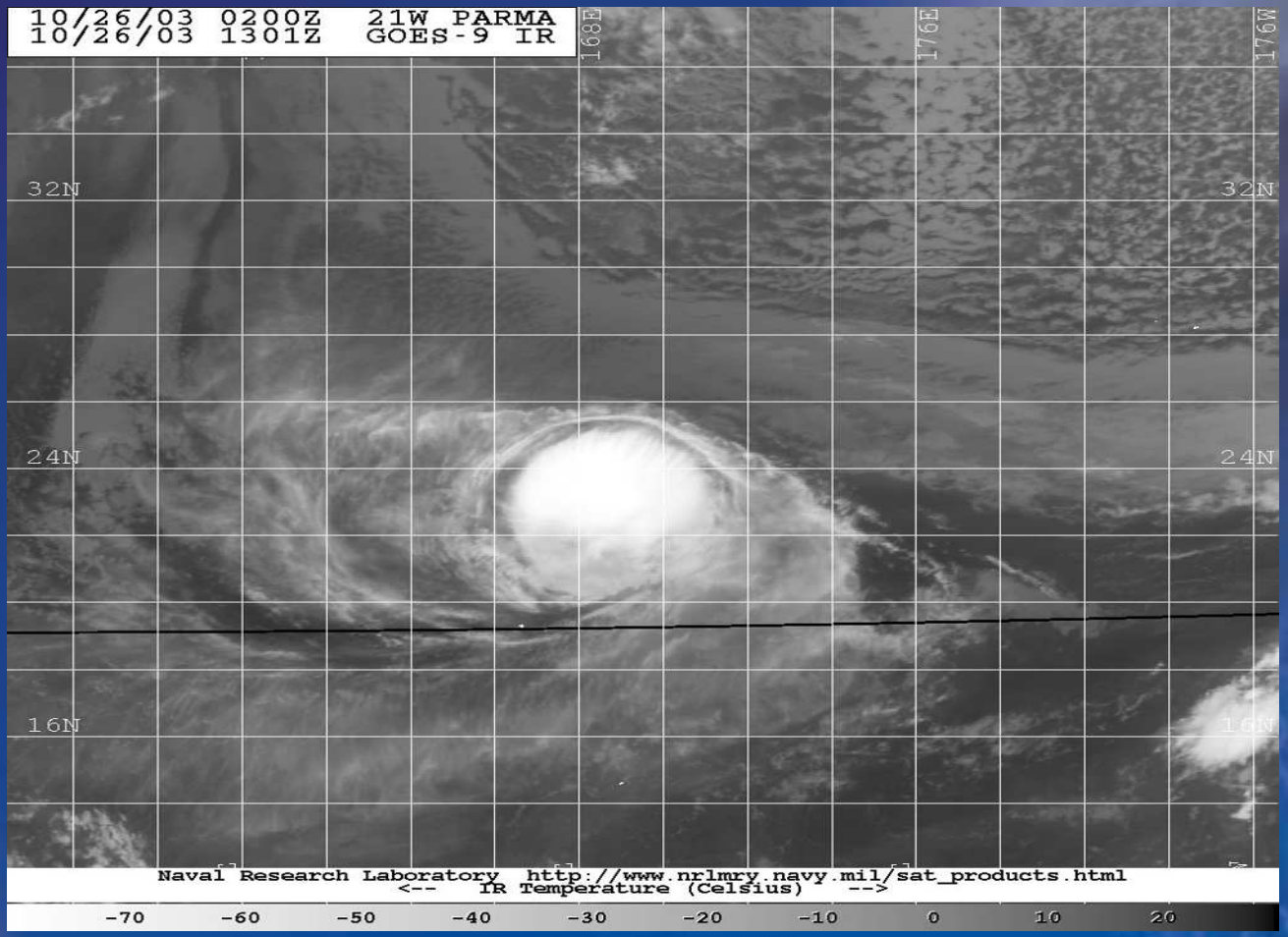
Center Finding



Center Finding



Center Finding



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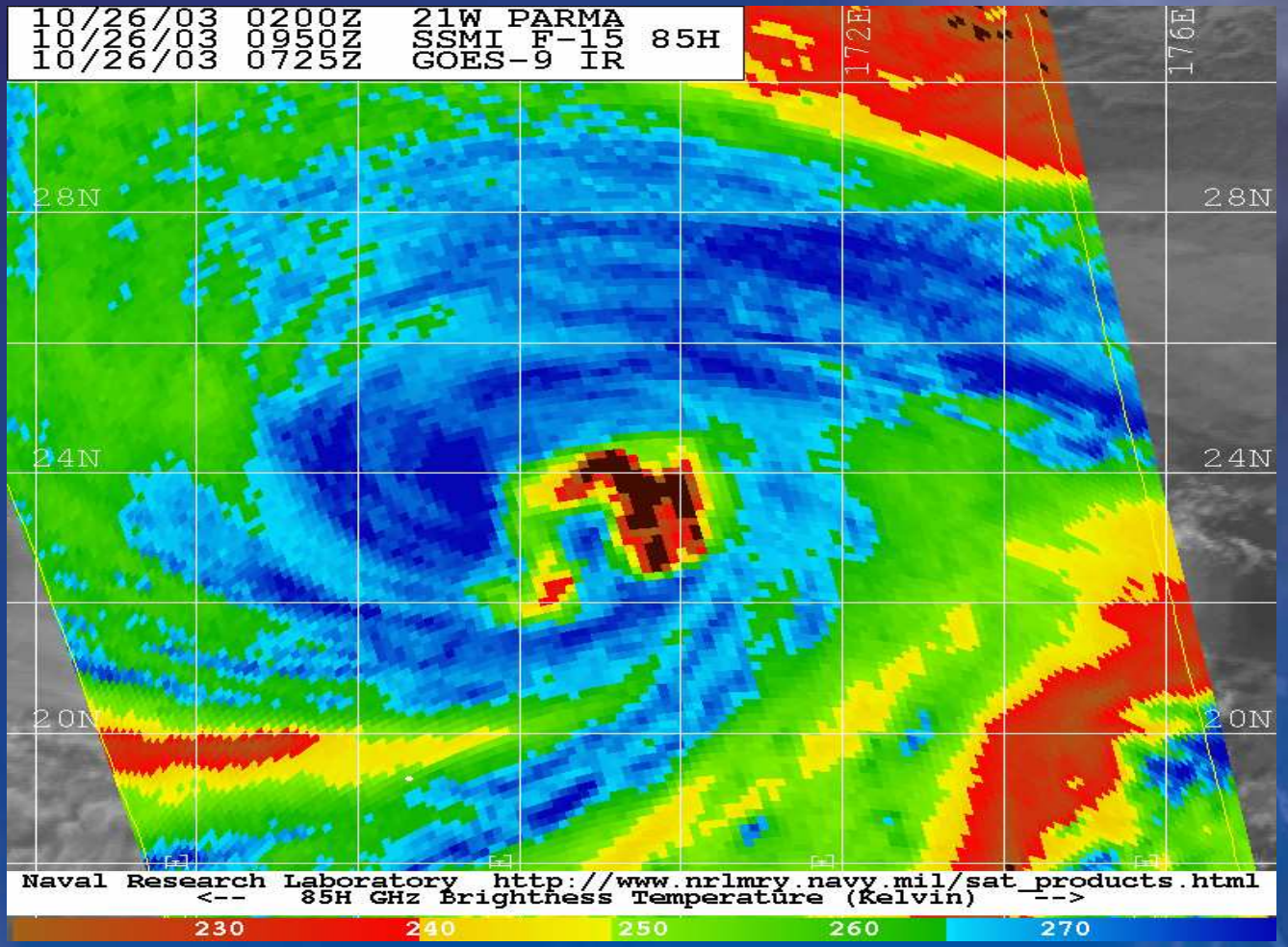
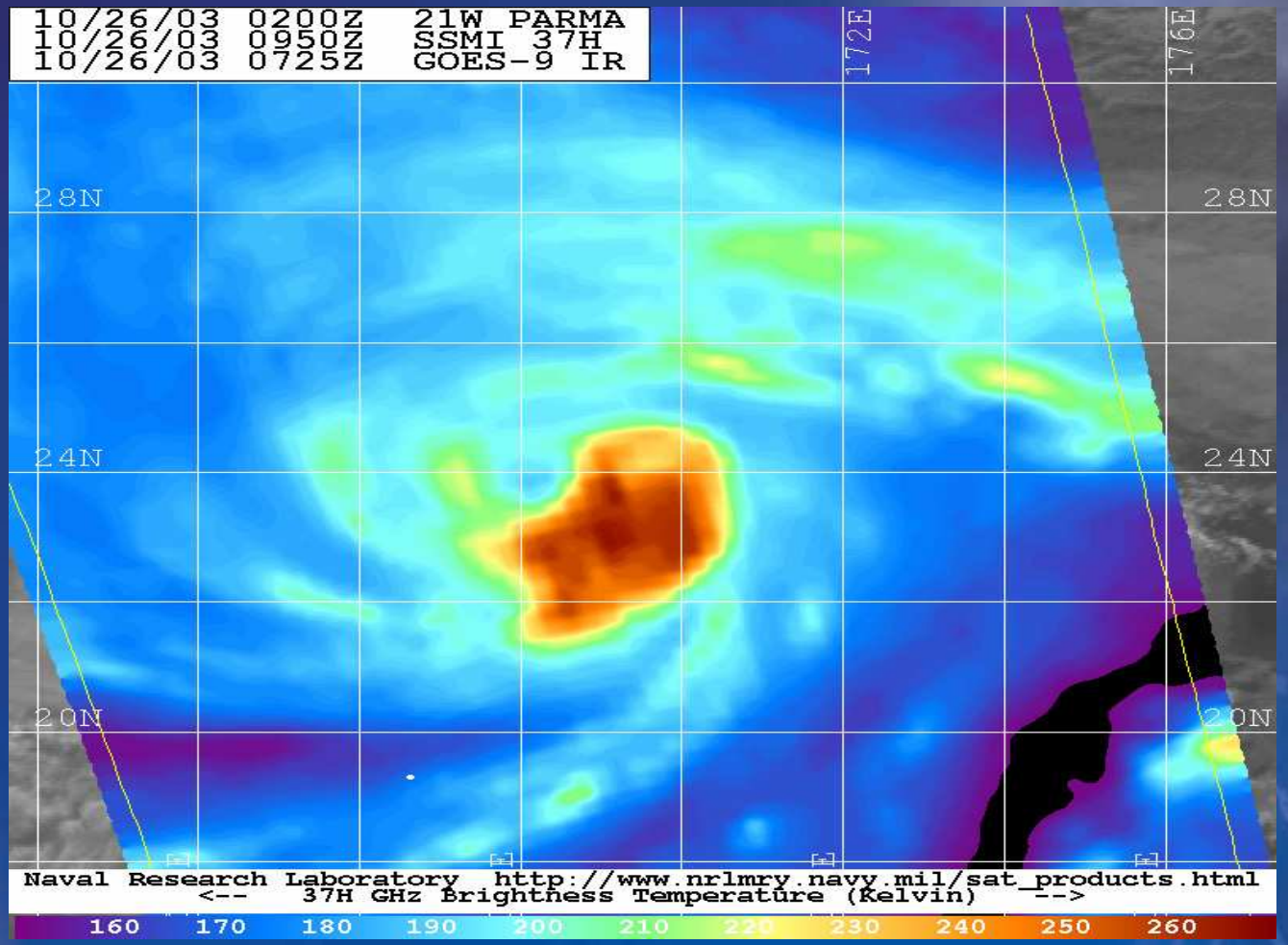
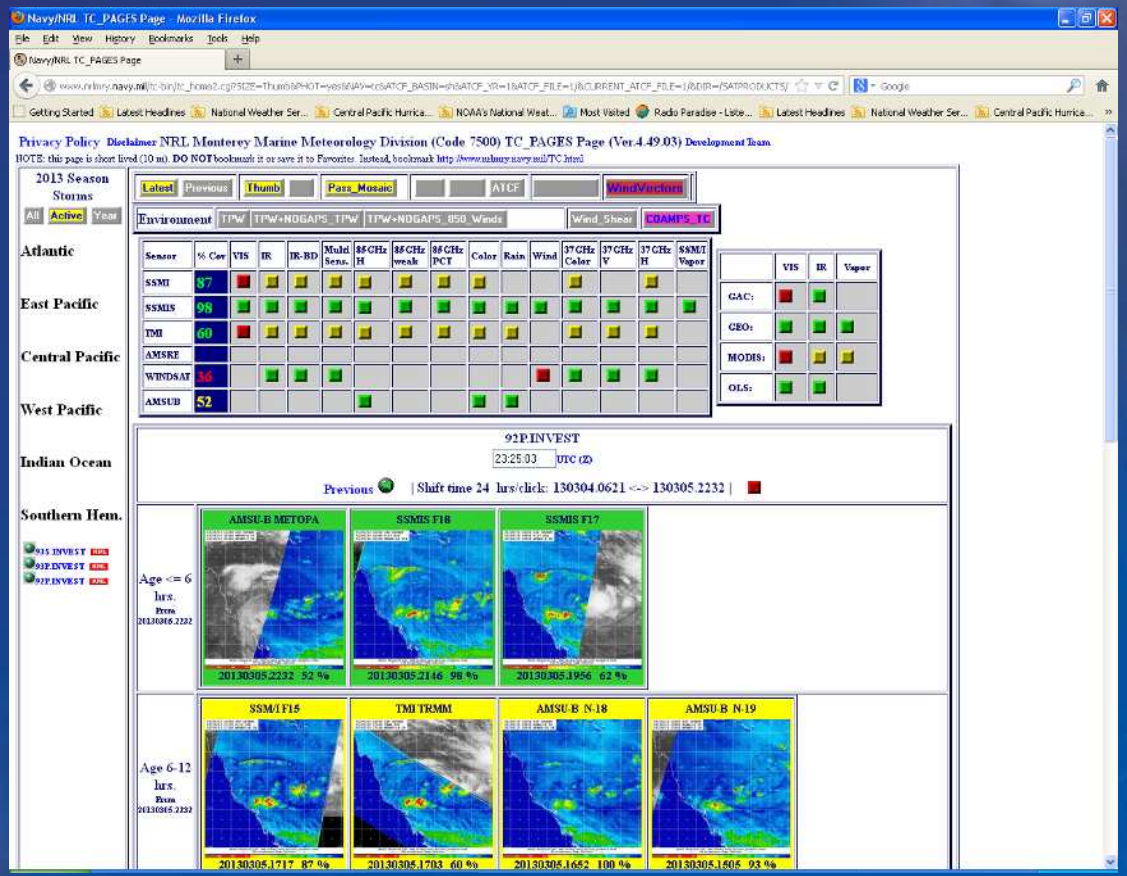


Center Finding

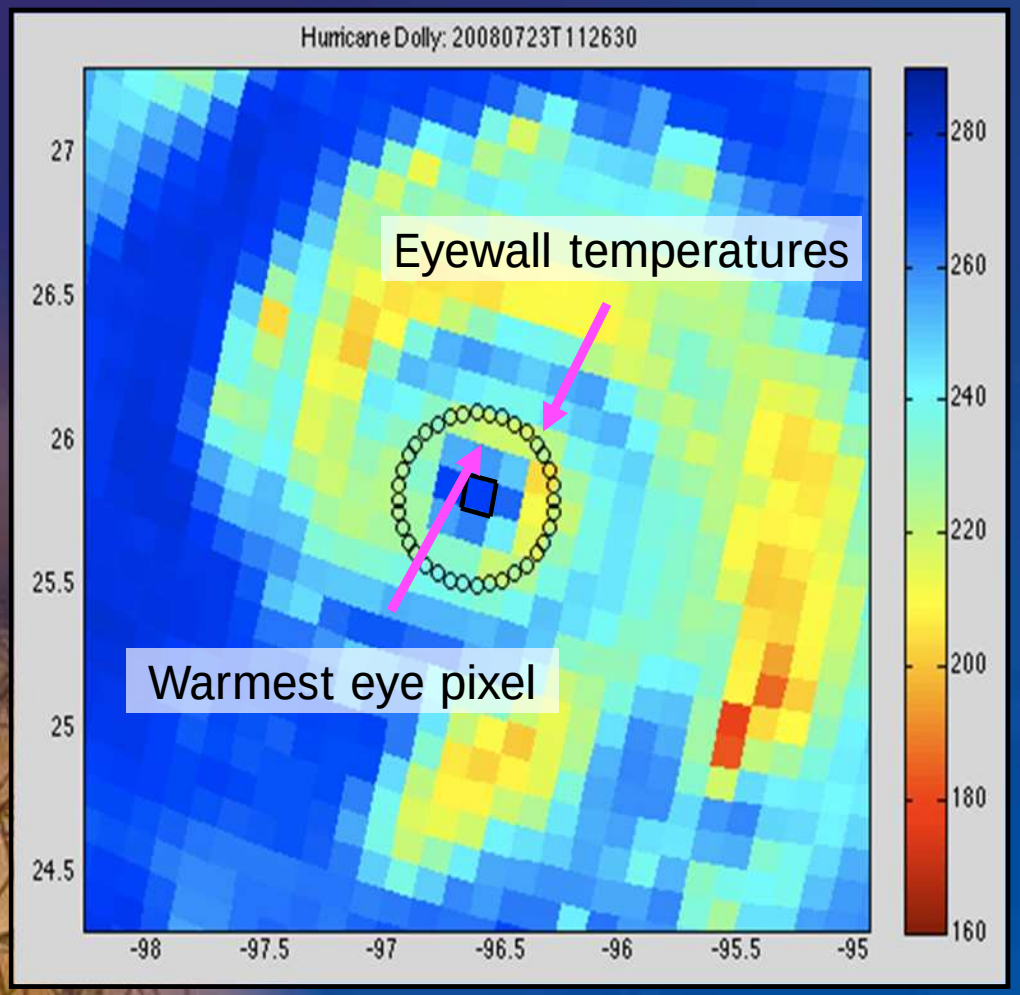


Microwave Imagery Availability

- Available from Naval Research Laboratory Monterey, CA:
  - http://www.nrlmry.navy.mil/tc_pages/tc_home.html



Microwave Data in ADT



- Uses the 85GHz brightness temperature signal to deduce the vigor and organization of the developing eyewall/eye, and calculate an intensity score

- If thresholds are exceeded, T number of 4.3 or 5.0 is overridden in ADT

AMSU Intensity Algorithm

- **A**dvanced **M**icrowave **S**ounding **U**nit on NOAA 15 -19, METOP, and Aqua
- Channels 5-8 in the 54 - 55 GHz range measure upper level warm core aloft
- Estimate MSLP via hydrostatic assumptions
- Algorithm needs RMW & outermost isobar input

CIMSS/NESDIS-USAF/NRL AMSU TC Intensity Estimation:
HURRICANE IOKE
Thursday 24aug06 Time: 0205 UTC
Latitude: 18.31 Longitude: -171.11
Storm position corresponds to AMSU-A FOV 3 [1<--->30]

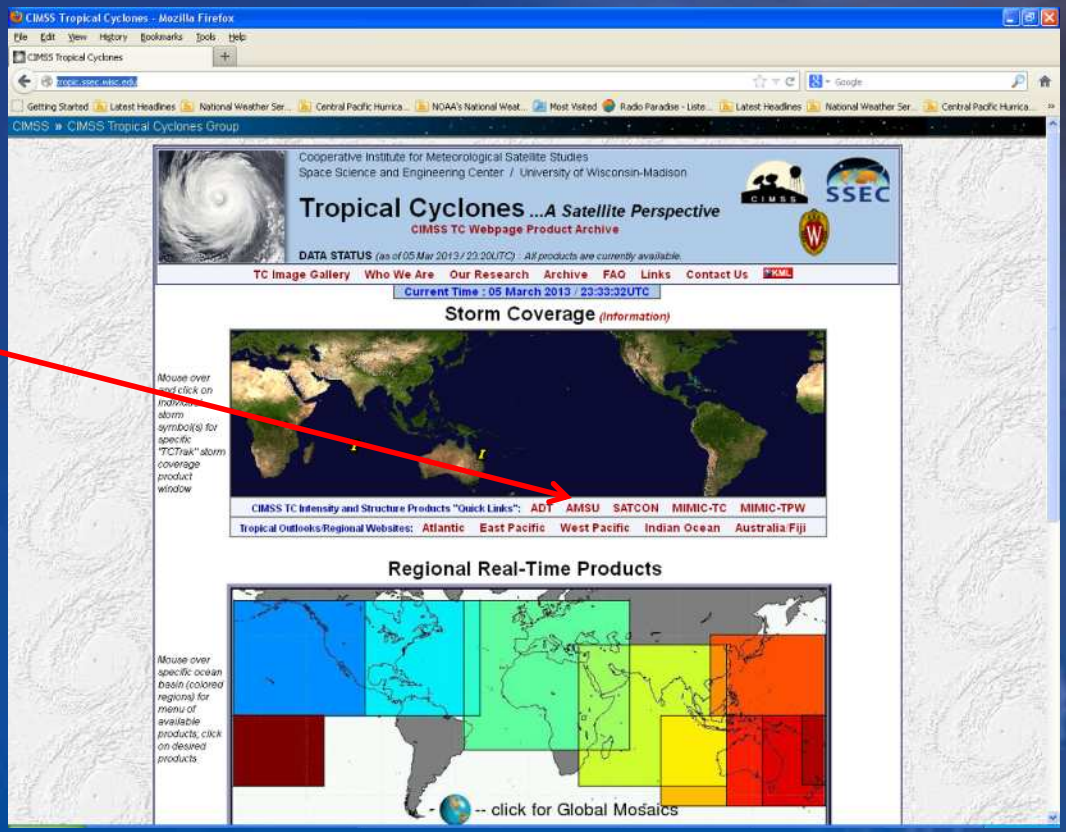
| Estimated MSLP: 975 hPa
| Estimated Maximum Sustained Wind: 80 kts
| Estimate Confidence: Fair (± 10mb ± 12kts)

Storm is sub-sampled: Bias correction applied is -6 hPa
Channel 8 (~150 hPa) Tb Anomaly: 1.41 (channel used for estimate)
Channel 7 (~250 hPa) Tb Anomaly: 0.69
RMW: 28 km
RMW Source is: TPC
Environmental Pressure: 1011 (TPC)
Satellite: NOAA-16
ATCF data for Month: 08 Day: 24 Time (UTC): 0600

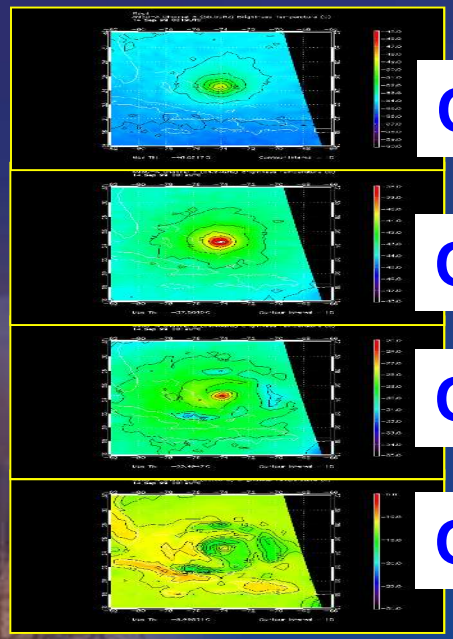
CIMSS AMSU Intensity Algorithm

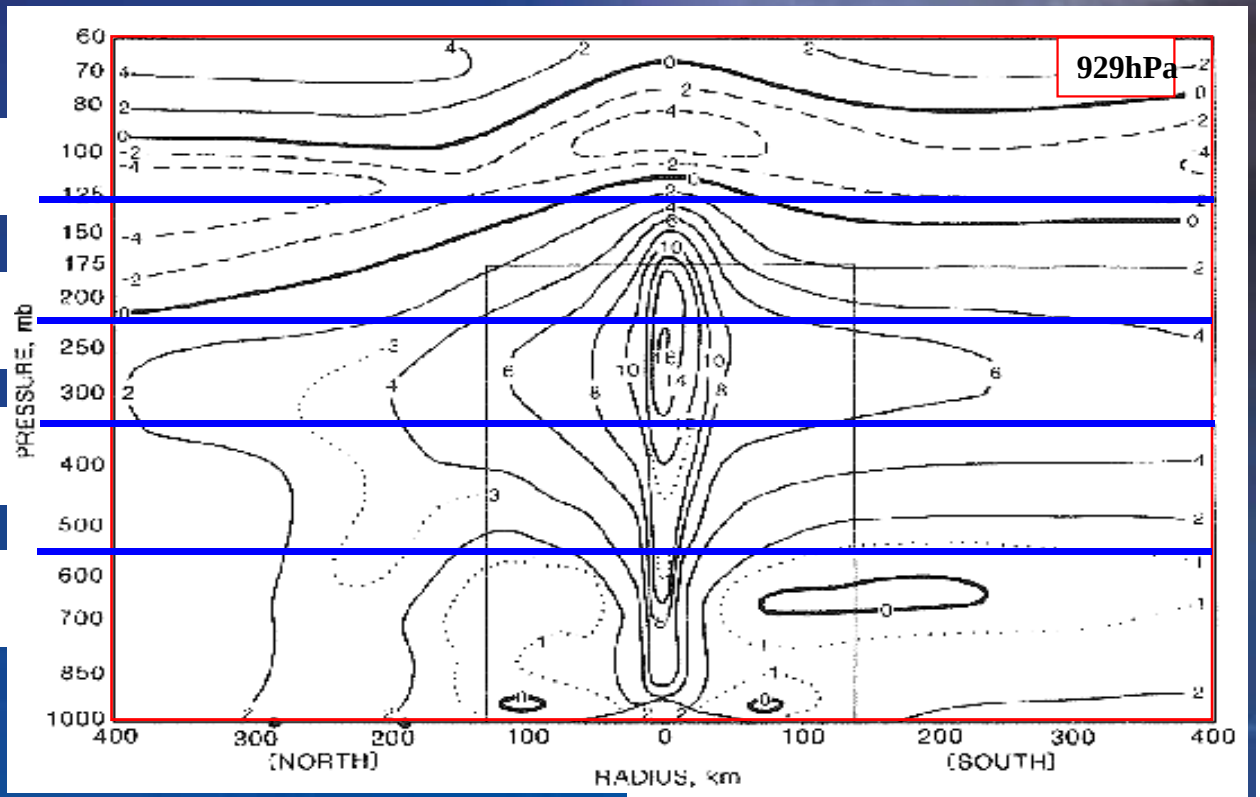
- Available from CIMSS website:
  - http://tropic.ssec.wisc.edu/

Access AMSU Data



AMSU Channels



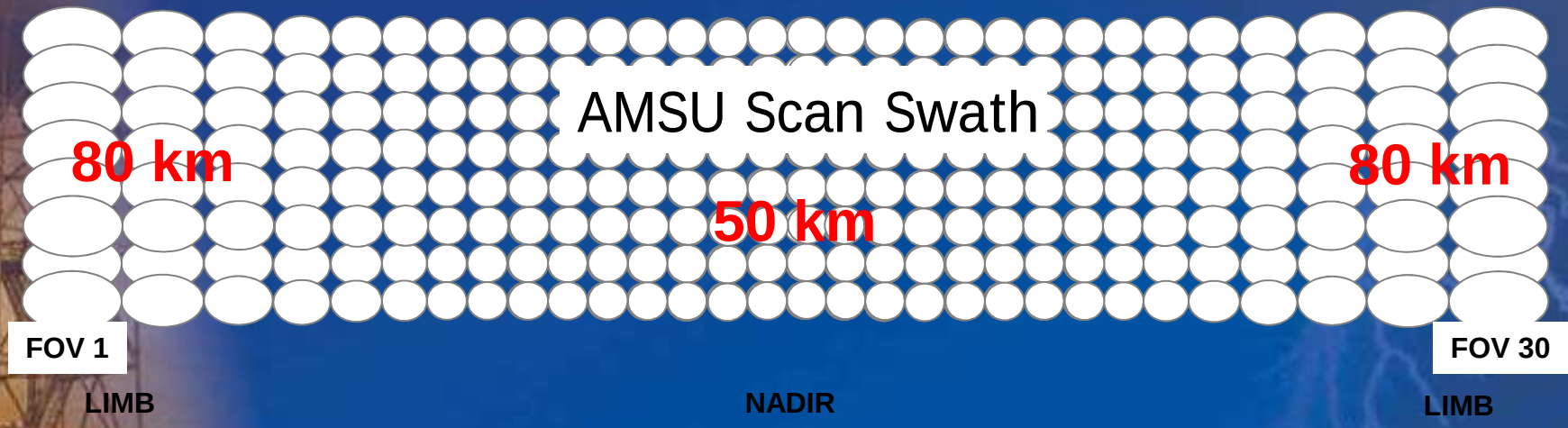


Hurricane Inez Sept 28 1966 (Hawkins and Imbembo)

Hydrostatic Eqn: $dp = -p\frac{g}{RT}\,dZ$

AMSU Sensor Characteristics

- Field of View (FoV) resolution varies across the scan swath due to the instrument's cross-track scanning strategy
- Best spatial resolution at nadir is ~50 km



AMSU Field of View

- Spatial resolution variability needs to be taken into account relative to the TC core position in the swath. A TC core-sized warm anomaly viewed at 50km will be better resolved then at 80km.
- FOV provided in message

CIMSS/NESDIS-USAF/NRL AMSU TC Intensity Estimation:
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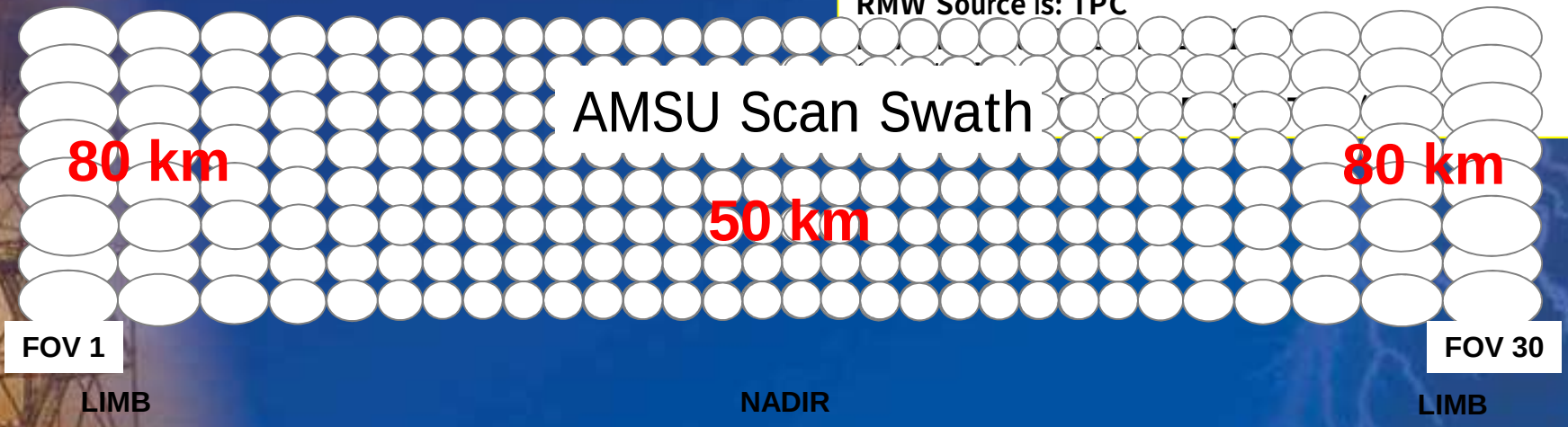
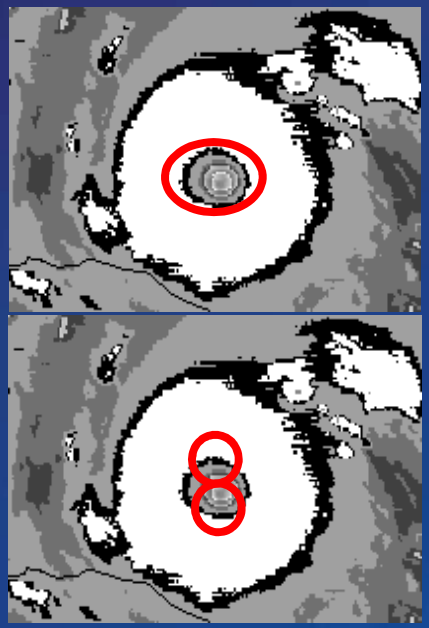
RMW Source is: TPC



AMSU Sub-sampling

- Near limb footprint
- "Bracketing"



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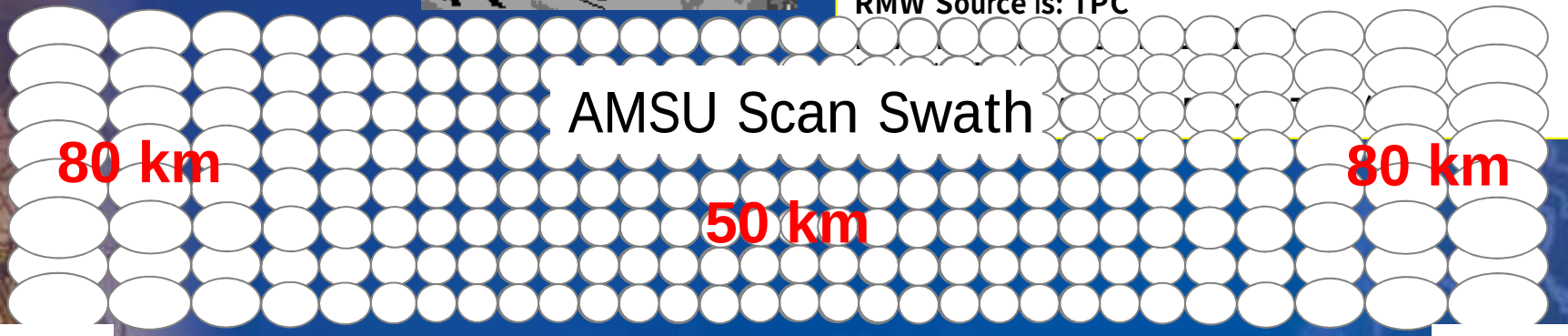

AMSU: Warm Core Size

- Environmental pressure and radius of maximum winds
- Algorithm needs to start with an input for warm core size
- Three possible sources:
  - Automated algorithm
  - ADT
  - NHC, CPHC, or JTWC

CIMSS/NESDIS-USAF/NRL AMSU TC Intensity Estimation:
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Satellite: NOAA-16
ATCF data for Month: 08 Day: 24 Time (UTC): 0600

CIMSS AMSU Intensity

- Output:
  - MSLP
  - MSW
- Confidence based on:
  - FOV
  - Any sub-sampling?
  - Quality of data

```
CIMSS/NESDIS-USAF/NRL AMSU TC Intensity Estimation:
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```
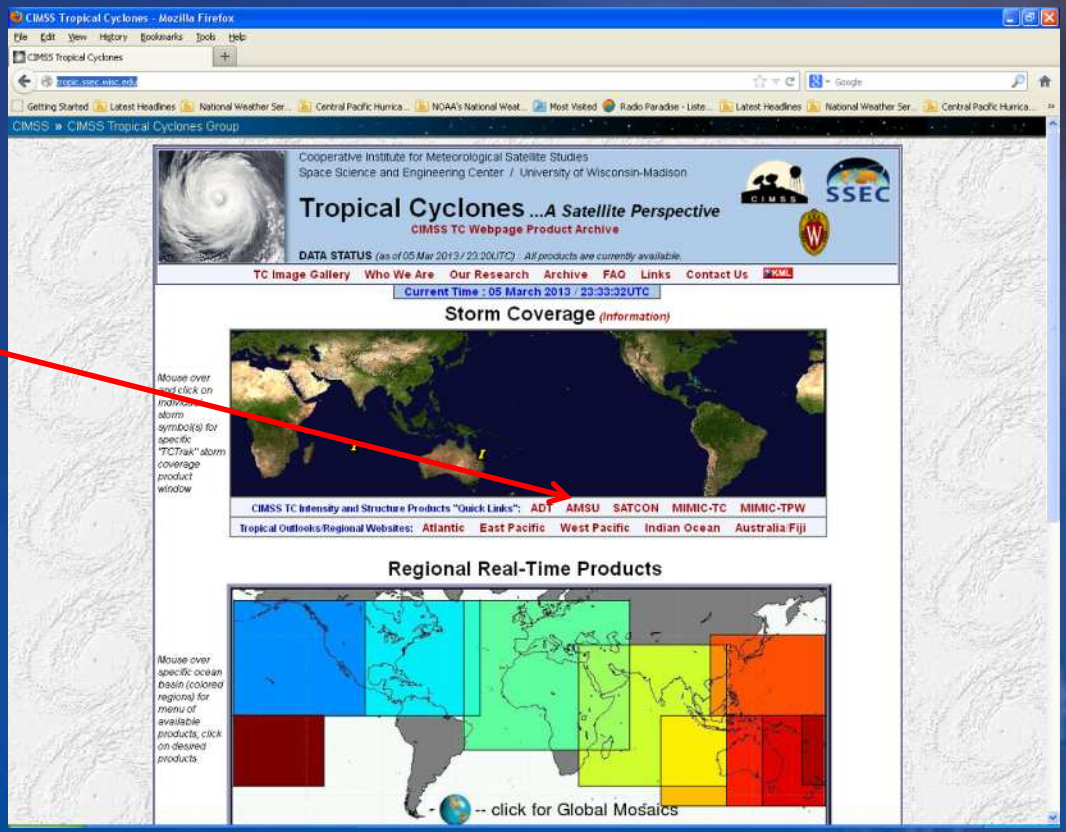

- Note: For TC < 45 kt, algorithm has high bias of ~ 4.9 kt

CIMSS AMSU Intensity Algorithm

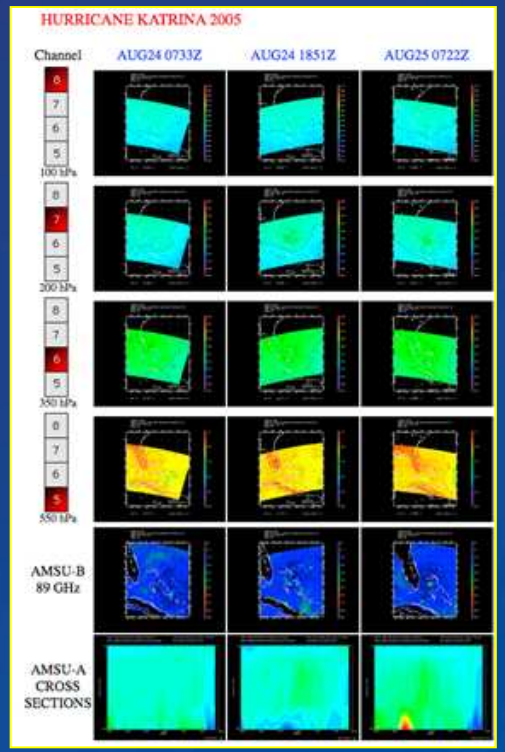
- Available from CIMSS website:
  - http://tropic.ssec.wisc.edu/

Access AMSU Data



Raw AMSU Data

- Data from channels 5 – 8 are available on the CIMSS web page



CIMSS/NESDIS-USAF/NRL AMSU TC Intensity Estimation:
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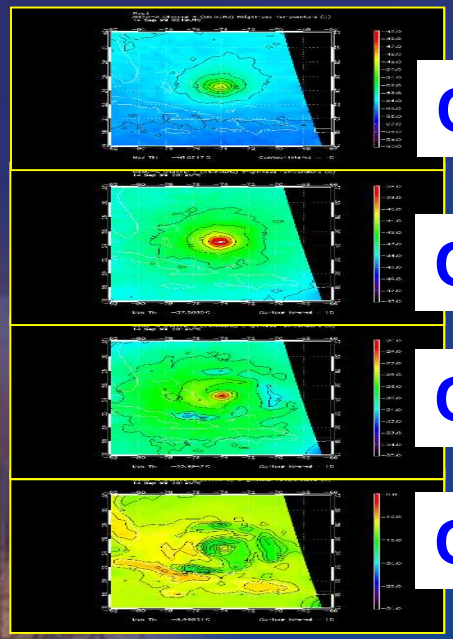
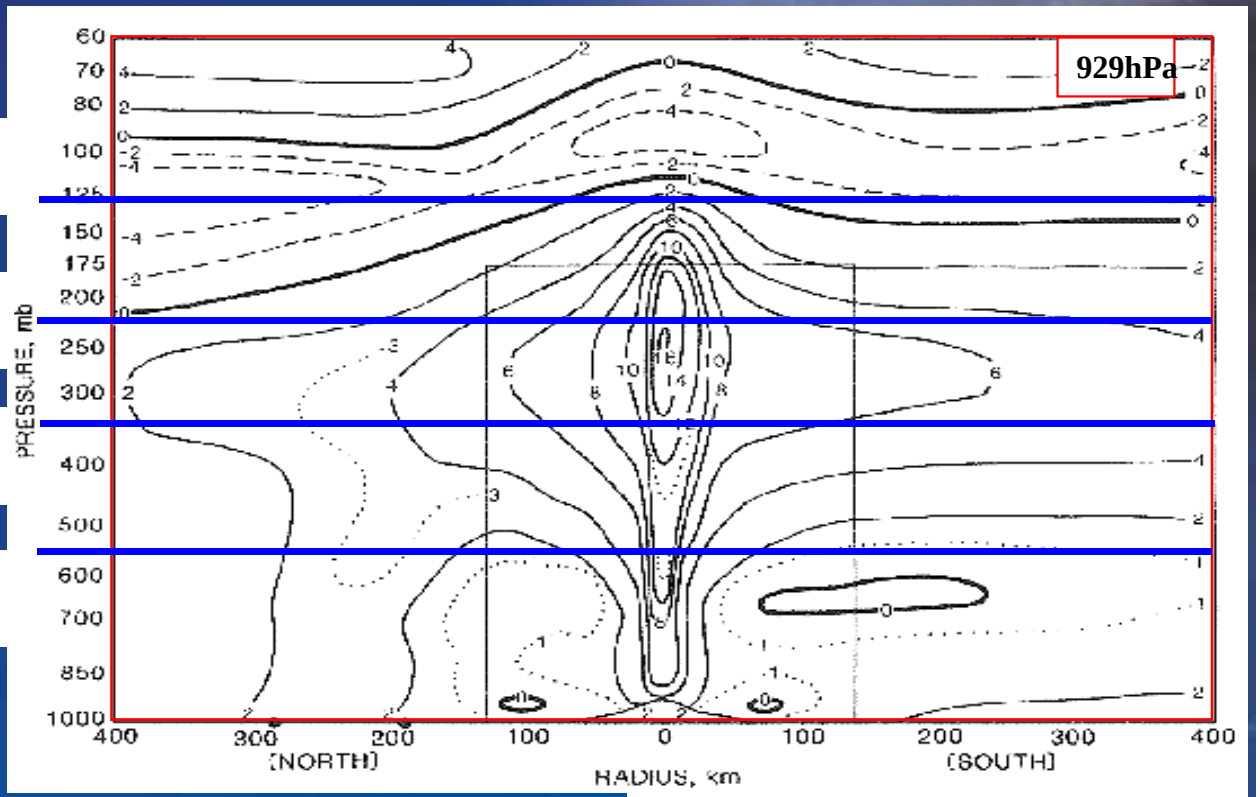
Raw AMSU Data

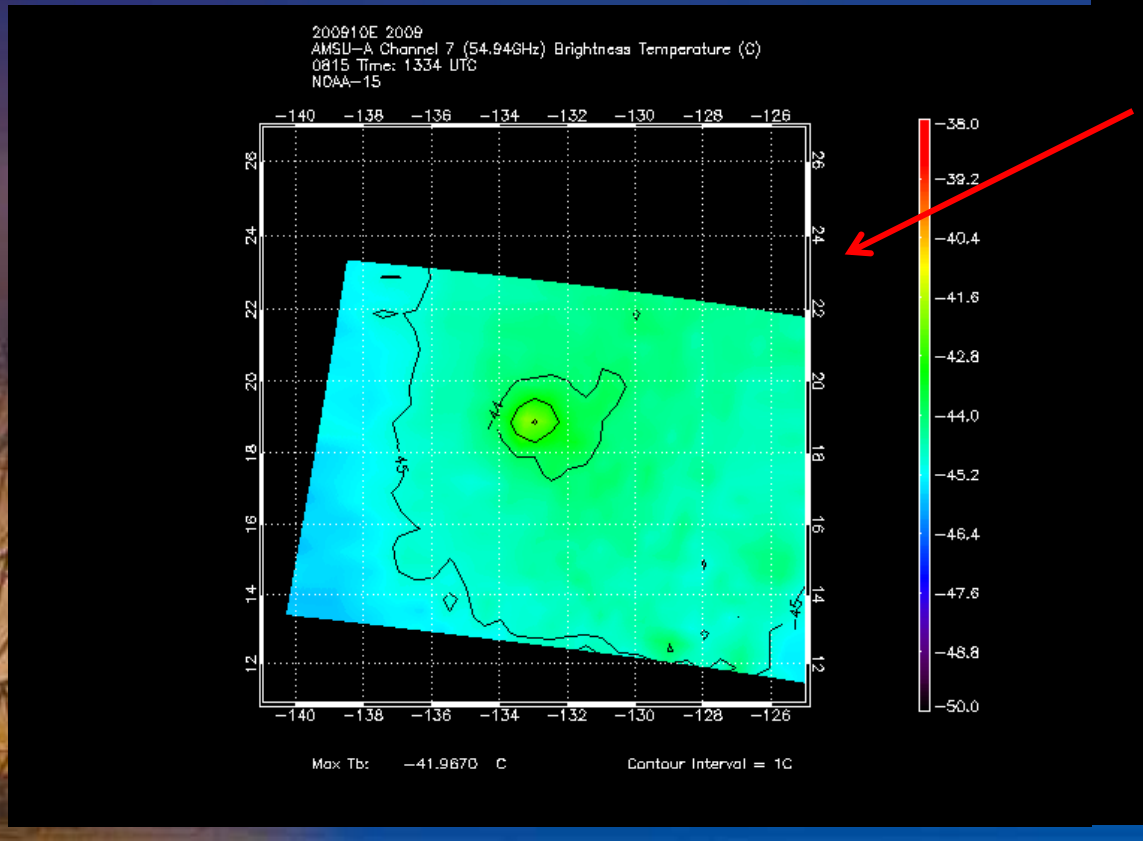


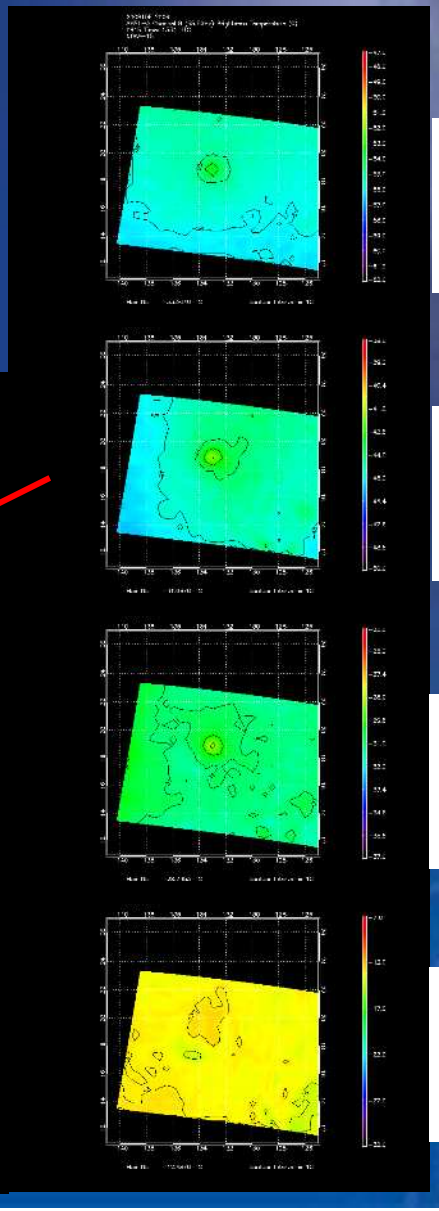


Hurricane Inez Sept 28 1966 (Hawkins and Imbembo)

Raw AMSU Data

- Hurricane Guillermo (2009)
  - August 15 1334Z
  - Max Wind ~ 110 kt





Ch 8
~ 125 mb

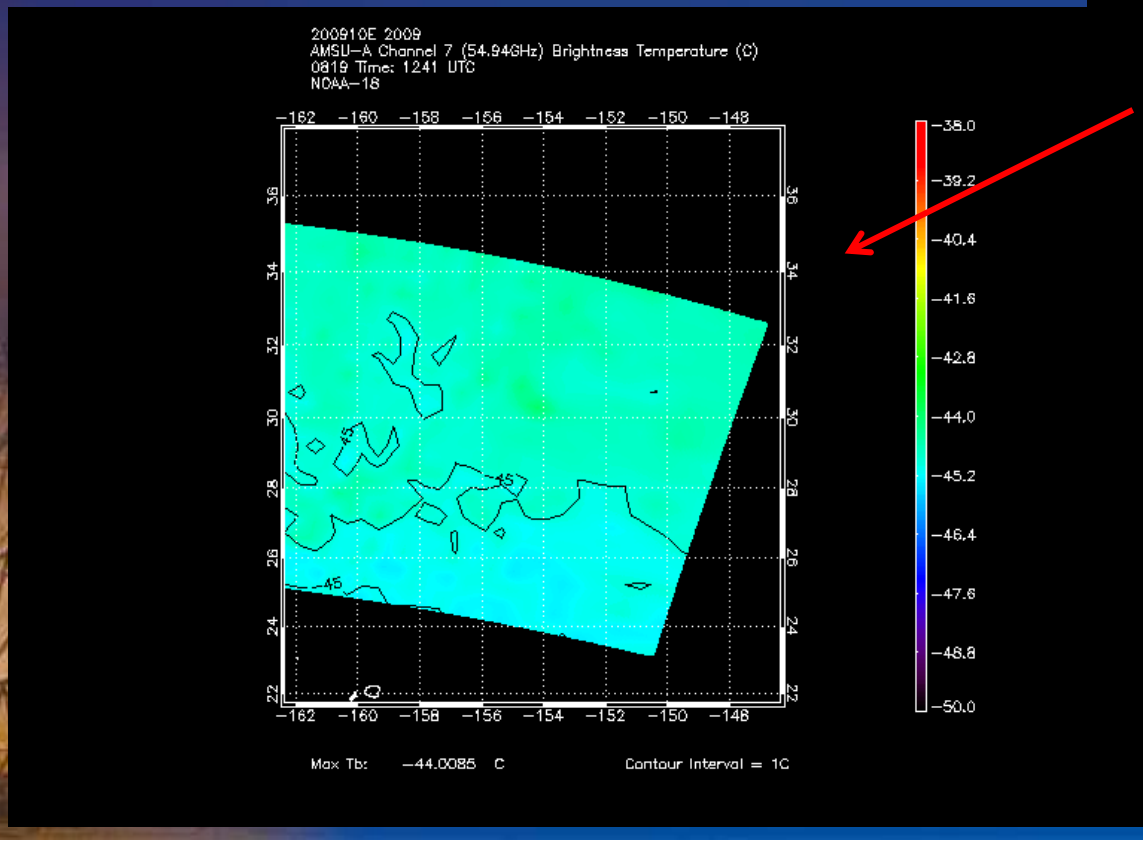
Ch 7
~ 225 mb

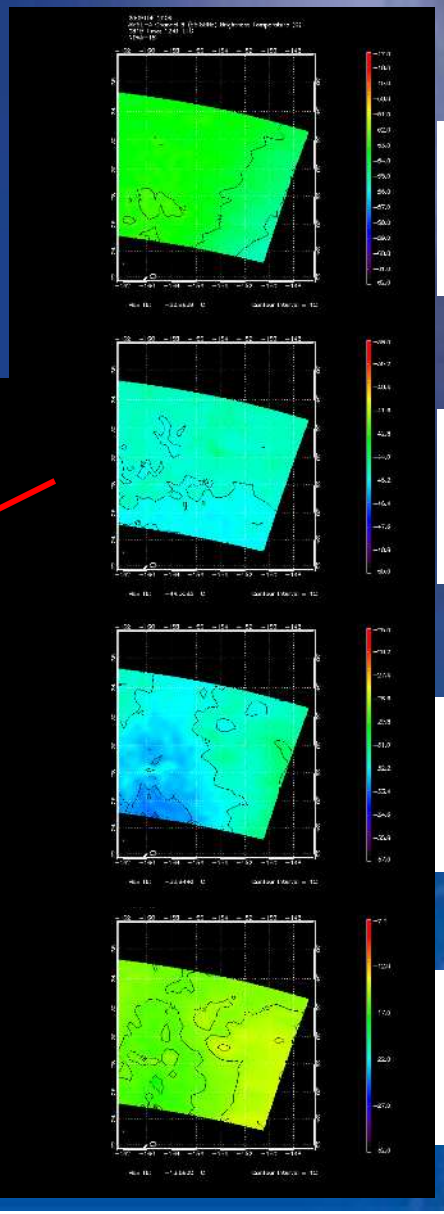
Ch 6
~ 350 mb

Ch 5
~ 550 mb

Raw AMSU Data

- Hurricane Guillermo (2009)
  - August 19 1241Z
  - Max Wind ~ 35 kt – Sheared!





Ch 8
~ 125 mb

Ch 7
~ 225 mb

Ch 6
~ 350 mb

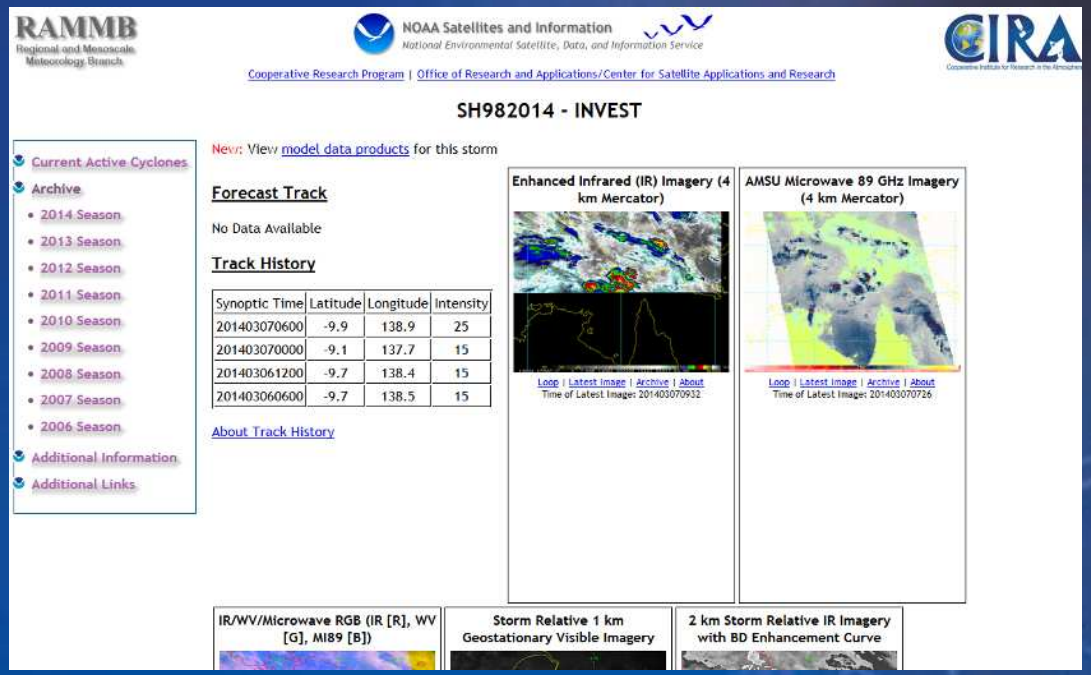
Ch 5
~ 550 mb

CIRA AMSU Intensity

- CIRA algorithm uses nearly same technique as CIMSS, but…
  - CIRA AMSU Intensity algorithm does NOT make adjustments for sub-sampling
  - Error slightly greater than CIMSS algorithm

CIRA Web Site

- Great Resource:
  http://rammb.cira.colostate.edu/products/tc_realtime/
  - AMSU Intensity
  - Satellite images
  - Track info
  - Ocean heat content
  - Multiplatform satellite surface wind analysis
  - ADT



CIMSS SATCON

- **SAT**ellite **CON**sensus
- Combines the confident aspects of the individual objective estimates into a single “best” estimate
- Members:
  - CIMSS AMSU
  - CIRA AMSU
  - CIMSS ADT

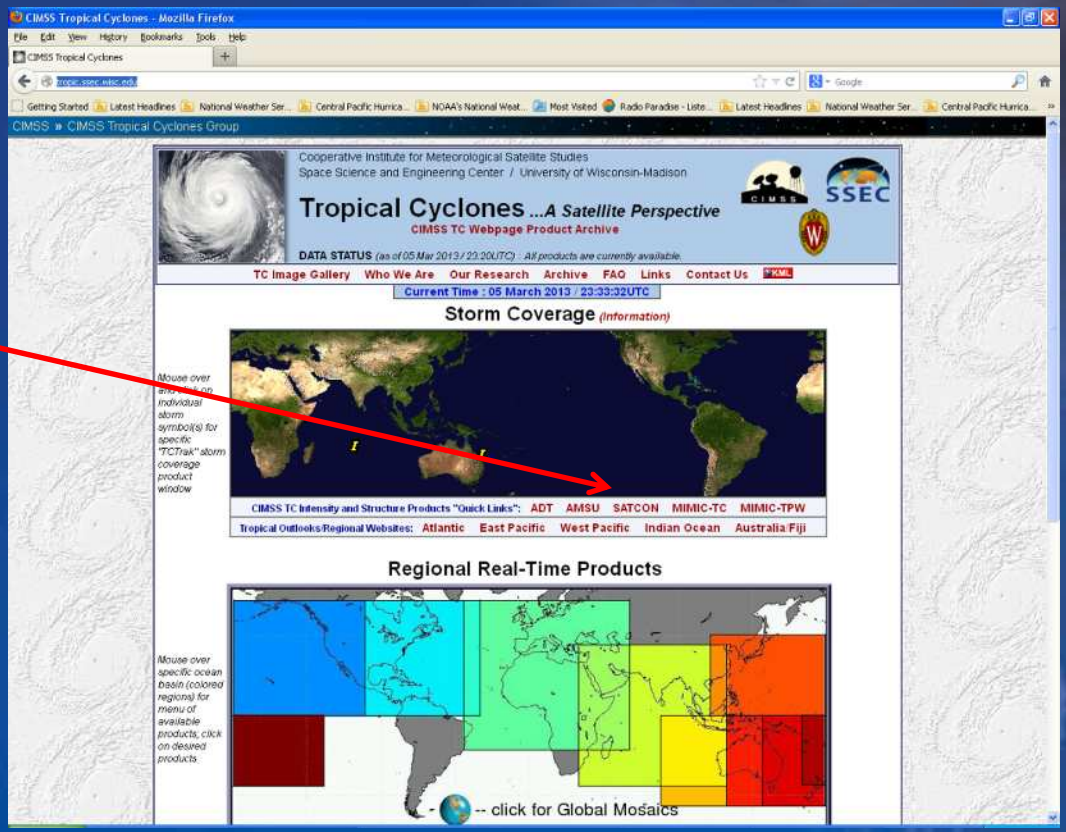
CIMSS SATCON

- The strengths and weaknesses of each method are assessed based on statistical analysis
- Weights then assigned to each method in the consensus algorithm based on situational performance
- Factors:
  - ADT scene type
  - Poor handling of sub-sampling by CIRA AMSU

CIMSS SATCON

- Available from CIMSS website:
  - http://tropic.ssec.wisc.edu/

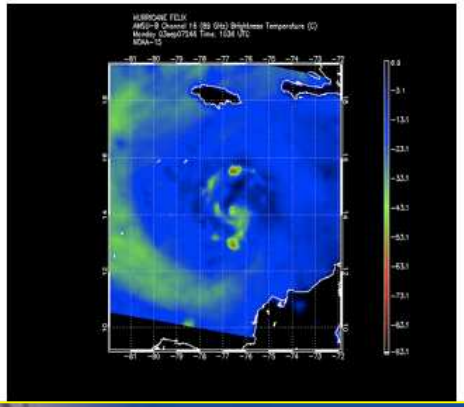
Access SATCON

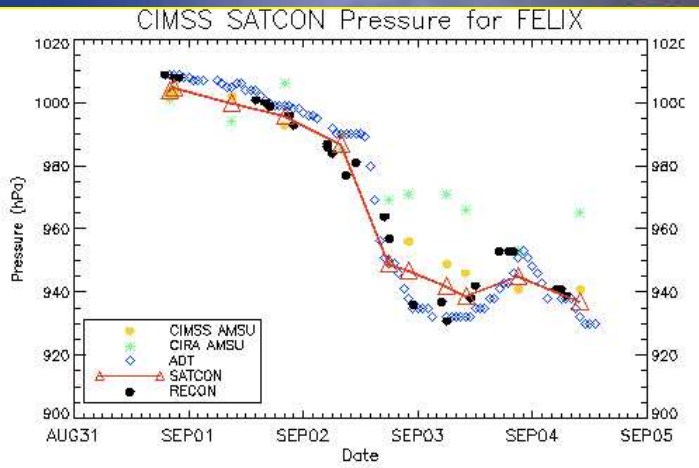


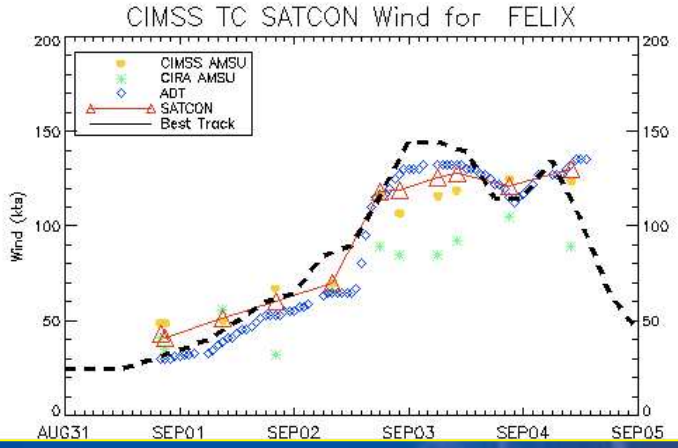
SATCON Web Site

CURRENT ESTIMATE
Date (yyyymmddhh): 2007090413
SATCON (3mem): MSLP = 937 hPa MSW = 130 kt
ADT: 932 hPa 132 kt Scene: EYE
CIMSS AMSU: 941 hPa 124 kt Bias Corr: -12 (IR)
CIRA AMSU: 965 hPa 89 kt clw: 1.28

Date	SATCON MSW	SATCON MSLP	CIMSS_AMSU MSW	CIMSS_AMSU MSLP	ADT MSW	ADT MSLP	CIRA_AMSU MSW	CIRA_AMSU MSLP
090410	130	937	124	941	132	932	89	965
090321	121	945	125	941	115	951	105	953
090310	128	939	119	946	132	932	92	966
090306	126	942	116	949	132	932	85	971
090222	119	947	107	956	127	938	85	971
090218	118	949	116	949	117	949	89	969
090208	70	987	70	990	65	990	66	985
090120	60	996	67	993	53	999	32	1006
090109	51	1000	50	1002	39	1005	56	994







http://cimss.ssec.wisc.edu/tropic2/real-time/satcon

CIMSS SATCON Performance: Pressure (1999 - 2010)

N = 289	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON	Dvorak
BIAS	0.3	- 2.5	-2.6	**0.1**	-2.0
AVG ERROR	5.4	8.9	6.8	**4.6**	6.8
RMSE	7.3	12.5	10.4	**6.5**	9.3

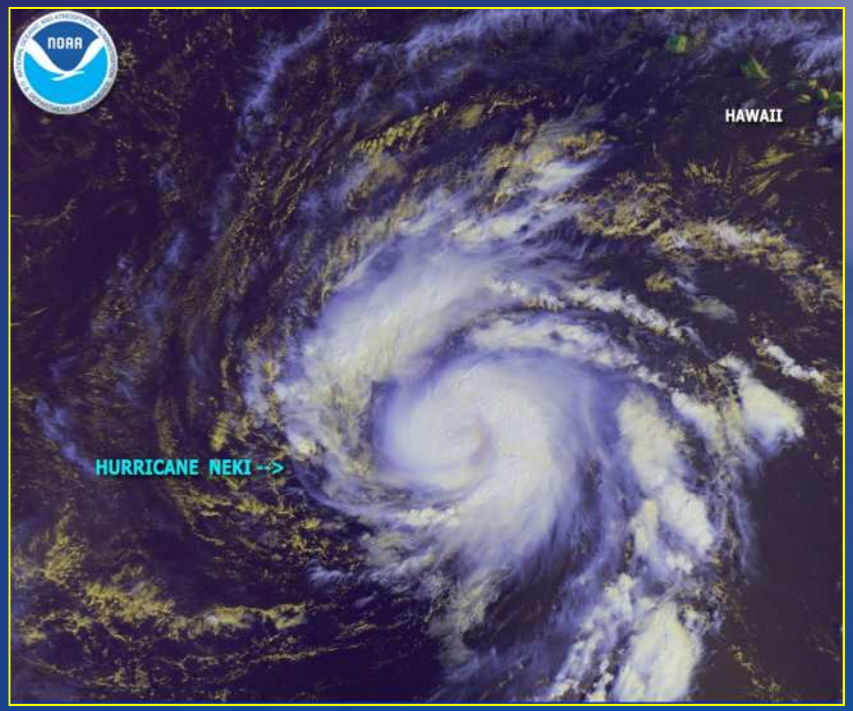
Validation is recon-measured central pressure within 3 hours of AMSU pass for MSLP and recon-aided Best Track for MSW

CIMSS SATCON Performance: MSW (1999 - 2010)

N = 289	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON	Dvorak
BIAS	0.6	- 2.5	-7.1	**- 0.5**	- 1.9
AVG ERROR	8.7	10.9	11.7	**7.1**	7.7
RMSE	11.1	14.3	15.6	**8.9**	9.9

Validation is recon-measured central pressure within 3 hours of AMSU pass for MSLP and recon-aided Best Track for MSW

Questions?



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