CIMSS-NRL Tropical Cyclone Efforts

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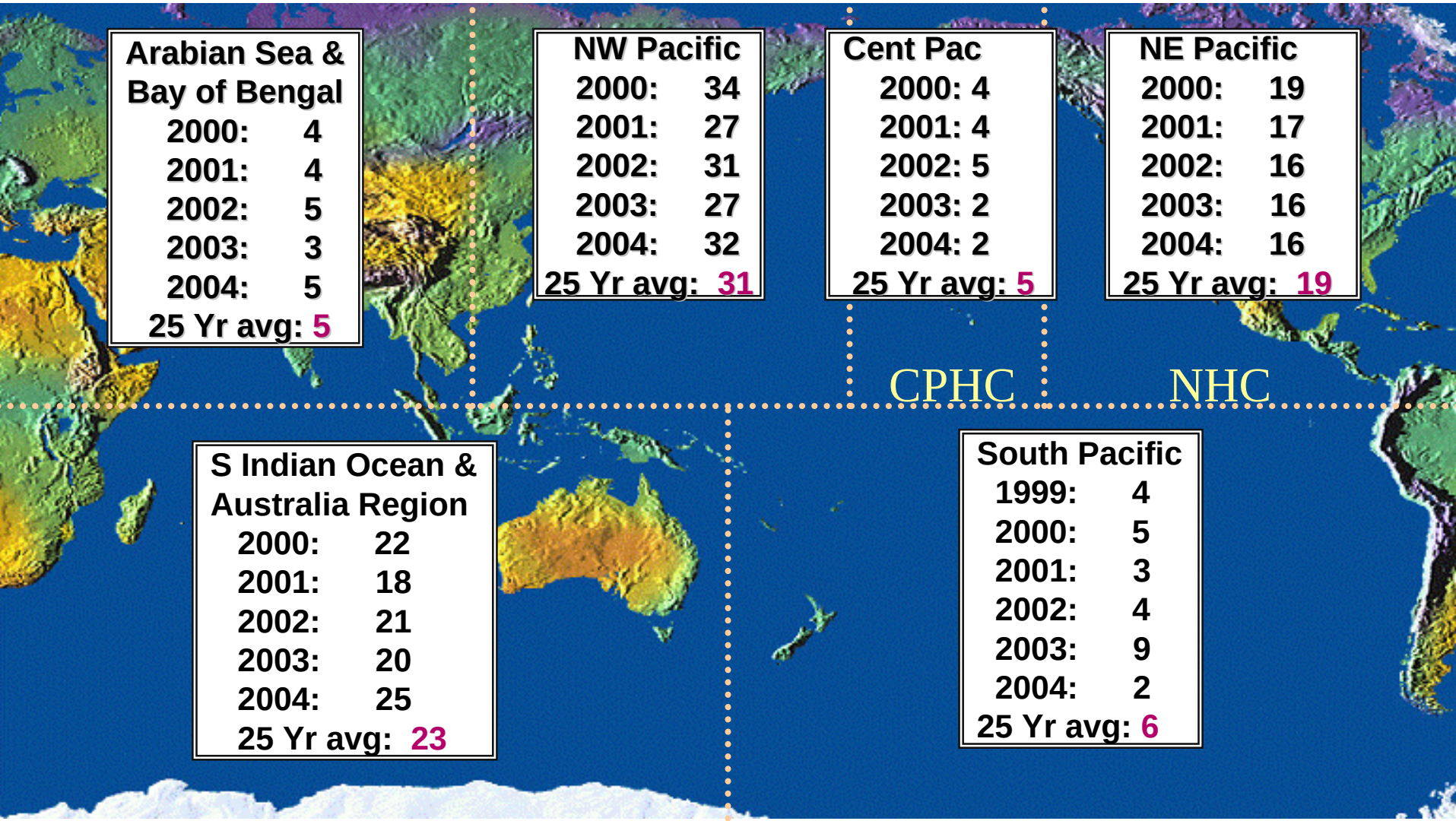
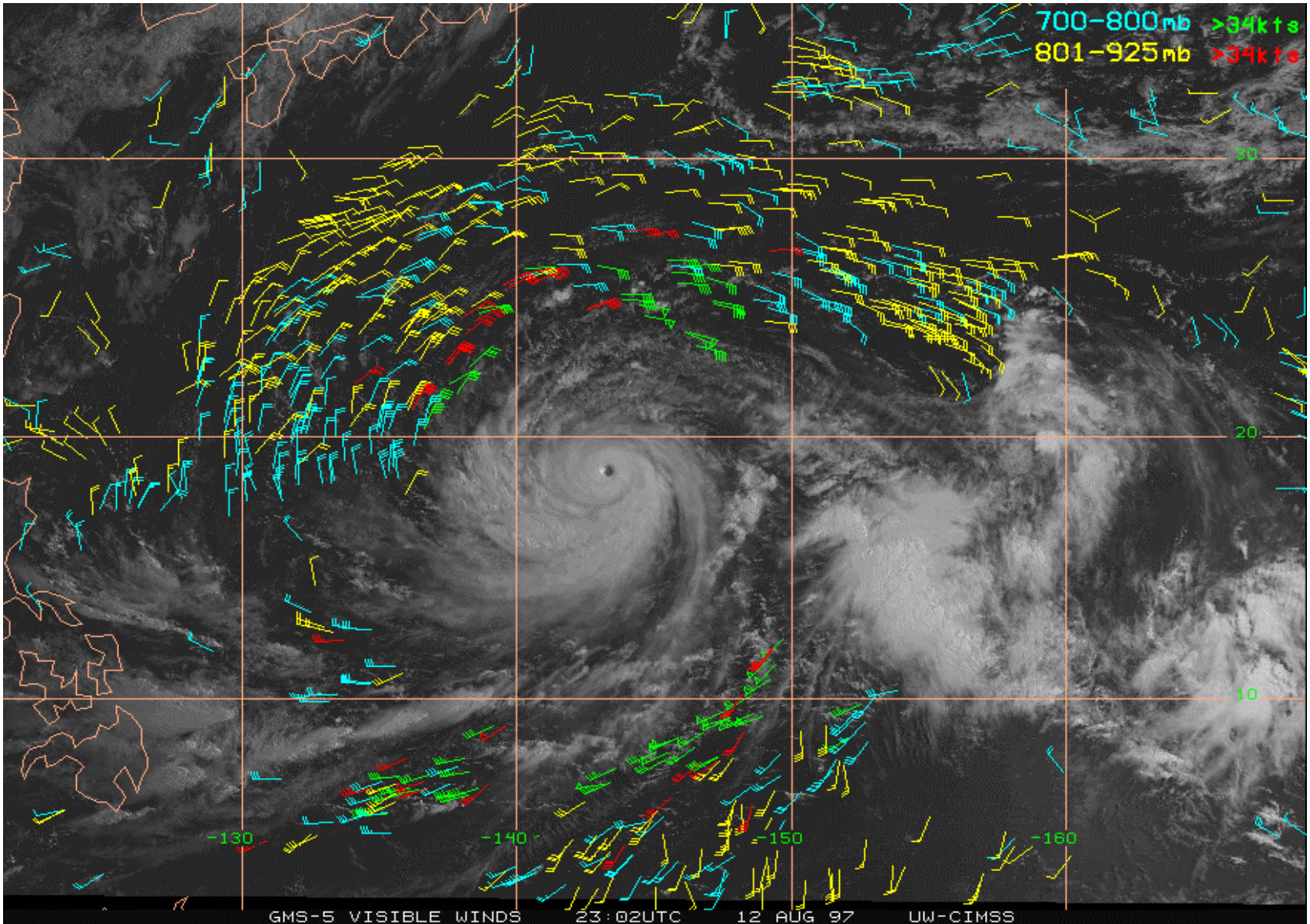
CIMSS, U. of Wisconsin, Madison

CIMSS 25th Anniversary
11-13 July, 2005

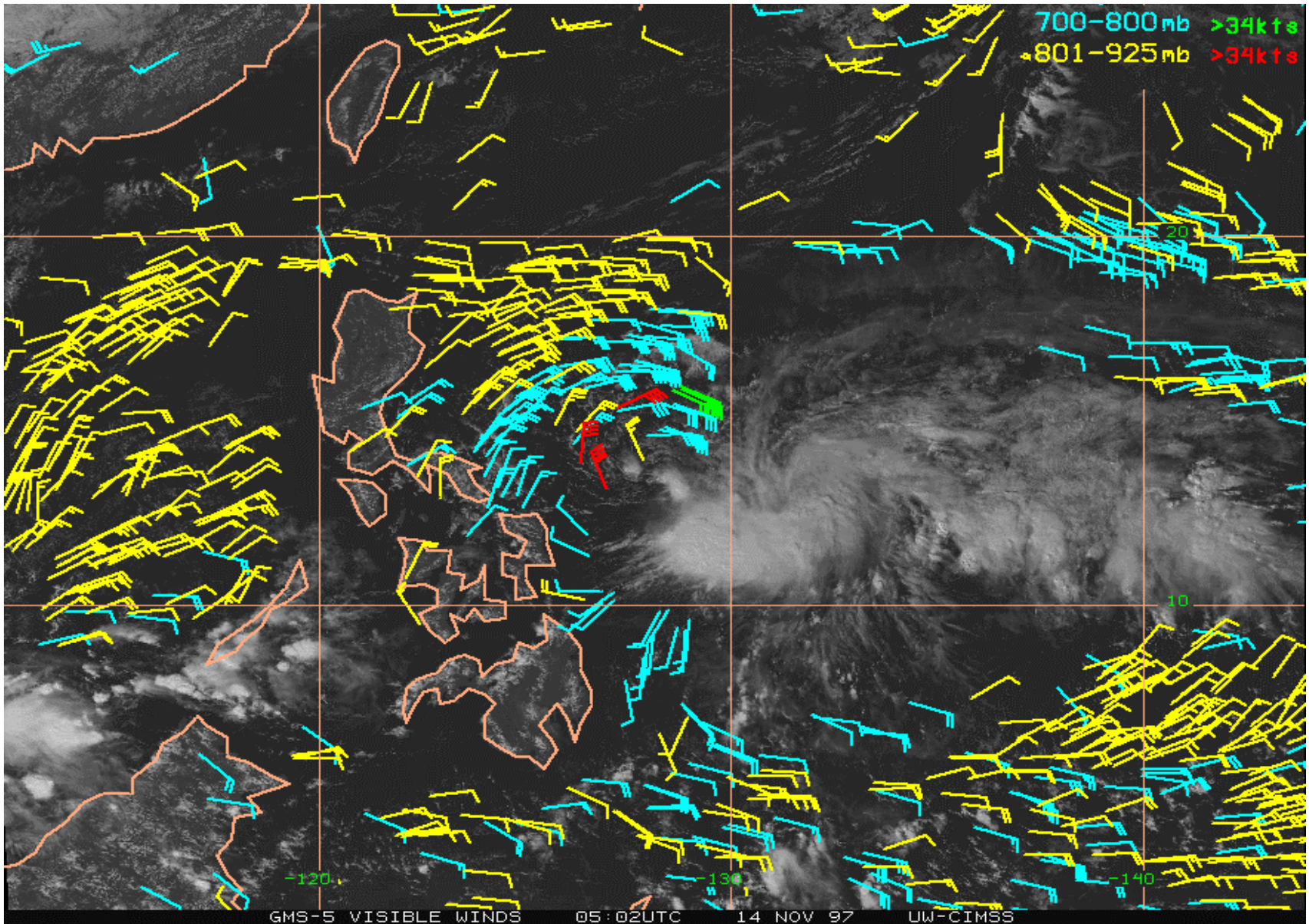
JTWC Domain TC Climatology
> 80 Storms/Year



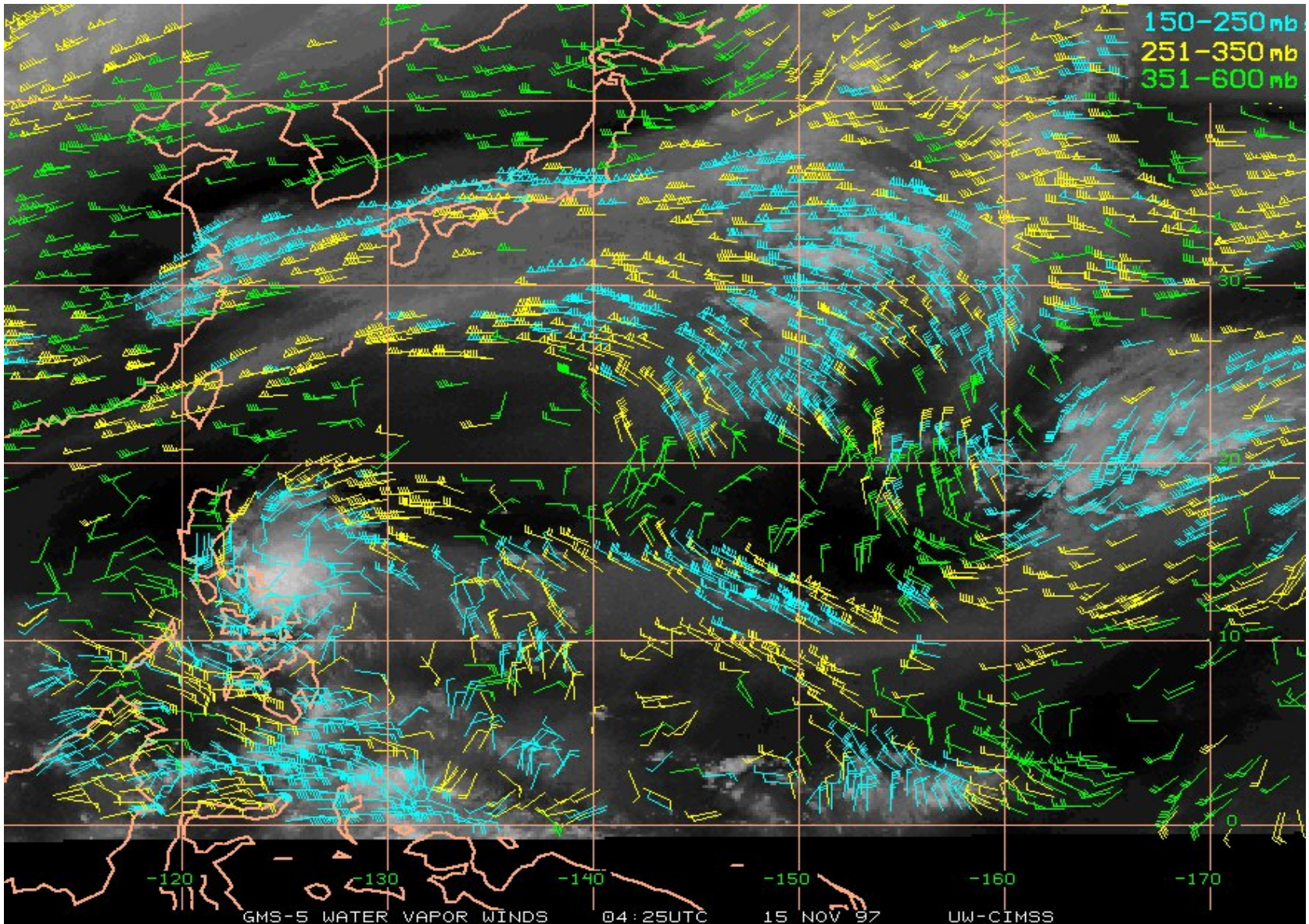
Low level visible cloud-tracked winds
Typhoon Winnie



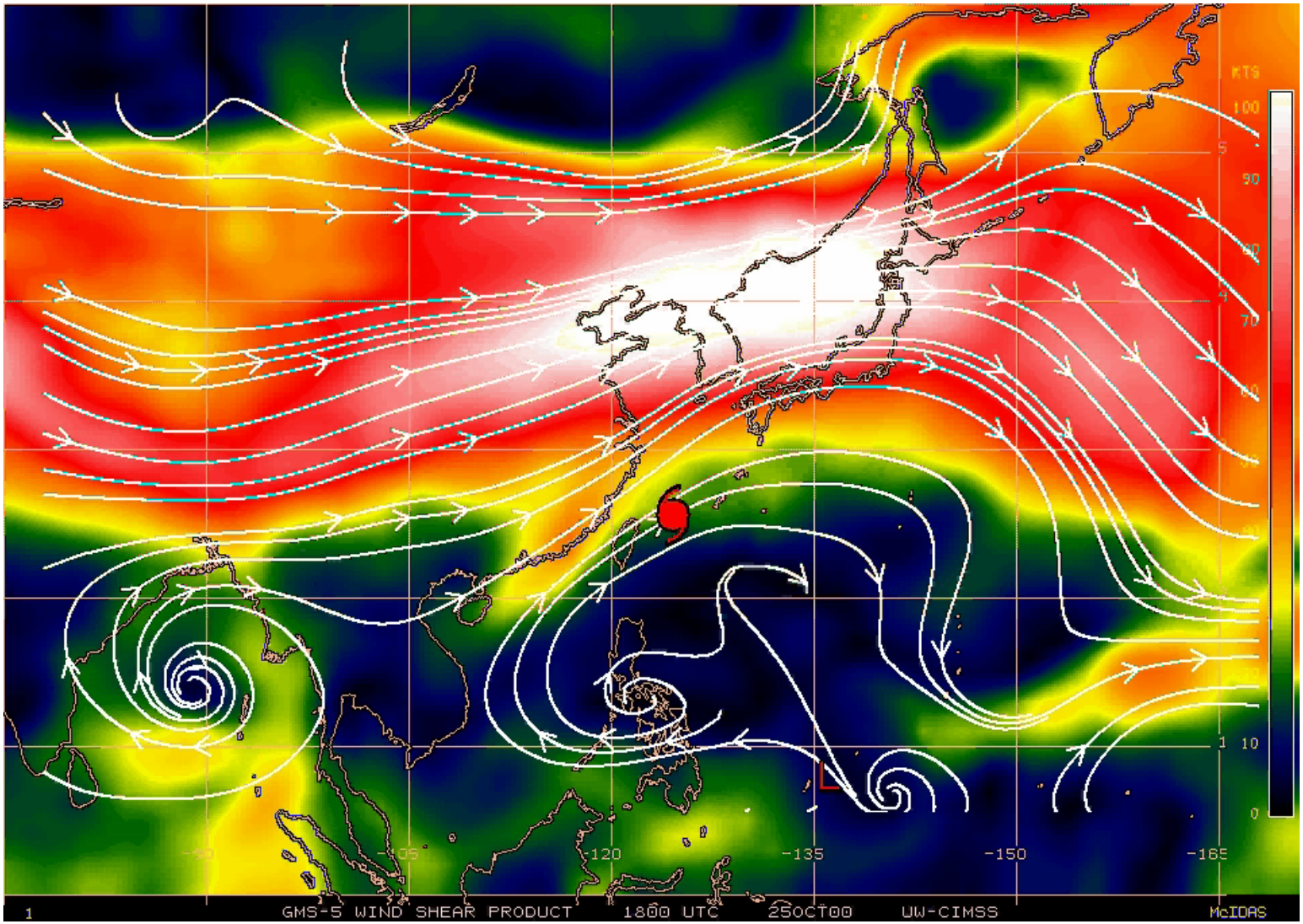
High Density visible cloud-tracked winds
Tropical Storm Mort



Upper-level water vapor-tracked winds
Typhoon Paka



Diagnostic Tools: CIMSS Wind Shear Fields



JTWC Water Vapor Wind Discussions

* " Satellite-derived water vapor wind data indicate there is *favorable* upper-level divergence above this system." Mid Pacific system, 3-15-97

* " Satellite-derived water vapor wind data indicate about *30 knots of vertical wind shear* between the surface and 200 mb exists…" TC 32P 3-15-97

* " Upper-level winds derived from water vapor imagery indicate this system is beneath *diffluent anticyclonic flow with light easterly shear*." IO 10-17-96

* " Water vapor-derived upper level winds indicate this disturbance is located to the *north of a tropical upper tropospheric trough (TUTT) cell*. The diffluent flow aloft is enhancing convective activity." WPAC 8-16-96

Point Papers: Capt. Etro/CO JTWC

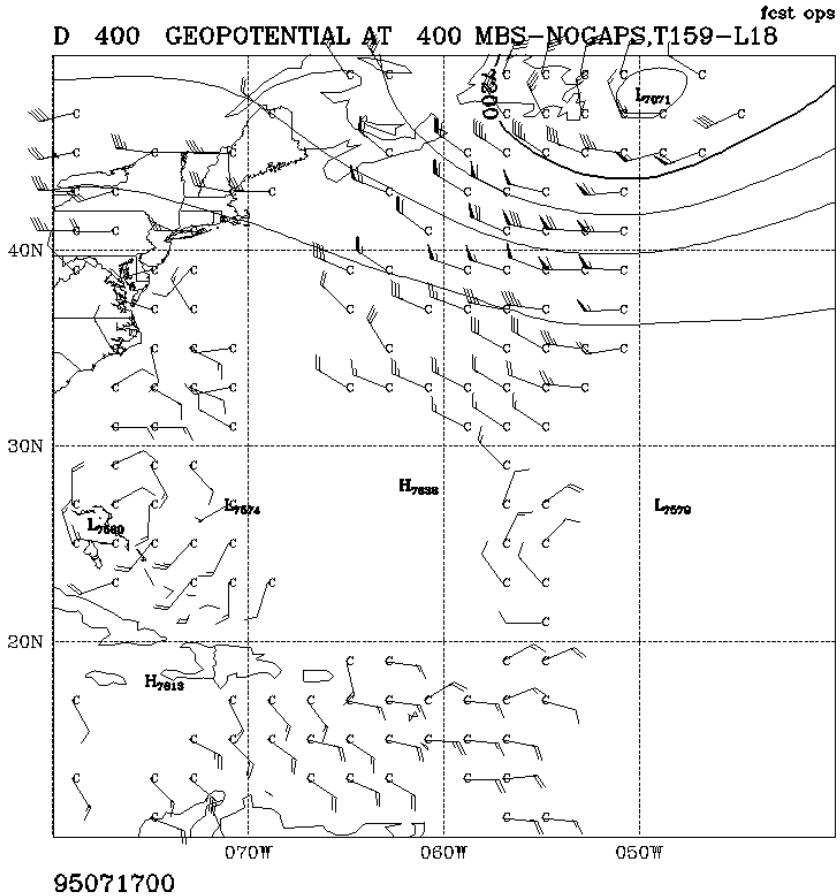
" Water vapor drift winds provide JTWC with the first ever high resolution, real-time, upper tropospheric wind data in the large data sparse areas of the western Pacific and Indian Oceans."

" The data …… has fundamentally improved the accuracy of our analyses and has added considerable skill to our forecasts."

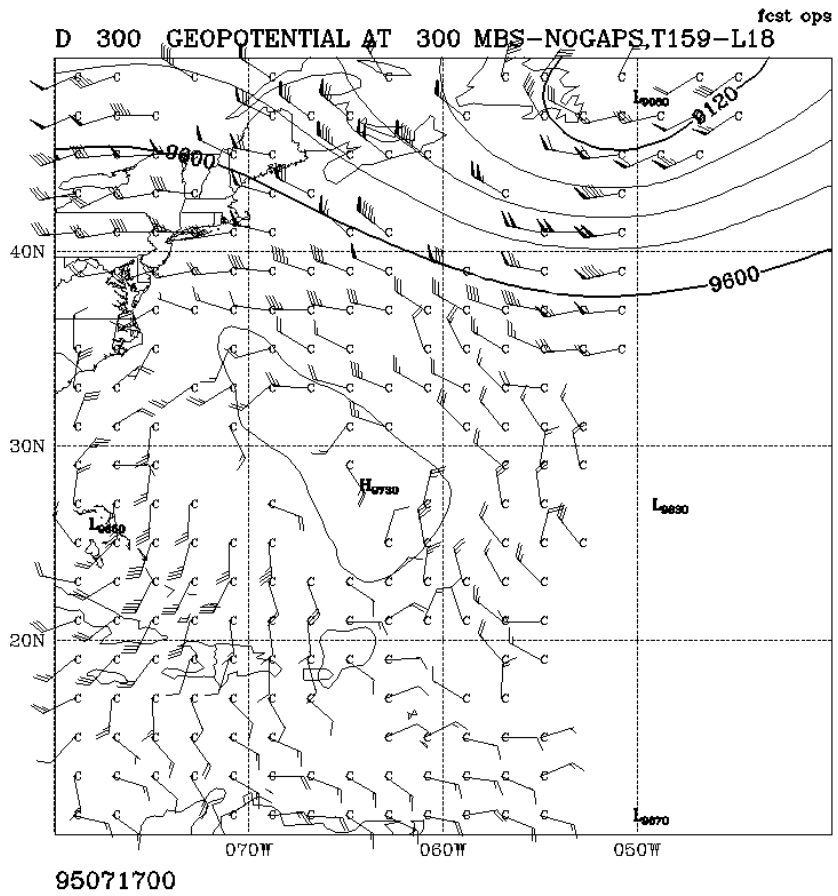
NOGAPS Geostationary Wind Data Assimilation

- **Experimental GOES-8 wind data sets via multispectral imagery at CIMSS for Tropical Storm Chantal and Hurricanes Humberto, Iris, and Luis (Velden et al 1997),**
- **NOGAPS data assimilation performed with and without the use of the WV winds for two time periods (13-20 July and 22 August-10 September 1995),**
- **Impact assessed by comparing NOGAPS forecasts for Chantal, Humberto, Iris, and Luis made with and without the use of the WV winds (Goerss et al 1996).**

GOES-8 WV/IR/Vis Wind data - Chantal

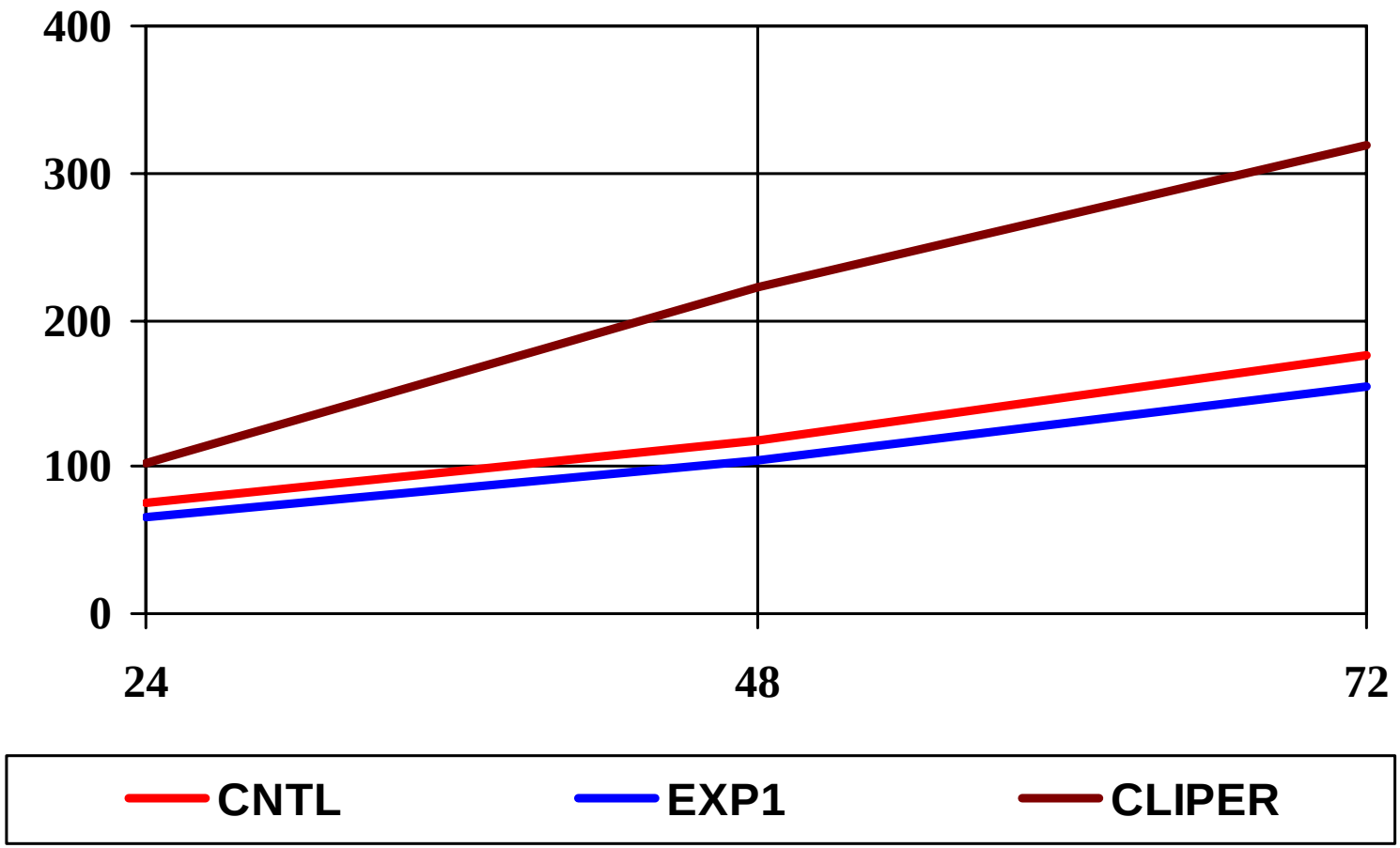


400 mb



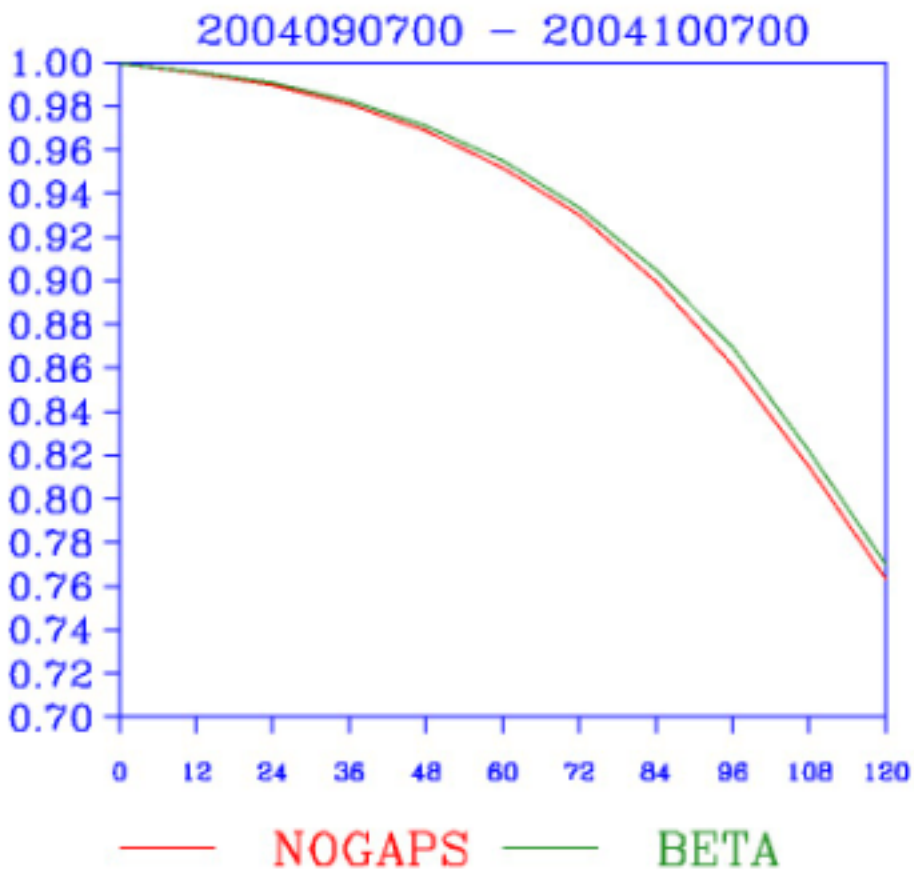
300 mb

NOGAPS Track Errors (NM)
Chantal, Humberto, Iris, & Luis

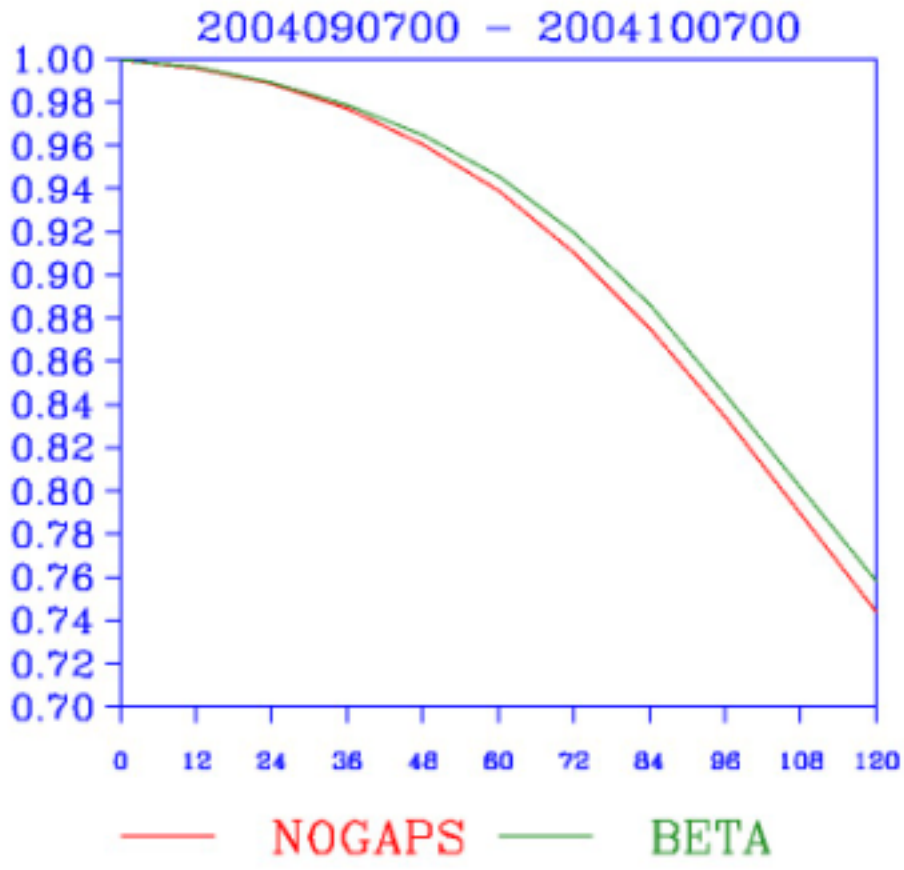


MODIS Impact
500 mb Height Anomaly Correlation

Assimilation of MODIS winds increases NOGAPS forecast skill by 1-3 hrs



Northern Hemisphere



Southern Hemisphere

World Firsts!!

* 1st near real-time production of high quality, high-density, upper-level wind data sets using both GMS-5 and GOES-8,

* 1st use of water vapor (WV) winds for operational tropical synoptic analyses and routine use in tropical cyclone warnings (JTWC),

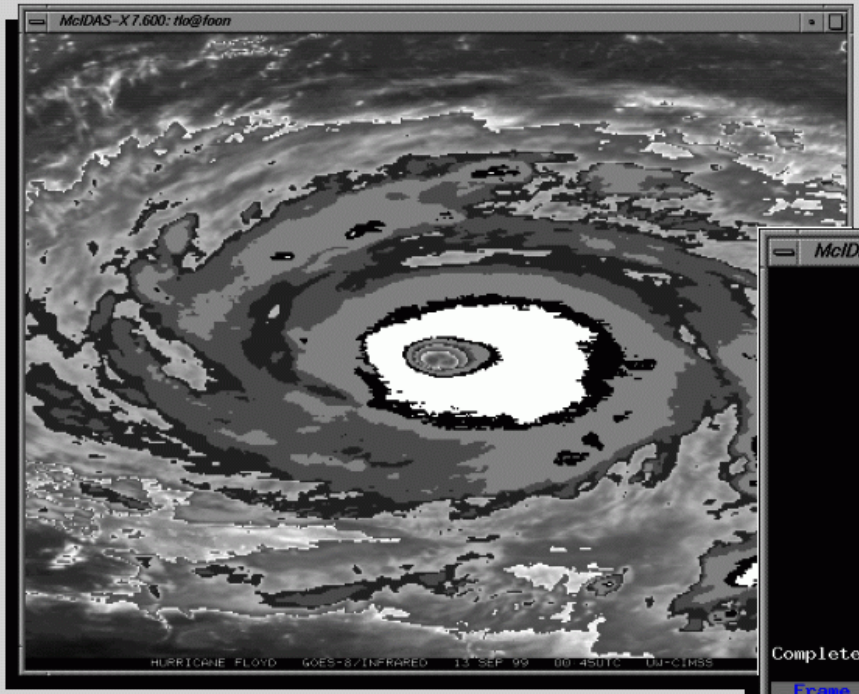
* 1st NWP (NOGAPS) to assimilate WV-tracked winds and show consistent improved tropical cyclone track forecast improvements (Goerss, et. al., 1997),

* 1st near real-time production of high quality, high-density, upper-level wind data sets in the southern Hemisphere. (Feb 1997)

* 1st production of near real-time, high density, IR and water vapor winds from GMS-5, GOES-9, and GOES-8 spanning from Asia to Africa.

* Meteosat and MODIS “winds” round out global satellite wind coverage.

UW–CIMSS
Objective Dvorak Technique (ODT)



McIDAS-X 7.600: tlo@foon

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**************************************************

                  UW - CIMSS
          Objective Dvorak Technique (ODT)
        Tropical Cyclone Intensity Algorithm

   Current Analysis -- Date: SEP 13   Time:   4500 UTC
        Lat:  23:27:49 N      Lon:  68:54:06 W

        CI No./Pressure   T-No.(ave)   T-No.(raw)
          6.4 / 937.6        6.4          6.5

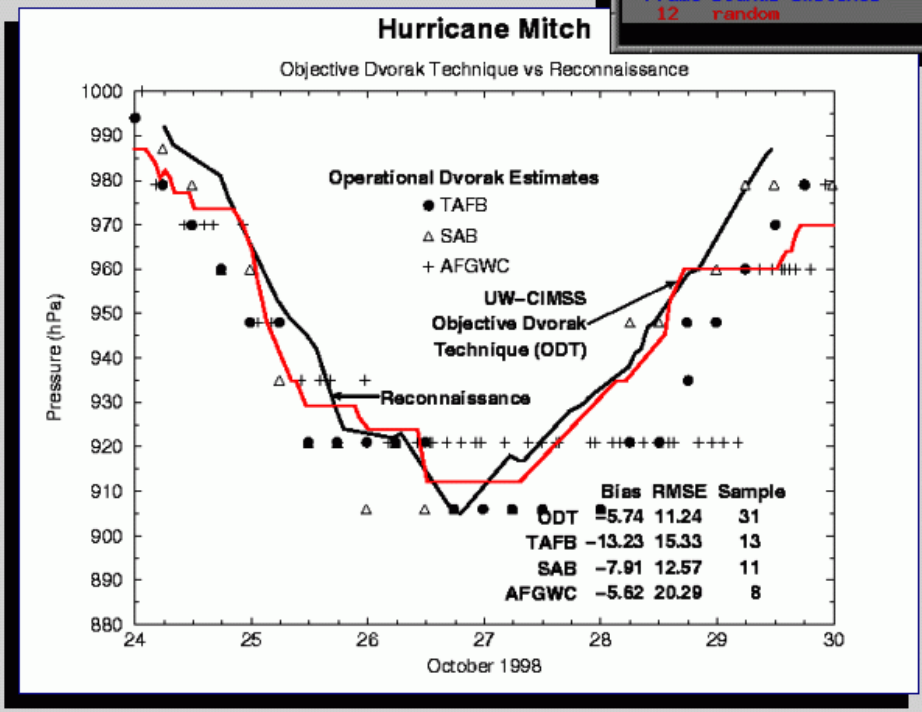
   Eye Temp :  19.7 C       Surrounding Temp : -68.6 C
                          Distance from center :  76 km
   Scene Type : EYE L

   Rule Flags:    STEP 9:  ON    RAPID DEEPENING: OFF

**************************************************

Completed OBJECTIVE DVORAK TECHNIQUE analysis

Frame Bounds Switches                  Date        Time   T
  12   random                    02 Nov 2000307 22:47:41 0[31]
```



Objective Dvorak History & Review

Dvorak Method: Too subjective and inconsistent.

Old Digital Dvorak: Erratic, handles limited storm cases.

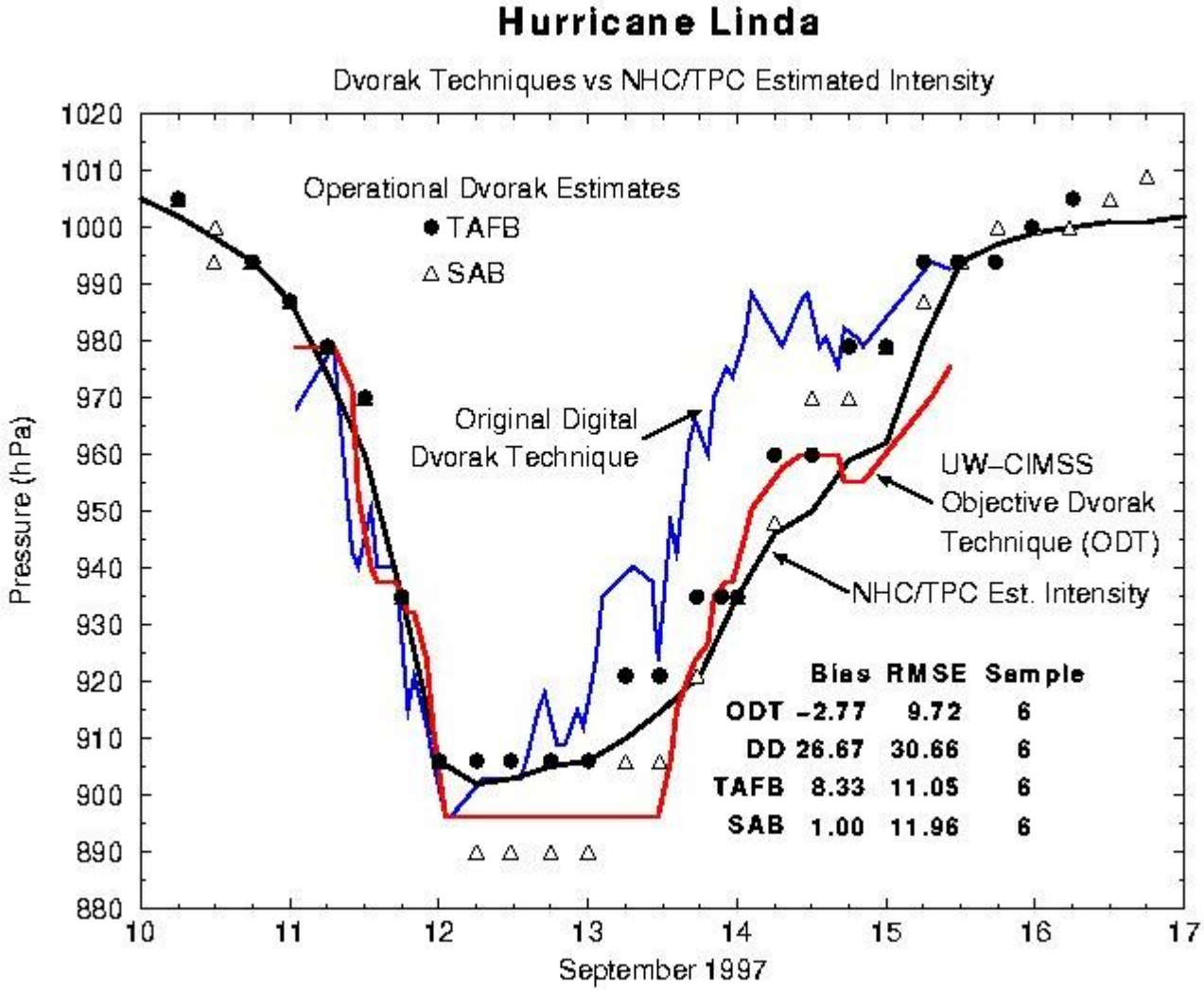
Objective Dvorak Technique: Consistently superior/equal to all other methods.

Objective Method:

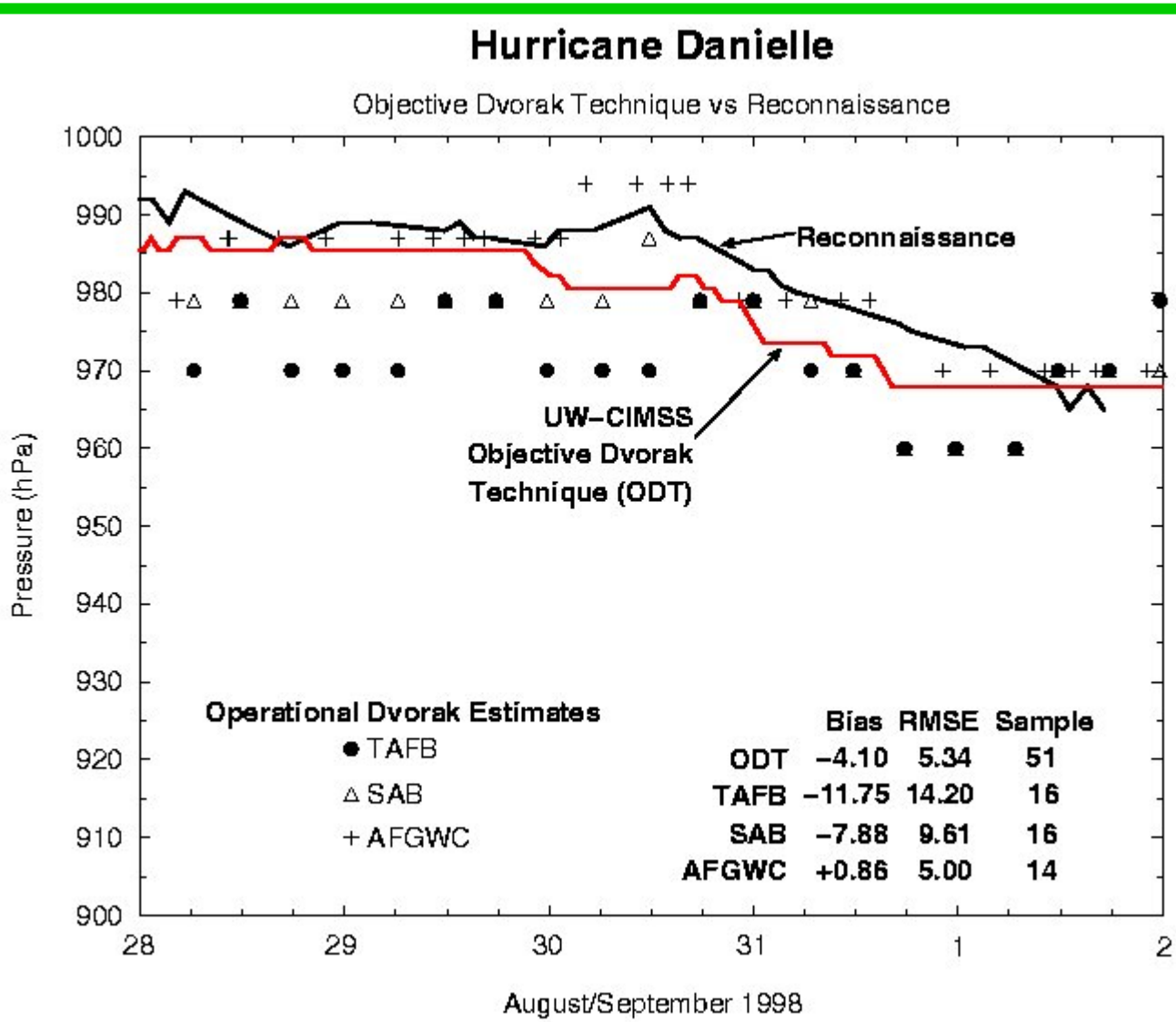
- based on digital IR data with scene identification and specific Dvorak rules.

- Computes eye and surrounding cloud top temperatures.
- Scene identification based on histogram and Fourier analyses of pixels in the eye and surrounding cloud structure.
- Calculate intensity estimate based on application of specific Dvorak pattern 'rules' for identified pattern.
- Adjustment based on linear-weighted time average.
- Final check for current intensity trend - Dvorak adjustment for weakening TCs.

Objective Dvorak - Linda



Objective Dvorak - Danielle



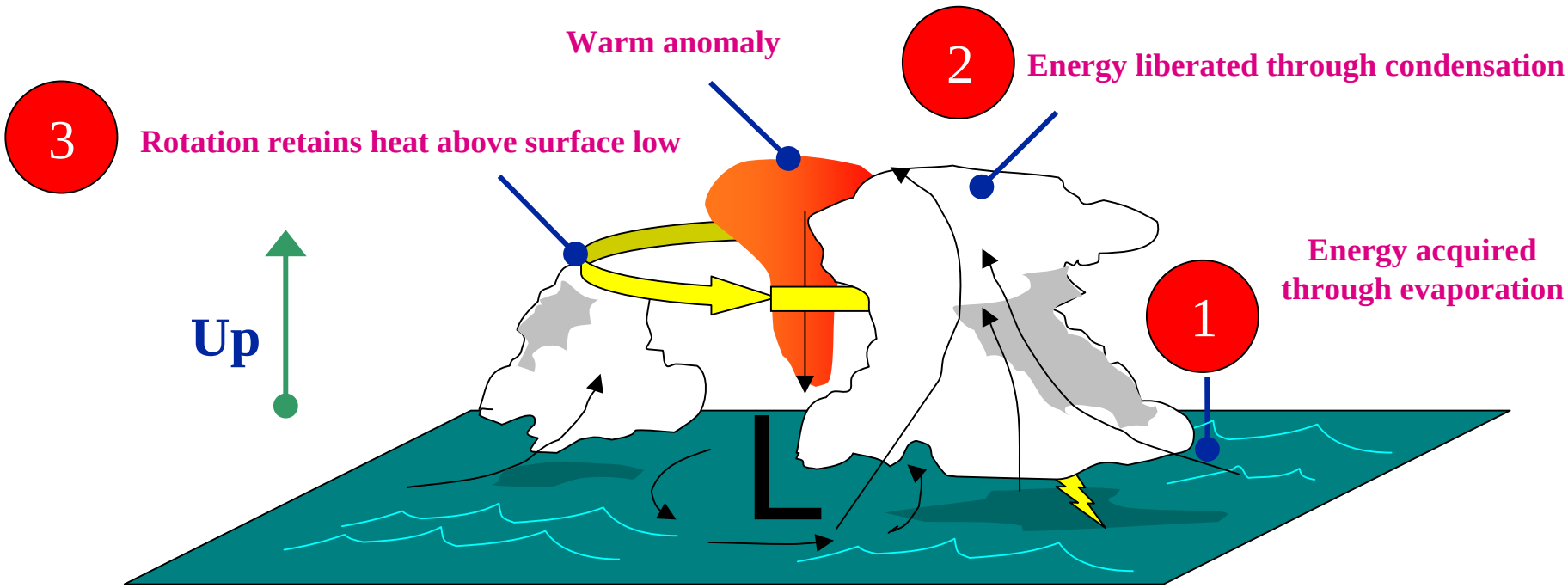
Advanced Objective Dvorak Technique (UW-CIMSS AODT)

Summary:

- Fully automated, including centering,
- Validated with extensive Atlantic and some East Pacific recon, better than 10mb RMSE,
- Revised eye and cloud scene types implemented,
- Latitude bias adjustment,
- Handles systems from tropical depressions and stronger,
- Quantitative values operationally used by multiple agencies.
- Validation stats permit multi-technique merging.

Tropical Cyclone Warm Core Basics

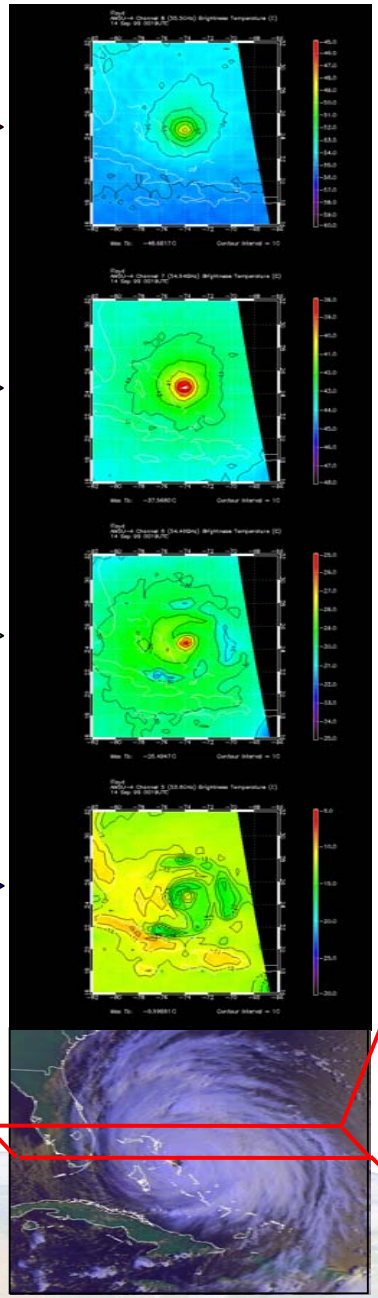
- Near isothermal inflow acquires energy through evaporation
- Deep moist convection transports high boundary layer θ_e air
- Rotation aids retention of heat (latent and subsidence)



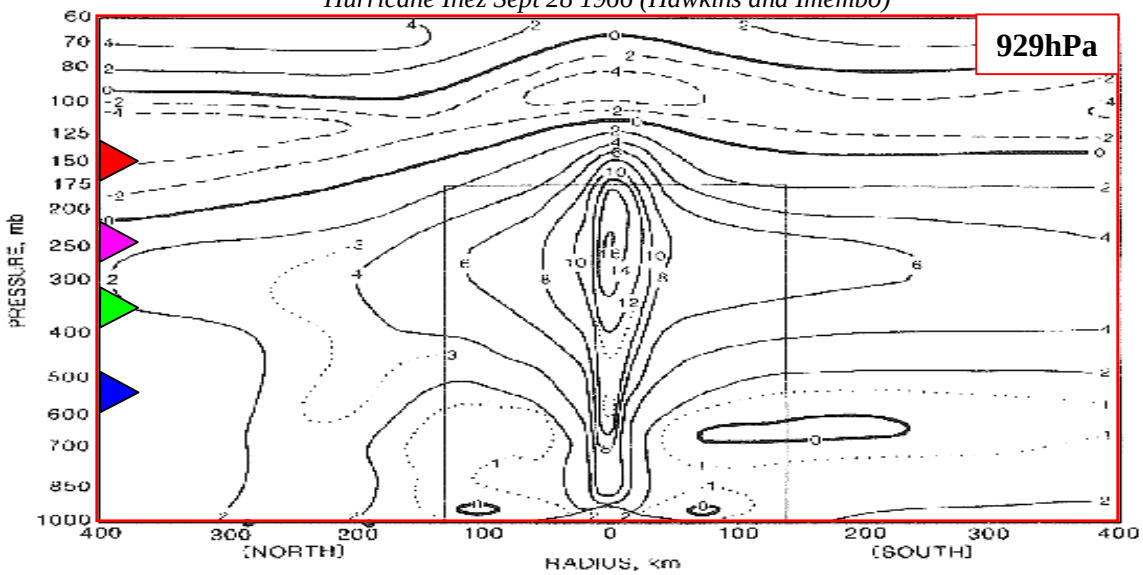
Brueske, Herndon, Kabat, Wacker

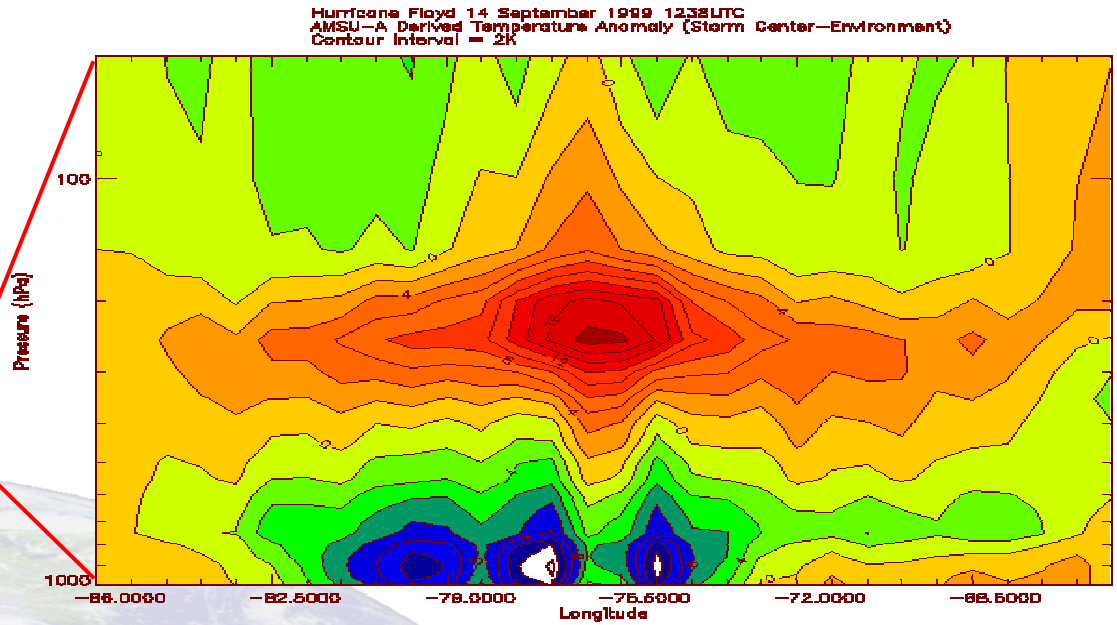
AMSU warm core anomalies

Hurricane Floyd Sept 14 1999

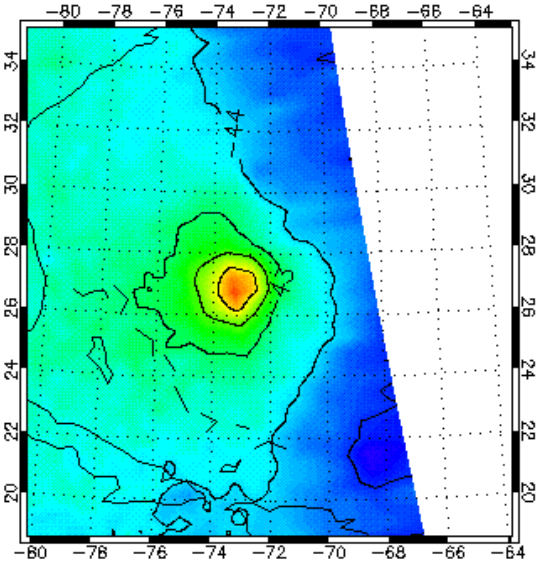


Hurricane Inez Sept 28 1966 (Hawkins and Imembo)

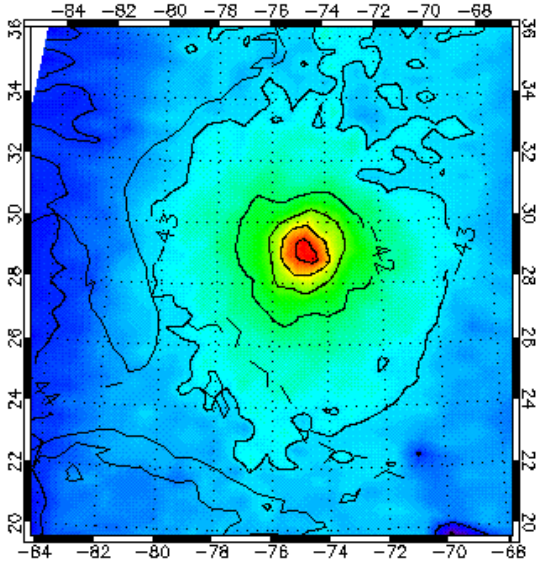




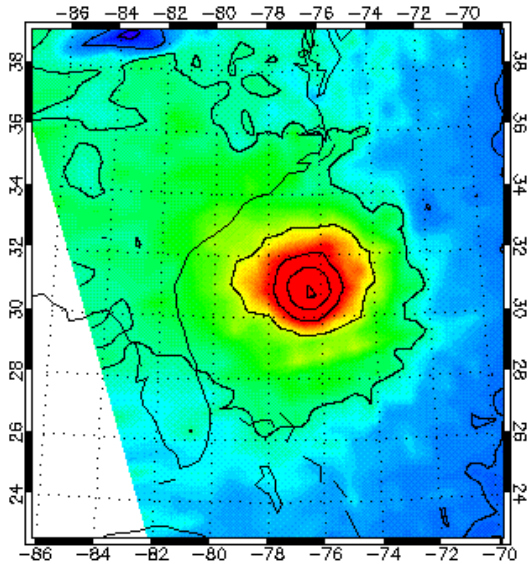
Hurricane Bonnie NOAA-15 AMSU-A 55 GHz Brightness Temperatures (C)



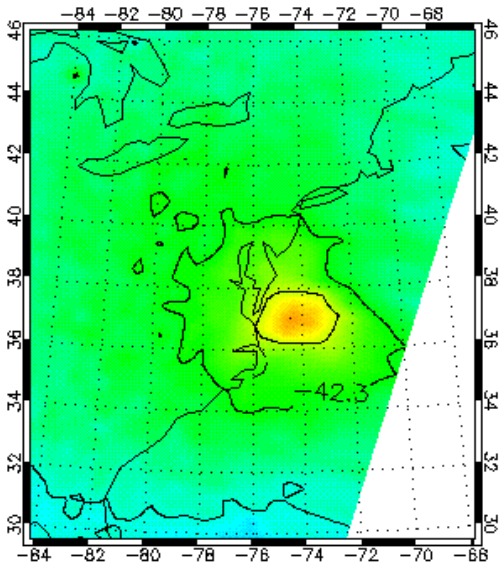
25AUG98 0017UTC
MAX Tb: –39.8C



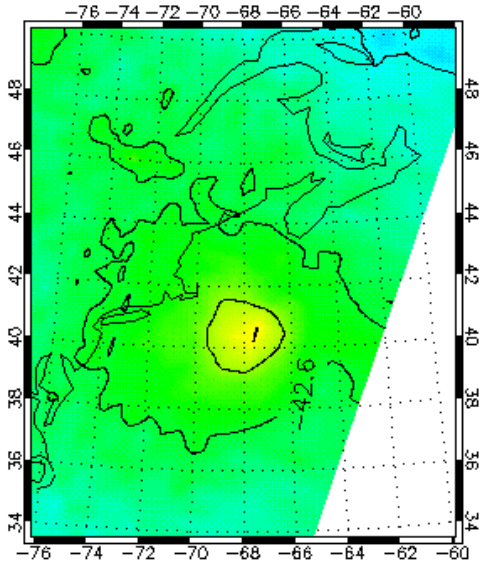
25AUG98 1252UTC
MAX Tb: –38.9C



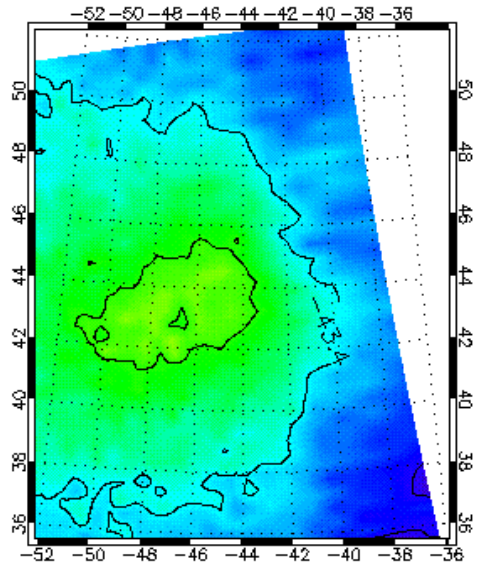
26AUG98 0007UTC
MAX Tb: –38.3C



28AUG98 1309UTC
MAX Tb: –40.5C



29AUG98 1247UTC
MAX Tb: –41.0C



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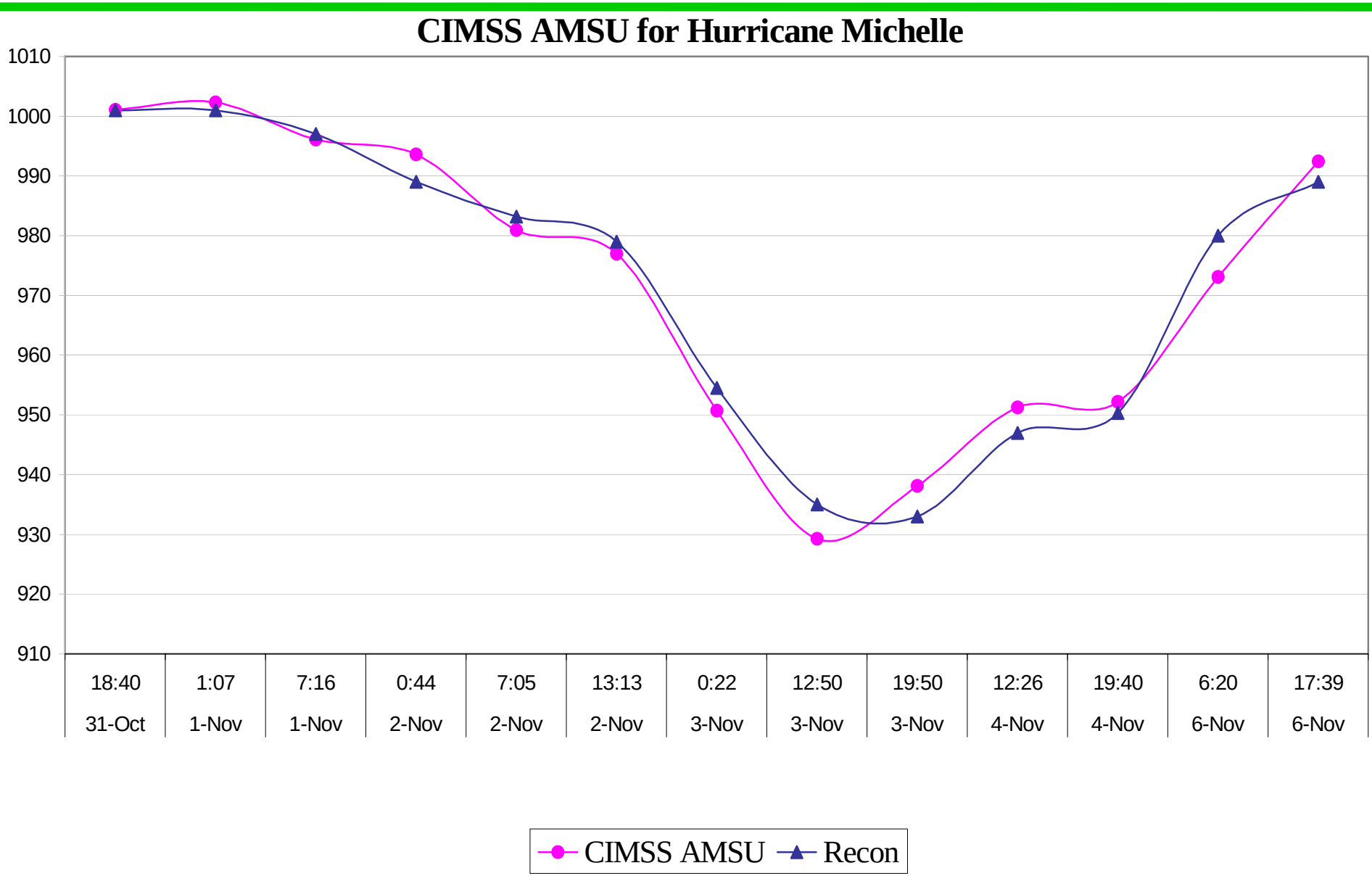
AMSU TC Intensity Estimates

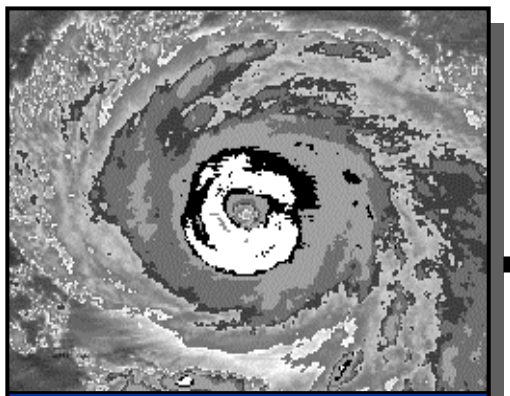


Summary & Future

- **AMSU Intensity Estimate Skill On Par W/Dvorak**
- **Addition of NOAA-18 AMSU**
- **Extension of method to DMSP SSMIS on F-16**
- **CSU collaboration (Dr. Mark DeMaria)**
- **Coupling with ATCF and NRL/MRY "INVEST" functionality**
  - Allow monitoring of suspected genesis regions
- **Ensemble TC Intensity Retrieval**
  - Combine strengths of AODT and AMSU for robust TC intensity estimation algorithm -- entire life cycle and circumstance set (e.g., landfall, etc.)

Merged TC Intensity Algorithm

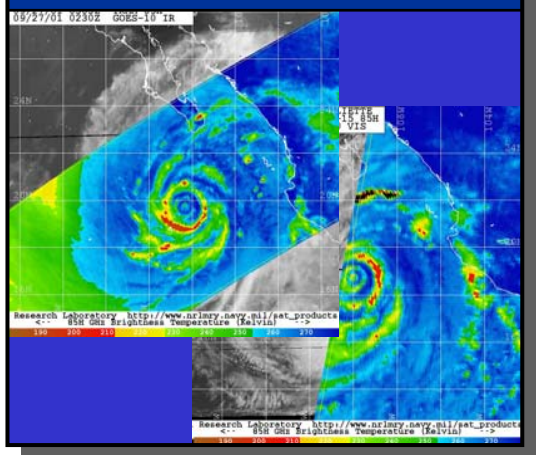
Mine inherent module strengths

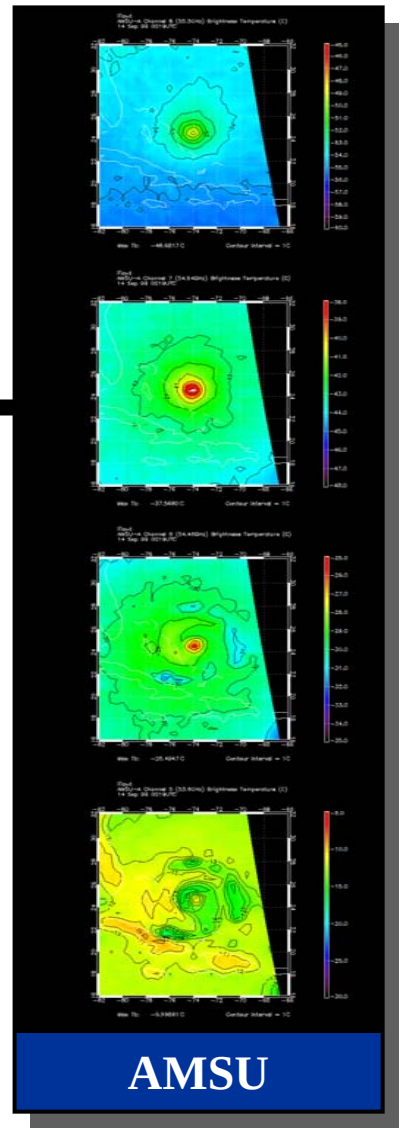


Current AODT

Integrated Satellite-Based TC Intensity Estimation System

Microwave imagery





AMSU

2005 Storms
All Active Year

Privacy and Security FNMOC Satellite Data Tropical Cyclone Page

Display Latest Prev. | 1_km: VIS IR | Info: General Tutorial

2005 Storms
All Active Year

Atlantic

East Pacific

Central Pacific

West Pacific

Indian Ocean

Southern Hemisphere

- 91S.INVEST
- 17S.NONAME
- 16P.HARVEY
- 15P.MEENA

Age: Latest | Display: Pass_Mosaic | Warn: Text Track ATCF | 1_km: Track&Image VIS IR WV | Scatt AM

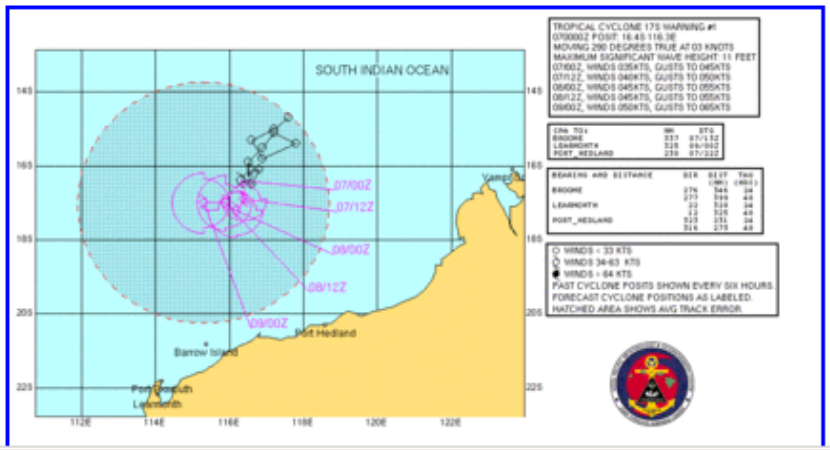
	VIS	IR	IR BD	Multi Sens.	85GHz H	85GHz weak	PCT	Color	Rain	Wind	37GHz Color	37GHz V	37GHz H	SSM/I Vapor	Scat
SSMI:															
TMI:															
AMSRE:															
WINDSAT:															

<= 6 hrs. old, <= 12 hrs. old, > 12 hrs. old

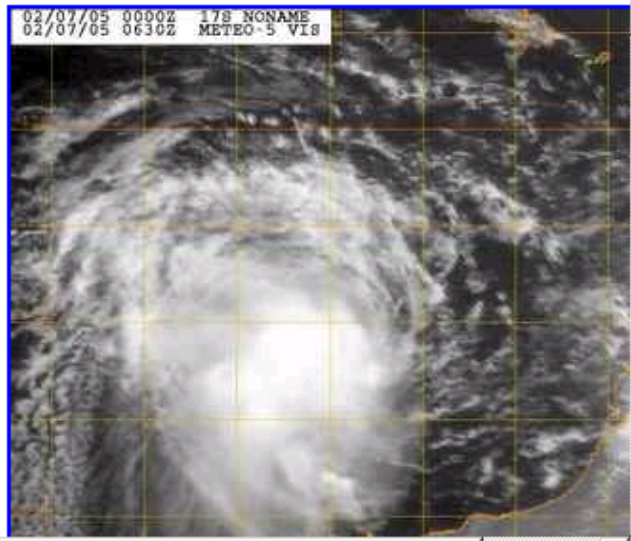
17S.NONAME, TRACK_VIS, 07 FEB 2005 0630Z 06:53:27 UTC (Z)

Tutorial: Overview COMET

Forecast by: Joint Typhoon Warning Center/Naval Pacific Meteorology and Oceanography Center
Graphic by: Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center



20050207.0630 latest1km



WindSat TC Applications

Sensor: Passive Microwave Conical Scanner - polarimetric
Spacecraft: Coriolis
Launch: 2003 (January)
Heritage: SSM/I

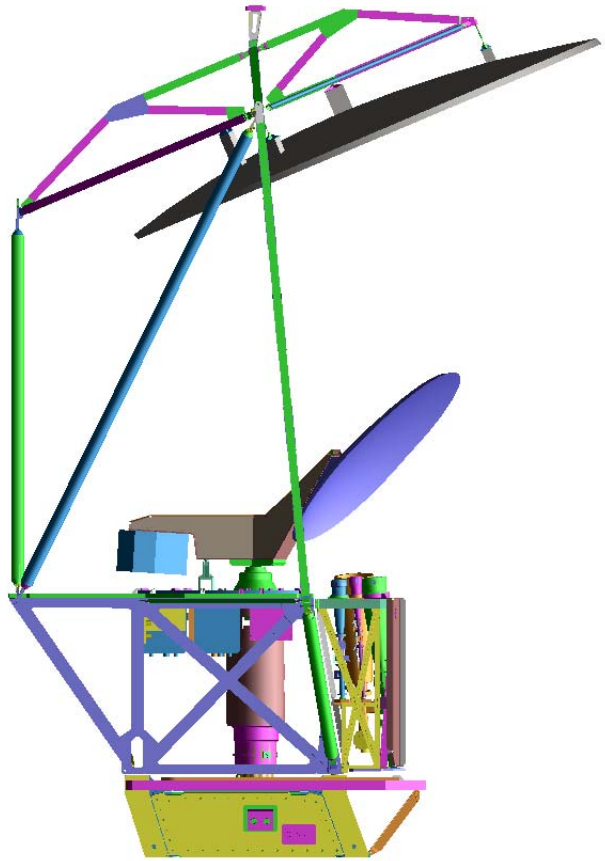
Channels: 7, 11, 19, 24, 37, No 85 GHz
~55, 40, 20, 13, 11, km

Swath: 1025 km

Enhancements for TC Applications:

(1) Surface wind vectors, non-rain areas,
(2) Spatial resolution (37 GHz),
(2) Sea Surface Temperature,
(3) High winds closer to intense rain.

Web Links: http://www.pxi.com/windsat.main.ht

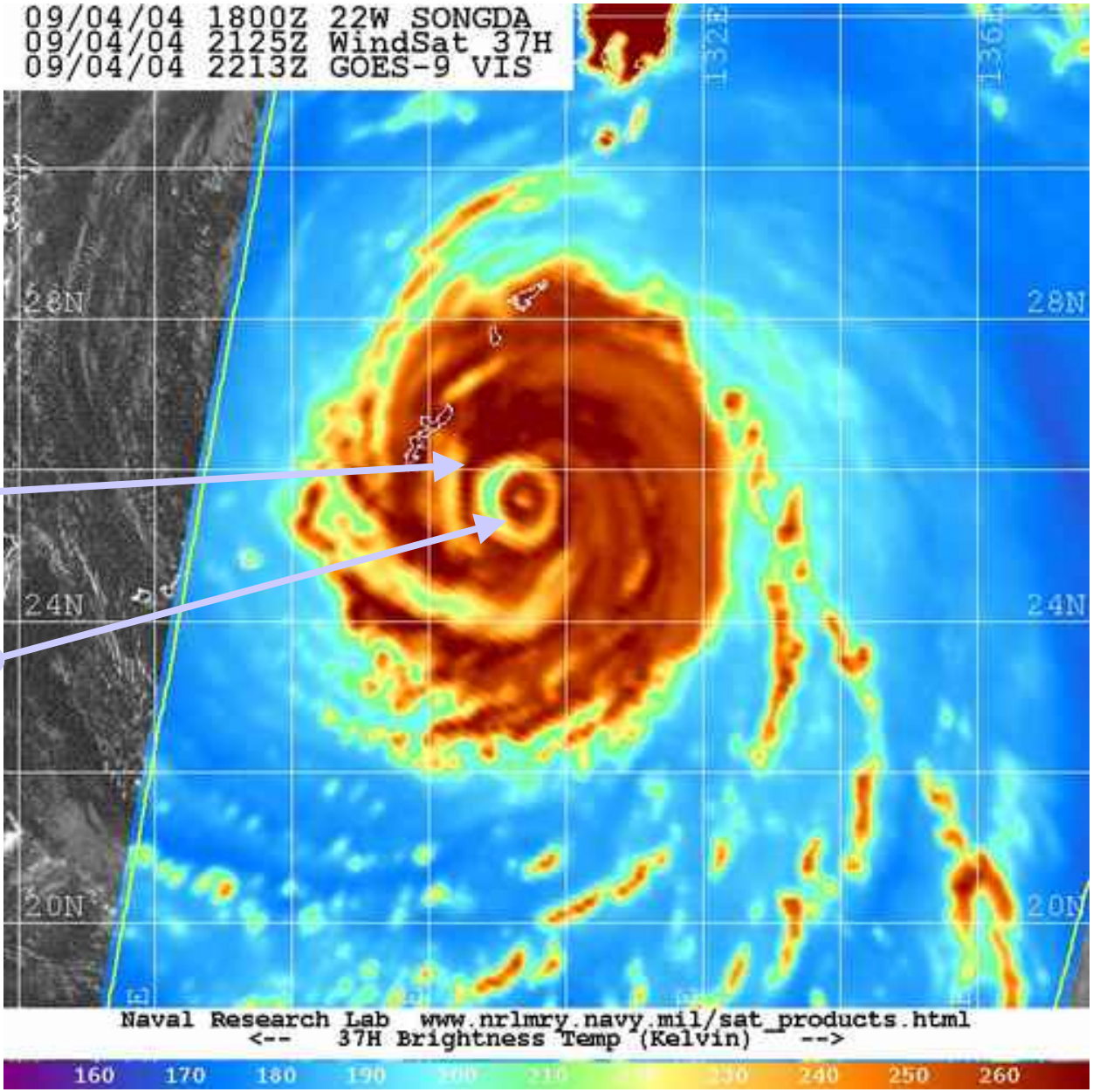


WindSat 37 GHz Imagery

WindSat SSM/I

Typhoon Songda

Double eyewall structure?



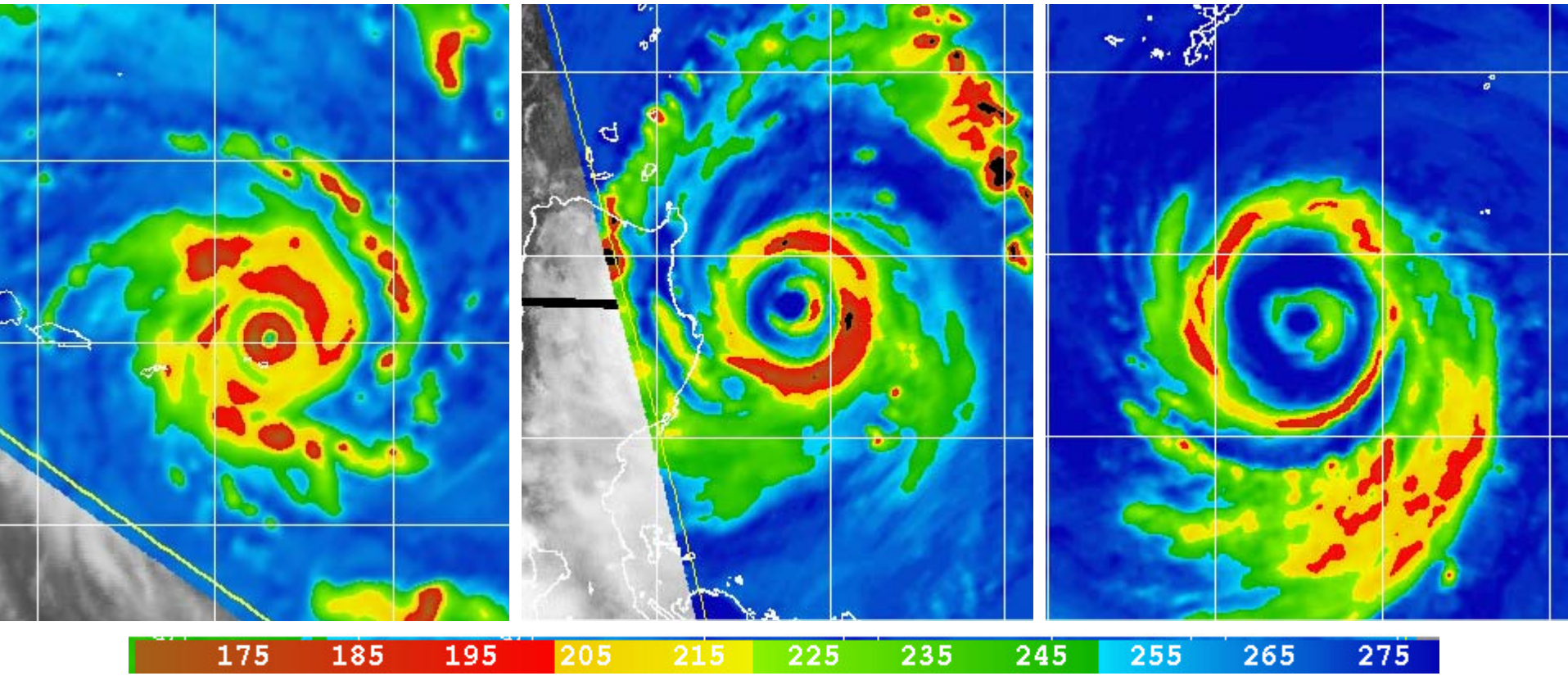
Tropical Cyclone Structure: Concentric Eyewall Evolution

Concentric Eyewall Storm Characteristics (2004)

Olaf 19P (SHEM)

Nida 04W (WPAC)

Dianmu 09W (WPAC)



85 or 89 GHz Brightness Temperatures

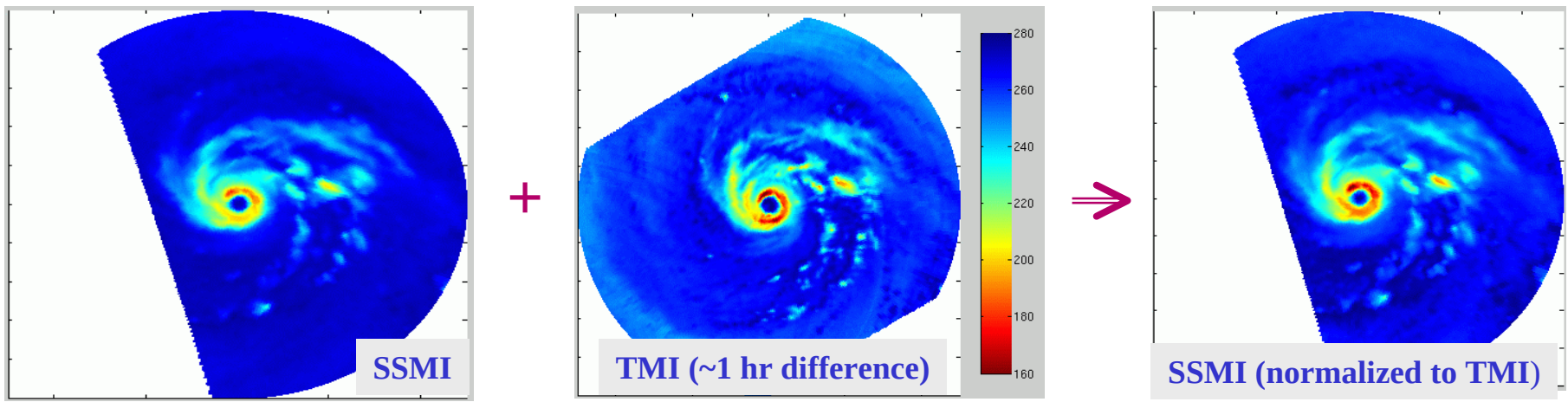
2x2 deg boxes

Microwave Imagery Morphing

Problem: Temporal sampling limitations (gaps) within passive microwave constellation: SSM/I (3), TMI, AMSR-E make eyewall cycle interpretation difficult.

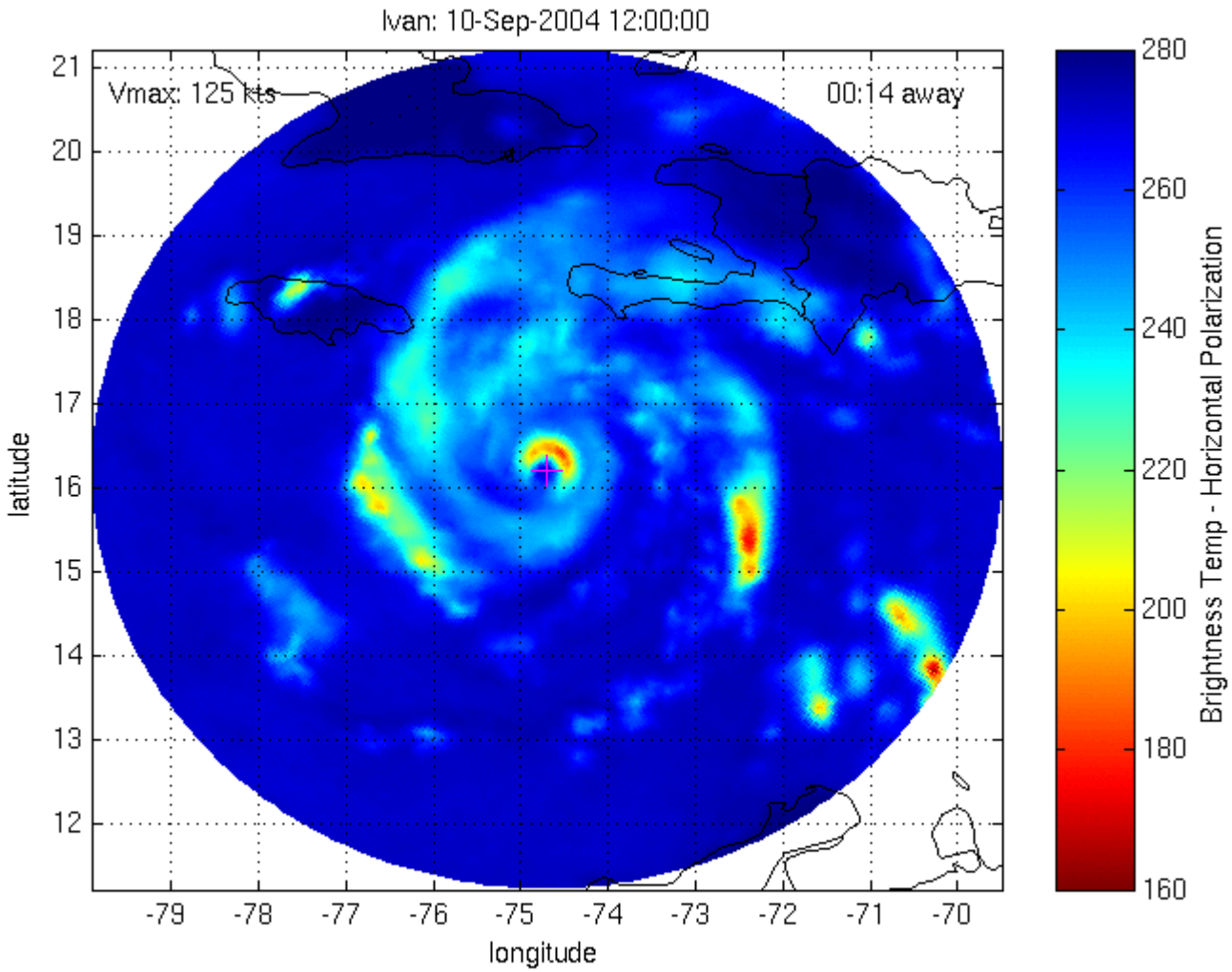
Approach: Use “morphing” technique on 85/89 GHz imagery to create temporal loop permitting TC structure animation and enhanced eyewall understanding.

Normalize SSM/I and AMSR-E to TRMM TMI data set.



Wimmers

Microwave Imagery Morphing

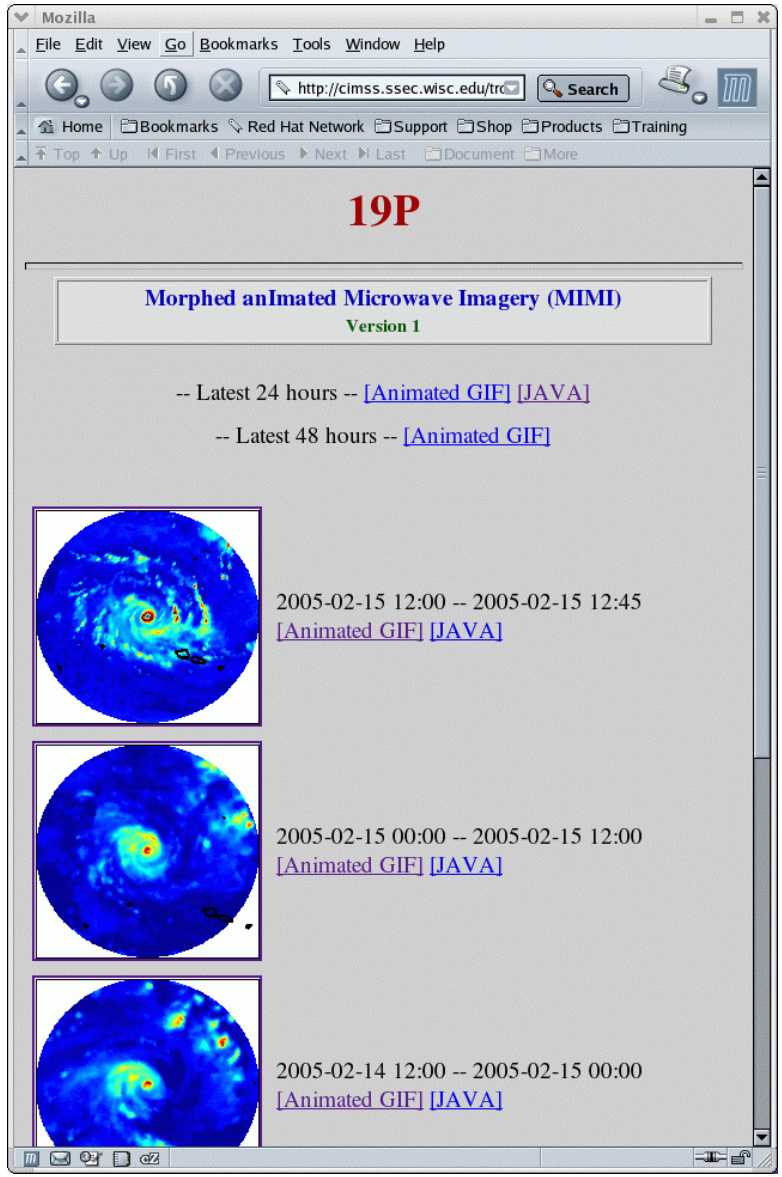


Example: Hurricane Ivan: September 10-11, 2004

Microwave Imagery Morphing: CIMSS/NRL demonstration website

http://cimss.ssec.wisc.edu/tropic/realtime/marti/

- TC near real-time morphing animation in 15-minute time steps
- Utilizes DMSP-13/14/15 SSM/I, TRMM TMI and Aqua AMSR-E
- Global coverage (all 5 basins) since September 2004
- Browseable history in animated 12-hour segments



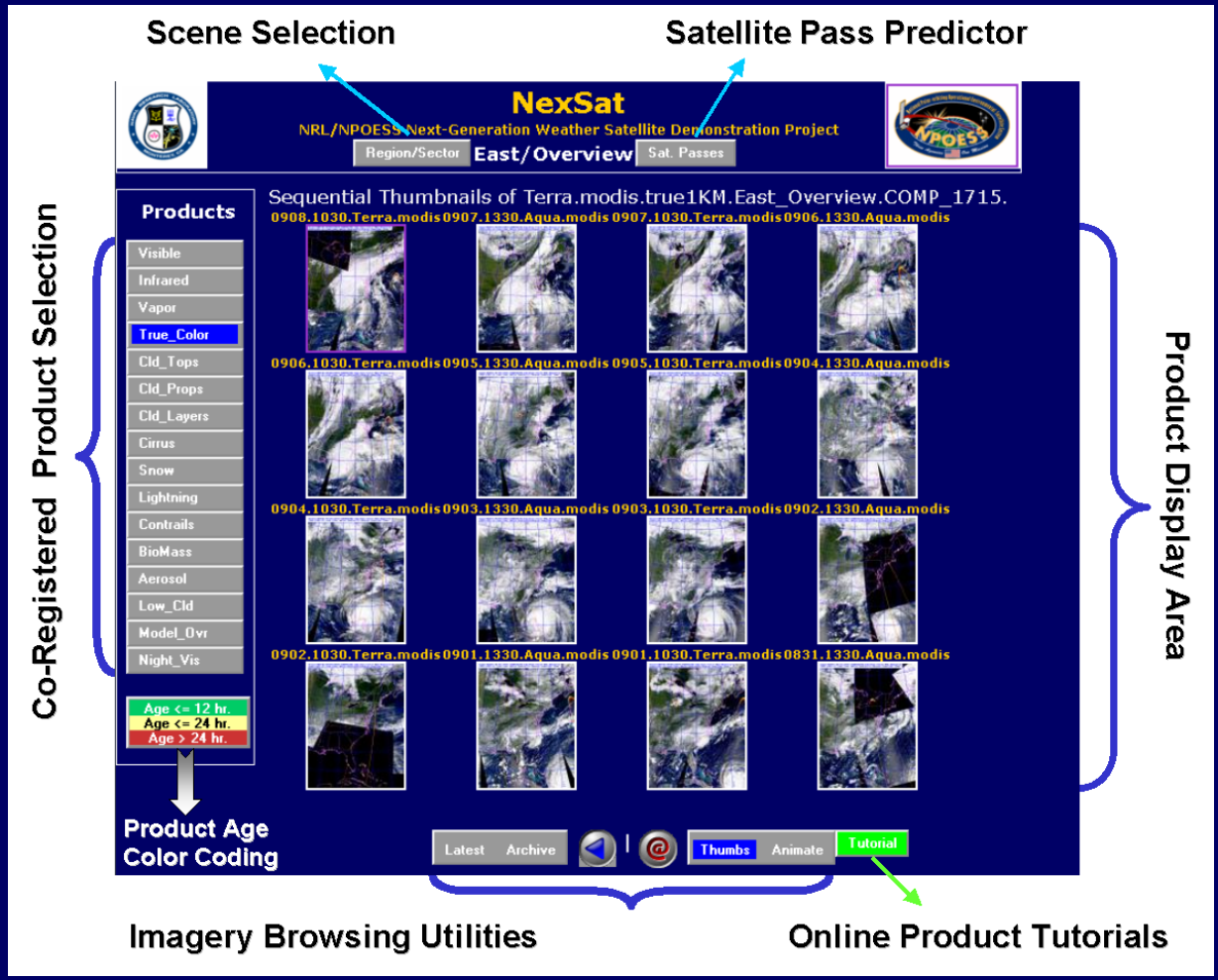
Summary (CIMSS Team)

- **World-class science applied to real world problems,**
- **Journal literature and technical conference presentations,**
- **Multi-sensor view applicable to multi-basin applications,**
- **Collaboration with the best globally,**
- **Superb track record for transitions to operations (JTWC, FNMOC, AFWA).**
- **A pleasure to work with!!**

Observations from watching Chris

- **Six one-line emails are better than a 30 second phone call.**
- **Emailing a co-worker next door is ok!**
- **“I need it ASAP, dude!”**
- **“They’re not looking at our products!!.”**

The *NexSat* Demo



NexSat offers a visually appealing, operationally intuitive, and information rich resource for exploration and discovery.