NRL Tropical Cyclone Web Page: 15 Years of Quasi-Operational and R&D Applications

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Organizations:

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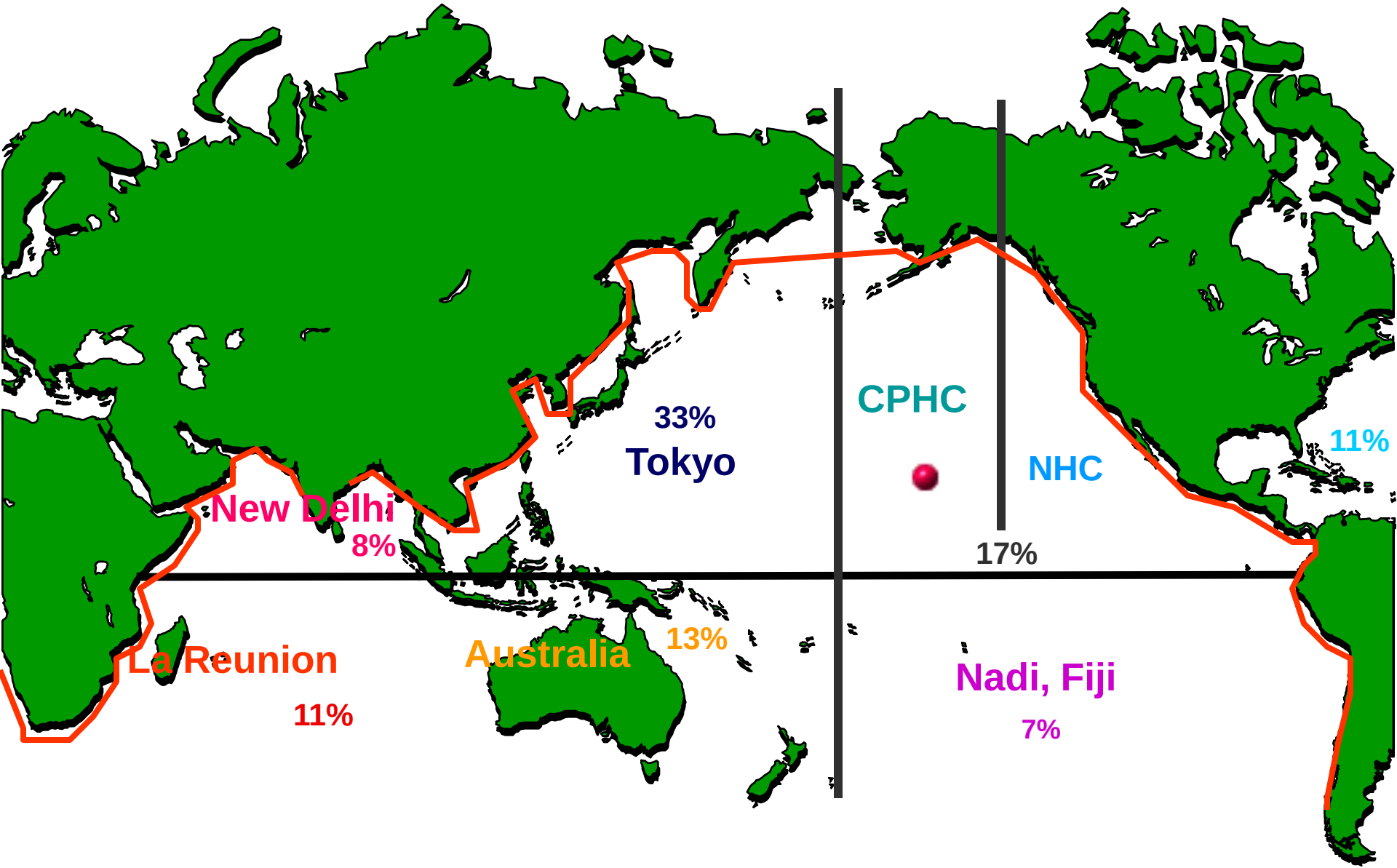
[2]Jet Propulsion Laboratory, Pasadena, CA
[3]Cooperative Institute for Research of the Atmosphere (CIRA), Ft. Collins
[4]Science Applications International Inc, Monterey, CA
[5]Fleet Numerical Meteorology and Oceanography Center, Monterey, CA

Sponsor:

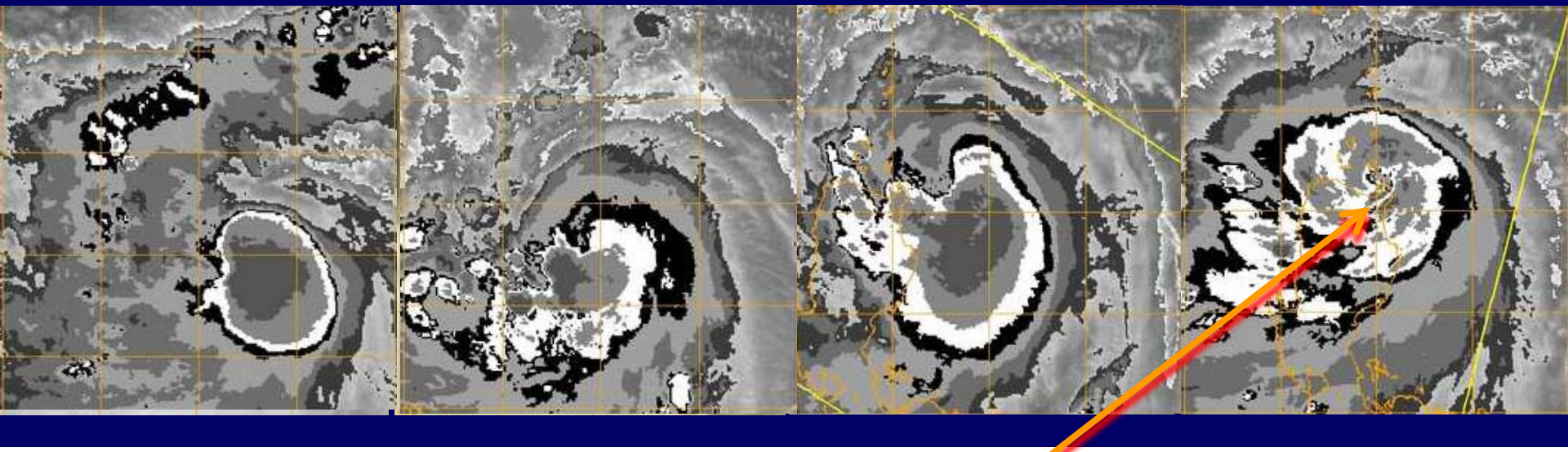
Office of Naval Research (ONR)
SPAWAR C4I PEO4
March 6, 2012

JTWC – Area of Responsibility

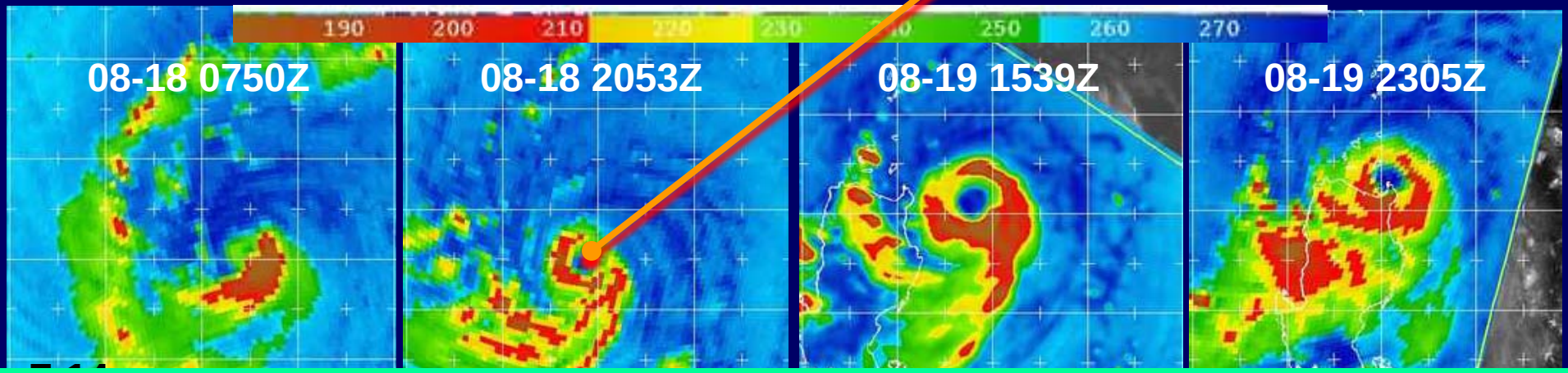
75% of the Planet, 89% of the TCs



Tropical Cyclone Monitoring



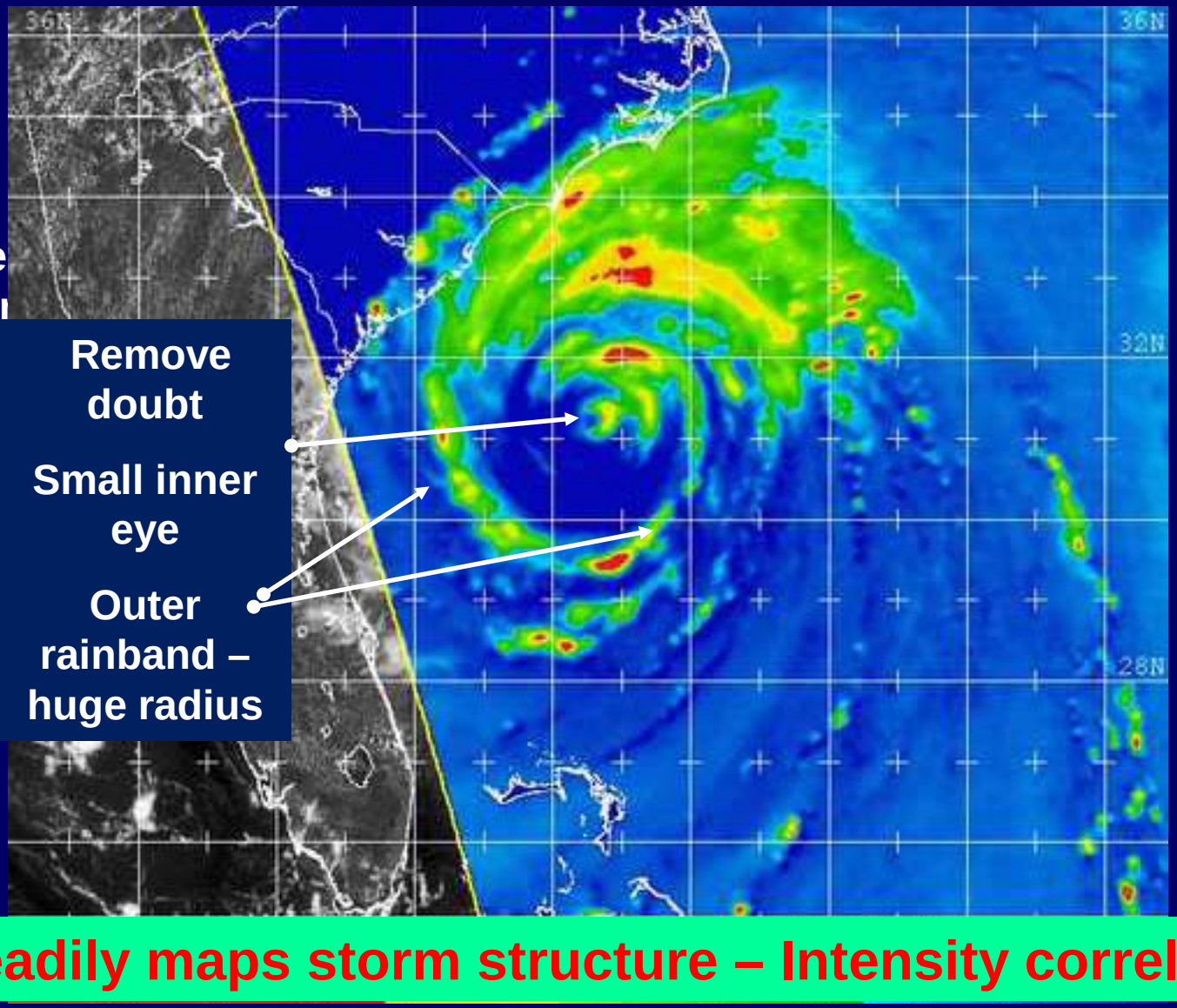
39 Hr Eyewall Evolution (Nuri): IR (MTSAT) vs Passive Microwave



Detects eye formation 24 hours earlier

Tropical Cyclone Monitoring

Hurricane Irene: 08-26-2011 GOES-13/NASA AMSR-E



Large
Hurrican

Remove doubt

Small inner eye

Outer rainband – huge radius

Readily maps storm structure – Intensity correlation

Tropical Cyclone Monitoring Needs

TC Monitoring Needs:

- Storm location, structure, and intensity anywhere (24/7)
- Mitigate vis/IR imagery limitations (cloud obscuration)

NRL Microwave Sensor Efforts

- Tap into near real-time microwave sensors
  - microwave imagers (SSM/I and TMI)
  - microwave sounders (AMSU-B)

Global resource: Public accessible web page

- Process satellite data for TCs in all basins
- Provide one-stop-shop for TC microwave products

2002 Storms

All | Active | Year

Atlantic

East Pacific

Central Pacific

West Pacific

Indian Ocean

Southern Hemisphere

- 96S.INVEST
- 14P.CLAUDIA
- 12S.FRANCESCA

Disclaimer **FNMOC Satellite Data Tropical Cyclone Page**

Display: Latest | Prev. Warn: Text | Track | ATCF 1_km: Track&Image | VIS | IR Info: General

SSMI Sectors:	VIS	IR	IR-BD	Multi-Sensor	85GHz-H	85GHz-H weak	PCT	Color	Rain	Wind	SSM/I Vapor			
TMI Sectors:	VIS	IR	IR-BD	Multi-Sensor	85Ghz-H	85Ghz-V	PCT	Color 85	Rain	Wind	Color 37	37GHz-V	37GHz-H	Liquid Water

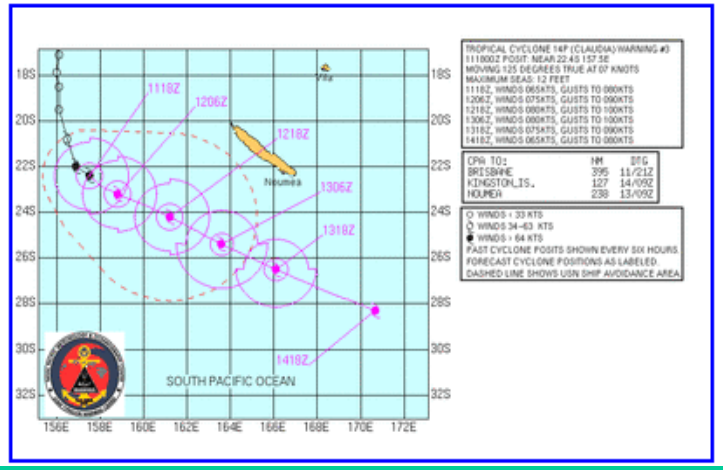
Latest	Upcoming Passes (more)	Current Time
SSMI: 02/11 1043Z	02/11 23:26 trmm 196.7	22:00:00 GMT
TRMM: 02/11 0830Z	02/12 05:58 trmm 529.8	

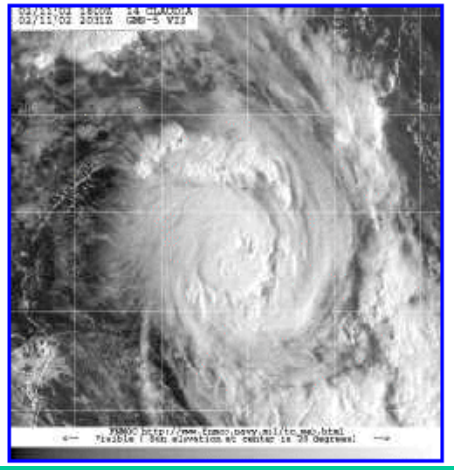
14P.CLAUDIA

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

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

1KM





- **Transition R&D demonstrations to operations:**
- **Fleet Numerical Meteorology and Oceanography Center (FNMOC)**

Tropical Cyclone Web Page

Transition to operations:

- Need 24/7 support
  - NRL works 8hr/day, 5 days/week
  - Things happen: power interruptions, computer issues

Fleet Numerical Meteorology and Oceanography Center

- Picked up the tasking to support JTWC and NHC
- National center of excellence for microwave imagers
- Involved in SSM/I cal/val since day 1

How did transition succeed?

- Same digital near real-time data sets
- Same SeaSpace TeraScan software early on for processing
- Small dedicated core teams collocated, little turnover
- Collaborative exploratory research and transition sponsoring

Team Monterey - Polar Orbiter Data

30 Sensors: 225 GB/day

Imagers (Vis/IR):	**NOAA – AVHRR (5)**
	DMSP - OLS (4)
	NASA - MODIS (2)
	NOAA - VIIRS
Microwave Imagers:	**DMSP – SSM/I (1), SSMIS (3)**
	NASA - TMI
	NRL - WindSat
Microwave Sounders:	**NOAA - AMSU-B (3), MHS (2)**
Microwave Radar:	**NASA - PR, CloudSat**

NRL TC Web Page

http://www.nrlmry.navy.mil/TC.html

"Active" Storms

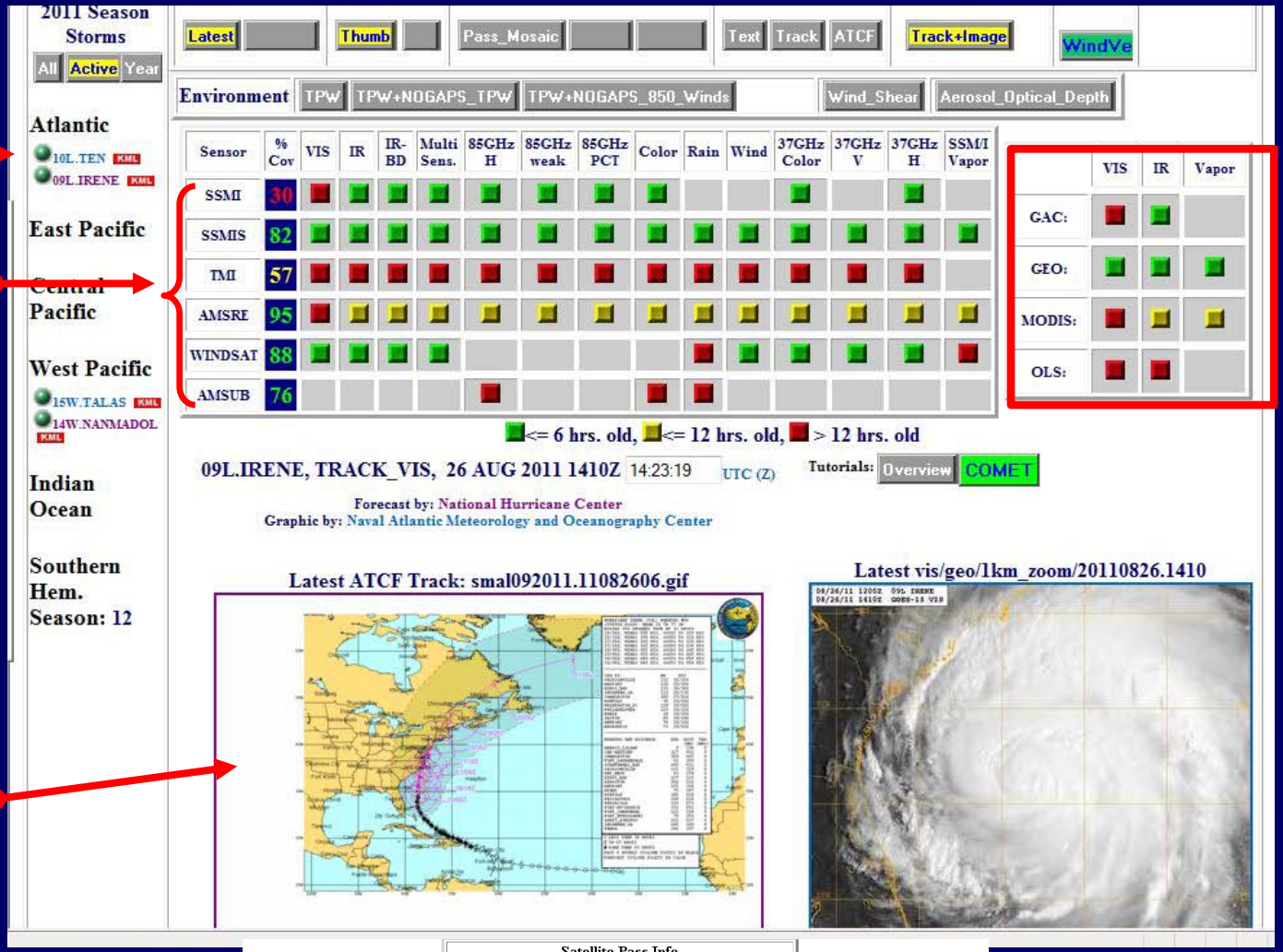
Microwave products

ATCF Track Graphic

Satellite Overpass Times

Suite of vis/IR and water vapor imagery from GEO/LEO sensors

Irene

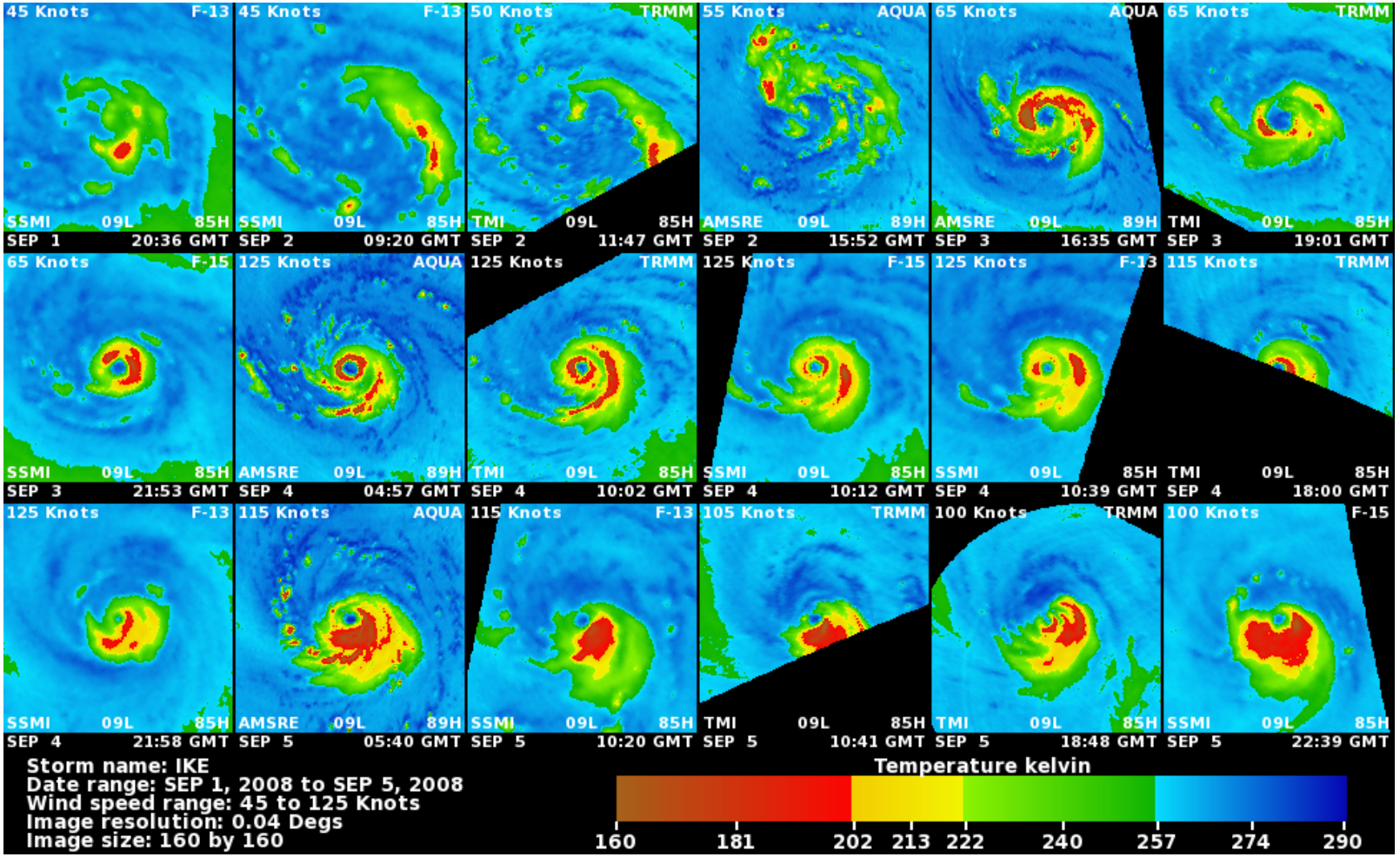


Satellite Pass Info

Sensor	Latest		Next (all)	
SSMI	02/26 2134 Z, F-15	1460	02/26 2135 Z, F-15	0343
TMI	02/26 1337 Z, TRMM	0221	02/27 0429 Z, TRMM	0407
AMSRE	02/26 1402 Z, AQUA-1	0017	02/27 0216 Z, AQUA	0326
AMSUB	02/26 1908 Z, N-15	0057	02/26 2229 Z, N-17	0622
SCATT	02/26 1945 Z, QUIK	1371	02/27 0653 Z, QUIK	0658

TC Structure Time Series

Hurricane Ike



Readily view storm structural evolution

NRL Tropical Cyclone Web Page

Key Ingredients:

- **Combined Navy 6.2/6.4 (exploratory and applications funding)**
- **Partnership with JTWC, NHC, & CPHC, “drive web page”**
- **Leverage and populate ATCF (Sampson)**

Early NRL Microwave Products

- **Joe Turk, Tom Lee, Kim Richardson, Buck Sampson, and John Kent**
  - **adding R&D AMSR-E (super sensor) when it came online**

How did the TC web page evolve?

- **Global feedback, WMO RSMC, country met offices, academia, others**
- **Policy change: R&D sensors available in near real-time**

Advanced Microwave Scanning Radiometer: AMSR-E

Sensor: Passive Microwave Conical Scanner
Spacecraft: EOS Aqua, ADEOS-2
Launch: May 2002, Dec 2002
Heritage: TMI, SSM/I

Channels: 6, 10, 18, 23, 36, **89** GHz
50, 50, 25, 25, 15, **5** km

Swath: 1600 km (1450 – AMSR)

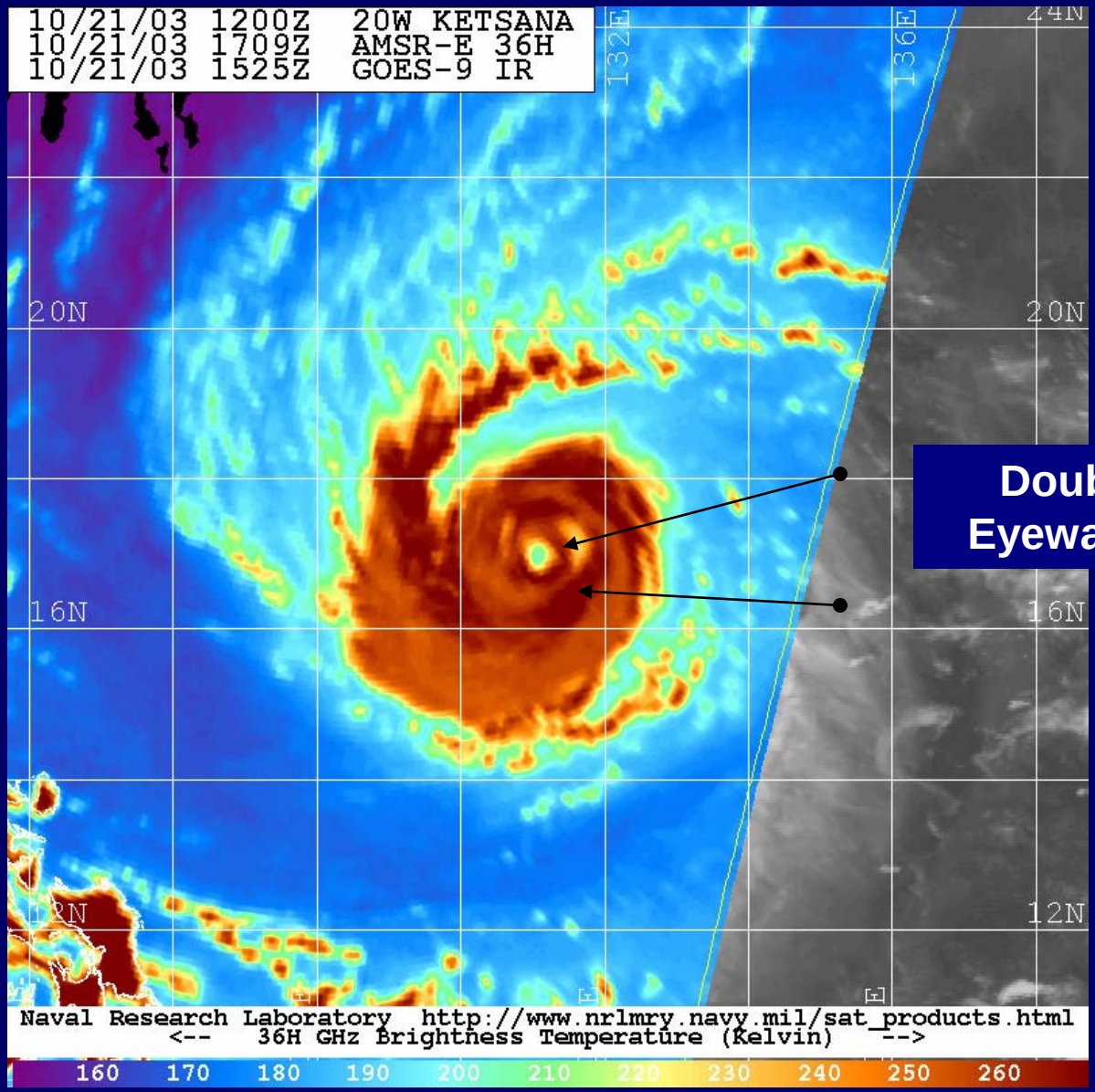
Enhancements for TC Applications:

(1) Spatial resolution (36 GHz),
(2) SST,
(3) High winds closer to intense rain.

Web Links: http://www.ghcc.msfc.nasa.gov/AMSR/
http://eos-pm.gsfc.nasa.gov/

AMSR-E Enhanced Resolution: 36 GHz

Typhoon Ketsana (20W)



Double Eyewalls?

R&D Satellite Data Latency

TRMM:

- Did not plan for near real-time product dissemination
- Immediately saw value in TC web page utility
- NASA revised data processing stream for TC and other users!

AMSR-E

- Followed example from TRMM and MODIS (RTDPE) processing
- Best overall imager due to spatial resolution and swath size

New sensors with near real-time data:

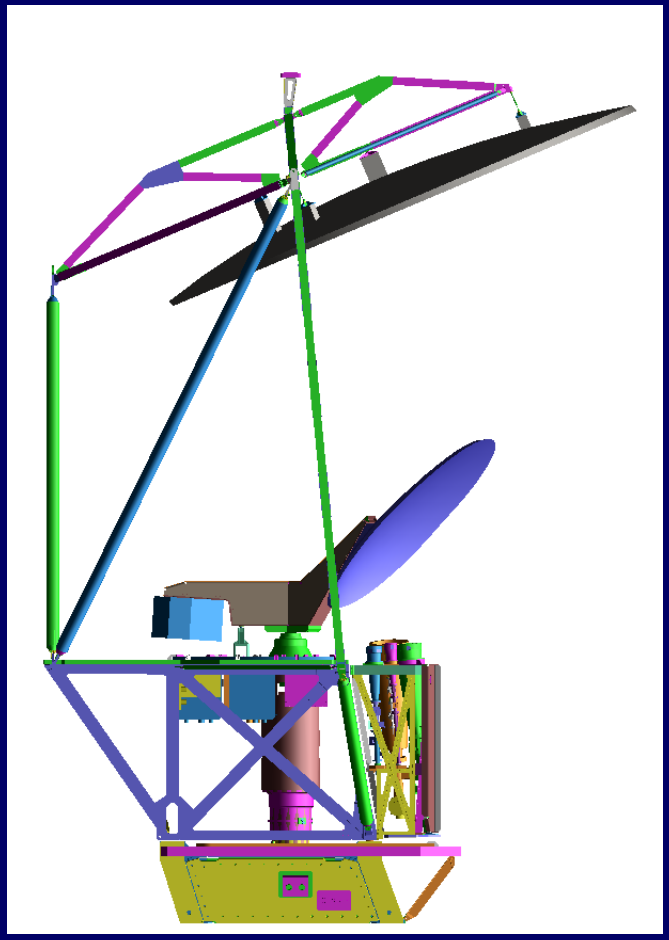
- Megha Tropiques MADRAS (available in Fall?)
- GCOM-W1 AMSR-2 (May 18, 2012)
- GPM (Global Precipitation Mission)

WINDSAT

Sensor: Passive Microwave Conical Scanner
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



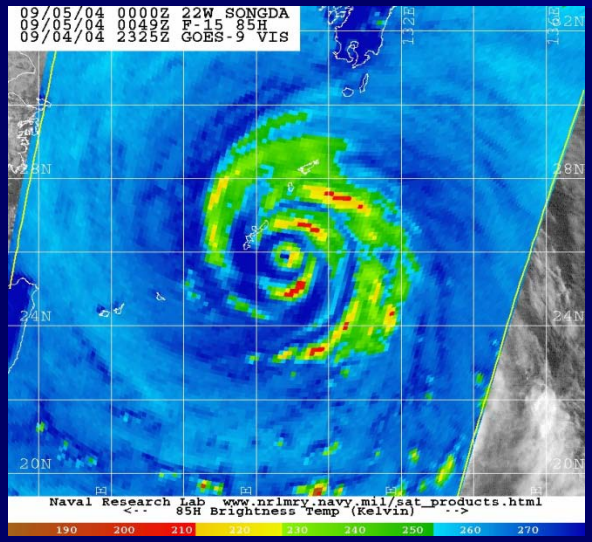
Enhancements for TC Applications:

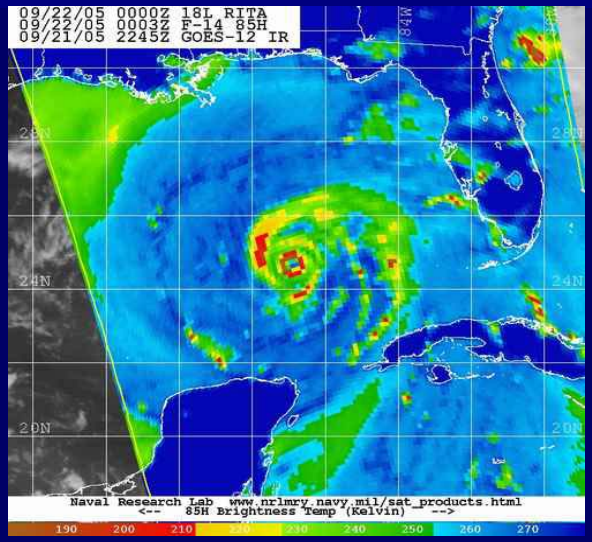
(1) Surface wind vectors, non-rain areas,
(2) Spatial resolution (37 GHz),
(2) Sea Surface Temperature,
(3) High winds closer to intense rain.

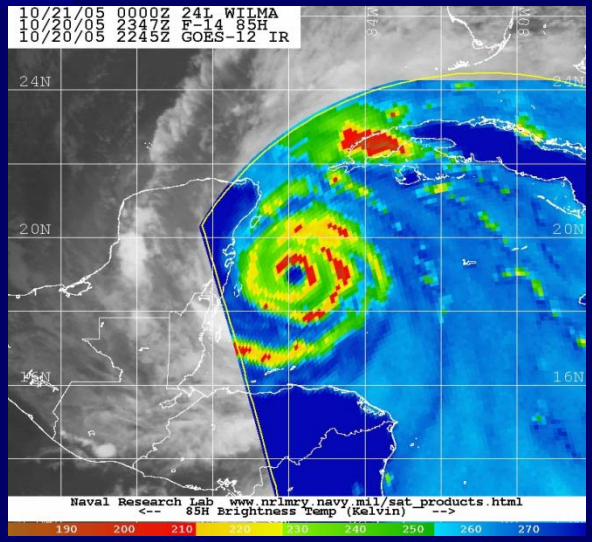
Web Links: http://www.pxi.com/windsat.main.html

WindSat TC Structure

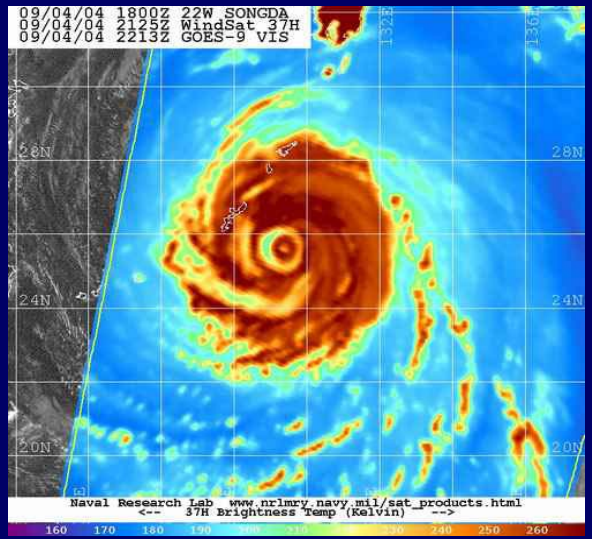
SSM/I 85 GHz H-Pol

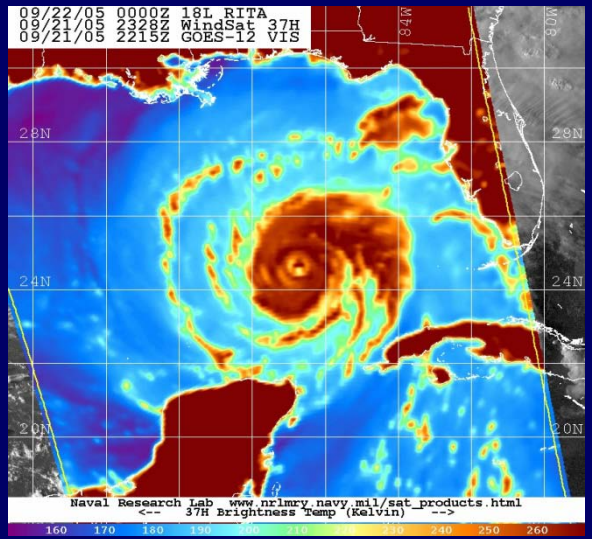


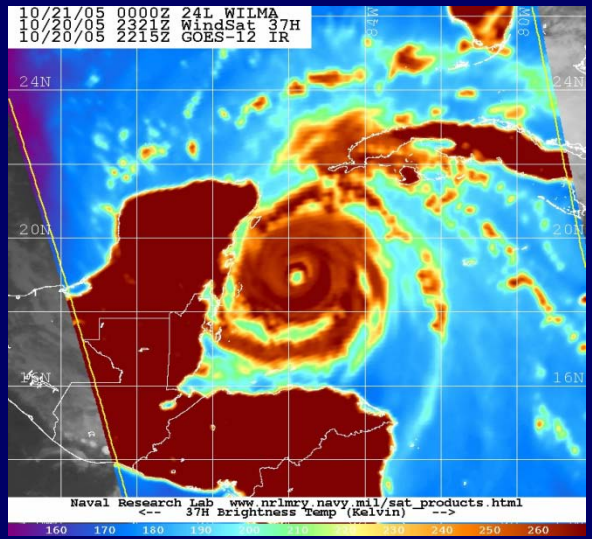




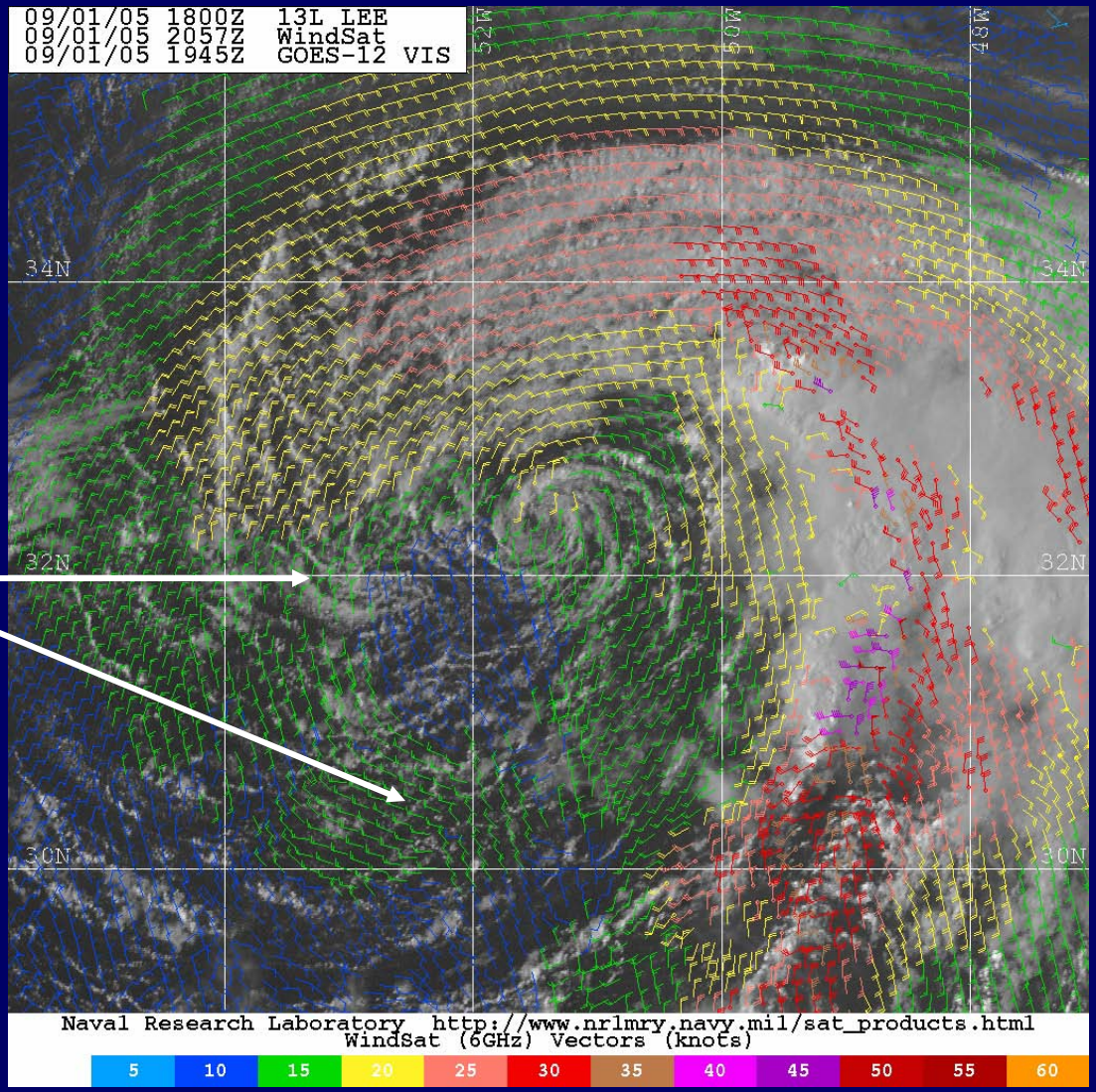
WindSat 37 GHz H-Pol







WindSat TC Winds



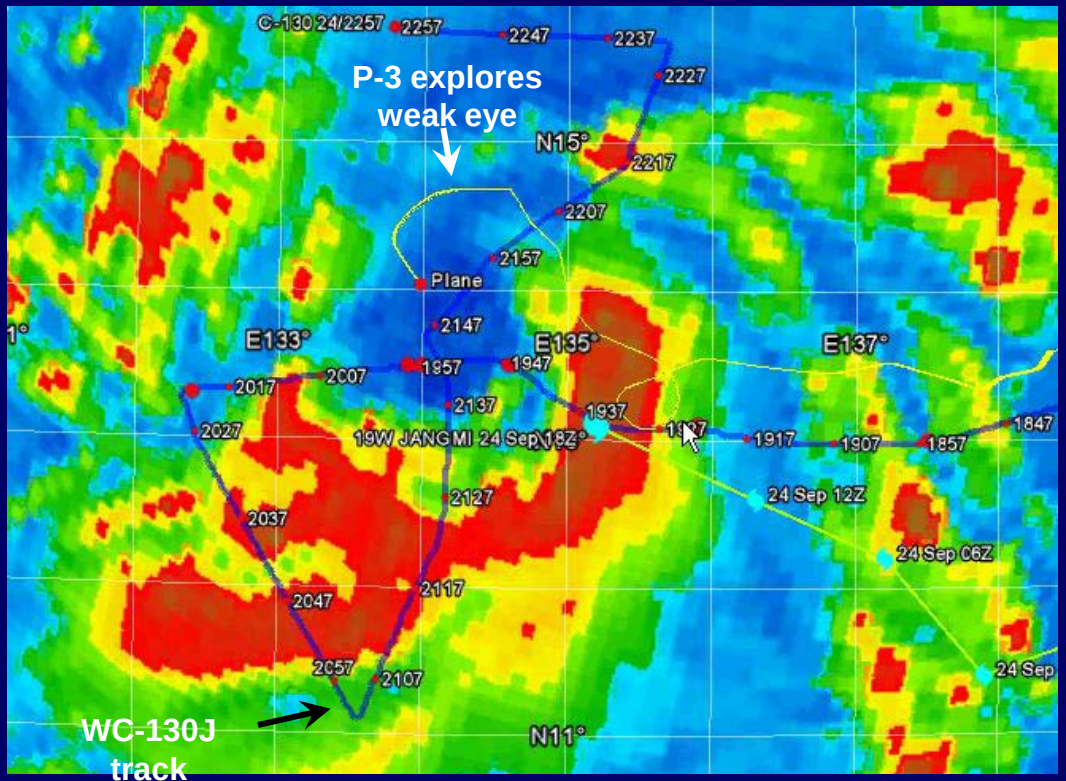
Weak SW quadrant winds highlighted

Exposed Low-level circulation

TCS-08 Satellite Visualization

TCS-08 flight tracks overlain on 85 GHz image

Google Earth kml files



NRL P-3 track

WC-130J track

Storm track

F-16 SSMIS 91 GHz imagery more clearly outlines the "open-weak" section of typhoon Jangmi's eye, greatly assisting P-3 flight operations

Megha Tropiques - MADRAS

Sensor: Passive Microwave Conical Scanner
Spacecraft: Mega-Tropiques
Launch: Oct. 12, 2011
Heritage: TMI

Channels: 18.7, 23.8, 36.5, 89, 157 GHz
~40, 40, 40, 10, 6 km

Swath: 1700 km

Enhancements for TC Applications:
(1) Tropical inclination (20 deg),
(2) 3-5 overpasses/day for TCs +/- 23 deg
(3) Data latency, additional stations in the work

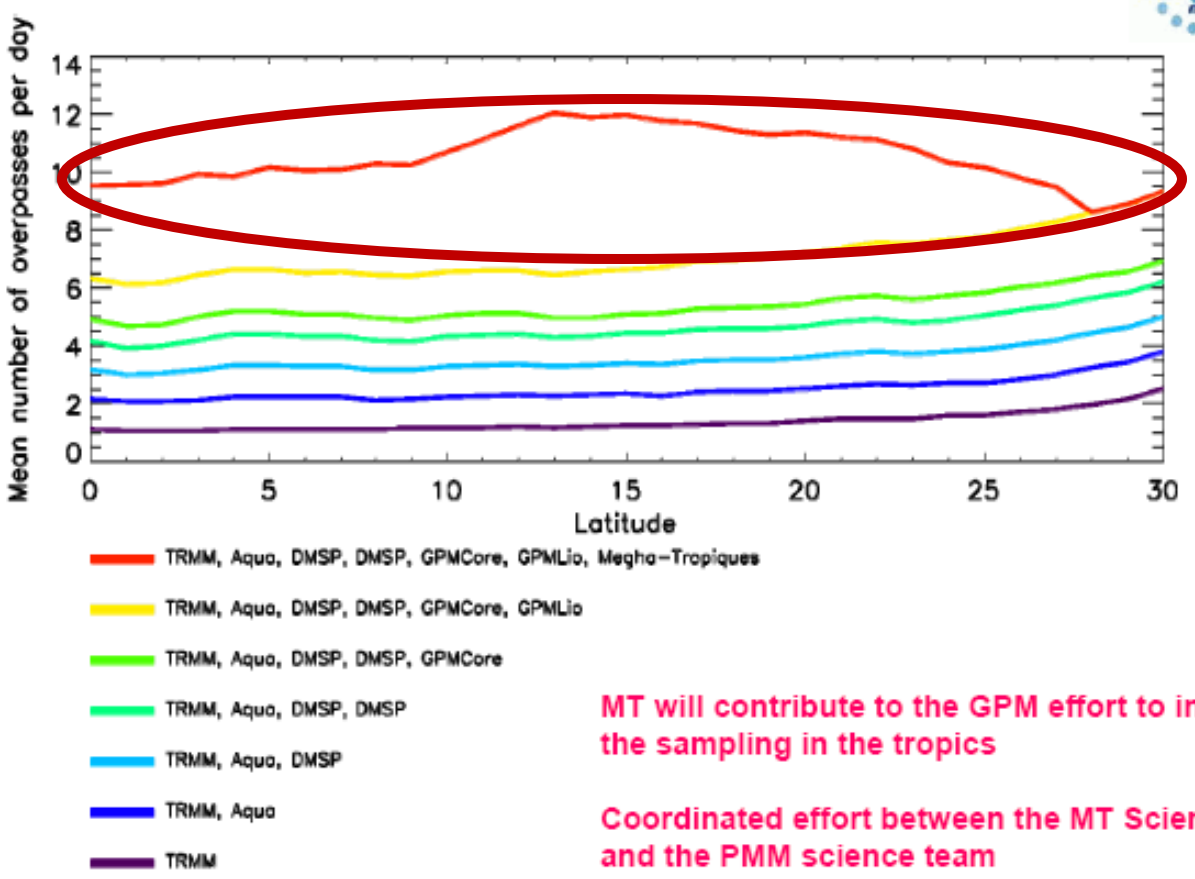
Source: N. Karouche, CNES

Web Links: http://meghatropiques.ipsl.polytechnique.fr/

Megha Tropiques - MADRAS

3-5 overpasses/ day for TCs +/- 23 deg

MT and GPM: a sampling story



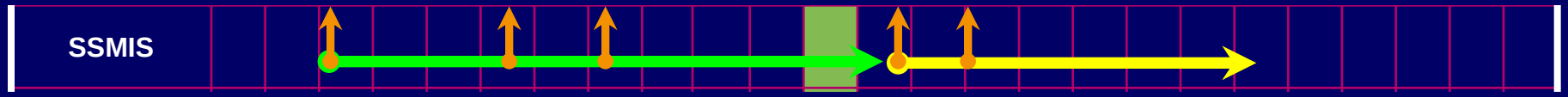
MT will contribute to the GPM effort to increase the sampling in the tropics

Coordinated effort between the MT Science team and the PMM science team

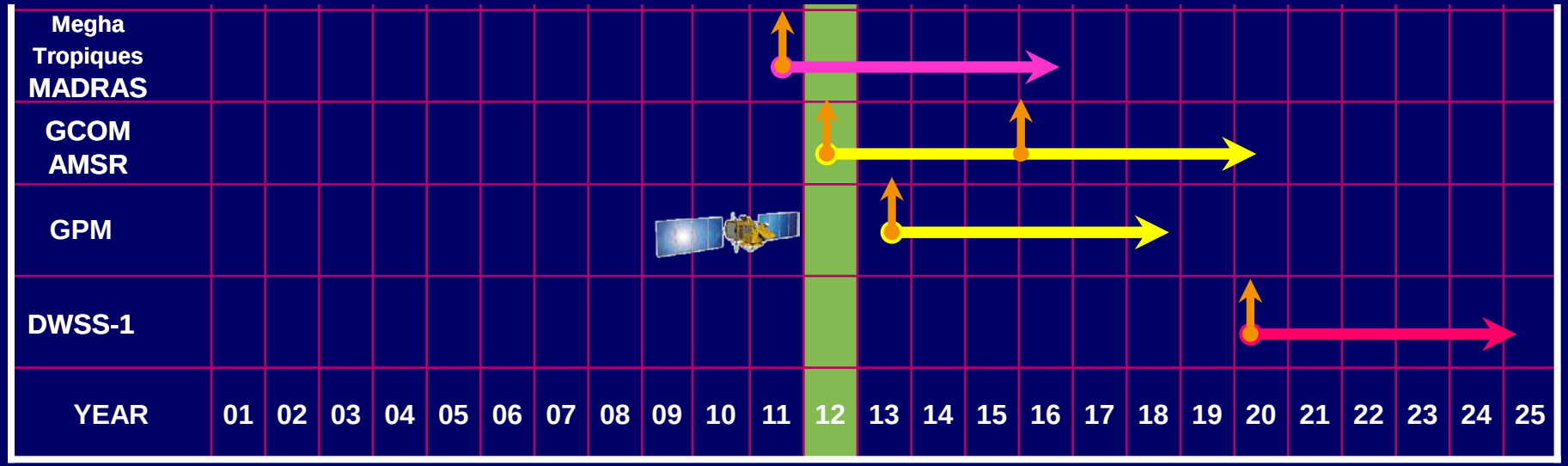
J. Hawkins, R Roca et al, MT Overview, Tucson, May 2010

Passive Microwave Imager Missions

What's left in a few years after SSM/I and old R&D satellites fail



Will these data sets be available in near real-time?

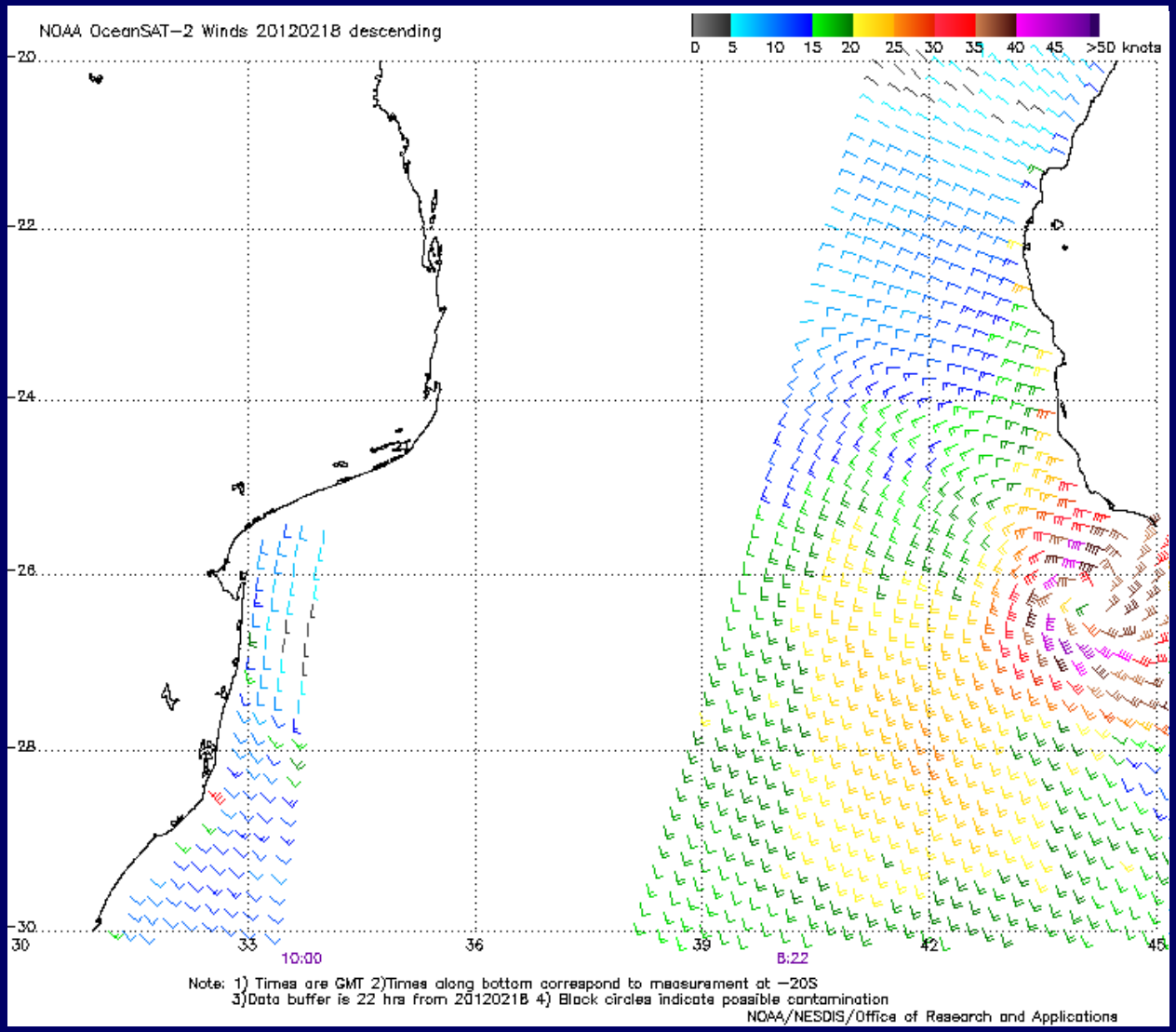


Launches | Primary mission | Extended mission | Future

Feb 2012
Hawkins

OceanSat-2 Wind Vectors (Demo)

12S
Giovanna
2-15-12
2124Z



Version 1.0
NOAA-NASA

Version 2.0
Next Step
Operational

Large wind field asymmetries

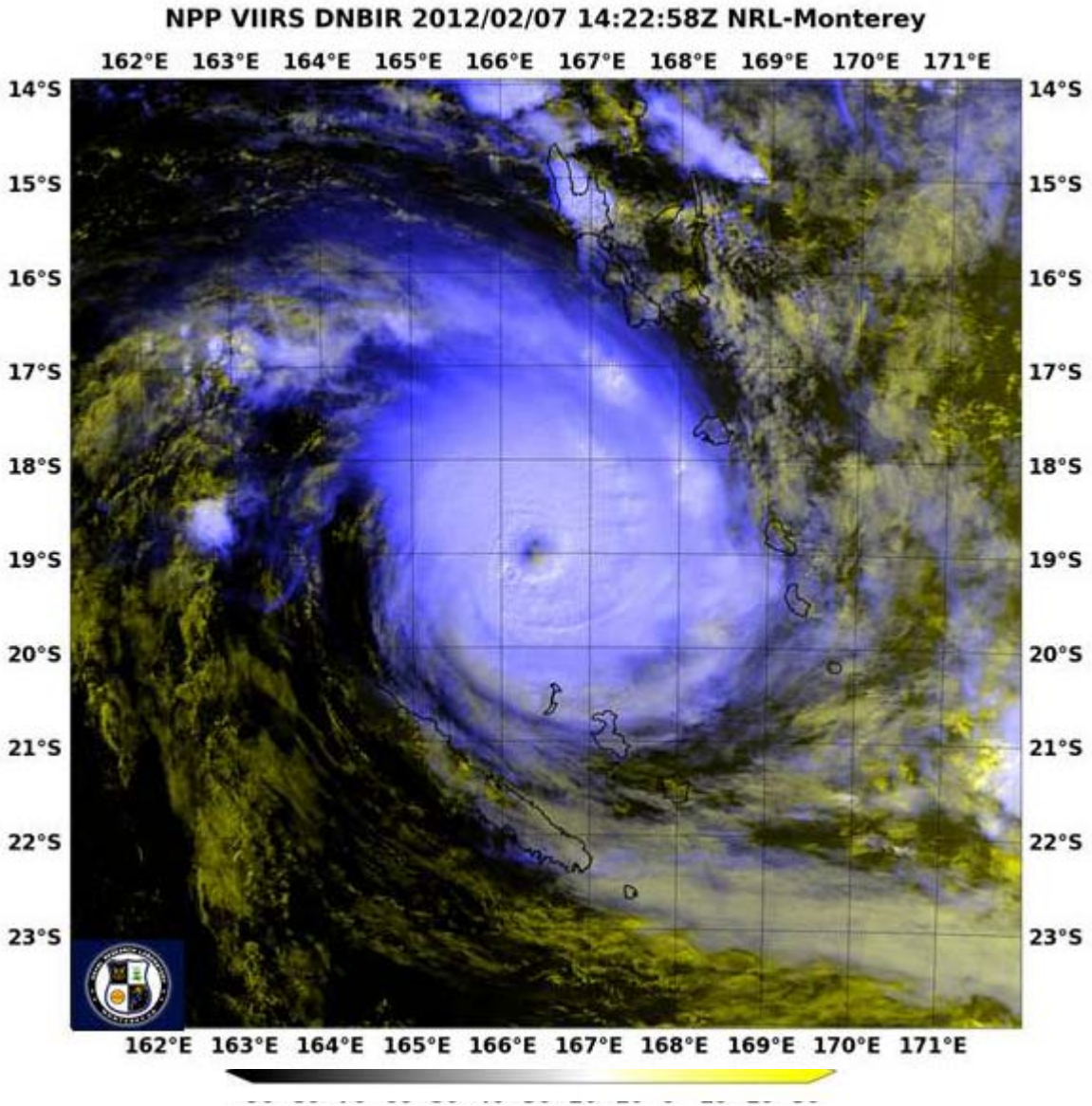
NOAA
Paul Chang

Suomi NPP VIIRS Day Night Band (DNB)

Tropical Cyclone 10P Jasmine

02-07-12 1422Z 0122 (Local)

Infrared Day Night Band IR-DNB Multi-spectral Low-clouds: Yellow Cirrus: Light blue



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15 Years of TC Community Availability

Naval Research Laboratory (R&D)
http://www.nrlmry.navy.mil/TC.html
Up to 5 Million Hits/Day

10+ Years of Operational Support

FNMOC
https://www.fnmoc.navy.mil/tcweb/cgi-bin/tc_home.cgi