Tropical Cyclone Intensity (TCI) Workshop
Introduction and Logisitics

- Thanks to Jim Moore, Scot Loehrer and Tammy Kepple for help with the logistics and organization. Thanks to NCAR for hosting.
- Thanks to Ron Ferek and ONR for support for the research and for the meeting.
- Cost sharing for refreshments of $10 each.
- Presenters are asked to keep presentations to 15 mins or less to allow adequate time for discussion
- 1.5 day meeting with ample time for discussion. Please think about cross-cutting and integrative themes for the DRI, along with your individual research

Overview of TCI

James Doyle[1] and Ron Ferek[2]

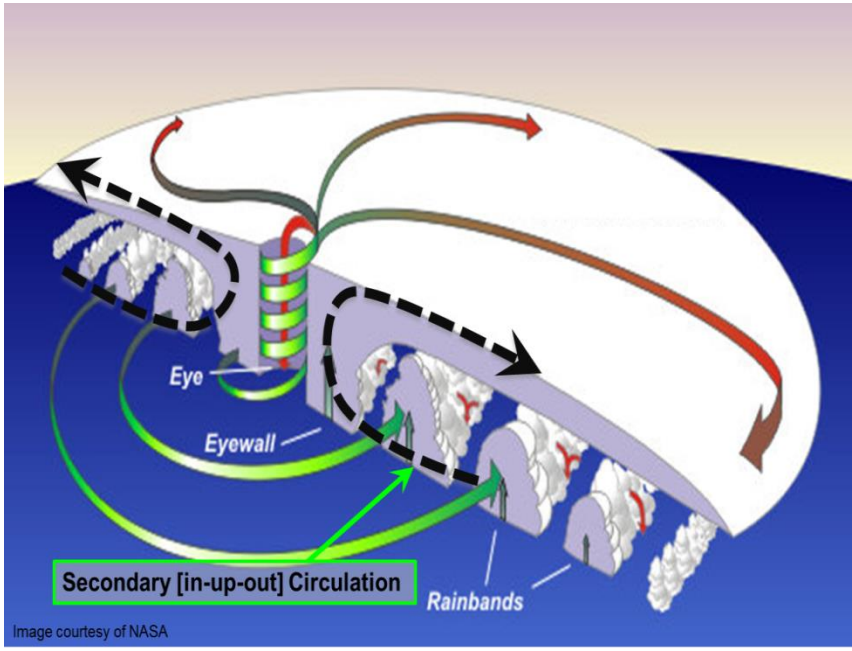
[1]Naval Research Laboratory
[2]Office of Naval Research

Hurricane Patricia from the NASA WB-57 (Joe Gerky, Pilot)

Tropical Cyclone Intensity (TCI)
Background

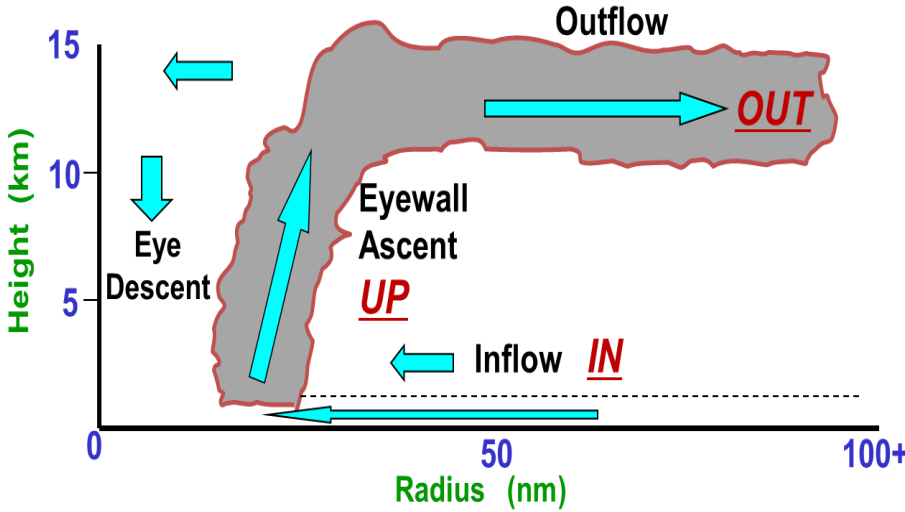
Role of Outflow in TC Intensification Has Been Relatively Unexplored

- Few detailed observations of TC outflow layer coordinated with inner core observations



Key Science Issues

1) Document the inner-core at high-resolution, as well as the larger-scale outflow structure
2) Understand the role of outflow during TC intensity changes
3) Explore air-sea interaction processes
4) Understand the impact of high-quality observations in the inner core and outflow layer on TC intensity and structure predictions.



Tropical Cyclone Intensity (TCI)
Background

NASA WB-57 Aircraft:

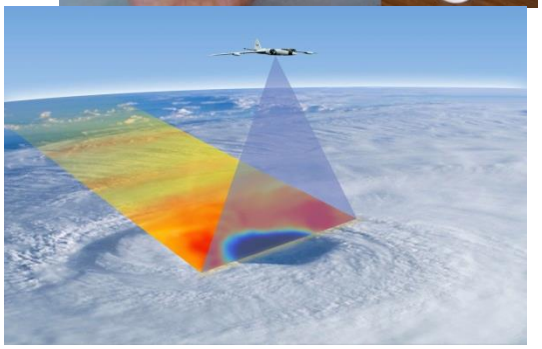
- Duration of 6 h and range of ~2000 nm, ~400 kt; cruise altitude > 60,000 ft.
- Based at Ellington AFB, TX; deployed to Harlingen, TX (EPAC); Warner Robbins AFB, GA (WATL)
- Coordination: NASA GH, NOAA P-3, AF C-130
  - C-130 deployed AXBTs in TROPIC (Beth Sanabia)

High Definition Sounding System (HDSS):

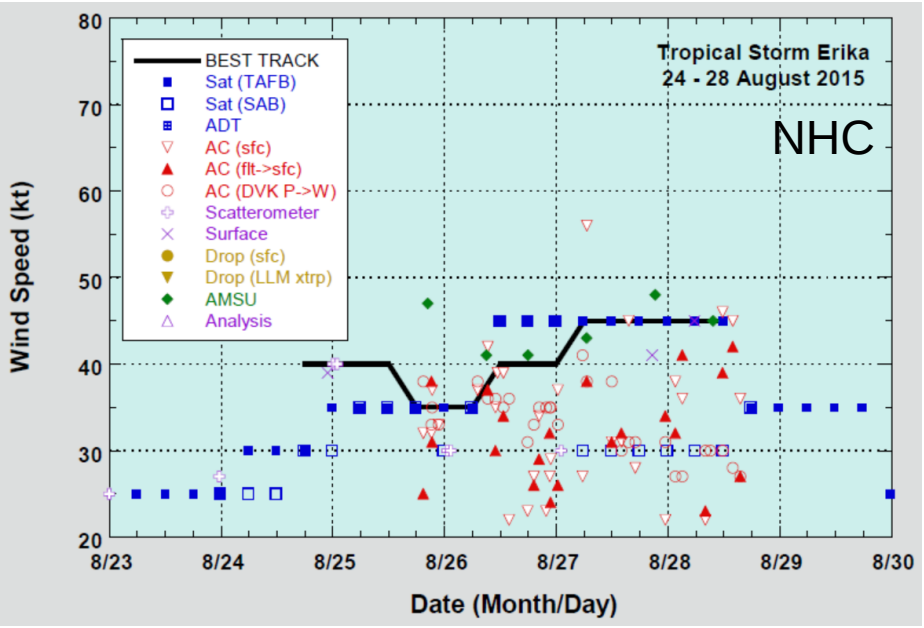
- Innovative eXpendable Digital Dropsonde (XDD) atmospheric profiling system (YES, Mark Beaubien)
- Profiles of pressure, temp., RH, winds, SST
- Capable of rapid sonde deployment (80+)

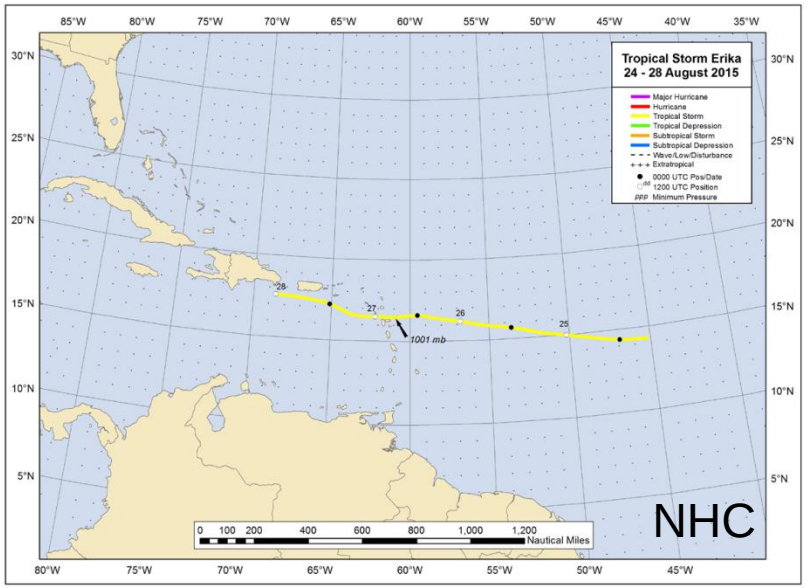
Hurricane Imaging Radiometer (HIRAD):

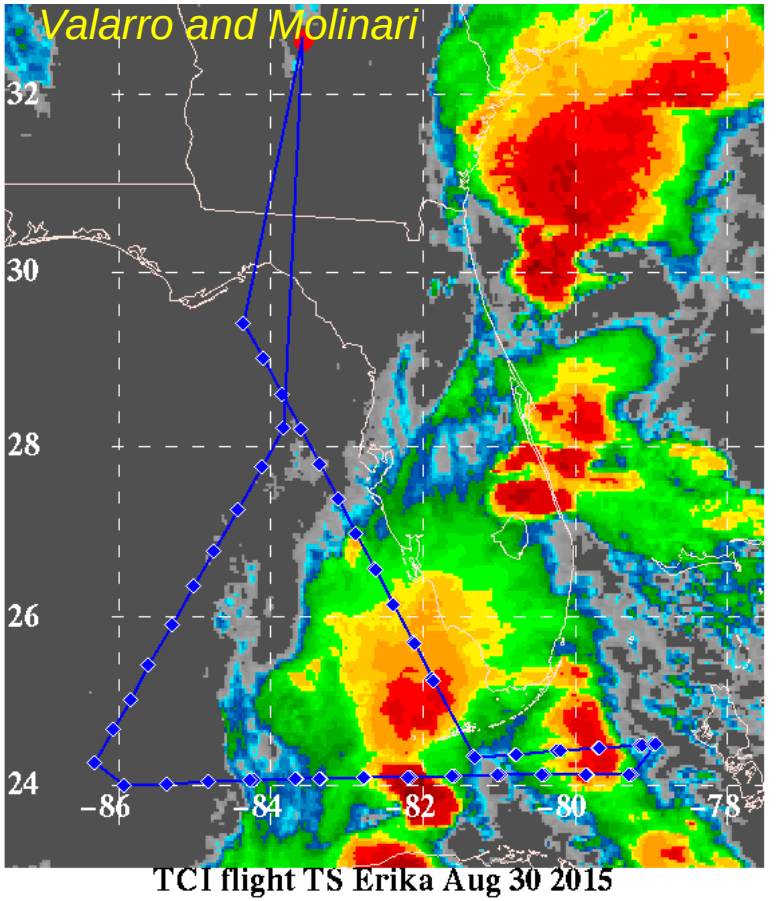
- Multi-frequency, passive C-band radiometer, that measures ocean surface winds through heavy rain
- NASA MSFC developed instrument (Dan Cecil, PI)



Tropical Cyclone Intensity (TCI)
Tropical Storm Erika (Aug 30)

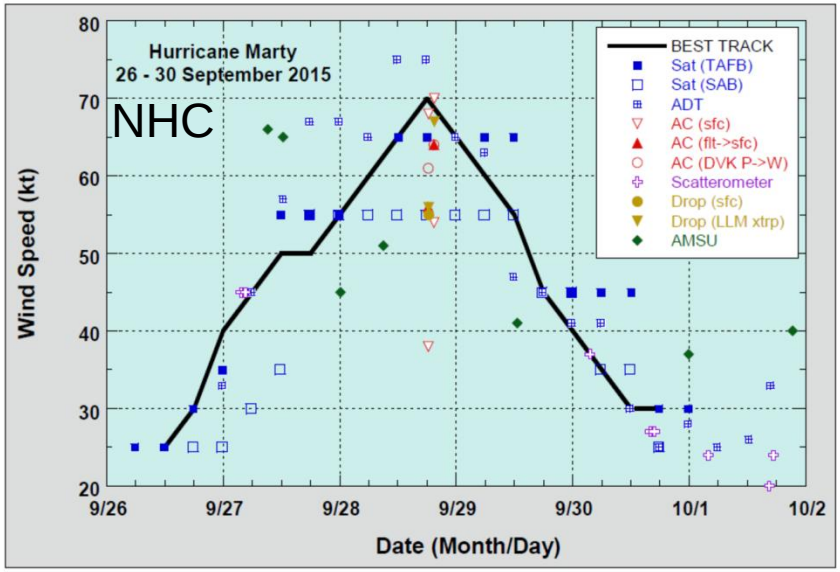


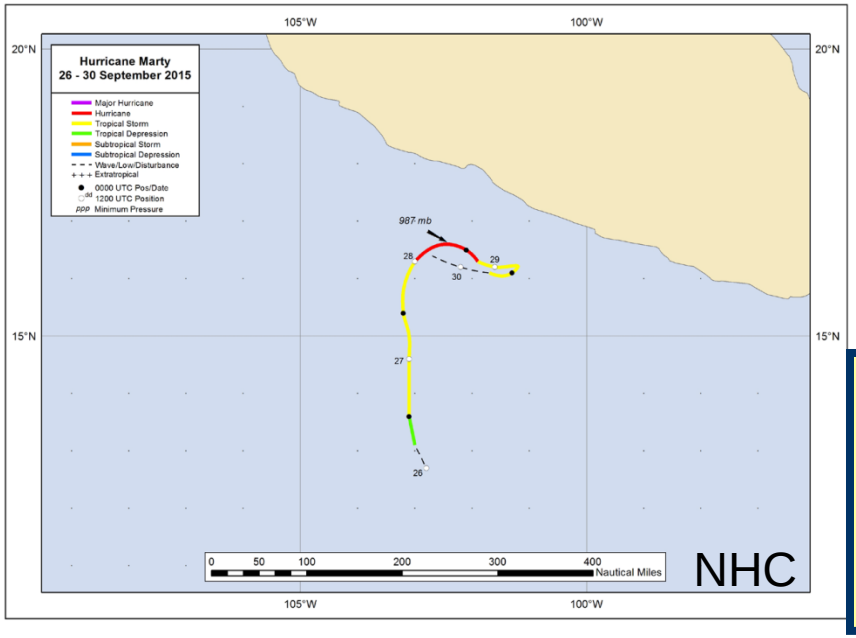


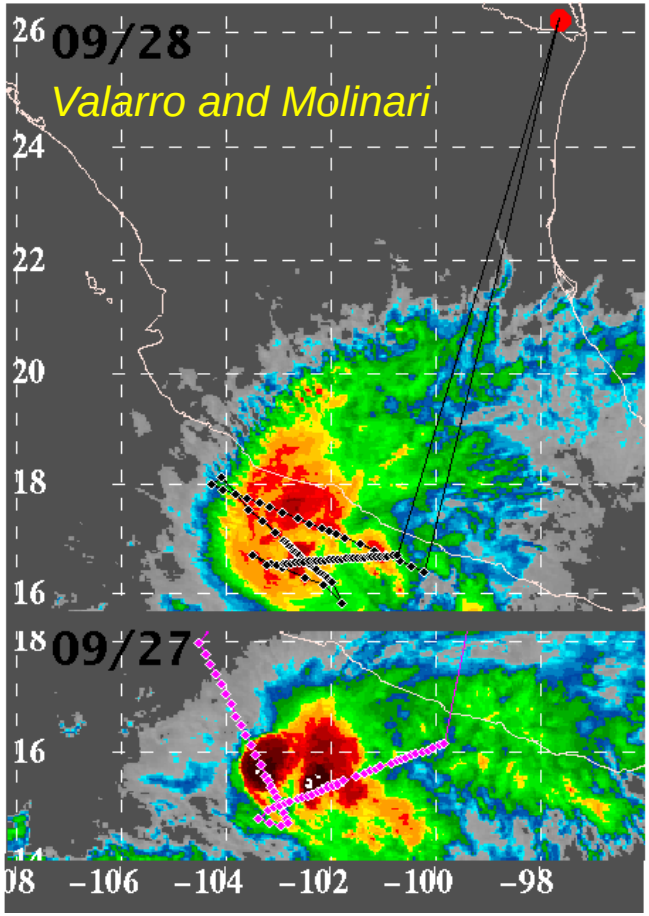


- TS Erika failed to intensify; model forecasts were quite poor
- TCI performed its first mission over convection and jet in the Gulf

Tropical Cyclone Intensity (TCI)
Hurricane Marty (Sep 27-28)

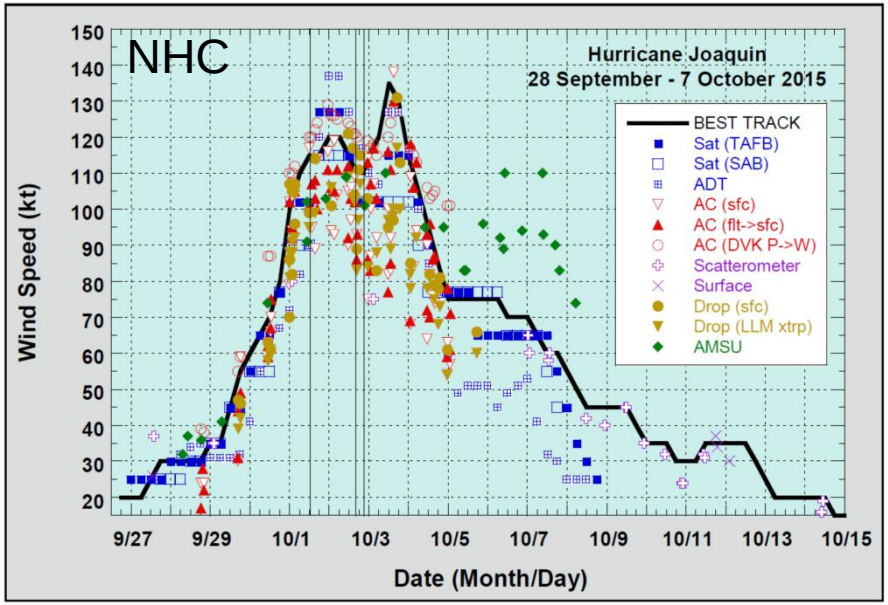


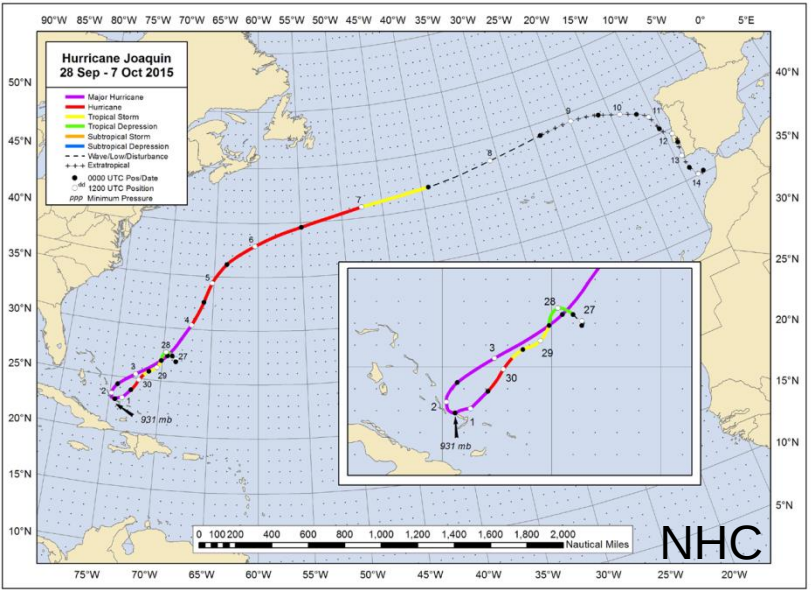


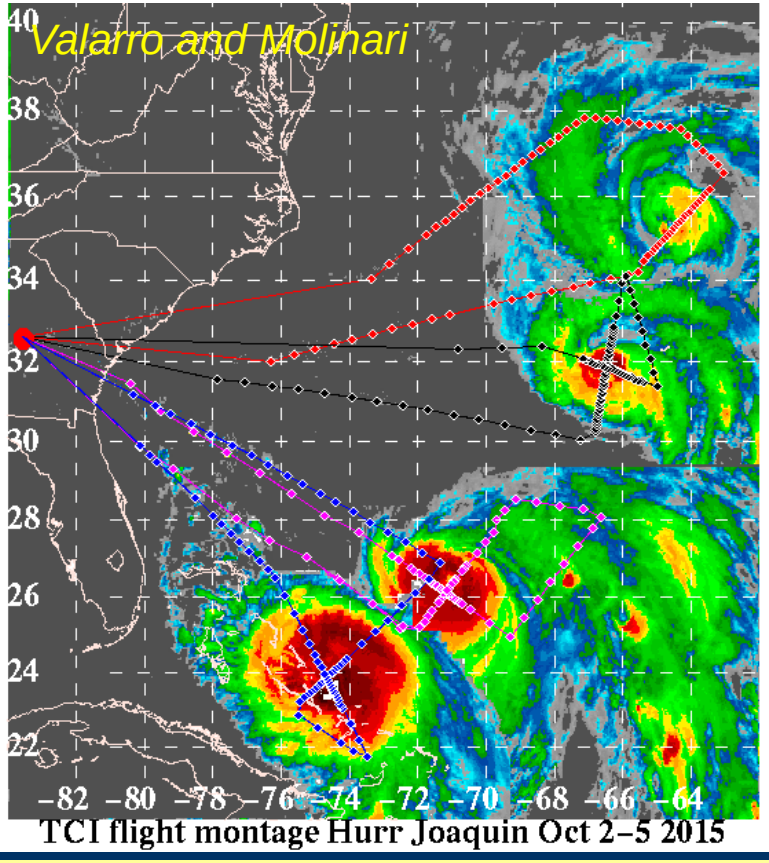


- Hurricane Marty (Cat 1) intensified in the presence of moderate shear
- TCI performed 2 missions with transects across eye and outflow

Tropical Cyclone Intensity (TCI)
Hurricane Joaquin (Oct 2-5)



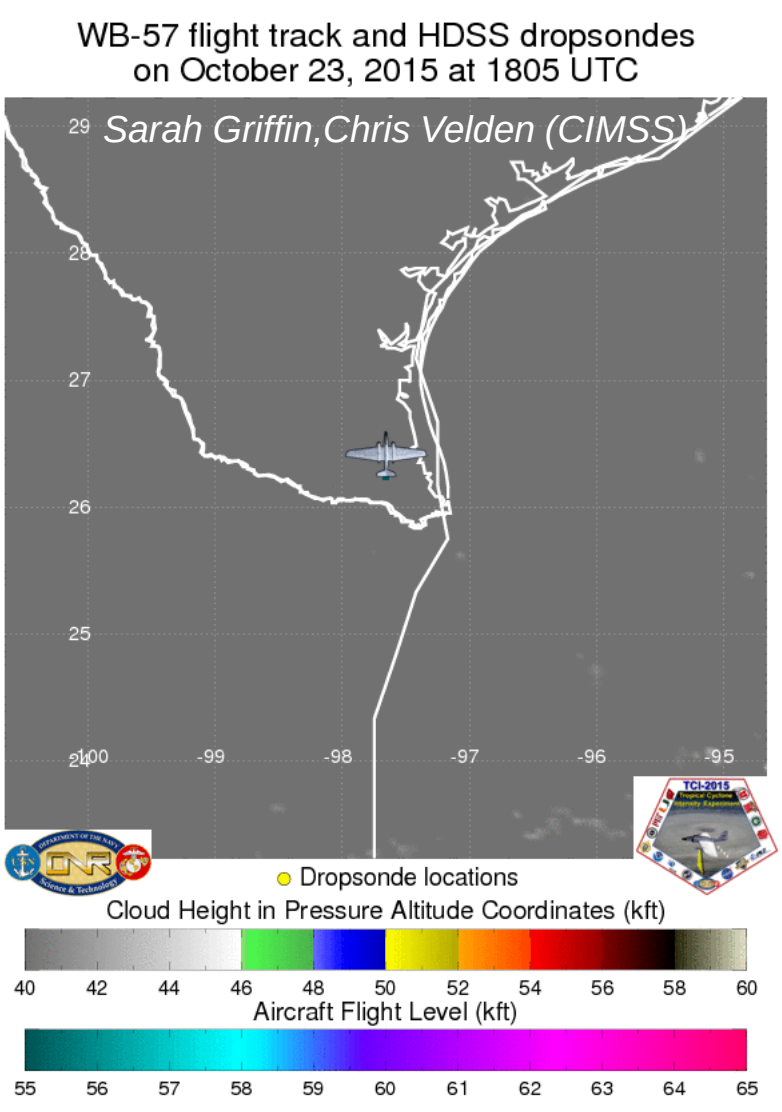


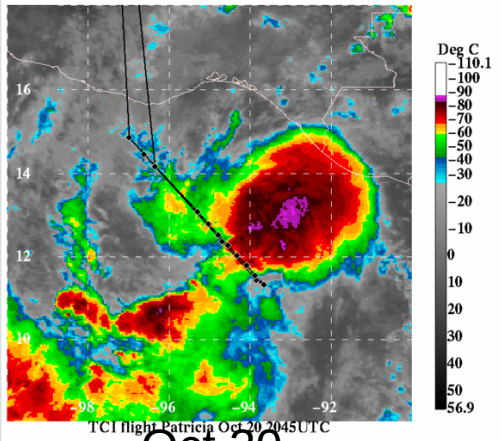


TCI flight montage Hurr Joaquin Oct 2–5 2015

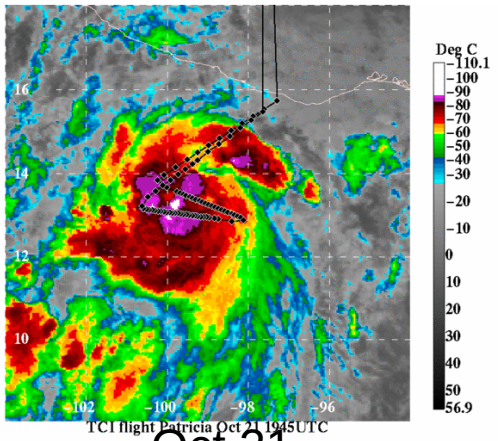
- Hurricane Joaquin (Cat 4) was the strongest W. Atlantic Hurricane in 5 years. (poorly forecasted)
- TCI performed 4 missions with transects across eye and outflow

Tropical Cyclone Intensity (TCI)
Hurricane Patricia (Oct 20-24)

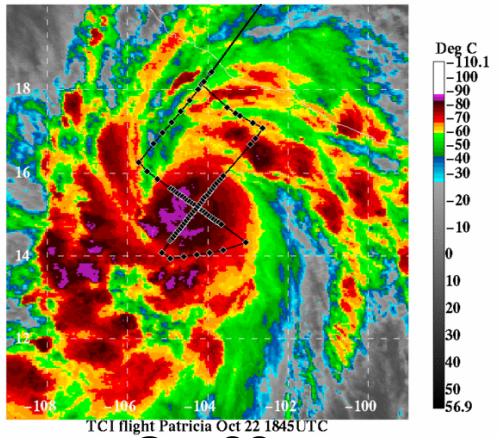




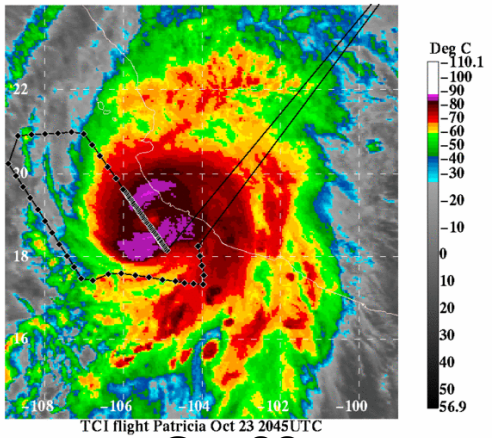
Oct 20



Oct 21



Oct 22



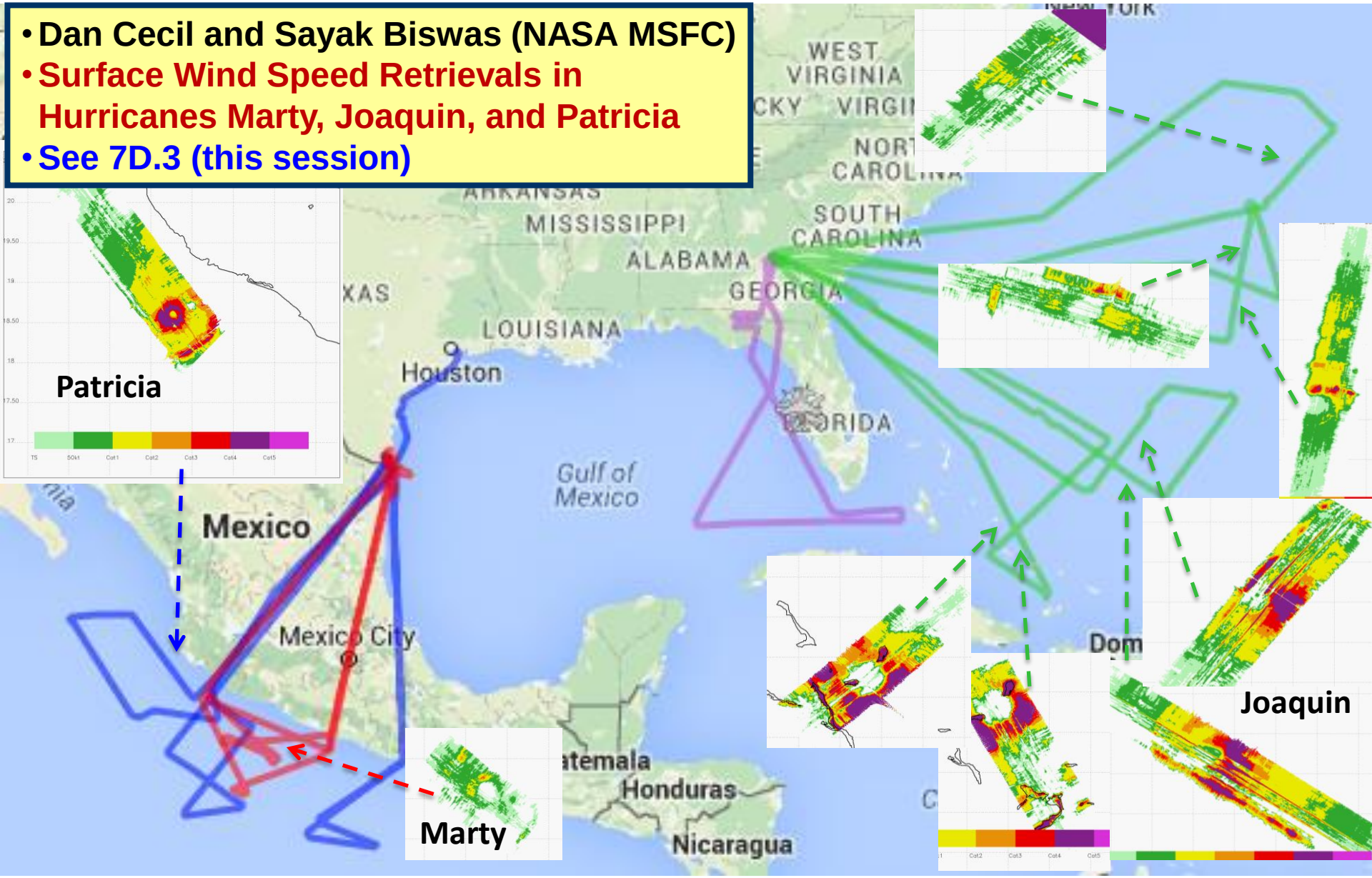
Oct 23

- Hurricane Patricia was most intense TC recorded in the W. Hemisphere (185 kts) (poorly forecasted)
- Intensified from a TS to Cat 5 in 24 h
- 46 dropsondes across Patricia at 2 nmi on 23 Oct

Tropical Cyclone Intensity (TCI)

Hurricane Imaging Radiometer (HIRAD)

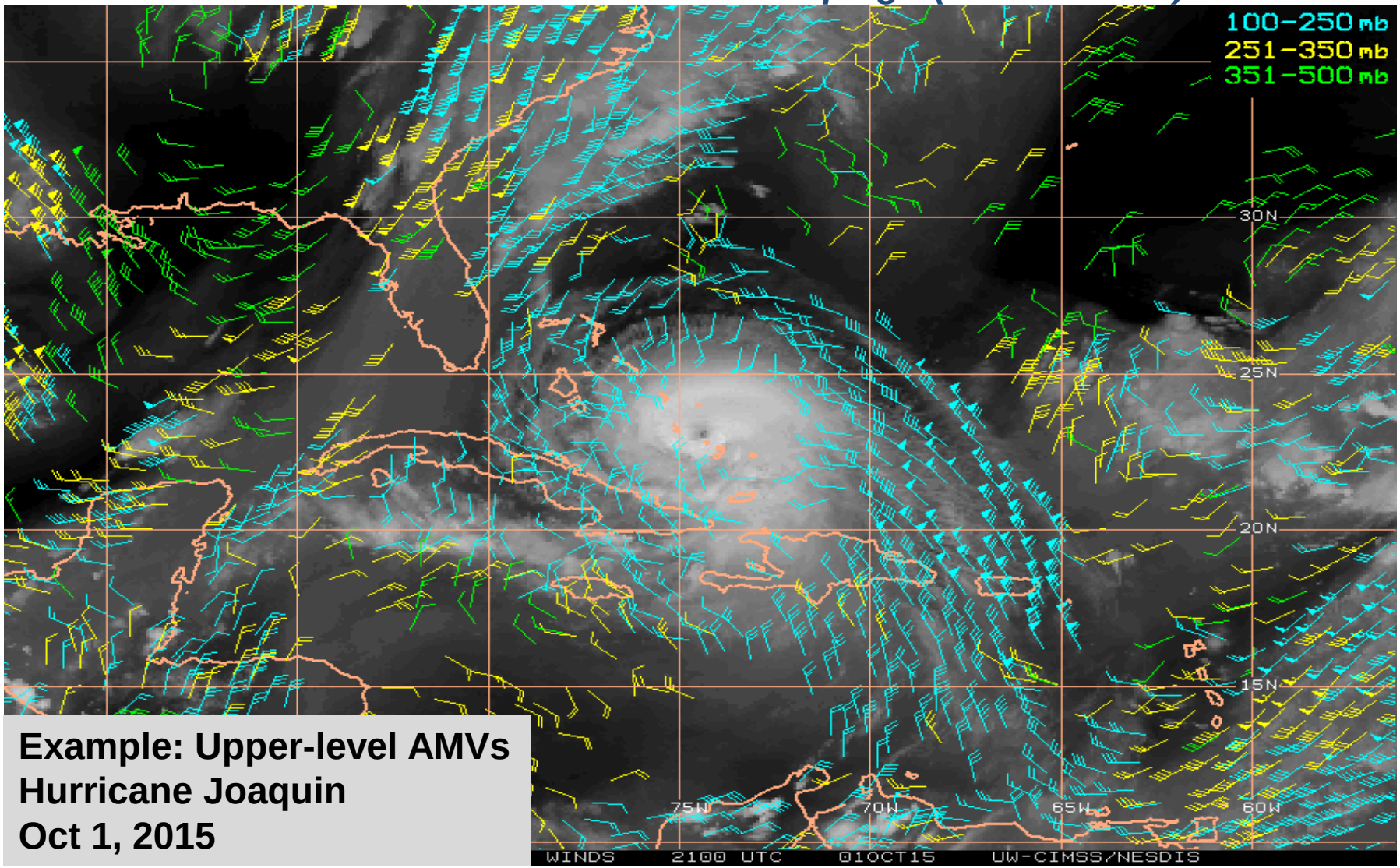
- Dan Cecil and Sayak Biswas (NASA MSFC)
- Surface Wind Speed Retrievals in Hurricanes Marty, Joaquin, and Patricia
- See 7D.3 (this session)



Tropical Cyclone Intensity (TCI)

Satellite-Derived Atmos. Motion Vectors (AMVs)

Processed at hourly intervals by the Univ. Wisc.-CIMSS TC Group for the duration of the TCI field campaign (Chris Velden)

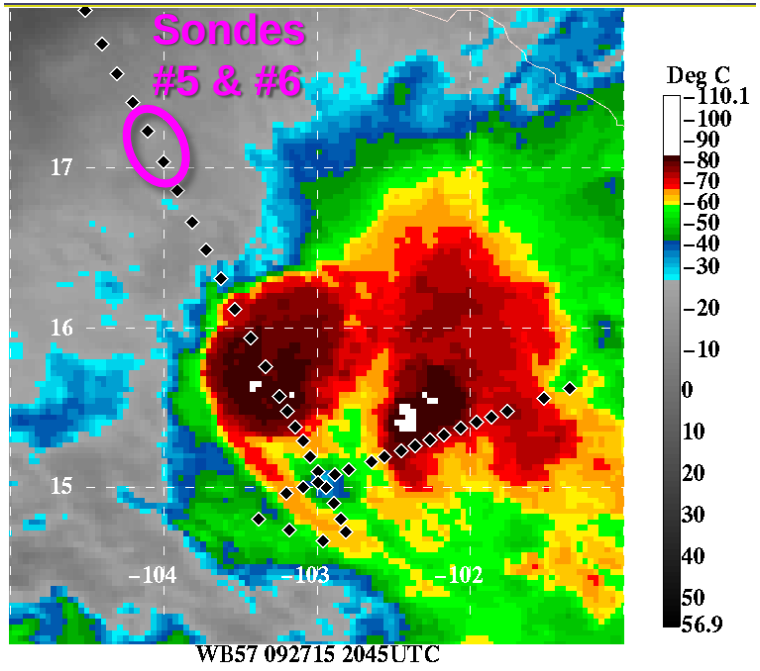


Example: Upper-level AMVs
Hurricane Joaquin
Oct 1, 2015

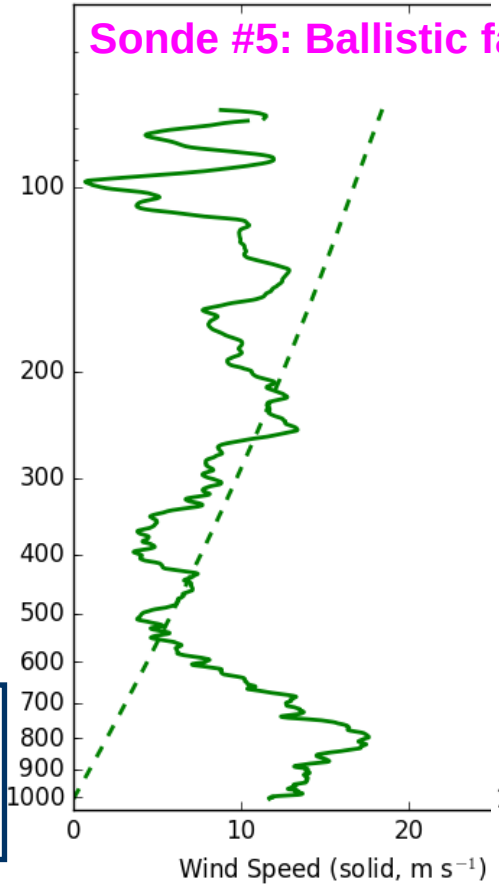
Tropical Cyclone Intensity (TCI)
HDSS Quality Control

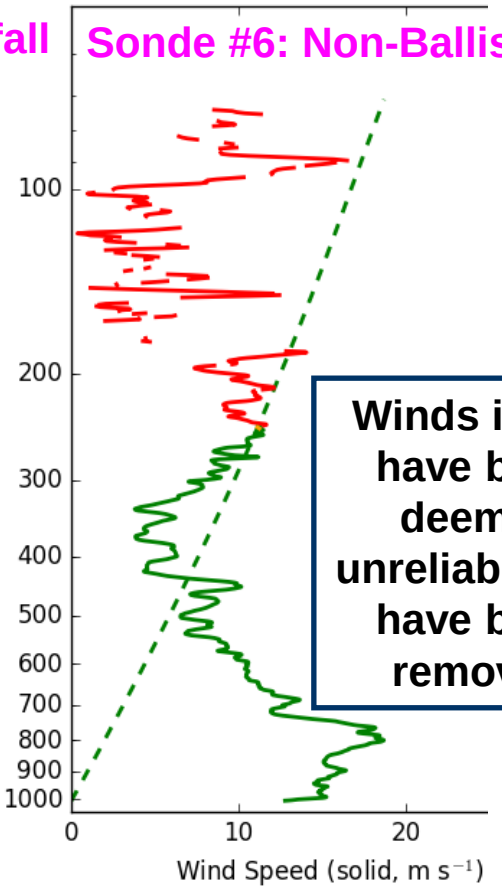
- Since HDSS is a new instrument, developing a QC procedure has involved identifying strengths and weaknesses of the instrument
- Team of 10 TCI scientists (led by Michael Bell) addressed these issues

Wind QC example: Tropical Storm Marty, 27 Sept 2015



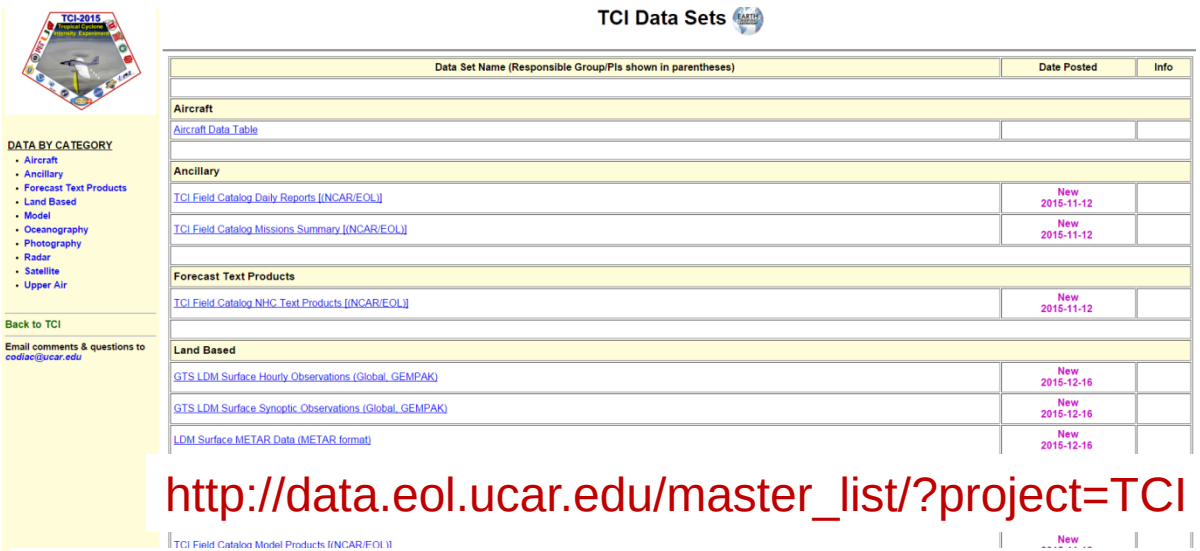
If a sonde falls in a non-ballistic fashion, the GPS-based wind measurements can be erroneous





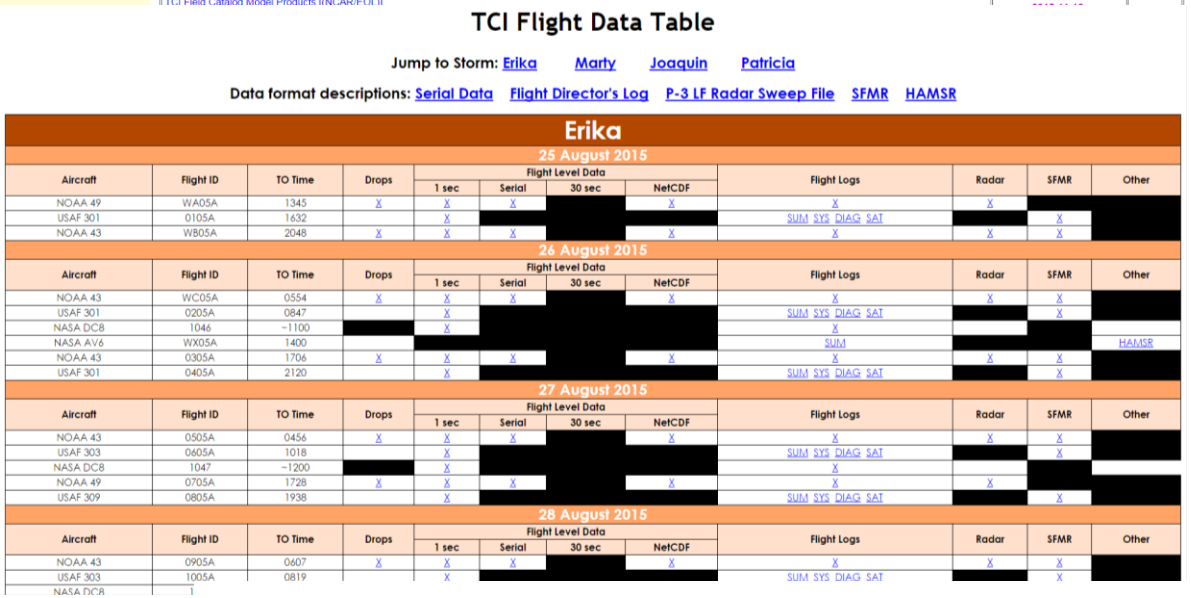
Winds in red have been deemed unreliable and have been removed

Tropical Cyclone Intensity (TCI)
TCI Long Term Data Archive at NCAR/EOL



http://data.eol.ucar.edu/master_list/?project=TCI

TCI Master List – Includes links to all TCI data sets, primary location for supplementary data (radiosonde, surface met, buoy, ship etc).



http://www.eol.ucar.edu/projects/tci/flight_data/

TCI Flight Data Table – Includes links to data from NASA WB-57, Global Hawk, and DC-8, NOAA P-3 and G-IV, and USAF C-130 for all flights into TCI-flown storms.

Tropical Cyclone Intensity (TCI)
Observations of 4 Unique TCs

- Unprecedented set of dropsonde and HIRAD observations in Hurricanes Marty, Joaquin, Patricia, and Tropical Storm Erika
- ~800 sondes deployed in 4 TCs in 11 WB-57 flights
- Observations in 2015 of Hurricane Gonzalo
- Systematic high-resolution observations of inner core and outflow from > 60 kft using HDSS and HIRAD.
- TC Dataset includes QCed dropsondes and HIRAD.

NOAA SHOUT

SHOUT-ONR TCI Collaborations During the 2016 Hurricane Field Campaign

Jason Dunion

University of Miami/CIMAS – NOAA/AOML/HRD – University at Albany/SUNY

ONR TCI Science Meeting, Boulder, CO: October 18-19, 2016

SHOUT 2016 Deployment

TCI-SHOUT mission science support (on-site & remote)

- J. Doyle, E. Hendricks, D. Herndon, D. Holdaway, W. Komaromi, J. Moskaitis, D. Ryglicki, G.Tripoli, and C. Velden

TCI COAMPS-TC Targeting and Outflow Guidance

- J. Doyle and J. Moskaitis

2016 SHOUT Global Hawk missions

- Hurricane Gaston (2): 20160824GH & 20160826GH
- Hurricane Hermine (2): 20160829GH & 20160831GH
- Tropical Storm Karl (2): 20160922GH & 20160924GH
- Hurricane Matthew (3): 20161005GH, 20161007GH, & 20161009GH

Global Hawk data collection

- HAMSR: microwave AMSU-like sounder
- HIWRAP: Dual-freq (Ka- & Ku-band), dual beam, conical scanning Doppler radar
- GPS dropsondes (629 total)

SHOUT 2016 Deployment

Mission summaries, dropsonde logs, AVAPs data (available 1-2 weeks)

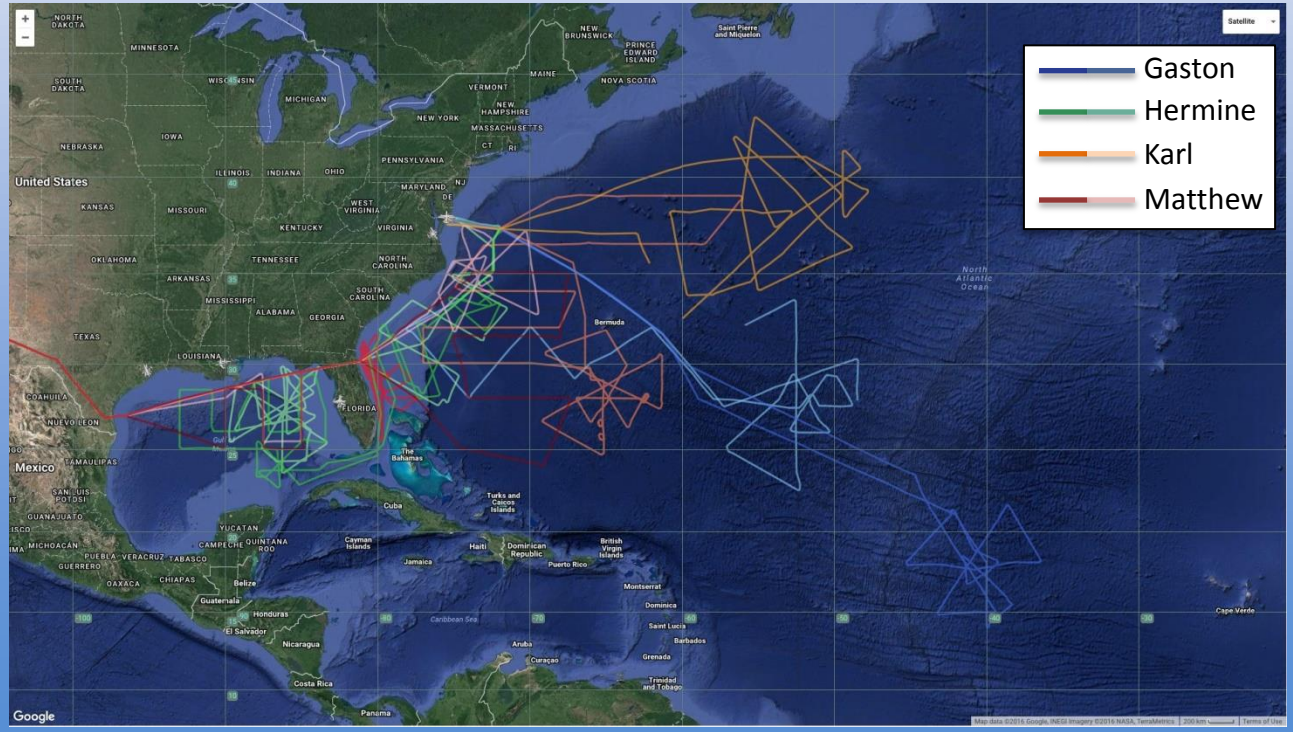
- ftp://ftp.aoml.noaa.gov/pub/hrd/data/global_hawk/shout2016/

HAMSR data (not yet available)

- https://microwavescience.jpl.nasa.gov/instruments/hamsr/

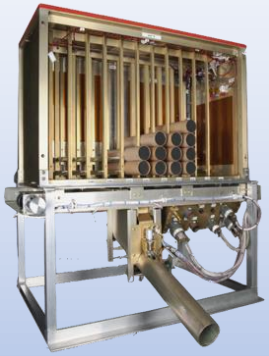
HIWRAP data (not yet available)

- http://har.gsfc.nasa.gov/index.php?section=13



2016 NOAA SHOUT
Global Hawk (AV-6) Instrumentation

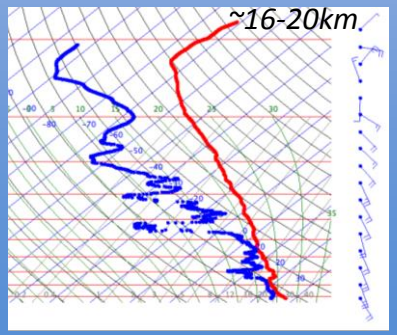
Airborne Vertical Atmospheric Profiling System (AVAPS)



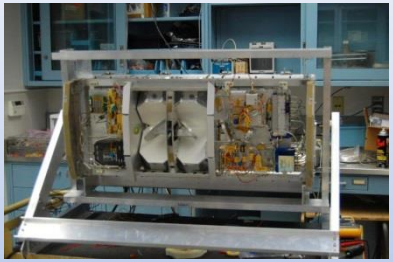
***PI**: Terry Hock, NCAR / Gary Wick, NOAA*

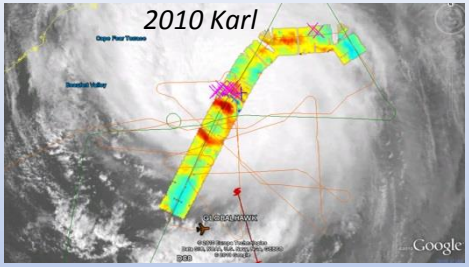
***Measurements**:*
- *Temperature, pressure, wind, & humidity vertical profiles;*
- *88 dropsondes per flight;*

***Resolution**:*
- *4 Hz (winds); 2 Hz (PTH);*
- *~2.5 m (winds), ~5 m (PTH);*



High Altitude Monolithic Microwave Integrated Circuit (MMIC) Sounding Radiometer (HAMSR)





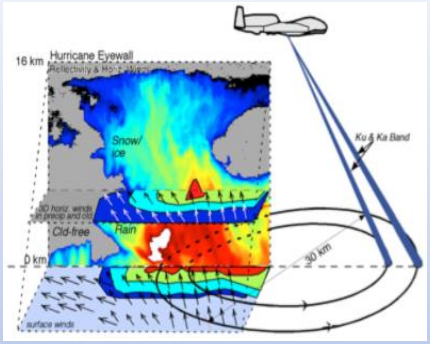
***PI**: Dr. Bjorn Lambrigtsen, JPL*

***Measurements**:*
- *Microwave AMSU-like sounder;*
- *25 spectral channels in 3 bands; (50-60 GHz, 118 GHz, and 183 GHz);*
- *3-D distribution of temperature, water vapor, & cloud liquid water;*

***Resolution**:*
- *2 km vertical; 2 km horizontal (nadir);*
- *40 km wide swath;*

2016 NOAA SHOUT
Global Hawk (AV-6) Instrumentation

High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)



***PI**: Dr. Gerald Heymsfield, NASA GSFC*

***Measurements**:*

- *Dual-frequency (Ka- & Ku-band), dual beam, conical scanning Doppler radar;*
- *3-D winds, ocean vector winds, and precip;*

***Resolution**:*

- *60 m vertical, 1 km horizontal;*