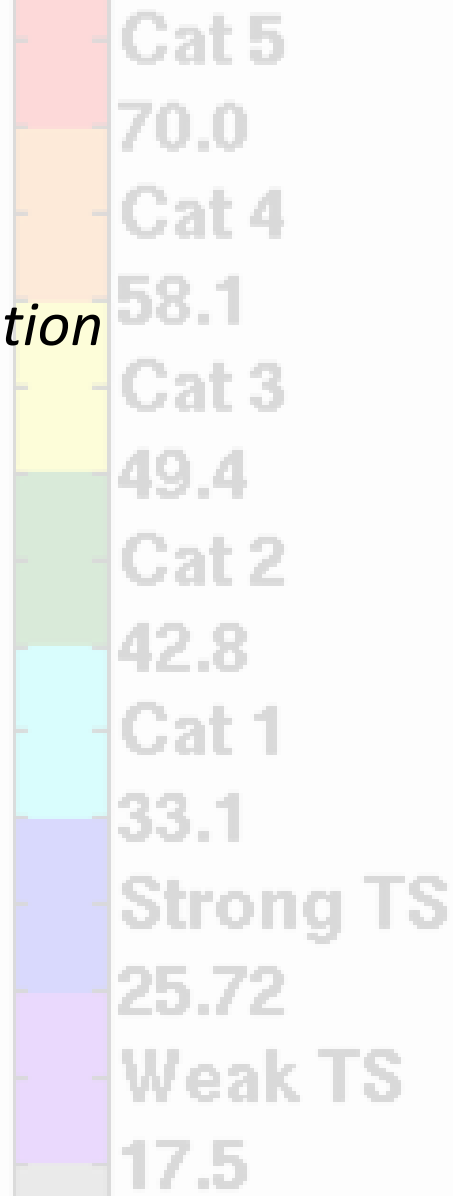
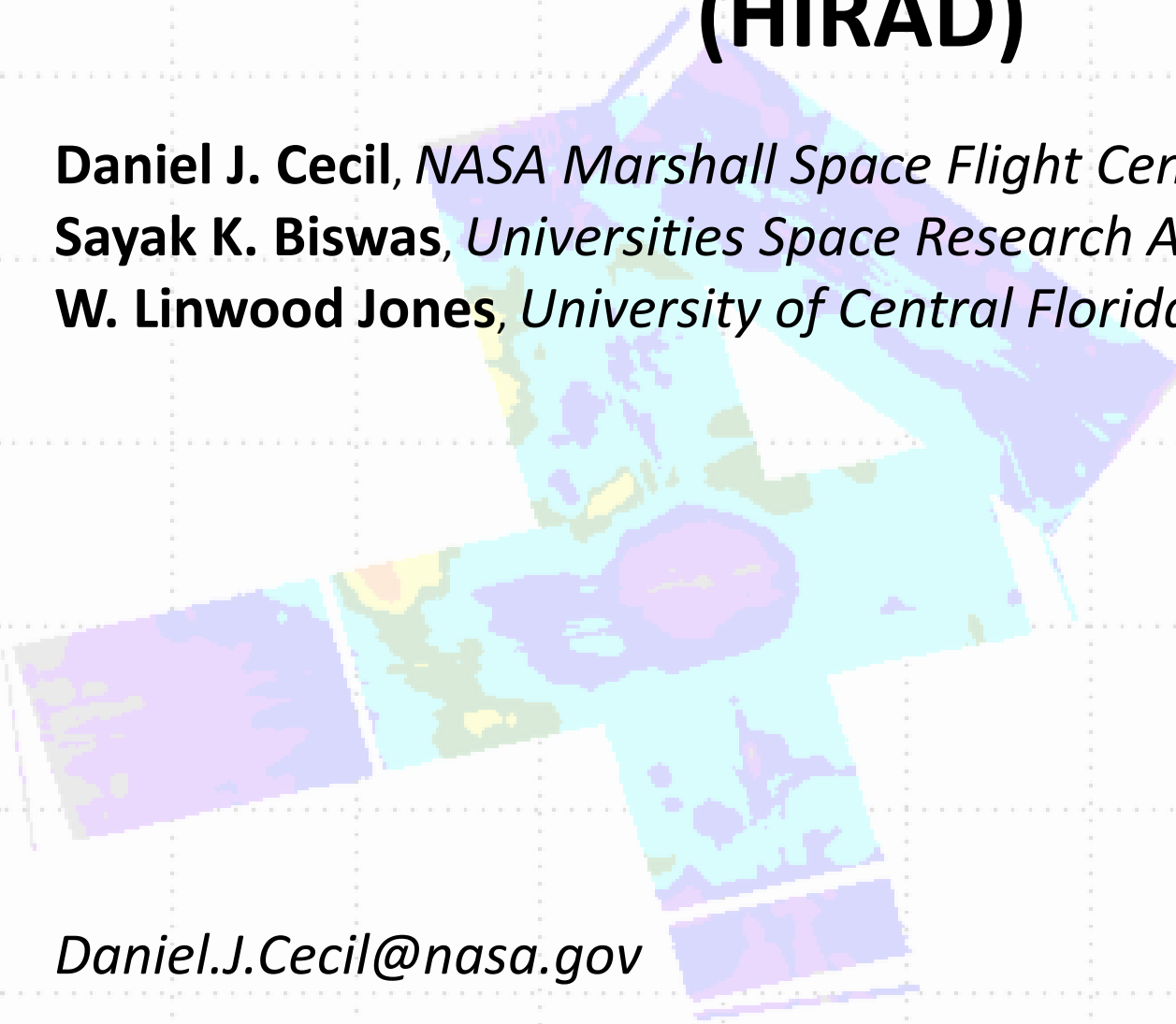


Hurricane Imaging Radiometer (HIRAD)

Daniel J. Cecil, *NASA Marshall Space Flight Center*

Sayak K. Biswas, *Universities Space Research Association*

W. Linwood Jones, *University of Central Florida*



Daniel.J.Cecil@nasa.gov

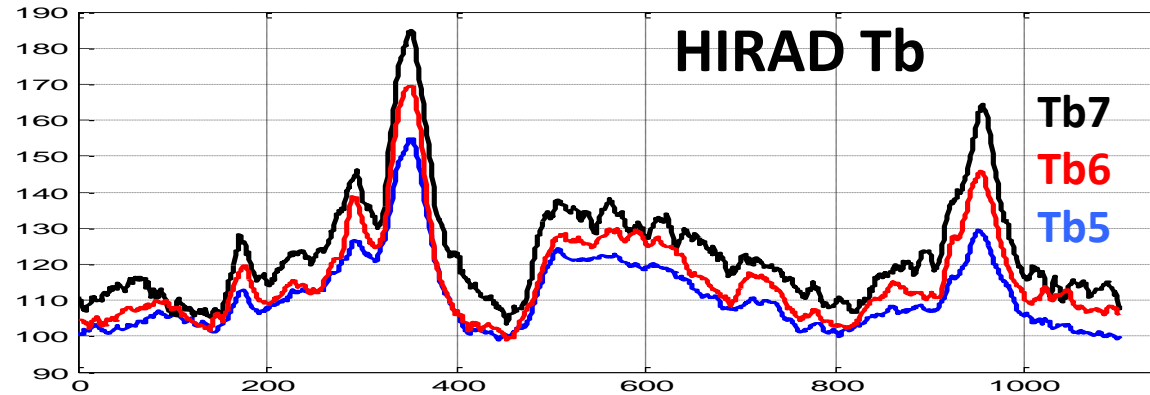
C-band (4, 5, 6, 6.6 GHz)
radiometer

Retrieval concept similar to
the operational Stepped
Frequency Microwave
Radiometer (SFMR)

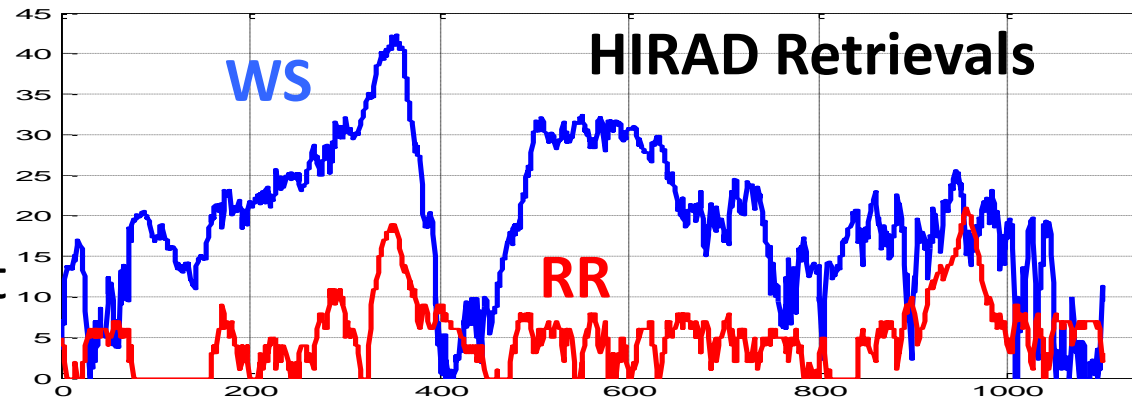
**Retrieve Wind Speed and
Rain Rate over ocean, *but
over a wide swath***

C-band frequencies have
varying sensitivity to rain but
~equal sensitivity to wind
speed (emission from foam
on wind-roughened ocean
surface)

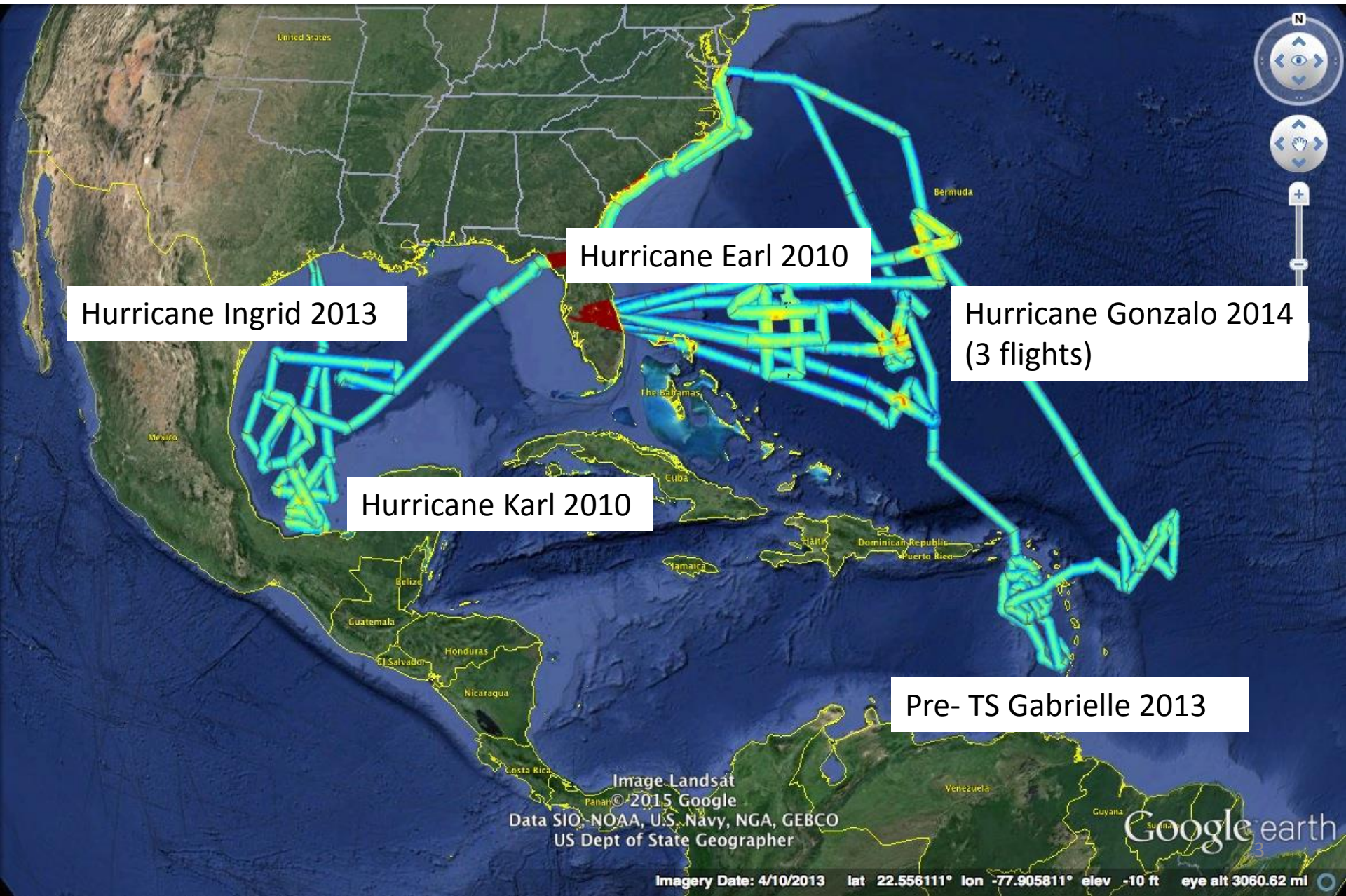
HIRAD Background



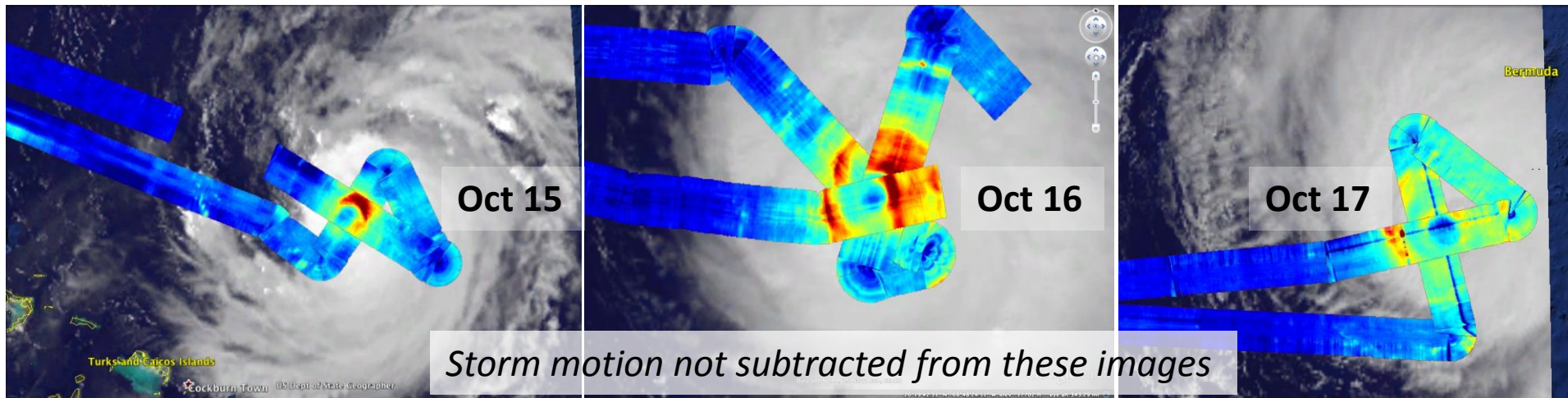
Hurricane Karl (2010) example



HIRAD Science Flights



Hurricane Gonzalo (2014)



Flown on NASA WB-57 based out of Houston, forward-deployed to Tampa

Cooperation between NASA HS3 program and ONR TCI program

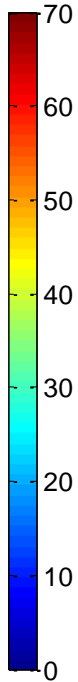
Instruments were integrated onto Global Hawk AV-1 in July for HS3, but AV-1 was unable to perform missions. WB-57 was available for hurricane flights because of the ONR program, so HIRAD and HIWRAP were moved from Global Hawk to WB-57. Kudos to all who made this switch possible!

Center Crossings at 20:34 and 21:12 UTC

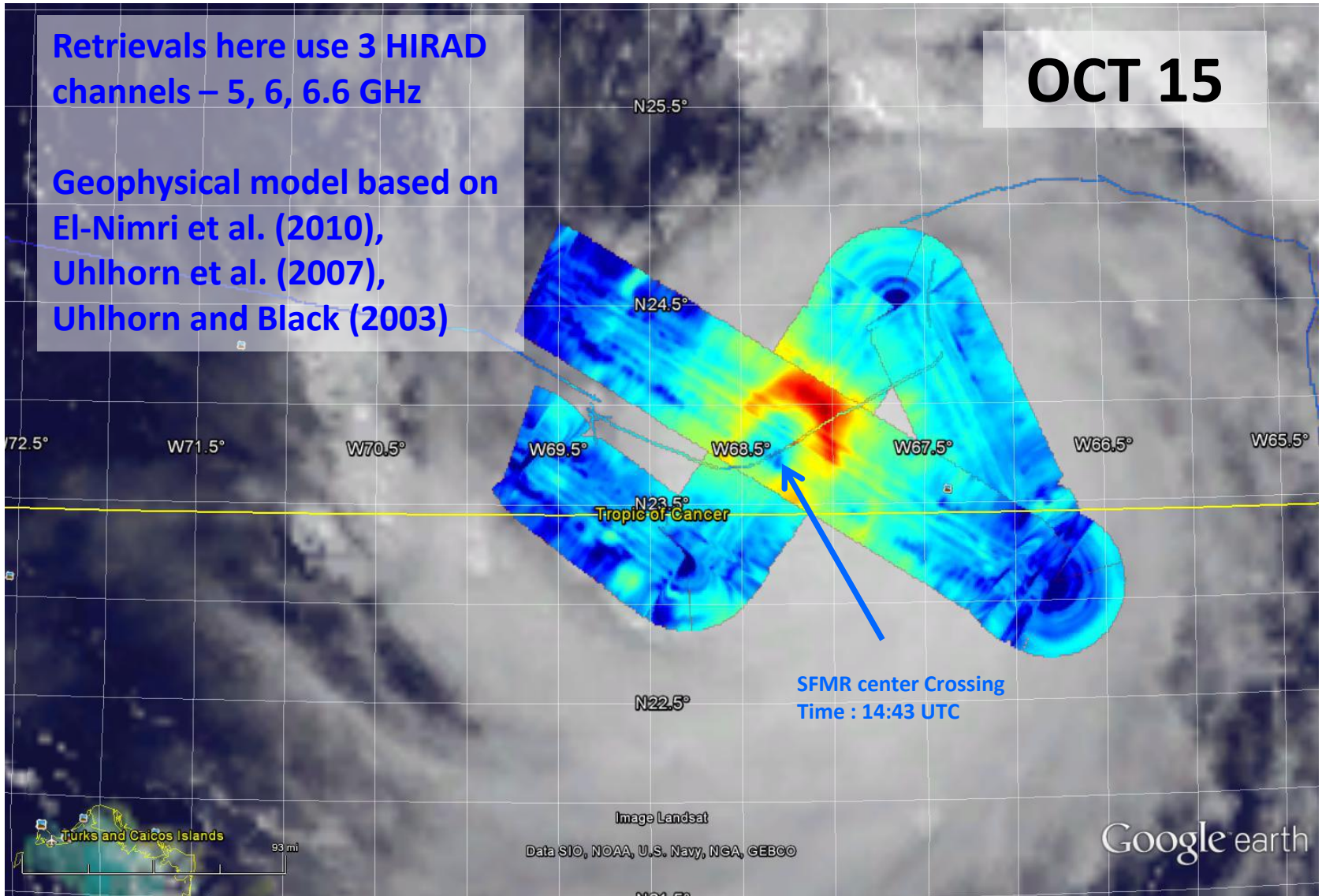
OCT 15

Retrievals here use 3 HIRAD channels – 5, 6, 6.6 GHz

Geophysical model based on El-Nimri et al. (2010), Uhlhorn et al. (2007), Uhlhorn and Black (2003)

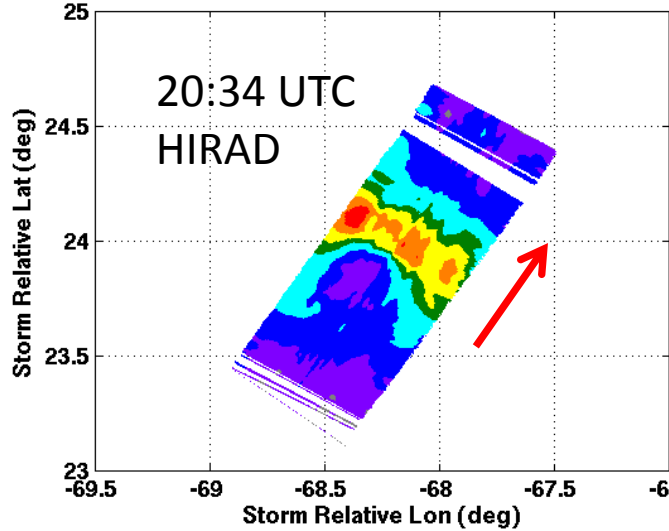


WS
(m/s)



Wind Retrievals – Oct 15 Gonzalo

LOS# 1 HIRAD Wind Speed (m/s), (Roll $< \pm 1$ deg)



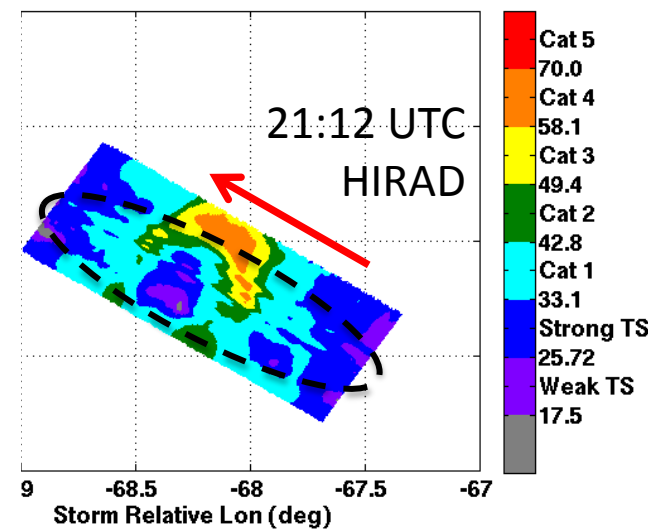
HIRAD has biases at some incidence angles, seen as along-track striping.

Also tends to be high-biased along left edge.

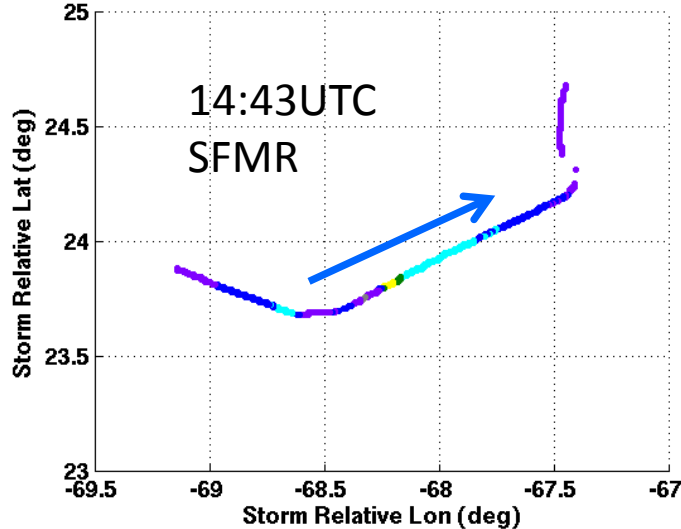
Work in progress

Retrievals here use 3 HIRAD channels – 5, 6, 6.6 GHz

HIRAD Wind Speed (m/s), (Roll $< \pm 1$ deg)

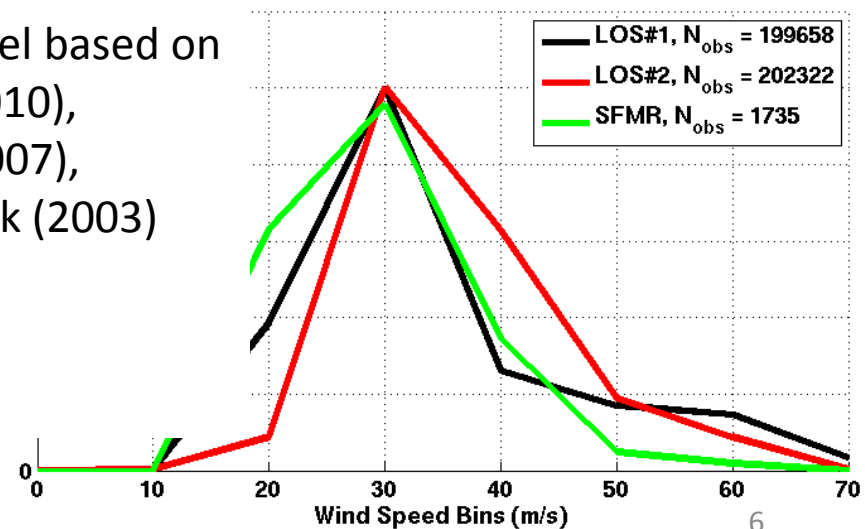


SFMR Wind Speed (m/s), (Over The Storm Portion)

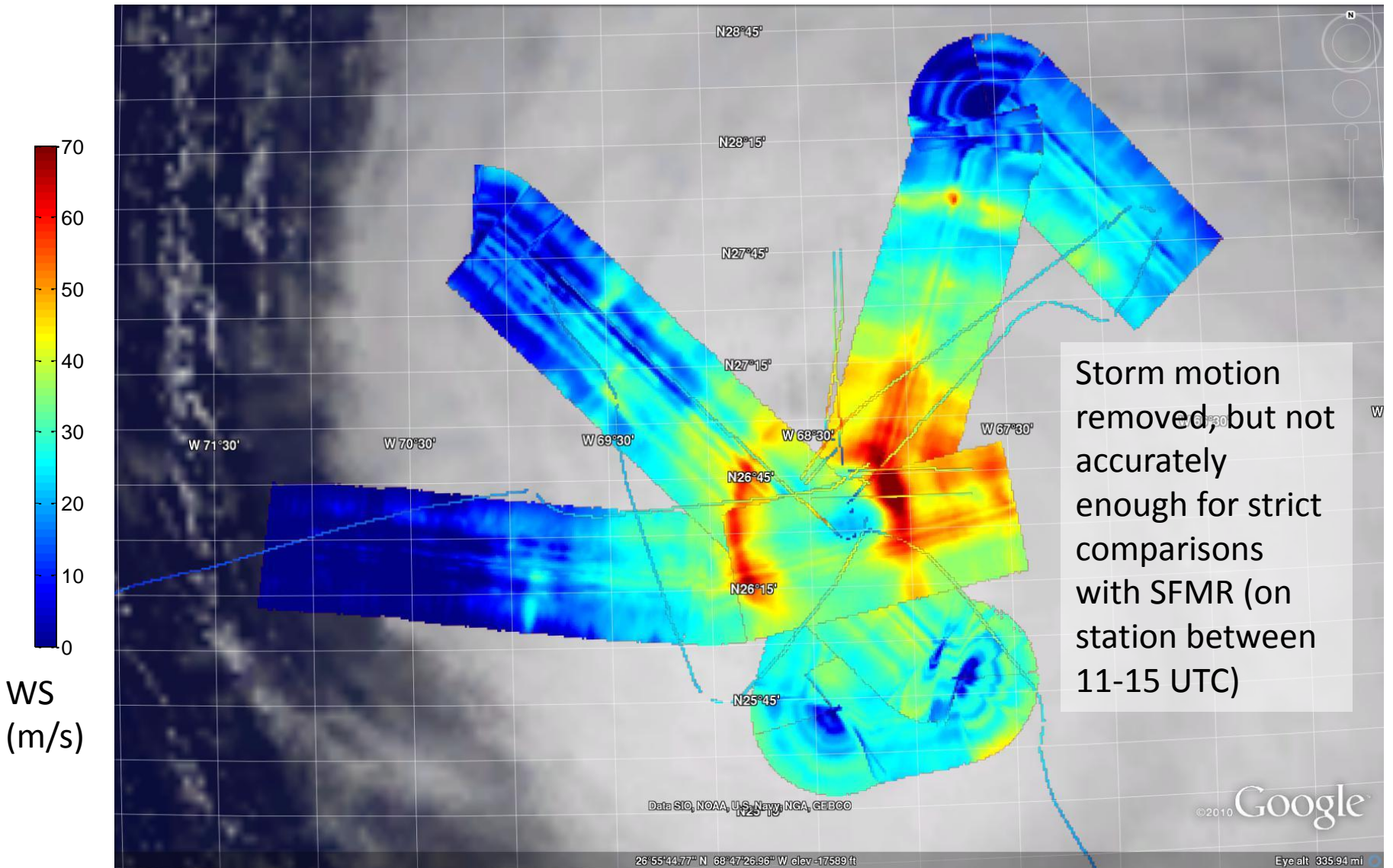


Geophysical model based on El-Nimri et al. (2010), Uhlhorn et al. (2007), Uhlhorn and Black (2003)

Wind Speed Histogram Comparison



Oct 16 Center at 1711, 1803, 1825 UTC



HIRAD Wind Retrieval, 16 Oct 2014 Gonzalo

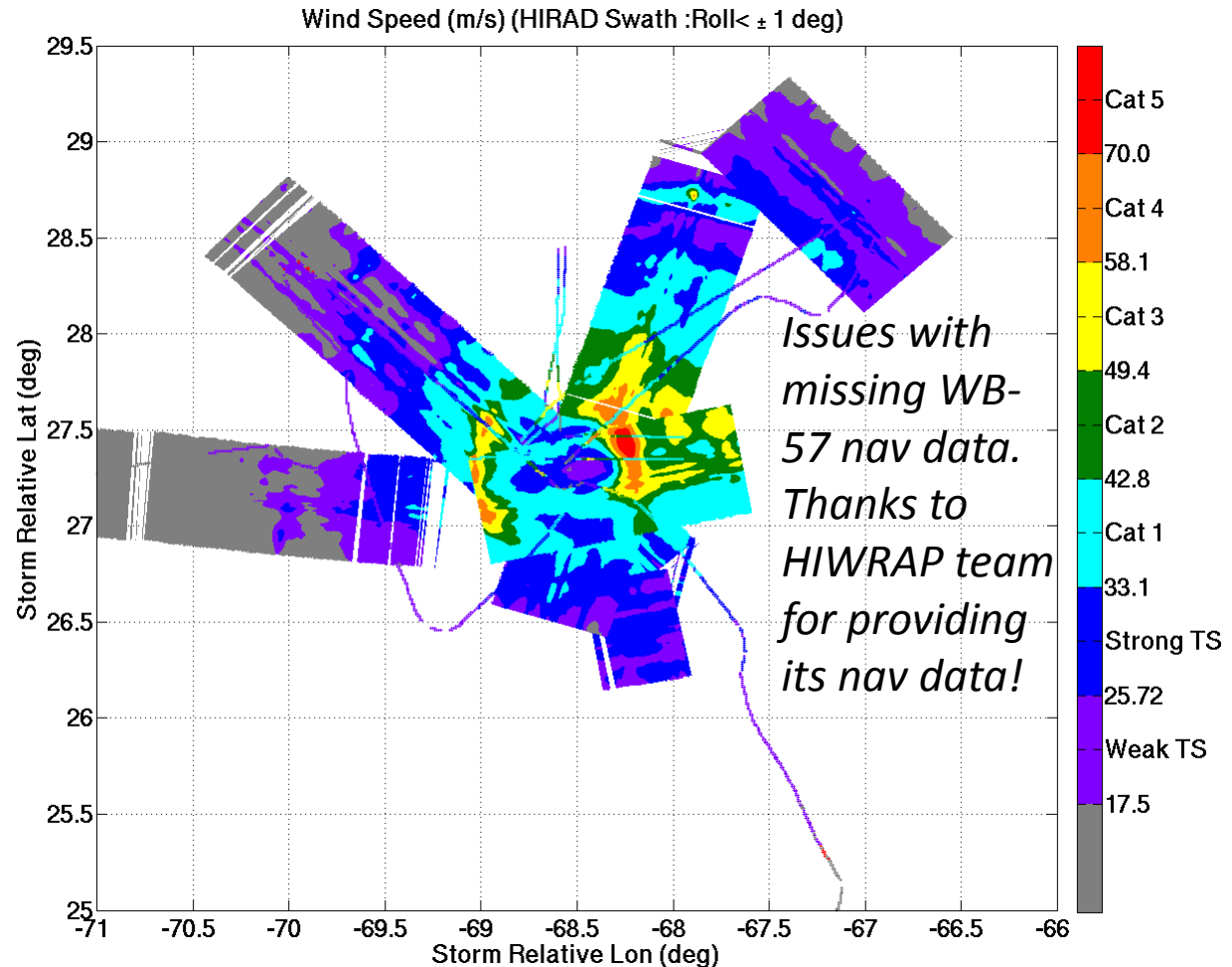
Along-track striping more pronounced, more difficult to remove than on other days

Our heaters turned on with inappropriate set points during this flight, making 16 Oct data difficult to handle

Some issues with removal of storm motion in this imagery, but correctable

The inner-core looks muddled here, but that I apparently because:

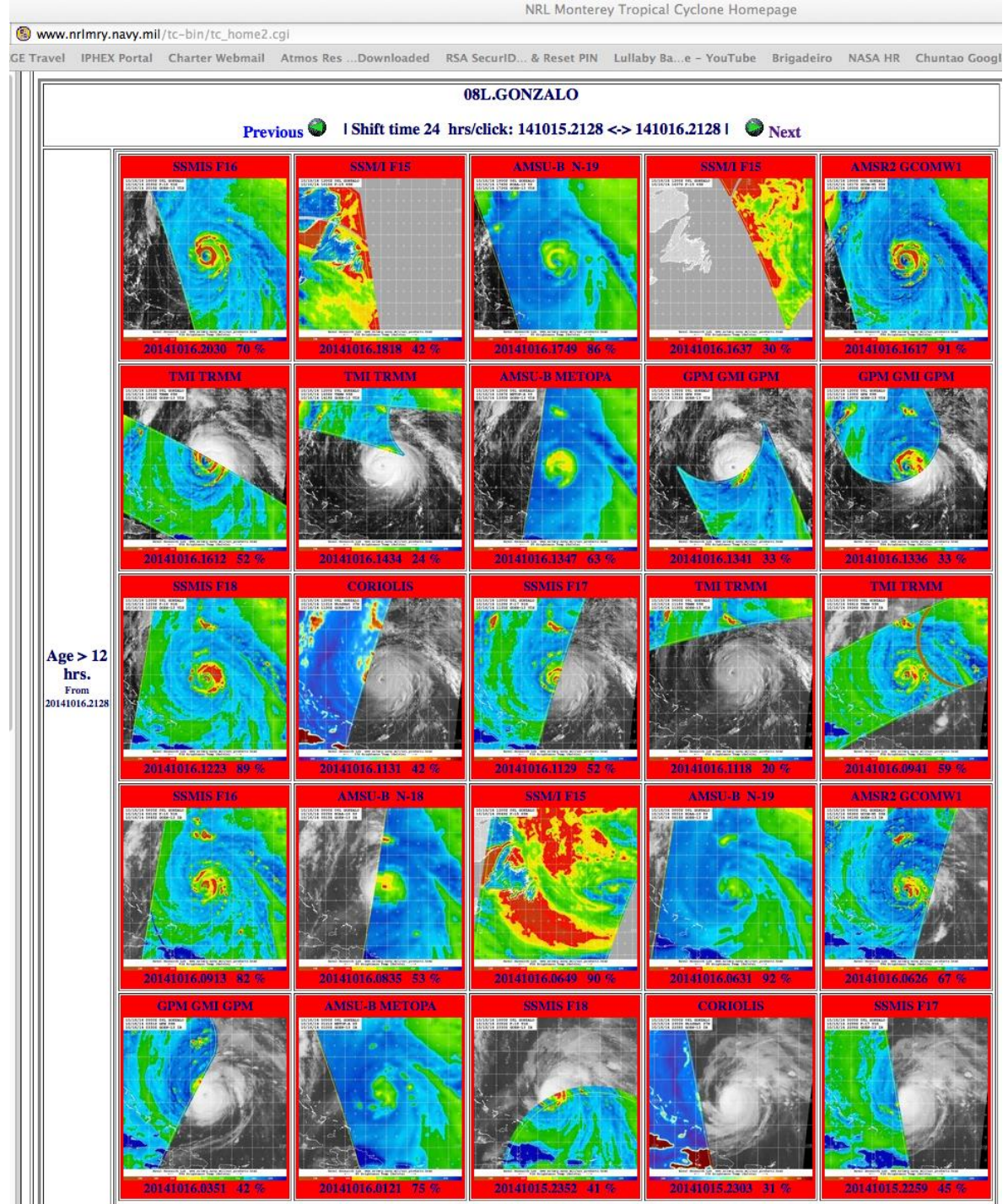
- an inner eyewall was strong on East and Northeast sides, weak elsewhere
- an outer eyewall was strong on West side, weak on South side



Eyewall Replacement Cycle during 16 Oct 2014 for Gonzalo

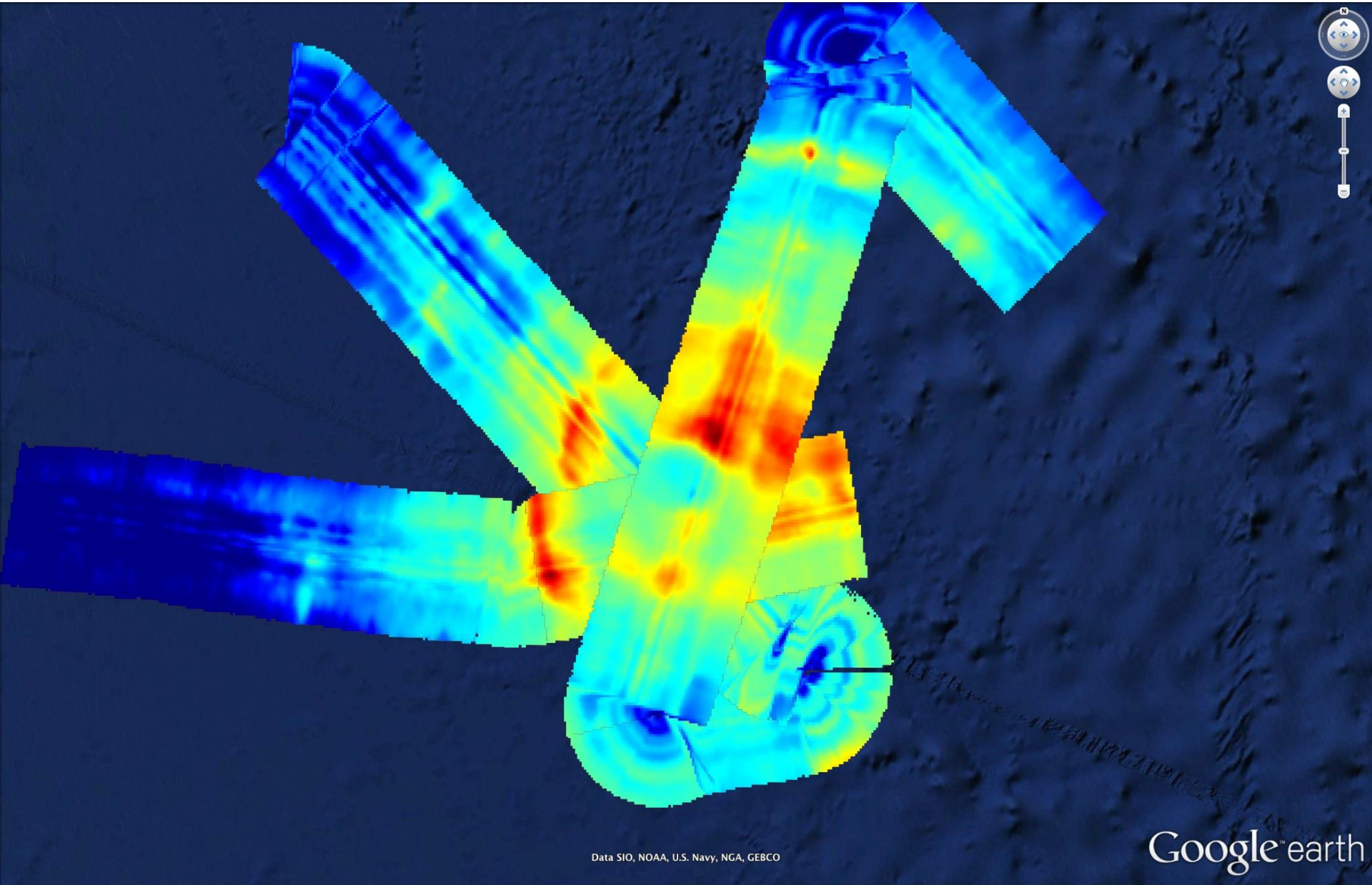
*85-89 GHz Mosaic
from NRL MRY TC
Web Page*

*WB57 on station
~1700-1830 UTC,
top row of
overpasses*



AMSR2 89 GHz at 1617 UTC 16 Oct

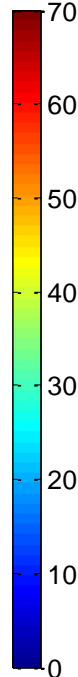
HIRAD at 1711, 1803, 1825 UTC



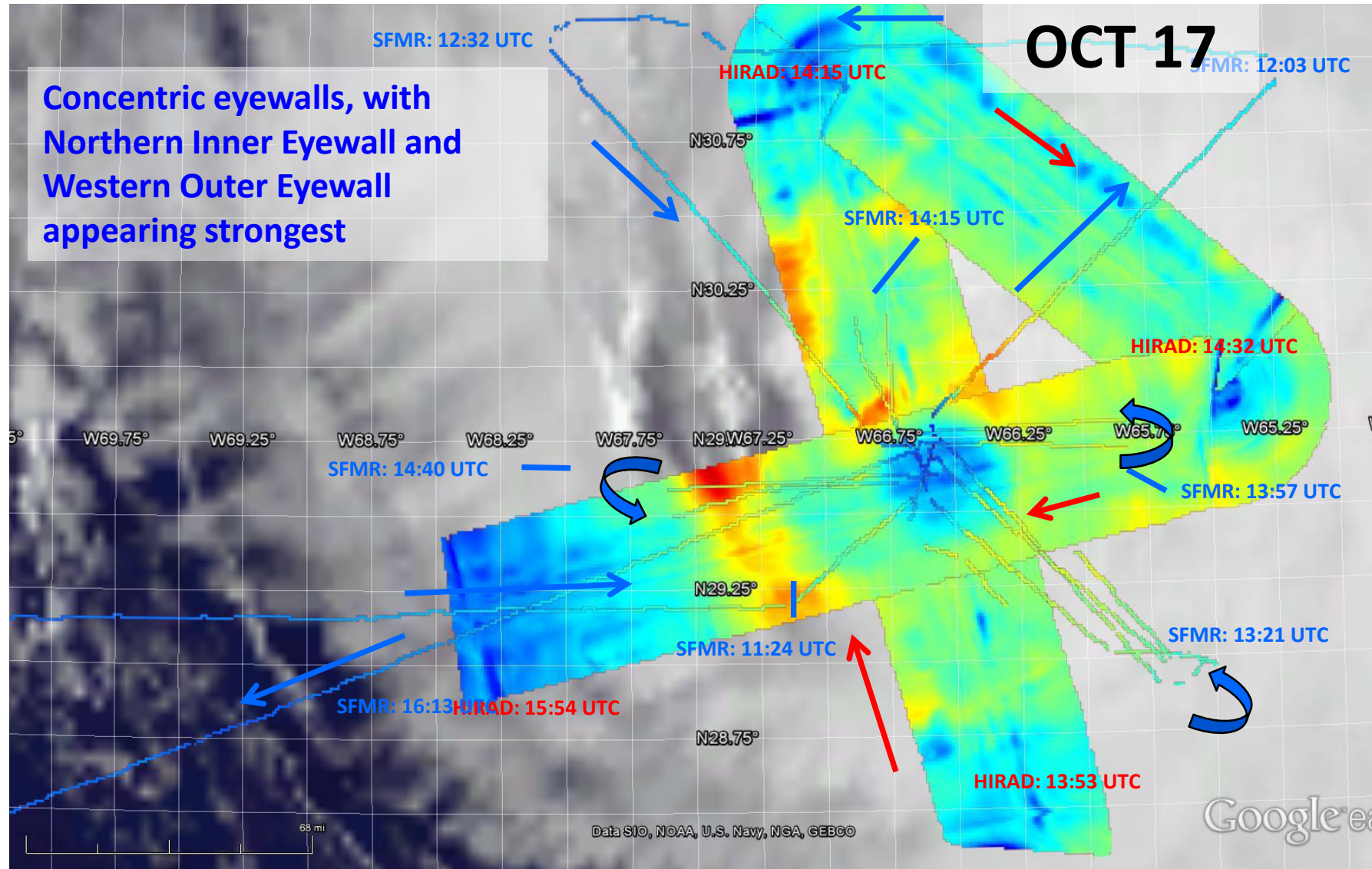
Center Crossings at 14:04 and 14:41 UTC

OCT 17

Concentric eyewalls, with Northern Inner Eyewall and Western Outer Eyewall appearing strongest

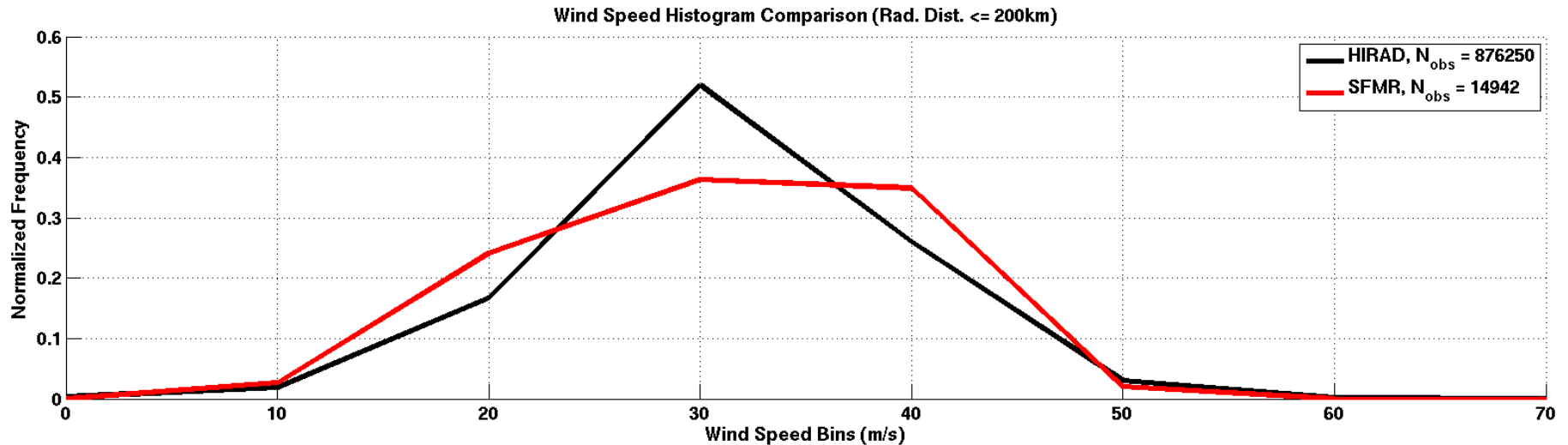
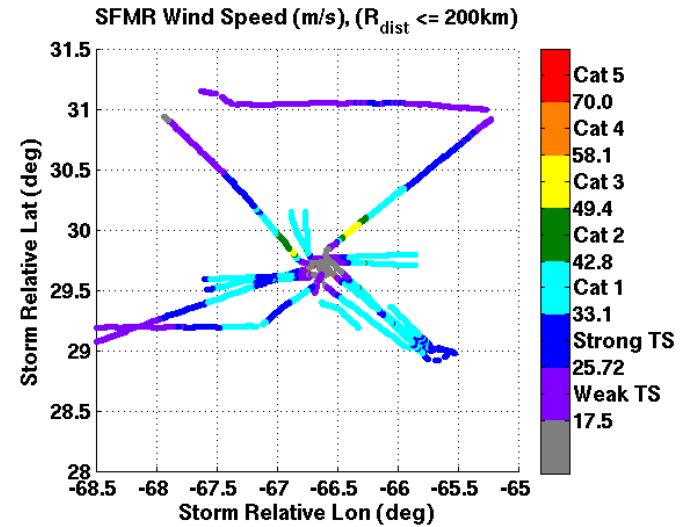
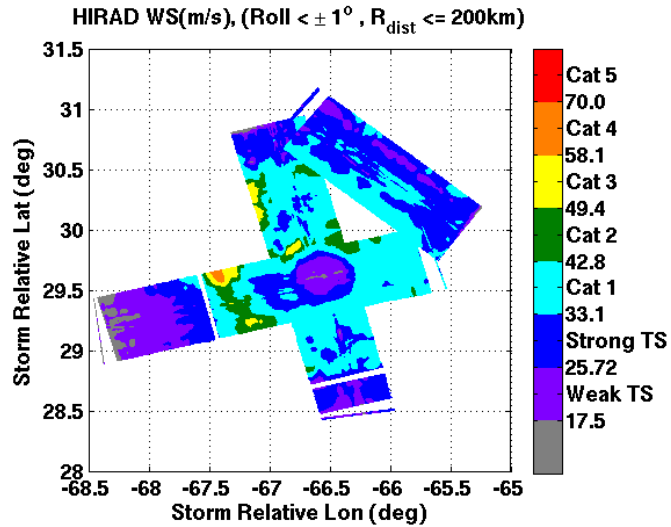


WS (m/s)

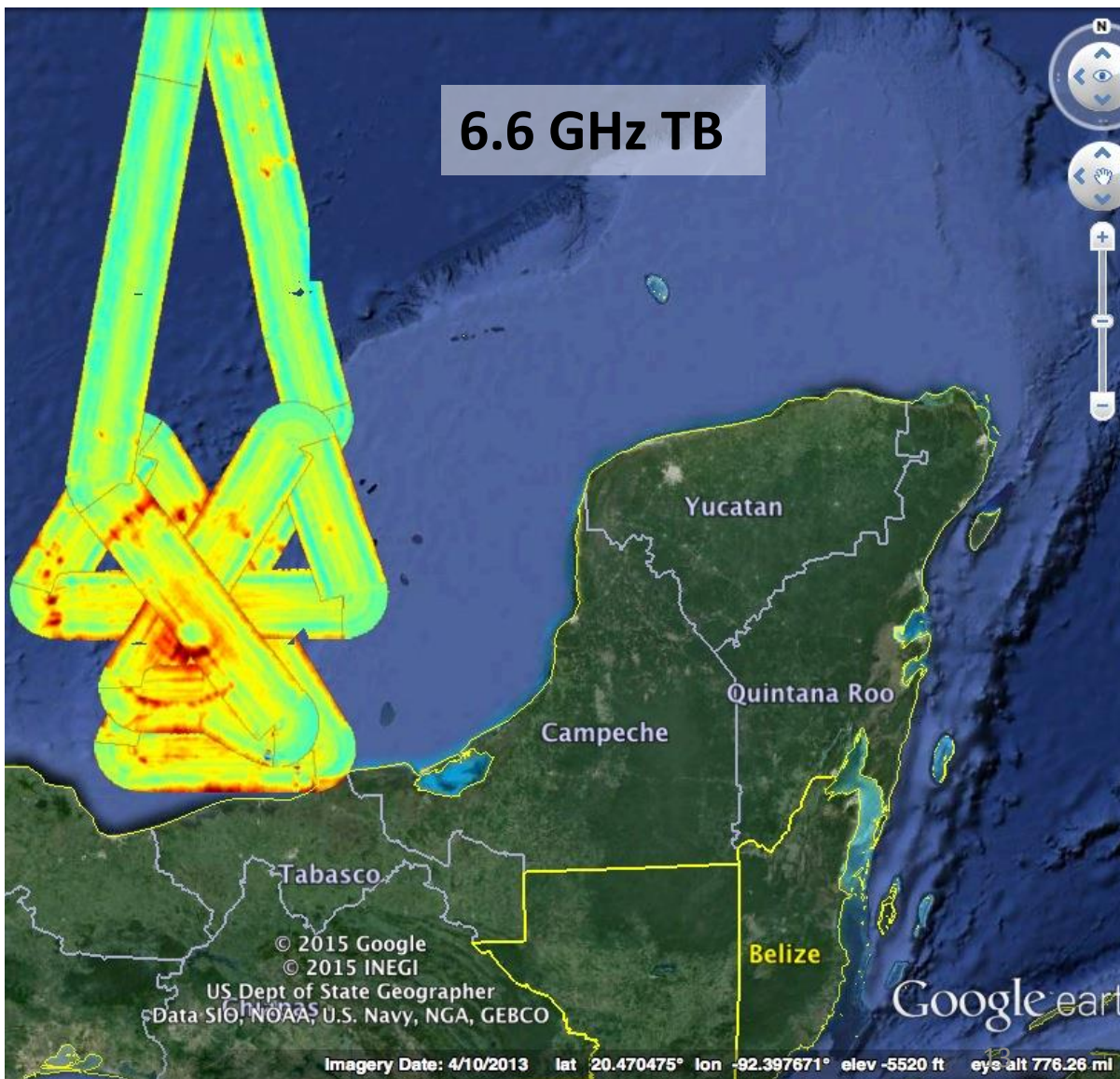
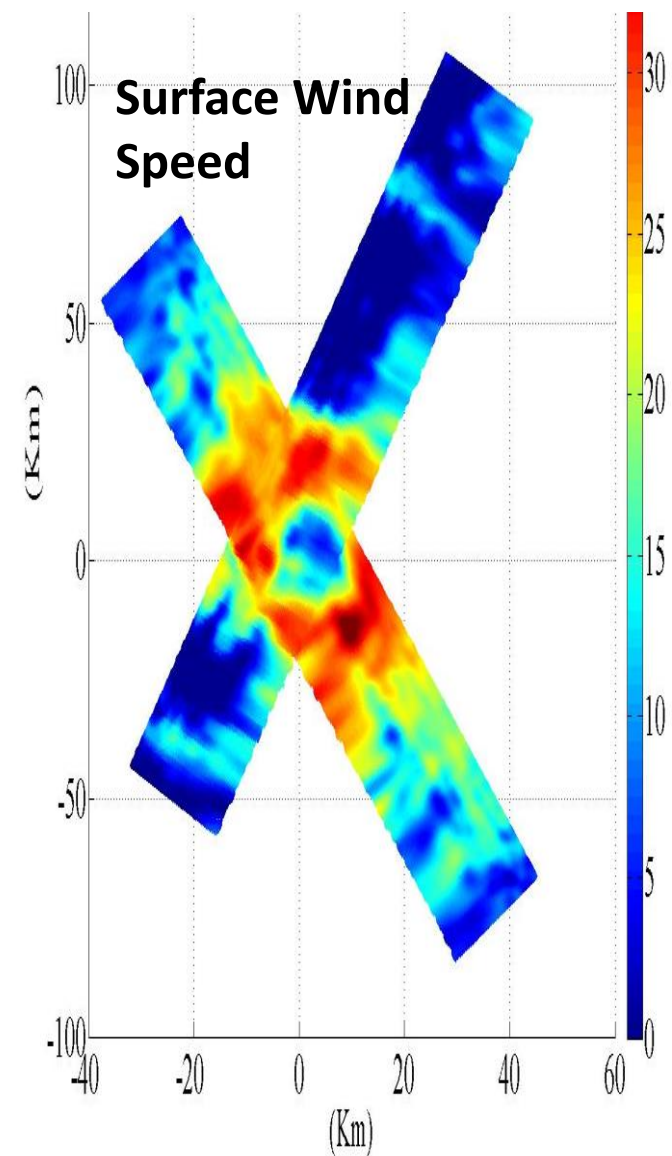


GOES Cloud Image @ 12:15 UTC

Wind Retrievals – Oct 17 Gonzalo



Hurricane Karl (2010) Brightness Temp and Wind Speed Retrieval



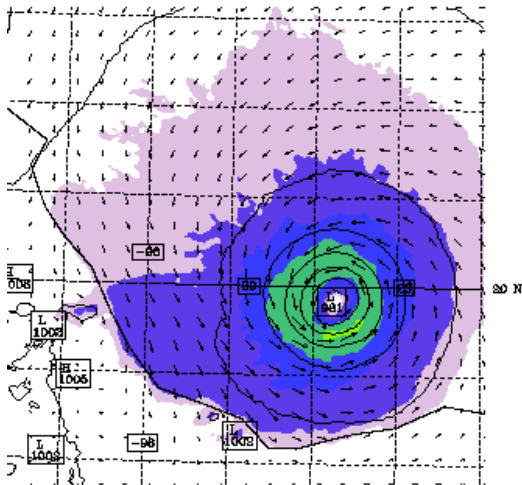
HIRAD Wind Retrieval, Assimilation for Hurricane Karl

Surface wind field in data assimilation experiments from Jason Sippel at GSFC

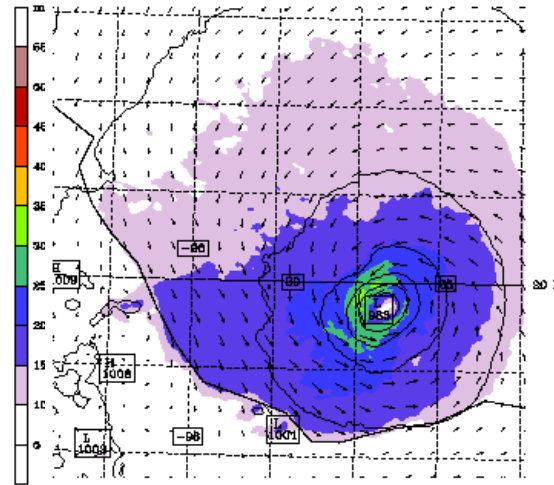
Adding HIRAD (bottom middle) improves characterization of asymmetric nature of wind field, and correctly reduces the horizontal extent of the wind field. Control and Control+HIWRAP(radar) experiments had Radii of 50-kt and 34-kt winds too large, compared to Best Track

Best results from assimilating Dropsonde, HIRAD, HIWRAP together

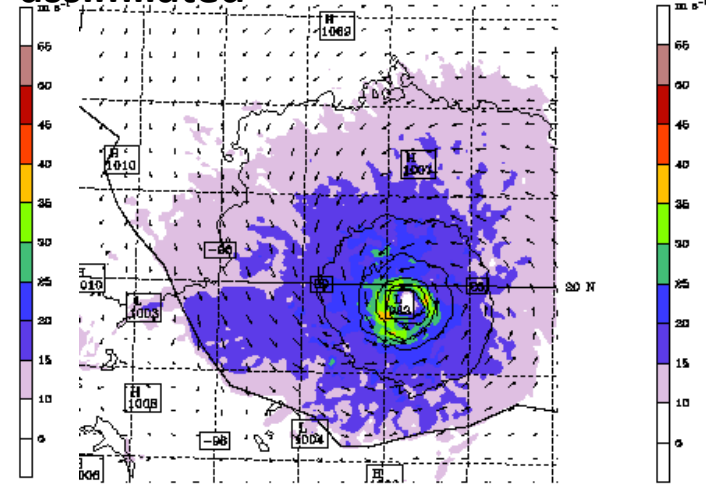
HIWRAP VAD wind assimilated



HIRAD surface wind and HIWRAP VAD wind assimilated



HIRAD surface wind, dropsonde wind, and HIWRAP VAD wind assimilated



Summary

- 3 Science Flights from WB-57 over Hurricane Gonzalo (2014)
- Wide-swath data helps paint a picture of hurricane structure
- Initial retrievals from Oct 15, Oct 17 flights look good, some systematic (scan-angle dependent) biases remaining
- Oct 16 data has more striping, but hurricane structure is there – eyewall replacement in progress
- Hurricane Karl (2010) wind retrievals tested in assimilation with dropsondes and HIWRAP; improved structure of wind radii

