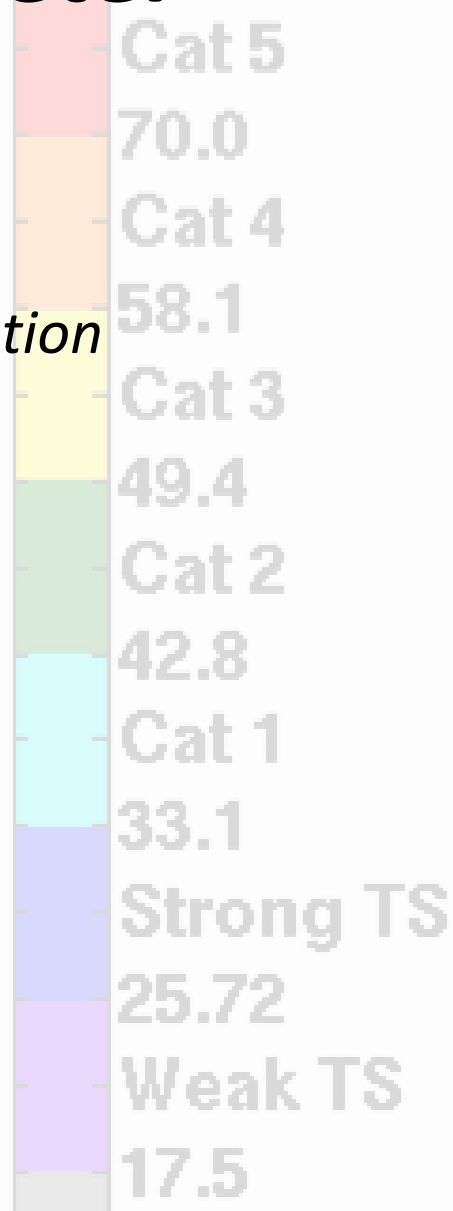
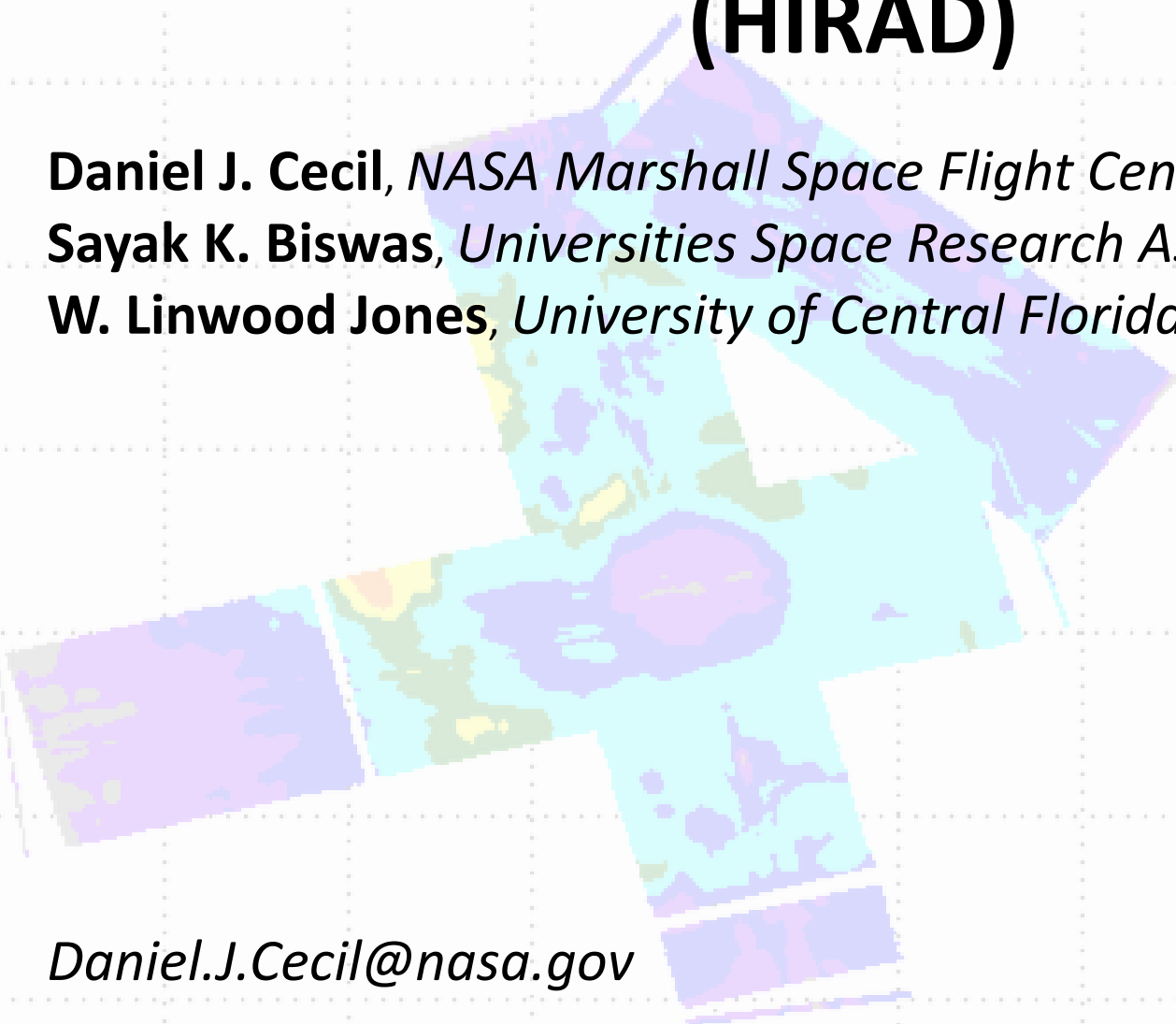


# Hurricane Imaging Radiometer (HIRAD)

**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*

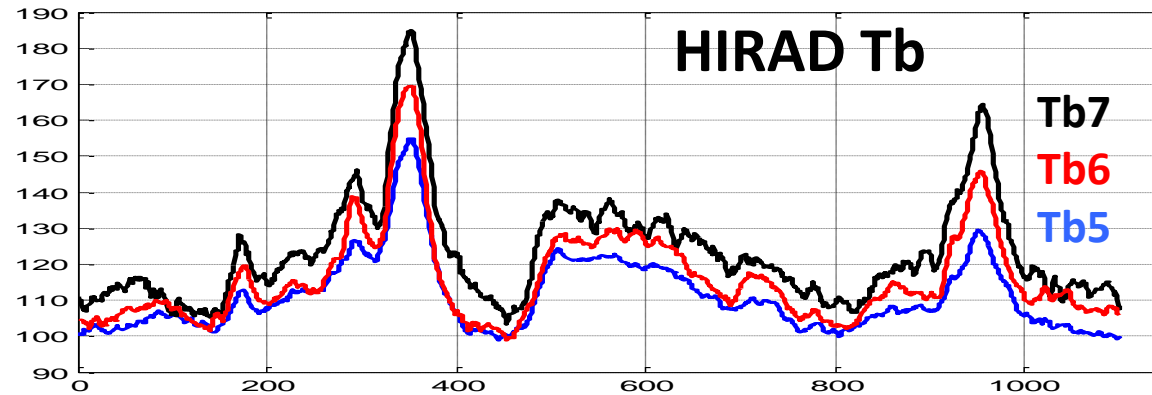
C-band (4, 5, 6, 6.6 GHz)  
radiometer

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

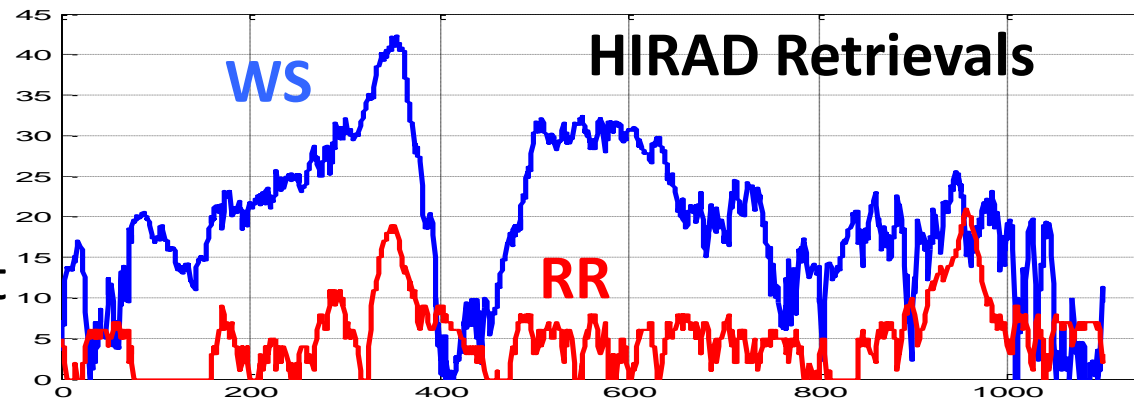
**Retrieve Wind Speed and  
Rain Rate over ocean, *but  
over a wide swath***

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

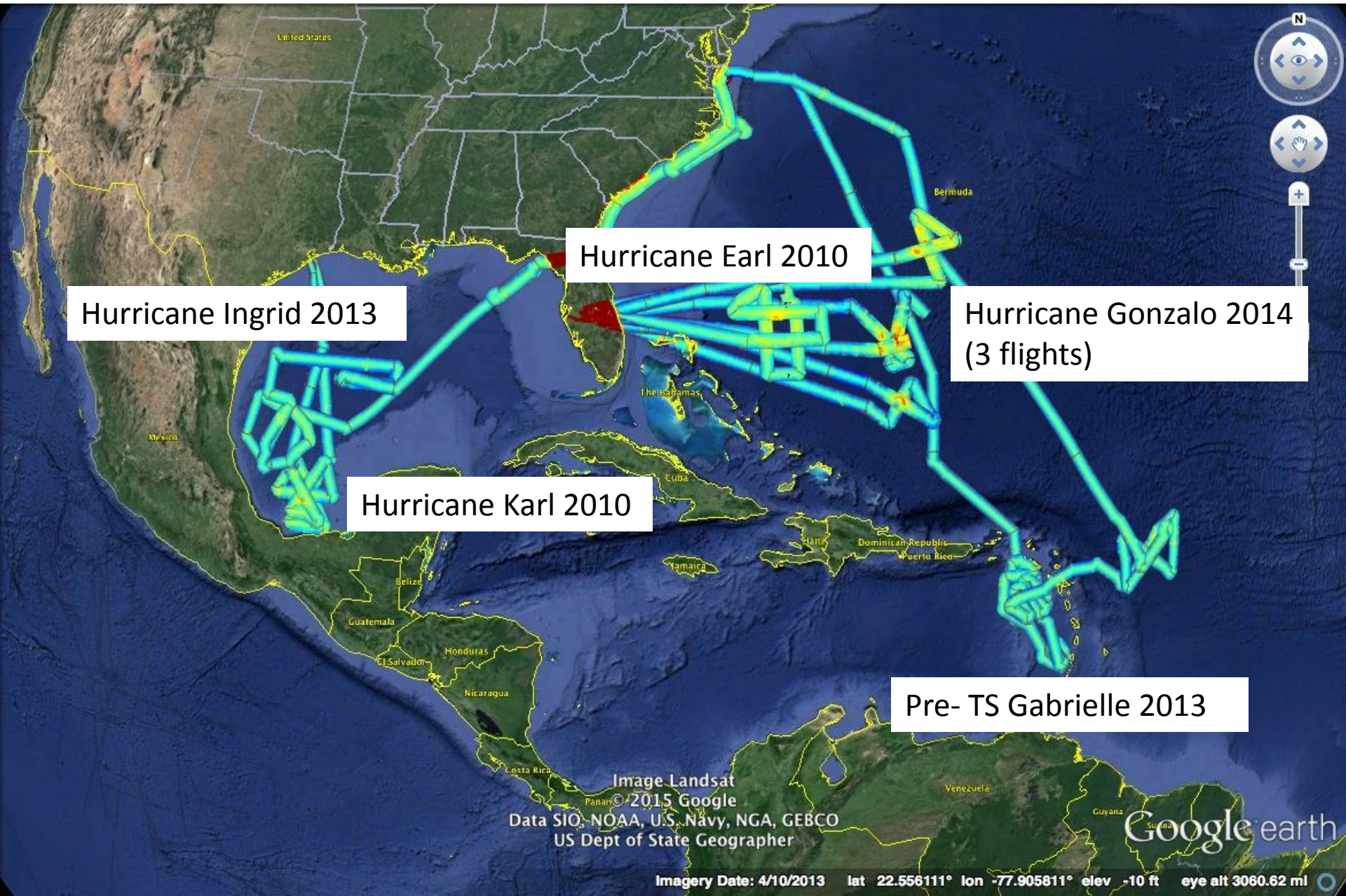
# HIRAD Background



*Hurricane Karl (2010) example*



# HIRAD Science Flights



Hurricane Ingrid 2013

Hurricane Earl 2010

Hurricane Gonzalo 2014  
(3 flights)

Hurricane Karl 2010

Pre-TS Gabrielle 2013

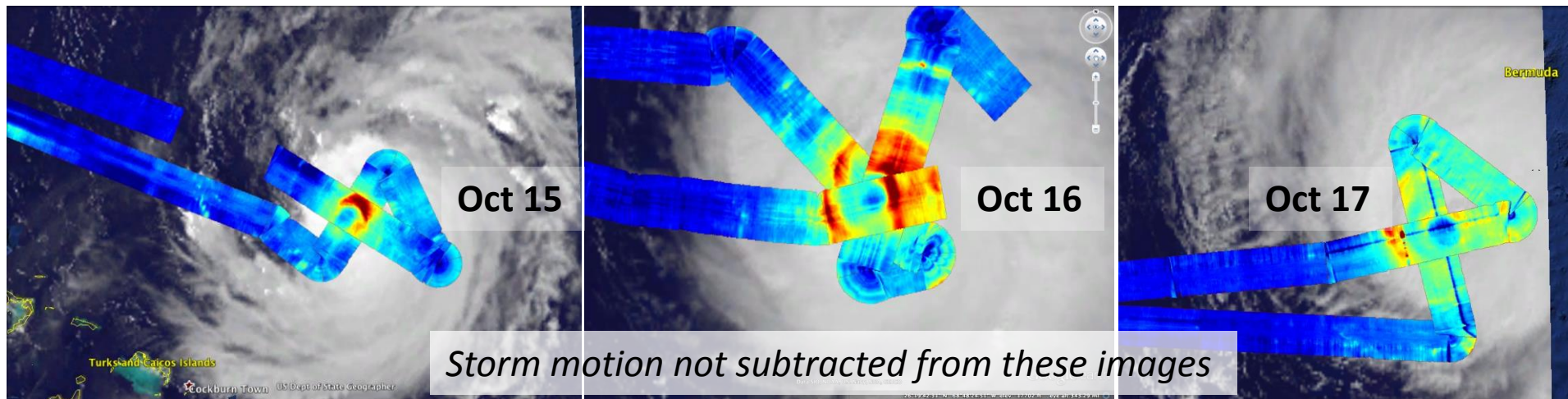
Image Landsat  
Panar © 2015 Google  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
US Dept of State Geographer

Google earth

Imagery Date: 4/10/2013 lat 22.556111° lon -77.905811° elev -10 ft eye alt 3060.62 mi



# Hurricane Gonzalo (2014)

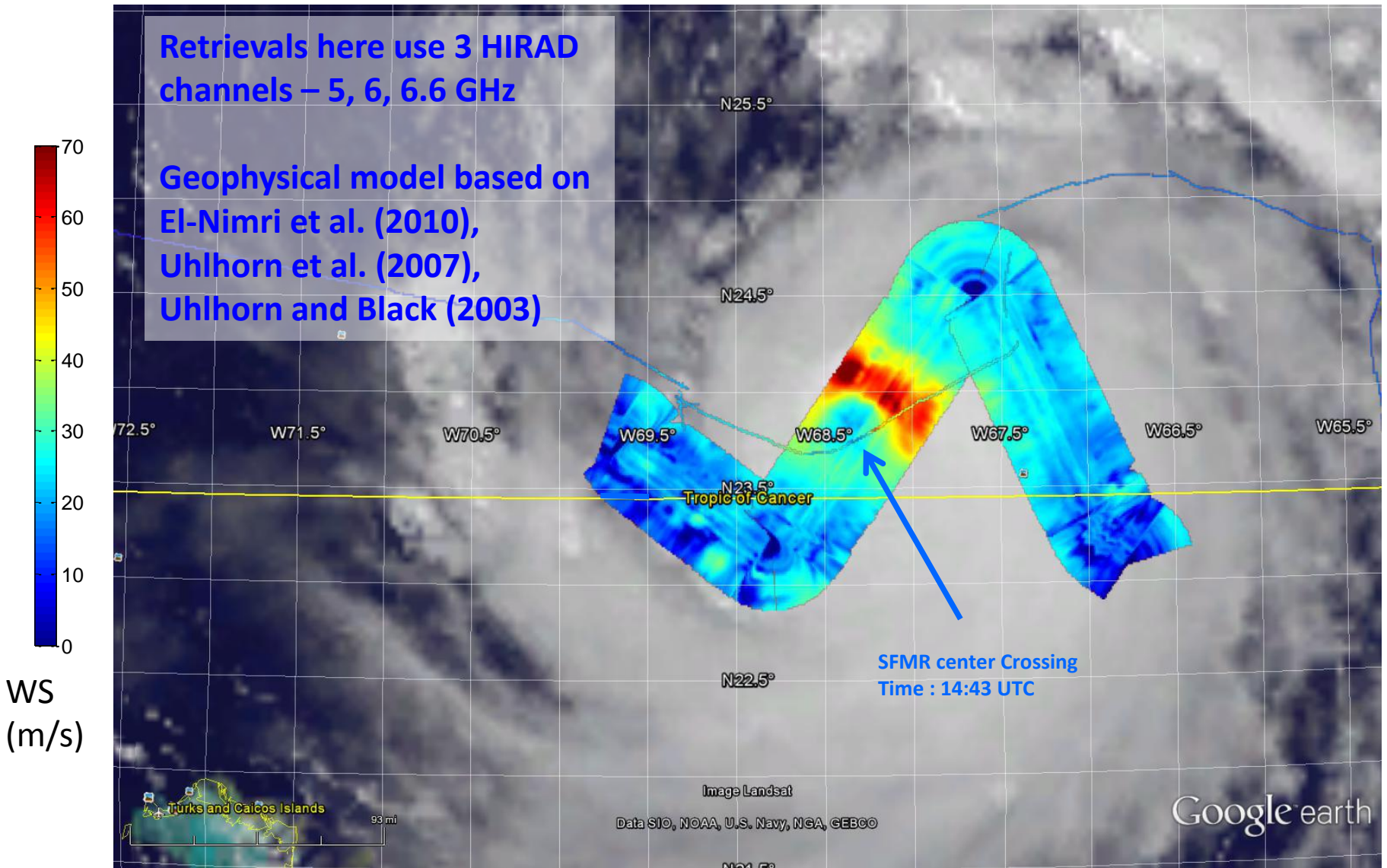


Flown on NASA WB-57 based out of Houston, forward-deployed to Tampa

Cooperation between NASA HS3 program and ONR TCI program

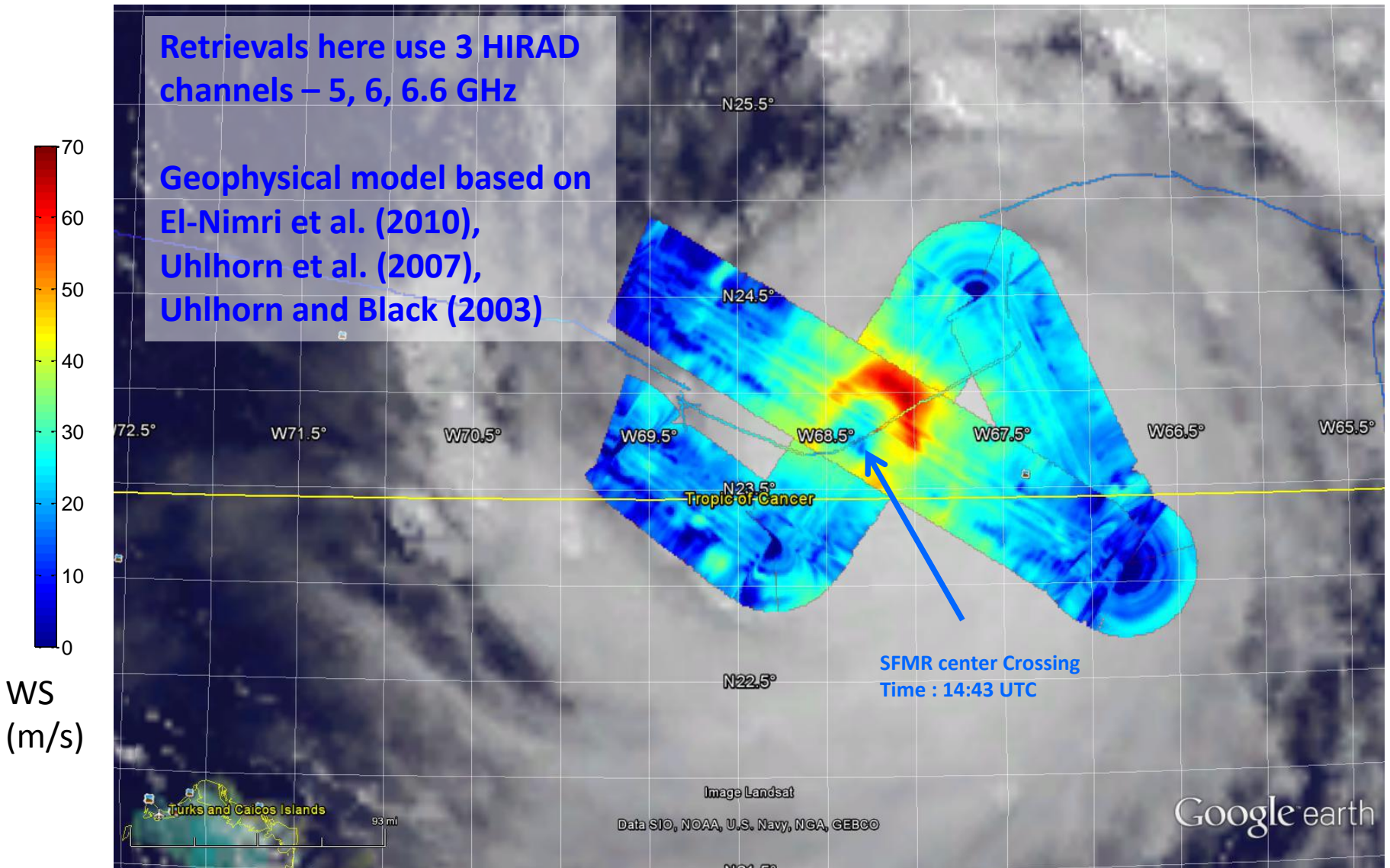
Instruments were integrated onto Global Hawk AV-1 in July for HS3, but AV-1 was unable to perform missions. WB-57 was available for hurricane flights because of the ONR program, so HIRAD and HIWRAP were moved from Global Hawk to WB-57. Kudos to all who made this switch possible!

# First Storm Center Crossing: 20:34 UTC



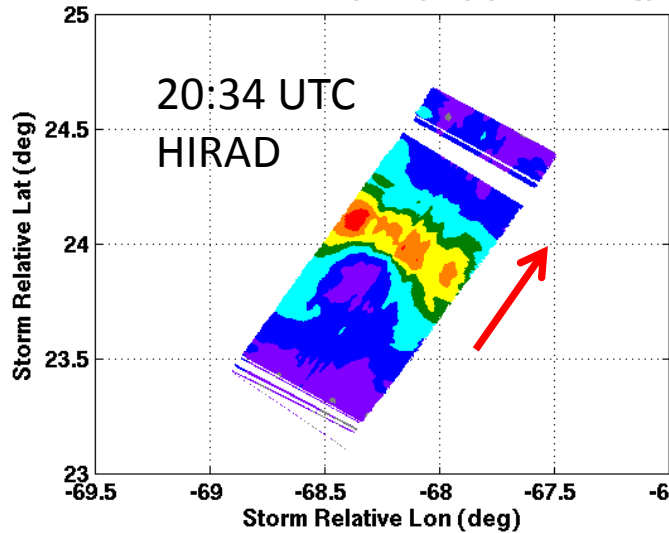


# Second Storm Center Crossing: 21:12 UTC



# Wind Retrievals – Oct 15 Gonzalo

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



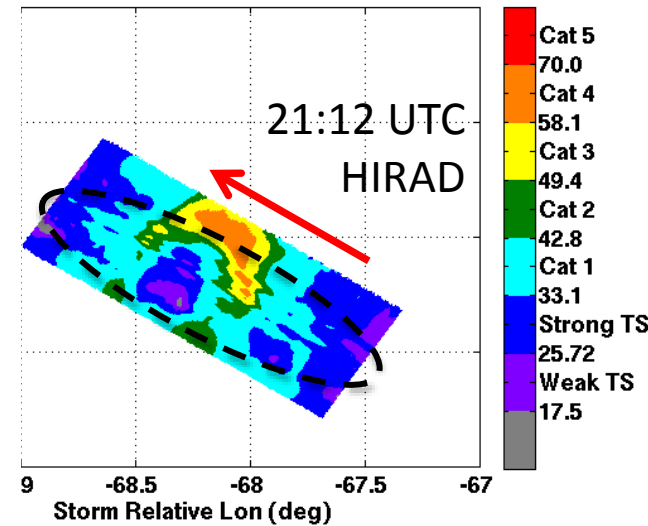
HIRAD has biases at some incidence angles, seen as along-track striping.

Also tends to be high-biased along left edge.

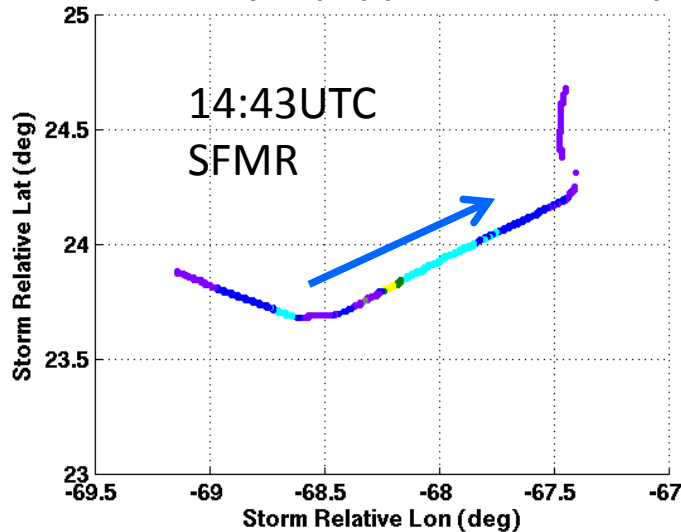
Work in progress

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

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

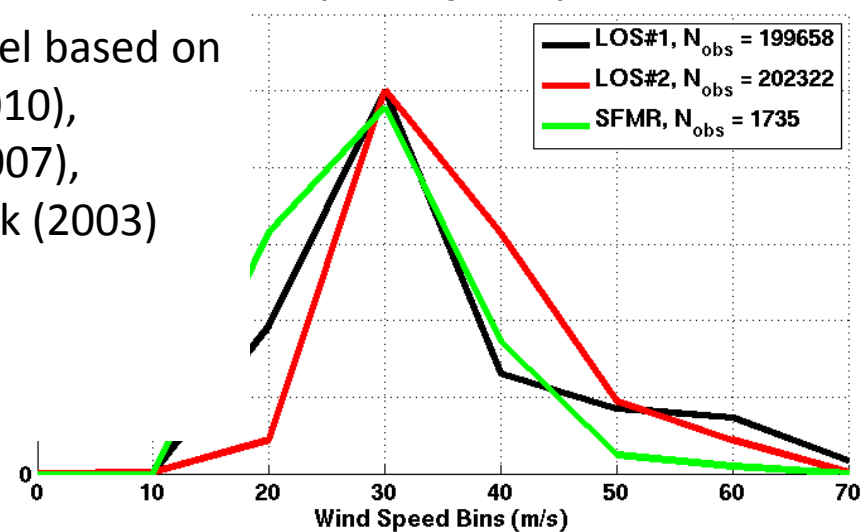


SFMR Wind Speed (m/s), (Over The Storm Portion)

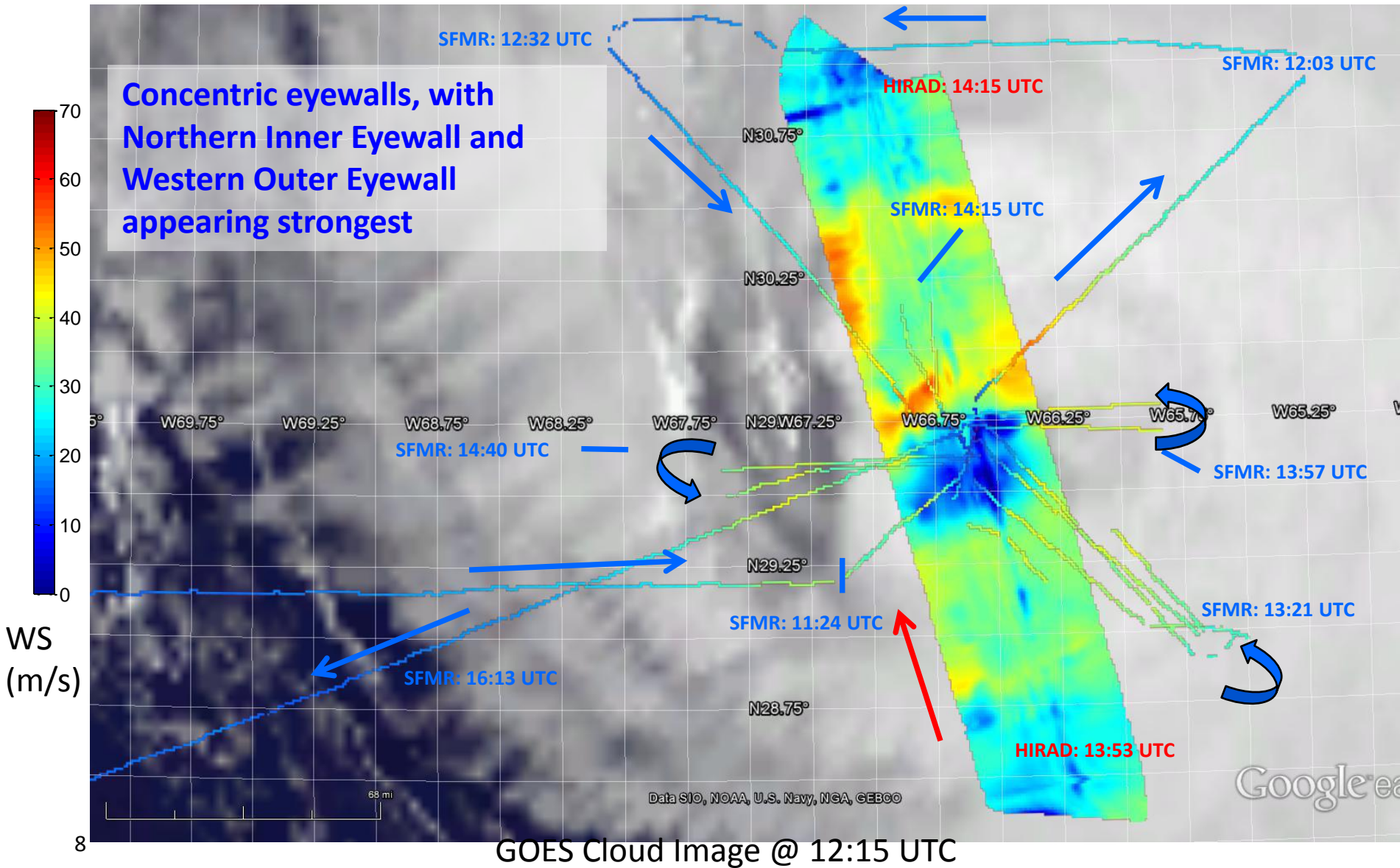


Geophysical model based on El-Nimri et al. (2010), Uhlhorn et al. (2007), Uhlhorn and Black (2003)

Wind Speed Histogram Comparison

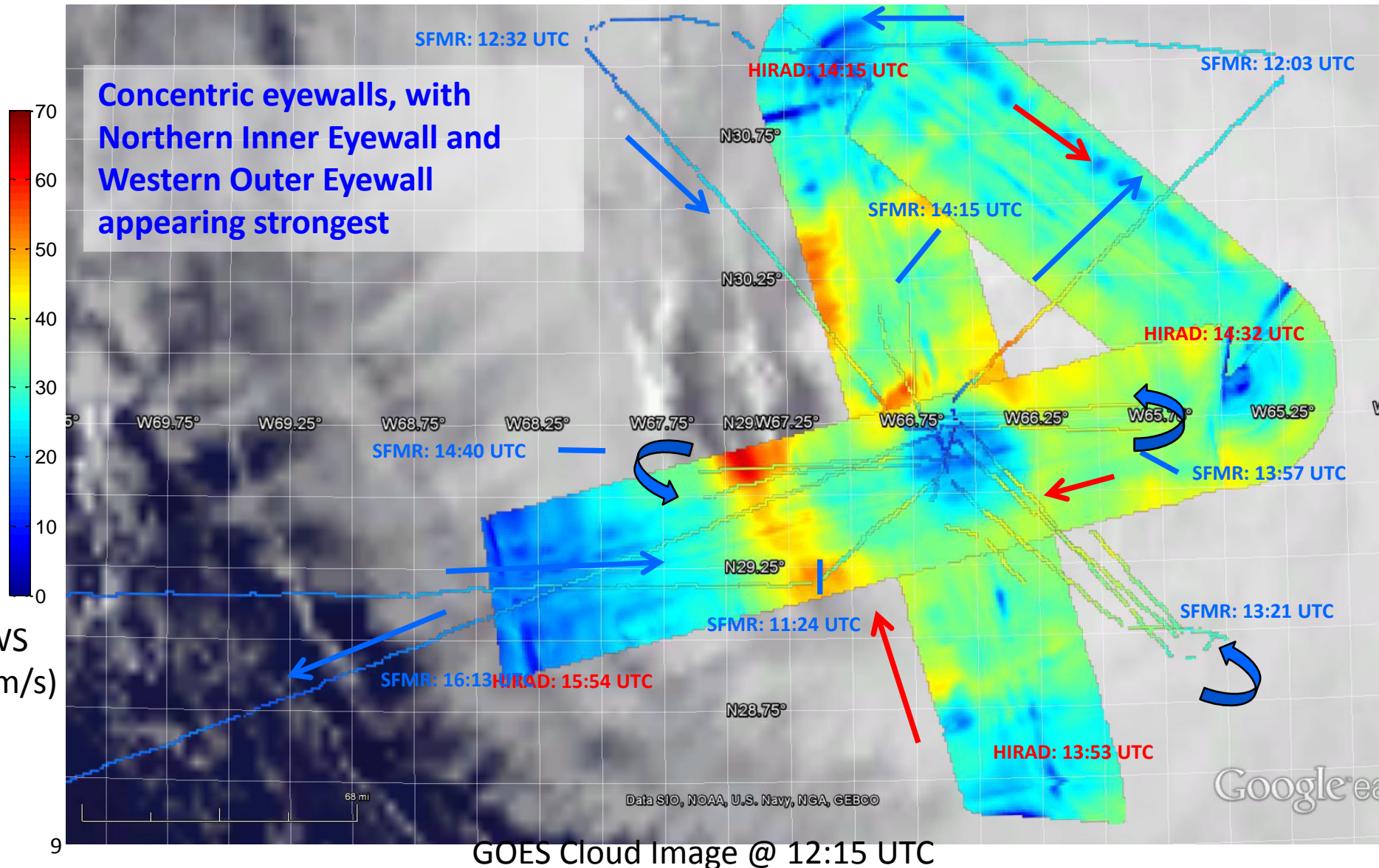


# First Storm Center Crossing: 14:04 UTC

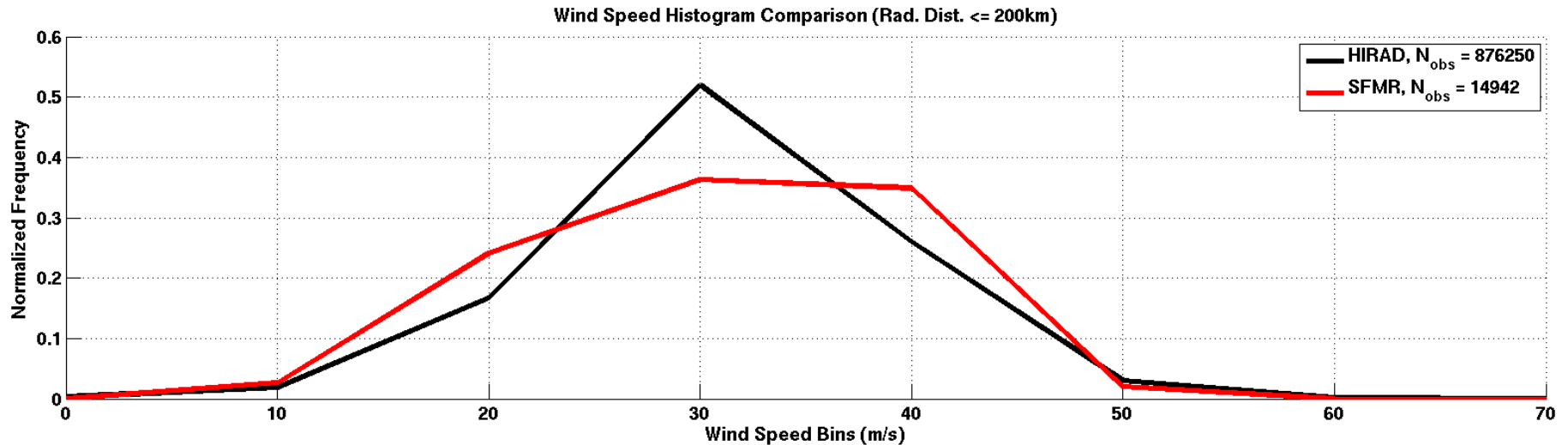
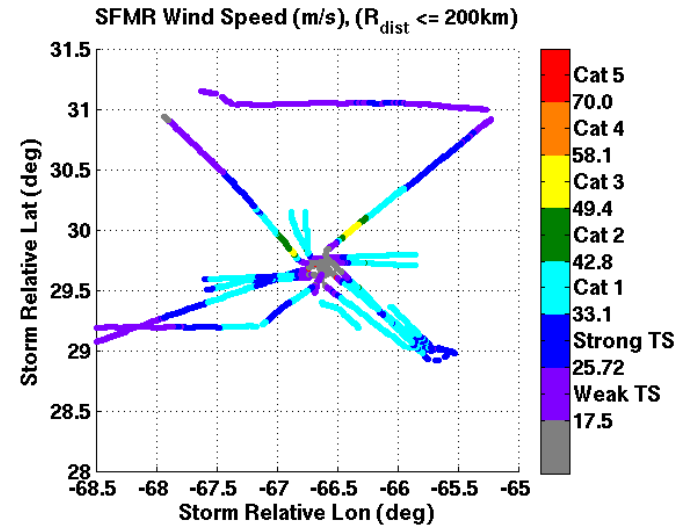
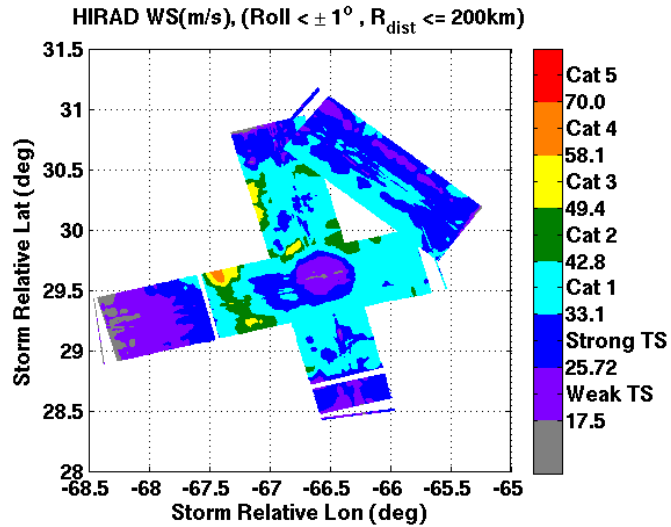




# Second Storm Center Crossing: 14:41 UTC

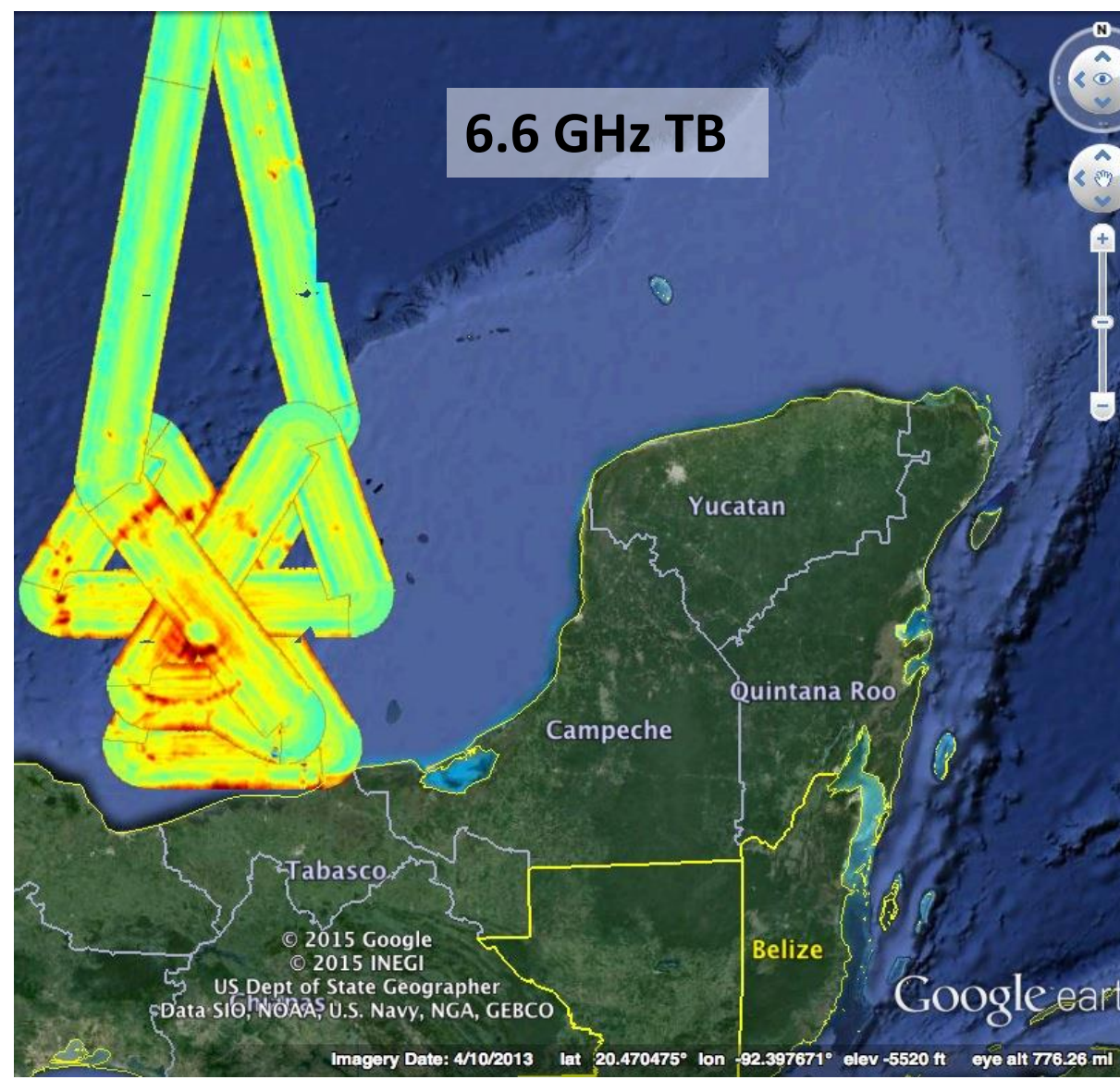
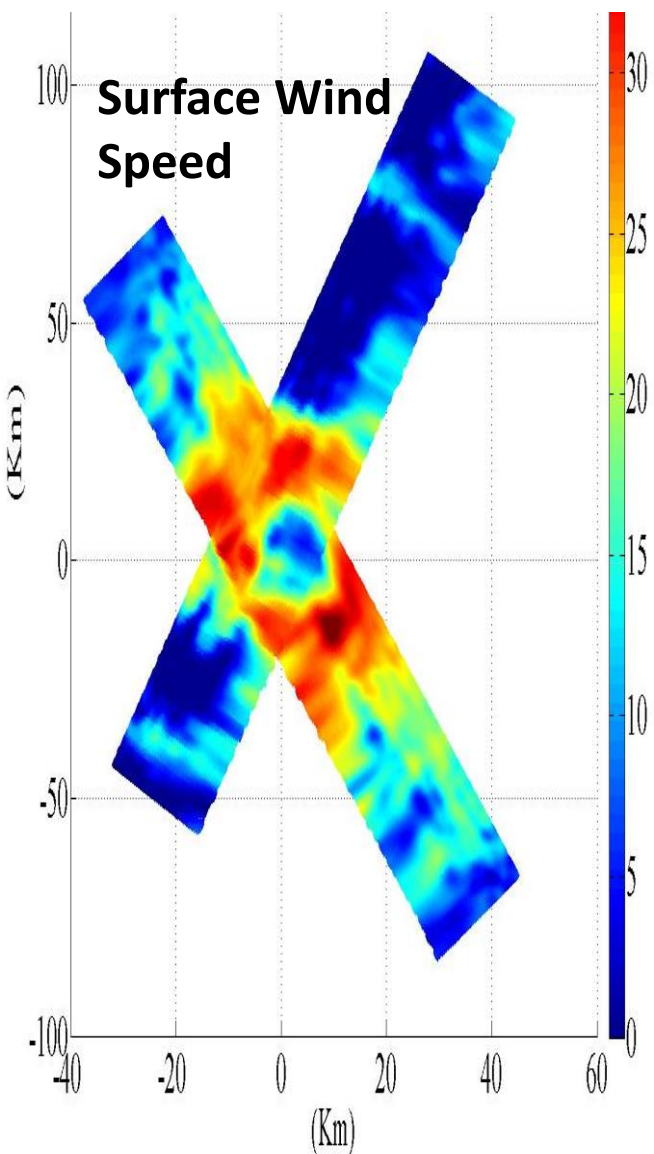


# Wind Retrievals – Oct 17 Gonzalo





# Hurricane Karl (2010) Brightness Temp and Wind Speed Retrieval





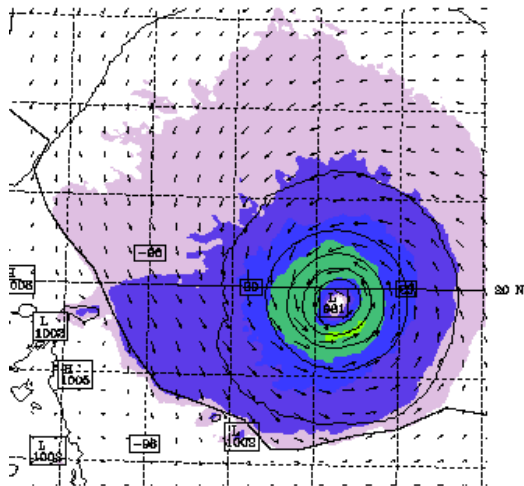
# HIRAD Wind Retrieval, Assimilation for Hurricane Karl

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**



# 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 needs more cleanup before retrievals, but hurricane structure is there
- Hurricane Karl (2010) wind retrievals tested in assimilation with dropsondes and HIWRAP; improved structure of wind radii

