Passive Microwave Data Exploitation via the NRL Tropical Cyclone Webpage: JHT Project Status

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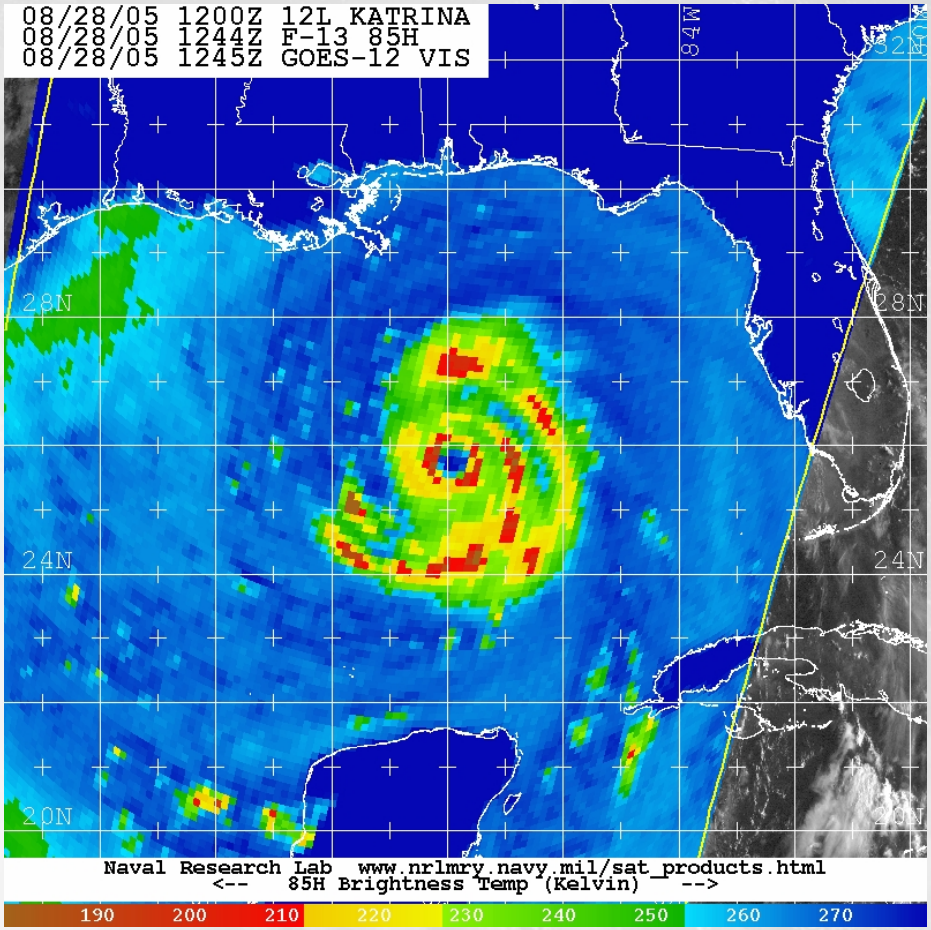
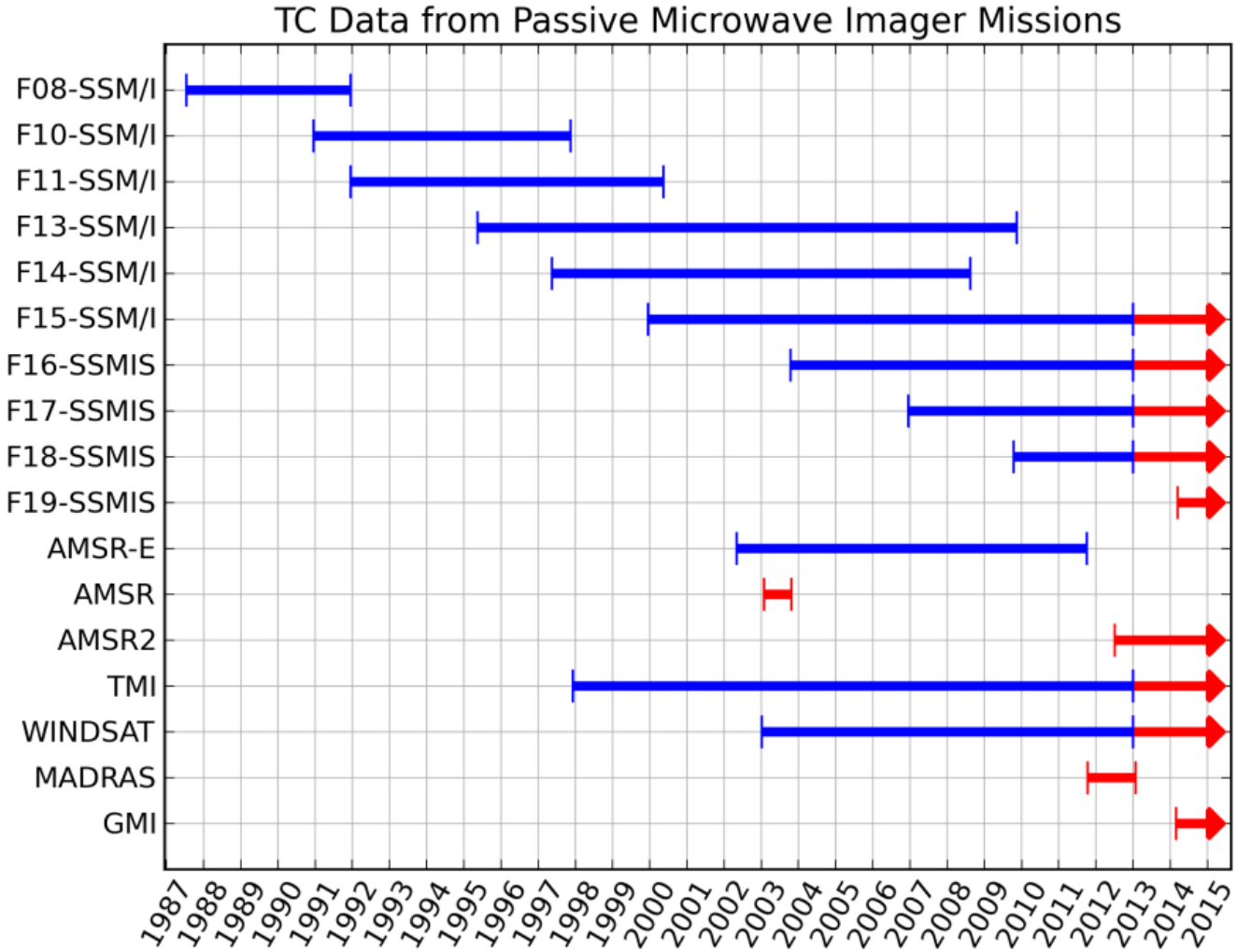
NRL JHT Goals

- Provide real-time and archived products using updated processing methodology:
  - Recalibrate ice scattering channels to common 89 GHz
  - Provide high resolution interpolation for consistent output analysis
  - Recenter imagery using CIMSS ARCHER
  - Use python as a cleaner and open source visualization
- Update color tables based on physical break points
- Devise parallax correction based on feature heights



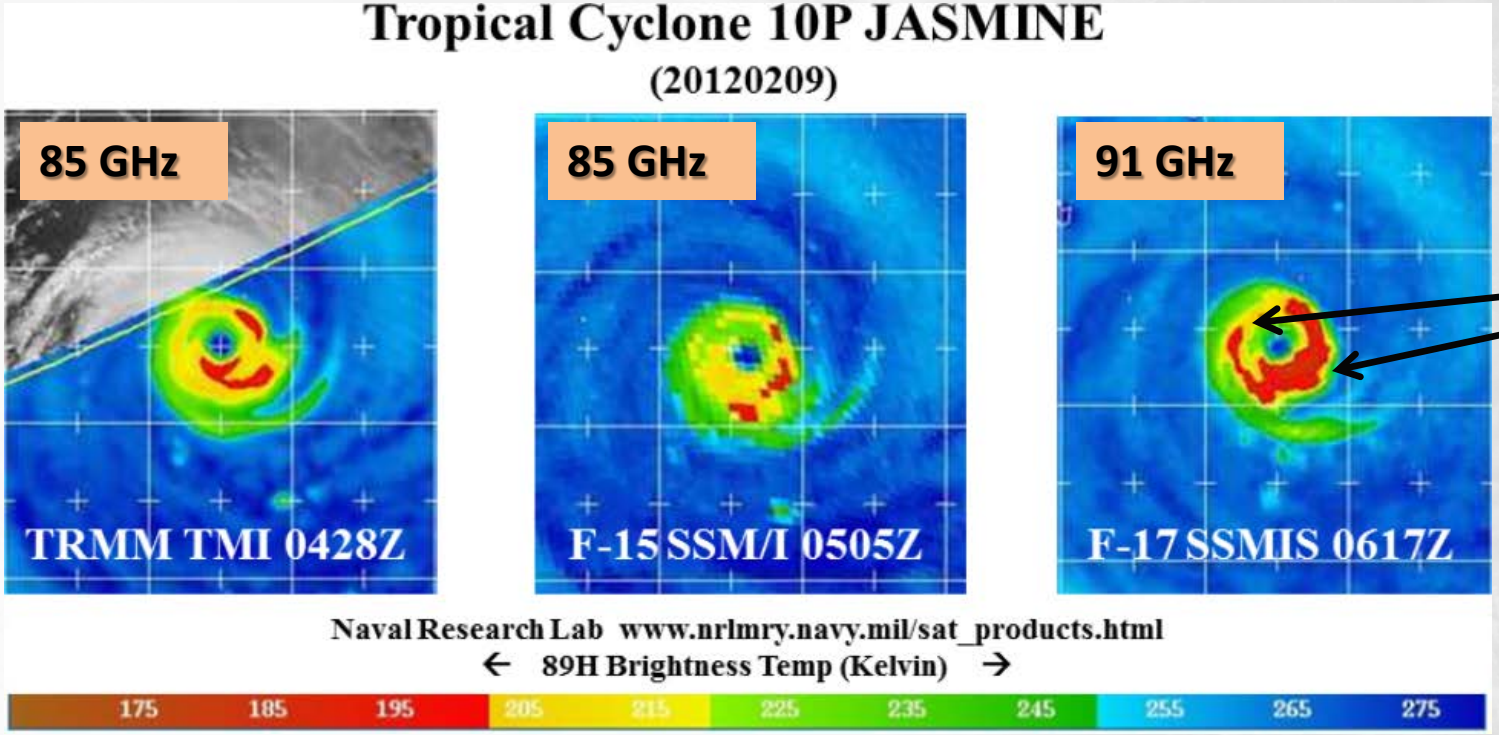
Microwave Imagers at NRL-TC (MINT)



- **Status of dataset**
  - SSM/I, TMI, SSMIS, and AMSR-E reprocessed (1987-2012)
  - 100,000+ global cases
  - Processing 20 TB WINDSAT dataset with all Stokes parameters

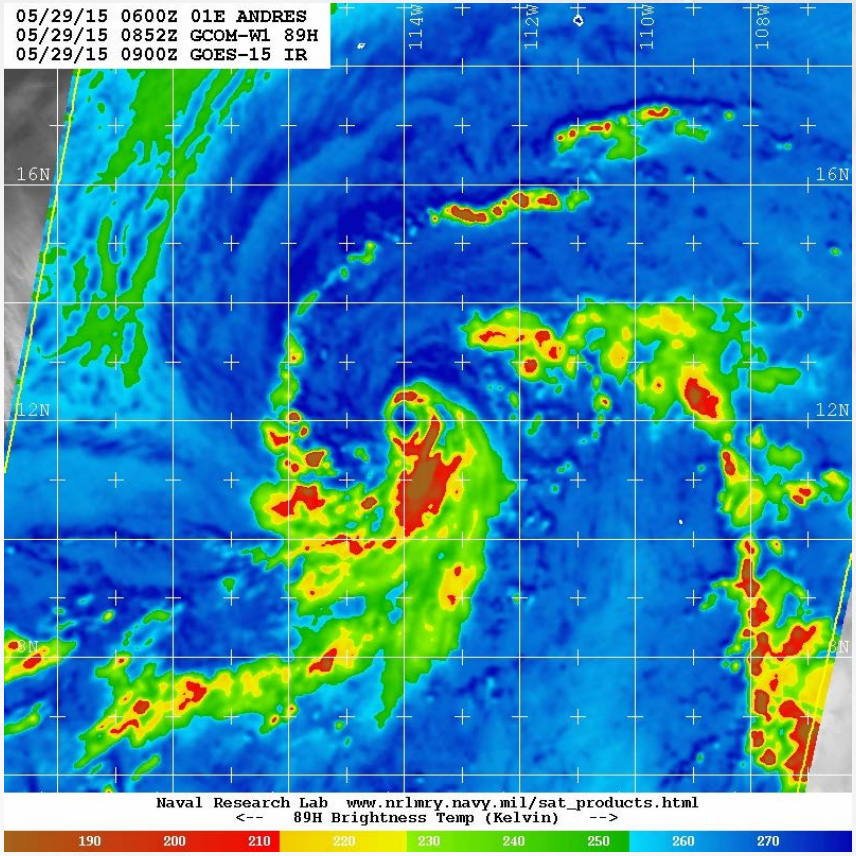
Recalibration to Standardize Microwave Ice Scattering Channel

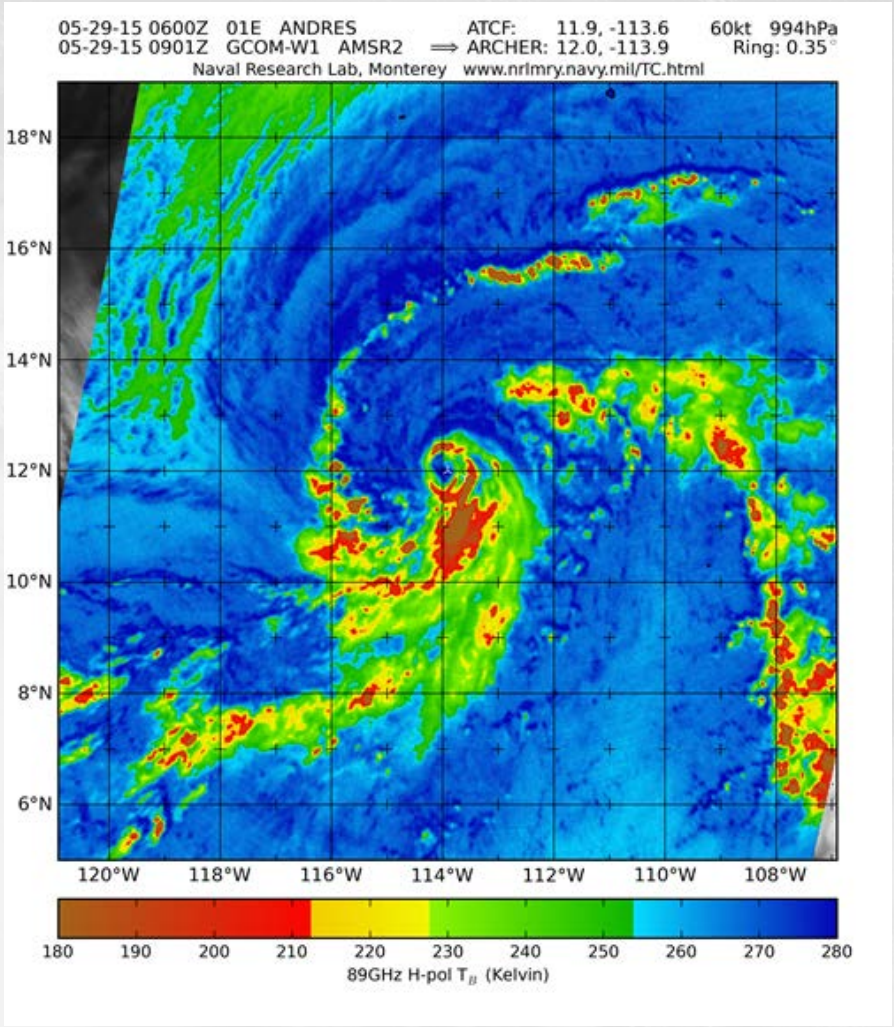
- **Each microwave sensor is associated with different measured frequencies, scan specifications, antenna lengths, orbital characteristics, etc…**
  - Differences in image resolutions and physical interpretation between sensors
  - E.g. scattering signal in 85GHz is weaker vs. that in 91GHz (Hawkins et al. 2008)

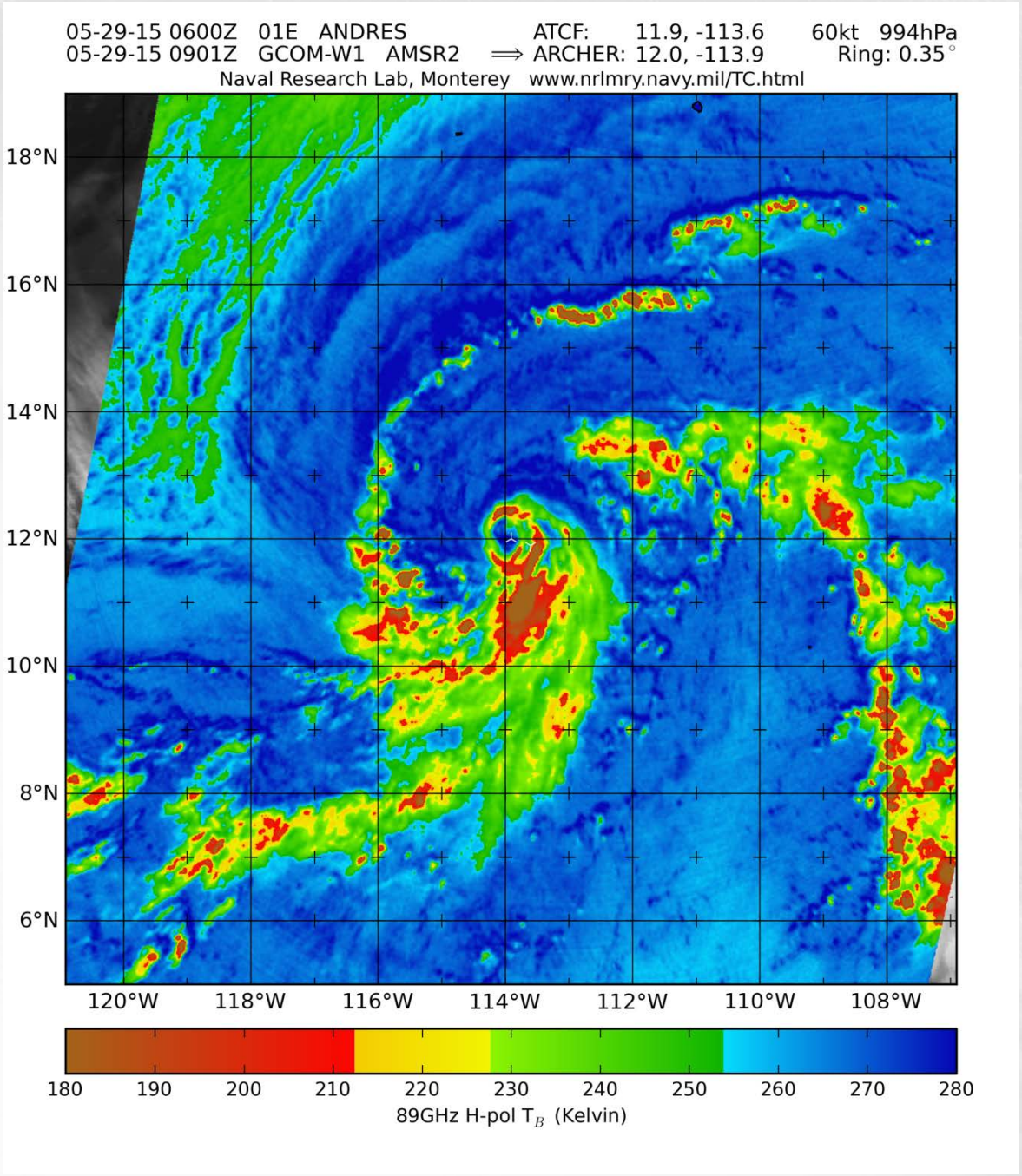


Lower T_B due to frequency difference, NOT intensity change

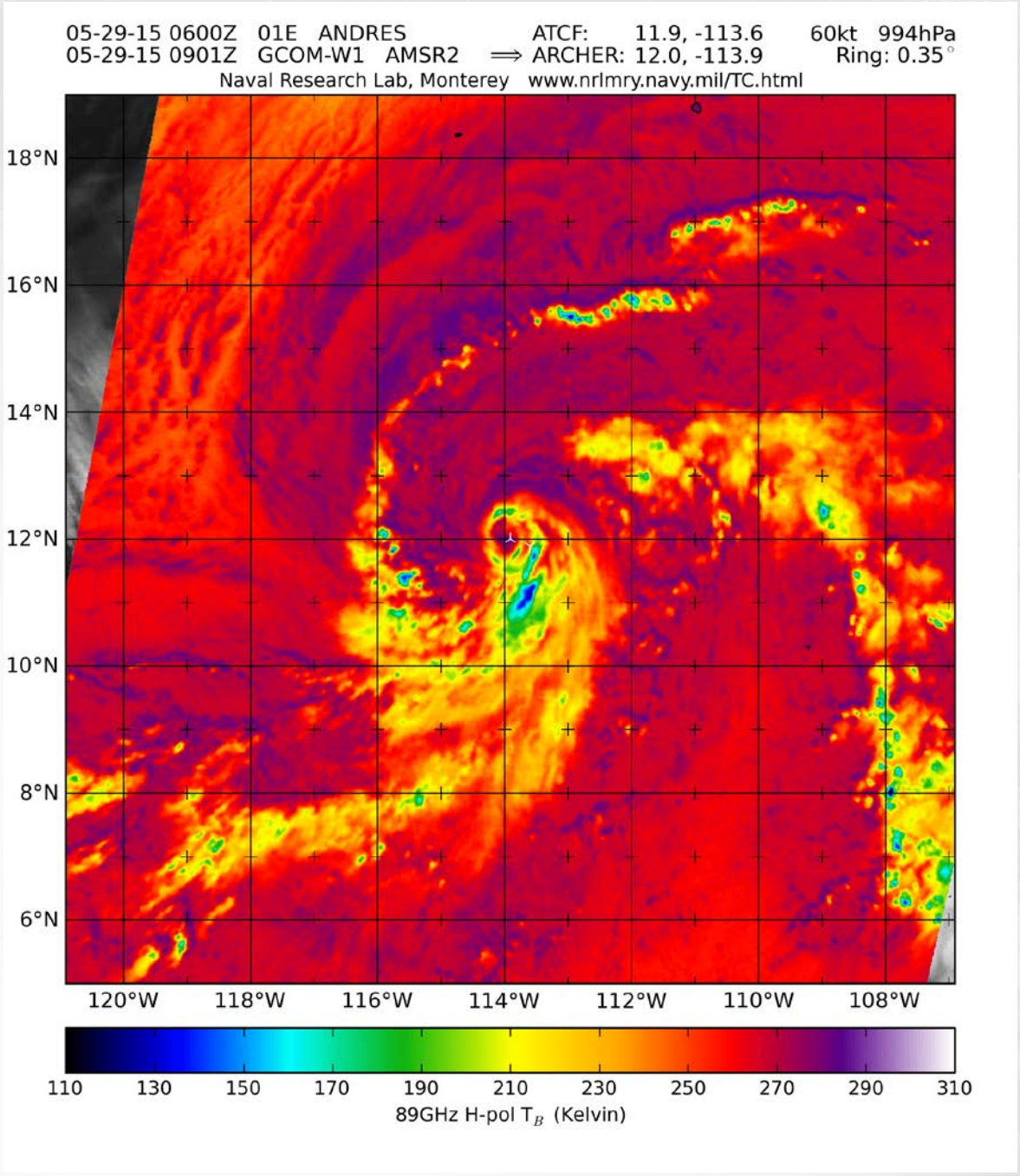
Current vs Planned Comparison



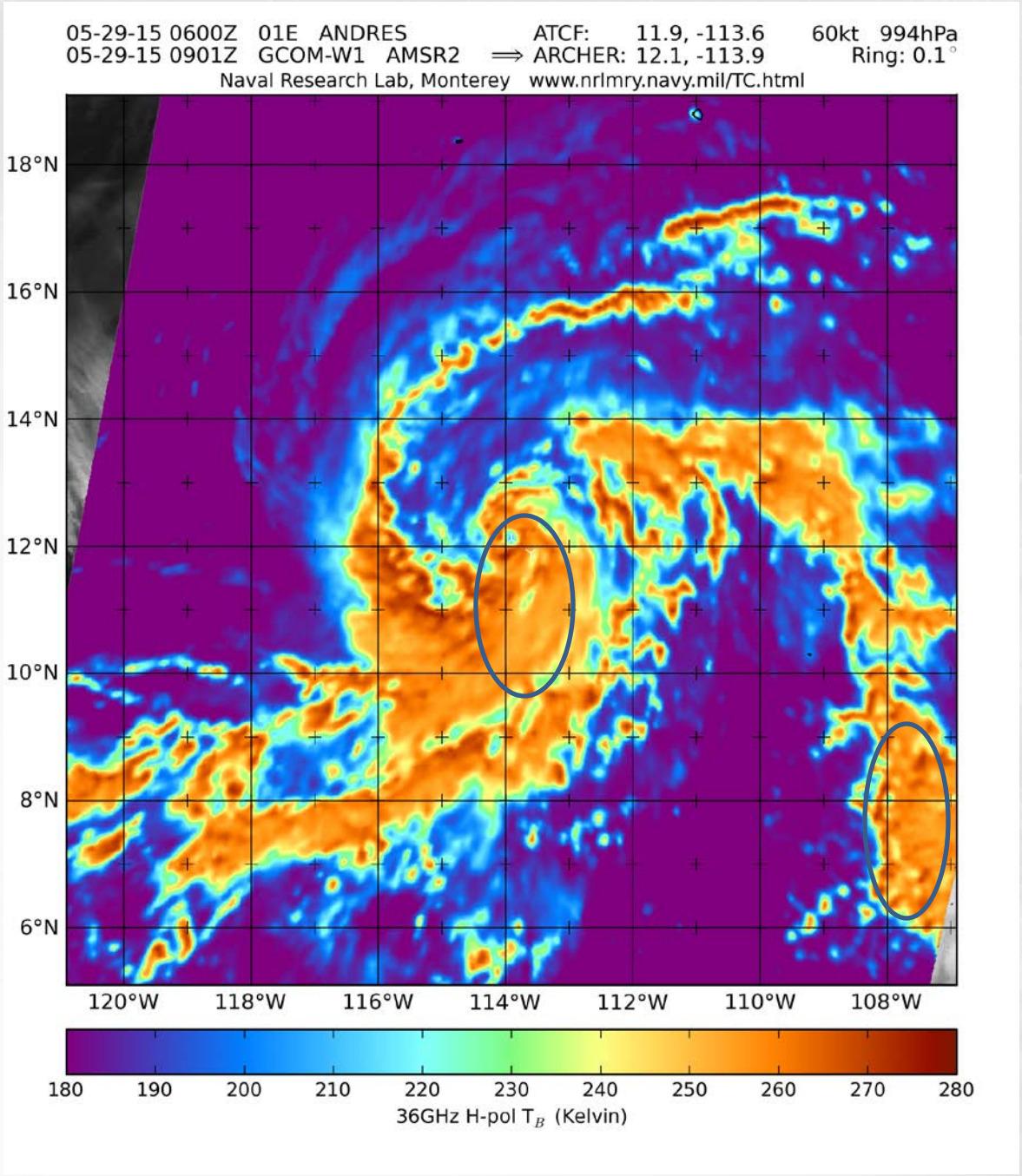




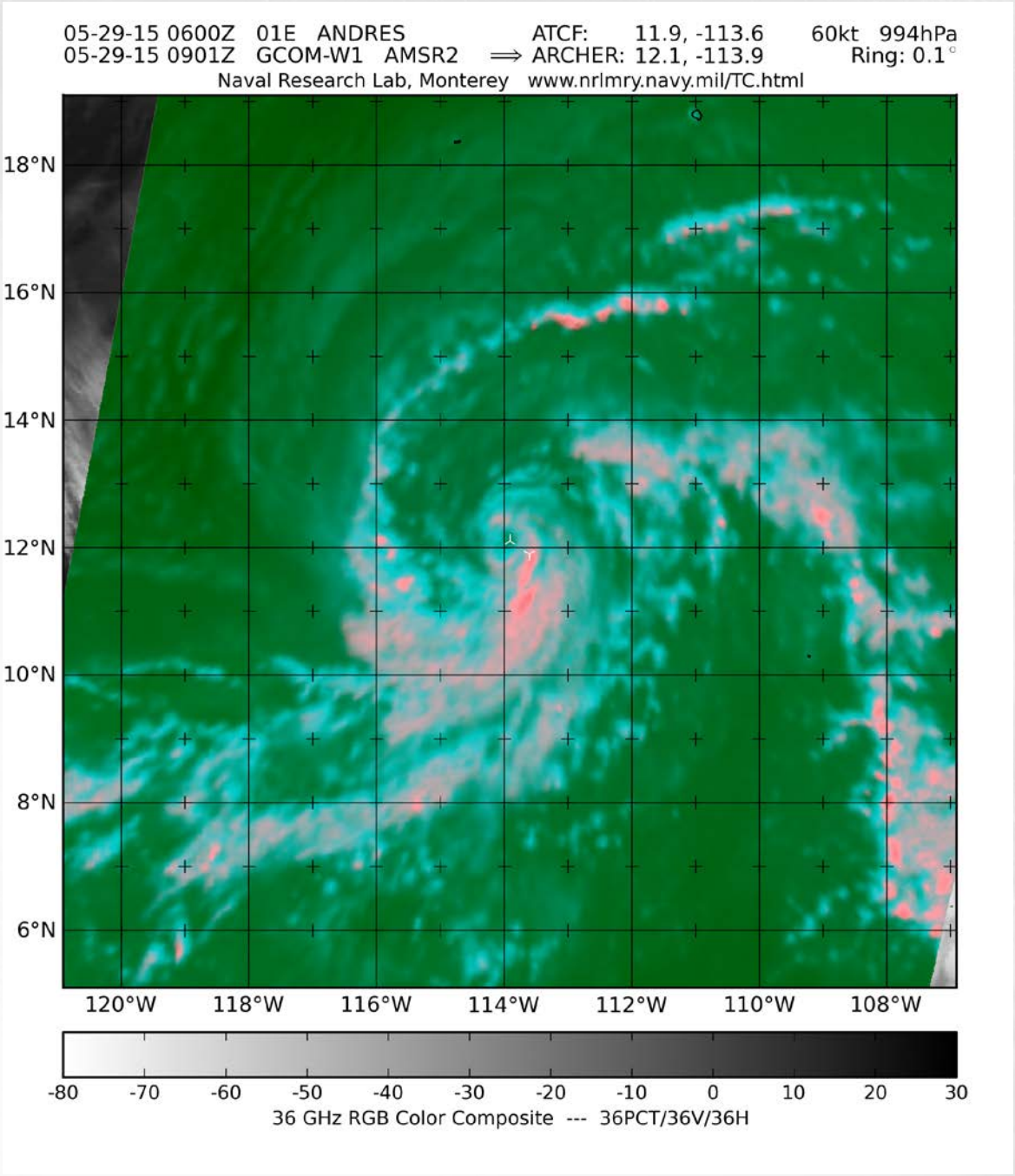
- Python-based product enhancements
  - More legible lat/lons labels outside of image
  - Addition of ATCF best track information
  - Addition of ARCHER analysis
  - Improved resampling scheme to preserve data fidelity



- Testing different color tables and ranges
  - Current NRL TC color schemes were developed from SSM/I data.
  - Higher resolution sensors and change in frequencies (from 85 to 89 GHz) result in different physical interpretation
  - Current example on the left emphasizes how deep convection with strong ice scattering is not easily seen



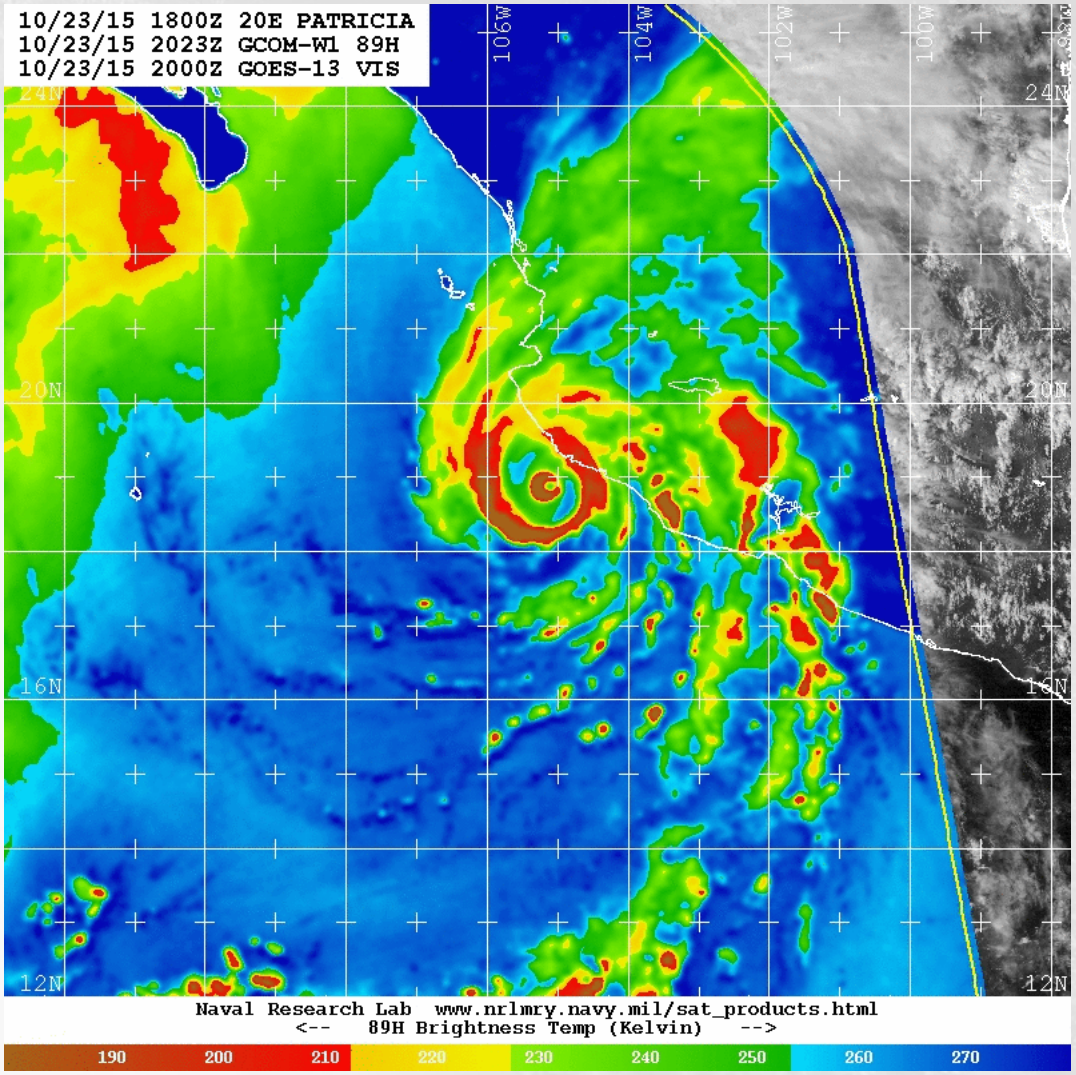
- Exploration of other available channels: 18 GHz
  - Sensors with higher resolutions (AMSR2, GMI) are able to provide structural information at lower frequencies
  - Note the detail of low level liquid water emission that is masked from scattering signal in 37 GHz



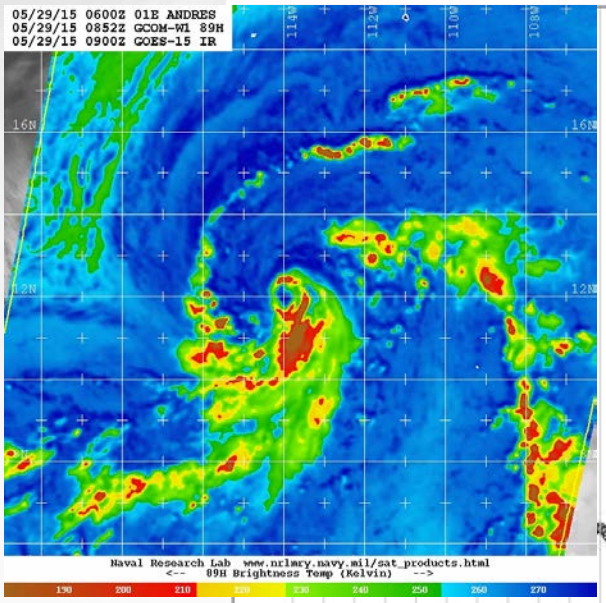
- Leveraging benefits of different channels to create RGB products that enhance multiple features
  - Current RGB color products are useful at isolating scattering from low levels, but are hard to see
  - Aiming to improve legibility and utility of RGB color products

Color Table vs. Spatial Resolution

- Overpass comparison of Category 5 Hurricane Patricia before landfall
  - AMSR-2 resolves inner core and eye
  - AMSU barely shows inner core
- Note range of colors represented
  - Important to relate signal to sensor resolution



Color Table vs. 89 GHz T_B Distribution



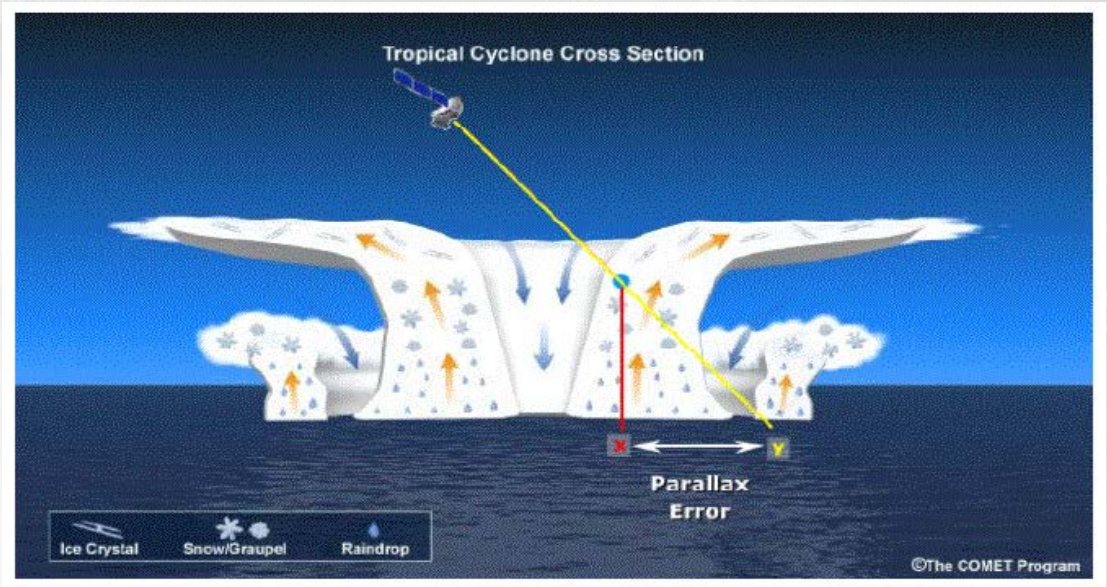
Red Line = Log(Counts)

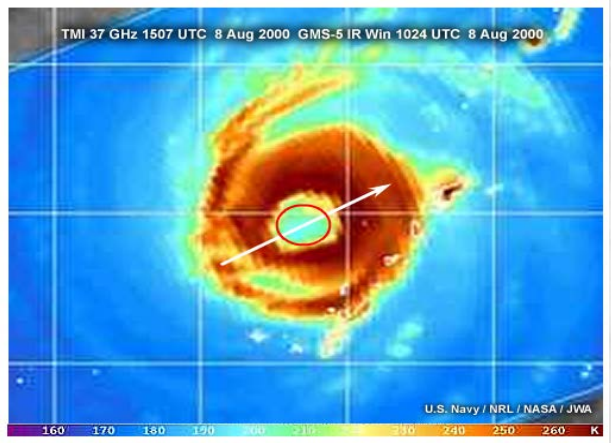
Black Line = Derivative

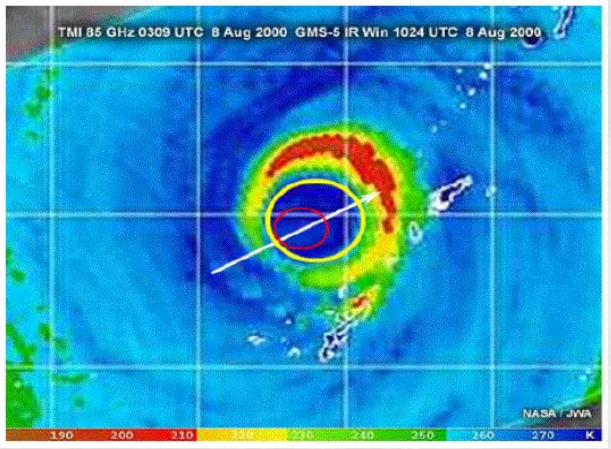
100 K 150 K 200 K 250 K 300 K 350 K

Need for Parallax Correction

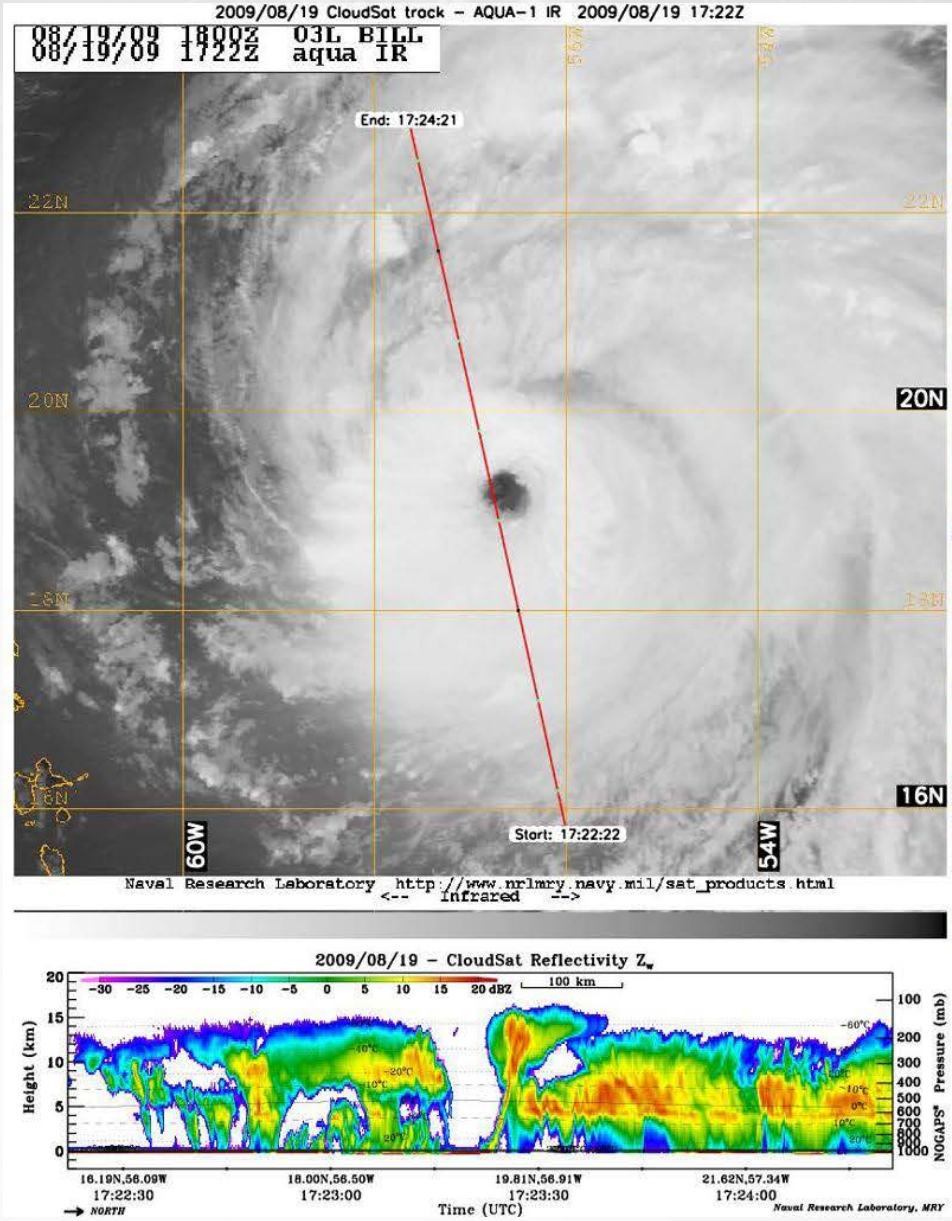
- Due to scan angle of imagery, atmospheric features are spatially displaced from their ground location
- A parallax correction regression will be researched to improve TC center fixing by microwave imagery.

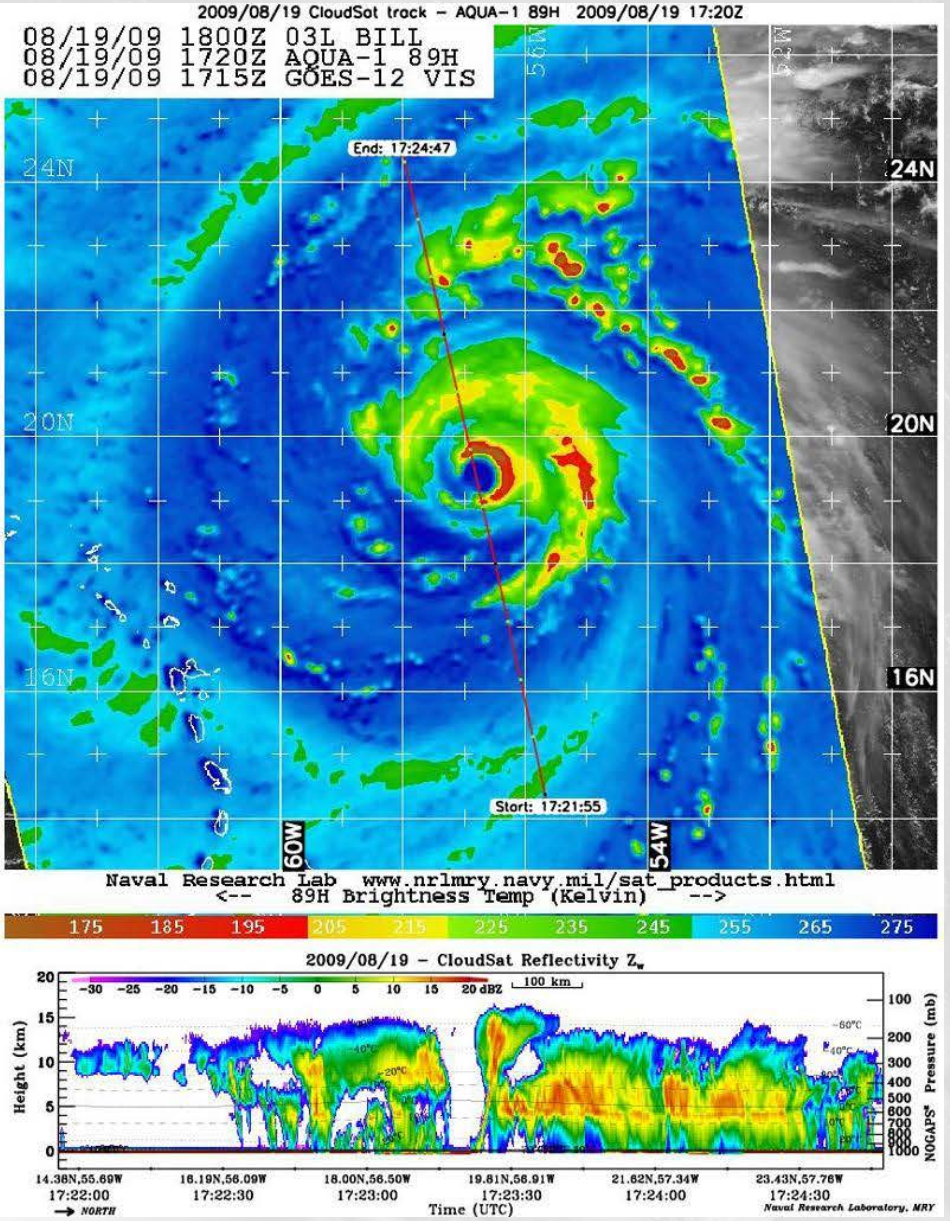






Estimating Parallax from Radar/MI Comparison

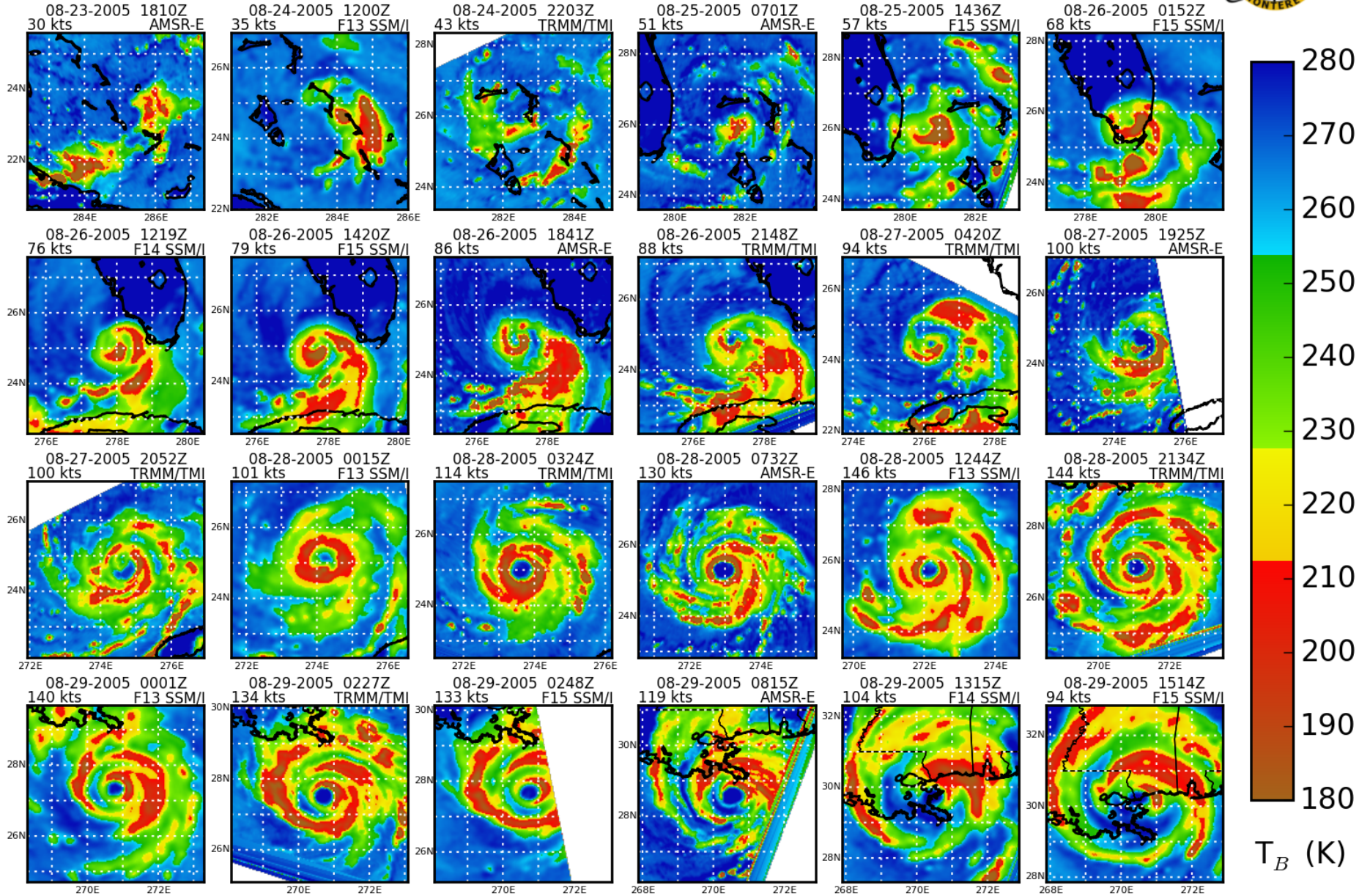




NRL JHT Conclusions

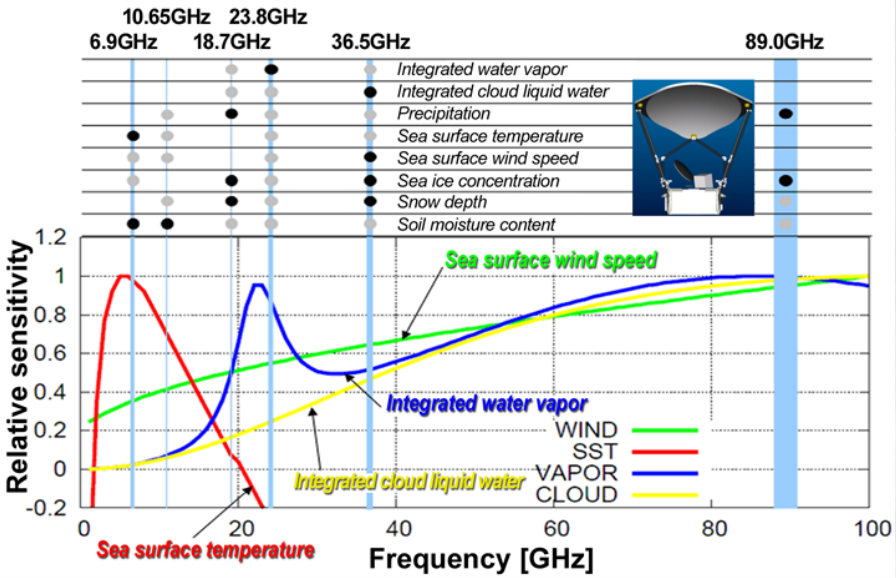
- Finalizing code to products new real-time images
  - Hope to start realtime demonstration with POCs at NHC, CPHC, and JTWC during the upcoming season (~June-July)
  - Will apply to back archive of storms since 1987 once POCs give okay with final image products.
- Running tests on new channels and colors. Will use historical dataset to better inform break points, ranges.
- Year 2 focus will be updating colors and presentation based on comments, researching and testing parallax correction scheme for surface centering.

Hurricane Katrina - AL122005 [89H GHz]



Extras

Microphysics and Remote Sensing



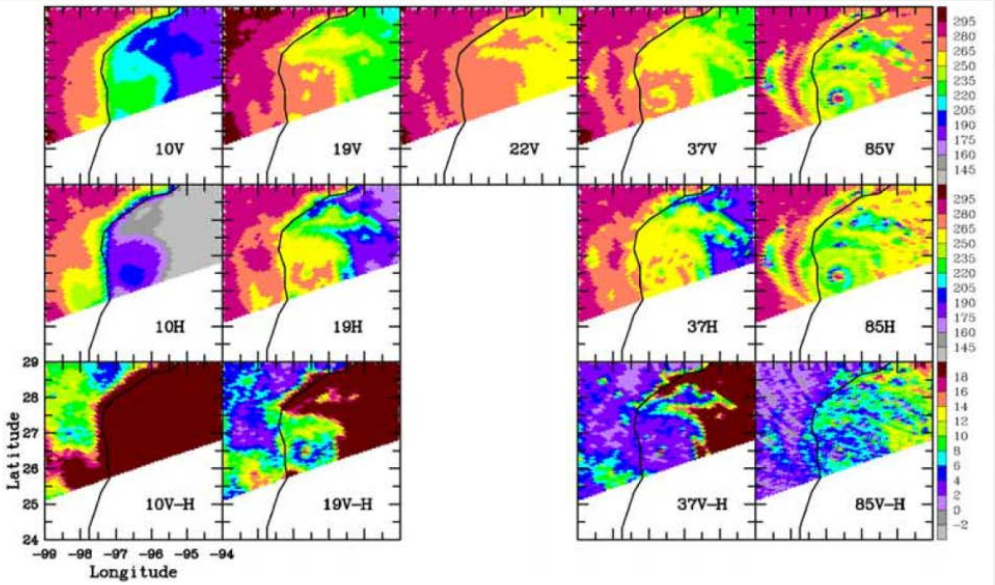
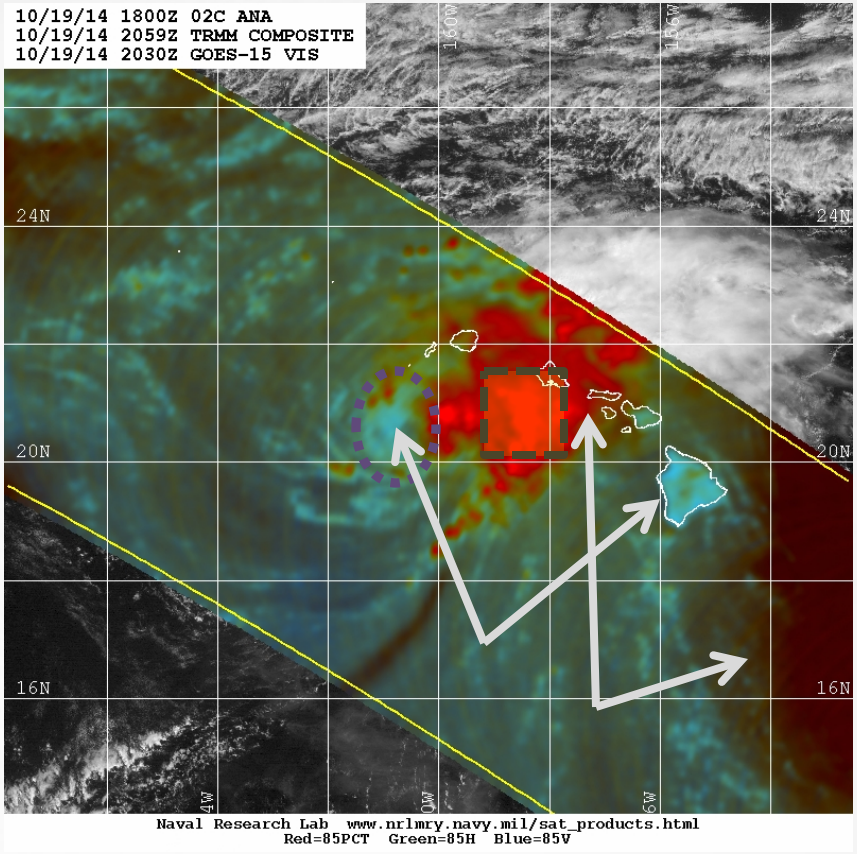


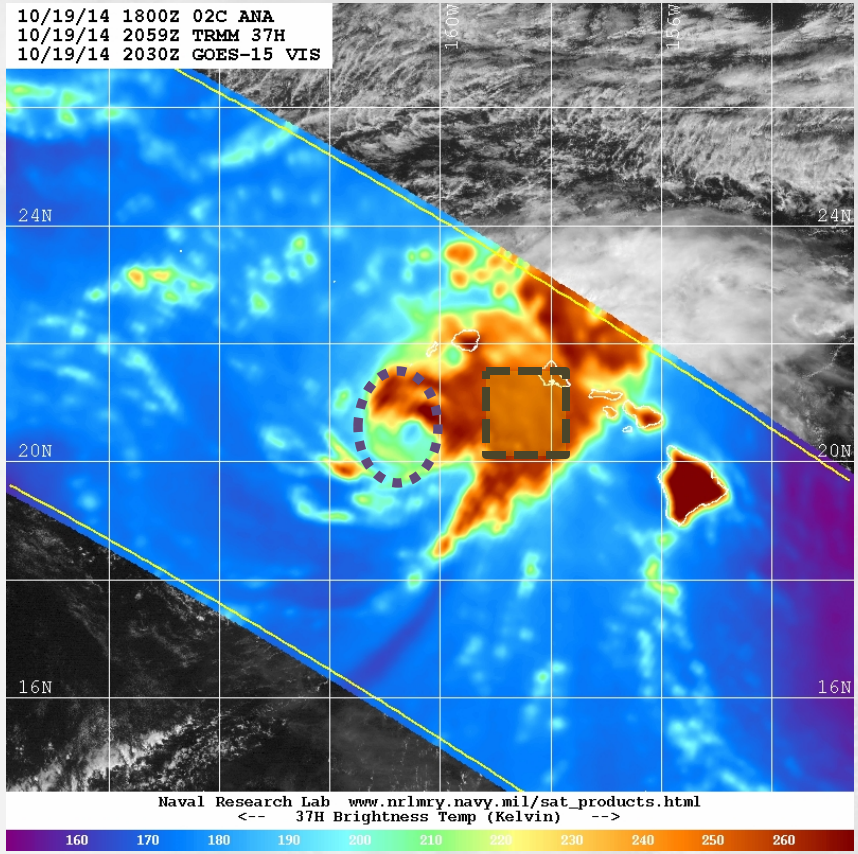
Figure courtesy: JAXA (top) and Wiedner et al. 2004 (bottom)

- Microwave sensing leverages atmospheric transmittance properties to observe water
  - Small ice crystals (cirrus) are largely transparent
  - Large ice scatters radiation (lowers T_B)
  - Liquid water absorbs/emits radiation (increases T_B)
- Lower frequency --> smaller wavelength (larger footprint)
  - Spatial resolution of 85/89/91 GHz better than 37, 19 GHz

Scattering vs. Emission

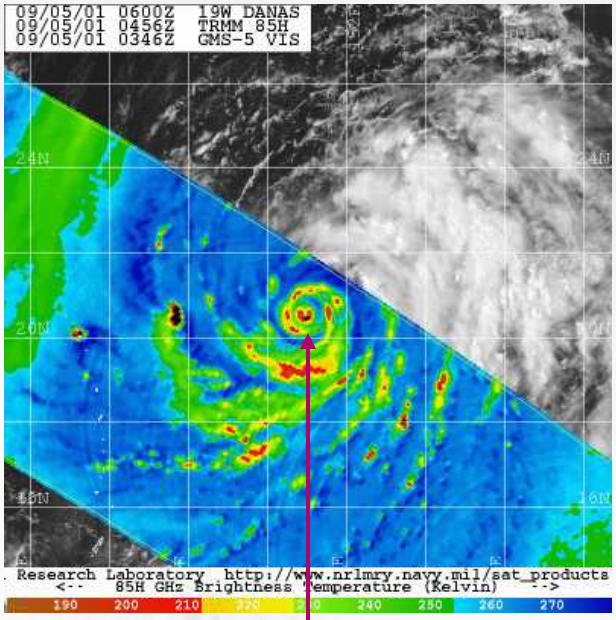
- **Scattering** by large/numerous ice reduces T_B
- **Absorption/emission** by liquid water increases T_B
- Mixed effect results in ambiguous interpretation of colors



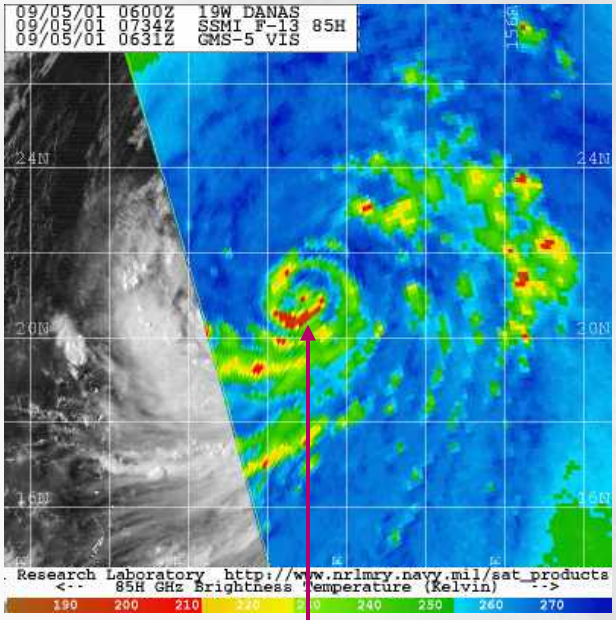


Considering Spatial Resolution

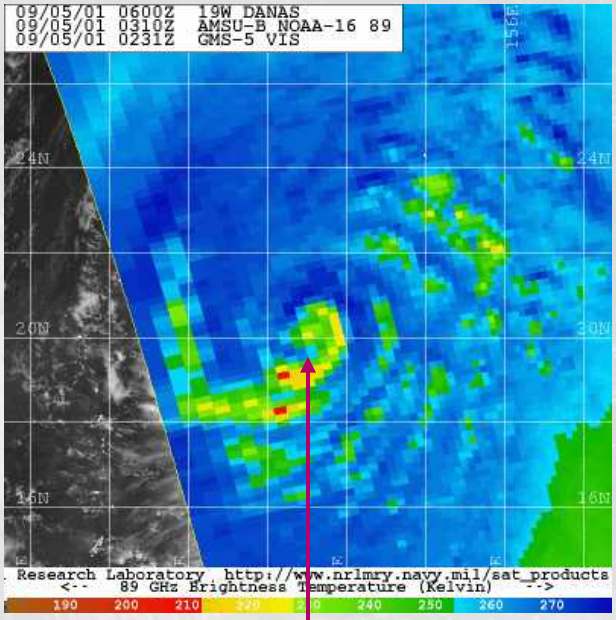
- Antenna size affects the ability to resolve TC features
- Microwave sounders (e.g., AMSU-B, ATMS) only resolve coarsest structures and have degraded signal swath edge



Small, intense eye with secondary eyewall developing.



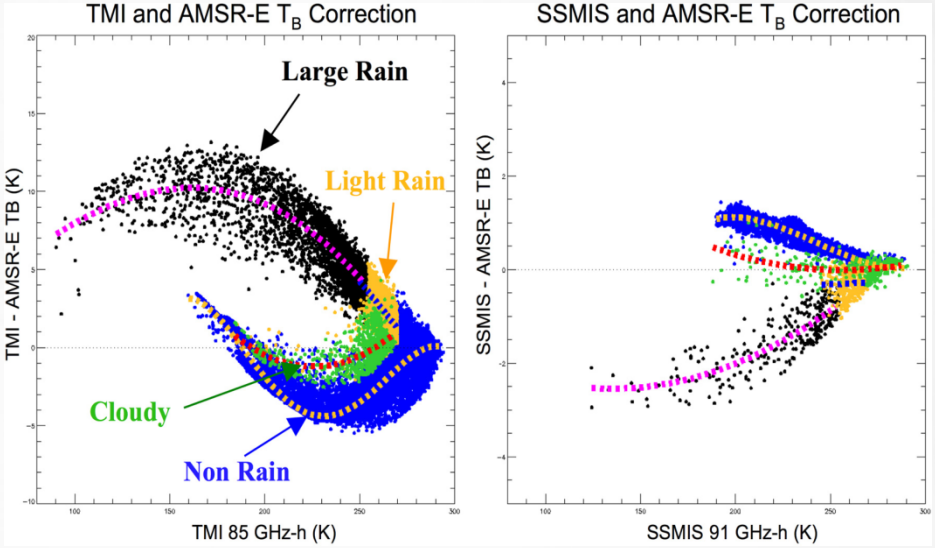
Small inner eye just visible, while secondary eyewall the main feature as reduced resolution.

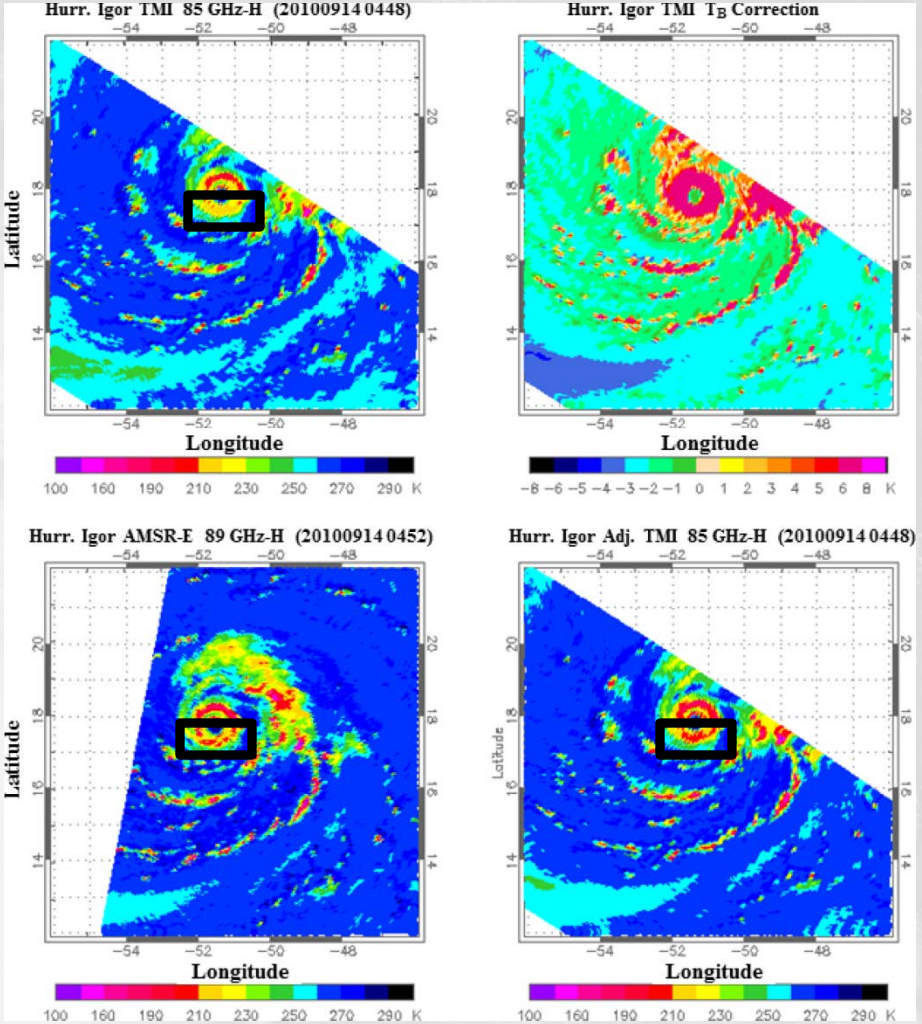


Inner eye not viewable, secondary eyewall difficult to fully identify.

Ice Scattering Recalibration

- Yang et al. (2014) used cloud resolving model simulations and cotemporal TC cases to derive recalibration regression coefficients from 85/91 GHz to 89 GHz
- Multiple high order equations derived based on radiative/precipitation scheme (see figure below)
- Results in lower RMSE between sensors and facilitates more robust objective analysis of convective strength





Need for Recalibration

- Different sensors have slightly different frequencies at the ice scattering channels: 85/89/91 GHz
- Differences in scattering signal affects brightness temperatures (~2-10 K) and physical interpretation
- A correction by Yang et al. (2014) recalibrates to a standard 89 GHz