HIRAD status report to GRIP

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HIRAD Team

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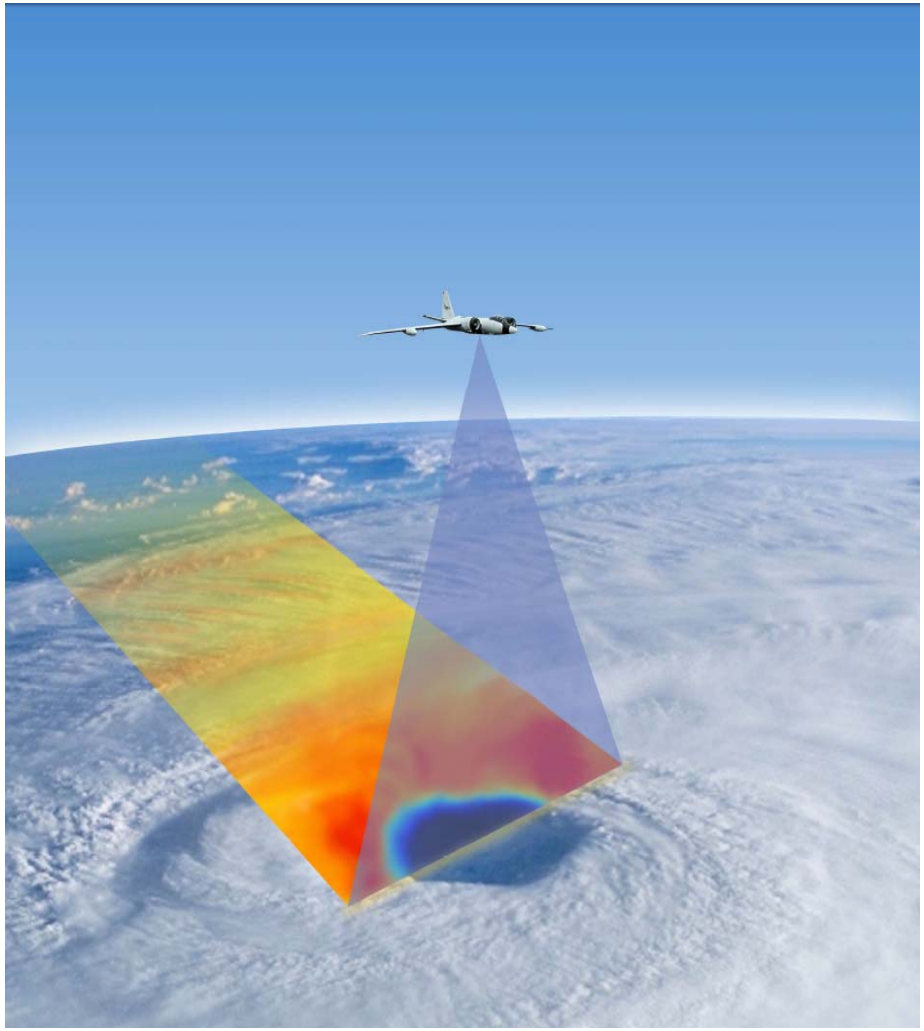
- **Dr. Peter Black**, *SAIC/NRL Monterey, consultant*
- **Robbie Hood**, *NOAA sponsor and original P.I.*

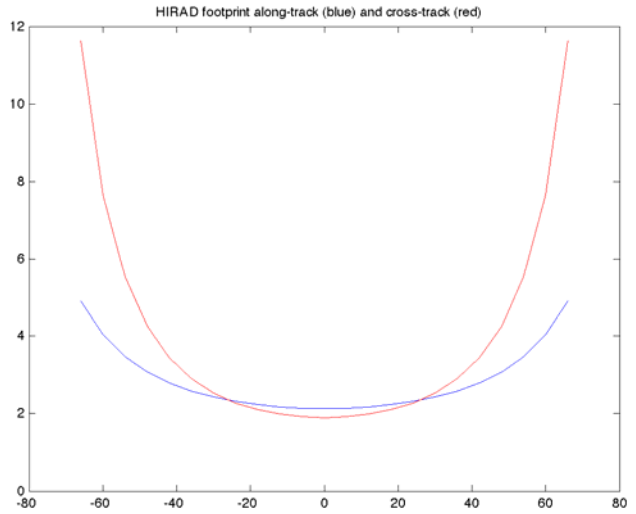
Hurricane Imaging Radiometer (HIRAD)

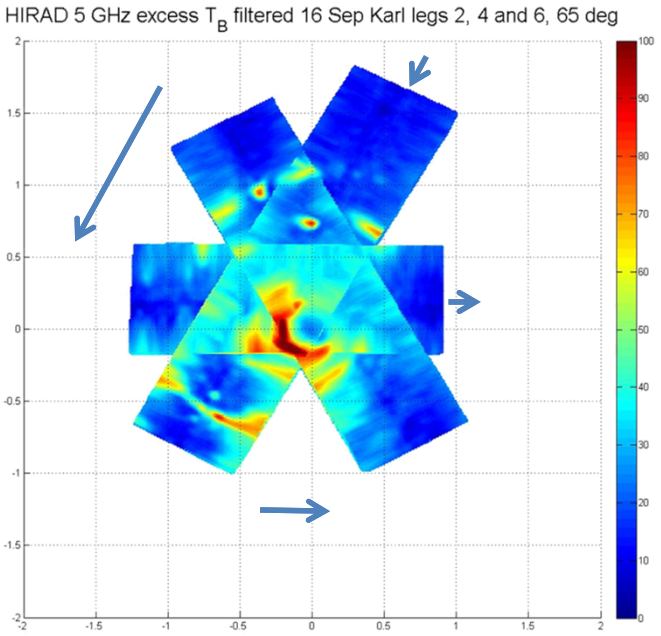
- A passive microwave radiometer (C-band, 4 frequencies), similar to SFMR: Measures emissivity and retrieves hurricane surface wind speeds and rain rates over a wide-swath:
  - Swath Width ~ 80 km
  - Resolution ~ 2 - 5 km
  - Wind speed ~10 – 85 m/s
  - Rain rate ~ 5 – 100 mm/hr
- Near-instantaneous mapping of entire inner-core hurricane surface wind field and rain structure.
- Surface wind and rain swath complements SFMR and airborne Doppler radar mapping of inner-core structure for improved short-term advisories and numerical model simulations.



HIRAD data products

- Brightness temperatures (T_B)
  - 4, 5, 6, 6.6 GHz
  - Footprint sizes, function of nadir angle, shown on the right
- "Excess" T_B
  - Difference from modeled cross-track profile
  - Example on the right
- Storm center (at crossing times)
- Wind speed, rain rate





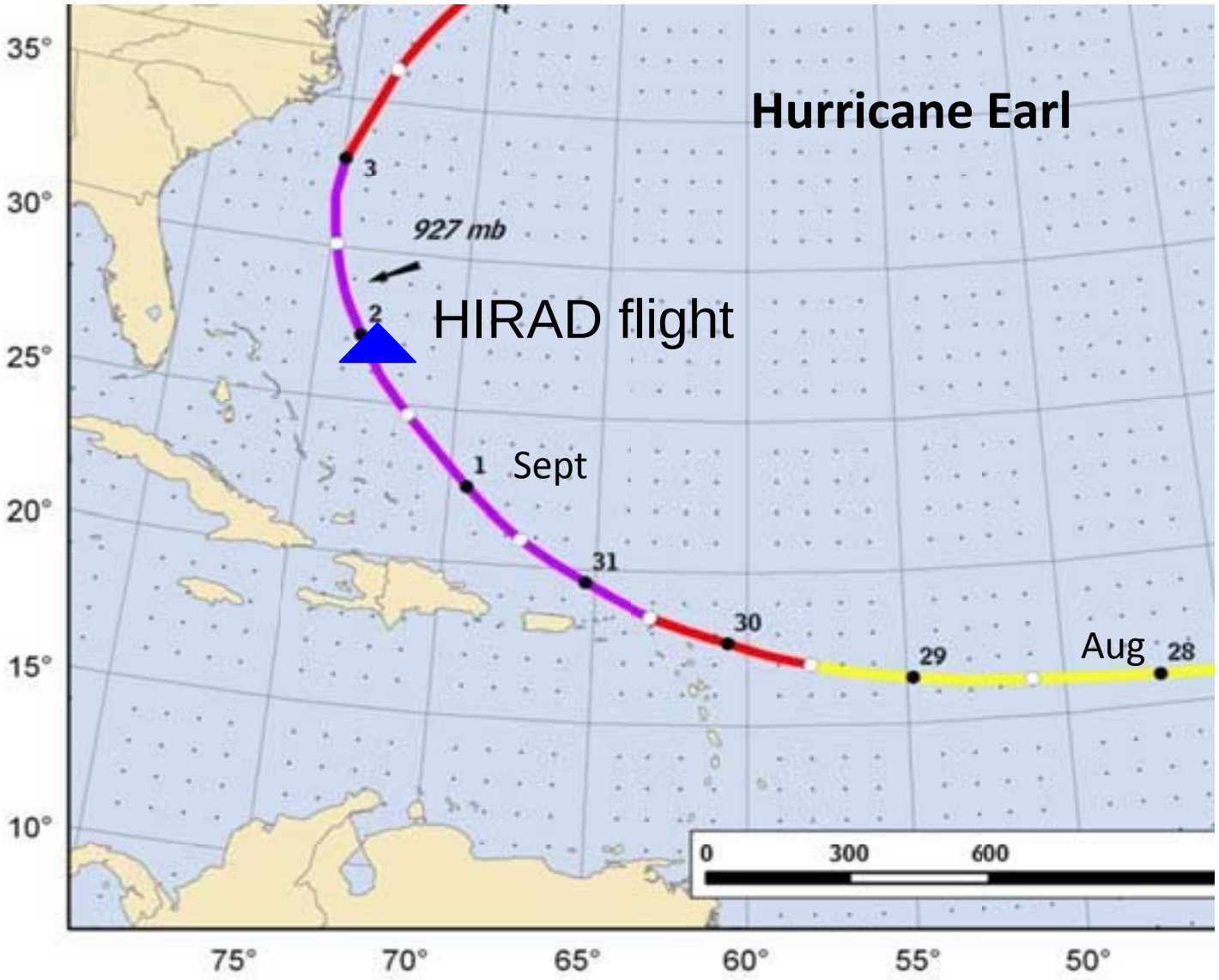
HIRAD flights during GRIP

- Platform: WB-57, based in Houston
- Flights:
  - Late 1 Sept (Earl), deployed from Tampa
    - Major objective: Coincident measurements with P-3 (SFMR)
  - 14 Sept (Karl) – Just after Karl named, prior to crossing Yucatan
  - 16 Sept (Karl) – Storm in the “middle” of the Bay of Campeche; best Karl flight
  - 17 Sept (Karl) – Just after landfall

Processed so far: Earl 1 Sept, Karl 16 Sept, 5 GHz only

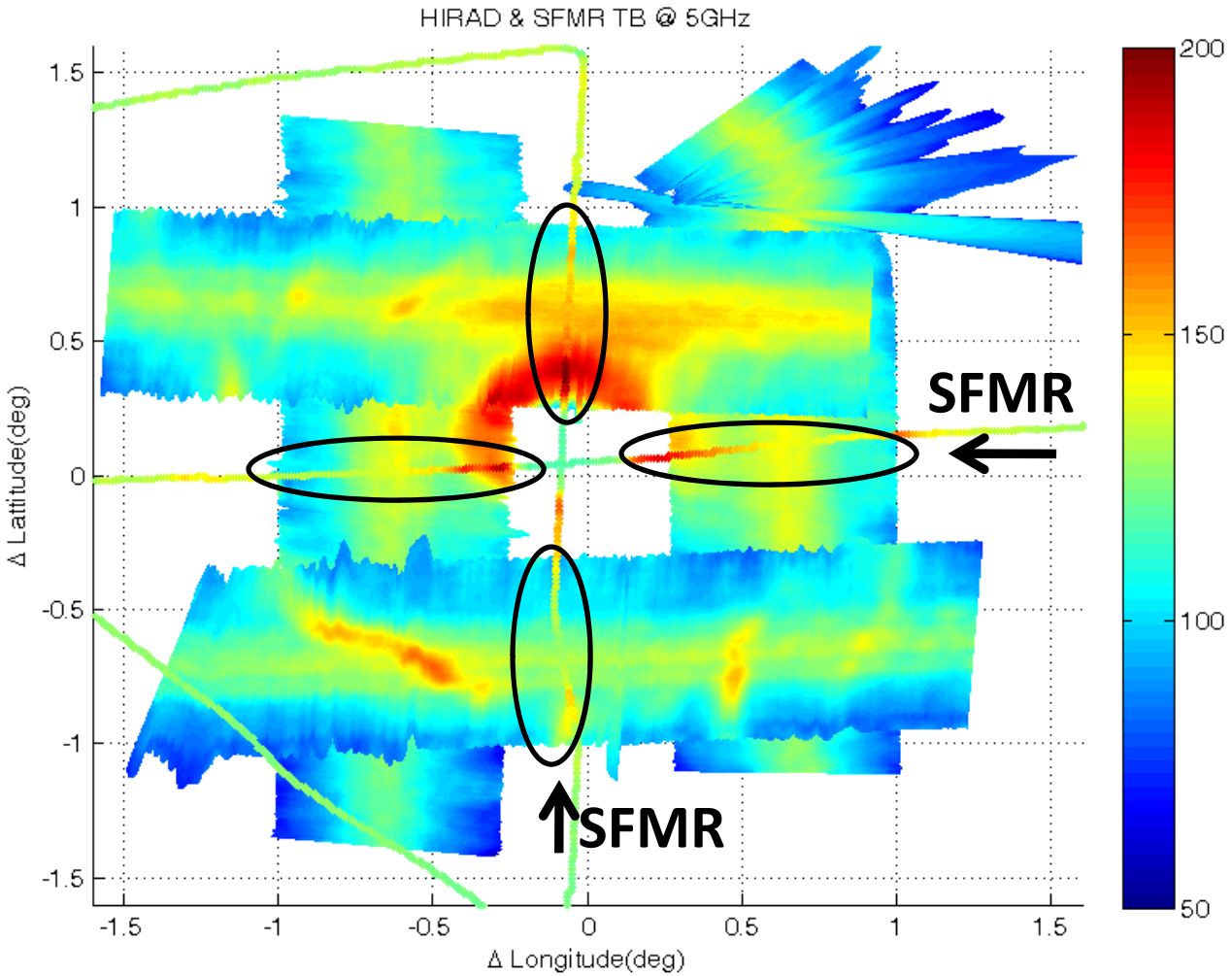
- Earl 1-2 Sept:
  - HIRAD's first flight; objective: validation obs with P-3's SFMR (fly box around vortex)
  - Over-storm time period: 23:20 – 01:35
  - SFMR crossed complete HIRAD swaths 4 times, including north and west parts of eyewall
- Karl 16 Sept:
  - HIRAD made 5 overpasses of the vortex (offset from center)
  - Comparison with P-3 radar verifies HIRAD capture of geophysical features

Hurricane Earl



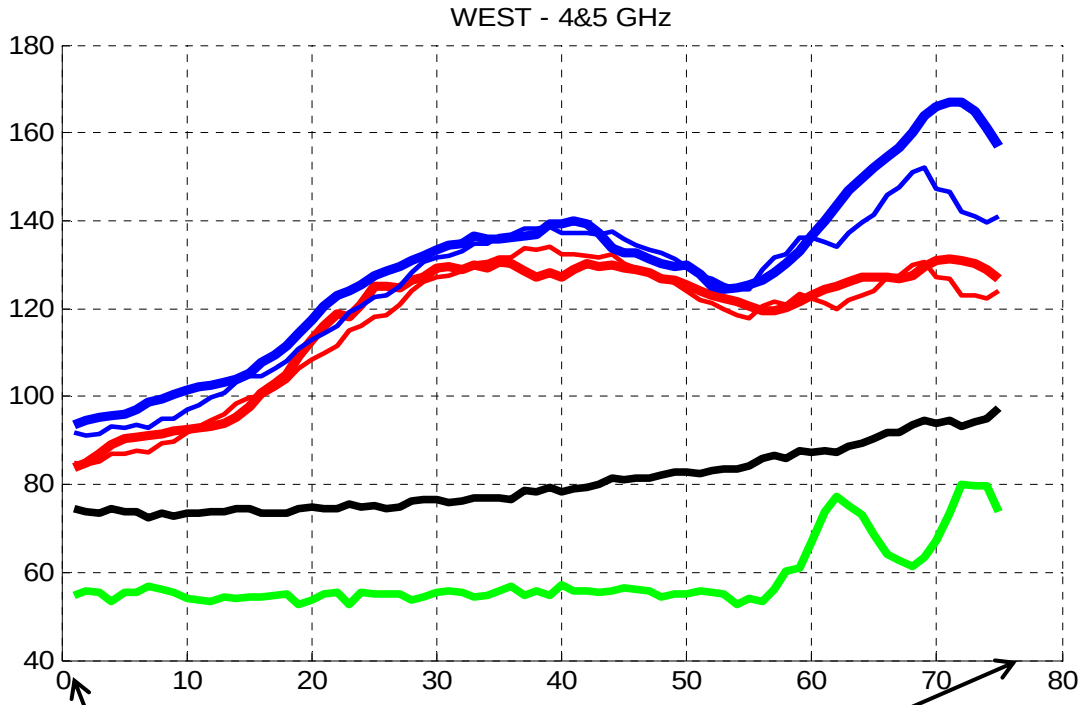
SFMR passes over HIRAD swath

Storm-centric coordinate system



HIRAD and SFMR should match at HIRAD's nadir point

HIRAD/SFMR West Leg Overpass



HIRAD Tb@ 4GHz

HIRAD Tb@ 5GHz

Model Tb@ 4GHz

Model Tb@ 5GHz

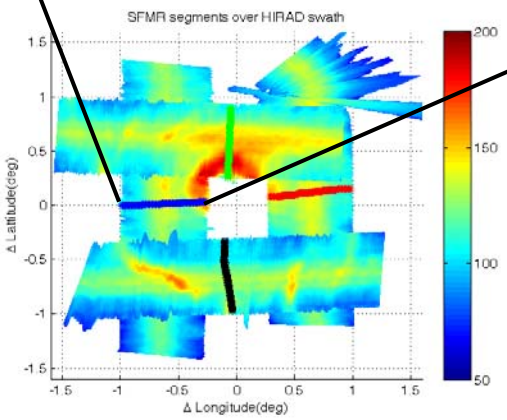
SFMR Wind +50 (m/s)

SFMR Rain +50 (mm/hr)

stop

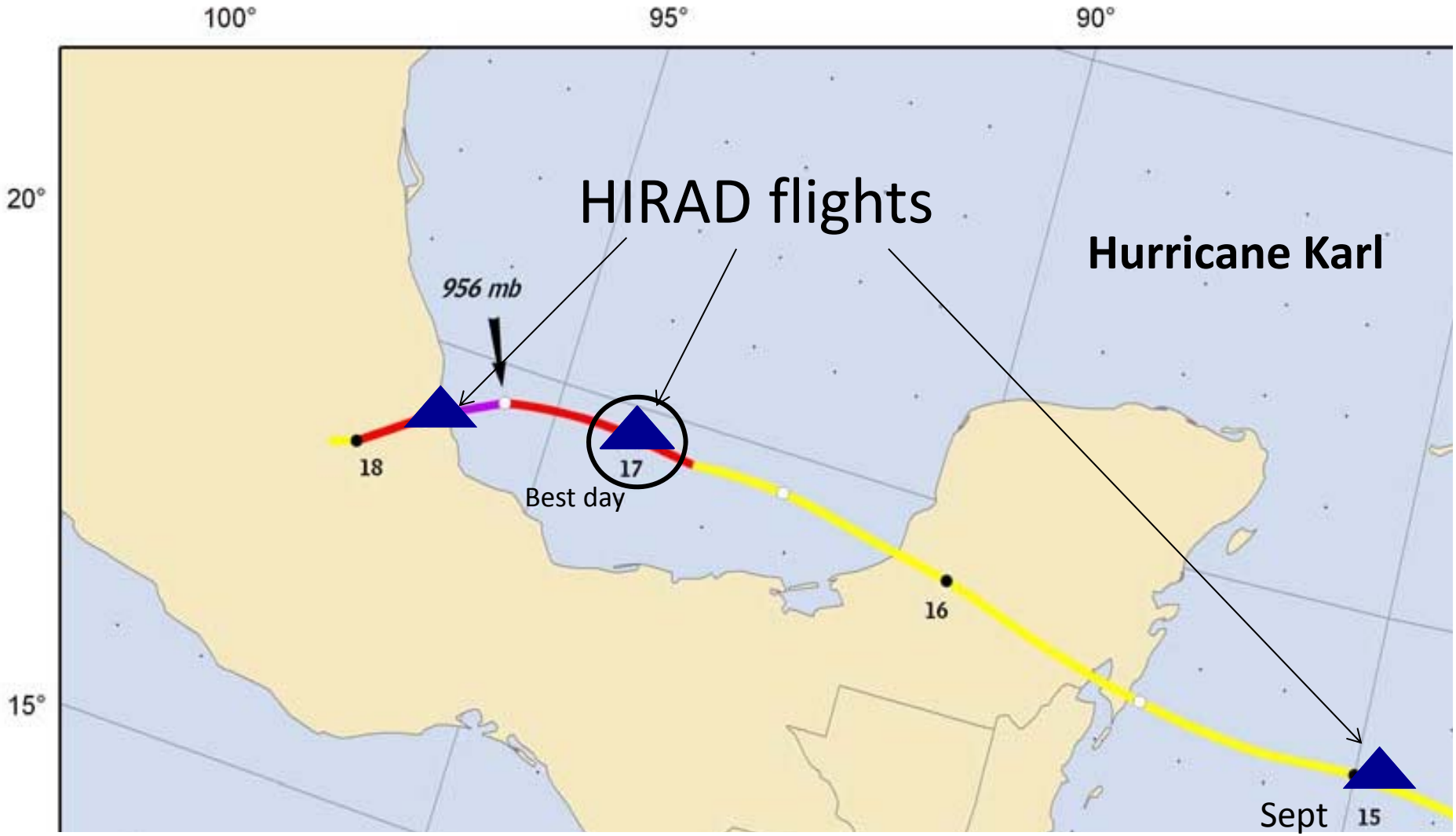
start

SFMR Flt Dir



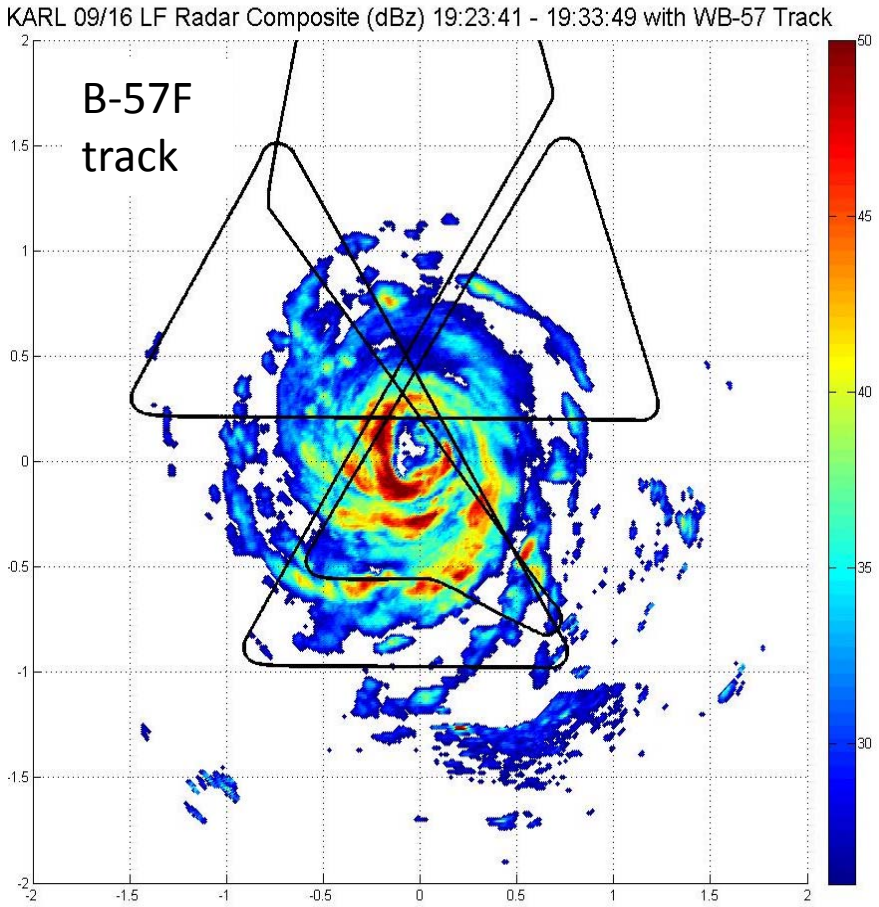
"Model" data are T_Bs computed from SFMR wind & rain fields (using HIRAD view geometry)

Karl Best Track

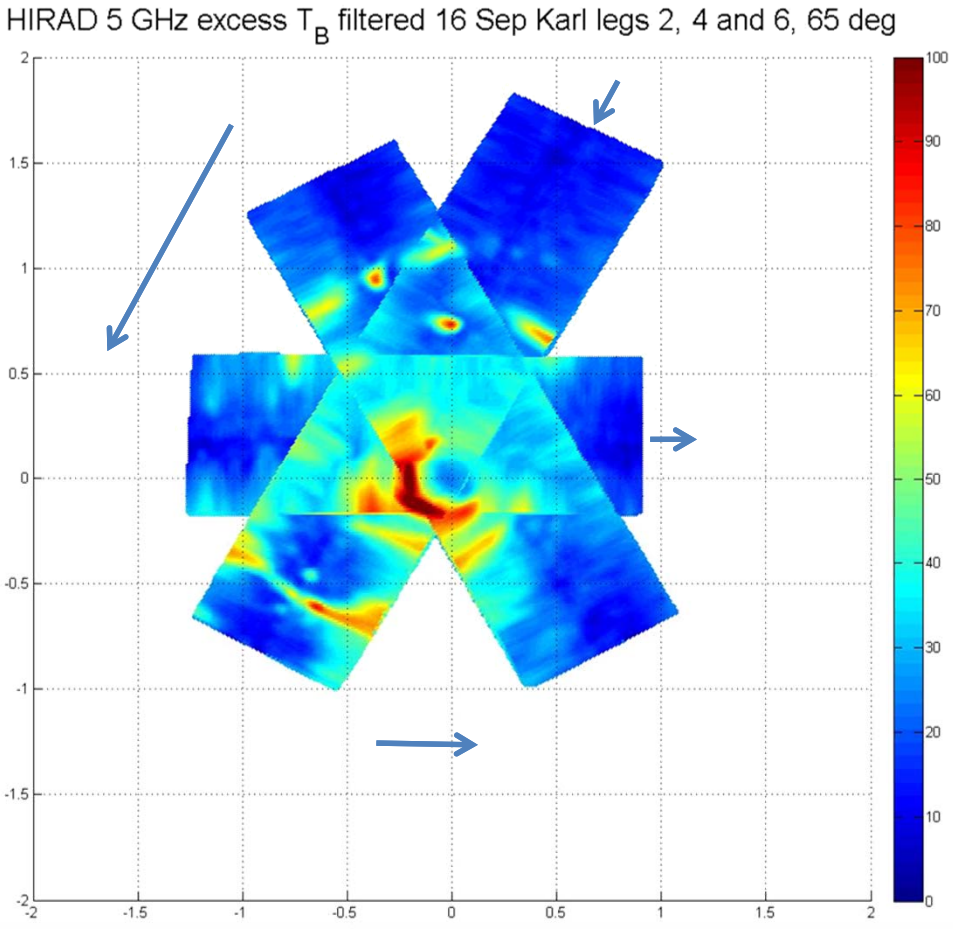


Sept 16 Karl flight

P3 radar reflectivity (left)
HIRAD excess Tb 5 GHz (right)

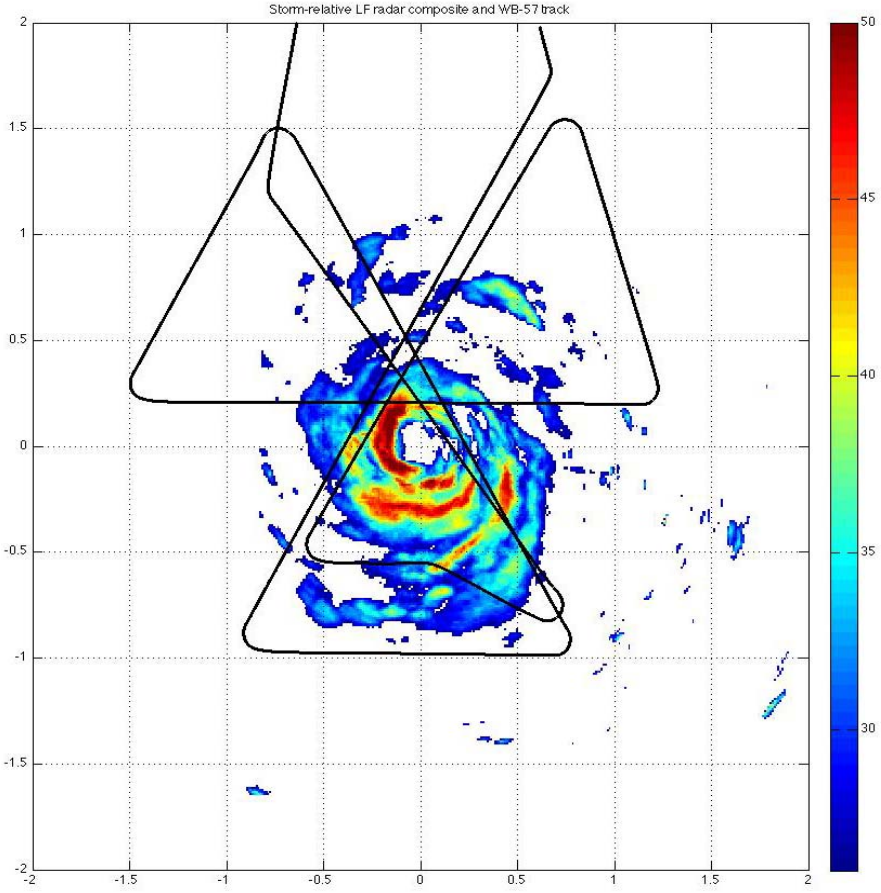


P3 radar center crossing ~19:30:20

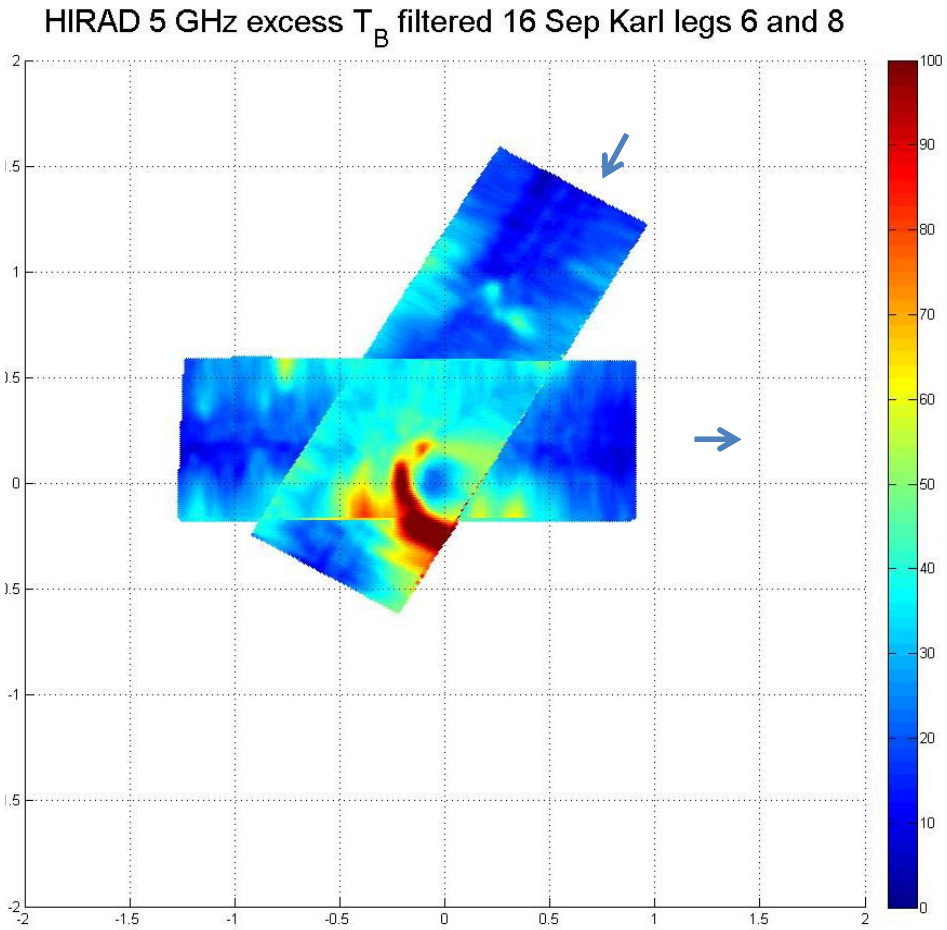


WB-57 HIRAD center crossings at
19:16:49, 19:52:37, 20:33:44

Later in the flight



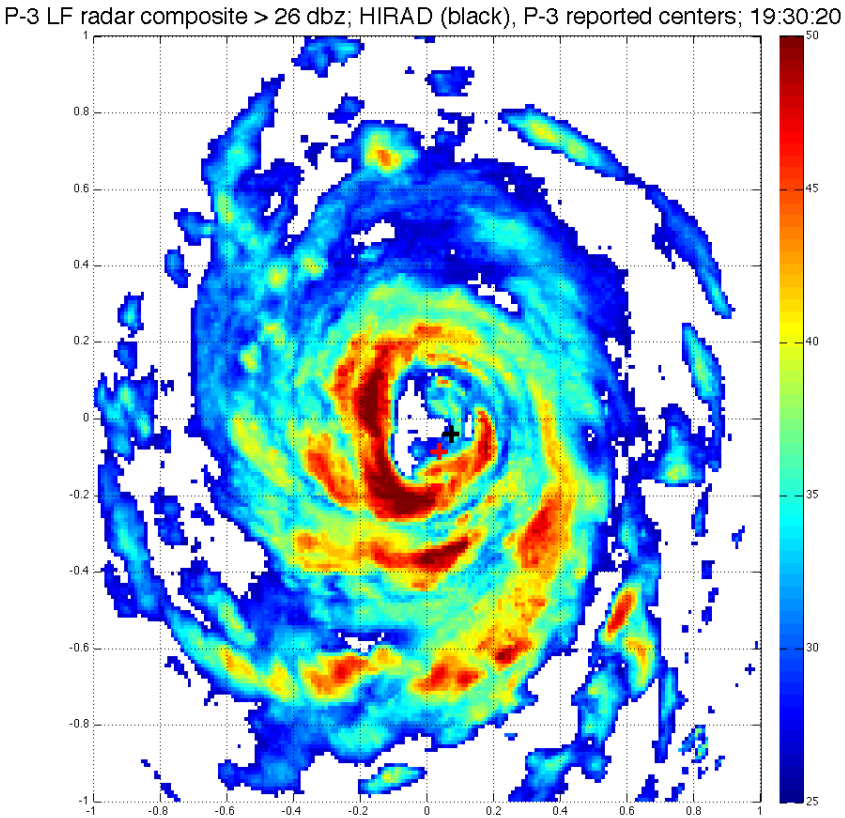
P3 radar center crossing ~20:42:08

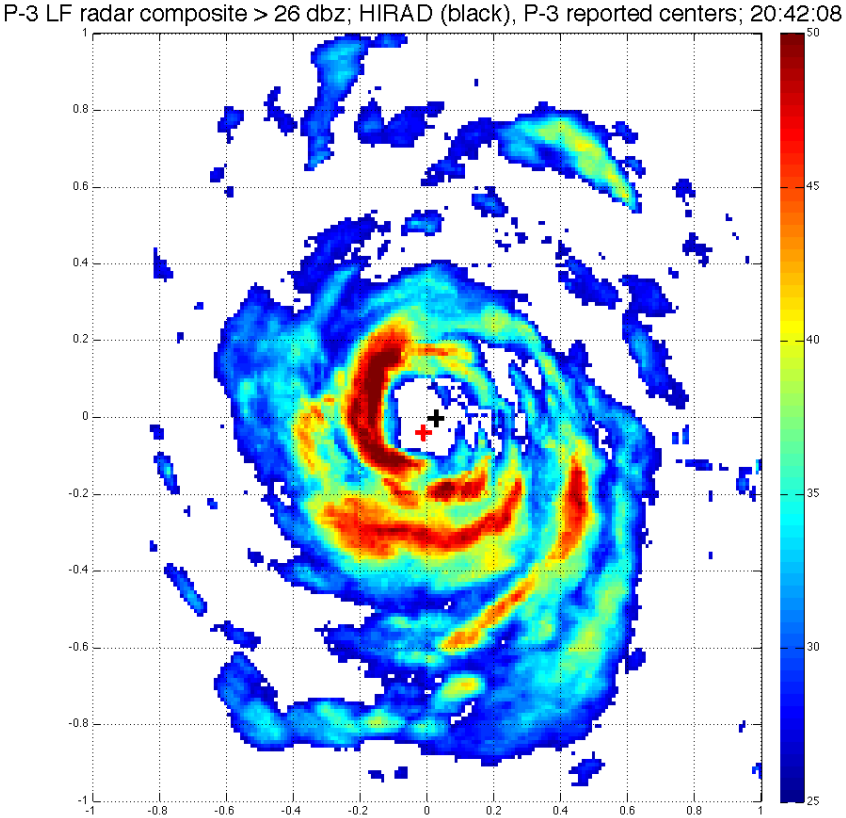


WB-57 HIRAD center crossings at 20:33:44 and 20:53:40

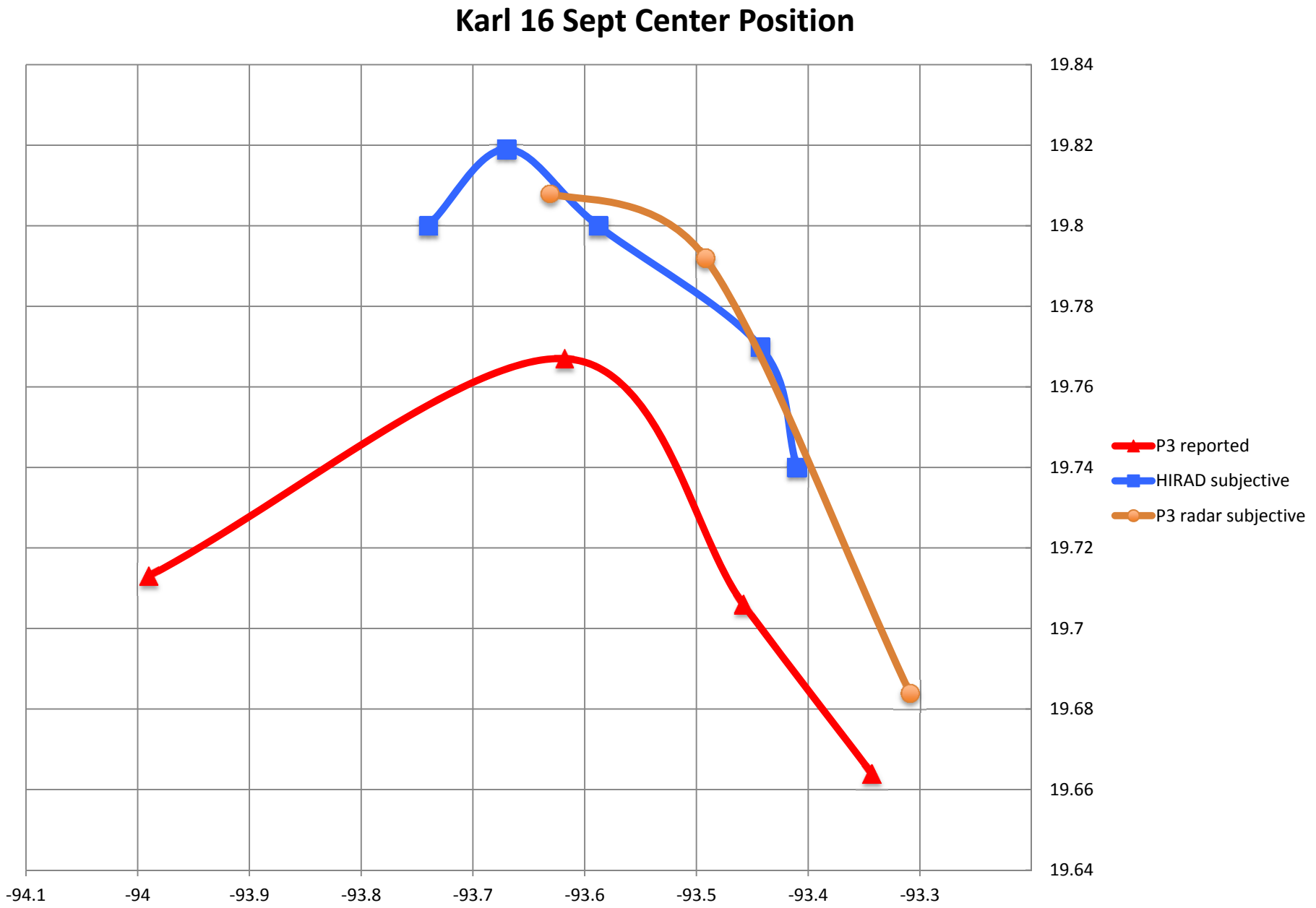
Composite P-3 LF radar reflectivity

Karl 16 Sept 2012





Red “+” is P-3 reported center; black “+” is HIRAD center


Karl 16 Sept Center Position
19.84
19.82
19.8
19.78
19.76
19.74
19.72
19.7
19.68
19.66
19.64
-94.1
-94
-93.9
-93.8
-93.7
-93.6
-93.5
-93.4
-93.3
P3 reported
HIRAD subjective
P3 radar subjective

GRIP Calibration and Data Analysis

(more details in Chris Ruf poster)

- Rain rate and wind speed retrievals require at least two calibrated frequencies
  - 5 GHz T_Bs (microwave brightness temps) have been successfully produced
  - Calibration of other 3 channels is work in progress; further instrument tests are underway to enable calibration and data production
  - Geophysical model function (GMF) developed by UCF (Jones) and HRD (Uhlhorn) will be used to retrieve rain and wind, after T_B calibration is complete
- HIRAD calibration issues and mitigation for HS3
  - Calibration uses internal reference blackbody targets and noise diodes
  - Dependence of calibration algorithm on reference T_B has uncorrected instrument temperature dependence (~25^o C variation during GRIP flights)
  - Temperature correction algorithm being developed for GRIP (requires additional instrument characterization testing)
  - Thermal control subsystem being upgraded for HS3 to greatly reduce instrument temperature fluctuations
  - More temperature measurements are being added to the instrument
  - Chamber tests will be conducted this summer in preparation for HS3

Summary

- HIRAD had successful flights over Earl and Karl
  - Best flights 1-2 Sept and 16 Sept
    - 14 Sept flight was cut short prior to reaching storm center
    - 17 Sept flight was after center had made landfall, winds were much weaker
  - T_B comparison with SFMR and with radar features are very encouraging
  - More details in Pete Black's poster
  - Data analysis is still ongoing
  - 5 GHz looks good for Earl and for 16 Sept Karl, and data have been deposited to the GRIP archive
  - Other frequencies require additional work, after which wind speed and rain rate will be retrieved
  - More details about calibration challenges in Chris Ruf's poster
  - We hope to complete the analysis before Aug. 1