HIRAD Status Report to HS3

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Presentation Outline

- HIRAD team
- Reminder of HIRAD capabilities
- GRIP flights summary
- Status of data analysis
- Status of instrument upgrades
- HIRAD requirements for calibration operations
- HIRAD data products
- Real-time data capability plans
HIRAD Team

• Dr. Timothy Miller, NASA/MSFC, P.I.
  – Atmospheric modeling, project management
• Mark James, NASA/MSFC, Lead engineer
• Dr. Linwood Jones, U. Central Fla., Co-I
• Dr. Chris Ruf, U. Mich., Co-I and lead instrument scientist
• Dr. Eric Uhlhorn, NOAA/AOML/HRD, Co-I
• Dr. J. Brent Roberts, NASA/MSFC, Co-I and data processing lead
• Dr. Sayak Biswas, NASA Post-Doc, MSFC
• 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 ~ 1-5 km
  - Wind speed ~10 – 85 m/s
  - Rain rate ~ 5 – 100 mm/hr
- Key Feature: Near-instantaneous mapping of entire inner-core hurricane surface wind field and rain structure.
- Operational advantages: Surface wind and rain swath will complement SFMR and airborne Doppler radar mapping of inner-core structure for improved short-term advisories and numerical model simulations.
HIRAD Heritage

• Currently, NOAA/AOC and the 53rd WRS use the SFMR instrument on their WP-3D and WC-130J hurricane reconnaissance aircraft to measure ocean surface wind speed. HIRAD uses the same physical principles as SFMR.

• Both of these instruments use multiple C-band frequencies to retrieve surface wind speed and rain rate simultaneously.

• HIRAD’s new contribution is that it obtains a swath of measurements, as shown below, rather than a single line under the aircraft.
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) – Best Karl flight
  – 17 Sept (Karl) – Just after landfall
GRIP Data Analysis and Preparations for HS3

• Rain rate and wind speed retrievals require at least two calibrated frequencies
  – 5 GHz $T_B$ s (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 (~$25^\circ$ 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
HIRAD Calibration During HS3

• In order to enable HIRAD calibration, we have some requirements and desires:
  • Required
    – Before and after each flight, measurement of blackbody target to be inserted under the aircraft
    – At least two CCL calibration flight segment during each storm flight – one on transit to the storm, one on return
      • Clear sky conditions (light clouds okay, but no precip)
      • Calm sea conditions (light winds okay, prefer buoy overpass if possible)
      • Level flight line (nominal aircraft pitch, no roll, straight flight line)
      • Open ocean scene (no land visible to either horizon in cross track direction)
        • > 10 sec required, >30 sec desired
  • Desired
    – CCL flight segment during tests from Dryden
    – CCL flight segment as frequently as possible during storm flights (e.g. beginning and end of flights, between legs over the storm)
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 real-time data processing

• This capability is under development
• We are presuming a real-time downlink capability of 1.6 Mbps, based on preliminary email discussions with Scott
• Approach will be to downlink a thinned subset of raw instrument data, and then process $T_B$ and geophysical retrievals on the ground
• Hence, our product will be NEAR-real-time, not real-time
  – Swath image production ~15-30 min after flight leg
  – Will require GH nav data for lat-lon placement