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° 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