Hurricane Studies With HAMSR

Status report — 4/1/02

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Background

The High Altitude MMIC Sounding Radiometer (HAMSR) is a microwave atmospheric sounder recently developed by JPL under the NASA Instrument Incubator Program. Using new technology, it is a small but accurate instrument that is well suited for hurricane studies. Operating with 25 spectral channels in the 50 - 190 GHz region, it provides measurements that can be used to infer the 3-D distribution of temperature, water vapor, and liquid water in the atmosphere, even in the presence of clouds. Parameters related to scattering from ice particles aloft as well as precipitation can also be inferred. During CAMEX-4, HAMSR was mounted in a wing pod of a NASA ER-2 research aircraft, which operates at an altitude of 65,000 feet and therefore can overfly hurricanes. HAMSR participated in a number of sorties during CAMEX-4, and a large amount of data was collected and is currently being processed and analyzed. The analysis effort is currently in its initial stages.

Overall Research Objectives

1. Obtain microwave soundings of key atmospheric variables in/around hurricanes
    - Provide calibrated brightness temperatures to other CAMEX investigators
    - Derive vertical sounding profiles of
        - temperature
        - water vapor
        - cloud liquid water
    - Infer scattering parameters
        - High frequency effects of ice particles
2. Use derived geophysical parameters to study the synoptics
    - Characterize the state of the local atmosphere
    - Study relevant processes
        - Horizontal and vertical moisture transport
3. Use scattering to study precipitation
    - High frequency perspective

HAMSR Measurements

1. HAMSR is a self-calibrating cross-track scanning instrument. The scan mirror makes a full revolution in a little more than 1 second. During that period it obtains a number of overlapping spatial samples of the scene below and several views of two internal calibration targets. From an altitude of 20 km it is about 40 km wide on the ground. A single field of view project to 2 km at nadir, and sampling intervals are 1 km cross-track.

2. The direct measurements are brightness temperatures for each field of view. There are 25 channels in 3 spectral bands. Band I, which is a temperature sounding band near 118 GHz was not operational during CAMEX. The remaining 15 channels are divided between the 8-channel 54-GHz temperature sounding band II and the 7-channel 183-GHz humidity sounding band III.

3. The primary derived measurements are vertical profiles of temperature, water vapor and liquid water, from the surface to 100 mb in 2-4 km layers.

Accomplishments To Date

1. Preparations for CAMEX-4
    - Reconfigured the instrument, in record time (from a May 2001 start)
    - Designed and manufactured a pressure vessel for ER-2 accommodation
    - Integrated with the ER-2 and carried out test flights, with flawless performance
2. Participation in CAMEX-4
    - Participated in nearly all flights until the final week
    - About 60 flight hours of data collected
    - Only 20% down time (outstanding performance for a brand new instrument)
3. Data
    - A CAMEX-4 data catalog has been developed
    - Calibration processing is under way

Research Plans: Data Sets

1. Calibrated brightness temperatures
    - Preliminary data set based on on-board auto-calibration
    - Definitive data set based on laboratory calibration
        - Measurements are under development
2. Geophysical retrievals
    - Vertical profiles: T, q, L
3. Scattering parameters
    - Scattering index

Status of data delivery: Delayed delivery due to delayed start of FY02 work

Research Plans: Future Studies

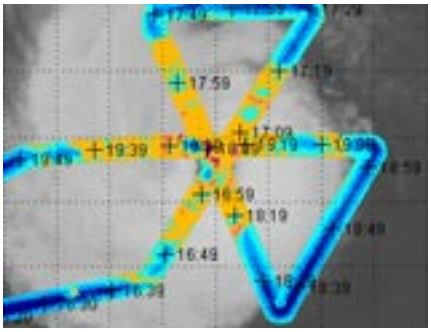
1. Local atmospheric state
    - 3-D fields of T, q, L from HAMSR profiles and other sources
2. Scattering studies
    - High-frequency HAMSR observations (>150 GHz) — Ice
    - Low-frequency AMPR observations (< 50 GHz) — Precipitation
    - Medium-frequency HAMSR observations (~ 50 GHz) — Mix
3. Precipitation studies
    - High-frequency scattering effects as surrogate measurement
    - Correlation with other sources
4. Tropical processes
    - Moisture transport in and around hurricanes

Research Plans: CAMEX-4 Case Studies

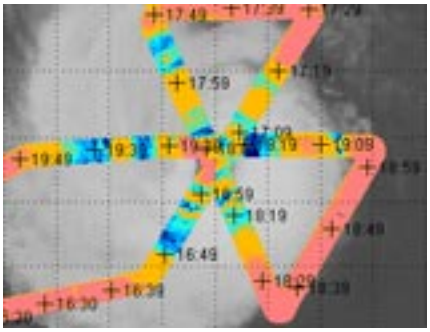
1. Andros Island (8/18) and Ocean buoy (8/26) flights
    - Suitable for geophysical calibration (benign conditions)
2. Hurricanes Erin (9/10) and Gabrielle (9/16)
    - HAMSR was fully operational
    - Substantial scattering effects observed, especially over Erin
        - Suitable for scattering and hurricane specific studies
3. Early off-coast convective-cell flights (9/3, 9/7, 9/9)
    - HAMSR was fully operational
    - Intermediate conditions (clear sky and convective cells)
        - Suitable for synoptic studies and cell studies

Sample Data

Hurricane Erin, 9/10/01

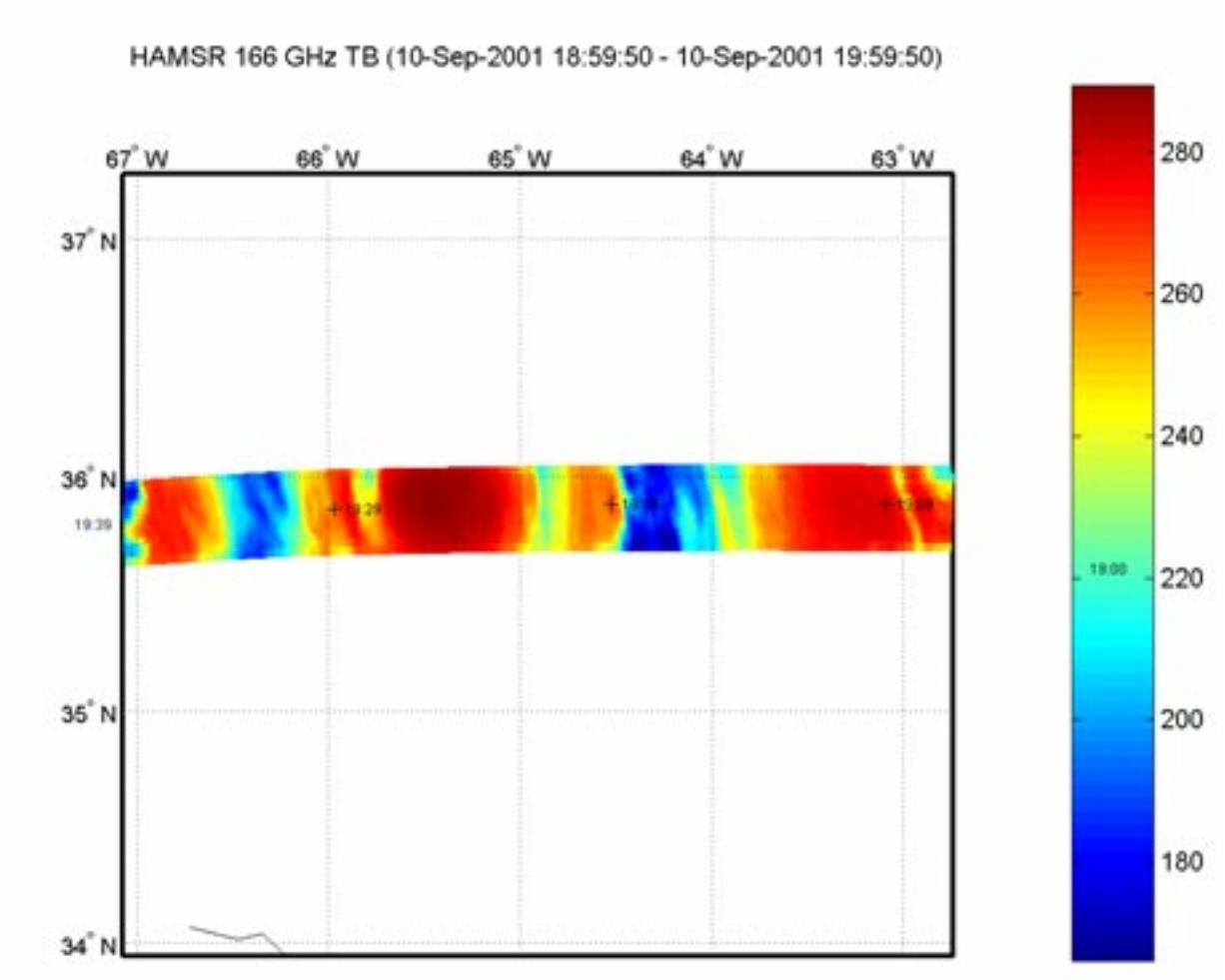


a. 50.3 GHz channel



b. 166 GHz channel

HAMSR data from hurricane Erin (9/10/01), showing the observations in two channels. Fig. a shows data from a transparent temperature channel. The ocean surface appears cold (blue) due to low emissivity. The eye of the hurricane is visible (note that it moves between successive legs of the flight). Fig. b shows data from a transparent moisture channel. Pink areas represent warm moisture 2-4 km above the surface (the surface itself cannot be seen). Blue areas represent regions that appear extremely cold due to scattering, primarily from high altitude graupel.



Close-up of one of the flight legs over Erin