NPOESS Aircraft Sounder Testbed-Microwave (NAST-M): Results from CAMEX-3 and WINTEX

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ABSTRACT

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Aircraft Sounding Testbed, or NAST, has recently been developed and deployed on the NASA ER-2 high-altitude aircraft. The testbed consists of two colocated scanning instruments: a Fourier-transform interferometer spectrometer (NAST-I) [1] with spectral coverage of 3.7-15.5μm, and a passive microwave spectrometer (NAST-M) with channels near oxygen absorption lines at 50-57 GHz and 118.75 GHz. NAST-M collected imagery from over 20 overpasses of hurricanes Bonnie and Earl during CAMEX-3 (Convection and Moisture Experiment, Florida, Summer 1998). The imagery clearly reveals the warm cores and convection morphology of hurricanes Bonnie and Earl.

INTRODUCTION

Aircraft-based imaging of temperature and precipitation using passive microwave radiometry has been studied by a number of investigators (see [2], for example). Multispectral microwave sounders exploit the frequency dependence of scattering from hydrometeors to provide information about particle sizes [3], cloud-top altitudes [4], and rain rate [5]. Recent studies [6] have demonstrated the ability of high-resolution microwave imagery to clearly resolve eyewalls of strong convection and warm cores within the eyes. In this paper, imagery collected over Hurricane Bonnie on August 26, 1998 is examined. Data from NAST-M are also compared with data from a coincident AMSU (Advanced Microwave Sounding Unit [7]) overpass which occurred on March 25, 1999 during WINTEX (WINTer EXperiment, Wisconsin, March/April 1999).

INSTRUMENT DESCRIPTION

The NAST-M instrument consists of two independent total-power radiometer systems which share a scanning reflector. The first radiometer (hereafter referred to as the "54-GHz radiometer") is a single-sideband system with eight channels from 50.3 GHz to 56.02 GHz, and the second radiometer (hereafter referred to as the "118-GHz radiometer") is a double-sideband system with nine channels from 118.75 $\pm$ 0.120 GHz to 118.75 $\pm$ 3.5 GHz. Both radiometers measure a single polarization, with the electric field oriented along-track at nadir. The package typically flies unpressurized at a nominal cruising altitude of approximately 20 km. The swath width is 120 km and the footprint diameter on the ground at nadir is 2.6 km. Detailed specifications of NAST-M are available in [8].

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AUGUST 26, 1998 OVERFLIGHT OF HURRICANE BONNIE

Two overpasses of Hurricane Bonnie on August 26, 1998 are shown in Fig. 1-4. Fig. 1 demonstrates the ability of the 118-GHz channels to resolve the eyewalls of the convective core. The cold temperatures (<200 K) observed are due to the backscatter of cold cosmic background radiation off suspended ice particles. The frequency dependence of this scattering is demonstrated by comparing the 118-GHz channels to the 54-GHz channels shown in Fig. 2. The radiometric signal from the eyewall and surrounding rain bands is much weaker at the 54-GHz frequencies. However, the structure within the eye is more clearly revealed near 54-GHz because of the contrasting signal due to cosmic background reflection off the ocean surface. The ability of the 118-GHz channels to resolve small convective cells is demonstrated in Fig. 3. A small cell is clearly visible in the 118-GHz imagery (15:00 UTC), but is not distinct in the 54-GHz imagery (Fig. 4). The vertical structure of the cell is also apparent in the 118-GHz imagery.

MARCH 25, 1999 COMPARISONS WITH AMSU

The NAST-M radiances observed on March 25, 1999 were compared with radiances observed by AMSU in the following way. First, a temperature retrieval was performed using the AMSU-A channels [9]. A humidity profile was obtained using data from a coincident radiosonde. These profile data were used in a forward model [10] to predict NAST-M radiances for viewing angles $\pm 50°$ from nadir. Corrections for antenna sidelobe spillover when viewing the internal calibration targets were derived from an earlier flight using radiosonde data and temperature profiles retrieved from AMSU. The results are shown in Fig. 5 and 6. Channels 7-9 of the 118-GHz system are significantly degraded due to RF losses in the preamplifier circuits, and are not shown. The brightness temperatures calculated from AMSU radiances are shown with a solid line, and NAST-M radiances (averaged over eight minutes of straight and level flight over water) are shown with asterisks. This and similar analyses suggest a worst-case absolute calibration accuracy of 1.5 K for all channels of the 54-GHz radiometer and channels 1-6 of the 118 GHz radiometer.

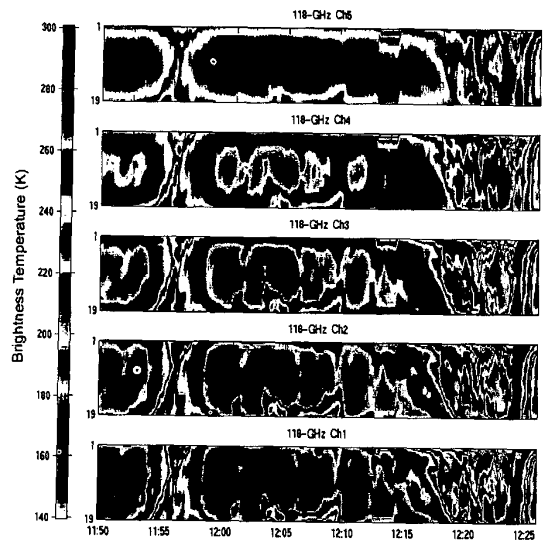

Figure 1: August 26, 1998 overflight of Hurricane Bonnie. The five most transparent 118-GHz channels are shown. Time (UTC) is indicated on the abscissa.

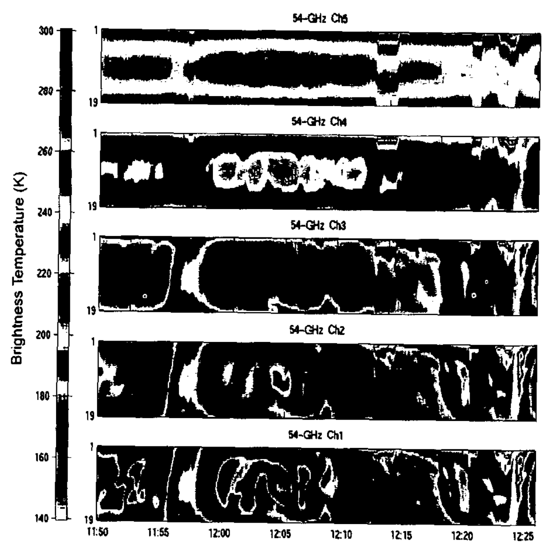

Figure 2: August 26, 1998 overflight of Hurricane Bonnie. The five most transparent 54-GHz channels are shown. Time (UTC) is indicated on the abscissa.

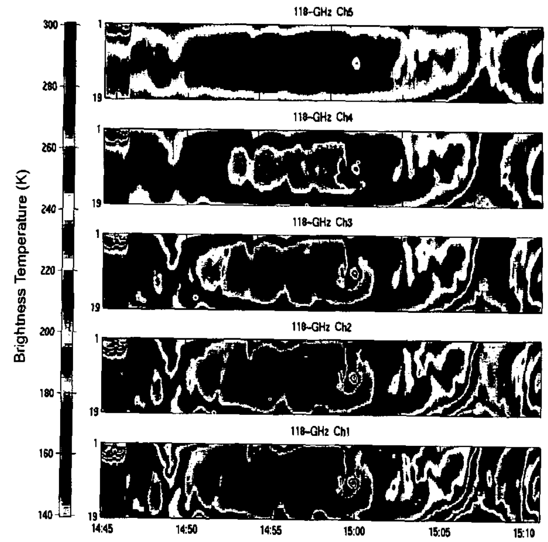

Figure 3: August 26, 1998 overflight of Hurricane Bonnie. The five most transparent 118-GHz channels are shown. Time (UTC) is indicated on the abscissa.

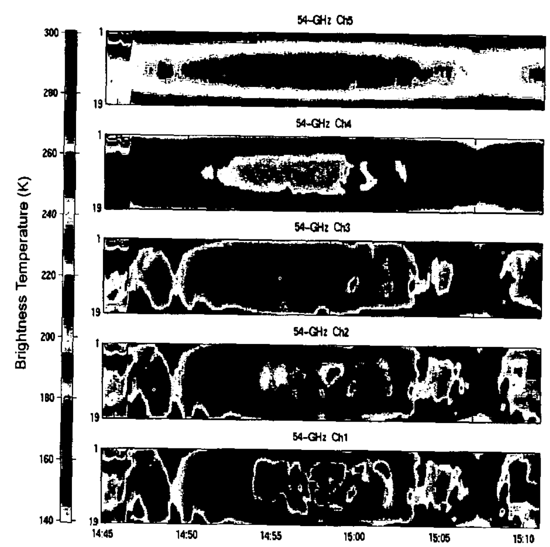

Figure 4: August 26, 1998 overflight of Hurricane Bonnie. The five most transparent 54-GHz channels are shown. Time (UTC) is indicated on the abscissa.

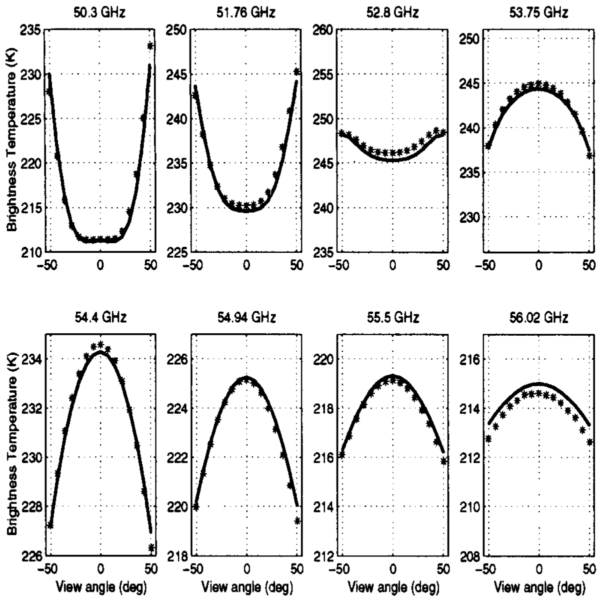

Figure 5: Comparison of NAST-M 54-GHz channels with March 25, 1999 AMSU overpass (00:41 UTC).

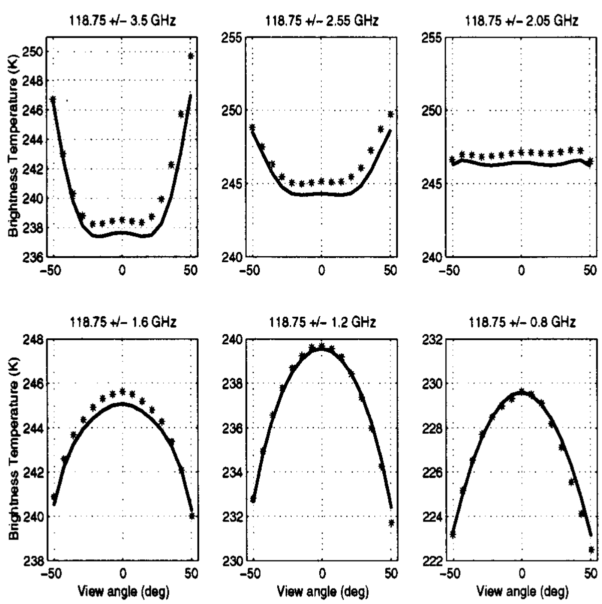

Figure 6: Comparison of NAST-M 118-GHz channels with March 25, 1999 AMSU overpass (00:41 UTC).

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