NOTES

Atmospheric Sounding Near 118 GHz

ALI D. S. ALI, PHILIP W. ROSENKRANZ AND DAVID H. STAELIN

Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge 02139

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ABSTRACT

The thermal emission spectrum of the atmosphere near the 118 GHz oxygen resonance has been measured from the NASA Convair-990 aircraft as it flew over clear air and storms. The instrument viewed the ground 45° from nadir with a 7.5° beamwidth. Brightness temperatures were measured in six bands 200 MHz wide centered at frequencies 821–1891 MHz from the line at 118.7505 GHz. The double-sideband super-heterodyne receiver had ~1 K sensitivity for 1 s integration. Comparison of observed clear air brightness temperatures (from 238 mb) with those computed for a coincident dropsonde yielded agreement within 1.4 K; the retrieved temperature profile agreed with the dropsonde with an average magnitude error of 1.4 K. Observations over precipitation yielded brightness perturbations as large as 30 K.

1. Introduction

In 1963, Meeks and Lilley (1963) proposed using the complex of oxygen (O_2) absorption lines at 60 GHz for temperature profile measurements. This technique was first successfully demonstrated in space by satellites launched in 1972 (Staelin *et al.*, 1973; Waters *et al.*, 1975), and in 1975 (Staelin *et al.*, 1977; Ledsham and Staelin, 1978).

Croom (1971) has discussed some of the advantages of the 118 GHz oxygen line relative to the 60 GHz complex for atmospheric probing: 1) It is an isolated line so that simpler superheterodyne radiometers may be used for sensing; 2) the 1^- line at 118.7505 GHz has the simplest Zeeman splitting pattern of all the O_2 lines, which is advantageous when retrieving temperature profiles at altitudes 50–150 km; and 3) for a given antenna diameter, the spatial resolution length at 118 GHz is half that for 60 GHz. Conversely, larger antennas are needed at 60 GHz for a given spatial resolution. The principal disadvantages of the 118 GHz line are the increased sensitivity to clouds (about twice that at 60 GHz), increased sensitivity to water vapor (about four times that at 60 GHz), and the slightly less advanced technology at 118 GHz.

This paper describes the first successful experiment for probing the atmosphere at 118 GHz. The first clear air temperature profile to be retrieved using this line is presented and compared with ground truth. This profile was probed by a downward viewing 6-channel radiometer, operated aboard the National Aeronautics and Space Administration (NASA) CV-990 aircraft flying near 238 mb. Ground truth was provided by a coincident dropsonde released from the CV-990.

Response of the radiometer system is also presented for rain cells viewed below the aircraft. Errors in the retrieved temperature profile caused by the raincells are presented and are consistent with raincell models.

2. The radiometer system

A double-sideband superheterodyne Dicke-switched spectrometer (Fig. 1) was operated aboard the NASA CV-990 aircraft for the NASA/NOAA (National Oceanic and Atmospheric Administration) Summer Microwave Hurricane Program (SMHP) during the summer and fall of 1978. The radiometer viewed 45° below the horizontal with a beamwidth of 7.5°. The local oscillator was centered precisely on the oxygen line frequency. The i.f. preamplifier for this system operated over the band 0.5–2.0 GHz and was followed by seven filter channels, each with a nominal bandwidth of 200 MHz, and one total power port; however, data from the most opaque channel (which is 607 MHz away from the center of the 118 GHz line) was rejected due to malfunctions. The fundamental integration time of the system was ~1 s, and the nominal rms sensitivity was 1 K.

Fig. 2 shows temperature weighting functions (looking down at ocean) for the six operating

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