RADIOMETRIC SENSING OF ATMOSPHERIC WATER AND TEMPERATURE

by

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ABSTRACT

The microwave spectrometer to be flown in the Nimbus E satellite in 1972 will be a five-channel spectrometer with local oscillator frequencies of 22.235, 31.4, 53.65, 54.9, and 58.8 GHz. These frequencies lie in a water vapor emission band, a microwave window, and at three points in an oxygen emission band, respectively. This thesis gives a theoretical evaluation of the accuracy of indirect sensing of atmospheric temperature, water vapor content, and liquid perturbing elements such as clouds, ocean foam, and variations in surface emissivity. Two types of experiments were performed with the pilot model of the spectrometer: (1) It was used to test the expressions for oxygen absorption by looking up from the surface. These measurements indicate that the Meeks-Lilley-Lenoir model is the best choice to describe the line width of molecular oxygen. (2) It was flown in an airplane over various atmospheric and surface conditions, including frontal systems, clear air and smooth and rough seas, as partial test of the theoretical predictions. These flights, combined with the theoretical predictions lead to the following conclusions:

The most important sources of error in inferred atmospheric temperature are heavy (>0.05 gm/cm^2) clouds over land. It is found that there is a region near 3 km in the atmosphere where clouds of any weights over ocean have no effect on inferred temperature. This applies to raining as well as non-raining clouds. Light and moderate clouds are not serious sources of error over either land or ocean, and neither are variations in surface emissivity. It is found that mean atmospheric layer temperatures can be inferred with greater accuracy than temperatures at a specified level. Using a statistical inversion method, expected rms errors in inferred 1000-300 mb, 300-100 mb, and 100-30 mb mean temperatures are each 1°K for 16 second integration, provided that the inversion algorithm takes climatic differences into account, and provided that the spectrometer is calibrated in orbit by means of radiosondes launched simultaneously with its overhead passage.

Atmospheric water vapor and liquid water can be inferred only over ocean because of the high and variable emissivity of land. The most important sources of error in the inferred values of these parameters are rain and very high seas (winds > 13 m/sec). Microwave emissivity spectra for several models of foam and whitecaps are computed. Variations in ocean temperature and cloud temperature are not significant sources of error. It is found that non-linearity is significant for the estimation of water vapor. Using a non-linear statistical inversion method, the expected rms error in inferred water vapor content is 0.31 radiosondes. The expected rms error in inferred liquid water content is 0.008 gm/cm^2, using a linear estimator.

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