Remote Spectroscopic Determination of Cloud Parameters

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Introduction

In February 1999, ground-based remote sensing of thick clouds was performed at Zvenigorod (Russia). The purpose of the study was to determine the liquid water path (LWP) and liquid water contents along the effective way of radiation in a cloudy layer and to determine the phase structure and presence of soot in clouds. During the experiment, there were clouds with base heights of a hundred meters.

The original method of determining the LWP and phase structure of clouds is based on optically passive (sun as a source of radiation) remote sensing of clouds in several spectral intervals (2.07 μm to 2.32 μm), differing in absorption by water and ice. The method is based on formal consideration of photon trajectories in cloud, which are the result of the sun light multiple scattering on cloud droplets. The effective photon path length in clouds may be measured using the absorption bands of stable gases of the atmosphere (O_2,CO_2,...). In this case, we may separate formally the processes of scattering and absorption in a cloud and consider absorption along the effective path of the sun light in a cloud. Then the spectroscopic analysis of absorption spectra of the solar radiation scattered by a cloud allows us to determine some characteristics of clouds; i.e., liquid water path, optical thickness, and mass scattering coefficient. The estimated accuracy of the liquid water path determination is 20% to 30%.

The measurements were carried out using a quick scanning infrared spectrometer controlled by a computer. By comparing a generated synthetic spectrum to the measured one, we were able to restore the relation of volume coefficients of absorption of water and ice. To determine the ratio of mass concentration of water and ice, we must estimate the error of approximation of chaotically oriented ice particles by equivalent sphere in conditions of multiple scattering in clouds.

The preliminary results of measurements showed that all sounded clouds consisted of water and ice. The ratio of volume absorption of water and ice varied from 0.4 to 3 when the air surface temperature changed from -20°C to 0°C. Liquid water path was in the range of 50 g/m^2 to 200g/m^2, while liquid water contents on an effective way of radiation in a cloud did not exceed 400g/m^2.

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