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Novel Ground-Based Instrument For Day-And-Night Monitoring Of The Stratosphere And The Upper Troposphere Temperature Profile

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The thermal structure of the stratosphere and the upper troposphere is one of the most important atmospheric characteristics determining the dynamic and photochemical processes in the atmosphere. At present, the data on the altitude distribution of the middle atmospheric temperature are almost entirely obtained by remote methods, mainly, radiometric sounding from the satellites within infrared and microwave frequency bands. Such measurements allow one to retrieve the temperature profile in a very wide altitude range from the surface layer to the mesosphere. However, they do not ensure obtaining of the data with time and space resolution that is required for studying the fast local atmospheric processes.

A promising information resource about fast local temperature variations is atmospheric self-radiation in lines of different spin-rotational transitions of molecular oxygen. Among with better time and space resolution advantages of this measurement method are its usability for round-the-clock and almost all-weather (excluding heavy clouds, rainfalls, and snowstorms conditions) observations.

The potential of the ground-based microwave remote sensing of the middle atmosphere has been discussed for a sufficiently long time [1]. Nevertheless up to date the ground-based microwave diagnostics of the middle atmosphere has not been realized for some hardware and software reasons.

In this work, we describe the design and characteristics of the novel complex combining new method for retrieval of the altitude profile of the middle-atmosphere temperature on the basis of the results of the ground-based observation of emission in the lines at the slope of the 5-millimeter absorption band of molecular oxygen, and a high-sensitive spectroradiometer for such sensing. The spectroradiometer measures the spectrum of atmospheric self-radiation brightness temperature within (52.5-53.5) GHz frequency bands with the resolution of 61 kHz. The retrieval method is based first on the Bayesian approach to solution of incorrect inverse problems and second on original technique for parameterization of the problem using approximation of the sought profile by an artificial neural network. Results of the measurements and retrieval procedure are statistical estimates, such as most probable profiles and confidence intervals by which accuracy of retrieval is assessed.

We present the results of the first experimental campaigns aimed at observation of the atmospheric self-radiation spectrum and retrieval of the temperature profiles in the stratosphere and the upper troposphere. We investigate the dependence of the altitude boundaries of retrieving domain on the spectral analysis bandwidth. For the brightness temperature spectrum within one absorption line of molecular oxygen with central frequency 53.0669 GHz (53.0-53.1 GHz), 95% confidence interval of retrieval to an accuracy better than 10 K has a lower limit of height of 20 km. For a wider band up to 52.7-53.1 GHz (including a section of the absorption band of molecular oxygen without resolving lines) this boundary descends to the height of 10 km, which permits controlling tropopause location and temperature.

We compare the obtained profiles with MLS Aura satellite data and results derived by Dr. M.E.Gorbunov from GPS radio occultation data recorded during COSMIC mission, and demonstrate that all three of the data sets are in good agreement.

1. J. W.Waters, Nature, 242, No. 5399, 506 (1973).