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INFRASOUND-RANGE PERIODIC VARIATION IN THE LIDAR SIGNALS FROM THE TROPOSPHERE AND THE STRATOSPHERE

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Wave propagation in the atmosphere is accompanied by variation in the atmosphere's density. The atmospheric wave phenomena can be divided into two main groups - waves caused by dynamic instabilities in shear streams (internal origin of the source) and dynamically stable waves with external origin of the source[1]. To the first type belong waves with period of less than the 5-minute Vaissala-Brunt limit. It is assumed that gravitation waves (which are widely studied, including by means of lidar sounding [2,3]) do not exist below this limit. The short-period wave and vortex atmospheric motions are of considerable practical importance for the air transport and are because of that the subject of theoretical and experimental studies. Our aim was to obtain experimental power spectra of lidar signals in sequential atmospheric layers with heights from 1 km to 30 km using a ground-based lidar.

We carried out two experiments on vertical sounding of the troposphere and the stratosphere on March 1 and 12, 1994, 20-24 hours local time, above the city of Sofia. A specific feature of our lidar (using a Cu-vapor laser) is the possibility of covering the entire sounding distance at an average laser power of less than 1 W. This is achieved through a high repetition rate (5 kHz), a photodetector operating in photon-counting mode, and a suitable accumulating system. The lidar's technical parameters were described in the Third International Lidar Researchers Directory,(1993), p.125. The lidar profiles are with spatial resolution 375 m and are obtained with accumulation time of 10 s. Consecutive series of 256 profiles for each experiment create the database which is used to form temporal series for the signals from the atmospheric layers. The statistical processing includes centring and normalising the series, as well sliding averaging of the spectra. The lower limit of significance of the spectral maximum was calculated with a confidence probability of 95%. Typical power spectra are shown in Fig.1 for the troposphere, the stratosphere, and the tropopause.

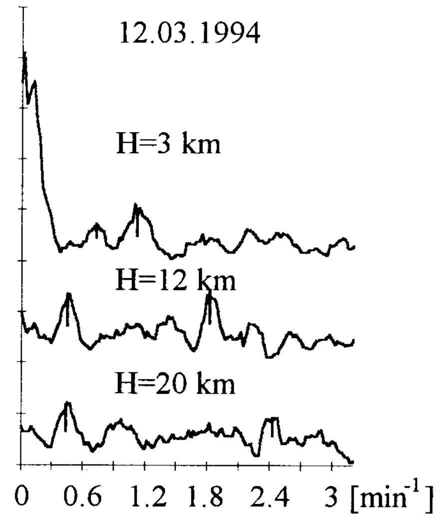

fig.1

After processing of all signals, it turned out that significant maximum were lacking in the spectra for certain heights, while for others such maximum were present at one or several harmonics. The frequencies for which period fluctuations of the signals appear depending on the height of the sounded layers are summarised in fig.2 and fig. 3 for the two experiments. The difference in the diagrams of the two experiments is obvious - in the diagram of 01.03.1994, no periodic signal fluctuations were detected up to a height of 16 km, while in the experiment of 12.03.1994 such fluctuations were present in all layers of the troposphere and the stratosphere. The difference in the two profiles consists in the presence of a cirrus cloud at a height of 8÷10 km during the entire experiment on 01.03.1994. For the sake of clarity, the respective averaged lidar profiles, corrected with respect to the square of the distance, are denoted by triangles on the diagrams (in arbitrary units).

The lidar signals from a given height are proportional to the atmospheric density and the aerosol concentration. The harmonic components in the spectra indicate the presence of wave or quasi-wave processes in the atmosphere. The periods of the fluctuations studied are between 30 s and 10 min. We obtained similar spectra as early as 1989, while spectra with larger periods were observed earlier by Stefanutti [4].

The qualitative difference in the power-spectra diagrams in the two experiments are indicative of the possible effect of cirrus clouds on the appearance of the wave phenomena. We intend to confirm this effect in subsequent experiments which we plan to carry out in the near future.

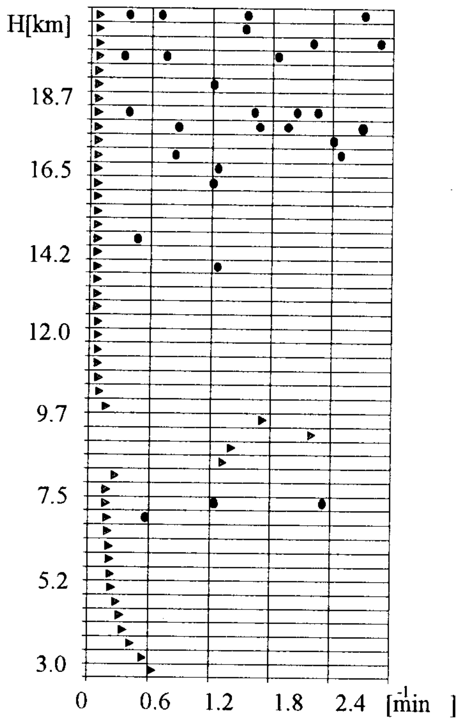

fig.2. Diagram of: • - significant power harmonics; ∇ - lidar profile in a.u., March 1,.1994 .

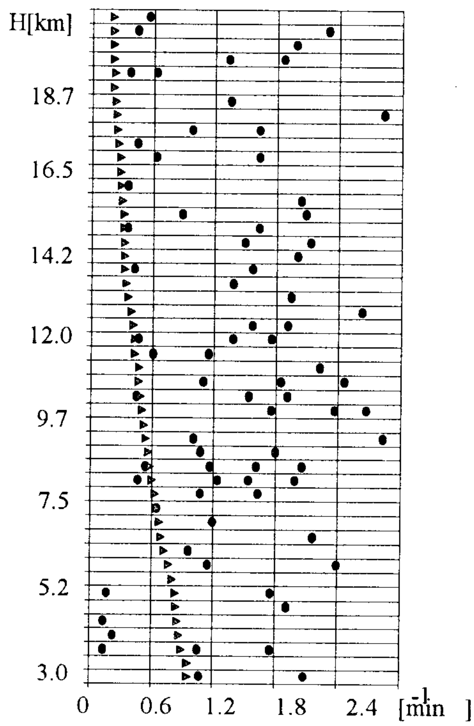

fig.3. Diagram of: • - significant power harmonics; ∇ - lidar signature in a.u., March 12, 1994

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