Abstract

The estimation of the exact height of the boundary between the air which participates in heat and mass exchange in the troposphere with the air of the stratosphere is important for climatology. The troposphere air is involved in mass transfer with the underlying surface. The concentration of aerosols and dust particles is higher than in the air of stratosphere. The aerosol increases the attenuation of light. Therefore, the abrupt change in attenuation coefficient of light will correspond to the height of this boundary. A method is developed for determining this height according to the data of simple and cheap optical sensor of radiosonde

Key words: boundary between troposphere and stratosphere, attenuation, optical sensor, radiosonde

1. Introduction

The estimation of the exact height of the boundary between the air which participates in heat and mass exchange in the troposphere with the air of the stratosphere is important for climatology and a number of practical problems, for example, detection of volcanic dust and smoke particles. This boundary is located in the area of tropopause but its exact location is unknown. The troposphere air is involved in mass transfer with the underlying surface. The concentration of aerosols and dust particles is higher than in the air of stratosphere. The aerosol increases the attenuation of light. Therefore, the abrupt change in attenuation coefficient of light will correspond to the height of this boundary. This height can be measured by using the actinometrical radiosondes which are quite expensive. A method is developed for determining this height according to the data of optical sensor of radiosonde. The proposed sensor is simple and cheap.

2. The equipment and method of measurement

The original purpose of the investigation was the goal to create cheap sensor for measuring of the cloud top height by using usual radiosonde. The photodiode of generating type (sensitive visible and near-infrared regions of the spectrum) was used to measurements. The sensors were installed on the radiosonde and oriented up along the rail. The radiosonde measured the sensor signal by integrated ADC and transmitted a signal with a period of 1 second. The data were recorded on the computer and after the end of launch data were processed. There were done 15 launches in various conditions on aerological station Dolgoprudny (27612). It turned out during processing of the data that the sensor is able to evaluate the attenuation of optical waves in the atmosphere and determine the vertical profile of the coefficient of attenuation.

3. The results of the measurements.
The sensor signal has strongly fluctuations due to swinging of the radiosonde. The attenuation coefficient is the derivative of the signal. Therefore it requires advanced signal processing. Data processing was carried out by two ways.

1. The first method is averaging of signals for 300 points (about 1500 meters) and the calculation of the increment signal. It was based on spatial averaging of the signal,

2. The second method is based on the selection of signal maximum and then and the calculation of the increment signal. This method provided high resolution.

![Fig.1](image1.png)

**Fig.1.** The reduction in light intensity calculated by the first method in triple launch. The abscissa shows the meters. The blue line is temperature.

The results of triple launch given in the fig. 1. Three radiosondes were launched simultaneously with a spatial resolution of 2 Km horizontally. The repeatability of the measurements in the troposphere is very high. Profile of attenuation in the stratosphere is measured worse. This is due to large variations in radiosonde. However, this method cannot show the fine structure of the attenuation.

![Fig.2](image2.png)

**Fig.2.** The reduction in light intensity calculated by the second method in triple launch. The abscissa shows the meters. The brown line is temperature.
The second method of calculating the attenuation gives the opportunity to see the fine structure of the troposphere (Fig.2). There were temperature inversions at altitudes approximately 2500 and 5000 meters. It is known that the aerosol accumulates under the inversion so the air in the inversion is transparent, and the attenuation becomes less.

A sharp decrease in attenuation is always present at a height close to the height of the tropopause, Fig.3.

![Graph](image)

Fig.3. The variability in tropopause height (red line) and a sharp decrease in attenuation (blue line). The y-ordinate is meters; the x-coordinate is the ordinal number of the launch.

The formation of troposphere inversion layer (TIL), i.e. sharp increase in temperature immediately above the tropopause, still not received sufficient explanation. Similarly, optical phenomena in TIL has not yet received an explanation. The airplane pilots detected features in the optical properties of TIL who see the haze at the intersection of the plane of the tropopause. One likely explanation may be the increased concentration of aerosols at this altitude, which is celebrated in a number of experiments.

4. Conclusions

The developed sensor can be used to estimate the vertical profile of attenuation coefficient in the atmosphere simultaneously with the measurement of CTH. It is advisable to continue research to obtain information about optical properties of the atmosphere. It would be useful to conduct a trial operation of the optical sensor on some aerological stations in a different climate zones.

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