POSSIBILITIES OF ATMOSPHERE OPTICAL CHARACTERISTICS MEASUREMENT DURING AEROLOGICAL SOUNDING

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Purpose of this work is the creation of an optical radiosounde for use on the network

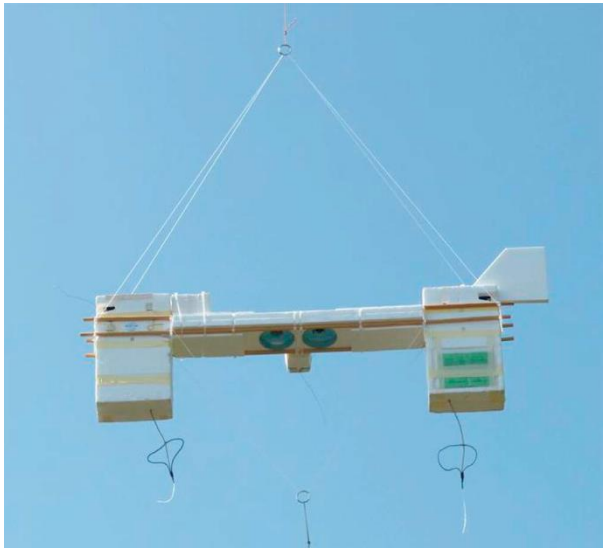


Fig.1. An optical radiosonde

Rolf Philipona, Andreas Kräuchi, and Emmanuel Brocard. Solar and thermal radiation profiles and radiative forcing measured through the atmosphere. GEOPHYSICAL RESEARCH LETTERS 2012

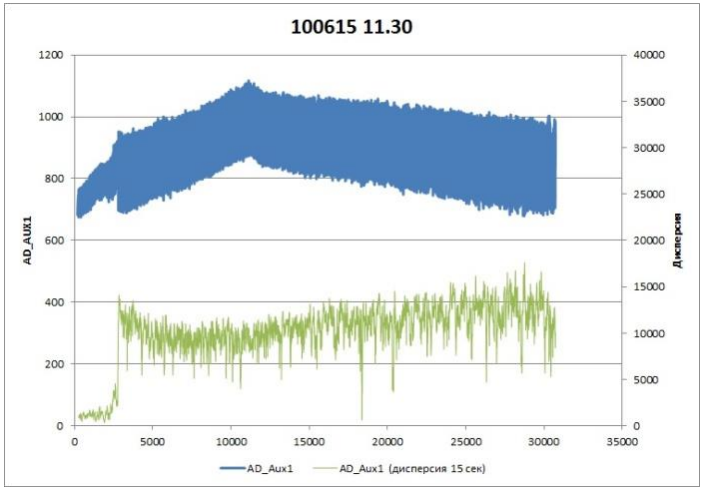
The vertical profile of optical characteristics determines many processes because about 30 % of solar radiation absorbed in the atmosphere. The optical characteristics are being measured now by using of special radiosounde with stable platform and expensive sensors (Fig.1). To carry out network observations it is necessary to equipt the usual radiosounde without stable platform with an optical sensor, the cost of which is comparable to a temperature or humidity sensor cost. This also requires development of signal processing methods.

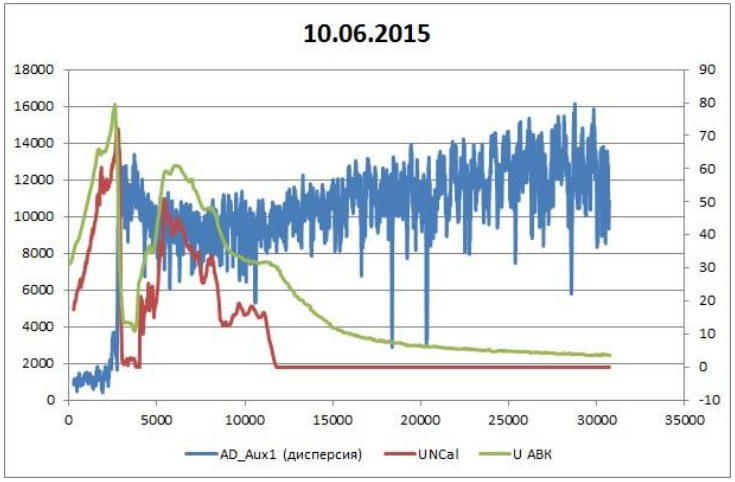
The optical radiosounde for use on the upper-air network

Fig.2. The optical radiosounde (photodiode is noted by blue arrow)

A radiosounde MODEM (France) was equipped by usual low-cost photodiode as a simplest optical sensor of visible light (Fig.2). The photodiode was connected to the ADC of the radiosounde and its signal was transmitted to the station once a second. During the flight, the sensor was oriented along the leer between the balloon and the radiosonde. Most radiosondes have an external sensor input and can be equipped with an optical sensor. The price of such a radiosonde will be 1 - 2 Euros higher then usual.

The measuring of the cloud top height (CTH)

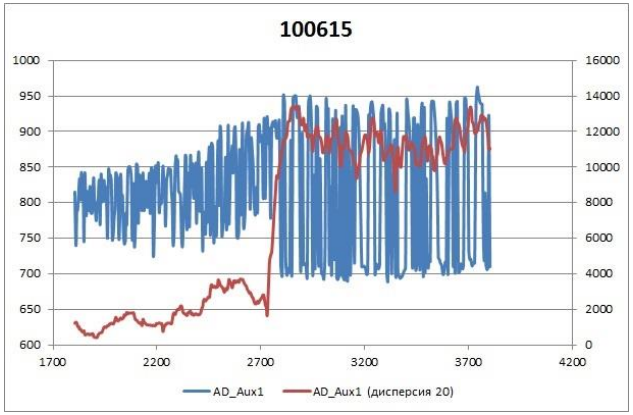


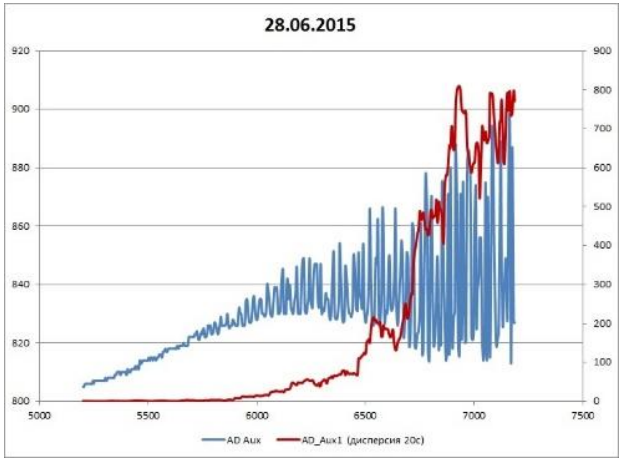


The initial purpose was the creation of sensor for measuring the cloud top height (CTH). On the left picture, the blue line is raw data. Green line represents variance. We see when the radiosonde crosses the boundary from the cloud into the clear sky, the variation increases dramatically. The comparison with the aircraft gave a difference of 30 meters. On the right picture the blue line is the variance. The red and green lines are data from the humidity sensors of the MODEM M2K2 radiosounde (France) and MRZ-3 (Russia), respectively. According to humidity sensors it is possible to determine the CTH, but the second peak in humidity corresponds to the clear sky.

Indication of the presence of precipitation in clouds

- It was observed that the signal variance behaves differently in clouds of different types. This may be due to the dependence of the scattering on the droplet size. The cloud droplets have a size of microns and precipitation particles a size of a millimeter. Accordingly, the variance of the signal in the cloud without precipitation will not decrease to zero (the upper figure is the blue line "raw" signal - red line variance). Large droplets, on the other hand, primarily scatter the incident light in the opposite direction and the variance of the signal in the cloud with raindrops decreases to zero. This allows you to determine the presence of precipitation particles in the cloud (bottom figure cumulonimbus cloud with precipitation-red line is variance).



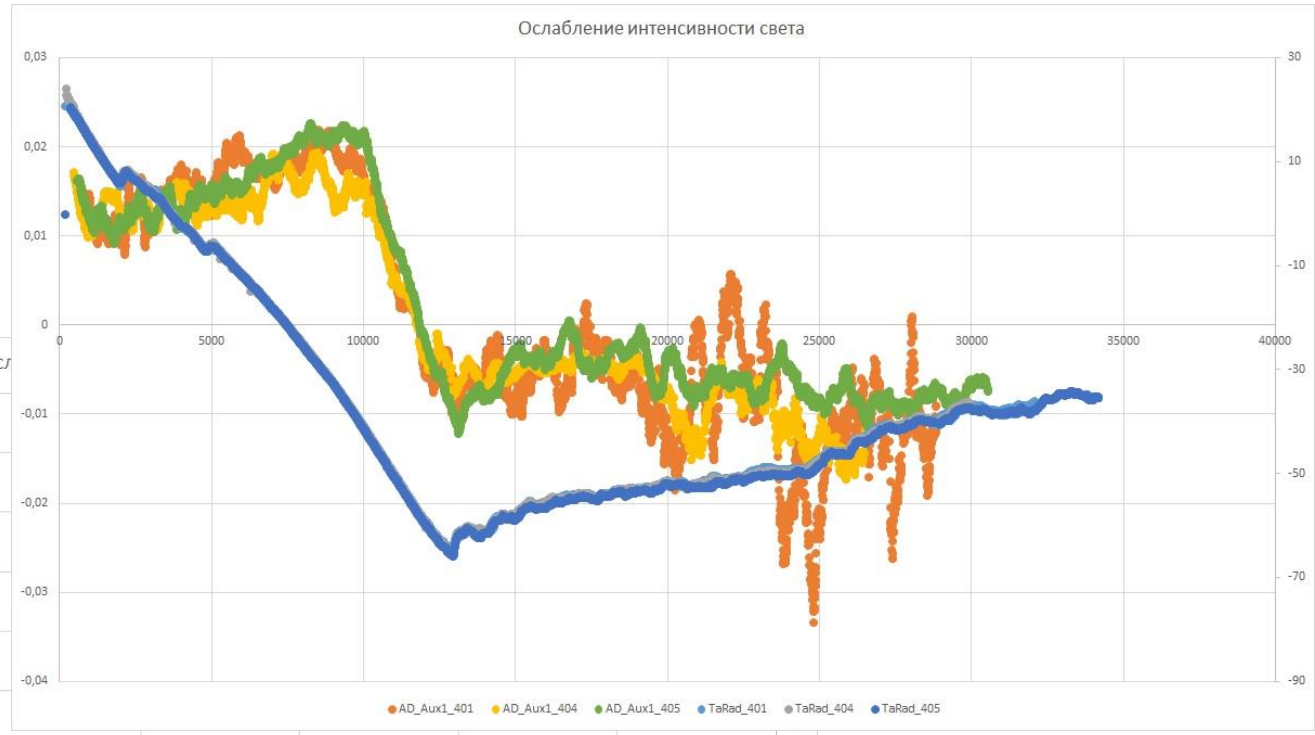


Measurement of the attenuation

- The developed optical sensor allows to estimate the degree of attenuation of solar radiation in the atmosphere in the required wavelength range using photodiodes of the corresponding range.
- The proposed method does not need stabilization. The leer with attached radiosonde makes oscillatory movements during the flight, but the average position of the leer is always located normal to the surface of the Earth. The optical sensor signal varies greatly. We used both a) the simple averaging procedure of 300 seconds of flight and b) the maximum search method . The results are shown on the next slide. Blue line is temperature, green line is attenuation factor.

The attenuation factor

a)



b)

Results

- The simple averaging allows us to determine the average slope of attenuation factor.
- The maximum search method allows us to see the fine structure.
- Here we can see a well known decrease in the attenuation in inversions and a sharp boundary between the air of the troposphere with aerosol and the air of the stratosphere without aerosol.

Summary

- This simple optical radiosonde can measure cloud top height
- It can detect precipitation particles in clouds
- The developed method allows to measure the average attenuation factor
- The maximum search method allows to measure the height of the boundary between the troposphere and stratosphere

Thank you for your attention