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Geophysics

Determination of Atmospheric Aerosol Optical Depth over Territory of Georgia during Different Regimes of Cloudiness Using the Satellite and Ground-Based Measurements Data

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ABSTRACT. The aerosol optical depth (AOD) of the atmosphere is one of the important parameters, which is characteristic for general aerosol pollution of the atmosphere. The present work shows some results of modeling of AOD distribution over the territory of Georgia with different cloudiness according to the methodology of the combined analysis of satellite and ground-based measurements of AOD in Tbilisi proposed earlier. In particular, the AOD values are followed by the total cloud cover values. Above the territories which are characterized by increased cloudiness, the AOD is also increased. Despite the fact that strong aerosol pollution of the atmosphere is observed in Tbilisi, the value of AOD during increased cloudness is a bit less than in other cities (Kutaisi, Batumi). During the cloudless days the AOD decreases with the increase of the distance from the basic air pollution source - Tbilisi city.

Key words: *atmospheric aerosol optical depth, satellite data.*

The aerosols of natural and anthropogenic nature are very important parameters of the atmosphere. Aerosols influence on the process of cloud and precipitation formation [1, 2], solar radiation regime [1, 3], the ecological state of environment [4, 5], etc. Therefore the aerosols exert a substantial influence on local and global climate change [1, 3, 4] and air quality [5], directly related with the human health [3,6], etc.

One of the main parameters, which characterize the general aerosol pollution of the entire thickness of the atmosphere, is the aerosol optical depth (AOD) of the atmosphere [3,4]. At present there are several ground-based [7] and satellite [8-10] systems for the operational global checking of the AOD in the world. In Georgia up to 1992 the values of AOD according to the observational data of the direct solar radiation for six actinometrical stations were determined [3,4].

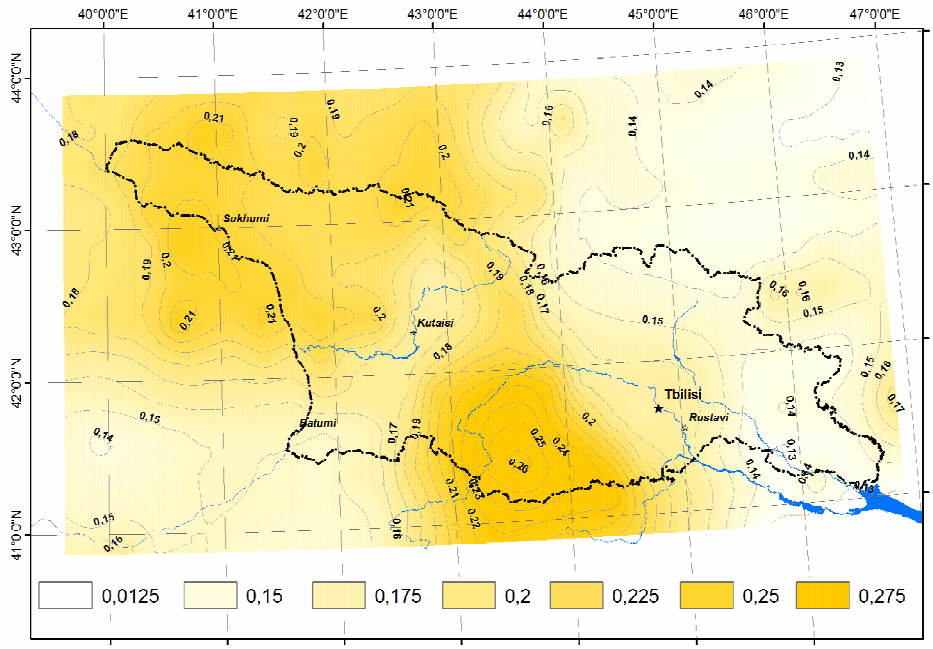

Fig. 1. Distribution of AOD over the territory of Georgia and adjacent countries for all days of observation.

From 2009 similar estimations of AOD values are conducted only for Tbilisi [6]. Via combined analysis of satellite and ground-based measurements carried out in Tbilisi it became possible to propose a methodology for determination of AOD distribution above the territory of Georgia [11,12]. Some new results of modeling of distributions of AOD over the territory of Georgia with different cloudiness obtained by the mentioned methodology are given below.

In the present work the data of the satellite and ground-based measurements of AOD obtained in 2009-2011 are used [6,11,12]. Data on the total cloud cover in Tbilisi and elsewhere in Georgia (9 stations) and neighboring countries (3 stations) were taken from the works [6,12,13]. The results of modeling of AOD distribution over the territory of Georgia are represented in Figs. 1-3.

Model of AOD distribution (for the wavelength 0.488 ìm) over the territory of Georgia and adjacent countries for all days of observation is presented in Fig. 1. During these days the mean coating firmament with clouds above the investigated territory was 66% (including: Tbilisi – 63%, Kutaisi – 73%, Sukhumi – 65%, Batumi – 67%; over the ridges in southern (65-70%), northwestern (65-90%) and northeastern (52-55%) parts of Georgia; eastern Georgia – 55-60%).

As follows from Fig. 1 the values of AOD vary from 0.150 to 0.275. Generally, the AOD values over the ridges (the southern and northwestern part of Georgia) are greater than over the valleys. This phenomenon can be explained by the presence of increased cloudiness, which, in addition to the direct visibility reduction, contributes to aerosols accumulation and their enlargement within the near-cloud space [2, 14].

For example, the vertical distribution of the concentration number of aerosols with over the radius of 0.35 μm was studied in various regions of Georgia. In particular, it was observed that within atmospheric layer less than five kilometer the aerosol distribution is quite steady slightly varying with elevation under the influence of cloudiness. However in the days with cumulus clouds mass of aerosols in the lower five kilometer layer increases approximately 1.4 times compared to cloudless days, while on days with clouds of various types including cumulus – 2.5 times [14]. In addition to this, the increased humidity of air in the layers of cloud formation, also contributes to the AOD increase [15,16].

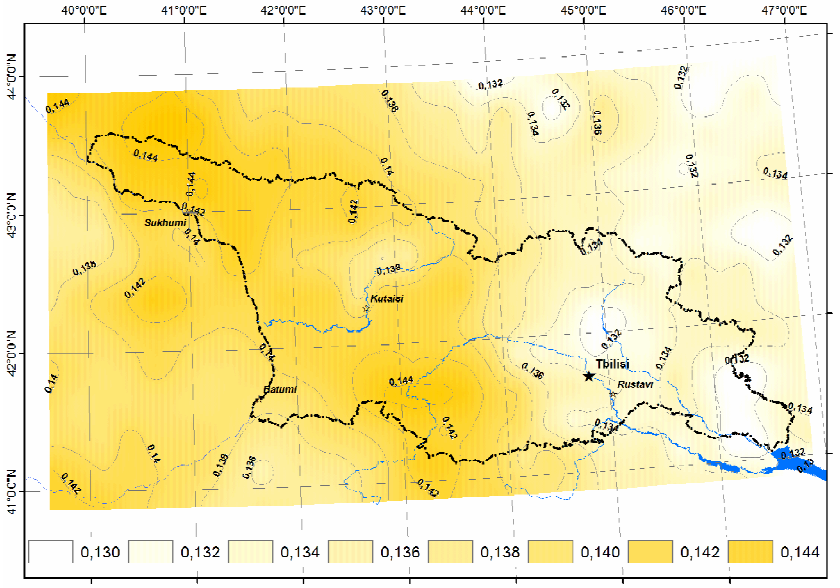

Fig. 2. Distribution of AOD over the territory of Georgia and adjacent countries for low cloud days of observation.

Thus, the AOD values are followed by the total cloud cover values. Above the places with the increased cloudiness, consequently, the AOD is increased too. Also we note that the overall vision of the AOD distribution over the study area as a whole is fitted good to earlier on the distribution of total cloud cover [17].

The model of AOD distribution (for the wavelength 0.488 μm) over the territory of Georgia and adjacent countries for low cloud days of observation is presented in Fig. 2. During these days above the investigated territory a mean coating firmament with clouds is 47 % (including: Tbilisi – 41 %, Kutaisi – 55 %, Sukhumi – 52 %, Batumi – 55 %; over the ridges in southern (43-50 %), northwestern (60-87 %) and northeastern (32-40 %) part of Georgia; eastern Georgia – 30-35 %).

In this case, the values of AOD change from 0.130 to 0.144. As for the foregoing model, in this one the increased values AOD above the places with the increased cloudiness are also outlined.

It is interesting to note that despite the fact that in Tbilisi the strong aerosol pollution of the atmosphere is observed, the AOD value during the days with clouds (Fig. 1,2) is a bit different from AOD in other cities (Kutaisi, Batumi) and even it is less than above the places with the increased cloudiness (the southern and northwestern part of Georgia).

Finally, the model of AOD distribution (relative units) over the territory of Georgia and adjacent countries for sunny (cloudless) days is presented in Fig. 3. This is an idealized model, which is rarely observed in real conditions. However, it makes it possible to compare the levels of the common aerosol pollution of the atmosphere in different places under the similar conditions (clear or clean sky).

As follows from Fig. 3, the decrease of the overall level of aerosol pollution of the atmosphere with an increase of the distance from its basic source - Tbilisi city is clearly outlined . In this case, in eastern Georgia aerosol pollution is higher than in western part. In contrast to the first two models the value of AOD in the cloudless sky above the ridges is lower than above the lowlands. Qualitatively this model corresponds rather well to the previously obtained by us maps of AOD distribution above the territory of Georgia.

The modeling of monthly and seasonal variations of AOD above the territory of Georgia with different cloudiness is provided. These models will be useful for studying the climate change, ecological control.

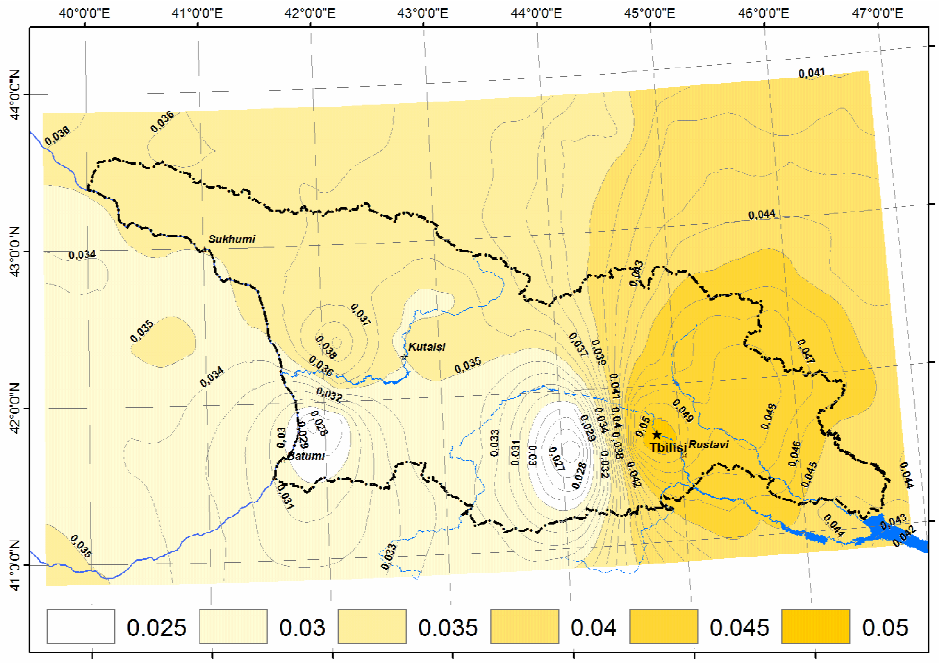

Fig. 3. Model of AOD distribution over the territory of Georgia and adjacent countries for sunny days.

გეოფიზიკა

ატმოსფერული აეროზოლების ოპტიკური სიღრმის განსაზღვრა საქართველოს ტერიტორიაზე ღრუბლიანობის სხვადასხვა რეჟიმის დროს სატელიტური და მიწისპირა დაკვირვებების მონაცემების გამოყენებით

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ატმოსფერული აეროზოლების ოპტიკური სიღრმე (აოს) წარმოადგენს ერთ-ერთ უმნიშვნელოვანეს პარამეტრს, რომელიც ახასიათებს ატმოსფერული ფენის აეროზოლებით დაჭუჭყიანებას. აღნიშნულ ნაშრომში წარმოდგენილია აოს განაწილების მოდელირების ზოგიერთი შედეგი საქართველოს ტერიტორიაზე სხვადასხვა სახის ღრუბლიანობის დროს სატელიტური და

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