SOLAR RADIATION EXTINCTION OVER THE USSR: THE ANTHROPOGENIC AEROSOL EFFECT

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A qualitative analysis of the contribution of anthropogenic aerosols to the spectral extinction of solar radiation in the atmospheric column is presented. It is demonstrated that such an input is found throughout the year in the western regions of the country, and in the eastern — during the summer months.

To account for the effects of the atmosphere on the radiation propagating through it, to develop techniques for forecasting optical weather conditions, and to select optimal deployment sites for various optical systems one needs data on the regime of spectral atmospheric transparency above the regions of interest. Deployment of the ozonometric stations network,[1] which also provides data on the spectral transparency of the total atmospheric column, and publication of data from this network[2] enabled us to map out the spectral transparency and aerosol extinction distributions over the USSR. Analysis of these maps revealed particular features in the distributions of the aerosol spectral extinction, which reflected the impact of anthropogenic pollution upon those characteristics. The present article addresses this particular problem.

If one considers the plots of the estimated anthropogenic aerosol transport over the USSR, published in Ref. 3, it can be seen that the principal aerosol transport to these areas must, by all appearances, be coming from Western and South-Western Europe. Due to the excessive concentrations of anthropogenic aerosols in these regions advection of air masses to the western part of the USSR must result in stronger aerosol extinction. An analysis of maps of aerosol extinction over the USSR in six spectral ranges (λ = 344, 369, 463, 530, 572, and 627 μm) demonstrates that such a situation is indeed observed. This effect is revealed in monthly and annual averages. In support of the above statement, Figure 1 shows a map of the annual average a real distribution of the aerosol radiation extinction at λ = 572 μm. It may be seen from this figure that aerosol extinction over the south-eastern European USSR is 1.5–2.0 times as high as over other regions of the country. That zone of excessive atmospheric turbidity exists practically constantly, the year round, and thus corresponds the plots presented in Ref. 3.

The second peculiarity of these plots consists in an extensive zone of higher extinction observed over the central USSR during the warm season. As shown in Fig. 2, this zone stretches latitudinally across the country, extending from the European USSR to the trans-Baikal region.

The appearance of such a zone is not related to anthropogenic aerosol outbreaks from Western Europe, as follows from the data on air-flow tracks given in Ref. 3 for the warm period of the year. In addition, Ref. 4 demonstrated that despite their low height the Urals mountain rang works as a barrier to aerosol transport by westerlies in the lower two kilometers of the atmosphere (where the principal aerosol mass load is usually concentrated). Such a zone is also impossible to explain by the areal distribution of industrial sources, i.e., by local pollution from enterprises active in the area. Comparing Fig. 2 with a map of the polluted zones for the USSR, taken from Ref. 5, it can be seen that these are quite different from each other.

The most probable explanation is, to our mind, that the latter feature results from air traffic emissions. Reference 6 reported that from 1973 to 1976 the amount of fuel combusted in the upper troposphere by the domestic air fleet had, on the average, increased by a factor of 1.2 in winter, and almost doubled during the summer months. Moreover, as seen from Fig. 3, taken from Ref. 7, the distributions of this additionally combusted fuel over the territory of the country is inhomogeneous and reminiscent of the distribution we have obtained for aerosol extinction, shown in Fig. 2.

This supposition is additionally supported by the fact that emissions of the combustion products of aircraft engine fuel at these altitudes is accompanied by the generation of cirrus (*Citr.*),[7] which may, under favorable conditions, expand into extended cloud banks. At low temperatures (usually below –40°C) the initially condensed water droplets quickly freeze, so that the arising track may exist for quite a long time' at humidities below 100%.[8] Obviously, the described processes must contribute to solar radiation extinction. The extent of that contribution would be determined by the intensity, routes, and altitudes of the flights — on the one hand, and by the meteorological conditions at the flight levels — on the other.

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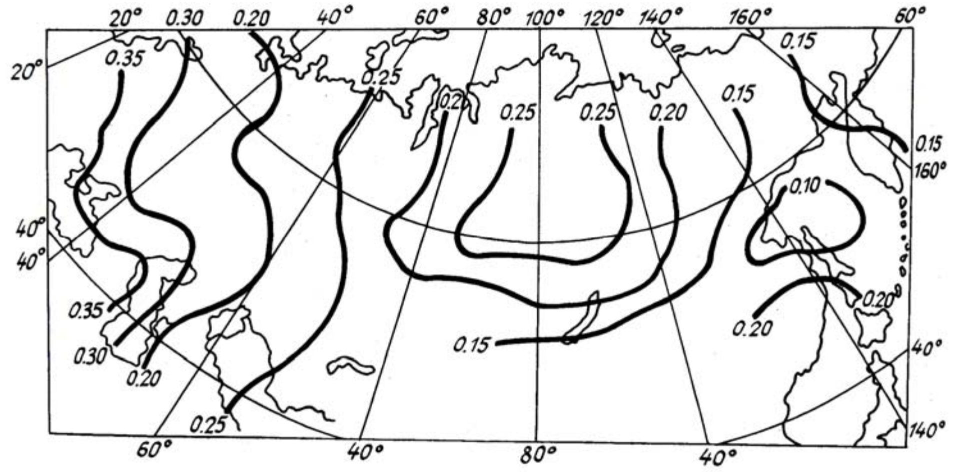

FIG. 1. Annual average aerosol optical depth over the USSR (λ = 572 μm)*.*

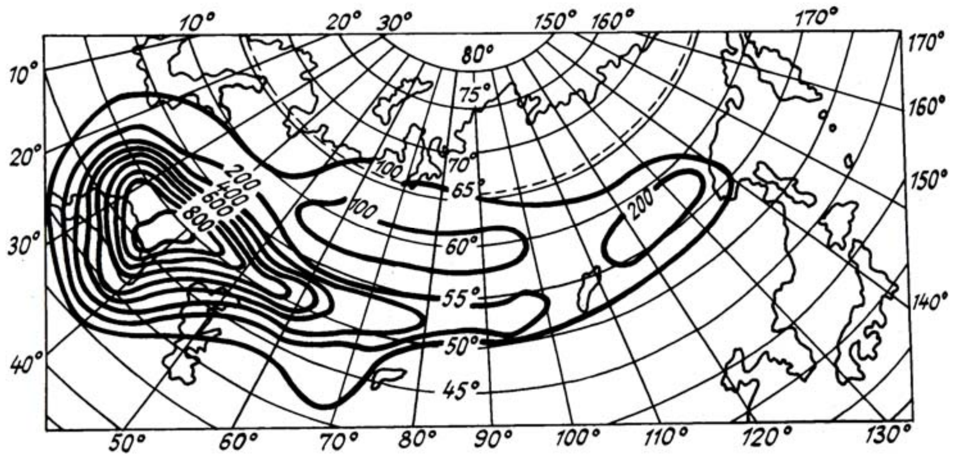

FIG. 2. Aerosol optical depth over the USSR, monthly average for August (λ = 572 μm)*.*

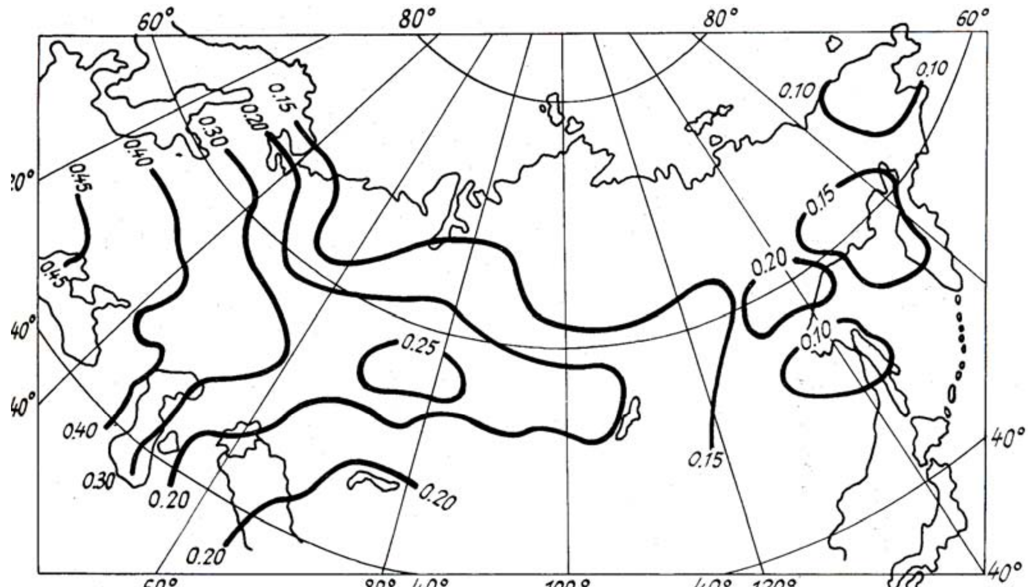

FIG. 3. Distribution of the amount of aircraft engine fuel combusted by civil aviation above 8 km, August 1976 (tons/day).

Thus, a qualitative analysis of the effect of enthropogenic aerosols upon the solar radiation extinction in the atmospheric column demonstrates it to be practically permanent in the western regions of the USSR. It is produced by polluted air masses coming from Western Europe and entering the country's air space. However, the corresponding summertime effect observed over the eastern part of the country results from rather heavy seasonal air traffic.

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