EVALUATION OF OPTICAL INSTABILITY OF THE ATMOSPHERE OVER THE CIS TERRITORY USING AEROLOGICAL SENSING DATA

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Data of ten-year measurements of the air temperature and pressure at the aerological network, and calculated root-mean-square values of the interdiurnal temperature difference at 15 *standard pressure levels (down to* 10 hPa*) have been used to determine the root-mean-square values of the refractive index inhomogeneity for* 50 *aerological stations located on the CIS territory. Mean vertical profile of the air refractive index inhomogeneity has been determined for this territory. Using the root-mean-square values of the refractive index inhomogeneities, that characterize optical instability of the atmosphere, we have performed zoning of the CIS territory relative to this characteristic.*

Qualitative comparison of the obtained characteristics of optical instability of the atmosphere to the observation data on the star image quality at three points: Novosibirsk, Mt. Sanglok (near Dushanbe), and at Pirkuli (near Baku), provided quite good results.

Analysis of the optical instability of the Earth's atmosphere (OIEA) is a very important aeroclimatological task to be achieved when choosing geographical localities for the deployment of large optical and, recently, of high-resolution radiotelescopes. The same refers to observatories and other research facilities the like. The term OIEA is usually understood as the degree to which the refractive index inhomogeneity is developed along a line of sight.

To make the selection of localities that may be promising for the deployment of observation points more efficient, it is proposed to preliminary analyze the OIEA over some preset territories (throughout the world including). That type of indirect assessment can be done using the many-year data of aerological observations compiled.

To make such analysis for the territory of our country, we made use of the data from 50 aerological stations[1] on the root-mean-square values of the interdiurnal temperature differences, $\sigma\Delta_T$, estimated over 12 many-year mean months, as well as on the mean temperature and air pressure at 15 standard pressure levels from 1000 and down to 10 hPa in the atmosphere.

The frequency range of fluctuations in the initial data on $\sigma\Delta_T$ is limited to $0.03-1.2\cdot10^{-5}$ Hz.[2]

Calculated for each of the 15 standard pressure levels were the dimensionless root-mean-square deviations of the refractive index $\sigma_{N'}$ and the contribution, in percentage, coming from each level to the mean, over all 15 levels, sum of $\sigma_{N'}$.

So, the profile of $\sigma_{N'}$ constructed using the data at 15 standard pressure levels for 50 aerological stations characterizes the OIEA for the whole CIS territory, thus being a kind of a characteristic scale. Using this scale we have isolated typical zones of the OIEA, in the atmospheric layer from 1000 to 10 hPa, on the CIS territory for each of the 12 many-year mean month.

ANALYSIS OF THE OIEA OVER THE CIS TERRITORY

Set out in Fig. 1 and 2 there are distributions of the relative season values of the OIEA over the CIS territory in the atmospheric layer from 0 to 30.5 km height.

The dots in the figures show the locations of aerological station locations, the list of which may be found in Ref. 3. The figures at the dots are the OIEA values in percentage. The isolines are depicted in a 20% interval. The dashed curves show the regions where the isolines have been drawn according to qualitative interpolation. The isolines have been drawn without the account for local relief. The zoning performed for highlands reflects the local features to a greater extent. For this reason, the OIEA values may strongly differ even for regions that are geographically close.

It is obvious from Figs. 1 and 2 that the distribution of OIEA has distinct seasonal features. Thus, the lowest values of OIEA are observed at all stations mostly in summer. That means that during summer time the atmosphere is most calm. The exceptions are Aldan station, where the minimum values occur during winter, Murmansk (spring), Arkhangelsk and Chetyryokhstolbovyi island (autumn), and Rostov-on-Don (spring and summer).

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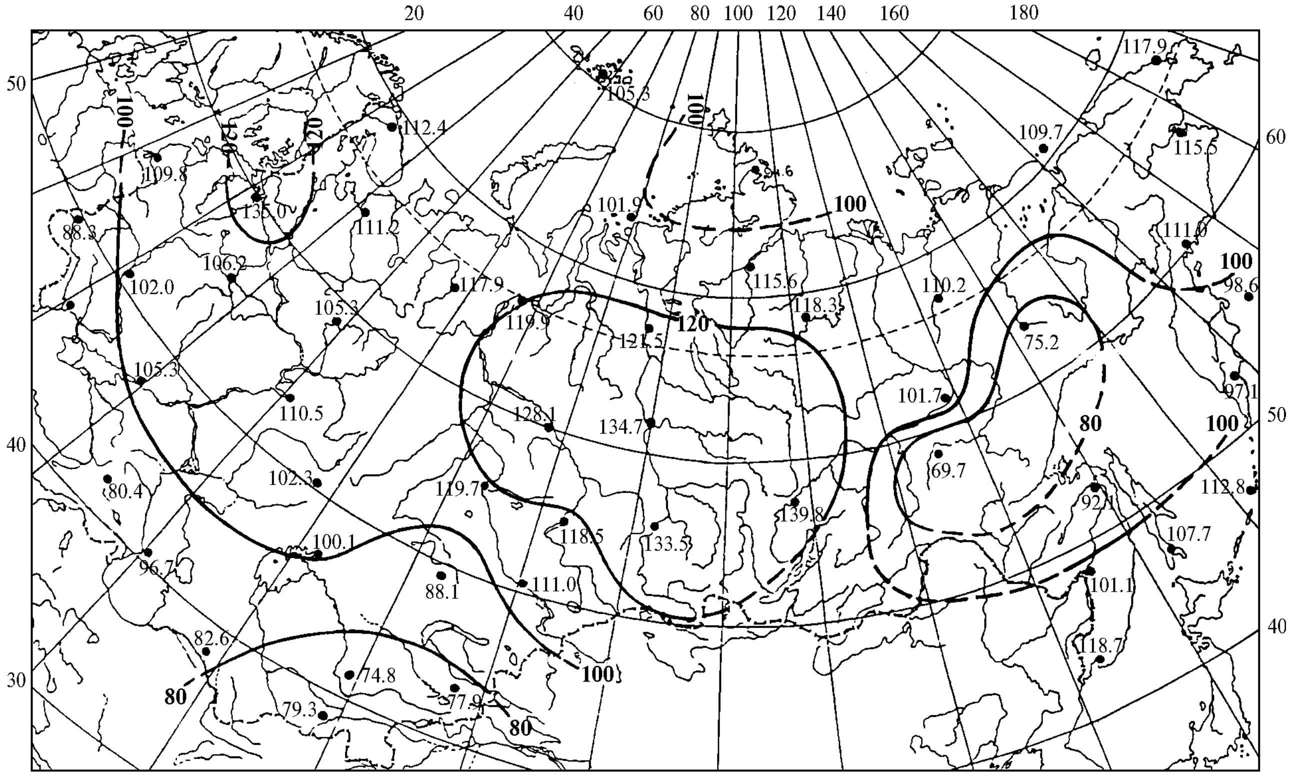
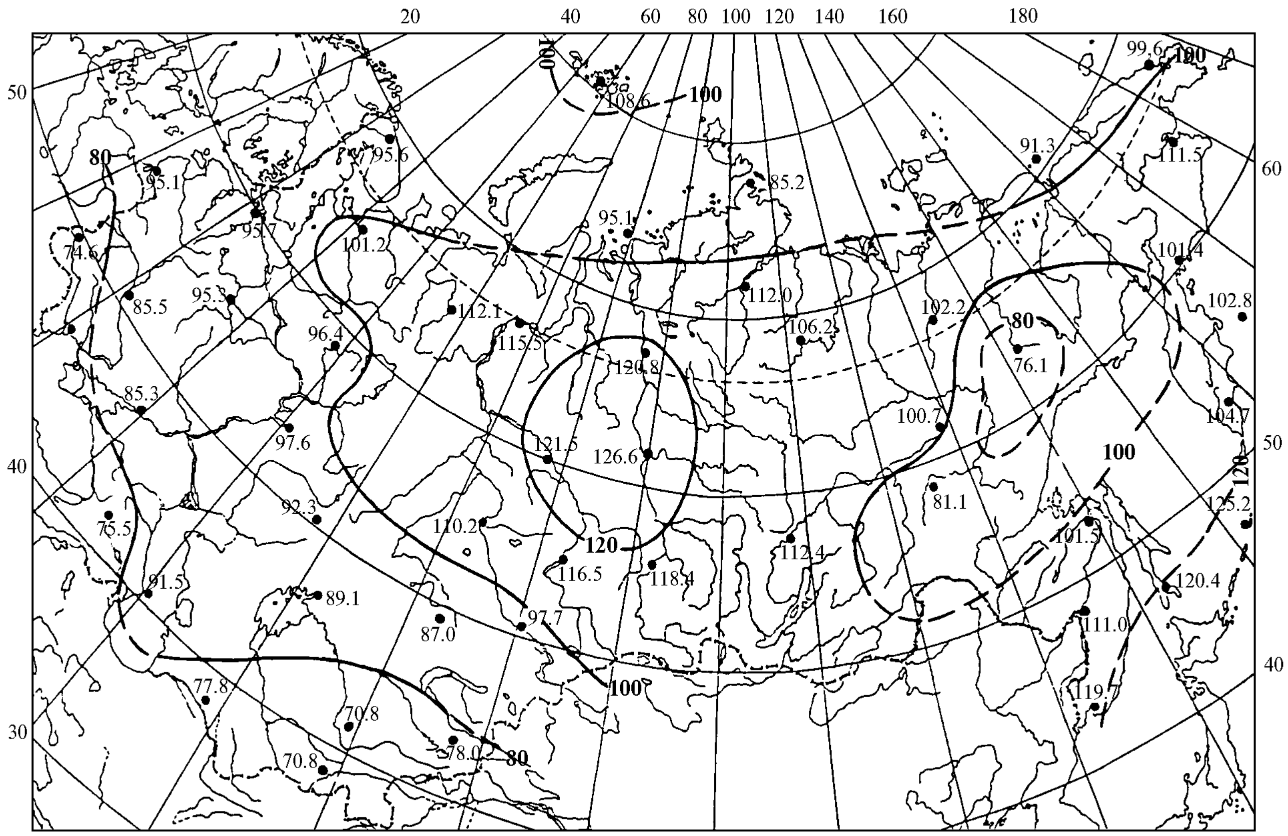


a



b

FIG. 1. Distribution of relative OIEA values in winter (a) and in spring (b).

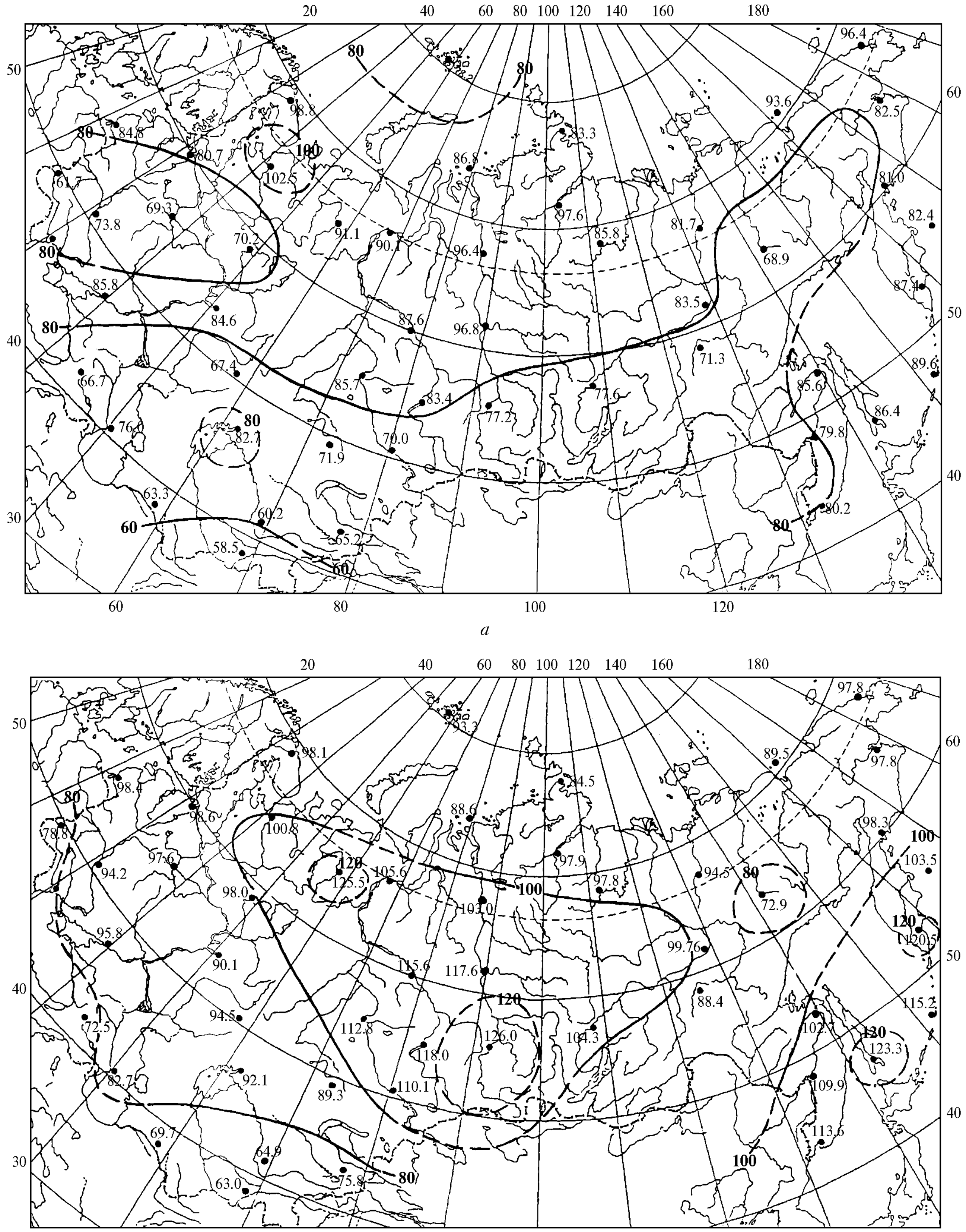


FIG. 2. Distribution of relative OIEA values in summer (a) and in fall (b).

In winter (see Fig. 1*a*) the highest instability is observed almost everywhere over the West Siberian plain and Middle-Siberian plateau, with the maximum of 135% in the atmosphere over Podkamennaya Tunguska station. The southern part of Kazakhstan and Central Asia with the minimum of 74% observed at Tashkent station and south-east Yakutia with the minimum of 70% at Aldan station are the regions most promising for investigations during winter time.

During the spring time (Fig. 1*b*) the values of OIEA decrease by 5 to 8%, on the average, over the whole territory studied, except for the eastern regions. Thus, the OIEA significantly increases on the island stations Yuzhno-Sakhalinsk and Simushir, by about 12%, and a little bit weaker at the continental ones: Khabarovsk and Nikolaevsk-on-Amur (about 70%). The most favorable ones, regarding the OIEA value, are the stations in Tashkent and Dushanbe (about 71%), as well as L'vov, Tbilisi, and Oymyakon stations (75–76%).

During summer time (Fig. 2*a*) the situation over the largest part of CIS territory is most stable. Only in Arkhangelsk the OIEA is above 100%. At Krasnoyarsk, Kirensk, and Podkamennaya Tunguska stations the OIEA values decrease by about 30% as compared to those in spring. The differences in the OIEA values at different stations decrease in summer from 40% to 20%.

During the fall season the values of OIEA increase and the isolines (Fig. 2*b*) tend to take the winter-time configuration. The OIEA values at the stations of South Kazakhstan and Central Asia change during this season only insignificantly.

Summarizing the results of zoning the CIS territory discussed, we should like point out the geographical regions and stations that could be considered as most promising for that type of research and observations.

It is characteristic of a many-year mean year that most low OIEA values may most likely be observed in the south Kazakhstan region and Central Asia (Dushanbe, Tashkent, and Alma-Ata, Ashkhabad being a little bit worse).

The values of OIEA observed in the south-east of Yakutia (Aldan and Oymyakon) and Caucasus (Tbilisi) are a little bit higher.

To judge on the applicability of the results obtained to assessment of astroclimate at a particular geographical point, in Fig. 3 the data on the OIEA values for a many-year mean season are shown together with the estimates of the turbulence angle t'', in units of seconds of arc, at Novosibirsk station, obtained also for a many-year mean season. It should be noted, that the OIEA has been calculated using the aerological data obtained during 10 years (1960–1970), while the data on t'' obtained during 1961–1963 (see Ref. 4). Observations of t'' have been carried out with an AZT-7 telescope (with the diameter of 200 mm) during dark time. This series of observation can be characterized by high statistical uniformity. The abscissa in this figure shows, by the initial letters, the seasons and the left ordinate the values t'' in the units of seconds of arc; t''_0, t''_{20}, t''_{45}, and t''_{70} means the values of t'' measured at the zenith angles of 0, 20, 45, and 70°, respectively. The coefficients of correlation between t'' and OIEA have been determined from these data. Thus, for zenith angle of 0° the correlation coefficient is 0.91, for 20° it is 0.88, for 45° it is 0.86, and for 70° it is 0.70. One can conclude from this that the quality of the star imaging at Novosibirsk station, as estimated by the value t'', as well as the OIEA, have seasonal behavior and vary synchronously.

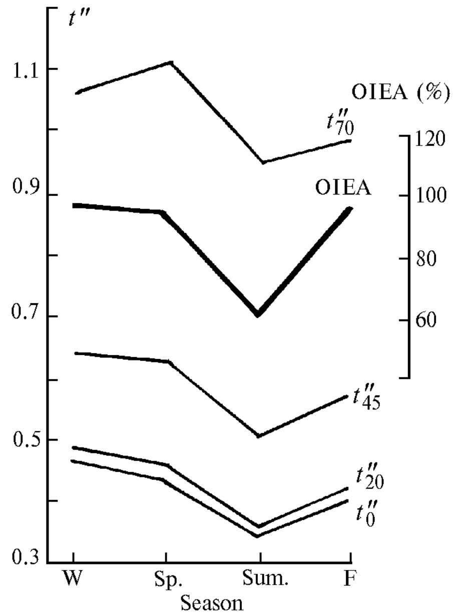


FIG. 3. Change of turbulence angle and OIEA for different zenith distances at Novosibirsk station for year seasons.

Annual behavior of the OIEA calculated for Dushanbe station and of t'' measured at Mt. Sanglok (about 80 km far from Dushanbe) as averaged over a many-year mean month are shown in Fig. 4. Similar data on OIEA acquired at Baku station and on t'' at the Pirkuli point (about 100 km far from Baku) are depicted in Fig. 5.

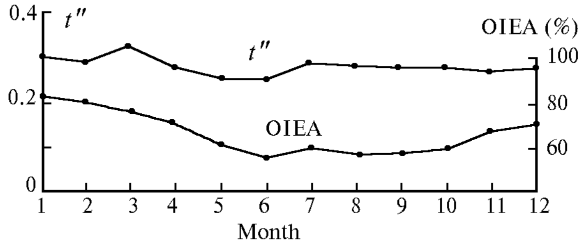


FIG. 4. Change of turbulence angle and OIEA for many-year mean month (Sanglok–Dushanbe).

The abscissa in these figures shows months and on the left ordinate the values of t'', in units of seconds of arc. The duration of the observations over t'' at the Mt. Sanglok covers the period from 1961 to 1963 and in Pirkuli from 1958 to 1961 (see Ref. 5).

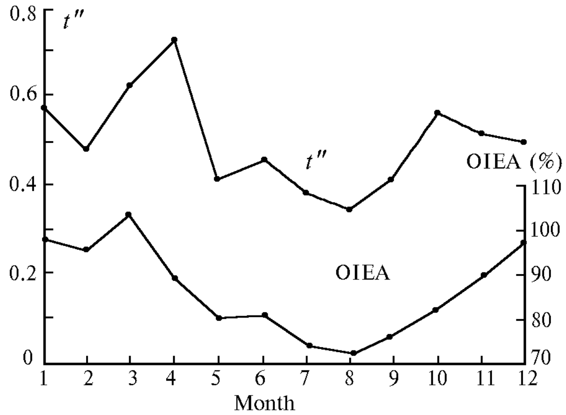


FIG. 5. Change of turbulence angle and OIEA for many-year mean month (Pirkuli–Baku).

Observations have been carried out during dark time with an AZT–7 telescope on the Mt. Sanglok and with a refractor of 108 mm diameter in Pirkuli. The values of OIEA have been calculated for the same period as in Novosibirsk. The data on t'' were reduced to the case of observations along the zenith. The correlation coefficients are 0.49 for Dushanbe station and 0.68 for the station in Baku. As seen from the values of the correlation coefficients, the interrelation between the OIEA and t'' is significant. This is supported by the results of the many-year evaluations of the Sun's image jitter performed at Sayan Sun observatory in 1962–1968, that exhibit quite distinct seasonal behavior with the jitter maximum in winter, and the minimum in summer.

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