Analysis of Observations
and Methods of Calculating
Oceanic Hydrophysical Fields

Some statistical properties of the inter-annual variability of the relative transparency of Black Sea waters*

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Abstract — The Secchi disk data-base compiled in the Black Sea from 1992 to 1993 has been investigated. The space–time variability of statistical properties (RMS deviations and trends) of the series of inter-annual anomalies of the relative water transparency is described.

The transparency field of Black Sea surface waters has been studied for a long period; however, our familiarity with the field's inter-annual variability still remains insufficient.

That problem has been in refs 1 and 2, where the investigators had attempted to assess the inter-annual variability of seawater transparency in the central part of the basin [1] and over the entire basin [2]. The results acquired in refs 1 and 2 display, however, a number of essential discrepancies, which is, apparently, associated with the difference in the methods applied to treat the initial data in refs 1 and 2.

In this connection, it will be recalled that in ref. 1, for analysing the data on inter-annual variability of the Black Sea water transparency, the investigators invoked Secchi disc \( z_s \) observations carried out in the abyssal Black Sea area, bounded by 40°20'-44°15'N and 31-38°E, over the periods from 1923 to 1927 and from 1972 to 1990. The mean annual values of \( z_s \), given in ref. 1 as a final product, were obtained through straightforward averaging.

Note that such an averaging procedure would have been correct if the total of the data-set being handled had been homogeneous. It should be born in mind, however, that, firstly, the field of Black Sea water transparency is essentially heterogeneous both spatially and temporally, and, secondly, data coverage of diverse sea areas and time periods is also uneven [2].

Bearing these points in mind, in order to provide for the uniform data distribution in ref. 2, we divided the Black Sea area into \( 0.5^\circ \times 0.5^\circ \) and \( 1^\circ \times 1^\circ \) boxes and mapped the basin by the types of seasonal variability of the relative water transparency. Then for each box, we calculated anomalous Secchi disc depths, \( \delta z_{aij} \), relative to the annual course, using the formula

\[
\delta z_{aij} = z_{aij} - \bar{z}_{aij},
\]

where \( z_{aij} \) is the measured value of \( z_i \); \( \bar{z}_{aij} \) is the average value of \( z_i \) for each \( i \)th month in the \( j \)th square.

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Figure 1. The distribution of the RMS deviations of (a) $\sigma_t$ and (b) trends $A_4$ of inter-annual anomalies of the relative transparency of Black Sea waters.

The values of $\delta z_{ij}$ calculated by equation (1) had been averaged over the entire sea area by years; the resultant function is shown in Fig. 5 of ref. 2.

That function, however, merely sketches the complex dynamics of inter-annual variability of the Black Sea water transparency. In the present paper, we will examine in more detail the spatio-temporal peculiarities of the distribution of some statistical characteristics of the $\delta z_{ij}$ series.

In the capacity of a data-base on optical properties of Black Sea waters, like previously [2], we have the Secchi disc data stored in the Marine Hydrophysical Institute's data-bank Black Sea containing 6000 measurements made from 1922 to 1993.