EVAPORATION FROM THE SURFACE OF THE BLACK SEA

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While studying the hydrometeorological regime of the sea, its separate parts and adjacent land, it is important to know the value of evaporation from the surface of separate parts of the sea in various seasons. This value is required for balance calculations, and it is quite natural, therefore, that the questions of evaporation from the surface of the Black Sea have been studied by many investigators. So far, however, we do not have the value of evaporation from the surface of the Black Sea, estimated on the basis of hydrometeorological data, relating to the whole sea and directly influencing the value of evaporation. According to the data of the « Climatic and hydrological Atlas of the black and Azov Seas » (published in 1956) and to the results of synchronous surveys, it has become possible to compute the value of evaporation from the surface of the Black Sea.

Original data and methods of treatment.

The reliability of the computed value of evaporation is chiefly determined by the calculation method and quality of original data. For this paper we have used charts of water temperature, absolute humidity and wind speed from the « Climatic and Hydrological Atlas of the Black and Azov Seas ».

We have computed the value of evaporation according to Samoilenko's formula :

$$H = BW (F_0 - fh)$$

Where H — is the value of evaporation in cm/day,

B— is the evaporation coefficient, which depends on the height of surveys above water surface,

W— is the wind speed in m/s,

F_0— is the vapor pressure in mm Hg at the surface temperature and S ‰ = 18 ‰,

fh— is the absolute humidity in mm Hh at the height of observations.

Coefficient B amounts to 0.0105 (3) if the height of the ship's bridge is 6 m. According to the author of the Oceanological tables, when computing the value of evaporation, it is necessary to increase coefficient B by 11 %, i.e. in our case B = 0.0117.

Monthly and annual charts of evaporation have been prepared in the followingway :

The isolines on the charts of water temperature have been assigned the values of vapor pressure (F_0).

The copies of these charts and the charts of absolute humidity (fh) were matched and at crossings of isolines the figures of the value (F_0 — fh) were plotted, according to which we have prepared the charts of distribution of this value. Then, by matching the charts (F_0 — fh) and the charts of wind speed we have obtained the charts of distribution of the value W (F_0—fh), which are, in fact, the charts of evaporation (in order to obtain evaporation in cm/day and then in cm/month it is sufficient to multiply the value W(F_0 — fh) by B = 0.0117).

The value W (F_0 — fh) for the whole sea has been averaged by means of planimetring of zones between isolines on the charts, drawn on even whole values of W(F^o — fh).

The mean value has been computed according to formula :

$$W\ (F_0 - fh)\ \text{mean} = \frac{\Sigma\ (Fo - fh)\ i.Si}{\Sigma\ Si},$$

where W(F^o — fh)i — is the mean value for the given zone,

Si — is the area of the zone in units of planimeter.

The planimetring has been verified by means of equation S sea = Σ Si,
where S of the sea — is the area of the sea in units of planimeter.

The value of evaporation from the whole sea has been calculated according to formula W(F_0 — fh).

The value of evaporation from the surface of the Black Sea.

The mean value of evaporation from the surface of the Black Sea for many years, which we have obtained by summarizing mean monthly values, is equal to 248 km^3.

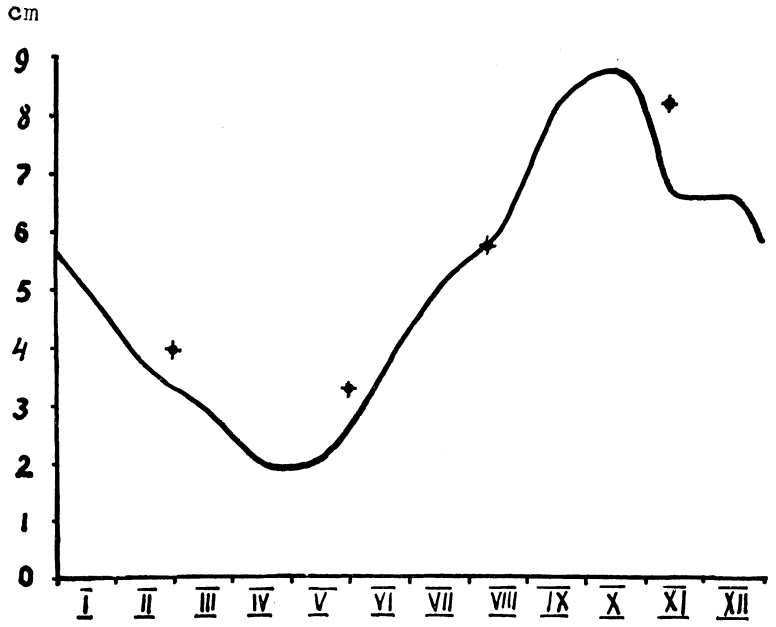

FIG. 1. — *Annual variations of evaporation from the surface of the Black Sea* (based on 1957 data).

The distribution of the value of evaporation per year is indicate in the table I and on the graph, figure 1.

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
cm	5,0	3,7	3,0	2,0	2,0	3,4	5,0	5,9	8,1	8,7	6,6	6,6	60
km^3	20,6	15,3	12,4	8,2	8,3	14,0	20,6	24,4	33,4	36,4	27,2	27,2	248

TABLE I. — *Annual variations of evaporation from the surface of the Black Sea.*

First of all it is necessary to mark rather smooth annual march of the value of evaporation with maximum values in october (to 8,7 cm) and minimum — in april — may (2 cm). The smooth march of the graph is somewhat disturbed by november value.

While analysing the charts of the Atlas for october - décember, one of the reasons for this deviation has proved to be an increased evaporation in december owing to considerable increase of wind speed all over the eastern part of the sea. If in october - november wind speed was, at an average, equal to 6 m/s, then, in december it was 8 m/s.

Having available the data of sinchronous surveys of the Black Sea for 1957, we have treated february, may, august and november surveys using the methods mentioned above.

The value of evaporation for 1957 from these charts have been computed and plotted on the graph of annual march in similar values and according to the dates of surveys (fig. 1).

The data of 1957 are in good conformity with mean curve for many years. The only exception is november, where the value of evaporation in 1957 is by 1,6 cm (24 %) more than the mean value for many years.

An approximate value of evaporation for 1957, computed on the basis of these four points, is about 66 cm, which is 10 % more than mean value for many years. On the basis of this one may assume, that fluctuations of annual value of evaporation are small and therefore cannot be the cause of any essential annual fluctuations of the water balance of the sea.

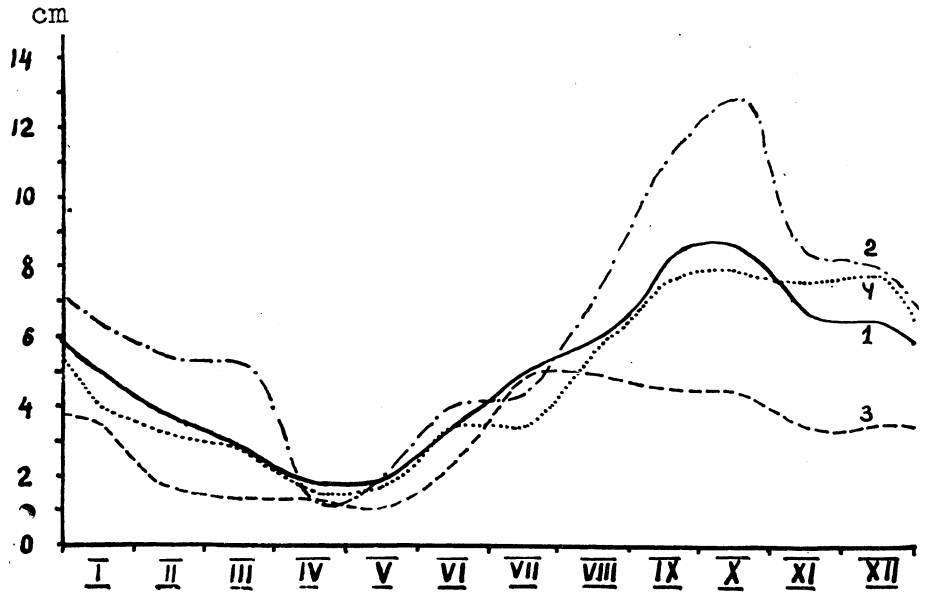

FIG. 2. — *Annual march of evaporation for separate regions of the sea : 1 average value for the whole sea; 2 area with centre* $\varphi = 44^{\circ}30'$, $\lambda = 37^{\circ}3'$; *3 area of Batumi* $\varphi = 41^{\circ}30'$, $\lambda = 41^{\circ}$; *4 southwest area* $\varphi = 42^{\circ}$, $\lambda = 29^{\circ}$.

Figure 2 shows the curves of the annual march of evaporation for separate regions of the sea. We have presented the curves of the greatest, smallest and mean values of evaporation.

The greatest difference in the values of evaporation of these regions is observed in autumn-winter period (to 8,5 cm in october), the smallest — in spring — summer period (to 1,5 cm in july). This fact is in line with hydrometeorological situation of the Black Sea during these months, which is rather uniform in spring and summer and complicated in autumn and winter.

The difference in annual sums of evaporation in separate areas of the sea, computed according to these curves, amounts to 39 cm (table 2).

Region	Sea as a whole	= 46° = 31°	= 44°30' = 30°	= 42° = 29°	= 41°30' = 38°	= 41°30' = 41°	= 44°30' = 37°
Value cm per year	60	54	75	58	46	38	77

TABLE 2. — *Evaporation of separate areas of the sea.*

The value of evaporation from the surface of the Black Sea, obtained by us, is equal to 243 km³ and is close to the data of SCHPINDLER, VODYANITSKY and ROZHDESTVENSKY (table 3).

The Author	Year	Value (km³)
SCHPINDLER (1)	1899	232
MELLER (1)	1928	354
SVERDRUP (7)	1942	363
VODYANITSKY (2)	1948	240
BRUJEVICZ (1)	1953	350
ROZHDESTVENSKY (6)	1953	240
NEUMAN and ROSENAN (5)	1954	397

TABLE 3. — *The annual value of evaporation according to the data of several authors.*

It is seen from this table, that the difference between separate groups of values of evaporation is rather great.

On the basis of all stated above we think it is possible to assume the mean value of evaporation from the surface of the Black Sea as equal to 250 km³ per year. There can be no doubt that as summarizing the numerous data of observations during recent years, the value obtained by us will by defined more precisely, but these specifications will not probably change it to a great extent.

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