GEOGRAPHICAL SCIENCES

THE METHOD FOR CALCULATIONS OF THE VERTICAL DISTRIBUTION OF TEMPERATURE FIELDS BY SATELLITE DATA ON THE EXAMPLE OF THE BLACK SEA

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The method for calculations of the vertical distribution of temperature fields by satellite data on the example of the Black Sea is presented. This method is described in the article [1].

Calculations of the vertical distribution of water temperature in the Black Sea are founded on the «Method of calculation of the vertical distribution of water temperature in the Black Sea based on satellite information» (hereinafter referred to as the Method) created by us in 2015 year [2].

In undertaking this work the developed Method [2] was significantly completed with new equations, criteria for calculations, corrections for the temperature of the water, which significantly improve the accuracy of the calculations of the vertical distribution of water temperature. Complex calculations of linear and exponential regression equations were included in the last Method version compare to Method of the 2015 year where the calculations were performed only on the equations of exponential regression [1, p. 98].

Method of calculation

Calculations of the vertical distribution of temperature fields in the Black Sea in a layer of 0 – 50 meters were carried out in three main stages.

The first stage – the finding of statistical dependences between the values of water temperature at the neighboring levels in the Black Sea according to the data of water temperature and the creation of regression equations.

The second stage – setting the criterion for calculating the vertical distribution of water temperature ($\pm\Delta T$).

The third stage – calculation of water temperature corrections at depths of 10, 20, 25, 50 meters.

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Development of regression equations and determination of criteria's for calculation

In each square (Figure 1) the equations exponential and linear regression were built for each month in the period May – October. The total number of equations exponential regressions amounted to 432 and linear regression equations – 432 respectively.

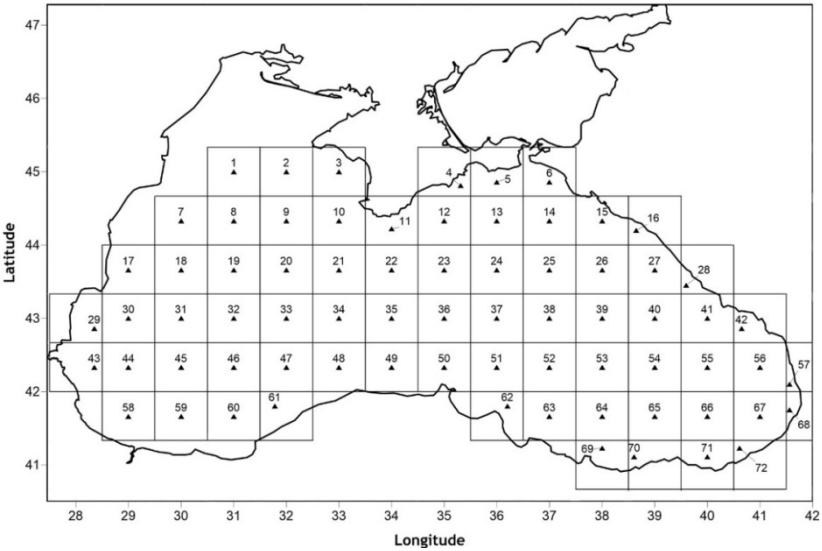

Figure 1. Location of squares (square size 40' to 60') for calculating regression equations in the Black Sea [1, p. 99]

The criterion (±ΔT) was used as determining factor in the calculations of the vertical distribution of water temperature on equations, exponential or linear regression.

Studies have shown (> 1000 numerical experiments) that when the deviation of the sea surface temperatures from climatic values of water temperature (T_{clim}) in the Black Sea is ±2°C a linear relationship between water temperature values is dominated on the neighboring levels.

Thus, if the value of the sea surface temperature (T_0) is in the interval $[T_{clim} - 2 < T_0 < T_{clim} + 2]$, the vertical distribution of water temperature is calculated by, exponential regression equations. If they are not included in this interval, the equations of linear regression are used.

To improve the results of calculation of the vertical distribution of water temperature based on the satellite data, regression equations were developed to calculate the water temperature corrections at depths of 10, 20, 25 and 50 meters.

Research has shown that water temperature corrections must be entered depending on the time of the year. So, for the spring – summer period the correction at depths of 10, 20, 25 meters should be introduced. For autumn correction should be introduced at depths of 10, 20, 25 and 50 meters.

Calculations of the vertical distribution of temperature fields by satellite data on the example of the Black Sea

The local calculation of the vertical distribution of water temperature in the Black Sea by satellite data in the layer 0 – 50 meters at several stations can be easily carried out by applying the developed equations. But if the whole water area of the Black Sea should be counted, this process is very time consuming.

Therefore, we designed a prototype of a computer program (hereinafter referred to as the Program) for the calculating of the vertical distribution of water temperature in the Black Sea by satellite data. The Program includes 864 exponential and linear regressions equations to calculate the vertical distribution of water temperature in the Black Sea and the months between May – October; linear regression equations to calculate corrections for temperature at standard levels (10, 20, 25, 50 meters); intervals to determine the calculation by exponential or linear regression equations.

Thus, the Program automatically determines where and by what equations the vertical distribution of water temperature in the Black Sea and the corrections to the water temperature can be calculated.

The initial data for the calculations are only daily satellite data of the sea surface temperature and the month of the year.

To visualize the results of the calculations by the Program the maps of the vertical distribution of temperature fields at standard levels, zonal (latitude 44° N) and meridional (longitude 36° E) sections for 30.05.2017, 27.06.2017 and 10.09.2017 were built.

The results of calculations of the vertical distribution of temperature fields on satellite data at the standard levels in the Black Sea for 30.05.2017 are shown in Figure 2.

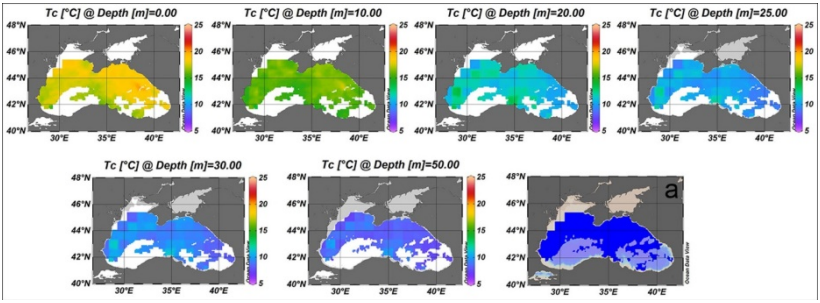

Figure 2. Maps of the vertical distribution of temperature fields (T_c) at the standard levels in the Black Sea for 30.05.2017. Map (a) is map of the distribution of satellite data for calculation [1, p. 109]

The results of calculations of zonal (latitude 44° N) and meridional (longitude 36° E) sections in the Black Sea for 27.06.2017 and 10.09.2017 are presented in Figure 3 respectively.

Figures 2 and 3 are built using computer program Ocean Data View (ODV) that is intended for the interactive exploration and graphical display of oceanographic and other geo-referenced profile, trajectory or time – series data [3].

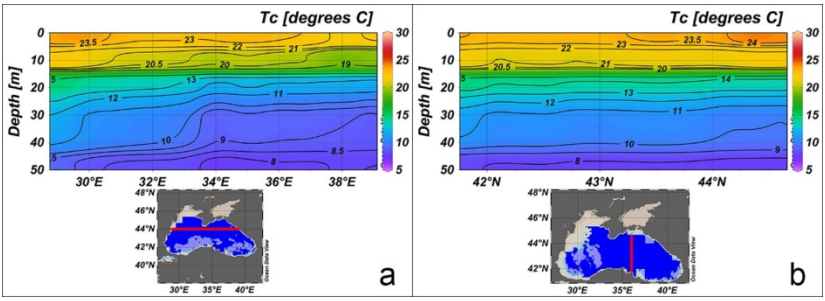

Figure 3. Distribution of calculated of water temperature (T_c) on zonal at latitude 44° N (a) and meridional at longitude 36° E (b) sections in the Black Sea for 27.06.2017 and 10.09.2017, respectively. The maps show the location of sections in the Black Sea [1, p. 109]

Designed by us, the prototype of a computer program to calculation of the vertical distribution of temperature fields in the Black Sea by satellite data could serve as a basis for the establishment of a «Monitoring system of water

temperature in the Black Sea». With the help of which the dynamics of water temperature and water temperature change effects on hydrobiological, hydrochemical, hydrophysical processes in the Black Sea and the ecosystem of the sea in general can be evaluated.

Research results from the calculations of the vertical distribution of water temperature in the Black Sea by satellite data at standard levels (0, 10, 20, 25, 30, 50 meters) in spring – autumn period showed that the change in the vertical profile of water temperature obeys the exponential law of distribution. The linear law of distribution is dominated when the deviation of sea surface temperatures (T_0) from climatic water temperature values (T_{clim}) is more than ± 2°C.

Water temperature corrections are introduced on the levels of 10, 20, 25 meters during spring – summer, and in autumn – on the levels 10, 20, 25, 50 meters.

Standard error (S) of calculations of the vertical distribution of water temperature in the Black Sea by satellite data in 2017 year is amounted to 2°C.

In our opinion the developed method for calculating of the vertical distribution of temperature fields by satellite data can be applied to others water area of the World Ocean taking into account their hydrological conditions.

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