Kordzakhia G.,[*], Shengelia L,[*], Tvauri G.,[**],Chitanava R[***].
[*] Institute of Hydrometeorology, Tbilisi Technical University,
[**] M. Nodia Institute of Geophysics, Tbilisi State University,
[***] The National Environmental Agency, Tbilisi.

UDC 551.46(262.5)+551.501.771

APPLICATION OF THE SATELLITE DATA FOR THE CREATION OF OPERATIONAL NUMERICAL FORECASTING TECHNOLOGICAL LINE OF THE BLACK SEA CONDITIONS

The determination of the ocean/sea surface temperature (SST) is important for solving various applied issues. One of the most important problems is the installation of the marine conditions numerical prediction technological operational line and disaster risk reduction (DRR) based on the SST satellite data.

The identification of SST is a complicated problem as the observational network creation like the ground based monitoring stations is very expensive. Invention of the Earth observational satellites solved the problem. The application of remote sensing appears to be the most effective tool for the detection of SST [1]. The necessary infrastructure is created, namely monitoring is carried out by the USA and European satellites. In Georgia the satellite receiving system was installed with the support of the EUMETSAT in the beginning of 2011.

The satellites provide acquisition of the observational data from oceanographic tide-gauges, separate platforms and drifters and hence allow their wide location in oceans and seas (Fig.1). These observational facilities including coast oceanographic stations and ships of opportunity supply accurate SST values. They have considerable spatial interruption. Therefore this does not allow restoring SST accurate fields for the marine basin.

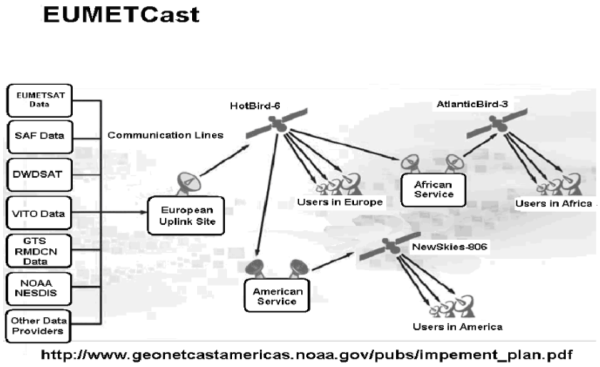


Fig. 1. EUMETSAT's Broadcast System for Environmental Data Dissemination System Based on Standard Digital Video Broadcast (DVB) Technology

Remote sensing provides the data quantitatively. Due to the fact that the nearest satellites are at the distance of several hundred kms from the Earth the problem of inadequate quality of this information remains. The latter requires the assessment of corresponding errors and certain corrections to control SST data in nearly real time. Inaccuracy of the remote sensing data can be connected with: i. Quality of the satellite information and/or ii. Errors of the SST calculation algorithms. The above-mentioned inaccuracy of the satellite data are excluded or minimized by the quality assessment and quality control (QA/QC) procedures based on the traditional means of SST observation [2]. Thus the real SST fields can be obtained only using all relevant SST observational facilities.

It is very important to be assured in the capabilities of the usage of the SST real data values based on remote sensing and assessment of the received results quality. For this objective the special numerical experiments are carried out based on the basin scale marine model [3]. This model experiments have methodological nature and the developed marine conditions predictions are not the real operational forecasts of the Black Sea, as in these experiments the meteorological real data on upper boundary are not accessible. In spite of this, based on these experiments it can be concluded about perspectives of creation of technological operational line of the marine conditions numerical forecastingn.

Calculation of the marine forecasts needs the knowledge of the initial sea conditions (three dimensional fields of hydrodynamic flow, sea temperature, salinity). If such initial fields are not accessible then zero initial conditions and at the sea surface available climatic data are used. In carried out additional numerical experiments SST real data values received from remote sensing are used as data on the sea upper boundary.

The model equations are solved by the two cycle splitting method that is in good adequacy with corresponding physical processes [4].

The time range of the equations integration can be divided: i. Obtaining of climatic hydrophysical fields; ii. Adaptation phase; iii. Forecasting phase.

At the first stage the integration of the equations is carried out until attainment of quasi stationary regime. The outputs of these calculations (hydrodynamic flow, sea temperature, salinity) are used as the initial conditions for adaptation phase.

From that moment the integration of the equations at adaptation phase is carried out with model climate conditions instead of zero initial conditions. In adaptation phase the impact of initial conditions are weakened and the output is determined by exposure to the atmosphere. Evidently the marine initial conditions are close to real initial hydrological regime and these fields (hydrodynamic flow, sea temperature, salinity) are used as initial for forecasting range.

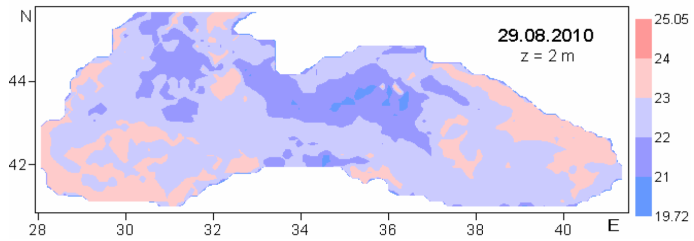
Additional numerical experiments are carried out for 10 days periods (integration periods: i. 23 August – 2 September 2010, ii. 29 June – 9 July 2010, iii. 22 July – 1 August 2010). The calculations are made with the use of the real SST data from remote sensing. These values are used as data on sea upper boundary for adaptation phase. For short, the results of the experiment for the first period are presented as the outputs of other two are similar.

The commencement of adaptation phase is taken at 12:00 hr August 26, 2010. If the meteorological real data on upper boundary are inaccessible then wind tangential stress and sea surface salinity climatic data are taken for the summer season. The Black Sea SST was defined on the basis of remote sensing.

The integration of model equation is carried for 10 days till September 02, 2010. Observed the Black Sea SST fields used in the model were determined for the period from the moment of model running till August 28, 2010. Therefore, from this time the Black Sea SST was not changed and remained the same until the end of the model experiment (20:00 h September 02, 2010). The time domain from the 20:00 h of August 28, 2010 till 20:00 h September 02, 2010 can be accepted for the forecasted range.

The commencement of adaptation phase is taken at 2:00 hr August 26, 2010. The meteorological real data on upper boundary are inaccessible; therefore wind tangential stress and sea surface salinity climatic data are taken for the summer season. The Black Sea SST was defined on the basis of remote sensing. In Fig. 2 the Black Sea SST fields determined from remote sensing for various time moments are presented. These values are used as the sea upper boundary data for adaptation phase.

a



b

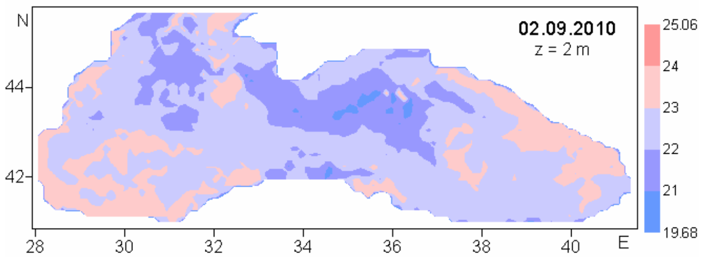


Fig. 2. The forecasted marine temperature fields: a. August 29, 2010 and b. September 2, 2010.

The integration of model equation is carried out for 10 days till 20:00 h September 02, 2010. Observed BS SST fields used in the model were determined for the period from the moment of model running till 20:00 h August 28, 2010 (Fig. 2.b). Therefore from this time the Black Sea SST was not changed and remained the same until the end of the model experiment (20:00 h September 02, 2010). The time domain from the 20:00 h August 28, 2010 till 20:00 h September 02, 2010 can be accepted for the forecasted range.

As an example, in Fig. 2 the forecasted marine temperature fields of the Black Sea are presented on 2 m depths (the nearest calculation level from the sea surface) in August 29, 2010 and September 2, 2010. The forecast outputs when the real SST is used from the satellite data by conditional consent will be called forecasted marine temperature fields. In case the experiment is run when the so-called model climate data is used by conditional consent the model forecast outputs would be called climate temperature field. For the comparison of forecasted marine temperature fields with the Black Sea SST real values the interpolation of the output data to the sea surface is needed. For the Black Sea the average vertical gradient of temperature field space distribution is 1^0C/1m. For matching SST data with forecasting temperature values the levels equaling due value – 2^0C would be added to the latter.

In Fig. 3 the temperature climate field for the Black Sea calculated from the model on the depth 2 m that is used as an initial condition for adaptation phase if the real values of SST are not available is shown. Comparing the pictures represented in Fig. 2 and Fig. 3 it can be concluded that the use of the real SST satellite data instead of the climatic data significantly changes the forecasted marine temperature values and substantially differs from the climate forecasted fields. That definitely indicates that the real satellite SST data must be taken into account during the diagnosis and forecast of the dynamics of the Black Sea basin.

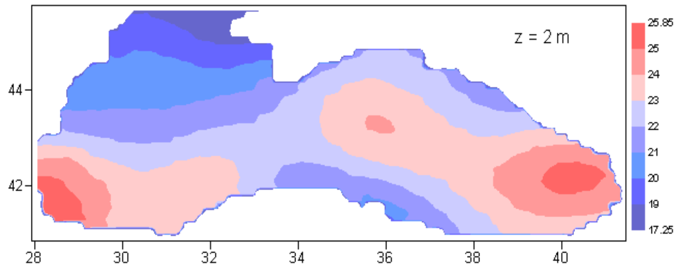


Fig.3. The climate temperature field of the Black Sea (summer season) on the depth of 2 m.

For the forecasted outputs validation, the sea surface temperature values calculated in three experiments were compared with the observed SST fields received on the basis of remote sensing on the same day. The comparison is made for the knots of the regular net where the temperature values can be determined from the satellite data i.e. for the knots free of clouds.The quantity of knots on the Black Sea is equal to 15874.

For the validation of the experiments outputs, forecasted marine temperature fields calculated for September 2, 2010 were compared with the same day observed sea surface temperature field received on the basis remote sensing data. The comparison is made for the knots of the regular net where the temperature values can be determined from the satellite information, i.e. these knots were not covered by clouds. For short the validation results are presented for only first experiment as the other two are very similar. The quantity of such knots on the Black Sea is equal to 6504. The territory free from clouds over the Black Sea is 41% for the first experiment. For the quantitative validation of the carried out experiment outputs, the statistical characteristics used in operational practice are applied, namely, mean square deviation (δ), maximal and minimal errors (ε_{max}, ε_{min}) for both forecasted marine temperature and climate temperature fields are determined.

Calculations carried out for the forecasted marine temperature fields (first experiment) show that these values are as follows:$\delta_1=1.4055^0$C,$\varepsilon_{max1}=4.11^0$C,$\varepsilon_{min1}=0.0010^0$C. The same computations run for the climate temperature field give: $\delta_1^*= 1.9336^0$C, $\varepsilon_{max1}^*= 7.053^0$C, $\varepsilon_{min1}^*= 0.021^0$C.

Based on the analysis of the above-mentioned statistical characteristics for all experiments can be deduced:

- The mean square deviation of forecasted marine temperature fields is significantly less (minimum at 30 %) than the corresponding values of the climate temperature field;
- The maximal absolute error of forecasted marine temperature fields is less than the corresponding values of the climate temperature field;
- The minimal absolute error of forecasted marine temperature fields is significantly less than the corresponding values of the climate temperature field.

On the basis of carried researches it could be concluded: i. Developed methodology is effective for determination of the Black Sea surface temperature real values; ii. The Black Sea SST determined real data application for forecasting of the Black Sea conditions is effective; iii. Implementation of the works for the creation of the technological line of the operational prediction of Black Sea marine conditions and disasters risk reduction is necessary and timely measure.

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უაკ 551.46(262.5)+551.501.771

თანამგზავრული მონაცემების გამოყენება შავი ზღვის ოპერატიული რიცხვითი პროგნზირების ტექნოლოგიური ხაზის შესაქმნელად კორძახია გ., შენგელია ლ., თვაური გ., ჭითანავა რ./საქართველოს ტექნიკური უნივერსიტეტის ჰიდრომეტეოროლოგიის ინსტიტუტის შრომათა კრებული-2011-ტ.117-გვ.59-61. ინგ.: რეზ. ქართ., ინგ., რუს.

განხილულია თანამგზავრული ინფორმაციის საფუძველზე განსაზღვრული შავი ზღვის ზედაპირის ტემპერატურული მონაცემების გამოყენების საკითხები შავი ზღვის მდგომარეობის ოპერატიული რიცხვითი პროგნოზირების ტექნოლოგიური ხაზის შექმნისათვის.

UDC 551.46(262.5)+551.501.771

Application of the Satellite Data for the Creation of Operational Numerical Forecasting Tecnological Line of the Black Sea Conditions. /Kordzakhia G., Shengelia L., Tvauri G., Chitanava R./Transactions of the Institute of Hydrometeorology of Georgian Technical University. 2011.v117. – pp. 59-61. - Eng.; Summ. Georg.; Eng.; Russ.
Use of the satellite information of the Black Sea surface temperature for the purpose of creation of a technological line of the operational forecast of the state of the Black Sea are considered.

УДК 551.46(262.5)+551.501.771

Использование спутниковой информации для создания технологической линии оперативного прогноза состояния Черного моря. Кордзахия Г.И., Шенгелия Л.Д., Тваури Г.А., Читанава Рю/ Сб. Трудов. Институт Гидрометеорологии, Технический Университет Грузии – 2011 – т.116,-с.59-61.– Анг.;Рез.Груз.,Анг., Рус.
Рассмотрены вопросы использования спутниковой информации о температуре поверхности Черного моря для создания технологической линии оперативного прогноза состояния Черного моря.