Russian Academy of Sciences

Institute of Numerical Mathematics

A NEW INTERPOLATION METHOD OF BLACK SEA SST DATA

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Introduction

In this work we propose a method for construction of temperature fields on a regular grid based on observation data subject to their transportation by currents. In this method we obtain firstly the additional set of data – ‘pseudo-observations’ at the required time moments and thus solve the problem of asynchronicity of geophysical information. Then using data observations and pseudo-observations we apply the well-known the Inverse Distance Weighted Method with weights constructed by special manner – the weights calculated according to the distance along the trajectories of liquids. We study the accuracy of this method and present the results of numerical experiments for the Black sea water area.

DATA INTERPOLATION METHOD

It is assumed that the temperature field in the ocean (sea) is adequately described by the solution to the convection-diffusion equation of the following form or, for simplicity, 'the equation is adequate':

$$\frac{\partial T}{\partial t} + (U, \nabla)T - div(\hat{a}_T \nabla T) + \lambda T = Q, \quad \Omega \times (0, \mathrm{T})$$

$$T \equiv T(\vec{X}, t),\ U = U(u, v, w),\ \nabla \equiv grad,\ \lambda = \lambda(\vec{x}, t) \geq 0, Q = Q(\vec{x}, t), divU = 0 \ \text{in} \ \Omega \times (0, T)$$

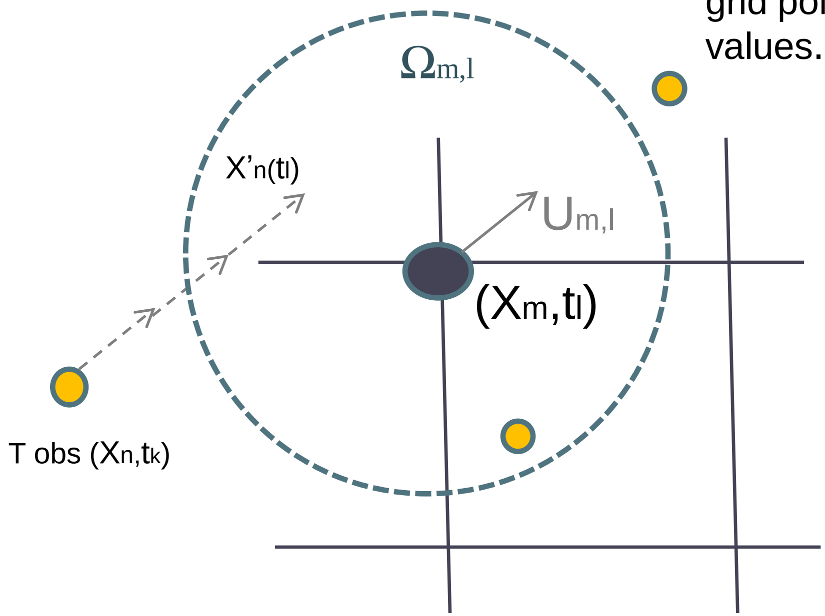
If we neglect the effects of diffusion and assume $\lambda \equiv 0, Q \equiv 0$

we get the convection equation $\frac{\partial T}{\partial t} + (U, \nabla)T = 0, \quad \Omega \times (0, \mathrm{T})$

We pose the problem: *interpolate the values of temperature on the set of regular grid points* $\{\tilde{X}_m, t_k\}$ *from the set of points* $\{\vec{\tilde{X}}_n(\tilde{t}_l), \tilde{t}_l\}$ *- points of the observation data* $T_{obs}(\tilde{X}_n(\tilde{t}_l), \tilde{t}_l)$. Assuming that in a neighborhood of the point $(\tilde{X}_n(t_k), t_k)$ the velocity field does not depend on *n,l*, approximately it is possible to accept:

$$\tilde{X}_n(\tilde{t}_l) = \tilde{X}_n(t_k) + U(\tilde{X}_n(t_k), t_k)(\tilde{t}_l - t_k) \qquad T_p(\tilde{X}_n(t_k), t_k) = T_{obs}(\tilde{X}_n(\tilde{t}_l), \tilde{t}_l)$$

DATA INTERPOLATION METHOD



With some assumptions, in the 'neighbourhood' of the regular grid point *(Xm, tk),* we get some formulas for the interpolant values. The simplest of them is the following one:

$$\vec{X}'_n(t_l) = \vec{\tilde{X}}_n(\tilde{t}_k) + \vec{U}_{m,l}(t_l - \tilde{t}_k)$$

(- pseudo observations, extrapolation level)

$$T_I(X_m, t_l) = \frac{\sum_{l=1}^{L}\sum_{n=1}^{N} r_{n,l}^{-\beta_{n,l}} T_{obs}(\tilde{X}'_n(t_l), t_l)}{\sum_{l=1}^{L}\sum_{n=1}^{N} r_{n,l}^{-\beta_{n,l}}}$$

(- interpolation level)

$$r_{n,k} \equiv r_{n,k}(m,l) = |(\vec{X}_m(t_l) - (\vec{\tilde{X}}_n(t_k) + \vec{U}_{m,l}(t_n - \tilde{t}_k)))| + \varepsilon_{m,l}$$

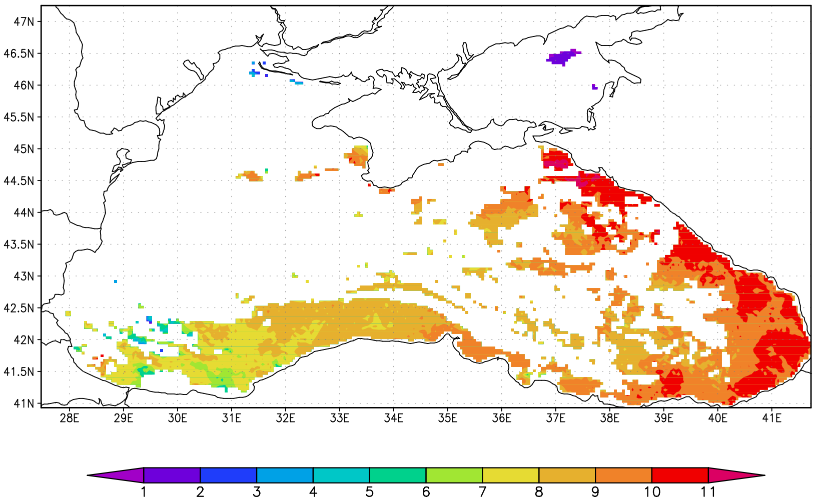
where $0 < \beta_{n,l} = \text{const}$, t_l, t_k, X_m - points of regular grids, $\tilde{X}_n(t)$ - the trajectory crossing the point $\tilde{X}_n(\tilde{t}_l)$ (- the point of the observation data $T_{obs}(\tilde{X}_n(\tilde{t}_l), \tilde{t}_l)$ at the time $\tilde{t}_l$ and at the point $\tilde{X}_n(\tilde{t}_l)$) , $T_p(\tilde{X}_n(t_l), t_l)$ - the pseudo-observation data.

The velocity components are assumed to be given (for example, those components are calculated by an appropriate model of water dynamics in a sea or an ocean [Zalesny V.B., Diansky N.A. et al.]).

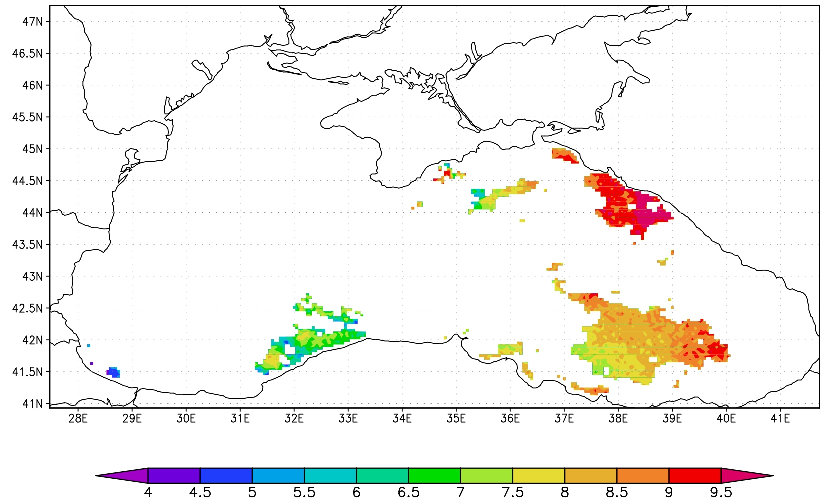
OBSERVATION DATA

SST, January 2008

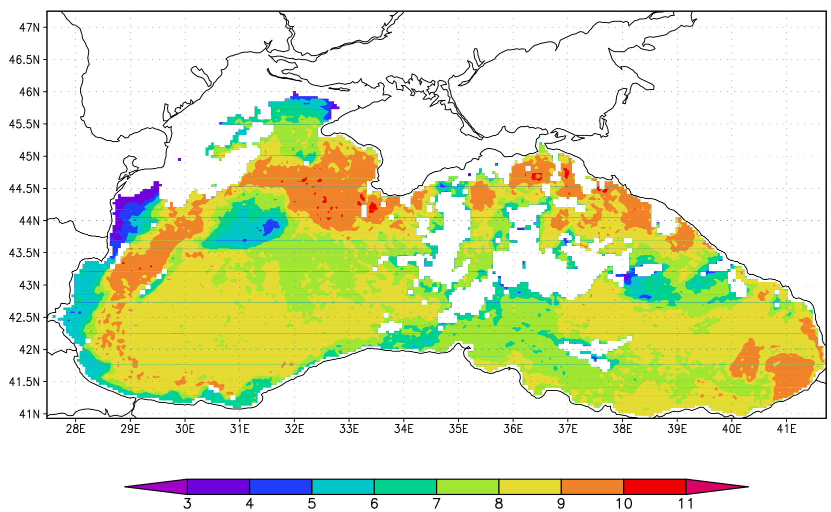
1st January 10:37



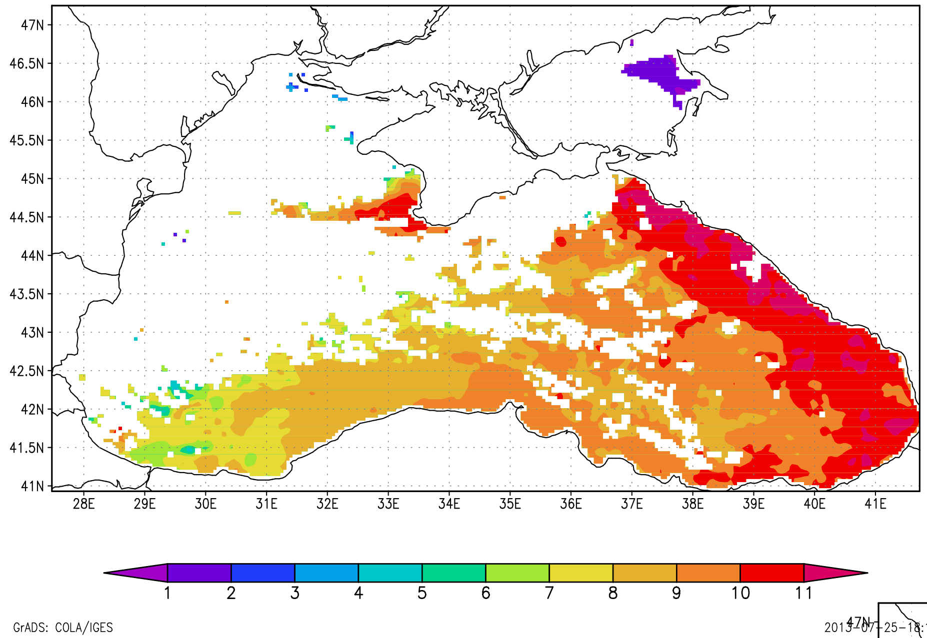
6th January 19:30



22nd January 13:58

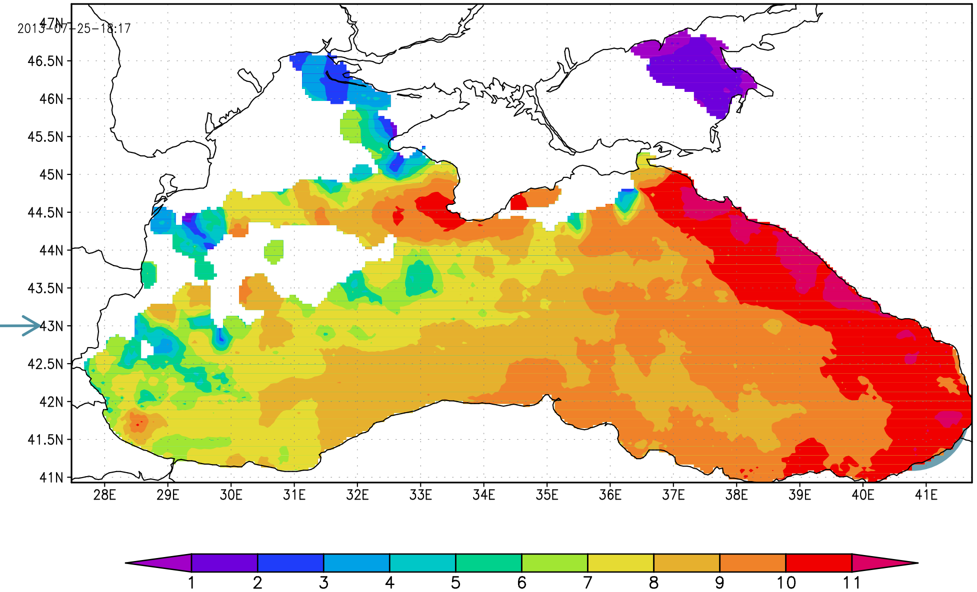


Results of numerical experiments

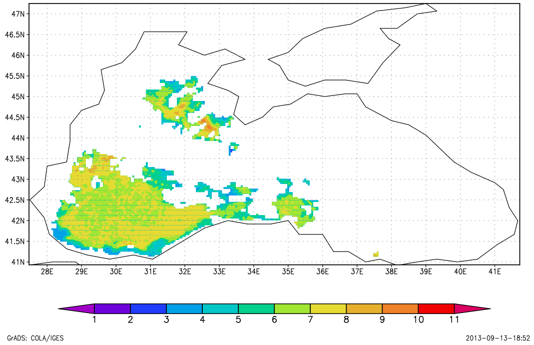


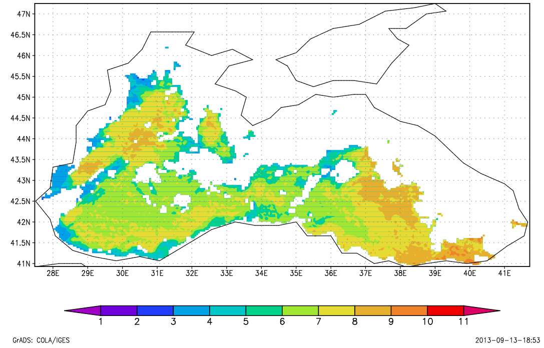
Black Sea surface temperature observation data for 01 January 2008 (24 hours)

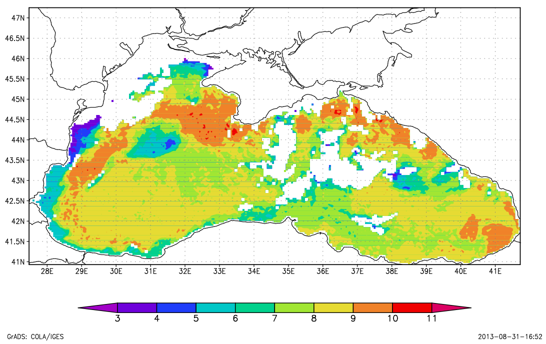
Results of calculations in the Black sea for 12:00 of 1 of January, 2008.
The radius of the 'neighbourhood' of the nodal point is 0.2 degrees,
Δk *= 12 hours*

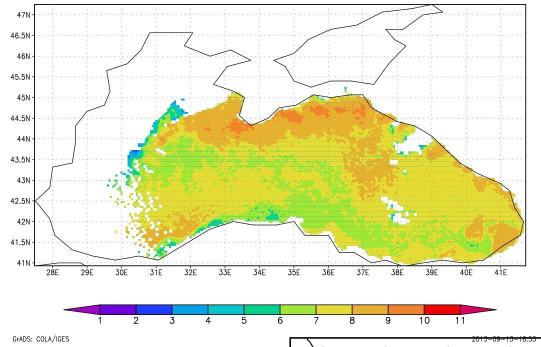


Results of numerical experiments

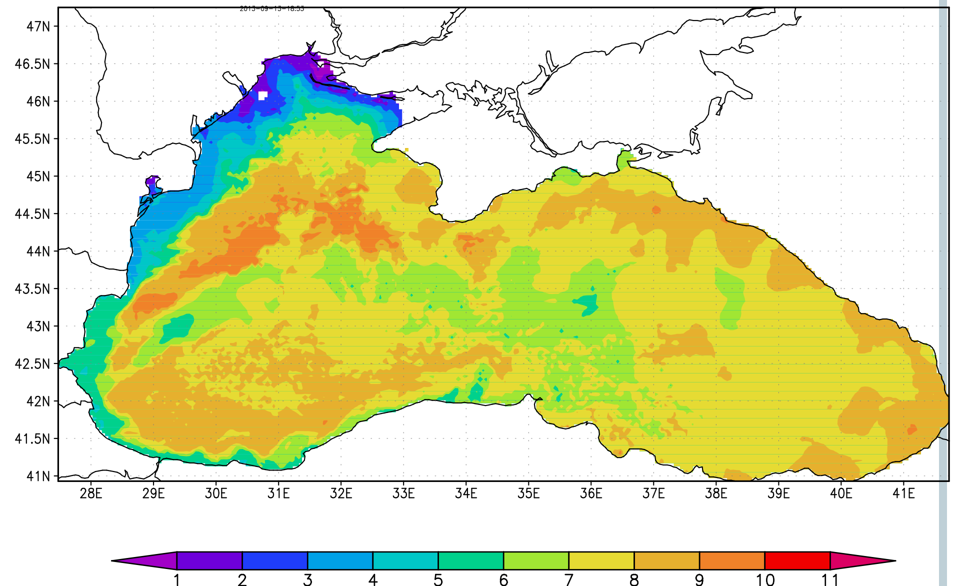






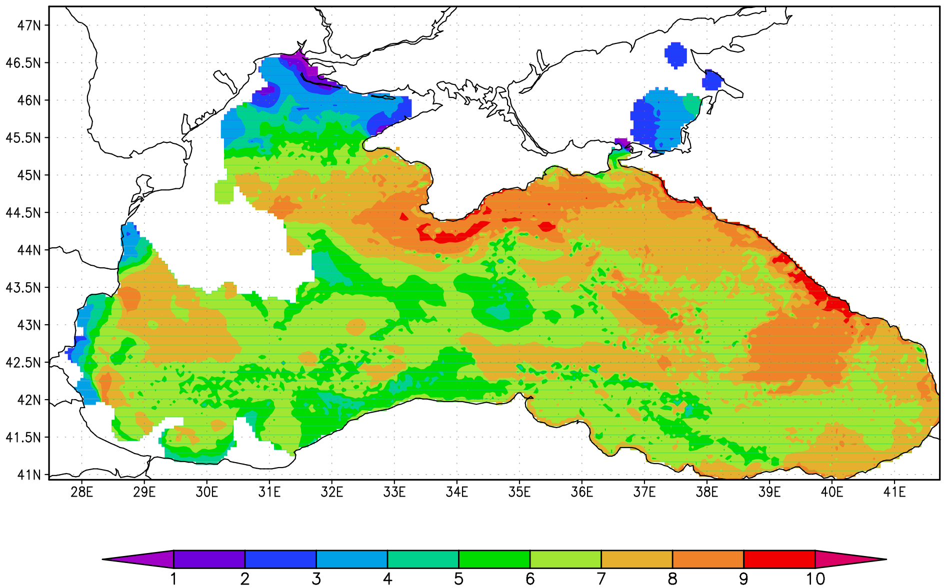


Black Sea surface temperature observation data for 00:30, 08:40, 13:58, 18:00
22th of January 2008

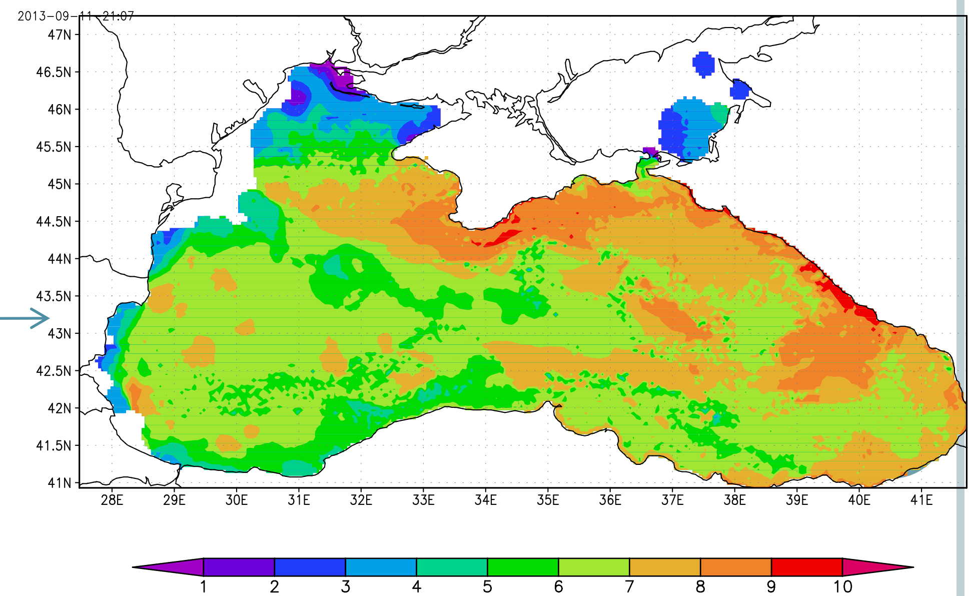


Results of calculations in the Black sea for 12:00, 22th of January 2008.
The radius of the 'neighbourhood' of the nodal point is 0.2 degrees,
Δk = *12 hours*

Results of numerical experiments

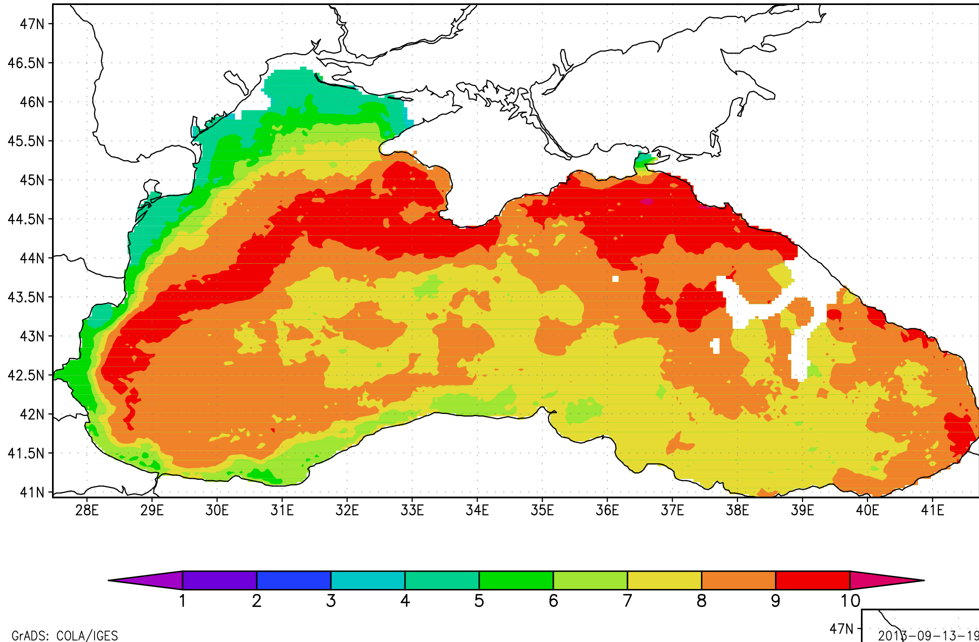


Results of calculations in the Black sea for 00:00 16th of January 2008.
The radius of the 'neighbourhood' of the nodal point is 0.2 degrees,
Δk = *12 hours*



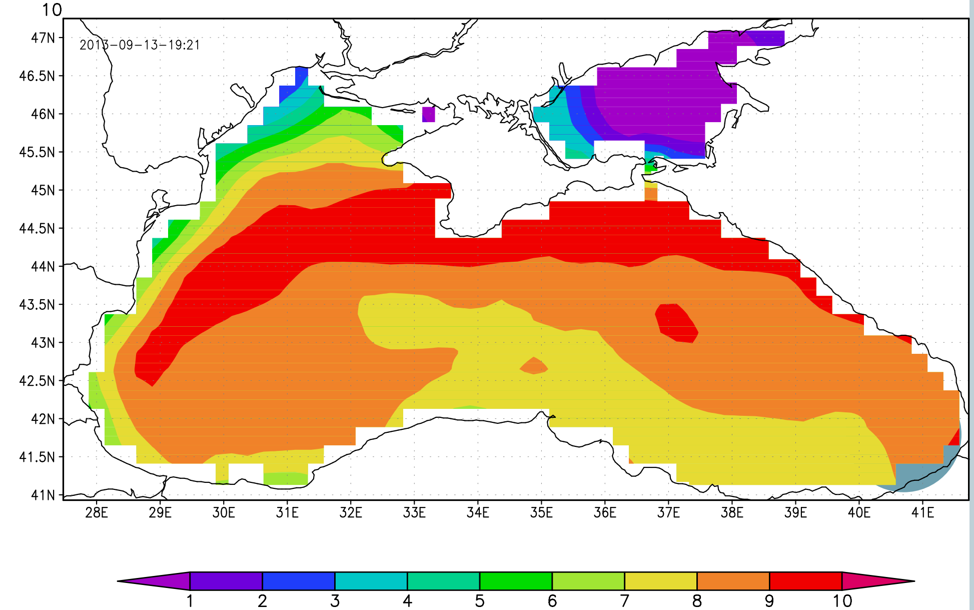
Results of calculations in the Black sea for 00:00 16th of January 2008.
The radius of the 'neighbourhood' of the nodal point is 0.2 degrees,
Δk = *24 hours*

Results of numerical experiments

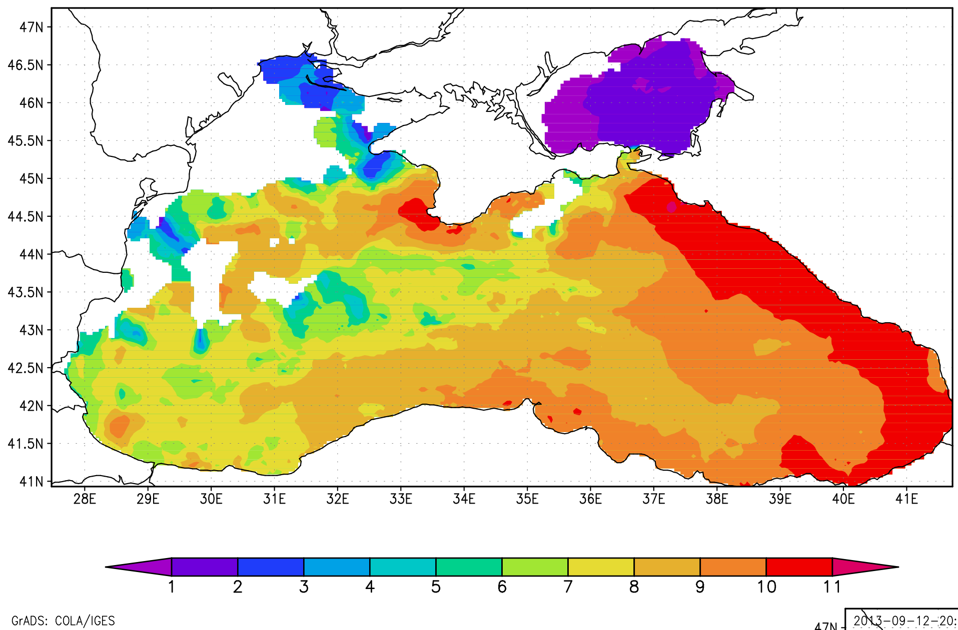


Average value of the new method calculations results in the Black sea for 00:00, 12:00, 24:00 26th of January 2008. The radius of the 'neighbourhood' of the nodal point is 0.2 degrees, Δk = *24 hours*

Average SST field for 26th of January 2008. Resolution 4 km. GODAE data (Global Ocean Data Assimilation Experiment).

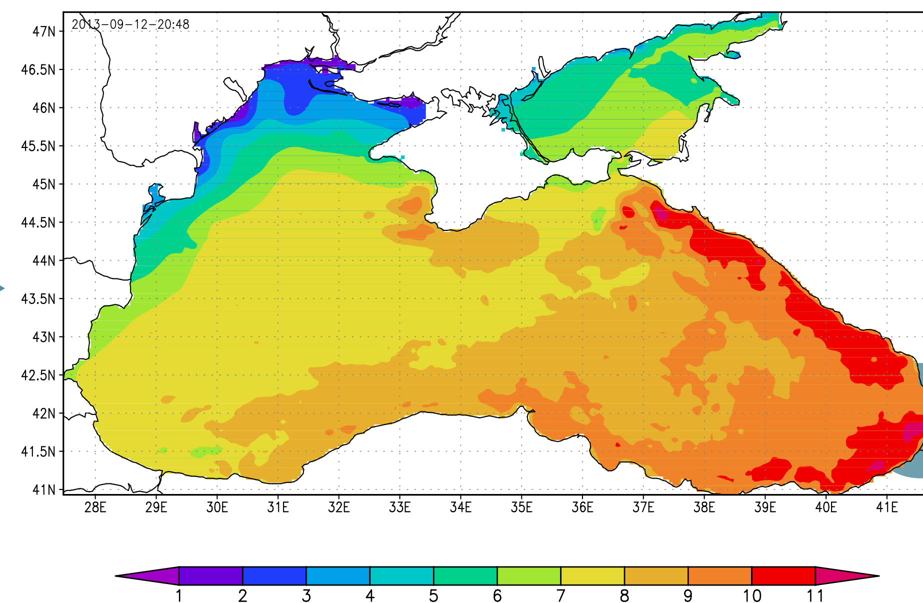


RESULTS OF NUMERICAL EXPERIMENTS



Results of the new method calculations in the Black sea for 23:59 1th of January 2008.
The radius of the 'neighbourhood' of the nodal point is 0.2 degrees,
Δk = *24 hours*

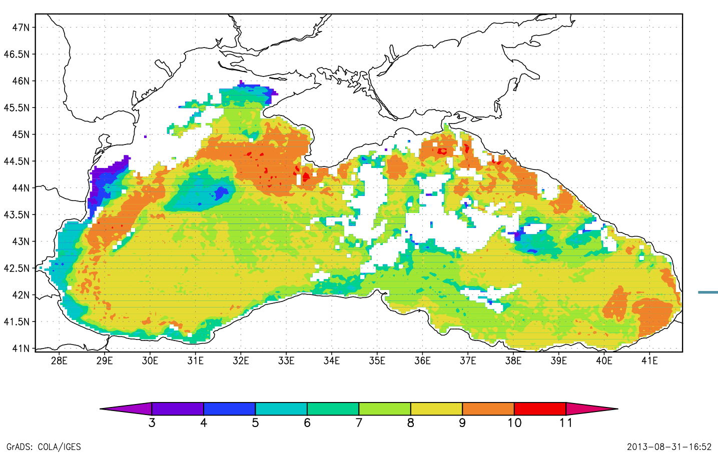
Model calculation with observation data assimilation for 1th of January 2008.
[V. Zalesny, N.Diansky,V. Fomin, A.Gusev]

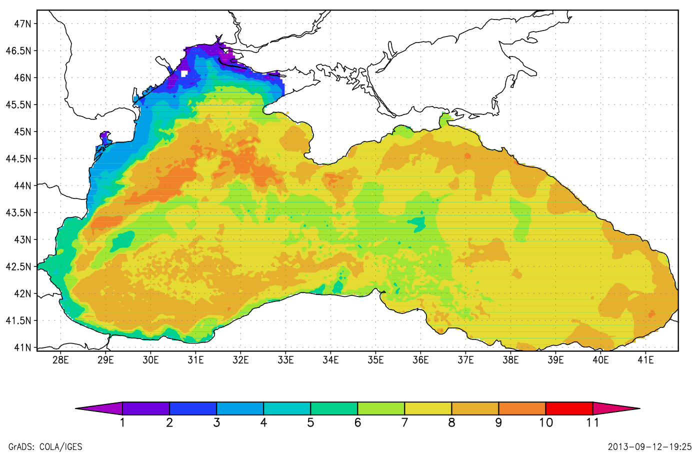


CONCLUSION

➢In this paper we have proposed a new method for interpolation of geophysical fields taking into account the peculiarities of currents in the sea. Numerical experiments use SST observation data in the Black Sea. The results of experiments with different coefficients and parameters are illustrated.

➢The numerical experiments have confirmed the theoretical statements of this work concerning the possibility and advisability of constructing interpolant of geophysical fields subject to convective currents in ocean and seas. We can assume that interpolation by the method proposed in this paper possesses accuracy acceptable for numerical solution of various problems of geophysical hydrodynamics.





Reference

1. *Zakharova N.B., Agoshkov V.I., Parmuzin E.I.,* The new method of ARGO buoys system observation data interpolation. Russian Journal of Numerical Analysis and Mathematical Modelling. Volume 28, Issue 1, 2013. pp. 67-84.

2. *Agoshkov V.I., Zakharova N.B*., The creation of piecewise - harmonic interpolation on spherical surfaces. Russian Journal of Numerical Analysis and Mathematical Modelling. Volume 27, Issue 6, Pages 523–538.

3. *Zakharova N.B., Lebedev S.A.,* Interpolation of on-line data of the ARGO buoys system for data assimilation in the World ocean circulation model. nn Actual problems in remote sensing of the Earth from space: Principal physics, physical methods and technologies for monitoring of environment, of potentially dangerous occurrences and objects. The proceedings. Vol. 7. No. 4. 2010. (In russian)

4. *G. I.Marchuk, V. P. Dymnikov, and V. B. Zalesny,* Mathematical Models in Geophysical Hydrodynamics and Numerical Methods of their Implementation. Gidrometeoizdat, Leningrad, 1987 (in Russian).

- Thank you !