Turbulent closures in a one-dimensional lakes model

Bogomolov V.[1,2], Stepanenko V.[2,3].

[1]Institute of Monitoring of Climatic and Ecological Systems, Siberian Branch of the Russian Academy of Science

[2] Research Computing Center, Moscow State University

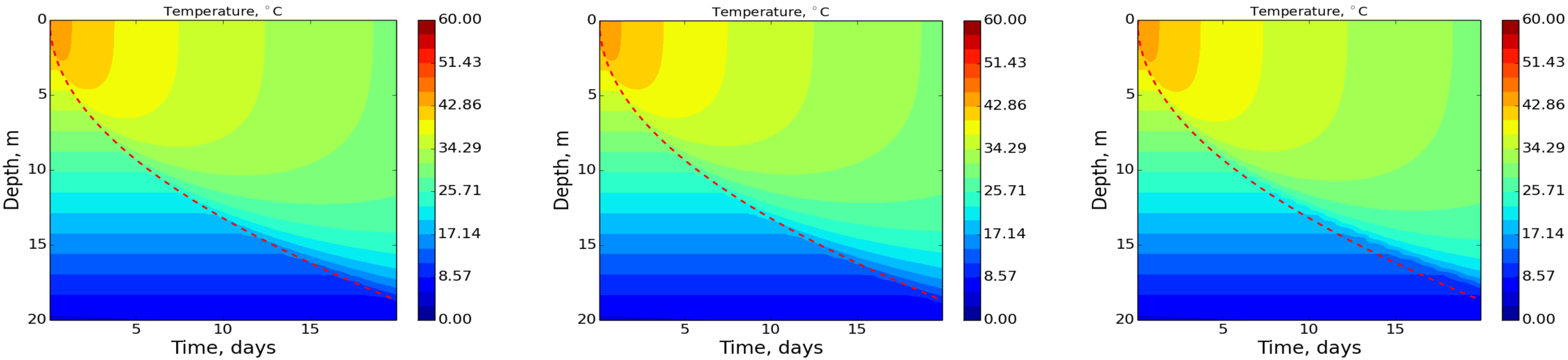
[3] Faculty of Geography, Moscow State University

[4] Institute of Geography, Russian Academy of Sciences

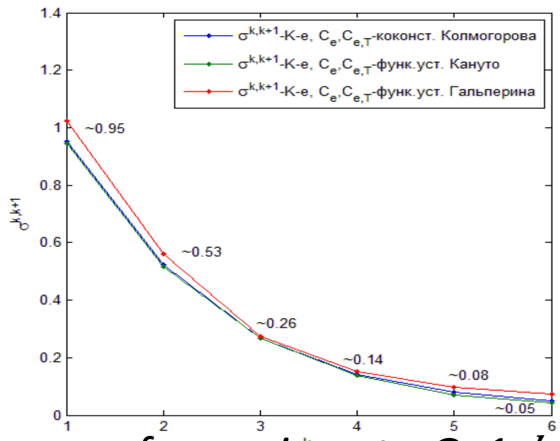
[5] Institute of Numerical Mathematics, Russian Academy of Sciences

The Kato-Phillips experiment for the $\boldsymbol{k}$-ε model

$\mathrm{Gr}1.7{:}\ \Delta t = 25, \boldsymbol{M^6} = \mathbf{640}$



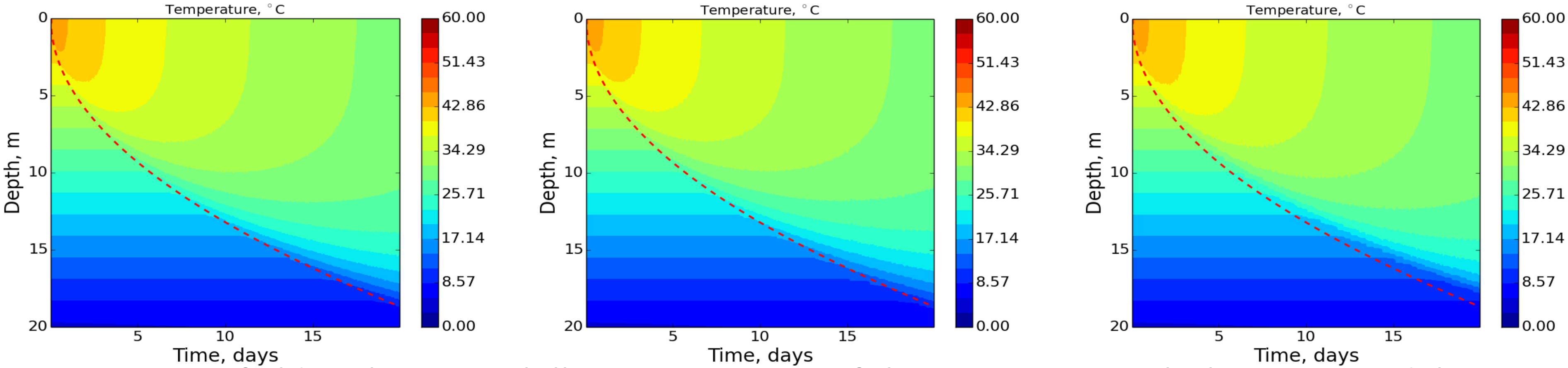
Temperature field in the Kato-Phillips experiments of the Gr.1 group with the LAKE model using the $k-\varepsilon$ closure: a) with C_e and $C_{e,T}$ as empirical constants; b) with d C_e and $C_{e,T}$ as functions of Canuto's stability ; c) with C_e and $C_{e,T}$ as Galperin stability functions



Mean rms deviation for the group of experiments Gr.1.k, where node 1 along the abscissa corresponds to the standard deviation between the experiments of Gr.1.1 and Gr. 1.2.

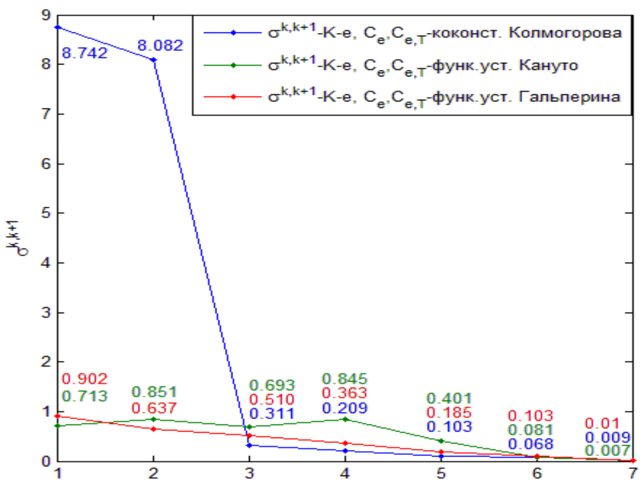
The Kato-Phillips experiment for the k-ε model

$Gr.2.6$: $M = 40, \Delta t^{1} = \mathbf{100}$ с



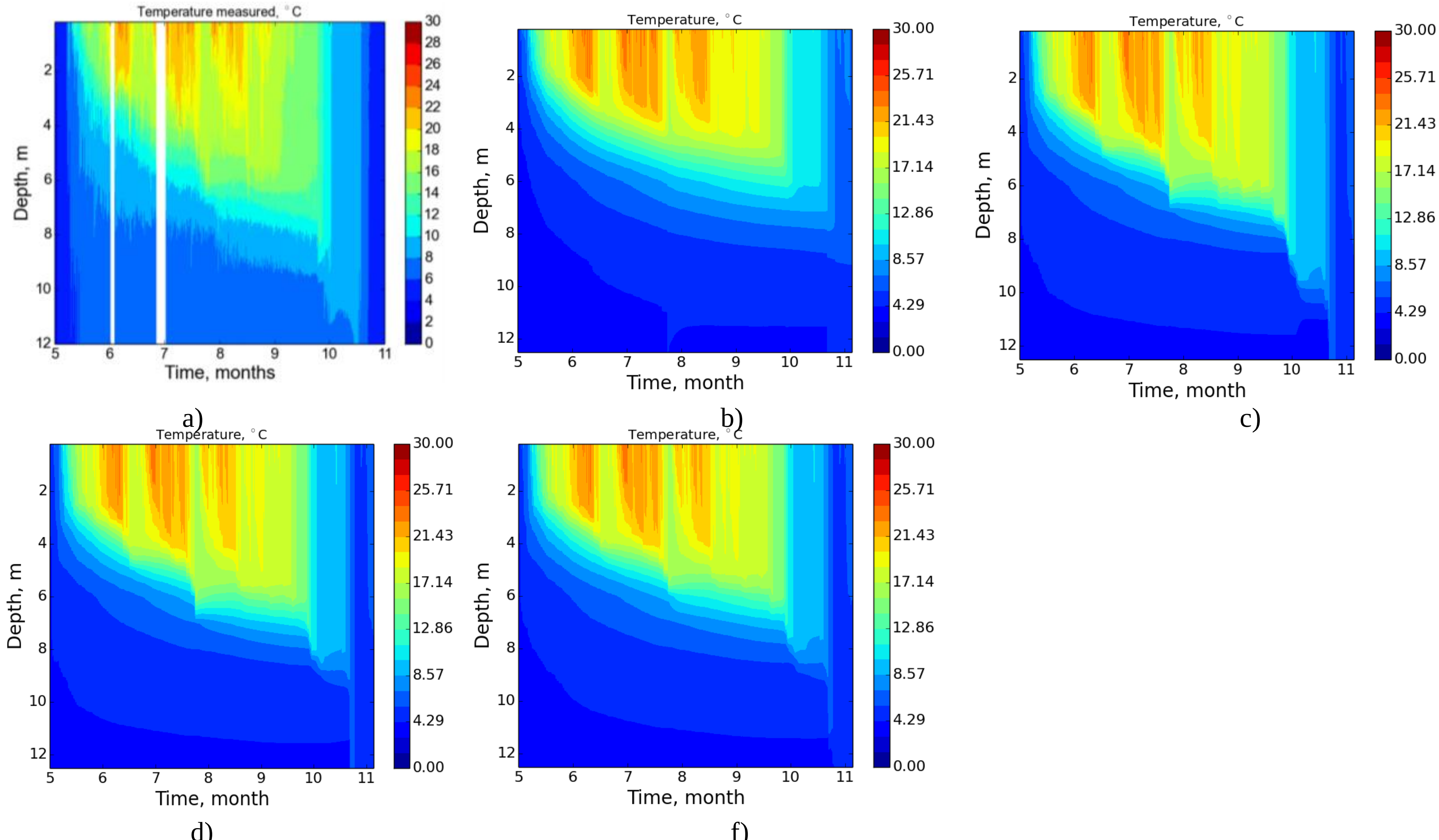
Temperature field in the Kato-Phillips experiments of the Gr.2 group with the LAKE model using the $k-\varepsilon$ closure: a) with C_e and $C_{e,T}$ as empirical constants; b) with d C_e and $C_{e,T}$ as functions of Canuto's stability ; c) with C_e and $C_{e,T}$ as Galperin stability functions

.



Mean rms deviation for the group by the experiment Gr.2.k, where node 1 along the abscissa corresponds to the standard deviation between the experiments Gr.2.1 and Gr.2.2.

Experiment with real atmospheric forcing for LAKE model with Hendersson − Sellers parametrization and $k - \varepsilon$ model.



Temperature distribution by depth and time for Lake Kuivajärvi: a) LAKE model with Hendersson-Sellers parametrization; b) measurement data; c) LAKE with closure of the the $k - \varepsilon$ empirical Kolmogorov constants d) LAKE with closure the $k - \varepsilon$ with Canuto stability functions; e) LAKE with closure k-ε with Galperin stability functions.

Results

Our results demonstrate that $k - \varepsilon$ closure allows for a smooth solution at timesteps Δt < 450 s, while the convergence of numerical scheme is attained at Δt < 100 s. In contrast, convergence of a lake model scheme using Hendersson-Sellers diffusivity is achieved if Δt < 3600 s, resulting in drastic reduction of the lake model runtime compared to using $k - \varepsilon$ parameterization. At the same time, the correctness of simulation results obtained with both schemes was very similar.

Thank you for attention!