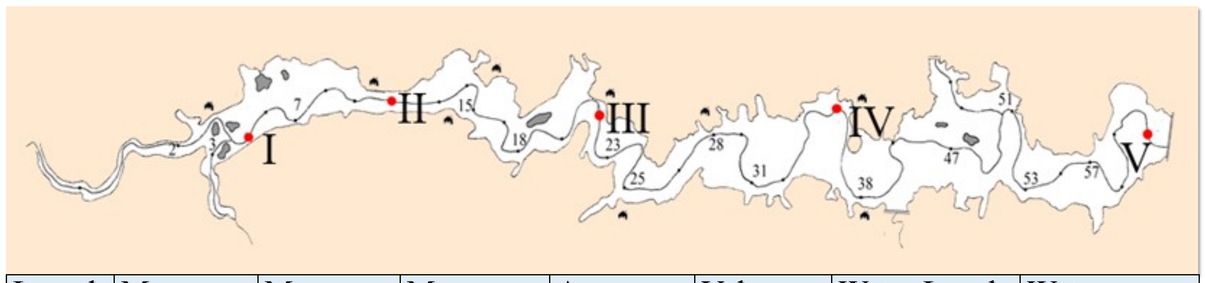
Dynamics of methane fluxes in the valley reservoir based on the results of field observations and mathematical modeling

Lomov V., Moscow State University, Faculty of Geography (Hydrology Department), Research Computing Center, lomson620@mail.ru
Stepanenko V., Moscow State University, Faculty of Geography (Meteorology and Climatology Department), Research Computing Center, stepanen@srcc.msu.ru
Grechushnikova M., Moscow State University, Faculty of Geography (Hydrology Department), Water Problems Institute, allavis@mail.ru
Repina I., Obukhov Institute of Atmosphere Physics, Moscow State University, Research Computing Center, repina@ifaran.ru

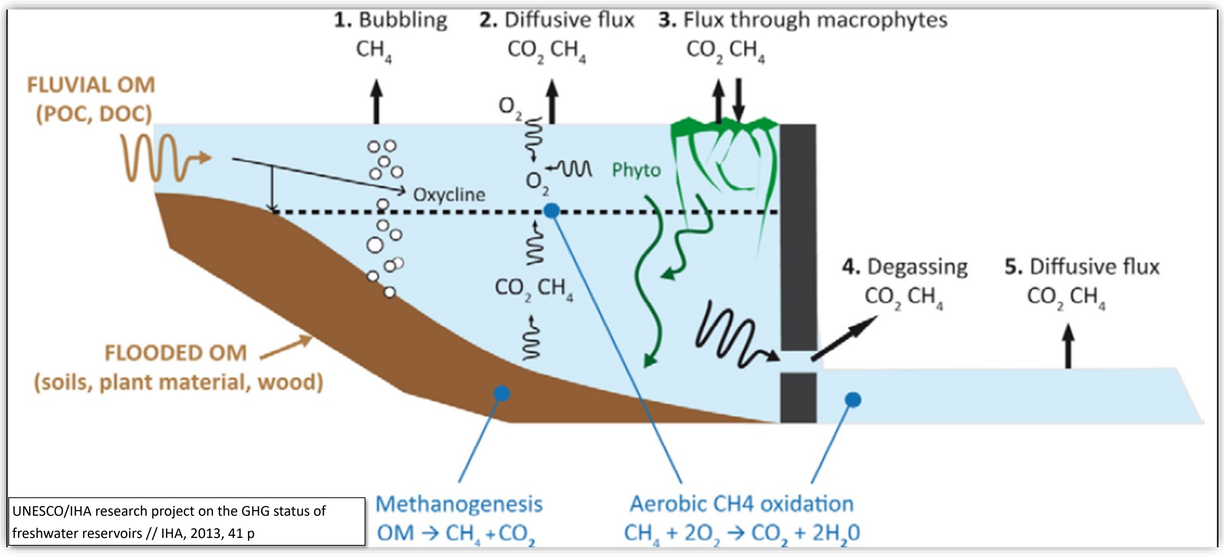
Estimation of the human activity impact on global warming is a very important goal nowadays. The main reason for planet temperatures rising is an increase in the concentration of greenhouse gases in the atmosphere. The main greenhouse gases are carbon dioxide and methane. The influence of the carbon dioxide has been investigated for a long time, while much less attention has been paid to the methane in this matter, however, more and more scientific articles have recently appeared on the topic of anthropogenic methane cycles and its emission into the atmosphere. The most significant anthropogenic sources of methane is waste fields, cattle pastures, rice areas, etc. One of the less obvious, but a significant source of the methane is artificial reservoirs. In order to more accurately assess methane emissions from reservoirs, it is necessary to study processes connected with methane fates in the aquatic ecosystems. For this problem, the Mozhaisk reservoir was chosen. This is a well-studied, small size, valley reservoir, where the study of methane fluxes has been carried out for 6 years, since 2015. Also, the Mozhaisk reservoir used as an object for testing the "LAKE" mathematical model. This one-dimension, hydrodynamics model can helps in estimation of the emission of methane into the atmosphere from the reservoirs surface.

Scheme of the Mozhaisk reservoir with reference observation stations, and main reservoir`s characteristics



Length	Max Breadth	Mean Breadth	Max Depth	Area	Volume	Water Level Amplitude	Water exchange koef.
28 km	2,6 km	1,1 km	22,6 m	30,7 km^2	0,24 km^3	6 m per year	1,78

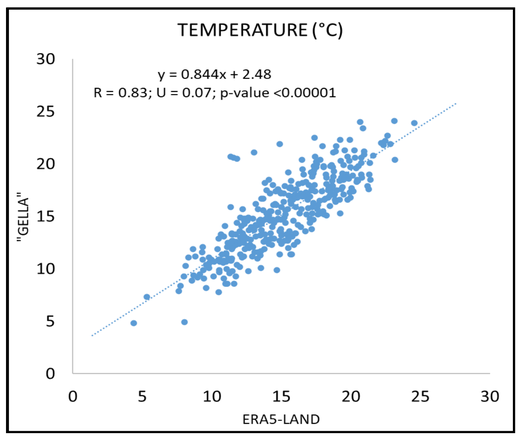
Methane fluxes in reservoirs ecosystem

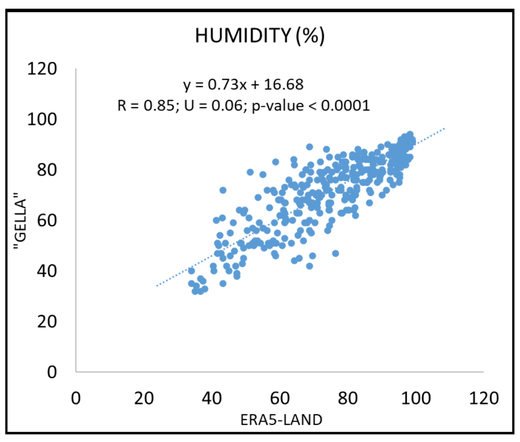


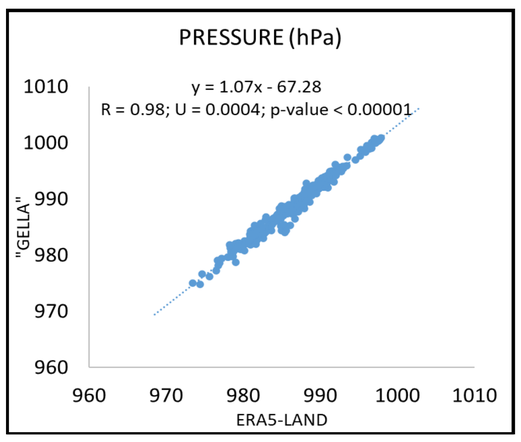
UNESCO/IHA research project on the GHG status of freshwater reservoirs // IHA, 2013, 41 p

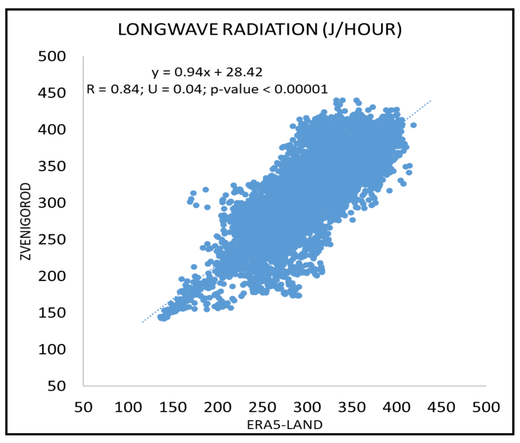
Correlation between ERA5-Land and Ground Observed Data

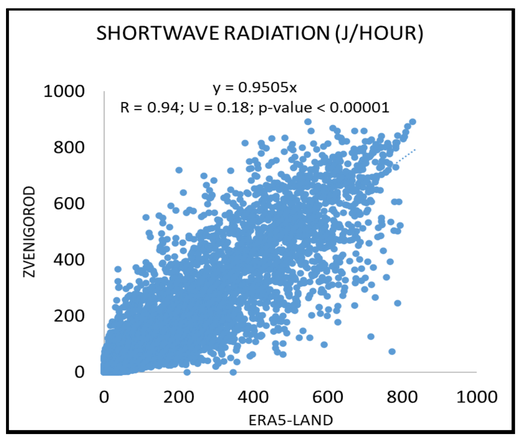
For more accurate calculations, the model requires high-resolution data. The ERA5-Land reanalysis (each hour data) was chosen as the source of information. Regression models were built for the connection between reanalysis data and ground-based observations (some of the characteristics were compared with data from the temporary floating station "Gella", radiation fluxes with the Zvenigorod observatory, precipitation with the Naro-Fominsk metеostation). Criteria were calculated such as Pearson's correlation coefficient (R), Theil's index (U), F-criteria for the regression.

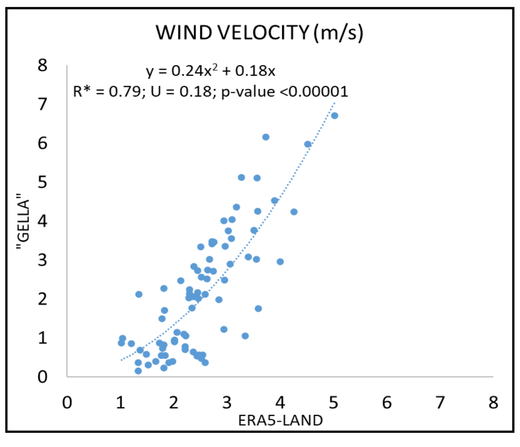


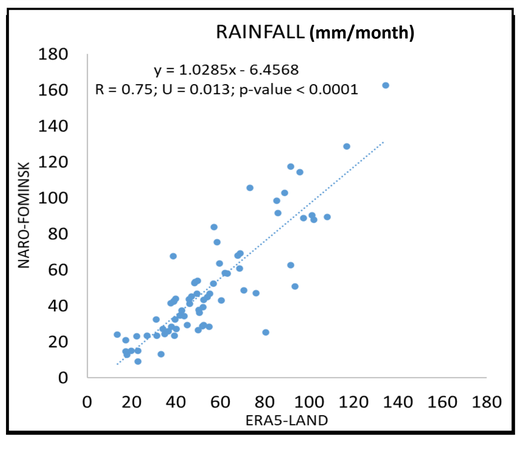










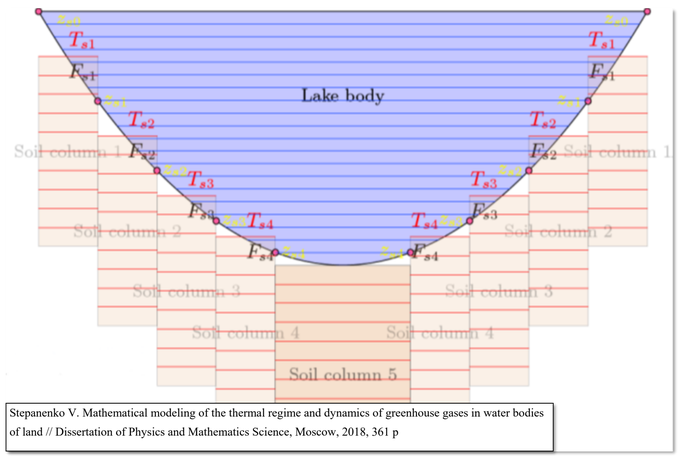


"LAKE" - is one-dimension, hydrodynamic model with include of biochemical calculation module. The model has 5 main calculation steps: Water Thermal Module, Sediment Thermal Module, Sediment Methane Module (the production of methane), Gas Transport and Bubble Transport Module (the fluxes of methane).

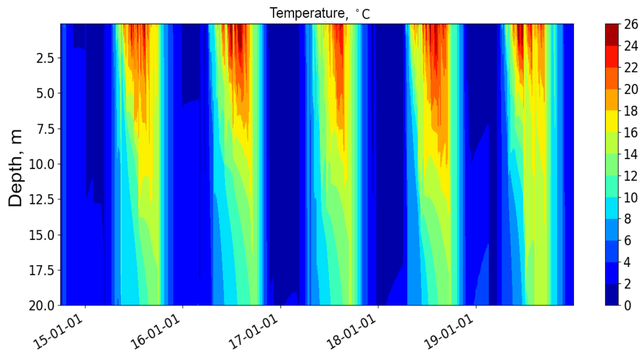
The main input data in this model is meteorological conditions:

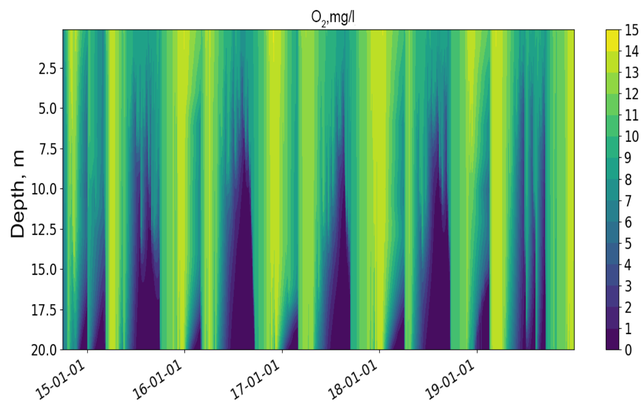
- *temperature,*
- *pressure,*
- *humidity,*
- *wind velocity,*
- *downwards fluxes of longwave and shortwave solar radiation,*
- *precipitation*

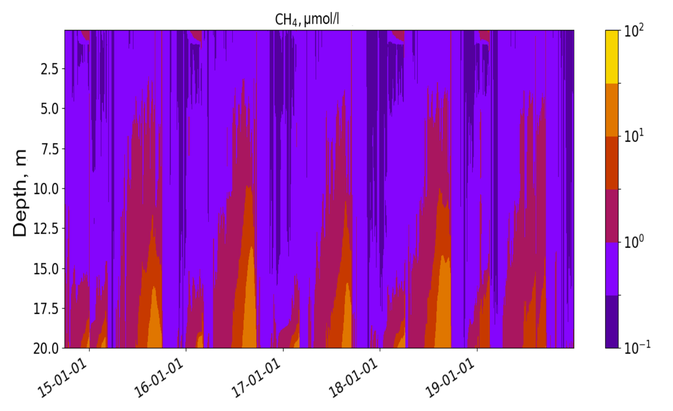
The calculation scheme of the "LAKE" model and the results obtained for the Mozhaisk reservoir for 2015—2019

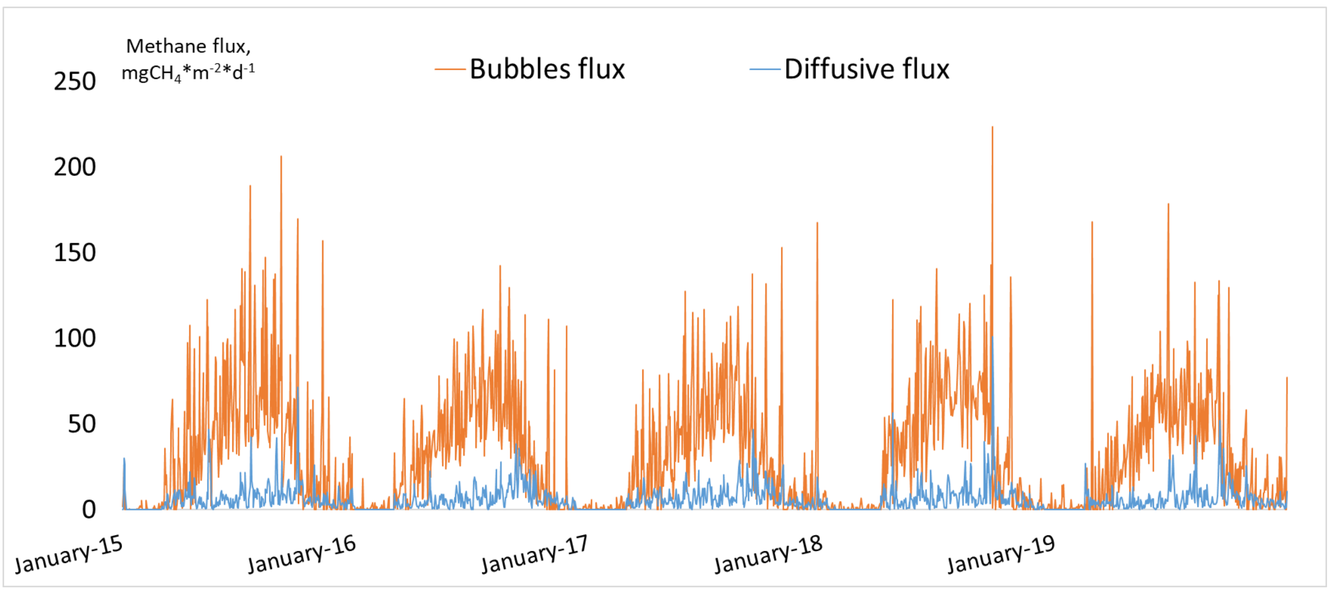


Stepanenko V. Mathematical modeling of the thermal regime and dynamics of greenhouse gases in water bodies of land // Dissertation of Physics and Mathematics Science, Moscow, 2018, 361 p









Year	Emission, according to "LAKE", тС-CH4	Emission according to field observations, тС-CH4
2017	308	425
2018	312	269
2019	305	596

CONCLUSIONS: The dynamics of methane fluxes into the atmosphere was successfully calculated using the one-dimensional hydrodynamic model "LAKE". Comparing the calculation results with the field observations since 2015 at the Mozhaisk reservoir showed, that the model already adequately reproduces the processes occurring in the reservoir, at the level of the first initial launches. However, it is necessary to calibrate the model further more to obtain more accurate parameter values and reliable results. The statistical analysis of the input meteorological characteristics for the model showed the possibility of using the reanalysis data for the calculation. That allows to carry out such calculations on any water body with sufficient accuracy. The development of this technique will make it possible to obtain reliable estimates of methane emission from reservoirs in different regions in the future.

The work was partially supported by the President`s grant MD-1850.2020.5