

DOI: <https://doi.org/10.37162/2618-9631-2023-2-6-34>

The COSMO-Ru2By configuration of the COSMO model: skill and methodology for estimating of the forecasts of β - and γ -mesoscale processes / Rozinkina I. A., Rivin G. S., Bagrov A.N., Blinov D.V., Bykov F.L., Vaskova D.V., Zakharchenko D.I., Bundel A.Yu., Vorobyeva E.V., Kirsanov A.A., Polyukhov A.A., Shatunova M.V., Shuvalova Yu.O., Eliseev G.V. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 6-34.

The paper gives a brief description of the COSMO-Ru2By configuration (the grid spacing is 2.2 km) of the COSMO model, which provides numerical weather forecasts for up to 48 hours for the European part of Russia and for the Republic of Belarus, as well the methodology and results of skill of these forecasts. The COSMO-Ru2By was realized in the Hydrometcentre of Russia and operates as an element of the COSMO-Ru operational limited-area numerical weather prediction system on the CRAY XC40-LC supercomputer.

The features of the COSMO-Ru2By are: 1) a vast calculation domain with a grid spacing that allows an explicit description of large (over 5-6 km high) convective motions and considering in detail the features of terrain; 2) the “embedded” technology for assimilation of DMRL-C Doppler weather radar data providing more accurate forecasts of rapidly developing weather processes for the next few hours; 3) coupled visualization system providing a great number of maps for different regions with a cascade image detailing. Operational trials in 2020-2021 showed a high skill of forecasts of the basic weather parameters with the COSMO-Ru2By. For comparison with forecasts of highly variable weather parameters (wind gusts, hourly precipitation, parameters in mountain areas, etc.) based on mesoscale models with lower resolution (e.g., COSMO-Ru6ENA, the grid size is 6.6 km), it was proposed to apply expanded trial approaches and criteria: e.g., the estimation over geographically homogeneous areas, the use of special criteria for predicting rare events, the comparison with radar data.

Keywords: numerical weather prediction, mesoscale atmospheric modeling, radar data assimilation, weather forecast skill estimation, non-hydrostatic atmosphere models

Tab. 2. Fig. 11. Ref. 25.

DOI: <https://doi.org/10.37162/2618-9631-2023-2-35-54>

Wind gustiness parameterization and long-range weather prediction / Fadeev R.Yu. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 35-54.

The paper discusses a number of refinements to the SL-AV atmospheric model, which allowed substantially reducing systematic errors in reproducing the averaged characteristics of the atmospheric circulation. Particular attention is paid to the wind gustiness parameterization and the calculation procedure of turbulent fluxes in the planet boundary layer. The statistical significance of the influence of the considered changes on the accuracy of atmospheric circulation simulation is concluded based on analyzing the quality of retrospective long-range forecasts with a lead time up to four months (for two seasons) and on studying the averaged characteristics of the model atmosphere in comparison with the ERA5 reanalysis.

Keywords: Atmospheric general circulation model, numerical weather prediction, parameterization, wind gustiness

Tab. 3. Fig. 4. Ref. 32.

DOI: <https://doi.org/10.37162/2618-9631-2023-2-55-76>

Statistical estimates of the parameters of winter and summer atmospheric centers of action based on 1992–2021 reanalysis / Balakin V.S., Shipko Yu.V., Kolychev O.V., Kyznetsov I.E., Zakusilov V.P., Shuvakin E.V. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 55-76.

The subject of the present study is climatological atmospheric centers of action (permanent and seasonal) of the Northern and Southern hemispheres for the central months of the winter and summer seasons. Data on 1000 hPa geopotential height from the NCEP/DOE AMIP-II reanalysis of atmospheric parameters for 1992-2021 are used as initial information. Software-implemented processing of long-term reanalysis data files made it possible to map of the distribution of synoptic centers of action at regular grid points (with a step of 2.5° in latitude and longitude). Statistical estimates of the parameters of atmospheric centers of action (location and intensity), including concentration ellipse characteristics, are presented. An analysis of the change in the characteristics as compared to the base climate period of 1961–1990 (according to the NCEP/NCAR reanalysis data) is given. The dynamics of the characteristics of the centers of action in the form of moving 10-year averages for 2000–2021 is demonstrated.

Keywords: atmospheric center of action, reanalysis, geopotential height, concentration ellipse, moving average, trend

Tab. 3. Fig. 15. Ref. 25.

DOI: <https://doi.org/10.37162/2618-9631-2023-2-77-92>

Synoptic conditions for the formation of dry and wet heat and cold waves in the Middle Volga region / Morozova S.V., Lapina S.N., Polyanskaya E.A., Alimpieva M.A. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 77-92.

The results of a synoptic-statistical analysis of dry and wet heat and cold waves of various duration and intensity in the Middle Volga region are presented. The waves were identified from the data on average daily air temperature and daily precipitation at Saratov station. Using the Euclidean distance, a classification of synoptic conditions was carried out, and the corresponding reference air pressure fields were identified.

Keywords: heat and cold waves, synoptic conditions of wave formation, method of references, transformational and dynamic processes

Fig. 7. Ref. 23

DOI: <https://doi.org/10.37162/2618-9631-2023-2-93-113>

Analysis of the synoptic processes leading to the occurrence of tornadoes in the Kursk region and nearby areas / Sannikova G.V. // Hydrometeorological Research and Forecasting, 2023, no. 2 (388), pp. 93-113.

The cases of tornado occurrence in the Kursk region and the nearest areas of the Belgorod and Orel regions in 2003 and 2019–2022 are considered. The conditions for the occurrence of the analyzed severe weather event are analyzed on the basis of surface, aerological, and satellite observations. The cases of mesocyclone tornadoes that led to the most devastating consequences, including death of people, are identified. The cloudiness parameters, air mass types, and variants of synoptic conditions accompanying tornadoes are systematized. The necessity of using data of numerical simulations with mesoscale models for tornado detection using DMRL-C radars is demonstrated.

Keywords: tornado, supercell, Chernozem region, Kursk region, DMRL-C

Tab. 4. Fig. 9. Ref. 15.

DOI: <https://doi.org/10.37162/2618-9631-2023-2-114-127>

Diagnosis of hail based on DMRL-C and numerical modeling data / Alekseeva A.A., Bukharov V.M., Losev V.M. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 114-127.

The results of improving the algorithms for diagnosing hail on the Earth surface and its size based on the DMRL-C network and numerical prediction data are presented. The algorithms are implemented as part of an automated technology that operates in real time, with the presentation of results in a database and in the form of maps. A two-hour (relative to the observation period) animation of the diagnosed hail zones is provided. An algorithm for identifying the phase state of precipitation in a cloud is implemented, which made it possible to refine the diagnosis of hail in late spring and early autumn, rejecting cases with snow and ice pellets. The results of verifying the probability of detection of hail are given. It is concluded that the results of improving hail diagnosis using radar data will make it possible to refine data on cases of hail reaching the Earth surface in the European part of Russia, supplementing the already existing ones, according to the information of the network of meteorological and remote observations, which is also of practical importance for producing more accurate storm warnings about the occurrence of the phenomenon.

Keywords: hail, diagnosis, phase state of precipitation in a cloud, radar data, DMRL-C network, automated technology

Fig. 5. Ref. 14

DOI: <https://doi.org/10.37162/2618-9631-2023-2-128-137>

Solving the problem of damping free oscillations of the water level surface in the Gulf of Finland / Klemm V.V., Korolyova O.A. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 128-137.

The proposed article is the third paper of the authors from Mozhaisky Military Space Academy published in Hydrometeorological Research and Forecasting journal (No. 1 (371) in 2019, No. 2 (380) in 2021), which show how optimization methods (from the classic calculus of variations to modern Pontryagin methods and the method of moments) can be applied for solving specific problems of managing natural processes.

In the present paper, a system of equations was chosen for forecasting storm surges in the Gulf of Finland, which, as calculations based on observations showed, allows predicting the maximum level of water rise at the Neva River mouth with an error not exceeding 10%. An algorithm for solving the problem of damping free oscillations of the water level surface in the Gulf of Finland is proposed. The results of calculations of control actions, as well as the levels of water rise during the damping of a free gravity wave with unilateral and bilateral actions are presented. The results of the calculations on the example of the flood on September 28-29, 1975 showed that when damping the free gravity wave of the storm surge, the maximum level of water rise at the Neva River mouth could be reduced from 280 to 194-195 cm, that is, by 85-86 cm (30%).

Keywords: storm surge, free oscillations of the water surface, control action

Tab. 2. Fig. 3. Ref. 8

DOI: <https://doi.org/10.37162/2618-9631-2023-2-138-155>

Deep neural networks of transformer architecture in problems of hydrological forecasts / Romanov A.V., Akmaev E.R., Chervonenkis M.A. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 138-155.

The theoretical analysis of modern neural network models used for processing time series is carried out. At the same time, special attention is paid to the architecture of building deep machine learning algorithms. The advantages of the neural network model Temporal Fusion Transformer (TFT), which is selected as the base for modeling the process of spring flood formation, are shown. The possibilities of using the TFT model for a long-term forecast of maximum water levels with a lead time of 60 and 90 days for several points of the Iset river (the basin of the Tobol river system) are numerically analyzed in detail. The daily time series for 27 years (1991-2017) for eight hydrometeorological characteristics were used as the initial information for training the model (dependent (trainable) sample). The results of forecasts for an independent sample (2018-2022), as well as operational forecast data for 2023 are presented. Several directions of development of neural network modeling for long-term and short-term forecasts of streamflow are identified.

Keywords: hydrological long-term forecasts, flooding, neural networks, discharge, water level, water regime, artificial intelligence, deep machine learning, Temporal Fusion Transformer

Tab. 3. Fig. 5. Ref. 13

DOI: <https://doi.org/10.37162/2618-9631-2023-2-156-173>

Changes in inventory data on pollutant emissions into the atmosphere over the Moscow region / Borisov D.V., Kuznetsova I.N., Nakhaev M.I. // Hydrometeorological research and forecasts, 2023, no. 2 (388), pp. 156-173.

For the planned modification of the air quality forecasting technology due to the transition to the new version of the CHIMERE chemical transport model, the updated EMEP-2020 emission data for the Moscow region were compared with the currently used EMEP-2013 data on emissions of priority pollutants into atmosphere. A 40 % decrease in the total volume of emissions has been revealed over the Moscow region in recent years, their spatial redistribution and changes in the contributions of industry sources to the total emission have been established. In EMEP-2020, as compared to EMEP-2013, the contribution of vehicle emissions and emissions from industrial combustion changed the most: it increased up to 58 and 27%, respectively. The comparison of 2019 and 2020 emissions is of particular interest: the inventory data revealed a slight decrease in total emissions (by 1–6 %) in 2020, which adequately correlates with restrictive measures during the COVID-19 pandemic.

The results of comparisons of the data on emissions into the atmosphere on the territory of Moscow according to Rosprirodadzor and EMEP-19 are presented and discussed. The coincidence of total emissions was established, with differences in spatial and sectoral distributions. The developed algorithms for the comparative analysis of EMEP and Rosprirodadzor data are universal and can be used to analyze updated information in any regions.

Keywords: EMEP emissions, chemical transport model, CHIMERE, Rosprirodadzor, COVID-19 pandemic

Tab. 3. Fig. 5. Ref. 13