ANNUAL REPORT ON GEOTRACES ACTIVITIES IN RUSSIA

May 1st, 2024 to April 30th, 2025

New GEOTRACES or GEOTRACES relevant scientific results

- Klyuvitkin and co-authors (2024) from Shirshov Institute of Oceanology RAS (SIO RAS) examined trace element vertical fluxes in two hydrothermal sites of Arctic segment of Mid-Atlantic Ridge. This study is the first investigation of deep sediment trap material collected at the Jan Mayen hydrothermal vent field area at 71° N and 6° W of the southernmost Mohns Ridge in the Norwegian–Greenland Sea. This area is characterized by high magmatic activity, axial volcanic ridges, and mafic-hosted volcanogenic massive sulfide deposits. Data on sinking particle fluxes from two hydrothermal settings, the Troll Wall and Soria Moria vent fields located about 4 km apart were obtained. These findings contribute to the limited number of studies investigating sinking particle fluxes from buoyant and neutrally buoyant hydrothermal vent fields in the ocean. The hydrothermal plume propagates subhorizontally in a northeasterly direction (~45°) within a layer that extends no more than 100 m from the bottom. The impact of hydrothermally derived particles is most evident at a depth of 30 m above the seafloor. The transportation of buoyancy hydrothermal plumes was significantly affected by tidal motion. Hydrothermally derived particles were represented by a low- to medium-temperature mineral association including barite, sphalerite, pyrite, chalcopyrite, gypsum, and non-crystalline Fe-Si oxyhydroxides. SM vent field is distinguished by a more pronounced influx of sedimentary matter compared to the TW field, accompanied by elevated fluxes of Zn and Ba. On the contrary, the TW field exhibits elevated values of Fe and Mn fluxes. This phenomenon is likely attributed to the absence of a single end-member fluid and the presence of sources of varying configuration and intensity, with differing fluid temperatures, within the studied fields. These study yields important geochemical and mineralogical data regarding hydrothermally derived sinking particles that provide a unique perspective on the mafic-hosted hydrothermal settings affected by hotspots.

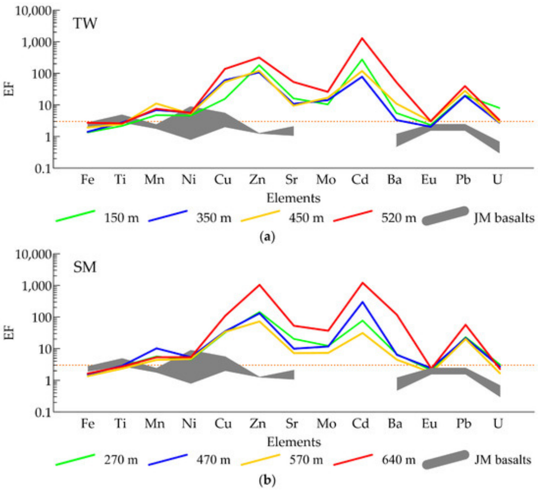

Figure RU-1. *Enrichment factors of elements in sinking particles relative to upper continental crust at TW (a) and SM (b) compared to the Jan Mayen region basalts.*

- A statistical summary of chemical composition of atmospheric aerosol was presented by S.M. Sakerin and his colleagues (2024) from V.E. Zuev Institute of Atmospheric Optics, Limnology Institute, Institute of Monitoring of Climatic and Ecological Systems, SIO RAS, Voevodsky Institute of Chemical Kinetics and Combustion (Russian Academy of Sciences) based on the long-term research results obtained in the Eurasian sector of the Arctic Ocean: concentrations of 8 ions, 22 trace elements, organic and elemental carbon

(OC, EC), as well as total carbon isotopic composition $\delta^{13}C$ [Sakerin et al., 2024]. The average aerosol characteristics were obtained: 5.14 μg/m^3 for the total ion concentration with a predominant contribution (72%) of Na^+ and Cl^- ions; 175 ng/m^3 for the total concentration of trace elements with a main contribution (70%) of terrigenous elements Fe and Al; 700 ng/m^3 for the OC concentration; 32 ng/m^3 for the EC concentration; and $\delta^{13}C$ = –27.9‰ VPDB. High enrichment factors of Cr, Ni, Se, Mo, Sn, Pb, Cu, Zn, As, Ag, and Sb (relative to the composition of the upper continental crust) are due to their anthropogenic origin. The spatial distribution of concentrations of all ions is characterized by a decrease (3.5 times, on average) from the Norwegian Sea to the Chukchi Sea. The spatial distribution of trace element concentrations was divided into three groups with maxima over the Norwegian, Barents, or Kara seas and a minimum over the Chukchi Sea. Characteristic features of carbon-containing aerosol also tend to change eastward: a decrease in OC and EC and heavier carbon isotopic composition.

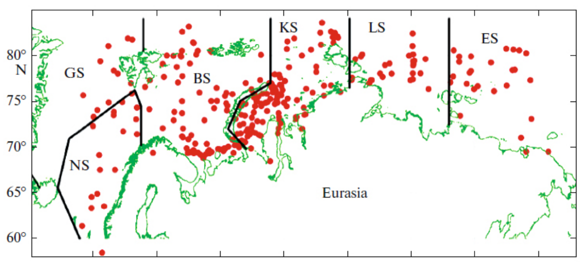

Figure RU-2. *Map of sampling sites in areas of different seas: Greenland (GS), Norwegian (NS), Barents (BS), Kara (KS), Laptev (LS) and East Siberian seas.*

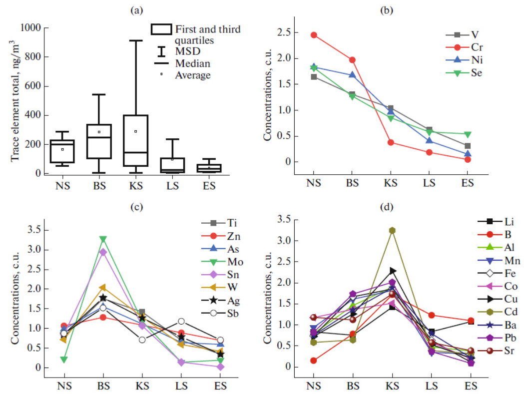

Figure RU-3. *Longitudinal distribution if statistical characteristics of (a) total element concentrations and (b,c,d) average concentrations of elements normalized to average values in Eurasian sector of Arctic Ocean.*

- Demina and co-authors (2024) from SIO RAS obtained first data on the concentrations of a number of trace elements and carbon (organic and carbonate) in the components of the bottom ecosystem of the East Siberian Sea. The distribution of a large group of trace elements (Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, Mo, Ag, Ba, Tl, Pb, Bi, Th and U) in mass taxa of benthic organisms, including bivalvia *Portlandia arctica*; crustacean Isopod (*Saduria sibirica, Saduria sabini*), echinoderms *Ophiuroidea Ophiocten sericeum*, and Holothuroidea *Myriotrochus rinkii*, was studied. The role of abiotic and biotic factors in the accumulation of chemical elements in benthic organisms was estimated. The lithological and geochemical characteristics of host bottom sediments, primarily, the organic carbon content and the grain-size composition, reflect the influence of abiotic factors. The biotic factor is responsible for the geochemical properties of trace elements, the level of organic carbon in organisms, and their feeding type. For the first time, a comparative assessment of the levels of organic carbon accumulation in mass taxa and host bottom sediments was made, and an important sedimentological function of detritophages and deposit feeders organisms was shown.

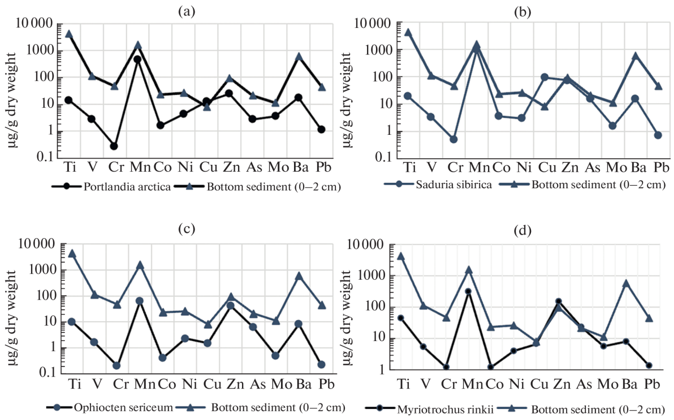

Figure RU-4. *Comparison of element distribution in the surface sediments and bottom organisms, including the whole body of bivalve P. arctica (a), whole body of isopod Saduria sibirica (b), body without intestines of Ophiuroidea Ophiocten sericeum (c), and Holothuroidea Myriotrochus rinkii (d).*

- Dubinin with co-authors (2024) from SIO RAS studied isotopic composition of sulfur in the Black Sea water. Elemental sulfur is a common product of hydrogen sulfide oxidation in the photic zone of meromictic basins due to the anoxygenic oxidation of H_2S by photosynthetic bacteria. The photic zone in the Black Sea is limited to 50-60 m, which is much higher than the upper limit of the hydrogen sulfide zone interface, which is at a depth of 90-100 m in the center of the sea. In peripheral areas of the Black Sea, the depth of the redox interface reaches 150-170 m, where, as expected, photoautotrophic bacteria are rare and in an inactive state. A study of the distribution of elemental sulfur in the Black Sea anoxic zone showed that waters from depths of 180-300 m are light sensitive. This was expressed as a sharp increase in sulfur concentrations up to 11.3 μmol/kg with background values of 0.15 - 0.18 μmol/kg under strictly anaerobic conditions. The activation of photoautotrophic bacteria in the samples after collection, which can be traced by the formation of elemental sulfur, occurs in the upper part of the anaerobic zone down to a depth of 300 m (a hydrogen sulfide concentrations ~ 66 μM). The values of δ^{34}S of produced elemental sulfur were -36.8±0.2‰ for the samples at a depth 260 m and -36.2 ±0.2‰ at a depth 250 m. These were 4.6 and 4.0‰ heavier than δ^{34}S of sulfide at the corresponding depths. Elemental sulfur enriched with the 34 isotope relative to sulfide is typical for the metabolic products of photoautotrophic bacteria. The appearance of the sulfur maximum coincides in depth and density with an increased concentration of particulate organic carbon and the maximum number of microorganisms in the upper part of the anaerobic zone. The hydrogen sulfide oxidation rate depends on lighting intensity, and reaches 9 μmol kg^{-1} day^{-1} in summer.

- Budko and colleagues from SIORAS (2024) focused their research on exploring the relationships between the composition of elements in biogenic carbonates such as shells of gastropods. The study investigated the relationship between the concentration of Li and Mg in the shells of *Peringia ulvae* and environmental factors such as temperature, salinity and productivity in isolated brackish lakes on the White Sea coast. A strong correlation was established between the content of these elements and the water temperature (r_s –0.87 for Li and +0.92 for Mg, both significant at p<0.01), indicating that changes in temperature can affect the concentration of these elements in mollusc shells. There was also a strong correlation between water salinity and these elements, but with an inverse relationship (r_s = +0.95 for Li and r_s = –0.90 for Mg, also significant at p < 0.01). This suggests that the interaction between these elements and salinity may be influenced by the inverse relationship between temperature and salinity in the water. With respect to temperature, regression analysis showed that up to 76% of the variation in the Mg/Ca ratio in *P. ulvae* can be explained by changes in temperature. Similarly, up to 83% of the variance in the Sr/Li ratio can be attributed to changes in temperature. These findings suggest that temperature plays a significant role in determining the concentrations of these elements in these mollusc species' shells.

- The obtained data on lithogeochemical characteristics of the silty–pelitic and pelitic sediments in the southwestern Kara Sea [Maslov et al., 2024], suggest the presence of a significant proportion of the lithogenic component. The distribution features of trace elements of different geochemical specializations in sands of different regions suggest the influence of erosion products of basic igneous rocks on the composition of surface bottom sediments of the northeastern Kara Sea, but do not agree with the conclusions resulting from analysis of their REE systematics. The latter indicates a significant role of erosion products of basic igneous rocks only in the sands of the Yenisei Bay. The $(La/Yb)_N$ and Eu/Eu* values typical of sands of other regions indicate the predominant role of erosion products of felsic igneous rocks in their composition (Fig. RU-5).

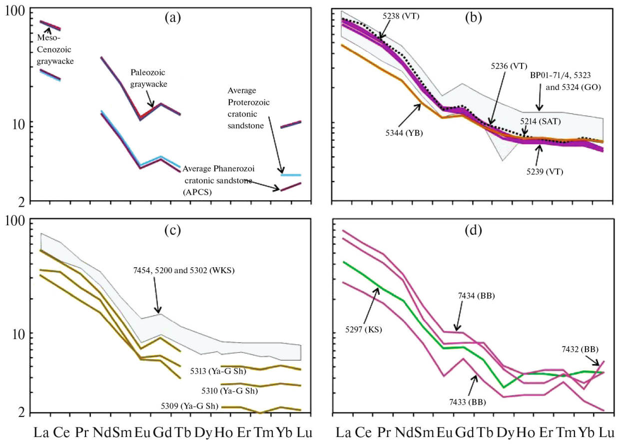

Figure RU-5. *Distribution spectra of chondrite-normalized rare earth elements in reference average cratonic sandstones and graywackes (a) and sands from different areas of the Kara Sea ((b)–(d)). Areas: GO, Gulf of Ob; YB, Yenisei Bay; SAT, St. Anna Trough; VT, Voronin Trough; WKS, West Kara Stage; Ya–G Sh., Yamal–Gydan Shoal; KS, Kara Strait; BB, Baydaratskaya Bay.*

GEOTRACES or GEOTRACES relevant cruises

- Investigations of sedimentation processes and climate change in the Barents and Kara Seas were carried out in **96th cruise of the RV Akademik Mstislav Keldysh** (from 25 July till 31 August, 2024) under the research program of Shirshov Institute of Oceanology, Russian Academy of Sciences (SIO RAS) "European Arctic: Geological Record of Environmental and Climate Changes". Principal researchers of the cruise are Dr. Marina Kravchishina (Past SSC member), Dr. Alexey Klyuvitkin, and Dr. Alexander Novigatsky (SIO RAS). Studies in the northern Barents Sea that is a hot spot of global warming, let us to reveal that the temperature of the Fram Strait branch of the Atlantic water (AW) is approximately 2°C higher than the summer average climatic temperature and is approaching the water temperature in late autumn. The influence of AW on sedimentation and climatic events of the transition period from the Late Pleistocene to the Holocene is studied based on the analysis of sediment cores collected in key sites of the northern marginal shelf troughs [Kravchishina et al., 2025].

Multidisciplinary study of the system "bottom sediments – water column – boundary atmospheric layer" was the main goal of the expedition and had three directions of investigation: (i) approbation of the methodology of operation of the moored autonomous hydrometeorological platform (or meteorological platform) "Sea–Air–Wave Station" (SAWS), developed in IO RAS [10]; (ii) three staging of modernized Automatic Deep-Sea Sedimentation Observatories (ADSO), developed in IO RAS; (iii) onboard observations – complex association networks at 183th oceanographic investigation stations and 5,377 nautical miles of continuous measurements in surface water layer and atmosphere along the ship′s route (Fig. RU-6). Studies were conducted in the northern part of the Barents Sea from 76°42′ N to 82°09′ N at the southern periphery of the Nansen Basin, on the shelf of Northern Spitsbergen, in the Kara and Pechora Seas.

The SAWS was tested in the northeastern part of the Barents Sea with a deployment depth of 164 m. SAWS operated in the automatic mode of monitoring meteorological and hydrological parameters of the environment, as well as concentrations of methane and carbon dioxide in the air for 19 days before the planned ascent [Sharmar et al., 2025 https://doi.org/10.1134/S0001437024700772]. Mooring design and instrumentation demonstrated validity of the meteorological buoy for usage as part of "Unified National Monitoring System of Climatically Active Substances". ADSO moorings will become an important component of this national monitoring system as well.

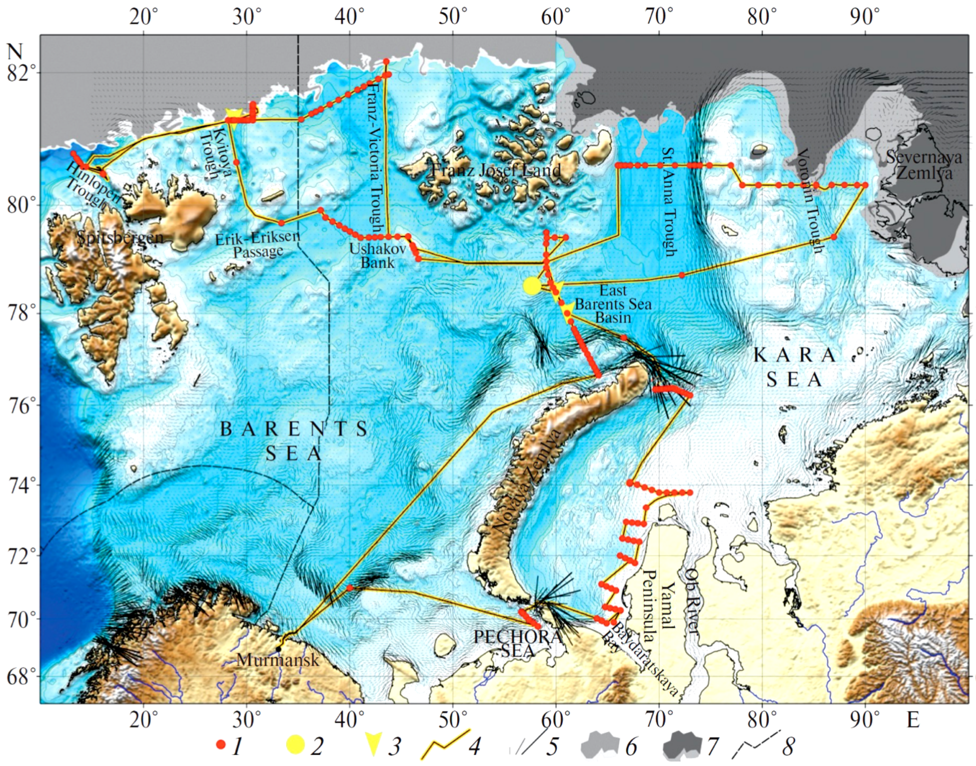

Figure RU-6. *Map of the expedition route and oceanographic investigation stations in July–August 2024: 1 – complex stations, 2 – SAWS, 3 – ADSO, 4 – ship route, 5 – current vectors (vector length reflects current velocity), 6 – ice cover on August 05, 7 – ice cover on August 15, 8 – frontiers of the Russian and Norwegian economic zones and the Fishery Protection Zone Around Svalbard. Current vectors are constructed by [Ivanov, Tuzov, 2021] based on reanalysis, http://bulletin.mercator-ocean.fr/en/PSY4#3/75.50/-51.33. The ice cover is shown from data of the Norwegian Meteorological Institute, https://cryo.met.no. Bathymetry based on GEBCO, https://www.gebco.net.*

New projects and/or funding

- Project of Russian Science Foundation RSF 25-17-00334 "Sedimentation and early diagenesis in the Arctic seas of Eurasia in areas of ongoing methane-rich fluid release" (Project leader Dr. M.D. Kravchishina)

  The last decade has been the warmest on record, with Arctic warming occurring 2-3 times faster, leading to reduced sea ice, multi-year ice loss, and glacier melting. Enhanced influence of the North Atlantic Current has caused 'atlantification,' changing Arctic climate states. These processes impact ecosystems in complex, nonlinear ways, with the ocean playing a key role in multidecadal climate variability. Understanding internal ocean mechanisms requires more observations, especially since sedimentation, diagenesis, and methane release are climate-sensitive. Methane trapped in sediments can be emitted into the atmosphere, originating from microbial activity, dissociation of gas hydrates, thermogenic processes, or abiogenic formation in oceanic crust. Arctic seas show signs of fluid unloading, with large hydrocarbon deposits, methane seeps, craters, and pockmarks indicating active sediment degassing. Although methane emissions are low in rate and short-lived compared to CO_2, they possess a greenhouse effect 10^5 times stronger, and their emissions have increased sharply since 2000. The rapid warming of the Arctic influences these processes, but their precise role remains a subject of active research and debate. This project aims to study sedimentation, methane concentrations, authigenic minerals, fluid sources, and the geochemistry of sediments and water column in the Arctic, in order to understand how modern methane discharge interacts with ongoing climate change — an area that has not been thoroughly explored before.

New GEOTRACES or GEOTRACES-relevant publications (published or in press) *(If possible, please identify those publications acknowledging SCOR funding)*

- Budko, D.F. (2024) Chemical elements in mollusks of separating water bodies of the White Sea: potential indicators of environmental variability Complex Investigations of the World Ocean. Proceedings of the VIII Russian Scientific Conference of Young Scientists, Vladivostok, May 13–17, 2024. 517–518. (in Russian)
- Demina, L.L., Galkin, S.V. Role of modern benthic organisms in the carbon production and transformation in the Laptev and East-Siberian Seas' bottom sediments. Materials of Russian scientific forum "Lithology and Marine Geology" devoted to 270-th Anniversary of Lomonosov Moscow State University. 24-27 September, 2024. Moscow. 67–70. (in Russian)
- Demina, L.L., Galkin, S.V., Solomatina, A.S. (2024) Trace elements and organic carbon in benthic organisms and bottom sediments of the East-Siberian Sea. *Geochemistry International,* 62(10), 1077–1095. https://doi.org/10.31857/S0016752524100043
- Dubinin, A.V., Rimskaya-Korsakova, M.N., Dubinina, E.O., Demidova, T.P., Semilova, L.S., Berezhnaya, E.D., Zologina, E.N., Ocherednik, O.A. (2024) Light Stimulation of Sulfide Oxidation in the Black Sea Anoxic Water Column. *Oceanology*, 64 (6), 810–819. https://doi.org/10.1134/S0001437024700541
- Klyuvitkin, A.A., Kravchishina, M.D., Starodymova, D.P., Bulokhov, A.V., Lein, A.Y. (2024) Sinking Particle Fluxes at the Jan Mayen Hydrothermal Vent Field Area from Short-Term Sediment Traps. *J. Mar. Sci. Eng.*, 12, 2339. https://doi.org/10.3390/jmse12122339

- Krasheninnikova, S.B., Lee, R.I., Sysoev, A.A., Mironov, O.A., Sysoeva, I.V., Gorbunov, R.V. (2024) Study of the distribution features of phytoplankton in the waters of the Kara Sea taking into account abiotic factors // BRICS regional cooperation: modern problems of ecology and nature management: materials of the second international. scientific-practical. conf., Petrozavodsk, September 18–20, 2024. Petrozavodsk: Karelian Research Center of the Russian Academy of Sciences, 2024. P. 58.
- Kravchishina, M.D., Klyuvitkin, A.A., Novigatsky, A.N. et al. (2025) Testing of a Climate Monitoring System Based on Moored Platforms, Observatories, and Shipboard Studies on Cruise 96 of the R/V Akademik Mstislav Keldysh. *Oceanology*, 65, 462–465. https://doi.org/10.1134/S0001437025700122
- Kudryavtseva, E. (2025) Methane emission from the Pregolya River Estuary (Baltic Sea). *Marine Pollution Bulletin*, 211, 117328. https://doi.org/10.1016/j.marpolbul.2024.117328
- Maslov, A.V., Nemirovskaya, I.A., Shevchenko, V.P. (2024) Geochemical characteristics of the pelite component of bottom sediments near the mouths of modern major rivers: how stable are they upstream? *Lithology and Mineral Resources,* 59(6), 611–627. https://doi.org/10.1134/S0024490224700767
- Maslov, A.V., Starodymova, D.P., Kozina, N.V., Migdisova, I.A., Novichkova, E.A., Alekseeva, T.N., Shevchenko, V.P. (2024) Chemical Composition of Sands in the Kara Sea. *Oceanology*, 64(1), 191–205. https://doi.org/10.1134/s0001437024700991
- Maslov, A.V., Starodymova, D.P., Migdisova, I.A., Kozina, N.V., Novichkova, E.A., Alekseeva, T.N., Shevchenko, V.P. (2025) Lithogeochemistry of Silty–Pelitic Bottom Sediments in the Southwestern Kara Sea. *Lithology and Mineral Resources,* 60(1), 25–42. https://doi.org/10.1134/S0024490224700834
- Novichkova, E.A., Demina, L.L., Starodymova, D.P., Matul, A.G., Kravchishina, M.D., Chekhovskaya, M.A., Oskina, N.S., Lozinskaya, L.A., Slomnyuk, S.V., Solomatina, A.S., Yakimova, K.S. (2024) Middle-Late Quaternary stratigraphy and sedimentation paleoenvironment n the Norwegian Sea based on a set of the paleomarker data. *Doklady Erath Sci.*, 519(1), 1825-1833. https://doi.org/10.1134/S1028334X24602876
- Sakerin, S.M., Polkin, V.V., Golobokova, L.P., Kalashnikova, D.A., Kravchishina, M.D., Kruglinskii, I.A., Onishchuk, N.A., Popova, S.A., Pochufarov, A.O., Simonova, G.V., Shevchenko, V.P., Shikhovtsev, M.Yu. (2024) Statistical summary of the chemical composition of atmospheric aerosol over the seas of the Eurasian sector of the Arctic Ocean. *Oceanology,* 64(6), 800–809. https://doi.org/10.1134/S0001437024700498 .
- Starodymova, D.P., Kotova, E.I., Shevchenko, V.P., Titova, K.V., Lukyanova, O.N. (2024) Winter atmospheric deposition of trace elements in the Arkhangelsk region (NW Russia): Insights into environmental effects. *Atmospheric Pollution Research*, 15(12), 102310. https://doi.org/10.1016/j.apr.2024.102310
- Tkachenko, Yu.S., Tikhonova, E.A., Soloveva, O.V. (2024) Content of Hydrocarbons in the Sea Bottom Sediments of the Kara Sea North-Eastern Part. *Processes in GeoMedia – Volume 8* / Ed. T. Chaplina. Singapore : Springer Nature, 2024. 199-212. (Ser.: Springer Geology). https://doi.org/10.1007/978-981-97-6627-7_17

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