

«High-performance cloud service for air quality assessment based on stochastic fractional equations»

The purpose of the project: The aim of the project is to develop a high-performance cloud service based on a new scientifically grounded mathematical model for assessing air quality in the cities of Kazakhstan, using the major industrial city of Ust-Kamenogorsk as a case study.

Amount of funding: 94,416,169.5 tenge (ninety-four million four hundred sixteen thousand one hundred sixty-nine tenge and fifty tiyn)

Priority area: «Information, Communication and Space Technologies»

Relevance of research:

In industrial cities of Kazakhstan, particularly in Ust-Kamenogorsk, air pollution is one of the major environmental problems that negatively affects public health and the ecological safety of the region. Existing methods of air quality monitoring and forecasting do not always take into account the complex processes of turbulent transport and dispersion of pollutants and are also limited in providing operational data in real time. This reduces the effectiveness of state environmental control measures and does not ensure the availability of information for society.

In this regard, the development of a new cloud-based SaaS service, built on a fractional-stochastic mathematical model and high-performance computing, is highly relevant. Such a service will allow predictive calculations in real time, take into account meteorological factors, automatically refine turbulence coefficients using machine learning methods, and provide results through user-friendly interfaces. The implementation of this solution will improve the quality of environmental monitoring, contribute to the development of national scientific and technical potential, and deliver significant social benefits.

Expected results:

1. A new fractional-stochastic model for the dispersion of harmful substances in the atmosphere;
2. Parallel algorithms for the implementation of the proposed model;
3. A SaaS service that automatically collects input data on current atmospheric pollution and wind information; performs predictive calculations based on the proposed model; automatically adjusts the diffusion coefficient using machine learning methods; and provides computation results to third-party developers via an API, as well as through a web interface and a mobile application with an interactive cartographic interface.

Fields of application of developments: The obtained scientific results and the developed high-performance cloud service can be applied in all laboratories engaged in chromatographic analysis of environmental objects, atmospheric air, and others. By reducing the cost of analysis, laboratories can increase their profit margins. In addition, the results of the project make it possible to forecast the technogenic situation, thus presenting practical interest for specialists in the fields of environmental and chemical sciences.

The name of the competition within which the project is being implemented:

Competition for Grant Funding of Young Scientists for Scientific and/or Scientific-Technical Projects for 2023–2025 (Ministry of Science and Higher Education of the Republic of Kazakhstan)

Publications:

1. Bakishev A.K., Madiyarov M.N., Alimbekova N.B., Baigereyev D.R., Baishemirov Z.D. Numerical solution of a fractional convection-diffusion equation for air pollution prediction // Vestnik KBTU. – №2(73). – 2025. – P. 279-289. <https://doi.org/10.55452/1998-6688-2025-22-2-279-289>
2. Madiyarov M.N. Veroyatno-statisticheskaya matematicheskaya model' v drobnykh proizvodnykh dlya prognoza zagryazneniya atmosfery: monografiya. – Ust-Kamenogorsk: VKU im. S. Amanzholova, Izdatel'stvo «Berel», 2025. – 92 p.
3. Madiyarov M.N.; Baigereev D.R.; Alimbekova N.B.; Bakishev A.K.; Mukhamediev G.Kh.; Apyshyev O.D.; Yergaliev E.K. Programma dlya EVM: «Programmnyy paket chislennogo modelirovaniya kachestva atmosfernogo vozdukha na osnove drobno-stokhasticheskikh differentsial'nykh uravneniy» Avtorskoe svidetel'stvo № 59486 ot «10» iyunya 2025 goda.
4. Madiyarov M.N., Baigereev D.R., Tukushova A. Otsenka ob'yomov vybrosov ot avtotransporta goroda Ust-Kamenogorska // Tezisy dokladov VII Vsemirnogo Kongressa Matematicheskikh tyurkskogo mira (TWMS Congress-2023), 20–23 sentyabrya 2023, g. Turkestan. – 2023. – P. 458.
5. Madiyarov M., Alimbekova N., Baigereev D. Primenenie drobnogo ischisleniya dlya zadach perenosa vrednykh veshchestv v atmosfere // Sbornik tezisev Mezhdunarodnoy konferentsii «Computational and Information Technologies in Science, Engineering and Education» (CITech-2024), 23–24 oktyabrya 2024, g. Almaty. – 2024. – P. 43.
6. Alimbekova N.B., Bakishev A.K., Madiyarov M.N., Yergaliev E.K. Konechno-elementnye metody resheniya nachal'no-kraevoy zadachi dlya drobno-differentsial'nogo uravneniya s peremennymi poryadkami drobnykh proizvodnykh // Tezisy dokladov Mezhdunarodnoy nauchnoy konferentsii «Neklassicheskie uravneniya matematicheskoy fiziki i ikh prilozheniya», 24–26 oktyabrya 2024, g. Tashkent, Uzbekistan. – P. 120.
7. Bakishev A.K., Alimbekova N.B., Berdyshev A.S., Madiyarov M.N. Chislennyy metod resheniya drobno-differentsial'noy zadachi fil'tratsii s peremennymi poryadkami drobnykh proizvodnykh // Tezisy dokladov respublikanskoy nauchnoy konferentsii «Sovremennyye metody matematicheskoy fiziki i ikh prilozheniya», 22–24 aprelya 2025, g. Tashkent, Uzbekistan. – P. 304.

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