Ministry of Science and Higher Education
of the Russian Federation

2023

ANNUAL REPORT

St. Petersburg Federal Research Center
of the Russian Academy of Sciences

St. Petersburg
2023

Ministry of Science and Higher Education
of the Russian Federation

ST. PETERSBURG FEDERAL RESEARCH CENTER
OF THE RUSSIAN ACADEMY OF SCIENCES
(SPC RAS)

ANNUAL REPORT

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The publication includes the main results of the St. Petersburg Federal Research Center of the Russian Academy of Sciences – scientific, organizational, educational, publishing and production activities in the field of computer science, robotics, nature management and agriculture in 2023.

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GENERAL INFORMATION

The St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS) is established in accordance with the orders of The Ministry of Science and Higher Education of the Russian Federation of December 18, 2019 No. 1399 and of July 08, 2020 No. 768 (information about the organization is entered in the Unified State Register of Legal Entities (USRLE) by the Federal Tax Service on July 17, 2020 No. 2207803466891) through the reorganization of the St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (SPIIRAS) in a form of joining:

The Federal State Research Institution "North-West Research Institute of Agricultural Economics and Rural Development" (IAERD);

The Federal State Research Institution "North-West Centre of Interdisciplinary Researches of Problems of Food Maintenance" (N-W CIRPFM);

The Federal State Institution of Science "St. Petersburg Scientific Research Centre for Ecological Safety of the Russian Academy of Sciences" (SRCES RAS);

The Federal State Institution of Science "Institute of Limnology of the Russian Academy of Sciences" (IL RAS);

The Federal State Research Institution "Novgorod Scientific Research Agriculture Institute" (NSRAI – Branch of SPC RAS).

According to the Charter the SPC RAS (the SPIIRAS successor) was founded as Leningrad Research Computer Center of the USSR Academy of Sciences by the Decree of the Council of Ministers of the USSR of December 19, 1977 No. 2643-p and the Decision of the Presidium of the USSR Academy of Sciences of January 19, 1978 No. 194.

The scientific and methodological management of the SPC RAS activities is performed by RAS through: Department of Nanotechnologies and Information Technologies of RAS, Department of Earth Sciences of RAS, Department of Agricultural Sciences of RAS.

SPC RAS is headed by the Director: Andrey L. Ronzhin, Doctor of Technical Sciences, Professor, Professor of RAS, appointed by the Order of The Ministry of Science and Higher Education of the Russian Federation of July 18, 2018 No. 20-3/114 п-о based on the Minutes of the labor collective General Meeting of March 23, 2018.

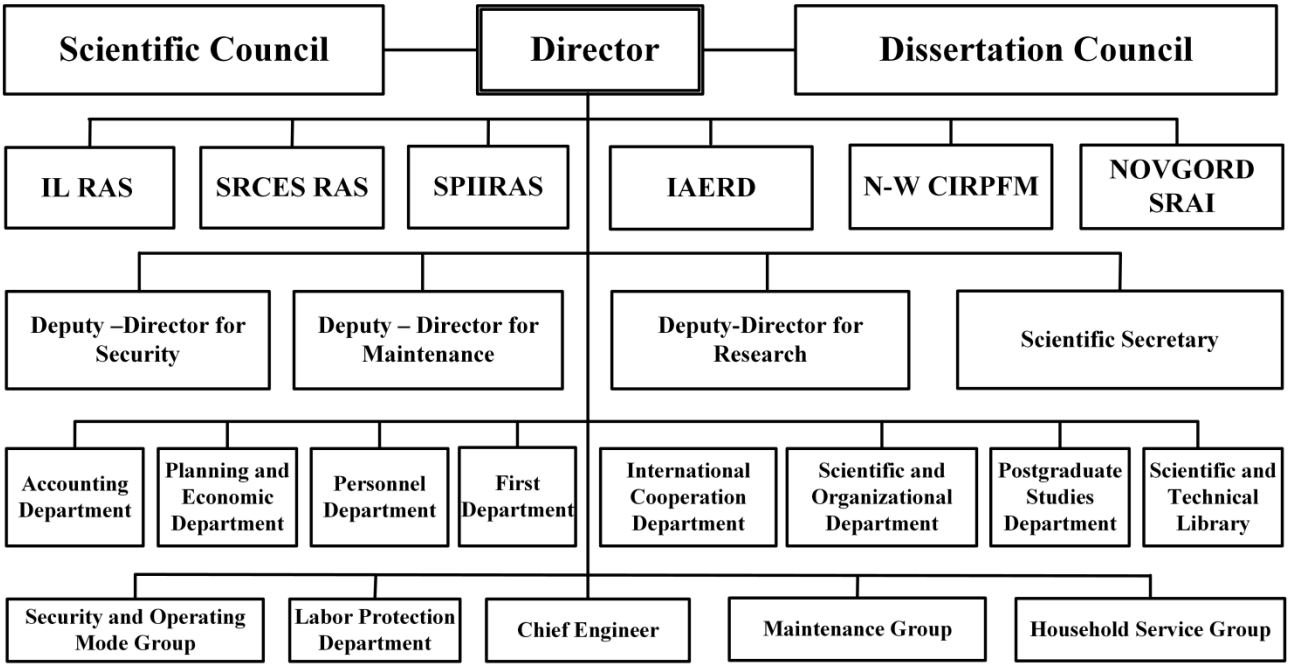
The Scientific Secretary of SPC RAS is Alexandra A. Zaitseva, Candidate of Technical Sciences.

The Deputy Director for Research is Sergey V. Kuleshov, Doctor of Technical Sciences.

The purpose and subject of SPC RAS activities are basic, exploratory and applied research aimed at acquiring new knowledge in computer science and automation, management methods and information and communication technologies, environmental safety, environmental protection, food security, economy and organization of the agro-industrial complex, contributing to its technological, economic and social development, implementation of scientific advancements and best practices, training of highly qualified professionals.

SPC RAS takes the experience and the heritage of united scientific organizations and successfully continues research aimed at developing and implementing strategic digital technologies and robotic systems designed to increase the efficiency of managing processes responsible for the socio-economic development of the North-West region of Russia, as well as ensuring security and enhancing the citizens' life quality.

Digitalization, ecology, agriculture form the core scientific research topics of the Center and correspond in importance to global trends. The institutes and centers involved in the SPC RAS establishing have a unique scientific groundworks, as well as human resources to implement the tasks of food, environmental and information security.


Scientific Council
Director
Dissertation Council
IL RAS
SRCES RAS
SPIIRAS
IAERD
N-W CIRPFM
NOVGORD SRAI
Deputy –Director for Security
Deputy – Director for Maintenance
Deputy-Director for Research
Scientific Secretary
Accounting Department
Planning and Economic Department
Personnel Department
First Department
International Cooperation Department
Scientific and Organizational Department
Postgraduate Studies Department
Scientific and Technical Library
Security and Operating Mode Group
Labor Protection Department
Chief Engineer
Maintenance Group
Household Service Group

Research Activity

Basic, exploratory and applied research and developments are done in the following areas in accordance with the SPC RAS Charter:

- fundamentals of information society development and the digital economy in Russia;
- fundamentals of complex modeling, automation of proactive monitoring and management of information processes in complex (info-, bio-, eco-, agro-, cogni-, socio-, geo-, aviation-space and transport) systems;
- fundamental and technological basics of artificial intelligence, big data, development of intelligent integrated decision support systems, multi-modal user interfaces in human-machine and robotic complexes;
- fundamentals and technological basics of information and cyber security, post-quantum cryptosystems;
- fundamentals of rational use of the territories' agricultural resources potential, conservation and reproduction of biological diversity of agricultural animals and crops to ensure food and environmental security of the Russian Federation;
- fundamental and technological basics for optimization of reclamation systems, construction and reconstruction of reclamation facilities that ensure the preservation of natural resources potential and increase the productivity of agro-landscapes;
- fundamentals and technological models aimed at effective management of the agroecosystems' production process based on adaptation, environment formation and biologization;
- fundamental and technological basics at cultivating economically expedient agricultural crops in order to create highly productive agro-phytocenoses;
- fundamental and applied technological basics of agricultural production that meet the needs of various population groups in a balanced high-quality agricultural raw materials for high-quality food supplies production;
- fundamental and applied basics of rational environmental management in the Arctic zone of the Russian Federation, given the

first priority to production and consumption of locally produced food stuffs with a high level of environmental and biological safety;
- fundamentals of innovative and investment development of agricultural sectors and enterprises;
- fundamentals of integrative processes development in regional agro-industrial complexes;
- fundamentals of rural territories development, land relations and land use in the economy agrarian sector;
- fundamental ecology-economic and legal problems for ecological safety ensuring;
- fundamentals of ecosystem health assessment and maintenance, methods for their state diagnostics and prompt warning an occurrence of threats to ecological safety;
- fundamental and applied basics of transformation and migration of ecotoxicants in the environment;
- basic and applied research of life cycles of natural and economic systems and objects of past environmental damage, methods and processes of rehabilitation of disturbed and polluted ecosystems and man-made landscapes, waste management systems;
- basic research on the origin, evolution, functioning, sustainability, and lakes restoration in different physical and geographical zones;
- development of the theory of eutrophication and pollution of internal water basins, formation of their water quality and scientific forecast of these processes based on long-term studies, accounting for natural, climatic and anthropogenic factors;
- research fundamentals for assessing and forecasting trends in the natural resource potential of the Russian Lake Fund, its protection and rational use, accounting for the socio-economic regions' development;
- basic and applied complex research of Lake Ladoga – the Neva river – the Gulf of Finland system as a geostrategic water object.

Within the Government Order approved by The Ministry of Science and Higher Education of the Russian Federation in 2023 SPC RAS worked on 17 State Budget tasks:

- Theoretical and technological basics of the digital transformation of society and the Russian economy (SPIIRAS).

- Development of basic theory and technology to analyse non-structured data and multimodal users' interaction, intelligent support for targeted collective behavior of participants in human-machine communities (SPIIRAS).
- Methodology and technologies of multi-criteria proactive life cycle management of available and prospective integrated state and commercial information management and telecommunication systems and networks (SPIIRAS).
- Theory of interaction between groups of heterogeneous robotic tools executing joint tasks via biosimilar self-learning systems for intelligent processing of large volumes of fuzzy information (SPIIRAS).
- Theoretical and technological basics for operational processing of large flows of heterogeneous data in socio-cyberphysical systems (SPIIRAS).
- Fundamental basics and practical applications of cybersecurity methods in critical infrastructures and development of post-quantum cryptosystems (SPIIRAS).
- Fundamental basics for development of the agro-industrial complex on the digital transformation of production and economic relations, refinement of spatial development, institutional environment and land relations in the North-West of the Russian Federation (IAERD).
- Development of basic, methodological and technological fundamentals for increasing agricultural production in the North-West and in the Arctic zone of the Russian Federation, ensuring food and environmental safety of the regions (N-W CIRPFM).
- Development of scientific basics for technological modernization of agricultural production in the Novgorod region, aimed at ensuring environmental and food security (Novgorod Research Agriculture Institute).
- Identification of new and insufficiently studied natural and anthropogenic ecotoxicants in environmental objects, study of their transformation mechanisms and impact on biota (SRCES RAS).
- Study of the regularities of transformation against the cumulative technogenic background of natural and economic systems of the Gulf of Finland basin (SRCES RAS).

- Ecological and economic and legal mechanism for minimizing transboundary environmental pollutions in the Baltic Sea region through the method of prevented environmental damage (SRCES RAS).
- Scientific basics for assessing the ecosystems' health in the North-West of Russia and preventing threats to environmental safety (SRCES RAS).
- Complex assessing of the ecosystems' dynamics of Lake Ladoga and its basin reservoirs under the impact of natural and anthropogenic factors (IL RAS).
- Innovative approaches to the use and management of water ecosystem resources (IL RAS).
- Development of complex methods for exploring and evaluating the characteristics of solid particles in the nanoscale size range in water bodies with different degrees of anthropogenic load (IL RAS).
- Patterns of lakes' distribution across Eurasia and assessment of their water resources (IL RAS).

Research done in 2023 on 84 projects included: 29 projects – on the grants of the Russian Science Foundation, 2 – on the grants of the St. Petersburg Science Foundation; 1 – on the grant of the Foundation for Support the Scientific, Scientific and Technical, and Innovative Activities; 3 – on the grants of the Russian Foundation for Basic Research; 6 – on the projects of Federal target programs and programs of the Russian ministries and services; 3– on the projects of MIC; 38 – on the projects of industrial enterprises; 2 – on the contracts with international partners.

The following organizations acted as customers: FSUE "State Research Institute of Applied Problems" (SRIAP); "SRI SS named after A.A. Maximov" – branch of FSUE "Khrunichev State Research and Production Space Center"; "Ecosystem" LLC; Kaliningrad State Technical University; RC "Module" JSC; "R&D CIT "PETROCOMETA" JSC; ITMO University; "HUAWEI TECHNOLOGIES Co. LTD"; "ACM Decisions" LLC; "Transoil" LLC; "SIRIUS" LLC; "Novbiotech" LLC; "Green City" JSC; Immanuel Kant Baltic Federal University (IKBFU); Leningrad Region FSI "Vyborg Animal Disease Control Station"; FRC CS "Surgutneftegas" PJSC; "RUFILMS INNOVATION" LLC; "ECOS SECURITY RUS" LLC; "GAZPROM NEFT" PJSC; "Ecostroy" SPbUE; "TBT" LLC; Lobachevsky State University of Nizhniy Novgorod; ;

“SPRUT” LLC; “PA VOZROZHDENIE” JSC; “bcc” LLC; “NATUR PRODUCT” LLC; “KALA RANTA” JSC; “Resource-Ate” LLC; “AQLADOGA” LLC; “SP ESHEMSERVICE” LLC; “EMC Engineering” LLC; Secretariat of the IPA CIS Council; FGBU “National Park “Kenozersky”; FGBU M. I. NIKIFOROV NRCERM of MChS (RUSSIA); “Head of the Peasant Farm Enterprise Yuri I. Stepanov” IE; “Lengiprotrans” JSC; “CiBiArI Global Property Management” LLC; State Fund for Industrial Development of Khanty-Mansi Autonomous Okrug–Yugra.

In 2023, 207 of the Center professionals attended 164 conferences, published over 790 scholarly articles, including:

– 93 publications indexed in the WoS system (of them 73 articles in professional journals, including 17 articles in Q1 journals);
– 313 publications indexed in the Scopus system (of them 153 articles in professional journals, including 26 articles in Q1 journals);
– 386 publications indexed in the RSCI system (of them 198 articles in professional journals included in the Higher Attestation Commission list, and 90 – in journals included in RSCI).

Some results of the SPC RAS intellectual activity in the year of 2023: 17 patents for inventions, 23 patents for utility models, 6 certificates of state registration of Databases and 47 certificates of state registration of computer programs.

During 2023 the Center contributed to the organization of 10 international scientific conferences, proceedings of 4 of them are indexed in the international databases WoS/Scopus.

The Center employs over 450 staff members, including: 5 Honored Scientists of the Russian Federation, 3 Academicians of the Russian Academy of Sciences, 3 Corresponding members of the Russian Academy of Sciences, 2 Professors of the Russian Academy of Sciences, 56 doctors of sciences and 111 candidates of sciences.

Educational Activity

SPC RAS has a right to maintain education activities as stipulated by the programs for training research as well as scientific and pedagogical personnel in postgraduate and continuous education according to a perpetual license (registration number L035-00115-78/00096292 dated 02.09.2020) issued by the Federal Service for Supervision of Education and Science and also has a perpetual state accreditation for education

activities through its “Postgraduate Studies, Information and Educational Technologies and Services Department” headed by Salukhov, Vladimir I., Associate Professor, Candidate of Technical Sciences, vsaluhov@bk.ru. The training and scientific programs for graduate students are exercised in the areas of:

Directions of training:

09.06.01 Computer Science and Engineering:

– direction “System analysis, control and information processing, statistics”;
– direction “Mathematic- and soft-ware of computers, computer complexes and computer networks”

10.06.01 Information Security:

– direction “Methods and systems of information security, information assurance”;

38.06.01 Economics:

– direction “Economics and national economy management”:
  - training profile – economy, organization and management of industries, complexes – agro-industrial complex and agriculture;
  - training profile – regional economy.

Group of scientific specialities 2.3. Information technologies and telecommunications (by scientific specialities):

– 2.3.1. System analysis, control and information processing, statistics.
– 2.3.5. Mathematic- and soft-ware of computers, computer complexes and computer networks.
– 2.3.6. Methods and systems of information security, information assurance.

Group of scientific specialities 5.2. Economics (by scientific speciality):

– 5.2.3. Regional and branch economics.

As of December 31, 2023, the post-graduate course counts 43 post graduate students.

Doctoral dissertation Council functions in specialities: 2.3.1. System analysis, control and information processing, statistics; 2.3.5. Mathematic- and soft-ware of computers, computer complexes and computer networks;

2.3.6. Methods and systems of information security, information assurance. In 2023 five candidate theses in technical sciences have been defended.

SPC RAS administers five basic departments in the leading St. Petersburg universities as well as three joint research laboratories.

Basic Departments:

- Research Automation at *The St. Petersburg State Electrical Engineering University, established in 1979.*
- Distributed Intelligent Automation Systems at *The St. Petersburg State Polytechnic University, established in 2009.*
- Information Security at *The St. Petersburg State University of Transport Communications, established in 2010.*
- Information Systems and Technologies in Economics at *The St. Petersburg University of Economics, established in 2017.*
- Information Technologies in Logistics at *The St. Petersburg School of Economics and Management NRU HSE, established in 2018.*

Laboratories:

- R&D Laboratory of Information Technologies in Transport Systems, Power Engineering, Automation and Modeling Systems *at Mari State Technical University, established in 2012.*
- Virtual Joint Laboratory at *The Military Teaching and Research Center of the RF Air Force "Military Air Force Academy", Voronezh, established in 2015.*
- Joint Research Laboratory for Robotic Systems' Design and Programming at *The St. Petersburg State University of Aerospace Instrumentation, established in 2016.*

Sessions of the city seminar on "Informatics and Automation" at the Scientific Council for Informatization of St. Petersburg are regularly held by the Center under the leadership of Corresponding Member of RAS Yusupov, R.M. and Professor Osipov, V.Yu.

The Center keeps scientific and technical collection of computing of SPIIRAS; the collection presents exhibits demonstrating the main directions of computer technologies development over preceding years. The collection history is inextricably linked with the history of establishing in 1974 the Computer Engineering Department at the Joffe Physical and Technical Institute (further LRCC, LIIAN, SPIIRAS and SPC RAS). The Center occupies the building that used to be the Carl May School premises with the current museum of the same name. Among the Carl May

School alumni: 40 members of the Russian Academy of Sciences and the Academy of Fine Arts, 156 Full Professors, two ministers, seven governors, four members of the State Council, twenty generals and admirals, three Heroes of Socialist Labor, two pilot-cosmonauts (G.M. Grechko and A.I. Borisenko).

Using the Museums' factual database the SPC RAS staff members run enlightenment and educational activities at the secondary and higher schools of St. Petersburg promoting, at that, the best scientific, pedagogic, cultural and ethical traditions of the Russian education and science.

Publication Activity

SPC RAS is a developer of an electronic editorial platform that provides automation of routine operations of publishers and editorial offices of scientific journals, transparency of the editorial process, generation of citation statistics and import/export of data to global indexes and aggregators of scientific information. In 2023, the platform hosted 4 journals: "Information and Control systems"; "Bulletin of Plant Protection", "Intelligent Technologies in Transport", "Informatics and Automation". SPC RAS is a co-founder of the journal "Izvestiya Russkogo Geograficheskogo Obshchestva".

Scientific Journal "Informatics and Automation"

Print media and online media – The journal "Informatics and Automation" (Proceedings of SPIIRAS) has been published since 2002, since 2016 is in the international database Scopus (CiteScore – 1.9, SJR – 0.24), in the List of the Higher Attestation Commission since 2011, in RSCI since 2018. ISSN: 2713-3192, E-ISSN: 2713-3206. Subscription Index (Catalogue "Post of Russia"): P5513. Languages: Russian, English. Publication Frequency: 6 issues a year.

The journal main categories:

- Mathematical Modeling and Applied Mathematics.
- Artificial Intelligence, Data and Knowledge Engineering.
- Digital Information and Telecommunication Technologies
- Robotics, Automation and Control Systems.
- Information Security.

In accordance with the nomenclature of scientific specialities approved by the Ministry of Education and Science of the Russian

Federation through the order of February 24, 2021, No. 118 the journal publishes articles on the following specialties:

1.1.4. Probability theory and mathematical statistics (physical and mathematical sciences),

2.3.1. System analysis, management and information processing (technical sciences),

2.3.2. Computing systems and their elements (technical sciences),

2.3.5. Mathematical and software support of computer systems, complexes and computer networks (technical sciences),

2.3.6. Methods and systems of information protection, information security (technical sciences).

Full-text versions of the articles are available on the journal's website: http://ia.spcras.ru.

Profile of the journal Informatics and Automation in Scopus: https://www.scopus.com/sourceid/21100793186.

Scientific Journal "Russian Geographical Society News"

Print media and electronic media – Journal "Izvestiya Russkogo Geograficheskogo Obshchestva" is published since 1865, in the List of the Higher Attestation Commission (VAK), indexed in the core of RSCI, ISSN: 2079-9705, E-ISSN: 2079-9713. Language: Russian. Publication frequency: 6 issues a year. The journal publishes articles on the speciality: 39.00.00 Geography.

The journal articles are available on the website of the Russian Geographical Society: https://www.rgo.ru/ru/obshchestvo/periodicheskie-izdaniya-rgo/zhurnal-izvestiya-rgo.

Conferences Organized in 2023

- XVIII All-Russian Scientific and Practical Conference "Prospective Systems and Management Tasks", April 3-7, 2023, Dombaj, Karachay-Cherkess Republic (Russia), https://psct.ru/, *(Yusupov, R.M., Ronzhin, A.L.*).
- Third International Conference on Agriculture Digitalization and Organic Production **(**ADOP **–** 2023), June 05-07, 2023, St. Petersburg (Russia), http://adop.nw.ru, (Scopus, Springer, SIST, Q4), (*Kostyaev, A.I., Surovtsev, V.N., Ronzhin, A.L.)*
- Seventh International Theoretical and Practical Conference "Simulation and Complex Modeling in Marine Technology and

Maritime Transport Systems" (SCM MTMTS-2023) within the International Marine Defence Show "IMDS 2023", June 22, 2023, St. Petersburg, Kronstadt (Russia), https://www.fleet-expo.ru/, http://simulation.su/, *(Yusupov, R.M., Sokolov, B.V.)*.

- 10th Interdisciplinary Workshop "Analysis of Spoken Russian" AP3-2023, June 29-30, 2023, St. Petersburg (Russia), https://phonetics.spbu.ru/novosti/12-q-seminar-ar3.html, *(Karpov, A.A.)*
- IX Interregional Theoretical and Practical Conference: "Advanced Lines of Development in National Information Technologies", September 19-23, 2023, Sevastopol, Crimea (Russia), http://pnroit.code-bit.com, (RSCI), *(Yusupov, R.M., Sokolov, B.V., Kasatkin, V.V.)*
- 7th International Scientific Conference "Intelligent Information Technologies in Engineering and Production" (IITI'23), September 25-30, 2023, St. Petersburg (Russia), http://rgups.ru:85/fronte (*Ronzhin, A.L., Kotenko, I.V.*)
- 11th All-Russian Theoretical and Practical Conference: "Simulation. Theory and Practice" (IMMOD-2023), October 18-20, 22, 2023, Kazan (Russia), http://simulation.su/static/ru-immod-2023.html, (RSCI), *(Ronzhin, A.L., Yusupov, R.M., Sokolov B.V.)*
- XIII St. Petersburg Interregional Conference "Information Security of the Russian Regions (ISRR-2023)", October 25-27, 2023, St. Petersburg (Russia), http://spoisu.ru/conf/ibrr2023, (RSCI), *(Yusupov, R.M., Sokolov, B.V., Kasatkin, V.V.)*
- 25th International Conference "Speech and Computer" (SPECOM-2023), October, 2023, https://specom.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2), (Karpov, A.A.)
- VIII International Conference "Interactive Collaborative Robotics" (ICR-2023), October, 2023, http:// icr.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2) (Ronzhin, A.L.)
- IV International conference "Piotrowski's Readings in Language Engineering and Applied Linguistics", November 22, 2022, St. Petersburg (Russia), (Ronzhin, A.L.)
- VII International Conference "Interactive Collaborative Robotics" (ICR-2022), December 16-18, 2022, Fuzhou, Jiangxi. (China), (Scopus, Springer LNCS/LNAI, Q3) (Ronzhin, A.L.)

Conferences to Be Organized in 2024

- All-Russian Scientific Conference that marks the 80th anniversary of the Institute of Limnology of the Russian Academy of Sciences. “Limnology in Russia”, February 12-14, 2024, St. Petersburg (Russia), https://limno.ru/2023/04/19/limnology_in_russia/, *(Kondratiev, S.A., Sapelko, T.V., Glibko, O.Ya.)*
- XIV All-Russian Scientific and Practical Conference “Prospective Systems and Management Tasks”, April 1-5, 2024, Dombaj, Karachay-Cherkess Republic (Russia), https://psct.ru/ *(Yusupov, R.M., Ronzhin, A.L.*).
- 4-th International Conference on Agriculture Digitalization and Organic Production **(**ADOP **–** 2024), June 05-08, 2024 (Minsk, Republic of Belarus), http://adop.nw.ru. (Scopus, Springer, SIST, Q4). (*Kostyaev, A.I., Komlach, D.V., Ronzhin, A.L.)*
- Third All-Russian Scientific and Practical Conference “Simulation of military purpose systems, military operations and processes of their provisions” (SMPS-2024), October 23, 2024., St. Petersburg (Russia), http://simulation.su/ *(Yusupov, R.M., Sokolov B.V.)*
- X Yubilee All-Russian Scientific and Practical Conference “Advanced Lines of Development in National Information Technologies” (PNROIT-2024), September 17-21, 2024, Sevastopol, Crimea (Russia), http://pnroit.code-bit.com (RSCI), *(Yusupov, R.M., Sokolov, B.V., Kasatkin, V.V.)*
- 9-th International Conference “Interactive Collaborative Robotics” (ICR-2024), October 14=18, 2024, Baku (Azerbaijan), htpp://icr.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2) (*Ronzhin, A.L.*)
- XIX St. Petersburg International Conference “Regional Informatics (RI-2024)”, October 23-25, 2024, St. Petersburg (Russia), http://spoisu.ru, (*Yusupov, R.M, Sokolov B.V., Kasatkin, V.V.*)
- 26-th International Conference “Speech and Computer” (SPECOM-2024), November 25-28, 2024, Belgrade (Serbia), https://specom.nw.ru/ (Scopus, Springer LNCS/LNAI, Q2) *(Karpov, A.A.)*

International Cooperation

In 2023 the engagements with international research community were continued by strengthening the existing interactions and international scientific cooperation through international contracts, agreements, the R&D contacts, information exchange. Also certain personal communications continued, in St. Petersburg at the premises of SPC RAS were received a group of HUAWEI Technologies Co. Ltd (5 persons), PRC; representatives of the management team of Republican Unitary Enterprise "Central Research Institute for Multipurpose Water Use" (RUE "CRIMWU") (3 persons), Minsk, Republic of Belarus; one representative of the German company GEA Farm Technologies RUS; one researcher from the University of Szeged, Hungary; two researchers from Vellore Institute of Technology, India; two researchers from International Scientific Complex "Astana", Republic of Kazakhstan; one – from ATMAN Yoga School, Romania. Young scientists mainly doctoral students have visited SPC RAS including those from: Kyrgyz Republic (1), Republic of Kazakhstan (1), People's Republic of China (1), Islamic Republic of Iran (1), Republic of Haiti (1), Republic of Uzbekistan (1), Republic of Yemen (1). Eleven specialists of the Center took 14 business trips in person to international events in Azerbaijan, Republic of Belarus, India, Republic of Kazakhstan, Slovak Republic, Republic of Latvia, People's Republic of China, Japan. In the current situation major interactions of researchers and professionals with international scholars acquired on-line format (workshops dealt with discussing and coordination of the terms and topics of joint research projects, the projects exercising, and participation in 142 international events and events with international involvement, including the ones in the Russian Federation).

Professional contacts were maintained with the following institutions:

- Institute of Control Systems of the Ministry of Science and Education of the Republic of Azerbaijan (Azerbaijan);
- Armenian National Agrarian University (Armenia);
- Belarusian State University (Republic of Belarus);
- University of Informatics and Radioelectronics (Republic of Belarus);
- Central Research Institute for Multipurpose Water Use (RUE "CRIMWU") (Republic of Belarus);
- Institute of Experimental Botany of the National Academy of Sciences of Belarus (Republic of Belarus);

- Joint Institute of Computer Science Problems of the National Academy of Sciences of Belarus (Republic of Belarus);
- Bulgarian Academy of Sciences, Engineering Sciences (Bulgaria);
- Budapest University of Technology and Economics (Hungary);
- Center for Environmental Research of the Hungarian Academy of Sciences (Hungary);
- Danube Research Institute (Hungary);
- Budapest University of Technology and Economics (BME) (Hungary);
- Institute of Information Technologies (Vietnam);
- Vietnam Academy of Science and Technology (Vietnam);
- Vietnam National University (Vietnam);
- Le Quy Don Technical University (Vietnam);
- Hellenic Mediterranean University (Greece);
- University of Cologne, Institute for Geology and Mineralogy (Germany);
- Indian Institute of Technology Hyderabad (India);
- Malaviya National Institute of Technology, Jaipur (India);
- Centre for Water Resources Development and Management (CWRDM), Kerala (India);
- Karnataka Environment Research Foundation (KERF), Bangalore, (India);
- Almaty University of Energy and Communications (Kazakhstan);
- L.N. Gumilyov Eurasian National University (ENU) (Kazakhstan);
- KATU named after S. Seifullin (Kazakhstan);
- A.Baitursynov Kostanay Regional University (Kazakhstan);
- "Astana" International University (AIU) (Kazakhstan);
- "Astana" International Research Complex (Kazakhstan);
- Cyprus University of Technology (Cyprus);
- Zhejiang Ocean University (China);
- Wenzhou University (WZU) (China);
- Liaoning University (China);
- Huawei Technologies Co. Ltd (China);
- Shanghai Gaitech Scientific Instruments Co., Ltd. (China);
- Harbin Polytechnic Institute (China);
- Mexican National Autonomous University – UNAM (Mexico);
- Institute of Mathematics and Informatics of the Academy of Sciences of Moldova (Moldova);

- Institute of Geography and Geoecology of the Mongolian Academy of Sciences (Mongolia);
- Mongolian Academy of Agricultural Sciences (MAAN) (Mongolia);
- Institute of Biology of the Mongolian Academy of Sciences (MAN) (Mongolia);
- University of Novi Sad (Serbia);
- Center for Arctic Research at the University of Northern Iowa (USA);
- Erzurum Technical University (Turkey);
- Istambul Aydin University (Turkey);
- Open Innovations Association FRUCT (Finland);
- Paul Sabatier University (Toulouse III) (France).

Research and contractual works were done on orders by the Secretariat of the CIS Interparliamentary Assembly (2); Huawei Technologies Co. Ltd (China) (3); Belarusian State University (1bilateral joint research project); under the Program "Integration" of the Union State of Russia and Belarus (1).

Expeditions

In 2023 SPC RAS researchers took part in 33 expeditions, including:

- 1 expedition to the Surgut subdistrict of the Khanty-Mansiysk Autonomous Disrtrict to monitor ecosystems around the drilling sites of "Surgutneftegaz" PJSC;
- 1 expedition to the Kurgalsky peninsula;
- 1 expedition to the lake Zabelskoye, Pskov Region;
- 1 expedition to the lake Rdeiskoye, Novgorod Region;
- 3 Ladoga expeditions aboard research vessels "Ecologist" and "Poseidon";
- 18 expeditions to the Lake Ladoga and reservoirs of the lake basin;
- 5 field trips to the Limnological station at the lake Krasnoye (Karelian Isthmus, Leningrad Region);
- 3 expeditions to the Lake. Sukhodolskoye, Leningrad Region.

In 2023, over 15 one-day visits were made to various regions of St. Petersburg, the Leningrad, Novgorod and Pskov Regions including those to Vyborg, Kingisepp, Luga, Gatchina, Novgorod, Pechora districts.

Monographs and Textbooks

1. *Perevaryukha, A.Yu.* Nonlinear Processes of Ecodynamics: System Analysis and Scenario Modeling. M.: RAS, 2023. 300 p. ISBN 978–5-907645–22–6.
2. *Laskin, M.B.* Methods and Models of Multidimensional Distributions in Tasks of Real Estate Market Analysis. SPb.: SPC RAS, 2023. 338 p.
3. *Talavirya, A., Laskin, M., Dubgorn, A.* Application of Simulation Modeling to Assess the Operation of Urban Toll Plazas. IntechOpen. Application of Simulation Modeling to Assess the Operation of Urban Toll Plazas. IntechOpen, 2023. 39 p. DOI: 10.5772/intechopen.1002003.
4. *Mangasaryan, V.N.* History, Philosophy and Methodology of Science. Scientific and Educational Publication for Postgraduate Students of the Russian Academy of Sciences. St. Petersburg Federal Research Center of the Russian Academy of Sciences.St. Petersburg: RCAN Publishers: 2023. 156 p.
5. *Korneva, L.G., Sharov, A.N., Sidelev, S.I., Zubishina, A.A., Medvedeva, N.G., Lazareva, G.A.*Water "flowering" by Cyanobacteria and Methods of Combating their Mass Development: Textbook. Dubna: State University "Dubna", 2023. 258 p.
6. *Kosmakov, I.V., Egorov, A.N., Yulepina, S.P.* "Features of the Geoecology of Lake Krugloye" Novosibirsk: Nauka, 2023. 76 p.
7. *Kondratiev, S.A., Anokhin, V.M., Golosov, S.D., Guzeva, A.V., Guzivaty, V.V., Dudakova, D.S., Zverev, I.S., Ivanova, E.V., Ignatieva, N.V., Izmailova, A.V., Karetnikov, S.G., Korneenkova, N.Yu., Krylova, Yu.V., Kurasho,v E.A., Mityukov, A.S., Naumenko, M.A., Pavlova,O.A., Pozdnyakov, Sh.R., Rasulova, A.M., Rybakin, V.N., Sapelko, T.V., Stanislavskaya, E.V., Tikhonova, D.A., Tokarev, I.V., Trifonova, I.S.* 80 Years of Limnology's Development at the Institute of Lake Science of the Russian Academy of Sciences. M.: RAS, 2023. 264 p. DOI: 10.12731/978-5-907645-12-7.
8. *Yuzhakov, A.A., Mukhachev, A.D., Laishev, K.A.* Breeds and Problems of Reindeer Breeding in Russia. M.: Nauka, 2023. 165 p.
9. *Shelepov, V.G., Zelenevsky, N.V., Donchenko, A.S., Plemyashov, K.V., Laishev, K.A.* Reindeer Anatomy. Textbook. Novosibirsk: Agronauka 2023. 411 p.

Conferences Proceedings

Speech and Computer. 25th International Conference, SPECOM 2023, Dharwad, India, November 29 – December 2, 2023, Proceedings, Part I. Springer Nature Switzerland AG. Alexey Karpov, K. Samudravijaya, K.T. Deepak, Rajesh M. Hegde, Shyam S. Agrawal, S.R. Mahadeva Prasanna (Eds.): LNCS, 2023. vol. 14338. 667 p. ISBN 978-3-031-20979-6, ISSN 0302-9743, URL: https://link.springer.com/book/10.1007/978-3-031-48309-7.

Speech and Computer. 25th International Conference, SPECOM 2023, Dharwad, India, November 29 – December 2, 2023, Proceedings, Part II. Springer Nature Switzerland AG. Alexey Karpov, K. Samudravijaya, K.T. Deepak, Rajesh M. Hegde, Shyam S. Agrawal, S.R. Mahadeva Prasanna (Eds.): LNCS. 2023. vol. 14339. 594 p. ISBN 978-3-031-20979-6, ISSN 0302-9743, URL: https://link.springer.com/book/10.1007/978-3-031-48312-7.

Interactive Collaborative Robotics. 8th International Conference, ICR 2023, Baku, Azerbaijan, October 25–29, 2023, Proceedings. Springer Nature Switzerland AG 2022. Andrey Ronzhin, Aminagha Sadigov, Roman Meshcheryakov (Eds.): LNCS/LNAI. 2023. vol. 14214. 396 p. ISBN 978-3-031-23608-2, ISSN 0302-9743. URL: https://link.springer.com/book/10.1007/978-3-031-43111-1.

Agriculture Digitalization and Organic Production. Proceedings of the Third International Conference on Agriculture Digitalization and Organic Production (ADOP 2023), St. Petersburg, Russia, June 05–07, 2023, Springer Singapore. Andrey Ronzhin, Alexander Kostyaev (Eds.): SIST. 2023. vol. 362. 434 p. ISBN 978-981-99-4164-3, ISSN 2190-3018. URL: https://link.springer.com/book/10.1007/978-981-99-4165-0.

Proceedings of the Seventh International Scientific Conference “Intelligent Information Technologies for Industry” (IITI’23) vol. 1. Sergey Kovalev, Igor Kotenko, Andrey Sukhanov (Eds.): LNNS. 2023. vol. 776. 450 p. ISBN 978-3-031-43788-5, ISSN 2367-3370.

Materials of the XVIII All-Russian Scientific and Practical Conference “Prospective Systems and Management Tasks”. Taganrog, Lukomorye Publishing House, LLC, 2023. 679 p. ISBN 978-5-902450-68-9.

Proceedings of 10th Interdisciplinary Workshop “Analysis of Spoken Russian Speech” (AR3-2023). U.E. Kochetkova, P.A. Skrelin (Eds.), 2023. 90 p. ISBN: 978-5-00197-081-1.

Proceedings of the 11-th All-Russian Scientific and Practical Conference “Simulation. Theory and Practice (IMMOD-2023)”.

V.V. Devyatkov (Ed.). Kazan, October 18-20, 2023. Kazan: Publishing House AN RT, 2023. 866 p. ISBN 978-5-9690-1151-9.

"Information Security of the Russian Regions (ISRR-2023)". XIII St. Petersburg Interregional Conference. St. Petersburg, October 25-27, 2023: Conference Materials. St. Petersburg: SPOISU, 2023. 401 p. ISBN 978-5-00182-087-1.

Regional Informatics and Information Security. Collection of Articles. St. Petersburg: SPOISU, 2023, vol. 12. 421 p. ISBN 978-5-00182-088-8.

Honors and Awards

- Bogomolov, A.V. – The 2022 Prize of the Government of the Russian Federation in the Field of Science and Technology – For the Developing and Creating New Technology.
- Kotenko, I.V. – Title of Honor: "Honored Scientist of the Russian Federation".
- Kodolova, A.V. – Medal "For Contribution to the Implementation of State Policy in the Field of Sientific and Technological Development".
- Zaytseva, A.A.; Naumenko, M.A. – Titles of Honor "Honorary Worker of Science and High Technologies of the Russian Federation".
- Alexandrova, N.A., Mikhailov, V.V., Tronin, A.A. – Gratitudes of the Ministry of Science and Higher Education of the Russian Federation for a significant contribution to the development of science and conscientious work.
- Kuleshov, S.V. – Winner of the St. Petersburg Government Prize in the nomination "Electrical and radio engineering, electronics and information technologies – A.S. Popov Prize".
- Ivanko, D.V. – Winner of the St. Petersburg Government Prize in the nomination "Natural and technical sciences – L. Euler Prize".
- Tyukalov, Yu.A., Arhipov, M.V. – Letter of Thanks from Ivanov, I.V. – the Deputy of the Legislative Assembly.
- N-W CIRPFM – SPC RAS – Gratitude from the St. Petersburg Legislative Assembly, by Kononenko, R.I. – the Head of the Communist Party Fraction.

- Abramov, M.V.; Alexandrova, N.A.; Danilova, T.A; Ignatieva, N.V.; Kiselyov, A.V.; Kislyakov, V.V.; Maltsev, Yu.R.; Medvedeva, N.G.; Mikhailov, V.V.; Moldoyan, N.A.; Naumenko, M.A.; Pilip, A.G.; Polyak, Yu.M.; Romanyuk, L.P.; Rybakin, V.N.; Silla, E.P.; Suvorova, L.I.; Tronin, A.A.; Tyukalov, Yu.A. – Certificates of Honor by the Russian Academy of Sciences for many years of conscientious work for the benefit of Russian Science, a great contribution to the development of basic and applied research.
- Levshun, D.S.; Chechulin, A.A. – Winners' 'Diplomas of the St. Petersburg 2023 Grants' Competition in the scientific, scientific and engineering activities in the form of subsidies.
- Abramov, M.V., Bushmelev, F.V., Dvoynikova, A.A., Ivanko, D.V., Korepanova, A.A., Markitantov, M.V., Oliseenko, V.D., Ryumin, D.A., Ryumina, E.V., Sabrekov, A.A., Stolyarova, V.F., Khlobystova, A.O. – Winners' Diplomas of the St. Petersburg grant competition 2023 for young candidates of sciences and young scientists from St. Petersburg Government.
- Laishev, K.A., Arhipov, M.V., Yuzhakov, A.A. – Certificates of the Agroindustrial Complex Committee of the Leningrad region.
- Begak, M.V. – Gratitude by the Federal State Autonomous Body Research Institute "Environmental Industrial Policy Centre".
- Bushmelev, F.V., Yerashov, A.A., Khlobystova, A.O. – Scholarship of the Government of the Russian Federation in the priority areas of the Russian economy modernization and technological development.
- Kotenko, I.V. – Winner's Diploma of the 2023 "Golden Names of the Higher School" competition in the nomination: "For contribution to Science and Higher Education", the sub-nomination "For Mentoring". League of Higher School Teachers. Ministry of Science and Higher Education of the Russian Federation.
- Kotenko, I.V. – The St. Petersburg Governor Diploma for active engagement in the scientific and business program at the exhibition of advanced technologies aimed at ensuring the security of individuals, society and the state "Expotechnostrage. Advanced Technologies Day".
- Kotenko, I.V. – The best paper award at the Twenty First National Conference on Artificial Intelligence with international participation, CAI-2023 (Smolensk, October 16-20, 2023).

- Kotenko, I.V. – The best paper award at the 2nd International Conference on Cyber Security (CSW 2023). Hangzhou, China. October 13-15, 2023. Hangzhou Dianzi University.
- Oliseenko, V.D., Khlobystova, A.O., Korepanova, A.A., Tulupyeva, T.V. – Winners of the Open competition of scientific articles under the track AI Journey Science for publication in the Journal "Doklady Akademii Nauk".
- Kotenko, I.V., Smironv, A.V., Teslya, N.N. – The best paper award at 2023 IEEE Ural-Siberian Conference on Biomedical Engineering, Radioelectronics and Information Technology (USBEREIT 2023).
- Saenko, I.B., Parastchuk, I.B. – Certificate for the best 2023 innovative project in the field of electronic educational resources, for the development of the electronic textbook "Informatics. Artificial Intelligence Technologies".
- Kulakov, A.Yu., Ikonnikova, A.V., Alestchenkova, T.L., Bobinina, Yu.V., Saveliev, A.I. and other – Diplomas for participation in the arranging of the "Army-2023 Forum".

SPIIRAS – Structural Division of SPC RAS

St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences was founded according to the Decree of the Council of Ministers of the USSR of December 19, 1977 and to the Decision of the Presidium of the USSR Academy of Sciences of January 19, 1978 as Leningrad Research Computer Center (LRCC) of the USSR Academy of Sciences based on the Department of Computer Science of Ioffe Physical and Technical Institute. Based on the Leningrad Research Computer Center (LRCC) was established one of the first global information and computer networks in the country, that is, AcademNet "North–West". In 1985 LRCC was transformed into the Leningrad Institute for Informatics and Automation of the USSR Academy of Sciences.

In 1992 the Leningrad Institute for Informatics and Automation of the USSR Academy of Sciences was renamed to St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (SPIIRAS) since the historic name of St. Petersburg had been returned to the city of Leningrad. In compliance with the Russian Federation Government Order dated December 30, 2013 No. 2591-p the Institute was turned over to the management of the Federal Agency for Scientific Organizations. By the Order of the Russian Federation Government of June 27, 2018 No. 1293-p the Institute is transferred to the management of The Ministry of Science and Higher Education of the Russian Federation

In accordance with Order of The Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 SPIIRAS acquired a status of SPC RAS structural department.

SPIIRAS does research in informatics, automation and robotics, information and telecoppmunication technologies.

Doctor of Technical Sciences Professor Osipov, Vasily Yu. is the Intitute Director.

Doctor of Technical Sciences Professor, Honored Scientist of the Russian Federation, Corresponding Member of RAS Yusupov, Rafael M. is the Leader of SPIIRAS Research Direction.

Candidate of Military Sciences, Silla, Evgeny P. is the Institute Scientific Secretary.

Members of the Russian Academy of Sciences

Yusupov, Rafael M., Doctor of Technical Sciences Professor, Corresponding Member of RAS, Honored Scientist of the Russian Federation, Winner of the RF Government Prize, Honorary Academician of Tatarstan Academy of Sciences, Honorary Professor of A.F.Mozhaysky's Military-Space Academy, Honorary Doctor of Petrozavodsk State University and of St. Petersburg University of Management Technologies and Economics – research basics of computer science, problems of society and regions' informatization, information and National Security, models' qualimetry; yusupov@iias.spb.su.

Yusupov R.M., Head of the Basic Department of Research Automation at St. Petersburg State Technical University "LETI".

Yusupov, Rafael M. is an expert of RAS, President of the National Simulation Society, Deputy Chair of the Scientific Council for Informatization of St. Petersburg , Co-Chair of the Coordinating Council of the Partnership for the Information Society Development in the North-West of Russia, member of the Scientific Councils of the Russian Academy of Sciences: "Scientific Telecommunications and Information Infrastructure", "High-performance computing systems, Scientific Telecommunications and Information Infrastructure" and the one on the theory of Controlled Processes and Automation; member of the International Academy of Navigation and Traffic Management (headed by Peshekhonov V.G.); member of the Russian National Committee for Industrial and Applied Mathematics; the Head of the scientific school "Informatization and Forming the Information Society" He actively contributes to evaluation and propagation of scientific knowledge participating in the activity of the international journal "Actual Problems of Aviation and Aerospace Systems" (member of the Editorial Committee); "Informatics and Automation (Proceedings of SPIIRAS)" (Editor-in-Chief); and many other national and international scientific journals, like: "Economics and Management", "Mechatronics, Automation, Control", "Informatization and Communication", "Telecommunications", "Bulletin of Cybernetics", "Applied Informatics", "Automation. Computer Science", "Robotics and Technical Cybernetics", "Information Technologies", "Problems of Information Security, Computer Systems", "Journal of Intelligent Control" (USA), "Cybernetics and Information Technologies" (Bulgaria). He also promotes the success of the folllowing regular national and international events: the St. Petersburg International Conference

“Regional Informatics”(Co-Chair of the Organizing Committee); the St. Petersburg Interregional Conference “Information Security of Russian Regions” (Co-Chair of the Organizing Committee); the VII All-Russian Scientific and Practical Conference “Advanced Management Systems and Tasks” (member of the Organizing Committee); Co-Chair of the Organizing Committee of the VIII International Scientific and Practical Conference “Promising directions for the development of domestic information technologies”; Co-Chair of the Program Committee of the 6th All-Russian Conference “Information technologies in management”; Head of the city scientific seminar “Informatics and Automation”, Chair of the SPC RAS Dissertation Council 24.1.206.01.

Laboratory of Applied Informatics and Problems of Information Society

Head of Laboratory: Geyda, Alexander S., Chief Researcher, Doctor of Technical Sciences, Associate Profesor, geida@iias.spb.su.

New Research Results

1. An approach to optimization and automationof numerical methods of the theory of wave propagation in three-dimensionalwaveguides has been developed. For the firsttime, the theory of pseudo differential operators and discrete analysis of variance were used to optimize the numerical method. A quantitativerelationship has been established between the parameters of the medium, the parameters of the numericalscheme and the accuracy of calculations. The number of calculated parameters requiring manual selection has been reduced, thus, reducing the possibilityof human error and allowing for deeper integration of complex numerical methods into application software.

2. The concept of remote immobilization of intelligent robots based on the useof directed electromagnetic radiation has been developed. The mechanisms of reversible and irreversible failures occurring in semiconductor devices, microcircuits and microprocessors influenced by powerful electromagnetic pulses, following both singly and periodically, are analyzed. A thermal model of the occurrence and development of reversible and irreversible failures in microcircuits under the periodic influence of sufficiently powerful electromagnetic pulses has been developed. Rated the danger of exposure of warm-blooded organisms to a sequence of ultra-wide-band electromagnetic pulses of subnanosecond duration.

3. A structural-angular method has been developed for accurate and approximate numerical-analytical solutions of inverse problems in radiation transfer theory bound with an analysis of hyperspectral remote sensing data of the Earth's cloudless atmosphere from space within the spectrum visible part.

4. A method has been developed for processing the paired tensor tremorograms reflecting the friendly movements of the test subject's hands that occur during the registration of tremor by a piezoresistive method using biofeedback in accordance with the methodology proposed by Professor S.P.Romanov for the objective diagnostics of Parkinson's disease, that allows to identify structural elements in the analyzed time series and describe them in terms of the similarity between the time series forming a pair.

Laboratory for Theoretical and Interdisciplinary Computer Science

Head of Laboratory: Abramov, Maxim V., Senior Researcher, Candidate of Technical Sciences, mva@dscs.pro.

New Research Results

1. Models and methods of automated prediction of the results of psychological tests “Big Five”, “16-factor R. Kettell test”, “Holland test” have been developed based on the observed digital footprints of users of the social network (posts, photos, community subscriptions, etc.), implemented in the prototype of the application of help in choosing a profession.

2. New methods have been developed to assess the severity of psychological characteristics based on graphical digital footprints (avatar) of a user in a social network. Groups of users with similar profiles of psychometric indicators were identified and a probabilistic graphical model was formed reflecting the relationship between the color of the pixel characteristics of the respondents' avatars and their profile of personal characteristics, that allows to automate the process of identifying personal characteristics based on data about he users' graphical digital footprints.

3. One of the main procedures at processing the algebraic Bayesian network (ABS), the global a posteriori inference, was accelerated by applying a new tertiary ABS structure to this task and using the canonical ABS representative, that allowed to expand the applicability of the apparatus of algebraic Bayesian networks to various practical tasks in regard to processing the expert knowledge and data with uncertainty.

4. New ways of processing the data uncertainty on episodes of risk-taking behavior in continuous models of behavior intensity assessment (regression and hybrid Bayesian trust network) have been developed. The stability of these models to input data errors has been established, thus, allowing them to be used as a basis in accounting for the human factor in the enterprise cybersecurity management based on employees’ self-reports and open data from their profiles in an online social network.

5. Heuristic methods have been developed to optimize the costs of cargo transportation by setting multi-link logistics routes based on data from open sources, what facilitates the development of automation at cargo transportation route planning and logistics’ digitalization.

Laboratory of Computer Aided Integrated Systems

Head of Laboratory: Smirnov, Alexander V., Doctor of Technical Sciences, Professor, Honored Scientists of the Russian Federation, smir@iias.spb.su.

New Research Results

1. An approach to intelligent monitoring of video interview with a candidate for the sales manager position manager has been developed, characterized by the use of a two-step method of analyzing video interviews, that consists in determining a personality portrait based on the big five personality traits at the first step and determining sales ability at the second step based on empirical expert knowledge. The effectiveness of the approach has been experimentally proven with our own database incorporating 50 people.
2. A method of ontology-oriented geo-analysis has been developed to determine the concentration of traffic accidents on sections of a road network based on the aggregation of information from heterogeneous sources and the formation of its general representation as an ontology according to specified parameters of space and time, characterized by the possibility of converting heterogeneous data sources and using federated SPARQL queries to simultaneously access multiple sources.
3. A method has been developed for developing and lesrning self-explanatory neural network architectures that allow explanations to be formed in terms of the ontology of a sudject domain by matching the output labels of a neural network to the relationships between concepts in the presence of a connection between internal representations generated in hidden layers of the neural network and ontology concepts. The method increases the interpretability of neural network results and allows them to be used in a number of critical applications where rich ontologies exist.
4. An approach has been developed to increase the efficiency of collaboration between human-machine communities in decision-making support tasks based on forming the recommendations for scenarios of joint actions and the use of agent modeling to assess the effectiveness of organizational decisions, characterized by the use of a set of ontologies, the formation of recommendations based on rules and machine learning algorithms, as well as comprehensive consideration of various factors

affecting the success of the group: task properties, participants, and interaction mechanisms.

5. A method has been developed for linking the named entities in the text containing the concepts of the Wikidata knowledge base, that consists in contextual search and definition of concepts related to the entity mentioned in the text throughout the Wikidata knowledge graph, what ensures that the method works based on the semantics embedded in the text with no need of a model learning and without reference to language.

Laboratory of Speech and Multimodal Interfaces

Head of Laboratory: Karpov, Alexey A., Chief Researcher, Doctor of Technical Sciences, Profesor, karpov@iias.spb.su.

New Research Results

1. A new mathematical and software for automatic audiovisual assessment of five personal qualities of a human has been developed, characterized by extracting and analyzing the most informative audiovisual features out of multimedia recordings of a person using face and body segmentation methods, demonstrating an increase in the values of average accuracy and correlation coefficient of 70% in comparison with known modern methods onopen multimedia databases; the first Russian-language audio-visual database has been developed and registered as intended for a multimodal assessment of personal qualities of Russian-speaking broadcasters (MuPTA).

2. A new two-level EMO-AVSR automatic recognition method and software complex have been developed for six classes of basic Russian speech for six classes of basic human emotions, based on cascading processing of video and audio information through the integration of modern neural network models (Reset, 3D CNN, Bi-GRU, etc.), approaches to automatic recognition of emotional states and the broadcaster's spoken language as well as methods of augmentation of audiovisual information, that allowed to increase the indicator value of the accuracy of emotional speech recognition for English and Russian languages, as compared with the known methods.

3. New mathematical and software for multi-task recognition of both emotional states and sentiment based on bimodal analysis of human audio, video and/or text data using modern neural network technologies with cross-modal attention mechanisms has been developed; the proposed methods of bimodal recognition (audio + video and audio+text) based on the results of experimental studies have improved efficiency indicators (accuracy and F-measures) of automatic recognition of emotions and sentiment in comparison with known methods.

4. An original method of integral assessment of the severity of destructive paralinguistic phenomena (lies, aggression and/or depression) in human spoken language is proposed, accounting for the recognition results of each of the three methods determining the phenomena under

consideration and calculating an integral assessment using the significance weight of paralinguistic phenomena and a set of proposed rules for receiving an integral assessment of the severity of destructive phenomena in speech by indicators integral average accuracy, completeness, and F-measure; also developed a software system that implements a set of methods for determining the paralinguistic phenomena under consideration and the proposed methodology is developed.

5. A new method of automatic recognition of human hand gestures is proposed, using an approach of transferring learning between models of isolated gestures in different sign languages with an emphasis on visual information analysis, that allowed to increase the accuracy of automatic hand gesture recognition compared to known methods, and has a potential to solve problems of machine translation of different sign languages, studying the influence of individual and cultural characteristics of languages gestures on social adaptation of deaf people and those with severe hearing impairments.

6. A software system for automaticspeech recognition in low-resource Karelian language (Livvikov dialect) has been developed, whose main components are hybrid acoustic models based on hidden Markov models and artificial neural networks, as well as statistical and neural network models of Karelian language; the software complex includes a pronunciation dictionary out of 144 thousand word forms with automatically generated phonetic transcriptions, and is designed to convert the sounding Karelian speech into a text representation, and to function as an effective tool for recording and preliminary analysis of Karelian speech and language material.

Laboratory of Research Automation

Head of Laboratory: Kuleshov, Sergei V., Chief Researcher, Doctor of Technical Sciences, Profesor of RAS, kuleshov@iias.spb.su.

New Research Results

1. Mathematical and software for localization of autonomous unmanned aerial vehicles (UAVs) based on video data from an on-board camera have been developed, assuring detection of the UAV's location in space based solely on video data of a territory where no flights have been performed before, and characterized by the use of an invariant representation of the underlying surface description obtained by neural network analysis of the results of remote sensing of the Earth (satellite images).
2. An architecture of an intelligent video monitoring system to observe the health of productive dairy cows has been developed, characterized by the use of a mathematical model of the productive life of a dairy herd and designed as a graph of conditions and production efficiency, allowing to provide early prediction of changes in the physiological state of animals, as well as to solve inverse problems of analyzing the studied processes.
3. The technological foundations to identify the text data generated via neural network technologies have been developed, containing heuristic rules based on the criterion of dependence the abstract volume (obtained via the associative-ontological approach) on the abstracting threshold, that allow to automatically evaluate the quality of text documents at monitoring and search engines while processing large amounts of unstructured data.
4. The technological foundations of dealing with dynamically changing Internet sources at the processing of unstructured data in conditions of a priori uncertainty have been developed, and the phenomena that arise during the automatic collection of documents in the tasks of forming monitoring systems or search engines have been analyzed.

Laboratory of Computer Security Problems

Head of Laboratory: Kotenko, Igor V., Doctor of Technical Sciences, Profesor, ivkote@comsec.spb.ru.

New Research Results

1. Models and algorithms for assessing the security of critical resources based on adaptive neural network filtering, a model of information security threats using Euclidean and Hamming distances between fuzzy sets, as well as a model of threats to the interfaces of an unmanned transport environment have been developed.

2. Within the framework of post-quantum cryptographic mechanisms based on noncommutative and commutative finite algebras , a new mechanism for constructing hidden group Digital Signature Algorithms (DSA), a new method for defining nonlinear mapping in multidimensional cryptography algorithms, and unified methods for defining vector finite fields have been developed.

3. Technologies have been developed for detecting cyberattacks and anomalies in critical information and telecommunications infrastructures of wastewater treatment facilities, based on the ideas of explainable artificial intelligence using convolutional neural networks for processing data from sensors with the transformation of the input one-dimensional data vector into a two-dimensional matrix for extracting nonlinear relationships between them. A cyber-physical testbed for the technological process of treatment facilities functioning at industrial plants and water utilities has been developed to simulate cyber-attacks and identify cyber-risks, allowing for assessing possible risks and identifying vulnerabilities in critical information and telecommunications infrastructures. The results were receined within the framework of the RSF and SPbSF Project No. 23-11-20024.

4. Models, methods and technologies for protecting information and telecommunication infrastructures against the computer attacks have been developed, characterized by the combined use and integration of various methods and approaches that assure early detection of anomalies in network traffic caused by computer attacks due to the use of models of artificial neural networks with long short-term memory (LSTM networks), ellipsoidal approximation of identifiable classes of technical condition by discrete wavelet transformations and operative validation of computer

attacks' consequences using stochastic networks. Experimental verification and validation have been executed for data transmission networks of the energy cluster. Results here received were presented within the RSF Project No. 21-71-20078.

5. General concept has been developed to dynamically assess the security of information systems in conditions of insufficient, inaccurate and contradictory source data, characterized by the use of an objective (empirical) system to formally describe knowledge about various aspects of the protected infrastructure's security with an implementation of potential threat modeling functionality in real time. Models and techniques for representing the exploits source (software) code ave been developed. The difference between the developed model of the exploit source code representation consists, on the one hand, in strictly following the main route of code execution, and on the other hand, in reflecting only the functional dependencies between imported names. It can link certain signs of attacking effects with the already existing characteristics of vulnerabilities and weaknesses that these exploits implement. Methods and algorithms for detecting attacks in the target information system have been developed to assess the likelihood of exploiting vulnerabilities (including zero-day vulnerabilities). To develop and implement the proposed methodology an experimental test bed has been designed through the use of a network emulation environment. The received results were presented as part of the implementation of the RSF Project No. 23-21-00498.

6. Methods and models for detecting anomalies and intrusions based on the use of federated learning have been developed. The developed models and techniques account for the types of data distribution between devices. In particular, for horizontally distributed data, a technique was proposed based on the application of transformation of source network data (at the stream and package levels) into images and convolutional neural networks trained in a federated mode. For vertically distributed data, the anomaly detection technique includes training decision trees using gradient boosting over decision trees using homomorphic encryption (SecureBoost). Another distinctive feature of the developed set of models and techniques is the data preprocessing technique, implementing the transformation of data into images, that allowing to account for the packages sequence and to extract temporal dependencies between them using convolutional neural networks. The received results are presented as part of the RSF Project No. 22-21-00724 implementation.

7. General concept of dynamic assessment of information system immunity at insufficiency, inaccuracy and inconsistency of initial data has been developed, distinguished by the use of an objective (empirical) system of formal description of knowledge about various aspects of the immunity of the protected infrastructure with the implementation of the functionality of modeling potential threats in real time. Models and methods for representing the source (program) code of exploits have been developed. The developed model of representing the source code of exploits differs, on the one hand, by strict adherence to the main code execution route, and on the other hand, by reflecting only functional dependencies between imported names. It allows for linking certain signs of attack impacts with existing characteristics of vulnerabilities and weaknesses that these exploits implement. Methods and algorithms for identifying attack impacts in the target information system have been developed to assess the probability of exploiting vulnerabilities (including the zero-day ones). To develop and implement the method, an experimental testbed was developed using a network emulation environment. The received results are presented within the framework of the RSF Project No. 23-21-00498.

8. Methods and models for detecting anomalies and intrusions based on the use of federated learning have been developed. The developed models and methods account for the types of data distribution between devices. In particular, for horizontally distributed data, a method was proposed based on the use of the original network data transformation (at the flow and package level) into images and convolutional neural networks learnt in a federated mode. For vertically distributed data, the anomaly detection method includes training decision trees using gradient boosting over decision trees using homomorphic encryption (SecureBoost). Another distinctive feature of the developed set of models and methods is the data preprocessing technique that implements the transformation of data into images, what allows for taking into account the sequence of packages, and extracting temporal dependencies between them using convolutional neural networks. The received results are presented within the framework of the RSF Project No. 22-21-00724.

9. A technology has been developed for multi-aspect modeling of critical infrastructure objects using Internet of Things technologies for the purposes of analyzing the cyber-physical attacks. The technology consists of five main stages: analysis and preprocessing of sourse data;

construction of the object network model; static and dynamic analysis of cyber-physical attacks; analysis and saving of the received results, and report generation. As part of the static analysis, malefactors move along the device/object compromise graph by assessing the probability of exploiting these vulnerabilities in accordance with the malefactors' parameters, as well as the parameters of the exploited vulnerabilities and the security tools installed on the device. As part of the dynamic analysis, a delay is additionally introduced between attempts to re-exploit the vulnerabilities, and a maximum number of such attempts is limited, after that the vulnerability will be considered detected and, upon a certain time, unavailable for exploitation. The received results are presented as part of the RSF Project No. 22-71-00107.

Laboratory of Autonomous Robotic Systems

Head of Laboratory: Saveliev, Anton I., Senior Researcher, Candidate of Technical Sciences, saveliev@iias.spb.su.

New Research Results

1. A mathematical model for controlling a group of ground robots has been developed, featuring new conditions for solving the problem, taking into account the redistribution of energy resources between robots and optimizing the performance of target tasks.
2. A set of algorithms for group centralized control of ground robots has been developed, distinguished by a set of rules and implementing the energy resources redistribution on routes between the locations of target tasks when moving in open spaces with variable terrain, ensuring a reduction in the overall time for completing the target tasks.
3. A method for simulating the unmanned aerial vehicle (UAV) landing on a mobile robotic platform under external influences has been developed, including an algorithm for the autonomous landing of UAV on a robotic platform with a fractal marker, that allows the formation of a data set for assessing the impact of external influences on the UAV landing time.
4. An algorithm for a ground robot localizing has been developed, based on semantic information about objects in the urban environment, excluding dynamic objects from consideration and improving the matching of key points, assuring an increase in the robot's localization accuracy by an average of 23%.
5. A method has been developed and an architecture for dynamic generating images of Head-up Display (HUD) for autonomous robots has been described, with due account for the tasks being performed and using edge computing to reduce the amount of information transmitted to the user. In a result of testing, it was found that for 87.5% of users such a HUD is preferable.

Laboratory of Big Data Technologies of Socio Cyber Physical Systems

Head of Laboratory: Levonevsky, Dmitry K., Senior Researcher, Candidate of Technical Sciences, levonevskij.d@iias.spb.su.

New Research Results

1. A conceptual model of a smart medical ward intended for automating the processes of monitoring and treating patients has been developed, and including specifications of actors, components, indicators, situations and their properties in a medical cyber-physical environment; within the framework of this model, some private submodels have also been proposed to illustrate data processing in smart medical wards when diagnosing paroxysmal sympathetic hyperactivity syndrome, thus, allowing for a significant (over 2 times) reduction in the time of staff work at diagnosing patients.

2. A method of proactive monitoring for implementation of technological processes at growing agricultural crops in automated greenhouses is proposed, that allow for proactive assessing the progress of the technological process execution, predicting microclimatic parameters based on previously collected data using the WEKA and AutoML – AutoWEKA tools, as well as selecting the best learning algorithm and determining its hyperparameters through Bayesian optimization and the combined CASH algorithm, what allows to save resources and adhere to technological maps with better more accuracy.

3. A practical solution to the NP-hard problem of calculating optimal piecewise constant approximations of multidimensional vectors with close to minimum values of the total square error over a given range of the number of clusters has been constructed, at that, three classical methods of cluster analysis have been modernized and a program for generating optimal approximations of a color image for a given number of colors has been developed, what opens up the prospect of developing a theory of optimal computer vision that will be useful in the operational recognition of signals of various natures.

4. A new method for autonomous trajectory planning of unmanned aerial vehicles with ultraviolet sensors to test the current-carrying elements of power transmission lines for the presence of corona discharges, that can lead to failures in the power system and are detected by ultraviolet radiation, is proposed, at that, the trajectory is planned in

accordance with the spatial and geometric characteristics of the tested power transmission line and the requirements for the quality of the collected data (representativeness, sample size, collection procedure unification).

5. A new comprehensive approach to multi-level synthesis for objects with a dynamic hierarchical structure is proposed based on modified methods of inductive and deductive synthesis of knowledge graphs on the example of an interactive service for digital cable television networks; a benchmark is developed that includes two realistic data sets for analyzing the SPARQL queries performance and for studying dynamic network monitoring; it is shown that the developed models of multi-level synthesis reduce time costs by up to 73% as compared with basic values.

Department of Prototyping the Robotic and Embedded Systems

Head of Department: Dashevsky, Vladimir. P., Senior Researcher, Candidate of Technical Sciences, vladimir.dashevsky@gmail.com.

New Research Results

1. As part of a long-term cooperation with Ravelin LLC, the 4-core SMARC system module based on the AM335x processor from Texas Instruments (USA) has been upgraded to revision 4. The number of components previously received from unfriendly countries has been significantly reduced, the above ensured a serial production of data modules with reduced cost. A new SMARC system module based on the RK3188 processor from Rockchip (China) has been developed and assembled. The novelty of this project is in the fact that the new processor module contains no components developed by companies from unfriendly countries, including secondary semiconductor components. In addition to abandoning the component base of Western production, the peak performance of the module has increased. The central processor module has 4 cores with a clock frequency of 1600 MHz. The memory capacity and the data memory limit are increased. In 2024, it is planned to launch Linux OS on the mentioned system modules and to transfer the application software.

2. As part of further cooperation with Sirius LLC, a new GW8C I/O board with 8 UART RS-485/232 ports was developed. As an alternative to the expensive solution based on the STM32H743 processor, the 8-port USB-UART CH348L interface from the Chinese company WinChipHead (Nanjing Qinheng Microelectronics Co.) was chosen. In 2024, it is planned to upgrade the software of the Ethernet-RS485/232 gateway (earlier developed in 2022) to support this board in all its main application modes.

3. Under cooperation with MkiS+ LLC, a prototype of an automatic identification system receiver module was developed and manufactured; the module meets the demand for equipping coastal radar infrastructure in Crimea and along the Northern Sea Route.

4. Under cooperation with Sirius LLC in 2023, a device for monitoring communication cables for 20 channels (PMK 20) was developed, designed for continuous measurement of the insulation resistance of control cores in a telecommunication cable and measurement

of the loop resistance of a control pair of cores short-circuited at the far end, that allow for monitoring the serviceability of telecommunication cables and predicting emergency situations in the cable network in advance, as well as eliminating malicious actions to introduce eavesdropping devices.

5. Specialized machine has been developed for organizing the production of non-essential, fastening and other parts from square-section rods with a square side from 6-12 mm, distinguished by a fully automatic cycle of operations necessary for the serial fabrication of bars at the production of instrument housings.

Laboratory of Information Technologies in System Analysis and Modeling

Head of Laboratory: Sokolov, Boris V., Chief Researcher, Doctor of Technical Sciences, Professor, Honored Scientist of the Russian Federation, two-time Winner of the Government of the Russian Federation Prize in Science and Technology, sokolov@iias.spb.su.

New Research Results

1. Scientific foundations of the applied theory of proactive management of information processes (IP) in the Industrial Internet (II) based on cloud and fog computing have been developed. The proposed methodology and technologies of proactive management of IP allow, in contrast to traditionally reactive management, to prevent in advance the prerequisites (not the consequences) of the occurrence of abnormal situations due to purposefully formed or promptly synthesized structural and functional redundancy of the resources of II objects to counter the said situations. The main scientific contribution of the received results is that modern informatics, thanks to the here developed theory, is enriched with the methodology and methodological support developed in classical cybernetics and neocybernetics. To date, this result has been implemented in the rocket and space and transport and logistics spheres.

2. Methodological and model-algorithmic support for solving problems of multi-criteria structural-functional synthesis of technologies and programs for integrating heterogeneous distributed information resources, including Earth remote sensing data used at proactive monitoring and management of the territories development within the Russian Federation, have been developed. The architecture and software complex for automating the processes of integrating heterogeneous data received from different types of Earth remote sensing spacecraft have been scientifically substantiated and practically implemented, thus, allowing to increase the efficiency of solving problems of information support for territorial development management.

3. A tabular model for operational object control has been developed, distinguished by the use of the conditions (predicates) description in the formation (synthesis) of control actions implementing only two vectors of required indicator values, and a failure to meet the conditions – by specifying a matrix of single deviations.

4. Based on the analysis of structural features of the problem of planning information processes at the interaction of moving objects, formulated as a large-scale non-stationary multi-criteria problem of scheduling theory and described in terms of the theory of optimal program control, here proposed its sequential decomposition into the problem of aggregated planning of operations included in the information process without their reference to time, and the problem of detailed planning of the said operations with reference to time. The advantage of this decomposition is that at its implemention through appropriate models and algorithms, it is quite possible to take into account at the constructive level all the main spatio-temporal, technical and technological limitations associated to the functioning of a group of moving objects (Zakharov, V.V., Sokolov, B.V., Ushakov, V.A.).

5. A new special model-algorithmic software (SMAS) has been developed for solving problems of forecasting the state and controlling complex dynamic systems in unstable immersion environments (gas and hydrodynamic environments, turbulent flows, atmospheric and oceanic phenomena, pricing processes on electronic capital markets), based on the concepts and technologies of cognitive computing and machine learning. A significant difference between the developed SMAS and the SMAS based on the theory of nonlinear chaotic systems is the transition from the paradigm of deterministic chaos to the paradigm of solving control problems taking into account the stochastic component of the observed processes. (Musaev, A.A.).

6. A formal description of the reliability and survivability indicators of complex objects with a reconfigurable structure, significance indicators, positive and negative contributions of individual functional elements (FE) into the reliability indicator of an object is given, taking into account the structural and functional features of the implementation of its operating modes under planned work conditions and emergency situations based on the first proposed concept of the parametric genome of the multi-mode objects' structure, as well as the logical-probabilistic and fuzzy-possibility approaches, allowing to calculate optimistic, pessimistic and average expected estimates of the above indicators (Pavlov A.N., Kulakov A.Yu.).

7. A system for recognition of biological objects based on convolutional neural networks has been developed using transfer learning to reduce the sample size of target object images. At the first stage, the

system is trained on a standard array of images of the MS COCO dataset (328 thousand images), and at the second stage, on an array of target object images (several hundred images). The system was trained and its recognition accuracy was tested using aerial photographs of herds of wild reindeer (in collaboration with the Taimyr Nature Reserves Federal State Budgetary Institution), and flocks and clusters of brent geese (in collaboration with the A.N. Severtsov Institute of Ecology and Evolution Problems of the Russian Academy of Sciences). (Sobolevsky V.A., Mikhailov V.V.).

Intelligent Systems Laboratory

Head of Laboratory: Iskanderov, Yury M., Doctor of Technical Sciences, Professor, Academician of the Russian Transport Academy, iskanderov_y_m@mail.ru.

New Research Results

1. Innovative methods have been developed capable of exercising reconfiguration, restructuring, adaptation of a uniform information space for existing and prospective supply chains within the concept of the industrial Internet of Things, with due account for changes in the external environment and the internal state of transport and logistics processes. Based on a new approach that implements the integral paradigm of actor-network theory, basic management technologies have been developed that ensure the functioning of supply chains as a targeted multisystem, where individual companies, organizations, enterprises are considered as certain centers of logistics activity, directly or indirectly linked in a single integral process of material flow management for the most complete satisfaction of consumer demands in accordance with the specified requirements.

2. Technologies have been developed to improve the quality indicators of machine learning methods at processing the network traffic based on segmentation of data samples to arrange for high-quality identification of the state of information security of cyber-physical systems (CPS). The received results allow for realizing the choice of a relevant machine learning method for the samples with different data (e.g., dispersion, sample share, data range, etc.).

3. New hybrid models of stationary objects in integrated supply chains (ISC) have been developed based on simulation modeling and data mining methods that account for the characteristic and hidden factors in their behavior. The use of the developed models allows for making informed decisions to better optimize the ISC functioning.

IAERD – Structural Division of SPC RAS

Institute of Agricultural Economics and Rural Development (IAERD) started out as the Research Institute for Economics and Organization of Agricultural Production for the RSFSR non-Chernozem zone under the VASHNIL Department for the RSFSR non-Chernozem zone, in accordance with the Decree of the RSFSR Council of Ministers dated September 14, 1977 No.483 and the Order of the VASHNIL Department for the RSFSR non-Chernozem zone dated September 27, 1977 No. 120.

In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 the united Russian Academy of Agricultural Sciences was established based on the Russian Academy of Agricultural Sciences and the All-Union Academy of Agricultural Sciences, and the Research Institute for Economics and Organization of Agricultural Production in the Russian Federation non-Chernozem zone was transferred to its management.

In accordance with the Order of the Russian Academy of Agricultural Sciences dated January 28, 1998 No. 14 the Research Institute for Economics and Organization of Agricultural Production in the Russian Federation non-Chernozem zone was renamed to the North-West Research Institute of Economics and Organization of Agriculture.

Based on the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p NWRIEOA was turned over to the management of the Federal Agency for Scientific Organizations

By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p NWRIEOA is transferred to The Ministry of Science and Higher Education of the Russian Federation management**.**

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 NWRIEOA

was renaimed into IAERD and received a status of the SPC RAS structural didision.

IAERD does basic, exploratory and applied research aimed at increasing the efficiency of scientific support of the Russian Federation in matters of economic, food and environmental safety. The research is inbtended for obtaining new knowledge in the rational use of agricultural resources of the of Russian North-West, the economy of the agro-industrial complex, innovative and investment development of agricultural sectors that contribute to technological, economic, social and human development, as well as sustainable development of rural areas of the Non-Chernozem zone of Russia.

Leading Researcher Candidate of Economic Sciences, Associate Professor Dibirov, Abusupyan A. is the Institute Head, szniesh@gmail.com, dibirov.a@spcras.ru.

Senior Researcher, Candidate of Economic Sciences Dzhabrailova, Bariyat S. is the Institute Scientific Scretary, barsa70@list.ru.

Members of the Russian Academy of Sciences

Kostyaev, Alexander I., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Economics, Doctor of Geography, Professor – theory and methodology of regional agro-economic research, theory of rural development, galekos46@gmail.com

Nikonova, Galina N., Corresponding Member of the Russian Academy of Sciences, Chief Researcher, Doctor of Economics, Professor – economics and management of the National economy, agrarian relations, institutional foundations and organizational and economic mechanism of sustainable rural development, state regulation of the land market, galekos@yandex.ru

New Research Results

1. Based on the analysis of the practice for developing new forms of rural space organization, its disadvantages were identified and conceptual provisions for eliminating the said disadvantages were formulated. Thus, municipal districts are recommended to switch to managing rural development through territorial public self-government upon the liquidation of rural settlements. At the same time, the centers of rural agglomerations and key settlements should be located not only in district centers, to eliminate the risks of “settling” the budget funds allocated for the development of rural areas in the cities and urban-type settlements, and also to direct them to the development of viable villages

and hamlets, ensuring the development of cultural and social spheres right in rural areas with the participation of key settlements provided with stable functioning of the Internet, electronic and other communications, as well as transport links with key settlements and centers of rural agglomerations.

2. Factors of growth and limitations of the effective scale in the agricultural production at digital transformation have been identified, with due account for the characteristics of agricultural sub-sectors, regional specifics, determining the increased differentiation of the development level, localization of agricultural production at large farms and over some rural areas, the increased risks of reducing the efficiency of the agricultural land use in the North-West of Russia, the requirements and approaches formulated to improving the system of state support for agriculture to overcome “the dependenced on past experience” and expand the range of farms comprehensively mastering digital technologies.

3. The performed statistical analysis of empirical data associated to farms over the Leningrad Region confirmed the presence of a positive relationship between the digitalization level, determined through the number of implemented digital technologies for monitoring and controlling the health and physiological state of cows, and the indicators of milk production efficiency, revealed that the observed difference in efficiency indicators is most significant between digitalized farms and the control group without the appropriate technologies, then with an increase in a number of implemented digital technologies, the effect is non-linear, especially in terms of production efficiency indicators, permitted to substantiate proposals for improving the methods of analysis and accumulation of assessments based on empirical data, what will increase the reliability in assessments of the digital technologies effectiveness, the influx of investments in their development and implementation into the agro-industrial complex.

4. A promising approach to decision-making in the development of environmentally friendly agricultural production has been proposed, based on the use of information systems, digital tools and data that increases the efficiency of agro-ecological measures, through the use of information system for decision making support (DMSS) aimed at assessing the environmental efficiency. The aove assumes: reducing the amount of nutrient losses from agricultural fields, and affecting the economic efficiency via changing the amount of subsidy depending on the selected measure, its parameters and localization, what will allow farmers

and agricultural enterprises' professionals to make an informed choice, and the management bodies in the agro-industrial complex to optimize the amount of state support for agro-ecological measures, as well as in the future to solve planning and management problems faster and more efficiently based on analytical DMSS and applied information systems when combining an array of digital data into accessible regional and federal databases.

5. The specificity of the current stage of digital transformation is identifined as a network interaction of communications by means of electronic programmable devices; so far, digitalization and digital transformation were determined without identifying the current stage specificity, started with the widespread use of the Internet and computer networks, what does not allow to correctly identify the specific and most promising prospectives for automation of production, communications and management at the current stage; defining the specificity of the current stage of digital transformation as network interaction of communications allows to identify the most promising areas of digital transformation in terms of the expected economic effect. Network interaction can provide the best opportunities for increasing efficiency in 1) accelerating purchases and sales, including the money movement, as well as due to tracking the movement of goods and logistics in general, 2) facilitating and accelerating the access of consumers and suppliers of goods and services to markets, accelerating the processes immediately preceding and completing purchases and sales, 3) in automation of process control, since there appears a good option to saturate objects of labor processes with sensors, combining them into a network with control devices. This result allows for optimizing the efforts and resources of digital transformation of the agro-industrial complex in the long term prospective, directing them to the most promising areas indicated above.

6. Conceptual provisions for solving problems of organizing the production chain from the deposit to the end consumer based on digitalization have been developed in order to meet consumer demands, taking into account the optimization of the economic activities of autonomous organizations and entrepreneurs – participants in the supply chain of value creation, based on a transparent pricing mechanism, which will increase the efficiency of resource use, reduce market uncertainty, the ability to predict the consequences of price volatility, reduce the negative impact of various factors through the widespread use of electronic means

of objective control of the parameters of the participants' activities by prioritizing weak links and bottlenecks in the production chain

7. Five main leads are proposed to improve the implementation of digitalization in small-scale farms: additional financing, development of digital infrastructure, human resources management, partnership of small-scale farms with stakeholders, and developing means of information security. Each of these areas is important and cannot be implemented without the others. Small-scale farms have fewer resources compared with medium and large structures, so the implementation of digital technologies in the case goes slower and requires more attention from the federal side.

8. Conceptual approaches have been developed to improve the institutional environment and land relations in the agricultural sector of the North-West, with due account for the specifics of the lands' rental potential and the actual level of the agricultural lands use. The mentioned approaches allow for adjusting the information support for land management based on the use of digitalization technologies, as well as the state support for the land demand, thus, contributing to the activation of the processes of returning the abandoned lands to circulation in the regions' rural areas.

N-W CIRPFEM – Separate Structional Division of SPC RAS

North-West Centre of Interdisciplinary Researches of Problems of Food Maintenance (N-W CIRPFM – SPC RAS) is the legal successor of the VASHNIL Department for the non-Chernozem zone of the RSFSR, established by the Decree of The Central Committee of the Communist Party of the Soviet Union and Council of Ministers of the USSR of March 20, 1974 No. 206

By the Decree of the RSFSR Council of Ministers dated April 3, 1990 No. 107, the VASHNIL Department for the non-Chernozem zone of the RSFSR was transformed in the Regional Department of the Russian Academy of Agricultural Sciences for the non-Chernozem zone of the Russian Federation. In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 the united Russian Academy of Agricultural Sciences was established based on the Russian Academy of Agricultural Sciences and the All-Union Academy of Agricultural Sciences, and N-W CIRPFM was transferred to its management.

Due to liquidation of the Regional Branch of the Russian Agricultural Academy for the non-Chernozem zone of the Russian Federation, and by the Order of the Russian Agricultural Academy dated January 04, 1996 No. 29 was established the North-West Scientific Center of the Russian Agricultural Academy. In compliance to the Order of the Russian Agricultural Academy dated November 16, 2001 No. 85 the North-Western Scientific Center of the Russian Agricultural Academy was transformed into the State Research Institution: North-West Scientific-Methodical Center of the Russian Agricultural Academy. According to the Order of the Russian Agricultural Academy dated June 23, 2009 No. 81 the State Research Institution: North-West Scientific-Methodical Center of the Russian Agricultural Academy was converted into the State Research Institution: North-West Regional Scientific Center of the Russian Academy of Agricultural Sciences.

Based on the Order of the Federal Agency for Scientific Organizations dated December 15, 2014 No. 1320, the State Research Institution: North-West Regional Scientific Center of the Russian Academy of Agricultural Sciences was renamed to the Federal State

Research Institution: “North-West Center for Interdisciplinary Researches of Food Maintenance”.

In compliance with the Federal Law “On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation” of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p N-W CIRPFM was turned over to the management of the Federal Agency for Scientific Organizations.

By the Decree of the Russian Federation President of May 15, 2018 No. 215: “On the structure of Federal Executive Authorities” and by the Order of the Russian Government of June 27, 2018 No. 1293-p N-W CIRPFM is transferred to The Ministry of Science and Higher Education of the Russian Federation management**.**

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 N-W CIRPFM received a status of the SPC RAS separate structural didision.

N-W CIRPFM – SPC RAS does basic, exploratory and applied research in the field of food security, with due account for the developing and mastering innovative technologies for the production, storage and processing of environmentally safe agricultural products.

Candidate of Technical Sciences Yury A. Tyukalov is the Center Director. Candidate of Agricultural Sciences Danilova, Tat’yana A. is the Center Scientific Secretary.

Members of the Russian Academy of Sciences

Zabrodin, Vasiliy A., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Biological Sciences, Professor – Arctic zone of the Russian Federation, branches of traditional nature management, epizootic and epidemiological welfare, reindeer diseases: diagnosis and treatment, improved technologies of reindeer husbandry, szentr@bk.ru.

Layshev, Kasim A., Academician of the Russian Academy of Sciences, Chief Researcher, Doctor of Veterinary Sciences, Professor – Arctic zone of the Russian Federation, branches of traditional nature management, epizootic and epidemiological welfare, reindeer husbandry, improved technologies of reindeer husbandry, improved technologies of reindeer husbandry, problems of rational nature management and environmental safety of the Arctic, layshev@mail.ru.

Ivanov, Alexey I., Corresponding Member the Russian Academy of Sciences, Chief Researcher, Doctor of Agricultural Sciences – general agriculture, land reclamation, agrochemistry and agro-soil science in part of soil fertility management and the production process of agricultural crops, ivanovai2009@yandex.ru.

Department of Agriculture and Crop Production

Head of Department: Arkhipov, Mikhail V., Chief Researcher, Doctor of Biological Sciences, Professor, winner of the USSR Council of Ministers Prize, maikl.arh1pov@yandex.ru.

New Researh Results

1. New technologies for the development of bushy fallow lands have been developed and tested, as well as fundamental, methodological and technological foundations for increasing agricultural production in the North-West of the Russian Federation, based on obtaining new knowledge in the field of food and environmental safety on agronomic, economic assessment and environmental safety of fertility restoration means and carbon-neutral technologies for the secondary development of bushy fallow lands.

2. New technologies have been developed and tested for early detection and rapid assessment of hidden damage to grain by the harmful turtle bug based on an improved X-ray method in grain processing technologies for the flour-milling and brewing industries, for an agronomic assessment of foliar feeding with a solution of potassium iodide on the yield of potatoes and spring barley on sod-podzolic soils of varying degrees of cultivation in order to optimize mineral nutrition, and use of multifunctional preparations based on entomopathogenic nematodes (family Steinernematidae) and their symbiotic bacteria Xenorhabdus sp. to protect potatoes against pathogens.

Department of Animal Husbandry and Environmental Management of the Arctic

Head of Department: Layshev, Kasim A., Chief Researcher, Doctor of Veterinary Sciences, Professor, Academician of the Russian Academy of Sciences, layshev@mail.ru.

New Researh Results

1. The conceptual foundations for the use of fences in reindeer herding have been formulated and scientific and innovative technological foundations for the fenced maintenance of reindeer in the forest zone have been developed for the first time, aimed at implementing the improved technologies for reindeer herding in the farms of the Arctic zone of the Russian Federation, and at increasing the meat productivity of reindeer along with stabilizing the number of livestock.

Novgorod SRAI – Branch of SPC RAS

The Novgorod Research Institute of Agriculture (NSRAI) was established as the Novgorod Regional Integrated Agricultural Experimental Station in accordance with the Decree of the Council of Ministers of the USSR dated January 30, 1950 and the Order of the Ministry of Agriculture of the USSR dated February 08, 1950 No. 237.

"Novgorod SRAI" is the legal successor of the Novgorod Research and Design – Technological Institute of Agriculture, formed in accordance with the Decree of the USSR State Agricultural Committee of August 19, 1988 No. 63 and the Order of the VASHhNIL Department for the non-Chernozem zone of the RSFSR of September 19, 1988 No. 127.

In compliance to the Decree of the President of the Russian Federation "About the Russian Academy of Agricultural Sciences" dated January 30, 1992 No. 84 and the All-Union Academy of Agricultural Sciences, the unified Russian Academy of Agricultural Sciences was established, and "Novgorod SRAI" was transferred to its management.

Based on the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p "Novgorod SRAI" was turned over to the management of the Federal Agency for Scientific Organizations.

By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p "Novgorod SRAI" is transferred to The Ministry of Science and Higher Education of the Russian Federation management.

In accordance with the Order of The Ministry of Science and Higher Education of the Russian Federation of December 18, 2019 No. 1399 "Novgorod SRAI" became a branch of St. Petersburg Federal Research Center of the Russian Academy of Sciences

The Novgorod Research Institute does basic and applied research in the technological, economic, and social development of the agro-industrial complex of the Novgorod region and the Russian Federation as a whole.

Candidate of Agricultural Sciences Zhukova, Maria Yu. is the Branch Director.

New Research Results

1. A project has been developed for the technological foundations of restoration and construction of drainage systems, based on the use of drainage trough structures with a distance of 25 m in combination with non-cavity drainage and without drainage using the acquired knowledge in the forming the ecological regimes in drainage systems.

2. Improved 4-field (25% legumes) and 5-field (40% legumes) fodder crop rotations were developed using mineral fertilizers in technological operations based on the planned yield, double application of new microbiological fertilizers Azotovit and Fosfatovit, ensuring the production of environmentally friendly agricultural feed with a productivity over 4.8-7.8 thousand tons of fodder units/ha, nutritional value for digestible protein of 0.45-0.74 t/ha, energy intensity of production of thousands of tons of fodder units 1.7-3.6 GJ, profitability over 137%, and allowed to increase soil fertility by 74-98 GJ/ha during rotation.

3. New knowledge was acquired on forming the ecological regimes in melioration systems of closed and open drainage under a dry growing season, when the designs of runoff valleys provided a more favorable water-air regime compared with the closed drainage designs, what led to an increase in the hay yield of perennial grasses by an average of 0.7 t/ha; new knowledge on the patterns of growth, development, formation of mowing mass, the duration of the growing season of annual introduced crops by species and varieties in the conditions of the 2023 growing season. Crops of paiza, chumiza, mogar provide 23-63 t/ha of green mass in the second half of the growing season and prior to frosts, sorghum crops – up to 35-88 t/ha. Based on the sorghum-sudanc hybrid Navigator example, the development of elements of technology for growing the introduced species in the northwest Non-Chernozem zone has been started. Analysis of the accumulated knowledge via digital technologies has allowed to identify the dependence of the yield of green mass, the duration of interphase periods of the development of introduced species on weather conditions; new knowledge about the effect of an organic feed additive – fulvic acid while feeding young cattle of reproductive age on the activation of metabolic processes in the body, optimization of biochemical blood parameters, improvement of reproductive functions by 15-20%, permit to recommend the use of fulvic acid as a feed additive in the diets of heifers over one year old on farms in the Northwestern region in the amount of 10-15 ml per head a day.

CRCES RAS – Separate Structural Division of SPC RAS

Scientific Research Center for Ecological Safety of the Russian Academy of Sciences (SRCES RAS) was established as an Institute of the USSR Academy of Sciences based on the Decree of the Presidium of the USSR Academy of Sciences of March 19, 1991 No. 74 and the Decree of the Presidium of the Leningrad Scientific Center of the USSR Academy of Sciences of April 2, 1991 No. 01-78; in accordance with the Decree of the Presidium of the Russian Academy of Sciences of December 18, 2007 No. 274 renamed to the Institution of the Russian Academy of Sciences St. Petersburg Scientific Research Center for Ecological Safety of the Russian Academy of Sciences.Based on the Decree of the Presidium of the Russian Academy of Sciences dated December 13, 2011 No. 262, the name of SRCES RAS was changed to the Federal State Institution of Science St. Petersburg Scientific Research Center for Ecological Safety of the Russian Academy of Sciences.In compliance with the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p SRCES RAS was turned over to the management of the Federal Agency for Scientific Organizations. By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p SRCES RAS is transferred to The Ministry of Science and Higher Education of the Russian Federation management**.** According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 CRCES RAS received a status of the SPC RAS separate structural didision.

CRCES RAS – SPC RAS does basic and applied research in environmental safety.

Doctor of Geological and Mineralogical Sciences Tronin Andrey A. is the Center Drector.

Candidate of Legal Sciences Kodolova, Alyona V. is the Center Acting Deputy Director for Research.

Manvelova, Alexandra B. is the Center Acting Scientific Secretary.

Laboratory for Bioelectronic Methods of Geoecological Monitoring

Head of Laboratory: Kholodkevich, Sergey V., Chief Researcher, Doctor of Technical Sciences, Academic Title – Senior Researcher, kholodkevich@mail.ru.

New Researh Results

1. Active and passive methods were tested in biomonitoring with assessment of the functional state of bivalve freshwater mollusks at their movement by the cage method and their exposure to waters of the eastern part of the Gulf of Finland of the Baltic Sea having different degrees of pollution through the bioelectronic systems recording the heart rate of mollusks. Together with biotesting, these methods ensure prompt identification of threats to environmental safety of coastal waters and their biota.

2. A comparative analysis of changes in the quality of natural waters (by physical and chemical indicators) was performed at a section of the Narva River (4 km below the Narva Hydro Power Plant) in regard to works on the reconstruction of the river bank line. An increase in turbidity and the content of some heavy metals in water and the sediments was revealed, however, there observed a decrease tendency for the content of phosphates and total nitrogen in the water.

3. The analysis of heavy metals (HM) content in sediments from the transboundary Narva River (Russia-Estonia) and in soft tissues of the bivalve mollusks Unio pictorum was carried out though the atomic absorption spectrophotometry (ICP-MS). For each metal, the HM bioaccumulation factors were calculated; the said factors can serve as an important feature in the analysis of biotopes for the HM pollution and a reliable indicator of environmental pollution by HM.

Laboratory of Biological methods of Environmental Safety

Head of Laboratory: Kuzikova, Irina L., Leading Researcher, Candidate of Biological Sciences, ilkuzikova@ya.ru.

New Researh Results

1. For the first time, the ability of the isolated bacterial strain Sphingopyxis sp. S7 to degrade along with highly toxic microcystin – LR (MC-LR) and other microcystin congeners – demethylated forms of MC-RR was demonstrated. The presence of the linearized form of MC-LR (m/z 1013) and tetrapeptide (m/z 615) in the products of MC-LR biodegradation indicates the destruction of MC-LR by the isolate S7 by the mlr mechanism.

2. The rate and extent of microcystin destruction depend on the chemical structure of microcystin and the cultivation conditions. The ability to biodegrade microcystin in high concentrations (up to 18.6 μg/ml), over a wide range of temperatures (from +9°C to +24°C) and pH (from 3 to 11) allows for to considering Sphingopyxis sp. S7 a promising strain for developing biotechnologies aimed at the remediation of contaminated environmental objects.

3. The effect of metabolites of toxic and non-toxic strains of cyanobacteria Microcystis aeruginosa on Unio pictorum mollusks was studied for the first time. Shown that cyanobacteria reduce the adaptive capacity of mollusks and cause their death regardless the toxicity of the M. aeruginosa strain. A decrease in the concentration of chlorophyll a and the content of MC-LR in water in the presence of mollusks was revealed due to its filtration.

Laboratory of Remote Methods for Geo-ecological Monitoring and Geoinformatics

Head of Laboratory: Gorny, Victor I., Leading Researcher, Candidate of Geological and Mineralogical Sciences, v.i.gornyy@mail.ru.

New Researh Results

1. Analysis of long-term results of satellite monitoring has revealed a monotonous decrease in moisture content in the south of the East European Plain over the past 20 years. In the coming decade, a further decrease in moisture content and agricultural productivity should be expected in the south of European Russia. Therefore, an increase in the contribution of the Non-Black Earth Zone to agricultural production is expected, what requires the development of a target program for the development of agriculture in the Non-Black Earth Zone of Russia.
2. Based on satellite monitoring and mathematical modeling of transboundary transport of aerosols in the atmosphere, it has been proven that episodic anomalous concentrations of sulfur dioxide in the atmosphere of northern Fennoscandia can be caused by anthropogenic factors, as well as by a natural factor – transboundary transport of the volcanic eruptions' products from Iceland.
3. Monitoring of the Amur River basin by the GRACE and GRACE FO satellites revealed an increase in the moisture content of the Amur River basin over the past 20 years, what increases the risk of flood formation. Variations in the gravity field illustrate the validity of the basin approach and the need to develop a new floods forecasting technique.
4. A simplified methodology for satellite mapping of the risk of overheating of the urban environment and economic damage from premature mortality caused by overheating has been developed and implemented using Lipetsk, Rostov-on-Don, Astrakhan and Omsk as examples. It has been shown that a reasonable strategy for managing the risk to public health caused by overheating lies in concentrating efforts and resources towards the most densely populated areas of the city.

Laboratory of Studying Migration Forms of Ecotoxicants in Environment

Head of Laboratory: Kudryavtseva, Valentina A., Head of Laboratory, Candidate of Chemical Sciences, valenkud@yandex.ru.

New Researh Results

1. A methodology has been developed to search for areas of increased environmental risk on the example of small rivers in St. Petersburg (the Karpovka River, the Black River), to study the influence of natural and climatic factors on the content of a group of heavy metals that are priority pollutants in water, bottom sediments, soils (Cu, Zn, Cd, Pb, Hg), to study the heterophase transformation of element forms with the receipt of integral characteristics of multicomponent environment.

Laboratory of Full-Scale Ecological and Chemical Research

Head of Laboratory: Zhakovskaya, Zoya A., Leading Researcher, Candidate of Biological Sciences, zazhak@hotmail.com

New Researh Results

1 For the first time, mono- and dioctyltin, as well as trichloroethyl phosphate, typical for the constant pollution of the aquatic environment with plastic components, have been detected in the bottom sediments of the littoral of Lake Ladoga and the Barents Sea.

2 It has been determined that the processes of tributyltin transformation actively proceed within a 10 cm layer, practically stopping in a 20-30 cm layer, which can be considered as a zone “preserving” the organotin compounds (OTC).

3. For the first time, a comprehensive analysis of samples of bottom sediments, macrophyte algae and mollusks (mussels) collected in a single location in the littoral of the Barents Sea has been performed. Different rates of degradation of the environmental protection system in the components of the aquatic ecosystem limit its ability to self-purify.

4. For the first time, a “bloom” dominated by Dolichospermum lemmermannii was recorded in two different subarctic oligotrophic lakes located in the White Sea basin. Microcystins (MC) were detected.

5. For the first time in a shallow eutrophic lake located in a continuous permafrost zone, the year-round presence of toxigenic Microcystis species producing MS in the water (during the ice-free period and during freeze-up) and ice thickness has been demonstrated.

6. For the first time, the ability of bottom epilithic macrocolonies of potentially toxic cyanobacteria Gloeotrichia cf. Natans, massively distributed in the Buotama River (Yakutia), to produce microcystins was assessed.

7. It has been shown that the use of planar sensors in bioelectronic systems allows for the analysis of water samples on general neurotoxicity, as well as for the determination of the biological activity for new promising photopharmacological compounds.

Laboratory of Methods of Rehabilitation of Technogenic Landscapes

Head of Laboratory: Bakina, Lyudmila G., Head of Laboratory, Doctor of Biological Sciences, Associate Professor, bakinalg@mail.ru.

New Researh Results

1. A comprehensive study has been exercised for composts from the SHW test ground "Novy Svet-ECO", different in the composting period and the extraction depth, in order to substantiate the possibility of their using as fertile soils during recultivation. The proposed and tested on the studied samples indicators of compost maturity – the ratios C:N, N-NO3/N-NH4 and the intensity of soil "respiration" – revealed their high information content.

2. It has been determined that the stage of "maturity" of composts from SHW is reached by 5-8 months of composting, provided that the layer thickness is less 1 m. Composts extracted from a depth over 1 m and formed under a lack of oxygen have an insufficient "maturity" degree. During the maturation process, the initial toxicity of composts is also eliminated: it has been determined that composts with an insufficient maturity degree belong to hazard class IV (low hazard), and samples of mature composts belong to hazard class V (practically non-hazardous).

3. The absence of toxicity and favorable agrochemical properties allow us to recommend the use of MSW composts as a fertile layer during the reclamation of closed landfills at its final biological stage in accordance with the Federal Law of 24.06.1998 No. 89-FZ; SP 2.1.7.1038–01. The high efficiency of using MSW compost taken from the Novy Svet-ECO landfill as a component of the fertile layer when growing perennial grasses has been proved by the results of a field experiment

4. Ongoing studies of oil-contaminated soils have allowed for studying the species diversity of hydrocarbon-oxidizing microorganisms in oil-contaminated soils using metagenomic analysis. It has been determined that the phylotypes of bacteria and micromycetes in the microbial community are associated with both different phases of oil degradation and the soil type. All diversity indices of sandy podzol are significantly inferior to those of sod-podzolic soil.

5. The studies performed through the method of metabolomic analysis of soils and metabolic profiling (non-targeted metabolomics) allowed for identifying soil metabolites and trends in their change under oil

pollution conditions. It was determined that under oil pollution, the relative content of monosaccharides in the soil decreased and the concentration of organic acids, as well as phenolic compounds and terpenoids, increased, what undoubtedly increases the allelopathic tension in phytocenoses. Despite the fact that the toxic effect of oil decreases over time because of its evaporation and decomposition, the toxicity caused by the allelopathic activity of micromycetes persists for a long time. The above is conditioned both by an increase in the number of toxin-forming fungi and an increase in the synthesis of toxic metabolites. The high informativity of the allelopathic activity coefficients proposed for assessing the allelopathic properties of microbiota is demonstrated.

Laboratory for Economic Problems of Environmental Safety

Head of Laboratory: Donchenko, Vladislav K., Chief Researcher, Doctor of Economic Sciences, Professor, Honored Scientist of the Russian Federation, Winner of the Academician M.I. Budyko Prize bestowed by the Government of St. Petersburg and the St. Petersburg Scientific Center, donvk2020@mail.ru.

New Researh Results

1. The results of the study of institutional processes that contribute to the disclosure of the problem of prevented environmental damage, defined in the model law of the CIS member states "On environmental safety. New edition" as the goal of preventive environmental policy of the closed nature management economy, have scientific novelty

2. Based on the results of a comparative analysis of the methods, tools and procedures of fiscal and preventive environmental policy, a new environmental and economic content in the concept of the "polluter pays" principle was revealed, focused on the economic accounting for the implementing the effect of prevented damage when collecting fees from economic entities imposing the negative impact on the environment, and the inclusion of production and consumption waste in the closed-loop nature management economy. This result is included in the texts of the model laws of the CIS member states "On Environmental Funds" and "On Access to Environmental Information (new edition)".

3. Recommendations have been proposed for the development of a specialized international system for statistical accounting of the formation of secondary resources (material and energy), the volumes of their processing into commercial secondary raw materials, and the volumes of sales of certified secondary raw materials at various markets.

4. A comprehensive method for preventing environmental damage to water bodies by a prompt identifying the illegal connections of domestic and industrial wastewater outlets to storm sewage in cities and towns has been developed. Recommendations for the implementation of this method were reported at a meeting of the Scientific and Technical Council of Rosprirodnadzor and adopted for implementation in 2024.

5. In the course of full scale tests, examples of the use of elements of a closed-loop economy in the ethnogeographic territories of the Leningrad and Pskov regions were demonstrated.

6. Analysis of judicial practice using examples of organizations whose economic and other activities may be associated with the likelihood of negative, excessive impacts on the environment revealed that if the organization's activities are implemented based on preventive environmental policy tools, such as: extended producer responsibility, best available technologies and best environmental practices, as well as the use of automatic environmental control systems, then the risk of insurance claims is minimal.

7. By Resolution of the CIS IPA dated 14.04.2023 No. 55-4, model laws were adopted, developed by SRCES RAS – SPC RAS: model law "On Environmental Safety (new edition)"; model law "On Environmental Funds"; model law "On Access to Environmental Information (new edition)".

IL RAS – Separate Structural Division of SPC RAS

In February of 1944, the Presidium of the USSR Academy of Sciences issued an Order on Establishing the All-Union Laboratory of Lake Science within the Department of Geological and Geographical Sciences in Leningrad, the main task assigned was "development of theoretical issues of lake science: origin and history of the development of main types of lakes; study of the lakes' water chemical and thermal balance; lakes'mineral, energy, plant and animal raw materials basis; lakes' influence upon the climate". The founder and ideological inspirer of the Laboratory developmet was an outstanding limnologist G.Yu. Vereshchagin.

Institute of Limnology of the Russian Academy of Sciences (IL RAS) was founded by the Decree of the Presidium of the USSR Academy of Sciences of July 29, 1971 No. 731. Based on the Decree of the President of the RSFSR of November 21, 1991 No. 228 "On the organization of the Russian Academy of Sciences", IL RAS became a part of the Russian Academy of Sciences as the Institute of Limnology of the Russian Academy of Sciences. In compliance with the Decree of the Presidium of the Russian Academy of Sciences dated December 18, 2007, No. 274 IL RAS was renamed to the Institution of the Russian Academy of Sciences: Institute of Limnology RAS. By the decree of the Presidium of the Russian Academy of Sciences dated December 13, 2011 No. 262, IL RAS was renamed into the Federal State Institution of Science: Institute of Limnology of the Russian Academy of Sciences.

In compliance with the Federal Law "On the Russian Academy of Sciences, reorganization of State Academies of Sciences and amendments to certain legislative acts of the Russian Federation" of September 27, 2013 No. 253-ФЗ and Decree of the Government of the Russian Federation of December 30, 2013 No. 2591-p IL RAS was turned over to the management of the Federal Agency for Scientific Organizations. By the Decree of the Russian Federation President of May 15, 2018 No. 215: "On the structure of Federal Executive Authorities" and by the Order of the Russian Government of June 27, 2018 No. 1293-p IL RAS is transferred to the Ministry of Science and Higher Education of the Russian Federation management.

According to the Order of the Ministry of Science and Higher Education of the Russian Federation of July 08, 2020 No. 768 IL RAS received a status of the SPC RAS separate structural didision.

IL RAS – SPC RAS does basic and applied research in limnology; developing methods intended for in-depth comprehensive study of the structural and functional features of lake ecosystems, restoration of lakes and reservoirs, their use for drinking water supply purposes, fish farming and recreation; solving lakes' monitoring and managing problems as well as tasks of their natural resources' rational use.

Candidate of Biological Sciences Glibko, Oxana Ya. is the Institute Head.

Candidate of Biological Sciences Mitrukova, Galina G. is the Institute Acting Scientific Secretary.

Laboratory of Geography and Hydrology

Head of Laboratory: Naumenko, Mikhail A., Doctor of Geographical Sciences, Professor, m.a.naumenko@mail.ru.

New Researh Results

1. Based on the developed methodology, an empirical physically substantiated correlation was specified between the surface temperature of the central part of Lake Ladoga and the stratification parameters over the open water period. The hysteresis phenomenon in the thermal regime of Lake Ladoga was confirmed. This allows for assessing the vertical stratification parameters based on water surface temperature via remote methods.

2. For Lake Ladoga and Lake Onega, as well as for the White, Baltic and Black Seas, the currents on the surface of the indicated water areas were calculated based on successive infrared satellite images via the MSS method adapted for inland waters. The method is in high demand due to the lack of the currents' direct measurements.

3. Using palynostratigraphy and correlation of palynological data with radiocarbon-dated sediment cores from the central part of Lake Ladoga, sedimentation rates and chronologies of reconstructed events of the late Pleistocene and Holocene in different parts of the lake were received. Currently the lowest sedimentation rate is specified.

4. The results received under the comprehensive study of the inland lakes of Lunkulansari and Valaam in the northern part of Lake Ladoga confirmed the hypothesis about the connection between the isolation of island lakes and the temporary disappearance of pollen of aquatic plants, what allows to speak about the indicator role of the macrophytes' pollen in the studies of level fluctuations in large water bodies. Based on the dynamics of organc mater accumulation, the stages of development in the inland lakes like Valaam and Lunkulansari islands associated with the postglacial history of Lake Ladoga were determined.

5. Anthropogenic events in the catchment area of the Lake Ladoga were identified in the course of a comprehensive study that included palynological analysis and data on the dynamics of phosphorus, metals and organic matter. The influence of anthropogenic impact upon the columns of bottom sediments of Lake Ladoga studied against the palynological data are mainly reflected in the dynamics of ruderal species. At that, the palynospectra

of small lakes in the Ladoga region contain pollen of cultivated cereals simultaneously with pollen of weeds, what indicates the spread of agriculture. Thus, for Lake Zatishie on the Karelian Isthmus, the appearance of cultivated cereals together with weeds is dated approximately 183 years ago (170±25 calibrated years ago). For this lake, it was possible not only to establish and date the beginning of agriculture, as well as to identify a separate zone characterizing anthropogenic vegetation.

6. The quantitative assessment of the lake fund of China, the DPRK, and the Republic of Korea has been completed. The lake index of the China regions has been calculated.

7. First results of the analysis for the climatic conditions influence upon the change in the lakes' areas within regions of insufficient moisturizing have been received

8. The studies of the Holocene organic matter accumulation in Lake Ladoga were continued. The time of the Holocene maximum of organic matter accumulation for the station 39 (Lake Ladoga) was determined – 9500-5900 cal. years ago with a relatively constant sedimentation rate – about 0.10-0.14 mm/year.

9. In the sediments lying at the base of the section in the southern part of the lake at a bottom depth of 44 m, fragments of fish were discovered for the first time for Lake Ladoga: vertebrae and scales of a river perch (Perca fluviatilis L., 1758), what allowed for reconstructing its size, age and season of death. The age of the enclosing sediments is preliminarily estimated as early Holocene (presumably pre-Ancylus/Ancylus).

Hydrobiology Laboratory

Head of Laboratory: Dudakova, Dina S., Researcher, Candidate of Biological Sciences, judina-dudakova.d@spcras.ru.

New Researh Results

1. In 2023, the chemical composition of low molecular weight organic compounds (LMWOC) in the buds of the semi-aquatic plant of the Caspian region Populus nigra L. was analyzed for the first time using gas chromatography-mass spectrometry. 49 compounds were identified, 10 remained unidentified. Among the main components of the extract were flavonoid compounds with pronounced biological activity. The study revealed full bactericidal activity against opportunistic microorganisms and airborne microflora at a minimum inhibitory concentration of 0.25 μg/ml. The detected LMWOC have potential for further studies of the antioxidant activity of biotechnological preparations and pharmaceutical substances. The practical significance of the results received is that LMWOC isolated from the buds of P. nigra of the Caspian region have prospects for obtaining biotechnological preparations and pharmaceutical substances. In particular, they can be used for the purification and rehabilitation of water bodies and, possibly, as allelochemicals to combat cyanobacterial blooms.

2. The comprehensive studies of the ecosystem of Lake Ladoga and its tributaries under the influence of natural and anthropogenic factors, performed in 2023, on the whole, once again confirmed the fact of a fairly favorable and stable state of the lake, as determined by natural environmental factors; at the same time, in local areas, the influence of anthropogenic factors is sometimes noticeable, what leads to disturbances in the course of lake hydrobiological processes, as reflected in the recorded corresponding changes in hydrobiological characteristics.

3. Continuation of long-term observations on Lake Krasnoye in 2019-2023 confirmed the decisive influence of temperature and water content on the state of its ecosystem under anthropogenic eutrophication: a decrease in the water level, especially in the summer-autumn period, and the setling of stable thermal stratification led to sharp changes in the oxygen regime (oxygen deficiency in the hypolimnion) and in the structure and productivity of biological communities; at the same time, a significant increase in the concentration of phosphorus in the water was noted, what caused intense water blooms because of the mass development of

cyanoprokaryotes, especially in the warmest years. Significant changes also occurred in the composition of submerged vegetation, what led to the establishment and aggressive spread of an alien species of pondweed against the background of a decrease in the water level. Following the peak of phytoplankton development, there followed a peak of zoobenthos, with a predominance of filter feeders, followed by an increase in the development of detritivores-collectors, swallowers and predators. In 2023, the increase in the level determined the development of fouling organisms, such as the bryozoan Plumatella fungosa, which had not previously been observed in the lake in such quantities. The appearance of alien species and all other signs indicate a deterioration in the state of the ecosystem of Lake Krasnoe and the quality of its water.

Hydrochemistry Laboratory

Head of Laboratory: Ignatieva, Nataliya V., Senior Researcher, Candidate of Geographical Sciences, natali_ignatieva@mail.ru.

New Researh Results

1. As a result of observations on the hydrochemical regime of the tributaries of Lake Ladoga and the Neva River at its source, taken in 2023, it was established that natural factors have a decisive influence upon its formation, while in most cases the hydrochemical indicators stayed in the same ranges as in preceding years. However, in some cases the influence of anthropogenic factors led to an increase in the indicators' number, most often this was noted in the Volkhov, Syas and small southern tributaries.

2. Study of the main hydrochemical parameters of the Lake Ladoga, undertaken in the summer-autumn period of 2023, confirmed the nature of the spatial distribution of the components of the water chemical composition and the presence of a number of trends identified in recent years. Thus, against the background of the previously identified trend of an increase in the share of hydrocarbonate ion in the anionic composition of the main water mass of the lake, an increased content of chloride ion, as well as sodium and potassium cations, was noted at some stations. In 2023, the oxygen content again did not exceed 100% in almost the entire water area of the lake, even in the summer, i.e. the presence of a trend that had emerged since 2019 was confirmed. In combination with low pH values, the said indicates intensive destructive processes. The continued growth of the concentration of total phosphorus (TP) in the lake was also confirmed. Thus, from 2002 – 2019 the average concentration of TP in the lake during the open water period was 10–14 μg P l-1, approaching the maximally permissible value for the lake, that equals 15 μg P l-1; in 2020–2022, it increased to 18–20 μg P l-1, and in August of 2023 – 19 μg P l-1, i.e. a further increase in TP and a stable excess of the permissible level were registered. At that, the concentration of inorganic phosphorus is increasingly below the sensitivity limit of analytical determination, what indicates an increase in the intensity of phosphorus turnover. In 2023, a further increase in the content of total organic carbon was detected in all limnic zones of the lake. A continuing excess of the maximally permissible concentration of petroleum hydrocarbons for water bodies of fishery importance has been registered throughout the lake's water area, with the

Volkhov, Svirskaya and Shlisselburgskaya bays with the adjacent southern part of the lake's water area, the northern skerry region, as well as the areas of the city of Pitkyaranta in the northeast and the city of Priozersk near the mouth of the Burnaya (Vuoksa) River in the west most often being in the environmental risk zone.

3. Based on the analysis of the seasonal dynamics of the main set of hydrochemical indicators of two lake-river systems: Lake Lopastnoye – Cherny Creek and Lake Uzkoye – an unnamed creek belonging to the selgov landscape of the North-Western Priladozhye, the features of the formation of the chemical composition of water in the lake and river sections of the water systems were revealed. The 2023 study turned out to be the finalizing stage in the development of lake-river systems functioning in the conditions of various geochemical landscapes' characteristics of the eastern part of the Karelian Isthmus, received from 2019-2023. It was established that, despite the fact that Lakes Lopastnoye and Uzkoye are located within 2.4 km from each other, their differences vary in morphometric characteristics and, from a theoretical point of view, in the nature of the processes occurring in them. Thus, Lake Lopastnoe, like most lakes on the Karelian Isthmus, is a low-mineralized sodium hydrocarbonate reservoir, mesotrophic in phosphate, while Lake Uzkoe is a sodium chloride mesotrophic reservoir with increased mineralization, what is less typical. The nature of the vertical temperature and chemical stratification in Lake Uzkoe, which has a tectonic position, gives grounds to preliminarily classify it as meromictic. The formation of the chemical composition of the water in the streams flowing out of the lake is determined mainly by the unsatisfactory state of the water in the source lake, and the influx of chemicals from ancient river catchments. Because of the low water consumption of the studied watercourses and the high self-cleaning ability, the intake of chemicals with the streams flowing from the Lopastny and Narrow lakes has practically no effect on the water quality of the water area adjacent to the northwestern coast of Ladoga.

4. Statistical estimates of 16 main hydrochemical parameters for 223 small lakes of the Republic of Karelia and 24 hydrochemical parameters for 715 lakes of the Kola Peninsula, divided into clusters according to their landscape affiliation, were derived. The said estimates give an idea of the hydrochemical characteristics for the lakes typical for various landscapes of Karelia and the Kola Peninsula. A number of patterns and features of the lakes hydrochemistry in various geochemical

landscapes were revealed. The use of mathematical and statistical methods aimed at searching for anomalies allowed for identifying 26 lakes in Karelia and 23 lakes over the Kola Peninsula (12 and 3.2% of the total number of sample lakes, respectively), being atypical for these territories. The anomalies' causes determined during the expert analysis let them be divided into natural anomalies and anthropogenically transformed lakes.

Laboratory of Complex Problems of Limnology

Head of Laboratory: Rybakin, Vladimir N., Senior Researcher, Candidate of Physical and Mathematical Sciences, v.n.rybakin@gmail.com.

New Researh Results

1. As a result of the study of the composition and structure of humic acids in the sediments of tundra lakes of the Kola Peninsula, Polar Urals and Yamal, as well as the Rybachy and Sredny Peninsulas and organic matter of the bottom sediments of the lakes and frozen soils on the Spitsbergen archipelago, a detailed ecological and geochemical characteristic of humic substances formed in the cold-water conditions of the Arctic were receive, the features of humification processes in various climatic conditions of the planet were clarified. Low resistance of humic substances of the lake sediments in the cryolithozone to mineralization compared to soil humus was shown. This aspect is important from the point of view of assessing the role of lakes in greenhouse gas emissions during permafrost degradation. It was determined that in the lakes over industrial territories of the Kola Peninsula, humic substance plays a key role in the detoxification of pollutants, in particular, heavy metals.
2. Research regarding the effects of ultrafine suspension of humic sapropel, produced out of the lake sapropel by a specially developed technology that includes ultrasound exposure, has demonstrated the possibility to apply the said ultrafine suspension for increasing the total yield of commercial products (biomass) of leafy vegetables and to increase the resistance of cells to unfavorable external conditions.

Laboratory of Mathematical Modeling Methods

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New Researh Results

1. For the first time, a prognosis on the consequences of an emergency oil spill in the waters of Lake Ladoga has been compiled based on 3D modeling. According to the calculation legend, 5,000 tons of oil were dumped into the lake. In the spring, oil slicks spread in the southern, southeastern and eastern directions, reaching the coastline in one to five days. The Volkhov Bay, Svirskaya Bay and the coast, where the Olonetskaya Specially Protected Natural Area (SPNA) is located, may be exposed to the greatest risk of pollution. In the summer, pollution moves in the western and southwestern directions. In this case, the city of Shlisselburg and the Petrokrepost Bay, the source of the Neva River, will be exposed to pollution. There is a high risk of oil getting into the Neva River. In the fall, pollution spreads to the east in the direction of the Olonetskaya SPNA, bypassing the Volkhov and Svirsky bays (inlets). During the spreading process taking from one to five days, the size of the slick increases – from 0.6 km2 at the time of the spill to ~50 km2 during the contact of the slick with the coastline.

2. A model of the channel and basin components of solid runoff of watercourses has been developed based on an assessment of the transport potential of the watercourse and the dynamics of the curves in the granulometric composition of bottom sediments, products of soil and channel erosion, allowing to assess the intensity of the redistribution of river sediments and bottom sediments along the river channel. At that, the model calculates the change profile of the bottom marks between two design sections, the distribution of the size of sedimented or moving particles, the mass of particles of the channel and basin components of sediment runoff and the share of the contribution of the basin component.

3. Mathematical modeling was applied to estimate modern climatic trends in hydrothermodynamic and chemical-biological parameters of the lakes in different climatic zones of Eurasia. The Flake-Eco model was used to study ice-thermal and oxygen conditions in the lakes. It is shown that since 1984, the surface water temperature in the

lakes in different climatic zones of the continent has increased, and similar trends are also observed for the bottom temperature. The zonal distribution of the average temperature along the water column and its time trends generally follows the distribution determined for the bottom temperature. It was found that a zonal decrease in the surface concentration of dissolved oxygen was observed in all climatic zones, the said reflects the inverse relationship between oxygen solubility and water surface temperature. Anaerobic conditions can occur in the lakes in all climatic zones. Such conditions occur least often in water bodies in the tundra, subarctic and continental zones. For obvious reasons, the maximum values of the anaerobic zone thickness occur in polar lakes isolated from a contact with the atmosphere. Nevertheless, the time trends are negative in these zones, while in all the other ones the trends are positive, so there persists a tendency for water quality in the lakes of these climatic zones to deteriorate.

4. The results of decoding satellite data of the physical-geographical countries of Eurasia show that the total area of various classes of water surface is approximately 24 million km2, of them 219 thousand km2 are water surfaces that have disappeared since 1984, and 1.15 million km2 have newly appeared. The largest share of the disappeared water surfaces from the area of water bodies of a single region falls on Central Asia. The most common class of water surfaces in Asia are water bodies with an indefinite seasonal hydrological regime, their share accounts for 1.76 million km2 (or about 30% of the total area of the water bodies in Asia). It is shown that 20% of the area of all classes of water surface of the continent falls on the territory of Russia. Within the territory of the country about 50% (2.4 million km2) of its water bodies are permanent water surfaces, this is only 6% less than in Europe and over 30% more than in Asia.

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