RUSSIAN ACADEMY OF SCIENCES

NATIONAL GEOPHYSICAL COMMITTEE

РОССИЙСКАЯ АКАДЕМИЯ НАУК

НАЦИОНАЛЬНЫЙ ГЕОФИЗИЧЕСКИЙ КОМИТЕТ

NATIONAL REPORT

for the

International Association of Hydrological Sciences

of the

International Union of Geodesy and Geophysics

2011–2014

НАЦИОНАЛЬНЫЙ ОТЧЕТ

для

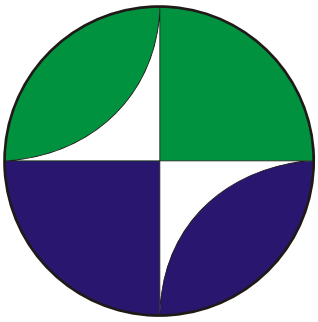
Международной ассоциации гидрологических наук

Международного

геодезического и геофизического союза

2011–2014

Москва 2015 Moscow



Presented to the XXVI General Assembly
of the
International Union of Geodesy and Geophysics

К XXVI Генеральной ассамблее
Международного геодезического и геофизического
союза

RUSSIAN ACADEMY OF SCIENCES

National Geophysical Committee

NATIONAL REPORT

for the

International Association of Hydrological Sciences

of the

International Union of Geodesy and Geophysics

2011–2014

Presented to the XXVI General Assembly

of the

IUGG

2015

Moscow

In this National Report are given major results of researches conducted by Russian hydrologists in 2011–2014 on the topics of the International Association of Hydrological Sciences (IAHS) of the International Union of Geodesy and Geophysics (IUGG). This report is prepared by the Section of Hydrological Sciences of the National Geophysical Committee of Russia.

В данном Национальном отчете представлены основные результаты исследований, проводимых российскими гидрологами в 2011—2014 гг., по темам, соответствующим направлениям деятельности Международной ассоциации гидрологических наук (МАГН) Международного геодезического и геофизического союза (МГГС). Данный отчет подготовлен Секцией гидрологии Национального геофизического комитета Российской академии наук.

DOI: **10.2205/2015IUGG-RU-IAHS**

Citation: Dzhamalov R.G., A.N. Gelfan, M.V. Bolgov Eds. (2015), National Report for the IAHS of the IUGG 2011–2014, *Geoinf. Res. Papers*, 3, BS3007, GCRAS Publ., Moscow, 16 pp. doi: 10.2205/2015IUGG-RU-IAHS

THE MOST SIGNIFICANT RESEARCH RESULTS IN HYDROLOGY, HYDROGEOLOGY, AND RELATED DISCIPLINES IN THE FIELD OF WATER PROBLEMS IN 2011-2014

The most significant research results in 2011

- Basic physics of the formation theory of catastrophic floods in river basins were developed. Mathematical models were created to reproduce the critical situation resulting in catastrophic floods under different natural conditions; methods were suggested for assessing the formation probability and the scale of floods and the sensitivity of their characteristics to possible climate changes and anthropogenic impact on river drainage basins. For the first time in the world, an approach to simulating the risk of floods was developed based on physically determined limits of meteorological impacts on river catchment areas and applied to rivers in European Russia (WPI RAS, L. S. Kuchment, Dr. Sci. (Phys.-Math.)).

- Regularities in the year-to-year and many-year variations of the annual, maximal, and minimal runoff in rivers of Russia and the world were examined, and new methods were proposed for assessing their statistical and stochastic parameters. For the first time, a complex spatial estimate of their variations over Russian Federation territory was obtained and compared with analogous characteristcs of world rivers. The genesis of river runoff in the northern European Russia and the basins of the Volga, Don, Ural, etc. was studied, and zoning of watersheds was carried out taking into account runoff formation features. The natural resources of surface and subsurface waters over period of 1970–2005 were revaluated and mapped. (WPI RAS, Doctors of Science S. G. Dobrovolsky (Geogr.), R. G. Dzhamalov (Geol.-Miner.), and M. V. Bolgov (Techn.)).

The most significant research results in 2012.

- A stochastic model of meteorological processes (stochastic weather generator) was developed to generate within-year variations of meteorological variables with daily resolution under different climate conditions. A dynamic–stochastic model was constructed, combining a deterministic model of snow cover formation and a stochastic weather generator; this model was used to evaluate the statistical charcteristics of year-to-year variations in snow cover water equivalent in European Russia, and the obtained estimates showed the model to be adequate. The development of the model is of special importance in the context of the considerable effect of year-to-year dynamics of snow cover on the climate system of high latitudes and the significant contribution of snowmelt water to river feeding in the major portion of Russian territory (WPI RAS, A. N. Gelfan, Dr. Sci. (Phys.-Math.)).

- It was shown that the principle of regulatory limitations of environmental impact, now in use in Russia (including the impact on water objects), based on systems of maximal allowable concentrations (MAC), should be replaced by a system based on the principle of best available technologies (BAT), which is in wide use in the world. The mechanisms and stages of implementation of this principle were developed. The main result of the passage to BAT should be the development of a simpler and more efficient system of environmental protection management in accordance with the obligations undertaken by the Russian Federation under the policy of governmental regulation of the environmental and technological safety within the Group of Eight. (WPI RAS, E. V. Venitsianov, Dr. Sci. (Phys.-Math.)).

The most significant research results in 2013

The catastrophic flood in the Amur basin (July–October, 2013) was simulated; the propagation of flood waves through the main river channel and its tributaries was calculated; the flood prevention effect of large reservoirs was evaluated with the use of physical-mathematical models of river runoff formation developed in WPI RAS. The use of the regulation capacity of the Zeya Reservoir was shown to reduce water levels at flood peak in the populated localities of the Middle Amur by up to 1.5 m. In pursuance of the Decree of RF President of August 31, 2013, no. 693, proposals of RAS to RF Government were prepared, regarding the substantiation of priority research lines for hazard assessment and the prediction of extreme floods in the Amur basin. Considering the huge losses caused by the flood of 2013, it can be stated that the implementation of those studies is among the issues of national security. (WPI RAS, V. I. Danilov-Danilyan, Corr. Member, RAS; A. N. Gelfan, Dr. Sci. (Phys.-Math.)).

- A method was developed for long-term (over an interval of 3 months) ensemble-based forecast of lateral water inlfow into reservoirs during floods, increasing the efficiency of integrated management of water resources systems and measures for flood control. The method includes the simulation of initial conditions on the watershed, the construction of an ensemble of possible meteorological scenarios for the forecast times and the simulation of an ensemble of hydrographs of spring water inflow into the reservoir. (WPI RAS, A. N. Gelfan, Dr. Sci. (Phys.-Math.)).

- Basic scientific principles of detecting xenobiotic water pollution by oil radionuclides in its emergency spills were formulated; analytical methods for their implementation with the use of domestic geophysical stations are proposed. A technology was developed for telediagnostics of the ecological status of

continental water objects as applied to oil pollution with the use of ultraviolet fluorescense lidars of stationary and mobile mounting on platforms in different positions. A methodological guide is prepared for the scientific principles of designing monitoring systems for water objects. A positive decision was received regarding the granting of a patent for the proposal (WPI RAS, G. M. Barenboim, Dr. Sci. (Phys.-Mathem.)).

The most significant research results in 2014

- The methods for hazard assessment and prediction of hazardous hydrological events under changing climate and anthropogenic load, developed in WPI RAS, were used to create a technology of hydroinformation support of decision making on engineering protection of populated localities in the Amur Basin, including an information–simulation complex ECOMAG for describing the processes of river runoff formatioin and hydrodynamic models describing the propagation of flood wave in the Middle Amur. The flood-control effect of the existing and anticipated reservoirs in the Amur Basin were constructed for the first time (Yu. G. Motovilov, Cand. Sci. (Geogr.), A. N. Gelfan, Dr. Sci. (Phys.-Mathem.)).

- A global electronic database on different-genesis floods in the world was created; the database has no analogues in terms of the details of studying and the completeness of data; now the database contains information on 474 floods in the territory of the Russian Federation and 2832 floods in other countries.

- A model of interaction between land surfce and the atmosphere was used to develop a procedure for assessing the possible changes in runoff and other water balance componetns for the basins of northern Eurasian rivers flowing in permafrost areas under extreme winter air temperatures. Long-term (up to the late XXI century) scenario forecasts of changes in those characteristics were

constructed for large river basins in the region for different climate scenarios. (WPI RAS, E. M. Gusev, Dr. Sci. (Biology)).

- Scientific principles were developed for complex monitoring of water objects in the context of ensuring their safety in the case of emergency spills of oil and oil products. For the first time in the world practice, the complex effect of hydrocarbon oil components, accompanying heavy metals, radionuclides, and rare-earth elements was studied with the use of new high-accuracy methods of studies and small-dimension fluorescent lidars. A methodological textbook was prepared for developing the monitoring of zones with high ecological risk under emergencies of natural and technogenic character on water objects (WPI RAS, G. M. Barenboim, Dr. Sci. (Phys.-Mathem.)).

- Proposals were developed for improving the legal and organizational mechanisms for the management of the country's water fund, in particular, for the transfer of a considerable portion of the related functions to the municipal level, a step, which will increase the efficiency of the water management activity as a whole.

A methodology and mechanisms for its implementation were developed for the coordination of water use strategies under incomplete competition and uncertainty conditions, which cause the risk of reducing the efficiency of utilization of resources. Economic mechanisms were substantiated and mathematical models were developed for resolution of conflicts (WPI RAS, V. I. Danilov-Danilyan, Corr. Member, RAS; V. G. Pryazhinskaya, Doct. Sci. (Techn.)).

- The state of water markets in the world was analyzed; it was shown that, against the background of increasing global deficiency of water resources, Russia can become a leader in the market of wet products. A concept of virtual water, as an alternative to real-water transportation, was developed for mitigating water

deficiency by the import of wet products. Proposals were developed regarding the mechanisms of Russia participation in international water trade, including virtual water. In the recent years, this has become an even more significant competitive advantage of Russia and a lever for the influence on the global economic and political situation (WPI RAS, V. I. Danilov-Danilyan, Corr. Member, RAS; I. L. Khranovich, Doct. Sci. (Tech.)).

ABSTRACTS OF ARTICLES FOR SOME MOST IMPORTANT RESEARCH RESULTS

1) Water Resources, 2013, vol. 40, num. 5, pp. 544-553

Tasks and function of a decision support system for water resources managment in the Lower Volga

Bolgov, Levit-Gurevich

DOI 10.1134/S0097807813050023

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=5&year=13&page=544

Abstract — The Lower Volga is a Russian region, which has a unique natural resources and a territory which is the area of collision of the interests of different economic branches that use water resources. The economic development of the region requires effective water resources management in harmony with natural conditions and the operation of the Volga–Kama reservoir system. A reliable management tool is a computer decision support system for the Lower Volga. The problems to be solved with this system answer the current water problems of the region. Data on the programs under implementation and to be developed are given; water apportioning model is given; and the way of coordinated choice of management regime of the Volga–Kama reservoir system and water resources use in the Lower Volga is demonstrated.

Keywords: Lower Volga, water resources, operative management, Volga–Kama reservoir system, water management decision support

2) Water Resources, 2013, vol. 40 number 6, p. 573-584

Current changes in river water regime in the Don River Basin

R. G. Dzhamalov, N. L. Frolova, and M. B. Kireeva

DOI 10.1134/S0097807813060043

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=6&year=13&page=573

Abstract — The formation and distribution of present-day water resources under the effect of changing climate are studied. Seasonal, annual, and many-year variations in the regime of spring-flood and dry-season runoff of rivers with drainage areas from 2000 to 20 000 km^2, reflecting the zonal landscape–climatic conditions of runoff formation, are considered. It is shown that various and often contradictory demands of water users to water supply distribution over seasons of the year result in that the entire water management complex depends on not only the total volume of water resources, but also on the water regime characteristics of rivers in different phases of hydrological year. It was established that the climate changes recorded in the recent decades radically change the pattern of space and time variations in runoff characteristics.

Keywords: water resources, natural groundwater resources, river runoff, groundwater runoff, runoff regime

3) Water Resources, 2012, vol. 39, number 6, p. 623-639

The formatiom of present-day resources of surface and subsurface waters in European Russia

R. G. Dzhamalov, N. L. Frolova, G. N. Krichevets, T. I. Safronova, M. B. Kireeva, and M. I. Igonina

DOI: 10.1134/S0097807812060036

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=6&year=12&page=623

Abstract—Variations in the characteristics of the annual, dry-season, and minimal monthly runoff in rivers of European Russia for the recent 35 years (1975–2005) have been estimated and analyzed in comparison with a period of approximately the same duration (1935–1969). The genesis of runoff for different river basins and the major causes of current changes in runoff characteristics have been studied. Regional regularities in the hydrological and geohydrological processes have been identified, and zoning of the territory has been performed with identification of specific features in the formation of river runoff in the European North and the basins of the Volga, Don, Ural, etc. The natural resources of surface and subsurface waters over 1970–2005 have been reestimated with the construction of appropriate maps. Water availability and load on water resources have been analyzed.

Keywords: natural groundwater resources, surface water resources, groundwater runoff, river runoff, runoff regime

4) Water Resources, 2014, vol. 41, number 2, pp.115-125

Disastrous flood of 2013 in the Amur basin: Genesis, recurrence assessment, simulation results

V. I. Danilov-Danilyan, A. N. Gelfan, Yu. G. Motovilov, and A. S. Kalugin

DOI: 10.1134/S0097807814020055

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=2&year=14&page=115

Abstract—The major formation factors of a disastrous flood in the Amur basin in July—September 2013 are discussed. The role of the Zeya and Bureya reservoirs in reducing the flood hazard is discussed. Preliminary estimates of the recurrence of peak flood discharge are given. It is shown that, considering the deficiency of data on water discharges along the river and the short duration of the available observation series, the estimates of flood hazard on the Amur R. obtained by statistical treatment of those data shows considerable uncertainty. A physical-mathematical model was developed to describe runoff formation in the Middle-Amur basin based on the ECOMAG information — simulation complex and a one-dimensional hydrodynamic model describing the motion of flood wave over a 600-km segment of the Amur R. was developed based on MIKE 11. The potentialities of the joint use of the proposed models to reproduce the behavior of water discharges and levels in different parts of the Amur R. during the propagation of the flood in 2013 and to evaluate the effect of withdrawals from the Zeya Reservoir to the water level regime of the Amur downstream of the Zeya R. mouth.

Keywords: flood, Amur, risk, simulation, reservoir

5) Water Resources, 2011, vol. 38 number 4, pp.470-483

Northen Dvina runoff simultion using land-surface model SWAP and global databases

E. M. Gusev, O. N. Nasonova, L. Ya. Dzhogan, and E. E. Kovalev

DOI: 10.1134/S0097807811030043

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=4&year=11&page=470

Abstract—The potentialities of a method for evaluating runoff from Northern Dvina basin, which is based on a model of heat and water exchange between land surface and the atmosphere (SWAP) in combination with input data based on global databases on land surface parameters and different variants of meteorological data (derived from reanalysis data; reanalysis data hybridized with ground based and satellite observations; observational data of meteorological stations situated in the river basin). In all three cases, an optimization was applied to some key model parameters, including the characteristics of the land surface and correction factors for precipitation and incoming radiation.

Keywords: river runoff hydrograph, interaction between the atmosphere and land surface, physically based modeling, global databases, Northern Dvina basin.

6) Water Resources, 2013, vol. 40, number 5, p. 535-544

Modeling streamflow of the Olenek and Indigirka rivers using land surface model SWAP

E. M. Gusev, O. N. Nasonova, L. Ya. Dzhogan, and G. V. Aizel’

DOI: 10.1134/S0097807813030056

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=5&year=13&page=535

Abstract—The potentialities of a technique for simulating the runoff from the Olenek and Indigirka river basins located in the Republic of Sakha (Yakutia) under the most severe climate conditions are investigated. The technique is based on a land surface model SWAP in combination with input data based on global data sets on land surface parameters and meteorological forcing data derived from

observations from meteorological stations situated within or near the river basins. To improve the calculation quality, an optimization procedure was applied to the key model parameters, including both land surface characteristics and (for the Olenek R.) the correction factors for precipitation and incoming radiation.

Keywords: river runoff hydrograph, land surface–atmosphere interaction, physically based modeling, global databases, the Olenek and Indigirka river basins, parameter optimization

7) Water Resources, 2013, vol. 40, number 3, p. 342-354

Transboundary water pronlems and approaches to their soluton:1. Formation of agreements

V. I. Danilov-Danilyan and I. L. Khranovich

DOI: 10.1134/S0097807813030032

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=3&year=13&page=342

Abstract — Conflict situations in transboundary water use and the associated problems of harmonization of the interests of the users who claim the resources of transboundary water bodies. Mechanisms are proposed for the harmonization of the interests of states using transboundary water bodies in the absence of agreements regarding joint management strategies. The harmonization is being carried out with the quantitative and qualitative characteristics of water resources under stochastic conditions taken into account.

Keywords: water resource, transboundary water body, water management system, active system, risk, chance, imperfect competition, two-stage stochastic problem, matching price

8) Water Resources, 2013, vol. 40, number 4, p. 441-447

Transboundary water pronlems and their solution: 2. Revision of agreements

V. I. Danilov-Danilyan and I. L. Khranovich

DOI: 10.1134/S0097807813040027

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=4&year=13&page=441

Abstract — Mechanisms are proposed for the harmonization of interests of states using transboundary water bodies in the cases where agreements on joint management strategies are to be revised. The harmonization is being carried out taking into account the quantitative and qualitative characteristics of water resources under stochastic conditions. The functioning of water bodies is considered under static conditions and in discrete time. The harmonization takes place within a manageable market of water resources.

Keywords: water resource, transboundary water body, water management system, management, market, price

9) Water Resources, 2012, vol. 39, num 2, p. 237

Harmonization of strategies for the use of transboundary water resources

V. I. Danilov-Danilyan, S. A. Ivankov, and I. L. Khranovich

DOI: 10.1134/S0097807812020030

http://maik.ru/cgi-perl/search.pl?type=abstract&name=watres&number=2&year=12&page=237

Abstract—An approach to developing harmonized strategies of the use of transboundary water resources is considered. The principle of open management is examined in two possible situations of strategy development—either there is no agreement between governments regarding the use of a transboundary water body, or the existing agreement is to be revised. Perfect harmonization is attained in both variants.

Keywords: transboundary water resources, water management system, stochastic conditions, open management, active system, perfect harmonization, manageable market.