Editorial to the special issue on natural hazards and risk research in Russia

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Received: 24 June 2017 / Accepted: 27 June 2017 / Published online: 11 August 2017
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Abstract The contributions of this special issue are centered on Russian natural hazard and risk research in the territory of the Russian Federation and the former Soviet Union. The overall aim is to promote the excellent research results in this scientific field which were, unfortunately, for decades only available to the Russian-speaking community. Despite the considerable research efforts undertaken by Russian scholars, methods and results are hardly known among non-Russian researchers and consequently neglected by the international research community simply because many sources are only available in Russian language. A prominent example includes the textbook “The fundamentals of avalanche science” by Bozhinskiy and Losev (1998), the Russian version originally published in 1987, which was only translated due to an initiative of the Swiss Federal Institute of Snow and Avalanche Research in Davos, Switzerland. Following a discussion among participants of the Third International Conference on Debris Flows in Yuzhno-Sakhalinsk in September 2014, we strongly believe that making accessible Russian research to the international hazard community will be of vital interest and will provide substantial added value to the progress in natural hazard and risk research.

Electronic supplementary material The online version of this article (doi:[10.1007/s11069-017-2976-2](https://doi.org/10.1007/s11069-017-2976-2)) contains supplementary material, which is available to authorized users.

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Below, an overview on the historical roots of research on different hazard types in Russia is provided, and major findings that influenced the Russian research efforts are reported. The second section introduces the different interdisciplinary articles of this special issue that summarize the state of the art in Russian research activities. The main aim was not to provide classical articles presenting case studies, but to allow the individual contributors to reflect on their opinion on findings for the ongoing scientific debates. Moreover, the voice in this special issue was given to Russian colleagues working in Russia which means to collect opinions of current research that are (or should be) influential on worldwide research activities.

Furthermore, on the Web page of the Natural Hazards journal at Springer accompanying this article a movie can be downloaded reporting on the first real-scale debris flow tests performed by the “Kazakh Scientific Research Institute for Hydrometeorology” in the early 1970s, until now one of the only in situ experiments on such a scale. This movie is an excellent example for the world-leading research activities at that time; the translation and voice-over were made possible through collaboration between Lomonosov Moscow State University, Russia, and the University of Natural Resources and Life Sciences in Vienna, Austria.

1 Natural hazard research in Russia

The history of natural hazard research in Russia can be divided into several successive periods. First studies on hazardous events trace back to the end of the eighth century, when various chronicles were established (Borisenkov and Pasetskii 1988). As for other regions of the world such as Europe (Keiler and Fuchs 2010), the information in these documents was mainly qualitative, and the most prominent hazard types recorded were floods, droughts, windstorms, hail and severe frosts. The descriptions chronicled included the geographical location of individual events, some spatial characteristics and the observed consequences. These roots of natural hazard research are supplemented by higher sophisticated observations once knowledge on hazard triggers increased, and are as such comparable to the development of scientific research in other regions such as for example Central Europe (Pfister 1999; Fuchs and Keiler 2013).

More quantitative scientific investigations on the territory of the contemporary Russian Federation started in the middle of the nineteenth century, when measurement devices allowed for reproducible observations, and scientific education reached broad levels of population. Since then, the genesis of dangerous natural phenomena, their distribution and conditions of initiation were studied, and quantitative information on floods, earthquakes, tsunamis, landslides, debris flows, snow avalanches, etc. became available. In parallel, the industrial revolution and the invention of new measurement devices allowed to start quantitative studies of most hazard types on the territory of Russia.

In the outgoing twentieth century, the ratification of Russia’s “State complex scientific-technical programme” on “Safety of population and industrial objects accounting the risk of manifestation of natural and technogenic catastrophes” in 1991 can be considered as the starting point of a new era of scientific research on natural hazards and risk. Under this program, much of the previous experience was summarized, and an album of maps of dangerous natural hazards on the territory of Russia was compiled. This album became a base for the “Science Atlas” published by the Ministry of the Russian Federation for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters together with

the Russian Academy of Sciences (Shoigu 2005). In the following years, studies on natural hazards and risk were conducted under the umbrella of the “Federal target programmes”, “Reduction of risks and abatement of consequences of emergency situations of natural and technogenic character in the Russian Federation for the period until 2010”, as well as “Reduction of risks and abatement of consequences of emergency situations of natural and technogenic character in Russian Federation until 2015”.

In the subsequent sections, we present briefly the variety of natural hazards on the territory of Russia as well as the main historical developments in scientific research.

1.1 Earthquakes

In the nineteenth century, the geological basis for investigations on the nature of earthquakes in Russia was set by I.V. Mushketov and A.P. Orlov, who issued the first Russian catalogue of earthquakes (Mushketov and Orlov 1893). The first electromagnetic seismograph was constructed by B.B. Golitsyn in 1906 (Galitzin 1910), and the development of a method to calculate the position of epicenters made systematic studies on seismicity and the internal structure of Earth’s crust possible (Galitzin 1914). B.B. Golitsyn suggested two types of seismic stations to be constructed: (1) tele-seismic stations for registration and study of remote earthquakes and (2) regional seismic stations for local studies (Galitzin 1912). Comprehensive regional seismic studies were related to the industrial development of Siberia, Central Asia, Kazakhstan and the South of the European part of country between 1928 and 1947. The consequences of the catastrophic Ashkhabad earthquake on October 6, 1948, exposed problems in the seismic monitoring and related studies in the country, and stimulated a further development of earthquake prediction and forecast. Furthermore, this event triggered comprehensive studies on earthquake causes, including geological and historical analyses and engineering research of the character of destruction. Due to the socioeconomic development starting in the 1950s, there was a strong need for detailed investigations of seismic hazards in the new developing territories until the 1970s. In parallel, a request to identify locations of nuclear weapon tests around the globe resulted in the development and construction of sensitive seismic equipment, and innovative sensors started to be positioned in adits and boreholes. In 1965, the Resolution of the Presidium of the Academy of Sciences approved the establishment of the “United system of seismic monitoring” in the USSR with reference and local stations. The first automatic seismotelemetric system for the collection and analysis of the seismic information was constructed in 1965 in Uzbekistan. The consequences of the catastrophic earthquakes in Uzbekistan in 1966 gave new impulse to the development of the observational network. A new organizational system was introduced in 1978 and made seismic observations operational. The development of the digital methods in the 1980s forced the government to arrange a settlement with the IRIS Consortium of universities dedicated to the operation of science facilities for the acquisition, management and distribution of seismological data, allowing to provide the USSR seismic stations with modern equipment. This step resulted in an inclusion of the Russian seismic monitoring network into the global one.

The first official normative map of the general (review) seismic regionalization (GSR) on the territory of the USSR was published by G.P. Gorshkov (1937). The studies of various scientists since the outgoing 1940s allowed to change the previously accepted “seismic actualism” approach (earthquakes occur where they happened before) to the seismogenetic two-stage method of seismic hazard assessment with elements of forecast. Practically, all the subsequently compiled GSR maps (1957 by S.V. Medvedev and B.A. Petrushevskii, 1968 by S.V. Medvedev and 1978 by M.A. Sadovskii) were based on this

method of determination of real and potential earthquake sources and the calculation of the expected shock at the Earth surface. However, up to the GSR map of 1978 such maps were not covering the entire Russian territory with the same data quality but region-specific, because the data used from different regions were collected differently and represented fragments from different regions and republics. Thus, the succeeding GSR map of 1997 was compiled differently, as a set of maps of seismic hazard for different elements at risk, considering different categories of responsibility and lifetime (SNiP 2000). The maps were regularly updated, and the most recent set was compiled in 2016 (Ulomov and Bogdanov 2016).

1.2 Tsunamis

The beginning of scientific tsunami studies in Russia can be scheduled with the catastrophic event in Kamchatka of November 5, 1952. A strong earthquake with $M = 8.5$ resulted in 2336 fatalities and high economic loss on the north Kuril Islands due to a subsequent tsunami. Almost all settlements at the southeast coast of Kamchatka and on the north Kuril Islands were destroyed. After the event a decision was made to establish a tsunami forecast service and a network of seismic stations in the Far East of Russia. At the beginning, the main activity was to collect and systematize any tsunami characteristics of the Pacific Ocean coastline (Solov'ev and Go 1975). Based on this inventory, the authors published a map of the focus points and tsunami heights along the coastline (Solov'ev and Go 1977). The study of earthquakes triggering tsunami hazards allowed them further to develop a so-called magnitude–geographical criterion, used up to present time in the Russian tsunami forecast service (Zolotukhin and Ivel'skaya 2010). In parallel, mathematical modeling of the tsunami extent, the timing and expected waves heights was developed (Poplavskii et al. 1997) and continuously enhanced (Kaistrenko 2011). An important step was the construction of special equipment to record long waves in the range of the tsunami at the shelf and in the open sea (Zhak and Solov'ev 1971). The maps of tsunami hazard (the possible wave height at a certain position at a coast with a repeatability of once per 50 or 100 years) were compiled and recently updated for all regions of Russia up to a repeatability of once per 1000 years (Pustolyakova 2017).

1.3 Floods

Studies on flood hazards in Russia are related to the flood history of St. Petersburg situated in the mouth of Neva River. The November 7, 1824, flood event with a water level of 4.2 m a.s.l. was the starting point for continuous records of the water level at the Kronstadt gauge (Figs. 1, 2). After the event, a competition was announced for flood protection works in St. Petersburg, and the event became a catalyst for the elaboration of structural mitigation. In 1825, Pierre-Dominique Bazaine, director of the Institute of Transportation Engineers, proposed constructing a 22-km-long dam across the Gulf of Finland from Lisy Nos through Kronstadt to Oranienbaum. While at that time the technical feasibility was questioned, the area of St. Petersburg is now protected by a similar dam completed in 2011, extending from Lomonosov northward to Kotlin Island (and the city of Kronstadt) and then turning east toward Cape Lisy Nos near Sestrotetsk.

Hydrology as a scientific discipline was formed in the beginning of twentieth century in Russia. The dependence of river runoff on altitudinal belts in mountain regions was studied by D.I. Kocherin. In 1927, he compiled a first map of the mean river runoff in the European part of the USSR (Kocherin 1927). M.A. Velikanov introduced the methods of

Fig. 1 Kronstadt Fußstock (tide gauge) with the flood water level of 1824. The zero of the Kronstadt gauge in the Gulf of Finland is taken as the basis for all governmental leveling works in Russia and is furthermore the reference height in many other Eastern European countries

Fig. 2 St. Petersburg's Karusel'naya Square (now Teatral'naya Square) during the 1824 flood. Painting by Fedor Yakovlevich Alekseev (1824)

mathematical statistics for hydrological calculations (Velikanov 1938). At the same time, the idea of a “geographical-hydrological method” of investigations based on possible dependencies between the amount of water in a particular region and the geographical landscape and its components was presented by Glushkov (1933). Mouravevsky 1946 further developed this method and presented the runoff as a geographical factor. The methods of hydrological prognosis started to be developed since the 1930s (Appolov et al. 1960). The first maps of the mean runoff for the territory of the USSR were drawn by Zaikov and Belinkov (1937). The historical distribution of peak flows and floods were analyzed by Zaikov (1954). The “Water cadaster of the USSR” (Sokolovskii 1939–1947)

was published, later continued by the “Hydrological yearbook.” A flood hazard information and forecast service is operational throughout the Russian Federation for all cities and settlements exposed to flood hazards. Recently, the consequences of floods started to be presented following the internationally recognized terminology (see contributions in this special issue).

1.4 Droughts

Systematic studies of droughts were started in the second half of the nineteenth century. K.S. Veselovskii made a first attempt to characterize the conditions of humidity and aridity of various climatic zones in Russia (Veselovskii 1857). However, over many years droughts were exclusively considered as negative influence on the crop capacity, and the published catalogues for the territory of Russia were based on data on the crop capacity of grain (Meshcherskaya et al. 2000). A number of the droughts criteria were proposed and different types of droughts were recognized: atmospheric, soil and mixed type (Selyaninov 1928; Pogosyan 1952; Baidal and Uteshev 1959). The conditions of and reasons for the drought formation were in focus of numerous studies during the twentieth century and beyond, involving the network of agro-meteorological stations. This network was established in the 1940s and 1950s and included more than 2000 stations at the peak of development, 1500 of which are still in operation today.

1.5 Snow avalanches

Snow avalanches, though not the most dangerous phenomena in terms of quantity of victims and degree of destruction, became one of the major research emphases in Soviet/Russian risk science. The review of the history of snow avalanche research in Russia can be found in Bozhinskiy and Losev (1998) and in Pudasaini and Hutter (2007) who report the first observations on snow avalanches from the nineteenth century along the Georgian Military Road (an approximately 200-km-long road connection between Tbilisi, Georgia and Vladikavkaz, Russia). It has been repeatedly been stated that the first Russian map of areas endangered by snow and ice avalanches was drawn for this region in 1855 by B.N. Statkovskii. In particular, the region around Mt. Kazbek (5047 m a.s.l.) is well known for the repeating catastrophic snow and ice avalanches affecting the road and in consequence raising the scientific interest on the topic due to the importance of the route for the Russian economy (Palibin 1884). The information on snow avalanche events was included in the “Chronological lists of notable natural events” which was part of the “Kavkazskii kalendar” (“The Caucasian Calendar”) annual serial since 1851.

The wide territory of Russia and the variety of climatic regimes requested for a method of hazard assessment based on a combination of geomorphological and meteorological factors responsible for snow avalanches formation. The basis for the “Geography of snow avalanches” was laid in the beginning of 1960s (Tushinskii 1970). The methods of forecast for snow avalanches of different genetic types were subsequently developed by the Hydrometeorological Service of the USSR, and the theories of formation, movement and deposition of snow avalanches were developed (Bozhinskiy and Losev 1998). Further, the mathematical equations to calculate the main dynamical characteristics of snow avalanches were suggested (e.g., Blagoveshchenskii 1991).

At present time, the Russian snow avalanche scientists maintain close contacts with their European and US colleagues. Numerical models such as RAMMS and SNOWPACK are tested and used in the conditions of the Russian regions, and the studies in the field of

snow avalanche risk are actively developing (Seliverstov et al. 2008; Shnyparkov et al. 2012; Fuchs et al. 2013; Komarov et al. 2016).

1.6 Debris flows

The first studies on debris flows were also related to their influence on the Georgian Military Road (Statkovskii 1859). At the end of nineteenth and beginning of the twentieth century, the first descriptions of debris flow processes and their catastrophic consequences were published in Russia (Pyl'tsov 1904). The first regional summaries on debris flows and mitigation measures can be found in the publications of Brilinskii (1936), Trofimov (1937), Kocherga (1937). The most productive period of studies on debris flows was between the 1960s and 1980s: A first summary on the geography of debris flows on the territory of the USSR was prepared by Lopatin (1964), and the cadastre of debris flow basins was published (Raushenbakh 1967; Khmaladze 1969). The first small-scale (1:8,000,000) "Map of the debris flows-endangered regions of the USSR" was constructed in 1975 and published together with a descriptive monograph (Fleishman and Perov 1976). The methods of debris flow investigations and a description of the mechanics of debris flows were summarized (Stepanov 1982; Stepanov and Stepanova 1991). In the 1990s, a first glossary of debris flow process appeared (Perov 1996) and a 1:15,000,000 "Map of the debris flows-endangered regions of the World" (Perov et al. 1997) was published.

The complete bibliography of the Russian, Soviet and post-Soviet scientific publications on all aspects of debris flow research in the country was published for the 1850–1968 period by Vlasov and Krasheninnikova (1969), for the 1969–1991 period by Vlasov (2008) and for the 1992–2009 period by Vlasov (2017).

1.7 National overview on natural hazards and risk

The variety of climatic, geological, lithological, geomorphological and orographic conditions determines the presence of practically all possible types of natural hazards at the Russian territory. The Russian communities and industry was numerously affected by different types of dangerous natural phenomena of different extent. The geography of the distribution of the most catastrophic natural hazards is presented in Fig. 3. The most frequent large catastrophic natural hazards were noted in the center of the European part of Russia, the North Caucasus, Primorsky Krai, Sakhalin, Kamchatka. The European part of Russia and Primorsky Krai are mainly exposed to natural hazards related to hydrometeorological processes and events, while North Caucasus, Sakhalin and Kamchatka related to earthquakes, snow avalanches and debris flows.

Annually, 150–250 emergency situations are registered in the territory of Russia. Their dynamics beginning from the 1990s is shown in Fig. 4. The lowest quantity of emergency situations was reported in 1993 (127) and the highest in 1998 (465). The mean quantity of emergency situations is 208, and the mean quantity of fatalities is 142.

The causes of the natural hazards can be divided as the following: 35% floods; 19% strong winds, tornadoes and windstorms; 14% heavy precipitation; 8% earthquakes; 7.5% heavy snowfalls and blizzards; 5% landslides, rockfalls and debris flows; 3% intensely cold weather and frost hazards; 2.5% snow avalanches; 2% droughts; 1% hail; and 1% icing, undercutting and karst collapses. Thus, more than 82% of all hazards affecting the territory of Russia are of hydrometeorological origin. The seasonal dynamics of hazards for the entire territory of Russia shows a gradual increase in the quantity of emergency situations

Fig. 3 Distribution of the most catastrophic natural hazards in the territory of Russia (Petrova and Shnyparkov 2004a): 1 earthquakes, 2 floods, 3 landslides, snow avalanches, debris flows, 4 strong winds, tornadoes, 5 frosts, snowfalls, blizzards

Fig. 4 Dynamics of the emergency situations due to natural hazards in the territory of Russia for the period between 1991 and 2015. The dotted line shows the trend in the number of emergency situations; the solid line shows the dynamics of the number of fatalities because of the natural hazards. Data for 2015 include only January till June

from winter to summer, following a decrease from summer to winter (Petrova and Shnyparkov 2004b).

The spatial distribution of emergency situations over the territory of Russia is similar in the twenty-first century compared to the past, with a cluster in the Northern Caucasus and along a region spanning from west to east from the center of the European part of Russia along the Kazakhstan border in the south up to the Transbaikial and in the south of the Primorsky Krai, Sakhalin and Kamchatka (Fig. 5).

Floods are prevailing in all regions of Russia except the North-West and Central Federal regions, where strong winds are the dominant hazard type. Annual fatalities are about 30–60 persons with some exceptional years where up to several thousand fatalities are observed. The maximum number of fatalities is a result from endogenic processes, corresponding to 90% of all fatalities, and 97% of the victims correspond to earthquakes and floods. Around 70% of the cities of Russia are exposed (Kurbatova et al. 1997), and in particular, heavy floods are a threat to 190 municipalities, whereas a total of 560 cities are affected by floods of medium and lower magnitudes. Strong winds are possible in all Russian cities, and about 100 settlements were damaged by strong winds and tornadoes in the last decades. About 110 cities are situated in zones affected by strong earthquake zones ($M \geq 7$) with a population higher than 12 million. Almost everywhere in the country, strong snowfalls and blizzards are possible. The undercutting of river banks resulting in landslides and rockfalls is possible in 550 cities. Tsunami is a threat to 14 cities. Snow avalanches are directly affecting eight cities and indirectly (destruction of communication lines) affecting another 35 cities; these figures for the debris flows are eleven and 32, respectively. The summarized economic loss due to natural hazards in Russia was estimated with 20–40 million US\$ (Osipov 2009).

Fig. 5 Spatial distribution of natural emergency situations in the territory of Russia for the period 1990–2009 (without the Crimea)

2 Content of individual contributions

On the national level of the Russian Federation, Osipov et al. (2017) present the most dangerous natural hazards that may cause considerable economic loss as well as fatalities and injuries. The history of studies in the assessment of different natural risk indices with respect to different end users is described, and the conceptual instruments used in the assessment of these indices are discussed. Finally, the principle GIS-based methodical approaches to the assessment and mapping of natural risk are provided. The article concludes with an outlook on future research needs related to nationwide vulnerability assessments.

Approximately 20% of the territory of the Russian Federation is potentially affected by earthquakes with an intensity of VII and higher (MMSK-86 scale), including the Northern Caucasus, Altai, Sayany, the Baikal area, Yakutia and the Russian Far East, including Kamchatka, Sakhalin Island and the Kuril Islands. Frolova et al. (2016a) address methodological procedures for risk assessment and databases used for risk computation at different scales ranging from national to local. Challenges involved in the application of simulation models and respective input data needed for earthquakes loss estimation are discussed, with a particular focus on information and Web technologies used for verification of data on the built environment and underlying vulnerabilities.

Timely and suitable action immediately after a strong earthquake can result in significant benefits in saving lives and reducing the overall and long-term impact of such events on the economy. Frolova et al. (2016b) describe how prompt and reliable information on losses may enhance emergency response and recovery. In their article, the authors analyze the factors which influence the reliability of earthquake impact simulation under emergency situation with a particular focus on an increase in reliability of loss assessment. The authors show how the reliability of loss assessment output of global models is directly dependent on the quality of input data and on the quality of simulation models. Main constraints on the accuracy and reliability of loss estimation result from input data on earthquake parameters (about 50%), model assumptions and regional parameters used for intensity simulation (about 30%), and model assumptions and parameters used for the simulation of damage to buildings and impact on population (about 20%).

In the contribution of Kazeev and Postoev (2016), pure scientific and applied research on landslide hazard and risk is presented with a focus on both the territory of the Russian Federation and the former Soviet Union. This research included a broad spectrum of studies on landslide processes based on monitoring data collected at specialized stations nationwide, as well as the data collected and analyzed by various government and academic research institutions. The contribution summarizes a vast body of knowledge encompassing an inventory of landslide cases, an overview of mechanisms of landslide development, monitoring and slope stability assessments. A new mechanism-based landslide classification is proposed, and a practical method of increasing slope resistance is presented.

Frolova et al. (2016c) present an evaluation of various aspects of hydrological hazards in the Russian Federation at different scales. A temporal assessment has shown an increase in the number and associated losses of hydrological hazards. With regard to floods, an interesting spatial pattern can be observed: While in the Asian part of the country the number of floods has increased, in estuarine areas in the European part of Russia the number and intensity of floods have significantly reduced since the middle of the twentieth century, especially in the 2000s. It is discussed in the contribution that these dynamics can

be attributed to flood runoff in the mouths of regulated rivers, with an effective system of flood and ice jam protection. An integrated index accounting for flood hazards and socioeconomic vulnerability was calculated for each region of Russia. Subsequently, a classification of flood risk is presented, taking into account more than 20 hydrological and socioeconomic parameters. Finally, hazard and vulnerability maps for the entire country were generated which can be used for water management and the development of future water resources plans.

The contribution by Shalikovskiy and Kurganovich (2016) proposes a hybrid approach to assess flood risk for the Russian territory combining quantitative and qualitative indicators. The article describes various methods to assess the flood risk, such as likelihood and magnitude of flooding, average annual damage and maximum damage. The authors present two types of flood risk maps: a first type intended to define the mathematical expectation of damage zones for reference buildings with possibility of risk calculation for other buildings using multiple factors and a second type of maps which is designed for the purpose of land use regulation and was based on a priori statistical estimates of flood risk.

Hydrological hazards at river mouths of the Northern Dvina and the Pechora rivers are presented by the contribution of Magritsky et al. (2016). The article is based on results of long-term monitoring, detailed studies and numerical simulation of hydrological hazards at the river mouths of the two major rivers in northern European Russia. Main hydrological hazards described include dangerous ice phenomena, inundations from both pure maximum stream flow and peak discharges with ice jams, surge-induced flooding, wind-induced down-surges, low-water periods and seawater intrusion into the delta branches. These hazards repeatedly caused significant socioeconomic loss and environmental damage to the adjacent riparian areas. Causes and characteristics of hydrological hazards have been evaluated and considered with respect to features, pattern and factors of their long-term, seasonal and spatial variability using statistic methods, remote sensing data and numerical simulation. Furthermore, the impact of regional climate change and economic activities is discussed.

The contribution of Agaonova et al. (2016) deals with dangerous ice phenomena on the lowland rivers of European Russia. Based on computation and modeling, the authors present flood dynamics on the basis of observations of 300 hydrological stations for the period between 1936 and 2013. The dynamics in the characteristics of the ice phenomena occurs under conventionally natural (primarily climatic) and anthropogenic factors. A diversity of natural conditions and degree of climatic changes within European Russia has allowed the authors to identify the main stages of the ice regime changes in the current climatic conditions.

Vinogradova and Vinogradov (2017) report on the experimental results of the artificially triggered debris flows experiments in the Chemolgan river basin, Kazakhstan, 1972–1976. These experiments, organized by the Hydrometeorological Research Institute of Kazakhstan (KSRHI, present successor: Kazhydromet), were the first full-scale experiments with detailed recording of multiple debris flows characteristics in the channel bed of approximately 7 km length. While some of the results have already been available to the international scientific community (e.g., Rickenmann et al. 2003), most of the material is still published in Russian (Khonin et al. 1976). Given the fact that these experiments were conducted quite early in the history of quantitative scientific research, the results were influential in stimulating further works on erosional and depositional patterns of debris flows. The movie about this experiment is available as online supplement to this special issue.

Perov et al. (2017) report on regional characteristics of debris flow hazards in Russia. Spatial features of debris flow processes within the country are analyzed, and a map of debris flow hazards in Russia is presented based on a classification of debris flow hazard areas into two zones, six regions and 15 provinces. Furthermore, an inventory of remarkable debris flow events is shown, with some parameters of their magnitude and impact. Major events are reported from Kamchatka–Kuril, the North Caucasus and the Baikal Province.

The contribution of Kazakova et al. (2016) deals with a large-scale assessment of snow avalanche and debris flow hazards in the Sakhalin region, Russian Federation. Their work explores the challenges of hazard assessment for urban areas exposed; more than 60 settlements are at risk of snow avalanches and more than 30 settlements for debris flow hazards. Data are provided for avalanche and debris flow events that occurred in the Sakhalin region between 1928 and 2015. In their paper, the method for the design of hazard maps is described, providing the starting point for any planning constraints in general settlement planning schemes. These maps further allow conducting an assessment of avalanche and debris flow risk within a short time period for a larger territory and at minimum cost.

The final contribution contained in this special issue is presented by Makitov et al. (2016) on research of hailstorm formation and development over the central part of the Northern Caucasus. The authors report radar observations which provided the basis for further computation and which were carried out continuously from the moment of the first radar echo registration until complete dissipation of the hailstorm. The distribution of the hailstorms first radar echo formation zones over the study area was compiled, and areas with the maximum frequency of the hailstorms first radar echo formation were defined. Hailstorm trajectories were analyzed, and the dynamic parameters of the hail core formation and development were evaluated. The paper ends with a comparison of hail storm characteristics in the Northern Caucasus with the hail storms of Mendoza, Argentina, and Alberta, Canada.

Acknowledgements We would like to express our sincere thanks to the entire team of the Editorial Office of Natural Hazards. Moreover, we would like to acknowledge the efforts of all the reviewers who supported this special issue with their knowledge on different aspects of natural hazard risk management and their constructive advice that helped us and the authors to further develop the individual ideas presented in the papers. We would also like to thank all the colleagues who contributed to this special issue, above all for their patience during the process of manuscript production and revision. The support of the Russian Science Foundation Grant No. 16-17-00104 “Snow avalanches and debris flows risk at the territory of Russia: estimation, forecast and mitigation measures” is highly appreciated.

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