Russian Journal of Earth Sciences, Vol. 22, ES01SI05
https://doi.org/10.2205/2022ES01SI05

Russian Journal of Earth Sciences

Special Issue: "Fundamental and Applied Aspects of Geology, Geophysics and Geoecology"

Results of monitoring of hazardous natural processes in the Belaya river basin

E. V. Kyul*[,1], N. V. Kondratyeva[2], M. M. Gedueva[1], and D. R. Dzhappuev[1]

[1]*Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences, Nalchik, Russia*
[2]*High-Mountain Geophysical Institute of Roshydromet, Nalchik, Russia*

Received 1 July 2021; accepted 10 August 2022; published 20 October 2022.

The main purpose of the research is to identify the presence of hazardous natural processes in the Belaya River basin. For this, field monitoring of hazardous processes was carried out according to the methodology developed and tested in the study of the Central Caucasus using technical means (GPS – survey of the study area and measurement of the characteristics of economic objects using a range finder). Based on the monitoring data, a digital cartographic visualization of the results was carried out, and an inventory of the flood and mudflow hazard of the river basin was compiled White. The monitoring results showed that the river basin. Belaya has an average degree of susceptibility to hazardous exogenous natural processes of various types – an average degree for mudflow processes, while the flood hazard can be an order of magnitude higher due to some natural and anthropogenic factors. Therefore, the annual geoecological monitoring of hazardous natural processes is necessary to assess the actual natural hazard of the region under study.

Keywords: monitoring, hazardous natural processes, river basin, national economic objects, digital cartographic basis, cadastre.

Citation: Kyul, E. A., N. V. Kondratyeva, M. M. Gedueva, and D. R. Dzhappuev (2022), Results of monitoring of hazardous natural processes in the Belaya river basin, *Russian Journal of Earth Sciences*, Vol. 22, ES01SI05, doi: 10.2205/2022ES01SI05.

1 Introduction

In recent years, the mountainous part of the northern slope of the Greater Caucasus has been well developed, and at the same time resource–intensive branches of the economy are developing new for this region. This leads to the fact that there is an activation of almost all types of hazardous natural processes (HNP), the nature of the descent of which often becomes catastrophic. The Belaya River basin is no exception.

The Belaya River, a left tributary of the Kuban River, a tributary of the 1st order, a river in the European part of Russia, in the western part of the Greater Caucasus, in the Krasnodar Territory and the Republic of Adygea [*All rivers*, 2019; *Water of Russia*, 2019; *State water register*, 2019; *Lurie et al.*, 2005] is shown in Figure 1 The origins of the r. Belaya are located at an altitude of 2300 m on the northern slope of the Main Caucasian ridge. The Belaya River flows into the Krasnodar reservoir, forming a delta with an area of 57 km^2. The Belaya River in length (273 km) is the longest tributary of the Kuban River, in area (5990 km^2) – the second after the Laba River. The main tributaries of the Belaya River: Kisha and Dakh (right), Kurdzhips and Pshekha (left). In the upper part (up to the village of Kamennomostskiy) the river bed is a narrow gorge, in the middle reaches (up to the city of Maikop) it is moderately meandering and weakly branched, in the lower section to the confluence of the left tributary of the river. Pshekha, moderately meandering, and downstream – it changes to very meandering, with a large number of islands, a sandy bed and low banks.

The width of the river also varies from 5 m in the upper reaches to 50–80 m in the lower reaches (below the city of Belorechensk). The average long–term water discharge also varies from 29 m^3/s in the upper reaches of the river to 109 m^3/s above the Belorechensk reservoir and 42 m^3/s below the reservoir. The river is fed mainly by rain. The river usually has a spring-summer flood (beginning in March and ending in August), as well as floods throughout the year. At the same time, the water level can fluctuate in the range of up to 2 m. The annual water runoff is 39, 24, 16 and 21%, respectively, in spring, summer, autumn and winter.

*Corresponding author: m.gyaurgieva@mail.ru

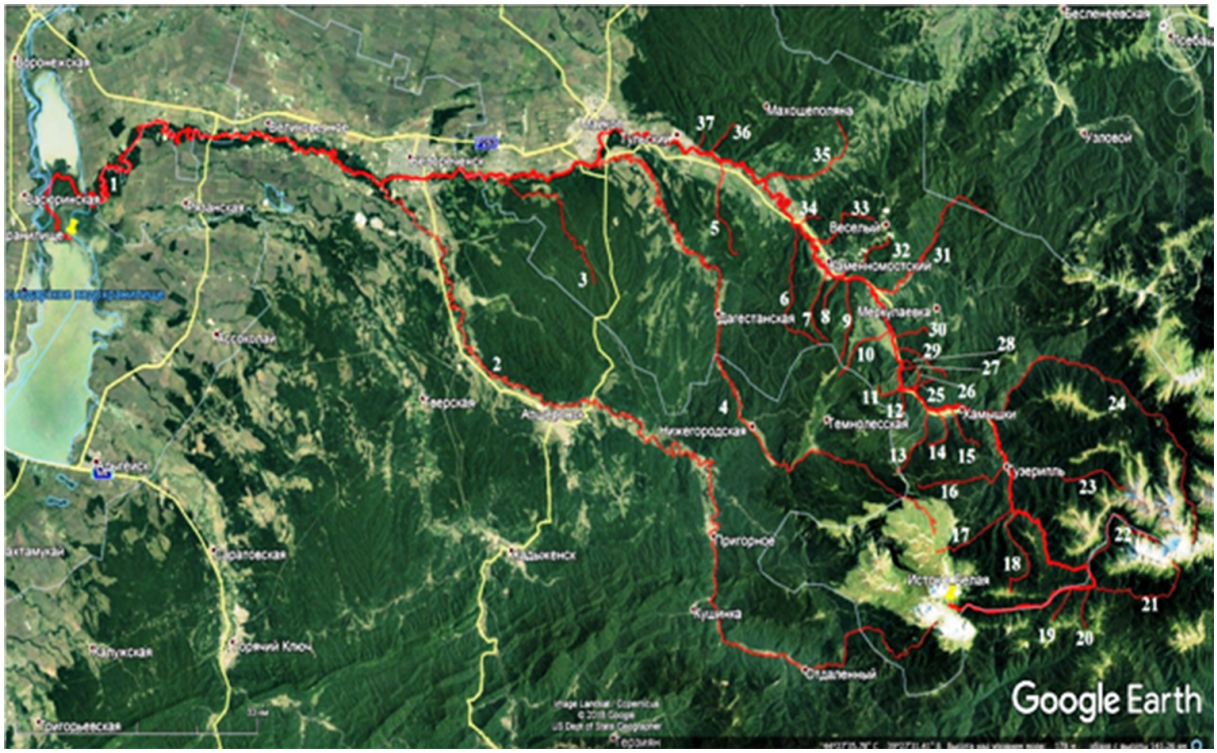

Figure 1: Hydrographic diagram of the study area. River basin White. 1 – Belaya R. 1st order, left tributary of the Kuba R.
Main tributaries of the Belaya (from the mouth counterclockwise): *Left tributaries of the 2nd order:* 2. – Pshekha R., 3. – Khanka R., 4. – Kurdzhips R. (Sukhoy Kurdzhips), 5. – Shuntuk R., 6. – Polkovnitskaya R., 7. – Aminovka R., 8. – Mezmay Creek, 9. – Rufabgo Creek, 10. – Doguaco R., 11. – Sibirka R., 12. – Sashkova R., 13. – Bzykha R., 14. – Khamyshanka R., 15. – Lipovaya R., 16. – Zholobnaya R., 17. – Armyanka R., 18. – (Mutnyj) Teplyak R. *Right tributaries of the 2nd order:* 19. – Kudo R., 20. – Malaya Chura R., 21. – Beryozovaya R., 22. – Chessu R., 23. – Molchepa R., 24. – Kisha R., 25. – Blokgausny Creek, 26. – Grushevaya R., 27. – Zolotoy Creek, 28. – Lipovy Creek, 29. – Syuk R., 30. Gruzinka R., 31. Dakh R., 32. Mishoko R., 33. Middle Khadzhokh R., 34. Small Khadzhokh R., 35. Fyunt R., 36. Maykopka R., 37. Chumnaya Balka R.

On the river Belaya 3 reservoirs: Tshchikskoye, built in 1940 near the mouth of the Belaya and included in 1973 as part of the Krasnodar reservoir; Maikop and Belorechenskoe, built in 1950 and 1954, respectively.

In general, the characteristics of the river. Beloyi points out that in this river basin, such dangerous processes as floods, floods and floods are possible, less often mudflows and alluvial floods, as well as associated HNP such as landslides, avalanches and taluses. Moreover, due to the presence of reservoirs, HNP can be anthropogenic in nature.

2 Materials and methods

Based on the analysis of a number of Cadastres [*Razumov et al.*, 2001; *Kondratyeva et al.*, 2015], literature on water resources [*All rivers*, 2019; *Water of Russia*, 2019; *State water register*, 2019; *Lurie et al.*, 2005], space images of different years of flight [*GIS-Lab*, 2015] and field research, a set of background (survey) maps M 1: 1,500,000 (exploration, development and exposure of the territory The Republic of Adygea (basin of the Belaya river) and the adjacent territories of the Krasnodar Territory: for the first time in the last 15 years, detailed surveys of the study area were carried out according to the degree of exposure to hazardous natural processes, taking into account the development of the territory (landscape analysis by type of land use) [*Kuhl and Borisova*, 2019]. For the main linear, in particular, highways and areal (settlements and recreational facilities) of economic objects according to the author's method [*Kyul*, 2020], a detailed inventory was made using additional technical means, namely, a survey of the study area using a GPS navigator and measurement of the characteristics of economic objects in the zone of their action using a range finder, which allows, in the future, to develop measures to reduce the level of exposure to hazardous processes to an acceptable minimum (picketage of emergency road sections with bridges, protective structures).

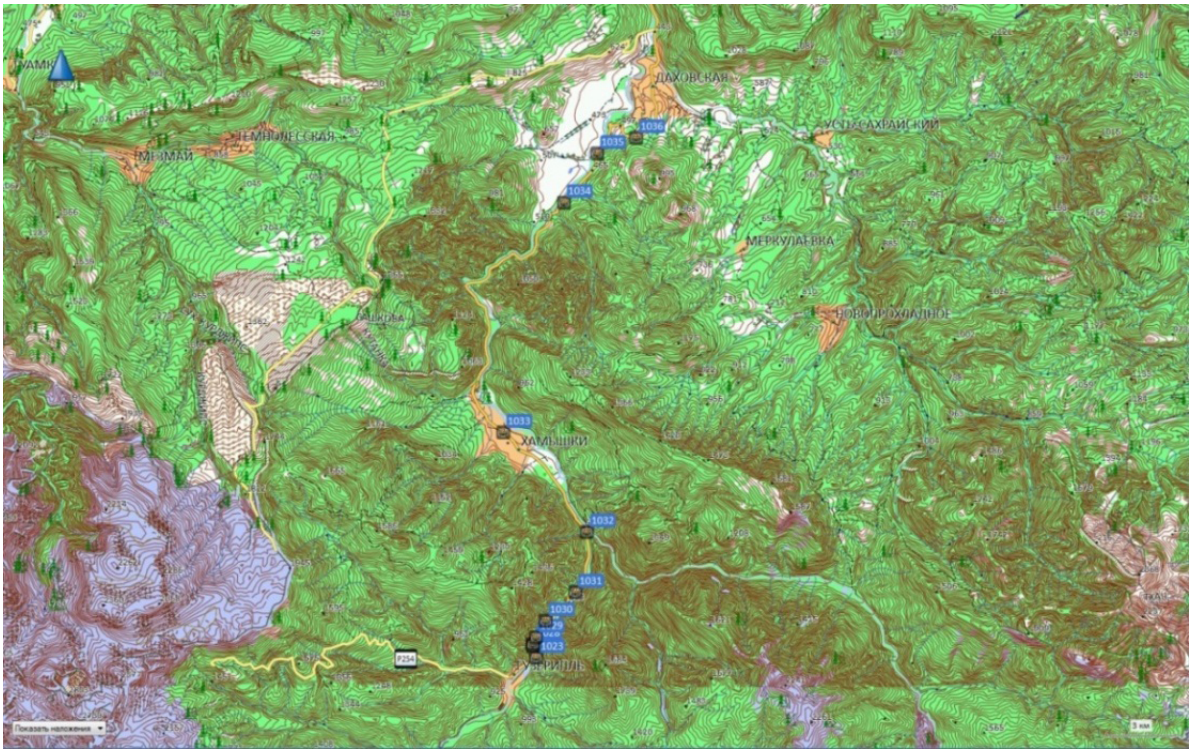

Figure 2: Survey points (GPS survey) of the Belaya River basin in 2019.

3 Results

During the geoecological field monitoring of the main river basins of the Western Caucasus for susceptibility to hazardous natural processes (avalanches, mudflows, landslides, avalanches, taluses and floods), the following main national economic objects were examined, namely, in the basin of Belaya and its two left tributaries of the 2nd order, the Kurdzhips and Pshekha rivers – 14 observation points, shown in Figure 2: 1) this is the Guzeripl village and a section of the Guzeripl – Dakhovskaya road with bridges, the village of Dakhovskaya and a section of the Dakhovskaya road – the Lago-Naki camp site, as well as a section of the Dakhovskaya – Maikop road; 2) along the Kurdzhips river – a section of the road Krasny Dagestan – Gumaika and the village of Nizhegorodskaya and the village. Gumayka; 3) Along the river. Pshekha – a section of the road of the village. Tsurevsky – the village of Chernigovskoe. Right tributaries, in particular the river. Kish were not surveyed, since they were well considered for avalanche and mudflow activity in the compilation of the Cadastre of the avalanche and mudflow hazard of the North Caucasus in 2001 [*Razumov et al.*, 2001] and the Cadastre of mudflow hazard in the South of the European part of Russia in 2015 [*Kondratyeva et al.*, 2015] The survey was carried out in the area of the location of linear economic objects, namely, highways. Based on the data obtained during the research, a digital cartographic base M 1: 100,000 was created for the territory of the Krasnodar Territory and the Republic of Adygea, as well as according to the results of certification and inventory – cadastres of mudflow and flood hazard for the Belaya River with left tributaries, the Kurdzhips and Pshekha rivers. Materials for the creation of interactive map-schemes have also been prepared for the study areas. With the help of the GIS–system, a raster layer (topographic base) was created, on which the next stage is created and added vector layers – the boundaries of the subjects of the Russian Federation, rivers, settlements, roads. When there is already a base, then a thematic layer is created, in this case it is a layer by points taken from a GPS navigator on hazardous natural processes in the Belaya and Malaya Laba river basins. Formed at this stage, the foundations of the map schemes for the regions where the surveys were carried out – the Republic of Adygea and the Krasnodar Territory, are shown in Figure 3. As a result of field research, based on monitoring data, an Inventory of flood and mudflow hazard in the Belaya basin (Republic of Adygea and the border areas of Krasnodar Territory) was compiled. The inventory is shown in Table 1.

To clarify the natural hazard for the main TPP (mudflows and floods) in the river basin. Beloi monitored the RIP in the summer of 2019 and identified the consequences of massive mudflows and floods, as well as areas of slopes with fresh traces of landslide and landslide and talus activity, formed as a result of surface washout, and led to the destruction of the road bed and their drift.

Table 1: Cadastre to the map of mudflow and flood hazard (Belaya river basin) based on monitoring results in 2019.

No.	No. by Cadastre [Kondratyeva et al., 2015]	Number according to the GPS navigator	Name of watercourse	The address of the mudflow basin	Genesis of mudflows/ flood	Maximum mudflow volume, W, m^3 (by analytical method) [Kondratyeva et al., 2015]	More info	Repeatability once every *n* years / date of descent	Type of dangerous natural processes
1	2	3	4	5	6	7	8	9	10
1–01	—	1043	R. Pshekha	Left tributary of the Belaya River	rain	—	Threat to the road and bridge	23.05.2019	Flood
		1042	R. Pshekha	Left tributary of the Belaya River	rain	—	Threat to the road and bridge	23.05.2019	Flood
		1042	R. Pshekha	Left tributary of the Belaya River	rain	—	Threat to the road and bridge	23.05.2019	Flood
		1041	R. Pshekha	Left tributary of the Belaya River	rain	—	Threat to the road and bridge	23.05.2019	Flood
		1037	R. Pshekha	Left tributary of the Belaya River	rain	—	Below p. Chernigov Threat to the road and bridge	23.05.2019	Flood
		1038	R. Tsitsa	Left tributary of the Pshekha River	rain	—	Above the village. Chernigovskoe. Threat to the road and bridge across the river Tsitsa	23.05.2019	Flood landslide array above and below the bridge
1–02	—	—	R. Khanka	Left tributary of the Belaya River	rain	—	—	—	Not surveyed
1–03	—	—	R.Kurdjips	Left tributary of the Belaya River	rain	—	—	22.05.2019	Flood
1–04	—	—	R. Shuntuk	Left tributary of the Belaya River	rain	—	Threat to Shuntuk settlement, road and bridge over the Shuntuk River	23.05.2019	Flood

At the same time, the existing system of protective mudflow and flood control structures (in most cases these are pipes of various diameters and from various materials, laid under the roadbed) is ineffective and requires repair or is simply absent.

In addition, for a correct forecast of flood and mudflow phenomena, it is necessary to additionally study nival-glacial processes, incl. glaciers and avalanches. This is extremely important for the study of avalanche processes in the area of the Lago-Naki recreation complex.

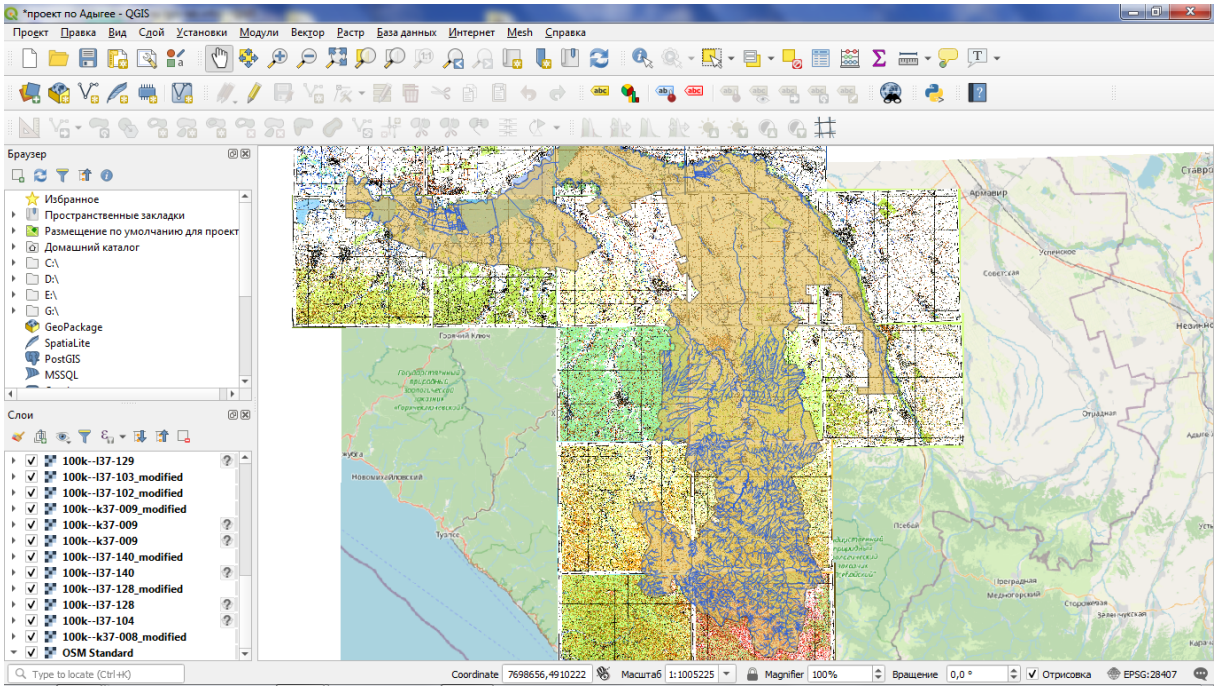

Figure 3: Screenshot of the digital base M 1: 200,000 on the territory of the Krasnodar Territory and the Republic of Adygea.

4 Conclusion

River basin Belaya has an average degree of natural, in particular, mudflow hazard. The susceptibility to flood processes can be an order of magnitude higher due to some natural (the presence of slopes with surface washout) and anthropogenic (a complex of reservoirs on the Belaya River) factors. In addition, stable changes in the climatic parameters of the mountain zone were found mainly during the period of mudflow and flood hazard in the region. Their direction indicates that the probability of the formation of hazardous natural processes in the mountainous regions of the North Caucasus does not decrease. And this must be taken into account when predicting the descent of the HNP.

Thus, it is necessary to carry out geoecological monitoring of landscapes, taking into account the development and dangerous natural process (DNP) with the expansion of the investigated territory and the capture of the foothill and plain zones. This will make it possible in the future to include in the assessment such types of DNP as karst, subsidence, erosion, flooding, as well as such unfavorable meteorological processes as drought, hail and others. This will make it possible in the future to make a complete comprehensive numerical integral assessment of the exposure of the territory of the DNP by a cartographic method, i.e. build a set of medium- and large-scale maps of the actual natural hazard (for the main types of DNP), taking into account the development. Zoning on the basis of such maps will make it possible to issue recommendations for the protection of the territory from the impact of NPP and reducing this impact to a minimum level.

References

All rivers, Information site about the rivers of Russia, https://vsereki.ru/, accessed: 2019-11-15, 2019.

GIS-Lab, Processing of multispectral images, https://gis-lab.info/qa/multispec-sat.html, accessed: 2019-12-06, 2015.

Kondratyeva, N. V., A. K. Adzhiev, M. Y. Bekkiev, M. M. Gedueva, et al., Cadastre of mudflow hazard in the South of the European part of Russia, *Nalchik: Printing House*, p. 148, (in Russian), 2015.

Kuhl, E. V., and N. A. Borisova, Geoecological zoning of the territory of the Republic of Adygea and Krasnodar Territory according to the degree of susceptibility to hazardous natural processes, in *Fundamental and applied aspects of geology, geophysics and geoecology using modern information technologies : V International scientific and practical conference, Republic of Adygeya, Maykop, May 20–24, 2019*, pp. 263–292, Materials of the V International Scientific and Practical Conference, 2019.

Kyul, E. V., Geoecological monitoring of dangerous natural processes, *International Journal of Ecology & Development*, *35*(2), 55–66, 2020.

Lurie, P. M., V. D. Panov, and T. Y. Yu., *The Kuban River: Hydrography and Flow Regime*, 500 pp., (SPb.: Gidrometeoizdat), (in Russian), 2005.

Razumov, V. V., V. V. Perekrest, N. P. Streshneva, et al., *Cadastre of avalanche-mud flow danger of the North Caucasus*, 112 pp., (SPb.: Gidrometeoizdat), (in Russian), 2001.

State water register, http://www.textual.ru/gvr/, accessed: 2019-11-15, 2019.

Water of Russia, Popular science encyclopedia, https://water-rf.ru/Water_objects/2150/White, accessed: 2019-11-15, 2019.