**Mud stream formation conditions and mud stream hazardous areas of the Chechen Republic**

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**Abstract.** Mud streams in the mountainous zone are formed almost everywhere in the Chechen Republic: on the northern slope of the Main Ridge and its spurs, the Skalisty, Pastibischny, Lesisty, Terskiy, Sunzhensky ranges and in the depressions between them. The conditions for the mud streams formation and mud stream hazardous regions of the Chechen Republic are determined by orographic tectonic-geomorphological, geological-lithological, soil-plant, anthropogenic and especially hydrometeorological conditions and affect the mud streams with their indicators. The variety and complexity of the relief, as well as the temperature regime, are used to predict the mud stream threat and develop anti-mud stream measures. The authors of the article provide the following indicators: air temperature regime, also values of average monthly and annual air temperatures, monthly values of vertical air temperature gradients in the Chechen Republic territory, changes in annual precipitation (mm) with terrain altitude above the sea level on the northern slope of the Eastern Caucasus, schematic map of orohydrography and mud stream channels of the Chechen Republic on a scale -1: 500,000.

**Introduction**

In the Chechen Republic, mud streams are caused by orographic, tectonic-geomorphological, geological-lithological, soil-vegetation, anthropogenic and especially hydrometeorological conditions. The latter directly affect mud streams by means of their following indicators: values and regime of air temperature, amount, composition, intensity of atmospheric precipitation, size and intensity of contemporary glaciation and snow cover melting, moisture content of the territory, presence of small rivers with large slopes of channels and their flood regime [1].

The variety and complexity of the relief, significant fluctuations in relative and absolute heights, combined with seasonal features of atmospheric circulation, create a great variety in the temperature regime on the territory of the Republic. In the high-altitude zone, the air temperature is also influenced by insignificant contemporary glaciation. In general, the typical air temperature is its increase from west to east, especially when considering its summer values, as well as its decrease with an increase in absolute heights for the territories under consideration (Tables 1, 2) [2].

**Material and research methods**

The intensity of the decrease in air temperature with altitude is not the same throughout the year. Throughout the territory under consideration, the smallest vertical air temperature gradients are observed
in the cold period (X-IV), and the highest in the warm (V-IX); more significant gradients are observed in its eastern part (Table 3).

**Table 1.** Average monthly and annual air temperature (°C) (western part of the Chechen Republic territory)

| M Station | Height, m | I    | II   | III  | IV   | V    | VI   | VII  | VIII |
|-----------|-----------|------|------|------|------|------|------|------|------|
| M Grozny  | 126       | -3.5 | -2.0 | 3.0  | 9.9  | 16.8 | 21.0 | 23.7 | 23.2 |
|           | 500       | -4.3 | -2.4 | 2.8  | 8.3  | 14.8 | 18.8 | 21.1 | 21.0 |
|           | 1000      | -5.3 | -2.9 | 2.6  | 6.3  | 12.3 | 16.0 | 17.8 | 18.2 |
|           | 1500      | -7.1 | -5.1 | -0.1 | 3.3  | 9.3  | 13.1 | 15.1 | 15.6 |
|           | 2000      | -8.9 | -7.3 | -2.8 | 0.3  | 6.3  | 10.2 | 12.4 | 13.1 |
|           | 2500      | -10.7| -9.5 | -5.4 | -2.7 | 3.3  | 7.3  | 9.7  | 10.6 |
|           | 3000      | -12.5| -11.7| -8.1 | -5.7 | 0.3  | 4.4  | 7.0  | 8.1  |
|           | 3500      | -14.3| -13.9| -10.8| -8.7 | -2.7 | 1.5  | 4.3  | 5.6  |
|           | 4000      | -26.1| -16.1| -13.4| -11.7| -5.7 | -1.4 | 1.6  | 3.1  |

**Table 1 extension.**

| M Station | Height, m | IX  | X   | XI  | XII | X-IV | V-IX | Year |
|-----------|-----------|-----|-----|-----|-----|------|------|------|
| M Grozny  | 126       | 17.8| 11.4| 4.4 | -0.6| 3.2  | 20.5 | 10.4 |
|           | 500       | 16.0| 10.2| 4.0 | -0.6| 2.6  | 18.3 | 9.1  |
|           | 1000      | 13.8| 8.7 | 3.5 | -0.6| 1.8  | 15.6 | 7.5  |
|           | 1500      | 11.4| 6.5 | 1.5 | -2.1| -0.4 | 12.9 | 5.1  |
|           | 2000      | 9.0 | 4.3 | -0.5| -3.6| -2.6 | 10.2 | 2.7  |
|           | 2500      | 6.6 | 2.1 | -2.5| -5.1| -4.8 | 7.5  | 0.3  |
|           | 3000      | 4.2 | -0.1| -4.5| -6.6| -7.0 | 4.8  | -2.1 |
|           | 3500      | 1.8 | -2.3| -6.5| -8.1| -9.2 | 2.1  | -4.5 |
|           | 4000      | 0.6 | -4.5| -8.5| -9.6| -11.4| -0.6 | -6.9 |

**Table 2.** Average monthly and annual air temperature (°C) (eastern part of the Chechen Republic territory)

| M Station       | Height, m | I    | II   | III  | IV   | V    | VI   | VII  | VIII |
|-----------------|-----------|------|------|------|------|------|------|------|------|
| M Grozny        | 100       | -0.1 | 0.9  | 4.0  | 13.4 | 19.7 | 22.8 | 26.4 | 25.2 |
|                 | 500       | -0.9 | 0.5  | 3.8  | 11.8 | 17.7 | 20.6 | 23.8 | 23.0 |
| M Botlikh       | 979       | -1.9 | 0.0  | 3.6  | 9.8  | 15.2 | 17.8 | 20.6 | 20.3 |
|                 | 1500      | -4.0 | -2.5 | 0.8  | 6.6  | 11.8 | 14.6 | 17.5 | 17.4 |
|                 | 2000      | -6.0 | -5.0 | -2.0 | 3.4  | 8.4  | 11.4 | 14.4 | 14.6 |
|                 | 2500      | -8.0 | -7.5 | -4.8 | 0.2  | 5.1  | 8.2  | 11.3 | 11.6 |
| M Sulak, high-mountain | 2923 | -9.9 | -9.7 | -7.2 | -2.6 | 2.2  | 5.2  | 8.5  | 8.9  |
|                 | 3000      | -10.0| -10.0| -6.8 | -3.0 | 1.8  | 5.0  | 8.2  | 8.8  |
|                 | 3500      | -12.0| -12.5| -9.6 | -6.2 | -1.6 | 1.8  | 5.1  | 6.0  |
|                 | 4000      | -14.0| -15.0| -12.4| -9.4 | -5.0 | -1.4 | 2.0  | 3.2  |

**Table 2 extension**

| M Station | Height, m | IX  | X   | XI  | XII | X-IV | V-IX | Year |
|-----------|-----------|-----|-----|-----|-----|------|------|------|
|           | 100       | 20.0| 13.6| 5.6 | 0.3 | 5.4  | 22.8 | 12.6 |
The average annual air temperature decreases, respectively, from 8.6 °C at an altitude of 1000 m, 6.2 °C - 1500 m, 3.6 °C - 2000 m, 1.0 °C - 2500 m, -1.5 °C - 3000 m, -4.1 °C - 3500 m to -6.6 °C at an altitude of 4000 m (Table 4). On average, the average annual air temperature for the territory under consideration is positive up to an altitude of 2800 m, above this altitude the average annual air temperatures are negative.

Average monthly positive air temperatures are observed up to an altitude of 4000 m in July-August. Above this altitude, the air temperature is negative throughout the year. During the cold period (X-IV), the average air temperature is positive up to an altitude of 1500-1600 m, above this altitude the average air temperature is negative. The average air temperature of the warm period (V-IX) is positive up to an altitude of 4000 m in July-August, and above this altitude it is negative [3].

Directly in the zone of contemporary glaciation, air temperatures are lower than at the same altitudes where there are no glaciers. When moving from rocky surfaces to a glacier, the air temperature drops sharply, that is, a "temperature jump" occurs, the magnitude of which is determined mainly by the size of the glacier. For small glaciers, such as the glaciers in the considered area, it is 0.5 °C [4].

The transition of the air temperature through 0 °C, i.e., the beginning of the mud stream dangerous period, observed at an altitude of 1000 m in the first decade of March, at an altitude of 2000 m is in the first decade of April and at an altitude of 3000 m in the second decade of May (Table 5).

Table 3. Monthly values of vertical air temperature gradients on the Chechen Republic territory (°C / 100 m)

| Month | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Year |
|-------|---|----|-----|----|---|----|-----|------|----|---|----|-----|------|
| 1     | -0.2 | -0.1 | 0.05 | 0.40 | 0.50 | 0.55 | 0.65 | 0.55 | 0.45 | 0.30 | 0.10 | 0.00 | 0.30 |
| 2     | 0.35 | 0.44 | 0.53 | 0.60 | 0.60 | 0.58 | 0.54 | 0.51 | 0.48 | 0.44 | 0.40 | 0.30 | 0.48 |
| 3     | 0.41 | 0.50 | 0.56 | 0.64 | 0.67 | 0.65 | 0.62 | 0.57 | 0.54 | 0.49 | 0.45 | 0.38 | 0.54 |

**Note.** * – These gradients were calculated by OVSNI NC HMC according to M Botlikh - M Sulak, mountain region.

**Research results and their discussion**

The average annual air temperature decreases, respectively, from 8.6 °C at an altitude of 1000 m, 6.2 °C - 1500 m, 3.6 °C - 2000 m, 1.0 °C - 2500 m, -1.5 °C - 3000 m, -4.1 °C - 3500 m to -6.6 °C at an altitude of 4000 m (Table 4). On average, the average annual air temperature for the territory under consideration is positive up to an altitude of 2800 m, above this altitude the average annual air temperatures are negative.

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Directly in the zone of contemporary glaciation, air temperatures are lower than at the same altitudes where there are no glaciers. When moving from rocky surfaces to a glacier, the air temperature drops sharply, that is, a "temperature jump" occurs, the magnitude of which is determined mainly by the size of the glacier. For small glaciers, such as the glaciers in the considered area, it is 0.5 °C [4].

The transition of the air temperature through 0 °C, i.e., the beginning of the mud stream dangerous period, observed at an altitude of 1000 m in the first decade of March, at an altitude of 2000 m is in the first decade of April and at an altitude of 3000 m in the second decade of May (Table 5).

**Table 4.** Average monthly and annual air temperature by altitude (°C) for the Chechen Republic territory

| Height, m | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | X-IV | V-IX | Year |
|-----------|---|----|-----|----|---|----|-----|------|----|---|----|-----|------|------|------|
| 100       | -1.8 | -0.6 | 3.5 | 11.6 | 18.2 | 21.9 | 25.0 | 24.2 | 18.9 | 12.5 | 5.0 | -0.2 | 4.3 | 20.9 | 11.5 |

**Note.** * – These gradients were calculated by OVSNI NC HMC according to M Botlikh - M Sulak, mountain region.
Due to the sharp dissection of the relief and large amplitudes of heights, atmospheric precipitation in the Chechen Republic is unevenly distributed. Their number varies from 480 mm at an altitude of 500 m, 630 mm at an altitude of 1000 m, 910 mm at an altitude of 2000 m and reaches a maximum of 1150 mm at an altitude of 3000 m. Above this altitude, the precipitation amount decreases and at an altitude of 4000 m it is 900 mm (Table 6).

**Table 6.** Change in annual precipitation (mm) with terrain height above the sea level on the northern slope of the Eastern Caucasus

| Height, m | Annual precipitation, mm |
|-----------|--------------------------|
| 500       | 480                      |
| 1000      | 630                      |
| 2000      | 910                      |
| 2200      | 960                      |
| 2400      | 1010                     |
| 2600      | 1060                     |
| 2800      | 1110                     |
| 3000      | 1150                     |
| 3200      | 1130                     |
| 3400      | 1080                     |
| 3600      | 1020                     |
| 3800      | 960                      |
| 4000      | 900                      |

**Table 7.** Average monthly, annual for cold (X-IV), warm and mud stream (V-IX) periods precipitation (mm) by heights
A small annual amount of precipitation is observed between the Skalisty and Glavny ridges, in the "rain shadow" zone, where its rate is 220-350 mm. [5].

Most of the annual precipitation falls on the warm, mud stream-prone period (V-IX) - 61-68% and only 32-39% in the cold (X-IV) with a maximum in May-July and a minimum in January-February. During the mud stream hazardous period, the territory under consideration receives an average of 65% of the annual precipitation (Table 7).

Accordingly, the vertical gradient of precipitation also changes with height, which up to an altitude of 3000 m is equal to 20-35 mm / 100 m. Above it, it is negative and as the absolute heights increase, it increases from -10 mm / 100 m at heights of 3000-3200 and up to -35 mm / 100 m at altitudes over 4000 m (Table 8).

### Table 7. Vertical gradients of atmospheric precipitation on the Chechen Republic territory

| Altitude zone, m | Vertical gradient, mm / 100 m | Altitude zone, m | Vertical gradient, mm / 100 m |
|-----------------|------------------------------|-----------------|------------------------------|
| 500-1000        | 30                           | 3000-3200       | -10                          |
| 1000-1200       | 35                           | 3200-3400       | -25                          |
| 1200-1400       | 30                           | 3400-4000       | -30                          |
| 1400-2800       | 25                           | more than 4000  | -35                          |
| 2800-3000       | 20                           |                 |                              |

### Table 8. Vertical gradients of atmospheric precipitation on the Chechen Republic territory

| Station                     | Height above sea-level, m | I    | II   | III  | IV   | V    | VI   | VII  |
|-----------------------------|---------------------------|------|------|------|------|------|------|------|
| M Grozny                    | 123                        | 18   | 16   | 25   | 32   | 53   | 70   | 57   |
| M Bamut                     | 345                        | 19   | 21   | 33   | 53   | 101  | 122  | 90   |
| M Vladikavkaz               | 668                        | 22   | 24   | 37   | 69   | 129  | 154  | 115  |
| M Vedeno                    | 715                        | 27   | 33   | 44   | 53   | 119  | 134  | 116  |
| M Sulak, high-mountain      | 2923                       | 34   | 41   | 67   | 128  | 158  | 169  | 135. |

| Station                     | Height above sea-level, m | VIII | IX   | X    | XI   | XII  | X-IV | V-IX | Year |
|-----------------------------|---------------------------|------|------|------|------|------|------|------|------|
| M Grozny                    | 123                        | 49   | 41   | 33   | 28   | 20   | 152  | 270  | 422  |
| M Bamut                     | 345                        | 69   | 58   | 37   | 31   | 21   | 215  | 440  | 655  |
| M Vladikavkaz               | 668                        | 85   | 75   | 46   | 34   | 24   | 256  | 558  | 814  |
| M Vedeno                    | 715                        | 107  | 87   | 56   | 39   | 26   | 278  | 565  | 843  |
| M Sulak, high-mountain      | 2923                       | 110  | 96   | 77   | 49   | 28   | 424  | 668  | 1092 |
Atmospheric precipitation in the territory under consideration falls in liquid, solid and mixed forms. At the same time, with height, the proportion of liquid and mixed precipitation decreases, and the proportion of solid precipitation increases. At an altitude of about 3000 m, solid precipitation makes up 100% in the period November-April, in other months their share decreases and in the mud stream-hazardous period (V-IX) it is only 23%. The share of liquid precipitation, on the contrary, increases and during this period they amount to 52% with the highest values in July-August (Table 9) [6].

Table 9. Average monthly amount of solid, liquid and mixed precipitation during the mud stream-hazardous period (X-IX) in mm, % of their total amount

| Station            | Height, m  | Months | solid | liquid | mixed | Total, mm |
|--------------------|------------|--------|-------|--------|--------|-----------|
| Sulak, high-mountain | 2923       | v      | 95    | 60     | 16     | 47        | 10        | 30    | 158 |
|                    |            | vi     | 25    | 15     | 85     | 50        | 59        | 35    | 169 |
|                    |            | vii    | 1     | 1      | 119    | 88        | 15        | 11    | 135 |
|                    |            | v     | 2     | 2      | 90     | 82        | 18        | 16    | 110 |
|                    |            | ix     | 28    | 29     | 39     | 41        | 29        | 30    | 96  |
|                    |            | v-ix   | 151   | 23     | 349    | 52        | 168       | 25    | 668 |

The greatest amount of precipitation, mainly in liquid form (heavy rains or steady downpours), during the mud stream-hazardous period falls at altitudes of about 3000 m, in the zone of non-sodded moraines. These sediments take an active part in the process of moraine material moistening and, consequently, in mud stream formation. Those precipitates that fall in a solid state during this period quickly melt and, like liquid ones, take part in the moistening of friable material, preparing it for movement. Due to the active development of convective clouds during the warm period of the year, steady downpours often fall on the territory under consideration. During the warm period in high-mountainous regions, heavy rainfall significantly prevails over steady downpours [7].

In high-water years, when the amount of precipitation during the cold period, which determines the soil moisture degree and the water content of rivers, exceeds their average long-term values and precipitation is observed in June - August above the norm, the rain mud streams probability increases sharply. The impetus for the mud stream process onset in these years can be a downpour with a precipitation of 25 mm / day. Also, for the years of average water content, showers of 50 mm / day, forming high floods, can serve as an impetus to the mud streams formation. Intense showers in the conditions of steep relief are instantly concentrated in temporary streams that can disturb the equilibrium state of friable material and landslide masses on the slopes. These movements, leading to the mud stream onset, coincide in time with the shower intensity maximums. The impulse to the mud stream process beginning is the maximum rainfall intensity of more than 0.1 mm / min. The critical rate of mud stream-forming precipitation in the area under consideration ranges from 25 to 50 mm per day. Heavy rainfall leads to the mud streams formation in the local areas of the Republic, and the frontal ones - on a significant territory. The precipitation amount for the previous months and the snow cover thickness characterize the moisture content of the territory. The climatic snow line here is 3980 m. It is the upper limit of the mud streams area [8].

Complex characteristics of mud stream phenomena
The Chechen Republic has 78 main mud stream channels, of which the following river basins are located: Fortanga - 5, Shalazha - 2, Gekhi - 1, Martan - 3, Goyt - 2, Sunzha - 2, Argun - 25, Sharoargun - 28, Dzhalka - 3, Khul-khulau - 4, Ansalta - 3. 58% of mud-and-stone streams, 33% of sedimentary and 9% of mud streams pass through them. Mud-stone mud streams play a leading role in high mountains 78%, and alluvial mud streams dominate in the middle mountains (62%) and low mountains (89%). Mud streams, which are the second most common in the middle mountains (29%), are inferior to mud streams in low mountains (7%) (Figure 1).
Figure 1. Schematic map of orohydrography and mud stream channels of the Chechen Republic

The solid component of mud streams in the highlands (more than 2000 m) are loose deposits of the rocky belt and fresh glacial moraines, in the middle mountains (2000-1000 m) - the material of ancient moraines, talus, avalanches, landslides, terrace alluvium, in the low mountains (less than 1000 m) - alluvial, diluvial-landslide, fine-detrital landslide deposits of erosional relief forms [9].

Mud streams of rain origin prevail (89%). There are no pure glacial mud streams, but mixed glacial-rain mud streams can form (8.5%). Snow mud streams are absent, snow-rain mud streams (1.5) and limnogenic mud streams (1%) are rarely formed.

Mud streams are formed at all altitude intervals, and their share increases from high mountains to low mountains. Glacial-rain mud streams follow the spread of contemporary glaciation, which in the Republic belongs to the scattered type, and is formed only in the highlands, due to glacial processes, mainly as a result of buried ice melting. Snow and rain mud streams are observed on the mid-mountain ranges slopes [10]. Limnogenic mud streams in the highlands are caused by the destruction of natural moraine dam and tarry moraine lakes, in the middle and low mountains - by the destruction of dams from landslide masses. Every year, the possibility of the anthropogenic mud streams formation, caused by the excess load on landscapes by irrational economic activities of a human and as a result of past military operations in the mountains, increases.

The debris flows volumes vary from tens to millions cubic meters. The most significant volumes are characteristic of mud streams that are formed in the regions of the Glavny Range northern slope and its spurs and in the North Jurassic depression, where in some cases they exceed 1 million m$^3$. Mud streams with volumes of no more than 10 thousand m$^3$ are observed in the areas of the forward ridges. Mud streams of small volumes (up to 10 thousand m$^3$) are formed almost annually, medium (10-100 thousand m$^3$) and significant (100 thousand m$^3$ - 1 million m$^3$), respectively, once every 1-5 years and once every 5-10 years old. Catastrophic mud streams (over 1 million m$^3$), on average, are formed once every 15-20 years [11].
On the territory of the Chechen Republic, the mud stream hazardous period in the highlands lasts from May to September, and the period of greatest danger is July-August, which is associated with the maximum precipitation and intense melting of snow and ice in the highlands, in the middle mountains - from April to September, in the low mountains from March to September.

Mud stream processes cause significant damage to all economy sectors of the mountainous regions of the Republic. Currently, mud streams periodically threaten 69 objects of the economy, including: 50 settlements and 19 sections of highways [12].

**Mud stream hazardous areas**

On the territory of the Chechen Republic mud stream basins are distributed unevenly, but it is clearly possible to distinguish areas of all 4 categories of mud stream hazard (Fig. 2). Based on the available materials, the entire mountainous zone of the Chechen Republic is subdivided into mud stream hazardous areas of all four mud stream hazard categories.

**LEGEND**

**MUD STREAM HAZARD CATEGORIES:**
- I category
- II category
- III category
- IV category

**WATER COMPONENT GENESIS**
- Snowmelt
- Glaciers
- Anthropogenic

**STREAM TYPE**
- Mud-and-stone
- Sedimentary

**OROHYDROGRAPHY**
- Peak and its height
- Glaciers
- Rivers
- Mountain passes

**BORDERSS**
- Chechen Republic
- Mud stream varying hazard categories

**INHABITED LOCALITIES:**
- Subject to mud stream hazard
- Non-subject to mud stream hazard

**ROADS**
- roads sections subject to mud stream hazard

![Figure 2. Schematic map of mud stream hazard areas of the Chechen Republic](image)

**I category region with high mud stream hazard is characterized by:**
- the development of large mud stream centers, mainly mud stream incisions, more than 3 km long, with their catchment areas 5 km² and more, or very active with current-generating surfaces with the least filtration coefficient, less than 0.01 mm / min; morphologically, the centers of dispersed mud stream are characterized by a dense network of furrows, potholes, trays of micro mud stream, landslides-streams, developing mainly on the bodies of large ancient landslides, less often in diluvial deposits; rocky hearths are confined to the landslide-talus slopes of ancient kars and trogs;
- the highest availability of liquid precipitation;
- the potential for the ice-rain mud streams formation as a result of buried ice melting;
- catastrophic discharge of high-density mud streams capable of exceeding 250 m³ / sec (for sediment mud streams);
- one-time volumes of removal is more than 1 million m³ (for mud-and-stone streams).
Within the Chechen Republic, there are three local areas of high mud stream hazard, confined to the large tributaries of the Argun and Sharoargun rivers. The first region is the mud stream basin of the Maistikhi river. It is a right tributary of the river. Argun and has a basin area of 97 km². Mud-stone mud streams are formed in this basin. The water component is formed by rare but intense heavy rains. The main types of mud stream centers are: 1 rocky mud stream center, 2 incisions and 9 centers of diffuse mud stream formation. The second region is the mud stream basin of the Khacharoyakhkriver, its right tributary. Argun, with a basin area of about 100 km² [13]. The mud-and-stone type mud streams of rain origin are formed here. Only the most powerful mud streams reach the river valley. Argun, where they formed an alluvial cone up to 350 m wide and up to 500 m long. Within the basin there are 2 incisions and 2 centers of dispersed mud stream formation. The third region is the mud stream basin of the Kenkhi river. It is a right tributary of the river. Sharo-Argun and has a basin area of 46 km³. Here mud-stone mud streams of rain genesis are formed. Partial accumulation of mud streams occurs at the mouth of the river Kenkhi, where a powerful fan is formed. Within the basin, there are 7 centers of dispersed mud stream, 5 incisions, 1 mud stream catchment.

In the main channels of the aforementioned mud stream basins, sedimentary mud streams can also be formed. The nature of the channels makes it possible to classify them as I category of mud stream hazard (basins of the Maistikhi and Khacharoyakhk rivers) and II category of mud stream hazard (basin of the Kenkhi river). The formation of sedimentary mud streams here is associated with the transformation of mud-stone flows as they move along the main channels.

Mud stream hazard period is May-September, with the greatest mud stream activity in July-August. The recurrence rate of catastrophic mud streams is 1 time in 15-20 years, large - 1 time in 5 years, small ones are formed annually.

**II category region with medium mud stream hazard is characterized by:**
- The presence of medium-sized mud stream centers: incisions with a length of 1-3 km, potholes with a length of 2-3 km, areas of their catchments 3-4 km², centers of dispersed mud streams, rocky centers, mud stream catchments, or runoff surfaces of medium activity with a filtration coefficient of 0.01-0.05 mm/m min;
- Flow rates of mud streams 250-100 m³/sec.;
- One-time volumes of mud streams removal from 100 thousand m³ to 1 million m³.

The area is orographically located between the Glavny and Skalisty ridges and covers the North Jurassic depression between them. In this area, foci are formed in diluvial rubble-clayey and landslide-talus sandy-carbonate deposits. A large mass of loose material for the mud streams formation is supplied by landslide flows in the upper reaches of mud stream rivers and numerous mud streams along their channels [12].

There are 30 centers of dispersed mud stream formation in the Argun basin, 21 incisions, 14 rocky centers, 9 mud stream catchments, 5 potholes. Here the most mud stream-prone are the channels of the Heldikhoyerk, Dzumserk, and Verdyerk rivers. In the Sharoargun basin there are 21 centers of dispersed mud stream, 19 times, 7 rocky centers, 3 potholes, 1 mud stream catchment. The most mud stream hazardous is the Dayakhk river bed. And in the south-east of the Republic, the upper reaches of the Ansalta river are dangerous.

Here, both mudstone and sedimentary flows are formed. The genesis of mud streams is mainly rain. Snow and rain mud streams are formed rarely.

The mud stream hazardous period is April-September.

The average frequency of mud streams is once every 5-10 years.

**III category region with low mud stream hazard is characterized by:**
- Development of predominantly small mud stream centers: mud stream catchments, potholes no more than 1 km long, rocky centers, centers of dispersed mud stream and single incisions, areas of their catchments of 2 km² or less, or weakly active drainage surfaces with a filtration coefficient of 0.05-0.1 m/min;
- Discharge of sedimentary flows 100-10 m³/s;
- Simultaneous volumes of mud-stone flows 100-10 thousand m³.
The area is orographically confined to the Skalisty and Pastbizhny ridges and the Shatoi depression. Rocky mud stream centers, confined to limestone cliffs, and the centers of dispersed mud stream are mainly developed on the Skalisty and Pasture Ridges. The latter represent an extensive network of furrows, couloirs, and talus trays. Despite the abundance of loose material, the foci are short, mud streams are rarely formed and they are of low thickness, due to the large number of karst forms that absorb most of the rather abundant sediments in this area. The Shatoi Basin is characterized by mud stream catchments and the centers of dispersed mud stream formation. In the eastern part of the region, the formation of mud streams is often associated with landslides-streams.

The following river channels are most dangerous: the upper reaches of the Martanka river (and its tributary, the Meredzhi river), Gekhi, Martan; in the basin of the Argun river - Syuzha, Varanda; in the upper reaches of the Dzhalka river - Alakskakh and Bass rivers; in the Khulkhulau basin in its right tributary Bulk, and in its upper reaches its constituent rivers Kharachoy and Okholitlau.

Here, mainly sedimentary mud streams are formed, much less often - mud-stone, mud flows are characteristic of the eastern part of the region. The genesis of mud streams is mainly rain. Snow-rain mudslides are rarely formed, which are the characteristic of the western part of the district, and limnogenic mud streams associated with landslides-streams are the characteristic of the eastern part of the district.

Mud stream hazard period is March-September.
Average frequency of mud streams is rare - 1 time in 10-15 years.

**IV category region with very low or potential mud stream hazard is characterized by:**
- discharge of sedimentary flows less than 10 m³/s;
- volumes of mud-stone and mud flows carried out less than 10 thousand m³.

The IV category of mud stream hazard also includes poorly studied areas or the areas where previously mud streams were not noted, but due to the ongoing changes in the natural environment, they may occur.

The area is orographically confined to the Lesisty (Black Mountains), Sunzhensky, Tersky ridges, where there are significant channel slopes, the presence of friable material or clayey, easily decaying rocks. In the eastern part of the Republic, within the Sunzhensky, Tersky ridges and the Black Mountains, there are valleys of permanent and temporary watercourses: gullies, ravines, ravines, potholes less than 1 km long, with widely developed landslide processes on clay slopes, where mud streams can form.

Basically, small sedimentary flows are formed in the area, caused by heavy rainfall. The formation of mud streams associated with anthropogenic activities in the areas of logging and construction is possible.

Mud stream hazard period is March-September.
The possibility of mud streams formation is very rare - once every 15 years or less.

**Summary**
The mud stream-hazardous period duration and mud stream activity at altitudes of more than 2000 m will increase in the coming decades in the North Caucasus, including in the Chechen Republic, due to climate warming, to an increase in the period duration of the positive air temperatures, an increase in the atmospheric precipitation amount, an increase snow line and increasing river flow. These phenomena will lead to an increase in the area of mud streams and the processes of frost weathering will increase the flow of significant masses of friable material necessary for the mud streams formation into the river beds. As a result of the landscape zones’ shift to higher elevations, the economic load in the most elevated parts of the Republic will increase, which will intensify anthropogenic mud stream processes there. The research data was obtained by the team of authors on the basis of the studied scientific and technical reports, which are summarized in the documents and publications of the high-mountain hydrometeorological research of the North Caucasus HMC department.

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