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Surface water and groundwater water interaction model in catastrophic floods and mudslides in the beds of mountain rivers

Nikita Tulenev
Russian Federation (n1tulenev@gmail.com)

Catastrophic floods and mudslides / mudflows are very dangerous disaster. Water volumes appear suddenly and continuously increasing in intensity and can spread with great speed, leading to catastrophic consequences – destruction and casualties [1]. These phenomena are typically nonlinear processes occurring in an open system with spatially distributed feedback [2].

Currently, most researchers consider as causes of such powerful water flows seasonal rapid melting of glaciers and intense rain showers. However, their localization is often in line with a separate small mountain river and dynamics of development raises a number of issues, primarily in connection with the justification of the amounts of water that are distributed on the surface and demonstrate the complex hydrodynamic behavior with obvious elements of self-organization.

Highlights in this project we consider the interaction of groundwater and surface water by means of the transport system 3D - cracks. In this case there are, two types of emissions to the surface of groundwater - the flash and relatively protracted continuous replenishment of surface runoff due to smooth outpouring of underground streams.

We rely on the concept, in which groundwater and surface water are not isolated systems, and is closely related to each other in the territory of a single watershed in the functioning of the overall transport system - 3D-network of cracks in the rock (visible manifestation of which is on the surface and the riverbed itself [3]).

Evaluative analysis of groundwater discharge into the river channel can hold a first approximation, by analogy with the artesian well, working in a mode of self-flowing. And in a similar way as it is possible to calculate the pressure at the bottom of the well based on its flow rate, we can estimate the pressure in the aquifer based on the amount obtained by mudflow or flood. In the case of a violent release according to our calculations, such pressure can reach tens of atmospheres. Such pressure may be due to various external factors (including seismic character).

In the event of a sharp increase in pressure under the influence of external factors, may occur short and violent eruption, which in mountainous terrain can form a mudflow. If pressure builds up gradually, which is more typical of the plains, the release can develop into increasing recharge the riverbed, which in turn may lead to flooding.

Thus, even if a catastrophic flood / mudflow originally formed for other reasons - because of melting glaciers or intensive / heavy rains, the presence on its way sectors fed by groundwater can significantly strengthen it.

If we talk about the comparison of these two models with the actual events taking place, the first time that may be associated with catastrophic flooding in Krymsk (July 2012.), And the second - the floods in the Amur River basin (September 2013) in Russia.

It is necessary to take into account the spatial extent of these dynamic phenomena. Groundwater resources are essentially spatially distributed. For example, the size of many artesian basins, ranging from hundreds to hundreds of thousands of square kilometers. Thus, the influence on the behavior of groundwater can have events that occur from them at a considerable distance. In particular, are essential earthquake.

Consideration of these tasks within the approaches of nonlinear physics can be very fruitful and constructive, not only in the fundamental aspect, but also for the development of advanced forecasting technology for mapping of acceptable risk in the operation of complex hydrodynamic systems.

1. Debris-flow. Hazards and Related Phenomena (Matthias Jakob, Oldrich Hungr), Springer, 2005, 745 p.
2. Nonlinear Science: Emergence and Dynamics of Coherent Structures, 2007, Alwyn Scott, 504 p
3. Trifonova T.A. Watershed as a self-organizing natural geosystem. Bulletin of the Russian Academy of Sciences. Geography, 2008, 1, p.28-36.