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# Regional based modeling approach for rainfall-induced debris flows in the continental-climatic Northern Tien Shan (SE Kazakhstan)

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The high mountain systems of Central Asia (Hindukush, Pamir and Tien Shan) are dominated by continental-climatic conditions. Nevertheless, westerly maritime air circulation and convective rainfalls during the summer season result in high rainfall intensities. In combination with a high availability of unconsolidated material rainfall triggered debris flows are prominent and intensive geomorphologic processes in these mountain areas.

The presented study aims to figure out a regional based modeling approach for rainfall-induced debris flow processes based on combination of a disposition model for debris flow starting zones with process-flow models. The investigation area has a size of about 700 square kilometers and is situated in the Northern Tien Shan mountains in SE Kazakhstan (investigation areas: valleys of Prochadnaja, Big Almatinka, Little Almatinka and Left Talgar). The area is characterized by mountain forest zone, alpine meadows and high-alpine glaciated areas with the highest peaks at 4500m.

In a first step the disposition (point of process triggering) of actual debris flows was analyzed. Due to different triggering mechanisms, the processes were divided into channel-type and slope-type debris flows. Detailed mapping of actual debris flows initiation areas and a GIS-based geostatistical disposition analysis are used to identify the main geofactor-variables and geofactor combinations which enhance the triggering of rainfall-induced debris flows.

It can be shown that both, longtime variable geofactors (such as local geomorphology and hydrology) plays a significant role for triggering debris flows, as well as mid- and short time variable geofactors. Especially actual permafrost distribution and degradation plus glacier retreat comes into the focus of interest. This is most notably for rainfall induced slope-type debris flows which primarily are triggered in the discontinuous and continuous permafrost areas eroding younger unconsolidated material from actual rock fall processes or little ice age moraines. In contrast, valley-type debris flows occur in steep and debris filled gauges and couloirs. In this context both, younger storages from recent mass movements as well as older and geomorphologically inactive slope talus and moraine material are eroded. They are notably significant even in the lower montane zone.

Based on the derived statistical correlations from the mapped processes potential points for debris flow cracks occurrences are calculated over the entire investigation area.

In addition to the disposition analysis and modeling, the debris flow process areas (transport zone and accumulation area) were calculated by an empirical-physical GIS-based approach combining a multiple flow-path model with a 2-parameter friction model, which originally was designed for wet-snow avalanches. The model parameters and therefore the simulated process flow behavior were calibrated based on the mapped process areas. The parameter settings for flow behavior were adapted to local conditions of the debris flow catchment area.

Overall, the presented investigations wants to give information on actual process behavior of debris flows in a continental-climatic mountain system as well as a possibility for GIS based regional hazard assessment and mapping.