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Surging glaciers everywhere? An updated inventory of surging glaciers for the Pamir Mountains derived from the analysis of multi-temporal optical satellite data

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Surging glaciers are one of the most fascinating events happening in nature, but the reasons for a surge to start or a glacier being of surge type or not are still poorly understood. Analysis of the published literature on surge-type glaciers revealed that their global occurrence is clustered in specific regions. Analysis of satellite data recently revealed numerous further surge-type glaciers as well as unprecedented details about the temporal evolution of glacier surges. The related studies revealed a high variability of surge types (e.g. regarding surge duration, frequency, advance rates, flow velocities) and provided new insights on the governing processes. Whereas extensive overviews with many so far not listed surge-type glaciers have been recently published for the Karakoram, western Kunlun Shan and north-eastern Pamir (Kingata Mts.), information on surge-type glaciers in the entire Pamir is only available from a historic database which lists about 80 glaciers that have surged back then but no detailed assessment from a more recent period (e.g. after 2000) is available.
In this study, we present a new inventory of surge-type glaciers for the entire Pamir considering earlier studies and a systematic analysis of Landsat satellite images acquired over the 1972 to 2018 period as well as Corona / Hexagon reconnaissance satellite images from the 1961 to 1980 period. Additionally, we used a 1968 DEM derived from Corona stereo images, the SRTM DEM from 2000 and the ALOS AW3D30 DEM from around 2009 to obtain surface elevation change patterns. Actively surging glaciers were revealed by analysing animations of image time series (25 years) and flicker images (between two years for all glaciers along with the elevation change pattern). The latter is well visible despite considerable DEM uncertainties and artefacts. We noted the timing of their surges (start, end), terminus advance rates, the type of surge (e.g. pulse-like, slow advance, tributary surge) and digitized all minimum and maximum extents.
In total, we identified almost 200 surge-type glaciers of which 5 are uncertain, as their characteristics are also compliant with an advancing terminus. The majority of the surging glaciers are clustered in the northern part of the study region, but very few of them are also in the southern part. Compared to the Karakoram or Kunlun Shan and as documented earlier, most surges in the Pamir are short lived (2-3 years), resulting in high flow velocities and a pulse like behaviour. All surging glaciers are valley glaciers, some of them are very small (0.3 km2), and interacting tributaries are common, i.e. the surge of one glacier is blocking the flow of another glacier (e.g. Bivachny). A small percentage surge internally (i.e. without an advancing terminus) and a few glaciers surged more than once or even twice during the study period (e.g. Medvezhiy). There is seemingly no consistency or clustering in the timing of surges, i.e. over the full study period they occur at any time.