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On the 'real' mass loss of some surging glaciers in the central Karakoram

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Several assessments of the mass changes of surging glaciers in the central Karakoram (and elsewhere) have shown near-zero changes over the typically decadal-long observation periods. This is in line with the theory that during a surge mass from a reservoir area is moved down-glacier to a receiving area with limited overall change. The resulting elevation changes of the glacier surface as determined by differencing DEMs from two points in time show a typical pattern (decreasing at higher, increasing at lower elevations) with a possible strong frontal advance (km scale) of the terminus. However, this is only half of the story as the observed mass gain at lower elevations is ultimately also a loss. This loss can only be determined when it is calculated separately and when sufficiently precise DEMs from the beginning and the end of a surge are available for each individual glacier.

As the latter are hard to obtain, this study presents a simplified geomorphometric approach to approximate a potential maximum surge volume for 20 glaciers with a channel-like glacier fore field. By assuming a semi-elliptical cross-section of the channels, simple measurements of their average width, height and length in Google Earth provide the volume. Further glacier-specific parameters are taken from a recently compiled glacier inventory (area, slope) and Google Earth (minimum length and highest/lowest elevations) to obtain characteristics such as elevation ranges and volume. The average annual specific volume loss for each glacier is then determined by dividing the calculated surge volumes by the respective glacier area and the duration of a full surge cycle (obtained in a previous study). Which glacier area (minimum?) and surge duration (only the active phase?) have to be taken for this calculation is likely a matter of debate.

With surge distances between about 1 and 5 km and channel widths (heights) between 300 and 700 (50 and 125) m, the surge volumes vary between 15 and 250 (mean 80) million km3. With a full surge cycle duration between 25 and 75 years, the corresponding annual mass losses vary between -0.05 and -0.25 (mean -0.13) m w.e. for the selected glaciers. Even if small, this bias is systematic and should thus be considered to tell the full story when calculating mass changes over a region with actively surging glaciers. At their maximum extent glaciers can be up to 23% (mean 11%) larger and 90% (mean 43%) longer than at minimum extent. Their minimum elevation can be between 200 and 1000 m lower.