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Identifying surging glaciers in the Central Karakoram for improved climate change impact assessment

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Several recent studies have investigated glacier changes in the Karakoram mountain range, a region where glaciers behave differently (mass gain and advancing tongues) compared to most other regions in the world. Attribution of this behaviour to climate change is challenging, as many glaciers in the Karakoram are of surge type and have actively surged in the recent past. The measured changes in length, area, volume or velocity in this region are thus depending on the time-period analysed and include non-climatic components. Hence, a proper analysis of climate change impacts on glaciers in this region requires a separation of the surging from the non-surging glaciers. This is challenging as the former often lack the typical surface characteristics such as looped moraines (e.g. when they are steep and small) and/or they merge (during a surge) with a larger non-surging glacier and create looped moraines on its surface. By analysing time series of satellite images that are available since 1961, the heterogeneous behaviour of glaciers in the Karakoram can be revealed.

In this study, we have analysed changes in glacier terminus positions in the Karakoram over different time periods from 1961 to 2014 for several hundred glaciers using Corona KH-4 and KH-4B, Hexagon KH-9, Terra ASTER, and Landsat MSS, TM, ETM+ and OLI satellite data. For the last 15 years, high-speed animations of image time-series reveal details of glacier flow and surge dynamics that are otherwise difficult to detect. For example, several of the larger glaciers with surging tributaries (e.g. Panmah, Sarpo Laggo, Skamri, K2 glacier) are stationary and downwasting despite the mass contributions from the surging glaciers. The analysis of the entire time series reveals a complex pattern of changes through time with retreating, advancing, surging and stationary glaciers that are partly regionally clustered. While most of the non-surging glaciers show only small changes in terminus position ($\pm$100 m or less) over the analysed time period, length changes of surging glaciers can exceed several kilometres with a continuum of advance rates and surge durations (from 2 to >10 years). Their highly variable extents have thus to be considered when glacier-specific volume changes and flow velocities are calculated.

In the presentation we will show our revised assignment of surging glaciers, their changing extents through time along with an analysis of their variable advance rates, and a spatio-temporal overview of glacier changes over the past 50 years.