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Large velocity fluctuations of Biafo Glacier, central Karakoram, between 2000 and 2009, at high spatial and temporal resolution from optical satellite images

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Recent observations suggest stable and advancing glaciers in the Karakoram, which contrast with mostly retreating glaciers in the Himalaya. The reason for the different glacier behavior in the Karakoram is not known and scarce mass-balance measurements on these glaciers have hampered a thorough assessment of trends in specific mass balances.

Here, we present surface-velocity measurements from the 63-km-long Biafo Glacier, central Karakoram, at high spatial and temporal resolution, derived from cross correlation of a dense time series of 25 ASTER optical satellite images. This time series provides evidence for significant velocity fluctuations between 2000 and 2009. We observe two different kinds of velocity fluctuations that are manifested in the ablation zone of Biafo Glacier. The first is seasonal and involves velocity changes of up to 150 m/yr between summer and winter. Such velocity fluctuations are well known from temperate valley glaciers and have been explained by increased basal sliding during summer. The second kind includes an acceleration phase of at least 2 years duration, with peak velocities in 2005, and a subsequent deceleration phase of at least 3 years. Changes in annual velocities during this time reach values of 100 m/yr and a downstream-migrating acceleration front. These interannual velocity fluctuations are restricted to the same parts of the glacier where we observe the seasonal velocity fluctuations and may therefore be related to similar processes that likely involve changes in the subglacial hydrology and basal sliding. Meteorological data from Pakistani weather stations close to the Karakoram suggest that during the acceleration phase, winters were relatively warmer and wetter than the long-term average, which would favor increased melt-water fluxes to the bed of the glacier.

Our data indicate considerable dynamics in the flow behavior of Biafo Glacier, which renders climatic interpretation of annual and maybe decadal changes in surface velocities problematic. While more detailed, ground-based studies are needed to better understand the physics and forcing of these interannual velocity fluctuations, our study has shown that sub-pixel cross correlation of optical satellite images is an accurate method to reliably measure surface velocities, which are on the order of $\sim$100 m/yr, on a monthly basis. This allows remote monitoring of glacier dynamics at high spatial and temporal resolution with relatively short lag times.