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Region-wide estimate of annual glacier mass balance for the Tien Shan and Pamir from 2000 to 2017

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The Tien Shan and Pamir, hosting more than 25'000 glaciers, act as important water towers for the dry, continental lowlands of Central Asia. Most glacier mass balance assessments focus on region-wide, decadal mass changes and only a few address seasonal or annual glacier mass balances. The regional annual variability is thus far poorly understood. However, it is essentially needed to improve our understanding of glacier runoff contribution. Here, multi-annual glacier mass changes derived from remote sensing were complemented with seasonal to annual mass balance series inferred from modelling closely constrained with repeated transient snowline observations on a regional scale.

To derive annual time series, transient snowline observations were used to calibrate an accumulation and temperature-index melt model for each year and glacier individually. The modelled decadal mass balance was constrained with glacier specific geodetic mass balances calculated from satellite stereo images. We calculated geodetic mass loss from 2004 to 2012 and annual surface mass balance time series from 2000 to 2017 for the Tien Shan and Pamir.

A geodetic mass loss of -0.52 $\pm$ 0.53 m w.e. yr-1 was calculated for the Tien Shan and -0.24 $\pm$ 0.43 m w.e. yr-1 for the Pamir from 2004 to 2012. First results from transient snowline-constrained modelling confirmed the decadal mass loss ranging from -0.36 $\pm$ 0.32 to -0.44 to $\pm$ 0.32 m w.e. yr-1 for 2000 to 2017 for the subranges Kyrgyz Ala-Too (Tien Shan), the Pamir-Alay (Pamir) and the Akshiirak range (Tien Shan). Lower rates of mass loss was encountered for the early years of the study period and exceptionally negative balances were found for most glaciers in 2008. Our results show a significant trend to increased mass loss for the Pamir-Alay and the Kyrgyz Ala-Too, accompanied with a moderate increase of the interannual variability with time. Annual variability is similar for the Kyrgyz Ala-Too and Pamir-Alay and is considerably smaller for the Akshiirak massif. For Akshiirak, the interannual variability seems to have increased in recent years, however, no significant trends in mass balance were observed.

Our time series, annually tied to transient snowline observations and linked to the geodetic estimates at the decadal scale, enable the analysis of yearly mass balance variability for glaciers in a region with few in situ measurements. Moreover, they deliver important baseline data for in depth analysis of the glacier response to climate fluctuations and enable to analyse the importance of glacier melt contribution to the hydrological cycle with an enhanced temporal resolution.