



Inter- and intraannual glacier elevation changes derived from TanDEM—X DEM data on the example of Inylchek Glacier, Tien Shan

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We investigate the potential of digital elevation models (DEMs) derived from high spatial resolution TanDEM-X (TDX) radar data to investigate glacier elevation changes in a high mountain terrain on an inter- and intraannual timescale. Such monitoring of glacier elevation changes is useful to estimate annual glacier changes and to identify potential hazards induced by rapid mass movement, such as glacier surges or increased glacier thinning rates. We used data acquired from the bistatic tandem formation of TerraSAR-X and TanDEM-X satellites in February 2012, March 2013 and November 2013 to generate DEMs by applying SAR interferometry. After proper alignment of the DEMs and correction of the radar penetration into snow and ice, we compared the elevation changes between TDX DEMs and C-band SRTM DEM from February 2000.

Results show mean mass balance changes of -0.24 ± 0.34 m w.e.a-1 for the northern Inylchek glacier branch and -0.13 ± 0.34 m w.e.a-1 for the southern Inylchek glacier branch for the timespan February 2000 to March 2013. An analysis of downwasting rates in the ablation area reveals mean elevation changes of -3 m per year at the northern glacier branch compared to -1.5 m per year at the southern glacier branch. Still, at higher elevations we identify also some areas with mass gain during the 2000 and 2013 period, which are mostly located in the accumulation areas of Southern Inylchek. Inter- and intrannual comparisons of the TDX DEMs alone reveal distinct patterns of mass gain and mass loss in ablation and accumulation areas of both glacier branches. The largest variations of the glacier surface of Southern Inylchek can be related to the influence of the subglacial Lake Merzbacher and an icefall in the accumulation area. Surface elevation changes of Northern Inylchek are also profound, but causes cannot easily be identified. Our study highlights the suitability of single-pair TDX DEM data to analyze inter- and intrannual glacier elevation changes due to the following reasons. First, the deviations between stable areas of all of the TDX DEMs are low (max. 0.1 ± 2.15 m). Second, the TDX DEMs are internally consistent: the sums of the independently calculated glacier elevation changes from 2012/02-2013/03 and 2013/03-2013/11 differ only by 0.07 m for Northern Inylchek and 0.03 m for Southern Inylchek compared to glacier elevation changes that are calculated directly from the DEM pair 2012/02-2013/11. Third, the absolute uncertainty of the glacier elevation changes is 1.13 m for the TDX DEM glacier comparisons, which is significantly lower than 5.23 m for the comparison between C-band SRTM and TDX DEMs.