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Detailed High Mountain Asia glacier mass balance from ASTER stereo imagery (2000-2016)

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Regionally-averaged mass balances are crucial to assess glacier contribution to sea level rise, but there is also a need to document volume and mass changes of individual glaciers to better understand their individual interaction with climate, their contribution to local downstream hydrology and verify glacier mass balance models.

In High Mountain Asia (HMA), there is currently a lack of up-to-date region-wide estimates of mass changes as the most complete studies relied on ICESat, which operated only until 2009. The ICESat sampling is also relatively sparse. Alternatively, other studies measured glacier volume changes from DEM differences, often relying on SRTM as one reference. The latter estimates are potentially subject to bias introduced by radar signal penetration into snow and ice, and they have a limited spatial coverage. The estimates based on the measurement of changes in the Earth gravity field using GRACE are also subject to potential biases because of the strong hydrological signal induced by the monsoon and human groundwater pumping, and the low spatial resolution of GRACE.

Here we address these limitations by computing the mass balance of 96% of the 87,000 glaciers (91,000 km^2) in HMA using time series of digital elevation models (DEMs) derived from Advanced Spaceborne Thermal Emission and Reflection (ASTER). The strength of our method lies in the use of a homogeneous and extensive (> 50,000 stereo scenes) set of DEMs that we generate in-house from ASTER stereo images. Our ASTER-derived volume changes and mass balances are validated against earlier geodetic estimates from optical (SPOT5, Pléiades) and radar (SRTM, TanDEM-X) imagery in the Mont-Blanc area (European Alps) and selected glaciers and regions of HMA.

We calculate an HMA-wide mass balance of -0.18 m w.e. yr-1 (-16.1 Gt yr-1) during 2000-2016. The obtained pattern of mass loss is consistent with previous estimates, as we found positive mass balance for Kunlun Shan, near zero mass balance for Karakoram and very negative mass balance for eastern Himalaya. We compare the regional estimates of mass changes with ICESat for 12 regions of HMA to understand the discrepancies between earlier studies over Pamir and Eastern Nyainquentanglha. These results will also help to characterize the spatial variability of glacier-wide mass balance and to assess the magnitude of SRTM penetration.