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Assessing the mass loss of glaciers using ICESat laser altimetry data

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The melt water of the glaciers on earth makes a substantial contribution to global sea-level rise. However, until recently most estimates relied on the extrapolation of measurements of few glaciers only which were upscaled to larger regions. Space-borne laser altimetry data from the ICESat GLAS sensor provides a global data set of elevation changes for the period 2003 – 2009. The accuracy of the altimetry measurements of about $\pm$0.5 m even over rough surfaces along with their small footprint (about 70 m) is making this data very suitable to assess elevation changes not only for the two ice sheets but also for the glaciers. This data set in combination with the recently finalized global glacier inventory (Randolph Glacier Inventory) allowed the first time to determine the glacier volume changes for larger regions. A major challenge with ICESat data is the sparse density of the tracks with increasing horizontal separation with decreasing latitude (from about 10 km up to more than 50 km), and the fact that the repeat tracks can be several hundred metres apart. Plane fitting and the comparison to the available global DEMs (SRTM and GDEM) is required to correct for the repeat track separation. The obtained elevation changes are usually extrapolated to larger glazierized regions based on the glacier hypsometries.
Results of two different studies of the local glaciers and ice caps on Greenland using similar data match well for the volume change (-40 km^3 vs. -42 km^3) with the highest loss in the south-eastern sector and lowest in the northern sector of Greenland. However, they vary between 28 $\pm$ 11 and 38 $\pm$ 7 Gt a-1 ($\sim$10 - 15% mass loss of glaciers on earth) due to different ice-density assumptions. Hence, while the measurements seem to be accurate the major challenge for assessing the glacier mass changes (and hence, their contribution to sea is the conversion from elevation changes to mass changes as snow and ice density and firn compaction have to be estimated or modelled.
The calculated mass loss of the glaciers of Tibet using ICESat data was -16 $\pm$ 7 Gt a-1 for 2003 – 2009 with balanced budgets in north-central and north-western Tibetan Plateau and significant mass loss on the eastern and southern parts. These results are in tendency in good agreement with few existing in-situ and geodetic-derived mass balance data from the similar region, but the absolute numbers vary. Overall, it could be shown that ICESat data is very useful to estimate the glacier volume and mass changes for larger regions but the uncertainty has to be carefully addressed.