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The third dimension of the RGI: Ice thickness distribution and volume of all glaciers around the globe

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The Randolph Glacier Inventory (RGI) provides outlines of all glaciers around the globe. This exceptional data set thus provides 2D information on the earth's glaciers. For climate impact studies (e.g. sea-level rise contribution, mountain hydrology) the third dimension of glacier inventory data, i.e. glacier ice volume and thickness distribution, is however urgently needed.

Here, a new physically-based approach is presented that allows calculating spatially distributed ice thickness and glacier volume for each individual glacier of the RGI. We apply this method to all glaciers and ice caps worldwide. Combining glacier outlines with terrain elevation models (SRTM/ASTER), we use a simple dynamic model to obtain ice thickness on a 25 to 200 m grid for about 170'000 glaciers by inverting their surface topography. Results are validated against a comprehensive set of thickness observations for 300 glaciers from most glacierized regions of the world.

For all mountain glaciers and ice caps outside of the two ice sheets (Greenland, Antarctica) we find a total ice volume of $170 \times 10^3 \pm 21 \times 10^3$ km^3, or 0.43±0.06 m of potential sea-level rise. We investigate the uncertainties in the RGI-based estimate of global glacier volume, compare our results with alternative approaches to calculate ice volume and thickness, and discuss the potential of this new, complete data set of glacier ice thickness.