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An assessment of the uncertainties in computing the glacier contribution to sea-level change by volume-area modelling

Roderik van de Wal and Aimée Slangen
Utrecht University, IMAU, Netherlands (a.slangen@uu.nl)

Sea-level change is an important issue in the field of climate change. Currently, the largest contributions to sea-level change are thermal expansion of the ocean water and the addition of mass through land ice melt. Here we focus on the calculation of the contribution by small glaciers and ice caps (GIC) on a century timescale. The model used here is based on volume-area scaling considerations. This approach is combined with a relation for the mass balance sensitivity of the GIC and the precipitation rate. We assess different aspects that contribute to the uncertainty in the prediction of the contribution of GIC to future sea-level rise. We distinguish uncertainties related to the GIC volume-area scaling method (scaling constant), uncertainties in the choice of glacier inventory, uncertainties related to the present-day imbalance, uncertainties in the mass balance sensitivity, and uncertainties in the climate models. Additionally, a validation of the model results for the past century GIC contribution (the imbalance effect) is presented, justifying the volume-area approach. We find that small variations in the scaling constant cause significant variations in the initial volume of the glaciers, but only limited changes in the resulting contribution to sea-level change. If two existing inventories are tuned such that the initial volume is the same, the GIC sea-level contribution over 100 years differs by 0.025 m, which is 16%. It appears that the mass balance sensitivity, which is based on a limited data set of 12 glaciers, is important: variations of 20% have an impact of 15% on the resulting sea-level projections. Another important factor is the choice of the climate model, as the GIC contribution to sea-level change depends largely on the temperature and precipitation taken from climate models. Reducing the variance in the climate models will significantly reduce the uncertainty in calculating the GIC contributions, and is therefore a crucial action to improve future sea-level projections.