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Peak water from glaciers: advances and challenges in a global perspective (Arne Richter Award for Outstanding Young Scientists Lecture)

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Mountain glaciers show a high sensitivity to changes in climate forcing. In a global perspective, their anticipated retreat will pose far-reaching challenges to the manage- ment of fresh water resources and will raise sea levels significantly within only a few decades. Different model frameworks have been applied to simulate melt water con- tributions of glaciers outside the two ice sheets for the recent IPCC report. However, these models depend on strongly simplified, and often empirical descriptions of the driving processes hampering the reliability of the results. For example, glacier retreat is parameterized with volume-area scaling thus neglecting the glacier's actual geome- try and the surface elevation feedback. Frontal ablation of tidewater and lake-calving glaciers, an important mass loss component for a third of the world's glacier area, is not accounted for.

Thus, a transition from the physically-based mass balance-ice flow models developed for single glaciers to the application at the global scale is urgently needed. The chal- lenges are manifold but can be tackled with the new data sets, methods and process- understanding that have emerged during the last years.

Here, we present a novel glacier model for calculating the response of surface mass balance and 3D glacier geometry for each individual glacier around the globe. Our approach accounts for feedbacks due to glacier retreat and includes models for mass loss due to frontal ablation and the refreezing of water in the snow/firn. The current surface geometry and thickness distribution for each of the world's roughly 200'000 glaciers is extracted from the Randolph Glacier Inventory v3.2 and terrain models. Our simulations are driven with 14 Global Circulation Models from the CMIP5 project using the RCP4.5, RCP8.5 and RCP2.6 scenarios.

Regionally specified cumulative global sea level rise due to glacier mass loss until 2100 is discussed in the light of model uncertainties and the advantages of using a physically- based approach. In particular, we focus on the timing of peak water from glacierized catchments in all climatic regions of the earth. The maximum rate of water release from glacial storage is subject to a high spatio-temporal variability. Peak water represents a crucial tipping point for sustained water supply even for regions with only a minor glacier coverage, and is relevant to the dynamics of sea level rise. Furthermore, we address the ratio between surface mass balance and frontal ablation of tidewater glaciers at the global scale.