Submitted Abstract

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Abstract

The excess meltwater that results from climate change induced mass loss of mountain glaciers is an important contributor to sea level rise (SLR). Up to now, large scale glacier observations and models have been used to estimate the amount of generated excess meltwater and its transient contribution to SLR under the assumption that meltwater is added to the ocean instantaneously and in its entirety. However, hydrological processes and water consumption during the transit from glacier to the ocean may affect the amount and timing of glacier runoff that eventually drains into the ocean. We hypothesize that some of the lost glacier ice may not reach the ocean at all or only at a much later stage.

In this study, we assessed the impacts of the hydrological pathway of meltwater from the glacier snouts to the ocean in the Indus Basin. With its large glacier ice reserves, relatively arid climate and large irrigation scheme, this basin provides the optimal case study for such an assessment. We coupled output from a detailed glacier model to the fully distributed hydrological model PCR-GLOBWB 2, and forced the models with bias-corrected historical and future climate data from the third phase of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3).

Our findings show that, particularly in (periods of) dry years, considerable fractions of excess glacier meltwater do not enter the ocean. The changes in hydrological stores indicate that much of it is withdrawn for surface water irrigation of cropland and eventually evaporates as a result. The increased surface water availability due to the presence of excess glacier meltwater leads to a lowering of groundwater irrigation and a reduction of the unsustainable depletion of the basin's groundwater store. In the future, increased availability of excess glacier meltwater and increased water withdrawals due to continued climate change and socioeconomic developments exacerbate these effects. Up to the end of century, depending on the specific climate scenario, around 12% of excess glacier meltwater does not enter the ocean directly.

We conclude that not all glacier mass loss can be assumed to contribute (directly) to SLR, which may lead to overestimation of future sea level rise. Further research is necessary to estimate the breadth of these effects at a global scale, but we hypothesize that this may also play a role in other glacierized basins with semi-arid downstream regions and considerable distances between the glaciers and the ocean.