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Integrating climate science, glaciology and hydrology to predict future run-off at the Greenland ice sheet margin: A case study from Ilulissat, West Greenland.

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Predicting future hydrological regimes with regard to climate change is an increasingly important task for hydrologists. In polar regions the task is more difficult due to the lack of datasets and long term monitoring as well as logistical difficulties in remote and inaccessible basins. Here, we demonstrate a case study predicting the future run-off in a difficult to model hydrological basin by integrating a range of data, methods and numerical models. A study, evaluating the future conditions in the Pakitsup Akuliarusersua basin near Ilulissat, West Greenland, was initiated to determine the viability of a small hydropower scheme based around two lakes adjacent to the ice-sheet margin. This basin is mainly supplied by meltwater from the ice-sheet margin and the position of the ice sheet relative to the lakes makes them sensitive to changes in drainage pathways. We combined glaciological and hydrological models with data from climate models in order to resolve these issues.

An ice dynamic model (Reeh, 1988), incorporating new digital terrain models for the ice sheet surface and basal topographies (Mottram and other, 2009), was driven by climate data from a combined global/regional climate model (HIRHAM4) for the period 1950–2080 (Stendel and others, 2007). The climate data was downscaled to catchment scale and corrected using observational data from the local area. The corrected HIRHAM4 output was used as input to a temperature-index mass-balance model (Reeh, 1991) and used to force the ice-dynamic model in order to predict the future ice sheet geometry and to drive meltwater production at the ice sheet surface. These ice sheet geometries were used to predict the size of the ice-sheet part of the hydrological basin for a range of different levels of ice sheet basal water pressure every 5 years from present day to 2080. Thus, the present analysis takes into account global and regional climate change, ice dynamical response and changes in the internal drainage system of the ice sheet.

We predict that the ice-sheet margin will continue its present thinning trend, causing a thinning of approximately 80 metres over the next 70 years, corresponding roughly to the current rate of ice-sheet thinning in the region, approximately 1 metre per year over the last 40 years. The predicted retreat rates are realistic from a glaciological point of view and cause only minor changes in the basin delineation for high (realistic) basal water pressures. Our analysis shows that the HIRHAM4 output needs substantial adjustment to reproduce observations on catchment scale and ice-dynamic models do not yet capture all the important processes of the ice sheet, in particular its dynamic response to an increase in the surface meltwater input to its internal drainage system. Nevertheless, the predictions from this study are realistic and take into account the most important processes occurring at the ice sheet margin.