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The Arctic hydrologic cycle and its variability in a regional coupled climate model

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Modeling the Arctic hydrologic cycle implies big challenges because of the non-linear behavior and interplay of its elements on different scales. Additionally, the Arctic environment is rapidly changing due to global warming and so are the freshwater components. Global general circulation models show remarkable differences in modeling the Arctic freshwater cycle. While they agree only on the general sinks and sources of the freshwater budget, they differ largely in the magnitude of the mean values as well as in the variability of the freshwater terms. Regional models can better resolve the complex topography and small scale processes, but they are often uncoupled, though missing the air-sea interaction. Additionally, regional models do mostly use any kind of salinity restoring or flux correction, thus disturbing the freshwater budget. Our approach to investigate the Arctic hydrologic cycle and its variability is a regional atmosphere - ocean model setup, consisting of a global ocean model with high resolution in the Arctic coupled to a regional atmosphere model. To account for all sinks and sources of freshwater, we include a discharge model providing lateral terrestrial waterflows. We run the model without salinity restoring or freshwater correction in the Central Arctic, which allows for the analysis of a closed freshwater cycle in the Arctic region with a fully coupled high resolution model. Since freshwater is exported from the Arctic Ocean to regions in the North Atlantic where deepwater is formed, and the deepwater formation is sensitive to changes in (temperature and) salinity, only small changes in the amount of this exported freshwater can influence the global climate via the global ocean circulation. Thus, we use our model setup not only to calculate changes in the mean values but also to understand mechanisms behind the variability of these freshwater components. More precisely, we investigate how variations in the atmospheric circulation influence the variability in the freshwater components.

As our model is regional, we need external forcing that is provided by data from a global model run. It is difficult to quantify by how much the model's variability is driven by the variability in the external forcing (external variability) and by how much the model develops internal variability. The influence of the forcing is for instance strongly dependent on the size of the model domain. To distinguish the model's internal variability from a signal in the Arctic climate we perform more than one simulation. Since these simulations, so-called ensemble members, are driven by the same forcing, they are not fully independent from each other. This makes it difficult to define statistical significance in order to distinguish between "noise" within the model and a signal in the variability of the freshwater components.