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Holocene retreat of Jakobshavn Isbræ

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Marine terminating glaciers, such as Jakobshavn Isbræ in West Greenland, are complex systems driven by a combination of changes in oceanic and atmospheric climate. The recent retreat and speedup of Jakobshavn Isbræ is mainly attributed to oceanic warming, while the general retreat of the Greenland ice sheet since the last glacial maximum is attributed to changes in surface mass balance. However, the relative impact of atmospheric and oceanic forcing on marine terminating glaciers of the Greenland ice sheet, and the corresponding time scales of the response remain unknown. We use a thermo-mechanical 3D ice sheet model to study the retreat history of Jakobshavn Isbræ during the Holocene (9500 BP to present) and compare it with available observational data.

The glacier retreat is simulated with the Ice Sheet System Model (ISSM) in a thermo-mechanically coupled 3D setup. The resolution is enhanced in areas with complicated topography and fast flowing ice. The model is run forward with different oceanic forcings starting from a recorded margin position at 9500 a BP. The simulated evolution of the front is compared to known geomorphological evidence, such as moraines and dated boulders.

The results show that the retreat in the fjord is strongly dependent on the bathymetry of the fjord. Furthermore, our results suggest that while surface mass balance dominates the retreat of the land based sections of the glacier, the fast flowing ice stream in the fjord is dominated by oceanic forcing and the dynamic response of the marine terminating front. Thus, our results indicate that the evolution of the land based and marine based ice in the area of Jakobshavn are driven by different external forcings, and that it is critical to resolve the detailed fjord topography in order to predict past and future changes.