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Fast retreat of a marine outlet glacier in western Norway at the last glacial termination

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Observations of marine outlet glaciers covering the last few decades show speedup and accelerated retreat, and the geologic record testaments that catastrophic changes occurred also in the past. However, the time scales of rapid outlet glacier retreat and the underlying drivers are still unclear. Here, we study the collapse of Hardangerfjorden glacier, an outlet glacier of the Scandinavian Ice Sheet, during the transition from the Younger Dryas cold period to the warming in early Holocene. We use dated terminal and lateral moraines as constraints for a simple ice flow model including calving. Our experiments suggest a fast and highly variable retreat history driven by surface melt and warming fjord waters, paced by fjord bathymetry as well as ice shelf dynamics. Grounding line retreat in response to the rapid, large early Holocene warming is simulated at rates below 200 m/a, punctuated by brief spells of swift retreat exceeding 500 m/a. Our findings imply that warming subsurface waters will continue to drive retreat of marine outlet glaciers in Greenland and elsewhere, but that recent elevated retreat rates observed are not likely to be sustained longer than a few decades. On centennial scales, retreat will likely be increasingly driven by a warming atmosphere.