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Simulating the retreat of the freshwater calving Glacier O'Higgins using a flow line model

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Glacier O'Higgins is an outlet glacier on the Eastern side of the Southern Patagonia Icefield which calves into Lake O'Higgins. The glacier has shown a very rapid retreat of about 15 kilometres during the last century. The retreat is thought to be triggered by warming climate. This caused the front, initially anchored on a small island, to retreat into deeper water, which strongly accelerated the retreat. We simulate the dynamics of the glacier with a vertically and laterally averaged flow-line model. The shallow ice approximation is employed and a constant rheological factor is assumed in Nye's flow law justified by uniform temperature distribution in the temperate O'Higgins Glacier. A Weertman-type sliding law is assumed. The maximum stand of the glacier during the last 100 years can be modelled by imposing a cooler climate forcing with a lower equilibrium line altitude (ELA) in comparison to the present. Model parameters are optimized by matching the modelled ice depth with the trim lines of the maximum stand. Subsequently a warmer climate with a lower ELA is imposed and the retreat of the front is modelled. Different calving models are tested to reproduce the historic record of the frontal retreat. An outlook is undertaken in order to understand how the glacier will evolve under different future climate forcings and assess its contribution to sea-level rise. We conclude that the initial retreat was caused by a slightly warmer climate but the rapid retreat during the last century is rather due to dynamical mechanisms than due to climate forcing per se. The flow line model proves to be a simple but appropriate tool to model these dynamical mechanisms of glacier behaviour.