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Modeled and reconstructed ice thickness of the Rhine Glacier during the Last Glacial Maximum

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Despite available geological evidence, only a few ice flow modeling studies have been done on the European Alpine ice cap during the Last Glacial Maximum (LGM). These studies show a good agreement with maximum glacier tongue extent reconstructed from moraines. However, the ice flow models systematically overestimate the ice thickness by up to 50% when compared to reconstructions based on trimlines, unless extremely low LGM precipitation is assumed. This discrepancy between model results and geological reconstructions is calling for a more detailed exploration of model sensitivity to uncertain ice physical parameters.
In this study, we investigate the effect of model parameters related to basal sliding and ice rheology of the Parallel Ice Sheet Model (PISM) at the Rhine Glacier. We evaluate whether a set of realistic parameters can reproduce the thickness of the Rhine glacier at the LGM reconstructed from trimlines, without involving extremely low precipitation rates. PISM is a state-of-the-art ice sheet model, which computes the extent and thickness of ice and its thermal and dynamic state, for given initial basal topography and climate forcing. Since PISM is based on simplified ice mechanics (combining shallow ice approximation and shallow shelf approximation), it is computationally fairly cheap and therefore allows to perform a large amount of simulations of the Rhine Glacier during the last 45,000 years.
An agreement between model results and geologic reconstructions is only reached for model parameters characterising unusually soft ice or very slippery basal conditions. We suggest that trimlines mapped in the Rhine valley may instead depict a transition zone between temperate and cold ice, or characterise another period than the LGM.