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Uncertainty quantification for melt rate parameters in ice shelves using simulation-based inference

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Mass loss from the Antarctic ice sheet is dominated by the integrity of the ice shelves that buttress it. The evolution and stability of ice shelves is dependent on a variety of parameters that cannot be directly observed, such as basal melt and ice rheology. Constraining these parameters is of great importance in making predictions of the future changes in ice shelves that have a quantifiable uncertainty. This inference task is difficult in practice as the number of unknown parameters is large, observations are often sparse, and the computational cost of ice flow models is high.

We aim to develop a framework for inferring joint distributions of mass balance and rheological parameters of ice shelves from observations such as ice geometry, surface velocities, and radar isochrones. Here, we begin by inferring a posterior distribution over basal melt parameters in along-flow sections of synthetic and real world ice shelves (Roi Baudouin). We use the technique of simulation-based inference (SBI), a machine learning framework for performing Bayesian inference when the likelihood function is intractable. The inference procedure relies on the availability of a simulator to model the dynamics of the ice shelves. For this we use the Shallow Shelf Approximation (SSA) implemented in the Python library Icepack. First, we show that by combining these two tools we can recover the underlying parameters of synthetic 2D data with meaningful uncertainty estimates. In a second step, we apply our method to real observations and get estimates for the basal melt rates which are coherent with the data when running the forward model over a centennial timescale.