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Parameterising ocean-induced melt of an idealised Antarctic ice shelf using deep learning

Clara Burgard[1,*] and Nicolas C. Jourdain[2]

[1] Univ. Grenoble Alpes, IRD, CNRS, Grenoble INP, IGE, 38000 Grenoble, France, clara.burgard@univ-grenoble-alpes.fr

[2] Univ. Grenoble Alpes, IRD, CNRS, Grenoble INP, IGE, 38000 Grenoble, France, nicolas.jourdain@univ-grenoble-alpes.fr

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Sea-level rise is one of the most visible and globally impacting consequences of climate change. Still, both the rate and magnitude of future sea-level rise come with large uncertainties. One of the most important processes governing the Antarctic contribution to sea-level rise is the ocean-induced melt at the base of Antarctic ice shelves. Ice shelves act as natural barriers to slow down the ice flow from the Antarctic ice sheet into the ocean. Fast thinning from below reduces this effect and has been shown to locally trigger irreversible instabilities, leading to a rapid increase in ice discharge into the ocean.

Still, the representation of sub-shelf melting in ice-sheet models comes with large uncertainties. The ocean circulation in ice shelf cavities is often not resolved by large-scale ocean models providing the input forcing to ice-sheet models. Instead, simple and complex parameterisations are used to link the hydrographic properties in front of ice shelves to the melt at their base. These parameterisations still struggle to accurately simulate basal melt patterns, mainly because they cannot take into account the horizontal heterogeneity of the bathymetry or ocean dynamics within ice shelf cavities, which cannot necessarily be described physically in a computationally cheap and generalised way.

We propose a new approach to tackle this issue. We train a deep neural network to emulate basal melt rates simulated by highly-resolved ocean simulations. Such a “deep emulator” can implicitly include more intrinsic information about the system than a “classical” physical parameterisation. Starting with an idealised ice-shelf geometry, we explore the advantages and limitations of this new approach, which has the potential to reduce uncertainties in ice-sheet projections. Additionally, we identify input variables that affect the resulting basal melt rates the most and that are potentially not included in existing parameterisations yet.