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The Elementary Marine Ice Sheet Model (EMISM)

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Ice sheet models become more and more components of global climate system modelling instead of stand-alone features to study cryospheric processes. Full coupling of ice sheet models to atmospheric and ocean models requires a standard for ice sheet models, and more precisely for marine ice sheet models, where complex feedbacks between ice and ocean, such as marine ice sheet instability, and the atmosphere, such as the elevation-mass balance feedback, operate at different time scales. Recent model intercomparisons (e.g., SeaRISE, MISMIP) have shown that basic requirements for marine ice sheet models are still lacking and that the complexity of many ice sheet models is focused on processes that are either not well captured numerically (spatial resolution issue) or are of secondary importance compared to the essential features of marine ice sheet dynamics. Here, we propose a new and fast computing ice sheet model, devoid of most complexity, but capturing the essential feedbacks when coupled to ocean or atmospheric models. Its computational efficiency guarantees to easily tests its advantages as well as limits through ensemble modelling.

EMISM (Elementary Marine Ice Sheet Model) is a vertically integrated ice sheet model based on the Shallow-Ice Approximation extended a Weertman sliding law. Although vertically integrated, thermomechanical coupling is ensured through a simplified representation of ice sheet thermodynamics based on an analytical solution of the vertical temperature profile, enhanced with strain heating. The marine boundary is represented by a parameterized flux condition similar to Pollard & Deconto (2012), based on Schoof (2007). A simplified ice shelf is added to account for buttressing of ice shelves in this parameterization. The ice sheet model is solved on a finite difference grid and special care is taken to its numerical efficiency and stability. While such model has a series of (known) deficiencies with respect to short time effects, its overall behaviour is in line with recent model simulations of Pine Island and Thwaites Glacier systems.

We perform a series of sensitivity experiments with EMISM and compare results to recent model inter-comparisons of the Antarctic ice sheet (e.g., SeaRISE, Favier et al. (2013)).

Future developments include the implementation of a variant of the coupled SSA/SIA to account for ice stream flow, upstream of grounding lines.