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Uncertainty quantification of Antarctic contribution to sea-level rise using the fast Elementary Thermomechanical Ice Sheet (f.ETISh) model

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Uncertainties in sea-level rise projections are mostly due to uncertainties in Antarctic ice-sheet predictions (IPCC AR5 report, 2013), because key parameters related to the current state of the Antarctic ice sheet (e.g. sub-ice-shelf melting) and future climate forcing are poorly constrained. Here, we propose to improve the predictions of Antarctic ice-sheet behaviour using new uncertainty quantification methods.

As opposed to ensemble modelling (Bindschadler et al., 2013) which provides a rather limited view on input and output dispersion, new stochastic methods (Le Maître and Knio, 2010) can provide deeper insight into the impact of uncertainties on complex system behaviour. Such stochastic methods usually begin with deducing a probabilistic description of input parameter uncertainties from the available data. Then, the impact of these input parameter uncertainties on output quantities is assessed by estimating the probability distribution of the outputs by means of uncertainty propagation methods such as Monte Carlo methods or stochastic expansion methods. The use of such uncertainty propagation methods in glaciology may be computationally costly because of the high computational complexity of ice-sheet models. This challenge emphasises the importance of developing reliable and computationally efficient ice-sheet models such as the f.ETISh ice-sheet model (Pattyn, 2015), a new fast thermomechanical coupled ice sheet/ice shelf model capable of handling complex and critical processes such as the marine ice-sheet instability mechanism.

Here, we apply these methods to investigate the role of uncertainties in sub-ice-shelf melting, calving rates and climate projections in assessing Antarctic contribution to sea-level rise for the next centuries using the f.ETISh model. We detail the methods and show results that provide nominal values and uncertainty bounds for future sea-level rise as a reflection of the impact of the input parameter uncertainties under consideration, as well as a ranking of the input parameter uncertainties in the order of the significance of their contribution to uncertainty in future sea-level rise. In addition, we discuss how limitations posed by the available information (poorly constrained data) pose challenges that motivate our current research.