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Marine ice sheet dynamics

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Ice sheets grounded below sea level, such as the West Antarctic ice sheet, differ from their continental counterparts because ice thickness and ice flux generally do not vanish at the grounding line. Consequently, marine ice sheets can lose mass not only though melting, but also through outflow of ice into the surrounding ice shelves. A key ingredient in modelling marine ice sheets is therefore the ability to predict ice flux at the grounding line.

In this presentation, we show how ice flux at the grounding line is determined by the mechanics of the ice sheet-ice shelf transition zone. Our results show that explicit integration of mass and momentum balance in a mechanical boundary layer coupling sheet to shelf flow allows ice flux to be calculated in terms of longitudinal stress at the grounding line. For a two-dimensional sheet-shelf system, in which there is no buttressing, this determines ice flux explicitly in terms of ice thickness at the grounding line.

Mathematically, the role of an ice flux boundary condition at the grounding line is to determine the rate of grounding line migration. In the second half of the presentation, we examine how the relationship between ice flux and ice thickness at the grounding line required by sheet-shelf coupling affects the existence and stability of stable marine ice sheet profiles. In line with the earlier conjectures of Weertman (1974) and Thomas and Bentley (1978), our results show that grounding lines situated on upward-sloping beds — as is the case in much of West Antarctica — cannot be stable if the ice shelves surrounding the ice sheet are not confined to embayments. For the case of confined ice shelves, stability depends critically on the response of the ice shelf calving front to grounding line retreat.

References

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