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Stability of the grounding lines in a regime of low driving and basal stresses

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Flow of many West Antarctic ice streams is characterized by low driving and basal stresses. However, existing theories of marine ice sheets are developed for a regime of high driving and basal stresses. Using analytical and numerical solutions of a widely used vertically integrated ice flow model, we show that the marine ice sheets in low driving/basal stress regime exhibit very different behavior from those in the regime of high driving/basal stress. Our analysis shows that the stability of distinct steady states is determined by the geometric parameters of the ice-stream bed, net accumulation rate and gradient of the accumulation rate parameters, suggesting a more complex (in)stability criterion than the marine ice sheet instability hypothesis. We also determine characteristic timescales of ice-sheet configurations perturbed from their steady states that can be used to determine whether particular configurations can be considered in isolation from other components of the climate system or whether their effects and feedbacks between the ice sheet and the rest of the climate system have to be taken into account.