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Interaction and variability of ice streams under a triple-valued sliding law and non-Newtonian rheology

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Ice streams are regions of fast flowing glacier ice that transport a significant portion of the total ice flux from present ice sheets. The flow pattern of ice streams can vary both temporally and spatially. In particular, ice streams can become stagnant, and change their path. We study the dynamics of ice streams using an idealized two dimensional horizontal model of an isothermal, non-Newtonian power-law viscous ice flow. The basal sliding law is assumed to be triple-valued.

We investigate the spatiotemporal patterns formed due to the flow over a flat bed, fed from a uniform upstream mass source. The ice flows from the mass source region through one or two gaps in a prescribed upstream topographic ridge which restricts the flow, leading to the formation of one or two ice streams.

We find a relation between the parameters of the ice rheology and the width of the ice-stream shear margins, and show how these parameters can affect the minimum width of an ice stream. We also find that complex asymmetric spatiotemporal patterns can result from the interaction of two ice streams sharing a common mass source. The rich spatiotemporal variability is found to mostly be a result of the triple valued sliding law, but non-Newtonian effects are found to play a significant role in setting a more realistic shear margin width and allowing for relevant time scales of the variability.