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Is Greenland's flow law flawed?

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Recent isotope measurements (Schaefer et al., 2016) reveal that Greenland was likely nearly ice free for extended periods of time during the past 1 280 000 years. This is not consistent with our current physical understanding of ice sheet dynamics. It implies that the Greenland Ice Sheet lost mass at a rate that cannot be explained by melting alone, even considering self-amplifying feedbacks. Nor can a nearly complete elimination of all ice on Greenland be explained by mere sliding of coastal ice into the ocean which is currently considered to be the fastest process for ice loss both in Greenland and Antarctica. As a consequence, it must be the flow of ice that is much more sensitive to temperature changes than we currently assume in most ice sheet models and thus sea level projections.

The flow of ice in models is currently often described by *Glen's flow law* $\dot{\epsilon} = A_0 \exp\left(-\frac{Q}{RT}\right) \tau^n$ (Cuffey Paterson, 2010). This flow law is central in all thermodynamically coupled ice-sheet models. However, the mathematical form as well as the flow parameters are highly uncertain. The activation energy Q controls the temperature sensitivity of the softness of ice and is central for understanding ice dynamics under global warming and resulting sea level rise. Here we assess the range of possible ice flow sensitivity that results from the combination of the experimental uncertainty ranges of this activation energy Q and the flow parameter A_0.