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# Scaling laws for iceberg calving

Jan Åström (1) and John Moore (2,3)

(2) Beijing Normal University, College of Global Change and earth System Science, Beijing, China (john.moore.bnu@gmail.com), (1) CSC - It-centre for science, P.O. Box 405, 02101, Esbo, Finland, (3) Arctic Centre, University of Lapland, PL122, 96100 Rovaniemi, Finland

Over the next century, most additional ocean water will come from ice sheets and glaciers, primarily through calving of ice into the oceans. Calving fluxes are prone to rapid and non-linear variability and therefore have proven difficult to include in models forced by evolving climatic variables. Theoretical and simulation first-principles fracture models are applied to investigating iceberg calving. We demonstrate that calving originates from general behaviour of unstable cracks in elastic media. Cracks in ice trigger calving events that have a striking statistical similarity to avalanches in Abelian sand-pile models. That is, both calving mass distribution and inter-event waiting times are similar to those of sand-pile models. The theoretical results are confirmed by a first-principles simulation model and field observations spanning 12 orders of magnitude in calving size. This suggests that calving termini are self-organized critical systems, hence the difficulty to parameterize calving in large-scale models. Subtle deviation from a critical point towards higher stability will lead to subcritical calving - small and infrequent calving events associated with glacier advance, while subtle deviation towards higher instability will lead to supercritical calving – larger and more frequent events associated with rapid retreat. Such behaviour is consistent with recent worldwide observations of ice shelf disintegration and irreversible tidewater glacier retreat in response to climate warming.