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Exploring Explanations of Subglacial Bedform Sizes Using Statistical Models

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Sediments beneath modern ice sheets exert a key control on their flow, but are largely inaccessible except through geophysics or boreholes. In contrast, palaeo-ice sheet beds are accessible, and typically characterised by numerous bedforms. However, the interaction between bedforms and ice flow is poorly constrained and it is not clear how bedform sizes might reflect ice flow conditions. To better understand this link we present a first exploration of a variety of statistical models to explain the size distribution of some common subglacial bedforms (i.e. drumlins, ribbed moraine, MSGL). By considering a range of models, constructed to reflect key aspects of the physical processes, it is possible to infer that the size distributions are most effectively explained when the dynamics of ice-water-sediment inter- action associated with bedform growth is fundamentally random. A ‘stochastic instability’ (SI) model, which integrates random bedform growth and shrinking through time with exponential growth, is preferred and is consistent with other observations of palaeo-bedforms and geophysical surveys of active ice sheets. Furthermore, we give a proof-of-concept demonstration that our statistical approach can bridge the gap between geomorphological observations and physical models, directly linking measurable size-frequency parameters to properties of ice sheet flow (e.g. ice velocity). Moreover, statistically developing existing models as proposed allows quantitative predictions to be made about sizes, making the models testable; a first illustration of this is given for a hypothesised repeat geophysical survey of bedforms under active ice. Thus, we further demonstrate the potential of size-frequency distributions of subglacial bedforms to assist the elucidation of subglacial processes and better constrain ice sheet models.