Geophysical Research Abstracts
Vol. 15, EGU2013-5809, 2013
EGU General Assembly 2013

Sizes and shapes of subglacial bedforms reveal an exponential size-frequency distribution

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Subglacial bedforms preserved in deglaciated landscapes record characteristics of past ice-sediment flow regimes, providing insight into subglacial processes and ice sheet dynamics. Individual forms vary considerably, but they can often be grouped into coherent fields, typically called flow-sets, that reflect discrete episodes of ice flow. Within these, bedform size-frequency distributions (predominantly height, width and length) are currently described by several statistics (e.g., mean, median, standard deviation) that, arguably, do not best capture the defining characteristics of these populations. This paper seeks to create a better description based upon semi-log plots, which reveal that the frequency distributions of bedform dimensions (drumlin, MSGL, ribbed moraine) plot as straight lines above the mode (ϕ). This indicates, by definition, an exponential distribution, for which a simple and easily calculated, yet statistically rigorous, description is designed. Three descriptive parameters are proposed: gradient (λ; the exponent, characterising bedforms likely least affected by non-glacial factors), area-normalised y-intercept (β_0; quantifying spatial density), and the mode (ϕ). Below ϕ, small features are less prevalent due to i) measurement: data, sampling, mapping fidelity ii) possibly post-glacial degradation or iii) genesis: not being created sub-glacially. This new description has the benefit of being insensitive to the impact of potentially unmapped or degraded smaller features and better captures properties relating to ice flow. Importantly, using λ, flow sets can now be more usefully compared with each other across all deglaciated regions and with the output of numerical ice sheet models. Identifying the characteristic exponential and that it is typical of 'emergent' subglacial bedforms is a new and potentially powerful constraint on their genesis, perhaps indicating that ice-sediment interaction is fundamentally stochastic in nature.