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Regular patterns in subglacial bedforms demonstrate emergent field behaviour

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Somewhat counter-intuitively, ice-sheets abhor flat beds when flowing over soft sedimentary substrates. Instead, they produce an undulated surface, metres in relief and with length-scales of hundreds of metres. The resistive stresses that such bumps impart on ice flow affect the functioning of ice sheets by slowing ice transfer to lower elevations for melting and calving. The most abundant roughness elements are drumlins, streamlined in the direction of ice flow. Understanding their formation has eluded scientific explanation for almost two centuries with the literature seeking mechanistic explanations for individual bumps. Here we analyse tens of thousands of drumlins and find that they possess a strong regularity in their spatial positioning, which requires interactions between drumlins during their formation. This demonstrates a pattern-forming behaviour that requires explanation at the scale of drumlinised landscapes, beyond that of individual drumlins. Such regularity is expected to arise from interdependence between ice flow, sediment flux and the shape of the bed, with drumlins representing a specific emergent property of these interactions. That bed roughness is found to organise itself into specific, predictable and patterned length-scales might assist next generation of ‘sliding laws’ that incorporate ice-bed interactions, thereby improving modelling of ice-sheet flow.