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Surface undulations of Antarctic ice streams tightly controlled by bedrock topography

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Ice dynamics models predict that fast-flowing ice streams transmit information about their bedrock topography most efficiently to the surface for basal undulations with length scales between 1 and 20 times the mean ice thickness. This typical behaviour is independent on the precise values of the flow law and sliding law exponents, and should be universally observable. However, no experimental evidence for this important theoretical prediction has been obtained so far, hence ignoring an important test for the physical validity of current-day ice flow models. In our work we use recently acquired airborne radar data for the Rutford Ice Stream and Evans Ice Stream, and we show that the surface response of fast-flowing ice is highly sensitive to bedrock irregularities with wavelengths of several ice thicknesses. The sensitivity depends on the slip ratio, i.e. the ratio between mean basal sliding velocity and mean deformational velocity. We find that higher values of the slip ratio generally lead to a more efficient transfer, whereas the transfer is significantly dampened for ice that attains most of its surface velocity by creep. Our findings underline the importance of bedrock topography for ice stream dynamics on spatial scales up to 20 times the mean ice thickness. Our results also suggest that local variations in the flow regime and surface topography at this spatial scale cannot be explained by variations in basal slipperiness.