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Progressive surface depression of an ice rumple in Thwaites Ice Shelf derived by high resolution digital elevation models

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Ice rumples are locally grounded features of ice shelves, elevated tens of meters above the surrounding ice shelf surface. Ice rumples may impact significantly on the dynamics of the grounding line of ice shelves, which is strongly related to their stability. In this study, TanDEM-X data were used to construct DEMs of the Thwaites Ice Shelf in West Antarctica with a time span of one year. Surface depression of approximately 15 m at the maximum was observed with which progressive unpinning of an ice rumple is suspected. Subsequently, an elastic deformation model with a finite spherical pressure source, which has been widely used to determine physical features of magma chambers in volcanic studies, was exploited to extract physical parameters of the ice rumple, including grounding location, ice shelf thickness, bed topography, and thickness change that induced surface deformation. The viscoelastic correspondence principle with the effective shear modulus assuming a simple linear solid is used to consider viscoelastic property of ice shelf. Finally, global optimization with constrained boundary conditions was utilized to fit the model to the observed deformation map. Observations of the ice rumple using high-resolution DEMs and the elastic deformation model are plausible, and the technique is expected to be applicable to other ice rumples.