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Surface curvature as a signature of dynamical thinning

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The contribution of polar ice sheets is one of the largest uncertainties in the estimate of the 21st century sea level rise. In particular, the dynamics of polar outlet glaciers is still not precisely constrained. Curvature of the surface in the across-slope direction could be an important parameter to better describe the local behaviour of an ice sheet. Indeed, plan curvature is linked to the convergence or divergence of ice flow clearly highlighting fast flowing regions (convergence) and ice ridges (divergence). Here, we propose to use the curvature to better describe outlet glacier dynamics through modelling and satellite radar altimetry comparisons.

We run a 3D full-Stokes ice flow model on a synthetic but approaching realistic geometry. The initial steady geometry exhibits a convergence of grounded ice toward an ice stream and flow further prolongates over the ocean with a floating ice shelf. A perturbation in sub-ice shelf melting is imposed leading to a clear signature at the surface of the grounded ice sheet: a lowering of the surface elevation together with an increase of the transverse curvature. We then derive results from satellite radar altimetry and investigate the behaviour of the ice sheet over the last decade. The dataset is from Envisat radar altimeter from autumn 2002 to autumn 2010. We process all of the 20Hz record to extract a linear height trend (dh/dt) every kilometre along track. This brings a 20-fold increase in the amount of data points compared to the classical cross-over analyses. A signature similar to one obtained with the model is observed over the glacier in the Amundsen Sea sector, region known to undergo severe imbalance. Last, the method is extended to other regions of Antarctica, and shows that Totten Glacier presents a very similar signature during the last years, suggesting that dynamical thinning is also occurring in this sector of the ice sheet.