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Satellite and GNSS identification of tidal flexure and velocity fluctuation in the grounding zone of outlet glaciers in the Transantarctic Mountains, Antarctica

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High precision GPS measurements across grounding zones around Antarctica show non-linear velocity variations in glacier flow in response to ocean tides. These periodic fluctuations occur at timescales of hours, days, weeks and longer and have been linked to tide-induced changes in basal stress for fast flowing ice streams in West Antarctica. Here we present similar observations of diurnal and fortnightly variations in velocity on a smaller scale for laterally-confined East Antarctic outlet glaciers which drain into the Ross Ice Shelf, through the Transantarctic Mountains.

Glacier velocities for two large glaciers in the Transantarctic Mountains were recorded using GNSS receivers positioned across and upstream of the grounding zone. The receivers measure vertical ice displacement in response to ocean tides as well as variation in horizontal velocity over periods of 4 to 5 weeks.

Horizontal velocities and vertical displacement are compared with interferometric synthetic aperture radar (InSAR) and surface feature tracking in the grounding zones of these glaciers, as well as with an inverse tide model. The satellite remote sensing techniques for continued monitoring of ice velocity use repeat pass imagery acquired over short time intervals in order to maintain image coherence, yet it is shown how this has potential to introduce systematic errors, particularly at the grounding-line, when values of daily or weekly displacement are extrapolated into annual velocity estimates. Periodic fluctuations can mask long term change in glacier dynamics from year to year, or produce statistically significant yet misleading results when calculations of velocity are made at different stages of the tidal cycle. Careful selection of image pairs and full understanding of the effect of tides on ice of varying thickness and grounding-zone configuration is required to mitigate these effects. The feasibility of using remote sensing to measure short-term velocity variation, and thereby infer glacier and grounding-zone characteristics, is also discussed.