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The heartbeat of a glacier: Cascading subglacial water pockets and ocean tides cause hourly to daily ice-flow variations of Priestley Glacier, Antarctica, detected with Terrestrial Radar Interferometry

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In Antarctica, basal melting in the ice-sheet's interior generates subglacial water that is routed via the subglacial hydrological system towards the margins. At the grounding zone, the subglacial meltwater comes into contact with ocean water subject to tides. The mixing of the two water masses may be one reason for velocities variations on tidal timescales, providing a window into processes of basal sliding. With this goal in mind, we instrumented a flowline across the grounding zone of Priestley glacier, Antarctica, with 4 differential GNSS stations co-located with advanced phase sensitive radars (ApRES) and tiltmeters all measuring continuously over several months. Moreover, we installed a Terrestrial Radar Interferometer (TRI) overlooking the glacier from an adjacent rock outcrop. The to our knowledge first-time deployment of the TRI in Antarctica reveals a stunning picture of grounding-zone dynamics providing spatially coherent 1D flowfields every 3 hours over a time period of 10 days. This enables interpretations of velocity changes measured by GNNS in an unprecedented spatial context. We complement our on-site geophysical dataset with airborne ice-penetrating radar as well as spaceborne InSAR data using timeseries from TanDEM-X, Sentinel-1A, and the ERS satellites.

TRI and GNSS stations jointly detect tidal velocity fluctuations (> 50 % around the mean) which decay landwards with increasing distance from the grounding line. Triple differences in satellite interferometry reveal transient bull's eye patterns far upstream of the grounding line quantifying localized surface lowering together with adjacent surface uplift. We interpret this as a result from abruptly migrating subglacial water pockets cascading over obstacles in the basal topography. The TRI also shows such bull's eye patterns pulsating in our highly resolved time series. Moreover, all GNSS stations and the TRI detect a short-lived acceleration event (~100 % horizontal speedup over 2 hours) paired with spatially coherent surface uplift (~15 cm). Magnitude and duration of this event suggests operation of hydraulic jacking, a mechanism explaining short-lived speed-ups with pressure variations in a linked-cavity system. However, usually this is pre-conditioned to the existence of significant surface meltwater entering the subglacial hydrological system, which is not the case at our study site. Our joint observations with multiple sensors and instruments therefore provide unique observations to further develop our understanding of basal sliding, particularly it's

dependency on upstream water supply and ocean tides.