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Bed-character dependent microseismicity clustering at Rutford Ice Stream, West Antarctica

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Microseismicity, induced by the sliding of a glacier over its bed and through bed deformation, can be used to characterize frictional properties of the ice-bed interface. Together with ice column deformation, these characteristics form the key parameters controlling ice stream flow. Here, we use naturally occuring seismicity to monitor temporal and spatial changes in bed properties at Rutford Ice Stream (RIS), West Antarctica, in order to characterize ongoing basal deformation and sliding. RIS is a significant contributor to the outflow of ice from West Antarctica, with speeds of ~1.1 m/day. Past geological and geophysical surveys, including drilling into the bed itself, have revealed pronounced bed topography and a sharp change in bed character along flow direction from presumably soft deformable to stiffer sediments. These complementary data as well as Rutford's flow characteristics allow us to interpret the seismic data in their geological context.

Our data consist of three months of seismic recordings from a 35-station seismic network located ~40 km upstream the grounding line of RIS, being collected in the framework of the BEAMISH project during the 2018/19 field season. An event catalogue derived using the QuakeMigrate and Nonlinloc software packages reveals an active seismic environment (~40,000 events in three months) with locally clustered microseismicity. Microseismicity occurs near the ice-bed interface and is concentrated in the transition region between presumed-soft and presumed-hard sediments. Within the more compacted sediments further seismicity occurs, predominantly along topographic lows, which form elongated, flow parallel sub-glacial valleys. Within the regions of activity, seismicity tends to cluster in focused spots of particular high activity. Repeated basal seismicity at spatially restricted locations has been observed before and was interpreted as being caused by 'sticky spots' within a more ductile deforming matrix. Our results, showing a close alignment of these sticky spots along structural and topographic boundaries, may indicate that such features form major obstacles for basal glacial sliding. In addition to these spatial variations, the average event frequency varies over time. We estimate an ~15 day periodicity to the activity with as many as 1200 events/day during the active times and as few as ~100 events per day during the more-quiescent times. This roughly corresponds to the period of the spring-neap tidal cycle

which has been shown to modulate the horizontal flow velocity of RIS. Time dependent variations in the frequency of microseismicity might suggest the glacial bed affected by these modulations.