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Subglacial hydromechanical Processes from Seismic Amplitude Versus Offset (AVO) Monitoring

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We present new insights into hydrologically-forced changes in subglacial mechanical properties and processes based on repeat acquisition of seismic reflection data at the Grubengletscher, Valais, Switzerland, combined with GPS monitoring and GPR surveying. The Grubengletscher flows noticeably faster (several tens of metres per year) than the majority of Alpine glaciers, facilitated principally by basal motion controlled by a previously unidentified mechanical process. Joint analysis of seismic reflection and GPR data allows mapping of the spatially variable thicknesses of the unlithified subglacial sediments. Amplitude-Versus-Offset (AVO) data, acquired repeatedly on sub-daily timescales during the evolving summer melt season using stationary receiver and shot arrays, reveal that the amplitude of the reflection off the interface between ice and subglacial sediments is characteristically higher in the morning than in the afternoon. Such diurnal changes in the basal reflection coefficient correlate, respectively, directly and indirectly with variations in horizontal surface motion and surface elevation change. After eliminating a range of alternative mechanisms we infer that the observed variations are most likely due to sub-daily increases in the Poisson's ratio of the subglacial sediments that scale directly with subglacial shear stress, sediment dilatation, and horizontal surface motion, and inversely with pore water pressure and surface elevation. Sediment deformation is therefore a key process facilitating enhanced glacier flow. Our study has important implications for glaciological and geophysical investigations of the dynamics of fast flowing outlet glaciers from the world's ice sheets.