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Is it possible to monitor Subglacial Hydraulic Processes with Ground-Penetrating Radar (GPR)?

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We discuss the scope of and potential pitfalls in conducting fixed-position, continuously repeated ground-penetrating radar (GPR) surveys to monitor hydrological processes operating at the bed of ice masses subject to perennial surface melting. Our study is based on fixed-position GPR data collected continuously between early morning and early evening at the Grubengletscher, Valais, Switzerland. Three significant events are observed in our GPR monitoring data: [a] very near-surface signal modifications reflected in the waveform of the ground wave due to increasing water content of porous near-surface ice during the day; [b] temporal changes in the reflection amplitude of the cold-warm ice interface; and [c] temporal changes in the reflection amplitude of the interface between ice and subglacial sediments. To derive true changes in basal reflection amplitude it is paramount that basal reflector amplitude is corrected for diurnally variable energy losses in the very near surface. This is achieved by normalising basal reflector amplitude by concurrent changes in ground wave amplitude, revealing a striking low in basal reflector strength in mid afternoon. Overall diurnal changes in basal reflector amplitude scale inversely with seismic reflection strength and horizontal motion of the glacier surface, and directly with surface elevation. Together these data sets suggest consistently that pore water pressure drops in mid-afternoon, increasing basal shear stress and sediment dilatation. We conclude that GPR monitoring promises to be a powerful tool in monitoring subglacial hydraulic processes and their temporally changing impact on glacier dynamics if a number of pitfalls are avoided.