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Hydraulic properties of and processes in subglacial till using 4-D electrical resistivity monitoring

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We recorded electrical resistivity data at the base of four boreholes drilled through Haut Glacier d'Arolla, Switzerland. The data were acquired repetitively every hour over two diurnal hydrological cycles in the late melt season, separated by ten days. 3-D data inversion allowed reconstruction of hourly variations in bulk resistivity in the subglacial sediment layer. Inverted resistivity models reflect establishment of channelised subglacial drainage in the study area between the two hydrological cycles, which is in agreement with previous work. Daily variations in bulk and water resistivity are in phase, and bulk resistivity amplitudes decrease away from the subglacial channel. Using electrical-hydraulic relationships proposed by Revil and Cathles (1999) we estimate metre-scale changes in the hydraulic conductivity and porosity of the subglacial sediment layer, accounting for increasing clay content and decreasing median grain radius with distance from the channel. Hydraulic conductivity and porosity were respectively calculated to decrease from 0.064 m/s and 0.34 at the channel to 0.033 m/s and 0.26 at a distance of 5 m from it. Error ranges from 0.021 m/s to 0.022 m/s for the two hydraulic conductivity estimates respectively, and is 0.01 for the porosity estimates. The hydraulic conductivity estimates are in agreement with previously inferred values, and the porosity estimates fall within the expected range for unlithified subglacial sediments. We conclude that collection and inversion of 4-D subglacial resistivity data is feasible and has the capacity to generate multi-dimensional images of hydraulic properties of and processes in subglacial till.