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Energy and moisture fluxes over and within frozen debris in polar conditions: evidence from the Taylor Valley, Antarctica

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Frozen debris surfaces of the McMurdo Dry Valleys region of Antarctica present a unique microclimate due to the low albedo of the dark sediment surface and complex patterns of heat exchanges through sublimation, melt and evaporation of moisture within the pore space of the debris. Understanding energy exchanges within and over these surfaces provides useful information for characterising mass-balance of frozen debris surfaces, production of sublimation till and soil development in cold and hyper arid environments. A field study in the Taylor Valley was conducted during the early summer, encompassing the period of melt onset. Measurements were made over and within four different surfaces including ice-capped morraines (10 and 20 cms), debris laden ice and ice-cemented sand. Measurements included the surface radiation budget, eddy covariance fluxes of sensible and latent heat, ground heat fluxes and temperature profiles to 40 cm and three weighing lysimmeters. Significant damping of ground temperature fluctuations with associated periods of stasis is evident near the freezing front.

A one-dimensional vertical numerical model has been established, which represents vertical flows of heat and moisture within the sediment, computing the ice-water phase transitions as well as evaporation and sublimation. It can either be forced by variations in the skin temperature, or by variations in the net radiation and sensible heat flux. The output is the temperature within the sediment as a function of depth and time, the water or ice content of the sediment and the latent heat flux in the atmosphere. Initial modelling of the heat fluxes shows that the damping and stasis can be represented in general terms.