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Carbon gas cycling in supraglacial debris covers

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Debris-covered glaciers extend over 4000 km2 in the high Asian Mountains and are significant and expanding features of most of the World's glacierized mountain ranges. Within supraglacial debris covers, a combination of fresh mechanically-weathered rock and an abundance of water and energy during melt seasons provides an ideal environment for chemical rock weathering and microbial activity. These processes involve exchange of carbon dioxide $CO2$ and methane $CH4$ with the atmosphere, while daytime heating of debris leads to evaporation of meltwater from the debris matrix. Debris-covered glaciers may therefore play an important role in regional and global cycling of major greenhous gases. This new project aims to address 2 key questions: (i) What are the important chemical and microbiological processes affecting carbon gas exchange within supraglacial debris covers? (ii) What are the rates and controls on gas exchange and how do these rates vary in time and space? Initial direct measurements of $CO2$ flux have been made using an eddy covariance (EC) and gas analyser system installed over debris cover at Miage glacier in the Italian Alps, during the melt season. Under fine weather conditions, there is a strong daily cycle in downwardly-directed $CO2$ flux, closely linked to variation in energy input to the debris, driven by the flux of shortwave radiation. In contrast, rainfall is associated with short pulses of upwardly-directed $CO2$ flux to the atmosphere. In common with previously published findings, these data indicate that supraglacial debris covers are a strong summer sink of $CO2$. At Miage glacier the mean summer (June-August) flux is almost 0.5 g carbon per day per square metre of debris, more than 2 orders of magnitude higher than reported fluxes over cryoconite. Current gas flux data are limited to a few points and this project will extend measurements to varying lithologies, elevations and glaciers in different climatic environments using portable greenhouse gas analysers in conjunction with the EC system. Direct flux measurements will be supported by in-field analysis of debris strucure and composition and subsequent laboratory analysis to determine the minerals, carbon content and microbial communities present in debris covers to uncover controlling processes and determine the relative roles of chemical weathering and microbial activity in carbon gas cycling.