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Ancient soil organic carbon in glaciers supports downstream metabolism in the European Alps

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Mountain glaciers and ice caps shrink at unprecedented pace with major implications for macroscale runoff patterns and sea-level rise. Building evidence suggests that glaciers, beside their prominent role in the hydrological cycle, are place for microbial and biogeochemical processes. In the Gulf of Alaska, glacial runoff was shown to be a quantitatively important source of ancient and labile organic carbon to marine ecosystems. However, both origin and chemical composition of glacial organic carbon nurturing downstream ecosystems remain elusive. This makes it difficult to understand the role of glaciers in carbon cycling. Here we present first evidence from 26 Alpine glaciers that glacial dissolved organic carbon (DOC), although very low in concentration (138 ± 96 μg C L^{-1}), contributes to carbon cycling in pro-glacial streams. We found that the bioavailability of glacial DOC (25 to 86 % labile) for microbial heterotrophs increased with its proteinaceous content and with age. Black carbon did not explain the variation in DOC age (600 to 8500 years), suggesting that ancient organic carbon other than black carbon contributes to DOC bioavailability. Proteinaceous moieties from glacial DOC were rapidly removed in the pro-glacial stream, where DOC bioavailability rather than physical processes drove excess $p\mathrm{CO}_2$ (E$p\mathrm{CO}_2$) in the streamwater as a proxy for *in situ* metabolism. Using mass loss data and carbon use efficiency (19.4 ± 7.2 %) data from glacial ice, we estimate that glaciers in the European Alps deliver 340 tons C yr^{-1}, of which 162 tons C are potentially respired as CO_2 to the atmosphere. These fluxes are small compared to those from high-mass-loss glaciers, such in Alaska, but they are unexpected biogeochemical links between low-DOC glaciers and the smallest of the headwaters in alpine fluvial networks.