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Dynamics of atmospheric-methane oxidation in glacier-forefield soils

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Mature upland soils are currently considered the sole terrestrial sink for atmospheric methane (CH_4). But little is known about CH_4 dynamics in young, developing soil ecosystems such as glacier forefields formed by progressive glacial retreat. Glacier forefields are situated on diverse bedrock types, exhibit a continuum of soil age (chronosequence), and are comprised of various geomorphological landforms, which may differ in physicochemical properties. These features may affect activity and community structure of aerobic methane-oxidizing bacteria (MOB) catalyzing atmospheric CH_4 oxidation. Moreover, MOB activity and community structure may be affected by environmental parameters subject to seasonal variability such as soil temperature, water content, and nutrient availability.

The aim of this study was to assess spatial and seasonal variability in atmospheric CH_4 oxidation in glacier-forefield soils derived from siliceous and calcareous bedrock. Specifically, we quantified soil-atmosphere CH_4 flux and CH_4 oxidation activity using the soil-gas-profile method and static flux chambers in soils of different age and belonging to different landforms. In these soils MOB abundance and variation in community structure were assessed by targeting the functional gene *pmoA* using quantitative PCR, TRFLP-based cluster analysis, and high-throughput DNA-sequencing technology. Seasonal variability in atmospheric CH_4 oxidation was assessed based on the same attributes measured with high temporal resolution throughout one snow-free season.

Most glacier-forefield soils acted as a sink for atmospheric CH_4 regardless of bedrock type, and CH_4 flux (-0.082 to -2.2 mg CH_4 m^{-2} d^{-1}) and MOB abundance (2.4×10^3 to 5.5×10^5 *pmoA* genecopies (g soil w.w.)$^{-1}$) increased significantly with soil age. Cluster analysis revealed variations in MOB community composition related to bedrock type rather than soil age, suggesting that distinct MOB communities provided a similar ecosystem service in soils on different bedrock. On the other hand, substantial differences in CH_4 flux were noted between soils of different landforms, with largest fluxes observed in well-drained sandhills (see above) and considerably smaller fluxes in fluvial landforms. Methane flux and oxidation activity revealed a prominent seasonal variability, attenuated in older soils. Based on our findings we propose a pattern for the establishment of the soil CH_4 sink in glacier forefields.