



Quantification of atmospheric methane oxidation in glacier forefields: Initial survey results

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The oxidation of CH₄ by methanotrophic bacteria is the only known terrestrial sink for atmospheric CH₄. Aerobic methanotrophs are active in soils and sediments under various environmental conditions. However, little is known about the activity and abundance of methanotrophs in pioneering ecosystems and their role in succession. In alpine environments, receding glaciers pose a unique opportunity to investigate soil development and ecosystem succession. In an initial survey during summer and autumn 2009 we probed several locations in the forefields of four glaciers in the Swiss Alps to quantify the turnover of atmospheric methane in recently exposed soils. Three glacier forefields (the Stein, Steinlimi and Tiefen) are situated on siliceous bedrock, while one (the Griessen) is situated on calcareous bedrock. We sampled soil air from different depths to generate CH₄ concentration profiles for qualitative analysis. At selected locations we applied surface Gas Push-Pull Tests (GPPT) to estimate first-order rate coefficients of CH₄ oxidation. The test consists of a controlled injection of the reactants CH₄ and O₂ and the tracer Ar into and out of the soil at the same location. A top-closed steel cylinder previously emplaced in the soil encloses the injected gas mixture to ensure sufficient reaction times. Rate coefficients can be derived from differences of reactant and tracer breakthrough curves. In one GPPT we employed ¹³C-CH₄ and measured the evolution of δ¹³C of extracted CO₂. To confirm rate coefficients obtained by GPPTs we estimated effective soil diffusivity from soil core samples and fitted a diffusion-consumption model to our profile data. A qualitative analysis of the concentration profiles showed little activity in the forefields on siliceous bedrock, with only one out of fifteen locations exhibiting substantially lower CH₄ concentrations in the soil compared to the atmosphere. The surface GPPTs with conventional CH₄ at the active location were not sensitive enough to derive meaningful first-order rate coefficients of CH₄ oxidation. The more sensitive GPPT with ¹³C-CH₄ resulted in a coefficient of 0.025 h⁻¹, close to the value of 0.011 h⁻¹ estimated from the corresponding concentration profile. Activities in the forefield on calcareous bedrock were substantially higher, with decreased CH₄ concentrations in the soil at three out of five locations. Estimated first-order rate coefficients from GPPT and profile at one selected location were 0.6 h⁻¹ and 1.3 h⁻¹, respectively, one to two orders of magnitude higher than values from the siliceous forefield. Additional analysis by quantitative PCR revealed substantially lower numbers of pmoA gene copies per g soil at the active location in the siliceous forefield compared to the selected location in the calcareous forefield. Reasons for these differences in activity and abundance are still unknown and will be subject of further investigations in an upcoming field campaign. The GPPT in combination with δ¹³C analysis of extracted CO₂ appeared to be a functioning approach to sensitively quantify low CH₄ turnover.