Geophysical Research Abstracts
Vol. 16, EGU2014-12734, 2014
EGU General Assembly 2014

Nitrification rates in Arctic soils are associated with functionally distinct populations of ammonia-oxidizing archaea

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The functioning of Arctic soil ecosystems is crucially important for global climate, although basic knowledge regarding their biogeochemical processes is lacking. Nitrogen (N) is the major limiting nutrient in these environments, and therefore it is particularly important to gain a better understanding of the microbial populations catalyzing transformations that influence N bioavailability. However, microbial communities driving this process remain largely uncharacterized in Arctic soils, namely those catalyzing the rate-limiting step of ammonia (NH_3) oxidation.

Eleven Arctic soils from Svalbard were analyzed through a polyphasic approach, including determination of gross nitrification rates through a ^{15}N pool dilution method, qualitative and quantitative analyses of ammonia-oxidizing archaea (AOA) and bacteria (AOB) populations based on the functional marker gene *amoA* (encoding the ammonia monooxygenase subunit A), and enrichment of AOA in laboratory cultures. AOA were the only NH_3 oxidizers detected in five out of 11 soils, and outnumbered AOB by 1 to 3 orders of magnitude in most others. AOA showed a great overall phylogenetic diversity that was differentially distributed across soil ecosystems, and exhibited an uneven population composition that reflected the dominance of a single AOA phylotype in each population. Moreover, AOA populations showed a multifactorial association with the soil properties, which reflected an overall distribution associated with tundra type and with several physico-chemical parameters combined, namely pH and soil moisture and N contents ($i.e.$, NO_3^- and dissolved organic N). Remarkably, the different gross *in situ* and potential nitrification rates between soils were associated with distinct AOA phylogenetic clades, suggesting differences in their nitrifying potential, both under the native NH_3 conditions and as a response to higher NH_3 availability. This was further supported by the selective enrichment of two AOA clades that exhibited different NH_3 oxidation rates. In addition, the enrichment cultures provided the first direct evidence for NH_3 oxidation by an AOA from an uncharacterized Thaumarchaeota–AOA lineage.

Our results indicate that AOA are functionally heterogeneous, and that the selection of distinct AOA populations by the environment can be determinant for nitrification activity and N availability in soils. Furthermore, our observations emphasize the fact that, disturbances in populations of specific microbial functional groups, such as nitrifiers, constitute potential response mechanisms to environmental changes. These findings are not only relevant for Arctic environments, but have implications for the role of AOA in nitrification in all soils.