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Do microbial communities adapt to the temperature of their climate?

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Terrestrial biogeochemical cycles are regulated by soil microorganisms. The microbial carbon release due to respiration and carbon sequestration through microbial growth determine whether soils become sources or sinks for carbon. Temperature is one of the most important environmental factors controlling both microbial growth and respiration. Therefore, to understand the influence of temperature on microbial processes is crucial. One strategy to predict how ecosystems will respond to warming is to use geographical ecosystem differences, in space-for-time (SFT) substitution approaches. We hypothesized (1) that microbes should be adapted to their environmental temperature leading to microbial communities with warm-shifted temperature relationships in warmer environments, and vice versa. Furthermore, we hypothesized (2) that other factors should not influence microbial temperature relationships, and (3) that the temperature sensitivity of microbial processes (Q10) should be linked to the microbial temperature relationships.

In this project, we investigated the effects of environmental temperature on microbial temperature relationships for microbial growth and respiration along a natural climate gradient along a transect across Europe to predict the impact of a warming climate. The transect was characterized by mean annual temperature (MAT) ranging from - 4 degrees Celsius (Greenland) to 18 degrees Celsius (Southern Spain), while other environmental factor ranges were broad and unrelated to climate, including pH from 4.0 to 8.8, C/N ratio from 7 to 50, SOM from 4% to 94% and plant communities ranging from arctic tundra to Mediterranean grasslands. More than 56 soil samples were analyzed and microbial temperature relationships were determined using controlled short-term laboratory incubations from 0 degrees Celsius to 45 degrees Celsius. The link between microbial temperature relationship and the climate was assessed by using the relationship between the environmental temperature and indices for microbial temperature relationships including the minimum (T_{min}), optimum (T_{opt}) and maximum temperature (T_{max}) for microbial growth as well as for respiration. To estimate the T_{min}, T_{opt} and T_{max} the square root equation, the Ratkowsky model was used.

We found that microbial communities were adapted to their environmental temperature. The microbial temperature relationship was stronger for microbial growth than for respiration. For 1 degrees Celsius rise in MAT, T_{min} increased 0.22 degrees Celsius for bacterial and 0.28 degrees Celsius for fungal growth, while T_{min} for respiration increased by 0.16 per 1 degrees Celsius rise. T_{min} was also found to be universally linked to Q10, such that higher T_{min} resulted in higher Q10. Other environmental factors (pH, C/N ratio, SOM, vegetation cover) did not influence the temperature relationships. By incorporating the determined relationships between environmental temperature and microbial growth and respiration into large scale ecosystem models, we can get a better understanding of the influence of microbial adaptation to warmer climate on the C-exchange between soils and atmosphere.