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Physiological responses of soil microorganisms to weeks, years, and decades of soil warming

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How soil microorganisms respond to global warming is a key question in microbial ecology and eminently relevant for soil ecosystems, the terrestrial carbon cycle, and the climate system. However, physiological responses of soil microorganisms – key to infer future soil-climate feedbacks – are poorly understood.

We here make use of the longest lasting *in situ* soil warming experiment worldwide, ForHot, in which an Icelandic subarctic grassland site has been exposed to natural geothermal soil warming for more than 50 years. Using a metatranscriptomics approach, allowing the comprehensive study of the entire active soil microbial community and their functions by analysing expressed genes, we revealed key physiological responses of soil Bacteria to medium- (8 years) and long-term (>50 years) soil warming of +6 °C.

Irrespective of the duration of warming, we observed a community-wide upregulation of central (carbohydrate) metabolisms and cell replication and a downregulation of the bacterial protein biosynthesis machinery in the warmed soils. This coincided with a decrease of microbial biomass, a decrease of total and biomass-specific RNA content, and lower soil substrate concentrations in the warmed soils. We conclude that higher biochemical reaction rates, caused by higher temperatures, allow soil Bacteria to reduce their cellular number of ribosomes, the macromolecular complexes carrying out protein biosynthesis. To further test this we revisited the site and conducted a short-term warming experiment (6 weeks, +6 °C), which supported our conclusion.

The downregulation of the protein biosynthesis machinery (i.e., the reduction of ribosomes) liberates energy and matter, leading to a resource re-allocation, and allows soil Bacteria to maintain high metabolic activities and cell division rates even after decades of warming.