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Do we obtain valid data from climate change incubations using soils of today?

E. MARIE MUEHE[1,2], ALEKSANDRA PIENKOWSKA[1], PAULA KOSEL[1], SCOTT FENDORF[3] AND THOMAS REITZ[1]

[1]Helmholtz Centre for Environmental Research - UFZ
[2]University of Tübingen
[3]Stanford University
Presenting Author: marie.muehe@ufz.de

Climate change alters every biogeochemical process in soils that can lead to unprecedented losses in soil health. Laboratory-, climate chamber-, and greenhouse-based soil and plant incubations are used to draw conclusions about the direction, extend, and mechanisms of biogeochemical changes that occur in soils upon exposure to alterations in precipitation pattern, temperature, and/or atmospheric CO_2. All these studies commonly use soils of today for simplicity and feasibility to mimic biogeochemical processes and outcomes of the future. Using soils derived from today's conditions disregards that soils may have evolved geochemically and microbiologically decades into the future. We are, thus, asking the question: Can we perform climate change experiments with a soil microbial community and geochemistry of today to realistically mimic biogeochemical processes and outcomes of the future?

To answer this question, soils from one to eight year long experiments under which they were subjected to either ambient or future climatic conditions were obtained. We re-exposed them in a crossfactorial design to both, present day and future, conditions. For an oxic soil having experienced eight years of night time temperature differences of up to 2°C and a 5% soil moisture increase in spring and fall, iron mineralogy was mostly affected by incubation conditions and not by soil history, whereas the opposite was true for soil respiration. For a fully flooded paddy soil having experienced temperature differences of 4°C and doubled atmospheric CO_2 for one year, reductive iron(III) dissolution was delayed but more pronounced for soils with a history of future compared to ambient climatic conditions, indicating a higher degree of aging of iron minerals due to climate differences. Interestingly, arsenic was released from these aged iron minerals to a much higher extend compared to soils of today, indicating that experiments with current soils underestimate contaminant threats of the future.

Our findings indicate that soil history plays a differential role for biogeochemical processes and outcomes of the future. Biogeochemical processes will not be different in soils of the future per se, but biogeochemical outcomes and time trajectories may be over- or underinterpreted when climate change studies use soils of today.