Using online N₂O isotopic measurements to understand grassland N₂O emission processes in a changing climate

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Biogeochemical processes in soils largely control the atmospheric mixing ratio of nitrous oxide (N₂O). The growing use of nitrogen (N) fertilizer in agriculture drives anthropogenic N₂O emissions, which currently surpass projections with some of the highest emissions. In order to adapt mitigation strategies and to model the future N cycle it is crucial to fully understand N₂O emission pathways in a changing climate. The underlying processes, attributed to microbial transformation of N, primarily occur via the oxic nitrification and anoxic denitrification pathways. These processes depend greatly on soil, plant and ecosystem properties, which in turn rely on meteorological drivers (e.g. air temperature and precipitation). This means that the many environmental factors that drive microbial activity and N₂O emissions in soils are vulnerable to climate change, including extreme events such as droughts. Consequently, the rates of nitrification and denitrification are expected to be strongly impacted by changing climatic conditions, which could also alter the N₂O production and consumption dynamics across the soil profile.

This study aims to understand how N₂O production and consumption pathways respond to the individual and combined effects of warming, elevated atmospheric CO₂ concentration, and drought-rewetting events in managed mountain grassland. For the first time, we use online, in-situ stable isotopic measurements of both surface N₂O emissions and of N₂O across the soil profile to distinguish pathways for N₂O production and consumption. Different modeling approaches will be used to reconstruct production and consumption dynamics from soil gas isotopic measurements, and to upscale results to examine global relevance.