Internationale Grünland-Konferenz/International Grassland Conference 2025 in Garmisch-Partenkirchen

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Mountain pastures

Author: Elisabeth Ramm[None]

Corresponding Author: elisabeth.ramm@kit.edu

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Plant & Microbial Biodiversity / 25

The soil microbiome –Mitigator or origin of climate change ?

Author: Michael Schloter[1]

Co-author: Stefanie Schulz

[1] *Helmholtz Zentrum München*

Corresponding Authors: stefanie.schulz@helmholtz-munich.de, michael.schloter@helmholtz-munich.de

The soil microbiome plays a pivotal role in biogeochemical cycles, particularly in carbon and nitrogen cycling, which are central to the regulation of Earth's climate. As global climate change accelerates, understanding whether the soil microbiome functions primarily as a mitigator or as a contributor to this threat is increasingly critical.
Recent advances in metagenomics, isotope tracing, and environmental modeling have revealed that soil microbial communities significantly influence carbon fluxes between terrestrial ecosystems and the atmosphere. Microbial processes such as SOM decomposition, nitrification, denitrification, and methanogenesis govern the turnover of key greenhouse gases, including carbon dioxide (CO_2), , nitrous oxide (N_2O), and methane (CH_4). In stable ecosystems, especially unmanaged forests and undisturbed grasslands, microbes facilitate carbon sequestration by stabilizing organic matter in soils and promoting plant-microbe symbioses that enhance biomass productivity and drought resilience. These functions position the soil microbiome as a potential climate change mitigator.
However, microbial contributions to climate change are highly context dependent. Disturbances such as intensive agriculture, deforestation, and permafrost thawing alter microbial community structure and function, often leading to elevated greenhouse gas emissions turning the soil microbiome into a potential accelerator of climate change.
Thus, the answer to the question - whether the soil microbiome is a mitigator or origin of climate change?—is not binary. The soil microbiome is both, and its trajectory is ultimately shaped by human stewardship as well as environmental conditions including climate change itself.
The key question is: How can microbial processes be managed or engineered to enhance their climate-mitigating capabilities? Promising strategies include promoting beneficial microbial taxa through conservation agriculture, rewilding degraded lands, applying biochar, and developing microbial inoculants designed to stabilize soil carbon. However, the high complexity and variability of microbial communities on the one hand and differences in site specific properties like soil type, management or climate on the other hand exacerbate prediction and control. Thus the "One fits all solution"might be never achieved. Furthermore, current Earth system models inadequately represent microbial processes, underscoring the need for more integrative research at the intersection of microbiology, soil science, and modeling.
The presentation will give an overview about current state of the art describing the dual role of the soil microbiome that can either buffer or exacerbate climate change mainly focussing on grassland ecosystems. The presentation will also address the question of the stoichiometry of nutrients and if subsequent adaptations in management might be a possibility to induce targeted changes in the soil microbiome composition and activity pattern, which could also influence greenhouse gas emission pattern .

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Biomass production of Grasslands: Spatial distribution of biomass production and feed demand in two contrasting regions of Bavaria, Germany

Authors: Sylvia Helena Annuth[None]; Thomas Schmitt[1]

Co-authors: Carolin Boos [1]; Lisa Hülsmann [2]; Sophie Reinermann [3]; Thomas Koellner [2]

[1] *Karlsruhe Institute of Technology (KIT)*

[2] *University of Bayreuth*

[3] *German Aerospace Center (DLR)*

Corresponding Author: bt308654@uni-bayreuth.de

For agriculture, biomass production for feeding livestock is an essential ecosystem service of grasslands. In line with the European Green Deal's farm-to-fork strategy, maximizing fodder production from existing grasslands is more sustainable than relying on high-intensive cropland feed. Reducing imports and dependency on cropland feed is a global environmental goal. However, it remains unclear whether current grassland resources can sufficiently meet livestock's energy needs. This study assesses the balance of metabolizable energy (ME) from grasslands in two contrasting regions of Bavaria, Germany. We estimate the ME balance per farm and year using data from the Integrated Administration Control System (IACS), including field usage, livestock information, and modeled yield data. We analyze variations between a dry year (2018) and a typical year (2020) under conventional and organic farming. Results show an average ME deficit of ~1,000 GJ per farm (equivalent to 17 dairy cows) in northern Bavaria, whereas the (pre-)Alpine region in southern Bavaria generally shows surpluses, roughly one potential additional dairy cow per farm (~60 GJ surplus). Within the southern region, a north-south trend appears, with deficits in the north and surpluses in the south. No clear pattern emerges in northern Bavaria. Organic farms tend to exhibit higher ME surpluses than conventional farms. A geographically weighted regression reveals that elevation, precipitation, agri-environmental schemes, and farming practices significantly influence ME balances, with effects varying spatially. These findings underscore the need of region-specific strategies to optimize grassland fodder production and enhance the resilience of livestock farming in a changing climate.

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An agent-based model to simulate field-specific nitrogen fertilizer applications in grasslands

Author: Andrea Kaim[1]

Co-authors: Thomas Schmitt [2]; Sylvia Helena Annuth [3]; Maria Hänsel [3]; Thomas Koellner [3]

[1] *Helmholtz-Zentrum für Umweltforschung - UFZ*

[2] *Karlsruhe Institute of Technology (KIT)*

[3] *University of Bayreuth*

Corresponding Author: andrea.kaim@ufz.de

Fertilization plays an important role in grassland management and decisions are usually made at farm level. Data on fertilizer application rates are crucial for an accurate assessment of the effects of grassland management on ecosystem services. However, these are generally not available on farm/field scale. To close this gap, we present an agent-based model for Fertilization In Grasslands (FertIG). Based on animal, landuse, and cutting data, the model estimates grassland yields and calculates field-specific amounts of applied organic and mineral nitrogen on grassland (and partly cropland). Furthermore, the model considers different legal requirements (including fertilization ordinances) and nutrient trade among farms. FertIG was applied to a grassland-dominated region in Bavaria, Germany comparing the effects of changes in the fertilization ordinance as well as nutrient trade. The results show that the consideration of nutrient trade improves organic fertilizer distribution and leads to slightly lower mineral N applications. On a regional scale, recent legal changes (fertilization ordinance) had limited impacts. Limiting the maximum applicable amount of organic N to 170 kg N/ha fertilized area instead of farm area as of 2020 hardly changed fertilizer application rates. No longer considering application losses in the calculation of fertilizer requirements had the strongest effects, leading to lower supplementary mineral N applications. The model can be applied to other regions in Germany and, with respective adjustments, in Europe. Generally, it allows comparing the effects of policy changes on fertilization management at regional, farm and field scale.

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Grassland ecosystem services in a changing climate –combining advisory guidelines and process-based modelling to support adaptation

Author: Pierluigi Calanca[1]

Co-authors: Kevin Kramer ; Marcio Dos Reis Martins

[1] *Agroscope*

Corresponding Authors: marcio.dosreismartins@agroscope.admin.ch, pierluigi.calanca@agroscope.admin.ch, kevin.kramer@agrosc

The National Climate for Climate Services (NCCS) is currently implementing a programme aimed at developing decision-making tools for dealing with climate change in Switzerland. As a contribution to "Ecosystem Services", one of the projects included in the programme, Agroscope is setting up an interactive information platform that will allow users to display the projected impacts of climate change on grassland ecosystem services. Given the practical scope, it is important that the data displayed on the platform match the information already available for advising stakeholders. For instance, the current fertilisation recommendations in the official guidelines published by Agroscope target yield levels that reflect the empirical knowledge obtained from field trials and monitoring programmes. To ensure consistency with this information, a mixed approach was therefore selected to develop the new platform, in which empirical relations between elevation, climate and management deliver the basis for creating maps of current productivity levels, while simulations with a process-based model driven with climate change scenarios are conducted to chart the impacts of elevated CO_2 concentrations, rising temperatures and shifts in precipitation patterns on grassland productivity. This presentation will illustrate the steps involved in the development of the platform and provide initial impressions of the final product.