EGU25-15806, updated on 14 Jun 2025
https://doi.org/10.5194/egusphere-egu25-15806
EGU General Assembly 2025

Sustaining livestock in Mongolia through integrated livestock–vegetation modelling

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The Mongolian Steppe Ecosystem is a highly vulnerable system, prone to degradation, driven in part by increasing livestock densities. While reducing livestock numbers is often suggested to alleviate pressure on grasslands, there remains a lack of tools for projecting forage availability, potential livestock densities, and the utilization of net primary productivity (NPP) into the future. Such tools could provide valuable guidance for developing effective policies and sustainable management strategies.

To address this gap, we employed a Dynamic Global Vegetation Model (DGVM), LPJ-GUESS, adapted with a daily allocation scheme for grasses, to which we added a simplified livestock submodule to simulate the effects of grazing on aboveground biomass. Forage availability was modeled using historical climate data (ERA5-Land, 0.1° resolution), while NPP utilization was assessed by comparing model runs with and without observed livestock numbers included. Using an iterative approach, potential livestock densities were determined as the maximum densities at which forage sufficiency was maintained over the period from 1970 to 2023.

Our results show a reasonable alignment between LPJ-GUESS modeled GPP and NPP, and GOSIF GPP as well as MODIS NPP. We show spatially explicit utilisation rates and compared actual livestock densities with potential densities, revealing areas of overutilisation that to some extent agree with degradation patterns. When combined with future climate projections, this approach offers a valuable tool for stakeholders and policymakers aiming to sustain the ecological balance and productivity of the Mongolian Steppe under changing climate and grazing scenarios.