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Multiple greenhouse gas feedbacks from the land biosphere under future climate change scenarios

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Atmospheric concentrations of the three important greenhouse gases (GHG) CO_2, CH_4, and N_2O are mediated by processes in the terrestrial biosphere. The sensitivity of terrestrial GHG emissions to climate and CO_2 contributed to the sharp rise in atmospheric GHG concentrations since preindustrial times and leads to multiple feedbacks between the terrestrial biosphere and the climate system. The strength of these feedbacks is determined by (*i*) the sensitivity of terrestrial GHG emissions to climate and CO_2 and (*ii*) the greenhouse warming potential of the respective gas. Here, we quantify feedbacks from CO_2, CH_4, N_2O, and land surface albedo in a consistent and comprehensive framework based on a large set of simulations conducted with an Earth System Model of Intermediate Complexity.

The modeled sensitivities of CH_4 and N_2O emissions are tested, demonstrating that independent data for non-land (anthropogenic, oceanic, etc.) GHG emissions, combined with simulated emissions from natural and agricultural land reproduces historical atmospheric budgets within their uncertainties.

21st-century scenarios for climate, land use change and reactive nitrogen inputs (Nr) are applied to investigate future GHG emissions. Results suggest that in a business-as-usual scenario, terrestrial N_2O emissions increase from 9.0 by today to 9.8-11.1 (RCP 2.6) and 14.2-17.0 TgN_2O-N/yr by 2100 (RCP 8.5). Without anthropogenic Nr inputs, the amplification is reduced by 24-32%. Soil CH_4 emissions increase from 221 at present to 228-245 in RCP 2.6 and to 303-343 TgCH_4/yr in RCP 8.5, and the land becomes a net source of C by 2100 AD. Feedbacks from land imply an additional warming of 1.3-1.5°C by 2300 in RCP 8.5, 0.4-0.5°C of which are due to N_2O and CH_4.

The combined effect of multiple GHGs and albedo represents an increasingly positive total feedback to anthropogenic climate change with positive individual feedbacks from CH_4, N_2O, and albedo outweighing the diminishing negative feedback from CO_2 fertilisation of terrestrial C storage.

This positive feedback from terrestrial biogeochemistry amplifies the traditionally defined physical equilibrium climate sensitivity by 23-28%,

Strong mitigation, reducing Nr inputs and preserving natural vegetation limits the amplification of terrestrial GHG emissions and prevents the land biosphere from acting as an increasingly strong amplifier of anthropogenic climate change.