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Copernicus Institute of Sustainable Development, Environmental Sciences Group
Water, Climate, & Ecosystem project

Modelling global mineral nitrogen leaching from natural ecosystems: impact of N deposition, climate, and CO_2 concentration

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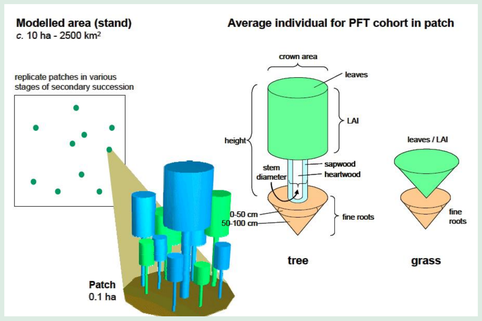
INTRODUCTION

Atmospheric N deposition has risen dramatically during the last century due to fossil fuel NOx emissions. The resulting increased N availability will stimulate productivity of natural ecosystems, which are mostly N limited.
Many ecosystems will become saturated with N, leading to increased nitrate leaching, which may cause groundwater pollution and eutrophication of aquatic ecosystems.
Nitrate leaching rates are difficult to predict since the ecosystem N balance is also influenced by atmospheric CO_2 concentration, which influences productivity, and temperature, which controls soil N mineralisation.
We aim to disentangle the effects of N deposition, climate, and CO_2 concentration on ecosystem nitrate leaching rates by means of a factorial simulation experiment with a dynamic global vegetation model.

METHODS

LPJ-GUESS

Individual-based dynamic global vegetation model that simulates vegetation dynamics and land carbon, water and nitrogen fluxes.

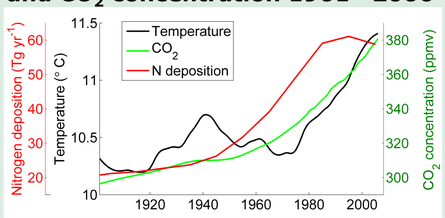


Factorial model experiment

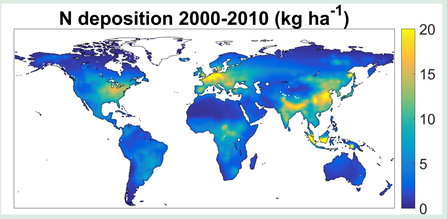
We performed eight historical simulations in which climate, CO_2 concentration, and N deposition were true values or held fixed at preindustrial values.

Sim	N dep.	climate	CO_2
1	constant	constant	constant
2	true	constant	constant
3	constant	true	constant
4	constant	constant	true
5	true	true	constant
6	true	constant	true
7	constant	true	true
8	true	true	true

Global temperature, N deposition and CO_2 concentration 1901—2006

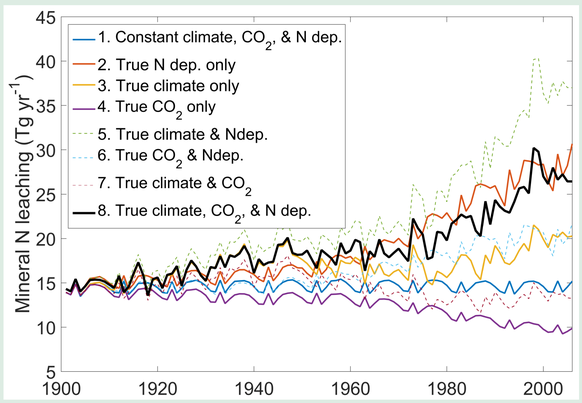


N deposition 2000-2010 (kg ha^{-1})



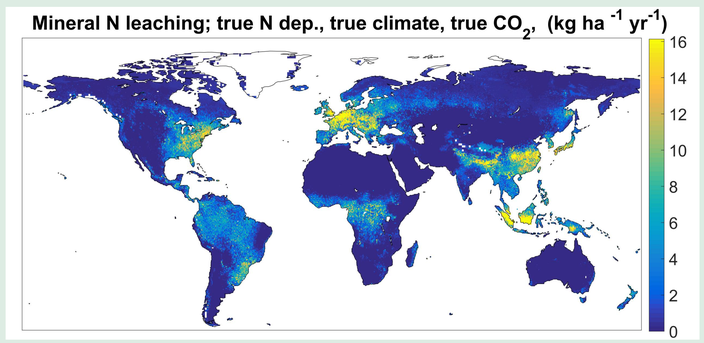
RESULTS

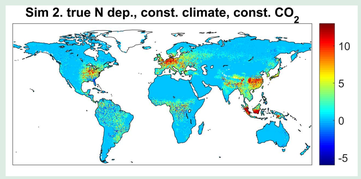
Total global N leaching for the different model experiments *Rising temperature stimulates nitrate leaching due to increased mineralisation. Increasing CO_2 leads to lower leaching due higher vegetation uptake*

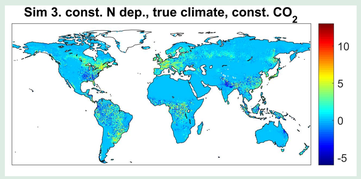


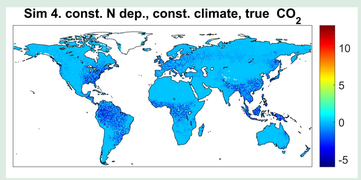
Right: mineral N leaching (1995-2005) difference with control (sim. 1), for sim 2, 3, 4 & 8

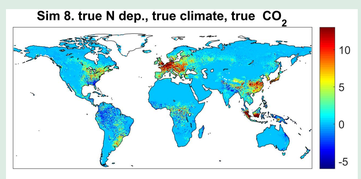
Below: absolute mineral N leaching (1995-2005) for sim. 8: true N dep., true climate, true CO_2











CONCLUSIONS

- N leaching is mainly determined by N deposition and N mineralisation
- Global warming and rising N deposition have a positive effect of comparable magnitude while rising CO_2 concentration has a negative effect
- The combined effect of the three drivers is an increase of ~40% over the last century.
- Strongest leaching increase in Europe and S-E Asia. Leaching decrease in the Amazon.

Smith et al., 2001, Global Ecol. Biogeogr.
Smith et al., 2014, Biogeosciences
Lamarque et al., 2013, Atmos. Chem. Phys

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