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Investigating wetland expansion and methane emission dynamics since the LGM using a dynamical global vegetation model

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Although methane is an important greenhouse gas, the CH4 budget and the attribution of relative emissions to specific sources is still poorly constrained. Emissions from wetlands contribute most to natural CH4 emissions and to its uncertainty. In bottom up model estimates, that prescribe wetlands using various wetland mapping datasets, uncertainties result mostly from the uncertain spatial distribution and global extent of wetlands, which ranges from 5.3 to 10.2 Mkm^2 (Zhang 2017). Reconstructions of past variability in CH4 from ice cores and of peatland extent from pollen data provide the opportunity to evaluate and independently test bottom up models. Such an investigation may not only help to clarify open questions about the underlying drivers of reconstructed past variability, but also help to further constrain bottom up models to give improved estimates for the present and the future.

Our goal is to reproduce and investigate the variability in terrestrial methane emissions and wetland extent since the Last Glacial Maximum using the LPX-Bern Dynamic Global Vegetation Model. LPX-Bern includes formulations for dynamic wetland expansion using a TOPMODEL approach (Stocker 2014) and an integrated methane module (Spahni 2011). Here we present results of a first preparatory transient simulation over the past 22,000 years. In the simulation, the wetland extent decreased slightly over the deglaciation by about -0.4 Mkm^2, which is the result of a decrease in the mid and low latitudes (-1.9 Mkm^2), in part following flooding of continental shelves, and an increase in high latitudes (+1.6 Mkm^2), following the retreat of the ice shield. The present day total wetland area of 8.9 Mkm^2 lies well within the wetland dataset spread. Modelled latitudinal distribution is shifted more towards higher latitudes with 2.6 Mkm^2 in boreal regions compared to estimates ranging between 1.1-2.1 Mkm^2. Although the resulting wetland methane emissions (154.3 TgCH4) and the global soil sink (26.4 TgCH4) for present day are comparable to bottom-up and top-down estimates (Kirschke 2013), and the variability in methane emissions shows features measured in ice-cores, such as high emissions during the Bølling/Allerød event, the overall trend of an approximately doubling of the CH4 concentration from the LGM to the early Holocene could not be reproduced with the current simulation setup. More rigorous evaluation of the model against available data and the implementation of necessary adjustments in the model setup will be the next steps in the ongoing investigation.

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Spahni et al. "Constraining global methane emissions and uptake by ecosystems." *Biogeosciences* 8.6 (2011): 1643-1665.

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