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On the factors controlling the atmospheric oxidative capacity and CH_4 lifetime during the LGM

Sergey Gromov (1,3), Benedikt Steil (1), Thomas Kleinen (2), and Victor Brovkin (2)

(1) Max Planck Institute for Chemistry, Atmospheric Chemistry, Mainz, Germany (sergey.gromov@mpic.de), (2) Max Planck Institute for Meteorology, Land in the Earth System, Hamburg, Germany, (3) Institute of Global Climate and Ecology (IGCE) Roshydromet and RAS, Moscow

In-depth interpretation of atmospheric methane (CH_4) paleo records requires comprehensive estimates of the climate-driven variations of its sources and sinks. The former, being difficult to estimate even for the present day conditions, are by large of biogenic origin and typically require rather complex parameterisations in modelling approaches. The latter, in contrast, can be reckoned with somewhat greater certainty about basic principles defining the atmospheric oxidative capacity (AOC), because tropospheric CH_4 is removed predominantly in reaction with hydroxyl radical (OH). In this study, we employ the comprehensive AC-GCM EMAC [1] for quantifying the contribution of different components of the climate system to the sensitivity of AOC changes between the present day (PD) and the Last Glacial Maximum (LGM, ~20ka BP). The LGM setup of EMAC accounts for relevant changes to the climate forcing, atmosphere physical state, kinetic chemistry, photolysis rates and emissions of trace gases from the biosphere, biomass burning and lightning sources *vs.* that in the PD.

Our simulation results suggest that the AOC in the LGM is principally driven by the emissions of reactive nitrogen oxides from lightning (LNO_X). The stark influence of LNO_X on the OH buffering in the free troposphere is reduced by the anthropogenic emissions of reactive C and N compounds in the PD. We further evaluate the adequacy of LNO_X source distributions resulting from different parameterisations available in EMAC. The most realistic ones suggest that convective activity shutdown (over the ice-covered high-latitude areas) and enhancement (over the enhanced continental areas in the tropics, foremost Oceania) in the LGM causes the migration of the LNO_X source to the lower latitudes, however without a substantial loss of its strength. This results in tropospheric CH_4 lifetimes comparable to that of preindustrial or PD (9-11 years) and hence a large reduction (a factor of 4-5 *vs.* PD) in the CH_4 surface sources that should fit the observations in the LGM. We subsequently propose a set of parameters required for an efficient CH_4 lifetime and OH distribution parameterisation suitable for models dealing with CH_4-inclusive climate-scale (transient) simulations.

References

1. Jöckel, P., *et al.*: Development cycle 2 of the Modular Earth Submodel System (MESSy2), *Geosci. Model Dev.*, **3**, 717-752, doi: 10.5194/gmd-3-717-2010, 2010.