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Simulation of comprehensive chemistry and atmospheric methane lifetime in the LGM with EMAC

Sergey Gromov and Benedikt Steil
Max Planck Institute for Chemistry, Atmospheric Chemistry, Mainz, Germany (sergey.gromov@mpic.de)

Past records of atmospheric methane (CH_4) abundance/isotope composition may provide a substantial insight on C exchanges in the Earth System (ES). When simulated in the climate models, CH_4 helps to identify climate parameters transitions via triggering of its different (natural) sources, with a proviso that its sinks are adequately represented in the model. The latter are still a matter of large uncertainty in the studies focussing on the interpretation of CH_4 evolution throughout Last Glacial Maximum (LGM), judging the conferred span of tropospheric CH_4 lifetime (λ) of 3-16 yr [1-4]. In this study, we attempt to: (i) deliver the most adequate estimate of the LGM atmospheric sink of CH_4 in the EMAC AC-GCM [5] equipped with the comprehensive representation of atmospheric chemistry [6], (ii) reveal the ES and CH_4 emission parameters that are most influential for λ and (iii) based on these findings, suggest a parameterisation for λ that may be consistently used in climate models.

In pursuing (i) we have tuned the EMAC model for simulating LGM atmospheric chemistry state, including careful revisiting of the trace gases emissions from the biosphere, biomass burning/lightning source, *etc*. The latter affect the key simulated component bound with λ, *viz.* the abundance and distribution of the hydroxyl radicals (OH) which, upon reacting with CH_4, constitute its main tropospheric sink. Our preliminary findings suggest that OH is buffered in the atmosphere in a similar fashion to preindustrial climate, which in line with the recent studies employing comprehensive chemistry mechanisms ($e.g.$, [3]). The analysis in (ii) suggests that tropospheric λ values may be qualitatively described as a convolution of values typical for zonal domain with high and low photolytic recycling rates ($i.e.$ tropics and extra-tropics), as in the latter a dependence of the zonal average λ value on the CH_4 emission strength exists. We further use the extensive diagnostic in EMAC to infer the sensitivity of zonal OH to changes in various component of the ES, $e.g.$ in stratospheric O_3 input and dynamics. Finally, we discuss the potential set of parameters required for efficient λ and/or OH parameterisation implementation in models dealing with (transient) climate simulations.

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