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Methane from the LGM to the present: The Natural methane cycle

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The time between the last glacial maximum (LGM) and the present is highly interesting with regard to atmospheric methane. Between the LGM and 10 ka BP atmospheric CH_4, as reconstructed from ice cores, nearly doubled, with very rapid concentration changes of about 200 ppb occurring during the Bølling Allerød (BA) and Younger Dryas (YD) transitions. During the Holocene, atmospheric CH_4 is very similar for 10 ka BP and PI, but CH_4 is about 15% lower in between at 5 ka BP.

We use a methane-enabled version of MPI-ESM, the Max Planck Institute Earth System Model, to investigate changes in methane cycling in a transient ESM experiment from the LGM to the present. The model is driven by prescribed orbit, greenhouse gases and ice sheets, with all other changes to the climate system determined internally. Methane cycling is modelled by modules representing the atmospheric transport and sink of methane, as well as terrestrial sources and sinks from soils, termites, and fires. Thus, the full natural methane cycle – with the exception of geological and animal emissions – is represented in the model.

Model results are compared to methane concentrations from ice cores, and key periods in climate/methane evolution are highlighted by detailed analyses. Methane concentrations can mainly be explained by emission changes, with LGM emissions substantially reduced in comparison to the early Holocene and preindustrial states due to lower temperature, CO_2, and soil carbon. For the large transitions during the deglaciation, such as the transitions from Older Dryas to BA, BA to YD, and YD to Holocene, ocean circulation changes are required to obtain atmospheric methane changes of sufficient magnitude and rapidity.