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Coupling bottom-up process modeling to atmospheric inversions to constrain the Siberian methane budget

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Methane (CH₄) is one of the most important greenhouse gases, but unexpected changes in atmospheric CH₄ budgets over the past decades emphasize that many aspects regarding the role of this gas in the global climate system remain unexplained to date. With emissions and concentrations likely to continue increasing in the future, quantitative and qualitative insights into processes governing CH₄ sources and sinks need to be improved in order to better predict feedbacks with a changing climate. Particularly the high northern latitudes have been identified as a potential future hotspot for global CH₄ emissions, but the effective impact of rapid climate change on the mobilization of the enormous carbon reservoir currently stored in northern soils remains unclear.

Process-based modelling frameworks are the most promising tool for predicting CH₄ emission trajectories under future climate scenarios. In order to improve the insights into CH₄ emissions and their controls, the land-surface component of the Max Planck Earth System model, JSBACH, has been upgraded in recent years. In this context, a particular focus has been placed on refining important processes in permafrost landscapes, including freeze-thaw processes, high-resolution vertical gradients in transport and transformation of carbon in soils, and a dynamic coupling between carbon, water and energy cycles. Evaluating the performance of this model, however, remains a challenge because of the limited observational database for high Northern latitude regions.

In the presented study, we couple methane flux fields simulated by JSBACH to an atmospheric inversion scheme to evaluate model performance within the Siberian domain. Optimization of the surface-atmosphere exchange processes against an atmospheric methane mixing-ratio database will allow to identify the large-scale representativeness of JSBACH simulations, including its spatio-temporal variability in the chosen domain. We will test the impact of selected model parameter settings on the agreement between bottom-up and top-down techniques, therefore highlighting how sensitive regional scale methane budgets are to dominant processes and controls within this

region.