

# (16-240328-B) Wetland Methane Emissions from the Boreal-Arctic Region: Magnitude, Temporal Dynamics, and Dominant Drivers

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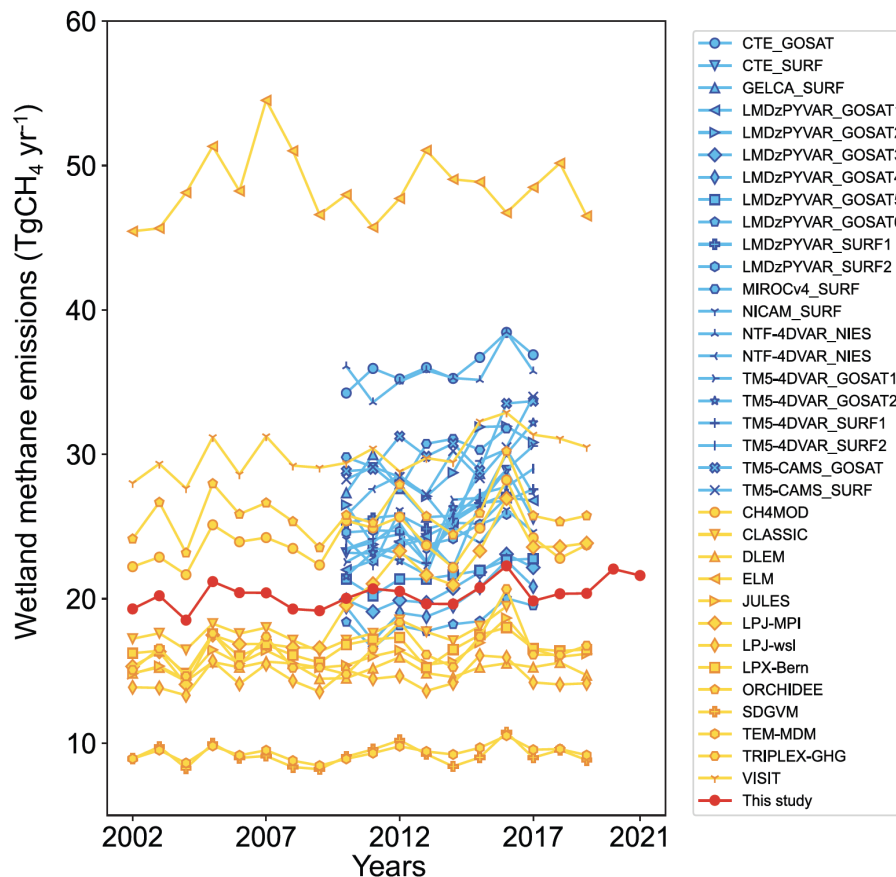
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Methane (CH<sub>4</sub>) is the second most important greenhouse gas, with a global warming potential 28-34 times greater than that of CO<sub>2</sub> over a 100-year time horizon. Wetlands are the largest natural source of CH<sub>4</sub> and represent ~20-30% of global CH<sub>4</sub> emissions. Wetland CH<sub>4</sub> emissions from the Boreal-Arctic region are highly sensitive to climate change, where significant warming has been observed recently. However, the magnitude, temporal dynamics, and dominant drivers of Boreal Arctic wetland CH<sub>4</sub> emissions remain uncertain, partially due to limitations in understanding and modeling of wetland CH<sub>4</sub> emission processes, and limited ground observations. In this work, we leveraged causality-guided machine learning, multi-source CH<sub>4</sub> observations (including eddy covariance towers in FLUXNET-CH<sub>4</sub> and chambers), and remote sensing, to estimate wetland CH<sub>4</sub> emissions in the Boreal-Arctic area from 2002 to 2021. Based on the generated regional dataset, we found a significant long-term trend and strong interannual variability of wetland CH<sub>4</sub> emissions dominated by warming and vegetation activities. Furthermore, we benchmarked the performance of 13 bottom-up and 21 top-down models in the current Global Carbon Project. Besides large discrepancies among the models, we also found that most models failed to capture the magnitude and trend of wetland CH<sub>4</sub> emissions in the Boreal-Arctic area during the past two decades.



**Figure 1.** Inter-annual wetland CH<sub>4</sub> emissions in the Boreal-Arctic estimated by top-down models (blue lines), bottom-up models (gold lines), and this study (the red line).