# Boreal–Arctic wetland methane emissions modulated by warming and vegetation activity

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## Science Question

- What is the multidecadal dynamics of Boreal-Arctic wetland $CH_4$ emissions?
- What are drivers of Boreal-Arctic wetland $CH_4$ emission variability and trend?
- What are the implications for modelling wetland $CH_4$ emissions?

## Analysis

- This study compiled eddy covariance and chamber observations and investigate the impacts of warming and vegetation activity on wetland $CH_4$ emission.
- A causality-guided machine learning approach (developed in first year of this CMS project) was used to upscale and analyze Boreal-Arctic wetland $CH_4$ dynamics.
- Trend and variability analyses are applied to the upscaled dataset to identify primary drivers of decadal changes in Boreal-Arctic wetland $CH_4$ emission.

## Results/Significance

- Two decades (2002–2021) of methane $CH_4$ revealed a ~10% increase.
- Wetland $CH_4$ emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%).
- Strong inter-annual variation was observed and peak emission was due to overlapping of arctic warming with wetland hotspots.
- 2 ° C temperature anomaly in 2016 led to the highest recorded annual $CH_4$ emissions (22.3 Tg $CH_4$ yr−1) over this region, driven primarily by Western Siberian lowlands.

## Acknowledgements

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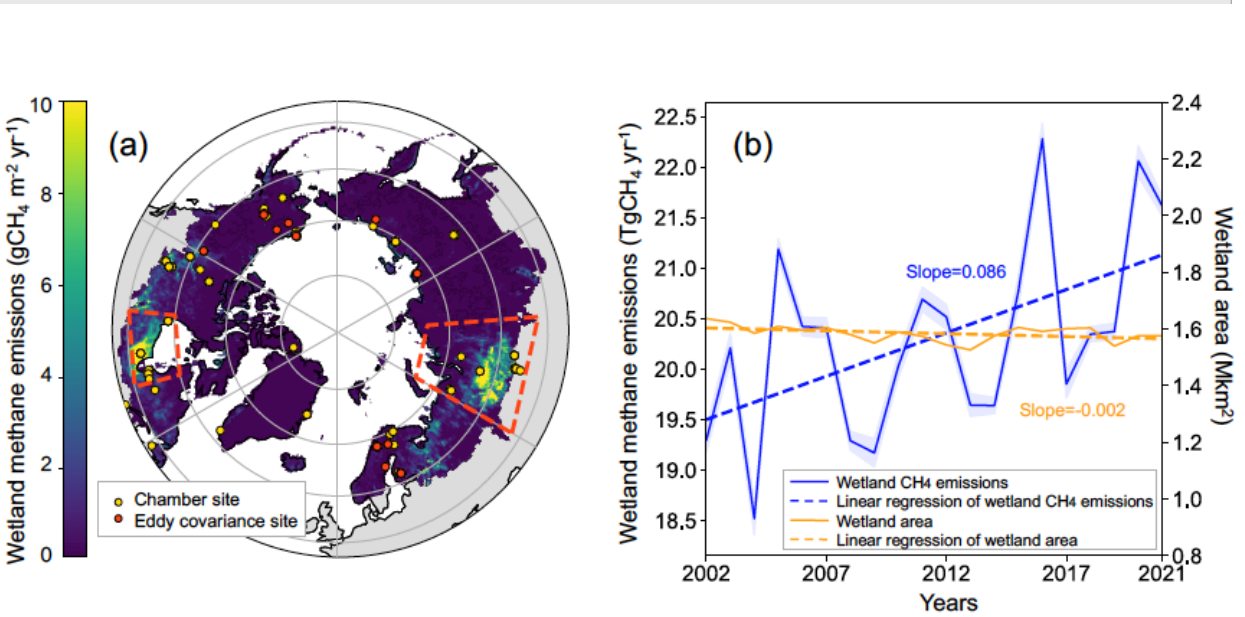


*Fig. 1: Significant increasing trend of wetland CH4 emissions in the Boreal–Arctic during 2002–2021. a, Spatial distribution of the long-term averaged wetland $CH_4$ emissions in the Boreal–Arctic upscaled by combining chamber and EC datasets. Red dashed boxes indicate two wetland hotpots: WSL (52–74°N, 60–94.5°E) and HBL (50–60°N, 75–96°W). b, Annual Boreal–Arctic wetland $CH_4$ emissions and wetland area dataset between 2002 and 2021. Dashed lines indicate the linear regression results for wetland $CH_4$ emissions (P=0.017, two-sided t-test) and wetland area (P=0.064). The blue shaded area indicates the s.d. in estimated wetland $CH_4$ variability due to model parameter uncertainty.*