

Methane in the climate system

From the last glacial to the future

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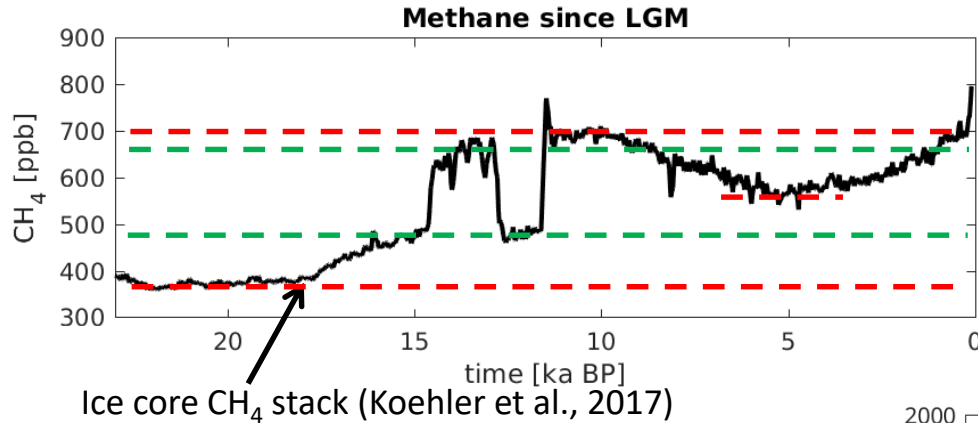
**PAL
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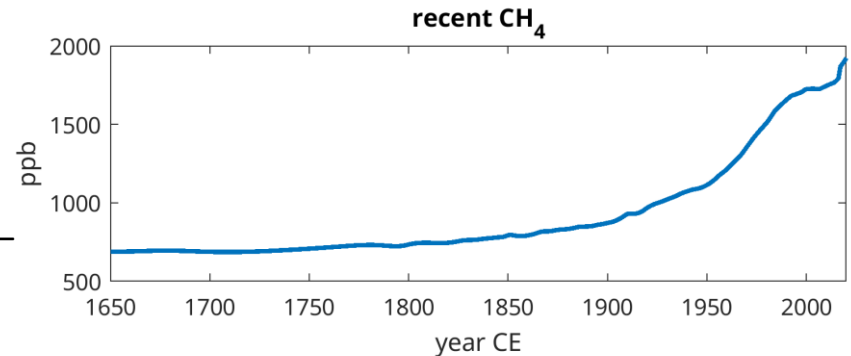
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What's interesting about Methane?

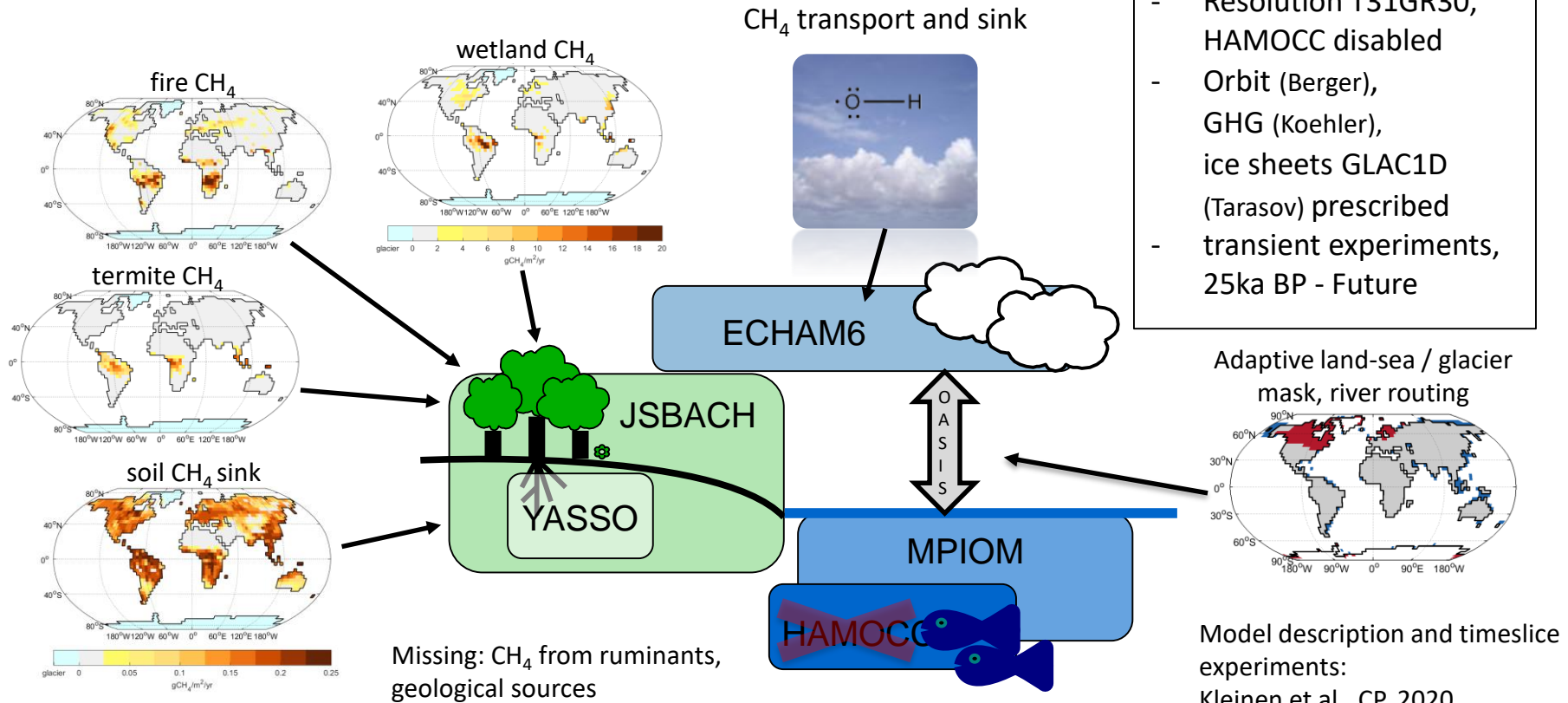


- 1) Doubling of methane LGM -- 10ka BP, Mid Holocene decrease by ~100 ppb, PI as 10ka BP
- 2) ~150 ppb very rapid changes around Bølling/Allerød – Younger Dryas

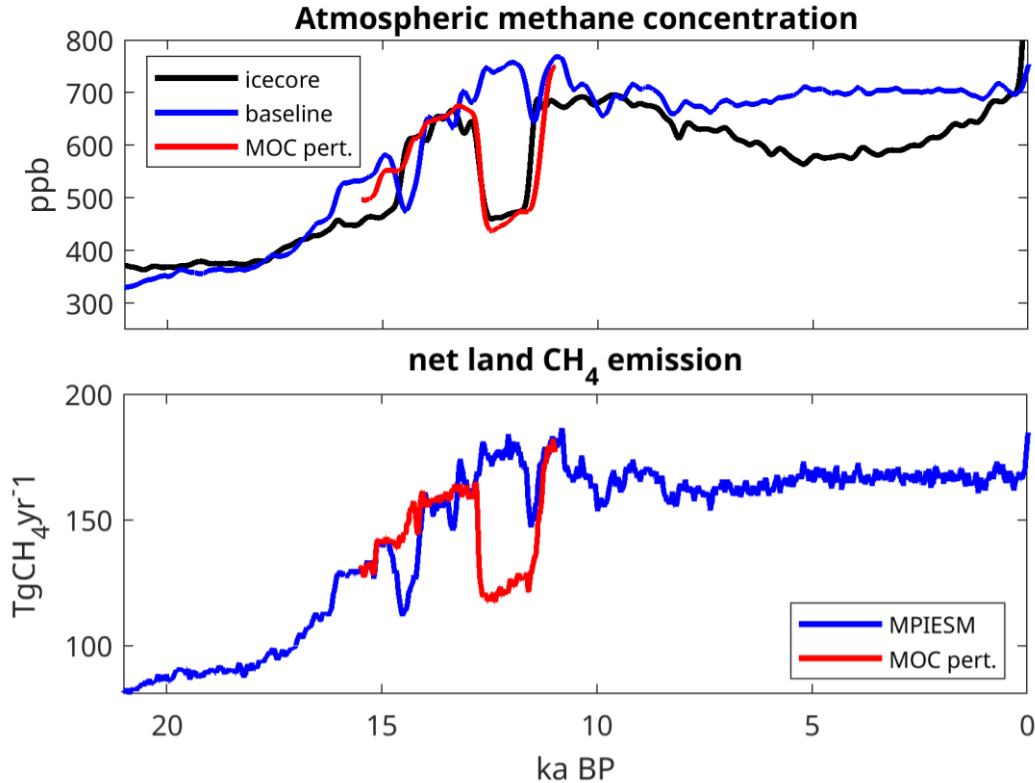
Recently, CH₄ has doubled AGAIN – how will this continue?



MPI-ESM 1.2

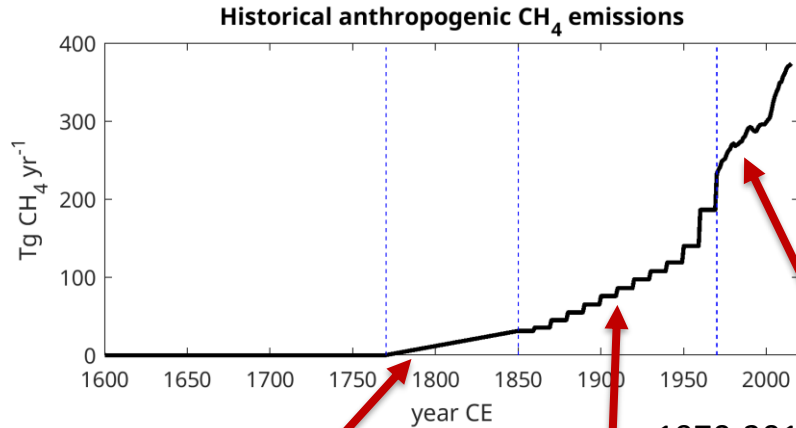


Atmospheric CH₄ – the past



- Atmospheric CH₄ reproduces LGM – 10 ka BP doubling in all experiments
- BA / YD reproduced in MOC perturbation experiment
- Largely driven by emission changes
- Mid-Holocene decrease???

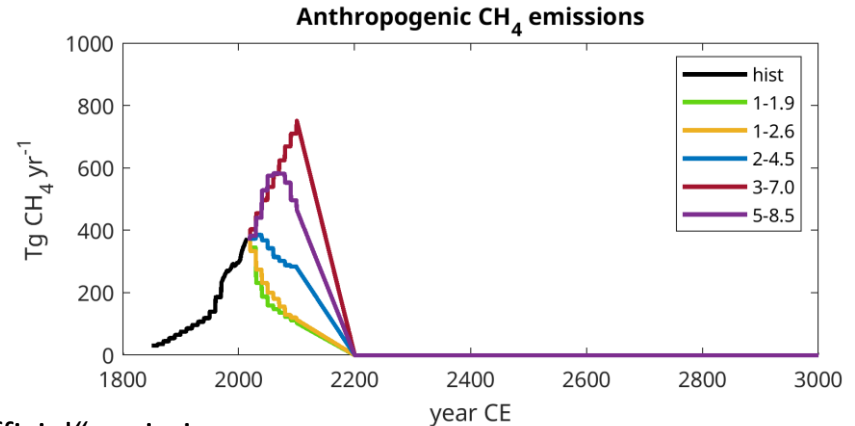
Anthropogenic CH₄ emissions



1770-1850: Linear interpolation from zero

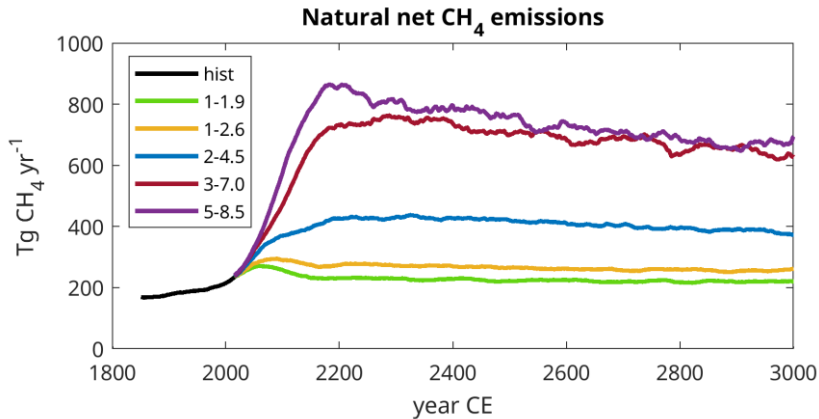
1970-2014: "Official" emission data from Hoesly et al.

1850-1969: Emission data from Hoesly et al. only as supplement



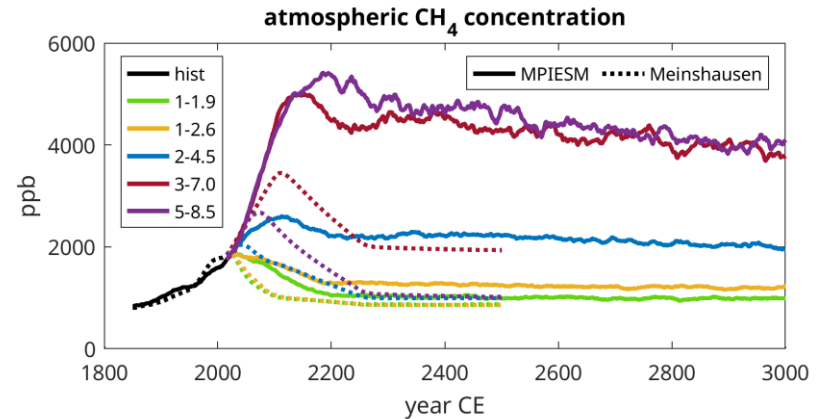
CO₂ forcing until 2500: Meinshausen et al., after 2500: obtained from CLIMBER2 EMIC
N₂O forcing until 2500: Meinshausen et al., after 2500: constant

Future CH₄



Natural CH₄ emissions increase strongly under future warming, emissions stay high for as long as conditions remain warm.

Natural emissions become larger than anthropogenic in scenarios > 2.6 W/m²



Atmospheric CH₄ substantially higher than in Meinshausen et al. scenarios.

Meinshausen assumed *constant* natural emissions after 2015 – obviously not appropriate.

Conclusions & Outlook

- Natural methane emissions double from LGM to PI
 - wetland methane emissions LGM – PI largely determined changes in soil C and atmospheric CO₂
 - Bølling-Allerød / Younger Dryas can be reproduced with appropriate MOC perturbation
 - Atmospheric sink not as mature as emissions, further work required
- Atmospheric methane will increase strongly in warmer climate
 - Natural emissions larger than anthropogenic in scenarios with forcing > 2.6 W/m²
 - CMIP6 scenarios underestimate natural emissions – future CH₄ likely higher than published by Meinshausen
 - Emissions (and thus concentrations) will stay high for as long as temperatures are warm