Modeling methane production and emission from thawing sub-sea permafrost on the warming Arctic Shelf

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Background:

Global warming accelerates the thawing of the large subsea permafrost (PF) reservoir on the Arctic shelf

This potentially > unlocks large stocks of organic matter (OM)
> through the microbial degradation
produces the potent greenhouse gas: methane (CH_4)

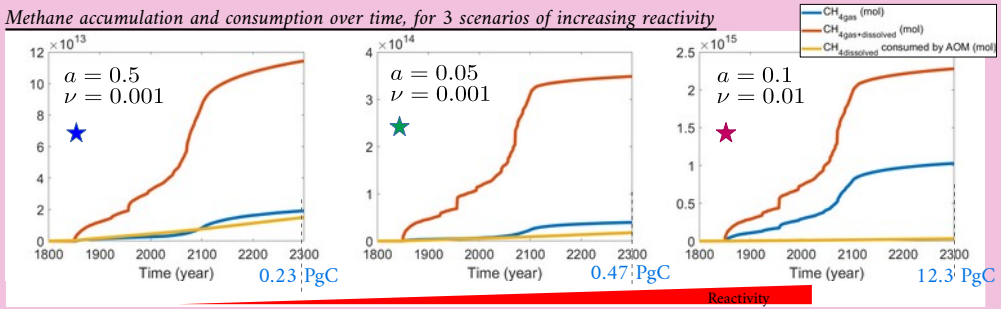
That could further intensify projected global warming.

How much CH_4 could be produced and ultimately released from Arctic sediments due to projected subsea PF thawing?

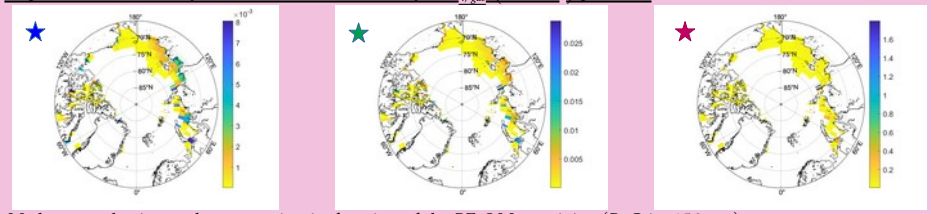
Results: (worst forcing scenario SSP5-8.5)

- Potential production of CH_4 (gas) varies between: ~0.01-30 PgC in 250 years (by 2100) ~0.05 – 40 PgC in 450 years (by 2300)
- Only a fraction of the produced CH_4 (dissolved) is consumed by Anaerobic Oxidization of Methane (AOM)
  The rest accumulates in the sediment maintaining supersaturation and thus CH_4 (gas) is formed.
- PF OM reactivity is the most important control and uncertainty → linked to the questions related to the onset of the microbial activity (weeks / hundred years timescale; liquid water content / temperature driven)

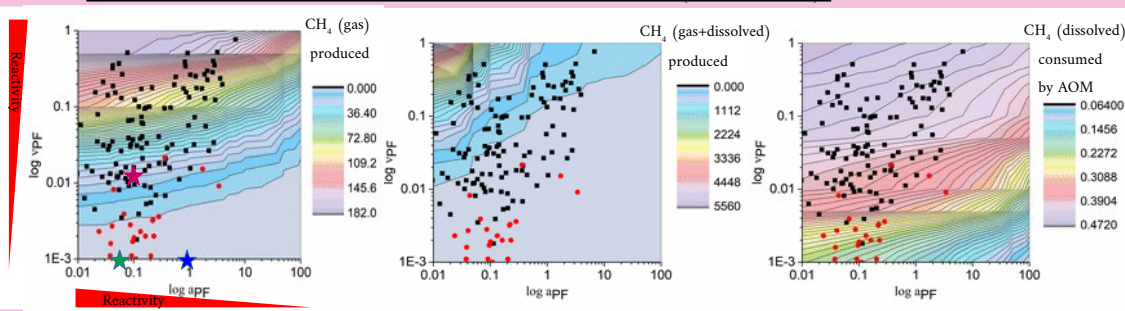
Methane accumulation and consumption over time, for 3 scenarios of increasing reactivity



Respective distribution of total, cumulative amount of $CH_{4,\,gas}$ (mol/cm^2) produced

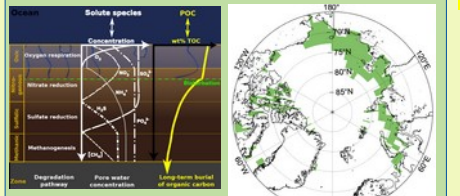


Methane production and consumption in function of the PF OM reactivity (PgC in 450 yrs)



Approach: nested model with

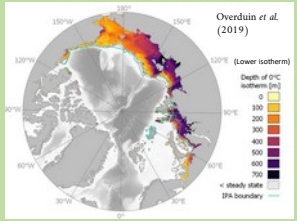
1D diagenetic model (BRNS) on a 2D Arctic shelf grid



Hulse *et al.* (2018)

initialized by

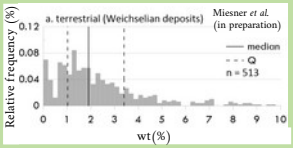
a global permafrost map (SuperMAP) obtained by a heat transfer model based on bathymetry and sea level rise



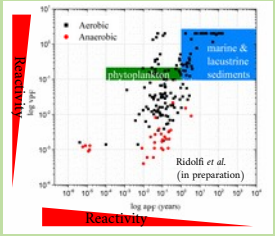
forced by

Critical model parameters are chosen based on a comprehensive analysis of published experimental data.

> PF OM content



> PF OM apparent reactivity



> Unfrozen sediment OM content distribution (Cascade dataset) Martens *et al.* (under review ESSD)

Max Planck Institute Earth System Model (MPI-ESM) JSBACH simulation results for the period 1850-2300