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Modelling of the influence of methane emissions in the North Sea region with ICON-ART

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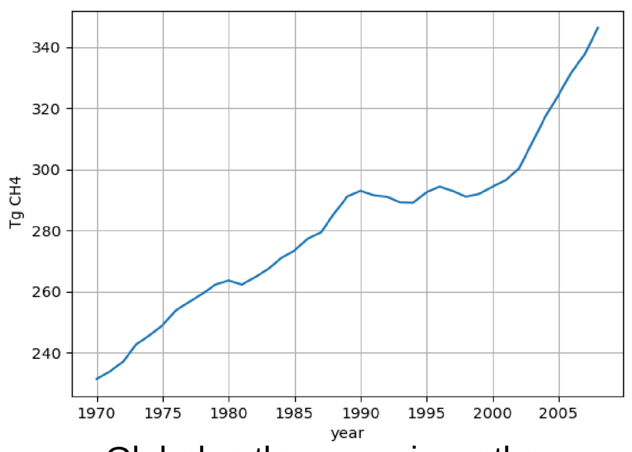
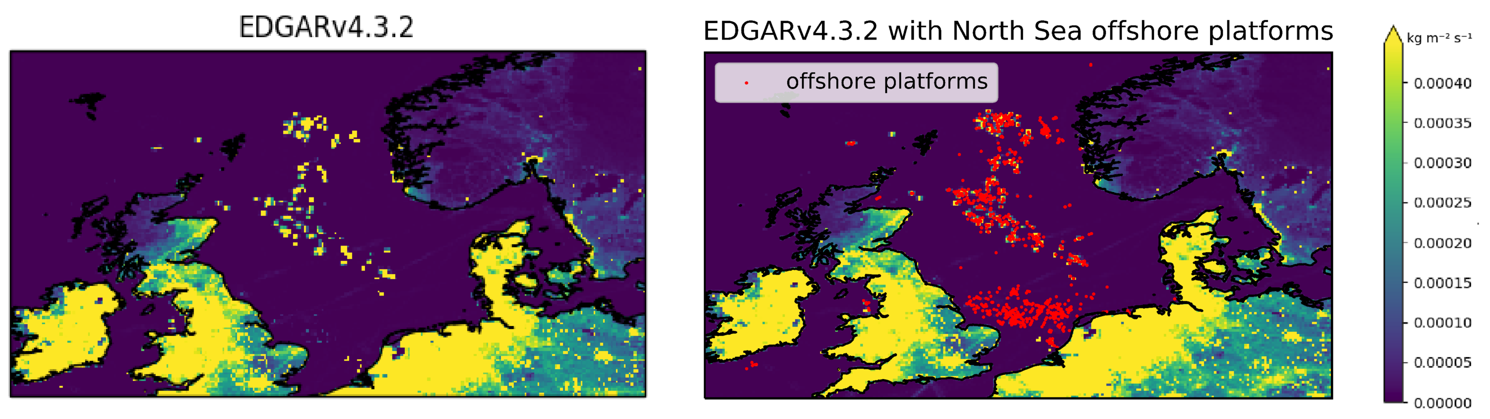
Motivation

Significance of methane (CH_4):

- Second most important greenhouse gas (GHG) after CO2
- Important source for O_3 in the troposphere
- Current increase: ~6 ppbv yr^{-1}
- Short atmospheric lifetime for a GHG: ~10 yr
- Transported over long distances



Global anthropogenic methane emissions in EDGAR dataset [1]

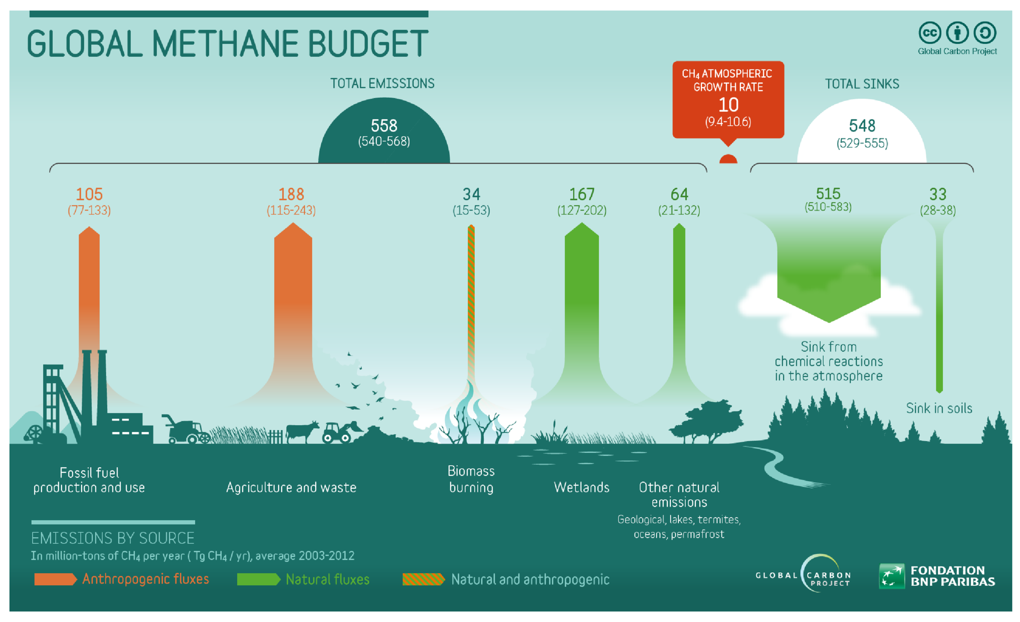


Anthropogenic methane emissions in EDGAR dataset [1] in January 2010, data from ECCAD [7]

Sources and sinks of methane:

- Uncertainties concerning the global distribution of sources and sinks [2]
- Largest loss of CH_4 due to its reaction with the OH radical [3]
- Discrepancies of bottom-up and top-down approaches [4]

➔ Quantification of processes



The global methane budget – sources and sinks [5]

Methane in the North Sea region:

- Emissions by inactive and active offshore platforms are highly uncertain
- Sea floor measurements near drill holes showed large CH_4 discharges [6]
- High correlation between methane emission and the location of offshore platforms
- Methane emissions caused by ships in the North Sea

The ICON-ART model

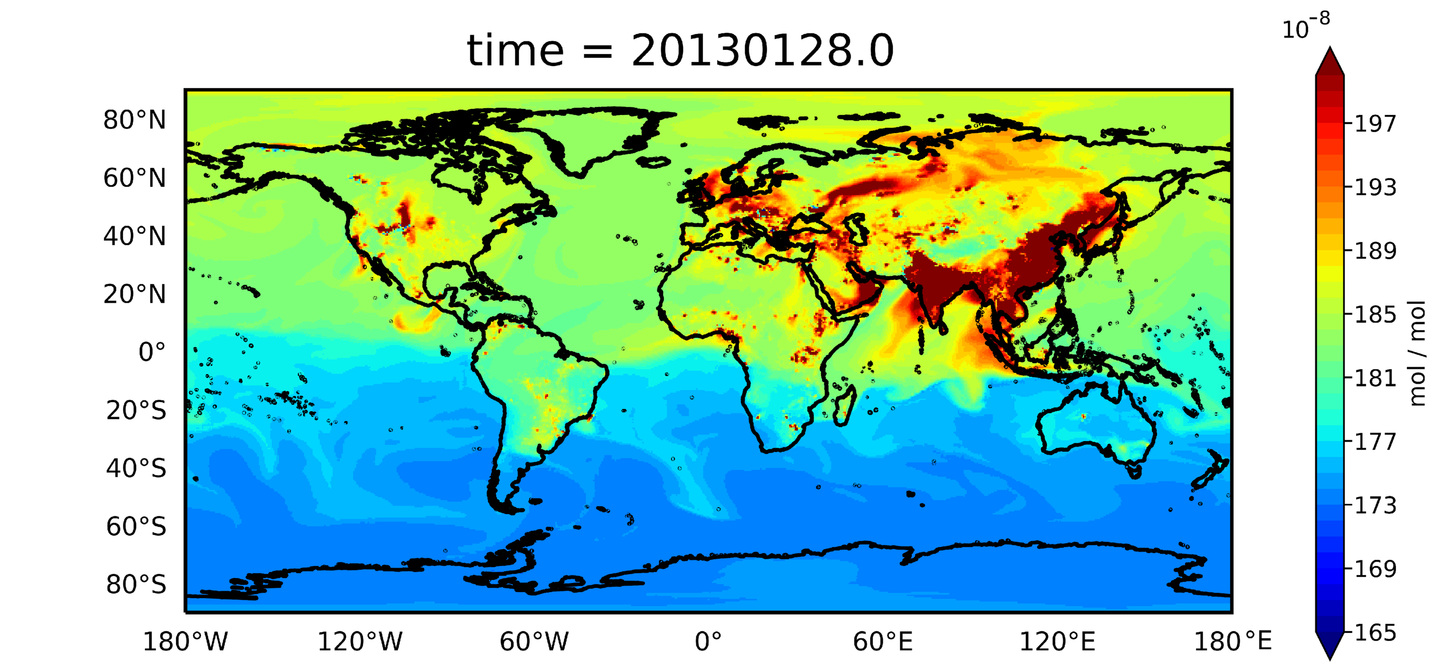
ICON-ART Version 2.3 Setup:

Globally constant initialisation value	1670 ppbv CH_4 (at lowest model level)
Simulation period	2012-02-03 to 2013-02-03
Global grid resolution	Horizontal: Δx ~80 km, Vertical: 90 Levels from 0 to ~80 km
Input emission inventory	EDGARv4.3.2 (monthly mean, 0.1°x0.1°)
Output	0.5°x0.5°, Δt= 12 hours

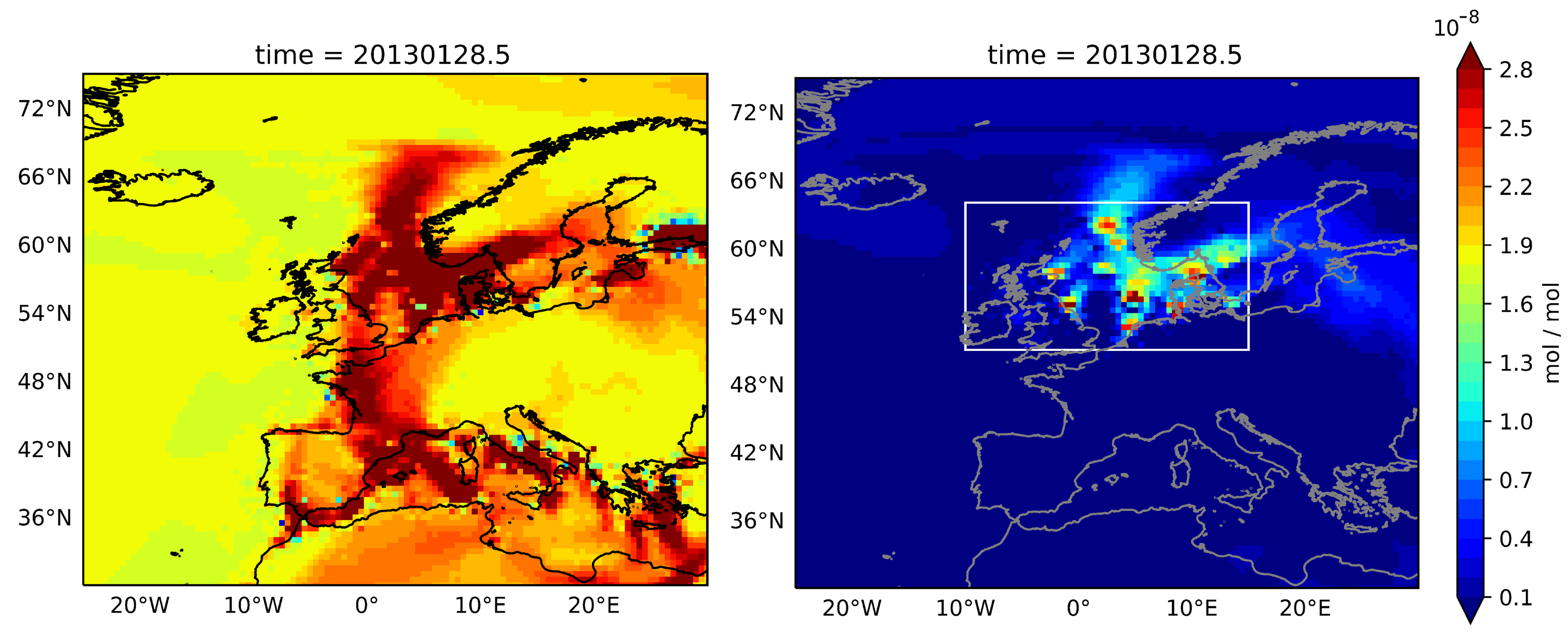
ICOsahedral **N**onhydrostatic model with **A**erosols and **R**eactive **T**race gases

Simulations		
1. CH_4 as transport tracer only		**2.** Tracer with simplified OH chemistry
(a) with emissions	**(b)** without sea emissions	**(c)** without North Sea emissions

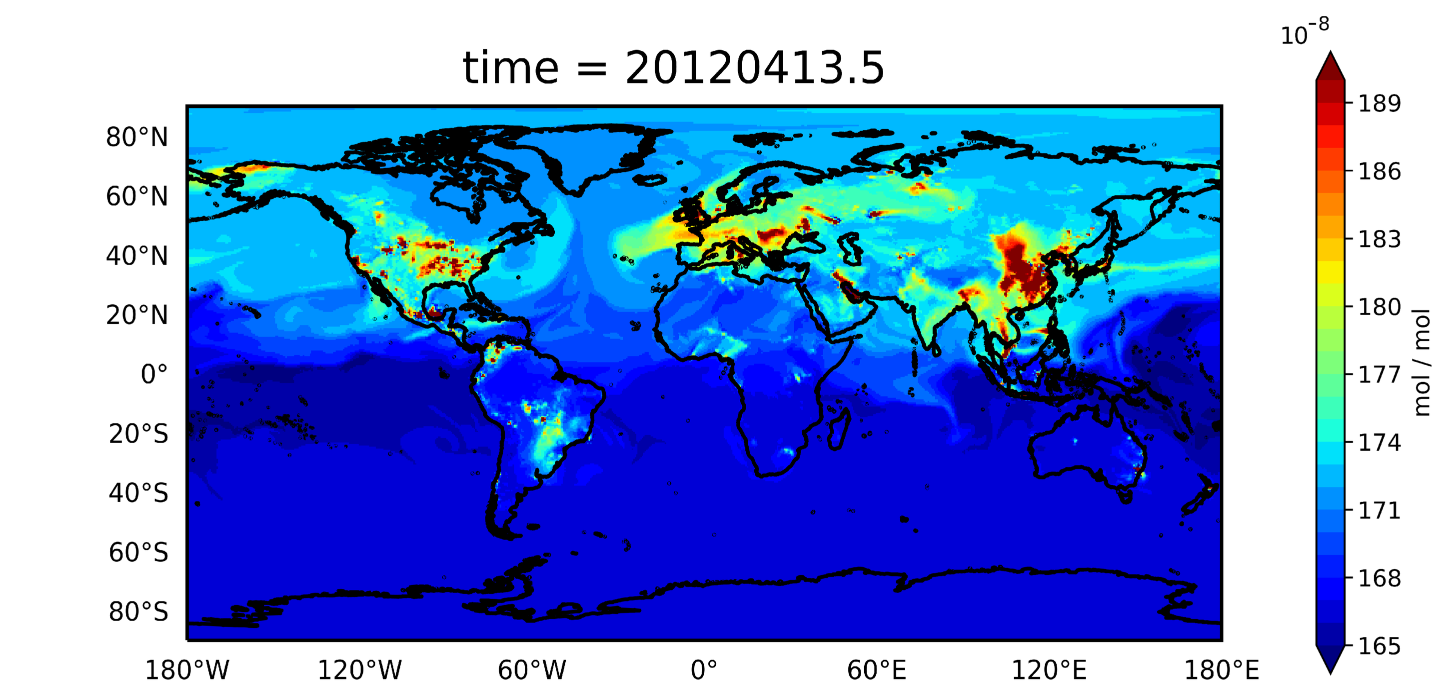
Modelling methane



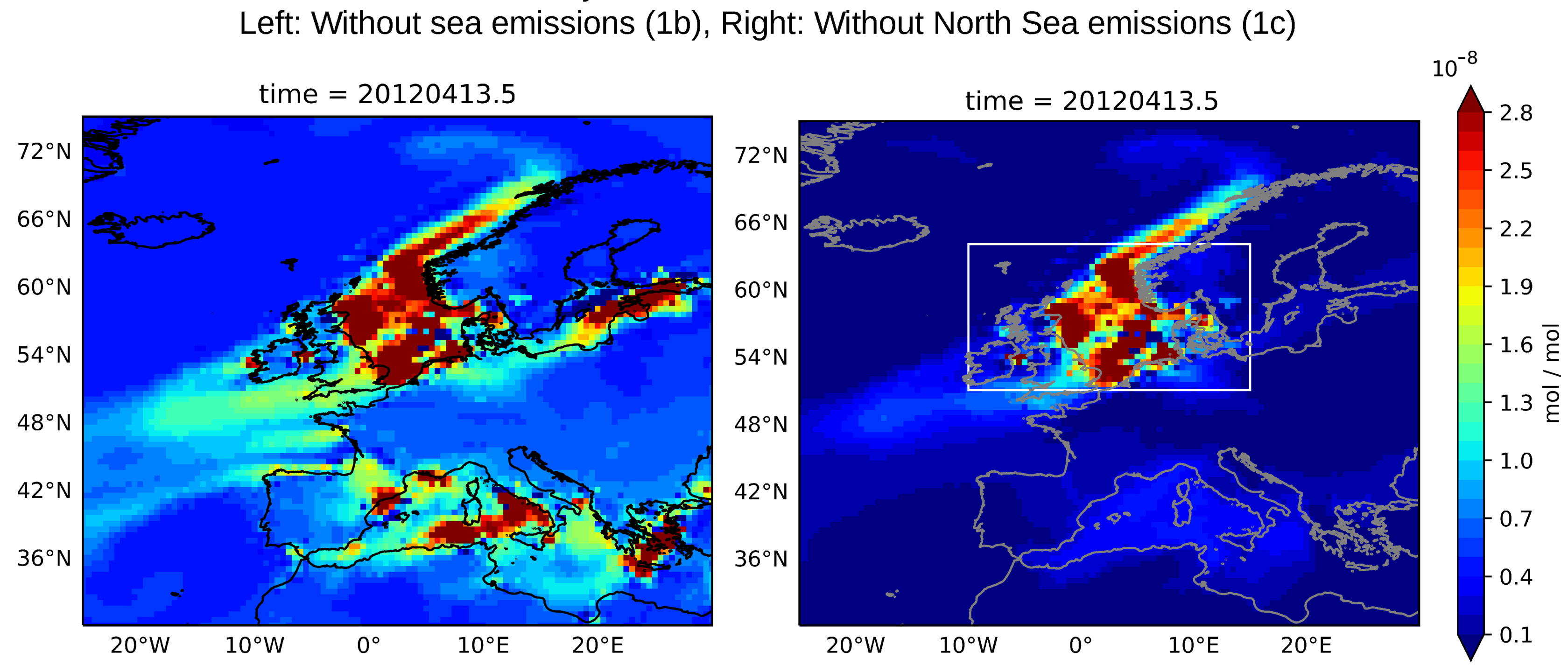
Methane Volume Mixing Ratio (VMR) after 360 days at lowest model level – transport tracer only (1a)



Methane VMR after 360 days at lowest model level – Difference to model run 1a
Left: Without sea emissions (1b), Right: Without North Sea emissions (1c)



Methane VMR after 69 days at lowest model level – simplified OH chemistry (2a)



Methane VMR after 69 days at lowest model level – Difference to model run 2a
Left: Without sea emissions (2b), Right: Without North Sea emissions (2c)

➔ **Model runs 1a / 2a show higher VMR of methane (~1.4% / ~1.6%) than 1b / 2b and 1c / 2c in the North Sea region after 360 / 69 days at lowest model level**

Outlook

- Adjustment of CH_4 emission fluxes from the North Sea
- Investigation of the global impact of adjusted emission fluxes for CH_4 budget
- ICON-ART "Full chemistry" CH_4 – HO_x – NO_x – O_x simulations of the North Sea with a few kilometers horizontal resolution

References

[1] G. Janssens-Maenhout et al. Verifying green-house gas emissions. The National Academies of Sciences, 1, 132-133, 2010.
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[3] S. Kirschke et al. Three decades of global methane sources and sinks. Nature Geoscience, 6:813–823, 2013.
[4] M. A. K. Khalil. Atmospheric Methane - Its Role in the Global Environment. Springer-Verlag, 2000.
[5] http://www.globalcarbonproject.org/methanebudget/16/files/MethaneInfographic2016.png
[6] J. Greinert et al. Cruise Report. GEOMAR Helmholtz-Ceter for Ocean Research Kiel, 2018.
[7] ECCAD. Emission of atmospheric compounds and compilation of ancillary data. http://eccad.aeris-data.fr

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