The ocean as a source of N_2O and CH_4

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Why are we interested in oceanic nitrous oxide (N_2O) and methane (CH_4)?

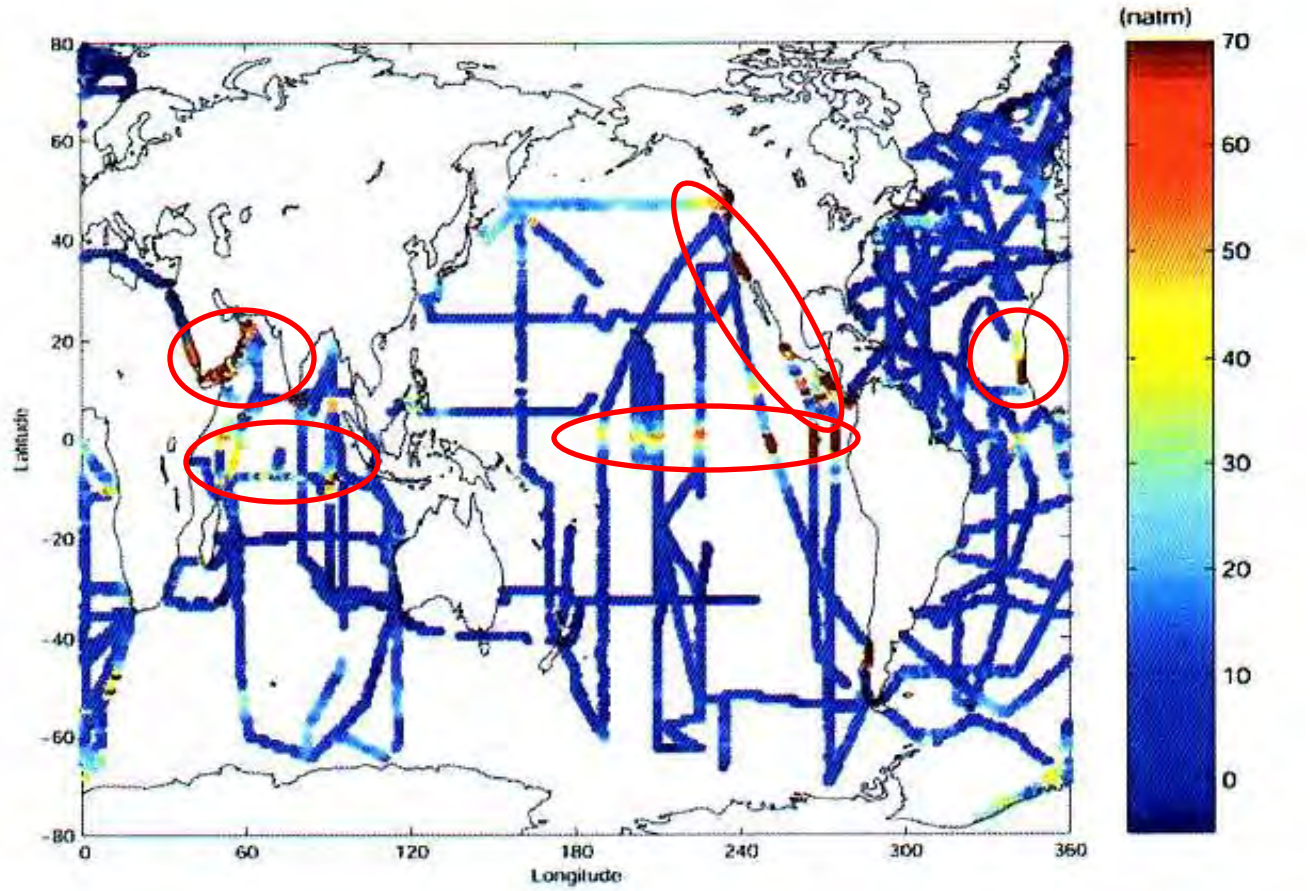
	Greenhouse gas	Stratos. O_3 depletion	Tropos. chemistry	% contribution of oceanic areas to global emissions	Atm. mixing ratios
N_2O	+	+		21 / 35 *	increasing
CH_4	+	+	+	7 **	increasing

* total sources / natural sources (IPCC, 2013).
** = 100*39/556 (Bakker et al., 2014/IPCC, 2013).

Global distribution of surface ΔN_2O (in natm)

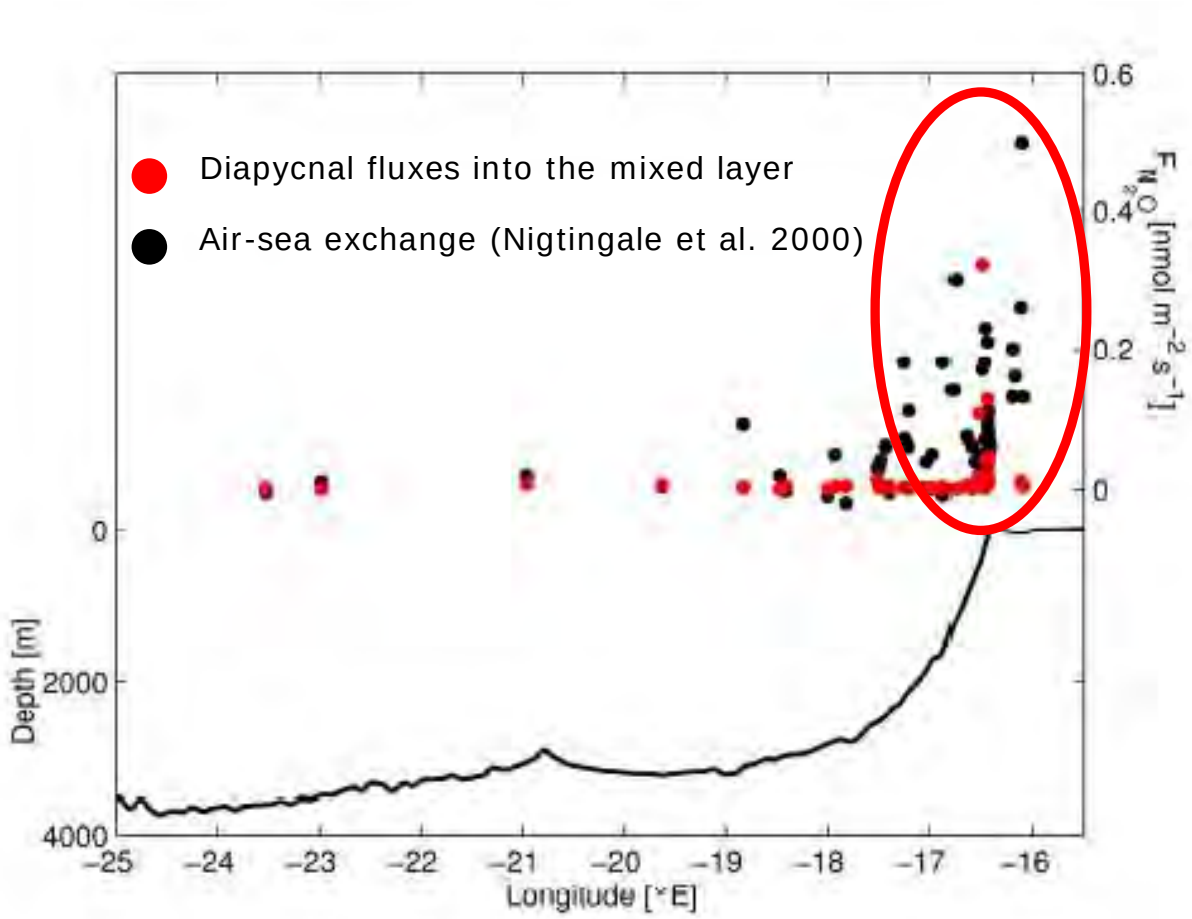
(Scripps & NOAA expeditions 1977-1996; Nevison et al., 2004)

$\Delta pN_2O = pN_2O(observed) - pN_2O(eq)$



N_2O mixed layer fluxes in off Mauritania: diapycnal fluxes < air-sea exchange

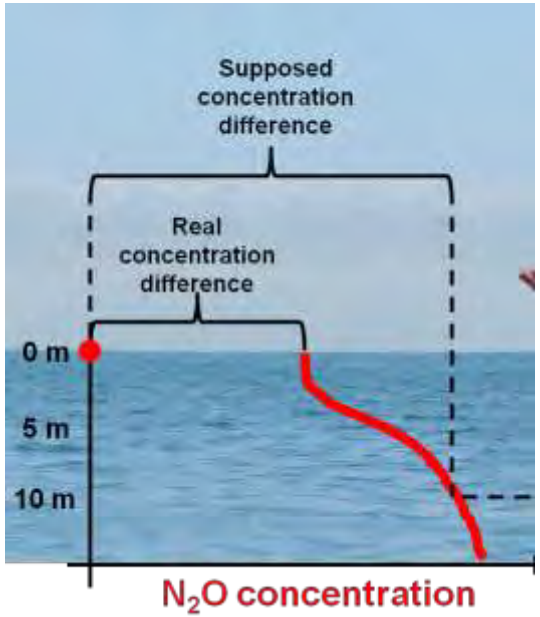
(Kock et al., 2012)



Inherent uncertainities of the N_2O air-sea flux density

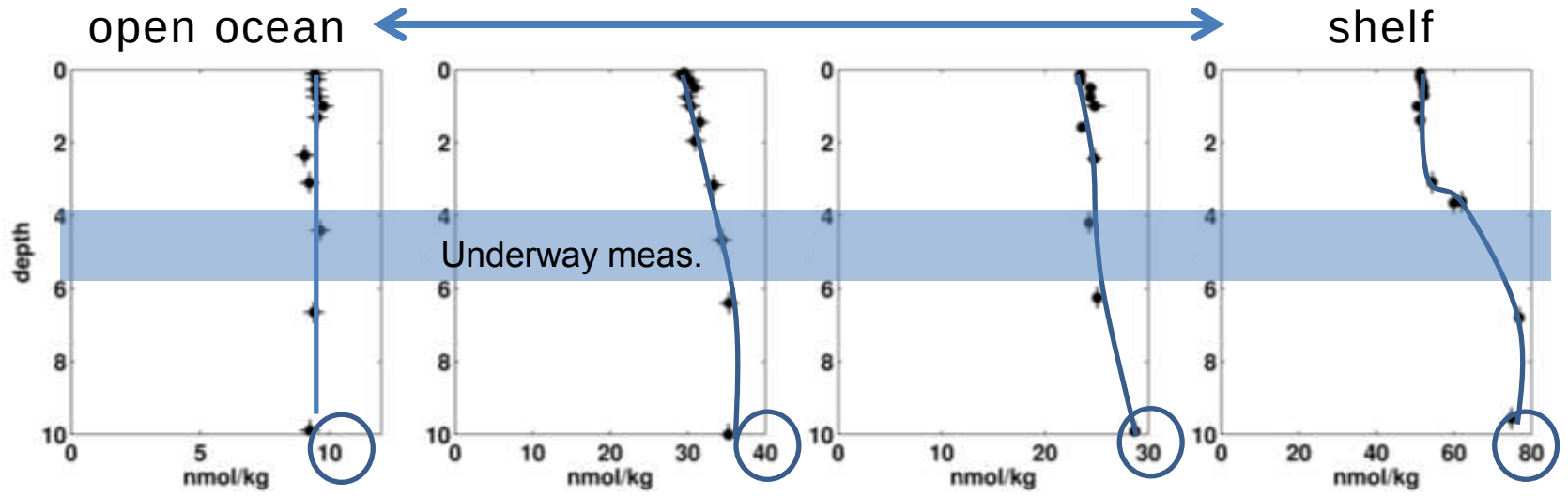
$$F = k_w ([N_2O]_w - [N_2O]_{eq})$$

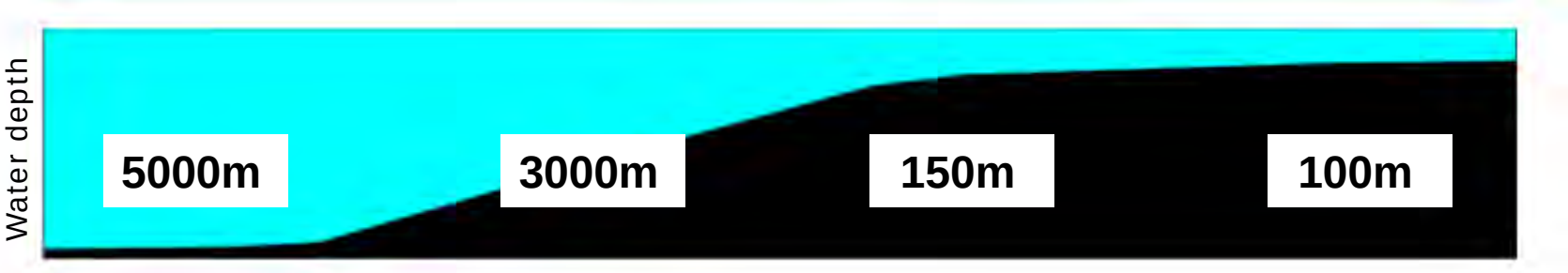
May be too high because of $[N_2O]$ gradients in the upper water column



M91 (Peru upwelling): N_2O in upper 10m

(Fischer et al., unpublished)

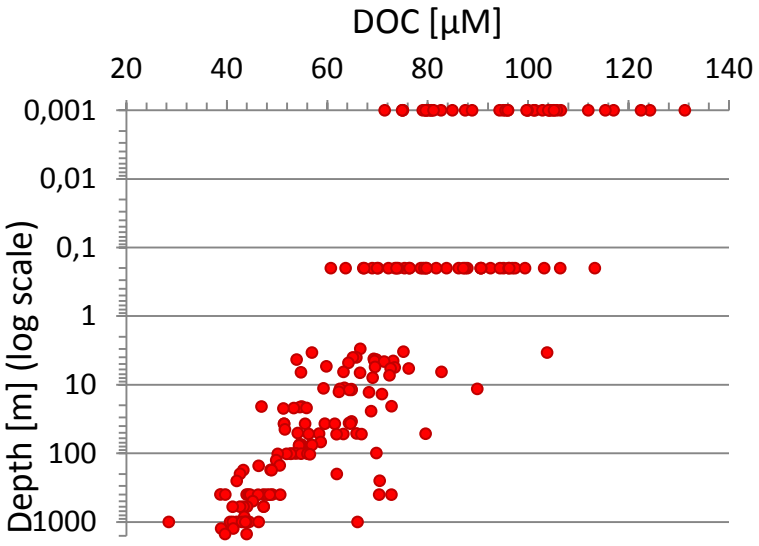




Inherent uncertainities of the N_2O air-sea flux density

$$F = k_w([N_2O]_w - [N_2O]_{eq})$$

May be reduced by enrichment of surfactants in sea surface micro layer

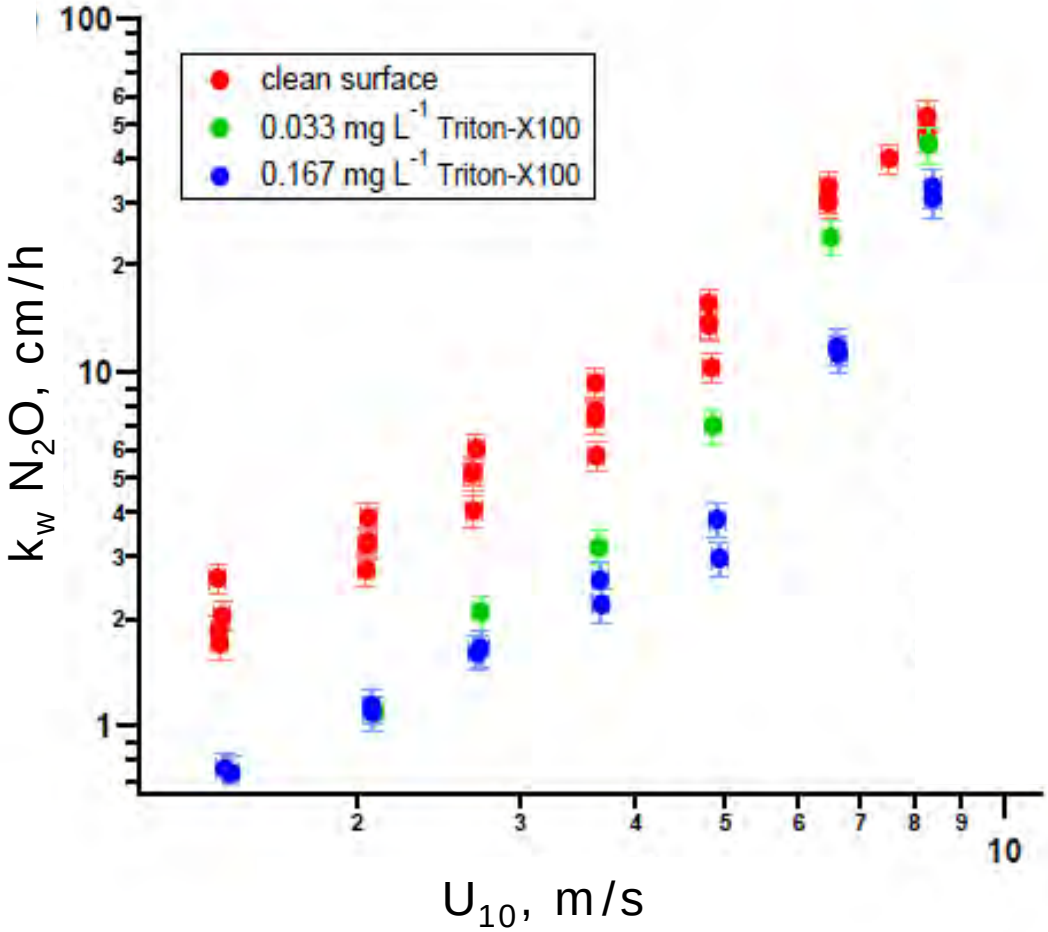


DOC data from M91, Galgani et al.

N_2O air-sea exchange is suppresed by surfactants

Results from a study in wind/wave tank (Aeolotron, U Heidelberg)

(Mesarchaki et al, 2015)



Short summary: N_2O

- The oceans are a major source of atm. N_2O

- Flux and emission estimates are still associated with a high degree of uncertainty

  - surfactants
  - conc. gradients towards air/sea interface
  - seasonal and interannual variabilities
  - ...

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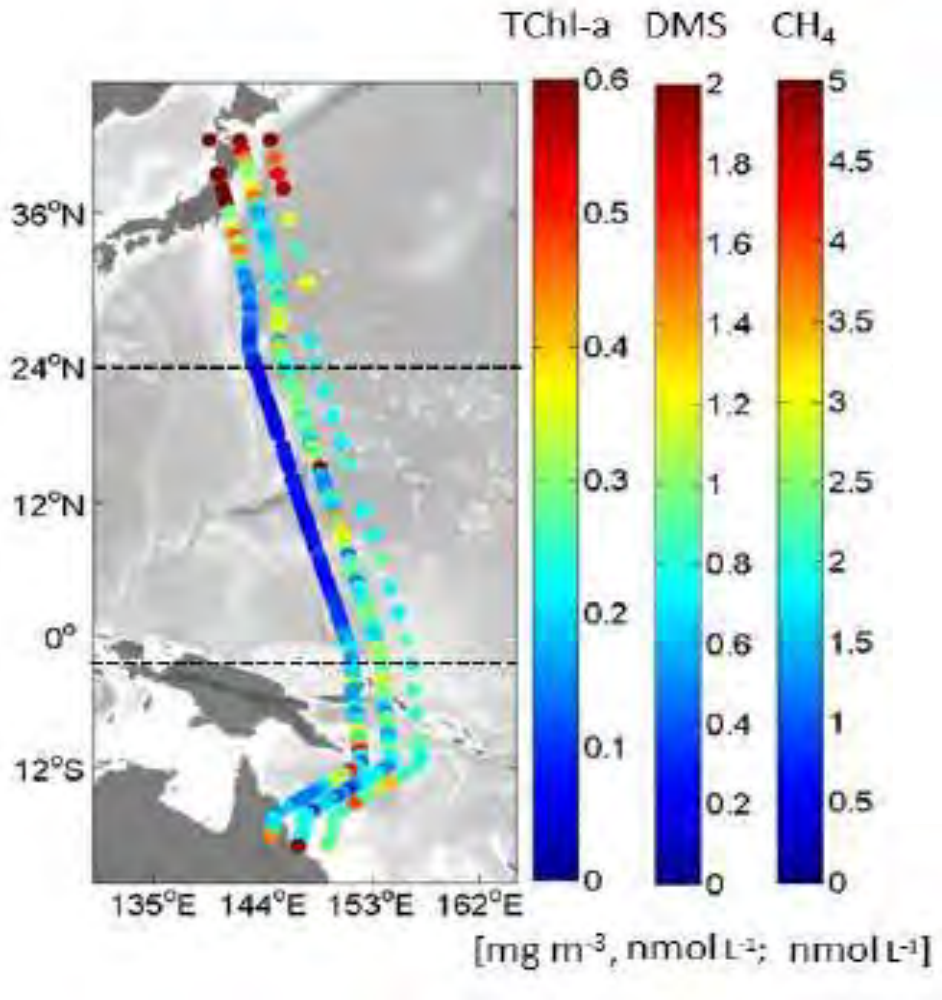
Why is the open ocean a CH_4 source at all?
-> methanogenesis is strictly anaerobic!

* total sources / natural sources (IPCC, 2013).
** = 100*39/556 (Bakker et al., 2014/IPCC, 2013).

CH_4 in the West Pacific Ocean

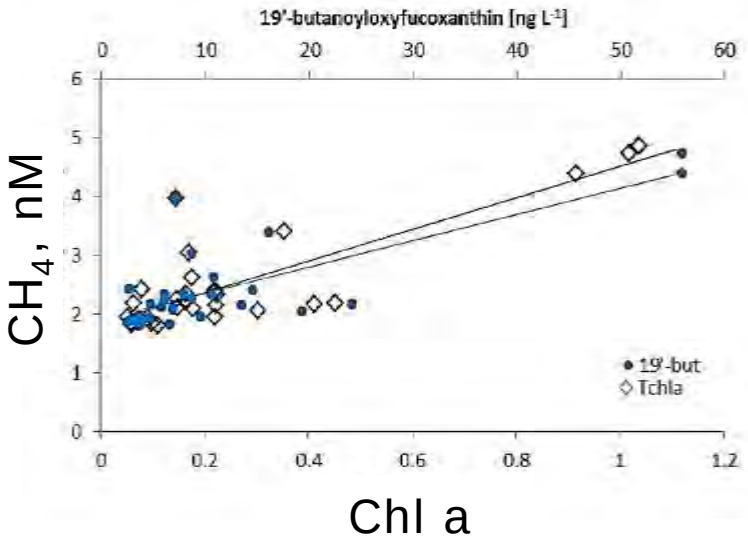
(TransBrom cruise, Oct. 2009)

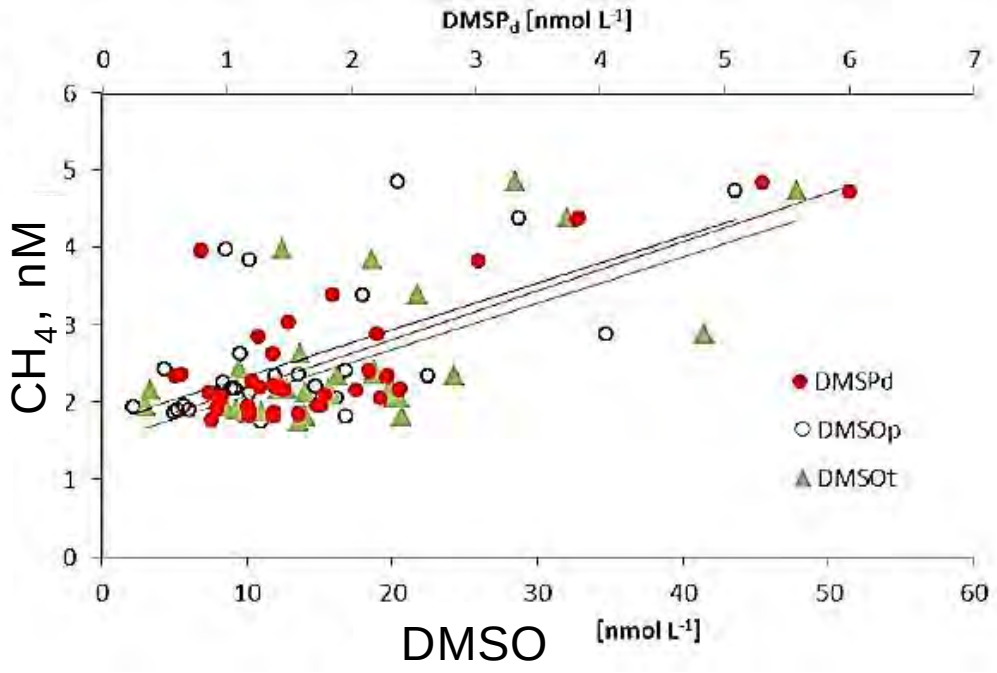
(Zindler et al., 2013)



CH_4 in the West Pacific Ocean: Aerobic production in the surface layer?

(Zindler et al., 2013)

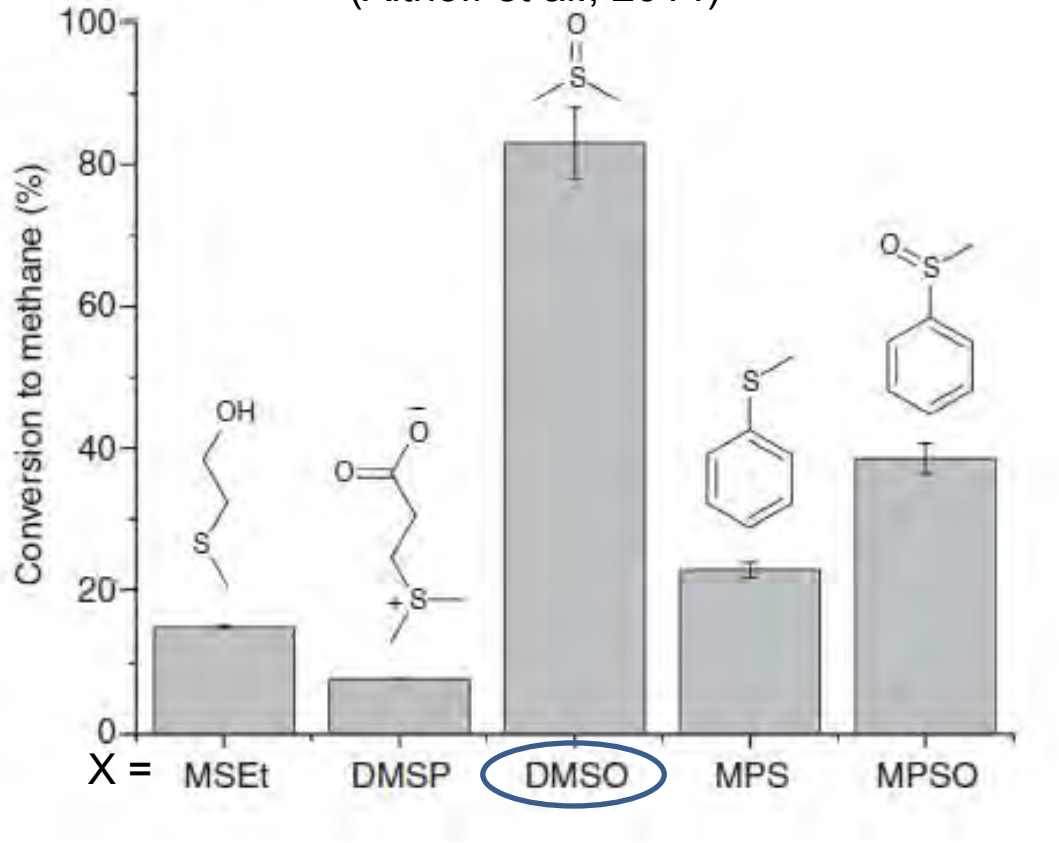




DMSO =
dimethyl sulphoxide, $(CH_3)_2SO$

Abiotic methanogenesis from organosulphur compounds under ambient conditions

(Althoff et al., 2014)



In aqueous solution: X + ASC + H_2O_2 + FH → CH_4

(ASC = ascorbic acid, FH = ferrihydrite, $5Fe_2O_3 \cdot 9H_2O$)

Short summary: CH_4

- The open ocean is a (minor) source of atm. CH4
- There might be alternative CH_4 prodcution pathways in the (oxic) upper ocean

Concluding remarks

- *There is a need to improve the estimates of oceanic emissions (= reduce the uncertainties: more data, better & comparable measurements)*

- *N_2O has been nominated one of only nine selected biogeochemical Essential Ocean Variables (EOV) by the International Ocean Carbon Coordination Project (IOCCP)*

What comes next?

- Establish a common measurement protocol for diss. concentrations
- Establish a global network of N_2O and CH_4 conc./flux measurements:
  - Time-series sites
  - Voluntary Observing Ship (VOS) lines
  - (Sensors on floats, gliders, …)
  - Eddy covariance measurements: at coastal stations / on ships ?
  - …