Nitrous Oxide Fluxes in the Eastern Tropical Atlantic Ocean

GEOMAR Helmholtz Centre for Ocean Research Kiel

RD 1 Ocean Circulation and Climate Dynamics
Düsternbrooker Weg 20
D-24105 Kiel

contact: tfischer@geomar.de www.geomar.de

T. Fischer, A. Kock, D.L. Arévalo-Martínez, P. Brandt, M. Dengler, H.W. Bange

BMBF-Verbundvorhaben **SOPRAN**

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SFB 754

EuroSITES European Ocean Observatory Network

N_2O 10% to 40% is from the ocean

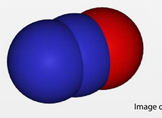


Image of molecule created by Ben Mills / Global Warming Art

N_2O producers

Nirosococcus oceanus
Watson ex Bergey's Manual of Systematic Bacteriology

Nitrifying microbes

Tom E. Morris

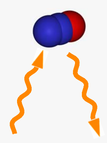
Denitrifying microbes

N_2O is accidentally released to the water by microbes, either as a byproduct during nitrification or as an intermediate product during denitrification.

Effects of N_2O emitted to the atmosphere

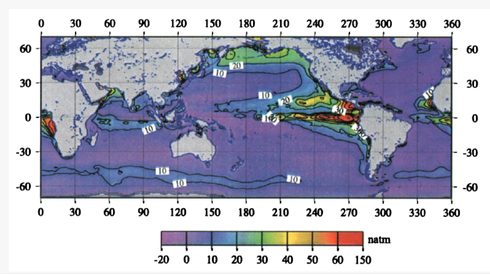
$O_3 \rightarrow O_2$

N_2O is currently the most important ozone depleting substance [Ravishankara et al. 2009].



The greenhouse potential of an N_2O molecule is 300 times that of a CO_2 molecule.

Where is N_2O emitted from the ocean ?



- In upwelling systems
- In regions where oxygen minimum zones occur in the water column

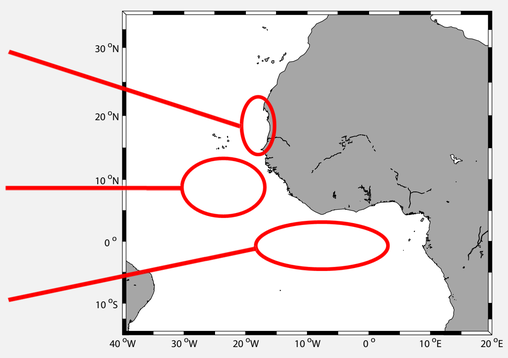
Surface N_2O superstauration after Suntharalingam and Sarmiento [2000] with data from Weiss et al. [1992].

Flux measurements in 3 locations of expectedly high oceanic N_2O emissions

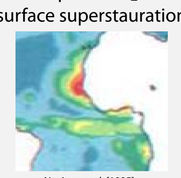
Mauritanian Upwelling

Guinea Dome Region

Equatorial Cold Tongue



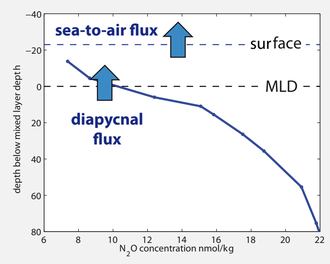
Reported N_2O surface superstaurations



Nevison et al. [1995]

Suntharalingam and Sarmiento [2000] with data from Weiss et al. [1992].

Sea-to-air flux versus diapycnal flux from below



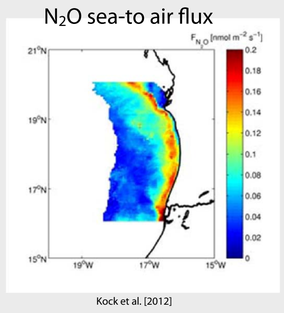
N_2O profiles from discrete samples

Measurements of diapycnal mixing allow estimates of diapycnal flux

Mauritanian upwelling

High N_2O fluxes in the coastal upwelling

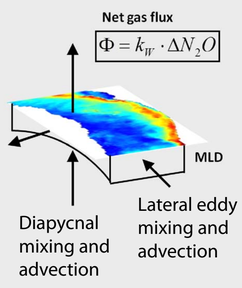
N_2O sea-to air flux



Kock et al. [2012]

Net gas flux

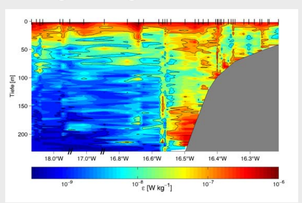
$$\Phi = k_W \cdot \Delta N_2O$$



Diapycnal mixing and advection

Lateral eddy mixing and advection

Strong mixing at the shelf break

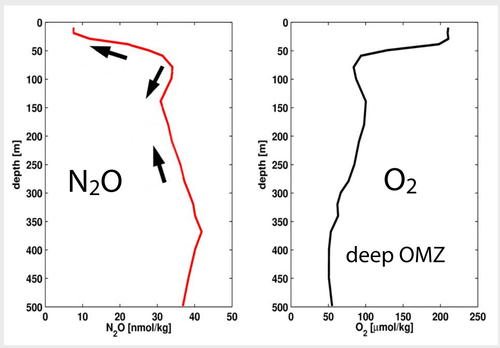


Schafstall et al. [2010]

Increased diapycnal mixing at the shelf break is a major contributor to high N_2O supply to the coastal mixed layer.

Guinea Dome Region

Low N_2O fluxes in the region of the Oxygen Minimum Zone (OMZ)



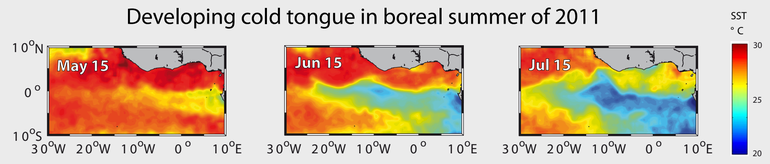
→ direction of diapycnal N_2O flux caused by diapycnal mixing.

N_2O concentrations are related to O_2. The deep oxygen minimum is isolated from the surface O_2, and so is surface N_2O isolated from deep OMZ N_2O.

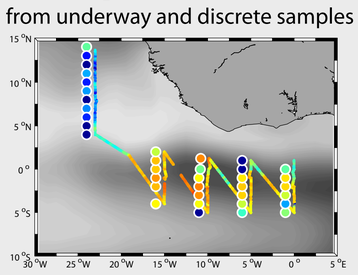
Equatorial cold tongue

High N_2O fluxes at the equator during cold tongue development

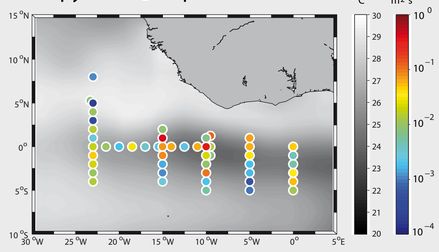
Developing cold tongue in boreal summer of 2011



N_2O sea-to-air flux from underway and discrete samples



Diapycnal N_2O upward flux to ML



N_2O sea-to-air flux and diapycnal supply from below are of the same magnitiude. Discrete sea-to-air fluxes are shifted 1 degree for convenience.

N_2O mixed layer budget discrepancy in coastal upwelling and open ocean

	Coastal Upwelling	Open ocean	Equatorial Cold Tongue
Sea-to-air flux	70 [1)]	10	35
Diapycnal flux	20 [1)]	1	50
Vertical advection	2 [1)]	<1	
Lateral advection		1 to 3	Fluxes in pmol/m²/s
N_20 production in mixed layer	<1 to 5 [1)]		

In the coastal upwelling and in the open ocean, the estimated total supply to the mixed layer cannot account for the estimated sea-to-air flux.

For the equatorial data we cannot assume a closed budget: available data is from the onset of the cold tongue, in a phase of presumably rising N_2O concentrations in the surface layer.

1) Kock et al. [2010]

A main suspect in coastal upwelling systems: surface slicks

Surface slicks cause smooth‚oily' water without capillary waves

Black patches and stripes in the satellite picture denote large regions void of capillary waves (Envisat SAR, Peruvian upwelling)

Picture courtesy of W. Alpers

Parameterization of Tsai and Liu [2003] for surface slicks shows reduced gas exchange and remediates dicrepancies.

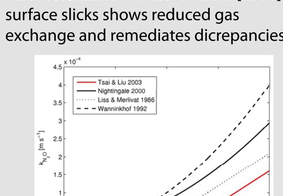


Fig. 2. Wind speed parameterizations used for the calculation of sea-to-air fluxes of N_2O. The black lines represent gas exchange parameterizations for conditions without surfactants while the red line represents the parameterization of Tsai and Liu (2003) for surfactant-influenced surface waters.

Kock et al. [2010]

References

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Acknowledgments

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