Nitrous Oxide Emissions from Eastern Boundary Ecosystems: Case Studies from Peru and Benguela Upwelling Regions.

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future ocean
KIEL MARINE SCIENCES

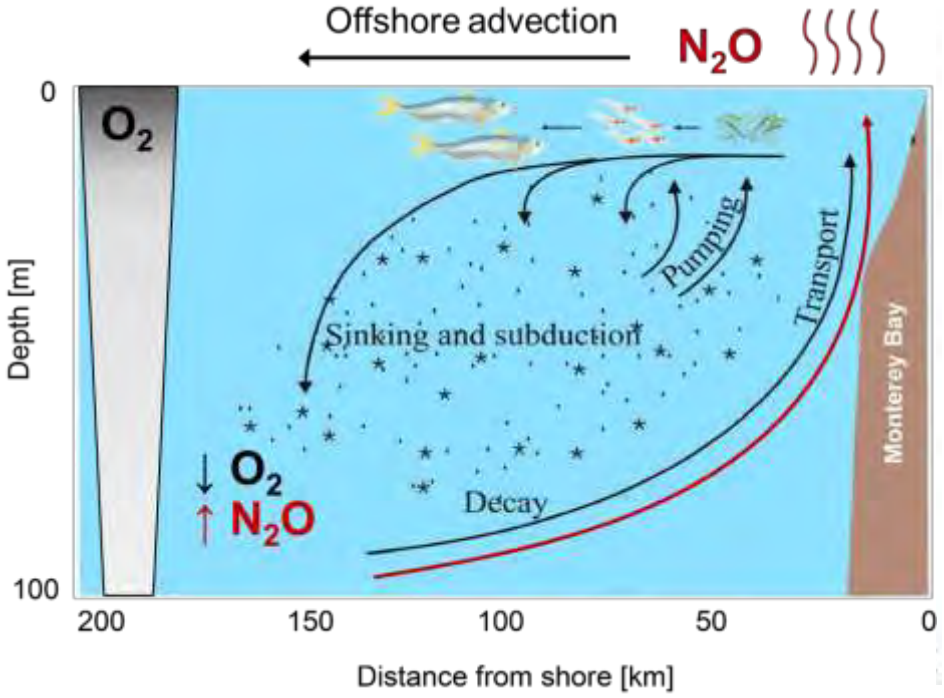
SOPRAN

InGOS
Integrated non-CO_2 Greenhouse gas Observing System

SFB 754

GEOMAR

Eastern Boundary Upwelling Ecosystems

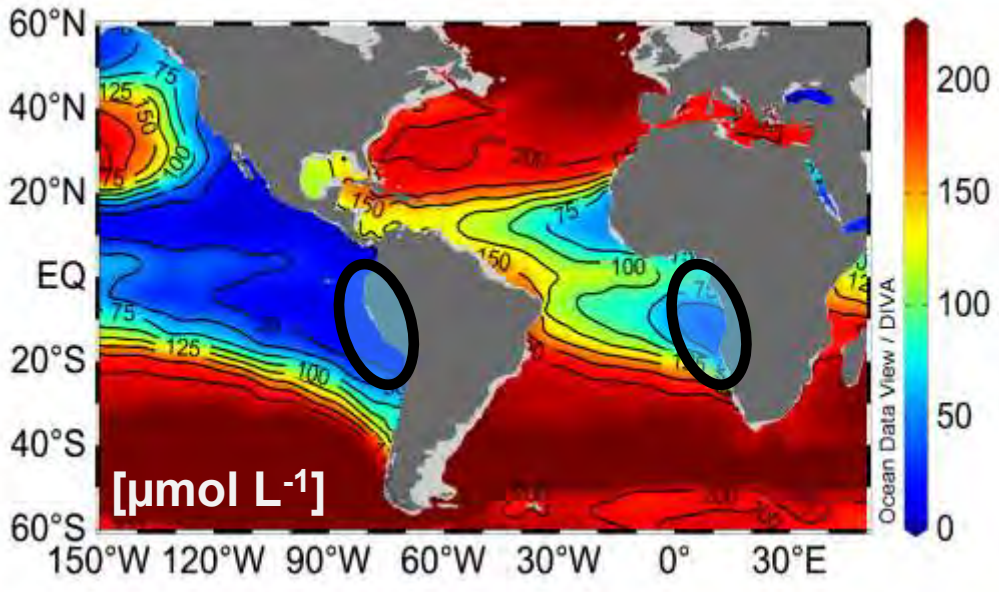


Modified from Chavez & Messié (2009)

- Alongshore equatorward wind.
- Offshore/Inshore transport.
- Enhanced primary production.
- Subsurface microbial respiration.
- Oxygen minimum zones.

N_2O?

Field work 2012-2013



Annual mean O_2 distribution at 400 m depth (1955-2012)

Underway N_2O (OA-ICOS)

N_2O, O_2, Nuts, *amoA*, *nirS*

Outline

I. Why EBUE's?

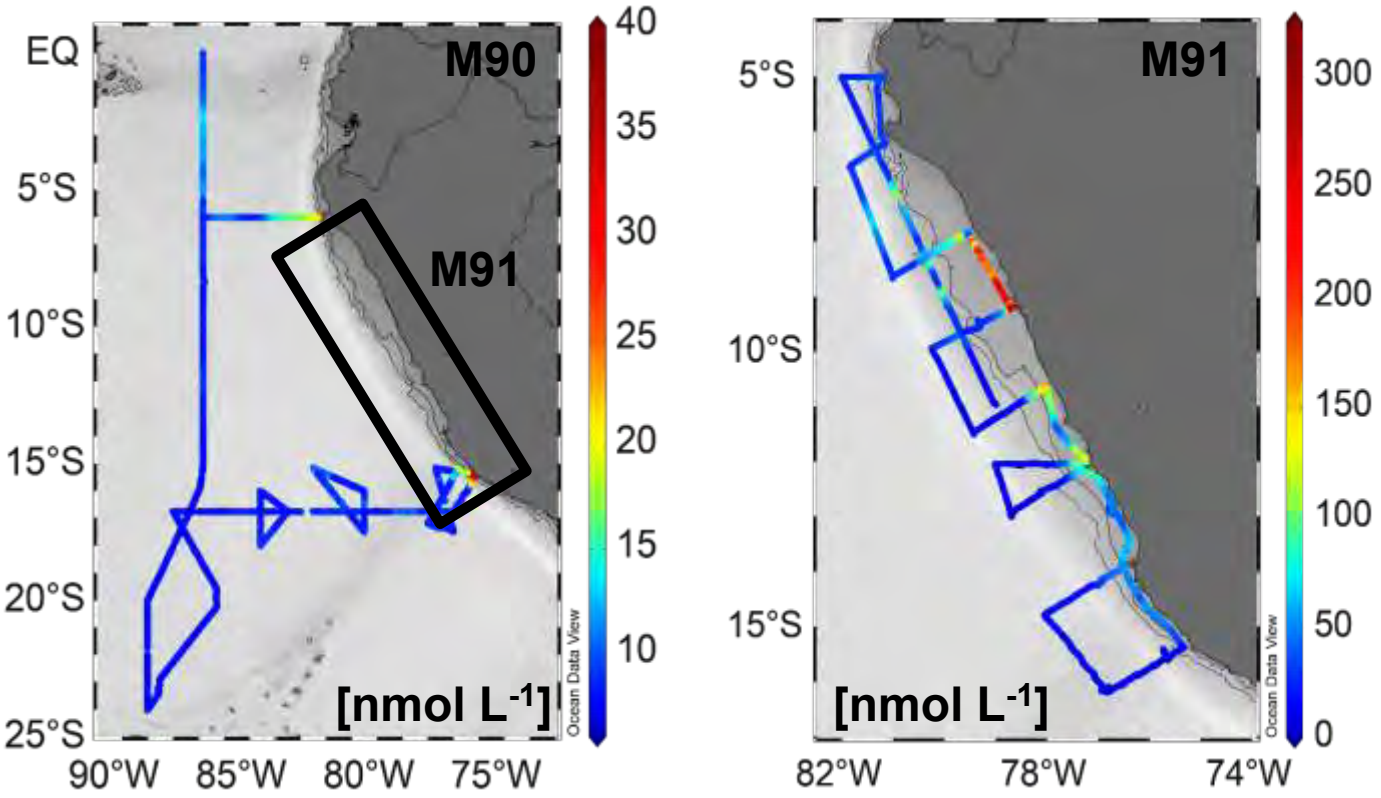
II. Peruvian upwelling

III. Northern Benguela upwelling

IV. Comparison of N_2O emissions

II. Peruvian upwelling

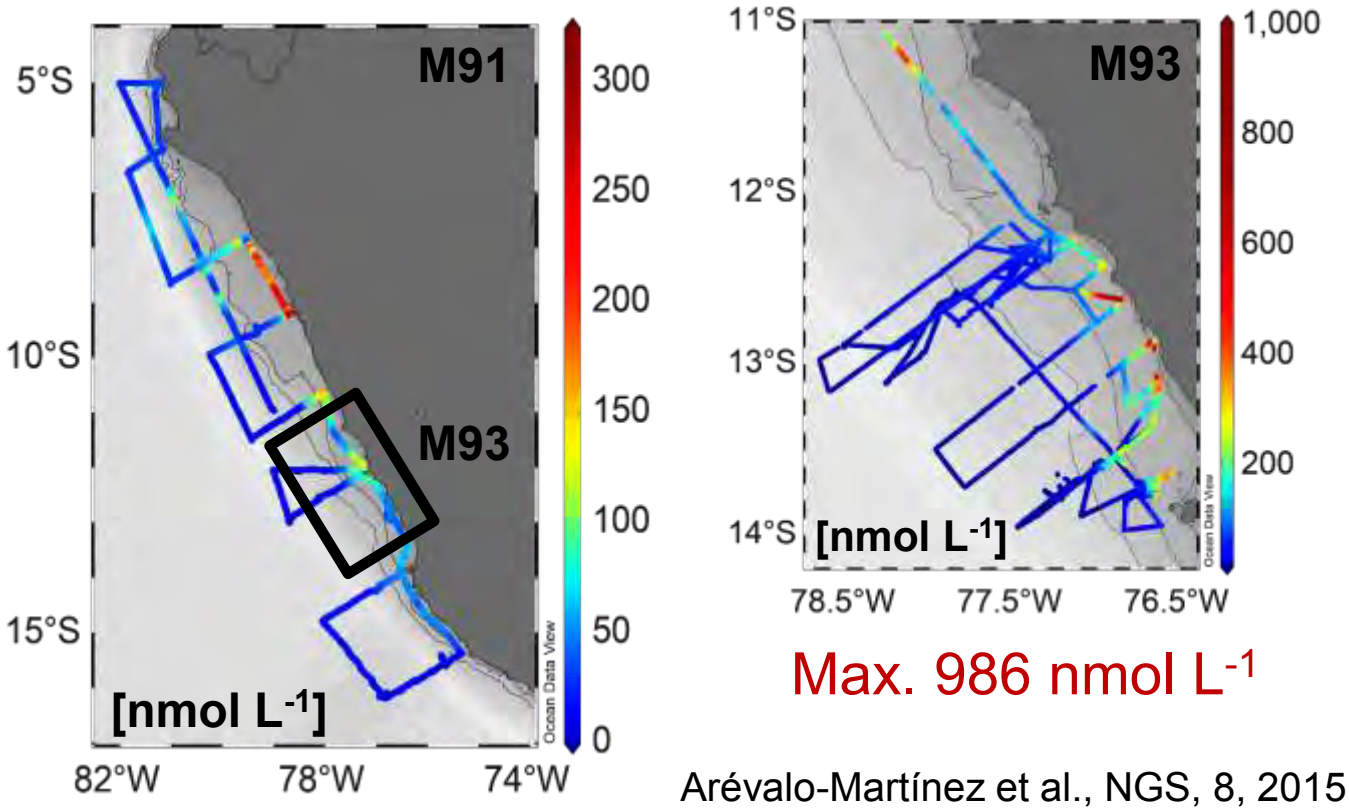
N_2O surface distribution off Peru



Arévalo-Martínez et al., NGS, 8, 2015.

Seawater N_2O concentrations during the M90 (Nov. 2012) and M91 (Dec. 2012) cruises.

N_2O surface distribution off Peru

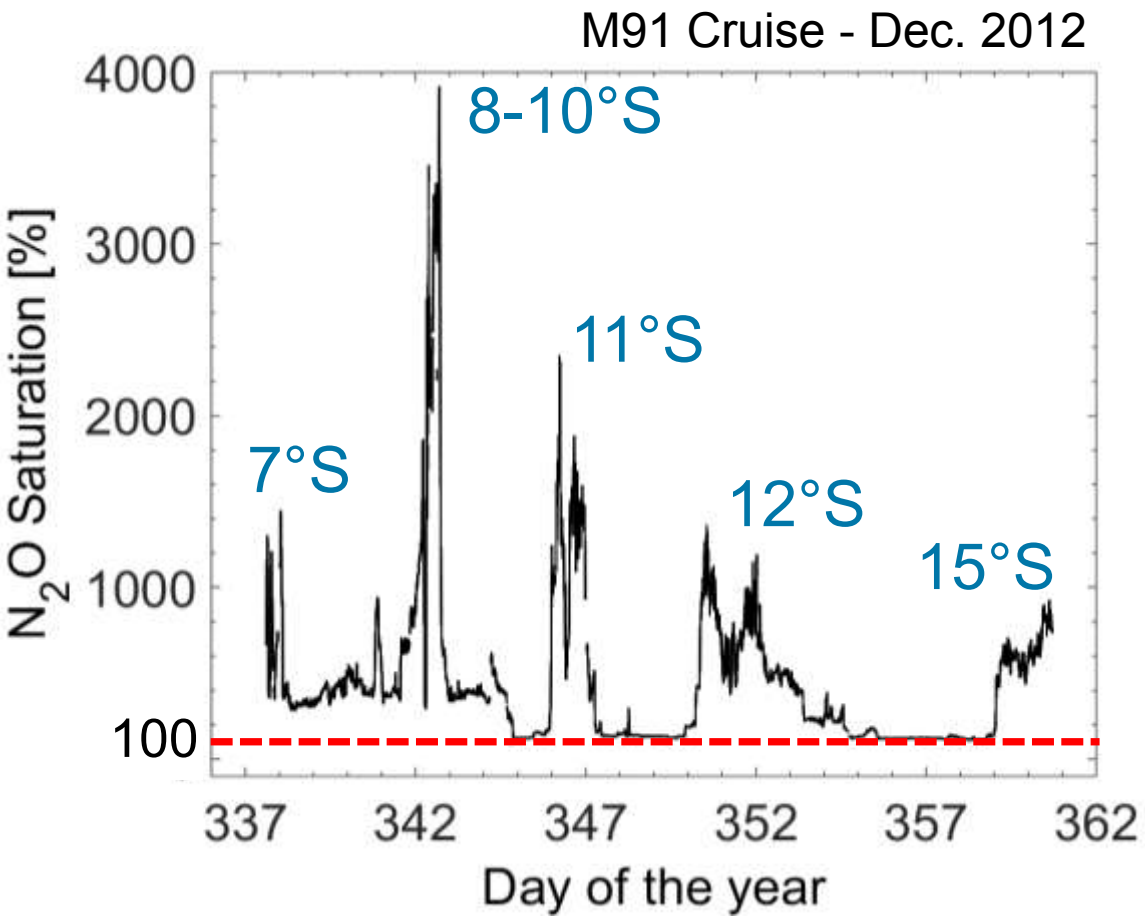


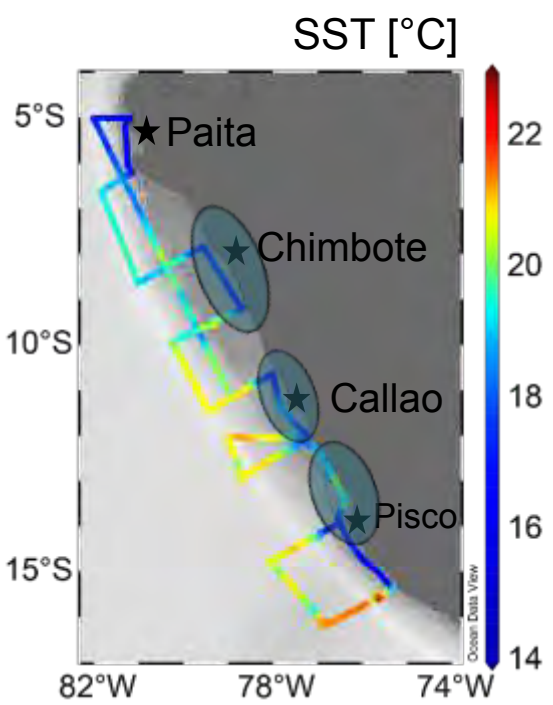
Max. 986 nmol L^{-1}

Arévalo-Martínez et al., NGS, 8, 2015.

Seawater N_2O concentrations during the M91 (Dec. 2012) and M93 (Feb.-Mar. 2013) cruises.

Peruvian upwelling: "hotspot" for N_2O emissions

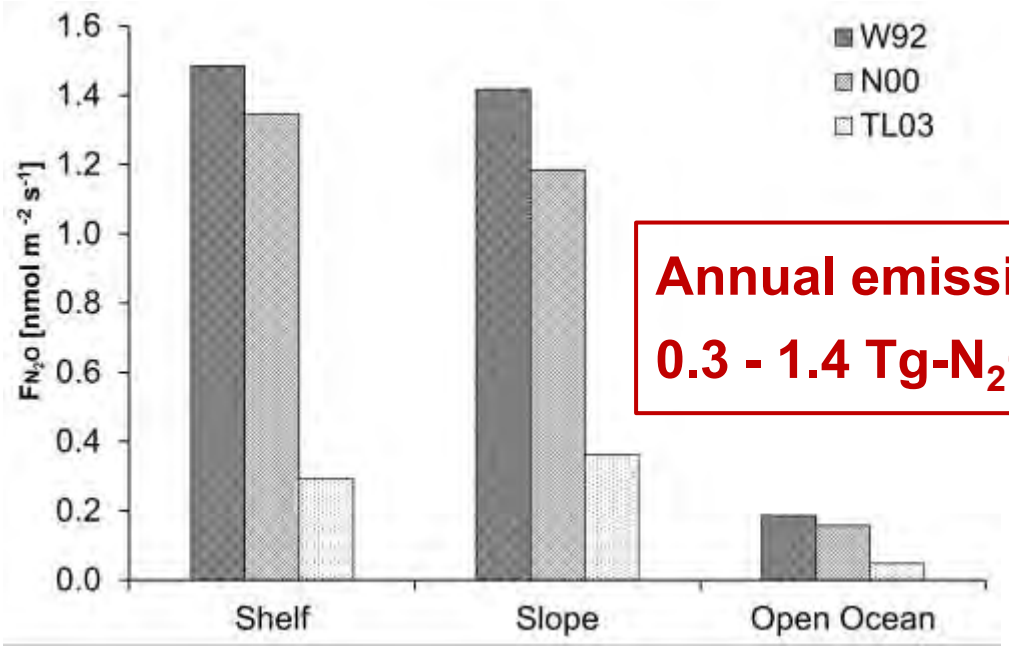




Main upwelling cells off Peru

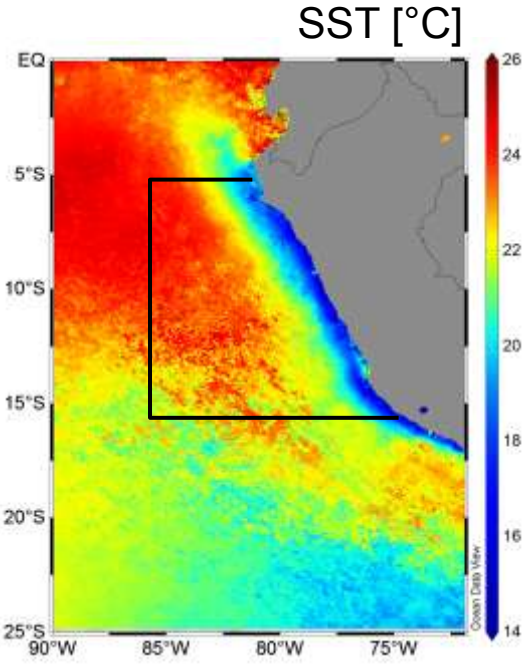
N_2O sea-to-air fluxes

Flux densities 5°S-16°S, 75°W-86°W



Annual emission:

0.3 - 1.4 Tg-N_2O



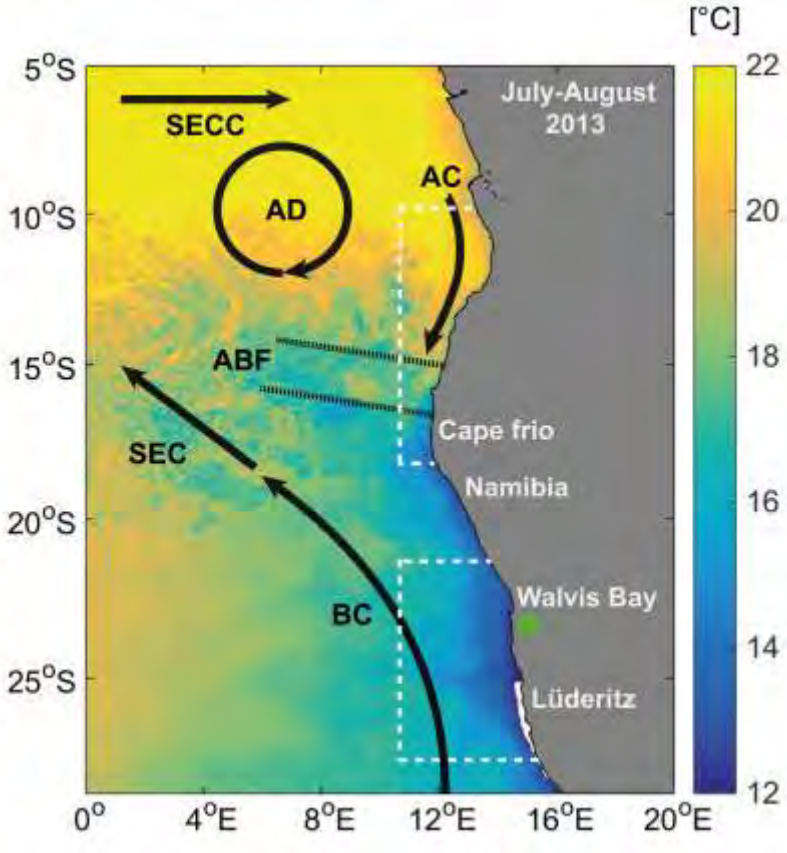
MODIS-Aqua 4km

Nov.-Dec. 2012

- Strongest outgassing shelf area.
- But: large uncertainties!

III. Northern Benguela upwelling region

Northern Benguela upwelling



MODIS-Aqua 4km SST

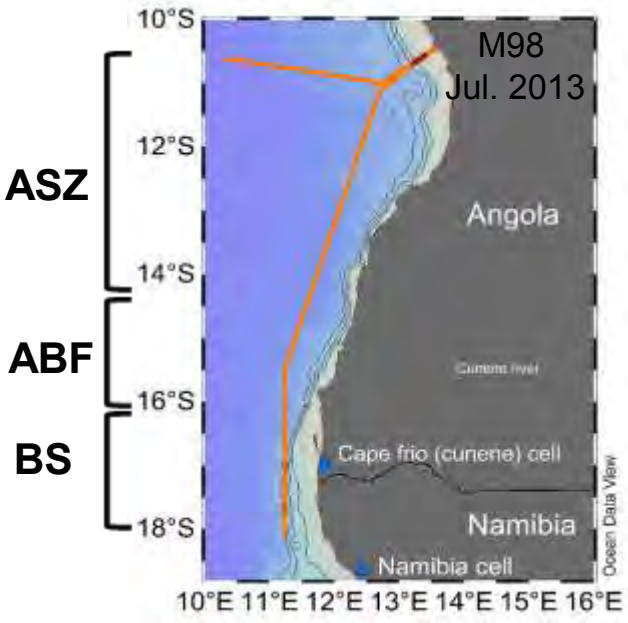
- Permanent upwelling.
- Strong cells at:

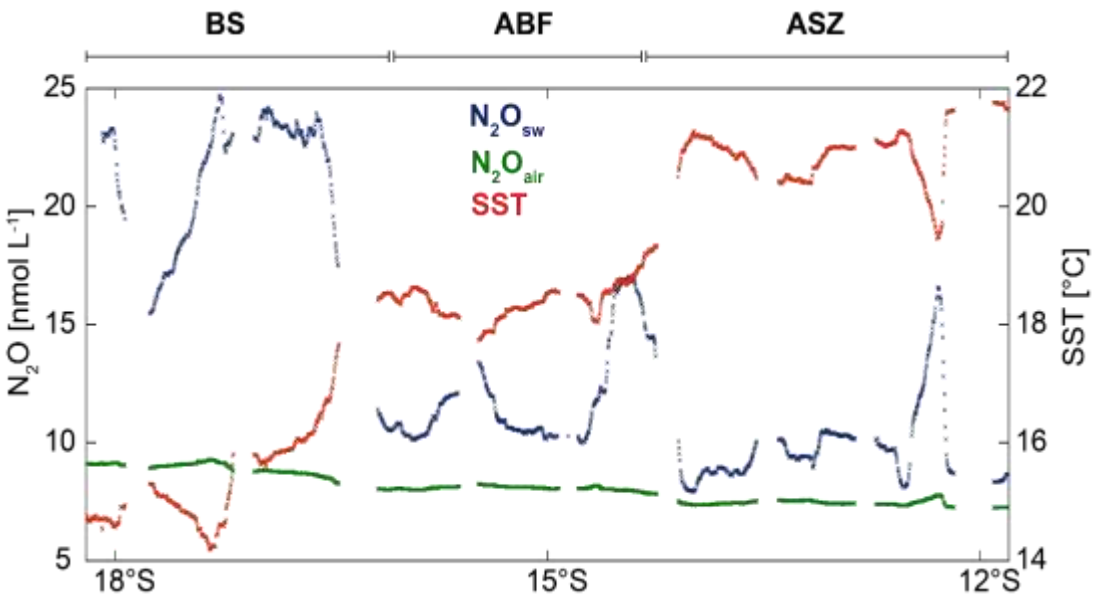
  17°S, 19°S, 23°S & 26°S
- OMZ 20°S-25°S
- Boundaries:

  Angola-Benguela Front

  Lüderitz upwelling cell

N_2O surface distribution off Benguela





- Moderate concentrations (7.8 - 24.4 nmol L^{-1})
- Good agreement with SST.

- Regional variability:
  - –Angola subtropical zone
  - –Angola-Benguela front
  - –Benguela system

N_2O sea-to-air fluxes

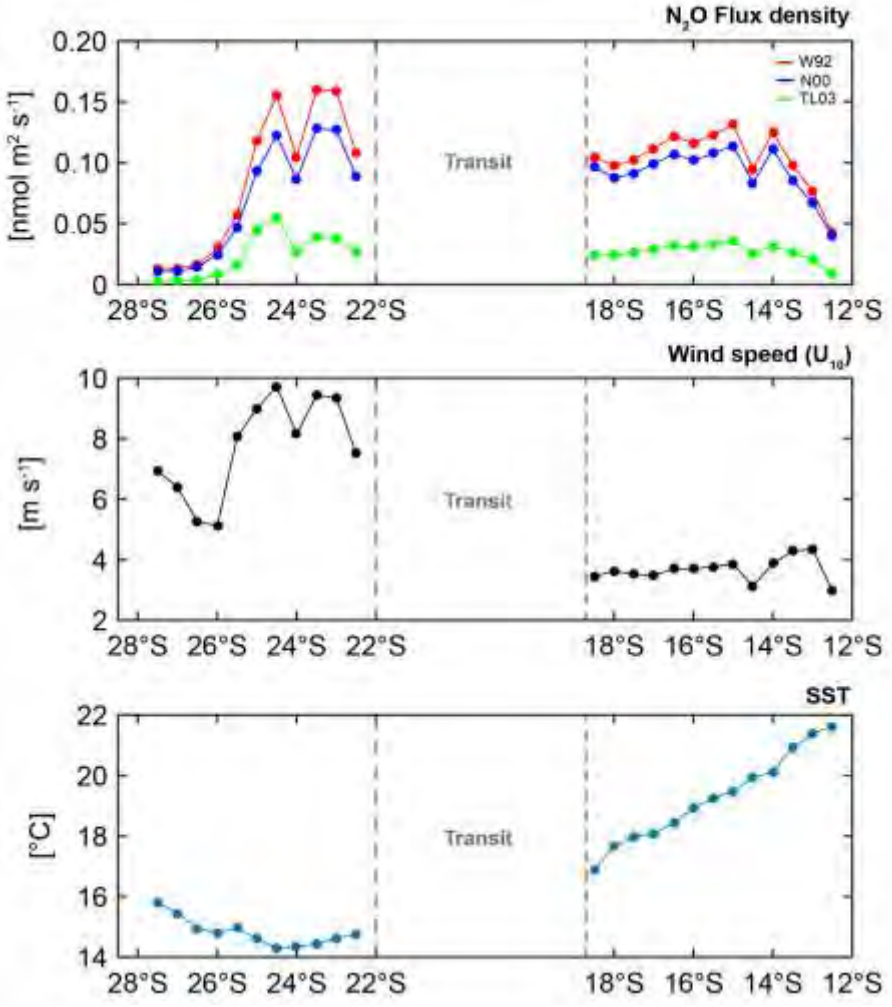
Predominance of positive fluxes

(indicating net outgassing)

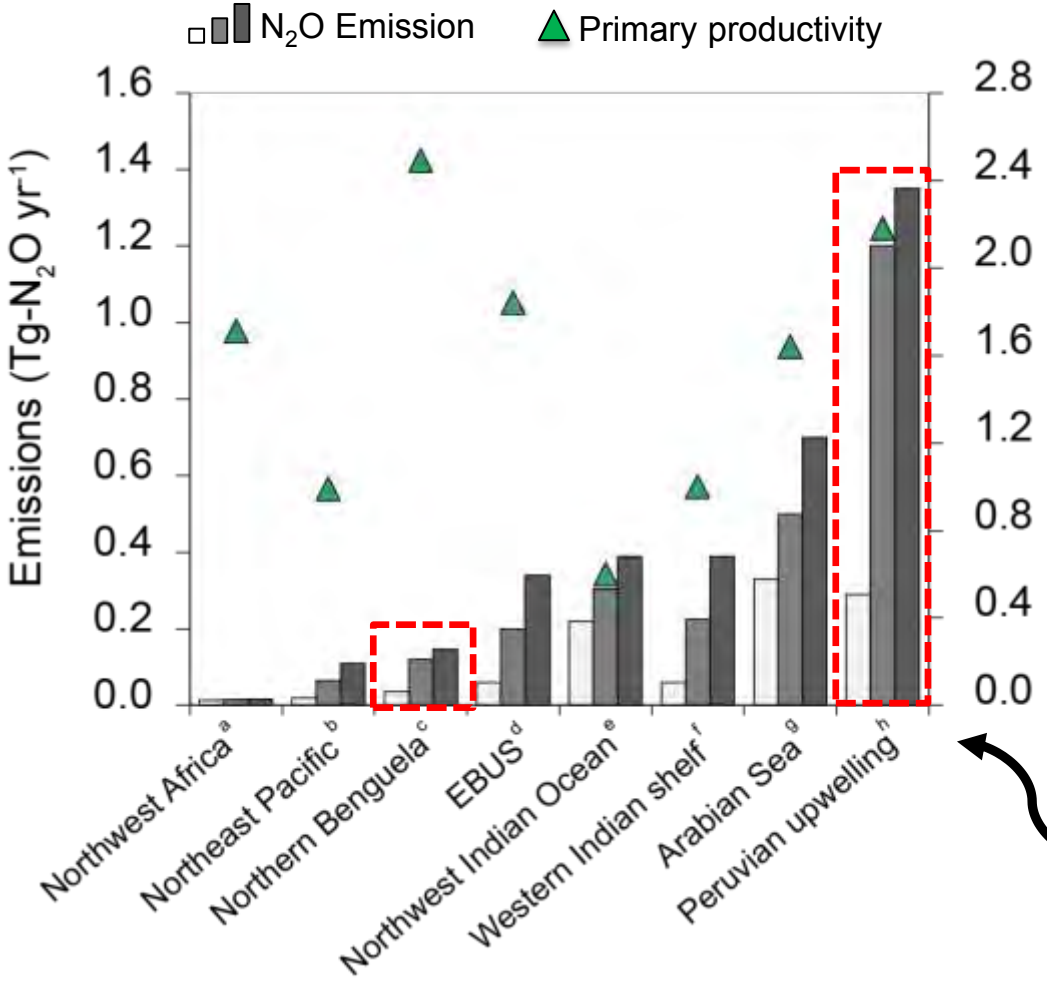
→ Meridional distribution of flux consistent with major upwelling cells off Namibia.

Annual emission:

0.0037 - 0.015 Tg-N_2O



IV. N_2O emissions from EBUE‘s



But:

- High uncertainties in *k* computation.
- Shallow stratification.
- Temporal/spatial variability.

Comparison of N_2O emissions from highly productive coastal upwelling systems.

Main points

- The contribution of the Peruvian upwelling to the global emissions of N_2O is higher than previously known (5-22% of the global ocean source)
- The northern Benguela upwelling system acts as a moderate source of N_2O (winter) to the atmosphere, despite its strong local contribution.
- Further assessments of long-term N_2O emissions from EBUE's are needed to elucidate potential changes with future ocean warming and deoxygenation.