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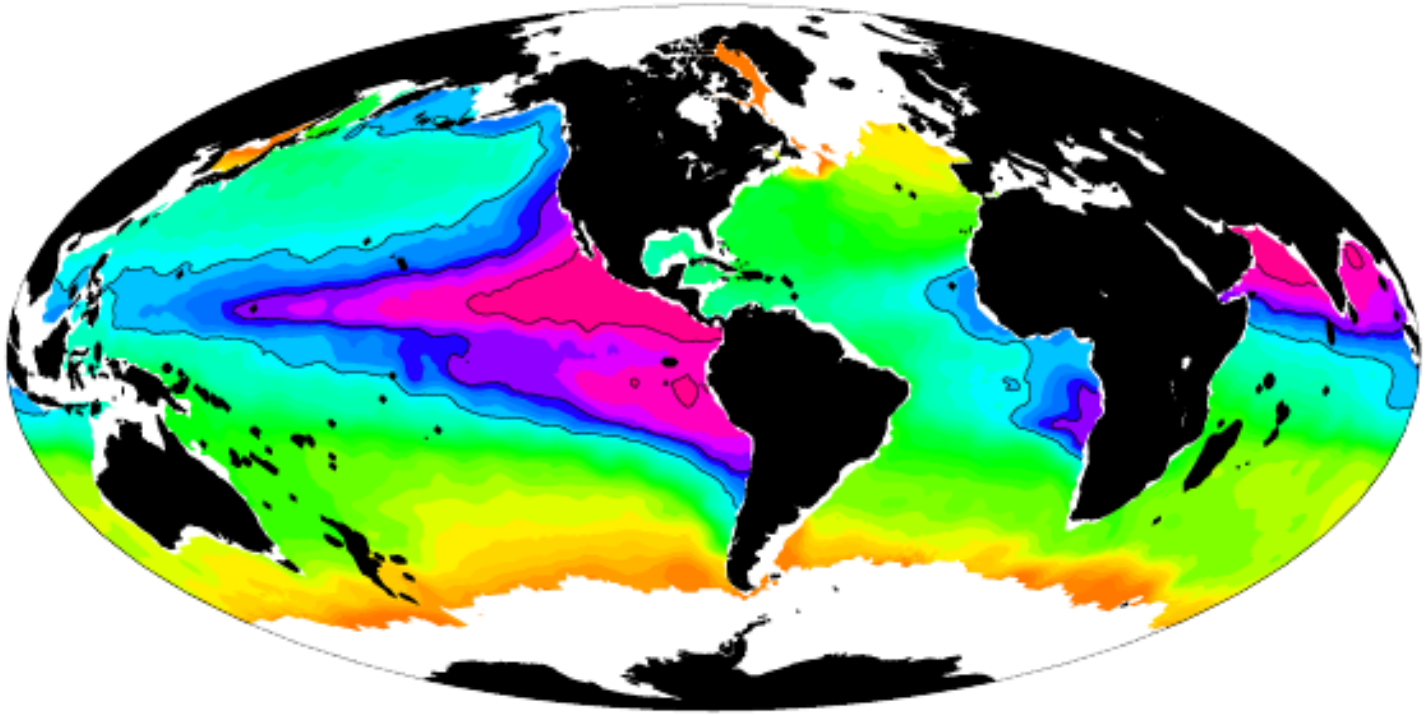
Biogeochemical Applications: Requirements, Synergies and Gaps.



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GOOS Essential Ocean Variables

BIOGEOCHEMISTRY
Oxygen
Nutrients
Inorganic carbon
Transient tracers
Particulate matter
Nitrous oxide
Stable carbon isotopes
Dissolved organic carbon
Ocean colour *(Spec Sheet under development)*

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GCOS Essential Climate Variables (ECVs)

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Oceanic	Physics:				
	Subsurface temperature, subsurface salinity, Subsurface currents, ocean surface stress, ocean-surface heat flux		GOOS/JCOMM		
	Sea-surface temperature, surface currents, sea-surface salinity, sea level, sea state, sea ice		GOOS/JCOMM	WGClimate	
	Biogeochemistry:				
	Inorganic carbon, oxygen, nutrients, transient tracers, nitrous oxide (N_2O), ocean colour		GOOS		IOCCP
			GOOS	WGClimate	IOCCG
	Biology/ecosystems:				
	Plankton, marine habitat properties		GOOS		GEOBON

Inorganic Carbon

Nitrous Oxide

Oxygen

Nutrients

Ocean Color

Transient Tracers

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ECV IN BRIEF

Domain: Ocean
Subdomain: Biogeochemical
Scientific Area: Carbon cycle and other GHGs
Products: Interior ocean N_2O
N_2O air-sea flux

Nitrous Oxide

Nitrous oxide (N_2O) is an important climate-relevant trace gas in the Earth's atmosphere. In the troposphere it acts as a strong greenhouse gas and in the stratosphere it acts as an ozone depleting substance because it is the precursor of ozone depleting nitric oxide radicals. The ocean - including its coastal areas such as continental shelves, estuaries and upwelling areas - contribute about 30% to the atmospheric N2O budget.

ECV Products

PRODUCT	DEFINITION	REQUIREMENTS				
		FREQUENCY	RESOLUTION	REQUIRED MEASUREMENT UNCERTAINTY	STABILITY	STANDARDS/ REFERENCES
INTERIOR OCEAN N_2O	XXX	Annual to decadal	Every 20°	discrete samples: ~±5%;	Not specified	www.ioccp.org/index.php/foo
N_2O AIR-SEA FLUX	XXX	Annual to decadal	Every 20°	cont. sampling: <±1%	Not specified	www.ioccp.org/index.php/foo

Selected Data Sources

- MarinE MethanE and NiTrous Oxide (MEMENTO) database
https://memento.geomar.de/submit-your-data

WMO IOC INTERNATIONAL COUNCIL FOR SCIENCE UN environment www.gcos.wmo.int gcos@wmo.int @gcos_un

Version: 2017.08.25

GOOS The Global Ocean Observing System

Essential Ocean Variable (EOV): Nitrous Oxide

Background and Justification

Nitrous oxide (N_2O) is an important climate-relevant trace gas in the Earth's atmosphere. In the troposphere it acts as a strong greenhouse gas and in the stratosphere it acts as an ozone depleting substance because it is the precursor of ozone depleting nitric oxide radicals. Because of the on-going decline of chlorofluorocarbons and the continuous increase of N_2O in the atmosphere, the contributions of N_2O to both the greenhouse effect and ozone depletion will be even more pronounced in the 21st century. The ocean - including its coastal areas such as continental shelves, estuaries and upwelling areas - is a major source of N_2O and contributes about 30% to the atmospheric N_2O budget. Oceanic N_2O is mainly produced as a by-product during archaeal nitrification (i.e. ammonium oxidation to nitrate) whereas bacterial nitrification seems to be of minor importance as source of oceanic N_2O. N_2O occurs also as an intermediate during microbial denitrification (nitrate reduction via N_2O to dinitrogen, N_2). Nitrification is the dominating N_2O production process, whereas denitrification contributes only 7-35% to the overall N_2O water column budget in the ocean. The amount of N_2O produced during both nitrification and denitrification strongly depends on the prevailing dissolved oxygen (O_2) concentrations and is significantly enhanced under low (i.e. suboxic) O_2 conditions. N_2O is usually not detectable in anoxic waters because of its reduction to N_2 during denitrification. Thus, significantly enhanced N_2O concentrations are generally found at oxic/suboxic or oxic/anoxic boundaries. The strong O_2 sensitivity of N_2O production is also observed in coastal characterised by seasonal shifts in the O_2 regime. A biological source of N_2O in the well-oxygenated mixed layer/euphotic zone seems to be unlikely. Global maps of N_2O in the surface ocean show enhanced N_2O anomalies (i.e. supersaturation of N_2O) in equatorial upwelling regions as well as N_2O anomalies close to zero (i.e. near equilibrium) in large parts of the open ocean. The MEMENTO (The MarinE MethanE and NiTrous Oxide database: https://memento.geomar.de) project has been launched with the aim to collect and archive N_2O data sets and to provide actual fields of surface N_2O for emission estimates.

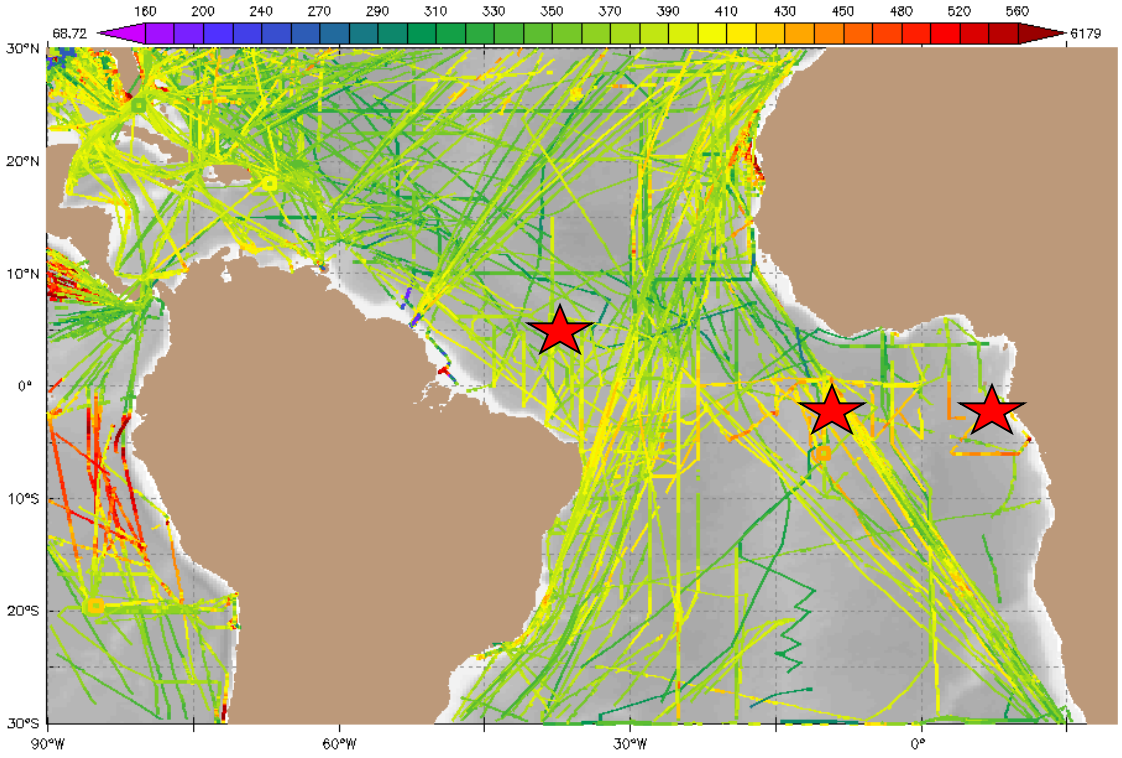
For the glossary of terms and list of abbreviations please see the back of the document.

Table 1: EOV Information	
Name of EOV	Nitrous Oxide
Sub-Variables	Nitrous Oxide (N_2O)
Derived Products	Global N_2O concentration fields, Global Ocean N_2O emission estimates
Supporting variables	Surface and subsurface temperature, Surface and subsurface salinity, Atmospheric pressure
Responsible GOOS Panel	Biogeochemistry Panel Contact: ioccp@ioccp.org

The Global Ocean Observation System (GOOS) is a permanent global system for observations, modeling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS provides accurate descriptions of the present state of the ocean, continuous forecasts of the future conditions of the sea.

WMO IOC UNEP ICSU SCOR

Carbon Dioxide fluxes

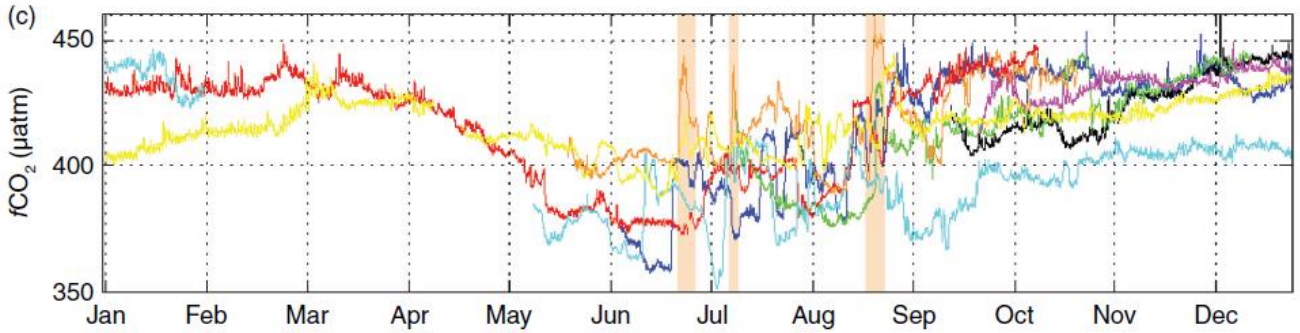


★ pCO_2 mooring

"The eastern tropical Atlantic is patchier than expected with area of low CO_2 concentrations neighbouring regions of large CO_2 outgassing"
Lefevre 2009

This is all pCO_2 data in the Tropical Atlantic Ocean in SOCAT

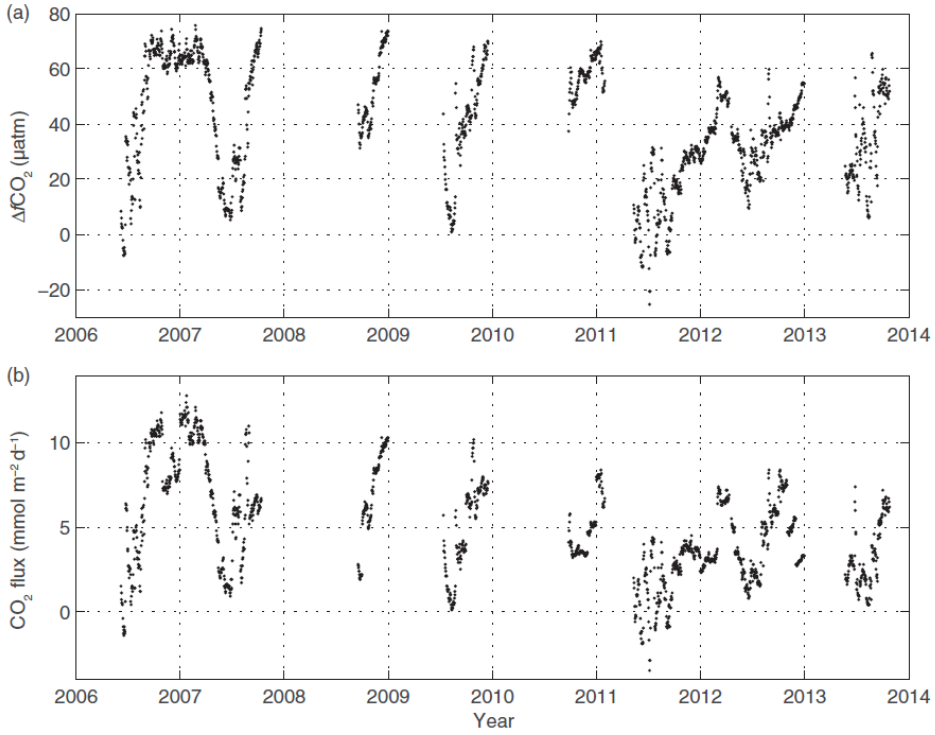
Carbon Dioxide fluxes



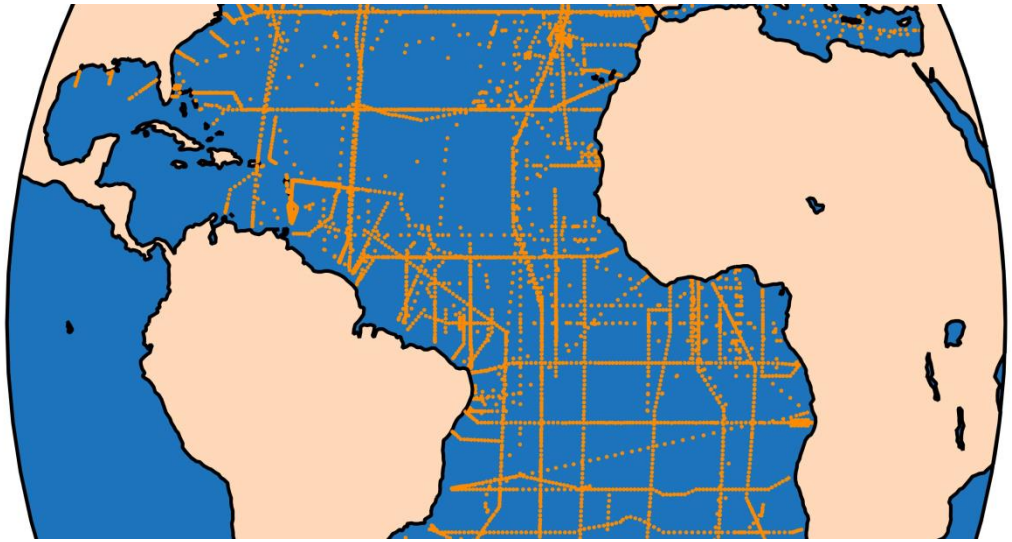
pCO_2 data from 6°S, 8°E, *Lefevre et al., 2016*

Long-term sustained observations are necessary to better document the processes affecting this region given the strong variability at this site.

In addition, more CO_2 sensors would be required to monitor the carbon properties in other parts of the tropical Atlantic and help to better understand the evolution of the source of CO_2 at the basin scale.

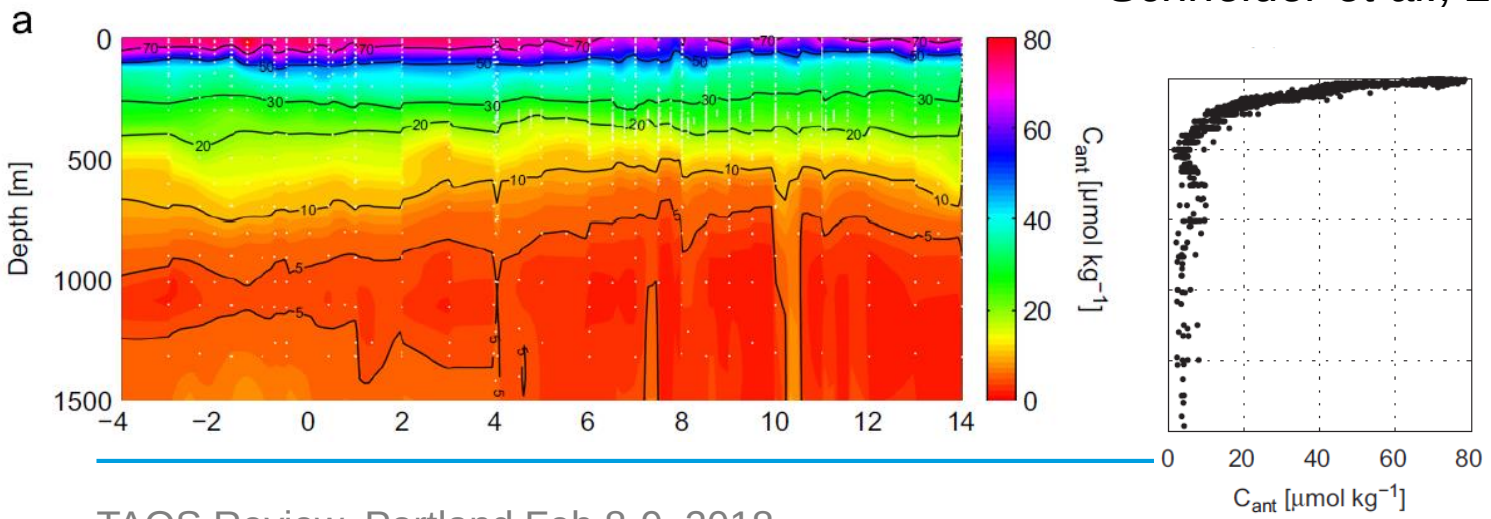


Interior ocean carbon

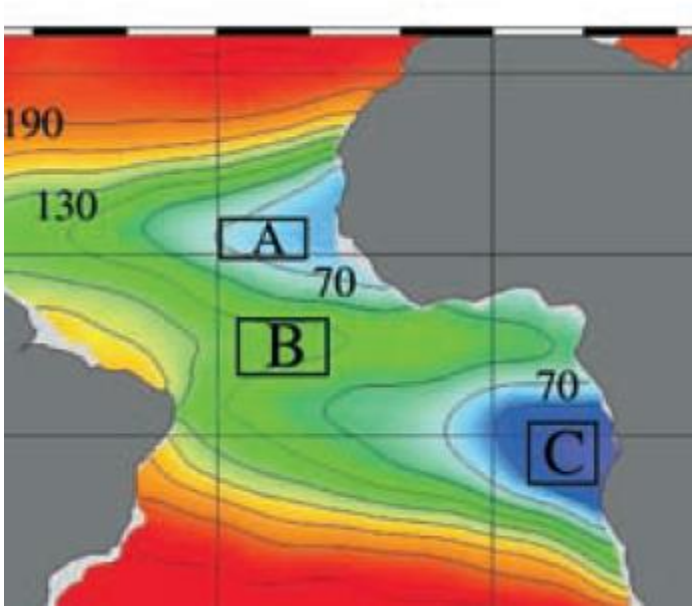


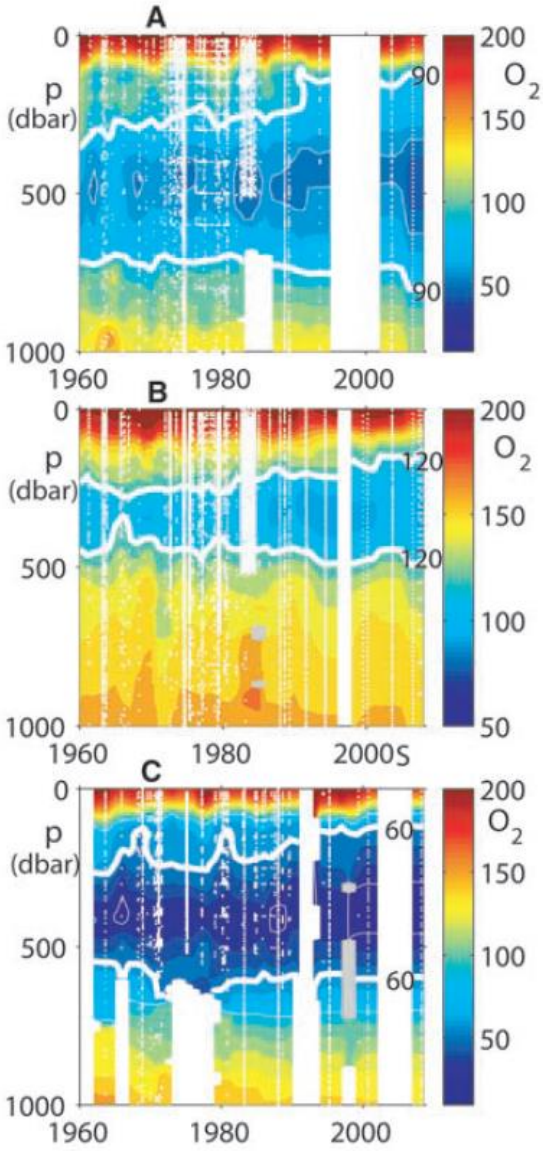
Station network in GLODAP, most of these stations do have inorganic carbon data, but not all.
Olsen et al., 2016

Anthropogenic carbon along 23°W
Schneider et al., 2012



Oxygen





Decreasing oxygen concentrations in the ETNA
Stramma et al., 2008

Oxygen minimum zone

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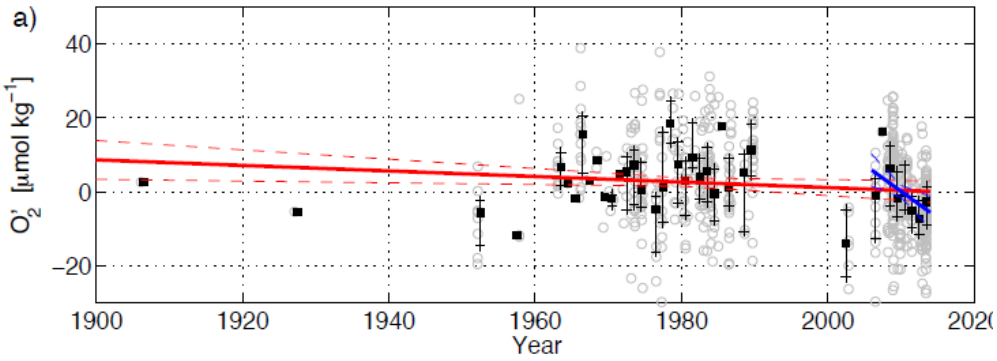
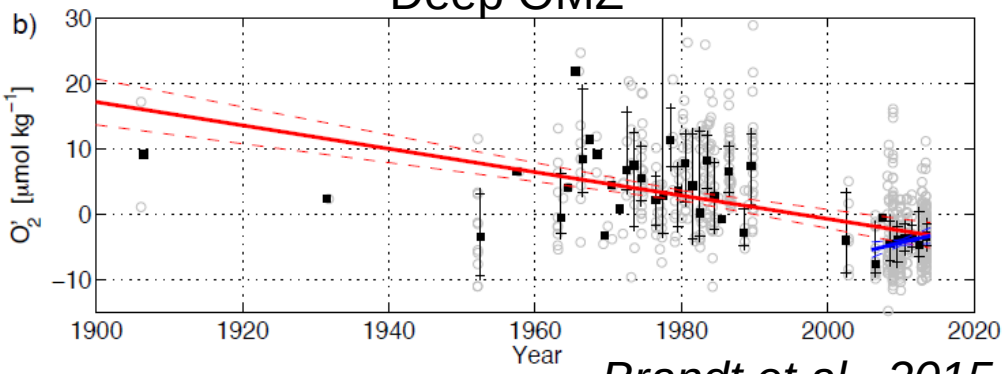
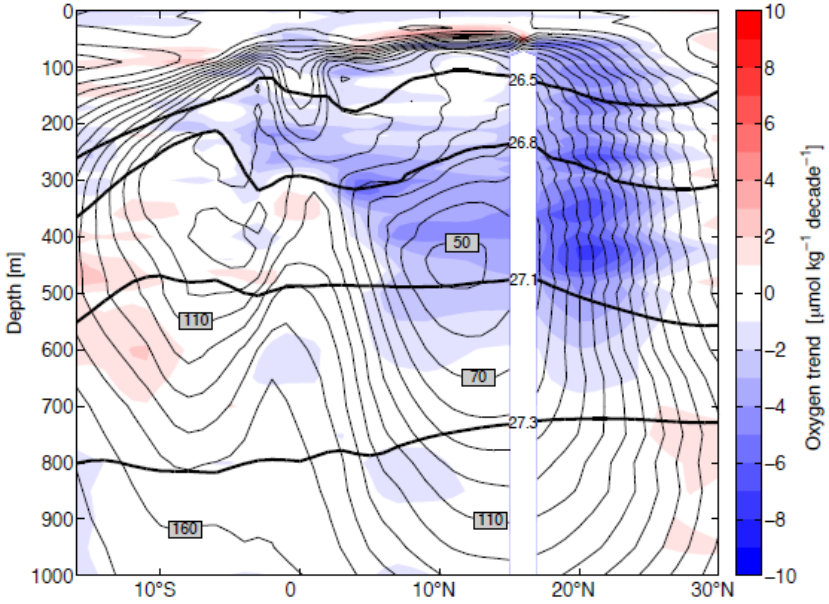
SFB 754

Intermediate OMZ



Deep OMZ





Brandt et al., 2015

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Nitrous Oxide

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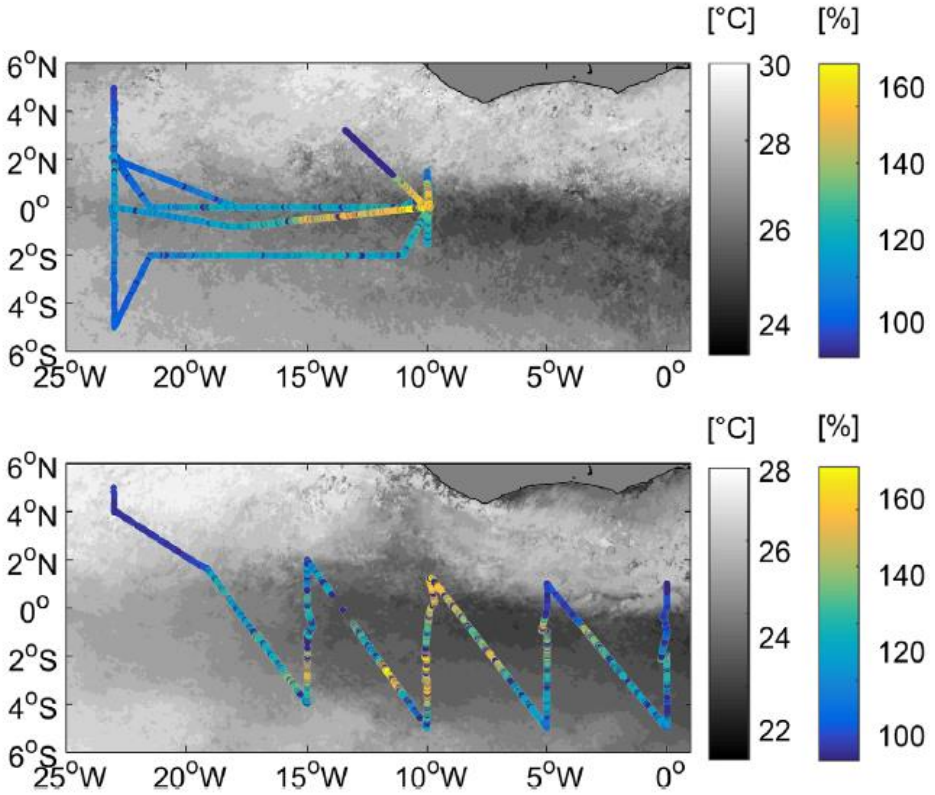
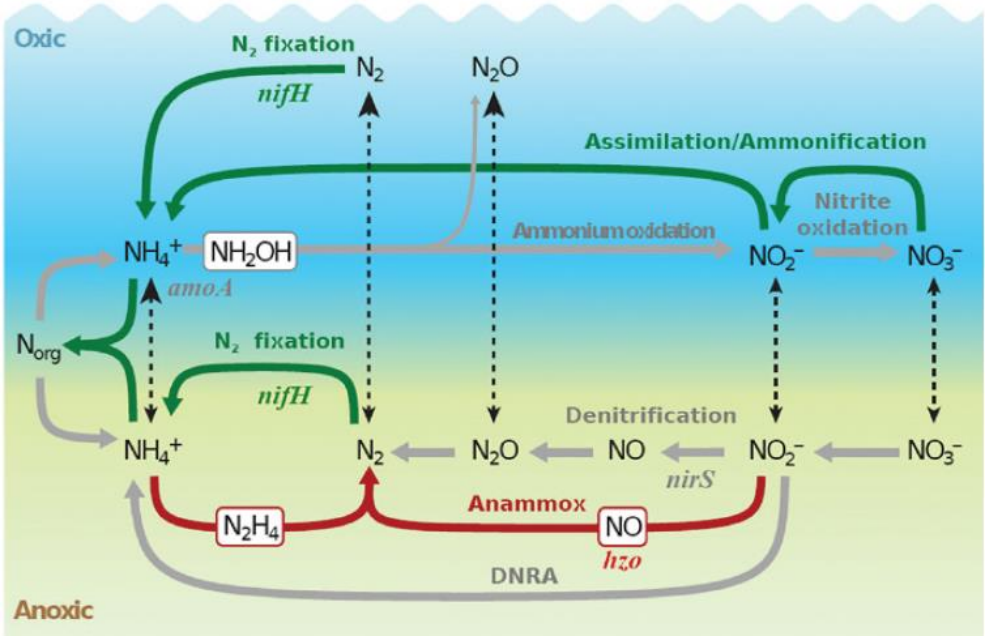
Estimated sea-to-air fluxes of N_2O from the ACT (5.2 +/- 2.6 mol m^{-2} d^{-2}) suggest that in May–July 2011this cold-water band doubled the N_2O efflux to the atmosphere with respect to the adjacent regions, highlighting its relevance for marine tropical emissions of N_2O.
Arevalo-Martinez et al., 2017

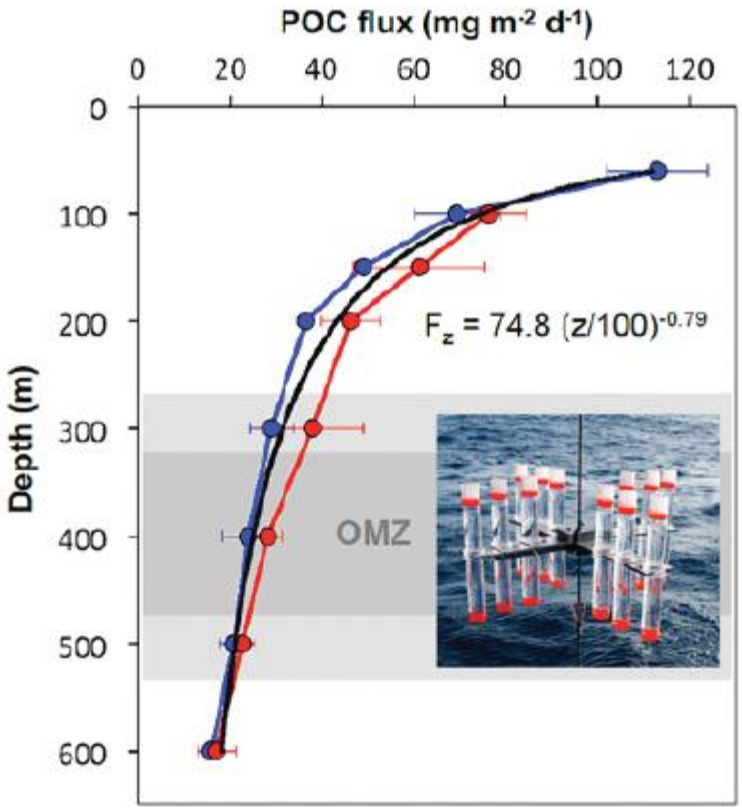


Nutrients



Complex cycle of nitrogen in OMZs

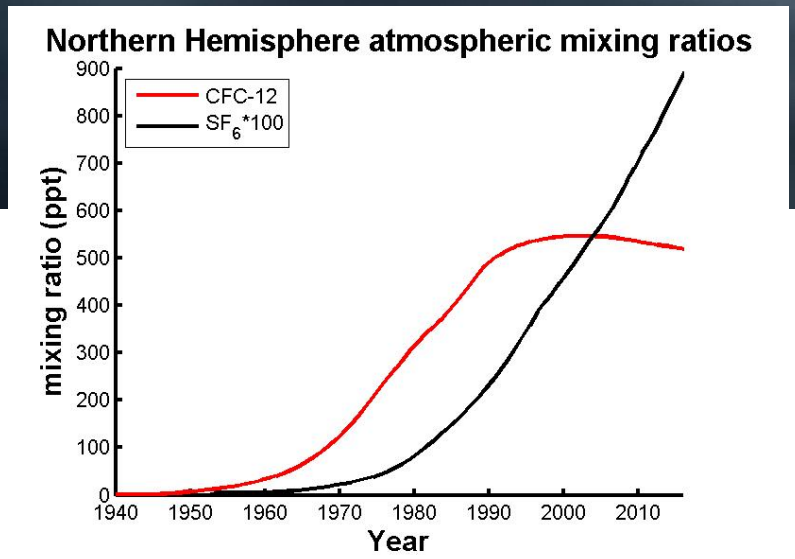
Dissolved Organic Carbon And Particulate Matter

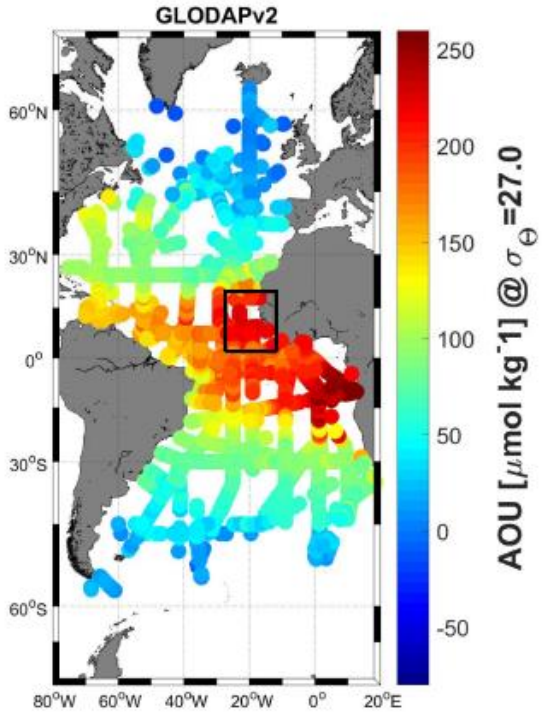


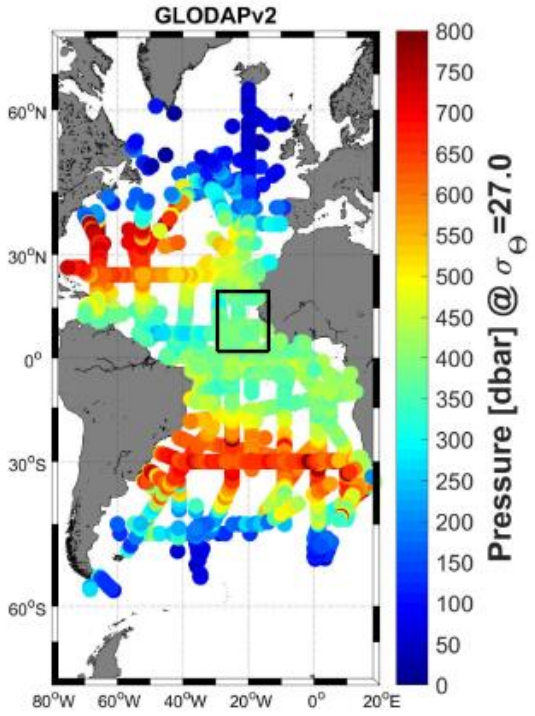
Dissolved organic Carbon (DOC) represents one of the largest exchangeable reservoirs of organic material on Earth, contributing to ~20% of the biological pump via meridional overturning circulation.

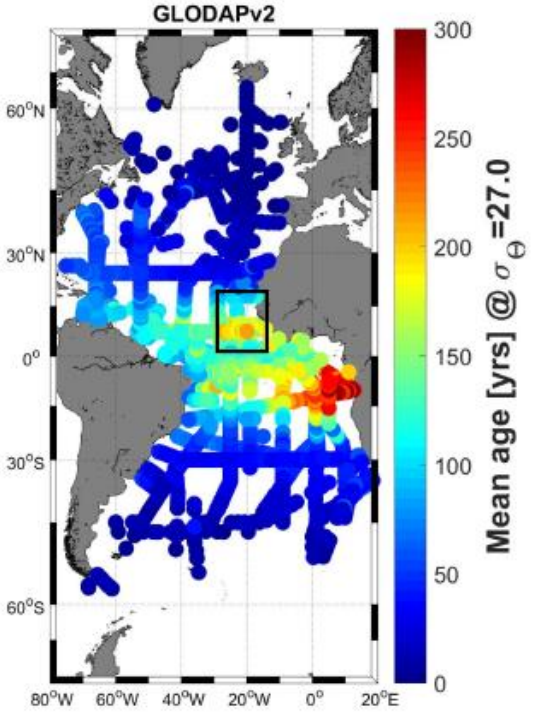
Observation of POM within a global observing system directly address the question of whether the ocean's biomass and productivity are changing

Transient tracers









Transient tracers