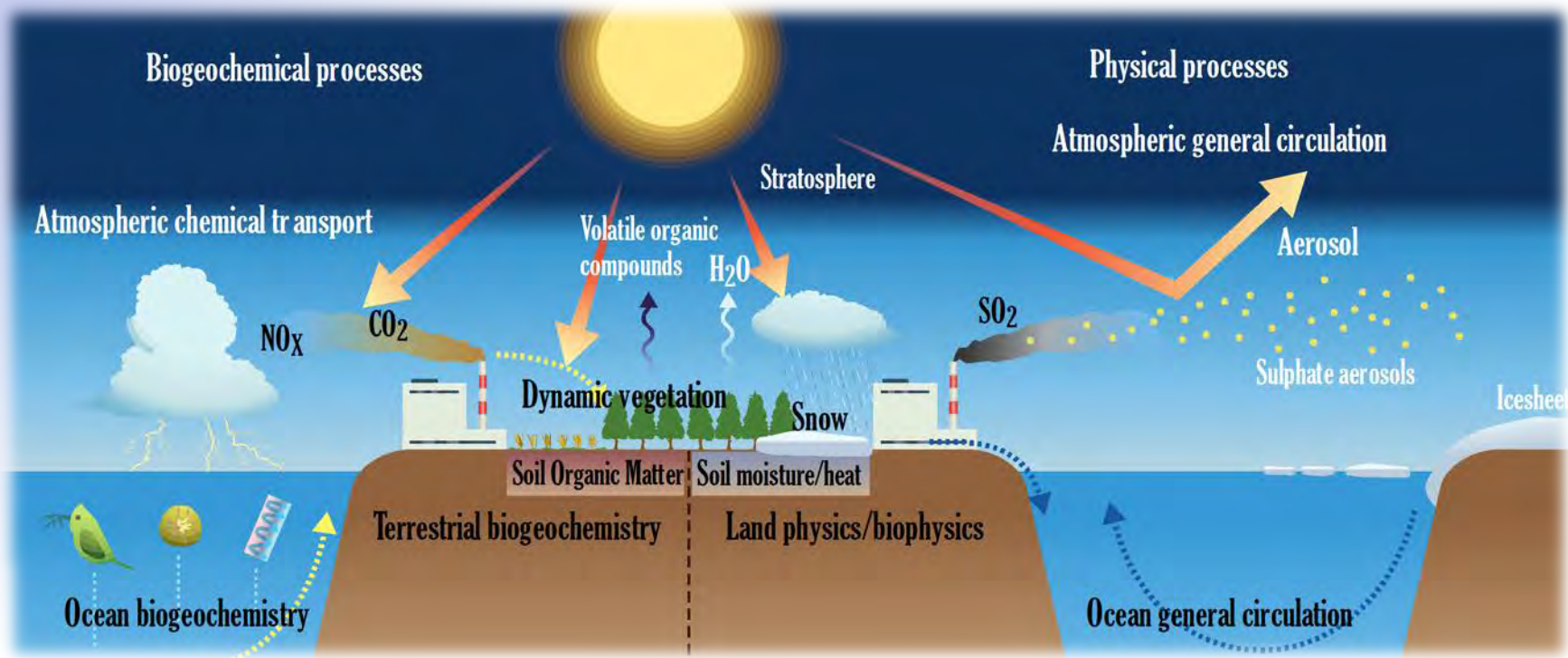


Development of the marine ecosystem model OECO2
to be embedded into the Earth system model
MIROC-ES2

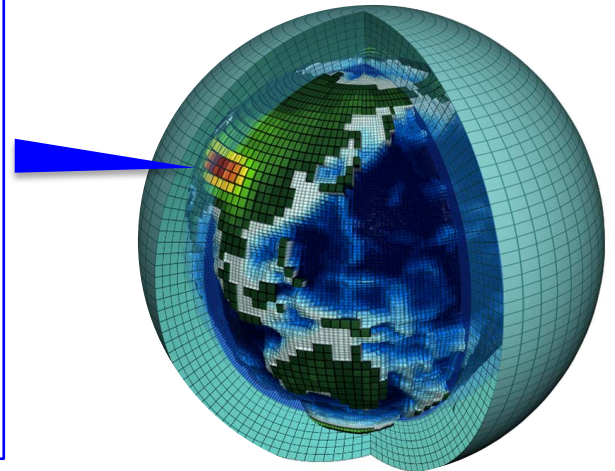
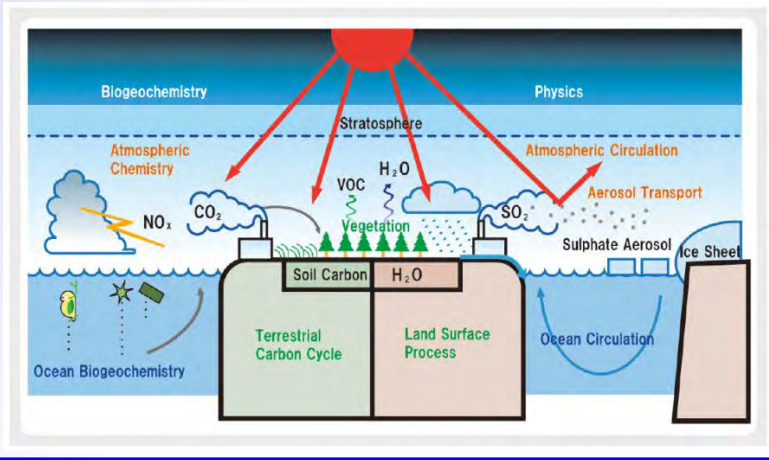
Michio Watanabe, Maki Noguchi-Aita,
Tomohiro Hajima, and Akitomo Yamamoto
(JAMSTEC, Japan)
michiow@jamstec.go.jp



Earth System Model: MIROC-ESM / MIROC-ES2

MIROC-ESM/-ES2 involves water circulation, biogeochemistry, and ecosystem in the ocean

Earth System Model



Earth System Model MIROC-ESM

- Thermal energy
- Hydrologic cycle
- Carbon Cycle

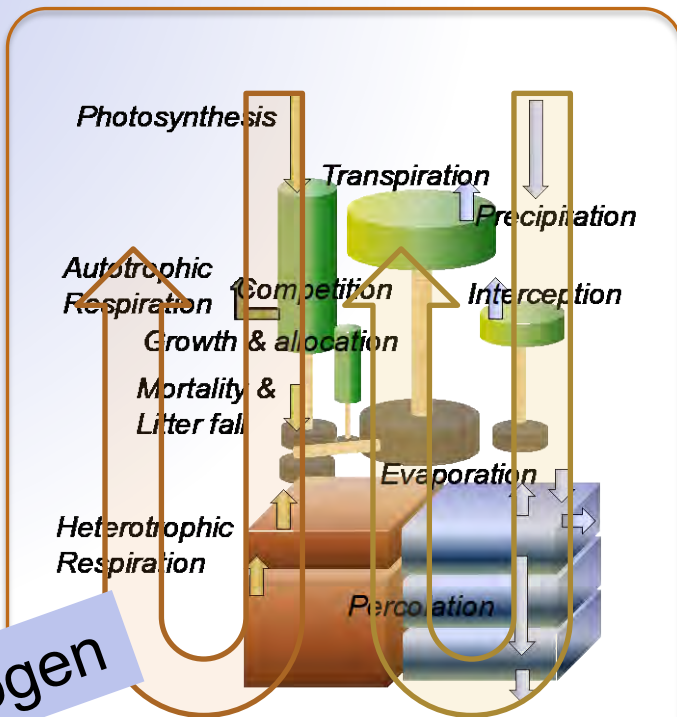
Physical Climate System Model **MIROC**
(Atmosphere – Ocean – Sea Ice – Land)

Marine / Terrestrial biogeochemical model
(Carbon & Nitrogen cycle)

CMIP5 version

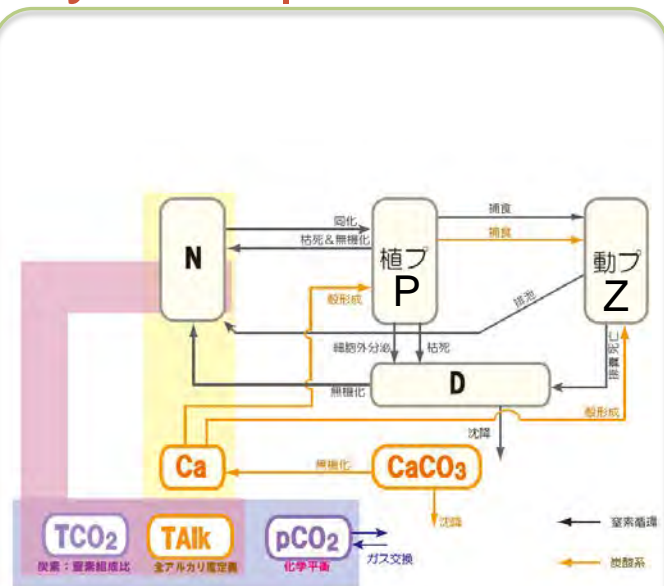
MARINE ECOSYSTEM MODEL: OECO1 (CMIP5 VERSION)

Terrestrial and Marine Ecosystem | CMIP5 Version



Terrestrial Ecosystem Model

- SEIB-DGVM (Sato et al. 2007, Ecol. Model)
- Carbon & Hydrological Cycle



Marine Ecosystem Model

- NPZD type
- Nitrogen cycle & Carbonate ion

An Earth-system perspective of the global nitrogen cycle

Nicolas Gruber & James N. Galloway

With humans having an increasing impact on the planet, the interactions between the nitrogen cycle, the carbon cycle and climate are expected to become an increasingly important determinant of the Earth system.

Anthropogenic

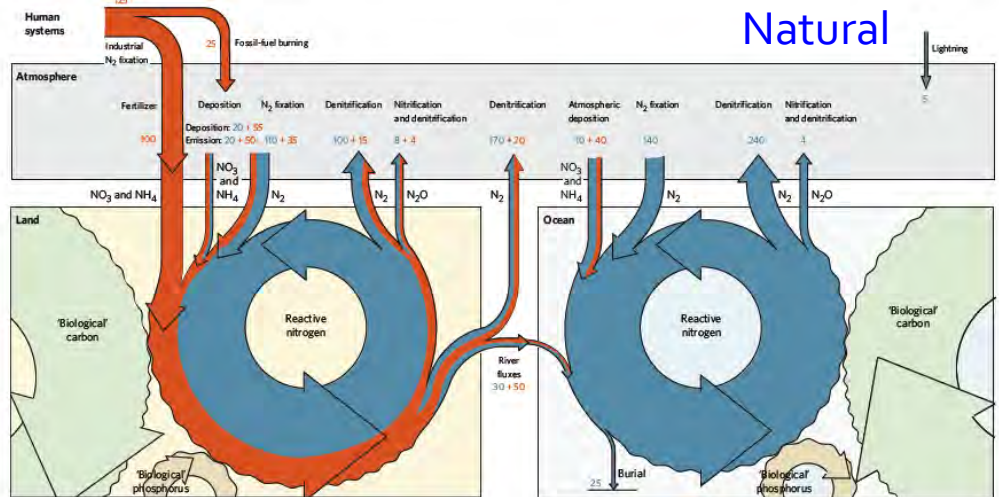
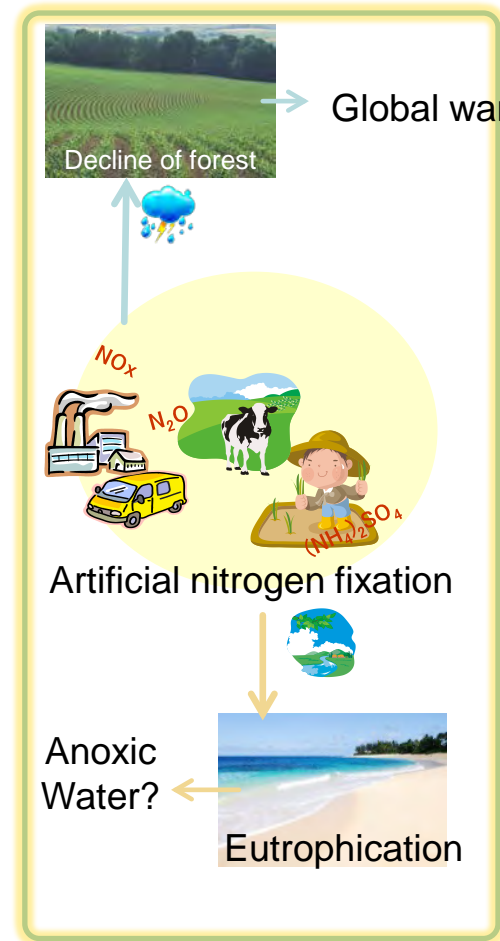


Figure 1 | Depiction of the global nitrogen cycle on land and in the ocean. Major processes that transform molecular nitrogen into reactive nitrogen, and back, are shown. Also shown is the tight coupling between the nitrogen cycles on land and in the ocean with those of carbon and

phosphorus. Blue fluxes denote 'natural' (unperturbed) fluxes; orange fluxes denote anthropogenic perturbation. The numbers (in Tg N per year) are values for the 1990s (refs 13, 21). Few of these flux estimates are known to better than ±20%, and many have uncertainties of ±50% and larger^{13,21}.



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In CMIP5 version

➔ nitrogen flow (Human impact)
 ➔ nitrogen flow (natural)

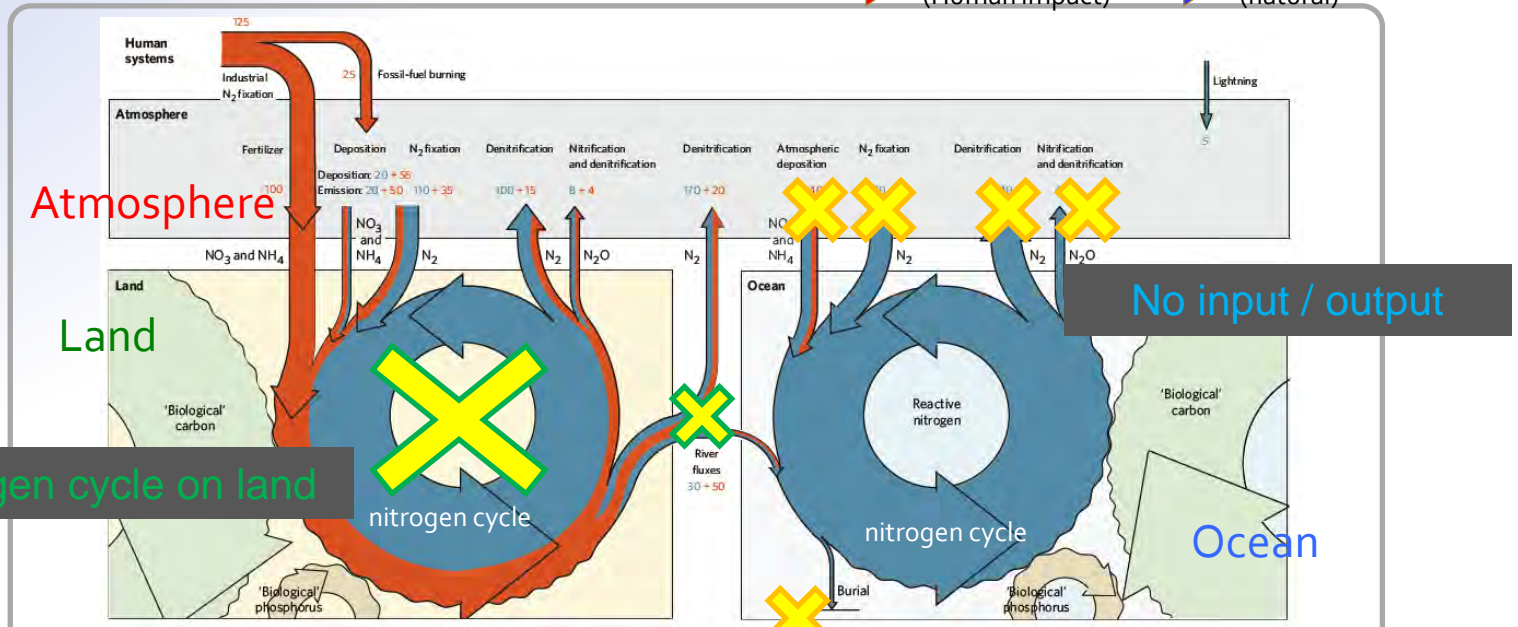
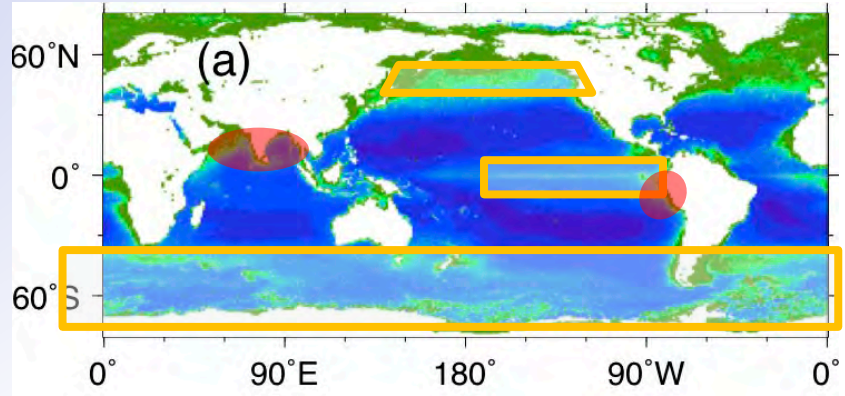


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Annual mean of Chlorophyll-a at sea surface

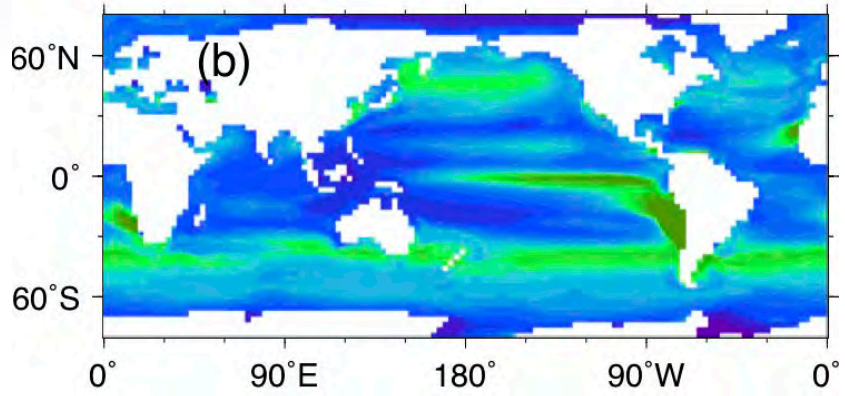
SeaWiFS



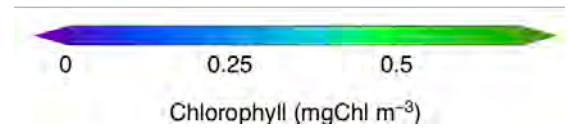
Anoxic regions

HNLC

Model

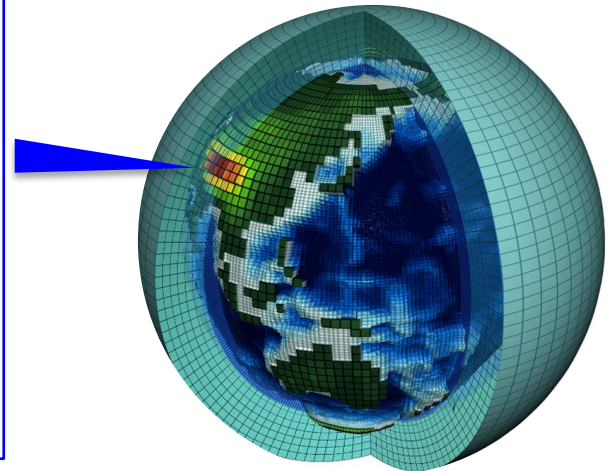
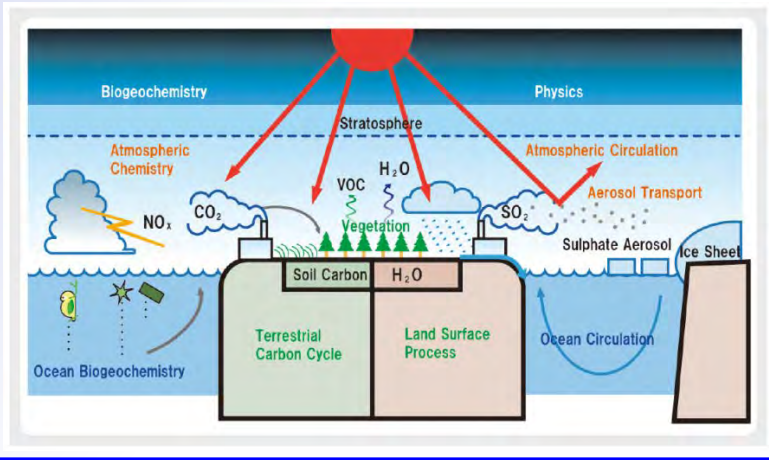


In CMIP5 version
No Fe cycle



MARINE ECOSYSTEM MODEL: OECO2 (CMIP6 VERSION)

Earth System Model



Earth System Model MIROC-ES2

Physical Climate System Model MIROC
(Atmosphere – Ocean – Sea Ice – Land)

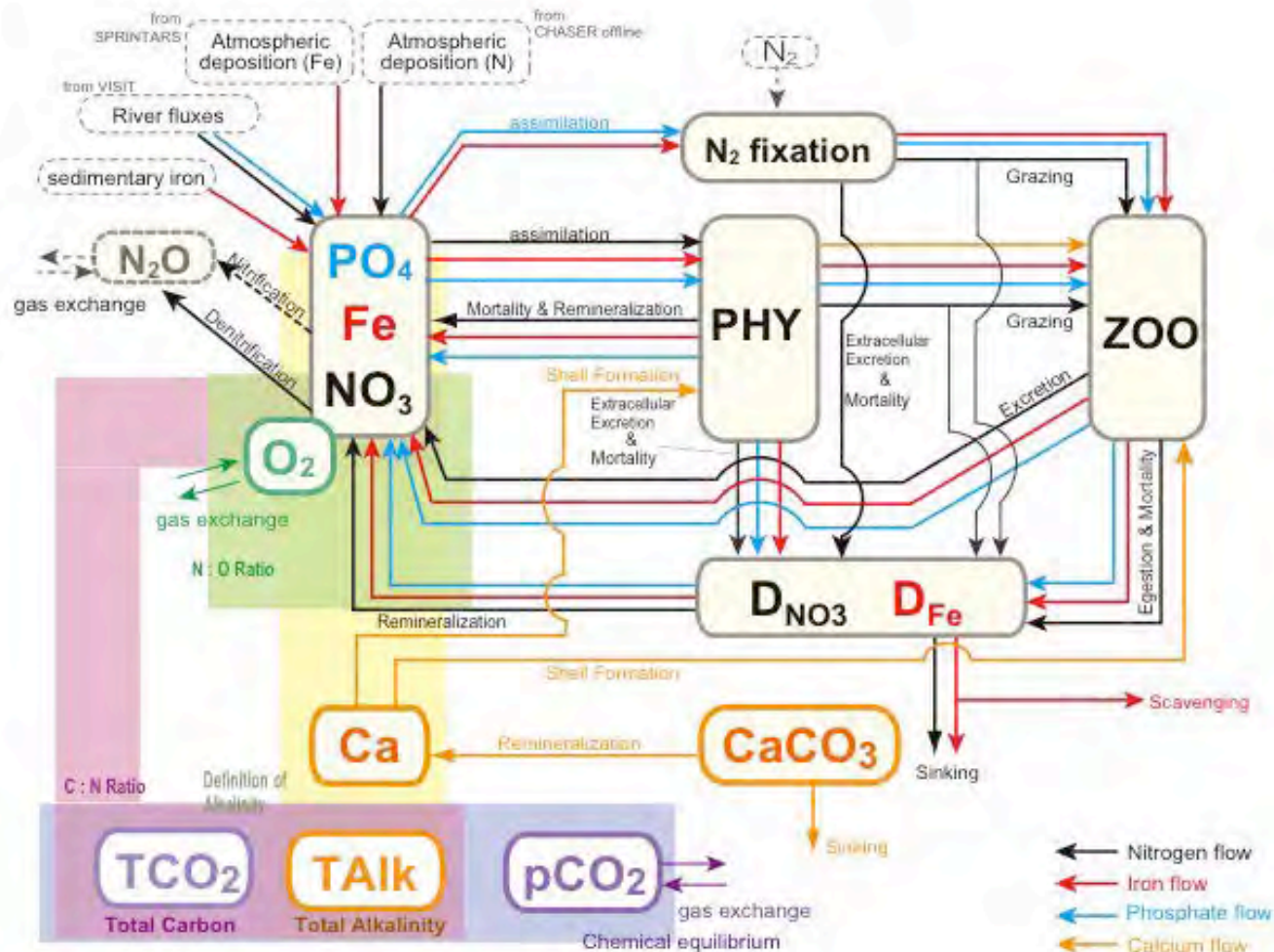
Marine / Terrestrial biogeochemical model
about Carbon & Nitrogen cycle

- Thermal energy
- Hydrologic cycle
- Carbon Cycle
- Nitrogen Cycle
- Iron Cycle
- Oxygen Cycle

NEW!

OECO2

Ocean Ecosystem Component for MIROC Version 2



Fe input

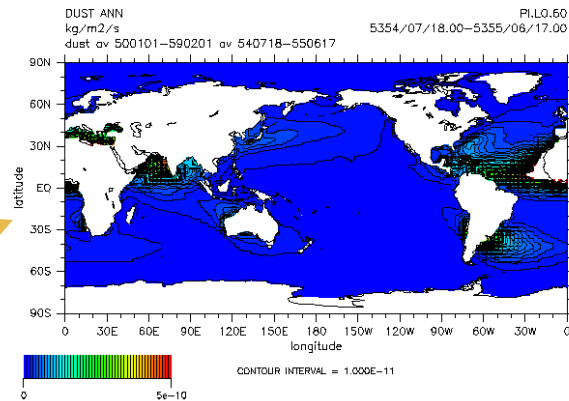
Aeolian dust input from land

total iron input to the oceans

ave. 3.5%

(Duce & Tindall 1991; Zhu et al., 1997)

MIROC-ES2 output



Hydrothermal iron flux

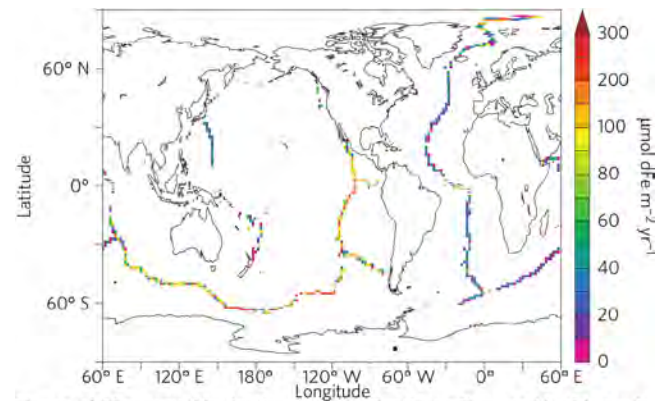
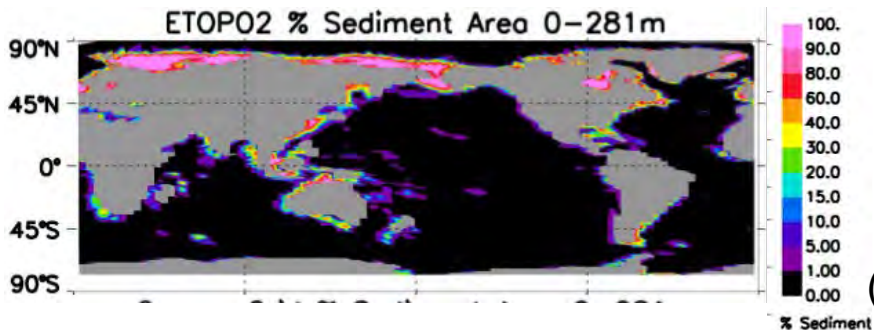


Figure 1 | The annual hydrothermal dissolved iron flux used in this study (hydrofe). The spatial variability reflects different ridge-spreading rates.

Sediment

From continental shelf

($2 \mu\text{mol Fe m}^{-2} \text{ day}^{-1}$)



(Moore and Broucher, 2008)

(Tagliabue et al., 2010)

Output of MIROC-ES2

NO_3
[mmol m^{-3}]

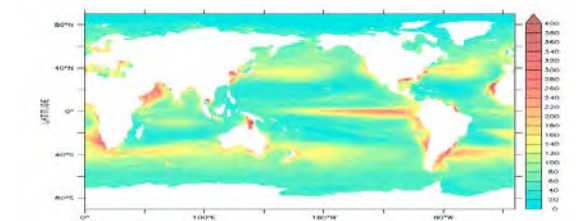
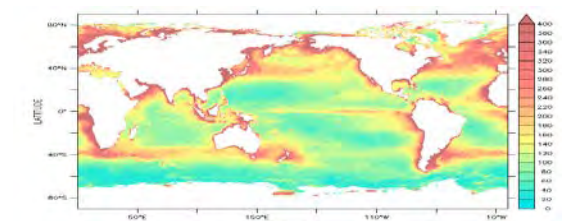
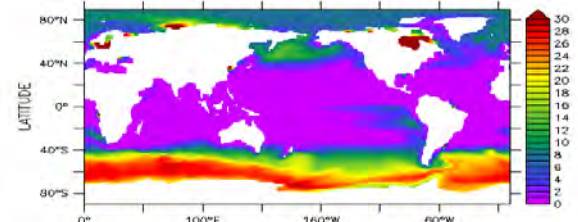
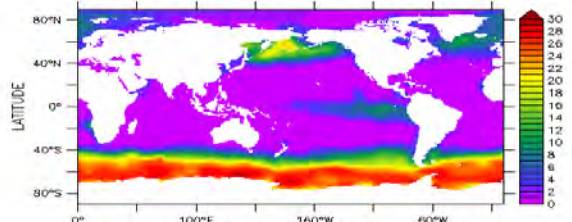
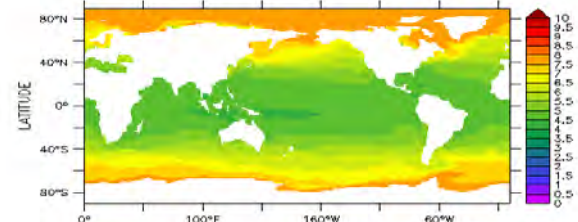
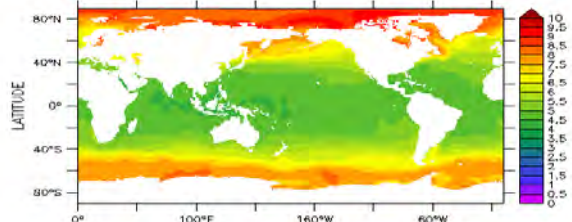
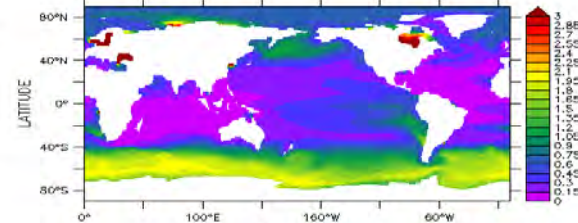
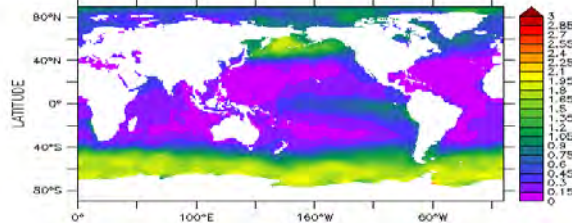
O_2
[ml l^{-1}]

PO_4
[mmol m^{-3}]

Ocean
NPP
[$\text{gC m}^{-2} \text{yr}^{-1}$]

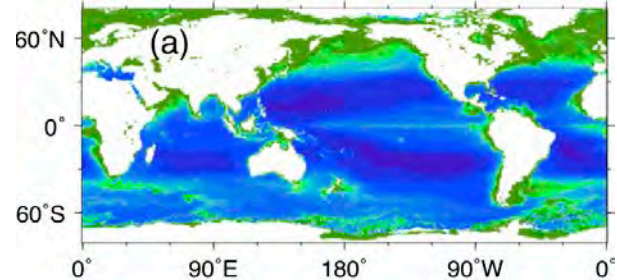
OBS.
(Seawifs for chl., WOA for others)

MIROC-ES2

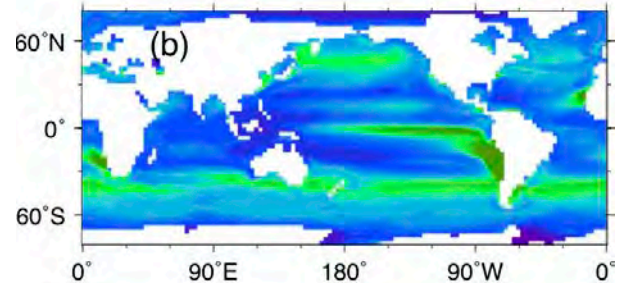


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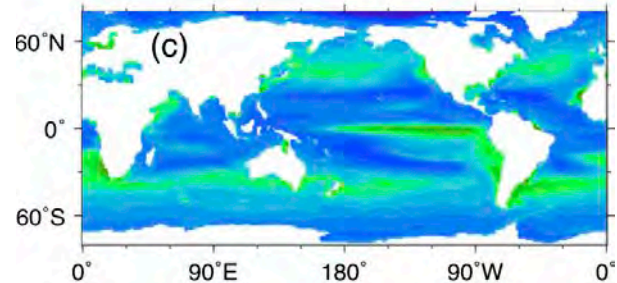
SeaWiFS



Model
(CMIP5 ver)



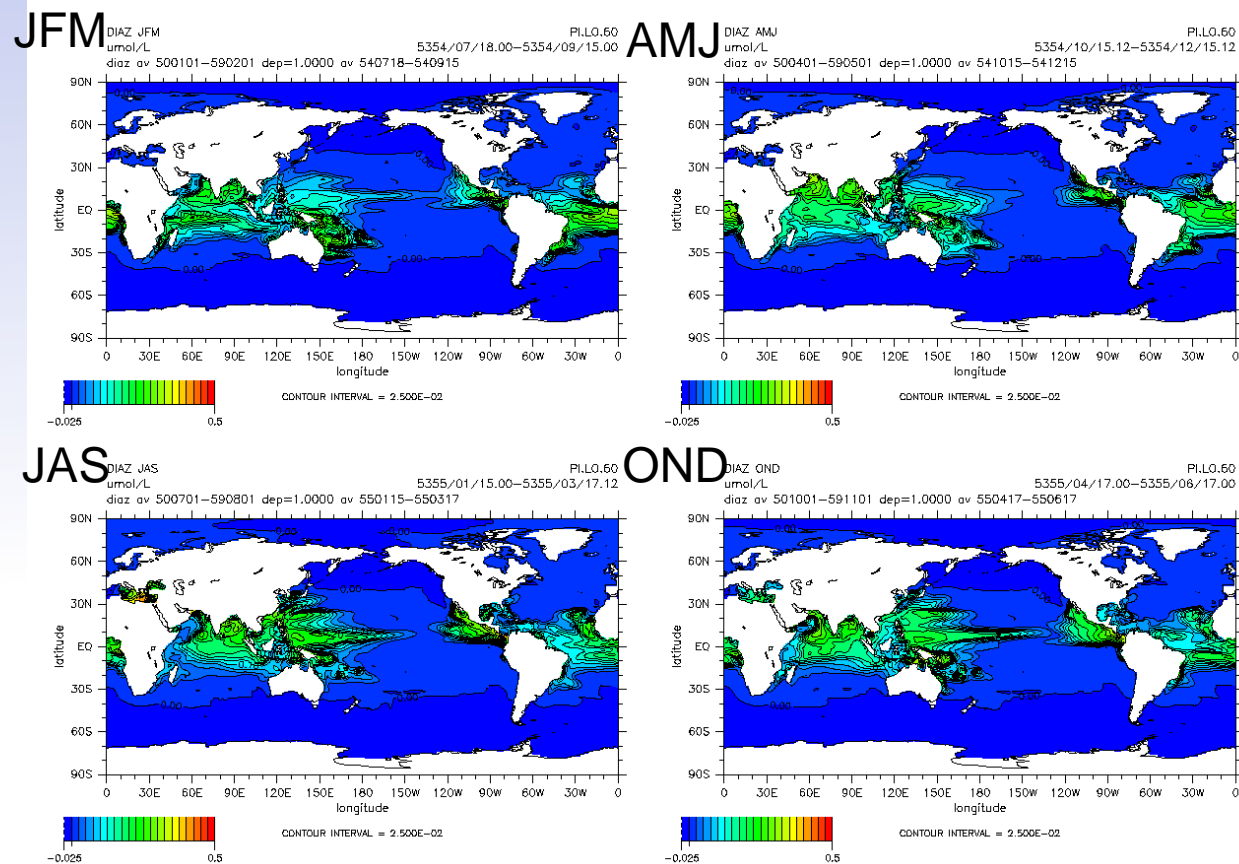
Model
(CMIP6 ver)



Chlorophyll (mgChl m⁻³)

(Watanabe et al., 2017)

N2 fixation: diazotroph



Diaz. works in low NO3 concentration waters

O2 distribution

MIROC-ES2

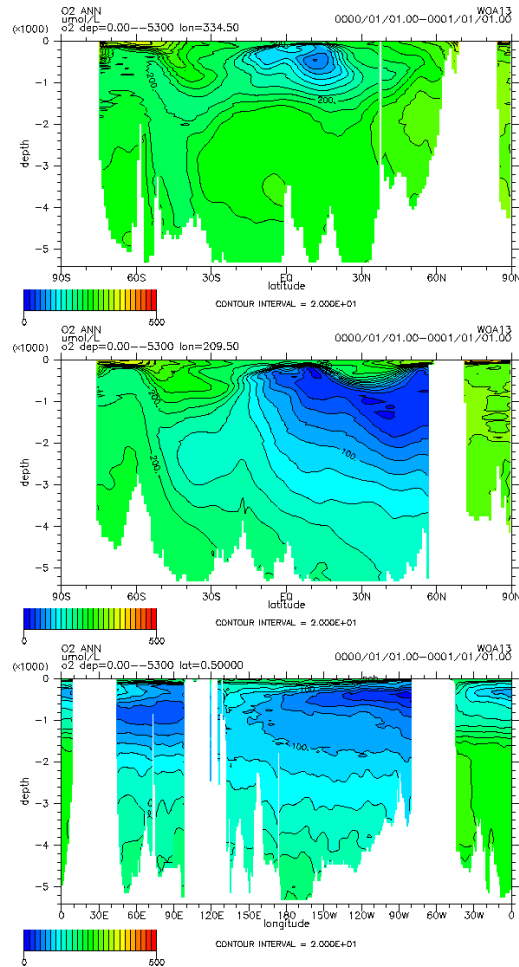
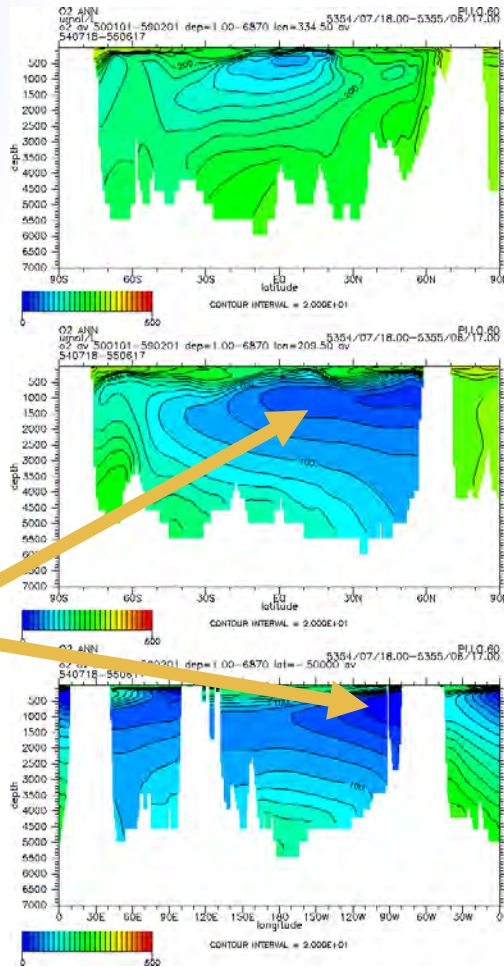
WOA13

25W

150W

anoxic water

EQ

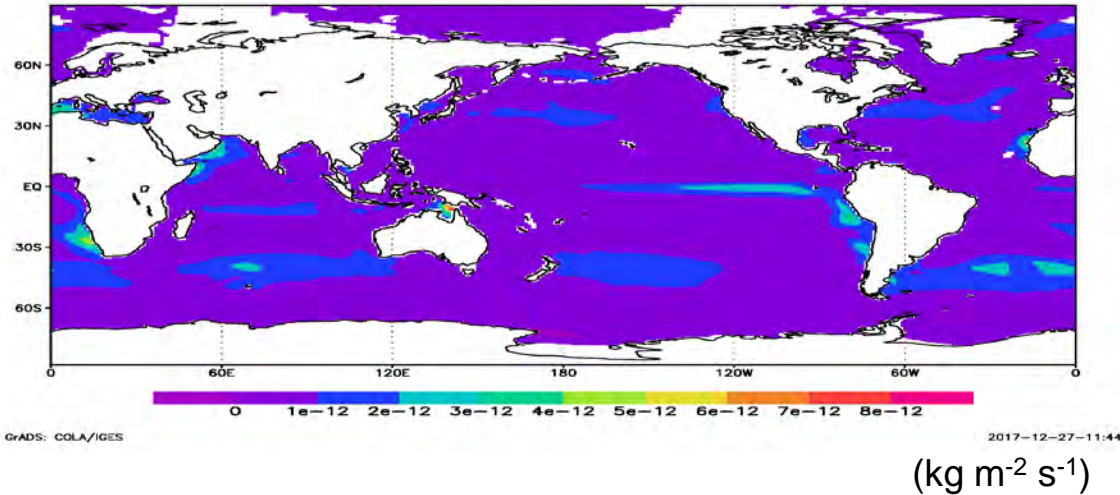


N₂O emission | offline model

Multiple GHGs projections

- N₂O

Air-sea N₂O flux (offline model)



The coupler is under construction

Summary

- For CMIP6,
 - Perturbation of global nitrogen cycle
 - Primary production (esp., HNLC region)
 - Iron cycle
 - Anoxic water
 - O₂ cycle
- OECO₂ (Ocean ecosystem component for MIROC, ver. 2)
 - Nitrogen cycle + Carbon, Fe, PO₄, O₂
 - Nitrogen cycle
 - River input
 - Atmospheric deposition
 - N₂ fixation and denitrification
 - Iron cycle
 - Atmospheric deposition
 - Sediment
 - Hydrothermal flux
- We would like to evaluate the impact of these input on each geochemical tracer cycle and on climate
- We are happy if you use output data of MIROC-ES2