

Global impact of benthic denitrification on phytoplankton physiology and N₂ fixation rates in an optimality-based model

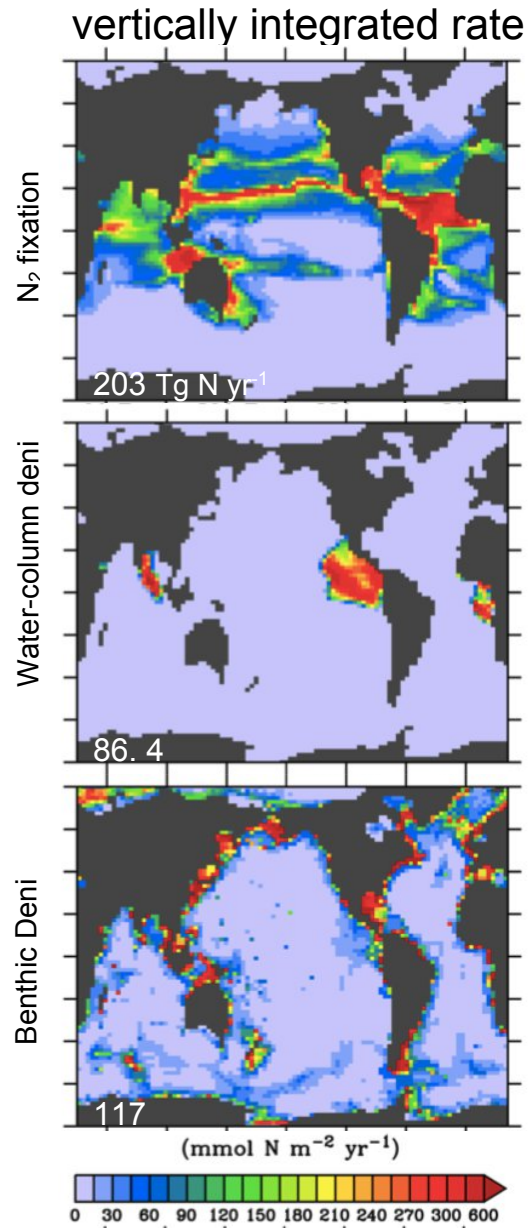
Na Li, Christopher J. Somes, Angela Landolfi, Chia-Te Chien,
Markus Pahlow, Andreas Oschlies

Marine Biogeochemical Modelling
GEOMAR Helmholtz Centre for Ocean Research Kiel

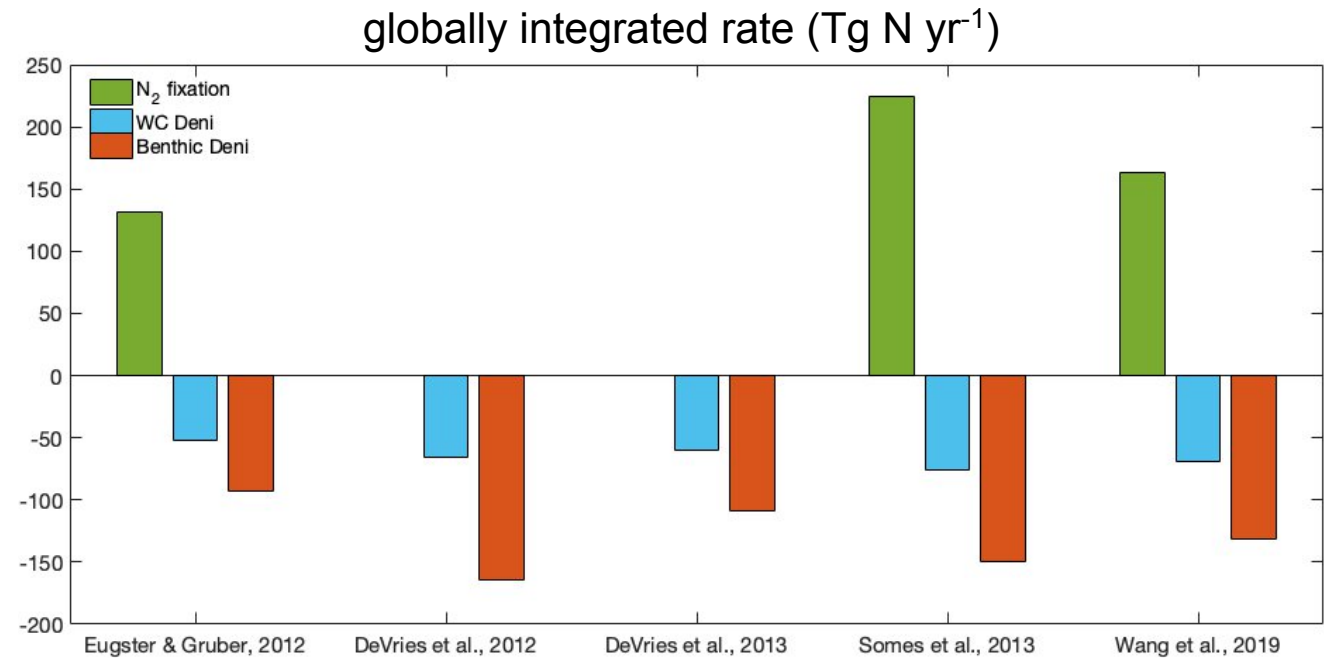
May 23-27, 2022



Motivation - Nitrogen fixation and Denitrification



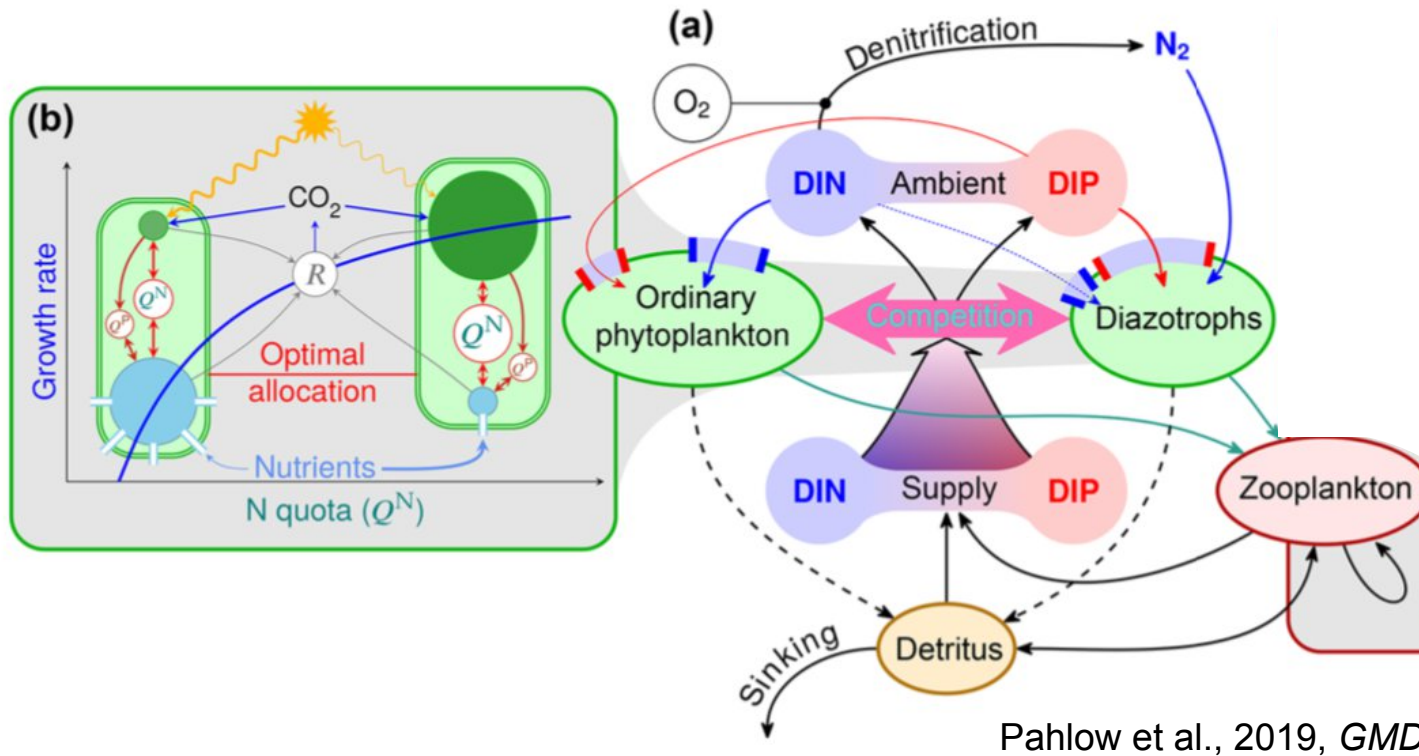
Somes et al., 2013, BG



- Nitrogen cycle, phytoplankton growth, biological carbon pump, climate change
- The globally integrated rate of *Benthic Deni* is higher than that of *WC Deni*, indicating a greater importance.

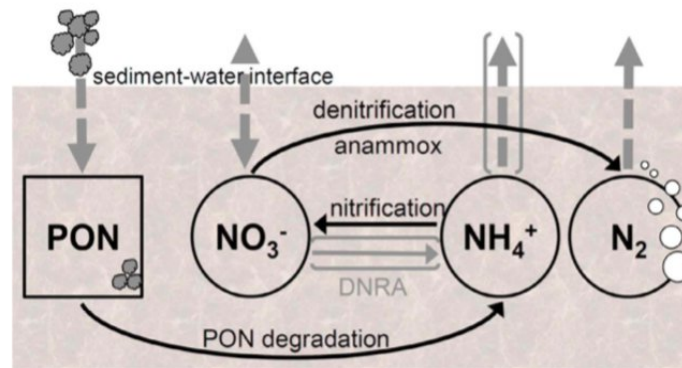
→ how does benthic denitrification influence phytoplankton physiology and N_2 fixation rates?

Method - Optimality-based Variable Stoichiometry Model



Pahlow et al., 2019, *GMD*

- variable C:N:P in **phytoplankton**, **N₂-fixing diazotroph** and **detritus POM**
- now implement benthic denitrification

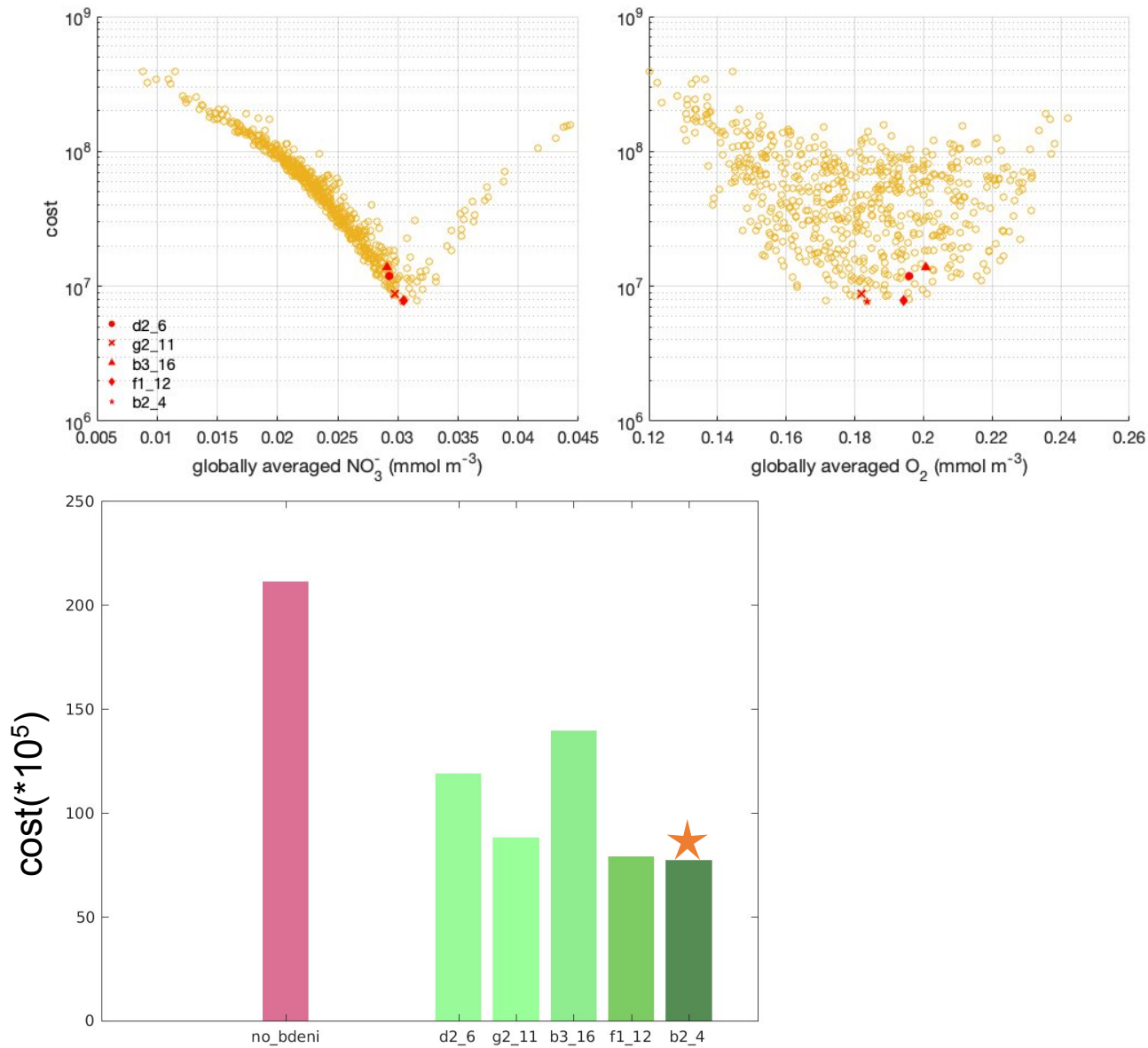


Bohlen et al., 2012, *GBC*
Somes and Oschlies, 2015, *GBC*

$$BenDen = \left(a + b \times c^{(O_2 - NO_3)_{bw}} \right) \times RRPOC$$

- a, b, c are constants
- rain rate of particulate organic carbon ($RRPOC$)

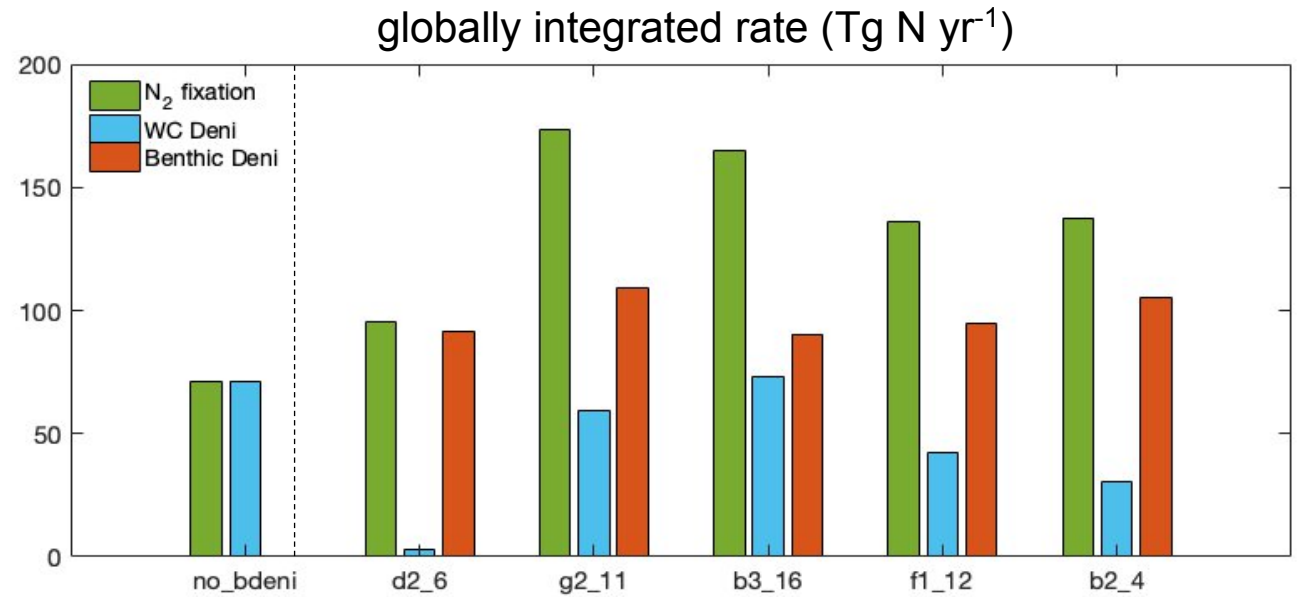
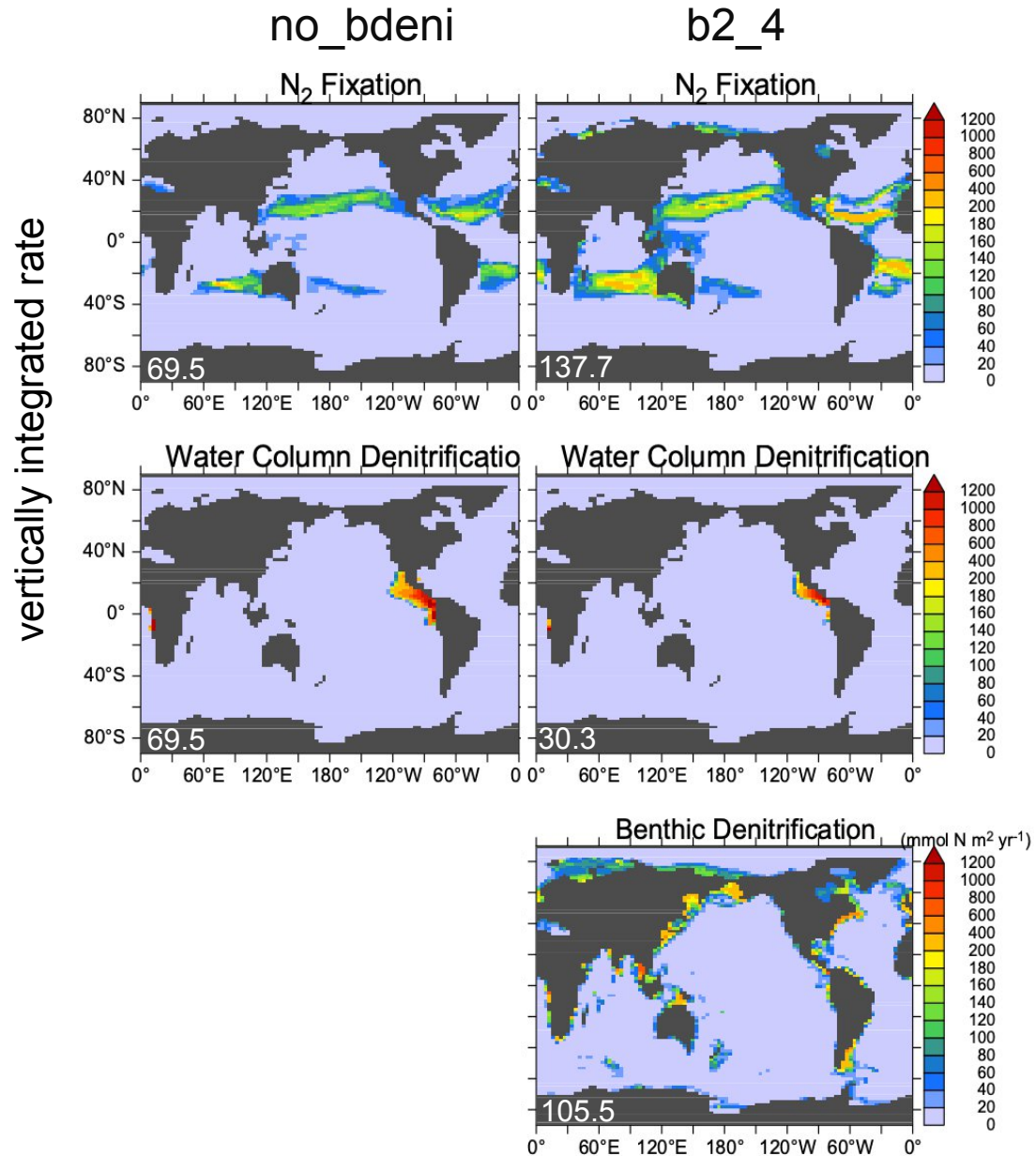
Calibration - optimize parameters and cost function



- 600 ensemble simulations with different parameter combinations
- $\text{cost}(\text{O}_2, \text{N}^*, \text{PO}_4^{3-}, \text{Chla})$
- $\text{N}^* = \text{NO}_3^- - 16\text{PO}_4^{3-}$

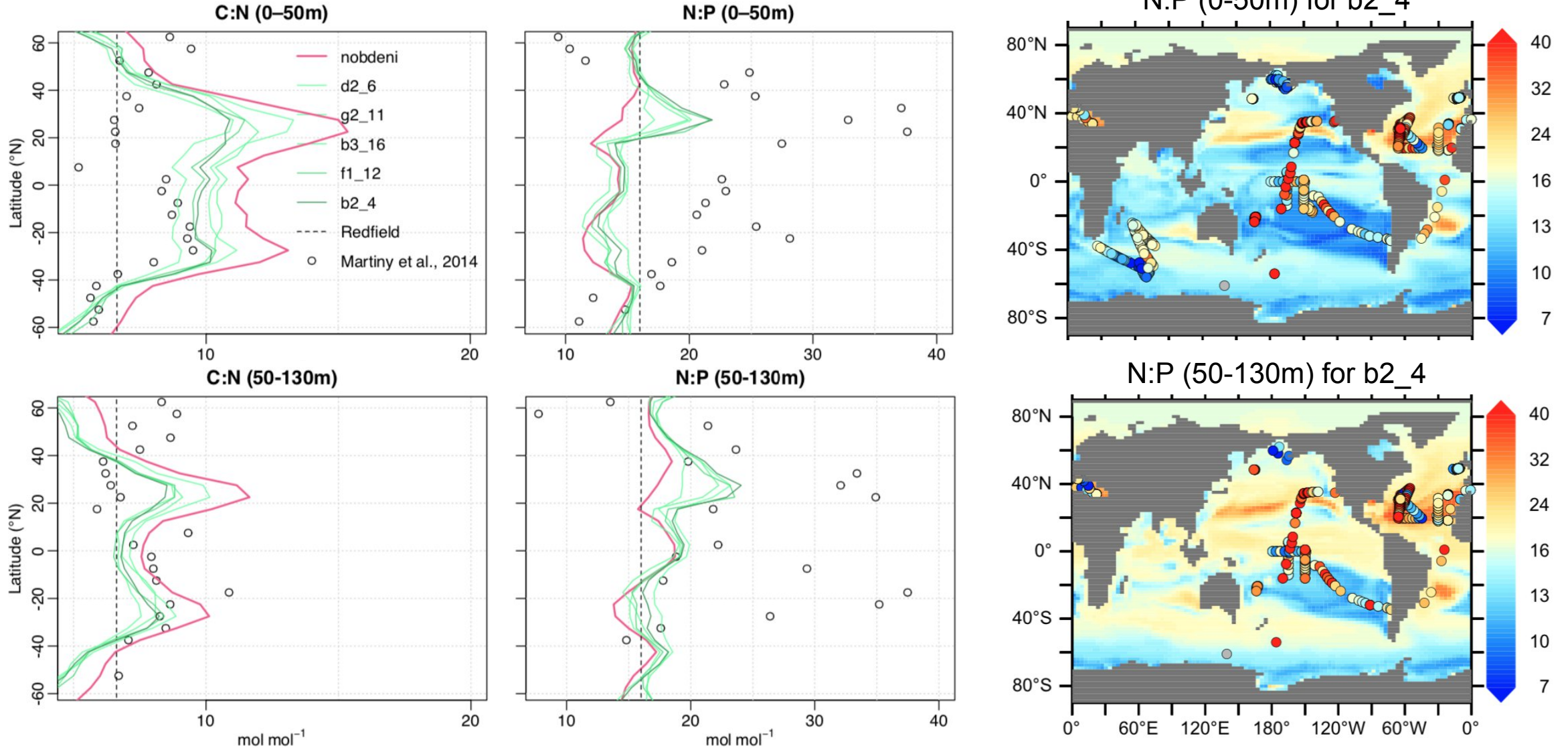
- 5 simulations with benthic denitrification

Results - Water-column Deni. and Benthic Deni.



- N₂ fixation is higher among simulations incorporated with benthic denitrification
- *WC Deni* shows a higher variability and lower rates relative to *Benthic Deni*

Results - Latitudinal patterns of particulate C:N:P ratios



- simulations with benthic denitrification better reproduce particulate C:N and C:P ratios

Conclusions

- Improves N_2 fixation and N^* .
- Particulate C:N and N:P is better reproduced, particularly latitudinal patterns of particulate C:N and N:P.
- Benthic denitrification plays an important role shaping N_2 fixation throughout the global ocean and should be considered when understanding and predicting changes to N_2 fixation.