Drivers of future changes in export production a model comparison

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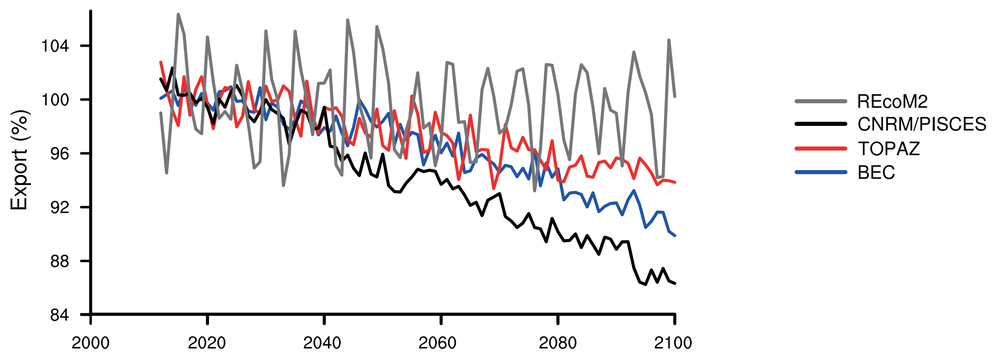
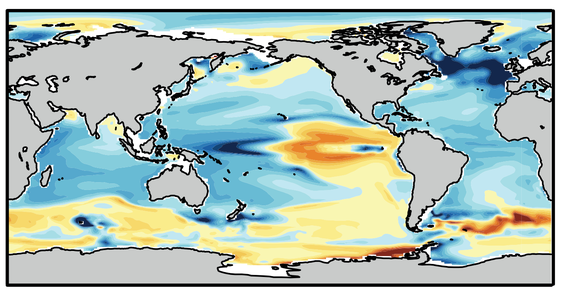
Introduction

Future changes in marine particle export production (EP) and their drivers are currently not well understood. Here we compare future projections of four different marine ecosystem models under IPCC's high emission scenario RCP8.5 over the 21st century with respect to changes in EP and export efficiency.

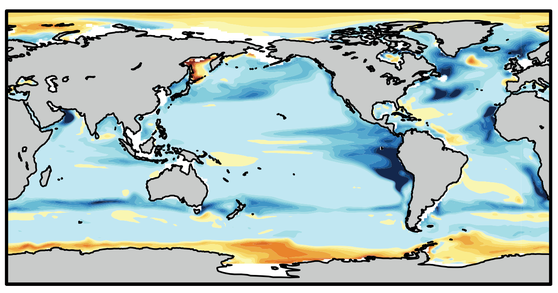
Models suggest decreases in global EP between -1 and -12%:



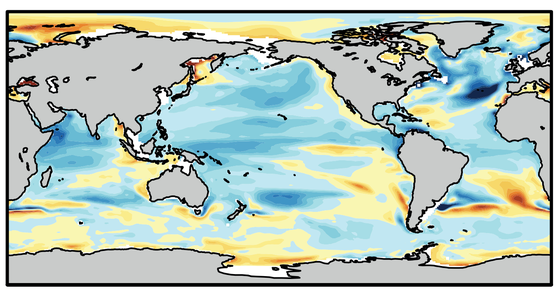
BEC



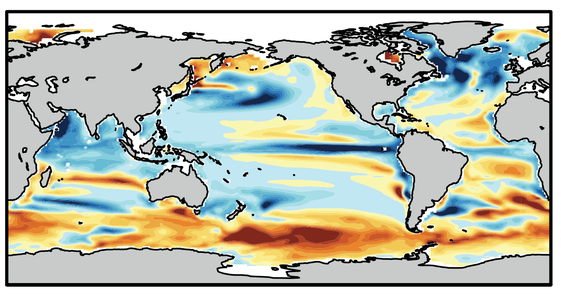
PISCES



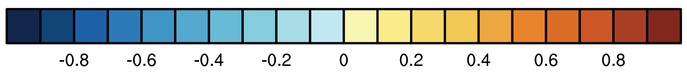
TOPAZ



REcoM2

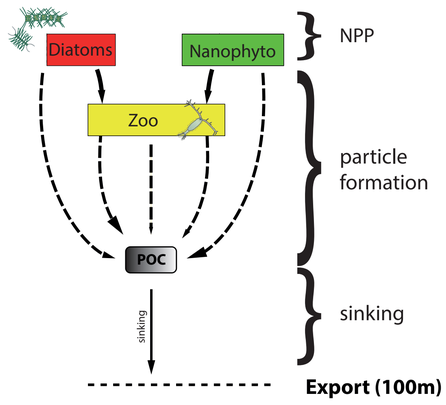


Regional changes [mol C m-2 yr-1]



Differences in future EP drivers

Division of EP drivers into
NPP, particle formation and particle sinking:



To understand **why EP is changing, we first divide it into the effects of NPP and e-ratio:**

EP = NPP * e-ratio

And then further divide the e-ratio into the effect of particle formation processes (f-ratio) and the effect of sinking processes (s-ratio):

e-ratio = f-ratio * s-ratio

The f-ratio describes the fraction of NPP that is formed into particles:

f-ratio = particle formation / NPP

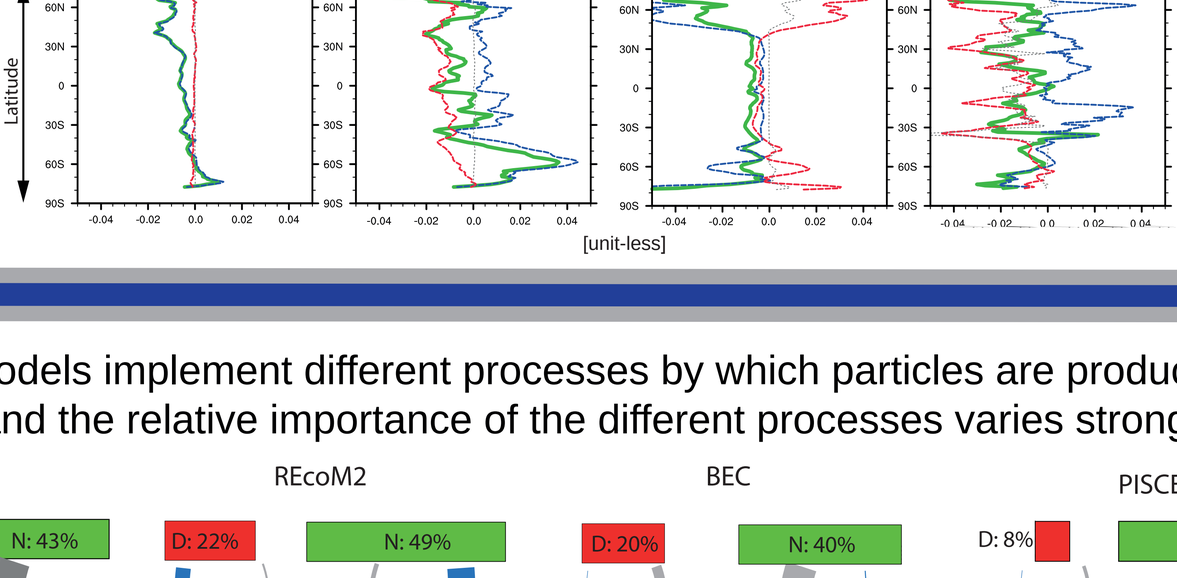
The s-ratio describes the fraction of particles that sink through the 100m depth level:

s-ratio = EP/particle formation

Different relative importance of changes in NPP and e-ratio for changes in EP:

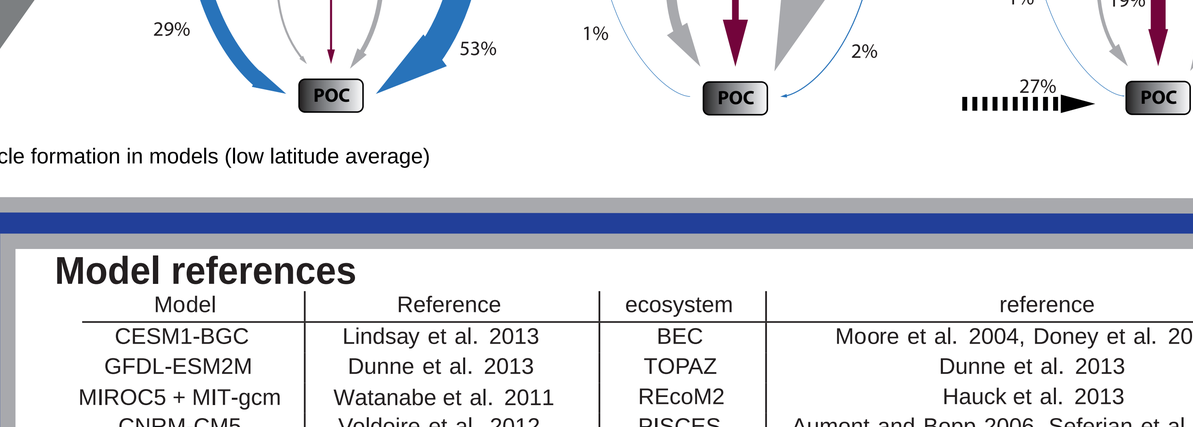
Taylor expansion of EP changes:

$$\frac{\delta EP}{\delta t} = \frac{\delta\ NPP}{\delta t} \times \text{e-ratio} + \frac{\delta\ \text{e-ratio}}{\delta t} \times NPP + \text{Residual}$$



Models do not agree if more or less particles will be formed relative to NPP, but most models agree on more intense remineralization in future:

$$\frac{\delta\text{e-ratio}}{\delta t} = \frac{\delta\ \text{f-ratio}}{\delta t} \times \text{s-ratio} + \frac{\delta\ \text{s-ratio}}{\delta t} \times \text{f-ratio} + \text{Residual}$$



Present-day differences

Boxes: Biomass structure
(in % of total biomass)

Diatoms

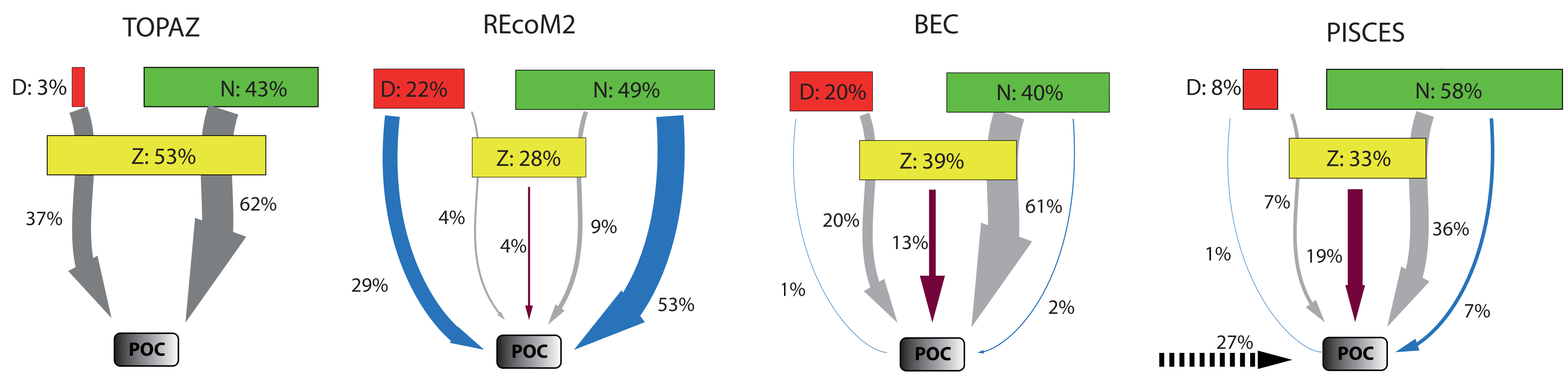
Nanophyto

Zoo

Arrows: Particle formation processes
(in % of total particle formation)

- POC production during grazing
- POC production via zooplankton mortality
- POC production via phytoplankton mortality and/or aggregation
- Aggregation of DOC

Models implement different processes by which particles are produced and the relative importance of the different processes varies strongly:



Present particle formation in models (low latitude average)

Acknowledgements

We thank all data providers of the CMIP5 and MAREMIP project for kindly providing the data. In particular we thank Olivier Aumont, Roland Seferian and Christoph Völker for their assistance in understanding model equations and the recalculation of limitation factors.
C. Laufkoetter thanks the European Union for financial support for this work through contract number FP7-PEOPLE-ITN-2008 238366 (Greencycles II).

Model references

Model	Reference	ecosystem	reference
CESM1-BGC	Lindsay et al. 2013	BEC	Moore et al. 2004, Doney et al. 2007
GFDL-ESM2M	Dunne et al. 2013	TOPAZ	Dunne et al. 2013
MIROC5 + MIT-gcm	Watanabe et al. 2011	REcoM2	Hauck et al. 2013
CNRM-CM5	Voldoire et al. 2012	PISCES	Aumont and Bopp 2006, Seferian et al. 2013