Iron supply to the Southern Ocean mixed layer from below: The ocean model effect

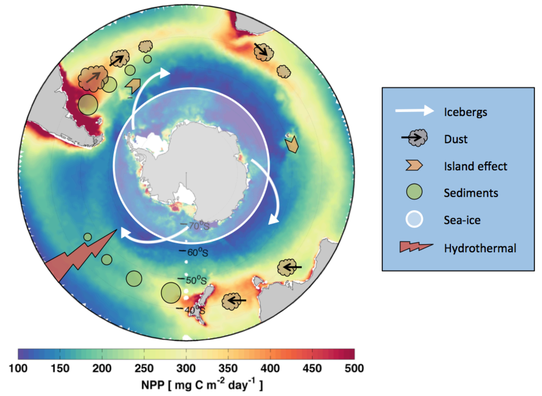
Vibe Schourup-Kristensen, Judith Hauck, Dieter Wolf-Gladrow and Christoph Völker

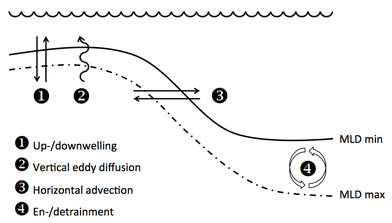
Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, 27570 Bremerhaven, Vibe.Schourup-Kristensen@awi.de

1. Introduction

The representation of net primary and export production in the iron limited Southern Ocean differs greatly between ocean general circulation biogeochemical models (OGCBMs).

Studies regarding iron supply to the surface mixed layer of the Southern Ocean have traditionally focussed on the input from dust, sediment and ice. Recently work however acknowledges the potential important role of the vertical supply, through entrainment, advection, diffusion and eddy mediated transport. For these processes, the physics of the ocean as well as the relative position of the MLD and the ferricline is important.





2. Methods

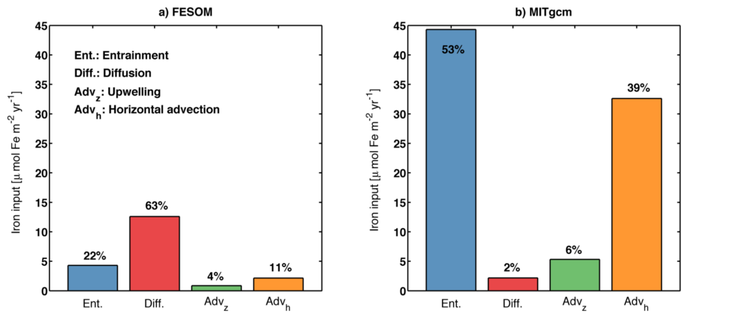
Two similar model runs with the biogeochemical model REcoM2 coupled to the global ocean general circulation models FESOM and MITgcm have been performed.
The flux of iron across the base of the mixed layer in the Southern Ocean was calculated for the two runs and analyzed on a seasonal scale in relation to net primary production in the area.
In the following, the Southern Ocean is defined as the area south of 50°S.

3. Results

Mean influx of iron to mixed layer

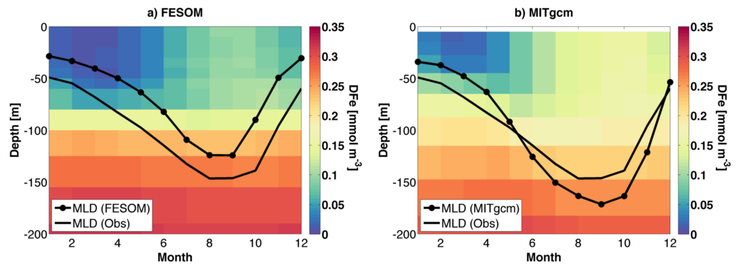
The mean input of iron to the Southern Ocean is on average much larger in the MITgcm than in FESOM.

- Entrainment provides the largest input of iron in MITgcm and diffusion in FESOM.
- In FESOM, the external iron sources are on the same order of magnitude as the input from below, whereas the supply from below by far dominates in the MITgcm.



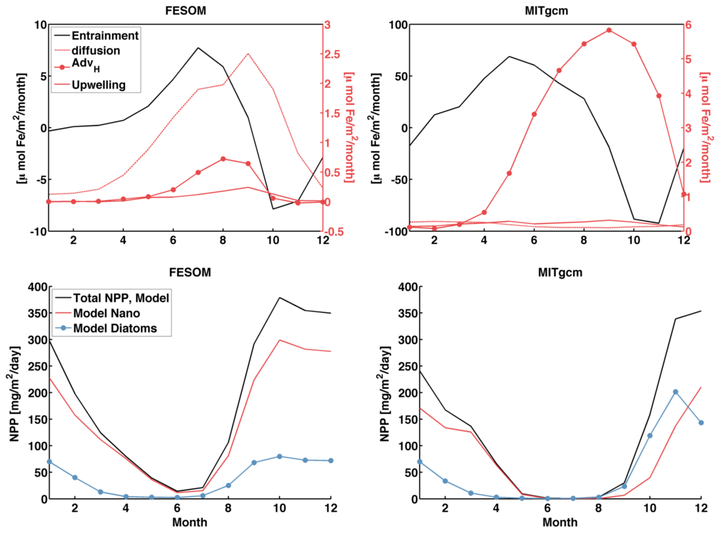
Seasonal cycle of mean iron profile and MLD

- The deeper MLD in MITgcm causes a larger supply of iron to the surface layer as the iron concentration at the base of the mixed layer is higher in this model.
- The large difference between MLD_{min} and MLD_{max} in MITgcm induces a large iron input through entrainment.



Seasonal cycle of NPP and iron input to the mixed layer

- In FESOM, the input of iron rises in June as the iron concentration at the base of the mixed layer increases.
- The input of iron from entrainment dominates the supply in the MITgcm from April to August.
- The higher iron input in MITgcm causes diatoms to dominate production in this model.
- The bloom occurs later in the MITgcm where light limitation dominates over iron limitation.



Total NPP and EP

- The total net primary and export production south of 50°S is highest in FESOM, but they are reasonable in both models.
- Diatoms are much more important in MITgcm, where the iron input is highest.

		FESOM	MITgcm
NPP	$[\mathrm{Pg\,C\,yr^{-1}}]$	3.10	2.1
EP	$[\mathrm{Pg\,C\,yr^{-1}}]$	1.12	0.61
fe-ratio		0.36	0.29

4. Discussion and Conclusion

The current study shows how differences in the ocean circulation and mixing leads to large differences in the vertical iron transport across the base of the mixed layer, both regarding the magnitude and mode of supply. And how it leads to subtle differences in the net primary and export production.

Despite higher surface iron concentrations in MITgcm, the yearly NPP is higher in FESOM. This happens due to dominance of the faster growing nanophytoplankton in FESOM, which also leads to a too early spring bloom.

In both models, the input of iron to the mixed layer from below is significant compared to external sources, implying that the state of the ocean circulation and mixing is important for the total iron supply.

Predictions of future changes in NPP and EP differs greatly between OGCBMs for the Southern Ocean. The current study suggests that part of the explanation lies in differences regarding the modeled ocean circulation and mixing, and the following vertical supply of iron to the mixed layer. Differences in light limitation does, however, also play a role.

Travel support for Vibe Schourup-Kristensen to the EGU General Assembly 2015 was provided by the Helmholtz Graduate School for Polar and Marine Research