The effect of cosmic dust on Southern Ocean biogeochemistry is small but non-negligible

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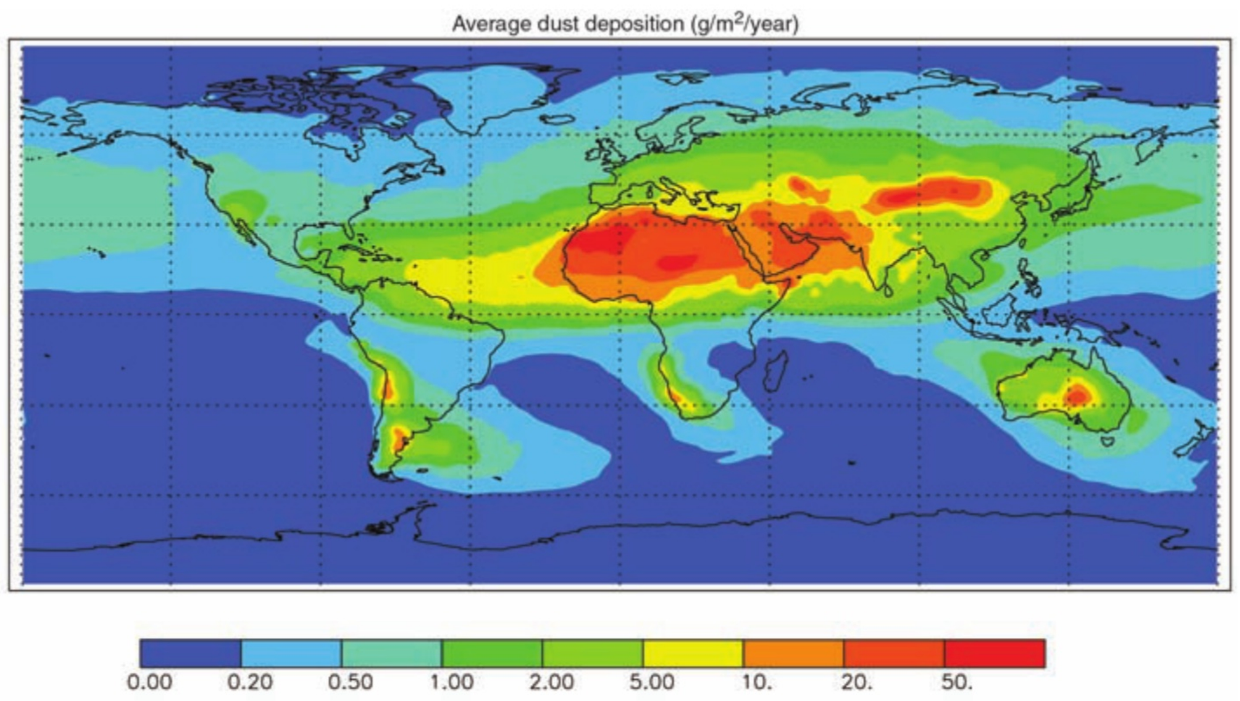
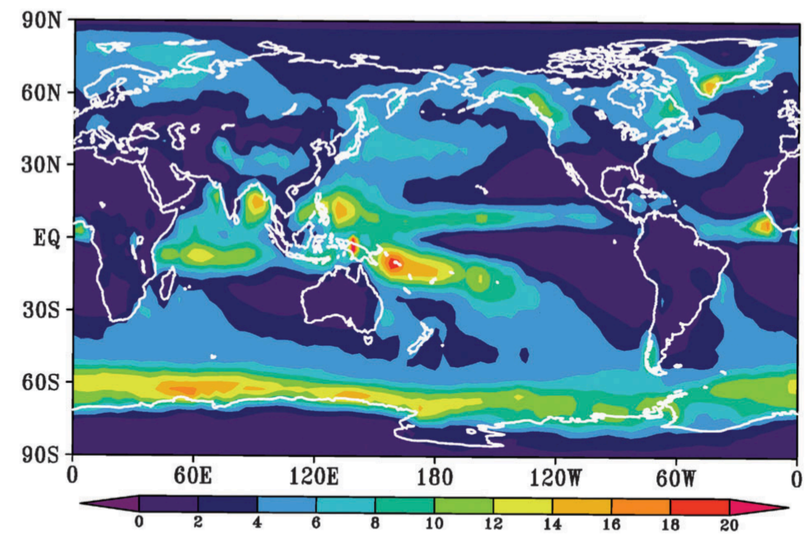
1. Introduction

Dust deposition over the ocean varies over more than five orders of magnitude, with high deposition rates downwind of deserts, but extremely low deposition over the South Pacific and the Southern Ocean. Although total cosmogenic dust deposition is much smaller, it is more evenly distributed and may be an important Fe source in these regions (Johnson, 2001).
We estimated Fe input from a new model climatology of cosmic dust deposition and estimated its effect on marine biogeochemical cycles with global models.



Jickells et al. (2005)

2. Methods

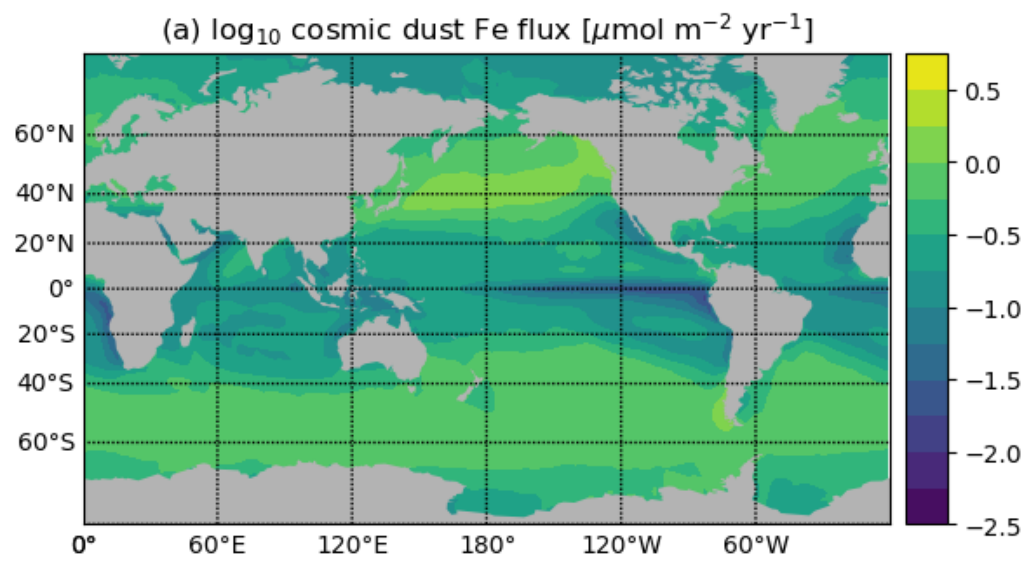


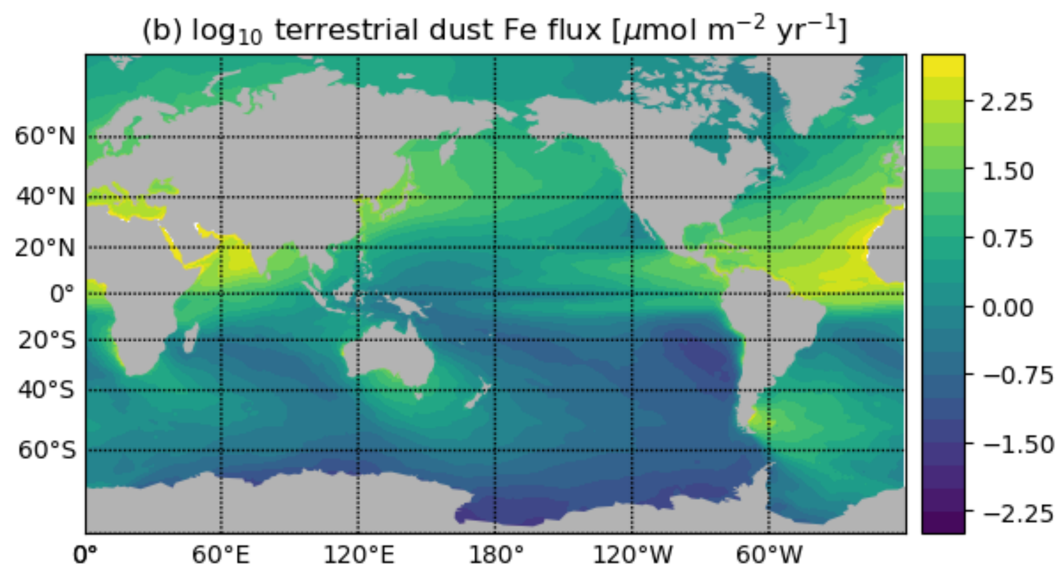
Deposition flux of meteoric smoke particles from the Unified Model, in 10^{-11} g cm^{-2} day^{-1}, Plane (2012)

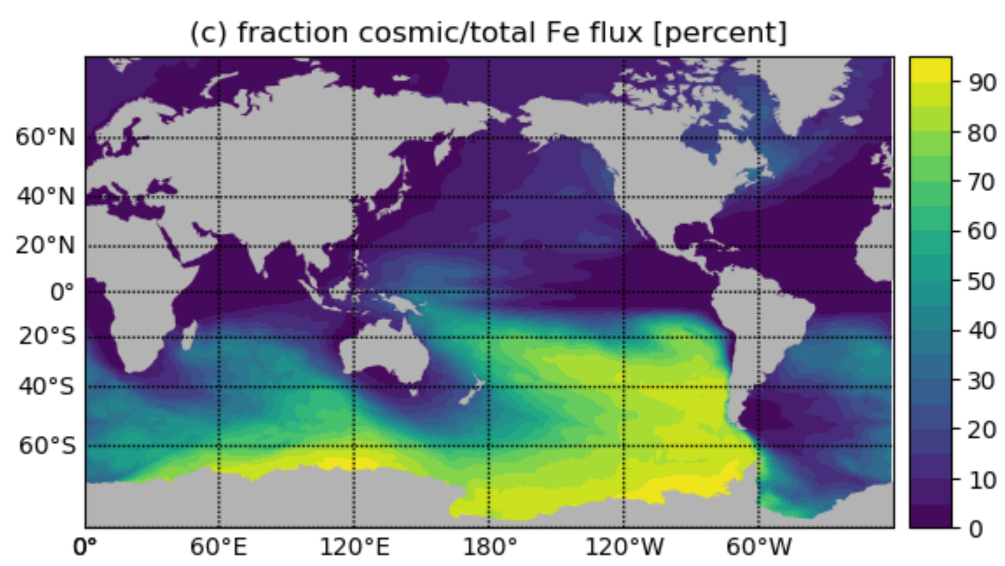
Modeled deposition flux for meteoric smoke particles from Dhomse et al., 2013 was converted to Fe flux and added to lithogenic dust in a global biogeochemical model of the ocean (Ye and Völker, 2017).

3. Results

1) Comparing Fe flux from cosmic and terrestrial dust

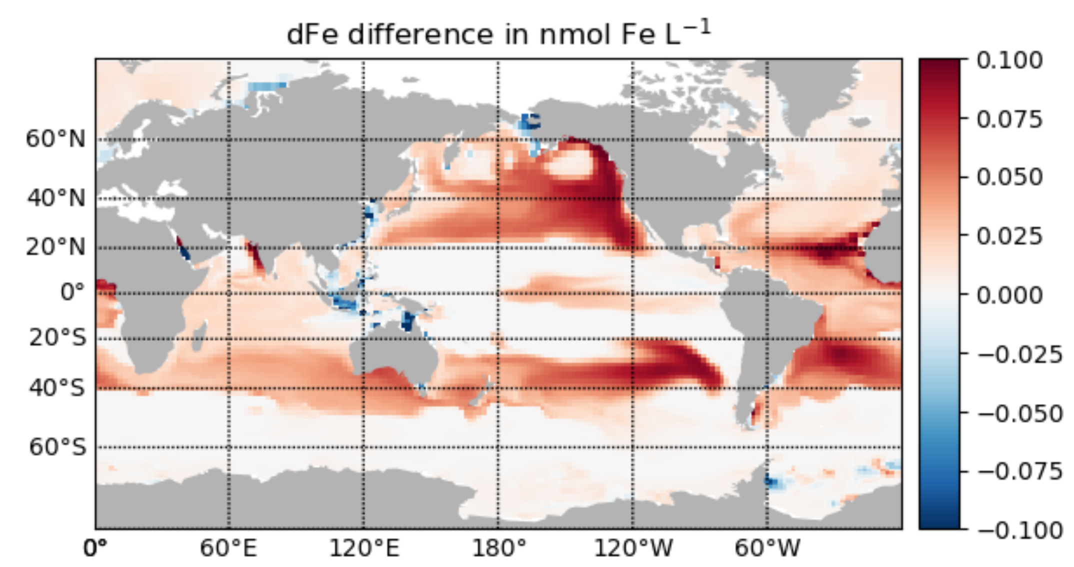






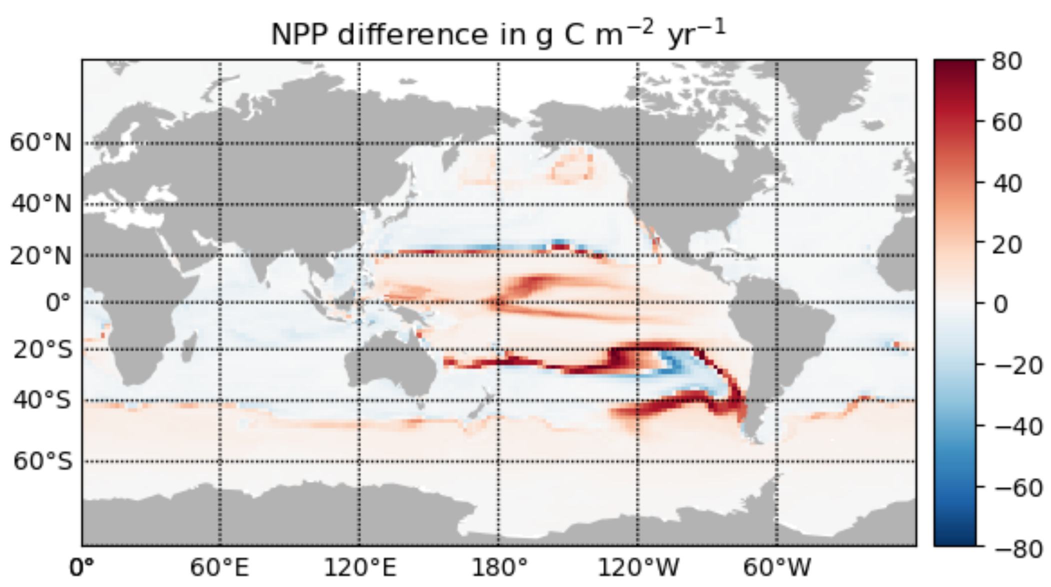
The iron flux from meteoric smoke particles (MSPs), albeit on average smaller, is distributed more homogeneously than the flux from terrestrial dust (note the different scales). In most regions it is only a small addition, but in the South Pacific and the indo-pacific parts of the Southern Ocean, it can actually dominate over terrestrial Fe flux. Dust flux from Albani et al, 2014, has been converted to iron flux, assuming a constant solubility of 2% and crustal Fe abundance of 3.5%.

2) Effect on dissolved iron



The additional flux of Fe from MSPs results in an increase of dissolved iron (dFe) that is mostly smaller than 0.1 nM. Although relatively, the MPS iron flux is largest in the Southern Ocean, the absolute changes in dFe are largest in the subtropics.

3) Effect on phytoplankton productivity



The increased dFe concentrations lead only to slight enhancement of phytoplankton net primary production (NPP) in iron-limited regions, and small reductions in NPP in the nitrogen-limited South Atlantic subtropical gyre, driven by macronutrient uptake in the Fe-limited regions. Production changes are largest near the boundaries between N- and Fe-limited regions.
Overall, the Fe input from MSPs leads to an increase of global NPP by 2% and of global export by 1%.

	Without cosmic dust particles	With cosmic dust particles
total dFe deposition 10^9 g Fe $year^{-1}$	317	329
global net primary production Pg C $year^{-1}$	44.33	45.38
global export production Pg C $year^{-1}$	9.71	9.80

4. Discussion

The additional iron flux to the ocean from the deposition of meteoric smoke particles is a significant part of the total deposition flux in the South Pacific and parts of the iron-limited Southern Ocean.
Nevertheless, the effect on biological productivity, both locally and globally is relatively modest. This is probably because in the regions where MSPs contribute disproportionally, the deposition flux of iron is less important than the flux of iron from below, through upwelling and the annual mixed layer cycle.

The magnitude of other important iron sources to the ocean (sediment diagenesis and hydrothermalism) is still unclear, which causes different biogeochemical models to have widely different Fe residence times (Tagliabue et al., 2016).
It is therefore important to analyse the robustness of our results with a suite of different ocean biogeochemical models. This is currently underway.

5. References

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