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Discussions

Interactive comment on "Dust deposition: iron source or sink? A case study" *by* Y. Ye et al.

Y. Ye et al.

ying.ye@awi.de

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This review was very helpful for improving our manuscript. Here we at first give answers to the more general open questions and then to each of the specific comments.

Open questions:

> *1. is the system iron or phosphate limited at the start of the experiment (DFe fairly high) (somehow picked-up on p9231, but without discussion of relevance for findings)*

The experiment site is a low-nutrient-low-chlorophyll region. Iron is not limiting compared to macronutrients. The N : P : Fe ratio in seawater before dust addition was about

38 : 1 : 0.5 (personal contact to C. Guieu, Pulido-Villena et al., 2010; Wagener et al., 2010), indicating a strongly P-limited system.

The importance of P-limitation has been mentioned in the manuscript under these aspects: 1) the biological model is based on P because of the P-limited system; and 2) phosphate added by dust particles induces phytoplankton growth in the model as suggested from the observations (Pulido-Villena et al., 2010). Dust addition supplied only a small amount of phosphate and biology still played a minor role in Fe cycling after dust addition. Therefore, our findings from the DUNE experiment are directly relevant for macronutrient-limited systems. To generalise the relevance of our findings, we considered the role of biological uptake and organic particles in a new equation for the critical DFe concentration and discussed examples from other ocean regions in the revised manuscript.

> *2. what is the relative importance of phosphate and iron input? is the simulated in- crease in chlorophyll caused by iron or phosphate?*

As in the answer to the 1. question and stated in the submitted manuscript, phosphate input by dust addition was more important for biology in DUNE and the Chl increase was caused by phosphate.

> *3. what is the source of particles in the later phase of the experiment (see Fig. 12, with high PFe values towards the*

There is no source of particles then. That figure shows the concentration of adsorbed iron on sinking particles, not iron contained in dust particles. Because small dust particles (P_d) sink at 0.2 m d^{-1}, they stay in the water column during the entire experiment, unless they form aggregates which sink faster. When Fe adsorption by these particles exceeds sinking loss, concentration of adsorbed iron (PFe) increases. p9235, l12–16 have explained this phenomenon: concentration of sinking particles decreases with time, whereas PFe per particle increases.

> *4. how significant are the results in a wider context, can they be generalized to natural dust input?*

We generalised the result by considering biological impacts in equation and discussed the possible effect of dust deposition in Fe-limited regions. Please see the reply to the comment by Alessandro Tagliabue.

Specific comments:

> *abstract: I think the identified processes (causal chain) should be put in a more prominent position (rather than the numerical values of the adsorption rates)*

We rephrased the abstract accordingly.

> *p 9223 l 8 add DUNE before 'Experiment description' (to distinguish from model exp.)*

It is done accordingly.

> *p 9224 l 4 if the system is P-limited, how significant is the P addition from dust in stimulating biological production? can the results be transferred to iron limited regions or in other words, is the P-limitation the reason for the existence of the threshold iron concentration?*

P addition doubled Chl concentration, shown in the measurements as well as in the model. P-limitation influences the size of the critical DFe concentration but is not the reason for its existence. The existence of a critical DFe concentration can be explained by a flux balance from and to the DFe pool. This could be a balance between dissolution from dust particles and adsorption onto dust particles, as in the P-limited system during DUNE, but it could also be a balance between dissolution and the sum of adsorption and biological uptake, as in a system where the biological cycling of iron is as important as the physico-chemical processes. In the revised manuscript, we discussed that in an Fe-limited system, high biological uptake and abundance of organic sinking particles can lower the critical DFe concentration.

> *l19 is the experiment from 11 to 19 june or from 10-18 (as the figures suggest)*

The experiment was from 10:00 on 10.06 to 10:00 on 18.06 and the dust addition was at 10:00 on 11.06. All figures show a time period from 00:00 on 10:06 to 00:00 on 19.06. "19" occurs in some of the figures because the numbers show the begin of one day. We will try to make the time axis of all figures consistently.

> *l20 'in the beginning of the integration' - specify more exactly here; a reference to the Annex could be given in this section.*

The exact time of dust addition was mentioned and a reference to the Annex for model equations added in the revised manuscript.

> *p 9225 l 3 the naming of P_d, P_s, P_l is somewhat confusing, since P_s is introduced as 'large' dust particles while the 's' implies small. also it would be more exact to replace 'size' by diameter or radius, or state that either is*

> *meant by size (size is used throughout the text, so this is the easiest way of clarifying)*

In principle, d is for dust, s for small and l for large. There are smaller and larger dust particles belonging to P$_d$ and P$_s$, respectively. We replaced "large dust particles" with "coarse dust particles" but kept P$_s$ because small detritus and small aggregates are also included in this size class. "Size" is clarified as diameter additionally.

> *l 8 define PAl here (move from p 9229 l 8)*

PAl is already defined on p9223.

> *p 9227 l 2 particles (D$_s$ and D$_l$) is also involved in PFe$_s$ and PFe$_l$: it would be useful to state how they are 'involved'*

The sinking organic particles are not involved in PFe$_s$ and PFe$_l$ but the iron adsorbed onto them. We rephrased this sentence.

> *l 7 here also the input of phosphate could be mentioned (with the given contents and solubility, the relativ scaling numbers are 0.231 for iron and 1.75 for phosphate)*

We added the exact amount of P addition in text in p9225 where the P content and solubility are mentioned.

> *p 9228 l 2 comparing will not "provide" realistic physical conditions - rephrase l12 I suggest to move 'similar' after 'of temperature' l15 cooling of surface waters - add: and warming of subsurface waters .. l25 similar to above: comparing / improving*

We rephrased these sentences and changed the order of the words accordingly.

> *p 9229 l 1 the section named simulation of CONTROL-meso also includes observations during DUNE and should be renamed accordingly*

In this section, we compared model outputs with observations merely to constrain the model; the observations are therefore not the focus of our manuscript. Observations have been described in detail in former publications of the DUNE project (e.g. Guieu et al., 2010; Wagener et al., 2010; Pulido-Villena et al., 2010).

> *l14 similar to 4.2 - include obs in heading*

See the answer above.

> *p 9231 l 1 I suggest to move the exact timing of the dust addition to a more prominent position*

We mention it now in the model description.

> *l 2 I fail to see the 'clear' diurnal pattern of Chl before the dust addition in Fig. 7*

The diurnal pattern can best be seen in Fig. 4 for CONTROL-meso; Fig. 7 has a colour scale that reflects the larger Chl increase in DUST-meso. We rephrased the description of Chl evolution.

> *l29 remove "s" at end of "magnitudes"*

This is done.

> *p 9235 l 9 the first 3 sentences of this para are non sequel*

The whole paragraph should describe the pattern of modelled DFe and PFe in the water column. The first sentence "The model reproduces the rapid decrease of DFe after the dust addition (Fig. 1)" gives a general description of modelled DFe. An unregularity in the model output is a slight DFe increase on 14th of June. Therefore we explain the reason for this with the second sentence: "DFe in surface water is elevated on 14 June because the lower water layer with higher DFe concentration is mixed up with surface water." After describing DFe, the third sentence passes on to PFe: "The pattern of PFe_{sorp} shows a different trend......". These sentences do not have a causal relationship.

> *l13 I'm still puzzled by the high concentration of iron adsorbed on particles towards the end of the exp. (Fig 12). what particles are still remaining in the water column to carry the iron? Fig.8 tells us they are all gone (save from P_d) does P_d change from iron source to sink?*

Yes, P_d is an iron sink towards the end of the experiment. Please see the answer to the 3. open question.

> *p 9241 refer to Table 1 and 2 for variables not explained in the annex*

We added the reference in the beginning of the appendix.

> *l 9 the layer is not vertical but horizontal - remove vertical*

Word is removed accordingly.

> *p 9242 l 8 This could be moved to the main text - does it help to understand Fig. 12?*

This can not explain PFe increase. Please see the answer to the 3. open question.

> *p 9252 Table 1 I suggest to put the footnote numbers in parentheses to avoid confusing them with exponents*

Parentheses are added to the footnotes.

> *p 9259 Table 8 how can the export be larger than the stock?*

The stock here means the total amount of PFe in water column, while the export is the accumulated flux. This is defined in Wagener et al. (2010). We defined it in the revised manuscript again.

References

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