Review of "Dust deposition: iron source or sink? A case study" by Ye et al., submitted for publication in Biogeosciences.

Alessandro Tagliabue
atagliab@gmail.com

1. Summary and Recommendation

In this submitted manuscript Ye et al use a one dimensional, intermediate complexity Fe – biology model to examine the results of a dust addition experiment conducted in a mesocosm in the Mediterranean near Corsica. A wide variety of 'iron-related' observational data was collected, which provided a unique opportunity to compare the output of the model to important Fe species that are not often comparable in other studies (in particular, particulate Fe species). The observational data has already been published in Biogeosciences (Wagener et al., 2010) and found that, perhaps counter-intuitively, dust deposition actually led to a reduction in dissolved Fe concentrations (dFe). The Ye et al study is a nice complement to this in that they show how this result can 1) also be obtained with an intermediate complexity Fe model, 2) be used to 'tune' important model rate parameters and 3) provide a theoretical framework to understand the broader consequences of this result (their 'critical' dFe parameter). This is of great interest to the readership of Biogeosciences and I recommend it be accepted for publication following revisions. In particular, I hope that my comments/ideas could help to add some nuances to the results of this study and provide a greater context for their quantitative relation of the result of dust deposition to the 'conditions' of the surface ocean. I feel a little more 'ambition' with the MS could only add to its impact

2. Major Comments

I'd like the authors to consider these two major remarks:

2.1 Relating the "DUNE" results to iron limited open ocean waters

The result that adding dust reduces dFe has important implications for how we understand the role of dust deposition in governing the supply of dFe to surface waters and the stimulation of phytoplankton growth. Think about the implications for how dust Fe supply to the sub-Arctic Pacific and Southern Oceans impacts phytoplankton growth that are implicit in these results. However, one important aspect of the "DUNE" experiment is that this was not an Fe-limited location. Therefore, variability in Fe uptake by the phytoplankton following addition of dust was minimal (as I understand it) and physio-chemical (or 'abiotic') processes dominated. I wonder how much of the observed decline in dFe following dust addition was due to this? If phytoplankton uptake of dFe were also occurring following dust addition (as would be expected in an Fe limited region), how would this moderate/change the results? The authors have a tool that could be used to examine this aspect. It would be nice to test with a sensitivity test what happens if you (artifically of course) increase the PO_4 concentration so that dFe was actually limiting prior to the dust addition. Do you see a decrease in phytoplankton biomass/increase in Fe limitation due to adsorption losses of the added dFe? Or, does including biotic uptake 'compete' with adsorption for the added dFe and still result in some increase in biomass? It would also be interesting to test different phytoplankton Fe uptake rates from the literature alongside this.

2.2 The "critical dFe concentration" concept

The authors define a "critical dFe concentration" above which addition of extra Fe would be lost from the dissolved pool, which is related to the 'properties' of surface waters. Initially, this is defined only considering the balance between Fe dissolution from dust and adsorption onto particles (equation 3). Later, this is further developed to include the role of Fe complexing ligands (equation 7). I like this analysis very much, but I feel that once equations 3 and 7 are arrived at everything ends rather abruptly! I would love to see a plot of discussion of the sensitivity of the result of equations 3 and 7 to realistic ranges in the parameters within. What could dominate it in the open ocean? Could a couple of examples be given? There are some process studies (Fecycle for example) where some/most of these parameters were measured to some degree. I think doing this would extend the interest in this framework beyond that for just Fe modellers! Finally, I must say that I don't like the term 'critical total dFe concentration', even if it is (by definition) a concentration … In the absence of biology, its applicability outside of this study may be hindered and I therefore see it more as a 'solubility balance' for an abiotic system, but I am ok with it if the authors explain that aspect. But how might it change/be adapted to include biotic uptake (in a flexible way to account for biota that are/are not Fe limited?), my comments in Sec 2.1 could help here? More exciting still could be to try and derive what this concentration (with or without biota) would be in some example regions of the ocean (challenging I know) and use it to discuss whether dust deposition in different regions would increase or decrease dFe. This, of course, is probably easier said than done, but could be something to think about?

3. Specific Comments

p9221, l3-4: There are quite a few modelling studies that are questioning the ultimate role of dust in governing dFe concentrations and highlight the importance of other Fe sources (sediments, hydrothermalism ...) (Moore and Braucher, 2008 BG, Aumont et al., 2008 GRL; Tagliabue et al., 2009 GRL; 2010 Nature GS)

p9221, l19: Baker and Croot's 2010 Marine Chemistry review would be an appropriate citation here.

p9222, l19, remove 'Island'
l20, replace 'in' with 'at'
l27, replace 'by'with 'using'
l29, this model has been simplified for DUNE, right?

p9224, l19-21, it might be nice to add how much Fe and P was added?

P9226, l20, again, how much P?!

P9226, l4-5, I assume this allocation of particles into Pd and Ps is arbitrary? No problem with that, but if there's a better reason it could be stated.

P9226, l19, 'The' concentration's' of dFe
l20, 'the' pFe flux
l21, model 'of' Ye et al.

P9227, l6, could mention that you provide the model equations in the appendix?

Sec 4.2.1 Could Chl/C variability in response to changing light field/stratification be important?

P9230, l20, add error bars to F6.

P9232, l1 difficult to see this on the figure

sec 4.3.3. you could add the observed information to the plot??? what are the implications of these tests?

Sec 4.3.4 again, observations could be added to the plot.
Am I right that no ligands are considered in this model? i.e., potentially ALL dFe could be lost? It is not Fe' (calculated from FeL, Kfel etc) that is adsorped?

P9235, l19-22, could this be connected to the observed increase in dFe at 10m in the observations?

P9236, l9-11, this statement needs a reference or two

(then see my comments on dFe crit).

4. Figures

There are a lot of figures! Here are some ideas:

Combine CTL-meso and DUST-meso figs into one, i.e., combine F4 + F7 and F5 + F11

Combine F8 + F9 + F10

add black outline to observations on F11 so they can be seen more easily!

Combine F11 + F12

5. References

Aumont, O., L. Bopp, and M. Schulz, What does temporal variability in aeolian dust deposition contribute to sea-surface iron and chlorophyll distributions?, *Geophys. Res. Lett.*, 35, L07607, doi:10.1029/2007GL031131 (2008).

Baker, A.R., and P.L. Croot, Atmospheric and marine controls on aerosol iron solubility in seawater, *Marine Chemistry*, 120, 4-13. (2010).

Moore, J. K. and Braucher, O. Sedimentary and mineral dust sources of dissolved iron to the world ocean. *Biogeosciences* **5**, 631-656 (2008).

Tagliabue A., Bopp, L., Aumont, O., Evaluating the importance of atmospheric and sedimentary iron sources to Southern Ocean biogeochemistry. *Geophys. Res. Lett*. **36**, L13601, doi:10.1029/2009GL038914 (2009).

Tagliabue, A., et al., Hydrothermal contribution to the oceanic dissolved iron inventory, Nature Geoscience 3, 252 - 256 (2010).

Wagener, T., Guieu, C., and Leblond, N., Effects of dust deposition on iron cycle in the surface Mediterranean Sea: results from a mesocosm seeding experiment, Biogeosciences, 7, 3769-3781, doi:10.5194/bg-7-3769-2010 (2010).