Biogeosciences Discussions

Biogeosciences Discuss., referee comment RC2
https://doi.org/10.5194/bg-2021-79-RC2, 2021
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Comment on bg-2021-79

Anonymous Referee #2

Referee comment on "Seasonal dispersal of fjord meltwaters as an important source of iron and manganese to coastal Antarctic phytoplankton" by Kiefer O. Forsch et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-79-RC2, 2021

Review of 'Seasonal dispersal of fjord meltwaters as an important source of iron to coastal Antarctic phytoplankton' by Forsch et al.

This manuscript aims to constrain the input and dispersal of Fe and Mn rich fjord water in an Antarctic Fjord. This is an interesting and important objective given that these metals are important drivers of primary productivity in the Southern Ocean, including coastal areas. Whereas it is known glacial melt must supply these metals, much is unknown about the underlying processes or the effective fluxes into Fe and or Mn limited waters that are generally located further away from direct sources. To tackle this difficult question, a whole suite of methods is used, including water column profiles, sediment and ice sampling as well as modeling work. This is a very comprehensive study and I really liked to conceptual model (Figure 10) that brings together all the different aspects, however, this clarity and synthesis is somewhat lacking in the text. Despite being generally well written from a language point of view, the text is often not clear (see specific comments) and the text sections are not always well connected. For example, the section on ligands (4.5) provides some discussion on (changes in) ligand concentrations and binding strengths, but ends with a very general section on the potential role of ligands in keeping Fe in solution but no real novel insights from the current data (or comparison to recent insights from an Arctic glacier Fe-speciation study, see specific comments). More importantly, the role of ligands or the balance between solubilization and scavenging is not at all considered in the modelling approach in the next section. In fact, I struggled to see what we learn about Fe in the modelling approach using conservative tracers, given that the elusive balance between solubilization and rapid scavenging / precipitation reactions is one of the most important reasons for our limited understanding of the Fe biogeochemical cycling. In the appendix, a 10% dissolution of TDFe is considered conservative, but no consideration is given to how much of this actually remains in solution and hence is subject to long range transport to Fe-poor regions. I realize it is no easy feat to constrain this, but I think it should be discussed and the modelling section could be shortened considerably.

Overall, I think this manuscript will provide a valuable addition to the literature. Nevertheless, it would benefit from shortening and conveying the novel insights from the

data more clearly as well as tying the different sections in the discussion better together (so that it is more one story rather than different aspects that only in the conceptual model really come together). I also noted that while Mn is often mentioned in the manuscript, it does not appear at all in the conclusions whereas I'm confident there are some interesting new insights into the biogeochemical cycle from Mn based on this dataset.

Specific comments:

In the introduction I missed Mn considering that Mn is known to be (co-)limiting, even in coastal waters such as the Ross Sea (https://doi.org/10.1038/s41467-019-11426-z)

120-130 bit late now, but surprised by the choice for stainless steel rather than titanium as used in TM ice core drilling and notably the razor could have easily been replaced by a ceramic knife

292 the work by Bown et al 2017 (https://doi.org/10.1016/j.dsr2.2016.07.004) seems relevant here

327 not sure I would describe an R^2 of 0.48 as highly correlated. And given the equation LpFe = TDFe – dFe, does a correlation between dFe and LpFe indeed imply exchange? I would assume the correlation is inherent to the definition.

389 'particulate Fe are associated with more crystalline and thus less labile Fe oxides'; less labile than the 'comparable fraction is refractory and is not liberated by any of the solution treatments (31%).' mentioned in the previous sentence?

475 'Since glacial meltwater is restricted to the surface, it constitutes a significant input of Fe to the surface throughout the growth season'; seems the statement on significance should come after the discussion in the following lines.

504 what is the statement on light limitation based on?

517-520 how were crustal vs authigenic material and the reported fraction identified?

524 ‘indicating a large oxide fraction is associated with this particulate matter’ this statement is not explained (or referenced)

534-535 875 nM is higher than TDFe measured (346.95±160.40 nM); why does this suggest settling loss through flocculation is likely occurring? TDFe is also made up of particles that could be emitted from the glacier. I agree there is loss and settling of Fe, but the argument based on TDFe eludes me.

537 – 539 also, the extrapolation approach here excludes any precipitation and is likely an underestimation of the endmember concentration.

541- 543 ‘However, subglacial… shelf (Schodlok et al., 2016).’ What is the relevance of this sentence, not clear

543 what export efficiency, previous sentence was on the width of the shelf?

558-587 what is the point of this section? The calculated sediment efflux of Fe is much higher than the global average which is somehow related to bioturbation, but how is not made clear. It is stated bioturbation would decrease the efflux, so how does it explain the higher than average efflux? Reference is made to Marsay, but it is not clear to me what the relation is between the current and those observations. This section should be clarified and can probably be shorter/ more succinct

561 ‘The result is deviation from results based on diffusion alone’ Rephrase

564 greater deposition than what?

577 what flux estimates, those of Pb?

582 DIR is never used

621 how does a scaling of dFe to LpFe correspond to an increase in eL between seasons. Please clarify

625 how does this compare to Arctic glacier work? Could ligands be outcompeted by particle scavenging? (Ardiningsih et al., 2020 https://doi.org/10.1016/j.marchem.2020.103815)

636-637 so the excess (strong?) ligands originate from Bransfield Strait? Not clear

642-643 Not necessarily, only if ligand induced dissolution occurs which is not demonstrated here

650-660 some general global implications regarding ligands are mentioned, but what is the insight generated from the current data?

663 what is the relation between icebergs, vertical shear and katabatic winds? Mentioning of icebergs seems out of place here

665 what is meant with 'export the surface layer efficiently'

679 export of surface water?

682-697 what is the point of this exercise were Fe is assumed to behave conservatively (i.e. like $\delta^{18}O$ used to estimate the meltwater fraction) whereas we know it does not, especially not in a productive region. The final statement (it is expected that the input of glacial meltwater throughout the melt season would supply some dFe to the surface) could have been made without this section.

698-723 this whole section does not contribute a single insight into the biogeochemical cycle of Fe (or new insights into the actual dispersion of melt water), so what does it contribute to the ms?

700 the $\delta^{18}O$ approach should differentiate between meteoric and sea ice melt so the MWf should not be influenced by sea ice melt

724-729 this section I found very confusing; dFe observations were made *prior* to a wind event; the model predicts upwelling if there is wind and the model results of upwelling are supported by the observations prior to upwelling? Also, how am I to see the elevated dFe in late spring at station S3 in fig3? No stations are labelled and the color scale is more or

less homogenous (all blue).

746 Only if Fe remains in solution and is not taken up by phytoplankton along the way, do we know anything about this?

756 this point was just made in line 734

768 what geochemical data?

774-775 confusing sentence; export of subsurface dye leads to a low surface concentration due to proximity to the surface?

775 'The upper ocean is more subject to changes in the upper ocean dynamics' that seems like an open door to me…

783 not sure it was shown, more argued / suggested

786-787 how does the comparison of dFe and the meltwater fraction in fig 3 'support to the modeled dynamics' ?

807 why would intensifying coastal currents lessen the likelihood for pulsed export of meltwater-derived Fe?

826 where is Barilari Bay and why is it relevant?

828-829 how can a single wind event along the WAP export 36 km^3 of meltwater if the total Antarctic meltwater discharge is only 32.5 – 97.5 km^3 yr^{-1}?

833 also larger than the total annual meltwater discharge. Something is incorrect or very unclear

843 why would a phytoplankton bloom lead to decreased ligand concentrations, not clear

and contradictive to section 4.5