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Corrigendum to “Iron from melting glaciers fuels the phytoplankton blooms in Amundsen Sea (Southern Ocean): iron biogeochemistry” (Gerringa et al., 2012)

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There was an error in the article on iron (Fe) chemistry affecting phytoplankton blooms in the Amundsen Sea (Gerringa et al., 2012). The contribution of Fe-input of melting glaciers to the phytoplankton consumption via horizontal turbulent diffusion was overestimated by a factor of approximately three orders of magnitude, which changes the main conclusion of the paper. After correction, the new conclusion of the paper is that instead of Fe from melting glaciers, recycled Fe, due to internal regeneration, appears to be important to the persistence of the bloom. This makes the title of the paper misleading.

Gerringa et al. (2012) analyzed a large number of water sampling stations in the Amundsen Sea (Southern Ocean) to study the fate of phytoplankton blooms in relation to Fe chemistry. In particular, the daily phytoplankton growth rate, here called G, or nutrient-Fe uptake in the photic zone was compared with nutrient-Fe supply via vertical and horizontal turbulent fluxes $F_z = K_z\partial Fe/\partial z$ and $F_h = K_h\partial Fe/\partial x$, respectively. We only considered one horizontal coordinate x. The vertical K_z and horizontal K_h turbulent diffusion coefficients were determined from vertical density and horizontal Fe distributions. In mathematical form, G depends on the vertical and horizontal turbulent flux variations, or net turbulent flux of a volume in which local recycling R may take place,

$$G = -\partial F_z/\partial z - \partial F_h/\partial x + R. \quad (1)$$

The description of this calculation in Gerringa et al. (2012) is correct as well as all computed fluxes. However, to be able to compare these fluxes with biological uptake, gradients (physically named as ‘divergence’) of the fluxes over distance must be calculated. While this was done for the vertical turbulent flux by considering its input into the photic zone represented by the mixed layer depth (MLD, 15.2 m), this was mistakenly omitted for the horizontal flux.

Table 2 in Gerringa et al. (2012) gives horizontal flux (‘lateral diffusion’) computed as a function of distance from the glacier source, for example at x = 40 and 70 km $|F_h^{DFe}| = 6.6 \times 10^{-5}$ and 3.1×10^{-5} mol m^{-2} day^{-1}, respectively (we ignore the signs indicating flux-directions as in Gerringa et al., 2012). In the correction, the horizontal flux difference at x = 55 km, halfway between 70 and 40 km, divided by the distance difference multiplied by the MLD, reads $|\partial F_h^{DFe}/\partial x| = ((6.6\text{-}3.1) \times 10^{-5}/((70\text{-}40) \text{ x } 10^3)) \times 15.2 = 1.8 \times 10^{-8}$ mol m^{-2} day^{-1} (distances in m). The contributions of vertical and horizontal turbulent fluxes are now similar in equation (1), both only contribute a few percent to G. This implies that R must be of the same order as G, unless G was overestimated based on the then available knowledge in literature.

However, the corrected horizontal flux difference of total dissolvable Fe (TDFe) analyzed in unfiltered acidified samples ($|\partial F_h^{TDFe}/\partial x| = 0.9 \times 10^{-6}$ mol m^{-2} day^{-1} at x = 55 km) is ~ 40% of the assumed Fe demand of the phytoplankton bloom of 2.3×10^{-6} mol m^{-2} day^{-1}. As discussed in Gerringa et al. (2012) however, the interpretation of the role of TDFe as an Fe-source for phytoplankton is difficult because of many unknowns. For example, the upwelling flux of TDFe is often simply assumed to be twice the flux of DFe. Vertical and horizontal diffusion calculations of TDFe are problematic. Near the seabed or near the glacier, TDFe can be considered as an external Fe-source when its bio-chemical availability is properly accounted for. However, in surface waters of a polynya, a large portion of TDFe is contained in algal cells which can hardly be seen as an external source. As a result, the fluxes are calculated over a concentration gradient of different TDFe sources. Therefore, although TDFe seems to form a substantial Fe-source for phytoplankton, the actual contribution is difficult to assess from our field data.

The corrected horizontal flux contribution of DFe from Pine Island Glacier changes the conclusion in Gerringa et al. (2012). In the center of the polynya, the fluxes from vertical upwelling, vertical fluxes from the sediment and the flux from the glacier of DFe are now of the same order of magnitude. This means that recycling must be important to sustain

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the bloom.

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