Wageningen, October 9, 2013

Dear Editor, dear Reviewers,

Please find attached the revised version of the manuscript 'Dissolved Fe across the Weddell Sea and Drake Passage: impact on nutrients uptake'. The submission of all new and revised documents is done according to the guidance received from the Copernicus office. In this letter, the authors will explain the improvements to the manuscript.

The authors would like to thank the editor and reviewers for their constructive comments. We believe the manuscript is now improved compared to the originally submitted version, following the specific and general comments from the reviewers as well as another critical look by the authors. The handling of the specific and general comments of the reviewers is clarified in the response to the reviewers comments found below. Below the changes in the manuscript are stated:

1. Text

The text has been improved in many parts of the manuscript, we believe it is now written more clearly with inprovements in the language use, as well as a shortening were possible. Also new section numbering is introduced; the section on hydrography is now a separate section. In the section on DFe in the surface waters in the Weddell Sea (originally section 5.2) 3 new subheadings are introduced, to improve the structure of the manuscript. Unfortunately, due to the new clarifications, the overall text is not shorter (although (the new) section 4 and section 6.2 have been shortened significantly). Also the following new references are introduced:

- Sedwick, P.N. et al. 2008. Deep Sea Research I 55, 911-925.
- Pollard, R.T. et al., 2009. Nature, 457(7229): 577-580.
- Measures, C.I. and Vink, S., 2001. Deep Sea Research Part II 48 (19-20), 3913-3941.
- Croot, P.L. etl. 2004. Deep Sea Research Part II 51 (22-24), 2857-2879.
- Boyd, P.W. et al. 2007. Science 315, 612-617.
- Sanudo-Wilhelmy et al., 2002. Marine Chemistry 77, 157-170
- Salter, I. et al. Deep-Sea Research II, 2007. 54 (18) , 2233-2259
- Smetacek, V., Klaas, C., Strass, V. Assmy, P., Montresor, M., Cisewski, B., Deep carbon export from a Southern Ocean iron-fertilized diatom bloom. Nature 487 (7407), S. 313–319, 2012. doi 10.1038/nature11229
- Wright, S., W., van den Enden, R., Pearce, I., Davidson, A.T., Scott, F.J., Westwood, K.J.,Phytoplankton community structure and stocks in the Southern Ocean (30-80 °E) determined by CHEMTAX analysis of HPLC pigment signatures. Deep Sea Research II (57), 758-778, 2010.

2. Figures

The following figures are adapted:

Figure 1a, 1b, 2b, 6,7,8,9. These adaptations are all minor improvements, for better presentation of the data, as proposed by the reviewers or after a critical look by the authors. No data is added or deleted from any figure.

3. Annexes
Two annexes are introduced. These present the –raw and processed- data on the phytoplankton community to back the arguments in the new version of the manuscript. With these annexes, supporting the new argumentation, we hope to meet the comments of the reviewers regarding the use of phytoplankton / diatom data in our argumentation. These annexes are included as supplementary table S1 and S2.

4. Acknowledgements and affiliations
We updated the acknowledgements and affiliations of the authors.

Hereby we are confident to have met the comments by the reviewers, and hope for a smooth continuation of the process. In case any question arise, please do not hesitate to contact me.

Yours sincerely,

Dr. Maarten Klunder (on behalf of the co-authors)

Detailed, point-by-point response to the reviewers comments
The responses to the comments are made in blue italic.

Anonymous Referee #1
Received and published: 23 June 2013
The manuscript of Klunder et al. la presents dissolved iron (DFe) measurements in the whole water-column along two transects in the Southern Ocean: one across the Drake Passage and a East-West transect in the Weddell Sea. In addition, nutrient uptake is calculated using differences in nutrient distribution between this and previous studies. Nutrient uptake and uptake ratios are discussed in the light of iron availability and its impact on plankton communities. Given the fact that iron availability is one of the main factors controlling productivity and nutrient uptake in open waters of the Southern Ocean, and that there are few DFe data available, result presented here are of great interest. The manuscript needs, however, to undergo a serious check by authors and co-authors before publication. The discussion on nutrient uptake in the Weddell Sea
is verbose and often too speculative, arguments are hard to follow also due to poor English (see comments below). Figure numbers in the text do not correspond to the corresponding

numbers in the figure panels, panels a and b not indicated in figures. Figure quality and presentation could also be improved: numbers on isolines are too small and the color scale is given twice in most figures (not necessary) and numbers
are also very small (see further comments below). As mentioned before, the English needs to be improved, I have made some suggestions for the introduction but the discussion (in particular section 4.2.1) also needs shortening and proof reading by anative speaker.

Additional comments:
Figures: Weddell Sea iron is presented from west to east while POC export, integrated DFe and Chla fluorescence from east to west. *Is corrected*

p. 7449, lines 7-9: I am not sure I understand the argument here: POC export should be a better proxy for past biological activity than Chla fluorescence. If POC export was higher so should be DFe uptake irrespective of Chla fluorescence values found during
the cruise. *The argument here is that POC export may explain Fe uptake in the past few months, whereas Chl a (as fluorescence) will serve as an indicator for recent uptake. these two patterns are used to discuss the DFe concentration. The manuscript text is adapted to state this more clearly.*

p. 7450, lines 26-28: I do not understand the sentence at all. . . *These sentences are adapted to be clearer.*

p. 7451, lines 16-29 and p. 7452, lines 1-2: Discussion difficult to follow and very speculative. Couldn't the high N uptake relative to Si be simply due to previous input of iron? What are the actual nutrient concentrations in this area? Can't the lower salinities constrain how nutrients concentrations (through freshwater dilution) should
be in the area? *Upon the comment of the reviewer we had another look at our argumentation. We agree that there are many uncertain factors in our original line of reasoning. In fact, when having a closer look at the nutrient concentrations we expect the ratios in the region east of ~15 W not to be influenced by sea-ice, but rather that this water mass is the Westward branch of the Weddell Gyre, and therefore the properties of this water are determined by water properties of the Weddell Gyre more to East rather than by local processes. The text is adapted accordingly and shortened.*

p. 7452, lines 3: "Diatoms are the most abundant phytoplankton species in theWeddell Sea": I wonder where the authors found this information. As an iron limited region the Weddell Sea planktonic system is most probably dominated by nanophytoplankton and the microbial loop. Also most of the paragraph is unnecessary (up to line 13) and the following sentence can be modified as: "Figure 8 d shows . . ..at DFe > 0.1 nM consistent with previous observation showing low N:P and N:Si uptake in iron limited systems (Marchetti and Cassar, 2009. . ..)." *We agree with the reviewer regarding the shortening of the paragraph and adjusted the text. Regarding the most abundant species; indeed it is debatable which species exactly are most abundant in the Southern Ocean. Satellite studies [Alvain et al., 2008] point towards nanoeukaryotes and diatoms during and preceding the same time of season as our cruise. However, there are results of biological measurements made on board at our specific stations [Alder-kamp et al., 2010]; [Neven et*

al., 2011], which arguably should reflect the species composition during the expedition most accurately. Page 4753 line 14-18 is rewritten accordingly.

p. 7452, lines 23-29: I fail to see how the "remaining nutrients" can explain the ratios of removal. Please explain the reasoning here. *The ratio of removal of nutrients is compared to that 'left behind' in the seawater; if the ratio of removal of N:Si is high (i.e. the uptake ratio of phytoplankton), then it is expected that Si in the upper layer is relatively high (low uptake) and N relatively low (high uptake) and therefore the ratio of the remaining nutrients in this water should be low. This is clarified in the text.*

p. 7453, lines 14-29 and p. 7454: I do not understand the point of comparing diatoms average size of Eastern Weddell Sea and Greenwich Meridian. Station 191 has also low N/P removal (at least when looking at fig 2A) than st. 187? Also I am not sure that average size of diatom community is very useful as size during uptake events might be different than the situation observed during the study. Further, since diatom species assemblage composition might be more important than some "average" size, and since the authors do not provide information on community composition in the area of study, I find all the arguments very speculative in my opinion not too helpful when trying to understand the impact of DFe on nutrient dynamics in the region. *We agree with the reviewer that other factors, such as species composition and a shift in time between uptake and sampling are also important here. However, we still suggest that our findings may indicate a relation between size and removal, as also backed by the referenced literature. We therefore include the phytoplankton data (both on size and composition) in two new supplementary Annexes, and rewrote this section; the tone is now more suggestive.*

Some improvement suggestions for the text:

p. 7436, lines 4-12: this paragraph can be shortened to: "It is now well established that phytoplankton growth in the High-Nutrients Low Chlorophyll (HNLC) Southern Ocean is primarily limited by low Fe concentrations (De Baar et al., 1990; Buma et al., 1991; De Baar et al., 1995, 1999, Smetacel et al., 2012). Several studies have reported dissolved Fe (DFe) values in the upper waters of the Weddell Sea (Sanudo-Wilhelmy et al. 2002; Lannuzel et al., 2008; Lin, 2011), but there have been few studies on dissolve Fe at depth in this area (De Jong et al., 2012)." *This section is rewritten, largely following the reviewers comment.*

p. 7436, lines 13-20: "North of the Antarctic Peninsula, the eastward flowing Antarctic Circumpolar Current (ACC) is forced through the narrow (800 km) Drake Passage, resulting in strong velocities (Sokolov and Rintoul, 2007). The distribution of DFe in the region around the Antarctic Peninsula has been relatively well studied in recent years (Sanudo-Wilhelmy et al., 2002; Lin et al., 2011). Thus far, no measurements of DFe over the whole water column of the Drake Passage were available.

p. 7438 line 14: "Although the outflow of WSDW is arguably. . .". *Agreed and adapted*

p. 7438 line 20: "Pacific Ocean, carrying properties of hydrothermal origin. . .". *Agreed and adapted*

Make sure all sentences are in the same tense (for example some results are presented in past and some in present tense). *Tense is double checked.*

Anonymous Referee #2
Received and published: 24 June 2013
Review of manuscript doi:10.5194/bgd-10-7433-2013 submitted to Biogeosciences Dissolved Fe across the Weddell Sea and Drake Passage: impact of DFe on nutrients uptake in the Weddell Sea M.B Klunder, P. Laan, H.J.W De Baar, I.A Neven, R. Middag, and J. van Ooijen

General comments

The manuscript by Klunder et al. presents the full water column sections of dissolved iron (dFe) along two transects of the Southern Ocean (Weddell Sea and Drake Passage) during the International Polar Year – GEOTRACES program (cruise ANT XXIV/3). The data is of high quality and novel in that this is the first time that full profiles have been reported in this region. The dFe data is described in terms of water masses, hydrography and sources, with a particular focus of dFe control of nutrient uptake. This is an important contribution to the scientific literature due to Fe limitation of phytoplankton communities in Southern Ocean waters and its consequential effect on the marine carbon cycle in the region.

In summary, the scientific significance is good, the scientific quality and presentation quality are both good-to-fair. The Fe data is of very high quality (which is the norm for the Royal NIOZ laboratory) and backed up by excellent analytical figures of merit, and the discussion of the distributions is by far the strongest part of this manuscript. However, I believe the manuscript needs to be improved before being suitable for publication
in Biogeosciences. In particular the abstract and discussion section are too long, and in the latter the sentences are sometimes speculative and repetitive. The paper would benefit from more paragraph breaks. The text concerning the nutrient ratio control by Fe limitation needs improving (there are several typographic errors) and it would benefit from another close read. Also, I am not convinced that the size of the diatoms is a good proxy for Fe limitation or nutrient uptake as other factors such as diatom species composition would likely play a more important role (and this manuscript contains no information on the phytoplankton community).

The Figures are generally good, although they could be easily improved with a bit more care. For example, different figures should be largely consistent with each other to aid the reader compare data easily. The sections (Figures 2, 3 and 4) run west-to-east, but Figure 7 runs east-to-west. The isolines on the ODV plots are very small, and figures with several different panels do not contain panel lettering, even though they are cited in the text. The figures could be better cited in the main body of text. The reference list is comprehensive and up-to-date.

I recommend the paper may be suitable for publication in Biogeosciences after revision. I provide some other specific and technical comments below, which I hope will help the authors improve this manuscript. It is frustrating that a reviewer has to pick up many typographic errors. This is the role of the author before submission and reduces the quality of the manuscript.

Specific comments

Title. No need for "in the Weddell Sea" at the end as you have already stated this. *Is adapted.*

Please be consistent with your tense throughout the manuscript. You switch between present and past tenses. *Noted and corrected*

"Nutrient" should often be singular where you have used the plural. *Noted and corrected*

There are often commas inserted in the text where they are not needed. And in other cases, commas are missing This makes the sentences hard to follow. Please scrutinise.

You use of brackets (especially for references) needs a careful check. *Noted and corrected*

Lines 37-41. You have been selective with which references you have chosen to cite here in iron limitation in the Southern Ocean. There are many other good papers by other labs. *The author agrees with the reviewer that there are more good papers. Some (key) references are added.*

Line 174-5. Is this a weblink to the Bruland database? This could do with updating as more data has been received since November 2011. *Is updated*.

Line 257. I have not heard of the LLoD concept. Surely a limit of detection is a precise value? *The limit of detection was determined regularly as mentioned in chapter 2 of the manuscript. The average value was +/-9 pm, and this was in line 257 noted as < 0.01 nM, in a general description of the range of observed values.*

Lines 380-384. Many other factors are involved between the relationship between dFe, fluorescence and POC export. This text needs improving as you have oversimplied the connections. *We agree with the reviewer that there are many complexing factors in these relationships. The text is rewritten upon a look into more (newly cited) literature. However, it is also the authors' point of view that some of these factors influence the phytoplankton growth, thereby the chlorophyll a and therefore the possible effects should be found back in the presented patterns. The section is partly extended / rewritten, including new references to literature.*

Line 516. Information on the species composition as well as the size of the diatoms would be very useful here. Can you provide details please?

Line 545-554. This section is largely speculative and hand-waving. Please re-write.

The response to both comments above: The data is included in the new Annex I and Annex II. Based on these Annexes, both reviewers comment (see also response to reviewer I comment (page 7253)), and further consideration, the complete section line 510-545 (in original manuscript) is rewritten.

Technical comments

Line 16. What is the difference in drawdown related to?

Line 20. Insert "and" before "the N:P"

Line 30. Add "the" before "Drake Passage" and no comma afterwards

Line 33. Has AABW been defined before? Care with defining acronyms on first use.

Line 44. "Lin et al., 2011"

Line 52: "Peninsula"

Line 71: "estimates"

Line 84. New paragraph

Line 116. "us" after "allows"

Line 121: "vegetative"? A better word could be "growing"

Line 132. Brackets need sorting

Lines 153-158. I like this approach to oceanographic consistency
Line 163. Baseline (singular)
Lines 179 and 215. Brackets!
Lines 188-190. Re-word this sentence
Line 290. Nutrient removal (singular)
Line 308. Brackets
Line 314-315. Use a space between a value and its unit and no "." Needed after "m"
Line 337. Brackets
Line 372. "m" not "meter"
C2980
Line 393: "was"
Line 491. "ratio was"
Line 493 "seawater was"
Line 503. Add "." at end of sentence
Line 534. Add "." at end of sentence
Line 564. No comma
Line 573. "Ridge"twice
Line 583-588. Use of brackets and other typos. Also, do not cite an abstract in the main body of the paper.
Line 673. Typos.
Line 644. Use English
All technical comments are noted, and text is adapted accordingly.