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Biogeosciences
Discussions

Interactive comment on "High variability of dissolved iron concentrations in the vicinity of Kerguelen Island (Southern Ocean)" *by* F. Quéroué et al.

F. Quéroué et al.

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Reviewer 1:

This manuscript shows the concentrations of dissolved (<0.22 μm) Fe in the water column (up to 1300 m) of the Kerguelen Island (covering coast to offshore waters). The authors attempt to explain the high variability of Fe concentrations found in this part of the southern ocean. Although dataset is valuable I think that the authors do not provide enough insights to demonstrate the sources and reasons for the variations of Fe concentrations. Although most of the hypotheses presented could be perfectly valid, they are hardly demonstrable with the data presented. For example, the higher con-

centrations measured close to the seafloor are justified by resuspension of sediments and porewater release, however other potential sources such as hydrothermal vents existing in the area are not considered in this case. As indicated by the authors since particulate Fe concentrations were not measured it makes difficult to confirm this hypothesis. Although I agree that biological uptake was probably the main responsible of the temporal decreasing of Fe above the plateau, other aspects influencing the concentration of Fe such as the presence of krill and/or whales (eg. Tovar-Sanchez et al. GRL 34 L11601, 2007; Nicol et al. Fish and Fisheries 11, 2010) should be, if possible, considered or discarded. Authors include atmospheric inputs as additional source, however the study only includes backward trajectories air masses without providing any chemical aerosol measurement. In the conclusions section the authors state that atmospheric inputs were negligible during KEOPS2 cruise however this paper does not present any data that confirm this fact. In summary, I believe that the authors present a valuable data set that could provide important information about the biogeochemical cycle of Fe in this part of the southern ocean, however I think that additional data (some of them are presented or under evaluation in separately papers as part of the special Issue) are necessary to support the main findings presented here.

We thank reviewer 1 for his/her review. This ms is not trying to present a full iron biological cycle for the KEOPS2 experiment; rather the dFe distributions and the reasons for the concentration variability. Dissolved Fe data presented in this paper together with particulate Fe data from a closely aligned companion study (van der Merwe et al., 2015) are combined by Bowie et al. (2014) in order to establish short-term Fe budgets at three sites (above the Plateau, in the recirculation area, and the HNLC area). The three papers should be read as an Fe collective whole. We made a substantial effort to cite data from papers from the special issue, in particular, concerning sedimentary inputs and particulate Fe data close to the seafloor. For example: "This is corroborated by high pFe values at A3-1 and A3-2 (30 and 15 nmol L-1 respectively) and pFe:pAl ratios that resemble basalt over the Kerguelen Plateau (van der Merwe et al., 2015)" or: "Moreover, close to the seafloor, van der Merwe et al. (2015) observed high values of pFe, pMn, and pAl, likely due to sediment resuspension." To support our hypothesis, lithogenic Si data are also highly cited throughout the manuscript (Lasbleiz et al., 2014).

In the following, we address the concerns of Reviewer 1 in terms of demonstrating the various sources:

Hydrothermal source: we agree that hydrothermal events are expected in our study area, more particularly in the vicinities of the Heard Island and the Leclaire Rise. Heard Island is located further South of the studied area and dFe inputs from this source could be advected to the Plateau area. The following sentences were added to the text: "Hydrothermal input may be an additional Fe source above the Kerguelen Plateau more particularly in the vicinity of the Heard Island. The Mn:Al ratio at this station is much lower than any of the other stations 0.007-0.009 (van der Merwe et al., 2015) and very similar to the Kerguelen Island Basalt mean of 0.004-0.010 (Gautier et al., 1990). This supports fresh weathering of basalt downstream of A3, which may be glacial/fluvial runoff or hydrothermal." At station R-2, both hypotheses were considered in van der Merwe et al. (2015) for the high Mn:Al ratios. We considered that the enriched Mn at R-2 could be due to either MnO2 enrichment in the surface sediments during redox cycling of early diagenesis (Planquette et al., 2013), or supplied via a Mn enriched source such as hydrothermal venting near the Leclaire Rise. The extremely low carbon content of the sediment at station R-2, as evidenced by its near white colour, low diatom content (L. Armand, pers. obs., 2012) and low carbon export flux (Laurenceau et al., 2014; Planchon et al., 2014), suggests that MnO2 enrichment in the surface sediments during redox cycling is more likely at R-2.

Krill/Whale: It is true that Antarctic krill eat diatoms and recycle iron in surface waters when feeding. Baleen whales eat krill, and defecation by baleen whales could be a major mechanism for recycling iron, if whale faeces contain significant quantities of iron (Nicol et al., 2010, Southern Ocean iron fertilization by baleen whales and Antarctic krill. Fish and Fisheries, 11: 203–209. doi: 10.1111/j.1467-2979.2010.00356.x,

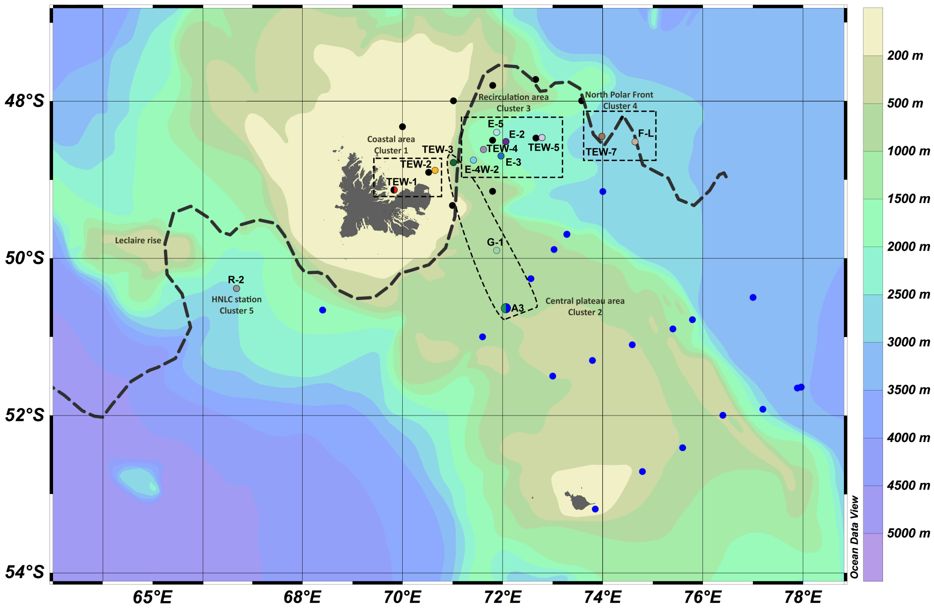
Schmidt et al., 2011, Seabed foraging by Antarctic krill: Implications for stock assessment, bentho-pelagic coupling, and the vertical transfer of iron, Limnol. Oceanogr., 56 (4), 1411–1428). Nicol et al. (2010) demonstrated that krill can act as a long-term reservoir of iron in Antarctic surface waters, by storing the iron in their body tissue. Populations of whales and krill can then store larger quantities of iron and also recycle iron in surface waters, enhancing overall ocean productivity through a positive feedback loop. Schmidt et al. (2011) suggested that due to their large biomass, frequent benthic feeding, and acidic digestion of particulate iron, krill might facilitate an input of new iron to Southern Ocean surface waters. However, as we do not have any data concerning these processes, we did not consider them in our manuscript.

Atmospheric inputs: this was also addressed by Reviewer 2. Therefore, we have modified substantially the paragraph in pages 245-246 and modified the conclusion. Please refer to our answer 2 to Reviewer 2.

"As indicated by the authors since particulate Fe concentrations were not measured it makes difficult to confirm this hypothesis." Particulate Fe was measured and reported in a companion paper. We cite the van der Merwe et al. (2015) article throughout the manuscript, so we do not understand the reviewer's comment.

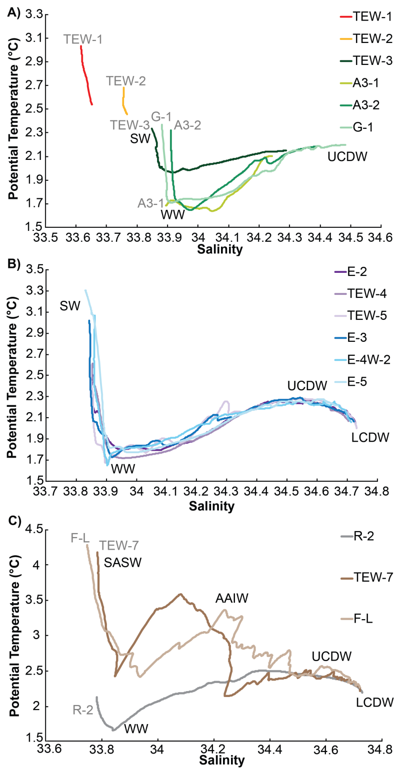
Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C1578/2015/bgd-12-C1578-2015-supplement.pdf

Interactive comment on Biogeosciences Discuss., 12, 231, 2015.



48°S
50°S
52°S
54°S
65°E
68°E
70°E
72°E
74°E
76°E
78°E
200 m
500 m
1000 m
1500 m
2000 m
2500 m
3000 m
3500 m
4000 m
4500 m
5000 m
Ocean Data View
Recirculation area
Cluster 3
North Polar Front
Cluster 4
Coastal area
Cluster 1
Central plateau area
Cluster 2
HNLC station
Cluster 5
Leclaire rise
TEW-1
TEW-2
TEW-3
TEW-4
TEW-5
TEW-7
E-2
E-3
E-4W-2
E-5
F-L
G-1
A3
R-2

Fig. 1.



A)
Potential Temperature (°C)
Salinity
TEW-1
TEW-2
TEW-3
A3-1
A3-2
G-1
SW
UCDW
WW
B)
E-2
TEW-4
TEW-5
E-3
E-4W-2
E-5
SW
UCDW
LCDW
WW
C)
R-2
TEW-7
F-L
SASW
AAIW
UCDW
LCDW
WW

Fig. 2.

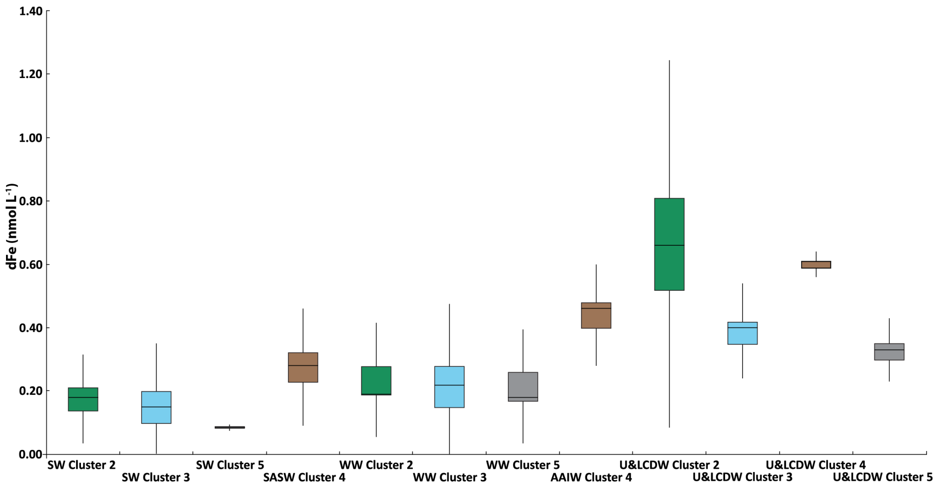

1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
dFe (nmol L-1)
SW Cluster 2
SW Cluster 3
SW Cluster 5
SASW Cluster 4
WW Cluster 2
WW Cluster 3
WW Cluster 5
AAIW Cluster 4
U&LCDW Cluster 2
U&LCDW Cluster 3
U&LCDW Cluster 4
U&LCDW Cluster 5

Fig. 3.

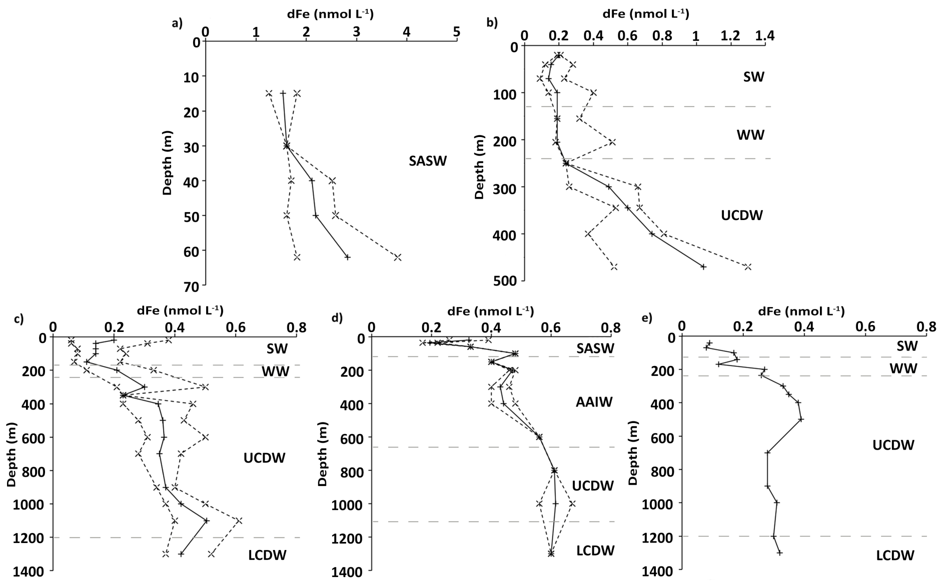
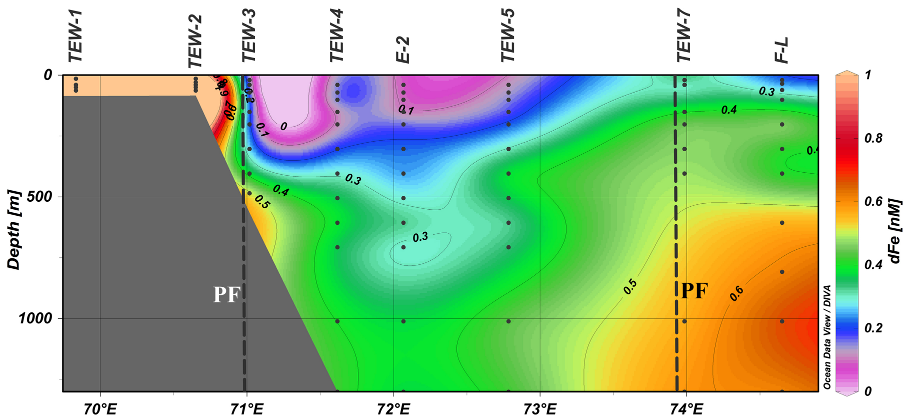
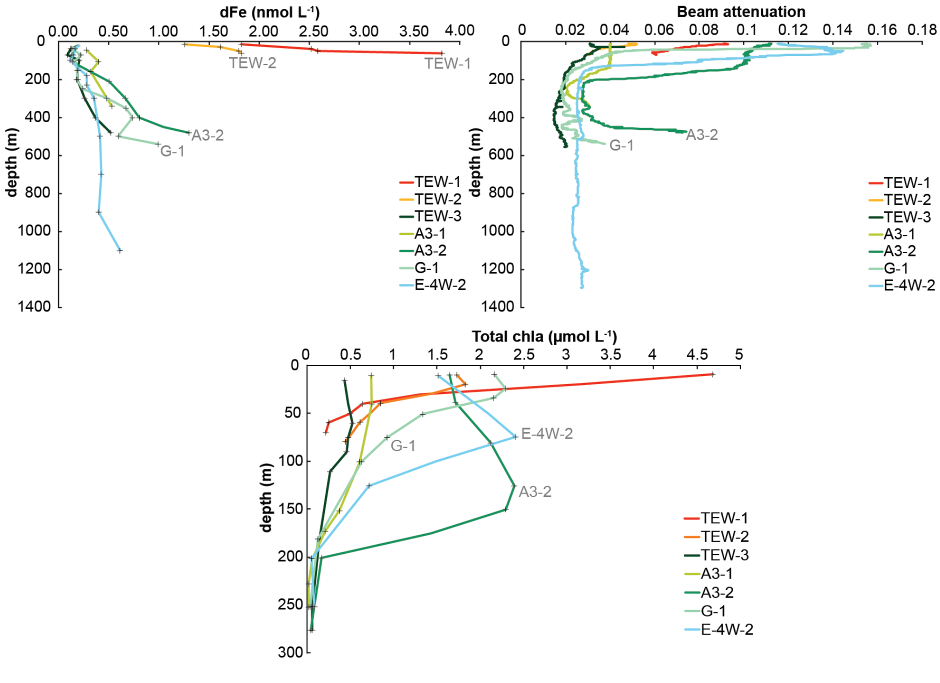

a)
b)
c)
d)
e)
dFe (nmol L-1)
Depth (m)
SASW
SW
WW
UCDW
AAIW
LCDW

Fig. 4.



TEW-1
TEW-2
TEW-3
TEW-4
E-2
TEW-5
TEW-7
F-L
Depth [m]
dFe [nM]
PF
PF
70°E
71°E
72°E
73°E
74°E
Ocean Data View / DIVA

Fig. 5.



dFe (nmol L-1)
Beam attenuation
Total chla (µmol L-1)
depth (m)
TEW-1
TEW-2
TEW-3
A3-1
A3-2
G-1
E-4W-2

Fig. 6.

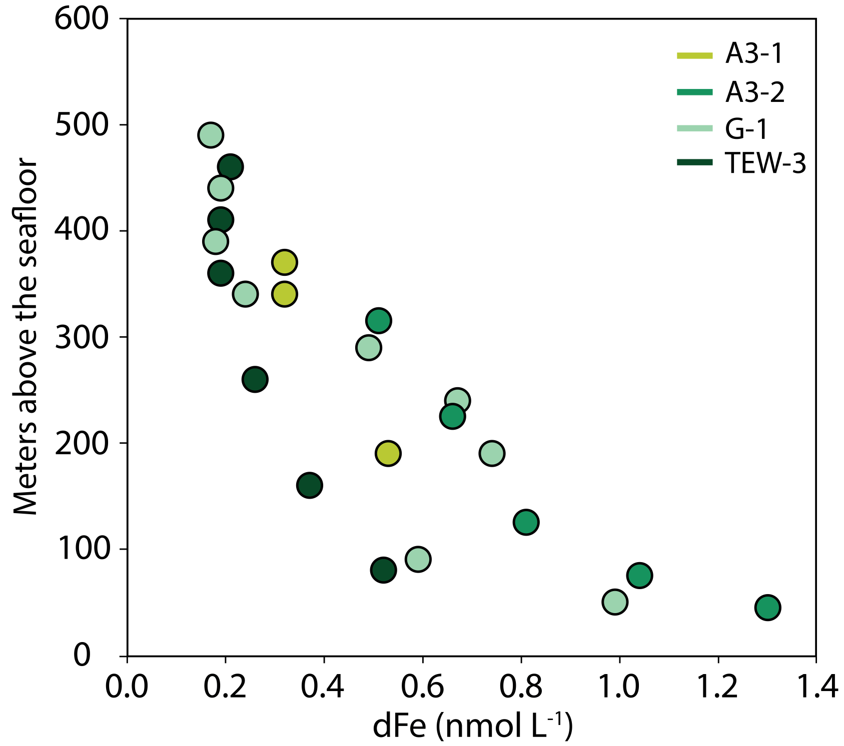

A3-1
A3-2
G-1
TEW-3
Meters above the seafloor
dFe (nmol L-1)
0
100
200
300
400
500
600
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

Fig. 7.

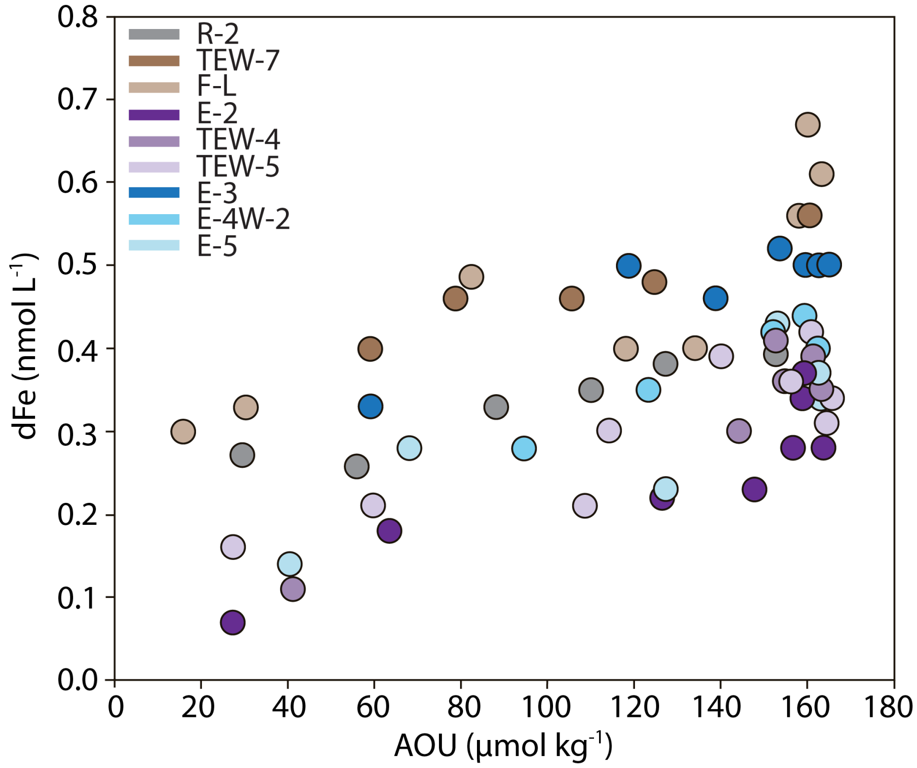

R-2
TEW-7
F-L
E-2
TEW-4
TEW-5
E-3
E-4W-2
E-5
dFe (nmol L-1)
AOU (μmol kg-1)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100
120
140
160
180

Fig. 8.