

Interactive comment on “Early season mesopelagic carbon remineralization and transfer efficiency in the naturally iron-fertilized Kerguelen area” by S. H. M. Jacquet et al.

Anonymous Referee #1

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Review of Early season mesopelagic carbon remineralization and transfer efficiency in the naturally iron-fertilized Kerguelen area by Jacquet et al.

Overview and major comments

This study is part of the KEOPS2 special issue investigating the downward flux of carbon in a naturally iron fertilized bloom in the southern ocean (Kerguelen). Although we recently gained knowledge on how POC is exported out of the sunlit layer of the ocean following natural fertilizations (Blain et al., 2007;Chever et al., 2010;Morris and Charette, 2013;Pollard et al., 2009;Le Moigne et al., 2014), a major unknown remains about the fate of the particulate organic carbon further down in the water column. This process is critical to understand if one wants to assess the genuine effect of Fe fertilization of atmospheric CO₂ concentrations. Jacquet et al present mesopelagic carbon remineralization rate data in the vicinity of the Kerguelen Islands. The paper focuses primarily on the differences in carbon remineralization rate between high and low iron regions and at different stage of the bloom evolution with emphasis on the efficiency with which POC is transferred into the ocean's interior. While I am not an expert in the “Barium” technique, my feeling is that the methods employed to derive estimates carbon remineralisation rate are well developed and sound, as are the estimates of POC export and primary production estimates presented elsewhere. Nevertheless, before I can recommend the manuscript for publication, significant modifications and improvement are necessary. The discussion lacks substance and only focuses on a basic description on the differences between difference sites sampled and the KEOPS1 results.

Reviewer: The authors do not clearly assess to which extent their metrics (r ratio, T_{400/800}) are impacted by the integration time of the various technique they used. The PP, the Th- POC export and the Baxs C remineralisation rate are all express as daily rates (g C m⁻²d⁻¹). However, PP (likely from bottle incubation, although the information is not available to the reader yet as Cavagna et al is not published) is integrated over a day (24or 12 hours incubation I assume) while the Th-POC export over a month (Le Moigne et al., 2013;Henson et al., 2011). The Baxs integration time seems less constrained and may well be over that of the Th-POC export. To overcome that problem, (Henson et al., 2011) integrated PP over a month which is comparable with the time-period which the Th technique integrates the POC-fluxes over. For instance, this has relevance to explain why the largest remineralisation rates (and subsequent r ratios, and T_s) are observed in the HNLC zone and why T_s (400 or 800) are on occasions larger than 100%. This needs to be assessed and discussed.

Reply: As detailed further below this has been discussed and revised in the ms.

Reviewer: Also, the manuscript would benefit of integrating recent observations about the mechanisms responsible driving the transfer efficiency in high latitude with highlights from some of the paper listed below (non exhaustive list though)(Henson et al., 2012;Le Moigne et al., 2012;Lam et al., 2011;Lam and Bishop, 2007;Maiti et al., 2013;Wilson et al., 2012;Buesseler et al., 2007;Morris and Sanders, 2012) etc... These propos dif- ferent processes as potential mechanisms to explain patterns in POC export/transfer efficiency in high latitude. It would be valuable to examine and discuss the dataset presented here regarding how the various locals Fe supply observed around the Kerguelen Islands impact patterns in POC export/transfer efficiency in high latitude. I do understand that this paper is part of a special issue and that a more comprehensive overview paper including this dataset might be put together later on. Nonetheless, a more thorough discussion of the results and their implications would be welcome to meet the publication criteria defined by Biogeosciences.

Reply: Discussion and references have been added in the ms.

Reviewer: Finally, the manuscript would benefit from serious improvement regarding language. It needs to be very thoroughly revised by a native english speaker, the text (including references list) is currently littered with typos and awkward sentences which makes the paper hard to read and sometimes confusing.

Reply: Language has been revised

Reviewer: Also, some manuscripts referenced in the text do not appear in the references list and the acronyms are not consistently used throughout the text.

Reply: References will be revised

Minor comments

P4_P9038, L10: Please refer to (Le Moigne et al., 2014) for most recent advance on the topic

Reply: the reference has been added in the text.

P4_P9038, L21: “and, and, and” rephrase. See general comment about language

Reply: the sentence has been rephrased.

P5_PP9039, L13: Any feeling on how long the Baxs technique intergrates the C remineralisation rate for?

Reply: The time window integration of the Ba signal ranges from few (1-3) days to few (1-2) weeks.

P5_P9039, L25: references

Reply: done

P6_P9040, L19: Dates please

Reply: dates have been added in the text

P9_P9043, L10: please specify “rates” after remineralization.

Reply: done

P11_P9045, L9: What are you referring to?

Reply: We referred to section 3.1. Note that these sentences have been rephrased as requested by the second reviewer. Some sentences about the surface Baxs signal have been added in section 3.1.

P11_P9045, L15: Four or for? needs rephrasing

Reply: we rephrased

P11_P9045, L28: The two

Reply: done

P12_P9046, L20 : Include (Robinson et al., 2014)

Reply: done

P13_P9047; L6: Sequestration efficiency refers to the sequestration efficiency (the excess of POC export divided by the excess of DFe supply) as defined in (Blain et al., 2007) and re-used in (Pollard et al., 2009; Morris and Charette, 2013; Chever et al., 2010; Le Moigne et al., 2014). Please stick to the established terminology to avoid confusion.

Reply: done

P13_P9047, L8: untill !!!! (“up to” would be adequate here).

Reply: done

P13_P9047, L10 and Table 2: EP/PP is called export efficiency (Buessler, 1998)

Reply: OK we mentioned it.

P13_P9047, L14: You imply here that remineralisation rates are a function of PP and export here (low PP/export; high remineralisation). Why C remineralisation rates would be negatively correlated with PP and export in the HNLC region?

Reply: The negative relationship between PP and PP and differences in EP/PP vs. MR have been discussed. The main reasons to explain the differences are the time delay between signals and differences in diatoms and sinking material.

P13_P9047, L16: Could you specify sampling depth? Trull et al and Laurenceau et al are not available yet.

Reply: done

P13_P9047, L22: Please provide information or references on what mechanism could potentially lead to an important winter production and subsequent export, *P13_P9047, L27:* you mean a previous winter bloom? and *P14_P9048, L3,* Is November in the Southern hemisphere wintertime? I believe not. The argument (or the date indicated) is not valid. Comparing that to previous estimation of C remineralization rate (from Baxs and other technique) estimated in other HNLC regions (and perhaps a bit further in the season) would provide valuable information on whether the HNLC region has intrinsically a more active heterotrophic community early in the season or whether the high C remineralisation rate observed here are an artefact of the Baxs technique integration time.

Reply (P13_P9047, L22, P13_P9047, L27 P14_P9048, L3): We checked Chla satellite image from the Giovanni online Visualization and Analysis system (NASA GES DISC). It appears that for different years, the R-2 and KERFIX area could indeed be subject to enhanced productivity during early spring periods, but it is not salient for winter period. The sentence has been revised in the ms. Also, as reported above the integration time of Ba ranges from several days to week and we can exclude a potential artefact of the Ba technique. According to results from Christaki et al. (this issue), the prokaryotic activity at station R-2 was low but column-integrated bacterial production (BP) below 150 m represents 41% of the 900 m column-integrated value, indicating that important mineralization of material transferred from the surface occurs at mesopelagic depths. Other parameters also show that an export event occurs at R-2 (Lasbleiz et al., this issue- Si:C, Laurenceau et al., this issue- particle composition, Dehairs et al., this issue- nitrate isotopes). Discussion has been revised.

P18_P9052: Nothing about the large remineralisation rate at the reference HNLC site in the conclusion?

Reply: Conclusion has been revised.