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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.

The authors do not clearly assess to which extent their metrics (r ratio, T400/800) 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 Ts) are observed in the HNLC zone and why Ts (400 or 800) are on occasions larger than 100%. This needs to be assessed and discussed.

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 different 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.

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

Minor comments P9038, L10: Please refer to (Le Moigne et al., 2014) for most recent advance on the topic P9038, L21: “and, and, and” rephrase. See general comment about language PP9039, L13: Any feeling on how long the Baxs technique intergrates the C remineralisation rate for? P9039, L25: references P9040, L19: Dates please P9043, L10: please specify “rates” after remineralization. P9045, L9: What are you referring to? P9045, L15: Four or for? needs rephrasing P9045, L28: The two P9046, L20 : Include (Robinson et al., 2014) 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. P9047, L8: untill !!!! (“up to” would be

adequate here). P9047, L10 and Table 2: EP/PP is called export efficiency (Buesseler, 1998) 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? P9047, L16: Could you specify sampling depth? Trull et al and Laurenceau et al are not available yet. P9047,L22: Please provide information or references on what mechanism could potentially lead to an important winter production and subsequent export. P9047, L27: you mean a previous winter bloom? 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 a artefact of the Baxs technique integration time. P9052: Nothing about the large remineralisation rate at the reference HNLC site in the conclusion?

References

Blain, S., Queguiner, B., Armand, L., Belviso, S., Bombled, B., Bopp, L., Bowie, A., Brunet, C., Brussaard, C., Carlotti, F., Christaki, U., Corbiere, A., Durand, I., Ebersbach, F., Fuda, J. L., Garcia, N., Gerringa, L., Griffiths, B., Guigue, C., Guillerm, C., Jacquet, S., Jeandel, C., Laan, P., Lefevre, D., Lo Monaco, C., Malits, A., Mosseri, J., Obernosterer, I., Park, Y. H., Picheral, M., Pondaven, P., Remenyi, T., Sandroni, V., Sarthou, G., Savoye, N., Scouarnec, L., Souhaut, M., Thuiller, D., Timmermans, K., Trull, T., Uitz, J., van Beek, P., Veldhuis, M., Vincent, D., Viollier, E., Vong, L., and Wagener, T.: Effect of natural iron fertilization on carbon sequestration in the Southern Ocean, Nature, 446, 1070-1074, 2007.

Buesseler, K. O.: The decoupling of production and particulate export in the surface ocean, Global Biogeochemical Cycles, 12, 297-310, 1998.

Buesseler, K. O., Lamborg, C. H., Boyd, P. W., Lam, P. J., Trull, T. W., Bidigare, R. R., Bishop, J. K. B., Casciotti, K. L., Dehairs, F., Elskens, M., Honda, M., Karl, D. M., Siegel, D. A., Silver, M. W., Steinberg, D. K., Valdes, J., Van Mooy, B., and Wilson, S.: Revisiting carbon flux through the ocean's twilight zone, Science, 316, 567-570, 10.1126/science.1137959, 2007.

Chever, F., Sarthou, G., Bucciarelli, E., Blain, S., and Bowie, A. R.: An iron budget during the natural iron fertilisation experiement KEOPS (Kerguelen Islands, Southern Ocean), Biogeosciences, 7, 455-468, 2010.

Henson, S., Sanders, R., Madsen, E., Morris, P., Le Moigne, F. A. C., and Quartly, G.: A reduced estimate of the strength of the ocean's bioloical carbon pump, Geophys. Res. Lett., 38, doi:10.1029/2011GL046735, 2011.

Henson, S. A., Sanders, R. J., and Madsen, E.: Global patterns in efficiency of particulate organic carbon export and transfer to the deep ocean, Global Biogeochemical Cycles, 26, 14, doi:10.1029/2011GB004099, 2012.

Lam, P. J., and Bishop, J. K. B.: High biomass, low export regimes in the Southern Ocean, Deep-Sea Research II, 54, 601-638, 2007.

Lam, P. J., Doney, S. C., and Bishop, J. K. B.: The dynamic ocean biological pump: insights from a global compilation of Particulate Organic Carbon, CaCO3 and opal concentrations profiles from the mesopelagic., Global Biogeochemical Cycles, doi:10.1029/2010GB003868, 2011.

Le Moigne, F. A. C., Sanders, R. J., Villa-Alfageme, M., Martin, A. P., Pabortsava, K., Planquette, H., Morris, P. J., and Thomalla, S. J.: On the proportion of ballast versus non-ballast associated carbon export in the surface ocean, Geophys. Res. Lett., 39, L15610, 10.1029/2012GL052980, 2012.

Le Moigne, F. A. C., Villa-Alfageme, M., Sanders, R. J., Marsay, C. M., Henson, S., and Garcia-Tenorio, R.: Export of organic carbon and biominerals derived from 234Th

and 210Po at the Porcupine Abyssal Plain., Deep Sea Research Part I, 72, 88-101, 10.1016/j.dsr.2012.10.010, 2013.

Le Moigne, F. A. C., Moore, C. M., Sanders, R. J., Villa-Alfageme, M., Steigenberger, S., and Achterberg, E. P.: Sequestration efficiency in the iron-limited North Atlantic: Implications for iron supply mode to fertilized blooms, Geophys. Res. Lett., 41, doi:10.1002/2014GL060308, 2014.

Maiti, K., Charette, M., Buesseler, K., and Kahru, M.: An inverse relationship between production and export efficiency in the Southern Ocean, Geophys. Res. Lett., 40, 2013. Morris, P. J., and Sanders, R. J.: A carbon budget for a naturally iron fertilized bloom in the Southern Ocean, Global Biogeochemical Cycles, 25, 2012.

Morris, P. J., and Charette, M. A.: A synthesis of upper ocean carbon and dissolved iron budgets for the Southern Ocean natural iron fertilization, Deep Sea Research II, 90, 147-157, 2013.

Pollard, R. T., Salter, I., Sanders, R. J., Lucas, M. I., Moore, C. M., Mills, R. A., Statham, P. J., Allen, J. T., Baker, A. R., Bakker, D. C. E., Charette, M. A., Fielding, S., Fones, G. R., French, M., Hickman, A. E., Holland, R. J., Hughes, J. A., Jickells, T. D., Lampitt, R. S., Morris, P. J., Nedelec, F. H., Nielsdottir, M., Planquette, H., Popova, E. E., Poulton, A. J., Read, J. F., Seeyave, S., Smith, T., Stinchcombe, M., Taylor, S., Thomalla, S., Venables, H. J., Williamson, R., and Zubkov, M. V.: Southern Ocean deep-water carbon export enhanced by natural iron fertilization, Nature, 457, 577-U581, Doi 10.1038/Nature07716, 2009.

Robinson, J., Popova, E. E., Yool, A., Srokosz, M. A., Lampitt, R. S., and Blundell, J. R.: How deep is deep enough? Ocean iron fertilization and carbon sequestration in the Southern Ocean, Geophys. Res. Lett., 41, 2489-2495, 2014.

Wilson, J. D., Barker, S., and Ridgwell, A.: Assessment of the spatial variability in particulate organic matter and mineral sinking fluxes in the ocean inte-

rior: Implications for the ballast hypothesis, Global Biogeochemical Cycles, 29, doi:10.1029/2012GB004398, 2012.

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