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Biogeosciences Discussions

Interactive comment on "Regional and temporal variability of sinking organic matter in the subtropical northeast Atlantic Ocean: a biomarker diagnosis" *by* I. J. Alonso-González et al.

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Reviewer #1: âĂĺ

General comments:

The authors investigate the regional and temporal variability of sinking organic matter in a region south of the Canary Islands. Both chlorophyll degradation products and amino acid analyses are applied to infer the origin and degradation state of the organic matter. This is in principle an important study, designed to test the influence of eddies on particle flux during both a summer and winter season in this eddy and filament influenced region. The paper is well written, but I have serious concerns mainly with

regard to the interpretation of the presented data:âĂĺ

Comment: We appreciate the reviewer's comment about our work.

Specific comments:

1. It is not clear in the context of this study why the stations to the very south (20N) are included in the analysis. If the main objective is to compare particle flux originating from different eddy types, then these 'S' stations appear a bit out of context, especially since the far-field stations already provide a non-eddy control.

Comment: Our study was conducted during two different periods of the year with the aim of evaluating the role of the Canary eddy field in the enhancement of organic matter fluxes, as well as to look at the spatial variability of organic matter fluxes in the Canary Current region during the time of the year when primary production is highest. Since regional scale variability in particle flux is also a major outstanding issue in biological oceanography we (and also reviewers #2 and #3) feel that we must include these "S" stations in our work.

2. It is hard to believe that there were no zooplankton present in the trap material. Anyone who has conducted any kind of shallow sediment trap work knows that swimmers are a regular occurrence in traps, usually dominating particles on the filters. The standard JGOFS trap protocol recommends a thorough analysis of the trap material, not just a cursory check. A non-quantitative removal of swimmers would seriously compromise the sample analysis.

Comment: We agree with the reviewer that a non-quantitative removal of swimmers would seriously compromise the sample analysis. However, swimmers were rarely present, but if so were processed in the laboratory according to the procedure described by Heussner et al. (1990). Large swimming organisms were removed by wet sieving through a 1 mm nylon mesh, while organisms <1mm were hand-picked under a microscope with fine-tweezers. A possible explanation to the low swimmers presence

in the trap material could be the short deployment time (24 h) or the fact that the cups were not poisoned during the short deployment time.

Action: We have included this information in the methods section (lines 148-152).

3. The authors measure GPP and respiration at each station, but never report NCP, which as it turns out, is negative during the summer months at most stations, even in the higher productivity zones. How is it then that any particle flux is occurring at all? Is it all due to advection of particulate material from the upwelling zone? If yes, then any inference to the productivity of the eddy is difficult to support.

Comment: The reviewer is right in his/her comment. Island eddies are not closed structures, rather they entrain and exchange water during their eddy-eddy and eddy-filament interactions. Presumably the entrainment of water with high content of organic matter would be stronger during the summer period, when island-eddies are more frequent and upwelling activity and Ekman transport are more intense. Anticyclonic eddies concentrate organic matter in their cores; this would explain the higher respiration rates compared to the cyclones. Nevertheless, cyclones may also entrain ambient water shifting the metabolic balance to heterotrophy (negative NCP) in spite of a low to moderate phytoplankton growth during summer. Overall, we agree with the reviewer in his/her appreciation that the negative metabolic balance could be caused by entrainment of organic matter advected from the upwelling, and thus "any inference to the productivity of the eddy is difficult to support".

Action: We have removed the community metabolism information from the manuscript, since we believe it is difficult to use unequivocally to interpret differences in the eddy fluxes.

4. Amino acids are very liberally used to infer degradation state and origin of the particles. No theoretical background is provided, despite this not being a common application in particle flux studies. For example, if culture experiments indicate the presence of an amino acid associated with an organism group or species, then its occurrence in the

field cannot be taken as an unequivocal evidence that exactly this group or species is present. In the current study, however, this is done: the relative distribution of diatoms and coccolithophorids is inferred solely based certain amino acids, without any parallel evidence such as microscopy, lipid analysis, genetic markers, carbonate and biogenic opal analysis etc. Also, amino acids certainly cannot distinguish coccolithophorids from the group of haptophytes. In comparison to the entire population of haptophytes, coccolithophorids are only a small component (see e.g., Haidar and Theirstein's work at BATS). There is a lot of hand waving on this subject, especially on p. 11106, lower paragraph.

Comment: We agree with the reviewer in the lack of theoretical background regarding the use of biomarkers. We did not provide theoretical background for using amino acids to infer degradation state and limited source because these techniques are commonly applied (see references below). We do not use amino acids unequivocally, but combine them with pigment data and other knowledge. We use them only to differentiate between opal-rich and carbonate-rich phytoplankton. The use of PCA has allowed amino acids to be used to infer degradation state and source much more robustly than early work in this area. Additionally, we suggest the presence of Coccolithophorids because this phytoplankton group has been identified as the main carbonate producer in the surface waters of the Canary Islands region (Sprengel et al. 2002; Abrantes et al. 2002). However, we understand the reviewer's point of view, so we have included a diagnostic table of pigments and amino acids with some references.

Some of the papers that have used amino acid and pigment composition to infer source in sediment trap studies:

Abramson, L., C. Lee, Z. Liu, J. Szlosek and S. Wakeham. 2010. Exchange between suspended and sinking particles in the northwest Mediterranean as inferred from the organic composition of in situ pump and sediment trap samples. Limnol. Oceanogr. 55: 725-739.

Engel, A., Abramson, L., Szlosek, J., Liu, Z., Stewart, G., Hirschberg, D., and Lee, C. 2009. Investigating the effect of ballasting by CaCO3 in Emiliania huxleyi: II. Decomposition of particulate organic matter. Deep-Sea Res. II, 56: 1408–1419, doi:10.1016/j.dsr2.2008.11.028

Fabres, J., Tesi, T., Velez, J., Batista, F., Lee, C., Calafat, A., Heussner, S., Palanques, A., Miserocchi, S. (2008) Seasonal and event-controlled export of organic matter from the shelf towards the Gulf of Lions continental slope. Cont. Shelf Res. 28: 1971-1983.

Goutx, M., S.G. Wakeham, C. Lee, M. Duflos, C. Guigue, Z. Liu, B. Moriceau, R. Sempere, M. Tedetti, and J. Xue. (2007) Composition and degradation of marine particles with different settling velocities in the northwestern Mediterranean Sea. Limnol. Oceanogr. 52: 1645-1664.

Ingalls, A.E., Lee, C., Wakeham, S.G., Hedges, J.I., 2003. The role of biominerals in the sinking flux and preservation of amino acids in the Southern Ocean along 1701W. Deep-Sea Research II 50, 713–738.

Ingalls, A.E., Z. Liu and C. Lee (2006) Seasonal trends in the pigment and amino acid compositions of sinking particles in biogenic CaCO3 and SiO2 dominated regions of the Pacific sector of the Southern Ocean along 170°W. Deep-Sea Res. I. 53: 836-859.

Ittekkot, V., Degens, E.T., Honjo, S., 1984a. Seasonality in the fluxes of sugars, amino acids, and amino sugars to the deep ocean: Panama Basin. Deep-Sea Research 31, 1071–1083.

Ittekkot, V., Degens, E.T., Honjo, S., 1984b. Seasonality in the fluxes of sugars, amino acids, and amino sugars to the deep ocean: Sargasso Sea. Deep-Sea Research 31, 1057–1069.

Lee, C., Cronin, C., 1982. The vertical flux of particulate organic nitrogen in the sea: decomposition of amino acids in the Peru upwelling area and the equatorial Atlantic. Journal of Marine Research 40, 227–251.

Lee, C., Hedges, J.I., Wakeham, S.G., Zhu, N., 1992. Effectiveness of various treatments in retarding microbial activity in sediment trap material and their effects on the collection of swimmers. Limnology and Oceanography 37, 117–130.

Lee, C., Wakeham, S.G., Hedges, J.I., 2000. Composition and flux of particulate amino acids and chloropigments in Equatorial Pacific seawater and sediments. Deep-Sea Research I 47, 1535–1568.

Liu, Z., C. Lee and S.G. Wakeham. (2006) Effects of mercuric chloride and protease inhibitors on degradation of particulate organic matter from the diatom Thalassiosira pseudonana. Org. Geochem. 37: 1003-1018.

Moriceau, B., Goutx, M., Guigue, C., Lee, C., Armstrong, R.A., Duflos, M., Tamburini, C., Charrière, B. and Ragueneau, O. 2009. Si-C interactions during degradation of the diatom Skeletonema marinoi. Deep-Sea Res. II, 56: 1381–1395, doi:10.1016/j.dsr2.2008.11.026

Müller, P.J., Suess, E., Ungerer, A., 1986. Amino acids and amino sugars of surface particulate and sediment trap material from waters of the Scotia Sea. Deep-Sea Research 33A, 819–838.

Tamburini, C., Goutx, M., Guigue, C., Garel, M., Lefèvre, D., Charrière, B., Sempéré, R., Pepa, S., Peterson, M.L., Wakeham, S.G., and Lee, C. 2009. Effects of hydrostatic pressure on microbial alteration of sinking fecal pellets. Deep-Sea Res. II, 56: 1533–1546, doi:10.1016/j.dsr2.2008.12.035

Wakeham, S.G., Lee, C., Peterson, M.L., Liu, Z., Szlosek, J., Putnam, I., and Xue, J. 2009. Organic biomarkers in the Twilight Zone - Time series and settling velocity sediment traps during MEDFLUX. Deep-Sea Res. II, 56 (2009) 1437–1453doi:10.1016/j.dsr2.2008.11.030

Action: We have included a diagnostic table (Table 3) of pigments and amino acids in the results section to clarify the conclusions.

5. The literature on chlorophyll degradation products as proxies of microzooplankton or mesozoopalnkton grazing is fairly old, and has to my knowledge not been corroborated in more recent literature. Much is interpreted into the occurrence of pheophytin-a, pheophorbide-a and pyropheophorbide a. For example, if mesozooplankton feed on microzoopankton, their preferred food source, what is the result in the pigment signature? Pigment would be likely degraded to not show a signal at all. Inferring from the absence of degradation pigment low grazing pressure by mesozooplankton would thus not be warranted.

Comment: Neither has it been invalidated. See the papers listed above for more modern interpretations based on PCA.

6. 11104, top: The authors do not carefully distinguish results obtained in their study region with those obtained in flux studies conducted at the oligotrophic ESTOC station to the north of the islands. In the same context (p. 11109): The work cited on flux results obtained at ESTOC did indeed present multi-year and mulitseasonal flux data, thus was misrepresented.

Comment: We agree with the reviewer in the unfair comparison stated here.

Action: We have removed the comparison with the Neuer et al. 2002 study.

7. The authors need to look into Mc Gillicuddy's observations (2007) of wind interaction with anticyclonic and cyclonic eddies causing upwelling and downwelling. This can give an alternative explanation to the observed difference in standing stocks between both eddy types.

Comment: We agree with the reviewer and appreciate the comment.

Action: We have followed the reviewer's suggestion and included this alternative explanation in the discussion section (lines 499-504).

Interactive comment on Biogeosciences Discuss., 6, 11089, 2009.