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Biogeosciences
Discussions

Interactive comment on "Volume distribution for particles between 3.5 to 2000 μm in the upper 200 m region of the South Pacific Gyre" *by* L. Stemmann et al.

L. Stemmann et al.

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We would like to thank the reviewer for their constructive reviews that increased the quality of the manuscript. The responses are given below together with the reviewer comment.

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General Comments: This paper presents some very nice and interesting data on the size distribution of particles at two contrasting stations in the South Pacific. There are two main results in this paper: 1) particle number spectra in the South Pacific, and 2) the small but not the large particle population exhibit diel behaviour. More of this type of high time and depth resolution data is what is needed to move forward with understanding the dynamics of the highly variable particle field, and this paper represents a nice contribution to the field. The diel result stands on its own and has very interesting implications for understanding particle dynamics. The interpretation of the number spectra results and subsequent conclusions need some more attention before publication, however, particularly in how the number spectra are transformed to volume/mass/POC spectra/concentration profiles. The results of these transformations hinge critically on the fractal dimension used, and not enough justification is given for the values they chose.

RESPONSE: It is absolutely right that the POC estimation using the particle spectra relies on critical assumption on the instruments, POC/DW ratio, fractal dimension and other. We do not have the information to test most of them in a precise way. Therefore, we have tried to assess the potential effects of changing the model parameters by calculating a range of POC estimates using different values. We have performed much more calculations that are in the manuscript. We have added a paragraph to explain better our choices.

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Specific Comments: Discussion Section 4.3: the sensitivity of the mass/volume spectra to the value of the fractal dimension (eg. Fig 9) highlights the limitation of the particle-counting approach to biogeochemistry. Unless we know how to transform particle number spectra into mass or volume units, the usefulness of knowing particle size spectra is lessened. It is therefore of utmost importance to constrain the fractal dimension as well as possible. Using POC measured from Niskin bottles is a good start for calibrating HIAC calculations. (In fact, the flow of the logic in section 4.3 could be improved; instead of starting with the assumption that HIAC measures a conserved diameter, pose it as a question, and use the POC data to help constrain it).

RESPONSE: In the laboratory, the HIAC and coulter spectra match very well. It is difficult to constrain the calibration using the field observation of POC because there is

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a great variability in the sampling. The POC was not measured in the same samples as the HIAC. So we prefer to start by using laboratory measurement on well known particles and make the hypothesis that the HIAC measures a conserved diameter and then quantify the error if the hypothesis is not valid.

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What other geochemical data are available from the cruise that could be used as an independent cross-check on particle mass calculated from the number spectra? It would be even better if measured dry weight data are available, since the dry weight to POC conversion is very variable (the authors use 2019988211;finds that this number ranges from 20-40I expect it could be very different in an ultra oligotrophic environment). The methods section stated that an in-situ pump was deployed. These can sample hundreds to thousands of liters, certainly adequate to collect enough large aggregates for POC and dry weight analysis. Is there anything available that could help constrain the fractal dimension for the UVP particles?

RESPONSE: We have used a POC/DW ratio of 50We would have liked to get better data to constrain the fractal dimension of the UVP particles. In fact the sediment trap data of particle mass flux have been included in the data set used in the work of Guidi et al to constrain the fractal dimension to a value of 2.3. It is better to use fluxes data rather than suspended particle data because the particles in the size range of the UVP are those that make the flux. The in situ pumps were moored only at 6 sites and only at two depths. The data are not yet available.

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Rather than derive a fractal dimension themselves, the authors use D710;3=2.3 from Guidi et al, in review, which was determined on the same cruise. However, even using D710;3=2.3 seems to greatly overestimate POC (5-10 fold, by my reading) from HIAC compared to the GF/F filtrations from Niskins (Fig 10). In fact, the predicted POC should probably be higher since it is possible that POC accounts for a larger fraction

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of dry weight in these oligotrophic regions. Doesn8217;t this imply that the fractal dimension for HIAC-sized particles should be even lower than 2.3? A more thorough justification of using D710;3=2.3 is certainly needed, particularly in light of the discrepancy between the HIAC calculations of POC and GF/F POC.

RESPONSE: The dataset for deriving a fractal dimension of 2.3 is more extended than the cruise sediment trap data. In the work of Guidi et al., the authors use 120 sediment traps data from different oceans and all located below 100 m and down to 1000 m depth. They use the mass flux recorded in the sediment trap to constrain the values of D3 . Then using a Monte Carlo procedure, Guidi et al, derived interval of confidence. We have used the lower value of 1.9 to recalculate the POC. The lower value has an important effect on POC estimate of the UVP particles because aggregates porosity has increased. The decreasing effect on the HIAC POC estimates is lower and closer to the values the measured POC in the deepest strata. There is still an over-estimation in the upper strata suggesting that the fractal dimension varied with depth.

Guidi et al., could not detect a change in the fractal dimension with depth between 100 and 1000 m. However it is possible that the fractal dimension changes with depth in the first 200 m depth because most of the biological processes (primary production, grazing) and physical processes (turbulence) varies a lot. In fact our observation in figure 10 shows that the POC derived from the spectra overestimates the measured POC much more in the upper 5 m depth than in the deeper layer suggesting that the fractal dimension could be even lower than 1.9 principally in the upper 5 m depth.

Finally in the revised manuscript, we have recalculated the spectra for figures 9 and 10 using in addition to a value of 2.3, the value of 1.9 in figure 9 and replacing 2.3 by 1.9 in figure 10. We have modified the text in the discussion and conclusion to express how important it is to have the information of the fractal dimension.

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p. 3392, lines 16-29 and Conclusions: given that the HIAC-calculated POC using

D710;3=2.3 is so different than the GF/F POC, and the UVP-calculated POC are uncalibrated, I am not convinced of the validity of using D710;3=2.3 across the board to compare the disproportion of mass between the two particle pools, and am particularly not convinced by statements in the conclusion that hinge on this, such as "we show that the number spectra can provide realistic estimates of particle mass...", and "the mass of large particles can equal the mass in the smaller particles...". This type of statement would be better supported by actual geochemical measurements of size-fractionated particles, something that is easy enough to do using in-situ pumps and doesn8217;t require the time and depth resolution of the techniques used here. A more appropriate conclusion would be to dwell on the statements the authors already make (Conclusions, lines 8-11), that knowing the geometric properties of particles is crucial in order to take advantage of these types of data, and further discuss the range in the particle mass concentrations as a result of different geometric properties.

RESPONSE: We agree with the reviewer that we should be more cautious in the conclusion and we have changed it accordingly.

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Introduction: The overall impact of this paper could be increased by putting the number spectra data into better context, particularly in the introduction. As biogeoscientists, we care about the particle number spectrum because it provides insight into particle dynamics and thus into carbon transport to depth, not because we might be able to calculate the mass of the Loch Ness monster. Plenty of other papers make these links (many referenced and/or even written by some of the authors, plus those by Alldredge et al, among others), but the introduction as written makes it feel like a mathematical curiosity rather than convincing us that it8217;s an important parameter for understanding the marine system. The promise of in-situ camera data is to allow sampling at time and depth resolutions that are not possible for discrete geochemical analyses. Further, constraining the particle number spectra would allow the extrapolation of results to size ranges that are usually not easily sampled. These are points that need to be

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made explicit in the introduction.

RESPONSE: We have changed the introduction to stress the point raised by the reviewer..

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Section 2.3: the fractal dimension ends up being a very sensitive parameter for transforming from number spectra to mass/volume spectra (cf. figures 8,9). It is worth putting in an equation showing how it is used in calculations (how d$_c, d_f, and D710; 3arerelated).$

RESPONSE: The complete description is given in other papers (Jackson et al,1995 and 1997) and we do not believe that it is appropriate to repeat it here.

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p. 3387, line 18: It8217;s interesting that the DCM does not coincide with the HIAC particle max. This (the fact that the DCM is deeper than the Prochlorococcus/HIAC peak at 100m) would be a good point to clarify, otherwise the logic in lines 20-24 is confusing.

RESPONSE: In fact the Cp data have shown that most of the particles in the layer where Prochloroccus dominated the phytoplankton were in fact non vegetal particles (Grob et al., 2007). According to these authors the fraction of vegetal particles increased with depth and was highest in the DCM. Because the HIAC measures all particles while the flurometer provides an index for physiological active cells, the DCM do not coincide with the particle max when non vegetal particle dominate. We have expanded this point in the manuscript.

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p. 3388, lines 11-12, 15: how were the aggregate and mesozooplankton observations made?

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RESPONSE: We have expanded this point in the manuscript.

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p. 3388, last paragraph: the unidentified objects are worth reporting, particularly since this is thought to explain the shallower slope for the number spectra at MAR, but the discussion could be shortened considerably as it fits into a curiosity category more than anything else.

RESPONSE: We keep the paragraph as it because we think that these objects are important.

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Technical Corrections: p. 3389, line 17: "steeper" corrected p. 3391, line 5: comma after D3=2.3; "compared to" corrected

Figure 8 is never referred to in the text! I think it belongs with p. 3391, line 19. The legend has a different variable convention than the figure caption.

RESPONSE: Right, we have corrected this point in the manuscript.

Interactive comment on Biogeosciences Discuss., 4, 3377, 2007.

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