Interactive Comment on "Global variability of phytoplankton functional types from space: assessment via the particle size distribution" *by* T.S. Kostadinov et al.

T.S. Kostadinov et al.

We thank Anonymous Referee #1 for providing useful comments to our manuscript. Below are our responses (plain font) to his/her comments (*italics*).

Responses to General Comments

In spite of these strengths, my biggest reservation with the manuscript is there seems to be two mixed agendas: 1) to bolster confidence in the Kostadinov et al. 2009 approach through additional validation with the Vidussi et al. 2002 HPLC estimate of size and comparison to two other PFT approaches; 2) to describe PSD trends in comparison with SST and chl. While I think both of these aspects deserve publication, I am not sure that combining them into the same manuscript is the best approach. I suggest that the authors consider separating these aspects into two separate manuscripts and develop each aspect more fully. One on hand, the validation paper could compare the Kostadinov et al. 2009 approach more fully to additional PFT methods in the literature beyond just Uitz et al. 2006 and Alvain et al. 2008. On the other hand, it seems that the trend aspects could use more in depth investigation of the relationship between PSD and chlorophyll beyond just correlation analysis. The manuscript mentions connections to physiological state and also the need for further work to assess the sensitivity to size limits and the feasibility of operational choice of dynamic ranges regionally (paraphrased from page 4312), in addition to further work to carefully validate and study parallel trends in the PSD products and their uncertainties to address biomass changes (paraphrased from page 4318), among others also mentioned. These aspects could be developed in greater detail if the manuscripts were split, as suggested.

The goals of our manuscript are to 1) Describe a very important application of the output of the Kostadinov et al. (2009) PSD approach, i.e. retrieval of the PFT's based on size as independently of Chl and absorption or pigments, which previous methods relied upon; 2) validate the results as best as possible given availability of global data and in-situ PFT methodology; 3) use the available SeaWiFS data set to calculate global climatologies and describe them, focus on a few well known sites and look at the time series of relevant variables, as well as perform basic analysis of decadal trends and relationships with ENSO. In preparing the manuscript, we arrived at the conclusion that a paper just on the validation of the PFT from PSD method is not publishable on its own. But a paper on applying this method to look at PFT's will require some form of validation. Hence the paper we submitted. That said, we do agree that this may seem like a lot to present in one paper.

Further it was not our objective to analyze relationships of PSD–derived variables to Chl or SST or other ancillary variables in detail – but rather to support the validation of the PFT from PSD method. As the reviewer suggests, that is the objective of possible future work and a different manuscript. Furthermore, the use of PSD parameters to retrieve actual particle volume and possibly carbon content and relating these retrievals to Chl is

what is of real importance to the community, and that is work in progress we are not ready to publish yet.

Responses to Specific Comments

Page 4302, lines 16-21 – Did you use the single 9 km pixel that contained the HPLC sample or another means of match-up (3x3 box, etc: : :)? Please clarify.
Yes, the single pixel only was used; this is now clarified in the text.

Page 4303, line 15 – it would be helpful if you could incorporate the geographical bounds of the regions you considered into a figure.
The following figure (Fig. 2) was added as requested:

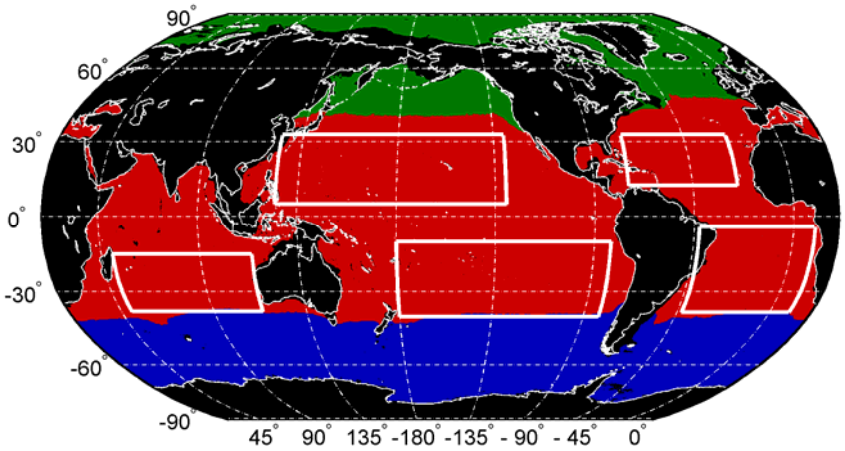

Figure 2. Boundaries of the nine geographical regions considered in the present analysis. The five subtropical oligotrophic gyres are delineated with white lines; boundaries are after McClain et al. (2004). The global deep waters (> 200 m depth, 'Global Region') are split into three sub-regions, namely Warm Ocean (red, > 15 ^{o}C decadal average SST), North Hemisphere Cold Ocean (green) and South Hemisphere Cold Ocean (blue). See Tables 1 & 2 and Sect. 2.5. Robinson's projection centered on 160^{o}W is used here and for all subsequent maps.

Page 4304, line 5-6 – the use of "inclusive" should be explicitly called out. I think what you are talking about is the use of data from 1997 – 2007, whereas data from 2000-2007 was considered separately due to the influence of ENSO. Please clearly define in sections 2.4 and 2.5 and find a term to refer to each timeframe of data.
'Inclusive' was deleted from the confusing sentence and Section 2.5, paragraph 1 was paraphrased to clarify what is meant by period with and without strong ENSO years. We believe the periods are clarified as is and no special terms are needed.

Page 4304, lines 14-15 – How to you define satisfactory, good and poor?
The use of these ambiguous classifications was abandoned, the specific R^2 values of the validation are now given in the sentence and only 'satisfactory, though clearly not excellent' vs. 'worse' is used.

Page 4304, lines 21-22 – "Namely, the SeaWiFS PFT retrievals showed a cluster of results near 45% : : :". This is not clear. Are you still talking about nanos? Why do you think this happens? This seems more like a ceiling in the retrieval. Elsewhere in the paper you mention a maximum of 51% for nanos, the figure looks to be clustering closer to 50% rather than 45%.
The sentence was rephrased to make it clear we are talking about nanoplankton. Indeed, the clustering is around 50 and we believe it is due to the mentioned ceiling in the retrieval, evident in Fig. 1.

Page 4304, line 24 – "validation should be considered as satisfactory" While I agree with the points that you bring up here and in section 4.2, declaring the statement above seems like hand waving. I think the definition of satisfactory needs to be stated clearly and the aspects that lead to a "satisfactory" conclusion needs more explanation.
This sentence was removed and the reader is now referred to Sect. 4.2 for further discussion of the validation.

Page 4310, line 18 – Please indicate why the 30Wand 140W meridional sections were selected. Why not a different location?
These sections were selected as representative of the Atlantic and Pacific Oceans and spanning most latitudes. They were meant as an example, rather than in-depth analysis at these specific locations. The Pacific section is nicely illustrative of the island effect of the Marquesas, as explained.

Page 4314, line 9 – "generally satisfactory" Again, please define following comments for pages 4304.
Usage was removed and concrete R^2 values are now given.

Page 4317, line 11 – you may want to also consider Gregg et al. 2005 in this discussion. Gregg et al. Recent trends in global ocean chlorophyll. Geophysical Research Letters (2005) vol. 32 (3) pp. L03606, doi:10.1029/2004GL021808.
A sentence was added in the discussion to include the results of Gregg et al. (2005).

Page 4317, lines 17-21 – Regarding the point brought up in these 2 sentences: : : I feel that this cold be accomplished with here, but needs more through analysis!
We thank the reviewer for this suggestion, but we believe that this is a matter that, as he/she points put, needs much further analysis and in our opinion certainly deserves a separate manuscript. Moreover, assessment of carbon biomass would be desirable as well, before attempting to resolve biomass vs. Chl changes. This is work still in progress. In summary, we believe this issue should be mentioned here but developed fully in another manuscript.

Page 4318, line 1 – "units of per century" Why was century chosen? This is confusing and misleading.
This was corrected in Table 1 and in the text as indicated.

Page 4318, line 18-20 – "Further work needs to be devoted to more careful validation and study of the parallel trends in the PSD products and their uncertainties in order to

address this important issue." What is stated as needing further work – isn't this the point of the manuscript? This should be fully developed in the two manuscript approach that I suggest!
Please see our response to the General Comments above.

Figure 10 – I find this figure confusing. In a bar graph, one expects to compare the values between this study and Alvain et al. 2008 side-by-side. This doesn't seem to be the case. It is confusing which values are Alvain and which are Kostadinov. Please find another way to present this idea/data.
As we explain in the text, the categorical classification of Alvain et al. (2008) is not directly comparable to the continuous PFT retrievals we generate. Also, Alvain et al. (2008) provide six different PF T categories. We therefore grouped the Alvain categories according top size to match our picos, nanos and micros. We then look at what our PSD algorithms says in terms of percentages for every pixels categorized as either picos or micros by Alvain. This is the analysis the bar graph is representing and we believe it's the best way to perform the inter-comparison and graphically represent it. The Figure caption was substantially edited to further clarify what the figure represents.

Responses to Technical Corrections
Page 4298, line 1 – there needs to be a better transition regarding the spatial difference between HPLC ship observations and satellite imagery.
Paragraph was edited to improve the transition as requested.

Page 4300, lines 14-15 – the authors use "was then", "were then" repetitively. Please reword the second occurrence.
Repetitive and unnecessary use of 'then' was eliminated.

Page 4301, line 10 – "very rare" Can this be defined quantitatively?
All monthly PSD slope images were tested and the PSD slope is never actually exactly equal to 4 at double precision, which means Eq. 2b is never used. The sentence was reworded so as to not imply actual usage of Eq. 2b. It is still included in the manuscript for completeness and because in practical application users may often need to use the Eq. with $\xi = 4$ exactly. The use of double precision representation in computation does not imply that many significant digits; the uncertainty around each value of ξ is treated separately in Kostadinov et al. (2009).

Page 4302, line 14 – NGDC ETOPO2 – should be defined
Citation of data source has been clarified as requested.

Page 4306, line 1-2 – "(note the same color scale is used)." I suggest adding "for all size classes" to the end of this statement.
Sentence fixed as suggested.

Page 4308, line 15 – "first-order correspondence" Define what you mean.
We assume reviewer means page 4307, Line 15

Changed ‘first-order’ to ‘visual’ to indicate that the correlation was not calculated quantitatively or analyzed in detail.

Page 4308, line 13 – “North Atlantic Drift Providence” I assume this is one of Longhurst’s provinces, but you should probably reword to clarify. Each other use of Longhurst’s provinces was clearly attributed.
Another citation of Longhurst et al (2007) was added to clarify the sentence.

Page 4309, line 13 – “w/chl” Please spell out.
‘decoupled from chl’ is now used.

Page 4309, line 19 – “large differences” is used repetitively. Please find another way to state the second occurrence.
Sentence was revised to remove repetitive use.

Page 4309, line 22 – “Fe” use “iron” instead.
Fixed.

Page 4310, line 6 – “This fell to almost 0% : : :” I assume you are talking about microplankton here, but should state to be clear.
Sentence was revised to clarify the meaning.

Page 4310, line 11 – degree symbol should be added to 3C and 8C
Fixed.

Page 4313, line 29 – missing “)”
Fixed.

Page 4314, line 1 – “This is an encouraging result: : :” Clearly state what you are referring to, low uncertainty?
Reworded sentence to clarify.

Page 4315, lines 16-18 – The sentence “The x-axes: : :” should be in the figure caption not in the text.
The sentence was moved to the caption of the figure.

Page 4315, line 24 – “(Fig. 11b)” I believe this should be Fig. 10b.
Fixed.

Page 4316, first paragraph – I believe all references to Fig. 12 should actually be Fig. 11.
Fixed.

Page 4317, lines 4-5 – Please reword this sentence. How can a warming be global if it is significant at only two locations? Remind the reader that significance is determined by the p-value.

The sentence was reworded and clarified, and an explanation of significance was added. The global trend observed may be driven primarily by a specific region, so that a globally significant trend doesn't imply locally significant trends.

Page 4317, line 29 – "decrease of -0.02/decade" Decrease of what? Particles? Please be explicit.
The sentence begins with 'The PSD slope trends…', so it is clear that the trend cited refers to the PSD slope, ξ. We believe this sentence does not need revision.

Page 4319, line 7 – state what years were considered for this analysis, it not clear if this is just 1997-1999 or 1997 – 2007.
The whole period 1997-2007 was used. This is indicated in the caption of Table2, but a clarification was also added in the text.

Table 1 – why do you report trends per century? Why not choose something more in line with the length of your data record?
Trends are now listed in per year, with the values multiplied by 100 for clarity. This keeps the values the same, but the presentation is less confusing and misleading.

Table 2 – state years of analysis in the first line of the caption rather than the last line. Check tense of all sentences.
Caption of Table 2 was edited as suggested.

Figure 4 – "number concentration" This is a confusing term. How about just number of particles per m3 as stated at the end of the caption.
Number concentration, area concentration, and volume concentration are standard terms used in marine particle size distribution and optics studies. Terms such as 'abundance' can be more confusing because it is not completely clear if the term refers to numbers, mass, and particles per m^3 is just the unit. We therefore believe that 'number concentration' should be preserved; however we do agree that sentences become more cumbersome with this usage and have edited the caption to clarify the unit earlier.

Figure 7 – check tense in caption
Tenses in caption were fixed.