

Response to the Reviewer #2 (OSD-8-C990-2012):

General Comments (Reviewer #2):

C01: The weakest element of this paper, I believe, is the fact that the estimated data are not compared to in situ measurements. However, I believe that the authors were creative in comparing their results with independent approaches to estimate chl-a concentrations for 2 of the 3 PFTs they identified. Although it remains to be proven that PhytoDOAS is applicable for identification of dinoflagellates, since no comparison was shown in this paper. To further prove the correlations between the chl-a estimated from PhytoDOAS and other approaches, I would suggest to plot the data one method against the other rather than simply showing maps of the trends in chl-a.

R01: Motivated by some comments given by the reviewers, we became convinced that the focus of this paper, based on the existing evidences, must be only on the group of coccolithophores. This is because the particular configurations developed so far in our method improvement is targeting mainly the PFT target of coccolithophores, even though the results are also reasonable for diatoms (compared to the result of Bracher et al. 2009). Therefore to adequately address this, opposed to the initial title chosen for the manuscript published in Ocean Science Discussion, we have modified the title as follows:

“Improvement to the PhytoDOAS method for identification of coccolithophores using hyper-spectral satellite data.”

This was also motivated by the lack of an appropriate in-situ or satellite dinoflagellate product to evaluate the PhytoDOAS dinoflagellate data set.

Moreover, as another data source for validating PhytoDOAS coccolithophores, we have used the global distribution of haptophytes obtained from a PFT method developed by *Hirata et al.* (2011). In this PFT algorithm the pigment-derived synoptic relationships are applied to the SeaWiFS level-3 chl-a products to reach the information of different PFTs. However, *Hirata et al.* (2011) showed that the currently available global HPLC-based data set on dinoflagellates is not normal distributed and a significant abundance-based relationship for dinoflagellates chl-a to total chl-a could not be inferred (which can then be used to derive a satellite-based estimate of dinoflagellate distribution).

In addition to validate our new coccolithophore PhytoDOAS product we also added a scatter-plot depicting the comparison of monthly means of PIC conc. from MODIS and chl-a contents of PhytoDOAS coccolithophores for a coccolithophore rich area in the North Atlantic covering the years 2003 to 2010 (according to *Sadeghi et al.* 2012). It is now shown as Fig. 9 in the revised manuscript.

C02: The main goal of this paper is to prove that PhytoDOAS is a powerful tool to estimate chl-a for numerous PFTs at the same time. Thus, why did the authors not include cyanobacteria in their analysis, since they already proved in a previous paper that it could be identified from this approach?

R02: As mentioned before in response to Reviewer #1 (in R05):

Cyanobacteria are spectrally more different as compared to the other PFTs' spectra incorporated in the current multi-target fit-mode. Technically, putting cyanobacteria in the simultaneous fit does not help to reach the optimal fit quality for this group and cyanobacteria have to be fitted in a different wavelength window in order to be retrieved optimal. In addition, the global distribution of cyanobacteria, as shown by instance by *Bracher et al.*, (2009) is also quite different from the other PFTs of interest, which is due to their specific oceanic habitats resulting from their specific biological growth conditions.

To address this issue, we have already added this explanation in sec. 2.4, where we talk in detail about the different considerations for choosing the right PFT set (according to the a-priori biological knowledge of PFT distribution), associated with the outcomes of the “orthogonality tests” (explained

as *Appendix A* in the revised manuscript).

Specific comments (Reviewer #2):

C03: Is it necessary to present the full description of the approach since it has already been published in other papers?

R03: That's true. However, the initial idea was to have a structure containing the main principal concepts and quantities of DOAS, which are essential for a reader to follow easier the modification exerted in PhytoDOAS. Nevertheless, to take similar points given by the Reviewers in this regard, we reduced the description part of DOAS consistently, which made the manuscript much shorter (about 2 pages). The full description of DOAS principles have been addressed by the cited appropriate papers.

C04: The authors should add a table for the symbols with their units.

R04: Since the DOAS description, as the most mathematical part of the manuscript, has been significantly reduced in the revised version, we think this table is not needed any more.

C05: The level of the English in section 3 is somewhat weaker than in the other sections and should be adjusted.

R05: It has been revised and modified. The English structure and formulation of the purposes have been changed in many paragraphs accordingly.

C06: Fig. 6: I think it would be more interesting to show a map of the ratio of the chl-a for each PFT instead than just showing the chl-a concentration. It could be 2 extra panels next to the chl-a maps. Same apply to Fig. 7.

R06: As mentioned in R01, since other PFT than coccolithophores have already been removed from the focus of the study, this comparison table may not be needed any more. However, a scatter-plot depicting the monthly means of PIC conc. and chl-a contents of PhytoDOAS coccolithophores has been added in the revised manuscript, pertaining to a coccolithophore rich area in the North Atlantic from 2003 to 2010 (shown as Fig. 9), as mentioned in R01.

C07: Fig. 8: I find that the comparison is weak between the different panels by only showing the maps. To make a stronger impression, the authors should plot the values of chl-a from PhytoDOAS and NOBM, and PhytoDOAS and PIC data, especially since they do not show in situ measurements to compare their chl-a estimates. Same apply to Fig. 9 and 10.

R07: Please see R07.

C08: Fig 9 and 10: Same as in Fig. 8

R08: Please see the response to R06.

Technical corrections (Reviewer #2):

P3, L26: change ‘as the measure of phytoplankton biomass’ for ‘as a proxy for phytoplankton biomass’
It has been corrected.

P6, L2-3: Please provide the units for L and wavelength

In the revised version, this part has been removed for the reduction of method description.

P6, L21 and eq3: As a general rule, I always prefer when a symbol is represented by a unique letter, otherwise SC could be confused by S*C. If possible, please modify the symbol for slant column density.

This might be confusing, because the “slant column density” has been usually denoted as “SC” in other DOAS literature, particularly in most of respective papers being referenced in this manuscript.

P15, L20: change ‘left panel’ for ‘top panel’

It has been modified.

P15, L25: change ‘right panel’ for ‘bottom panel’

It has been modified.

P16, L13: add ‘f’ in ‘PFT targets are fitted. . .’

It has been corrected.

P16, L27-29: Please clarify this sentence.

The sentence has been modified as:

“Since a reliable fit, associated with a low fit residual, corresponds to a low value of averaged chi-square, the latter quantity can be used as an indicator of the fit quality. The PhytoDOAS triple-target fitting represents lower averaged chi-square values as compared to the PhytoDOAS single-target fitting values and therefore is of higher accuracy.”

P17, L14: remove ‘too’

This sentence has been changed through a complete modification of section 2.4.

P18, L4-6: I disagree with this sentence, there is actually strong difference over wavelength below 495, especially in the zone 480-495.

Of course, there is also difference in this band interval. However, the idea is to expand the fit-window in a way to cover more regions of difference. In this sense, the observed difference over 500 nm is of importance.

P19, L19-20: Change ‘while now also. . .’ to ‘while the North Atlantic and the North Pacific now show.’

The sentence has been accordingly modified.

P19, L21-23: Please work on these two sentences, they simply don’t read well.

The sentence has been modified.

P19-20, first paragraph of section 3.2: Please remove this paragraph, or reduce in size since most of its information is already available in the legend of fig. 8 and 9.

The paragraph has been shortened and modified, as well as the captions of respective Figures.

P20, L13: Please remove ‘As shown in Figs. 8 and 9’ and add ‘Fig 8 and 9 in the parenthesis of L14. It has been modified accordingly. However, it must be noted that in the revised manuscript, the locations of paragraphs in this section have been exchanged according to the order of the products presented in the revised figures.

P20, L23: Remove ‘(upper panel in Figs. 8 and 9)’ and ‘(lower panel)’
It has been modified.

P20, L28: It should read (Balch et al. 2005), not Balch et al. (2005). The same apply on P21, L6.
It has been corrected over the whole manuscript.

P21, L8: Please remove ‘which are shown in the’ and rather put ‘middle panels of Figs 8 and 9’ in brackets.
Through rewriting of the whole section 3.2, the respective sentence has been already modified.

P21, L19: I would add a sentence stating that the chl-a is much lower in NOBM than from PhytoDOAS.
We have already add this sentence.

P21, L21-22: Please move ‘which had been achieved before in Bracher et al. (2009)’ at the end of the sentence.
The sentence has been moved accordingly.

P21, L27-29: Please change for ‘diatom chl-a (Fig 10, upper panel) is compared to a diatom. . .’
It has been modified accordingly.

P21, L29: Please remove ‘As shown in this figure’
It has been removed.

P22, L2: remove ‘result’
It has been removed.

P22, L6: I believe we should read ‘cannot’ instead than ‘can not’
It has been replaced accordingly over the whole manuscript.

P23, L11: replace ‘at’ by ‘over’ in ‘. . .small region at one day.’
It has been modified.

P23, L13: replace ‘the reason’ by ‘a reason’
It has been modified.

P23, L14: replace ‘where’ by ‘which’ in ‘. . .where is almost blank . . .’
This sentence has been already removed trough general revising of this section.

P24, L21: should read ‘global’ not ‘globla’
This sloppiness has been corrected.

P24, L22: should read: ‘. . .for comparing with the PhytoDOAS dinoglagellates.’

It has been modified accordingly.

P24, L25: add an 's' to 'result' in '. . .MODIS-Aqua PIC results. . .'

It has been done.

P26, L3: Should read 'We thank Erika Allhusen for her support. . .'

It has been corrected.

P27, L23: the year of reference Burrows et al. doesn't match the year on page 9.

That's true; 1996 is the correct one. However, by reducing the section of the DOAS description, this citation has been removed along with respective paragraph, as well as other paragraphs.

P28, L30: the year of reference Mitchell et al. doesn't match the year on page 10

It has been corrected.

P29, L21: Röttgers is not spelled like Roettgers in the text, on page 15

It has been corrected.

P29, L32: remove 'b' to the year, 2002b, same on P9

It has been modified accordingly.

P30, L13: remove 'c' to the year, 2001c

By reducing the section of the DOAS description, this citation has been already removed.

Fig. 4: the legend states that the dinoflagellates is scaled to 0.75, whereas the caption states that it is scaled to 0.1

This has been corrected.

Fig. 8: Should read Coccolithophores (remove the 'o'). Also, I think it's confusing to write 'the northern spring', I would simply state: '. . .over the months of April, May and June 2005'. Same apply to Fig. 9 and 10.

It has been modified accordingly.

Fig. 9 and 10: same as in Fig. 8

It has been modified accordingly.

Fig 11: In middle panel, what is the meaning of the gray pixels, no chl-a for coccolithophores or flag pixels (cloud)? What is the scale for the 3 panels?

The gray pixels refer to the pixels which are flagged out during the PhytoDOAS fitting process, mostly due to the cloud contamination. The color scale for the two lower panels have been added in the revised manuscript.