

Interactive comment on “Quantitative observation of cyanobacteria and diatoms from space using PhytoDOAS on SCIAMACHY data” by A. Bracher et al.

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General comments

This manuscript examines the feasibility of applying Differential Optical Absorption (DOAS) Spectroscopy techniques to the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY). The authors evaluated the technique using in situ data and then applied the method to global observations. The basis for the approach involves discrimination of Vibrational Raman Scattering spectral signature in backscattered radiation and its modification by absorption due to dissolved organic matter and phytoplankton. Additional considerations are made for contributions

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by weak atmospheric absorbers (e.g., ozone and other gases), as well as Raman scattering by air molecules, the effect of which is treated as pseudo-absorption (Vountas et al., 2007). The method is novel and has the potential to augment the arsenal of techniques for probing spatial and temporal patterns in phytoplankton functional groups on regional and global scales.

The manuscript assumes a high degree of familiarity with prior literature describing the technique. The authors may wish to consider giving more background about the method and a concise, yet comprehensive explanation of how phytoplankton absorption is derived. As it stands, frequent cryptic references to terminology and methodology explained elsewhere makes this a difficult read. More detailed explanation of how results were derived would also be helpful. Possible inclusion of a diagram or an equation describing steps involved in processing and the fitting sequences for differential absorption might be helpful.

In general, the manuscript could be greatly improved by better organization and improved clarity in objectives and explanation of results. The authors might wish to consider including a short paragraph in the introduction explaining the organization of the paper. The introduction provided a thorough review of the approaches for discerning phytoplankton taxonomic composition using pigment chemotaxonomy, as well as absorption-based and satellite ocean color approaches. While informative, the introduction tended to meander and its relevance to the PhytoDOAS method was not always apparent.

The authors provide preliminary results that appear consistent with in situ observations as well as with a NASA Ocean Biogeochemical Model patterns. The authors reference other work examining global distributions of taxa based on pigment and optical approaches. However, they failed to examine their findings in the context of patterns observed in these other studies. This would have been a useful comparison and provide further evaluation of the PhytoDOAS method as applied to the SCIAMACHY data.

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Overall, the manuscript provides useful information about a novel approach that has the potential to yield further insight into phytoplankton composition and associated implications for biogeochemical cycling. With revision, the manuscript should be a valuable contribution. More specific comments are given below:

Specific comments

1. Abstract, lines 16-18 - the authors' use of cryptic statements such as "including the information of the sensor's optical paths" and "DOAS fits of inelastic scattering" should be minimized in the abstract and throughout the manuscript, and replaced clear and understandable statements. As noted above, a reader must necessarily be familiar with the prior literature on this method, particularly Vountas et al. (2007), to be able to follow this manuscript and understand the terminology. The manuscript would be improved if descriptions of the approach were clear and succinct (see first paragraph in this review for suggestions).

2. Introduction, p. 4561, lines 17-20 - the intensity of carbon fixation and its relationship to export is a function not only of the phytoplankton size and composition, but of the overall trophic community structure. This point should be acknowledged by the authors and note that differences in phytoplankton composition reflect a broader suite of associated differences in autotrophic and heterotrophic interactions.

3. Introduction, p. 4562, lines 3-8 - differences in pigment absorption can be attributed not only to the "package effect" or self-shading of pigment molecules, but also due to molecular interactions of pigment molecules in their corresponding pigment-protein complexes (Johnsen et al., 1994).

4. Introduction - a general comment about the introduction is that it is written more as an annotated bibliography. Relevance to the current work was not always apparent. The authors may wish to revise this to better express linkages between prior literature and their current work.

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5. Methods, p. 4565, lines 1-3 -information about pixel size would be helpful here. It is mentioned later in the discussion, but would be appropriate to state in methods. The large pixel size of this instrument limits its application to open ocean and necessitates analyses over longer time periods than conventional ocean color sensors. This point should be acknowledged.

6. Methods, p. 4565, lines 18-22 - this section lacks clarity. The authors need to be more explicit in what is meant by high-frequency spectral structures (frequency of electromagnetic radiation or frequency of variability as a function of wavelength?). What criteria are used to define the low order polynomial, or is it a fit to residual variability not accounted for by other contributions? What is meant by “low-order”?

7. Methods, p. 4566, lines 7-18 - more explanation about the purpose of the eigen-vector analysis would be helpful. Was this to account for unexplained variation in the sensor data? Presumably, the analysis in waters low in cyanobacteria and diatoms provided a baseline for correction of image data acquired in other regions. Correct?

8. Methods, p. 4567, lines 7-8 - a brief explanation of the basis for the pseudo-absorbers and ring spectrum would be helpful.

9. Methods, p. 4567, lines 8-15 - reproduction of the Vountas et al. (2007) Eq. 1 would be useful here.

10. Results, p. 4570, lines 7-8 - another reference to subtraction of a low order polynomial, but no explanation given as to how this is derived. Is this the same polynomial referenced on p. 4565? What do the authors mean by the statement that the differential spectra are correlated with pure water absorption? Are they saying effects of water absorption are embedded in the phytoplankton differential absorption spectra? What statistical basis is there for saying that these spectra are correlated?

11. Discussion - the manuscript would be strengthened if the authors compared their global distributions to those generated by other pigment-based and satellite-derived

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approaches referenced in the manuscript.

12. Discussion, p. 4574, lines 9-18 - the argument that the PhytoDOAS method is not “empirical” is questionable. The method does provide a different approach to discrimination of cyanobacteria and diatoms as generally classified by the shape spectra given in Fig. 1. Perhaps the authors could emphasize this aspect as a fundamental difference from other approaches. Additionally, the statement that the method “directly” retrieves chl concentration could be contested. As the authors themselves point out, there are numerous factors influencing the relationship between in vivo absorption and pigment concentration which will affect the result.

13. Fig. 3 - the spectral range given for the fitted cyanobacteria spectrum in the top panel differs from that in Fig. 2. Please explain.

Technical corrections

1. Abstract, line 20 - Avoid using acronyms without definition, i.e., NOBM.
2. Introduction, p. 4561, line 2 - “As IS well known”
3. Introduction, p. 4561, lines 25-26 - suggested word substitution: “diagnostic” for “specific”.
4. Introduction, p. 4562, line 8 - “It PARTIALLY explains”
5. Introduction, p. 4563, line 7 - “THE Aiken et al. (2007) APPROACH WAS applied”; also in line 16 - “different phytoplankton communities WITH respect”
6. Introduction, p. 4563, line 27 - “slant columns” and “absorbers” should be clearly defined.
7. Results, p. 4570, line 12 - spelling of “eigenvector”
8. Results, p. 4571, line 27 and elsewhere - NOBM “Model” is redundant.

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Johnsen, G., et al., In vivo absorption characteristics in 10 classes of bloom-forming phytoplankton: Taxonomic characteristics and responses to photoadaptation by means of discriminant and HPLC analysis, *Mar. Ecol. Prog. Ser.*, 105(1-2), 149-157, 1994.

Vountas, M., Dinter, T., Bracher, A., Burrows, J. P., and Sierk, B.: Spectral studies of ocean water with space-borne sensor SCIAMACHY using Differential Optical Absorption Spectroscopy (DOAS), *Ocean Sci.*, 3, 429-440, 2007, <http://www.ocean-sci.net/3/429/2007/>.

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