GLOBAL YEARLY OBSERVATION OF DIFFERENT PHYTOPLANKTON GROUPS USING PHYTODOAS ON SCIAMACHY DATA: VALIDATION AND FIRST APPLICATION

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ABSTRACT

Global information on the quantitative distribution of major functional phytoplankton types (PFTs) of the world ocean is important for understanding the marine phytoplankton's role in the global marine ecosystem. This study shows global biomass distributions from 2008 of different dominant PFTs analysed with PhytoDOAS, a method of Differential Optical Absorption Spectroscopy (DOAS) currently specialized for diatoms and cyanobacteria [1] from satellite data of SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Cartography) on ENVISAT. PhytoDOAS global maps of phytoplankton distribution are validated with collocated pigment water samples analyzed via HPLC. The global PFT satellite data sets are used as input data for and for validation of a biogeochemical model.

1. INTRODUCTION

To understand the marine phytoplankton's role in the global marine ecosystem and biogeochemical cycles it is necessary to derive global information on the distribution of its biomass and primary production, in particular the distribution of major functional phytoplankton types (PFT) in the world oceans. Using common ocean color sensors like SeaWiFS or MERIS, only the overall phytoplankton biomass or the dominant phytoplankton group can be derived (e.g. [2]). In order to get a global quantitative estimate of different PFT in the oceans, the Differential Optical Absorption Spectroscopy (DOAS), a technique established for extraction of atmospheric components from high spectrally resolved UV-VIS data, was adapted to the retrieval of the absorption and biomass of two major phytoplankton groups (PhytoDOAS) from data of the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) satellite sensor [1]. Within this method, hyperspectral information of SCIAMACHY is used to obtain the distinctive absorption characteristics from the different phytoplankton groups. In the presented study the method has been extended to another wavelengths range in order to differentiate within the prokaryotic algae between phycoerythrine containing cyanobacteria and other procaryotic phytoplankton (mainly Prochlorococcus-type). We have extracted the quantitative phytoplankton group information for one year from SCIAMACHY. The data set was validated against in-situ data and used for first applications in a biogeochemical model study.

2. DATA AND METHODS

Within this study the PhytoDOAS method was applied to SCIAMACHY data to extract information on different phytoplankton groups. SCIAMACHY measures back scattered solar radiation in the UV-Vis-NIR spectral region with a high spectral resolution (0.2 to 1.5 nm). In order to identify these characteristic absorption spectra in SCIAMACHY data in the range of 430 to 500 nm we used in-situ measured phytoplankton absorption spectra from two different RV Polarstern expeditions where different phytoplankton groups (diatoms and cyanobacteria) were representing or dominating the phytoplankton composition. In addition, SCIAMACHY data in the range of 530 to 590 nm were analysed with PhytoDOAS to identify absorption of the photosynthetic pigment phycoerythrine.

3. RESULTS

Results from PhytoDOAS clearly show the absorption inprints from different phytoplankton groups in the SCIAMACHY data (see Fig.1, and also Fig. 3 in [1]). The conversion of these differential absorptions by including the information of the light penetration depth, according to [4], leads to globally distributed biomass concentrations for these characteristic phytoplankton groups (corresponding to chl a). Monthly averages for the global biomass concentrations of the three phytoplankton groups for the year 2008 have been retrieved. These global maps of phytoplankton distribution were validated with collocated in-situ data from various Atlantic cruises in 2008 determined via

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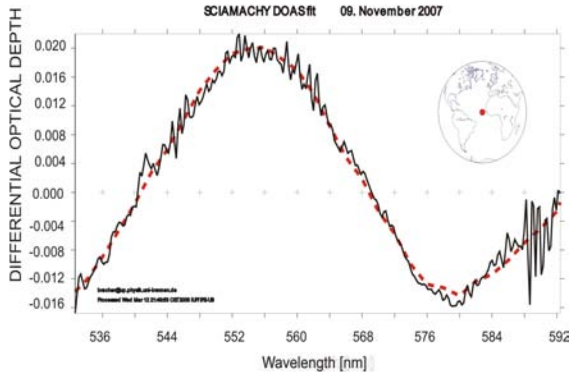

Figure 1. Differential Optical Depth of a spectral PhytoDOAS fit with SCIAMACHY data (black) from 9 Nov 2007 at 11°N and 23°W for phycoerythrine containing phytoplankton. Phytoplankton group specific differential absorption cross section of a pure cyanobacteria natural sample was used (taken from Atlantic cruise ANTXXIII-1 at 23°N and 22°W on 29 Oct 2005). The scaled in-situ phytoplankton differential absorption of this phytoplankton group is shown in red. Figure from [3].

HPLC pigment analysis and applying the CHEMTAX program [5]. Fig. 2 shows the global diatom biomass distributions for monthly means (Jan, Apr, Jul, Oct) of 2008 retrieved with PhytoDOAS from SCIAMACHY data. Yearly data sets of Globcolour data (merged SeaWiFS /MODIS/MERIS chl-a product) and PhytoDOAS phycoerythrine-containing phytoplankton biomass distributions have been used as initial conditions to constrain a 1-dim model of Fe speciation and biogeochemistry, coupled with the General Ocean Turbulence Model (GOTM) and a NPZD-type ecosystem model which has been applied for the Tropical Eastern North Atlantic Time-Series Observatory (TENATSO; model details in [6]. The yearly data set of PhytoDOAS total cyanobacteria chl-a has been used to validate the performance of the model for year round dynamics of cyanobateria at the model site.

4. CONCLUSION

The PhytoDOAS method applied to SCIAMACHY satellite measurements enables for the first time to establish a global data set on quantitative distribution of different phytoplankton groups. As first applications has shown this data base can be used by a wider community for the purposes of optical and ecosystem modeling.

5. AKNOWLEDGEMENTS

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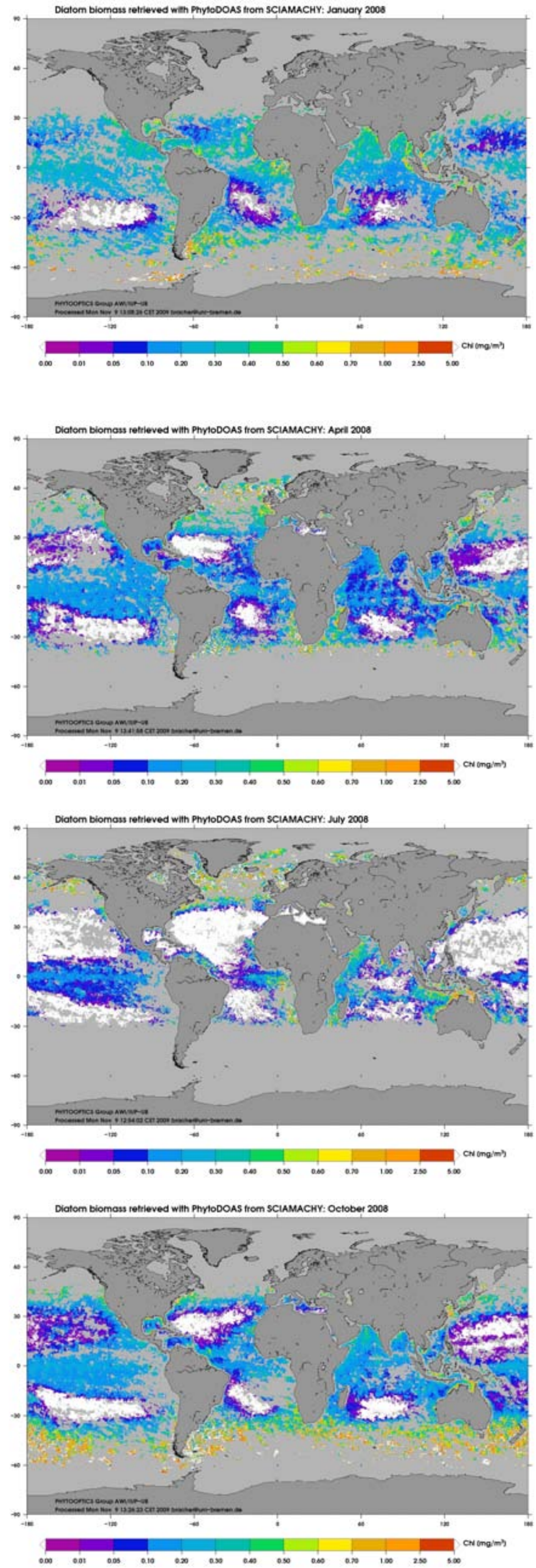

Figure 2. Monthly averages of global diatom biomass (chl-a) determined by using PhytoDOAS with SCIAMACHY data. At grey areas no SCIAMACHY data were available, at white areas no diatom absorption has been detected. Figure from [3].

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