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Ocean Science
Discussions

Interactive comment on "Parameterization of the light absorption properties of chromophoric dissolved organic matter in the Baltic Sea and Pomeranian Lakes" *by* Justyna Meler et al.

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Anonymous Referee #1

General comments

The paper presents very interesting work. Obviously, a lot of careful work has gone into this study and the assessment of model performance is detailed and thorough. It does, however, not become clear what the motivation for of this work is. What are potential applications for each of the presented models and where is the advantage over previously published work? What progress has been made?

Reply: We would like to thank Reviewer 1 for appreciation of our work. We will make

effort to explain our motivation and implication of our research and proposed model in the broad context of the possible application in remote sensing, biogeochemistry and carbon cycle studies in enclosed marine basins and estuaries and fresh water lakes. The Reviewer #2 has similar remark therefore we have added a short paragraph in Introduction that fit our research in the broader aspects of applied environmental studies. Proposed new paragraph and references is included below:

"The CDOM is very reliable predictor of the dissolved organic carbon concentration in fresh and estuarine waters (Brezonik et al., 2015; Kutser et al., 2015; Tomig et al., 2016). The new ocean color operational satellite missions like the Sentinel-3 OLCI mission and pace sensors of the European Earth Observation Copernicus program and the VIIRS sensors of the US Joint Polar Satellite System program offered the medium ground resolution (in order of 250 m), which would be suitable for remote sensing observation of inland water bodies (Palmer et al., 2015; Kwiatkowska, et al, 2016). The optical properties of CDOM abundant in fresh and estuarine water at high concentration of CDOM usually shift the spectral maximum of the water transparency to solar radiation and water leaving radiance toward the longer wavelength (Darecki et al., 2003; Morel and Gentili, 2009). In extreme cases, in humic boreal lakes, the CDOM reduces the water leaving radiance intensity in the visible spectrum almost to null (Ficek et al., 2011; Ficek et al., 2012; Ylöstalo et al., 2014). To minimize this effect, the remote sensing algorithm for retrievals of the bio-optical and biogeochemical variables in optically complex waters were based on spectral bands combinations at longer wavelengths where CDOM absorption is low (e.g. Ficek et al., 2011). Therefore there is need for development of models that would enable to reconstruct the complete CDOM absorption spectrum. The detailed spectral information of CDOM absorption is needed for example to calculate the spectral indices related to molecular weight, degree of photochemical transformation (Helms, et al., 2008) or aromaticity (Weishaar et al., 2003). "

The references list has been updated with those cited in this paragraph.

Specific comments

1. Why was a linear function fitted to the data in Figure 2 Data presented on Figure 2 were showed in the semi – logarithmic scale (the aCDOM(400) on X-axis is shown in logarithmic scale, the spectral slope S is shown in linear scale). We have used the logarithmic function (equations 10, 11 and 12), to approximate relationship between aCDOM(400) and S, and therefore graphical representation of logarithmic function in a semi-logarithmic scale, is a straight line. 2. Slope values for the data set presented seem fairly high. What about the quality of the data used to establish the models developed here: is there a dependency of slope values on concentrations which is caused by artifacts due to limited data quality (the use of a short pathlength in combination with relatively low CDOM concentrations)? Low coefficients of determination for the calculation of slope values point towards issues here.

We disagree with the reviewer comment. The Baltic Sea CDOM absorption data were analyzed twice with focus of on the spectral slope values and its dependency with CDOM absorption coefficient values. The fist study published by Kowalczuk et al., (2206) presented the differences between spectral slope values calculated with different methods (linear vs. non-linear) and different spectral range used for slope calculations. We have proved in that paper that non-linear fitting methods returns higher slope values compared to linear fit log-transformed absorption data, and that the broader spectral range the smaller uncertainty is slope values would be achieved. The averaged spectral slope value S300-600 (calculated with use of non-linear fitting method) presented in the paper by Kowalczuk et al., (2006) was 0.02334 nm-1 (n = 1610, C.V. = 12%) The second study, published by Kowalczuk et al., (2015), presented most complete to date statistical distribution of the spectral slope values in the function of salinity in the Baltic Sea. This statistical distribution has been derived upon 3636 measured aCDOM(ïĄň) spectra and the spectral slope was calculated with use the same Matlab code and in the same spectral range as we used in the current submission Presented variability range of the spectral slope S, contained within 0.015 to 0.030, plus few point

over the value of 0.030. We have also characterized the CDOM optical properties in end members: in the inflowing riverine fresh waters and in marine open Baltic Sea waters. The statistical description CDOM optical properties in open Baltic Sea waters presented in the paper by Kowalczuk et al., (2015) were as follow: salinity at the surface: 7.381 $\pm$ 0.209, aCDOM(350) = 1.617 $\pm$ 0.233 m-1, and S300-600 = 0.0232 $\pm$ 0.0015 nm-1, (n = 673). The fresh water end member was characterized by following average and standard deviation values: salinity = 0.918 $\pm$ 0.546; aCDOM(350) = 8.705 $\pm$ 2.842 m-1 and spectral slope coefficient S300-600 = 0.0185 $\pm$ 0.0008 nm-1, respectively (n = 30). The Baltic Sea data set used in the current submission were a subset of the data described by Kowalczuk et al. (2015). The same method for spectral slope calculation has been applied in to process the aCDOM(ïĄň) in lakes. In the current manuscript we presented the spectral slope variability range within 0.007 up to 0.30, both in lakes and Baltic Sea, (see, Table 2). The CDOM absorption and spectral slope variability and averaged values were very close to those already reported by Kowalczuk et al., 2006 and 2015. The lower spectral slope values were observed in lake waters, which agrees with current the knowledge about the spectral properties of CDOM absorption (CDOM absorption in fresh water is larger and absorption spectra flatter). The observed inverse dependence of the spectral slope with increasing CDOM absorption has been explained in details in paper by Stedmon and Markager (2003) and explored further in the paper by Kowalczuk et al. (2006).

We were very conservative in while performing aCDOM(ïĄň) data base re-analysis and only those spectral slope values were used in Kowalczuk et al. (2015) paper that were fitted with R2 at least 0.99. The re-analysis of CDOM absorption data based presented in paper by Kowalczuk et al., (2015), contained CDOM spectra measured with different brands of research grade spectrophotometers and different pathlengths used in measurements. We did not observed any statistical difference related to subset of data measured with different apparatus or different pathlenghts. We can assure that 5 cm cuvette used in CDOM absorption measurement in open Baltic Sea water gave similar results as CDOM absorption spectra measured with use of 10 cm cuvettes. We quite confident in quality of our data and we do not see any issue related to low quality of data.

3. Direct comparison of the different models (presented here and previously published) might be easier if values were presented in separate tables for every statistic metric rather than each model. Similarly, Figure 10 could be re-arranged, so that each panel shows the outputs of all models for a single chlorophyll concentration which would enable a more direct comparison.

Reply: The figure 10 has been re-arranged according to reviewer suggestions.

4. Page 7: It would be helpful to add a short description and purpose of the different statistical metrics. Reply: The following paragraph has been added to explain statistical metrics used in uncertainty analysis.

Linear metrics are represented by relative mean error and standard deviation were used to measure dispersion of results and asses the modes uncertainty. The relative mean error (Eq. 5a) is the average of all relative deviations between measured and calculated values and it quantified the systematic error. Standard deviation (Eq. 5b) is the dispersion around the average error due to random errors and it quantified the statistical error. Logarithmic metrics were used to better describe the uncertainty in the data ste varying in the range of several orders of magnitude. The standard error factor described how many times the error is deviated from the average value. .

5. The structure, especially of the Discussion section (e.g. paragraph ll. 537.), should be revised as it is difficult to follow the argumentation at times. The Discussion contains paragraphs better suited in the Introduction and Results sections.

The revised manuscript structure will thoroughly corrected in terms of used argumentation and clarity. The whole manuscript will be edited to clarify the English usage, grammar and style.

Technical comments

The language needs to be tidied up thoroughly prior to publication. It distracts from the content.

Reply: We will send the revised manuscript to a English editor prior its submission to a journal editor office.

The symbols for CDOM absorption coefficients and abbreviation for chlorophyll a concentration are used inconsistently throughout the manuscript.

Reply: It has been amended.

Lines 177 – 180: Add reference for protocol used in this work.

Reply: It has been amended.

Line 188/ Eq. 4: Specify at which wavelength chlorophyll specific absorption coefficients calculated.

Reply: It has been amended.

Line 198: The term 'standard deviation' is slightly mis-leading in this context as Eq. 5b is used as descriptor of the overall error rather than variability in the data.

Line 203: Move symbol definitions to the top of the paragraph, i.e. line 197.

Reply: It has been amended.

Line 264: How are relative RMSE values calculated? If a parameter has a logarithmic distribution, simply dividing the RMSE by the mean value creates a potential bias.

Reply: All optical parameters values were presented in logarithmic scale, because in this way the relationship between these parameters (which varies with respect to more than two or three orders of magnitude) are more visible. The linear metric were applied to untransformed values of optical and bio-optical parameters. Due to broad range of variability (spanning up to three orders of magnitude) we additionally used the logarithmic metric to reduce to bias due to occurrence of very high values in the data set, that could impact the linear metrics calculations.

Line 452: ‘uncertainty level’ - Which statistical metrics does this refer to?

Reply: “Uncertainty level” in this line is refer to arithmetic metric.

Line 519: This paragraph contains multiple subjective assessments of model performances. It would be helpful to add numbers to support the statements made.

Reply: We will revise the Discussion section to make our statements clear, and to assess the model performances on objective arguments.

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