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Biogeosciences
Discussions

Interactive comment on "A new parameterization for surface ocean light attenuation in Earth System Models: assessing the impact of light absorption by colored detrital material" *by* G. E. Kim et al.

Anonymous Referee #1

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General Comments:

The manuscript addresses the sensitivity of global ocean biogeochemistry to in-water sunlight attenuation by colored detrital material (CDM). This is done by running an existing Earth system model, including an ocean biogeochemistry component, with two different in-water solar transmission parameterizations, and comparing the results. The first solar transmission parameterization, previously developed and implemented, considers attenuation by pure seawater and chlorophyll concentration, as is typical of present day climate models. The second transmission parameterization, developed as

part of this study, adds attenuation from the combination of non-algal detrital particles and dissolved organic material (Adg).

The addition of Adg in the solar attenuation parameterization serves, in general, to reduce the penetration of depth of sunlight, and reduce the total amount of biomass in the water column. In addition, the depth distributions of biomass and nutrients are altered, with (generally) increases near the surface and decreases at depth. The study addresses the influence of Adg on modeled ocean biogeochemistry in various biomes. The depth-dependency in biomass change between the model runs varies with biome. The depth dependency is then explored in terms of nutrient and light limitation.

The "big picture" conclusions are threefold. First, the study puts forth a new solar transmission parameterization that directly includes attenuation by non-algal detrital particles and dissolved organic material. Second, (generally) increased light attenuation due to the addition of Adg serves to increase near-surface chlorophyll, but decrease the total (depth integrated) chlorophyll. Third, and perhaps most important, the study shows that understanding changes in total biological productivity requires depth-resolved quantities.

The study is interesting, clearly explained, relevant to BG readers, and has significant scientific merit. Understanding and accurately predicting ocean biogeochemistry (especially primary production and carbon sequestration) is necessary and important for addressing climate change issues. The work is novel by putting forth a solar transmission parameterization that depends on CDM, and demonstrating the influence of light attenuation by CDM on ocean biogeochemistry via Earth system model runs. Results are clearly explained and logically follow the analyses. The authors should be commended for their attention to detail in preparing their manuscript. Not a single typo, or grammatical error was encountered during multiple reads of the manuscript. This is extremely rare.

The verity of model results presented in the study depends partially on the accuracy of the improved solar transmission parameterization presented in Section 2.1 of the manuscript. The "base-case" solar transmission parameterization can be traced back to data and curve fitting given in Morel (1988). The "new" solar transmission parameterization (given in Section 2.1 of the manuscript that explicitly includes CDM) is not however thoroughly presented. The reader is only told the new parameterization is "the best fit function" to "244 concurrent measurements". Quantitative information about the goodness of fit is not presented. Nor is the true number of degrees of freedom (perhaps something like 8 given the very limited spatial distribution of observations) discussed. Therefore, the reader can't judge the quality of the "new" parameterization and its appropriateness for a global model.

The manuscript title that begins "A new parameterization for surface ocean light attenuation" doesn't accurately reflect the paper content. The parameterization is explained in less than a page and supported by only a single figure (Figure 2). In situ data that validate the parameterization (or not) are never presented. A very first logical step in parameterization development would be to address the validity of a correlation between chlorophyll concentration and CDM, as the "chlorophyll only" parameterization considered in the study may implicitly include CDM (according to Morel 1988 the parameterization includes the influence of chlorophyll "and co-varying material"). Before explicitly including CDM it should be shown that it does not truly co-vary with Chl. The NOMAD data presented in the study easily allow for this. The study seems more of a numerical exploration of how ocean biogeochemistry could change if models considered slightly more solar attenuation that may be attributed to underestimating the influence of CDM in existing parameterizations. Such a numerical exploration is still interesting, novel, and has scientific merit.

Restating the above paragraph more succinctly, if a "new parameterization" (implied by the word "new" to be better than existing) is a goal of the study, then the paper would benefit from a much more through motivation, presentation, discussion and validation of the parameterization itself. If the focus is Earth system and biogeochemical model

results considering two different parameterizations (the way the paper reads now), the paper would benefit from backing off on promoting a "new parameterization".

Specific Comments:

Pg 3907, Line 20. Technically the sentence should read "implicitly includes the light attenuation of all other aquatic constituents presumed to be directly in proportion with Chlorophyll".

Pg 3909, Line 6. Sentence indicates "variations in light attenuation in ESMs were previously attributed to phytoplankton pigment only". However this is not technically true as pointed out by the authors (See pg 3907, lines 19-20, also Jerlov 1976 and Morel 1988).

Pg 3909, Line 19 CDOM only absorbs solar radiation within a small portion of the solar spectrum (i.e. the UV and blue wavebands). Suggesting that CDOM "accounts for a large fraction of the non-water absorption 'especially' in the UV and blue wavelengths" seems misleading. It is really 'only' in the UV and blue wavelengths.

Pg 3910, Line 25 The reason CDOM isn't included in the Kd(r) parameterization isn't because CDOM absorption in red wavelengths is smaller than in blue-green wavelengths, it's because CDOM absorption in red wavelengths is extremely small compared to absorption by seawater and chlorophyll in the red wavelengths.

Pg 3915, Line 3. It is simply stated that the comparison is for "average results for the final 100 years of the model runs". Would be nice to know how that time period came about and how sensitive the results are to the time average.

Pg 3915, Line 10. An artifact of the "new" parameterization is a decrease in attenuation due to the Chl component alone. So, in regions with little CDOM, the "new" parameterization that adds (CDOM) attenuation can actually result in decreased (overall) attenuation. The manuscript would benefit by an additional sentence or two commenting on this result. For example, is it an unintended consequence of the "new" curve (surface) fit? Does it make physical sense?

Pg 3921, Line 20. The manuscript states that impacts due to "altering the visible light field" are investigated. While this is technically correct, it seems that altering "attenuation of the in-water light field" is a more accurate description. The former can suggest the incident light field is altered, and that is not the case.

Figure 2 The comparison of Equations 3 and 5 applied to NOMAD data could be clarified. First, given the NOMAD data are from 8 locations, coloring the data by location would help the reader interpret the true number of degrees of freedom. Second, the distribution looks extremely bimodal. If a handful of outlying points were removed the regression line looks like it would have a slope very near 1.0. It would be interesting to know the location of data points that fall well below the 1:1 line. Again, this could be indicated by color coding.

Figure 12 The 40% decrease in irradiance at ∼145 m depth suggests a significant change. However, in absolute terms, back of the envelope calculations following Morel (1988) suggest that for a relatively large noontime surface irradiance value (1000 W/mˆ2) and a modest upper ocean chlorophyll concentration (0.1 mg/mˆ3), the net irradiance at 145 m depth is < 0.01 W/mˆ2, and most likely insignificant. Curves (probably on a log scale) should be added to Figure 12 showing absolute changes.

Technical Corrections:

Pg 3908 line 20. Text indicates "studies", but then goes on to mention only a single study (Gnanadesikan and Anderson 2009).

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