

Interactive comment on “The value of adding optics to ecosystem models: a case study” by M. Fujii et al.

M. Fujii et al.

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First of all, the authors greatly appreciate the quick and constructive review on our manuscript. We have revised our manuscript as attached, basically according to the reviewer’s comments in such ways described below.

Responses to specific comments

With regard to POC and NAP: The reviewer is correct in pointing out that a phytoplankton C-to-POC ratio is known to vary substantially: the ratio is observed to vary within a range of 0.25 to 0.40 (by a factor of 1.6), as mentioned in the manuscript. Below the depth where phytoplankton grow, we expect the phytoplankton C-to-POC ratio to decrease with depth as a result of remineralization as well as flux from above. We optimized NAP concentration in the model so that a ratio of absorption by NAP to that

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by particle ($a_{\text{NAP}} / a_{\text{p}}$) would lie in an observed range of 0.1 to 0.17 (by a factor of 1.7). Considering that the range of phytoplankton C-to-POC ratio is derived from measurements in various oceans (Behrenfeld et al., 2005; Behrenfeld and Boss, 2006) while the range of $a_{\text{NAP}} / a_{\text{p}}$ is obtained only in the equatorial Pacific, the authors anticipate the modeled NAP still has as much as, or even greater uncertainty than the phytoplankton C-to-POC ratio, although we lack more field estimates in both ratios. This is the reason why the authors used the phytoplankton C-to-POC ratio in the parameterization of total scattering by particles, rather than explicitly-predicted NAP concentrations, in this study. Using the phytoplankton C-to-POC ratio of 0.3 (and assuming uniform between picoplankton C-to-POC1 and diatom C-to-POC2), POC1 and POC2 are obtained from modeled picoplankton and diatom C, respectively. The authors have moved two sentences in p1593, lines 10-14 to just in page 1592, line 16 so that the sentences here would be: “Assuming no contribution of CDOM to backscattering (e.g., Stramski et al., 2004), backscattering coefficients by algae and the co-varying particles are expressed as a function of POC concentration of small and large particles (POC1 and POC2, respectively) (mg m^{-3}), which consist of algal and associated NAP related to small and large phytoplankton functional groups, respectively. Results from previous studies indicate that the ratio of phytoplankton carbon to POC varies between about 25% and 40% in space and time (e.g., Eppley et al., 1992; DuRand et al., 2001; Gundersen et al., 2001; Oubelkheir et al., 2005). Considering these studies, we fix the ratio of both picoplankton carbon to POC1 and diatom carbon to POC2 to 0.3. Backscattering by small and large POC (POC1 and POC2), bbp_1 and bbp_2 , are formulated as follows (based on Fig. 4 (b) in Stramski et al., 1999):”

With regard to case studies and tuning: The authors understand fully the importance of information on the error statistics such as variational adjoint method. However, as the reviewer also mentions, implementation of such as procedure is a significant time consuming task which, we believe, is of marginal benefit at this stage of the development of the model. We did perform an objective sensitivity analysis in which each parameter was changed individually within a +/-30% range. We do plan to carry out a full adjoint

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analysis in future studies as we further develop the model.

Responses to Technical corrections

(1) Abstract, line 5-6 in the previous manuscript: the authors have replaced a word “necessary” with “desired” so that the revised phrase would be “it is desired to model light distribution accurately.”

(2) Abstract, line 24-25 in the previous manuscript: The sentence has been changed from: “Sensitivity analysis of the model results to optical parameters reveals the significant role of colored dissolved organic matter to the modeled properties.” to: “Sensitivity analysis of the model results to optical parameters reveals the significant role of played by colored dissolved organic matter through its influence on the quantity and quality of the ambient light”

(3) p1588, line 15 in the previous manuscript: The authors have checked Rothstein et al. (2006) and have confirmed there is no description of harmful algal blooms in the paper, as the reviewer pointed out. Therefore, the authors have modified this sentence to “Rothstein (2006) have specifically recommended the development of ecosystem models which includes optics.”

(4) p1594, line 22 in the previous manuscript: The time step used in this study is three hours, and the authors have include the value so that the sentence is “The short time step of the model (three hours) is needed to simulate diurnal cycles of biology”.

(5) Following the reviewer’s comment, the authors have replaced “biogeochemistry” with “biogeochemical properties” (for Abstract, line 1, p1589, line14, p1595, line 26, p1598, line 11, and p1599, lines 7, 20 and 25)

(6) p1597, line 23 in the previous manuscript: The authors have included a short formula so that the sentence has been modified to “Beam attenuation, especially by particles ($C_p = a_p + b_p$), has been measured often in the equatorial Pacific (e.g. Chung et al., 1996; Bishop, 1999; Gardner et al., 2003; Behrenfeld and Boss, 2006).” The

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complete formula appears as Equation (11).

(7) p1598, line 8-10 in the previous manuscript: The sentence has been changed from: “To elucidate how model results are affected by variations in the optical model parameters, we conduct the model sensitivity simulations to them by changing their parameter values individually from 0.7 to 1.3 times the standard values, encompassing the bulk of observed values (Table 2).” to: “To elucidate how model results are affected by variations in the optical model parameters, we conduct a sensitivity study of the model to those parameters by changing their values individually by 30% of their standard values. Such variability encompasses the bulk of observed values (Table 2).”

(8) Caption to Figure 5: The sentence has been modified to “Dots denote the U.S. JGOFS EqPac observations in August-September (Survey II; TT011) and October (Time series II; TT012) of 1992 (Murray et al., 1995, 1996, 1997; Balch and Kilpatrick, 1996; Barber et al., 1996).”

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