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# *Interactive comment on* "Optimization of Biological Production for Indian Ocean upwelling zones: Part – I: Improving Biological Parameterization via a variable Compensation Depth" *by* Mohanan Geethalekshmi Sreeush et al.

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Reviewer-2 gave very valuable comments especially for clarifying certain wording issues we had in the original manuscript. We sincerely thank the reviewer for enlightening us with the idea of "autotrophic compensation depth" which otherwise will not have been contrasted explicitly versus the community compensation depth. As per the definition we learnt from Marra et al., (2014) (thank you for pointing out this paper, this clarified us certain wording issues we had), the autotrophic compensation depth is the depth where the gross primary production (GPP) balances the autotrophic res-



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piration (Ra) or in other words the depth at which the Net Primary Production (NPP) equals zero. (ie. NPP = GPP – Ra). We admit that there were some wording issues in the original manuscript about the definition of compensation depth which created the confusion whether the compensation depth defined here is autotrophic compensation depth or community compensation depth, However, here we note that, the Ocean Carbon-cycle Model Intercomparison Project (OCMIP – II) protocol recommends the community compensation depth adapted from (Smetacek and Passow., 1990). According to this definition the community compensation depth is the depth at which the phytoplankton photosynthesis is great enough to balances the community respiration (ie. both the autotrophic and heterotrophic respiration). At the community compensation depth, the Net Community Production (NCP) is Zero. i.e. NCP = NPP - Rh (Marra et. al., 2014, Regaudie-de-Gioux, A., and C. M. Duarte, 2010, Gattuso et. al., 2006). As per the OCMIP-II protocol we have to stick to the community compensation depth, as our intention here is to suggest a spatio-temporal variability to it through Compensation Irradiance (Ecom). Defining so, the Ecom is again the minimum light irradiance at which phytoplankton photosynthesis is great enough to balance the community respiration and the depth at which the irradiance is equal to the compensation irradiance is referred as community compensation depth (Sarmiento and Gruber, 2006). Therefore there is absolutely no error in this hypothesis as per Sarmiento and Gruber, (2006) and also after reading Marra et al., (2014) and Regaudie-de-Gioux, A., and C. M. Duarte, (2010). Again highlighting from the paper of Regaudie-de-Gioux, A., and C. M. Duarte, (2010) the compensation irradiance for the community metabolism is the irradiance at which gross community primary production balances respiratory carbon losses for the ENTIRE community (Gattuso et. al., 2006, Regaudie-de-Gioux, A., and C. M. Duarte, 2010). This means that the OCMIP-II protocol suggests the compensation depth as the depth where the gross primary production is equal to the community respiration. Therefore we are not falsified in our definitions of compensation depth. At the same time we admit that in the original manuscript it was mentioned as ‘compensation depth is the depth at which the photosynthesis equal to planktonic respiration’ (line-214). This





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we corrected in the revised manuscript.

With the literature survey suggested by the Reviewer-2 we are clear in the definition and concept of autotrophic compensation depth and community compensation depth. However the present study focus to parameterize a spatio-temporally varying compensation depth (i.e., Community compensation depth [Smetacek and Passow., 1990, Najjar and Orr, 1998]) in the OCMIP –II protocol in order see whether it reduces the seasonal biases in the carbon cycle which is reported as a caveat in model simulations by Orr et. al., 2003.

Another important point raised by the Reviewer-2 is that whether our choice of 10 w/m2 cut-off as compensation irradiance (Ecom) is justified when converted it to mole photon/m2/day. We argue that this choice is indeed justified especially in the view of following points.

1. The observations show that the primary production reduces rapidly to 20% or less of the surface value below threshold of 10 W m-2 (Parsons et. al., 1984, Ryther, 1956).

2. Higher ocean temperature (those in the tropics) enhances the respiration rates resulting in high compensation irradiance (Parsons et. al., 1984, Ryther, 1956, Lopez-Urrutia et. al., 2006, Regaudie-de-Gioux, A., and C. M. Duarte, 2010).

3. The Table-1 of Regaudie-de-Gioux, A., and C. M. Duarte, (2010) says that the $0.4 \pm 0.2$ mole photon/m2/day in case of Arabian Sea which is close to what 10Wm-2.

We have revised the manuscript by taking into account all the comments by the reviewer. A point-by-point reply to reviewer's comment is as follows. For clarity the comments are shown in blue fonts.

1. Line 121. I disagree with citing "Sarmiento et. al. 2006." First, It should actually be "Sarmiento and Gruber. 2006" since that is the only citation for 2006. Sarmiento and Gruber is a book, with only one mention of the compensation depth; hardly justifying a citation when there are whole contributions dealing with it (e.g., Marra et. al., 2014,

DSR 83:45-50). Better would be Ryther, from L&O, 1956, but which in the references is listed as “2003.”

We apologize for the citation error in the manuscript. We corrected the citations, Sarmiento and Gruber, 2006 and Ryther, 1956. As per your suggestion a literature review has been conducted on Marra et. al., 2014 and further added discussions based on this paper.

2. Line 120. They use the old symbol for irradiance. Use ‘E’.

Modified the symbol for compensation irradiance as ‘Ecom’.

3. Line 124: “Suppressed”? Not Suppressed, but the growth will be negative, phytoplankton will decline through respiration.

Corrected as suggested.

4. Line 125: Here is the crux of the matter. The authors continually confuse the community compensation depth with the autotrophic compensation depth. I have argued that the latter is more appropriate, since if autotrophic production is negative, the community compensation depth will be 0m: at the ocean’s surface. The compensation irradiance is not where “planktonic photosynthesis” equals respiration, it is where GROSS photosynthesis = autotrophic respiration.

It seems as if the authors want the community compensation depth (See papers Carlos Duarte, e.g.), and that’s ok. They just have to define their parameters. Najjar and Keeling (1997), based on oxygen distributions can give only the community compensation depth.

5. Line 141: work in units of quanta, not energy. I’ve made the conversion and it appears that is equivalent to 1.7 mol photons/m2/d. or about 6% of the total daily surface irradiance. For a community compensation irradiance, that might be ok, but I don’t agree that that is the right parameter.

A better way to get the compensation depth is to use the base of the chlorophyll-a maximum as the bottom of the euphotic zone. There is justification for this experimentally (Marra et. al., 2014), and also intuitively, in that it captures all the autotrophic biomass. This of course is the autotrophic compensation depth, which I argue is better for modeling purposes than a community compensation depth.

Reply 4 & 5

Thank you for pointing out the wording confusion in the manuscript writing regarding the definition of compensation depth and educating us about the autotrophic compensation depth. Here we note that, through this study we are trying to parameterize a spatio-temporally varying compensation depth in the OCMIP –II protocol which is community compensation depth, not autotrophic compensation depth. The definition is made as "the depth at which the phytoplankton photosynthesis is great enough to balance the community respiration or the depth at which compensation irradiance for community metabolism is received (the irradiance at which gross community primary production balances respiratory carbon losses for the entire community) [Gattuso et. al., 2006, Regaudie-de-Gioux, A., and C. M. Duarte, 2010, Sarmiento and Gruber, 2006]. As per the protocol of OCMIP-II we stick to the community compensation depth because of following reasons:

(a) The OCMIP –II protocol defines it clearly as a community compensation depth above which is the production zone and below is the consumption zone (Najjar and Orr, 1998). And the OCMIP –II models are very successful in simulating the annual mean state of the carbon cycle.

(b) If we introduce the autotrophic compensation depth, which is depth at which phytoplankton photosynthesis equal to the autotrophic respiration, we will lose the contribution of inorganic carbon sources from the heterotrophic respiration (Regaudie-de-Gioux, A., and C. M. Duarte, 2010) and there is possibility that this will affect the annual mean carbon cycle which is net effect of both autotrophic as well as heterotrophic res-

piration.

However we do agree that in the original manuscript there were confusions in the wording of our definitions, which we revised.

6. Line 252: Again, there is a confusion about which compensation depth the authors are reffering to. My guess is that Smetacek and Passow (1990) are talking about the community compensation depth, whereas what is mentioned here is the autotrophic compensation depth.

Corrected accordingly.

7. Line 262: Ryther (2003) ?? The rest of the ms is the working out of the model results, which I can't really comment on. But the results all stem from the compensation depth. It is not clear to me whether the model currency is oxygen or carbon.

Corrected Ryther (2003) as Ryther (1956). The model currency for OCMIP –II protocol is Phosphate and Dissolved Inorganic Carbon (Najjar and Orr, 1998).

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