

## ***Interactive comment on “Coccolithophore biodiversity controls carbonate export in the Southern Ocean” by Andrés S. Rigual Hernández et al.***

**Andrés S. Rigual Hernández et al.**

arigual@usal.es

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We sincerely thank Dr Alex Poulton (reviewer 2) for the valuable comments and suggestions that have helped to improve the original version of the manuscript. We have carefully considered all his comments and have addressed each of his concerns as outlined below.

R2-Cx : Referee comment, R2-Rx: authors response.

R2-C1: The manuscript by Rigual Hernandez et al. represents a comprehensive study of species-specific fluxes of coccolithophore-derived CaCO<sub>3</sub> fluxes to the deep-sea in

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the Southern Ocean. The manuscript is well written and easy to follow, and provides several new insights into the important role of numerically rare coccolithophore species with high relative coccolith and cellular CaCO<sub>3</sub> content. Such understanding has been well recorded in terms of production and export in northern polar and sub-polar waters, but the manuscript by these authors reveals the importance of this processes in the Australian-New Zealand sector of the Southern Ocean. There are no significant issues with the methods or conclusions, and only a few points that need clarity or further referencing.

R2-R1: We sincerely appreciate reviewer 2 for taking the time to carefully read the manuscript and providing valuable comments and references that helped to improve the manuscript.

R2-C2: Ln 39: ‘E. huxleyi dominates remote sensing images as a result of higher cell abundance and detachment of its small coccoliths.’ This is an oversimplification and ignores the vital role of the characteristic light-scattering properties and size of E. huxleyi coccoliths, in addition to its tendency to shed coccoliths and characteristic bloom formation.

R2-R2: The sentence referred by reviewer 2 has been replaced by the following: “This observation contrasts with the generally accepted notion that high PIC accumulations during the austral summer in the subantarctic Southern Ocean are mainly caused by E. huxleyi blooms.”.

R2-C3: Ln 56-57: ‘decline in saturation state of carbonate minerals in seawater makes the biological precipitation of carbonate difficult and increases dissolution rates of their shells or skeletons’. Current theoretical consensus of the response of coccolithophores to carbonate chemistry (e.g. Bach et al., 2015) specifically relates their internal calcification to substrate availability (HCO<sub>3</sub><sup>-</sup>) and inhibition by proton (H<sup>+</sup>) concentrations; i.e. different carbonate chemistry parameters than inferred in the text (i.e. CaCO<sub>3</sub> saturation state). Bach et al. (2015). A unifying concept of coccolithophore sensitivity

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to changing carbonate chemistry embedded in an ecological framework. Progress in Oceanography, 135, 125-138.

R2-R3: The sentence highlighted by Reviewer 2 has been modified taking into consideration his suggestion and the reference of Bach et al. (2015) is now mentioned in the text (see lines first part of the introduction of the corrected version of the manuscript). Please note that in this part of the introduction we are talking in general about marine calcifying organisms, i.e. not specifically about coccolithophores.

R2-C4: Ln 92-95: As well as recent work by Trull et al. (2018) showing that satellite ocean colour based PIC estimates can be unreliable in Antarctic waters, should also cite Holligan et al. (2010) which came to the same conclusion earlier.

R2-R4: Corrected according to reviewer 2's suggestion. Holligan et al. (2010) paper is now mentioned together with Trull et al. (2018) in the new version of the manuscript.

R2-C5: Ln 131-132: 'which that', delete one or the other, both not necessary.

R2-R5: Corrected according to reviewer 1 and 2's suggestion.

R2-C6: Ln 294-295: 'For the ks value of each taxa, data from the literature were (Table 1)' – sentence not finished.

R2-R5: The sentence referred to by reviewer 2 has been modified. Now it reads: "For the ks value of each taxa, data from the literature was employed (Table 1)."

R2-C7: Ln 329: Missing word – 'later' at end of sentence 'i.e. approximately eight months <later> (Fig. 2).'

R2-R5: We intended to say that the period of elevated coccolith flux lasted about 8 months. However, this information is not of critical importance and therefore we have deleted the end of the sentence.

R2-C8: Fig. 2. Would it not be better to make the y-axis on these plots the same scale?

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R2-R5: Corrected according to reviewer 2's suggestion. The y-axes have now the same scale in each station. Please note that in figure SAM site two axes (coccospheres and PIC) required different scale due to the different magnitude of these parameters compared to those of the SOTS site.

R2-C9: Ln 417-419: This is an interesting point, as it is similar to loss terms found specifically for coccolithophores from microzooplankton grazing in the temperate N Atlantic setting (60-80%; Mayers et al., 2019). Mayers et al. (2019). Growth and mortality of coccolithophores during spring in a temperate Shelf Sea (Celtic Sea, April 2015). Progress in Oceanography 177, 1010928.

R2-R9: We appreciate reviewer 2's suggestion. This is a good point that has been included in the new version of the manuscript (see section 4.1 of the new version of the manuscript).

R2-C10: Ln 490-492: Again, although Trull et al. (2018) recently identified over-estimate of coccolithophore PIC in the Southern Ocean by the NASA satellite ocean colour-based PIC algorithm, this was examined earlier by Holligan et al. (2010). In the case of Holligan et al. (2010), the difference was attributed to the lower coccolith and cell CaCO<sub>3</sub> content of *E. huxleyi* found in the S Atlantic (Scotia Sea). This is in general agreement with the reasoning suggested here (i.e. issues over the coccolith specific-area:mass ratios for the dominant reflective particles), though differs over whether this is considered a problem with *E. huxleyi* or *C. pelagicus* (or other species with high coccolith CaCO<sub>3</sub> content).

R2-R10: We agree with reviewer 2. The text has been modified including Holligan et al. (2010) reference in the manuscript. Now it reads: "Since satellite reflectance observations are mainly calibrated against Northern Hemisphere PIC results (Balch et al., 2011; Balch et al., 2016), the lower the calcite content of dominant *E. huxleyi* morphotypes (B/C) in the Southern Ocean compared to their northern hemispheric counterparts has been suggested as a possible factor causing the over-estimation of

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PIC concentrations in the Southern Ocean. Following this reasoning, we speculate that differences in other components of the coccolithophore assemblages, and particularly, differences in *C. pelagicus* numbers, could contribute to the over-estimation of PIC concentrations by the satellite PIC algorithm in the Southern Ocean. Indeed, . . .”

R2-C11: Ln 570: Should the units not be 0.4 Tmol C yr<sup>-1</sup>?

R2-R11: Reviewer 2 is correct, this error has been corrected in the new version of the manuscript.

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