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Comment on bg-2021-201

J.K.B. Bishop (Referee)

Referee comment on "Bridging the gaps between particulate backscattering measurements and modeled particulate organic carbon in the ocean" by Martí Galí et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-201-RC2, 2021

Review: bg-2021-201. Bridging the gaps between particulate backscattering measurements and modeled particulate organic carbon in the ocean. Martí Galí, Marcus Falls, Hervé Claustre, Olivier Aumont, Raffaele Bernardello

Overview. The authors compare PISCES model simulations and observed in-situ proxies for particulate organic carbon (POC) concentration in small (sPOC) and large size (bPOC) particle fractions in the 0-200 m epipelagic and 200m-1000m mesopelagic zone at several biomes in the world oceans. The observed in-situ sPOC and bPOC are derived from backscattering sensor data from biogeochemical ARGO floats (BGC-ARGO). bbp700 data are filtered to remove spikes – yielding a background profile representative of the small particle fraction (sbbp) and large particle spike anomaly (bbbp). The resultant sbbp data is scaled by a formula that includes a biome dependent multiplier and a depth decreasing ratio of POC/scattering with an assumed asymptotic value. The bPOC data are calculated from the anomaly contributed to by spikes and the same conversion factor is applied.

To my knowledge, this is the first sucessful attempt to reproduce subsurface particle concentrations in a model. This paper is very well written and logical in its development and summarizes areas where model and observations agree well and where there is disagreement. It highlights the value of optical sensors on floats. In the conclusions, there are concrete recommendations for added observations that will enhance insight into model parameterizations.

This is perhaps the most informative paper I have reviewed. The authors did a great job. The length of the following text reflects my excitement about the product. The recommendation of this reviewer is to publish after revision and a quick rereview. There is some more work with referencing. This should take little time.

There are some areas that could be clarified. ACRONYMS often appear without definition.

Please add a table to ACRONYMS and clarify important ones in the text. Furthermore the representation of stocks (units mmol POC m^{-2}) in a 200 m epipelagic layer and 800 m thick mesopelagic layer in the figures confuses the presentation of the paper. Please use mmol POC m^{-3}. Another point of confusion is the use of bPOC to describe the large particle size fraction. Most of the particle literature uses "S" small and "L" large; it would be helpful to use this terminology. In the conclusions it might be important to mention that the international program GEOTRACES will produce comprehensive information on size fractionated particle chemistry (after Lam et al. 2011 – 2015), many of these data sets are growing in availability. Finally, as summarized, there are a number of float based optical systems that could be productively co-deployed within the BIO-ARGO framework that would illuminate particle flux processes. I think the flux float described by Bourne et al. 2021 (Biogeosciences, 18, 3053–3086, 2021) is a worthy addition to the list, such instruments were envisioned by Claustre et al. (2009) and will be ready. I also think the community should convene a review of the developing suite of sensors that could contribute to an evolved BIO-ARGO that answers key questions regarding modelling needs.

Reference to observations of Bishop and Wood (2009, in the southern ocean) using floats is relevant. They talked about varied criteria for MLD as well as transient stratification, and the concept of burst sampling. They deployed transmission and scattering sensors and had metrics for export and timing for exported material to reach 800m. (doi:10.1029/2008GB003206).

Detailed comments.

L8: Not sure where the 4Pg C number comes from. Needs a reference. Most of the numbers in the text are in the range of 0.5-2. You could say is dwarfed by the 1000 Pg C in DIC pool (above 100 m). Or is this an estimate for the entire water column.

L11-12: 80-90% Reference? Lam et al. 2011?

L13: Define ACRONYM PISCES.

L16: bPOC is not defined. Above… most literature refers to "L" POC (large).

L51-54: Stemmann and Boss (2012), Cael and White, 2020; Stemmann et al., 2004a), particle populations are usually partitioned into a few.... Other references? Certainly this has been described in literature back to the 1970's.

L70: Small POC can drive vertical POC fluxes across the mesopelagic layer. Needs better

wording of "Small POC can drive..." Small POC does not drive... but convective mixing or subduction of small POC can transport POC below the euphotic layer (or epi pelagic layer) into the mesopelagic layer, adding to POC export...

L 132: a fluorometer... optical backsattering. name manufacturer. Use specific language.

L136: ... the latter were flagged... need more information… Provide an example how data were flagged.

L141: Define ACRONYMS

L149: NAOS, remOcean and other ACRONYMS should be tabulated.

L156: Reference needed... σ_θ exceeded the surface reference value by 0.03 kg m^{-3}. Bishop and Wood (2009) seems a good one.

L 164: "The baseline and spike signals were converted to sPOC and bPOC...". Are there observations that confirm this correspondence. Please calculate the volume of water seen by the scattering sensor and the likelihood of the sensor seeing large particles. The only study I am aware of is Bishop and Wood (2008 Deep-Sea Research I55, 1684–1706) who concluded: "Those [referring to spikes] of the scattering sensor mostly appear to reflect abundances of larger and chain forming phytoplankton, protist grazers and possibly large aggregates. Nearly transparent particles like marine snow are not readily detected in transmitted light but are easily detected using reflected light. "

Line 181. Reference to Fig. 2. Should not the green dotted line in the deep mixed layer reflect the average of POC/bbp over the interval, not the value at its deepest limit? Please explain more clearly why or why not.

L 199. Equation 2. zref = max ("X","Y"). Reads like computer code . Try to clarify in the text what is meant.

L 222. Please explain briefly terms like "RC parameterization".

Please define all ACRONYMS somewhere.

L310. Fig. 4. Add log tic marks. Rather than regular grid on x axis. Otherwise… nice figure.

L349. Fig. 6 (and corresponding similar figures). When printed. The various blue/cyan lines in panel (a) and (d) are completely lost.

L440-441. …"Bishop et al. (1999) suggest a plausible range of 815–1630 mmol C m^{-2} (Appendix A)".

In the Appendix, the authors overlooked Bishop (1999) "Transmissometer measurement of POC". Their Figure 2 shows tight correlation of c vs POC below 500 nM. Deep-Sea Research I, 46 (1999) 353-369. Bishop (1999) found that the slope of correlations is very similar in almost all environments described – including the Atlantic – all samples were collected by in-situ filtration and compared to the same co-deployed 1-m pathlength transmissometer. Modern transmissometers accept more forward scattered light so the slope changed from 16 to 27. Never-the-less the correlations with beam c or beam cp remains robust in the upper kilometer. The same cannot be said of scattering (e.g. Bishop and Wood, 2008, Deep-Sea Research I 55, 1684–1706). See also Boss et al. 2015. Progress in Oceanography 133 (2015) 43–54. There will always be more assumptions for conversion of bbp to POC. I almost think that BIO-ARGO should consider bringing transmissometers back.

L 616-617. On the other hand, it is unclear to what extent the bPOC inferred from the bbp700 spike signal is capturing mesozooplankton biomass… See. Comments above based on Bishop and Wood (2008; Deep-Sea Research I, 55, 1684–1706). The other point to make is that spikes seen even if they are all particles, dont adequately predict the complete particle spectrum of particles that dominate the sinking flux.

L 619-621. "Imaging devices mounted on BGC-Argo floats may provide more accurate quantification of bPOC, allowing for the separation of detrital bPOC (Trudnowska et al.,2021) from mesozooplankton and micronekton (Haëntjens et al., 2020)". As UVP methodology has not yet been proven on a float… an appropriate additional reference is Bourne et al., 2021 (Biogeosciences, 18, 3053–3086). These authors have documented an imaging carbon flux measuring float with the ability to separate and quantify particle classes contributing to flux. The instrument will be able to perform missions lasting seasons to years. It would be great to co-deploy this system with a UVP-modified float as the authors suggest.

In the Summary, There shoud be mention international programs like GEOTRACES (Lam et al. 2011,2015) that are currently at sea in the global ocean and are doing an excellent job of quantifying the large and small particle abundances and chemistry in the ocean water column. The product from GEOTRACES is an asset to such synthesis efforts.

End of Review. Jim Bishop, UC Berkeley