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Seasonal dynamics of mesopelagic organic particles in the subpolar North Atlantic. Learning from the crosstalk between biogeochemical Argo float measurements and PISCESv2 simulations

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Organic particle populations in the mesopelagic layer span a wide range of sizes and sinking speeds. A long-standing paradigm in ocean biogeochemistry posits that large, fast-sinking detrital particles contribute to most of the vertical export flux of particulate organic carbon (POC), whereas small, slow-sinking or suspended particles comprise most (>90%) of the stock. Over the last decades, most studies have placed emphasis on understanding and predicting the vertical fluxes driven by large particles owing to their influence on ocean carbon storage. Yet, there are compelling reasons to study the dynamics of suspended and slow-sinking small POC (sPOC) in greater detail. First, sPOC likely supports most of the mesopelagic respiration. Second, recent studies have shown that a number of mechanisms can inject large amounts of sPOC into the mesopelagic layer, to the point that the sPOC fraction may seasonally dominate total vertical POC fluxes. Thus, better accounting for sPOC fluxes might allow us overcome historical difficulties in balancing mesopelagic carbon budgets.

In the last decade, hundreds of bio-optical sensors deployed on autonomous profiling robots (bgc-Argo floats) have enabled observation of small particle stocks between the sea surface and 1000 m depth with a profiling frequency of 1-10 days. These observations are showing that mesopelagic sPOC follows distinct seasonal cycles in different oceanic areas, and allow identification of sPOC supply events (e.g., caused by vertical mixing or by disaggregation or fragmentation of larger particles) and of net sPOC removal. Regarding ocean biogeochemistry models, they have traditionally been tuned to estimate sinking POC fluxes but failed to capture POC stocks. Recently, the formulation of POC degradation rates in the model PISCESv2 was changed and a POC reactivity continuum approach was adopted, which greatly improved the representation of small and big POC stocks. These parallel developments now enable the quantitative assessment of mesopelagic POC dynamics.

Here we analyze the annual cycles of mesopelagic sPOC in the subpolar North Atlantic, as seen by biogeochemical Argo floats, and compare them to their PISCESv2-simulated counterparts. We then discuss the processes that drive mesopelagic sPOC seasonality in the observations and in 1D model simulations. Finally, we present a genetic algorithm approach that uses biogeochemical Argo float observations to optimize the PISCESv2 parameters that influence sPOC, focusing on the interplay between particle degradation rate and sinking speed.