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A mechanistic reproduction of particle transformation via fragmentation and diel vertical migration

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The export efficiency of the biological carbon pump depends on a multitude of processes that can affect the sinking speed of particulate organic matter (POC). The uncertainty surrounding factors that promote particle aggregation (e.g. through transparent exopolymer particles – TEP), remineralization (e.g. via microbes) and zooplankton consumption and fragmentation (e.g. coprophagy) has led to inconsistent estimates and future predictions for global export flux amongst earth system models. Two of the most unaccounted-for and least understood processes for constraining these simulations of POC flux are fragmentation and diel vertical migration (DVM) by zooplankton, with the majority of CMIP6 model omitting these from their frameworks. Fragmentation rates can be physically-mediated (e.g. turbulent shear) or biologically-mediated (e.g. “sloppy feeding” by zooplankton) and drive remineralization and thus flux attenuation. Another zooplankton activity, DVM, also contributes to export flux. the resulting export flux. DVM, where organisms nocturnally migrate to surface waters to feed and descend during the day, has great implications for biogeochemical fluxes of nutrients and provides a mechanism for POC to bypass potential transformation via fecal pellet production at depth. Here, we use a 1-dimensional particle model (SISSOMA) that includes mechanistic descriptions of key particle transformation processes (aggregation, remineralization, fragmentation etc.) to explore the potential consequences of fragmentation and DVM. SISSOMA enables study into the formation and fate of particles in the mixed layer, producing particle size distributions of the flux exported. Through sensitivity tests on the drivers of fragmentation rates, fed by Underwater Vision Profiler (UVP) and Biogeochemical-Argo floats observations, we can determine what drives particle size distribution and ultimately carbon export. We apply a DVM component to SISSOMA, driven by ecological observations of migrating zooplankton (e.g. EcoTaxa) to investigate the extent to which this process contributes to export flux and its particle size composition. We implore future modelling and observationally-based studies related to constraining the biological pump to consider these processes when designing their research.