Controls over the export flux of marine snow into the deep ocean

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The oceanic biological carbon pump (BCP) regulates the Earth carbon cycle by transporting part of the photosynthetically fixed CO$_2$ into the deep ocean. Suppressing this mechanism would result in an important increase of atmospheric CO$_2$ level. The BCP occurs mainly in the form of organic carbon particles (POC) sinking out of the surface ocean. Various types of particles are produced in the surface ocean. They all differ in production, sinking and decomposition rates, vertically and horizontally. The amount of POC transported to depths via these various export pathways as well as their decomposition pathways all have different ecological origins and therefore may response differently to climate change. Here I will briefly review some of the processes driving both particle export out of the euphotic zone (0-100m) as well as particles transport within the mesopelagic zone (100-1000m). In the early 2000s, strong correlations between POC and mineral (calcite and opal) fluxes observed in the deep ocean have inspired the inclusion of “ballast effect” parameterizations in carbon cycle models. These relationships were first considered as being universal. However global analysis of POC and mineral ballast fluxes showed that mineral ballasting is important in regions like the high-latitude North Atlantic but that in most places (some of which efficiently exporting) the unballasted fraction often dominates the export flux. In such regions, we later on showed that zooplankton-mediated export (presence of faecal pellets) and surface microbial abundance were important drivers of the efficiency of particles export. Similar trends were found globally by including bacteria and zooplankton abundances to a global reanalysis of the global variations of the POC export efficiency. This implies that the whole ecosystem structure, rather than just the phytoplankton community, is important in setting the strength of the biological carbon pump. Further down in the water column (mesopelagic zone), processes impacting the transport of particles are less clear. Sinking particles experience a number of biotic and abiotic transformations during their descent. These includes solubilization, remineralisation, fragmentation, ingestion/active transport, break down among others. While some potential factors such as O$_2$ concentration and temperature have been proposed as powerful controls, globally evidences are often inconsistent. Current challenges related to the role of particles consumption by zooplankton and fishes as well as the role of particles attached prokaryotes (bacteria and archaea) in setting the efficiency of the carbon transport in the mesopelagic zone will be discussed.