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An Observationally Constrained, 234Th-Derived Global POC Flux Model

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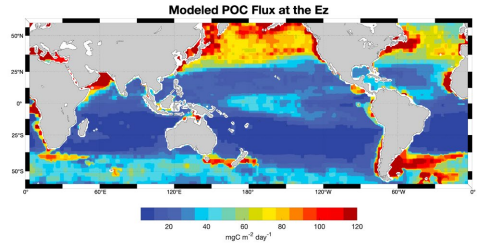

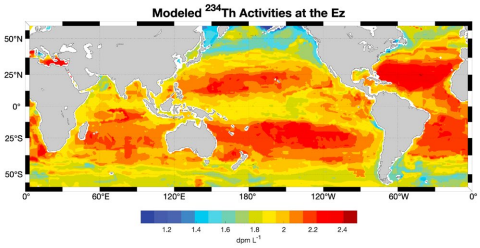

The biological carbon pump (BCP) performs a significant role in mitigating increasing anthropogenic CO_2 emissions and consequent heating effects [1]. Quantifying the contribution of the BCP to carbon sequestration has been the topic of several recent studies, with the average yearly POC flux out of the upper ocean ranging from 4 to 12 PgC year^{-1} [2].

Here we use the commonly employed Thorium-234 (^{234}Th) proxy to determine carbon fluxes throughout the world's oceans. The disequilibrium between ^{234}Th (half-life ~24.1 days), a highly particle-reactive radionuclide, with its parent, Uranium-238 (^{238}U, half-life ~4.5 x 10^9 years), can be used to quantify ^{234}Th fluxes out of the surface ocean [3]. Along with the particulate ratio of ^{234}Th with POC (^{234}Th:POC), these measurements have been used to estimate POC fluxes throughout the water column [4].

Using a global database, over 60,000 global measurements of ^{234}Th, ^{238}U, and ^{234}Th:POC were regressed to a 2.8-degree grid using a suite of Machine Learning (ML) and Minimum Variance algorithms [5]. This gridded data was then used to drive a 3D global model of POC fluxes out of the regionally varying Euphotic Zone (EZ) using a set of sparse, implicit and explicit transport matrices derived from a global, coupled General Circulation Model [6].

Our model captures known major features of ^{234}Th, with an average of 2.03±0.20 dpm L^{-1} globally and greatest activities in ocean gyres. The model estimates an average of ~6.3 PgC year^{-1} of POC out of the EZ, with an average flux of 44±43 mgC m^{-2} day^{-1} and greatest fluxes in the coastal, equatorial, and extreme latitude regions. Furthermore, our model predicts that the Pacific Ocean contributes to ~50% of the annual flux, with ~3 PgC year^{-1}, followed by the Atlantic Ocean, with a ~30% contribution of ~2.1 PgC year^{-1}.

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