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Seasonal, interannual and decadal patterns in deep ocean particle flux in the Sargasso Sea and linkage with upper ocean physics and biology

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The Oceanic Flux Program (OFP) time-series off Bermuda has produced an unequalled, nearly continuous, high resolution record of particle flux in the deep Sargasso Sea that spans more than thirty years. The OFP time-series, in conjunction with the co-located BATS and BTM time-series, has provided key data in which to assess how seasonal and non-seasonal variability in the deep ocean flux is linked with physical and biological processes and with meteorological forcing. The record length of the OFP time-series allows us to statistically describe how the particle flux measured for any period in the seasonal cycle relates to its expected magnitude, based on the long-term flux climatology at this site. Using a gamma probability distribution model, we recast raw data into flux probabilities to quantitatively explore the short-term flux variability that overlies the seasonal flux pattern and to evaluate interannual and decadal trends. As observed in meteorological data, inter-annual variability in deep water particle flux is greatest during the transitional seasons of early winter and late spring, when surface stratification is weak and the influence of mesoscale physical variability most pronounced. In addition to biological phenomena (e.g. salp blooms), transient meso-scale features such as passage of productive eddies, which alter upper ocean export and mixing characteristics, may generate short-lived extreme flux “events”. Yet not all productive eddies passing over the site have an effect on the deep flux, underscoring the importance of ecosystem structure and physics on the coupling between surface ocean productivity, surface export flux and deep particle flux generation. Causative processes that influence this coupling can be identified through detailed examination of organic and inorganic flux components. Overall, the annually-integrated flux is highly sensitive to the magnitude of the flux anomaly (relative to the long-term climatological mean state) during the transitional early winter and late spring periods. When the wintertime North Atlantic Oscillation index is low, the flux anomalies tends to be positive, suggesting an influence of wintertime storminess on the export efficiency of the biological pump.