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Factors controlling interannual variability of vertical organic matter export and phytoplankton bloom dynamics. A numerical case-study for the NW Mediterranean Sea.

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Mid-latitude spring blooms of phytoplankton show considerable year-to-year variability in timing, spatial extent and intensity. It is still unclear to what degree the bloom variability is connected to the magnitude of the vertical flux of organic matter. A coupled three-dimensional hydrodynamic-biogeochemical model is used to relate interannual variability in phytoplankton spring-bloom dynamics to variability in the vertical export of organic matter in the NW Mediterranean Sea. Simulation results from 2001 to 2010, validated against remote sensing chlorophyll, show marked interannual variability in both timing and shape of the bloom. Model results show a tendency for the bloom to start later after cold and windy winters. However, the onset of the bloom occurs often when the mixed layer is still several hundred meters deep while the heat flux is already approaching zero and turbulent mixing is low. Frequency and intensity of wind episodes control both the timing and development of the bloom and the consequent export flux of organic matter. The wintertime flux is greater than zero and shows relatively low interannual variability. The magnitude of the interannual variability is mainly determined in March when the frequency of windy days positively correlates with the export flux. Frequent wind-driven mixing episodes act to increase the export flux and, at the same time, to interrupt the bloom. Perhaps counterintuitively, our analysis shows that years with discontinuous, low chlorophyll blooms are likely to have higher export flux than years with intense uninterrupted blooms. The NW Mediterranean shows strong analogy with the North Atlantic section within the same latitude range. Hence, our results may also be applicable to this quantitatively more important area of the world ocean.