A Lagrangian view of spring phytoplankton blooms

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The basic one-dimensional mechanism behind spring phytoplankton blooms is investigated using a Lagrangian NPZD model, where the movement and transfers of nutrient parcels are solved by tracking a nitrogen parcel. The Lagrangian framework is useful for understanding how the nitrogen cycle works in the ocean since it naturally follows the movement of materials through the turbulent ocean environment. The model reveals that the onset of spring blooms depends on the cumulative euphotic age, which is the total time that inorganic nutrient is exposed to light before the photosynthetic conversion to phytoplankton biomass. A spring bloom occurs when nutrient parcels accumulate enough light exposure through multiple entries to the sun-lit zone near the surface or by residing near the surface. This is regardless of the underlying mechanism, such as critical depth hypothesis or critical turbulence hypothesis. The difference between the two modes lies in how cumulative euphotic age is accumulated and this can be distinguished by examining the cumulative euphotic age spectrum.

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