Highly intermittent plankton ecosystem: observations and new models

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Phytoplankton requires both light and nutrient, thus requires to stay in the upper ocean where turbulence stirs water column. Turbulence mixes oceanic properties, such as salinity and temperature. How does it mix phytoplankton? How do they distribute in space. Traditionally, biologists use Niskin Bottle (~1 m) to sample water in order to identify phytoplankton cells and measure the average concentration of chlorophyll. Therefore, no information is available how phytoplankton distribute below one-meter scale. A conventional CTD mounted cage may caries a Seapoint chlorophyll fluorometer that allows a fine scale observation of fluorescence. But the configuration of the probe prevents without disturbing the phytoplankton natural distribution. We introduce how to measure phytoplankton at a micro scale without agitating the natural field. And we also present the implication of such micro scale distribution for plankton ecosystem model.

We have developed two types of fluorescence probe, LED (~2 cm resolution) and laser (~2 mm resolution) and mounted these probes on a free-fall microstructure profiler (TurboMAP-L). Both probes measure phytoplankton distribution without agitating the field. We have found the LED data are significantly different from the laser data that exhibit highly intermittent features. The variability may be quantified by the coefficient of variation (CV=standard deviation/mean). The millimeter scale fluorescence field exhibits considerably high intermittency attaining that the CV exceeding 1.

In order to take account the intermittent feature of phytoplankton distribution we have developed a new ecosystem model making use of closure approach that has been applied to turbulence studies. We have developed NP, NPZ and NPZD closure model and compared the new models against the convensional models. Also we have implemented NP and NPZ closure model to the one dimensional mixed layer model (GOTM). We found that high variability expands the stability domain of parameter space. We also found that variability accelerates trophic transfer from low to high component (P or Z). We will discuss the implication of the new ecosystems to biogeochemical cycles.

Keywords: phytoplankton, turbulence, microstructures, ecosystem model