Trait Scaling Laws of Phytoplankton

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Scanning flow cytometry devices on lakes measure physiological traits, such as size and fluorescence, of millions of algal and bacterial particles at high spatial and temporal resolution. Together with measurements of resource availability, such as light and nutrients, this data gives us an unprecedented view on composition and dynamics of complex natural communities in terms of their physiological traits, which may eventually lead to new insights into global nutrient cycles.

The distributions of various traits in natural phytoplankton communities often follow power laws over many orders of magnitude. This is remarkable considering that these distributions are the result of many microscopic processes on both evolutionary and ecological time scales, and may lead to the hypothesis that, through some sort of self-organization, natural phytoplankton communities get poised in a near-critical state. Algal blooms, the sudden massive proliferation of single species, may be dynamical manifestations of near-critical behavior. Under the criticality hypothesis, we should be able to predict critical exponents and relations among them by means of relatively simple interacting particle models on trait space.

In order to study trait scaling laws under controlled conditions, mono-cultures have been exposed to different light intensities in the lab and sampled frequently with a flow-cytometer. The resulting fluorescence distributions indeed follow interesting scaling laws, which give us some hints to the underlying fundamental ecological processes of cell growth and reproduction. We present a class of particle models that is able to explain the observed scaling laws from the lab experiments, and may be the basis for future multi-trait community models.