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Separating direct acidification response signal from variability in plankton dynamics.

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Motivation of my research.
Ocean acidification is one of the major anthropogenic stressors on ecosystems because it perturbs the cycling of carbon. The concentration of atmospheric carbon dioxide (CO_2) has increased since the Industrial Revolution at an unprecedented rate and oceanic water has become 30% more acidic. It is largely unknown how phytoplankton respond to ongoing acidification. Phytoplankton comprise about 5000 species that are diverse in morphology (with cell diameters ranging from 1 to 10000 μm) and in physiology. They are not only main primary producers of the aquatic food web but also exert a tight control on oceanic and planetary biogeochemistry. Many studies on ocean acidification were conducted as mesocosm experiments, where enclosed water volumes were exposed to different CO_2, light, and temperature conditions. Mesocosm studies typically exhibit variability even within similar treatments, which makes it complicated to identify exclusive responses to acidification. This variability emerges from uncertainties in internal community structure and phytoplankton physiology. We need to understand the origin and extent of ecological and physiological uncertainties to explain the observed changes in biogeochemical processes and specify variability in model simulations.

How we address uncertainty.
We approach uncertainties by analyzing sensitivities of model results and relate these to the variability observed in data from mesocosm experiments. We developed a model that resolves organism size as the trait determining characteristics of plankton community. Cell size affects many processes in marine systems as nutrients uptake, energy allocation, interaction with grazers, aggregation and sedimentation, and it is specially important for phytoplankton since they are mostly unicellular organisms. The advantage of this size-trait modeling approach is that the community is not split in size classes with different mathematical expressions. In contrast, only one equation for the mean size evolution is required and the community size distribution emerges as model solution. Moreover, our size-trait model is adaptive, continuously refining calculations of relevant production and loss processes. By monitoring the community size evolution, the model mirrors how individuals, seeking optimum growth rate under environmental changes, are selected. It has been shown that subtle differences in size-trait dynamics alone can give rise to large differences in growth and decay biomass, compared to variations due to external environmental factors, as light and temperature. The solutions depend on initial community composition and initial physiological rates. This sensitivity can explain differences between model results in spite of similar environmental conditions. Using a combined data-model approach, we can validate our model by comparing observed with simulated trajectories and unravel needs in terms of data accuracy for the initial period of an experiment. The expected outcomes of our sensitivity and uncertainty analysis are: i) to identify major sources of variability in mesocosm experiments, ii) to quantify uncertainties (noise), iii) to relate these uncertainties to the direct response to perturbation (signal-to-noise ratio), iv) to design experimental setups that may potentially reduce this signal-to-noise ratio.