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Alternate history: A synthetic ensemble of ocean chlorophyll concentrations

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Internal climate variability plays an important role in the abundance and distribution of phytoplankton in the global ocean. Previous studies using large ensembles of Earth system models (ESMs) have demonstrated their utility in the study of marine phytoplankton variability. These ESM large ensembles simulate the evolution of multiple alternate realities, each with a different phasing of internal climate variability. However, ESMs may not accurately represent real world variability as recorded via satellite and in situ observations of ocean chlorophyll over the past few decades. Observational records of surface ocean chlorophyll equate to a single ensemble member in the large ensemble framework, and this can cloud the interpretation of long-term trends: are they externally forced, caused by the phasing of internal variability, or both? Here, we use a novel statistical emulation technique to place the observational record of surface ocean chlorophyll into the large ensemble framework. Much like a large initial condition ensemble generated with an ESM, the resulting synthetic ensemble represents multiple possible evolutions of ocean chlorophyll concentration, each with a different phasing of internal climate variability. We further demonstrate the validity of our statistical approach by recreating a ESM ensemble of chlorophyll using only a single ESM ensemble member. We use the synthetic ensemble to explore the interpretation of long-term trends in the presence of internal variability. Our results suggest the potential to explore this approach for other ocean biogeochemical variables.