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Reduced mixing generates oscillations and chaos in the oceanic deep chlorophyll maximum

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Deep chlorophyll maxima (DCMs) are widespread in the tropical oceans. These deep layers of high chlorophyll concentration reflect a compromise of phytoplankton growth exposed to two opposing resource gradients: light supplied from above and nutrients supplied from below. It is often argued that DCMs are relatively stable features. However, here we show by means of advanced computer simulations of a 1D biological-physical model that reduced vertical mixing can generate oscillations and even chaos in phytoplankton biomass and species composition of DCMs (Huisman et al. 2006 Nature 439: 322-325). These fluctuations of the DCM are caused by a difference in the time scales of two processes: (1) rapid export of sinking plankton, withdrawing nutrients from the euphotic zone and (2) a slow upward flux of nutrients fuelling new phytoplankton production. The fluctuations predicted by the model are consistent with complex phytoplankton dynamics observed in the Hawaii Ocean Time-series data of the subtropical Pacific Ocean. Climate models predict that global warming will reduce vertical mixing in the oceans. Our model results indicate that such reduced mixing will generate more variability in DCMs. Thus, climate change may enhance the variability in oceanic primary production, and thereby reduce carbon export into the ocean interior.