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Potential predictability of marine ecosystem stressors on interannual to decadal timescales

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Marine ecosystems are increasingly stressed by human-induced perturbations to the Earth system. Warming, acidification, deoxygenation, and changes in net primary productivity (NPP) are commonly considered to be important potential stressors. In addition to long-term trends sustained through anthropogenic perturbations to the Earth system, potential marine ecosystem stressors are known to exhibit variations over a wide range of spatial and temporal scales associated with natural variability in the climate system. For resource management, it would be of great value if these stressors are predictable in the near-term (seasonal-to-decadal timescales). However, the potential predictability of those stressors remains largely unexplored, with exceptions being sea surface temperature (SST) and NPP in the tropical ocean.

Here, we use large ensemble simulations from the GFDL Earth system model ESM2M to quantify the potential predictability of marine ecosystem stressors. At six different starting points in a preindustrial control simulation, we generated forty 10-year-long ensemble simulations with initially infinitesimal dynamical perturbations. Our results show that the potential predictability of the stressors at the surface is between 4 and 6 years on the global scale. The potential predictability generally increases with depth to more than 10 years below 100 meters. On regional scales, SST and pH have high predictability in the North Atlantic and the Southern Ocean; for NPP the potential predictability is high in the subtropical gyres. To better understand the drivers of predictability, we decompose pH into the corresponding carbonate chemistry components and oxygen into the contributions from apparent oxygen utilization (AOU) and solubility. The potential predictability of pH at any depth is mainly driven by alkalinity and dissolved inorganic carbon. The loss of predictability in oxygen in the upper ocean arises from the solubility component, whereas for depths below 100 meters it is due to the AOU component. Our results showing multi-year potential predictability for multiple stressors is the first cornerstone to foster broader community efforts in developing new predictions of ecosystem stressors.