**Improving the initial state of biogeochemical components in Earth System Models**

The cycling of nutrients and carbon in the ocean and land systems has adjustment timescales that extend out to centuries and millennia. For high-resolution models, these long timescales make it computationally infeasible to spin-up the biogeochemical components of Earth-system

models (ESMs) by simply time-stepping them forward until transients die out. As a result, ESMs typically experience a drift for the first several hundred to thousand years of simulation as the oceans adjust to the surface forcing and the soil carbon and nutrient pools adjust to the drifting climate. Furthermore, biogeochemical modules in ESMs have many parameters that are calibrated by “fitting” the model to observations rather than from first principles. The biogeochemistry initialization problem therefore consists of finding a consistent set of parameters and biogeochemical state variables that minimize model drift and mismatch of the resulting model state with a sparse and noisy observational database.

Our newly funded project will address this problem by implementing Newton-Krylov spin-up methods to the marine biogeochemical module (MARBL) in an offline approach using tracer-transport operators derived from E3SM’s ocean component (MPAS-O). We will also work towards extending the Newton-Krylov techniques to E3SM's land model (ELM) so that we can generate a fully coupled initial state for the Earth's carbon cycle. In this presentation I will briefly review previous work done in the context of CESM-POP2 model and describe what we hope to achieve in the context of E3SM's ocean component (MPAS-O) in the coming year.