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Evaluating coupled ecosystem ocean circulation models: can we trust the concept of preformed nutrients?

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It is common practice to separate inorganic nutrient concentrations in the interior of the ocean into a preformed and a remineralised pool by following an "oxygen saturation approach" (based on additional measurements of oxygen, temperature and salinity). By definition, the preformed pool is exported from the surface to the deep ocean (by subduction or mixing) during water mass formation while the remineralised pool constitutes the accumulated signal of organic material remineralised along the way from the surface to the sampling location. The concept is increasingly popular as it helps, e.g., to disentangle physical and biogeochemical deficiencies of coupled ecosystem-circulation models. However, the concept is based on a number of assumptions which are not always met. Among them are, (1) perfect oxygen saturation during water mass formation, (2) insignificant subsurface warming, and (3) linear mixing of source waters. Only a limited number of studies have evaluated this approach systematically, e.g. using biogeochemical ocean models run into steady state. Based on results from a coupled ecosystem-circulation model which has additional, explicit, representations of preformed/remineralized nutrients we examine pitfalls of the "oxygen saturation approach". The volume weighted distribution of total phosphate (preformed + remineralised) from our model compares well with observed phosphate (World Ocean Atlas). At the same time the distributions of preformed phosphate computed using the oxygen saturation approach clearly differs between model and data, suggesting the need to compare preformed and remineralised nutrients independently. However, comparing preformed nutrients from our explicit tracer and those computed via the oxygen saturation approach tells that the interpretation of preformed nutrients computed from data or model output may be ambiguous. We discuss implications for model-observation intercomparisons.