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Linking contemporary parametric model uncertainties to projections of biogeochemical cycles

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Anthropogenic emissions of greenhouse gases, such as CO_2 and N_2O, warm the earth. This in turn modulates the atmospheric greenhouse gas concentrations. The underlying feedback mechanisms are complex and can be counterintuitive. Earth system models have recently matured to standard tools tailored to assess and understand these feedback mechanisms. Along comes the need to determine poorly-known model parameters. This is especially problematic for the ocean biogeochemical component where respective observational data, such as nutrient concentrations and phytoplankton growth, are rather sparse in time and space. In the present study, we illustrate common problems when attempting to estimate such parameters based on typical model evaluation metrics. We find very different parameter sets which are, on the one hand, equally consistent with (synthetic) historical observations while, on the other hand, they propose strikingly differing projections into a warming climate. By the example of simulated oxygen concentrations we propose a step forward by applying variance-based sensitivity analyses to map the respective parameter uncertainties onto their local manifestations - for both contemporary climate and climate projections. The mapping relates local uncertainties of projections to the uncertainty of specific model parameters. In a nutshell, we present a practical approach to the general question of where the present-day model fidelity may be indicative for reliable projections.