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Using parameter estimation to reduce future climate-carbon cycle projection uncertainty

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Predicting the responses of terrestrial ecosystems to future global change strongly relies on our ability to accurately model global scale vegetation dynamics and surface CO_2 fluxes. However, terrestrial biosphere model carbon cycle processes remain subject to large uncertainties, partly because of unknown or poorly calibrated parameters.

We can use the unprecedented amount of *in situ* and Earth Observation data to optimize these model parameters, as well as the considerable advances in parameter estimation techniques. Most of these techniques use Bayesian data assimilation approaches, which allow for objective calibrations of key model processes and parameters against observations, reducing the associated uncertainty. However, calibrating against present-day observations does not necessarily give us confidence in the future projections of the model, given that they are likely to exceed historical and present-day conditions. The relatively shorter timescales of present-day observations mean these cannot be directly used to create constraints on changes in the Earth System over the next century. Instead, we need to develop methods to translate short-term constraints into reductions in long-term projection uncertainty, bridging the gap between contemporary model optimisations and future predictions.

In this presentation, we will discuss two experiments highlighting how we can use parameter estimation to reduce model uncertainty and translate this information into constraints on future climate.

The first demonstrates how we can use manipulation experiments to increase our confidence in optimized parameters. We use data from two nitrogen-limited sites from the Free Air CO_2 Enrichment experiment to optimize model parameters. The optimization is performed against ambient and elevated CO_2 conditions simultaneously, giving us a better insight into nitrogen limitations on CO_2 fertilization at these sites.

The second demonstrates how we can combine local model calibration with the emergent constraint approach. Using a parameter perturbation ensemble, we identify an emergent relationship between the optimal temperature for photosynthesis in tropical forests, and the projected amount of atmospheric CO_2 at the end of the century. We combine this with a constraint

on the optimum temperature for photosynthesis in tropical forests derived from eddy-covariance measurements and parameter estimation techniques to reduce the likely range of future atmospheric CO_2 in a coupled climate-carbon cycle model under a common emissions scenario.