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Sensitivity of land carbon feedbacks, temperature controls on photosynthesis and interactions with the wider climate system

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Much of what we currently know about uncertainties arising from land carbon cycle processes comes from comparison of available models (C4MIP and increasingly CMIP5 simulations). While they remain a core tool to characterise the implication for these uncertainties for future projections, differences in model complexity limits our ability to identify which aspects of land surface modelling determine spread in future projections. Here we make use of a perturbed parameter approach, used previously to explore atmospheric feedback uncertainty, to explore uncertainties within the land carbon cycle of a coupled carbon cycle GCM (HadCM3C). We show that the temperature dependence of photosynthesis is the dominant uncertainty within this framework, and the resulting spread in future CO_2 and temperature are comparable with current uncertainties within emission scenarios and climate sensitivity (respectively) in the next century. This result both highlights the important role that land carbon processes play within the Earth System and raises questions about how we represent photosynthesis within current land carbon cycle models, highlighting the need to understand the role that acclimation processes may play in this.

We go on to show results from a larger ensemble modelling approach that looks at how uncertainties within land carbon representation interact with uncertainties from atmospheric feedbacks within full coupled climate model GCMs (HadCM3C). We compare the results from this experiment with what we'd expect based on simple model tools (commonly used in Integrated Assessment models). We find that while these interactions do not lead to any systematic deviation from what we'd expect from simple model assumptions, they can lead, in individual models, to significant enhancement or damping of the future response over what would be expected.