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Towards a quantification of process-based uncertainties in the nitrogen effect on carbon-climate interactions

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A suite of new land-surface models has emerged in recent years that account for the effects of terrestrial nitrogen (N) dynamics on terrestrial carbon (C) uptake and release, and therefore their effect on the feedbacks between the land carbon cycle and climate. These models have demonstrated that, in general, N dynamics attenuate the response of the terrestrial C cycle to both increasing atmospheric carbon-dioxide and changing climate. Taken together, the two effects lead – in general but not always – to an increased built-up of carbon-dioxide in the atmosphere by the end of the 21^{st} century. The reasons for the substantial divergence in the estimates remain largely unexplained, although model-intercomparison studies suggest that alternative assumptions about (1) the level of flexibility in terrestrial C:N ratios (stoichiometry), as well as the response of (2) biological N-fixation and (3) N losses to altered N and C availabilities may play a key role.

Here, we use a number of alternative process-formulations of these three key N cycle processes within the framework of the O-CN land surface model for an RCP 2.6 and 8.5 climate change scenario to investigate i) what the overall uncertainty in N-cycle feedbacks of current generation models are; ii) which (, where, and when) processes contribute mostly to this uncertainty; and iii) whether modern date data can possibly constrain this uncertainty. We find that there is considerable uncertainty in future projections, despite reasonably comparable modern time estimates of the C cycle. The differences are accentuated in the stronger change scenario (RCP 8.5), and are in particular strongly dependent on the assumed response of biological N fixation. Based on our results, we provide some recommendations for the development of the next generation of nutrient enabled carbon cycle models.