

Can we bet on negative emissions to achieve the 2°C target even under strong carbon cycle feedbacks?

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## Abstract

Given the narrowing windows of opportunities to stay below 2°C, negative emission technologies such as Bioenergy with Carbon dioxide Capture and Storage (BioCCS) play an ever more crucial role in meeting the 2°C stabilization target (Fuss et al. 2014). Negative emission technologies –if deployable at a sufficiently large scale during the second half of this century –would make the 2°C target more feasible in the midst of the slow political progress. However, such technologies are currently at their infancy and their future penetrations may fall short of the scale required to stabilize the warming (Scott et al. 2013). Furthermore, the overshoot in the mid-century prior to a full realization of negative emissions would give rise to a risk because such a temporal but excessive warming above 2°C might amplify itself by strengthening climate-carbon cycle feedbacks, which are known to be positive albeit with large uncertainties (Friedlingstein et al. 2006). When one considers other classes of carbon cycle feedbacks including those with permafrost thawing and wildfire, such a risk could be even higher. It has not been extensively assessed yet how carbon cycle feedbacks might play out during the overshoot in the context of negative emissions, while the literature on carbon cycle feedbacks has burgeoned in recent years.

This study explores how 2°C stabilization pathways, in particular those which undergo overshoot, can be influenced by carbon cycle feedbacks and asks their climatic and economic consequences. We compute 2°C stabilization emissions scenarios under a cost-effectiveness principle, in which the total abatement costs are minimized such that the global warming is capped at 2°C. We employ a reduced-complexity model, the Aggregated Carbon Cycle, Atmospheric Chemistry, and Climate model (ACC2) (Tanaka et al., 2013), which comprises a box model of the global carbon cycle, simple parameterizations of the atmospheric chemistry, and a land-ocean energy balance model. The total abatement costs are estimated from the Marginal Abatement Cost functions for CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and BC, which are derived from Azar (2013).

Our preliminary results show that, if carbon cycle feedbacks turn out to be stronger than what is known today, it would incur substantial abatement costs to keep up with the 2°C stabilization goal. Our results also suggest that it would be less expensive in the long run to plan for a 2°C stabilization pathway by considering strong carbon cycle feedbacks because it would cost more if we correct the emission pathway in the mid-century to adjust for unexpectedly large carbon cycle feedbacks during overshoot. Furthermore, our tentative results point to a key policy message: *do not rely on negative emissions to achieve the 2°C target*. It would make more sense to gear climate mitigation actions toward the stabilization target without betting on negative emissions because negative emissions might create large overshoot in case of strong feedbacks. Our simple approach illuminates a need for investigating this issue further by using a range of models including coupled Earth System Model (ESM)-Integrated Assessment Models (IAMs).

## References

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