

## ***Interactive comment on “Impacts of climate mitigation strategies in the energy sector on global land use and carbon balance” by K. Engström et al.***

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Resonse to D.B. Kirk-Davidoff (Referee)

As editor, I am submitting a reviewer comment, thus closing the discussion, in light of the authors' long wait for the completion of this review process and of the first reviewer's excellent and thorough review. The authors present a study of an integrated assessment model in which they first find parameter settings that allow the model to approximate a set of scenarios described in the Shared Socio-economic Pathways framework, and then add a mechanism intended to represent a carbon tax imposed on fossil fuel combustion, and note the impact of this tax on gross world product, on fossil fuel use, and on agricultural activity. I concur with the first reviewer's comments

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and recommendations, especially with regard to the desirability of a more realistic accounting of the local cost to wealth of climate impacts (since these are already spatially resolved for use in the ecosystem model). I have a number of additional suggestions for clarifications. It was not immediately clear to me that the various SSP scenarios would be imposed on the model through parameter choices (as opposed, for example to forcing the model through variable population growth rates or some other forcing mechanism). The introduction could be rewritten to make this much clearer, and also to address the first reviewer's concerns about how consistent the model trajectories are with the SSPs as defined. The discussion of "damage on GWP" is confusing- this seems to be just a proxy for global warming averted, but since the climate-economy model calculates GWP explicitly, couldn't the GWP itself be shown, so that the increase in GWP due to the optimized carbon tax would be apparent in Figure 4? Similarly, the terms "challenges to adaptation" and "challenges to mitigation" don't seem to be as parallel in meaning as their grammatical parallelism would suggest. "Challenges to adaptation" seems to indicate political resistance to adaptation, while "challenges to mitigation" seems to indicate a structural likelihood of a lot of damage to GWP due to warming. Perhaps these should be rephrased as "resistance to mitigation" and "wealth available for adaptation" (which would have the opposite sign to "challenges to adaptation")? In this regard, l. 21 on page 8 seems problematic without a clear baseline: since higher means more damage per unit Carbon emitted, the required reduction in emissions to achieve a given reduction in damage is actually less, though of course the reduction in emissions required to achieve a given low \*level\* of damage would be larger.

Response: Dear editor, Thank you for your comments. The model is driven by inputs such as population and economic growth and scenarios are differentiated on the basis of these inputs, as well as parameter choices. Following your suggestion this is clarified in the introduction, also emphasising the value of the study in providing independent interpretations of the SSP narratives, compared with the published realisations in the SSP database. It is important to note there is no objective "right" interpretation of these

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(qualitative and relative) narratives in quantitative terms. Thus there is a place for different interpretations based on different defensible approaches to stimulate debate and accommodate the many dimensions of uncertainty surrounding the actual evolution of the biophysical-societal system in the 21st century. In this light we believe our study is a relevant and valid alternative contribution, complementing the “official” SSP projections. The damage on GWP is proxy for the impact of global warming. The climate economy model does not calculate GWP explicitly, but GWP is the sum of all countries’ GDPs (provided from the SSP database). Throughout the manuscript we used the SSP terminology which ‘collapses’ the multi-faceted futures described by each SSP onto the two dimensions of “challenges to adaptation” and “challenges to mitigation”. This terminology is now well-established in relevant literature and it would be confusing to adopt alternative terminology in this paper. We assumed that the challenge to mitigation impacts the level of the global carbon tax that can be implemented in the respective scenario. For example, with larger challenges to mitigation the carbon tax level would be less optimal, while the level of the global carbon tax is optimal in scenarios with low challenges to mitigation. We clarified in the revised manuscript that the characteristics of the SSPs determine the challenge to mitigation and that it is not a political resistance to mitigation per se that differentiates the SSPs. For example, in the regionalized, not internationally cooperating SSP3 world with the use of unconventional and domestic energy resources the implementation of a global optimal carbon tax would be very challenging. Challenges to adaptation map to both the level of climate-related damages expected in the absence of adaptation, and the amount of adaptive capacity implied by the SSP storyline. Thus, for example, the highly engineered and developed infrastructure and attainment of human development goals implies a low challenge for adaptation, rather than there is much wealth needed for adaptation.

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