

Interactive comment on “Geologic constraints on earth system sensitivity to CO₂ during the Cretaceous and early Paleogene” by D. L. Royer et al.

D. L. Royer et al.

droyer@wesleyan.edu

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We thank Ken for taking time to read our manuscript and to post a guest comment. This is much appreciated. Our responses follow Ken's numbering system.

1. Because our manuscript focuses strongly on the climate feedbacks that impact climate sensitivity, we thought it would be most helpful and appropriate to define climate sensitivity in terms of these feedbacks. To our knowledge, there is nothing factually-wrong with our definition.

2. We agree that the language concerning the PETM is too strong and we will adjust this section per Ken's suggestion.

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3. The issue of whether CO₂ is a forcing or a feedback has been raised by other reviewers. In our revisions we will clarify the language on this issue. Most importantly, our definition of Earth system sensitivity accommodates for CO₂ changes that are associated with feedbacks. As a result, in order for this concept to be useful, the assumption we are making (and that we will state explicitly in the revisions) is that all of the feedbacks are responding to the climate state. That is, for example, if something causes the Earth to warm (could be CO₂, could be something else), the relationship between CO₂ and global temperature will remain within certain reasonable bounds.

However, there are some forcings that we consider external to the climate system. That is, changes in these forcings will tend to shift the relationship between CO₂ and temperature. These external forcings are solar evolution, paleogeography, and biological innovation. Ken brings up the last factor. In this case, yes, ideally we want to quantify and externalize this forcing. We discuss at length the probable impacts of all three factors. We can quantify with relative ease the effect of solar evolution. Paleogeography and biological innovation (independent of climate state) are much more difficult, but most data point to an effect that is small enough not to impact our basic conclusions (presence of a 3+ °C ESS for some of the Cretaceous and early Paleogene).

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