Review of Abels et al., “Carbon isotope excursions in paleosol carbonate marking five early Eocene hyperthermals in the Bighorn Basin, Wyoming,” Climate of the Past Discussions (cp-2015-48)

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This manuscript represents a significant revision of the original submission, of which I also reviewed. I appreciate the authors’ diligence in trying to address my primary comment, namely that background $p\mathrm{CO}_2$ is not required to have remained constant during the early Eocene. Towards this, the authors now include two separate sections evaluating their records in terms of both constant and changing background $p\mathrm{CO}_2$ (Sections 3.3 and 3.4). However, the analysis described in Section 3.3 “CIE comparison with fixed background $p\mathrm{CO}_2$” and the associated modeled values within Figure 5 are not correct due to an error in how the equations from Schubert and Jahren (2012) are applied here (detailed below).

I do wish to highlight that the closing statement from Section 3.3 (Lines 329-331) “changing photosynthetic discrimination in isolation and under the assumption of near-constant background $p\mathrm{CO}_2$ cannot explain the variation in CIE expression in Bighorn Basin soil carbonates” is correct; however, the calculation used to get this result (and the calculated values themselves) is not correct. Because this result is not a significant part of the work presented here (for example, this result is not reported within the Abstract or Conclusions sections), I do not feel that reanalysis and revision of this section should be required for publication. Instead, I fully support (without any further justification) if the authors wish to simply cut this analysis (i.e., Section 3.3) and accordingly revise any text that references this section. However, in the event the authors do feel strongly that this section is needed, I hope that my review of this work would help guide a reanalysis and revision.

Error in calculations described within Section 3.3 (and thus “modeled” values reported in Fig. 5):

On lines 302-304, the authors now state, “For any background $p\mathrm{CO}_2$ condition prior to the PETM ($p_{bkg,PETM}$) we can calculate plant carbon isotope discrimination ($\Delta_{bkg,PETM}$) using equation 6 of Schubert and Jahren (2012).” However, this equation represents the $\Delta^{13}\mathrm{C}$ response to $p\mathrm{CO}_2$ for two species of herbaceous plants grown under well-watered conditions and cannot be used here to calculate plant carbon isotope discrimination. Note that the $\Delta^{13}\mathrm{C}$ values calculated using this equation for ambient $p\mathrm{CO}_2$ equal $\Delta^{13}\mathrm{C}$ values similar to the wettest places on Earth (discussed at the end of section 4 within Schubert and Jahren, 2012). Therefore, for any background $p\mathrm{CO}_2$ value used, calculated $\Delta^{13}\mathrm{C}$ values using this equation will represent a maximum possible value. Eqn 6 of Schubert and Jahren (2012) should only be used to evaluate *relative* changes in $\Delta^{13}\mathrm{C}$, and should not be used to calculate absolute $\Delta^{13}\mathrm{C}$ values (Schubert and Jahren, 2015). This has now been shown quantitatively within Cui and Schubert (2016, GCA, see Fig 1), which shows that the absolute $\Delta^{13}\mathrm{C}$ value may differ greatly for a given $p\mathrm{CO}_2$ level (inset; similar $\Delta^{13}\mathrm{C}$ range to modern data, e.g., Diefendorf et al., 2010, PNAS), but the relative change in

Δ^{13}C value per change in $p\mathrm{CO}_2$ (i.e., the slopes of these three curves, which we call "*S*") is consistent for all three of these curves.

The authors then continue by stating (lines 304-307), "Adding this value and $D\Delta_{PETM}$ we obtain the value of PETM photosynthetic discrimination, Δ_{PETM}." *This value* here refers to the value for $\Delta_{bkg,PETM}$, which as stated above is not representative of late Paleocene Δ^{13}C. Second, the value for $D\Delta_{PETM}$ used here (+0.8‰), appears to be calculated using a single *n*-alkane record and single benthic record, but no justification for choosing these specific two records from the hundreds of available records is provided. The value for $D\Delta_{PETM}$ can vary greatly based on the records chosen; this is particularly important to justify given the strong sensitivity between $D\Delta_{PETM}$ and $p\mathrm{CO}_2$ (see Fig. 2 within Schubert and Jahren 2013).

Third, the authors state (lines 305-307), "We then invert the photosynthetic discrimination equation to find the PETM $p\mathrm{CO}_2$ concentration (p_{PETM}) that gives the estimated discrimination." Here, it appears the authors again (incorrectly) use Eqn 6 from Schubert and Jahren (2012) to plug in their calculated Δ_{PETM} values (determined using the steps described above) in order to solve for p_{PETM} (i.e., PETM $p\mathrm{CO}_2$). They then plot the change in PETM $p\mathrm{CO}_2$ (Dp_{PETM}) (calculated as the difference between $\mathrm{p}_{\mathrm{PETM}}$ and $p_{bkg,PETM}$) across a range of $p_{bkg,PETM}$.

Last, the authors use "Dp_h values estimated for each event" (e.g., the value for Dp_{PETM} incorrectly calculated above) to calculate $D\Delta_h$ for each event "using the previously referenced photosynthetic discrimination equation" (although this step needs clarification), and this value is then used to calculate $D\delta_p$ (*via* their Eq 2). This calculated (modeled) value is then compared to the measured value. Not surprisingly, the calculated value does not match the measured value. The conclusion is correct (the measured value will not match the modeled value when assuming a constant background $p\mathrm{CO}_2$ for all events), but the calculated values for the "modeled plant CIE" shown in Fig 5 are not correct. Most striking, the slopes for the two initial $p\mathrm{CO}_2$ scenarios shown (250 and 3000 ppmv) should not be parallel to each other, and initial $p\mathrm{CO}_2 = 3000$ should yield a smaller modeled plant CIE than initial $p\mathrm{CO}_2 = 250$ ppmv, provided that "that peak $p\mathrm{CO}_2$ change for each hyperthermal (Dp_h) is a linear function of marine (benthic) CIE magnitude."