Here the authors compare a compilation of tree ring and leaf isotope data from around the world with isotopic simulations from two common land surface models. While several studies have compared isotopic estimates of iWUE with model simulations of iWUE, especially at regional scales. This study is novel in that it is one of the few to actually investigate isotopic tracer simulations within models as a critical diagnostic for how accurate models are at simulating the global C cycle. In principle, this approach allows us to evaluate to what extent the terrestrial biosphere is being fertilized by increased atmospheric CO2; however, I think that the authors could further partition the response of iWUE into its component processes of assimilation and transpiration (at least in the models). This may also help reconcile why the models appear to show differing degrees of iWUE response.

General Comments:

I suspect that the two models investigated here differ considerably in how stomatal conductance is simulated and this is having a big impact ultimately on the isotopic tracers. While these models may be responding similarly to increases in atmospheric CO_2 they may be responding to different metrics of atmospheric water vapor. As the authors point out, assimilation in CLM is modeled as a function of RH and CO2, while it is my understanding that in LPJ stomatal conductance is modeled as a function of VPD. While RH and VPD may be inversely related in some environments, this is not always the case and their relationship might vary over the 20th century. It would be nice to see how assimilation and transpiration have responded over the 20th century independently in the two models. This may also help explain why LPX and CLM show different responses of iWUE over the 20th century.

Specific Comments:

P1L12 ‘water loss by transpiration.’

P2L4 ‘and water transpiration’

P2L22 Graven article is on 14C not 13C as cited. Check reference as they may have also included 13C in their simulations.

P2L27 conductance can be of CO2 or H2O, could be more specific here and say ‘transpiration’ as the process and H2O as the mass.

P3L7 While the authors mention many 13C tree ring records, they fail to mention the pioneering work by Tans et al. which is found in the references.

P3L22 ‘to complement recent advances in simulating marine carbon isotopes’

P4L24 ‘reactant to product’

P5L10 I believe that diffusion is only relevant for fractionation in non vascular plants such as bryophytes as well.

P6L6 more realistically related to the gradient between internal water pressure and atmospheric water pressure (approximated as vapor pressure deficit or VPD).

P7L7 del 13C signature of what? Atmosphere? Please clarify

Eqn 8 Isn’t this the same as Eqn 7? But not quite sure c* is specified in Eqn 7.

P9L9 del 13 C is estimated as the 'weighted flux' of component GPP fluxes from PFTs from within grid cell. Omit 'GPP is used as a weight'.

Eqn 11. I don't think that this equation is necessary (especially given the number of equations already included) and this can simply be explained.

P10L14 While this approximation of 36.16 holds well within 0.1% isotopic ratio differences are per 1000, so is this enough significant figures?

P11L1 Not sure that you need to correct for the offset if you are only focusing on the trends and normalizing them across sites, regardless this should not affect your analysis.

P12L18 Were the CLM and LPX simulations conducted with or without land use change and does this have any impact on the global isotopic budget.

P13L13 'changes in the atmospheric del13C source'

P13L15 'globally-averaged' what? Soil, atmosphere?

P13L34 2.42 and 3.22 per mil these should have units

P14L8 Maybe these global mean estimates should be reported first before noting all the regional differences and more nuanced results.

P14L12 'bias of the models'

P14L28 Were any trend statistics (e.g. Mann-Kendall) conducted on the observations or models?

P15L10 These aren't really 'spatial' correlations

P15L15to21 This paragraph seems to fit better in the methods

P16L24 Model simulations with increased CO_2 and constant climate change could be compared at least quantitatively to FACE data

P16L34 'Recall, however, that …represent annual or multi-annual averages that have been weighted by C assimilation or alloclation'

P17L28 This paragraph is rather short think about combining.

Eqn. 14 Would also be interesting to compare how conductance is simulated in LPX. While assimilation in both models is clearly responding to increasing atmospheric CO_2, I suspect that transpiration may be responding differentially in the models due to different stomatal response to atmospheric water demand.

P18L27 For the CLM response you should look at the relative changes in CO_2 and relative humidity over time (this should be a prognostic variable in the model). Also see work by Isaac Held on the response of the hydrologic cycle to atmospheric warming. Essentially, at the global scale RH does not change in response to warming; however, this might not be true over land. So it would be interesting to see in CLM how RH has changed at the tree ring sites.

P20L5 Similar work by Penuelas et al (2011) has shown an increase in water use efficiency but not necessarily an increase in annual ring width. However, a true test would be the relationship between WUE and Biomass- not sure if Klein looked at biomass in this study.

P20L9 It seems that both of these FACE studies report a consistent increase in WUE, but of slightly different magnitudes. It is interesting that the responses are so different between European forests and the N. American forests. Unfortunately, most of the FACE studies have been conducted in the Eastern US, where there are no tree ring isotope records.

Figure 3. not so sure that the Carvalhais estimates are 'observations', maybe 'derived from' or 'constrained by' observations.

Figures 5 and 6. I am not sure that you need both of these figures as they illustrate the same data. Perhaps move one to supplemental.

Figure 7. Can you include all of the tree ring records as thin grey traces in this figure? Would be nice to see some distribution of the observations to see if all the obs are bound by the model simulations.

Figure 8. Not sure that you need the discrimination equation, which should be defined in the text.

Figure 9. The right hand panels where certain variables have been kept constant is not explained in the caption

Figures 11 and 12. Once again these figures are both great but they illustrate redundant information maybe move one to the supplemental information.

In summary, with tree ring isotope data we are only able to approximate iWUE and cannot partition this response between assimilation and transpiration. However, in the models you can partition these processes, so it would be interesting to see how transpiration and assimilation are responding in the models, which may help identify processes that can reconcile these model simulations.