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Interactive comment on "Bottomland hardwood forest growth and stress response to hydroclimatic variation: Evidence from dendrochronology and tree-ring δ^{13}C values" *by* Ajinkya G. Deshpande et al.

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(1) Other than soil moisture, the authors did not make any substantive effort to consider other differences between the wet and dry sites. The wet sites would have enhanced ET (more E) and therefore higher humidity in the canopy, this would affect VPD and evaporative demand on the leaves. The surface water would also lead to a different bowen ratio and perhaps less extreme temperatures for the soils. The reduced heating at the soil surface would reduce convection and mixing into the canopy that might influence flushing of the canopy. My general concern is that while the broader regional

meteorological conditions might be similar between sites, the actual conditions in the canopy could be very different. This could indeed modulate growth and d13C in a way that is not really about "physiological resilience" as the authors state but more simply that the trees are just experiencing different physical forcing.

Authors' Response: We agree with your concern about differences in site-level latent heat flux and higher evaporation as a result of ponding at the wet site. This can certainly result in lower VPD in the canopy and reduce canopy conductance. However, it needs to be noted that the wet site mainly gets flooded intermittently. Although this can result in higher overall soil moisture, surface water does not necessarily occur at this site throughout the growing season. Therefore, the effect of higher evaporation at this site would be more significant on short temporal scales. Our current setup in which the δ13C measurements are annually resolved may not be suitable for detecting this effect. Additionally, if more evaporation and lower VPD in the canopy of the wet site were prominent over the entire growing season, it should have resulted in enriched δ13C values during extremely wet years because of reduced canopy conductance, which we did not observe. However, we will make improvements to the introduction and discussion to acknowledge this effect.

(2) The authors should take a more mechanistic approach to interpreting their d13C data. This does not need to involve a highly sophisticated model but a simple approach that considers d13C as a function of atmospheric 13C and A/g (as in the Farquhar model). While I think it is qualitatively fine to discuss d13C variability as merely a "stress indicator" this not necessarily true. Notably, the trees at the wet and dry sites have similar growth rates but very different d13C values. One question that I have is whether there is a source of depleted CO2 that emitted from the waterlogged sites that influences the d13C of the cellulose there. For example, if these soils produce isotopically depleted methane that is oxidized to CO2, this could deplete the isotopic ratio of the soils. The most interesting finding in the study is that d13C for the wet sites show their more depleted values when growth rates are lowest. This is a very unique

and exciting result. A series of simple sensitivity tests with a d13C cellulose model could be very helpful.

Authors' Response: As per your second comment, we have converted our carbon isotope results to Δ13C notation, which includes the effect of atmospheric δ13C. We have now also calculated iWUE as per your suggestion. However, iWUE values are very strongly correlated to Δ13C values inversely, therefore, comparing either of the two values with climate data yields relationships that are similar in strength. Hence, it might be better to use either Δ13C or iWUE instead of both. We were equally excited and intrigued to see depleted δ13C values when growth rates were lowest at the wet site and we also modeled δ13Cwet- δ13Cpredicted from dry sites versus precipitation as you have recommended. However, the relationship was not significant and hence, it is difficult to draw conclusions. We think it would be more interesting to highlight that tree-ring δ13C values at the wet site are not dependent on climatic conditions and do not affect growth rates as opposed to the drier sites, where these relationships are more prominent.

(3) The design of only measuring d13C during extreme years is not ideal with respect to understanding how a previous year influences d13C. The authors would need to measure the isotopic ratio of the cellulose for the year following the extreme year as well to see if that signal shows up. It is too late to ask this, but the authors would have a more compelling argument regarding previous years if they had used this approach.

Authors' Response: We completely agree with your comment about assessing tree-ring δ13C from years following extreme years but we were constrained by sample size limitations which prevented us from analyzing a more continuous tree-ring δ13C record.

(4) This is a rather simple comment, but I was surprised to see the authors did not use VPD as an explanatory variable. Particularly as to whether the response of wet site to precipitation was a result not of soil moisture stress (i.e. precip.) but actually because drier years were associated with higher VPD.

Authors' Response: We wished to analyze the effect of VPD on growth and δ13C but we could not do so because the weather stations closest to our sites did not have past relative humidity measurements. Also, since we are using past data from the nearest NOAA weather stations, the climate data used in the study represents regional-scale conditions. Therefore, we have not made interpretations about site-specific microclimatic conditions.

Small comments:

100: How was the frequency of flooding characterized between sites?

Authors' Response: Flooding frequency was characterized by visual assessment during our bi-weekly visits over the course of two years (2017-2019). Also, following major storm events such as Hurricane Harvey, we documented flooding depth but representing those sporadic measurements seem to be out of the scope of this study. In an Earth Resistivity Tomography study conducted by researchers from the Department of Geology and Geophysics, Texas A&M University, soil resistivity was measured before and after multiple storm events. We have added their average site-level resistivity measurements to Table 1.

254: The actual number of d13C measurements and presentation of the data is sort of obscured. It would be nice to see a time series of all the d13C even if the time series is discontinuous.

Authors' Response: This is a very valid suggestion. We have added a figure representing the Δ13C chronology similar to Figure 2. The figure is also attached with our response.

Fig 3: Were BC and DB not different as well?

Authors' Response: The difference between BC and DB was not statistically significant atα=0.05 (p=0.08) because DB values were slightly more variable.

269: The presentation of the actual correlation analyses would be nice to have in the main text even if the correlations were insignificant. This especially true for the lag analyses.

Authors' Response: The correlation analyses results are in supplementary tables 1 and 2. We added those tables to the supplementary material because of their large size but we can move them to the main content, if required.

272: "...that for the wettest site, growth rates would decline due to flood stress..."

Authors' Response: Sentence rephrased as suggested.

285: With respect to previous season effect on d13C, it would seem the biggest effect would be from the late growing season of the previous year.

Authors' Response: We analyzed the effect of previous season on $\triangle$13C using the same approach as we did for the current season (described in lines 219-223). We did not find a significant effect of previous year's August-October climate on tree-ring $\triangle$13C. However, as referee-1 has also suggested, we have made changes to lines 394-401 acknowledging that there could be an effect of previous season in the low-density earlywood of Q. nigra tree-rings. The lower density of earlywood in these ring-porous oaks and as a result of using annual ring composites, a relatively smaller effect of previous year's conditions could have been present but was difficult to detect.

297: It is noted that d13C and precip. are not correlated for the wettest site. However, it is interesting that the distance between d13C at the wettest site and the regression between d13C and precip. for the driest sites increases as it gets drier. A potentially useful variable would be ïAËŻDËĞ 13C defined as d13Cwet - d13Cpredicted from dry sites.

Authors' Response: This is a great observation. Following your suggestion, we ran the model as you have described but unfortunately, we could not find any significant correlation. However, as this trend is observed only during two specific years, we assessed the monthly climatic measurements and observed that during those two years, spring

had been much drier followed by sizeable precipitation in the summer. As a result, by sampling the tree-ring as a whole, δ13C values were depleted as a result of largely non-stressful mid- and late-growing seasons. Therefore, in Figure 5a, in which we have compared δ13C values with spring precipitation, depleted δ13C values for those two years correspond to low precipitation.

307: You say growth was sustained at wet sites even during dry years but it is also true that growth did decline somewhat during dry years, so there was some sensitivity.

Authors' Response: Sentence rephrased to: "trees at this site were able to minimize growth inhibition during stressful conditions as compared to trees at the drier sites."

Figure 6: As mentioned above, the points on the lower left of the graph (low d13C and low ring width) are extremely interesting. I would like to see a more mechanistic approach to explain them.

Authors' Response: Two out of the three points on the lower left are the two years with drier spring seasons followed by relatively wetter summers, thus resulting in lower growth but depleted δ13C. The third point corresponds to a year with a relatively wetter spring followed by a drier late-summer. Hence, these "outlier" points are results of more abrupt changes in seasonal climatic conditions from spring to summer during some years. We do not see such outlier data points at the drier sites because overall drier conditions at these sites result in δ13C enrichment as opposed to the wetter site. We will add this explanation in the discussion section. Building a mechanistic modeling approach to explain these three points is proving difficult because of the large scattering and randomness in the δ13C measurements from the wet site.

314-326: The first paragraph of Discussion is too long. It is fine to revisit some of the context and motivation for the study here, but this can be shortened to 1-2 sentences and then jump into discussing the results.

Authors' Response: Paragraph rephrased and shortened to "Bottomland hardwood forests in the southeastern United States have been reduced to a small proportion of their original expanse. The hydrology of these wetland forests has been altered due to land use change and river regulation (Wear and Greis, 2002; Blann et al., 2009; Dahl, 2011) and the alteration is exacerbated by hydroclimatic anomalies such as droughts and floods (Ferrati et al., 2005; Erwin, 2008). These disturbances coupled with topographic heterogeneity cause some portions of these riverine wetland forests tend to be drier than others."

333: I was a little confused about the comment of more heterogenous growth at waterlogged sites. I don't remember that result being presented and it is difficult to understand why. On the one hand, waterlogging does not have a big effect on growth but its presence or absence on the local scale does drive differences in growth. Please clarify.

Authors' Response: Yes, the presence or absence of waterlogging on a local scale causes more heterogenous growth at the wettest site. This is interpreted from the lower series intercorrelation value for this site shown in Table 3. This lower series intercorrelation value indicates differences in tree-level growth rates within the wettest site.

338: As noted, there is an argument for physiological resilience at the wet site but also an argument that because of the site's hydrology, soil moisture changes persist across years and reduces the response to precipitation variability. This could therefore be a physical/hydrological not physiological process.

Authors' Response: We completely agree with this point and we think that our results are better indicative of physical/hydrological differences between sites rather than the interpretation that trees at the wettest site are more physiologically resilient. We are therefore omitting the resilience narrative from this study and will explain our findings as a result of differences in physical/hydrological conditions between sites.

As noted, I think it is worth addressing whether there could be low d13C in the atmo-

sphere of the waterlogged site.

Authors' Response: Although this site experiences waterlogging more often than the other three sites, which very rarely get flooded, it doesn't remain waterlogged throughout the growing season. Flooding occurs at the wet site at specific periods during the growing season and conditions transition from flooded to non-flooded and vice versa as the growing season progresses. Therefore, phenomena such as low VPD or the presence of depleted δ13C in the canopy due to methane production would be ephemeral and difficult to detect in annual tree-rings. These effects can possibly be detected by employing a model like CANISOTOPE, which requires site-level eddy flux and micrometeorological measurements. It could also be possible to observe these effects in tree-ring cellulose by segregating earlywood and latewood. However, a large number of our sampled tree-rings were narrow with the earlywood-latewood distinction being barely visible. A more advanced ring-cutting method would be required as compared to the manual approach that we have used.

400: The role of previous season's conditions on d13C is not sufficiently established here for reasons described above. More attention and discussion needs to be paid as to why the analysis might be limited i.e. you would need to measure the d13C following an extreme year.

Authors' Response: We have rephrased lines 394-401 to: "It is apparent that if wood at the very beginning of the growing season is formed using assimilates from the previous growing season, earlywood tree-ring Δ13C does not have a correlation with early-growing season precipitation from the current year (Helle and Schleser, 2004; Porter et al., 2009; Schollaen et al., 2013). In our study, tree-ring Δ13C is well-correlated with early-growing season precipitation from the current growing season. Although this indicates that majority of annual wood is formed using assimilates from the current growing season, it needs to be noted that earlywood portions of ring-porous oaks like those of Q. nigra have lower wood density (Gasson, 1987; Lei et al., 1996; Rao, 1997). Therefore, by using entire annual ring composites, the relatively small signal from the previous year could be present but not distinctly detected. Hence, comparing our RWI and tree-ring Δ13C values with previous years' climate yields no correlation (p>0.05) indicating its relatively weak effect." It needs to be noted that we have not only used rings from extreme years but also moderate years to cover a wider range of hydroclimatic conditions. This will be clearer from the new Δ13C chronology figure that we are adding. However, we completely agree with your suggestion about assessing tree-ring δ13C from years following extreme years but our sample size limitation prevented us from analyzing a more continuous tree-ring δ13C record.

406: Not "harsher" conditions, per se, but conditions less favorable to the species.

Authors' Response: Edited as per suggestion.

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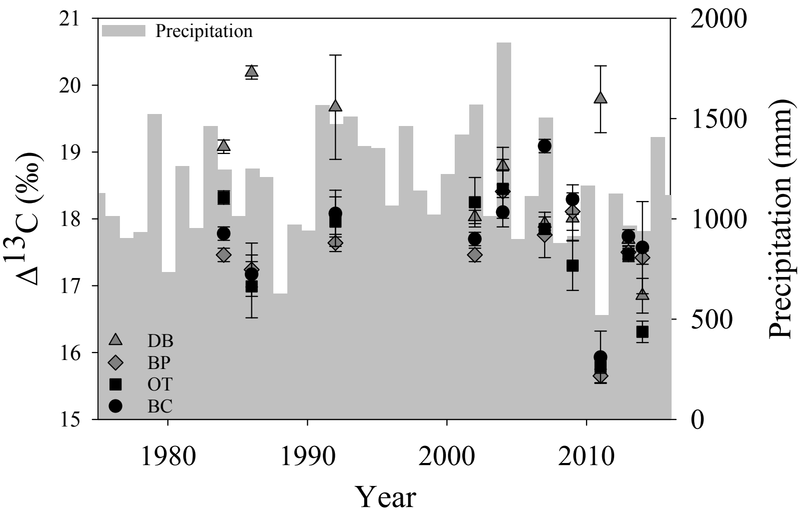

Fig. 1. D13C chronology