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Interactive comment on "An Overview on Isotopic Divergences – Causes for instability of Tree-Ring Isotopes and Climate Correlations" *by* Martine M. Savard and Valérie Daux

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First, I would like to thank the authors for conducting this synthesis. The authors did a great job on synthesizing and explaining all the different sources of divergence caused by multiple factors recorded in Carbon and Oxygen isotopes in the wood.

At the beginning of this review, the authors explain the differences between the "divergence" topic in the tree ring community versus the divergence that can be found in isotopic measurements in Tree rings. I see why the Authors are attributing the term divergence to the examples they show. However, it is not clear if the term divergence is the correct term. It is fine to use this term as long the authors make sure that they are

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referring to the divergence to the climate signal and eventually highlight that this "issue" falls into the problems we as scientists have when we want to interpret the isotopic records in Tree rings. I do appreciate the sections where they make recommendations and a strong call to the good practices so future researchers can take this advice to minimize the chances of losing the climatic signal.

REPLY – We sincerely thank referee 1 for the constructive comments and suggestions compiled above and below. Regarding the usage of 'divergence', we agree with the referee that this term should be restricted to describing tree-ring isotopic departures from climatic parameters. That is what we rigorously do in the manuscript. The introduction explains lines 30-32: ÂńWhen correlations between climatic parameters and tree-ring proxies show periods of instability such that correlations weaken, become non-significant or change in signs, the relationship between proxies and climatic data shows a 'divergence'. Âż Further down (lines 44-45): ÂńThe present article deals with the 'isotopic divergence', which we define here as the middle- to long-term (>10 years) loss or change in signs of correlations between a climatic parameter and tree-ring isotopic ratios (d13C, d18O, or rarely d2H). Âż

Anonymous Referee #2 Some other suggestions Received and published: 1 May 2020

One comment I should mention is that the review is highly focused on climate reconstructions, while the ecophysiological responses to environmental cues are somewhat left a little bit on the side, as something that is dampening or disrupting the climate signal.

REPLY – It is right to reckon that the article focuses on the tree-ring isotopes-climate relationships with the main purpose of climatic reconstruction as explained in the introduction (lines 61-63): ÂńGiven the need for careful assessments of isotopes as climate proxies for various regional contexts and tree species, this synthesis of the up-to-date information on isotopic divergences aims at: (1) describing the main isotopic divergence types and discussing their potential causes, and (2) reviewing research av-

enues to identify them and account for them (Table 2). Âż On one hand, wide ecological changes are not included here on purpose as we wanted to restrict the covered topic to TR isotopic divergences due to direct tree responses. On the other hand, we see the ecophysiological approaches to assess tree responses to changes as part of eventual solutions for circumventing some isotopic divergence issues (see for instance Section 5; lines 543-557). Therefore, we do not take action in response to this comment.

So, the more specific comments are more targeted to references in the literature (given this manuscript is a review) plus some other clarifications if the author agrees.

Line 125. The Model "MAIDEN" is not well explained, so I recommend explaining it a little bit, so the reader can understand what the model it's all about.

REPLY – Lines 121-125 define the general approach to mechanistic modeling, which applies to MAIDEN as well as to the other models of the kind. We do not want to place too much emphasis on MAIDEN, but following the suggestion of referee 1, we explain briefly the main structure of MAIDENiso as follows (starting lines 123): Âń Most models make forward predictions and allow verifying that the measured tree-ring isotopic trends compare well with the isotopic outputs modelled with the meteorological and non-meteorological inputs, and identifying processes behind isotopic responses. For instance, MAIDENiso is an expanded growth model which includes C and O modules. The model allows reproducing fractionation of carbon isotopes due to atmospheric CO2 diffusion to the site of carboxylation, enzymatic photosynthesis and respiration, and estimates oxygen isotopes in precipitation, soil water and xylem water, and the fractionation in leaves due to due evapotranspiration and to biochemical formation of cellulose (details in Danis et al., 2012; Boucher et al., 2014). Âż

Line 131 The citation for the Vaganov model it should be correctly cited, or add the papers where Vaganov published originally, then, of course, you can use other citations as usage examples.

REPLY – Good point. We will correct the name of the model and will refer to Vaganov

et al., 2011.

Line 89 and Line 359 The percentage of oxygen isotope exchange during cellulose synthesis, as you mention, can indeed be variable. Recently there is a published paper addressing this same possibility and highlights some of the possible hypotheses that can be involved in such phenomena. Probably this is a reference you might be interested in exploring. New Phytologist (2020) doi: 10.1111/nph.16484

REPLY – Good point; this newly published reference is pertinent. We will add a citation to this article at former line 359 and add the full reference to the final list. The text will read: Âń However, this proportion may vary over growing seasons and longer periods, and due to relative humidity conditions, (Gessler et al., 2009; Szejner et al., 2020). Âż

Line 253 The PIN correction of the pCO2 influence on the D13C discrimination should be double-checked. I think Gagen et al. 2007 made the first mention of the Pin correction that I know of. The Holocene, 17(4), 435–446. https://doi.org/10.1177/0959683607077012

REPLY – Correct. We will replace the citation to McCarroll et al., 2009 by a citation to Gagen et al., 2007.

Line 206 Another recent publication Citation that you might be interested in exploring about age effects in Tree ring isotopes is form Xu et al. 2020. I think this is relevant to your review as it addresses the age-related effect concerning Climate reconstructions. 2020 Journal of Geophysical Research: Biogeosciences, 0–2. https://doi.org/10.1029/2019JG005513

REPLY – Good point; this freshly appeared reference is pertinent. We will add the text below with the citation to this article at the end of the last paragraph in section 3.3, and add the full reference to the final list. Âń Finally, in some cases, though there is no trend in the tree-ring isotopic series, the response to climate in the isotopic chronologies may be age-dependent. For instance, in Picea Schrenkiana from northwestern

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China, d18O and d13C values in trees under 125 years have stronger response to relative humidity than trees older than 270 years. The diminution of the strength of the correlations with tree age advocates for the incorporation of young trees only to develop a non-divergent composite chronology. Âż Xu, G., Wu, G., Liu, X., Chen, T., Wang, B., Hudson, A., 2020. Age-related climate response of tree-ring d13 C and d18 O from spruce in northwestern China, with implications for relative humidity reconstructions 0–2. https://doi.org/10.1029/2019JG005513 Lien 262. I agree that there is no overarching consensus over how to correct the pCO2 effects on the discrimination of 13C. But I find a bit troubling this sentence "A wise approach is to test the various corrective methods and assess the performance of the resulting series with climatic reconstruction model." This statement is for me, suggesting that we should select the best fit to climate. I think this is a bit biased and undermined the fact that we still do not fully understand how the pCO2 is affecting gs and A. so I think this part needs to be careful on not incentivize researchers to select the best fit, but instead, incentive to investigate what is the mechanisms and how the pCO2 is or not affecting the Carbon chronologies. Then I suggest reviewing Global Change Biology, 22(2), 889–902. https://doi.org/10.1111/gcb.13102

REPLY – We agree. The text will be modified as follows: Âń A wise approach is to investigate the potential influence of pCO2 on isotopic ring series and the gas-exchange response mechanisms in trees prior to selecting a corrective method (Voelker et al., 2016; Savard et al., 2020). Âż

Line 287 I think this part needs this reference. Dorado-Liñán, I et al. 2016. Climate Dynamics, 47(3–4), 937–950. https://doi.org/10.1007/s00382-015-2881-x

REPLY – We agree. The modified text will be: Âń Yet, studies in northwestern Norway (Young et al., 2010), the Northern boreal zone (Seftigen et al., 2011) and Northern Spain (Dorado-Liñan et al., 2016) depicted divergences between temperature records and ïĄď13C series of pines (Pinus sylvestris or Pinus uncinata) during episodes of decoupling between irradiance and temperature linked to either changes in large scale

atmospheric circulation (in the first two references), or large volcanic eruptions (in the third one). Âż Dorado-Liñán, I., Sanchez-Lorenzo, A., Gutierrez Merino, E., Planells, O., Heinrich, I., Helle, G., Zorita, E., 2016. Changes in surface solar radiation in Northeastern Spain over the past six centuries recorded by tree ring δ13C. Clim. Dyn. 47, 937–950. https://doi.org/10.1007/s00382-015-2881-x

Line 345 This reference also can be useful here Carbone, M. S. et al. 2013, The New Phytologist, 200(4), 1145–55. https://doi.org/10.1111/nph.12448

REPLY – We agree. The modified text will be: ÂńThe proportion of direct assimilates increases progressively at the expense of reconverted stored material, until they are the only carbohydrate source for building new plant tissues and storing reserves, mainly as starch (Carbone et al., 2013; Kimak and Leuenberger, 2015). Âż Carbone, M.S., Czimczik, C.I., Keenan, T.F., Murakami, P.F., Pederson, N., Schaberg, P.G., Xu, X., Richardson, A.D., 2013. Age, allocation and availability of nonstructural carbon in mature red maple trees. New Phytol. 200, 1145–1155. https://doi.org/10.1111/nph.12448.

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