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Interactive comment on “δ^{13}C values in stalagmites from tropical South America for the last two millennia” *by* Valdir Felipe Novello et al.

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Response to the Reviewer 2

We appreciate the time and effort of the reviewer to evaluate our manuscript. We understand that this reviewer is not from the speleothem community, which we believe is a positive aspect, showing that our data can be of interest to a broad audience. Although we do not agree with some of the reviewer's comments, they have certainly helped us to clarify possible confusing points in our text, making her (his) contribution extremely important for our work. This reviewer appears to have been somewhat confused about what is our introduction and what is our discussion/conclusion section. For example, all comments provided below by the reviewer are related to vegetation. However, vegetation plays only a minor role in our interpretation. Our conclusion is that the d13C in the stalagmites from South America is related with local hydrology due to the process called Prior Calcite Precipitation (PCP), which occurs in the epikarst and is independent from vegetation. We mention the vegetation mainly in the introduction (section 1 and 2) as a part of the overall background information. To avoid this kind of misunderstanding we have removed and/or changed some sentences regarding vegetation that are not important to our discussion. We believe that all topics have been addressed in our revision and clarified by the comments below.

Reviewer Comment (RC)

RC: This paper presents 10 new speleothem d13C records included in a new dataset of 25 speleothem d13C records meant to characterize the last 2ka (in fact the last 1.4 ka) over tropical South America.

Answer: We present 13 new speleothem d13C records and the time period studied in the manuscript was the last 2 ka. Only the Principal Component Analysis (PCA) was performed over a time period of 1.4 ka because most of the records only cover this time period. We also wish to highlight that some of the stalagmites studied here are much older than 2 ka, and these data are also presented in the dataset that we are making available.

RC: This series of data is used to reconstruct a general pattern of the climate evolution during the medieval climate anomaly and the little ice age. Main results show that low d13C values are related to high C3 plant density in the soil above the cave and highlight a breakdown between monsoon variability and local hydroclimate after 1750 CE based on the establishment of an index associated to mean hydrologic conditions. Main focus of the paper was to test the influence of local hydroclimate, temperature and changing vegetation types on the carbon isotopes. The use of C stable isotope in speleothems has been poorly explored with complex interactions among the different drivers which makes difficult the climatic or environmental interpretations and I acknowledge the attempt of the authors. However none of these drivers (temperature, hydroclimate and vegetation cover) is really discussed for each record and general conclusions are often based on specific observations without in-depth argumentation.

Answer: As was mentioned by the reviewer, we discuss in our introduction that the d13C data from stalagmites have been ignored in many publications around the world, instead focusing only on the d18O values, mainly due to the complexity of d13C interpretations. The main aim of our study was therefore to provide a large set of speleothems d13C data to the community to encourage further research into the use and interpretation of this proxy. It was never our intention to discuss the drivers in each individual record. As we mention in sections 1 and 2, the d13C in stalagmites is sensitive to several drivers, which makes it difficult (and sometimes impossible) to disentangle competing processes. In fact, the complexity of d13C interpretations is seen as the main reason why these data have hitherto been neglected in many publications (as we mention in our introduction). But we believe there is value in presenting multiple records from the same continent and investigating their commonalities through a principal component analysis, thereby interpreting this proxy from a new perspective. Thus, this paper aims to: (1) provide new data that were hitherto not available to the scientific community, thereby facilitating further studies based on this proxy; (2) identify the dominant drivers of d13C over South America, allowing a first interpretation of the full dataset; (3) highlight the potential of this proxy for future paleoclimatic, paleoenvironmental and geochemical studies.

RC: I feel concerned by the fact that if temperature influence is eventually discarded, there is little evidence of what would be the expression of a local hydroclimate and the associated vegetation types. Indeed no information was given by the authors about the vegetation cover that is supposedly at the origin of the d13C and the absence of calibration makes the demonstration rather poor. When I started to look for such information through the original publications, I found that vegetation was defined at only 3 records upon 25 (I had no access to Utida et al 2020) mixing up biome with

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Discussion paper

composition of the vegetation type or physiognomy. For example the record of Tamboril is located within a Â′n Native semi-deciduous forests: : :ÂËŹz, Paraíso is Â′n densely covered by rainforest ÂËŹz and Mata Virgem is Â′n located in the Eastern regions of the tropical Savannah known as 'Cerrado' and the Amazon Forest ÂËŹz. For the last one, it is impossible to know whether the Cerrado or the Amazon forest is characterizing the area. These are two different biomes, and the reader would like to know about the vegetation type that grows above the cave, as for instance gallery forest, grassland with Cactaceae, campo limpo: : :etc).

Answer: We wish to emphasize that the main conclusion of our paper is that Prior Calcite Precipitation (PCP) is the main driver of d13C variability in stalagmites (note that this was also confirmed by reviewer 1). PCP is related to the local hydrology, but not to vegetation. Thus, we see no reason to provide such a detailed discussion regarding the vegetation at each individual site, since it plays at best a minor role our interpretation. During wet events the PCP rate decreases, which results in more negative d13C values in the stalagmites. Also, during wet periods decomposition of organic matter in the soil is enhanced, which provides more depleted values to the seepage solution, and therefore, to the stalagmites. Thus, the hydrological effects on vegetation will only reinforce the isotopic results in stalagmites derived by PCP, but this process is not related to specific species or types of plants.

RC: Under such poor descriptions of the vegetation cover, I have difficulties to believe the conclusion Â′n Most locations were dominated by C3 plants over the last two millennia ÂËŹz.

Answer: As discussed on lines 84-86 (from the original submission), geochemical models (Dreybrodt, 1988; Baker et al., 1997; McDermott, 2004) applied to stalagmites, using d13C values for the bedrock of +1‰ (typical values for South American carbonates) predict values below -6‰ for stalagmites where the predominant vegetation is composed of C3 plants. Considering that most of the stalagmites presented in this study have absolute values below -6‰ we believe that the argument that most locations were dominated by C3 plants is valid. This result is consistent with most d13C studies performed in Brazilian soils that also show a predominant composition of C3 plants over the country during the last 2 ka (Pessenda et al., 1996, 1998, 2004, 2005; Freitas et al., 2001; Schel-Ybert 2003; Calegari et al., 2013, 2017). However, we have improved this discussion in the manuscript to clarify this aspect.

RC: Finally the authors concluded that the dataset was able to show that _18O and _13C generally co-varied except at Tamboril cave and did not discuss the soil richness which was first expressed as a significant factor for @13C.

Answer: This is not our conclusion. We present the correlation between d18O and d13C for each stalagmite in Table A1. In some stalagmites the two isotopes are correlated, while in others they are not. Hence the Tamboril cave record is not an exception. The reasons why the two isotopes are correlated are discussed on lines 92-102 (from the original submission). They are mainly related to the fact that the amount effect influences the d18O values while PCP drives the d13C, and both these forcing are related to rainfall amount. The soil richness plays no role in this process.

RC: Neither was discussed the composition of the local/regional vegetation types that grow today above the cave.

Answer: We discuss this on lines 203-214 (from the original submission) and we present the vegetation map in Figure 1.

RC: Information are mixed up and some main points presented at the beginning of the ms are simply abandonned when reaching the discussion part. For instance, at Jaragua cave a decrease of 9 ‰ in the _13C values was interpreted as Â′n resulting from a combination of changes above the cave, including: changes in the predominant vegetation type from C4 to C3, increase of organic matter and soil horizons ÂËŹz which does not bring any strong information about the results.

Answer: In our introduction (section 1 and 2) we provide the reader with a complete review about the mechanisms that drive the d13C variability in stalagmites, as well as a complete review of all studies that already used d13C in stalagmites from South America. We believe that this information is important since we are introducing a new stalagmite d13C dataset that was never interpreted before. However, some of the information provided from the previous papers (which focused on multiple time scales) does not applie to the new dataset with respect to the last 2ka. The example of Jaraguá cave was discussed in the introduction, among other examples, only to contextualize the d13C studies in stalagmites from South America.

RC: Moreover the breakdown between @18O and @13C after 1750 CE could also be due to deforestation and/or high fire activity.

Answer: This is indeed an interesting suggestion. We have reprhased this sentence, incorporating this suggestion. Now the sentence reads "...the hydrologic variability inferred from PC1-δ13C is biased by vegetation changes, which respond to other influences beyond the local rainfall amount, such as temperature, atmospheric CO2, deforestation and fire, parameters that have increased significantly over the last 250 years."

RC: A comprehensive bibliography about the vegetation change and fire history of the different study areas is missing for the discussion. This paper needs a complete revision adding more precise information to support the interpretations and the conclusions.

Answer: We provide an exhaustive review regarding the mechanisms driving the d13C variability in stalagmites and a complete review covering all studies about d13C in stalagmites from South America. The vegetation changes are only one of many possible forcings behind the d13C variability in the stalagmites, and the main conclusion of our paper is that the d13C values are responding to changes in PCP rate, related to local hydrology (which is independent of vegetation changes). Thus, we see no reason to provide a detailed bibliography of vegetation (or fire) changes, since this is not the focus of our paper. Furthermore, the literature indicates that vegetation did not undergo significant changes during the last 2 ka in South America (Pessenda et al. 1996, 1998, 2004, 2005; Freitas et al., 2001; Schel-Ybert, 2003; Calegari et al., 2013, 2017). We wish to emphasize that our interpretations and conclusions are well supported by previous studies that we discuss in the introduction (section 1 and 2), including papers regarding d13C values in speleothems from South America as well as other tropical locations around the world.

RC: A proper discussion would also include the description and calibration of the vegetation and their influence on the obtained results. For these reasons I do not recommend this ms for publication.

Answer: The dataset presented by us in this paper is the result of tens of years of research made by different research group hosted at different institutions around the world. The presented study sites are from regions that are often very difficult to access, such as remote locations in the interior of the Amazon basin or high elevation sites in the Andes. To obtain calibration studies from all these sites is almost impossible and is far beyond the scope of this paper. Again, we wish to stress that vegetation changes play only a minor importance in our interpretations. We wish to highlight that the main aim of this paper is to provide and to describe a new dataset. We believe that this dataset contains valuable material for studies about geochemistry, paleoclimatology, paleoenvironment, caves, as well as for future calibration studies. By employing the data we make available here, other researchers can improve upon our study or provide alternative interpretations regarding the d13C values in stalagmites. We believe that this aspect alone is relevant for publishing this dataset and making it available to the scientific community.

RC: Specific issues and comments -Line 60 : importance of the tree roots : what about the herbs ?

Answer: We replaced the word (tree) by “plant”.

RC: -Line 86 what about the CAM plants which are abundant in some regions covered by the data set ?

Answer: We added the sentence "... the presence of CAM plants can complicate this interpretation since this type of plant presents a large range of δ13C values."

RC: -Line 127 last glacial

Answer: We have corrected this error.

RC: -Most of the sites located in the Caatinga show high abundance of Cactaceae which are C3 plants but do not represent dense forest neither rich organic soils. This should be mentionned and taken into account in the discussion.

Answer: We removed the sentence suggesting specific isotopic values for Caatinga and Cerrado. We believe this sentence was sowing confusion rather than aiding in the discussion, since Caatinga and Cerrado both feature C3 plants.

RC: -Comparisons with d18O records show that there is little difference with the d13C records regarding the climate interpretation and the authors come to the same conclusions except for the last centuries. Consequently, the gain of the d13C analyses in speleothem records is not clear.

Answer: d18O values in speleothems are generally considered to be proxies for climate interpretations. As we show in our manuscript, d18O and d13C have different drivers, yet the fact that both isotopes are correlated indicates that d13C can also be used as an important proxy for climate science. Our paper is the first to discuss both isotopes in a large set of data from South America, which makes our results novel and relevant to the speleothem community. Similar studies have been carried out in other regions of the world with differing results, mainly because d18O is not considered a proxy for the hydrological conditions outside the tropics, and because the strong temperature seasonality at high latitudes strongly affects the d13C in stalagmites (see Fohlmeister et al., 2020). In this way our results are unique.

RC: -Some interpretation/conclusion sound fuzzy. For instance at Jaragua cave a decrease of ‰ in the _13C values was first interpreted as Â′n resulting from a combination of changes above the cave, including changes in the predominant vegetation type from C4 to C3, increase of organic matter and soil horizons ÂËŹz. Later in the paper the vegetation hypothesis is abandonned and the decrease was finally related to temperature and atmospheric CO2.

Answer: We discussed this example in our introduction (section 2.2) as part of the overall review of prior studies related to d13C and speleothems in South America. This example was taken from Novello et al. (2019), but in the same paragraph (lines 123-142 from the original submission) we also present results from other studies that come to different conclusions. However, we agree that this discussion may have created some confusion. We have therefore removed part of this discussion to emphasize our main interpretation that is related to PCP.

RC: -How do we know that Â′n Most locations were dominated by C3 plants over the last two millennia and are characterized by speleothem _13C values more depleted than -6 ‰ ÂËŹz as no description of the vegetation is given? Also Line 87 Â′n Variations in soil _13C values and their evolution over time are controlled by carbon inputs from vegetation, which is proportional to the organic matter amount and vegetation density; ÂËŹz was promising but without any description of the vegetation it is difficult to evaluate the influence of the plant composition on the @13C.

Answer: See our answer above. This explanation is also included on lines 81-86 (from the original submission).

RC: -Line 209-213 Cerrado is also a tropical forest so what do you mean by Â′n Tropical Forest ÂËŹz ? also in the legend of figure 1 Rainforest/Atlantic forest, Atlantic forest is a biome that includes many vegetation types among them the rainforest (with no majuscule). What is the legend referring to ? Also line 289 what do the authors mean by Â′n a tropical forest ÂËŹz ? is it a rainforest or a seasonal forest or a dry forest or a semi-deciduous forest or a cloud forest?

Answer: Cerrado is defined as a Brazilian Savanna and/or a tropical Savanna (Ruggiero et al., 2002; Jepson, 2005; Brannstrom et al., 2008). Tropical forests in Brazil are characterized by Amazon and Atlantic forests as is indicated in Figure 1 and its legend, defined by Olson et al. (2001). This is the standard nomenclature used in many papers (Keller et al., 2001; Rocha et al., 2009; Alvez et al., 2010; Xaud et al., 2013).

RC: -Line 211 the 3 sites that are called Â′n andean sites ÂËŹz are located in very different environmental conditions : Huagapo, 3850 m asl should correspond to a high elevation grassland as the tree line never climbed further up than _3500 m in the last 3000 years, Umajalanta 2650 m asl Â′n monsoon-related convection and condensation over the Amazon Basin ÂËŹz which corresponds to a cloud forest, Palestina, 870 m asl, the transition between rainforest to cloud forest.

Answer: We do not discuss Andean sites on line 211 because it is not our intention to describe all sites individually. In this paragraph, we only present the dominant climate/vegetational settings over South America.

RC: -Line 228-230 Are you saying that Cerrados and rainforest have the same d13C ? Â′n The vegetation domains of Tropical Forests (Rainforest/Atlantic forest) and Cerrado include the speleothems with the lowest _13C values (mean of -8.9 ‰ and -8.5 ‰ respectively),.. ÂËŹz

Answer: No, this is not what we meant to express with this sentence. We have removed this sentence from the manuscript to avoid misunderstanding.

RC: -Line 232 Appendix Fig A2 What is meant by highland records ? they are located in three different vegetation covers (see above). Then the @13C should be different for each of these vegetation types. Why isn't it so ?

Answer: We have removed this figure from our paper. We realize that this figure did show confusion, rather than adding new information to our discussion.

RC: -Line 235-238 then it is not correlated with vegetation as it was explained at the beginning of the manuscript? Answer: Yes. It is not correlated with vegetation. At the beginning of the manuscript we presented a literature review, which is not necessarily consistent with our own analysis and interpretation of the data.

RC: -Line 248 etc MCP-PCA could also include the degree of opening of the vegetation types that grow above the cave in the discussion.

Answer: In this paragraph, we only describe the results. The interpretation of the data is in the section 'Discussion; on lines 304-323 (from the original submission). There we mention this aspect.

RC: -Line 254 this could have been shown also with d18O ?

Answer: Yes, we show this in both isotopes in Figure 4 and discuss this aspect on lines 314-323 and lines 331-337 (from the original submission).

RC: -Line 278 denser vegetation : this could be checked

Answer: We replaced this statement with "increase of vegetation density".

RC: -Line 290 I disagree here because in the Caatinga there is no C4 plants, a high density of C3 deciduous trees plus the Cactaceae (C3 carbon metabolism).

Answer: We did not mention in this paragraph that the Caatinga includes C4 plants. To avoid confusion, we have removed this sentence, as it was not considered relevant for our discussion.

RC: -Line 291 TR5 add the vegetation type/ the environment of the cave

Answer: We did not provide the vegetation type in this instance, because we do not want to mislead the reader in believing that the d13C values from TR5 are related to vegetation. As we document in this paragraph, they are more related to hydrological conditions.

RC: -Line 291-303 : the d13C relates to climate and evaporation ? not anymore with soil thickness ? and what about plant assemblages ? these last two points are not discussed (also line 333) when they were listed as main factors of d13C variability earlier in the ms.

Answer: As can be seen from our Discussion, the variability in d13C values in our dataset is mainly related with hydroclimate, and not vegetation or soil thickness. Furthermore, significant changes in vegetation and soil thickness are not expected to have occurred during the last 2 ka, as these processes require more time to take place.

RC: -Line 311 C3 plants do show a broad range of physiognomies in the Tropics Line 311: this was not really demonstrated in the ms neither in Novello et al 2019

Answer: The plant physiognomies are not relevant for our analysis. Our study is focused on geochemical proxies in stalagmites. Vegetation processes play only a minor role in our interpretation, as mentioned above.

RC: -Line 313 If d13C reflects hydroclimate, why analysing the Carbon stable isotope as @d8O proved to be efficient in that field?

Answer: We are exploring a new proxy with several implications for climate, environment, cave and geochemical studies. As we state above: "Our paper is the first to discuss both isotopes in a large set of data from South America, which makes our results novel and relevant to the speleothem community. Similar studies have been carried out in other regions of the world with differing results, mainly because d18O is not considered a proxy for the hydrological conditions outside the tropics, and because the strong temperature seasonality at high latitudes strongly affects the d13C in stalagmites (see Fohlmeister et al., 2020)". In this way our results are unique.

RC: -Line 334 after 1750 CE, may be consider deforestation ? which could eventually introduce a discussion on the vegetation cover ?

Answer: Please see our answer above. We have changed our statement regarding this aspect.

RC: Line 336 which vegetation changes and where ?

Answer: It is clear that we are discussing PC1 in this instance. We simply list possible influences that may affect the entire dataset.

RC: Line 337 vegetation responds to other influence: : :yes I thought it was soil thickness ? Although here it is the temperature that is inferred.

Answer: We list possible influences on vegetation in a continental scale, which could affect all sites simultaneously. Soil thickness is a local influence.

RC: Line 349 so again not related to vegetation

Answer: See our answers above. Our paper is not about vegetation. The vegetation is only one of many aspects possibly influencing our proxy.

RC: Line 354 This could be an important issue to consider for instance when comparing with other compilation Line 354 356 I do not agree with this conclusion. The predominance of C3 plants on the study sites was not shown.

Answer: See our comments above about this statement.

RC: Line 363 365 what is the novelty here ? it was already showed by d18O?

Answer: See our answers above. We are exploring a new proxy and providing a new dataset to the scientific community composed of data collected over the entire South American continent. This is why we submitted this dataset for publication to ESSD; a journal focused on publishing novel data sets.

RC: Line 366-367 and deforestation ?

Answer: See our answer above. We provide a comment about deforestation in the discussion.

RC: Tables and Figures Table 1 Add at least the biome in front of each site and the vegetation type that grows above the cave.

Answer: This information is already contained in Figure 1. We do not have space to include an additional column in this table.

RC: Table A1 add the length of the speleothem

Answer: This information is not relevant for the data interpretation and is not discussed anywhere in our manuscript.

RC: Figure 1 Legend figure 1 : Cerrados with S

Answer: The correct word is Cerrado (without S), as provided in the text.

RC: Figure 2 what don't we see 25 points ?

Answer: Please see our answer provided to reviewer 1. Some of the stalagmites are from the same cave and/or are from regions with the same climatic conditions. These stalagmites were merged and are represented by a single point. We have improved the description of this correlation in the Methods section..

RC: Figure A1 is not lisible

Answer: This figure aims to illustrate the range of the d13C values covered by South America's speleothems. For this purpose, the data organization as presented, is the best way to show all records together.

RC: Figure A2 : what do you call a vegetation domain ? a biome ? a vegetation type ? anyway this is none of the category represented here. It is not possible to relate the d13C to the vegetation cover. This point needs further development in your argumentation.

Answer: We grouped the stalagmites growing under similar or closely related vegetation conditions to see if there are isotopic differences between these groups. However, this figure did not reveal any significant differences. Thus, we decided to remove it from the manuscript.

References:

Alves, L.F., Vieira, S.A., Scaranello, M.A., Camargo, P.B., Santos, F.A.M., Joly, C.A., Martinelli, L.A.: Forest structure and live aboveground biomass variation along an elevational gradient of tropical Atlantic moist forest (Brazil). Forest Ecol. Manag., 260, 679-691, 2010.

Baker, A., Ito, E., Smart, P.L. and McEwan, R.F.: Elevated and variable values of d13C in speleothems in a British cave system. Chem. Geol., 136, 263–270, 1997.

Brannstrom, C., Jepson, W., Filippi, A. M., Redo, D., Xu, Z., Ganesh, S.: Land change in the Brazilian Savanna (Cerrado), 1986-2002: Comparative analysis and implications for land-use policy. Land Use Policy, 25, 579-595, 2008.

Calegari, M.R., Madella, M., Vital-Torrado, P., Pessenda, L.C.R., Marques, F.A.: Combining phytoliths and soil organic matter in Holocene palaeoenvironmental studies of tropical soils: the example of an oxisol in Brazil. Quarter. Int., 287: 47-55, 2003.

Calegari, M.R., Madella, M., Brustolin, L.T., Pessenda, L.C.R., Buso Jr. A.A., Francisquini, M.I., Benassolli, J.A., Vidal-Torrado, P.: Potential of soil phytoliths, organic matter and carbono isotopes for small-scale differentiation of tropical rainforest vegetation: A pilot study from the campos nativos of the Atlantic Forest in Espírito Santo State (Brazil). Quarter. Int, 437: 156-164, 2017.

Dreybrodt, W.: Processes in Karst Systems. Springer Series in Physical Environment. Springer, Heidelberg, 282pp, 1988.

Fohlmeister, J., Voarintsoa, N. R. G., Lechleitner, F. A., Boyd, M., Brandstätter, S., Jacobson, M. J. and Oster, J.: Main controls on the Stable Carbon Isotope Composition of Speleothems. Geochim. Cosmochim. Acta, GCA11710, 2020.

Freitas, H.A., Pessenda, L.C.R., Aravena, R., Gouveia, S.E.M., Ribeiro A.S., Boulet,

R. Late Quaternary vegetation dynamics in the southern Amazon Basin inferred from carbon isotopes in soil organic matter. Quarter. Res, 55, 39-46, 2001.

Jepson, W.: A disappering biome? Reconsidering land-cover change in Brazilian savanna. The Geographical Journal, 171 (2), 99-111, 2005.

Keller, M., Palace, M., Hurt, G.: Biomass estimation in the Tapajos national Forest, Brazil Examination of sampling and allometric uncertainties. Forest Ecology and Management, 154, 371-382, 2001.

McDermott, F.: Palaeo-climate reconstruction from stable isotope variations in speleothems: a review. Quat. Sci. Rev., 23, 901–918, doi .org /10.1016 /j.quascirev.2003.06.021, 2004.

Novello, V. F., Cruz, F. W., McGlue, M. M., Wong, C. I., Ward, B. M., Vuille, M., Santos, R. A., Jaqueto, P., Pessenda, L. C. R., Atorre, T., Ribeiro, L. M. A. L., Karmann, I., Barreto, E. S.; Cheng, H., Edwards, R. L., Paula, M. S. and Scholz, D.: Vegetation and environmental changes in tropical South America from the last glacial to the Holocene documented by multiple cave sediment proxies. Earth Planet. Sci. Lett., 524, 115717, doi.org/10.1016/j.epsl.2019.115717, 2019.

Pessenda, L.C.R., Aravena, R., Melfi, A.J., Telles, E.C.C., Boulet, R., Valencia, E.P.E., Tomazello, M. 1996. The use of carbon isotopes (C-12, C-13) in soil to evaluate vegetation changes during the Holocene in Central Brazil. Radiocarbon, 38 (2), 191-201, 1996.

Pessenda, L.C.R., Gomes, B.M., Aravena, R., Ribeiro, A.S., Boulet, R., Gouveia, S.E.M. The carbon isotope record in soils along a forest-cerrado ecosystem transect: implications for vegetation changes in the Rondônia State, southwestern Brazilian Amazon region. The Holocene, 8: 599–603, 1998.

Pessenda, L.C.R., Ribeiro, A.S., Gouveia, S.E., Aravena, R., Boulet, R., Bendassoli, J.A.: Vegetation dynamics during the late Pleistocene in the Barreirinhas region, Maranhão State, Northeastern Brazil, based on carbon isotopes in soil organic matter. Quarter. Res., 62, 183–93, 2004.

Pessenda, L.C.R., Ledru, M.P., Gouveia, S.E.M., Aravena, R., Ribeiro, A.S., Bendassolli, J.A., Boulet, R.: Holocene palaeoenvironmental reconstruction in northeastern Brazil inferred from pollen, charcoal and carbon isotope records. The Holocene, 15: 814-22, 2005.

Rocha, H.R., Mazi, A.O., Cabral, O.M., Miller, S.D., Goulden, M.L., Saleska, S.R., R.-Coupe, N., Wolsy, S.C., Borna, L.S., Artaxi, P., Vourlitis, G., Noguiera, J.S., Cardoso, F.L., Nobre, A.D., Kruijt, B., Freitas, H.C., Von Randow, C., Aguiar, R.G., Maina, J.F.: Patterns of water and heat flux across a biome gradient from tropical forest to savanna in Brazil. J. Geophys. Res., 114, G00B12, 2009.

Ruggiero, P.G.C.; Batalha, M.A.; Pivello, V.R., Meirelles, S.T.: Soil-vegetation relationship in cerrado (Brazilian savanna) and semideciduous forest, Southern Brazil. Plant. Ecology, 160, 1-16, 2002.

Scheel-Ybert, R., Gouveia, S.E.M., Pessenda, L. C. R., Aravena, R., Coutinho, L.M., Boulet, R.: Holocene palaeoenvironmental Evolution in the São Paulo State (Brazil), based on anthracology and soil d13C analysis. The Holocene, 13 (1), 73-81, 2003.

Xaud, H.A.M., Martins, F.S.R., Santos, J.R.: Tropical forest degradation by mega-fires in the northern Brazilian Amazon. Forest Ecol. Manag., 294, 97-106, 2013.

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