We are grateful for the reviewer's comments on manuscript cp-2023-2. We addressed the reviewer's comments below in italicized text.

RC1: 'Comment on cp-2023-2', Anonymous Referee #1, 18 Mar 2023

"Spatiotemporal ITCZ dynamics during the last three millennia in northeastern Brazil and related impacts in modern history" presents a new composite speleothem δ18O record (using new data and previously published data) as well as a new δ13C record used to characterise precipitation and vegetation/soil cover over northeast Brazil for the Late Holocene. The authors make clear links to the necessity for this research in South America, and frame it within the context of the increased proportion of the Brazillians who experience water scarcity in modern times. By analysing samples taken from sites at the southernmost extent of the ITCZ, they are able to link periods of changed precipitation to the movement of the ITCZ.

Strengths

This is relevant research with tangible outcomes for policy. Combining multiple stalagmite proxies can overcome some of the drawbacks encountered by single-proxy studies. It is great to see the continued use of already-published data, supplemented by new data. I really enjoyed the links between the proxy record and historical climate events – finding historical climate information is non-trivial, well done to the authors for their persistence. The introduction and study set-up is good.

Weaknesses

The main weakness of the manuscript is that there is no consideration of the impact of hydrological processes on speleothem δ18O, the primary proxy of the study. Treble et al. (2022) showed in a global analysis of coeval calcite and dripwater samples that karst hydrology exerts a control on speleothem δ18O, and that the variability of δ18Oc can exceed that which can be attributed to rainfall δ18O. In the absence of cave monitoring data in the paper, the authors should add some discussion of how the karst processes at each site impact their results (or could impact their results) and how the composite handles this variability. The introduction/literature review should do also do a more thorough job of what controls δ18O in NEB. The RN composite appears to only have uncertainty in the time domain, while other composites (e.g. Kaufman et al., 2020) include uncertainty in the composited proxy value.

Thank you for your comments. Certainly your suggestions will help us improve our manuscript in order to produce a high-quality paper.

We will expand our discussion of hydrological controls on $\delta^{18}O$ in stalagmites in the Introduction and Discussion sections. Unfortunately, a monitoring program cannot be successfully implemented in the studied caves because modern dripwater in these caves is very rare and intermittent, preventing an adequate monitoring program.

The hydrological processes controlling speleothem $\delta^{18}O$ will be folded into a more exhaustive literature review, as suggested. According to Treble et al. (2022), the variability of the global $\delta^{18}O$ values for speleothems originating from the same cave is ~ 0.37‰, which can attributed to karst fractionation effects. Changes in $\delta^{18}O$ of rainfall that exceed this value, are therefore, in general recorded as a climate signal in stalagmites. While some time intervals in our stalagmites from the same cave are bellow this limit, the overall $\delta^{18}O$ variability in our record is much larger than 0.37‰, and we thus interpret these changes in $\delta^{18}O$ as a result of rainfall changes precipitation. Furthermore, the $\delta^{18}O$ variability recorded throughout the period analyzed, is similar for stalagmites from the same cave and between the two studied caves, further reinforcing the notion that these records can be interpreted in a paleoclimatic context. The compositing procedure has a minimal impact on the variance of the $\delta^{18}O$ record since the ISCAM procedure normalizes $\delta^{18}O$ data before combining them. As discussed further below, after normalization, the difference between stalagmite records is significantly reduced.

As far as uncertainties of the composite record are concerned, we will include revised text as listed below in the Results section (after line 349) and add a new Figure to the supplemental material (Figure S7).

As discussed in Kaufman et al. (2020), there does not exist one preferred standard procedure to calculate proxy errors when a composite is produced. Unfortunately, the ISCAM program (Fohlmeister, 2012) does not return a proxy error as part of the output. It rearranges the proxies to obtain the best calculated age and then calculates the average of the proxy data after normalizing them. As outlined in the Methods section, our record includes only two overlapping stalagmites per period, as the top and base of the FN1 and FN2 stalagmites were not suitable to be used in the composite, respectively. Hence the proxy error can be quantified as the difference between the two $\delta^{18}O$ records at any point in the time. We created a new Figure showing the ISCAM-calculated ages for each stalagmite, plotted together with the final composite. We will include this Figure in the Supplement to clarify the uncertainties related to our $\delta^{18}O$ records. The figure below is already adapted for all color-blind readers, including the monochromatic view.

"The composite calculation rearranges the proxies in order to obtain the optimal calculated age and then calculates the average of the proxy data after normalizing the records. The RN record only contains overlapping segments between two stalagmites per period. Hence the RN composite proxy error can be quantified as the difference between the $\delta^{18}O$ of the stalagmites combined for any given point in time (Figure S7). The largest error occurs between 1460 and 1700 CE, when the maximum and minimum values of FN1 and TRA7 are 2.25 ‰ and -0.40 ‰, respectively. This is a period when FN1 registers a dry interval that is not clearly seen in TRA7. The period extending from 1370 to 1460 CE, is characterized by an anti-phased signal between FN1 and TRA7, and hence the RN Composite shows a smoothed signal during this time."

However, please note that the high-density of precise ages with errors of approximately 22 years in our stalagmite records, combined with similar variability between different stalagmites from the same and different caves, provide robust evidence that our isotope composite records regional climate and environmental parameters.

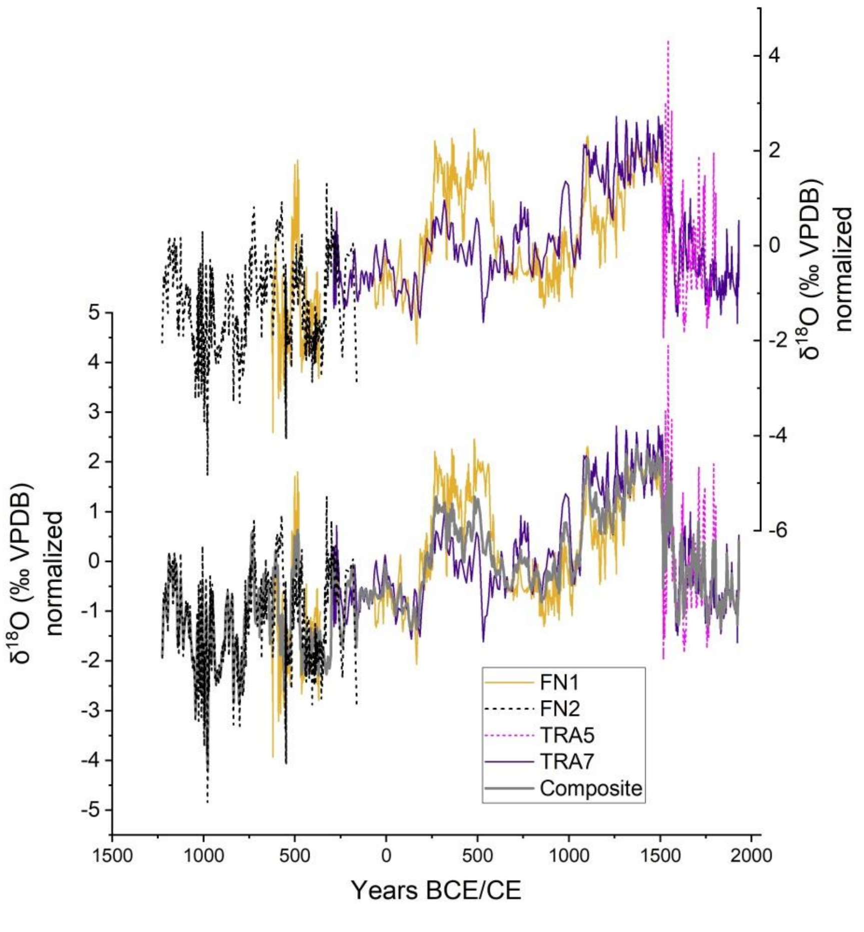


Figure S7 – Oxygen isotope and age model results calculated by ISCAM for stalagmites and Composite. The normalization of the data is performed by ISCAM (Fohlmeister, 2012).

Specific comments and questions

1. Figure 1

Please shade either the land or the ocean to differentiate them. Please choose an accessible colour palette – the rainbow colour palette is not useful for colour blind readers.

Thank you for bringing this issue to our attention. The journal editorial team already mentioned that we had to adapt the figure for color blind readers during the revision stage. Shading the land helped to differentiate it from the oceanic area. The color palette of Figure 1 is now more accessible. Please see the respective figure and caption below.

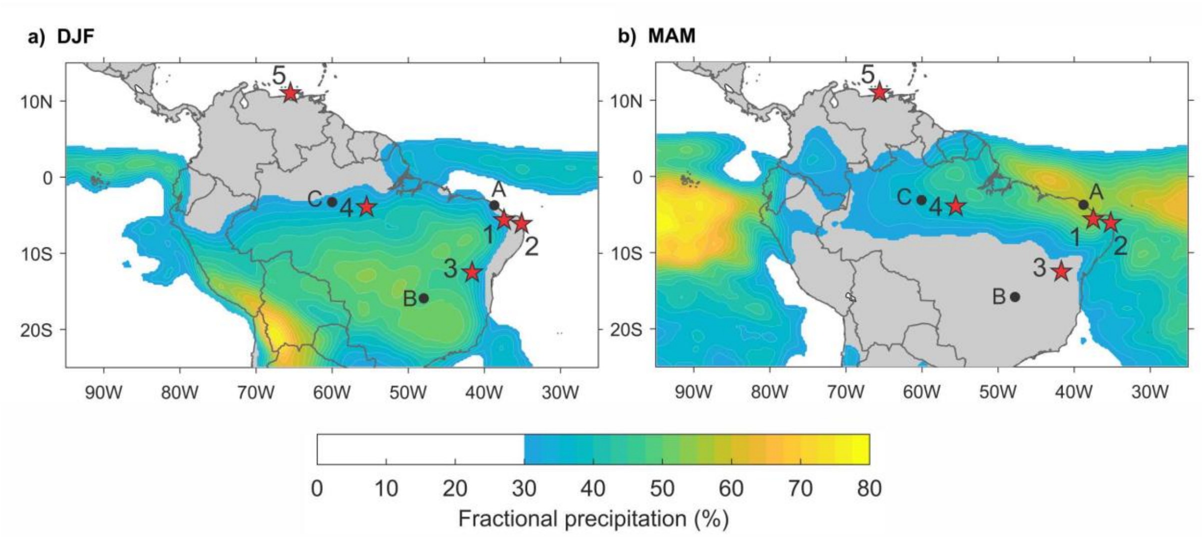


Figure 1 – Location and precipitation climatology of study sites during the austral summer (DJF – December to February) and autumn (MAM – March to May). Color shading indicates percentage of the annual precipitation total that is received during either DJF or MAM and highlights the extent of (a) the SASM over the continent and (b) the ITCZ over the ocean. Precipitation data is from the Global Precipitation Measurement (GPM) mission, with averages calculated over the period 2001–2020. 1) Trapiá and Furna Nova Cave (this study), 2) Boqueirão Lake (Utida et al., 2019), 3) Diva de Maura Cave (Novello et al., 2012), 4) Paraíso Cave (Wang et al., 2017), 5) Cariaco Basin (Haug et al., 2001). GNIP stations: A) Fortaleza, B) Brasília, C) Manaus.

2. Line 163: please clarify whether you analysed the precipitation data as annual (or hydrological year), monthly, or daily totals.

The data for Fortaleza, Brasília and Belterra ANA stations were analyzed on a monthly timescale. The reference period for calculating GPCC anomalies is 1961-1990. Anomalies are obtained by removing the long-term average, calculated over the reference period, from the monthly observed values. We clarified this in the text and in the caption of Figure 2.

*"In N-NEB, we analyzed **monthly** precipitation data from Pedra das Abelhas Station – RN (Fig. 2a), from 1911 to 2015 (n=103)."*

3. Figure 2

Figure 2 has been changed as discussed below. The revised Figure is also shown below this discussion.

Please change green dots to another colour (black?). Please also change the green line in the top panel to a different colour.

The green color of Figure 2 has been changed to black.

Consider changing the red-blue colour palette – in maps this palette is often used to show temperature variability, and so I find it slightly misleading here.

Thank you for pointing this out to us. We changed the color palette and also made additional substantive changes to the Figure to address all comments. Please see the revised Figure 2 and the associated Figure caption below.

Please change the legend in the top panel to 'Site precipitation – GNIP' and 'Site precipitation – ANA' to be consistent with 'Site δ18O – GNIP'.

The site description has been changed as suggested. Please see the revised Figure 2 below.

The caption suggests that the correlation map correlates observed precipitation against observed δ18O – suggested rephrase: "Figure 2 – monthly mean observed precipitation amount for ANA stations and δ18O values for GNIP stations (IAEA-WMO, 2021) (green dots), with correlation maps between gridded precipitation anomalies and GNIP δ18O anomalies…." And then carry on from (a) with the rest of your caption, while also adding (star 1) at line 201 for Pedra das Abelhas station.

Please clarify what correlation was used.

The caption of Figure 2 was modified according to suggestions, and the green dots were changed to black. Please see the figure and caption below. In Figure 2 we used the Pearson's correlation to produce the spatial correlation maps. This information was also included in the figure caption.

The difference between GNIP rainfall amount and ANA rainfall amount is really large between Fortaleza and Pedras de Abelhas. These sites are so close, have you double checked that that is correct?

The sites are close to each other indeed. However, this small distance is sufficient to slightly change the precipitation amount at these sites. Fortaleza Station is closest to the coast, and precipitation from the ITCZ is more intense than at the Pedra das Abelhas Station, which is located 88 km further inland, and thus just marginally influenced by the ITCZ. We plotted the GNIP stations' position in Figure 1 to clarify this aspect. Please see the revised Figure 1 above. Although, there are differences in precipitation amount, the precipitation trend is similar.

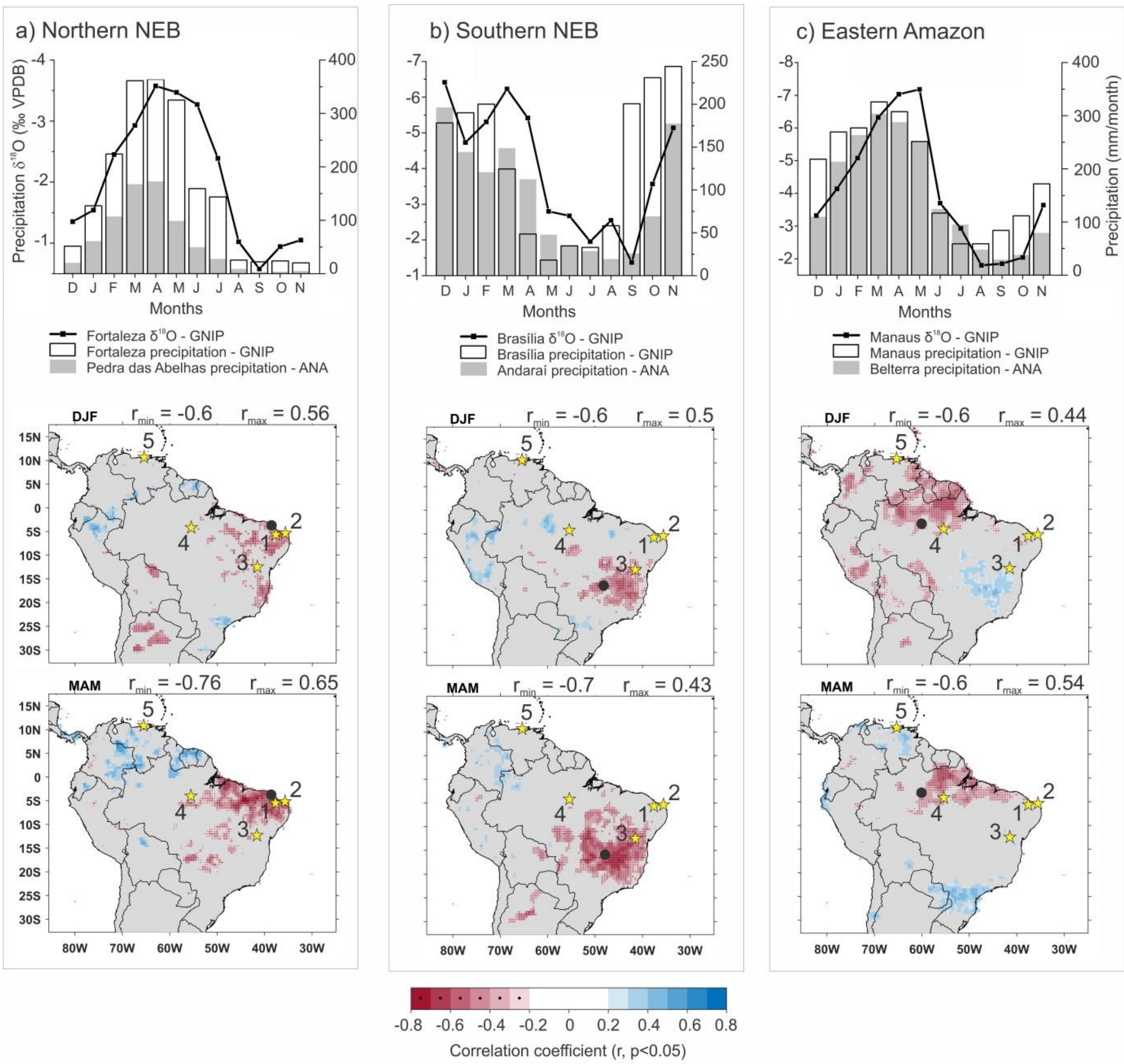


Figure 2 – Monthly mean observed precipitation amount collected at ANA and $\delta^{18}O$ values for GNIP stations (IAEA-WMO, 2021) (black dots) and correlation maps between gridded precipitation and $\delta^{18}O$ anomalies from the same stations (black dots) for: (a) Northern NEB, Fortaleza and Pedra das Abelhas stations (star 1), (b) Southern NEB, Brasília and Andaraí stations (star 3), c) Eastern Amazon, Manaus and Belterra stations (star 4). The maps show the spatial correlation between $\delta^{18}O$ anomalies at GNIP stations and GPCC gridded precipitation anomalies based on the period 1961-1990 for December to February (DJF) and March to May (MAM) for Fortaleza, Brasília and Manaus stations (Ziese et al., 2018). The $\delta^{18}O$ values (left y axis) and precipitation (right y axis) for each station were obtained from the GNIP IAEA/WMO database. Stars indicate the site locations: 1) Trapiá Cave, Furna Nova Cave and Pedra das Abelhas ANA Station (reference period 1910-2019), 2) Boqueirão Lake (Utida et al., 2019), 3) Diva de Maura Cave (Novello et al., 2012) and Andaraí ANA Station (reference period 1960-1986), 4) Paraíso Cave (Wang et al., 2017) and Belterra ANA Station (reference period 1975-2007), 5) Cariaco Basin (Haug et al., 2001).

4. Line 184: add reference to Fig 2.

Thank you for mentioning this. Figure 2 will be mentioned in the line 184 of the original manuscript.

5. Line 190: add ref to Fig 2C

Thank you for mentioning this. Figure 2a and 2c will be mentioned in line 190 as showing a negative spatial correlation in Northern NEB.

6. Line 208: why 1960 – 2016 as a reference period? The WMO uses 1961-1990 for long-term monitoring, or the 3 decades prior to the most recent year ending in 0 (e.g. 1991 – 2020) for short term changes. Could you please justify your choice or change to a standard ref. period.

The reference period will be changed from 1960-2016 to 1961 to 1990, whenever possible, as suggested by the WMO. However, in some cases this is not possible due to missing data. We therefore included in the caption of Figure 2 the reference period analyzed for each ANA station whenever it is different from the standard period.

7. Line 216: Figure 2C.

The correct Figure will be listed in the revised text.

8. Line 272: typo, please correct to 'would not affect'

Thank you for pointing out this typo. It will be corrected.

9. The δ18O data are of different resolutions – can you please clarify how the iscam handles differently-sampled data

The calculations made by the ISCAM (Fohlmeister, 2012) provide an interpolation of each dataset to the same resolution before merging them. Therefore we can use the original datasets containing the depths and corresponding proxy result at different resolutions in order to produce this unique record.

10. Line 331: please change 'first 1800 years' to 'the period spanning 1940 CE to 130 BCE' for less ambiguity.

The sentence fragment will be substituted to "the period spanning 130 BCE to 1940 CE" in order to be consistent with always citing the oldest age first.

More detail is needed about the C-A correction and how it was calculated (this could go in the Supplement. Could you please add the initial mean and corrected mean δ18O values for each interval to your Table S3. Something like the below?

We use the aragonite-calcite fractionation offset described by Zhang et al. (2014) obtained for stalagmites from China. We used equation 1 below to consider the proportion between calcite and original aragonite for each stalagmite interval of RN stalagmites, according to Table S3. We included the mean $\delta^{18}O$ for each interval before and after C-A correction in Table S3. Please see the Table below.

$$\Delta^{18}O_{C-A\,corr} = \frac{sample\ calcite\ \%}{100\%\ original\ aragonite}\ x\ calcite\ fractionation\ offset$$

*Table S3 – Speleothem intervals according to texture and mineral weight proportion (wt). Texture description: A – crystals with mosaic and columnar fabrics; B – interbedded needle-like crystals. *Obtained by Utida et al. (2020). C-A: calcite-aragonite correction*

Speleothem Mineralogy							
Sample	Interval (mm)	Age (yr BCE/CE)	Texture	Aragonite (wt %)	Calcite (wt %)	$\delta^{18}O$ mean (‰ VPDB) before C-A correction	$\delta^{18}O$ mean (‰ VPDB) after C-A correction
TRA5	30-54	1855 to 1745 CE	A	0.0	**100.0**	-3.50	-2.65
	54-87	1745 to 1640 CE	A	0.0	**100.0**	-3.56	-2.71
	87-108	1640 to 1565 CE	A	0.0	**100.0**	-3.58	-2.73
	108-178	1565 to 1490 CE	A	0.0	**100.0**	-3.40	-2.55
TRA7*	0-173	1940 CE to 130 BCE	A	0.0	**100.0**	-2.80	-1.95
	173-215	130 to 290 BCE	B	**99.0**	1.0	-2.14	-2.13
	215-270	290 to 3000 BCE	B	**87.1**	12.9	-3.12	-3.01
FN1*	0-27	1790 to 1170 CE	B	**85.2**	14.9	-2.14	-2.01
	27-83	1170 to 610 CE	B	**90.6**	9.4	-2.87	-2.78
	83-128	610 to 80 CE	A	0.0	**100.0**	-1.87	-1.03
	128-202	80 CE to 1730 BCE	B	**94.5**	5.5	-2.54	-2.49
FN2	6-31	189 to 660 BCE	B	**94.7**	5.3	-1.20	-1.15
	31-56	660 to 960 BCE	B	**94.8**	5.2	-1.56	-1.52
	56-63	960 to 1005 BCE	B	**94.8**	5.2	-2.03	-1.99
	63-95	1005 to 1265 BCE	B	**93.4**	6.6	-1.94	-1.88

11. Can you please move Figure 3 earlier in the manuscript.

The figure will be moved to the location where it is first mentioned in the text.

12. Line 362-368: I suggest you reword this to demphasise the 4.2 ka event (which your record mostly postdates). Something like "A generally drier climate prevailed in NEB after the 4.2 ky BP (Before Present) event in the Mid-Holocene (ref). This led to the development of the Caatinga, a sparse vegetation cover which has persisted in NEB to the present (ref). These drier conditions …."

We will reword the sentence as suggested.

13. Line 368-9: it is unclear if this is statement 'more negative δ13C values in stalagmites are associated with...' refers to NEB samples or is a general statement. If general, please add impact of temperature and PCP (see Fohlmeister et al. 2020), and perhaps relocate this to the literature review.

In this statement, the more negative $\delta^{13}C$ refers to the stalagmite samples from the same caves. We modified the text to clarify this. Please see the revised sentence below.

"When erosion events remove most of the soil cover, there is an increase in the carbon contribution from local bedrock (mean $\delta^{13}C$ of 0.5 ‰), which leads to higher $\delta^{13}C$ values in the NEB stalagmites from RN. On the other hand, more negative $\delta^{13}C$ values in stalagmites are associated with increased soil coverage and soil production (Utida et al., 2020)."

14. Figure 3

As for other figures, please change the colour scheme.

Please make the lines in the legend thicker so that the colours are easier to see.

Please update the 99% confidence interval to a shaded band – the two cyan lines are hard to see (assuming there are 2? In some places it seems like the black line is outside of the bounds of the 99% confidence interval? E.g. see ~1100 CE).

The U-Th data should have a label (i.e. a) to be consistent with the other data presented here.

Can this figure be combine with Figure 4? There is a lot of overlap.

15. Figure 4

As for Figure 3 re. colour palette, composite, and U-Th data.

Are the older TRA7 δ13C data needed – suggest removing them if they are not referred to in the paper.

We have combined the answers for the above two questions and comments (14 and 15):

The Figures 3 and 4 were combined and the older part of TRA7 was removed from the main text, and the complete TRA7 data in the original Figure 3 was moved to the Supplement (Figure S5). We do not discuss in detail the older interval of TRA7 because it has no significant variability that is worth discussing in comparison with the other records we are presenting. The two curves representing the 99% confidence interval for the RN Composite were updated with grey color and enlarged for easier viewing. Two periods in the RN Composite age model confidence interval show a large range of variability, around 350 BCE and the base of the Composite around 1200 BCE. However, this does not affect our main interpretation. Please, see the updated version of Figure 3 below.

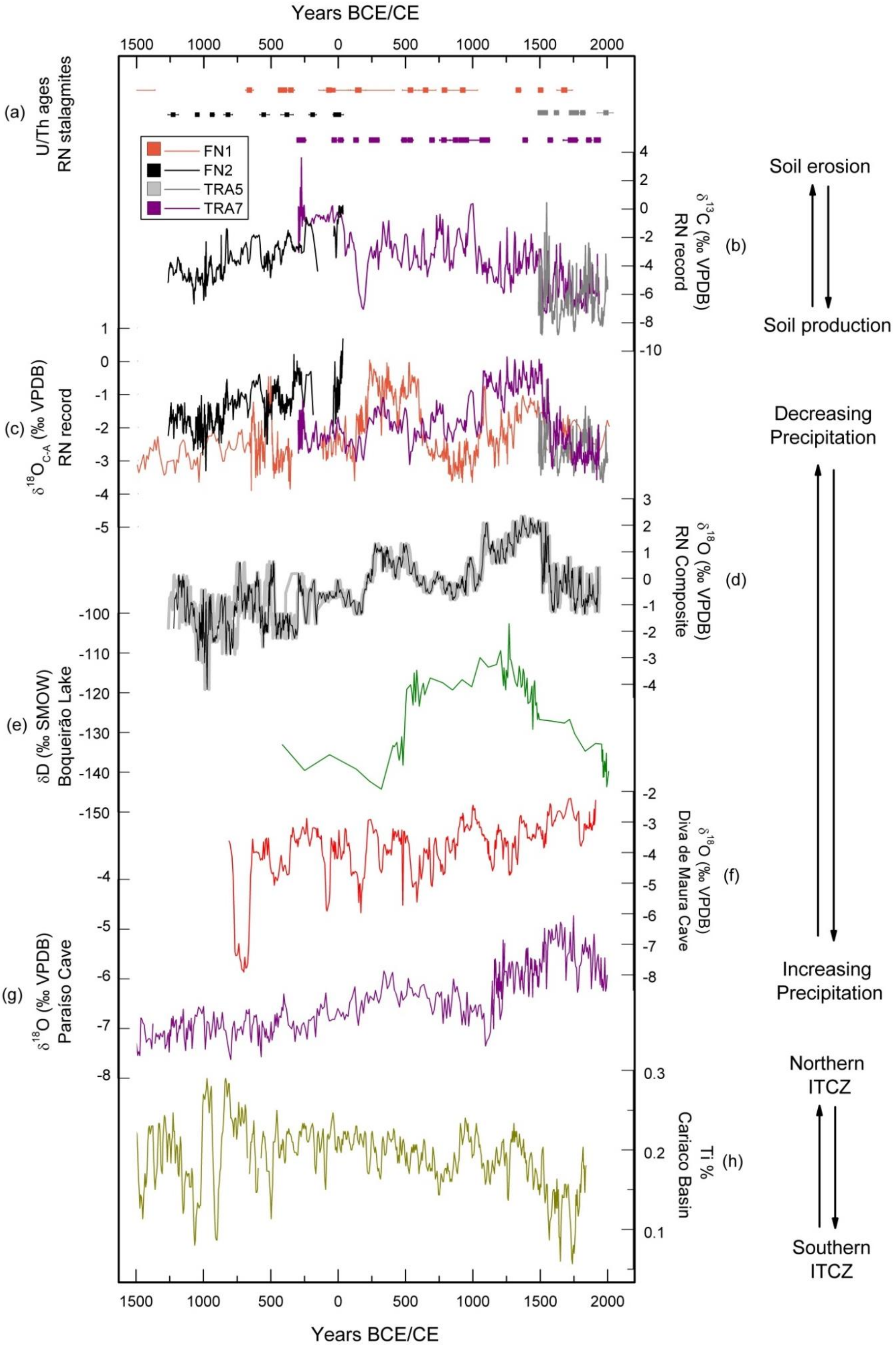


Figure 3 – Rio Grande do Norte stalagmite isotope records and comparisons with other records from South America. A) U/Th ages from each stalagmite studied. B) Raw data of $\delta^{13}C$. c) Oxygen isotope results corrected for calcite-aragonite fractionation ($\delta^{18}O_{C\text{-}A}$), according to weight proportion of mineralogical results. D) $\delta^{18}O$ RN Composite constructed using stalagmite records from NEB (black line). Grey shaded area

denotes the 99% confidence interval of the age model. E) Boqueirão Lake δD record (Utida et al., 2019). F) DV2 $\delta^{18}O$ speleothem record from Diva de Maura cave, southern NEB (Novello et al., 2012). G) PAR01 and PAR03 $\delta^{18}O$ records from Paraíso cave stalagmites, eastern Amazon (Wang et al., 2017). H) Ti record of Cariaco Basin (Haug et al., 2001).

Have you quantified the difference in δ13C between samples? From ~1500 CE onwards they don't appear to covary closely.

The reviewer is correct – there are indeed some differences between the TRA7 and TRA5 $\delta^{13}C$ records that can be explained by different time resolutions between these samples. Therefore, the last 500 years were interpreted only based on TRA5. Furthermore, we did not discussed $\delta^{13}C$ during the last 500 years because the soil signal might be affected by anthropogenic impacts. Although the area above Trapiá cave probably was not occupied by settlements, the local communities have been exploring the carbonate rocks above the cave, since the exposed karst is easy to remove, and collected wood for local use, which could impact the soil $\delta^{13}C$ signal.

16. Line 417: can you please expand on why DV2 and the RN record differ? "The general trend towards more positive values" – please add over what time period this trend occurs, as I don't think it persists over the whole records.

The text was expanded according to your suggestion. Please, see the modifications we made below.

"It is important to note that the RN record exhibits a climatic signal that is distinctly different from the from DV2 speleothem record from Diva de Maura Cave in S-NEB (Novello et al., 2012). Although both regions are affected by the same mesoscale atmospheric circulation, the RN site receives its precipitation directly from the ITCZ. At the S-NEB site, on the other hand the primary source of precipitation is associated with the monsoon, as it is located too far inland to be affected directly by the ITCZ. The general trend toward more positive values, as a result from insolation forcing, occurs from 150 to 1500 CE in the RN Composite, but from 600 to 1900 CE in the DV2 sample (Cruz et al., 2009; Novello et al., 2012). This trend is a result of the persistent dry conditions in the entire NEB region following the 4.2 ky BP event. However, the DV2 record does not document the same multidecadal and centennial-scale climate variability as recorded in the RN speleothem record, nor the less dry interval from 600 to 1060 CE seen in the RN Composite (Fig 3)."

17. Line 421: please change 4.2 ka BP, or whatever convention you choose and be consistent throughout.

Both mentions will be corrected to 4.2 ky BP.

18. Line 452: please explain why you think AMV and RN decoupled after ~0 CE.

The original graph was plotted backwards in the manuscript, which affected the relationship between the AMV and RN. We corrected this error and rewrote the paragraph, now discussing the corrected relationship between the RN Composite and the AMV. In this new version of Figure 5, the decoupling between the RN Composite and the AMV reconstruction occurs between 1400 and 1500 CE. We do not have a definite answer as to why this decoupling occurs, but it might be related to differences in age models and data range. Both reconstructions come with their own sets of uncertainties that can affect the relationship. The fact that the RN Composite and the AMV reconstruction diverge most prominently during the Current Warm Period might indicate that external (i.e. greenhouse gas) forcing might affect the relationship between the two records. An alternative explanation is that Pacific multidecadal variability modulated this relationship, since the state of the Pacific can affect the relationship between the AMV and Nordeste rainfall (He et al., 2021). However, while assessing these non-stationarities in the relationship is important and has to be investigated in more detail in future work, it is somewhat beyond the scope of this paper. The text will *be corrected in the manuscript from lines 446 to 454. The revised Figure 5 and the revised text are shown below.*

"There is a relationship between the $\delta^{18}O$ values in our RN speleothems and the ITCZ displacement toward the warmer hemisphere which helps explain paleoclimate variability observed in N-NEB. In order to reinforce this idea, the RN Composite was compared with Atlantic Multidecadal Variability (AMV) (Lapointe et al., 2020) (Fig 4). Some studies suggest that the warm phase of the AMV forces the mean ITCZ to shift to the north of its climatological position, causing a reduction in NEB rainfall (Knight et al., 2006, Levine et al., 2018, He et al., 2021), while a recent study suggests that warm phase AMV would cause a weakening of the ITCZ from February to July (Maksic et al., 2022). The driest periods from 750 to 500 BCE, 200 to 580 CE and 1100 to 1400 CE occurred during long periods of relatively warm AMV anomalies, considering the average temperature of 22.19°C for the period, which would force a northward ITCZ displacement or an ITCZ weakening. In both cases the result would be reduced precipitation over NEB. Although there is a decoupling between our results and the AMV between 1400 and 1500 CE, these differences might be related to age model uncertainties affecting the chronologies of the RN Composite and the AMV record. Opposite conditions between RN Composite and the AMV can also be observed during the Current Warm Period and require further investigation."

19. Figure 5

I think you have accidentally plotted the Lapointe AMV backwards.

Thank you for making us aware of this mistake in Figure 5, which has now become Figure 4. We corrected the graph and present the new version below, adapted for font size and suitable for readers with color blindness.

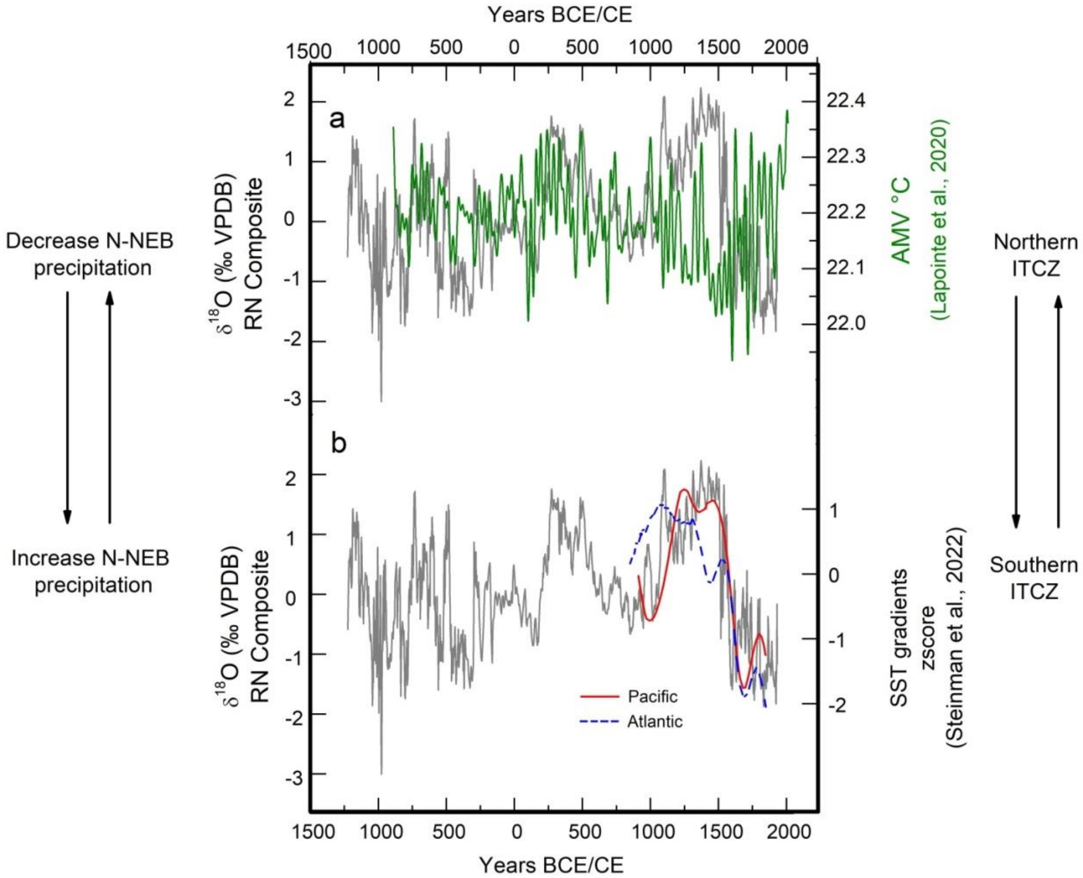


Figure 4 - $\delta^{18}O$ RN Composite compared with (a) Atlantic Multidecadal Variability (Lapointe et al., 2020) and (b) Pacific and Atlantic Sea Surface Temperature gradients calculated (z-score) according to Steinman et al. (2022). Atlantic: 2σ range of 1,000 realizations of the Atlantic meridional SST gradient (north – south). Pacific: median of 1,000 realizations of the Pacific zonal SST gradient (west – east).

20. Line 503: please move Figure 6 up to about here.

The figure will be moved to where it is first being discussed in the text. The Figures was updated and has now become Figure 5.

21. Line 520: please capitalise 'Indigenous'

The word will be capitalized.

22. Line 521 – "Entire Indigenous tribes died of starvation as a consequence of this drought and a related smallpox epidemic" – this suggests the smallpox outbreak was caused by the drought – is that correct? Suggest rewording to "Entire Indigenous tribes died of starvation as a consequence of this drought and a concurrent smallpox epidemic"

Thank you for this important comment. The correction is absolutely necessary and the text will be changed to: "Entire Indigenous tribes died of starvation as a consequence of this drought and a concurrent smallpox (variola) epidemic".

23. Line 529: what is the age error at 1770 CE – adding the uncertainty might bolster your point that this event is the 1776-1778 drought

24. Line 535: as per above please add age uncertainty.

For both comments 23 and 24 above, we will include a discussion about age model errors for TRA5. This is similar to the comment made by the second reviewer and we will also include a description of the U/Th ages to better explain the age results and age models. Please also see the answers we provide for Reviewer 2 for further details.

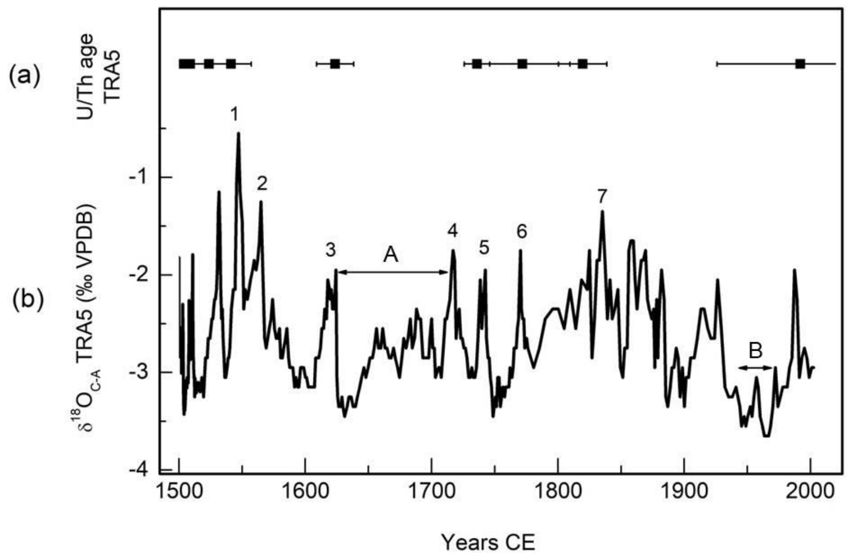
The errors of our age model for TRA5 are around ± 30 years (95% confidence interval) and we are thus aware that this uncertainty complicates the attribution to a single three-year long event. There exist no precipitation reconstructions or observations from this region between 1500 and 1850 CE, aside from these historical drought records. We thus consider our speleothem-based record as a first attempt to reconstruct precipitation in Northeast Brazil that would allow a comparison with historical droughts. If our speleothem records regional hydroclimate, it should retain a signal of the most intense droughts over NEB that are known to have struck the region based on the available historical literature of Brazil. The historical droughts we discuss in the paper, and we identify in our record, are the longest drought events in Northeast Brazil that occurred within the zone of influence of the ITCZ, and are thus probably the most likely to be recorded by stalagmites. Note that despite dating uncertainties of our record, the $\delta^{18}O$ peak of each drought event recorded, is consistent with the historical record of Lima and Magalhães (2018). Furthermore, the period between 1620 and 1717 CE is devoid of any abrupt drought events in the TRA5 stalagmite, which is again consistent with the historical records. Lima and Magalhães (2018) registered only 3 short drought events within this period of almost 100 years. It is also important to mention that Lima and Magalhães (2018) report all drought events in NEB and do not indicate their location. As discussed above northern and southern NEB are influenced by different climatic systems, the ITCZ and SASM, respectively, and this can explain, in part, the differences between historical and stalagmite records of Rio Grande do Norte.

25. Line 544: suggest reword to "Although the TRA5 speleothem chronology precision is reduced during the last ~150 years…"

The sentence will be changed according to the suggestion.

26. Figure 6: as for earlier figs, add a, b… label for U-Th data

The figures were updated and the suggested modifications were made. Figure 6 is now Figure 5. Please, see the revised version of the Figure below.



(c) NEB drought events (yr CE)		
#Event	Historical	TRA5
1	1553	1546
2	1559	1564
3	1614-1615	1620
4	1720-1727	1717
5	1744-1748	1740
6	1776-1778	1770
7	1835-1833	1835

Figure 5 – TRA5 record and equivalent historical record. (a) U/Th age is represented by black dots and horizontal lines indicate age uncertainty. (b) $\delta^{18}O_{C-A}$ record, numbers represent the peak of a drought event. A - Few drought events interval from 1620 to 1717 CE. B - 1940s to 1970s period. (c) the occurrence of historical drought years compiled from Lima and Magalhães (2018).

27. Line 567: "these data suggest a trend toward increased aridity over NEB from 3000 BP to present…" Please be consistent with use of BP vs BCE. At line 495 you say the last 500 years were the wettest of the last 2 millenia, which contradicts the above statement.

Thank you for calling attention to this erroneous statement. We reworded this sentence. It is now consistent with our interpretations. Please see the revised sentence below.

"The N-NEB record presents a trend toward drier conditions from 1000 BCE to 1500 CE as is also being observed in the Diva de Maura Cave in S-NEB, interpreted as an ITCZ withdrawal and SASM weakening, respectively. Although the two records are influenced by distinctly different climate systems with different precipitation seasonality, ITCZ and SASM dynamics are known to be closely linked (Vuille et al., 2012)."

28. Line 572: "drought period between 1500 and 1750" – Is this referring to the drought events in TRA5? The wording suggests it is linked to the RN composite, which shows abrupt change at~1500 CE to wetter conditions. Could you please clarify. Throughout, I suggest you make sure you are consistent with naming conventions between samples and between the composite record and the individual samples. Perhaps consider adding sub-headings to differentiate the longer composite record and the more recent drought record.

In order to clarify the sentence mentioned, we will change the word "period" in line 572 to "events" ("the drought events between 1500 and 1750 CE"). We also will change the name of section 5.2 to "The TRA5 $\delta^{18}O$ stalagmite as a recorder of extreme dry events". The composite is already called RN Composite in the section Materials and Methods. A thorough review of the manuscript will be performed to clarify any other misleading nomenclature.

29. The data availability statement is missing.

The following data availability statement will be included at the end of the manuscript.

“Data availability

The dataset generated as part of this study will be available in the PANGAEA website.”

30. Table S1and S2 – please use a different symbol to denote data from Cruz et al. as * is used elsewhere in the table

The asterisk symbol will be replaced by 1 superscript in Table S1. In Table 2, the information “Data obtained by Cruz et al. (2009)” is not necessary and will be removed.

31. Alves 2003 – this link is broken and I could not find the article at the website.

The link will be corrected in the manuscript and you can also check here.

https://colecaomossoroense.org.br/site/wp-content/uploads/2018/07/HISTÓRIA-DAS-SECAS.pdf

References

Fohlmeister, J.: A statistical approach to construct composite climate records of dated 684 archives, Quat. Geochronol., 14, 48-56, https://doi.org/10.1016/j.quageo.2012.06.007, 685 2012.

Haug, G., Hughen, K.A., Sigman, D.M., Peterson, L.C., Röhl, U.: Southward migration of the Intertropical Convergence Zone through the Holocene, Science, 293, 5533, 1304-1308, https://doi.org/10.1126/science.1059725, 2001.

He, Z., Dai, A., Vuille, M.: The joint impacts of Atlantic and Pacific multidecadal variability on South American precipitation and temperature. J. Climate, 34(19), 7959-7981. https://doi.org/10.1175/JCLI-D-21-0081.1, 2021.

IAEA/GNIP - Global Network of Isotopes in Precipitation, The GNIP Database, https://nucleus.iaea.org/wiser, last access: 20 August 2021.

Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P.S., Heiri, O., Davis, B.: Holocene global mean surface temperature, a multi-method reconstruction approach, Sci Data 7, 201. https://doi.org/10.1038/s41597-020-0530-7, 2020.

Knight, J.R., Folland, C.K., Scaife, A.A.: Climate impacts of the Atlantic Multidecadal Oscillation, Geophys. Res. Lett., 33, L17706, https://doi.org/10.1029/2006GL026242, 2006.

Lapointe, F., Bradley, R.S., Francus, P., Balascio, N.L., Abbott, M.B., Stoner, J.S., St-Onge, G., De Coninck, A., Labarre, T.: Annually resolved Atlantic Sea surface temperature variability over the past 2,900 y, Proc. Natl. Acad. Sci., 117, 44, 27171–27178, https://doi.org/10.1073/pnas.2014166117, 2020.

Levine, A.F.Z., Frierson, D.M.W., McPhaden, M.J.: AMO Forcing of Multidecadal Pacific ITCZ Variability, J. Clim., 31, 5749–5764, https://doi.org/10.1175/JCLI-D-17-0810.1, 2018.

Lima, J.R., Magalhães, A.R.: Secas no Nordeste: registros históricos das catástrofes econômicas e humanas do século 16 ao século 21, Parcer. Estratég., 23, 46, 191-212, 2018. Available at: https://seer.cgee.org.br/parcerias_estrategicas/article/view/896/814.

Maksic J., Shimizu, M.H., Kayano, M.T., Chiessi, C.M., Prange, M., Sampaio, G.: Influence of the Atlantic Multidecadal Oscillation on South American Atmosphere Dynamics and Precipitation, Atmos., 13, 11, 1778, https://doi.org/10.3390/atmos13111778, 2022.

Novello, V.F., Cruz, F.W., Karmann, I., Burns, S.J., Stríkis, N.M., Vuille, M., Cheng, H., Edwards, R.L., Santos, R.V., Frigo, E., Barreto, E.A.S.: Multidecadal climate variability in Brazil’s Nordeste during the last 3000 *years based on speleothem isotope records, Geophys. Res. Lett., 39, L23706, https://doi.org/10.1029/2012GL053936, 2012.*

Treble, P.C., Baker, A., Abram, N.J., Hellstrom, J.C., Crawford, J., Gagan, M.K., Borsato, A., Griffiths, A.D., Bajo, P., Markowska, M., Priestley, S.C., Hankin, S., Paterson, D.: Ubiquitous karst hydrological control on speleothem oxygen isotope variability in a global study, Commun. Earth Environ., 3, 1–10. https://doi.org/10.1038/s43247-022-00347-3, 2022.

Utida, G., Cruz, F.W., Etourneau, J., Bouloubassi, I., Schefuß, E., Vuille, M., Novello, V., Prado, L.F., Sifeddine, A., Klein, V., Zular, A., Viana, J.C.C., Turcq, B.: Tropical South Atlantic influence on Northeastern Brazil precipitation and ITCZ displacement during the past 2300 years, Sci. Rep., 9, 1698, https://doi.org/10.1038/s41598-018-38003-6, 2019.

Utida, G., Cruz, F.W., Santos., R.V., Sawakuchi, A.O., Wang, H., Pessenda, L.C.R., Novello, V.F., Vuille, M., Strauss, A.M., Borella, A.C., Stríkis, N.M., Guedes, C.C.F., De Andrade, F.D., Zhang., H., Cheng, H., Edwards, R.L.: Climate changes in Northeastern Brazil from deglacial to Meghalayan periods and related environmental impacts, Quat. Sci. Rev., 250, 106655, https://doi.org/10.1016/j.quascirev.2020.106655, 2020.

Vuille, M., Burns, S.J., Taylor, B.L., Cruz, F.W., Bird, B.W., Abbott, M.B., Kanner, L.C., Cheng, H., Novello, V.F.: A review of the South American monsoon history as recorded in stable isotopic proxies over the past two millennia, Clim. Past, 8, 1309–1321, https://doi.org/10.5194/cp-8-1309-2012, 2012.

Wang, X., Edwards, R.L., Auler, A.S., Cheng, H., Kong, X., Wang, Y., Cruz, F.W., Dorale, J.A., Chiang, H.-W.: Hydroclimate changes across the Amazon lowlands over the past 45,000 years, Nature, 541, 204-207, https://doi.org/10.1038/nature20787, 2017.

Zhang, H., Cai, Y., Tan, L., Qin, S., An, Z.: Stable isotope composition alteration produced by the aragonite-to-calcite transformation in speleothems and implications for paleoclimate reconstructions, Sediment. Geol., 309, 1-14, https://doi.org/10.1016/j.sedgeo.2014.05.007, 2014.

Ziese, M., Rauthe-Schöch, A., Becker, A., Finger, P., Meyer-Christoffer, A., Schneider, U.: GPCC Full Data Daily Version 2018 at 1.0°: Daily Land-Surface Precipitation from Rain-Gauges built on GTS-based and Historic Data [dataset], https://doi.org/10.5676/DWD_GPCC/FD_D_V2018_100, 2018.