Climate of the Past Discussions

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Comment on cp-2021-54

Anonymous Referee #2

Referee comment on "Early Holocene cold snaps and their expression in the moraine record of the eastern European Alps" by Sandra M. Braumann et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-54-RC2, 2021

Summary of the manuscript

This manuscript presents 27 new Be-10 dates on the timing of Holocene glacial advances in the Eastern Alps of Europe and correlates them with inferred meltwater events within the North Atlantic. Their findings corroborate previous studies from the Western Alps and peripheral regions of the North Atlantic, which is glacial advances in those regions were the result of cold atmospheric temperatures being advected eastward from the Atlantic, and that the Atlantic was cold as a result of a slowdown in AMOC, which was a result of enhanced freshwater input from the Laurentide Ice Sheet.

Summary of my assessment

This manuscript was an absolute delight to read! Scientifically, the results support the conclusions (with a few very minor exceptions, discussed below) and the discussion was beyond interesting, it was enlightening. Aesthetically, the writing was silken, the figures were beautiful, and the logical organization of the manuscript was thoroughly evident. In my opinion, this paper should be published with a few moderate and several minor revisions.

Major Points

As I said, I have no "major" issues with this paper. I do, however, have three "moderate" points for the authors to consider:

First, there is a slight age inversion between MFI 4 (dated to 10.8 ± 0.7 ka) and MFI 3 (dated to 11.2 ± 0.8 ka). While these two events are indistinguishable in timing from each other based on the Be-10 dates, we know from the geomorphology that MFI 4 must be older than MFI 3. While this apparent age inversion is noted on line 407, it isn't (as far as I noticed) mentioned again. Thus, the discussion on lines 437-441 seems strange. The authors say MFI 3 falls within the PBO (defined as 11.30-11.15 ka in Europe), but MFI 4 does not. In reality, MFI 4 must have preceded MFI 3, so if only one of them is associated with the PBO, it's more likely MFI 4. In short, I don't see how *both* of the following could be true: (1) MFI 3 correlates with the PBO and (2) MFI 4 postdates the PBO and correlates with a summer cooling detected in Swiss and Austrian lake sediments.

Second, I was surprised that the authors did not acknowledge the possibility that the boulders dating to c. 700-1500 years ago (JAM-18-07, JAM-18-16, and LAR-19-23) were actually deposited more recently (c. the 18th century?) and contain inherited nuclides from prior exposure. The evidence from these two valleys for glacial advances c. 500 CE and c. 1300 CE is tenuous, in my opinion. The data *permit* glacial advances at those times, but the evidence is not compelling. I was pretty skeptical of glacial advances at those times in these two drainages—until I read about the evidence elsewhere in the Alps for glacial advances at those times (e.g., the boulder from Ochsental dating to 1500 ± 40 years, the sediment and peat profiles from various glacial forefields in the Eastern Alps, and the documented glacial advances in the Western Alps at those times. In light of the evidence from elsewhere in the Alps for glacial advances at c. 500 CE and 1300 CE, I think the interpretation presented by the authors—that these two valleys also hosted ice advances

at those times—is reasonable, but the alternative possibility, that these three samples contain inherited nuclides from prior exposure should be discussed in the text.

Third (and perhaps less importantly than the two previous points), I find it curious that both valleys have moraine ridges just outside the LIA margins that are ~8-10 m wide, rich in fine-grained sediment, and devoid of boulders. While the authors suggest these ridges (J2 and L2) might be equivalent to the c. 10 ka Grüne Kuppe moraine in the adjacent landscape of Ochsental (lines 452-465), the fine-grained nature of these ridges seems anomalous—and suggests to me that they have a different origin from the boulder-rich ridges (moraines) present in these alpine valleys. In particular, I wonder if J2 and L2 might be some sort of push-ridge associated with the LIA advance? That's speculative, of course, but no more speculative (in my opinion) than their potential association with the Grüne Kuppe moraine. In any event, the true age of the undated J2 and L2 ridges is *not* an essential point to this manuscript—but their fine-grained nature *does* seem anomalous and cry out for an explanation.

Minor Points

Line 16: I think there should be a hyphen between ice and margin.

Lines 20-21: I think the MFI should be listed in chronological order, so oldest first.

Line 24: I think "millennial scale" should be hyphenated.

Line 25: I think “contemporaneous” is possibly too strong; I’d suggest “indistinguishable in timing” instead.

Line 32: I think a reference or two should be provided for the duration of the YD and (less importantly) for the beginning of the Holocene. Yes, these dates are common knowledge—but someone(s) did some groundbreaking research at some point to determine those dates and their efforts should be acknowledged, in my opinion.

Line 35: “Centennial scale” should always be linked by a hyphen, I believe, so: “centennial-scale.”

Line 35: I remember Bob Anderson (CU-Boulder) commenting on one of my manuscripts and saying that “to be” was the weakest of all verbs, so to avoid whenever possible. In this case, “to be” can be deleted and the sentence remains grammatically correct (and becomes more concise).

Line 36: Stylistically, I think references should also be cited in chronological order, because that helps me learn the history of the field, but I recognize that some journals prefer/require citations to be in alphabetical order. In this case, it’s neither. Also, the “e.g.” should be followed by a comma (so, “e.g.,”) and there should be a space after the semicolons and before the next name.

Line 77: “State of the art” should be hyphenated, I believe. So, “state-of-the-art.”

Figure 1: Is an absolutely stunning figure, it contains *so* much information, and is an absolute delight to look at. I hope the person (or people) who made it are proud of their efforts, it is a real accomplishment.

Line 101: “Geographic” can be deleted. (Are their locations that are not geographic? I can’t think of any… so the word can be deleted for greater conciseness without loss of meaning.

Line 112: Delete the “a” before “snow cover.”

Line 126: This might be the previous semester speaking—in which I taught mineralogy/petrology despite being a geomorphologist—but I think “quartz yield” would be a better phrase here than “quartz content.” The lithologies present in these valleys must truly have greater quartz “contents” than these, as some of the quartz was etched away in the cleaning process, was it not? “Quartz content,” to me, suggests some sort of modal norm, potentially applicable to some sort of classification scheme—while “quartz yield” suggests this is how much quartz we got out of the rock.

Line 134: How do you know the boulders were carved out of the bedrock by glacial flow? Why couldn’t they have tumbled onto the glacier’s surface from the adjoining cliffs and been carried to the ice margin. In *theory*, the boulders were plucked out of the bedrock and never saw “the light of day” until they were deposited on the moraines—but was this really what happened? How do we know?

Line 142: Is there a difference between “complemented” and “updated?” If not, I’d delete complemented and just use updated. I think “updated” is the more commonly used verb.

Line 144: I think the first “historical” should be deleted. First, I’m not sure those moraines are really historical, in the meaning of the word, and second, the sentence is somewhat circular sounding as written.

Lines 150-151: Is the datum for this DEM actually sea level, and not some ellipsoid height? (I know this is nitty-gritty technical, but would you please confirm which the DEM is referencing with regards to its elevation?) See the last two paragraphs of Greg Balco’s blog post here (https://cosmognosis.wordpress.com/2017/03/28/is-a-cheap-gps-ok-for-elevation-measurements-or-do-you-need-a-fancy-one/) for more details, but the gist is that this is a frequent and impactful error on cosmo ages.

Line 157: As above, I think “quartz content” should be “quartz yield.”

Line 171: How can an individual boulder have an arithmetic mean age? (Other than by the counting statistics at the accelerator, which I’m assuming is not being referenced.) If the authors are referring to the counting statistics from the accelerator’s beam line (or whatever it’s called), that should be specified for clarity. My hunch, though, is that this statement (of the boulder ages being arithmetic mean ages) is a typo—and that only the landform ages are arithmetic means. But please, if I’m off the mark with my hunch, just clarify what’s being discussed/reported here.

Line 186: Reviewers don’t often say this (at least I don’t think they do…), but I just want to praise how logical and organized the Results and Discussion are, the thought that the authors have put into this manuscript is clearly evident!

Line 198: As above, I think the fine-grained nature of ridges J2 and L2 is an important observation with regards to their origin(s).

Figure 2: Is absolutely stunning… I really like how the authors have shaded the moraines by color and used the right-angle lines to connect the sample dots with the boxes with their ages and names. The 1-m hillshade background doesn’t hurt either!

Figure 3: Also very nice!

Line 244: The abbreviation “c” shouldn’t be used to start a sentence, even in capitalized form. Instead, I’d recommend using “approximately” instead. Also, in my experience “c.” or “ca.” for “circa” are only used with regards to approximate dates, not approximate distances, or other quantities.

Figure 4: Awesome, just like Figure 2…

Figure 5: Beautiful, just like Figure 3.

Line 276: I think the word "risky" is misleading. At first I thought you were saying that it was too dangerous to sample there, as rocks might fall down as squish you while you're trying to hammer out a sample, but then the phrase "to tackle with SED of boulders" made me realize that you're talking about scientific risk, not personal risk. I'd encourage you to preface risky with scientific, so "scientifically risky," unless you *are* concerned about being squished, in which case I'd recommend you drop the "to tackle with SED of boulders" part of the sentence.

Line 293: I'm not seeing the gray-shaded bars… do you mean the thin black lines instead, for each individual sample? Perhaps "bars" should be singular, "bar," instead? Also, the vertical uncertainty bar in the background—which I'm guessing is what you're talking about—seems kind of greenish, but perhaps that's me.

Figure 6: Also, while we're talking about Fig. 6, I don't really understand the differences between the three types of uncertainty you report on the mean age, and I think other readers might also struggle. I understand total uncertainty (reported in red) is the production rate and spike uncertainty added in quadrature, but I don't really understand the importance of the difference between the 1-sigma uncertainty (±16 years) and the standard error of the mean (±9). I guess I would have thought they were the same thing, with the "standard error of the mean" being the correct term and the "1-sigma uncertainty" being the not-really-100%-approved-by-statisticians version of the "standard error of the mean." Your paper isn't the place to teach readers about statistics—but a few sentences somewhere in the text about the differences between these things would help me (and I think others) out. (Thanks for considering this request!)

Line 300: I think "supplements" should be capitalized, and the final "s" in it dropped. So, "Supplement."

Table 1: Are the elevations really meters above sea level, or meters about some ellipsoid? (As above, what is really 0 m elevation in the DEM?) Also, "quartz weight" would be better reported as "quartz mass." Also, **I think the 10th column from the left (3rd from the right) is mislabeled.** It says it's a ratio of Be-10 to Be-9, but that's what the column to the left reports and the units in this column are atoms, and a ratio shouldn't have units. Finally, how can we possibly know the average thickness of the samples to a 10th of a millimeter? While you could just reduce the reported precision (as I suspect the true precision of these measurements is being overstated)—I'm also curious as to what method you used to calculate these numbers, as it's not stated in the text (that I saw) and I'd potentially like to use the same method in my own research.

Line 313: "11 230" should be reported as "11,230" or, alternatively, all the other 5-digit ages should be reported in the same fashion, with a space between the 3rd and 4th digits.

Lines 323-327: This advancement—of adding a late spike of Fe to help process small-volume samples—seems worth of a sentence in the abstract, in my opinion. It's a really methodological advancement for cosmo, I think, and well worth highlighting, in my assessment.

Table 2: Same 4 points as for Table 1 above.

Figure 7: Same comment about the meaning of the reported statistics (i.e., what's the difference between the 1 sigma uncertainty and the standard error of the mean) as for Figure 6. In other words (in case my point/uncertainty has been unclear), what are these two statistical calculations telling us? When would/should we refer to one and when should we refer to the other?

Lines 344-345: I think 1-3 references would be appropriate here. Who did the work that leads us to expect LIA moraine formation between 1250 and 1850 CE?

Line 345: As discussed above in the "moderate points" section, I think "recorded" is too strong a word for the evidence this manuscript presents, "suggested" might be a good alternative.

Line 361: While you interpret JAM-18-16's 1070 yr age as a minimum age, because that dates to the beginning of the MWP and the boulder might have toppled. The boulder might, alternatively, host inherited nuclides, in which case the 1070 yr age would be a maximum age. I think this possibility should be acknowledged in the text.

Line 377: "Centennial scale" should be hyphenated.

Figure 8: There isn't a year 0 in the CE chronologic system, as far as I know. I believe the "CE" dating convention is the same as the "AD" dating convention, with the years matching one-to-one and the meaning ascribed to them (the two-letter abbreviation) being the only difference. Because the Roman's didn't have the concept of zero, the numbering goes directly from 1 BC to 1 AD. Thus, as far as I know, the CE system also goes from -1 to 1 with no zero (but feel free provide a citation correcting me if you think I'm wrong). Also, on a much less nit-picky note, Figure 8 is really well designed! I like your use of color—and how time runs from left to right, that makes it easier to read in my opinion.

Line 399: **This is the same section heading as 5.1.** I think you might mean "The moraine record of the early Holocene" here.

Line 462: I don't think the word "evolving" should be used with regards to species, except in the case of evolution in the Darwinian sense. I think you might be thinking of an upward migration in the treeline, is that right? Also, pinus cembra should be italicized, I think, and shouldn't pinus be capitalized as well?

Figure 9: I'm not familiar with the word "warves." It's at the top of the figure, sideways, in association with PBO. Do you mean varves instead? And if so, what do varves have to do with the PBO? Also, with regards to (g) and (h), what do the uncertainty bars represent, 1-sigma uncertainties?

Line 467: I'm not familiar with the word "detrical." Do you mean "detrital" instead?

Line 491: I had a stats prof who said the word "significant" should only be used in scientific writing to mean "statistically significant" (at a specified threshold). That might be a stats professor's view of the world—but I see no reason why "substantial" couldn't be used here instead.

Line 491: "large scale" should be hyphenated, I believe.

Line 493: Was the Icelandic ice mass really an ice sheet (>50,000 km2) vs. an ice cap (<50,000 km2)?

Line 501: I believe "hemisphere" should be capitalized.

Line 502: Essentially the same point, I think "northern hemisphere" should be capitalized.

Line 508-509: I have two minor points about "there is evidence of more subdued glacial discharge during the EH that results in a deceleration of the thermohaline circulation." First, I think 1-3 references should be cited here, in support of that statement. Second, the term "thermohaline circulation" seems to have gone out of fashion, so I'd recommend you use "AMOC," meridional overturning circulation, or something of that nature.

Line 513: I think "glaciated" should be deleted, because it is redundant with "glaciers" two words previous.

Line 517: "ice bergs" should be one word, "icebergs."

Line 518: I don't know if you need to introduce the term/concept "H0" into the paper. Its fine if you want to—but, if I'm not mistaken, the term is only used in this paragraph (lines

515-531) and “H0” does not appear on Fig. 9 (YD is used there instead).

Line 519: I’m not familiar with the word “detrical,” do you mean “detrital” instead?

Line 521-522: The sentence says Jennings et al. (2015) found 6 DCPs, but Fig. 9 shows 7. Maybe someone discovered a 7th one later (I don’t know that literature well enough), but it seems like possibly a typo so I thought I’d mention it.

Line 523: The reference to “Fig. 8a” should be to Fig. **9**a.

Line 531: A figure number is missing from “Fig. g-h.”

Line 534: I think “Resulting” should be preceded by “The,” so “The resulting freshwater…”

Line 543: “sea ice” should be hyphenated.

Line 555: I think there's a typo here… do you mean the western margin of the North Atlantic? Or the eastern margin of the LIS? The "western" margin of the LIS would be in the Canadian prairie... at least, that's the thought that comes to my mind as I read the sentence.

Line 556: I think "perturbated" should be replaced with "reduced," as "perturbed" (note the spelling difference) means changed or altered, while "reduced" specifies the direction of change.

Line 573: Delete "have," it's not necessary.

Appendix A: I think it's great that you included so many photos of the sampled landscapes, that really helps the curious reader understand each boulder's context within the landscape.

Line 612: "unweatherd" should be "unweathered."

Line 617: I looked for your samples on the ICE-D Alpine database and was unable to find them. What's the timeline for getting the samples posted?

Line 632: Is “inatura” supposed to be capitalized? (I don’t know… but it seems likely to me.)

The Supplement: Once again, it’s really nice that you included multiple photos of every boulder, I like your thoroughness!

Supplement, 5th line to the caption for Table A2: I think the “therefore” in “and was therefore used to quantify” should be deleted, its unnecessary (the sentence makes sense without it).

One final note: thanks so much for submitting this manuscript to Climate of the Past. I know reviewers don’t often tack on such comments—but your manuscript was such a delight to read, and the figures were so well made!