General comments

This short paper discusses how a Greenland isotopic data can record information on winter blocking events over the North Atlantic region. The paper is based on isotopic data and a long reanalysis, and performs various statistical analyses. The authors propose physical interpretations by determining how water is transported in the atmosphere.

The paper is interesting and fits nicely in the scope of Climate of the Past. I have a few remarks that could be integrated easily.

We would like to thank the reviewer for the appreciation/suggestions/comments/feedback that will help us improve our manuscript, and for taking the time to read and review our paper.

Major comments

Investigating the relation between this isotopic record and blocking events and the consequences on surface variables is probably innovative. The authors mention very recent references, which is fine, but could also have searched for references at the turn of the 21st century, who looked at relations between the atmospheric circulation and surface variables, e.g. (Meeker et al., 1997). The relationship between atmospheric patterns and surface extremes has been investigated since (Robertson and Ghil, 1999; Yiou et al., 2012; Yiou and Nogaj, 2004), just to cite a few. And the relation between the jet stream and European extremes was recently discussed by (Xu et al., 2024). Therefore, a more thorough bibliographic search would certainly be welcome, to put the results of the paper in a fair perspective.

We agree that additional literature should be cited in the draft. In the revised version of the manuscript, we will improve the introduction by including not only recent studies but also earlier works, and taking into account the reviewer's suggestions.

The adjective "extreme" appears in the title and in several instances of the manuscript. The only extremes that are discussed are the values of the isotopic record, not hydrological or temperature extremes in Europe. The authors essentially discuss "warmer/colder" or "wetter/drier" than normal, which does not correspond to usual definitions of extremes. This should be amended in the manuscript.

We agree that phrasing wamer or colder may indicate a change in the mean. However, using ETCCDI indexes imply already the occurrence of the extreme. Nonetheless, we are going to change the wetter/drier terms in more/less occurrence of extreme rainfall events periods.

The authors quickly deduce from Figure 2 that the relation between the isotopic record and the atmospheric circulation is unequivocal. In order to draw any conclusion between local (European) surface variability and blockings in the past, the authors should also determine the expected value of the isotopic record conditional on the occurrence of blocking (what they compute is Z500 conditional on the value of the isotopic record).

The occurrence of atmospheric blocking during low $\delta^{18}O$ values is linked to a specific dipole pattern, with low pressure over Greenland and high pressure in a blocking configuration over Europe, which limits the transport of water vapor to Greenland. In contrast, other types of blocking over Europe may lead to different atmospheric circulation over the North Atlantic and therefore have less influence on $\delta^{18}O$ variability. We propose computing the average blocking frequency over the same region where high pressure is observed in the instrumental period, and then averaging $\delta^{18}O$ values in the NGT stack for those years when the blocking index is above or below 1σ. The same approach can also be applied to the long-term reconstruction period.

The paper could also have discussed a few key events that occurred since 1600, including volcanic eruptions, solar minima, etc.

We will broaden the discussion by including known events.

Specific comments

l. 70: the description of PRCPTOT is not clear. Cumulated over what time scale?

PRCPTOT is defined as the cumulative amount of daily rainfall recorded on wet days over a given period. A wet day is defined as a day with more than 1 mm of rainfall. In this case, the period considered is each month of the winter season (December–February, DJF). For a better clarity, we will add this information in the data and Method section, in the revised version of the manuscript.

l. 73: the data description is not very informative. What is the input of the AI reconstruction? What is its added value here?

CRAI uses a U-shaped neural network composed of partial convolutions (see the referenced paper for construction details). The network was trained using historical simulations from Earth System Models (ESMs) in the CMIP6 archive. The main goal of the CRAI dataset is to reconstruct climate extreme indices, particularly for periods and regions with sparse observational data. We used this dataset to show that the same patterns observed in E-OBS also appear in CRAI, although with less homogeneity compared to the E-OBS. We will clarify in the text the added value of using CRAI.

l. 84: I do not understand what "[…] series assumes high and low values according to certain thresholds." Please rephrase.

We are going to modify the text as suggested.

l. 86: Why does a +/- 1 sigma threshold meet "both criteria"? Figure 1 (and text): how is sigma computed? What period? sigma obviously increases with time in Fig. 1c.

We tested several thresholds, namely 0.5, 0.75, and 1 sigma. The proportions of values exceeding these thresholds were approximately 31%, 23%, and 16%, respectively. Based on these results and the sample size during the observation period, we considered 1 sigma as the

level that represents extreme cases. We are going to report the definition of the corrected sample standard deviation for simplify the reading. As reported in L. 87, we compute the sample standard deviation over the whole observation and long-term perspective periods. Therefore, the extreme values in the NGT stack $\delta^{18}O$ in the observation period are determined using the sample standard deviation over the observation period (1920 – 2011). This applies to the long-term perspective period (1602 – 2003).

Eqs. (1) and (2): I assume that the blocking indices are determined on daily time scales. Most papers (including (Tibaldi and Molteni, 1990)) use a lowercase \phi for latitude.

The atmospheric blocking index explained in the text refers to Davini et al. (2012). In their paper, the \phi latitude is in capital letter. For coherence in explaining such method, we adopted the same notation.

l. 126: Here, and in many other places, the authors are very qualitative: Figure 2a shows a cyclonic anomaly over the North Atlantic (albeit not as deep as the cyclonic anomaly over Greenland in Fig. 2b). The absence of symmetry in the maps of Fig. 2 is not very surprising. The values of Z500 and wind speed anomalies are symmetric over Greenland, though, which is the first criterion expressed by anomalies of the isotopic record. Since the North Atlantic atmospheric circulation goes eastward, and yields geostrophic features (regardless of the presence of a blocking feature), no real symmetry of the Z500 field east of Greenland should be expected.

Thank you for this comment. We are going to rephrase and improve our descriptions in the revised version of the manuscript.

l. 170: The association between high pressure patterns with increased frequency of synoptic-scale blocking circulation is demonstrated by (Yiou and Nogaj, 2004).

We thank the reviewer for this suggestion.

l. 178—206: the discussion is very qualitative, with many adverbs ("clearly", "remarkably", "notably", etc.) that could be assorted with numbers, to reach objectiveness.

We are going to include numbers (i.e. ratio with respect the two densities (pos. and neg.)) in order to be less subjetive.

l. 199: verb missing in sentence.

We are going to rephrase the sentence.

Figures 6 and 7, l. 237: the results that are reported do not say anything about extremes, which are in the tails of the distributions. None of the figures show any change in the tails of distributions. It is already interesting to discuss how the centers of the distributions change.

We agree that the tails do not show significant changes. However, values around +1 (panel b) and -1 (panel d) reveal a shift in the distribution. We discussed these changes as a fingerprint

of wetter or drier conditions. Nevertheless, we agree that the text can be rephrased to emphasize shifts toward more extreme values.

l. 240: why would it be "logical" to extend this study to other ice cores? Would any change (especially for other Greenland ice cores) be expected? If so, this would rather invalidate the whole approach, wouldn't it? As a perspective, what would seem natural (to me), would be to investigate the how natural forcings can affect features of the atmospheric circulation. This issue is barely discussed in the manuscript, while it is a key aspect of paleoclimate studies.

We are going to remove this paragraph. However, Greenland climate variability, recorded by ice core $\delta^{18}O$, is influenced by several natural forcings, such as the NAO and AMO. Our point was that ice cores from northern Greenland also reflect atmospheric blocking patterns, while ice cores from other regions of Greenland may capture different local or regional climate signals that are more relevant to those specific locations.