

## ***Interactive comment on “Climate indices in historical climate reconstructions: A global state-of-the-art” by David J. Nash et al.***

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Response to Short Comment by Drs Domínguez-Castro and Vaquero [SC1]

We thank Drs Domínguez-Castro and Vaquero for their time and thought, which will help to improve significantly the overall quality of the manuscript. We respond to each question raised in turn:

[SC1] The documentary sources provide a huge quantity of information about climate variability of the past. Nevertheless, there is high variability in the quality, quantity, formats, contents, objectives, etc. of the climatic information provided by these sources. This makes very difficult to unify indexing methodologies for all the documentary sources. For this reason, a review article of the indexing methodologies and the

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identification of indexing best practice is necessary, pertinent, and really welcomed. We want to provide some comments that can be useful to broaden the discussion about indexing.

We consider that an article that wants to provide a “Guidelines for generating future documentary-based indices” must analyse the advantages, disadvantages as well as the limitations of the different indexing methods used until now. We think that this discussion is missing in the manuscript and we provide here some topics that could be interesting to address:

[Response] Thank you for these observations. As noted in our response to RC2, we do not agree that there is insufficient critical analysis in the manuscript, but we respond now to each of your suggestions in turn.

[SC1] Use of different kinds of documentary sources: there are indices constructed from a unique documentary source, e.g. a private diary (Brázdil et al., 2008; Domínguez-Castro et al., 2015), series of acts of municipal and ecclesiastical institutions for a location (Barriendos, 1997; Domínguez-Castro et al., 2018), series of correspondence (Fernández-Fernández et al., 2014; Rodrigo et al., 1998)... However, other indices are constructed putting together information from many different documentary sources (e.g. Brázdil et al., 2016; Camuffo et al., 2010). Probably in the first case, it is easier to detect and correct unexpected bias or homogeneity problems. In the second case you can usually analyse longer periods or larger regions, but at the risk of including inhomogeneities.

[Response] This is a useful point. We will review the manuscript and distinguish examples where we have indices based on single documentary sources or phenological proxies. This will need to draw on examples from a wider geographical range than the European examples suggested. We will also emphasise the comparative ease of detecting unexpected bias or homogeneity problems in single source series versus multiple source series.

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[SC1] Subjectivity in the indexation: probably, the unique objective indices are those based on the presence or absence of a meteorological phenomenon, e.g rainfall, snowfall, wind, fog... If one has this information at daily scale, the index is almost directly comparable with the instrumental series e.g. Domínguez-Castro et al., 2019. It is easy to think that the subjectivity increases with the number of categories of the indices, but more categories provide more variability. On the other hand, there are also many "uncategorized indexes", a few examples are: appearance of ice and freeze-up dates (Takács et al., 2018), flowering /grape harvest dates (Aono and Kazui, 2008), number of days under drought conditions (Domínguez-Castro et al., 2008)... This difference could be discussed deeply.

[Response] We take your point about subjectivity in indexation (which has already been discussed at length in the literature). However, we are not sure of the relevance of what you refer to as 'uncategorized indices' for our paper. Taking the example of ice phenology from Takács et al. (2018), this study focusses on the timing of freeze up rather than developing indices of winter severity from such information. The mere existence of a dataset that might be used to produce indices does not, in our eyes, qualify a study for inclusion in our already lengthy manuscript. We will, however, check the suggested literature to make sure we haven't missed any examples of actual index approaches (note: Aono and Kazui (2008) is mentioned in section 3.1).

[SC1] Resolution: the time resolution of an index can be daily, weekly, monthly, seasonal, annual or larger time resolution. Are there problems when, for instance the annual/seasonal indices are built just adding seasonal/monthly indices? Frequently, the documentary sources have bias to some season due to the climate and/or the nature of the documents. It is common that the documentary sources provide more information about extreme seasons (winter or summer), or in specific periods of the year in which the climate was determinant for some agricultural labour. For this reason, one must be very carefully when computing annual index just from the addition of seasonal indices and this could be reflected in the text.

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[Response] Thank you for this comment. This is a good point and we will integrate additional text into section 8 where relevant.

[SC1] The meaning of “0 index”: frequently “0 index” is considered as “normal” condition, but this can be confounded with cases when no information is available. We need to be sure to assume it, that the consulted documentary sources cover the entire period with the same quality. This is easier to evaluated when only one documentary source is used for the whole studied period.

[Response] This is an issue already referred to in the second point made by RC1 – we repeat our response here: “There are two main approaches used to define “0 index” values. One – implicit in the Pfister method – is that no description means no number: a gap in the time series rather than a 0. Other studies make an implicit assumption that, in some circumstances, no weather description can be taken as an indication of normal conditions. We will insert additional text about this in Section 8 and include a paragraph in section 9.2 where we discuss confidence and uncertainty in index-based climate reconstructions.”

[SC1] The distribution of the index values: For reconstruction purposes, it is useful that the index shows similar distribution to the variable to be reconstructed. Nevertheless, this is not always possible, as in some examples provided in this paper (e.g. figure 2 shows a possible bias to negative values, and Mertz lAs reconstruction shows less “-1 values” (14) than “-2 values” (20), when probably the opposite is expected). Something similar happens in Figure 8 that shows less “1 values” (abundant flows, mainly concentrated in the last decades) than large swells (“2 values”). Probably, this is because the used documentary sources record better the extreme than the more common events. Anyway, we think it is an interesting topic to discuss in the paper.

[Response] This is a valuable point that we will mention in section 9.2 on uncertainty (also with reference to a recent publication by White, Pei 2020).

[SC1] In general, the classic methodology that uses three, five or seven indices is

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deeply discussed in the paper compared to other methodologies for each type of documentary source that have appeared in recent years. We consider that these particular methodologies have enormous advantages for performing reconstructions and they should be discussed.

We understand that it is impossible to cite all the published articles in the field or to analyse all the methodologies developed in a single paper for all the meteorological variables or events. However, we think that it is possible to include more recent publications. Here we provide some examples.

Regarding the European temperature indices, the more recent work cited dates from 2015. We recommend to include some recent papers as (Brázdil et al., 2019; Fernández-Fernández et al., 2017; Fila et al., 2016; Filipiak et al., 2019; Mrgic, 2018; Rodrigo, 2019). Some of the methodological approaches of these papers are interesting and have not been discussed in the manuscript.

With respect to European precipitation indices, the most recent work cited dates from 12 years ago. Some proposals to update these references are (Brázdil et al., 2019; Bullón, 2011; Fernández-Fernández et al., 2015; Filipiak et al., 2019; Metzger and Tabeaud, 2017; Rodrigo, 2019). Again, these papers have interesting methodologies that have not been discussed.

[Response] We accept the general point made here. We will evaluate the methodologies of the more recent literature mentioned to see if they warrant inclusion in the revised version of the manuscript. Again, the key criterion for the inclusion of any study is that it applies an indexing approach in the wider tradition described for Europe-focused research. Mere overviews on available documentary information for a specific period and region (e.g. Mrgic 2018 for the Balkans) will not qualify a study for integration. We realise that we handle this differently at times for non-European regions, as we see value in pointing the anglophone academic community to these regions. However, there is already plenty of information on available sources for Europe-focused climate

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[SC1] Moreover, the authors affirm in the section “Climate indices in Europe” that the information about temperature is more frequent and with a better quality than the precipitation information (e.g., line 124 “Temperature is the most common meteorological phenomenon analysed in Europe” or line 154 “Often the same scale is applied for both temperature and precipitation indices; however, precipitation indices may show more gaps than their temperature counterparts as data may be seasonal or more sporadic”). We think this assumption is true for central and northern Europe, but it is not for the Mediterranean region, for example, where the references to the lack or excess of precipitation are clearly more frequent than those for temperature. This is because the Mediterranean climate is more temperate but has important precipitation extremes. This is a very important point in the article, because the effect of the different climates in the indexing is almost missing in the review, and this is a key issue in a review wanting to cover different regions of the globe.

A mention to pro pluvia rogation ceremonies as a documentary proxy of European droughts is missing. This proxy has been used in the last decades to understand drought variability in preinstrumental period in various European countries as Spain (Barriendos, 2010; Bravo-Paredes et al., 2020; Domínguez-Castro et al., 2008, 2010, 2012; Tejedor et al., 2018), France (Garnier, 2010), Italy (Piervitali and Colacino, 2001) or Portugal(Fragoso et al., 2018). Moreover, different methodologies have been used to extract the climate information of this proxy as the liturgical act (Martín-Vide and Val-Ívá, 1995), the expenses (Álvarez Vázquez, 1986), the period of time with continuous rogations (Domínguez-Castro et al., 2008) or the area occupied by the text dedicated to the celebration in the chapter acts (Gil-Guirado et al., 2019). All these methodologies are different to the three, five or seven indices discussed in this paper, and have their advantages and disadvantages that would require a detailed analysis.

Moreover, it would be interesting to cite articles of other variables, as sea level (Camuffo et al., 2017; Camuffo and Sturaro, 2003) in which interesting methods have

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been developed or about snowfalls reconstruction (Enzi et al., 2014).

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[Response] We agree that our statement about temperature as the most common phenomenon should be differentiated with regard to the Mediterranean situation, and we will do this accordingly. The commentators identify correctly an incoherence in the manuscript. While we initially discussed and decided not to integrate proxy indices such as pro pluvia rogation ceremonies in sections concerning Europe, we softened this approach for non-European regions. We will clarify this in the revised introduction and will provide (in section 2.6) the most important references to this long-established index type. Space precludes a full coverage of these and comparable indices relating to Europe, so we will emphasise that our key focus is on narrative sources. Regarding the other variables mentioned (e.g. snowfall or sea level/submersion), most studies focus on reconstructions of occurrence or the creation of new proxy data, rather than differentiated index-like values. Hence, we do not intend to include these contributions.

[SC1] Additionally, we can point out one minor suggestion:

Line 474 “Finally, Dominguez-Castro et al. (2018) built a long precipitation series for 1891–2015 CE based on descriptions of rain ceremonies in Quito, Ecuador”. This is not correct. Domínguez-Castro et al. (2018) presents a precipitation instrumental series from Quito (1891-2015) and a series of wet and dry extremes from rogation ceremonies from 1600.

[Response] Thank you for this correction, which we will apply accordingly.

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