

Comment on cp-2021-49

Anonymous Referee #4

Referee comment on "Was there a volcanic-induced long-lasting cooling over the Northern Hemisphere in the mid-6th–7th century?" by Evelien van Dijk et al., *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2021-49-RC4>, 2021

My review of submission cp-2021-49 by van Dijk and co-authors focuses on the paleoclimate part of the paper and not on the models, as the latter are not my field of expertise. In their contribution, the authors seek to answer the question whether long-lasting cooling occurred over the Northern Hemisphere following a cluster of large 6th and 7th century eruptions which occurred in 536, 540, 574 and 626 CE according to sulfur deposits in bipolar ice cores. The authors do so by comparing proxies (mostly tree-ring reconstructions) with model output.

The idea of the paper is nice, but I have a few major comments that shall be addressed by the authors in a revised version:

- The title is misleading, no proxy record has hitherto posited that the 6th century eruptions would have been at the origin of a long-lasting hemispheric cooling. Instead, a study based on data from the Alps and Altai (by Buntgen and colleagues, 2016) has just pointed to marked cooling at these two sites. Other tree-ring records do not suggest a comparable cooling. Speaking of hemispheric cooling is thus an overstatement and should be changed.
- Along the same line, starting from line 32ff the authors state that cooling might have exceeded that of the LIA and focus on two site chronologies that were presented in 2016. While the authors rightly present the results of this study, and add the reply provided by Helama and colleagues from 2017, they ignore a vast body of proxy studies that have been published on the topic and where the chronologies cover many sites of the NH. By focusing only on the LALIA study, they ignore a large body of spatial and temporal reconstructions covering the period of interest. The authors should therefore present a more balanced assessment of the existing data by including e.g., Schneider et al. (2015, ERL), NTREND (spatial and temporal; Wilson et al., 2016 QSR ; Anchukaitis et al., 2017 QSR), Guillet et al. (2017 NCEO) or the most recent TRW-based paper from the tree-ring community published lately by Buntgen et al (2021) in NCOMM.
- Chapter 2.2: It is not clear to the reader how the authors did the tree-ring analysis. They provide a long discussion on advantages of MXD over TRW data, but it is very

unclear how the authors did the reconstructions and what they did with the data. How were the sites/data chosen? More details need to be provided here as it remains very unclear to the referee how the proxy series were developed.

- The same holds true for the NH approach: why did they not use the spatial reconstruction data from Anchukaitis et al. (2017) or Guillet et al. (2017)?
- Another major drawback is the restriction of the comparison of model with tree-ring data (lines 349ff) just between the Alps, Altai (both known for excessive cooling in tree-ring records) and Scandinavia. Why did the authors not rely on the full set of tree-ring reconstructions and include a comparison for Siberia, Central Asia and North America?

For the paper to become acceptable, the breadth of the proxy records needs to be widened and the methods need to be described in much more detail.

Minor points:

Line 2-4 (Abstract): to which "multiple paleo proxies" are the authors referring to? This is a misleading statement as the proxy records pointing to massive and long lasting cooling are few. This needs remediation

Line 12/13: "see" should be changed to "sea"

Lines 19-21: This needs some rephrasing, stating that the cooling was 20 years in the proxy records is somewhat an overstatement. The initial cooling was in fact there, but temperature recovered rather quickly to more normal conditions and reached "fully normal" after two decades. Some clarification would be good here.

Line 30: what lines of evidence do you have to compare the 6th century cooling to the conditions that led to the LIA? I suggest that either references are provided or that this statement is removed.

Line 152: How does peak cooling in models compare with proxies? How does the amplitude of cooling compare between the two datasets?

Line 155: what do you mean with background level for AOD? <0.1 ?

Line 376: the LALIA concept is based on records from two sites. The authors should go beyond these sites and analyze all data that exists in the NH. It is unclear why the study is limited to Alps, Altai and Fennoscandia

Line 386: use the data presented in the Buntgen et al. (2021) ensemble study instead