Climate of the Past Discussions

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Comment on cp-2021-82

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Referee comment on "The 1600 CE Huaynaputina eruption as a possible trigger for persistent cooling in the North Atlantic region" by Sam White et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-82-RC5, 2021

The study investigates the likelihood of a slowdown in the SPG around the onset of the LIA being linked to the 1600 Huaynaputina volcanic eruption. In order to resolve this issue, the authors attempt to integrate evidence from model-based simulations of past climate conditions with proxy-based paleoclimatic reconstructions and historical records. Despite the inconclusive results, the study highlights both the advantages of adopting an interdisciplinary approach as well as the challenges and limitations of bringing together and interpreting various sources of information.

General comments:

In my opinion, the multi-disciplinary nature of this study represents a considerable strength of this work. In general, the manuscript is well written and the findings are presented in a clear and logical manner. The evidence is interpreted objectively and the authors clearly acknowledge the limits of the analysis. From the presented results, conclusions are drawn to the extent that the simulation, reconstruction and limited observational data from the period allow. However, the unconventional structure is rather confusing since the introduction, methods description and some of the results are all blended together, and this also makes it somewhat difficult to distinguish for example what was done in previous studies and what represents original analysis. The authors should therefore seriously consider whether restructuring the manuscript in a more conventional format would be beneficial.

Currently, a large part of the discussion is dedicated to discussing the historical / societal impacts of cold conditions at the end of the 16th and during the early 17th century. Greater focus on integrating and discussing the results of the modeling, proxy and historical datasets in more detail would be helpful.

Another important point is recognizing and acknowledging discrepancies between model-based simulations with proxy-based reconstructions, which has consequences for understanding uncertainty and the overall reliability of these data sources. This issue is highlighted for example by Figure 6, which shows poor spatial agreement between modeled and reconstructed temperatures. Model simulations are often associated with high uncertainty particularly in relation to post-volcanic cooling and, for example, over-estimation of the magnitude of post-volcanic cooling by some models has been known to occur (e.g. Chylek *et al.*, 2020; Hartl-Meier *et al.*, 2017). Better understanding of some of the shortcomings of these datasets and limitations in their utility within the context of this study could be achieved by exploring a broader set of model simulations or model types to help disentangle the possible influence of model bias and a more detailed examination of the proxy-based temperature reconstructions would also be helpful in this regard.

It is also necessary recognize the potential importance of background climate conditions in modulating the (cooling) response of the North Atlantic to large volcanic eruptions based on the state of the climate system. In relation to this point, the role of internal variability and specifically the potential role of the North Atlantic Oscillation (NAO) in the initiation of SPG weakening and cooler conditions in the north Atlantic sector remains a subject of debate (e.g. Trouet *et al.*, 2009; Lehner *et al.*, 2012). For this reason, some type of examination and discussion of the modes of atmospheric variability in the north Atlantic within this context would be helpful.

One obvious limitation is that most of the presented evidence for the SPG shift is either indirect / circumstantial or entirely model-based. Although the study provides a compelling narrative characterizing anomalously cold conditions in the early 17^{th} century, a certain leap of faith is currently required to link an SPG mode shift to these changes. In any case, more information would be required to clarify the relationship between the eruption, short-term and long-term cooling and how these events and changes relate to the state of the SPG. Ultimately, there are limits to the answers that modeling can provide and additional more direct proxy data would likely be required to better understand the dynamics of oceanic circulation and atmospheric dynamics during this period to more precisely pin down the timing, duration and extent of the purported SPG slowdown. Perhaps then it would be possible to confirm or refute the attribution of the observed longer-term cooling in the early 17^{th}C, and by extension the initiation of an SPG slowdown, to a volcanic trigger.

Specific comments:

L63-72: While it may perhaps be possible for such changes to occur without invoking substantial changes to atmospheric dynamics in the North Atlantic, the background state of the atmosphere, internal variability and the role of the NAO cannot be discounted *a priori*, particularly as these factors may act to modulate the response of the climate system to a large volcanic event.

L89: The phrase ‘possibilities for adaptation’ seems a bit vague and it is not clear what this refers to. Please specify / clarify this point.

Figure 2: For easier interpretation of the figure, it may be clearer to also state in the panel sub-headings that the plots are showing temp. / Sv. anomalies.

L233: It is not clear whether this implies that only a 30-yr segment length was used or a range of segment lengths (30-yr+) was examined. If it is the former case, please remove 'minimum' to avoid confusion. Otherwise, please specify the range of segment lengths utilized.

Figure 5: Please specify in the figure caption what the purple dots in top-left plot represent.

L203-210: What was the size of the reconstructed grid cells? Which instrumental dataset was used for calibration? How were the chronologies merged and how was the reconstruction performed (e.g. PCA, nesting), etc.? In general, more detailed information about the development of the spatial reconstruction is needed here (or at least in supplementary materials).

Figure 6: How does the NVOLC reconstruction compare with N-TREND (and model output) over the investigated period? Currently, only NVOLC is compared to model output, whereas N-TREND is only used for illustration and is not compared to NVOLC or the modeled temperatures. The highly anomalous cooling in SE Europe in the NVOLC reconstruction (Fig. 6a) is rather suspicious and I wonder how robust this feature is. According to Supplementary Figure S3 in Guillet et al. (2017), most of northern Europe and parts of western / southwest Europe calibrate well, whereas calibration / verification statistics are very weak for NW, central and especially eastern and SW Europe. Consider that poor spatial representation of reconstructed temperatures may cause disagreement with modeled temperatures in some areas. Likewise, specific limitations of the model may also lead to disagreement. Such considerations should be acknowledged and discussed.

L286: Why is the NVOLC v2 reconstruction shifted by +0.5 K?

L350: I suggest that a more appropriate term to use in this context would be 'support' rather than 'appear to confirm'.

L368-370: So, considering the timing, might this in fact suggest that the Huaynaputina eruption is rather unlikely to be the cause of the SPG slowdown?

L371-385: Another possibility could be that a pronounced shorter-term cooling impact of the Huaynaputina eruption was ‘superimposed’ on the longer-term cooling trend, which may have been initiated prior to 1600 (either in response to the cluster of late-16th century volcanic eruptions or otherwise). Evidence for volcanic-induced short-term cooling is on firmer ground as the results are consistent with this type of response to the eruption (Fig. 6c) and this is also consistent with the duration and magnitude of inferred NH cooling responses to large (tropical) eruptions more generally based on proxy reconstructions (e.g. Esper et al. 2015) and modeling of surface air temperature. In contrast, the mechanism for initiating longer-term cooling / SPG slowdown and attribution of such changes to a particular volcanic event is highly uncertain and rather problematic.

L376-377: One could argue that it is uncertain whether this issue could be definitively resolved through modelling alone.

L395-397: I would recommend reformulating this sentence considering that, based on extensive paleoclimatic evidence, the occurrence of cool (wet) summers during this period is actually not in question. Therefore, rather than ‘confirming’ this, it would be more appropriate to state that this study provides further support and a broader context for such conditions at that time.

Minor / technical comments:

L95: consider ‘… activation (or lack thereof) …’
L186/380/384: ‘an SPG’ rather than ‘a SPG’
Fig.4 legend / L233 / (L303): ‘ice break-up timing data’ instead of ‘date data’
L223: consider ‘obtained’ instead of ‘gained’
L238: consider ‘recorded’ rather than ‘left’
L239: ‘latter’ rather than ‘later’?
L243: Suggested wording adjustment: ‘These observations were recorded in areas with flat terrain …’
L266: ‘did or did not turn back’ or alternatively ‘ships could pass or were forced to turn back’
L267: ‘turn back during a voyage’ or perhaps ‘terminate a voyage’?
L268: ‘cold conditions’ or ‘cold temperatures’ / ‘dangerous sailing conditions’ or ‘danger posed by sailing conditions’
L280: Change ‘NTREND’ to ‘N-TREND’. Also, something is missing here - consider: ‘… in each year over the 1601-1609 period …’?
L287: should the range be 1593-1650 instead of 1593-1640?
L290: Consider: ‘The analysis in Figure 7 indicating the ice …’
L293: ‘can occur’ rather than ‘can happen’
L303: please change ‘wrt’ to ’w.r.t.’
L308: ‘detected in’ rather than ‘detected at’?
L362: ‘as a Possible Trigger’?
L372: remove ‘has’?
L375: ‘any role of’?