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Comment on acp-2022-187

Anonymous Referee #2

Referee comment on "How volcanic eruption latitudes diversify surface climate responses" by Seungmok Paik et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-187-RC2, 2022

Review of "How volcanic eruption latitudes diversify surface climate responses " by Paik, Min, Son, Soon-Il An, Kug, and Yeh

The work by Paik et al. studies the volcanic imprint on surface climate in the CESM Last Millennium ensemble (Otto-Bliesner et al., 2016) dependent on the latitude of eruption. A topic, which has been addressed by several authors before .This particular study concentrates on the influence of tropical, northern, and southern volcanic eruptions on the surface climate, specifically on the role of El Niño–Southern Oscillation, monsoonal precipitation and the Northern Hemisphere stratospheric winter climate. The results suggest that volcanic eruptions modulate surface climate by warming the sea surface temperature over the equatorial eastern Pacific and strengthening the stratospheric polar vortex but with diverse patterns depending on eruption latitudes. El Niño-like responses tend for example to amplify summer monsoon drying, which is stronger after tropical eruptions compares to northern and southern ones. After tropical and southern eruptions a strengthened Arctic polar vortex is found that, is accompanied a positive Arctic Oscillation response in boreal winter, while northern eruptions only weekly influence the Arctic polar vortex and associated surface responses .
I recommend major revisions as I have a couple of major concerns:

General comments:
The CESM Last Millennium ensemble has been widely studies with respect to volcanic eruption of different season and latitudes (e.g. Stevenson et al., 2016; Zuo et al., 2018, 219a;b,;2021). In particular, the work on the volcanic impact on tropical hydro climate is therefore repetitive. Zuo et al. published four papers on this topic in the last four years using the same model simulations and the same volcano classification. While the authors cite the 1st three papers of Zuo and co-workers, a citation of the recent work by Zuo et al. (2021) on the dependence of global monsoon response to volcanic eruptions on the background oceanic states is missing. This is in particular important as the current paper has a complete session 3.2 on it.
Hence, I ask myself with respect to tropical hyroclimate what do we learn from this study what we did not know beforehand. Are there are any new insights? I miss a thorough and careful comparison of your results with respect to Zuo et al in the discussion section. In

addition, there are also many other papers on the hydro climate impact of volcanic eruptions dependent on their latitude (e.g. Liu et al, 2016; 2018; Zhuo et al. 2021; Pausata et al., 2015. At the end of the paper in the discussion session, it would be also important to discuss how your results fit into the broader picture. Is this consistent or are there differences/uncertainties, which we need to understand and address further
The aim and the purpose of this paper is not really clear to me. I would like to see a much better motivation of the current study, e.g. what is your driving question? I recommend to narrow down the subject of the study and to focus on one or two specific questions e.g. the impact of the eruption of latitude on the NH winter response. Maybe it would make sense to distinguish even a bit further between the latitude of the eruptions. NH hemisphere eruptions could lead to very different forcing pattern see for example Toohey et al. (2019, their supplementary Figure 3). Hence, their impact on atmospheric circulation and surface climate could be quite different.
I have difficulties with the criteria for the classification of tropical northern and southern eruptions. This selection criterion, which was introduced by Samantha Stevenson in her study in 2016, is related to the atmospheric aerosol load and mostly used in the context of the CESM Last Millennium ensemble.
Looking to Figure S1, one can clearly see that the pattern of the southern eruption is quite similar to the tropical one while the pattern of the northern eruptions looks quite differently. The peak aerosol mass of the southern eruption is still located in the inner tropics and close to the equator. This also explain why southern and tropical eruption have a similar influence on the NH winter hemisphere in the CESM Millennium runs. The term "southern" is t quite misleading here in particular if one compare the response to other studies, which make a clear separation between tropical and extratropical eruption e.g. Zhuo et al. (2021). This might also explain some of the literature difference with respect to the ENSO response.
I recommend to revise/reevaluate the applied classification criteria. Does it really makes sense for your study or would another criteria e.g. tropical and extratropical eruption much more appropriate? If there are statistically not enough southern hemisphere extratropical eruptions one can either focus on tropical and NH extra tropical only or use a multi-model approach by including PMIP3 or PMIP4 simulations.

Specific comments:
Introduction: Some recent literature is missing:
• Tropical hydroclimate e.g. Zuo et al., (2021); Zhuo et al. (2021); Predybalo et al (2020), Ward et al (2021)
• NH winter response: Zambri et al. (2017), Dalla Santa et al (2021) and references therein, Coupe and Robock (2021)
Page 14, line 295 ff: The paragraph about the Laki eruption has to be revised. The spatial distribution looks completely weird, see for comparison Zambri et al (2019). Laki is an Icelandic fissure eruption, which erupted on 8 June 1783 and lasted for 8 months. It is located at 64 N so it could be easily included in the polar vortex. It might be that not only the timing but also the spatial distribution of the Laki eruption is wrong in the CESM Millennium ensemble. Please check this carefully and adapt your interpretation.
Page 10- 12: How consistent are your results with Zuo et al. (2021) in particular Figure 5 with their Figure 8?
Page 19, line 391-391: "First study" is not correct in particular with respect to the ENSO response, see general comment above . So please revise this accordingly
Page 20, line 406: the southern eruptions considered here are not high latitude eruptions
Page 20, line 421: Your classification is too coarse to really have an important impact for the volcanic impact on decadal predications. Looking to the different spatial distribution for NH mid and high latitude extratropical eruptions, see e.g. Toohey et al. (2019), you will expect quite different surface climate responses although both would be quantified in your classification as northern.

Table 1: Please refer here to the original table by Stevenson et al. (2016).
Figure 1: The surface temperature plots are not readable at all.
Figure 3: Why are there are significant dots in the years prior to the eruptions in panel c) and e).
Figure 8: The panels a) and c) look quite similar, are they are the same? What does the black dots show in panels b) and d)? I also do not completely understand if you have values only at four levels, then the distinct maximum between 10 and 200 hPa would not make sense.

References:

Coupe, J., and Robock, A., 20121 : The influence of stratospheric soot and sulfate aerosols on the Northern Hemisphere wintertime atmospheric circulation. J. Gephys. Res., 126, e2020JD034513, doi:10.1029/ 2020JD034513.

DallaSanta, K. and Polvani, L. M., 2022: Volcanic stratospheric injections up to 160 Tg(S) yield a Eurasian winter warming indistinguishable from internal variability, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2022-58, in review,.

Liu, F., Chai, J., Wang, B., Liu, J., Zhang, X., and Wang, Z, 2016.: Global monsoon precipitation responses to large volcanic eruptions, SCI. REP.-UK., 6, 24331, https://doi.org/10.1038/srep24331.

Liu, F., Li, J., Wang, B., Liu, J., Li, T., Huang, G., and Wang, Z., 2018.: Divergent El Niño responses to volcanic eruptions at different latitudes over the past millennium, Clim. Dynam., 50, 3799–3812, https://doi.org/10.1007/s00382-017-3846-z.

Otto-Bliesner, B. L., Brady, E. C., Fasullo, J., Jahn, A., Landrum, L., Stevenson, S., Rosenbloom, N., Mai, A., and Strand, G., 2016: Climate variability and change since 850 CE: An ensemble approach with the Community Earth System Model, B.500, Am. Meteorol. Soc., 97, 735–754, https://doi.org/10.1175/BAMS-D-14-00233.1.

Pausata, F. S. R., Chafik, L., Caballero, R., and Battisti, D. S., 2015: Impacts of high-latitude volcanic eruptions on ENSO and AMOC, P. Natl. Acad. Sci. USA, 112, 13784–13788, https://doi.org/10.1073/pnas.1509153112, 2015.

Predybaylo, E., Stenchikov, G., Wittenberg, A. T., and Osipov, S.,2020: El Niño/Southern Oscillation response to low-latitude volcanic eruptions depends on ocean pre-conditions and eruption timing, Commun. Earth Environ., 1, 1–13, https://doi.org/10.1038/s43247-020-0013-y.

Stevenson, S., Otto-Bliesner, B., Fasullo, J., and Brady, E , 2016.: "El Niño like" hydroclimate responses to last millennium volcanic eruptions, J. Climate, 29, 2907–2921, https:doi.org/10.1175/JCLI-D-15-0239.1.

Toohey, M., Krüger, K., Schmidt, H., Timmreck, C., Sigl, M., Stoffel, M. and Wilson, R. 2019: Disproportionately strong climate forcing from extratropical explosive volcanic eruptions. Nature Geoscience, 12, 100-107. doi:10.1038/s41561-018-0286-2

Ward, B., Pausata, F. S. R., and Maher, N.: The sensitivity of the El Niño–Southern Oscillation to volcanic aerosol spatial distribution in the MPI Grand Ensemble, Earth Syst. Dynam., 12, 975–996, https://doi.org/10.5194/esd-12-975-2021, 2021.

Zambri, B. Robock, A. Mills, M. and Schmidt, A 2019: Modeling the 1783–1784 Laki Eruption in Iceland: 1. Aerosol Evolution and Global Stratospheric Circulation Impact, J . Geophys. Res. Atmos , https://doi.org/10.1029/2018JD029553

Zambri B., LeGrande, A. N., Robock ,A., and J. Slawinska, J. 2017: Northern Hemisphere winter warming and summer monsoon reduction after volcanic eruptions over the last millennium ,J . Geophys. Res. Atmos.,122, 7971–7989,doi:10.1002/2017JD026728.

Zhuo, Z., Kirchner, I., Pfahl, S., and Cubasch, U.,2021: Climate impact of volcanic eruptions: the sensitivity to eruption season and latitude in MPI-ESM ensemble experiments, Atmos. Chem. Phys., 21, 13425–13442, https://doi.org/10.5194/acp-21-13425-2021.

Zuo, M., W. Man, T. Zhou, and Z. Guo, 2018: Different impacts of northern, tropical, and southern volcanic eruptions on the tropical pacific sst in the last millennium. J. Climate,

31, 6729-6744, https://doi.org/10.1175/jcli-d-17-0571.1.
Zuo, M., T. Zhou, and W. Man, 2019a: Hydroclimate responses over global monsoon regions following volcanic eruptions at different latitudes. J. Climate, 32, 4367-4385, https://doi.org/10.1175/jcli-d-18-0707.1.
——, 2019b: Wetter global arid regions driven by volcanic eruptions. Journal of Geophysical Research-Atmospheres, 124, 13648-13662, https://doi.org/10.1029/2019jd031171.
Zuo, M., W. Man, and T. Zhou, 2021: Dependence of global monsoon response to volcanic eruptions on the background oceanic states, Journal of Climate pp 1, 1520-0442. https://doi.org/10.1175/JCLI-D-20-0891.1