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Interactive comment on "Quantifying CanESM5 and EAMv1 sensitivities to volcanic forcing for the CMIP6 historical experiment" *by* Landon A. Rieger et al.

Landon A. Rieger et al.

landon.rieger@usask.ca

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The authors would like to thank reviewer #1 for the thoughtful comments. Their suggestions have helped to clarify important model parameters as well as experimental results.

1 General Comments

There is some general issue throughout the text incl. the abstract with respect to the name of the volcanic forcing data set. To my understanding GLOSSAC and the CMIP6 Stratospheric Aerosol data set are not the same. The stratospheric aerosol data set for CMIP6 is build on the Global Satellite-based Stratospheric Aerosol Climatology (GloSSAC, Thomason et al., 2018) for the satellite area (from 1980) onwards. The version 3 (Luo, 2017) is based on GloSSAC v1.0 (Thomason et al., 2018), while the revised version v4 for Jan 1991-Dec 1994 (Luo, 2018) is based on the new data set GloSSAC v1.1 (Thomason 2018). So there exist no GLOSSAC version 4. Please check and revise the text carefully with respect to the name convention.

Lines 6-10 of the abstract have been updated to:

"To improve this situation for CMIP6 a two step process was undertaken. First, a combined stratospheric aerosol dataset, the Global Space-based Stratospheric Aerosol Climatology, GloSSAC, was constructed. Next, GloSSAC, along with information from ice-cores and sun photometers, was used to generate aerosol distributions, characteristics and optical properties to construct a consistent stratospheric aerosol forcing dataset for models participating in CMIP6."

In the release note to version 4 of the stratospheric aerosol data set for CMIP6 (Luo, 2018), some first comparison between Stratospheric Aerosol Optical Depth and extinction of version 3 and 4 were already made with similar results as listed in section 2. This should be mentioned.

Thank you, that should be included and this is now discussed on Page 3 Lines 16-17. *"Luo et al., (2018) show the magnitude of these changes at several latitude bins and times for 1020 nm, and the following analysis expands on this at 550 nm in the context of this paper."*

2 Specific Comments

Title: The title is a little bit misleading and need to be changed as the authors consider only the Post Pinatubo episode (1990 -1996) and not the full CMIP6 historical period.

Changed to "Quantifying CanESM5 and EAMv1 sensitivities to Mt. Pinatubo volcanic forcing for the CMIP6 historical experiment"

Page 1, line 20 (also page 12, line 7), "can be as large as 3 C" . Maybe the authors could be more specific here and can give the exact duration and the altitude of this local maximum. If I look at figure 5, I can hardly see a temperature anomaly of 3C. A supplementary lon/lat figure might be helpful here to better illustrate this point.

Thank you, an additional latitude-time figure (Figure 6 in the paper also attached here) has been added to clarify the temperature anomalies and discussed on page 10 Lines 10-13. Hopefully this new figure, along with Figure 5, help clarify the spatial extent and magnitude of the anomalies.

Page 2, line 2, "an estimated 10 Tg of sulfur into the stratosphere." The S emission of Mt Pinatubo is uncertain current estimates range between 5 to 10 Tg S, see for example Timmreck et al. (2018) , p 2583.

Revised to *"the 1991 eruption of Mt. Pinatubo injected an estimated 5-10 Tg of sulfur into the stratosphere (Guo et al., 2014, English et al., 2013, Dhomse et al., 2014, Timmreck et al., 2018)"* on Page 2 Line 2.

Page 2, line 16-18, Please reformulate this sentence as it is a bit misleading. Solomon et al (2011) and Fyfe et al (2013) used an updated version of the Sato et al. (1993) data set which includes the more recent eruption.

We don't think *Solomon et al.,* (2011) used the most recent version of Sato et al., but

instead used the *Vernier et al.,* (2011) climatology derived from CALIPSO measurements to extend measurements post-2000. The updated Sato dataset was published in December 2012, and used OSIRIS data as opposed to CALIPSO, so these datasets will differ somewhat. While *Fyfe et al.,* (2013) used the updated Sato climatology, they did so only until 1993 (1998 was also tested), at which point they transitioned to the Vernier dataset.

Page 3, line 7, " an error was found " You can be more specific here and mention that it was a CLAES cloud clearing problem which affected the Pinatubo period mostly in the first months after the eruption , see "Release Notes Stratospheric Aerosol Radiative Forcing and SAD version v4.0.0 1850 - 2016 (Luo, 2018).

Thank you, updated with suggested explanation on Page 3 Lines 7-8.

Page 5, line 8, Some information about the vertical resolution in the stratosphere and in the tropical tropopause region in the CanESM5 would be nice

The vertical resolution is approximately 1-2km in the lowermost stratosphere. This has been added to the CanESM5 and EAMv1 model description on Page 7 Line 6.

Page 5, line 17, Same for the EAMv1.

The vertical resolution is approximately 1-2km in the lowermost stratosphere. This has been added to the EAMv1 model description on Page 7 Line 16.

Page 5, line 26, One has to be careful to compare here not apples and oranges. All the cited papers (Minnis et al., 1993; Stenchikov et al., 1998; Ramachandran et al., 2000) show a decrease in net shortwave flux radiation but mention an increase in reflected shortwave radiation.

Thank you, clarified to *"and increases in reflected radiation at the top of the atmosphere"* on Page 7 Line 25.

Page 8, line 8, "three realizations were performed using the EAMv1 model" As

the EAMv1 model produces the QBO, I wonder about the QBO in the model. Were the QBO in different phases in the model run and how does they differ from the actual observed phase?

The QBOs were in different phases during the eruption, although none matched the observed phasing precisely. The attached figure shows the QBO Index (as calculated from Christy and Drouilhet (1994) for the three EAM simulations and RSS observations. This is now briefly discussed on Page 7 Lines 17-18.

Christy, J. R., & Drouilhet Jr, S. J. (1994). Variability in daily, zonal mean lower-stratospheric temperatures. Journal of climate, 7(1), 106-120.

Page 12, line 10-11, I wonder if you had a look on possible changes in sea ice in the CanESM5?

We did not look at sea ice specifically, but both the ocean heat content, and temperature outside of the tropics remain unchanged between version. The now included Figure 6 on Page 11 shows this more clearly and discussed on Page 10 Lines 13-15.

Figure 3, The authors might think about to present the flux anomalies in the more common way with negative net short wave flux anomalies and net positive LW anomalies.

Switched throughout to the more common convention.

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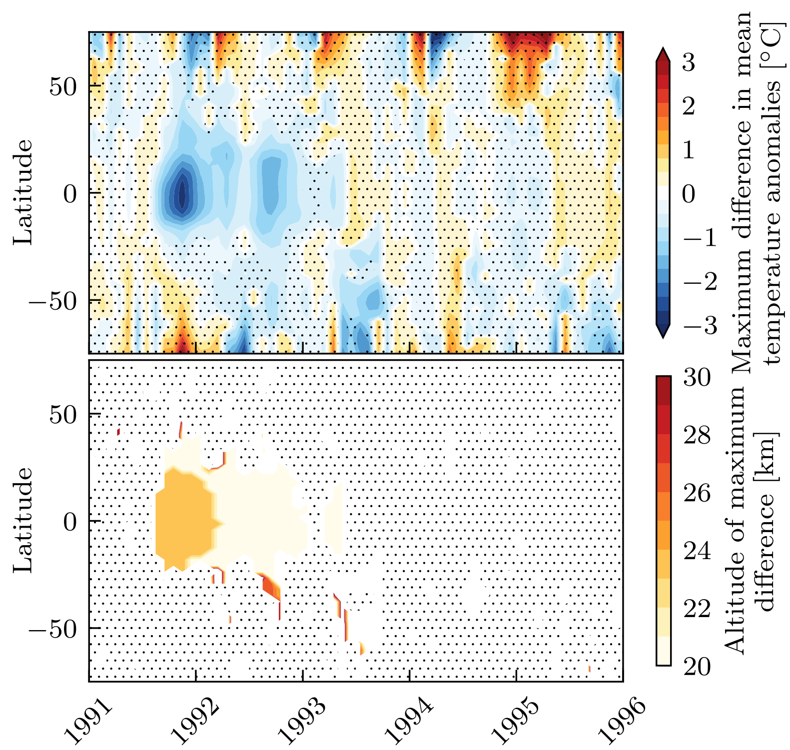

Fig. 1. The top panel shows the maximum difference in monthly temperature anomalies at any altitude as a function of latitude and time. Bottom panel shows the altitude at which the maximum occurs.

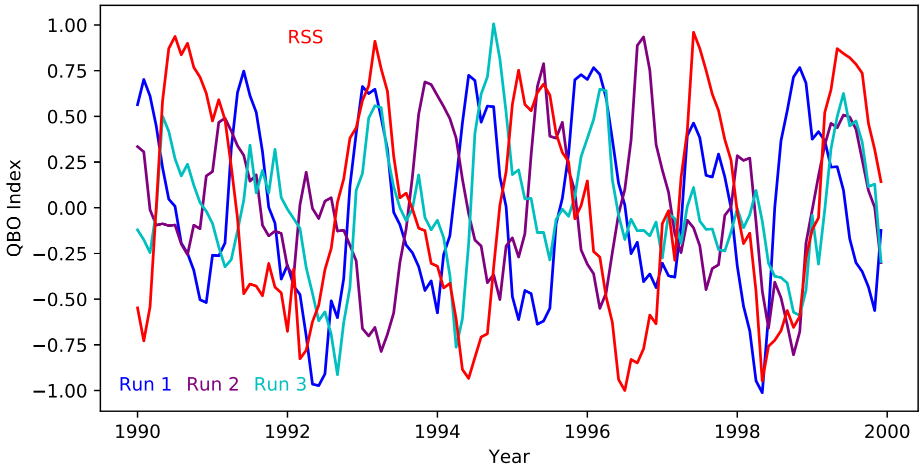

Fig. 2. QBO Index (as calculated from Christy and Drouilhet (1994) for the three EAM simulations and RSS observations.