Response to Referee 2 (Dr. Fanglin Yang)

Thank you very much for your review.

This study investigates changes of 2-m temperature over the globe following three major volcanic eruptions in the past few decades using 11 global atmospheric reanalysis data sets. Multiple linear regression (MLR) is used to remove variations of 2-m temperature that corresponds to or forced by seasonal harmonics, trends, QBO, solar cycle, and a combination of tropical SST modes. Then, residuals of the MLR is considered to be the signal of volcanic eruptions in the couple of years immediately following each of the three major eruptions.

Even though many investigations have been published in the past to understand the impact of volcanic eruption on atmospheric circulation and surface temperature, it still presents a great challenge to quantify the impact with certainty. For observational study, it is difficult to separate changes in temperature induced by volcanic eruption from those induced by atmospheric and oceanic internal variability and external forcing. For numerical modeling, models may not be able to capture all natural variability, and the specification of volcanic forcing is often inaccurate. This study is based on linear regression and bears the same shortcomings of all statistical analyses; however, it is for the first time multiple analyses are used, and the residuals from different reanalysis data sets all showed similar patterns of cooling over the globe in the summer and fall following the three major volcanic eruptions. The authors also compared their MLR approach with the SVD approach found in previous studies, and confirmed both approaches produced similar cooling patterns. The magnitude of the cooling documented in this study is in general smaller than that reported in previous studies. This has implications for how to quantify volcanic forcing in numerical models for climate change study.

This manuscript is well written and well organized. I would recommend it be accepted for publication in ACP after the following few minor comments are addressed.

Thank you very much for your evaluation.

Minor comments

1) Please add a paragraph to the Introduction session to describe how volcanic eruption affects the surface temperature through direct radiative forcing and/or indirect changes in atmospheric circulation.

In the first paragraph of the Introduction, after the first two sentences (at page 2, line 3), we will add the following sentences:

The increased concentration of aerosols in the stratosphere causes a net negative radiative forcing at the surface (Robock, 2000), resulting in cold surface temperature anomalies when averaged globally or over the tropics. The geographical distribution of the surface temperature anomalies is, however, found to be much more complicated. Robock (2000) reviewed observations and theory of winter-time warming over the Northern Hemisphere (NH) continents (or the wave pattern of warm/cold anomalies) that result from changes in the tropospheric and stratospheric circulations after large eruptions. The surface temperature response at the regional scale is thus not only influenced by the direct radiative forcing but also by the dynamical response of the atmospheric circulation. Studies on the geographical distribution of the surface volcanic response all show complex patterns of cooling and warming (e.g., Kirchner et al., 1999; Yang and Schlesinger, 2001).

2) Is the 2m temperature response documented in this study consistent with the atmospheric temperature changes described in Fujiwara et al. (ACP, 2015) ?

It is not easy to compare because Fujiwara et al. (2015) looked at 1-year averaged responses, while the current study examines 3-month averaged responses. Also, Fujiwara et al. (2015) used pressure-level data, where temperatures are extrapolated down to 1000 hPa in most reanalyses over land (except for MERRA). Despite these differences, the 1000 hPa level results in Fujiwara et al. (2015) and the zonal mean surface results in the current study are consistent with each other in the sense that they both show qualitatively similar cooling responses.

3) It has been know that CFSR was constructed from a few different streams of analyses covering different time periods. Discontinuities are often found across the streams. Have the authors noticed the same feature and applied any technique to reduce the jumpiness?

All other reanalyses also have execution streams (e.g., Figure 2 of Fujiwara et al., 2017). We have not applied any special treatment for the stream change points. We have not noticed any issues that may be related to the stream changes in this volcanic study.

Fujiwara, Wright, et al. (2017), Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems, Atmospheric Chemistry and Physics, 17, 1417-1452, doi: 10.5194/acp-17-1417-2017.