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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Long-range isentropic transport of stratospheric aerosols over Southern Hemisphere following the Calbuco eruption in April 2015" *by* Nelson Bègue et al.

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Dear editor and reviewers,

First all, we thank you for attention that you wiil grant to our manuscript :"Long-range transport of stratospheric aerosols in the Southern Hemisphere following the 2015 Calbuco eruption" (acp-2017-544). Please, find attached our responses to your comments and the revised manuscript. In the revised manuscript, we made an effort to improve the quality of the English and the figures. The English of the revised manuscript was checked by a native English speaker. The modifications are indicated by italic and red bold fonts in the revised manuscript.

As a contact author, I confirm that all co-author concur with the submission of this manuscript.

sincerely,

Nelson BEGUE

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2017-544/acp-2017-544-AC1-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-544, 2017.

Response to anonymous referee 1's comments

First of all, the authors acknowledge the referee for his constructive comments and suggestions. In the revised manuscript, the authors made an effort to improve the quality of the English and the figures. The English of the revised manuscript was checked by a native English speaker. The modifications are indicated by italic and red bold fonts in the revised manuscript.

- **Specific points:**

Referee 1 : I would suggest adding in the introduction some recent works that have shown how significant explosive volcanic eruptions can be for the stratospheric dynamics, by affecting large scale trace species transport and age of air, via radiative perturbations due to volcanic aerosols (Ray et al., 2014). Although the largest emphasis has been given to major tropical eruptions and their induced dynamical effects (Pitari et al., 2016a), extratropical eruptions in the last 15 years may also have had a significant role in lower stratospheric trends of key dynamical quantities (Kremser et al., 2016).

Authors : This part of the introduction in link to the helpful role of the explosive volcanic eruption on the stratospheric dynamic was improved by including the references suggested by the referee 1 (See revised manuscript).

Referee 1 : Page 4, Lines 11-15: Regarding QBO effects on mid-latitude transport of the volcanic plume, I suggest citing Pitari et al. (2016b). In this paper, the e-folding time of the stratospheric sulfate plume caused by four major past tropical eruptions has been studied in a modeling experiment focusing on the QBO role. Their conclusion is in agreement with those in the Trepte and Hitchman (1992) paper.

Authors : We thank the referee 1 for this relevant reference. As suggested by the referee 1, this reference was included in the revised manuscript.

Referee 1 : Page 10, Lines 16-27: Again, the only studies cited here are the ones from Trepte in 1992-1993. I feel that the addition in the discussion of Pitari et al. (2016b) would enrich the discussion by offering further evidence of the behaviour of the aerosol plume under different QBO regimes.

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Fig. 1.

Response to anonymous referee 2's comments

First of all, the authors acknowledge the referee for his constructive comments and suggestions. In the revised manuscript, the authors made an effort to improve the quality of the English and the figures. The English of the revised manuscript was checked by a native English speaker. The modifications are indicated by italic and red bold fonts in the revised manuscript.

- **General points:**

Referee 2 : the Calbuco eruption in April and 2) the reaching of the record ozone hole size in October. Based on the results of the SD-WACCM* and FR-WACCM simulations, Solomon et al. (2016) and Ivy et al. (2017) declared that the first event (eruption) led to the second one. In other words, according to Solomon et al. (2016) and Ivy et al. (2017), the Calbuco aerosol plume (including various volcanic gas emissions) penetrated the polar vortex and caused the record Antarctic ozone hole size after the eruption. On the other hand, according to the findings presented by the authors (Bègue et al., 2017), the Calbuco aerosol plume could not penetrate the polar vortex and lead to additional ozone depletion, because the plume was confined between the subtropical barrier and polar vortex. Since the results of the SD-WACCM and FR-WACCM simulations were published before, the above-mentioned contradiction between the conclusions made by two different research groups should be considered, analyzed, and discussed by the authors of the paper under consideration (Bègue et al., 2017).**

***SD-WACCM is the specified dynamics Whole Atmosphere Community Climate Model**
****FR-WACCM is the free-running Whole Atmosphere Community Climate Model**

Authors : We thank the referee 2 for these two relevant papers. The results presented in our study are not in contradiction to the works of Solomon et al. (2016) and Ivy et al. (2017). Our study is based on isentropic analysis of the volcanic plume. In particular, we discussed on the transport of the volcanic plume exclusively at 400 K which correspond to the isentropic level where the plume is observed at Reunion. Figure 4 and 5 reveal that the meridional transport of the plume occurred between 12 and 20 km. As a consequence, the transport of the Calbuco plume at another isentropic level associate to another pathways described in our study is possible. Figure 5b reveals also the possibility to the Calbuco plume to penetrate the polar vortex at the end of August 2015. This assumption seems to be consistent to the works

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Fig. 2.

Response to anonymous referee 3's comments

First of all, the authors acknowledge the referee for his constructive comments and suggestions. In the revised manuscript, the authors made an effort to improve the quality of the English and the figures. The English of the revised manuscript was checked by a native English speaker. The modifications are indicated by italic and red bold fonts in the revised manuscript.

- **Specific points:**

Referee 3 : Firstly, I consider use of the word "isentropic" within the phrase "long range isentropic transport" in the title, and at other points in the manuscript, to be inappropriate. The topic of the paper is to assess the long-range transport of the plume – but although the long-range transport of the constituents within an airmass might generally be expected to be isentropic, for a volcanic plume this is very often not the case, due to sedimentation of ash particles (with also any accomodated sulphur) or from growth of the particles within the plume (if the plume is long-lived enough and has sufficient growth).

The vertical profile measurements suggest some elements of the plume extend down to several kilometers below the main altitude of the SO2. Whether this is indicative of some separation of the plume (related to the ash) is not clear from this analysis. Nevertheless, this issue of volcanic plumes in general not necessarily being isentropic in my opinion means it would best to avoid the word "isentropic" within the phrase "Long-range transport" (unless the analysis specifically shows this to be the case). For this reason, the first non-minor revision I ask is for the authors to remove the word "isentropic" from the title.

Authors : We understand the point of view of the referee 3, as a consequence, the term of « isentropic » was removed in the revised manuscript.

Referee 3 : The authors state with certainty that the aerosol particle size distribution is unimodal, but the OPC only measures particles which are larger than 250nm, with the behaviour of particles smaller than that size simply not monitored. And yet the particles measured by the OPC are really only measuring those particles in this "shoulder" of an accumulation mode, which may only be reflecting the size distribution of one particular subclass of particles. Murphy et al. (2014) identify three main particle types in the stratosphere (sulphuric, meteoric-sulphuric and organic-rich), and one could potentially

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Fig. 3.