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Comment on acp-2022-38

Anonymous Referee #1

Referee comment on "Impact of Holuhraun volcano aerosols on clouds in cloud-system-resolving simulations" by Mahnoosh Haghighatnasab et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-38-RC1, 2022

Review of the manuscript numbered acp-2022-38

Title: "Impact of Holuhraun volcano aerosols on clouds in cloud-system resolving simulations" written by Haghighatnasab et al.

Manuscript number: "acp-2022-38".

Decision: "Major revision"

In this study, the authors conducted numerical simulations targeting on the eruption of Holuharaun volcano by the NWP mode of ICON, and investigated the impacts of aerosol emitted from the volcano on N_d, LWP, cloud fraction, and cloud albedo. Through their analyses the authors clarified that the impact of the aerosols on the LWP and cloud fraction was mainly explained by the difference of the meteorological condition between inside and outside plume, although the increase of N_d was clearly seen as the impact of the aerosols. In my understanding, the response of the LWP and cloud fraction to the aerosol variation are featured topics in the scientific community and the results of this study are interesting. So, I encourage the authors to conduct this study. Most part of the manuscript is well written, but there are several issues to be addressed.

Based on the descriptions outlined above, my decision is "major revision", and I encourage the authors to revise the manuscript.

General Comment:

1: The discussion about the radiative forcing.

The authors discussed the effects of the emitted aerosol on the radiative forcing based on the results of cloud albedo. However, the goal of this study is to understand how LWP and cloud fraction respond to the aerosol variation, as the authors indicate in the body of the manuscript. So, the discussion about the radiative forcing and cloud albedo will make readers to confuse the main topic of this study. Of course, I understand that the radiative forcing and cloud albedo are really important for the climate study, but focusing on the LWP and cloud fraction makes the main message of this study clear. The discussion about the cloud albedo and radiative forcing in discussion section, which can be created in the revised manuscript is better, or the discussion of them in supplementary information is another option.

2: The logic about the enhancement of RWP and precipitation is not clear.

In the section 3, the authors suggest that the decrease of the light rain and increase of the heavy rain in volcano simulation based on Fig. 6a. In addition, the authors suggest that the enhancement of the RWP is decreased by 15 % and no difference in RWP over outside of plume based on Table 1. I agree these suggestions, but it is not clear about why the decrease of the light rain and the increase of the heavy rain can result in the decrease of the enhancement of RWP and as consequence, increase of LWP. The manuscript is not so long at current version, and therefore, the author can add detailed descriptions about the reason. Such descriptions will help readers to understand the authors' suggestions more clearly.

3: The validity of the discussion based the method used in this study.

First of all, I appreciate the authors' effort to conduct the numerical simulation by using ICON-NWP and to develop the method for implementing aerosol effects. The effects of aerosols on the cloud microphysical properties can be calculated by the coupling method used in this study. However, the method cannot implement feedback of cloud process to aerosol field. If the authors conducted the ICON-NWP coupled with aerosol transport

model or chemical transport model online, the results about the LWP adjustment and cloud fraction adjustment would be changed. I understand that the simulation by ICON-NWP coupled with aerosol transport model or chemical transport model online is one of the future study of authors' group, however, discussions about the limitation about the method used in this study and discussions about the difference of the results from the online coupled model and this study should be added.

Specific Comments:

Figure 1: What does the color of Fig. 1 mean? Elevation from sea surface? The caption about the color and the color bar should be added.

Line 59: The information of the layer thickness is required.

Line 65-66: What physical variables were used for the initial and boundary condition? Such information is important for other scientists to trace the simulations by other models.

Line 68: In this part, the authors indicate that analyses period is from 1 to 7 September, 2014. Is the period corresponding to the period of the calculation? If so, did the author check the effects of spin-up was sufficiently small? In such regional scale simulation, we do not analyze first several hours to avoid the artificial wave generated during initial shock.

Line 79: In this part, the authors indicate that the input variables of COSP are temperature, pressure, cloud fraction, and cloud water content. For simulating MODIS's signal, the information of size distribution function is required. The information about the size distribution of hydrometeor should be added in the method.

Section 2.2.: In this section, the authors describe the method for implementing aerosol effects on the ICON-NWP, and the authors shows distribution of column-mean CCN as shown in Fig. 3. I think the distribution of CCN is reasonable. However, there are no information about the vertical distribution of CCN. Based on the body of the manuscript, the data for SO_2 was originated from OMPS product. I think that the product is vertical column amount of SO_2. Which layer did the authors add the SO_2? Based on my experiences, the layer that aerosols are input is really sensitive to the simulated impact of aerosol on cloud microphysical properties. In addition, did the authors assume SO_2 gas is as sulfate aerosol particle?

As well as the SO_2, water vapor is also emitted by the eruption, and the emitted water vapor can affect the meteorological field and cloud properties. Did the author only consider the emission of SO_2?

Line 193-195: In this part, the authors suggest that the decrease of the probability of clouds with low LWP and the increase of the probability of clouds with high LWP. I agree the suggestion, but I cannot agree "thicker clouds (with high LWP)" and "shallower clouds (with low LWP)" from the results shown the manuscript. Does the word "thick" and "shallow" mean "geometrically thick" and "geometrically thin"? If so, the author should show the cloud geometrical thickness. If the authors just want to discuss the probability of clouds with low and high LWP, the words "thick" and "shallow" are not necessary.

As well as the terminology, if the thick clouds increase in the simulation with volcano emission, such difference can result in the change of the circulation. Did the author check the cloud distribution (geographical distribution, vertical structure of clouds and so on)?

The discussion about why the decrease of the probability of clouds with low LWP and the increase of the probability of clouds with high LWP occurred is also useful for readers.

In addition, grid line in each frequency distribution (Figs. 4, 5, 6, and 7) will be helpful for readers to distinguish the shift of peak and find the decrease of low LWP and the increase of high LWP.

Line 218-238: As I mentioned in the general comment, this part is not the main topic of this study. So, I recommend the authors to create new section "discussion" after conclusion or just before the conclusion and move this part to the new section. Again, I understand that the radiative effect is important, but this is not the main topic of this study. Alternatively, I ask the authors to add more descriptions about the enhancement of RWP and precipitation as I mentioned in the general comment.

Minor Comment:

Line 47: "(Toll et al., 2017)" should be "Toll et al. (2017)"

Table 1: The unit of LWP and RWP is g m^{-2}

Line 157: I think that "(factual and counterfactual)" is not necessary.

Figure 4. How did the author define the "Inside" and "Outside" plume?

Line 275: The URL of CAMS reanalysis data is not correct. The URL has been moved to "ht
tps://confluence.ecmwf.int/display/COPSRV/Copernicus+Atmosphere+Monitoring+Service
+-+CAMS"