Review of "*Impacts of the Icelandic Holuhraun volcanic eruption on cloud properties using regional model cloud-aerosol simulations*"

by Yoshiaoka et al.,

General comments:

In this study, the authors explore the effect of the Holuhraun eruption on cloud properties on a kilometer-scale simulation within the UK Met Office Unified Model. In their setup, the authors employ a detailed cloud microphysical scheme and an interactive aerosol module, making their simulations well-suited to study aerosol-cloud interactions resulting from the Holuhraun eruption. They furthermore nicely outline the importance of considering meteorology and background aerosol conditions in regions that are not directly affected by volcanic aerosol when determining the effect of volcanic aerosols on clouds.
The manuscript is logically structured and well written and merits publication provided that the following comments are addressed.

Specific comments:

- P6, L210-211: Could the authors clarify the rationale behind using a 5 km cloud top threshold? Why was this specific threshold chosen? Given that cloud phase is strongly temperature-dependent, a threshold more directly related to cloud thermodynamics, such as cloud top temperature, may be more appropriate.
- P7, L226-229: The bounding boxes used for the satellite and model data differ in size and shape, which likely introduces biases when comparing in-plume and out-of-plume cloud properties. Since meteorological conditions and, therefore, cloud characteristics vary spatially, using different out-of-plume areas may influence the interpretation of perturbation signals. Furthermore, the authors provide little information on how they define the rectangular boundary that envelops the in-plume regions (I assume it is similar to that in Peace et al., 2024). Could the differences reported in Table 4 stem from different areas of in- and out-of-plume? This is for sure the case for the data from Haghighatnasab et al. (2022), and looking at Peace et al. (2024), the regions are also different.
- P7, L231-232: The threshold of 0.5 DU for defining in-plume regions in the model was chosen to align spatial patterns with satellite data. However, this lower threshold could lead to an underestimation of sulfate burden and, consequently, cloud condensation nuclei (CCN) and cloud droplet number concentration (CDNC) in the model. It would be informative if the authors could show the sensitivity of CDNC to different threshold choices, for example, what changes occur if a 1 DU threshold is applied? Could this partially explain the remaining CDNC underestimation, even after retuning?
- P7, L246-248: The authors claim that their model-derived CDNC is comparable to MODIS-derived CDNC, yet no supporting analysis is provided. MODIS CDNC retrievals are predominantly sensitive to cloud top, while for the model, a liquid-water-weighted vertical average is computed. Although this weighting gives some emphasis to upper layers, it likely results in lower CDNC values compared to satellite retrievals. I know that it is intricate to perform a fully definition-aware comparison between

model and satellite observations (e.g., using a satellite simulator like COSP). I would, nevertheless, ask the authors to somehow show that their CDNC values are comparable to the satellite-derived ones. Alternatively, would it be feasible to extract model CDNC at cloud top for a more definition-consistent comparison?

Minor Remarks:

- P5, L180-187: The authors first perform a 60-day spin-up for the aerosol fields. Are these global simulations nudged to the actual meteorology?
- P7, L244: *"… Section 2.9 …"* This should be 2.8.
- P18, L425: *"… 1.57 …"* It is 1.56 in Fig. 8.
- P21, L476: *"… enhancement for volcano on versus volcano off in the first week in the plume region …"* If I understood correctly, this should be the ERUPTION effect, so I would call it like that.
- P21, L482: *"… the in-plume and out-of-plume regions …"* If I understood correctly, this should be the LOCATION effect.

References:

Haghighatnasab, M., Kretzschmar, J., Block, K., and Quaas, J.: Impact of Holuhraun volcano aerosols on clouds in cloud-system-resolving simulations, Atmos. Chem. Phys., 22, 8457–8472, https://doi.org/10.5194/acp-22-8457-2022, 2022.

Peace, A. H., Chen, Y., Jordan, G., Partridge, D. G., Malavelle, F., Duncan, E., and Haywood, J. M.: In-plume and out-of-plume analysis of aerosol–cloud interactions derived from the 2014–2015 Holuhraun volcanic eruption, Atmos. Chem. Phys., 24, 9533–9553, https://doi.org/10.5194/acp-24-9533-2024, 2024.