Dear Dr. Dhomse and reviewers,

Thank you for reviewing our manuscript titled “Retrieval of bimodal aerosol size distributions for stratospheric sulfate and smoke aerosols using multi–wavelength satellite measurements” (egusphere-2026-2377). We thank you for your help in improving the quality of the manuscript.

We have carefully reviewed the referee comments and revised the manuscript. A point-by-point response to all referee comments have been posted online. Summary of the revisions made based on referee comments and specification of all other changes made to manuscript are below.

Response to Referee #1

The approach for retrieving bimodal lognormal stratospheric aerosol size distributions for sulfate and smoke aerosols has been carefully documented, tested, and validated using synthetic and observational multi–wavelength aerosol extinction measurements. Revisions are made to i) improve methodology descriptions, ii) highlight the novelty of the approach, and (iii) demonstrate the robustness with respect to the operational method.

We revised the manuscript to highlight the need for smoke-aware retrieval. These include:

- Recent decadal observations of smoke in the stratosphere shift the assumption of the typical aerosol composition in the stratosphere (new lines: 34–37), with smoke radiative and chemical impacts in the stratosphere, and extinction profiles, distinct from sulfate aerosols (new lines: 37–41, 72–75).
- There is a clear gap in operational solutions from satellite which match the long standing stratospheric aerosol in situ data record of polydisperse distributions (new lines: 47–52, 81–86, 95–98, 100–102, 109–114).
- There is a need to better characterize the aerosol properties of recent frequent and intense wildfire events transporting smoke into the stratosphere (new lines 59–63, 69–72, 75–76, 99–100).

We revised the manuscript to clarify the retrieval methodology. These include:

- The formulated extinction ratios from Mie Theory are unique for bimodal distributions due to the impacts of the large particle concentrations (new lines: 226–229), and amended fig. 2 and caption (new lines: 233–239).
- The Angstrom exponent solution space used to retrieve characteristics of the course mode is more explicitly defined (new lines: 243–245, 247–248).

We revised the manuscript to highlight retrieval performance. These include:

- The agreement between in situ and satellite retrieved aerosol microphysical properties using the approach here for stratospheric smoke (new lines: 590–593 and 672–674).
- Fig. 6a has a revised legend to match panels b–d (new line: 302).
- The caption for fig. 7 is revised to match figs. 8–9 (new line: 316).
- The revised caption of fig. 10 describes the retrieved number density for retrievals initiated at the bounds of the uncertainty range (new lines: 416–417).
- The use of a strict uncertainty range (± 20 %) is added to the discussion in sect. 6 (new lines: 645–646).
- Fig. C3, presented in AC #1 is added to the supplement to highlight the retrieval approach here against the in situ measurements and SAGE III/ISS operational aerosol product.

Response to Referee #2

Revisions have been made to i) provide a more thorough review of stratospheric aerosol measurements and analysis of spaceborne multiwavelength stratospheric aerosol extinction measurements, and ii) supplement retrieved stratospheric aerosol properties from SAGE III/ISS validated against in situ measurements with ground based lidar measurements.

Full response and list of revisions are included in AC #2. A summary of changes include:

- Introduction (sect. 1) is revised to include a review of historical stratospheric multi-wavelength extinction observation analysis (new lines: 80–88). Further review of stratospheric aerosol size distribution retrievals from solar occultation measurements from ACE-FTS and SAGE II and SAGE III are included (new lines: 90–92, 104–117). A revised introduction of the contributions of this work is formally presented (new lines: 119–129, 132–134).
- Retrieval Algorithm Theoretical Basis and Framework (sect. 3) is revised with the addition of Table 1 describing the complex aerosol refractive indices (new lines: 214–215).
  Additionally, application of the refractive indices in sect. 5 for SAGE III/ISS retrieved aerosol optical and microphysical properties and balloon-borne in situ measurements are better specified (new lines: 424–425, 432–434).
- Revisions include descriptions of global ground based lidar retrievals of stratospheric smoke aerosol properties in the introduction for descriptions of stratospheric smoke aerosol properties (new lines: 30–32, 34–37, 39–41, 72–75), in sect. 5 for analysis of the 2017 PNE pyroCb outbreak (new lines: 429–430, 443–445, 454–456, 500–501), and in sect. 6 in discussion of stratospheric smoke aerosol size distributions and microphysical processing (new lines: 592–597, 657–658, 684–686).

Other Revisions

1. All instances of “SAGEIII/ISS” are changed to “SAGE III/ISS”.
2. Lines 55–60 are added to emphasize in situ data contributions to stratospheric aerosol research used to inform aerosol size distribution retrieval algorithm development and validation.

Minor Changes to Formatting/Style:

3. Line 45–47 are edited for readability, an in text citation is corrected for “Christian et al., 2019” to “Christian et al., 2020”.
4. Lines 62–66 are edited for readability and an in text citation is added in line 66.
5. Lines 67–69 change “..pyroCb events..” to “..wildfires and pyroCb events..”.
6. Lines 95–97 change “..large volcanic eruptions..” to “..moderate to large volcanic eruptions..”
7. Lines 102–104 are edited to elaborate “aerosol size distributions” to “stratospheric aerosol size distributions” and “..must be characterized..” to “..must be characterized, and more frequently sampled..”.
8. Lines 162–165 are edited for the in text citation from “..(Deshler, 2003).” to “..(Deshler, 2023; Kalnajs & Deshler, 2022).”.
9. Lines 288–290 are edited to improve description to “The retrieval framework uses two solution spaces to infer aerosol size distribution parameters of a bimodal lognormal distribution from multi–wavelength observations. The retrieval performed over the solution spaces consider the spectral properties of the aerosol population which are inherently independent of aerosol loading.”
10. Lines 290–291 are edited from “..spectrum..” to “..UV–NIR spectrum..”.
11. Lines 293–294 are edited to “..($d_{p,\,Fine}$, $\sigma_{g,\,Fine}$, $d_{p,\,Coarse}$) until the final results are self consistent.”
12. Lines 297–300 include added descriptions of sulfate aerosol with “(75 % H_2SO_4 by weight)” and descriptions of the selected SAGE III/ISS wavelengths with “(384 nm, 756 nm, and 1544 nm)” and referring to “Table 1”.
13. Lines 336–341 are edited from “fig. 2” to “fig. 2a” or “fig. 2b”, and elaborated from “..observational data” to “..observational data which are mapped to the solution space.”.
14. Lines 359–360 are edited from “The retrieval first..” to “The retrieval algorithm first..”.
15. Lines 371–372 and 374–376 include specification of “stratospheric” for the aerosol size distribution.
16. Lines 374–376 changes “derived” to “inferred”.
17. Lines 432–434 adds additional information on figs. 11 and 15 with “SAGE III/ISS aerosol extinction measurements and calculated values from retrieved size distributions are overlaid in figures 11 and 15, respectively, with retrieved SAGE III/ISS profiles labeled as sulfate or smoke values.”.

18. Lines 452–453 are edited for clarification with “Strong agreement in SAGE III/ISS retrieved and WLPC measured volume densities are shown in the smoke enhanced layers and throughout the vertical profile.”
19. Lines 445–447 is edited for typo of “0.5” to “0.5 km”.
20. Lines 533–534 are edited for specificity to say “..in the higher altitude layers”.
21. Lines 599-600 are edited qualitatively from “assume” to “typically assume exclusively”.
22. Lines 655–657 are edited for brevity.
23. Lines 686–690 are edited for specificity of coincident measurements from SAGE III/ISS and WLPC.
24. Acknowledgements are updated in response to RC #2.
25. References are updated to include new cited works in response to RC #2.