Response to Anonymous Referee #2:

We also thank the Referee #2 for his/her comments on our work. We have carefully considered all the comments and revised the manuscript according to these comments. Below is a point-by-point response to these comments.

Aerosol single scattering albedo (SSA) is a critical parameter for characterizing aerosol scattering/absorption properties. However, obtaining accurate long-term global SSA datasets remains challenging due to limitations and uncertainties in satellite-based measurements. This manuscript constructs two long-term monthly mean SSA datasets over land by synergizing satellite observations (from OMI and POLDER) and ground-based AERONET measurements through the Ensemble Kalman Filter (EnKF) technique. The datasets provided in this study could improve the estimation of aerosol radiative effects and contribute meaningfully to climate change assessments. I would like to recommend the publication of this manuscript as the following issues are addressed.

General comments:

Could you please provide the corresponding AOD data as a quality control reference in your dataset? As you are aware, the uncertainty in the merged SSA product is closely related to AOD. Providing AOD data can help users implement effective quality control when utilizing the SSA dataset.

Response: Thank you for your suggestion. The uncertainty of SSA is indeed closely related to AOD, as also pointed out by Referee #1. In response to this issue, we have adopted an AOD threshold filtering of satellite-derived SSA, following the recommendations of Referee #1. Specifically, for the POLDER product, we retain data based on the GRASP AOD threshold of approximately 0.3 at 440 nm. For the OMI product, we follow the AERONET standard and only include data when the AOD at 440 nm exceeded 0.4. Since the resulting monthly averaged AOD values represent filtered AOD (based on quality control), rather than the actual monthly average at each grid point, we decided not to include the AOD data in the supplementary files to avoid potential misinterpretation.

Did you derive the monthly mean SSA from the original daily satellite products? If so, how was the monthly average calculated, and were any quality control measures applied during the process? These details should be clearly described in the data section.

Response: We have added the information in Section 2.1.

"For the data fusion, the OMI SSA retrievals are interpolated to the AERONET measured wavelength of 440 nm (Dong et al. 2023). Specifically, we first calculate the monthly mean AOD and AAOD at 440 nm from daily observations, requiring at least three valid daily observations per month. The monthly SSA is then derived from the corresponding monthly AOD and AAOD. To ensure the reliability of the SSA data, AOD threshold filtering is applied to the daily data. Only daily observations with AOD at

440 nm greater than 0.4 are used in the monthly averaging of AOD and AAOD, consistent with the AERONET Level 2.0 criteria." For POLDER, *"the monthly mean SSA is calculated using the same method as for OMI. However, we follow the GRASP quality control criteria by retaining only daily observations with AOD at 443 nm greater than 0.3 for the monthly averaging."*

Would it be possible to include the merged SSA results at 550 nm based on POLDER? It is commonly used in both satellite retrievals and model applications, which would enhance the usability and comparability of the dataset.
Response: Thank you for your suggestion. We have added the merged data at 550 nm based on POLDER data at 565 nm in the supplementary material (Figures S2, S6~S8, S11, S29, S30).

Why is the spatial resolution of the merged dataset set to 1°? The SSA background field can vary significantly within a 1° grid cell, which is also a key reason for the limited representativeness of ground-based observations. The dataset at a finer resolution, such as 0.5°, could potentially improve the effectiveness and applicability of ground-based observations.
Response: We set the spatial resolution to 1° primarily based on the following three considerations:

1. This resolution is appropriate for applications in climate modeling.
2. 1-degree grid cell provides a sufficient number of observations to compute representative errors at each location. This is particularly important for OMI, which has a relatively coarse spatial resolution (approximately 0.25 degrees). At 1-degree resolution, each grid cell can include up to 16 observations, allowing for more stable estimation of representative error. In contrast, a 0.5-degree grid cell would only contain about 4 observations, leading to larger random errors in the estimation.
3. The results at 1-degree and 0.5-degree resolutions are relatively similar in theory, but the 1-degree resolution significantly reduces the computational resources required for constructing the background error covariance matrix.

Specific comments:

Please specify the start and end months for 231/106 members of the ensemble in Section 2.1.
Response: We have added the information in Section 2.1.

For the global ensemble dataset, each grid cell may contain different numbers of effective members. Could it be that some grid cells have too few members? Could you provide the distribution of effective member counts across the global grid cells?
Response: We have added the information about the number of ensemble members available for each grid cell in Figure S1 and Figure S2. To ensure robust statistical representation, we required that each grid cell contain no fewer than 30 ensemble members for constructing the ensemble. This criterion has also been clarified in Section

2 of the revised manuscript.

Figure 6: The title appears to be incorrect, which should refer to the analysis based on OMI.

Response: We are sorry for the mistake. We have revised it.

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