Reviewer5 (CC Feng Xu)
Title: Synergetic Retrieval from Multi-Mission Spaceborne Measurements for Enhancement of Aerosol and Surface Characterization
Recommendation: Minor Revision
This manuscript by Litvinov et al. presents a comprehensive study on a synergistic aerosol and surface retrieval method using combined datasets from multiple satellite missions, including S5P/TROPOMI, S3A/B OLCI, and Himawari-8/AHI. The authors proposed an innovative methodology for harmonizing diverse measurements from different satellite platforms to better constrain aerosol and surface properties. The retrieval results are validated against AERONET observations and compared with products from other satellite sensors. The novelty of this work lies in its generalized retrieval framework and the demonstrated improvements in aerosol microphysical property retrievals.
Major strengths:
- The proposed algorithm builds upon a well-established heritage algorithm - GRASP, developed by Dubovik et al. (2011, 2004).
- The manuscript is well structured, technically robust, and presents extensive validation results.
- The authors reasonably demonstrate that synergizing LEO+LEO and LEO+GEO measurements can significantly enhance retrieval accuracy. This is probably the first paper to implement a unified retrieval scheme across such a broad constellation of multi-mission instruments.

Response:
We are very grateful for the very supportive words of these studies and the time the reviewer spent reading the manuscript and providing valuable feedback.

Minor weaknesses and suggestions:
- The synergetic retrieval relies on the imposition of temporal constraints on the retrieval quantities. In this context, the initial setting of Lagrange multipliers is crucial. It would be helpful for the authors to include a table summarizing these values and cite one or two references describing their derivation—e.g., based on climatological estimates of the least unsmooth solution.
Response:
Many thanks for these suggestions. Section 2 was updated with a more detailed description of the GRASP algorithm, multi-pixel approach, and multi-pixel constraints.

- What is the impact of re-gridding the measurements to a 0.09-degree spatial resolution on the measurement uncertainty? It might help to clarify whether this process reduces the random noise while potentially retaining or amplifying the biases.
Response:
It is very difficult to estimate this impact since it can be different for different instruments. In particular, we don't expect a big effect on TROPOMI since it already has quite coarse native resolution, and 0.09 degrees is very close to the TROPOMI native resolution in the SWIR range. At the same the effect on OLCI and AHI instruments can be bigger. This may also be one of the reasons why the "weights"

for OLCI and AHI measurements were smaller than for TROPOMI after "optimization" tests. We have not discussed this in the paper since separate studies are required on this topic yet to get clear answers.

- In the summary, the authors could briefly discuss potential future developments, such as a dynamic pixel-scale retrieval uncertainty estimation framework. This could follow the methodology proposed by Dubovik et al. (2004) for quantifying pixel-scale retrieval error and assessing the impact of aerosol model assumptions.

Response:

These are good suggestions. Indeed, synergy provides a lot of advantages already, but it also raises a number of important remote sensing questions. The effect on error estimation is one of them.

- Figure captions, labels, and legends are currently difficult to read. Please consider increasing the font size and improving clarity to enhance readability.

Response:

Figures and captions were updated.

Overall, this is an important and timely contribution to the field of satellite aerosol remote sensing. I recommend acceptance after minor revisions that address the points above.

Response:

Many thanks. The reviewer's support is very much appreciated.