Reviewer4
Review of Litvinov et al., “Synergistic Retrieval from Multi-Mission Spaceborne Measurements for Enhancement of Aerosol and Surface Characteristics”
Summary:
This paper introduces a variant of the GRASP approach, “SYREMIS/GRASP”, that performs synergistic aerosol property retrieval from observations provided by a combination of platforms in Low Earth Orbit (LEO) and Geostationary orbits (GEO). The concept is demonstrated as LEO+LEO using the combination of S3A/OLCI, S3B/OLCI and S5P/TropOMI and as LEO+GEO by adding Himawari-8. The effort includes aggregation all data on common grids (temporal / spatial), determining “weights” of each observation based on information content, and applying the forward model (GRASP) that represents the combination of information. Some assumptions about spatial and temporal smoothness or variability are necessary in regards to aerosol and surface variabilities. Evaluation, compared to AERONET, is performed for retrieved parameters of Aerosol optical depth (AOD), Angstrom Exponent (AExp) and single scattering albedo (SSA), demonstrating “added value” of synergistic retrievals as compared to GRASP-based single-instrument retrievals. On a global scale, retrieved-AOD is compared to the VIIRS Deep Blue product, and surface BRDF is compared to historical MODIS-derived products. The paper concludes with suggestions that “such extended aerosol characterization with high temporal resolution is required in air quality studies, for monitoring aerosol transport, aerosol-cloud interaction, etc.”

Evaluation:

I am not convinced by this paper at all. Rather than a comprehensive step-by-step approach, the presentation feels more like magic. What is this SYREMIS anyway? Where is the acronym defined? What is it doing? How are sensors weighted? I don’t understand the paragraph (Lines ~195) about what is meant by “close spectral measurements” and “different accuracy of radiometric calibration and different bandwidths of the observations”. Nor do I understand the claim that the “weight of TROPOMI … should be stronger … can be explained ... by higher information content and better radiometric accuracy.” (maybe references?). What information about aerosols and surfaces is contained by each observations/measurement? Where does layer height information come from? Cloud masking?

I am not convinced that the scatter plots are significantly improved by all-instruments versus single-only. And if better accuracy, then so what? What are the restrictions if all data must be collocated perfectly? How are instrument calibrations and angular differences included? I just have questions and more questions about GRASP, how the data are selected and collocated, how to deal with missing data, poor calibrations, *etc*, *etc*. etc. In fact, the term “*etc*” is used way too many times during this paper. The figures need more complete captions, the titles of panels need more clarity, and the density scatterplots need colorbars. I do not understand what is sensor-specific “extract” in any of the figures. In terms of the SYREMIS method, is it slow? Fast? Can it be used in operations? How idoes this algorithm improve air quality applications (e.g. estimating aerosol at the surface)?
What does it mean to compare SYREMIS with VIIRS for AOD and with MODIS for BRDF? Where and why are their big differences? Because the heritage products do

not have sufficient information content? Or is the new technique wrong? Fig 16 differences of 0.4 in AOD are huge, so are 0.1 differences over ocean. Figure 19 refers to 1st 2nd and 3rd parameters, I see only 2nd and 3rd.
Finally, this paper needs severe editing. Many words, sentences and paragraphs make no sense. There are incomplete sentences and an overuse of the term "etc". Why is "weight" in quotes every time? Also many acronyms need defining – including SYREMIS, POLDER-3/PARASOL, PACE, HARP, and maybe every satellite missions.
Frankly, while I am disappointed with the authors for sending out such a poor draft of a paper, I am almost angry with the EGUsphere editors for letting this paper go to review. The technique is likely useful, and the community needs good products. However, the paper is nowhere close to being acceptable in its present form.

Response:
Many thanks to the reviewer for his criticism. We agree that some aspects may not be clearly presented in the initial version of the manuscript. Therefore, the manuscript was revised, taking into account the reviewer's comments and criticism.

Overall, the following corrections were performed:

1. More detailed description of the physical basis of the synergetic approach, such as data preparation for synergy, forward modelling, application of the GRASP retrieval algorithm for SYREMIS (SYnergetic REtrieval from multi-MISsion instruments) approach, and multi-pixel synergetic concept. The weighting and a priori constraints used in SYREMIS/GRASP are discussed in more detail in Section 2 and the new Appendix A. We also emphasized the differences and advantages in comparison to the existing methods (Sections 1, 2).
2. The results are presented in more detail, showing the advantages of the synergetic approach (Sections 2.4 and 3). To avoid confusion, Section 3 was subdivided into 4 subsections:
    - 3.1 SYREMIS/GRASP LEO+LEO synergy performance versus AERONET.
      Here, we presented the validation results for all instruments in the synergy, as well as for the AOD, AE, and SSA extracted from the synergy for the specific time of TROPOMI, OLCI-A, and OLCI-B measurements. This allows us to demonstrate how retrieved parameters are aligned to each other in time.

    - 3.2 SYREMIS/GRASP LEO+LEO inter-comparison with GRASP single instrument retrieval over AERONET.
      Here, we show the added value of the synergy in comparison to the single-instrument GRASP retrieval. The evaluation accounts for the following 4 criteria simultaneously:
      a). Performance in AOD (the highest rank in the evaluation)
      b). Performance in AE
      c) Performance in SSA
      d) Number of pixels passed the quality filtering criteria.

- 3.3 SYREMIS/GRASP LEO+GEO synergetic performance versus AERONET.
  Here we presented the validation results for all instruments in the synergy, as well for the AOD, AE, and SSA extracted from the synergy for the specific time of TROPOMI, OLCI-A, OLCI-B, and AHI measurements. This allows us to demonstrate how retrieved parameters are aligned to each other in time in LEO+GEO synergy. Due to the huge volume of the new information in LEO+GEO synergy, a separate publication is under preparation on this topic

- 3.4 SYREMIS/GRASP aerosol and surface products global intercomparison.
  Here we present the preliminary results of the global AOD and BRDF properties intercomparison, showing qualitative agreement but quite big quantitative differences between synergy and single instrument products. Preliminary discussion is provided though a separate publication is under preparation on this topic.

To better show the performance of the SYREMIS/GRASP approach, the validation figures were changed, and the tables with statistical validation characteristics were added. The discussion of the synergetic results is considerably extended. With all these modifications, the advantages of the synergetic retrieval over a single instrument should be well seen.

3. The scientific discussion is substantially extended in the manuscript.
4. The paper was carefully reviewed, and the English language was improved.

Note in the updated validation plot above, the number of datapoints N in each plot is different compared to the number of datapoints in the original Figs. 2 and 3 in the first submission of the manuscript; this is because the updated plots were created with updated AERONET Level 2 products. The latest access date to AERONET is 2025 July 18, which is about 2 years after the creation of the original plots in the first version of the manuscript. "