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Atmospheric Measurement Techniques Discussions

Interactive comment on "Inversion of multi-angular polarimetric measurements over open and coastal ocean waters: a joint retrieval algorithm for aerosol and water leaving radiance properties" *by* Meng Gao et al.

Anonymous Referee #1

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The paper by Gao et al describes the application of a joint retrieval algorithm for aerosol properties and water leaving radiances (WLR) to multi-angle measurements of radiance and polarization from RSP for different situations (open ocean, coastal waters, low and high aerosol load). They compare 2 different bio-optical models and find that a more complex model with 7 parameters is needed for coastal waters if the WLR is high (and aerosol load low) while for open ocean or coastal waters with low WLR a simple model just depending on the CHL - a concentration is sufficient, or even better. The paper is very relevant to the NASA PACE mission. I recommend publication after

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Discussion paper

addressing my comments below.

General Comments

- The description of the inversion method needs to be somewhat extended. It is mentioned that the cost function of Eq.3 is being minimized. I am surprised that there is no regularization term in the form of a side constraint (i.e. difference with prior or smoothness) included in the cost function. It might be that the authors implicitly include regularization through the Levenberg-Marquardt (LM) method, because in this method the difference with the previous iteration step is being minimized. If this is the case, it should be explicitly mentioned that regularization is brought in through the LM method. Although this is common practice, it is a non-optimal way of including regularization (see e.g. Rodgers, 2000).

- The approach of uncertainty estimation through an ensemble approach with different 1st guess state vector is very interesting and provides useful insight in the retrieval result. However, I find that the resulting uncertainties are over-interpreted when it comes to trading these uncertainties against the PACE requirements. As the authors note themselves in the paper, it can happen that a retrieval with a wrong model leads to a smaller uncertainty but the retrieval result is obviously worse (i.e. due to a bias) than the retrieval with a more correct model but a larger uncertainty (found from the ensemble approach). So, I suggest to remove this discussion from the paper or at the very least provide the right perspective. Something that could be compared against the PACE requirement is the difference between a retrieval result and a validation measurement, although also here one has to be very careful given the small sample. - For the case with high aerosol load, the authors adjust the imaginary (part of the) refractive index (IRI) in a rather ad hoc way by changing the value at 410 and 470 nm. It seems that the spectra from 'd Almeida do not include the right spectral variation for all aerosol types. I would advise the authors to see how things change if they also include Brown Carbon in the PCA analysis, using the IRI spectra of Kirchstetter, et al., (2004), (Evidence that the spectral dependence of light absorption by aerosols is affected by organic carbon,

J. Geophys. Res., 109, D21208, doi:10.1029/2004JD004999.) At least this possible solution should be discussed in the paper.

Minor comments: - p2, l25: Correct reference for SPEXone is: Hasekamp et al., JQSRT, 227, 170 - 184, 2019, doi: https://doi.org/10.1016/j.jqsrt.2019.02.006. The correct reference for the underlying polarimetric measurement technique (spectral modulation) is: Snik et al, Appl. Opt., 48(7):1337-46, 2009, doi:10.1364/AO.48.001337.

- p3, l23: typo "measurments"

- p3, l31: It would be useful to include for the different cases investigated in the paper an indication of the error on radiance and polarized radiance that result from the model.

- p9, l16: For cloud screening based on goodness-of-fit, please refer to Stap et al., (2015). Sensitivity of parasol multi-angle photo-polarimetric aerosol retrievals to cloud contamination. Atmospheric Measurement Techniques, 8 (3), 12871301. Retrieved from https://www.atmos-meas-tech.net/8/1287/2015/ doi: 10.5194/amt-8-1287-2015

- p12, l5: The difference between RSP and HSRL=0.015. This seems well within the 1-sigma error so why do you expect it is caused by the different viewing geometry? At least mention that the difference is within 1-sigma error.

- p14, l1: "relative viewing azimuth" –> "relative azimuth"

- p14, l9: It seems chi2 is larger for the model with more parameters while I would expect better capability to fit the measurement with more parameters. Please explain.

- p18, l10-11: "The maximum uncertainties for AOD are at 410nm with a value of 0.009". How does this relate to the error in AOD of 0.017 quoted one sentence earlier?

- p22, l1: "MOIDS" –> "MODIS"

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