Atmospheric Measurement Techniques Discussions

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Comment on amt-2020-507

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Referee comment on "Efficient multi-angle polarimetric inversion of aerosols and ocean color powered by a deep neural network forward model" by Meng Gao et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-507-RC3, 2021

The authors use a preexisting radiative transfer (RT) code to train a neural network (NN) to output polarimetric radiances at the angles and wavelengths of the AirHARP instrument. The computationally inexpensive NN forward model is then paired with the inversion module of the preexisting MAPOL algorithm to produce a new hybrid retrieval (FastMAPOL) that is less computationally expensive than the original method. The FastMAPOL retrieval is tested on both synthetic data and real ACEPOL measurements made by the AirHARP instrument and, in both cases, good retrieval performance is observed.

Polarimetric remote sensing has the potential to provide enhanced aerosol information but the large number of free parameters in most multiangle polarimeter (MAP) retrieval algorithms generally prohibits the use of precomputed lookup tables. This fact frequently necessitates computationally expensive online radiative transfer calculations which pose a significant challenge for operational algorithms that need to process very large data volumes. The authors provide a convincing demonstration of a machine learning approach that significantly reduces this computational burden. Care is taken to ensure that the NN reproduces the original RT with high fidelity and tests involving synthetic and real data both show good retrieval performance. The approach appears to be technically sound and has the potential to serve as a foundation for retrieval developments pertaining to PACE and other future missions employing MAPs. Furthermore, the content of the manuscript is well organized, and the material is clearly appropriate for AMT. Therefore, once the comments below have been addressed, I can confidently recommend publication.

Specific Comments

- P2, LN21: The list of MAPS in the sentence beginning on this line seems to have an extra "and". It also is inconsistent in its use of the name of sensor or the overarching mission. I would recommend rephrasing.
- P3, LN22: Did the authors intended to say "...references within)."?
- P4, LN2: Citation should be inline (no leading parenthesis)
- P4, LN4: Should read "...benefits of using..."

- P4, LN32: "have" should be "has"
- P5, LN8: It would be clearer to say something along the lines of "...observational altitude..." since not all members of the HARP family are aircraft instruments.
- P6, LN6: AirHARP's swath width aboard the ER2 should be provided.
- P6, LN8: Is σavg the regular standard deviation of all 100 pixels in the box or is it the standard error of the mean (e.g., σ/sqrt(N)=σ/10)? The latter strikes me as a more appropriate choice as I believe the retrievals are performed on the means of the aggregated 10x10 boxes. The definition of σavg needs to be clarified, and justification for that particular definition should be provided.
- P6, LN18: As I understand it, σNN is actually the difference between the RT code and NN, not the NN's uncertainty in an absolute sense. I would recommend clarifying what is meant by "uncertainty" here.
- P6, LN32: I generally take "trace gases" to be those gases in the atmosphere other than nitrogen, oxygen, and argon. Was Rayleigh scattering from these three non-trace gases taken into account above the aircraft? Please clarify.
- P7, LN18: The term "visible spectrum" should be replaced with something that also includes HARP's 870 nm NIR channel.
- P7: The vertical profile assumed for the simulated aerosol should be described.
- P9, LN13: Only 14 quantities are listed but it's stated that the forward calculation uses 15 parameters. The 15th parameter should be included in this summary paragraph (presumably ozone column density?).
- P9: Should some of the quantities in the equations of section 2.2 have an azimuthal dependence, as well as solar and viewing zenith angle dependence? Why do the equations here show these quantities to be functions of the latter two, but not relative azimuth?
- P9: Equation (11) contains an extra parenthesis.
- P10, LN11: This sentence needs to be reworked so that it is grammatically correct. Also, it should be specified exactly which angle is less than 1° (viewing zenith angle?).
- P11, L2: A more precise description of the method of random sampling should be given. Are the variables being drawn from a uniform distribution (log-uniform distribution in the case of Chla)?
- P12, LN14: Here it is stated that separate NNs are used for reflectance and DoLP. Instead of two separate NNs, another potential approach would have been to use a single NN with an 8-dimensional output (4 reflectance + 4 DoLP values). It would be beneficial if the authors could further elaborate on the pros and cons of these two possible approaches, and their motivation for using the particular 2 network architecture that was ultimately chosen.
- P19, LN 5: Is the added noise uncorrelated in angle, polarization and wavelength? If so, how would the authors expect more realistic calibration errors (which likely will be strongly correlated among these three dimensions) to impact their results?
- P22: There is an extra parenthesis in the title of the Chla subplot of Figure 9.
- P22, LN5: The last two sentences of this paragraph have several grammatical errors and are a bit confusing. I suggest rephrasing.
- P23, LN14: Should read "...less sensitive to outliers." (No "the")
- P23, LN14: "...applied to the synthetic measurements..."
- P23, LN23: The sentence starting on this line has several grammatical errors and needs rewriting.
- P23, LN28: It would be clearer if the phrase "the reduction of" was changed to "reduce".
- P25, FIG12: The figure would be easier to interpret if the caption explained that the "hole" in the middle of the three polar plots was due to water condensation on the lens. I thought it was a plotting artifact, as it lines up the "0°" label, until I read the full condensation explanation later in the text. It might even be good to remove the "0°" tick completely.
- P26, LN20: The last sentence needs to have grammatical errors fixed and its meaning clarified.

- P27, LN5: More discussion of the along-track stripping in χ^2 values should be provided. In many cases, it does not seem to correlate with the number of view angles available. For example, the most prominent ~10 pixel wide dark red strip of χ^2 in Figure 15 is actually offset to the right by about five pixels of the band of missing angles at nadir. What is the cause of this artifact?
- P28, FIG15-17: If it is easy to add, it would be informative to include a fourth subplot with the retrieved Rrs in these figures.
- P29, FIG18-19: I'm struggling to see the value in these two figures given the very coarse across-track averaging. Why resolve along-track data at ~0.5km when averaging across-track at tens of km? In my mind, a better approach might be to average all pixels within a circle of some radius of the HSRL/AERONET/SeaPRISM measurements. Alternatively, these figures could be removed altogether, while still reporting the average values for each of the 3 scenes. (Much of the pixel-level information is already conveyed in figures 15-17).
- P30, LN16: Was the speed up factor of FastMAPOL every specified? How long does a retrieval using equivalently accurate RT take with regular MAPOL on the same hardware?
- P21, LN12: I think the authors intend to say "...HARP2 is likely to have high*er* accuracy..."