Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-407-AC2, 2020

Atmospheric Measurement Techniques Discussions

Interactive comment on "A study of polarimetric noise induced by satellite motion: Application to the 3MI and similar sensors" *by* Souichiro Hioki et al.

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Received and published: 23 December 2020

Thank you very much for reading through our manuscript and providing us positive and constructive review. We are confident that the manuscript becomes more beneficial for the community by addressing to the points you raised. We are grateful for your inputs and we are more than happy to respond to your questions and comments:

- It would be better to use the term 'error' instead of 'noise'

We agree with the reviewer. The term "noise" may not be precise as it implies the completely random noise. In the revised manuscript, we replace the word "noise" with

"error".

- Also, I suggest to clearly quote values for bias and RMSE as measures of accuracy.

We understand the reviewer's suggestion, and we completely agree with him that the bias and RMSE are useful measures of the uncertainty, particularly when the error distribution is close to normal (or close to any distribution for which the population standard deviation exists). The problem for this particular case is that the distribution does not look like a normal distribution. We found that the histograms can be empirically fitted with t-distributions with degree of freedom between 2 and 4, which implies that the population variance likely exists, but providing the bias and RMSE might be misleading to the readers who are likely be using these parameters as a location and scale parameters of a normal distribution. In the attached Figs. 1 and 2, we show the histogram of the DOLP error and L_p error together with the normal distributions constructed from the mean and sample standard deviation. For this reason, we don't find it significantly useful to provide the mean and RMSE in place of median and 9th-95th percentile range. If the reviewer has a strong recommendation and elaborated discussion, we would greatly appreciate that and we could consider again providing bias and RMSE in the revised manuscript.

- Probably here the 15.9-84.1 percentile range is more useful.

We agree with the reviewer that the addition of the 15.9-84.1 percentile range serve for the better characterization of the histogram. The numbers will be included in the revised manuscript.

- Please quote the bias and RMSE for all 4 categories in the abstract.

Providing specific numbers in the abstract would be useful. We add the median and 5th to 95th percentile range to the revised abstract as we consider they are less misleading parameter to characterize the distribution than the bias and RMSE.

- Which wavelength has been used for this study?

The wavelength used was 0.869 μm. It is briefly mentioned in the Section 2.2.1 (line 90), but in the revised manuscript, we emphasize this once again in Section 3 “Results”.

- For clear-sky over land, I would expect the error at 860 nm is much larger than at 670 nm. I would recommend to show errors at both wavelengths.

We appreciate reviewer’s insightful comments. We confirmed that the error is indeed smaller at 670 nm, and we add the results for the clear-sky over land in the revised manuscript.

- Please make clear that the resulting errors are on L1B product

Thank you very much for the encouragement. We emphasize that the resulting errors are on the L1B product in the revised manuscript.

- Please relate the errors to the total error budget of the 3MI.

The 3MI’s target error in the polarimetry is defined on clear-sky homogeneous scene over dark surface (Fougnie et al. 2018 JQSRT), and the value is 5×10^{-4} in terms of polarized reflectance. In Fig. 3, we show the fraction of pixels that satisfy the target accuracy for each bin of along-track Laplacian. Given that 68.2% of data falls within the $\pm 1\sigma$ (i.e. RMSE) if the error distribution follows the normal distribution, we could interpret that the specification is well satisfied in a particular bin when the fraction exceeds 68.2%. The figure shows that the 3MI target accuracy will be met for fairly homogeneous scenes (low along-track Laplacian), but with an increase of inhomogeneity, the target accuracy would be difficult to be met.

- How do these errors relate to errors on aerosol and cloud properties?

We are not aware of relevant study regarding the error in cloud retrievals, but the error estimation by the reviewer gives an insight into the accuracy needed for retrievals. The cloud droplet effective radius retrieval is unlikely be affected as it is sensitive to the geometric location of the rainbow, but the effective variance retrieval might be affected. In the revised manuscript we refer to the reviewer’s work.

- Also the case of clear-sky over ocean would be interesting.

We add this class in the revised manuscript as in the histograms in Figs. 1 and 2. Indeed, the L_p errors are small compared to the cloudy scenes. The DOLP errors are larger because of highly polarized dark ocean.

- Can the median be interpreted as the median of the ΔDOLP distribution corresponding to a given value of L_{AT}/L?

Yes, exactly. We clarify this point in the revised manuscript.

- Why are these large parts in Fig. 7 (preprint) ‘Gray hatched’ but not in Fig. 6 (preprint)?

It was because Fig. 7 (preprint) took too wide range of abscissa compared to Fig. 6 (preprint). We adjust the right end of the abscissa to 95% of the data for both L_p and DOLP errors in the revised manuscript.

- I would say this is not the ‘prediction of noise/error’ but rather an ‘understanding of error’. I suggest to move this part (results from the Mote Carlo simulations) to an Appendix.

In the interpretation of the data, the reviewer’s comment is reasonable and we agree that the part of Monte Carlo model may hamper the flow of the paper. Our intent by saying “prediction” is rather for unforeseen future missions or past missions without compatible orbit/swath polarimeter with higher spatial resolution. For those missions, the error estimates from the Monte Carlo model would be a “prediction”, and we believe that it is important to deliver the message that such a prediction is proven valid at least at the spatial scale of 1 km (SGLI pixel size). We therefore move the method to the Appendix and summarize the result as a discussion in the revised manuscript.

Thank you very much again for your careful comments and constructive discussions. As mentioned above, nearly all your comments will be incorporated into the revised manuscript and we always welcome your questions and suggestions in the following review process if deemed necessary.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-407, 2020.

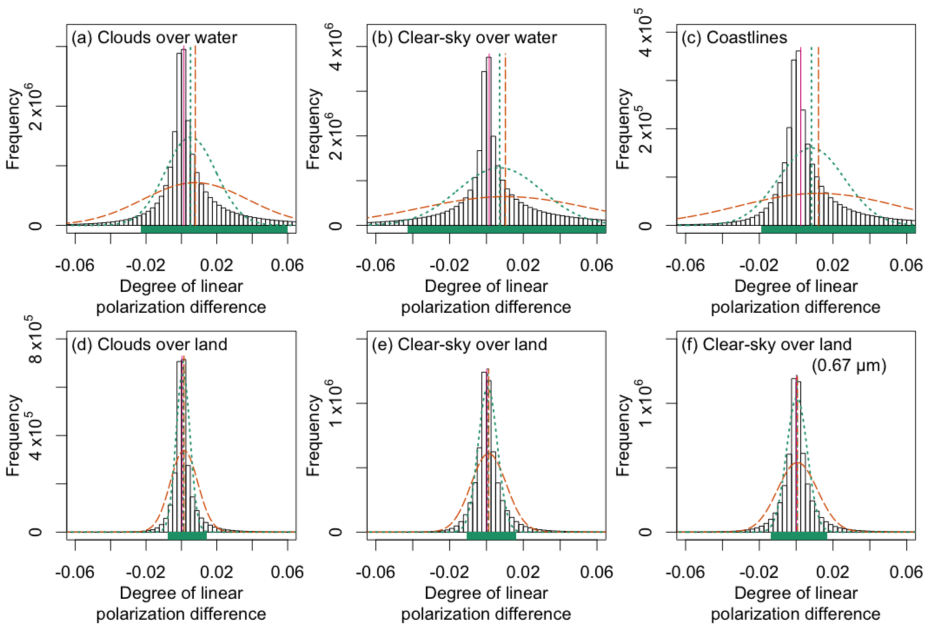

Fig. 1. Histogram of degree of linear polarization error with median (magenta line), the normal distribution with mean and sample standard deviation of all data (orange), and the normal distribution with mean

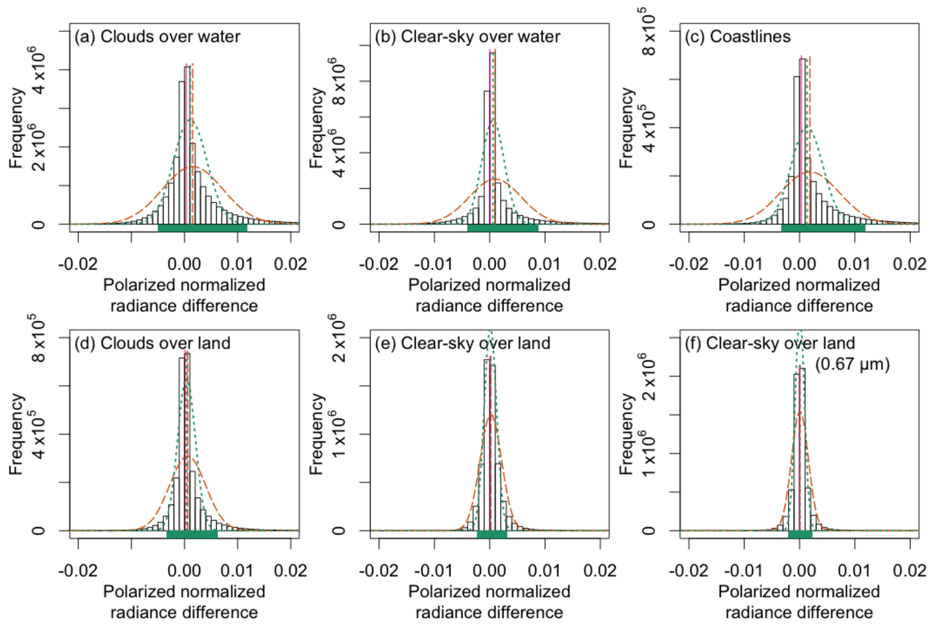

Fig. 2. Histogram of polarized normalized radiance error with median (magenta line), the normal distribution with mean and sample standard deviation of all data (orange), and the normal distribution with mean

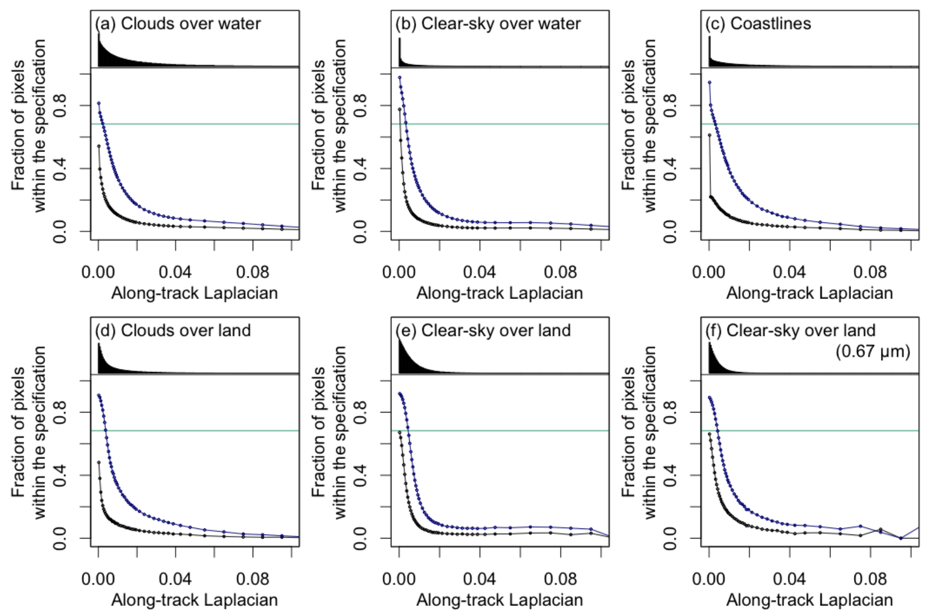

Fig. 3. The fraction of pixels within the POLDER specification (dark blue) and the 3MI specification (black) in each bin of along-track Laplacian. The density histograms of the along-track Laplacian is presen