Application of SGLI data to aerosol studies with 3MI: measurement uncertainty induced by satellite motion

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Abstract

The 3MI (Multi-viewing, Multi-channel, Multi-Polarisation Imager) is a planned spaceborne sensor on the MetOp Second generation-A satellite platform. The 3MI acquires narrow-band wide field-of-view images of the Earth at 12 wavelengths with significant overlaps. The 3MI sensor computes linear polarization states as well as the intensity at 9 wavelengths by merging three sequentially obtained images. This study investigates the uncertainties and potential bias induced by this merging process. Utilizing the data of the existing spaceborne polarimeter (SGLI), we produce the proxy and reference 3MI radiance data. The comparison shows that the positive bias of DOLP up to 0.06 is expected for highly inhomogeneous cloud scenes.

1. Background and Strategy

The 3MI sensor computes the three Stokes parameters from three wide field-of-view Earth images acquired sequentially at time interval of 0.25 seconds. During this time interval, the satellite propagates by about 1.8 km and the shifted three images must be interpolated before they are merged to compute the Stokes parameters. The interpolation could positively bias the polarization when the scene is inhomogeneous.

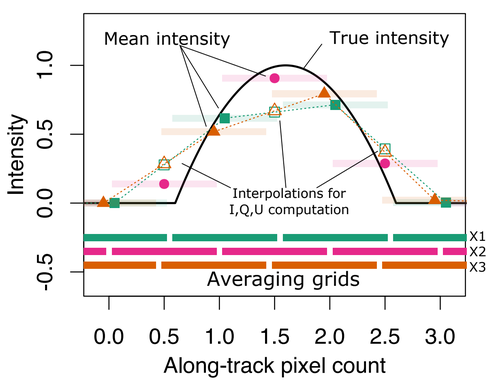

Fig. 1. Example demonstrating the effect of the interpolation.

Question

What is the expected magnitude of errors in polarized normalized radiance and degree of linear polarization (DOLP) for a given scene inhomogeneity?

Our Strategy

1. Produce the 3MI proxy and reference data from the actual measurements from the SGLI (Second Generation Global Image) data
2. Compute the difference between proxy and reference data to evaluate the error. Check the dependence on scene inhomogeneity.

Fig. 2. The question to be addressed and our strategy.

2. Data and Methods

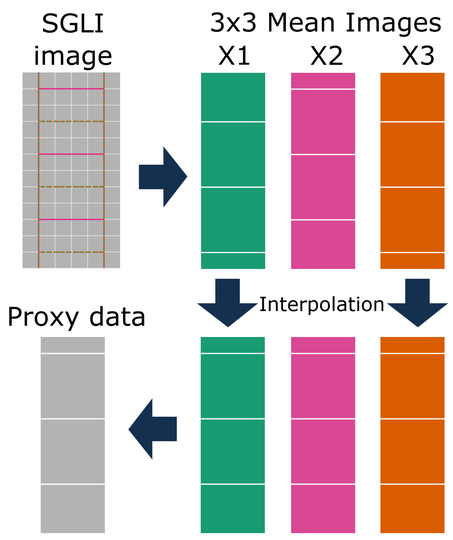

Fig. 3. Schematics of the proxy data production

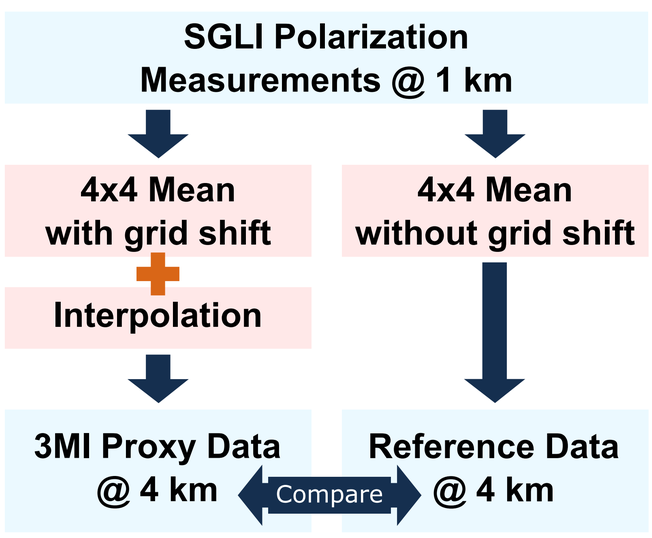

Fig. 4. Dataflow of the proxy and reference data production

We produce the proxy and reference data from the SGLI Level 1 polarization channel products. For the proxy data, we compute the mean of 4 x 4 pixels in different averaging grids for three consecutive acquisitions (X1, X2, and X3), and then interpolate the averaged image before computing the Stokes elements in the proxy data. For the reference data, we apply the same averaging grid for all of X1, X2, and X3. No interpolation is performed.

3. Error-ATL Correlation

The error in the second element of Stokes parameters (Q) is linearly correlated to the Along-track Laplacian (ATL).

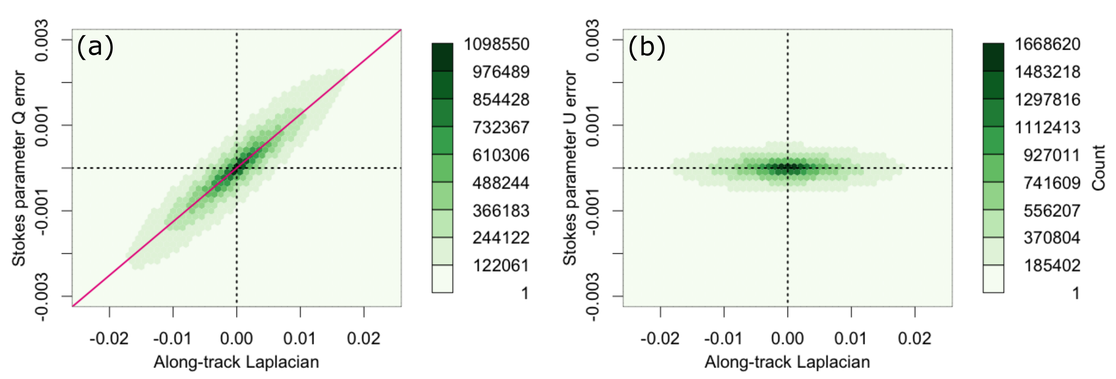

Fig 5. (a) Correlation between along-track Laplacian and Stokes parameter Q (b) Same as (a) but for U. The image is from 2020.

4. Results from 1-year Data

Using the correlation showin in Section 3, a correction is applied based on the along-track Laplacian. Seasonal and geographic distribution of the residual error is shown below.

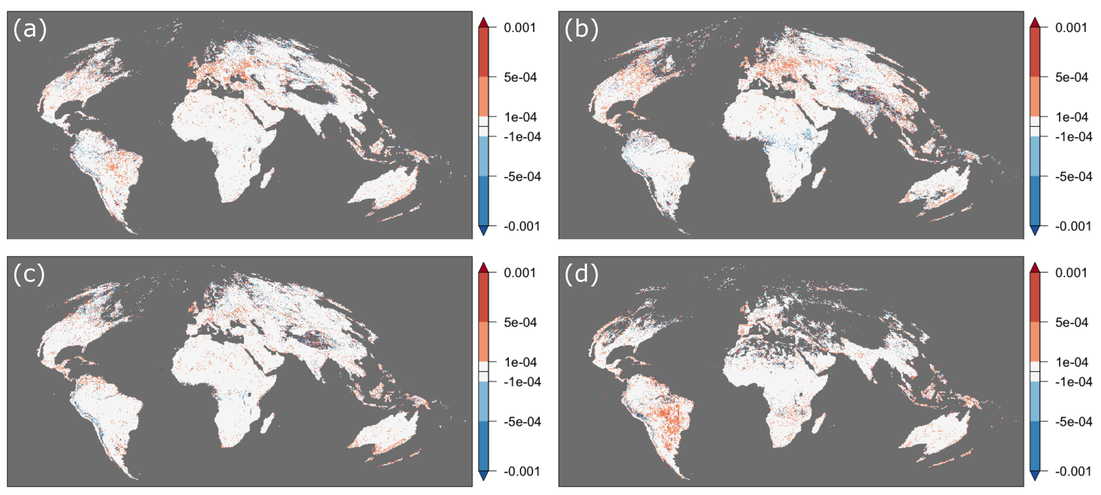

Fig 6. Seasonal and geographic variation of the residual bias. (a) MAM (b) JJA (c) SON (d) DJF.

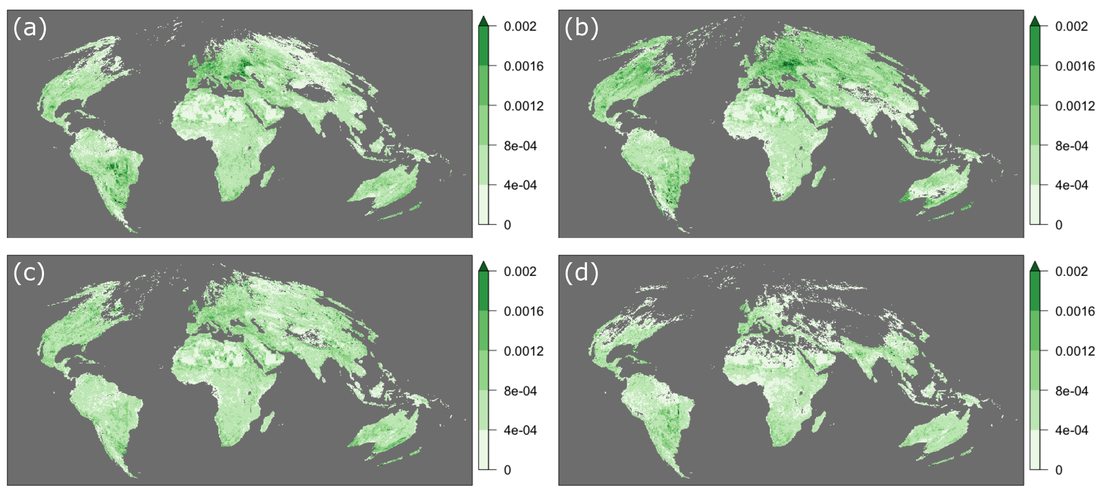

Fig 7. Samea as Fig. 6 but for the residual standard deviation.

5. Conclusions

The error increase with increasing along-track Laplacian (ATL). The magnitude of error is predictable with the ATL.

After applying the correction based on the ATL, the residual bias is within 10^{-4} and the standard deviation is less than $2x10^{-3}$.

Uncertainties at pixel level will be included in 3MI L1B product and this work contributes to provide realistic uncertainties needed for retrievals and assimilations.

Acknowledgments

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