Uncertainties of 3MI's Polarimetric Measurements over Inhomogeneous Cloud Scenes

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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 can measure the linear polarization along with 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.

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.

2. Data and Methods
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. Results from Single Granule
The positive error is pronounced on coastlines and DOLP bias is larger over land and clouds than over clear-sky oceans.

4. Results from 1-Week Data
The proxy data is generated from the 1 week of global SGLI data (September 20-26, 2018) and compared to the reference. Results over oceans with normalized radiance greater than 0.2 are selected to analyze cloud pixels.

5. Conclusions
The biases increase with increasing along-track Laplacian. The magnitude of error is predictable with a statistical model. This result will be refined by considering the instrument’s point spread function.

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

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