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Atmospheric Measurement Techniques Discussions

Interactive comment on "Prediction Model for Diffuser Induced Spectral Features in Imaging Spectrometers" *by* Florian Richter et al.

Anonymous Referee #1

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General comments

This is a well written paper. However, what this paper is currently missing in my opinion is visualization of the measured and processed data. Can you please add visualizations of actual measured data (both spectral and images) and results from each of the modeling steps? It would be interesting for readers to see how speckle patterns of that diffuser look and the pattern propagation to the final imaging plane. Can you also add some figures from the laser spectra used? Just as background information you could include in the introduction that sources like lasers produce temporal speckle and diffusers produce spatial speckle. Speckle pattern created by a diffuser can be averaged for example by rotating the diffuser during the measurement.

This is slightly off from the focus on algorithm development itself, but very important what comes to the proper operation of the instrument. What are the criteria for the diffuser to reduce speckle effect and how does that affect overall performance of the instrument? Are there any tradeoffs?

Maybe you could add reasoning why this specific glass volume diffuser was selected and refer to studies on some diffuser contamination and radiation tests? Contamination/degradation of the diffusers is to my understanding a major issue in satellite measurements. This is at least a problem at UV and visible and it has much larger effect than speckle. Since diffraction limit increases at longer wavelengths, at NIR and SWIR diffuser speckle is worse than at visible spectral range. You could mention this in the paper.

Specific comments:

Page 1, row 22: "… spectrometers with fine spectral resolution and strict demands to radiometric accuracy …" You could specify these "strict demands" in the paper. At least stray light is usually a problem in imaging spectrometers.

Page 2, row 29: "… end-to-end measurements by van Brug and Courrèges-Lacoste (2007) as well as models for different speckle averaging effects …" Can you explain in detail what end-to-end measurements were these and what existing speckle averaging methods are available (both hardware and software)?

Page 5, Figure 2: Regarding the setup, please specify the type of optical fibers used between the tunable laser source and the fiber tab and between the fiber tab and the fiber output. You could say that since your spectral tuning range is narrow, you can use single mode fibers to transmit the laser beam and create uniform illumination.

You could also show in a figure how spatially uniform the radiation output from the single mode fiber is before it hits the diffuser. Is there any spatial speckle created by the single mode fiber? You could mention that multimode fibers should not be used as they generate severe spatial speckle that can be worse than the diffuser speckle. The speckle pattern by the multimode fiber changes when the fiber bends only slightly. In addition, can you please draw Figure 2 so that it is easier to see which cables are optical fibers and which of them are electrical cables.

Page 5, Figure 2: Please replace “Powermeter" with “Power meter"

Page 5, rows 109–111: Can you please give references to these data products?

Page 5, row 110: Please replace “... CO2, Aerosols, or the O2 absorption . . ." with “. . . CO_2, aerosols, or the O_2 absorption ..."

Page 6, rows 117–118: “For the NIR the laser source has a center wavelength of 780 nm and a nominal linewidth of 300 kHz." Can you give the nominal linewidth in wavelengths?

Page 6, rows 125–126: “The SWIR laser source center wavelength is 1550 nm, with single mode output of nominal 150 kHz linewidth.” Can you give the nominal linewidth in wavelengths?

Page 6, row 129: Please define a speckle oversampling ratio.

Page 7, row 162: Please define f_m.

Page 7, row 167: You have an error in the spatial offset equation $\Delta b = k\frac{c}{\Delta f}$. Because $\lambda = \frac{c}{f}$ and its derivative is $\Delta\lambda = -\frac{c}{f^2}\Delta f$, the spatial offset equation should be $\Delta b = k\Delta\lambda = -k\frac{c}{f^2}\Delta f$. How does correcting this affect the results?

Page 8, row 172: Please present exact equation for the path length probability density function $p_l(l)$.

Page 8, row 178: There is one extra parenthesis, please replace $\Delta b(\Delta f))$ with $\Delta b(\Delta f)$.

Page 8, row 180: There is a typing error in Equation (10), the integrals’ limits should be $\int_{-\infty}^{\infty}$ (instead of $\int_{\infty}^{\infty}$).

Page 8, row 181: “... $P(h)$ is the aperture function of the imaging system ..." Please present the exact equation for $P(h)$.

Page 8, row 180: There is a typing error in Equation (18), the integrals’ limits should be $\int_{-\infty}^{\infty}$ (instead of $\int_{\infty}^{\infty}$).

Page 10, row 225: “Therefore, the resultant speckle correlation function at the detector $\mu_{det}(\Delta a, \Delta b)$ is a convolution of ...". Please present $\mu_{det}(\Delta a, \Delta b)$ as an equation.

Page 10, row 250: “We assume, that detector noise is averaged in this step" Can you please add what the noise properties of the detector are (e.g. in V/$\sqrt{\text{Hz}}$) and what integration times were used?

Page 10, Subsection 4.4 Predicted SFA: Since this subsection includes only one sentence, to me it makes more sense to remove this subsection 4.4 and move the equation to the beginning of Section 4, right after Eq. (7). There you could also define $M_{polarization}$, $M_{spectral}$, and $M_{detector}$ and link these symbols to the steps 1, 2, and 3.

Page 11, Table 2: Based on the values of $M_{polarization}$, $M_{spectral}$, and $M_{detector}$, the SFA on the first row of Table 2 should be 0.0039 (not 0.0040). Can you please give SFAs in percents in Table 2?

Page 11, row 254: "It is also dependent on detector noise, which explains slightly higher averaging factors than predicted." Can you predict noise properties of the detector used and add them to the calculations?

In results section: How much diffuser speckle contributes to the overall measurement uncertainty?

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