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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.

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General comments

During the operation of spectrally highly resolving satellite sensors (SCIAMACHY, OMI) small wiggles were observed in the spectrometer data whose origin was unclear in the beginning. Finally they could be explained by interference patterns (speckles) of the diffuser used for radiometric in-orbit calibration. The manuscript describes a model to predict these features.

The developed model is physically sound and has been validated using laboratory measurements at two wavelengths. While the technical content is complete and well explained, I miss some motivation and explanation of the effect in the Introduction and

an illustration and discussion of the practical relevance in the Results and Discussion section. I recommend publication after these minor revisions are made.

Specific comments

The modeled effect is not well known in the scientific community. It is difficult to believe that sunlight induces noticeable interference effect in solids because speckles are typical for lasers, but not for natural light. You should mention in the Introduction the puzzling spectral wiggles in the order of a few percent discovered in data of the SCIAMACHY and OMI instruments (described and illustrated by van Brug et al., 2004). Interference effects require that the coherence length is larger than the size of material inhomogeneities, thus you should quantify the coherence length of sunlight and compare it with the typical scale of inhomogeneities in diffuser material. According to Divitt and Novotny (2015) the coherence length of sunlight is 80 x wavelength, which corresponds to 62 μm and 126 μm at the wavelengths of your measurements (777 nm, 1570 nm). You should also mention that the effect is not restricted to diffusers, but occurs for all static measurements of a solid. Point out its relevance for laboratory calibration of spectrometers and spectral measurements using a fixed set-up of target, spectrometer and light source; and explain that the effect vanishes if one of these is moved or tilted during the measurement, as in case of remote sensing.

The importance of the effect and the model for practical applications should be graphically illustrated in the Results and Discussion sections. In particular a plot of the wavelength dependency should be added due to its high relevance for spectral measurements. The wavelength dependency cannot be assessed from the equations, thus a graphical illustration would help the reader to grasp the importance of the described effect. Furthermore, such a plot would allow comparing at least qualitatively the modelled spectral dependency with observed spectral patterns, e.g. as in Fig. 1 of van Brug et al. (2004).

Line 21f: "Since Spectral Features are of statistical nature and cannot be mitigated by any post-processing steps". Correction may indeed be difficult, but not because the effect is of statistical nature, but because the intensity of the pattern and its position on the focal plane are difficult to calculate accurately because they depend on a number of parameters which are difficult to measure with sufficient accuracy (temperature, pressure, isotropy of incident light field).

Technical corrections

line 18: "diffuser introduces a statistical interference phenomenon" I suggest to delete statistical (as it is a geometric effect, not a statistical one) and replace "phenomenon" by "pattern"

Line 50: unwanted "features". Unclear: What do you mean with unwanted? Unexplained?

Line 51f: "The SFA value is then calculated as the standard deviation of the normalized signal over a certain spectral width, that includes multiple features." The definition of SFA is unclear: normalized to what? What means "certain spectral width"? Is standard deviation calculated over time or over wavelength? The definition only gets clear at line 106f together with Eq. (3). Improve here the explanation and refer for details to Eq. (3).

Line 76f: "Sun's light . . . is assumed to be spatially coherent giving the distance from the Sun to the Earth and the limited acceptance angle of the spectrometer." The coherence of light from a spatially incoherent spherical source is in fact valid immediately beyond a distance of a few wavelengths (Agarwal et al. 2004), thus the spatial coherence of sunlight has nothing to do with the Earth-sun distance. Quantify instead the coherence length, e.g. by citing the result 80 * Lambda by Divitt and Novotny (2015). Also the influence of the acceptance angle of the spectrometer is not clear. Either explain or remove it.

Line 77f: "the temporal coherence is very short compared to the detector integration time, which is in the order of seconds" Quantify the temporal coherence and replace

seconds by milli-seconds. The sunlight coherence time is 3 fs according to Herman et al. (2014) who cite the "Optics" book of Hecht (2016).

Line 120: add a reference for Eq. (4).

Line 233f: "the fitted mean free path length of our diffuser sample is determined as ls = 53μm" Explain how you fitted the free path length. The mean free path length depends on wavelength as the scattering probability is wavelength-dependent. Hence, add the wavelength.

Line 300: Coernicus –> Copernicus

References

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