**Atmospheric
Measurement
Techniques**
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Discussions

Interactive comment on "Contiguous polarisation spectra of the Earth from 300–850 nm measured by GOME-2 onboard MetOp-A" *by* L. G. Tilstra et al.

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We would like to thank Dr. Ruhtz for performing a thorough review and for the many helpful suggestions to improve the paper. We respond to each of the review comments below. For the sake of clarity, the review comments are given in italics whereas our response is printed in normal font.

General comments:

This paper assumes in some cases a deep pre knowledge or an in depth search thru

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the references. This could be improved by a view additional formulas, explanations and a list of abbreviations. The results suggest a good agreement with the models, but the differences and possible explanations are not discussed in very detail. It would be helpful to have some quantitative formulas and the real calculation of the stokes fractions with error assumptions. For example, I did not find any information about the correction of spectral band differences between the PMD-s and PMD-p channels. It might be negligible for PMD band integration, but in high resolution mode it could lead to false Stokes fractions and might be important in the absorbing regions in the NIR and maybe in the UV as well. Another point might be if the calculation takes the mispointing angles of the satellite inertial reference system into account. This would change the observation geometries and changes in scattering angle assumptions.

The difference in wavelength calibration between PMD-p and PMD-s has been taken into account. This was indeed not mentioned explicitly in the paper. To explain more about the approach followed to calculate the Stokes fraction we have, therefore, included in section 3.2 of the paper a list of the steps that need to be taken to calculate the Stokes fractions.

These steps are:

1. Determine the raw signals for PMD-p and PMD-s.

2. Perform a dark current correction.

3. Correct for Pixel to Pixel Gain (PPG).

4. Determine the spectral calibration of the PMDs.

5. Perform an etalon correction.

6. Correct for straylight.

7. Determine the viewing and solar angles.

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8. Calculate the single scattering $(U/Q)_{ss}$ ratio.

9. Determine the Mueller Matrix Elements (MME).

10. Calculate Stokes parameter Q/I using Eq. 167 (PGS-7.0).

11. Calculate the radiance I using Eq. 216 (PGS-7.0).

Additionally, in the revised manuscript we now report for each of the case studies the magnitude of the differences that are found between measurement and simulation. We now also mention explicitly what causes these differences between the measurements and the simulations.

Specific comments:

[Please note, that the line numbers below relate to the old manuscript version, i.e., they relate to the initial manuscript version of the submission phase, and not to line numbers of the AMTD paper. Related to this, some of the issues mentioned below were related to the initial manuscript version and had already been addressed in the AMTD paper.]

18: The GDF was not mentioned or proposed before. The reader does not know about it until he reads the full paper.

This issue had already been addressed in the AMTD paper.

94-100: The formulas represent an ideal case. What about errors of the angles relative to the reference frame definition.

This section of the paper provides a brief introduction to polarisation in general. The equations are, at this point in the paper, not specifically describing the polarisation measurements taken in the GOME-2 PMD RAW mode.

The radiometric response of the GOME-2 instrument has been measured during the on-ground radiometric characterisation campaign. Errors in, for instance, the angles relative to the reference frame definition will influence the dependence of the instrument on the incident light but this is all recorded in the radiometric key data of the instrument.

126: Could not find the calculation and the value of the depolarization factor in the reference (Bates 1984). In comparison to the description of Tilstra 2003 its not very helpful. A good description is given by a more recent publication of Rosanov 2014, JQRST.

The parameter Δ in equation 7 is not the depolarisation factor ρ_n, it is the parameter defined as $\Delta = 2\rho_n/(1 - \rho_n)$ as in, for instance, van de Hulst (1981).

The value of the depolarisation factor for natural light ρ_n at 300 nm is not given explicitly in the paper by Bates but it may be calculated from Table 1 in this paper, which provides (amongst other things) the effective King correction factor F_K(Air) as a function of wavelength. According to Bates, at 300 nm F_K(Air) amounts to 1.055. From this one can calculate the depolarisation factor ρ according to

$$F_K \equiv \frac{6 + 3\rho}{6 - 7\rho} \quad \Rightarrow \quad \rho = \frac{6(F_K - 1)}{3 + 7F_K} \approx 0.03178 \,. \tag{1}$$

The expression for the King correction factor can be found in, for instance, van de Hulst (1981). For the parameter Δ at 300 nm we now find the value of 0.0656 using $\Delta = 2\rho_n/(1 - \rho_n)$.

We have changed the manuscript text in the following way:

"...where Θ is the single scattering angle, and $\Delta = 2\rho_n/(1 - \rho_n)$ is a correction factor for depolarisation due to molecular anisotropy. The parameter ρ_n is the depolarisation factor for natural light which may be calculated directly (van de Hulst, 1981) from the reported values of the King correction factor F_K found in, for instance, Bates (1984). At $300\,nm$, $F_K = 1.055$ leading to $\rho_n = 0.03178$. The correction factor Δ thus amounts to 0.0656 at this wavelength."

135: I suggest to move the orbit description from below (144) upwards.

We agree and have made the suggested change.

140:What is the pixel wavelength resolution and the FWHM? What is the FOV of one pixel and how many pixel has one track?

The spectral resolution ranges from 0.2 nm in the UV to 0.4 nm in the NIR. These numbers relate to the FWHM of the slit function of the detector pixels.

The nominal footprint size (for the main science channels) is $80\,\text{km} \times 40\,\text{km}$ (across $track \times along$ track). In the normal mode of operation the number of pixels in one forward scan is 24. For the backward scan, this number is 8. The total number of forward scan pixels in (the sunlit portion of) one orbit track is about 11000.

We now additionally mention the number of pixels in one track (roughly 11000) and the fact that the spectral resolution reported is the FWHM of the detector slit function. The footprint size was already mentioned in the paper.

174: The reference was not available.

The referenced document by Munro and Lang can be downloaded from the EUMET-SAT website:

http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_
FILE&dDocName=pdf_ten_990011-eps-gome-pgs&RevisionSelectionMethod=
LatestReleased&Rendition=Web

The reference in the bibliography of the paper now mentions the availability of this document via www.eumetsat.int.

185: The description of the spectral bands is not very specific. Better descriptions are given in the reports GOME-2 polarization study B + C/D.

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The description of the PMD bands is not very detailed, but the paper is not focusing on these PMD bands. They are mentioned here primarily to put the PMD RAW measurements into perspective. Figure 1 in the paper provides a qualitative overview of the PMD bands, in the pixel domain and in the wavelength domain. For more specific quantitative information, the reference to Munro and Lang (2011) may be used. Additionally, we now also refer to Lang (2010). (This reference was already part of the bibliography.)

Note that the descriptions of the PMD bands in the GOME-2 Polarisation Study phase B and phase C/D reports are very outdated. The PMD band definitions used in these reports were pre-launch definitions and cannot be used.

202-208: The reference and the description is unclear.

This paragraph has been completely rewritten to make it more clear. For example, we have added a list of the steps that need to be taken to calculate the Stokes fractions.

The referenced document by Munro and Lang can be downloaded from the EUMET-SAT website:

http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_
FILE&dDocName=pdf_ten_990011-eps-gome-pgs&RevisionSelectionMethod=
LatestReleased&Rendition=Web

The reference in the bibliography of the paper now mentions the availability of this document via www.eumetsat.int. (Also see our response to the review comment related to line 174.)

220: surface LER? Please name it at least one time (Lambertian Equivalent Reflectivities)

This issue had already been addressed in the AMTD paper.

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282: I would not use such abbreviation in a written publication.

[The abbreviation meant here is "w.r.t.".]

We have changed it into "with respect to".

303: Here it came into my mind to check the calculation of Q/I in more detail, but unfortunately I could not find a proper description. Please check if this can be described in more detail.

In the paper we now have a list of the steps that are needed to calculate the Stokes fraction Q/I and the Earth radiance. We also refer explicitly to the specific equations in the GOME-2 Product Generation Specification (PGS) document that are used.

As for the feature near 800 nm mentioned in line 303, it is not a result of errors in the calculation of Q/I, it is caused by imperfections in the radiometric key data.

381: See 282

Done.

Fig.1 A table with numbers would be better or a graph with the spectral sensitivity. The position within the references is not correct.

The paper is not focusing on the PMD bands, so the exact values for these bands (as provided by a table) are not relevant in the context of this paper. We have, however, added a reference to Lang (2010) so that the reader can find the exact definition of these PMD bands. A weblink to the Lang (2010) document is now added to the reference in the bibliography, so that the report can be accessed easily.

Fig.2: LER see above

This issue had already been addressed in the AMTD paper.

Fig.3: I would suggest to mention the FWHM (Full width half maximum) spectral resolution range (3-35nm).

This issue had already been addressed in the AMTD paper.

Fig.4: (in red) is somehow misleading, because there is some red in Fig.2 but makes no sense.

We used a red colour in Figure 4 for the PMD RAW mode. It is true that a red colour is also present in Figure 2. However, the two figures are very different and in the paper no link between the colour usage of the two figures is suggested. Also, the caption of Figure 4 explicitly explains the meaning of the red colour.

Fig.6: What special geometries? You may provide a short description.

We agree and have added a sentence to explain this.

Fig.9: I suggest to mention the chlorophyl and red edge peak.

This issue had already been addressed in the AMTD paper.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 11309, 2013.