Atmos. Meas. Tech. Discuss., 7, C1692–C1697, 2014
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Atmospheric Measurement Techniques Discussions

Interactive comment on "Effect of surface BRDF of various land cover types on the geostationary observations of tropospheric NO₂" *by* K. Noguchi et al.

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Received and published: 14 July 2014

We would like to thank the referee #2 for providing helpful comments for the original manuscript. We took into account these comments for the revised manuscript. We describe our responses to the referee's comments below.

Major comments:

1. My main concern is that the step from AMF to NO2 values is not discussed at all.

Reply: We agree with the Referee's comment, and made a new subsection (Section 3.5) for the discussion on the step from AMF to NO2 values. In this subsection, we

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added Figure 12 to show the result for the urban surface type as an example.

2. In the introduction a few studies are mentioned that estimate the amount of over or underestimation due to incorrect albedo treatment, but you are not discussing whether your study confirms their findings or not. On p.3445 l. 12f you mention that Heckel et al. and Russel et al. “indicate that the error from surface albedo was especially large”, and I think it would be an important piece of information of how large exactly and in which direction, so that during the discussion of your results you can refer to those numbers for comparison.

Reply: In response to the comments, we now mention the results of Heckel et al. and Russel et al. quantitatively (in the second paragraph of Introduction). The results of Heckel et al. are also compared with our results in the discussion of BAMF (as the third paragraph of Section 3.3). As their focus is mainly on the effect of spatial resolution of the surface reflectance but not of BRDF, we cannot conduct a direct comparison with our results.

3. You could also add whether the differences of 0-20% of tropospheric NO2 VCDs based on LER and BRDF determined by Zhou et al. is an over- or under determination.

Reply: Zhou et al. [2010] had a conclusion that the difference could be both overestimation and underestimation depending on the viewing angles (Figure 9 of their paper). Zhou et al. [2010] focused on a solar-synchronous satellite and they assumed relatively constant solar zenith angles and changing viewing angles. On the other hand, we assume a geostationary satellite where solar zenith angles largely change with a constant viewing angle. Therefore, these studies are complementary to each other and we cannot simply compare both results. We added these descriptions in the third paragraph of Introduction and in the third paragraph of Section 3.2.

4. All those values, including the results by Lin et al. mentioned in the introduction should be picked up again in the discussion or concluding section for comparison.

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Reply: As suggested by the reviewer, we added the discussion for comparison including Lin et al. in the third paragraph of Section 3.2.

5. Some general remarks about NO2 satellite measurements in an urban / rural / ocean / etc. environment are (or will be) overestimating / underestimating by about x% in summer / fall / winter / spring would complete your study nicely and would provide easy to use information for other validation studies.

Reply: As was described in the response to the first comment of Referee 2, we added a discussion in Section 3.5.

6. P. 3450, l. 1f: instead of "very small" you could mention how small.

Reply: The number of the pixels is twenty out of 4248 pixels for the urban type, and only one for the rice paddy type. We changed the corresponding sentence in the second paragraph of Section 3.1 as follows:

"This is because the number of the pixels for 100% is very small, only 20 pixels out of a total of 4248 urban type pixels and just 1 pixel for a total of 3418 rice paddy type pixels."

7. P. 3451, l. 21f and Fig. 7 and 10: If the rice paddies are filled with water in summer, why is there a difference to the water land type especially in the morning?

Reply: Indeed there is a difference of 1-2% between the pure water type and the rice paddy type, although the amount is smaller than the difference from other types ($\sim$10%). Such small differences could be attributed to non-water-covered regions like footpaths (with the width of $\sim$1m) between rice fields. We added the following sentence in the second paragraph of Section 3.2.

"The difference from the pure water type could be attributed to the non-water-covered regions of rice paddies, such as footpaths between rice fields."

The referee focused on the morning values, but there is also a difference in the after-

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noon, which is shown in Figure 7. This means that the difference is not specific to the morning.

8. P. 3452, l. 9f: instead of just saying “the difference will become large” you can mention whether it leads to an over- or underestimation.

Reply:

- To answer the referee’s question, we additionally calculated the AMFs for the NO2 profile which has concentrations ten times larger than those of the original profile in the lowermost 1km layer. After the sentence mentioned by the referee in the second paragraph of Section 3.3, we added a description on the results (l. 226, p. 7 in the revised manuscript).

- In this context, we also found a poor description as follows (P. 3452, l. 3-4 in the original manuscript):

“As a result it follows that wherever a high concentration of NO2 exists in the lower layers, the AMF’s difference among land cover types will become large.”

We think this description also has a similar problem, and we added the quantitative description after this sentence as follows:

“For example, if the NO2 concentrations in the lowermost layers (0–1 km altitude) are ten times larger than the ones of the original profile (Fig. 4), the variability of AMFs for BRDF among land cover types changes from 48 % to 53 % (in the case of LT12).”

- Since the results for BSA are clearer than those of BRF, we have changed the albedo type in Figure 9 from BRF to BSA in the revised manuscript.

We hope these additional corrections satisfy the referee’s intention.

9. P. 3453, l. 22f: Again, as already mentioned, instead of “will cause larger errors of the AMF” you could be more specific how large this error can get and in which direction.

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Reply: After the sentence pointed out by the referee in Concluding remarks, we added the following description (l. 293, p. 9 in the revised manuscript).

"For example, if we use the BSA approximation instead of BRDF, the amounts of the underestimation (in the morning) and overestimation (in the afternoon) of the tropospheric VCD of NO2 reach 15 % and 9 %, respectively, for the very polluted winter case with a ten times larger concentration of NO2 in the lowest layer (0–1km altitude). The size and direction of the error depend on the relative location of the satellite to the observation point on the surface."

10. Fig. 8: I cannot really distinguish the different curves, since they are so close together, how about just using one local time and make the plots bigger?

Reply: Following the suggestion, we now show only the data for LT12.

11. Fig. 5-10: You could add a label box with the different land surface types and the corresponding colors instead of mentioning them in the caption, which would be clearer.

Reply: We added label boxes to Figures 5-10 as requested.

12. You could make clearer why you are focusing on the AMF calculation for geostationary observations. Of course viewing angles, measurement times and spatial resolution might be different, but your calculations can be applied to other satellite observations as well. I suggest that either you widen the scope of your study a little and mention possible effects on other satellite NO2 retrievals, and/or you clarify where your findings are specific to geostationary observations and why they cannot be applied to other retrievals.

Reply: The reason why we focused on a geostationary satellite was because we expected the influence of BRDF on the geostationary measurements throughout the day due to the large change of SZA and solar azimuth angle. We added the following sentence in the fourth paragraph of Introduction.

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“Discussion of the effect of BRDF on geostationary measurements is important since solar zenith angles and azimuth angles change largely throughout the day in geostationary measurements, much more so than for low earth orbits. The effect of BRDF can be critical, in particular if the diurnal variation of a tropospheric species is to be determined.”

We also added the following sentence in the fifth paragraph of Concluding remarks.

“The findings in the present study are based on the geometry among the sun, an observed point on the ground surface and a satellite (an observer) and are possibly specific to the geostationary observation assumed in the present study. Detailed analysis for other satellite retrievals will be needed. ”

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 3443, 2014.