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Interactive Comment

Interactive comment on "Urban Visible/SWIR surface reflectance ratios from satellite and sun photometer measurements in Mexico City" *by* A. D. de Almeida Castanho et al.

A. D. de Almeida Castanho et al.

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We thank the reviewer for the valuable comments. All the comments have been addressed and we have made the appropriate clarification requested by the reviewer in the manuscript.

Authors Response to the General Comments from Referee #3:

The paper does not intend to define a ratio that should be used in all urban areas in the world, we are making it clearer in the manuscript so there is no doubt about it (Page 2, Line 15, Page 21, Line 19). The paper presents results from unprecedented field measurement showing that in Mexico City the ratio of blue (0.47 μm) and red (0.66 μm), to near-infrared (2.1 μm) varies depending on types of surfaces

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in urban (roofs, asphalt) and non-urban (vegetation) areas. The results were compared to a reference library of surface reflectances of urban and vegetation scenes (roads, parking lots, roofs, vegetations, dry grass, etc.). The finger prints of these different types of surfaces show that the urban elements present higher ratios than the vegetation. The results retrieved from satellite in this work are in agreement with the reference library considering that it is a an average of 1.5 km box that contain different fractions of urban as well as vegetation depending on the urbanization level of each region. We noticed a decrease in the ratio with increase in vegetation among the regions (in between the UNAM and Corena sites). This paper intends to show that 0.73ś0.06 ratio obtained for the Mexico City urban area is larger due to urbanization. This ratio strongly depends on different urbanization levels, different fractions of urban to vegetation, different materials and so on. If this value is not considered, it can produce an overestimation of the satellite AOD retrieval over Mexico City. The same may happen over other urban areas. We strongly encourage similar analyses in other urban areas to enhance the development of a parameterization of the surface ratios accounting for urban heterogeneities. This issue was clarified in the text (Page 2, Line 13; Page 20, Line 17).

Other comments:

Referee Comment: 1. The title: “Urban Visible/SWIR surface reflectance ratios from satellite and sun photometer measurements in Mexico City,” does not seem to capture the overall theme of this study. The study is about aerosol retrieval from satellite measurements over Mexico City and the title ought to reflect that.

Authors Response: The referee is right and we accept to change to a title that better represents our findings. The new title is: “Analysis of Visible/SWIR surface reflectance ratios for aerosol retrievals from satellite in Mexico City urban area”

Referee Comment: 2. A flow chart showing steps followed in the quality assurance would be easier to follow and is recommended.

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Authors Response: For the purposes of this paper, we believe a flow chart is unnecessary. We clarify a few points in the text and description of the methodology to address this comment by the reviewer (Page 9, Line 11).

Referee Comment: 3. Only 4 out of 9 pixels are averaged to simulate reflectance at 1.5 km resolution. Certainly this results in under sampling and introduces a bias in simulated reflectance. The authors need to address this issue.

Authors Response: This methodology was applied to minimize cloud or shadow contamination in the pixels following MODIS algorithm procedures. It was safer to average 4 of 9 pixels rather than increase the risk of contamination by clouds or shadows in the average. We also tried a symmetric filtering of the pixels by discarding only the highest and the lowest reflectance values. Comparison between the two approaches did not show any bias at all in the final AOD and surface ratios products. In conclusion we decided to be more conservative and avoid a possible contamination in the pixels giving priority to darkest pixels once there was no bias observed in final products. This issue has been better addressed in the manuscript (Page 9, Line 22).

Referee Comment:4. MODIS Level-1B reflectance data at 500 m resolution is used to compute the standard deviation of the reflectance at 0.66 μm. It is not clear how the authors obtained 500 m resolution data given that MODIS does not have 500 m resolution band at 0.66 μm.

Authors Response: The MODIS L1B product (MOD/MYD02HKM.A*.hdf) provides 500 m resolution data at 0.66 μm, because. MODIS bands #1 and #2 (0.66 μm) are acquired at 250m spatial resolution, while bands #3 to #7 are acquired at 500 m spatial resolution. Therefore, MOD/MYD02HKM.A*.hdf provides data at 500m spatial resolution for bands #1 through #7.

Referee Comment: 5. Page 8119, lines 1-13. The authors need to show wavelengths, bandpasses, and other important optical characteristics specific to the five Microtops-II instruments.

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Authors Response: The characteristics and wavelengths of the instruments are presented in Table 1. However, following the referee's suggestion, we added in the text that the filters used in all channels have a peak wavelength precision of ś1.5 nm, and a full width at half maximum (FWHM) band pass of 10 nm. (Page 7, Line 17). Some of the cited references may contain more detailed information about the Microtops, which we do not need to repeat in this paper.

Referee Comment: 6. Page 8120, lines 10-11. Microtops II calibration (against Cimel sunphotometer) was done on March 2-4 and March 25-27 and no calibration in between. It is not clear how the authors determined the calibration for March 5-24.

Authors Response: The calibrations strategy is a compromise between the quality of the data and the maximization of measurements. We decided to make two periods of calibration in the beginning and at the end of the experiment to analyze how the calibration coefficients changed during one month. From the calibration analyses we didn't notice any trend in the calibration coefficient from the beginning to the end of the experiment. Therefore only one set of calibration coefficients were used for the whole period for each instrument. Also, the Microtops instruments have showed stability for longer periods of time, well over the 21-day period between our calibrations. We added a comment on this in the manuscript (Page 9, Line 7).

Referee Comment: 7. Page 8121, line 4. "The Aerosol optical properties were analyzed using AERONET measurements from 1999-2000." And then on page 8122, line 14 "Aerosol optical properties were defined using the AERONET database from 2002 until 2005." The authors need to confirm that the intervals are correct?

Authors Response: The correct period of the optical properties analyses was from 1999 to 2005. The period from 2002-2005 was used on the validation comparison between AERONET and MODIS retrievals in this work. These corrections have been added to the manuscript (Page 11, Line 20).

Referee Comment:8. Page 8123, line 8. Do the authors mean "sensor zenith angle $>$

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40_” or “sensor zenith angle $<$40_?”

Authors Response: The correct one is sensor zenith angle $<$ 40, and it has been corrected in the manuscript (Page 12, Line 18).

Referee Comment: 9. Page 8123, line 12. It is not clear how the “scattering angle $>$ 140_” relates to “BRDF effect” as implied in this sentence.

Authors Response: This has now been corrected in the manuscript (Page 12, Line 21). We meant to say that the surface reflectance is non Lambertian, as shown in the changes in the ratio VIS/SWIR as a function of scattering angle. This difference is significant for larger scattering angles and has to be taken into account as is done in MODIS collection 5.

Referee Comment: 10. Page 8124, line 5-6. The “.... the blue ratio results are presented in Fig. 2b just as a reference, and will not be considered any further in the rest of this paper.” The reviewer then wonders how the authors obtained aerosol optical depth at 550 nm as shown in Figure 5, if not through interpolation of blue and red bands.

Authors Response: The blue band from MODIS was not used to interpolate the AOD with the red band. This procedure would infer larger uncertainties into the analyses, once the surface reflectance ratio in the blue would also have to be estimated. The retrieval is based on a lookup equation that relates the TOA reflectance (at 0.66 μm) to an aerosol optical depth (at 0.55 μm), for a given surface reflectance, aerosol optical model, and satellite and solar geometries. The AOD at 0.55 μm is extrapolated to 0.66 μm and used for the computation of the TOA reflectance at this wavelength. The extrapolation of the AOD is based on the spectral dependence of the aerosol optical properties that we assumed based on the AERONET measurements. The lookup equations were defined based on simulations of the TOA reflectance for several aerosol optical depths using SBDART under the relevant conditions (surface reflectance, geometry, water vapor amount). This information has been clarified in the

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manuscript (Page 18 , Line 21)

Referee Comment: 11. Page 8124, line 8. “The reflectance of an aerosol layer ....” The reviewer recommends the use of “scattering” instead of “ reflectance” in this sentence.

Authors Response: We accepted the suggestion and changed to “scattering”, as this is the appropriate word for that description.

Referee Comment: 12. Page 8125, line 10. “.... analysis of the surface spectral reflectance over urban areas requires a high spatial resolution due to the heterogeneity of the surface cover” and then on line 17, “.... the 4 m resolution can still have a mix of different surface materials or shadows ....” As the authors may have discovered increasing the spatial resolution does not necessarily improve surface homogeneity, but might make it worse. A lower spatial resolution data (e.g. 10 km) would be preferable in order minimize BRDF effects from small structures, shadows, etc. In this study the effect of BRDF on the new ratio was not addressed and may be important.

Authors Response: We notice that (Page 12 ,line 22) over the same pixel, there may still be significant variability from one day to another, and one of the factors affecting this can be due to a BRDF effect. However, with this data set that we have available, it is hard to make conclusions on the BRDF effect. On the other hand, as the referee indicated previously, the Cloud Absorption Radiometer instrument on board the J31 aircraft can help to better understand the BRDF effect in Mexico City urban area, and this has been highlighted in the manuscript (Page 13, Line 1), and is expected to be the subject of a different study. The most reasonable conclusion that can be drawn with our data is that on average, the analyzed urban sites showed ratio values of 0.73 ś 0.06 for scattering angles lower than 140ž and 0.77 ś 0.06 for larger ones. Furthermore, due to high spatial variability, we concluded that validation can best be performed by averaging at 10x10km spatial resolution.

Referee Comment:13. Page 8127, line 4, delete “for.”

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Authors Response: It has been deleted.

Referee Comment: 14. Page 8127, line 9, the authors recommend use of the ratio of 0.73 over urban areas based on their results from Mexico City. But there is not enough evidence to show that the new ratio would work in other urban cities.

Authors Response: As we discussed in the general comments, this manuscript does not claim that the value 0.73ś0.06 is applicable to all urban areas. We presented this value as representative of Mexico City urbanized areas. The paper shows that over the urban areas of Mexico City there is an increase in the visible/NIR ratio that, if not taken into account, can cause significant overestimation in AOD retrievals from satellite. This issue was made clearer in the manuscript (Page 2, Line 13, Page 20, Line 17).

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 8113, 2007.

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