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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Calibrated sky imager for aerosol optical properties determination" *by* A. Cazorla et al.

**A. Cazorla et al.**

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Answer to reviewer #3

We would like to thank reviewer #3 for his helpful comments on the paper, we think that the criticism raised by the reviewer will be very useful for the improvement of our manuscript.

Starting with the criticism on the election of AERONET and CIMEL sun photometer, despite its limitations, we must say that the present manuscript represent a first step in a study that analyzes the capability of the Whole Sky Imager, WSI, to retrieve the microphysical properties from the sky radiance measured with it. A second paper that is in preparation will present the procedures to use the full potential of the WSI using similar algorithms to those used by AERONET with CIMEL radiometer data. On the



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other hand, this manuscript presents the extension and improvements of the procedure developed for a non-calibrated CCD Sky Imager (Cazorla et al., 2008a, 2008b). Obviously, as the reviewer suggests, the use of other instruments in operation at the ARM Southern Great Plains (SGP) could be considered for a future work.

Concerning the criticism on the 'radiance and cloud screening uncertainties' we will include appropriated information on the revised version. In our answer to specific comments, see bellow, we offer some answers to the reviewer's critiques.

In the next paragraphs we will answer to the reviewer's specific comments.

1) We agree with the reviewer in his comment on about temporal resolution. Nevertheless, our interest in the comparison between AERONET CIMEL radiometer and the WSI derived aerosol optical properties is due to the more ambitious goal of using the WSI radiances to retrieve the microphysical properties of the atmospheric aerosol, an aspect that represents the second step after the study presented in this paper. As stated above, the reviewer's suggestion on the comparison of our aerosol optical depth retrieval procedure against other instruments in operation at ARM SGP will be considered as a future work.

2 and 6) The data set used in this work has been selected with rigorous criteria. As a first step WSI radiances associated to images labeled as cloudless with the WSI algorithm has been selected and AERONET level 2 data has been used, doubtful cases has been rejected. Nevertheless, in the revised version additional details, published elsewhere, on the cloud retrieval algorithm of WSI will be included.

3) Following the suggestion of the reviewer, in the revised version of the manuscript we will include the adequate description of the WSI design, operation and the measurements uncertainties of the various characteristics relevant to the use of our retrieval algorithm. Nevertheless, we must say that all the references included in the paper that may not be directly accessible can be requested to the Atmospheric Optics Group at Scripps, in fact this is the way the Granada team co-authoring this paper got ac-



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cess to them some years ago. Moreover, the ARM program has a description of all of their instruments and the WSI description with a handbook that can be easily find (http://www.arm.gov/publications/tech_reports/handbooks/wsi_handbook.pdf). In this sense we will include this handbook on the reference lists.

In reference to the radiances uncertainties associated to the WSI, as can be read in the above mentioned handbook the radiance calibration constant can be retrieved with a 0.5% uncertainty, but this not mean that the radiance uncertainty reach this value because, as the reviewer states the calibration lamps used presents an uncertainty around 2-3%. This means that the final uncertainty associated to the radiances provided by the WSI will be slightly above 3% and likely 5% will be a more conservative value. This level of uncertainty is in the range of that associated to the radiance calibration of CIMEL radiometers (Alados-Arboledas et al., 2008).

4 and 7) As stated above our interest on the comparison of our retrieval procedure applied to the WSI has two main reasons. By one hand, is part of a study that will use retrieval algorithms similar to those used in the inversion of CIMEL radiometer data (Olmo et al., 2006) to retrieve the microphysical properties from the WSI radiances. At the moment a different approach using a non-calibrated CCD Sky Imager has been approached by some of the authors of the paper under discussion (Olmo et al., 2008). On the other hand, we have tried to apply to a radiance calibrated CCD system, like WSI, procedures similar to those successfully applied to a non-calibrated Sky Imager (Cazorla et al, 2008b). Nevertheless, testing our retrieval procedure of aerosol optical depth against additional instrumentation at ARM SGP could be part of a future study.

5) The question on the temporal resolution and the time needed to obtain a complete set of spectral images with WSI will be clarified in the revised manuscript. Nevertheless, we must say that the resolution of the WSI in the data set used in this work was 6 minutes. However, this time can be adjusted (it cannot be adjusted at the SGP site since the instrument is not available anymore). The images are acquired in milliseconds and the rotation of the filters does not take very long. The acquisition of the



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almucantar or principal plane radiance by CIMEL radiometers takes several minutes, whereas the sky cameras measures those planes in one snap.

8) MBD has been computed, in the usual way, as the summation of differences between WSI estimates and CIMEL estimates, of the different variables, divided by the total number of data. The RMSD has been computed as the squared root of the result of summing up the square of the differences between WSI estimates and CIMEL estimates, for the different variables, divided by the total number of data. The appropriate formulas, not expressed here due to the requirement of plain text, will be included in the revised version of the manuscript.

9) Following the reviewer's suggestion we will consider the future test of our retrieval procedures against data sets acquired at other locations that combine WSI and CIMEL or MFRSR.

10) As indicated above, the final goal of the complete study, that includes as a first step the analyses presented in this paper, is the retrieval of aerosol microphysical properties from the WSI radiances. In this sense we have focused our study on hemispherically cloudless skies. On the other hand, the use of principal plane radiances for the retrieval of aerosol optical depth, following our algorithm requires the use of these hemispherically cloudless skies

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