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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Atmospheric aerosol characterization with a ground-based SPEX spectropolarimetric instrument" *by* G. van Harten et al.

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We thank the two referees for their thorough reviews.

This publication is part of a cluster of publications about the SPEX instrument concept that have been submitted to various journals. The referees are fully correct in remarking that several other publications that are referenced in this manuscript were not yet published at the time of submission. However, the two most relevant publications are now online: Di Noia et al. (2014) (http://www.atmos-meas-tech-discuss.net/7/9047/2014/amtd-7-9047-2014.html) describes in detail the

retrieval algorithm that was adopted in this manuscript, and Van Harten at al. (2014b) (http://www.opticsinfobase.org/ao/abstract.cfm?URI=ao-53-19-4187) describes the transmission correction algorithm that is used for post-facto calibration. The references Van Harten et al. (2014a) and Rietjens et al. (2014) are much more general and not directly pertinent to any of the conclusions drawn in this paper.

It is clear that we need to introduce more concisely the particular goals of this publication, also in the context of the other papers. We emphasize here (and we will emphasize in the revised manuscript) that first and foremost this paper describes the as-built groundSPEX instrument, its calibration and error analysis, and the foundation for the forward error propagation through a retrieval algorithm to derived aerosol parameters. For this study, we adopt the retrieval algorithm of Di Noia et al. (2014), but obviously also other and future algorithms can be used. As this instrument has only recently been commissioned for operation, a complete statistical comparison of aerosol parameters with large amounts of AERONET data beyond the results that are presented can only be left for future work. We will gratefully adopt the suggestion of reviewer #2 to compare raw groundSPEX and CIMEL data, i.e. radiometry (441, 675, 870 nm) and polarimetry (870 nm) as a function of pointing angle, for the four days that co-located data were acquired. We are currently analyzing the raw data and are producing plots that will feature in the revised manuscript. This will indeed yield a better split-up of the intrinsic measurement errors and the intrinsic retrieval errors. We will also explain better the procedures for radiometric calibration, which are intimately linked to the radiometric calibration of the CIMEL.

Moreover, we emphasize here and in the revised paper that the goal of groundSPEX is not to match or surpass the ability of AERONET to obtain highly accurate AOT data. Our contribution with groundSPEX to the existing atmospheric measurement techniques is the end-to-end demonstration of microphysical aerosol characterization capabilities of a novel polarimetric technique. The direct added value w.r.t most CIMEL instruments is polarimetry at all wavelengths at high accuracy, as demonstrated in the manuscript. This is crucial to unambiguously retrieve several (complementary) aerosol parameters, most notably microphysical parameters like the size distribution and complex refractive index (i.e. chemical composition). These parameters are constrained differently, if not better than with CIMEL radiometric measurements. Quantitative measurements of such microphysical parameters are for instance crucial to better understand the relations between aerosols and health, and between aerosols and climate. Retrievals of groundSPEX data yields several aerosol parameters, like size distribution and refractive index, but also diffuse-sky AOT, which are all determined simultaneously to provide a best fit to the multi-dimensional data. The AOT of AERONET is the only direct measurement, providing accurate data and reliable error bars, and is therefore used for a fair comparison on the level of derived parameters. And even though groundSPEX does not perform direct-sun measurements, the retrieved groundSPEX AOT data does not appear to be of "notably lower accuracy" (see e.g. Fig 5), although we readily admit that the accuracy is of course a bit worse. The error in the AERONET direct-sun AOT is typically 0.01 with an upper limit of $\sim$0.02 [Dubovik et al, JGR 105 (2000)]. The uncertainty mainly comes from the transmission degradation of the interference filters. Therefore, for level 1.5 data without post-calibration, we adopt 0.02 as error bar.

Indeed, CIMEL now also offers four polarimetric bands at visible wavelengths; the one at Cabauw only offers polarimetric data at 870 nm, and hence it has the potential for better constrained aerosol retrievals [Li et al, JQSRT 110 (2009)]. However, its polarimetric implementation is susceptible to temporal variations and polarization-dependent transmission degradation, whereas the SPEX concept enables snapshot measurements with high intrinsic polarimetric stability. In this paper we explore the benefits of this novel polarimetric measurement technique. In the revised paper we will provide a detailed comparison of the polarimetric implementation for both instruments. We perform a comprehensive error analysis for the as-commissioned groundSPEX instrument, identifying both systematic and random errors, and their propagation to the retrieved aerosol parameters. Complete benchmark data products from the polarimet-

ric mode of the CIMEL are, to our knowledge, unfortunately not available for detailed comparison of retrieval parameters like particle size distribution and refractive index.

Furthermore, SPEX spectropolarimetry also permits the measurement of polarization in spectral bands, like the O2A band, which enables retrieval of aerosol stratification. Finally, groundSPEX furnishes an excellent test-bed for future satellite observations with a SPEX instrument, as the measurement concept of the CIMEL is just too different.

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