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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol physical and chemical properties retrieved from ground-based remote sensing measurements during heavy haze days in Beijing winter" *by* Z. Q. Li et al.

Anonymous Referee #1

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Review for Atmospheric Chemistry and Physics Discussions

Title: Aerosol physical and chemical properties retrieved from ground-based remote sensing measurements during heavy haze days in Beijing winter

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General Comments: This paper presents an in depth study of two multi-day haze events that occurred in Beijing in February 2011 (2 days duration) and February 2012 (3 days duration). Some of the results are interesting and the authors present a very nice comparison of Black Carbon (BC) mass as inferred from the remote sensing (col-

umn integrated) to in situ measurements at the ground. However, the discussion of the boundary layer depth in relation to conversion of column mass BC to surface concentration is somewhat weak. Boundary layer height and aerosol layer height are often quite different depending on the way boundary layer height is defined. Please state in your paper how Zhang et al. (1990) determined boundary layer height. There are several lidars operating in Beijing, therefore a much better estimate of the aerosol layer height should be available.

Some other analysis and results are not convincing and should be either redone or removed from the manuscript. Using only 5 days of data to construct an aerosol model typical of winter heavy haze days in Beijing is not robust (and is in fact misleading), especially when a much larger sample size of data are available. For example you could use all of the AERONET data at Beijing (many years of data are available) during winter months at high AOD (>1.5 at 440 nm) to construct a more robust winter haze model and this would also enable a rigorous analysis of variability of these types of events. For example, you should note that the relationship between PM2.5 and AOD (500 nm) based on these two haze events will not always be as accurate as suggested by the linear regression presented in Fig. 12. In fact the extreme pollution event that occurred in Beijing on January 11, 2013 had PM2.5 > 800 mg/m3 and AOD (500 nm) $\sim$1.5, therefore your linear regression equation would have yielded an estimate of PM2.5 that is about 800% too low!

Other aspects of the paper where I recommend revision or additional analysis are discussed below in the Specific Comments.

Specific Comments:

Page 5094, line 12: AERONET direct sun measurements are made every 15 minutes, not 10 minutes as you say in this sentence.

Page 5094, Section 2.1: Please state whether the data you present in this paper is AERONET Level 1.5 or Level 2.0 data. Additionally you discuss the direct sun calibra-

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tion (lines 19-25) of the Cimel sun-sky radiometer but do not provide enough specifics. For instance the Litang mountain Langley site is not considered a standard mountain Langley site for AERONET (Mauna Loa and Izana are). Therefore please provide some specifics on the AOD levels at this site during the Langley measurements and the repeatability of the Vo values obtained from the Litang site. Also give an estimate of the AOD uncertainty that results from this calibration and compare it to the $\sim$0.01 to 0.02 uncertainty for field Cimels, and 0.002 to 0.009 for Langley calibrated reference Cimels in AERONET (Eck et al., 1999). Regarding the vicarious calibration for sky radiances, please give an estimate of the calibration uncertainty since the vicarious method is not discussed in Holben et al. (1998) as you suggest.

Page 5095, lines 2-3: This sentence is confusing since sky dimming (irradiance reduction) is more closely related to AOD and not visibility, since visibility is weighted by near surface concentrations and not total column concentrations.

Page 5095, lines 5: Please explain why RH<90% was selected as your threshold since fog has 100% RH, so why not use a higher RH threshold, say 95%?

Page 5095, lines 15-16: Please revise this sentence to explain that higher Angstrom exponent can mean either more fine mode particles relative to the coarse mode particles or it could also be due to smaller radius fine mode particles (fine mode radius can vary substantially due to coagulation, humidification, and/or cloud processing).

Page 5095, lines 17-19: Please reference Sinyuk et al. (2012) regarding the measurement limitation of AERONET Cimels, which is 10 counts at 440 nm in AERONET and that this threshold is related to the issue of diffuse scattering into the instrument FOV. Also state in the text whether the 440 nm raw counts actually approached the 10 count cutoff value for the observations presented in this paper.

Page 5096, lines 1-3: In section 2.1 you suggest that the data you present in this paper are AERONET data, yet it seems that the ground reflectance that you used is not consistent with AERONET. You used MODIS surface albedo from Li et al (2006)

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while AERONET uses the MODIS derived data base described by Moody et al. (2005) in conjunction with ecosystem based BRDF models (also from MODIS) to account for the large variation in albedo as a function of solar zenith angle (see Eck et al. (2008)). Please explain why the data processing you applied is not consistent with AERONET and make it clear that there are differences in the way you have processed this data.

Page 5096, lines 3-5: The Smirnov et al. (2000) cloud screening describes the use of triplet stability and also the 2nd derivative of the AOD in time to filter spikes, for cloud screening of the AOD data. The almucantar asymmetry check (not mentioned at all in Smirnov et al. (2000)) is done for additional cloud screening of the sky radiances prior to input to the Dubovik retrieval algorithm and is described by Holben et al. (2006; SPIE).

Page 5097, lines 17-20: Note that not all coarse mode particles in China are dust particles, some are fly ash emitted during coal combustion.

Page 5097, lines 24-26: It should be noted that the spectral variation in SSA as a function of Angstrom or Fine Mode Fraction was shown in much more detail from the AERONET Beijing site climatology in Eck et al (2010).

Page 5099, lines 20-23: In addition to volume percentage please also give the AOD of each mode, as the fine mode AOD and coarse mode AOD are also output computations of the Dubovik AERONET retrievals. Volume is somewhat misleading for these haze cases since a relatively large volume of coarse mode particles yields a relatively low value of AOD.

Page 5100, lines 20-22: The values of the real part of the refractive index at 675 nm are 1.50 in 2011 and 1.48 in 2012, which are almost equal given the uncertainty of the retrieval for this parameter. Therefore I don't think you can state with much confidence that there is more water in the 2012 event.

Page 5101, lines 19-23: This discussion of the high dust loading in winter is very

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misleading since for the cases presented in this paper the coarse mode fraction of the AOD is only ∼3 to 10% of the total AOD at 440 nm. In other words the Fine Mode Fraction (FMF) of these cases range from 0.90 to 0.97 at 440 nm, thereby these are pollution-dominated events with likely a significant amount of the coarse mode composed of fly ash and not desert dust. FMF of optical depth is more important than fine or coarse volume ratio in the context of aerosol radiative effects.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 5091, 2013.