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Atmospheric Measurement Techniques Discussions

Interactive comment on "Columnar aerosol size distribution function obtained by inversion of spectral optical depth measurements for the Zanjan, Iran" *by* A. Masoumi et al.

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First of all, we are grateful to the anonymous referee #2 for his/her comments/suggestions.

General comments

This study examines the aerosol size distribution over the arid environment of Zanjan in northwestern Iran. More specifically the authors used an inversion scheme for the retrieval of the aerosol size distribution from sun photometer measurements. In this *field there are already some widely used algorithms, like King's inversion method, the algorithm by Dubovik and King used also in AERONET and the algorithm of Nakajima applied for measurements of the PRIDE sun photometer. These widely used algorithms are not discussed in the manuscript and the authors do not emphasize on the usefulness of their proposed methodology. Moreover, the results obtained are not compared at all with those of the aforementioned algorithms, which is a critical point for the justification of the method used. Since the results are somewhat interesting and the new method proposed may be also applied in other regions throughout the world I believe that more sensitivity analysis and comparison with other algorithms must be done in order the manuscript to warrants publication in AMT.*

At first, we affirm that this paper doesn't state new technique for determining aerosol size distribution (ASD) and it is only an old technique that applied for our region data. We are at the beginning of the way and we are only team in the extensive and important region ($\sim$ 1800 $\times$ 3000 km^2) of the world that study aerosols. We installed the sunphotometer (SPM) on the autumn 2006. We initially reviewed papers and saw some old techniques about retrieval of aerosol size distribution (ASD) from AOD and used these techniques for retrieval of ASD. In this paper, we used sun-transmitted light at different wavelengths for determining ASD. It is now used sun-scattered light that received at different scattering angles for ASD determining. The new methods such as AERONET inversion method are more accurate than our used method because of more ($>$22) scattering angles instead of our method that used 4 AODs. Our method only gives semi-quantitative ASD that conforms somewhat to results of new methods. We will add a paragraph to a section Method of revised paper and discuss other techniques in it. We also add a section to revised paper and will show our method and AERONET method results in it that is described hereunder replying first specific comment.

Specific comments

It is really unexpected that the authors used a refractive index without imaginary part (purely scattering aerosols) since it is well known that the dust, especially in UV, has a significant absorption. The refractive index is an important parameter for retrieving the aerosol size distribution. The inclusion of an imaginary part how much would differentiate the results? This is a critical point of the article and the overall analysis.

We used the method of Ref. (King et al., 1978) that supposed aerosols as spheres with refractive index ($m' = 1.45 - 0i$). We now agree with you about using a precise aerosol refractive index and apply it. The detailed report is presented in here. Aerosols of our region are divided to urban-industrial and dust aerosols. First type is fine and we can suppose that as aerosols with radii smaller than 1 micron (submicron). The refractive index of them at 4 wavelengths 440, 670, 870 and 1020 nm are almost the same and are:
$m' = 1.40 - 0.02i$.
Dust aerosols commonly have radii $>$ 1 micron and refractive index of them is supposed as:
$m'(\lambda = 440nm) = 1.60 - 0.0030i; m'(\lambda = 670nm) = 1.60 - 0.0015i;$
$m'(\lambda = 870nm) = 1.60 - 0.0010i; m'(\lambda = 1020nm) = 1.60 - 0.0010i;$
We use now both previous and new assumptions of refractive index in our method. We retrieve ASD from both them and compare them with AERONET method conclusions for some days of this year for our station (IASBS station). For example, we exhibit 3 days results in here.

1. 7 Jan 2010. A day with minimum amount of AOD (τ_a (440nm) = 0.054) and large amount of Angstrom exponent (α = 1.77). The Fig. 1 and Fig. 2 are presented here. The only basic difference between old and new refractive indices is seen at very coarse aerosols that increase for new amount of refractive index. Dust aerosols radii

often are bigger than 1.9 micron (Ref: Dubovik et al., Journal of the atmospheric sciences, 59, 590-608, 2002) and results of method with new refractive indices confirm it. Also the supermicron aerosols volume concentration is increased slightly from 21% to 22% and other results of our method are almost unchanged.

2. 24 June 2010. A very dusty day with large amount of AOD (τ_a (440nm) = 1.451) and minimum amount of Angstrom exponent (α = 0.04). The Fig. 3 and Fig. 4 are presented here.
We see that for our method with new refractive index, amount of coarse aerosols is decreased, but amount of very coarse ones is increased instead. Also the supermicron aerosols volume concentration is increased slightly from 95% to 97% and other results of our method are almost unchanged.

3. 16 April 2010. A day with AOD (τ_a (440nm) = 0.113) and Angstrom exponent (α = 0.75). The Fig. 5 and Fig. 6 are presented here.
The only basic difference between old and new refractive indices is seen at very coarse aerosols that increase for new amount of refractive index. Also the supermicron aerosols volume concentration is increased slightly from 67% to 69% and other results of our method are almost unchanged.

Finally, we see that general behavior of ASD at our method is similar to AERONET method results especially for fine and coarse aerosols. But our method results are semi-quantitative and its accuracy is less than new methods. On the other hand, applying accurate refractive index in our method doesn't have considerable changes in results and only move boundary of fine and coarse modes from $\alpha \sim$ 1.2 to $\alpha \sim$ 1.3. We will add a section to revised paper and discuss effect of change of aerosol refractive index in it.

Over an arid environment as Iran is, I would expect a larger coarse mode fraction in the aerosol size distribution. However, in the discussion of the figure 1 the authors state "As it appeared in Fig. 1, even though always the number of very fine aerosols is more than other aerosol sizes, but for 82% of the days, number of coarse aerosols is more than fine ones and for these days alpha <1.2. For rest of the days, number of fine aerosols is more than coarse aerosols and alpha >1.2." This sentence is really confused and it has no good sense. I cannot understand if the number of coarse or fine aerosols is larger than that of the coarse-mode ones and in which case. Also, this is very hard to use as criterion for the discrimination between coarse and fine aerosols the alpha value 1.2. Some more clarification and discussion is needed here.

We define n(r) as the number of particles per unit of area per the unit radius interval, in a vertical column through the atmosphere (cm$^{-2}\mu$m^{-1}). But people often define n(r) as the volume of particles per unit of area per the unit logarithm of radius interval, in a vertical column through the atmosphere (μm^3/μm^2) in new techniques such as AERONET method. We wrote only that number of very fine aerosols always is more than other aerosol sizes and it is confirmed by Junge size distribution. But volume of aerosols is important in determining of fine or coarse mode. We also saw that for $\alpha < 1.2$ supermicron aerosols volume concentration is more than 50% and vice versa. We also applied new amounts for refractive index of aerosols and saw that boundary value of Angstrom exponent changed from $\alpha \sim 1.2$ to $\alpha \sim 1.3$ that is explained above.

Regarding the Fig. 2, it seems somewhat unexpected that all the 3 days to present aerosol size distribution with the same mode radii. I doubt if somebody can fix initially in the methodology-algorithm the radii values for individual aerosol sizes. The radii as well as the logarithmic stdev are usually retrieved by the algorithms (e.g King's algorithm, Dubovik's algorithm, Nakajima's algorithm).

We see that Angstrom exponent determines relative population of aerosols in the four mentioned classes of aerosol sizes and that the aerosol size distributions for days of constant α have almost the same behavior.

It is expected that the most of the cases would correspond to coarse-mode aerosol dominance over this arid environment. However, despite the fact that desert dust is the dominant aerosol type over the study location any discussion about desert dust, exposure, transport, etc is missing.

We stated about sources of desert dust aerosols in the subsection 4.2. and section 5. of the paper. We also used an output of NOAA ARL (Aerosol Resource Laboratory) HYSPLIT model (for example see Fig. 7.).

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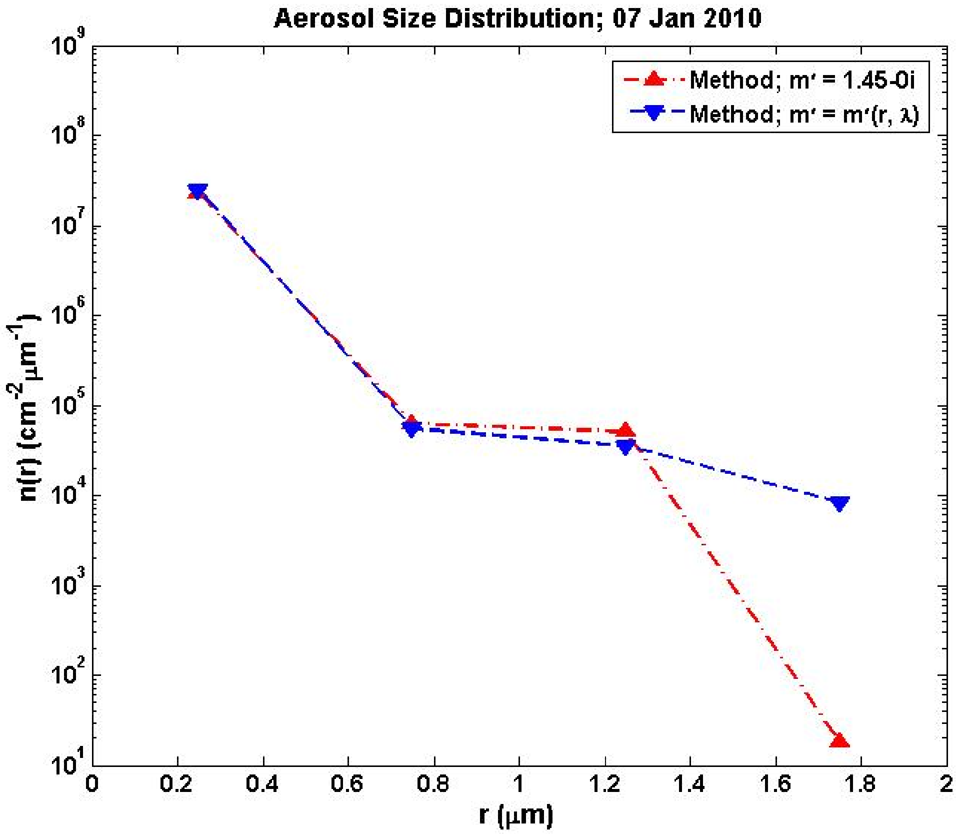

Fig. 1. Daily-averaged aerosol size distribution (1/ cm2 micron1) for 7 January 2010 for Zanjan, Iran. Our method is employed with old and new refractive indices respectively.

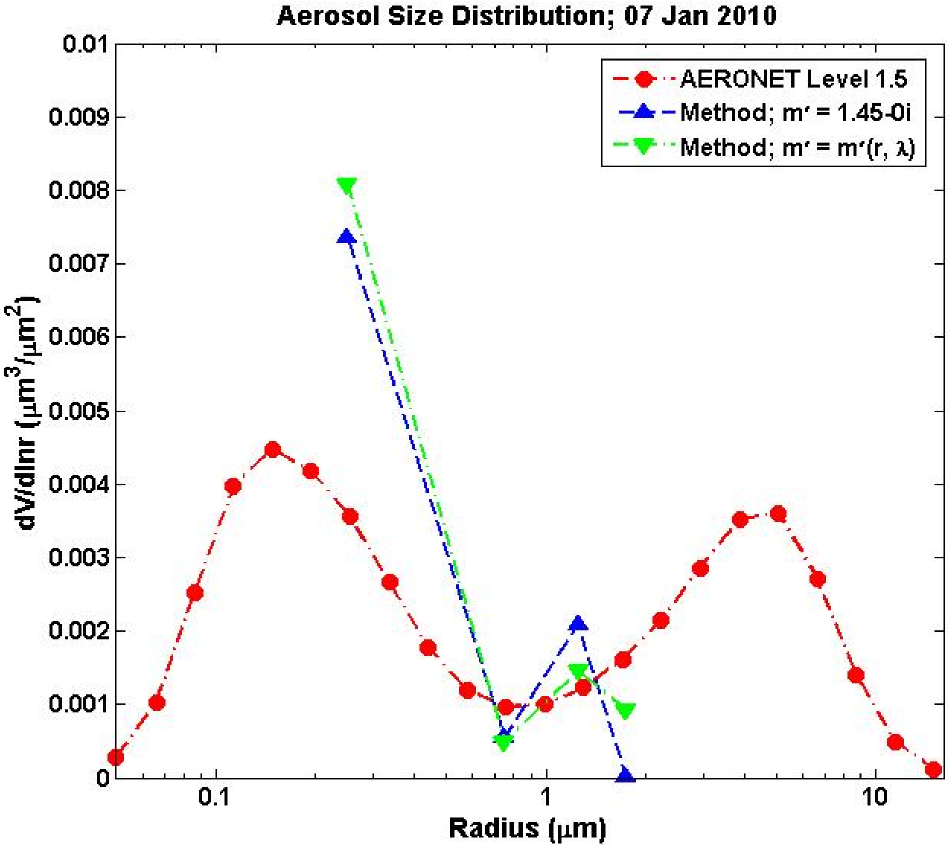

Fig. 2. Daily-averaged aerosol size distribution (micron3 /micron2) for 7 January 2010 for Zanjan, Iran. AERONET and our method with old and new refractive indices are employed respectively.

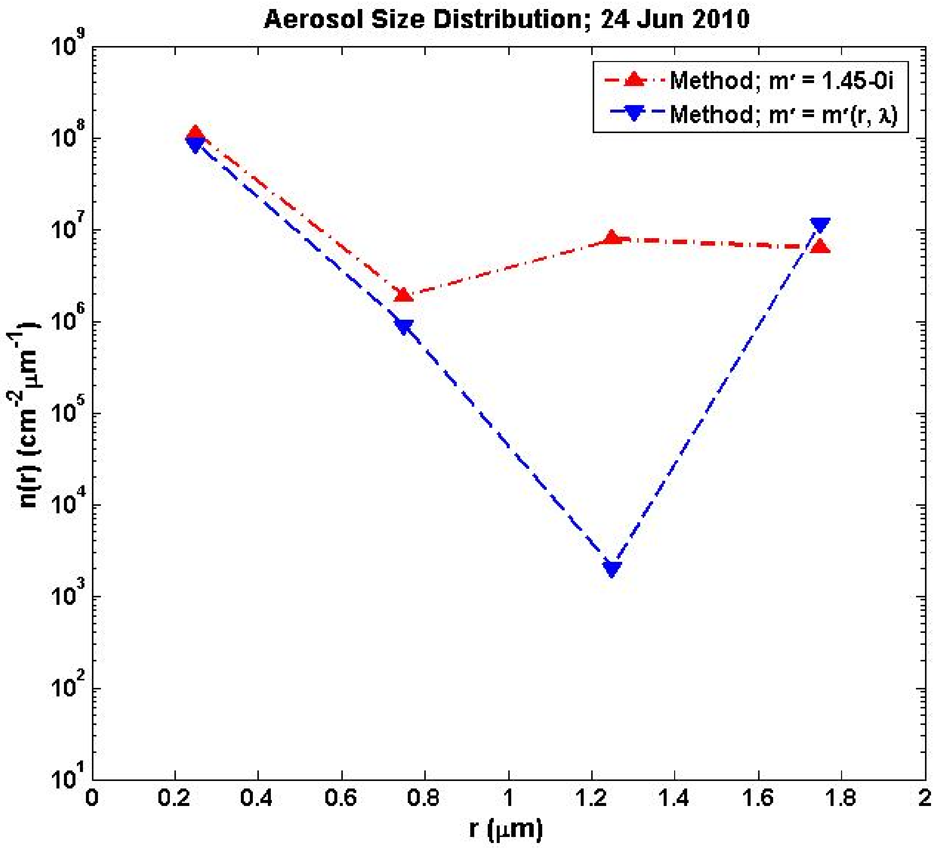

Fig. 3. Daily-averaged aerosol size distribution (1/ cm2 micron1) for 24 June 2010 for Zanjan, Iran. Our method is employed with old and new refractive indices respectively.

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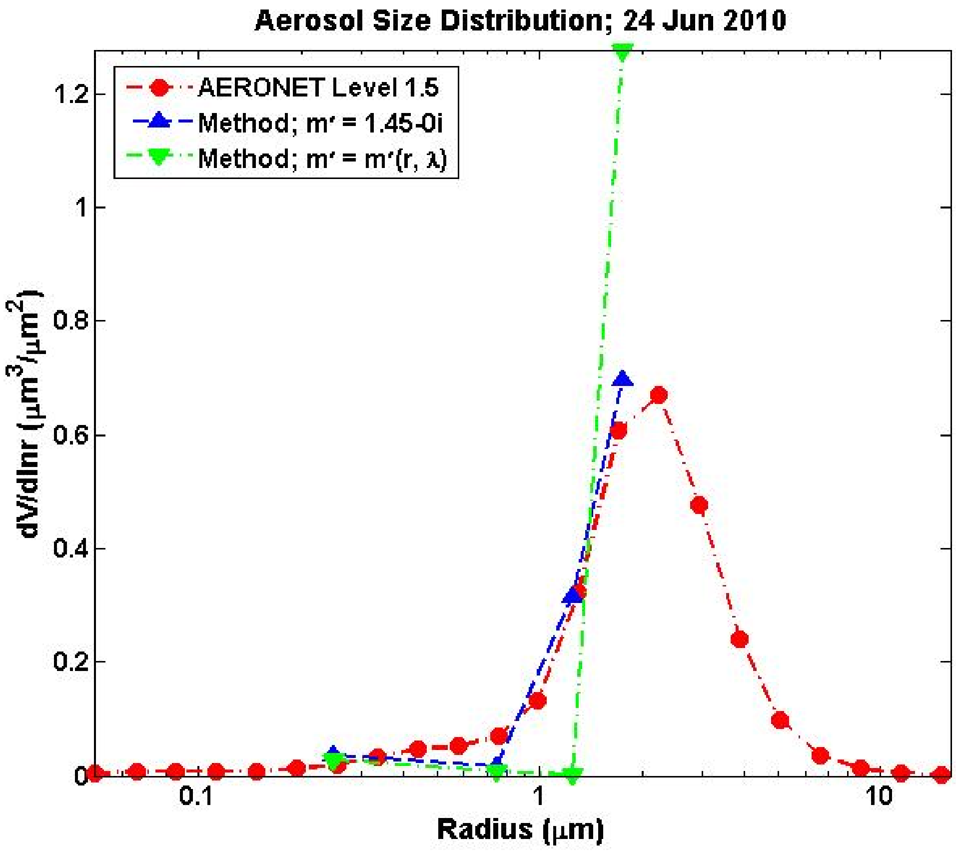

Fig. 4. Daily-averaged aerosol size distribution (micron3 /micron2) for 24 June 2010 for Zanjan, Iran. AERONET and our method with old and new refractive indices are employed respectively.

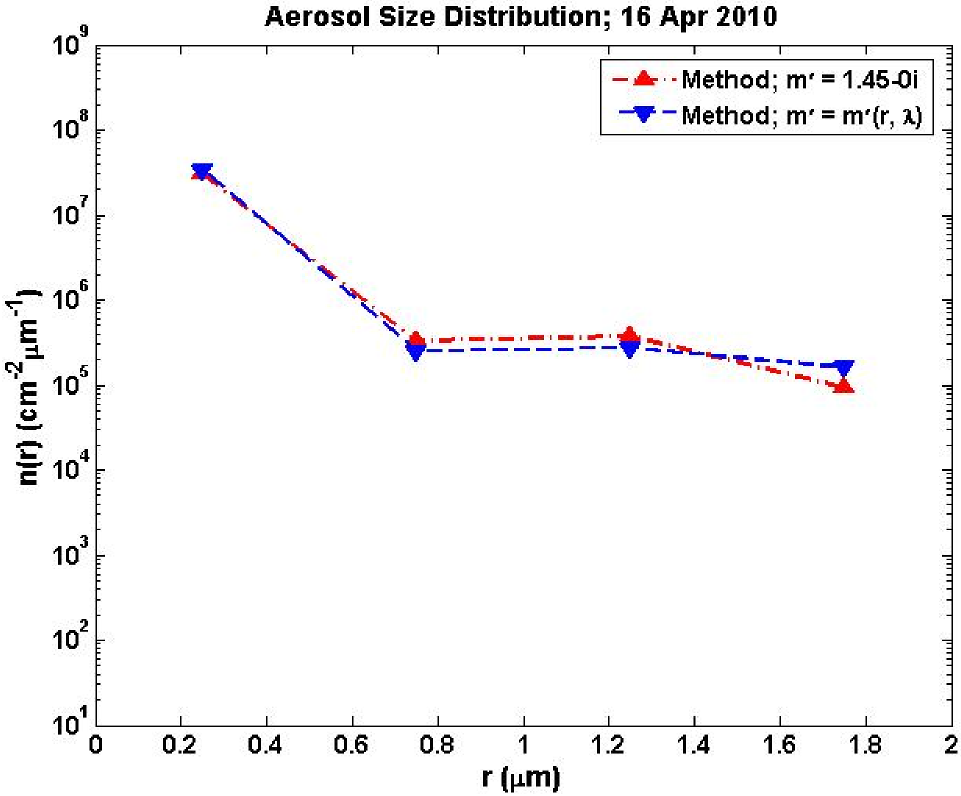

Fig. 5. Daily-averaged aerosol size distribution (1/ cm2 micron1) for 16 April 2010 for Zanjan, Iran. Our method is employed with old and new refractive indices respectively.

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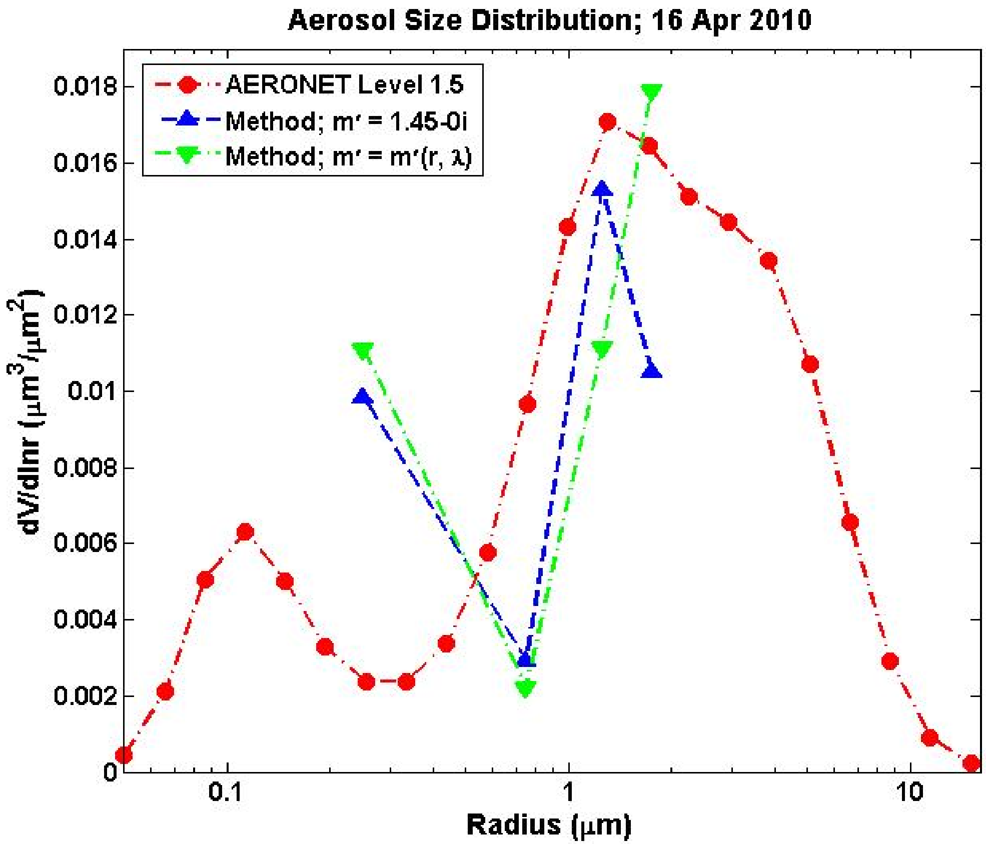

Fig. 6. Daily-averaged aerosol size distribution (micron3 /micron2) for 16 April 2010 for Zanjan, Iran. AERONET and our method with old and new refractive indices are employed respectively.