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Atmospheric
Measurement
Techniques
Discussions

Interactive comment on "An empirical model of optical and radiative characteristics of the tropospheric aerosol over West Siberia in summer" *by* M. V. Panchenko et al.

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Journal: AMT Title: An empirical model of optical and radiative characteristics of the tropospheric aerosol over West Siberia in summer Author(s): M.V. Panchenko et al. MS No.: amt-2011-145 MS Type: Research Article Special Issue: Remote sensing of aerosols and clouds (EGU 2011)

Reply to the comments made by Review#1

First, authors are very grateful to the reviewer for the hard work, highly professional analysis and very useful comments. All these comments will be taken into account in the revised version. We also will take all necessary measures to improve English in the

manuscript.

Major remarks:

1. It is very necessary for the authors to significantly improve English language. I am not a specialist in English, however, I see that almost every sentence should be checked.

We agree with this remark. Before final submission, we will send the text to http://languageediting.nature.com/ for the language check.

2. I would recommend to improve the structure of the text. The "part 2" can be moved to the "Introduction" after its stylistic improvement. The "Discussion" part should be added in the text. The "Introduction" is too small. It will be nice to see the brief description of other publications on aerosol vertical profiles and on radiative flux calculation approaches to underline the new features of the proposed approach

Yes, the structure of the manuscript will be changed. The "Discussion" section will be added to the text. The "Introduction" part will be expanded, and brief description of other publications on aerosol vertical profiles will be added. As for radiative flux calculations, we think that it is more appropriate to describe the features of our approach in "Radiation calculations" section. The broadband solar radiation fluxes in the molecular-aerosol, plane-parallel atmosphere were calculated using the Monte Carlo algorithm developed earlier [Zhuravleva et al., 2009]. The shortwave spectral interval 0.2–5.0 μm was divided into 31 subranges [Slingo, 1989]. The transmission function of atmospheric gases within each band was approximated by a finite exponential series (correlated k-distribution method, [Lacis and Oinas, 1991]) as in [Ricchiazzi et al., 1998; Clough et.al., 2004; Mayer and Kylling, 2005; Garcia et al., 2011]. Molecular absorption coefficients were calculated taking into account all atmospheric gases included into the AFGL model using the HITRAN2008 database and MT_CKD v.2.4 continuum model (http://rtweb.aer.com/continuum_frame.html). Results of the numerical simulation have shown that the errors in calculating the transmission function in the most considered shortwave ranges do not exceed 1%. The exceptions are two spectral regions 4.6-4.8 and 4.8-5.0 μm where the errors reach 5%. The use of more sophisticated method which accounts for overlap of the absorption bands of different gases [Firsov and Chesnokova, 1998] makes it possible to decrease this error to $\sim$ 1%. However, because the values of broadband radiative fluxes are of the main interest in this work, and the contribution of the aforementioned spectral regions into the total flux (0.2 – 5 μm) is less than 0.2%, we do not apply here this more accurate but laborious procedure. The Monte Carlo method was used for solving the radiative transfer equation within each of 31 subrange (forward photon tracing method), analogously to that described, for example, in [O'Hirok and Gautier, 1998; Mayer and Kylling, 2005]. It was assumed that the aerosol optical characteristics (extinction coefficient, single scattering albedo, scattering phase function of aerosol particles), molecular scattering coefficient and albedo of the underlying surface are constant within i-th subrange. The comparisons showed the numerical simulation results to be in a satisfactory agreement with the results of line-by-line calculations and the data of field measurements [Zhuravleva and Firsov, 2004; Tvorogov et al., 2008; Chesnokova et al., 2009].

3. It will be helpful if the scheme of the empirical model is included as a separate figure. This will help in better understanding the text. Otherwise there is too many pieces of different information, which is not easy to combine in mind.

The scheme of the model (figure) and its description are added to the text.

4. The abstract should include some details of the proposed aerosol model and the results of radiative calculation.

The abstract is expanded, and all required information is added.

Minor remarks.

All minor remarks concerning corrections of individual terms and sentences are taken into account in revised manuscript and all proposed corrections are made (items 1, 2,

3, 4, 7, 8, 9, 11, 12, 14, 17). Here we respond only to the items which require detailed explanation.

5. I would recommend to include a special table with the description of the instruments used in this study, the advantages and shortcomings.

Brief description of the instrumentation is added to text.

6. P. 142 line 16. Can soot absorption play any role in this assumption? This should be discussed.

At this stage the role of soot is insignificant, because here we assume that the aerosol is non-absorbing. Soot is introduced in calculations later.

10. P.146. line 9. It would be interesting to see the Figure describing these results.

The presented figures show comparison of the results of our calculations with experimental data on the degree of linear polarization of the scattered radiation (a) and spectral dependence of the ratio of the scattering coefficient at several values of relative humidity to the scattering coefficient of the aerosol dry matter (b). The experimental data are taken from (Kabanov M.V., Panchenko M.V., Pkhalagov Yu.A., Veretennikov V.V., Uzhegov V.N., and Fadeev V.Ya. Optical properties of coastal atmospheric hazes (Nauka, Novosibirsk, 1988)

See attachments: Graph1, graph2

13. P.146 lines 20-23. This is a quite interesting result. Do the SSA changes agree well with other data or models (in addition to Oklahoma airborne measurements)? Or the difference lies within an accuracy of measurements? Please, add some additional discussion.

Comparison of the obtained estimates of the average profile of the single scattering albedo with the data of airborne measurements available in literature is added to the text. But, some aspects of a technique complicate the comparison. a) Regular measurements of the vertical profiles of SSA are carried out mainly for dry aerosol [Han Z., Montague D.C., Snider J.R.: Airborne measurements of aerosol extinction in the lower and middle troposphere over Wyoming, USA, Atmospheric Environment, 37, 789-902, 2003; Andrews, E., Ogren, J. A., Sheridan, P. J., and Ferrare, R.: Vertical properties of aerosol optical properties at the ARM Southern Great Plains CART site, J. Geophys. Res., 109, D06208, doi:10.1029/2003JD004025, 2004; Taubman, B. F., Hains, J. C., Thompson, A. M., Marufu, L. T., Doddridge, B. G., Stehr, J. W., Piety, C. A., and Dickerson, R. R.: Aircraft vertical profiles of trace gas and aerosol pollution over the mid-Atlantic United States: Statistics and meteorological cluster analysis, J. Geophys. Res., 111, D10S07, doi:10.1029/2005JD006196, 2006; Andrews, E., Sheridan, P. J. , and Ogren J. A.: Seasonal differences in the vertical profiles of aerosol optical properties over rural Oklahoma, Atmos. Chem. Phys. Discuss., 11, 11939-11957, doi:10.5194/acpd-11-11939-2011, 2011]. b) Only few authors (for example, [Öström, 2000]) undertake attempts to simulate the SSA variations taking into account the change of aerosol parameters under the effect of real relative humidity of air. c) The main part of investigation is carried out for submicrometer aerosol, and the less part of papers reflect the properties of particles up to 10 μm. One should take into account this fact, because, according to the data of [Han et al., 2000; Andrews et al., 2011], vertical profiles of SSA of submicron particles and particles of larger size, including coarse fraction, are different. Also, the results obtained by different authors are obtained in different regions, different seasons, and in different height ranges. Taking into account the aforementioned ideas, we cannot correctly compare our data with the data of other authors. Nevertheless, in this paper we compare our data with the data on aerosol radiative characteristics obtained by Andrews et al., 2011. The data of long-term airborne measurements of the single scattering albedo and phase function asymmetry factors of dry aerosol are presented in this paper. Some data are obtained for the size spectrum containing, the same as in our model, both submicrometer and coarse fractions. Undoubtedly, there are objective differences in the geographical conditions of the regions of observations, dynamics of long-range transport of admixtures

and hence, different aerosol composition in the troposphere.

15. P.148, line 7. Do you use in RT modeling the scattering phase function or asymmetry factor? If you use only asymmetry factor, it is better not to show the additional characteristic here.

The scattering phase function was used for simulation of the radiative fluxes.

16. P.148. 4.1 Subsection. It would be interesting to see the results of the variant when the radiative parameters are calculated using the exact refractive index and size distribution from the empirical model. Please, discuss this in the text.

In subsection 4.1 we discuss, how critical is the use of the aerosol optical characteristics known in narrower wavelength range for simulation of broadband fluxes. This problem is well-known and arises in situations when experimental data are used for calculation of the radiative fluxes.

For example, Henzing J., et al., 2004: Effect of aerosols on downward shortwave irradiances at the surface: Measurements versus calculations with MODTAN4.1 // J. Geoph. Res. 2004. V. 109. D14204, doi:10.1029/2003JD004142; Michalsky J. J., et al., 2006: Shortwave radiative closure studies for clear skies during the Atmospheric Radiation Measurement 2003 Aerosol Intensive Observation Period // J. Geoph. Res. 2006. VOL. 111, D14S90, doi:10.1029/2005JD006341, 2006; Garcia O. E. et al, 2011: Shortwave radiative forcing and efficiency of key aerosol types using AERONET data // Atmos. Chem. Phys. Discuss., 11, 32647–32684, www.atmos-chem-phys discuss.net/11/32647/2011/doi:10.5194/acpd-11-32647-2011

We consider this problem using the OPAC model (Subsection 4.1). The results of radiative calculations, presented in Subsection 4.2, are obtained for exact size distribution and refractive index from empirical model.

18. P.149,. line 2. Did you calculate the flux or the dose as was mentioned on page 148? Please, clarify. The radiative fluxes were calculated in the range (0.2 -5 μm). The

specification will be added to text.

19. P. 149 line 1. You used the AOT=0.262 for this sensitivity study. Did you try larger values? The differences can be more dramatic. May be this should be reflected in the text.

Undoubtedly, the differences can be more dramatic at increasing AOD. However, according to the data of long-term satellite measurements over West Siberia and near-ground measurements in the city of Tomsk, the respective average values AOD in summer are close and are τa(0.5 μm) $\sim$0.16. As the empirical model is developed for West Siberia, in this paper we consider only the conditions corresponding to the peculiarities of this region. Brief comment will be added to text.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/5/C447/2012/amtd-5-C447-2012-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 137, 2012.

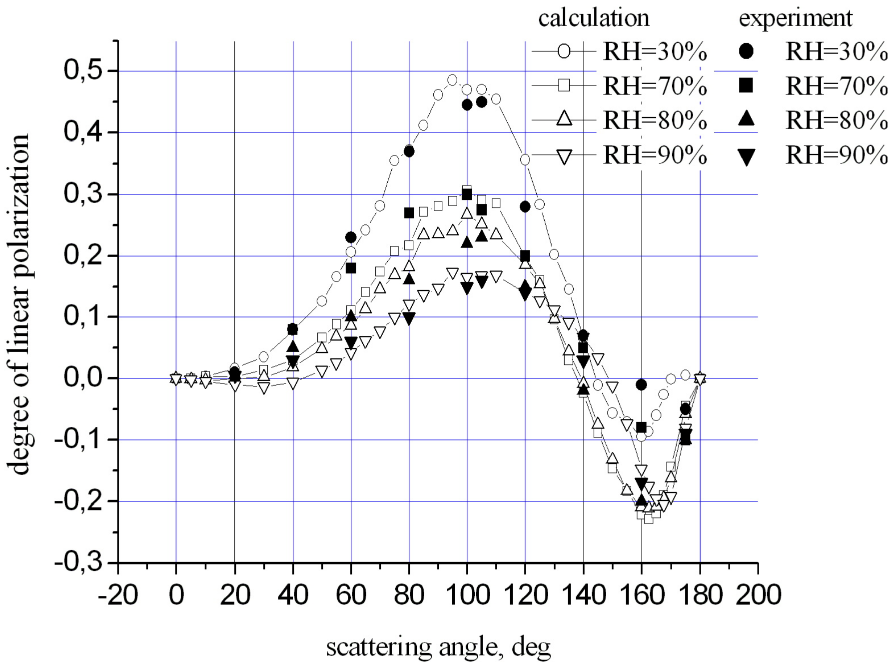

Fig. 1.

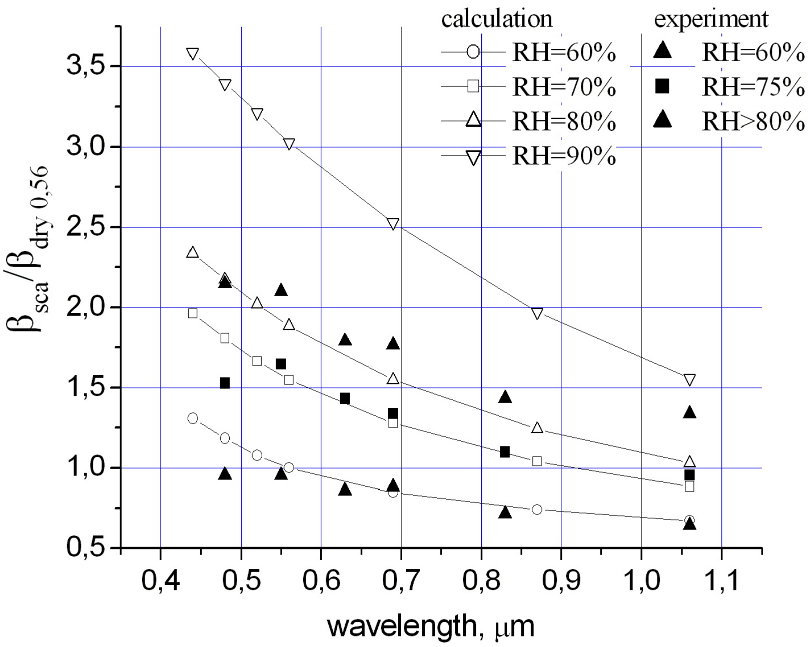
calculation
experiment
RH=60%
RH=70%
RH=80%
RH=90%
RH=60%
RH=75%
RH>80%
3,5
3,0
2,5
2,0
1,5
1,0
0,5
β_{sca}/β_{dry 0,56}
0,4
0,5
0,6
0,7
0,8
0,9
1,0
1,1
wavelength, μm

Fig. 2.