Determination of the complex refractive index and microstructure of atmospheric aerosol using the data on scattering and extinction of radiation

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One of the components of the method of active spectral nephelometry is retrieval of the parameters of particle microstructure from the optical data (Panchenko et al, 2008). At the first stage, the data measured by nephelometer were inverted to the complex refractive index and particle size distribution. The data set included the coefficients of angular scattering at the angle of 45° at three wavelengths (0.41, 0.51, and 0.63 μm) and polarized and cross-polarized components of the scattered light at 90° scattering angle at two wavelengths (0.44 and 0.51 μm). However, such set of optical parameters does not allow separate determining the real and imaginary parts of the complex refractive index, but only their linear combination. To avoid this ambiguity, we apply joint analysis of the data of measurements of light scattering in a local volume and measurements of atmospheric transparency at a 1 km long near-ground horizontal path in wavelength range 0.4 to 3.9 μm.

The retrieval procedure included the following steps: 1) calculation of the set of kernels of the integral Fredholm equation for the prescribed set of particle radii and their optical constants in the ranges $r = 0.03 – 2$ μm, $n = 1.33 – 1.7$, $\chi = 0 – 0.1$ (where n and χ are real and imaginary parts of the refractive index, respectively); 2) solving the inverse problem for all kernels using the iterative algorithm; 3) selection of the values of the real and imaginary parts of the refractive index and corresponding particle size distribution. For selecting the values n and χ, we used two criteria: 1) minimum of the optical discrepancy; and 2) minimum of the norm of second derivative of the logarithm of differential concentration.

First, inverse problem was solved for the model optical characteristics calculated by Mie formulas for superposition of wide lognormal distribution of non-absorbing aerosol particles and narrow lognormal distributions of black carbon (BC) at different ratios of the aerosol and BC volumes. Then the data of field measurements were inverted.

Figure 1, a shows the optical discrepancies when inverting only the scattering characteristics measured by the nephelometer, and Figure 1, b demonstrates optical discrepancies when inverting the scattering and extinction coefficients together.

It is seen that, when inverting only the scattering coefficients (Fig.1, a), where is an ambiguity in selection of the values of the real and imaginary parts of the complex refractive index (wide range of n and κ gives the minimum of the discrepancy).

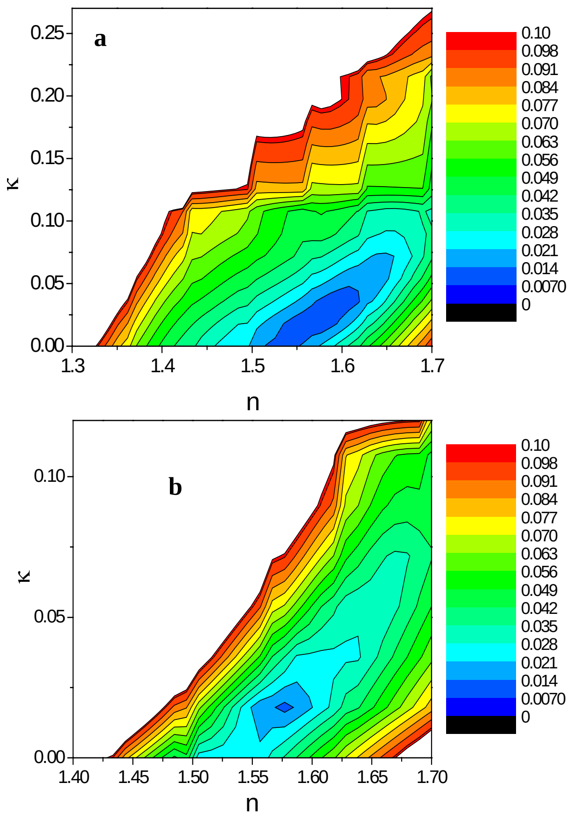

Figure 1. Discrepancy when inverting the data of the nephelometer (a) and the nephelometer and the transparency meter (b).

When the data of aerosol extinction have been included into the retrieval procedure, the only minimum of the discrepancy is observed on the n – κ plane (Fig. 1, b). It means that the values of the real and imaginary parts of the refractive index are determined unambiguously. Extension of the wavelength range up to 3.9 μm allowed us to reliably retrieve the particle size distribution functions in wider radius range of particles than inverting only the data of scattering in visible wavelength range.

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Panchenko, M.V., Sviridenkov, M.A., Terpugova, S.A., and Kozlov, V.S. (2008) *International Journal of Remote Sensing*, **29**, 2567 – 2583.