Modeling of optical properties sea-salt aerosol in the surface layer of the marine and coastal atmosphere

G. A. Kaloshin

V.E. Zuev Institute of Atmospheric Optics Rus. Acad. Sci., Siberian Branch, Tomsk, 634055, Russia
Keywords: aerosol extinction, Mie scattering, wind mode, fetch.
Presenting author email: gkaloshin@iao.ru

A microphysical model for the surface layer of marine and coastal atmospheric aerosols that is based on long-term observations of size distributions for 0.01–100 μm particles in different geographic sites is presented. The fundamental feature of the model is parameterization of amplitudes and widths for aerosol modes of the aerosol size distribution function (ASDF) as the functions of the fetch and the wind speed. The ASDF shape and its dependence on meteorological parameters, the altitudes above sea level (H), the fetch (X), the wind speed (U) and the relative humidity (RH) is investigated. The spectral profiles of the aerosol extinction coefficients calculated using the MaexPro (Marine Aerosol Extinction Profiles) are in good agreement with the observation data and the numerical results obtained from avalable aerosol models. Moreover, the MaexPro was found to be an accurate and a reliable instrument for investigation of the optical properties of atmospheric aerosols.

The particle size distribution dN/dr of the coastal aerosol microphysical model, in the range of the particle radii 0.01–100 μm, may be expressed as the sum of four modified lognormal functions, (Piazzola, Kaloshin, 2005; Kaloshin G., Grishin I., 2011) similar to the models NAM and ANAM:

$$\frac{dN}{dr} = \sum_{i=1}^{4} \frac{A_i}{f} \exp\left\{ -C_i \left(\ln\left(\frac{r}{fr_{0i}} \right) \right)^2 \right\} \qquad (1)$$

where: r_{01} = 0.03, r_{02} = 0.24, r_{03} = 2, r_{04} = 10 μm; f is represents the humidity growth factor; Ai is denotes the amplitude of the ith mode; Ci is is the width of the i^{th} mode. The selected particle size of 0.01 – 100 μm is due to the special attention given to the wavelength band of 0.2 - 14 μm, where the aerosol extinction is of great practical interest.

Having obtained the aerosol size distribution and the refraction index, we next calculate the aerosol extinction σ(λ) value by means of the classical Mie solution, assuming the aerosol particles are spherically shaped (Boren, Huffman. 1983).

The aerosol substance is a combination of the following materials: a dry substance, sea salt and water as listed in Table 1.

Table 1. Comparison between theoretical predictions and experimental measurements.

Mode	Materials	The mode size, μm	References
1	Insoluble	0.03	Shettle, Fenn (1979)
2	Soluble	0.24	Volz (1972)
3	Salt + water	2	Shettle (1979)
4	Salt + water	10	Hale, Query (1973)

In the model MaexPro, the real and imaginary parts of the complex optical index for the components of the aerosol particle substance have been taken from the empirical results as shown by (Volz, 1972) by means of an extrapolation in the wavelength band 0.2 – 14 μm, sampled at the interval Δλ = 0.001 μm.

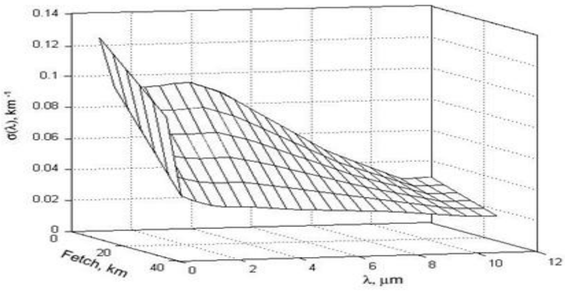

Figure 1. The spectral aerosol extinction coefficient σ(λ) vs. fetch X: H = 20 m, RH = 75%, U = 3.3 m/s.

Figure 1 shows how significant the dependence of the extinction spectra on the fetch parameter is. It is clear that at small values of the fetch (3-10 km) the extinction spectra decline steeply; this is typical for coastal aerosol. With increasing fetch, the extinction spectra become almost uniform as expected for marine aerosols, which means that in the coastal environment the fetch can be used in the same way as the air mass parameter (Gathman and A.M. van Eijk, 1998).

Based on the comparison with the observations, we conclude that the MaexPro is capable to realistically describe the impact of several different factors, such as meteorological parameters, the geometrical features of the shoreline and the wind mode. The calculation results are in agreement with the observation data at changing meteorological parameters obtained in different geographic sites by different authors.

Boren, C.F., D.R. Huffman. (1983). NY: Wiley.
Gathman S.G., van Eijk. Proc. SPIE 3433, 41-52 (1998).
Hale G.M., M.R.Query. (1973). Appl. Opt. 12: 555–563.
KaloshinG., GrishinI.(2011).Atm.-Ocean.49(2),112-120.
Piazzola J., Kaloshin G. (2005). J. Aerosol Science, 36(3), 341-359.
Shettle, E.P., R.W. Fenn. (1979). Report No. AFGL-TR-79-0214.
Volz F.E. (1972). Appl. Opt., 11, 755-759.