Temporal Variability of the Near-Surface Aerosol Content from Daily Observations at IAP Scientific Station Near Moscow During 1991 – 2002

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Introduction

Directed scattering coefficients D at a wavelength of 550 nm and a scattering angle of 45° have been measured once an hour at the Institute of Atmospheric Physics (IAP) Zvenigorod Scientific Station (50 km west of Moscow) since the beginning of 1991. The airflow that passed through the chamber of the nephelometer was heated for about 20°C. It was then compared with the outdoor temperature to obtain scattering coefficients caused by the aerosol dry fraction.

Estimating the Mass Concentration

Aerosol mass concentration M was estimated according to a one-parameter aerosol optical model (Gorchakov et al. 1981), assuming the density of the aerosol matter to be 1.5 g/cm^3. The final relation is:

$$M\ (\mu g/m^3) = 2.4 \cdot 10^3\ D\ (km^{-1} \cdot ster^{-1}) \qquad (1)$$

Thus, the calculated value of aerosol mass concentration refers to the aerosol submicron fraction. For the time series of the daily averaged aerosol concentration, see Figure1.

The highest concentrations were recorded in the summer and fall of 2002. These are connected with the forest and peatbog fires in the Moscow region. Further, only the data acquired up to July 2002 are analyzed.

Probability Distribution Function

The probability distribution function (PDF) of aerosol mass concentration is well approximated by logarithmic-normal distribution with a median concentration of 21 μg/m^3 and a variance of the logarithm of concentration about 0.45. The empirical PDF and its lognormal parameterization are presented in Figure 2.

Interannual Trend

Annual mean values of mass concentration are presented in Figure 3. A negative trend of about 0.7 μg/(m^3•year) is observed. Note, the growth of mean mass concentration in 2002 (even

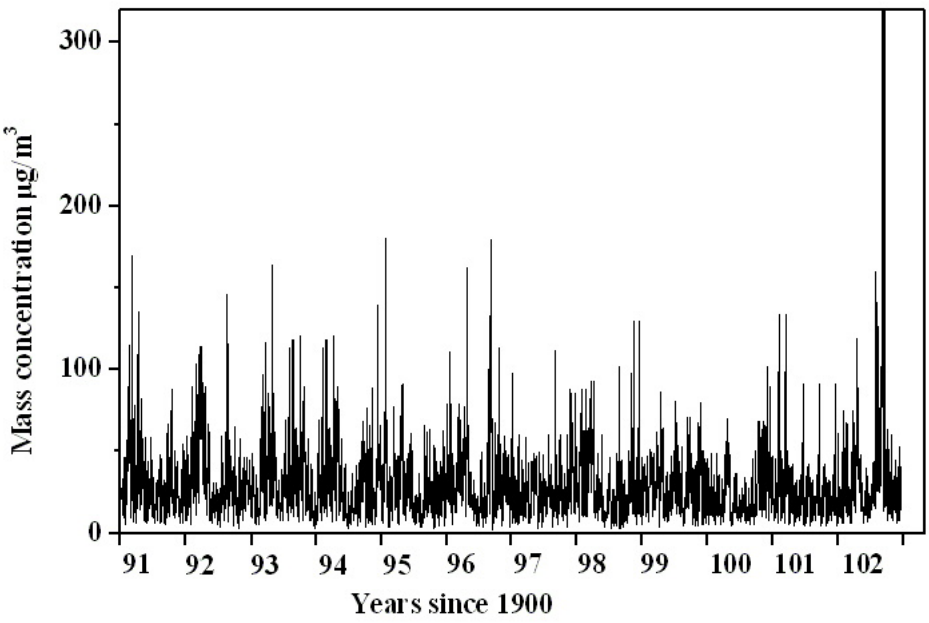

Figure 1. Time series of aerosol concentration.

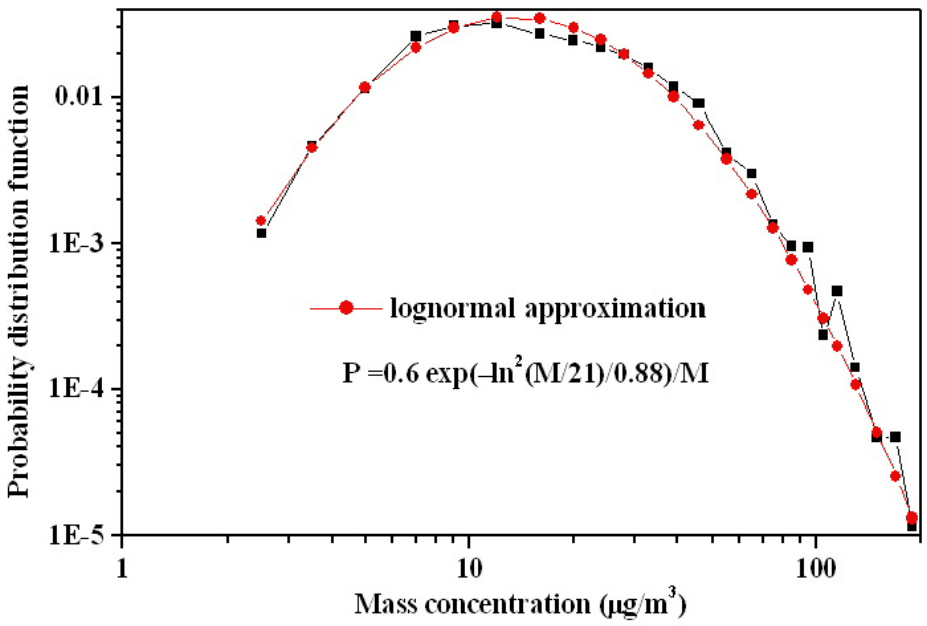

Figure 2. PDF of aerosol mass concentration.

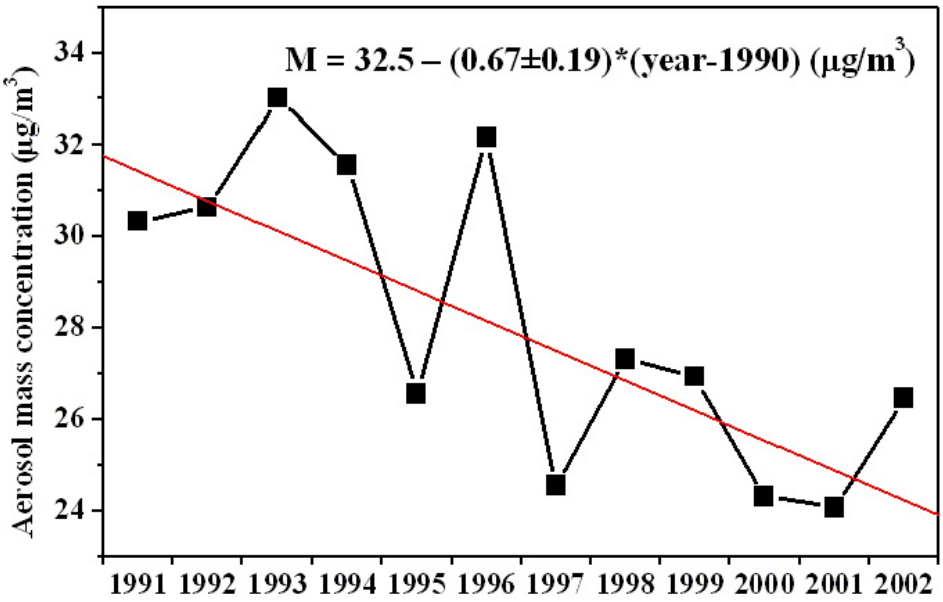

Figure 3. Trend of mean annual values of aerosol mass concentration.

excluding a period of fires) was continued in 2003, and, possibly, the decrease in concentration during the 1990s is a part of an oscillation with a longer period.

Interseasonal Variability

Monthly mean values of M (see Figure 4) show a noticeable peak in spring and a low in summer. In summer (in particular in June and July), the variance of the monthly mean concentration is significantly less than that in spring. Note, the seasonal cycle of M during 1991–1995 displays a second weak maximum in fall.

Spectral Analysis

Smoothed power spectra of variations of daily mean aerosol concentration are presented in Figures 5 and 6 for two ranges of periods. The annual cycle and its second and third harmonic make the basic contribution to the long-period variability of the aerosol content. Maxima corresponding to periods of 45 and 55 days are also observed. A power spectrum in a 2-30-day interval is characterized by the spectral density increase with period T at approximately $T^{1.2}$. Local maxima are observed at periods of 7, 10, and 22 days.

Wavelet Analysis

Wavelet analysis shows significant changes in the intra-annual spectral structure of M for different subperiods (Figures 7 and 8). According to Figure 7, the intensity of semi-annual mode decreased in the second half of the 1990s and at the beginning of this century. Remarkable modulation with a period

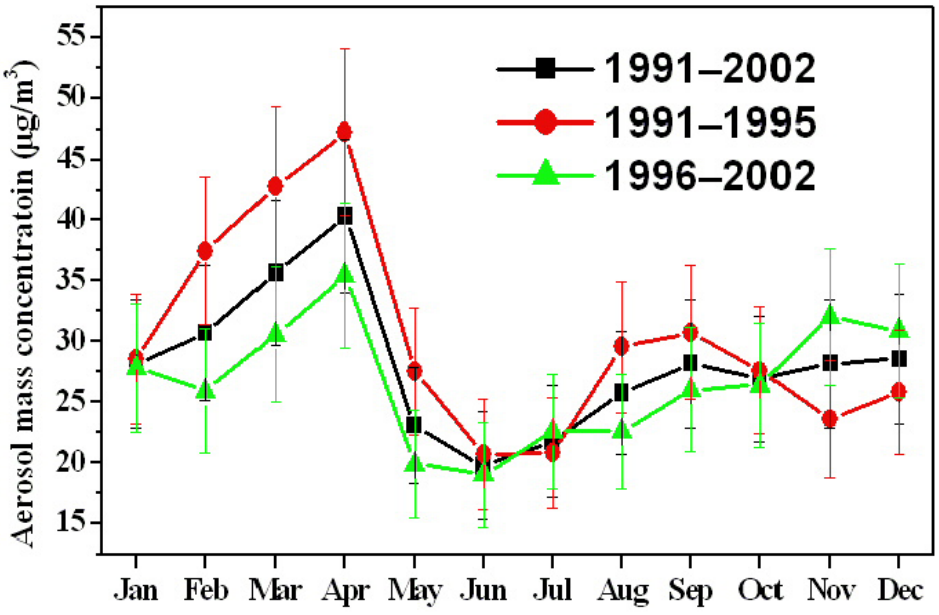

Figure 4. Seasonal course of aerosol mass concentration.

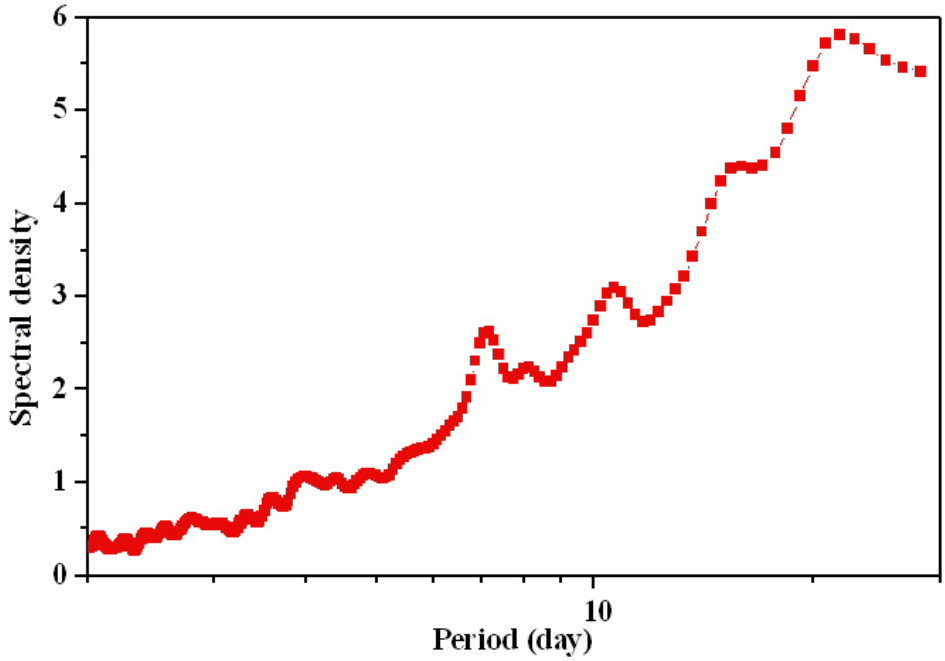

Figure 5. Power spectrum of aerosol variability.

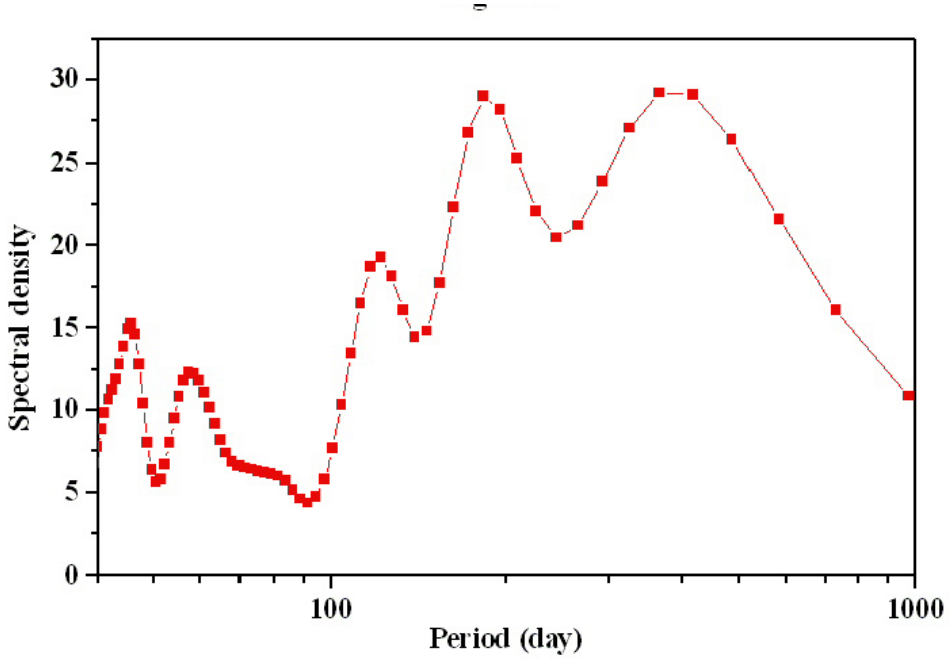

Figure 6. Power spectrum of aerosol variability.

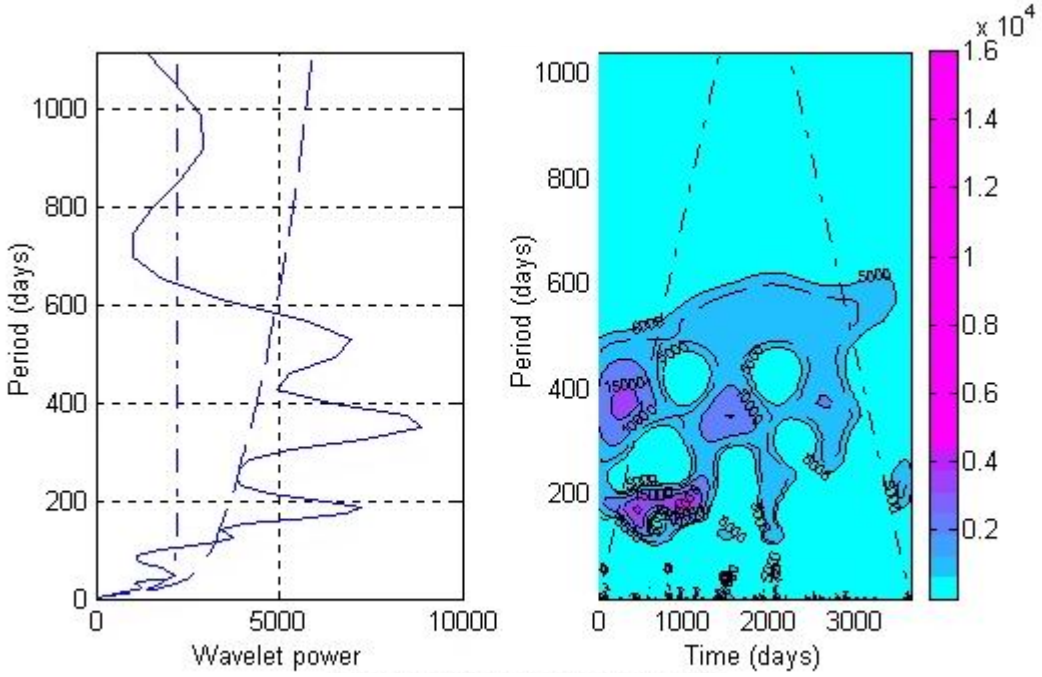

Figure 7. Wavelet spectrum of coefficients.

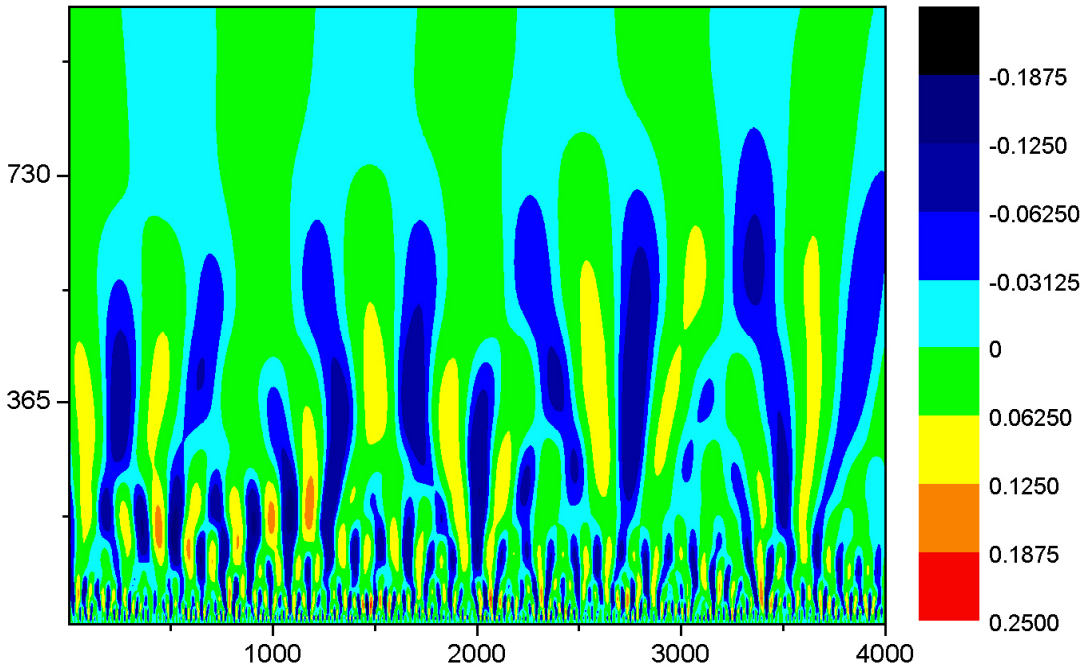

Figure 8. Power wavelet spectrum of mass concentration variability.

about 3 years was noted for the annual mode. It also displayed a general decrease of the annual mode maxima. The most significant contribution of the mode was a period of about 50 days, which was noted in the middle of the observed period.

Conclusions

Local changes of the near-surface aerosol content M during 1991-2002 show remarkable variations from synoptic (about one week) to interannual (about 3 years) time scales. The M decrease during the observed period was the prevalent general tendency during the observed period. This tendency was accompanied by noticeable changes in the annual and intra-annual modes, including weakening of annual and semi-annual modes.

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