THE INTERNATIONAL CONFERENCE ON THE 120TH ANNIVERSARY OF THE BULNAY EARTHQUAKE: ADVANCES IN ASTRONOMY AND GEOPHYSICS

THE MEASUREMENT RESULTS OF AEROSOL OPTICAL PROPERTIES AT THE ULAANBAATAR STATION OF THE SKYNET NETWORK

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INTRODUCTION

The determination of the optical parameters of atmospheric aerosols has many scientific and practical implications, including the assessment of regional air quality, the study of air pollution sources, and the study of the impact of air pollution on the health of residents [1-3]. For this purpose, some atmospheric optical parameters in Ulaanbaatar were investigated.

Ulaanbaatar is the capital city of Mongolia, located in the confluence of the Tuul and Selbe rivers, and surrounded by mountains. It has a continental harsh climate: dry and windy spring, hot and sunny summer, fine autumn and cold dry winter.

In this study, using a total of 60795 data measured by the skyradiometer POM-01 during cloud-free 2119 days over 8 years (extending from 2017 to 2025) at Ulaanbaatar station of the international network of SKYNET, the temporal variations of aerosol optical thickness (AOT) at 500nm wavelength, Angstrom exponent (AE) and volume size distribution (VSD) of aerosols were determined.

METHODOLOGY

The intensity of direct solar radiation penetrating the Earth's atmosphere decreases due to scattering and absorptions of molecules of gases and aerosols in the atmosphere. The attenuation of the direct solar radiation is determined by the Bouguer-Lambert-Beer Law [4-5].

The AOT is determined by the following equation:

$$\tau_a(\lambda) = \frac{1}{m(h_\Theta)}\left(lnI_{0,\lambda} - lnI_\lambda\right) - \left[\tau_R(\lambda) + \tau_{O_3}(\lambda) + \tau_{mg}(\lambda) + \tau_{P_w}(\lambda)\right] \quad (1)$$

Here, $\tau_a(\lambda)$ – aerosol optical thickness, $m(h_\Theta)$ is the atmospheric optical mass, $I_{0,\lambda}$ is the solar constant at a certain wavelength of spectrum, I_λ is the measured direct solar radiation at a certain wavelength of spectrum at groundlevel, $\tau_R(\lambda)$ – optical thickness of Rayleigh scattering, $\tau_{O_3}(\lambda)$ – optical thickness of ozone, $\tau_{mg}(\lambda)$ – optical thickness of mixed gases, and $\tau_{P_w}(\lambda)$ – optical thickness of water vapor.

The Angstrom exponent at a certain spectral wavelength is defined by the ratio of AOT and the wavelength as shown below.

$$\alpha = -\frac{ln\left(\frac{\tau_\lambda}{\tau_{\lambda_0}}\right)}{ln\left(\frac{\lambda}{\lambda_0}\right)} \quad (2)$$

where, α is the Angstrom exponent, τ_λ is the AOT at the spectral wavelength λ, and $\tau_{\lambda 0}$ is the AOT at the spectral wavelength λ_0 which is chosen as a reference.

The greater value of α then dominantly distributed are the fine-sized aerosols in the air, and in contrast, the low value indicates that the large-sized aerosols are dominant [6].

Aerosols suspended in the air vary with the size distribution [6]. The volume size distribution of aerosols expresses the number of aerosols with a certain radius per volume, and it is evaluated by the following expression:

$$\frac{dV_i(r)}{d\ln(r)} = \sum_{i=1,..,N}\frac{C_{v,i}}{\sqrt{2\pi}\sigma_i}exp\left(\frac{-\left(\ln r - \ln r_{v,i}\right)^2}{2\sigma_i^2}\right) \quad (3)$$

Here, $C_{v,i}$ is the concentration of different modes, $r_{v,i}$ is the volume median radius of each modes, and σ_i is the standard deviation.

RESULTS

Table 1. The number of measurements during cloud-free days in each month of every year.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	5	72	51	11	5	592	838	585	350	444	560	594
2018	657	748	1067	979	1193	980	554	768	713	887	693	716
2019	866	992	1063	984	1218	180	835	901	1093	801	677	358
2020	833	756	836	1471	907	821	691	588	738	746	550	558
2021	465	664	915	991	707	780	763	475	551	699	335	29
2022	241	631	661	832	911	567	378	466	858	579	422	32
2023	239	722	837	780	598	707	485	577	450	716	260	23
2024	261	616	918	683	702	581	603	380	661	615	335	569
Total						60795						

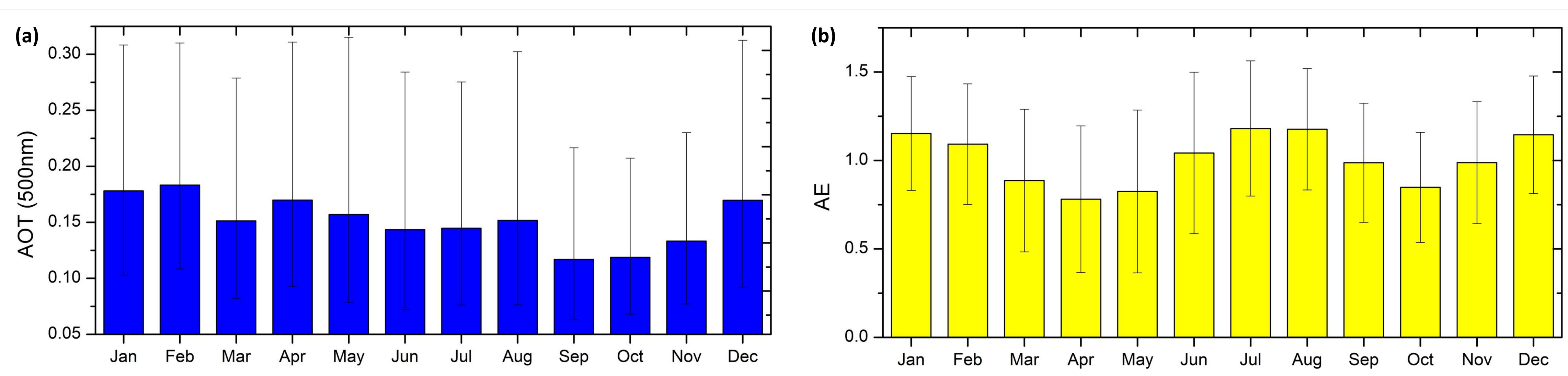

Figure 1. Monthly mean values and standard deviation of (a) AOT at 500nm and (b) AE in Ulaanbaatar.

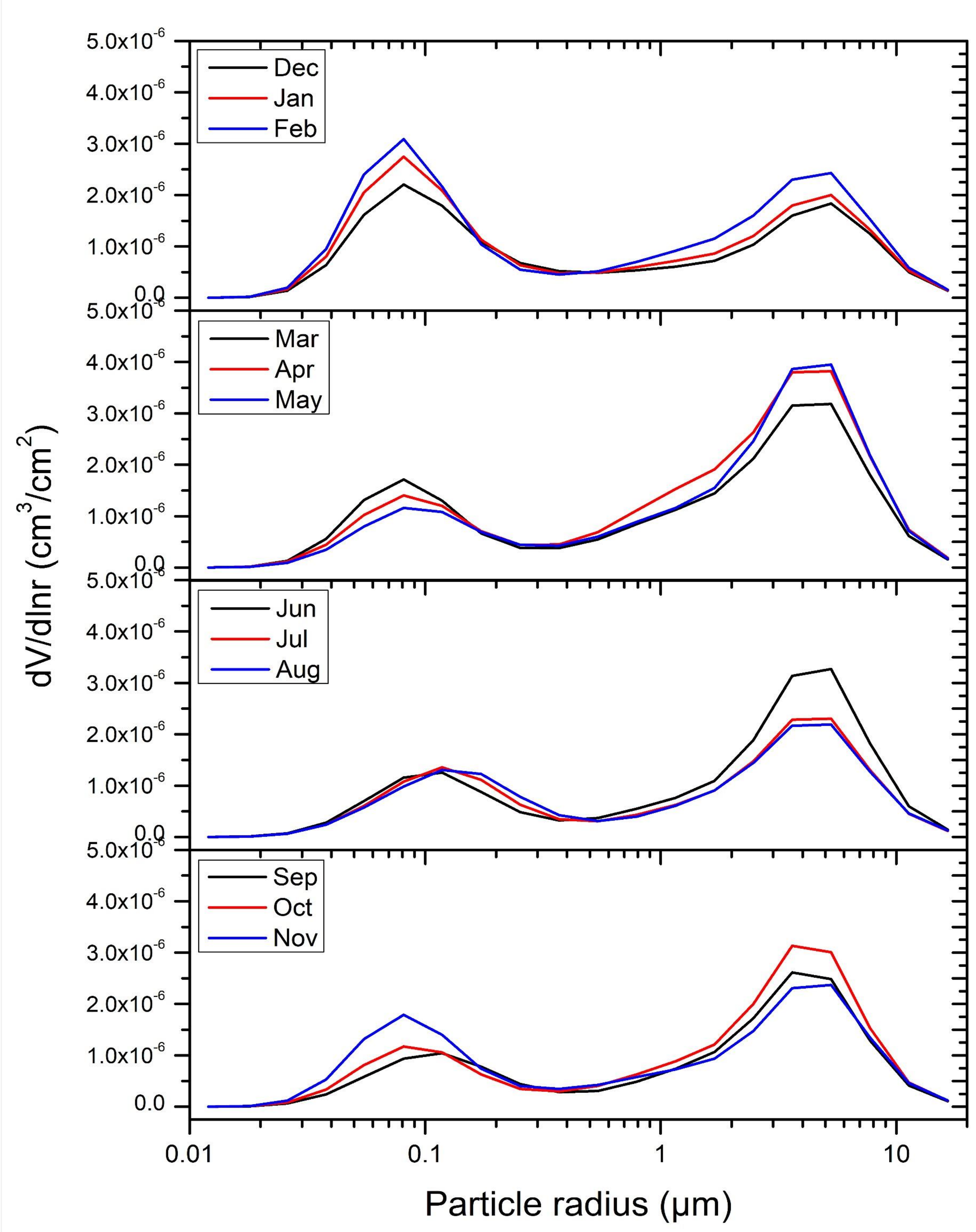

Figure 3. Volume size distribution of aerosols in Ulaanbaatar.

ANALYSIS

- During the study period, an explicit seasonal routines were observed from the annual variations of AOT and AE at Ulaanbaatar station: AOT is relatively steady in spring and summer, a decrease to minimum level in autumn, and a striking increase to maximum in winter, and again a decrease from spring to autumn, while the monthly mean values of AE increase in the summer, decrease in autumn, increase in winter and decrease again in spring.
- Annual mean value of AOT is 0.149, the maximum value of AOT is 0.183 in February, and the minimum value of AOT is 0.117 in September.
- Due to households burning large amounts of biomass, fine-grained aerosols are more prevailing in winter, while coarse-sized aerosols are dominant in the atmosphere due to the dust storm in spring in Ulaanbaatar.

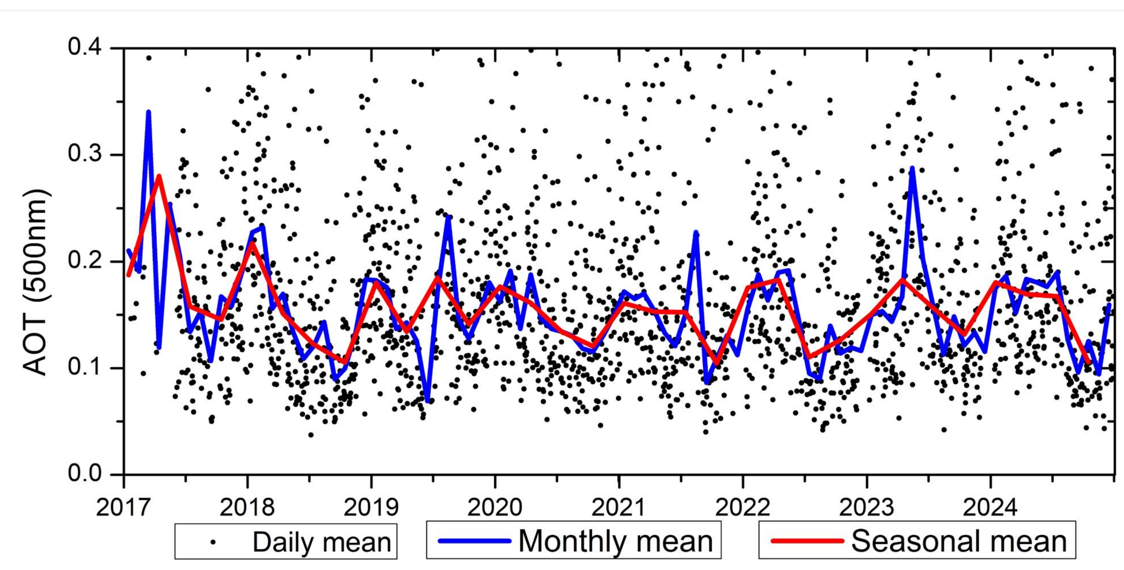

Figure 2. Temporal variations of AOT at 500nm over 8 years (extending from 2017 to 2025) in Ulaanbaatar.

CONCLUSIONS

Using ground-based skyradiometer POM-01 data measured between 2017 and 2025 at the Ulaanbaatar site, aerosol optical thickness (AOT) at 500nm wavelength, Angstrom exponent (AE) and volume size distribution (VSD) of aerosols were investigated. The main results are listed below:

- In this site, monthly mean value of AOT varies depending on the sourses and size of aerosols through the year.
- The annual mean value of AOT at 500nm is 0.149, varying from 0.117 (in autumn) to 0.183 (in winter).
- Compared to other seasons, fine-mode aerosols predominate in winter, while coarse-mode aerosols are more prevalent in spring.

ACKNOWLEDGEMENT

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