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بررسی خصوصیات اپتیکی هواویزها در شهر کرج با استفاده از شیدسنج خورشیدی دستی کالیتو

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چکیده- در این مطالعه داده‌های شیدسنج خورشیدی دستی کالیتو در یک بازه یکساله برای شهر کرج گزارش می‌شود.همچنین با استفاده از عمق اپتیکی هواویزها، که معیاری از چگالی عددی هواویزهای موجود در جو است، و نمای آنگستروم، که معیاری از ابعاد ذرات غالب در جو است، ذرات جوی این دوره یکساله دسته بندی شده است. میانگین عمق اپتیکی هواویزها در طول موج‌های ۴۶۵، ۵۴۰ و ۶۱۹ نانومتر به ترتیب مقادیر۰/۲۰،۰/۲۶و۰/۲۵ بوده است و میانگین نمای آنگستروم در این دوره اندازه‌گیری۰/۷۶ بوده است.

کلید واژه-شهر کرج، شیدسنج خورشیدی دستی کالیتو، عمق اپتیکی هواویزها، نمای آنگستروم.

Investigation of optical characteristics of aerosols in Karaj city using Calitoo handheld Sun-photometer

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Abstract-This study presents the Calitoo handheld Sun-photometer data during 11 months between September-26 2019, to August-31 2020, for Karaj city. Using the aerosol optical depth (AOD), which is a criterion of the numerical density of the AOD in the atmosphere, and the Angstrom exponent, which is a criterion of the size of the dominant particles in the atmosphere, the atmospheric particles of this period are categorized. The average AOD at 465, 540, and 619 nm was 0.20, 0.26, and 0.25, respectively, and the average Angstrom view during this measurement period was 0.76.

Keywords: Karaj city, Calitoo handheld Sun-photometer, Aerosol Optical Depth (AOD), Angstrom exponent.

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1. Introduction

Atmospheric aerosols are tiny solid and liquid particles suspended in the atmosphere from few nanometers to a few tens of micrometers [1].Marine salts, dust, and sulfate produced from the ocean surface are part of the atmospheric aerosols, but a part of the atmosphere's dust is related to human activities [2].Aerosols play an essential role in predicting the Earth's climate. To reduce the high uncertainty of the aerosols, it is necessary to accurately and continuously measure the characteristics and distribution of aerosols [1] [3].

Satellite remote sensing measurements help to extract aerosol optical properties on both local and global scales [4] [5].The ground measurement of the aerosols provides complete information about the optical and microphysical properties of the aerosols and their radiative transfer effects on a specific area [6] [7].

The development of the Aerosol Robotic Network (AERONET) in recent decades has been significantly improved the ability to investigate the optical properties of aerosols such as the aerosol optical depth using automated ground-based remote sensing methods [8].Aerosol optical depth time series are continuously available with very high time resolution for specific stations on the ground [9].

2. Data and methods

During the measurements, a handheld Calitoo Sun-photometer (SPM) manufactured by Tenum company has been used to characterize the rate of aerosols in the atmosphere and to determine their size distribution in the atmosphere of Karaj for a period between September-26 2019, to August-31 2020. The Calitoo SPM records the aerosol optical depth at three wavelength channels, blue (465nm), green (540nm) and red (615nm). The Calitoo SPM is equipped with a GPS, a pressure, and temperature sensors. Due to the use of components with the latest technologies in the Calitoo SPM, it is a low-cost, accurate, and portable measurement tool. It should be noted that the Calitoo SPM has been qualified by Laboratoired'OptiqueAtmosphérique at Lille (France) in March 2013 [10].

The measurement principle is to point the Calitoo SPM manually toward the direct Sunlight and search for the maximum flow. Calitoo SPM records only the maximum value at the three wavelength channels. The AOD is an indicator of the amount of aerosols in the atmosphere and can be obtained after subtraction of the Rayleigh optical depth of all wavelengths (465, 540, and 615 nm), from total optical thickness of the atmosphere at the corresponding wavelengths [11]. In retrieving the AOD at 540 and 619 nm, the ozone optical depth also should be taken in account [12]. The Angstrom exponent is determined by a logarithmic fit to the AOD when it is plotted versus the logarithm of the wavelength. The obtained AODs at two wavelengths, 465, and 619 nm have been used to retrieve Angstrom exponent [13] [14].

3. Results

3.1 Calitoo handheld SPM Data

Calitoo handheld SPM measurements are performed daily from September-26 2019, to August-31 2020.Data collection was performed hourly from12:00 to 18:00in local time. When the sky had a cloud along with the sunlight path, measurement has not been done. During this period, 3648 data (Level 1) were recorded. From the Level 1 data, 1030 of them were selected for Level 1.5.Fig.1 shows the time series of the AOD level 1.5 at 465, 540, and 619 nm wavelength channels.

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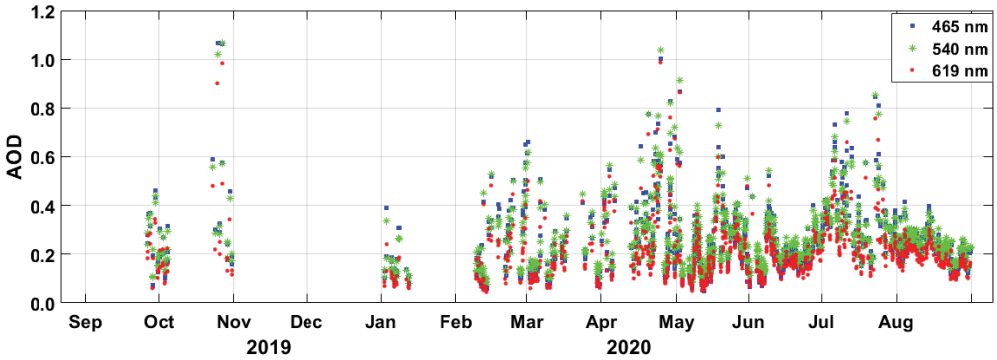

Figure 1: Aerosol optical depth time series at 465, 540, and 619 nm wavelength channels for the period from Sep-2019 toAug-2020.

Figure 2 shows the time series of the aerosol optical depth at 465 nm and the angstrom exponent extracted from the AOD at two wavelengths of 465 nm and 619 nm between September 2019 and August 2020. Following the dots on Fig 2, it is observed that often with increasing (decreasing) the AOD, the angstrom exponent decreases (increases), which indicates the predominance of coarse (fine) particles in the atmosphere.

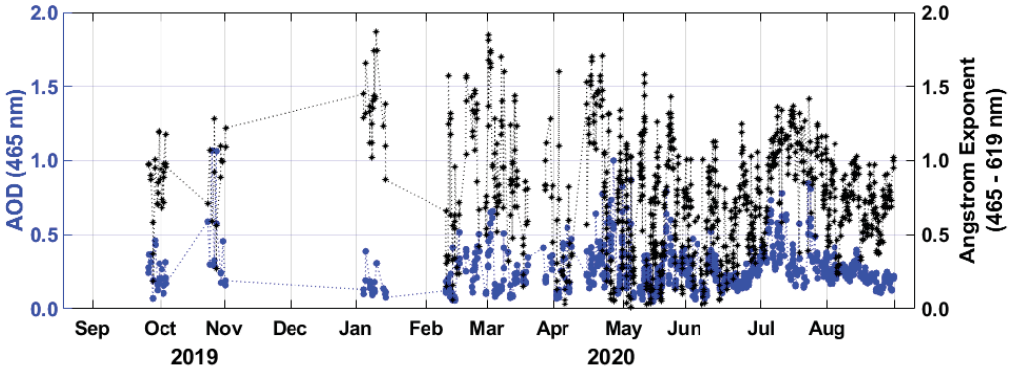

Figure 2: Time-series of the aerosol optical depth at 465 nm (Blue) and the angstrom exponent (Black) between September 2019 and August 2020.

In Fig. 3, scatter plot of the angstrom exponent is plotted versus AOD at 465 nm from Sept-2019 to Aug-2020.Using this scatter plot, can categorize different types of aerosols. Measurements are shown in reddots. The colours in Fig. 3 show the range of AOD and angstrom exponent variations of different atmospheric aerosols.Brown, orange, yellow, dark blue, and light blue colours represent atmosphere with dominant particles of biomassand urban pollution, fine and coarse particles, desert dust, ocean drizzle, and clear air, respectively.

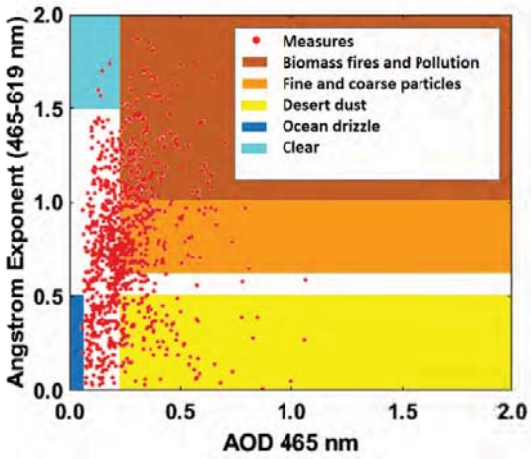

Figure 3: Scatter plot of angstrom exponent versus AOD at 465 nm. The red dots show all data measured in the period between Sept-2019 to Aug-2020.

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4. Conclusions

We have reported AOD values derived from Calitoo handheld Sun-photometer during 11 months measurementsbetween Sept-2019 to Aug-2020 inKaraj city. During this period, 3648 level 1.0 data were recorded at each of the465, 540, and 619 nm wavelength channels. Finally, 1030 of them were selected as data of level 1.5 (Fig. 1). The average AOD values at 465,540, and 619 nm wavelength channels were 0.20, 0.26, and 0.25, respectively. The average value of angstrom exponentextracted from AOD at 465 and 619 nm obtained 0.76 in the measurement periodThe classification of aerosols usingtwo AOD and angstrom exponent parameters shows that suspended particles in the atmosphere of Karaj during themeasurement period included biomass and urban pollution, fine and coarse particles, desert dust, oceanic drizzle, andclean air with the percentage of 14.56%,14.75%,8.15%,0.29%,0.40%, respectively.As one can see, most of theaerosols in the Karaj atmosphere are dust and a mixture of coarse- and fine-mode particles.

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