Effect of the main active volcanoes on aerosol optical properties

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Abstract. Processing of the measurements obtained by the AERONET network of the optical parameters characteristic of the atmospheric aerosol carried out makes it possible to compare the optical effects of 2020 volcanic eruptions to those results for 2019 concerning Mexico City and Mauna Loa site. Both the monthly spectral means of AOD and the monthly means of fine and coarse volume concentration show an increase for the months of January and February 2020 (Volcanic eruption period) compared to the same period in 2019 at Mexico City. Those corresponding to Mauna-Loa seem not sensible with very low values. The effects of ashes of the two-studied volcano are very different, led to a low increase in optical depth comparatively to the contribution of anthropogenic aerosol at Mexico- City (low continental spread) and led to a non-significate effect at Mauna-Loa (high marine spread).

1 Introduction

Volcanic eruption is one of the leading natural processes injecting massive ashes and gases into the troposphere and stratosphere [8, 18]. The clouds of ash and materials could affect neighbouring towns 45 and 60 km away, they can have a significant effect on the Earth's atmosphere and environment at several spatial and temporal scales [11]. The explosions with SO_2 plumes can reach beyond the tropical tropopause into the stratosphere, remaining for several weeks or months in the upper troposphere and lower stratosphere [18, 21]. Sulfur dioxide that constitutes a significant part [17] and other volcanic sulfur-bearing gases transform to sulfate aerosols [5] that have a notable impact on the atmosphere's absorption and scattering of the incoming solar radiation [6]. The solid emissions from a volcanic eruption have various sizes, from very fine particles (< 5 µm) to a multi-metric block, the whole being normed tephra. During the eruption, multiple plumes are injected at different altitudes and points in time containing SO_2 and ash, making this eruption challenging for the modelling world [10]. The responses of climate also help us to understand important radiative and dynamical processes that contribute to the climate system to both natural and anthropogenic forcing [2].

This study aims to determine the last effect of volcanic eruptions of two important sites (Popocatepetl and Kilauea) on the optical properties of aerosols. We concentrate on aerosol optical depth at 0.5 µm, $AOD_{0,5}$ that characterizes the transparency of the atmosphere and quantifies the extinction of the incident radiation in a column of atmosphere, both by diffusion and by absorption [3, 4]. We also analyze information on the aerosol load by volume particle size distributions [13, 14, 15], based on measurements obtained by the AERONET network [9].

2 Sites and Method

The concerned two volcanoes are considered among the most dangerous in the world:
Popocatepetl was a Mexican volcano, located in the Centre of the country, 60 km southeast of Mexico City (19.33N, 99.18 W, 2268 m), and the last eruption in January 2020.
Kilauea is one of five volcanoes on the island of Hawaii, the largest in the US state archipelago, near Mauna Loa (19.53 N, 155.57W, 3402 m); it is not a single volcano but a multitude of craters scattered over a vast area with the last eruption in December 2020.
The AERONET network [9] is a ground-based remote sensing aerosol network for solar

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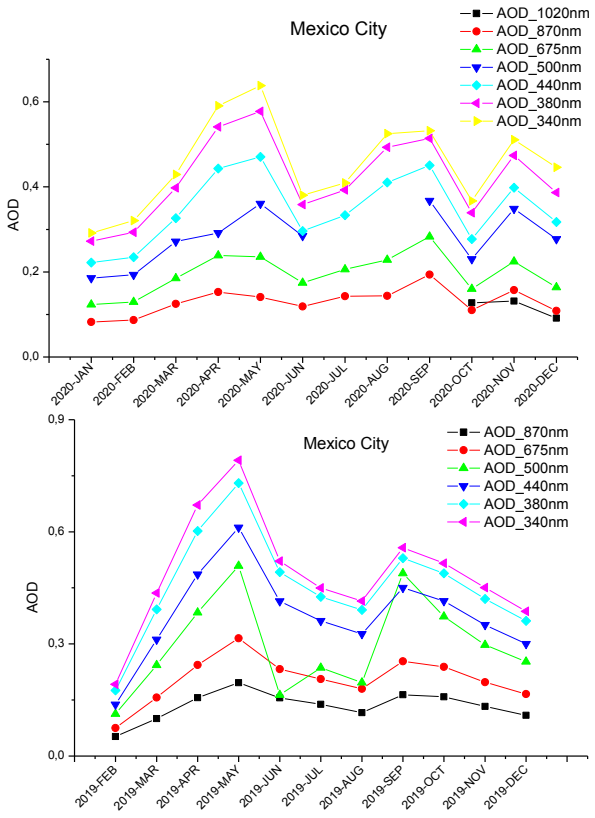
photometric measurements set up by NASA to estimate the immediate and dissipated sun-oriented radiation. All data are obtained using the CIMEL normalized sun-photometer at main ostensible wavelengths over the day (340, 380, 440, 500, 675, 870, 1020 nm and 1640 nm) in addition to a 936 nm water vapor band).

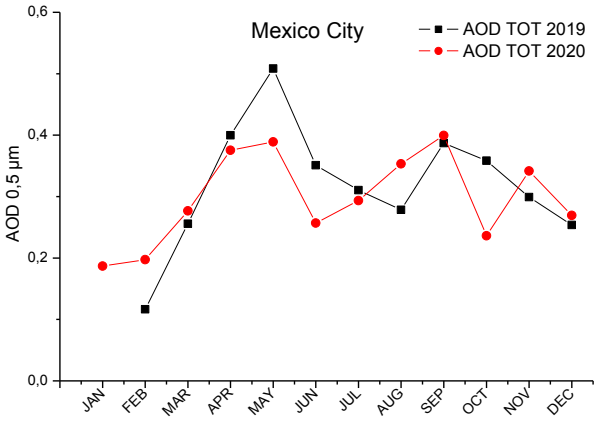
3 Results

3.1 Mexico City

The monthly spectral means of AOD show a normal regular variation with relatively high values (Figures 1), which present pronounced disturbances in summer 2019. Those corresponding to SW vary between 0.1 (winter) and 0.5 (spring), with an annual average greater than 0.3 pollution threshold recommended by the WHO. The $AOD_{0,5}$ recorded an increase for the months of January and February 2020 (Volcanic eruption period) compared to the same period in 2019. This increase also appears at the level of fines and coarse particles (Figure 3); it does not reflect a significant effect and remains within the range error interval around the annual mean.



Figs 1. Spectral AOD at Mexico city (2019, 2020)



Figs 2. Monthly average of $AOD_{0,5}$

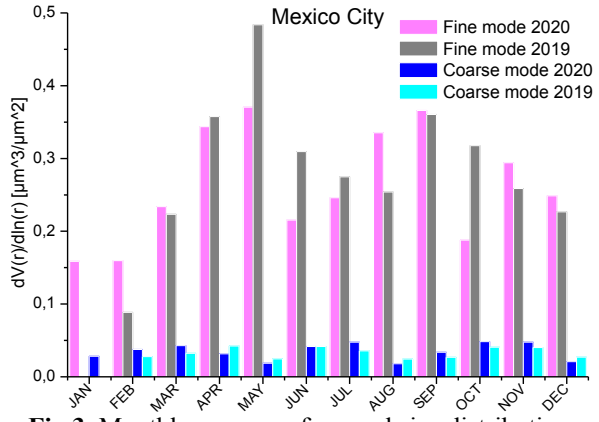
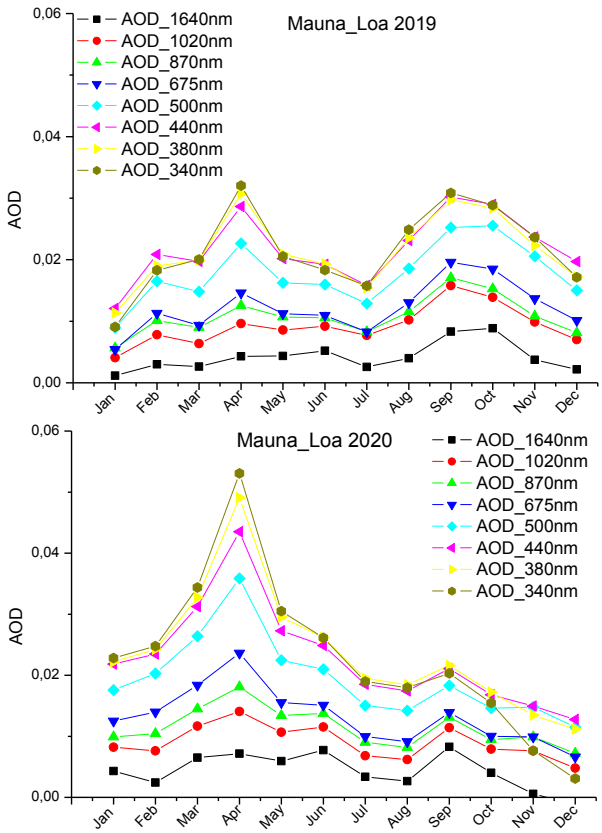


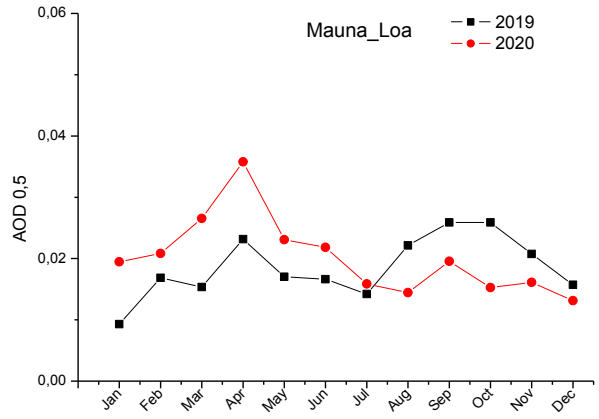
Fig 3. Monthly average of aerosol size distribution

3.2 Mauna-Loa site

The monthly spectral means of AOD show a normal regular variation with very low values (Figures 4). Those corresponding to the SW remain around 0.02 as an annual average. The AODs record an increase for the winter and spring 2020 seasons compared to the same period in 2019. This increase appears noticeably at the level of fines and large particles (Figure 6) but does not reflect a significant effect because all the values are very low.



Figs 4. Spectral AOD at Mauna-Loa (2019, 2020)



Figs 5. Monthly average of $AOD_{0,5}$

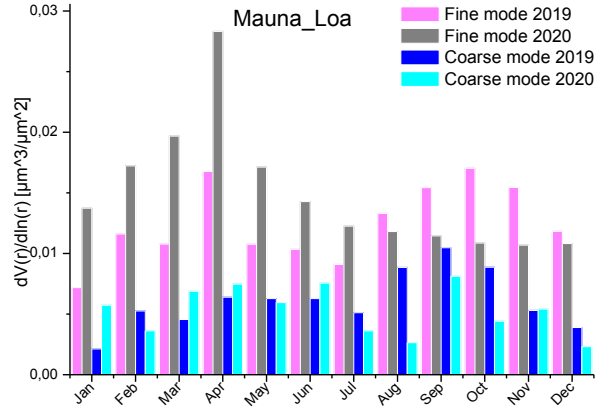
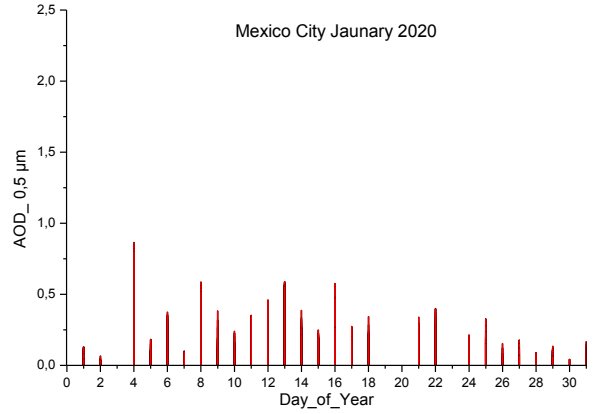
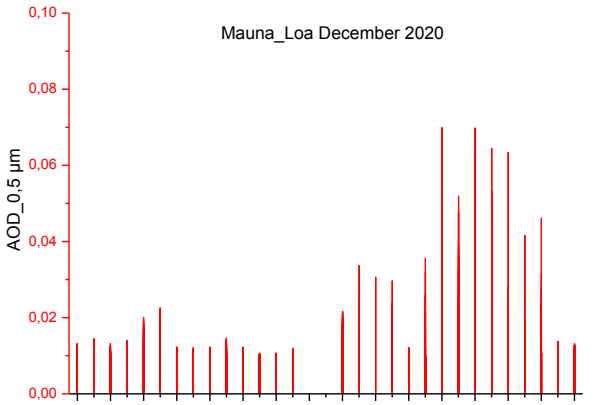


Fig 6. Monthly average of aerosol size distribution





Figs 7. Daily measurements of $AOD_{0,5}$

4 Conclusion

The maximum total optical depths coincide with a series of volcanic explosions observed in January in Mexico. As ash emissions moving which spread over large areas, it contributes to the highest observed volume concentration of fine and coarse aerosols; still it does not reflect a significant effect and remains within the range error interval around the annual mean, which is always high due to the sizeable anthropogenic aerosol contribution. The aerosol optical thickness in Mauna Loa remains low, even during eruption days (<0.03) due to the increased spread with marine winds.

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