Decrease of tropospheric ozone concentrations associated with Saharan dust outbreaks

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From May to September 2012, ozone reductions associated with fifteen Saharan dust outbreaks (SDOs) which occurred between May to September 2012 have been evaluated. Moreover, a particle concentration threshold, from which the ozone depletion can be considered statistically significant, has been determined.
The study of interactions between ozone and coarse particles (size >1 μm) is based on an hourly time scale. Time series of ozone concentrations in which its seasonal component was removed have been used and as a result, the effect of the solar radiation on the ozone variability has been minimized.

The campaign was performed at a mountain station located near the eastern coast of the Iberian Peninsula. The sampling site named "Aitana" (38°16´N; 0°41´W; 1558 m a.s.l) is on the top of a mountain range located inland in the province of Alicante, in southeastern Spain. The station is situated 25 km from the Mediterranean coast and about 300 km from the nearest North Africa point. Particulate matter characterization and meteorological dynamics in the sampling point can be consulted in Galindo et al., 2015.

The instrument used to measure particle concentration was an optical counter Grimm 190, which is able to determine particle number concentrations in 31 particle size channels from 0.25 μm to 32 μm. Concentrations of O_3 were registered using a Dasibi model 1008 UV absorption continuous analyzer. Meteorological data (temperature, wind velocity, solar radiation, precipitation, relative humidity) were obtained from a weather station located 10 m above the ground.

The sampling site was influenced by SDOs for a total of 75 days (~50% of the entire study period). These Saharan dust events were distributed in 15 different periods.

In order to determine a particle concentration threshold from which a statistically significant decrease in ozone concentrations is produced, a comparison between hourly ozone average concentrations recorded without SDO (O_3-NSDO) and those obtained under SDO has been carried out. Four different ozone scenarios depending on the particle concentration during a SDO are taking into account: a) during SDOs independently of the hourly particle concentration (O_3-SDO); b) during SDOs when particle concentration exceeds the median hourly values (O_3-N>N-median); c) when exceeds the hourly particle mean values (O_3-N>N-mean) and d) when is over the P75 (75th percentile) hourly particle values (O_3-N>N-P75). With the O_3 values obtained from each of the four intensities, the corresponding ozone percentage reduction has been calculated. Furthermore, to ascertain when the ozone reduction can be considered significant a statistical comparison (Mann-Whitney test) has been performed. The O_3 value obtained without SDO (O_3-NSDO) has been used as a reference level. Table 1 shows the results.

Table 1: Concentrations and percentage reductions of O_3 and significance levels.

O_3	***Value±error (ppb)***	***↓ΔO_3 (%)***	***Significance[a]***
NSDO	58.1±0.2		
SDO	57.5±0.2	1.0	0.257
N>Nmedian	55.8±0.2	4.0	0.000
N>Nmean	54.7±0.3	5.9	0.000
N>NP75	54.3±0.3	6.5	0.000

[a]: Levels upper than 0.05, do not reject the null hypothesis, that is, the means are statistically equals between the groups.

The condition O_3-N>N-median (with p-value < 0.05) is enough to obtain a statistically significant ozone reduction (4.0%). Table 1 also reveals that an increase in the particle concentration during SDOs produces a greater decrease in ozone concentrations.
The ozone reduction can vary according to the SDO and in certain cases this percentage can reach values of higher than 15%. The negative gradient of ozone concentration during the course of the Saharan episodes vary from 0.2 to 0.6 ppb·h^{-1} with an average value of 0.39 ppb·h^{-1}. The negative correlation between ozone and coarse particles occurs almost simultaneously. Moreover, although the concentration of coarse particles remained high throughout the SDO, the time series shows the saturation of the ozone loss.

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