Sub-micron particle characterization downwind the Tula industrial area

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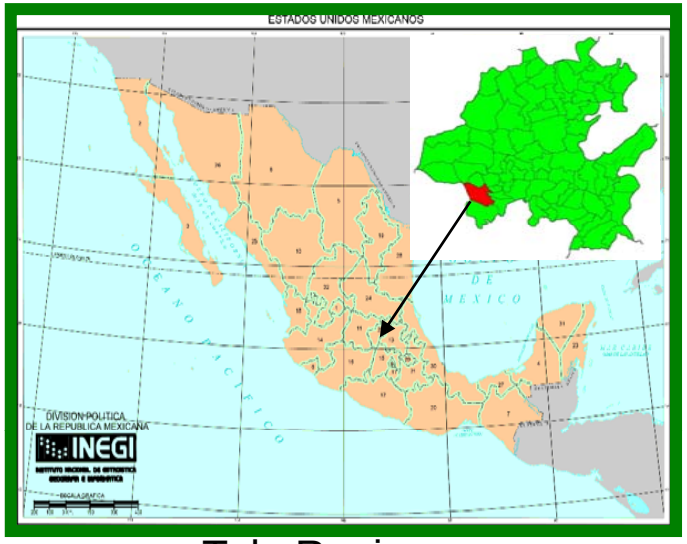
INTRODUCTION

In order to determine the formation and growth of atmospheric particles, it is important to study the mass growth and number of sub-micron particles for different diameters, as well as to establish their relation with light scattering, black carbon, weather variables, and pollutants gases.

Sub-micron particles in Tula region has not been sufficiently characterized, in spite of the damage to the visibility and the environment. Tula site is a suburban and agricultural zone near to a refinery, a power plant, cement plants, and open-sky mines. At this site, an Integrating Nephelometer (Model 3563 TSI), a SMPS (Model 3936 TSI), an Aethalometer (Magee Scientific, Model AE-16), and a mobile laboratory, were placed to measure light scattering coefficients, particle size distribution, black carbon concentration, criteria pollutants and meteorological parameters, respectively. Such measurements were carried out during the MILAGRO campaign in 2006.

Measurement site and equipments



Tula Region

Nephelometer

SMPS

Aethalometer

METHODOLOGY

All measurements were performed in real time each 10 minutes, from 00:00 to 24:00 h every day, from 2006/03/24 to 2006/04/21.

Particle size distributions (number and mass) correspond with the 16-794 nm diameter range.

Light scattering coefficients were measured in three wavelengths, 450, 550, and 700 nm. However, only the 450 nm wavelength was used to perform the analyses.

All data from Nephelometer, SMPS, Aethalometer, meteorological parameters and criteria gases, were hourly averaged in the time intervals: 01-06 h, 07-10 h, 11-14 h, and 15-24 h, for the diameter ranges: 16-100 nm, 101-400 nm, and 401-794 nm. Log-Normal function was used to analyze particle mass and number distributions.

The particles mass and number growth rate, from each diameter range and time interval were carried out too, for those days with low and high pollution, respectively.

RESULTS

Global Analysis

For the entire campaign, figures 1-3 show the results on light scattering, black carbon concentrations, and particles size distribution.

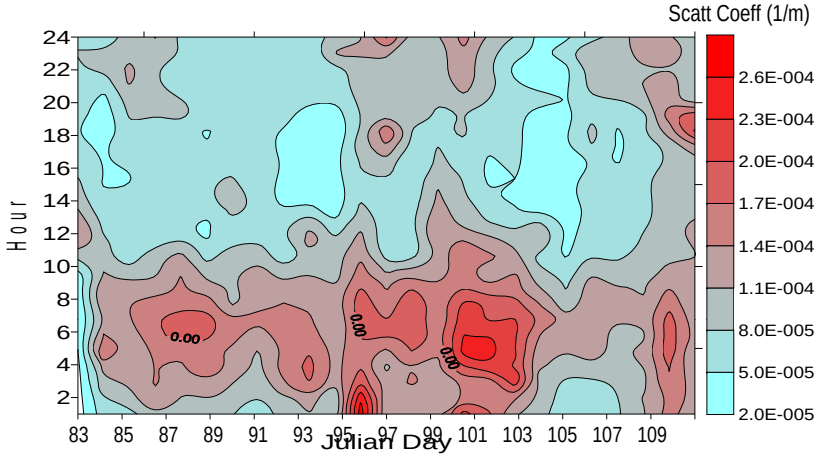


Fig. 1) Light scattering coefficients

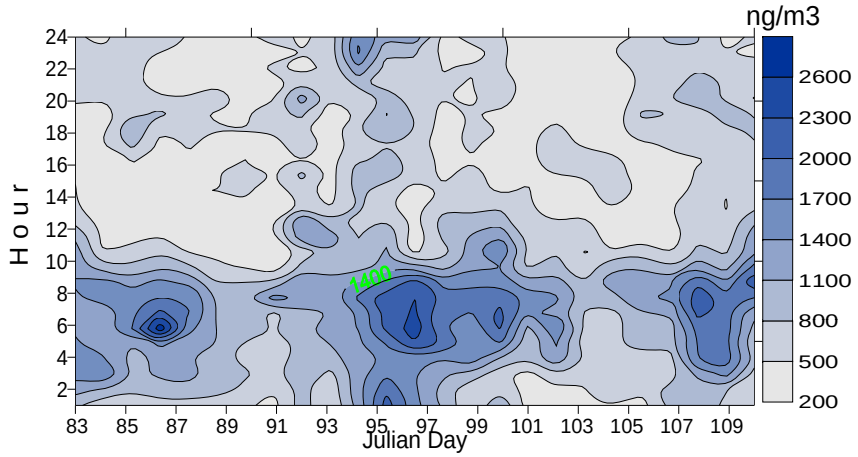


Fig. 2) Black Carbon concentrations

Dp (nm)	Log Dp
16	1.2
25	1.4
40	1.6
64	1.8
100	2.0
157	2.2
250	2.4
400	2.6
638	2.8

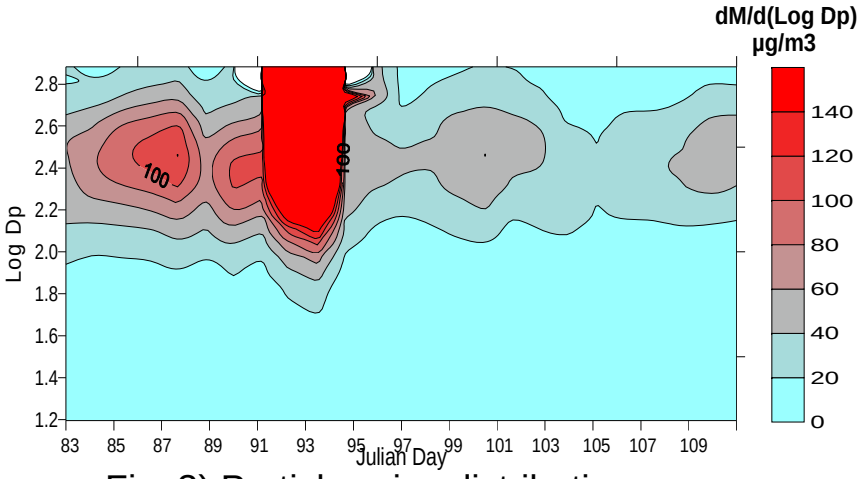


Fig. 3) Particles size distribution

Mass distribution and light scattering

The 100-400 nm and 402-694 nm diameters ranges were responsible for light scattering. During early hours in highly polluted days, 100-400 nm range was more important than the other range.

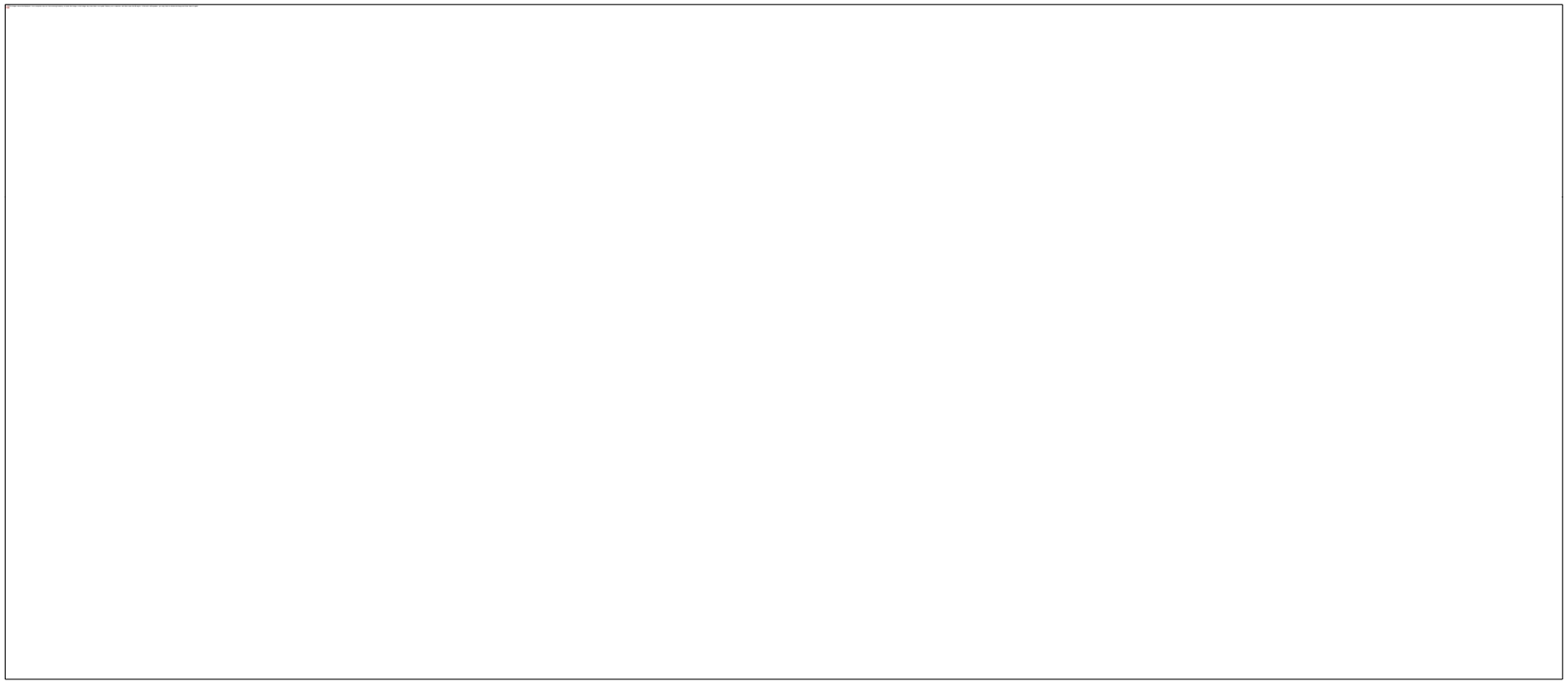


Fig. 4). Hourly tendencies in mass distribution and light scattering coefficients, in three different diameters ranges. A) Lowly polluted days. B) Highly polluted days.

Particles mass growth rate [(μg/m^3)/h] in three diameters ranges

	MD/SD	MD/BD
Low Pollution	1.81	21.99
High Pollution	0.79	263.92

Small Diameters (SD) = 16-98 nm
Middle Diameters (MD) = 100-400 nm
Big Diameters (BD) = 402-694 nm

Number distribution and nitrogen oxide

In the 16-98 nm diameter range, number distribution follows a similar tendency than that of NO. For both data sets, maximum values are out of phase by 5 hours. Nanometric particles were fresh, or were they growing? Which is the nanometric source?

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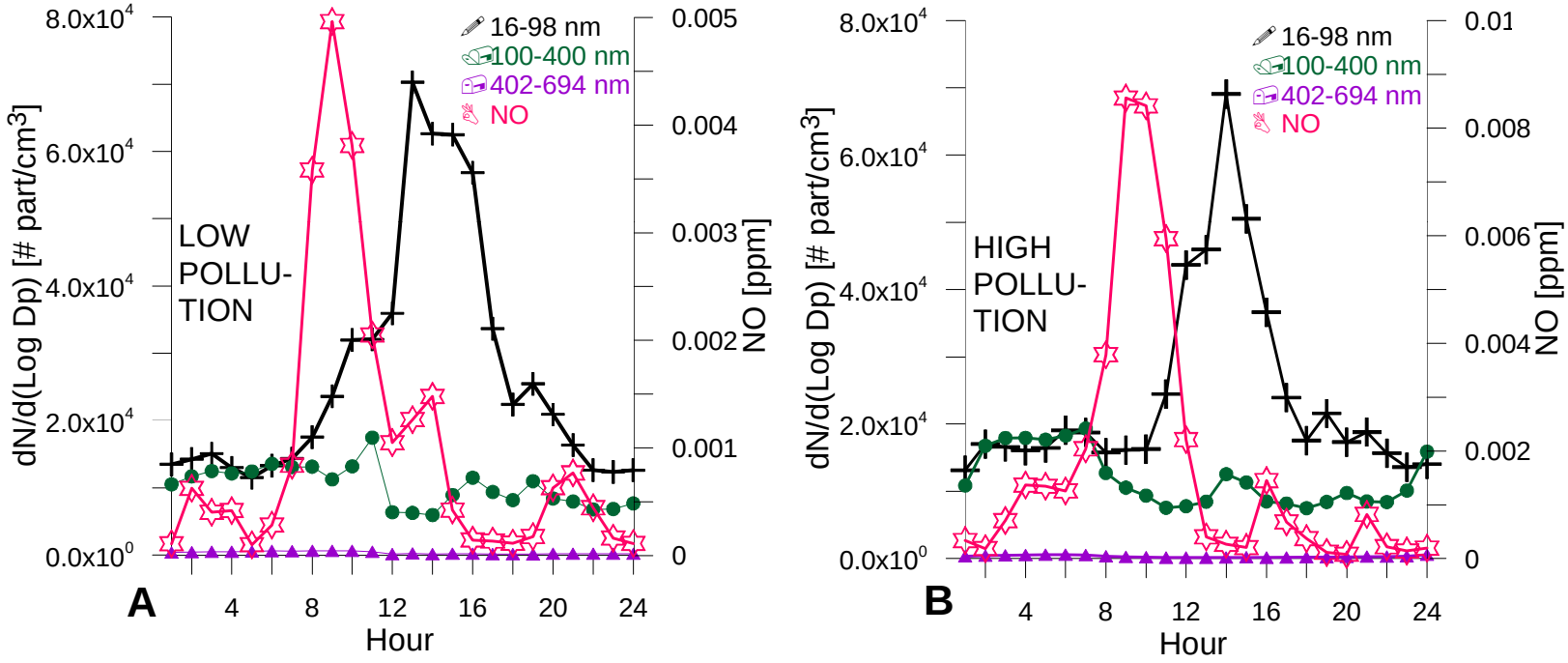

Fig. 5). Hourly tendencies in number distribution and NO, in three different diameters ranges. A) Lowly polluted days. B) Highly polluted days.

Tendencies of BC, CO and NO

Black carbón and CO had very low correlation, because for lowly polluted days $R^2 = 0.4785$, and $R^2 = 0.3407$ for highly polluted days. NO did not show any relation with Black Carbon.

The BC mass was 4.24% of the total mass of sub-micron particles.

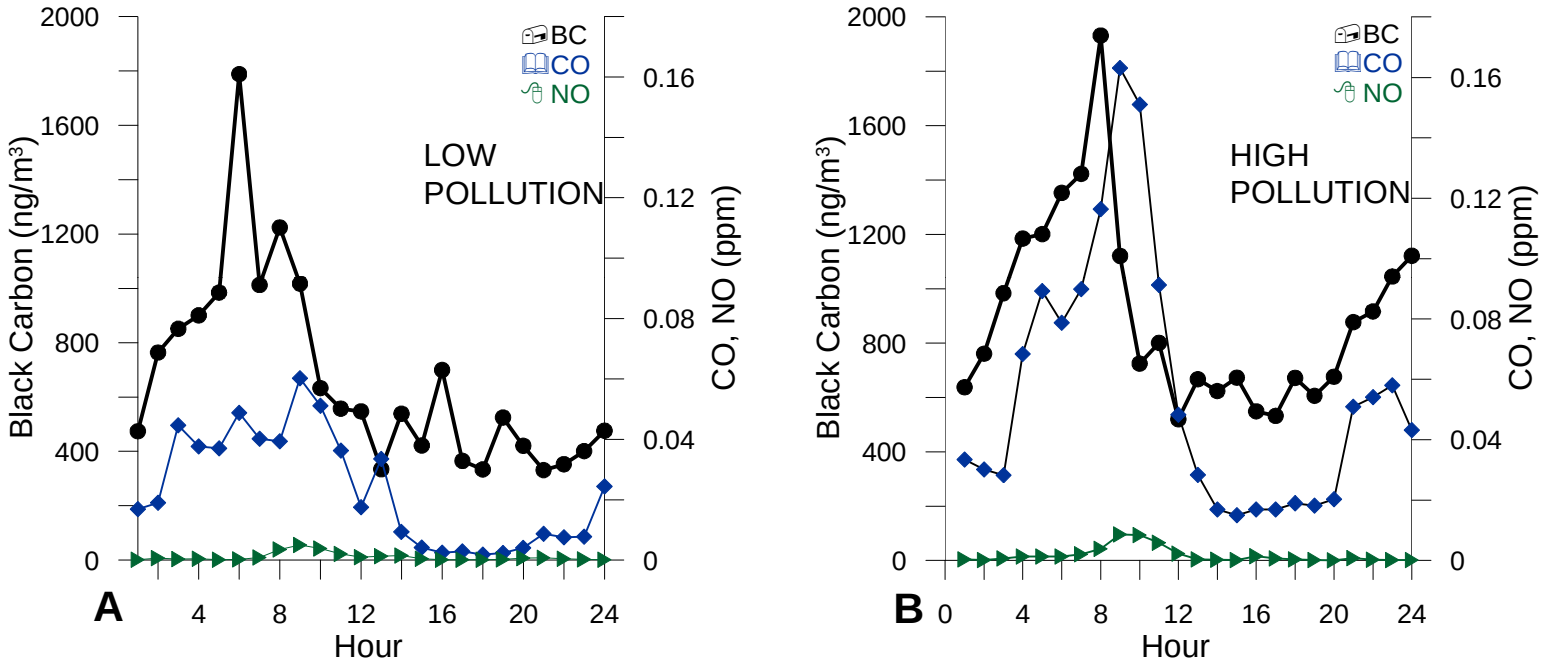

Fig. 6). Hourly tendencies in BC, CO and NO. A) Lowly polluted days. B) Highly polluted days.

Wind speed and wind direction

The predominant directions of wind were SW and SE, in low and high polluted days, respectively. If the refinery and the power plant are placed 6 km toward NE, which is the source of the sub-micron particles?

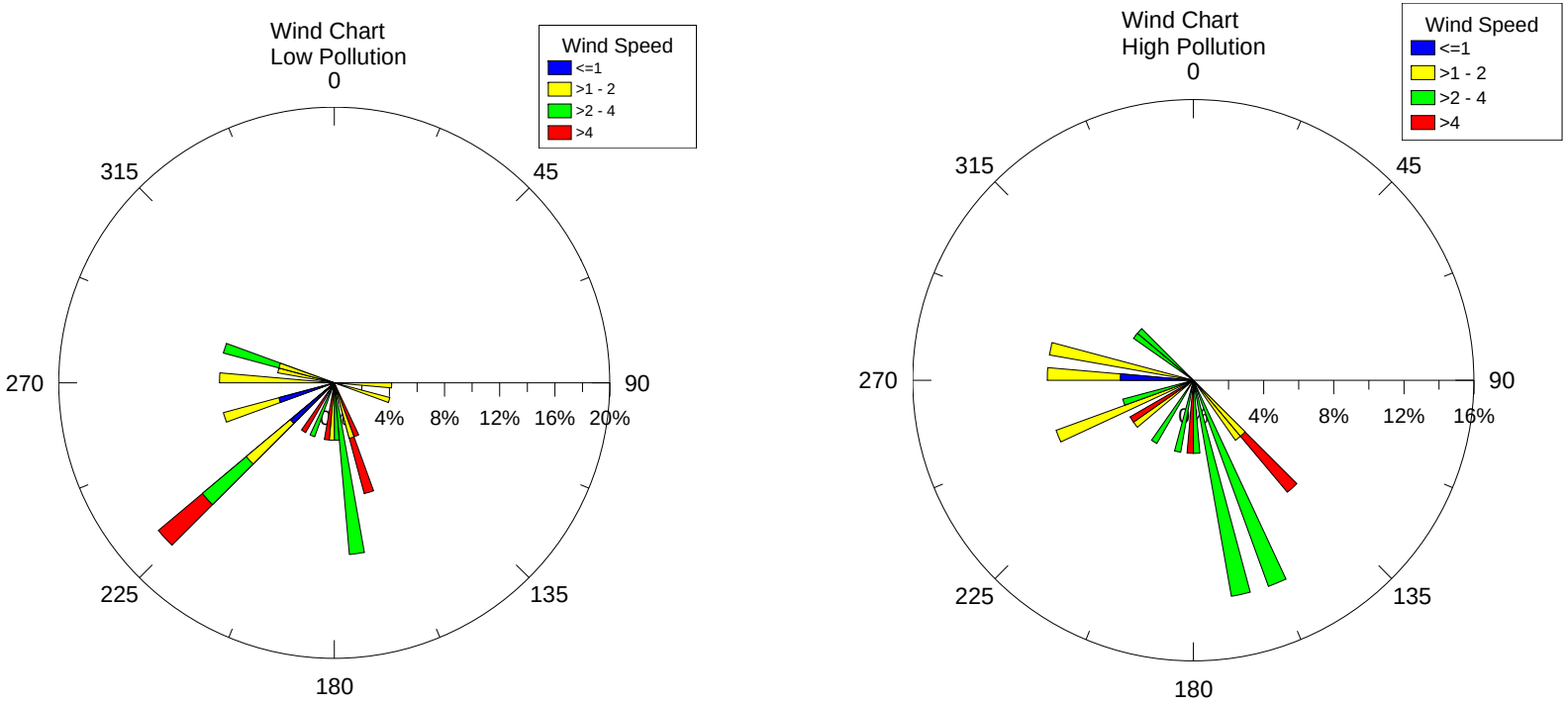

Fig. 7) Wind chart. A) Lowly polluted days. B) Highly polluted days.

CONCLUSIONS

1. The highly concentrations of sub-micron particles were observed from 01-06 h.
2. Light scattering was mainly related to middle sub-micron particles.
3. Middle particles grow up 264 times more quickly than the big particles, and 2 times more quickly than the nanometric particles.
4. BC and CO showed low correlation.
5. BC was 4.24% of the total mass of sub-micron particles.
6. Wind direction seems to be unconnected with the sub-micron particles concentrations.