Documentation of the diurnal PM10 concentration cycle for the urban site of Venice-Mestre

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Introduction

Stable boundary layer conditions are long known for causing increasing concentration of pollutant concentrations. In a recent study by the authors (Pernigotti et al. 2007), emphasis was given to the documentation of the diurnal cycle of Particulate Matter with diameter < 10µm (PM10) in relation to the atmospheric stability for a high-concentration episode. It was found that daily concentration variations are significant and can be larger than the daily average values. Moreover, evening static stability conditions are critical for PM10 increase, while even stronger night-time and early morning stability is concomitant with marked PM10 decrease. In this contribution a four-year data set of two-hourly PM10 concentration values measured at the traffic site of Venice-Mestre is analyzed with a specific focus on the intra-diurnal variations, and atmospheric static stability observations measured with a radiometer (MTP5-HE located 25km to the west in the city of Padua, Ferrario et al. 2006) when available, to substantiate the earlier findings cited above.

PM10 concentration

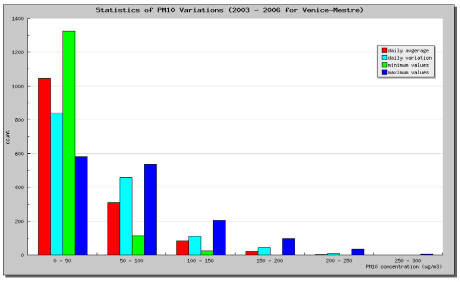

Figure 1 Daily average, maximum daily variation, minimum, and maximum values of PM10 concentration measured at the traffic station Venice-Mestre for the period 1 Jan 2003 – 31 Dec 2006. The measurements are made for two-hourly intervals.

Episode 19-26 Dec 2005

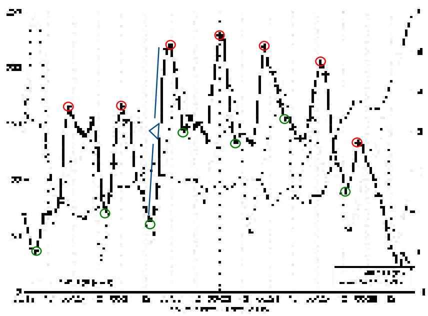

Figure 2: 19-26 Dec 2005, 2h-ly data, left axis for PM10 in µg/m³ (solid line), right axis for difference of potential temperature between 200m and ground level in K (dotted line), and wind at 100m above ground in m/s (dash-dotted line). Maxima (peaks), Minima, and variation are indicated in the plot.

Timing of Max/Min

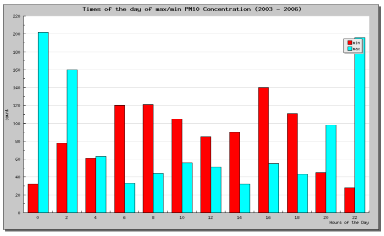

Figure 3 Histogram of time of the day of relative minimum (red, left bars) and maximum (cyan, right bars) values of PM10 concentration (counted extrema > 30 µg/m³).

Variability

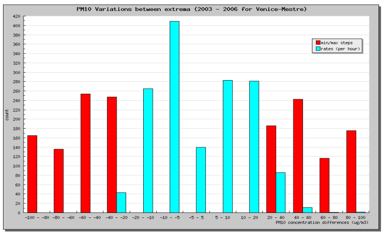

Figure 4 PM10 variations between adjacent minima and maxima (> 30 µg/m³). Red bars (left) denote the absolute variation, while the cyan bars (right) denote the rate of change per hour of the same variations.

Static stability

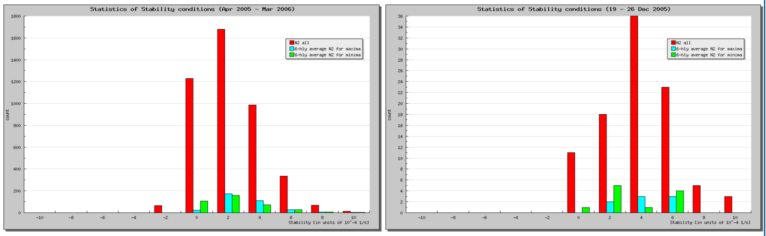

Figure 5 Atmospheric static stability in terms of the Brunt-Vaisala frequency N² in 10⁻⁴/s for the Christmas 2005 episode (left panel) and the year 1 Apr 2005 – 31 Mar 2006 (right panel). The red and leftmost bars denote all stability values, while the cyan/middle and the green/rightmost bars denote static stability at the time of minimum and maximum PM10 concentration, respectively.

Conclusions

In this study the two-hourly PM10 concentration evolution for the 4-year data set 2003-2006 was found to exhibit:

- **a significant number of days with daily averages above 50 µg/m³ (~400 in 4 years, Fig. 1);**
- **daily variations often of the same magnitude, or larger, than the average daily values (Fig. 1/2);**
- **peaks that mostly occur in the late evening and early night hours, while minima that are more evenly distributed during the day, with preferred occurrence in the early morning and mid-afternoon (Fig. 3);**
- **variations between maxima and minima that easily reach 100 µg/m³ and clearly depend on the peak concentrations (high correlation between maximum and variation, Fig. 4);**
- **hourly rates of change that reach 20 µg/m³/h and more (Fig 4).**

For the period Apr 2005 – Mar 2006 temperature profiles retrieved with a microwave radiometer (MTP5-HE, located 25km to the west in the city of Padua) were available. Static stability, estimated between 200m and the ground, was found to be important for PM10 accumulation, however the analysis yielded:

- **no simple dependence of static stability on neither the absolute value nor the increase of PM10; for the entire data set the correlation between 6-hly averaged N² and PM10 increase from minima to peak is 0.26, while for the 19-26 Dec 2005 episode (Fig. 2) a very high correlation of 0.88 results;**
- **that a relatively moderate static stability appears to be sufficient to allow for significant accumulation, and marked decrease in PM10 also in strongly stable conditions, (Fig. 5).**

A characteristic time lag of the peak concentration (22-02LT) w.r.t. the evening peak emission (18-20LT) is likely to be related to the formation of secondary PM10. The relevant processes include transformation of NOx into NO3- and NH4NO3, whose stabilization is favored at low temperatures (Putaud et al. 2004).

References

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