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ANALYSIS OF AN ACUTE PM EVENT OVER NORTHERN ITALY: THE CASE STUDY OF 24TH JANUARY- 4TH FEBRUARY 2017

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Abstract: This work describes the analysis of acute PM event, which took place between the ending of January and the beginning of February 2017. Basically, such period was characterized by very low depth of the atmospheric boundary layer and stagnant conditions over northern Italy; thus the already existent pollutants trapped into the lower atmospheric layers favoured the formation of secondary aerosols. Our findings point out the impact of the meteorological conditions on the secondary particles formation processes which resulted in an extremely high PM levels in Emilia Romagna region.

Key words: *air pollution, acute event, PM, Po valley, Emilia Romagna region***.**

INTRODUCTION

The Emilia-Romagna region is located in the south-west part of the Po valley basin, a densely populated and heavily industrialized area, where the synoptic configuration of high pressure over the western Mediterranean basin frequently result in atmospheric stagnant conditions for the air masses at ground level. Particularly during the cold season, such meteorological situation favours the pollutants trapping into the lower layers of the troposphere (Strafoggia et al. 2017, Pietrogrande et al. 2015).

The purpose of this study is to address the acute pollution events by investigating the emission/formation processes of primary and secondary particles in the lower atmospheric layer over the Emilia Romagna region. Thus, by using the simultaneous measurements of PM overall the regional domain, and of particles chemical compositions at the urban background sampling sites of Bologna, was pointed out that the pronounced increase of aerosols fine fraction can be ascribed mainly to secondary inorganic aerosols formations.

DATA AND METHODS

The PM data collected by the official air quality monitoring network of Emilia Romagna region - composed of 47 stations - were analysed. In addition, for this study, observations of PM_1, $PM_{2.5}$ and PM_{10} as well as the organic and the elemental carbon and secondary inorganic aerosols (SIA: sulfate, nitrate and ammonium) at station called *MainSite* in Bologna (BO) were elaborated together with atmospheric radio-soundings and wind speed and direction measurements observed at rural background station of San Pietro Capofiume. In order to underpin the atmospheric observations performed at/from ground level, the meteorological situation on synoptic scale was investigated by using the ECMWF operational products provided over the continental area of Mediterranean basin.

RESULTS AND CONCLUSIONS

The ending of January 2017 was characterized by high levels of pollutants overall the Po valley. For the Emilia Romagna region we have seen a slight increase of PM levels starting from January 19

(maximum for the 22nd and 23rd January of 79 ug m^{-3} observed in Modena and 60 ug m^{-3} in Rimini) followed by a couple of days in which no particular event occurred. The 27th - keep continuing for three days - the PM concentrations started to enhance again overall the regional area. The collected data on 31th January pointed out an abrupt increase of pollutants at ground level: in the area between Modena and Bologna the PM_{10} concentrations were higher than 200 ug m^{-3} and they kept such levels for three days following. The maximum of 247 ug m^{-3} was observed at Porta San Felice station in Bologna, as depicted in the Figure 1.

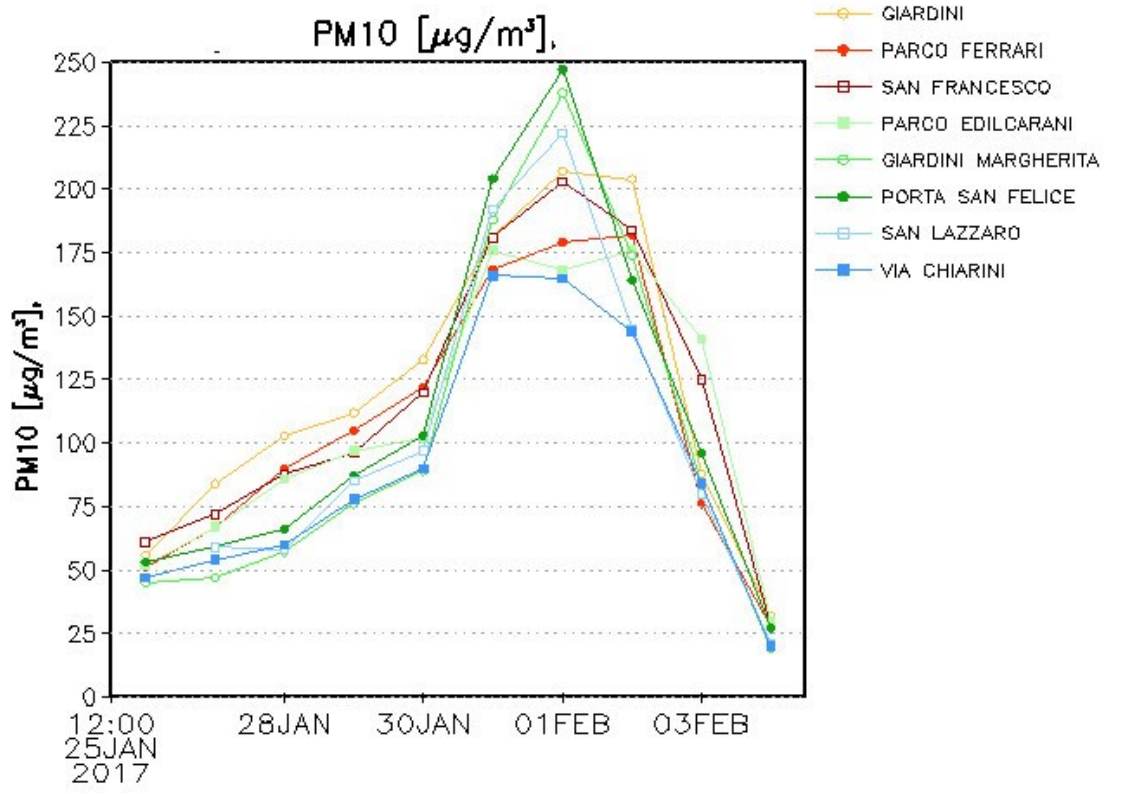


Figure 1. Time serie of daily PM_{10} concentrations [ug m^{-3}] measured between 25th January and the 4th February of 2017 at the air quality stations: in the legend stating from above, the first four belong to Modena district the remaining to Bologna one.

As reported in Fig. 1, very acute PM_{10} event was registered by the observational network of Emilia Romagna region (notice that the law threshold is 50 ug m^{-3}). We have seen a clear similarity of $PM_{2.5}$ time series to PM_{10} ones, but not for PM_1, which was measured only at the special station called *Mean Site* of Bologna (see Pietrogrande et al., 2015). During the three days of high PM levels, we have seen a strong similarity among stations located in the flat part of Emilia Romagna region. The meteorological condition, analysed on synoptic scale for those days, pointed out an high pressure situation over the northern Italy, which resulted in very low depth of atmospheric mixing layer. Thus, the thermal inversion located at a few hundred meters above the ground resulted in low wind conditions - completely decoupled with upper layers - with clouds which were affected by a slow subsidence process as well.

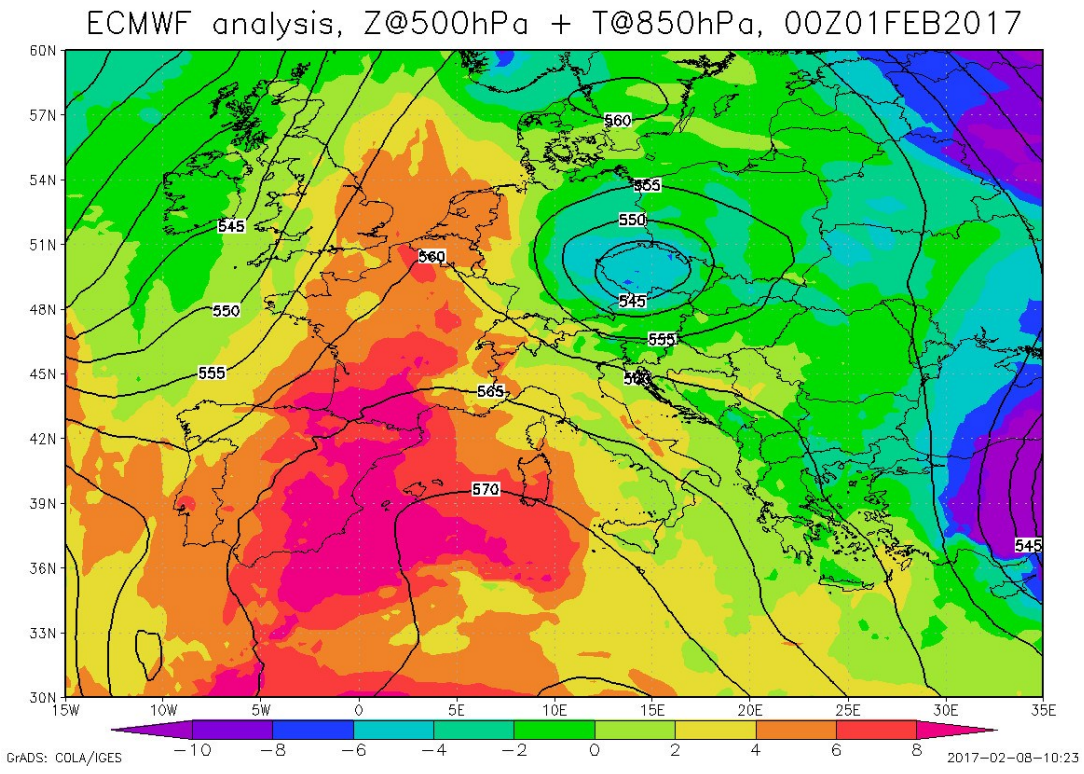
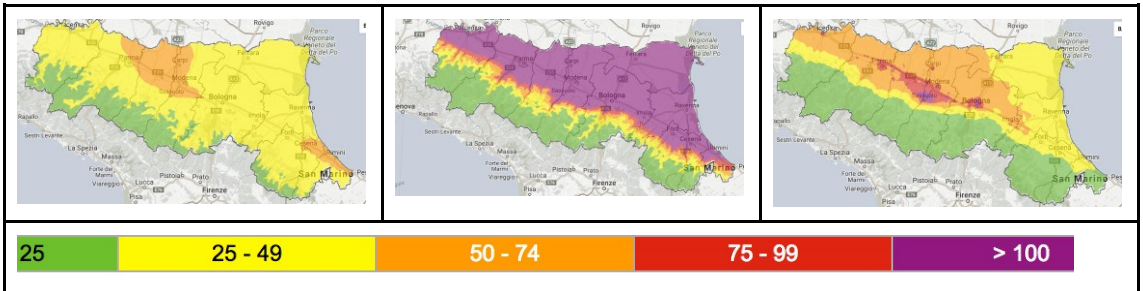


Figure 2. The synoptic situations as calculated by ECMWF IFS model over the Mediterranean basin. Geopotential at 500 hPa and air temperature at 850 hPa are reported.

Thus, the pollutions accumulation near the surface level significantly enhanced as result of concomitant factors:

- subsidence due to high pressure over the continental scale;
- thermal inversion at a few hundreds meters above the ground;
- stagnant condition in the mixing layer
- starting from the 30 January, warm air masses coming from south-west resulted in further push from above resulted with an enhanced trapping of pollutants near the ground.

However, starting from 30 January - for three days - the high PM levels were almost homogeneously distributed over the regional area, as depicted in Figure 3 panel *b*, and the different spatial distribution of PM_{10} before and after che event is depicted in panel *a* and *c* respectively.



a) PM_{10} [ug m^{-3}] (26 JAN 2017) | **b) PM_{10} [ug m^{-3}] (1 FEB 2017)** | **c) PM_{10} [ug m^{-3}] (4 FEB 2017)**

Figure 3. Daily PM_{10} concentrations as produced by PESCO system (please see https://www.arpae.it/cms3/documenti/_cerca_doc/meteo/ambiente/descr-pesco.pdf) before (panel a), during (panel b) and after (panel c) the PM acute event which took place beteween 31 January and 2 February 2017.

Such situation of pollutants homogeneity over a larger area encompassing Bologna, allowed us to pick out the *Main Site* of Bologna - where a special measurements were available as well - as station representative of the flat part of the ER region. Analysis of PM_{10}, $PM_{2.5}$ and PM_1 ratios (not shown) suggested that the major contribution to the total suspended matter (i.e. PM_{10}) cames from secondary aerosols formations, which have an aerodynamic diameter between 1 and 2.5 um. To underpin this hypothesis we report in Fig. 4 the time series of organic and elemental carbon, and the Secondary Inorganic Aerosols (SIA: sulphate, nitrate and ammonium), as well as of elemental and organic carbon (typically produced by combustions). Besides, the mass closure of chemical speciation was performed at Bologna, which demonstrate that the secondary inorganic aerosols goes up till the 53% during the event, compared with the 34% observed during the ten days before (Fig 4, panel b).

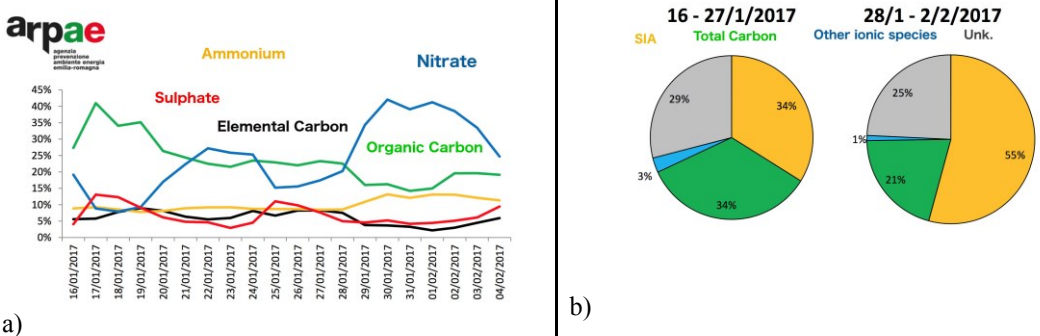


Figure 4. In the panel a is reported time series (percentage values) of organic and elemental carbon (typically produced by combustions)., and the secondary inorganic aerosols (SIA: sulphate, nitrate and ammonium). In the panel b is depicted the mass closure of $PM_{2.5}$ before (pie on the left) and during the event (pie on the right).

The nitrate showed the most significant increase with respect to ammonium and sulphate. On the other hand, no relevant increment in elemental and organic carbon were observed in terms of percentage in the $PM_{2.5}$ mass even during the acute PM event.

By summarizing, we can state that the concomitant stagnant conditions associated with thermal inversion, strongly favored the secondary aerosols formations processes associated with acute PM event overall the flat part of Emilia Romagna region. Although we have seen that in this case the heating systems, the vehicles/traffic emissions, the wood burning did not significantly contribute to such acute event, the authors would like to remind that, generally, during the cold season, they are the major cause of acute pollution events together with secondary aerosols formation as well.

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