European Geosciences Union General Assembly 2011, Vienna, Austria , 03 – 08 April 2011

PM10 air quality variations in urbanized areas and industrialized creek valley in Istanbul

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Abstract

PM10 pollution episodes associated with emissions and meteorological situations in Istanbul is investigated. The air quality stations in ten urban areas in both Asian and European sides including industrialized Kağıthane creek valley which is at the northeast part of the old city are used in the study. In both Asian and European sides, EU's daily average PM10 air quality standards were exceeded approximately throughout the year (The current period of PM10 measurements in industrialized creek region is eight months). Besides, in order to account for possible long range transport of particles in Istanbul, the association of the PM10 levels with backwards trajectories was examined.

Introduction

Air pollution that adversely influences human health and environmental future is a major problem of mega cities. Local sources as well as meteorological and topographic conditions can strongly affect the spatial and temporal variability of particulate matters. Especially, particulate matters may rise from a wide variety of mobile, stationary and natural sources. Anthropogenic particles mainly consist of diesel powered fuel combustion, industrial processes, agriculture and coal burning for different purposes.. Istanbul is one of the significant and historically ancient mega cities in the world and located at two continents as Europe and Asia. The city has experienced serious air quality problems in the past. They were explained and discussed in the literature.

Data and Methods

The financial, commercial and cultural center of Turkey, Istanbul is one of the biggest metropolitan of the world with 13 million population in western part of Turkey (Marmara Region). It has faced with many environmental problems as a result of rapid development of financial and industrial sectors. Istanbul has got a lot of different region with different topography. One of them is Kağıthane district where has complex topography, industrial factories and intense urbanization (Figure 1). Kağıthane valley is the source part of the Golden Horn and forming the natural harbor that has sheltered in the Golden Horn waterway, named in antiquity because of its shape is an estuary that receives water from Kağıthane and Alibeyköy creek. The Kağıthane creek region is one of the most polluted locations in Istanbul due to its topographical form and pollutant sources in the region.

Figure 1. Map of Marmara of region (left panel) and Kağıthane (right panel).

This study is supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) as a name of Investigation of Air Quality in Kağıthane region of İstanbul. Some air pollution parameters (PM10, CO, SO_2, NO, NO_2, NO_x, O_3) since 1 April 2010. Daily time series results is shown in Figure 2. PM_{10} concentrations monitoring was continuous and hourly averages were recorded in µg/m^3. This monitor is based on the principle of beta ray absorption by particles, which are sampled through the instrument and collected on a fiber-glass filter tape Wedding beta-gauge PM_{10} monitors. Wedding beta-gauge PM_{10} monitor is one of the US EPA-designed of equivalent methods. According to this technique, PM_{10} particles are continuously collected on the filter tape and detected once every hour. The instrument is automatically calibrated with two self-calibration mass standards during each sampling period.

We have been analyzed meteorological condition due to better understand episode days air quality and back trajectory analysis have been done for long range transportation using Hysplit.

Result and Discussion

An episode day in Istanbul is analysed in this study. As seen at Figure 2, daily average PM10 values change generally between 50 and 150 µg/m^3 in eight months. However, some values are greater than 150 µg/m^3. As seen Figure 1 the region is in valley and there are a lot of industrial items in the region. Three of four sides of the station is surrounded with motorways and the TEM highway, main road between Asia and Europe, which is only 2 km north of the station. In addition to the traffic contribution, soil borne dust is another source because of the topographic structure. PM10 values increase in the morning and evening due to increasing traffic. PM10 values seen on Sunday tend to decrease because of rare traffic. Some of main air pollution sources in the region is traffic, heating, industry and long range transportation. The population density in the area is increasing in terms of dense housing, shopping center, stadium and road near by the region.

When we obtain annual cycle data we can see seasonal changes and heating effect on air pollution changes during a year. There are some high values during the 8 months and one of them seen in mid of April. Concentration reaches extremely high values continued four days between 13-16 April 2010 (138, 106, 183, 252 µg/m^3) in the city.

Residential heating source effect will be revealed more clearly by seasonal considerations and the completeness of measurements in a year. Differences in the area do occur during the observation period, like the increase in number of buildings and vehicles. The energy sources also evolute to more environmental-friendly types, i.e. new vehicles with less CO_2 emmission are used day by day.

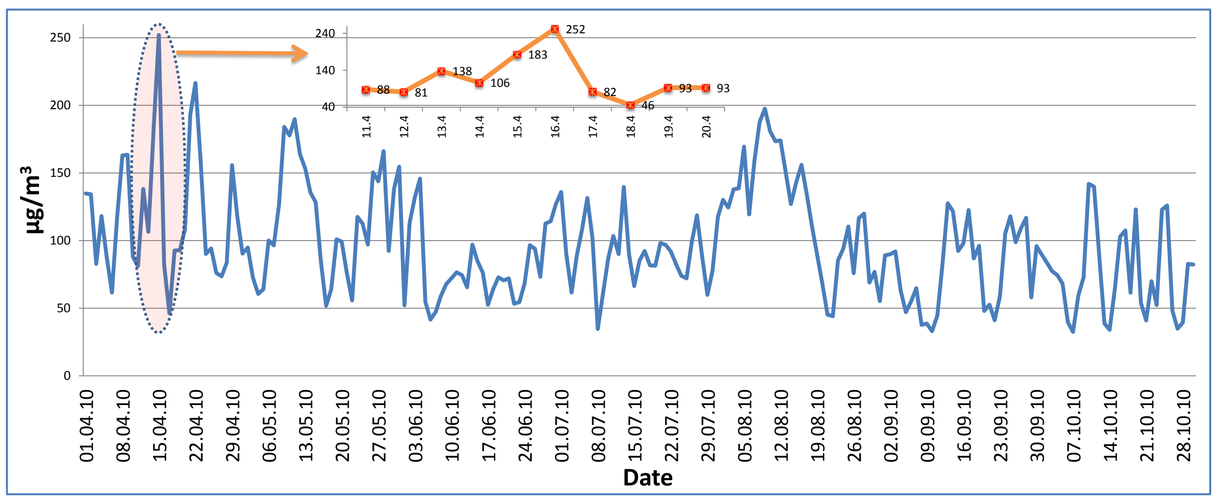

Figure 2. Daily average PM10 values in Kağıthane.

Meteorological conditions and Back trajectory

Between 13.04.2010 and 16.04.2010, northwestern Turkey is under high pressure effect with clear sky and diurnally varying surface temperature, except 14th of the month, when some rain is observed during daytime. The mean sea level pressure, 500 hPa geopotential height and 1000-500 hPa thickness (15.04.2010 00UTC GFS Analysis from wetter3.de) is given at Figure 3. Istanbul didn't receive any measurable rain even on 14th April, but it was almost overcast. Due to the high pressure, clear sky, weak horizontal wind and subsidence at lower levels of the atmosphere, the temperature profile near the surface was changing with respect to long wave terrestrial radiation emitted from surface. That's why the night inversions were dominant factor determining the weather conditions in local scale. This brings out a trapping mechanism for the pollutants under the inversion level, especially at valleys like Kagithane region. Figure 4 shows the thermodynamic diagram for Istanbul for 15.04.2010 00UTC. The surface inversion and weak winds, as well as the dry low level conditions indicate the existing subsidence.

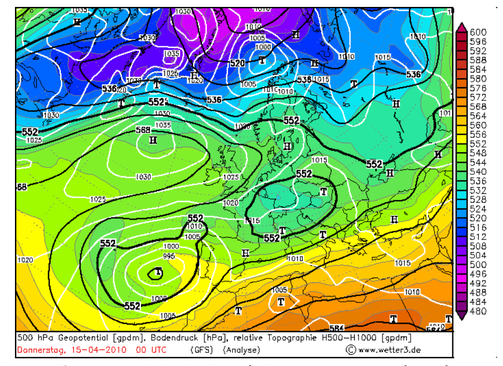

Figure 3. MSLP, 500 hPa geopotential and 1000-500 hPa thickness for 15.04.2010 00UTC. GFS Analysis from wetter3.de archive.

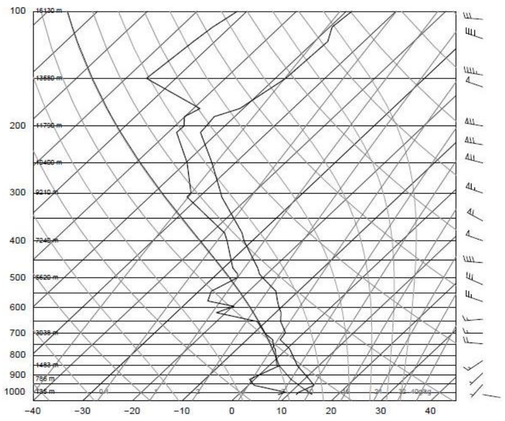

Figure 4. Skew-T log-p diagram for 15.04.2010 00UTC, obtained from Istanbul ravinsonde observation at http://weather.uwyo.edu/upperair/sounding.html.

In order to see if there is a long-range transport, Hysplit Back trajectory analysis have been done for İstanbul (41.15N - 29.00E) in April 15, 2010 (Figure 5). It had been accomplished 72 hours back trajectory analysis for 12UTC times and for 10m, 500m, 1000 m and 2500m above ground levels. Ensemble analysis shows while 3 daily backward trajectories are over Black sea through 10m level at 00UTC; it's been moved over Marmara region at 12UTC. Although if we extend the backward time period, the backward trajectories are from over Greece, implicitly Mediterranean Sea at 1000m AGL; while the backward trajectory are from over Russia from ground to 500m AGL; none of them shows an exact source for PM10. As a result, the source of the PM10 is considered to be local more than long-range transport.

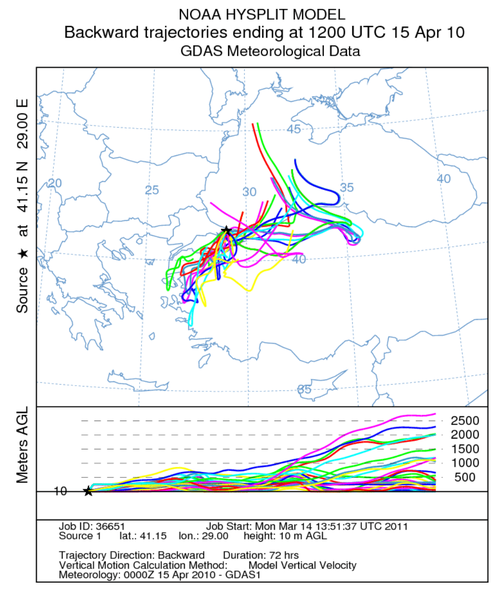

Figure 5. Hysplit Back trajectory analysis

Conclusion

At this study, air quality data of eight months have been analyzed. Generally, daily PM10 values are higher than the 50 µg/m^3 value which is the European air quality limit. One of the exceedances was seen in mid of April. Concentration reaches extreme values during 13-16 April 2010 in the Kağıthane region. Because the station is surrounded with motorways and two highways which are the two main roads between Asia and Europe, low level air quality values had been seen. In addition to the traffic pollution, soil born dust is another pollutant factor which is the result of the topographic structure. Due to the increasing traffic, PM10 values increase at the morning and the evening. Because of the slight traffic rate, PM10 values decrease on Sunday. The other main air pollution sources in the region are: heating, industry, construction activities and long range transportation. The population density of the area is increasing because of housing, shopping centers, stadium and the road near by the region.

Acknowledgements

The authors are grateful for providing air quality data to Environmental Ministry of Turkey. This work was part of the Turkish Scientific and Technical Research Council Project No: 109Y132.