Characterization of ozone and particulate matter levels in a coastal site with the application of a trajectory clustering correlation methodology

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Sisi (Malia), Crete, Greece, 17-20 October, 2005

10th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

INTRODUCTION

Atmospheric trajectories and cluster analysis have been employed to study pollutants from sources situated at long distances (e.g. Moody, 1986; Brankov et al., 1998).

Cluster analysis is a statistical tool that can be used to find out relationships between the large-scale weather regime patterns and the pollution climatology of a site. This method classifies a large set of trajectories into dominant groups called clusters.

The relationship between synoptic-scale atmospheric transport patterns and the surface levels of air pollutants (O₃ and PM₁₀) observed at a coastal site (northeastern Iberian Peninsula) is analyzed by the application of a trajectory clustering correlation methodology.

Cities of Barcelona (BCN; 41.4N, 2.11E) and Cap de Creus (CC; 42°31N, 3°31E) are analyzed by the application of a trajectory clustering correlation methodology.

The city of Barcelona (BCN; 41.4N, 2.11E) and the rural site in Cap de Creus (CC; 42°31N, 3°31E) are analyzed by the application of a trajectory clustering correlation methodology.

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For PM10 measurements, KZ filtering technique is not applied due to the inability of the method to discern the occurrence of episodes with aerosol increase from the climatic behavior of this pollutant (e.g., Sahara Dust outbreaks).

A cluster algorithm (Dorling et al., 1992; Jorba et al., 2004) was implemented to analyze the backward trajectories arriving at BCN at 18 UTC. O3 and PM10 concentration levels measured by air quality stations in BCN and CC are segregated according to the backtrajectory clusters.

A statistical analysis is then applied in order to determine significant differences associated to each cluster.

**METHODOLOGY**

**Data base:**
- 2000 – 2003 8-hour-daily-mean time-series of O3 on BCN and CC.
- 2000 – 2003 daily-mean time-series of PM10 on BCN.
- 2000 – 2003 2-day kinematic HYSPLIT backtrajectories computed with FNL data.

Due to the interest in studying the relation between the transport of pollutants with meteorological situations, a spectral decomposition is applied to the O3 database in order to separate the short-term component (meteorological-related) from the seasonal component (long-term-climatic variation) embedded in the time-series.

Kolmogorov-Zurbenko filter is used for this purpose (Zurbenko, 1996).

**BACKTRAJECTORY CLUSTER ANALYSIS**

Cluster algorithm: Four years (2000-2003) of 2-day 500m-kinematic back trajectories, computed with the HYSPLIT Single-Particle Lagrangian Integrated Trajectory model version 4 (HYSPLIT) (Draxler and Hess, 1998) with FNL meteorological data, were clustered and classified in groups of similar length and curvature.
INFLUENCE OF SYNOPTIC METEOROLOGY ON SURFACE POLLUTANTS CONCENTRATION: OZONE

The short-term component of O₃ concentration has been related to cluster analysis results. Box-whisker plots show this relation for the urban (top panels) and the rural site (bottom panels).

- Situations embedded in cluster E present the highest increase in O₃ levels, especially during summer in both sites.
- Attending to the direction of air masses (eastern advections) and the simultaneous high levels in both sites, one could relate these O₃ concentrations to a regional transport of air masses with higher O₃ concentrations or primary pollutants from the WMB and the European continent to the eastern coast of the IP.

Cluster E groups situations characterized by recirculation of air masses for several days over the region, presenting high O₃ levels, with a higher increase in the concentrations for CC (rural site) than in BCN (urban site).

Following Jiménez and Baldasano (2004), the stagnant meteorological conditions during summertime and the local transport of polluted air masses mainly from the emitter urban area of BCN provoke the accumulation of O₃ in the NOₓ-limited rural site of CC.
INFLUENCE OF SYNOPTIC METEOROLOGY ON SURFACE POLLUTANTS CONCENTRATION: OZONE

- The short-term component of O$_3$ concentration has been related to cluster analysis results. Box-whisker plots show this relation for the urban and the rural site.

- Westerly situations (cluster SW and NW) are characterized by a decrease of pollutants in both regions.

- Important decrease in cluster SW during wintertime for both sites.

- Northwestern situations (cluster NW) just present an important decrease in O$_3$ levels in the rural stations during summertime.

- The development of the local wind Tramuntana (northern wind) near CC may contribute to the decrease in O$_3$ concentrations. Usually, the BCN urban site is not directly affected by the Tramuntana wind.

INFLUENCE OF SYNOPTIC METEOROLOGY ON SURFACE POLLUTANTS CONCENTRATION: PARTICULATE MATTER

- Northern, eastern and western flows are characterized by lower PM10 mean concentrations.

- It is important to remark that eastern situations are characterized by low winter levels of PM10. This behavior is opposed to the observed with O$_3$ which presents a clear increase on concentration compared with the climatic compound. Eastern flows are maritime air masses that present low concentration of PM10.

- Cluster Rw presents more scenarios with higher concentrations related to re-suspension of aerosols due to the recirculation of air masses over the region of study.
This behavior is observed also in cluster Re, which presents the higher mean values of PM10. This cluster includes marked episodes of re-suspension of aerosols with high concentrations of PM10 related to the accumulation of aerosols within the region for several days due to the low baric gradient situation with slow motions.

The significance of the Saharan dust outbreaks over the IP is also observed in cluster SW, with higher levels of PM10. This cluster groups the back trajectories with a marked southwestern component, which may be related with advective situations of warm air masses from the north Africa to the IP with high concentrations of aerosols.

On the other hand, cluster NW presents the lower levels of PM10. The advective characteristics of this cluster and the association with the front pass situations with development of rain contribute to the decrease of PM10 concentrations.

CONCLUSIONS

Although the results show a clear decrease in O₃ levels during wintertime, it is remarkably the higher concentrations of O₃ associated to eastern regional transport from western Mediterranean basin.

During summertime, O₃ levels increase, especially in meteorological situations characterized by low-pressure gradient with recirculations of air masses within the WMB, and under dominated anticyclonic situations.

PM10 concentrations present a smooth behavior between clusters, with higher levels associated to anticyclonic and low-pressure gradient situations characterized by important atmospheric subsidence over the zone and slow flows with important resuspension of aerosols.

Saharan dust outbreaks over the IP are also identified in cluster SW, with higher levels of PM10 exceeding the 75 percentile.

The trajectory clustering correlation methodology appears as a useful tool for the study of air quality scenarios related to meteorological situations.
Thanks for your attention