An extraordinary ozone episode in Madrid (april, 2000) during night time: a modelling study

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1 Introduction

Ozone is an important secondary pollutant in the atmosphere and also a strong oxidant. Ozone episodes are defined as periods of time during the day where the ozone concentrations are found to exceed the acceptable levels which are commonly defined in the EU Directives or National standards. High ozone concentrations are usually produced during the afternoon period when the primary pollutants emitted during the day have reacted chemically, driven by solar radiation and temperature which peak around noon and afternoon, respectively. Because of the transport and influence of the primary pollutants in the central urban areas high ozone level are usually found in the suburban areas where primary emissions are smaller and ozone produced during morning hours is distributed based on the atmospheric transport. This leads to typical ozone episodes which usually occur in the April – October period each year. Exceptional ozone episodes are considered those produced at unexpected times or days of the year as it is the case for the episode between 2h00 – 6h00 on the 29, April, 2000 over Madrid (Spain) city. The explanation should also be somehow exceptional. Moreover, if the ozone levels reach values of 1000 $\mu g/m^3$ or more as was the case over Madrid the explanation to be found should be somehow more exceptional. Stratosphere-troposphere exchange can play an important role when explaining these unique episodes, Stohl A. and Trickl T.[1] (1999), Liu et al.[2] (1987).

2 Madrid Unique Episode

In the morning hours of April, 29, 2000 the air quality networks of both the Madrid Community and Madrid City observed extraordinary high values of ozone between 2h00 and 6-7h00. The Madrid Community network has nine stations and the Madrid City network has 24 stations. Figure 1 and 2 shows these concentrations for two of the Madrid Community monitoring stations.

We have used the OPANA modelling system which is a model composed by the REMEST (non-hydrostatic mesoscale meteorological model, based on the MEMO model (University of Karlsruhe, Germany, 1994) and the SMVGEAR model (University of Los Angeles, USA, 1994: see also San José et al.[3] 1999) to simulate the episode on the mesoscale. We have found that winds during the hours before the episode and after the heavy traffic of the friday evening (week end) were in direction to the North-East (Figure 3) and at about 1h00 on April, 29, 2000 the wind turned 180 degrees to direction South-West on the layers of about 400 m above ground level (Figure 4). These circumstances can be interpreted as the ozone produced during the friday, 28, April, 2000 is accumulated in the residual layer and because of a strong convergence of winds on the upper layers and following the fact that the ozone accumulated is transport to North-East direction and returned to the Madrid position after 180 degrees wind change direction.

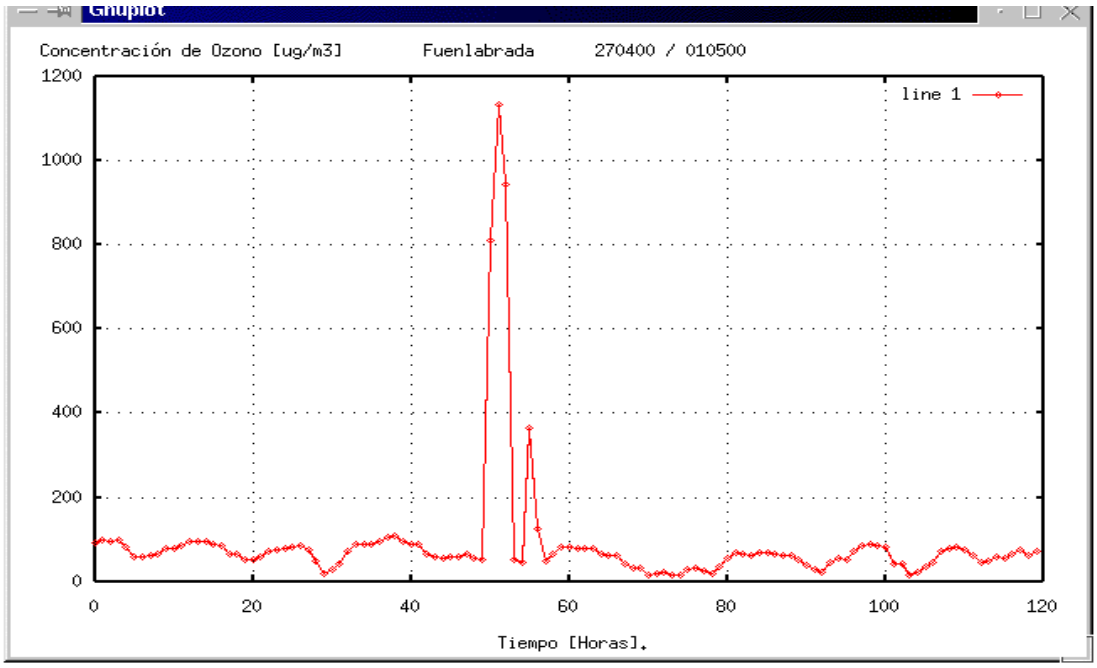

Figure 1 Ozone concentrations in the Fuenlabrada monitoring station (Madrid Community) during the ozone episode. The pattern shows data on April, 27, 2000 – May. 1, 2000.

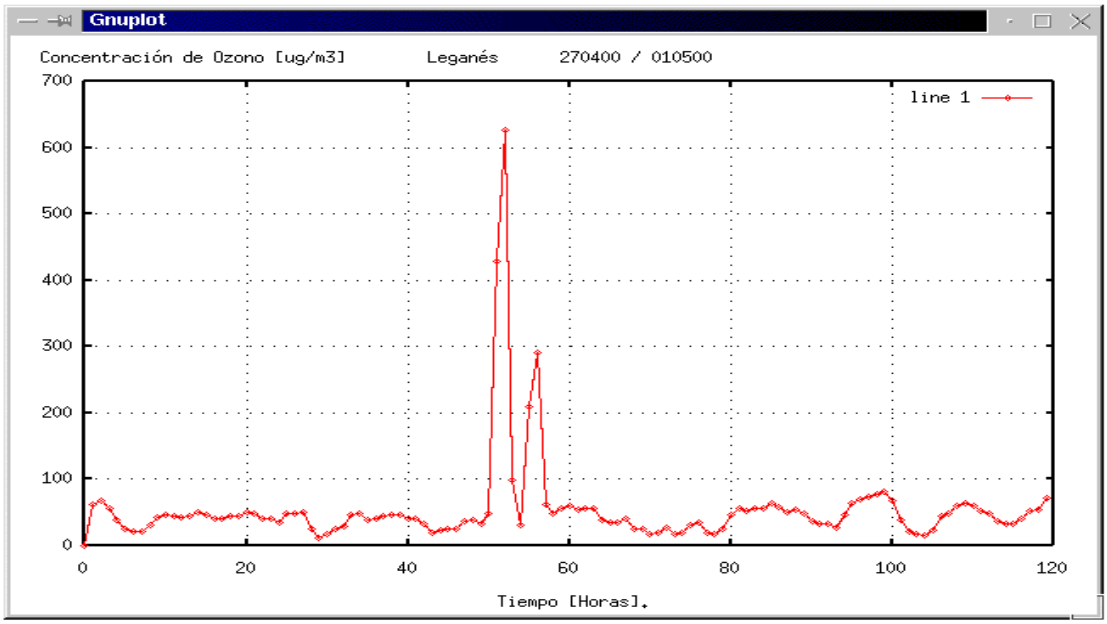

Figure 2 Ozone concentrations in the Leganés monitoring station (Madrid Community) during the ozone episode. The pattern shows data on April, 27, 2000 – May. 1, 2000.

The second tool used is the trajectory model FLEXTRA (Stohl et al.[4] 1998). The model was run by using ECMWF datasets. Backward trajectories were calculated ending on a regular grid, and Figure 5 shows those trajectories that descended by more than 5000 m and, at some point of their travel, reached the stratosphere (potential vorticity greater than 1.6 potential vorticity units). It can be seen that the Iberian Peninsula was affected by an airmass that originated in the stratosphere. It seems possible that high concentrations of ozone were transported from the stratosphere to the area of Madrid. Less evidence is that these trajectories reach the surface however. Once the ozone is in the upper layers of the Madrid domain at approximately the time of the ozone episode in discussion,

stability is very week and thus neutral turbulence over large urban areas (as it is the case of Madrid) during night periods is expected. This suggestion is supported by the REMEST model analysis, that show Monin-Obukhov lengths at surface level close to neutral values.

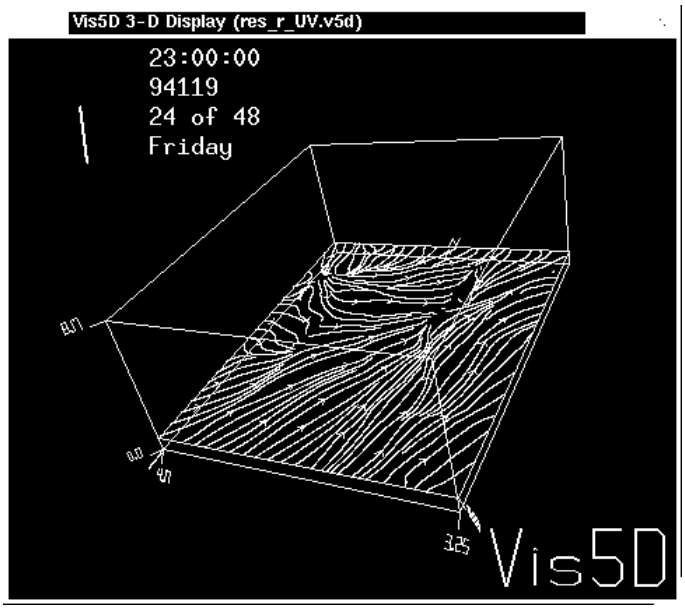

Figure 3 Winds are blowing direction to North-East at 23h00 on Friday, 28, 2000 at 400 m above ground level.

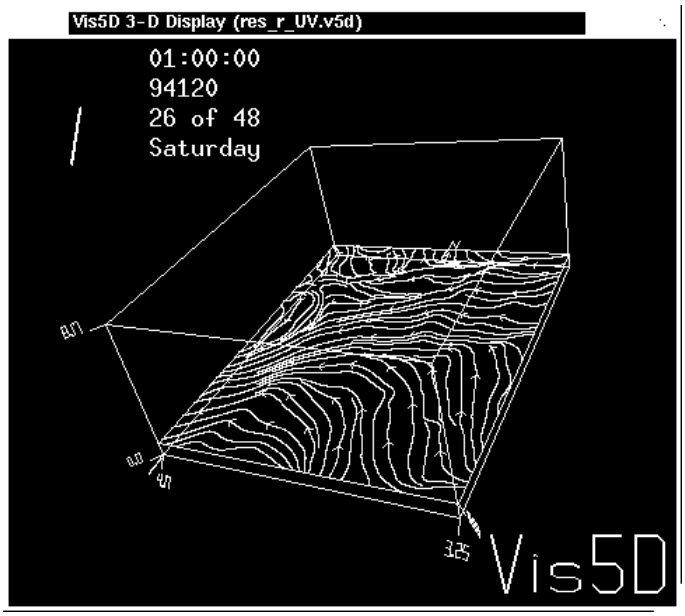

Figure 4 Winds are blowing direction to South-West at 1h00 on Friday, 29, 2000 at 400 m above ground level.

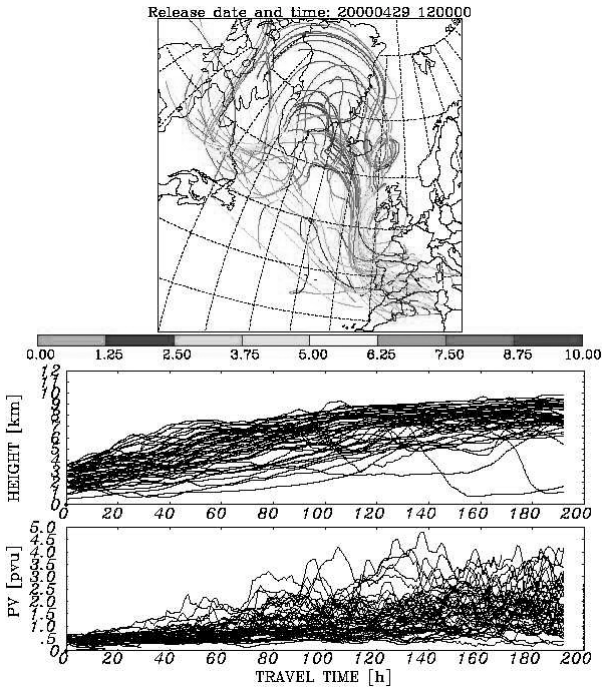

Figure 5 Ensemble of three-dimensional trajectories depicting the intrusion of stratospheric air into the troposphere.

3 Conclusions

During the early morning hours on April, 29, 2000, a time series of observation data suggesting that a unique and exceptional ozone episode occurred in Madrid city and surrounding areas was witnessed, where monitoring stations reported ozone concentration levels up to 1190 $\mu g/m^3$. In this contribution we will present simulation results based on two different modelling approaches. The first one is a trajectory analysis with FLEXTRA trajectory model with ECMWF datasets, carried out in the University of Munich and the second one is the application of the OPANA Air Quality Modelling System over the Madrid Community and City domains. Both models were applied during simulation periods which included the Madrid "exceptional ozone episode". Trajectory analysis supports ozone intrusion from elevated layers that might have brought significant amounts of ozone from the stratosphere to the 1000-2000 m layer during April, 28-29, 2000 over the Madrid domain. On the other hand, OPANA results regarding upper layer wind trajectories on late hours on April, 28, 2000 (friday evening) over Madrid domain, showed that the main wind direction , being south west, turned 180 ^{o} one to two hours before the "episode", bringing back the ozone generated on the day before (typical weekend day, high traffic rates, etc.). On the other hand, convergence of winds along the south-west north-east axis over the Madrid Community shows an important correspondence with the sequence of air monitoring stations observing the high exceptional ozone values. Preliminary conclusions show that the exceptional meteorological and climate conditions on such a night could be reason for the occurrence of such high values. Additional technical circumstances (such as technical incidences in some monitoring stations) also showed that some instruments could not work properly under such high concentrations.

4 Acknowledgements

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5 References

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