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URBAN AEROSOLS SURVEY USING LIDAR AND NUMERICAL MODEL

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INTRODUCTION

The impact of particulate matters and aerosols on environment and on radiative forcing is well recognized. However variety in size and composition of aerosols makes a complete characterization difficult, which is more pronounced for urban aerosols. Moreover the spatial and time distributions of aerosols in the atmosphere are inhomogeneous, which increases the difficulty in aerosols characterization. To overcome these difficulties combining in situ sampling techniques (like as DMA or OPC) and remote sensing monitoring system like as Lidar leads to an appropriate methodology. Moreover the high temporal and spatial resolution of elastics-backscatter Lidar provides a real-time monitoring of the PBL in the form of time-height-backscatter plots. This characterization leads to a better interpretation of ground-based pollution measurement regarding to the PBL dynamics.
Coupling point and remote measurements of aerosols to a dispersion numerical model provides an efficient tool regarding to the evaluation of pollution impact on the regional scale. Very few studies (Duclaux, 2002, Beniston, 1990 and Fiorani, 1997) have been reported concerning photochemistry processes.
In this paper, we present a new methodology for urban aerosol survey, coupling Lidar measurements and numerical models. The aim of this study is build a continuous survey of aerosol impact on the local and regional scale.
First evaluation of this method was done during a winter smog episode in 2001, where the aerosol mass loading in the PBL could be evaluated and main emissions sources could be retrieved, applying back-trajectories calculation.

METHODS

Continuous monitoring of the vertical and time distribution of atmospheric aerosols content is performed using a stand-alone Lidar device located at the University campus of Lyon in the North part of the city. The Lidar system is based on a pulsed Nd-YAG laser source emitting at 355 nm, assuring also eye-safety. To retrieve the aerosols optical properties (backscattering and extinction) and the aerosols mass loading from Lidar measurement, a typical urban aerosol size distribution for Lyon (Duclaux, 2002) was assumed. Three different modes of the aerosols size distribution were taken in account, distinguished by its size, shape and composition. The aerosols with size less than 20 nm soot monomer, particles size ranged between 20 and 500 nm, where fractal shape of soot aggregate with typical monomer size of 20 nm and a fractal dimension D (1.75) (Gangopadhyay, 1991, Sorensen, 1992) were assumed. For aerosols with size bigger than 500 nm, a mixture of spherical silica (0.4) and soot (0.6) was assumed (Kasparian, 1998).

To evaluate the origin of the different air parcels monitored by Lidar, numerical simulations of air particle trajectories were performed with the model ADMS-3 (CERC, 2000). This code, based on dispersion calculation of point sources, models the wind field applying Fourier transform on the solution of the linear equations of motion (FLOWSTAR ; Hunt, 1988). The model calculates a steady wind field, assuming that the velocity is given at a point location. It assumes that the terrain is relatively flat, and it includes atmospheric stability effects, using Monin-Obukhov similarity theory. This flow model has been applied on a 32 km x 32 km domain centred on the city of Lyon, including hilly relief in the west and in the north. Assuming a linear evolution of the wind field between two hours, direct and back trajectories passing at a height of 50 m above the Lidar location were then calculated using a simple Eulerian advection scheme, with a time step of 1 minute.

CONCLUSIONS

The air masses history of the smog episode could be well evaluated using the models output simulation. From the Lidar aerosol monitoring, the time and vertical distribution of the mass of the particulate matter mass could be retrieved showing high loading in the PBL. Merging both evaluation methods, main emission aerosols sources have been identified and comparison with point measurements pointing out a good correlation.

Improvement of this methodology, which is in elaboration, is the retrieving of the aerosol size distribution from a multi-wavelengths Lidar, which will reduce the errors of the estimation of the aerosol mass loading and the uncertainty on the model to retrieve the aerosols sources.

This study shown that Lidar and the numerical model are very complementary tools in order to evaluate and survey the local and regional impact of aerosols pollution.

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