Air pollution monitoring based on remote sensing and simultaneous ground PM 10 and PM2.5 measurements: the 'WebAir-2 project'

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Abstract WebAir-2 EUREKA project aims to expand the basic air quality modelling technology (web-based client server) developed in E!3266 WebAir project. WebAir-2 will incorporate different technologies such as satellite remote sensing data and ground PM samples for monitoring air pollution and in addition 3G mobile phone technology will be used for personalized health related information, warnings and exposure reports. Emphasis will be given to the development of statistical models for PM against AOT derived from MODIS data. Due to inadequate spatial-temporal coverage of air pollution from existing air pollution stations, MODIS products can assist to this task both spatial and temporal. The statistical AOT model will be cross-validated during satellite overpass based on handheld sun-photometers and daily CIMEL sun-photometer (NASA/AERONET network) measurements. Moreover ground LIDAR measurements for vertical distribution of the aerosols will be carried out. Based on these data, a 3D nested grid Eurelian model CAMx will be used to generate the dynamic boundary conditions for the Cyprus model domain.

1 Introduction

In the last 35 years a noticeable effort has been dedicated to urban air pollution research. However modeling air pollution especially in urban areas and even more in a regional scale is still pending (Pujadas et al. 2000). In many cases (Pummakarnchana et al. 2005, Pfeffer et al. 1995) a network of ground air pollutants stations is set in the area of interest in order to record air pollutants. However such methodology has a high cost (implementation and maintenance) while at the same time it is spatially limited (point measurements) (Ferradás et al. 2010).

On the other hand satellite remote sensing of air quality has evolved dramatically over the last decade (Randall 2008, Hadjimitsis et al. 2002, Hadjimitsis, 2009). Spectral variations, recorded by satellite sensors are indicators of aerosol particles and therefore air pollution. When solar radiation undergoes through the atmosphere it produces a general decrease in the spectral irradiance which is related to the optical thickness of the atmosphere. These effects are due to the scattering and wide band absorption produced by both aerosol particles and atmospheric gases (Pujadas et al. 2000).

Air pollution is a serious problem in many heavily populated and industrialized areas For this reason many air pollution studies have appeared in the international literature (Kambezidis et al. 1998). The aim of the EUREKA project "WebAir2" is to expand the basic air quality modelling technology firstly in E!3266 WebAir project. WebAir-2 aims to combine different technologies such as satellite remote sensing data and ground PM samples for monitoring air pollution and in addition 3G mobile phone technology will be used for personalized health related information, warnings and exposure reports. The first case studies are located in areas of Cyprus and Croatia (Fig, 1)

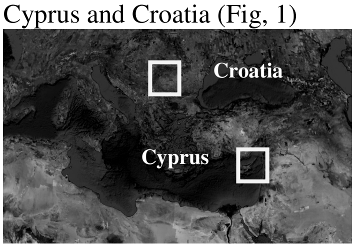

Fig. 1. Cases studies of the WebAir-2 project (Cyprus and Croatia)

2 Methodology

The overall methodology of the project is shown in Fig. 2. Both ground and satellite measurements will be acquired in order to evaluate the potential of satellite remote sensing for monitoring air pollutants. Indeed, the aim of WebAir-2 project is to develop statistical models for deriving the relationship between PM (2.5 PM or/and 10 PM) against Aerosol Optical Thickness (AOT) which is derived directly from satellite data such as the Moderate Resolution Imaging Spectroradiometer (MODIS) or indirectly from Landsat TM/ETM+ images (see Hadjimitsis 2009, Hadjimitsis 2008). For validation purposes the AOT will be cross-validated by the following ground-based means for AOT measurements during the satellite overpass: (a) the handheld sun-photometer MICROTOPS II (b) the CIMEL sun-photometer which is part of the NASA/AERONET network (c) and the LIDAR.

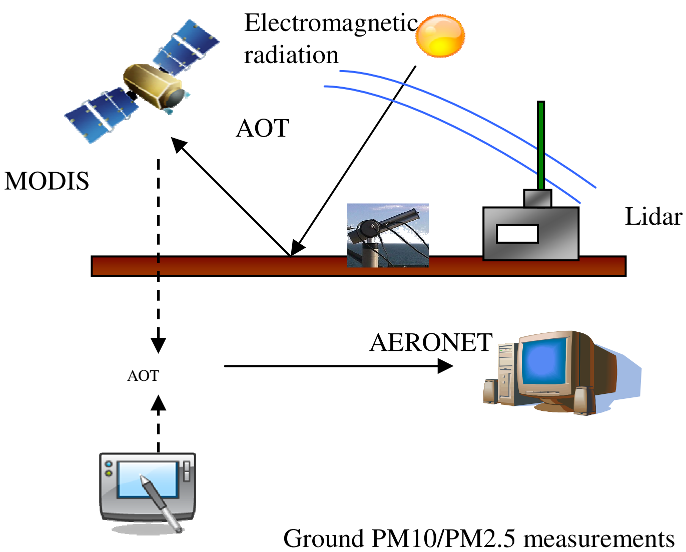

Fig. 2. Methodology for ground and satellite collection

3 Data

3.1 Ground PM Measurements

For the aims of the project several measurements will be carried out using either handheld sun-photometers or the Cimel sun photometer (Fig. 3). Sun photometers are handheld instruments that are used in order to retrieve Aerosol Optical Thickness – AOT, (at 500nm), while the Cimel sun-photometer is an automatic sun-sky scanning radiometer. Cimel sun-photometer installed at the Cyprus University of Technology premises is part of the AERONET network (AErosol RObotic NETwork).


Fig. 3. CIMEL SUN-PHOTOMETER - Hand-held Sun photometer - Microtops II (Cyprus University of Technology Premises-Remote Sensing Lab)

Daily measurements from these instruments will be used in order to correlate the AOT with the PM10 and/or PM2.5 data provided from ground stations For the Cyprus case study, air pollution data will be obtained from the Department of Labour and Inspection, Air Quality Control sector.

3.2 Lidar measurements

The Lidar transmits laser pulses at 532 and 1064 nm simultaneously and collinear with a repetition rate of 20 Hz. The two polarization components at 532nm are separated in the receiver by means of polarizing beamsplitter cubes (PBC). A special optomechanical designs allows the manual ±45°-rotation of the whole depolarization detector module with respect to the laser polarization for evaluating the depolirization calibration constant of the system. The receiver is ready to accommodate one more channel for detection of the Raman shifted radiation at 607nm. Photomultiplier tubes (PMTs) are used as detectors at all wavelengths except for the signals at 1064 nm (avalanche photodiode, APD). A transient recorder that combines a powerful A/D converter (12 Bit at 20 MHz) with a 250 MHz fast photon counting system (Licel, Berlin) used for the detection of 532 radiation, while only analog detection is used 1064nm. The raw signal spatial resolution is down to 7.5 meters.

3.3 Satellite data

Monitoring air quality for urban and sub-urban areas using conventional methods requires expensive equipment. Air pollution measurements are always related to the area where the air quality stations are located. However, remote sensing images can fill this gap since satellite images cover vast areas (Hadjimitsis 2008). This is possible to be performed if AOT values, retrieved from satellite sensors such MODIS, are related with PM10 and/or PM2.5.

The MODIS Aerosol Product (MOD 04) monitors the ambient aerosol optical thickness over the oceans globally and over a portion of the continents. Furthermore, the aerosol size distribution is derived over the oceans, and the aerosol type is derived over the continents. Daily Level 2 (MOD 04) data are produced at the spatial resolution of a 10 × 10 1-km (at nadir)-pixel array (HandBook MODIS).

3 Preliminary results

PM10 were kindly provided from Department of Labour and Inspection, Air Quality Control sector, for a 5 year period 2005 and 2010. Fig 4 shows the distribution of PM10 for Nicosia and Limassol towns based on the ground stations of the Department of Labour and Inspection.

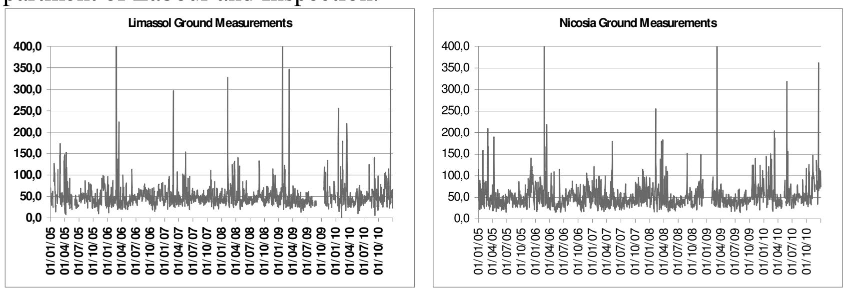

Fig. 4. PM10 measurements for Limassol and Nicosia towns (period 2005-2010).

These data area going to be used in order to validate the correlation model between AOT (derived from MODIS products) and ground PM measurements. AOT values as found from MODIS images is shown in Fig.5.

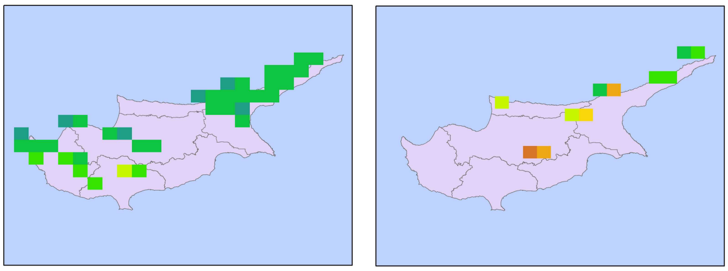

Fig. 5. AOT values from MODIS products

4 Future Work

When the data are collected and analyzed then for emissions, a dust entrainment model will be adapted from the EUREKA E! 3266 Webair (I), in order to generate dynamic source terms for the two cases studies. The results of the re-suspension model will be compared with ground measurements and from remote sensing data derived from satellite imagery (e.g. MODIS). This will also explore the potential of using the satellite data for data assimilation to improve the emission model performance. Model validation for the entrainment model will use selected episodes where monitoring data and/or satellite data are available for comparison of model results and observations.

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