Atmospheric aerosols and climate studies

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The research activity of the group have been focused in 2008 on the following tasks:

- **Measurements:** LIDAR, sun photometer, *in situ* sampling and characterization of aerosol.
- **Data analysis:** lidar, sun photometer, satellite data.
- **Modelling:** Radiative forcing calculation using a "2-stream" radiative transfer model. Analysis of aerosol climate effects by a climate "regional" model.

Systematic measurements of atmospheric aerosols properties at Lecce using a LIDAR started in 2000, in the framework of the european project EARLINET (from 2006 EARLINET-ASOS). As a by-product of this activity, we can measure the height of the planetary boundary layer (PBL), which is an important parameter for many atmospheric studies, including air-quality issues. In particular, the analysis of the evolution of the PBL during a day has been made by combining experimental and model data in 2008 [1,2]. The PBL has usually a diurnal cycle in which the maximum height is reached around noon. In the analyzed case, the growth of the PBL height is interrupted, and it actually decreases around noon so that a minimum, instead of a maximum, is observed. The origin of this behaviour is found in the deviation of the trajectories of the air parcels due to the sea breeze. The observed behavior is well reproduced using a simple model. This can explain the anomaly that has been previously observed in Lecce, namely that the PBL height measured around 13:00 UT in summer is lower than that measured in winter.

The other main experimental activity about the remote sensing of aerosol in atmosphere is sun photometry. Lecce operates a sun photometer within the AERONET network coordinated by NASA. This instrument is complementary to the LIDAR and the other aerosol monitoring systems. Furthermore, data from several stations in the world are available in near real time on the web. As an example of the activity in this field, we report the work that has been recently published in [3]. Aerosol physical properties over Lecce obtained by AERONET have been combined with air-mass back-trajectories and analyzed to identify source regions and pathways of air masses carrying aerosols to south-east Italy. Also the dependence of aerosol mean optical properties on advection patterns can be determined. In 38 % of cases it was possible to identify 3 geographical areas as aerosol sources, with definite optical properties; in 62 % of cases the advection patterns were not associated with a specific area but they were mixed. As a consequence, the properties of the aerosol associated to these mixed advection patterns are a mixing of those belonging to the geographical area previously identified.

One of the reasons why a knowledge of the atmospheric aerosol properties is important is that they influence the climate by different process. In particular (but this is only one aspect of a very complicated, and scientifically stimulating, matter) they scatter and absorb solar radiation so that they influence the radiative balance of the Earth-atmosphere system. Because of the multiplicity of sources, and the relatively short lifetime of aerosol, their abundance and properties are extremely variable both in space and in time. Thus, it is necessary to feed appropriate radiative transfer models using experimental data to be able to determine the radiative effect of the aerosol, both in short and in long term at a given area. Aerosol data from AERONET and an atmospheric radiative transfer model has been used to calculate the direct radiative effect by anthropogenic aerosol (DREa) in the solar ($0.3 - 4\mu m$) and infrared ($4-200\mu m$) spectral ranges for six Mediterranean sites. The sites are differently affected by pollution and together reflect typical aerosol impacts that are expected over land and coastal sites of the central Mediterranean basin. The average of DREa monthly-means referring to all sites has allowed getting a Top of the Atmosphere (ToA)-

and surface-DREa yearly-mean value of -(3 ± 2) and -(5 ± 3) Wm^{-2}, respectively at solar wavelengths. Last data, even if refer to a particular year, indicate that the radiative energy-balance of Central Mediterranean land and coastal sites is quite affected by anthropogenic particles [4]. The positive difference between the ToA and surface radiative forcing indicates an average warming of the atmosphere.

This aspect is strictly connected to the possibility of predicting the climate. The only way to do this is to use an appropriate model, and it is intuitive that a tradeoff must be established between the resolution of the model and the geographical area that the model must reproduce. A state of the art trade-off is represented by the so-called "regional models" in which a limited area is simulated at high resolution. We have started an activity in this field in collaboration with ICTP (Trieste) . The RegCM model has been used to investigate over the Mediterranean aerosol climate effects during significant pollution events occurred in the past. Particular attention has been given to the simulation of dust outbreaks. Preliminary results on the use of RegCM to simulate July-2003 dust events occurred over the Mediterranean have been presented at the 4th SPARC General Assembly held on 2008 in Bologna, Italy [5].

An important aid to the understanding of the role of aerosols in climate comes from satellite data, that can assure a global coverture and a relatively high temporal resolution.

We have used satellite data from the MODIS sensor, onboard of the satellites TERRA and AQUA, as ancillary data in many aerosol studies, but they can also been used as a unique source of information for air quality. This is a crucial issue for public health and it is very important to develop tools to integrate local data of particulate matter (PM) concentration obtained by public measurement stations. Such data are intrinsically local and the "instantaneous picture" given by satellite sensor on board of satellites can be used to link different local data and to determine what is the best location for these local sampling sites. The Aerosol Atmospheric Optical Depth (AOD) over the Puglia region has been retrieved in different size pixels. The aim of this work is to understand in what conditions the measured AOD, which is the result of a spatial integration over a relatively large area, and over the whole column of atmosphere, can be representative of the concentration of particulate matter measured in a single point at ground. Understanding this point is important because it would be a great advantage to rely on satellite measurements instead of increasing the number of local sampling measurements. Preliminary results of the correlation between satellite measured AOD and PM concentration have been presented at [6]. This activity is performed within the strategic project of Puglia region "SIMPA".

The intrinsic global character of the satellite data makes possible to use them to determine the transport processes. As an example, it has been possible to identify sources of anthropogenic aerosols looking at the so called fine fraction (FF), i.e. the fraction of the observed AOD ascribed to particles whose dimension is smaller than $1\mu m$. In particular, AOD and FF values have been retrieved in square boxes of variable size (from 10 km x 10 km up to 300 km x 300 km) centered at Rome, Lecce and Lampedusa, which are representative of sites differently affected by pollution and the dependence of AOD and mean values on box size have been investigated [7].

Finally, we mention that an important effort is devoted to *in situ* measurements of aerosol. Such kind of activity is the only one that allows a complete characterization of the aerosols but it has the limitation that is strictly local. However it is important for many reasons, as an example such kind of measurements are necessary for an accurate validation of models. In particular, chemical properties of the sampled aerosols can be retrieved, and, to establish the impact of long range transported air masses on sampled particles, their composition has been correlated with the transport pattern as obtained by backtrajectories [8].

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