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SCOUT aerosol campaign: Temporal and spatial variations of aerosols at Thessaloniki, Greece

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The Scout Aerosol Campaign

SCOUT-O3 Aerosol Campaign's major goal was the improvement of the understanding on spatial and temporal variability of aerosol optical properties and also how their changes affect UV levels at the ground. Aerosols is a parameter that is closely linked to climatic changes and therefore their effects on UV radiation should be described and quantified to the best possible degree of accuracy. Aerosol optical properties, and especially their vertical profile, are among the most important unknowns when simulating measured radiation quantities by Radiative Transfer models.

Selected well-focused studies were performed to measure and model spectrally different UV radiation quantities (global and direct irradiance, spectral radiance as a function of incidence and azimuth angle and actinic flux) under different aerosol and cloud conditions. A suite of instruments providing radiation, cloud, aerosol, and other ancillary measurements were employed in an experimental campaign, with the aim to collect a comprehensive, homogeneous data set which will allow:

- The parameterization of aerosol properties from radiation measurements and comparison with in site and remote sensing measurements
- To investigate the influence of aerosol properties on UV radiation for different conditions and aerosol load types.

For that purpose a campaign was organized from 12-25 July 2006, at Thessaloniki, Greece, a site with significant aerosol load and high probability of day-to-day aerosol variations, and of alternating clear and cloudy days with different cloud patterns. Analysis of the measurements with the aid of radiative transfer model calculations were used to describe the effects of aerosols on surface UV, with particular emphasis to the effect of the spatial variability of aerosol optical properties (such as optical depth and Angstrom coefficients).

Map of the Campaign area

During 3 cloudless days of the campaign 3 transportable instruments performed measurements of aerosol optical depth at various locations around the city. The sites that the measurements took place are shown in the map of the campaign area. Measurements at each site were performed with the use of Microtops instruments three times during each day. The operators of the instruments performed measurements at four sites and then repeated this procedure three times. This was decided in order to see also any temporal changes comparing measurements at the selected sites with those at the city-center site were all radiation instruments were located.

Aerosol optical depth spatial variability

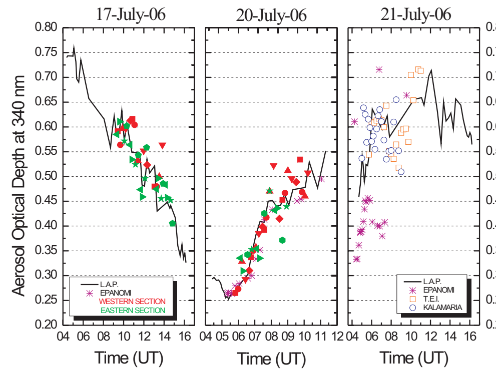

Figure 3. Aerosol optical depth measurements on 17, 20 and 21 of July with the help of transportable instruments at various sites (see map). Different symbols represent the different locations that the measurements took place.

Aerosol optical depth measurements performed on 17, 20 and 21 of July. Measurements for the different city locations were compared with those at the city-center site. All aerosol optical depth values correspond to the wavelength of 340nm.For the third day (July 21st, as shown in figure 3) TEI and Kalamaria sites correspond to the western and southern city remote stations (see map).The radius of the area covered by the transportable instrument was about 7Km. No significant variability was found between measurements of the western and the Eastern part of the city compared with the main university monitoring station. Measurements for the first two days follow clearly the daily variations of the aerosol optical depth as measured in the main site. The western part of the city is considered as the most polluted one due to the fact that is really close to the city's industrial area compared with the southeastern part. However, total column optical depth variations during these days were similar for all the sites where measurements performed.

Aerosol effects on UV irradiance

Measurements of Ultraviolet spectral irradiance with a Brewer MKIII spectroradiometer together with model simulations with the use of the LibRatran radiative transfer model (Mayer and Kylling, 2005) were performed for the 23rd and 25th of July, 2006. The difference of the aerosol optical depth for the two days is shown in the upper plot of figure 1. For July 23rd the total column aerosol optical is almost constant (0.4 at 340 nm) and for July25th it is shows a diurnal pattern with higher values found in the evening (aerosol optical depth of 1.1 at 340 nm). This variability and the differences among the two days are not rare for the urban environment of Thessaloniki. For this particular case, the reason for this difference is an aerosol layer at 1.5 Km altitude that was present on July 25th and was captured by the LIDAR measuring system that participated in the SCOUT aerosol campaign (see relevant poster in this session).

Differences in the UV irradiance (at 340nm) reaching the earth's surface between the two days, were found to be up to 30%. These differences depend on the aerosol load difference and on solar zenith angle. In addition, using the radiative transfer model simulation, global irradiance, differences compared with a case of an aerosol free atmosphere found to be up to 20% and 40%, for the 23rd and the 25th of July, respectively. The solar zenith angle dependency can be attributed to the direct sun irradiance attenuation that is higher for higher zenith angles (higher air mass factors).

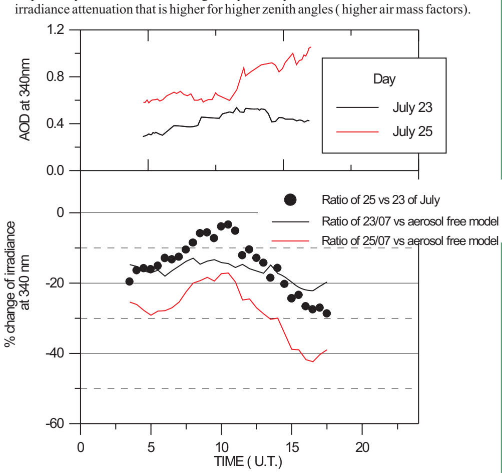

Figure 1. Measurements of aerosol optical depth (upper plot) and global UV irradiance differences (at 340nm) (lower plot).

Spatial and temporal aerosol properties - comparison of the two main sites

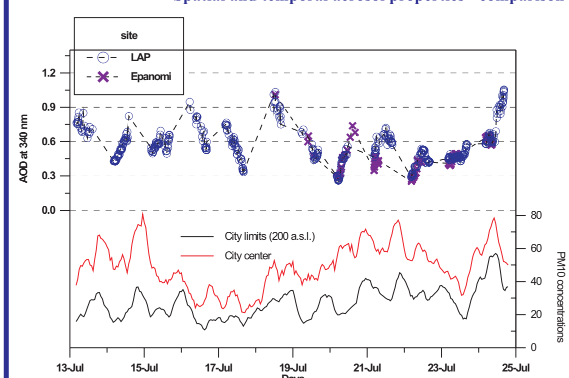

Figure 4.(Up) Measurements of aerosol optical depth at Thessaloniki (blue) and Epanomi (purple) at 340 nm. (Down) Measurements of Pm-10 surface concentrations.

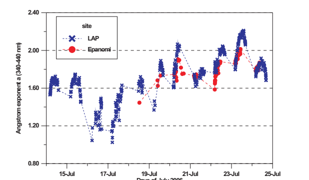

Figure 4a. Measurements of Angstrom exponent a at Thessaloniki (blue) and Epanomi (red)

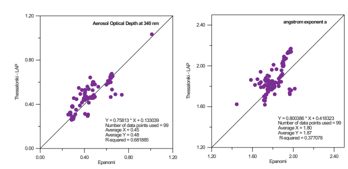

Figure 4b. Comparison of aerosol optical depth at 340nm (left) and angstrom exponent a (right) measured at the two sites.

Measurements of aerosol optical depth and angstrom exponent a were performed in Thessalonki center (Lap) and at the site of Epanomi (see map) using a CIMEL sun-photometer (Epanomi) and two spectroradiometers measuring direct sun irradiance (Thessaloniki). Day to day variations followed almost the same pattern for both sites despite the fact that Epanomi is situated 20Km outside (South) of the city center monitoring site. Optical depth and angstrom exponent at the city center site gave higher values compared to Epanomi, but the differences were small (on the average 0.03 and 0.07 for the whole period, respectively). This effect can be mainly attributed to the North and North-East flows of air masses at various altitudes that were present during the whole period of the campaign. This was found using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Draxler and Hess, 1997). This model uses the meteorological data produced by the ETA Model of the National Weather Service of Spain to compute advection and dispersion of air parcels. Maximum differences for the two sites were found in July 21st (see also right panel of Figure 3). For that particular day the surface PM-10 concentrations have shown maximum differences comparing a site at the city center and a site at the city limits situated in higher altitude, indicating enhanced local (city) aerosol sources that probably did not reach the second site (Epanomi).

Aerosol vertical profiles

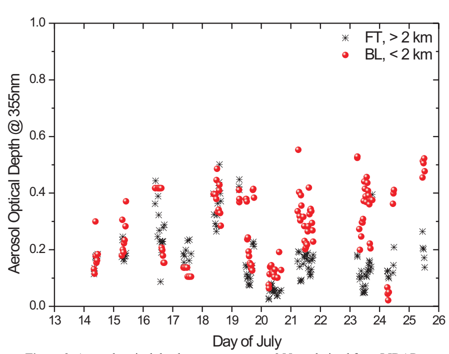

Figure 2. Aerosol optical depth measurements at 355nm derived from LIDAR measurements. The contribution of the lower part (altitude less than 2 Km) and the upper part of the atmosphere is shown

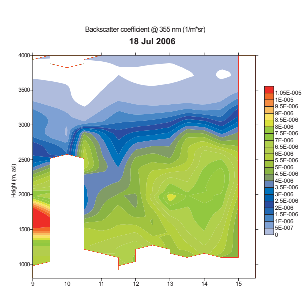

Figure 2a. Backscatter coefficient at 355nm derived from LIDAR measurements for July 18th.

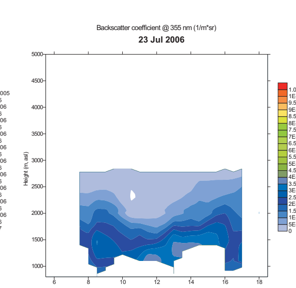

Figure 2b. Backscatter coefficient at 355nm derived from LIDAR measurements for July 23rd.

For the period of the campaign various cases of aerosol vertical profile patterns have been observed. For the first period of the campaign (14-18 of July) aerosol layers from 1.5 to 2.5 Km were measured by the Lidar system. The contribution of these layers to the Total column aerosol optical depth can be seen in figure 2. Aerosols found in altitudes higher than 2 Km contribute from 30-50% to the total aerosol load. The backscatter coefficient of aerosols at 355nm for the 18th of July is shown in figure 2a, where the above mentioned layers can be seen. For the second period of the campaign (19-24 of July) the contribution of the aerosols found in altitudes higher than 2 Km was lower than 0.1 at 355nm. Backscatter Lidar measurements for July 23 are shown in figure 2b. Similar patterns for the campaign area have been found also in the past. Amiridis et al., 2005 showed that aerosols measured in altitudes from 1.5 to 2.5 Km play an important role to the total aerosol load of the area. These air masses are transported to the city area mainly from North East directions. During these periods (that appear mainly in the summer months) the aerosol optical depth in Thessaloniki reaches its maximum values (Kazadzis et al., 2007).

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