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Tracking Regional Anthropogenic Air Pollution: A Case Study in Israel

Yevgeny Derimian · Arnon Karnieli · Levana Kordova · Abraham Zangvil

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Abstract Typical mid-winter anthropogenic air pollution episodes are caused when pollutants are trapped in the lower atmospheric boundary layer due to the generation of surface inversion favored by synoptic conditions. We analyzed the optical properties of atmospheric aerosol particles obtained during one such episode using a sun/sky radiometer at two measurement sites: one located in the densely populated and industrialized central part of Israel, and the other in a reference site, about 150 km away. Aerosol optical thickness and volume size distributions showed an increased burden of fine aerosol particles in the central part of Israel. In order to verify the local origin and anthropogenic nature of the effect, the analysis was accompanied by examinations of the synoptic conditions, air mass backward trajectories, and conventional *in situ* air pollution measurements made by a ground-based sampling station. This case study shows the ability of optical measurements to track urban and industrial atmospheric air pollution expressed by high concentration of fine aerosol particles. In addition, it emphasizes the role of local Israeli air pollution sources and may explain the difference in the properties of long-term aerosol optical observations between the two sites. The advantages of the optical method presented are speed (almost instantaneous), automated measurement, and sensitivity to aerosol particle concentration as well as aerosol size fraction. The drawback is that the optical measurements discussed deal only with aerosol particles and cannot distinguish between different types of pollutant gases.

Keywords air pollution · aerosol · optical measurements · case study · Israel

Y. Derimian · A. Karnieli (✉) · A. Zangvil
The Remote Sensing Laboratory,
Jacob Blaustein Institutes for Desert Research,
Ben-Gurion University of the Negev,
Sede Boker Campus, 84990 Sede Boker, Israel
e-mail: karnieli@bgu.ac.il

L. Kordova
Israel Ministry of the Environment,
Tel Aviv, Israel

1 Introduction

The term "atmospheric aerosols" refers to solid and liquid particles suspended in the air. Such particles are produced by a variety of different processes that occur on land and water surfaces, and in the atmosphere itself. Coarse aerosol particles generally originate from natural sources and may contain airborne mineral dust or sea-salt spray. Typically, the size distribution of coarse aerosols has a mode above one micron. Fine aerosol particles that have a mode in the submicron range tend to originate from urban and industrial sources, including transportation, power generation, and secondary material formed by gas-to-particle conversion mechanisms (Seinfeld and Pandis, 1998). Natural sources like smoke from biomass burning, ash, and sulfur dioxide released from volcanic eruptions, are also included among the fine particles. Alongside aerosol particles, urban and industrial sources also generate air pollutant gases, such as sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), and tropospheric ozone (O_3). Concentrations of both aerosol particles and pollutant gases tend to increase during air pollution episodes.

Studies of air quality and pollutant sources in Israel are challenging due to interactions between imported pollution, local pollution sources, various synoptic conditions and complex topography. There have been numerous studies on air quality in Israel addressing pollutant gas concentrations and measurements of particulate mass concentrations at the surface level. Koch and Dayan (1992) and Nirel and Dayan (2001) investigated SO_2 and NO_x pollutant gases from local sources in the Coastal Plain of Israel, together with meteorological condition analysis. A numerical simulation was applied by Ranmar et al. (2002) to show transport of air pollutants from the Tel Aviv metropolitan area and the Gaza Strip into inland areas of Israel. Results were confirmed by aircraft and ground-based monitoring station measurements. Imported air pollutants were discussed by Matvev et al. (2002) and Wanger et al. (2000), among others; both indicate Europe as a source of imported pollution to Israel. Dayan and Levy (2002) explored the synoptic-scale atmospheric circulations that influence high levels of ozone concentrations over Israel.

Despite these efforts, little attention has been given to the characterization of aerosol particles. Aerosol particle samplers operated by the Ministry of the Environment and the Israel Electric Company are located in several places in Israel, mostly in and around Tel Aviv. These systems measure the aerosol mass concentration without distinguishing between coarse (PM10) and fine fractions (PM2.5). Only a few stations also measure the fine fraction. In any case, these systems do not measure aerosol size distribution, although this is of importance in distinguishing between coarse natural and fine anthropogenic aerosols in the dusty environment of Israel. Breathable submicron aerosol particles are considered to be the particle type most harmful to human health, thus, along with concentrations, knowledge of aerosol size distribution is important.

Many research efforts are underway to characterize and model the optical and microphysical properties of aerosols. This is because aerosols have important consequences for global climate, ecosystem processes and human health. Aerosol particles or particulate matter (PM) can scatter, absorb sunlight, and alter the physical properties of clouds, consequently affecting the radiative budget of the Earth and rates of evaporation and precipitation (Charlson et al., 1992; Hansen et al., 1997; Kaufman & Fraser, 1997; Kaufman et al., 2002; Levin et al., 1996; Menon et al., 2002; Rosenfeld et al., 2001). Increased concentrations of anthropogenic aerosols can trigger attacks of respiratory diseases and even premature death.

Several different methods can be employed to monitor atmospheric aerosols and to study air quality:

- *In-situ* ground sampling and analysis of the air, based on well-developed physical and chemical principles. Ground level concentrations are measured by automatic air monitoring stations;
- Optical ground measurements of the atmospheric column. The aerosol concentration and size fraction can be assessed by optical parameters such as aerosol optical thickness (AOT or τ_{ext}) and AOT spectral dependence;
- Satellite remote sensing, with its large area of coverage, has become a powerful data source for assessing optical properties of atmospheric aerosols and gases. This may assist in effective monitoring of air pollution, including sources and affected areas (Chu et al., 2003; Engel-Cox et al., 2004; Hutchison, 2003; Hutchison et al., 2004; Kaufman et al., 2002; Wang & Christopher, 2003).

The objectives of this study were to demonstrate the ability to monitor and characterize anthropogenic air pollution using optical remote sensing measurements of aerosol properties, and to identify the role of local air pollution sources in Israel, which is expected to explain the general difference between aerosol optical properties measured in two geographically distant sites. The optical remote sensing observations were complemented by synoptic and air mass backwards trajectories analyses, as well as by conventional *in situ* air pollutant measurements. A case study of an air pollution episode occurring in the urbanized Coastal Plain of Israel during winter 2003 is presented.

2 Study Area

The eastern Mediterranean is characterized by several types of atmospheric aerosol, namely marine aerosols; continental dust originating from North African, Sinai, and Saudi Arabian deserts; and anthropogenic aerosols, originating mainly either locally or in Europe (Andreae et al., 2002; Formenti et al., 2001; Gerasopoulos et al., 2003; Ichoku et al., 1999; Israelevich et al., 2003; Kubilay et al., 2003). Pollutant transport from other surrounding countries, (Erel et al., 2002), or aerosol mixing are, however, also possible.

The Tel Aviv metropolitan area is located in the central, densely populated, industrial part of Israel (Figure 1). The northern Negev desert is located about 150 km away, and is considered to be less affected by local human-induced aerosols. It was expected that local anthropogenic pollution episodes may be geographically distinguished, while intense dust storms, which have distant sources, will cover the entire region and affect both locations equally. *In situ*

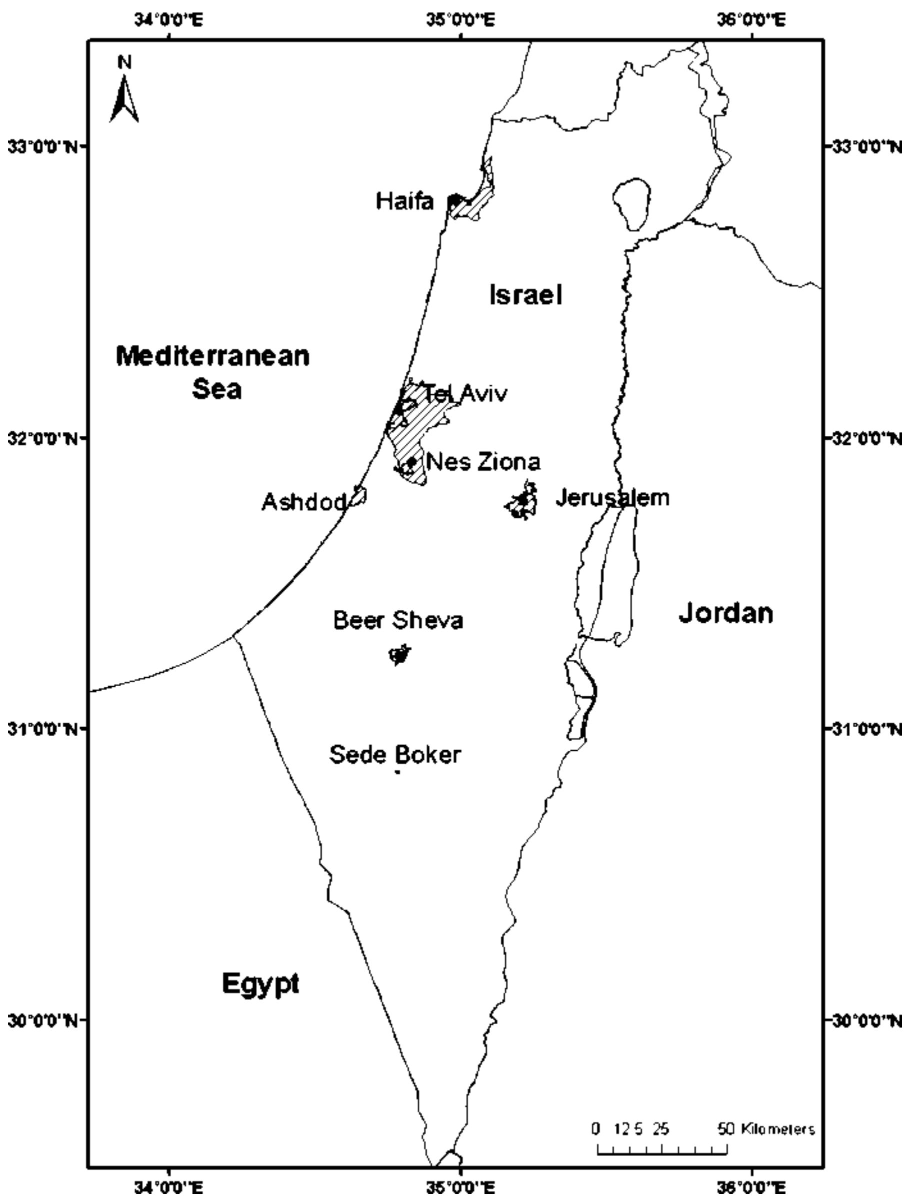

Figure 1 Map of the study region and the analyzed sites. *In situ* air pollution measurements were conducted in Tel Aviv and Beer Sheva, and aerosol optical measurements were taken in Nes Ziona and Sede Boker.

sampling of air pollution and optical observations of atmospheric aerosols were conducted in both areas. The desert area was selected as a reference.

3 Methodology and Instrumentation

The air pollution episodes of winter 2003 were investigated by analyzing the following parameters: (1) atmospheric aerosol optical and microphysical properties derived from sun/sky radiometer measurements; (2) synoptic conditions obtained from the Israel Meteorological Service and the NOAA-CIRES Climate Diagnostic Center website; (3) air mass backward trajectories obtained from the 3-D HYSPLIT model; and (4) mixing ratios of atmospheric pollutants obtained from *in situ* sampling stations operated by the Israel Ministry of the Environment and the Israeli Electric Company.

3.1 Optical measurements

Optical measurements were recorded by sun/sky radiometers (CIMEL). The radiometers record direct sun measurements every 15 min, with a 1.2° field of view at 340, 380, 440, 500, 675, 870, 940, and 1,020 nm nominal wavelengths. One instrument is located in the town of Nes Ziona (31°55′N, 34°47′E, 40 m a.s.l.) and the second at the Sede Boker Campus of Ben-Gurion University of the Negev (30°51′N, 34°47′E, 470 m a.s.l.) (Figure 1). Both instruments belong to the worldwide Aerosol Robotic Network (AERONET) program, operated and maintained by the National Aeronautic and Space Administration (NASA) (Holben et al., 1998). The spectral aerosol optical thickness was retrieved at seven of these wavelengths from direct sun measurements; the 940 nm channel was used to retrieve water vapor content. The angular distribution of sky radiance was also measured at 440, 670, 870, and 1,020 nm. The measured spectral sun and sky radiances were used to retrieve aerosol optical and microphysical parameters using the AERONET inversion code (Dubovik and King, 2000), which produces models of homogeneous spheres and randomly oriented spheroids. For the fine mode aerosols, a spherical model with 5% sky radiance fitting error criteria was used, and for coarse mode aerosols, a spheroid model with a fitting error of 10% or better was used. In addition, to ensure reliability of the retrieved aerosol properties, a number of restrictions were applied: (1) the number of symmetrical scattering angles in inverted almucantar should be equal to, or higher than, 21; and (2) the minimal solar zenith angle should lie between 25° and 77°. More details on the retrieval algorithm and accuracy assessments can be found in Dubovik and King (2000), Dubovik et al. (2000), Smirnov et al. (2000), Dubovik et al. (2002a, 2002b).

It should be noted that the sun/sky radiometers are located about 20 km away from the *in situ* air sampling sites in the Tel Aviv metropolitan area, and about 50 km away in the Negev desert. However, sun/sky radiometers continuously measure the integrated aerosol properties through the entire atmospheric column. This kind of measurement should be sensitive to aerosol circulation and optical properties in the entire region and therefore is representative of both sites.

3.2 Meteorological data

The most important meteorological factor affecting the vertical and horizontal dispersion of air pollution is a temperature inversion in the lower few hundred meters of the atmosphere. Radio-sonde observations, including vertical profiles of temperature and humidity, for the studied air pollution episode (24–27 January 2003) were obtained from the Israel Meteorological Service located near Tel Aviv. Generally, changes in lower atmospheric stability are controlled by migrating pressure systems. Since we are dealing with the atmosphere a few hundred meters above the Earth's surface, sea level pressure charts are most suitable for representing the synoptic systems affecting these layers. We usually expect low level inversions affecting air pollution to occur in the vicinity of surface high pressure systems, while the low pressure systems are associated with unstable air and no inversions. Mean sea level pressure charts for the same period were obtained from the NOAA-CIRES Climate Diagnostic Center website (http://www.cdc.noaa.gov/Composites/Day/).

3.3 Backward trajectories

A 5-day air mass backward trajectory analysis was obtained from the 3-D HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model invented by the National Oceanic and Atmospheric Administration Air Resources Laboratory (NOAA ARL) (Draxler & Hess, 1998; Draxler & Rolph, 2003; Rolph, 2003). Calculations were performed at multiple levels 500, 2,000, and 5,000 m above ground level using a global reanalysis meteorological dataset.

3.4 Conventional *in situ* measurements

Mixing ratios of atmospheric pollutants were measured in air monitoring stations. These stations are located at roof height in representative areas not adjacent to specific emission sources such as industrial plants or heavy traffic. In the Tel Aviv metropolitan area, we chose an air monitoring station located in a dense commercial area in the center of Tel Aviv. In the southern part of Israel, we chose the Beer Sheva station, located on the outskirts of this city. This station, although affected by much lower traffic volumes than Tel Aviv, is impacted by the desert due to its geographical location.

In the conventional air monitoring stations, we measured several major pollutants: SO_2, nitrogen oxides ($NO_x = NO + NO_2$), CO and O_3. The analytical monitors in each station are fully automated and approved by the United States Environmental Protection Agency (EPA). They also include a daily automated calibration system. Once a year, the stations conduct quality control and quality assurance tests. Analyzers used in the ground-level measurements are summarized in Table I. Five-minute average concentrations for gas pollutants and half-hour averages for aerosols are stored in the data-logger.

Table I List of equipment used in the ground-level measurements

Air pollutant	Equipment
Sulfur dioxide	Fluorescence SO_2 analyzer (Thermo Environmental Instruments, Frankllin, MA, Model 43C)
Nitrogen oxides: nitrogen monoxide and nitrogen dioxide	Chemiluminescence NO-NO_2-NO_x analyzer (Thermo Environmental Instruments, Model 42C)
Ozone	UV Photometric O_3 Analyzer (Thermo Environmental Instruments, Model 49C)

4 Analysis and Discussion

4.1 Case study analysis

During January 2003, the Israel Ministry of the Environment reported several days of high air pollution levels. Figure 5 shows the daily mean concentrations of SO_2 and NO_x during these outbreaks. Three of those days (24–26 January 2003) that showed increased air pollution and successive optical measurements in both monitoring sites were selected for more detailed analysis. It was assumed that climatic features aggravate the problems of anthropogenic air pollution dispersion, and that the synoptic conditions should be analyzed in conjunction with an episode of increased air pollution.

4.1.1 Optical Measurements

The diurnal variability of aerosol optical thickness at 440 nm for the three analyzed days at the Nes Ziona (area affected by pollution) and Sede Boker (distant from pollution sources) sites are presented in Figure 2a and b. The respective aerosol volume (V) size distributions, $dV(r)/d \ln r$, where r is particle radius, are shown in Figure 2c and d. The volume size distribution is bimodal and contains fine ($0.05 < r_f < 0.6$ μm) and coarse ($0.6 < r_c < 15$ μm) mode fractions. Both pairs of figures demonstrate the differences between the two sites as characterized by both the optical and the microphysical properties of the aerosol. The AOT at the Nes Ziona site systematically increased during the daytime, when the level of air pollution may have increased due to anthropogenic activity (Figure 2a). This afternoon increase in AOT did not occur on clear days with low AOT values. The fine mode of daily averaged volume size distribution in Nes Ziona was also intrinsically high, and exceeded the coarse mode throughout the analyzed period (Figure 2c). Note that the AOT values and fine fraction began to decrease on 26 January. This is in accordance with the synoptic analysis described below, which reports the beginning of a change in synoptic conditions on this day. In contrast to the Nes Ziona site, the AOT and the volume size distributions at the Sede Boker site on these days were stable and suggest low aerosol concentrations (Figures 2b, d).

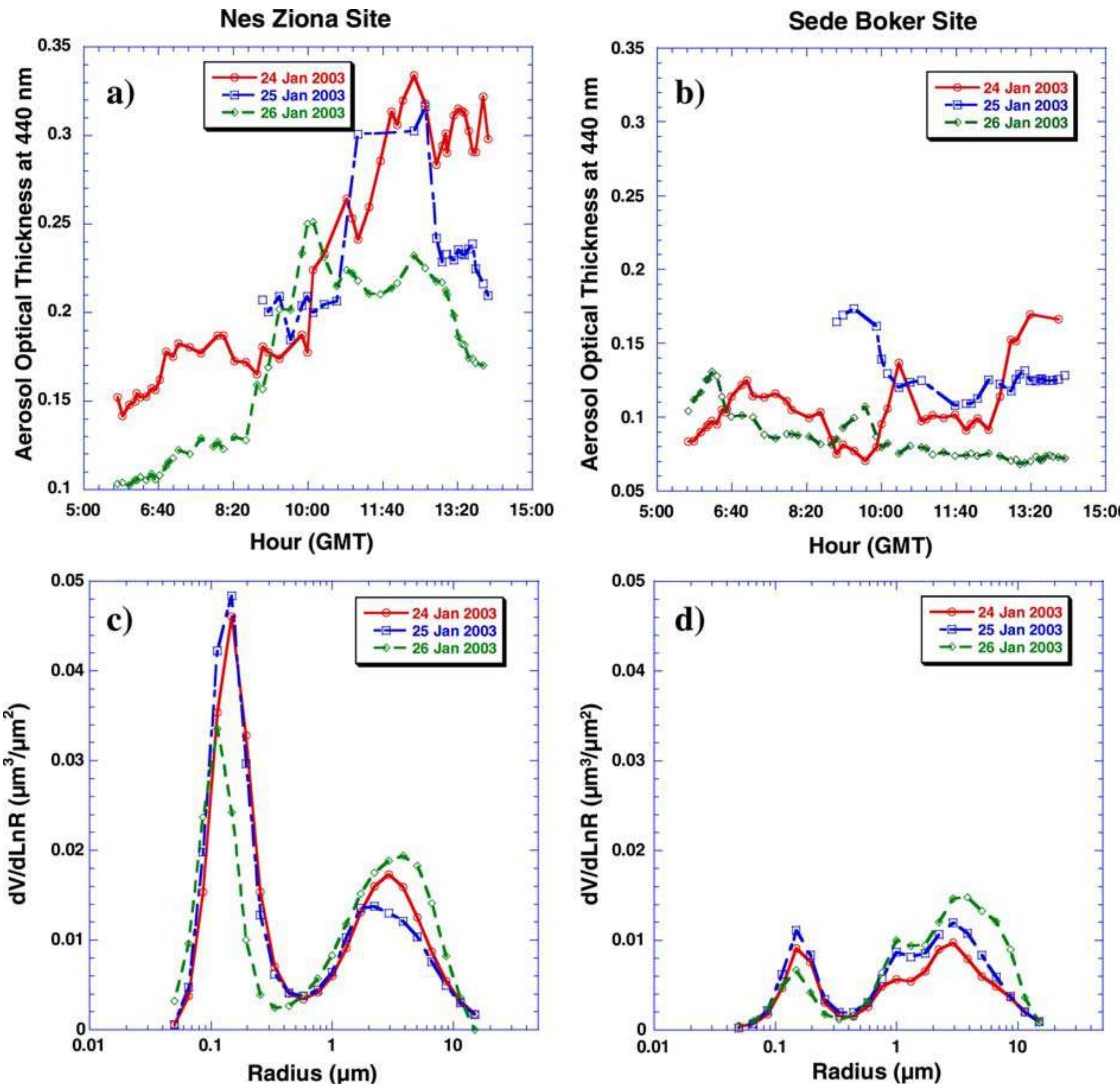

Figure 2 Diurnal variability of aerosol optical thickness (AOT) at the Nes Ziona (a) and Sede Boker (b) sites, and daily mean values of volume size distribution at the Nes Ziona (c) and Sede Boker (d) sites. Data are presented for 24–26 January 2003.

4.1.2 Synoptic Analysis

On 24 and 25 January 2003 an intense system of high pressure covered the entire area from southern Russia and Turkey to the eastern Mediterranean, and low pressure extended northward from the southern Red Sea (Figure 3a, b). This surface pressure pattern was accompanied by weak east to south-easterly winds and by low relative humidity over Israel. During late afternoon a weak sea breeze penetrated the Coastal Plain, causing the winds to shift and blow temporarily from the north-west with an increase in humidity. At the upper levels (not shown) a ridge of high pressure covered the eastern Mediterranean causing subsidence over the region. This pressure system caused the development of a very strong surface inversion to a height of about 200 m at night and in the early morning hours, topped by an isothermal layer extending to about 600 m. These are ideal conditions for trapping air pollution near the surface. On 26 January this situation started to change when a surface low (Figure 3c, d), accompanied by a weak upper

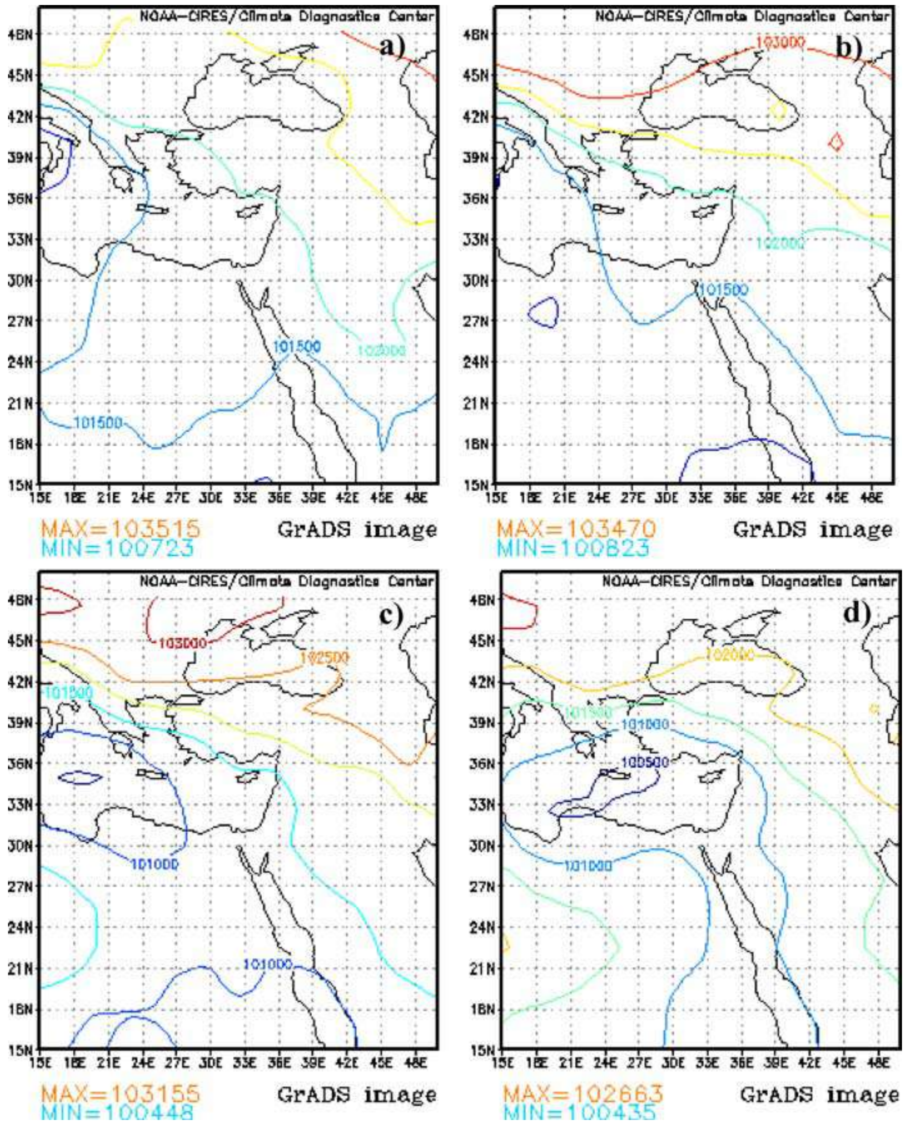

Figure 3 Mean sea level pressure on 24 (a), 25 (b), 26 (c) and 27 (d) January 2003. Pressure values in Pascals.

trough (not shown), moved into the western part of the eastern Mediterranean near 20 E. Further movement eastwards of this system to the island of Crete on 27 January completely destroyed the inversion, thereby terminating the severe air pollution episode (see section on meteorological data above).

4.1.3 Backward Trajectories

As mentioned above, polluted air masses may have a source some distance from the site of the air pollution event, and be transported to Israel from Europe. Thus, in addition to the above-mentioned synoptic conditions, a 5-day air mass backward trajectory was analyzed in order to identify a possible source of the pollution. Studies of the vertical distribution of aerosol concentration show various ranges of aerosol presence in the eastern Mediterranean. According to some sporadic observations and modeling, dust particles were found to occur between about 1.2 km and 5 km, and even up to 8 km (Alpert et al., 2004; di Sarra et al., 2001; Hamonou et al., 1999; Tsidulko et al., 2002). Pollution concentrations were present in lower layers of about 1 km up to 3.5 km (Dulac and Chazette, 2003; Formenti et al., 2001, 2002a, 2002b). Based on these and a more recent study that demonstrated low altitude pollution and high altitude dust transport in the area of interest (Derimian et al., 2006), the backward trajectories of air masses at 500 m were taken to be indicative of surface air mass origin, and the highest level of 5,000 m revealed the high altitude long-range aerosol transport. The backward trajectories for the three analyzed days (Figure 4) show that air masses at low altitudes came mainly from south-easterly or south-westerly directions. The air masses at high altitudes came from a westerly direction. These air masses usually cross the Mediterranean Sea, carrying maritime aerosols and supplying desert aerosols from the north African deserts but not air pollution from Europe. However, the observed aerosol loadings, as will be shown later, were dominated by the fine fraction of aerosols and consequently could be neither dust particles nor maritime in origin. The backward trajectories together with described synoptic conditions support the hypothesis of a local origin of the air pollution.

4.1.4 In situ Air Pollutant Sampling

SO_2, NO_x and O_3 have relatively short tropospheric lifetimes measuring from several hours up to a few days, and are common anthropogenic pollutants. Pollutants with short residual times have major effects on a local or regional rather than on a global scale (Seinfeld & Pandis, 1998). Most SO_2 emissions originate from a small number of major point sources (oil refineries and power plants) as a result of the sulfur released during fossil-fuel combustion. The main anthropogenic sources of NO_x emissions are high-temperature combustion processes, such as those that occur in motor vehicle engines, power plant boilers, and industrial incinerators. Nitrogen oxides are not found in the fuel that is burned but rather are a result of the reaction between nitrogen and oxygen at high combustion temperatures in the atmosphere. Thus, NO_x can be used as a tracer for urban and industrial air pollution.

A comparison of daily mean values of mixing ratios of SO_2, NO_x (NO_x = NO + NO_2), and O_3 measured by conventional air sampling for January 2003 in the central Coastal Plain (Tel Aviv) and southern (Beer Sheva) regions of Israel is presented in Figure 5. During the entire month in the Tel Aviv region, several outbreaks of NO_x and SO_2 mixing ratios were observed. In addition, daily mean values

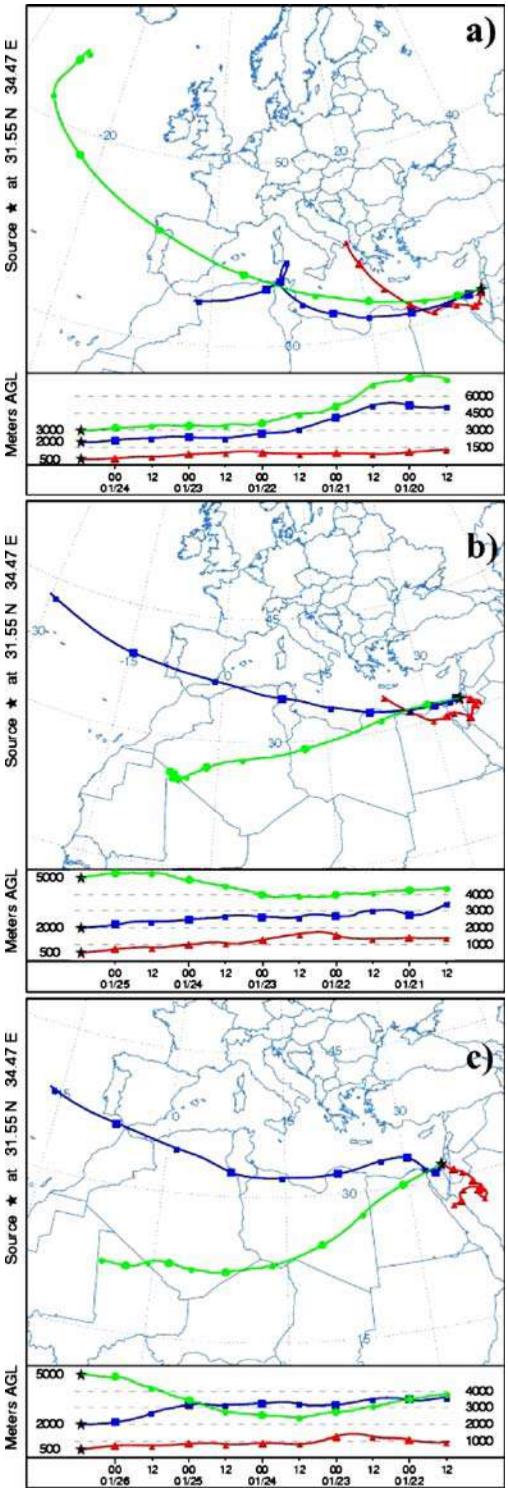

Figure 4 Five-day backward trajectories of air mass at 500, 2,000, and 5,000 meters above ground level for 24 (a), 25 (b), and 26 (c) January 2003. The backward trajectory ended at 1100 GMT.

of the mixing ratios in the Tel Aviv region exceeded the values observed in Beer Sheva. The average values (±SE) of NO_x and SO_2 concentrations in Tel Aviv and Beer Sheva for the three days (24–26 January) for which simultaneous optical remote sensing observations exist were: NO_x 133.4 ± 11.7 ppb (Tel Aviv) and 14.5 ± 0.9 ppb (Beer Sheva); SO_2 4.17 ± 0.18 ppb (Tel Aviv) and 2.14 ± 0.03 ppb (Beer Sheva). The average values of O_3 were 13.5 ± 1.2 ppb and 26.9 ± 1.3 ppb in Tel Aviv and Beer Sheva, respectively. Relatively small and non-overlapping standard errors indicate significant differences.

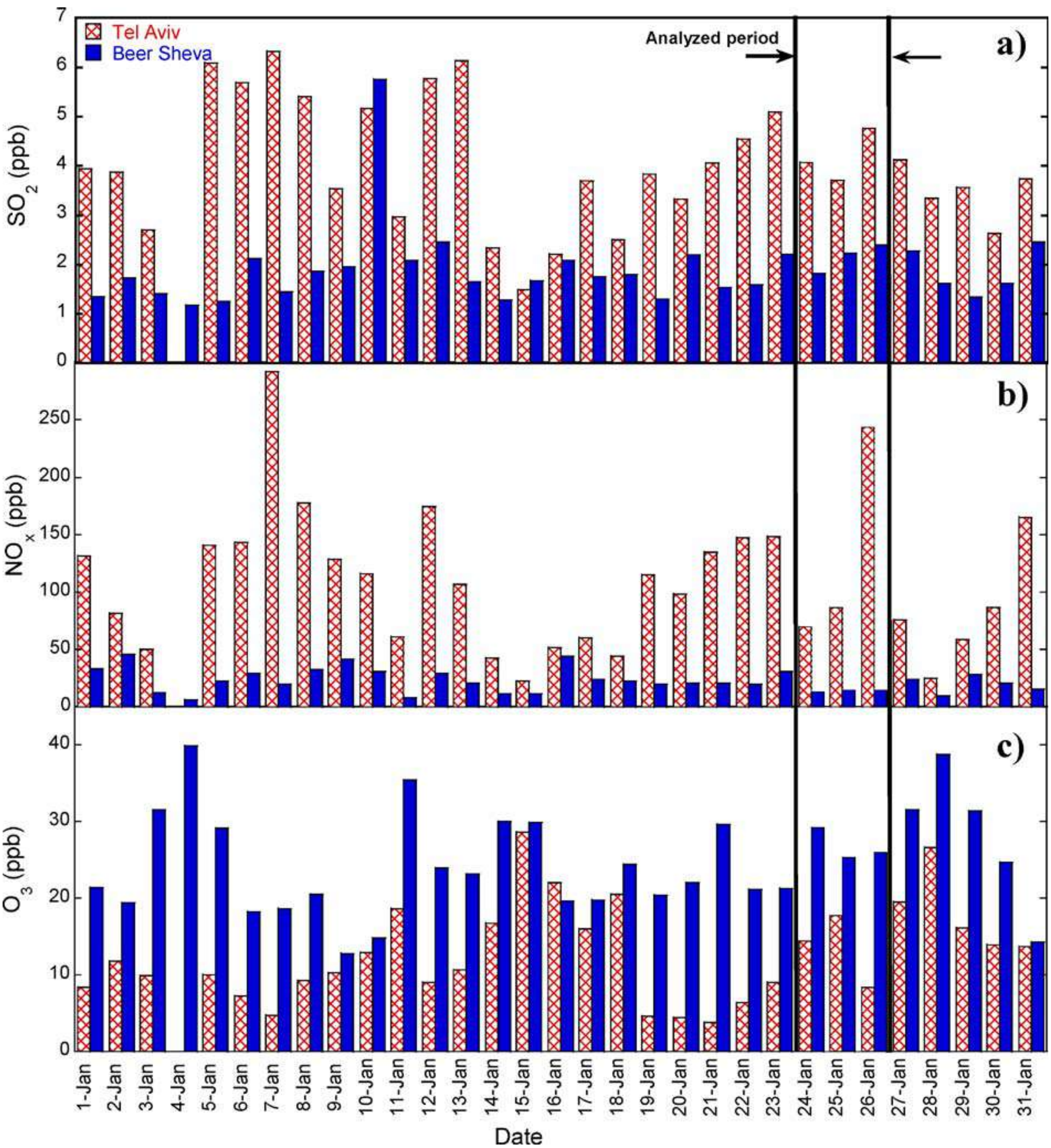

Figure 5 Comparison of daily mean values of SO_2, NO_x and O_3 mixing ratios measured in Tel Aviv and Beer Sheva during January 2003, including the three days over which the corresponding aerosol optical properties were analyzed.

It should also be emphasized that the air breathed by pedestrians and drivers during this period was of much poorer quality, as revealed by measurements from the monitoring stations located at roof height.

The measured O_3 is "bad" tropospheric ozone—a pollutant that, at elevated concentrations, can lead to respiratory problems in humans (Seinfeld and Pandis, 1998). Despite the fact that O_3 is a pollutant, its concentration in the urban and industrial area of Tel Aviv is lower than that in Beer Sheva. In addition, as seen in Figure 5b and c, reductions in O_3 concentrations correspond to periods of elevated NO_x levels. However, this situation is not contradictory since the net O_3 concentration is a product of the complex interplay between ozone sources and sinks. This includes photochemical production and destruction, intrusion from the stratosphere, transport from other regions of troposphere, as well as wet and dry deposition. The level of NO_x plays a critical role in the photochemical production or destruction of O_3. This level also depends on local O_3 concentration. Among other factors that affect O_3 concentration are increase in water vapor concentration, which leads to O_3 destruction, and intensity of solar radiation, which influences the efficiency of photochemical processes (Seinfeld & Pandis, 1998). Higher humidity of coastal areas, reduction of solar radiation intensity by pollution haze (confirmed by higher values of aerosol optical thickness), and the possible effects of NO_x on O_3 destruction all might explain the observed behavior of O_3 concentrations.

4.2 Optical data—general comparison

We have described an event in which the concentration of fine particles in the Nes Ziona site exceeded that at Sede Boker. Is this situation unique for the study region? In order to answer this question we present a general comparison between aerosol properties from the two AERONET sites using data from four consecutive years (2000–2003). Figure 6 shows a scatter-plot of AOT at 440 nm caused by fine and coarse particles at Nes Ziona versus Sede Boker. This AOT, caused by fine and coarse particles, is a product of the AERONET inversion procedure described in the section on optical measurements above. It can be seen that the correlation with fine AOT is lower than that for coarse AOT. Moreover, fine AOT values shifted from the one-to-one line toward the axes

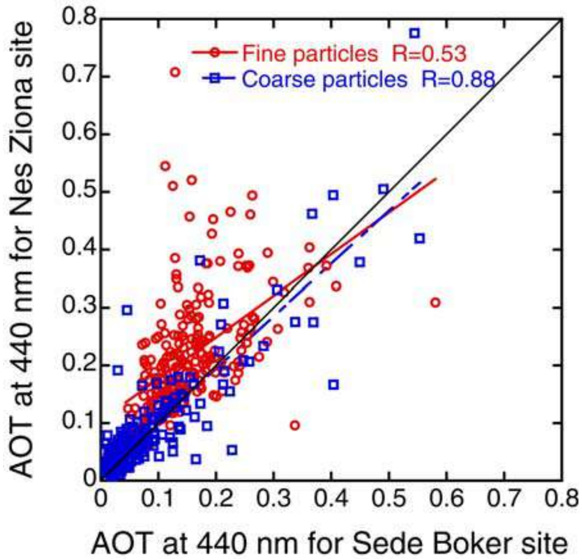

Figure 6 Correlation between the measured aerosol optical thickness at 440 nm caused by fine and coarse particles at the Nes Ziona and Sede Boker sites, based on 4 years of measurements (2000–2003).

representing Nes Ziona. This means that light extinction at the Nes Ziona site was more affected by the burden of fine particles, and that the high concentrations in Nes Ziona are not correlated with concentrations at Sede Boker. The higher correlation of coarse AOT from the two sites supports the hypothesis that there is a similar effect of coarse particles on both sites due to extensive dust storm events. The same conclusion can be inferred by analyzing the averaged aerosol volume size distributions (Figure 7a). The averaged fine mode fraction is dominant for the Nes Ziona site, while the averaged coarse mode fractions are almost the same for both sites. The particle volume concentration (C_v)—a numerical characteristic of the volume size distributions—can be used for quantitative estimation of the differences. C_v is calculated as:

$$C_v = \int_{r_{\min}}^{r_{\max}} \frac{dV(r)}{d\ln r} d\ln r \qquad (1)$$

Figure 7b and c show mean values and associated standard errors of the mean for the particle volume concentrations of the fine and coarse mode fractions. The mean values and standard error bars confirm a significant difference between volume concentrations for the fine fraction, and no significant difference for the coarse fraction.

4.3 Representativeness of the case study

An air pollution episode is defined as a half-hour NO_x concentration level that is double the Israeli air quality standard (the half-hour standard is 500 ppb), and that occurs in three out of eight air monitoring stations over the Tel Aviv Metropolitan area. According to the Ministry of the Environment, the frequency of high air pollution episodes in this area is one to six episodes per year, based on air-monitoring networks established in 1998. In addition, dozens of cases exceeding this standard have been measured in other monitoring stations.

Dayan and Rodnizki (1999) analyzed the temporal behavior of the Atmospheric Boundary Layer (ABL) in Israel on the basis of 3 years (1987–1989) of measurements conducted by the Israeli Meteorological Service. They reported a frequency of occurrence of elevated capping inversion of about 10–20 days per month during the period from October to April. The frequency of capping inversion starts to increase during the summer months and can reach a maximum of 27–29 days per month in August. In addition, the height of this upper inversion reaches its minimum value during the summer months and its maximum during the winter. Radiative inversion can induce development of a stable boundary layer (SBL) during the night. As reported by Dayan and Rodnizki (1999), the distribution of the occurrence frequency of SBL is opposite to that of capping inversion. The frequency of SBL is about 15 to 20 nights per month (based on 2300 GMT measurements) during October to April. However, the frequency starts to decrease in summer

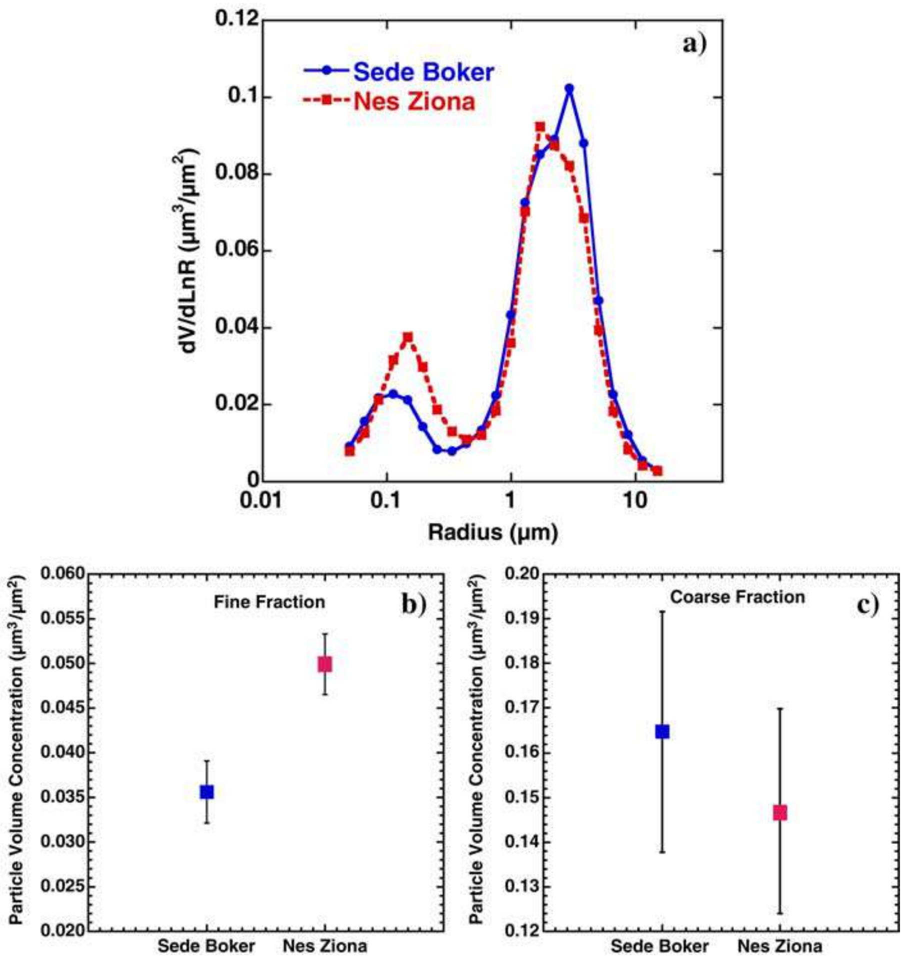

Figure 7 (a) Mean aerosol volume size distributions for Nes Ziona and Sede Boker sites. The mean values were calculated by weighting them by AOT. (b, c) Mean values of particle volume concentration for fine (b) and coarse (c) fractions, for the Nes Ziona and Sede Boker sites. Data are based on 4 years of measurements (2000–2003). *Vertical bars* Standard error of the mean.

and reaches an average minimum of 7 nights in August. The depth of the SBL reaches its maximum (~425 m) in spring, then suddenly drops to about 300 m in August, after which it stays almost constant (~300 m) for the rest of the year until the beginning of the following spring.

As described above, development of capping and radiative inversion is quite frequent in the study area. Such inversions trap local pollution and thus local pollution sources can make an important contribution to regional air quality. Our study shows that pollutant concentration was elevated in the densely populated and industrialized central part of Israel during a capping inversion episode.

5 Conclusions

This paper focuses on the investigation of an air pollution episode in the Coastal Plain of central Israel. A specific case study was presented in the context of general differences in measured optical and microphysical atmospheric aerosol characteristics at two Israeli sites. The study involved analysis of aerosol optical properties, synoptic conditions, air mass backward trajectories, and ground-base *in situ* air pollution sampling. It was found that, due to unfavorable synoptic conditions, air pollutants of local origin were trapped near the surface during several days of observation. The measurements of atmospheric aerosol optical and microphysical properties during this episode showed a clear response to the burden of fine aerosol particles in the densely populated and industrial central part of Israel. Conventional sampling of air pollutants supports the presence of elevated levels of urban and industrial air pollution in this region. The results presented demonstrate the dominant role of local pollution sources in a specific air pollution event. According to a study conducted in Israel, the role of local air pollution sources is important due to the frequent occurence of synoptic conditions that make pollution dispersion difficult. Such conditions can occur in around 30 to 90% of the days in each month, depending on the season (Dayan & Rodnizki, 1999).

The current study also demonstrates the ability to monitor urban and industrial aerosol particles by optical measurements. The advantages of this method are speed (almost instantaneous) and the automated type of measurement. The drawbacks are that the presented optical measurements cannot distinguish between different types of pollutant gases, and they do not represent a continuous spatial distribution of aerosol properties. However, the latter can be achieved by using optical measurements from spaceborne systems. We also conclude that combining surface sampling, remote sensing measurements and analysis of synoptic conditions enables both detection of air pollution and allows distinction to be made between local and imported pollution.

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