

Physico-chemical Investigations of Urban Aerosols

A contribution to subproject SATURN

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Summary

Aerosol concentrations were measured at two sites in the Mediterranean: the Finokalia site on the island of Crete (Greece) and aboard the Aigaion which was located in the Eastern Mediterranean area between the Greek mainland and the island of Crete.

Aim of the research

To investigate physico-chemical transformations of aerosol in an urban plume.

Activities during the year

Field campaign in the Mediterranean during January.

Principal results

Within the EU project 'Sub-aero' (ENVK2 1999 00052) measurements in the summer campaign were performed between 8th July and 2nd August 2000 at Finokalia station (35° 19' N, 25° 40' E) on the island of Crete. A five-day cruise took place between 25 and 30 July 2000. This coincided with the land-based field campaign in Finokalia. The research vessel, 'Aigaion', was subcontracted from the National Centre for Marine Research and was equipped with a chemistry laboratory and other essential consumables. The boat cruised in the Aegean Sea along selected tracks defined by forward and back trajectory modelling as calculated with the sampling site in Crete as the end point. Detailed characterisation of the particulate matter physico-chemical characteristics was performed and the chemical analysis reveals the importance of specific components in the PM mass. Nucleation events were observed and their sources are under investigation.

A winter campaign was performed between 7 – 14 January 2001 at the Finokalia station on the island of Crete. Nucleation events were observed more often in the winter period compared to the summer and the aerosol mass concentration was lower in winter compared to summer data.

Aerosol scattering coefficients were measured with a three-wavelength integrating nephelometer (TSI model 3563). An Anderson Instrumentation was used to determine black carbon concentrations. The laser aerosol spectrometer (LASX, Particle Measuring Systems) was also used with 3-min time intervals throughout the summer and winter Finokalia campaigns. Detailed gaseous phase measurements for a number of photo-oxidants were continuously performed (NO₂, NO, SO₂, O₃, nitrous acid, HNO₃). Berner Cascade Impactors with 10 impaction stages were

employed both at Finokalia and onboard the Aigaion boat. A High Volume Impactor (Andersen GS2312 BL) sampler was deployed at a location 2 km inland from the main Finokalia sampling site. A number of micro-meteorological parameters were measured by a Vaisala portable weather station at Finokalia. The parameters included temperature, wind speed and humidity. Finally, two Scanning Mobility Particle Sizers (SMPS) measured submicrometer aerosols in the range 3 to 1000 nm in diameter both at Finokalia and onboard the boat Aigaion. These instruments were set to record measurements at 3-minute time intervals.

R/V Aegaeo was chartered for 5 days (25-29 of July) in order to perform atmospheric aerosol and gaseous species measurements across the Aegean Sea and in parallel to the on-going field campaign at Finokalia Crete. All major equipment described below was loaded and installed on the research vessel between the 22nd and 23rd of July. On the 24th of July a test cruise in the Saronic Gulf was conducted in order to ensure that all instruments were operational and function according to specifications. The following equipment was used onboard the vessel: 0: Radar and meteorological mast, 1: Omnidirectional inlet with 2.1 μ m 50% cut-off sampling head for aerosol samplers 4,5 and 6., 2: Berner Cascade Impactor, 3: Andersen High Volume Impactor, 4: Denuder/ filter pack sampling system, 5: Aethalometer, 6: Scanning Mobility Particle Sizer, 7: Ozone analyser, 8: Inlet for prototype trace-gas analysers, 9: Prototype trace gas analysers (O_3 , NO, NO_2 , HNO_2 , HNO_3).

During the both campaigns in Finokalia integrated gas and fine particulate species concentration measurements were made by means of denuder/filterpack systems. Ion Chromatography is currently being used to determine concentrations of HCl, HNO_3 , HONO, NO_2 , SO_2 , NO_3^- , SO_4^{2-} , Cl, NH_4^+ and H^+ .

The sampling at Finokalia site was carried out on the roof of small building. The impactors were fixed on the stage facing the usual wind direction at the height about 3 m above the ground. The impactor had an inlet providing approximately 15 μ m upper cut-off particle size for samples. The samples were deposited on Nuclepore foils greased with Apiezon L vacuum grease. This reduced the particle bounce. Sampling was carried out approximately in 24-hour intervals. The mass size distributions were obtained from the mass of particulate matter deposited on the individual stages, volume flow rate of aerosol and total time of sampling. During the summer period a total of 21 mass size distributions were obtained. The distributions were predominantly bimodal with mode mean diameters around 0.3 and 5 μ m. In several cases additional mode appeared at around 1 μ m. Coarse particles were beige in colour corresponding to mineral dust, fine particles (< 0.5 μ) were black indicating the presence of soot from combustion. Mass concentration (corresponding to about 15 PM) varied between 20 to 70 μ g/m³. The raw mass size data were inverted into smooth mass size distributions by the MICRON code. The inverted distributions were integrated to obtain PM₁, PM_{2.5}, and PM₁₀.

A standard Scanning Mobility Particle Sizer (TSI, Inc.), which consists of TSI 3071 Electrostatic Classifier and TSI 3022 low flow rate Condensation Particle Counter was used. During the summer season the SMPS was set to sheath and inlet airflow rate of 9.0 and 0.9 l/min, respectively, to provide size range bounds 7.8 – 327 nm. In winter season sheath and inlet airflow rate of 10 and 1.0 l/min was used, respectively, which corresponds to size range bounds 7.5 – 316 nm. In both cases the preimpactor with nozzle 0.457 mm was used, giving 360 nm (summer) or 338 nm (winter) cut diameter. The instrument worked periodically with 60 s upward data scan, followed by 30 s downward scan. Using this procedure about 20.000 and 7.000 particle number

size distributions were obtained for summer and winter season, respectively. The distributions were corrected for multiple charging (TSI SMPS software, Version 3.0).

During the summer campaign particle concentration varied from $1 \cdot 10^3$ to $2 \cdot 10^3 \text{ cm}^{-3}$. The particle distributions were monomodal with concentration maximum around 80-120 nm. The exception was July 14 –15 where modes with maximum around 40 nm (July 14 in the morning) and 20 nm (July 15 in the afternoon) appeared, which lasted for couple of hours. Number distributions measured during the winter season were predominantly bimodal. Particle concentrations varied from $5 \cdot 10^2$ to $5 \cdot 10^3 \text{ cm}^{-3}$ with maxima around 20-40 and 80-200 nm, respectively.

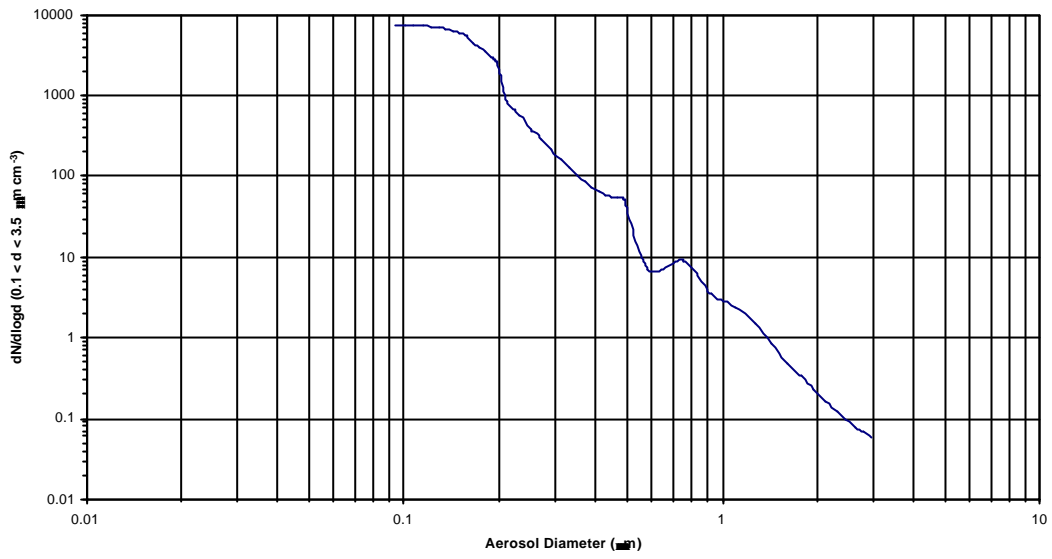
Main conclusions

- Fine particulate matter in the Eastern Mediterranean is a complex mixture of different inorganic and organic species. The Mediterranean area is polluted from urban areas, long-range transport and ship traffic.
- New particle formation is observed in the Mediterranean area.
- Resuspension of dust and other natural sources (e.g. sea salt, Saharan dust) contribute considerable in the aerosol mass.
- Higher aerosol and photo-oxidant concentrations are observed during summer compared to the winter concentrations.

Aims for the coming year

- Analysis of data from the Winter and Summer campaigns at Finokalia
- Investigate the use of black carbon as a tracer of anthropogenic pollution
- Continued chemical analysis
- Investigation of nucleation events

Grand Average Number Size Distribution during the SUBAERO Crete 2001 January Campaign



Grand Average Number Size Distribution during the SUBAERO Crete 2000 July Campaign

