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Sources of Total Particles and Cloud Condensation Nuclei Levels in the Eastern Mediterranean: Urban vs Remote Background Environments

Bougiatioti A[1,2]*, Kalkavouras P[1,2], Zarmpas P[1] and Mihalopoulos N[1,2]

[1]*Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, Greece*

[2]*Institute for Environmental Research & Sustainable Development, National Observatory of Athens, Greece*

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***Corresponding author:** Bougiatioti A, Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete & Institute for Environmental Research & Sustainable Development, National Observatory of Athens, P. Penteli, 15236, Greece

Abstract

Atmospheric particles play a key role in climate change, via absorption and scattering of the incoming solar radiation, especially those originating from anthropogenic activities. Aerosol particles also act as Cloud Condensation Nuclei (CCN) "indirectly" forcing climate through the modification of cloud properties and precipitation efficiency. The activation of particles to form CCN depends mostly on particle size and chemical composition and differs depending on the location and emission sources. Measurements took place at two different environments in the Eastern Mediterranean; an urban background site located downtown Athens and the remote background station of Finokalia on the island of Crete. The aim of the study is to characterize the levels and distribution of total aerosol particles (CN) and CCN in the different environments and analyse the role of anthropogenic sources in the measured levels.

Keywords: Cloud condensation nuclei; Urban; Remote background; Anthropogenic sources

Introduction

Aerosol particles are both primarily emitted in the atmosphere from natural and anthropogenic sources but also formed by secondary processes that include the partitioning of semi-volatile components between the gas and the aerosol phase, such as condensation and nucleation [1]. Depending on the environment and the proximity to emission sources, particles can exhibit significant differences in their number size distribution as well as their chemical composition, which directly impacts on their ability to act as CCN and ultimately as cloud droplets.

Instrumentation and Methods

Measurements took place at two different environments in the Eastern Mediterranean; an urban background site at the premises of the National Observatory of Athens (NOA) at Thissio (Hill of Nymphs, 37°97'N, 23°72'E). More details about the location can be found in Fourtziou et al. [2] The second site was the remote background station of Finokalia on the island of Crete (35°20'N, 25°40'E; http://finokalia.chemistry.uoc.gr; Mihalopoulos et al. 1997) [3]. Finokalia station is far away from any large city and human activity while Thissio is away from major highways, thus with limited direct local emissions. Measurements at the remote background site took place from November 2015 until August 2016 and at the urban site from August 2017 until May 2018.

For the determination of the total particle number, particle number size distributions were monitored at the aforementioned locations. At Thissio, a TSI Scanning Mobility Particle Sizer (SMPS, 3034) was used to measure the size distribution of particles with diameters from 10.4-470nm (scanned range), with a 5min time resolution. SMPS measurements were corrected using the Aerosol Instrument Manager inversion software (AIM, TSI version 6.0), containing correction for multiply charged particles. At Finokalia, a TROPOS-type custom-built SMPS [4] was operated for measuring the size distribution of aerosol particles with diameters from 9- 848nm, every 5min, as well. The recorded number size distributions were corrected for particle losses by diffusion on the various parts of the SMPS following the recommendations by Wiedensohler et al. [4].

CCN concentrations (cm^{-3}) were measured between 0.2&1.0% supersaturation using a Droplet Measurement Technologies (DMT) Continuous Flow Streamwise Thermal Gra-

dient CCN counter [5] at both locations during the designated measurement periods. In the current study, the flow rate was 0.5Lmin-1 with a sheath-to-aerosol flow ratio of 10:1, and a top-bottom column difference, ΔT, varying between 4&15K. Concentrations were measured at 5 different levels of supersaturation (0.2, 0.38, 0.52, 0.66 & 0.73%) for 15min, yielding a CCN spectrum approximately every hour.

All aerosol particle number size distributions were binned in order to obtain the relative changes of the three main particle modes, namely "Nucleation mode" (with diameters less than 25nm), "Aitken mode" (diameters between 25&100nm) and "Accumulation mode" (with diameters exceeding 100nm). The concentration of particles in each mode is obtained from the respective SMPS bins as being the sum of particle concentration in all the size bins of the corresponding diameter range (i.e. 10-25 for nucleation, 25-100nm for Aitken and 100-470nm for accumulation at Athens, and 9-25nm for nucleation, 25-100nm for Aitken and 100-848nm for accumulation at Finokalia, respectively).

Results and Discussion

CCN measurements

CCN measurements indicate that in the urban environment during winter, concentrations are almost 5-fold higher than the respective ones at the remote background site, and this is attributed to the additional anthropogenic sources in a large urban center such as Athens. Additionally in Athens, the CCN number increases significantly with increasing supersaturation, indicative that in urban environments there is a much larger amount of small particles which tend to activate at higher supersaturation levels. These particles could originate from combustion emission sources such as traffic or biomass burning, which are enhanced during wintertime. These particles may be less hygroscopic than larger, more CCN-active particles and require higher level of supersaturation in order to activate and grow to CCN-relevant sizes.

Impact of anthropogenic sources

From the binned particle number concentrations for Nucleation, Aitken and Accumulation mode it occurs that at Finokalia, Aitken and accumulation mode particles were of 386 ± 305 & 1,506 ± 1,107cm^{-3} while at Thissio the concentrations are remarkably higher, and the respective values were of 1,435 ± 412 &5,517 ± 1,893cm^{-3}. The total average particle number concentrations (N_{total}) were calculated to be as 8,652 ± 8,137cm-3& 2,958 ± 3,579cm^{-3} at Thissio and Finokalia, respectively which are well in the range of the respective values reported by Salma et al. [6] in the city center of Budapest and in a near-city background. Furthermore, on average, N_{total} at Thissio during winter were higher compared to summer by 53%, while at Finokalia were higher by 24%. Figure 1 depicts the mean diurnal variability of Nucleation-mode (≤25nm) particles at both measurement sites. A clear seasonal trend is observed at both sites, with a burst of particles taking place around noon, consistent with new particle formation events, with corresponding peaks being observed earlier during spring and summer, accordingly to the solar irradiance cycle. Higher concentrations are observed during winter at both sites with concentrations at Athens being once more around 5-fold higher. In Athens particles in nucleation mode exhibit a dominant profile peaking during the morning between 7:00 & 9:00LT, which is consistent with the morning traffic. Also, during winter at Athens there is a peak between 18:00 & 20:00LT, which could be attributed to local combustion emission sources [7].

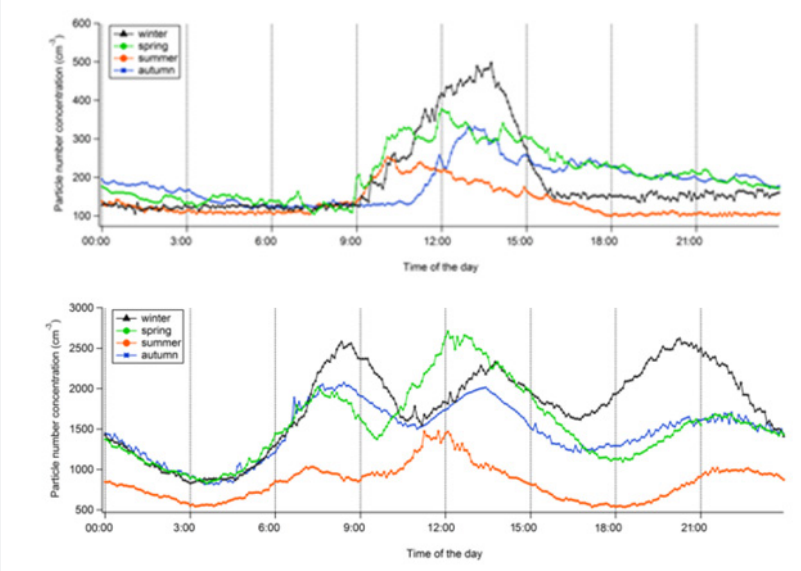

Figure 1: Average diurnal variability of Nucleation mode particle number concentration at Finokalia (a) and Thissio (b) during the measurement period.

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Conclusion

Total particle (CN) and CCN number concentrations were monitored at two different environments in the Eastern Mediterranean in order to investigate the contribution of anthropogenic sources. It occurs that aerosol particle levels are significantly higher at the urban environment, both for CN as well as for CCN. Significantly higher levels are observed during wintertime, when additional anthropogenic emissions dominate the urban atmosphere, contributing an eminent ultrafine mode (<100nm) from emission sources such as central heating systems and biomass burning used for domestic heating purposes. These sources can contribute to an almost 5-fold increase in particle concentrations compared to the background conditions, impacting on the air quality and aerosol physicochemical properties.

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References

1. Hofman J, Staelensa J, Cordell R, Stroobantsa C, Zikovac N, et al. (2016) Ultrafine particles in four European urban environments: Results from a new continuous long-term monitoring network. Atmospheric Environment 136: 68-81.
2. Fourtziou L, Liakakou E, Stavroulas I, Theodosi C, Zarmpas P, et al. (2017) Multi-tracer approach to characterize domestic wood burning in Athens (Greece) during wintertime. Atmos Environ 148: 89-101.
3. Mihalopoulos N, Stephanou E, Kanakidou M, Pilitsidis S, Bousquet P, et al. (1997) Tropospheric aerosol ionic composition in the Eastern Mediterranean region. Tellus B 49: 314-326.
4. Wiedensohler A, Birmili W, Nowak A, Sonntag A, Weinhold K, et al. (2012) Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions 5(3): 657-685.
5. Roberts GC, Nenes A (2005) A Continuous-Flow Streamwise Thermal-Gradient CCN Chamber for Atmospheric Measurements. Aerosol Sci Technol 39: 206-221.
6. Salma I, Németh Z (2018) Consequences of dynamic and timing properties of new aerosol particle formation and consecutive growth rates. Atmos Chem Phys.
7. Ng NL, Herndon SC, Trimborn A, Canagaratna M, Croteau RPL, et al. (2011) An Aerosol Chemical Speciation Monitor (ACSM) for routine monitoring of the composition and mass concentrations of ambient aerosol. Aerosol Sci Technol 45(7): 770-784.

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