CityZen

megaCITY - Zoom for the Environment

Collaborative Project

7th Framework Programme for Research and Technological Development

Cooperation, Theme 6:

Environment (including Climate Change)

Grant Agreement No.: 212095

Deliverable D2.4.4, type O

Publication on aerosol impact

Due date of deliverable: project month 36

Actual submission date: project month 36

Start date of project: 1 September 2008 Duration: 36 months

Name of lead beneficiary for this deliverable: PKU

Scientist(s) responsible for this deliverable: M. Gauss (met.no), Yuanhang Zhang (PKU)

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Publication on aerosol impact

Several publications on aerosols, their distributions and their impact have been issued by CityZen. It is well recognized that aerosols (particulate matter), together with ozone, represent the most relevant air pollution leading to adverse health effects. At the same time aerosols also have an impact on climate. In the Pearl River Delta in particular, air quality and atmospheric visibility has been deteriorated by high concentration of ozone and fine particles during the last decade. Transformation and transport of air pollutants show rather unique characteristics under conditions of high concentrations of primary and secondary pollutants. Possible impacts on regional air quality and climate change are a major concern of the Chinese government as well as the global community.

The focus of this deliverable was originally meant to be on the Pearl River Delta. However, as problems connected to particulate matter are serious also in the other 'CityZen' hotspots, particularly the Eastern Mediterranean, also non-PRD related publications are listed as relevant for the frame of this deliverable. Most of the publications are available online. Only fully peer-reviewed publications are listed first. Further below, non-peer reviewed or publications under review will be mentioned.

***

Gerasopoulos, E., Amiridis, V., Kazadzis, S., Kokkalis, P., Eleftheratos, K., Andreae, M. O., Andreae, T. W., El-Askary, H., and Zerefos, C. S.: Three-year ground based measurements of aerosol optical depth over the Eastern Mediterranean: the urban environment of Athens, Atmos. Chem. Phys., 11, 2145-2159, doi:10.5194/acp-11-2145-2011, 2011.
http://www.atmos-chem-phys.net/11/2145/2011/acp-11-2145-2011.pdf

Abstract. Three years (2006–2008) of ground-based observations of the Aerosol Optical Depth (AOD) in the urban environment of Athens, in the Eastern Mediterranean, are analysed in this work. Measurements were acquired with a Multi-Filter Rotating Shadowband Radiometer at five wavelengths. The daily average AOD at 500 nm is 0.23, and the mean Ångström coefficient calculated between 415 and 867 nm is 1.41. The annual variability of AOD has a spring maximum dominated by coarse dust particles from the Sahara (AOD 0.34–0.42), while the diurnal pattern is typical for urban sites, with AOD steadily increasing throughout the day. The greatest contribution to the annually averaged AOD, accounting for almost 40%, comes from regional and local sources (namely the Istanbul metropolitan area, the extended areas of biomass burning around the north coast of the Black Sea, power plants spread throughout the Balkans and the industrial area in the Po valley, with average daily AOD in the range of 0.25–0.35). An additional important contribution (23%) is dust from Africa, whereas the rest of Europe contributes another 22%. The geographical distribution of the above sources in conjunction with the prevailing synoptic situation and contribution of local sources, lead to mixed types of aerosols over Athens, with highly variable contribution of fine and coarse particles to AOD in the range 10%–90%. This is the first long-term, ground based data set available for Athens, and it has also been used for the validation of satellite derived AOD by MODIS, showing good agreement on an annual basis, but with an overestimation of satellite AODs in the warm period.

***

Hatzianastassiou, N., A. Gkikas, N. Mihalopoulos, O. Torres, B. D. Katsoulis: Natural versus anthropogenic aerosols in the eastern Mediterranean basin derived from multi-year TOMS and MODIS satellite data, J. Geophys. Res., 114, D24202, doi:10.1029/2009JD011982, 2009.

Abstract. In the present study we investigate the spatial and temporal variation of aerosol optical thickness (AOT) in the eastern Mediterranean basin, and more specifically in the area extending from 28.5ºN to 42.5ºN and from 18.5ºE to 35.5ºE, which includes large urban areas and megacities such as Cairo, Istanbul, Athens, Izmir, Ankara, and Thessaloniki. For this purpose we use long-term AOT data from the Total Ozone Mapping Spectrometer (TOMS) version2 converted to 500 nm (AOT_{500}) for the period 1980–2001 and Collection 005 AOT data at l = 550 nm (AOT_{550}) from Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua satellites for the periods 2000–2005 and 2002–2005, respectively. The spatial and temporal variation of AOT shows a good agreement between TOMS and MODIS, in terms of geographical patterns, which maximizes the usefulness of TOMS AOT product given its long temporal coverage (climatological). According to MODIS-Terra, the annual mean AOT550 over the studied region equals 0.22 ± 0.05 (monthly values ranging from 0.14 to 0.32) and shows strong spatial inhomogeneities. The smallest values (down to 0.1) occur over the western, and especially in the northwestern, part of Greece, over the northern part of Anatolian peninsula and also over the sea of east Mediterranean. The largest AOT values (up to about 1.0) occur over northern Africa, Middle East, and the adjacent coasts, and over the Anatolian plateau. These high aerosol loadings are of natural origin, mainly desert dust. However, very large values (up to 0.8) are also found over large urban areas surrounding megacities, associated with anthropogenic, apart from natural desert, aerosols. By using TOMS AOT data as proxy for the dust source, and the difference of MODIS-TOMS AOT as an indicator of the anthropogenic aerosol component, the relative contribution of natural versus anthropogenic sources of aerosols has been derived for the eastern Mediterranean area. Limitations of this approach are discussed and the associated uncertainties are also evaluated and discussed.

***

Theodosi, C., U. Im, A. Bougiatioti, P. Zarmpas, O. Yenigun, N. Mihalopoulos, Aerosol chemical composition over Istanbul, Science of the Total Environment, 408, p. 2482–2491, 2010.

Abstract. This study examines the chemical composition of aerosols over the Greater Istanbul Area. To achieve this 325 (PM10) aerosol samples were collected over Bosphorus from November 2007 to June 2009 and were analysed for the main ions, trace metals, water-soluble organic carbon (WSOC), organic (OC) and elemental carbon (EC).
PM10 levels were found to be in good agreement with those measured by the Istanbul Municipality air quality network, indicating that the sampling site is representative of the Greater Istanbul Area. The main ions measured in the PM10 samples were Na^{+}, Ca^{2+} and non-sea-salt sulphates (nss-SO_4^{2-}). On average, 31% of Ca^{2+} was found to be associated with carbonates. Trace elements related to human activities (as Pb, V, Cd and Ni) obtained peak values during winter due to domestic heating, whereas natural origin elements like Al, Fe and Mn peaked during the spring period due to dust transport from Northern Africa. Organic carbon was found to be mostly primary and elemental carbon was strongly linked to fuel oil combustion and traffic. Both OC and EC concentrations increased during winter due to domestic heating, while the higher WSOC to OC ratio during summer can be mostly attributed to the presence of secondary, oxidised and more soluble organics. Factor analysis identified six components/sources for aerosol species in PM10, namely traffic/industrial, crustal, sea-salt, fuel–oil combustion, secondary and ammonium sulfate.

***

Im, U., K. Markakis, A. Unal, T. Kindap, A. Poupkou, S. Incecik, O. Yenigun, D. Melas, C. Theodosi, N. Mihalopoulos, Study of a winter PM episode in Istanbul using the high resolution WRF/CMAQ modeling system, Atmospheric Environment, 44, p. 3085-3094, 2010.

Abstract. High winter-time PM10, sulfate, nitrate and ammonium levels in Istanbul were investigated using a high resolution WRF/CMAQ mesoscale model system. A model-ready anthropogenic emission inventory on 2 km spatial resolution was developed for the area and the present study is the first attempt to test these emissions. The results suggested that the system was capable of producing the magnitudes. PM10 levels calculated by the model underestimated the observations with an average of 10 per cent at Bogazici University sampling station, whereas an overestimation of 12 per cent is calculated for all stations. High uncertainties, particularly in traffic and coal combustion, led to over estimations around emission hot spots. Base case results together with the sensitivity studies pointed significant contribution of local sources, pointing to the need of control strategies focusing on primary particulate emissions.

***

Koçak, M., Theodosi, C., Zarmpas, P., Im, U., Bougiatioti., A., Yenigün, O., Mihalopoulos, N.: Particulate matter (PM10) in Istanbul: Origin, source areas and potential impact on surrounding regions, Atmos. Environ., doi:10.1016/j.atmosenv.2010.10.007, 2010.

Abstract. Water-soluble ions (Cl^-, $NO3^-$, $SO2^{4-}$, $C2O4^-$, Na^+, $NH4^+$, K^+, Mg^{2+},Ca^{2+}), water soluble organic carbon (WSOC), organic and elemental carbon (OC, EC) and trace metals (Al, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Cd and Pb) were measured in aerosol PM10 samples above the megacity of Istanbul between November 2007 and June 2009. Source apportionment analysis using Positive Matrix Factorization (PMF) indicates that approximately 80% of the PM10 is anthropogenic in origin (secondary, refuse incineration, fuel oil and solid fuel combustion and traffic). Crustal and sea salt account for 10.2 and 7.5% of the observed mass, respectively. In general, anthropogenic (except secondary) aerosol shows higher concentrations and contributions in winter. Mean concentration and contribution of crustal source is found to be more important during the transitional period due to mineral dust transport from North Africa. During the sampling period, 42 events exceeding the limit value of 50 mgm^{-3} are identified. A significant percentage (91%; n=38) of these exceedances is attributed to anthropogenic sources. Potential Source Contribution Function analysis highlights that Istanbul is affected from distant sources from Balkans and Western Europe during winter and from Eastern Europe during summer. On the other hand, Istanbul sources influence western Black Sea and Eastern Europe during winter and Aegean and Levantine Sea during summer.

***

Hu X., Li Y., Li J., Wang X., Zhang Y., Interaction of Ambient PM10 among the Cities over the Pearl River Delta, 2011, Acta Scientiarum Naturalium Universitatis Pekinensis, 47(3), 519-524, (in Chinese).

Abstract. The Models-3/CMAQ modeling system was applied to investigate PM10 pollution over the Pearl River Delta (PRD) region during October 2006. Sensitivity analysis was conducted to examine the relationship between the reduction of different source emissions and the consequent change of PM10 concentrations, and to quantify the interaction of air pollution among adjacent cities. The results show that PM10 pollution is a regional-scale issue in PRD. Guangzhou, Foshan Jiangmen and Dongguan, contribute to the PM10 in PRD remarkably. The relative sensitivity coefficient was proposed to determine the impact of regional pollution sources. The PM10 concentrations in Zhuhai, Jiangmen, Zhongshan, Foshan cities are significantly influenced by regional source

emissions. The intercity transport has been the important factor of PM10 pollution in PRD. To improve the air quality in PRD area, effective control of emission sources should be highly reinforced, together with consentaneous programming, intensive collaboration, joint prevention and control.

***

Xiao, R., N. Takegawa, M. Zheng, Y. Kondo, Y. Miyazaki, T. Miyakawa, M. Hu, M. Shao, L. Zeng, Y. Gong, K. Lu, Z. Deng, Y. Zhao, and Y. H. Zhang, Characterization and source apportionment of submicron aerosol with aerosol mass spectrometer during the PRIDE-PRD 2006 campaign, Atmos. Chem. Phys., 11, 6911-6929, 2011.
http://www.atmos-chem-phys.net/11/6911/2011/acp-11-6911-2011.pdf

Abstract. Size-resolved chemical compositions of nonrefractory submicron aerosol were measured using an Aerodyne quadrupole aerosol mass spectrometer (Q-AMS) at the rural site Back Garden (BG), located ≈50 km northwest of Guangzhou in July 2006. This paper characterized the submicron aerosol particles of regional air pollution in Pearl River Delta (PRD) in the southern China. Organics and sulfate dominated the submicron aerosol compositions, with average mass concentrations of 11.8±8.4 μgm^{-3} and 13.5±8.7 μgm^{-3}, respectively. Unlike other air masses, the air masses originated from Southeast-South and passing through the PRD urban areas exhibited distinct bimodal size distribution characteristics for both organics and sulfate: the first mode peaked at vacuum aerodynamic diameters (D_{va}) ≈200 nm and the second mode occurred at D_{va} from 300–700 nm. With the information from AMS, it was found from this study that the first mode of organics in PRD regional air masses was contributed by both secondary organic aerosol formation and combustion-related emissions, which is different from most findings in other urban areas (first mode of organics primarily from combustion-related emissions). The analysis of AMS mass spectra data by positive matrix factorization (PMF) model identified three sources of submicron organic aerosol including hydrocarbon-like organic aerosol (HOA), low volatility oxygenated organic aerosol (LV-OOA) and semi-volatile oxygenated organic aerosol (SV-OOA). The strong correlation between HOA and EC indicated primary combustion emissions as the major source of HOA while a close correlation between SV-OOA and semi-volatile secondary species nitrate as well as between LV-OOA and nonvolatile secondary species sulfate suggested secondary aerosol formation as the major source of SV-OOA and LV-OOA at the BG site. However, LV-OOA was more aged than SV-OOA as its spectra was highly correlated with the reference spectra of fulvic acid, an indicator of aged and oxygenated aerosol. The origin of HOA and OOA (the sum of LV-OOA and SV-OOA) has been further confirmed by the statistics that primary organic carbon (POC) and secondary organic carbon (SOC), estimated by the EC tracer method, were closely correlated with HOA and OOA, respectively. The results of the EC tracer method and of the PMF model revealed that primary organic aerosol (POA) constituted ≈34–47% of OA mass and secondary organic aerosol (SOA) constituted ≈53–66% of regional organic aerosol in PRD during summer season. The presence of abundant SOA was consistent with water soluble organic carbon (WSOC) results (accounting for ≈60% of OC on average) by Miyazaki et al. (2009) for the same campaign. OOA correlated well with WSOC at the BG site, indicating that most OOA were water soluble. More specifically, approximately 86% of LV-OOA and 61% of SV-OOA were estimated as water soluble species on the basis of carbon content comparison.

***

Under review:

Yoon, J., W. von Hoyningen-Huene, M. Vountas, and J. P. Burrows: Analysis of linear long-term trend of Aerosol Optical Thickness derived from SeaWiFS using BAER over Europe and South China, Atmos. Chem. Phys. Discuss., 11, 20757-20792, 2011.
http://www.atmos-chem-phys-discuss.net/11/20757/2011/acpd-11-20757-2011.pdf

Abstract. The main purpose of the present paper is to derive and discuss linear long-term trends of Aerosol Optical Thickness (AOT) at 443 and 555 nm over regions in Europe and South China. These areas are densely populated and highly polluted. The study uses the Bremen AErosol Retrieval (BAER) and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data for AOT retrievals in the specified regions from October 1997 to May 2008. In order to validate the individually retrieved AOTs and the corresponding trends, AErosol RObotic NETwork (AERONET) level 2.0 data have been used. The retrieved AOTs were in good agreement with those of AERONET ($0.79 \leq R \leq 0.88$, $0.08 \leq RMSD \leq 0.13$). The contamination of BAER aerosol retrievals and/or AERONET observations by thin clouds can significantly degrade the AOT and lead to statistically non-representative monthly-means, especially during cloudy seasons. Therefore an inter-correction method has been developed and applied. The "corrected" trends for both BAER SeaWiFS and AERONET AOT were similar having an average of relative error ≈25.19%. In general terms, negative trends (decrease of aerosol loading) were mainly observed over European regions, with magnitudes up to −0.00453 (−1.93 %) and −0.00484 (−2.35 %) per year at 443 and 555 nm, respectively. In contrast, the trend in Pearl River Delta was positive, most likely attributed to rapid urbanization and industrialization. The magnitudes of AOT increased by +0.00761 (+1.24 %) and +0.00625 (+1.15%) per year respectively at 443 and 555 nm.

***

Non peer-reviewed:

Of relevance for the impact of aerosols on climate, calculations have been performed with the aerosol-climate model of CityZen partner FZJ. An institute report series will appear during autumn 2011 at FZJ / "Schriften des Forschungszentrums Jülich", Reihe Energie & Umwelt / Energy & Environment Band / Volume 116, with the title "CITYZEN Climate Impact Studies", edited by Martin Schultz, ISSN 1866-1793, ISBN 978-3-89336-729-0. This publication collects three studies from the CITYZEN project with relevance to climate change, the second of which (paper no. 2) will address aerosol impact from megacities in particular. The report will appear in print and online at http://wwwzb.zb.kfa-juelich.de/publikationen/schriftreihe.asp?Schriftreihe=64 before the end of September 2011, with the following table of Contents is as follows (paper no.2):