atmosphere

Editorial

Special Issue: Air Pollution at the Urban and Regional Level: Sources, Sinks, and Transportation

Elena Svilenova Hristova [1,*] and Manousos Ioannis Manousakas [2]

1 Department of Meteorology, National Institute of Meteorology and Hydrology, 1784 Sofia, Bulgaria
2 Laboratory of Atmospheric Chemistry, Paul Scherrer Institute (PSI), 5232 Villigen, Switzerland
* Correspondence: elena.hristova@meteo.bg

1. Introduction

Air pollution poses a significant risk to human health. Emissions from industrial activities, energy production, transport, waste management activities, and natural sources contribute to the many air-pollution-induced problems, such as reduced visibility, adverse health effects, and global climate change. Air pollution is not a local concern. The residence time of pollutants in the atmosphere can extend from several days to months, and the corresponding spatial transportation scales are proportionally large, ranging from local to continental. Even though there is no region not affected by air pollution at some level, the situation is significantly worse in urban areas. Urban areas are hotspots of air pollution, especially the large and densely populated metropolitan areas. Air pollutants can vary in type and characteristics, can be of gaseous or particulate form, and can either be directly emitted or formed in the atmosphere from their precursor molecules.

The aim of this Special Issue was to gather up-to-date research knowledge aiming at assessing air pollution at the urban and regional level, including both experimental and monitoring studies and mathematical/numerical modeling studies.

2. Results

The publications of the issue cover the subjects of air pollution with particulates and gaseous pollutants (five), Particulate Matter (PM) sources and source apportionment (three), Carbonaceous species (Organic and Elemental or Black Carbon) in the atmosphere (two), and Ozone-related pollution (one). The relatively large geographical coverage of the studies included in this issue provides a good overview of particulate-related pollution on an intercontinental level. The Special Issue contains ten published studies referring to different regions around the world: Europe (five), Asia (three), and the Middle East (two). A brief overview of the main finding and conclusions of the studies included in the Special Issue will be presented below in chronological order of publication.

In the first publication, the authors used modeling approaches to study the atmospheric composition in Sofia, Bulgaria [1]. The models used were WRF as a meteorological pre-processor, CMAQ as a chemical transport model, and SMOKE as the emission pre-processor of Models-3 system. Based on the findings of the study, it was identified that the daily concentration variation of the two main air pollution species—NO_2 and $PM_{2.5}$—have different magnitudes, and the effect of different emission sources on the relative contributions to the concentration of the species is highly variant. The results produced by the CMAQ "integrated process rate analysis" demonstrate the complex behavior and interaction of the different processes. Further analysis of these processes; their spatial, diurnal, and seasonal variability; and their interactions can be helpful for an explanation of the overall picture and origin of the pollution in the considered region.

The second paper tackled the subject of the effect of vehicular emissions on air pollution in Warsaw, Poland, and specifically the impact a modernization of the fleet composition could have in reducing pollutant concentrations in the region [2]. Using the Calpuff model,

check for updates

Citation: Hristova, E.S.; Manousakas, M.I. Special Issue: Air Pollution at the Urban and Regional Level: Sources, Sinks, and Transportation. *Atmosphere* **2023**, *14*, 132. https://doi.org/10.3390/atmos14010132

Received: 2 December 2022
Accepted: 4 January 2023
Published: 7 January 2023

simulations of the yearly averaged concentrations of NOx, CO, PM_{10}, and $PM_{2.5}$ were estimated, together with an assessment of the population's exposure to individual pollutants. The simulations indicated that a fleet modernization following the latest European standards would reduce NOx concentrations due to reduced emissions from passenger cars, heavy-duty vehicles, and public transport. On the other hand, improving air quality in terms of CO concentration is based exclusively upon the modernization of gasoline-powered cars. Finally, it is suggested that despite the substantial contribution of traffic to the overall PM concentrations in the area, modernization of the fleet leads to only minor effects because PM pollution in Warsaw originates mainly from the municipal sector and transboundary inflow.

The authors of the third publication investigated the concentrations of organic (OC) and elemental carbon (EC) between May 2018 and March 2019 in Amman, Jordan [3]. The results show that the OC and EC annual mean concentrations in $PM_{2.5}$ samples were 5.9 ± 2.8 μg m^{-3} and 1.7 ± 1.1 μg m^{-3}, respectively. It was found that OC and EC concentrations were mostly in the fine fraction of PM. During sand and dust storm (SDS) episodes, OC and EC concentrations were higher than the annual means. Based on this observation, the SDS episodes were identified as being responsible for an increased carbonaceous aerosol content in addition to the overall increase in $PM_{2.5}$ and PM_{10} concentrations, which may have direct implications on human health.

The fourth publication was focused on the determination of black carbon (BC) in $PM_{2.5}$, using both experimental and modeling approaches in two Bulgarian cities—Sofia and Burgas—during October 2020 and January 2022 [4]. For the experimental evaluation of BC, the Multi-Wavelength Absorption Black Carbon Instrument (MABI) was used, while for the modeled ones, data from the chemical transport models (CTM) of the European (regional) air quality system established at the Copernicus Atmosphere Monitoring Service (CAMS) were utilized. The BC and $PM_{2.5}$ concentrations were higher in January than in October for both cities. It was identified that in October, the model underestimated the observed BC concentrations (Sofia 2.44 μg m^{-3}, Burgas 1.63 μg m^{-3}) by 17% and 51%, respectively. In January 2021, the observed monthly BC concentrations were higher (Sofia 3.62 μg m^{-3}, Burgas 1.75 μg m^{-3}), and the model's bias was less than in October, with an observed overestimation of 22% for Sofia. Regarding $PM_{2.5}$, the relative bias in October (17% for Sofia, and 6% for Burgas) was less than the relative bias in January when the model underestimated $PM_{2.5}$ monthly mean concentrations by 20% (Sofia) and 42% (Burgas).

In the fifth publication, the authors investigated the effect of cooking processes in Dammam City, Saudi Arabia, by directly measuring the emissions from the chimneys of different types of restaurants and the surrounding ambient air [5]. Five air pollutants were measured simultaneously. The highest mean levels of CO (64.8 ± 44.3 ppm), CO2 (916.7 ± 463.4 ppm), VOCs (105.1 ± 61.3 ppm), NO_2 (4.2 ± 2.4 ppm), and SO_2 (8.0 ± 7.4 ppm) were recorded in chimneys of grilling restaurants. Similarly, the highest pollutant concentrations were recorded in the areas adjacent to the grilling restaurants compared to other restaurants using different cooking processes.

The authors of the sixth publication analyze the relationships between the particulate matter concentration and land use changes in the Beijing–Tianjin–Hebei region, China, from 2015 to 2018 [6]. The obtained results are sumarazed in three main conclusions: (1) an improved sine function model can suitably fit the periodic changes in the particulate matter concentration, with the average R2 value increasing to 0.65 from the traditional model value of 0.49, while each model coefficient effectively estimates the change characteristics of each stage; (2) among all land use types, the particulate matter concentrations in construction land and farmland are high, with a large annual difference between high and low values; (3) the landscape pattern of land use exerts a significant influence on the particulate matter concentration.

The characteristics of the difference between the concentration of resuspended dust (Ci) and the background concentration of roads (CBg) and the background of city atmosphere (Bg) concentration measured were compared with the effects of traffic and weather conditions discussed in the seventh publication [7]. The PM reduction measures are being implemented according to the occurrence of high concentrations of PM10 and PM2.5 provided by the city Bg observations in South Korea. The work mainly focuses on the following four topics: (1) the increased level of resuspended dust according to vehicle speed and silt loading (sL) level; (2) the difference between atmospheric pollution concentration at adjacent monitoring stations and background concentration levels on roads due to atmospheric weather changes; (3) the correlation between traffic and weather factors with resuspended dust levels; (4) the evaluation of resuspended dust levels by road section. The results of this study suggested the need for an efficient alternative considering the effect of yellow dust over time, because, due to the occurrence of yellow dust, Bg can differ from the resuspended dust concentration. Additionally, the concentration of resuspended dust on roads may differ significantly from that of the adjacent Bg observation caused by vehicles driving on roads. Therefore, it is suggested that a more frequent occurrence of high levels of resuspended dust may occur, and research should be continued to quantify the influence of dust collected through mobile measurements and to provide accurate forecasts.

The authors of the eighth publication studied the O_3 pollution situation in Tai'an, China, from May to September in the period from 2016 to 2021 [8]. They found that the pollution during this period was mainly light pollution, accounting for 69% to 100% of the total polluted days, with June being the most polluted month. High temperature (>30 °C), low relative humidity (20~40%), and low wind speed (1~3 m/s) provided favourable meteorological conditions for the generation of O_3, especially with a prevailing southerly wind, resulting in light and air pollution in Tai'an. The results of backward trajectory analysis showed that in the summer pollution trajectories, the pollution trajectories in the southwest direction accounted for the highest proportion of all kinds of trajectories. When the southerly winds dominated, the accumulated O_3 concentrations were significantly higher than those of the surrounding cities due to the blocking of the northern mountains. The comparison of the average O_3 concentration obtained for three monitoring stations in Tai'an (Renkou School station closer to the mountain, and the Dianli College and the Shandong First Medical University stations relatively far away from the mountains) indicated 13~15 $\mu g/m^3$ higher O_3 concentration at the Renkou School station than at other stations, indicating that the Renkou School station was more affected by the obstructions of the mountains. The application of WRF-CMAQ in this study to quantify the blocking effect of the mountains indicated that the average O_3 concentrations in Tai'an decreased by about 1.7~7.5 $\mu g/m^3$ after reducing the terrain height of Mount Tai in the model.

The study presented in the ninth publication is an analysis the consequences of implementing the official scenario prepared for air quality improvement in Warsaw, Poland, particularly in terms of population exposure and the associated health risks at the end of the present decade. The main tool used was a Gaussian system, CALPUFF, for modelling atmospheric pollution dispersion [9]. Four pollutants, NOx, PM10, PM2.5, and BaP, all of which presently exceed environmental limits in Warsaw, were considered. The results show a reduction in population exposure attributed to the specific pollutants and scenarios being implemented. The final reduction in population exposure to NOx is about 28% which means that the base avoidable mortality assigned to this pollutant is 743 avoidable deaths, which would be reduced by about 204 cases. The analogous result for PM2.5 was a more significant (~30%) reduction in population exposure would reduce the number of avoidable yearly deaths by 607 cases from the initial value of 2023 avoidable deaths. The reduction in exposure to PM10 was similar, amounting to about 28%, while for carcinogenic BaP, it is as much as approximately 50%.

The last publication in this Special Issue is on the application of the EPA PMF 5.0 model to the PM2.5 chemical composition and hygroscopicity for the period August 2016–July 2017 in Athens, Greece [10]. Source apportionment analysis identified six major sources, including four anthropogenic sources (vehicle exhaust and no exhaust, heavy oil combustion, and a mixed source of secondary aerosol formation and biomass combustion) and two natural sources (mineral dust and aged sea salt). The authors found that the mixed source is the main contributor to PM2.5 levels (44%), followed by heavy oil combustion (26%) and automotive emissions from road traffic and non-exhaust emissions (15%). The aerosol hygroscopic growth factor is mainly related to mixed source (36%) and heavy oil combustion (24%), and to a lower extent with vehicle exhaust (by 19%), aged sea salt (by 14%), and unburned vehicle exhaust (c 6%).

3. Conclusions

Urban air quality is determined by many factors: air masses, characteristic local flow and meteorology, low dispersion ability in built-up environments, the concentration of emission sources of different types, and various chemical processes. The publications in this Special Issue address the topics of air pollution with particulates (PM10, PM2.5) and gaseous pollutants (NO_x, NO_2, SO_2, CO, VOCs, O_3); PM sources and source apportionment; and Carbonaceous species such as Organic and Elemental or Black Carbon. Both experimental and modelling approaches are applied. The relatively wide geographic range of the studies provides a good overview of particulate matter pollution at the intercontinental level. All ten published studies cover different regions of the world: Europe (Poland, Greece, Bulgaria), Asia (South Korea, China), and the Middle East (Saudi Arabia, Jordan).

Since the chemical composition of PM remains a reflection of complex, site-specific processes, research aimed at better understanding the sources of PM, and the processes they undergo in the atmosphere remains very relevant. Therefore, this Special Issue will continue to summarise the research in this field (https://www.mdpi.com/journal/atmosphere/special_issues/0Q62Z8ZMZQ, 6 January 2023).

Author Contributions: Conceptualization, E.S.H. and M.I.M.; methodology, E.S.H.; writing—original draft preparation, E.S.H. and M.I.M.; All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The editor would like to thank the authors for their contributions to this Special Issue and the reviewers for their constructive and helpful comments to improve the manuscripts.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ivanov, V.; Georgieva, I. Basic facts about numerical simulations of atmospheric composition in the city of Sofia. *Atmosphere* **2021**, *12*, 1450. [CrossRef]
2. Holnicki, P.; Nahorski, Z.; Kałuszko, A. Impact of vehicle fleet modernization on the traffic-originated air pollution in an urban area—A case study. *Atmosphere* **2021**, *12*, 1581. [CrossRef]
3. Hussein, T.; Li, X.; Bakri, Z.; Alastuey, A.; Arar, S.; Al-Hunaiti, A.; Viana, M.; Petäjä, T. Organic and Elemental Carbon in the Urban Background in an Eastern Mediterranean City. *Atmosphere* **2022**, *13*, 197. [CrossRef]
4. Hristova, E.; Georgieva, E.; Veleva, B.; Neykova, N.; Naydenova, S.; Gonsalvesh-Musakova, L.; Neykova, R.; Petrov, A. Black Carbon in Bulgaria—Observed and Modelled Concentrations in Two Cities for Two Months. *Atmosphere* **2022**, *13*, 213. [CrossRef]
5. ElSharkawy, M.F.; Ibrahim, O.A. Impact of the Restaurant Chimney Emissions on the Outdoor Air Quality. *Atmosphere* **2022**, *13*, 261. [CrossRef]
6. Zhai, H.; Yao, J.; Wang, G.; Tang, X. Impact of Land Use on Atmospheric Particulate Matter Concentrations: A Case Study of the Beijing-Tianjin-Hebei Region, China. *Atmosphere* **2022**, *13*, 391. [CrossRef]
7. Hong, S.; Yoo, H.; Cho, J.; Yeon, G.; Kim, I. Characteristics of Resuspended Road Dust with Traffic and Atmospheric Environment in South Korea. *Atmosphere* **2022**, *13*, 1215. [CrossRef]
8. Ge, Y.; Chen, C.; Jiang, Y.; Yang, T.; Kang, H.; Li, J.; Zhao, X.; Zhang, Y.; Li, M.; Hou, T.; et al. Characteristics of Ozone Pollution in Tai'an and Topographic Effects of Mount Tai. *Atmosphere* **2022**, *13*, 1299. [CrossRef]

9. Holnicki, P.; Kałuszko, A.; Nahorski, Z. Scenario Analysis of Air Quality Improvement in Warsaw, Poland, by the End of the Current Decade. *Atmosphere* **2022**, *13*, 1613. [CrossRef]
10. Diapouli, E.; Fetfatzis, P.; Panteliadis, P.; Spitieri, C.; Gini, M.I.; Papagiannis, S.; Vasilatou, V.; Eleftheriadis, K. $PM_{2.5}$ Source Apportionment and Implications for Particle Hygroscopicity at an Urban Background Site in Athens, Greece. *Atmosphere* **2022**, *13*, 1685. [CrossRef]