frontiers | Frontiers in Sustainable Cities

TYPE Editorial
PUBLISHED 07 March 2024
DOI 10.3389/frsc.2024.1379626

OPEN ACCESS

EDITED AND REVIEWED BY
Ulas Im,
Aarhus University, Denmark

*CORRESPONDENCE
Ravi Yadav
✉ yadavravi38@gmail.com
Vrinda Anand
✉ vrinda.anand@tropmet.res.in
Saroj Kumar Sahu
✉ sarojksahu@gmail.com
Ravi Kumar Kunchala
✉ rkkunchala@cas.iitd.ac.in
Bhishma Tyagi
✉ tyagib@nitrkl.ac.in
Gufran Beig
✉ beig@nias.res.in

†PRESENT ADDRESSES
Ravi Yadav,
Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China
Saroj Kumar Sahu,
Department of Environmental Science, Berhampur University, Brahmapur, Odisha, India

RECEIVED 31 January 2024
ACCEPTED 19 February 2024
PUBLISHED 07 March 2024

CITATION
Yadav R, Anand V, Sahu SK, Kunchala RK, Tyagi B and Beig G (2024) Editorial: Anthropogenic trace gases and their linkages to meteorology and climate change. *Front. Sustain. Cities* 6:1379626. doi: 10.3389/frsc.2024.1379626

Editorial: Anthropogenic trace gases and their linkages to meteorology and climate change

Ravi Yadav[1*†], Vrinda Anand[1*], Saroj Kumar Sahu[2*†], Ravi Kumar Kunchala[3*], Bhishma Tyagi[4*] and Gufran Beig[5*]

[1]Atmospheric Pollution and Transport Modeling (APTM) Division, Indian Institute of Tropical Meteorology, Pune, India, [2]Department of Botany, Utkal University, Bhubaneswar, India, [3]Centre for Atmospheric Sciences, Indian Institute of Technology, Delhi, India, [4]Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, Sundargarh, Odisha, India, [5]School of Natural Sciences and Engineering, National Institute of Advanced Studies Indian Institute of Science Campus, Bengaluru, India

KEYWORDS

trace gases, aerosol, emissions, meteorology, biomass burning, climate change, COVID-19, satellite

Editorial on the Research Topic
Anthropogenic trace gases and their linkages to meteorology and climate change

Anthropogenic trace gases and climate change are the most significant environmental problems that mankind has been confronting in recent years. About 55% of the world's population lives in urban areas, and this trend is expected to continue to 68% by 2050 (Molina, 2021). Urbanization and economic growth in developing countries are accelerating, can lead to higher levels of trace gases [e.g., surface ozone (O_3), volatile organic compounds (VOCs), oxides of nitrogen (NOx), sulfur dioxide (SO_2), carbon monoxide (CO, etc.) and particulate matter ($PM_{2.5}$ and PM_{10})], resulting in sharp decline air quality (Fu and Chen, 2017) and poses threats to human health and ecosystems health (Apte et al., 2018). Additionally, the cocktail of high concentrations of pollutants has caused frequent pollution episodes and low visibility (Molnar et al., 2020). DeLang et al. (2021) have reported that O_3 exposure in Asia and Africa has been increasing globally, partly due to highly populated and polluted regions. Moreover, it has been worsening mainly in low- and middle-income countries, driven by anthropogenic activities (Silva et al., 2016; Turnock et al., 2020). Surface O_3 naturally occurs in low amounts, but unhealthy O_3 is formed when high levels of anthropogenic trace gases, such as VOCs and CO, oxidize in the presence of solar flux and a sufficient amount of NOx in the lower troposphere (Yadav et al., 2022) (Equation 1).

$$\text{VOC} + \text{NOx} + \text{sunlight} \rightarrow O_3 + \text{“carbonyls products”} + \text{“secondary organic aerosol (SOA)”} \quad (1)$$

Surface O_3 is a criteria pollutant and greenhouse gas that is bad for humans, vegetation, and nature. O_3 exposure mortality worldwide was estimated at ∼365,000 [95% uncertainty interval (UI): 175,000, 564,000] in the year 2019 (Malashock et al., 2022). SOA is a significant component of particulate matter (Guenther et al., 2006), particularly particles with a diameter of 2.5 microns or less ($PM_{2.5}$). Particulate matter has a very complex composition, and its main components are trace elements, carbon-containing components, sulfates ($SO4^{2-}$), nitrates (NO_3^-), ammonium salts (NH_4^+), organic matter, etc. (Jun et al., 2013).

Some VOC products may also participate in forming and growing new particles, known as SOA. On the other hand, the conversion of gaseous precursors (SO_2, NOx, and NH_3) is the key pathway to form SO_4^{2-}, NO_3^-, and NH_4^+, such as gas-phase, aqueous phase, and heterogeneous reactions. Among them, SO_4^{-2} is ubiquitous and is a key constituent of $PM_{2.5}$ in the atmosphere, accounting for 10–35% of total mass. $PM_{2.5}$ is a major cause of haze and can scatter and absorb sunlight, reduce atmospheric visibility, and increase radiation forcing, leading to global climate change (Cheng et al., 2016; Liu et al., 2020). The changes in the mixing ratios of anthropogenic trace gases and the role of this in different aspects have become significant concerns. Hence, the proposed Research Topic was motivated to investigate the information on their origins and sinks, physical and chemical processes, and distribution of trace gases, which are vital for accurately predicting the environment and climate conditions. A total of six research and one review article have been published on the current topic under the particular issue, which is related to air quality and its link to climate change and meteorology.

What we know about the history of the novel coronavirus, which we call COVID-19, is that it was first detected at the end of 2019 in Wuhan, China, and set off a global pandemic. Therefore, many countries have taken action and imposed lockdowns to preventive measures around the world to combat COVID-19, but at the same time, environmental conditions like air quality for the moment have led to significant improvements due to reductions in anthropogenic activities. However, besides local anthropogenic emissions, the air pollution footprints are unique over the Arabian Peninsula (AP), where natural mineral dust is dominated. Hence, Karumuri et al. have reported the role of the COVID−19 lockdown in the distribution of aerosol ($PM_{2.5}$, PM_{10}, and AOD) and trace gases (NO_2 and SO_2) concentrations over the Arabian Peninsula (AP). They used *in-situ* and satellite datasets, and WRF-Chem simulations were performed to investigate the changes in emissions during the lockdown period. They suggested that the COVID-19 lockdown over AP significantly reduces the trace gas levels, but no improvement was seen in particulate pollution. and has a slight impact on the particulate concentrations over the central and northern AP due to the dominant contribution of dust emissions to the particulate concentrations. It indicates that dust emissions and large-scale dynamics play an important role in particulate pollution levels over the AP. The study's implication could be very important for air quality where dust emissions are a prominent source.

The solar eclipse provides a rare opportunity to take measurements of trace gases and weather parameters to observe the photochemistry under atmospheric conditions when solar radiation reduces. The annual solar eclipse occurred on 21 June 2020, and hence, Prakash et al. have highlighted how solar eclipses impact the atmospheric trace gases and weather parameters over Northwestern India with the help of statistical analyses. By comparing the normal days, they found large variations in trace gases with meteorological parameters and about a 23% reduction in O_3 during the solar eclipse day. Overall, this study can suggest the essential implications of the dynamics of photochemical processes.

Volatile organic compounds (VOCs) are the most reactive species and play a significant role in the photochemical processes despite their presence at very low in the air, which is now getting more and more attention. Therefore, air quality monitoring networks have also added VOC measurements in recent years in addition to the criteria pollutants like CO, NOx, O_3, and PMs (Lee et al., 2002). Long-term exposure to elevated aromatic VOC concentrations can cause acute and chronic health issues. Sahu et al. reported BTEX variations and weather parameters on different time scales over an eastern Indian site, Bhubaneswar, based on 2 years of continuous measurements. They also highlight the CO and NOx emissions patterns for the study region. They suggested that traffic is the most dominant source of NO_X, VOC, and CO at Bhubaneswar rather than residential and industrial sectors. Lower BTEX concentrations were in pre-monsoon and monsoon seasons due to the wash-out effect in locally generated and transported air. The transport of oceanic air resulted in the lowest pollution concentrations during these seasons. Overall, these results imply that controlling traffic-related emissions would be the main advantage to improving air quality.

O_3 is controlled by its production, sink, and net transport (advection/convection and diffusive) in the atmosphere. Sagar et al. represent how chemical kinetics control O_3 variability on diurnal and seasonal time scales using known chemical kinetics and a radiative transfer model at the study site in South India. In this work, they conducted continuous long-term measurements of O_3, nitrogen oxides (NOx = NO + NO2), and meteorological data in the suburban location of Shadnagar, India. Data analyses were performed to investigate the governing processes that control O_3 variability on diurnal and seasonal time scales. The role of chemistry in O_3 variability, including formation and destruction processes, was investigated using known chemical kinetics and a radiative transfer model. The average net production and net transport of near-surface O_3 were 3.18 and 0.87 ppbv/h, respectively, while horizontal advection was 0.01 ppbv/h in the daytime. The production of O_3 was found to be dominant, indicating the influx of ozone at the site. Overall, they suggested spatio-temporal variability in near-surface O_3 is strongly controlled by net production in Shadnagar and may be applicable in similar environments globally. These results help to understand the O_3 chemistry and its sources affecting air quality.

Typically, most of the time in a year, air quality is determined by particulate pollutants, and the high loading of aerosols in most cities in India poses a significant challenge for policymakers to bring down the pollution level within the ambient air quality standard (Balakrishnan et al., 2019). Payra et al. have performed a comprehensive evaluation of aerosol optical depth (AOD) products which has retrieved from two satellites, including Visible Infrared Imaging Radiometer Suite (VIIRS) and Aqua-Moderate-Resolution Imaging Spectroradiometer (MODIS) over India. The study has also highlighted the validation of satellite AOD and ground-based AOD from AERONET at 550 nm wavelength. Overall, the study shows that both satellites offer high-quality AOD products, while MODIS performs slightly better than VIIRS over India. Overall, High-resolution satellites are

10.3389/frsc.2024.1379626

essential in monitoring and evaluating accurate and precise air quality information.

Choudhary et al. reported the features of air pollutants ($PM_{2.5}$, PM_{10}, NO_2, CO, O_3, and SO_2) and their prediction using data mining algorithms from 01 January 2019 to 01 June 2021 in India's industrial eastern coastal state. Overall, The study outcome will be helpful to environmental policymakers in understanding the distribution of air pollutants and how to strategize air pollution reductions and enhance air quality.

Dewan and Lakhani have presented an up-to-date review article discussing ozone and its precursor gases, emission sources, dynamics, chemistry, and linkages with climate change connection. It has also highlighted the challenges and limitations associated with climate-O_3 linkages and their incorporation in models due to uncertainties in the magnitude and signs of projected precursor emissions in response to future climate change and the difference in models.

Author contributions

RY: Writing—original draft, Writing—review & editing. VA: Writing—original draft, Writing—review & editing. SS: Writing—original draft, Writing—review & editing. RK: Writing—original draft, Writing—review & editing. BT: Writing—original draft, Writing—review & editing. GB: Writing—original draft, Writing—review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

References

Apte, J. S., Brauer, M., Cohen, A. J., Ezzati, M., and Pope, C. A. (2018). Ambient PM2.5 reduces global and regional life expectancy. *Environ. Sci. Technol. Lett.* 5, 546–551. doi: 10.1021/acs.estlett.8b00360

Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., and Cohen, J. A. (2019). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. *Lancet Planet. Health* 3, e26–e39. doi: 10.1016/S2542-5196(18)30261-4

Cheng, Y., Zheng, G., Wei, C., Mu, Q., Zheng, B., Wang, Z., et al. (2016). Reactive nitrogen chemistry in aerosol water as a source of sulfate during haze events in China. *Sci. Adv.* 2:e1601530. doi: 10.1126/sciadv.1601530

DeLang, M. N., Becker, J. S., Chang, K.-L., Serre, M. L., Cooper, O. R., Schultz, M. G., et al. (2021). Mapping yearly fine resolution global surface ozone through the bayesian maximum entropy data fusion of observations and model output for 1990–2017. *Environ. Sci. Technol.* 55, 4389–4398. doi: 10.1021/acs.est.0c07742

Fu, H., and Chen, J. (2017). Formation, features and controlling strategies of severe haze-fog pollution in China. *Sci. Total Environ.* 578, 121–138. doi: 10.1016/j.scitotenv.2016.10.201

Guenther, A., Karl, T., Harley, P., Wiedinmyer, C., Palmer, P. I., and Geron, C. (2006). Estimates of global terrestrial isoprene emissions using MEGAN (model of emissions of gases and aerosols from nature). *Atmos. Chem. Phys.* 6, 3181–3210. doi: 10.5194/acp-6-3181-2006

Jun, T., Tiantao, C., and Zhang, R. (2013). Chemical composition of PM2.5 at an urban site of Chengdu in southwestern China. *Adv. Atmosp. Sci.* 30, 1070–1084. doi: 10.1007/s00376-012-2168-7

Lee, S. C., Chiu, M. Y., Ho, K. F., Zou, S. C., and Wang, X. (2002). Volatile organic compounds (VOCs) in urban atmosphere of Hong Kong. *Chemosphere* 48, 375–382. doi: 10.1016/s0045-6535(02)00040-1

Liu, T., Clegg, S. L., and Abbatt, J. P. D. (2020). Fast oxidation of sulfur dioxide by hydrogen peroxide in deliquesced aerosol particles. *PNAS* 17, 1354–1359. doi: 10.1073/pnas.1916401117

Malashock, D. A., Delang, M. N., Becker, J. S., Serre, M. L., West, J. J., Chang, K.-L., et al. (2022). Estimates of ozone concentrations and attributable mortality in urban, peri-urban, and rural areas worldwide in 2019. *Environ. Res. Lett.* 17:054023. doi: 10.1088/1748-9326/ac66f3

Molina, L.T. (2021). Introductory lecture: air quality in megacities. *Faraday Discuss.* 226, 9–52. doi: 10.1039/D0FD00123F

Molnar, A., Imre, K., Ferenczi, Z., Kiss, G., and Gelencser, A. (2020). Aerosol hygroscopicity: hygroscopic growth proxy based on visibility for low-cost PM monitoring. *Atmos. Res.* 236:104815. doi: 10.1016/j.atmosres.2019.104815

Silva, R. A., West, J. J., Lamarque, J.-F., Shindell, D. T., Collins, W. J., Dalsoren, S., et al. (2016). The effect of future ambient air pollution on human premature mortality to 2100 using output from the ACCMIP model ensemble. *Atmos. Chem. Phys.* 16, 9847–9862. doi: 10.5194/acp-16-9847-2016

Turnock, S. T., Allen, R. J., Andrews, M., Bauer, S. E., Deushi, M., Emmons, L., et al. (2020). Historical and future changes in air pollutants from CMIP6 models. *Atmos. Chem. Phys.* 20, 14547–14579. doi: 10.5194/acp-20-14547-2020

Yadav, R., Beig, G., Anand, V., Kalbande, R., and Maji, S. (2022). Tracer-based characterization of source variations of ambient isoprene mixing ratios in a hillocky megacity, India, influenced by the local meteorology. *Environ. Res.* 205:112465. doi: 10.1016/j.envres.2021.112465