Seasonal variation of short-lived climate forcers/pollutants at Paknajol, an urban area in the city of Kathmandu, Nepal

D. Butero1, P. Cristofanelli1, A. Marinoni1, B. Adhikary2, R. Duchí3, S.D. Shrestha3, G.P. Verza4, T.C. Landi1, F. Calzolari1, M. Bussetto1, F. Biancofiore5, P. Di Carlo2, M. Rupakheti6, A. Panday2, and P. Bonasoni1

1CNR-ISAC, Bologna, Italy. 2ICIMOD, Kathmandu, Nepal. 3Ev-K2-CNRR, Kathmandu, Nepal. 4Ev-K2-CNRR, Bergamo, Italy. 5CETEMPS, L’Aquila, Italy. 6IASS, Potsdam, Germany

Background
Air pollution is a major environmental challenge in South Asia, which is facing severe air-quality issues related to the presence of a large and widespread thick layer of atmospheric pollutants (the Atmospheric Brown Cloud). The short-lived climate forcers/pollutants (SLCF/P), such as black carbon and ozone, play a crucial role in terms of air quality, with a total population greater than 2.5 million. In this work, we present one full year of measurements (February 2013 – January 2014) of black carbon (eqBC) and ozone (O3), as well as aerosol concentration and mass, carried out at Paknajol (27°43′4″N, 85°18′32″E; 1380 m a.s.l.), an urban area in the tourist district of Thamel, Kathmandu. The information gathered during the investigation period paint a picture of the state of air quality in Kathmandu and may be useful to implement control measurements in order to mitigate the impact of high pollution levels in the Kathmandu Valley.

Measurement site and experimental set-up

Measurements at Paknajol were started in February 2013 in the framework of the Sussex-ABC field campaign.

Measurement programs:
- surface O3 (UV-absorption analyser, Thermo 498)
- equivalent black carbon (eqBC, multi-angle absorption photometer – Thermo MAAP 5012)
- meteorological parameters (VAISALA WXT520)
- aerosol number concentration and size distribution (accumulation and coarse fractions, optical particle counter – FAI Instruments OPC Monitor)
- on-line 24-h resolution PM2.5, PM10 (FAI Instruments SWAM, β-absorption technique)

The sampling site is placed on the top of a building (25 m a.s.l.), having a 360° free horizon in a range of 300 m. Measurements at Paknajol are representative of the Kathmandu urban hot-spot.

Results (1): diurnal cycles

Aerosol observations had well-defined seasonal cycles, with low values during the monsoon and the highest in winter. Diurnal cycles were strongly influenced by local sources and PBL dynamics.

For O3, the highest values were observed in the pre-monsoon, while the lowest during the summer monsoon. The diurnal cycle was characterized by a afternoon- evening peak, deriving from the roles of photochemistry, PBL dynamics and wind breeze.

Sensitivity tests using a recurrent neural network model and different subgroups of proxies suggested that the noon-evening high O3 values during pre-monsoon were mainly due to dynamical aspects (vertical intrusion from upper layers and/or horizontal advection), while the early-morning and noon-peak mixing ratios were mainly explained by photochemistry activity.

Results (2): influence of large-scale circulation

To investigate the variability of large-scale atmospheric dynamics, 5-days HYSPLIT back-trajectories have been calculated at 00, 06, 12 and 18 UTC.

6 prevalent circulation patterns have been identified (Arabian Peninsula, South-western, Western, Regional, Bay of Bengal, Eastern).

The diurnal variations of eqBC and O3 have been analyzed as a function of the different clusters. For eqBC, the diurnal variation was only in part dependent on the air-mass patterns, while O3 showed significant differences also for what concerns the shape of the diurnal variation curves and the magnitude of maximum and minimum values.

Conclusions

- Very high values of SLCF/P characterized the whole measurement period, indicating the persisting poor air quality conditions in Kathmandu.
- 124 days (51.4% of the investigation period) exceeded the 24-h limit of 120 μg/m3 proposed by the Government of Nepal.
- 138 days (36.5% of the dataset) exceeded the Interim Target-1, T-T (maximum daily 8-hour average >160 μg/m3) and Air Quality Guidelines, AQG (maximum daily 8-hour average >100 μg/m3) thresholds defined by WHO for O3.
- The variations in the eqBC, O3 and aerosol particle number concentrations were mainly driven by local pollution sources activity (road traffic, domestic emissions, biomass burning), and by local and large-scale dynamics and photochemistry.
- Major vegetation fires significantly contributed to the enhanced O3 levels, especially during the pre-monsoon season: by neglecting days with large open fire occurrences, all the IT-1 exceedances for O3 were removed and 88 AQG exceedances were retained.
- The large-scale circulation impacts the SLCF/P diurnal cycle.
- Implementation of control measures to mitigate the occurrence of acute pollution levels in the Kathmandu Valley is highly needed.

Acknowledgments

This work was supported by the National Project NextData, funded by the Italian Ministry of University and Research. The authors thank the International Centre for Integrated Mountain Development (ICIMOD) and the Institute for Advanced Sustainability Studies (IASS) that led the Sustainable Atmosphere for the Kathmandu Valley (SusKat-ABC) project. The usual disclaimers apply.

Contact: d.putero@isac.cnr.it

Our scientific research activities are aimed at better understanding the air quality and the climatic conditions of the Kathmandu area: however, we are aware that following the recent and awful earthquakes, it is more important to support and provide help to our Nepalese friends and their families, besides the lovely Kathmandu Valley.