Planetary Boundari Layer Effect on Vertical Transport of Black Carbon Concentration under Different Meteorological Conditions

Julaha, Kajal
2022

PLANETARY BOUNDARY LAYER EFFECT ON VERTICAL TRANSPORT OF BLACK CARBON CONCENTRATION UNDER DIFFERENT METEOROLOGICAL CONDITIONS

Kajal JULAHA[1,2], Nadežda ZÍKOVÁ[1], Saliou MBENGUE[3], Vladimír ŽDÍMAL[1]

[1] Institute of Chemical Process Fundamentals of the CAS, Prague, Czech Republic, julaha@icpf.cas.cz
[2] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
[3] Global Change Research Institute of the Czech Academy of Science, Brno, Czech Republic.

Keywords: PBL -eBC interaction, 250m-meteorological tower, Meteorology, Long-range transport

INTRODUCTION

The planetary boundary layer (PBL), the lowest part of the troposphere, has a higher aerosol concentration than the rest of the atmosphere because pollutants emitted from the surface are constrained in PBL. Among all aerosols, absorbing aerosols, mainly black carbon (BC), has the strongest interaction with PBL (Bond et al., 2013) and plays a vital role in modifying the diurnal evolution of PBL.

In the present study, we analyzed the impact of equivalent black carbon (eBC) aerosols at two different heights (4 m and 230 m) on the PBL height under different metrological conditions such as clear sky, foggy (visibility ≤ 1km), and hazy days (visibility ≤ 8km during the non-fog day), high relative humidity, temperature, and observational data; also, diurnal and seasonal variability was evaluated.

EXPERIMENTAL SETUP

The eBC concentration was measured from 1/2020 to 12/2020 by Sunset Analyzer simultaneously at 4 m and 230 m on a 250m-meteorological tower at National Atmospheric Observatory Košetice (NAOK; 49°35'N, 15°05'E), located at a rural background in the Czech Republic. The eBC concentrations were calculated from raw Sunset analyzers data according to Zíková et al. (2016). The PBL height has been taken from the ERA5 dataset (Hersbach H. et al., 2018).

RESULTS AND CONCLUSIONS

In this study, the mean eBC concentration was found the highest in winter (Dec-Feb), lower in spring (Mar-May) and autumn (Sep-Nov), and the lowest during the summer (Jun-Aug). In contrast, the average PBL height was the lowest in autumn, followed by summer and winter, and was measured the highest during the spring (*Figure 1*) due to the higher number of rainy days during the summer, resulting in lower PBL height. The eBC concentration at ground level showed peaks during mornings and evenings, likely due to local sources and the PBL diurnal evolution. At 230 m, eBC concentration displayed an opposite diurnal pattern similar to the diurnal pattern of the PBL height.

Several case studies were studied to find the impact of different meteorological conditions. The development of PBL was suppressed by fog and haze, further weakening the vertical mixing of aerosols, leading to higher eBC concentration at the ground. High RH (≈ 100%) with high temperature (28 °C) yields the highest PBL height and higher eBC concentration at 4m compared to 230 m.

Elevated eBC concentrations during noon and late-night have also been observed, driven by the transport of aerosols from distant sources. The long-range transport of aerosols was confirmed by air mass back trajectories using the HYSPLIT model. The eBC concentration was higher below the PBL height than above the PBL.

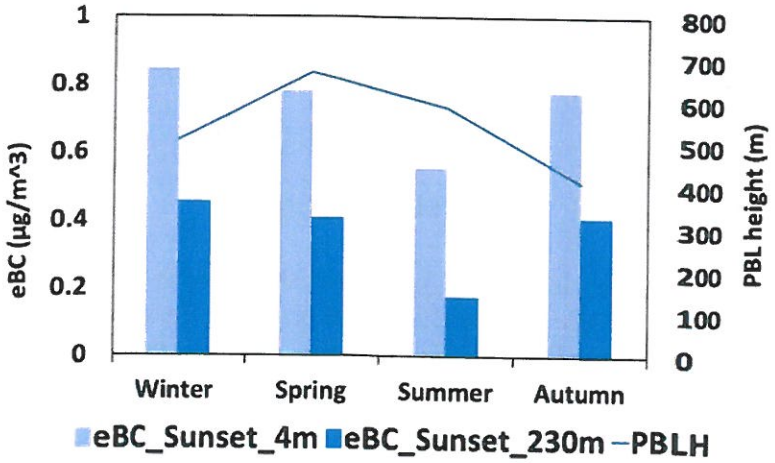

Fig. 1. Seasonal comparison of eBC concentration at two different heights and PBL height.

ACKNOWLEDGEMENT

This work was supported by MEYS of the Czech Republic under grants ACTRIS-CZ LM2018122.

REFERENCES

Bond, Tami C., Sarah J. Doherty, David W. Fahey, Piers M. Forster, Terje Berntsen, Benjamin J. DeAngelo, Mark G. Flanner et al., Bounding the role of black carbon in the climate system: A scientific assessment, *Journal of geophys. Res.: Atmospheres* 118, no. 11: 5380-5552, (2013).

Hersbach, H., B. Bell, P. Berrisford, G. Biavati, A. Horányi, J. Muñoz Sabater, J. Nicolas et al., ERA5 hourly data on single levels from 1979 to present, *Copernicus Climate Change Service (C3S) Climate Data Store (CDS),* [data set], (2018).

Zíková, Naděžda, Petr Vodička, Wolfgang Ludwig, Regina Hitzenberger, and Jaroslav Schwarz., On the use of the field Sunset semi-continuous analyzer to measure equivalent black carbon concentrations, *Aerosol Sci. Tech.,* 50, no. 3: 284-296, (2016).