INTERACTIONS BETWEEN AEROSOLS, PLANETARY BOUNDARY LAYER HEIGHT, AND REGIONAL WIND CIRCULATIONS OVER METRO MANILA

ABSTRACT

Ambient fine particulate matter ($PM_{2.5}$) levels in Metro Manila have consistently exceeded the guideline values set by the World Health Organization. Although there has been much progress in monitoring, chemical characterization, and source apportionment of aerosols in this megacity, research on its response to meteorological forcing have been scarce. In particular, the relationship between $PM_{2.5}$ concentrations and planetary boundary layer height (PBLH) has not been studied due to insufficient observations. Measurements from a High Spectral Resolution Lidar (HSRL) deployed at the Manila Observatory as part of CAMP^{2}Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) filled this gap and allowed for PBLH estimation and aerosol typing. This research, therefore, investigated the influence of PBLH on $PM_{2.5}$ concentrations and the impacts of regional wind circulations on the temporal evolution of aerosol pollution and the planetary boundary layer (PBL) structure. From January 2019 - June 2020, $PM_{2.5}$ concentrations and meteorological parameters were measured using a Beta Attenuation Monitor (BAM) and an automatic weather station, respectively; while the HSRL provided a relatively long-term, continuous measurements of aerosol optical properties. Synoptic and mesoscale wind circulations were simulated using the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem). Results show that daytime PBLH trend was closely associated with temperature while there was less variability in the nighttime PBLH, except for elevated heights during peak southwest monsoon months. The diurnal pattern of $PM_{2.5}$ and PBLH were similar across seasons, i.e., lower $PM_{2.5}$ levels were observed during daytime when PBLH was high. However, the magnitude of the daytime-nighttime differences in $PM_{2.5}$ and PBLH varied and a significant inverse correlation between daytime $PM_{2.5}$ and PBLH was only found in DJF (December, January, February). The generally weak inverse correlation between $PM_{2.5}$ and PBLH is attributed to horizontal directional wind shear between synoptic and mesoscale circulations which create stagnant conditions that promote aerosol accumulation. Results also show that aerosol layering within the PBL was associated with mountain breeze while there was no significant diurnal variation of PBLH during periods of strong southwest monsoon. These findings are relevant for understanding the factors that affect aerosol pollution in areas with complex topographies as well as those in monsoon regions.