Characterization of Particle-Bound Influenza Virus in the Urban Environment

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Background

Respiratory droplet is the primary transmission model for influenza virus infection. However, recent reports show that respiratory droplets with smaller particulate matter (PM) size is able to stay suspended in the air for a long time, also contain the influenza virus and can potentially cause disease spread. The objective of this study is to investigate the interactions of chemicals and influenza virus on $PM_{2.5}$ (≤ 2.5 μm) in the atmosphere by local emissions and long-ranged transportation.

Results

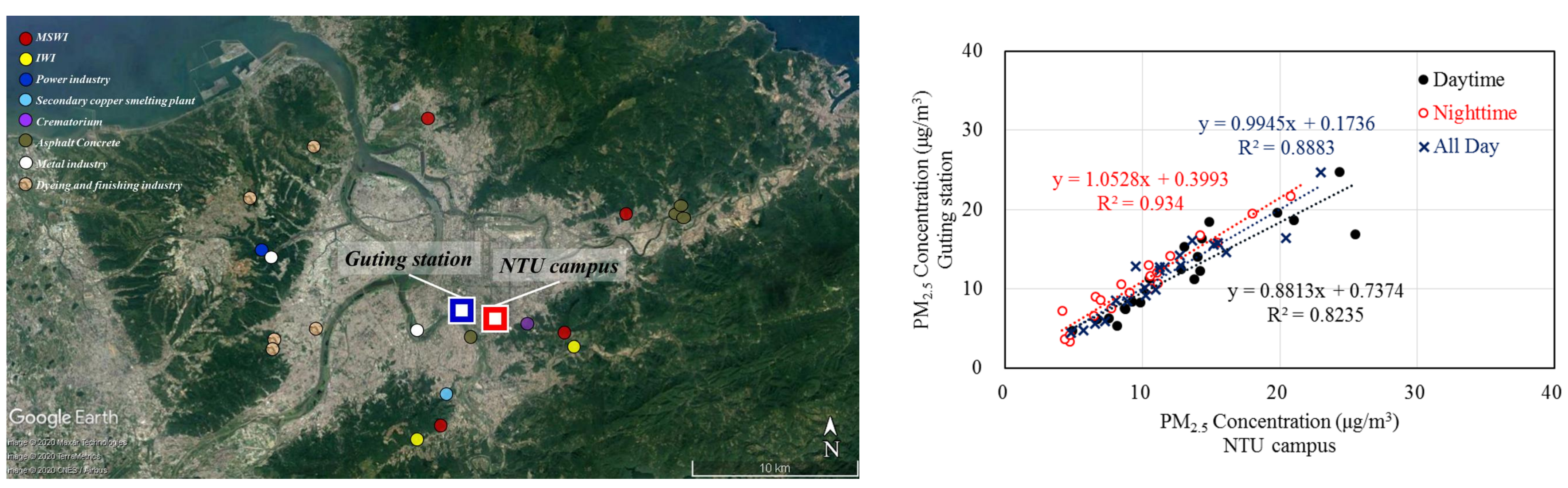

Figure 1. Geographic information of National Taiwan University (NTU) campus (sampling site; Taipei, Taiwan), Taiwan EPA air quality monitoring station (Guting station) and stationary source. We observed high correlations between the sampling site (NTU campus) and the EPA air quality monitoring station (Guting station) for daytime, nighttime and all day during 24 December 2019 to 13 January 2020.

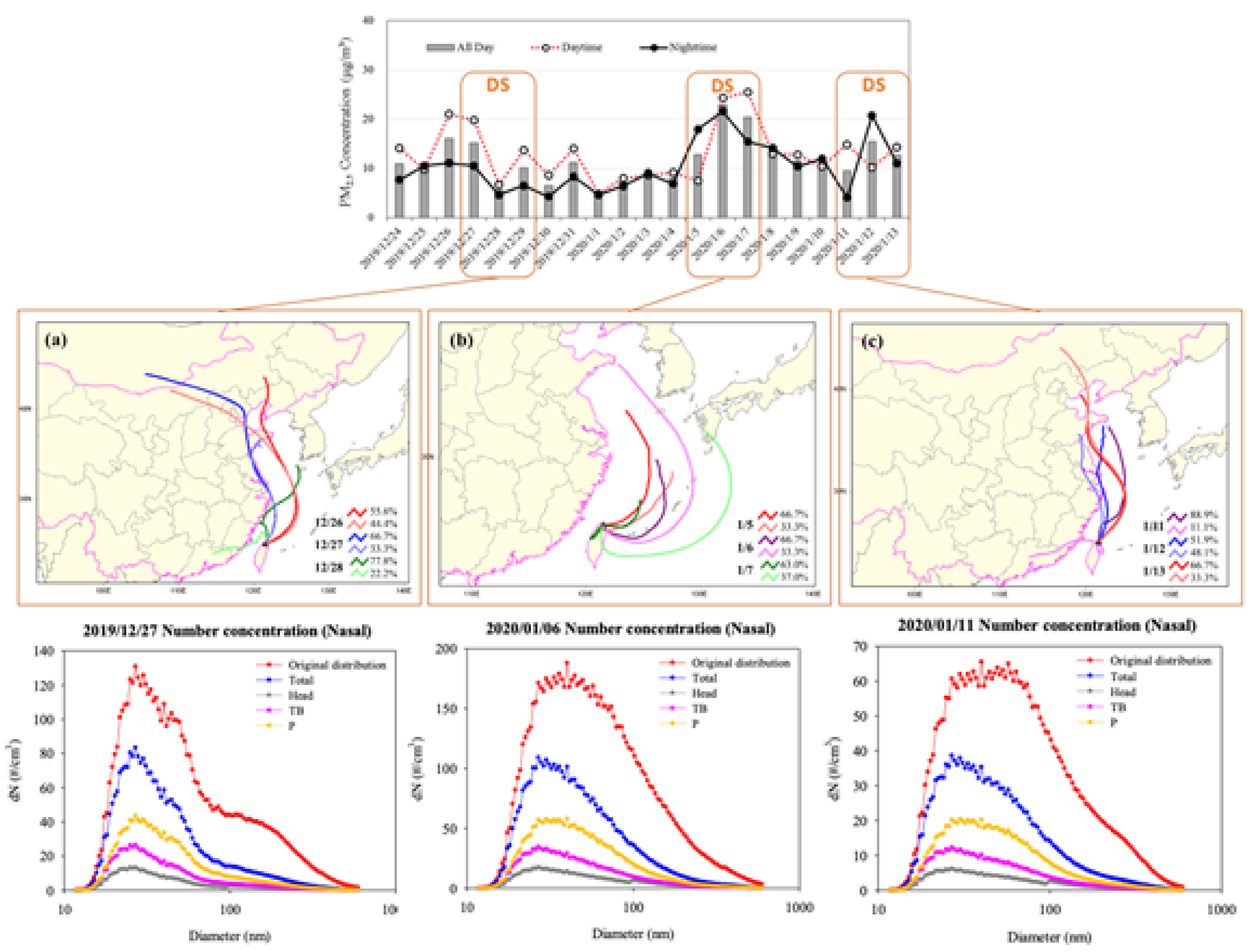

Figure 2. Daily $PM_{2.5}$ concentrations in the sampling site. There were three dust storm (DS) events that occurred on 26~28 December 2019, and 5~7 and 11~13 January 2020. The alveolar epithelium is the primary target site for influenza virus infection. An average of 50.3% of inhaled $PM_{2.5}$ was able to be deposited in the lungs during the study period with 10.6% of deposited $PM_{2.5}$ in the head and nasal region, 15.9% in the tracheobronchial (TB) region, and 23.8% in the alveolar region.

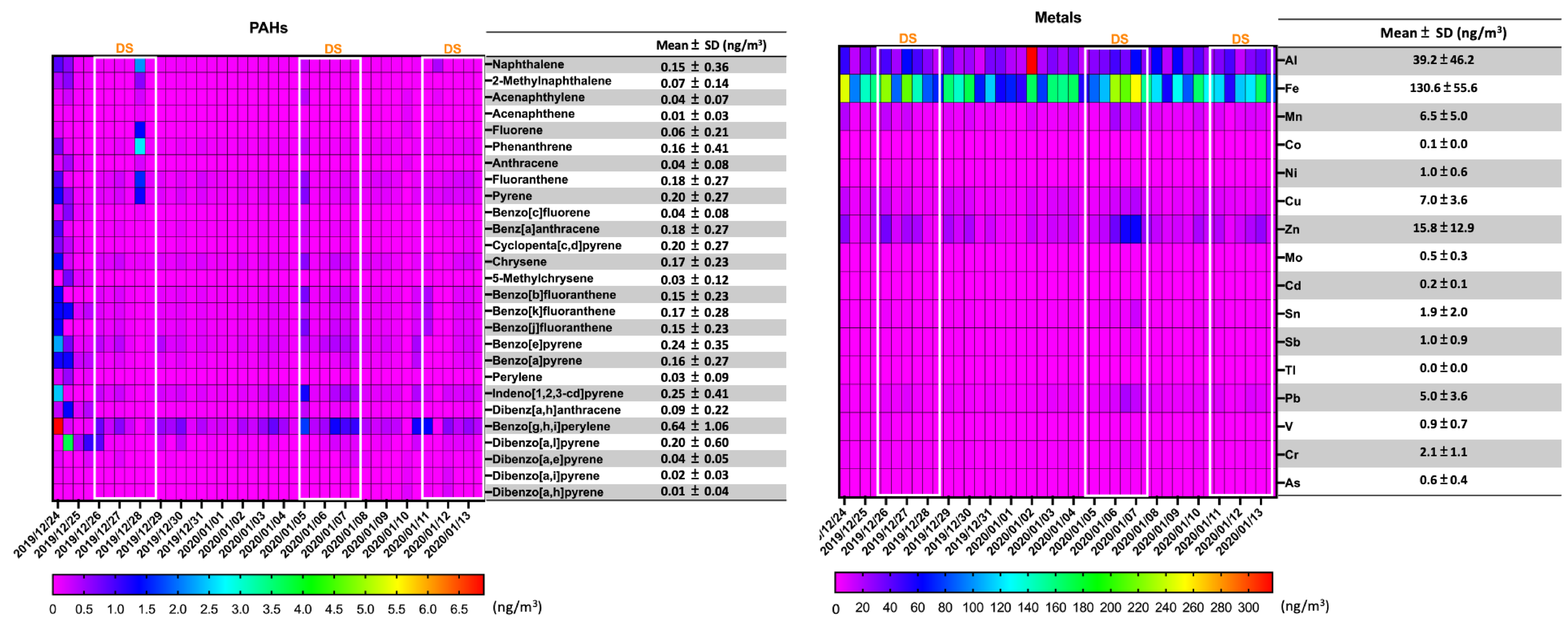

Figure 3. Heatmaps for daily levels of polycyclic aromatic hydrocarbons (PAHs) and metals in $PM_{2.5}$ during the study period. We found that PAH levels were relatively higher at the beginning of the sampling period from 24 to 25 December 2019 due to local emission sources. Metal levels were higher at the beginning of the study period (24~25 December 2019). We found that the three DS events caused higher metal levels in $PM_{2.5}$, especially Al, Fe, Mn, Cu, Zn, and Pb.

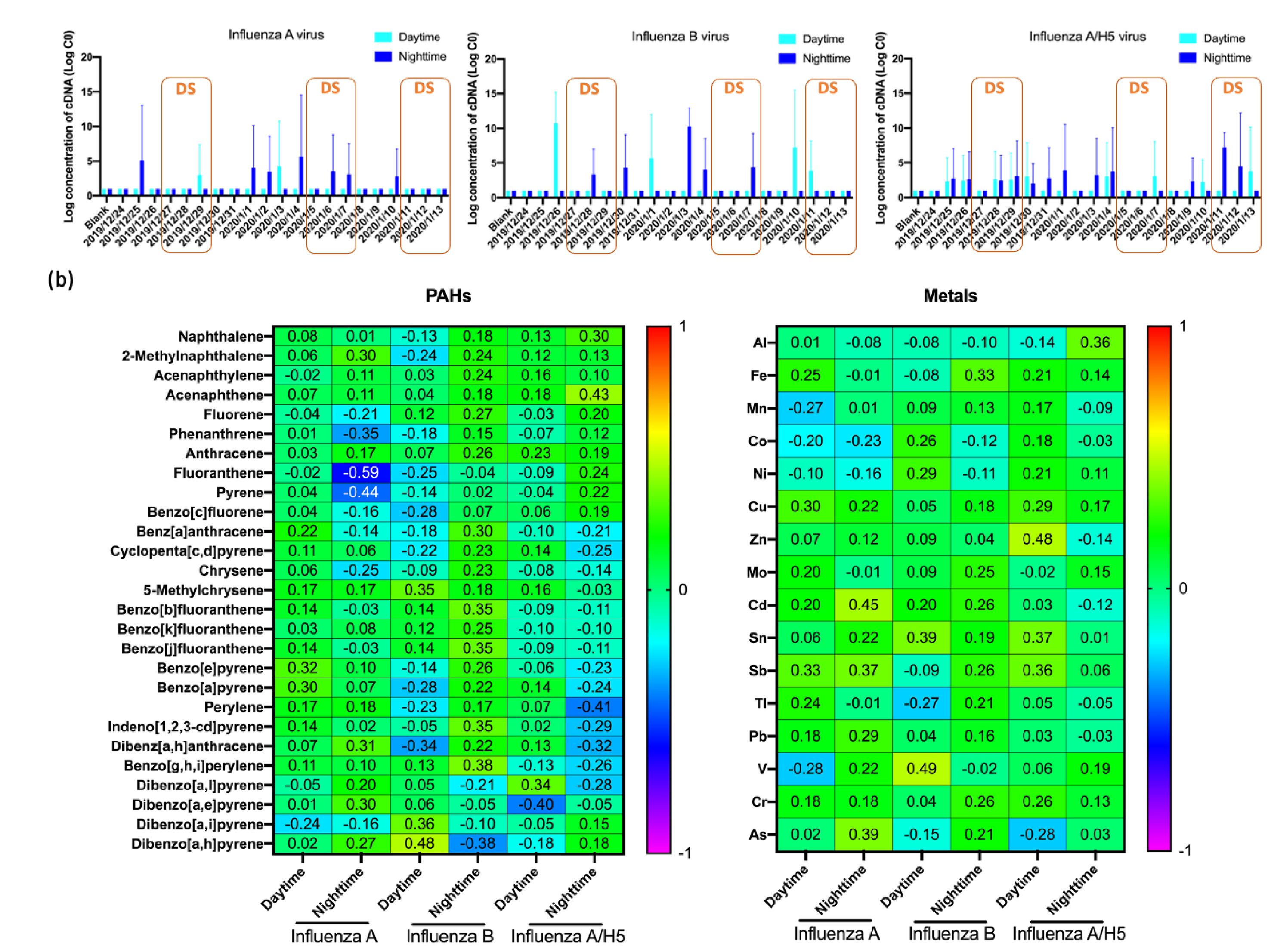

Figure 4. cDNA levels of the influenza A, B, and A/H5 viruses in $PM_{2.5}$ during the study period. Influenza A/H5 virus was epidemic during the study period. The three influenza virus variants were commonly detected between the DS and non-DS periods. Next, we found that FL and Pyr were negatively correlated with the influenza A virus. D(ah)P was positively correlated with the influenza B, and Acp was positively correlated with the influenza A/H5 virus. Cd was positively correlated with the influenza A, V was positively correlated with the influenza B virus, and Zn was positively correlated with the influenza A/H5 virus. These results imply that chemical compounds of $PM_{2.5}$ may interact with the influenza A/H5 virus, which could be associated with virus viability on $PM_{2.5}$.

Conclusion

The significance of this work is that ambient $PM_{2.5}$ is a direct transmission mode for influenza virus infection to the human alveolar epithelium. In conclusion, chemicals in $PM_{2.5}$ may play vital roles in terms of viable influenza virus in the atmosphere.

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