New Remote Sensing Inversion and Numerical Assimilation Technique of the Vertical Structure of PM2.5 Ammonium Concentration

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Ammonium salt (NH_4^+) is an important component of fine aerosol particles ($PM_{2.5}$), accounting for about 5-10% of its total mass concentration, which can increase to ~ 20% during severe pollution. NH_4^+ can neutralize acids, regulate the concentration and composition of PM2.5, and affect air quality, and also act as cloud condensation nuclei, which can affect the radiative energy balance and climate change in direct or indirect ways. In this study, a new technique was developed to invert the vertical profile information of NH_4^+ concentration based on the vertical detection of aerosol LIDAR, and the numerical model assimilation technique was further used to construct the three-dimensional reanalysis data of NH_4^+ concentration. Based on this, the vertical distribution and temporal trend of NH_4^+ concentration in the urban boundary layer of Beijing were analyzed, and the hourly evolution of the whole pollution process was tracked. The results show that the vertical distribution of NH_4^+ concentration at the altitude of 300-700 m in the urban boundary layer shows a surprising single-peak distribution, with hourly concentrations up to about 50 μg m^{-3}, which is three times of the ground level concentration, in contrast to the conventional pattern of decreasing concentration with altitude. This vertical structure is closely related to the observed escape of ammonia (NH_3) or NH_4^+ from upwind industrial sources through elevated stacks. The NH_4^+ plume emitted from these sources can easily be transported at an altitude of 270-750 meters for about 6 hours to Beijing, a distance of more than 250 kilometers away. This study reveals the impact of NH_4^+ emissions from non-agricultural sites on the vertical structure of aerosol NH_4^+ in the urban boundary layer, suggesting potential opportunities for limiting such emission sources to curb $PM_{2.5}$ pollution in the North China Plain.

References

Yang, T, H. Li, W. Xu, Y. Song, L. Xu, H. Wang, F. Wang, Y. Sun, Z. Wang, P. Fu, Strong Impacts of Regional Atmospheric Transport on the Vertical Distribution of Aerosol Ammonium over Beijing. 2024. *Environmental Science & Technology Letters*, 11, 29-34.

Wang, H, **Yang, Ting***, Wang, Z, Li, J, Chai, W, Tang, G, Kong, L, Chen, X. An aerosol vertical data assimilation system (NAQPMS-PDAF v1.0): development and application, *Geoscientific*

Model Development, 3555-3585, 2022.

Wang, F, **Yang, Ting***, Wang, Z, Wang, H, Chen, X, Sun, Y, Li, J, Tang, G, Chai, W. Algorithm for vertical distribution of boundary layer aerosol components in remote sensing data, *Atmospheric Measurement Techniques*, 6127-6144, 2022.

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