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Aerosol-PBL interaction: an important process for haze pollution mitigation in both megacity and regional scales

Xin Huang, Zinlin Wang, and Aijun Ding
School of Atmospheric Sciences, Nanjing University, Nanjing, China

Aerosols in the atmosphere could perturb the energy balance of the Earth-atmosphere system, and hence influence regional or even global climate change. Our recent studies have highlighted the importance of aerosols on local meteorological conditions, especially the evolution of the planetary boundary layer (PBL). The suspended aerosols could greatly reduce incoming solar radiation, decrease the surface heat flux, heat the atmosphere and stabilize the temperature stratification, thereby suppressing daytime PBL development and then enhancing haze pollution in turn. Such a positive feedback has been defined as aerosol-PBL interaction, which is of great importance in both megacity and regional scales.

Aerosol-PBL interaction has been found to enhance air pollution in megacities in China. Black carbon (BC) has been identified to play the key role in modifying the PBL meteorology and hence enhancing the haze pollution. With model simulations and data analysis from various field observations, we demonstrate that BC induces heating in the PBL, particularly in the upper PBL, and the resulting decreased surface heat flux substantially depresses the development of PBL and consequently enhances the occurrences of extreme haze pollution episodes. In addition, comparison between long-term radiosonde observations and reanalysis data also confirmed such interaction Under polluted conditions, a significant heating in upper-PBL with a maximum temperature change of about 0.7 oC and a substantial dimming near the surface with a mean temperature drop of -2.2 oC under polluted conditions in Beijing. The crucial factors influencing such interactions included vertical distribution of aerosol, aging processes of BC as well the underlying land surface

Aerosol-PBL interactions also play substantial roles in regional-scale meteorology and air pollution. We demonstrated that a typical intensive biomass burning pollution led to a large decline in near-surface air temperature and redistribution of precipitation in East China. As another radiative actively aerosol, mineral dust can also notably change PBL temperature stratification and wind speed, which in turn modify the emission intensity of itself. Further, the mixed pollution from biomass burning, dust storm and anthropogenic emissions usually gives rise to multi-layer aerosols, which has been found to pose significant feedback in middle/lower troposphere. Moreover, horizontal long-range transport and aerosol-PBL interactions interlink air pollution in multiple regions, causing long-lasting haze episodes at regional scale. Our results highlight the importance of aerosol-PBL interaction and coordinated cross-regional emission reduction in haze mitigation.