Accuracy assessment of CAMS and MERRA-2 reanalysis $PM_{2.5}$ and PM_{10} concentrations over China

ABSTRACT

Rapid industrialization and urbanization significantly contribute to air pollution in China. Essential constituents of air pollution are fine and coarse particulate matter which are the total mass of aerosol particles with aerodynamic diameters smaller than ≤2.5 μm ($PM_{2.5}$) and ≤10 μm (PM_{10}), respectively. These particles may cause severe health effects, and impact the atmospheric environment and climate. However, the limited number of ground-based measurements at sparsely distributed air quality monitoring stations hamper long-term air pollution impact studies over large areas. Although spatial data on $PM_{2.5}$ and PM_{10} are available from reanalysis models, the accuracy of such data may be reduced in comparison with ground data and may vary regionally and seasonally. Therefore, a long-term evaluation of reanalysis-based $PM_{2.5}$ and PM_{10} against ground-based measurements is needed for China. In this study, surface-level $PM_{2.5}$ and PM_{10} concentrations from 2014 to 2020 obtained from the Copernicus Atmospheric Monitoring Service (CAMS), and from the second version of Modern-Era Retrospective analysis for Research and Applications (MERRA-2) were evaluated using ground-based measurements obtained from 1675 air quality monitoring stations distributed across China. High $PM_{2.5}$ and PM_{10} (μg/m^3) concentrations from ground-based measurements were observed in many parts of China (including the North China Plain: NCP, Yangtse River Delta:YRD, Pearl River Delta: PRD, Central China, Sichuan Basin: SB, and northwestern region: Tarim Basin). The patterns of the spatial distributions of $PM_{2.5}$ and PM_{10} obtained from CAMS and MERRA-2 across China are similar to those of the ground-based monitoring data, but the concentrations from both models are substantially different. CAMS significantly overestimates $PM_{2.5}$ and PM_{10} over most regions, in particular over urban and desert areas, whereas MERRA-2 seasonal and annual mean concentrations were more accurate over the highly polluted areas in central and eastern China. The lowest $PM_{2.5}$ and PM_{10} concentrations were observed over the Tibetan Plateau and Qinghai, where CAMS and MERRA-2 datasets were substantially underestimated. Furthermore, both CAMS and MERRA-2 under-and over-estimate the PM concentrations in both low and high pollution conditions. Overall, this study contributes to understanding of the reliability of reanalysis data and provides a baseline document for improving the CAMS and MERRA-2 datasets for studying local and regional air quality in China.