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A new remote sensing method for PM2.5 based on coupling semi-empirical and numerical model

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Fine particulate matter (PM2.5), as a major kind of air pollution, is composed of a complex mixture of solid or liquid airborne particles, including sulfate, nitrate, ammonia, black carbon, mineral dust, and water, which may cause heart disease and lung cancer, as well as both chronic and acute respiratory diseases, such as asthma. According to the World Health Organization's report in 2016, 91% of the world's population was living in places where the WHO air quality guideline levels were not reached. Therefore, it is important to monitor ground PM2.5 concentrations with high resolution at a large scale, which is fundamental to understanding its tempo-spatial distribution, transport paths, formation mechanism, mitigation strategies, etc.

In the previous research, the semi-empirical method (SEM) of physical mechanism based on the physical mechanism between PM2.5 and AOD has been developed (Lin et al. 2015). The results show the method's capacity to identify PM2.5 spatial distribution with high-resolution at national, regional, and urban scales and to provide useful information for air pollution control strategies, health risk assessments, etc.

However, the double parameters (K and) of aerosol characteristics are obtained based on long-term observational data regression in a low spatial and temporal resolution. In the high-resolution PM2.5 concentration inversion (1km), it is usually difficult to establish such a dense ground-based observation network. Therefore, although the inversion results above the station have high accuracy, the inversion accuracy in the area far away from the station is limited, which underscores the need to incorporate the variations in aerosol characteristics in this model.

Numerical chemical transport model (CTM) can provide a more complete spatial distribution and solve the problem of insufficient ground observation data to a certain extent. Although the uncertainty of PM2.5 absolute concentration simulation at individual stations is high, the overall aerosol characteristics pattern simulated are relatively more reliable with emission information in high spatial-temporal resolution driven by reasonable meteorology. Thus, in order to improve the SEM and assess the effect of the variations in aerosol characteristics on satellite, in this study, we try to incorporate the SEM with the CTM together by simulating the double parameters with the concept in the SEM by using the numerical data. The results showed better agreements between satellite-retrieved and ground-observed PM2.5(with daily averages of 0.87) compared with that of the previous SEM (with daily averages of 0.69) in the same study region. This new method not only can take the advantages from both the SEM and CTM but also be suitable for operations with a quite low computation cost than the CTM itself.