Geophysical Research Abstracts
Vol. 21, EGU2019-11929, 2019
EGU General Assembly 2019

Evaluation of the effect of heavy aerosol pollution on MAX-DOAS retrievals of aerosols and trace gases derived with the PriAM and MAPA inversion algorithms from simulated data

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Several episodes of large-scale air pollution incidents with heavy aerosol amounts have drawn a lot of attention in China in recent years. Since secondary formation of aerosols could play an important role in the formation of such pollution events, vertical profiles of trace gas precursors and aerosol properties are required. Ground-based Multi Axis (MAX-) Differential Optical Absorption Spectroscopy (DOAS) technique is a state of the art remote sensing technique for deriving vertical profiles of trace gases and aerosols, which are important for studying the formation mechanism of secondary aerosols. However MAX-DOAS results under heavy aerosol pollution scenarios are often arguable because of the complex radiative transfer and artifacts of the inversion algorithm. The evaluation of profile inversions from MAX-DOAS under heavy aerosol pollution scenarios has not been systematically performed. In this study, these effects are evaluated based on synthetic data derived from radiative transfer simulations, which are then analysed by the PriAM and MAPA inversion algorithms. PriAM and MAPA belong to the optimal estimation method and the look up table approach, respectively. In the analysis, three aerosol vertical profiles were considered: Exponential, Boltzmann and Gaussian aerosol shapes. The aerosol optical depths (AOD) ranged from 0.1 to 5. For the Exponential profile, PriAM showed good results with the AOD increasing from 0.1 to 5, and a high correlation coefficient R2 (0.95) between the retrieved Exponential shape profile and the real profile. For Gaussian and Boltzmann shape profiles, the correlation coefficients were lower ((81.2% and 72%, respectively). Interestingly, the correlation can be improved by optimizing the a priori profile covariance matrix. Considering the applicability of the inversion algorithms for determining the surface-near aerosol extinction, the corresponding results of the two profile algorithms were compared. The study showed that the PriAM is more suitable for Exponential profiles than MAPA, and MAPA shows better results for the Boltzmann and Gaussian profiles.