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Development of Hybrid algorithm based on DOAS and PCA for PBL SO_2 column retrieval from UV Hyperspectral satellite sensor

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In this study, we investigated the effects of signal-to-noise ration (SNR), ozone, aerosol, and measurement geometry on the PBL sulfur dioxide (SO_2) slant column density (SCD) retrieval accuracy using a Differential Optical Absorption Spectroscopy (DOAS) and a Principal Components Analysis (PCA) algorithm based on synthetic radiances under various observation conditions. Synthetic radiances for various observation conditions were made using linearized pseudo-spherical scalar and vector discrete ordinate radiative transfer (VLIDORT). We, then, retrieved SO_2 SCDs using two algorithms and compared the retrieved SO_2 quantities against true SO_2 SCD used for the RTM as input data. Comparing between the SO_2 SCD retrieval accuracy using PCA and DOAS under three SNR senarios (720, 1440, and 2880), we could clearly find that the performance of PCA is slightly better for the level of low SO_2 than DOAS. In case of SO_2 vertical column density (VCD) less than 8 $\times$ 1015 molecules cm-2, the average absolute percentage difference (APD) between true SO_2 SCDs and those retrieved by DOAS (PCA) increase to 148.7% (132.1%) under SNR 720 condition. Errors in PBL SO_2 SCD retrieval using two algorithms tend to significantly increase with total O_3 VCD, aerosol opdical depth (AOD), and solar zenith angle (SZA) under low SO_2 condition. For the surface reflectance of 0.04, the uncertainties of SO_2 SCD retrieval using DOAS (84.9%) at low SO_2 levels are significantly larger than that using PCA (70.0%). This study is the first to quantify the effect of the clean sector on the PBL SO_2 SCD retrieval accuracy using PCA. The high AOD and O_3 VCD in the clean sector are found to lead to large uncertainties in SO_2 SCD retrieval using PCA. Given the merits of which DOAS and PCA retrieval tequinqe, we developed a new DOAS – PCA hybrid algorithm in which the SO_2 SCD result of the DOAS method is used as the initial SO_2 SCDs to select pixels in the clean sector as input to the PCA algorithm. It may be thought to reduce the SO_2 SCD retrieval error caused by using the SO_2-contaminated pixels as the clean sector pixels in PCA algorithm. The SO_2 retrieval performance of our hybrid algorithm is also analyzed and discussed using Geostationary Environment Monitoring Sensor (GEMS) synthetic radiance and Ozone Monitoring Instrument (OMI) L1B data.