Polarization Crossfire sensors onboard Chinese satellites for atmospheric environment monitoring

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Aerosols are important component of the global atmosphere. The fine mode of aerosols obtained special attention from the scientific research community as it is not only prominent in the field of environment and human heath, but also affects the earth-atmosphere radiation balance. Focusing on globally remote sensing of fine particulate matter from space, the first dedicated satellite observation strategy for PM 2.5, including the polarization cross- fire (PCF) sensors strategy and the PM2.5 remote sensing strategy, has been developed. The PCF satellite sensors have been successfully developed and launched on board the Chinese GaoFen-5(02) Satellite in September 2021 and the DQ-1 satellite in April 2022, providing global multi-angle polarization observations of the earth-atmosphere system twice a day. The PCF suite is composed by the Particulate Observing Scanning Polarimeter (POSP) and the Directional Polarimetric Camera (DPC) sensors together. In which the DPC inherits the instrument design of POLDER, provides multi-angular polarization observations of the visible to near-infrared bands, while the POSP mainly inherits the instrument desigh of APS, except for changing the along-track scanning mode to cross-track. POSP provides polarization measurements within large field-of-view (FOV) from −50 ° to 50 ° in the spectral range of 380–2250 nm, which can fully cover the swath of DPC. By the means of pixel matching and the cross calibration from POSP to DPC, the sophisticated joint measurements of multi-angular intensity and polarization could be obtained from the PCF suite in the spectral range of UV to SWIR. A semi-empirical physics model for remote sensing ground-level mass concentration of fine particulate matter, named by PMRS model, was also developed. PMRS model is a relatively universal parameterization scheme that is established to realize the conversion from the total column AOD to PM mass concentration near the ground, with the assumption of the vertical distribution of atmospheric particles, hygroscopic growth factor and mass extinction efficiency. Based on the optimal estimation inversion framework and synthetic data of PCF, the key aerosol parameters, including aerosol optical depth (AOD), fine mode fraction (FMF), aerosol layer height (H) and the fine-mode real part of complex refractive index (m_r and m_i) and the surface parameters are simultaneously retrieved, and the $PM_{2.5}$ is estimated by the PMRS model. The feasibility and rationality of the PCF strategy is demonstrated by the inflight PCF measurements onboard GaoFen-5(02) and DQ-1 satellites.

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