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Cloud-Target Calibration for Fengyun-3D MERSI-II Solar Reflectance Bands: Model Development and Instrument Stability

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Radiative calibration of satellite spectral radiometers is essential for their downstream applications. The Medium Resolution Spectral Imager (MERSI-II) is a key instrument of the Chinese polar orbit Fengyun-3D (FY-3D) satellite. However, its calibration performance has not been sufficiently studied, which limits its broad application. This study revealed the feasibility of a cloud-target method for assessing the MERSI-II calibration performance in solar bands. The top-of-atmosphere (TOA) reflectances for six MERSI-II reflective solar bands (RSBs) were numerically simulated using a rigorous forward radiative transfer method and cloud properties from well-collocated and well-calibrated Moderate Resolution Imaging Spectroradiometer (MODIS) operational cloud products with strict constraints. Only ice cloud targets were examined in the collocation due to their better homogeneity. The excellent agreement between our simulated reflectance and the MODIS reflectance (relative differences (RDs) of over 90% are within a 5% uncertainty range in six bands) validates our models. The simulated results in MERSI-II bands 1–4 showed reasonable agreements with the MERSI-II operational reflectance, i.e., mean RDs <3%, while the RDs in bands 6 and 7 reaches 12% and 6%, respectively. Our systematic cloud-target-calibration results over three years (2019–2021) indicated clear signal degradation of the MERSI-II solar bands, and those in the two cloud-absorbing bands, which reached ～15% and ～12% (in the three years), respectively. More importantly, we removed degradation biases to improve the current calibration accuracy to a stable value within 3%. Due to its robust performance, our cloud-target-based calibration method can be applied to future MERSI-II sensors to monitor solar band stability.