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Fast radiative transfer models for retrieval of cloud properties in the back-scattering region: application to DSCOVR-EPIC sensor

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In this work, the requirements for the retrieval of cloud properties in the back-scattering region are described, and their application to the measurements taken by the Earth Polychromatic Imaging Camera (EPIC) on board the Deep Space Climate Observatory (DSCOVR) is shown. Various radiative transfer models and their linearizations are implemented, and their advantages and issues are analyzed. As radiative transfer calculations in the back-scattering region are computationally time-consuming, several acceleration techniques are also studied.

The radiative transfer models analyzed include the exact Discrete Ordinate method with Matrix Exponential (DOME), the Matrix Operator method with Matrix Exponential (MOME), and the approximate asymptotic and equivalent Lambertian cloud models. To reduce the computational cost of the line-by-line (LBL) calculations, the k-distribution method, the Principal Component Analysis (PCA) and a combination of the k-distribution method plus PCA are used. The linearized radiative transfer models for retrieval of cloud properties include the Linearized Discrete Ordinate method with Matrix Exponential (LDOME), the Linearized Matrix Operator method with Matrix Exponential (LMOME) and the Forward-Adjoint Discrete Ordinate method with Matrix Exponential (FADOME). These models were applied to the EPIC oxygen-A band absorption channel at 764 nm.

It is shown that the approximate asymptotic and equivalent Lambertian cloud models give inaccurate results, so an offline processor for the retrieval of cloud properties in the back-scattering region requires the use of exact models such as DOME and MOME, which behave similarly. The combination of the k-distribution method plus PCA presents similar accuracy to the LBL calculations, but it is up to 360 times faster, and the relative errors for the computed radiances are less than 1.5% compared to the results when the exact phase function is used. Finally, the linearized models studied show similar behavior, with relative errors less than 1% for the radiance derivatives, but FADOME is 2 times faster than LDOME and 2.5 times faster than LMOME.