

Polychromatic effect of fast gaseous absorption modeling in scattering radiative transfer

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Satellite radiance data assimilation under cloudy conditions requires a fast radiative transfer (RT) model that takes the cloud absorption and scattering into account. A common scheme employed in these fast models is to include a RT solver such as the doubling-adding or multi-stream discrete-ordinate method, which compute a solution for a given set of parameters such as the atmospheric optical depth profile that have been averaged with the instrument spectral response function (SRF). However, such a practice in general introduces errors in simulating radiances that have finite bandwidths, because the RT solvers in general require monochromatic optical parameters as inputs. In this study, we estimate these errors for both broadband and narrowband sensors by examining the polychromatic effects when the NOAA fast gas optical transmittance model (OPTRAN) is applied to simulate cloudy radiances. Calculations using OPTRAN are compared with those using a Line-by-line model and with those using the Optimal Spectrum Sampling (OSS), which, like OPTRAN, employs a fast computation algorithm, but has included schemes to reduce the polychromatic effect. We study the angular dependence of the band transmittance due to non-monochromatic gas absorptions and atmospheric inhomogeneity and its contravention to physical principle used in common radiative transfer equations. This study addresses common problems in monochromatic and polychromatic radiative transfer calculations and identifies the application range using OPTRAN and OSS transmittance models in case of scatterings. Real satellite observations from Advanced Microwave Sounding Unit (AMSU) and Atmospheric Infrared Sounder (AIRS) are also applied in this study.