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The description of 2D radiative transfer using 1D radiative transfer model with effective coefficients: the methodology and validity study

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Independent pixel approximation (IPA) is often used to approximate radiative transfer (RT) in the case of 2D and 3D geometries. However, the results of IPA can be quite misleading in some cases. Therefore, we propose the improved methodology to study 2D radiative transfer in clouds using 1D radiative transfer equation with effective coefficients.

In particular, 1D radiative transport equation with effective coefficients is suggested to be used to calculation of horizontal spatial distribution of reflected brightness coefficient in 2D regions. Each effective 1D coefficient contains corresponding 2D coefficient averaged over height with different weight functions. In addition, the effective extinction coefficient can depend on photon propagation direction, and effective scattering coefficient can depend separately on both incident photon direction and scattered one. The solution of this 1D transport equation is carried out by the modified discrete ordinate method. As usually, in the framework of the discrete ordinate method, it includes the representation of the phase function by Legendre expansion and the replacement of the integro-differential equation via the system of algebraic equations. The resolving of algebraic system is performed by the successive–orders–of–scattering iteration process.

The method permits to find spatial sub-regions, where two-dimensional effects in brightness coefficient are essential and IPA model is inapplicable. It permits to obtain approximate horizontal distribution of brightness in such sub-regions.

The method is applicable to aerosol-cloud layers with arbitrarily distributed non-homogeneities (vertical and horizontal). Therefore, it is useful for the parameterization of 2D effects is atmospheric remote sensing problems.