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Gaussian smoothing for the Independent Pixel Approximation applied to actinic flux density fields in inhomogeneous clouds

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The main objective of the presented study is to provide a fast and easy-to-handle method for introducing parameterized horizontal photon transport to mimic radiative smoothing effects in Independent Pixel Approximation (IPA) simulations. In the IPA the radiative transfer in a cloud field is calculated at high resolution by making 1D computations for every cloud column.

The IPA is a very time-saving possibility for simulating 3D radiative transfer in the atmosphere, compared to more exact methods, employing for example Monte-Carlo techniques or the Spherical Harmonics Discrete Ordinate Method (SHDOM). By definition it is not possible to calculate horizontal photon fluxes by IPA calculations, i.e. radiative smoothing is not taken into account. For inhomogeneous 3D input fields, i.e. inhomogeneous clouds, the lack of horizontal photon transport leads to significant errors (up to 30% locally in the present study).

Consequently, the resulting actinic flux density fields show a very rough structure. The local discrepancies lead to enhanced or reduced photolysis rates of photosensitive chemical species. Free radical production or loss rates will change locally, which could influence the atmospheric chemical reaction cycles. In this study, the radiative smoothing is approximated by applying a Gaussian smoothing algorithm to the calculated actinic flux density fields. The fields are divided into several horizontal layers for which individual degrees of smoothing are employed. The necessary degree of the artificial smoothing is analysed empirically on the basis of exact 3D simulations prepared with SHDOM. The results are compared to an improved smoothing algorithm whose parameters are determined with the help of a point spread function. The input cloud fields are of stratocumulus type and were produced with a newly developed cloud generator which is presented in another abstract in this issue (s. V. Venema et al.).