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McSCIA: application of the Equivalence Theorem in a Monte Carlo radiative transfer model for spherical shell atmospheres

F. Spada[1], M. C. Krol[1,2,3], and P. Stammes[4]
[1]Institute for Marine and Atmospheric research Utrecht (IMAU), Utrecht, The Netherlands
[2]Netherlands Institute for Space Research (SRON), Utrecht, The Netherlands
[3]Meteorology and Air Quality, Wageningen University, The Netherlands
[4]Koninklijk Nederlands Meteorologisch Instituut (KNMI), De Bilt, The Netherlands

Abstract. A new multiple-scattering Monte Carlo 3-D radiative transfer model named McSCIA (Monte Carlo for SCIAmachy) is presented. The backward technique is used to efficiently simulate narrow field of view instruments. The McSCIA algorithm has been formulated as a function of the Earth's radius, and can thus perform simulations for both plane-parallel and spherical atmospheres. The latter geometry is essential for the interpretation of limb satellite measurements, as performed by SCIAMACHY on board of ESA's Envisat. The model can simulate UV-vis-NIR radiation.

First the ray-tracing algorithm is presented in detail, and then successfully validated against literature references, both in plane-parallel and in spherical geometry. A simple 1-D model is used to explain two different ways of treating absorption. One method uses the single scattering albedo while the other uses the equivalence theorem. The equivalence theorem is based on a separation of absorption and scattering. It is shown that both methods give, in a statistical way, identical results for a wide variety of scenarios. Both absorption methods are included in McSCIA, and it is shown that also for a 3-D case both formulations give identical results. McSCIA limb profiles for atmospheres with and without absorption compare well with the one of the state of the art Monte Carlo radiative transfer model MCC++.

A simplification of the photon statistics may lead to very fast calculations of absorption features in the atmosphere. However, these simplifications potentially introduce biases in the results. McSCIA does not use simplifications and is therefore a relatively slow implementation of the equivalence theorem.

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