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1D radiative transfer simulation of complex aerosol-cloud structure. Sensitivity study and implication to regional forcing estimates

L. Doppler (1,2), F. Ravetta (2), J. Pelon (3), and J. Fischer (1)

(1) Freie Universität Berlin, Institut für Weltraumwissenschaften, Berlin, Germany, (2) LATMOS, IPSL, Université Pierre et Marie Curie, Paris, France, (3) LATMOS, IPSL, CNRS, Jussieu, Paris, France

The spatial distribution of aerosol and clouds in the atmosphere leads, in a significant number of cases, to the occurrence of a complex vertical stratification and large horizontal variability. This is especially the case when low and mid- level clouds are embedded over the ocean in absorbing aerosol layers near polluted areas or biomass burning regions. This implies at the same time difficulties to determine representative optical and microphysical properties in any vertical column from remote sensing observations, and problems to perform accurate radiation budget analysis at the regional scale. A set of representative cases for such complex aerosol and clouds structures has been looked at. The last version of the radiative transfer (RT) code *MOMO* (*Matrix Operator MOdel*) of Free University of Berlin has been used to simulate 1-D radiative transfer in shortwave (SW) and in longwave (LW) and perform sensitivity tests for a few representative cases. The parameters identified to characterize the impact of errors in RT simulations are: 1) the heights and thicknesses of aerosol and clouds layers, and 2) clouds and aerosol optical properties (cloud effective radius, cloud liquid water content, cloud phase, aerosol single scattering albedo, extinction coefficient, asymmetry factor). Simulations of radiative fluxes, spectral radiances and irradiances, net fluxes for different altitudes and radiative heating-rates in SW and LW have been performed using the above described parameters and background vertical profiles for temperature and moisture as inputs of the RT model. First application is the improvement of satellite retrievals of clouds properties. Indeed, for instrument channels used to retrieve the clouds properties, complex structures with embedded aerosol and clouds layers may lead to similar top of atmosphere spectral radiances as compared to single layer structures having other properties (e.g. an absorbing aerosol layer over warm clouds as in the Gulf of Guinea would impact the retrieval of cloud properties). Examples are given and discussed. Another application is the error analysis in the computation of radiative forcing in a given region, using similar typical aerosol and cloud structure as identified from observations. The sensitivity analysis is used to identify criticality of input parameters. Outputs are the top of atmosphere and surface radiative forcings for mixed aerosol and cloud layers. Uncertainties resulting from spatial or temporal variability are then discussed.