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The Uncertainties Involved with Radiative Transfer Parameterization of the Cloud-Aerosol Transition Zone: Weather Research and Forecasting Model (WRF)

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To this date, a number of studies have quoted that the shift from a cloud-free to cloudy atmosphere (and vice versa) contains an additional phase, named "Transition (or twilight) Zone", which may represent a variety of atmospheric processes: hydrated aerosols, cloud fragments sheared off from the adjacent clouds, decaying and incipient clouds, etc. However, the information available about radiative effects of this phase is still very limited. The microphysical and radiative characteristics of the transition zone lay on the border between those corresponding to a cloud and those corresponding to an atmospheric aerosol. As a result, in most meteorological and climate studies, the condition of sky is assumed to be either cloudy (fully developed cloud) or cloud-free (dry aerosol), neglecting the transition zone. This implies that these models consider the area/layer corresponding to the transition zone as either cloud or aerosol. The purpose of this communication is to show the shortwave radiative effects driven from different possible treatments of the transition zone. To this aim, the relatively detailed shortwave radiation parameterizations included in the Weather Research and Forecasting model (WRF) version 4.0, which allow users to consider different treatments of aerosols and clouds (RRTMG, NewGoddard and FLG), were isolated from the whole model. These parameterizations were then utilized to perform a number of simulations under ideal "cloud" and "aerosol" modes, for different values of (i) cloud optical thicknesses resulting from different sizes of ice crystals or liquid droplets, cloud height, mixing ratios; and (ii) different aerosol optical thicknesses combined with various aerosol types. The optical thickness under both aerosol and cloud modes was considered to vary between 0.1 and 2, which is a common range of optical thickness for the twilight zone. The resulting shortwave broadband global, beam and diffuse irradiances at the Earth surface were analyzed. According to the results obtained: (1) RRTMG and FLG seem to be the most and least sensitive models to different treatments of the transition zone, respectively, (2) different treatments of transition zone may lead to a remarkable difference in the diffuse and global irradiances resulting from the effects of the atmospheric column, (3) beam radiation seems to be the least sensitive component of the shortwave radiation to different treatments of the transition zone.