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Impact of an improved shortwave radiation scheme in the MAECHAM5 General Circulation Model

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Abstract. In order to improve the representation of ozone absorption in the stratosphere of the MAECHAM5 general circulation model, the spectral resolution of the shortwave radiation parameterization used in the model has been increased from 4 to 6 bands. Two 20-years simulations with the general circulation model have been performed, one with the standard and the other with the newly introduced parameterization respectively, to evaluate the temperature and dynamical changes arising from the two different representations of the shortwave radiative transfer. In the simulation with the increased spectral resolution in the radiation parameterization, a significant warming of almost the entire model domain is reported. At the summer stratopause the temperature increase is about 6 K and alleviates the cold bias present in the model when the standard radiation scheme is used. These general circulation model results are consistent both with previous validation of the radiation scheme and with the offline clear-sky comparison performed in the current work with a discrete ordinate 4 stream scattering line by line radiative transfer model. The offline validation shows a substantial reduction of the daily averaged shortwave heating rate bias (1–2 K/day cooling) that occurs for the standard radiation parameterization in the upper stratosphere, present under a range of atmospheric conditions. Therefore, the 6 band shortwave radiation parameterization is considered to be better suited for the representation of the ozone absorption in the stratosphere than the 4 band parameterization. Concerning the dynamical response in the general circulation model, it is found that the reported warming at the summer stratopause induces stronger zonal mean zonal winds in the middle atmosphere. These stronger zonal mean zonal winds thereafter appear to produce a dynamical feedback that results in a dynamical warming (cooling) of the polar winter (summer) mesosphere, caused by an increased downward (upward) circulation in the winter (summer) hemisphere. In addition, the comparison of the two simulations performed with the general circulation model shows that the increase in the spectral resolution of the shortwave radiation and the associated changes in the cloud optical properties result in a warming (0.5–1 K) and moistening (3%–12%) of the upper tropical troposphere. By comparing these modeled differences with previous works, it appears that the reported changes in the solar radiation

scheme contribute to improve the model mean temperature also in the troposphere.

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