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Evaluation of the ECHAM family radiation codes performance in the representation of the solar signal

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Abstract. Solar radiation is the main source of energy for the Earth's atmosphere and in many respects defines its composition, photochemistry, temperature profile and dynamics. The magnitude of the solar irradiance variability strongly depends on the wavelength, making difficult its representation in climate models. Due to some deficiencies in the applied radiation codes, several models fail to show a clear response in middle stratospheric heating rates to solar spectral irradiance variability; therefore, it is important to evaluate model performance in this respect before doing multiple runs. In this work we evaluate the performance of three generations of ECHAM (4, 5 and 6) solar radiation schemes by a comparison with the reference high-resolution libRadtran code. We found that all original ECHAM radiation codes miss almost all solar signals in the heating rates in the mesosphere. In the stratosphere the two-band ECHAM4 code (E4) has an almost negligible radiative response to solar irradiance changes and the six-band ECHAM5 code (E5c) reproduces only about half of the reference signal, while representation in the ECHAM6 code (E6) is better – it misses a maximum of about 15% in the upper stratosphere. On the basis of the comparison results we suggest necessary improvements to the ECHAM family codes by the inclusion of available parameterizations of the heating rate due to absorption by oxygen (O_2) and ozone (O_3). Improvement is presented for E5c and E6, and both codes, with the introduced parameterizations, represent the heating rate response to the spectral solar irradiance variability simulated with libRadtran much better without a substantial increase in computer time. The suggested parameterizations are recommended to be applied in the middle-atmosphere version of the ECHAM-5 and 6 models for the study of the solar irradiance influence on climate.

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