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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impact of an improved radiation scheme in the MAECHAM5 General Circulation Model" *by* C. Cagnazzo et al.

C. Cagnazzo et al.

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Response to the 2nd Review of "Impact of an improved shortwave radiation scheme in the MAECHAM5 General Circulation Model" by Cagnazzo et al.

Reply to Referee 1

Response to points in general comment:

1. Validation procedure: Thank you for expressing your satisfaction for the validation procedure: We are also happy that you have found the revised version very much improved and that you have approved our validation procedure.

2. Contradiction between the conclusions of Nissen et al. and the conclusions of Cagnazzo et al. (2006):

We would like to inform Referee 1, that the contradiction is not between Nissen et al. and Cagnazzo et al. - but between Nissen et al. and a number of published works, including Cagnazzo et al. Some of these publications have been cited in our work (Egorova et al. 2005, Iacono et al. 2002, Manzini and McFarlane 1998, Steil et al. 2003) but it is also known from comparisons done elsewhere that the SW4 scheme included some of the deficiencies we have (for instance, Morcrette 2002)..

However, the contradiction between the conclusions of the two recent ACPD papers (Caganzzo et and and Nissen et al.) concerning the suitability of the SW4 code for calculating accurate heating rates in the upper stratosphere is a valid concern and we are aware of it. The different results have been pointed out to one of us (MAG) by a coauthor of Nissen et al. This motivated MAG to analyze the codes and three issues with the implementation of the FUBrad code have been identified. These concern:

- the computation of upwards optical paths above 70 hPa in FUBRad - the coupling of SW4 and FUBRad by means of TOA transmissivities - the differentiation of the coupling of SW4 and FUBRad for clear sky and cloudy subcolumns.

By their nature these problems have impacts on the heating rates in the middle atmosphere and in the troposphere, and we think that the current implementation of FUBRad in ECHAM5/MESSy needs to be substantially revised.

A detailed comment including introduction, a list of questions that may help to understand the problems and a detailed description of the shortcomings and the associated lines in the code has been compiled and sent to K. Nissen on March 14, 2007. If requested, the report can be made available for Referee 1 or for ACP.

We also have serious doubts on the validation procedure applied in Nissen et al., not showing a difference of the heating rates and limiting the comparison to one single profile. In addition, as discussed in Collins et al. (2006) and before that in the reports on ICRCCM-1 and ICRCCM-3 (Intercomparison of Radiation codes in climate models), only line-by-line radiation transfer models seem to be able to provide a reference for

ACPD

6, S7322–S7327, 2007

Interactive Comment

radiative transfer schemes for general circulation models. It is not clear to us that a detailed code as LibRadtran is such a line-by-line model.

Therefore - based on our multi-year and wide ranging expertises, we think that the inference "Ě 4-band ECHAM5 Ě.. should produce realistic results in climate integration" in Nissen et al. is vague and by now obsolete.

Our replies above indicate the issues with Nissen et al. are not expected to impact our work. We therefore do not agree with the suggestion of Referee 1 that it is necessary to fully resolve this controversy between the papers before the possible publication of our work on ACP.

3. The mesosphere and its importance: As it is well know, an atmospheric general circulation model needs to extend above the region of its focus, because of artificial boundary effects on the motion of a fluid. For instance, if a model has a rigid top, upward propagating waves can be reflected and affect the motion below. Therefore, atmospheric models usually have "sponges" close to their tops. However, some of these "sponges" have unwanted effects (Shepherd et al. 1996). In the MAECHAM models there is a parameterization of gravity waves that acts as a physically based "sponge" in the mesosphere, in order to avoid the unwanted effects described in Shepherd et al. (1996). To describe how the SW6-SW4 difference influences not only the upper stratosphere but also the part of the mesosphere covered by the model, is of interest because it sheds light on how the gravity wave parameterization and the mesospheric large scale flow interact and how, consequently, the lower levels may be further affected dynamically. Basically, the interest lays in the understanding of the momentum transfer between vertical layers of the atmosphere - a very important modeling aspect. Therefore, we have not changed Section 4.

Response to specific comments:

p.3, right, 4th paragraph:

Yes, the LBL code does include O2 absorption.

The referee is right: The sentence has been modified in the paper: “However, in the mesosphere, the SW6 performance does not agree so well with the LBL and a clear improvement cannot be concluded (the maximum bias is 1.5 K/day at 0.1 hPa). This result is consistent with the fact that oxygen absorption is not included in the first band of SW6, whilst it is considered in the LBL calculations (part of the negative bias is due to neglecting the oxygen absorption)”.

p. 8, Table 1: We think this information is a detail not really useful to the reader. Adding the required table (published in our response p. S7006) would render the paper more technical.

Response to technical and typographical corrections:

p.3: The Line-by-Line has been cited for the first time at the beginning of Section 3 without any acronym whilst the LBL acronym is used for the first time in the second paragraph of Section 3, without any spelling. Now the acronym has been added at the beginning of Section 3, thank you.

p. 4, left, L-17 Fig.5 top right has been corrected in Fig.4 top right, thank you

p.5, left, L-2 corrected, , thank you. The spell-checker has been run again.

References:

Egorova, T., Rozanov, E., Zubov, V., Manzini, E., Schmutz, W., and Peter, T.: Chemistry-climate model SOCOL: a validation of the present-day climatology, Atmos. Chem. Phys., 5, 1557 1576. SRef-ID: 1680-7324/acp/2004-4-2227, 2005.

Iacono, M. J., Delamere, J. S., Mlawer, E. J., and Clough, S. A.:Cloudy Sky RRTM Shortwave Radiative Transfer and Comparison to the Revised ECMWF Shortwave Model, Twelfth ARM Science Team Meeting Proceedings, St. Petersburg, Florida, April 8-12, Atmospheric and Environmental Research, Inc. Lexington, Massachusetts,

2002. Manzini, E., and McFarlane, N. A.: The effect of varying the source spectrum of a gravity wave parameterization in a middle atmosphere general circulation model, J.Geophys. Res., 103, 31523- 31539, 1998 Morcrette, J.-J. (2002), Assessment of the ECMWF model cloudiness and surface radiation fields at the ARM SGP site, Mon.Wea.Rev., 130, 257-277.

Shepherd, T. G., K. Semeniuk, J. N. Koshyk (1996), Sponge layer feedbacks in middle-atmosphere models, J. Geophys. Res., 101(D18), 23447-23464, 10.1029/96JD01994.

Steil, B., Bruehl, C., Manzini, E., Crutzen, P. J., Lelieveld, J., Rasch, P. J., Roeckner, E., and Krueger, K.: A new interactive chemistry-climate model: 1. Present-day climatology and interannual variability of the middle atmosphere using the model and 9 years of HALOE/UARS data, J. Geophys. Res., 108(D9), 4290, doi:10.1029/2002JD002971, 2003.

Reply to Referee 2

Thank you for your appreciation of our work and your comments, that have indeed helped us to improve the manuscript.

Since 1991, there have been several works to evaluate the radiative transfer parameterizations in GCMs with respect to LBL models. For example, the most important project is the Intercomparison of Radiation Codes in Climate Models (ICRCCM; Ellingson and Fouquart, 1991; Ellingson et al., 1991; Fouquart et al., 1991). ICRCCM-1 for longwave, ICRCCM-3 and the Radiative Transfer Model Intercomparison Project for LW and SW have shown that there is a pretty good agreement between the main and currently used Line-by-line models (see also Collins et al., 2006).

Therefore a parameterization, whether it has 4, 6, or N bands which agrees better than another one with such line-by-line models, is better suited to represent radiation transfer in the atmosphere than a scheme less apt at providing such an agreement.

The 6-band version of the SW scheme improves the agreement with such a line-by-line model relative to the 4-band version, so is considered to be better suited to its purpose.

In the Abstract (toward the end of the right column) and in the Conclusion (end first paragraph) we have added the sentence:

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.

2. As suggested, in the abstract we do not mention 1-3 bands but 4-6, as in the rest of the text.

References:

Collins, W. D., et al., (2006), Radiative forcing by well-mixed greenhouse gases: Estimates from climate models in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), J. Geophys. Res., 111, D14317, doi:10.1029/2005JD006713.

Ellingson, R. G., and Y. Fouquart (1991), The intercomparison of radiation codes in climate models–An overview, J. Geophys. Res., 96, 8925-8927.

Ellingson, R. G., S. J. Ellis, and S. B. Fels (1991), The intercomparison of radiation codes used in climate models–Long-wave results, J. Geophys. Res., 96, 8929-8953.

Fouquart, Y., B. Bonnel, and V. Ramaswamy (1991), Intercomparing shortwave radiation codes for climate studies, J. Geophys. Res., 96, 8955-8968.

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