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Geoscientific Model Development Discussions

# *Interactive comment on* "Evaluation of the ECHAM family radiation codes performance in the representation of the solar signal" *by* T. Sukhodolov et al.

**Anonymous Referee #2**

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## 1 General comments

In this paper the authors present a method to extend the short wave (SW) radiation parametrization of ECHAM based climate and chemistry climate models in a way to enable the realistic modeling of 11 year solar cycle variations in the heating rates of the visible and UV part of the spectrum. To achieve this goal the authors introduce additional heating rates, including the absorption of UV radiation by $O_2$ at the Lyman-alpha line and the Schumann-Runge continuum and bands/ Herzberg continuum (also $O_3$) according to Strobel (1978).



This approach has been used before by several modeling groups to get a more realistic solar signal in the middle atmosphere. The paper can not be published in its current form, but has to be revised thoroughly. The authors should include the answers to the following question into their revised manuscript: How is the temperature climatology affected by the additional heating introduced for all periods except for the predefined 'grand minimum'.

## 2 Specific comments

In the following the specific comments are ordered according to the sections.

Abstract

The abstract announces the evaluation of three different generations of ECHAM radiation schemes (E4, E5, and E6). But the evaluation of the E4 radiation scheme is completely missing in the paper. Also there is no evaluation of the original standard E5 radiation scheme included, instead an updated version of the original scheme is used, that uses the 6-band SW radiation parametrization of the ECMWF (Cagnazzo et al., 2007). The abstract should reflect the analysis contained in the paper.

1 Introduction

The description of the approach by Nissen et al. (2007) is not correct and can be misleading. As written in the manuscript the reader could suppose that the 6-band SW parametrization of E5 (which is already an update of the standard E5 4-band SW parametrization by Cagnazzo et al. (2007)) has been replaced by a 49-band SW

parametrization by Nissen et al. (2007). Instead they replaced the UV-visible band of standard E5 4-band SW radiation scheme at model levels where the pressure is less than 70 hPa, by a 49-band parametrization based on Strobel (1978) (Schumann-Runge bands and continuum) Shine and Rickaby (1989) (Herzberg-, Hartley-, Huggins-, Chappuis-Band), and Chabrillat and Kockarts (1997) (Lyman-alpha). The Nissen et al. (2007) method (FUBRAD) is therefor also comparable to the methods of Egorova (2004) or Formichev et al. (2004). The statement about the computational costs of the FUBRAD scheme (increase of CPU costs by a factor of 8; page 1340, line 14) is not contained in the cited papers Nissen et al., (2007) and Kubin et al. (2011).

2 Description of the original ECHAM solar radiation codes

The description of the ECHAM SW radiation parametrization is rather unorganized. At first the reader should be informed about the basic evolution of the SW radiation parametrizations in the three mentioned ECHAM models. E.g. 2-band SW with 1 band UV-visible and 1 band near infrared (NIR) (Fouquart and Bonnel, 1980) in ECHAM4 (E4); extension in ECHAM5 – 3 bands for NIR with the same single band for UV-visible (E5); replacement of the 4-band SW scheme by the 14-bands RRTM in ECHAM6 (E6). This general description can be followed by the description of the update to the ECHAM5 SW radiation parametrization by Cagnazzo et al. (2007). In the next section more details on the UV-visible part can be given, where the authors can mention that at least for the UV-visible band there was no change from E4 to E5. Although the study is only concerned with the UV-visible part of the spectrum, the authors should consider to expand their table 1 by some information about the other bands of the SW parametrizations. The authors should give a new label to the upgraded version of the E5 SW radiation scheme, as the original E5 SW radiation scheme is the 4-band Fouquart and Bonnel scheme.



3 Validation

The results of the validation presented in figure 2 are not adequately discussed. Before discussing the solar signal between the minimum and the maximum of the 11-year solar cycle at the bottom of the figure, the authors should discuss the shortwave heating rates profile at the top of the figure. More attention should be paid to the fact that the upgraded E5 and the E6 SW radiation schemes both overestimate the heating rates near the stratopause by 2 K/day (E5) and 4K/day (E6), compared to the line-by-line reference model libRadtran. According to figure 2 (top) this is mainly due to an overestimation of the heating rates in the range from 250–440 nm (E5) or 263–345 nm (E6). Here it would be interesting to see the behaviour of the original E5 SW radiation scheme (4-band) for the UV and visible band from 250–690 nm in comparison to the libRadtran line-by-line reference model in the same wavelength range. This analysis should be included in the revised manuscript. Some statements concerning the discussion of figure 2 have to be sorted clearly, depending on whether referring to the absolute heating rates or the solar signal in heating rates between solar maximum and minimum.

On page 1343 (line 17) the authors give a reference to the SPARC CCMVal (2010) report for the updated E5 code, but this radiation code did not participate in that initiative. The updated E5 code participated only in the Forster et al. (2011) study.

4 Implementation

As GMD is a journal dedicated also to the publication/ documentation of more technical issues in modeling, the authors should give more details about the scaling procedure, that is an essential part of their approach to include the 11-year cycle variations. The scaling coefficients should be tabulated for both radiation codes (E5 and E6), although

only valid for the specific task and the specific spectral irradiances used in this study.

The information about the wavelength ranges of the additional bands is not included (only for the Huggins bands). An additional table with these bandwidth informations should be included.

The statement on page 1345, line 5-6: "... *parametrizations for HAR and HUG are in a good agreement with libRadtran*." The results from figure 2 clearly show the discrepancy between the heating rates calculated with the line-by-line model and the heating rates within the wavelength ranges 250–440 nm (E5) or 263–345 nm (E6), it is therefor not correct to state a good agreement with libRadtran.

The statement on page 1346, line 4-6: "... *the inclusion of these parametrizations does not change much the absolute values of the heating rates and therefore does not require any retuning of the original codes*." Even an increase in heating rates less than 1 K/day can lead to significant temperature changes locally, but also non-locally through wave mean flow interactions and feedbacks on the temperatures. This is also claimed by the authors in their introduction. Have the updated versions of the E5 and E6 SW radiation parametrizations been tested online in the respective ECHAM models? Results from such simulations would be helpful to support the cited statement. The method presented in this paper to add the 11-year solar cycle to the heating rates, introduces extra heating rates for all months except for the predefined 'grand minimum' month. This extra heating has the potential to change the climatology of the climate model.



## 3 Technical corrections

Throughout the paper there are a lot of missing articles.

Page 1338,
line 8: ... to prove a reasonable ...
line 12: ... In the stratosphere the ECHAM5 code ...
line 13: ... while the representation in the ECHAM6 code ...
line 25: ... in the visible ...

Page 1339,
line 7: ... Ermolli et al., 2103 ... - correct year to 2013.
line 15: ... affecting the Brewer–Dobson ...
line 21: ... chemical, dynamical and temperature feedbacks.
line 22: ... of the radiative transfer ...

Page 1340,
line 2: ... of the SPARC CCMVal-2 ...
line 13: ... to the 6-band scheme ...
line 14: ... by the parametrization ... roughly a factor of 8.
line 15: ... to apply parametrizations for the missed ...
line 20: ... with a relatively ...

Page 1341,
line 10: ... to the shortwave part ...
line 16: ... it has an almost ...
line 20: ... SSI ... – this abbreviation has not been defined before.
line 23: Since the ECHAM5 code ...

line 26: ... was the adaptation ...

Page 1342,
line 20: ... The irradiance spectrum ...

Page 1343,
line 7: The first band of E5 covers ...
line 12: ... important for the mesosphere, ...
line 16: ... half of the solar signal compared to ...
line 19: ... to an underestimation of the solar ...
line 23: (Ermolli ... is correct the absolute values of the missed ...
line 26: ... that the underestimation of the solar signal ...
line 29: ... there is a 12% shift ...

Page 1344,
line 1: ... the the ... - remove one 'the'.
line 9: ... we used the parametrization ...
line 12: where the mean LYA ...

Page 1345,
line 5: show that the parametrizations ...
line 9: ... of the applied parametrizations ...
line 11: ... underestimates the absolute ... in the mesosphere, the heating ...
line 12: ... using the full flux ...
line 14: ... However, to avoid an overestimation ...
line 15: ... the fact that the original ... in the Hartley
line 18: avoid an overestimation ...



line 23: ... due to the implemented ...
line 26: ... The implemented parametrizations of ...
line 27: ... changes with the reference

Page 1346,
line 1: ... . And ... - new sentence should not begin with 'And'. Replace with 'The'
line 3: ... compare ... - correct to ... compared ...
line 9: ... (10°, 40°, 70°) ... shown that the parametrizations
line 10: ... and the applied scaling ...
line 11: depend on the position ...
line 13: ... regarding the specific
line 16: For the previous ... with a constant ozone
line 17: ... the ozone profile is modulated by ...
line 21: ... In this case the original ...
line 22: irradiance differences ...
line 23: ... The total heating rate
line 24: ... compare ... - correct to ... compared ...

Page 1347,
line 7: ... to correct the revealed problems by the implementation of parametrizations
line 9: ... agreement with a reference model ... of the solar signal ...

Page 1351, Table 1 caption: ... absorbers in the UV ...

Page 1353, Figure caption: ... minimum and maximum (max–min)

Page 1355, Figure caption: ... solar may ... - correct to solar max ...

Interactive comment on Geosci. Model Dev. Discuss., 7, 1337, 2014.