

1 Dear referees,

2 Thank you for your useful comments, corrections and suggestions.

3

4 To Boris Fomin:

5 **To try a method that is described in Fomin and Correa (2005)**

6 Certainly, it would be interesting to try the method presented in your paper. However, since
7 our paper is dedicated to the radiation schemes used in ECHAM GCMs we will not include
8 analysis of your scheme into this paper, but we will contact you separately concerning this
9 topic.

10

11 To Anonymous Referee #2:

12 Comments on page C231

13 **The authors should include the answers to the following question into their revised**
14 **manuscript: How is the temperature climatology affected by the additional heating introduced**
15 **for all periods except for the predefined 'grand minimum'.**

16 and page C234

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

28 The considered codes overestimate the total heating rate in absolute values both during
29 minimum and maximum solar conditions compare to libRadtran and this is the feature of the
30 original schemes. However, the difference between libRadtran and E5 or E6 in case of solar
31 minimum is bigger than in case of solar maximum, because in case of solar maximum the
32 result of E5 or E6 is also influenced by the lack of variability representation. And by adding
33 our extra heating we just fix the problem and don't introduce any heating over the existing
34 difference in case of solar minimum. Here is an example:

35 The difference between libRadtran and E5 at 44 km in solar minimum is ~1.6 K/day

36 The difference between libRadtran and E5 at 44 km in solar maximum is ~1.44 K/day

37 The difference between two above values is ~0.16

38 The extra heating added at this altitude is also ~0.16

39 Therefore we only make this delta (E5 or E6 minus libRadtran) constant in time. Of course,
40 the mean delta over the whole modelling time will be greater with extra heating than without
41 extra heating, however the second one is less only because of the bad representation of the

1 solar signal, and the first one will be equal the delta in the “grand minimum” and will be
2 constant in time.

3 This is a tricky part and we will rewrite it in more details.

4 Regarding the online testing of parameterizations we should note that this was not our goal in
5 this particular paper to analyze the temperature climatology, which depends on many
6 processes besides short-wave heating that have to be also taken into account in the analysis,
7 what makes the question highly model dependent. Also this extra heating is less than 1% from
8 the absolute values and does not exceed natural variability and uncertainty of the observed
9 temperature, therefore it will not introduce dramatic changes. The extra heating was applied in
10 SOCOL 3.0, which is under evaluation in the framework of CCMI, also in three papers by
11 Anet et al., similar approach (E4+) was tested by Egorova et al., (2004), showing no
12 extraordinary result in temperature climatology.

13

14 The abstract announces the evaluation of three different generations of ECHAM radiation
15 schemes (E4, E5, and E6). But the evaluation of the E4 radiation scheme is completely
16 missing in the paper. Also there is no evaluation of the original standard E5 radiation scheme
17 included, instead an updated version of the original scheme is used, that uses the 6-band SW
18 radiation parametrization of the ECMWF (Cagnazzo et al., 2007). The abstract should reflect
19 the analysis contained in the paper. C231

20 Here it would be interesting to see the behaviour of the original E5 SW radiation scheme (4-
21 band) for the UV and visible band from 250–690 nm in comparison to the libRadtran line-by-
22 line reference model in the same wavelength range. This analysis should be included in the
23 revised manuscript. C233

24 ECHAM4 and the original ECHAM5 schemes are the same in the UV and have a negligible
25 solar signal, what was already analyzed before several times. Therefore we didn’t include its
26 analysis into the paper. However, in terms of absolute values it can be interesting, as you
27 pointed, and we will include this part for the more complete picture of the ECHAM radiation
28 codes family.

29

30 The description of the ECHAM SW radiation parametrization is rather unorganized. C232

31 Although the study is only concerned with the UV-visible part of the spectrum, the authors
32 should consider to expand their table 1 by some information about the other bands of the SW
33 parametrizations. The authors should give a new label to the upgraded version of the E5 SW
34 radiation scheme, as the original E5 SW radiation scheme is the 4-band Fouquart and Bonnel
35 scheme. C232

36 The description and the labeling of the schemes are reconsidered and rewritten. The table 1 is
37 extended by the information about the other bands.

38

39 The description of the approach by Nissen et al. (2007) is not correct and can be misleading.
40 C231

41 This part is carefully reformulated in conformity with the cited paper.

42

1 The results of the validation presented in figure 2 are not adequately discussed.

2 Some statements concerning the discussion of figure 2 have to be sorted clearly, depending on
3 whether referring to the absolute heating rates or the solar signal in heating rates between
4 solar maximum and minimum. C233

5 This part is reformulated

6 On page 1343 (line 17) the authors give a reference to the SPARC CCMVal (2010) report for
7 the updated E5 code, but this radiation code did not participate in that initiative. The updated
8 E5 code participated only in the Forster et al. (2011) study. C233

9 The updated E5 code participated in chapter 3 of the SPARC CCMVal (2010) report as
10 ECHAM5

11 The scaling coefficients should be tabulated for both radiation codes (E5 and E6) C233

12 The information about the wavelength ranges of the additional bands is not included (only for
13 the Huggins bands). An additional table with these bandwidth informations should be
14 included. C234

15 The scaling coefficients are presented as well as the bandwidth information of the extra
16 heating parameterizations.

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

22 The statement "...parametrizations for HAR and HUG are in a good agreement with
23 libRadtran" refers to the extra heating parameterizations and not to the figure 2. The picture
24 with the comparison of the extra heating parameterisations and libRadtran was not included to
25 the paper, but we will also include it.

26

27 Special thanks for technical corrections!

28

1 **List of relevant changes**

- 2 1. Abstract is corrected
- 3 2. Section 2 is partly rewritten, new designations (E4, E5c) added.
- 4 3. Second half of section 3 is significantly rewritten, analysis of the E4 scheme added
- 5 4. Section 4 is partly changed, the equations are the same
- 6 5. Section 4.1 is slightly extended
- 7 6. Conclusions are corrected
- 8 7. Figure 2: E4 added
- 9 8. Added new Figure 3
- 10 9. Figures 4, 5, 6: legend corrected
- 11 10. Table 1 is extended
- 12 11. Added table 2