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Interactive Comment

Interactive comment on “Towards a better representation of the solar cycle in general circulation models” *by* K. M. Nissen et al.

Anonymous Referee #4

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The paper presents a comparison of a spectrally crude with an updated version of a more eloborated heating rate parameterization for the middle atmosphere, the code FUBRad. The parameterization FUBRad has been improved in respect of UV flux sensitivity and has been included as a submodule in the ECHAM/MESSY environment.

The paper has two interesting aspects: first, the FUBRad code is validated by comparison with a spectral high resolution radiative transfer code, and second, the solar Lyman alpha line has been included in the code, which is not very common for middle atmosphere heating rate parameterizations. Nevertheless I doubt if the improved scheme is really an important step towards a better representation of the solar cycle in climate models, as the title suggests. First, I agree with Reviewer 2 who found the statements which relate the improvements of the new scheme when compared with the standard scheme of ECHAM to the high spectral resolution somewhat misleading as the standard scheme does not include a UV band at all. As the authors state in the introduction, there have been many solar cycle studies in the past, and most GCM solar sensitivity experiments are using at least a separate UV channel, see for example Haigh, Matthes etal., Palmer and Gray, Brasseur, Tourpali etal., Rozanov etal. , Egorava etal.. The last two models also include O2 absorption and the last also absorption of Lyman alpha. One would therefore be interested, how the FUB scheme compares to the other schemes. Second, the impact of solar variability cannot be realistically deduced without including the effects of the changed UV flux on ozone chemistry, i.e. varying photolysis has to be included as an integrated part of the experiments, as have been already done by Tourpali etal. 2003, or Egorova etal. 2004. What may be missing in the literature is a consistent treatment of photolysis and heating in 3D models, as realised in the Landgraf and Crutzen approach which should be usable also within the ECHAM5/MESSY environment. Third, the FUB scheme seems to be a collection and even a mixture of different parameterizations using different theoretical backgrounds. These codes have been tested for their own. Whereas the validation of the FUB scheme would be a valuable check inside a solar cycle study, it does not deserve an independent publication, especially as the disrepancies between the FUB scheme and the reference are not further discussed in the paper (see specific comments), and/or the effects of ozone photolysis are missing. In summary, I do not recommend the paper for publication in its present form, but I would ask the authors to either augment their work by a comparison with earlier work and analysis of differences, and a more detailed comparison with the reference calculation, as suggested in the specific comments, or to include their results in a possible forthcoming paper in a condensed form.

Specific comments

p47 l09: the sentence suggests that interactive ozone is not necessary. First, this contradicts somewhat the following summary of the paper of Shibata and Kodera, and second, I would take this phrase as a rough approximation only valid around the stratopause.

p48 l11 *radiative forcing* add *additional*

p48 paragraph l09 In order and paragraph l15 The aim of the paper

That some spectral information is needed is a well known fact for which is no need to be demonstrated again in this generality. It could be interesting to ask what spectral resolution is necessary and if one has to include O2 absorption when studying the solar effects in the stratosphere. In addition, here previous work has to be mentioned (eg. Egorova et al., Rozanov et al.), and it should be motivated why schemes used in previous studies have to be improved.

p49 efficiency factors

It is not completely clear from the text how the efficiency factors are used in the model. Perhaps I'm wrong, but as long as the photolysis products are not transported and the release of stored chemical energy is not included explicitly in the chemical module of the model (which is not the case here), besides the correction for the so-called airglow the efficiency is only further reduced by chemoluminescence, the exact amount of which can only be evaluated when using a complete chemical model. Probably a good approximation could be using the relation given in Fig. 26 of Mlynczak and Solomon. Using the net heating rate of Strobel would be equivalent to loose all the chemical energy.

p51 Validation, first paragraph, last sentence, The radiative transfer

Do you use the plane-parallel approximation? Which Rayleigh scattering coefficient has been used for the SRBs, if at all?

p51, third paragraph, Fig. 1

Inspecting Fig. 1 (and also Fig. 3), there may be a small error in the pressure or altitude scale, as the 0.01 level does not meet the 80km, whereas in Fig. 2 and Fig. 5 they do.

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How does the reference and FUBRad scheme compare for higher solar zenith angles, for example the case shown Fig.2 ?

l17 see comment on efficiency factors

l20 'close agreement'

I cannot follow this statement. There is a astonishing better agreement of the ECHAM5 code in the altitude range 20-30km with the reference when compared to the FUBRad scheme. In relative terms, this seems to be significant for the stratosphere and should be analysed.

p53, paragraph: Fig. 4

The dominance of Lyman-alpha at 80 km for solar variability is amazing. Taking a 5-fold higher amplitude of Lyman-alpha compared to SRBs (40% compared to 8%) and reading 0.5 and less 0.02 K/d differential heating rate I estimate from Figure 4 that Lyman-alpha also dominates the heating rate by a factor of five (roughly). Here probably the very low efficiency of SRB when using the Strobel net heating rate causes this low value, if the heating rates shown are net heating rates indeed. Using the parameterization of Strobel, but total heating rate, and approximating the absorption coefficient of O2 for Lyman-alpha with 1e-20 cm-2, the absorbed energy for Lyman-alpha is at most about 60% of the SRBs, in a small altitude range around 80 km for a Lyman-alpha photon flux of 5e11 cm-2 s-1. Mlynczak and Marshall 1996, Fig. 5 show a net daily average heating rate for Lyman-alpha of 0.3 K/day at the equator, which is not compatible with the heating rate difference of about 0.5 K/day in Fig. 4. Therefore, I would ask the authors to verify their results.

In addition, the authors mention that the SRB contribution may be underestimated by a factor of two. As the Strobel parameterization is used in many middle atmosphere models, the authors should try to analyse the discrepancy in more detail.

p53, paragraph Temperature response

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Interactive Comment

For the simulations the NIR had been included?

p53, l14 Do you think the results of Matthes et al. who run a complete annual cycle can be compared with the perpetual January experiments? Would you expect that the results of Matthes et al. could be modified using the new scheme?

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 45, 2007.