Reply to Review 1

We summarize our answers to the questions of review 1. Moreover the manuscript is changed taking into account the questions and comments (the changed manuscript is attached to the reply of review2).

Comment (Abstract): Could the author specify that the ECHAM general circulation model (GCM) has been developed by the Max-Planck Institut fuer Meteorologie for clarity purposes.

→ Done, however not in the abstract. It is now mentioned in the introduction.

Question 1 (Introduction): The authors are mentioning that the long-wave spectrum is divided into 16 bands ranging from 3.33-1000 microns. Could the authors please provide the same information for the UV-Vis and NIR. In section 2.2 it mentions that the UV-Vis band ranges from 250-690nm and therefore I would assume that the NIR is covered by three bands which range from 0.69 micron to 3.3 microns. But I am not sure that this is the case. This needs to be made clearer.

→ The UV-VIS band ranges from 0.25 to 0.69µm and the NIR band from 0.69-4.00µm. Values are now mentioned in the manuscript .

Question 2 (Introduction): The paper mentions that Rayleigh-Scattering is not considered in the submodel RAD_FUBRAD which looks at the UV-Vis regions at pressure levels below 70hPA, i.e. in the stratosphere and mesosphere. It seems to me that in the stratosphere and mesosphere Rayleigh-Scattering would be one of the most important radiative mechanism. Do the authors mean that the short-wave heating rates are not affected much by Rayleigh-Scattering? Or do the submodels RAD and RAD_FUBRAD overlap in pressure levels so that stratospheric and mesospheric Rayleigh-Scattering is treated in RAD. This needs to be clarified.

→ Yes, FUBRad neglects Rayleigh scattering. RAD_FUBRAD and RAD do not overlap in pressure levels (if FUBRAD is switched on): FUBRAD replaces RAD for VIS-UV between TOA and 70 hPa. As mentioned in chapter 2.2 Rayleigh scattering is parametrized in the Chappuis und Huggins bands by a reflecting layer in the lower atmosphere. According to e.g., Strobel (1978), it is of sufficient accuracy for applications in MA GCMs (see also Interactive comment on Atmos. Chem. Phys. Discuss., 7, 45, 2007). Now clarified in chapter 2.2.

Question 3 (Introduction):The paper also states that the submodel RAD_FUBRAD does not consider scattering by aerosols and clouds, although stratospheric aerosols are known to have an important radiative effect. Again, do the authors mean that they do not have a large effect on the heating rates? Or are the stratospheric aerosols treated in the submodel RAD. Do the pressure levels of the submodel RAD and RAD_FUBRAD overlap? This needs to be explained more clearly.

→ Direct aerosol and cloud effects are not considered in FUBRAD. However, the reflection of UV-VIS on clouds and aerosols is considered in the upward flux, as mentioned in answer 2. Now clarified in chapter 1 and 2.2. Moreover, the effect of missing scattering on aerosols can be seen in figure 2 (compare RAD_SHORT_V1 and RAD_SHORT_V2, with and without FUBRAD respectively), not showing a big difference (up to maximal 10 %). Now clarified in chapter 2.2.

Question 1 (Submodel RAD) Do the submodels RAD and RAD_FUBRAD overlap in height?

→ RAD_FUBRAD and RAD do not overlap with height. If FUBRAD is switched on, shortwave radiation fluxes due to ozone and oxygen absorption are calculated at pressures equal or lower than 70hPa in the UV-Vis with FUBRAD (replacing the shortwave radiation scheme of Fouquart and Bonnel used in RAD). At pressures higher than 70 hPa the UV-Vis shortwave radiation fluxes are calculated by RAD_SHORT_V1 in one spectral interval as in the original ECHAM5 code, or modified as in RAD_SHORT_V2.

Question 2 (Submodel RAD) Is it possible for the authors to describe the differences between RAD_SHORT_v1 and RAD_SHORT_v2 in more detail.

→ *Of course we can, a more detailed description is now given in section 2.1.*

Question 1 (Sub-Submodel RAD_FUBRAD)

→ See answer above.

Question 2 (Sub-Submodel RAD_FUBRAD)

→ See answer above.

Question 3 (Sub-Submodel RAD_FUBRAD) As the authors are giving a reference for the Ozone absorption cross sections in the Chappuis bands could they also specify where the other gaseous optical properties are coming from. I assume that they are either based on the HITRAN database or on GEISA.

→ *As the absorption cross sections are described in Nissen et al. (2007), they are not explicitly mentioned in the actual manuscript: Temperature-independent absorption cross sections are taken from Molina and Molina (1986) where available (206–347 nm) and from WMO (1986) between 347–362nm. For Lyman-α line the parametrized effective cross sections are depending on the O_2 slant column as suggested by Chabrillat and Kockarts (1997).*

Question 1 (Submodel CLOUDOPT) What are the options for cloud overlap?

→ *Here we used maximum random overlap in agreement with the ECHAM5 treatment (for details see Roeckner et al. 2003). The possible cloud overlap assumptions in radiation computation of EMAC are maximum-random overlap (default), maximum overlap and random overlap.*

Question 2 (Submodel CLOUDOPT) What is the original reference for the ice-crystal optical properties. Are they based on A. Baran or P. Yang optical properties for example or something else.

→ *The specific relations for the solar spectral bands are given in Rockel et al (1991) and are based on Mie calculation, a specific correction for the asymmetry factor is applied to account for non-sphericity of ice crystals (Roeckner et al, 2003). Mass absorption coefficients for liquid and ice clouds are parametrized as described by Roeckner et al. (2003) based on classical approaches from Stephens et al. 1990 and Ebert and Curry (1992). Text changed accordingly.*

Spelling

→ *Corrected.*

References:

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Molina, L. T. and Molina, M.J. (1986): Absolute absorption cross sections of ozone in the 185- to 350-nm wavelength range, J. Geophys. Res., 91(D13), 14501–14508, doi:10.1029/JD091iD13p14501.

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