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Interactive comment on "Simulation of tropospheric chemistry and aerosols with the climate model EC-Earth" *by* T. P. C. van Noije et al.

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We thank the reviewer for the positive review and his/her constructive comments.

In response to the reviewer's main comment/concern related to frequency of the coupling (i.e., 6-hours) between EC-Earth and TM5 and how this frequency affects the chemical results, we would like to point out that the internal time step of TM5 is much shorter than the coupling time step, which only sets the data exchange between IFS and TM5. Details are given in our answers to the reviewer's specific comments below. The reviewer comments are given between quotes.

"Abstract, Line 13. Please don't use "which likely reflects an". It either does or doesn't or should be mentioned."

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We have removed "likely".

"Abstract, Line 18. I would add the value of the CH4 lifetime for EC-Earth, and then discuss the % change. You should state that this is the total atmospheric lifetime (vs that with OH)."

We have changed the sentence to "The atmospheric lifetime of methane in EC-Earth is 9.4 years, which is 7% longer than the lifetime obtained with ERA-Interim but remains well within the range reported in the literature."

"Page 1937, line 29. Another very good reference is Lamarque, J-F, L. K. Emmons, P. G. Hess, D. E. Kinnison, S. Tilmes, F. Vitt1, C. L. Heald, E. A. Holland, P. H. Lauritzen, J. Neu, J. J. Orlando, P. Rasch, and G. Tyndall, CAM-chem: description and evaluation of interactive atmospheric chemistry in CESM, Geosci. Model Dev., 5, 369-411, doi:10.5194/gmd-5-369-2012. (also in GMD)."

We have included this reference.

"Page 1938, line 15. "Decadal simulation. . . for present-day conditions". Is this a perpetual 2000 type of simulation, or do you run from 2000 through 2009?"

The setup of the simulations is explained in Section 3. The simulations are listed in Table 2.

"Page 1939, line 4. "Version 2.3" The abstract denotes the EC-Earth version as "2.4"?"

This was indeed a bit confusing. As stated in the abstract, the integration of TM5 is part of EC-Earth version 2.4. However, the atmosphere-ocean GCM used in our study is the same as in version 2.3. For this reason we refer to version 2.3 (the version used for CMIP5) in our description of the atmosphere-ocean GCM (Section 2.1). To clarify that TM5 is part of version 2.4 we have included the following sentence in Sect. 2.2: "The new model configuration with TM5 has been released as part of EC-Earth version 2.4".

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"Page 1939, line 4. "IFS model cycle" What is a model cycle?"

This is the standard terminology used by the ECMWF (see http://old.ecmwf.int/research/ifsdocs/).

"Page 1940, line 15. "3x2 degrees, 31 levels" Why such coarse resolution, especially since the EC model is run at 1.125 degrees? Also, is it really necessary to decrease the vertical levels to 31 (from 62 in the IFS)? If this were just about numerical cost, it would be nice to state this. If there is a technical reason why you've decided to have different horizontal and vertical resolutions that also would be important to state."

The reason for the relatively coarse resolution is indeed to reduce the numerical cost. 3x2 degrees is the standard resolution of TM5 for global chemistry applications, and the 31 levels are similar to the standard setup for offline simulations of tropospheric chemistry. We will clarify this in the text.

"Page 1941, line 5. "data exchange between TM5 and IFS is set to 6-hours" In most CCMs, the chemistry is inline and the chemical constituents are modified at least every hour (most less than that). Does this mean you calculate photochemistry just 4x per day?"

No, the internal time step in TM5 is much smaller than the exchange time. The operator splitting and time stepping applied in the model is the same as in the offline version of TM5 and has been described by Huijnen et al. (2010). A time step of half an hour is used for most processes, including the calculation of the photolysis rates. The chemical differential equations are solved using a time step of 15 minutes.

"Page 1942, section 2.2.3 Transport. The TM5 advection routine can use two schemes and it is stated that model simulations presented in this work used the Russell and Lerner (1981) approach. What is not stated is what the advection routine is in ECEarth. One can imagine when the EC-Earth / TM5 is fully coupled (not just one way as shown in the paper), that this could cause issues. In the future, do the authors plan to have

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the advection handle by the climate model in the fully coupled configuration?"

Also in the two-way coupled system, the tracer transport will be done in TM5. Transport in TM5 is mass conserving, while IFS uses a semi-Lagrangian advection scheme, which by itself does not conserve mass. As mentioned in the "Discussion and conclusions" section, this is an advantage of our system compared to C-IFS, in which the transport takes place inside IFS.

"Page 1947, line 25. "linear interpolation" I believe you mean you are doing a linear interpolation of the seasonal cycle for the emissions?"

Correct. We have now clarified that the RCPs are provided monthly emissions and adapted the text as suggested.

"Page 1956, lines 5-12. It would also be nice to report the lifetime with respect to OH (see Prather et al., 2012). In addition, adding the observed OH distribution (based on Spivakovsky et al., 2000) to the figure 3 would be interesting."

We have added the lifetime with respect to OH, and included two panels in the figure showing the OH distribution based on Spivakovsky et al. (2000).

"Page 1958, line 21. "Table 6" You mean "Table 5"?"

Thank you. The number has been corrected.

"General comment on the ozone section: It is a bit on the long side, especially compared to the discussion of OH and CO. You may want to make this section more concise. Also, it would be nice to know why the STE is lower in both model versions (relative to other published studies). Is this a direct result of too little ozone in the lower stratosphere or a dynamics/transport issue?"

We tried to carefully description of the differences between the simulations and the observational datasets. For that reason we prefer to keep the section as it is.

As described in Sect. 2.2.7, the vertical profile of ozone in the stratosphere is relaxed

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to a climatological dataset constructed from sonde and satellite observations. Thus, ozone concentrations are constrained to realistic values at altitudes above $\sim$ 100 hPa in the extratropics. Biases in the lowerlying parts of the stratosphere must therefore be caused by transport issues. A detailed analysis of this is beyond the scope of this paper.

"Page 1972, lines 5-6. "photolysis rates" Please be specific in this work how often these rates are updated for the present version and future versions. I.e., are you really only updating photolysis rates every 6 to 3hours?"

No, the photolysis rates in the current configuration are updated every 30 minutes, as in the offline version of TM5 at the same resolution. The operator splitting and time stepping applied in the model is described in the paper by Huijnen et al. (2010).

Interactive comment on Geosci. Model Dev. Discuss., 7, 1933, 2014.