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Geoscientific
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Discussions

Interactive comment on "A quasi chemistry-transport model mode for EMAC" *by* R. Deckert et al.

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Dear reviewers,

thanks a lot again for the very helpful and constructive comments. We have been discussing the five remaining questions and would you please find our reply below.

With kind regards,
the authors

Reply to Dr van Noije

i. In the introduction the authors explain the problem of diverging meteorological states in coupled simulations and how this interferes with the analysis of responses to chemical perturbations. The QCTM is proposed as a means to simulate identical meteorolog-

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ical sequences despite the perturbed chemistry. Another well-known way to produce similar sequences of meteorological variability is nudging. In fact the results presented in this paper are themselves based on simulations in which the tropospheric dynamics is nudged toward ECMWF reanalysis fields. I therefore recommend including a short discussion of the nudging method and of its limitations compared to QCTM.

Thanks a lot for your suggestion and we have added the following passage into the manuscript: "The nudging method alone (e.g. Jöckel et al., 2006) does not represent an appropriate alternative to the QCTM. As the term implies, nudging is a weak Newtonian relaxation of the internally calculated dynamical tendencies towards a prescribed meteorological state. At the same time, parameterizations and small-scale dynamical processes are not subject to any direct nudging. Hence, the butterfly effect is still present and binary identity, as defined above, not given. Figure 2" (would you please see the revised manuscript) "exemplifies the issue. It shows the difference in zonal-wind velocity between two nudged simulations with the CCM EMAC (see Sect. 2). The simulations obey the scenarios BASE and ROAD in Hoor et al. (2009), thus differ in a 5% disparity of NO emission from road traffic, but otherwise share identical setup, initialization, executable, and nudging of dynamical tendencies. A few hours after initialization, the small-scale dynamical features have diverged due to the feedback between dynamics and chemistry, generating a low signal-to-noise ratio for the difference in mixing ratios of chemical substances such as CO or O3 (not shown). Yet, the nudging will prevent the model dynamics from complete divergence".

Reply to Dr van Noije

v. In section 3.1 the five options for I_H2O_TENDENCY are not well explained. For instance, why is it mentioned for all options that the H2O tracer is defined? It is also not clear if the tracer is always defined in the whole atmosphere or for some options only in the stratosphere and mesosphere. If the first is the case, it should be mentioned how the initialization is done in the troposphere (from specific humidity). Further, for the option "I_H2O_TENDENCY=1" an offline oxidation source is not "added" but is

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replacing an existing representation. The authors should also better explain how the synchronization takes place and clarify when the H2O mixing ratios (tendencies) are updated from the specific humidity (tendencies) or vice versa. As for QCTM only the option "I_H2O_TENDENCY=2" is relevant, the description of the other options is better placed in an appendix. In any case, I propose to rewrite this part and clarify the above.

We have altered the relevant section:
"The submodel H2O serves several purposes. It creates and initializes the gas-phase tracer H2O as part of the model chemistry, in contrast to the specific humidity being inherent to the ECHAM5 core model. To clearly separate these two aspects, we will refer to the water vapor fields from the H2O submodel as H2O tracer, and to the water vapor field from ECHAM5 as specific humidity. Additionally, it provides an option to apply for the H2O-tracer tendency a climatology associated with CH4 oxidation. Furthermore, it controls the feedback between the H2O tracer and the specific humidity via synchronization. For any model time step after initialization, the synchronization first replaces value and tendency of the H2O tracer by those of the specific humidity. Then, chemical processes bring about a new tendency of the H2O tracer, either as online field from a chemistry submodel, or as climatology from the H2O submodel itself, or as a sum of the two. Finally, the new tendency replaces that of the specific humidity. Any replacement in either direction takes into account the different units of measurement. The details of the last replacement depend on the I H2O TENDENCY switch in the CPL namelist of the H2O submodel (see Appendix B). The preferred setting for the QCTM is I H2O TENDENCY= 2, implying an exclusive usage of offline water vapor tendencies in the final replacement mentioned above. These offline fields are calculated based on a satellite climatology of CH4 mixing ratios and pre-calculated climatological conversion rates from a coupled simulation. The default involves monthly average conversion rates from a MAECHAM4/CHEM simulation (Steil et al., 2003) which correspond to photolysis and oxidation of CH4 by OH, O1D, and Cl. Alternative input data may be selected through the submodel namelists."

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Additionally, we moved the explanation of the I_H2O_TENDENCY switch into the appendix:
"There are five different options for the switch I H2O TENDENCY in the CPL namelist of the H2O submodel. Among these, the option I H2O TENDENCY= 2 is the preferred setting for the QCTM (see also Sect. 3.2).
- I H2O TENDENCY=-2 or -1: The H2O tracer is not synchronized with the specific humidity. The two options differ in the initialization of the H2O tracer during the EMAC start-up. Option -2: initialization from the specific humidity. Option -1: initialization from satellite data in the stratosphere and the mesosphere in order to speed-up the spin-up.
- I H2O TENDENCY=0: The H2O tracer and the specific humidity are synchronized, taking into account online H2O-tracer tendencies from a chemistry submodel, e.g. MECCA1. Initialization of the H2O tracer is as for option -1.
- I H2O TENDENCY= 1: Same as for option 0, but an offline tendency from climatological CH4 oxidation is added to the online H2O-tracer tendency.
- I H2O TENDENCY=2: Same as for option 1, but only the offline H2O-tracer tendency from climatological CH4 oxidation is accounted for."

Reply to Dr van Noije
11. Page 2194, line 21: The "CPL namelist" is introduced without explanation what "CPL" stands for.

CPL stands for coupling. The distinction between CPL and CTRL (control) namelists of a submodel is an important aspect of the MESSy user interface (see Jöckel et al., 2005, 2010): CTRLs control the submodel core layer of a submodel, whereas CPLs are relevant for the coupling of submodels and the overall system.

Reply to Dr van Noije
24. Table 1: Please specify the ECMWF re-analysis that was used.

We used the operational-analysis data from the ECMWF. These are preprocessed to generate the nudging data for divergence, vorticity, temperature, and surface pressure,

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all in spectral representation.

Reply to Dr Lauer

2. p. 2190, l. 7-8: "...as a substitute of the feedbacks between chemistry and dynamics:" This is of course not true as the offline fields simply replace the online fields, which in turn might cause feedback between chemistry and dynamics. Please consider a more precise formulation.

Thanks a lot, and the formulation is misleading indeed. We have modified the relevant sentence: "In order to avoid the feedbacks, the simulations adopt the following offline chemical fields".

Interactive comment on Geosci. Model Dev. Discuss., 3, 2189, 2010.