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Geoscientific
Model Development
Discussions

Interactive comment on "The SOCOL version 3.0 chemistry-climate model: description, evaluation, and implications from an advanced transport algorithm" *by* A. Stenke et al.

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Referee 2

First of all, we would like to thank all referees for their valuable comments and suggestions, which helped us to improve the manuscript. In the following we provide our response to the specific comments.

1. *The authors should clarify the hybrid nature of the old transport scheme and*

mention the operator splitting between horizontal and vertical advection in the introduction.

We added the following text to the introduction: "The hybrid advection scheme applied in previous versions of the CCM SOCOL has been described in details by Zubov et al. (1999). The hybrid advection scheme uses the operator splitting approach, i.e. vertical and horizontal transport are calculated separately. In vertical direction it utilizes the Eulerian scheme proposed by Prather (1986), while in the horizontal direction a semi-Lagrangian scheme (Ritchie, 1985; Williamson and Rasch, 1989) is applied."

2. *I was always surprised how bad the semi-Lagrangian scheme in SOCOL performed; can implementation errors be excluded?*

   We checked the code and its performance extensively for different set-ups (Zubov et al., 1999; Rozanov et al., 1999; Rozanov et al., 2001). Therefore, implementation errors can be excluded to the greatest possible extent. The code behaves reasonably in most cases, except in the case of extremely sharp horizontal tracer gradients. Problems occur mostly during the austral winter when heterogeneous chemistry is very active inside the polar vortex, leading to a strong horizontal inhomogeneity for some trace species (e.g., HCl).

3. *Define/use CCly consistently in all parts of the paper.*

   Done, see first comment of referee 1.

4. *Please clarify what is done where with the water vapour (CTM/Climate Model).*

   Additional text included: "SOCOLvs3 considers only one water vapor field, i.e. the ECHAM5 water vapor. Large-scale advection, cumulus convection and the tropospheric hydrological cycle are calculated by the GCM, while chemical water vapor production/destruction as well as PSC formation are calculated by the chemistry module." (p3428, l7)

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5. *P3424, line10: change campaign to initiative*

   Done.

6. *I presume all your tests were done at L39?*

   Yes, that's right. We clarified this in the paper: "Within SOCOLvs3, 39 levels are used by default." (p3425, l16) "Both model simulations were performed with a vertical resolution of 39 levels." (p3428, l11)

7. *Could you clarify the horizontal and vertical grid of the CTM please (Gaussian, same as climate model)?*

   We changed the first sentence of Sect. 2.2: "The CTM MEZON has the same vertical and horizontal grid as MA-ECHAM5, i.e. the chemical calculations are performed on the Gaussian grid with a hybrid sigma-p coordinate in the vertical."

8. *Start 2.2 with: The CTM MEZON . . .*

   Done.

9. *If I understand correctly your transport time-step was 2 hours and has now been reduced to 15 minutes. Wouldn't the performance of the semi-Lagrangian scheme improve as well using a 15 minute time-step?*

   No, unfortunately it does not. We applied a 15 minute time-step for some sensitivity experiments with SOCOL vs2.0 and did not obtain any improvement in the simulated tracer distributions.

10. *P3432, line 17: Move this paragraph up.*

    Done, moved to p3432, l2.

11. *P3432, line 27: Mention time-step caveat.*

    As mentioned above, we do not expect large impacts of the reduced advection time-step on the simulated tracer distributions.

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12. *Not sure I understand the following statement; I assume your transport is done on the corresponding Gaussian grid as is the radiation? I would guess the other effect is second order? Isn't it more problematic that you have diagnostic vertical velocities? Some models have prognostic velocities in a semi-Lagrangian context (e.g. UMUKCA)?*

    We assume that this comment is related to the discussion about the wind-mass inconsistency problem and the potential benefit of a grid-point dynamical core. Yes, our tracer transport is determined on the Gaussian grid. It is hard to say which effect is more important. In general, it would be necessary to ensure that all changes in pressure levels due to advection match the pressure level changes determined by the surface pressure at t+dt, no matter how it is done.

13. *P3435, line 4: Maybe you could expand this point to illustrate the change that occurs due to the interactive ozone.*

    We included the results for ECHAM5 (T31L39) without interactive ozone in Fig. 2 (green line) and added some further discussion to the text: "However, it should be mentioned that the pure GCM MA-ECHAM5, without coupled chemistry (green line in Fig. 2), shows similar temperature biases in the polar winter stratosphere to SOCOLvs3. During other seasons (spring and summer, not shown) MA-ECHAM5 shows up to 5 K higher temperatures in the upper stratosphere. These differences are most probably related to different stratospheric water vapor concentrations: Since MA-ECHAM5 does not include chemical water vapor production, upper stratospheric water vapor concentrations in MA-ECHAM5 are 2-3 ppmv lower than in SOCOLvs3, resulting in less longwave cooling in MA-ECHAM5. Comparing stratospheric ozone distributions in MA-ECHAM5 and SOCOLvs3 reveals largest differences in polar fall and winter. During this time shortwave heating by ozone is negligible in polar regions, indicating that the specification of the ozone distribution (fixed ozone versus interactively coupled ozone) has only a minor impact on simulated temperatures in the polar stratosphere."

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14. *P3441, line 8: I am surprised by this statement, Why is this? Is the resolution still too low?*

    The simulated ozone distribution in SOCOLvs3 seems to be rather insensitive to the applied resolution. From a sensitivity simulation with SOCOLvs3 in T42L90 resolution we find a slight improvement in high latitudes w.r.t ozone, but the differences to the model runs in L39 vertical resolution are smaller than between SOCOLvs2 and vs3. Unfortunately, we don't have any results for higher horizontal resolutions, e.g. T63.

15. *P3443, line 21: Please explain the difference in definitions.*

    Within SOCOLvs3 we used a passive CO_2 tracer. As lower boundary condition we prescribed monthly and zonal mean CO_2 mixing ratios including a linear trend of 1.5 ppmv/yr together with a climatological, but latitudinally varying seasonal cycle (Hall and Prather, 1993). In SOCOLvs2 we applied a similar procedure, but instead of a seasonally varying CO_2-like tracer we used a passive tracer with a linear increase in time. Further explanation included in the text.

16. *P3445, line 14: How are vertical velocities coupled?*

    Not sure that we understand this comment: The tape recorder signal is influenced by the large-scale upwelling simulated by the model and possible numerical effects, i.e. numerical diffusion, which might depend on the applied vertical resolution. In SOCOLvs3 the vertical propagation of the tape recorder signal has slowed down compared to SOCOLvs2, but compared to HALOE it is still too fast.

Interactive comment on Geosci. Model Dev. Discuss., 5, 3419, 2012.