Geoscientific
Model Development
Discussions

Interactive
Comment

Interactive comment on "Numerical issues associated with compensating and competing processes in climate models: an example from ECHAM-HAM" *by* H. Wan et al.

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We thank referee #2 for the helpful comments and suggestions. Our reply is given below.

Eq 2: should be "+ Delta t P"?

Yes, there should be a plus sign instead of minus. Correction is made in the revised manuscript.

Scheme 2: I didn't find the description of the "Euler-backward [adjustment] factor" in the second stage clear. It looks like the term in N is updated according

to an Euler-forward step using the initial stage solution S* and the term in C is further updated by an Euler-backward step, but there is no further update to the term in P. Could this be explained and justified more clearly?

The adjustment factor $1/(1 + C\Delta t)$ comes from an attempt to discretize the complete sulfuric acid gas equation with the Euler-backward scheme, in which iterative evaluations of aerosol nucleation are used to avoid the need for a nonlinear solver. We explain this in the revised manuscript, and refer to Sect. 3 of Kokkola et al. (2009) for the detailed derivation.

Reference:

Kokkola, H., Hommel, R., Kazil, J., Niemeier, U., Partanen, A.-I., Feichter, J., and Timmreck, C.: Aerosol microphysics modules in the framework of the ECHAM5 climate model – intercomparison under stratospheric conditions, Geosci. Model Dev., 2, 97–112, doi:10.5194/gmd-2-97-2009, 2009.

In testing variations of Schemes 1 and 2:

- formally, the trapezoidal scheme has alpha=0.5 by definition - if you are only considering the case with alpha=0.5, why bother including alpha in (9)? (And relates to comment on description of scheme 3 below.)

We meant to use the generalized trapezoidal formula in which the trapezoidal method and Euler-backward scheme are two instances with different parameters. In the revised manuscript, we follow the referee's suggestion and directly use the value 0.5 in Eq. (9).

- for Scheme 1lm, it is mentioned that all available H2SO4 gas is able to condense - different to the 95% of the explicit schemes. Explain why this change is made.

The change in the limiter helps to eliminate positive errors in high aerosol loading regions discussed in the last paragraph of Sect. 4.2. This is explained in the revised paper.

For scheme 3 (and related to above): the implicit scheme in eq. 15 is the "trape-zoidal" scheme introduced earlier (so you could make that connection clear), but then the value alpha=1 is used, which makes the scheme (15) the "Euler-backward" scheme, also referred to earlier, but without the need for introduction. Why not simply state that the Euler-backward scheme is used to update (12)?

The manuscript is revised as suggested. We now state that the Euler-backward scheme is used to update (12).

Should there be a reference from the text to Figure 3e from the last para on p696?

A reference is added.

p.699: Runge-Kutta schemes are a family of predictor-corrector schemes, i.e. shouldn't be "[RK] and explicit predictor-corrector"

To our knowledge it is not common in the literature on ODE methods to define Runge-Kutta schemes as predictor-corrector methods, although both share the iterative nature. Therefore we distinguish them in the paper.

p.699: "visually indistinguishable" - can you put a number on it? The former is rather dependent on how you choose to plot! A number would also make it comparable to the later remark of a 1% difference achieved with the adaptive sub-stepping.

The corresponding sentence is changed into "In our simulations with the 1EP scheme, 8 sub-steps (7.5 min sub-step size) turns out sufficient to provide a less than 2% error in the annual mean H2SO4 gas burden, and less than 15% errors in the annually averaged zonal mean concentration. "

p.700, discussion of Figure 6: "confirm that if the clipping factor 95% is changed to 100%, the solution ... starts to oscillate again". From the figure, both solutions demonstrate the oscillations wrt number of sub-steps.

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The sentence is changed into "when the clipping factor is changed from 95% to 100% in scheme 1EP, the persistent positive errors associated with small sub-step numbers disappear."

Figure 1 caption: use "Scheme 1" and "Scheme 2" for consistency with the text

The caption and panel titles are revised as suggested.

Figure 2: the scheme labels in each plot are very small. Perhaps better: a single legend at the side?

A legend is added as suggested.

Figures 3 and 5: sub-plots are too small to be comfortable to read.

We will make the plots and font sizes larger in the GMD paper.

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