

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

**H. Wan et al.**

hui.wan@zmaw.de

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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**

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**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 11m, 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.

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**For scheme 3 (and related to above): the implicit scheme in eq. 15 is the "trapezoidal" 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 H<sub>2</sub>SO<sub>4</sub> 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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