

Referee report on the manuscript
“Implementation of splitting methods for air pollution modeling”
by M. Schlegel, O. Knoth, M. Arnold and R. Wolke
submitted for publication to Geosci. Model Dev. Discuss.

The manuscript discusses important implementation issues of a regional air-pollution model, including parallel processing, operator splitting algorithms and multirate time stepping. These issues are also relevant for a global air-pollution model. In general, it is difficult to combine operator splitting and multirate time stepping with parallelism, as this has to be done in an efficient way and without loss of numerical properties such stability and accuracy. The authors carefully explain how this can be done and the paper therefore seems to be definitely of interest for the readers of GMD.

The only serious drawback of the paper is its English: in some parts the manuscript is rather difficult to read due to unfortunately formulated sentences.

Furthermore, the authors should use the standard definitions of the speedup and the parallel efficiency (see e.g. Section 4.3 in book [1]). More specifically, the speedup can *not* be expressed in percent.

Specific (technical) comments and corrections:

1. I think “multirate time integration” should somehow appear in the title of the paper.
2. Introduce abbreviation RK (Runge–Kutta) on p. 2938, line 21.
3. P. 2939, line 2: replace “for this sub problem” with “for the chemistry problem”.
4. Reformulate the sentence on lines 8–9 on the same page.
5. Reformulate the sentence on the edge between pages 2939 and 2940 as: “The approach is based on an IMEX splitting presented by Knoth and Wolke (1998a), which we briefly outline here. Consider an equation. . .”
6. Reformulate lines 6–7 on p. 2940: “Denote the time substeps in the explicit method by $\tau_j = \dots$, with c_i monotonically increasing with i . Then the algorithm . . . can be outlined as follows.”
7. line 17, the same page: “in common notation” \rightarrow “in standard RK notation”.

8. General for Section 2: I guess it would be useful for a reader to emphasize that the IMEX approach of the authors can be seen as a higher-order generalization of the popular source splitting.
9. P. 2943, line 2: more explanations on what “linear invariants” mean is needed because the audience is not purely mathematical.
10. P. 2943, line 4: “...into slow and fast blocks that means that...” → “...into slow and fast blocks, flux splitting means that...”.
11. Explain “correlated cell influxes” on line 8–9, p. 2943.
12. The same place: please provide a bit more explanation on how the mass conservation is achieved.
13. Reformulate the last sentence before Section 3.1: “Since the workload balancing gets more complicated as the program complexity increases, we will also comment on this issue”.
14. Remove comma after “the COSMO model” in line 26, p. 2944.
15. Reformulate the sentence “Furthermore perpendicularly to the interface...” on line 21, p. 2945. Note that “extend” is a verb, “extent” is a noun.
16. Reformulate the sentence “As source terms of previous explicit stages are not needed...” on p. 2947, line 5.
17. Reformulate/split the sentence “Choosing the number of sub steps to be taken...” on p. 2949, line 8.
18. Split the long sentence connecting pages 2949 and 2950, clearly explaining all different types of flux exchanges.
19. Explain what “incremental” flux exchange means (p. 2950, line 11).
20. Correct “to nodes a the graph” on p. 2952, line 20.
21. P. 2953, line 14: “satisfying” → “satisfactory”.
22. P. 2954, line 7: insert comma in “...to minimize idle times during computation, it generally...”.
23. P. 2955, line 1: “when distributing ...” → “when solving ...”.

24. Insert missing commas in line 8, p. 2956.
25. P. 2958, line 1: Reformulate “Employing a multi constraint balancing approach the parallel speedup is acceptable.” e.g. as “A reasonable parallel speedup can be achieved by employing the multi constraint balancing approach as described in Section. . . .”
26. Insert more space between the two rows of RK tables in Table 1.
27. Avoid the unnecessary use of colors in the pictures—why not to use dashed and dotted lines with different markers?

[1] J. J. Dongarra, I. S. Duff, D. C. Sorensen, and H. A. van der Vorst. *Numerical Linear Algebra for High-Performance Computers*. SIAM, Philadelphia, PA, 1998.