Summary

F. Saito et al. paper addresses the problem of numerical computation of ice age in ice sheet models. Indeed, calculation of ice age is the major challenge of ice sheet modeling in various applications beginning with the preliminary choice of potential target place for deep drilling of ice sheets and ending with the accurate interpretation of ice cores.
The study area in Saito et al. manuscript is limited by a summit position of an ice sheet where the benchmark – an analytical solution for the ice age can be set. The authors examine two semi-Lagrangian RCIP schemes performance and compare results with more traditional Eulerian upwinding schemes for solving an advection equation.

General remarks

It should be noted that a family of RCIP schemes have been applied earlier in various problems of hydrodynamics, hydraulics etc., but their application for ice age calculation in ice sheet modeling is a novel and, perhaps, a promising approach. In reality, of course, we face with 3D problems of ice age computation, either when it is necessary to build the ice age field of the whole ice sheet or to construct a model chronology of a virtual ice core. From this point of view, the submitted research of Saito et al. may be considered as just an academic exercise comparing various numerical methods for highly idealized environmental conditions, which never occur in reality. Nevertheless, such kind of research are useful because they indicate possible pitfalls of rather traditional methods and introduce new approaches for solving tantalizing tasks in ice sheet modeling. In the 'Discussion and conclusion' section the authors reasonably point that the advection problem can be attributed not only to ice age calculation but also to calculation, for instance, of ice temperature. Anyway, further application of the RCIP method and its comparison with the Eulerian schemes in 3D will inevitably face with the choice of a true benchmark, which are, indeed, absent except in case of visual calculation of annual ice layers in ice cores. Moreover, for model interpretation of ice cores a very effective back-tracing method was suggested (Huybrechts et al., Climate of the Past, 2007) which is a powerful tool for dating of ice cores using ice sheet modeling technique. In the 'Discussion and conclusion' section authors mention that their aim is to proceed with examination of the RCIP scheme in 3D. In this view, I think it would be reasonable to outline possible restrictions, challenges and limitations of future research.
Another problem, which was not elucidated in the manuscript is the computational cost of application of different numerical schemes. I think it would be easy to do since all experiments were performed on the same computer facility. There is only short note on that (Line 239). The trade off between time of computation and accuracy in some cases may play for the simpler but faster method.
In general, the manuscript is well structured, the figures are informative (except the note below concerning an a possible additional figure).

Line by line comments

The title of the paper. The core of the paper is a set of comparisons between performance of the semi-Lagrangian RCIP schemes and the Eulerian once. Actually, there is nothing in the manuscript about ice sheet models. Therefore, it would be reasonable to be more precise in formulation of the title.

Line 15. "… more generally in tracer transport …". This statement is somewhat confusing. Dating of ice cores is not limited to tracer transport. This definition (tracer transport) may be attributed to Lagrangian or semi-Lagrangian methods only.

Section 1.1 and 1.2 The section lacks short general description of the semi-Lagrangian method in the context of its comparison with the pure Lagrangian and the Eulerian. Since the problem of interpolation is the most important in semi-Lagrangian schemes, it will be very much handful to make a (sketch) figure illustrating application of a 1-D semi-Lagrangian approach using definitions of the variables mentioned in the manuscript (arrival and departure points etc.). It would be also appropriate to address the reader to a classical paper (Stanoforth and Côté, 1991, Semi-Lagrangian integration schemes for atmospheric models: a review. Mon.Weather Rev., 119(9), 2206-2223.)

Line 61. Please comment on the first use of $g(x_j)$. What is it, what is the purpose of its introduction etc.

Line 187. To be precise, Rybak and Huybrechts (2003) did not employ semi-Lagrangian approach, but pure Lagrangian particle tracing.

Line 394. "Figure 14 is the result …" should be reformulated like, for instance, "Results of transient experiments are presented in Figure 14 …". Same is in Line 395: "same as IN Fig. 6 AND 7." Same is in the next sentence.

Line 459. Please, check equation for ζ. What is Z^{14}? Please, explain why did you use this particular formula for the smooth discretization? What did you mean under "some trial and error". In my view, you should be more exact.

Line 482. Please, indicate that your computations can be related to the summit points of ice sheets only, which are accepted stable throughout the time spell of numerical experiments.

Line 482. In my view, the fragment of the text "… ice-sheets under various configurations" is somewhat confusing. The results of the study are attributed to summits of ice sheets only, and their configurations have no any connection with the research.