Dear F. Parrenin,

Thank you very much for reviewing our manuscript.

Response to the comments:

1. Second-order scheme. We performed some additional experiments and compared the first-order scheme against the second-order scheme by de-Almeida et al. within the EISMINT framework. Enclosed we show some results with flat topography because the interpretation is easier without topographic effects. We also conducted experiments with the same mound topography as in the manuscript which where leading to the same conclusions.

The differences in the centre of the ice sheet are not big, as can be seen in Figures 1,2 and 4. Only near the surface there are some deviations which are linked to the two-level time scheme and the introduction of new ice at the surface. However in total, the differences between first and second order at the ice core location C1 and C2 are negligible.

Nevertheless, the differences near the ice sheet margin are substantial as can seen be seen in Figures 3 and 4. Figure 3 shows a virtual ice core in the ablation zone whereas ice core C1 and C2 lay in the accumulation zone. In order to close the δ^{18}O cycle in Earth-System-Models the values at the margin are of interest and therefor the difference between second and first order matters. Previous studies of tracer transport in ice sheets were mostly focussed on the ice sheet interior and for that purpose still first order backtracking method may be sufficient.

This deviations between first and second order in the ablation zone are likely associated to the greater velocity gradients near the margin. In addition during ice sheet build up the velocities vary more in the ablation zone, which is better handled by the two-level time scheme with second order accuracy.

The differences between first and second order are substantial near the margin but we can not proof if second order is really better in the scope of this paper. Therefore, a detailed comparison of different Semi-Lagrangian, Lagrangian and Eulerian schemes in ice sheet models is currently ongoing and will be condensed into a subsequent manuscript. Nevertheless for now, we assume that the second order scheme delivers better results near the margin and therefore it the additional numerical costs of about 5 times compared to the first order one are acceptable.

In addition a comparisons of first order and second order Semi-Lagrangian schemes in atmospheric models can be found in McGregor 1993 and in Staniforth and Pudykiewicz 1985.

Staniforth and Pudykiewicz 1985 found that first order schemes are inaccurate for large Courant numbers and exhibit poor conservation properties. McGregor 1993 observed that a first order scheme with straight lines and velocities taken at the end point produces an error of 4% each time-step for trajectories in a solid-body rotation problem.

We will include a comparison of first and second-oder schemes in the revised version of the manuscript.

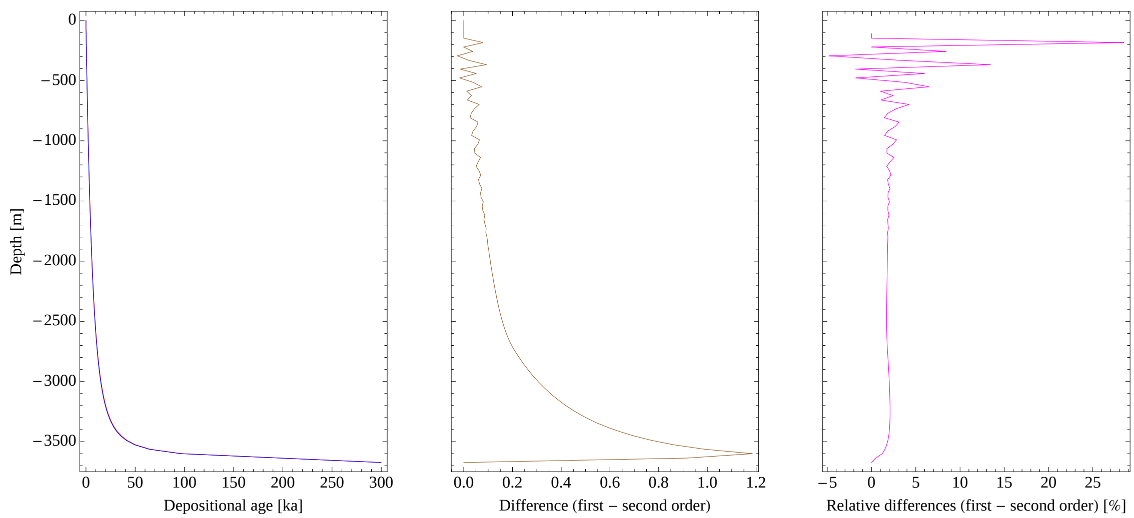

FIGURE 1. Simulated ice core C1 at x=y=750 km. The figure on the left shows depth vs depositional age in *ka* with first order in red and second order in blue. The middle figure shows the absolute difference (first - second order) and the right figure the relative difference in %.

2. Vostok ice core: We included a sentence in 3.2.1 Discussion for Greenland and Antarctica:

"In addition the 40km grid does not resolve details in the bedrock topography, which has a strong influence in the stratigraphy of the Vostok ice core (Parrenin et al., 2004)."

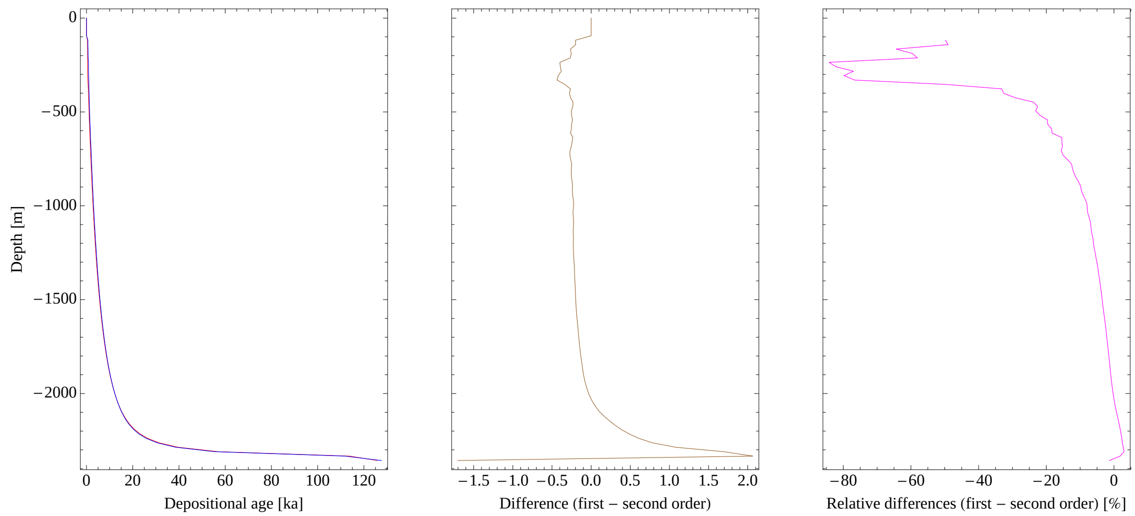

FIGURE 2. Ice core C2 with the same figure arrangement as in C1.

Thanks for the technical corrections! We have changed the manuscript, accordingly.

Sincerely,

T. Goelles et al.

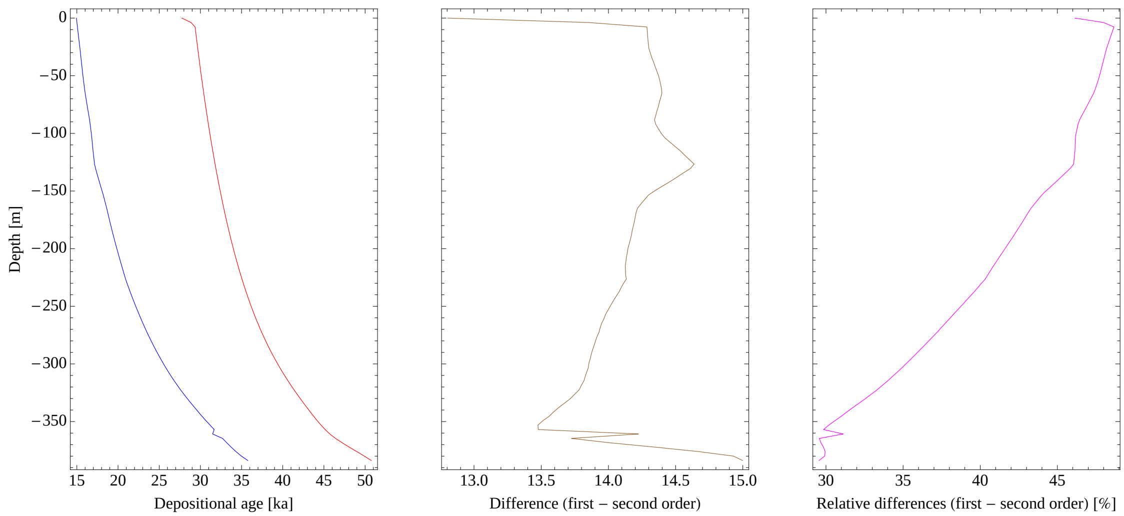

FIGURE 3. Ice core in the ablation area at x=y=1250 km. This core is not included in the discussion paper but illustrates the differences between first and second order in the ablation zone and will be included in the final version.

References

McGregor, J. L.: Economical Determination of Departure Points for Semi-Lagrangian Models, Mon Weather Rev, 121(1), 221230, 1993.

Staniforth, A. and Pudykiewicz, J.: Reply to comments on and addenda to some properties and comparative performance of the semilagrangian method of Robert in the solution of the advectiondiffusion equation, Atmosphere-Ocean, 23(2), 195200, doi:10.1080/07055900.1985.9649224, 1985.

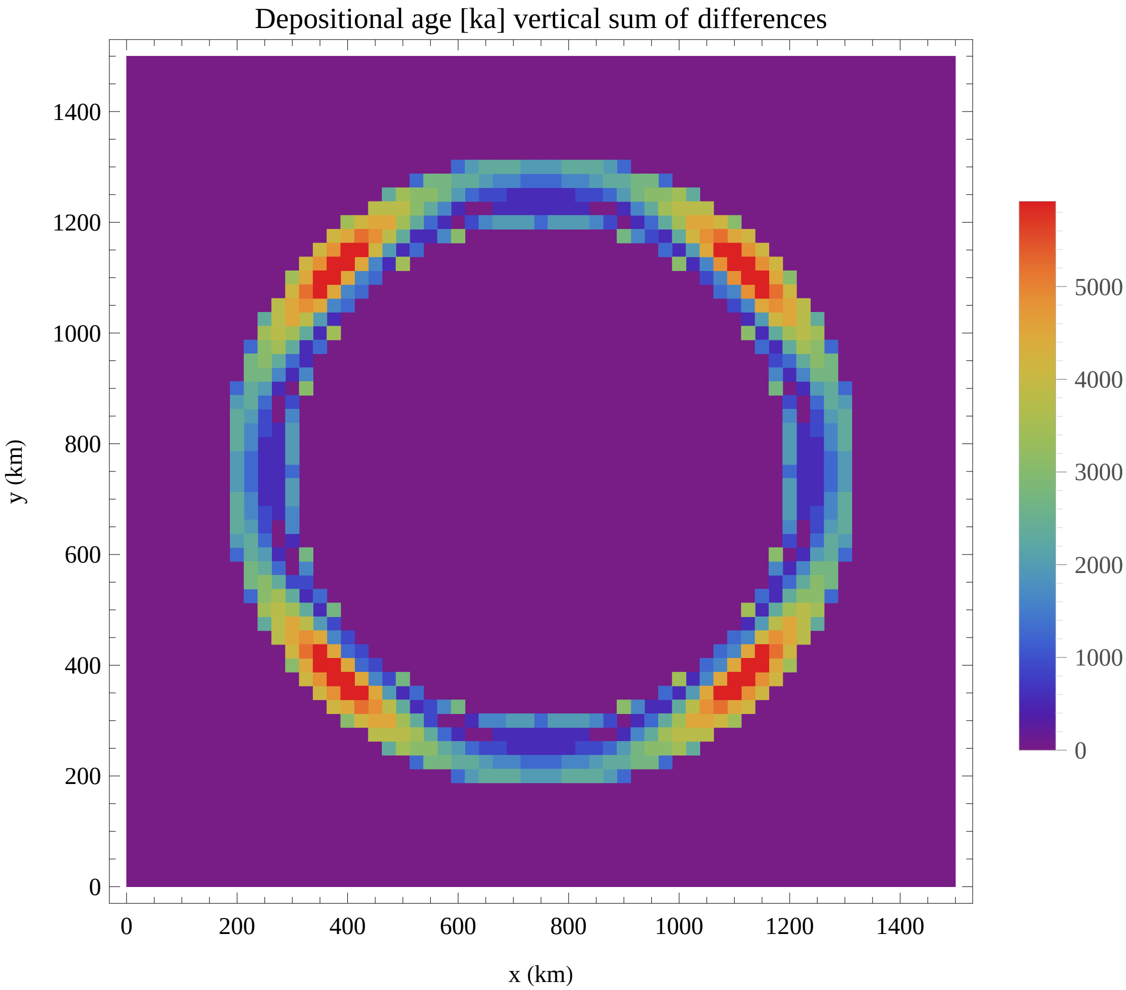

FIGURE 4. Vertical sum of the absolute value of the differences at each grid cell: $\sum_{ks=1}^{ksmax} \left| \frac{\text{first}(ks) - \text{second}(ks)}{\text{first}(ks)} \right|$