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Interactive comment on "Semi-Lagrangian transport of oxygen isotopes in polythermal ice sheets: implementation and first results" *by* T. Goelles et al.

G. K. C. Clarke (Referee)

clarke@eos.ubc.ca

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Adding a tracer tracking capability to a well-regarded, well-supported and readily available ice sheet model is a substantial contribution and one that certainly merits publication in GMD. Although I have several critical comments they are not intended to derail this effort.

Comments:

1. It is unquestionably true that second-order schemes can yield greater accuracy than first-order ones. The usual consequence of this fact is not that results from second-order models are more accurate than those from first-order models but that for second-

order models a larger time step can be employed to obtain the same level of accuracy. If the computational overhead required to apply a second-order scheme is substantial then it is entirely possible that a first-order scheme might be a better choice.

Thus my comment echoes that of referee Frederic Parrenin: It would strengthen this contribution if the superiority of the second-order scheme (in terms of accuracy and calculation time) over the first-order scheme was demonstrated rather than simply asserted.

2. I am concerned that the polythermal capability of SICOPOLIS is being misrepresented in this submission. In the temperate parts of polythermal ice sheets water isotopes are not passive tracers — at the very least one cannot rely on this assumption. The fact that SICOPOLIS can handle polythermal ice masses is a definite plus but this is only because it should help the model to do a better job of modelling the ice dynamics.

Using SICOPOLIS to trace the ice particle trajectory through zones of temperate ice does not face up to the problem that the key assumption of passive tracers is at risk when ice becomes temperate. At that point, a potentially mobile water phase appears. If one refers to Greve (1997, eqtn 2.16) one finds a water flux divergence term and in other work (Greve, 1997, eqn 18) a water drainage function D(w) to make this fact explicit. The only way the passivity assumption could be justified is if the water phase is completely immobile, in which case the bulk contribution would remain unchanged. One can assume this in the model but it may not match real behavior. Thus temperate or formerly-temperate ice should be entirely avoided when interpreting passive tracers. It might be worthwhile to use SICOPOLIS/SICOTRACE as a means of identifying this kind of ice so it can be avoided in ice core studies.

The authors' failure to acknowledge this problem leads to some claims that ring hollow or miss the point:

"tool to investigate the transport of any kind of passive tracer inside polythermal ice sheets" (p. 1138, Lines 14-15)

"temperate ice has significant consequences on the ice dynamics (Lliboutry and Duval, 1985) and therefore on isotope and tracer transport in general." (P. 1139, Lines 5-6)

"SICOSTRAT is capable of reconstructing the three-dimensional delta 18O concentration of a polythermal ice sheet" (p. 1140, Lines 4-5)

"The diffusion of delta 18O over multi-annual periods is considered to be negligible in ice (e.g., Jean-Baptiste et al., 1998)." (p. 1140, Lines 13-14) [This statement applies to the solid diffusion of water isotopes in ice but not to the intergranular transport of liquid water in temperate ice. Thus it justifies the assumption that water isotopes are passive tracers in cold ice only.]

Interactive comment on Geosci. Model Dev. Discuss., 7, 1137, 2014.