Interactive Comment on: "Modelling debris transport within glaciers by advection in a full-Stokes ice flow model" by A. Wirbel et al.

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We would like to thank Garry Clarke for his thorough and valuable review and for providing helpful comments on our manuscript.

1 Specific Comments

Comment: *For me the main source of confusion was whether a dimensional or dimensionless treatment was being followed. I got the impression that in fact both points of view were being taken but that the dividing lines were unclear. For example, the debris diffusivity D has dimensions* $\mathrm{m}^{-2}\ \mathrm{s}^{1}$ *(as it appears in Equation 5a) but on Page 9, Line 14* $D = 10^{-6}$ *suggests it has become dimensionless for the LeVeque test. Contributing to this confusion is the fact that time steps of* $0.01\,\pi$ *and* $0.1\,\pi$ *(dimensionless?) and mesh sizes of* $L_{csize} = 0.15\ \mathrm{m}$ *are discussed on the same page. Please clarify here and elsewhere.*

Response: Thanks for this comment, we were not completely clear about this point. We follow a dimensional treatment throughout this study. In the case of the "rotating three body problem" (de Frutos et al., 2014) (Sect. 4.1), we enlarge the computational domain from $\Omega = (0,1)\times(0,1)$ to $\Omega = (0,100)\times(0,100)$ meters in order to allow direct evaluation of the performance of chosen mesh refinement thresholds, which have units, that we apply in the glacier cases. In this manner, the size of concentration features in the test case becomes comparable to that of the concentration features in the glacier cases. This allows us to evaluate the suitability of chosen mesh refinement thresholds (c_{vol} and L_{csize}) that we also apply in the presented glaciological applications. To facilitate the understanding of dimensions used, as well as to highlight the actual equation we solve in our model, we have added Eq. 1 (Equation 6a in the revised manuscript) to the manuscript. Assuming an incompressible fluid and a constant diffusivity (D), Eq. 5a becomes:

$$\frac{\partial c}{\partial t} = D\nabla^2 c - \boldsymbol{u}\cdot\nabla c. \tag{1}$$

The assumptions used here have been stated in the manuscript. From Eq. 1 above it becomes apparent that D has the dimensions of $\mathrm{m}^2\ \mathrm{s}^{-1}$ when c is assumed to be dimensionless, as it is in our study. Timesteps as multiples of π in the advection tests stem from the angular velocity chosen in the de Frutos tests (de Frutos et al., 2014), where a whole rotation takes 2π seconds. We have clarified the dimensional approach we take in the manuscript by adding information on the dimensions of parameters at the following locations in the manuscript:

- $D = 10^{-6}\,\mathrm{m^2\,s^{-1}}$, Page 9 Line 14
- $\Omega = (0,100) \times (0,100)$ meters, Page 9 Line 15
- $0.01\,\pi$ s; $0.1\,\pi$ s, Page 9 Line 19
- $2\,\pi$ s (T), Page 9 Line 20
- T, at $t = 1.5$ s, Page 9 Line 26
- $2\,\pi$ s (T), Page 9 Line 30
- $\Omega = (0,32) \times (0,32) \times (0,40)$ meters, Page 9 Line 31
- $0.04\,\pi$ s, Page 9 Line 32
- $0.1\,\pi$ s, Page 12 Line 14
- $2\,\pi$ s, Page 12 Line 15
- $0.01\,\pi$ s; $0.1\,\pi$ s, Page 13 Line 4 and captions of Figs. 6-7
- $dt = 0.1$ s, $dt = 0.01$ s, $dt = 0.001$ s, $dt = 0.0005$ s, $t = 0.5$ s, $y = 0.6$ m, $x = 0.75$ m, $y = 0.85$ m, $x = 1.0$ m, Page 2 Lines 1-4, Lines 10-11, Line 13 and captions of Figs. A2-A5 in the supplementary material

2 Technical Corrections

We thank Garry Clarke for the careful reading of the manuscript and adapted the text to meet the suggested Technical Corrections.

Comment: *Figure 1 The caption should read "Kennicott Glacier" (spelling)*
Response: Corrected.

Comment: *P03, L29 "Eulerian" (not Eularian)*
Response: Corrected.

Comment: *P10, L04 917* $\mathrm{kg\,m^{-3}}$
Response: Inserted space.

Comment: *P10, L30* $x = 1800$ *m and* $x = 1900$ *m*
Response: Inserted units.

Comment: *P20, L19 Bozhinskiy et al. (1986): Check caps style*

Response: We checked the reference Bozhinskiy et al. (1986) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

Comment: *P20, L28 Glen (1955): Check caps style*

Response: We checked the reference Glen (1955) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

Comment: *P21, L07 John and Novo (2011): Check caps style*

Response: We checked the reference John and Novo (2011) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

Comment: *P21, L28 LeVeque (1996). Caps style*

Response: We checked the reference LeVeque (1996) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

Comment: *P22, L15 Nye (1957): Caps style*

Response: We checked the reference Nye (1957) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

Comment: *P22, L35 Ostrem (1959): Caps style*

Response: We checked the reference Östrem (1959) and adapted the capitalization of the title according to the reference style used in The Cryosphere.

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