Comment on 'Assesment of sub-shelf melting parameterisations using the ocean-ice sheet coupled model NEMO-Elmer/Ice'

presented on 15th of February 2018 by Favier et al.

In the manuscript, Favier et al., introduce the coupled model NEMO-Elmer/Ice and use it to assess the perfomance of sub-shelf melt parameterisations. This is done for an idealized setup of an ice-sheet and ocean system and using one coupled model. Although generalisation of the results to different geometries should be made with care, this study is of great interest for ice-sheet modellers relying on such parameterisations and reveals the advantages and disadvantages of the individual parameterisations ranging from simple linear parameterisation to the more complex plume and box model parameterisations. I have a few major comments on the manuscript:

Major comments:

- **Figures 5 and 6:**
  It is currently difficult to follow the reasoning of the main results because the figures are hard to read. The different model results are tricky to distinguish and partly not visible at all. My proposition is to split both figures into two figures each, one containing the information from the simple parameterisations and one from the plume and box model parameterisations.
  Some small changes could help to improve the understanding: (a) increasing/decreasing the dash length for the BME parameterisations with increasing number of boxes and for PME with increasing numbers, (b) if possible increased linewidth and legend font size would be great, (c) the $\pm 50\%$ range of ocean model results could be indicated in grey.
  In some cases, data is missing, e.g., in Fig. 5 panel (C) $M+_{700}$ is missing after 70yrs, in panel (E) M_{lin} is hard to see, in panel (F) $BM_{5,500}$ stops after 50 years. In Figure 6, panel (B) $BM_{2,700}$ stops after 60 years, in (D), $M_{lin,700}$ is missing after 80 years and in panel (E), M_{lin} (red) is not visible.

- **Plume parameterization:**
  More detail is needed: the explanation of why the melt rates show this patten of no melting near the grounding line and then increase towards the calving front without a melt-peak and decline afterwards is unclear to me, see also comment on page 17, lines 6-9.
  Given that its effecive grounding line depth is always the central grounding line, I would expect the PME3 parameterisation to yield results along the center line $y = 40$km that are similar to a line plume model. In Figure 8 (g) of Lazeroms et al. 2019 (doi:10.1175/JPO-D-18-0131.1) melt rates calculated with a comparable plume parameterisation and with a full plume model are shown for PIG with a melt rate peak around 15km and a decrease afterwards. Is this pattern different from the pattern you find here because of the higher T_0 value used (1 degree at depth versus -1 degree)? If yes, how could this be improved?

Minor comments

- page 4, line 12: Please check the reference to Schoof 2007, 'Ice sheet grounding line dynamics: Steady states, stability, and hysteresis'.
- page 8, line 19-20: Please clarify which formulation you mean.
- page 11, line 31: It would be great to have here a short explanation what the second parameterisation is about.
- page 12, line 5: Please add α in formula (7) to make it easier to understand its purpose, e.g., in Table 3.
- page 12, line 9: You could refer here additionally to the Appendix where you explain the effective grounding line depth.
- page 12, line 24ff: Please clarify that you explain the calibration of the coupled runs.
- Figure 3: Warm1 profile is missing in Panel (E). Generally, the details of this figure are hard to see. Could you maybe increase linewidth? And make the color schemes more intuitive by , e.g., using blue for the "Cold" scenario?
- page 15, line 20: Maybe add the missing plots in a supplement.
- page 15, line 30: The pattern in the TYP-10m experiment looks different from the other coupled runs as it shows melting at the opposite margin of the ice-shelf - why could this be the case? And what causes the wave-like pattern in the basal melt rates of the coupled model?
- page 15, line 33: 'occurs' instead of 'falls'?

- Figure 4, Appendix D4: It's not clear why there is no melting in the area $y \leq 40$m for PME4: the algorithm (as described in the Appendix) would identify the closest grounding line point as the effective grounding line depth for points in this region. An example is shown in Figure E1 (C, example 2). I guess that those points are excluded based on the criteria for PME1?

- page 16, line 3: 'are similar by construction'.

- page 17, lines 6-9: Please clarify: I do not understand why a plume rising from only a limited number of directions reduces the melt rates, since, as explained in the Appendix and in Lazeroms et al., 2018, the effective grounding line depth is calculated as an average and similarly the effective slope is an average value (or the local gradient)?
  Also, I would expect the central grounding line point to be generally part of a 'valid' direction, since it is the deepest point of the ice shelf - how can then the melting at the 'inner sides' of the ice shelf increase, because the plumes can emerge from 'more deeper portions'?
  And third, it is not clear to me how a 'combination' of more plumes can generate higher melting towards the ice front? Shouldn't in this case, because plumes can emerge also from shallower grounding line regions, the effective (average) grounding line depth be shallower than close to the grounding line? Wouldn't in this case the thermal driving be also lower (WARM profile)? Then the higher melting must relate to the plume scaling and the dimensionless melt rate curve $\hat{M}(\hat{X})$ or $g(\alpha)$?

- page 17, line 25: I think 'latter' and 'former' are switched.

- Figure 5: What causes the variations in the coupled model run in basal melt fluxes in comparison to the parameterisations?

- Figure 5 B: Some parameterisations show a decrease after $\approx$ 70 years. Is this because ice-shelf area is lost?

- page 20, line 18: $M_{quad,700}$ does not seem to do well for Warm3.

- page 20, line 26-27: '.. reflects the increase in thermal forcing compared to the depth-dependent forcing.' I do not understand your statement here: the thermal forcing for 500m depth is lower at depth and higer towards the surface and seems on average to be comparable to the thermal forcing in the depth-dependent parameterisation (Figure 3)?

- page 20, line 27-29: 'However, if the given...'. Please clarify: how does this statement relate to the result that in the 'Cold0', 'Warm3' experiments, the SLC for 500m is higher for all parameterisations while in the 'Warm0,1,2' all parameterisations using 700m have higher SLC?

- page 21, line 24, Figure 7: Please indicate that the RMSE is calculated by summing the deviations of SLC over all experiments (if this is true).
- Figure E1: If one doesn't know that the difference between PME1 and PME2 is how the calculation of the effective angle, it's confusing that Panel (A) shows both parameterisations.
- Appendix A: Please explain u_m^b and u_b.
- page 27, line 13: Please define θ.
- page 29, line 3: I think with 'checkerboard noise' you refer to Fig. 4 ?
- page 30, line 11: Since the formulas are not complicated, it would be helpful to add them here.

Technical issues

- page 1, line 20: 'ice mass loss' and 'ice-shelf thinning' are exchanged?
- page 2, line 3: 'lowering of grounded ice surface'?
- page 4, line 4: 'controlled by Glen's flow law'.
- page 4, line 9: switch 'Seroussi and Morlighem, 2018' and 'equivalent to the SEP3 method in'.
- page 7, line 23: 'this' too much.
- page 11, line 17: ice-shelf basal slope θ.
- page 11, line 25: Appendix C.
- page 12, line 25: Figure 3.
- Figure 3: Panels (C), (D), (E) are switched to (D),(E),(F).
- page 31, line 4: anti-clockwise
- Figure E1: 'used in the present paper'.
- page 23, line 34: 'Ekman pumping'.
- page 24, line 33: 'multiple'.
- page 27, Appendix B should be Appendix C.
- page 31, Figure E1 should be D1.
- page 32, Sections E1 and E2 should be D5, D6.

- page 33, Appendix F should be E.
- page 33, Figure G1 should be F1 and ‘Nico-’ can be deleted in the title.
- page 34, Appendix G
- page 36, line 20: ‘received’ too much.