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Interactive comment on "Simulated retreat of Jakobshavn Isbræ during the 21st century" *by* Xiaoran Guo et al.

Anonymous Referee #1

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This paper presents a modelling study of Jakobshavn Isbrae using the ice flow model BISICLES. The model is initialised and calibrated to fit the observed front retreat and annual velocities between 2004 and 2013.

Three parametrisations are used to control the position of the front:

- basal melting (Eq. 11),
- calving based on a crevasse depth criteria (Eq. 10),
- and a parametrisation meant to represent the buttressing of the ice melange in the front and that affect the driving stress (Eqs. 8-9) near the front.

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Discussion paper

Because it is a target for the calibration, the total observed front retreat is well reproduced by the model. The timing of the front variations with winter advance and summer retreat is captured by the model, however the seasonal variability is overestimated at the end of the period because the model does not reproduce the winter calving. Finally, the model is used to estimate the evolution during the 21st century.

The results during the calibration are convincing and well discussed. However, I found that few points are missing for the description of the model and set-up, the initialisation and calibration is relatively hard to follow as it involves many steps that have been implemented manually and the discussion mainly concentrates on what the model has and forget to include what is missing. I give more details below.

- My main remark concerns the parametrisation of the buttressing by the ice melange. The boundary condition for the front is not mentioned in the model description but should be the difference between the force exerted by the ice and the back stress from the sea water. It would seem natural to implement the effect of the ice melange as an additional back stress. The parametrisation implemented here modifies the driving stress near the front. More justification for this implementation is really required. Is this process really needed to reproduce the front variations? What appends if there is only the calving parametrisation? Moreover, the effect is proportional to the fjord temperature and is thus continuously increasing in the future simulations. However, as the temperature increases, we may expect some kind of threshold where the ice melange disappears and its effects become negligible?
- Few important informations are missing for the model description: What is the temperature field for the initialisation? Is the model thermo-mechanically coupled? What is the mesh resolution?
- The description of the initialisation is very hard to follow. For example for the step 2, we don't know what is the target to adjust β. In step 3, it is said that β from

step 2 is used but that there is no calving, however β controls the calving criteria. It is said that $\gamma = 1$, however in page 9, Eq. 11, it is said that γ was derived from the 1985 observed submarine melt rate.

- The discussion mainly focuses on the effect of the shear margins and the fact that due to the non linearity in the ice flow law the effective viscosity decreases as the strain-rates increase. This mechanism is described as a positive feedback, however I'm not sure that this is the right term, as both the velocities and the strain-rates are the results of the force balance equation, so that the velocities and the effective viscosity depends on the model parameters and boundary conditions. But is it difficult to describe this as a feedback as they both are solution of the same equation. However, the results are certainly dependent of the ice flow law and the value of the stress exponent, and we certainly may expect that the results would be different with a linear flow relation, or, as discussed, a flow band model that would parametrised the lateral drag. The mesh resolution might also influence the results as the resolution should be sufficient to properly capture the steep velocity gradients to represent this effect. In addition, the comparison with Bondzio et al. (2017) might be a bit confusing as Bondzio et al. include the thermo-mechanical coupling (which is absent here?), and they report that the warming from shear heating accounts for 20 to 30% of the decrease in effective viscosity. There is also several mechanisms that could affect the viscosity of the shear margins with potential feedbacks, this includes damage, cryo-hydrologic warming, anisotropy etc... This could be discussed also.
- Finally it would be also interesting to see or at least discuss how the model results are sensitive to other uncertainties in the model; this includes the description of the bedrock and the basal friction law, especially the linear assumption that is used here.

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