Overall comments

The manuscript analyses sources of uncertainty in modelling frazil ice. Frazil-ice processes are complex but are geophysically significant in a range of cryospheric settings. The manuscript falls within the scope of *The Cryosphere*. The manuscript analyses a wide body of literature in a thorough and careful fashion and includes lots of helpful review/analysis. It then undertakes a systematic formal uncertainty analysis which is a worthwhile novel advance in the field; in contrast previous analysis was more ad hoc and based on a limited exploration of parameter space. The manuscript compares single and multiple-size-class models and finds that (within the types of experiments considered), single-class models can be tuned to match the results of multiple-size-class models. Different sources of uncertainty in different types of models are systematically quantified and discussed. While the type of calculations are limited to examples motivated by simple laboratory experiments (and the picture may be more complex in the field), this study achieves significant and worthwhile results within its context. *The paper is well written, thorough and insightful and should be published subject to the minor comments below.*

Minor comments

- Code/data: I was not sure whether the code developed/used in this study was already available and if so where? The submission guidelines suggest:

  Authors are encouraged to deposit software, algorithms, and model code in FAIR-aligned repositories/archives whenever possible. These research outputs are then cited in the manuscript using the received DOI and included in the reference list. The manuscript must then include a section entitled "Code availability" or, in the case of data and code, "Code and data availability".

- L18: Could mention geophysical contexts like plumes of Ice Shelf Water under floating ice sheets.
- L48: Sentence probably needs splitting.
- L50: Perhaps add or substitute a geophysical example (e.g. from seismology)
- L56: A different kind of thing, but probabilistic methods are sometimes used in processing observational data (Frazer, E. K., Langhorne, P. J., Leonard, G. H., Robinson, N. J., & Schumayer, D. (2020). Observations of the size distribution of frazil ice in an Ice Shelf Water plume. *Geophysical Research Letters*, 47, https://doi.org/10.1029/2020GL090498)
- L74: The choice of *e* to denote thickness was a bit confusing as the letter is usually reserved for Euler's number. I'm not sure if there is a particular precedent or motivation. Perhaps *e* related to edge length? Similarly, the definition of *a* above equation (2) might be somewhat confusing (as it denotes only part of the surface area, not the whole). If there is a source of both of these choices come from, it would be good to mention it.
- L92: not very clear what delta_T refers to at this stage (I see you come back and discuss it later, so it would be sensible to add some cross references and/or consider consolidating the discussion)

- L108-109: It seems to be assumed that seeding and secondary nucleation produce crystals of the same size. This might be as good as any other assumption but could be spelled out more clearly
- L118: while relying on this precedent is fine, I think the main issue is that the flocculation rate in this form is independent of the number of the number of crystals. The nucleation term written (2) in equation (1) will be proportional to the square of the number of crystals while the flocculation term written (3) will be linear in the number of crystals. [I would think that both these terms arise from the same type of processes and should both be quadratic.]
- L180-188: the reference to Appendix A could have been put nearer the start of the paragraph? The whole of this paragraph was relatively technical and could have been move the appendix, perhaps. It would have been good to have a brief explanation of how this scheme was chosen (especially because other studies didn't necessarily use the same method).
- Figure 1: I found the graphs quite cluttered and hard to read. Could experiment with different colour schemes, larger figure panels (there was quite a bit of white space), perhaps one/two less data series. Perhaps the left panel would have been more useful plotted at some later time instead (e..g t=300s).
- Table 1: I spotted n_max here but missed where it was discussed in the main text (I saw it in L160 but not discussed in paragraph starting L105). It is quite a significant fudge factor so needs discussing somewhere in words when the notation is first introduced.
- Section 3: I felt this could be moved to an appendix/supplement. It wasn't clear that anything was particular to this manuscript. Perhaps a one paragraph summary could go at the start of what is currently section 4.
- L360: Presumably the minimum threshold is related to what you assume about nucleation. Secondary nucleation is about breaking off fragments of ice off, so presumably the minimum size might relate to this process and might not necessarily be the same as the scale that might be expected from classical nucleation theory.
- L386-395: Of course, in geophysical contexts, this uncertainty is even worse.
- L415: *e* and *r* should be italicized.
- Around equation (25), perhaps link back to equations (3) and (4) somewhere. It's not immediately clear how great a range of uncertainty there is in Nu as Nu is a rather complex function of the parameters. Also the logarithm symbol should be in Roman font.
- L445: A more general issue is that the choices of parameters are not independent, but may trade off against each other. I think this could have been discussed more strongly at various points.
- L447 paragraph: the meaning of these symbols is defined quite a long way removed from this section, perhaps a bit more of a reminder of what they mean might help follow the paragraph.
- Figure 4: there seems to be a slope variation from w proportional to r to w proportional to r^n where n \approx 1/2 which will reflect different dynamical regimes. The simplified approach (a_d) constant doesn't have this feature.
- Table 2: consider adding a column of parameter names/descriptors

- Table 3: Perhaps add the simplifications (t_s,a_d=0) in cases 1-2 more clearly (or in the caption).
- L517/L550: the sensitivity to initial conditions that you find is quite worrying for users of such models, as the initial conditions will be hard to know/control. I wondered if you had thought about what controls how long the ICs matter for?
- L572: the logic seems somewhat back-to-front here. It isn't the initial distribution that's key here, but rather what you assume about nucleation processes.
- L634: this might be true in the lab but not clear in the field
- L639: this is convincingly shown in this context (and is an important outcome), but might not be true in more complex situations where there is more complex evolution of the mean crystal size.
- L741: Rees Jones, D. W. (not Jones, D. W. R)