Review of revised version of Hofstede et al., Evidence for a grounding line fan at the onset of a basal channel under the ice shelf of Support Force Glacier (West Antarctica) revealed by reflection seismics (tc-2020-54)

General Comments

The authors are to be fully commended for doing a very effective job of addressing the comments and suggestions from the initial round of reviews. From my perspective, I am pleased to see that the authors have made an attempt to engage with relevant glacial geological literature that addresses many of the comments on the first submission.

There are a few issues that I would like to either re-emphasise, or issues that have arisen because of the changes to the manuscript. This manuscript's significance is that it is the first time that we have seismic observations of the sediments in the vicinity of an active ice shelf channel (making it worthy of publication). I don't dispute the potential for the subsea reflections reported in the manuscript to advance understanding of ice shelf channel processes of deposition, but I remain of the opinion that the authors are currently making slightly unfounded leaps from their (important) seismic observations of the subsea sedimentary structures, to some of their interpretations. As such, I think that the authors should consider carefully how far they wish to push some of their observations, which are prominent in the title of the paper (i.e. "*Evidence for a grounding line fan at the onset of a basal channel*…."). Most of what I critique below relates to the 'interpretation' of the chaotic reflections in section 4.5 of the manuscript, that despite engaging with relevant literature, doesn't do a good job of justifying why 'chaotic reflections' equate to a grounding line fan. An interpretation must be based on good logic and a strong argument, and at present this isn't the case here where there is a leap from 'chaotic reflections' to 'grounding line fan'.

[*Note that after having completed my review it became apparent to me that figure 2 includes what I would argue is some critical evidence, not currently described in the paper, that would very much strengthen the argument for a grounding-line fan. The authors may therefore want to consider some tweaking to figure 2 to present these data more effectively, and the inclusion of some additional text in the results and interpretation. This would bring stronger evidence for their interpretation of the near-grounding line deposits being associated with a grounding-line fan to the fore. Although it is a small part of the paper, since it is specifically mentioned in the title it is important to strengthen this interpretation.*]

Specific Comments

1. I remain totally unconvinced under any definition (i.e. glaciological, geological, geographical) that Support Force Glacier can be classified as West Antarctica. It initiates near South Pole, drains through the East Antarctica Ice Sheet (cf. page 3, line 27 of the manuscript), and becomes afloat east of the Dufek Massif of the Pensacola Mountains. Yes, it flows into the Filchner Ice Shelf, but I would not ascribe Recovery Glacier to West Antarctica on that basis. How about a compromise, and just refer to it as in 'Antarctica' in the title?

2. The updated version of the manuscript (and the new title) refers to 'evidence for a grounding line fan'. I cannot see geomorphological (seabed morphology) evidence for the presence of a grounding line fan in the manuscript (on page 10, line 15 the authors describe the seafloor around the basal channel as "fairly flat"), so the evidence for a "fan" is based solely on the seismic-derived subsea reflections ('*post review' update: see **). In the case of the latter, the authors need to either strengthen that argument substantively to make the

case for a 'fan', or to reduce the leap in interpretation a little. What is the geological smoking gun in the subsea stratigraphy that justifies this interpretation? Reference to geological literature on seismic stratigraphy may help in this regard. A grounding line fan is a geomorphological landform that may be identified in the geological (geophysical) record from particular stratigraphic structures and relationships between geological (geophysical) units. At present, I cannot see how the seismic data presented in the manuscript justifies such a strong argument that the data provides "*Evidence for a grounding line fan at the onset of a basal channel under the ice shelf of Support Force Glacier*…", the new title of the manuscript. Yes, it's fine to have 'interpretations' but such interpretations must be grounded in either specific observations and/or supporting evidence/analogies from relevant literature. At present, I don't see that a "grounding line fan" interpretation is securely built from the current observations and the literature.

3. The abstract states "*…..below the basal channel, the seismic profiles show an 8 km long, 3.5 km wide and 200 m thick sediment sequence with chaotic reflections we interpret as a grounding line fan deposited by a subglacial drainage channel directly upstream of the basal channel*." (underlining by reviewer). The authors should be encouraged to consider the implications of this interpretation. Firstly, that is a huge volume of sediment (~5.6 km^3) deposited by a single subglacial drainage channel. If true, it would indicate a high discharge channel persisting in/around the same location for a significant period of time, and long-term grounding line stability (or some significant flood events e.g. https://doi.org/10.1017/aog.2019.30 - ~60 m of sediment emplaced in a 4 week window). In addition, if that amount of sediment were deposited in that location, why is there not a geomorphic expression of it? Surely the seabed should have a topographic high associated with the unit of sediment deposited by the channel? If it does not, then what has caused the deposition of sediment adjacent to it? If the argument is that the subglacial water is the cause of high sedimentation rates at the position of the thick sedimentary unit with the chaotic reflections, then what is causing high sedimentation rates elsewhere along the grounding line where there are not meltwater portals/an ice shelf channel? The manuscript's abstract suggests "only little basal melting" which seems incompatible with high sedimentation rates elsewhere along the grounding line.

4. The chaotic reflections are critical to the interpretation of the 200 m thick sediment sequence as being a grounding line fan. What is the justification for this interpretation? What is it specifically about the reflections (e.g. thickness, scale, morphology etc.) that provides diagnostic evidence of deposition by meltwater? The authors should be encouraged to justify the description of these reflections a 'chaotic'. Based on figure 2d, to me it looks like the reflections, whilst sloping, curved, disturbed etc. actually have some lateral continuity and stratification, so their description as 'chaotic' may be a misnomer. These reflections are key to the interpretation of the sedimentary unit as a grounding line fan (see point 2 above), but the building blocks from those observations to the interpretation stage are currently weak – better description of the form and stratigraphic relationships of the reflections is needed (in sections 3.2 and 3.3), and then the interpretation of them as representing a grounding-line fan needs to be built on this description supported by reference to the relevant (glacial) geological literature (which the authors do to some extent in section 4.5). To evidence a fan, I would expect seaward dipping reflections in the along ice flow directions, and across flow reflections that showed evidence for channel migration across the fan ('*post review' update: see ***).

At present the paper doesn't describe the chaotic reflection zone in detail (e.g. there is little description of them in the results section (3.2/3.3) - either perpendicular or parallel to ice flow - and they are not effectively annotated on figure 3c), and there is a leap in the logic, from (a) chaotic reflections; to (b) grounding line fan; without the necessary steps in-between. What is it about these 'chaotic' reflections that makes them diagnostic of deposition by subglacial meltwater and therefore the argument for them representing a grounding line fan? At present, the manuscript doesn't make that case. The interpretation that the sediments provide "evidence for a grounding line fan" (as stated in the title) cannot be based solely on spatial coincidence and the fact that the deposits are unconsolidated; there may be alternative explanations for those "chaotic reflections" being located where they are (e.g. subglacial deposition and/or deformation prior to grounding line retreat), and it remains entirely possible that these subsea sediments have nothing to do with the processes occurring at the present-day (/Holocene) grounding line.

5. On page 10, line 15 – do the authors mean "subglacial structure"? Would "subglacial stratigraphy beneath the seabed" not be more appropriate?

6. Line 9-10 of abstract. You cannot have bedrock that has been deposited under "different glaciological circumstances" (unless it is from the Ordovician or Carboniferous periods etc.). As such, a re-phrasing of this sentence is needed.

7. Page 3, lines 13-15 – These key questions don't necessarily align with the title and abstract of the paper. Consider adapting?

8. Figure 3c – can the authors annotate the chaotic reflections on seismic profile 3 (as well as on the schematic), as they have for figure 2? The spatial relationship between the ice shelf channel and the chaotic reflections in this figure is critical to the finding of a "grounding line fan" so it needs to be made obvious to the reader. Personally, I found it impossible to see how the authors had extracted the zone of 'chaotic reflections' drawn in the adjacent schematic from figure 3c (seismic profile III). Based on what is presented, the chaotic reflections seem to extend far beyond the lateral limits of the ice shelf channel, which contradicts the statement on page 20, line 23 that they are "only present under the basal channel".

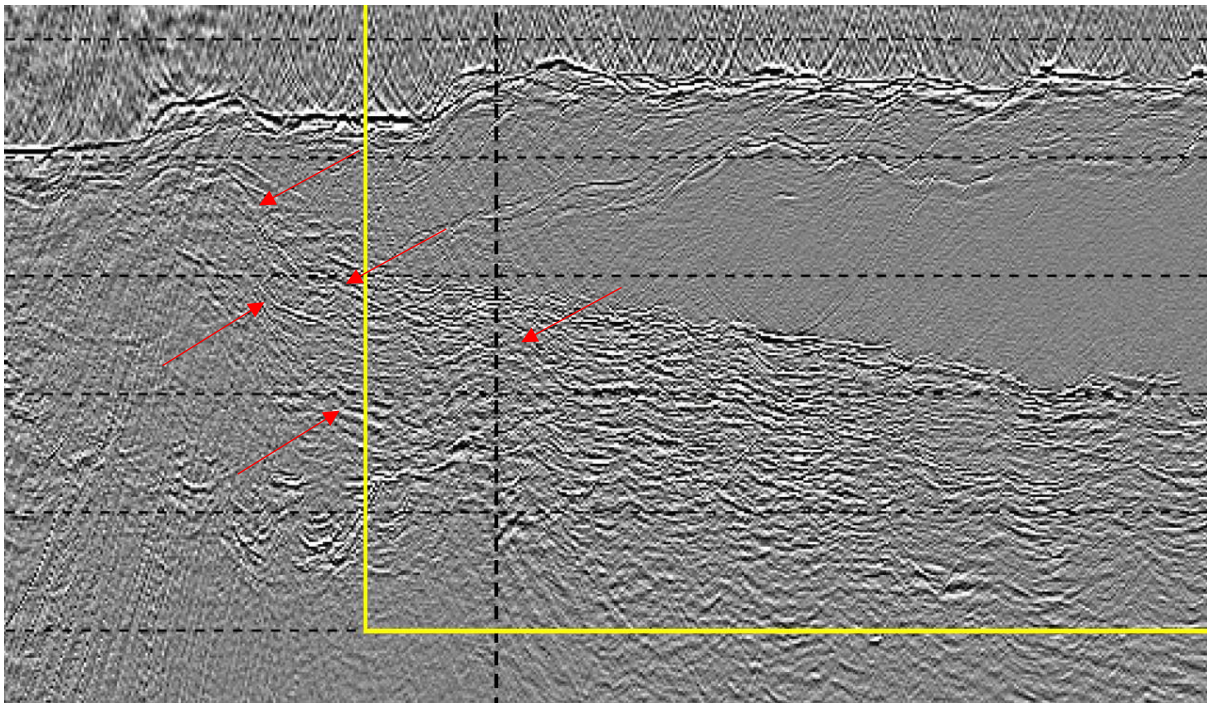
9. Figure 3 – there are very significant differences between 3c and the other two seismic profiles in this figure. The ice-water interface seems to be a more complex reflection, and there is a poorly defined seafloor reflection (in comparison to the strong ice-water reflection and obvious seafloors of 3a & 3b). Could attenuation of signal be part of the explanation for the weaker, more chaotic, subsea reflections of 3c? The data presented in 3c also looks a little noisier?

'Post-review' Comments

* actually, looking at figure 2 (2a & 2d) in detail, I think the authors could make the argument that there is geomorphological evidence for there being a grounding line fan (*but they don't currently do this in the manuscript*). Based on figure 2a, the seafloor is clearly dipping seawards within interval II between shots 46 and 112. The authors should make more of this, as it would strengthen the underpinning of their interpretation for a fan being present at the grounding line. Can you include

some back of the envelope calculations of slope gradient etc. of the seafloor and compare to the surface gradient of known submarine fans?

**Also looking at figure 2a, I also wonder if the authors are throwing away some critical observations that would further strengthen their argument (i.e. the dipping reflections between shots 38-53. Are these not seaward dipping reflections in the along ice flow direction that would be diagnostic of fan-like deposition? Or am I making too much of the data? It looks to me like (a) there is a dipping seafloor here; and (b) dipping reflections seawards of the grounding line (located at SP26). This is the part of 2a I am referring to (possible dipping reflections are annotated):



Dr Neil Ross
Newcastle University
18th December 2020