Review of “Recent rift formation and impact on the structural integrity of the Brunt Ice Shelf, East Antarctica” by De Rydt et al.

This manuscript reports on detailed observations and model analysis of two rifts in the Brunt Ice Shelf. These rifts may threaten the structural integrity of the shelf, and at the very least have caused quite some concern for the fate of the Halley Research Station on the shelf. An impressive array of observations have been collected on the behaviour of these rifts, and the observations alone reveal quite a lot about the nature of rift propagation. A numerical model is applied to determine the orientation of principal stresses in the shelf, and a clever heuristic algorithm for manually modeling the trajectories of the cracks is applied. This heuristic proves successful for replicating the observed trajectories of the rifts to date, and suggests at possible future crack trajectories and their influence on the ice shelf. The manuscript is generally well written and organized, and is likely to find broad interest among ice shelf glaciologists. I really only have minor comments and suggestions for the manuscript to clarify certain aspects and elaborate on others.

The abstract notes that a “simple fracture propagation criterion” was successfully used to hindcast the rift trajectories and suggest future trajectories. The term “fracture criterion” is commonly used to represent something like “stress intensity exceeding fracture toughness” from fracture mechanics or “stress exceeding strength” from strength of materials theory. What has actually been applied is a heuristic for iteratively and manually lengthening fractures based on (visual?) inspection of the orientation of the first principal stress ahead of the current crack tip location. I actually think this is quite a clever method, so I am not criticizing it here. Rather, I think it is somewhat misleading to call it a “fracture criterion” or “fracture model” in the usual sense of these terms. Perhaps I am being overly picky about nomenclature here, but after reading the abstract I was expecting to see more of a “hands off” fracture propagation model based on my understanding of the usual use of the term “fracture criterion.”

In general I think a bit more detail is needed on the modeling aspects of this study. In particular, more information is needed on the inverse modeling and fracture propagation algorithm. Specifically:

- Is regularization used in the inversion? If so, how much? And how is the level of regularization determined? The pattern of stresses will vary depending on level of regularization applied (which is often at least partially a subjective decision). Since you are relying on the stress orientations for predicting fracture trajectory, some details here are needed.
- It might be helpful to see an example of a single step of the crack propagation algorithm to better outline this heuristic procedure. For example, show the current extent of the crack, and the stress rosettes ahead of the crack, at a scale that resolves the step size (chosen as the mesh resolution here). Ahead of an existing crack there will be multiple rosettes, in principle one rosette for every triangular finite element (since you are using linear elements). Unless there is a rosette in an exact straight-line distance ahead of the current rift tip, I presume some choice must be made about some kind of averaging of the principal stress directions from rosettes in the vicinity of the tip. Is this simply a choice based on visual inspection? The directions may not vary much in this particular case study, but if the rift encounters a region of strongly varying flow then the decision about what direction to manually project the rift may not be so straightforward.
- P15 L30 (and subsequent residual reporting): I don’t think the “mean residual” is the best measure of model performance here, since you are looking at a misfit that can have positive and negative values. You could have areas of very large negative and positive misfit (indicating a potentially poor fit to the observed data) and yet still have a mean/median residual close to

zero. In this case it would be better to report something like the root mean square or mean absolute deviation.

- Figure 8: The stress rosettes are too small to see! The areas around the rifts could be zoomed in on much more, as it is not necessary here to see the full extent of previous figures. As the figure stands currently, I cannot really judge the performance of your manual rift trajectories. It is clear that they are quite close to the actual trajectories, but I think most readers would like to better see the detail around the individual cracks than the whole ice shelf domain.

Additional specific and line-by-line comments:

- The use of the term “chasm” sounds particularly ominous, but is a rather vague and unspecific term for a rift. This term is not defined at first use in the manuscript either, which could leave some readers in question as to what specifically a chasm is (especially as “chasm” and “rift” are used interchangeably in the text). Moreover, in the literature I don’t see the term “chasm” being used to describe rifts, which in the context of an ice shelf refers specifically to a through-thickness fracture (and not other features that might also be considered “chasms” such as partial-thickness crevasses or moulins). Since the manuscript is dealing specifically with through-thickness fractures, I would recommend using the more common and specific term “rift”. I have no problem with using “chasm” in a naming convention (e.g. “Chasm 1”).
- Throughout the text you interchange Halley “VI” and Halley “6” for naming the research station. For example, Figure 1 shows “Halley 6” and “Halley 6a” but the caption notes “Halley VI” and “Halley VIa". Probably best to choose one style of naming and stick to it throughout.
- P2 L8: calving induced -> “calving-induced”
- P3 L8: ice-shelf wide -> “ice-shelf-wide”
- P4 L6: it could be helpful to indicate on an earlier figure the outline of this previous calving event. It is eventually shown in Figure 8, but when discussed in the early part of the manuscript here it might be helpful on e.g. Figure 1 or 4 as well.
- Figure 2 caption:
  - In describing panel (b), you mention “blue-to-purple” dots for GPR data, but I only see pink dots which seem to indicate the crack tip. Can you clarify?
  - The radius of circles in panel (b) are said to represent the “local strain rate” which presumably is measured along baselines between pairs of GPS stations across the rift (this is later described on P7). It would be worth being more specific about this in the caption here, as strain rate is formally a tensor.
  - In describing panel (c), you mention the “Gatekeeper” but I didn’t see this defined.
- Describing “average propagation speed” of a rift (Figure 2 caption and elsewhere) may not be appropriate if the lengthening of the rift comes in episodic bursts (which seems to often be the case). The distribution of actual propagation speeds would be strongly bi-modal, with long periods of no propagation and short periods of very fast propagation. For such a distribution, the mean is probably not a meaningful measure of central tendency. It might be more appropriate to describe this as something like a “lengthening rate,” which would of course have the same units but not the same meaning as “propagation speed.”
- Figure 3: It’s not clear how/why the blue dots have been connected in panel (a)
- P6 L 6-7: It is rather hard to see this in Figure 3, as the horizontal scale has presumably been adjusted to view the meteoric inclusion rather than to highlight the fracture identification. As

both points are interesting in this context, perhaps it would be appropriate to show additional panels that zoom in on the fractures in the radar sections.

- P6 L9: extend -> extent
- P7 L24-25: I'm not sure I would call the rate of opening across an existing fracture a "strain rate." You can use the same units, but this isn't really a material rate of strain in the usual sense of the term "strain rate." Ahead of the crack tip this term would be appropriate.
- Figure 4: upon reading the text describing the Halloween Crack and studying Figure 4, I was missing the context of the general flow structure of the ice shelf. Although this later comes in Figure 7, it would have been helpful at this stage to determine whether the GPS baselines are representative of the crack's influence or just the divergent flow dynamics due to the geometry of the shelf and the presence of the McDonald Ice Rumples.
- P9 L30-31: this may in fact always be the case if rifts propagate in episodic bursts, which relates to my comment above about characterizing an "average" propagation speed.
- I struggled with Figure 5, as I didn't yet have the context of the flow vectors shown in Figure 7. At this point I wasn't sure whether the Halloween Crack was an opening-mode crack or a shear crack (the situation is more obvious for Chasm 1). The distinction is important for interpreting this figure. If it has any component of shear, then the change in baseline is in part due to shear translation across the crack. Clearly from panel (b) the appearance and influence of the crack is obvious. However, I think it would be helpful to resolve the GPS signals into components transverse to and parallel to the crack, after which the specific components of shear translation and crack opening can be resolved. Using a simple baseline connecting stations across this crack does not resolve this.
- Figure 5 panel (c) (and in text on P 11): This baseline is across the McDonald Ice Rumples and thus beyond the extent of the Halloween Crack, so I don't see why they would have anything to do with the crack. The change in baseline looks to me like it is due to the flow diverging around the ice rumples, which would happen with or without the crack. Thus I'm not convinced that this panel is useful here. I suspect that it is simply coincidence that the change from linear to nonlinear baseline rate-of-change (blue to red in the panel) happens around the same time the crack forms.
- P10 L2: as per comment above about resolving shear vs. opening displacement, I'm not convinced that the baseline change is due solely to "opening of the crack"
- P11 L12: as above, "spreading rate" may have both opening and shear components
- P11 L14: but you don't have GPS data for the K0-I0 baseline on the date that the crack formed, so I don't see how you can substantiate this claim. The extension rate may have sharply increased, but can this not be (at least in part) due to changing flow dynamics from these units diverging around the ice rumples?
- P11 L20: I'm convinced on the influence of the crack for H0, and probably at least partially for I0. However, does the speed normally increase in the region of I0 as the ice shelf moves past the ice rumples and begins to flow more or less unobstructed? A version of e.g. Figure 7a from before the Halloween Crack formed would be helpful for addressing this question.
- P13 L10: high strain -> high strain rate
- P14 L20 (and elsewhere): principle stress -> principal stress
- P14 L25: do you mean Sentinel-1 here?