Referee comments in red italics.
Author response in black.

Referee #1

General comments

This manuscript by Kelka et al reports an application of automatic lineament detection of a large-scale subsurface fault network in Australia. Authors use a compelling geophysical dataset and provide a precious comparison between various automatic lineament detection and manual lineament detection. The manuscript is well-written, rather efficient in delivering its message, and figures are important and well designed, even if some are too small, given the richness of the details they bear. This manuscript is an important contribution as large-scale mapping of lineaments (here faults) is an area of growing impact in geology, wether it is for resource exploration, but also for structural integrity of an area and seismogenic risk. I think it fits perfectly the thematic of the special issue it aims at but there is some points that would benefit some more explanations. Hereinafter are reported some relatively minor questions, remarks and suggestion I wish the authors can answer before publication

Specific comments

- *What is the depth reached by the subsurface dataset? Could not subsurface and surface data combined to produce a 3D mapping that also take into account the dip of the faults? I guess they here are vertical, but such approach will be usable in other tectonic context, hence it would be an added value to be able to get the dip of faults from this kind of datasets. Also would the use of a subsurface data help in areas with limited outcrops due to vegetation?*

  The presumed subsurface lineaments were derived from gravity and magnetic images, which are not associated with a specific depth. These datasets are inherently ambiguous in identifying depth, and while depths can be assumed, we do not make that interpretation in this work. We do assume all lineaments are vertical. Such a workflow would likely also be useful in areas with dense vegetation with limited outcrops. With additional work we may be able to develop some assumptions to infer relative depths and dips of the lineaments derived using various approaches, but the work involved would merit a subsequent study as it could likely produce a 3D fault map.

- *My main problem is that this paper present a workflow, but there is no actual workflow diagram that would make it easier for the reader to understand what are the inputs, treatments and outputs at the different steps. Each steps are individually well illustrated and explained, but I missed a nice overall figure for the workflow.*

  We now included a simple workflow diagram in figure 1 of the manuscript

- *It seems that the authors restrict this workflow to regolith, and its interest to Australia. I understand that this is a special issue, but Solid Earth is a large-scope publication, and so I suggest authors extend the interest of this study beyond Australian mining in regoliths in the introduction and discussion*

We changed the wording in the abstract (line 11) not only referring to regolith but to regions comprising thick cover in general.

- *There are been numerous studies that use drone/lidar images to map fractures from automatic lineament detection, should it be discussed what exactly does the subsurface geophysical dataset add to the table? There is two lines about that around l. 297 but it is very shallow, could you develop?*

  Great question. Lidar images collected by drones represent only the change in surface properties such as elevation or surface geology. We have added the following to the introduction text (lines 36 -44) to make this point more apparent: *"Datasets such as lidar, digital elevation models, or radiometrics data represent only the change in surface properties such as elevation or surface geology. These lineaments may or may not represent structures that extend into the subsurface. By using datasets that represent the subsurface (i.e. gravity and magnetics) lineaments extracted are directly representative of changes in the subsurface. The challenge is (1) identifying if the lineaments from any dataset are geologically meaningful and (2) if lineaments from surface and subsurface datasets represent the same structure (e.g. fault, lithologic boundary)."*

- *I miss a brief discussion about the uncertainty and resolution of the method (e.g. on the orientation of lineaments, length, or % of lineament actually existing)*

  Assessing the uncertainties related to the mapping of the lineaments is hard to address in the region we analysed in the manuscript. For the manual interpretation this is clearly related to the person mapping them. However, fro the automatic mapping the main source of uncertainty will be the resolution of the underlying dataset or the pre-processing of the data (e.g. upward continuation for the automatic gradient extraction). Field work could potentially help but we did not do this. We added to the discussion: Uncertainty in manual lineament mapping is directly related to the person's experience and the scale they are intending on mapping. The manual extraction of lineaments in this study focused on the regional linear trends (lineament greater than 1km). Addressing uncertainty for the automatic lineament mapping is hard and directly related to the resolution of the underlying datasets. In case of the automatic gradient extraction, the upward continuation can pose another source of uncertainty related to the loss of detail that increases with higher upward continuations. For an example of how uncertainly in lineament mapping can be assesses statistically, we refer to Pawley et al. (2021).

  Pawley at al. (2021) performed a statistical analysis on the extracted lineaments which is much easier in the case of dyes as they can be directly mapped.

- *The area of study has a long and complex geological history. So how do you know that the lineaments are indeed from the same long-term tectonic history which would be relevant to the fluid flow and related ore deposit?*

  Known locations of mineral commodities in the region have been associated with crustal-scale shear zones (Eisenlohr et al., 1989; Fraser et al., 2007). Part

of the intent of this work is to provide a workflow to explore whether or not these subsurface structures are identifiable at the surface via surface datasets such as elevation and radiometrics. We are not presuming that all surface lineaments are associated with sunsurface structures and identify the combined use of lineament density maps in conjunction with subsurface lineaments to try and identify areas where lineaments spatially coexist and hence could be geologically meaningful.

- *Is there any way to interpolate between the large gaps by giving the machine a specific regional trend?*

  We presume this comment refers to the lineaments and how connected they appear to be. If the automated algorithms did not connect lineaments, there is a reason (relating to thresholding of the edge amplitude or the angle at which each line segment should be connected) so interpolation applied in this context would remove these built-in constructs that define a lineament (which is specific to each method). With some methods, such as the algorithm in PCI Geomatica, parameters can be adjusted to allow for lineament connections at greater distances. Adjusting these parameters may be more appropriate and also highlights the problem of scale discussed in the Discussion section. The length of lineaments is limited depending on a multitude of factors including data density, resolution and area extent.

- *Finally, some paragraphs are really hard to get because of the overuse of jargon, unexplained terms that the non-specialized reader will left puzzled with, without any reference. I am referring to the treatment part mainly: "10 Gaussian to the Kernel"; "Akaike information criteria"; "Sobel filtering"; "Green function"; "Canny edge detection". What are those? Please explain in a few words and add references for more in-depth explanations.*

  We tried to explain our approach for obtaining the best-fit model of the principal orientations better and added references for the Aikake information Criteria as well as for the Sobel and Canny edge detection filters. The references that already exist in the text for performing gradient edge detection ("worming") are in our opinion suffice to point the interested reader towards the relevant literature.

Technical comments:

- *The abstract should summarize the main results of the study please replace l. 10 onwards with the actual finding of your study.*
- *1 why is it challenging only in Australia?*
- *We* changed the first sentence to: Mineral exploration in areas comprising thick and complex cover represents an intrinsic challenge. Also our training dataset to established this workflow is from Australia and hence the regional focus. *24 « « these and existing» suggest these don't actual exist, please reword*

  We rephrased to: "Here we utilize these and previously acquired gravity…"

- *30-33: complicated long sentence, could you add a break?*

- *42:what exactly is a targeting map?*
    - *A targeting map should allow to narrow down the area for exploration.*
- *Can the Olympic Dam located on fig 2?*

  No, the Olympic Dam is situated outside the area 9a please see response below

- *Figure one is small and the located area reported in a too subtle way.*

  We reworked the entire figure one that now also includes a workflow diagram. We omitted figure four and merged it with figure 1to allow the reader to better orient themselves within the framework of the Gawler Craton mineral deposit such as the Olympic Dam.

- *Is there a cross-section available for the area*

  Unfortunately, there are no cross-section available for this region.

- *Line 101: not sure transported cover is the good wording, what do you mean?*

  We remove the word "transported" and only address it as cover now

- *114: what analytical products? That is rather vague*

  We remove the entire sentence 'The data was reprocessed to produce a series of analytical products intended to aid interpretation."

- *139: parenthesis missing after figure 4*

  As we removed figure 4 we modified this sentence to "Ongoing exploration in the Central Gawler Craton targets…"

- *150 it is under explored yet exploited for 125 years??*

  The greater vicinity around the mine is relatively underexplored . *However, we changed the sentence to "*We choose the area in the Central Gawler Craton around the Tarcoola mine, an Au-deposit mined for over 125 years"..

- *155 157 : please remove the teaser*

  We removed line 155-157 from the manuscript