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Interactive comment on "The Kenya Rift revisited: insights into lithospheric strength through data-driven 3D gravity and thermal modelling" *by* Judith Sippel et al.

Anonymous Referee #1

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Dear colleague,

Please find below my comments on the manuscript entitled: "The Kenya Rift revisited: insights into lithospheric strength through data-driven 3D gravity and thermal modelling" by Judith Sippel et al. My comments are also attached in a pdf file.

General comments ———————— This is a clear and interesting paper which presents new results in the form of 3D gravity, thermal and rheological model for the Kenya rift area. However, a geological setting section is missing. In addition, it is unclear how the crustal structure is constrained. A discussion on the uncertainty of the crustal structure is missing.

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Discussion paper

1. The paper fits well the scope of SE. 2. The paper presents 3D density-gravity, thermal and rheological models of the Kenya rift area. To my knowledge this is new, this kind of modeling has never been done for this area before. 3. The authors draw several conclusions from their models which can help the understanding of the geology of the area. However I find some of their conclusions are weak because they are based on results which are not well constrained (crustal structure). 4. The scientific methods and assumptions are valid. 5. I find some of their results are weak. Notably, it is not really clear how the thickness and geometry of the different blocks in the upper and basal crustal layers are constrained though a lot of their interpretation is based on those results. 6. The descriptions of the models and methods are in general accurate. However, a description of the geometry of the model is missing (dimensions. . .) and the method for constraining the crustal structure (geometry and thickness of the different crustal blocks) is unclear. 7. Previous works are referenced well. 8. The title clearly reflects the content of the paper. 9. The abstract summarizes well the content of the paper. 10. The paper could be better organized. Notably a geological setting section is missing after the introduction. That would be useful for the reader to have a summary of the geology of the area and of the main geodynamic events. 11. The article is in general well written. The language is fluent and precise. 12. The mathematical formulae are correctly defined. 13. The tables are clear. 14. The reference list is complete and relevant. 15. Useful supplementary material is included in the form of four detailed appendixes.

Specific comments ———————— Part 1: The introduction is fine. However, the paragraphs (line 17, page 2 to line 14 page 3) describing the interactions between mantle dynamics and lithosphere is not clear. What kind of interactions are you talking about? (is it rifting? volcanism? doming?). It is not clear how your model can help to improve the understanding of these interactions. Please be more accurate. You consistently refer to western and eastern Kenya throughout the paper. What do they represent? Is western Kenya located west of the rift and eastern Kenya east of the rift? Please specify it at the beginning of the paper (in the introduction for example).

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A section "Geological setting and/or history" is missing between the introduction and part 2. Such a section may be useful to readers who are not familiar with the geology of the Kenya rift area and the main geodynamic events (amalgamation, rifting episodes, plume emplacement. . .).

Part 2: At the beginning of part 2 some important information are missing such as the dimensions of the model and an accurate identification of the different density layers you are considering (for example, you should indicate that your modeled mantle has two layers, the first between Moho and 1000 km deep and the second between 100 km deep and 200 km deep. . .).. Line 21 (page 4) to line 17 (page 5): this part describing the basin formation would fit better in a “Geological setting” section. For the upper mantle density distribution (between Moho and 100 km deep): which data do you favor: KRISP or Achauer and Masson(2002)? Line 11 (page 9): why “starting” model? Do you test different density models for the mantle?

Part 2.3.2: I understand the density is computed for depth between 100 and 200km. Are those density depth-averaged? This is not clear...

Part 3.4: I understand that the density and thickness of the upper crustal layer blocks and basal crustal layer blocks are constrained in order to best-fit the observed gravity. However, the way it is done is not clear. Is it done manually? Have you used a specific method? Are the blocks consistent with the five tectono-thermal crustal domains? What is the uncertainty on the crustal structure? Please be more accurate. The crustal structure is important for your later discussion. What ‘s the reference density column for the gravity computation?

Part 3: The sentence: “the modeled thickness. . . . . and the Moho geometry” (line 31-33 page 12) is not clear. Again, how are the different crustal blocks delineated? I understand those are constrained from KRISP data but how are they constrained away from the KRISP profiles?

Part 4.2: What is the error between the modeled and observed heat flow?

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Part 5.1.1: The sentence “hence these local. . . . . thickness maxima” (line 32 page 16 – line 2 page 17) is not clear.

Part 5.1.2: Conclusions are drawn from the upper and basal crustal layer density distribution. However, the data constrains are poor. So a discussion on the uncertainty of the crustal density distribution would be interesting.

Line 5 (page 18): you interpret mafic rocks below the Kenya rift though it is low Vp and low density. Could it be something else? What are the reasons to interpret this as mafic rock despite low Vp and density? Again, it is not clear how the thickness of the basal crustal layer is constrained away from the KRISP profiles though your interpretation is based a lot on this result.

Part 5.2.1: What are the depths of observed seismic peaks at the various points? This could be useful to include those peaks on the YSE profiles of fig. 9.

Line 9 page 24: it looks volcanism is offset towards western (and not eastern) boundary on the fig. 10a in the northern Kenya rift. . Line 11 -21 (page 23). The discussion on the plume-lithosphere interaction is not clear. That would be useful to indicate the location of plume impingement on a figure (figure 10 a for example). The link between the plume and strain localization is not clear. What is the link between the plume emplaced beneath a compositionally heterogeneous crust and the focusing of crustal thinning within the Southward tapering Arabian Nubian Shield? Line 16-18 (page 25): local areas of mass excess rather be related to ignored positive thermal anomalies?

Technical corrections ———————— Line 4 (page 5): “earliest extension” is written twice. Line 4 (page 5): “Paleo-Eocene” instead of Paloecene.

Figures: please add a title for each figure for clarity. Please add the names of the main structural features when it is relevant (Anza basin, Turkana Trough, etc. . .). Figure 5a: what is the grey square? Indicate on fig 10a the location of plume impingement.

Some comments on the references: ref. Allen and Allen 2009 or 2013? ref. Baker,

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Mitchell and Williams 1988 is missing in the text. ref. Cacace et al. (2016): isn't it Cacace and Scheck-Wenderoth (2016)? ref. Melnick et al. (2015). in the reference list it is 2012. the ref. Morley et al. (1999) (line 27 page 2) is missing in the reference list. ref. Strecker et al. (1990) is missing. ref. Turcotte and Scubert (2014) is missing. ref. Goetze (1978) is missing. ref Onuonga et al. (1997) is missing in the reference list. ref. Halls et al. (1987) is missing in the reference list. ref. Burov(2011) is missing in the reference list. ref. Catuneaanu et al. (2005) is missing in the reference list. ref. Seton et al. (2012) is missing ion the reference list. ref. Fuchs et al. (2013) is missing in the reference list.

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/se-2016-139/se-2016-139-RC1-supplement.pdf

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