Dear authors,

The paper ‘What does it take to restore geological models with ‘natural boundary conditions’?’ is an interesting work on structural restoration. The authors used an analogue laboratory model that is imaged with X-ray tomography, to gain new insights in the boundary conditions needed for structural restoration modelling. The authors have already done a lot of work to improve the quality of the manuscript. The majority of the initial manuscript is rewritten, carefully considering all the given comments during the first round of review.

When reading the revised manuscript, I had some more general thoughts and comments, listed below. Please find a document with more detailed line-by-line comments attached. If something is not clear, I would be happy to discuss it further. I hope this is all constructive and helps you to further fine-tune your manuscript.

- Especially in the abstract, but also in the introduction, make it more clear what is new about your work and what it adds to structural basin reconstruction in general. This will helps readers to quickly see what they can expect.
- When a basin forms, the interaction of tectonics (kinematic boundary conditions) and the basin infill (factors as sedimentation, erosion, compaction, etc.) can be important. I understand you simplified the influence of sedimentation and erosion by the punctual sedimentation that you applied in your analogue model, but I think it would be good to go a bit more in detail about this topic. Now you only mention it briefly in the last part of the discussion. I suspect that incorporating the basins infill in a future version of the model can help gain some insights in the fault effective viscosity.
- The viscosity inside faults plays an important role in your study. I miss some information about previous research (with actual references) on this topic in your introduction/methods section.
- The manuscript includes a lot of figures and tables. You can try to lower the amount of figures and tables by combining some diagrams into one figure. This will make the paper more synoptic and easier accessible. I added some suggestions for this. Also, try to use your figures a bit more by referring to them in the text. This can help you guide the reader.
- Maybe you can add a supplement with all your X-ray images, as the manuscript only comprises the final cross-section of your experiment. It would be nice to be able to see the build-up of the analogue experiment.

Line-by-line comments

Page 1

- **Lines 4-6:** In seismic basin analysis, flattening the base of a sedimentary sequence is a commonly used trick as a quick 'restoration' method. Maybe specify here the type of restoration. Also, maybe later in the introduction, explain a bit why in *analogue/numerical structural restorations* you classically flatten the top surface. Because when you flatten at the base of a layer, you remove the influence of thickness variations in sedimentation for the restored layer.
- **Lines 26-29:** I miss a sentence about how structural restoration helps with the stated 'problem' about filling the data gaps.
- **Line 38:** Remove *'also'*.
- **Line 51:** *'implementations'*, you mean numerical models?
- **Line 56:** *'in cases such as salts basins …'*, are salt basins the only basins giving problems with numerical models? How about inverted basins? If only salt basins form problems, maybe explain a little bit why and remove *'cases such as'*.

Page 2

- **Lines 7-10:** A little difficult to follow; have faults been neglected in all restoration methods or only in numerical test-cases?
- **Line 29:** Explain a bit about what a *'free surface'* is.
- **Lines 30-33:** Confusing sentence, please rewrite.
- **Lines 43:** Maybe you can add here shortly that you are explaining the method in section 2.2. Also, put the footer with the explanation of FAI here instead of page 3, as this is the first mention of FAI.
- **Lines 59-60:** Change to *'the experiment presented in this study has a size …'*.
- **Lines 71-88:** Change *'a … part'* to *'the … part'*.

Page 3

- **Lines 37-40:** To make this sentence easier to read, maybe start a new sentence of the part starting at *', particularly to stabilize …'*.
- **Lines 47-49:** *'This is … we apply'*, the *':'* makes the sentence a little confusing, please rewrite.
- **Line 79:** Maybe add a reference here?

Page 4:

- **Line 6:** What is an FGMRES solver?

Page 5:

- **Lines 8 & 9:** When reading this, it is not directly clear to me that Figure 4 is the tomographic image of the ending point of your analogue experiment, and also the starting point of the numerical modelling experiment. Maybe explain a bit more here. Also, maybe you can make 1 figure from figures 3 and 4.
- **Lines 51-52:** Please explain why it is not necessary for your study to know the total amount of extension and its velocity. These are particularly interesting parameters, as they give important clues that help understand basin-forming dynamics.
- **Lines 71-75:** Confusing sentence, please rewrite.
- **Lines 76-79:** Confusing sentence, please rewrite.
- **Lines 90-93:** Maybe you can explain this a bit further, either here or in the discussion. Compaction and decompaction can have an important influence on structural restoration.

Page 6:

- **Line 4:** What kind of *'specific deformation'*? Maybe explain a bit how you determine the deformation you use in the different structural settings to remove fault throw.
- **Lines 14-15:** What do you mean with *'In this section, the material properties described in Table 4 are used'*? That for the in section 4 described experiment the properties of Table 4 were used?
- **Lines 19-21:** In this paragraph, maybe explain shortly why you choose these viscosity values.
- **Sections 4.1:** I've now read this section a couple of times and it's still not very easy to read. I don't know if this is possible, but it might help if you add a figure showing all the parameters used in the described equations (or you add them to one of your figures). Also, use your figures to explain your text, now you're mainly referring to tables, but you also got a lot of figures, maybe they can help.
- **Lines 27-29:** Confusing sentence, please rewrite.
- **Lines 38-40:** Here you can refer to Figure 1.
- **Line 48:** What is a *'CFL condition'*?'

Page 7:

- **Lines 1-5:** *'This is an issue … velocity field.'* Maybe explain this a bit more.
- **Lines 12-13:** You mean *'… from a computational point of view'*?

Page 8

- **Line 22:** Change to *'On the other hand …'*
- **Lines 47-51:** Confusing sentence, please rewrite.

Page 9:

- **Line 11:** Change *'litterature'* to *'literature'*.
- **Line 28:** Which previous simulations? Maybe add some references.
- **Line 31:** You mean condition or conditions?
- **Line 40:** Change *'wether'* to *'whether'*.

Page 10:

- **Figure 7:** Please make 2 or 3 columns from your legend, so that the text does not overlap with the graphs.
- **Description Figure 7:**
    - From reading the description, it is still not completely clear what I am looking at in this figure. What information can I get from the diagram? Maybe rewrite the description a bit with the comments below. Adding a title to the diagram might also help.
    - Define *'this time'* and *'the corresponding cross-section'* (both in the second line).
    - You refer to Figure 4, for showing the different interfaces, but in Figure 4 is only a scale bar showing the *'layers'*. Figure 4 does not explain the difference between a *'layer'* and *'interface'*.
    - Maybe put the explanation of what an interface exactly is at the beginning of the description.

Page 11:

- **Figure 9:** Please make 2 or 3 columns from your legend, so that the text does not overlap with the graphs.
- Maybe you can make 1 figure from figures 7 and 9. Then it's also easier to see the difference between the two. Or put them next to each other on the same page.
- **Figure 10:** Maybe explain a bit what x and y represent. I assume they are the x and y explained in Figure 2, so you can refer to that figure here.

Page 12:

- **Line 28:** Change to *'Secondly, …'*.

Page 13:

- **Lines 12-13:** Maybe explain a bit more how fault histories and mechanical properties differ from your experiment and the real world. Also, it is actually quite interesting to see that some faults display inversion, while other don't. It might be interesting to write a bit more about this. Maybe your experiment can give some insights to basin inversion.

Page 15:

- **Line 5:** Please specify *'more' natural conditions*.

Page 16:

- Maybe you can also put figures 13 and 16 next to each other, to lower the amount of figures and the space they take.
- **The first paragraph of the Discussion:** This is a good, to the point, summary of what this study adds to the current understanding of the topic. I was missing this in the introduction/abstract so maybe you can insert this part there.
- **Lines 36-37:** You mean tectonic setting (without the 's')?
- **Line 39:** Remove *'however'*.
- **Line 40:** *'… some model parameters (e.g., other boundary conditions or material properties).'* Please specify which 'other' boundary conditions or material properties.

Page 17:

- **Figure 18:** Also here, make 2/3 columns of the list with interfaces. Maybe, this diagram can be merged into the same figure together with figures 7 & 9.
- **Lines 3-12:** This paragraph might fit better in the methods, as it explains your choice for the conditions you used for the left and bottom boundaries.
- **Lines 34-1 (page 18):** Confusing sentence, please rewrite.

Page 18:

- **Lines 13-15:** Rephrase.
- **Line 17:** Maybe *'future studies'* fits better here instead of *'further studies'*.
- **Lines 16-27:** What could be interesting as well, is looking into which viscous fault behaviour drives fault inversion, to gain new insights on basin inversion.
- **Lines 37-39:** Strange sentence, please rephrase. Probably removing *'first'* would help.
- **Line 41:** Can you specify the deformation types you're thinking of here?
- **Line 49:** Yes! It would be cool to compare your results with seismic data.
- **Lines 62-64:** Maybe add a reference here.
- **Lines 69-72:** Confusing sentence, please rewrite.
- **Lines 72-76:** Long sentence, that is a bit confusingly written. To make your statement more powerful, maybe rewrite into 2 sentences.
- **Lines 78-81:** Confusing sentence, please rewrite.
- **Lines 84:** What do you mean with *'leaving more freedom to the model'*?