Response to the comments made by Frank Peel (referee #1)

Dear Frank,

first of all thank you very much for all the work you put in reviewing “Reconstructing 3D subsurface salt flow” (se-2021-153)! We have rarely received such a through, informative and constructive review! Also many thanks for your sketches. These are super informative! We have now submitted a revised document in which we incorporated all suggestions from your side.

Here the response to your comments:

1. “Addition of cross sections to the paper” (your page 1):

   Please find in the attached pdf a revision of all figures – now including 4 cross-section figures directly based on your cartoons.

   - Figure 1 now includes two cross sections (b and c) that illustrate the difference between a basin in Archimedean equilibrium and an actively withdrawing supra-salt basin. We have furthermore added some simple formulas for further understanding. We will use this figure in the revised document to better discuss why we use the static equilibrium model for our salt reconstruction (also see point 2).
   - The cross sections of new figure 4 shows the restoration procedure of this paper, guided by sketch number 2 of your review. It is shown that the backstripping approach only includes unloading (and for scenarios 2 and 3 decompaction); this contrasts the classical vertical shear methods for palaeotopographic restoration.
   - The cross sections of new figure 5 are 2D restorations extracted from the 3D restoration along seismic lines Norg XL 8000 and Twente IL 9000 (location on figures 2, 6, 7, 8, 9, 10).
   - The cross section of new figure 9 shows the difference between the restoration approach of this paper and classic Airy-isostatic balancing based on a figure you sent informally by email.

2. “Applicability of Archimedean equilibrium approach” (your pages 1 and 2):

   We adressed this important point in the revised ms in the two last paragraphs of the introduction. Revised Figures 1b and 1c (see above and attachment) now allow to show and discuss the difference between a basin in static equilibrium and one which is not. You suggested that salt withdrawal and lateral salt flow in the Zechstein basin was rather small (in comparison e.g. to the GOM) and therefore likely allowed application of the equilibrium model; we now discuss this, and point out at the same time that the model procedure forwarded is also in the study area limited, e.g. when reaching piercement structures or in the very initial phase of post-salt sedimenttation (Early Triassic).

3. “Better explanation of restoration procedure” (your page 4):

   We now provide an improved description of the restoration procedure based on new figure 4. We added detail to the originally too brief method section; e.g. your question about “the space above the top surface: air or seawater”. We originally restored everything subaerially. Following our informal email exchange and looking at the restored top surfaces (residual topographies) of the model (-> please see new figure 10; might be shifted in place in the revised ms), we ran all restorations again using submarine conditions (seawater density above restored top surface).

Remodelling was anyway necessary because of the use of wrong physical property values for the Chalk Group (see referee#2).

4. “Restoration process independent of basement tectonics”:

We hopefully clearifed this in the revised paper. It is clear that any change in basement configuration will affect the current model; however, if known, where and what kind of change occurred, this can be introduced into the restoration procedure.

5. All comments on page 6:

All followed.

What we did not do: We left the TWT unit as “ms TWT” (SI unit) -> Fig. 3

In summary, thank you very much for your very thorough and helpful review! Your review provided the base for 3 completely new figures, and one completely revised figure. The new residual topography figure 9 also results from a suggestion by you (and your group in your emails).

Best wishes

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Response to the comments made by referee #2

Dear referee #2,

thank you very much for your straightforward, constructive and positive review of the ms "Reconstructing 3D subsurface salt flow" (se-2021-153).

Here is our response to your comments:

(1) "Introduction, motivation for conducting the study can be addressed in a clearer way":
We addressed the motivation for conducting the study more clearly. We stressed that the method proposed provides insights into 3D subsurface salt flow and redistribution on basin-scale, the rise and fall of salt structures and associated depocentre development, and external forces' impact on subsurface salt movement.

(2) "Table 1, density", but also Young's Modulus, Poisson Ratio of Chalk:
The physical properties for the Chalk were wrong. This error was not only in table 1, the same mistake was also in the lithological model used for backstripping and decompaction. We consequently re-ran all restorations of the study with revised chalk values (from onshore NL) provided by Hunfeld et al. (2021). Please find in the attached pdf the revised table and revised model results (e.g. in figures 5; 6; 7; 8; and 10). Please note that the revised models additionally contain a change suggested by reviewer Frank Peel: surfaces that were restored to a level below zero were treated as submarine, contrasting the original model (fully subaerial restoration). Yet, the new model results are quite similar to the original restoration results.

(3) "present-day cumulative average density":
Yes, this is grain density + porosity; we will make clear in the upcoming revisions.

All other suggested changes (lines 129, 144, 145, 146-147, 170-173, 210, 212) are now in the revised manuscript.

Again, thank you very much for your helpful review, particularly for exposing the mistake in our lithological model!

Best wishes

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Reference: Hunfeld, L.B., Foeken, J.P.T., and van Kempen, B.M.M.: Geomechanical parameters derived from compressional and shear sonic logs for main geothermal targets in The Netherlands. TNO: https://www.nlog.nl/sites/default/files/2021-12/data_selection_and_methods.pdf, last access: 11.04.2022.