Review of "**The analysis of slip tendency of major tectonic faults in Germany**" by Luisa Röckel, Steffen Ahlers, Birgit Müller, Karsten Reiter, Oliver Heidbach, Andreas Henk, Tobias Hergert, Frank Schilling.

Review by David A. Ferrill

**GENERAL**

The manuscript provides new slip tendency analyses to constrain the potential for fault activity in Germany, which is important for assessing seismic hazard as well as other fault related processes such as energy extraction and subsurface disposal or storage activities. This is a very interesting manuscript – the material should be of interest to a broad readership, and make a very nice contribution to Solid Earth.

My greatest concern with the article is that, for the article to stand alone and be easily understood, it needs to illustrate the regional stress field and provide representative slip tendency plots. Lacking this information, the slip tendency fault maps are difficult to understand and the related description is rather abstract.

A second concern is related to the justification for the assumption of a vertical fault set. This vertical-fault assumption needs to be (i) justified by providing the geological basis for assuming the faults are vertical, or (ii) explained with appropriate caveats provided regarding impacts of an incorrect assumption on slip tendency results for the stress fields of Germany.

Below are several specific comments and suggestions that could help improve the manuscript. Additional editorial comments are marked in an annotated pdf that will also be provided with this review.

We appreciate the very constructive comments and suggestions of the reviewer David Ferrill and tried to improve the manuscript according to his suggestions. E.g., we included the information on the stress field based on observations and we added the suggested slip tendency plots for different depth levels based on the model data from Ahlers (2021). We would also like to thank the reviewer for the comments in the attached document. See also below the answers to the specific comments.

**SPECIFIC COMMENTS**

**Description and illustration of stress states and slip tendency plots for study area (Section 2.1, 3D Stress State):**

What are the stress regimes in Germany? This section should summarize the stress state of the study area in terms of stress regimes (e.g., normal faulting, strike-slip faulting, thrust faulting), maximum horizontal stress directions, and variation as a function of depth. In present form, the paper relies on Ahlers et al. (2021), and discusses the stress analysis methodology of Ahlers et al. (2021) but not the result of that analysis which is a primary input for the slip tendency analysis in this paper.

Thank you for the suggestion. In subsection 2.2 “Stress State” we integrated a brief section (lines 72 - 80) highlighting the stress regimes and orientations in different areas of Germany. We also added subfigure 1 (b) that displays the available stress data (orientation, regime and location of stress magnitude data) in Germany from the World Stress Map (Heidbach et al. 2018) and the magnitude data base by Morawietz & Reiter (2020).

Furthermore, we added the major results from Ahlers et al. (2021) relevant to our analysis (lines 95 - 107). This includes a description of the stress regimes and orientations in 1 km depth and 8 km depth (mostly strike-slip regime and normal faulting regime respectively) as well as the new subfigures 1 (c) and (d) that visualize these results.

The manuscript would be greatly improved by illustrating the stress states by providing a map with representative slip tendency plots for subregions. Specifically, I recommend a map similar to figure 7 in Morris et al. (2021). Such a map would convey not only stress orientations, but also stress regime (cf. figure 1 in Morris and Ferrill, 2009, The importance of the intermediate principal effective stress ($\sigma'_2$) to fault slip patterns. Journal of Structural Geology 31, 950-959). Because of the variation in regime as a function of depth indicated by figure 11 of Ahlers et al. (2021, Solid Earth), it may be necessary to provide maps with representative slip tendency plots at two depths.

We added the new subfigures 1 (c) and (d) that also include the mentioned slip tendency stereo plots in depths of 1 km and 8 km. We chose the subregions according to variations in the orientation of the maximum horizontal stress and within different crustal units (shown in the new subfigure 1(a) to discriminate between such regions.

**Assumption of “Vertical fault set” (Section 2.2):**

Is there a technical basis for the “vertical” assumption, or is this just a matter of convenience? This assumption has major impact on slip tendency, and results are highly sensitive to stress regime. Please provide (i) a geological basis for assuming the faults are vertical rather than some other dip angle, and/or (ii) a rationale for making the assumption, with acknowledgement that -- if wrong -- this assumption can introduce large error in slip tendency calculation. Vertical faults may be ideally oriented for slip in a strike-slip stress regime, whereas vertical faults are never ideally oriented for slip in normal faulting or thrust (reverse) faulting Andersonian stress regimes. Therefore, the vertical-fault assumption will tend to skew slip tendencies lower values for stress regimes other than strike-slip regime.

GEOTIS is a huge database but information on the fault dip or type is only available for a subset. Since GEOTIS offers an exceptionally detailed and comprehensive fault data set, we still wanted to use this set despite the incomplete data to consider the more diverse strike pattern and spatial coverage the set offers. The use of a uniform dip allows the consideration of the entire data set and furthermore highlights the effect of the fault strike more clearly.

Following your suggestion, we included a statement in the description of the Vertical fault set (lines 141 - 144), highlighting the influence of the chosen uniform fault dip on the reliability of the results.

**Results Section 3.1 – Vertical fault set:**

Manuscript states that “Results near surface are visualized” (Line 115): What depth, and why near surface? Earthquakes tend to nucleate at significant depth rather than near the surface.

As noted earlier, if not correct, the vertical fault assumption is problematic and may artificially skew slip tendencies lower for stress regimes other than strike-slip regime where vertical faults are ideally oriented for slip. It would be good to acknowledge this in this results section

The visualization of results near the surface was due to a technical issue that has since been resolved. The map now shows the top view to be consistent with the figures displaying the Andersonian and Semi-Realistic fault set. However, we added subfigure 12(a), a cross section through the Vertical fault set in 8 km depth, where the majority of earthquakes have been localized alongside said seismic events.

We added a new paragraph to section 4.3 Influence of fault dip (lines 326 - 329), pointing to the source of error through the implementation of the faults as vertical in the respective stress regimes.

**Subscripting for slip tendency symbols**:

In all figures and throughout article, need to be consistent with subscripting of Ts, Tsnorm, Tseff, and Tsnormeff for consistency with text.

We replaced all figures referring to one of the above-mentioned slip tendency types with updated figures with consistent subscripts.

**Referencing**:

Although cited in the text, Morris et al. (1996) is missing from the reference list:

- Morris, A.P., Ferrill, D.A., Henderson, D.B., 1996. Slip tendency analysis and fault reactivation. Geology 24, 275–278.

Recommend citing the following paper in the Introduction (Line 41) as a very careful example of regional slip tendency analysis of 3D faults:

- Morris A.P., Hennings, P.H., Horne E.A., Smye, K.M., 2021. Stability of basement-rooted faults in the Delaware Basin of Texas and New Mexico, USA. Journal of Structural Geology 149, 104360.

We thank the reviewer for notifying us about the missing reference. We have added it to the list of references and have added the suggested reference to the list of previous works.

**References:**

Ahlers, S., Henk, A., Hergert, T., Reiter, K., Müller, B., Röckel, L., Heidbach, O., Morawietz, S., Scheck-Wenderoth, M., and Anikiev, D.: The Crustal stress state of Germany - Results of a

3D geomechnical model, TUdatalib [data set], https://doi.org/10.48328/tudatalib-437, 2021b.

Heidbach, O., Rajabi, M., Cui, X., Fuchs, K., Müller, B., Reinecker, J., Reiter, K., Tingay, M., Wenzel, F., Xie, F., Ziegler, M. O., Zoback, M.-L., and Zoback, M.: The World Stress Map database release 2016: Crustal stress pattern across scales, Tectonophysics, 744, 484–498, https://doi.org/10.1016/j.tecto.2018.07.007, 2018.

Morawietz, S. and Reiter, K.: Stress Magnitude Database Germany v1.0, GFZ Data Services [data set], https://doi.org/10.5880/wsm.2020.004, 2020.