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Solid Earth
Discussions

Interactive comment on "Discrete element modeling of a subduction zone with a seafloor irregularity and its impact on the seismic cycle" *by* Liqing Jiao et al.

Anonymous Referee #2

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This manuscript uses a DEM subduction zone to investigate the role of seafloor geometry in the seismic cycle. This type of modeling is useful for improving our understanding of the mechanisms that control size, timing, and location of large megathrust earthquakes. The discrete element approach used in this study offers a promising avenue toward linking seismic observations with physical processes driven by fault geometry. However, the novel contributions of this particular study are not obvious. The study reproduces observed behavior but does not offer significant new insight into the mechanisms that control the observations. I suggest that the simulation results should be compared to a reference model without a subducting seamount. This information can be used to more robustly demonstrate the role of geometry on the seismic cycle.

Furthermore, a suite of simulations can be run to test the role of different geometries on seismic behavior.

In line 130, Is the regeneration of particle bonds appropriate for a deforming fault gouge? Loss of cohesion in the damage zone might be better captured by withholding bond generation or regenerating bonds at lower strength.

In line 145. The mean radius of elements is 1km. Are the elements heterogeneous in size? If so, what are the range of particle radii used? Somewhere, there should be a discussion of the implication of using particles that are 1km in radius. The roughness that results from large particles would influence the slip behavior along the fault. How would using smaller elements alter the observations? What about the grain size distribution? There are essentially two scales of geometry here. First, stress heterogeneity set up by particle to particle asperities (km-scale). Second, the stress concentration set up by the imposed seamount (39km wide, 6km high). I suggest discussing more of the first to understand the role of particle roughness on seismic cycle.

The model is initialized with the seamount already subducted. The deformation that would have been associated with its emplacement is not captured here. The deformation associated with prior seamount subduction would presumably alter the timing and location of the splay faults. See [1].

Line 197. The rebound tends to reset the state of stress with respect to what? How is this quantified?

Section 4. The comparison to natural observation is good, but there is a lack of discussion about implications of the results. Furthermore, generalizing the interpretations beyond the Sumatran subduction zone to subduction zones in general would be helpful. The author is very focused on discussing how this resembles one particular subduction system. The DEM model presented here does not fully capture the physics of the Sumatran subduction zone. The DEM model instead can be used as a tool to investigate the role of seafloor geometry on the seismic cycle in general, rather than attempt to explain the specific behavior at one locality.

The author suggests that seafloor irregularities play a significant role in the seismic cycle. However, with only one simulation, causal links between seamount subduction and the seismic cycle are not robust. This claim must be supported by control simulations. The manuscript would be improved if results of a flat subduction interface were included. Some previous discrete element models [1,2] demonstrate clear earthquake cycles with periodic big events, without including a subducting seamount. Comparison of the results to other models and with a control simulation (subduction with no seamount) would improve the quality of the manuscript.

In line 500. The wording is unclear.

In line 531. I think this sentence captures the significant seismic hazard implication for the model and should remain. However in line 535, “in the near future” is defined as less than 100 years or one earthquake cycle. What additional seismic hazard estimation do the results afford, beyond saying that one earthquake will happen within the next earthquake cycle?

Line 750. Figure 7. Please include those reference points A to K

Line 770. Figure 9. The time scale over which deformation takes place in these displacement figures needs to be made clear. (a) and (b) are showing cumulative displacement over 80 years while (c) and (d) show displacement during one event only. Figure labels might make this clearer.

Line 780. Figure 10. Gray lines represent 0.2 year time intervals. During all of the big events, there are many gray lines. This means the fast slip events have durations of over 1 year?

References

[1] Foo, Wey Yi. Effects of Seamount Subduction on Tectonic Accretion, and Erosion, and Forearc Evolution: Discrete Element Simulations. Diss. Rice University, 2017.

[2] Fournier, Thomas, and Julia Morgan. "Insights to slip behavior on rough faults using discrete element modeling." Geophysical research letters 39.12 (2012).

[3] Blank, D. G., and J. K. Morgan. "Precursory stress changes and fault dilation lead to fault rupture: Insights from Discrete Element Simulations." Geophysical Research Letters 46.6 (2019): 3180-3188.

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