Review of the paper "A Study of Earthquake Recurrence based on a One-body Spring-slider Model in the Presence of Thermal-pressurized Slip-weakening Friction and Viscosity" by Jeen-Hwa Wang

This paper studied earthquake recurrence by numerical simulations of a one-degree-of-freedom spring-slider model with thermal-pressurized slip-weakening friction. The paper investigated the effects of the viscosity and the wear process on the recurrence time, slip amount for each event, slip velocity, and so on.

The many parts of the main results stated in the manuscript would not be obtained or read from the simulation results shown in Figs. 4-12. The main reasons of this were the assumption of the constant U_c in the simulations for the examination of the wear effect (Figs. 8-12) and the way of drawing Figs. 4-12.

Regarding the following specific comments [1]-[6] at least, the numerical simulations should be conducted appropriately and the manuscript and figures should be modified before the publication.

Major comments

[1] L.23-28 (Abstract), L.385, etc.

The Author stated that the effect of the wear process increases with C. However, the dependency of C on T_R or D is not obtained from the simulation results shown in Figs. 8-12. This is because U_c was assumed to be constant and the same in (a)-(d) for each figure, as stated in L.266-269 and captions of Figs. 8-12, which means that the other parameters (at least one among ρ_f, C_v, μ_f, Λ, and D_0) varied with C in (a)-(d) for each figure. In order to investigate the effect of C solely, the other parameters (ρ_f, C_v, μ_f, Λ, and D_0) should be constant and the same in (a)-(d), and thus U_c should change in (a)-(d) and vary with h(t) (i.e., the cumulated slip). It is better to calculate U_c using h=CS(t) for every time step in the simulations.

[2] ・L.285-286: “The left-handed-side panels in Figs. 5–7 show that V_m and D decrease when … U_c … increases”

・L.290-293

・L.309-310: “The phase portraits shown in the right-handed-side panels of Figs. 5–7 exhibit that … the size associated with D decrease with increasing h.”

The values of V_m, D, and the slope at the two fixed points cannot be compared among Figs. 5-7 because V and U would be normalized by different values of V_{max} and U_{max} among the figures. I guessed that V_{max} and U_{max} correspond to the maximum values of V and U in (a) for each figure and that the maximum values decreases with increasing U_c when $\eta \neq 0$, similar to the cases with $\eta=0$ (Fig. 4).

I suggest that V and U should be normalized by V_p and $V_p\tau_{max}$, respectively, where τ_{max} is the maximum value of the horizontal axis (1300) in Figs. 4-12.

[3] ・L.17-18: “T_R increases when U_c decreases or η increases”

・L.286-287: “T_R increases when either η increases or U_c decreases”

T_R increases when η increases for U_c=0.8 (Fig. 7), while T_R decreases when η increases for smaller U_c (Figs. 5 and 6). The behaviors of stick-slips should be investigated more carefully.

[4] ・L.276-277: “The value of τ_D increases with U_c”

・L.286: “while τ_D increases with η and U_c”

The τ_D values are unclear in the left panels of Figs. 4-6. Please add the enlarged figures for only one event.

[5] L. 278-282, L.288-292, L.405-407

I cannot understand what “the slope values at the two fixed points” means. $(V/V_{max})/(U/U_{max})$? Or $\frac{U_{max}}{V_{max}}\frac{dV}{dU}$?

[6] Some characters in the numerical formulas are very confusing.

- About slip and cumulative slip
  - u and U in the friction law (equation 2, the second term of the right side of equations 3 and 4, Figure 3, etc.) would represent the time-varying slip amount for one event.
  - u and U in $u-u_0$ and $U-V_p\tau$ (the first term of the right side of equations 1, 3, and 4, Figure 1, etc.) show the time-varying cumulative slip.
  - Also ΣU in Figs.4-12 correspond to the time-varying cumulative slip.
  - The (maybe time-varying) cumulative slip used in the wear effect is S(t). Is S(t) the same as ΣU in Figs.4-12?
  - Is D(t) in S(t)=ΣD(t) different from D (final slip of each event, defined at L. 16)?
- About friction, is *f* in L.155 the same as μ_f (L.156 etc.)?

Minor comments

[7] The topic on the wear process starts abruptly at L.20 in Abstract and the last paragraph of Section 4 (Simulation Results, p.11). To clarify the subjects of this paper, it would be better to add the statement that this paper investigated the wear process to the first sentence in Abstract and to the Introduction. In addition, the statements on the wear process in p.11 should be moved to somewhere before Section 4.

[8] L.53: ‘the Nankaido trough’ → ‘the Nankaido segment of the Nankai Trough’?

[9] L.60: "$T_R=\Delta\sigma^{2/3}M_o^{1/3}/1.81\mu v_l$"

The assumption of constant $\Delta\sigma$ and v_l is not needed to derive this relation. If $\Delta\sigma$ or v_l varies with time, also T_R varies with time.

[10] L.71-72

I cannot understand the meaning of 'the distribution of T_R'. The probability density distribution of T_R?

[11] L.87: 'the Nankaido trough' → 'the Nankai trough'? Or 'the Nankaido segment of the Nankai Trough'?

[12] L.152-153: "The latter is not appropriate in this study because of the request of constant velocity. "

The equations of SOP model for variable velocity are shown in Rice (2006), which can be solved numerically. It should be noted that I agree to adopt AUD model in this study in order to examine the wear effect.

[13] L.163 (equation 2)

How did the Author treat equation 2 for the stable sliding (e.g. cases shown in Figs. 11d and 12d)? u=0?

[14] ・L.167-168: "The force drop is lower for larger u_c than for smaller u_c."

・L.399: "larger U_c yields a lower ΔF than smaller U_c"

The final friction drop is 1, regardless of u_c and U_c (Fig. 3). Did the Author mean "the force drop for a certain displacement"?

[15] p.8

υ decreases with increasing T and η is proportional to υ. However, η was assumed to be constant in this study. I wonder if the simulations with η depending on T are possible. The Author does not have to conduct such simulations in this study, but the comments on this may be interesting.

[16] L.222: “V_p must be much smaller than 1”

The value of V_p depends on $D_o\omega_o$. How large is $D_o\omega_o$?

[17] L.223: “V_p is taken to be 10^{-2}”

Do the results change if V_p is another value?

[18] Section 4 (Simulation Results)

The results of the numerical simulations stated in pp.12-13 and L.381-414 should be moved to Section 4.

[19] L.252-253

The references are needed.

[20] L.264-265, L.377-378 etc.: “U_c is proportional to C”

This phrase seems to be strange for me because the variable is S(t) and C is the proportion coefficient.

[21] L.265: “This”

What does the word “this” show? The sentence just before this word? The fact “the more mature the fault is, the thicker its slip zone is” comes only from h(t)=CS(t).

[22] L.274-276: “the force drop, ΔF, decreases with increasing U_c, thus indicating that larger ΔF yields higher V_m and larger D”

I cannot understand the logic of this sentence. The Author’s intention may be “ΔF decreases with increasing U_c for a certain finite displacement” because the friction drop reaches 1 when displacement is ∞ regardless of U_c (Fig.3). If so, however, this phrase have no relation to “larger ΔF yields larger D”.

[23] L.292-293

The U_c values are different from those in L.248 and figure captions.

[24] L.301-305

In a one-degree-of-freedom spring-slider model with constant friction parameters, the system reaches limiting cycles even in the previous studies listed in L.304-305, although I have not checked the results by Kostić et al. (2013a) and Franović et al. (2016). The Author may consider the initial transient phase, but the phase depends on the assumed initial state before the spring starts to be pull with the driving velocity of V_p. The behaviors of the limiting cycle reflect the parameters of the friction and of the system properly. It should be noted that the very small transient phase was also observed in Rice and Tse (1986) (the reference in L.298).

[25] L.309-310

I cannot understand that the right panels show T_R.

[26] L.314

I cannot understand why larger η generates chaos.

[27] L.318

The slope values at V=0 and U=0 decrease with increasing η more drastically for the larger U_c.

As pointed out in my comment [2], the slope values should not be compared among the figures because U_{max} and V_{max} values are different among the figures.

[28]L.319

The references are needed.

[29]L.321: “the effects”

The effects of temporal variations of η and U_c?

[30]L.329-330: “$\Lambda=(\lambda_f-\lambda_n)/(\beta_f+\beta_n)$”

It would be better to move this to p.7, adding the definition of λ_f, λ_n, β_f, and β_n.

[31]L.338: “$\mathrm{\mu_f}$” → “μ_f”

[32]L.347: “$\mathrm{\rho_f}$” and “n” → “ρ_f” and “n”

[33]L.362-364

The Author used the words “time-varying”. However, “the increase in permeability can result in the increase in pore pressure due to slip” would be better because “This” in the sentence “This can reduce the frictional resistance” obviously means an increase in the pore pressure.

[34]L. 410: “$\underline{\mathrm{C}}$” → “C”?

[35]L.411: “approaches unity”

The slope values seem to become smaller than unity in Figs. 9-12. Plotting the slope values (with time or slip) may clarify this point.

Why does the unity important? The slope values depend on the V_{max} and U_{max} values.

[36] Bizzarri (2010) showed the effects of the wear process on the stick-slip behaviors, assuming the friction law with thermal pressurization, and thus the results on the wear processes in this study are not new. I suggest that the statements on the results of the simulations including both the wear processes and the viscous effects (Figs. 11 and 12) are added.

[37] Are the η and C values used in the simulations consistent with those estimated by observations or laboratory experiments in previous studies (e.g., Boneh et al., 2014, pageoph)?

[38] Vertical aces in Figs. 4-12

Please add the scales of the $\Sigma U/U_{max}$ aces. The maximum of $\Sigma U/U_{max}$ must be larger than 1 because U/U_{max} reaches 1 or larger in the right panels of (a).

[39] Fig.8-12

Why do the behaviors of the stick-slips (e.g., T_R, D, and V_m) vary with time in spite of the constant U_c?

[40] Figs.11(a) and 12(a)

Why $V_m/V_{max} \neq 1$? I guessed that V_{max} was defined as V_m in (a) for each figure in Figs. 4-10.

Why is the maximum of U/U_{max} larger than 1? I guessed that U_{max} was defined as the maximum of U in each figure in Figs. 4-10.

[41] Figs. 11(d) and 12(d)

Why are there two thin solid lines? Why is $\Sigma U/U_{max}$ constant (thick solid line)?