Solid Earth Discussions

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Comment on se-2021-6

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Community comment on "Very early identification of a bimodal frictional behavior during the post-seismic phase of the 2015 M_w 8.3 Illapel, Chile, earthquake" by Cedric Twardzik et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-6-CC1, 2021

Dear Dr. Twardzik,

Your study "Very early identification of a bimodal frictional behavior during the post-seismic phase of the 2015 Mw8.3 Illapel, Chile, earthquake" unravels the evolution of early afterslip during the first 12 hours that follow the 2015 Illapel earthquake. You find two separate regions of afterslip, north and south of the mainshock rupture, that accumulate slip with different mechanisms. The southern region is almost entirely seismic, as shown by the tight correlation with the moment of aftershocks. Indeed, an Mw 7.1 aftershock occurred there in the first 20 minutes following the mainshock and it was followed by an Mw 6.8 aftershock some 5 hours later. When the coseismic offsets of these aftershocks are removed, the geodetic inversion does not resolve significant slip at that location. In the northern patch, there is spatial overlap between afterslip and aftershocks, but no correlation between the evolution of afterslip and the evolution of aftershocks (either considering the number or moment). Hence, these observations provide clear evidence for the spatial heterogeneity of the constitutive behavior. The study provides observational evidence for afterslip to be virtually entirely seismic at some locations. These results are important, providing clear evidence against the common assumption that stable or strengthening frictional regimes are dominant during the postseismic period. In hindsight, this is not surprising because Bath Law indicates that Mw 7+ earthquakes are likely after an Mw 8+ earthquake, but this study sheds nice new light on the phenomenon.

The study is clear and well-targeted. I just have a few minor comments.

Abstract lines 1-3: a lot of "slip" in just a few sentences.

Line 34: unclear what "potentially reducing the propagation of errors" means.

Line 46-48: detection of early aftershocks after the Gorkha earthquake was discussed in the study

Wang, X., Wei, S. and Wu, W., 2017. Double-ramp on the Main Himalayan Thrust revealed by broadband waveform modeling of the 2015 Gorkha earthquake sequence. *Earth and Planetary Science Letters*, *473*, pp.83-93.

Line 64: 15 GNSS stations within 350 km does not sound like much. Discussion of resolution and sensitivity is in order.

Lines 104-113: Not sure why a Monte Carlo sampling method is used here as the problem is entirely linear and can be solved by least squares with Laplacian regularization. It would be useful to document the resolution of the inverse problem or to characterize it with a checkerboard test.

Line 137: I can't recall an example of the opposite. Do we have examples of afterslip distributions that are firmly not time/space separable?

Line 143-144: Note the work of

Salman, R., Hill, E.M., Feng, L., Lindsey, E.O., Mele Veedu, D., Barbot, S., Banerjee, P., Hermawan, I. and Natawidjaja, D.H., 2017. Piecemeal rupture of the Mentawai Patch, Sumatra: the 2008 mw 7.2 North Pagai earthquake sequence. *Journal of Geophysical Research: Solid Earth*, *122*(11), pp.9404-9419.

that indicates afterslip in the area that ruptures coseismically. The study provides a numerical model based on rate-and-state friction that explains the phenomenon by the fact that the coseismic rupture extended significantly into a velocity-strengthening region.

Lines 156-158: Is it possible that this deep slip patch may in fact represent strain on crustal faults above the megathrust?

Line 181: Wasn't the geodetic moment 8E19 Nm after the deep patch is removed? So the seismic moment is actually greater than the geodetic moment? Also, shouldn't the comparison be with the geodetic moment at the time of the Mw 7.1 earthquake instead of at the end of the 12 hours?

Figure 2: It would be useful to show the "time since mainshock" as a second x-axis. Please also indicate the moment magnitude of the two large aftershocks next to their dashed blue lines.

Figures 3 & 5: the repetitive degrees around every subplots are redundant. Consider showing only the left and bottom ones. Consider better showing the trench with the usual chevrons. Indicate the meaning of the blue area in the legend. Add the moment magnitude of the aftershock next to the respective star.

Figure 4: Remove the title "postseismic 12 hours" as it shows afterslip distribution for longer periods.

Figure 7: This should be replaced by a composite with Figures S7.1 and S7.2. The corresponding discussion of the number of aftershocks and the logarithm of the same in the main text is not particularly useful. Instead, focus on the obvious difference between Figures S7.1 and S7.2.

Finally, please consider commenting the phenomenology shown in Figure S7.1. Why is the cumulative moment of aftershocks increasing so much in the northern segment around 6-7 hours? How does that translate in terms of fault slip? It does not seem clear from the various figures. It is hard to tell if the moment is significant because the plots use "normalized" time dependence. Since the geodetic and afterslip moment are so similar to the south, why not using moment (Nm) as the y-axis?

Best wishes,

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