Testing aftershock decaying model by using aftershocks from the relocated earthquake catalog in Taiwan

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Summary

Based on Dieterich’s aftershock decaying model, the initial aftershock production rate, \( n(0) \), is proportional to the background seismicity rate \( n(0) \) after the mainshock, and the seismicity rate \( n(t) \) is proportional to the stressing rate \( J(t) \) (Dieterich, 1994). One important and potentially testable prediction of this model is that the relaxation time \( t_r \) of the aftershocks scales with the stressing rate, according to \( t_r \propto \sqrt{J} \).

Here, we use the Taiwan CWBSSN (1991-2006) catalog to examine this aftershock decaying model. We use 16 aftershock sequences, and 3 secondary aftershock sequences around the Taiwan area to test the decaying model. The magnitude of these events ranges from \( M_3 \) to \( M_6 \). Our result suggests that relaxation time \( t_r \) may be proportional to \( 1/\sqrt{J} \).

Also, the initial seismicity rate \( n(0) \) in a secondary aftershocks sequence is proportional to the seismicity rate right before the secondary mainshock \( n(0) \).

Our observation also suggests that the ratio of the secondary aftershock seismicity rate follows the same decaying model as the primary aftershock seismicity rate decay, as expected from the model.

Aftershock decaying model

To fit the aftershock seismicity rate, we use 3+1 parameters: \( n(0) \), \( t_r \), \( \alpha \), and \( p \) in eq(1) and eq(2). In order to fit the seismicity rate of the secondary aftershocks, we first use eq(1) to model the primary aftershock seismicity rate \( n(0) \), then use eq(2) to fit the secondary seismicity rate.

\[ n(t) = \frac{n(0)}{\left(1 - \frac{t}{t_r}\right)^{\alpha}} + n(0) \]

\[ n(t) = \frac{n(t_{obs})}{\left(1 - \frac{t}{t_r}\right)^{\alpha}} + n(0) \]

Relation between relaxation time and depth

Secondary aftershocks in main decay sequence

Fig. 1: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The mainshock occurred on July 5, 1999. The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.

Fig. 2: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.

Fig. 3: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.

Fig. 4: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.

Fig. 5: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.

Fig. 6: The secondary sequence occurred after the mainshock \( M_0 = 7.3 \). The rate of secondary aftershock sequences from an earthquake catalog are used to predict the moment.