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Relation between tidal triggering effect and interplate seismicity along the Tonga-Kermadec trench

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Tonga-Kermadec Trench is one of the world's most earthquake-prone zone. A convergence rate of plate increases from the south to the north and in proportion to it, seismicity rate is increasing [Ide, 2013, Nature Geo.]. In this area, larger earthquakes with M>=7.5 including intraplate earthquakes have most occurred around 1980 and 2010 relatively. About the former period, it was pointed out that p-value (Schuster, 1897, PRSL, it's an index to express correlation between the seismicity and the tide. Generally when it is less than 0.05, judged to the correlation is high significant) was lowered before Tonga earthquake in December 1982 (Mw7.5) and increased after the mainshock by Tanaka, et al. [2002, GRL], using the GCMT data from 1977 to 2000. About the latter period, the interplate earthquake (Mw7.6) has occurred in March 2009 near the 1982 earthquake.

In this study, we investigate the temporal variation of p-value before and after the mainshock in 2009 by using the GCMT data whose end period was extended to 2013. We target interplate earthquakes in the global CMT catalogue (rake angle is 60-120 degrees, depth is 0-70 km, strike angle is 150-230 degrees, the periods is 1977-2013). Theoretical tidal response in the crust is expressed as summation of the earth tide and ocean tidal loading effect. The former is calculated by "earthtide_mod" [Ozawa, 1974; Nakai, 1979; Kamigaichi, 2015, personal com.], the latter is calculated by the modified program [Kamigaichi, 1998, PMG; Kamigaichi, 2015, personal com.] based on "Gotic2" [Matsumoto, et al., 2001]. These programs use the PREM as an earth model in order to calculate the green function and output the strain tensor at the hypocenter of each events [Kamigaichi, 2015, personal com.]. We calculate delta CFF with the frictional coefficient is 0.4 on the fault plane from the strain tensor obtained. We set 50 events as the calculation unit in order to estimate the temporal variation of p-value and shifted them at every 1 event. The results are as follows.

A. p-value decreases gradually before the 1982 mainshock and increases after that.

B. p-value decreases gradually (but at least 0.1) before the 2009 mainshock and increases after that.

C. There is five times of periods when p-value becomes less than 0.05 (Dec. 1982, Jan. 1988, Jun. 1993, Apr. 1998, Aug. 2000). However, about four times except for the mainshock in 1982, low p-value does not correspond large earthquakes with M>=7.0.

A p-value is expected be an important tool for earthquake forecast because p-value decreases before large earthquakes and increases after them (e.g., 2004 Off Sumatra earthquake (Mw9.0) and its largest aftershock (Mw8.6), and 2011 Off Tohoku earthquake (Mw9.0) [Tanaka, et al., 2010, 2012, GRL]). However, if we conduct the earthquake forecast using temporal changes of p-value, we must take into account the false alarm such as "item C" above mentioned.

Keywords: Earth tide, Ocean tidal loading effect, delta CFF, p-value, Tonga-Kermadec trench