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Active fault displacement records for constructing a slip models for future earthquakes

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We show here an idea for estimating heterogeneous slip distributions for scenario earthquakes from displacement distributions of past earthquakes measured along active fault traces. To relate them each other, we need the following two facts. One is a relationship between slips on a causative fault and displacements appearing on its surface rupture. The other is a variation of slip distributions caused by repeated earthquakes on one fault plane.

We discuss the relationship between slip on a causative fault and displacement appearing on the surface rupture based on published studies for past earthquakes which caused surface breaks and whose detailed slip distribution were analyzed, such as 1992 Landers, 1995 Hyogo-ken Nanbu (Kobe) and 1999 Chi-Chi earthquakes. The displacement distributions on those active fault traces seem to be correlated with the long-wavelength component of the slip distributions on shallow part of the causative fault planes. The correlation gets lower with slip on deeper part and becomes almost nothing with those deeper than 10km, unless a large asperity expand deeper than 10km.

There is no data to discuss how much slip distribution vary for repeated earthquakes deep on a causative fault. Only displacement distributions along surface traces by repeated earthquakes are examined and discussed for a few cases, e.g. by Lindvall et al. (1989) and Sieh and Jahns (1984). Their studies have shown that displacement distributions on surface ruptures are always similar inside one segment. Reports of displacements of past plural events at a point are more abundant. Some show roughly constant values and others show fairly fluctuated values. Slip distribution in depth direction is evidently varied for every earthquake on one segment because slip distribution of past earthquakes often have slip concentrated in a certain depth ranges and because Mw6-7 earthquakes sometimes do not break the earth surface even though they are estimated to have occurred on clearly traced active faults.

We decide a principal to construct a slip distribution model from a displacement distribution on an active fault trace considering all the results indicated above. Variation along strike direction is assumed from a displacement distribution along a surface trace. For variation in depth direction, several types are assumed from the slip distributions of analyzed past earthquakes. The slip is converged to zero around the bottom of seismogenic zone referring to the results of simulations considering brittle-ductile transition of the medium at such depth (Tse and Rice, 1986).

We applied this idea to the Uemachi fault system. The accumulated offsets are obtained at plural points along this fault system by reflection surveys and borings. Including these data, all available data were compiled to construct a three-dimensional structure model of the Osaka plain (Horikawa et al., 2002) and we can abstract a interpolated, continuous distribution of average uplift rate along the fault system from the depth variation of key layers like Ma3 layer. As only one data is available about a displacement for a single event for this fault system, we assume that a displacement distribution for a single event is similar to the average uplift rate distribution. The uplift rate is varied from 0.1 to 0.4 m/Ky over the fault system. If we put together the displacement on the main and side streams, the uplift rate distribution show two peaks. We can assume a two-asperity slip distribution model with a larger-area, larger-slip asperity at north and a smaller-area, smaller-slip asperity at south. The variation in depth direction is assumed referring to the slip distributions of past earthquakes. Stress drop on the fault plane is computed from these slip distribution models using the same procedure with Kubota et al. (1997) which is based on Okada (1992) and introduced into dynamic rupture simulations (Kase et al., in this conference).