Consideration of uncertainty in strong-motion prediction and seismic hazard analysis

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The Kumamoto earthquakes were earthquakes that were long-term evaluated by the headquarters of earthquake research promotion of Japan. The earthquakes occurred in a part of the Futagawa fault zone and the Hinagu fault zone where the seismic hazard maps with specified seismic source fault were published. Based on the knowledge obtained from the analysis of the Kumamoto earthquake, we will consider problems in strong-motion prediction and seismic hazard analysis, especially handling of uncertainty in prediction of future events. We classify the uncertainty in assessment into aleatory variability and epistemic uncertainty. The aleatory variability is evaluated as a random variable, and the epistemic uncertainty is evaluated using a logic tree.

(1) Consideration of uncertainty in setting earthquake magnitude (seismic moment)
a) Consideration of epistemic uncertainty about the concept of model setting of fault geometry
Considering the epistemic uncertainty with respect to the setting of the size of source fault, it is necessary to consider the following model in addition to the basic model according to the current ‘recipe’.
1) Model assuming that the source fault length is longer than the surface fault length.
2) Model assuming that depth of lower end of fault slightly deeper than the lower limit of the seismogenic layer.
3) Model with the top of the source fault at 0 km (ground).
4) Model considering uncertainty in setting dip angle.

b) Consideration of uncertainty concerning outer source fault parameters
It is important to properly consider the epistemic uncertainty accompanying the selection of the equation and the aleatory variability included in the prediction in parameter setting of the source fault model using the empirical formula.
1) Epistemic uncertainty on selection of empirical formula in L-Mo relation and Mj-Mw relation.
2) Aleatory variability in Mo-S relation and Mo-A relation.

(2) Consideration of uncertainty in modeling position and shape of source fault
In the strong-motion evaluation, the emphasis was mainly on modeling of short period strong-motion generation, the source fault was within the seismogenic layer, and its upper end was not 0 km (surface). In order to predict the strong ground motion in the very vicinity of the fault, detailed modeling of the position and shape of the source fault with the top end depth of 0 km is necessary. It is necessary to consider the uncertainty concerning detailed modeling of position and shape.

(3) Consideration of uncertainty in inner parameters of source fault model
In the strong-motion prediction by simulation using the fault model, it is necessary to evaluate both "average ground motion level" and "variation of ground motion due to model uncertainty". For that purpose, it is necessary to consider the uncertainty in the inner parameters of source fault model. It is important to consider the uncertainty concerning starting point of rupture, asperity position, inhomogeneity of effective stress of asperity, the setting of slip velocity time function in the shallower part than the seismogenic layer. In the prediction using simulation, it is necessary to clarify relationship

between the reproduction model of the past earthquake and the model for prediction.

(4) Consideration of uncertainty in subsurface structure model
The uncertainty of underground structure model is hardly considered compared with the modeling of source fault. A model based on dense observation data is being developed in the land area, but there is large uncertainty in the ocean floor area. In order to cover up to about 1 to 2 Hz, it is necessary to consider aleatory variability due to random inhomogeneities. In the evaluation of the amplification factor by the shallow ground, consideration of the epistemic uncertainty due to the lack of data is a future subject.

(5) Consideration one size smaller earthquakes than the characteristic earthquake
The earthquake on April 14 (M6.5), which is thought to be a smaller earthquake than the characteristic one, but the maximum seismic intensity 7 is observed. Modeling magnitude and occurrence frequency of smaller earthquakes than the characteristic one is an important issue.

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