資料３－３

平成 20 年 3 月 18 日
緊急地震速報検討委員会

中・長期的課題について

気象庁地震火山部

大きな震源域を持つ地震の即時予測

京都大学防災研究所　山田真澄氏の研究（2007年地震学会秋季大会予稿集より）

A22-11

断層の有限性を考慮した緊急地震速報システム:
近地・遠地観測点のリアルタイム判別手法

○山田真澄（京都大学）、 Tom Heaton（カリフォルニア工科大学）

Early Warning Systems for Large Earthquakes: Classification of Near-source and Far-source Stations

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Earthquake early warning systems collect seismic data from an occurring event, analyze them quickly, and provide estimates for location and magnitude of the event. In order to extend early warning systems for large earthquakes, it is necessary to estimate the fault rupture extent and slip on the fault in real time. The objective of this research is to develop a methodology to classify stations into near-source and far-source since this can be used for identifying the fault geometry if there is a sufficiently dense seismic network.

Data

Strong motion data of earthquakes with magnitude greater than 6.5 were collected and classified into two predefined groups: records from near-source stations (fault distance < 10 km) and far-source stations. This particular set of data is called the training set.

Method

We assume the discriminant function to classify records into near-source and far-source is expressed as a linear combination of the log of ground motion amplitudes (e.g. peak ground acceleration, velocity, displacement). We applied Bayesian approach to the training set and find the coefficients in the discriminant function.We also performed Bayesian model class selection to find the best combination of the ground motion measures

Result

Bayesian model class selection analysis shows the combination of vertical acceleration and horizontal velocity produces the best performance of the classification. The discriminant function produced by the Bayesian approach classifies near-field and far-field data, and gives the probability for a station to be near-field, based on the ground motion measurements. This discriminant function is useful to estimate the fault dimension in real-time, considering the fault finiteness of large earthquakes.

$$f = 6.046 \log_{10}(\text{Vertical Acc}) + 7.885 \log_{10}(\text{Horizontal Vel}) - 27.09 \quad (1)$$

$$prob(station=near\text{-}source)=1/(1+\exp(-f)) \quad (2)$$

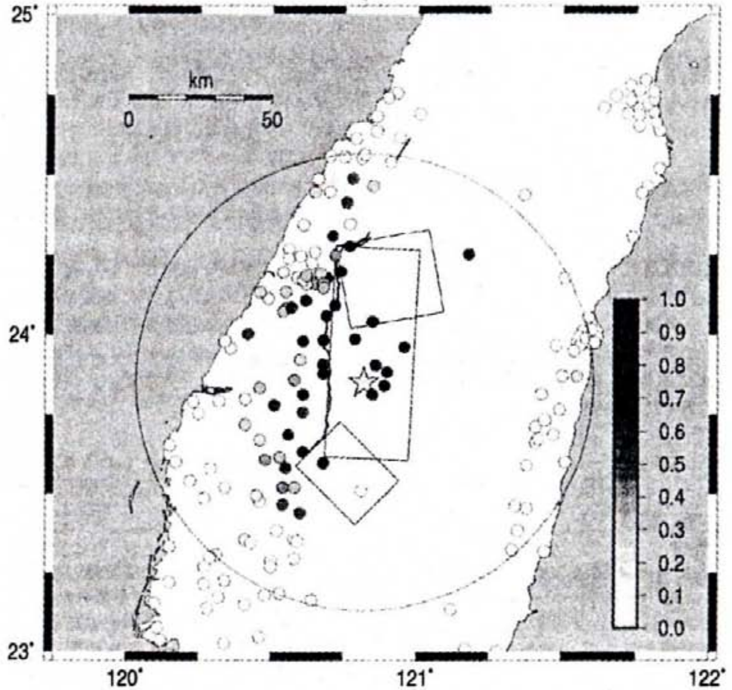
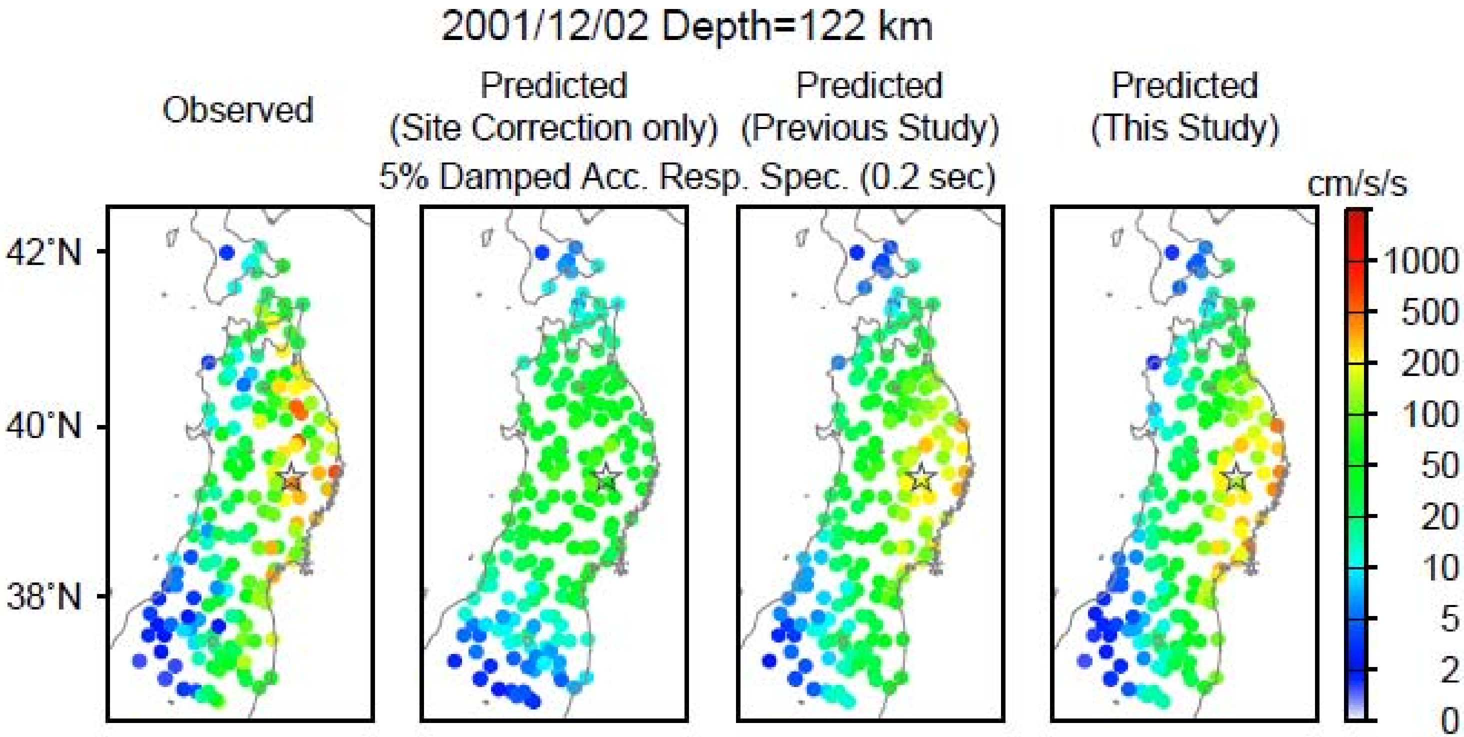


Figure 1: Probabilities of near-source based on the optimal discriminant function obtained by the Bayesian approach. Darker marks have higher probability that the station is located at near-source.

Reference: Yamada, M., Early Warning for Earthquakes with Large Rupture Dimension, Ph.D. thesis, California Institute of Technology, 2007.

深発地震の予測震度補正

深発地震の異常震域の推定などを、距離減衰式に対して補正項を加える形で実現する方法が提案されている。



観測値と補正した予測値の比較例

森川ほか(2006)：東北日本の異常震域に対応するための最大振幅および応答スペクトルの新たな距離減衰式の補正係数,日本地震工学会論文集,第6巻,第1号より

震源、経路特性をふまえた震度予測

神田(2007)による地盤伝播特性を考慮した震度推定

・震源深さ20km未満

$$I = -a_1 \log(X) + b_1 M + c_1 + p_1$$

・震源深さ20km以上

$$I = -a_2 \log(X) + b_2 M + c_2 \log(h) + d_2 + p_2$$

ここで，Xは震源距離(km)，Mは気象庁マグニチュード，hは震源深さ(km)，a, b, c, dは回帰パラメータで震度予測しようとしている地点ごとに求める.

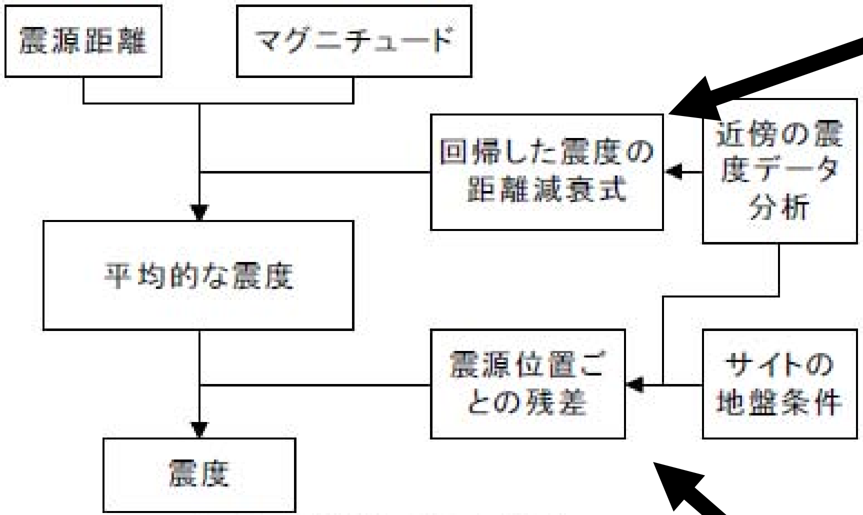


図-5　震度推定法の評価フロー

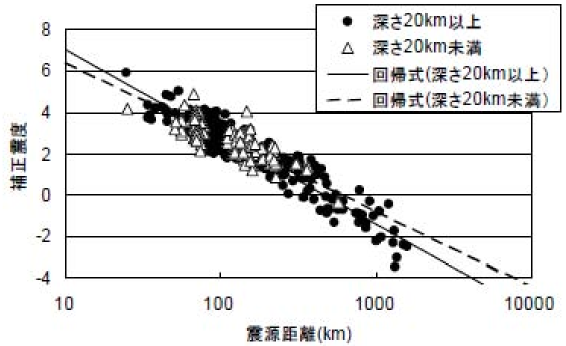
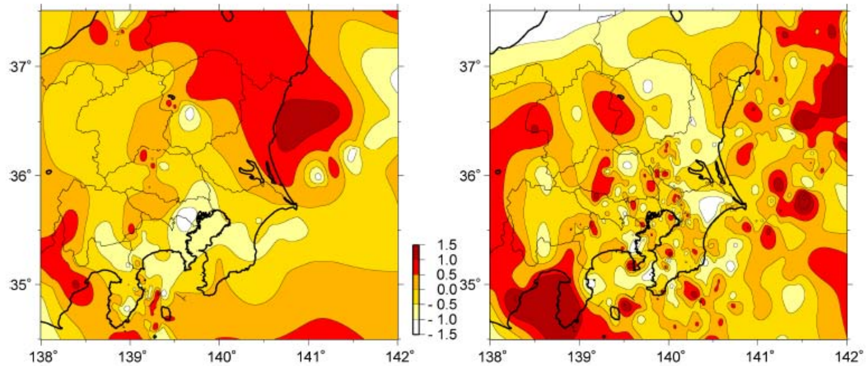


図-6　観測震度と回帰距離減衰式（横浜）
（M6.0，深さ 20km 以上は深さ 35km に換算）



震源深さ 20km 未満の場合の残差 p_1　　震源深さ 20km 以上の場合の残差 p_1
（どこを震源とする地震が横浜中区山手町で揺れやすいかを示している．）

図-7　距離減衰式の残差のコンター（横浜）

神田 克久(2007)：観測データに基づいて地盤伝播特性を考慮した震度推定，震度計の設置促進と震度データの利用高度化に関するシンポジウム論文集，土木学会，pp. 46-51.