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ひずみ集中帯におけるトモグラフィー解析のための初期モデルの検討
Estimation of a feasible initial velocity model and earthquake locations for seismic tomography in the Niigata region

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Niigata area is part of a broader region, located in the central and north-eastern part of Japan, known for its high strain rates (Sagiya et al., 2000). To have a detailed understanding of the seismotectonic characteristics in the Niigata region, we have installed a dense temporary network of about 300 seismic stations. In a previous study (Enescu et al., 2010) we have obtained a detailed tomographic image of the crustal structure in the region, using the earthquake data recorded during intense observations, as well as previous data recorded by the permanent Hi-net network. The study revealed the undulated surface of the basement rock, hidden under a thick low-velocity layer consisting of thick sediments and volcanic rocks of the Niigata basin. The earthquake locations, inverted together with the velocity structure, became systematically shallower (by more than about 3km), in agreement with results reported in other studies (e.g., Kato et al., 2009). However some earthquakes, especially those that occurred in the off-shore areas, persistently remained located deeper.

In this study we focus on the reliable determination of earthquake locations since they may play a critical role for an accurate imaging of the velocity structure in this complex tectonic region. We use the Joint Hypocenter Determination (JHD) algorithm (Kissling et al., 1994; Shibutani et al., 2005) to invert for the precise earthquake locations, improved 1D velocity model and station corrections. We select only data obtained during intense earthquake observations, from December 2008 to September 2009. We use as a starting 1D model the velocity structure obtained for the region by Shibutani et al. (2005), using the same JHD technique.

The most prominent features of the JHD relocated earthquakes are: a) a shift of the depth location by about 3km in the on-shore Niigata basin region, which includes the aftershock area of the 2004 Mid-Niigata earthquake; b) a shift of up to 10km upwards for the hypocenters that occur in the off-shore regions, in particular those located in the aftershock area of the 2007 Chuetsu-oki earthquake and c) a horizontal shift of up to 3 to 5km in the N65degW average direction for the epicenters in the on-shore Niigata basin region. These results are in agreement with those obtained in several previous studies (e.g., Shibutani et al., 2005; Yukutake et al., 2008; Kato et al., 2009). Although the earthquakes used in this study occurred after December 2008, the fault-like structures in the areas of the 2004 and 2007 Niigata earthquakes can still be recognized from the earthquake hypocenter distribution.

The station corrections pattern shows consistency with the shallow subsurface velocity structure: relatively large positive travel-time residuals in the Niigata basin and negative residuals in the Echigo Mountains to the east.

The obtained 1D velocity model has lower velocities in the upper 7km, compared with the 1D model of Shibutani et al. (2005) and is similar in the deeper part. To further check the reliability of our results, we have considered a different starting 1D velocity model that has significantly lower velocities in the upper layers and performed the JHD inversion. The relocated earthquakes had a similar hypocentral distribution to those obtained by using Shibutani et al. (2005) crustal structure as starting 1D velocity model. Thus, we consider the relocated earthquakes to be robust enough for obtaining a reliable 1D velocity structure.

The relocated earthquakes and the improved 1D velocity model obtained in this study will be used to update our previous tomography results and discuss in more detail the relation between the earthquake activity and velocity structure in the Niigata region.

Keywords: Niigata region, earthquake relocations, velocity structure