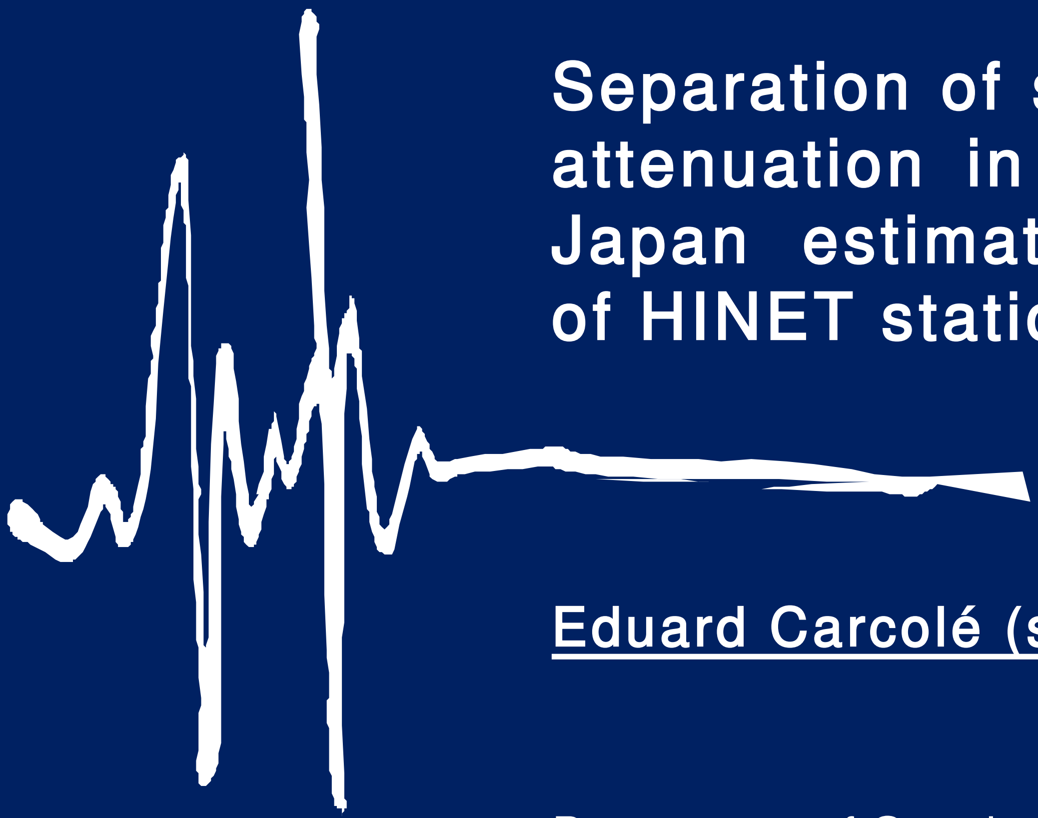

Separation of scattering and intrinsic attenuation in the lithosphere of all Japan estimated from observations of HINET stations

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Attenuation: Scattering Loss and Intrinsic absorption

The solutions of the Radiative Transfer Equation have been used to model the behavior of the envelopes of high frequency seismograms. These solutions depend on two parameters: scattering loss and intrinsic absorption.

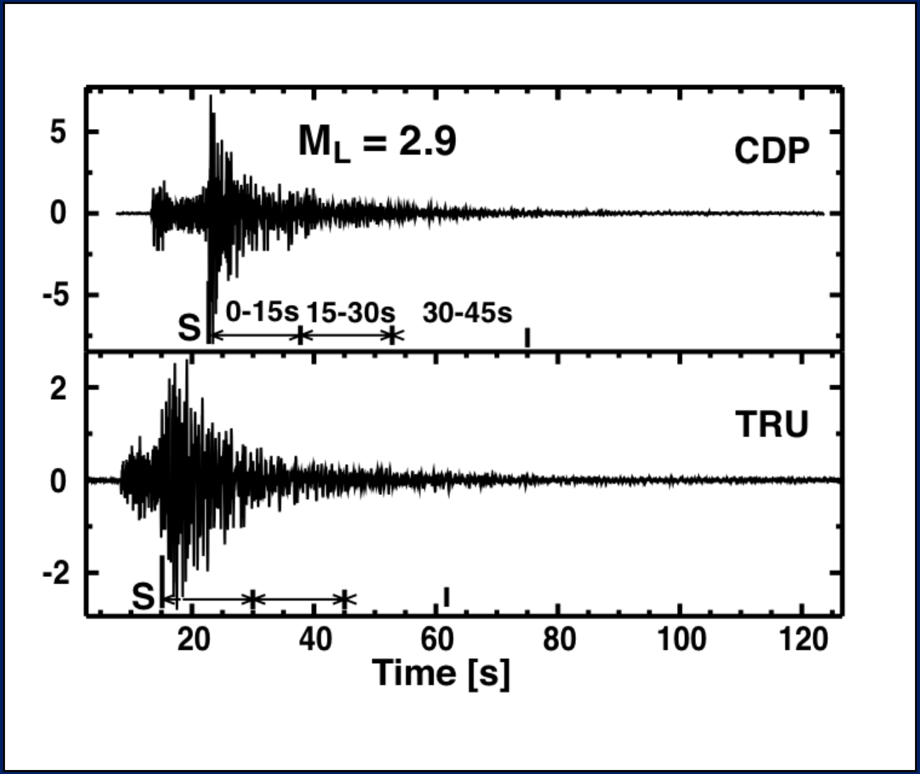
$$Q_s^{-1} = gv/\omega$$

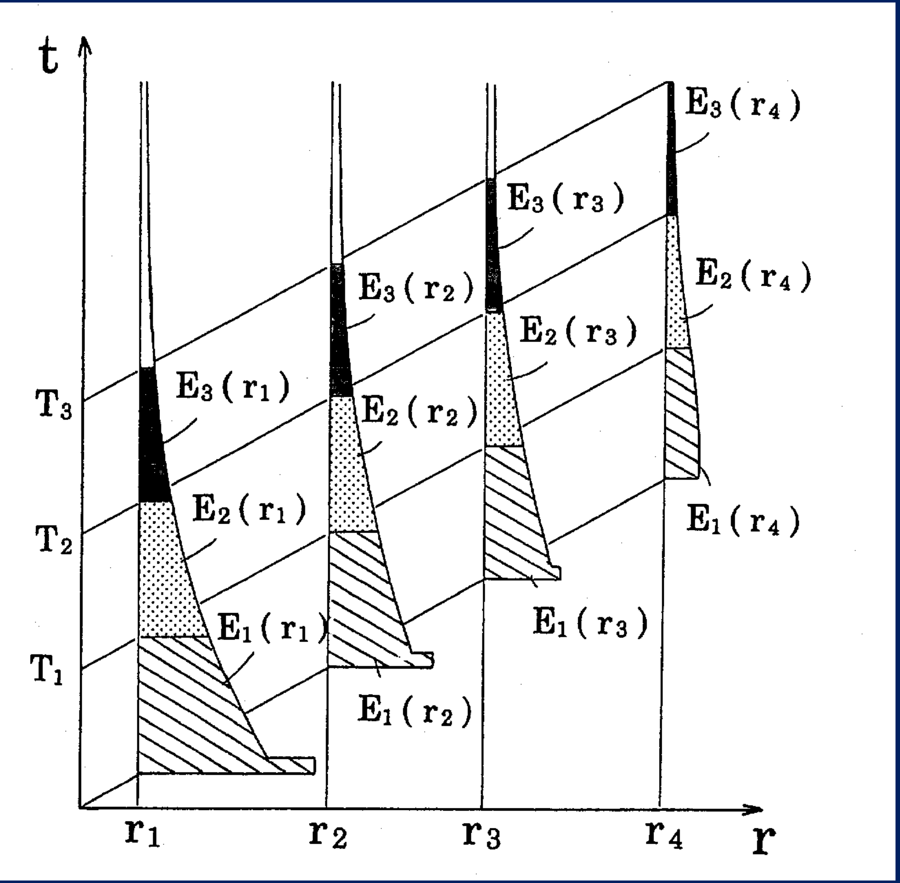
$$Q_i^{-1} = hv/\omega$$

Hoshiba et al. (1991) and Fehler et al. (1992) developed the Multiple Lapse Time Window Analysis (MLTWA) to separately estimate both parameters using S-coda waves.

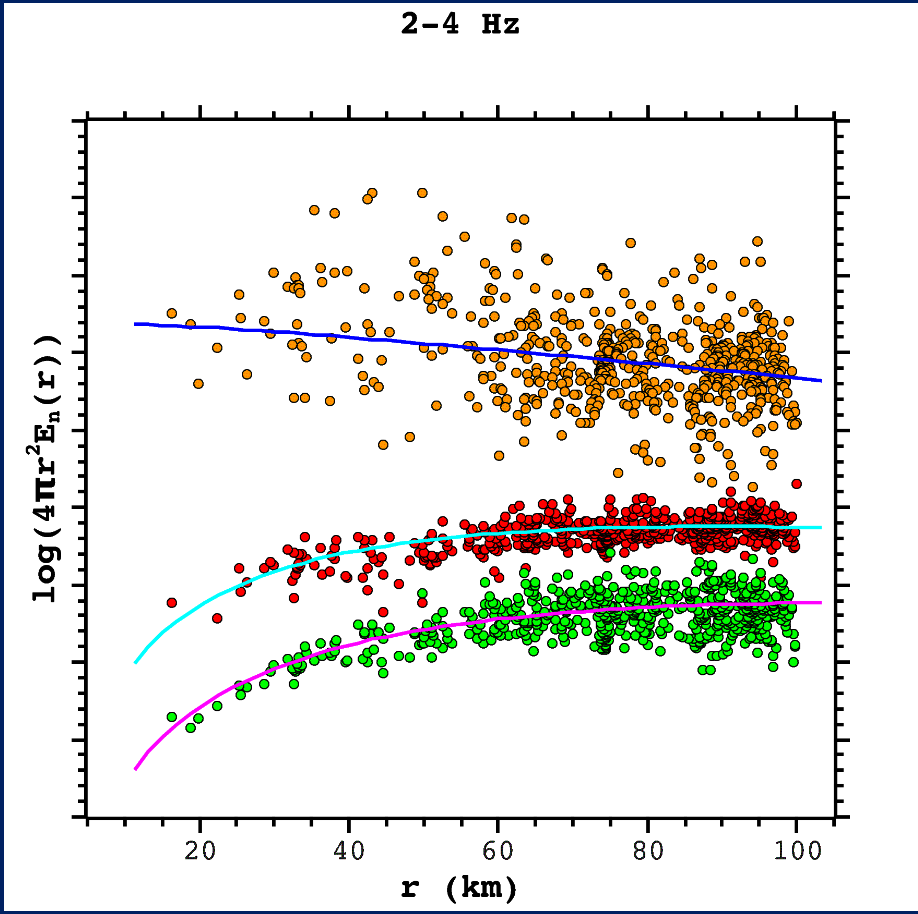
In this presentation I would like to show high resolution maps of scattering loss and intrinsic absorption for different frequency bands in all Japan by using the MLTWA.

Multiple Lapse Time Window Analysis





The MLTWA allows estimating the scattering loss and intrinsic absorption from the energy contained in three time windows for events with different hypocentral distances.



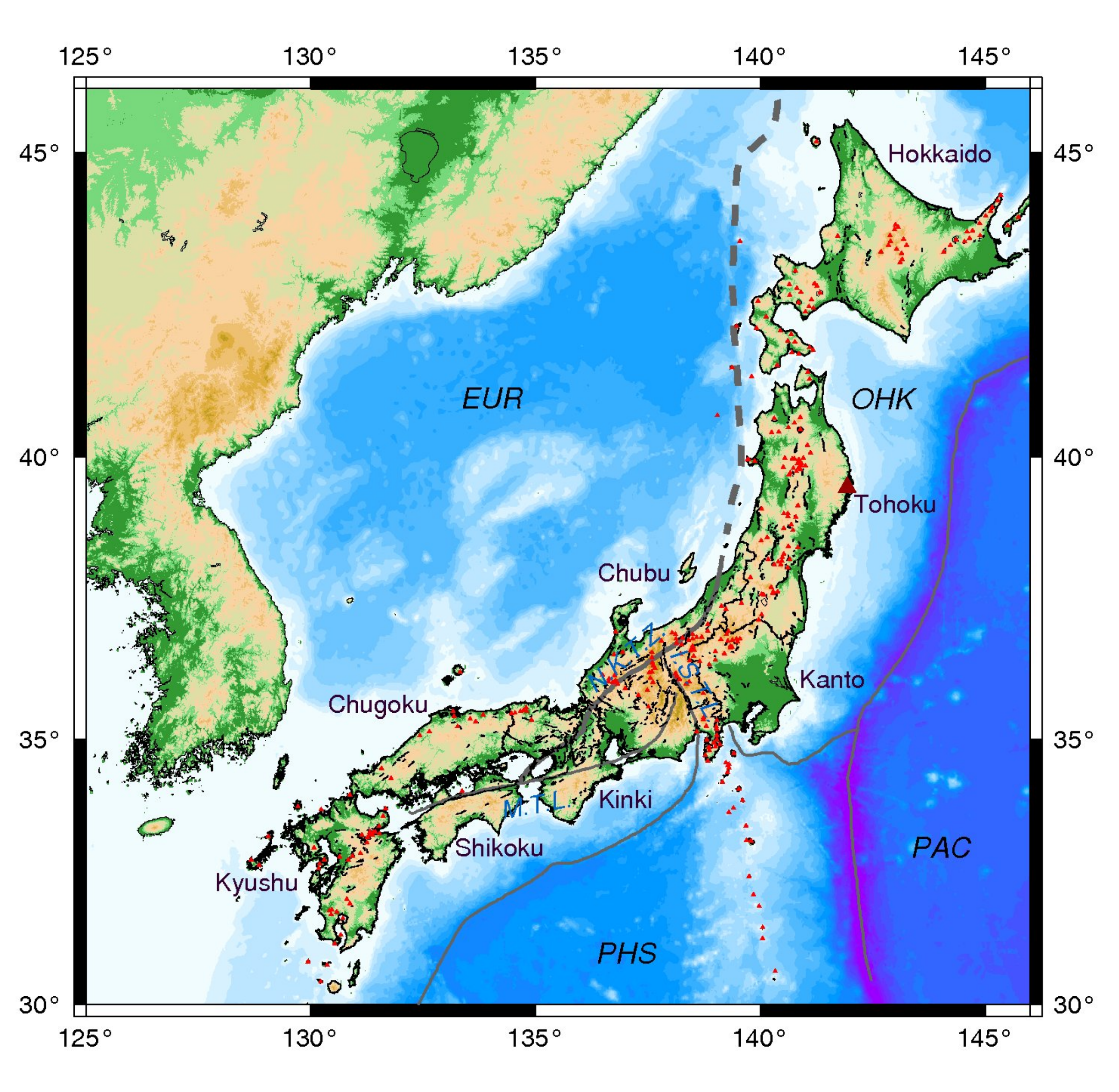
We plot the logarithm of the energy obtained from each window as a function of the hypocentral distance.

We perform a non-linear fit by using a simple model (isotropic scattering and constant absorption):

we use Paasschens' solution (1997) in this study for modelling coda waves' envelopes.

To perform the non-linear fitting we used the Levenberg-Marquard algorithm.

Geotectonical Characteristics of Japan

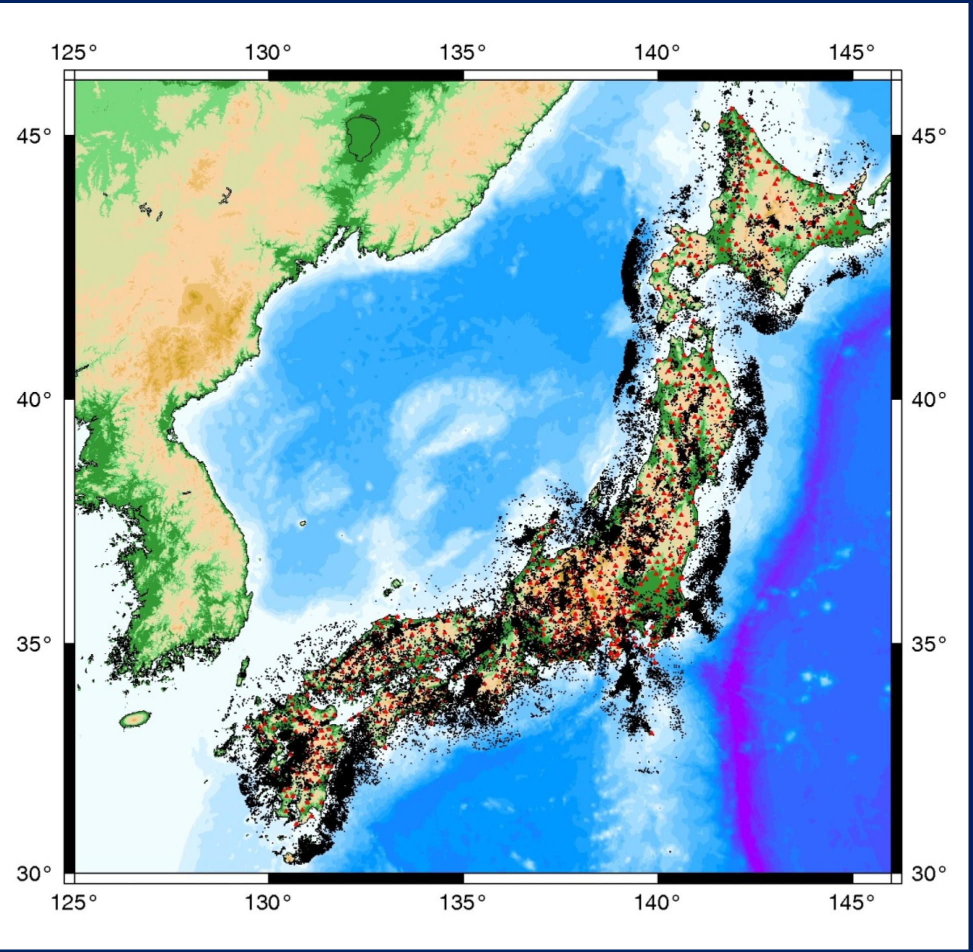


4 tectonic plates exist in and around Japan: the North American plate, the Eurasian plate, the Philippine Sea plate and the Pacific plate.

Two of the plates subduct beneath the Japan Islands: the Pacific plate moving towards the west, and the Philippine Sea plate moving to the north-west.

The regional stress field caused by the motions and interactions of these plates produces intense seismic and volcanic activities and active crustal movement beneath Japan.

Data and Method



We use data obtained from Hi-net (high sensitivity seismograph network) consists of about 772 borehole-type high sensitivity seismic stations.

Seismographs are installed at the bottom of the borehole of about 100m depth. Some reach depths of 3km.

Hi-net stations uniformly covers the Japanese Islands with a spacing of 20–30 km, allowing us to plot high resolution maps

For this study, we have collected:
135,000 events with
magnitudes 1.5 - 3.5,
maximum depth of 40km and a
maximum hypocentral distance of 100km
June 2002-December 2007 (4.5 years).

At least 20 events are collected in every station, otherwise results are not shown.

Data and Method

We consider the square sum of the three component amplitudes of the incoming S-waves and the following coda as a measure of the energy arriving to the station.

Then, a single energy envelope, representing the total energy arriving to each station will be considered for each event. From this envelope, attenuation parameters will be evaluated.

We obtained about 190,000 useful envelopes.

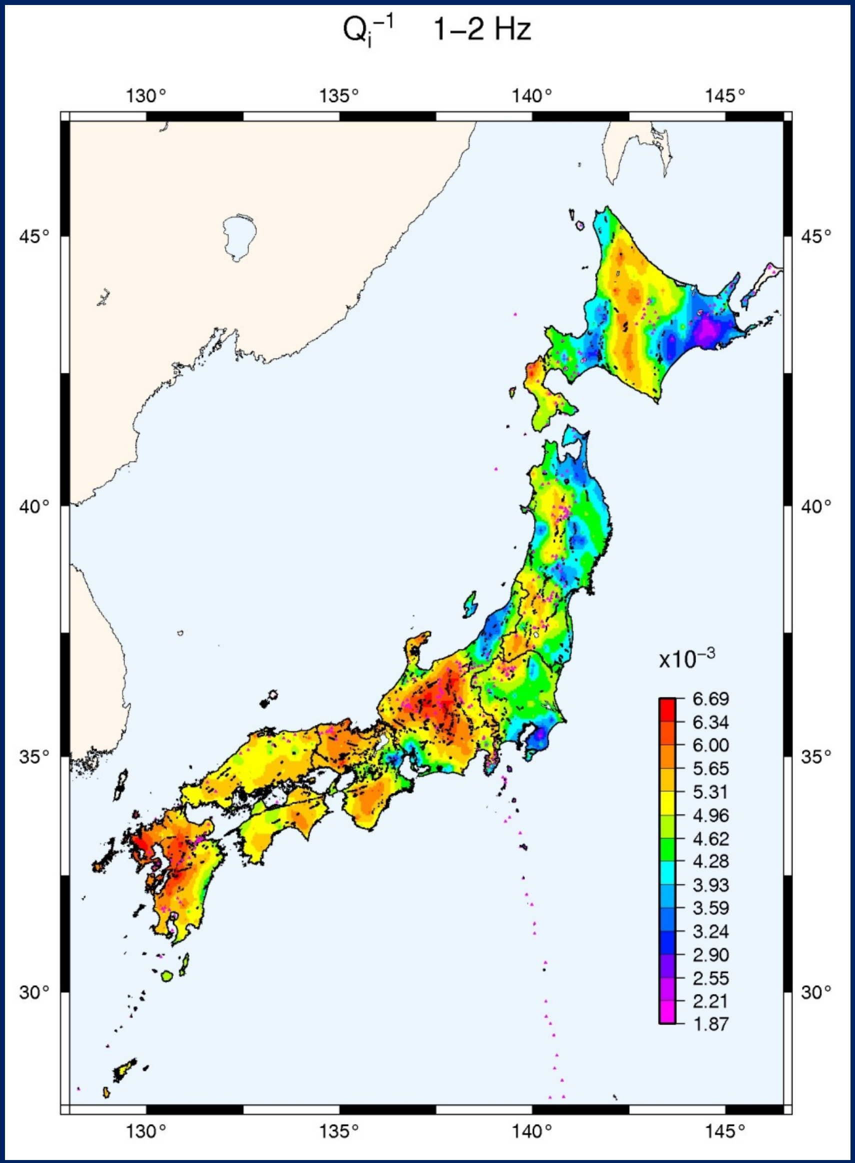
We study the attenuation parameters in 5 frequency bands covering the range 1-32Hz: 1-2Hz, 2-4Hz, 4-8Hz, 8-16Hz and 16-32Hz.

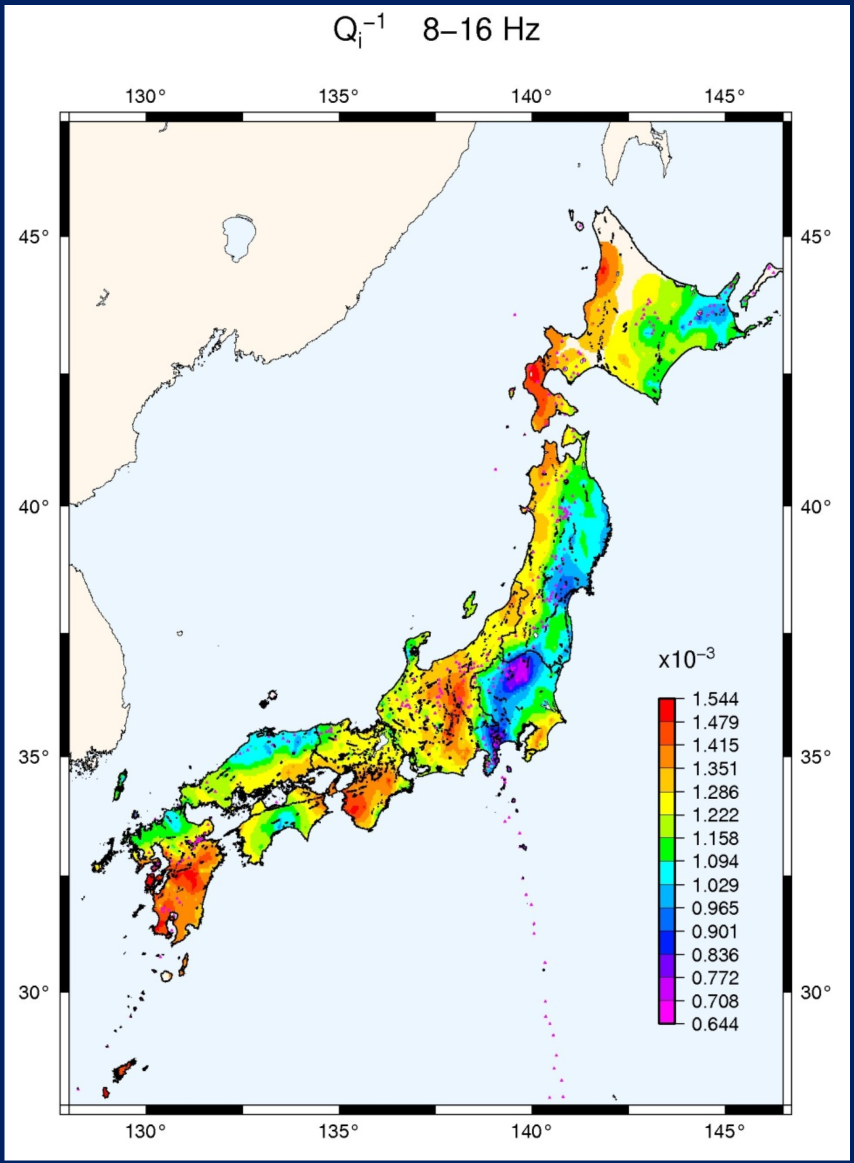
We compute the attenuation parameters for each station.

The results of every measure for each attenuation parameter is assigned to the coordinates of each station.

Mapping of the results has been performed by means of GMT routines.

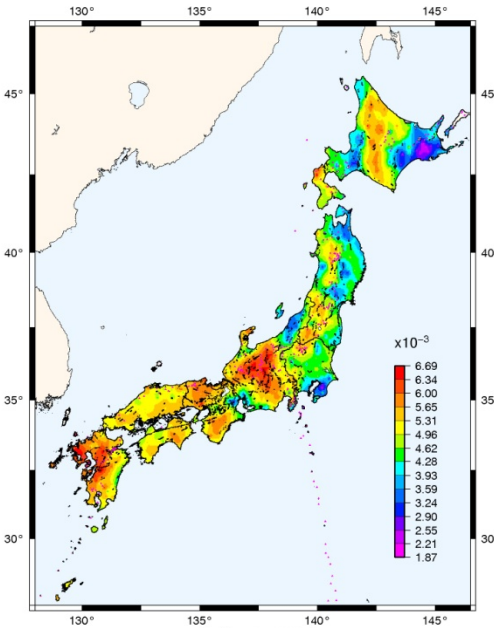
Intrinsic Absorption



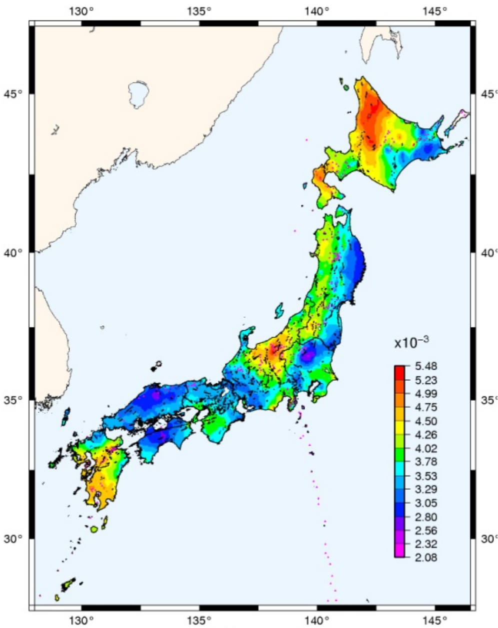


Intrinsic Absorption

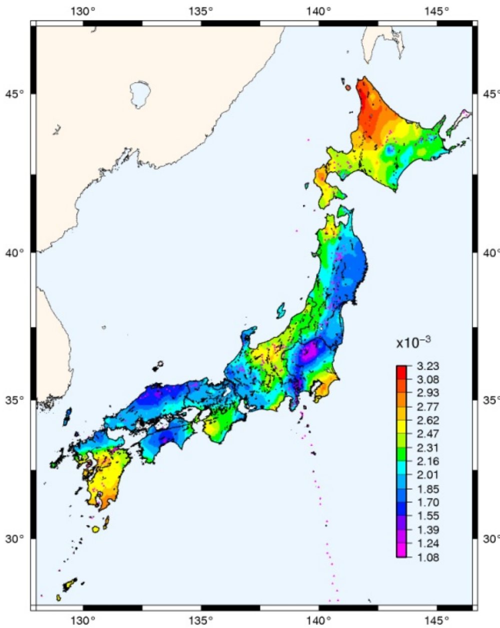
Q_i^{-1} 1–2 Hz



Q_i^{-1} 2–4 Hz



Q_i^{-1} 4–8 Hz

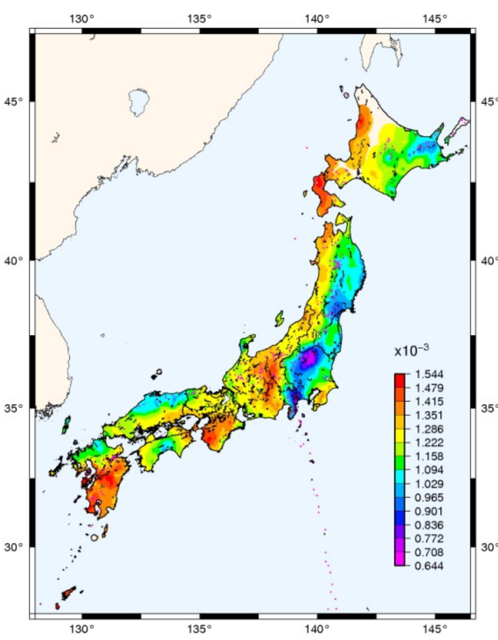


Main Characteristics:

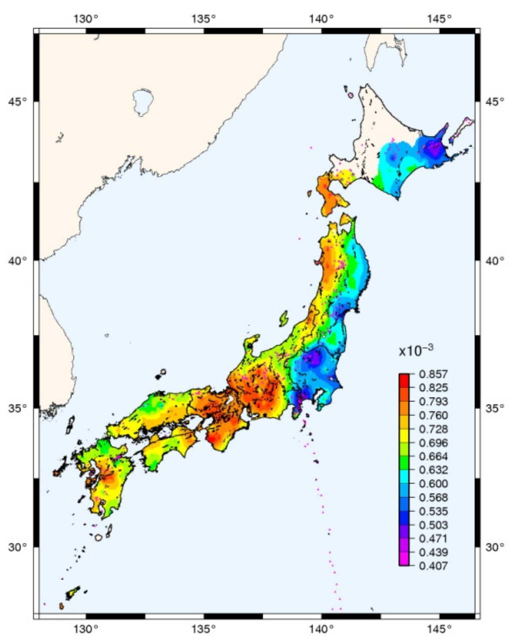
High levels of absorption in Hokkaido.

Higher absorption in the west side of Tohoku area.

Q_i^{-1} 8–16 Hz



Q_i^{-1} 16–32 Hz



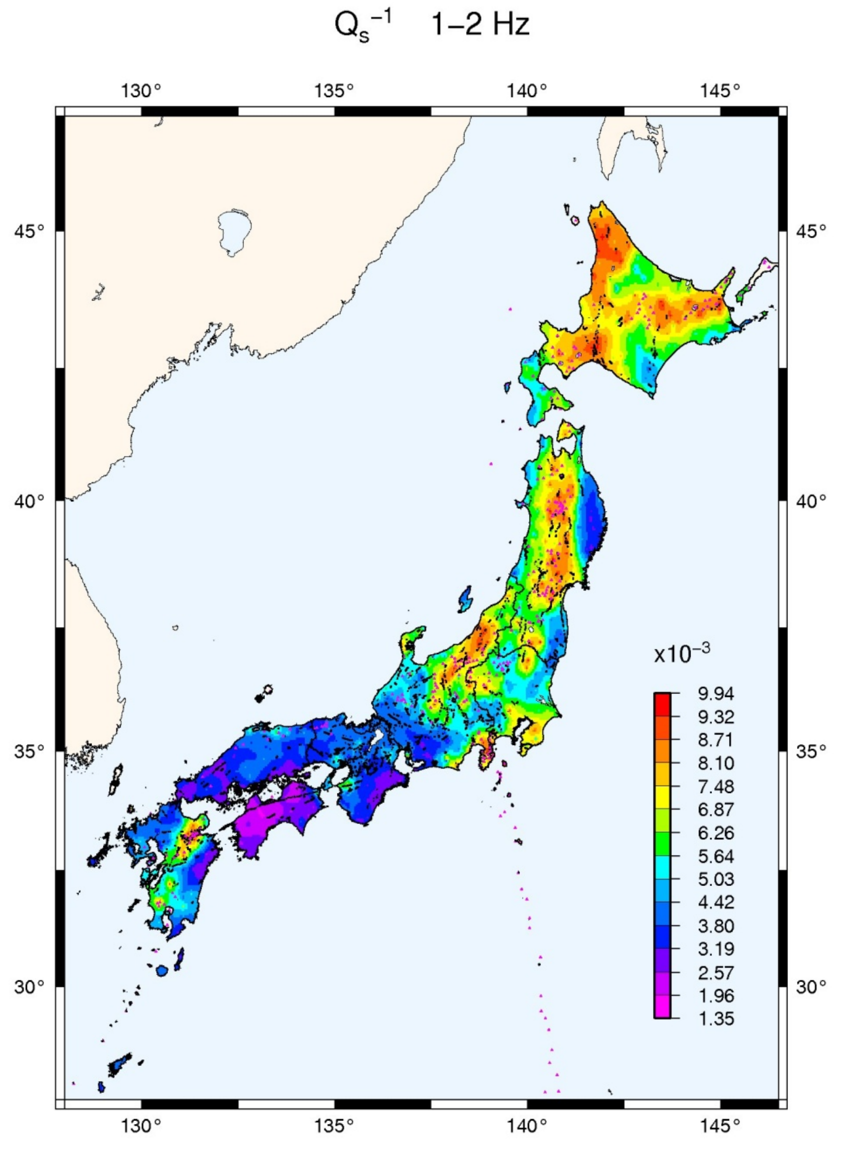
High absorption in the volcanic arc in Tohoku for the lower frequencies.

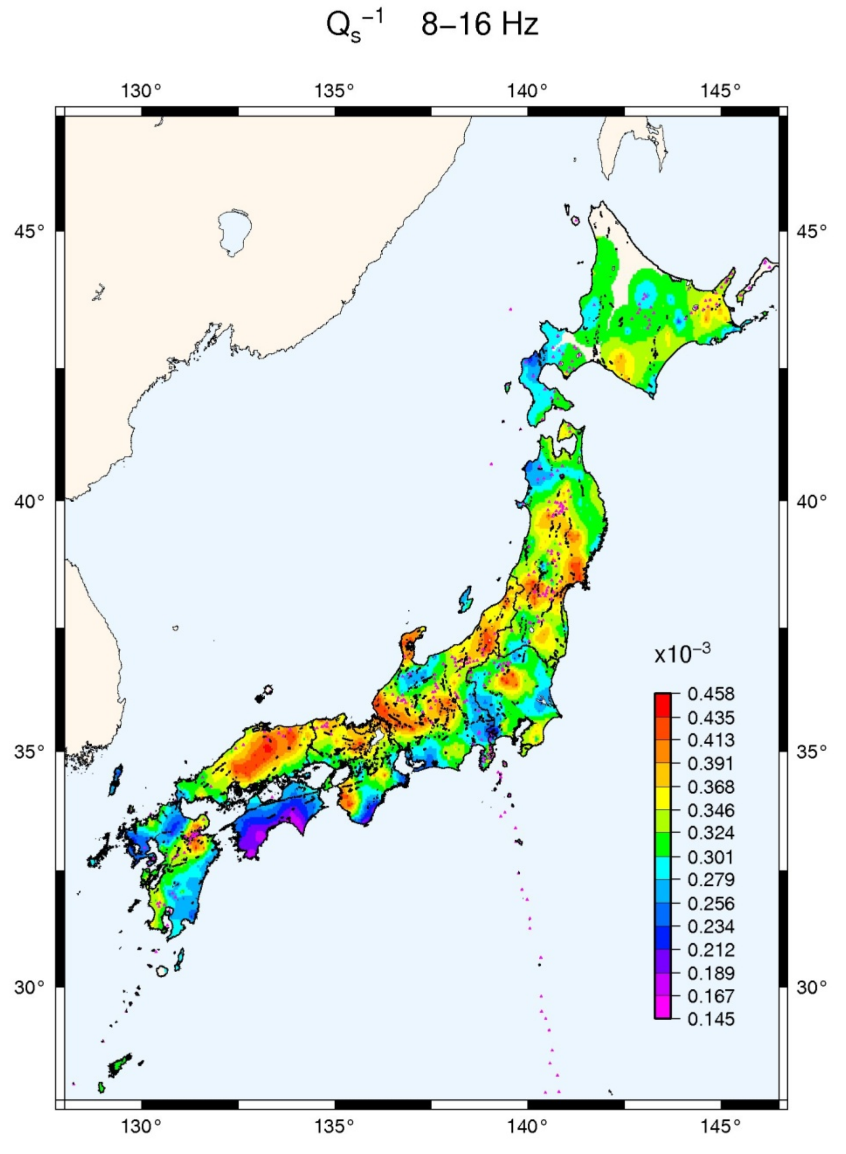
High absorption in Central Japan.

High absorption in the “Kinki spot” in Kii peninsula.

Higher absorption in Kyushu than in Chugoku and Shikoku regions.

Scattering Loss





Scattering Loss

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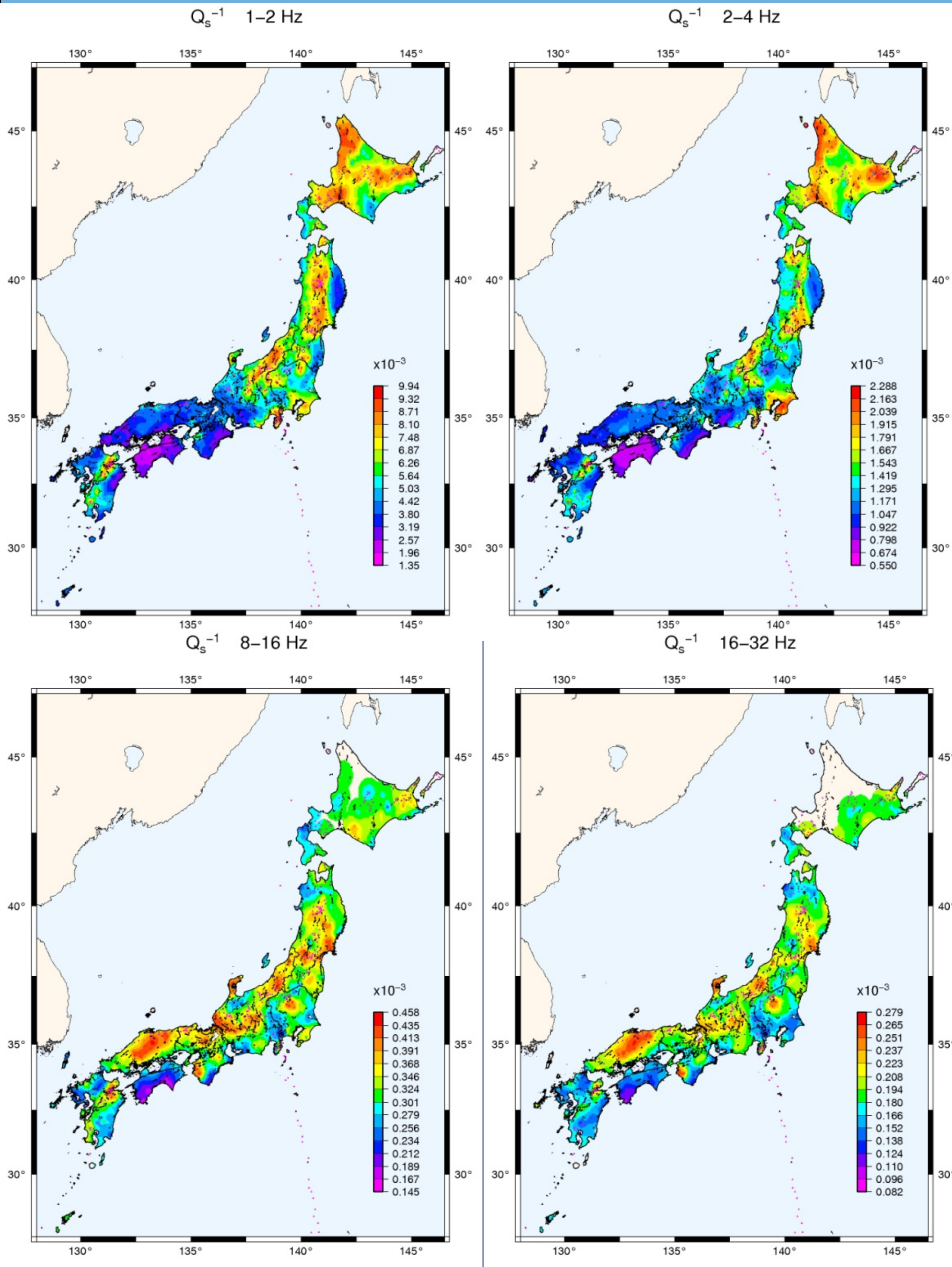

Scattering loss is high in the volcanic arc in Hokkaido and Tohoku areas for the 1-2Hz band.

High values on the Sendai plains.

High values in some regions of Central Japan.

High values in Chugoku region for 4-8Hz, 8-16Hz and 16-32Hz. Also for the “Kinki” spot.

Low values in Shikoku for all the frequency bands and higher values in Kyushu.

Velocity Tomography and Attenuation

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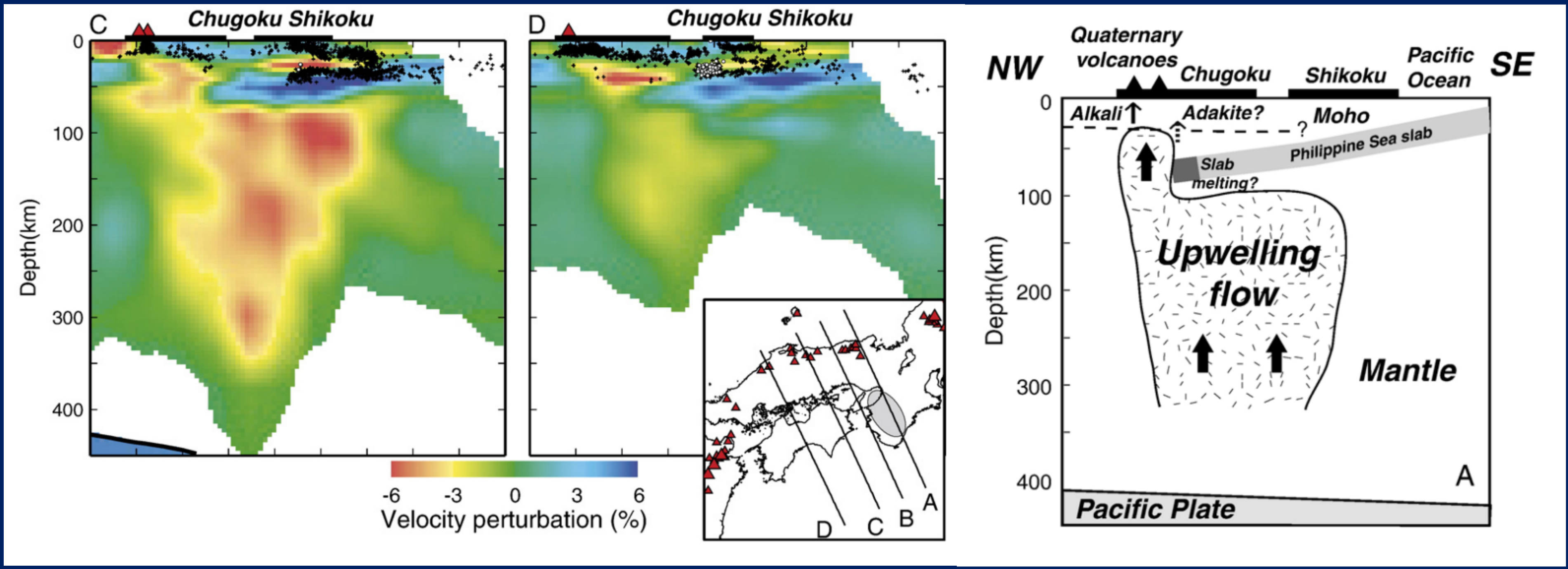
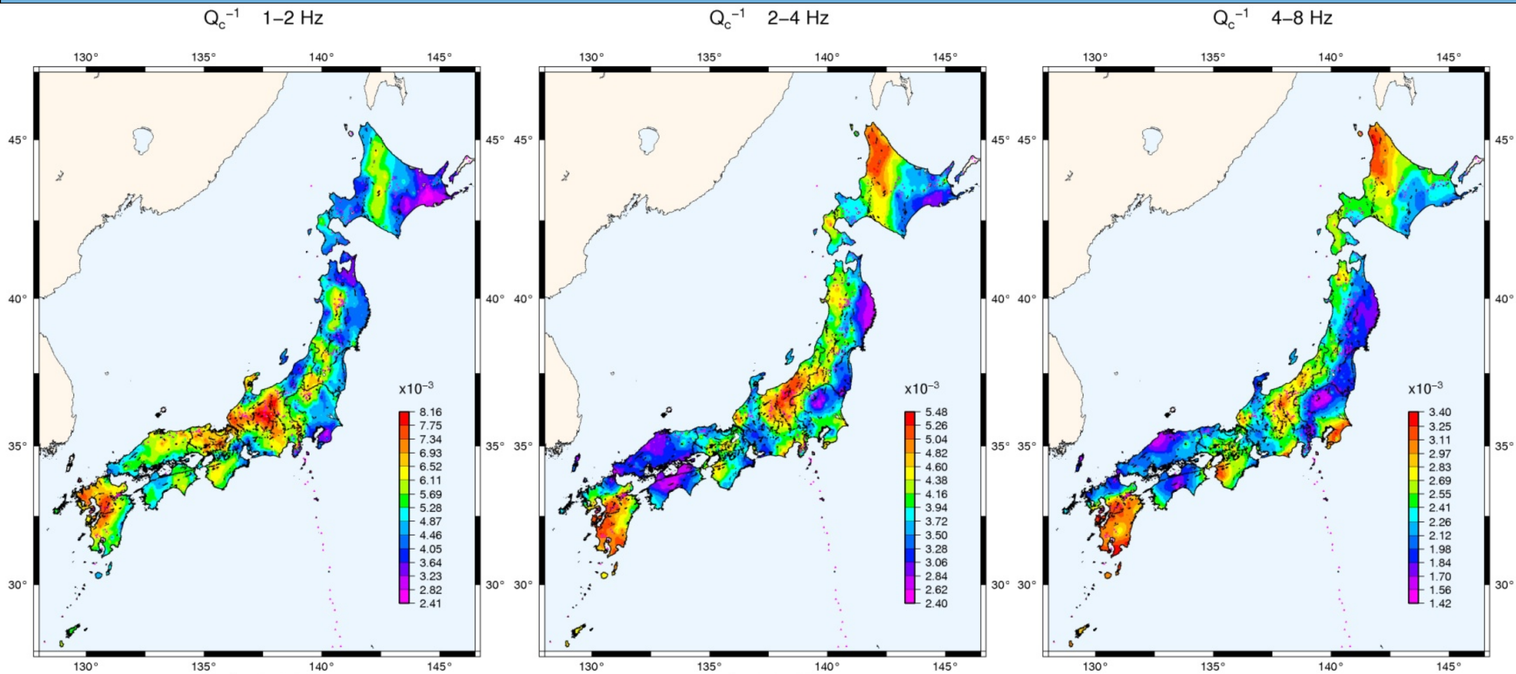


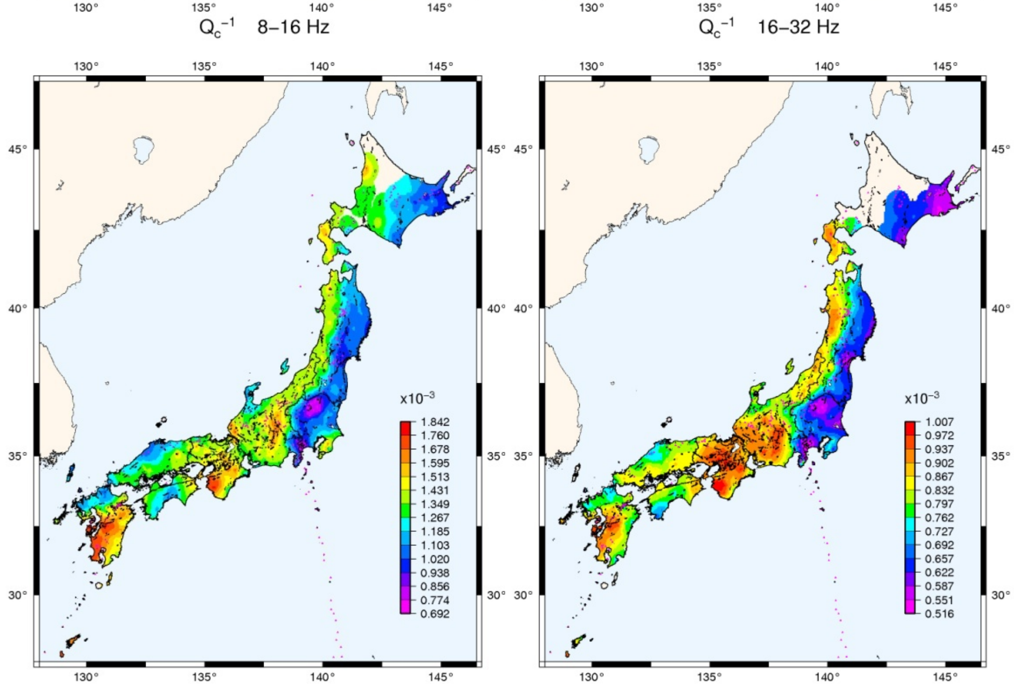
Results from J. Nakajima, A. Hasegawa (2007) 90–105.

This is an example of velocity tomography study in Chugoku-Shikoku regions that correlate with our results for strong scattering in Chugoku region.

The existence of low velocity anomalies, usually interpreted in terms of magma/water flow in velocity tomography studies, correlates with strong scattering and/or intrinsic absorption regions for some frequency bands.

Coda





We also computed Q_c^{-1}

Coda Q_c^{-1} was computed using a time window from $2t_S$ to t_S+45s.

This time window is inside the time window used to compute intrinsic absorption and scattering loss (from t_S to t_S + 45s).

Coda Q_c^{-1} shows a distribution very similar to intrinsic absorption.

Comparison of Coda and Intrinsic Absorption

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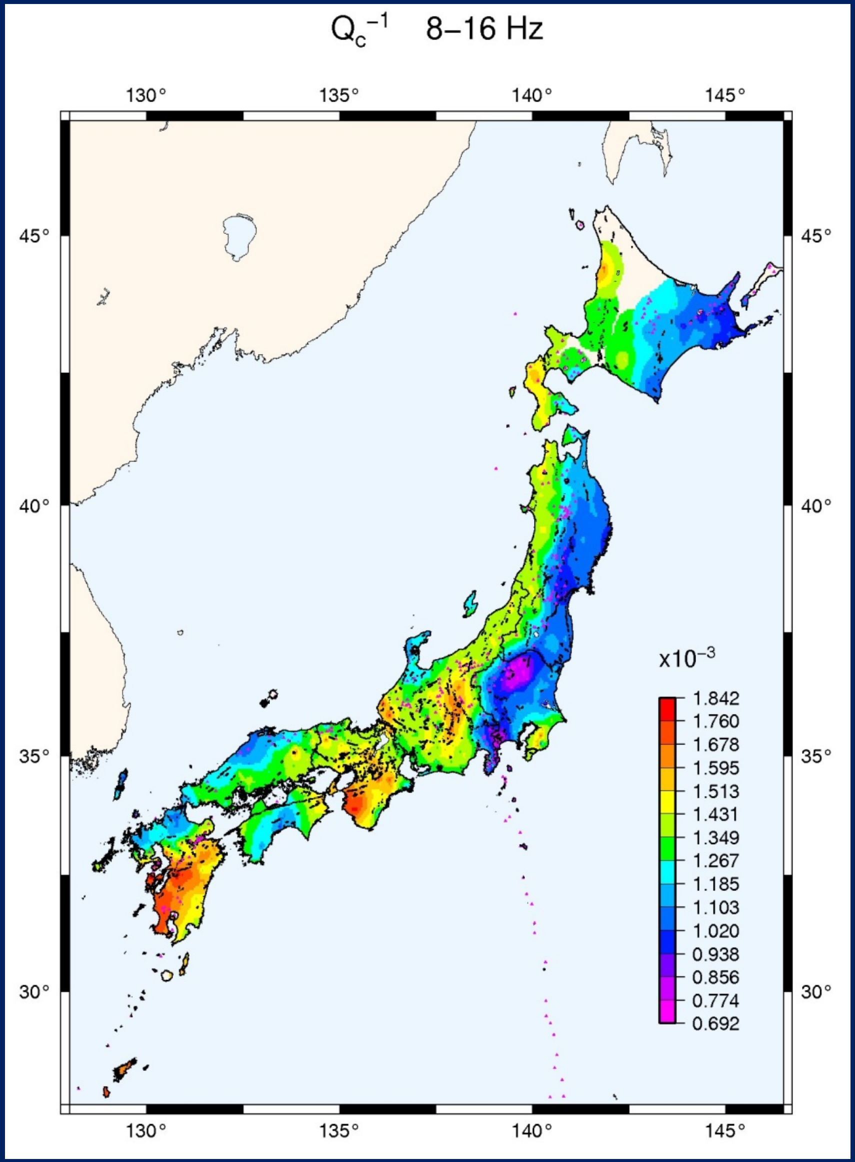
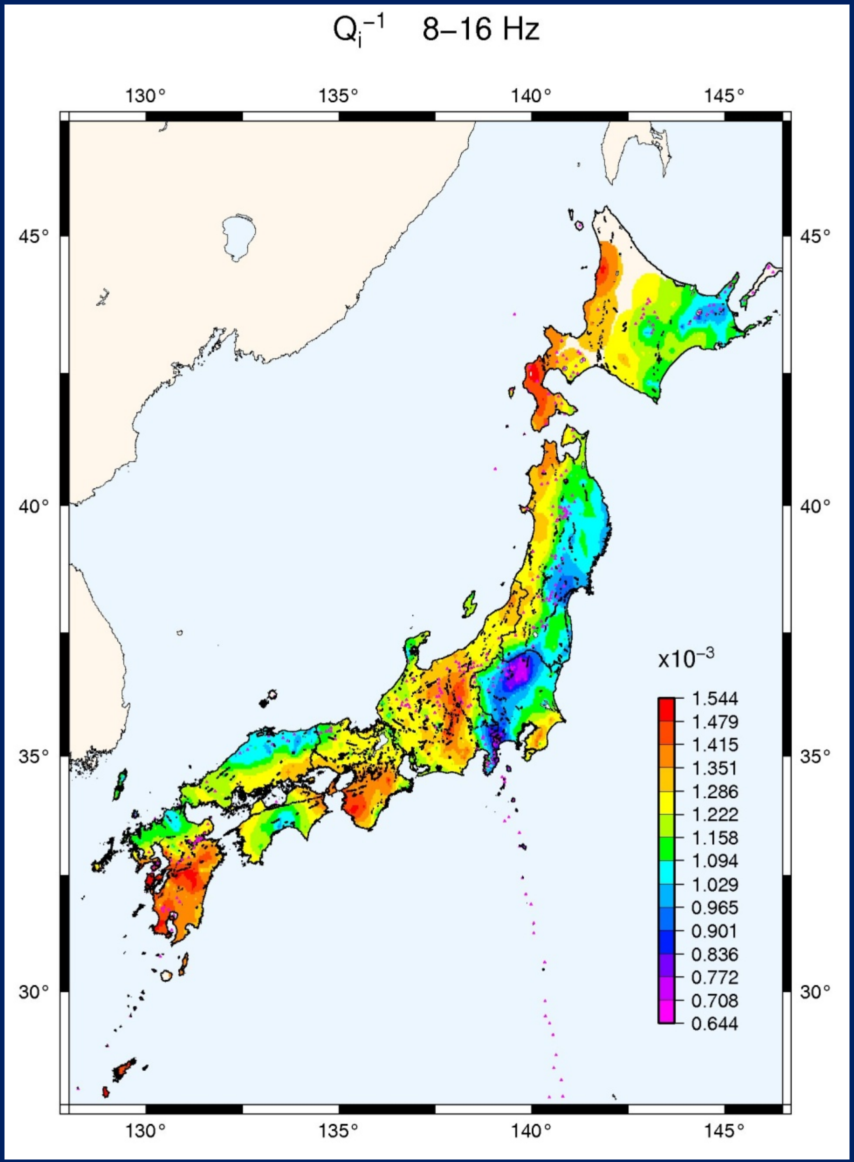
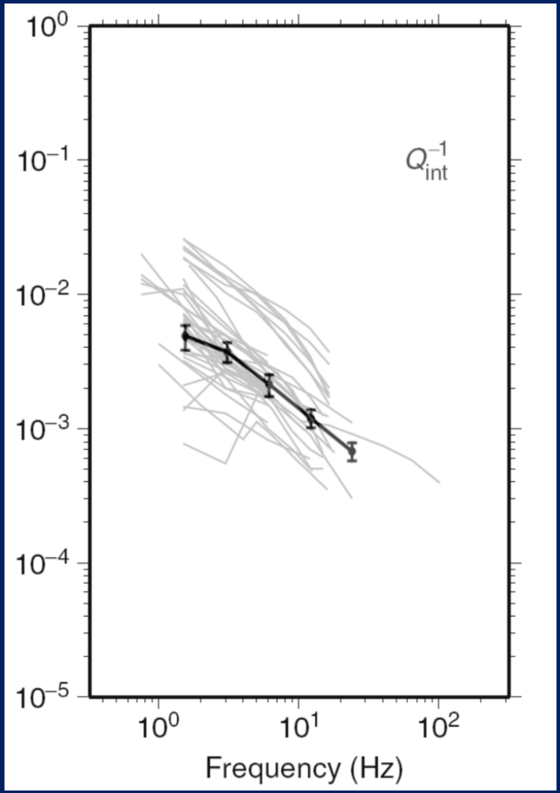




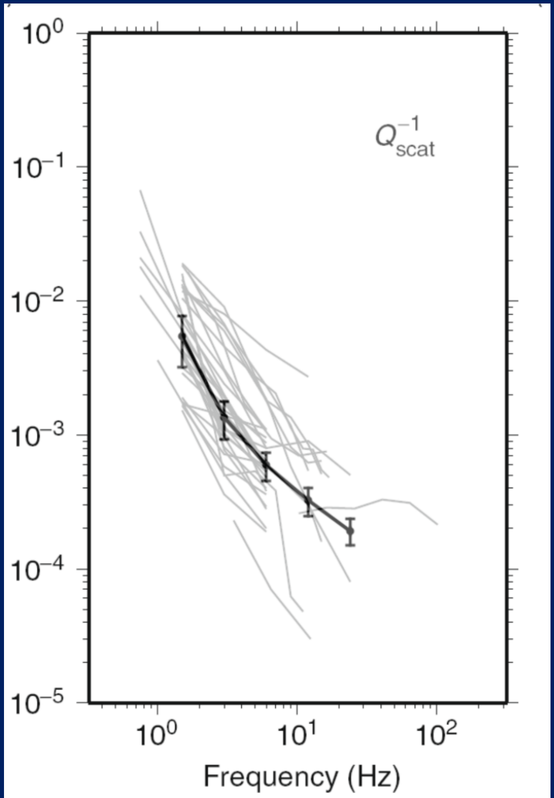
Comparison with other regions of the world

We plot the frequency dependence of the average values of the attenuation parameters in Japan and compare with results obtained in other regions of the world.

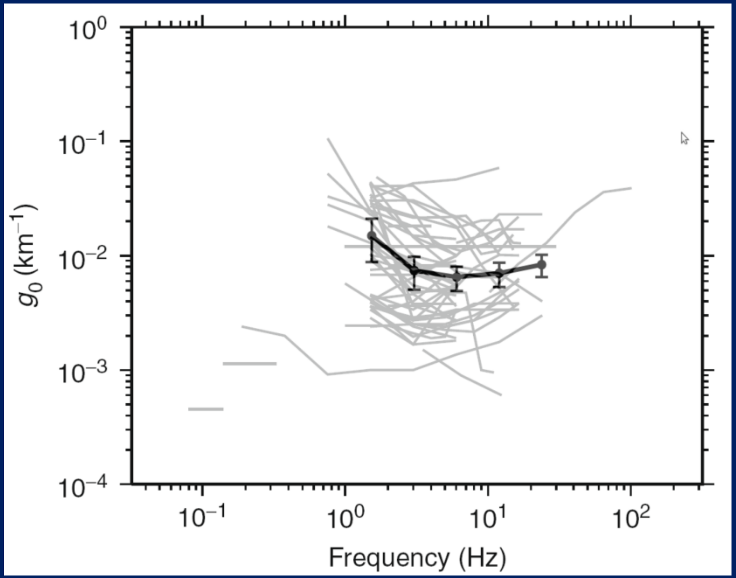
Intrinsic Absorption



Scattering Loss

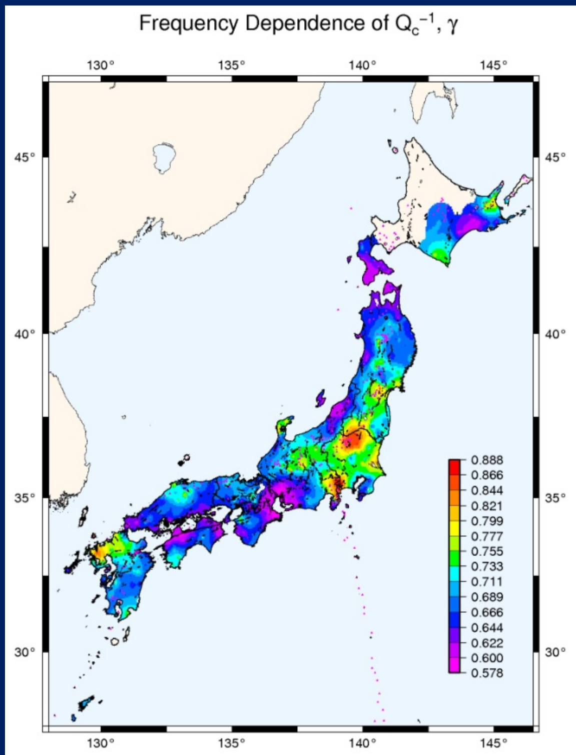


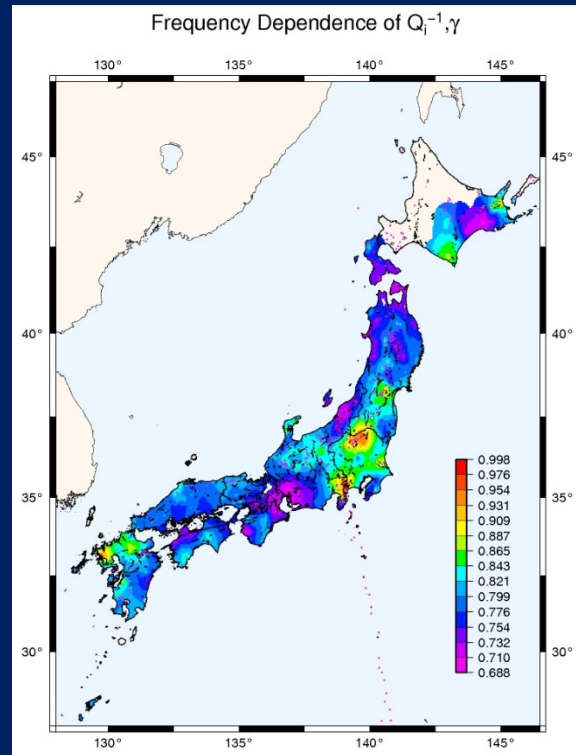
Scattering Coefficient

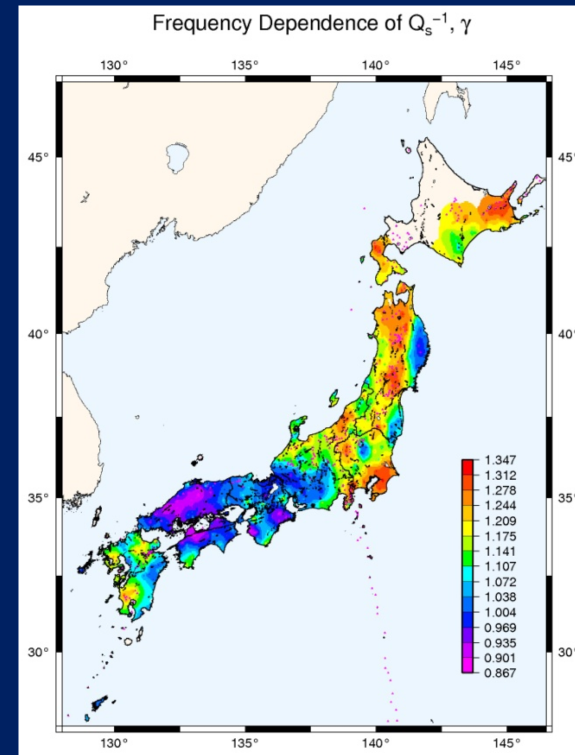


Yoshimoto and Jin (2008)

Frequency dependence log $Q/Q_0 = \gamma \log f$ EGU 2009







We compute log $Q/Q_0 = \gamma \log f$

Notice the similarity of the frequency dependence between coda decay and intrinsic absorption.

The frequency dependence of scattering loss shows a clear difference between Northeastern Japan and Southwest Japan.

CONCLUSIONS

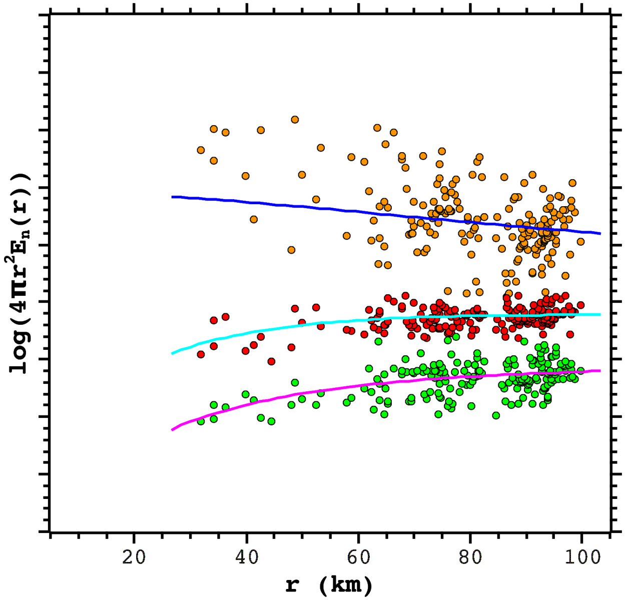
We have shown attenuation maps of all Japan by using Hi-net data from 772 stations and processing information from 135,000 events, and we have obtained about 190,000 useful seismic envelopes to perform the analysis.

The maps show important variations in the attenuations parameters that can be correlated with previous results obtained by velocity tomography.

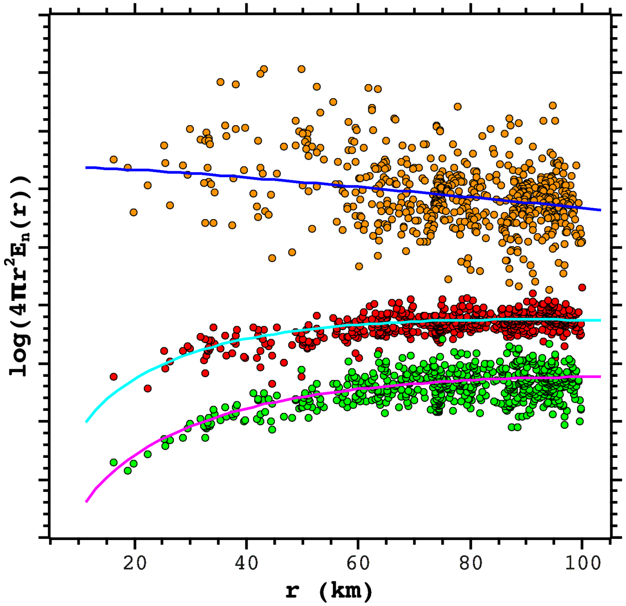
Volcanic arcs appear as strong scattering regions in the 1-2Hz band.

Intrinsic absorption and coda decay show a very similar behaviour.

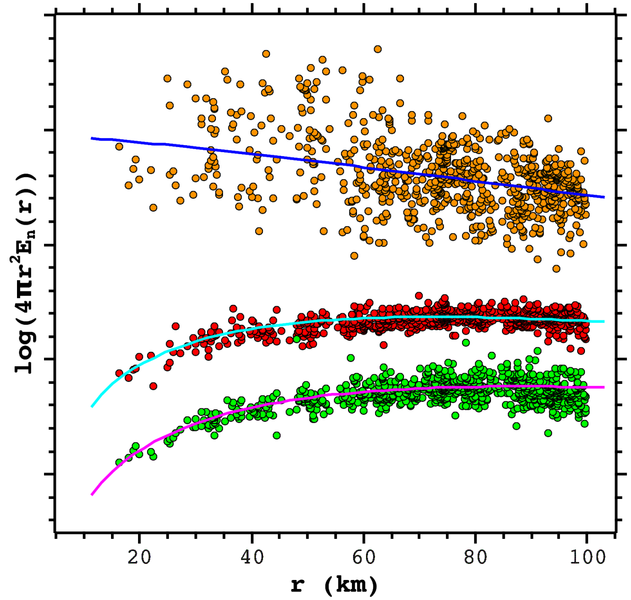
1-2 Hz



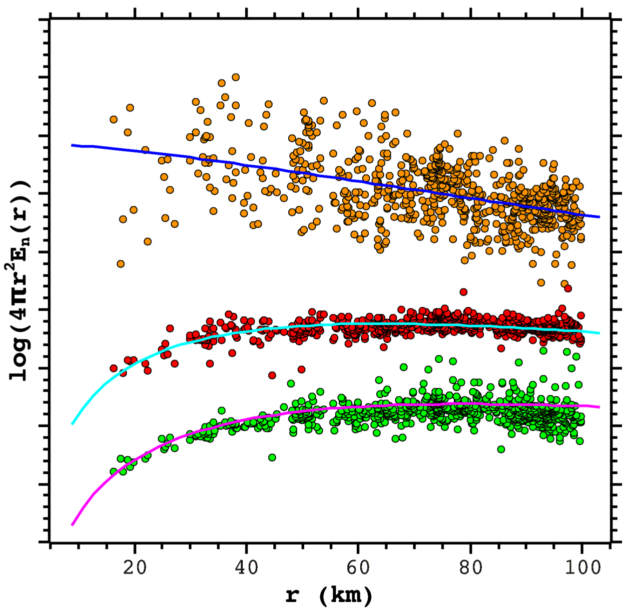
2-4 Hz



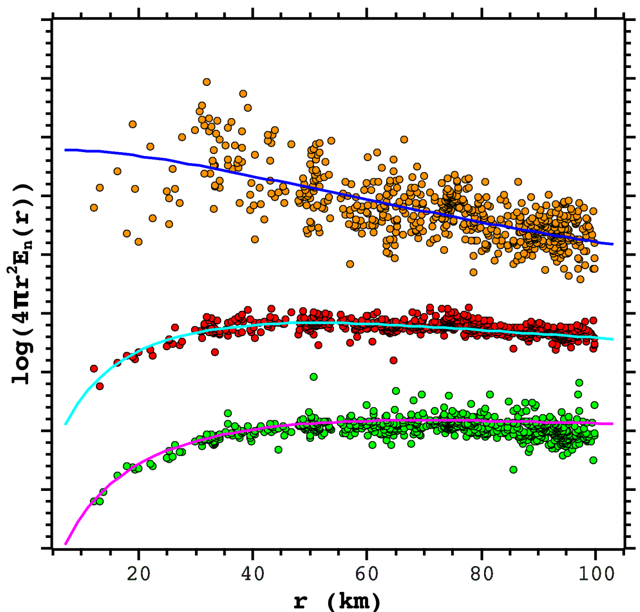
4-8 Hz



8-16 Hz



16-32 Hz



The integrals for the three windows are fitted to a synthetic model by means of a least square algorithm.

To carry out this non-linear fitting we used the Levenberg-Marquard algorithm.

Mapping the results has been performed by means of GMT routines:

We created a grid with a spacing of 0.04º (about 4.5 km) from the original data and we used the function “surface” to generate a continuous map with a tension factor of 1.0, which is the maximum value.

We notice here that the function surface interpolates the value of a parameter between the stations in order to assign a value to each point of the grid. In this way a continuous distribution may be shown in the maps.

The function “grdmask” is used with a radius of 0.25º; then, the map shows no results if there is no information from any station inside this radius for each grid point. This choice limits the maximum interpolation distance in the map.

In conclusion, the values of the parameters have been decided as a trade-off between trying to show an informative continuous distribution and at the same time trying to keep the maximum original information about local variations of the parameters being measured.

Comparison with Jin and Aki (2005)

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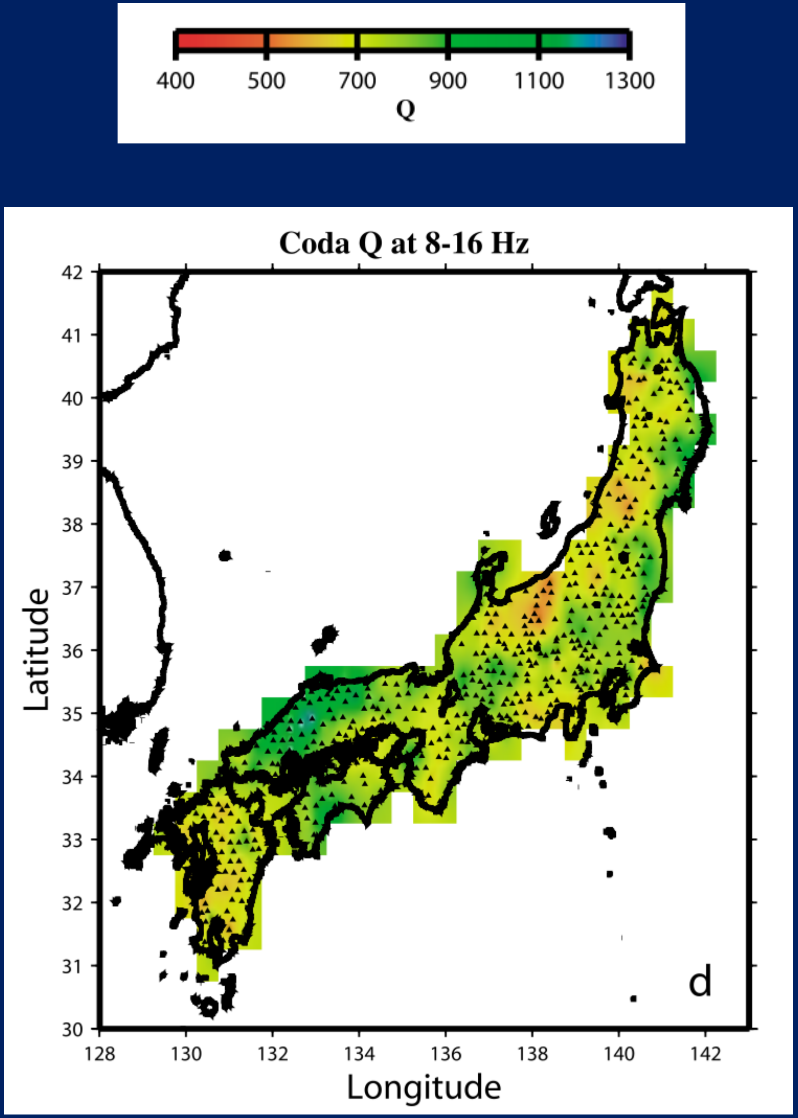

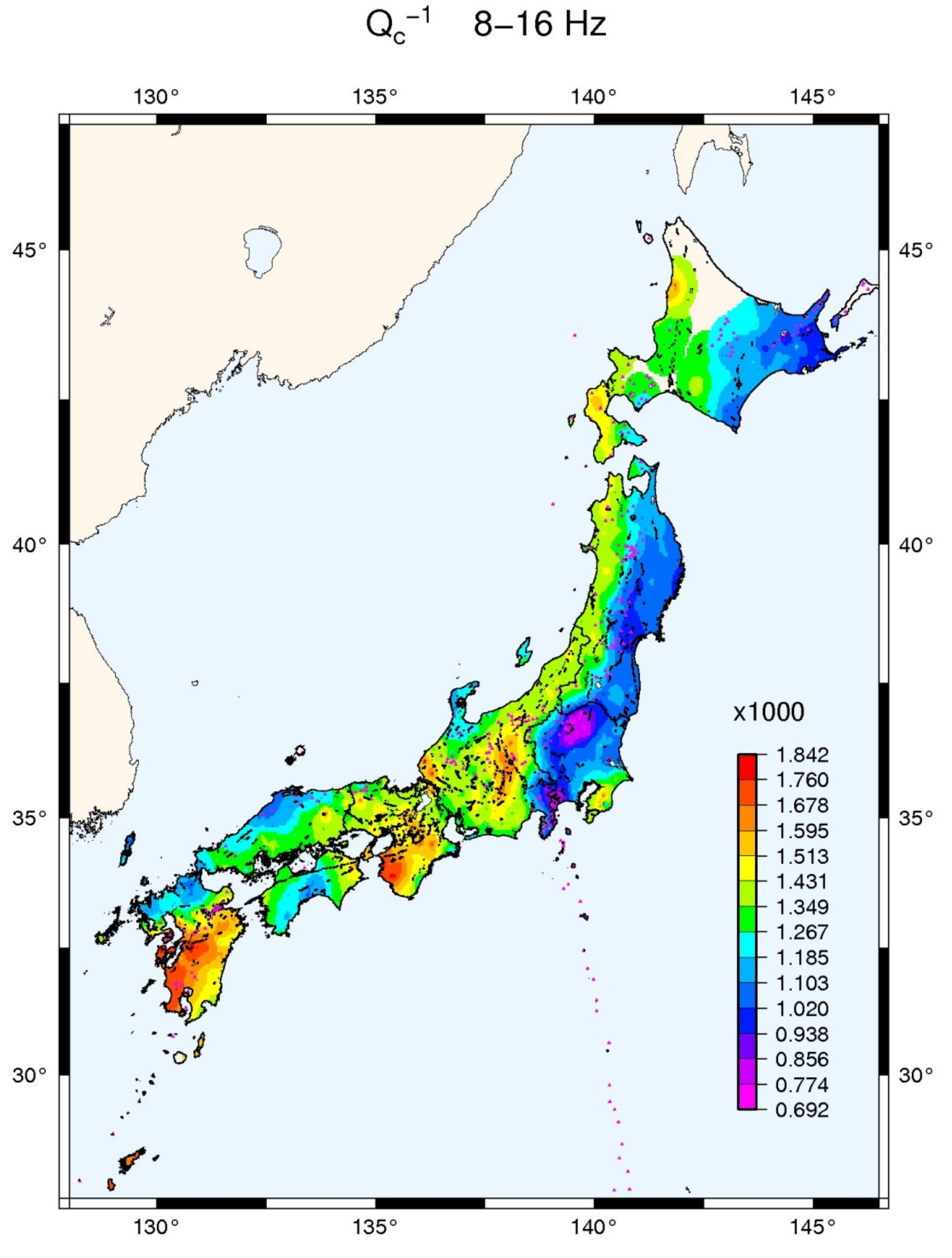

Comparison with Jin and Aki (2005)