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Strong lateral variations of seismic attenuation properties in Taiwan

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Seismic attenuation parameters in Taiwan have been obtained by using a modified “Multiple Lapse Time Window Analysis” approach in order to take into account the scattering anisotropy. MLTWA method exploits the spatio-temporal dependence of the ratio between coherent and incoherent seismic intensity to determine the scattering and absorption properties of a heterogeneous medium. In addition to the mean free path l (or the scattering quality factor Q_{sc}), the seismic wave propagation is controlled by a parameter g (independant of l) which determines the angular redistribution of energy upon scattering (scattering anisotropy). Preferentially forward (resp. backward) scattering corresponds to $g > 0$ (resp. $g < 0$), with $g = 0$ for isotropic scattering. We use Monte-Carlo simulations to compute Green functions and sensitivity kernels for Q_{sc}, Q_i (absorption quality factor) and g in media with an heterogeneous crust overlying a transparent mantle.

We analyse seismic records of local earthquakes with magnitude greater than 3.5 which occurred between 1994 and 2016. For each stations, we collect events within a radius of 100 km and a maximum depth of 40 km. About 350000 waveforms with a S/N ratio greater than 4 in the coda are selected. Seismic energy in three 15 s time windows from the S-wave arrival are measured in 3 frequency bands (1-2, 2-4 ,4-8 Hz). To account for site amplification and source amplitude, we normalize observed energy by the average energy in a late coda window at 65 s from the origin time of the earthquakes. For every station, we analyse the normalized energy in the three time widows as a function of the hypocentral distance. In order to determine the attenuation parameters Q_{sc}^{-1}, Q_i^{-1} and g with related errors, we implement a Levenberg-Marquardt algorithm. To guide the inversion, we use the sensitivity kernels for the attenuation parameters computed with our Monte-Carlo approach.

Overall, Taiwan is more attenuating than most orogens with a mean effective scattering loss $(Q_{sc}^{*})^{-1} = Q_{sc}^{-1}(1-g)$ about 0.012 and a mean intrinsic absorption Q_i^{-1} about 0.009 at 1.5 Hz. Our maps reveals strong lateral variations of attenuation with scale length from 10 to 100 km. Scattering loss $(Q_{sc}^{*})^{-1}$ varies over more than one order of magnitude across Taiwan (between 0.0022 and 0.16 at 1.5 Hz) . By contrast, absorption fluctuations are about 30%. The more attenuating zones are the Coastal Range and the Costal Plain where scattering dominates over absorption at low frequency, and inversely at high frequency. These regions are also characterized by strong backscattering ($g < -0.85$) at 1.5 Hz and rather high V_P/V_S ratio. Scattering becomes much more isotropic at high frequency. We speculate that the observed strong backscattering at low frequency is related to strong impedance fluctuations in the crust induced by the presence of fluids.