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Three-dimensional Qs structure of the Hikurangi subduction zone, central North Island, New Zealand

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The combination of Vp, Vs, Qp and Qs provides powerful constraints on the physical state of the crust and upper mantle. In this study, the three-dimensional (3D) Qs structure of the Hikurangi subduction zone, in central North Island, New Zealand is imaged down to 300 km. The results supplement previous studies that determined Vp, Vp/Vs and Qp from the Central North Island Passive Seismic Experiment in 2001. S wave spectra of 2435 earthquakes are analysed between 1 and 25 Hz to determine values of t^*, the whole path attenuation operator. The t^* values are initially inverted for 3D, frequency-independent, path-averaged Qs using a previously determined 3D seismic velocity model, within a grid oriented parallel to the trench. The grid spacing varies from 20 to 40 km horizontally and from 4 to 50 km vertically. The attenuation images reveal a clearly-defined, low-attenuation slab ($Qs > 1000$), consistent with the old ($120\,Ma$) slab being cold. Qs, like Qp, resolves the slab more distinctly than Vp or Vp/Vs. The mantle wedge, below 40 km, is more attenuating ($Qs < 600$) than the slab. The regions of highest attenuation ($Qs < 100$) are found in the fore-arc crust, above 40 km. However, there are significant variations along-strike of the subduction zone. Intriguing differences between the 3D structures of Qs and Qp are apparent. In particular, the most pronounced region of low Qp (in the mantle wedge at 50 to 85 km depth below the central part of the Taupo Volcanic Zone) is not reproduced in the Qs results. Investigation of the 3D Qs/Qp patterns gives insight into the physical composition and thermal structure of the subduction zone.