Controls of stress and water saturation on in-situ *Q* for shallow (< 1 m), unconsolidated sand

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Field investigations into the simultaneous effects of water saturation and stress on seismic attenuation are scarce. However seismic attenuation may be used to place constraints on water saturation with depth, at least for homogenous, porous media (Fig. 5). We use a publicly available seismic dataset [*Lorenzo et al.*, 2013] collected in a mid-size sand tank (~6 x 9 x 0.44 m) both for open evaluation of these relationships. In the presence of large *Q* gradients the assumed equivalency of *Q* between the raypaths of the reference and measured signals can lead to false *Q* estimates (e.g. < 0). We employ a modified spectral ratio method to estimate in-situ *Q* so that the average *Q* along the measured and reference ray paths differ.

We estimate local *Q* values from average raypath *Q* values, penetration depths, and travel times. Local *Q* values (Q_{int}) increase the most with depth ($dQ/dz = 43\ m^{-1}$) and stress ($dQ/d\sigma = 0.0025/Pa$) in dry sand and the least in partially saturated sand ($dQ/dz = 10\ m^{-1}$ and $dQ/d\sigma = 0.0013/Pa$) where attenuation created by local fluid flow reaches a maximum. Anomalous *Q* deviations outside this range can be explained by a divergence in effective stress, attenuation mechanism, or lithology.