Differential travel time delay associated with attenuation
Bill Menke, February 13, 2017

We compare propagation through two attenuating layers:

	Layer 1	Layer 2
Thickness, km	200 km	200 km
Vs	4.5 km/s	4.5 km/s
Vp/Vs	1.8	1.8
Qs	200	10-50
Qp/Qs	$3Vp^2/4Vs^2$	$3Vp^2/4Vs^2$

We compute Azimi-style P wave and S wave pulses for each layer and bandpass filter them between 0.01-0.10 Hz. We then determine the differential travel time delay (lag) for P waves through layers 1 and 2, and S waves through layers 1 and 2 using cross-correlations. The results indicate that lag increases approximately linearly with 1/Q for both P waves and S waves. The P wave lag at Qs=10 is about 1 seconds and S wave lag is about 4 seconds. The ratio of S lag to P lag increases with 1/Q and is about 4 at a Qs of 10.

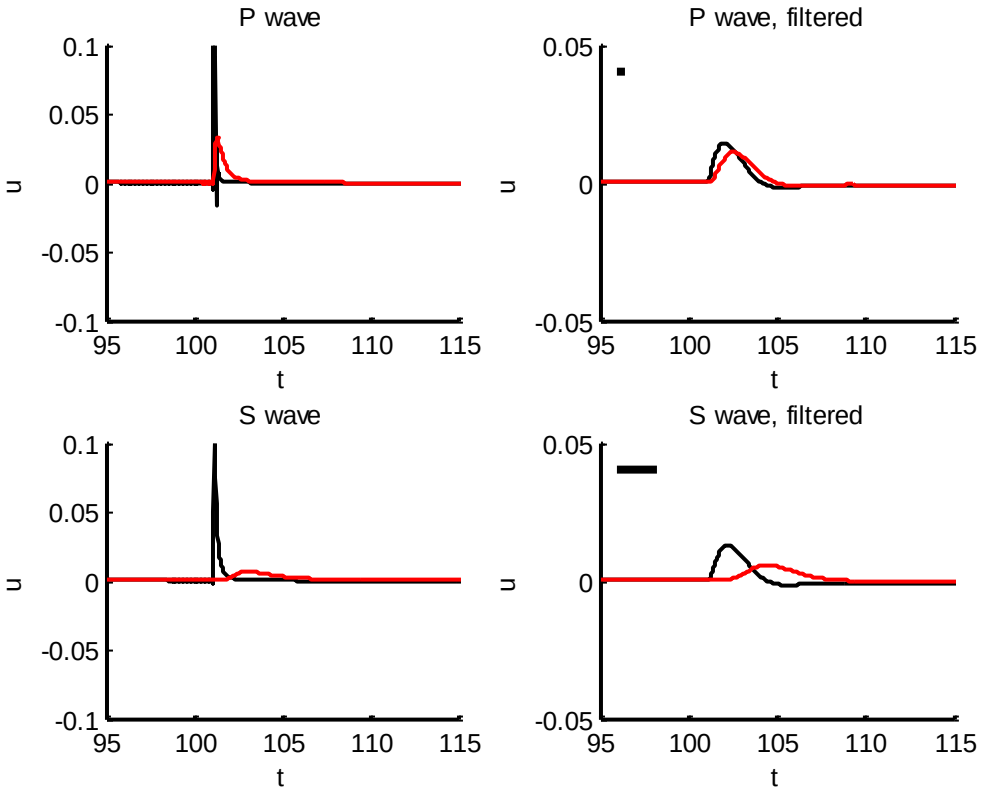

Figure 1. Azimi pulses for Layer 1 (black) and Layer 2 (red), for Qs=20 in Layer 2. Both unfiltered and filtered pulses are shown. Lag calculations use the filtered pulses. The horizontal bars show the delay.

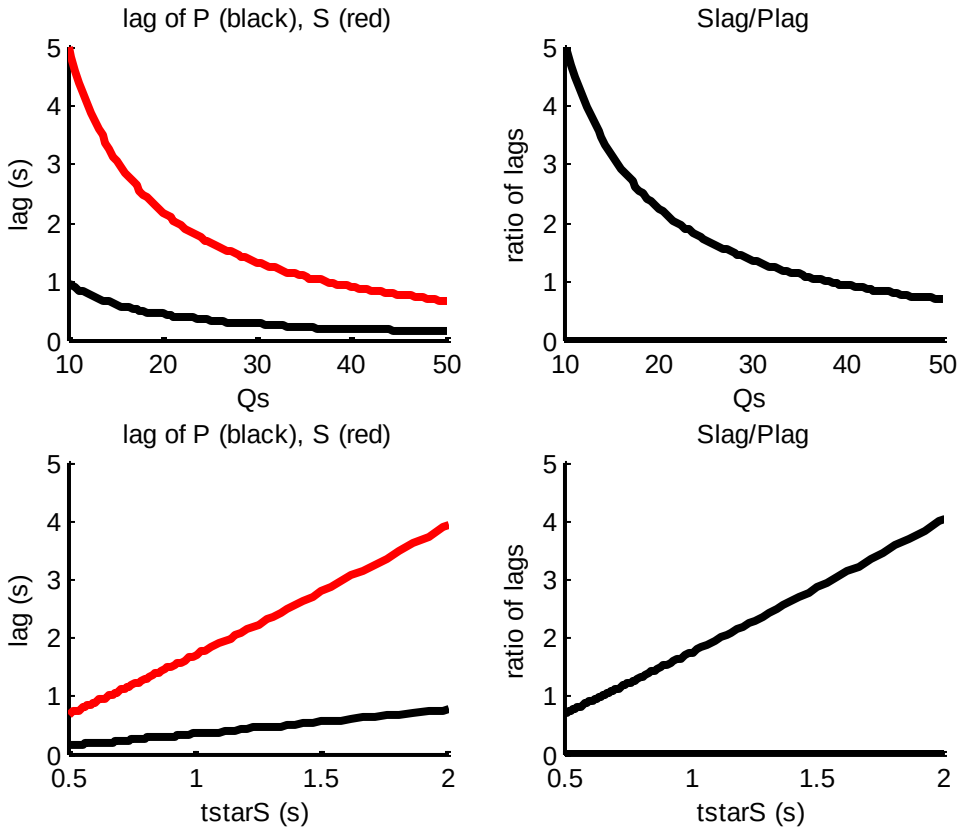

Figure 2. Results of simulation. (top left) P wave lag (black) and S wave lags(red) decrease with Qs of Layer 2. (top right) Their ratio also decrease. (Bottom left) Equivalently, increase with tstarS = x/(Vs*Qs). (Bottom right) Their ratio also increases.

See Aki and Richards, Quantitative Seismology (2012, their Problem 5.16) for the formula for Qp/Qs, which assumes that attenuation arises from shearing. Qp/Qs=2.43 for the parameters in Table 1.