Is there non-linearity evidence in the Aquila earthquake strong-motion recordings?

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The main-shock and the strongest aftershocks of the L'Aquila, 2009 earthquake were recorded by several strong-motion instruments close to the epicentre.

Given the maximum PGA (0.66 at AQK station), the presence of non-linear soil effects has been investigated. We were interested not only in the classical shear-modulus degradation in cohesive soil, but also in the amplitude-increasing non-linearity described by Bonilla *et al.* (2004) for cohesionless saturated soils, since gravel is common in the Atreno Valley. Unfortunately, the data of the reference station on bedrock (AQP) are not available for the main-shock. We decided then to investigate the possible non-linear effects comparing the HVSR for the main-shock and the aftershocks. This technique has been applied by other researchers to previous earthquakes (e.g., Dimitriu *et al*., 1999; Dimitriu *et al*., 2000).

We performed the analyses comparing the main-shock HVSR (tab.1) with the average HVSR of the 10 strongest aftershocks (tab. 2) at 4 station AQK, AQA, AQV and AQG. (see fig 1 for location). The signals were de-trended and band-pass filtered in the 0.2-25 Hz range.

At the AQK station the HVSR of the main-shock shows a faint sign of increased amplitude non-linearity (the frequency and the amplitude both slightly increase). At AQG the mainshock HVSR is close to the aftershock average and well within the standard deviation.

The AQA and AQV stations show a more complex pattern, with the enhancement of amplitude of some peaks and the reduction of others.

References

Bonilla L. F., Ralph J. Archuleta, D. Lavallée (2005) Hysteretic and Dilatant Behavior of Cohesionless Soils and Their Effectson Nonlinear Site Response: Field Data Observations and ModelingBulletin of the Seismological Society of America, 95, 2373–2395.

Dimitriu P., I. Kalogeras,N. Theodulidis(1999) Evidence of nonlinear site response in horizontal-to-vertical spectral ratio from near-field earthquakes, Soil Dynamics and Earthquake Engineering, 18, 423-435.

Dimitriu P. , N. Theodulidis, P. -Y. Bard (2000) Evidence of nonlinear site response in HVSR from SMART1 (Taiwan) data, Soil Dynamics and Earthquake Engineering, 20, 155-165.

Table 1 - Main shock

ID	Date	OT (UTC)	Lat (1)	Lon (1)	Depth (1)	Ml (1)	Mw (2)	Strike, Dip, Rake (2)
2206496920	06/04/2009	1.32.39	42.334	13.334	8.8	5.8	6.3	127, 50, -109

(1) - Istituto Nazionale di Geofisica e Vulcanologia

(2) - Harvard CMT

Table 2 - Main events of the sequence

ID	Date	OT (UTC)	Lat (1)	Lon (1)	Depth (1)	Ml (1)	Mw (2)	Strike, Dip, Rake (2)
	13/04/2009	21.14.00				4.2		
2206550980	09/04/2009	19.38.16	42.501	13.356	17.2	4.9	5.2	123, 53, -110
2206541910	09/04/2009	4.32.44	42.445	13.42	8.1	4		
	09/04/2009	3.14.00				4.2		
2206539720	09/04/2009	0.52.59	42.484	13.343	15.4	5.1	5.4	130, 48, -110
	07/04/2009	21.34.00				4.2		
1206521070	07/04/2009	17.47.37	42.275	13.464	15.1	5.3	5.5	106, 51, -138
2206516040	07/04/2009	9.26.28	42.342	13.388	10.2	4.7		

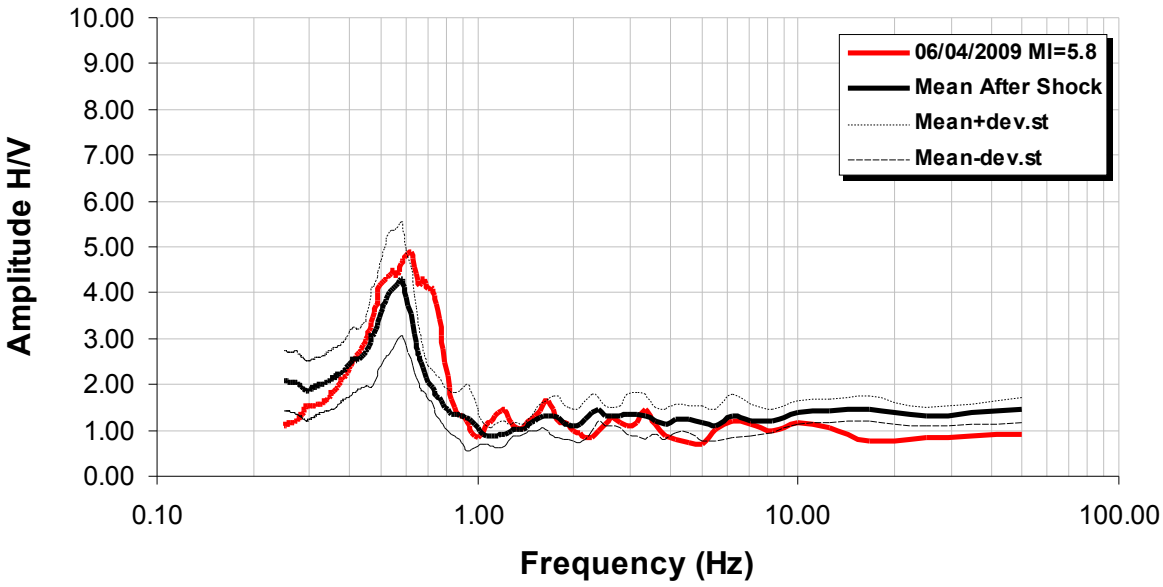
(1) - Istituto Nazionale di Geofisica e Vulcanologia

(2) - Harvard CMT

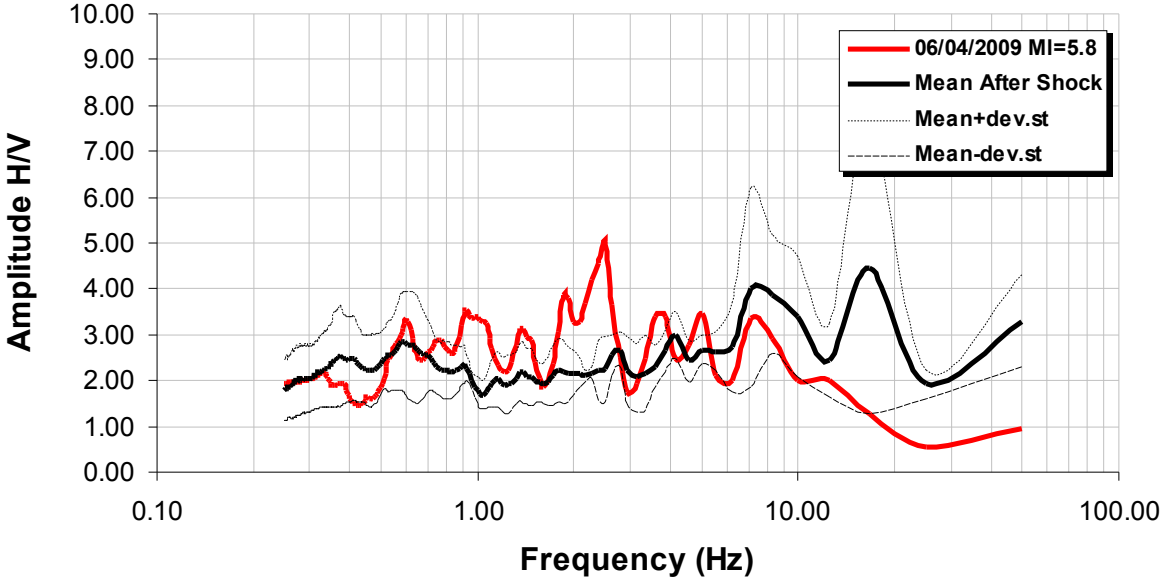
Table 3 - RAN stations

Code	Name	Lat	Long	Class EC8
AQA	L'AQUILA - V. ATERNO -F. ATERNO	42.376	13.339	B
AQG	L'AQUILA - V. ATERNO -COLLE GRILLI	42.373	13.337	B
AQV	L'AQUILA - V. ATERNO - CENTRO VALLE	42.377	13.344	B
AQK	AQUIL PARK ING.	42.345	13.401	C

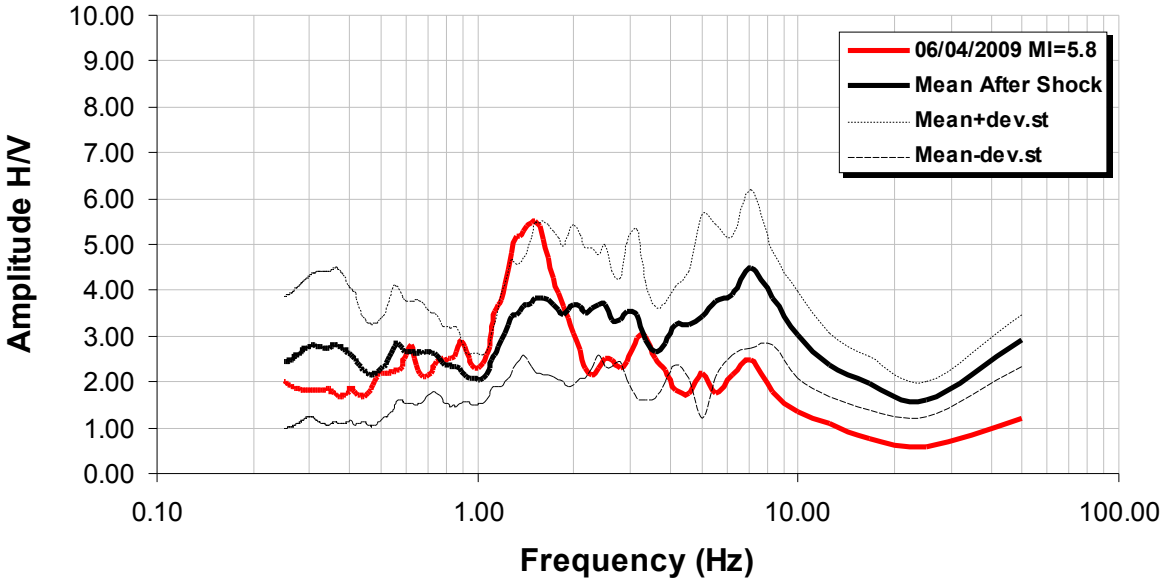
H/V AQK Station



H/V AQA Station



H/V AQV Station



H/V AQG Station