Instrumental investigations after the 6 April 2009 L'Aquila earthquake

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Ameri G.[1], Augliera P.[1], D'Alema E.[1], Franceschina G.[1], Galadini F.[1], Ladina C.[2], Lovati S.[1], Luzi L.[1], Maistrello M.[1], Marzorati S.[1], Massa M.[1], Piccarreda D.[1], Puglia R.[1]

[1]Istituto Nazionale di Geofisica e Vulcanologia – Sezione di MILANO- PAVIA

[2]Istituto Nazionale di Geofisica e Vulcanologia – Centro Nazionale Terremoti

ABSTRACT

This work synthesizes the activities conducted in the field by The Milano-Pavia Department of INGV in the three months following the Mw 6.3 event occurred on 6 April 2009 at L'Aquila town (central Italy).
The work has been carried out in three phases:
1) deployment of several strong-motion stations in order to record the strongest aftershocks in the near-field, in the days which followed the main event; 2) detection of local site effects in the framework of the C.A.S.E. project, to investigate the seismic response of the areas selected for the construction of the emergency residences for homeless people; 3) geophysical investigations as a contribution to the seismic microzoning for the post-emergency reconstruction in the municipalities with the highest degrees of damage.
Phases 2 and 3 had the aim of individuating the soil resonance frequencies through the empirical analysis of the ground motion, such as ambient noise and weak motion, recorded by temporary seismic stations.
The stations have been installed in sites with different lithologic and geomorphologic conditions, and a huge data set has been collected to investigate site effects. The instruments have worked from 7 April to 13 July 2009; recording 469 aftershocks in the local magnitude range 2.5 - 5.3.
The analysis carried out for phases 2 and 3 was based on the spectral ratio techniques, using a single station (Nakamura technique, and Horizontal to Vertical Spectral Ratio (HVSR) of weak motions) or a reference station (Standard Spectral Ratio, SSR).
In the three phases the aftershocks have been recorded in 30 sites, corresponding to 25 localities inside the province of L'Aquila; using 11 seismic stations, 9 velocimetric sensors and 8 accelerometers. Finally 70 ambient noise measurements have been executed.

Phase 1

Deployment of several strong-motion stations in order to record the strongest aftershocks in the near-field, in the days after the main event. The instruments are installed near Municipalities with high degrees of damage: Onna, Paganica, Fossa, S. Eusanio Forconese

Fig.1.1 Installation Type

a) All stations are installed in free field, near the urbanized areas

b) The sensor are buried below 30 cm of soil

c) The stations are powered with solar pannels and syncronized with gps antenna. The seismic data are recorded in local memory card

d) The instruments are shelted in the watertight box

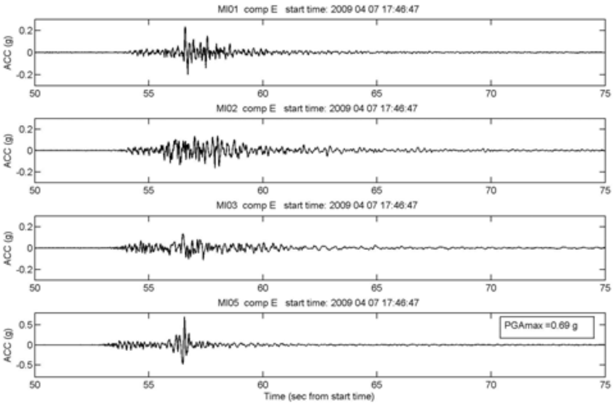
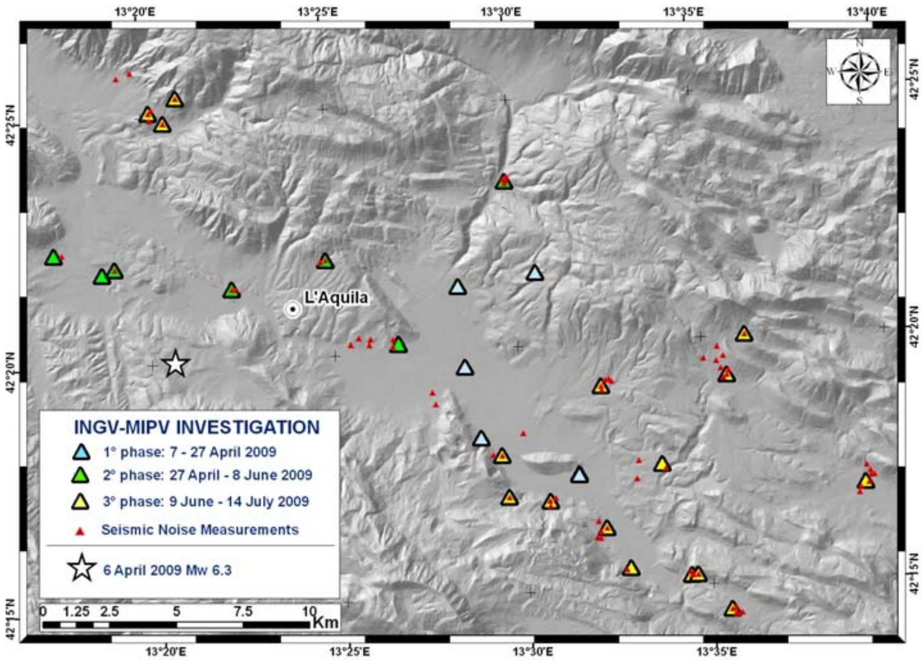


Fig.1.2 Strongest aftershocks recordings

The strong motion stations recorded all strongest aftershocks without saturation of the signal.
The max Peak Ground Acceleration recorded is 0.69 g at 5.4 Km (epicentral distance) during 7 April 2009 Ml 5.3 earthquake
Dowload the data: http://rais.mi.ingv.it

STA_CODE	SITE	LON	LAT	ELEV (m)	SENSOR 1	SENSOR 2	RECORDER	OWNER	DATA TYPE	PHASE
MI01	PESCOMAGGIORE	13.5098	42.3580	740	LE3D-1s	Episensor	RTF130	INGV-MIPV	earthquake	1
MI02	PAGANICA	13.4743	42.3545	648	LE3D-5s	Episensor	RTF130	INGV-MIPV	earthquake	1
MI03	ONNA	13.4757	42.3274	581	LE3D-5s	Episensor	RTF130	INGV-MIPV	earthquake	1
MI04	FOSSA	13.4814	42.3031	612	LE3D-1s		RTF130	INGV-MIPV	earthquake	1
MI05	S. EUSANIO FORCONESE	13.5253	42.2895	585	LE3D-5s	Episensor	RTF130	INGV-MIPV	earthquake	1
MI06	CAMARDA	13.4979	42.3894	807	LE3D-1s	Episensor	RTF130	INGV-MIPV	earthquake	2
MI07	BAZZANO	13.4459	42.3362	662		Episensor	RTF130	INGV-MIPV	earthquake	2
MI08	SANT'ANTONIO	13.3713	42.3574	650	LE3D-1s	Episensor	RTF130	INGV-MIPV	earthquake	2
MI09	SAN GIACOMO	13.4144	42.3658	782		Episensor	RTF130	INGV-MIPV	earthquake	2
MI10	SANT'ELIA 1	13.3184	42.3368	607	LE3D-5s	Episensor	RTF130	INGV-MIPV	earthquake	2
MI11	SASSA ZONA POLIVALENTE	13.3184	42.3660	657	LE3D-5s		RTF130	INGV-MIPV	earthquake	2
MI12	CESE DI PRETURO	13.2910	42.3716	672		Episensor	RTF130	INGV-MIPV	earthquake	2
MN02	MONTICCHIO	13.4615	42.3153	551	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN12	MONTICCHIO	13.4603	42.3194	551	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN13	SANT'ELIA 1	13.4331	42.3382	623	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN14	SANT'ELIA 2	13.4241	42.3369	626	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN15	BAZZANO	13.4433	42.3356	607	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN16	BAZZANO	13.4434	42.3378	629	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN17	SANT'ANTONIO	13.3730	42.3574	651	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN18	SANT'ANTONIO	13.3713	42.3574	650	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN19	CAMARDA	13.4977	42.3887	805	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN20	CAMARDA	13.4987	42.3897	809	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN22	CAMARDA	13.4987	42.3909	827	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN23	CAMARDA	13.4970	42.3900	803	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN24	SAN GIACOMO	13.4121	42.3652	765	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN25	SAN GIACOMO	13.4147	42.3658	787	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN26	SANT'ELIA 1	13.4325	42.3365	595	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN27	SASSA ZONA POLIVALENTE	13.2124	42.3645	654	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN28	SASSA ZONA POLIVALENTE	13.3184	42.3660	657	LE3D-5s		RTF130	INGV-MIPV	noise	2
MN29	CESE DI PRETURO	13.2944	42.3717	672	LE3D-5s		RTF148	INGV-MIPV	noise	2
ANG1	VILLA SANT'ANGELO	13.5328	42.2730	624	LE3D-5s		RTF130	INGV-MIPV	noise	3
ANG2	VILLA SANT'ANGELO	13.5338	42.2694	578	LE3D-5s		RTF130	INGV-MIPV	noise	3
ANG3	TUSSILLO	13.5334	42.2674	593	LE3D-5s		RTF130	INGV-MIPV	noise	3
ARI1	ARISCHIA	13.3385	42.4193	852	LE3D-5s		RTF130	INGV-MIPV	noise	3
ARI2	ARISCHIA	13.3296	42.4322	850	LE3D-5s		RTF130	INGV-MIPV	noise	3
ARI3	ARISCHIA	13.3232	42.4307	806	LE3D-5s		RTF130	INGV-MIPV	noise	3
ARI4	ARISCHIA	13.3375	42.4157	861	LE3D-5s		RTF130	INGV-MIPV	noise	3
ARI5	ARISCHIA	13.3435	42.4146	807	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR1	BARISCIANO	13.5954	42.3220	855	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR2	BARISCIANO	13.5928	42.3195	890	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR4	BARISCIANO	13.5901	42.3254	941	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR5	BARISCIANO	13.5905	42.3301	979	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR6	BARISCIANO	13.5841	42.3263	934	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR7	BARISCIANO	13.5932	42.3270	985	LE3D-5s		RTF130	INGV-MIPV	noise	3
BAR8	BARISCIANO	13.5919	42.3228	905	LE3D-5s		RTF130	INGV-MIPV	noise	3
CAS1	CASENTINO	13.5112	42.2791	603	LE3D-5s		RTF130	INGV-MIPV	noise	3
CAS3	CASENTINO	13.5112	42.2808	591	LE3D-5s		RTF130	INGV-MIPV	noise	3
CAS4	CASENTINO	13.5139	42.2817	563	LE3D-5s		RTF130	INGV-MIPV	noise	3
DEM1	SAN DEMETRIO NE' VESTINI	13.5512	42.2869	624	LE3D-5s		RTF130	INGV-MIPV	noise	3
DEM2	SAN DEMETRIO NE' VESTINI	13.5524	42.2929	651	LE3D-5s		RTF130	INGV-MIPV	noise	3
DEM3	SAN DEMETRIO NE' VESTINI	13.5645	42.2897	695	LE3D-5s		RTF130	INGV-MIPV	noise	3
FOS2	FOSSA	13.4865	42.2973	623	LE3D-5s		RTF130	INGV-MIPV	noise	3
FOS4	FOSSA	13.5005	42.3041	570	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI03	ONNA	13.4757	42.3274	581	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI04	FOSSA	13.4814	42.3031	612	Le 3D 1s		RTF130	INGV-MIPV	earthquake	3
MI05	SANT' EUSANIO FORCONESE	13.5251	42.2890	585	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI14	VILLA SANT'ANGELO	13.5365	42.2706	587	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI14	VILLA SANT'ANGELO	13.5365	42.2706	587	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI15	VALLECUPA	13.5740	42.2532	680	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI15	VALLECUPA	13.5740	42.2532	680	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI16	PEDICCIANO	13.5916	42.2412	749	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI16	PEDICCIANO	13.5916	42.2412	749	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI18	FOSSA	13.4905	42.2970	622	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI18	FOSSA	13.4905	42.2970	622	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI19	CASENTINO	13.5114	42.2806	579		Episensor	RTF130	INGV-MIPV	earthquake	3
MI20	STIFFE	13.5465	42.2568			Episensor	RTF130	INGV-MIPV	earthquake	3
MI21	FOSSA	13.4928	42.2828	741	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI21	FOSSA	13.4928	42.2828	734	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI22	VALLECUPA	13.5767	42.2534	692	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI22	VALLECUPA	13.5767	42.2534	692	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI23	ARISCHIA	13.3372	42.4183	832	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI23	ARISCHIA	13.3372	42.4183	832	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI24	ARISCHIA	13.3498	42.4228	1042	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI24	ARISCHIA	13.3498	42.4228	1042	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI25	ARISCHIA	13.3435	42.4146	813	Le 3D 5s X494		RTF130	INGV-MIPV	earthquake	3
MI25	ARISCHIA	13.3435	42.4146	813	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI26	SAN DEMETRIO NE' VESTINI	13.5630	42.2914	691		Episensor	RTF130	INGV-MIPV	earthquake	3
MI27	SAN PIO DELLE CAMERE	13.6552	42.2819	796		Episensor	RTF130	INGV-MIPV	earthquake	3
MI28	POGGIO PICENZE	13.5370	42.3186	713	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI28	POGGIO PICENZE	13.5370	42.3186	713	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI29	BARISCIANO	13.6034	42.3336	1190	Le 3D 5s	Episensor	RTF130	INGV-MIPV	earthquake	3
MI29	BARISCIANO	13.6034	42.3336	1190	LE3D-5s		RTF130	INGV-MIPV	noise	3
MI30	BARISCIANO	13.5944	42.3205	899	Le 3D 5s		RTF130	INGV-MIPV	earthquake	3
MI30	BARISCIANO	13.5944	42.3205	899	LE3D-5s		RTF130	INGV-MIPV	noise	3
PED3	PEDICCIANO	13.5935	42.2417	727	LE3D-5s		RTF130	INGV-MIPV	noise	3
PED4	PEDICCIANO	13.5959	42.2399	720	LE3D-5s		RTF130	INGV-MIPV	noise	3
PED5	PEDICCIANO	13.5938	42.2393	567	LE3D-5s		RTF130	INGV-MIPV	noise	3
PED6	PEDICCIANO	13.5929	42.2396	736	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO1	SAN PIO DELLE CAMERE	13.6575	42.2856	797	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO2	SAN PIO DELLE CAMERE	13.6566	42.2816	752	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO3	SAN PIO DELLE CAMERE	13.6592	42.2843	783	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO4	SAN PIO DELLE CAMERE	13.6575	42.2842	765	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO5	SAN PIO DELLE CAMERE	13.6519	42.2783	759	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO6	SAN PIO DELLE CAMERE	13.6531	42.2801	752	LE3D-5s		RTF130	INGV-MIPV	noise	3
PIO7	SAN PIO DELLE CAMERE	13.6558	42.2877	817	LE3D-5s		RTF130	INGV-MIPV	noise	3
POG1	POGGIO PICENZE	13.5391	42.3208	745	LE3D-5s		RTF130	INGV-MIPV	noise	3
POG2	POGGIO PICENZE	13.5405	42.3211	738	LE3D-5s		RTF130	INGV-MIPV	noise	3
POG3	POGGIO PICENZE	13.5371	42.3174	701	LE3D-5s		RTF130	INGV-MIPV	noise	3
POG4	POGGIO PICENZE	13.5417	42.3202	745	LE3D-5s		RTF130	INGV-MIPV	noise	3
STI4	STIFFE	13.5446	42.2562	597	LE3D-5s		RTF130	INGV-MIPV	noise	3
TUS1	TUSSILLO	13.5318	42.2675	590	LE3D-5s		RTF130	INGV-MIPV	noise	3
VAL1	VALLECUPA	13.5735	42.2545	682	LE3D-5s		RTF130	INGV-MIPV	noise	3
VAL5	VALLECUPA	13.5745	42.2536	702	LE3D-5s		RTF130	INGV-MIPV	noise	3
VAL6	VALLECUPA	13.5767	42.2534	693	LE3D-5s		RTF130	INGV-MIPV	noise	3



Phase 2

Detection of local site effects in the framework of the C.A.S.E. project, to investigate the seismic response of the areas selected for the construction of the emergency residences for homeless people. The aim of investigation was to assess the soil resonance frequencies through the empirical analysis of the ground motion, such as ambient noise and weak motion, recorded by temporary seismic stations installed at free field site.

The INGV-MIPV Department investigated 7 polygon area in the municipality of L'Aquila: Camarda, Bazzano, Sant'Antonio, San Giacomo, Sant'Elia, Sassa Zona Polivalente, Cese di Preturo.

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

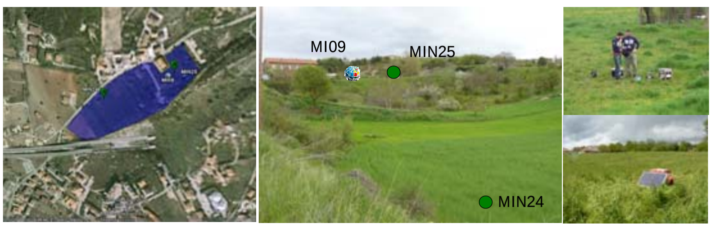


Fig.2.1 Investigations in the San Giacomo area (L'Aquila).

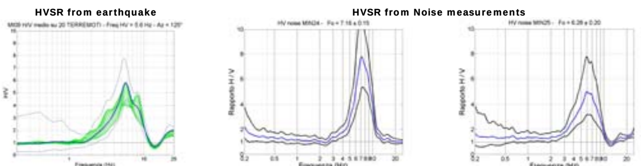


Fig.2.2 Results of empirical analysis (Horizontal to Vertical Spectral Ratio) in the San Giacomo area

Phase 3

Geophysical investigations as a contribution to the seismic microzoning for the post-emergency reconstruction in the municipalities with the highest degrees of damage.
The stations have been installed in sites with different lithologic and geomorphologic conditions, and a huge data set has been collected to investigate site effects.
The INGV-MIPV Department investigated 4 Macro Areas (13 municipalities) :
MA 4: Poggio Picenze, Barisciano, S. Pio delle Camere
MA 5: Onna
MA 6: Villa S. Angelo, Tussillo, S. Eusanio Forconese, Casentino, Fossa
MA 7: Arischia, S. Demetrio ne' Vestini, Stiffe, Vallecupa, Pedicciano

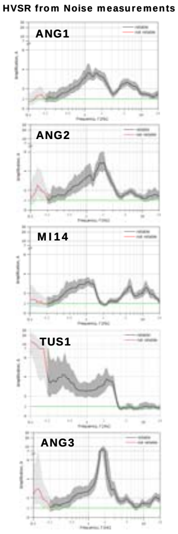


Fig.3.1 Investigations in the Villa S. Angelo municipality

The measurements are executed near urbanized area and in the "red area" of the maximum damage