Geophysical Research Letters

Supporting Information for

Evidence of underground electric current generation during the 2009 L'Aquila earthquake: Real or instrumental?

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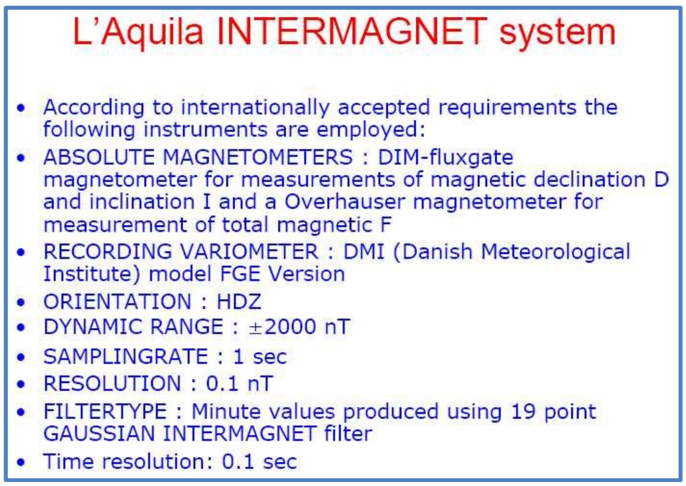
Introduction

Here there are figures, tables, and text in support of the main paper.

Text S1. Fluxgate data reported by *Nenovski* [2015] are from the INTERMAGNET station at the Geomagnetic Observatory of L'Aquila. According to *Nenovski* [2015], the fluxgate is oriented in the geographic reference frame XYZ. In fact, the fluxgate is HDZ oriented. The misunderstanding is due to an error in describing data in the database from which Nenovsky downloaded magnetic data (see http://roma2.rm.ingv.it/it/risorse/banche_dati/39/ osservazioni_relative_al_sisma_del_6-4-2009_a_l-aquila). Knowing the orientation of the fluxgate is required for deriving total magnetic field data from fluxgate components by means of the magnetic declination and inclination obtained using a DIM (Declination Inclination magnetometer) fluxgate theodolite. During 2009 in the Geomagnetic Observatory of L'Aquila there was no fluxgate XYZ oriented (personal communication of the staff of the observatory). See also the description of the INTERMAGNET system in *Palangio* [2009] that we report below



Adapted from Palangio, P. (2009), Magnetism and Electromagnetism in Central Italy, *University of L'Aquila, Italy,* (available at ftp:geospserver.aquila.infn.it/isssGeom&Ion08/palangio.pdf).

Still, *Nenovski* [2015] on page 7477 write

"The INGV magnetometers are a fluxgate magnetometer for measurements of magnetic declination, D, and inclination, I, and an overhauser (absolute) magnetometer for measurement of total magnetic field, F."

Let us say that a fluxgate magnetometer measures the variation of the geomagnetic field components and not the magnetic declination and inclination. The magnetic declination and inclination are obtained using a DIM fluxgate theodolite.

Text S2. *Nenovski* [2015] is unclear in describing the onset time of the reported coseismic effects that he affirms to have the same seismogenic source. More precisely:

1) In the Introduction section (page 7477) he write
"*The analysis revealed an existence of transient magnetic field signal that appears immediately after the EQ shock. The signal exists within the first 5 min. The transient magnetic field signal emerging at the time of the main shock moment (01:32:40 UT) and lasting for several minutes after it,…*"

2) In section 3.1 (pages 7478-7479) he write
"The magnetic disturbances started simultaneously at all the magnetometers with a time delay of ~5s compared to the EQ main shock moment fixed at 01:32:40.400 UTC [Orefice et al., 2013]. Having in mind that the distance between the observatories and the EQ hypocenter is equal to 10.7 km, the observed delay time can be attributed to the seismic waves travel times to reach the measurement points where the EQ shaking induces observed high-amplitude magnetic field bursts. The seismic wave velocity is thus estimated equal to 2.1 km/s. Therefore, the magnetic field bursts were considered to be initiated practically simultaneously with the seismic waves that reached the observation point."

   The transient magnetic field signal grows at the end (maybe he wanted to write *at the beginning*) *of the seismic wave passage, retaining its maximum for about 15 s and begins to fade for about 200 s. The signal totally disappeared after 300 s (~5 min).*

3) In the Conclusion section (page 7482) he write
Primary coseismic variations initiated at the Mw6.1 EQ main shock are recorded by 1 s fluxgate and overhauser (absolute) magnetometers data. These consist both in a magnetic field offset of amplitudes ranging between 0.1 ÷ 1 nT and in a transient magnetic field signal of amplitude 0.8 nT.

   "*The magnetic field observations around the L'Aquila earthquake main shock reveal a transient signal that appears and fades within the first 5 min after the EQ shock. An electric current generation (electrification process) in the EQ nucleation zone is suggested as an underlying mechanism of the recorded transient magnetic field signal.*"

Therefore, it is not clear if, according to *Nenovski* [2015], the onset of the magnetic effects is simultaneous with the origin time of the 6 April main shock, or if the magnetic effects appear at the arrival of the seismic waves in the Geomagnetic Observatory of L'Aquila.

Table S1. The 6 April 2009 main shock, the M_L4.7 aftershock, and the two largest aftershocks (from *Centro Nazionale Terremoti* – INGV, http://cnt.rm.ingv.it/).

yy – mm – dd	origin time (hh:mm:ss)	epicentre		depth (km)	magnitude
		latitude (°N)	longitude (°E)		
2009 – 04 – 06	01:32:40.400	42.342	13.380	8.3	M_W6.1
2009 – 04 – 06	01:36:29.190	42.352	13.346	9.7	M_L4.7
2009 – 04 – 07	17:47:37.340	42.303	13.486	17.1	M_W5.4
2009 – 04 – 09	00:52:59.690	42.489	13.351	11.0	M_W5.2

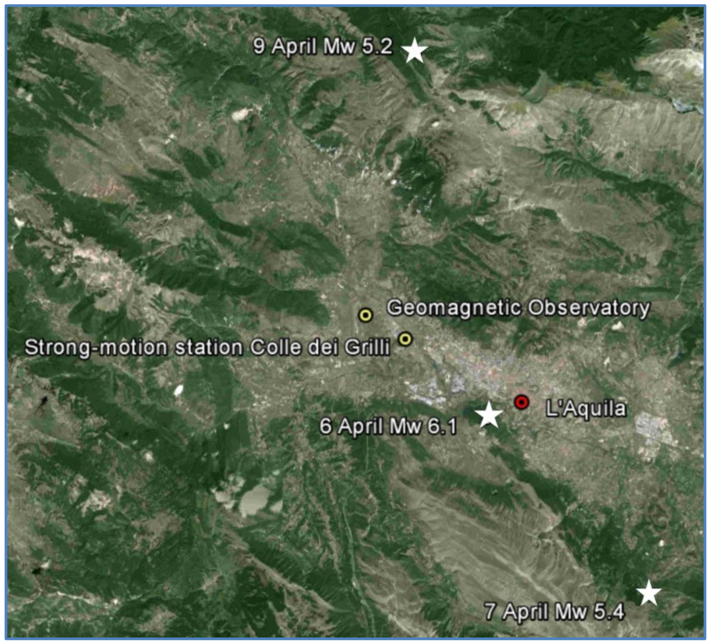
Table S2. Magnetic and seismic stations	latitude (°N)	longitude (°E)	distance from the epicentre of 6 April main shock (km)
Geomagnetic Observatory of L'Aquila	42.382*	13.317*	~ 7
Strong-motion station – *Colle dei Grilli*	42.373	13.337	~ 5

* The coordinates refer to the centre of the observatory.

Table S3. Magnetometers	instrument	measurement	sampling (s)	resolution
INGV INTERMAGNET station	overhauser	total magnetic field	1	0.1 nT
	three orthogonal fluxgates sensors HDZ oriented	variation of the magnetic field components	1	0.1 nT
INGV Helmholtz coil system	overhauser	total magnetic field	60	0.1 nT

UNIVAQ station	three orthogonal fluxgate sensors HDZ oriented	variation of the magnetic field components	1	0.01 nT
	three orthogonal induction sensors HDZ oriented		1	0.01 mV

a)



b)

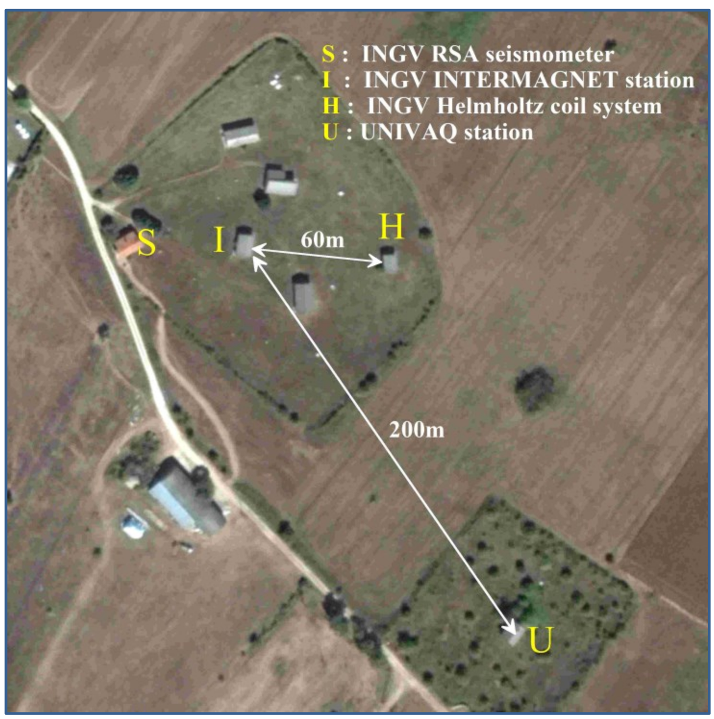


Figure S1. a) Black-yellow dots show the position of the Geomagnetic Observatory of L'Aquila, and the strong-motion station of *Colle dei Grilli* (see Table S2). White stars are the epicentres of the 6 April 2009 main shock and the two largest aftershocks (see Table S1).
b) Positions of the buildings at the Geomagnetic Observatory of L'Aquila where magnetic and seismic sensors are located.

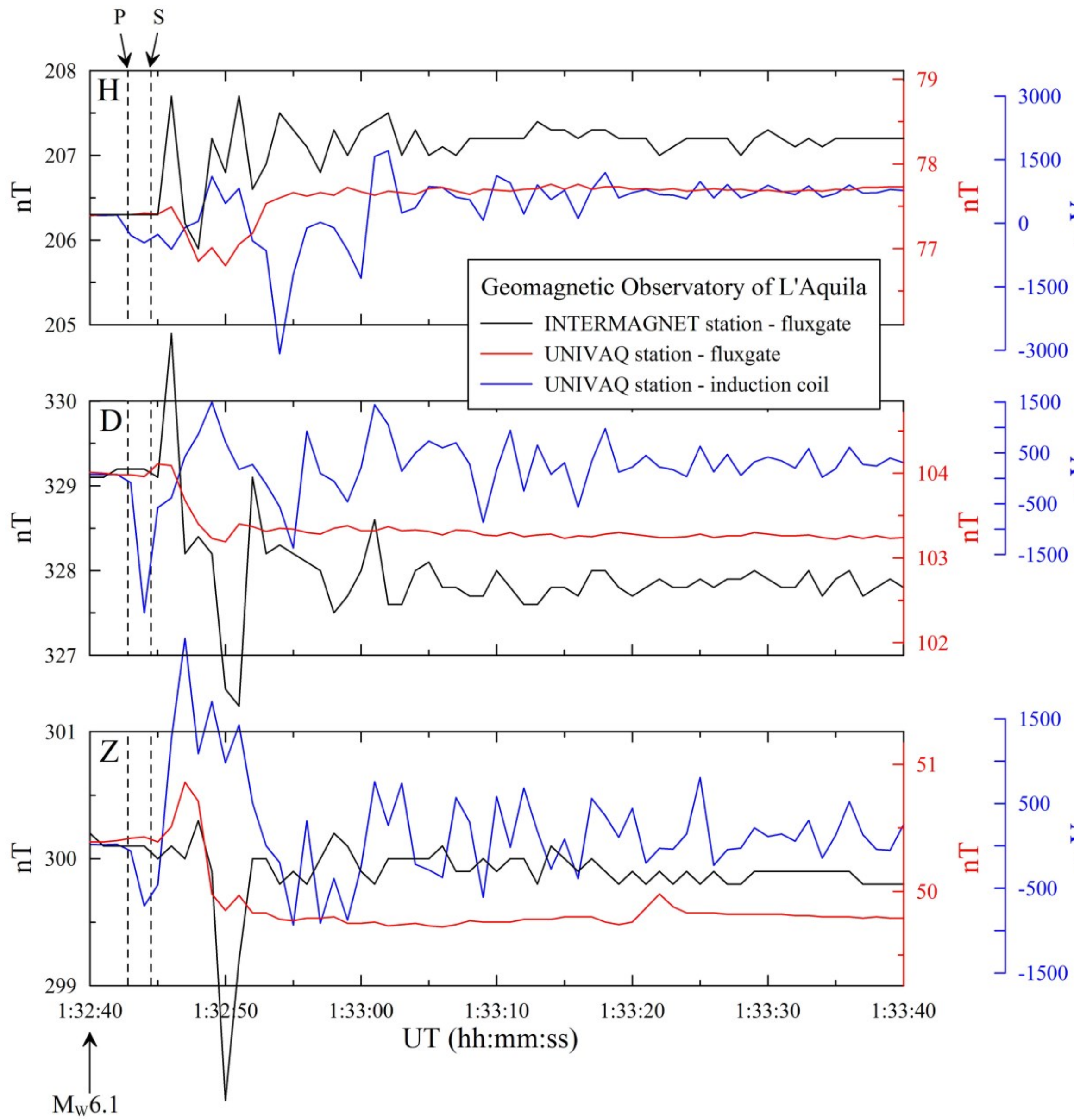


Figure S2. Enlarged view of Figure 3 in the main paper. P and S are the arrival times in the observatory of the P wave and S wave of the M_W6.1 main shock. Note that in induction magnetometer data the onset of the rapid changes is in correspondence with the arrival of the P wave, whereas in fluxgate data is in correspondence with the arrival of the S wave.

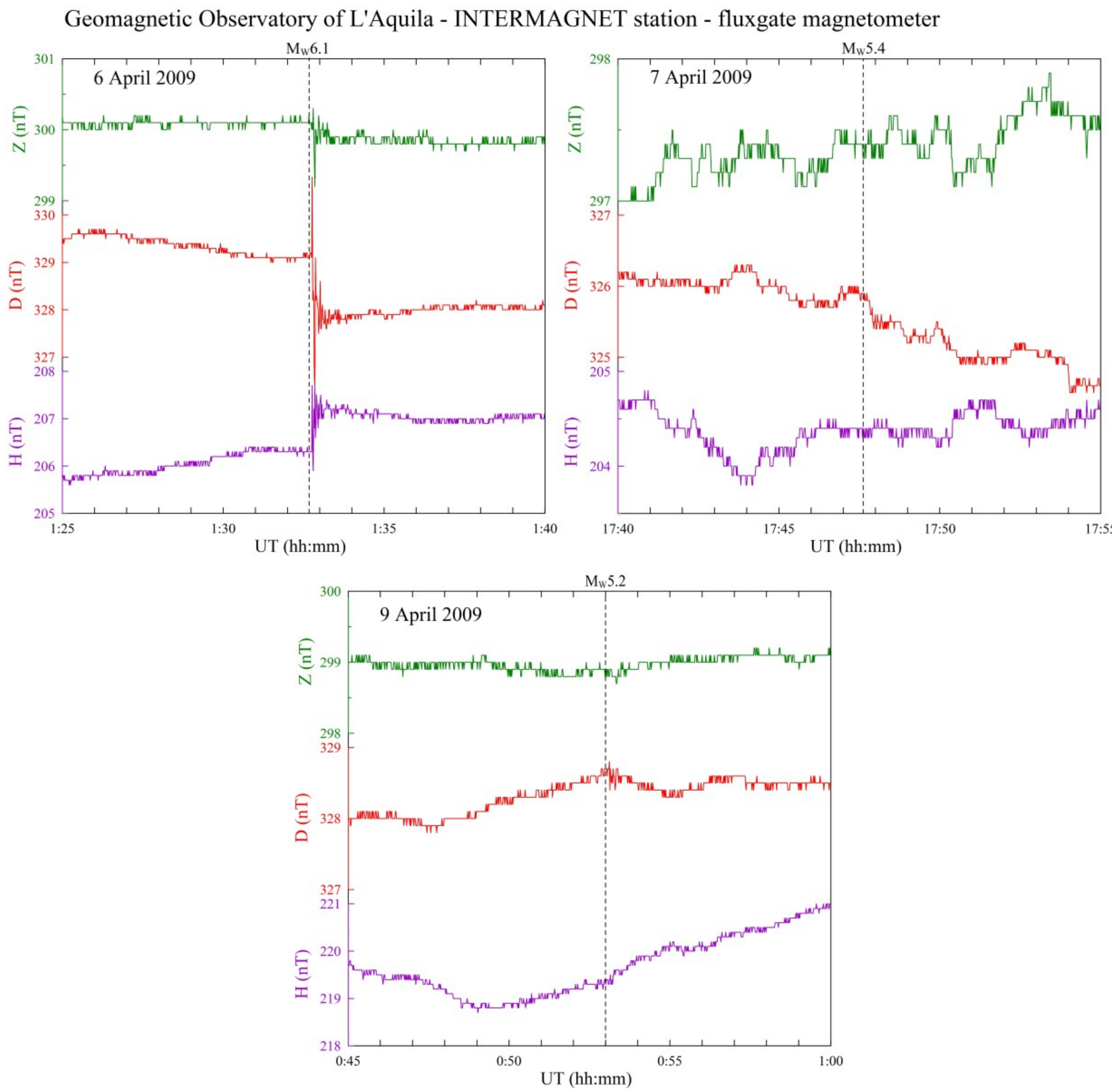


Figure S3a. Magnetic field H, D, and Z components from the fluxgate magnetometer of the INTERMAGNET station at the Geomagnetic Observatory of L'Aquila in correspondence with the 6 April M_W6.1 main shock, and the two largest aftershocks of 7 and 9 April.

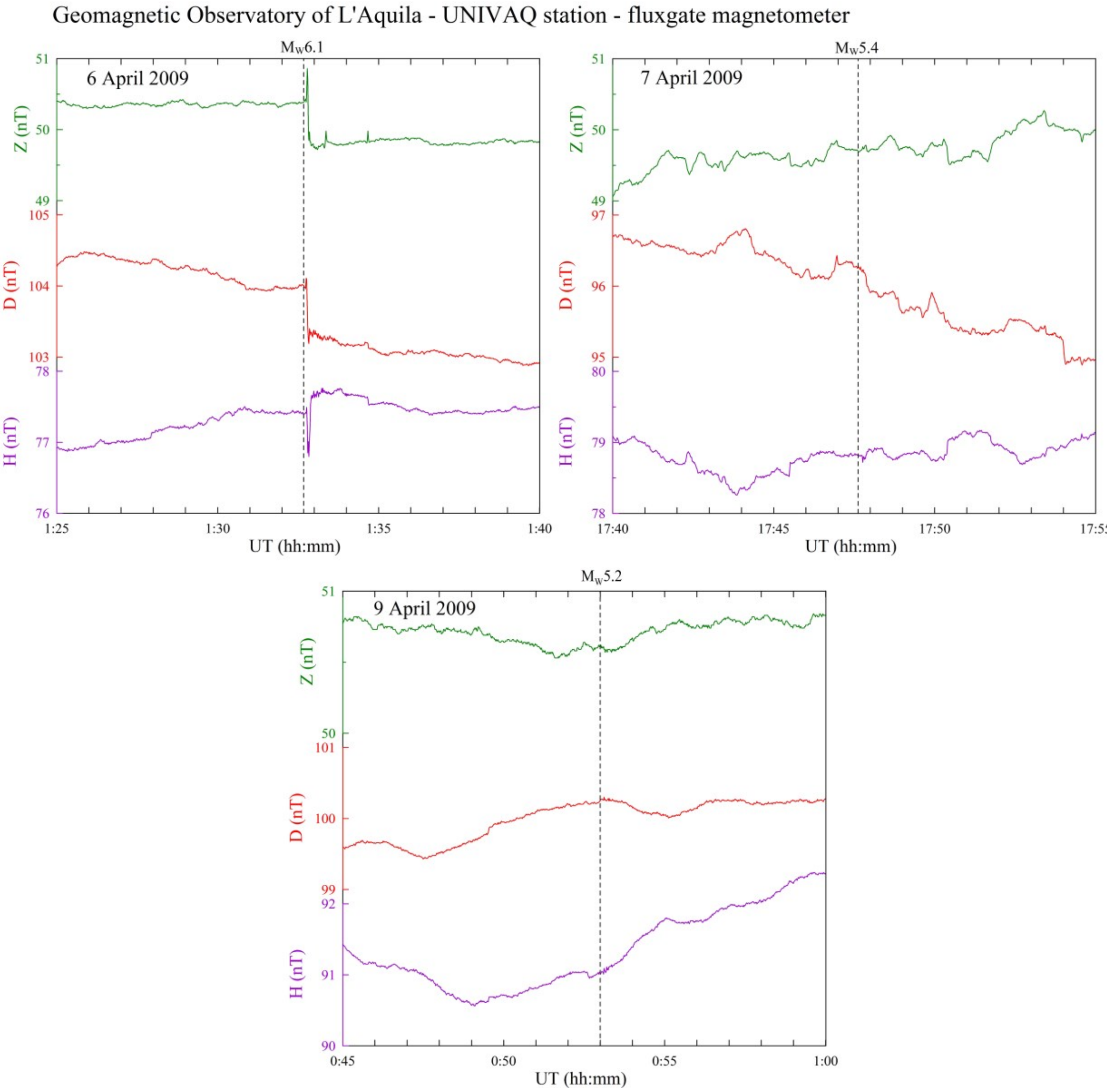


Figure S3b. Magnetic field H, D, and Z components from the fluxgate magnetometer of the UNIVAQ station at the Geomagnetic Observatory of L'Aquila in correspondence with the 6 April M_W6.1 main shock, and the two largest aftershocks of 7 and 9 April.

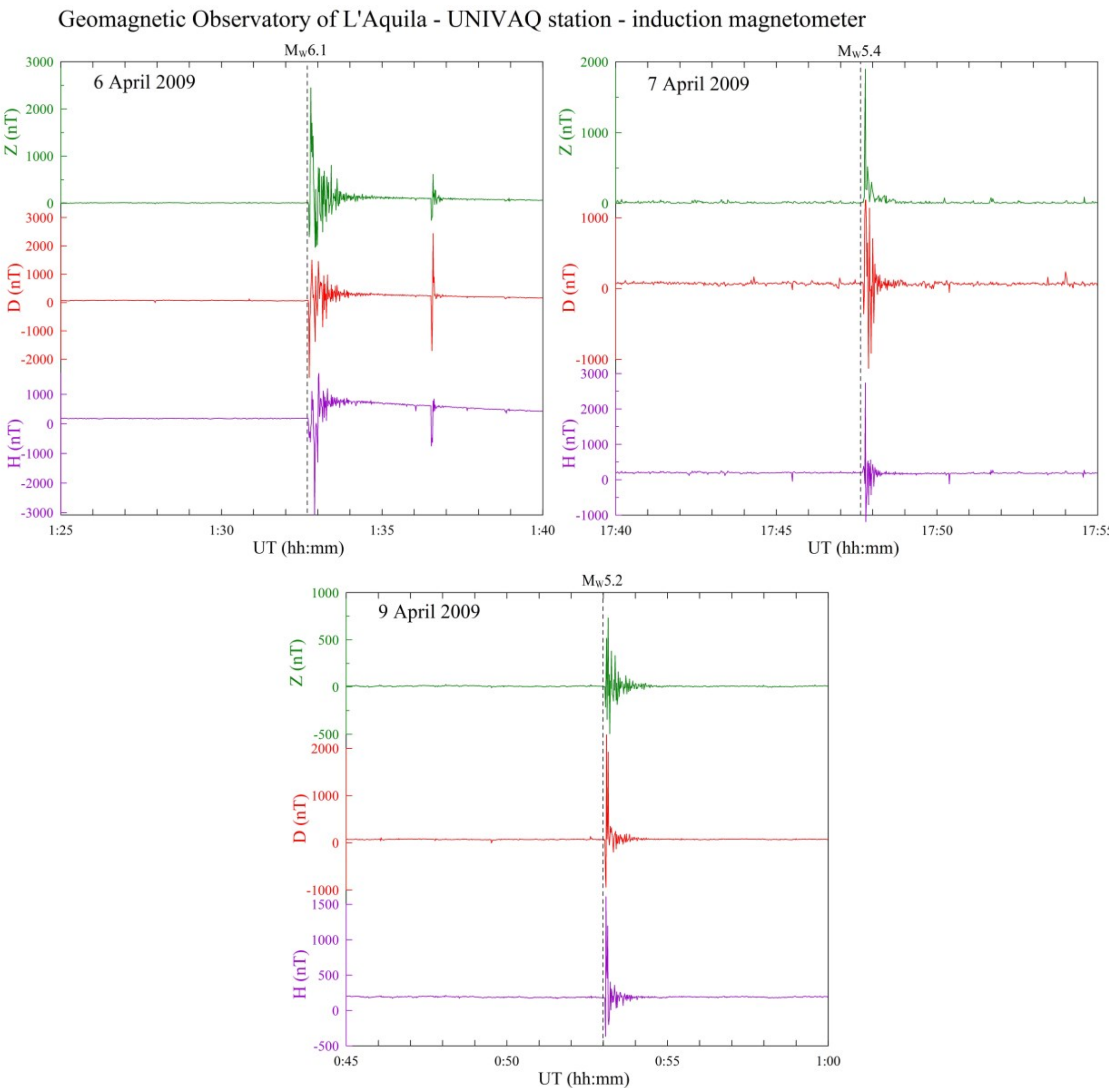


Figure S3c. Magnetic field H, D, and Z components from the induction magnetometer of the UNIVAQ station at the Geomagnetic Observatory of L'Aquila in correspondence with the 6 April M_W6.1 main shock, and the two largest aftershocks of 7 and 9 April.

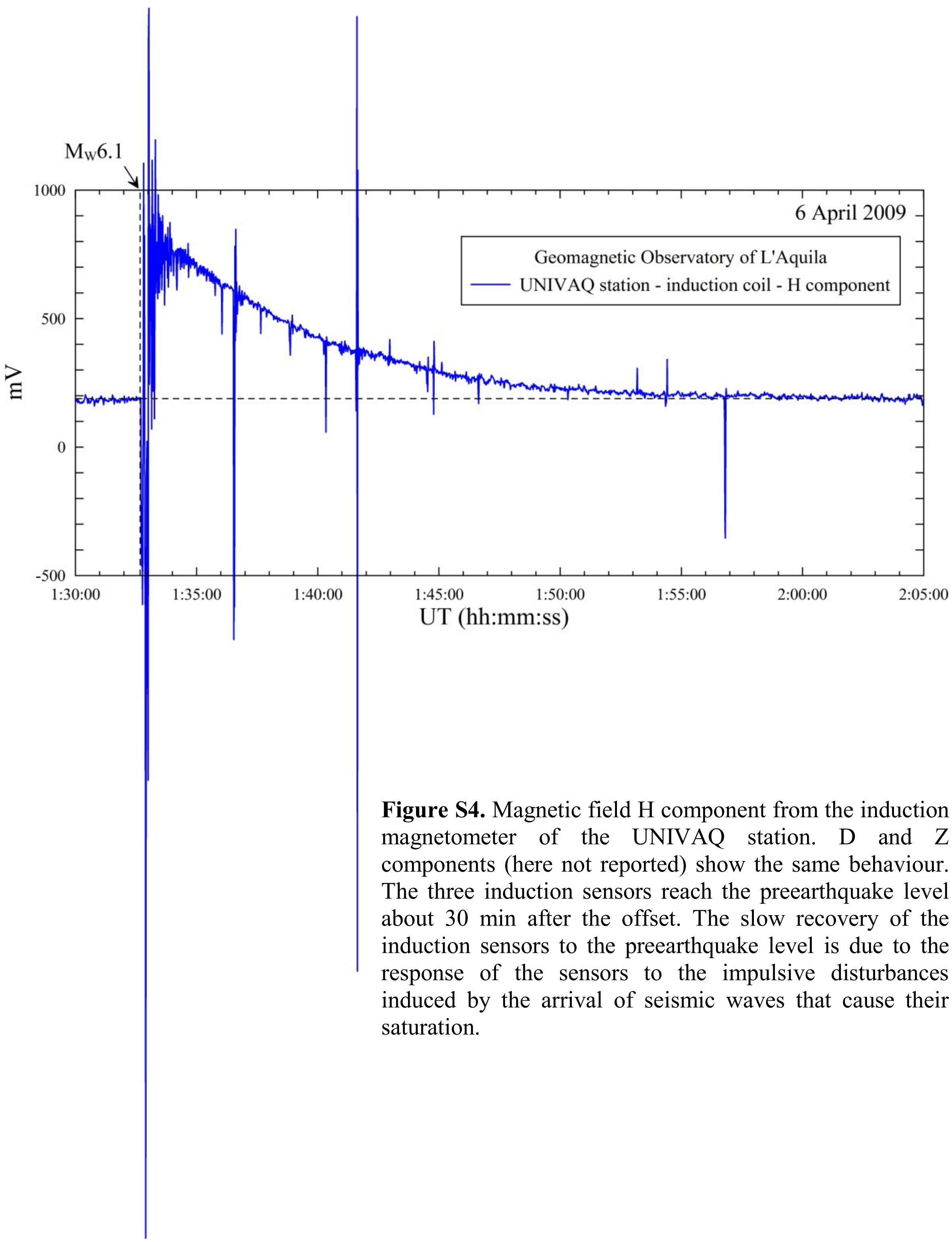


Figure S4. Magnetic field H component from the induction magnetometer of the UNIVAQ station. D and Z components (here not reported) show the same behaviour. The three induction sensors reach the preearthquake level about 30 min after the offset. The slow recovery of the induction sensors to the preearthquake level is due to the response of the sensors to the impulsive disturbances induced by the arrival of seismic waves that cause their saturation.

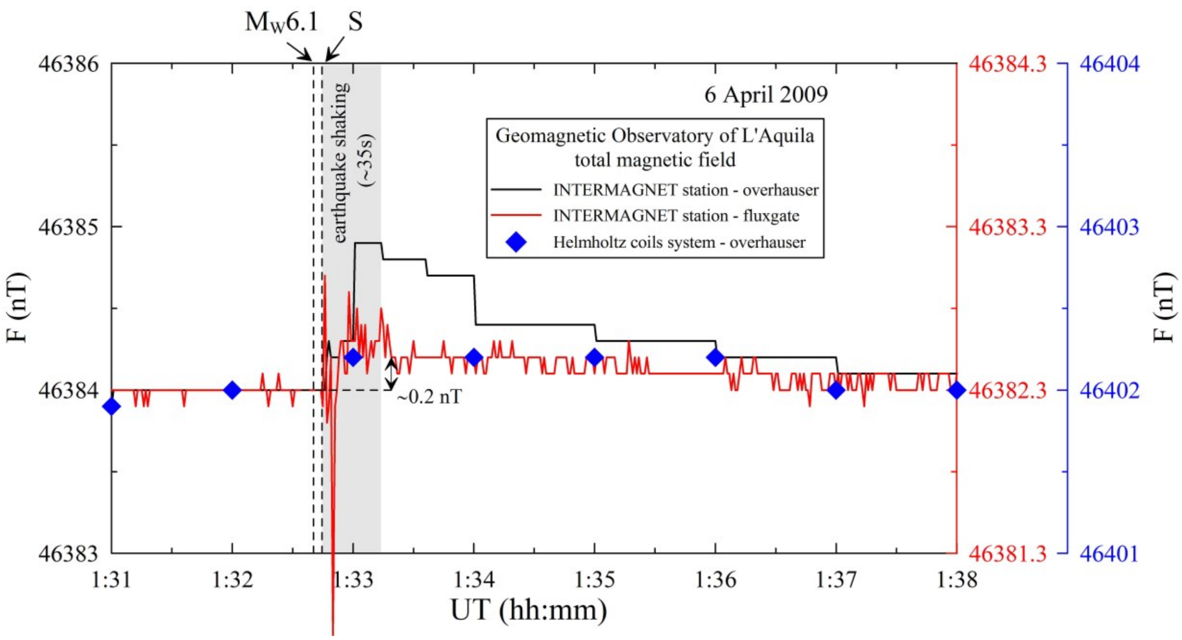


Figure S5. Enlarged view of Figure 5 in the main paper from 01:31 to 01:38 UT where total magnetic field data obtained from the INGV fluxgate components are shown including the period of the shaking of the sensors (see the shaded area). S is the arrival time in the observatory of the S wave of the M_W6.1 main shock. The effect of the earthquake shaking on the total field from the fluxgate components is evident. In the figure we can see that total magnetic field records from the INTERMAGNET fluxgate components and the overhauser of the Helmholtz coil system show a small offset of ~0.2 nT apparently in correspondence with the 6 April main shock. However, taking into account our discussion in the main paper, a more convincing explanation for this small offset than that of seismo-electric disturbances, may be found in the permanent displacement of the magnetometers from their original position as a result of the earthquake, or in the normal natural variation of the geomagnetic field.