Solid Earth Discuss.,
doi:10.5194/se-2016-89-AC3, 2016

Solid Earth Discussions

Interactive comment on "Ionospheric influence on the seismo-telluric current related to electromagnetic signals observed before the Wenchuan M_S = 8.0 earthquake" *by* Mei Li et al.

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Received and published: 28 July 2016

We thank the reviewer for his comments! Answers are given below.

1 Background of the investigation in this paper

There are an increasing number of reports that ULF electromagnetic emissions are recorded at several, hundred, and even several thousand kilometers away from the epicenters before some strong earthquakes. It is also well established that, during rock experiments conducted under laboratory conditions, a strong electrical current and electromagnetic emissions are produced when rocks are stressed, especially at the stage of the main rupture although there is no clear physical mechanisms of these

electromagnetic emissions.

As the development of satellite Earth Observation (EO), there is an increasing amount of evidence that during some last stages of the long term process of preparation, there could be a transfer of energy between lithosphere, atmosphere and ionosphere, so as to introduce the concept of a lithosphere–atmosphere–ionosphere coupling (LAIC) or interacting among the three involved layers of the Earth. Several tentative LAIC models have been constructed based on ground-based and ionospheric observations prior to strong earthquakes and the investigation of influence of earthquake related external electrical field on ionospheric parameters has been gained much achievement. At the same time, the ionosphere plays an important role in electromagnetic propagation at Extremely Low Frequency (ELF) and Very Low Frequency (VLF), the ground and the ionosphere are good electrical conductors and form a spherical Earth-ionosphere waveguide. In addition, in the Controlled Source Electromagnetic (CSEM) method, widely used in petroleum exploration or mining, the ionospheric influence on electromagnetic (EM) fields should be considered when the distance between a large-scale and large-power fixed source and the receiver is up to one thousand kilometers. EM fields can be amplified in the ionosphere as it is shown when we use analytical solutions of Maxwell equations, as well as numerical ones of the "Earth-ionosphere" mode with a source on the Earth's surface or in the subsurface of the Earth.

2 Ground-based ULF electrical emissions during the Wenchuan MS=8.0 earthquake

The Hebei ULF (0.1-10 Hz) electromagnetic observation network was constructed at the beginning of 1980s after the occurrence of the July 28, 1976, Tangshan MS 7.8 EQ with the aim of monitoring fluctuations in the electromagnetic radiations before seismic activities mainly around Beijing. More details of the observation system can be found in Zhuang et al. (2005) and Li et al (2013).

The system measures electrical signals and a DJ-1 recorder is employed to record the potential difference between two electrodes (SN, South-North and EW, East-West).

The recording method uses an analog automatic real-time continuous pen recorder with a speed of 1 mm/s. In general, only parallel lines with perpendicular automatic clock marked signals on the record paper around a drum and six lines are left per hour. A blank record paper replaces the recorded one at 9:00 AM (local time) everyday (seen attached Fig.1).

Attached Fig.1 is copy of a part of normal original record (EW component) from 9:00AM, 1 to 9:00 AM, 2, May, 2008 at Gaobeidian station. Corresponding letters: A denotes a start record point, i.e. 9:00 AM, 1, May; B is a normal record line; C indicates a manually marked time, i.e. 20:00, 1, May; D indicates an automatic marked perpendicular hour line, i.e. 20:00, 1, May; and E shows an end record point, i.e. 9:00 AM, 2, May.

During the period from January 2007 to December 2008, electrical emissions were recorded at three among four (only four stations run normally during this time) stations (Fig.3 in revised paper attached) and the recording at Gaobeidian station shows a typical fluctuation character. Anomalous emissions first appeared at the end of October 2007 and the information was not recorded everyday but it is mainly accumulated in SN direction.

On 2 November 2007, our work team went to Gaobeidian station to check observing environment and eliminate probable interferences.

Attached Fig.2 is a picture taken on 2 November 2007 at Gaobeidian station. The work team check real-time recording paper.

This kind of situation lasted till the beginning of April, 2008, from when relative high frequency and large amplitude signals were recorded almost every day with a persistent time. On May 9, 2008, 3 days before the Wenchuan MS 8.0 EQ, the amplitudes of signals were suddenly subjected to an abrupt enhancement at the same time, between 5:00 AM and 7:00 AM, both in the SN and EW directions and the abnormity reached to the climax stage ($\sim$1.3 mV/m for electric field) till on 17 May, 2008.

During this period, the work team went to most of stations to check related recordings and their observing environment. And they were right at Sanhe station when the Wenchuan earthquake took place.

Attached Fig.3 is a picture taken on 7 May 2008 at Gaobeidian station. The work team check real-time recording paper.

Attached Fig.4 is a picture taken on 7 May 2008 at Ningjin station. One of the observers of Langfang station measured the magnitude of the recorded signals.

After May 18, the total signal amount decreases sharply and the character of the signals at this stage is more like that before April 2008. The SN information lasted till the end of September 2008 except for high emissions appearing before several powerful aftershocks. It is the first time that the abnormality is with such a large amplitude and such a long duration in the observation history of this network although several strong EQs were recorded before (Li et al., 2013).

Fortunately, our reseach team traced this kind of obvious emissions during all this period and went to the stations several times to check observing environment and search probable interferences but found none. While the large Wenchuan MS=8.0 earthquake took place during this period. So this obvious ULF eminssions probably are related to this event.

3 As for the homogeneous isotropic conductivity of the Earth

The hypocenter depth of the Wenchuan main shock is 19 km and as a matter of fact, no one exactly knows the right conductivity of the Earth on one hand. On the other hand, it is difficult to the right frequency of the signals observed during the climax stage because of an analog observation and real-time signals are added together. So according to ULF observing frequency 0.1-10 Hz band, we set f=1 Hz during calculations. Then the advantageous conductivity of the Earth at this frequency is attained by the skin-depth formula. All these uncertain values maybe underscores our results,

which is discussed in the paper.

4 As for English language and grammar problems appeared in the paper

We feel grateful to the reviewer for pointing out this problem. We have already corrected some language and grammar problems according to Professor Dr. Freund's advices and we all try our best to improve our writing English.

In addition, the revised paper will be attached and all modified are in red. Figures attached also are some ULF real-time recordings at Gaobeidian station:

Fig.5 Picture of real-time recordings from 9:00 AM, 13 to 9:00 AM, 14, February, 2008 at Gaobeidian station.

Fig.6 Picture of real-time recordings from 9:00 AM, 8 to 9:00 AM, 9, May, 2008 at Gaobeidian station.

Fig.7 Picture of real-time recordings from 9:00 AM, 12 to 9:00 AM, 13, May, 2008 at Gaobeidian station.

Fig.8 Picture of real-time recordings from 9:00 AM, 20 to 9:00 AM, 21, May, 2008 at Gaobeidian station.

Please also refer to:

Li, M., Lu, J., Parrot, M., Tan, H., and Zhang, X.: Review of unprecedented ULF electromagnetic anomalous emissions possibly related to the Wenchuan MS = 8.0 earthquake, on 12 May 2008. Nat. Hazards Earth Syst.Sci., 13(2), 279–286, 2013.

Zhuang J, Vere-Jones D, Guan H, et al. Preliminary Analysis of Observations on the Ultra-Low Frequency Electric Field in the Beijing Region. Pure & Applied Geophysics, 162(6), 1367-1396, 2005.

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/se-2016-89/se-2016-89-AC3-supplement.pdf

Interactive comment on Solid Earth Discuss., doi:10.5194/se-2016-89, 2016.

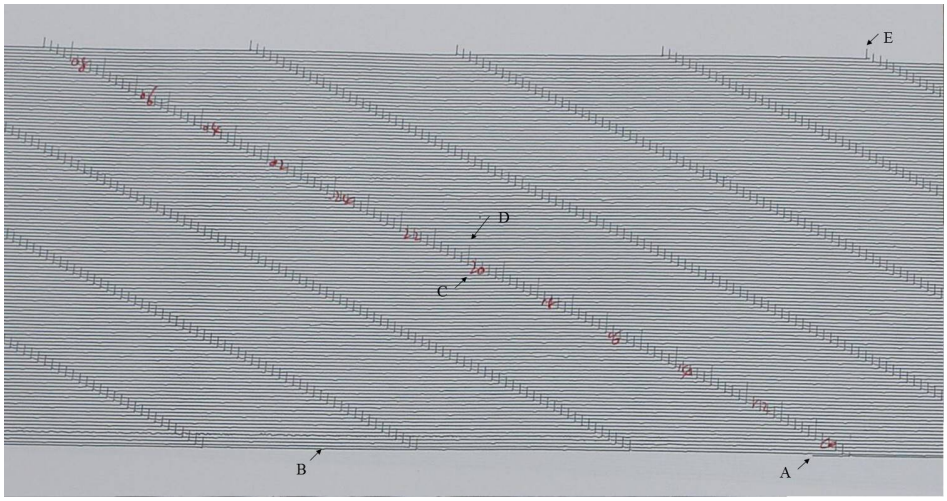

Fig. 1.

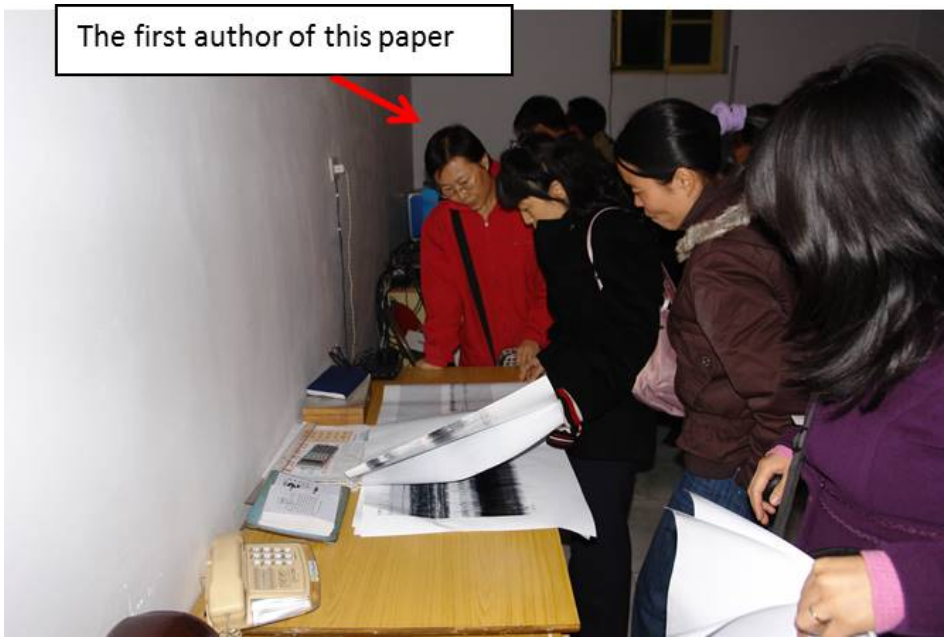

Fig. 2.

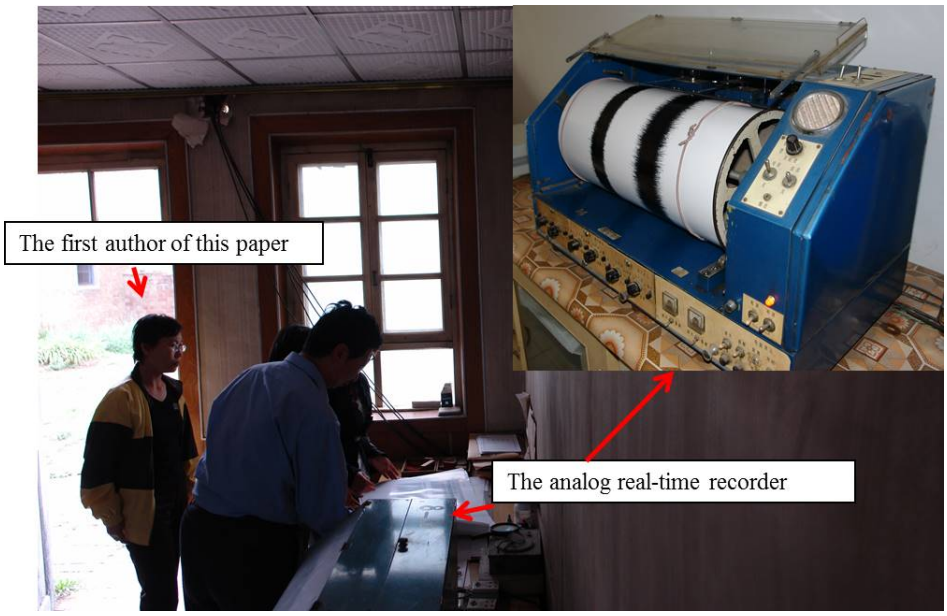
The first author of this paper
The analog real-time recorder

Fig. 3.

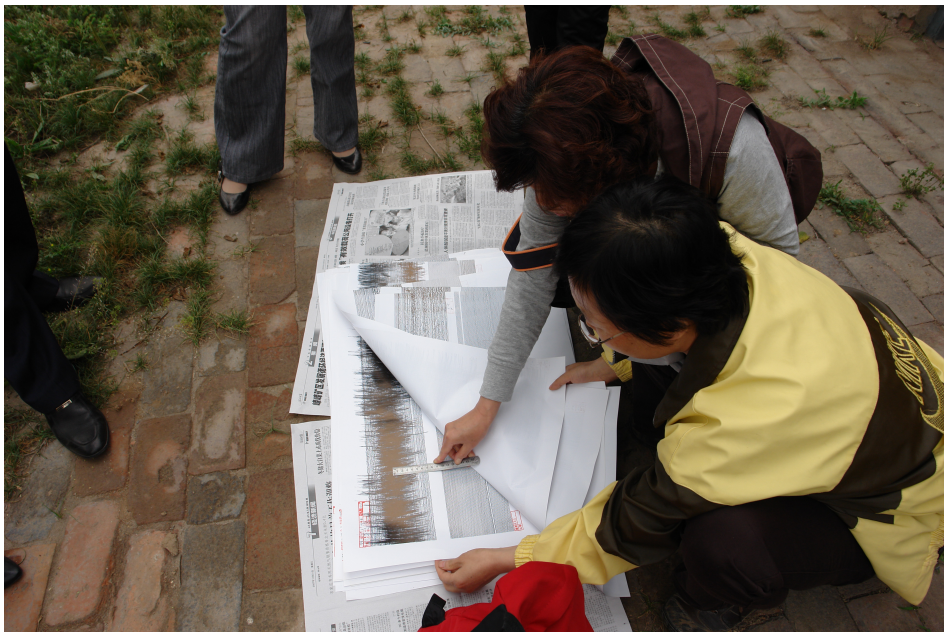

Fig. 4.

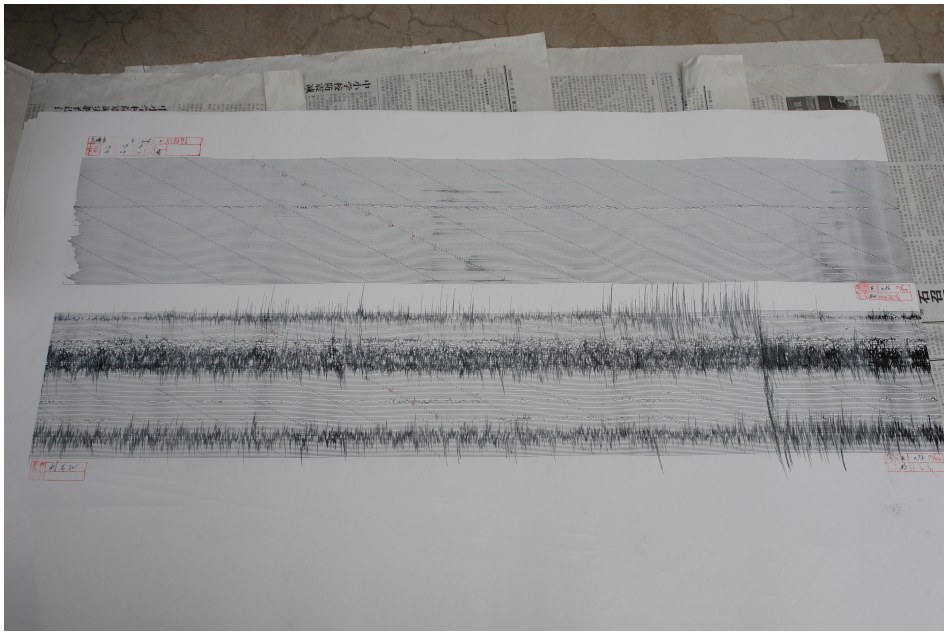

Fig. 5.

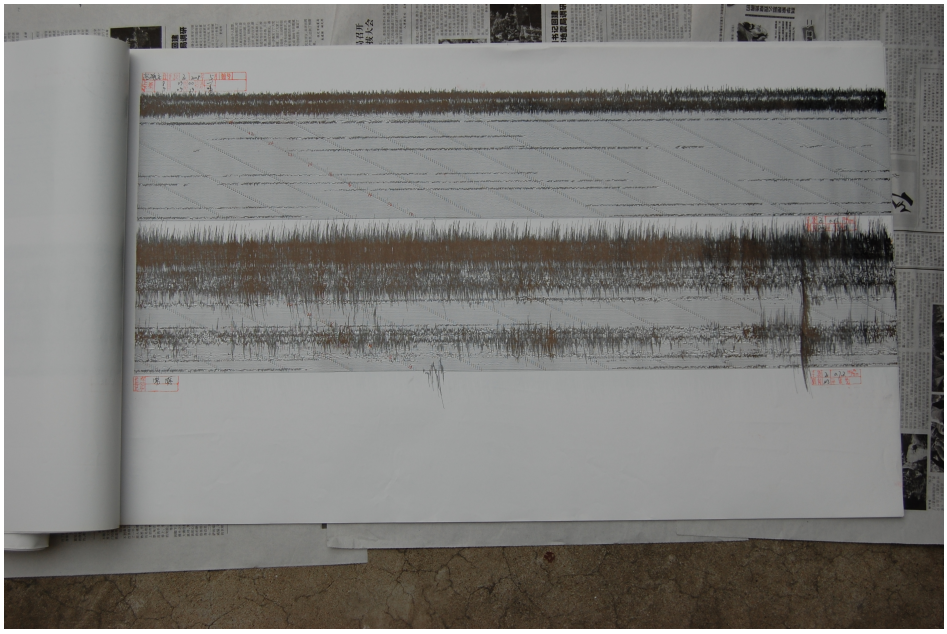

Fig. 6.

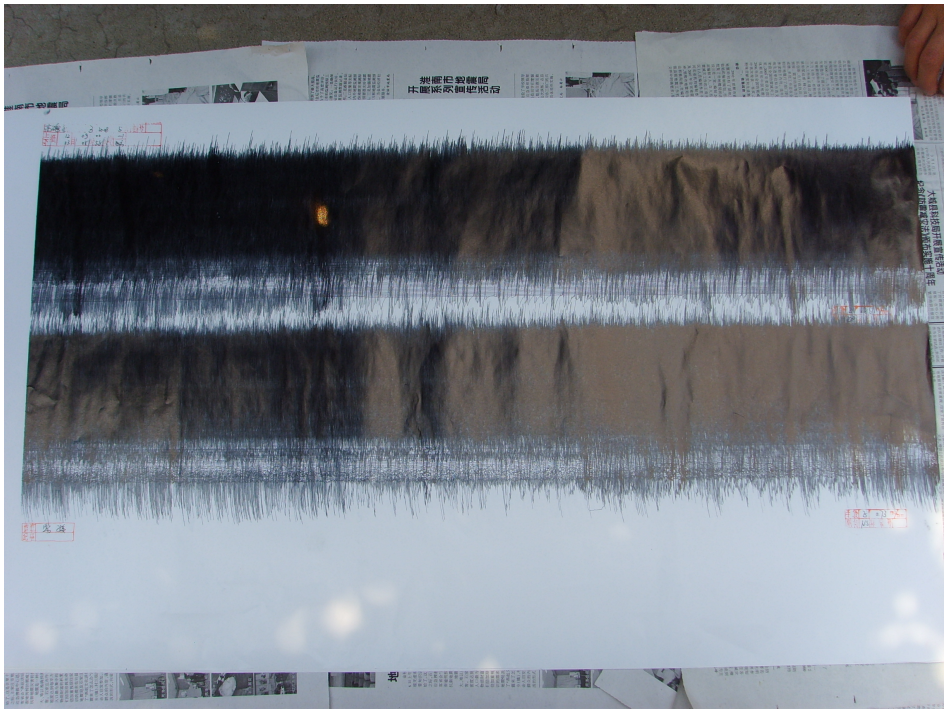

Fig. 7.

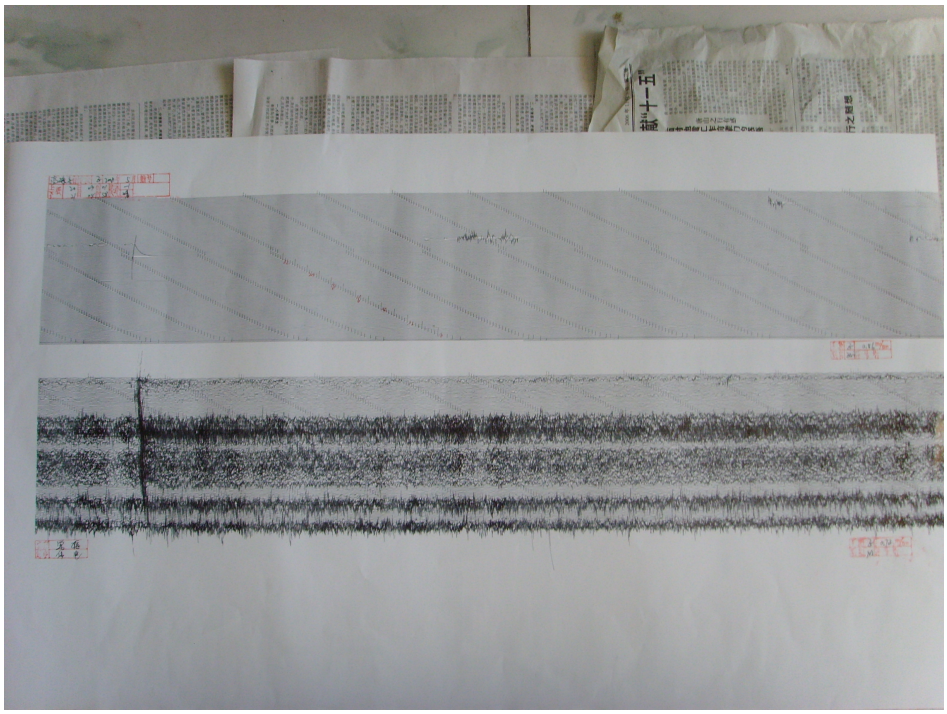

Fig. 8.