cnes
ON EARTH, IN SPACE
26
Oct 14th 2008
E-SPACE & SCIENCE
THE SCIENTIFIC BULLETIN OF CNES, CENTRE NATIONAL D'ETUDES SPATIALES

Demeter and the Earth's fields

Sources

Spacecraft observations of electromagnetic perturbations connected with seismic activity
F. Nemec, O. Santolık, M. Parrot and J. J. Berthelier
Geophysical Research Letters, vol. 35, mars 2008

Over the last 20 years, many scientific publications have discussed the existence of precursor signs in the ionosphere before major earthquakes. However there is a lot of uncertainty and controversy about whether these signs are actually related to seismic activity. This is because variations in the characteristics of the ionosphere depend on many factors and in particular on solar activity.

The scientific objectives of the DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) Space mission are to characterize electromagnetic signals corresponding on the one hand to anthropic activity and on the other to natural phenomena such as earthquakes and volcanic eruptions. This paper is about these last natural phenomena.

DEMETER's instruments measure six components of the electromagnetic field over a wide range of frequencies and analyze the ionized environment. The satellite data are correlated with data collected on Earth, particularly concerning the location of earthquakes or the state of the ionosphere over seismic regions such as California and Japan. Maps of Total Electronic Content, with very high temporal and spatial resolution, are then generated.

Maps of the mean intensity of the electrical field were produced according to several parameters (daytime side/ night-time side, period of the year, signal frequency, geomagnetic activity). The authors then statistically analyzed the intensity of the electric waves measured by DEMETER's antennas during more than 9,000 earthquakes to determine the main characteristics of seismic effects on the electronic parameters of the ionosphere. They divided the earthquakes into four groups according to their depth of origin (less than or equal to 40 km, or more) and the moment that they occurred (day or night).

The intensity of the signal received when the satellite passed close to the epicentre of an earthquake less than five days before and less than three days afterwards, was then compared with its mean intensity at the same place and under the same conditions.

The data are then analyzed using the superimposed epochs method. All earthquake occurrences are adjusted to a zero time. The results are plotted on a grid as a function of the distance over time with respect to this origin and as a function of the proximity of the orbit's ground track to the epicenter. For any given earthquake, only a few cells of the grid have information in them.

Notes

Ionosphere:
The ionosphere is the highest part of the Earth's atmosphere. It starts at around 120 km in altitude and extends up to the magnetosphere (which is at about 1,000 km). The density, there, is so low that, when subjected to ultraviolet radiation from the Sun, electrons (which have a negative charge) escape from the molecules and atoms there, which then ionize positively.

Anthropic activity means human-related activity.

cnes
ON EARTH, IN SPACE
26
Oct 14th 2008
E-SPACE & SCIENCE
THE SCIENTIFIC BULLETIN OF CNES, CENTRE NATIONAL D'ETUDES SPATIALES

A tormented sky and quakes beneath the ground

Notes

Total Electronic Content:
Amounts of free electrons in a ionospheric column measured by the travel time of an electro-magnetic wave between an emitter and a receiver.

Sun synchronous orbit:
Orbit which combines altitude and inclination in such a way that a satellite on that orbit passes over any given point of the Earth's surface at the same local solar time. The surface illumination angle will be nearly the same every time.

Polar orbit:
A satellite on a polar orbit passes above or nearly above both poles of the Earth. This orbit is often used for remote sensing.

The operation is repeated for all earthquakes of a magnitude greater than 4.8 that take place less than 1,100 km from the orbit ground track. This led to 4,552 earthquakes being plotted over three years. To avoid confusion between pre- and post-seismic effects, the aftershocks are not taken into account. At the end, the values obtained in each cell of the grid are statistically analyzed and the result plotted in the form of relative intensity.

The intensity of the waves measured by DEMETER for a frequency range between 1 and 2.4 kHz starts decreasing a few hours before the earthquakes, by about 6 dB. This result corresponds to an electric field measured at night for earthquakes less than 40 km deep, of a magnitude greater than 4.8 and for which the epicentre's distance from the ground orbit track is less than 330 km. The decrease is greater to the extent that the magnitude is greater.

No changes have been observed in the ionosphere during the day and for deep earthquakes. The observation of a decrease in the electric field indicates that this is not a direct effect of an earthquake but rather a modification of the conditions under which geomagnetic waves are propagated.

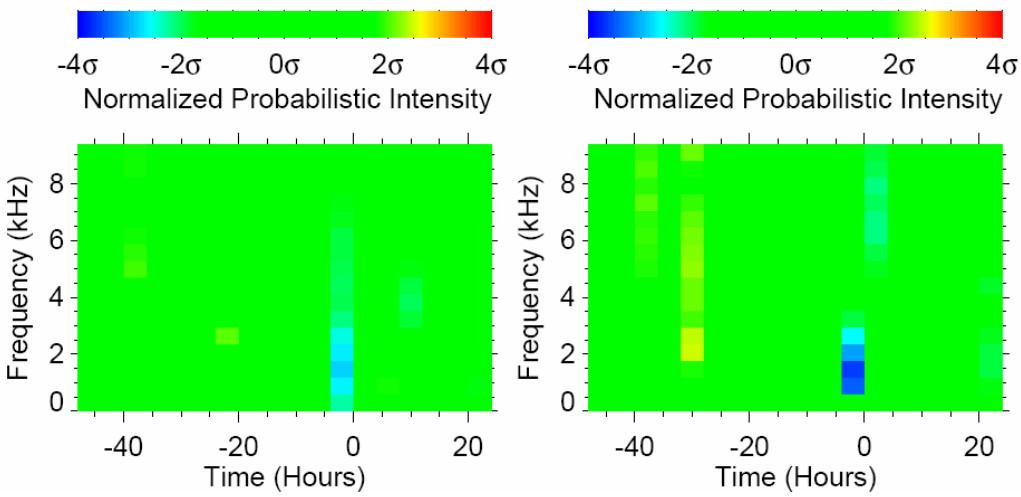

Fig. 1: (left) Frequency-time spectrogram of the normalized probability intensity obtained from the night-time electric field data measured within 330 km of earthquakes with magnitudes greater than or equal to 4.8 and depth less than or equal to 40 km. (right) The same, but for earthquakes with magnitudes greater than or equal to 5.0.

cnes
ON EARTH, IN SPACE
26
Oct 14th 2008

E-SPACE & SCIENCE
THE SCIENTIFIC BULLETIN OF CNES, CENTRE NATIONAL D'ETUDES SPATIALES

From premonition to premonitory signs ?

Contacts

Michel Parrot
Laboratoire de Physique et Chimie de l'Environnement (LPCE)
Orléans
mparrot@cnrs-orleans.fr

This study demonstrates that seismic activity does influence the ionosphere and that the effect is perceptible at an altitude of 700 km before some earthquakes occur. The disturbance is real but weak and can only be revealed statistically. No conclusions are thus possible about the occurrence of this disturbance of the electric field for any given earthquake, nor about any general earthquake predictions. Other parameters measured by DEMETER are currently being studied in the same way to try and understand the ways in which seismic activity can affect the ionosphere.

More on the web

Demeter Science Mission website

LPCE website

CETP website

CESR website

IPGP website

OPGC website

USN website

Centrum Baden Kosmicznych (Pologne) website

More about CNES

CNES

CNES space scientific missions

DEMETER at your service

DEMETER was launched by a DNEPR rocket from Baikonur on 29 June 2004. The satellite was placed on a sun-synchronous, circular, polar orbit at an altitude of 710 km.

For storing and transmitting the data collected on board, DEMETER has a very large 8 Gbit memory and a broadband telemetry channel of 16.8 Mbits/s, reserved for its scientific payload. The data are processed at the Science Mission Center (CMS-*Centre de Mission Scientifique*) at the LPCE in Orleans.

The data are received through a CNES-based telemetry station. They are automatically relayed between the satellite and the CMS and are made available to scientists and invited investigators taking part in the mission. There are several levels of access available, from 'quick-looks' that synthesize results from all of the experiments for each half orbit, up to level 2 data that enable scientists to compare the results of several instruments. The satellite orbit data and the tools used for processing these files are also available on this server. Throughout the mission, the CMS is in charge of programming the scientific payload.

E-Space&Science keeps you informed about results on CNES supported scientific programmes

Publishing Director: **Yannick d'Escatha** ■ Managing Director: **Pierre Tréfouret** ■ Editor: **Michel Viso** ■ Assistant Editor: **Martine Degrave** ■ Circulation: **INIST diffusion** ■

Subscribing
Send a blank E_Mail to:
French version: www.cnes.fr/ESSfr
English version: www.cnes.fr/ESSen

Unsubscribing
Send a blank E_Mail to:
French version: www.cnes.fr/ESSfr
English version: www.cnes.fr/ESSen