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Abstract 1-10

Ionospheric disturbances recorded by DEMETER satellite over active volcanoes: August 2004 to December 2010

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On volcanoes, it is relatively common to observe smooth increasing EM anomalies during the months to years preceding an eruptive event. These time changes may be very small and may be undetectable over a short time span, as for satellites for instance. In addition to these smooth anomalies, transient anomalies, of tens of seconds to hours, may appear during the weeks prior to eruptions. These signals are enhanced during magma migration or an explosive phase. The mechanisms are well known and it is well accepted that long term changes are due either to piezomagnetic, thermomagnetic or resistivity changes which are the key mechanisms depending on the type and the dynamical state of the volcano under consideration. Electrokinetic effects which are signals generated by transfer of electric charges carried by fluid flow may become a preponderant mechanism when hydrothermal systems takes place in the upper part of the volcanic edifice. On most of the volcanoes, transient volcano-EM signals are enhanced during the two months preceding the surface activity. These phenomena can be observed with sophisticated electromagnetic networks.

Because only few active volcanoes are well monitored by dense ground based stations, satellite missions devoted to monitor natural hazards are expected to bring into light new results in a global approach of monitoring natural hazards. Relatively few researches had been devoted to the detection of volcanic activity by satellites (i.e. [1], [2]). Thanks to DEMETER satellite which was essentially dedicated to monitor ionospheric disturbances generated by natural hazards on the Earth, a unique opportunity to study pre-eruptive anomalies in the ionosphere linked to volcanic activity was offered. A first attempt was published ([3]) which has shown that 30 of the 74 eruptions recorded during the period August 2004 to December 2007 were accompanied by 48 anomalies in the time window of 30 days preceding the onset of surface activity till 15 days after (noted hereafter [-30d,+15d]). In the new study

extended to December 2010, an extensive research of anomalies in the ionosphere by DEMETER satellite is presented over a time window of [-60d, +15d] ([4]).

Frame of the dataset

The constraints of the dataset were as follow:

- The time window on which anomalies in the ionosphere are searched was framed to 60 days before till 15 days after the onset of the volcanic activity ([-60d, + 15d]),
- Anomalies were only investigated along upward or downward orbits when the distance between the footprint of the satellite and the active volcano was less than 500 or 900 km for a Volcanic Explosivity Index less, or above 1,
- Volcanoes located between -50°S and +50°N were only taken into consideration to avoid large natural ionospheric disturbances due to large magnetic activity at high latitudes. In addition, the effect of the natural magnetic activity on ionospheric anomalies was studied for the three thresholds of Kp index 300, 200, and 150. Results are not drastically modified which confirm the magnetic disturbances are not the cause of the ionospheric anomalies,
- When an earthquake of magnitude 4.5 and above was recorded along the segment of the satellite orbit under consideration, the anomaly was not retained.
- Upwards (South to North) and downward (North to South) orbits in the time window ([-60d, + 15d]) were studied.
- Information on the volcanic activity was given by the Global Volcanism program (http://www.volcano.si.edu/education/tpgallery.cfm?category=Shield%20Volcanoes).

Anomalies

Between August 2004 and December 2010, 136 eruptions with respect to the database criteria have occurred. For each of them, a time window of [-60d, +15d] around the onset of volcanic activity was defined. All the orbital segments with a distance to the volcano less than 500 or 900 km based on the VEI index were computed. Analysis of the records of the electric and magnetic, ionic and electronic temperatures and densities was achieved.

269 anomalies were recognized which were distributed along 89 eruptions on 73 volcanoes. The morphology is distributed along 5 types ([4]). In average 10 to 26 eruptions per year have occurred during the 6.5 years of consideration. The appearance of anomalies is not enhanced by the global magnetic activity, the largest numbers of anomalies were recorded between 2008 and 2010 when Kp values were at the lowest level.

The distribution of the percentage of anomalies of type 1 (ionospheric electrostatic turbulence) and 2 (electromagnetic discharge) per periods of 15 days in the time window [- 60d, + 15d] give information on the distribution of anomalies with time. The maximum number of anomalies whatever the anomaly type is, occurs between [- 30d, - 15d] before the eruptive event. This maximum value is gradually decreasing when we consider the 15 days time windows more and more in advance of the eruption.

The wide variety of numerous observations leads to suppose that ionospheric anomalies could be more related to volcanoes on which explosive activity takes place. However, the anomalies seem to be independent of the location, the morphology and the type of the volcanic edifices. In addition, the emergence and the number of ionospheric anomalies seem not be linked to the duration of quietness of the volcanoes. On the other hand, the computation of the average number of ionospheric anomalies versus VEI index over the 6.5 years of records shows that more the strength of the eruption is, (i) more anomalies can be observed, and (ii) larger the maximum number of anomalies may be. Although these results are based on a relatively small database (269 anomalies), the results are coherent and indicate that there is a relationship between the increasing strength of the volcanic activity and the number of anomalies in the ionosphere which can be observed between 60 days before an eruption till 15 days after.

References

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