PREDICTION OF EARTHQUAKE IN IRAN USING ISL AND IAP INSTRUMENT OF DEMETER SATELLITE

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Nowadays, using satellite precursors is one of the most popular methods in the prediction of earthquake. The plasma parameters of ionosphere measured by DEMETER satellite have been considered as a precursor by many researchers (Sharma et al., 2011; Liu et al., 2010). In this study, the statistical hypothesis testing like GLR is applied to the plasma parameters of ionosphere to detect the anomaly induced by earthquake in Iran.

One of the most useful satellites which can be used for this prediction is DEMETER, the French micro-satellite, lunched in a circular polar and quasi-sun-synchronize orbit at an altitude of 650 Km on June 29, 2004. The main scientific mission of it is to study the ionospheric perturbation which is originating from seismic activities. There are several instruments onboard DEMETER to survey ionospheric parameters. The ISL and IAP instruments employed in this article are clear-cut example of these instruments. ISL actually is a standard Langmuir probe which is designed to measure the electron and ion densities and electron temperature of plasma of ionosphere. The main function of IAP is to measure the major ionospheric ions O^+, H^+ and He^+ and their temperature (Sarkar et al., 2007).

Many researches over decades attribute the anomaly of ionospheric parameters to the seismic activities such as earthquake. Although the extensive study on the ionosphere has resulted in the detection of anomaly in the plasma parameters due to earthquake, the ionospheric parameters are affected more by solar activities than by seismic events (Sharma et al., 2006). Hence, the appropriate modelling describing the influence of solar on ionosphere is valuable in this prediction.

In this study, the statistical hypothesis testing is used to detect the perturbation in mentioned ionospheric parameters. There are two hypotheses in this method: a null hypothesis and alternative hypothesis contracting against the null (Kay, 1993). In the null hypothesis, it is assume that the earthquake will not occur or its magnitude is low. In contrast, the alternative hypothesis state that the earthquake will occur with the magnitude greater than 5.5. The test tries to check that the null hypothesis is accepted or rejected. In the other words, if the solar activity is modelled as the sum of sinusoidal terms with periods of 1 day and 27 days plus a constant C_i , the test can be performed as bellow:

Null hypothesis: $$x_i[n]=\sum_{k=1}^{M}\left(A_{ik}\cos(\omega_k n)+B_{ik}\sin(\omega_k n)\right)+C_i+w_i[n] \quad (1)$$

Alternative hypothesis: $$x_i[n]=\sum_{k=1}^{M}\left(A_{ik}\cos(\omega_k n)+B_{ik}\sin(\omega_k n)\right)+C_i+S_i+w_i[n] \quad (2)$$

Where $x_i[n]$ is the *i*th plasma parameter versus sampling time *n*. A_{ik} , B_{ik} and C_i are the coefficient describing the effect of solar activity on $x_i[n]$, $w_i[n]$ is additive white Gaussian noise and S_i is the perturbation originated from earthquake.

The generalized likelihood ratio test based on Neyman-Pearson theorem used to determine that whether S_i is statistically zero (null hypothesis) or not (alternative hypothesis). This test states that to maximize P_d for given P_{fa}, reject null hypothesis (decide big earthquake will be occur) if the following likelihood ratio $L(x)$ is greater than threshold (η)(Kay, 1993):

$$L(x) = \frac{f(x;H_1)}{f(x,H_0)} \quad (3)$$

Where $f(x,H_0)$ and $f(x,H_1)$ are probability density function of $x_i[n]$ under null hypothesis and alternative hypothesis, respectively. The threshold η will be determined by P_{fa} using following equation:

$$P_{fa} = \int_{\{x:L(x)>\eta\}} f(x;H_0)dx \quad (4)$$

If false alarm rate set as one false a year (P_{fa} = 0.027) and the test run for 10 case study listed in Table 1, the probability of detection is calculated as P_d = 0.9.

Table 1. Different case study for calculating P_d (www.demeter.cnrs-orleans.fr)

No.	Date	Time (UTC)	Latitude	Longitude	Magnitude
1	Oct. 07, 2004	21:46:15	37.40	54.58	5.6
2	Jan. 10, 2005	18:47:26	37.38	54.58	5.4
3	Feb. 22, 2005	2:25:22	30.80	56.76	6.5
4	Feb. 28, 2006	7:31:03	28.18	56.76	6.2
5	March 25, 2006	7:28:57	27.57	55.87	5.9
6	March 31, 2006	1:17:02	33.65	48.91	6.1
7	June 28, 2006	21:02:09	26.82	55.90	5.8
8	June 18, 2007	14:29:49	34.52	50.84	5.5
9	Aug. 27, 2008	21:52:40	32.36	47.36	5.8
10	July. 30, 2010	13:50:13	35.20	59.23	5.6

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