Statistical analysis of ULF seismo-electromagnetic phenomena in Kanto, Japan

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Abstract　Previous statistical studies have indicated that the ULF seismo-magnetic phenomena contain precursory information and can be useful in short-term forecasting of sizable earthquakes. In practice, for given series of precursory signals and related earthquake events, the efficiency of forecast is a function of the leading time of alarms (Δ) and the length of alarm window (L). To find out the best prediction strategies, Molchan's error diagram has been employed. A modified area skill score, which measures the area between actual prediction curve and random prediction line, is introduced to assess the efficiency of different prediction strategies. The results indicate that ULF magnetic data of KAK contains higher precursory information when Δ is around 1 or 2 weeks and L is less than 2 weeks; the optimal strategy of short-term forecasts is: Δ =8 days, L =1 day. The methodology proposed in this study could help to evaluate and find the optimal policy of other different measurements for short-term earthquake forecasting. The best combination of all available observations may provide better forecasting results and is worth further study.

1. Introduction

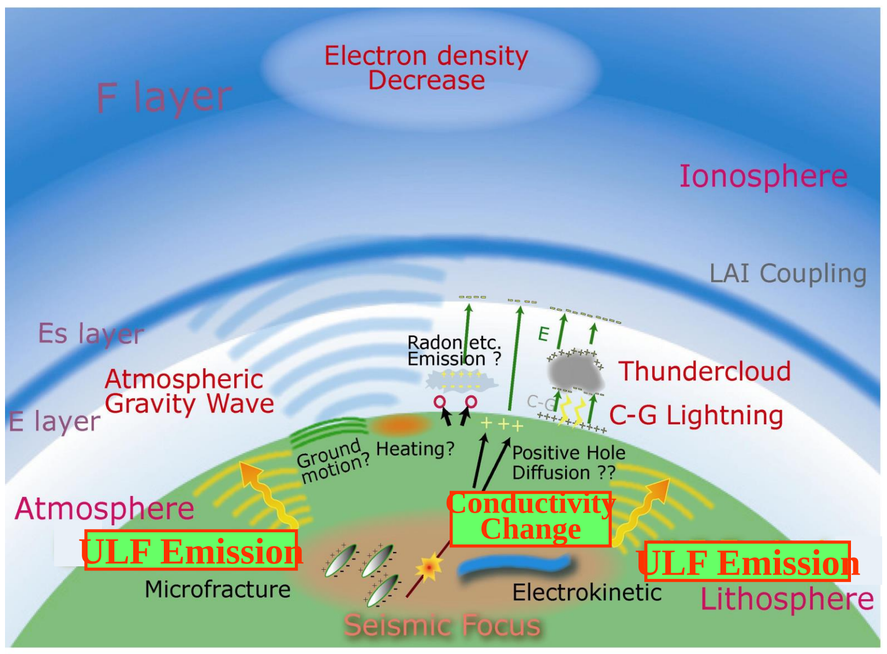

Fig 1. A scenario of seismo-electromagnetic phenomena.

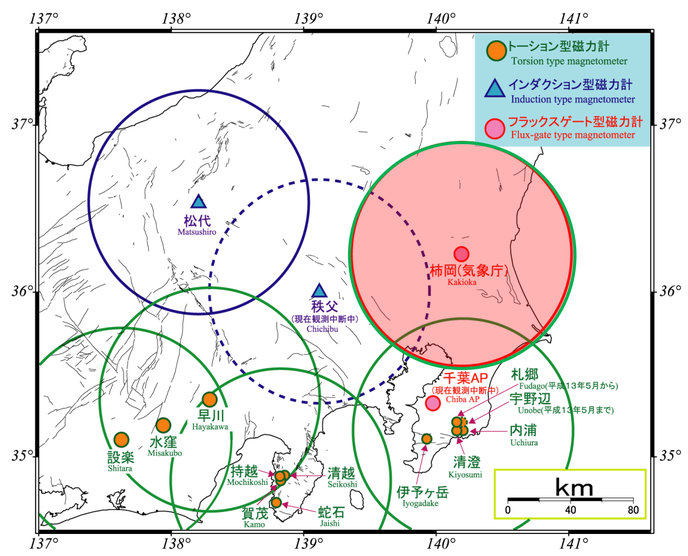

Fig 2. The ULF geomagnetic observation network in Kanto-Tokai area, Japan.

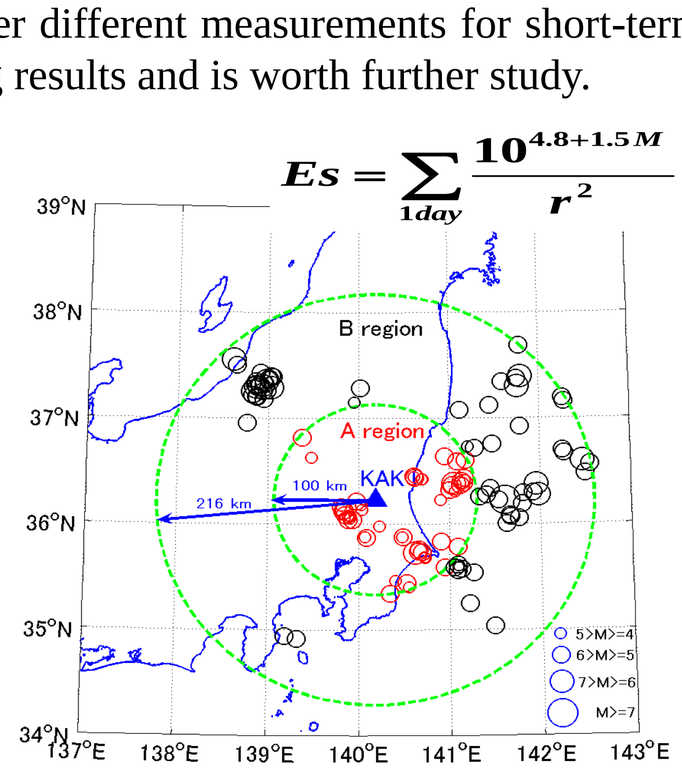

Fig 3. Spatial distributions of earthquakes with Es>10^8 around KAK station during 2001~2010.

2. Statistical studies

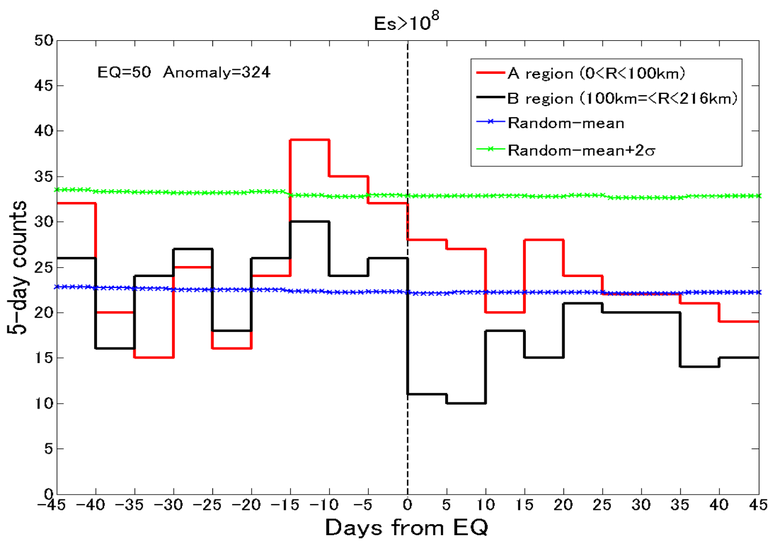

Fig 4. The dependence on epicenter distance: 5-day counts for Regions A and B. The red and the black lines demonstrate the results of 5-day counts for Regions A and B, respectively.

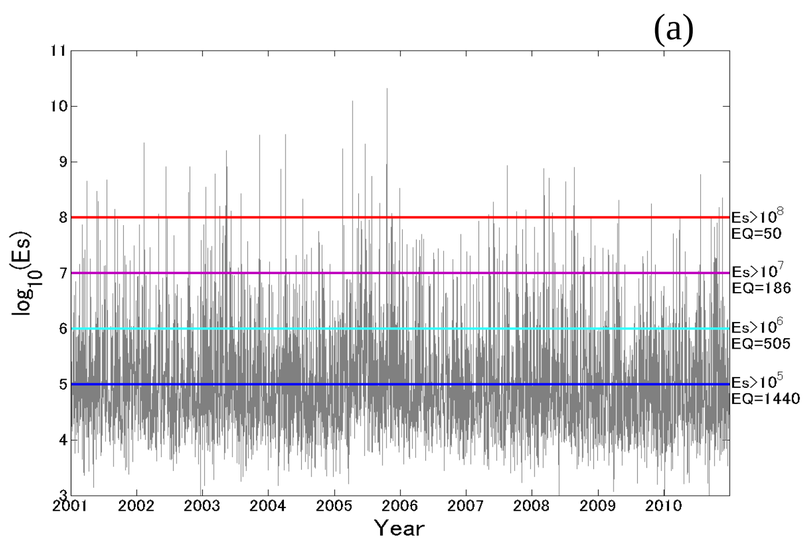

Fig 5. The dependence on earthquake energy: (a) The Es variation in Region A during 2001~2010; (b) 5-day counts for different Es thresholds. The blue, the pale-blue, the purple, and the red lines demonstrate the results of 5-day counts for the Es thresholds 10^5, 10^6, 10^7, and 10^8, respectively.

3. Searching for the optimal prediction strategy

	EQ	No-EQ	Total
Alarm	**n1**	**n2**	**n1+n2**
No-alarm	**n3**	**n4**	**n3+n4**
Total	**n1+n3**	**n2+n4**	**n1+n2+n3+n4**

Alarm rate: τ=(n1+n2)/(n1+n2+n3+n4);
Detecting rate: ν=n1/(n1+n3);
(*Molchan, 1991*)

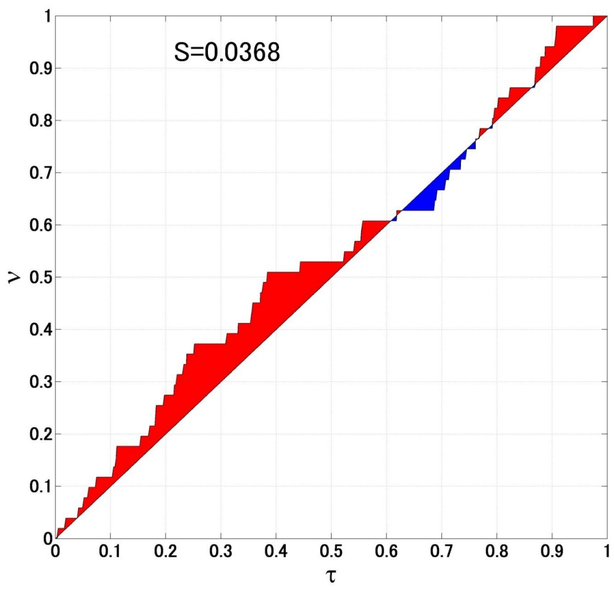

Fig 6. An example of computing the area skill score. The Areas above the random prediction line are counted as positive (shown in red) and the areas under the random prediction line are counted as negative (shown in blue).

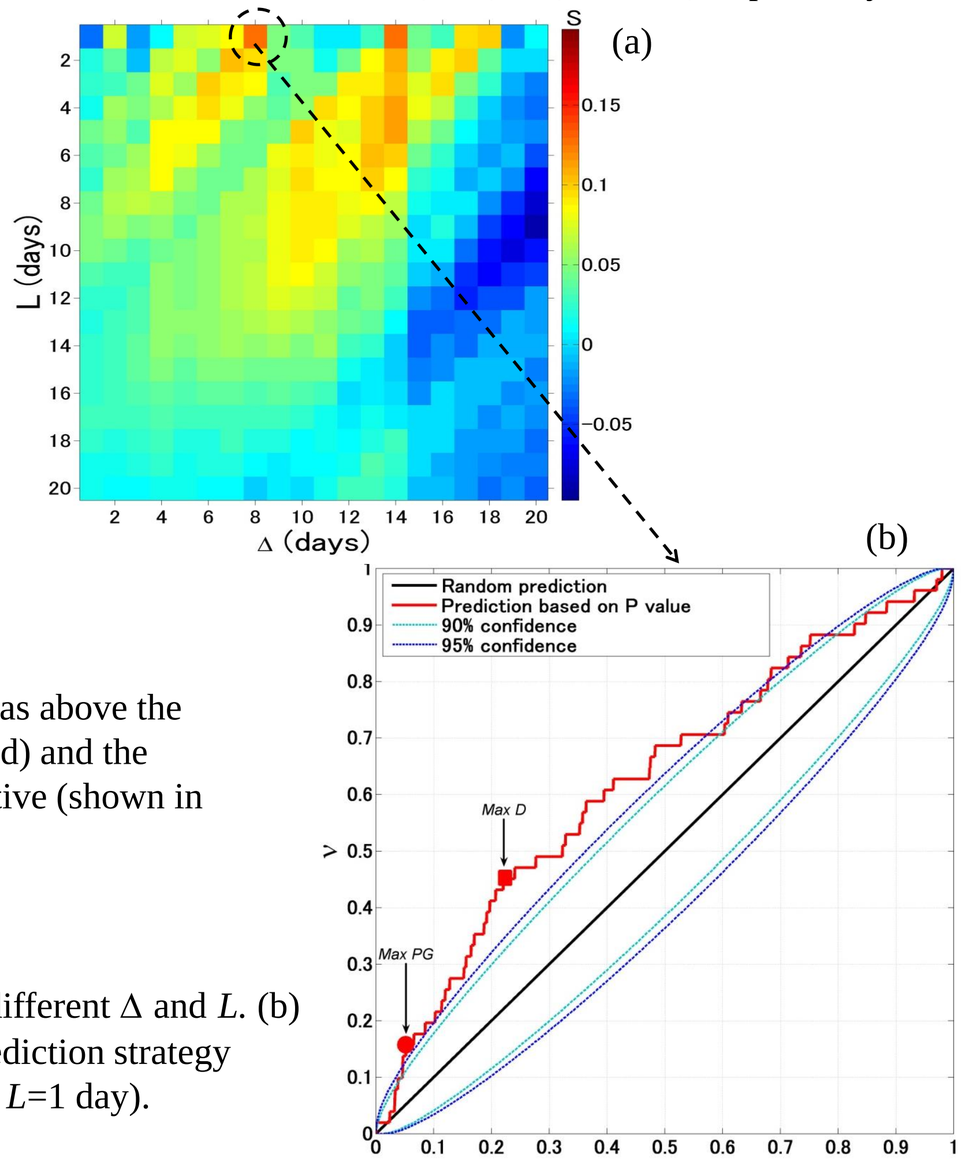

Fig 7. (a) Area skill scores for predictions with different Δ and L. (b) The Molchan's error diagram of the optimal prediction strategy based on the ULF magnetic data (Δ=8 days and L=1 day).