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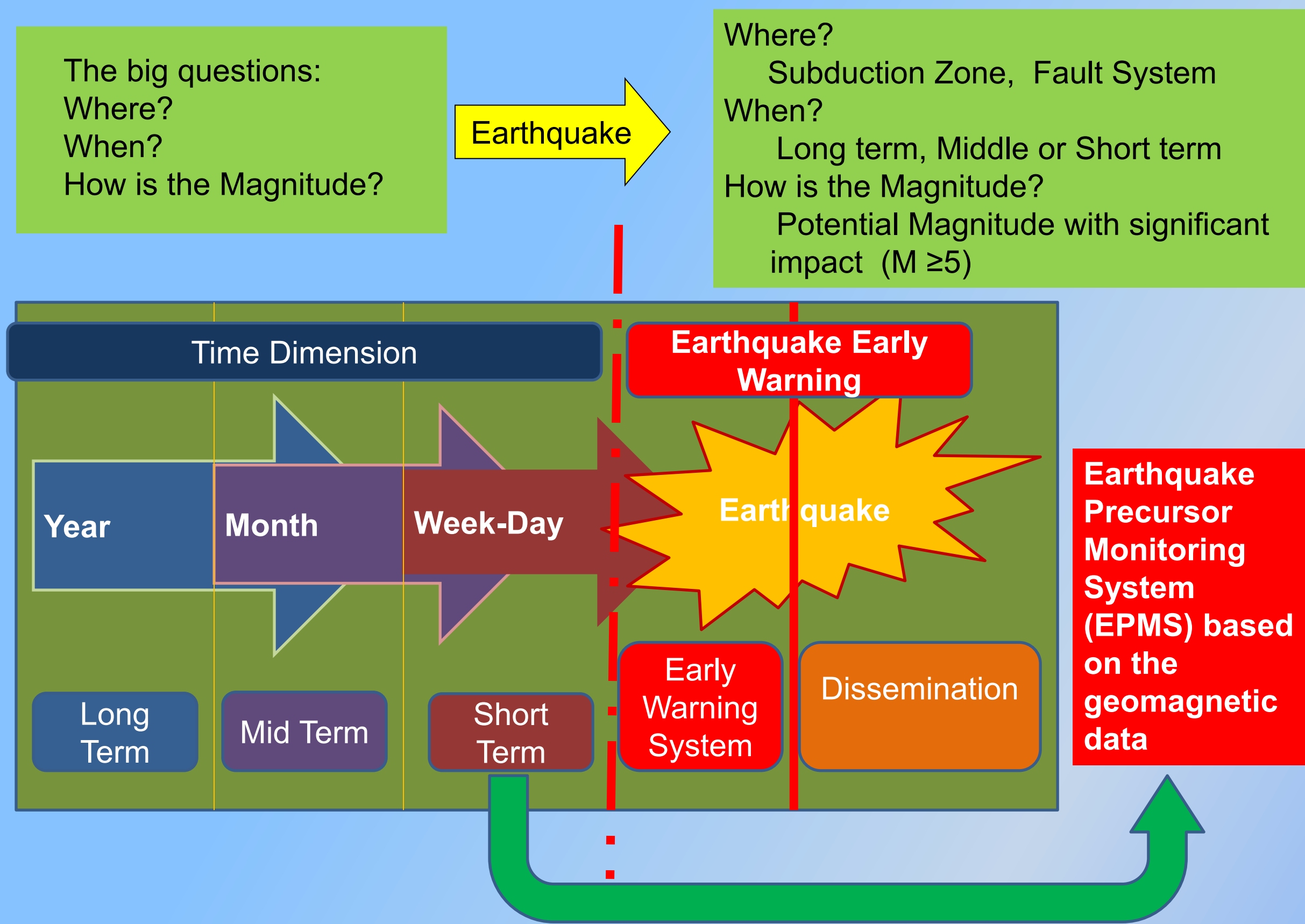
IMPROVING THE ANALYSIS METHOD OF ULF GEOMAGNETIC DATA FOR EARTHQUAKE PRECURSOR MONITORING IN THE SUMATERA REGION

M. Syirojudin¹, Masturyono¹, J. Murjaya¹, S. Ahadi¹, A. Yoshikawa²

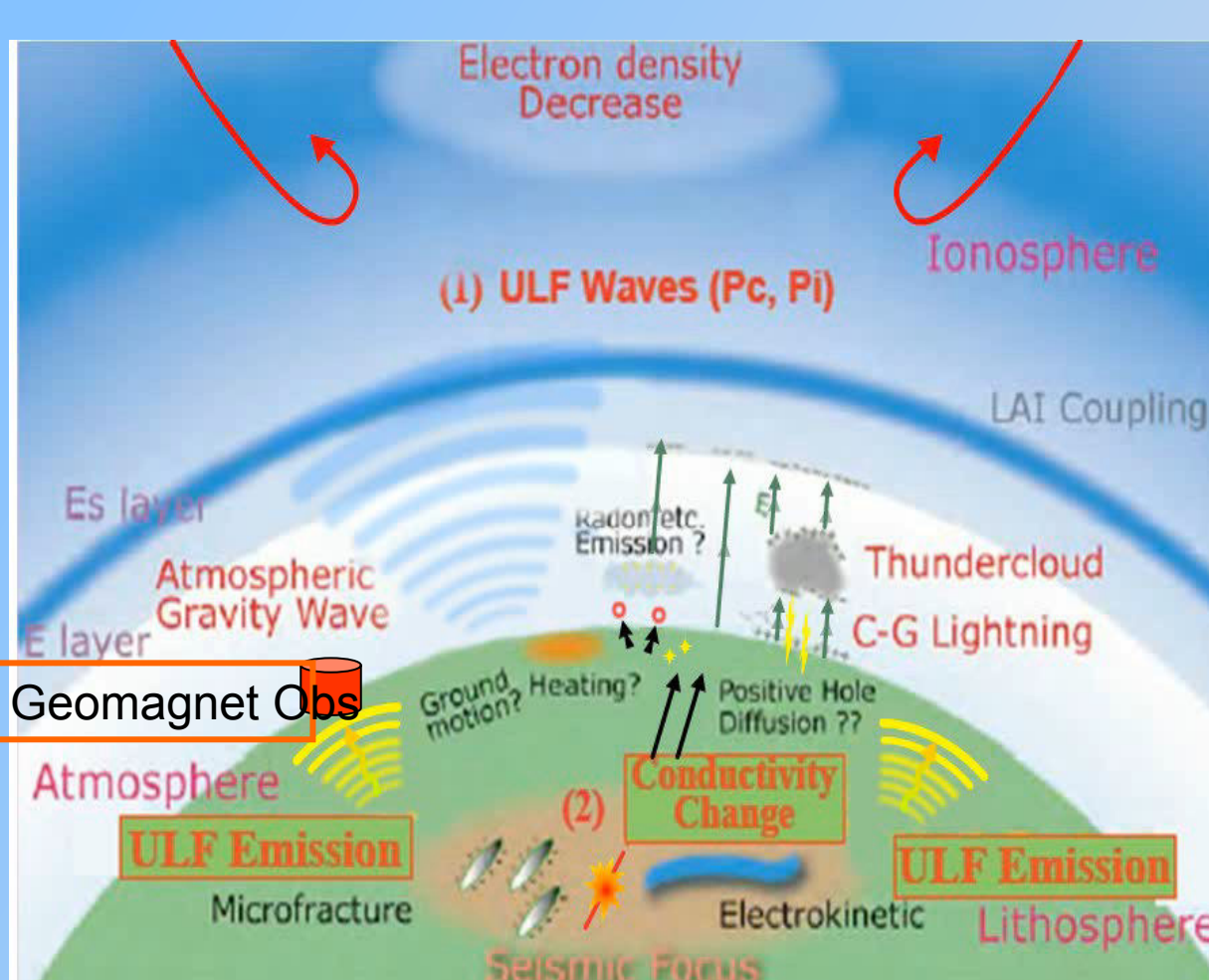
¹Meteorological, Climatological and Geophysical Agency, Jakarta, Indonesia. ² ICSWSE, Kyushu University, Japan.

Abstract:
Although earthquake prediction is still controversial for seismologists, there has been significant progress in the detection of earthquake precursors using geomagnetic data. We developed the Earthquake Precursor Monitoring System (EPMS) based on the geomagnetic data recorded in the Geomagnetic Stations located in Sumatera. The geomagnetic anomaly is calculated and analyzed weekly using the power spectral ratio method of the Ultra Low Frequency (ULF) signal. The Anomaly is used to estimate the magnitude and lead time of the coming potential earthquake, while the azimuthal coverage of the anomaly sources are used to determine the direction and distance of the earthquake. By running EPMS for about three years, we found that the systems are able to predict earthquakes with Magnitude > 5 from 2014 that have occurred at Sumatera region. The occurrence of the predicted earthquakes are in the range of 3-24 days after the geomagnetic precursor detected and the location of the earthquakes are within the cross-section area of the azimuthal coverage between two or more stations. By using the result of 30 predicted earthquakes we find an empirical formula to estimate the magnitude as $M=0.088 \cdot \text{Amp} + 0.002 \cdot \text{distance} + 4.334$. This result has the possibility to improve monitoring of the precursor of large earthquake.

WHAT IS EARTHQUAKE PREDICTION?



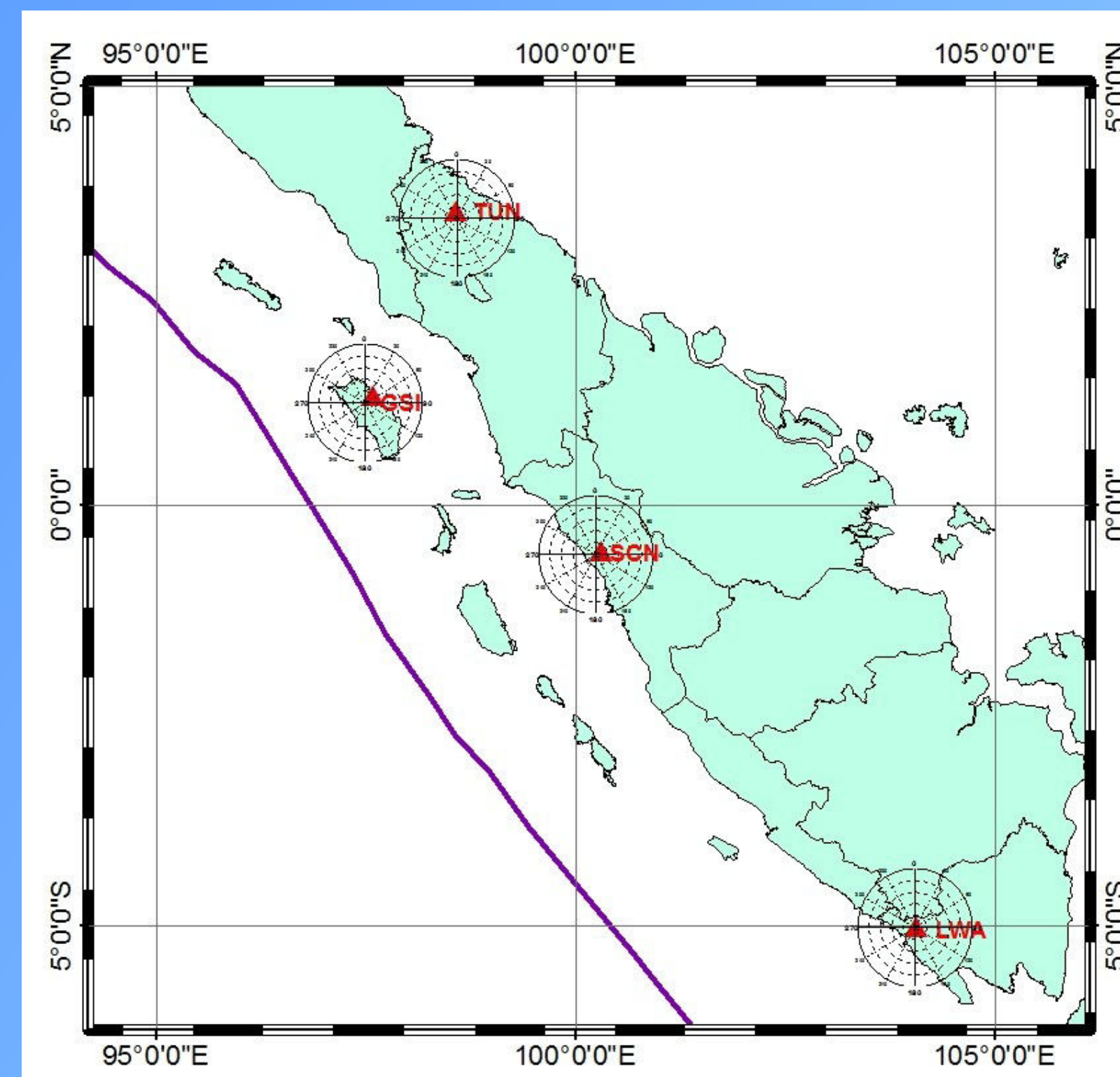
LAI COUPLING MECHANISM



ULF ($f < 1$ Hz) Emission anomalous for earthquake prediction can be analysis due to:
(Yumoto et al., 2009 and Ahadi et al. 2015)

1. Open crack of micro fracture activity in the lithosphere can release ULF emission
2. Z component have sensitive response for local geomagnetic anomalous (such as this emission)
3. For more clear anomalous detection from ULF emission can be analysed from the power spectrum ratio Z/H.

SENSOR NETWORK LOCATIONS IN SUMATERA



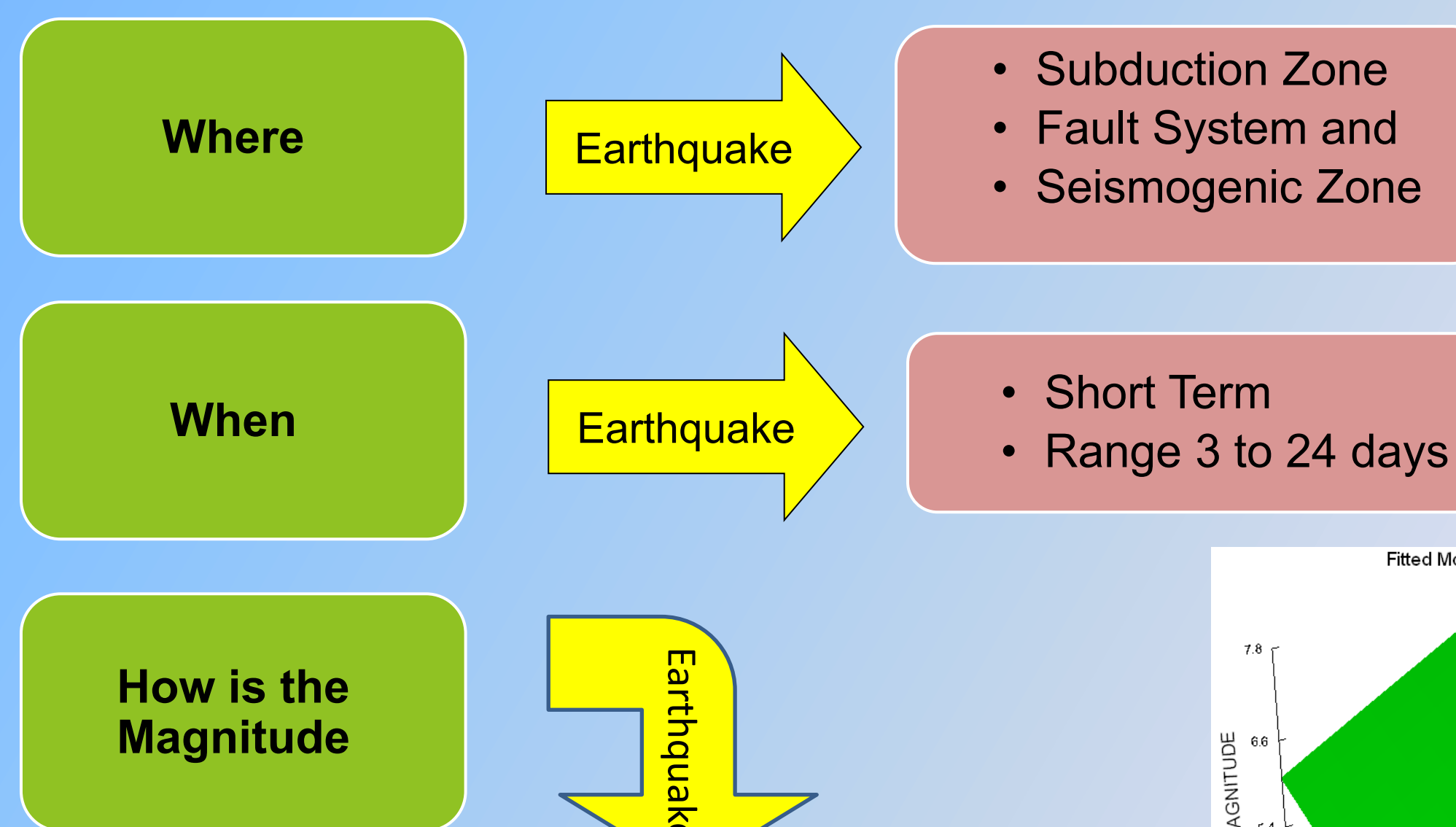
Instrument Specifications
• Sampling Rate 1 Hz
• Range 1 – 70000 nT



IMPROVING THE ANALYSIS METHOD

1. Analyzing full day data to EPMS
2. Using multi-station network to confirm ULF emission anomalous which has been produced by the micro fracture activity.
3. Using spectral signal analysis to filter artificial signal noise

ANSWER THE BIG QUESTIONS ABOUT THE PREDICTION



According to the formula:
 $M=0.088 \cdot \text{Amp} + 0.002 \cdot \text{distance} + 4.334$

• Std Error = 0.2 ; $R^2 = 0.724$; N Sample = 30

RESULTS



Based on the EPMS data from 02 Apr to 02 May 2017, precursor anomalous are detected in 27 Apr 2017 by the parameter in Table 1:

Table .1
Geomagnetic anomaly

No	Date	Time (WIB)	Station	Amplitude	Azimuth (°)
2	27-Apr-2017	05	TUN	-	-
			GSI	-2.53	108
			PPI	-3.08	320

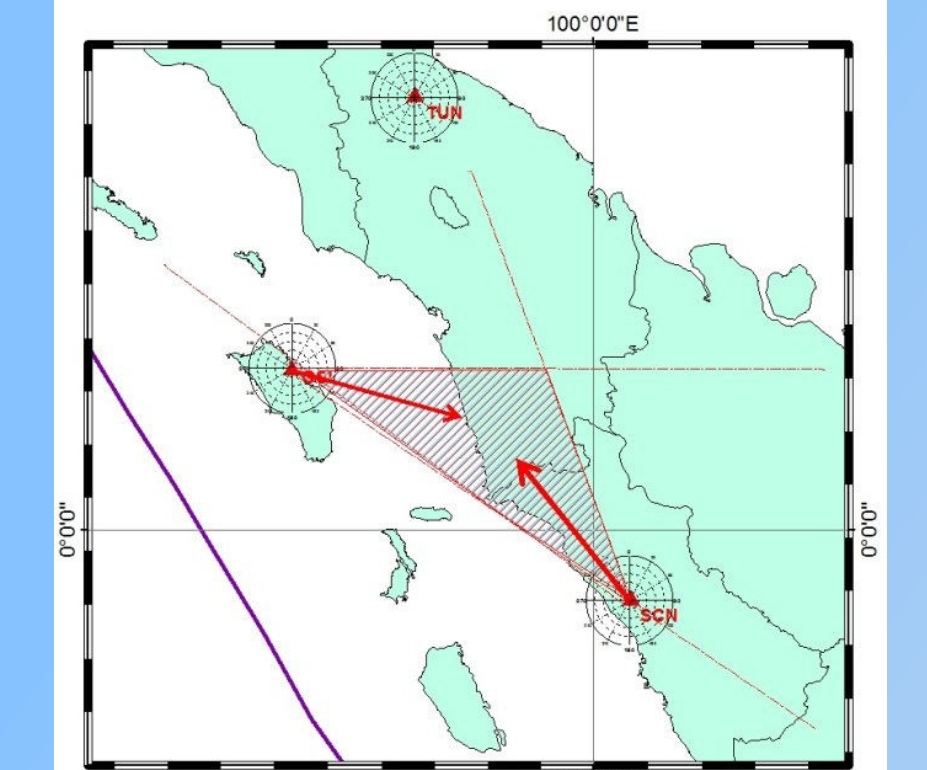


Figure 1. Earthquake prediction zone

With the parameter analysis in Table 1, We predict that an earthquake will occur as described in Table 2 below:

Table .2
FORECAST

Time Range	Location	Magnitude	Impact	Comment
30 Apr – 20 May 2017	Sumatera Fault West-north Padang (see figure 1)	5.0 ± 0.2	Sibolga II SIG (see figure 2)	Still being monitored until 20 May 2017

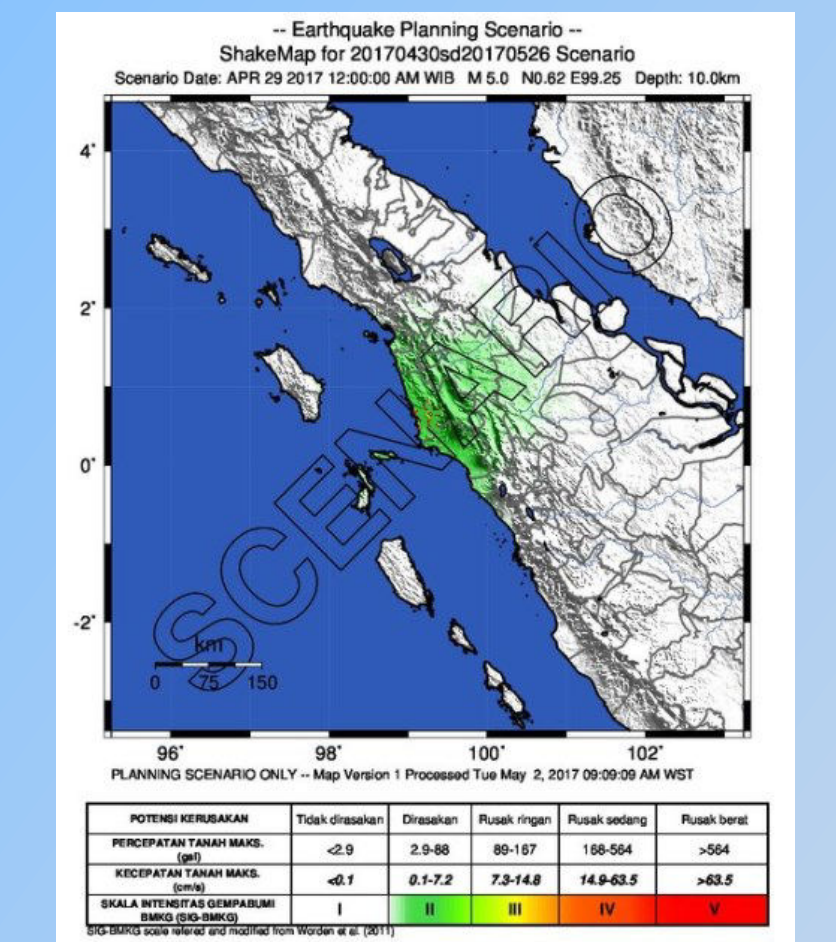
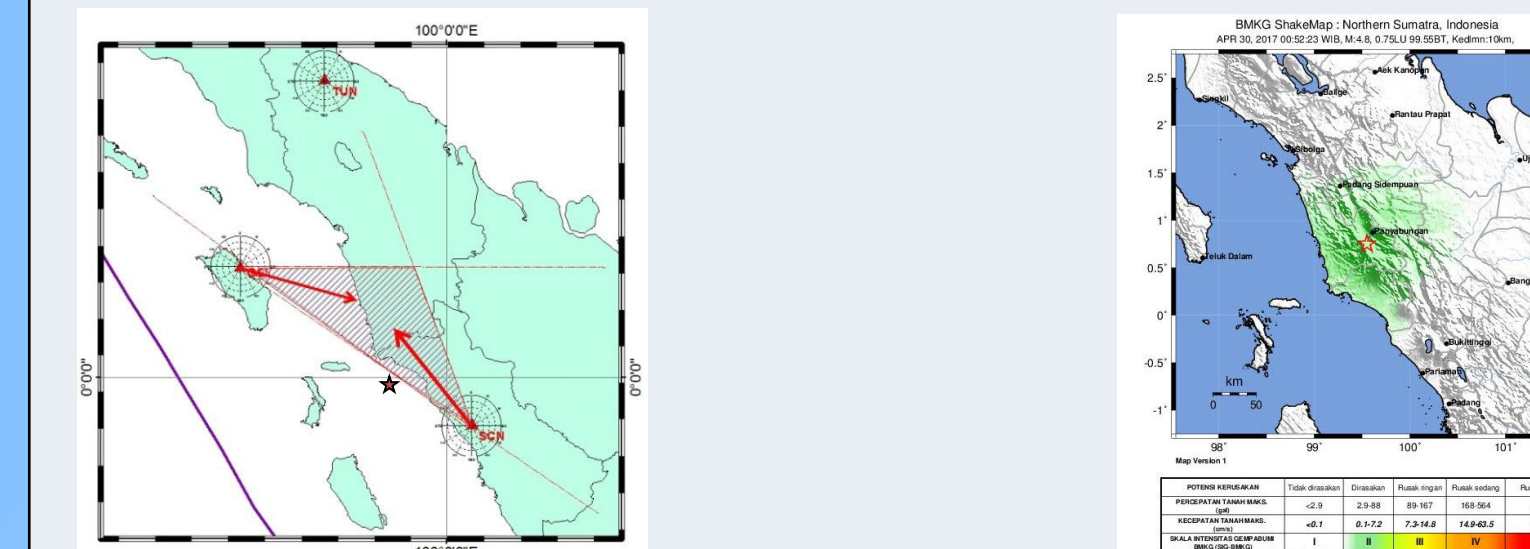


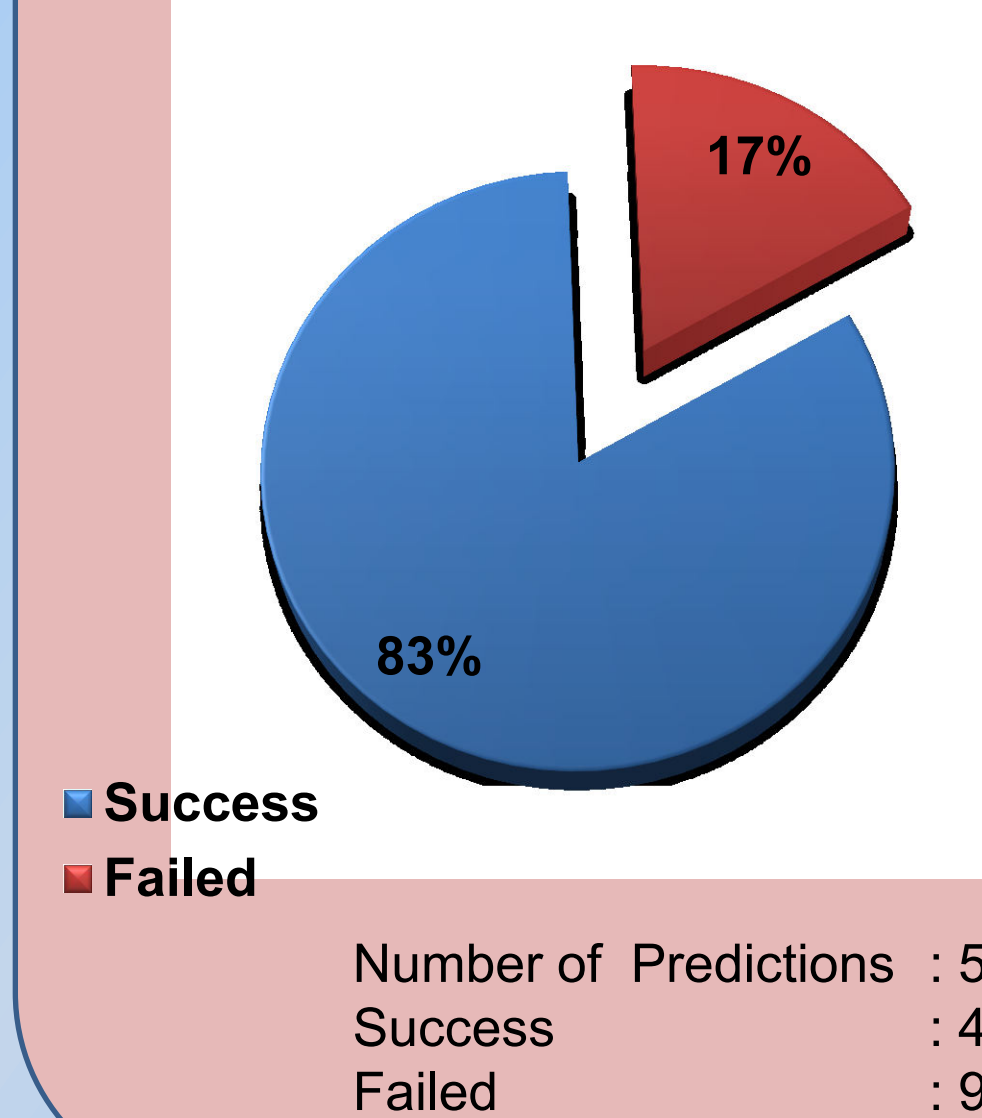
Figure 2. Shakemap scenario for earthquake impact in SIG (Indonesian Earthquake Intensity Scale)

VALIDATION

No.	Parameter	Prediction	Earthquake Events
1	Time	Anomaly : 27-April-2017, 05:00 WIB	00:52:23 WIB
		Range: 30 Apr 2017 – 26 Mei 2017	30 Apr 2017
2	Location	Sumatera Fault North West Padang According to shaded area	0.77 LU 99.56 BT, Depth 10 km. 21 km North East Mandailingnatal -SUMUT
3	Magnitude	5.0 ± 0.2	5.1
4	Impact	Sibolga II SIG	Mandailingnatal II SIG



Prediction Earthquake Result Period 2016 - 2017



CONCLUSIONS:

1. Based on our analysis results, we conclude that the improving method of ULF Geomagnetic data for EPMS in Sumatera have a good accuracy with 83% success rate;
2. We need to add some geomagnetic sensor in Sumatera to cover this region and to produce more accurate results.

REFERENCES:

1. Ahadi, et. Al. (2015): Anomalous ULF Emissions and Their Possible Association with the Strong Earthquake in Sumatera, Indonesia during 2007-2012. J. Math. Fund.Sci. Vol 47, No.1 2015, 84-103.
2. Yumoto, et. al. (2009). A new ULF wave analysis for Seismo-electromagnetic using CPNN/ MAGDAS data. *Physics and Chemistry of the Earth*, 34, 360-366.