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Shear Wave Splitting Analysis Beneath Sumatra For-Arc Inferred from Broadband Seismic Network Station

Lewi Ristiyono[1], Chichi Nurhafizah[1], Suhenri Purba[1], Marhaposan Situmorang[2]
[1]Badan Meteorologi Klimatologi dan Geofisika, Indonesia
[2]Department of Physics, FMIPA, Universitas Sumatera Utara, Medan, Indonesia

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A B S T R A C T

The observation of broadband network seismic had been deployed in Sumatra For-Arc. The waveform data for this study were recorded from January 2014 – December 2016. The earthquake event data were selected with the epicenter of around 950 – 1800 in distance and Magnitude with more than 7 Mw. In this case, we use shear wave splitting to determine an anisotropic structure in Sumatra For-arc. Seismic Anisotropy can perform as a tool to classify and observe anisotropic structures of subsurface deformation processes beneath Sumatra For-Arc. The valid outcomes, in this case, have been gained that they only correspond to the upper layer, which has the delay time duration of 0.5 – 0.8 s is the anisotropic layer located in the Mentawai Island. The fast an anisotropic polarization direction found in Sumatra For-arc are parted into NE-SW direction found on the upper layer.

Corresponding Author:

Lewi Ristiyono,
Badan Meteorologi Klimatologi dan Geofisika, Indonesia
Email: lewi.r@yahoo.co.id

1. INTRODUCTION

Sumatra is section of the Indonesia archipelago which has special geological conditions. It is positioned between two massive plates, Indo-Australia Plate in the south and Eurasia Plate in the north. The subduction of these two plates results in one of the most energetic seismic things to do in the world (Figure 1). And if we seem to be the proportion of the earthquake in Indonesia (Figure 2), indicates Indonesia are is a very energetic area. The Sumatra Subduction Zone is one of the fantastic examples to find out about ocean-continental-subduction zone on a large scale.

Thus, Sumatra is considered as an perfect surroundings to study the reason of earthquake mechanism in a subduction zone is a vicinity where the Indo-Australia Plate is converging underneath the Eurasia Plate.

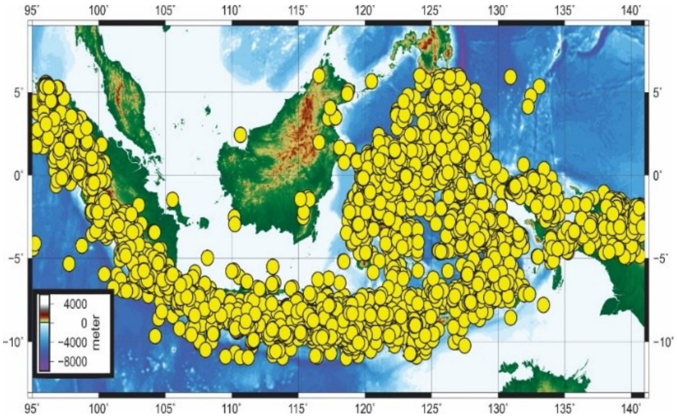

Figure 1. Seimicity of Indonesia

The Indo-Australian Plate is moving northward at a rate of 6-7 cm/year [1], [2]. This Subduction movement influences tectonic activity that occurs in Sumatra and some smaller islands around it.

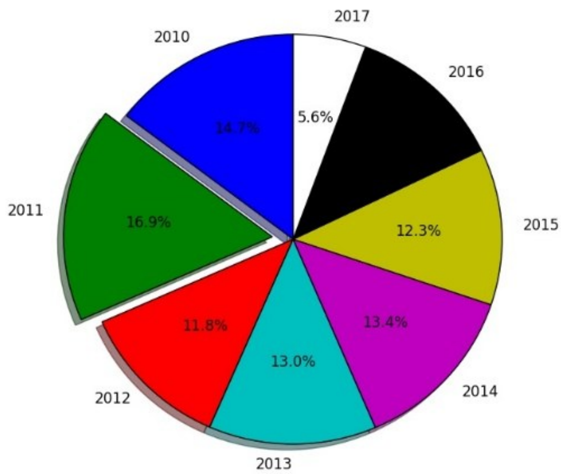

Figure 2. Percentage of Earthquake in Indonesia 2010-2017, August

A study by [3], [4] is one of the most detailed studies focusing on the subduction zone and fault in the north of Sumatra. In addition, a study by [5], [6] estimated anisotropic layers in Sumatra and Java by using a few stations. Consequently, it only involves some of the investigated regions. In this case, the Sumatra For-arc is a region that has a significant tectonic type. Up to this time, the study is still limited to an anisotropic observation which is close to the Sumatra For-Arc.

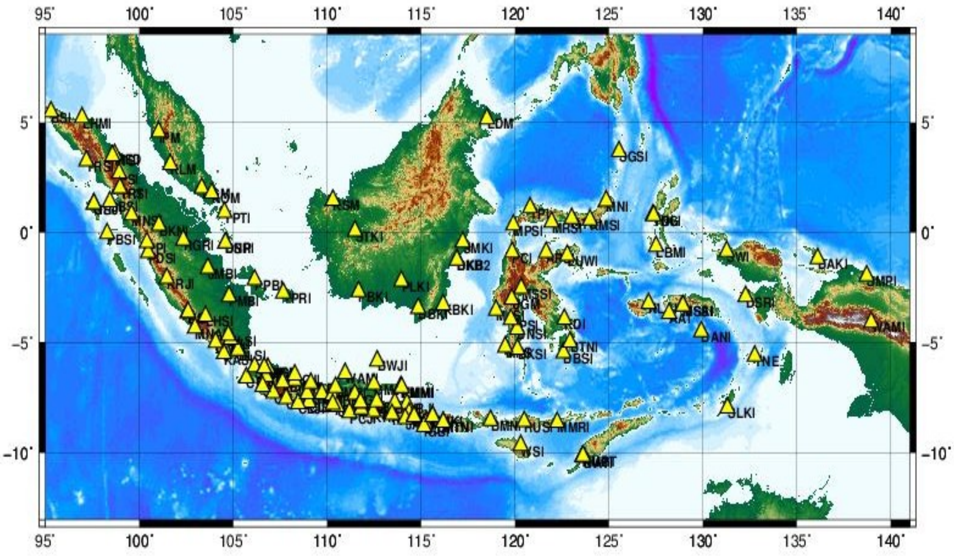

Figure 3. BMKG (IA) Seismic Network

These two factors are the heritage of the study of anisotropic shape in Sumatra. This is file is furnished with shear wave splitting commentary using facts taken from some seismic broadband station of the BMKG community in Indonesia (Figure 3). The statement is constant with the preceding studies [7]–[9]. Yet, it gives a denser density of earthquake monitoring station which deployed in Sumatra For-arc. Thus, it is feasible to supply a better constraint to decide an anisotropic shape in Sumatra For-arc. In this research we choose to center of attention on Sumatra Island, even though the preceding research have investigated a tectonic records of Sumatra Island in Figure 4, starting from the plate reconstruction to the tomography, the research have not explored but the subduction precipitated by the mantle motion

2. DATA AND METHOD

This analyze about employed data that have been taken from six eternal stations of BMKG (IA) at the identical time as GFZ (Geo For-Schungs-Zetrum) neighborhood and BMKG Libra Networks used to be used to estimate the anisotropic characteristic below Sumatra For-Arc. Table 1 shows the neighborhood of earthquake monitoring stations. The statistics for this find out about was once earthquake records recorded from January 2014 – December 2016. The earthquake match data had been chosen with the epicenter of spherical 850 – 1800 in distance and Magnitude with greater than 7 Mw. The motive for deciding on the epicenter due to the fact the event gorgeous a shear wave splitting analysis on SKS/SKKS wave phase.

Table 1. Station Seismic Monitoring

No	Station	Lat	Long	Sensor
1.	SNSI	2.408	96.32	STS 2
2.	PBSI	-0.054	98.28	STS 2
3.	SISI	-1.326	99.08	STS 2
4.	PPSI	-2.7630	100.09	STS 2
5.	EGSI	-5.3524	102.27	STS 2
6.	GSI	1.3039	97.575	STS2, Triaxial

The distance additionally may want to warranty that the seismic wave nonetheless had ample energy [10]–[13]. Shear wave splitting used the teleseismic data, specially SKS/SKSS phase, ordinarily to reflect the anisotropic characteristics of the higher mantle [14], [15]. Figure 5 suggests most of the occasions that the BMKG station discovered in Sumatra For-arc and surrounding regions. Before conducting the shear-wave splitting analysis, first of all, the data of the SKS/SKKS wave section had been filtered, aiming to expand the signal-to-noise ratio (SNR) and steadiness of the shear-wave splitting measurement by way of the use of a bandpass filter with the frequency of 0.05-4 Hz. This filtering resulted in, extra or less, the same splitting parameter. Consequently, it showed that the high-frequency scattering does now not influence the considerable result.

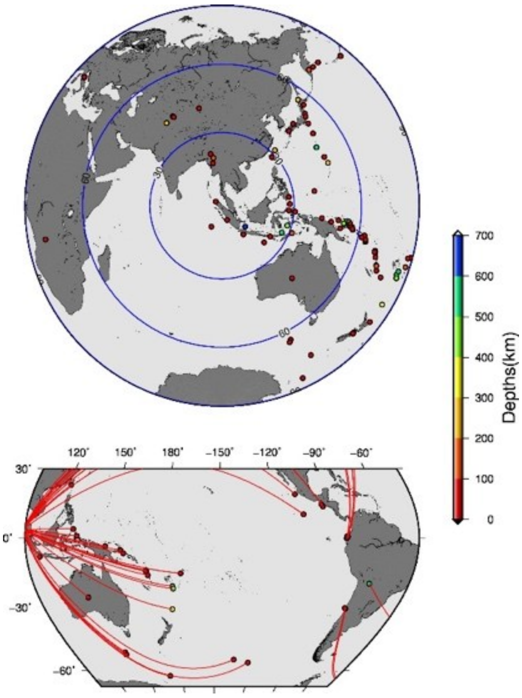

Figure 4. Tele-seismic Event

3. RESULTS AND DISCUSSION

Before plotting the parameter of the result of the shear-wave splitting size the use of a technique developed through [14], some seismograms recorded from the earthquake data that did not meet the standards had been deleted. A seismogram recorded from the earthquake statistics that did not meet the criteria had been deleted. A waveform of the earthquake that produced a extend time of extra than three seconds would be deleted. The prolong time usually takes place for round 1 or 2 seconds. Every delay time of more than three seconds would be regarded unrealistic to the appreciation of anisotropic media underneath the earth mantle [16], [17]. The seismic section was then checked visually and analyzed by the usage of a seismogram displayer as Figure 6 shows.

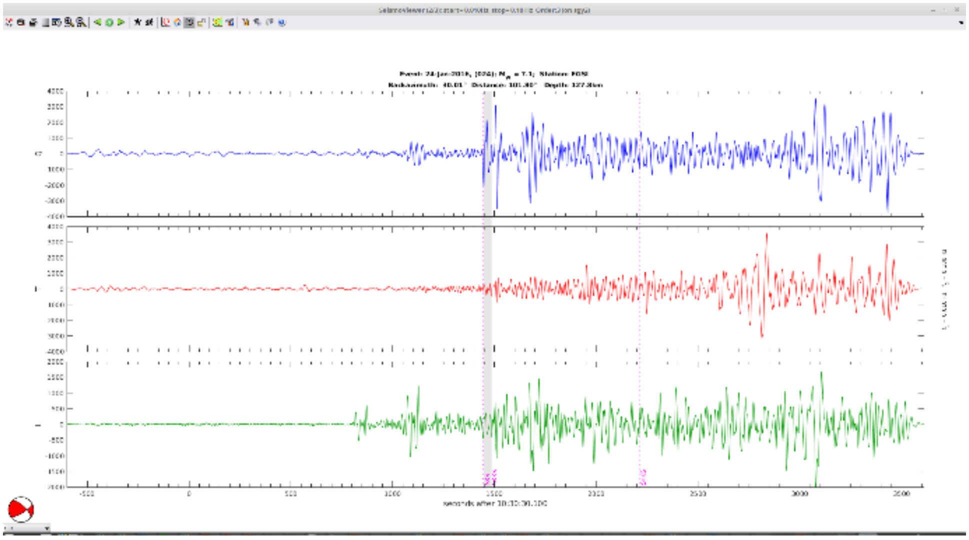

Figure 5. Seismogram viewer after changing into LTQ (Radial, transverse, and Vertical) and applied Band Pass Filter to reduce noise

The preparing bend, remaining plot, and diffuse plot are appeared utilizing these codes. The representation of 96041 stations appears the esteem near to zero will speak to way better quality of the indicator within the relapse demonstrate. It can be seen from figure 3 that the Stacked LSTM performed best compared to the types of the station. We will also see that the single-cell worked incredibly utilizing 100 input days but we found that this kind of setup was as well computationally costly. The bidirectional LSTM moreover performed more awful with more input days. Based on the series data of temperature of 96041 stations, the MSE value is 0.01, and R2 value is 0.98.

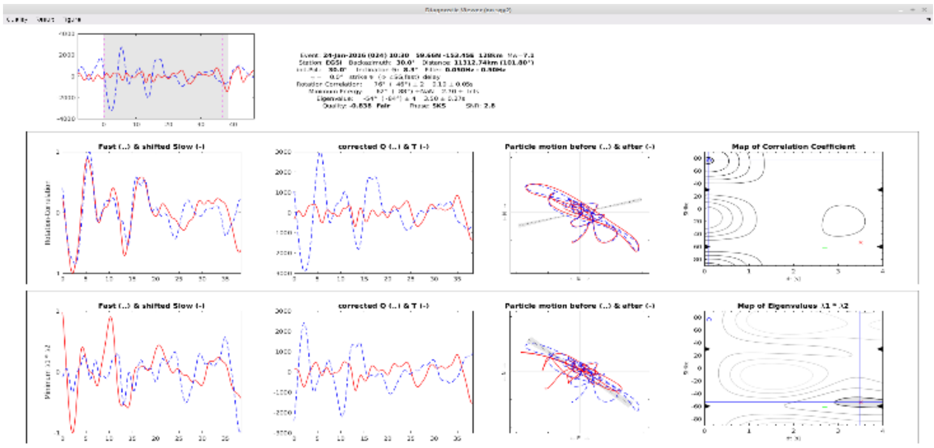

Figure 6. Example of splitting measurements of EGSI station obtained using Split-Lab

The observation of the seismic anisotropy in Sumatra For-Arc shows the end result of the shear-wave splitting calculation. For-Arc location is a place engulfing trench in the front of Sumatra For-Arc consists of six recording stations; SNSI, PBSI, SISI, PPSI, EGSI, and GSI. On the different hand, in For-Arc area of Mentawai Island, the end result of shear wave splitting measurements exhibit that there are two anisotropic layers; upper and lower layers. The decrease anisotropic layer produces the lengthen time at the price of about 1.4-1.8 s that possesses the identical polarization course of NE – SW (northeast-southwest), and it is perpendicular to the trench located in front of Sumatra For-Arc. The result of the shear-wave splitting measurement on the Mentawai Island indicates that the path is usually parallel with Indo-Australian Absolute Plate Movements.

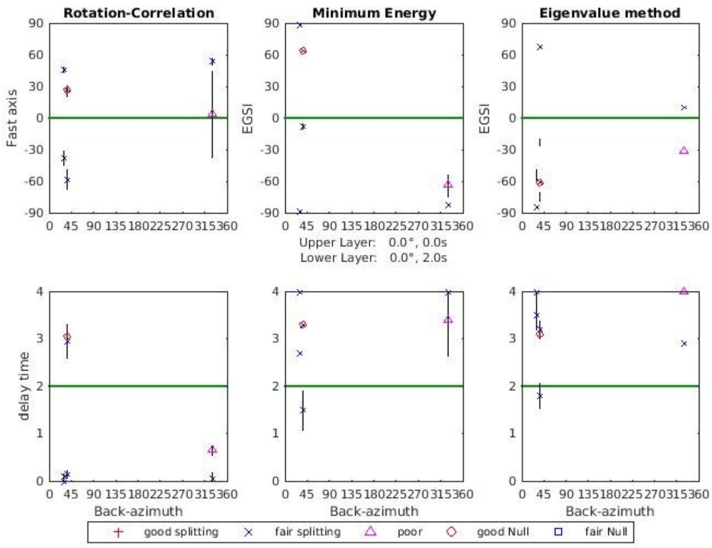

Figure 7. Example of double layer model fit at EGSI stations

The top left panel indicates the uncorrected radial (dashed) and transverse (solid) components. The middle and bottom rows of panels show the diagnostic plots for the rotation-correlation technique and the transverse aspect minimization method, respectively: from left to right, the corrected quickly (dashed) and sluggish (solid) components, the corrected radial (dashed) and transverse (solid) components, the uncorrected (dashed) and corrected (solid) particle motion diagrams, and the maps of correlation.

Three extraordinary splitting methods are compared (Rotation-correlation, Minimum Energy, and Eigenvalue). For every technique, the returned azimuthal version of speedy orientation estimate (top row) and lengthen time estimates (center row) are shown.

This result does now not swimsuit the international commentary of trench that had been conducted by way of [14]. However, this result is relevant to the result of studies performed through [5], [12], [16] which show that the result of the shear-wave splitting observation carried out on the Mentawai Islands possesses a polarization route that is parallel with the Absolute Plate Movements (APM). This discovering indicates that there are anisotropic plates underneath the Mentawai Islands.

These layers are anticipated to be subduction plates that exist below the Mentawai Islands. On the higher anisotropic layer, it confirmed the extend time at the rate of around 0.5-0.8 s that possesses a polarization direction which W-E (west-east) and parallel with the trench. This discovering potentially shows that there is a shallower anisotropic quarter than a subduction zone. This anisotropic layer is presumed upon a Mentawai Fault that exists below the Mentawai Islands. An appropriate rationalization describes the polarization course which is perpendicular to the trench is the anisotropic layers under the earth crust.

4. CONCLUSION

In this study, we current a new shear wave splitting end result in Sumatra For-Arc. The shear-wave splitting measurement from SKS/SKKS segment used to be conducted by using teleseismic facts taken from a everlasting station in Sumatra For-Arc. The valid effects have been won that they only correspond to six stations. The findings show that there are two foremost anisotropic layers fashioned in the For-Arc place (the Mentawai Island). The top layer, which has a extend time period of 0.5 – 0.8 s is the anisotropic layer placed in the Mentawai Island. The quick and anisotropic polarization path determined in Sumatra For-Arc is divided into the North East-South West direction located on the top layer.

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