# INTISARI

## VARIASI TEMPORAL ENTROPI PERMUTASI DAN KERAPATAN SPEKTRUM DAYA PADA *AMBIENT SEISMIC NOISE* YANG TEREKAM SELAMA PERIODE ERUPSI GJÁLP 1996 DAN MERAPI 2010

Afif Rakhman
14/374997/SPA/0520

Dalam beberapa tahun terakhir, analisis *ambient seismic noise* secara luas diterapkan dalam studi peramalan *(forecasting)* erupsi gunung api. Variasi *ambient seismic noise* biasanya terjadi lebih awal dibandingkan sinyal prekursor lainnya. Salah satu pendekatan baru dalam analisis *ambient seismic noise* adalah perhitungan variasi temporal entropi permutasi. Sebelumnya telah diketahui bahwa penurunan entropi permutasi secara siginifikan selama 8 hari sebelum peristiwa erupsi subglasial Gjálp (Islandia) 1996 dapat diindikasikan sebagai salah satu prekursor jangka pendek. Berdasarkan perhitungan variasi temporal frekuensi dominan (DF) dan sentroid (CF), penurunan tersebut diperkirakan akibat berkurangnya intensitas aktivitas seismik pada komponen frekuensi tinggi (> 1 Hz) yang disebabkan kenaikan magma ke bagian atas kerak bumi. Pada studi ini kami menyajikan penerapan simultan perhitungan variasi temporal entropi permutasi (*permutation entropy* atau PE) dan kerapatan spektrum daya (*power spectral density* atau PSD) pada analisis erupsi subglasial Gjálp 1996 dan erupsi eksplosif Merapi (Indonesia) 2010. Perhitungan PE digunakan untuk melihat tingkat stokastik sinyal menjelang erupsi, sedangkan perhitungan PSD digunakan untuk melihat variasi derau latar *(background noise)* pada beberapa pita frekuensi. Data seismik kontinu yang digunakan pada studi ini diperoleh dari IRIS Waveform Depostory (USA) dan BPPTKG (Indonesia). Hasil perhitungan PSD pada studi ini dapat mengkonfirmasi dengan baik penurunan intensitas aktivitas seismik pada pita frekuensi tinggi bersamaan dengan kenaikan intensitas pada frekuensi rendah di stasiun HOT23, HOT14, dan HOT25 selama 8 hari sebelum erupsi Gjálp. Perhitungan terkait erupsi Merapi 2010 memperlihatkan penurunan nilai PE secara berangsur-angsur dari ~ 0,98 di awal September menjadi ~ 0,91 sebelum onset erupsi pertama tanggal 26 Oktober pukul ~ 10.02 UTC di stasiun PUS. Meskipun demikian, penurunan tersebut tidak terkonfirmasi pada stasiun DEL dan PLA yang berada lebih jauh dari puncak. Variasi PSD pada pita frekuensi rendah dan tinggi di stasiun PUS hampir selalu beriringan, semakin linier, dan mengalami kenaikan tajam pada enam hari menjelang erupsi pertama. Dua onset erupsi utama pada 26 Oktober dan 4 November berkesesuaian dengan dua puncak PSD tertinggi pada pita frekuensi tinggi maupun rendah. Faktor utama yang diperkirakan mempengaruhi perbedaan hasil perhitungan PE dan PSD antara Islandia dan Merapi adalah perbedaan tatanan geologi. Sifat hamburan *(scattering)* gelombang pada komponen frekuensi tinggi akibat kenaikan magma tidak begitu mengalami penurunan di Merapi karena geometri internalnya yang berupa saluran magma tunggal dari dapur magma yang terhubung secara vertikal ke kantong magma. Selain itu, terdapat pula perbedaan pada ragam gempa vulkanik yang terjadi, kemiringan lereng, ketebalan lapisan kerak benua, serta jenis lapisan batuan.

**Kata-kata kunci:** erupsi, Gjálp, Merapi, *ambient seismic noise*, PE, PSD

# ABSTRACT

## TEMPORAL VARIATION OF PERMUTATION ENTROPY AND POWER SPECTRAL DENSITY ON AMBIENT SEISMIC NOISE RECORDED DURING THE ERUPTION PERIOD OF GJÁLP 1996 AND MERAPI 2010

Afif Rakhman
14/374997/SPA/0520

In recent years, ambient seismic noise has been widely used along with the continuous observation of volcanic signals. The variation in ambient seismic noise usually occurs earlier than other precursor signals. One new approach in the analysis of ambient seismic noise related to periods of volcanic unrest is the permutation entropy (PE) calculations. It was previously observed that a significant reduction in permutation entropy during the 8 days prior to the subglacial eruption of Gjálp 1996 could be indicated as one of the short-term precursors. Based on the calculation of the temporal variation of the dominant and centroid frequencies (CF and DF), the decrease is estimated to be due to the lack of high frequencies (>1 Hz) in the noise wave-field caused by high absorption losses as the hot magma uprises to the upper crust. In this study we present the simultaneous application of the calculation of the temporal variation of permutation entropy (PE) and power spectral density (PSD) in the analysis of the subglacial eruption of Gjálp 1996 and the explosive eruption of Merapi (Indonesia) 2010. The calculation of PE aims to see the stochastic level of the signal before the eruption, while the PSD calculation is used to see the variation in background noise in several frequency bands. The continuous seismic data used in this study were obtained from the IRIS Waveform Depostory (USA) and BPPTKG (Indonesia). The results of the PSD calculation in this study can well confirm the decrease in the intensity of seismic activity in the high frequency band together with the increase in intensity in the low frequency at the HOT23, HOT14, and HOT25 stations during 8 days before the Gjálp eruption. The Calculation of PE temporal variations related to the 2010 Merapi eruption shows a gradual decrease in the PE value from ~ 0.98 in early September to ~ 0.91 before the onset of the first eruption on 26 October at ~ 10.02 UTC at the PUS station. However, this decrease is not well confirmed for DEL and PLA stations which are farther from the top of the Merapi. The level of background noise in the low- and high-frequency bands appeared to have the same tendency, getting more linear and experiencing a sharp increase in the six days leading up to the first eruption. Two primary eruption onsets on 26 October and 4 November corresponds to the two highest PSD peaks, both in the low and high-frequency bands. The main factor which is thought to influence the differences in the results of PE and PSD calculations between Iceland and Merapi is the difference in geological setting. The scattering characteristic of waves at high frequency components due to the increase in magma has not decreased significantly at Merapi because of its internal geometry which is a single magma channel from the deep magma chamber which is connected vertically to the shalow magma chamber. In addition, there are also differences in the variety of volcanic earthquakes that occur, the slope of the slopes, the thickness of the continental crust layer, and the type of rock layer.

**Keywords:** eruption, Gjálp, Merapi, *ambient seismic noise*, PE, PSD