Does seismic noise in southern Tangerang relates to rainfalls over its surrounding districts? - preliminary results

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Why study ambient seismic noise and rainfall?

Rainfall dataset is a crucial element in the development of hydrometeorological hazard mitigation strategy. Thus, an alternative source of rainfall data is always compatible with a limited network of in-situ rain observation in a region with a complex rain system such as western Java (Djamil et al., 2023; Jaelani et al., 2026).

In this study, we explore a possible source of rainfall data from the ambient seismic noise. In Bangladesh, seismic noise at 2Hz and 5Hz correlate well with rainfall from ~20km distance (Bin Abdul Rahman et al., 2024) (Fig. 1). Thus, we explored the relationship between seismic noise record from southern Tangerang (WJA19) with daily in-situ rainfall data under the radius of 20km.

Seismic noise and rainfall data around southern Tangerang

The seismic record used in this study, labelled as WJA19, is from a temporary seismic station located in southern Tangerang for the period of 14th June to 3rd August 2016 (52 days) (Rosalia et al., 2022) (Fig. 2, 3, & 4). While the daily rainfall dataset consist of three rain gauge stations managed by the Directorate of Water Resources (Dirjen SDA - PU) (Jaelani et al., 2026) and another three climate stations managed by the Indonesian Meteorological and Climatological Services (Staklim BMKG) (Fig. 3, & 4).

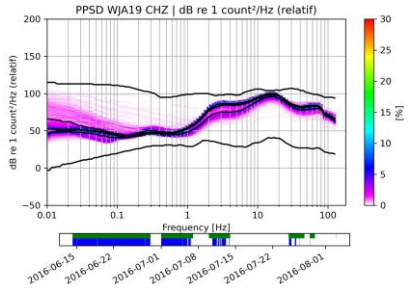


Figure 2. Probabilistic Power Spectral Density (PPSD) of WJA19 seismic record for vertical component

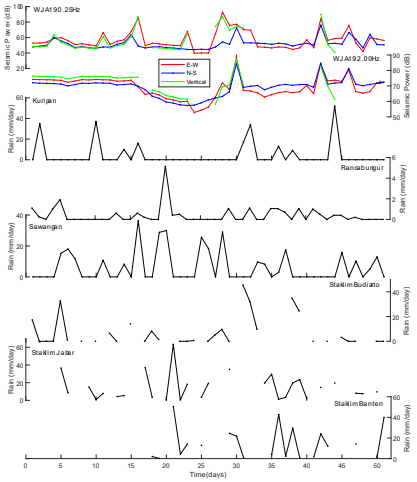


Figure 3. Daily time series of the ambient seismic noise of WJA19 sliced at 0,25Hz and 2.00Hz from the three components (E-W, N-S, and Vertical), and rainfalls from the six locations. See Fig. 4 for the spatial plot.

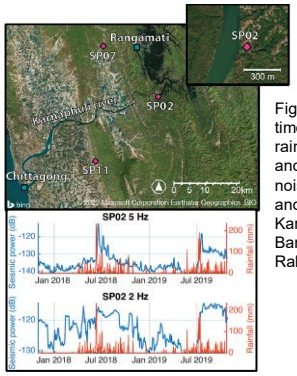


Figure 1. Locations and time series of the daily rainfall (Rangamati) and ambient seismic noise (SP02) at 2Hz and 5Hz around Karnaphuli river in Bangladesh. (Bin Abdul Rahman et al., 2024)

How to check their relationship?

The relationship between ambient seismic noise and rainfall is identified by applying cross-correlation analyses to a pair of signals. The method identified the level of temporal dependency between two signals based on their phase relationship.

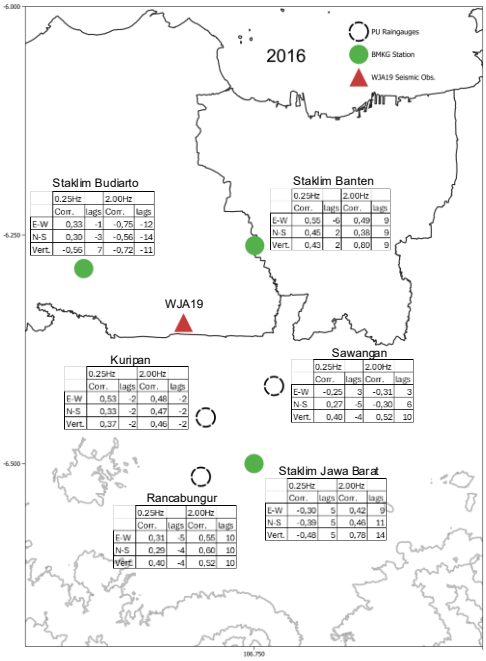


Figure 4. Locations of WJA19 (triangle) and the six rainfall observations (circles). Table in each location displayed their maximum correlation scores and their corresponding time-lags from the cross-correlation analyses shown in Fig. 5 for each of their three components (E-W, N-S, and Vertical). Positive (negative) lags are when seismic noise purposefully lags (leads) rainfall.

Which time-lag to look at? and what is their role in improving correlation scores?

The correlations scores at 0 day lag between the sliced ambient seismic noise at the two frequencies with the six rainfall records are rather small (Fig. 5). However, one might posit that the possibility of ambient noise seismicity in recording surrounding rainfall could be identify from the positive high correlation scores at the positive time-lags. This condition mostly occurred in Staklim Banten, Staklim Jabar, and Rancabungur mainly for the 2.00Hz signal (Fig. 4 & 5).

On the other hand, an increasing correlation scores along the positive time-lag (e.g., Staklim Budiarto for 2.00 Hz slice) could also indicate a delayed processes by the seismic noise in recording the surrounding rainfalls.

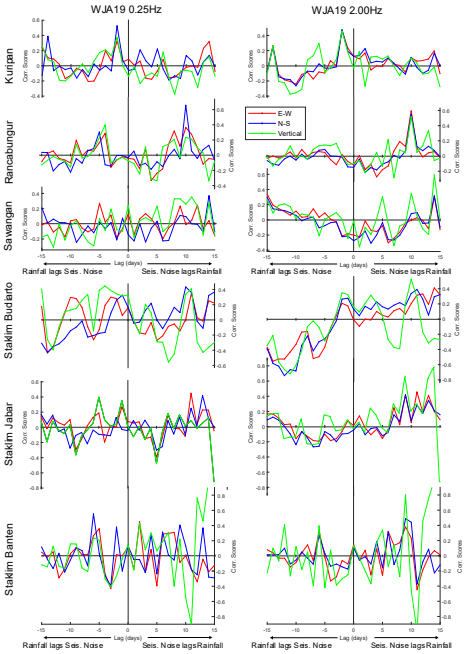


Figure 5. Cross-correlation scores within 15 days time-lag window of each rainfall record with each of their three components (E-W, N-S, and Vertical) of the two sliced frequencies (0.25Hz and 2.00Hz) of the ambient seismic noise of WJA19. Positive (negative) lags are when seismic noise purposefully lags (leads) rainfall.

So how is the relationship? and what was missing in this study?

Our preliminary study to uncover the relationship between ambient seismic noise in southern Tangerang and rainfall from its surrounding districts shows a rather mixed depictions, where stronger correlations occurred with distance rainfalls (Rancabungur, Staklim Jabar, Staklim Banten) rather than their nearest one (Kuripan and Sawangan).

On the other hand, a relatively small number of sample sizes renders a limited interpretation of the cross-correlation results. Thus, the identified relationship may not be robust.

Several steps to overcome the above caveats and improve our analyses:

1. Perform similar analyses on more seismic records as shown in Rosalia et al. (2022) supported by western Java rainfall as shown by Jaelani et al. (2026).

2. Conduct rigorous statistical analyses by utilizing significancy test, extreme values, and multivariate methods (principal component analyses, etc.).

References

- Bin Abdul Rahman et al. (2024) (doi.org/10.3389/feart.2024.1334248)
- Djamil et al. (2023) (doi.org/10.1063/5.0181430)
- Jaelani et al. (2026) (doi.org/10.1071/ES24040)
- Rosalia et al. (2022) (doi.org/10.1186/s40562-021-00208-5)