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COMMENT
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Comment on "Seismic Velocity Variations at Different Depths Reveal the Dynamic Evolution Associated With the 2018 Kilauea Eruption" by Liu et al.

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Key Points:

- The tremor signals appeared on the ambient noise cross-correlation functions (CCFs) should be from the Kīlauea summit, not Pu'u'ō'ō
- The tremor sources changed after the beginning of the eruption
- The apparent temporal variations of the CCFs related to the tremors reflected the change of noise source rather than medium velocity

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Abstract Liu et al. (2022, https://doi.org/10.1029/2021GL093691) used Rayleigh waves extracted from the cross-correlation of ambient noise recorded by two stations to monitor the seismic velocity variations associated with the 2018 Kīlauea eruption. However, their study ignored the fact that the tremors on the Island of Hawai'i were dominated by a source at the Kīlauea summit before the eruption. Close inspection of the waveforms of the station pair PAUD-STCD shows a simple, mistakenly identified wave traveling direction in Liu et al. (2022, https://doi.org/10.1029/2021GL093691). A correct wave traveling direction agrees with the noise source model, where the dominant tremor source should be at the Kīlauea summit. Because of the drastic change in the tremor source after the eruption, the cross-correlation of the tremor records may reflect predominantly changes in the source rather than in the medium properties between the two stations.

Plain Language Summary More and more studies are using seismic records to understand the volcano eruption process. A very recent study monitored the dyke intrusion near the Pu'u'ō'ō right after the start of the 2018 Kīlauea eruption, by observing increased seismic wave arrival times. However, after re-inspecting the data, we find their study understood the source location emitting the seismic waves wrong. Thus, their observed increased seismic wave arrival times can no longer be explained by the proposed dyke intrusion in the rift zone. We further suspect that the temporal variations of the seismic source contributed greatly to the arrival time variations.

1. Introduction

Ambient noise cross-correlation technique has been used to monitor underground medium changes, especially in the volcanic area (e.g., Brenguier et al., 2008). Recently, Liu et al. (2022) used the software of Yao et al. (2006) to calculate ambient noise cross-correlation functions (CCFs) and looked into the ballistic Rayleigh wave part of the CCFs for potential medium temporal variations with respect to the 2018 Kīlauea eruption. However, they made a simple mistake when interpreting the wave traveling directions as represented by the positive and negative time lags of the CCFs and thus interpreted the tremor source location incorrectly.

In the caption of Figure 2 in Liu et al. (2022), they wrote "Positive sides show the Rayleigh waves traveling from STCD to PAUD, whereas negative sides show waves from PAUD to STCD." Furthermore, in Section 2.2, Liu et al. (2022) wrote "The negative side of the CCF is dominated by oceanic noise (>3 s) traveling from PAUD to STCD, which was stable throughout the time before and after the eruption. The positive side was dominated by the tremor signal (1–2.5 s) traveling from STCD to PAUD (from Pu'u'O'o)." However, using all the available station pairs on the Island of Hawai'i, Wei and Shen (2022) found that the dominant direction of low-frequency (oceanic) noises was from the eastern part of the island, opposite of what was stated in Liu et al. (2022), and high-frequency local noises (tremors) are dominated by a source at the Kīlauea summit (Donaldson et al., 2017; Soubestre et al., 2021).

2. Discussions

In Figure 1a, we show that cross-correlation between station A and B is calculated in a way that the positive and negative lags represent the waves traveling from A to B and from B to A, respectively. This definition is the same as Equation 2 in Yao et al. (2006).

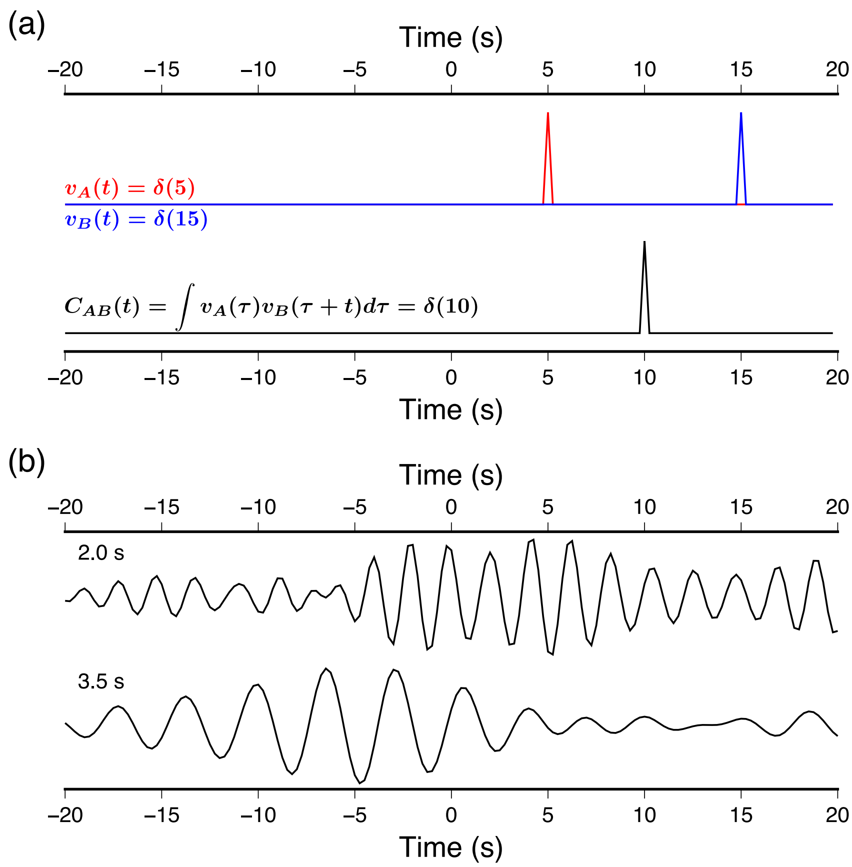

Figure 1. (a) Two Dirac delta functions and their cross-correlation function (CCF), as an example of our cross-correlation calculation. (b) The CCFs of station pair PAUD-STCD, on 11 April 2018, filtered around 2 and 3.5 s in the same way as Liu et al. (2022).

In Figure 1b, we show two CCFs that we calculated, for station pair PAUD-STCD, with a decimated sample rate of 4 Hz, on 11 April 2018 (Julian day 100), where PAUD is station A and STCD station B. The waveform has been filtered in the same way as in Liu et al. (2022), at two periods: 2 and 3.5 s. Because the CCF waveforms in early 2018 were quite coherent (Liu et al., 2022), only showing one-day's result is enough for our following discussions. Our CCFs are consistent with Liu et al. (2022), as both studies showed that, at the period of 3.5 s, the negative lag has a considerably larger amplitude than the positive lag. However, we identify the negative lag as representing waves traveling from STCD to PAUD (approximately east to west), on the contrary to Liu et al. (2022). Thus, we suggest that Liu et al. (2022) simply interpreted the wave traveling direction of the two CCF lags reversely and incorrectly.

Thus, the tremor signal arrival times on the positive lag should reflect waves traveling from PAUD to STCD and the tremor source should be located at the Kīlauea summit (Donaldson et al., 2017; Soubestre et al., 2021; Wei & Shen, 2022), not Pu‘u‘ō‘ō. As the Kīlauea summit is not located along the great circle path of the station pair PAUD-STCD, the arrival times of the tremor signals on the CCFs are not determined by the medium properties between the station pair, but by the geometry and medium properties between the summit and each station (Figure 2). The observed time delay of the tremor signals on the CCFs during the eruption could be explained by several other mechanisms not related to the medium property changes between PAUD and STCD as interpreted by Liu et al. (2022): (a) The change of the tremor sources during the eruption (Soubestre et al., 2021), (b) A velocity decrease between the summit and the station STCD, (c) A velocity increase between the summit and the station PAUD, or (d). The combinations of (a)–(c). Taking into account the great CCF waveform alterations since the eruption in the tremor frequency bands (Liu et al., 2022) and the very different tremor activities (both in location and mechanism) with respect to the eruption (Soubestre et al., 2021), we expect that the tremor source variations played a significant role in the arrival time difference. We argue that without a quantitative correction of

Geophysical Research Letters

10.1029/2022GL102596

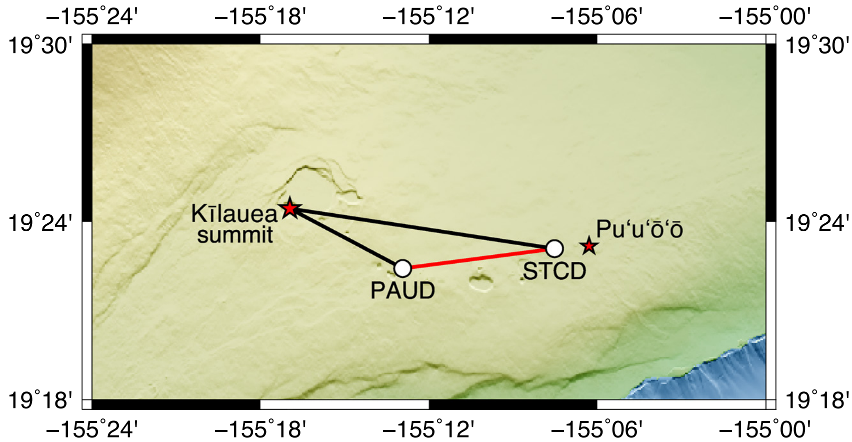

Figure 2. A map of the study region. The circles mark the seismic stations PAUD and STCD. The stars mark the tremor source located near the Kīlauea summit in Wei and Shen (2022) and the tremor source assumed at the Pu'u'ō'ō in Liu et al. (2022). The red line marks the assumed tremor Rayleigh wave raypath between the two stations in Liu et al. (2022), whereas the black lines mark the actual raypaths from the tremor source near the Kīlauea summit to the stations.

the effect of variations in the tremor source it is premature to attribute the arrival time differences to the medium velocity variations between the two stations. The synthetic tests performed in Section 2.4 of Liu et al. (2022) were not convincing, as it is not surprising that the surface wave arrival times are way less sensitive to the source depth than the source-receiver distance.

Moreover, for the observations at low-frequency (~0.2–0.3 Hz), Liu et al. (2022) did not consider the potential interference between the fundamental and the first higher mode Rayleigh waves on the Island of Hawai'i (Wei et al., 2023), which might further bring uncertainties to their estimated velocity variantions and dike intrusion depth.

3. Conclusions

By comparing the waveforms in Liu et al. (2022) and our calculation, we concluded that Liu et al. (2022) made a simple mistake on the wave traveling directions of the different CCF lags. Their study ignored the dominant tremor source near the Kīlauea summit before the eruption (Donaldson et al., 2017; Soubestre et al., 2021; Wei & Shen, 2022) and the effect of its drastic change on the CCFs during the eruption. This caused an incorrect interpretation of the data and their conclusions were no longer supported.

Data Availability Statement

All the seismic data of this study are publicly available from IRIS, under the network code HV (https://doi.org/10.7914/SN/HV).

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References

Brenguier, F., Shapiro, N. M., Campillo, M., Ferrazzini, V., Duputel, Z., Coutant, O., & Nercessian, A. (2008). Towards forecasting volcanic eruptions using seismic noise. *Nature Geoscience*, *1*(2), 126–130. https://doi.org/10.1038/ngeo104

Donaldson, C., Caudron, C., Green, R. G., Thelen, W. A., & White, R. S. (2017). Relative seismic velocity variations correlate with deformation at Kīlauea volcano. *Science Advances*, *3*(6), e1700219. https://doi.org/10.1126/sciadv.1700219

Liu, Z., Liang, C., Huang, H., Wang, C., & Cao, F. (2022). Seismic velocity variations at different depths reveal the dynamic evolution associated with the 2018 Kilauea eruption. *Geophysical Research Letters*, *49*(3), e2021GL093691. https://doi.org/10.1029/2021GL093691

Soubestre, J., Chouet, B., & Dawson, P. (2021). Sources of volcanic tremor associated with the summit caldera collapse during the 2018 east rift eruption of Kīlauea volcano, Hawai'i. *Journal of Geophysical Research: Solid Earth*, *126*(6), e2020JB021572. https://doi.org/10.1029/2020jb021572

Wei, X., & Shen, Y. (2022). P waves emerged from ambient noise cross-correlation post the 2018 Kīlauea eruption revealing middle crust velocity discontinuities beneath the Island of Hawai'i. *Geophysical Research Letters*, *49*(16), e2022GL098470. https://doi.org/10.1029/2022GL098470

Wei, X., Shen, Y., & Morgan, J. K. (2023). Shallow volcano-tectonic structures on the Island of Hawai'i imaged by multimode Rayleigh wave ambient noise tomography. *Journal of Geophysical Research: Solid Earth*, *128*(5), e2022JB026244. https://doi.org/10.1029/2022jb026244

Yao, H., van Der Hilst, R. D., & De Hoop, M. V. (2006). Surface-wave array tomography in SE Tibet from ambient seismic noise and two-station analysis – I. phase velocity maps. *Geophysical Journal International*, *166*(2), 732–744. https://doi.org/10.1111/j.1365-246x.2006.03028.x