Does f_0 from noise match f_0 from ground motions?

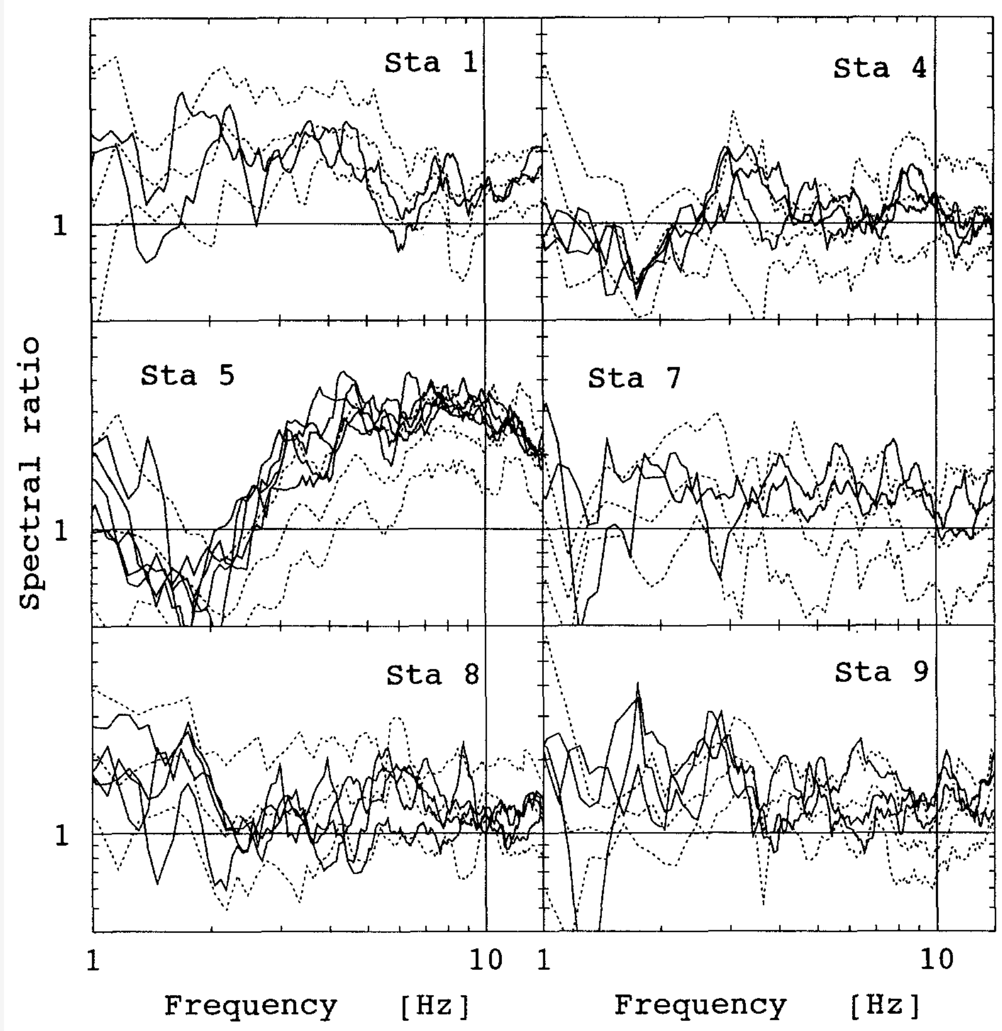
Dongyoup Kwak

Yes vs. No

- ✓ Yes
  - Chávez-García et al (1996) (6 sites)
  - Mucciarelli et al (2003) (1 site)
  - Rodríguez and Midorikawa (2003) (9 sites)
  - Haghshenas et al (2008) (104 sites)
  - Moya et al (2000) (7 sites)
  - Senna et al (2008)
- ✓ No
  - Satoh et al (2001) (20 sites)

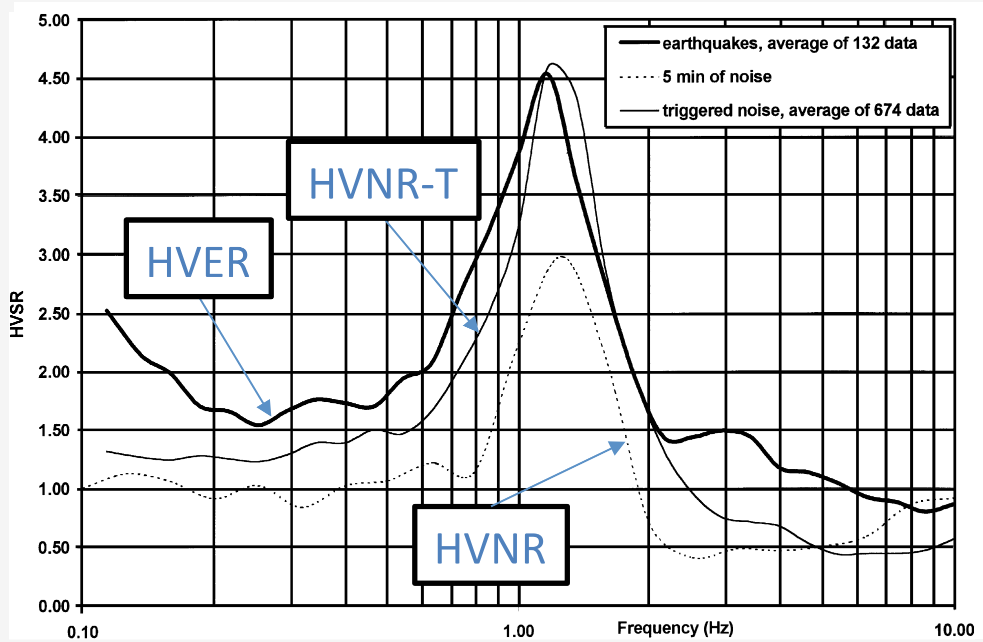
YES: CHÁVEZ-GARCÍA ET AL (1996)

- Region & site conditions
  - Northern Greece
  - 6 stations on a hill
- Data
  - HVER: 68 earthquakes (10 sec window around the largest amp)
  - HVNR: pre-event signal (5 sec)
- Interpretation
  - Reasonably match each other



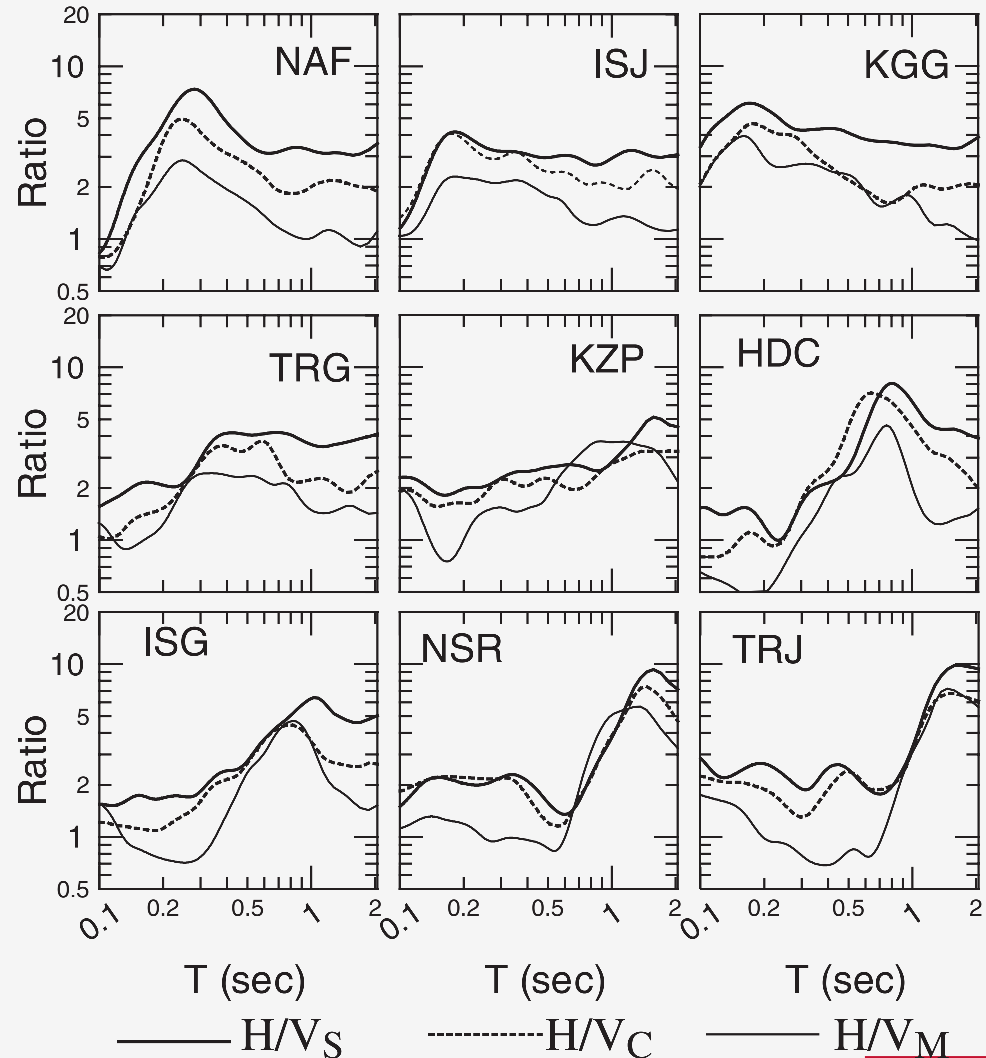
Yes: Mucciarelli et al (2003)

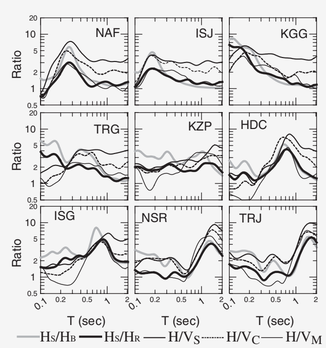
- Region & site conditions
  - Southern Italy
  - 1 stations on lacustrine valley
  - Noisy industrial area
- Data
  - HVER: 132 earthquakes (full length)
  - HVNR-T: 674 noise records (big enough to trigger seismometer)
  - HVNR: Use five of 1 min samples
- Interpretation
  - Good match btw HVER and HVNR-T
  - Good match btw HVER and HVNR for f_0, but not for amp.



YES: RODRÍGUEZ AND MIDORIKAWA (2003)

- Region & site conditions
  - Yokohama (near Tokyo), Japan
  - 9 vertical arrays on varying geology (fill to soft rock)
- Data
  - HVER: 15 earthquakes (S-wave; 20 sec window)
  - HVNR: 15 noise samples (20.48 sec window)
- Interpretation
  - The f_0 coincide at all sites
  - HVNR is the best match to H/H with reference site approach



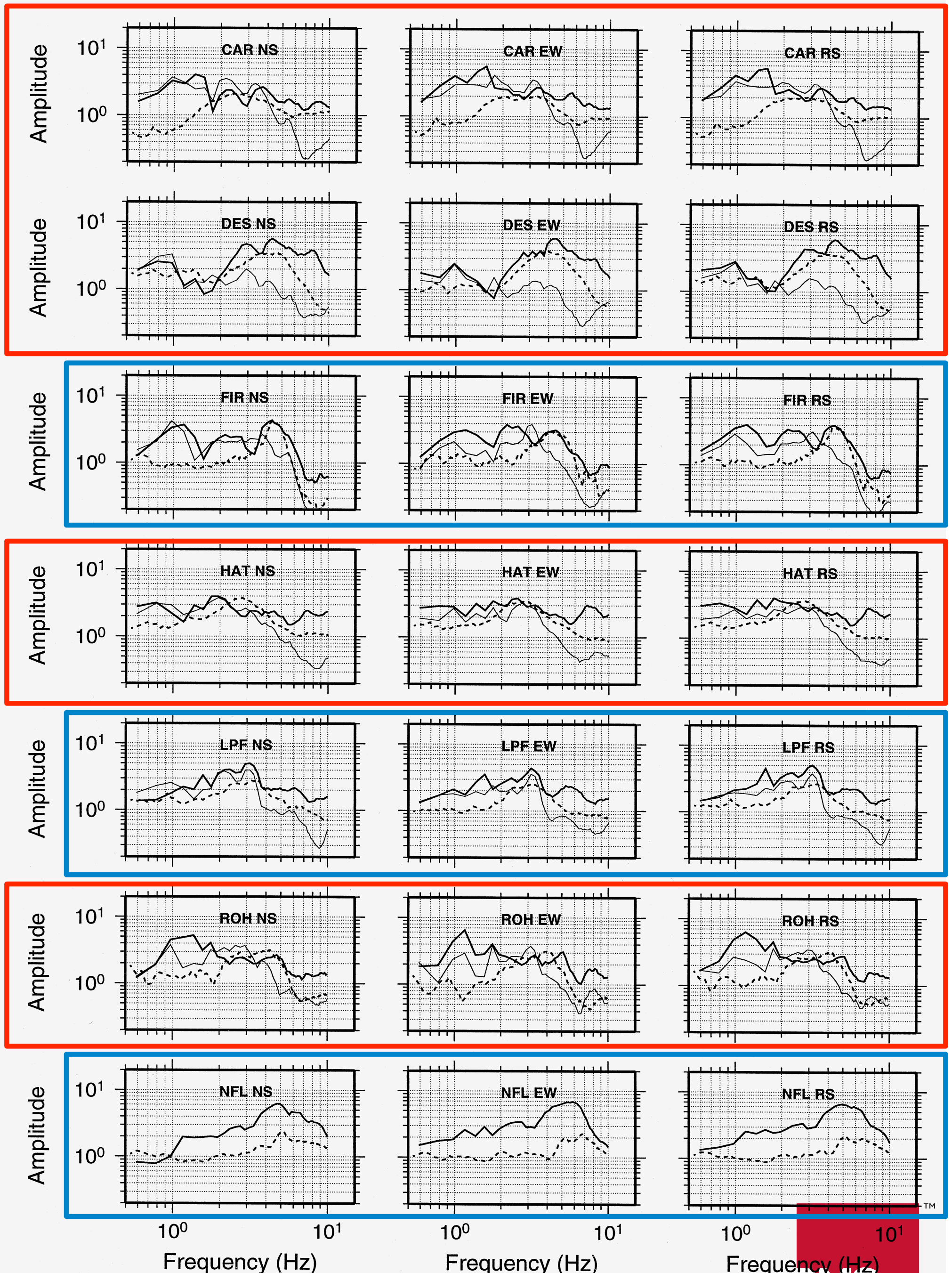


YES: HAGHSHENAS ET AL (2008)

- Region & site conditions
  - Europe, Caribbean, Tehran
  - 104 sites
- Data
  - HVER: Earthquakes
  - HVNR: Microtremor, or extracted from pre- or post-event noise
- Interpretation
  - Very good agreement btw f_0 of HVER and f_0 of HVNR (81% of sites)
  - Disagreement at thick, low frequency, continental sites (low noise level; no clear peak from HVNR)

YES(?): MOYA ET AL (2000)

- Region & site conditions
  - San Jose, Costa Rica
  - 7 sites (6 on soft soil, 1 on rock)
  - Metropolitan area
- Data
  - HVER (thick solid): 68 earthquakes (S-wave; 4 sec window)
  - HVNR (dotted): pre-event signal (15 sec)
- Interpretation
  - Bad match for 4 sites
  - Good match for 3 sites



RMS™

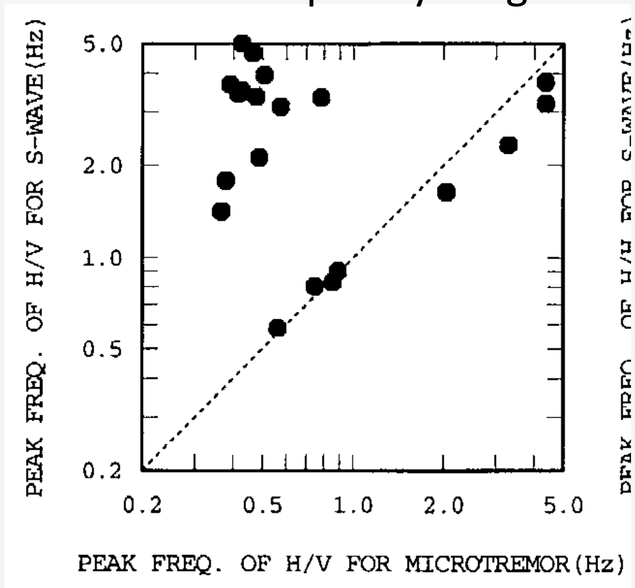
NO(?): SATOH ET AL (2001)

- Region & site conditions
  - Sendai basin, Japan
  - 20 sites (soft soil to rock)
- Data
  - HVER: 43 earthquakes (S-wave; 10 sec window)
  - HVNR: 15 min sampling (40.96 sec window)
- Interpretation
  - No correlation at full frequency range (0.2 – 5 Hz)
  - Good match if consider frequency less than 1 Hz

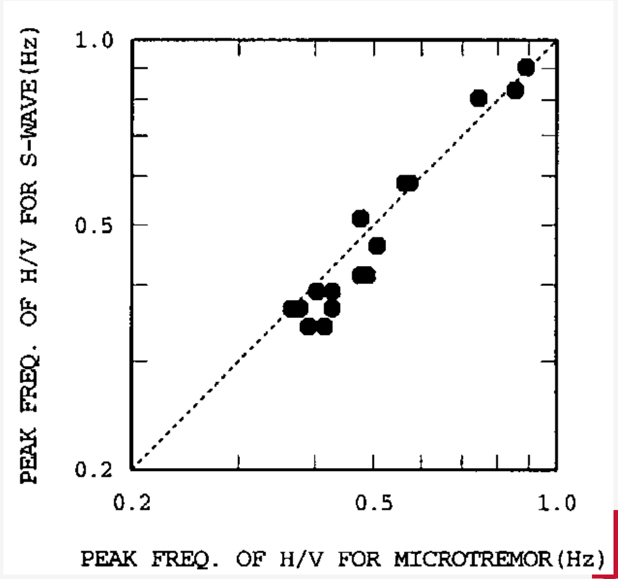
❖ *If there is a peak at high frequency from HVNR, its f_0 corresponds to the f_0 of HVER.*

❖ *The f_0 of HVNR peaks at low frequency match with f_0 of HVER peaks even though the HVER peaks are not the highest.*

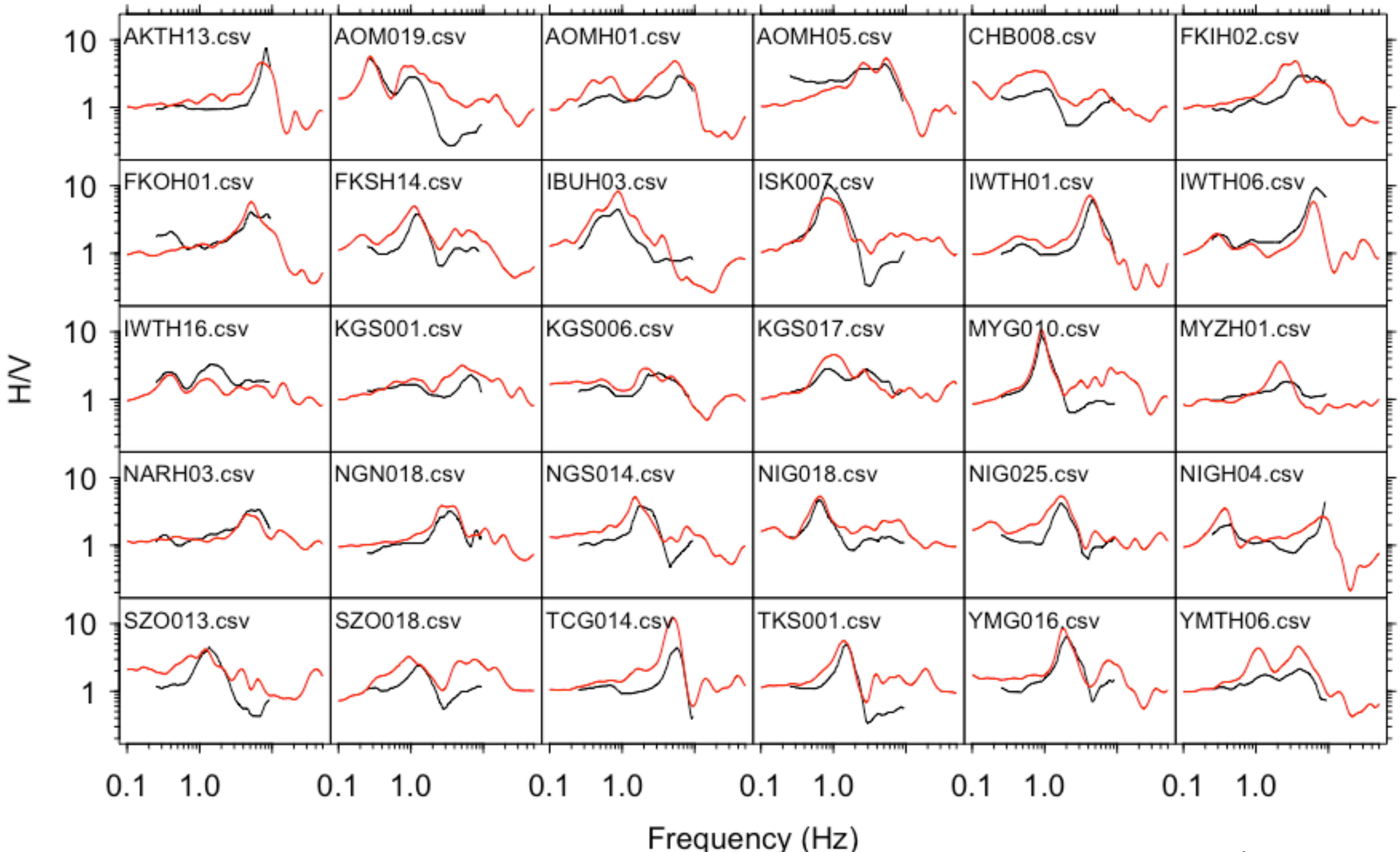
Full frequency range



Frequency range < 1 Hz and Amp > 3

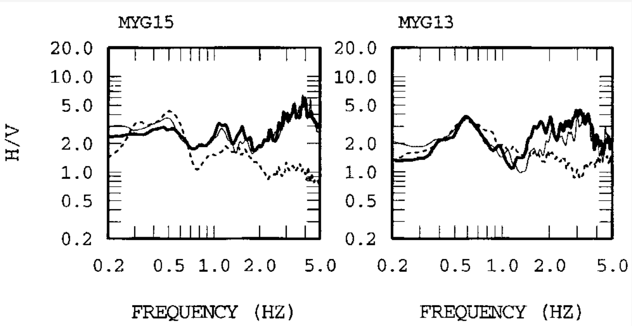


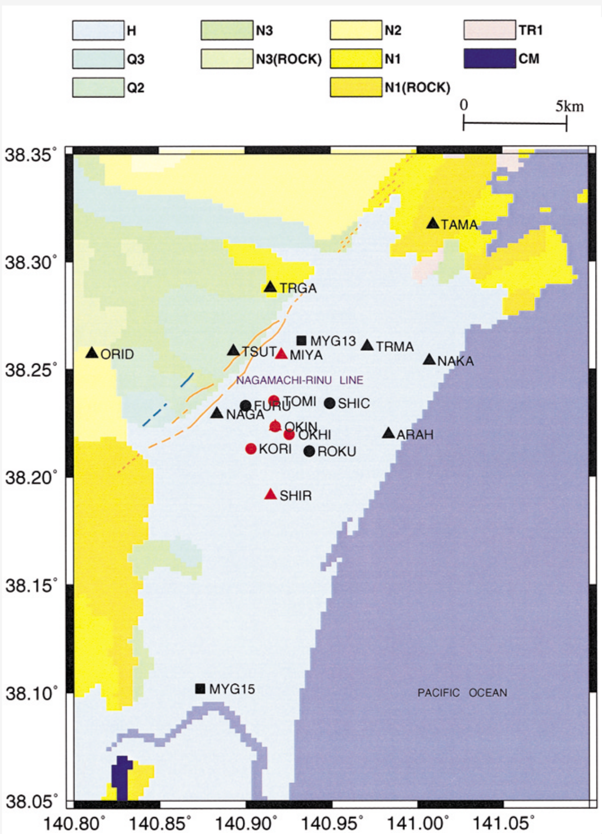
Yes: Senna et al (2008)

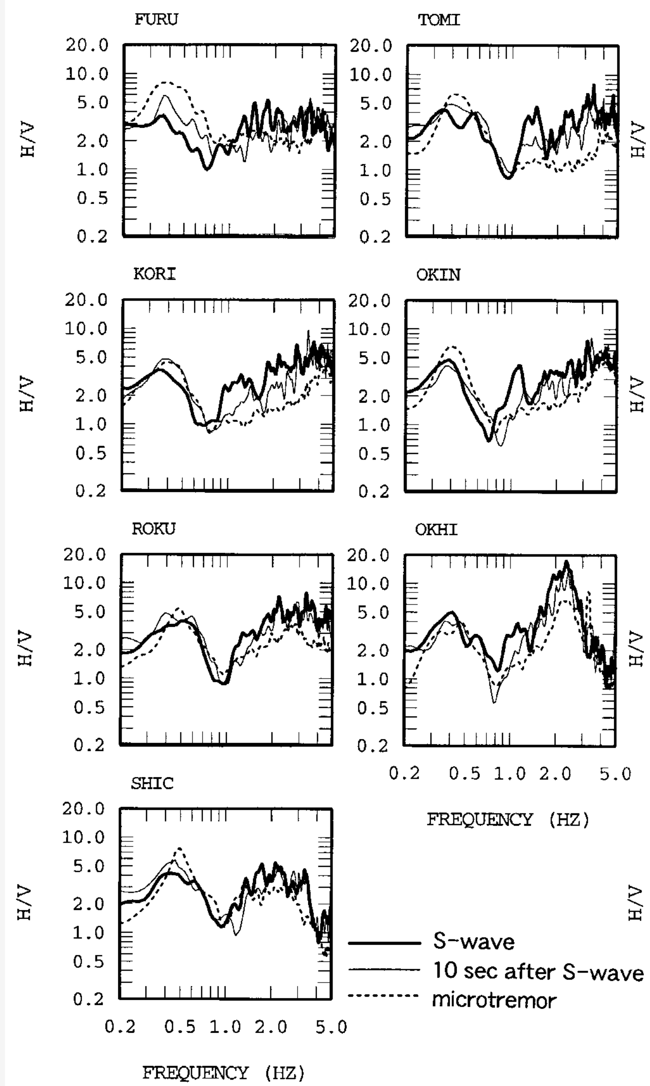


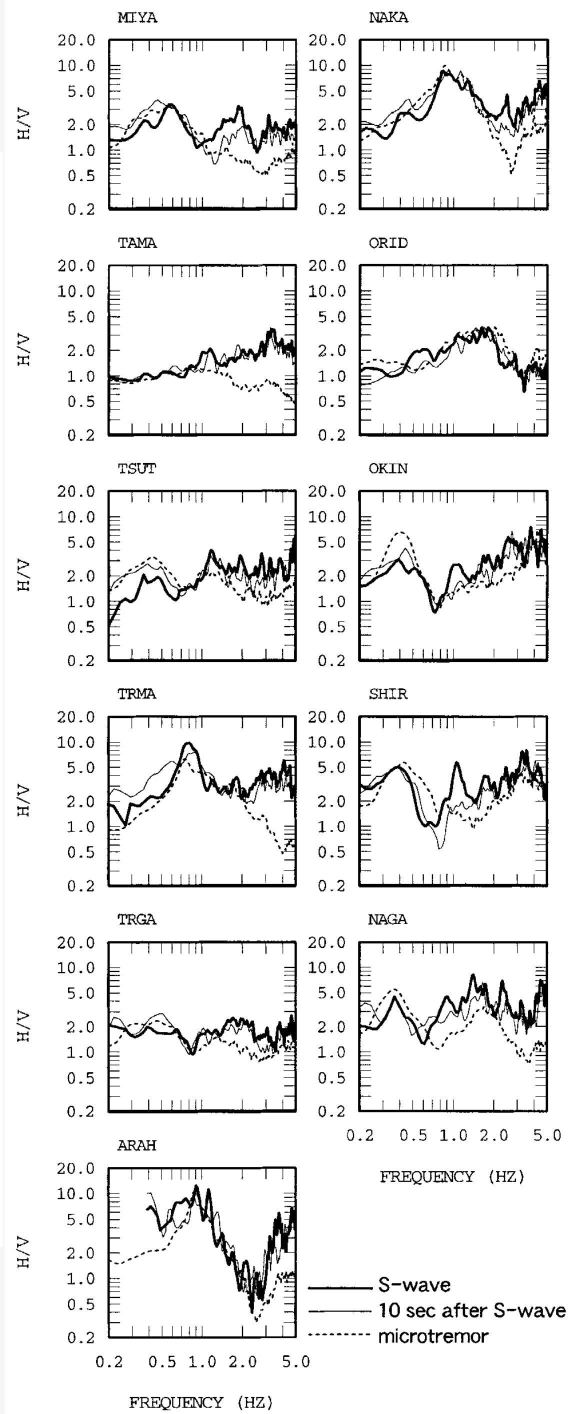
Red: HVER
Black: HVNR

No(?): Satoh et al (2001)









Summary

- Agreement:
  - HVNR from ambient vibrations big enough to trigger a seismometer has good correlation with HVER (Mucciarelli et al 2003).
  - Good correlation of f_0 between HVER and HVNR across continents (Europe, Central America, Japan)
  - Good correlation between HVNR-based site amplification and non-referenced site amplification for 2007 Niigata earthquake (Senna et al., 2008)

- Disagreement:
  - At thick, low frequency, and continental sites, HVNR does not show clear peak whereas there is a peak from HVER (Haghshenas et al., 2008).
  - HVNR does not show peak at high frequency whereas there is the highest peak from HVER (Satoh et al. 2001).
  - No correlation between HVNR-based site amplification and recorded strong motion amplitude or damage for 1994 Northridge earthquake (Trifunac and Todorovska, 2000)

➢ Based on literature data: if there are HVNR peaks, those peaks correspond to HVER peaks.

➢ HVNR matches better to site amplification ($H_{surface}/H_{rock\text{-}outcrop}$) than HVER (Rodríguez and Midorikawa , 2003).

References

- Chávez-García, F. J., L. R. Sánchez, and D. Hatzfeld (1996). Topographic site effects and HVSR. A comparison between observations and theory, *Bull. Seism. Soc. Am.*, **86**, 1559-1573.
- Haghshenas, E., P.-Y. Bard, N. Theodoulidis et al. (2008). Empirical evaluation of microtremor H/V spectral ratio, *Bull. Eqk. Eng.*, **6**, 75-108.
- Moya, A., V. Schmidt, C. Segura, I. Boschini, and K. Atakan (2000). Empirical evaluation of site effects in the metropolitan area of San José, Costa Rica, *Soil Dyn. Earthq. Eng.* **20**, 177–185.
- Mucciarelli, M., M. R. Gallipoli, and M. Arcieri (2003). The stability of the horizontal-to-vertical spectral ratio of triggered noise and earthquake recordings, *Bull. Seismol. Soc. Am.* **93**, 1407–1412.
- Rodríguez, V. H. S. and S. Midorikawa (2003). Comparison of spectral ratio techniques for estimation of site effects using microtremor data and earthquake motions recorded at the surface and in boreholes, *Eqk. Eng. Str. Dyn.*, **32**, 1691-1714.
- Satoh, T., H. Kawase, and S. Matsushima (2001). Differences between site characteristics obtained from microtremors, S-waves, P-waves, and codas, *Bull. Seismol. Soc. Am.* **91**, 313–334.
- Senna, S., S. Midorikawa, and K. Wakamatsu (2008). Estimation of spectral amplification of ground using H/V spectral ratio of microtremors and geomorphological land classification, *J. Jpn. Assoc. Earthq. Eng.* **8**, 1-15.
- Trifunac, M. D. and M. I. Todorovska (2000). Long period microtremors, microseisms and earthquake damage: Northridge, CA, earthquake of 17 January 1994. *Soil Dyn. Eqk. Eng.*, **19**, 253-267.

RMS™