

July 17, 2020

Reviewer comments to the manuscript:

Title: Using Horizontal to Vertical Spectral Ratios to construct shear-wave velocity profiles

Author(s): Janneke van Ginkel et al.

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MS Type: Research article

General comments

Dear Author(s),

I received your manuscript with the credentials above. First, The author(s) clearly present a methodology to compute HVAN from large data. Second, the author(s) estimate a frequency-depth relationship for deep sedimentary basins. Third, the author(s) touches upon the complex issue with the nature of the noise wavefield and the wave type contributing to the H/V spectral ratio (Earthquake or noise). With these points, I strongly believe that this manuscript is of interest to the seismological/Geophysical community and deserve further consideration for publication by the EGU-SE journal.

For the manuscript, I do have a number of comments. My comments below are mostly technical (formulations, formatting). I recommend minor revision.

Specific comments

Velocity Profiles from teleseismic phases

- P10Figure5. change the presentation of Figure 5. (a) for example should contain H/V (+average) results from each teleseismic event for the seismometer at the surface only; (b) at 50m, Add (f) for the average at each seismometer.
- P11Figure6. I think that you should edit (a) and (b) so that they have the same background topography. The main difference should be on the approach used to estimate Vs. Eventually indicate the location of outlier stations G45 and G52

Technical corrections

Abstract

- P(age)1L(ine)1: *For hazard assessment ... => For SEISMIC hazard assessment ...*

- P1L8-12: *The H/V ratios of the ambient ... Rayleigh wave ellipticity*. The sentence does not fit here. Move the sentence after P1L12-13 ... *we invert the H/V ratios for velocity profiles*. or at the end of P1L15.

Introduction

- P2L24-25: has a strong effect => has strong effects
- P2L27: Remove reference: (Fig.2)
- P2L28: The following sentence is not clear: " ... including the effect of the sedimentary cover on wave propagation". Better: " ... including the *local site effects assessment* of the sedimentary cover on wave propagation?"
- P2L29: This study => The current study
- P2L30: for each borehole => at each borehole
- P2L31: and sediment depth => and the overall sediment thickness
- P2L34: ambient noise field or microtremors => ambient noise field (microtremors)
- P2L39-40: The H/V method is based on the assumption that when a strong ... => When a strong ...
- P2L46-47: ... from the recorded data before we make the H/V division. => ... from each component of the recorded data before we estimate the H/Vs.
- P2L51: and are used as a tool for estimating shear-wave velocities => and are analysed for estimating shear-wave velocities
- P2L53: the computed H/V => the estimated H/V
- P3L64: all borehole seismic stations. Optionally specify the number (N) of boreholes so that the sentence read as: all N borehole seismic stations
- P3L69-70: our model with => our estimated model with

Geological setting

- P3L71: and recent hazard models => and recent seismic hazard models
- P4Figure1 Caption: ... in orange/yellow . No space before the "dot".

Existing velocity models

- P4L90: ... the velocity model model... . Remove one occurrence of "model"
- P4L91: pressure => compressional. (There are more occurrences, please check)
- P4L94: Pressure See previous comment
- P4L100: 0m to 200m => 0 to 200m

- P5L103-4: Although several high quality shear-wave velocity profiles across different scales became available over the last years, in situ velocity measurements for each seismic station in the Groningen network are missing and form the objective of our work. => Please reformulate. (For example) In summ, several high-resolution shear-wave velocity profiles across different scales became available over the last years for the Groningen area. Our findings complement available information.(?)

Data set

- P5L123: For calibration purposes we use => For calibration purposes, we use
- P5Table1: add two columns one with approximate epicentral distance to a reference station and the second the azimuth
- P6Figure2 Caption: 50 depth interval => 50m depth interval

Velocity Profiles from teleseismic phases

- P6L126: With their arrivals, body waves ... => Incoming body waves ...
- P6L127 resulting in both vertical and horizontal motions. => resulting in amplification of both vertical and horizontal seismic motions.
- P6L128. Teleseismic S-phases are transmitted into the NSG with angles smaller than 5 degrees with vertical. => We assume that telseismic ... or add a reference at the end of your statement.
- P6L130: ... is trapped. => ... is trapped and reverberated to cause site amplification.
- P6L130: The interference of multiple reverberations within the soft layer leads to a resonance pattern in which certain frequencies are amplified and others interfere destructively. Please add a reference or leave the statement out, unless you have investigated it yourself. Consider also the previous comment if the two sentences can be merged or not.
- P7Figure3. Please indicate on the figure your direct S phase and the coda window (and the subsequent weaker shear-wave phases). Caption ... (seismometer G300, epicentral distance ???? km). ... (seismometer HGN, epicentral distance ???? km)
- P7L144: (FAS) (e.g. in Bard (2002) => (FAS; e.g. Bard, 2002)
- P7L145: Here we present how we calculate H/V curves from power spectrum densities (PSDs) => Here we estimate H/V curves from power spectrum densities (PSDs)
- P7L145: Computation of a PSD starts with computing a FAS => We obtain the PSD by first estimating the FAS that we use in Equation (?)
- P7L151: which normalization makes the spectrum => which makes the spectrum?
- P8L173: The amplitude of $f_0 = 0.18$ Hz, => The (H/V?) amplitude AT $f_0 = 0.18$ Hz
- P9Figure4, y-axis: (H/V?) amplitude
- P9L179: arrivals (Table 1) and Fig. 5 shows => arrivals (Table 1). Fig. 5 shows

- P11L196: bed rock => bedrock
- P11L201-202: After all, for 63 stations shear-wave velocities are calculated. => After all, shear-wave velocities are calculated at 63 stations.
- P13L219: Some areas might do have constraints from a few deep wells, => some area have depth constraint from few deep wells in the area, but ...
- P13L221-222: For these regions outside Groningen, one... resonance frequency f_0 in the form => Please reformulate. (For example) Alternatively to using Equation 4 together with an average NSG shear-wave velocity as found in the previous section for the sediment thickness of NSG, we first use the large data set available for the Groningen area to establish a frequency-depth relationship. The newly established relationship is then used to estimate the sediment thickness for NSG where the geology is the same.(?). If not the relationship doesn't hold.
- P13L224-225: Comparing Eqs. 4 and 6 one can see that if the lossless single-resonating wave assumption is taken (Eq. 4) the factor a and b in Eq. 6 correspond to $V_s/4$ and => (Please reformulate) In the particular case of a lossless single-resonating wave assumption, the factor a and b in Eq. 6 correspond to $V_s/4$ and (see Equation 4).
- P13L229: In comparison, => For comparison,

Probability density functions of ambient noise H/V spectral ratio

Different terminology for the H/V for body wave, surface waves, ellipticity

- P14L235-236: Remove the sentence: "In the previous section, we presented site specific shear-wave velocities based on the fundamental resonance frequency from teleseismic phases."
- P14L237: we calculate or calculated?. Chose one form for the whole sentence.
- P14L236-237: Therefore in this section... in Section 5. Please reformulate. (for example; In this section, we estimate the H/V spectral ratios using ambient noise wavefield. The obtained results are compared with modelled H/V spectral ratio. For the H/V modelling, we use the algorithm based ??? (body waves? Surface waves?) and the velocity profiles derived in Section 5 as input models.
- P15L249: Figure 10 shows examples (... PDF HVAN for station ???). The sentence reads incomplete.
- P15Figure: Please add an inset or header on each subfigure to indicate the recording length. The Figures could also fit in a single column.
- P15L253: Generally, H/V calculations => Generally, H/V estimations (Nota: Calculation and modelling vs estimation from data!)
- P16Figure11: ... and the secondary peak (around 0.45Hz) reflects the higher mode for Rayleigh waves. => ... and the secondary peak (around 0.45Hz) reflects the higher mode for Rayleigh waves or the presence of a second strong impedance contrast.

- P17L278: were => where
- P18L311: either the vertical or horizontal component vanishes => the energy on the vertical component vanishes.
- P18L313: In reality, => in practice?
- P18L313: rarely, pure => never, purely
- P19L324-325: ellipticity ratio H/V of the fundamental mode => ellipticity of the fundamental mode
- P19L326: corresponding to the vanishing of the horizontal component. => corresponding to changes in particle motion.
- P19Figure13. RayDec and HVAN seems not to be on the same scale. Please check your settings in geopsy, processing window, and use "square average" for the calculation

Discussion

- Please discuss the H/V data integration through PDF HVAN
- There is a clear correlation around 0m/s. Many stations have delta Vs of -150 m/s. Any comment? or consider these stations as outlier?
- the established frequency-depth relationship for deep structures