

## ***Interactive comment on “Event couple spectral ratio Q method for earthquake clusters: application to North-West Bohemia” by Marius Kriegerowski et al.***

### **Anonymous Referee #1**

Received and published: 27 October 2018

Dear authors,

This paper demonstrates a new method to estimate attenuation (Q) using earthquakes. The authors exploit the dense hypocenter distribution of earthquake swarms in order to extract seismic wave attenuation at only a part of raypath at depth, which can achieve high resolution results. The authors demonstrate this approach using numerical modeling tests, and then apply it to field earthquake records at North-West Bohemia. The authors found that their results are very scattered, including the large number of negative Q values. They analyzed these results based on the location of events, and then found the correlation of negative Q values with the event location.

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Estimation of the attenuation factor at high resolution is very important topic in applied seismology, and using seismic swarms to estimate local attenuation seems promising approach. The authors demonstrated the feasibility of the approach using well thought numerical modeling tests. Although the field application resulted in very scattered values in Q values, the authors discussed its reason considering several scenarios e.g., wave scattering and rupture dynamics. The authors' findings on the systematic changes of frequency contents depending on the event location would be interesting for various research groups, not limited to attenuation measurements.

Overall, the paper is reasonably well written. The processing techniques, figures and discussion are clear, and almost all conclusions are supported, although several discussions and explanations need to be more clarified. I have several comments, in order to further clarify technical details and the authors' claims. Please look at my comment below for more details.

Best regards.

Comments:

-Section 3 Synthetic study

1. Page 5, Line 23-25, “The size of blue points in Figure 3 represents relative number of pairs based on ray tracing through a 1D layered model”: What the blue dots in Figure 3 indicate is not clear. Earthquake swarms are indicated by red dots. Please elaborate more on the definition of “event couples” in this figure.
2. Page 8, Line 7-8, “S phase results match the model at NKC but show strong scattering at LBC”. Can you elaborate why this is the case?
3. Source time function is half sine shaped but the width depends on the magnitude, which seems realistic. Can you comment on how this source time function is representative in this field?
4. Velocity model is 1D (see Fig 4), and high frequency component that is used is

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around 80 Hz (see Fig.9c). The short wavelength component is around 60 m assuming  $V_p=5000\text{m/s}$  in this case. In 1D velocity model used in the test does not include any spatial heterogeneity in the order of this short wavelength. Can you comment on to what extent we can ignore effects of spatial heterogeneity that is sensitive to the high frequency components in the data? I found that the authors discussed the effect of wave scattering in section 4 and 5. It would be good to mention here that these effects will be discussed later.

-Section 4 Application to North West Bohemia

5. Figure 9: I did not find sentences explaining Fig. 9 in the main text.

6. Page 11, lines 10-11, "It becomes evident that larger incidence angles ( $> 8$  degrees) show a tendency to produce negative  $Q^{-1}$  while results from events with steep incidence angles produce positive  $Q^{-1}$  values." : Please mention that this refers to Figure 12(b), otherwise it does not make sense.

-Section 5 Interpretation and Discussion

7. Page 13, Lines 21-22, "Mousavi et al. (2017) assume a highly fractured medium in combination with accumulated free gas or fluids. Our findings support this hypothesis." : I did not see the clear relation between the authors results and this hypothesis. Please elaborate more.

Other minor comments:

-Page 5, Line 9 and 10: "(Dt, red dashed line, Fig 1)"-> (Dt, green dashed line, Fig 1), "(Dp, green dashed line, Fig 1)"-> (Dp, red dashed line, Fig 1)

-Page 8, Line 3, "Data windows without seismic events in the recorded data have been manually extracted. . .": I understand that the authors meant field recorded data by "the recorded data" in this sentence. I suggest explicitly mentioning so since it is confusing as to be synthetic data.

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-Page 10, Line 10, "as Figure 11 (right) indicates" -> as Figure 11 (left) indicates?

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Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2018-87>, 2018.

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