Dear Editor,

Please consider my comments to the manuscript entitled

Structure of Suasselka Postglacial Fault in northern Finland
obtained by analysis of local events and ambient seismic noise

by Afonin et al. (doi 10.5194/se-2016-90).

The authors analyse data from a temporary network consisting of 12 stations deployed in the vicinity of the Suasselka post-glacial fault to study the fault inner structure. Many analysis tools are used, which support a complementary approach to fault zone characterization. However, I feel that parts of the analysis and parts of the presentation and discussion can be improved. The manuscript should be suitable for publication in *Solid Earth Discussions* after some moderate to major revision.

I waive my anonymity,

Gregor Hillers

General comments:

The authors discuss aspects of low-velocity damage zones and some resulting implications for faulting. However, in the introduction, they refer only to damage zones in strike-slip faulting environments. These damage zones are persistent features of mature strike-slip fault zones. They evolve over geologic times; their width and the velocity reduction depends roughly on the cumulative fault offset. In addition to this persistent structure, the degree of the velocity reduction, being a proxy for the material's degree of granularity, varies on time scales associated with the seismic cycle. How does this concept relate to the context of post-glacial faults discussed here? What is the cumulative offset of such faults in general and of the Suasselka fault in particular? What is the sense of motion? Under these circumstances, is the signature of a distinct low-velocity zone expected to be resolved?

Considering the earthquake analysis, the database of (downdip) earthquakes observed with the network could be further considered for reconstruction of observables that can be used to infer fault structure. (The authors claim that 2-15 km deep seismicity indicates that the fault is still active (line 14 page 5). Does the fault reach 15 km deep?) Fault zone head or trapped waves can provide important, high-resolution information on material contrasts along and within fault zones. Distinguishing events that do or do not excite head or trapped waves indicate dis-/continuous structural elements.

Considering the noise analysis, the authors group cross-fault correlation pairs (termed Group 1) and pairs of stations located on either side of the fault (Group 2). (How are pairs including the 6 stations (50% of the stations) located on top of the mapped fault (Fig. 1) classified?) This approach may certainly be motivated by the relatively sparse station spacing. However, it also reflects the first-order concept of a low-velocity zone sandwiched betweent two competent blocks. I think the authors must discuss the application of this model better.

Then, the width of the inferred low-velocity region from group-1 results is simply estimated to correspond to the smaller wavelength in the considered frequency band, 1.5 km. This is quite a large value for a fault characterized by a small cumulative offset (the authors may compare this to values obtained from the normal fault hosting the L'Aquila earthquake—or any other well-studied fault exhibiting similar characteristics, but not strike slip faults in California). What prevents the authors from regionalizing the results as in doi:10.1007/s00024-014-0872-1? First, dispersion curves can be obtained from each pair. This yields, second, 2-D lateral group velocity maps on a grid, which can, third, be inverted for local shear wave profiles.

I think the figures can very much be improved. Is the data from the “areomagnetic” map used as a background synonymous with topography? If not, why is (areo)magnetic data used in the background? Figures 1-3 can be merged into two figures, perhaps even into just one. Please provide a large-scale inset that shows the target region, say, in relation to Scandinavia or Finland. The red “lines” under the DAFNE network in Figure 1 appear as rectangle, boxes. Show the seismicity in Figure 3 in relation to the mapped Suasselka fault. Consider an inset that shows the depth distribution of the seismicity (with error bars).

Figure 4: Why not use white for zero amplitude.The figures all look the same; that is what the authors point out in the text, but I wonder whether elimination of redundant data wouldn't be a better strategy for visualization here. I find the colorrange not exhausted in Figure 5.

Specific comments:

page 1, lines 11, 17: I doubt whether the network with station spacings on the order of 10 km allows probing of the “inner structure” of the fault, except, as said, if high-resolution approaches based on fault zone trapped and head waves are considered.

p 1, l 28: More than one rupture is needed to create a low-velocity zone (see above).

P 2, l 15: Consider references to earthquake and noise tomographies in fault zone environments by A. A. Allam et al. and D. Zigone et al.

p 3, l 32: If the sensors were repeatedly visited, why did problems with cables persist?

Consider a homogeneous, standard date format.

P 5, l 26: “distortion” of EGF: In the present context, “decrease in signal-to-noise” ratio would perhaps be better.

p. 7, l 5-8: Is there an inversion performed to conclude the 5 m top-layer-thickness? Could the authors briefly comment on the main ingredients?

p. 7, l 10 ff: Is the symmetry larger 15 km/ asymmetry smaller 15 km a persistent feature of all correlations? Or is it somehow related to just station DF01?

P 7, l 15 ff: Overlapping of pulses at short wavelength is not indicative or related to asymmetry. In general, I find the discussion as to why EGFs are asymmetric at distances smaller than 15 km confusing. How are the envelopes constructed and group velocities estimated? On each lag-side individually? Or are negative and positive lag EGFs stacked?

P 8, l 3: Can error bars be added to Fig 10? They are also given in Fig. 11.

p 9, l 16: I find it too vague and not supported by robust observations to talk about “inside the fault area”, if this refers to the low-velocity region that is imaged by the adhoc 2-group approach (see above).