COGEAR

MODULE 3:

Comparison between measurement techniques at sites investigated by AUG and SED

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Comparison between measurement techniques at sites investigated by AUG and SED

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1. Introduction

An experiment was setup to compare surface wave dispersion curves retrieved by means of passive and active methods. The passive measurements are based on the analysis of the ambient noise wavefield, contrary to active measurements based on the controlled excitation of the seismic wavefield. The detailed description of the methods, experiments and results for both passive and active surveys can be found in the published COGEAR deliverables 3.1.2 and 3.1.1 respectively. The goal of this report is to present and discuss the comparison of the final results.

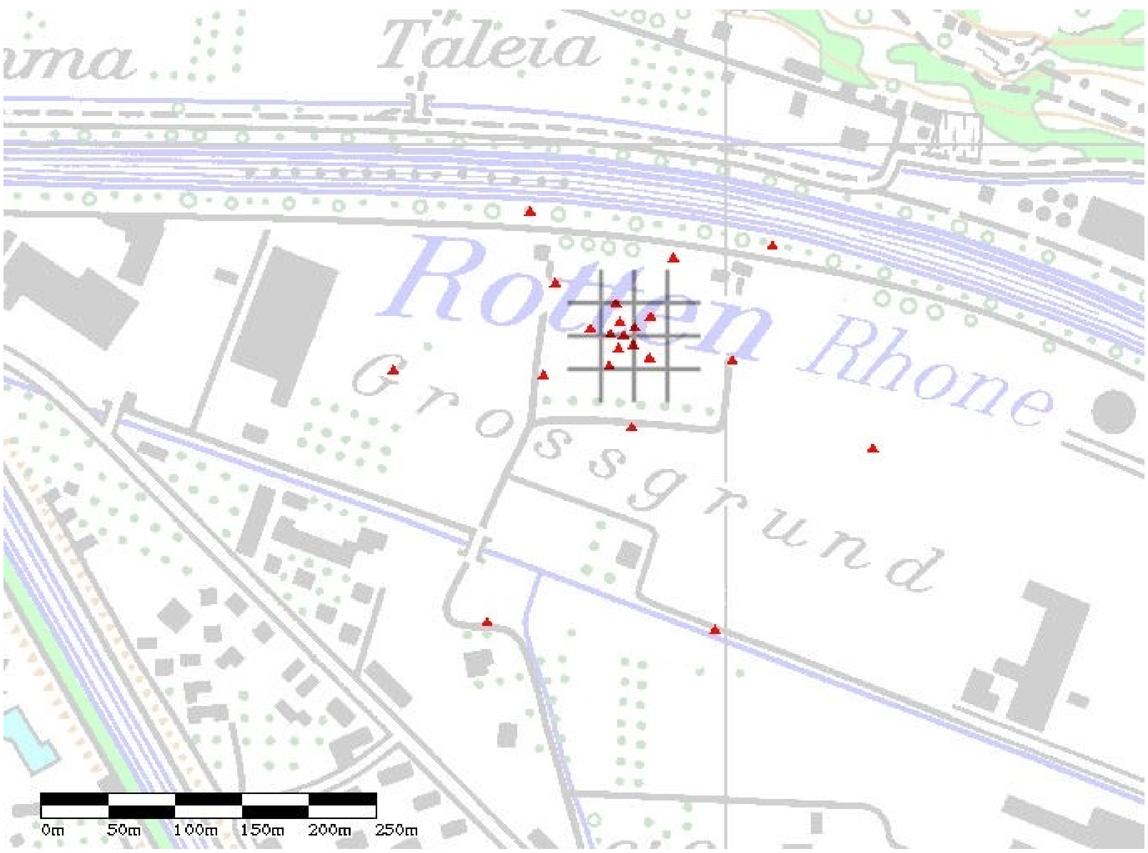

Figure 1: Station geometry, red triangles denote position of the sensors setup up for the ambient noise measurement. A grid of geophones (6 profiles in total) utilized for the active survey is figured by gray lines.

Let us shortly describe the background of the experiment. The datasets were collected in the field next to the bank of the Rhone river close to the city of Visp

(Figure 1, site AVIS2 – see deliverable 3.1.2). A semi-permanent station (VIS2) was deployed at this site during winters 2007/2008 and 2008/2009 (see the COGEAR deliverable 3a.1.1.1). Moreover, a new semi-permanent strong motion station has been operating at the same site since the beginning of 2010. Generally, the site can be descried as a mountain valley plain comprising fluvial, lacustrine and moraine deposits.

The ambient noise measurements were conducted with three-component velocity sensors (Lennartz, LE3D-5s) and the active survey was performed with 48 three-component geophones (4.5 Hz). The sledge hammer method was used to generate seismic waves in the active survey. The ambient noise measurement was performed in the summer 2006, whereas the active survey was performed in the fall 2007.

2. Results of the comparison

The ambient noise data were processed with different high-resolution *f-k* methods originally proposed by Capon (1969) and further developed by (Kind et al., 2005; Fäh et al., 2008; and Poggi and Fäh, 2010). The data acquired during active survey were processed with *fk*-MUSIC method (Iranpour et al., 2002). Both Love and Rayleigh fundamental mode dispersion curves were estimated analyzing the both datasets. The final set of dispersion curves is plotted in Figure 2.

Concerning dispersion curves retrieved from the ambient noise, it was possible to follow the fundamental mode of both Rayleigh and Love wave down to 1.2 Hz. In case of Love waves, it was not possible to pick any dispersion curve for frequencies higher that 4.5 Hz. In case of Rayleigh waves, it was possible to follow the dispersion curve just up to 6 Hz. The estimation of the Rayleigh dispersion curve was further extended up to 20 Hz by the directional filtering of the picked *f-k* maxima (see later Figure 3). However, the uncertainty of the dispersion curve for this frequency band (6 – 20 Hz) is high, and this part of dispersion curve was not even used in the velocity profile inversion (see deliverable 3.1.2).

On the other hand, dispersion curves retrieved from the active survey cover the frequency range from 3 to 100 Hz. Different symbols distinguish different source-receivers geometries. Dispersion curves from the active survey are in good agreement with each other for the 10 – 40 Hz frequency band. The inconsistencies for higher frequencies (> 40 Hz) can be addressed either to mode jump or presence of small-scale lateral heterogeneity.

The dispersion curves retrieved by passive and active experiments deviate significantly from each other for the overlapping frequency band (3 – 20 Hz). Let us discuss the observed discrepancies. A large scatter of maxima in *f-k* domain was found for ambient noise data for frequencies higher than 5 Hz. A directional analysis of the ambient noise wavefield was performed to better understand such phenomenon. The maxima picked in the *f-k* domain were sorted into 18 bins with respect to direction of propagation (each bin corresponds to the sector of 20 degrees).

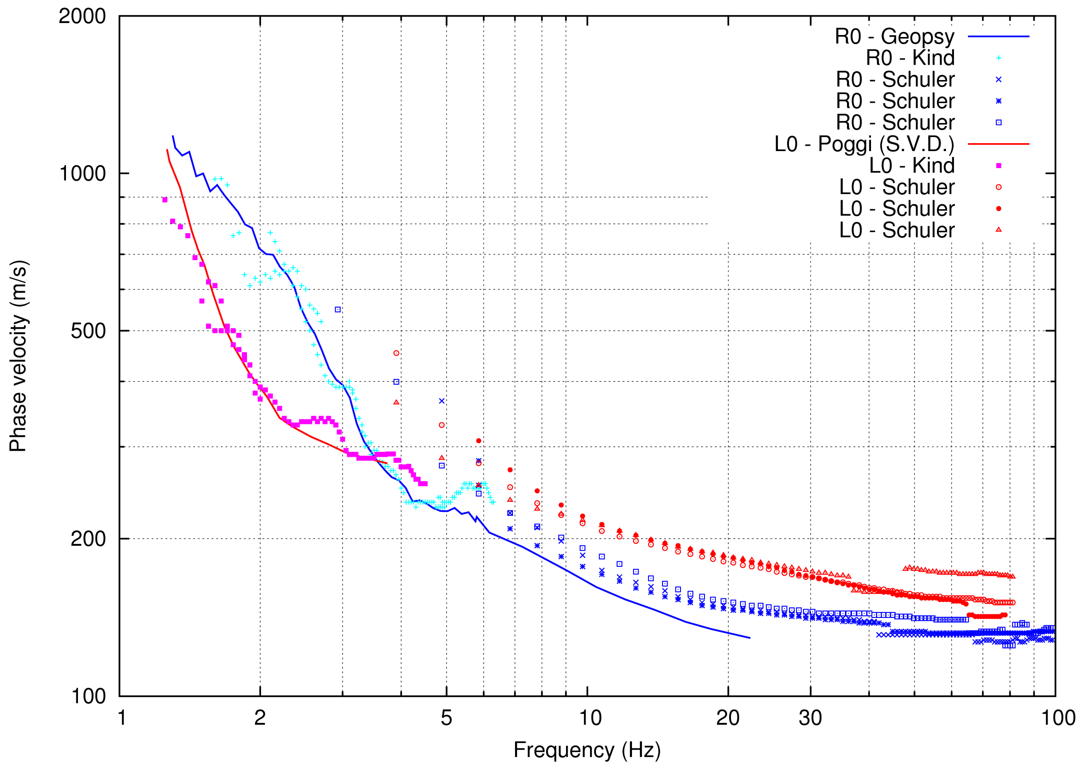

Figure 2: Dispersion curves for the site retrieved by different methods: R0 stands for the fundamental mode of Rayleigh waves, L0 stands for the fundamental mode of Love waves. Curves retrieved from the ambient noise are denoted 'Geopsy' if using Sesarray software (Wathelet et al., 2005), 'Kind' if using software developed by Kind et al. (2005), and 'Poggi' if using software developed by Poggi and Fäh (2010). Curves denoted 'Schuler' are based on active survey, different symbols distinguish different source-receiver geometries.

The result for the vertical component of the most inner array ring is depicted in Figure 3. The distribution of sources is clearly directional. Generally, the strongest contribution comes from the east-west/west-east directions (the direction of the valley). The scatter of the points below 6 Hz is relatively low for all directions, close to the picked dispersion curve. However, one can observe a very different picture for frequency band of 6 – 10 Hz. The strongest contribution comes almost exclusively from east/south-east (direction of propagation towards 220 – 320 degrees) and the observed apparent velocities indicate a jump with respect to the lower frequencies (<6 Hz). This can be addressed to excitation of higher mode for this range of directions (i.e., for this kind of sources). Nevertheless, the scatter of the points is too high to pick reliably the dispersion curve of the possible higher mode. A small contribution with consistent apparent velocities comes from west (direction of propagation towards 80 – 120 degrees). Thus, the pick of the high-frequency part (6 – 20 Hz) of the Rayleigh dispersion curve was performed exactly just for these directions (80 – 120 degrees). The results are heavily affected by an aliasing phenomenon for frequencies higher than 10 Hz.

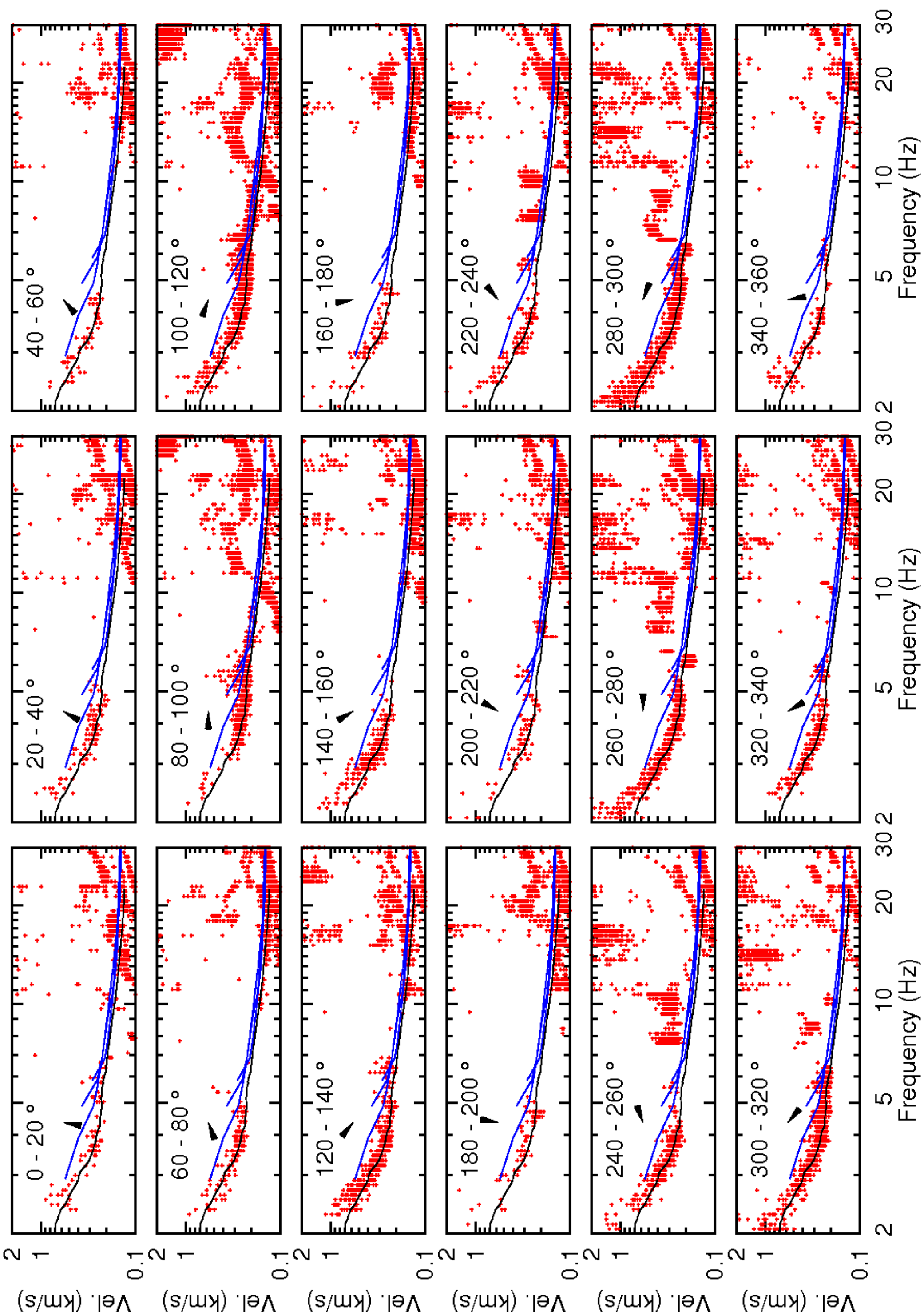

Figure 3: Directional dependence of the picked maxima (red dots) in the *f-k* domain for the vertical component of the ambient noise. Interval of the azimuths considered for each plot is in the left top corner and depicted by black arrow. The solid black curve is the dispersion curve retrieved from the ambient noise (by Geopsy) and the set of blue curves are the dispersion curves based on active survey (see Figure 2).

The frequency of 6 Hz is also the limit, where the results of the active survey start to deviate strongly from the passive experiment (the apparent velocities are higher compared to noise). This can be explained by an inaccurate definition of the resolution limit for the active survey. The resolution limit was found by an analysis of a synthetic dataset. However, in presence of the ambient noise, the resolution can be altered. Particularly, it is difficult to generate a strong low frequency (<10Hz) signal just with the sledge hammer, so the level of the induced seismic signal maybe comparable to the ambient noise (thus insufficient). The use of 4.5 Hz geophones may also influence the quality of the results for the very low frequencies (<4.5 Hz). The presence of the strong noise (2.5 Hz, 4-5 Hz and 9 - 10 Hz peaks) with the origin in the Lonza factory may also influence the results of the active survey. This disturbance was identified on the all array recordings made in 2007 and also on semi-permanent station recordings (2007-2009), whereas is missing on the recordings acquired in 2006 (thus for passive array measurement discussed here).

3. Conclusions

The results of passive and active surveys were compared. Dispersion curves obtained by the active survey are complementary to dispersion curves estimated from the ambient noise. The use of the ambient noise constrains very well the low frequency part (1.5 – 6 Hz) of the dispersion curve, whereas the active measurement constrains the high frequency part, as expected. The combination of the two approaches results in the broadband dispersion curves (1.5 – 100 Hz). The lower resolution limit of active surveys has to be analyzed carefully especially with respect to the energy content of the source.

4. References

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