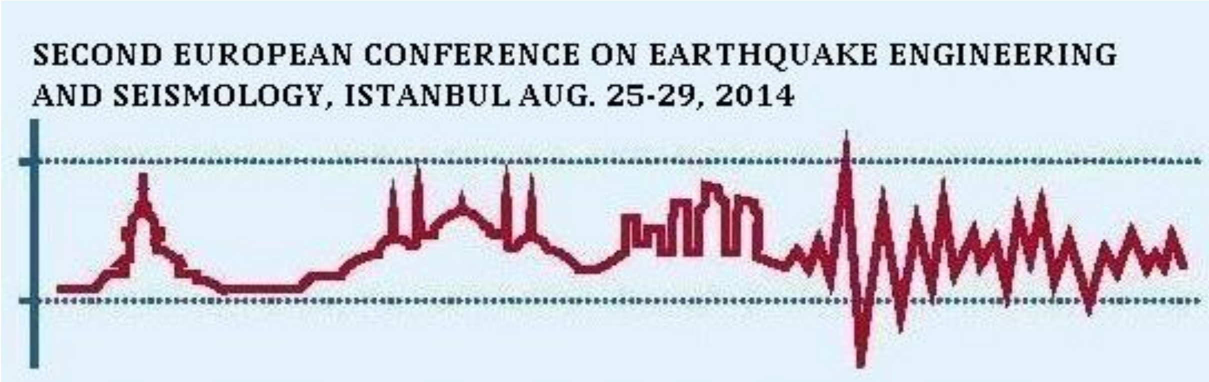

COHERENCE SPECTRA OF ROTATIONAL AND TRANSLATIONAL COMPONENTS RECORDED BY THE S-5-SR SENSOR

Alexey A. LYUBUSHIN[1] Zdeněk KALÁB[2] , Markéta LEDNICKÁ[3], Jaromír KNEJZLÍK[4]

For full description of the ground vibration it is necessary, in addition to three translational components and strain, to consider also three rotational components (e.g., Båth, 1979, Teisseyre et al., 2006). Traditionally, only the translational components of the earthquake ground vibration and structural response have been recorded. Classical Russian pendulum seismometer S-5-S was modified for recording of the rotational components of ground motion (Knejzlík et al., 2012). This seismometer was used for mining induced seismic events monitoring in the Karviná region. Together, classical translation vibrations were recorded (Kaláb and Knejzlík, 2012, Kaláb et al., 2013). Measurement in near-source area is necessary because rotational components are quickly attenuated. Our first records of rotational component were obtained during the experimental seismic monitoring in 2010/11 and 2011/12 that confirmed rotational component existence – besides natural earthquakes – also for the mining induced seismic events (wave pattern example on Figure 1). The values of ground rotational motion around the vertical axis recorded in the seismic station at Doubrava village exceeded value of 1 mrad.s^{-1}. Numerical study of measured rotational component attributes is presented in this paper.

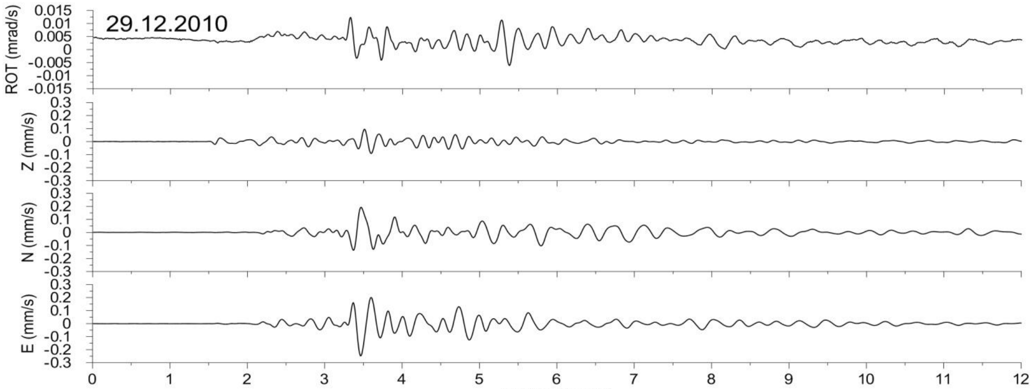

Figure 1. Examples of rotational component of ground vibration velocity around the vertical axis and translational components of ground vibration velocity (down from top vertical, horizontal N-S, horizontal E-W components); mining induced seismic event from Karviná region (29/12/2010, distance seismic station-focus about 5.1 km)

[1] Prof., DrSc, Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia, lyubushin@yandex.ru
[2] Prof., PhD., Institute of Geonics, Academy of Sciences of the Czech Republic, Ostrava –Poruba, Czech Republic, kalab@ugn.cas.cz
[3] Eng., PhD., Institute of Geonics, Academy of Sciences of the Czech Republic, Ostrava –Poruba, Czech Republic, lednicka@ugn.cas.cz
[4] Eng., PhD., Institute of Geonics, Academy of Sciences of the Czech Republic, Ostrava –Poruba, Czech Republic, knejzlik@ugn.cas.cz

Laboratory tests of the S-5-SR were carried out to obtain information about the new seismometer behaviour and to calibrate its basic parameters. A test vibration table, that is located at the Geophysical Institute of the ASCR, Prague, was used. Both translation and rotational movements of the table is possible to set up. Anchoring of the S-5-SR on the desk is presented in figure 4. Natural period of pendulum was setted-up to 5s and system was optimally damped.

To obtain maximum accuracy of measurement, an output signal from the seismometer was analysed using Brüel & Kjær Spectral Analyzer Type 2031. Sensitivity constant for angular velocity $k(d\varphi/dt) = 52.6$ V.s.rad^{-1} was obtained and sensitivity constant $k(\varphi) = 1393$ V.rad^{-1} was set for an angular displacement channel. Sensitivity $kp = 1.1$ mV/Hz was taken for a parasitic sensitivity on a translational oscillation perpendicular to the pendulum and its rotational axis on stationary amplitude 50 µm (peak-peak). As a result, $k(d\varphi/dt)$ to kp ratio is better than 40 dB within frequency range 0.2 – 25 Hz. Due to non-linearity of SET and limited amplitude of damping feedback signal, the range of measured amplitudes is limited to 10 mrad/s. Sensitivity is limited by noise level 1.1 µrad/s below 0.5 Hz (Kaláb and Knejzlík, 2012).

To present record of mining induced seismic event (see Figure 1), squared Morlet wavelet coefficients were calculated and plotted (Figure 2). This methodology is used for detailed analysis of geophysical and environmental data (Lyubushin, 2007).

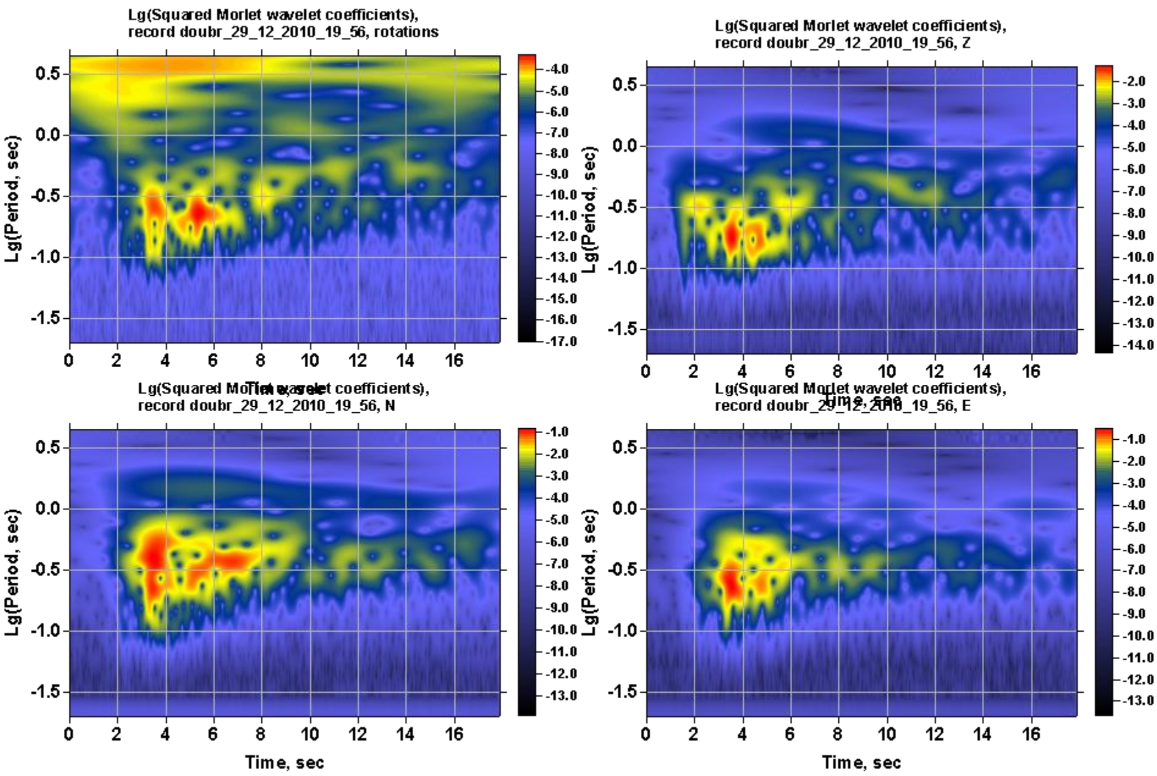

Figure 2. Squared Morlet wavelet coefficients of mining induced seismic event (29/12/2010)

On Figure 3, there are 3 time-frequency diagrams of evolution of the squared coherence spectrum (squared correlation coefficient which depends on frequency) for 3 pairs: (Rot,Z), (Rot,N) and (Rot,E). The estimates where performed within moving time window of the length 2 seconds. For presented wave pattern, maximum coherences are in frequency range 5 – 20 Hz, i.e. in the frequency range of seismic event. These maxima could not be influence of translation signals because attenuation between rotational and translational component is about 40 – 60 dB in given frequency range according laboratory tests on vibration table. This result documents that frequency range and prevailing frequencies of recorded wave patterns of translational and rotational components is almost identical. The most significant coherence during whole elaborated time is possible to define for “Rot, E” squared coherence spectra. We suppose that it is due to local geological or tectonic pattern of place with station.

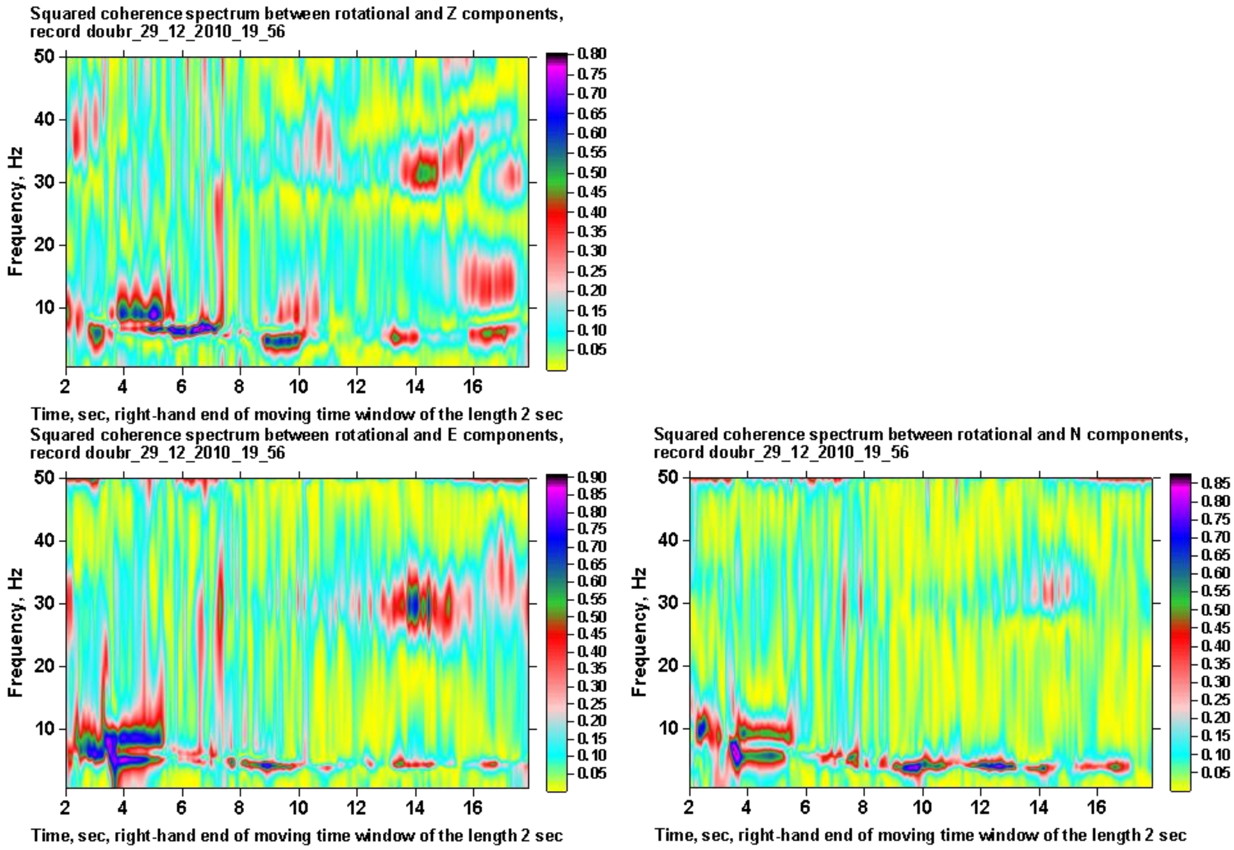

Figure 3. Time-frequency diagrams of evolution of the squared coherence spectrum for analyzed mining induced seismic event (29/12/2010)

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