EGU21-11008
https://doi.org/10.5194/egusphere-egu21-11008
EGU General Assembly 2021

Persistent monochromatic seismic signals across central Europe: AlpArray data indicate a man-made seismic source for regional wave propagation studies

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Consistent and monochromatic signals appear as sharp peaks in frequency spectra or as continuous lines in spectrograms on many permanent and temporary seismic stations in Central Europe, especially in South-Eastern Germany, Austria and the Czech Republic. Similar observations have already puzzled the seismic community more than 20 years ago. Here we report on new observations of such monochromatic seismic signals within a 1 – 10 Hz range across central Europe using the dense AlpArray network.

We identify several monochromatic signals on both permanent and temporary stations. The respective frequencies of e.g. 1.72 Hz, 2.08 Hz, 2.77 Hz or 4.16 Hz are generally stable even over long time spans (months to years). Strikingly, all such signals at any given station show identical and simultaneous short-term (minutes to days) frequency variations of up to 0.4% of the central frequency. These variations precisely correspond to fluctuations of the frequency of the European electric power network, which is regulated to 50 Hz +/- 0.4%. In fact, all persistent seismic signals that follow this behavior have frequencies of 50 Hz / n with n being an integer number (50 Hz / 29 = 1.72 Hz, 50 Hz / 24 = 2.08 Hz, 50 Hz / 18 = 2.77 Hz, 50 Hz / 12 = 4.16 Hz). We show that if the frequency of an observed spectral line is an integer fraction of the power network frequency (and only in that case) it will perfectly follow the fluctuations of the power network. This obviously raises questions about the nature of the signal itself, in particular if it is of seismic or maybe electro-magnetic origin.

We confirm that the signals are of seismic origin and we have identified water turbines inside river power plants as the source. The observed frequencies correspond well to reported rotation frequencies of water turbines at several different river power plants in Southern Germany and Austria. The seismic signals may propagate to almost 100 km from the corresponding plant. We analyze the spatial distribution of signal amplitudes for a selected river power plant in Austria, and show that it is similar to expected isolines of seismic shaking for an earthquake in the region.

Knowing the source of those exotic signals potentially enables us to use them for seismo-tectonic purposes. The long-term (several years) stability and the permanent availability (24h operation of water turbines) render them very interesting sources e.g. for studying temporal seismic velocity

variations in the shallow crust.