Seismic signals from trains: equidistant spectral lines

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We analyze in detail the seismic vibrations generated by trains, measured at distance from the track with high sensitivity broadband sensors installed for the AlpArray project. The geometrical restrictions of the network resulted in a number of instruments deployed in the vicinity of railway lines. On seismic stations within 1.5 km of a railway, we observe characteristic seismic signals that we can relate to the passage of trains. All train signals share a characteristic feature of sharp equidistant spectral lines in the entire 2–40 Hz frequency range. For a site located 300 m from a busy track, frequency spacing is between 1 and 2 Hz and relates to train speed. The spectrograms of individual trains show acceleration and deceleration phases that match well with the expected driving profile for different types of trains. We discuss possible mechanisms responsible for the strikingly equidistant spectral lines. We search for Doppler effects and compare the observations with theoretically expected values. Based on cepstrum analysis we suggest quasi-static axle load by consecutive bogies as the dominant mechanism behind the 1–2 Hz line spacing. The striking feature of the equidistant spectral lines within the train vibrations renders them seismic sources which may have potential for seismic imaging and attenuation studies.