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Seismoelectric ground response to local and regional earthquakes

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During earthquakes magnetotelluric stations occasionally record electric and magnetic signals similar to seismograms. The major part of these magnetic signals is induced by the seismic movement of the magnetometers (induction coils) in the static magnetic field. In contrast, the electric field signals are caused by the seismoelectric effect. Based on more than 600 earthquakes from Chile, Costa Rica and Europe we established a logarithmic magnitude-distance-relationship describing the magnitude threshold to be exceeded for observing seismoelectric (SE) signals with standard magnetotelluric (MT) recording units at given hypocentral distance r and for noise levels less than 3 μV/m. The log(r) term results from the geometric spreading of the radiated seismic waves.
A comparison of SE signals at different hypocentral distances shows that observability is not only influenced by the amplitude of the incoming seismic wave. It also depends on the geological structure underneath the station which causes a unique frequency dependent SE response. To quantify these site effects we computed spectral seismoelectric transfer functions representing the ratios of the spectral amplitudes of SE records and acceleration seismograms (SESRs). Some stations show constant SESRs in the major frequency range, while others show a decrease with increasing frequencies. Based on the current Biot-type seismoelectric theory constant SESRs can be explained by coseismic SE waves alone. The observed SESR amplitudes at some sites are indeed consistent with theoretical expectations for electrically highly resistive soils or rocks, in agreement with the local geology of the investigated areas. The frequency dependence of SESRs observed at other locations can be explained if the incident SE waves consist not only of coseismic arrivals but also of a significant contribution from SE interface response waves which are generated at electrical or mechanical boundaries. Therefore, frequency-dependent SESRs can be regarded as an expression of a seismoelectric site effect, which depends strongly on the hydraulic and lithologic conditions underneath the recording station.