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Modeling and observations for Resonance Seismometry

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We study the interaction of a seismic wave-field with a spherical acoustic gas-or fluid-filled cavity. The intention of this study is to identify characteristic features in the interaction that may help detecting cavities in the subsurface. This is important for many applications, as in particular the detection of underground nuclear explosions which are to be prohibited by the Comprehensive-Test-Ban-Treaty (CTBT). On-Site Inspections (OSI) should assure possible violations of the CTBT to be convicted if suspicious seismic events that may have been caused by nuclear explosions are detected by the international monitoring system (IMS). One primary structural target for the field team during an OSI is the detection of cavities created by underground nuclear explosions. As one seismological technique resonance seismometry is mentioned in the treaty which refers to detection of cavity-resonances but also includes the detection of structural anomalies by other passive seismic techniques.

Therefore we investigate different aspects of wave field interaction as the occurrence of resonances, the influence of the presence of a cavity on the surface-wave dispersion and the appearance of scattered and circumferential waves. For that purpose we performed waveform modeling using an analytical solution as well as numerical forward modeling using the spectralelements suite Salvus. To complement our theoretical investigations, we analyze data from two seismic surveys collected at analogue sites conducted and provided on behalf of the OSI division of the Comprehensive Test Ban Treaty Organization (CTBTO). Through the active seismic experiment above a natural cavern in Felsőpetény (Hungary) the wave-field interaction can be studied directly as it is recorded and illuminated by a co-located shot and receiver array both covering a 300 m x 300 m area on top of a natural cavern. In contrast, during a passive seismic experiment above an active mine in Kylylahti (Finland) 46 seismic stations were recording for one month along two profiles, which enables testing of methods that require continuous data as ambient noise techniques. We present an overview of the state of the art of our analysis and findings.