Geophysical Research Abstracts
Vol. 20, EGU2018-7903-1, 2018
EGU General Assembly 2018

Seismo-acoustic signals of the Baumgarten (Austria) gas explosion detected by the AlpArray seismic network

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On December 12, 2017 a devastating release and combustion of gas occurred at the Baumgarten gas hub, which is a major European distribution hub for natural gas located in Eastern Austria. The incident caused one fatal casualty, left over 20 people injured and led to a temporary increase of natural gas price by more than 80% in several countries in Europe. According to forensic investigations the subsequent failure of two closing lids led to the sudden and consecutive release of highly pressurized natural gas from two gas filtering devices (operated at 35 and 70 bar, respectively) which then got ignited. By visual inspection of the waveforms, we detected a characteristic signal that is apparently associated to the sudden gas release on more than twenty permanent and temporary broadband seismic stations installed within a distance of 150 km from the gas hub. The temporary stations are part of the European AlpArray project, which covers the entire Alpine orogen and its close surrounding.

The earliest detected signal is most prominent in the 2-4 Hz range at stations in a distance range from 40 to 80 km and travels with an apparent velocity of approximately 350 m/s. We thus infer that it propagates acoustically through the air, while no seismic arrival (propagating through the ground) could be clearly detected. The sudden release of gas above the surface efficiently generated acoustic infrasound waves, which then locally coupled into the seismic vault structure and thereby created measurable ground motion detected by the seismometers. From the acoustic signal, we are able to infer the origin time of the first gas release. In addition, a detailed analysis of the signal characteristics sheds light on the temporal evolution of the accident, which may help the ongoing police investigation of the causes.

For normal weather conditions, infrasound signals are expected to be detected only at larger distances (>120km), where the stratospheric refracted waves reach the surface. However, several hours before the Baumgarten gas explosion, a cold front had passed the area, which induced multiple temperature inversions at few kilometers in altitude. Temperature and wind speed profiles from the day of the explosion confirm that this creates several potential waveguides for infrasound waves within the troposphere, and the acoustic waves can then be easily detected at distances of several tens of kilometers from the source. Based on realistic temperature, pressure and wind speed models from the time of the explosion, provided by the European Centre for Medium-Range Weather Forecast, we simulate the infrasound wave propagation using a 3D acoustic raytracing code. Strong westerly wind in shallow and higher atmosphere render the infrasound propagation highly anisotropic, matching our detections. Refracted waves from within the troposphere and the stratosphere are detected in eastern directions, while the west shows a shadow zone in agreement with the modeling. Both tropospheric and stratospheric signals can be used to better understand the phenomena at the source of the acoustic waves.