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Airbursts as a viable source of seismic and acoustic energy for the 2016 InSight geophysical lander mission to Mars: analysis using terrestrial analogues

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The explosion of a bolide as a terminal airburst, before impact into a planetary surface, is a well-documented source of both seismic and acoustic energy[1]. Here we aim to define some diagnostic properties of a recorded airburst time-series and determine detectability criteria for such events for a single station seismo-acoustic station on the Martian surface.

In 2016 NASA will launch the InSight geophysical monitoring system. This lander will carry in its SEIS payload two 3-component seismic instruments – the Short Period (SP) and Very Broadband (VBB) seismometers, as well as a micro-barometer for measurement of atmospheric pressure fluctuations. The SEIS and MB packages aboard InSight could potentially be used together for seismo-acoustic detection of impact or airburst events.

In past studies, this technique has been used to analyse and model the Washington State Bolide[2] and, more recently, the Chelyabinsk fireball in 2013[3]. Using a multi-station array, it is possible to estimate total kinetic energy of a bolide, its line-of-sight direction and the approximate time of its terminal burst[4]. However, with only a single station, as would be the case on Mars, more creative methods must be employed to extract information from the event.

We explore the diagnostic waveform properties of an airburst, including various arrivals from the event. We also show how dominant frequency changes with distance from the event, altitude and yield. Several terrestrial events are analysed, including the 2013 Chelyabinsk fireball. We present theoretical calculations of the likely proportion of bolide terminal bursts on Mars relative to impacts, based on differences in the structure and composition of the Martian atmosphere. We go on to predict the seismic arrivals that may be observed by InSight from the coupling of the acoustic blast into the Martian crust. It is hoped that these diagnostic tools will be useful to identify and quantify bolide terminal bursts on Mars over the course of the InSight mission.

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[2] - Arrowsmith, Stephen J., et al. "A joint seismic and acoustic study of the Washington State bolide: Observations and modeling." *Journal of Geophysical Research: Atmospheres (1984–2012)* 112.D9 (2007).

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[4] - Brown, Peter G., et al. "An entry model for the Tagish Lake fireball using seismic, satellite and infrasound records." *Meteoritics & Planetary Science*37.5 (2002): 661-675.