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Computational fluid dynamics simulations of infrasound generation process by meteorites

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The worldwide installation of the International Monitoring System is necessary to verify the Comprehensive nuclear Test-Ban Treaty which outlaws nuclear explosions. Its aim is to detect with certainty any nuclear test explosion of at least 1 kiloton (1000 tons TNT equivalent). The stations of this network, which record infrasound, often detect meteorite entries. It is essential to know if recorded signals correlate with a meteoritic entry or another phenomenon such as explosions, earthquakes or volcanic irruptions. The main objective of this work is to model the emission and the propagation of infrasound generated by meteorites. This is done by combining CFD simulations of shock waves with acoustic atmospheric propagation models. In a first step the trajectory of the meteorite is investigated. Newton's laws of motion are applied, in addition to the ablation phenomenon. It appears that input parameters (velocity, altitude, angle of entry, ...) controlling the trajectory are difficult to evaluate, so a sensitivity analysis of the influence of these parameters on the trajectory has therefore been conducted. This initial study provides the range of key parameters (velocity, density, evolution of the Mach, Reynolds and Knudsen number...) during the entry. In a second step, the pressure field in the vicinity of the meteorite is simulated using Euler equations, which are solved using a finite volume method (elsA©, ONERA). The influence of the parameters such as the diameter and the velocity of the meteorite on the pressure signal, at different radial distances away from the trajectory, is quantified and compared to an empirical line-source shock model. Finally the pressure signal is propagated at very long distances using a nonlinear ray tracing method. The matching of the CFD and acoustics models is performed at a distance where the shock is locally cylindrical and weakly nonlinear. The distance at which this matching is performed is discussed. This computational method is carried out in the case of the meteorite of Carancas, which impacted in Peru in the 15th September 2007.