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Numeric and experimental investigation of the sound generating mechanisms of a starting jet in volcanic eruptions

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Every volcanic eruption generates in its very first stage an impulsively starting free jet, and while continuous free jets have been investigated and optimised during the last 60 years, the impulsively started jet is still relatively unexplored. Its sound structure is qualitatively different from the sound generated by a continuously blowing jet. We focus here upon the very first stage of a supersonic free round jet, when the flow is only few diameters long and the vortex ring generated by the sudden expansion interacts with the shock-waves and the shear layer. Direct numerical simulations with more than 2 109 grid points are carried out, discretising the compressible Navier-Stokes equations to compute both the fluid flow and the noise radiated by the interaction of the shear layer, the shock-waves and the vortex ring in a compressible free round jet. The first acoustic wave radiated due to the strong expansion at the nozzle in the first stage is also computed. As a result of the mentioned interaction, a sound level of 111[dB] at a distance of 100 diameters from the jet axis has been computed. The acoustic signal of more than 2000 eruptions has been recorded with synchronised microphones at Stromboli and Mount Etna in order to identify the sound generating mechanisms and to compare with the numerical simulations. An interaction between the shear layer, the shock-waves and the vortex ring has been investigated using numerical methods in an impulsively started supersonic free round jet and noise levels of order of the loudest acoustic phenomenon in the continuous jet have been identified and quantified. Numerous short volcanic eruptions were recorded at Stromboli and Etna covering a range of very short to medium length eruptions. Statistical and modal analysis are performed on the different eruptions and compared to the numerical computations to identify the different sound source mechanisms in the signals, which are observed in the computations.