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Numerical simulation for 3-D infrasound propagation in shadow zone using a one-way approach

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INTRODUCTION AND MAIN RESULTS

The propagation of infrasound through the atmosphere is influenced by factors such as temperature and wind speed gradients, topography, and geometry of the source. These factors can create shadow zones where geometric acoustic approximations are no longer valid.

To address this challenge, our study proposes a 3-D numerical method that reconstructs the observed signals without relying on geometric acoustics assumptions while avoiding the computational expense of full direct numerical simulations.

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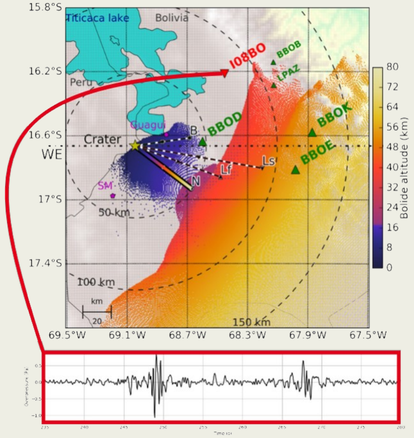
Case study

The Carancas meteorite fell on September 15, 2007, at approximately 16h40. It generates seismic and infrasound signals detected on local stations. Some numerical studies were carried out to describe the propagation from the meteor to the stations in order to find back the signals measured at the stations. An example in the case of the supersonic fall of the meteor acoustic generation only is the numerical analysis with geometrical acoustics of meteorite fall with arrival times and acoustical ray paths (Gainville et. al)[1].



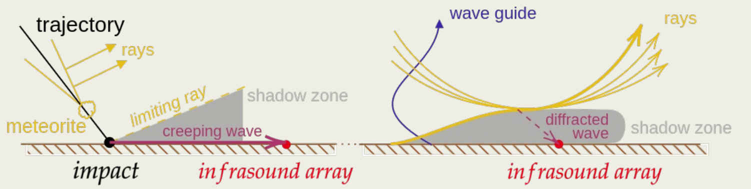
Here is the map of Carancas. The colored points represent the location of ground reflection of rays emitted by a sonic boom for a trajectory. Colors refer to the altitude of emission of the sonic boom. Referring to the simulation, there are no arrivals at IS08.

However, the infrasound signal shows clear arrivals from the Carancas meteorite. This is because the station is located in a **shadow zone**. The geometrical approach is no longer valid in this zone.

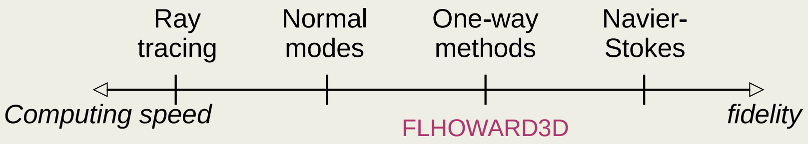
1 Gainville, O., Henneton, M., Coulouvrat, F., 2017. A re-analysis of Carancas meteorite seismic and infrasound data based on sonic boom hypothesis. Geophysical Journal International 209, 1913–1923

Numerical simulation in the shadow zone

The shadow zone can be defined geometrically as the area where no ray can propagate. It can be created by the source geometry (left scheme) or by temperature or wind gradients (right scheme).



Infrasound can, though, be detected due to the diffraction effect. Here are the main numerical methods used for infrasound propagation:

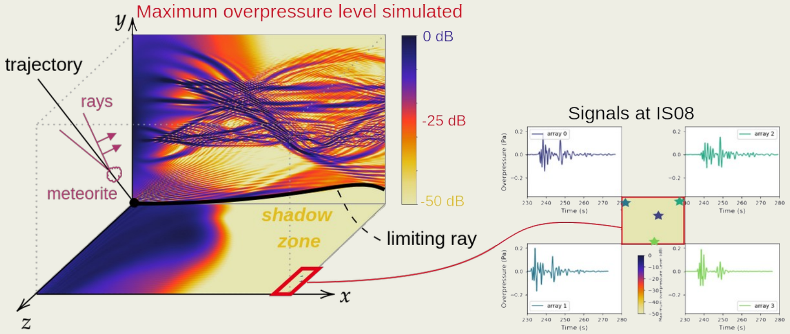


FLHOWARD3D

- ✔ Consideration of diffraction effects (shadow zone), flows, small scale heterogeneities, least numerical resources
- ✗ Backscattering

Results and Perspectives

Results of the FLHOWARD3D simulation with the trajectory N (represented on the map of Carancas) :



➡ The simulation gives signals in the shadow zone

To go further, different trajectory configurations can be tested, and with clustering methods, signals at the station can be regrouped into three categories:

1 point = 1 simulation