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Using seismic data to detect and study bolides: the case study of May 11th, 2011 bolide.

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Abstract

The entrance of bolides in the atmosphere creates infrasound waves. Some consequence is that infrasound frontwave travels through atmosphere and can interact with ground turning into seismic waves. The opportunity of having seismic stations near bolide trajectory can generate significant seismic signal that can be studied to extract extra information. This can help the characterization of the bolide in addition to classical methods giving clues about trajectory and size of the bolide.

On May 12th, 2011 a bolide crossed Northeast Iberian Peninsula near East Pyrenees where density of seismic stations is higher than in other parts of Spain due to its moderate seismic activity surveillance. The bolide crossed near several seismic stations and some significant signals have been detected on them. For now at Spain there are very few cases of detections with more than one seismic station [3].

1. Introduction

The entrance of bolides in the atmosphere creates infrasound waves. The understanding of this process can give us information taking into account infrasound and seismic data. The scheme from Figure 1 explains the different ways infrasound is generated and is transformed into seismic waves in addition to the seismic waves that can be generated from the impact of the meteorite.

On May 12th, 2011 at 01h30m41±1s T.U.C. a bolide occurred in the Northeast of the Iberian Peninsula. There are video records from different Spanish Meteor Network (SPMN) video stations. The absolute magnitude was -17±2. The duration was about 5 s. with moderate-slow velocity and multiple fulgurations This bolide crossed a region covered by seismic stations from Geological Institute of Catalonia (IGC) (Figure 3). From this network, it seems that stations CAVN, CORG, CTRE and CEST, ARBS, CLLI, CBRU have detected an event that can be related to the bolide of May, 12th (Figure 2). Proximity of seismic stations and size of bolide make think that this hypothesis can be right.

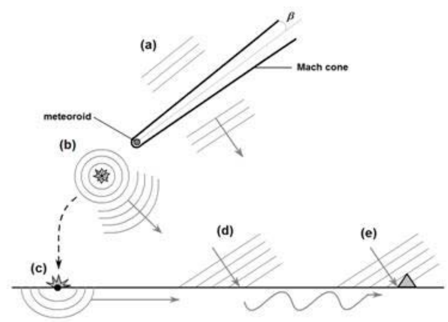

Figure 1: Meteor infrasound generation scheme and the different mechanism that generates infrasound and seismic waves from [2]. (a) Generation of shockwaves during hypersonic entry. (b) Generation of shockwave during meteoroid fragmentation. (c) Seismic wave generation during meteorite impacts. (d) Seismic precursor wave generation through matching of surface wave speeds (P, S or Rayleigh). (e) Direct coupling of the atmospheric pressure wave with the surface at the site of the seismic station (gray triangle).

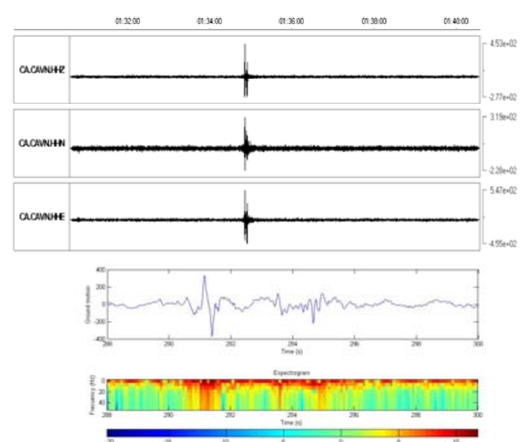

Figure 2. Filtered seismic signal (above) and spectrogram (bottom) with significant event related to the May 12th bolide recorded at the seismic station CAVN.

Figure 2. Geological institute of Catalonia (IGC) seismic network.

The signals need to be processed first in order to extract basic information as travel times of waves. These travel times extracted from the different seismic stations need to be in concordance with the views of cameras available at different Spanish Meteor Network (SPMN) stations (Figure 4). Such records allow to obtain orbital data too.

Figure 4 shows how, taking into account the times obtained from the video imagery and the arrival times of the different seismic events, the seismic events are in agreement if the bolide was around 3000km far away.

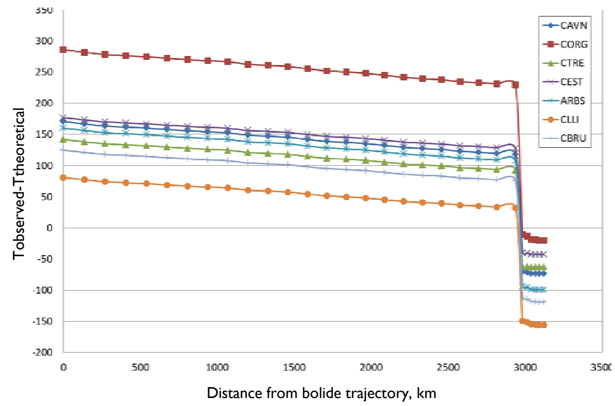

Figure 4. Comparative from computed travel times computed from bolide trajectory and times where events have been detected at different seismic stations. When the difference between theoretical time and computed time cross 0 value indicates the coherence between the bolide and the seismic event from a station. It can be seen that the selected stations and the measured events agree each other.

2. Discussion and conclusion.

The preliminary results extracted from seismic data indicate that we can be in front of a multiple seismic detection of the May, 12th 2011 bolide.

More analyses are needed in order to definitively validate this hypothesis and to extract important information from the seismic data.

The fact of having multiple seismic detection will allow us to test different existing algorithm and techniques that have been used in other bolides [4],[5],[6].

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