Theoretical and Experimental Analyses of Infrasound-Electromagnetic Data Fusion

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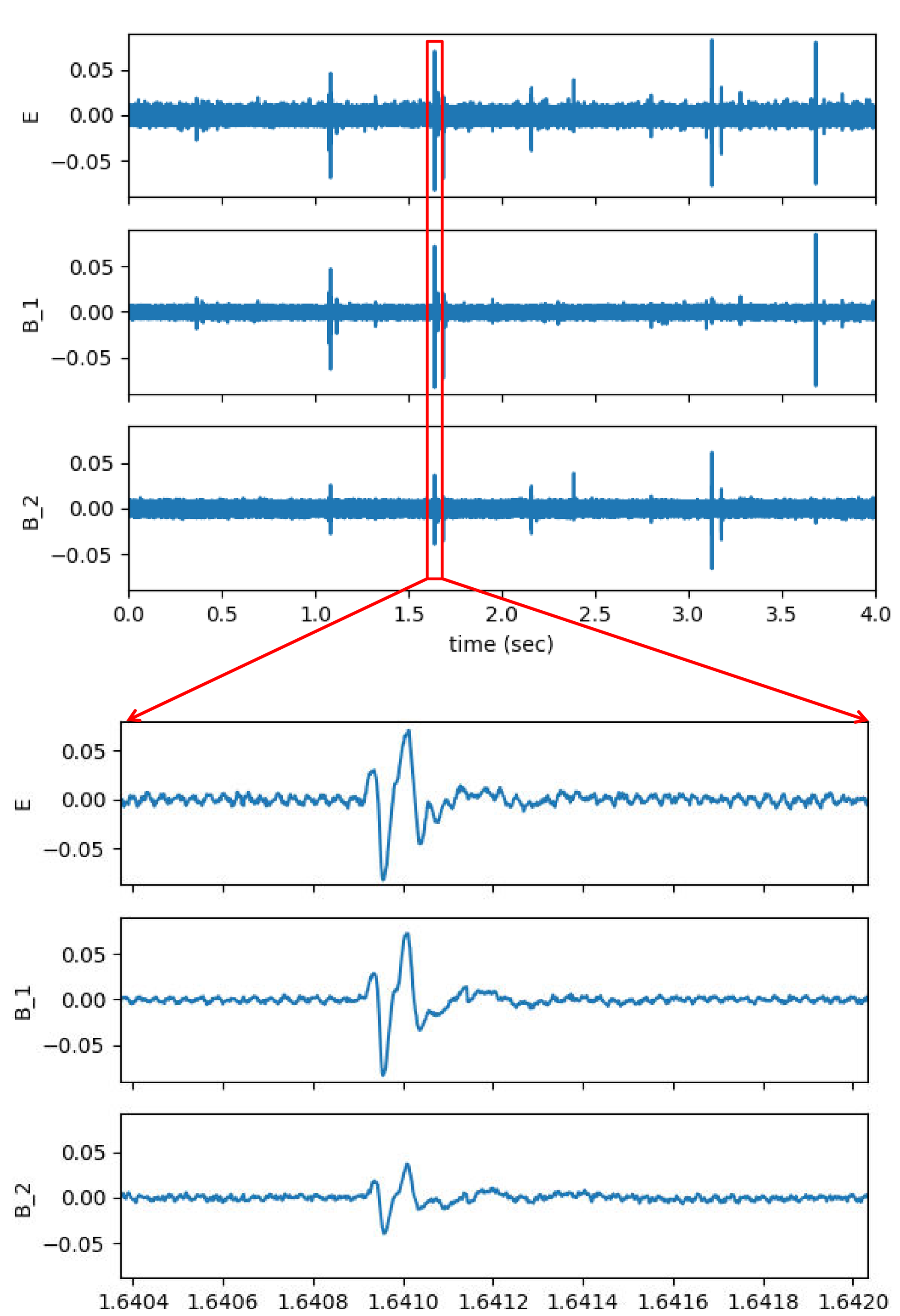
Electromagnetic pulse (EMP) has been proposed as a means of discriminating nuclear explosions from other atmospheric events. It was eventually excluded from the official IMS technologies because of its high false alarm rate due to lightning electromagnetic pulses [1]. Here we examine a possible method of overcoming this obstacle by merging data retrieved from infrasound (IS) with electromagnetic measurements. As the infrasound signal produced by lightning discharges is not detected at distances over 100-150 km [2], it is expected that IS data would not correlate with the EM signal arriving from the same locations at respective times. Thus, coincidence of both IS and EM signal emerging simultaneously from the same location may serve as an indication of a nuclear explosion.

Theoretical estimations, based on global average, predict a detection rate of one lightning per second for a typical electromagnetic receiver which is capable of detecting nuclear explosion from a distance of 2500 km [3]. However, it is shown that once an infrasound event is detected, the time window determined by the IS system location accuracy and the sector determined by the directional accuracy of the two crossed loop antennas leave us with only a few lightning signals requiring further discrimination. This discrimination is achieved by spectral analysis.

An antenna was located adjacent to IMAR infrasound array at Mt. Meron, Israel, and the measured electric and magnetic fields have been recorded for a continuous period of three days. The EM data was searched for possible signal arriving from respective time and location. We present here examples and statistical analysis of the results. These results give hope that the proposed data fusion method can implemented to enhance both detection and discrimination capabilities of the IMS.

Introduction

A prerequisite for using EMP as an indicator for a nuclear experiment, is having discrimination capability between lightning discharges and explosions. The presented method is based on data fusion of Infrasound (IS) and EMP. It is suggested to locate an EM antenna adjacent to the IS array, and keep records of its measurements. Upon arrival of an IS detection, a limited region in space and time is being defined in which the triggering event may be found. This reduces the number of lightning discharges one has to deal with. After removal of the lightning associated EM signal by spectral methods, most of the IS detections will not be accompanied by a respective EM signal and thus can be declared as non Treaty relevant events.



Methodology

An IS detection provides an estimation of time and location of triggering event. An adjacent antenna keeps records of the EM measurements. Upon arrival of the IS detection , one should look at the EM recordings, and focus on signals coming from the IS estimated directions. Spectral analysis, based on first moment of spectra (i.e. the "average frequency") filters out almost all lightning discharges, which are the vast majority of EM events. It is expected that after removing lightning signals, most IS detections will not be accompanied by any EM signal.

We have located an antenna in the vicinity of IMAR infrasound array at Mt. Meron, Israel. Continuous measurements of three days have been recorded and analyzed. For each occasion of electric field above a given threshold, Fourier transform has been computed and the first moment of spectrum has been recorded. (Here we present results relating to threshold of 0.2 v/m.)

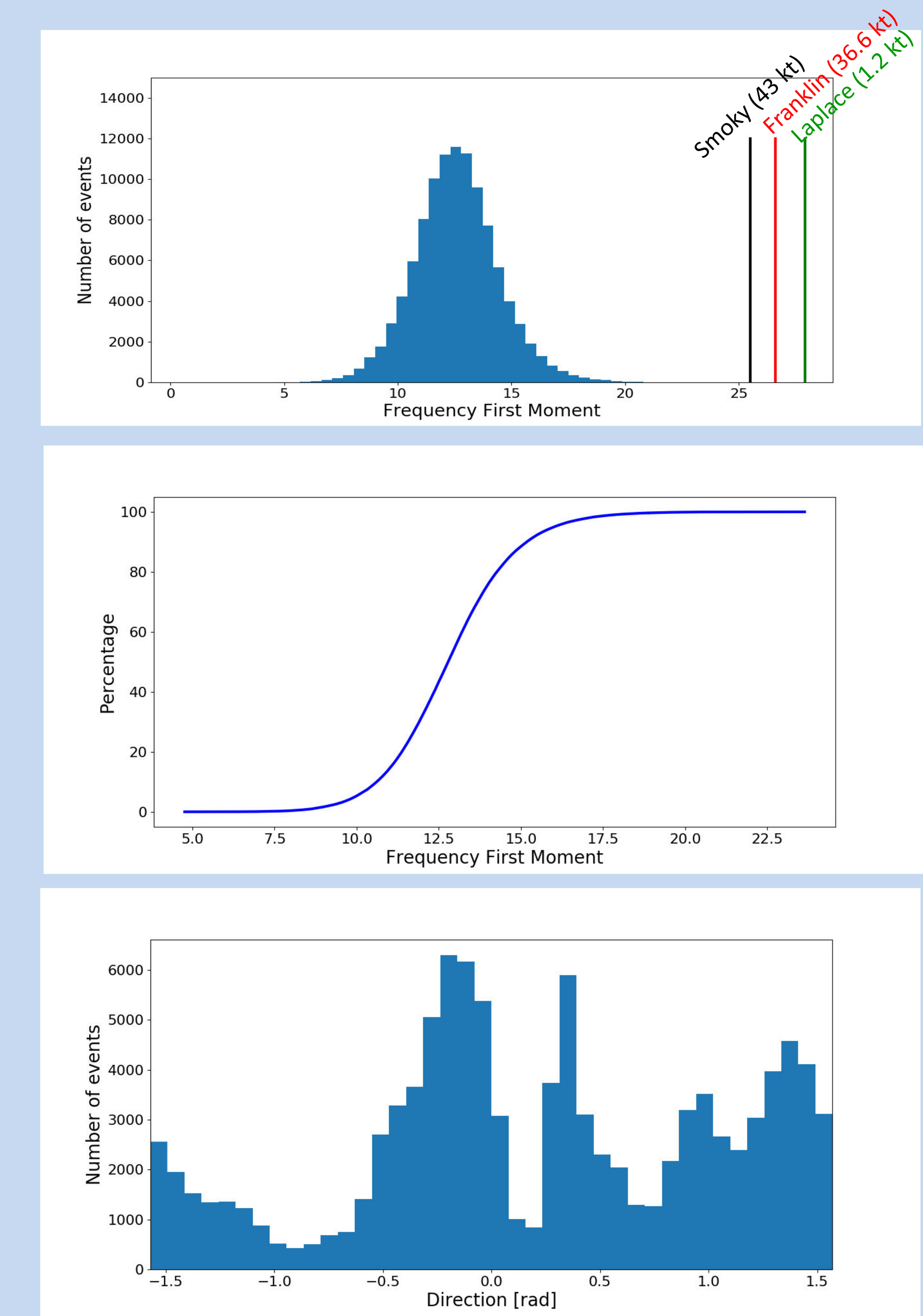
First moment of spectra have been computed in a similar manner for EM signals from nuclear tests taken from published measurements of Plumbbob operation [4]. It is shown that first moment can be a good discriminator between lightning discharges and nuclear tests.

Results

The first moment of spectra from $>10^5$ lightning discharges is presented in the upper panel. Similar analyses have been performed on published results from representative nuclear tests [4], and their results are presented as well. Nuclear tests yield spectra with higher moments and thus can be easily discriminated from lightning discharges.

Middle panel presents the cumulative percentage of lightning discharges as a function of their first moment. 99.9% of the moments are below 20 kHz. Thus, a simple analysis can recognize the event as a lightning, eliminating the need of manual analysis.

It should be noted that not all signals have to be analyzed. Magnetic antenna provides directionality of the signal (lower panel). As the EM analysis follows the IS event detection, only those signal arriving from respective direction should be considered. Other signals are irrelevant to the IS detection and can be ignored.



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