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MODELING OF THE MINOR UNCLE
EVENT**

Author(s): **Rodney W. Whitaker
Susan D. Noel
Wayne R. Meadows**

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Infrasonic Observations and Modeling of the Minor Uncle High Explosive Event

Rodney Whitaker, Susan D. Noel, and Wayne R. Meadows

EES-5 Los Alamos National Laboratory

ABSTRACT

Minor Uncle was a Department of Defense sponsored explosive test of 2440 tons of ammonium nitrate and fuel oil (ANFO) executed on June 10, 1993, at White Sands Missile Range, NM. Los Alamos National Laboratory made infrasonic observations of this event at three stations: Los Alamos, NM, 250 km range; St. George, UT, 750 km range; and the Nevada Test Site, NV, 928 km range. All three stations obtained positive results and had very low background noise levels. Data from all stations will be presented, and normal mode calculations of the wave propagation, including upper atmospheric winds, to St. George will be compared to the data.

BACKGROUND

We present long range, low frequency observations of the Minor Uncle HE detonation. The data are in the infrasonic part of the acoustic spectrum, generally 0.1 Hz to 10.0 Hz, and were recorded at three arrays operated as part of the Los Alamos verification program. Array locations and distances from the event are: Los Alamos, NM, 250 km; St. George, UT, 750 km; and the Nevada Test Site (NTS), NV, 928 km. All three stations had four infrasound microphones in a diamond shaped array. Conditions at all three sites were excellent with low pre-event background levels. Data are processed with standard time-delay and sum beamforming techniques to derive correlation coefficient, trace velocity, and direction to source. Minor Uncle was the eighth large scale DNA experiment we have observed, and a composite summary plot of results is included at the end. Further background information about this series of measurements can be found in Whitaker and Mutschlecner (1988).

Signal energy is propagated to long range via a ducted, multi-hop process, in which the signal may reach 50 to 100 km altitudes. Over these paths, atmospheric winds can influence propagation and we have derived a normalization procedure to account for the seasonal variation of the upper atmospheric wind, Mutschlecner and Whitaker (1988). These normalized pressures are termed wind corrected amplitudes (WCA), and all pressures presented are wind corrected peak to peak amplitudes. With the conditions for Minor Uncle, the largest signals expected would arrive with an average velocity (surface distance divided by travel time) of about 0.29 km/s, representing waves that were refracted at 50 to 60 km altitudes. Larger average velocities indicate lower refraction altitudes; and smaller indicate higher.

Minor Uncle Results

Figures 1 - 3 present summary beamformer output for the three arrays with main signal energy arriving at the following times: Los Alamos -1524 to 1526; St. George- 1548 to 1551; and NTS- 1557 to 1605 (all times are UT). Event zero time was 1510 UT. Each dot represents the beamformer output for a 20 second window of data. Figures 4 -10 show raw channel data (volts) for the signal arrivals at the three sites. Array location is given at the top of each set. Four minutes of data are shown for each channel in each figure. The numbers below or within the "Channel One" panel give the average propagation velocity of the feature. Distinct arrivals are apparent at all stations, have been seen on previous events, and depend on the detailed atmospheric structure at event time. Figures 11 to 12 show the winds at altitude at event time and are normal for this time of year (zonal are east/west, meridional are north /south). These data are from a rocketsonde launched from White Sands Missile Range at event time.

Figure 13 gives the combined results of our observations for Direct Course (DC), Pre-Direct Course (PDC), Mill Race (MR), Minor Scale (MS), Misty Picture (MP), Misers Gold (MG), Distant Image (DI), and Minor Uncle (MU). The peak to peak, wind corrected pressure amplitude is given as a function of scaled range. Here, because of the ducted nature of the propagation, we scale the range by the charge weight raised to the 0.5 power. The least squares fit has a σ (log WCA) of 0.15.

Figure 14 shows the results of a normal mode calculation of the signal at the St. George array. A version of the normal mode propagation code due to Pierce and Posey (1976) was used and included the winds as measured by the WSMR rocketsonde. Fifty modes were used in the calculation with horizontal phase velocities from 0.331 km/s to 0.357 km/s and angular frequencies from 0.01 s^{-1} to 3.6 s^{-1} . These phase velocities span the range appropriate for the wind formed duct from the source to ST. George. A CIRA model atmosphere was used with 2 km thick layers. The main features of the signal are reproduced by the calculation.

Summary

Long range infrasonic observations of the Minor Uncle ANFO explosive test were made at three stations by Los Alamos National Laboratory. These results were added to the data base of previous measurements for such tests. This series of events provides homogeneous sources for the study of long range infrasound propagation in the 1 Hz region of the spectrum. Normal mode calculations, including winds, reproduce the main features of the data recorded at St. George.

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Mutschlecner, J. Paul. and Whitaker, Rodney W., 1988, "The Correction of Infrasound Signals for Upper Atmospheric Winds", in Fourth International Symposium on Long Range Sound Propagation, NASA-CP-3101, compiled by William L. Wilshire, Jr.

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FIGURE CAPTIONS

Figures 1 -3: Summary plots of beamformer outputs for the three stations. Correlation coefficient, trace velocity, and source azimuth are plotted as functions of time. Station identification and passband are shown in header at the top of each plot.

Figures 4-10: Raw channel data (volts) as function of time for three arrays. Distinct arrivals of larger signal amplitudes are evident. Numbers under these features are the average travel velocities for the features. Station names are in the header information at the top of each plot. Four channels are shown from which the correlation between channels is easily seen.

Figure 11: Zonal (east/west) wind profile from WSMR rocketsonde. Wind speed is in meters per second and altitude is in kilometers.

Figure 12: Same as Figure 12 but for the meridional (north/south) component.

Figure 13: Combined results for all the WSMR explosive tests measured by Los Alamos in terms of WCA versus scaled range.

Figure 14: Calculated waveform at St. George array shown as volts versus time (seconds) after the event zero time. Both segments cover four minutes of data, and the top panel begins at 39 minutes after zero time or at 1549 UT.

LOS ALAMOS ARRAY (PC) DAY Day 161 1993

20 samples/sec 0.49 to 2.99 Hz norm

20 sec window Channels 1 2 3 4

Time (UT)

Figure 1

ST GEORGE PC SETUP DAY Day 161 1993
20 samples/sec 0.49 to 2.99 Hz norm
20 sec window Channels 1 2 3 4

Figure 2

Figure 3

LOS ALAMOS ARRAY
Day 161 1993 1522:00

Figure 4

Figure 5

ST GEORGE ARRAY
Day 161 1993 1548:00

Figure 6

ST GEORGE ARRAY
Day 161 1993 1552:00

Figure 7

NTS ARRAY
Day 161 1993 1555:00

Figure 8

NTS ARRAY
Day 161 1993 1559:00

Figure 9

NTS ARRAY
Day 161 1993 1603:00

Figure 10

Figure 11

Figure 12

Figure 14

Address:

Dr. Gilles A. Daigle

National Research Council of Canada

Institute for Microstructural Sciences

Ottawa, Canada

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