Superboom Caustic Analysis and Measurement Project

The Superboom Caustic Analysis and Measurement Project (SCAMP) is a NASA project designed to characterize the spatial evolution of a sonic boom head wave (or caustic) along a 4 km array of microphones. The experiment was set up near the Goldblatt Dry Lake in the Antelope Valley, beneath the northern edge of the Black Mountain Supericorridor. Over the course of two weeks, NASA JPL research aircraft performed supersonic passes over the array, generating 70 sonic booms in total.

Over the course of this experiment, four high-rate accelerometers were deployed in various array configurations. Of the 70 sonic booms generated for the experiment, 63 accelerometers successfully recorded 17 accelerometers were not deployed at all. One configuration was a monolateral array with 30 in separation between the sensors. Another two were orthogonal arrays with baseline lengths of 58 m and 44 m, including both monolateral and equal depth, in one configuration, each sensor was placed in a different condition: one at 48 m, one at a 30 m hole, a third on the natural desert surface, and the fourth on the concrete foundation of a demolished building. This array produced data on the response of the ground to the sonic boom.

Surface Response to Pressure Wave

In a separate set of booms as part of the SCAMP experiment, we instrumented Building 4800 on the NASA Dryden campus with three accelerometers on the foundation and two accelerometers on the roof. The accelerometers were installed infrequent 2011. The building shows significant amplification in the horizontal direction, with peak overpressure and peak ground acceleration of 7.2 cm/s² and 0.7 cm/s² respectively.

We drilled two boreholes for the SCAMP experiment in an effort to find a depth at which a sensor could be mounted, such that the seismic signature of the sonic boom will have attenuated enough to record. This turned out to be even more appropriate for the experiment. As seen in the figure below, using the accelerometers at the bottom of a 12 ft hole and at a height of 6 ft, the distance between the ground and the ground level can be recorded by the microphone at a frequency of 50 Hz. It is shown that the seismic signal at the bottom of a 12 ft hole is dominated by amplification over ground motion.

Implications for Earthquake Warning Systems

Sonic booms from space shuttle re-entry are readily detectable on modern seismometers [Kanamori et al., 1995, Garcia et al., 2002]. The figure on the right shows a record of a sonic boom from an F-18 at Edwards AFB. The blue trace is a microphone in the free field, and the green trace is the vertical displacement from nearby CISN station EDW2. The displacement is integrated from velocity and inverted to overlay with the microphone record. The initial sonic boom phase, the N-wave, has a characteristic shape which is easily discernible in displacement when integrated from velocity.

The figure on the right shows a sonic boom recorded on the SCAMP array. Again the blue trace is a microphone record. The green trace is recorded by an accelerometer at the bottom of a 12 ft hole and at a height of 6 ft. The blue trace is a microphone in the free field, and the green trace is the vertical displacement from nearby CISN station EDW2. The displacement is integrated from velocity and inverted to overlay with the microphone record. The initial sonic boom phase, the N-wave, has a characteristic shape which is easily discernible in displacement when integrated from velocity.

Conclusions

We have recorded a total of 70 sonic booms with high rate accelerometers recording up to 1000 samples per second. At least 15 more booms are scheduled before the conclusion of the project. The dataset includes sonic booms ranging from 0.1 to 10 psf overpressure recorded with various array configurations. These records will help determine the best means for hardening an earthquake warning system against false positives from sonic booms.

References


