Background

The Superboom Caustic Analysis and Measurement Project (SCAMP) is a collaborative effort between Sonic Boom Warning Systems, Inc. and NASA Dryden Flight Research Center. This project aims to evaluate the effects of sonic booms on Earthquake Warning Systems in order to prevent such systems from experiencing false alerts due to sonic booms. The area above the Antelope Valley, California includes the High Altitude Supersonic Corridor and the Black Mountain Supersonic Corridor. These corridors are among the few places in the US where supersonic flight is permitted, and sonic booms are common in the region.

NASA conducts regular supersonic flight experiments in the vicinity of Edwards Air Force Base, and accelerometers were positioned to record during three of these experiments. The first, Sonic Boom on Big Structures (SONMOD), took place in the fall of 2016. This experiment generated 62 distinct sonic booms that were recorded in and around the Consolidated Services Facility, a large building at Edwards AFB. The second, the Superboom Caustic Analysis and Measurement Project (SCAMP) occurred in May 2011 near Cuddeback Dry Lake in the Mojave desert. This experiment generated 70 sonic booms, of which 37 were recorded by accelerometers. Finally, in October 2011 five sonic booms were recorded at Building 4800 on the NASA Dryden campus as part of the Waveform and Sourcefield Perception and Response (WSPR) experiment. In all, 74 distinct sonic booms have been recorded to date, with as many as nine dedicated SonicBoomFlights anticipated in the future.

Surface Response to Pressure Wave

Sonic booms from space shuttle re-entry are readily detectable on modern seismometers [Van Der Woerd et al., 1991; Sonett et al., 2002]. The figure on the right shows a record of a sonic boom from 10:12 at Edwards AFB. The upper trace is a microphone in the free field, and the green trace is the horizontal component of the roof motion at the building site. 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 signal from the sonic boom would be significantly attenuated. As shown in the figure below, this depth was found to be approximately 66 in. When the borehole walls are relatively close to the source, the seismic signal is significantly attenuated due to absorption in the surrounding medium.

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 be attenuated enough to register. This turned out to be the borehole depth. As seen in the figure below, this depth is relatively close to the source. The upper trace is a microphone in the free field, and the green trace is the horizontal component of the roof motion at the building site. The blue trace shows a record of a sonic boom from 10:12 at Edwards AFB. The upper trace is a microphone in the free field, and the green trace is the horizontal component of the roof motion at the building site. 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 signal from the sonic boom would be significantly attenuated. As shown in the figure below, this depth was found to be approximately 66 in. When the borehole walls are relatively close to the source, the seismic signal is significantly attenuated due to absorption in the surrounding medium.

Implications for Earthquake Warning Systems

Sonic Booms and EQW Systems

Sonic booms from space shuttle re-entry are readily detectable on modern seismometers [Van Der Woerd et al., 1991; Sonett et al., 2002]. The figure on the right shows a record of a sonic boom from 10:12 at Edwards AFB. The upper trace is a microphone in the free field, and the green trace is the horizontal component of the roof motion at the building site. 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 signal from the sonic boom would be significantly attenuated. As shown in the figure below, this depth was found to be approximately 66 in. When the borehole walls are relatively close to the source, the seismic signal is significantly attenuated due to absorption in the surrounding medium.

In a separate set of booms as part of the WSIRF experiment, we instrumented Building 4800 on the NASA Dryden campus with 17 accelerometers as the foundation and 2 accelerometers on the roof directly above the lower part. The figure on the right shows the spectral ratio of the vertical and horizontal components of the roof sensor to the basement sensor. Because sonic booms are dominated by much higher frequencies than earthquakes, building response is best illustrated at frequencies over 50 Hz. The building has significant amplification in the horizontal channels between 75 and 120 Hz, while the amplification in the vertical channel is predominantly in the 40-80 Hz range.

Conclusions

We have recorded 74 sonic booms with high rate accelerometers recording up to 1000 samples per second. At least 15 more booms are scheduled for the conclusion of the project. The dataset includes sonic booms ranging from 0.1 to 10 psf overpressures recorded with various array configurations. These records will help determine the best locators for hardening an Earthquake Warning System against blast-like responses from sonic booms.

References