Listening for Bolides: Balloon-Borne Detection of Infrasound Waves

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Abstract

The Earth's atmosphere acts as a witness plate for incoming meteors. Flashes from bolides are reported at rates of a few per month (https://cneos.jpl.nasa.gov/fireballs/), and the infrasound disturbances produced by impactors have been sensed by ground-based microphone arrays over vast distances (e,g,, Silber, Brown & Krzeminski 2015). In principle, the detection of these events can help us characterize the small end of the Near Earth Object (NEO) population. We report on experiments to determine the sensitivity of infrasound instruments on balloon platforms.

Overview of Experiment

In September 2016 and July 2017 we flew infrasound instrumentation on balloons and coordinated those flights with ground-based explosions. Our expectation was that infrasound signals would have reduced amplitudes in the stratosphere (roughly proportional to the square root of the ambient pressure), but, despite that attenuation, the signal-to-noise ratio (SNR) would be much better from balloon-borne platforms than from the ground, for two reasons. First, the lack of wind noise on the balloon platform greater reduces the background (compared to the ground-based case), and second, the stratospheric duct should propagate infrasound signals effectively. Both of our balloon-borne experiments detected signals over large distances. The figure shows three blasts (3000-lb ANFO) detected from balloons at altitudes of 15 and 35 km (solar and NASA balloons). The blast site was 350 - 400 km distant. Multiple arrivals were detected, indicating separate propagation paths between the blast and the balloon.

Conclusions

We show here the first balloon-borne detection of a known ground source. The NASA balloon confirmed a very low-background environment, detecting a 0.06 Pa (P2P) wave with a SNR of 20. The amplitude from 15 km altitude was 5x stronger than from 35 km.The wave amplitude at 35 km roughly corresponds to predicted amplitude relative to the Vaughn (NM) signal.

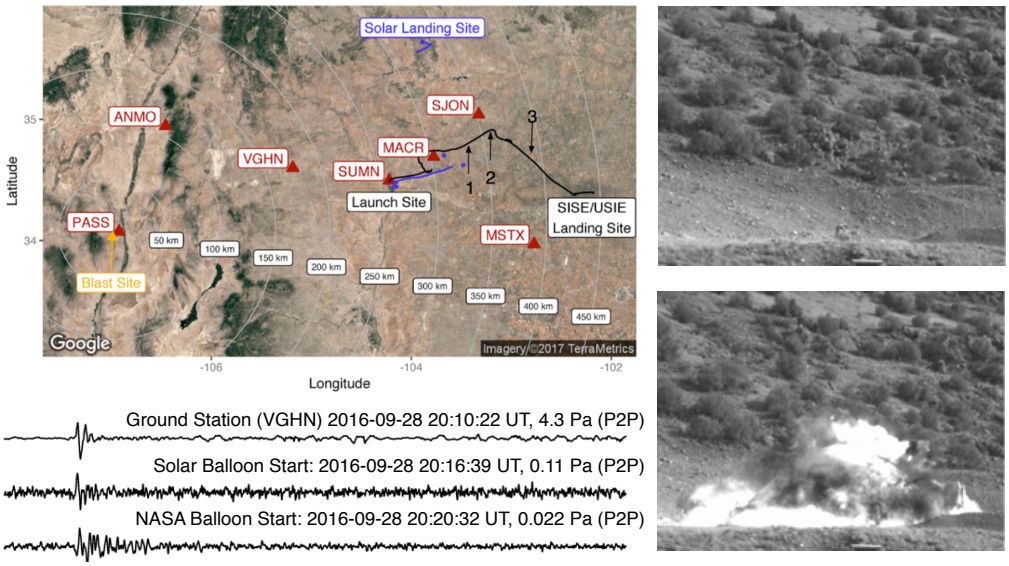

Fig. 1: Top left: blast location, ground stations and balloon trajectories. Right: snapshots of the blast. Bottom left: infrasound pressures recorded on the balloons and the Vaughn, NM station.