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Geoacoustics Takes to the Sky
Airborne Geoacoustics Workshop
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Low frequency sound waves transmit information on both natural and anthropogenic phenomena, transfer energy between the lower and upper atmosphere, and often propagate for thousands of kilometers. These sound waves are typically in the "infrasound" (below human hearing) range. Although the vast majority of geoacoustic sensor networks have existed on the Earth's surface, microphones drifting in the atmosphere may have much greater sensitivity as well as sample regions inaccessible from the ground.

In 2014, infrasound microphones were launched into the stratosphere for the first time in half a century. Over the next two years, successive deployments demonstrated that the high altitude geoacoustic wave field was substantially different from that near the Earth's surface. Results also suggested that airborne networks could detect signals at greater ranges than those on the ground.

A workshop convened at Sandia National Laboratories brought together airborne geoacoustics teams to discuss recent years' progress, the state of the science at present, and future directions. Members were interested in remote detection of human activity and geohazards, energy transfer between the lower atmosphere and the thermosphere, sub-kiloton bolide flux estimation, and a mission to Venus to detect the acoustic signature of air-coupled seismic waves. Participants agreed that airborne geoacoustics represented an important and potentially disruptive contribution to infrasound research with applications to these areas and beyond.

Areas that require additional attention include noise characterization, instrument standardization and calibration, mission design, multi-sensor networks, and improved means of sensing acoustic waves at altitude. For example, data from several flights contained high levels of non-acoustic interference correlated between sensors. While improved system designs appeared to mitigate the problem, its cause remains unknown. Attendees have developed several different instrument packages, which they agreed should be tested at ground facilities and fly together as well. Experiments over the last two years have relied on "free rides" on other institutions' balloons. Participants noted that having dedicated geoacoustic flights would assist in noise control, increase scientific gain, and permit more targeted initiatives. Several means of determining acoustic direction-of-arrival were discussed, including a horizontal sensor network deployed at altitude, multiple free-flying balloons, and new instrument concepts capable of air motion detection.

Everyone agreed that collaborative experiments increase scientific gain while diminishing risk and costs. Ideas included overflying well-characterized ground acoustic sources, deploying multiple independent balloons to facilitate signal discrimination and interpretation, and fielding ultra long duration (months to years) balloons. Expected results include quantification of the poorly understood wave field in the upper troposphere/lower stratosphere, determination of the acoustic energy flux into the upper atmosphere, detection of small bolide strikes, examination of acoustic phenomena that seldom reach the ground, and inversion of ionospheric fluctuations for their acoustic source. Continued development can enhance the Comprehensive Test Ban Treaty's International Monitoring System as well as prepare for a mission to the planet Venus.

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The lower stratosphere viewed from a solar powered hot air balloon. This region is ideal for detecting long range geoacoustic signals. Participants in a January 2017 workshop discussed this newly-emerging field of high altitude geoacoustics.

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