Scientists identify distinctive deep infrasound rumbles of space launches

June 10 2021

Credit: CC0 Public Domain

After their initial blast, space rockets shoot away from the Earth with rumbles in infrasound, soundwaves too low to be heard by human ears that can travel thousands of miles.

New research used a system for monitoring nuclear tests to track the infrasound from 1,001 rocket launches. The research identified the distinctive sounds from seven different types of rockets, including the Space Shuttles, Falcon 9 rockets, various Soyuz rockets, the European Space Agency's Ariane 5, Russian Protons and several types of Chinese Long March rockets.

In some cases, like the Space Shuttle and the Falcon 9, the researchers were also able to identify the various stages of the rockets' journey.

The new information could be useful for finding problems and identifying the atmospheric re-entry or splashdown locations of rocket stages, according to the new study published in *Geophysical Research Letters*, AGU's journal for high-impact, short-format reports with immediate implications spanning all Earth and space sciences.

Infrasound represents acoustic soundwaves below the general threshold of frequency that humans can hear. But while higher frequency noises are louder close to the source of things like nuclear explosions, low-frequency infrasound travels longer distances. Infrasound is produced by natural events as well as technological sources, and has been used to detect remote volcanic eruptions or the hum of the ocean swell.

To listen in on rocket launches, the authors tapped into a global monitoring network. After the United Nations General Assembly adopted the Comprehensive Nuclear-Test-Ban Treaty in 1996, scientists set up the International Monitoring System (IMS). This system is currently characterized by a series of 53 certified and operational infrasound stations around the world. Micro barometers at the IMS stations can detect the infrasound released by large nuclear explosions.

These stations also gather the infrasonic sounds released by other large explosions such as volcanic eruptions or space rocket launches. The researchers wanted to see if they could detect and characterize the launch of space rockets around the world.

They examined 7,637 infrasound signatures recorded at IMS stations from 2009 to mid-2020, a period that included 1,001 rocket launches. The team only examined rocket launches that occurred up to 5,000 kilometers from an IMS station, but found the acoustic signals from rocket launches could sometimes be detected up to 9,000 kilometers away, according to author Patrick Hupe, a researcher at the German Federal Institute for Geosciences and Natural Resources.

The researchers found infrasonic signatures for up to 73% of these rockets, or 733. The other 27% of launches they couldn't detect because the rockets had smaller thrusts or the atmospheric conditions didn't favor the propagation over long distances.

For the ones they did detect, they could determine the type of rockets launched, everything from the Space Shuttles, the last of which launched in 2011, to Russian Soyuz rockets. In total, they examined the signatures for seven rocket types to derive a relation between the measured amplitude and the rocket thrust: Space Shuttles; Falcon 9s; various Soyuz rockets; the European Space Agency's Ariane 5; Russian Protons; Chinese Long March 2Cs, 2Ds, 3As, 4Bs, and 4Cs; and Long March 3Bs.

Space Shuttle vs Falcon 9

The researchers also took a closer look at two different rocket types—the Space Shuttle and the Falcon 9.

They found they could identify the infrasonic signals of various stages of flight for these rockets. For the first, a Space Shuttle launched from Kennedy Space Center in November 2009, the team detected the infrasound created by the splash down of the fuel boosters before they detected the acoustic signal of the initial rocket launch because they dropped down closer to the infrasound station than the launch site. In other words, the rocket was faster than sound.

"The rocket was faster than the infrasound propagated through the atmosphere," Hupe said.

They also examined the launch and descent of SpaceX's Falcon 9 rocket, which has a partially reusable rocket that reentered the atmosphere and landed successfully on a drone ship in the ocean in January 2020. Hupe's team could detect both the takeoff of the rocket and the landing of the first booster.

"By processing the data and also applying different quality criteria to the infrasonic signatures we were able to separate different rocket stages," Hupe said.

"The ability to detect different types of rockets could be helpful," said Adrian Peter, a professor of computer engineering and sciences at the Florida Institute of Technology that wasn't involved in Hupe's work but who has studied the infrasonic signatures of rockets before.

He said the characterization of different stages of rocket launches could be useful for determining future problems. For example, if a rocket didn't launch properly or exploded, researchers might be able to detect what went wrong by analyzing the infrasonic signature, especially when the information is correlated with sensor readings from the rockets themselves.

Peter adds that it's great to see researchers harnessing the information gathered by a monitoring network that was initially only intended to watch for nuclear launches and explosions.

"Now we're leveraging it for other scientific applications," he said, adding that there are likely further uses for this type of data.

More information: Christoph Pilger et al, 1001 Rocket Launches for Space Missions and Their Infrasonic Signature, *Geophysical Research Letters* (2021). DOI: 10.1029/2020GL092262

Provided by American Geophysical Union