

M0.0 METEOR EXPLOSION - RUSSIA

Friday, February 15, 2013 at 03:20:26 UTC

A meteor entered the Earth's atmosphere and blew apart over the city of Chelyabinsk, 1500 kilometers (930 miles) east of Moscow on Friday, February 15. The explosion caused a massive shock wave that damaged hundreds of buildings and injured more than 1,000 people in the Chelyabinsk region. There was no advance warning before the meteor appeared in the sky.

This meteor is the largest reported since 1908, when a meteor hit Tunguska, Siberia. There were no injuries in that event, but thousands of square miles of forest in remote Siberia were flattened.

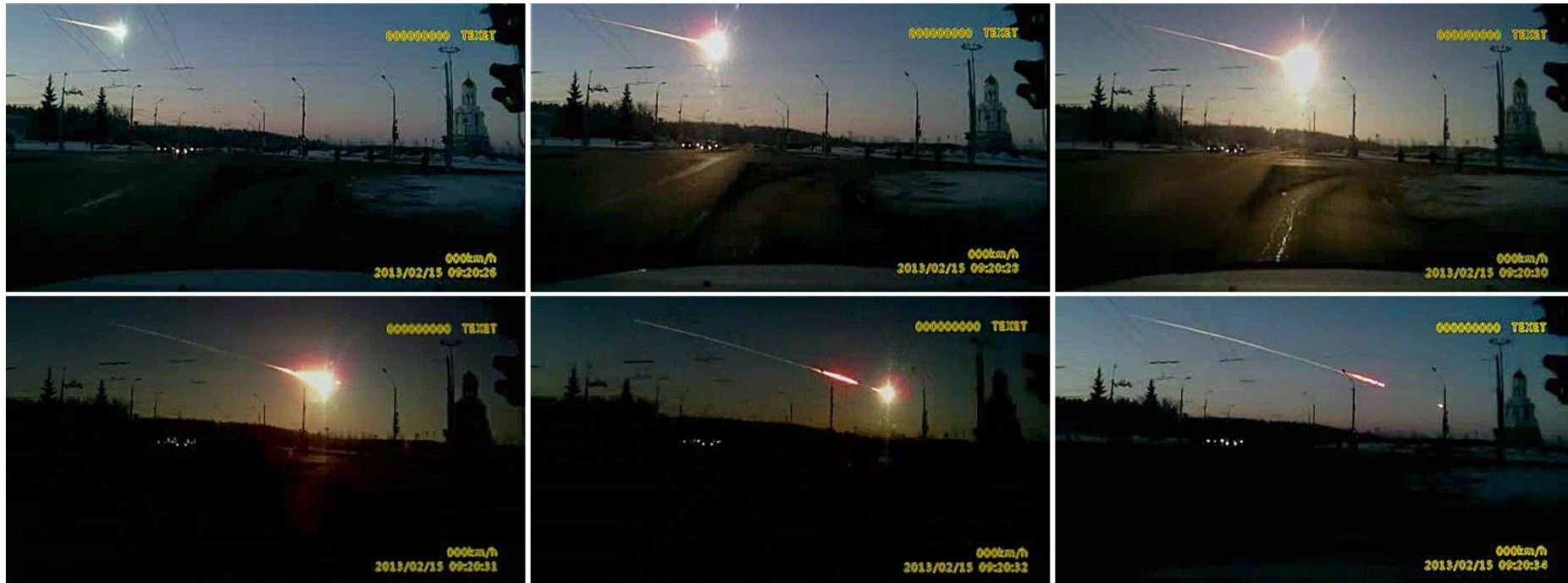


image courtesy space.com

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The meteor trail was visible for about 30 seconds, indicating a shallow entry with a grazing impact through the atmosphere.



In this combo made from frame grabs from a dashboard camera video, a meteor streaks through the sky over Chelyabinsk.

(AP Photo/AP Video)

A **meteoroid** is a sand- to boulder- sized particle of debris in the Solar System. When a meteoroid enters the Earth's atmosphere, often it is burned up by friction and the heat of the atmosphere. When it is heated in the planet's atmosphere and is visible, it is called a **meteor** (shooting star).

Objects larger than several meters can explode in the air and create damage. Only rarely is a meteor large enough to survive its fiery passage through the atmosphere and reach the ground.

These are called **meteorites**. Meteorites often hit the ground at tremendous speed up to 30,000 km an hour (18,650 mph) — releasing a huge amount of energy.

Meteorites strike the earth about 5 to 10 times a year. Most fall over uninhabited areas.



A Perseid meteor lights up as it streaks through the Earth's atmosphere, as seen and photographed by Ron Garan while aboard the International Space Station in 2011. (NASA)

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The meteor entered the atmosphere at about 40,000 mph (18 kilometers per second).

It is estimated that the meteor was 17 m (55 feet) in diameter and weighed 10,000 tons.

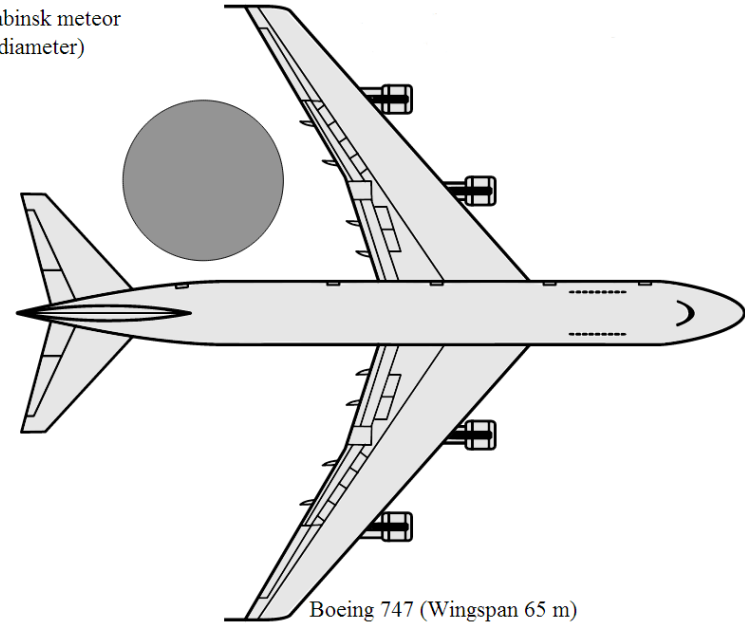
The energy released in the explosion is estimated and reported by NASA to be between 300-500 kilotons of TNT.



A circular hole in the ice of Chebarkul Lake where a meteorite reportedly struck the lake near Chelyabinsk.

(AP Photo)

Chelyabinsk meteor
(17 m diameter)



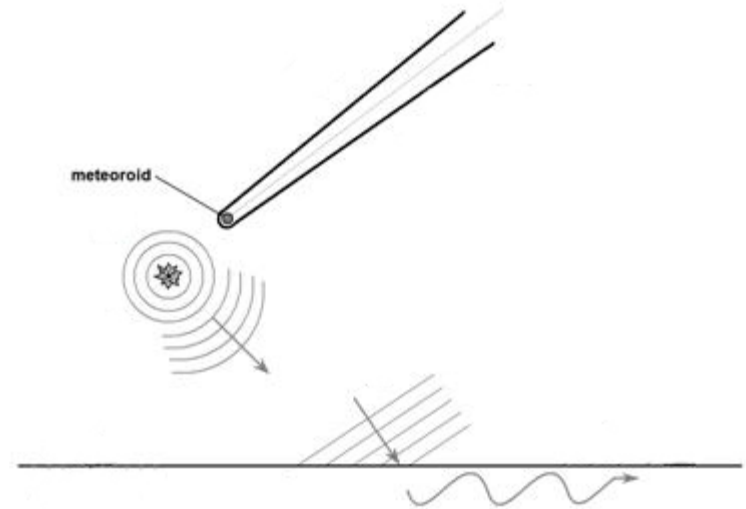
Boeing 747 (Wingspan 65 m)

Size comparison of the
Chelyabinsk meteor and a Boeing 747

(Modified from Tobias1984)

The energy from the explosion created pressure waves in the atmosphere that rapidly moved outward from the entry point and spread around the globe. The downward directed waves coupled into the ground and spread outward as an elastic wave in the Earth.

These two waves – in the Earth and in the atmosphere – travel at very different speeds. The waves in the ground travel quickly - at about 3.4 km/s – and attenuate rapidly, whereas the waves in the atmosphere are much slower (~0.3 km/s) and can travel for great distances.

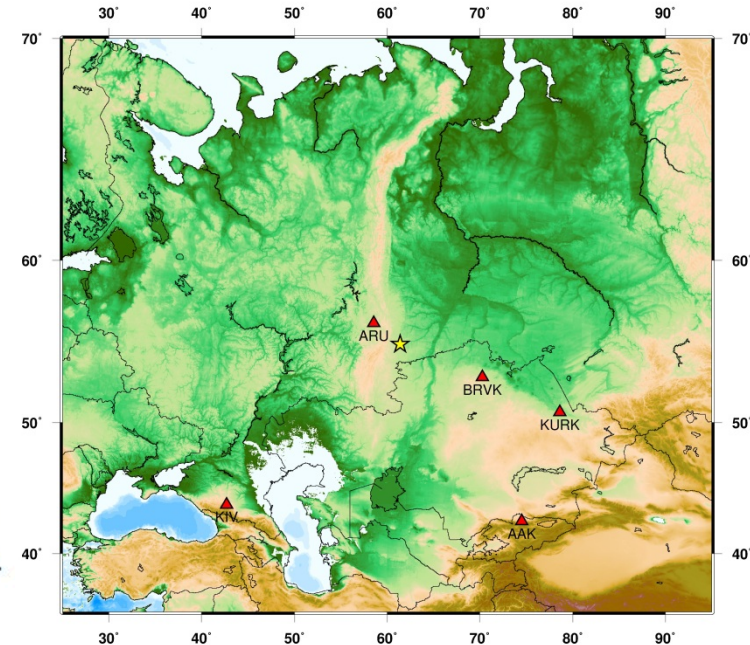
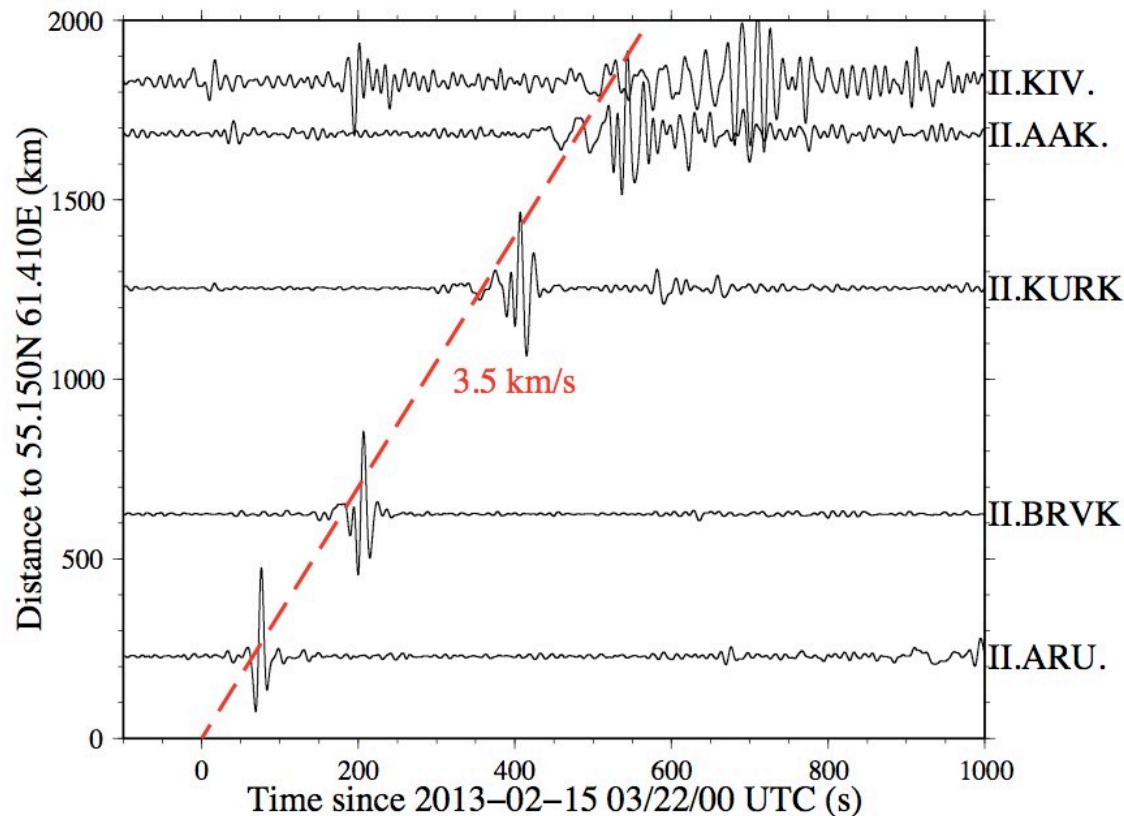


Schematic diagram of meteor with mechanism of airwave-seismic generation. Shockwaves are generated during meteoroid explosion and spread out in all directions. The energy directed toward the Earth's surface can be converted into seismic surface waves. Travel via surface wave speeds allows these waves to arrive prior to the infrasonic wave.

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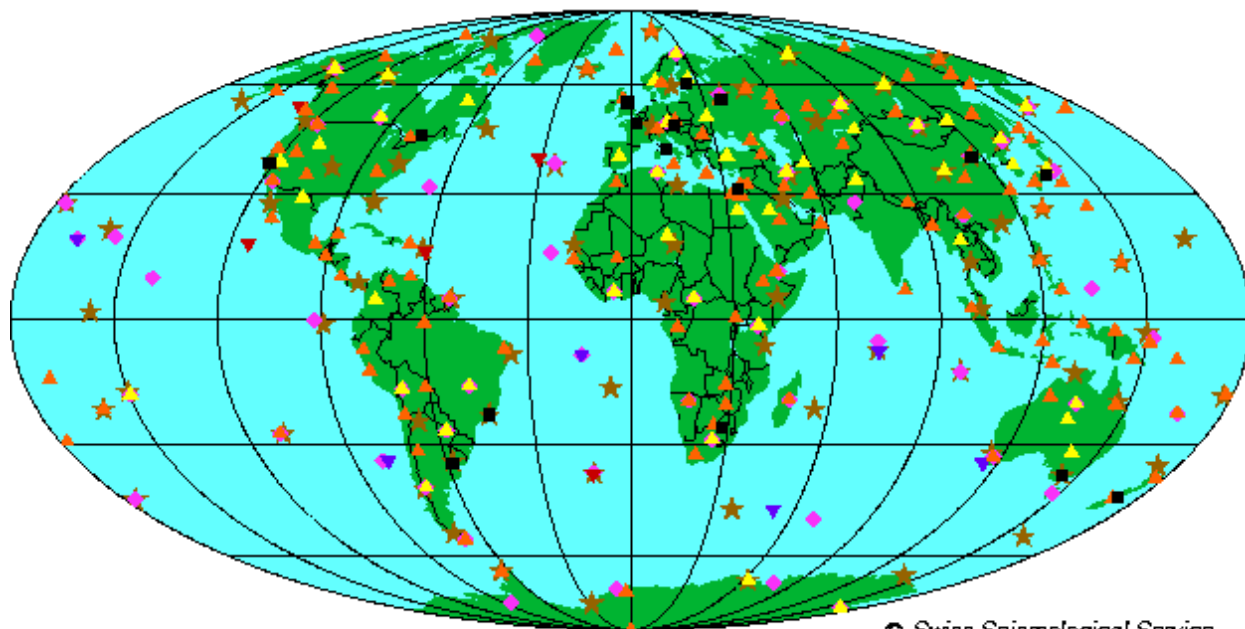
The explosion was large enough to generate surface waves in the Earth that were clearly recorded on IRIS/USGS Global Seismographic Network (GSN) stations up to 2000 km away.



Surface waves generated by the Russia meteor explosion and recorded by the IRIS/USGS Global Seismographic Network.

(Zhigang Peng, Georgia Tech)

The International Monitoring System (IMS) of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), which is designed to record nuclear explosions in the atmosphere and underground, clearly recorded the meteor explosion. The IMS uses four state-of-the-art technologies: seismic, hydroacoustic, infrasound and radionuclide. 44 stations of the IRIS/USGS GSN contribute to the IMS as auxiliary or primary stations.



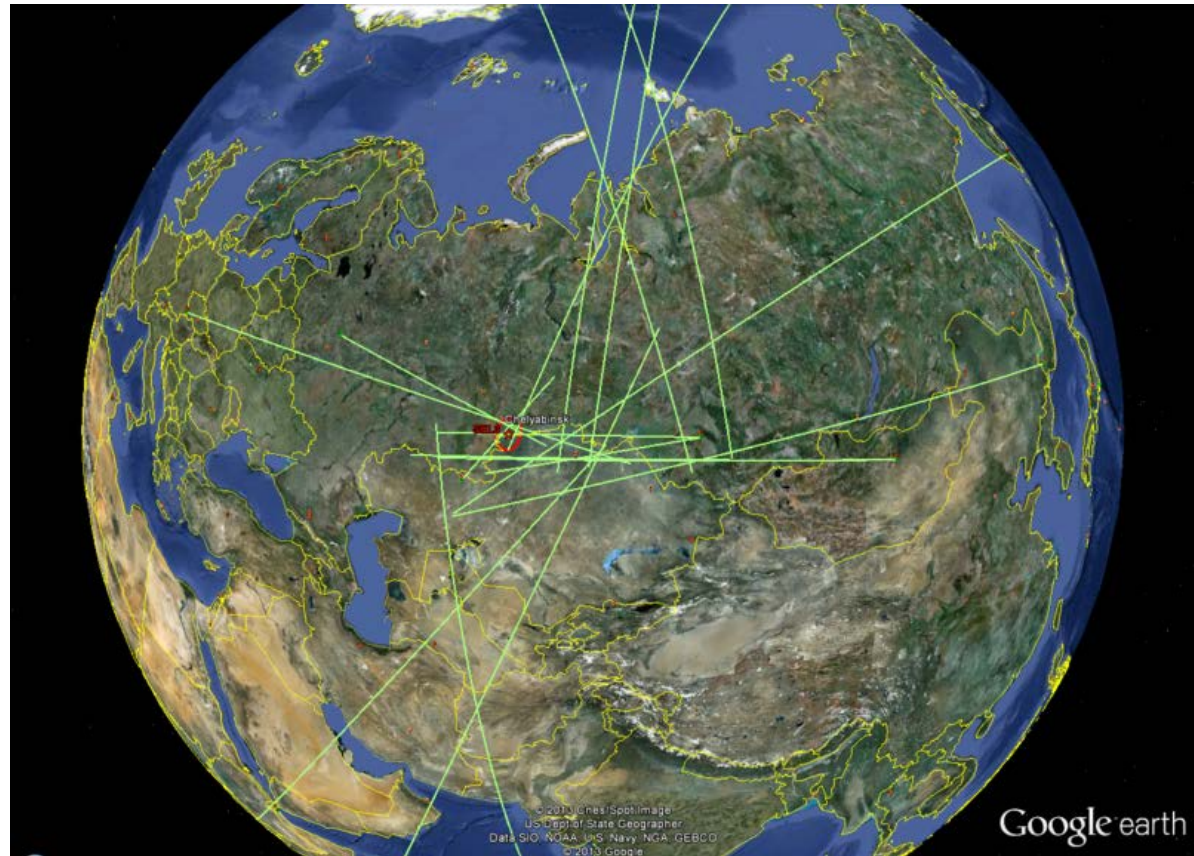
© Swiss Seismological Service

IMS network

- ▲ Primary Station
- ▼ T-phase Station
- ★ Radionuclide Station
- ◆ Infrasound Station
- ▲ Auxiliary Station
- ▼ Hydrophone Station
- Radionuclide Laboratory

The atmospheric waves – referred to as infrasound and observed at great distances over a broad range of sub-audible frequencies – were observed at much greater distances. The blast was detected by infrasound stations throughout the world, including 17 stations in the CTBTO's network.

The meteor blast was not a fixed explosion, Pierrick Mialle, an acoustic scientist for the CTBTO, said in a statement. Instead, the meteor was traveling faster than the speed of sound, burning up as it went. "That's how we distinguish it from mining blasts or volcanic eruptions," he said.



Infrasound stations in the CTBTO's network as far away as Antarctica tracked the blast's low-frequency waves as they traveled through Earth's atmosphere.

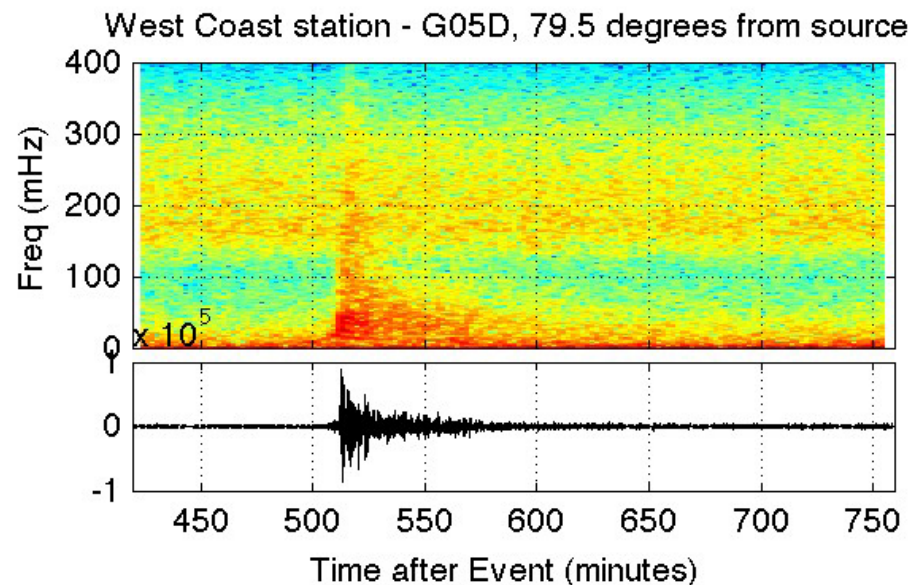
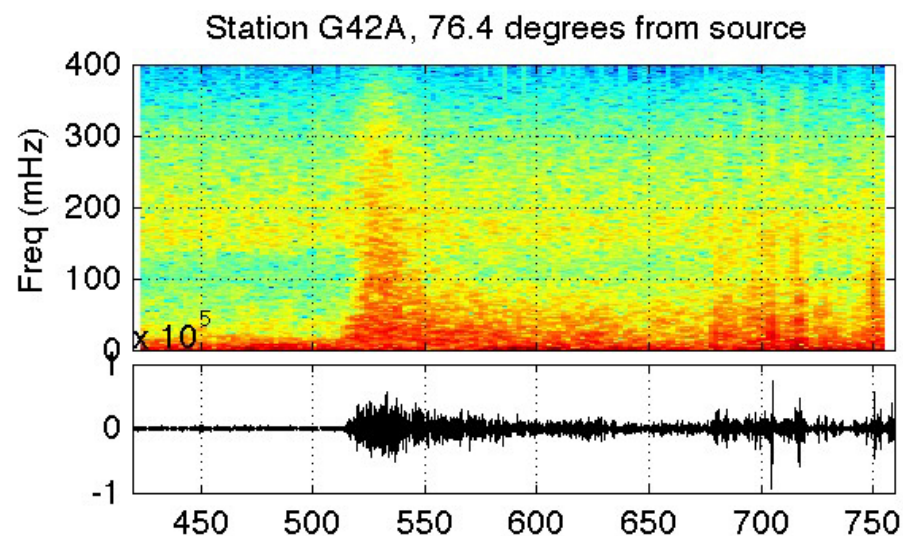
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People in the US could not hear the low frequency waves that were emitted in the atmosphere but the waves were recorded by an array of infrasound sensors in the US that are part of Earthscope's USArray.

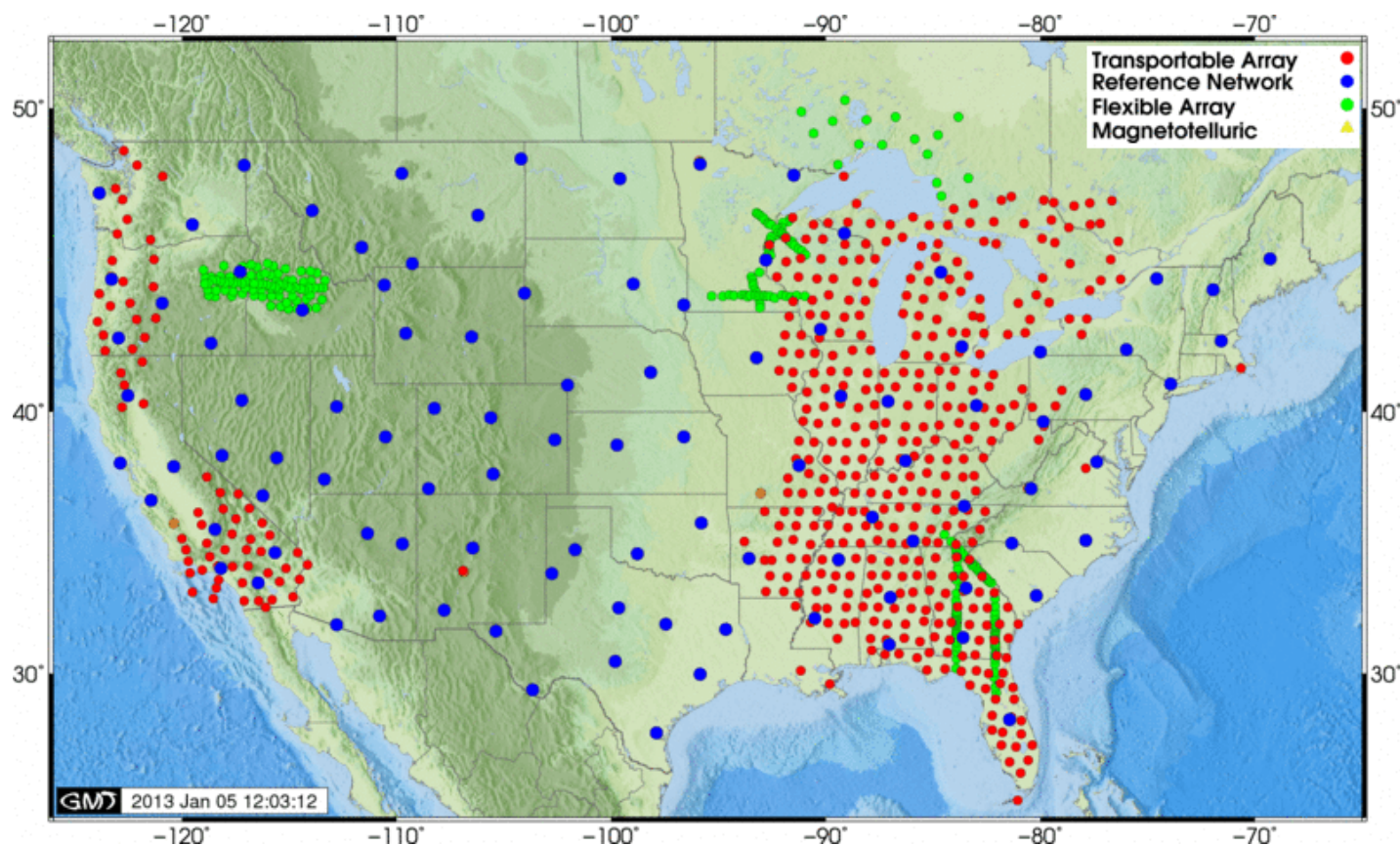
Spectrograms from two USArray
infrasound stations in Oregon (G05D)
and Wisconsin (G42A), LDF channel
Filtered between 0.02 – 0.12 Hz

(Catherine Degroot-Hedlin, UCSD)



USArray: A Continental-Scale Seismic Observatory

Each of the Transportable Array stations includes infrasound and seismic sensors.

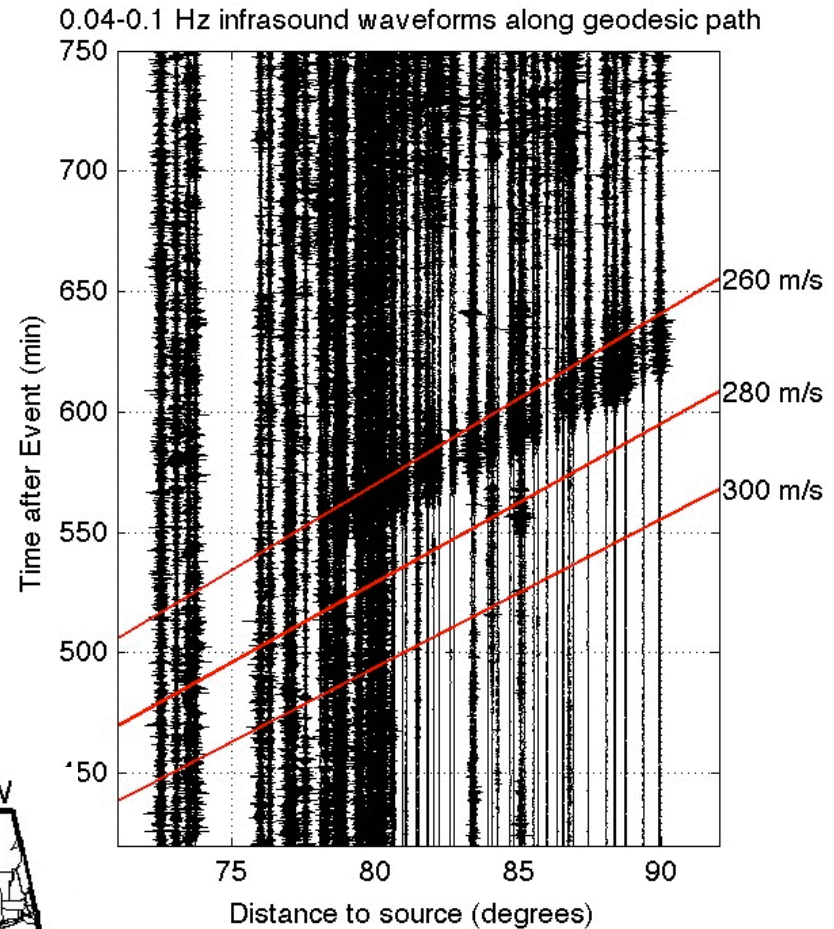
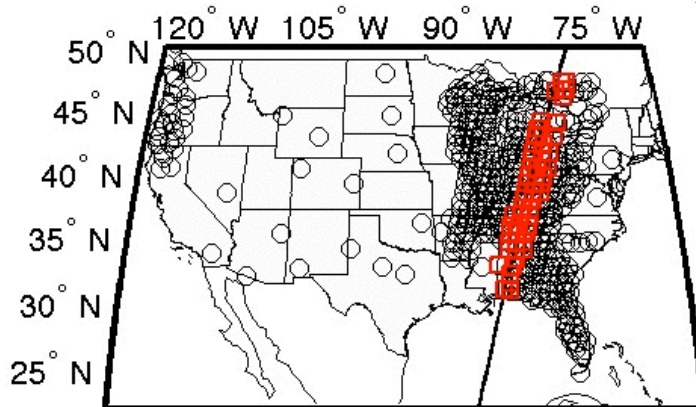


Operating USArray Stations. The 400 active transportable array stations are plotted in red. Permanent stations are plotted in blue.

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When the waves reached the eastern US, after almost 10 hours travelling through the atmosphere across the Arctic from the impact site in Russia, they were well recorded on special infrasound detectors installed at USArray stations extending from the midcontinent to the eastern seaboard. The spectacular USArray recordings from the meteor show complex arrivals lasting for almost an hour.



USArray infrasound, LDF channel, record section 5 filtered between 0.02-0.12 Hz.
(Catherin Degroot-Hedlin, UCSD)

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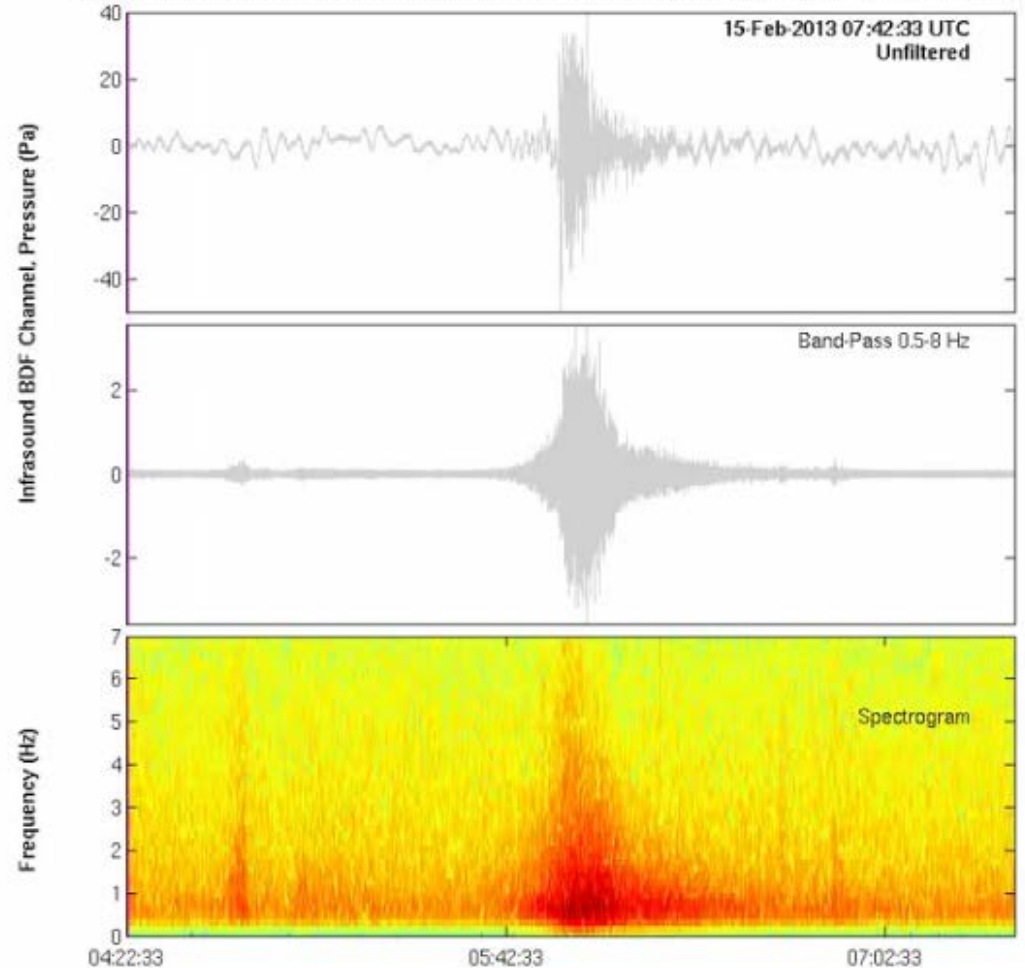
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The sound of the meteor blast, as recorded in Alaska by USArray station TOLK. The sound is sped up 500 times to make it audible to human ears.



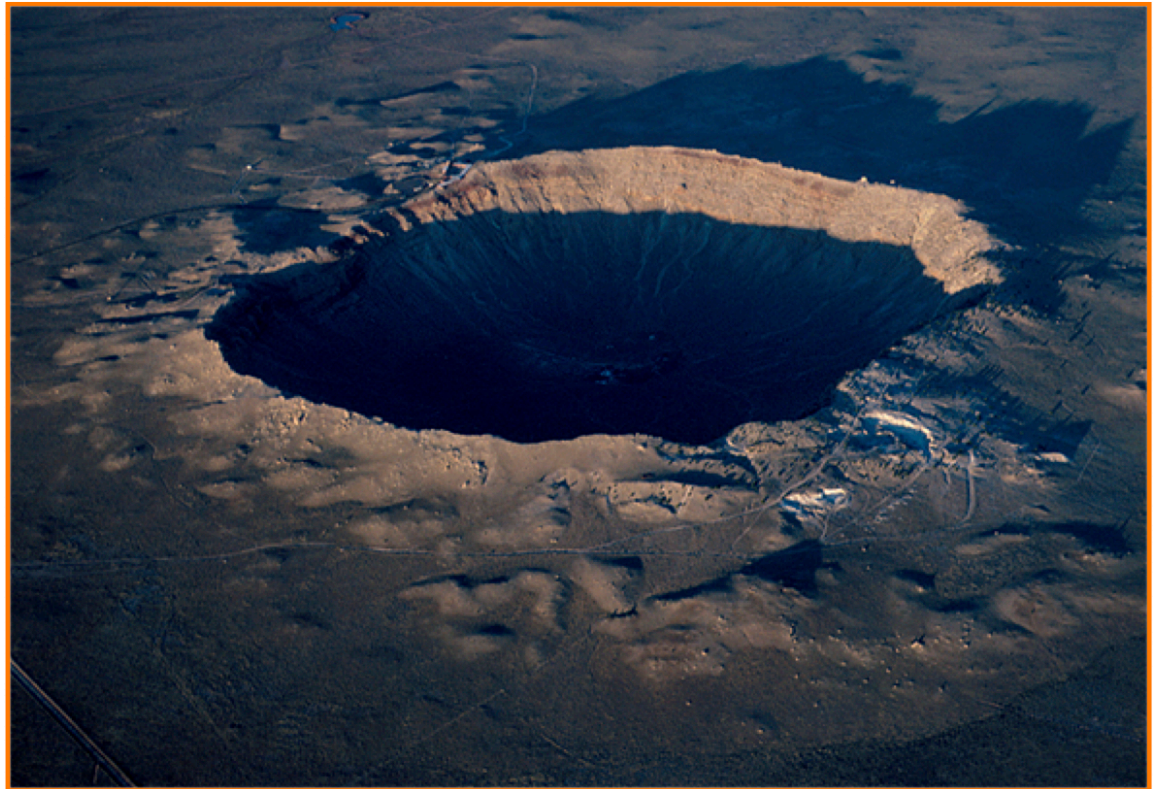
Google Earth

February 15, 2013, Russian Meteor, Infrasound BDF channel
Toolik Lake Research Station, Station TOLK, Distance 54.1°/6018 km, Azimuth 13.4°



Even larger impacts from space occurred before recorded human history.

Fifty thousand years ago, a rock about 46 m (150 feet) wide crashed into what is now Arizona. Today, Meteor Crater is nearly 1.6 km (1 mile) across, 3.9 km (2.4 miles) in circumference and more than 167 m (550 feet) deep.



Meteor Crater is a meteorite impact crater approximately 43 miles east of Flagstaff, near Winslow in the northern Arizona desert of the United States.