Incoming! Then outgoing! Waves generated by Russian meteor recorded crossing the US

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Meteor trail over eastern Russia is seen in this image from the Russian Emergency Ministry. Credit: Russian Emergency Ministry

(Phys.org) —A network of seismographic stations recorded spectacular signals from the blast waves of the meteor that landed near Chelyabinsk, Russia, as the waves crossed the United States.

The National Science Foundation- (NSF) supported stations are used to study earthquakes and the Earth's deep interior.

While thousands of earthquakes around the globe are recorded by seismometers in these stations—part of the permanent Global Seismographic Network (GSN) and EarthScope's temporary Transportable Array (TA)—signals from large meteor impacts are far less common.

The meteor explosion near Chelyabinsk on Feb. 15, 2013, generated ground motions and air pressure waves in the atmosphere. The stations picked up the signals with seismometers and air pressure sensors.

The ground motions were recorded by the GSN and the TA. The pressure waves were detected by special sensors that are part of the TA.

"The NSF-supported Global Seismic Network and EarthScope Transportable Array made spectacular recordings of the Chelyabinsk meteor's impact," says Greg Anderson, program director in NSF's Division of Earth Sciences.

"These recordings of seismic waves through the Earth, and sound waves through the atmosphere, are good examples of how these facilities can help global organizations better monitor earthquakes, clandestine nuclear tests and other threats."

Incoming! Then outgoing!

The Chelyabinsk meteor exploded in the atmosphere at approximately 9.20 a.m. local time.

The blast caused significant damage in the city, breaking thousands of windows and injuring more than 1,000 people.

Energy from the blast created pressure waves in the atmosphere that moved rapidly outward and around the globe. The blast also spread within the Earth as a seismic wave.

The two wave types—seismic wave and pressure wave—travel at very different speeds.

Waves in the ground travel quickly, at about 3.4 kilometers per second. Waves in the atmosphere are much slower, moving at about 0.3 kilometers per second, and can travel great distances.

Trajectory of the meteor as it neared impact in Russia. Credit: Wikimedia Commons

GSN stations in Russia and Kazakhstan show the ground-traveling wave as a strong, abrupt pulse with a duration of about 30 seconds.

The atmospheric waves—referred to as infrasound—were detected across a range of inaudible frequencies and were observed at great distances on infrasound microphones.

When the infrasound waves reached the eastern United States—after traveling 8.5 hours through the atmosphere across the Arctic from the impact site in Russia—they were recorded at TA stations at the Canadian border.

The infrasound waves reached Florida three hours later, nearly 12 hours after the blast.

Is it a bird, a plane, a...meteor? A view of the meteor as it streaked by buildings in Russia. Credit: Russian Emergency Ministry

Infrasound sensors at TA stations along the Pacific coast and in Alaska also recorded the blast, but with signatures that were shorter and simpler than those recorded by stations in the mid-continent and along the southeastern seaboard.

The duration of the signals, and the differences between the waveforms in the east and west, scientists believe, are related to the way in which energy travels and bounces on its long path through the atmosphere.

EarthScope Transportable Array

The Transportable Array is operated by the IRIS (Incorporated Research Institutions for Seismology) Consortium as part of NSF's EarthScope Project. It consists of 400 stations traversing the United States, recording at each site along the way for two years.

Each of the TA stations was originally equipped with sensitive broadband seismometers for measuring ground motions, but in 2010, NSF awarded the University of California, San Diego, in cooperation with IRIS, funding to add pressure and infrasound sensors.

These special sensors help scientists understand how changes in pressure affect ground motions recorded by the TA's seismometers and provide a view of regional pressure changes related to weather patterns.

The sensors also record events such as tornadoes, derechos, rocket launches, chemical explosions—and meteor impacts.

The Chelyabinsk meteor is the largest signal recorded to date.

Provided by National Science Foundation

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