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Airbursts

This image of a vapor trail was captured about 125 miles (200 kilometers) from the February 2013 Chelyabinsk meteor event, about one minute after the house-sized asteroid entered Earth's atmosphere.

Credit: By NASA, Alex Alishevskikh

Each year, millions of pebble-sized meteors strike Earth's atmosphere and burn up harmlessly.

But once a century, a house-sized meteor makes contact—and explodes in the air with devastating results.

In 2013, one such airburst occurred in Russia.

The Chelyabinsk meteor broke apart miles above the surface, with 30 times the force of the Hiroshima atomic bomb.

It blew out a million windows over 200 square miles and injured 1,600 people.

In 1908, near the remote Russia-Mongolia border, a larger airburst occurred.

Scientists who arrived on the scene found it had flattened 80 million trees over 800 square miles.

Events like this happen every millennium, and in 1700 BC, there was an even bigger one.

North of the Dead Sea, in what is now Jordan, 50,000 people were vaporized in an instant.

A flash of extreme heat, over 7200 degrees Fahrenheit, disintegrated houses, melted sand and stone, and turned pottery to glass.

A tidal wave of boiling saltwater swept inland, poisoning the soil. The area, which had been continuously inhabited for 2,500 years before that, lay desolate for 600 years after.

Since the Chelyabinsk meteor in 2013, NASA initiated a program to identify and track objects within 5 million miles of Earth that could enter our atmosphere and cause an airburst.

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Background: Airbursts

Synopsis: Tons of pebble-sized and smaller meteors disintegrate in Earth's atmosphere every day, while much-rarer huge asteroid impacts that may liquefy Earth's surface and change the trajectory of life strike every few million years. But what happens when mid-sized objects smash into the planet? In 2013 and 1908, we witnessed dramatic airbursts over southern Russia, and researchers have found evidence of a similar event that wiped out thriving Middle Eastern communities 3,700 years ago.

- When huge asteroids slam into Earth, they create huge impact craters and may cause global extinctions, as we have described in previous *EarthDate* episodes about the dinosaur-killing Chicxulub impact crater near Mexico's Yucatan Peninsula.
- On the other end of the spectrum, we rarely notice the sand-grain- to boulder-sized space objects that pummel Earth every day, burning up in the atmosphere.
- But what happens to space objects that are in between these two end members? Here are some important definitions of these objects.
  - **Comets** are large icy objects in space.
  - **Asteroids** are large rocky or metallic objects in space.
  - **Meteoroids** are small objects in space that may be icy, rocky or metallic, but that range from sand-sized to boulder-sized—up to 3 ft (1 m) wide.
  - **Meteors** are space objects that have contacted Earth's atmosphere and are beginning to incinerate, creating a visible vapor trail. Sometimes these are referred to as shooting stars, but if they are exceptionally bright they are called **bolides** or **fireballs**.
  - **Airbursts** are violent explosions that occur when mid-sized meteors streak through the atmosphere, disaggregating as they begin to burn up.
  - If a space object makes it through the atmosphere and hits Earth, it probably started as an asteroid, but once it hits the surface it is called a **meteorite**.
- On February 15, 2013, a dramatic airburst occurred just north of Russia's border with Kazakhstan near the town of Chelyabinsk, providing an unprecedented view of what happens when mid-sized asteroids streak through our atmosphere.
  - Many buildings and Russian cars are equipped with video cameras that captured the event from a variety of perspectives, enabling scientists to reconstruct the meteor's violent entry into Earth's atmosphere.
  - Here is their interpretation: A stony asteroid about the size of a house or small building (55-65 ft or 17-20 m diameter), weighing about 10,000 tons, entered the atmosphere at a velocity of 40,000 mph (64,400 km/h) and broke apart 12-15 mi (19-24 km) above ground, generating a shock wave that was the equivalent of a 470-kiloton TNT explosion—30-40 times stronger than the Hiroshima bomb.
  - It triggered seismometers as far away as Antarctica, and dust stayed in the atmosphere for months.
  - The airburst blew out more than a million windows over a 200-mi² (500-km²) area and injured 1,600 people. Miraculously, no one died.
  - Within three days, meteorites were found, one as large as a desk. These objects are still under study, providing clues about the origins of our solar system.
  - Scientists estimate that objects of this size probably impact Earth every 10 to 100 years.

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References: Airbursts

An Exploding Meteor May Have Wiped Out Ancient Dead Sea Communities | Science News
Tunguska Revisited: 111-year-old Mystery Impact Inspires New, More Optimistic Asteroid Predictions | Phys.org
Five Years after the Chelyabinsk Meteor: NASA Leads Efforts in Planetary Defense | NASA
Chelyabinsk Meteor: A Wakeup Call for Earth | Space.com

Contributors: Juli Hennings, Harry Lynch

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Background: Airbursts

Fallen trees at Tunguska, 1927.

Credit: By CYD [Public domain]

- On June 30, 1908, an airburst event is believed to have occurred farther east near the town of Tunguska, north of Russia's border with Mongolia.
  - Although it took scientific parties until 1920 to make the trek to the extremely remote area in the Irkutsk region to investigate, the evidence of the airburst was obvious: It blew down more than 80 million trees in a radial pattern over 830 mi² (2,150 km²).
  - It is thought to have killed at least three people, but no impact crater or meteorite has yet been located.
  - Researchers think that this airburst occurred 6-9 mi (10-15 km) above Earth's surface as a 160- to 260-ft- (50- to 80-m)-wide stony body exploded with a shock wave that would have registered 5.0 on the Richter earthquake magnitude scale.
  - It was a 10- to 30-megaton explosion, 500 to 2,000 times stronger than the Hiroshima bomb, and possibly the equivalent of an airborne Mount St. Helens explosion.
  - Scientists estimate that these types of events occur on average once every millennium.
- In 2018, scientists found evidence of a similar event that occurred 3,700 years ago—around 1700 BC—in the land of Middle Ghor in the Middle East, north of the Dead Sea.
  - The region is now in Jordan, and 13 years of archaeological finds in five large sites demonstrate that it was continuously inhabited for more than 2,500 years until a sudden calamity brought an end to civilization in the area.
  - About 120 prosperous settlements occupied by 40,000-65,000 people in an area more than 200 mi² (500 km²) in diameter suddenly were abandoned, marked by evidence of extreme heat and wind.
  - Radiocarbon dating indicates that 3,700 years ago, the adobe-type mud-brick walls of all aboveground structures disappeared suddenly, leaving only the stone foundations.
  - At the center of the presumed airburst was the town of Tall el-Hammam, where 3,700-year-old pottery was found to be quite unusual.
    - The exposed surfaces had turned to glass, or vitrified.
    - Zircon crystals within the pottery had been turned into a gas—requiring a temperature above 7230°F (4000°C).
    - However, parts of the same vessels that were buried in the ground were unaffected, indicating the incredibly intense heat was incredibly brief, possibly lasting for just 1 second.
    - High winds distributed tiny spherical grains of melted rock, some of which stuck to the ancient vitrified pottery surfaces as they cooled.
  - The shock wave from the event covered the eastern part of the fertile farming region with boiling tidal waves of salt- and sulfur-rich brines that were swept ashore from the Dead Sea.
  - It took 600 years for the soil to recover enough for civilization to reestablish farming in the area of the poisoned land.
  - No impact craters or meteorites have been found in the area.
  - The searing heat may reflect an explosion that occurred much closer to the ground than the more recent Russian airbursts.

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- On the day the Chelyabinsk airburst occurred in 2013, a UN committee on Near Earth Objects (NEOs) was meeting in Vienna, Austria, to finalize a recommendation about how to defend Earth from these frightening events. NASA Planetary Defense Officer Lindley Johnson called the Russian airburst a "cosmic wakeup call."
  - NASA's NEO Observations Program focuses on finding asteroids 460 ft (140 m) or larger. This size range starts about seven to eight times larger than the Chelyabinsk object.
  - Five years later, scientists have increased their NEO database by 84 percent, discovering more than 17,500 NEOs. More than 8,000 of the larger ones are now being tracked, but many more remain to be found.
  - In 2016, NASA established a Planetary Defense Coordination Office to ensure early detection of potentially hazardous objects within 5 million mi (8 million km) of Earth, and to provide communications and response regarding threats.
  - Many technologies are being tested to track and respond to impacts, including kinetic impact nudging of asteroids—basically nudging the objects off-course so they head away from Earth.
  - Since 2013, a few objects the size of the Chelyabinsk meteor have flown inside of our moon's orbit, and some have surprised us.
  - The Large Synoptic Survey Telescope in Chile will make us better able to detect NEOs starting in the 2020s.

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