

Broken glass yields clues to climate change

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Dust particles in the atmosphere range from about 0.1 microns to 50 microns in diameter (microns are also known as micrometers, abbreviated as μm). The size of dust particles determines how they affect climate and weather, influencing the amount of solar energy in the global atmosphere as well as the formation of clouds and precipitation in more dust-prone regions. The NASA satellite image in this illustration shows a 1992 dust storm over the Red Sea and Saudi Arabia. Credit: Composite illustration ©UCAR. This image is freely available for media use. Please credit the University Corporation for Atmospheric Research.

Clues to future climate may be found in the way that an ordinary drinking glass shatters. A study appearing this week in *Proceedings of the National Academy of Sciences* finds that microscopic particles of dust,

emitted into the atmosphere when dirt breaks apart, follow similar fragment patterns as broken glass and other brittle objects. The research, by National Center for Atmospheric Research (NCAR) scientist Jasper Kok, suggests there are several times more dust particles in the atmosphere than previously believed, since shattered dirt appears to produce an unexpectedly high number of large dust fragments.

The finding has implications for understanding future [climate change](#) because dust plays a significant role in controlling the amount of solar energy in the atmosphere. Depending on their size and other characteristics, some [dust particles](#) reflect solar energy and cool the planet, while others trap energy as heat.

"As small as they are, conglomerates of dust particles in soils behave the same way on impact as a glass dropped on a kitchen floor," Kok says. "Knowing this pattern can help us put together a clearer picture of what our future climate will look like."

The study may also improve the accuracy of weather forecasting, especially in dust-prone regions. Dust particles affect clouds and precipitation, as well as temperatures.

Shattered soil

Kok's research focused on a type of airborne particle known as mineral dust. These particles are usually emitted when grains of sand are blown into soil, shattering dirt and sending fragments into the air. The fragments can be as large as about 50 microns in diameter, or about the thickness of a fine strand of human hair.

The smallest particles, which are classified as clay and are as tiny as 2 microns in diameter, remain in the atmosphere for about a week, circling much of the globe and exerting a cooling influence by reflecting heat

from the Sun back into space. Larger particles, classified as silt, fall out of the atmosphere after a few days. The larger the particle, the more it will tend to have a heating effect on the atmosphere.

Kok's research indicates that the ratio of silt particles to clay particles is two to eight times greater than represented in climate models.

Since climate scientists carefully calibrate the models to simulate the actual number of clay particles in the atmosphere, the paper suggests that models most likely err when it comes to the number of silt particles. Most of these larger particles swirl in the atmosphere within about 1,000 miles of desert regions, so adjusting their quantity in computer models should generate better projections of future [climate](#) in desert regions, such as the southwestern United States and northern Africa.

Additional research will be needed to determine whether future temperatures in those regions will increase more or less than currently indicated by computer models.

The study results also suggest that marine ecosystems, which draw down carbon dioxide from the atmosphere, may receive substantially more iron from airborne particles than previously estimated. The iron enhances biological activity, benefiting ocean food chains, including plants that take up carbon during photosynthesis.

In addition to influencing the amount of solar heat in the atmosphere, dust particles also get deposited on mountain snowpacks, where they absorb heat and accelerate melt.

Glass and dust: Common fracture patterns

Physicists have long known that certain brittle objects, such as glass or rocks, and even atomic nuclei, fracture in predictable patterns. The

resulting fragments follow a certain range of sizes, with a predictable distribution of small, medium, and large pieces. Scientists refer to this type of pattern as scale invariance or self-similarity.

Physicists have devised mathematical formulas for the process by which cracks propagate in predictable ways as a brittle object breaks. Kok theorized that it would be possible to use these formulas to estimate the range of dust particle sizes. He turned to a 1983 study by Guillaume d'Almeida and Lothar Schueth from the Institute for Meteorology at the University of Mainz in Germany that measured the particle size distribution of arid soil.

By applying the formulas for fracture patterns of brittle objects to the soil measurements, Kok determined the size distribution of emitted dust particles. To his surprise, the formulas described measurements of dust particle sizes almost exactly.

"The idea that all these objects shatter in the same way is a beautiful thing, actually," Kok says. "It's nature's way of creating order in chaos."

Provided by National Center for Atmospheric Research

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