Using 3D Laser Scanning Technology to Create Digital Models of Hailstones

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Using 3D Laser Scanning Technology to Create Digital Models of Hailstones

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Abstract

The emergence of 3D scanning technologies has provided a new opportunity to explore the shape characteristics of hailstones in great detail. The ability to effectively map the shape of hailstones will improve assessments of hailstone aerodynamic properties, how their density relates to their strength, and how radar energy is scattered. Ultimately, 3D scanning of hailstones will contribute toward research in hail detection, forecasting, and damage mitigation of severe hail, which accounts for well over $1 billion in annual insured losses.

The use of a handheld 3D laser scanner in a field setting was explored during field campaigns in 2015 and 2016. Hailstones were collected following thunderstorm passages and were measured, weighed, and scanned. The system was successful in capturing 3D models of over 40 hailstones. A full scan takes approximately three minutes to complete and data can be captured at a resolution of 0.008 cm. It is believed this is the first time such a system has been used to produce 3D digital hailstone models. Analysis of the model data has showed that hailstones depart from spherical shapes as they increase in diameter and that bulk density and strength show little correlation. While the dataset presented here is small, the use of 3D scanners in the field is a practical method to obtain detailed datasets on hailstone characteristics. In addition, these data could be used to 3D-print hailstones to explore their aerodynamics, to produce cavity molds for ice impact tests, and for modeling radar scattering properties of natural hailstone shapes.

3D laser scanning and hail

Hailstorms account for over $1 billion dollars in annual insured property losses and their increasing trend seen over the past two decades has outpaced advances in observation, forecasting, and mitigation of hail damage (Changnon et al. 2009; Roeder 2012; Kunkel et al. 2013). Beginning in 2012, the Insurance Institute for Business & Home Safety (IBHS) began a comprehensive research program with the overarching goal to help mitigate property losses from severe hail. A component of this initiative included determining the properties of hailstones that must be accounted for in laboratory material impact tests such that the results of these standardized test methods would be reasonably predictive of real-world performance of building materials. Subsequently, this led to a field campaign to measure the physical and material properties of hail and to explore emerging technologies to aid in this effort.

It is well known that hailstones are found in a variety of non-homogeneous shapes and can have large protuberances, which makes characterizing their true shape difficult using conventional means (i.e., caliper or ruler). Obtaining an accurate volume through physical measurements is also difficult even when measuring multiple dimensions. In the past, record-breaking hailstones were kept in cold storage so a cast could be made of the hailstone. The impact craters of giant hailstones have also been examined and molds made of their shapes as well (Knight and Knight 2001). While the process is effective in capturing the hailstone shape, it is cumbersome and time-consuming. A method was needed that provided accurate 3D measurement data without substantial contamination or melting of the hailstone prior to strength testing. The fine-scale, non-homogeneous nature of hailstones provided the motivation to investigate how 3D laser scanners could be applied toward hail research.

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