The Chelyabinsk meteor

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A review is given about what was learned about the 0.5-Mt Chelyabinsk airburst of 15 February 2013 by field studies, the analysis of recovered meteorites, and numerical models of meteoroid fragmentation and airburst propagation. Previous events with comparable or larger energy in recent times include only the 0.5-Mt -sized 3 August 1963 meteor over the south Atlantic, for which only an infrasound signal was recorded, and the famous Tunguska impact of 1908. Estimates of the initial kinetic energy of the Tunguska impact range from 3 to 50 Mt, due to the lack of good observations at the time. The Chelyabinsk event is much better documented than both, and provides a unique opportunity to calibrate the different approaches used to model meteoroid entry and calculate the damaging effects of a shock wave from a large meteoroid impact. A better understanding of what happened might help future impact hazard mitigation efforts by calibrating models of what might happen under somewhat different circumstances.

The initial kinetic energy is estimated from infrasonic signals and the fireball's lightcurve, as well as the extent of the glass damage on the ground. Analysis of video observations of the fireball and the shadow movements provided an impact trajectory and a record of the meteor lightcurve, which describes how that energy was deposited in the atmosphere. Ablation and fragmentation scenarios determine the success of attempts to reproduce the observed meteor lightcurve and deceleration profile by numerical modeling. There was almost no deceleration until peak brightness. Meteoroid fragmentation occurred in different forms, some part of the initial mass broke in well separated fragments, the surviving fragments falling on the ground as meteorites. The specific conditions during energy deposition determined the fraction of surviving mass. The extent of the glass damage was mapped by visiting over 50 villages in the area. A number of numerical simulations were conducted that attempted a more realistic release of energy along the trajectory and these results were compared with observations of blast wave arrival times and the extent of the glass damage. The shape of the damaged area could be explained from the fact that the energy was deposited over a range of altitudes. The study of the recovered meteorites provided insight into why the Chelyabinsk meteoroid broke at a relatively high altitude. Its material properties were determined by events that may date back to the Earth-Moon impact event.