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Modelling Hail Impact, part 1: How many hail stones of what size?

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A variety of aggregated variables are used in order to characterize the potential impact of hail on property and vehicles. Maximum hailstone size and hail-kinetic energy are two of them.

However, the maximum hailstone size need not to be the largest contributor to losses. And large hail kinetic energies can be generated by many small or few large stones. While many small stones may not cause damage to property at all, few large stones can just miss small objects at risk like cars or solar panels.

We aim to characterize hail events by less aggregated variables than maximum hailstone size or hail-kinetic energy.

To do so we analyse the 22,000 hail observations from the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS). These data provide minimum, mean and maximum hailstone size, duration of hail and overall hailstone number density at the ground.

We use this data to fit a Marshall-Palmer distribution that allows modelling the rate of hail stones hitting the ground per unit area, time and size bin during the passage of a hail storm.

One result of the model is that event hail-kinetic energy goes approximately with the squared maximum hailstone size. This is in line with observations by Auer (MWR, 1972).

As a validation experiment the results of this model are compared to observations of hail kinetic energy and maximum hailstone size in Southern France published by Fraile et al. (AR, 2003).

The model can be used for Monte-Carlo simulations of hail fall on various components of subjects at risk.

In part two of this contribution an engineering fragility model is introduced that combines modelled hail hazard with material resistance and their uncertainties to probabilistically assess building vulnerability and estimate financial consequences.