OUT OF THE

TEXT: TIM SCHRÖDER

Severe hailstorms frequently cause enormous amounts of damage in Germany. But where, when and why hail falls from the sky still remain poorly understood aspects. Accordingly, stakeholders like insurers want to be better informed about hail-related risks. REKLIM researchers in Karlsruhe have now estimated the hail risk from different datasets and investigated how the likelihood of hailstorms is being affected by climate change.

Hailstorms aren't just a threat to car owners: the clumps of ice, which can reach tennis-ball size, can also damage roofs, house fronts, solar panels, greenhouses and crops.

For the residents of Reutlingen, it felt like they were being bombarded. On 28 July 2013 a severe thunderstorm swept over the city, raining down golf-ball-sized and tennis-ball-sized hailstones on the city and neighbouring towns. The clumps of ice shattered roof shingles, house fronts, greenhouses and solar panels, and dented cars. In the fields, they battered the crops.

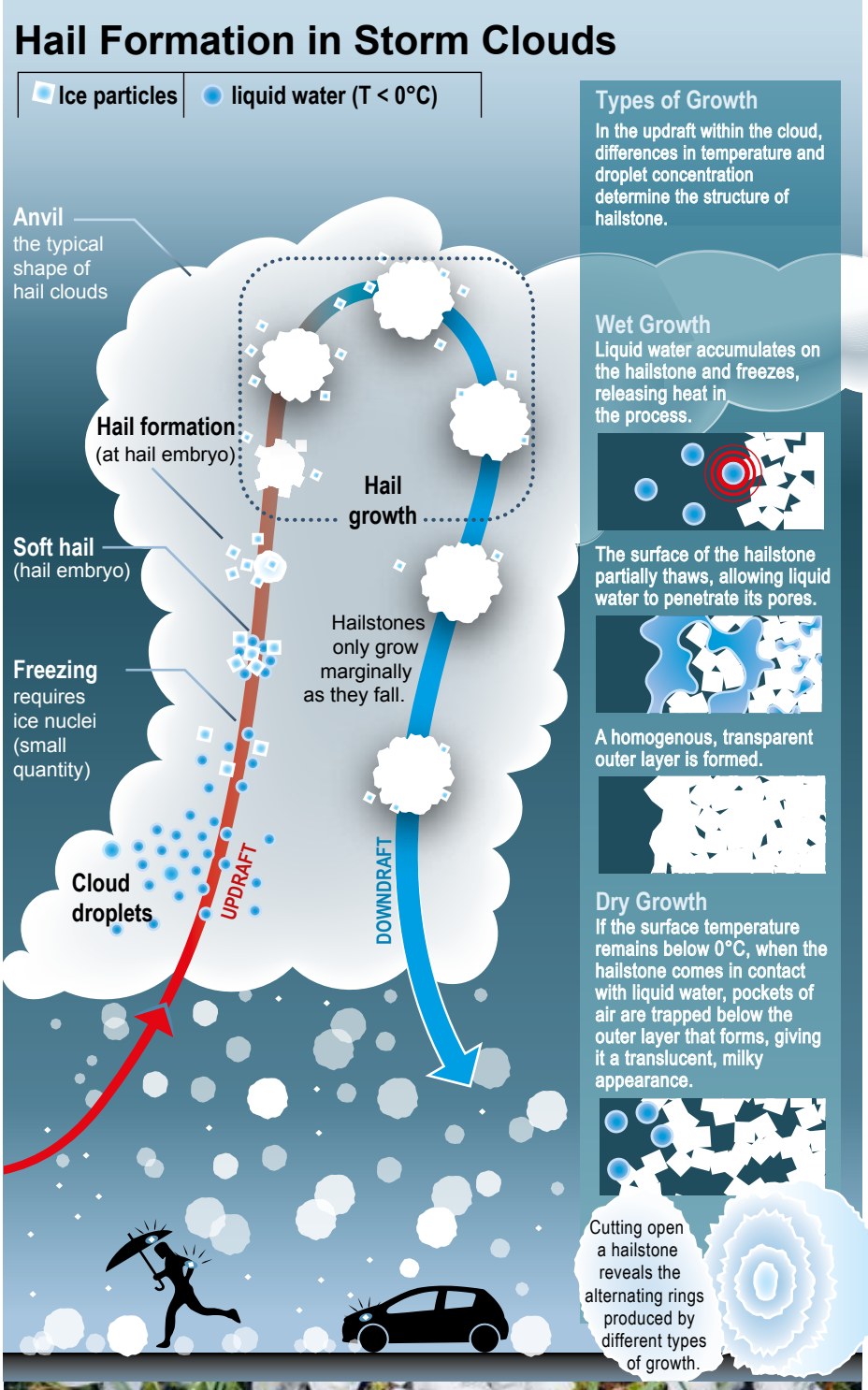
Though the hailstorm lasted just a few minutes, the damage was immense, with more than one billion euros in insured losses. Yet, despite hail's destructive potential, it has long been overlooked in Germany. In addition, hail normally affects only very small areas, since thunderstorms usually have a diameter of roughly ten kilometres. But hail, as the example from Reutlingen shows, is a serious risk. In Germany and in Europe, hail is responsible for around 40 percent of the insured losses from natural catastrophes, putting it on par with the losses produced by winter storms (43 percent).

Knowledge gap regarding hail

In 2010 the meteorologist Prof Michael Kunz began developing methods suitable for estimating hail hazards and related risks. Today he and his colleagues at the Karlsruhe Institute of Technology (KIT) can in fact say with considerable reliability where and how frequently severe hailstorms occur. In this regard, the experts have developed a corresponding hazard and damage model. Kunz's work is also interesting for insurers. "Hail isn't measured by conventional ground-based meteorological stations, unlike temperature or precipitation," Kunz explains. As a result, when it comes to hail, the concrete data that is urgently needed is very hard to come by.

Essential data for insurers

Insurance companies need to know, for example, how much damage a so-called 'one in two hundred year event' can cause. These extreme events, statistically speaking, only occur once every 200 years. According to a European Union regulation, the Solvency II Directive, insurance companies must be capable of covering losses from 1:200 events using their own resources or through reinsurance policies. "When we know how often hailstorms are likely to hit a given region, we can then combine that information with maps of the local buildings to estimate the maximum potential damage," says Dr Klaus Zehner, Deputy Chairman of the Board of the SV Sparkassen Insurance (Sparkassenversicherung) in Stuttgart. "The hail damage mo-

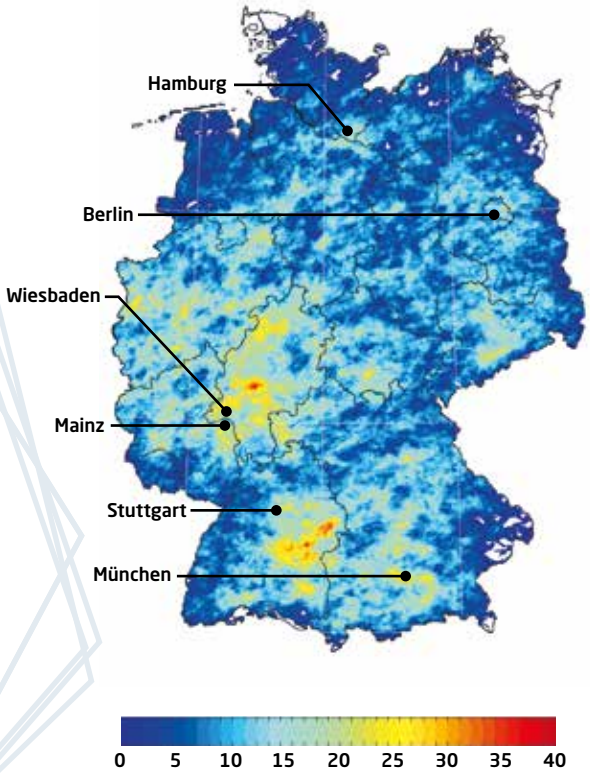


Largest hailstone:
14.1 cm diameter

FROM SMALL TO FIST-SIZED

On 6 August 2013, a hailstone measuring 14.1 centimetres in diameter fell from the sky in the town of Undingen, Swabian Jura. But such huge hailstones are an exception to the rule; in roughly half of all hailstorms in Germany, the stones are only one to two centimetres in diameter.

Average size:
ca. 2 cm diameter



MORE HAILSTORMS IN THE SOUTHWEST

This map of Germany shows the total number of summer days with hailstorms from 2005 to 2018, and indicates that it hails much more often in southwest Germany than in the north or northeast. The explanation: in addition to its warmer climate, the region is home to mountain ranges like the Black Forest and Spessart, and storms often form on the lee side of these ranges.

del developed by Michael Kunz and his team supplies us with the information we need."

Computational model compensations for lack of data

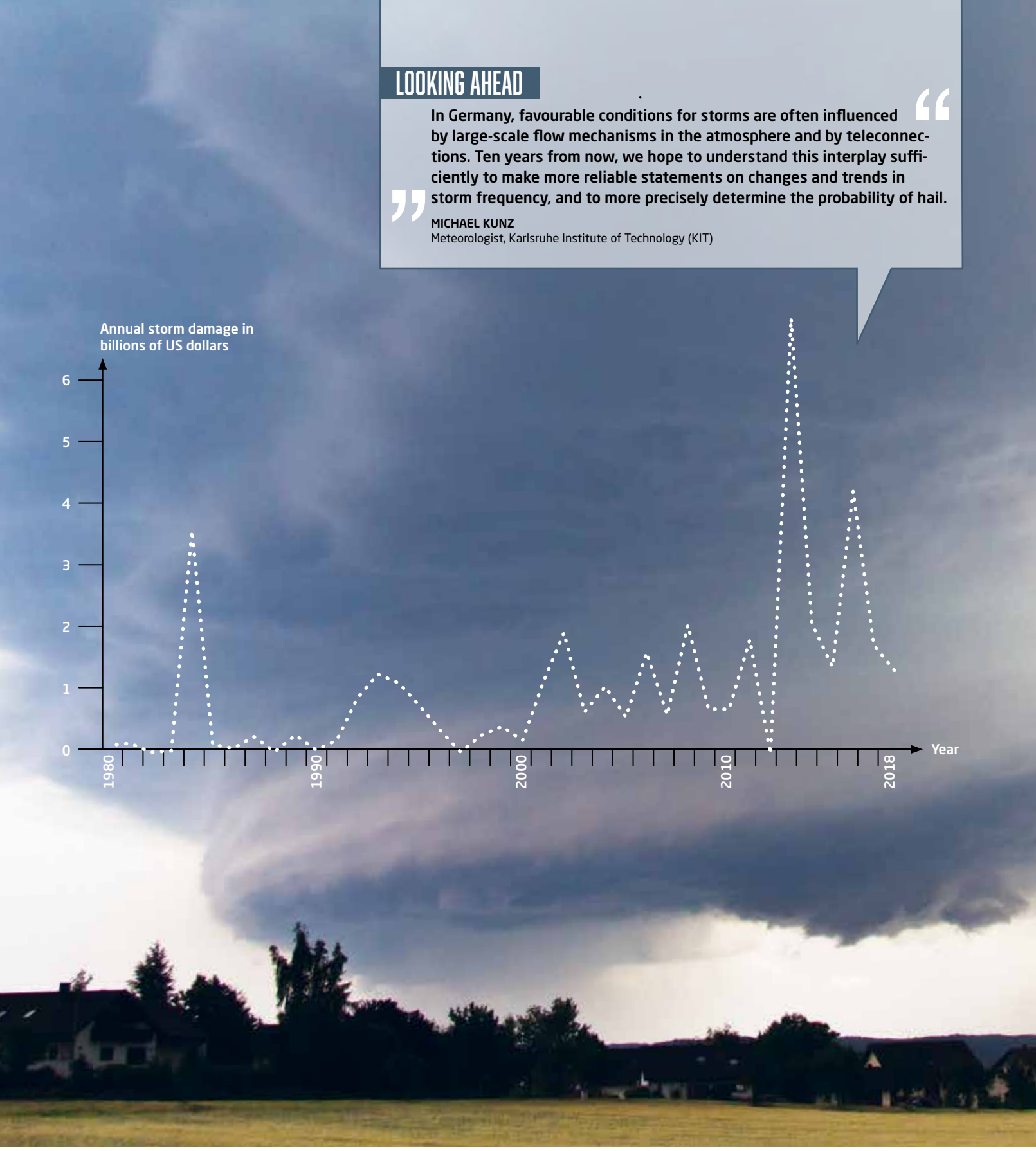
More precisely, Dr Manuel Schmidberger, who wrote his PhD on the topic under the supervision of Michael Kunz, uses data from the German Meteorological Service's radar stations; spread across Germany, they record all precipitation, including hail. Since radar data has only been archived since 2005, the timeframe is too short to draw reliable conclusions regarding the frequency and intensity of hailstorms. Nevertheless, the available data can be comprehensively analysed. First, the computer is 'fed' the data on actual hailstorm events in Germany. These events are then stochastically simulated over a long period of time – e.g., over 10,000 years – and thus multiplied. The computer model can then calculate how often these events occur, where they propagate and how severe they can be. As Michael Kunz explains: "On the basis of real events, the computer synthesises new ones, which it distributes over several thousand years. That gives us a wealth of synthetic events, which allows us to estimate the hail hazard at each grid point in Germany – regardless of whether this point has been affected in the past or not. Here the most important aspect is that the synthetic hailstorms do not modify the observed hail climatology."

In the insurance sector, stochastic simulation is a tried and proven tool for estimating the frequency and scale of damaging events that occur only rarely. "With the help of the hail model, we're now able to estimate the width, length and form of the hailstorm tracks in both Germany and France," says Kunz. As such, the computational model delivers the information insurance companies need in order to assess the consequences for their portfolio of insured assets. In addition to

LOOKING AHEAD

> In Germany, favourable conditions for storms are often influenced by large-scale flow mechanisms in the atmosphere and by teleconnections. Ten years from now, we hope to understand this interplay sufficiently to make more reliable statements on changes and trends in storm frequency, and to more precisely determine the probability of hail.

MICHAEL KUNZ
Meteorologist, Karlsruhe Institute of Technology (KIT)



We know that hail is produced in anvil-shaped storm clouds like this one. However, given the complex physical processes involved in their formation, we are still unable to predict hailstorms with pinpoint accuracy.

TALLYING UP THE DAMAGE

According to data from the Munich Reinsurance Company, severe storms accompanied by lightning, hail, gale-force winds and flash floods are doing more and more damage in Germany. On the one hand, this is due to the growing frequency of extreme weather events; on the other, buildings, vehicles and infrastructures are often more susceptible to damage.

the Sparkassen Insurance, today many other companies also rely on similar data produced in Karlsruhe.

Hotspot: the lee side of mountain ranges

The results of the hail analyses also show other interesting things: for example, hailstorms predominantly occur in the comparatively warm southwest corner of Germany – especially on the lee side of mountain ranges like the Black Forest. The warm and moist air masses from the southwest usually flow around the Black Forest to the east and west. On the lee side of the mountain range, they collide with one another, leading to vertical lifting. When this happens, there is a greater likelihood of hailstorms, which means a higher hazard and risk for local residents and insurers. According to Klaus Zehner, "Michael Kunz's efforts have bridged the gap between research and business. In my opinion, this is an excellent example of how science can shape practice."

Prediction not yet possible

As such, the regions most prone to hail are now known – at least over a long-term period. But even the experts in Karlsruhe can't say where exactly an individual hailstorm is most likely to occur. A piece of information that would be extremely valuable for various users: if a thunderstorm just misses a given city and hits, for example, a marshland area instead, the damage will be substantially lower. As Kunz explains, "Hailstorms are more or less selective events. However, the prediction of thunderstorms is very inaccurate due to the complex physics and the large number of processes involved. As such, the exact spot where damage is expected to be highest can't realistically be predicted."

In the REKLIM network, Michael Kunz and his team also explored the question of how the number of storms has changed in the past due to climate change. To do so, they used climate data provided by the Helmholtz Centre for Materials and Coastal Research in Geesthacht (HZG). The experts at the HZG are using their coastDat program to model the climate in Europe in high resolution. The coastDat simulations provide Michael Kunz information on the atmosphere's vertical moisture, temperature, and wind profiles during the last 50 years, the main parameters that determine whether or not a storm is formed and its severity. The less stable the stratification of the atmosphere is, the higher the likelihood that the cumulus clouds will develop into a storm. "In the coastDat data we've analysed so far, we can see a rise in the frequency of favourable conditions for thunderstorms in Germany, especially in the southwest," says Kunz. In addition, for the future additional analyses of regional climate models using similar methods show an increase in the probability of thunderstorms. Yet it remains unclear how often these conditions will actually produce hailstorms, because the data from the climate models does not provide insights into the complex physical processes within clouds that lead to hail formation. Nevertheless, the trend is clear: more storms mean a higher risk of hailstorms.

IN BRIEF

- **Hailstorms are isolated events, their formation is nearly impossible to predict, and they can cause tremendous damage. Meteorologists have now identified which regions of Germany are most prone to hailstorms.**
- **New computational models allow us to reliably estimate hail damage and risk.**
- **Climate simulations prepared by the REKLIM network indicate that, due to climate change, the frequency of thunderstorms has increased and is expected to increase further - throughout Germany, and especially in the southwest.**