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National Centre for Climate Services NCCS
Federal Office of Meteorology and Climatology MeteoSwiss

Hail Climate Switzerland

National hail hazard maps

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Federal Office of Meteorology and Climatology MeteoSwiss
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Federal Office for Civil Protection FOCP

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sia
schweizerischer ingenieur- und architektenverein
société suisse des ingénieurs et des architectes
società svizzera degli ingegneri e degli architetti
swiss society of engineers and architects

ASA | SVV
Schweizerischer Versicherungsverband
Association Suisse d'Assurances
Associazione Svizzera d'Assicurazioni
Swiss Insurance Association

VKG Vereinigung Kantonaler Gebäudeversicherungen
AECA Association des établissements cantonaux d'assurance

A NATIONAL HAIL REFERENCE THROUGH COMBINED EXPERTISE

Every year in Switzerland, hailstorms cause damages amounting to several million Swiss Francs; they thus represent one of the country's greatest natural hazards. For the sectors that are most severely affected – ranging from agriculture to forestry, insurance, and construction, as well as the operational management of fire departments and civil defence systems – there is a need for a uniform, spatially differentiated climatological basis for the assessment of hail risk. Existing principles are based on outdated datasets, use divergent methods, and can only be compared to one another to a limited extent. In the project "Hail Climate Switzerland", various actors from the private and public sectors have come together under the leadership of the Federal Office of Meteorology and Climatology MeteoSwiss to develop a uniform national reference on hail hazards. This intensive cooperation benefits all project partners: the Foundation for Prevention of the Public Insurance Companies for Real Estate (FPPIRE), the Swiss Insurance Association (SVV), Swiss Hail Insurance (Schweizer Hagel), and the Swiss Society of Engineers and Architects (SIA), as well as the Federal Offices for Civil Protection (FOCP), for Agriculture (FOAG), for the Environment (FOEN), and MeteoSwiss. By means of this collaboration, specialist knowledge from practice, administration, and research can be combined and focused, thus creating added value for users interested in hail information. The project results can be applied to the planning of preventative measures against hail damage, the assessment of hail events, and the calculation of insurance premiums. The various hail products developed, such as the hail frequency and hail hazard maps, are based on the country-wide weather radar network of MeteoSwiss and a specially developed statistical method for the evaluation of radar data. The "Hail Climate Switzerland" project has been implemented as a priority theme within the framework of the National Centre for Climate Services (NCCS), thereby extending the services offered by the federal government for application-oriented climate information for Switzerland.

Peter Binder
Director, MeteoSwiss and Chairman of the NCCS Board of Directors

Switzerland:
32 times
Hailstones 2 cm or larger per year*

Canton Ticino: 31 **Canton Vaud:** 25
Hail days per year*

April: 2 **July:** 9
Hail days in Canton Bern*

Canton Bern: 16 times **Canton Grisons:** 5 times
Hailstones 4 cm or larger per year*

HAIL FREQUENCY

Sophie, a winemaker, insures her harvest against hailstorms, which occur frequently in summer and could potentially destroy all of her vines. In Switzerland, hail occurs particularly often in the cantons of Ticino, Bern, and Lucerne, as well as along the Jura.

→ Page 4

HAILSTONE SIZES

Lucia, an insurance agent, recommends that a company garage its vehicle fleet, as there is a known risk of damaging hailstones the size of an "Einfränkler" (2 cm). Hailstones of this size can be expected fairly often in Switzerland.

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* Average values over the summer half-year (April to September) for the reference period 2002–2020.

NEW HAIL PRODUCTS FOR SWITZERLAND

The following products are available: information on **hail frequency, hailstone sizes,** and **return periods.** These products refer to the period of available radar hail data from 2002 to 2020 and will be updated monthly and annually with the latest data. The hail seasons for the summer half-year from April to September are covered. In addition, hail hazard maps provide the most precise data basis available in terms of time and location for the assessment of the risk of hail damage in all regions of Switzerland. In this way, those affected from the respective sectors can implement targeted measures to reduce or bear the risks associated with hail.

PROJECT "HAIL CLIMATE SWITZERLAND"

This project has been challenging in many ways. As a small-scale weather phenomenon, hail is difficult to measure systematically. The short data series complicate assertions about rare events, and the range of demands from the user sectors is extensive. For this reason, MeteoSwiss has reprocessed its archive of radar hail data, using innovative statistical methods to create national hail hazard maps. The bundled expertise of all those involved in the project and the close exchange with practitioners were of key importance in the implementation of this usage-oriented project. The new hail products describe the frequency and intensity of hail events in Switzerland and are freely available to anyone interested.

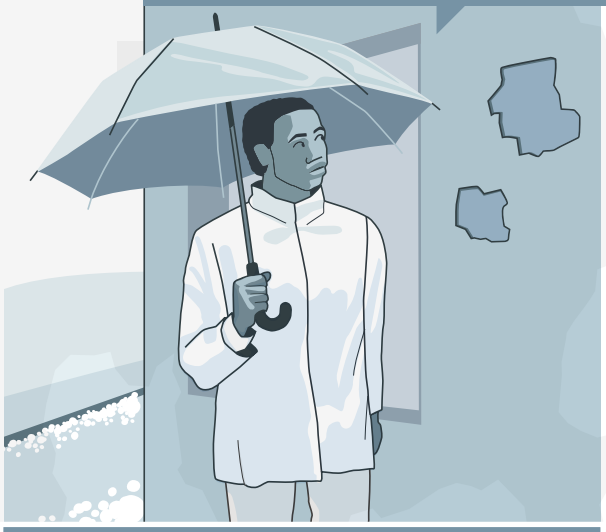
Further information can be found at **www.hailclimatology.ch** on the NCCS web platform

Canton Luzern:
5–6 cm
on average once every 50 years per km²

Widespread in Switzerland:
at least 3 cm
on average once every 50 years on the rooftop

2 %
probability of exceedance of 5–6 cm hailstone size per year and km²

2 %
probability of exceedance of 3 cm hailstone size per year on the rooftop



METHODS

Anna, a fire brigade commander, is well prepared for her station's next encounter with a hailstorm. Thanks to the new methods, she can take into account the threat of hail when planning operations.

→ Page 6

RETURN PERIODS

Nico, a homeowner, must consider the local hail hazard when renovating his building's facade. He chooses the appropriate material based on the size of the hailstones that can be expected in his area approximately once every 50 years.

→ Page 7

HAIL FREQUENCY

Information on the frequency of hail events is important for agriculture, as even small hailstones can cause considerable damage. In Switzerland, damage to agricultural crops due to hail amounts to around 65 million Swiss Francs every year. Hail is most common in the summer months. The regions of southern Ticino, Emmental, Entlebuch, and Napf, as well as along the Jura are most severely affected.

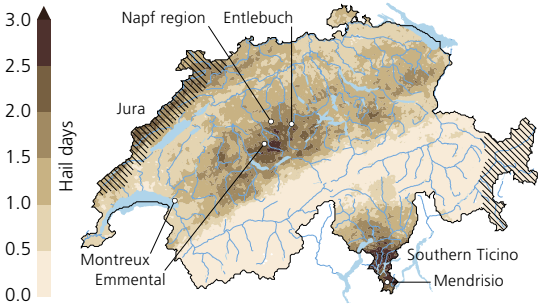
"Plants are particularly vulnerable to hailstorms. Spatial and temporal information on hail frequency indicates the regional hail hazard and can serve as a basis for decision-making on risk-reducing measures such as hail protection systems or insurance."

Pascal Forrer
Director, Swiss Hail Insurance

Hail Days

Average number of hail days per km² in the summer half-year

Slightly lower data quality



Hail Days in Switzerland

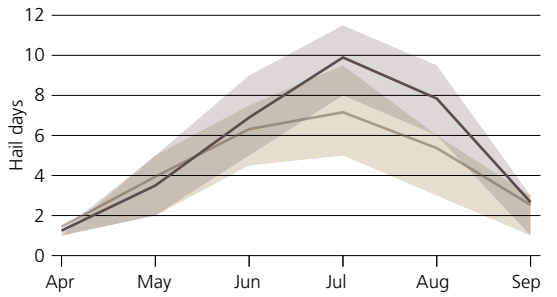
Hail frequency is expressed here in terms of the number of hail days, a phenomenon that occurs regularly in Switzerland. Across the entire data series, an average of 33 hail days* per summer half-year are observed across Switzerland. The number of hail days is spatially unevenly distributed across the country. Especially in southern Ticino, Emmental, Entlebuch, and the Napf region, as well as along the Jura, there are areas in which hail can be expected quite often. In some parts of southern Ticino, it hails up to three times a year on average. The minimum number of hail days is found in the inner-Alpine regions, where in isolated incidents no hail days at all have been registered since 2002.

Annual Cycle of Hail Days

Average number of hail days per month in the cantons of Ticino and Vaud

Average for Canton Ticino — Range of fluctuation for Canton Ticino**

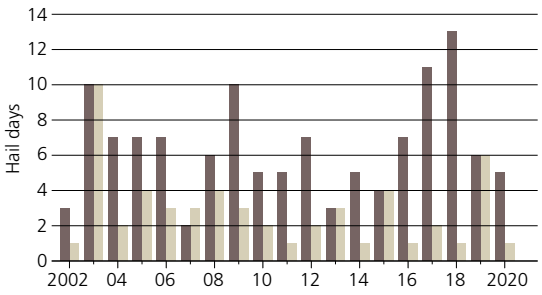
Average for Canton Vaud — Range of fluctuation for Canton Vaud**



Time Series of Hail Days

Number of hail days per summer half-year in

Mendrisio (TI) and Montreux (VD)



Temporal Development of Hail Days

Hail days are less likely from October to March than during the summer half-year. The maximum number of hail days per month is observed in the period between June and August, as the thunderclouds in which hailstones can form occur more frequently in the summer.

The number of hail days fluctuates considerably from year to year due to meteorological conditions, as can be clearly seen in the example of the time series for the municipalities of Mendrisio and Montreux.

* This refers to days in which an area of at least 100 km² throughout Switzerland is affected.
** Range of fluctuation: 25 % to 75 % quantile.

Terms Related to Hail

Hail cannot be measured comprehensively on the ground. All the products presented are based on radar hail data (occurrence and hailstone size) derived from radar measurements with the help of algorithms. The radar hail data are checked for plausibility with selective ground observations such as actual observed hailstones or damages.

Radar hail data from the period of 2002 to 2020 were used for the project's products. In total, approximately one million five-minute radar hail records were checked and corrected. The spatial resolution of the radar hail data is one square kilometer.

Hailstone size (i.e., Maximum Expected Severe Hail Size, or ***MESHS***) is defined as the maximum expected hailstone size per square kilometer. Conversely, this means that most of the hailstones in reference to this one square kilometer will be smaller.

Hailstone size on a reference area (i.e., Largest Expected Hail on a reference Area, or ***LEHA***) describes the largest expected hailstone on a reference area smaller than the square kilometer considered by *MESHS*. *LEHA* is statistically derived from the hailstone size *MESHS*. The maximum hailstone size predicted by *MESHS* is expected on one or only a few *LEHA* reference areas within the *MESHS* square kilometer. However, the probability of such an occurrence is very small. On the majority of the smaller reference areas, *LEHA* sizes are expected.

Hail probability (i.e., Probability of Hail, or ***POH***) refers to the probability with which hail can be expected on the ground per square kilometer.

Hail days are defined as days with a high probability of hail (*POH* ≥ 80%). Here, the 24 hours between 8 a.m. and 8 a.m. of the following day (CEST) are considered.

Hail area denotes the area affected by hail per hail event (*POH* ≥ 80%).

HAILSTONE SIZES

In Switzerland, hailstones with a diameter of 2 cm or more must often be expected. Without risk-reducing measures, such hailstones can cause considerable damage to a vehicle fleet. The greater the size of the hailstones, the greater the extent of the damage; however, the bigger the hailstones, the less often they occur.

"The processed hail data provide the insurance industry with new types of information that facilitate the determination of the risk of hail damage, especially to vehicles. The hail hazard maps are thus a valuable tool for raising awareness and improving advice, risk assessment, and risk-based pricing."

Patric Deflorin
President, Non-Life Insurance Board of the SVV

2 cm

4 cm

Where do we find "Einfränkler"

A hailstone with a diameter of 2 cm corresponds roughly to the size of an "Einfränkler", or a 1-Franc Swiss coin. How often such hailstones occur depends on the region under consideration. In the Emmental, for example, hailstones of diameter of 2 cm or more are observed on an average of up to two days per year. In the canton of Grisons, in contrast, hailstones the size of a "Einfränkler" are less common.

Which is more common: "Einfränkler" or golf balls?

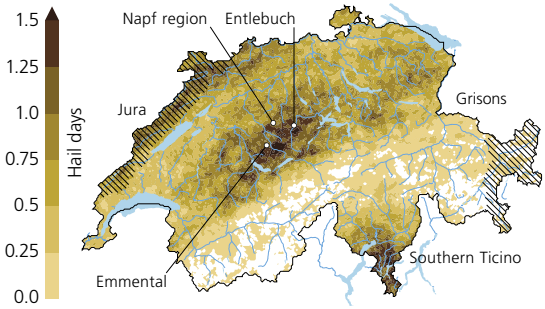
In Switzerland, a hail event with hailstones at least the size of a 1-Franc coin can be expected around 32 times* per year on average, whereas events with hailstones the size of a golf ball are expected around 29 times* per year. However, this frequency corresponds to the maximum expected hailstone size *(MESHS)* for an event, a size that only occurs sporadically and is therefore unlikely to be directly observed.

* This refers to days featuring hailstones of this size or greater and in which hail was observed across Switzerland over an area of at least 100 km².

Hailstones of 2 cm or larger in diameter

Average number of days with hailstones ≥ 2 cm per km² in the summer half-year

Slightly lower data quality



Hailstones of 4 cm or larger in diameter

Average number of days with hailstones ≥ 4 cm per km² in the summer half-year

Slightly lower data quality

Record Events Impact Large Areas

Two of the largest hail events between 2002 and 2020 in terms of area occurred on 23 July 2009 and 1 July 2019. The areas affected were 10,000 km² and 8,000 km² in size, respectively, and the maximum hailstone sizes were 5 to 6 cm; in 2009 in particular, this event caused considerable damage to buildings across Switzerland, estimated at 261 million Swiss Francs. According to historical sources, the largest hailstone ever found fell from the Swiss sky on 2 August 1927 – with a diameter of about 13 cm, the size of a fist!

Hail area on 23 July 2009

Slightly lower data quality

Hail area on 1 July 2019

Slightly lower data quality

Report Hail

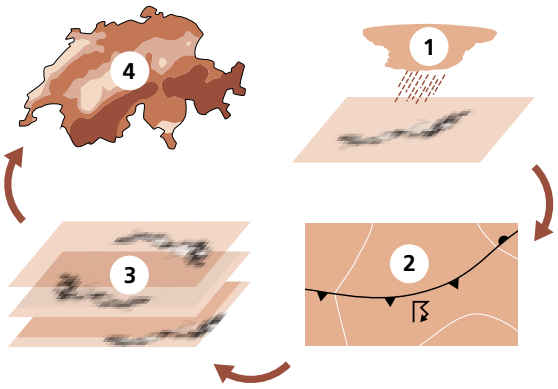
If you observe hail yourself, you can report the hailstone size via the MeteoSwiss-App and thereby help to further improve the data!

METHODS

New radar hail data and methodical approaches allow the calculation of return values in the form of hailstone sizes in rare events and the estimation of hailstone sizes in smaller areas, as developed for the application. The results facilitate the assessment of the hail hazard and the conducting of risk analyses – for example, in civil protection and operational planning during natural hazard events.

"Detailed knowledge on the spatial occurrence of hail supports both risk analyses at the cantonal and regional levels and municipal operational planning. It complements the findings of the National Risk Analysis 2020, in which hail was identified as the fifth greatest natural risk in Switzerland."

Stefan Brem
Head of Risk Analysis and Research Coordination, FOCP



Replication of observed hail events in the resampling process

Trajectories of hailstones were analyzed and resampled in order to better estimate the spatial hazard.

1. Analysis of places of origin, trajectories, and hailstone sizes for hailstorms.
2. What weather conditions bring about hail?
3. Calculation of further possible hail events from the weather data.
4. Determination of the frequency of hailstone sizes in different areas.

On the Trail of Potential Hailstorms

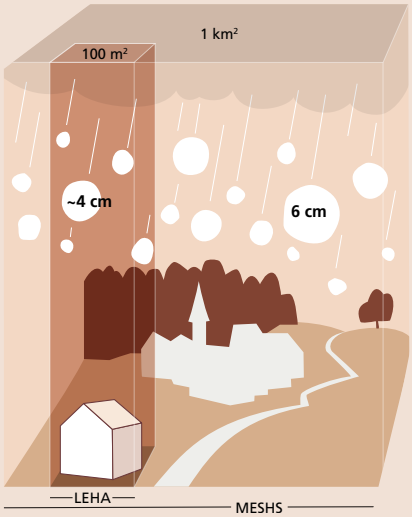
In an international comparison, the time series of the radar hail data is fairly long, at 19 years – and yet rather short for climatological analyses. Because hail events occur on a very small scale, there are many areas in which hail was rarely or never observed during the measurement period. In order to be able to make comprehensive statements about the hazard posed by hail events, a resampling approach (a statistical method from risk modeling) has been applied. The aim is to replicate observed hail events in such a way that the entire range of possible events is captured. In order to be able to make assertions about the frequency of hailstone sizes, the trajectories, hailstone sizes, and areas, as well as the large-scale weather conditions of over 40,000 hail events measured by the weather radar were analyzed. With the help of time series of weather conditions from past decades, hail events that seem possible in the current climate on the basis of the observational data were simulated. Thus, a spatial assessment of the hazard, for instance for a return period of 50 years, can be realized based on the simulated hail events.

From the Square Kilometer to the Rooftop

The maximum expected hailstone size *MESHS* derived from the weather radar refers to the area of one square kilometer. However, reference areas are generally smaller: a single-family house, for example, has a footprint of around 100 square meters, or 10,000 times smaller than the *MESHS* area. Because only a few of the very largest hailstones fall within a square kilometer, the probability that such a hailstone will fall on the roof of a specific house is quite small. In order to obtain a meaningful basis for analyses on user-defined reference areas smaller than one square kilometer, the *LEHA* statistic derived from MESHS based on a typical hailstone distribution is used. Damage data on hail events from the insurance partners as well as hailstone sizes observed and reported via the MeteoSwiss-App support the *LEHA* approach.

From *MESHS* to *LEHA*

MESHS: Maximum hailstone per 1 km²
LEHA-100: Largest hailstone per reference area of 100 m²



RETURN PERIODS

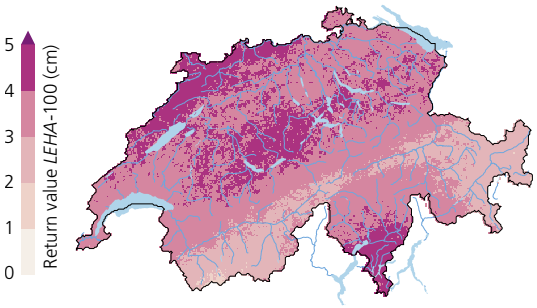
In order to implement targeted measures against hail damage, it is important to know what hailstone sizes must be expected over a considered period of time – such as the service life of a building – and how often. The expected hailstone sizes for certain return periods allow the calculation of this probability.

"A clear, convenient, and trustworthy assessment of the return period of natural hazards is important for the determination of proportionate protection goals in building standards, as well as for planners in practice. To the delight of the SIA, these assessments have been significantly improved through this partner project."

Christoph Starck
Managing Director, SIA

Building Protection Hazard Map

LEHA-return value of hailstone sizes (cm) for a 50-year return period and a reference area of 100 m²



Practical Example: Building Protection

Return values of hailstone sizes play an important role in building protection, among other sectors. On average, hailstorms in Switzerland cause damages to buildings amounting to 93 million Swiss Francs each year. To protect a building, materials and construction methods should reflect sufficient hail resistance. For the building protection hazard map, the return values of hailstone sizes for the 50-year return period were converted from *MESHS* to *LEHA*-100. The reference area of 100 square meters, selected with the input of the stakeholders involved, corresponds roughly to the floor area of a typical single-family house. According to the building protection hazard map, based on the 50-year return period, hailstone sizes of at least 3 cm must be expected on the reference surface of a house roof, although it cannot be ruled out that the maximum hailstone size within the square kilometer will exceed 6 cm. The building protection hazard map forms the basis for validating the specifications of the SIA's building standards*. These standards set out the areas in which hail-resistant construction is necessary and define what measures are appropriate.

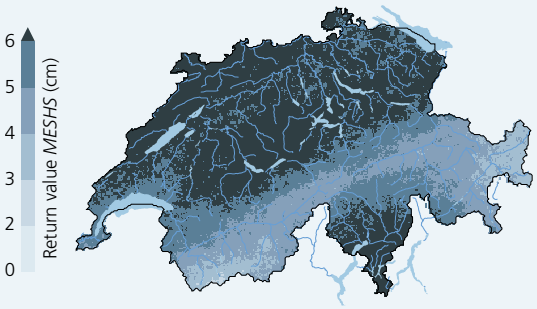
*Norm SIA 261/1 Einwirkungen auf Tragwerke – Ergänzende Festlegungen (2020).

"The new hail hazard maps represent the challenge of hail risk in a comprehensible visual form. In the case of cantonal building insurance, the largest share of damages from natural hazards over the last ten years has been due to hailstorms. This makes targeted and efficient preventative measures all the more important."

Markus Feltscher
Member of the Board, APIRE

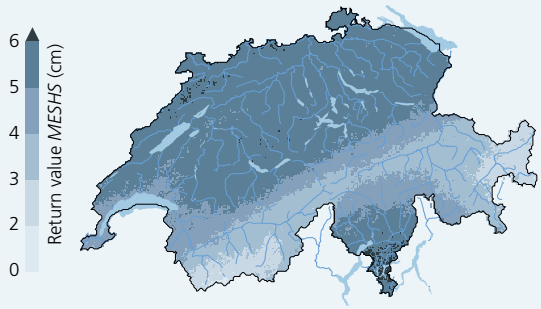
50-Year Return Period

MESHS-return value of hailstone sizes (cm) for a 50-year return period



20-Year Return Period

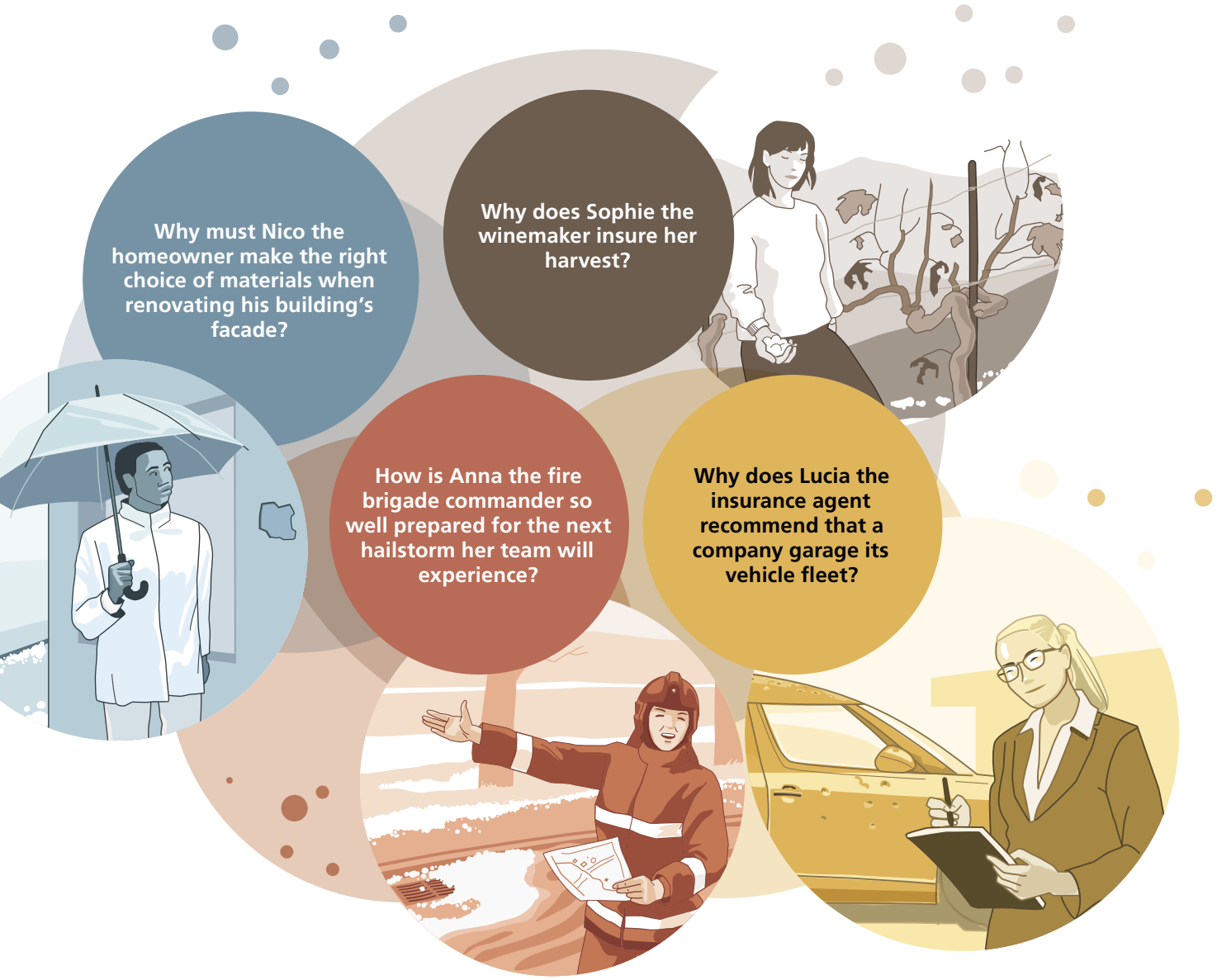
MESHS-return value of hailstone sizes (cm) for a 20-year return period



Interpretation Aid for the Return Periods

The new hazard maps present hailstone size as a function of the return period T. They describe the hailstone size that under today's climatic conditions will be exceeded with a probability of 1/T per year per radar pixel. For example, the map with the 20-year return values shows the hailstone size that will be statistically exceeded once every 20 years, or with a probability of 5 % per year: generally, 5–6 cm per square kilometer. At this spatial resolution, the hazard maps form the scientific basis for assessing the risk of hail in Switzerland. Due to the complexity of the weather phenomenon of hail, as well as the short data series, regionally rare occurrences, technical measurement inaccuracies, and statistical assumptions, the return values and especially the long return periods are subject to uncertainties that are generally in the range of plus/minus 0.5 to 1 cm*.

* More detailed information can be found in the technical report at
www.meteoswiss.admin.ch > Climate > Swiss climate in detail > Hail climatology



With the help of the data from the "Hail Climate Switzerland" project, the hail hazard in Switzerland can be accurately represented, with regional and temporal differences readily apparent. The processed data series of radar hail data and their statistical analysis have provided the foundation for the newly available hail information from this public-private partnership project.
www.hailclimatology.ch

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