K.A.R.L.®
Köln.Assekuranz Risiko Lösungen

KA Köln.Assekuranz Agentur
Ein Unternehmen der ERGO

K.A.R.L.® Release 2019

heavy rainfall - hail model - climate data

The progress never stops and experience gained is waiting to be put into practice. That is why we have thoroughly revised and extended K.A.R.L. for its 10th anniversary. New about K.A.R.L. is a heavy rain model, which quantifies the risk resulting from heavy rain worldwide and tried and tested by K.A.R.L. methodology. KA Köln.Assekuranz is thus breaking new ground worldwide and offering its clients an analytical approach for assessing and evaluating this natural hazard. In addition, K.A.R.L. now takes into account climate data that uses projections to illustrate climate development on the basis of a scenario. These larger developments were supplemented by a large number of improvements. In the vast majority of cases, the analysis results remain stable, but there are also clear differences between „old“ and „new“ at individual locations investigated. Of course, we have analysed these deviations and checked them for plausibility. After all, it is always our goal to come as close as possible to the „actual“ risk with our models.

In detail, we have introduced innovations and made changes in the following topics:

Heavy Rainfall

A newcomer to the spectrum of natural hazards investigated by K.A.R.L. is the subject of heavy rainfall. Two reasons led us to take a closer look at this topic:

- In recent years, there has been an increase in the number of reports of disasters caused by sudden and unexpectedly heavy rainfall. In this context, we need only recall the events that occurred in Genoa in 2018 (bridge collapse after storms) and on the holiday island of Mallorca (storms, floods).
- Climate researchers assume that the distribution of precipitation over the year will become more highly contrasted as a result of climate change: Especially in summer, the longer-lasting, unpleasant but otherwise harmless rains will be replaced by sudden, short-term and extremely heavy downpours. As a result, the probability of heavy rainfall events occurring increases, as does the associated risk.

Heavy rainfall is usually a relatively limited phenomenon and can also occur in flood-safe zones. Conversely, heavy rain events that occur far away from an investigated site and do not directly affect it may cause flooding or flash floods at the investigated site. The hazard locations of a heavy rainfall and the flash flood caused by it are therefore not identical. K.A.R.L. therefore assesses flood and heavy rain risks separately, as these are independent risks.

Heavy rainfall can cause damage which - unlike floods or flash floods - can occur in the smallest of spaces. First and foremost is the flooding of cellars and underground car parks and their entrances, inner courtyards closed on all sides, underground passages and small local depressions. In addition, there is the possibility of damage caused by the penetration of rainwater into buildings, vehicles and means of transport (wagons, containers, crates, packaging foils, etc.) as well as damage caused by infrastructure systems undermined by water.

Furthermore, the risk of being affected or damaged by heavy rain depends on the absorption capacity of the local wastewater systems. These are normally designed for rainfall at statistical intervals of 3 to 10 years due to economic considerations. This is then the so-called „design rainfall“, which is used as a basis for dimensioning the sewage systems. A higher degree of protection is rarely found, as it is either too expensive or technically not feasible at all. If the design rainfall is exceeded, there will be overflow, leakage of sewer water at the surface and the associated consequential damage.

A model developed by KA based on globally available climate data and calibrated on the basis of measured precipitation data from more than 1,700 weather stations worldwide is used to calculate the heavy rainfall hazard and the resulting risk. This model provides approximate values for the expected maximum daily precipitation for each point on Earth (except Antarctica) and for all return periods between 1 and 10,000 years.

Assuming that the calculated 5-year heavy rain corresponds approximately to the locally valid design rainfall, the frequency distribution modelled with K.A.R.L. can be used to estimate how often and to what extent this can be exceeded and the resulting overall risk.

Climate Data

Climate is the average weather, observed and measured over a longer period of time. Most climate data are based on a thirty-year observation period. So, if you use the most recent measured weather data from 1988 to 2018, you actually only learn what the climate was like about 15 years ago, in 2003. However, with K.A.R.L. we would like to be able to provide our customers with the current climate data for 2019 - and of course also for 2020, 2021, etc. at a later date. Since there are only half of the weather observations available that we would need today (the 15 years to 2033 are still missing), we had to choose a different path: We have supplemented the climate data that K.A.R.L. has used so far and that reflect the state around the turn of the millennium with model-calculated data from climate models. For this purpose, we have drawn on the NCAR Community Climate System Model (CCSM), whose projections for the future have also been included in the reports of the IPCC (International Panel of Climate Change). We used scenario A1b, which assumes a moderate increase in CO_2 in the Earth's atmosphere by 2099.

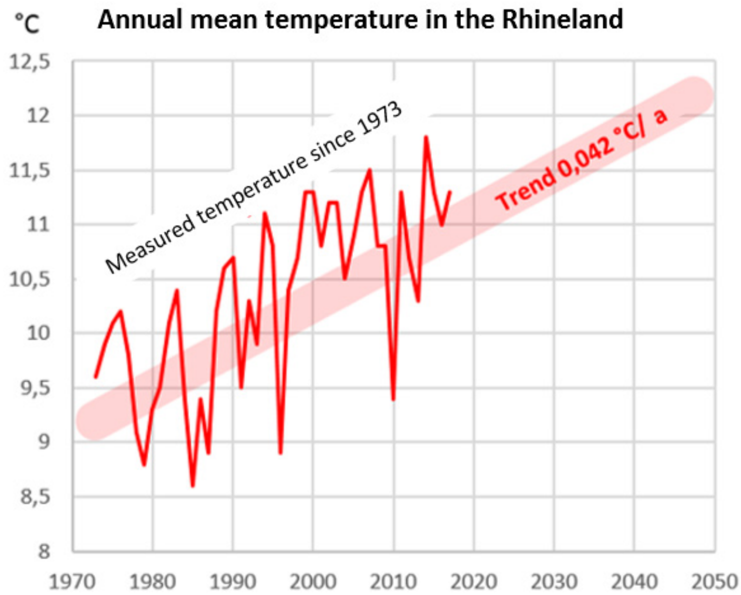

Fig. 1 measured annual mean temperatures using the example of the Rhineland and the resulting trend (Source: KA)

Looking back on the last 1 to 2 decades, this model corresponds very well with the actual observed global warming, which we were able to confirm by random sampling at several points of the earth. According to scenario A1b, for example, an average annual global warming of 0.042 °C is expected for the Cologne area. This may not sound particularly exciting at first, but it means that the average annual temperature here will probably rise from 10.1 °C in 2000 to 12.2 °C in 2050. This is not noticeable, since the annual mean temperatures of the individual years (i.e. the weather of these years), shown in Fig. 1 as a red line, can vary more strongly and cover the creeping trend in the background.

Comparable developments also apply to the expected precipitation or the number of hot summer days possible in the future. For more information, see K.A.R.L.® Insights Heatwave 2018 (Edition 03/2018).

We assume that this model will also accurately reflect the climate development on our planet in the future - at least in the next 2 to 3 decades. We have thus put K.A.R.L. in a position to always take into account the current state of the climate as well as that of the coming years in its risk analyses.

How climate change can affect the heavy rain risk is impressively demonstrated by the example of Munich, for which the diagram in fig.2 compares the model-calculated maximum daily precipitation of the years 2000 and 2050. According to this, a significant intensification of the maximum daily precipitation by 15 to 20 percent can be expected, especially beyond the 50-year event. However, this is also accompanied by a shift in the return periods: a „rain of the century" in 2000 turns into a 50-year event in 2050 and 500-year downpours into 200-year events.

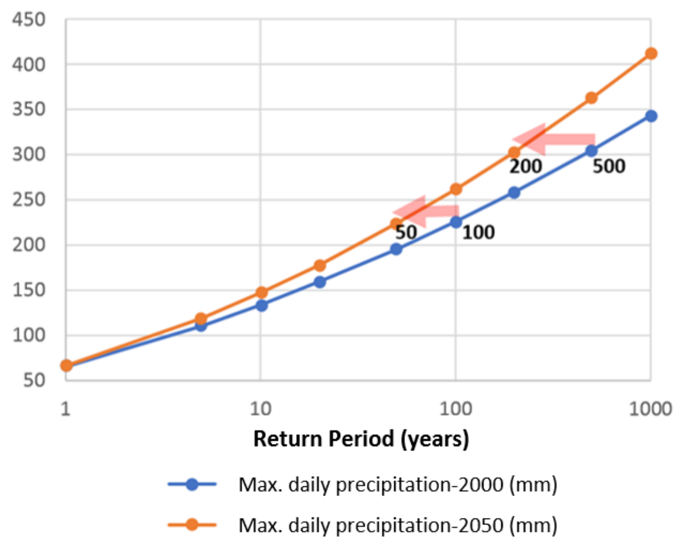

Fig. 2 Shifting of RP of heavy rain events (Source: KA)

Overall, this theoretically means a doubling of the risk resulting from heavy rainfall within the period from 2000 to 2050.

This makes K.A.R.L. a unique system that describes the heavy rain risk worldwide in numerical terms and that can be adapted annually depending on climate change. Projections to specific target years in the future are also possible in this way, as shown by the example of Munich.

Hail

K.A.R.L. entered the stage in 2008 with a new model that was able to calculate the degree of hail hazard worldwide. This model differed fundamentally from all previous attempts to describe the risk of hail because it no longer relied on the loss data collected by the insurance industry in the past. On the basis of current meteorological data and the regional climate parameters derived from them (annual and monthly temperatures, precipitation levels, evaporation rates and the level of the zero degree level above the terrain level), it was investigated to what extent such factors either favour or prevent the occurrence of hail and how they might possibly compensate each other. Since hail is also tied to thunderstorms in most cases, the lightning frequency was also included in the model calculations. As a result, key figures between zero (no hail hazard) and 14 (extremely high hail hazard) are given, which we call „hail potential". The model and hail potential were already calibrated in 2008 on the basis of weather and climate data from the USA (source: NOAA). Even then, we were able to assign the statistical return periods of hailstones of different diameters to all hail potentials and correlate the corresponding expected loss amounts with them.

Now it was time to thoroughly revise this hail model once again and to incorporate additional experience from the past ten years. Essentially, the adjustments made consist of giving greater weight to the monthly evaporation rates, taking into account the number of „hot days" above 20 °C as an additional hazard factor and including local topography more strongly in the hazard analysis. In addition, the model-calculated climate anomalies of the IPPC scenario A1b are now also included in the K.A.R.L. hail model, so that the effects of climate change on the degree of hail hazard are also included in the evaluations.

Fig. 3 shows the recalculated global distribution of hail potentials for 2019. The known hail hazard concentrations - midwest and eastern half of the USA, areas in southern Brazil and its neighbouring states, southern and central Africa, the Mediterranean region, the southern slope of the Himalayas, and the Australian east coast - also reappear here. Added to this are numerous small-scale deviations from the hail model previously used, which can no longer be depicted on a world map scale, but also new, extensive danger areas in the southern half of Russia and in northeastern China. Especially in the latter region the hail hazard has been underestimated so far, which is impressively documented by the video (last call 15.01.2019), available here.

As with heavy rainfall, the hail hazards calculated by K.A.R.L. will also be dynamically adapted to the conditions of climate change from 2019 onwards. One development that can be seen in this context is that the hail risk in many countries of the world may even decrease slightly in the future. That is the good news. The bad news is that heavier rainfall could soon replace hail as the main risk factor.

Compared to the other natural hazards, we have made the biggest changes to the K.A.R.L. hail model. In extensive test series with several thousand test sites, we were able to establish that this K.A.R.L. conversion even led to an improvement in the calculated risk for more than 27% of the sites investigated. At just under 16 %, however, the hail risk worsened.

We expect to publish further detailed information on the „new" hail model in a special K.A.R.L. Insight in the course of 2019.

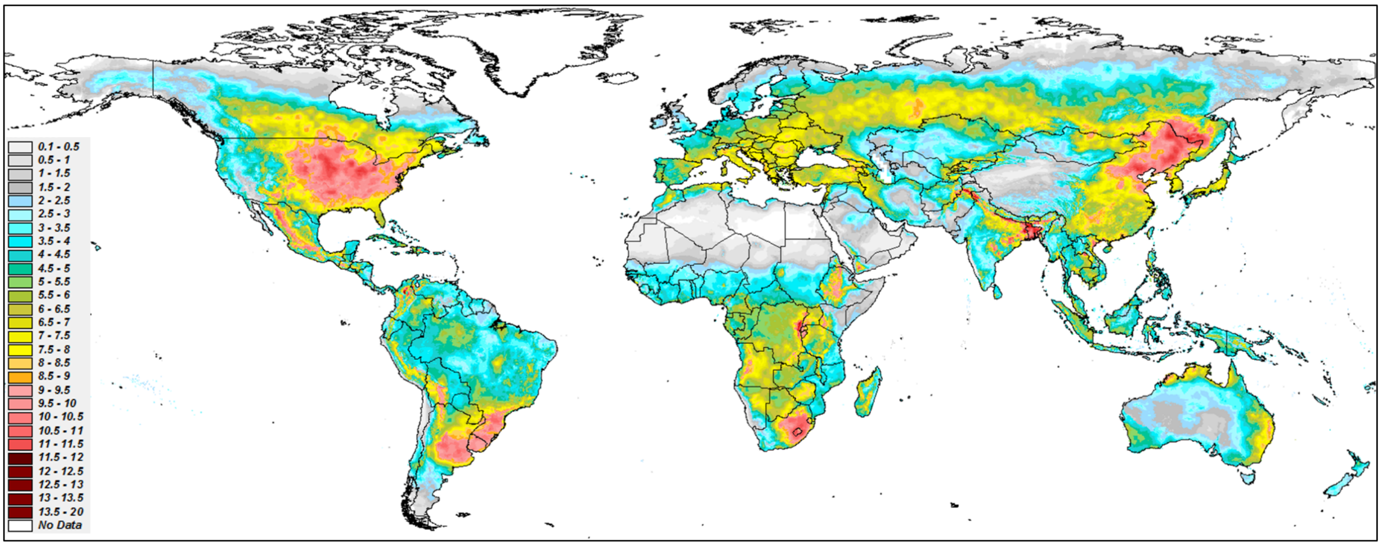

Fig. 3 Map of the new K.A.R.L. hail model (Source: KA)

Tornado

Tornadoes and hail often occur under the same weather conditions. For this reason, both analyses are still closely linked in K.A.R.L. The changes we have made in the hail model therefore also have a logical impact on the analysis of tornado risks, including dynamic adaptation to climate change. Apart from the Midwest of the USA, the tornado risks in the rest of the world are relatively inconspicuous, so that the deviations from previous analyses caused by the K.A.R.L. adaptation also remain marginal.

Surge

K.A.R.L. also focused on the future right from the start when it came to flooding and avoided „looking in the rear-view mirror“ as far as possible. This has been well worth it. Therefore, we continue to pursue the concept of researching where floods are POSSIBLE at all on the basis of the landscape structure reconstructed from digital elevation models. It does not matter whether floods have already taken place at an investigated location, whether an open water body is nearby, whether a thunderstorm could flood the area, or whether a main water pipe could burst. The only decisive factor is whether water - however it may have got there - can either drain off quickly or only very gradually. For more than 10 years, K.A.R.L. has thus had a reliable and field-proven tool at its disposal that also draws attention to potentially flood-prone areas far away from rivers, streams or the seashore.

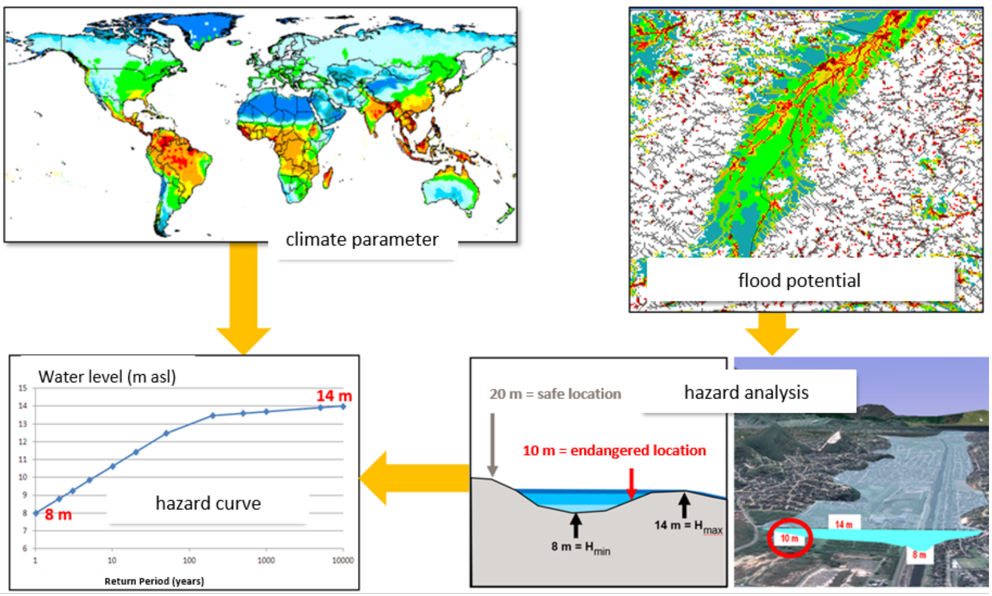

Fig. 4 Calculation steps of the flood risk (Source: KA)

A second, but no less complex step is hazard analysis. Here, K.A.R.L. must independently find out at which point in the immediate vicinity it sets the normal water level and up to which maximum height it can let the water rise from there, taking into account the regional climatic conditions, before it may find additional drainage paths in other directions.

While the first step, the detection of flood potentials, has been doing its job reliably for many years, the second is the more critical one. That is why we keep it under constant observation and monitor every flood event that comes to our attention and whose circumstances we can reconstruct, what K.A.R.L. would have said about it and whether its risk classifications would have been realistic. In addition, hundreds of risk studies that we have carried out manually with K.A.R.L. in recent years (expert analyses) have resulted in numerous experiences that we have now included in K.A.R.L.

These actions in K.A.R.L. have even led to a more or less significant reduction in the calculated risks for more than 20% of the locations. In contrast, the risks worsened for slightly more than 10 %. The rest has remained. Overall, we have thus been able to take away some of K.A.R.L.'s „pessimism", its tendency towards worst-case assessment.

We have not (yet) considered a possible link between climate change and the frequency and intensity of floods, because it is not as scientifically clear as we would wish. However, we will continue to pursue this issue and adapt K.A.R.L. accordingly in due course.

Storm Surge and Tsunami

Storm surges and tsunamis are special cases of coastal flooding. For this reason, the adjustments we have made to the subject of flooding naturally also affect the calculation of these risks.

Where relevant concrete information - e.g. statistics on the maximum wave heights to be expected - is available, K.A.R.L. naturally calculates the storm surge and tsunami risks on the basis of this data and does not use its own approximate models. For storm surge in particular, we carefully examined these data sets in 2018 and adapted and updated them.

In addition, we have noticed several times in recent years that some of the sites we have investigated are located in the immediate vicinity of the coast, so that they are virtually unprotected from storm surges and tsunami waves and have not been secured by suitable technical protective measures, e.g. a dike, as K.A.R.L. had previously assumed automatically (if no other information was available!). An example of this are the storage sites in Newark (USA) shown in Fig. 5, which were severely affected by a storm surge caused by Hurricane „Sandy" in 2012. There was no protective wall here and the embankment was unable to withstand the metre-high surf waves.

Fig. 5 View of the port facility in the port of Newark, NJ, USA (Source Google Earth/Streetview)

We have now incorporated these findings into K.A.R.L. in the sense of a worst-case approach (it is better to overstate a risk than to overlook it). As a result, the risk rating for storm surge has worsened in almost 18% of the potentially endangered sites we investigated. On the other hand, the storm surge risks identified by K.A.R.L. have even decreased due to the adjustment of other risk factors in almost 20% of the sites examined. In the case of tsunami risks, 10 % of the locations examined improved and only just under 3 % worsened. Overall, K.A.R.L. has therefore moved away from its worst-case philosophy here as well but has become somewhat more critical in justified individual cases.

Earthquake

Over the past ten years, we have repeatedly updated the earthquake lists used by K.A.R.L. to include the „newly added" earthquakes so that our statistical analyses are always up to date. Essentially, we have relied on the publicly accessible databases of the USGS (United States Geological Survey). During this time, the USGS was not inactive: In the meantime, our American colleagues have updated, revised and partly re-evaluated the data of many earthquakes, especially earthquakes that occurred some time ago. We have made these new data sets fully accessible to K.A.R.L. This has made the earthquake hazard analyses more precise. However, this has not led to any major deviations from the previous K.A.R.L. analyses: Just under 2.6 % of the locations investigated have improved. The calculated risks worsened by 3.2%. The vast majority of the locations tested, a good 94 %, remained virtually unchanged.

Outlook

Now, on the occasion of its 10th anniversary, the most powerful and sophisticated K.A.R.L. is at your disposal. But of course we will not be satisfied with that, because we have a multitude of ideas for possible K.A.R.L. extensions, some of which can be traced back to suggestions and questions from our customers. So there will be no standstill. We will inform you about further developments in good time. Let us surprise you.

If you would like to discuss this paper with us, we look forward to hearing from you.

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