Karlsruhe Institute of Technology

Climate and Environment news

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February 2026

Cover Photo
Layers of hail.
(Photo: Jannick Fischer)

Dear readers,

The first few weeks of 2026 have once again demonstrated how closely political, economic, and environmental developments are linked. Rising energy prices, geopolitical tensions, and competition for critical raw materials show how urgently we need more resilient systems.

Science provides concrete solutions for this. A team at KIT is studying super storms up close to better understand the formation of large hailstones and improve warning systems. Fossilized horseshoe crabs could provide clues to rare earths in the future – an important building block in view of global supply chain risks. And geological data helps refine climate models so that decisions can be made on a more informed basis. Technological solutions are also in focus: aquifer storage enables heat and cold to be stored seasonally and cost-effectively – an approach with great potential for municipal heat planning at a time when Europe is realigning its energy systems.

At the start of the year, I would also like to inform you that the KIT Center for Climate and Environment has been renamed the KIT Center for Climate, Environment, and Resources (CLEAR). The new name reflects an expanded mission that now places greater emphasis on the sustainable use of natural resources. Against the backdrop of global uncertainties, there is a particular need for strong research, exchange, and innovation – and CLEAR makes a significant contribution in this regard.

With kind regards,

Prof. Dr. Ina Schaefer
Vice Provost for Research

Supercell in New Mexico, June 8, 2025 (Photo: Jannick Fischer)

In the middle of a hailstorm

How KIT researchers chase extreme thunderstorms to better understand the formation of hail

Destroyed roofs, dented cars, ruined crops: even a few minutes of intense hail can cause enormous damage. Despite improved weather forecasts, it is still difficult to accurately predict the location, timing, and intensity of hailstorms: Until now, there has been a lack of direct measurement data from the updraft zones of thunderclouds, where hail forms, that sufficiently characterizes the hail growth process.

A research team at the Institute for Meteorology and Climate Research – Atmospheric Risks (IMKTRO) at KIT, led by Prof. Michael Kunz, is working to close this gap. In the DFG project LIFT ("Understanding Large Hail Formation and Trajectories"), the researchers are using special measuring systems that allow them to observe hail formation directly. During so-called "storm chasing" missions in the summer months, the researchers bring special wind and hail probes into the updraft areas of thunderstorm cells – where hailstones grow until they fall out of the cloud due to their weight.

"Our probes measure temperature, humidity, wind direction, and wind speed in the zone where hail forms," says Jannick Fischer, postdoctoral researcher at IMKTRO. "From this data, we can reconstruct the trajectories of the hailstones and track when they grow or melt."

Launch of a hail probe into a supercell. (Photo: Jannick Fischer)

Since large hail events are rare in Germany, the KIT team participated in the international ICECHIP campaign (In-situ Collaborative Experiment for the Collection of Hail in the Plains) in the USA in May and June 2025. For six weeks, the researchers traveled with international teams to study supercells over the Great Plains.

May 25, 2025, became the "golden day" of the campaign: a particularly powerful supercell formed near Afton, Texas. It produced hailstones with diameters of up to 15 centimeters – about the size of grapefruits. The KIT team successfully deployed six hail probes into the updraft area, while partners from the Australian Bureau of Meteorology launched three more probes.

Both teams were able to track the development of the supercell in real time: The KIT probes recorded vertical speeds of up to 59.7 m/s, while the Australian team even recorded 72.6 m/s – a new record. "This corresponds to wind speeds of over 250 kilometers per hour – stronger than in most hurricanes, where such speeds only occur horizontally," says Elias Hühn, a doctoral student at IMKTRO who is evaluating the measurement data. "We are now combining the probe data with radar and model data to understand how and where hail forms – this is the key to truly understanding the processes inside supercells."

Layers of hail. *(Photo: Jannick Fischer)*

These unprecedented records make it possible to describe the physical processes inside a thundercloud in detail for the first time. The temperature and humidity profiles show how the transitions between wet and dry growth occur and which conditions lead to particularly large hailstones. At the same time, the data provide clues as to how hail moves within the cloud – and when it begins to melt or break apart.

The researchers are now evaluating thousands of data sets and linking them with radar images, drone recordings, and ground measurements of hailstones. "The new in-situ measurements enable us to better understand the physical parameters of hail formation and to validate model simulations accordingly," says Kunz.

In the long term, the results should help to optimize radar warning systems and forecast models, making hail warnings more accurate and reliable. For the researchers, however, the campaign was not only a scientific experience, but also a human one: "You stand under a rotating supercell, see lightning in all directions, and know that you are in the middle of nature's laboratory," says Fischer. "This is research at the limit – and that's exactly why it's so fascinating." ■

Wood in Motion

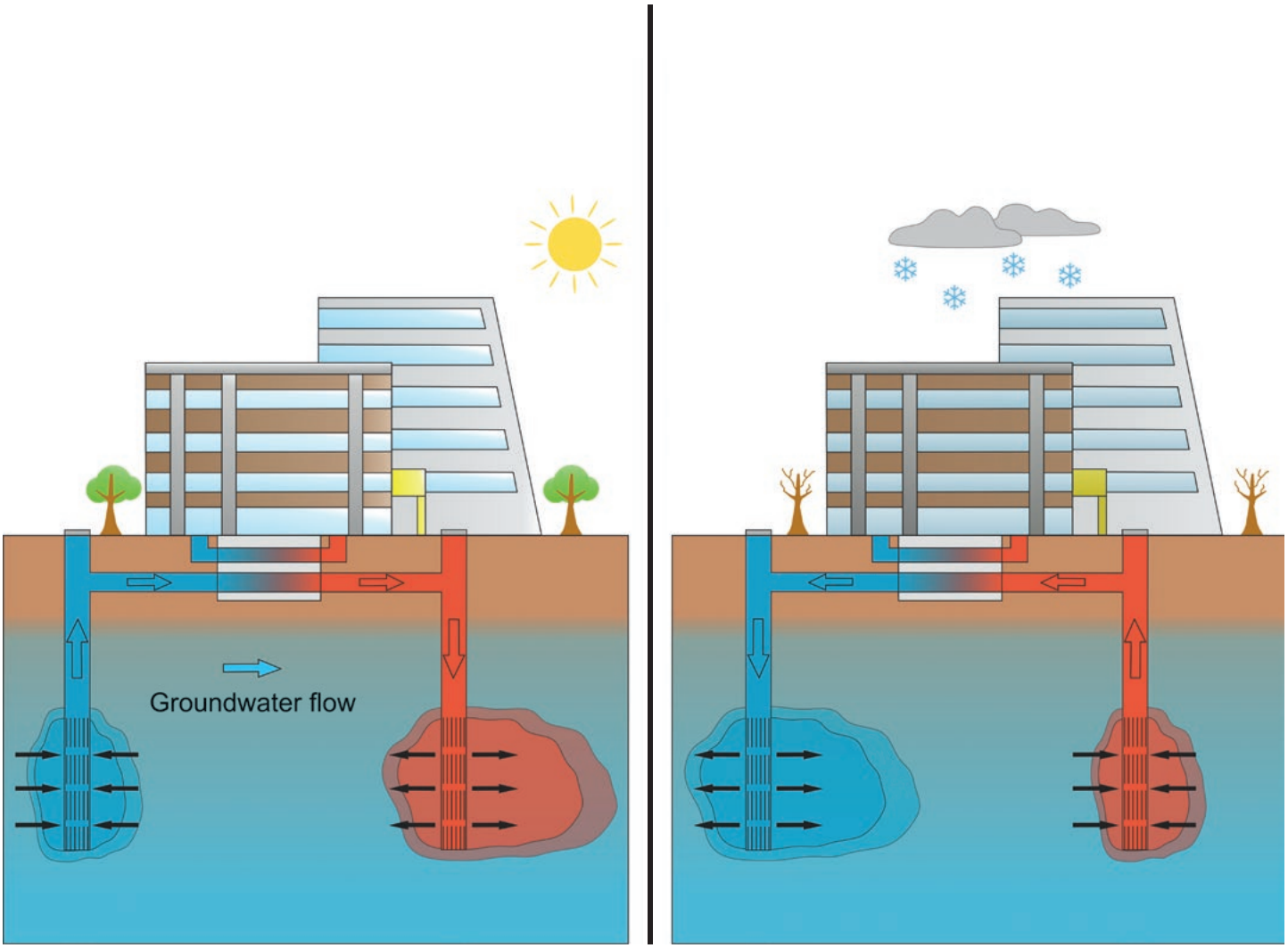
Fallen trees affect the ecology and safety of rivers

When fallen trees enter rivers, they begin a second life as part of the ecosystem. Exposed to currents, sediments, and collisions, they gradually lose bark, mass, and shape. This large wood influences river morphology, habitat formation, and the carbon cycle, yet its physical degradation has barely been studied.

At the Institute for Water and Environment of the KIT, Dr. Jiangtao Yang investigates how wood pieces wear down during river transport. In a specially designed tumbling apparatus, he simulates the movement of logs along the riverbed and measures how quickly different wood types are abraded. The experiments reveal how transport processes shape not only individual pieces of wood but also determine how long they remain in the river system before breaking apart. The goal is to understand how energy, material properties, and contact with sediments determine the rate of degradation.

These insights are important for both ecology and river engineering. As wood moves downstream, it can form logjams that create valuable habitats but also pose risks to bridges or dams. "Large wood is a natural part of rivers," says Yang. "If we understand how it degrades, we can make rivers safer and at the same time more ecologically stable." ■

The beginning of a second life: dead wood in a stream.
(Photo: Jiangtao Yang)



Aquifer storage – a thermal storage technology that cools in summer (left) and heats in winter. (Image: Ruben Stemmle, KIT)

Seasonal storage and CO_2 savings

Aquifer thermal energy storage (ATES) systems are cost-effective heat and cold storage systems.

Heating and cooling account for around one-fifth of global greenhouse gas emissions. To date, only a small proportion of the energy required comes from renewable sources. Aquifer thermal energy storage (ATES) can be a lever here: they store excess heat and cold – such as summer heat from roofs, networks, or systems and winter cold from the environment – and make it available when it is needed. A team at KIT has evaluated the investment costs of 133 ATES systems. The result: large, low-temperature ATES are the most cost-effective seasonal thermal storage technology.

ATES systems use aquifers as storage space. Groundwater circulates between two wells. In summer, heat is fed in, which is used for heating in winter; in winter, these storage systems store cold, which cools buildings in summer. Because no artificial storage facility has to be built, the costs per storage volume are low compared to other seasonal thermal energy storage systems – less than €10/m³. Aquifer thermal energy storage is ideal for hospitals, data centers, or residential areas where heating and cooling requirements are similar.

The study by researchers at KIT shows that the larger the plant, the better the price-performance ratio. From around 2 MW of installed capacity, investments level off at around €300/kW – a clear economy of scale. Aquifer storage also comes out on top in terms of energy stored (typically €130–1,630/MWh; for very large storage facilities ≤€400/MWh). Large aquifer storage facilities therefore significantly reduce investment costs.

ATES systems require permeable aquifers and stable groundwater conditions in order to recover cold or heat with a good yield. The drilling itself is only a small item; the majority is accounted for by surface technology, such as heat pumps, heat exchangers and piping.

According to the study, more than half of the area in Germany is well to very well suited for aquifer storage. For municipal heat planning, the team recommends systematically building low-temperature ATES systems – including cooling, which has often been neglected in legislation to date. "Where the hydrogeology is suitable and heating and cooling are considered together, aquifer storage is the most cost-effective seasonal thermal storage solution," says Professor Philipp Blum from the Institute of Applied Geosciences (AGW) and one of the initiators of the study: "Aquifer storage is good for the climate, reliable in operation, and extremely attractive for future investments due to its short payback periods." ■

Nature as a model for sustainable technologies

New topic "Bioeconomy" at KIT

For billions of years, nature has been demonstrating how material cycles work. The new "Bioeconomy" topic at the KIT Climate and Environment Center takes up its principles: Researchers are transferring biological processes into technical applications. In doing so, they aim to support the industry's transition toward more efficient resource use and the replacement of fossil fuels with renewable raw materials, while generating added value and jobs. Dirk Holtmann and Ulrike van der Schaaf from the Institute for Bio- and Food Process Engineering are spokespersons for the new topic.

"Bioeconomy means transferring biological principles to the economy – from new processes for CO_2 utilization to the upcycling of residues from food production," says van der Schaaf. Specifically, it involves using biological resources – such as microorganisms, enzymes, or plant by-products – as raw materials or catalysts. Van der Schaaf's team is investigating how residues from the food industry can be refined and used as functional ingredients.

Holtmann and his team are working on "feeding" microorganisms with green electricity. In bioelectrochemical reactors, they convert CO_2 into biofuels or basic chemicals. "We want to show that electrical energy can be directly translated into biochemical products," says Holtmann. "This not only avoids CO_2, but also utilizes it." Van der Schaaf and Holtmann are jointly researching CO_2-based processes for producing new food components.

The topic of bioeconomy is not a completely new field of research at KIT. It brings together existing activities under one roof and connects teams that are advancing bio-based technologies. "The goal is to create innovations that allow us to act ecologically while remaining economically viable," says Holtmann. ■

Fossil Traces

Can horseshoe crabs serve as indicators for rare earth elements?

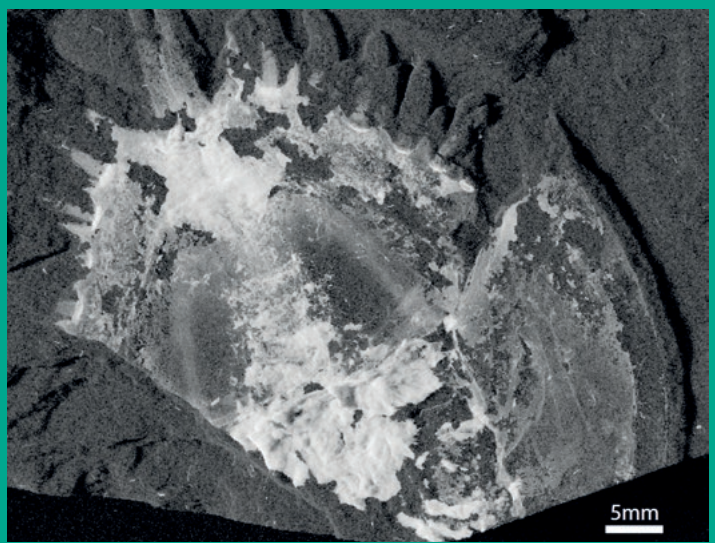
Horseshoe crabs and their ancestors have existed on Earth for more than 470 million years. Now they could help scientists read the geological traces hidden in rocks. At KIT, a team led by Sara Kimmig from the Institute of Applied Geosciences is investigating whether these ancient creatures can reveal the presence of rare earth elements in their ancient ecosystems. The researchers are pursuing an unusual idea: Fossils as geochemical archives that may record whether valuable mineral deposits once existed – or still exist – in their surroundings.

Chiara Heischmann with a female horseshoe crab (Carcinoscorpius rotundicauda) *from the Philippines. (Photo: Sara Kimming)*

At the SOLEIL synchrotron near Paris, researchers recently detected a striking enrichment of rare earth elements in a fossilized horseshoe crab. The pattern was so unusual that they interpreted it as likely evidence of hydrothermal solutions that left chemical traces during rock formation. This process, known as diagenesis, also plays a role in the formation of ore deposits.

With start-up funding of €10,000 from the Future Field Stage 1 Funds, Kimmig has launched a pilot study to investigate this mechanism. Bachelor's student Chiara Heischmann is analyzing modern and fossilized horseshoe crabs from the collections of the Natural History Museum in Karlsruhe. The aim is to find out how and where trace elements are incorporated into the shells – and whether these signatures can provide clues about the geochemical environment.

In order not to damage the often rare and valuable fossils, non-destructive micro and elemental analyses are used to map the specimens. In a later phase, the results will be compared to fossils found near known ore deposits. "If their fossils provide clues to ancient geological processes," says Kimmig, "horseshoe crabs could not only be among the most evolutionarily successful animals, but also become a key in the search for critical raw materials." ■



Synchrotron image of a fossilized horseshoe crab (specimen ID #0032-Y). The white areas show an increased concentration of the element yttrium (Y) in the fossil body. (Photo: Sara Kimming)

Science meets urban society

corner: Tool for science communication

With corner, KIT brings science into the city, to citizens who want to have a say, contribute ideas, and participate in research. The mobile knowledge transfer infrastructure, consisting of two converted office containers, is intended as a place for dialogue – open, low-threshold, and temporary. The aim is to engage in conversation about issues relating to the city and society and to make research visible and accessible.

The focus was not purely on imparting knowledge, but on exchange between equals. Visitors were able to contribute their perspectives – for example, on the "Art Wall," where they visualized what energy looks like to them, or on city maps where places of fair housing were marked. Using building blocks, maps, and discussions, a diverse range of impressions emerged of what affordable and sustainable living means today.

corner was first opened in fall 2025 as part of the KIT Science Week and the Karlsruhe City Festival. It was located at Kronenplatz and invited visitors to linger and participate. Under the headline *"How do we live? Now / in the future / together / in the city,"* the team presented an exhibition on the EU research project PREFIGURE, a video installation, and a supporting program with lectures, discussions, and participatory formats.

corner is intended as a permanent infrastructure: the content changes, but the location remains a tool for science communication and participation. corner is currently touring European cities and is scheduled to return to Karlsruhe in 2026. corner is headed by Prof. Michael Janoschka, it is a project of the Institute for Regional Science and Division IV – Natural and Built Environment at KIT, and is open to new topics, projects, and ideas from science and society. ■

corner: A meeting place for discussion, reflection, and research. *(Photo: Bernd Seeland)*

Science for Impact

In 1825, the Karlsruhe Polytechnic, the predecessor of KIT, was founded. In the anniversary year 2025, marking its 200th birthday, there were numerous events. The KIT centers Energy, Mobility Systems, People and Technology, Climate and Environment, HealthTech, KCETA, MaTeLis, and KCIST also contributed to the celebrations. During the Schlosslichtspiele Light Festival Karlsruhe from August 14 to September 14, 2025, they presented their contribution "Science for Impact," artistically realized by Los Romeras, which conjured up the fascinating world of science in impressive images and vibrant colors using projection mapping on the facade of Karlsruhe Castle. ■

"Science for Impact" on the facade of Karlsruhe Palace *(Source: Los Romeras)*

Gold prospectors

In a podcast by ZEIT WISSEN, Prof. Jochen Kolb and his team talk about their work searching for gold in Finland. https://www.zeit.de/wissen/2025-10/goldsuche-finnland-rohstoffe-kobalt-bergwerk-skandinavien (in German only) ■

Innovative environmental research at The LÄND

To mark the anniversaries of KIT and the Baden-Württemberg State Institute for the Environment (LUBW, 50 years), a joint workshop on innovative approaches in environmental research was held for the first time on November 4, 2025. More than 70 researchers from KIT and LUBW spent a whole day together attending lectures, participating in discussions, and networking. The agreement on strategic cooperation between the two institutions was also renewed during the event. ■

Great interest in "innovative environmental research in The LÄND" *(Photo: Sascha Schäfer)*

Prof. Harald Kunstmann


(Photo: Private)

As an observer for KIT, Prof. Harald Kunstmann took part in the UN Climate Change Conference COP30 in Brazil last November. For the hydrologist and climate researcher, attending such conferences provides a platform for professional exchange: "It is possible there to present research results to political decision-makers, establish new contacts, initiate international collaborations, and explore opportunities for implementing newly developed methods," says Kunstmann. "In the field of climate science in particular, international projects and the necessary data bases only come about through personal encounters and long-term trust."

Kunstmann is deputy director of the KIT Alpin Campus in Garmisch-Partenkirchen. In a joint appointment with the University of Augsburg, he also holds the chair for Regional Climate and Hydrology. In his research, Kunstmann combines hydrological and atmospheric models to better understand the regional impacts of climate change, particularly with regard to water availability, droughts, and flooding. The focus is on regions that are particularly affected by climate change, such as the global south, and here e.g. on improving the seasonal predictability of heat and drought, i.e. months ahead. Kunstmann emphasizes the role of scientists in public debate: "We must explain research results in an understandable way and be present where decisions are made." International climate conferences are a unique venue for this, he says, because "only here do such diverse actors as science, politics, and non-governmental organizations come together." ■

Dr. Susanne Benz


(Photo: Private)

For three years, Dr. Susanne Benz has been leading a junior research group at KIT-IPF – funded by a Freigeist Fellowship from the Volkswagen Foundation. Her topic: How can cities become more resilient to heat? Benz is investigating how urban heat is formed, which population groups are particularly affected, and how such hotspots can be better identified with the help of geodata, AI, and cost-effective measurement methods.

Her group bears the programmatic name GRUSS – Geoinformatics for Climate Resilient Urban Systems. Ten researchers work together in an interdisciplinary fashion: from analyzing heat stress and issues of environmental justice to supporting authorities in monitoring urban biodiversity. One project, for example, shows that people with foreign citizenship in Germany are more likely to live in particularly hot residential areas – with consequences for their health and quality of life.

Why KIT? "Firstly, Karlsruhe is my home," says Benz. "Secondly, KIT offers exactly the interfaces I need thanks to its broad range of subjects – from social space analysis and urban research to geoinformatics and AI."

Ultimately, Benz and her team want to answer one question: How can cities be designed to protect people and nature even in a hotter future? ■

Science or swimming pool?

15 students attend the first "Climate and Environment" science camp

For 15 students, it wasn't a question, but a decision in favor of curiosity, a spirit of inquiry, and the future. At the beginning of September, the "Climate & Environment" Science Camp took place at KIT for the first time. For a week, they immersed themselves in the everyday life of climate and environmental research with experiments and excursions. The new Science Camp thus complements the already established offerings in fields such as electrical engineering, particle physics, and energy with a highly topical subject. The Science Camp was organized by the Center for Media Learning and the Baden-Württemberg Student Academy, financed by foundation funds (the Sparkasse Environmental Foundation, the Karl Schlecht Foundation, and the Schroff Foundations). The development and implementation were supported by Department IV "Natural and Built Environment" and the South German Climate Office at KIT. The KIT Center for Climate and Environment itself kicked off the program. In small groups, the participants developed their own projects on the atmosphere, water cycle, ecosystems, and soil.

We would like to take this opportunity to thank the many colleagues at KIT who were involved and whose enthusiasm made this week such a great success! Exciting results were obtained through experiments, research, and data analysis, which were presented to family and friends at the end of the week in the Triangel am Kronenplatz. The visits to various institutes were particularly impressive: in the wind tunnel at IWU, in the hydraulic engineering laboratory, at the city trees at ITAS, and at the weather balloon launch at IMKTRO, the students gained first-hand insights into research practice. The visit by SWR to the balloon launch even attracted media attention and increased the visibility of the new Science Camp. They are therefore a double win for KIT: for the young people, who experience science in an open, inspiring atmosphere, and for KIT, which strengthens its social impact, because the enthusiasm for research continues long after the camp week is over. Science during the holidays? For us at KIT, it's more than just an offer. It's an invitation to help shaping the future. ■

Jan Cermak is the new speaker of the GRACE graduate school

"GRACE stands for a structured path to the PhD, a wide range of qualification options, and a vibrant network."

The new GRACE speaker Jan Cermak. (Photo: Private)

GRACE brings together doctoral training at the KIT Climate and Environment Center. The graduate school connects doctoral projects and offers young researchers interdisciplinary perspectives, training in key skills, and international networking opportunities.

Prof. Dr. Jan Cermak, Institute for Meteorology and Climate Research (IMKASF) and Institute for Photogrammetry and Remote Sensing (IPF), is the new GRACE speaker. For him, GRACE is less of a "program" and more of a scientific community: a platform where doctoral students can exchange ideas, learn from each other, and develop their skills.

GRACE offers a broad portfolio of training and networking opportunities for this purpose. At the end of the program, graduates should not only have successfully completed their dissertation, but also know, for example, how to organize projects, communicate science to the public, or translate their own ideas into start-up projects.

Cermak brings experience from the intersection of climate, data, and remote sensing research – and, above all, the conviction that excellent science requires excellent conditions. GRACE, he says, aims to provide this framework: a clearly structured path to the PhD, a wide range of qualification options, and a vibrant network. ■

Further information at:
www.grace.kit.edu

Sustainable, digital, cooperative

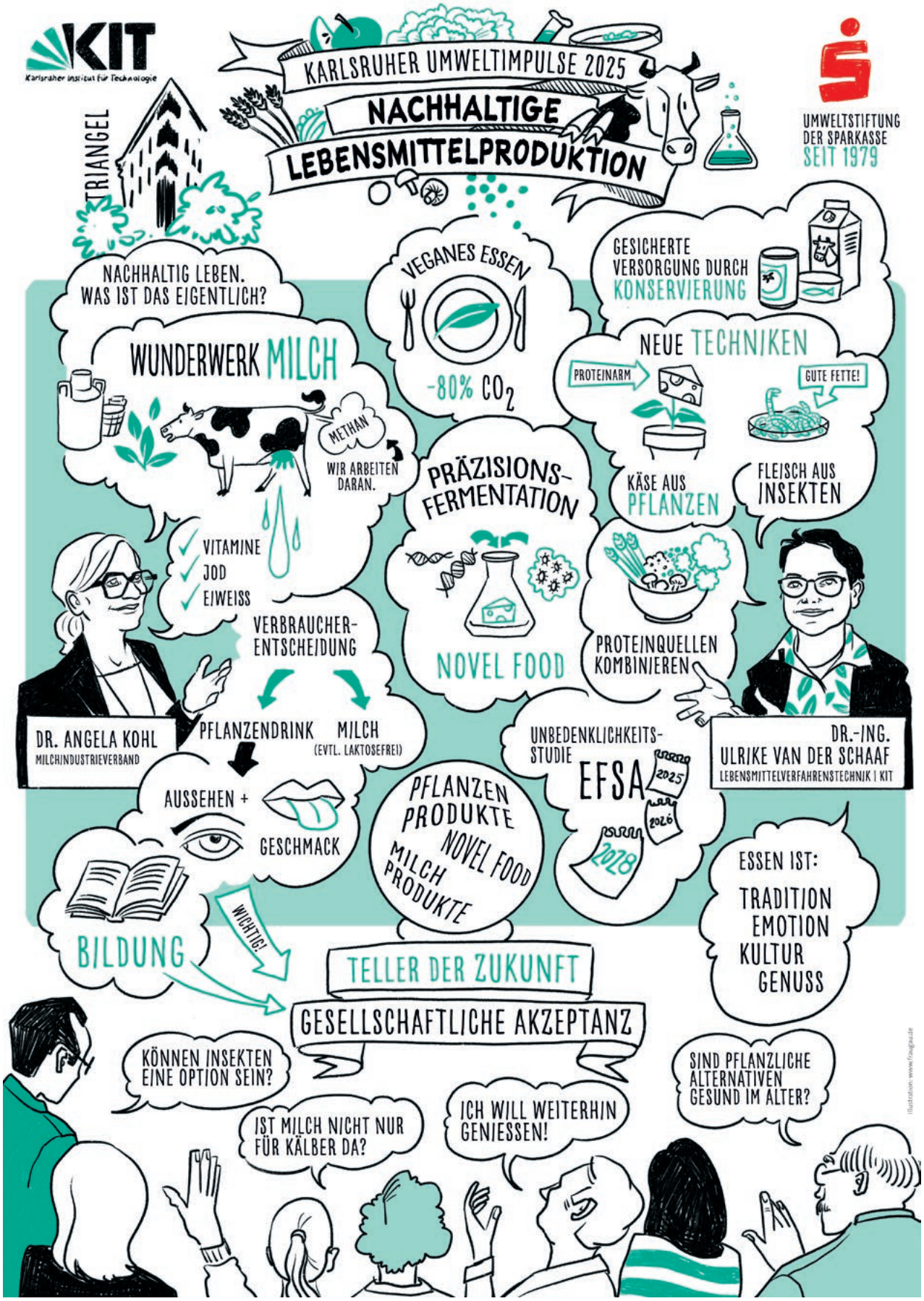
The path to a circular economy

The circular economy is increasingly becoming the focus of sustainable transformation – and was the topic of the KIT Business Club's fireside evening in September. Around 35 guests from research and industry discussed how value chains can become material cycles. In her opening presentation, Prof. Kora Kristof, Vice President for Digitalization and Sustainability at KIT, made it clear that circular strategies are difficult to implement without digital transparency: only when data on materials, components, and processes is available can products be designed to be truly circular.

Prof. Volker Schulze from the Institute for Production Technology (wbk) showed what this can look like in practice using the example of the "Circular Factory" collaborative research center: from automated disassembly and quality checks to remanufacturing. Impulses from industry came from Evonik, which is developing a process for recovering polymer building blocks, and Schneider Electric, where digitalization and electrification are seen as levers for circular business models.

The evening was organized by KIT's Innovation and Relations Management (IRM) department. Dr. Markus Florian Bauer from the Technology Marketing & Transfer (TMT) team emphasizes the importance of such formats for exchange: "Many solutions for the circular economy only emerge when we bring research and business together around one table. Our mission is to build precisely these bridges." ■

Well attended: KIT Business Club fireside evening. (Photo: KIT)



A visual record of an evening (in German only) where science, industry, and the public came together to think about the future of our food: The poster was created live during the panel discussion at the Karlsruhe Environmental Impulses 2025 event. Illustrator Eva Gau picked up on key questions from the audience: How are new protein sources changing our eating habits? What role will milk play in the future? And how can we win consumers over to sustainable solutions? The discussion thus became an image that conveys the diversity of the topic at a glance.

(Concept idea: Almut Ochsmann, illustration & layout: Eva Gau / www.fraugau.de.)

KIT Center for Climate, Environment and Resources

Scientific Spokesperson:	Prof. Dr. Christoph Hilgers
Deputy Scientific Spokesperson:	Prof. Dr. Thomas Leisner

Spokesperson of Topic 1:	Atmosphere:	Prof. Dr. Thomas Leisner
Spokesperson of Topic 2:	Water:	Prof. Dr. Olivier Eiff
Spokesperson of Topic 3:	Georesources:	Prof. Dr. Jochen Kolb
Spokesperson of Topic 4:	Ecosystems:	Prof. Dr. Nadine Rühr
Spokesperson of Topic 5:	Urban Research:	Prof. Dr. Michael Janoschka
Spokesperson of Topic 6:	Natural Hazards and Risk Management:	Prof. Dr. Michael Kunz
Spokesperson of Topic 7:	Data Science in Climate and Environmental Research:	Prof. Dr.-Ing. Stefan Hinz
Spokesperson of Topic 8:	Circular Economy and Environmental Technologies:	Prof. Dr.-Ing. Volker Schulze
Spokesperson of Topic 9:	Bioeconomy:	Prof. Dirk Holtmann

Five degrees warmer

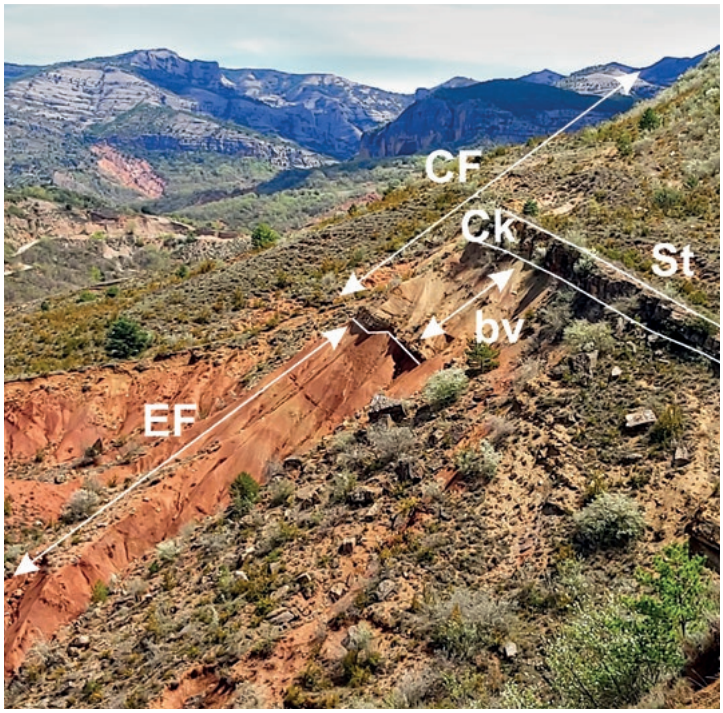
Continents in the extreme climate of the PETM

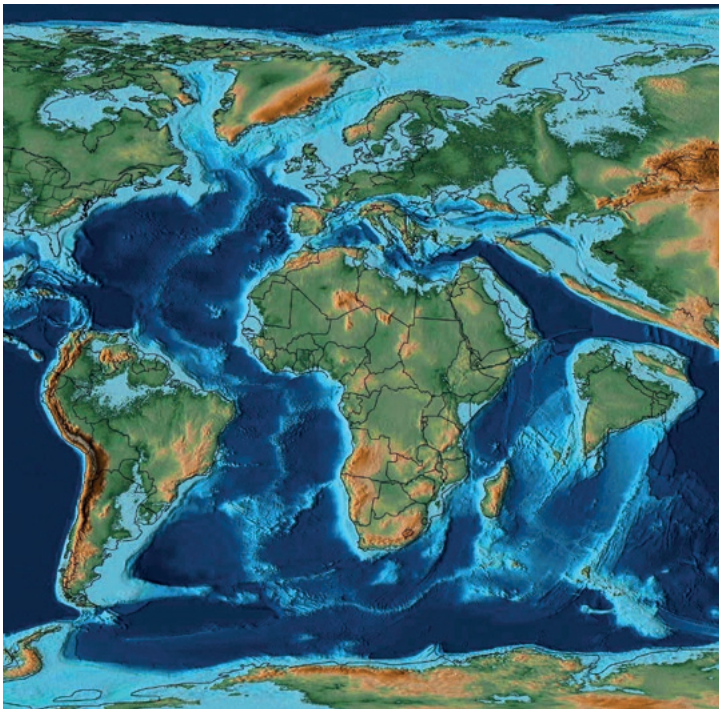
During the transition from the Paleocene to the Eocene 56 million years ago, the Earth experienced one of the most severe natural warming events in its history: the Paleocene-Eocene Thermal Maximum (PETM). How extreme this warm period was on the continents is shown by a study in which the climate researcher and doctoral student Kim Stadelmaier from KIT-IMKTRO was involved.

To this end, an international team examined soil carbonates in the southern Pyrenees. The results are clear: soil temperatures in summer rose by around five degrees during the PETM compared to the late Paleocene. At the same time, climate model analyses show that the temperature gradient between lower and higher latitudes flattened significantly – warm conditions extended far into northern regions.

Stadelmaier compared the new proxy data – indirect climate information from rocks – with global DeepMIP simulations and derived the CO_2 ranges for which models and measurements agree. The study, published in *Nature Communications Earth & Environment* in July 2025, is an important test for today's climate models and improves our understanding of how warming and extreme events could develop in a hotter future. ■

Original publication: Újvári, G., Kele, S., Rinyu, L. et al. Substantial continental temperature rise over the Paleocene-Eocene Thermal Maximum in the Pyrenees. *Commun Earth Environ* 6, 499 (2025). https://doi.org/10.1038/s43247-025-02479-8





Sediment layers in the southern Pyrenees near Esplugafreda (Spain) that document the climate around the Paleocene-Eocene Thermal Maximum (PETM). These rocks contain soil carbonates that provide clues about the temperatures at that time. In addition, the figure shows the location of the region and the topography at that time during the global warm period 56 million years ago.
(Photo: Gabor Ujvari; after Scotese, 2016)