Karlsruhe Institute of Technology

Climate and Environment news

NEWSLETTER OF THE KIT CLIMATE AND ENVIRONMENT CENTER

ISSUE 01 | 2025

Volcanism
The Smallest Quakes Reveal Magma

Lithium
Battery Raw Materials from Geothermal Water

Organic Waste
Preventing Slag Formation in Furnaces

Extreme Rainfall
Test Plot in the Meadow

TABLE OF CONTENTS

IMPRINT

Issued by
Karlsruhe Institute of Technology (KIT)
KIT Climate and Environment Center

Campus North
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen,
Germany

Campus South
Kaiserstraße 12
76131 Karlsruhe, Germany

KIT Climate and Environment Center
Office
Phone: +49 721 608-28592

Coordinated by
Dr. Kirsten Hennrich
Email: kirsten.hennrich@kit.edu

Edited and Typeset by
sciencerelations.de

Translation by
Katharine Schmidt, M. A.

Layout
Karlsruhe Institute of Technology (KIT)
AServ – HA-Dok – CrossMedia –
Grafik

PDF download (German/English) at
www.klima-umwelt.kit.edu

July 2025

Cover Photo
Mobile volcano-monitoring sensor station on the Methana Peninsula.
(Photo: Jan-Phillip Föst)

Dear Readers,

This year is a special one for KIT. Two hundred years ago, on October 7, 1825, the Karlsruhe Polytechnic was founded. That institution developed into the Universität Karlsruhe, which merged in 2009 with the Forschungszentrum Karlsruhe GmbH to become Karlsruhe Institute of Technology. We can look back on 200 years of scientific inquiry, in which much has happened and much has changed. In this connection, I heartily recommend to you the online exhibition featuring 100 objects from the past 200 years.

We are very happy to be able to present to you in this newsletter three young female scientists who are on the path to a professorship.

Today we are employing new methods to conduct research on old questions, and we are gaining new knowledge – for instance, that under the surface in the volcanic Eifel region and the Methana Peninsula in Greece, all is not as peaceful as has been presumed.

Of course, there are also new challenges to be addressed with the new methods. Particularly in areas of research involving data with high temporal and spatial resolution, approaches using AI have yielded major innovations and new options for evaluating and analyzing data. This opens up many methods for research on the environment and climate – for example, in hydrology and flood forecasting.

Last but not least, I am happy that this newsletter contains a new heading. "Resource-conserving Circular Economy" is an important field of research, in which KIT can make significant contributions.

I hope you enjoy reading this issue!

Yours,

Professor Dr. Oliver Kraft
Vice President Research, Teaching, and Academic Affairs

With extreme rainfall, every minute counts: AI systems can provide precise warnings of imminent flooding – even in small catchment areas. (Image generated using OpenAI's DALL·E)

Artificial Intelligence for Early Warning Capability

KI-HopE-De Aims to Make Possible Flood Forecasts for Small Catchment Areas

Flood damage does not occur only along large rivers such as the Oder, Elbe, or Rhine. In smaller catchment areas, too, during continuous or extreme rainfall events, streams and rivers can quickly overflow their banks, causing major flooding. The situation can get particularly critical in river catchment areas with an area of five to 500 square kilometers. Whereas large stretches of water are monitored via a dense network of gauges and measuring stations, there is a lack of necessary infrastructure and sufficient data along the courses of smaller rivers. In these areas, meteorological forecasts are often unreliable, and the generation of runoff occurs extremely fast – thus, it is a great challenge to provide precise forecasts and adopt protective measures in time. This is the starting point for the project KI-HopE-De – an initiative funded by the German Federal Ministry of Research, Technology and Space, with the participation of the Institute for Water and Environment (IWU) at KIT. The goal is to develop a forecasting system for smaller water catchment areas that will function reliably, even where conventional methods have until now met their limits. IWU is joined in this research effort by KIT's Institute of Statistics and its Institute of Meteorology and Climate Research.

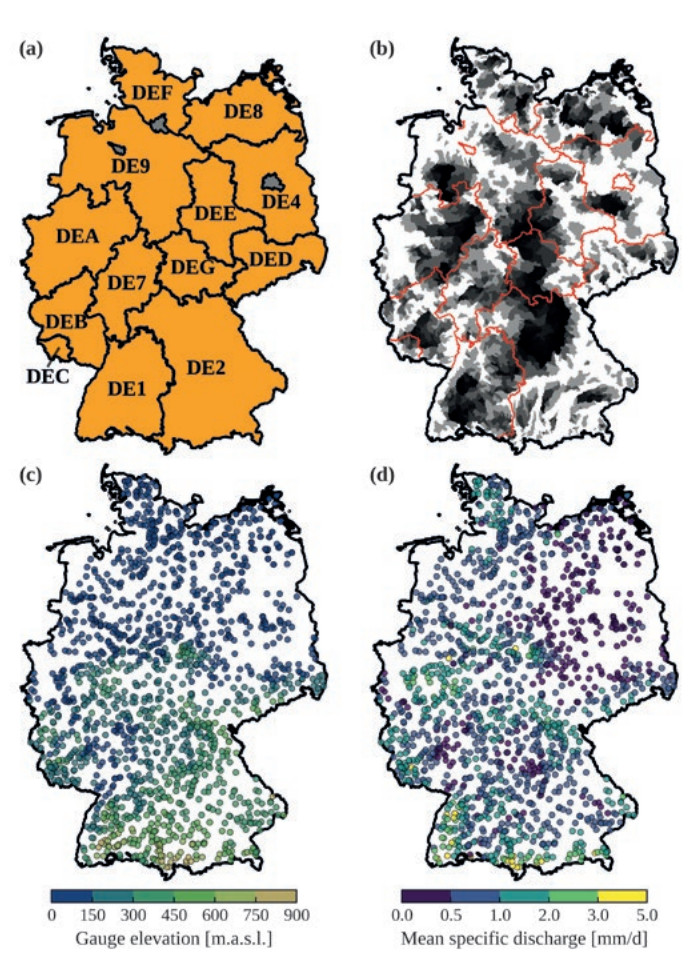
The project relies on a basis of machine learning – a subarea within the field of artificial intelligence that aims to detect statistical patterns in large datasets. The idea is to detect connections between meteorological and hydrological conditions and actual floods. The project makes use of weather forecasts and probabilities, rather than fixed individual models, to yield more robust assessments.

To this end, the models use a modular system that, depending on the available data, can work with weather forecasts, radar images, satellite data, and terrain models, in addition to information on soil moisture and vegetation. Thus, the risk of flooding can be calculated in real time – both for cases of persistent, continuous rainfall and for sudden, extreme rainfall.

The models are being trained with data on outflow and water levels, so that they can work out forecasts a few hours in advance. "We need a system that will work reliably, even in the face of great uncertainty – one that is robust, scalable, and adaptable for different regions," says Ralf Loritz, leader of a junior research group at IWU.

The preparation of the data poses a particular challenge: In Germany, hydrological data are organized on a federal basis and often structured in different ways. In order for the models to function across regional boundaries, the data from the different federal state offices must first be laboriously harmonized.

For that reason, the team is working closely together with the German Weather Service, the Rhineland-Palatinate State Office for the Environment, and the North Rhine-Westphalia State Office for Nature,



Artificial intelligence requires data: Thousands of water-gauge measurements throughout Germany provide the basis for AI-supported flood forecasting. (Image: Loritz et al. 2024, CC BY 4.0)

Environment and Consumer Affairs. In three model regions – Baden-Württemberg, North Rhine-Westphalia, and Rhineland-Palatinate – the system is being tested, validated, and refined, together with these partners. "Precise fine-tuning in practice is crucial, in order to make possible the integration into existing systems later on," says Loritz. One key goal of the project is to significantly improve the precision of forecasts, in comparison with conventional methods. Initial studies have indicated that with deep-learning methods, it is possible to increase the quality of forecasts by up to 20 percent – a major advance for regions in which, up till now, dependable early warning times have been rare.

Even if KI-HopE-De is not aiming to immediately launch a ready-to-use warning system, it is creating an important scientific foundation for such a system. The methods and models that are being developed are to be integrated later on into existing systems, or to be refined to serve as building blocks for new applications. An additional aim of KI-HopE-De is to develop publicly supported alternatives and to transfer know-how over the long term to specialist government authorities. "Our goal is to create a tool that can be employed throughout the Federal Republic," says Loritz. "It is meant to contribute over the long term to the early detection of risks, the prevention of damage, and the protection of lives." ■

Volcano under Observation

Mobile Sensors Detect Hidden Activity under the Methana Peninsula

Idyllic, but active? The Methana Peninsula in the Saronic Gulf harbors volcanic potential. (Photo: Jan-Phillip Föst)

The Methana Peninsula in the Saronic Gulf, only 45 kilometers from Athens, is known as a dormant volcano. In the MeMax project, an international research team that includes participants from KIT is examining the region with the help of highly sensitive seismic sensors. The goal is to detect the slightest vibrations, which provide an indication of hidden magmatic processes.

"We want to find out how active Methana actually is, still – to see if something is moving under the surface," says Jan-Phillip Föst, a doctoral candidate at KIT's Geophysical Institute and at RWTH Aachen University. As of 2024, in addition to the measuring stations existing before then, 15 mobile sensors have been recording seismic signals all around the area.

Through the analysis of these data, a more precise picture of the inner structure of the volcano and its surroundings is emerging. It is especially important to determine whether signals are tectonic in origin, or if they are indicative of magmatic movement. That is a significant difference, because only the latter indicates the possibility of renewed volcanic activity.

This research is part of the European project MULTIMAREX, which is examining interactions between earthquakes, volcanism, and tsunamis in the Mediterranean region. "We should not underestimate volcanoes that are presumed to be at rest," says Föst. ■

Installation of a seismic sensor: The team is measuring the slightest vibrations throughout the area of the Methana Volcano. (Photo: Jan-Phillip Föst)

Klemens Slunitschek (doctoral candidate in the project) in front of the pilot system for extracting lithium from geothermal water.
(Photo: Jochen Kolb / KIT)

Lithium from the Depths

Paths to Sustainable Extraction from Geothermal Water

Lithium is known as a key raw material for the energy transition – for electric cars, for the storage of electricity, and for the battery technologies of tomorrow. However, lithium mostly comes from just a few countries, such as Chile, Argentina, and Australia. Due to this geopolitical situation, lithium is increasingly being classified as a critical metal. According to forecasts, worldwide demand could rise by 2030 to up to 550,000 tons per year. This makes it all the more important to find regional and environmentally sound alternatives – for instance, from the hot underground water used in geothermal power plants.

The geothermal power plant in Bruchsal, operated by energy supplier EnBW, (Energie Baden-Württemberg AG), was the focus of research. At that plant, hot water at temperatures ranging from 60 to 80 °C, with a high salt content, is drawn from the depths to generate electricity and heat. "This water contains up to 160 milligrams of lithium per liter, and about four times as much salt as seawater," says Professor Jochen Kolb, professor for geochemistry and economic geology. The goal was to extract the lithium – without disrupting the geothermal cycle.

In a comprehensive laboratory study, the team tested the use of different materials for the selective binding of lithium. A manganese oxide that had been synthesized by the team itself and tested under realistic conditions in the pilot system at the Bruchsal plant was particularly effective. The adsorption of the lithium onto it proceeds quickly and selectively – after one minute, 55 percent of the capacity is already reached. The discharge of the material is effected via weak hydrochloric acid, and it results in a lithium chloride solution like the one used in the production of lithium throughout the world.

The economic and environmental feasibility was also investigated within the framework of the project group. Modeling done at the University of Göttingen shows that it would be possible to extract lithium for decades from a geothermal power plant without causing adverse impacts for the plant, or significant dilution effects underground. One hour of operation could provide enough lithium for a car battery, and two hours would be enough for an e-bike.

The greatest challenge now lies in technical implementation for large-scale technical applications. The fine powders that performed outstandingly in the laboratory must be converted into a practical form – for instance, embedded in porous foams, or in substrate materials. This is the starting point for a new project that is currently in the evaluation phase.

"Our research shows that it is possible to extract metals such as lithium directly from water – in a resource-conserving and regional approach," says Kolb. Such an approach could offer a new way forward not only for geothermal power generation, but also for the recycling of batteries or the processing of water in other industries. ■

Oxy-PAHs: From the Air or the Soil?

A New Isotope Method Aims to Better Trace Pollutants back to Their Source

Jannatul Mawya Liza, a doctoral candidate at the Institute of Geography and Geoecology (IFGG) at KIT, is developing a method for precisely determining the origin of oxygenated polycyclic aromatic hydrocarbons (oxy-PAHs). These organic pollutants are considered to be – like their precursors, the polycyclic aromatic hydrocarbons (PAHs) – carcinogenic and mutagenic. Oxy-PAHs are not only released into the environment during the combustion of organic materials; they also arise in a secondary manner from PAHs, either via photochemical oxidation in sunlight, or through microbial processes in the soil.

Although they emerge from different sources, oxy-PAHs are chemically identical. "The unambiguous attribution to the sources is the precondition for good risk assessment and appropriate countermeasures," says Liza. Oxy-PAHs generated by photochemical oxidation spread through the air and contribute to air pollution. Oxy-PAHs of microbial origin, conversely, indicate contamination in local soils. "Depending on the origin, one must either reduce emissions or rehabilitate the soil," says Liza.

Liza's approach makes possible for the first time the differentiation between oxy-PAH sources: On the one hand, it combines the analysis of carbon isotopes ($\delta^{13}C$) und hydrogen isotopes ($\delta^{2}H$). On the other hand, the analytical approach is buttressed by a broad range of experiments: In the laboratory, Liza is carrying out controlled combustion tests and thereby collecting suspended particulate matter. She is running microbial conversion experiments in soil microcosms and analyzing samples from various locations. "In the long run, Liza's research can contribute to the development of effective strategies for the abatement of oxy-PAHs," says Professor Wolfgang Wilcke, head of the working group on soil chemistry and soil physics at IFGG. ■

Jannatul Mawya Liza, a doctoral candidate at IFGG, is investigating the origin of oxy-PAHs. (Photo: Li Zhang)

How Water Actually Flows

New Approaches in Research on Extreme Rainfall

Extreme rainfall events have become one of the most frequent causes of flood damage in Germany. Unlike the case with conventional river flooding, the water does not come from stretches of water that have overflowed their banks, but rather it falls directly and intensely from the sky – onto paved-over surfaces, and into saturated soils and depressions. About half of all flood damage in Germany is in the meantime attributable to such events.

Field experiment with tracer dye on a sloping meadow – with the mobile test bed, the team is simulating real-life extreme rainfall scenarios. (Photo: KIT-IWU / Peter Oberle)

But while flood control along rivers has been studied for decades and is well established, in many places there is no solid foundation for models for extreme rainfall events. To change that situation, a research team led by Dr. Peter Oberle at KIT's Institute for Water and Environment (IWU) investigated how extreme rainfall spreads on natural surfaces, using a mobile field laboratory near Karlsruhe. In an unusual approach, the experiments did not take place on an artificial surface, but rather on a real meadow with natural vegetation – thus, under realistic conditions. In the process, the researchers systematically varied the slope, the vegetation density, and the season.

The study focused on the so-called flow-resistance coefficient – a central parameter in flow models. It indicates how intensely water is restrained on its path over a surface. Up until now, engineers have had to estimate this value. "With the help of tracers, sensor technology, and laser scans, we were able for the first time to gain dependable data from the field," says Oberle. To that end, his team carried out 840 individual experiments, in which the flow velocity, water depth, and the retained volume, in addition to the infiltration of the soil, were precisely measured.

The goal of the project was to adapt 2D flow models to the particular challenges of extreme rainfall. "With these models, it is possible to draw up more exact hazard maps, and cities can be provided with an improved basis for their planning," says Oberle. In a subsequent step, the method is to be adapted for farmland. About 90 percent of the usable area in Baden-Württemberg that has relevance for extreme rainfall consists of meadows, cropland, and boundary surfaces. ■

Hydrogen in Rock

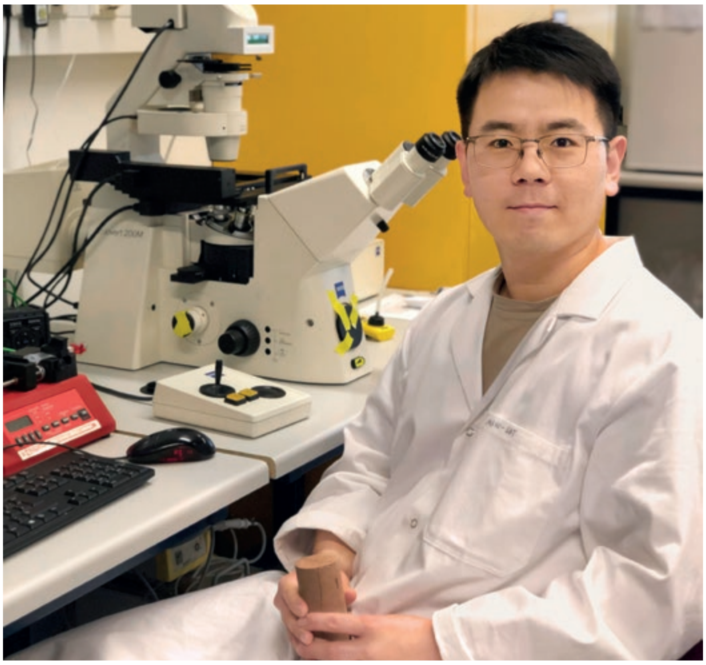
How Safe Is Underground Storage?

Hydrogen plays a key role in the energy transition. If it is to be used as a seasonal reserve or as compensatory storage for renewable energy sources, what is needed are not only green production methods, but also large-volume storage solutions. One very promising option is presented by underground hydrogen storage (UHS) – for instance, in depleted natural-gas deposits. But how stable is hydrogen in underground geological formations?

To answer this question, a research team at KIT's Institute of Applied Geosciences (AGW) used hydrogen in the laboratory to treat sample rocks removed from porous storage rock. The aim was to better understand the chemical changes under realistic pressure and temperature conditions. The finding was that while reactions took place, they were not caused directly by the hydrogen, but rather by the imbalance between the rock and the newly introduced fluid. Such reactions would have also been possible with other gases.

In rocks that do not contain sulfide minerals, such as pyrite, the hydrogen proved to be more stable than had been presumed till now. In the next stage, the team is now systematically examining pyrite-rich rocks from other European deposits, in order to also assess potentially more reactive formations.

"Our tests show that hydrogen is geochemically relatively inert in suitable formations," says Chaojie Cheng, a research scientist at AGW and the study's lead author. "That contradicts many previous model calculations – and it is an encouraging finding for the further development of this storage technology." While they conduct research on geochemical processes, team members are also examining microbial processes in which microorganisms can transform hydrogen into methane or hydrogen sulfide. In special test rigs, the researchers are clarifying how fast such reactions occur and the conditions under which they occur – and whether they can be avoided or even systematically controlled. ■



Chaojie Cheng, a research scientist at AGW, in the laboratory, investigates the geochemical stability of hydrogen in porous storage rock. (Photo: Private / Chaojie Cheng)

The Anniversary Year 2025 – A Long Tradition in the Environmental Sciences

The 200th anniversary is being marked at the KIT Climate and Environment Center, as elsewhere at KIT. Since 1825, future-oriented research has been conducted in Karlsruhe. The beginnings were indeed dominated by the environmental sciences. Thus, nearly 50 years before the founding of the Polytechnic, meteorological measurements were being taken by Johann Lorenz Boeckmann, and as early as 1807, Johann Gottfried Tulla established a school of engineering. These facts and others on the history of the environmental and climate sciences at the institution now known as KIT will be presented over the course of the year at various events, and information on them will also be accessible afterward online. Karlsruhe is, after all, not just known for mechanical engineering, but has also served as an important catalyst in other fields. ■

Tasting Insects

Tasting insects was a highlight at the stand of the Climate and Environment Center for the open-house day in mid-May on KIT's Campus South. In addition, research at the Center was concretely presented with vivid experiments and a multifunctional touchscreen. ■

The Center's team before the big crush. (Photo: Gerce Wolff)

The Guest from India

Dr. Ramanuj Banerjee, the Indian embassy's science counsellor, visited KIT and the KIT Climate and Environment Center on May 27, 2025. The communication between the two parties was very open. We were happy to learn more about the goals of the Indian government, and to discuss the synergies and advantages of closer collaboration between our countries. The visit took place at IMKAAF (Institute of Meteorology and Climate Research Atmospheric Aerosol Research), followed by a demonstration in the AIDA cloud chamber. ■

Dr. Banerjee (middle) on his visit to KIT and the AIDA cloud chamber (Photo: KIT)

Professor Dr. Franziska Meinherz


(Photo: Chiara Bellamoli/KIT)

What does sustainable mobility look like when you conceptualize it not from the perspective of planning departments, but rather in accordance with people's everyday lives? Professor Franziska Meinherz has been a tenure-track professor for urban and mobility geography at the Institute of Geography and Geoecology at KIT since 2024. With her working group, she is exploring how a socially equitable mobility transition can be achieved.

Meinherz's analysis focuses on how mobility is implemented in everyday life – and asks which social groups are thereby systematically disadvantaged. "We are interested, for example, in people whose mobility is limited by care work, their income, or safety concerns – and in how their experiences can contribute to the finding of sustainable solutions."

At the same time, the aim is to show that many of these resource-conserving mobility practices are not to be understood as being inadequate, but rather that they should serve as models for society. Meinherz also takes a critical look at temporary bicycle infrastructure and pop-up measures – for instance, with a view toward their democratic legitimation, their suitability for everyday life, and their social impact.

In the next few years, she wants to bolster the prospects for implementation: How can ambitious transport objectives be developed in such a way as to be compatible with the lived reality on site? "We should not conceptualize mobility from above," she says, "but rather in keeping with everyday life as it is lived – only then will it be possible for the mobility transition to be really equitable." ■

Professor Dr. Martina Klose


(Photo: Private)

Since January 2025, Dr. Martina Klose has been a tenure-track professor for aerosols in the earth system, at KIT's Institute of Meteorology and Climate Research Troposphere Research. Her research focuses on aerosols in the atmosphere – above all, on mineral dust. It is stirred up by the wind and has an impact on many processes, from cloud formation to the radiation balance. "We are investigating, for example, the characteristics of the dust particles and how long they remain in the air," Klose says. She combines theoretical concepts, numerical models, and measurements in the laboratory and the field. Her findings are being incorporated into climate models and helping in the assessment of how the interaction between natural aerosols and the atmosphere could change in the future. ■

Professor Dr. Nevena Andrić-Tomašević


(Photo: Private)

Professor Nevena Andrić-Tomašević is investigating how tectonic processes, climatic effects, magmatic processes, and surface processes jointly shape the development of sedimentary basins and mountain ranges. Since April 2021, she has been a tenure-track professor (W1) at KIT's Institute of Applied Geosciences, where she leads the research group "General Geology." Andrić-Tomašević is analyzing the impact that processes like heat flows, fluid movement, or so-called slab-tearing processes – that is, the breaking off of subduction plates deep under the surface – have on geological structures and the genesis of natural resources. Her research is yielding findings with importance for issues such as CO_2 storage, geothermal energy production, and the genesis of critical raw materials. ■

When Heat Persists

Adapting to Climate Change

Summer has arrived, with warm days, visits to outdoor pools, evenings on the patio, and cooling ice cream. But what happens if the heat persists, and barely dissipates? Let's recall the summer of 2003, when a record for Germany was set in Karlsruhe, at 40.2 °C. According to climate simulations that KIT's Institute of Meteorology and Climate Research Troposphere Research has been involved in, similarly hot summers will occur more often in the future. That means that we must increasingly be prepared for and adapt to extreme temperatures. Sustainability is crucial in this respect. The *Innovationscampus Nachhaltigkeit* (Innovation Campus Sustainability, known as ICN) was established in early 2024, with the aim of shaping a livable future. Funded by the Baden-Württemberg Ministry of Science, Research, and the Arts, the project PROLOK was set up by us at ICN, together with the University of Freiburg, the KlimaPlus consulting firm, and the *Regionalverband Südlicher Oberrhein* (Southern Upper Rhine Association). The goal is to develop a process chart for the preparation of heat response plans by smaller municipalities. Why is that important? Adaptation to climate change, especially to extreme heat, is essential. Even small municipalities with limited financial resources and staff should be able to put together a heat response plan for their inhabitants. PROLOK helps them to create a plan as effectively and transparently as possible. We have received a considerable amount of support from the town of Ihringen, which lies in the middle of Rhine Valley and is greatly impacted by heat. The municipality provided crucial support in the structuring of our process chart. To sum up: The rising temperatures throughout the world are causing ever more extreme heat waves, which are perceptible at the local level. Projects such as PROLOK, which address these challenges in cooperation with municipalities, are contributing to greater sustainability in our world. ■

Fun with COMPASS: Participants from the third cohort at a workshop in Potsdam. *(Photo: Susanne Gatti)*

Strategically Planning One's Next Career Steps – With COMPASS

Mentoring Program Provides Support for Career Planning in Research and Management

How would I like to work in the future? Which professional opportunities offer the best fit for my skills and values? And what do I need in order to gain access to them? The mentoring program COMPASS, offered by the Helmholtz Association, helps researchers in early phases of their career, and people involved in research management in the research field of Earth and Environment, to answer these questions. "We want to create spaces in which people can consciously reflect on their professional future – whether in research, industry, or at government authorities," says Dr. Elijah Bleher, Head of the Graduate Program at KIT's Institute of Meteorology and Climate Research Atmospheric Environmental Research (IMKIFU), and the person in charge of COMPASS.

COMPASS combines individual mentoring by veteran subject-matter experts and managers with realistic workshops, and it facilitates interaction on an equal footing. The supporting program provides the impetus for career-path planning, the analysis of one's strengths, and for decision-making. The goal is to support the mentees in the systematic development and pursuit of their career goals.

The fourth cohort of the program starts in January 2026, and it will run for 18 months. Postdocs and science managers in the Earth and Environment research field can apply from September 8 through October 5, 2025. Three of the 24 mentees from the seven Helmholtz centers can come from KIT. ■

More information: https://www.ce-atmochange.kit.edu/968.php

New Thinking about Old Materials

Lead Project at KIT Pools Expertise in Search of Resource-efficient Material and Product Systems

Nearly all industrial sectors rely on global material flows. Until now, there has been a lack of systems that can account for material requirements, energy use, and environmental impacts in a holistic way. KIT is working on this challenge in a new lead project: "Integrative Resource-efficient Circular Systems." The goal is to rethink cycles of materials and components – from the extraction of raw materials to recycling.

Dozens of research groups from the areas of civil engineering, mechanical engineering, natural sciences, and economics are contributing their expertise to this endeavor. "Sustainability does not begin with recycling," says Professor Volker Schulze, Head of the Institute of Production Science and one of the coordinators of the project. "Recycling has to be factored in already in design and manufacturing," he says. His interest lies in how components can be processed and recycled following their use.

Professor Christoph Hilgers, Chair of Structural Geology at KIT, also a coordinator of the lead project, and scientific spokesperson of KIT's Climate and Environment Center, adds: "We want to better understand the interaction between the technology sphere and the geosphere, and to close circular systems – in order to reduce environmental impacts and the quantities of raw materials and residual materials."

The participants have all adopted a systemic perspective: Instead of linear production models, they are concerned with integrative circular systems – including digital twins for use in the analysis of material and energy flows. "At KIT, we are linking engineering, geology, and environmental science," says Schulze. "This is our strong point – and our responsibility." ■

KIT lead project: Keeping product components in circulation.
(Photo: Thomas Heitz / Adobe Stock)

Preventing Incrustation in the Furnace

KIT Researchers Are Analyzing Residue in Biomass Combustion – With the Goal of More Efficient and Resource-conserving Use of Residual Materials

Many times, when people think about organic waste, what comes to mind is composting or biogas production. But some organic wastes end up in biomass combustion plants, in particular those that are heavily contaminated. There, energy is generated from the heterogeneous material – and along with it, a technical problem: Deposits in the combustion chamber and incrustation on the surfaces of heat exchangers cause wear in the plants and give rise to high maintenance costs. In addition, the slag that is generated must be disposed of.

To address those challenges, several combustion plants, an engineering firm, and KIT are working together in a project funded by the German Federal Ministry for Economic Affairs and Climate Action. Their goal is to be able to regulate the combustion of biomass so that the generation of deposits and incrustations is minimized. They want to be able to recycle the slags – and thereby conserve valuable materials.

A team led by Professor Jochen Kolb at KIT's Institute of Applied Geosciences is contributing to the project from a geoscience perspective. "Our task is to analyze the mineral components in the combustion residues," Kolb says. To that end, the researchers are combusting biomass components in laboratory experiments at realistic temperatures and under defined conditions, and subsequently analyzing the composition of the ash that is generated. The key question concerns the minerals that are created at various temperatures: Are loose, removable crusts being generated – or hard, adherent deposits on the walls of the combustion chamber, and coatings on the metal heat exchangers?

The range of fuels being tested: Biofuel mixes that are being analyzed at KIT with regard to their potential for generating deposits. (Photo: Kolb / KIT)

This information is incorporated into so-called phase diagrams. They show which mineral phases are stable at particular temperatures. On this basis, researchers aim to give the operators of biomass combustion plants empirically sound recommendations for optimizing the operation of their plants – depending on the respective biomass that is used.

One finding thus far is that even presumably unproblematic operating conditions can result in deposits and losses of efficiency. "Our studies show that problematic coatings are often created even at temperatures that lie significantly below the ash melting points of the biomass fuels," Kolb says. "The generation of residues that become solid begins already at temperatures around 750 °C to 850 °C – although sintering temperatures in accordance with the German industrial norm (DIN) are mostly assumed to begin at more than 900 °C, and reach up to 1000 °C."

Amid the combustion heat, new mineral structures are created, and they differ in accordance with the temperature and composition of the fuel. In the process, solid, compact slags predominate on the grate; in the combustion chamber, mainly sintered and vitreous deposits; and in the boiler area, to an extent, voluminous coatings ranging from hard to particulate. With the help of sintering experiments at the lab and pilot-plant scales, the researchers are testing to determine which biofuel mixes display high or low caking potential. This kind of differentiation is helpful for systematic influencing of the processes.

When it's too late: Slag and loose deposits from a biomass furnace – disposal required. (Photo: Kolb / KIT)

In pursuit of practical applications, researchers are using biomass fuel mixes at four biomass fuel plants for months at a time under realistic conditions. Some of the fuel mixes employed have already been optimized, and others have been left in their original state, to gain a better understanding of coatings as a function of inputs, and to obtain information for subsequent improvements. During planned stoppages, the project partners systematically test the deposits and coatings. In this way, they are generating a dataset that reveals the effects of the mix, the temperature, and of combustion management during operation.

Only the best combinations are ultimately used. "That lowers risk, increases running times, and brings us one step closer to the vision of an intelligent, forward-looking circular economy," says Kolb. Last but not least, the project is making a contribution to the energy transition: Via the optimized use of biofuels, fossil fuels can be conserved and the energy efficiency of decentralized plants can be increased – a goal that is also becoming ever more important for thermal planning in municipalities. "Our project is making biomass heating plants more robust, more economical, and more climate-friendly," says Kolb. "That benefits operators, municipalities, and the environment in equal measure." ■

KIT Climate and Environment Center

Scientific Spokesperson:	Professor Dr. Christoph Hilgers	
Deputy Scientific Spokesperson:	Professor 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. Dr.-Ing. Dirk Holtmann

We will report in detail on the new topic "Bioeconomy" in the next issue of the newsletter.

The Eifel Region Is Sleeping – But How Deeply?

New Analysis of Old Data Reveals Signs of Hidden Magmatic Activity

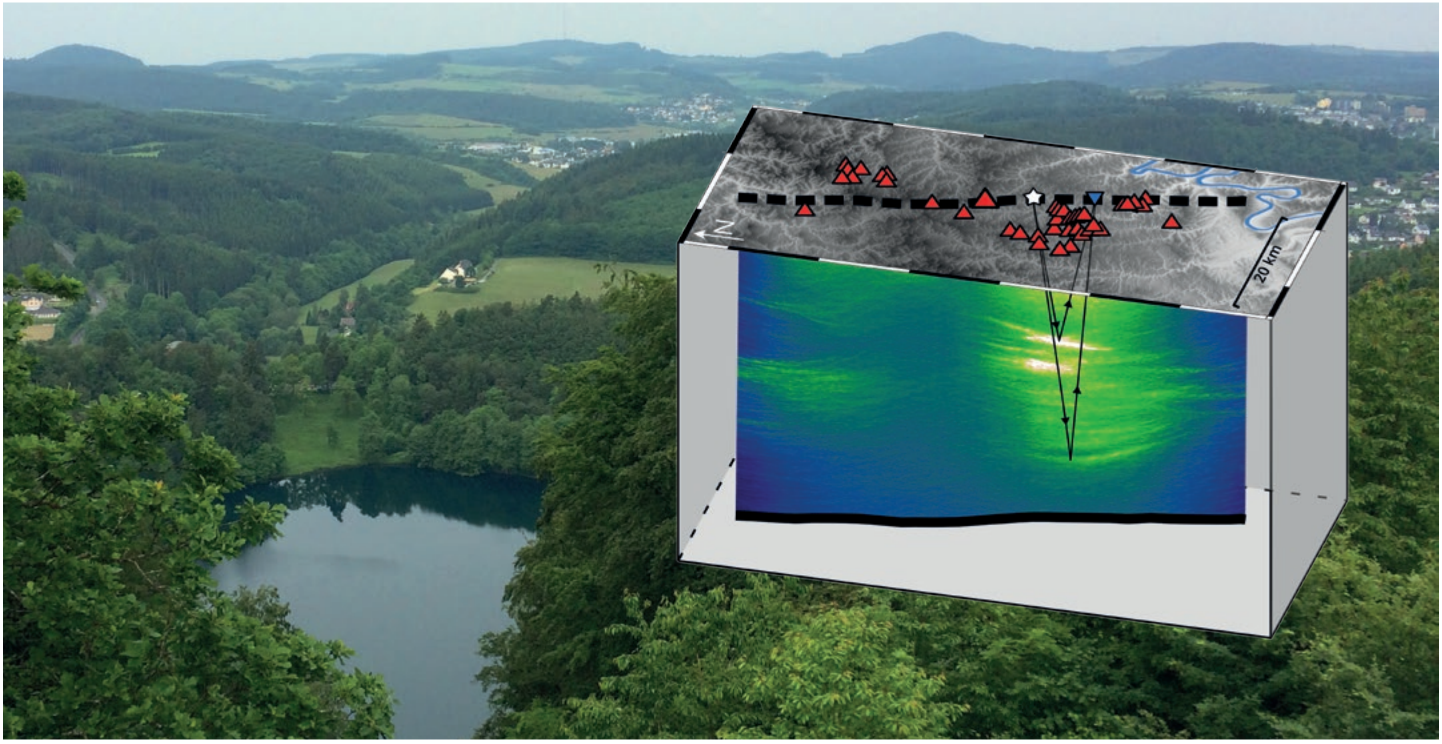
A research team including participants from KIT recently discovered that the volcanic underground in the Eifel region may not be extinct, but rather only dormant. The researchers carried out a new analysis of seismic data from the 1980s. They found a number of zones at depths of 15 to 30 kilometers that had unusually strong reflections – indicating areas of active magmatism.

An imaging process that was developed at the Technical University Bergakademie Freiberg (in Saxony) has made it possible to more precisely assign the older time-based signals to the depths. "Our analyses permit a more exact imaging of the structures than was possible 40 years ago," says Dario Eickhoff, lead author of the paper and a doctoral student at KIT's Geophysical Institute.

"Eruptions in the near term are very unlikely in the Eifel," Eickhoff continues. "But in the past, magma has risen to the surface as quickly as within a few days." For that reason, the researchers are calling for new geophysical measurement campaigns, in order to identify changes underground, and better evaluate risks.

"Our study shows how new scientific knowledge can be gained by applying present-day methods to old data," says Eickhoff in conclusion. "That holds relevance for further research." ■

Original publication: Seismic reflection imaging of fluid filled sills in the West Eifel volcanic field, Germany. Geophysical Research Letters 51.24 (2024). DOI: 10. 1029/2024GL111425



Seismic image of the underground in the West Eifel area: Yellow zones indicate strong reflections at a depth of up to 30 km – in the exact area where a cluster of young volcanoes (red triangles) is located on the surface. *(Photo: Hannes Schlender / scienceRELATIONS, Illustration: D. Eickhoff / KIT-GPI)*