Karlsruhe Institute of Technology

Climate and Environment news

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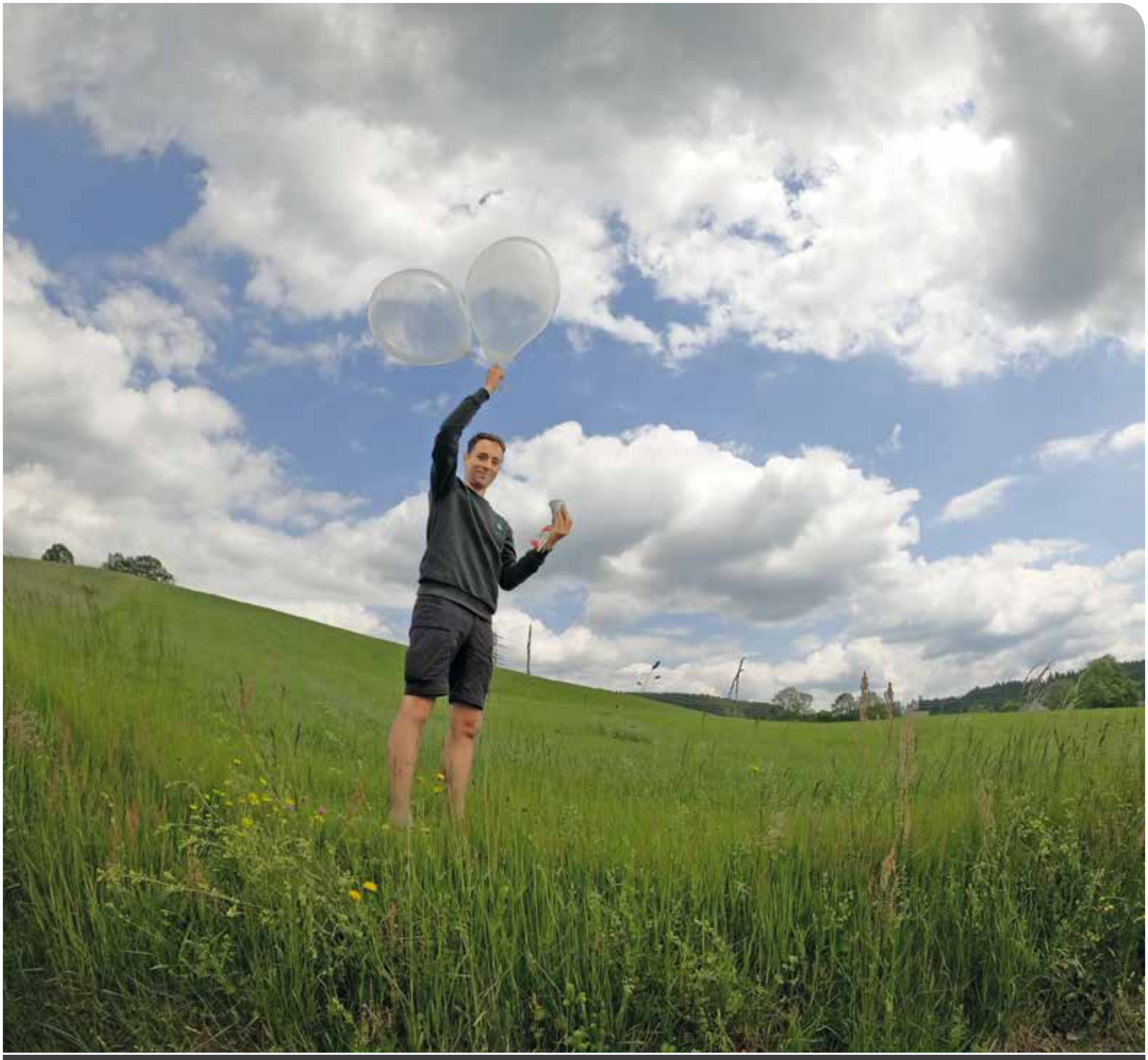

LIFT
On the Hunt for the Storm

Wine-growing
Protection from Salts

Cooperation
Tackling Environmental Problems Together

Urban Research
As Complex as the Environment Itself

IMPRINT

Issued by
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March 2024

Cover Photo
Helium-filled balloons carry measuring sondes into the storm cell (Photo: Kunz)

Dear Readers!

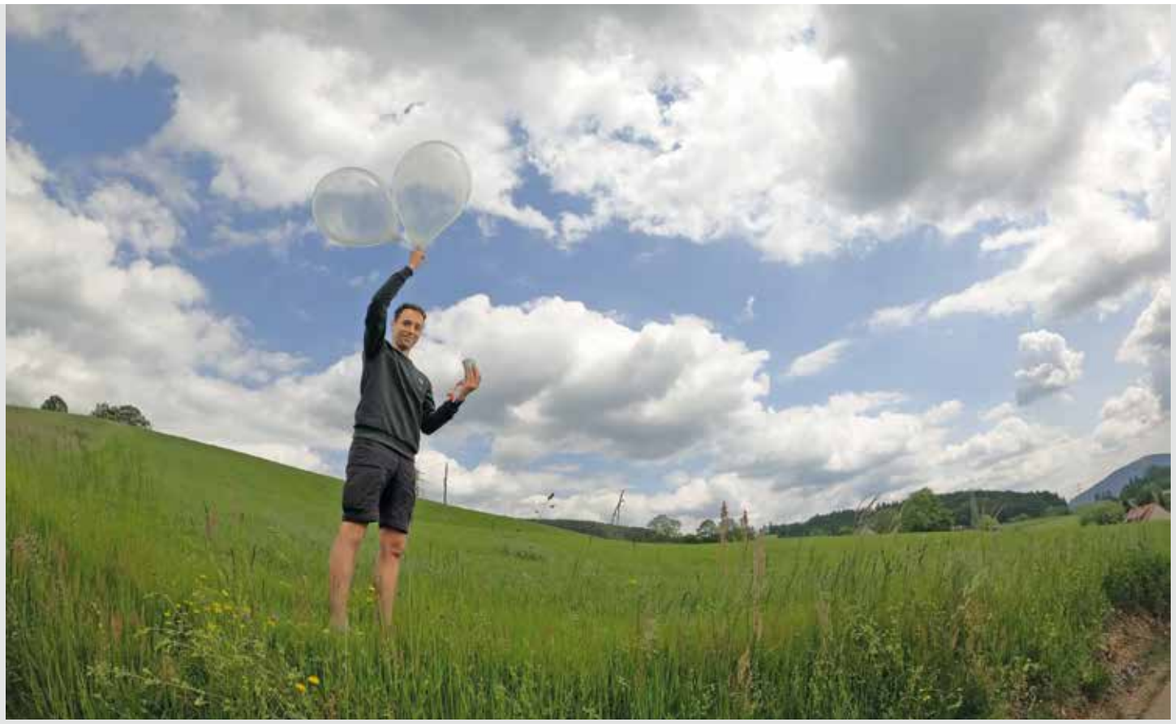
The past few months have once again shown us how urgent it is to tackle climate change and to use and shape our environment sustainably. The devastating forest fires in Western Europe and Australia, for example, have not only threatened countless animal and plant species, but have also destroyed the livelihoods of many people. Disasters like these once again highlight the need to take measures to protect our planet.

Apart from the direct effects of climate change, however, there are also positive developments that we can be proud of. In urban planning, the focus is increasingly shifting to sustainable mobility, while demand for fair trade products from organic farming is on the rise in consumer goods. These conscious decisions by consumers help to reduce our carbon footprint.

The KIT Climate and Environment Center is also playing its part in finding solutions to the challenges of climate change. Our researchers are working on innovative approaches to predicting extreme weather situations, adapting to climate change, and planning our living space sustainably - both in rural and urban areas. We are proud to be part of this important work and are pleased with the progress we have already made.

In this issue of our newsletter, we would like to introduce you to some of our current projects and give you an insight into our research. We would also like to encourage you to take an active role in protecting our environment. We hope that this issue will provide you with interesting information and inspire you to become active yourself. Only together can we shape a more sustainable future.

Yours, Professor Dr. Oliver Kraft, Vice President Research



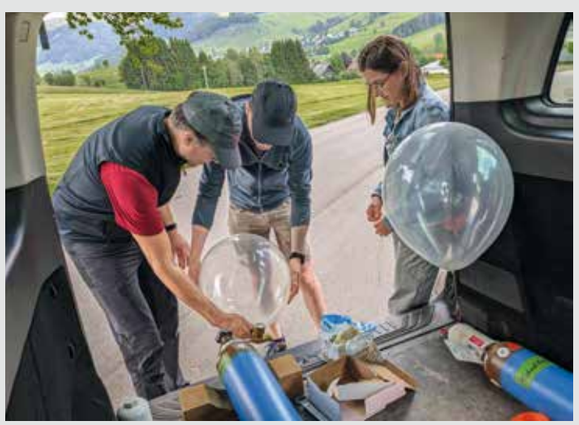
Exact weather forecasts and good scientific instinct allow helium-filled balloons to carry the measuring sondes directly into the storm cell. (Photo: Kunz)

LIFT: Understanding Hailstorms

On the Hunt for the Storm

The record was short-lived: In July 2023, the largest hailstone ever measured in Europe, 16 centimeters in diameter, fell from the sky in Italy. Five days later, a chunk of hail which was also found in Italy measured 19 centimeters – just two centimeters short of the world record. Scientists at KIT want to find out what happens in storm clouds that lead to such extremes. For this purpose, they are working together with cooperation partners from Germany, Australia, and the USA in a project funded by the German Research Foundation (DFG): "LIFT – Understanding Large Hail Formation & Trajectories".

The most important measuring instruments which the team led by Professor Michael Kunz from the Institute of Meteorology and Climate Research (IMK) uses to investigate the growth of hail are small, very light sondes that look like yoghurt pots and contain measuring electronics. In the updraft of the thunderclouds, they detach from the helium balloons that have carried them up into the air and then move on with the current in the cloud. It is precisely these trajectories that determine the growth of the hailstones in size.



Transport balloons are filled with helium. (Photo: Kunz)

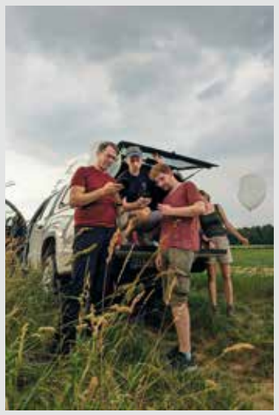
The team carried out the first measurements in the summer of 2023, when the Swabian MOSES measurement campaign was also underway to collect extensive weather data. "The summer of 2023 was rather unusual in terms of thunderstorms," says Kunz. "In southern Germany, there were mainly large thunderstorm complexes with numerous thunderstorm cells."

Therefore, it took special skill to obtain good measured data. The researchers relied on the latest generation of short-term ensemble predictions from the German Weather Service – i.e. several predictions for the same time and the same area, but each assuming slightly different initial conditions. "The closer the thunderstorm gets, the smaller the differences in the ensemble predictions become. This enables us to be in the right place at the right time with the sondes," Kunz explains.

In the field, however, it is still up to the expert to bring the sondes to the center of the action. Dr.

After deployment: The probes weigh only a few grams. (Photo: Kunz)

Jannick Fischer, postdoc at IMK, has just the right eye for this task: "The cloud base, for example, must not be too high so that the sonde can be caught by the upwinds." When this happens, the seemingly fragile structures take off: "We have already measured upwinds of over 100 km/h," says Kunz. Such measurements are possible because, in addition to temperature and humidity, the sondes constantly record their location via GPS.



On the hunt for the storm: Preparations for the start of the sondes. (Photo: Kunz)

This allows the researchers to understand which trajectories the hail takes and under which conditions it forms in the storm. If the temperature is relatively high, wet growth occurs, i.e. water attaches, which then also freezes. "Wet growth leads to clear hailstones," Kunz explains. "Dry growth leads to air pockets and the hailstones become milky white and opaque."

The data collected by the sondes within the storm complement the observations by other measuring systems, such as radar measurements or drones that take aerial photographs of the hailstones on the ground. Using AI, the researchers can determine the size distribution of the hail across the area.

"Hail is a problem that increasingly concerns us in agriculture, but also in the built environment and renewable energy systems", says Kunz. "Photovoltaic plants are very sensitive to hail, and the efficiency of wind turbines is also reduced if the rotor blades are damaged by hail." It is therefore important to understand how hail forms, what conditions favor massive hailstones, and how warning can be improved.

LIFT is intended to create the conditions for this. Kunz explains: "With LIFT, we want to create the basis for more accurate warnings of large hailstorms. This is essential for large solar plants and their protection, for example – but also for every individual who does not want to be knocked down by 20-centimeter chunks of ice." ■

Wine-growing

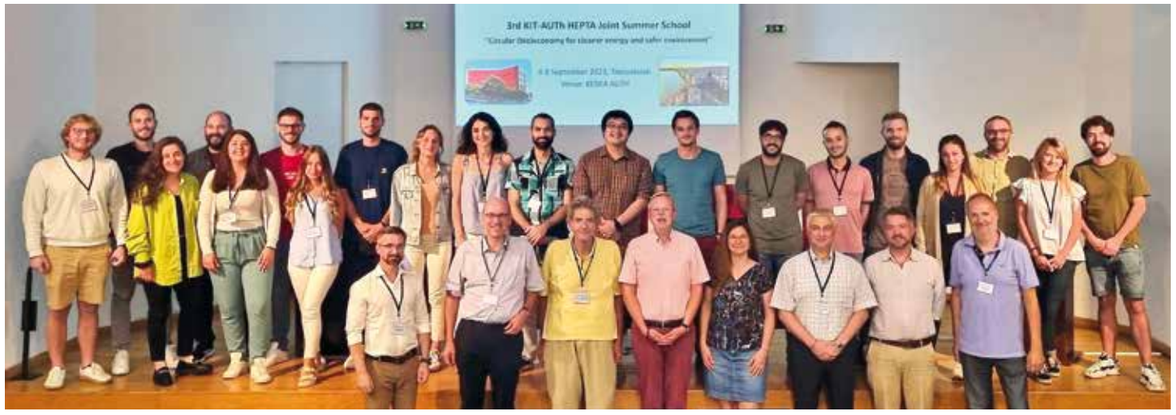
New Salt-resistant Genes

Southern wine-growing regions are often no paradise for the grapevine. The soil contains a lot of salt, and the climate is becoming increasingly warm and dry. Artificial irrigation causes even more salts to enter the soil. They disrupt photosynthesis and diminish the yield.

In times of climate change, new, salt-resistant cultivars are needed. "Such resistances occur in the wild vine Tebaba from the North African Atlas Mountains," says Professor Peter Nick of the Joseph-Gottlieb Kölreuter Institute for Plant Sciences (JKIP) at KIT. He and his team investigated the reason: Although the salt is being absorbed and transported into the leaves, an altered metabolism protects the photosynthesis process from the elevated salt concentration.

The task now is to find the responsible genes. This will then enable traditional plant cultivation in combination with moleculobiological analysis to provide more salt-resistant types of vine quite quickly: Certain molecular markers indicate which seedlings carry Tebaba's genes for salt tolerance. "This underscores the importance of biodiversity," says Nick. "We need the natural gene pool so that even on a heated planet we can still engage in agriculture." ■

Salinity stress causes the leaves of the grapevine to turn red. (Photo: © JKIP)



Participants of the third summer school in Thessaloniki in 2023. (Photo: AUTh)

Cooperation between KIT and Aristotle University of Thessaloniki

Win-win: Similar Challenges, Different Cultures

There are environmental problems in Greece as well as in Germany. Though they might show in different forms in the two countries, German and Greek scientists can share their experiences and gain valuable insight from each other in this exchange. A successful example of this is the long-standing cooperation between KIT and the Aristotle University of Thessaloniki (AUTh).

On the Greek side, Professor Nicolas Moussiopoulos is one of the initiators of this cooperation. Up until 2021, he was the head of the Energy Department at the AUTh. He began his scientific career in the 1970s with a degree in mechanical engineering, followed by his doctorate and habilitation at the University of Karlsruhe. "After I returned to the AUTh in Greece, I always campaigned for scientific cooperation with Germany, especially with Karlsruhe," says Moussiopoulos. "Many students want to go to Germany, and on their return, they bring back important impulses."

In 2018, the opportunity arose to intensify the exchange in the environmental sector. "KIT offered an initiation visit to Thessaloniki," remembers Professor Johannes Orphal, who has been Head of KIT's Division IV – Natural and Built Environment since 2020. He was already familiar with the AUTh from many European networks for atmospheric, climate and environmental research.

Within a short period of time, the two managed to jointly obtain project funding from the German Academic Exchange Service (DAAD). Combined with funds from the Helmholtz Association, it enabled already three AUTh-KIT summer schools. Since 2019, the Helmholtz Association has provided additional support: Twelve doctoral researchers at KIT and at the AUTh are being jointly supervised within the framework of HEPTA (Helmholtz European Partnership for Technological Advancement). And 2022 saw a "Memorandum of Understanding" between the AUTh and KIT, which was signed at the highest level and is intended to further develop the cooperation.

From right to left: Professor Johannes Orphal, Professor Marina Stefanova (TSS2023 Administrator), Dr. h.c. Nikos Efthymiadis (CEO of Thess INTEC), former AUTh Rector Professor Dimitrios Koveos, and Professor Nicolas Moussiopoulos. (Photo: AUTh)

"The AUTh and KIT can learn a lot from each other," says Orphal. "We should take the interdisciplinary culture at the AUTh, where natural scientists, humanities scholars, and engineers work together closely, as an example." But Moussiopoulos also sees KIT as a model: "The integration of non-university and university research in the same way as at KIT would also be a benefit for Thessaloniki." ■

More information: HEPTA (Helmholtz European Partnership for Technological Advancement) is a Helmholtz grant in sustainable technologies. Twelve doctoral researchers are being supported in their doctorate in the fields "air quality", "atmospheric physics", and "biomass". https://www.imk-asf.kit.edu/english/Projects_4061.php

HEPTA

Clearer Profile for Urban Research at KIT

SStrategy Paper to Help Coordinate Research Activities

Cities are built environments – and therefore just as complex as the natural environment. At KIT, various institutes and researchers are working to investigate and better understand the city and the possibilities for its further development. At the end of June, the Topic Spokesperson for Urban Research Professor Michael Janoschka and the Deputy Topic Spokesperson Professor Frank Dehn launched an initiative to better coordinate the diverse activities at KIT with "Stadt.Forschung", a workshop on urban research.

"We expected ten participants when we invited people to the workshop," says Dehn. "In the end, however, almost 40 colleagues came." This demonstrates how important a holistic view of urban research is to all stakeholders, Dehn continues. As an example of the complexity of the issue, he cites the city of Barcelona. The Spanish metropolis has recently largely cleared its central areas of car traffic. With such a significant change, it is of course not just motorized traffic that needs to be considered.

"Sociological, economic, infrastructural, and ecological aspects also play an important role," Dehn explains. "How is consumer behavior changing? How do we handle sealed surfaces? And how are neighborhoods developing?"

Participants of the workshop "Stadt.Forschung" on 30 June, 2023. (Photo: K. Hennrich)

In order to find answers to such complex questions, the research activities of the various disciplines relating to cities are to be coordinated at KIT and brought into closer contact with each other. To this end, the workshop dealt with the questions of where research currently stands and what the future needs are. "On this basis, a strategy paper is to be developed over the next few months," says Dehn – with the aim of giving the research area a clearer profile. ■

MOSES Improves Weather Forecast

Better Understanding of Formation and Course of Thunderstorms

Due to climate change, extreme weather events are becoming more frequent, causing more damage. More precise weather forecasts are important in order to predict the course of storms on a small scale. This is exactly what atmospheric scientist Dr. Annika Oertel, head of the newly founded junior research group "Mesoscale Processes and Predictability" at the Institute of Meteorology and Climate Research (IMK), works on. The group combines data from the mobile atmospheric observation platform KITcube with the numerical weather forecast model of the German Weather Service (DWD). The aim is to find out how the KITcube's observations can influence the modeling of thunderstorms and weather forecasts.

The KITcube measures atmospheric data up to an altitude of five kilometers. (Photo: Oertel)

To do this, Oertel uses observation data from the 2023 Swabian MOSES measurement campaign: The KITcube measured parameters such as temperature, humidity, air pressure, and wind speed up to an altitude of around five kilometers. The task of Oertel's team is to prepare the data for integration into the DWD's weather forecasting system.

The DWD then adds the experimental data to its forecast cycle – but without influencing the current weather forecast, as the project still is at the research stage. The observation data is then merged with the DWD model data. Oertel speaks of data assimilation: "As a result, there is a consistent description of the atmosphere at a particular point in time. This shows us how the observation data can influence the weather forecast." The results of the modeling are sent back to KIT for evaluation.

If the forecasts improve, the DWD will be able to collect data, such as that from the KITcube, for its own forecasts in the long term. Oertel aims to gain a better understanding of the formation and course of thunderstorms through the cooperation project and to investigate how these processes are represented in numerical weather forecast models. ■

Science Communication

Focussing on Complexity

The goal of the KIT Climate and Environment Center (ZKU) is to introduce scientific findings into the public debate. This year saw various different, sometimes unusual formats – such as a project with the Badisches Staatstheater Karlsruhe. The cooperation between actors and scientists offered surprising insights and showed just how different these two worlds of culture and science are.

The KIT Climate Lecture with Professor Markus Rex was probably one of the year's highlights. In a well-filled Audimax he told the interested listeners about the German polar research vessel Polarstern's journey to the Arctic. At the reception right after his guest presentation "Trapped in Ice at the North Pole" Rex was in high demand for discussions – this is science up close.

In July, the Environment and Resources Knowledge Week took place in Karlsruhe, during which KIT as well as many other participants from the State Museum of Natural History through to the Karlsruhe Transport Authority (KVV) engaged in dialogue with the public. The program included lots of activities relating to science, for example a science walk, presentations, exhibitions, and the Familiy and Friends Day.

A panel discussion about circular economy also received positive response. The significance of ethically sourced resources and the fight against poverty played a great role. The most important messages were captured by Graphic Recording. "This way, the discussion becomes comprehensible for the public," says Dr. Kirsten Hennrich, Head of the ZKU Office and in charge of its science communication. "Our goal is to bring facts into the public," adds Professor Christoph Hilgers, scientific spokesperson of the ZKU, "so that people can form informed opinions on the basis of scientific findings." ■

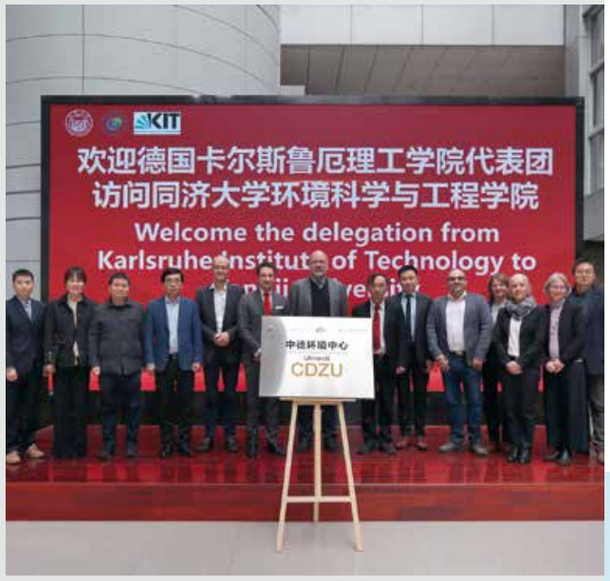
The panel discussion Karlsruher Umweltimpulse brings together politics, science, and economy. From left to right: Ina Kruwinnus (presenter), Dr. Christian Graf (Baden-Württemberg Ministry of Economy, Labour and Tourism), Professor Armin Grunwald (KIT), Christian Masurenko (EC Terra), Professor Jochen Kolb (KIT). (Photo: K. Hennrich)

Award-winning!

The NECOC research project (short for Negative Emissions through converting Carbon diOxide to Carbon) led by Dr. Benjamin Dietrich received the 2023 Gips-Schüle Research Award endowed with EUR 50,000. The project developed a multi-stage process to filter CO2 from the ambient air and convert it into pure carbon. Detailed information on the procedure can be found in our podcast "Umwelt. wandel.wissen.nutzen" (in German) on Spotify. ■

Visiting Shanghai

Researchers visited Tongji University in Shanghai from January 9 to 12, 2024 in order to further develop the German-Chinese Environment Center. In addition to plenary discussions, in-depth bilateral talks, and laboratory visits, the program also included visits to potential industrial partners such as Bosch, Adidas, and Covestro. All of these companies have sustainability strategies and are working on circular economy processes and climate neutrality concepts. ■



The ZKU delegation visiting Tongji University in Shanghai. (Photo: CESE, Tongji)

Please Repeat!

On July24, there was a small premiere at the KIT Institute of Geography and Geoecology (IfGG). As part of Professor Nadine Rühr's inaugural lecture, a symposium was held with all of the Institute's professors. This is special, because our colleagues are spread across several locations of KIT. It is a great idea to bring everyone together. This calls for a repetition – either at the IfGG or in other institutes, then perhaps with a focus on postdocs and doctoral candidates. ■

Dr. Peer Nowack

(Photo:KIT)

Tenure-track Professor Dr. Peer Nowack has headed the Chair of Artificial Intelligence in the Climate and Environmental Sciences at Karlsruhe Institute of Technology (KIT) since March 2023.

His research group combines machine learning methods with numerical Earth system models and Earth observations, such as satellite data.

Before joining KIT, Nowack worked in England for almost a decade. After completing his studies in Interdisciplinary Natural Sciences at ETH Zurich, followed by his PhD at the University of Cambridge, he held positions at the University of East Anglia and Imperial College London.

"The transfer to KIT really appealed to me because of the interdisciplinary orientation of the new chair," says Nowack. "There is a high level of expertise in computer science and atmospheric sciences at KIT, as well as tremendous amounts of data from unique model simulations and measurement campaigns. I want to help make even better use of this wealth of knowledge."

His group's research ranges from reducing uncertainties in climate predictions to developing more computationally efficient Earth system models. This involves the use of explainable AI methods, among other things: "Our goal is to better understand and predict the climate system, and we are also working, for example, to take advantage of machine learning for more precise environmental measurements," says Nowack. To this end, he also still has team members in England. ■

Prof. Volker Schulze and Prof. Frank Schultmann

(Photo:KIT)

Professor Volker Schulze

(Photo:KIT)

Professor Frank Schultmann

"Recycling is important for a sustainable economy," says Professor Volker Schulze, Head of the Manufacturing and Materials Technology Research Department and Spokesperson of the Topic Circular Economy and Environmental Technologies at KIT, which was initiated in July 2023. "We need to take the idea even further, though." There are always certain losses in recycling, and the recovered material does not have the same quality as the original raw material. Products and components, Schulze explains, should therefore be kept in their original function for as long as possible before they are recycled.

Refurbished products, however, do not have the same value as new goods – at least in the customer's perception. Concepts such as remanufacturing therefore need new impetus: "If we want to make economy circular, we have to consider its interactions with society," says Professor Frank Schultmann, Head of the Institute for Industrial Production (IIP) and Deputy Spokesperson of the Topic. "The transformation must address technical and ecological challenges. However, it must also be economically viable and requires acceptance."

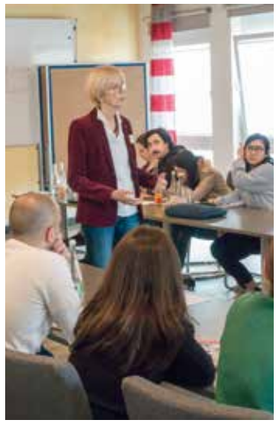
Schulze sees KIT in a leading scientific role: "Here we have the technological and socio-economic expertise to promote this change." A strategy process is currently underway in this Topic. "We are still open to all colleagues who would like to get involved in this subject," the Spokesperson adds. ■

Tackling Climate Action with the Karlsruhe Climate Pact

A Climate Protection Project of All Karlsruhe Universities with the City of Karlsruhe

On November 14, 2023, interested parties met for a workshop on urban transformation in the context of the city of Karlsruhe's Climate Pact. Founded in September 2021, the Climate Pact is a platform for regular exchange between the eight universities in Karlsruhe and the city. The common goal is to develop strategies that contribute to achieving the Paris climate objectives. To this end, the dialog between the stakeholders is strengthened and synergies are created for effective climate protection measures.

The workshop offered a wide range of topics in various discussion rounds - from mobility and energy to education, nutrition, and health. I was particularly pleased with the moderation of the topic "Climate Protection and Resilience," in which we intensively discussed the Karlsruhe climate protection concept, access to data, the prioritization of implementation processes, and optimum communication strategies. The discussions showed the complexity of the topic and the numerous aspects which we need to take into consideration on the path into a sustainable future. The concluding panel discussion enabled a wide exchange on all the topics covered. It was inspiring to see how different perspectives and ideas came together, and how many participants contributed their views on the challenges of climate change. The results and ideas from the workshop will now be incorporated into the further development of the Climate Pact in order to make the future of our city more sustainable. ■



Participants of the SDG Summer School for Renewable Energy in Brühl in October 2023. / Discussion with doctoral researchers. (Photos: Lieber)

Summer School on Complexity of Renewable Energy

Georgian Researchers Exchange Ideas with Doctoral Researchers

In 2023, the Summer School of the Graduate School for Climate and Environment (GRACE) addressed the topic of renewable energy. Twenty-eight doctoral and early-career researchers came together in Brühl in October in order to partake in the SDG Summer School for Renewable Energy.

"It is important to us that the Summer School's topic always relates to specific research projects," says Dr. Andreas Schenk, scientific coordinator of GRACE. This year, it was the DAMAST project, which was funded by the Federal Ministry of Education and Research. Within the scope of DAMAST, German and Georgian partners are researching the safety of dams in tectonically endangered areas using the example of the Caucasian Enguri dam.

German and Georgian researchers presented their findings in Brühl and discussed it with the doctoral researchers. Hydropower as a renewable energy has the advantage of being able to provide base load power, i.e. it is also available when wind and solar power plants do not supply enough electricity.

But there are also ecological disadvantages. "The complexity of the topic became clear during the Summer School," says Schenk.

The Georgian researchers received very positive feedback from the doctoral students. According to Schenk, the Summer School was also a positive and important experience for them: "The concept of the Summer School is still less well-known in Eastern Europe and Asia. The participants from Georgia enjoyed it very much." ■

More information:
www.grace.kit.edu

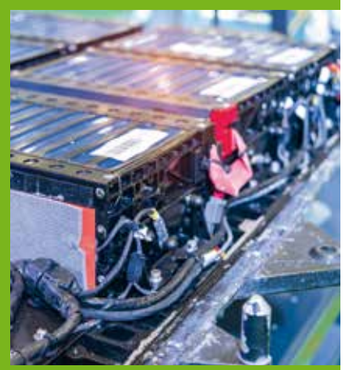
THINKTANK

Thermal Water for Battery Production

Domestic Lithium Source

Efficiency and use of resources are becoming increasingly important topics for the economy and the energy transition. The "Industrial Resource Strategies" think tank advises politicians and industry on these topics on a scientific basis - also with regard to the new EU Battery Regulation that came into force in August of last year. It sets requirements for the sustainable mining of the main raw materials for batteries, such as lithium. "Strengthening the circular economy, as provided for in the EU Battery Regulation, is an important starting point for making the supply of raw materials more resilient," says Professor Jochen Kolb of the Institute of Applied Geosciences at KIT. "In the case of lithium, however, this is not enough." The think tank has therefore published a study on the topic of "Lithium in Europe".

As the demand for lithium will increase significantly over the next 20 years, Europe needs additional domestic sources of lithium. According to the study, these can be exploited by researching new extraction methods and technologies. For example, at geothermal power stations in south Germany: Lithium can be extracted from thermal water here – in Bruchsal alone, this would produce lithium for around 20,000 car batteries per year. "Short transportation distances, flexibility compared to other suppliers, security of supply, and extended supply chains: We use geothermal water as a raw material more efficiently," Kolb explains. "This has the side effect that there could also be an economic boost for geothermal energy." However, further adjustments would be required for domestic raw material extraction and recycling, he added. ■



Lithium car battery – the raw material should be extracted in a sustainable manner. (Photo: xiaoliangge, Adobe Stock)

More information:
www.thinktank-irs.de

Water for Hydrogen Production

We Need to Talk!

Something is bothering Dr. Florencia Saravia: "Green hydrogen is important for the energy transition. But we are not talking about where the water for its production should come from. We need to change this immediately." In order to draw attention to this previously neglected topic, the German Technical and Scientific Association for Gas and Water (DVGW) recently published a fact sheet summarizing the most important correlations between water demand and hydrogen production. Saravia is Head of the "Water Chemistry and Water Technology" division of the DVGW Research Center at the Engler-Bunte Institute of KIT. She was significantly involved in the publication.

Energy production and water scarcity – this combination inevitably prompts thoughts of North Africa, an ideal location for generating solar energy, but one that is also very dry for the most part. "The import of hydrogen is essentially an import of water. Locations with increased water stress are therefore unsuitable for producing the gas," Saravia says, but then recommends taking a differentiated view of the problem: "North Africa is not just the Sahara and Sahel. There is enough water in the coastal regions, namely seawater."

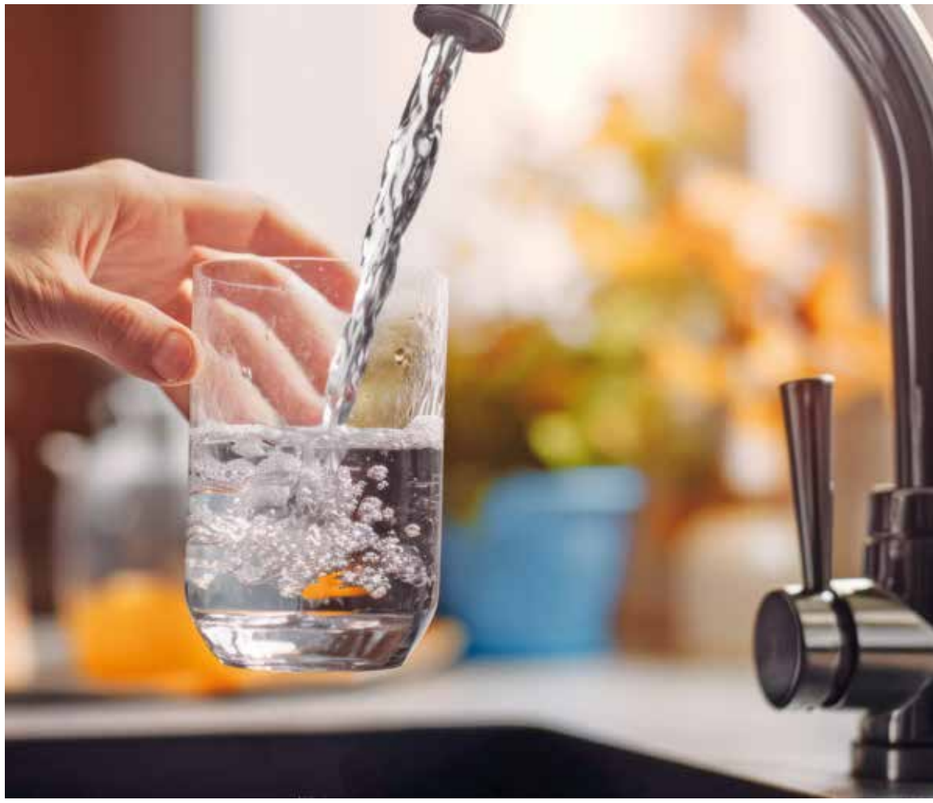
When processed appropriately, water from the oceans is perfectly suitable for electrolysis, i.e. the separation of water into hydrogen and oxygen. If, for example, power-to-gas (PtG) plants are built in North African coastal regions in which solar or wind energy is used to produce hydrogen, this can even have a positive impact on the local water supply. "In addition to water for electrolysis, desalination plants can also produce drinking water," Saravia explains.

While drinking water may be a welcome by-product of PtG technology, the chemical engineer and water chemist categorically rules out the possibility of turning drinking water into hydrogen: "Drinking water is a human right. We must not use it as a source of renewable energy." This is not even necessary, as biologically purified wastewater can now be treated in such a way that it can then be used as ultrapure water in electrolysis, says Saravia.

One of the reasons for this is that the PtG industry's demand will be relatively low. According to the DVGW fact sheet, production of 40 gigawatts of hydrogen by the middle of the century will annually require 40 million cubic meters of freshwater, not including the cooling water requirement. For comparison: Berlin alone requires around 230 million cubic meters of water every year; the energy sector even uses nine billion cubic meters of water as cooling water, of which at least 300 million cubic meters evaporate.

In addition, the scientist, who also teaches at KIT alongside her research for the DVGW, would like to draw attention to the supply situation and the consequences of water use for PtG in Europe and Germany: "There are also ‚dry' areas here," she says, naming Brandenburg, Saxony-Anhalt, Mecklenburg-Western Pomerania, and Franconia. The situation is more relaxed in other federal states. And Germany also has coasts on the North and Baltic Seas: "If we talk about the right location, the water supply for hydrogen production is not a problem here," says the researcher.

"Nevertheless, we urgently need a water strategy and good water management for the energy sector," Saravia emphasizes. She considers legislators, regulatory authorities and also operators of future plants responsible for this. The right locations need to be selected for the electrolysis plants and there needs to be public acceptance – from the water supply to the handling of by-products. "After the production of ultrapure water, a concentrate containing salt has to be disposed of. We need to develop clever solutions for this. Otherwise resistance will be inevitable." ■



Drinking water: Too precious for the production of hydrogen. (Photo: Margo Alexa, Adobe Stock)

KIT Climate and Environment Center

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Spokesperson of Topic 3:	Georesources:	Professor Dr. Jochen Kolb
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Thermodynamics and Land Surface Temperature

PNAS Paper Deepens Understanding of Climate Change

Radiation, evaporation, and air motion affect the land surface temperature in a highly complex process. Researchers of the Max Planck Institute for Biogeochemistry and of KIT have shown in a PNAS publication that these processes can be traced back to simple physical principles that create predictable patterns.

The land surface heats up due to solar radiation and the greenhouse effect. Long-wave radiation, evaporation, and air movement triggered by so-called convective turbulence make for cooling. Sarosh Alam Ghausi of the Max Planck Institute for Biogeochemistry used thermodynamic principles to explain these processes – comparable to the energy source and work involved in generating electricity in a power plant.

Ghausi used this approach to investigate temperature differences between rainforests and deserts: It is not the lack of water that heats up the deserts, but the more intense solar radiation and the subtropical location. The Hadley circulation contributes to the warming of the atmosphere there and weakens the atmospheric power plant.

Professor Erwin Zehe of KIT, who is Ghausi`s doctorate supervisor, says: "These results deepen our understanding of climate change and enable the optimization of evaporation models." ■

More information:
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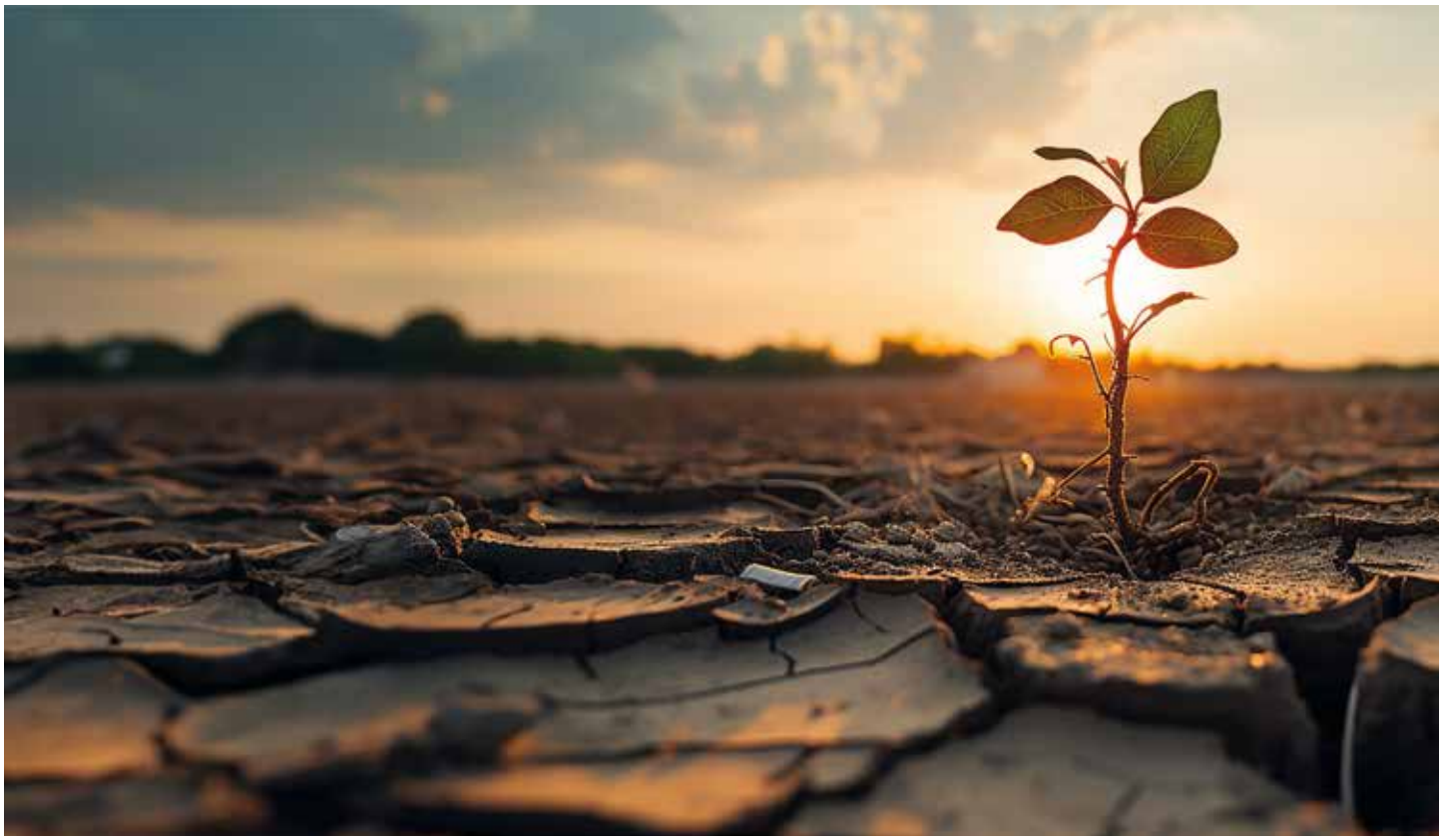

Intensive solar radiation strongly heats up deserts in subtropical zones. (Photo: Usman, Adobe Stock)