Karlsruhe Institute of Technology

CLIMATE AND ENVIRONMENT news

Newsletter of the KIT Climate and Environment Center

Issue 01|2021

Dear Readers!

Which challenges and findings are we facing in terms of climate and the environment after 18 months of a pandemic? This issue covers various aspects. Read about the restrictions that had to be managed by our early-stage researchers, about new findings on the atmosphere, which were obtained thanks to the unusual situation, and about the impacts of tunnel construction on the generation of renewable energy.

We also report about our three Humboldt Fellows. I wish you an interesting and enjoyable read.

Yours,
Professor Dr. Oliver Kraft
Vice-President for Research

Climate Change Enhances Loss of Biodiversity

Amboseli National Park in Kenya: Shrinking glaciers cause water shortage. (Photo: A. Arneth, KIT)

Global warming causes mountain glaciers to shrink. In semi-arid regions, such as Amboseli National Park in Kenya, however, ecosystems in the valleys depend on the glaciers' melting water in summer. Less melting water may result in water shortage for plants and animals. This may threaten their existence.

"This is one of many examples of how climate change can lead to biodiversity loss," says Professor Almut Arneth from the Atmospheric Environmental Research Division of KIT's Institute of Meteorology and Climate Research (IMK-IFU), KIT's Campus Alpine in Garmisch-Partenkirchen.

An analysis by her and an international team of researchers reveals: Many goals defined by international organizations for the preservation of biological diversity are now at stake due to climate change. Many factors threaten biodiversity, above all the largely unsustainable use of land and ocean ecosystems by humans. "But even if we would get to grips with overfishing, many fish species will be stressed by climate change alone in the next decades," the ecosystems researcher explains. She thinks that biodiversity targets need to be revised to account for climate change. And she adds that biodiversity may help mitigate climate change, as many ecosystems on land and in oceans absorb CO_2 from the atmosphere. Arneth emphasizes: "We need a better coordination of political agreements and scientific findings."

More information:
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Turning Old into New
Chemical Recycling of Plastics by Pyrolysis
Page 2

Hot Summers
Students Develop Strategy against Heat Stress
Page 3

For Better Water Quality
Three Humboldt Fellows, Three Approaches
Page 4

Soil Mechanics and Rock Mechanics
More than Drilling Blast Holes
Page 6

Better Protection of the "Lungs of the Landscape"

KIT Researcher Studies Riparian Zones of Creeks and Small Rivers

Riparian zones in three different environments, from left to right: Semiarid Mediterranean, subhumid Mediterranean, and boreal in summer. (Photos: J. Ledesma, A. Lupon)

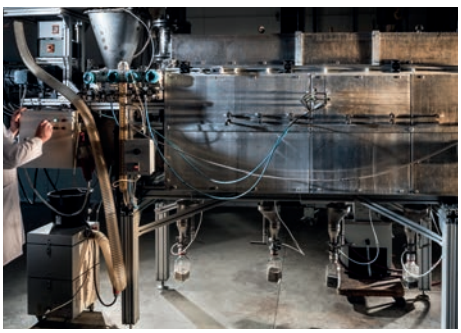
Water quality of creeks and rivers mainly depends on the soils in the riparian zones. In this respect, the dominant source layer is of highest importance. Within the EU-funded project RIPARIONS, Dr. José Ledesma from KIT's Institute of Geography and Geoecology (IFGG) studies what exactly happens in this layer.

"This soil layer contributes most to water flux and to the biological and chemical composition of water in creeks and small rivers," the environmental researcher says.

The project is aimed at collecting data on the activity in this layer in the region of Catalonia, Northern Spain. "I would like to test in a Mediterranean environment the model I developed for the riparian zones in the boreal forest in Sweden," Ledesma says. "Knowing more about how substances from forest soils enter creeks and rivers in different climate zones will help us predict the impacts of anthropogenic activities and climate change on water quality in Europe. This way, sustainable management will be successful. "After all, creeks and small rivers are the lungs of the landscape," he adds. Their wide catchments make up about 90 percent of the global creek and river network.

Turning Old into New

KIT Studies Chemical Recycling of Plastics



Pyrolysis plant for mixed plastic wastes at ITC. (Photo: M. Breig, KIT)

KIT is pushing the recycling of plastics: At the THINKTANK "Industrial Resource Strategies," KIT's Institute for Technical Chemistry (ITC) and Institute for Industrial Production (IIP) work on a loop for plastic wastes. "All plastic wastes that cannot be sorted into pure fractions for subsequent melting will be recycled by e.g. pyrolysis at KIT," says ITC Head Professor Dieter Stapf. By means of this chemical process, plastic polymers are decomposed into small molecules and impurities are separated. Ideally, high-quality pyrolysis oils and gases result. They can then be used instead of petroleum for the production of plastics.

Currently, only about 20 percent of the wastes disposed of as recyclables are turned into plastics again. The problem is that these wastes contain many composites, such as Tetra Pak packages. In addition, these wastes contain impurities or fractions that have been disposed of incorrectly. "Only about one third of the plastic products are packaging wastes disposed of as recyclables or plastic bottles," Stapf says.

Recycling of building insulation material: Thermal insulation material is crushed and recycled as pyrolysis oil. (Photo: M. Breig, KIT)

"At the THINKTANK, KIT researchers also have an eye on the remaining fractions, such as technical plastics in cars, building insulation materials, or rotor blades of wind turbines. We need ways to recycle these materials, that is also what we are interested in."

Keeping Creatives Cool

Students Develop Strategy against Heat Stress

Every summer, 1,400 creative artists and cultural workers are sweating at their workspace in Alter Schlachthof (the Old Slaughterhouse) Karlsruhe. Even during temperate summers, the area heats up to an extreme level. The next summer however could be different. In a transdisciplinary research-based teaching project, 19 students from the KIT Department of Architecture worked out a strategy against the heat stress in the area. Dr. Peter Zeile, scientist at the Department's Institute for Urban and Landscape Design, has supported them and is impressed: "Urban planners, architects, and construction physicists met to develop different solutions – creatively and in direct

Overhead irrigation to achieve a cooling effect. (Photo/illustration: H. Merkle, M. Weber)

dialog with all stakeholders. Despite the COVID-19 lockdown resulting in the work taking place almost exclusively digitally, they quickly created groups, developed a spirited sense of togetherness, and transferred their findings into high-quality and esthetic ideas."

The results are proposals in the area of water, vegetation, structural modifications, and temporary measures that can be implemented quickly without much effort, for example overhead irrigation. "Due to the specific application and the exchange between all those involved, the students had a very productive project experience," Zeile reports. "They could make a real contribution to a better environment."

The heat is on: Scan the QR code for videos about the project.

Sustainability – but How?

Sustainable Construction Means Finding Optimal Ways out of the Dilemma

In sustainable architecture, every single structure has to be sustainable. (Image: Pixabay)

Durable? Energy-efficient? Environmentally friendly? Many buildings claim to be sustainable. However, only individual aspects of the concept are actually fulfilled. "For true sustainability, economic, ecologic, and social aspects all have to be considered," says Professor Dirk Hebel, Dean of the Department of Architecture at KIT.

One approach is to insulate the building well enough to allow it to be heated efficiently. "But that already has a drawback: Common insulating materials are hazardous waste." After dismantling, they end up on a landfill or get burned. Better to find appropriate material. But where does that come from? Are long transport distances justified? Maybe it is possible to instead recover equivalent material from old existing buildings in the spirit of circular economy. Meanwhile, these buildings represent "bound CO_2 which should be preserved for as long as possible." Instead of demolishing them, conversion and reconstruction should be considered.

"We are virtually always researching a dilemma," Hebel states. "Sustainable architecture should not be seen as a specialist discipline only to be considered when needed. Every line drawn, every single structure has to be sustainable. The goal is to find the right balance towards an overall positive outcome."

All Good Research Things Come in Threes

Three Water Qualities, Three Approaches, and Three Humboldt Fellows at the Water Chemistry and Water Technology Division of the Engler-Bunte Institute

On the way from the spring to the sewage treatment plant, water is polluted by industry and agriculture, decomposition products, faeces, and pharmaceutical residues. How can we clean the water better and add to its value?

Dr. Samuel Bunani. (Photo: KIT)

Drinking Water without Pollutants

Dr. Samuel Bunani starts where use of water starts: In natural reservoirs. Their qualities vary depending on the region. Often, the water contains heavy metals, organic trace substances, and natural substances that make water processing difficult.

In Burundi, where Bunani comes from, "fluorides are the biggest problem. In Northern Germany, the problem is arsenic," he explains. For such water to become potable, these pollutants have to be removed. For this purpose, different methods, including membranes, can be applied. Bunani is an expert in this field and he is convinced: "By adequately optimizing our method, efficiency can be very much enhanced." He considers this a big opportunity for Burundi. For this reason, he would like to continue his work later at the university there.

Dr. Marta Gmurek. (Photo: KIT)

Wastewater without Antibiotics Resistance Genes

Another challenge consists in bacteria. Many of them are resistant to antibiotics. Via outlets of sewage treatment plants, the resistance genes may enter the aquatic environment. Such bacteria are far more difficult to remove by simple disinfection than other bacteria, including pathogens. This is why biologically cleaned wastewater is subjected to a secondary treatment of much higher efficiency in order to guarantee ecological safety before it enters surface water.

This is the field of work of Dr. Marta Gmurek. She combines three methods: Membrane filtration, ozonation, and sunlight-initiated photocatalysis. "I am fascinated by molecular biology. It is thrilling for me to concentrate my experience as an engineer on the removal of antibiotics-resistant genes."

Dr. Xiao Keke. (Photo: KIT)

Sewage Sludge as a Resource

Dr. Xiao Keke from China considers freedom of research in Germany a particular chance. "Germany has a leading role in water technology. The Humboldt Fellowship gives me the opportunity to self-define the focus of my work."

Her work focuses on what appears to be the last remnant: Sewage sludge from water treatment plants. A pool of waste? Not for Keke. She studies processes to recover methane and nutrients, including proteins, carbon, and nitrogen, from the sludge. "The sludge is a resource!" And it will be good to use it in the future.

(Photo: KIT)

Professor Frank Dehn

Concrete and cement: Both have been used by humans for thousands of years. Construction industry has vast experience. Can there be anything new in this field? A lot, says Professor Frank Dehn. He heads the Materials Testing and Research Institute (MPA) of KIT. There, research focuses on how materials behave under changed climate and environmental impacts in order to ensure permanent stability of buildings. "We think in advance about the theoretically possible solution." As regards recycling or new process technologies, Dehn thinks that there still is considerable potential in efficient and resource-saving construction. Work also includes the transfer of new knowledge to standardization in the construction sector. This is a tough task, but Dehn is highly motivated: "Innovation has to be transferred to practice because there it will be fully effective."

(Photo: KIT)

Professor Peter Nick

"From trinity to quadrinity." This is how Professor Peter Nick wishes the disciplines of KIT to be visible. Apart from energy, information, and mobility, biology could be more visible, Nick says. "Without any basic understanding of forms of life and their laws, we will not be able to solve social problems of sustainability."

Nick heads the Molecular Cell Biology Division and is involved in actively shaping science at KIT. His motivation is "strengthening critical analysis across disciplines, the ethically reflected backbone of research." This also characterizes his teaching work and the Forum for Critical Interdisciplinarity, a platform co-initiated by him for controversial debate among disciplines and hierarchical levels. Many people are talking about dialog, Nick is living it.

(Photo: Private)

Professor Michael Kunz

"When I am standing at the top of a mountain and look down into the valley, much that worries me every day becomes very small and insignificant – this brings me down to Earth." This attitude characterizes the scientific life of Professor Michael Kunz, Head of the Atmospheric Risks Group of the Institute of Meteorology and Climate Research - Troposphere Research Department (IMK-TRO) and Spokesperson of the Center for Disaster Management and Risk Reduction Technology (CEDIM).

Kunz is a passionate hiker and skier and conducts research into extremes. His group studies heavy thunderstorms and hailstorms and develops damage models in cooperation with insurance companies. Kunz is particularly fascinated by hailstorms: "In strong thunderclouds, updrafts may reach extreme speeds of up to 200 km/h – stronger than in a hurricane and in vertical direction. This is crazy!"

At CEDIM, the meteorologist and his highly committed team carry out forensic analyses of worldwide disasters. "It depends on humans, their preparation, experience, and risk competence whether an extreme event turns into a disaster. We study how this disaster came about and estimate the damage: How many people are affected, how many emergency shelters are needed, are critical infrastructures damaged severely?"

Kunz's motivation is to quickly make available important information to important stakeholders and to cooperate with intrinsically motivated people across borders of disciplines. "Only by bringing together methods and results from various disciplines will we be able to roughly understand disasters and their impacts."

KIT Climate and Environment Center

Scientific Spokesperson:	Professor Dr. Erwin Zehe
Deputy Scientific Spokesperson:	Professor Dr. Thomas Leisner

Spokesperson of Topic 1:	Atmosphere and Climate:	Professor Dr. Thomas Leisner
Spokesperson of Topic 2:	Water:	Professor Dr. Olivier Eiff
Spokesperson of Topic 3:	Georesources:	Professor Dr. Jochen Kolb
Spokesperson of Topic 4:	Ecosystems:	Professor Dr. Almut Arneth
Spokesperson of Topic 5:	Urban Systems and Material Flow Management:	Professor Dr. Stefan Emeis
Spokesperson of Topic 6:	Natural Hazards and Risk Management:	Professor Dr. Michael Kunz
Spokesperson of Topic 7:	AI in Environmental Sciences:	Professor Dr. Stefan Hinz

Drilling blast holes to advance the roof section of the Brenner Base Tunnel in 2015. (Photo: P. Kudella, KIT)

Anything but Boring

Soil and Rock Mechanics: A Mecca for Frontier Workers with Imagination Who Enjoy Detective Work and the Occasional Surprise

Zero to thirty meters: That is the interesting depth for any foundation, urban tunnel, flood control construction or wind turbine anchoring. Dr. Peter Kudella explains the work of the KIT Institute of Soil and Rock Mechanics, which he is heading and describes as extremely diverse. "We examine the soil on or in which construction is planned. We observe its composition and deduce how it is likely going to behave."

Soil often needs to be viewed from two sides, as it will be fundament as well as building material. "A causeway, for example, rests on something, but is also made of the same material."

The thinking about loads needs to be oriented in two ways as well: Static and cyclic. There are buildings that, once constructed, remain standing for decades, representing a more or less consistent load on the ground. Then there are regularly recurring events. For instance, the wind is blowing at a wind turbine, or it is not. It changes direction. All these forces have an impact on the turbine's anchoring in the ground. "Especially regarding the cyclic soil mechanics, we are still conducting almost basic research to predict long-term behavior."

Considering that this expertise is needed in virtually every construction project, its research and academic landscape is remarkably small. "That is why I welcome every initiative, also here at KIT, to train more and better," says Kudella. He describes the ideal soil and rock mechanic as a frontier worker with imagination who enjoys surprises and detective work.

Geotechnical engineering, accordingly, is less about how the soil became like it is. Rather, the central question is: How does it react to interference and how can that be used? Additionally, there is another dimension to consider. "The typical construction engineer is concerned with walls and beams, thinking in planes and straights. However, subsoils are three-dimensional and there are stresses in any direction. Also, you cannot see through it – you have to imagine it and describe it mathematically."

And then there are the surprises. When building, you never now what was there before. According to Kudella "that makes it all the more interesting because it requires intuition. A good example is the tram here in Karlsruhe. During construction of a tunnel, an objection was raised: What if there are any cellars in the projected course that are not recorded in the plans, perhaps built secretly?" So, a search was conducted and they found – nothing. The tunnel was built without any disruption.

Assembly of the tunnel boring machine in the DESY starting shaft in Hamburg, 2010. (Photo: P. Kudella, KIT)

INDISTRIAL RESOURCE STRATEGIES

THINKTANK Collaborates with Industry

Recycling the automotive industry's plastic components has always been problematic, because they mostly are mixed plastics. The Industrial Resource Strategies THINKTANK and automobile manufacturer Audi are tackling the challenge. In a joint pilot project, they aim to chemically recycle automobile plastics and return the fractions into a resource-saving cycle. "This example illustrates very well how we work", says Professor Jochen Kolb, who works at the KIT Institute of Applied Geosciences and chairs the THINKTANK's steering committee. "We find a relevant topic, approach it scientifically, bring it to public attention, and develop concrete projects collaborating with partners from the industry." Another collaboration with the company iPoint focuses on blockchain technology. This approach is also aiming to advance the development of a sustainable closed loop economy.

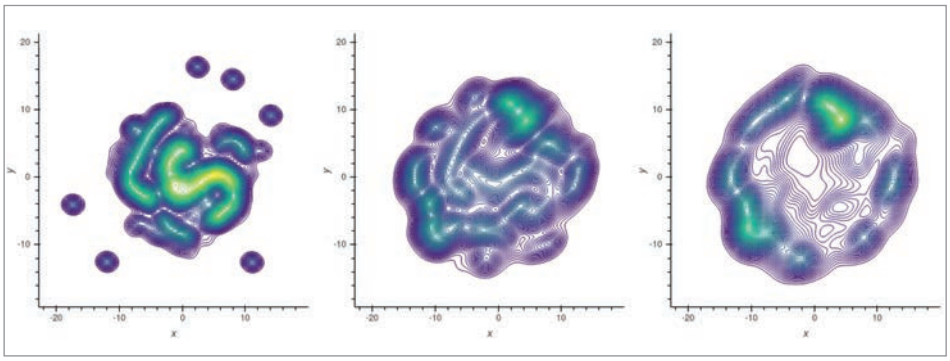
More information in German:
www.thinktank-irs.de

Podcasts: Karlsruhe's Contributions to Climate Research

The global climate is changing: It is getting warmer, rainfalls and sea levels are changing, ecosystems are under stress. This has social and political impacts and requires societal prioritizing, differentiated communication, and technical ideas. In a podcast series called "Karlsruher Beiträge zur Klimaforschung" (Karlsruhe's Contributions to Climate Research), which started in May 2021, KIT scientists talk about their work and how it is contributing to climate research. It includes observation and analysis of interconnections in the climate system, forecasts, research of climate impact, socio-scientific classifications, and technical considerations.

www.klima-umwelt.kit.edu/podcast

Winner of the Helmholtz Information & Data Science Academy (HIDA) Datathon



Example of different point densities in a 2D layout. (Illustration: J. Polz)

At the HIDA Datathon on November 5 and 6, 2020, scientists of the Helmholtz Association collected problems from the field of environmental science and tried to solve them using data science methods. Christian Werner, Max Graf, and Julius Polz from the KIT Institute of Meteorology and Climate Research – Atmospheric Environmental Research were able to win the challenge "Spot the mistake in ~50 million data points, cleverly." The goal was to find faulty data points in the soilNet data about soil humidity and temperature from the TERENO station "Hohes Holz." You can find detailed information on the solutions on https://cloud2.imk-ifu.kit.edu/index.php/s/YEPP-9WOF0NPQ4pAo.

Congratulations to the winners!

Falling Walls Lab: The Winner Is Christian Scharun

Christian Scharun (center) at the award ceremony of the Falling Walls Lab on June 16, 2021. (Photo: L. Albrecht, KIT)

The jury and audience award of Falling Walls Lab Karlsruhe on June 16, 2021 went to Christian Scharun from the Institute of Meteorology and Climate Research with his talk on "Greenhouse Gas Emissions." Falling Walls Lab is an international competition offering emerging talents and creative minds an opportunity to showcase themselves and their innovative ideas. By winning, Scharun was selected as representative of Southern Germany at the worldwide finals in Berlin in November 2021.

Congratulations!

Dissertation Prize

We congratulate Dr. Ralf Loritz from the Institute for Water and River Basin Management – Hydrology for winning the German Hydrological Society's prize for the best dissertation in 2020. Loritz obtained his doctorate in "The role of energy and information in hydrological modeling." He made a major contribution to the modeling of river drainage basins in the range of 1 to 250 km².

SOUTH GERMAN CLIMATE OFFICE

Global Climate Protection as a Regional Challenge

Due to the strong connection between measures of climate protection and regional infrastructure, the South German Climate Office, in cooperation with the German Association of Local Public Utilities Baden-Württemberg, is organizing a series of workshops within the KIT Future Fields excellence project. In these workshops, they aim to clarify which measures of climate protection are already in place and how these measures can be prioritized and standardized based on scientific methods. Money and time are limited; therefore, it is important for local businesses to be able to know which measures are the most effective for them specifically – also taking social and climate boundary conditions into consideration. To answer these specific questions, the hosts of the workshop series examine how a long-term win-win situation could be achieved, collaborating with several KIT institutes. This means advancing local climate protection, as well as generating and answering related research questions, resulting in KIT contributing to the implemention of global decisions on a local level, ultimately affecting everyone's life.

Exchange of Expertise in Times of the Pandemic

Micro-projects are set up to facilitate international exchange. (Illustration: Pixabay)

Supporting doctoral candidates with their scientific work? "That is working well enough digitally," says Professor Stefan Hinz, Spokesman of the GRACE graduate school. Instead, he is worried about the international exchange. The usually mandatory three months abroad are canceled in times of the pandemic. "Our newest idea are micro-projects, in which multiple doctoral candidates are collaborating in transnational tandems" – in reality working from their homes, virtually interconnected daily. GRACE supports them in finding a partner and how to optimally set up the process. However, the participants' respective supervisors have to get involved, too. "In exchange, the micro-projects offer a return on invests," according to Hinz. The goal is to have tandems publishing together or even prepare a larger research proposal. That is benefitting the supervisors, too. A first trial is already running at Hinz's Institute. "Anyone willing to join is welcome. Personally and institutionally."

SPECIAL PUBLICATION

Mobile Cloud Chamber PINE about to Provide Time Series

Mobile cloud chamber PINE and stationary dynamic cloud chamber AIDAd at IMK-AAF. (Image: O. Möhler, KIT)

Scientists at KIT surrounding Dr. Ottmar Möhler from the Institute of Meteorology and Climate Research – Atmospheric Aerosol Research Division (IMK-AAF) have been exploring cloud formation for a long time. Recently, they added a new tool: The mobile cloud chamber PINE (Portable Ice Nucleation Experiment). This device passed all tests comparing to the KIT's AIDA cloud chambers and delivered convincing results during its first deployment in the US and the Azores.

"When working in our AIDA chambers, we have to bring the aerosols into the lab, whereas with the new mobile chamber, we can take it outside and measure ice and cloud formation directly on site," Möhler explains. The chamber works fully automatically and can be controlled remotely. Soon, PINE is going to be used at mountain or field measurement stations for aerosols and trace elements, for example in the Swabian Jura, Czechia, or Austria to measure ice-forming particles over a longer period of time. The resulting time series should provide further information about the origin and variety of these particles.

Möhler, O. et al.: The Portable Ice Nucleation Experiment (PINE): a new online instrument for laboratory studies and automated long-term field observations of ice-nucleating particles. Atmos. Meas. Tech., 14, 1143–1166, 2021

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Karlsruhe Institute of Technology
Kaiserstraße 12
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President:
Prof. Dr.-Ing. Holger Hanselka

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

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Karlsruhe Institute of Technology (KIT) – The Research University in the Helmholtz Association

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 6 08–2 85 92
www.klima-umwelt.kit.edu

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