Karlsruhe Institute of Technology

CLIMATE AND ENVIRONMENT news

Newsletter of the KIT Climate and Environment Center

Issue 01|2020

Dear Readers!

While the world is fighting the Corona pandemic, we should not forget that many other challenges continue to exist. These challenges have to be kept in focus. Climate change does not stop during the Corona pandemic, trees are not fertilized by an increasing CO_2 concentration contrary to our expectations, the ozone hole over the Arctic appears more often. Hence, it is worth pursuing our objectives with unabated commitment. We will provide a brief overview of successes achieved by researchers of the KIT Climate and Environment Center on their way towards a healthy climate and clean environment. From improved drinking water supply to cleaned wastewater to more sustainable tools – our scientists deal with challenges of any type worldwide.

We would be happy if you would join us again on our discovery trip.

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

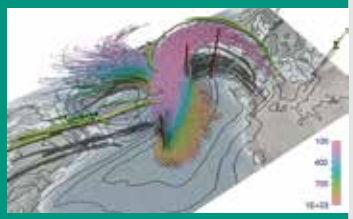
Hot and Dry: Carbon Balance of Trees Is About to Tip

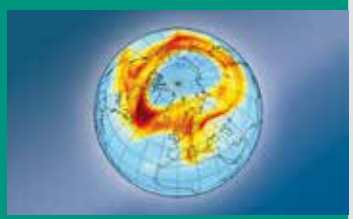
When the CO_2 concentration in the air increases, some plants grow better. But this so-called fertilization effect can hardly compensate the impacts of a CO_2 increase in the atmosphere on climate. This was proved for Aleppo pines by research teams from the Institute of Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU), KIT's Campus Alpine in Garmisch-Partenkirchen, LMU Munich, the University of Vienna, and the Weizmann Institute of Science in Rehovot (Israel).

In automatic measurement chambers, Aleppo pines were exposed to increasing temperatures. (Photo: Plant Ecophysiology Lab, KIT)

Under extreme heat and drought, the trees are locking down. "The plants increasingly close the stomata of their leaves or needles in order to lose as little water as possible," KIT biologist Benjamin Birami explains. "This means that less CO_2 for photosynthesis is taken up via the stomata. As of a certain temperature, a higher CO_2 concentration can no longer compensate this reduction and the carbon balance turns negative." For Aleppo pines growing in the research greenhouse at Garmisch-Partenkirchen, this transition point was reached at 30°C: The trees spent more CO_2 than they took up, irrespective of how well they were supplied with it.

Growth conditions are optimal in a small temperature range only, which is specific of the plant species. As soon as the temperature leaves this optimal range, the positive CO_2 effect declines. Our central-European spruce, for instance, is stressed at temperatures above 25°C already. Birami emphasizes: "The supporting effect of CO_2 is very limited. We must prevent the climate from getting much warmer."





More Drinking Water for Lima

Drone Data and Artificial Intelligence for Sustainable Water Concepts

Lima is deemed the driest capital in the world. About one third of the Peruvian population is living there and the number is increasing. In parallel, economy is growing. "All this together is a problematic combination. Furthermore, climate change aggravates water scarcity," says Dr. Felix M. Riese. Within the framework of the TRUST collaboration project funded by the Federal Ministry of Education and Research and his doctorate at the Institute of Photogrammetry and Remote Sensing (IPF) of KIT, Riese traveled to Lima and took along two drones and a suitcase full of batteries. In the Andes at a height of above 3000 m, the physicist coordinated a drone measurement campaign to gather soil moisture data in the Lurin catchment area, from which drinking water for Lima will be extracted.

Felix M. Riese prepares the drones for a flight in the Andes mountains. (Photo: F. Riese)

"In combination with satellite images, we can determine where deserts are located or where agriculture uses river water for irrigation purposes," Riese explains. Hydrologists put the data into hydrological models. From modeling, drinking water extraction concepts will be derived. Moreover, Riese and his colleagues used artificial intelligence to develop methods to automatically generate soil moisture, soil type, and land cover maps from these data. The scientists also want to strengthen the open-access concept in science. "The software and our raw data will be made freely accessible, such that also other scientists involved in similar projects can work with them."

ErWiN Fights Forest Fires

New Collaborative Project Produces Important Basic Knowledge for Management Recommendations

Fabian Faßnacht and his colleagues also use the experience gained in Chile: With the help of a drone, they took photos of forest areas after a fire. (Photo: F. Faßnacht)

Climate change will probably be accompanied with more warm and dry summers. This increases the risk of forest fires. But what exactly do we know about forest fires? Not enough. For this reason, the collaborative project ErWiN was launched on June 01, 2020, coordinated by KIT. Scientists in the team of Dr. Fabian Faßnacht from the Institute of Geography and Geoecology seek to better understand how fires spread in the forest.

First, forest fire models used in North America and in the Mediterranean will be adapted to our conditions. "We want to divide Central European vegetation into different categories of burning materials. To what an extent are certain types of vegetation burnable and how is the burning material arranged in space," Faßnacht says. These adapted models will then be verified by post-modeling of fires in Central Europe. Then, scenarios will be run to find out which management measures help prevent the fire from spreading.

In addition, deep learning methods will be used. "With GPS cameras, we will take photos of different situations in the forest. Then, we will ask experts to estimate the fire risk for this situation and will try to teach this expert knowledge to an algorithm," says the forest scientist. In the future, the risk of a fire will be estimated by image recognition.

Cleaning Wastewater

Efficient Removal of Bacteria from Wastewater by Ultrafiltration

Ultrafiltration might become the gold standard for the removal of undesired microorganisms from wastewater. Professor Thomas Schwartz from KIT's Institute of Functional Interfaces (IFG) and his colleagues have demonstrated that this method most efficiently removes potentially pathogenic and antibiotics-resistant bacteria from wastewater. In some cases, hardly any bacterial contaminations could be detected in the filtrate afterwards. Wastewater treatment with ozone is not that effective.

"However, ozonation also is important," Schwartz says. "It removes problematic chemical pollutions. Trace substances would pass the pores of the filtration membranes and, hence, enter the environment. Combination of both methods would be ideal." Still, a challenge remains: The bacteria get caught by the membrane and form the so-called retentate when backwashing the membrane. "This critical biomass in the retentate has to be treated separately by combustion, for instance."

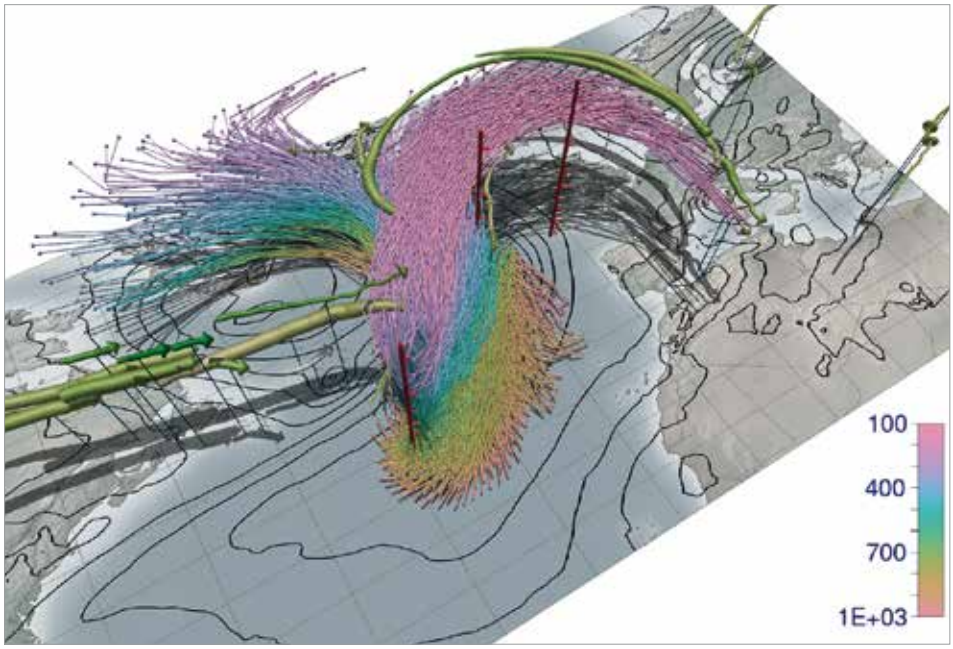
Ultrafiltration pilot plant at the Steinhäule sewage treatment plant in Neu-Ulm. (Photo: Dr.-Ing. Johannes Alexander, IFG)

According to Schwartz, it is not necessary to backfit every sewage treatment plant. The need for backfitting depends on how strongly a sewage treatment plant is polluted and on whether wastewater comes from hospitals or slaughterhouses. It is also important where the processed wastewater flows to. Sometimes, cleaned wastewater is passed into swimming lakes or surface water used for drinking water production. "The one-health principle and healthcare have to be in the focus!"

About Waves and Weather

Researchers Seek to Better Determine Probabilities for Weather Forecasts

Hot sun and high air humidity all over Germany may result in local thunderstorms and lightning. But where and when exactly? "The answer lies in the interaction of large-area waves in the atmosphere with the local weather conditions," says Professor Peter Knippertz from KIT's IMK. Waves can be predicted rather well over several days, local thunderstorms cannot. "Vice versa, clouds may cause the wave position to become unstable. This makes even large-area forecasts very difficult."



Visualization of weather forecast is a major topic of "Waves to Weather." The figure shows hurricane "Lorenzo" in September / October 2019, the strongest tropical hurricane ever recorded that far east. The forecast is shown for paths of ascending hot and humid air from sea level up to the jet stream (green arrows). Different colors represent the height of the paths in the unit of pressure hPal. (Source: Rautenhaus et al. 2020, ECMWF Newsletter No. 162, https://met3d.wavestoweather.de/met-3d.html)

This especially applies to the tropics, where thunderstorms occur daily and forecasts are extremely difficult. At the same time, many people are living there and their supply with food and energy often depends on weather. Issuing more reliable warnings of devastating weather conditions, hence, will save lives and the infrastructure.

"Basically, weather forecasting always is a probability problem." Small errors in the current state of the atmosphere rapidly grow in the forecast. Within the framework of the "Waves to Weather" project, Knippertz and his team study how these probabilities can be determined more precisely. "Waves to Weather" is the first project given the status of a "joint project" by the World Meteorological Organization. "Having this status, we can achieve much more."

"Corona Is a Catastrophe, but, Fortunately, It Is Taking Its Time."

He is the brains behind the German data for the global Corona map of Johns Hopkins University (Baltimore, USA): James Daniell from the Center for Disaster Management and Risk Reduction Technology (CEDIM) and his team are continuously collecting data about the pandemic. (Photo: James, Daniell, KIT)

This is how James Daniell from KIT's Center for Disaster Management und Risk Reduction Technology (CEDIM) describes the current pandemic. The disaster risk analyst is one of the founders of Risklayer. The team of KIT's startup produces estimates and surveys of impacts of floods, storms, volcanic eruptions, earthquakes and other disasters. Presently, it is generating maps of the spread of Covid-19. These maps are the source of German data used for the well-known Johns Hopkins global map.

"Although the spread is rather slow, Corona-related decisions require quick reliable data to assess risk trends at any time," Daniell says. The work of risk analysis always focuses on three questions: What are the processes and hazard metrics? What or who is affected? How big is the damage?

In the case of Corona, this is rather complex: The hazard, i.e. the virus, is not visible and does not respect any borders. Exposure does not affect any physical capital. Instead, all people are affected and they are mobile and have contact with each other. Hence, there are many interfaces for the infection to spread. And vulnerability, the extent of damage, concerns many intangible assets, such as health, education, or social life.

To make the situation comprehensible, infection, death, and recovery data must be transmitted from the village to the district level in the first instance. From the 401 German districts, the data then have to be transmitted as quickly as possible to the state level and from there to the national level. Actually, data transmission via state lines takes two to three days. Then, these data can be incorporated in models of the Robert Koch Institute. Data transfer for Risklayer takes 12-24 hours. "This still is slow, but much better."

Can automation help? Hardly, Daniell says, because counting automatisms do not detect potential errors. In the case of Covid-19, for example, some media outlets added up the figures of an autonomous town and the surrounding district, although the town figure had already been included in the district figure. "This makes forecasts incorrect and is fatal for political decisions. You need a watchful eye." For this purpose, Risklayer uses scraping and crowd sourcing. Thousands of websites are scraped by hand, but by many persons at the same time. Currently, about 80 volunteers regularly supply data including second-in-command, KIT Geoecology student, Johannes Brand. Nearly all contributors come from some sort of research organization, universities or companies.

According to Daniell, Germany should improve its disaster management scheme in this direction and learn from other nations. On the Philippines, which are affected by many disasters every year, each municipality has a disaster management unit of its own. "Such structures, combined with the German technical, scientific, and financial potential, would prepare Germany well for the next time. Corona is our case study in this respect."

(Photo: KIT)

Professor Dr.-Ing. Hansjörg Kutterer

From Karlsruhe to Munich, then to Hanover and Frankfurt, and back to Karlsruhe – after about 20 years, Professor Hansjörg Kutterer has returned. Since October 2018, he has been heading the Chair for Geodetic Earth System Sciences at KIT's Geodetic Institute. "The conceptual orientation of this position and the KIT itself attracted me. Karlsruhe has always been a good location for earth sciences." Kutterer knows what he is talking about: He studied at the then University of Karlsruhe and was conferred his doctorate and habilitation there. KIT did not yet exist. The scientific atmosphere at KIT inspires the engineer. "Geodesy as an interdisciplinary subject can contribute a lot to further strengthening interdisciplinary collaboration."

(Photo: KIT)

Professor Dr.-Ing. Erwin Zehe

Since early 2019, Erwin Zehe has been the Scientific Spokesperson of the KIT Climate and Environment Center. "A fascinating task," says the hydrologist from KIT's Institute for Water and River Basin Management. "I see the Center as a thinktank, where we can think freely about thrilling problems." In spring 2019 already did scientists from different disciplines meet to discuss the importance of artificial intelligence in research. Zehe also attaches importance to offering early-stage researchers a platform to present their work. "And I want to further strengthen the link between research and the 'outside world', our relations to the city of Karlsruhe, to the citizens, and to culture in order to foster mutual inspiration."

(Photo: Adam Schultz/Schmidt Science Fellows)

Dr. Andreas Schlüter

How do large-area atmospheric waves influence precipitation variability above Africa? And how can precipitation be predicted best? These were the big questions addressed by Dr. Andreas Schlüter in his doctoral thesis written at the Institute of Meteorology and Climate Research, Department Troposphere Research (IMK-TRO) of KIT. "I have demonstrated the great potential of these waves for precipitation forecasts and, in collaboration with mathematicians, I have developed a statistical model for rain forecasts in the tropics," the meteorologist says. "Africa is the continent that depends most on precipitation. More than 90% of agriculture is rainfed. More than half of the people are working in this sector. Economy and food security depend on precipitation."

Schlüter is convinced that "big problems can only be solved interdisciplinarily." Schmidt Futures and the Rhodes Trust agree and fund his interdisciplinary research with a fellowship in the amount of US Dollar 100,000. In April 2019, Schlüter was admitted to the Schmidt Science Fellows Program in New York. Now, he continues his work at Stanford University in California. With the help of artificial intelligence, he will develop new models to forecast harvests for regional decision-makers to store sufficient food or to cultivate millet instead of corn in the case of an imminent drought. "Here, various disciplines, such as informatics, food security, and economics, come together. This is a nearly unique situation," Schlüter says. Using scientific findings to produce a great outcome in reality, that is what he cares about.

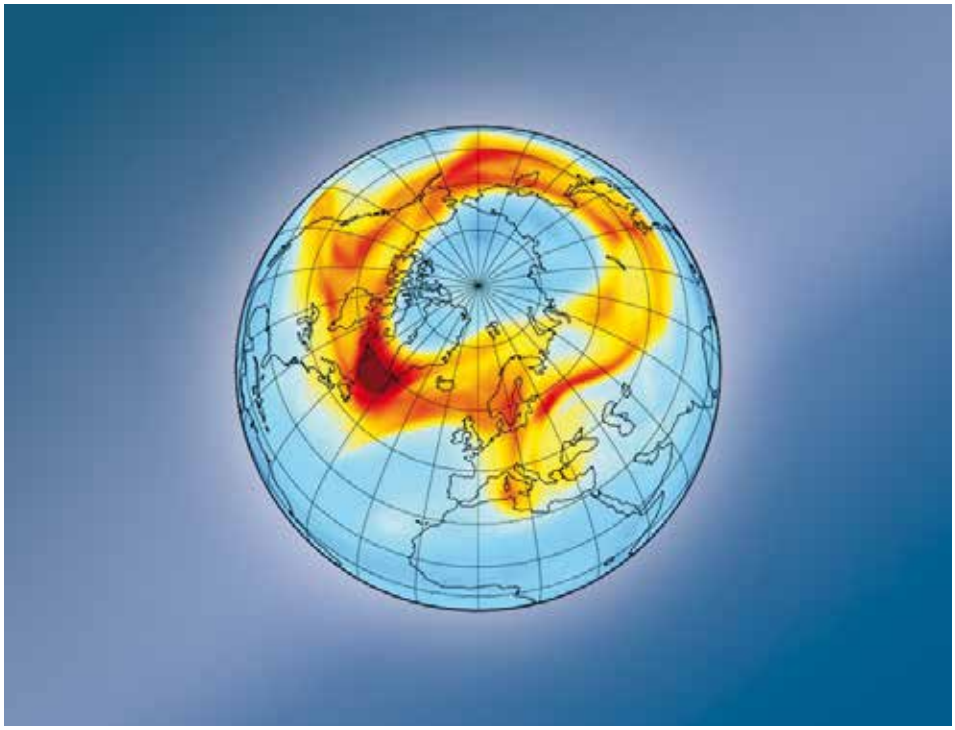
KIT Climate and Environment Center

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.-Ing. Franz Nestmann
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

Ozone Hole Above the Arctic: A Signal of Climate Change?

Montreal Protocol as a Model of Success – Lessons that can be learned



The Arctic "ozone hole" on March 10, 2020: Above the Arctic, ozone column densities normally reach a maximum (red colors). Due to extremely low temperatures in the Arctic stratosphere, a deficit in ozone layer thickness developed this spring (blue colors above the Arctic). (Data from the analysis archive of the Copernicus Atmosphere Monitoring Service of the European Centre for Medium-Range Weather Forecasts)

For decades, chlorofluorocarbons (CFCs) have been used as propellants in sprays, coolants in air conditioners, or in insulating foams. However, CFCs damage the ozone layer. For this reason, they were banned from industry worldwide when the Montreal Protocol was adopted in 1987. Still, they will remain in the atmosphere for a long time. In spring 2020, an unusually big "ozone hole" opened above the Arctic. "It takes a very long time for CFCs to be transported out of the stratosphere and degraded. We will have to deal with them for decades," says Dr. Björn-Martin Sinnhuber from KIT's Institute of Meteorology and Climate Research (IMK-ASF). His colleague Professor Peter Braesicke points out: "Still, the Montreal Protocol is a success model. In the past twenty years, concentration of ozone-depleting substances in the atmosphere decreased considerably. But such extraordinary situations like the Arctic "ozone hole" remind us of the fact that we cannot sit back and relax." Both KIT researchers are among the authors of the Scientific Assessment of Ozone Depletion 2018 by the World Meteorological Organization.

Meanwhile, the "ozone hole" has closed again. Or to be more precise, the air has mixed. This results in somewhat less ozone in the northern hemisphere, but this loss will be compensated by natural supply in summer. Braesicke says: "We do not have to be concerned about this single event. But it shows that it is important for the countries to further comply with the agreement. And we might learn from the Montreal Protocol something for our efforts to mitigate climate change."

Climate change might also play an important role in the development of the Arctic "ozone hole." Every year, the classical ozone hole forms above Antarctica, but it hardly occurs in the Arctic. This winter, very low temperatures in the stratosphere caused the ozone layer above the Arctic to become thinner. "One factor is the natural variability of warm and cold winters, the other factor is climate change," Braesicke says.

The Earth's atmosphere is subject to warming, but only in the bottom layer, the troposphere. The stratosphere, the second floor of the atmosphere, by contrast, is subject to strong cooling. In the past 30 years, a very cold winter that was colder than all winters before occurred every five to ten years. "At about minus 80C°, polar stratospheric clouds form. On their surfaces, chemical reactions take place, which lead to ozone depletion," Sinnhuber explains. "The problem of the ozone layer is closely associated with climate change – the much bigger and even more complex problem."

THINKTANK Achieves First Success

About two years ago, the "THINKTANK Industrial Resource Strategies" started operation. Now, it is time to draw a first interim balance: "We have successfully completed two projects. Some projects initiated in the starting phase are still running, other new projects have been started. The results are very positive," says Professor Jochen Kolb from KIT's Institute of Applied Geosciences, who chairs the steering group.

Under the heading of "Surface Engineering," researchers studied resource-efficient production. Their finding: By the optimization of metal surfaces, corrosion resistance can be improved and the service life of tools can be increased. A second project focused on circular economy: Which reuse or recycling options are optimal for a product and its lifecycle? "Recycling, reuse, and remanufacturing must be studied holistically," Kolb explains. "Here, economic, ecological, and social aspects play a role."

Schlosslichtspiele 2019 "Our only blue one"

A successful fund raising and crowd funding campaign launched by ZKU helped realize the contribution to the Karlsruhe Schlosslichtspiele 2019. From August 08 to September 15, 2019, the projection "Our only blue one" by Maxin10sity was presented almost every evening. In total, 316,000 visitors enjoyed the 2019 Schlosslichtspiele lightshow. We would like to thank our supporters and donors.

ZKU lights up Karlsruhe: The contribution "Our only blue one" fascinated many thousands of visitors last summer. (Photo: Schlosslichtspiele Karlsruhe 2019, KME/Jürgen Rösner)

Alexander Gerst Brings Back KIT Flag

In 2013, the KIT flag made of pure silk was sent via ESA to Houston (Texas, USA) to accompany Alexander Gerst on his first trip to the ISS as a flight engineer in 2014. The flag had to be extremely thin, as the weight of luggage taken along into the orbit is strictly limited.

On July 12, 2019, Alexander Gerst brought back this flag when he visited the KIT for conferral of the honorary doctorate. At KIT, he would like to have it displayed at a place, where it can be seen by many young people to remind them of what is possible if you want it.

"Astro-Alex" back at his alma mater – from the left: Frank Schilling, Holger Hanselka, Friedemann Wenzel, Alexander Gerst, and Georg Weiß. (Photo: KIT)

Water Science and Engineering Master's Program

Since the 2016/17 winter semester, the master's program of "Water Science & Engineering" has been offered by the KIT Department of Civil Engineering, Geo- and Environmental Sciences (http://www.wasser.kit.edu/english/msc_watscieng.php) with 24 study places and interdisciplinary courses

mainly in English. Students acquire broad and substantial understanding of the complex relationships in environmental systems as well as comprehensive methodological competence. On this basis, they can independently develop strategies and technical solutions for sustainable water resources management taking into account social and economic criteria.

By May 2020, 38 students completed the program. Currently, about 90 students have enrolled, of these 45% are female. About 60% of the students come from more than 25 countries abroad. Due to the high demand, admission has now been restricted.

K3 Congress on Climate Change, Communication, and Society

After the kickoff in Salzburg in 2017, the second K3 Congress took place at KIT on September 24 and 25, 2019. About 500 participants discussed perspectives and aspects of climate communication in a number of debates and workshops. The highlights were keynotes by George Marshall (Climate Outreach), Harald Welzer (sociologist), and Eckart von Hirschhausen (presenter, comedian, and physician).

Climate. Communication. Arts

Climate communication is diverse and just a few sentences for explanation often are not sufficient. For twelve years now, the South German Climate Office has made climate research known and usable. The ways in which this is done are very different. Early this year, the Center for Art and Media (ZKM) in Karlsruhe organized this year's panel discussion under the heading "Erde, was nun? Überleben in der Critical Zone" (Earth, what now? Surviving in the critical zone). The well-attended event with the South German Climate Office participating in the discussion succeeded in communicating not only natural science, but also requirements made by society. Another project of arts students from the Karlsruhe University of Arts and Design with the Climate Office focused on society. With the help of artificial intelligence, they graphically edited photos to show the future world according to climate simulations. The Climate Office will continue to deal with artificial intelligence. Currently, a scientific project in the area of forestry is being started. Such projects represent new approaches to climate communication.

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Loss and Benefit

People say that Corona is like a magnifying glass. The GRACE Graduate School used this magnifying glass to have a look at its offerings. As everything today, offerings have been strongly reduced. But how reduced can education and training in science work? Dr. Andreas Schenk, scientific coordinator of GRACE, takes stock: "Some changed offer works well and is worth to be continued. But some important options for young scientists were also lost."

In his opinion, the change from the seminar to the webinar is positive. Considering the impact on the environment and costs, people will more often think about whether their presence and the associated travels will be necessary in future.
Still, conferences are hugely missed. "Young scientists, who are new in the community, need personal meetings and conversations for networking. Now, this opportunity is lacking."

But there are also benefits, Schenk says: "Science and society come closer to each other. People see that research is development and that answers may change with every new study published. And people accept this. I wish all young researchers that they will continue to receive this appreciation."

SPECIAL PUBLICATION

What Do Fertilizers Have to Do with Ice Clouds?

With the Russian high-altitude research aircraft "Geophysica," researchers flew from Kathmandu in Nepal up into the uppermost level of the monsoon: In this way, they could make measurements directly in the aerosol layer. (Photo: Erik Kretschmer, IMK-ASF/KIT)

Every year when the monsoon comes, a thick layer of aerosol forms at about 15 km height above entire Asia. This mystery in climate research has now been solved by Michael Höpfner and his team from IMK-ASF of KIT.
The suspended particles largely consist of crystalline ammonium nitrate. This is several times a surprise. Actually, this aerosol is rather typical of near-surface fine dust pollution. It is formed from ammonia gas after fertilization. "During the monsoon, air movement is so strong that the aerosol reaches such high altitudes," Höpfner says. The highly water-soluble ammonium might also be expected to rain down quickly, especially during the monsoon. But the ammonium nitrate particles developing at this high altitude stay there. Moreover, ammonium nitrate is liquid in pure form, whereas the aerosols are solid – and this is where the difference lies for weather and climate. "Solid particles act as nuclei for ice crystals at higher temperatures. This means that ice clouds are formed much earlier."
Such cirrus clouds retain the Earth's infrared radiation. Another result might be that temperature increases with the number of cirrus clouds, or vice versa. And this process might probably be controlled by our way of farming.

Höpfner, M. et al.: Ammonium nitrate particles formed in upper troposphere from ground ammonia sources during Asian monsoons. Nature Geoscience, 12, 608-612m, 2019. https://doi.org/10.1038/s41561-019-0385-8

Wagner, R. et al.: Solid Ammonium Nitrate Aerosols as Efficient Ice Nucleating Particles at Cirrus Temperatures. Journal of Geophysical Research: Atmospheres, 125 (8), 2020. https://doi.org/10.1029/2019JDO32248

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