Karlsruhe Institute of Technology

CLIMATE AND ENVIRONMENT news

Newsletter of the KIT Climate and Environment Center

Issue 01|2018

Dear Readers!

The summer was hot and dry. For the months from April to July, the highest average temperatures ever were measured in Germany. The associated drought had serious consequences: forest fires, crop failures, an extremely low water level in rivers, and damage to infrastructure facilities. This is reported by the Center for Disaster Management and Risk Reduction Technology (CEDIM) of KIT. The present issue highlights how drought and water shortage are counteracted in the Jordan Valley. There, researchers of KIT are working on an integrated water resources management scheme, in spite of all political tensions in this region. This is a good example of how climate and environmental research can reach into society. Enjoy reading.

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

Water for the Jordan Valley

Taking water samples in the Jordan Valley. (Photo: Dr. Anna Ender)

Dates, bananas, tomatoes, eggplants – the lower Jordan Valley covers fertile farmland. But hot, nearly precipitation-free summers and strong population growth place strain on the region. Water is scarce. Since 2006, scientists of KIT have been cooperating with colleagues of other German research institutions, partner universities in Jordan, Israel, and the Palestinian territories as well as companies and local authorities to establish an integrated water resources management scheme in this region. In June, the third phase of the SMART projects, SMART-MOVE, was completed.

"We have developed an early warning system that indicates contamination of spring water with fecal bacteria, which often occurs after strong rain in winter," says Dr. Julian Xanke, researcher at KIT's Institute for Applied Geosciences. In addition, vulnerability maps were generated. They help identify regions in which groundwater quality is at highest risk. In less "vulnerable" areas, it is possible to reuse cleaned sewage for irrigation purposes. As the cities are growing, the amounts of sewage increase as well.

Work of the KIT researchers also focuses on controlled groundwater recharge, i.e. use of the geological subsurface to store surface water. There, it is protected from contamination and evaporation. Water management tools were applied to evaluate the available water resources for later sustainable use. The strategies derived help local authorities secure supply of the population with water. Julian Xanke emphasizes: "In spite of the political tensions in this region, all parties cooperated well for the sake of the cause."

Water OR Energy? Water AND Energy!

The Nexus Approach Combines both Resources in Construction

Low-energy heating, solar panels, and external insulation: in the construction sector, we keep a careful eye on the energy transition, but not on the water transition. Dr. Witold Poganietz and Dr. Helmut Lehn of KIT's Institute for Technology Assessment and Systems Analysis (ITAS) agree that both resources should not be considered separately, but combined semi-centrally. "It is profitable to analyze 1000 housing units or more together," Poganietz says.

In simple words: sewage from the shower is warm. Energy was used to heat it up. Sewage from the toilet and kitchen is rich in nutrients. From both, energy might be recovered using heat exchangers and a biogas facility. Moreover, service water might be recovered for certain purposes, such as irrigation.

Sewage is more than just waste: from the low-energy house to the resource-efficient district.

The team of Lehn and Poganietz studies which type of water-energy coupling is advantageous under various conditions. These studies are all about money, but also about the climatic, cultural, and social background in various regions.

However, the big obstacle is the same worldwide. "The taboo of talking about toilet water," says Lehn. Contrary to waste. Germany is the world champion in sorting waste. So, why not considering sewage a resource? A company in Singapore even produces drinking water from sewage. Lehn: "I tested a bottle of it – and I am fine."

Surprise in the Corn Field

Trace Gases from Energy Plants May Change Air Quality

In Germany, energy plants, mainly corn and rape, are grown on every fifth hectare of farmland. How does this influence the air? This was the question studied by scientists of KIT, Helmholtz Zentrum München, and the Leibniz Centre for Agricultural Landscape Research. For a period of three years, they measured emissions of biogenic volatile organic compounds (BVOC) from corn, rape, and ryegrass. With the help of a new technique based on large chambers and a proton transfer reaction mass spectrometer, a number of components were identified.

"We were surprised to find many terpenoids in corn, in particular in the flowering phase, the magnitude being about the same as that of already known alcohol emissions," says principal investigator Dr. Rüdiger Grote of the Atmospheric Environmental Research Division of KIT's Institute of Meteorology and Climate Research on Campus Alpine. Terpenoids are highly reactive and have a considerable impact on air chemistry. They tend to entangle with each other and, in this way, form fine dust and cloud condensation nuclei. Similar to exhaust gases from cars, they reduce air quality.

Emissions of biogenic volatile organic compounds from corn measured by the large measurement chambers exceeded those of rape and ryegrass. (Photo: Felix Havermann)

So far, mainly poplars used for the production of wood fuel have been known to emit large amounts of reactive BVOC. "Although corn cannot compete with poplars, we should consider the emissions of crops much better in future modeling," says Grote. If fields with strongly emitting plants are located in the vicinity of cities, increased ozone formation may result, as nitrogen oxides from urban traffic react with BVOC from the corn. These emissions might also influence regional precipitation patterns.

Sensitive and in Danger

How Man and Climate Change Regionally Modify the Nature of South America

One fifth of the world's freshwater reservoir: the Amazon River is the largest river by discharge volume of water in the world. Its riparian forests are flooded regularly. In addition, large areas of permanently wet mangroves and swamps as well as very dry savannas exist in South America. Wetness here, aridity there: climate change and man enhance both, says plant geographer Professor Dr. Florian Wittmann of the Department of Wetland Ecology of KIT's Institute of Geography and Geoecology. The tree expert studies how the sensitive forest of South America reacts.

Palm swamps on the upper Rio Negro. (Photo: Florian Wittmann)

Deforestation to obtain pastures and grow soy beans, for instance, modifies the regional climate. Wherever woodlands are cleared, conditions become drier. At other places, the frequency of extreme floods increases. "The trees there have adapted by evolution and are rather tolerant to floods, but they also need times without water." On large areas, dams are built. Water is removed for generating water power. As Brazil is rather flat, it is not possible to dam water with the help of the relief. Instead, wide areas are flooded, which are far too wide to be cleared before. In this way, many tree species may become extinct, forests are rotting in the water. However, the supposedly environmentally friendly damming of water results in CO_2 emissions that by far exceed those of fossil fuel combustion.

"A vicious circle," says Wittmann, who communicates the findings of his studies to politics in the South American countries. He points out, for example, that it is hardly important whether a river is dammed at one or at twenty places. "The impact exists. Hence, it is better to concentrate on a river close to the energy-hungry industrial centers of Rio and Sao Paulo and leave the others untouched."

And the ecoregime is influenced by something else: sewage. So far, sewage produced by about 300 million inhabitants ends up unfiltered in rivers and the sea. To better estimate this impact, intensive research is required.

This Might Become Expensive

Tsunamis Could Cause Tourism to Lose Hundreds of Millions of Dollars Every Year

A single wave and everything lies in ruins: tsunamis have a highly destructive power. Dr. Andreas Schäfer of the Geophysical Institute (GPI) analyzed the damage caused to buildings together with economic data. The model developed by his team theoretically determines the probability of a tsunami in a certain region and the potential loss for local businesses resulting from repairing the damage. Worldwide, several hundreds of millions of dollars might be lost by tourism every year on average. Schäfer presented this finding at this year's annual conference of the European Geosciences Union (EGU).

Tsunamis often leave places of devastation. (Photo: WikiImages, www.pixabay.com)

According to Schäfer, this knowledge is of no help to each individual hotel and it is not intended to scare tourists, as tsunami events are much too rare: "We rather want to make local businesses and politics think of warning systems, of protection dams, evacuation routes, and signs." After all, it is the only natural disaster, where people can co-determine to a certain extent how devastating the consequences are. In case a tsunami is approaching, there always is a certain time left until it hits the coast. This time has to be used and it is good to know how. "We want to provide information as far as general safety is concerned. And we achieve this by referring to concrete costs for the decision-makers," Schäfer says. Studies will not be limited to tsunamis. It is planned to extend the model to cover risks, such as storms or earthquakes.

Measurement Instruments for Mars Mission Tested in the Black Forest

The Former Ore Mine in Schiltach Is an Extraordinarily Calm Place

Rudolf Widmer-Schnidrig installs a terrestrial reference seismometer near the tent with the Mars seismometer. (Photo: Philippe Labrot, IPGP, Paris)

Military airbase in Vandenberg, May 05, 2018, 4 a.m.: on the Pacific coast of California, the spacecraft of the "InSight" Mars mission is launched in dense fog. On November 26, 2018, the lander is to reach the Red Planet and to study its interior for a period of two years. "This is the result of close cooperation between the USA and Europe," says Rudolf Widmer-Schnidrig of the Joint Geoscientific Observatory (Black Forest Observatory, BFO) in Schiltach, which is operated jointly by the KIT and Stuttgart University. German, French, and US scientists and engineers have developed the experiments and instruments that are now on their way to Mars with the NASA spacecraft.

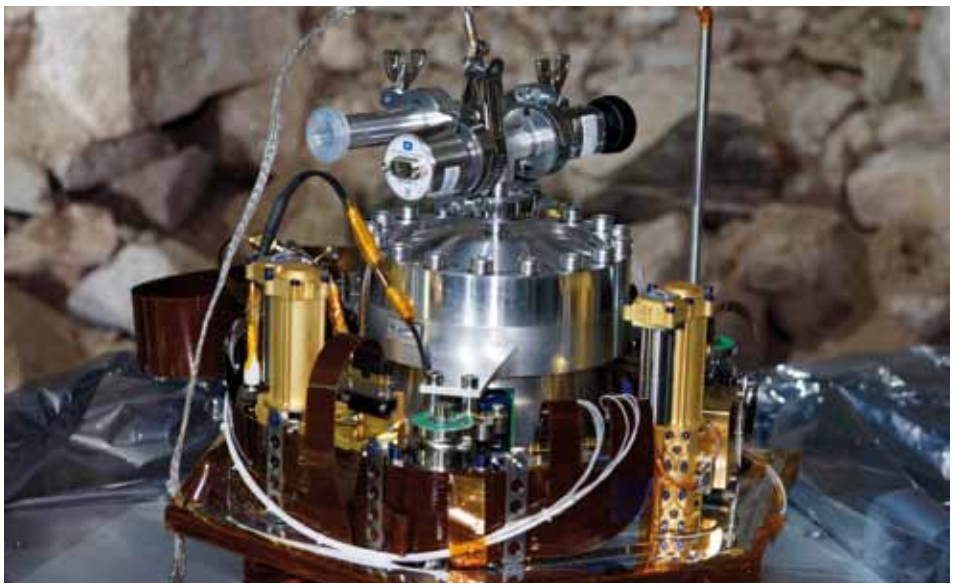
Among the instruments on board of the spacecraft is a seismometer package of the French space center CNES, whose "twin" was tested by Widmer-Schnidrig and his team in a tunnel system of the former ore mine in Schiltach in the Black Forest. The package contains six sensors measuring ground motions in the vertical and two horizontal directions. "This twin will serve as a spare system during the mission," says the seismologist. This means that whenever there will be a problem with the seismometer on Mars, tests will be carried out with the spare device on Earth, before commands will be sent to the seismometer on Mars to solve the problem.

Test conditions at the BFO are excellent: seismic noise in the tunnel system is very small, such that sensitivity of the Mars seismometers can be tested in comparison to the best terrestrial seismometers. The principle: in the seismometer, a sample mass is suspended from a spring. Motion of this sample mass is measured relative to the housing.

However, a very important fact has to be considered: gravity on Mars is much smaller than on Earth. In a Mars seismometer, the spring has to be weaker or the sample mass has to be smaller than in a seismometer used on Earth. "With a few tricks, we can simulate Mars conditions well, but an uncertainty remains," says Widmer-Schnidrig. "On Mars, the instruments will be exposed to the sun, wind, and the regolith, the finely grained rock on Mars. Hence, they are shielded. But high temperatures make the springs softer, cold makes them stiffer. This will influence the measurement results."

On the Red Planet, the seismometer is to record quakes and to help determine the mechanical properties of the interior of Mars: how thick are the crust, mantle, and core? The sensor package HP3 (Heat Flow and Physical Properties Package) of the German Aerospace Center (DLR) will additionally measure heat flow from the interior. The RISE experiment of the Jet Propulsion Laboratory JPL of NASA will measure motions of the rotary axis of the planet.

More information on the mission can be found on the websites of NASA: www.mars.nasa.gov/insight/mission/instruments/



The Mars seismometer tested in the BFO tunnel: the vacuum chamber with the sensors is positioned between three motorized foot screws (only two are visible). With these screws, the seismometer is leveled. (Photo: Philippe Labrot, IPGP, Paris)

(Photo: private)

Professor Andreas Rietbrock

Openness of his colleagues at KIT made it easy for Professor Andreas Rietbrock to settle in Karlsruhe. Since October 2017, he has been heading the Geophysical Institute. Before, Rietbrock, who specialized in earthquake research, conducted research and taught at the University of Liverpool in Great Britain for 15 years. The charm of starting something new made him return to Germany. And the geophysicist has a lot on his agenda: "I want to combine numerical simulation of fracture processes and wave propagation during earthquakes with observations. We need both approaches to better understand the processes." A large part of his work will take place in South America, among others in cooperation with the University of Nice. Rietbrock is particularly interested in large quakes in the subduction zones.

(Photo: private)

Dr. Hendrik Andersen

"This is a great confirmation of my work" – commented Dr. Hendrik Andersen the Climate Award granted to the geographer by the Reinhard Süring Foundation in Frankfurt this March. Every three years, the foundation honors excellent research in the area of climatology at the German Climate Conference. Andersen received the award for his doctoral thesis. Based on satellite data, he studied the interactions between aerosols and clouds. For the first time ever, Andersen used quantitative methods, among others from the area of artificial intelligence. The award motivates the scientist for his future tasks: as a member of the working group for geophysical remote sensing, Andersen now wants to study fog in the Namib Desert.

(Photo: private)

Professor Jochen Kolb

After nine years of research and resource exploration work in Denmark and Greenland, he moved to Karlsruhe. Since October 2016, Dr. Jochen Kolb has been professor for geochemistry and ore geology at KIT's Institute of Applied Geosciences. He is specialized in hydrothermal deposits. With his team, he studies the cycle of metals that migrate in hot waters in the Earth's crust: where do they come from, how are they transported, why are they precipitated in large amounts at certain points?

To better understand these processes, he plans to enhance trace element analytics. By means of a laser, Jochen Kolb wants to study smallest zonings in the minerals. "For future resource security, we have to be able to predict which resources are located deeper in the Earth's crust without our knowing anything about it on the Earth's surface," the geologist says. "This will also reduce the risk of exploration companies finding nothing."

Resource security also is in the focus of the THINK TANK "Industrial Resource Strategies," whose steering group is chaired by Jochen Kolb. The Think Tank was opened at KIT in February 2018 and is funded by the State Ministry of the Environment of Baden-Württemberg and industry partners. "Here, politics, science, and industry meet to answer questions that are relevant to society," says Jochen Kolb.

So far, three research topics have been defined: firstly, scientists want to make resource data transparent along the complete chain of values added. Secondly, ecological and economic advantages of recycling shall be assessed to improve the products and, hence, increase the recycling rate. Thirdly, the Think Tank focuses on new technological developments: are the resources sufficient? Do we have to establish trade relations to countries possessing the required resources? The Think Tank will find the answers.

KIT Climate and Environment Center

Scientific Spokesperson:	Professor Dr. Frank Schilling
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 Risks Management:**	Professor Dr. Michael Kunz

Crossing the River Rhine

Professor Johannes Orphal Argues in Favor of Close Scientific Relations between Germany and France

Research par excellence on either side of the river Rhine: the German-French Initiative (DeFI) at KIT helps build science bridges. (Railway bridge Kehl, photo: H. Helmlechner – Eigenes Werk, CC BY-SA 4.0)

A long-term structural framework is needed: as Scientific Head of the German-French Initiative at KIT (KIT-DeFI), Professor Johannes Orphal, Director of the Institute of Meteorology and Climate Research (IMK) of KIT and Scientific Spokesperson of the "Atmosphere and Climate" Program, is committed to collaboration between the neighboring countries and calls upon politics.

25 years ago, Orphal was conferred his doctorate in France. Later, he was granted his post-doctoral lecture qualification there, contrary to what had been recommended to him: "People always told me that the US or the United Kingdom were THE countries of science. This bothered me a lot, because France also is a great nation, not only from the cultural point of view or in football, but also in science."

He felt particularly attracted by the French perspective of science. "In Germany, we have a rather technical approach to science. We focus on machines, on down-to-earth innovation, on technology transfer, and industry. In France, by contrast, the approach also is of mathematico-philosophical character. People try a lot, look far into the future, ask fundamental questions. When I was a child, I was fascinated by the books of Jules Verne, because I found both in them."

Also today, students and early-stage researchers in Europe are not only interested in multidisciplinary, but also in transnational development, Orphal says. But he sees many obstacles: "During studies, these obstacles first are of organizational nature. It is not just academic education and learning, but also living, support, or healthcare. Graduates are interested in secure income over a long term, family support, and pension benefits. High risk – high gain is not everyone's cup of tea."

Orphal thinks that politics now is to establish program structures that better consider the researchers' career planning. In his opinion, the Bologna Process with Europe-wide studies and the latest plans of Brussels for European universities need a stronger political commitment. "In my view, the big European framework is still lacking."

Orphal, who was granted the German-French Gentner-Kastler Prize and the Humboldt-Gay-Lussac Prize of the Académie des Sciences in Paris in 2017, suggests to test closer collaboration between Germany and France first. Then, successful efforts can be transferred to the European level. In fact, Emmanuel Macron and Angela Merkel repeatedly declared that they intend to intensify scientific collaboration of both countries. "But it is not sufficient to launch another fellowship program. A reliable framework also is required for graduates. Why don't the countries invest a billion euros each for this purpose? Compared to the other budgets, this is peanuts." Orphal thinks that too few initiatives have been started for this purpose so far.

In his field of work, Orphal proposed a German-French climate institute under binational administration. In the areas of nuclear and fusion research, such bridges across the Rhine have long been established, an example being the ITER Research Reactor in Cadarache. Other "topical areas" are artificial intelligence, cyber security, and data protection. Also in these areas, much money is spent for transnational research. "But only, because these investments would be made anyway. The science world, however, is much larger than one-sided interests. Collaboration is important, in particular regarding energy concepts for the future and in the area of environmental and climate research, because these topics should not be determined by national goals."

In Orphal's opinion, border-crossing research in these areas should be organized on the highest political level. "We can pave many ways bottom-up and are doing so already. But we will achieve more when there also is a corresponding top-down process." Orphal considers the work for this his mission in life. He insistently argues for scientific collaboration across the river Rhine and, with a twinkle in his eye, adds: "A train from Karlsruhe to Paris needs just about 2 hours, a train to Berlin takes more than 5!"

KIT Environment Lecture: Science and Research as a Basis for Future-oriented River Policy

Professor Franz Nestmann (KIT), Dr. Birgit Esser, and Professor Thomas Leisner (KIT) at the KIT Environment Lecture on January 30, 2018. (Photo: KIT)

On January 30, 2018 at this year's KIT Environment Lecture, more than 100 guests listened to the fascinating insights into the activities of the German Federal Institute of Hydrology, which were provided by its head, Dr. Birgit Esser. The federal institute does not only carry out research projects of its own, but also gives advice in the area of watercourse development. Diverse uses of rivers – as watercourses, as living and recreation areas for animals and humans, or as sewage disposal systems – result in special ecological challenges.

Apart from watercourse development, research also covers ecological integrity of rivers to protect and preserve the habitats of fish and other organisms. Another challenge consists in the control of more than ten thousand novel pollutants that are constantly discharged into the water bodies. "The substances and their impacts often are still completely unknown," Dr. Esser says. The Federal Institute of Hydrology, hence, works on identifying the substances and their sources and on developing options for actions.

Hydrology Day 2019

The Hydrology Day will take place on March 28/29, 2019, in Karlsruhe. The event will be entitled "Information und Organisation in der hydrologischen Forschung und Praxis" (information and organization in hyrological research and practice). For information on registration and the program, click www.tdh2019.kit.edu/ (in German only).

Master's Program of Water Science & Engineering

In the 2016/17 winter semester, KIT started to offer the Master's Program of Water Science & Engineering for interdisciplinary, research-based education at the interface of water-related engineering and natural sciences. The program is internationally oriented, courses are mainly offered in English.

Education covers in-depth knowledge, methodological know-how, and a specialization in one of the four profiles "Water Technologies & Urban Water Cycle," "Fluid Mechanics & Hydraulic Engineering," "Environmental System Dynamics & Management," and "Water Resources Engineering."

Graduates are able to independently develop strategies and technical approaches to the sustainable management of water resources, including technologies for the more efficient use of the limited water resources or investigation of the impacts of global change on the water cycle and water-related material cycles.

http://www.wasser.kit.edu/english/msc_watscieng.php

CLM Assembly

For the 13th time, users of the regional climate models COSMO-CLM and ICON-CLM met for a four-day workshop on latest developments in modeling. In the plenum and small groups, participants from more than 30 countries discussed new projects and further development of model systems. The event was organized by KIT and took place from September 18 to 21, 2018 in Karlsruhe. A highlight of the assembly was the KIT Climate Lecture given by Professor Thomas Stocker, Bern, on September 19, 2018.

THW President Visited the Center for Disaster Management and Risk Reduction Technology (CEDIM)

On April 19, 2018, the President of the Technisches Hilfswerk (THW, Federal Agency for Technical Relief), Albrecht Broemme, and the Head of the Staff Unit "Forschung und Innovationsmanagement" (research and innovation management), Klaus-Dieter Büttgen, visited CEDIM and the KIT.

After a presentation of CEDIM and a visit of the Institute for Nuclear and Energy Technologies (IKET) that is one of the partners of CEDIM and works on the topics of nuclear safety research and agent-based simulation for critical infrastructures, the guests were also taken to the fire protection hall of the Research Center for Fire Protection Technology (FFB) and the Research Center for Information Technology (FZI). The visit focused on intensifying cooperation.

Representatives of CEDIM and THW visit the fire protection hall of the Research Center for Fire Protection Technology (FFB) of KIT. (Photo: Susanna Mohr)

GRACE: KIT Will Fund the Graduate Program in Future

Things have been going rather well: since 2011, the GRACE Graduate School has been supporting doctoral researchers in the areas of climate and the environment during their doctorates. So far, 190 early-stage researchers have taken part, 90 are currently attending the School.

Doctoral researchers ideally start GRACE shortly after their registration for the doctorate at the department. Apart from a course program parallel to research, GRACE also covers a stay of three months' duration in the USA, Switzerland, France or Australia, for instance. "At places, where international cutting-edge research is conducted," says program coordinator Dr. Andreas Schenk. "Some even stay there for a longer time, mostly in science, but also in industry."

It is both a chance and a challenge, also for those, who established the program. GRACE means a balancing act between a large scope of topics and in-depth coverage. The solution is clustering: apart from general courses, technical short courses are offered to six to twelve participants each. Course contents are tailored to the participants' needs. Obviously, this concept is successful. In the past years, GRACE had a constant number of participants, which is not least a result of recommendations by GRACE graduates and their supervisors.

GRACE also supports early-stage researchers in large-scale cooperation projects. Interested groups are invited to contact Andreas Schenk.

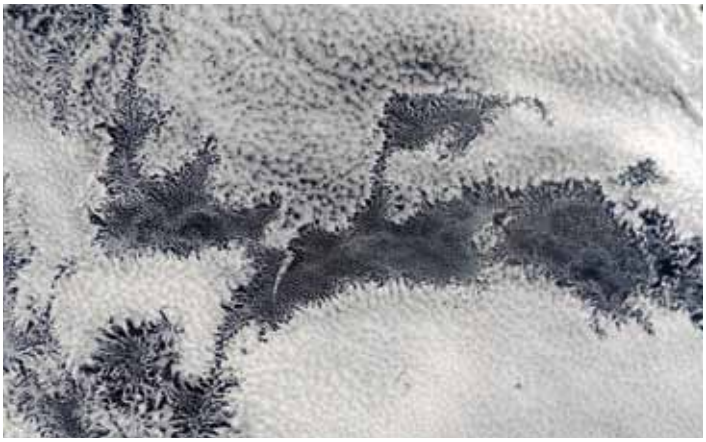
So far, funds have been provided mainly by the Helmholtz Association. Now, KIT has decided to continue funding the School. Schenk: "We are on a good way, I am very optimistic."

Is the Effect of Aerosols on Cloud Properties Overestimated?

Processes in clouds are among the biggest mysteries in climate research. Dr. Hendrik Andersen and colleagues of KIT and ETH Zurich studied the impact of aerosols on cloud properties and found that it is smaller than that of temperature stratification or air humidity at cloud level.

The scientists used artificial neural networks, a statistical method taken from the area of artificial intelligence. Neural networks simulate information transmission from nerve cells to the brain. Doing this, they learn complex and non-linear relationships between input and output information. To model cloud properties, for example, aerosol amounts and meteorological framework conditions, such as air humidity and temperature, are input.

"Often, relationships are not linear in nature. Neural networks can reproduce this much better than conventional statistical methods," Andersen explains. Evaluations of satellite data spanning 15 years also yielded regional patterns. In certain regions, stability of the lower troposphere is very important to the degree of cloudiness, in other regions it is not.



Clouds above the sea off the coast of Peru from the satellite's perspective. (Photo: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC)

Andersen H., Cermak J., Fuchs J., Knutti R., Lohmann U.: Understanding the drivers of marine liquid-water cloud occurrence and properties with global observations using neural networks. Atmos. Chem. Phys., 17, 9535 – 9546, 2017. https://doi.org/10.5194/acp-17-9535-2017

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