Karlsruhe Institute of Technology

Issue 2|2014

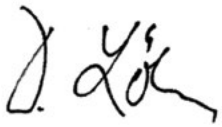
CLIMATE AND ENVIRONMENT news

Newsletter of the KIT Climate and Environment Center

Editorial

Sustainable use of water is one of the most important topics of the future: How do we keep the global water resources clean? How do we open up so far unused sources of water? And how do we equitably distribute the water? These are questions, the solution of which will strongly influence the lives of countless people.

Water and water research by the KIT Climate and Environment Center are in the focus of the present newsletter. Work extends from water extraction in Asia and Africa to the investigation of antibiotics-resistant bacteria in sewage treatment plants to an appeal to carefully use the energy and raw materials contained in the sewage. This large range of topics impressively reflects how several research disciplines of our KIT Center jointly conduct research into this relevant area. And it demonstrates how environmental problems can be resolved successfully by both fundamental research and engineering applications.



Yours Professor Dr. Detlef Löhe, Vice President for Research and Information

From the Bomb to the Cow

60 Years of Atmospheric Environmental Research in Garmisch-Partenkirchen

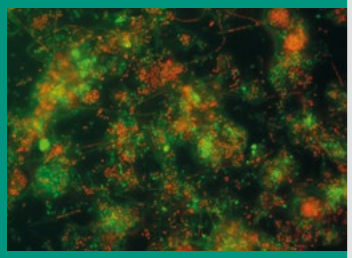
It is a history of thematic evolution Professor Dr. Hans Peter Schmid tells about the Institute of Atmospheric Environmental Research (IMK-IFU): "In 1954, the Institute first studied the impacts of atomic bomb tests on the atmosphere," the Head of IFU says. "For this purpose, the Institute developed the basics that were also applied in later areas of research, i.e. clean air, acid rain, and the ozone hole." After 40 years as a member of the Fraunhofer Society, the IFU joined the Institute of Meteorology and Climate Research (IMK) of today's KIT in 2002. Present work of the scientists concentrates on the complex interaction between land ecosystems and climate change.

In mid-July, IMK-IFU celebrated its 60th anniversary. The heading of Schmid's speech on this occasion summarized the evolution of research topics: From the bomb to the cow. "Radioactive fall-out resulting from tests of atomic bombs or impacts of agriculture under conditions of climate change – IFU's research focuses on anthropogenic impacts on atmosphere and climate," Schmid explained.

Today's projects of IMK-IFU increasingly address regions in Africa and Asia. "The ecosystems of these regions strongly differ from those in Europe," climate researcher Schmid explains. "But we know very little about how climate change is compatible with man's economic activities."

700 guests attended the 60th anniversary of IMK-IFU. (Photo: KIT)

This type of research, no matter whether it takes place in Africa or Bavaria, requires close cooperation with local partners. "Only with local support can we determine the data required to understand the overall system and to make better prognoses with respect to the future regional development of the climate," Hans Peter Schmid says. To ensure local support of IMK-IFU at Garmisch-Partenkirchen, Schmid attaches high importance to public relations. "700 guests came to our open day. We successfully pointed out to them that we conduct research here in the region in order to contribute to solving global problems."



Aerotram Measures Air Quality as It Drives by

AERO-TRAM gathers speed again. At the end of this year, the tram developed by the Institute of Meteorology and Climate Research – Troposphere Research Division (IMK-TRO) in cooperation with the enviscope company and operated by the Karlsruhe Transport Authorities is planned to measure air quality in the conurbation of Karlsruhe again.

For a period of at least two years, the trace gas and fine dust concentrations in the air will be measured in both urban and rural areas. The AERO-TRAM will be operated on two routes of 80 km and 50 km in length, respectively. A measurement system on the roof of the tram continuously sucks in air and analyzes its impurities, completely unnoted by the passengers inside the tram. Trace gases, such as ozone, nitrogen oxides, carbon dioxide, and carbon monoxide, are

On two routes, AERO-TRAM measures air quality in the conurbation of Karlsruhe. (Photo: KIT/IMK-TRO)

measured. In addition, the number and size of aerosol particles, very small solid and liquid constituents of the air we breathe, are determined.

"While conventional stationary measurement systems monitor air quality at certain points only, AERO-TRAM covers a wide geographic area and allows to determine temporal and spatial fluctuations of pollutant concentration," Rowell Hagemann, IMK-TRO, explains. Another objective of the measurement campaign is to identify meteorological impacts on air quality. The data collected during the 3300 drives of the first measurement campaign for the first time revealed an unusually high aerosol concentration with very small particles in the rural area. Due to their wind dependence, they were assigned to industrial emissions.

As a result of the measurement program of several years' duration, the AERO-TRAM is a unique project worldwide. The project that is partly funded by the Baden-Württemberg Ministry of the Environment was one of the winners of the competition "Germany – Land of Ideas" in 2011.

INTERNET:
www.aero-tram.kit.edu

Integrated Water Resources Management: Extracting, Distributing, and Cleaning of Water as well as Sewage Management

For twelve years now, KIT scientists have been supporting the establishment of an integrated water supply system in the Indonesian region of Gunung Kidul on the island of Java. After the completion of a cave power station in 2010, the researchers concentrated on improving water quality and establishing a sustainable sewage management system.

To clean the extracted cave water, researchers of the KIT Institute of Functional Interfaces (IFG) and the KIT Institute for Water and River Basin Management, Division of Aquatic Environmental Engineering (IWG-SWW), together with partners from industry and Indonesia, first installed a sand filter. At a hospital, they built a pilot plant, in which various water cleaning technologies were compared under local conditions. For use at the villages, simpler technologies working without electrical power were developed.

For sewage management of one village, scientists of the Institute for Water and River Basin Management built three biogas facilities. Here, biogas and fertilizers are produced from animal manure and toilet sewage of several households. "First, many inhabitants did not like the idea of using their neighbor's fecal matter to produce gas for cooking," Maria Kaiser says, who was involved in the construction of the plants. "On the other hand, however, they were highly interested, because they do no longer have to buy gas and fertilizers."

The plants consist of a concrete ring inserted into the ground. A movable bell is placed on top of it. Toilet sewage, manure, and organic wastes are mixed in a basin and fed into the biogas facility. During microbial decomposition lasting about 30 days, a gas is produced that can be used for cooking. The remaining solids are dried and used for fertilizing the fields.

The project ended in November this year. The know-how, however, will remain in Indonesia. Major elements of the project

The drawing on the container of the pilot plant explains the sewage treatment taking place inside and familiarizes the inhabitants and users with the new technology. (Photo: KIT/IWRM)

were the training of workers and information of the population. Now, the technologies can also be transferred other villages and regions.

INTERNET:
www.iwrm-indonesien.de

KIT Participation: New Research Center for the Use of Underground Coal Fires

Together with the Australian University of Queensland, the Chinese Tianjin University, and the Indian Institute of Technology in Madras, the KIT is involved in the establishment of a new research center. At the "International Center for the Exploitation of Subsurface Fires", future studies are to focus on the control and the potential economically efficient use of underground coal fires.

Fires in underground coal deposits frequently develop spontaneously, e.g. by lightning strikes or local overheating, if the coal is in contact with oxygen. It is very difficult to extinguish such fires. Often, coal beds burn for decades or even centuries. "About 10% of the annual coal production burn below the surface," Henning Bockhorn of the Engler-Bunte Institute, Division for Combustion Technology, says. "As a result, large amounts of fossil fuels are lost unused and enormous amounts of CO_2 are emitted."

At the new center, the scientists plan to study how such subsurface coal fires can be controlled and whether they can be used to produce mixtures of carbon monoxide and hydrogen. These synthesis gas mixtures might be converted into ammonia, methane, or synthetic fuel via the Fischer-Tropsch process.

Underground coal fires destroy about 10% of the world's coal production. (Photo: José Torero Cullen, University of Queensland, Brisbane)

Apart from Professor Bockhorn, ten other KIT researchers of various disciplines are involved in the establishment of the center and in acquiring third-party funding for the project. Early this year, the scientists involved met at a first workshop in Brisbane to discuss central issues. Professor Jürgen Mlynek, President of the Helmholtz Association, visited the Australian project partners in October and supports KIT participation.

INTERNET:
vbt.ebi.kit.edu/index.pl/professor/bockhorn

Use of Karst Water in Vietnam: Innovative Extraction Technologies to Secure Water Supply in Mountainous Regions

To get water, the inhabitants of the Dong Van karst plateau in the north of Vietnam often have to go long ways. Most of the rain falls in the summer months. During the rest of the year, there is hardly any precipitation. Moreover, most of the water rapidly drains away in the karstic underground. There are only a few above-ground water reservoirs, such as rivers or creeks. They are often located far away from the settlements.

To improve water supply, German and Vietnamese partners of universities, research institutions, industry, and authorities have joined the BMBF-funded project KaWaTech. "We use the extreme differences in elevation in the mountain region and install a pumping system operated with water power," Philipp Klingel of the KIT Institute for Water and River Basin Management (IWG) says. "In this way, water can be pumped from a creek to higher altitudes even during the dry season."

The extraction plant is to be connected to an already existing water power plant. So far, it has been used for electricity production. However, it has to be shut down in the dry season due to the lack of water. "We specially designed the extraction module for the small water quantities. Hence, the system can be operated throughout the year," Peter Oberle, IWG, explains.

The extraction plant is not operated with a turbine, but with an inversely operated pump that is coupled to an extraction pump. "Such a pump is cheaper, easier to maintain, and, hence, excellently suited for use in emerging nations," Oberle says. The water pumped to the surface is then planned to be passed on to the settlements via a gravitation-based distribution network.

The planning phase of the bilateral project has largely been completed. Plant construction is to start next year. The German scientific partners are four institutes of the KIT and the Ruhr-Universität Bochum. German industry partners involved in the project are KSB AG, Frankenthal, and Markus Klotz GmbH, Bad Liebenzell.

Steep hillslopes and deep canyons characterize the karst region of Northern Vietnam. (Photo: KIT/IWG)

INTERNET:
www.kawatech.kit.edu

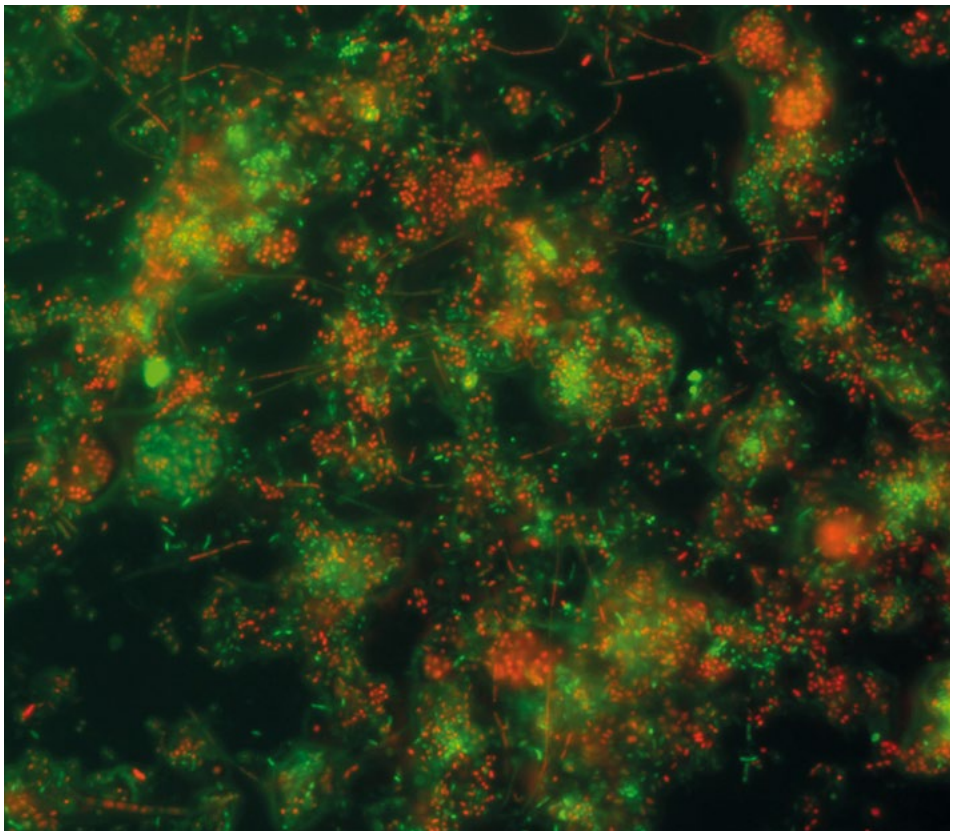
Sewage Treatment Plants – Pools of Antibiotics-resistant Bacteria?

Antibiotics-resistant bacteria develop at places, where many antibiotics are used, for example, at hospitals. Together with the sewage, they are released into the aquatic environment. From there, they may affect human beings again. This problem may even be aggravated at places, where the sewage is cleaned, i.e. at sewage treatment plants. There, bacteria get into contact with many other pathogens and may transmit their resistances to them via mobile genetic elements. How can this be prevented? This question is studied by scientists of the Institute of Functional Interfaces (IFG) of KIT under the BMBF-funded TransRisk research project.

The scientists first analyzed where in the water cycle such bacteria can be found and how high their concentration is. Using modern molecular biology and cultivation methods, they searched for bacteria and specific resistance genes in hospital sewage, outlets of sewage treatment plants, stormwater overflow tanks and settling basins as well as in the groundwater of a model region in South Germany. Work concentrated on the detection of enterococci, bacteria of the type Pseudomonas aeruginosa, as well as on staphylococci and enterobacteria. These pathogens may carry resistances against various antibiotics and often cause problems in the health sector.

The high concentration of pathogens and the abundance of resistance genes in hospital sewage and municipal sewage treatment plants were no surprise. In the downstream aquatic areas, the resistance genes in particular were found down to the groundwater. The abundance of pathogens does not always correspond to the abundance of resistance genes. "Microbial concentration is reduced in sewage treatment plants. The resistance genes, however, may accumulate there," Dr. Thomas Schwartz, IFG, explains. According to Schwartz, countless bacteria of different types are encountered in every activated sludge floc. Under favorable chemical conditions, they have an optimum opportunity of exchanging their resistance genes. As a result of horizontal gene transfer, also bacteria that have not been in contact with antibiotics acquire resistances.

Preparation of water samples in the laboratory. (Photo: IFG/KIT)



Microscopic image of an activated sludge sample of a sewage treatment plant. Bacteria are made visible by different fluorescent colorants. (Photo: Thomas Schwartz)

Moreover, resistant pathogens might be selected under the comparably low antibiotics pollution of the sewage. "Many pathogens stimulate a stress response when they get into contact with antibiotics, also at low concentrations. Under these conditions, they appear to take up resistance genes very easily," Dr. Schwartz says.

More detailed studies revealed that total bacteria concentration can be reduced by a treatment with ozone in a fourth cleaning stage at the outlet of sewage treatment plants. Highly robust bacteria, however, appear to survive this treatment. Among them, a rather high percentage carries antibiotics resistance genes. "It is still unclear whether these bacteria also include pathogens that might be hazardous to human health. In this respect, further studies are required."

The TransRisk project started in 2011 and will be completed soon. The findings obtained are planned to be analyzed in further detail under an EU-wide project from 2015.

INTERNET:
www.transrisk-projekt.de
www.ifg.kit.edu/english/index.php

(Photo: private)

Susanne Lackner

Professor Dr. Susanne Lackner accepted a W1 professorship of the Chair for Water Chemistry and Water Technology in early September. Work of the ecological engineer focuses on the reduction of the nitrogen content of wastewater. For this purpose, Susanne Lackner combines engineering with microbiology: "Since the 1990s, new bacteria have become known, which efficiently convert nitrogen. Hence, it is possible to remove nitrogen from wastewater at low cost. To specifically use the cleaning effect of these microorganisms, it is not only necessary to have appropriate biological conditions at the sewage treatment plant. Also the technology has to be developed accordingly." Since 2012, Professor Lackner has been working on reaching this objective at KIT. Before, she worked at Stuttgart, Munich, Kopenhagen, and in Canada.

(Photo: private)

Wolfgang Wilcke

Professor Dr. Wolfgang Wilcke considers the KIT to be a special institution: "I am appealed by the model character of the KIT, in which a university has merged with a non-university research institution. Here, we have the opportunity to implement both very good education and very good research with a reasonable equipment." In April 2014, the geoecologist returned from Bern to Germany and accepted the professorship for geomorphology and soil science at the KIT. His working group of the Institute of Geography and Geoecology (IfGG) focuses on studies of biogeochemical processes in soils and terrestric ecosystems. "We have to understand how we influence soils with our western lifestyle," Wilcke says, "and which impacts that has on global ecosystems."

(Photo: private)

Andrea Iris Schäfer

Clean drinking water is of vital importance in particular for children. In developing countries, many people have no access to this vital liquid. Daily, countless people die from polluted water. Practicable technologies for water processing and the removal of dissolved pollutants therefore are in the focus of Andrea Iris Schäfer's research. Thanks to the Helmholtz recruitment initiative, the graduate chemical engineer has now returned to Germany with her family after more than 20 years abroad. At KIT, she accepted the Professorship for Water Processing Technology in spring 2014. In addition, she heads the Membrane Technology Division of the KIT Institute of Functional Interfaces.

"In the 1990s, I could pursue this topic much better abroad than in Germany," Andrea Schäfer says. She spent long years of studies and research in France, Australia, Scotland, and Tanzania. In recent years, she developed a very robust system for water processing together with a team of students and her husband Bryce Richards, who has also taken up work as a Professor at KIT since spring: "The core components of the system are special membranes, by means of which pollutants, bacteria, and viruses as well as health-damaging ions are removed from the water," Professor Schäfer explains. The necessary energy is supplied by solar systems or wind turbines. A pilot system was tested extensively in Tanzania.

Now, transition to series application is required. "The technology has to be further developed for the systems to work in other African countries as well," Schäfer says. "Here at the KIT, I have a good research environment and many colleagues working in interesting areas, such as materials development. This activity may be linked with my water research work."

Andrea Schäfer points out that also framework conditions in Germany have developed positively. She is mother of four children aged from 2 to 14. "Although many services offered by schools, offices, and authorities are still tailored to mothers staying at home and KIT still has some potential for improvement, life can be managed now with a little bit of improvisation."

KIT Climate and Environment Center

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Spokespersons of Topic 5:	**Urban Systems and Material Flow Management:** PD Dr. Stefan Norra and Dr.-Ing. Rainer Schuhmann
Spokesperson of Topic 6:	**Natural Hazards and Risk Management:** PD Dr. Michael Kunz

Resource-efficient City: Precious Wastewater

By Dr. Helmut Lehn, Institute for Technology Assessment and Systems Analysis (ITAS)

Wood model of the Jenfelder Au new housing estate area, Hamburg. (Photo: H. Lehn)

Since 2007, the number of people living in cities worldwide has exceeded that of people living in rural areas. The billions of urban inhabitants are largely dependent on the surrounding regions. Energy, construction materials, food, water: Nearly everything that is of vital importance is supplied by the countryside. If cities grow – and this is what they are doing to a considerable extent – the countryside has to increase supplies. To prevent this development from resulting in strong conflicts between city and country, we have to make the cities resource-efficient. The principle of "avoiding, reducing, recycling" that is known from waste management should not only apply to household waste, but also to construction materials and reusable civil engineering or operating materials of the city, and above all to water.

Saving drinking water is an important topic. So far, however, discussion has ignored the fact that cities are flow-through systems. They discharge a certain percentage of only partly cleaned wastewater into creeks and rivers. Together with the sewage, also reusable materials are discharged unused. Sewage is no waste, but an important resource! Apart from heat, i.e. thermal energy, and chemical energy in the form of carbon compounds, it contains nutrients urgently required by agriculture, such as potassium, nitrogen, and phosphorus. To better use sewage as a resource, new urban water and sewage management schemes have been developed since the 1980s. Now, consistent further development work is required.

Work should focus on the separate treatment and use of different partial sewage flows. The complete sewage volume is no longer mixed with rainwater from roofs and roads in one sewer system. Instead, various types of sewage are treated and used separately. In a newly developed area in Lübeck, rainwater is separated from toilet sewage (so-called blackwater) and the remaining sewage from showers, bathtubs or washing machines (so-called greywater) and treated separately. Rainwater is subjected to percolation. Greywater is cleaned by vegetated soil filters (so-called constructed wetlands). Toilet sewage is transferred to a biogas facility together with organic waste.

To produce biogas, the sewage must not be diluted too much. The citizens of the Lübeck area therefore use vacuum toilets similar to the toilets of airplanes. Every flush needs less than one liter of water (other toilets require six to ten liters). As a result, drinking water consumption is reduced considerably. A similar approach is pursued by the city of Hamburg in its new settlement project "Jenfelder Au", where about 200,000 people will live from 2016 (Figure 1).

The housing estate project of Arnimplatz, Berlin, has another focus. There, blackwater and greywater of about 40 new apartments are collected separately. A simple heat exchanger transfers the thermal energy of the greywater from the bathtub, shower, or washing machine to the fresh warm water. The cooled-down greywater then is subjected to microbiological cleaning in the basement. After UV disinfection, it is used as water for flushing the toilet again.

Other projects – mainly in Scandinavia and Switzerland – focus on the recovery of plant nutrients. As their concentration is highest in urine, separating toilets are used. Their user friendliness, however, still needs to be optimized.

Concepts for resource-optimized use of partial sewage flows depend on local conditions. All of them require several lines for the supply and removal of various types of water. Although use of partial flows seems to be a far way off, buildings have to be prepared for it now. Architects and engineers are to develop proposals as to what has to be done today when constructing new buildings or reconstructing old buildings. Construction regulations should be adapted accordingly. Also KIT's inventory of buildings is not yet prepared for using partial sewage flows. We, scientists and facility managers, should develop a plan for the adequate reconstruction of buildings and implement it. The users of the buildings should participate in this process. If this process would be included into the education program, this would really be excellent!

KIT Climate and Environment Center's Annual Meeting

On July 9, 2014 at the second Annual Meeting, the winners of the Sparkasse Environmental Award 2013 were announced. The prize was given to Dipl.-Ing. Franz Dichgans for his Master's Thesis on "Numerical modelling of a subnatural rock ramp" as well as to Dr. Jan Ungelenk for his PhD Thesis on "Tin tungstate – a light-activable catalyst" and to Dr.-Ing. Frederik Trippe for his work on "Techno-economic assessment of alternative configurations for the production of biomass-to-liquid (BtL) fuels and chemicals". The keynote lecture was given by Prof. Frank Schilling speaking about "Geo resources – protect the environment or export of risks".

Determination of Emissions in the Capital

For the determination of emission of greenhouse gases from spatially defined sources, such as a city, terrestrial remote sensing instruments were used for the first time. These Fourier spectrometers measure wavelength intervals in the near-infrared range, in which carbon dioxide and methane absorb solar radiation.

In a measurement campaign in Berlin, this method that was developed at IMK-ASF, is applied for the first time: With five terrestrial remote sensing instruments distributed throughout the city area, increased values in the plume of Berlin as well as background concentrations are determined. The difference between the two values is the actual amount of emitted carbon dioxide and methane.

The instruments used have been developed by KIT in collaboration with the Bruker company within the Helmholtz research infrastructure ACROSS.

The awardees and their supervisors as well as Prof. Horn (KIT/Sparkasse Environmental Award), Mr Huber (Sparkasse Karlsruhe Ettlingen), Prof. Löhe (Vice President KIT), and Dr. Mentrup (Lord Mayor of the City of Karlsruhe). (Photo: Irina Westermann)

Beijing: DFG-NSFC Symposium on Geogenic Arsenic in the Environment

This symposium financed by the Sino-German center for research promotion in Beijing took place from September 21 to 27, 2014 and was attended by 50 scientists from 6 countries. The aim was to discuss ongoing research regarding the importance of arsenic in the environment. In China, arsenic in groundwater and dust is a major issue and a threat for the health of millions of people.

VDI Badge of Honor for Prof. Emeis

Prof. Dr. Stefan Emeis (IMK-IFU in Garmisch-Partenkirchen) was awarded the badge of honor for his volunteering work at VDI (Verein Deutscher Ingenieure) relating to the standardization of remote meteorological measurement methods.

Our congratulations!

Dipl.-Met. Ralph Oestreicher, Dipl.-Met. Wolfgang J. Müller, Prof. Dr. Stefan Emeis (from left to right) at the badge of honor award ceremony on November 5, 2014. (Photo: VDI)

GRACE Doctoral Students at the ESADE Business School

Learning about teamwork and team leading when building towers. (Photo: Jose Marquez Prieto)

Five days, 40 hours, six program blocks – the crash course on business development at the ESADE Business School, Barcelona, leaves the participants little time for sightseeing. Every year, GRACE invites five doctoral students to participate in this training course. This year, one of them was Winfried Bulach, doctoral student at the KIT Institute for Technology Assessment and Systems Analysis (ITAS).

"This was a good opportunity for me to obtain insight into business development and management," Bulach says. "Normally, this topic is hardly covered at the university." From strategy and concept development to marketing and funding to staff management and intellectual property rights, the course participants familiarized with all important aspects of business development.

"It the objective of GRACE to impart not only specific and interdisciplinary knowledge, but also additional key qualifications," Elis Engelmann, administrative coordinator of the graduate school, says. "Such competences help the doctoral students prepare optimally for their further career in science, industry, or at their own company."

At the moment, Bulach does not plan to establish a company of his own. He wants to complete his doctoral thesis, in which he compares the ecobalances of composting and fermentation. Still, he very much profited from the training course. In his opinion, such background knowledge is also useful for careers in e.g. industry. Soon, Bulach will leave for a stay of several months in Switzerland, which is a central component of the GRACE qualification concept. For Bulach, this will be the last step prior to the completion of the graduate school.

INTERNET:
www.grace.kit.edu

Additional Staff for KIT's Water Research

Since September 2014, the group "Regional Climate and Hydrology" on Campus Alpine, Garmisch-Partenkirchen (Atmospheric Environmental Research Division of the Institute of Meteorology and Climate Research), has a new member of staff: Dr. Jakob Garvelmann will work in the research area of alpine water research with a focus on snow hydrology.

For this purpose, an innovative measurement network to study the variability of snow depths, energy exchange with the atmosphere, and runoff processes during snow melting is planned to be installed at the TERrestrial ENvironmental Observatory (TERENO) in the foothills of the Alps. This research area is closely linked to the professorships for hydrogeology and hydrology of KIT. Garvelmann is one of two additional post-docs, who are supposed to extend the scope of KIT's water research. Both scientists are to work specifically at the interfaces of several institutes in order to foster networking.

On October 28, 2014, the winners of the Green Talents competition of the Federal Ministry of Education and Research (BMBF) visited KIT. Among others, the young scientists met KIT scientists working in the area of worldwide water research. This initiative of the BMBF is intended to promote exchange with excellent young scientists from all over the world. The winners visit several science institutions in Germany and are offered the opportunity to stay here for research.

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