Issue 1|2017

CLIMATE AND ENVIRONMENT news

Newsletter of the KIT Climate and Environment Center

Editorial

We long expected the news, but were still shocked: By decision of US President Donald Trump, the USA will withdraw from climate protection – on the federal level at least. The goal of the Paris Climate Agreement to keep global warming to less than 2 degrees will thus become more difficult to reach than ever before.

Still, we should not lose confidence. This also is the message of the present newsletter. Global community already proved that it is able to preserve important living conditions on our planet by joint efforts to protect the ozone layer, which have advanced well. We will continue to do our utmost for the same to be achieved in the area of global warming. Our research results and communication with society play a very important role in this process.

Yours,
Professor Dr. Oliver Kraft
Vice President for Research

SaWaM: Data-based Use of Water Resources

Water supply is potentially insecure for about 80% of the world's population. According to estimates of the UN, presumably 1.8 billion people will be threatened by absolute water scarcity, less than 500 cubic meters of water per person and year, by 2025.

How much water will be available in arid and semi-arid regions of the Earth in the future? How can reservoirs and irrigated agriculture be managed? These are the questions covered by the KIT-coordinated project "Seasonal Water Resources Management in Semi-arid Regions: Transfer of Regionalized Global Information to Practice" (SaWaM).

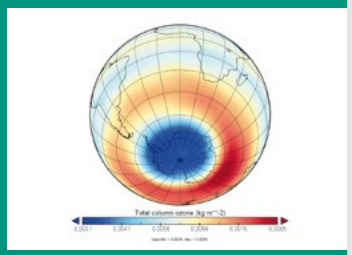
The project funded by the Federal Ministry of Education and Research (BMBF) makes global satellite and model data usable for regional water resources management and seasonal forecast.

"This problem is particularly relevant to areas already suffering from water scarcity," says Professor Harald Kunstmann, Deputy Head of the Atmospheric Environmental Research Division of KIT's Institute for Meteorology and Climate Research (IMK-IFU) in Garmisch-Partenkirchen.

Members of the SaWaM consortium at their kickoff meeting on KIT's Campus Alpine in Garmisch-Partenkirchen. (Photo: Harald Kunstmann)

Observation data relating to the water cycle are rare or of limited use due to their insufficient resolution. Under SaWaM, researchers now plan to analyze the performance of global hydrometeorological data products and optimize them with the help of newly developed decision support methods.

A special focus lies on seasonal forecast of the most important water resources parameters for the next six to twelve months. "SaWaM will provide information on future development of water availability, above all for the management of reservoirs and irrigated agriculture," Kunstmann says. To ensure practical applicability of the methods developed, the project consortium cooperates closely with local decisionmakers, research institutions, and companies in the target regions.



Winter School at Summer Temperatures

Discharge measurement under flash flood conditions. (Photo: Maren Haid / KIT)

It is well-known that the water level of the Dead Sea drops dramatically. The consequences for the climate, people, or hydrogeology of the region, however, are far less studied. Within the DESERVE (DEad SEa Research VEnue) virtual Helmholtz Institute, international researchers under the direction of KIT now study these and related problems. Last December, the project partners for the second time organized a winter school for young scientists in the said region.

From December 4 to 15, 2016, 25 participants, mainly master's and doctoral students of the DESERVE partner institutes met in Madaba, Jordan. Among KIT's project partners are GFZ Helmholtz Centre Potsdam – German Research Centre for Geosciences, the Helmholtz Center for Environmental Research (UFZ) Leipzig as well as institutes in Israel, Jordan, and Palestine. The winter school focused on so-called sinkholes. They develop, because the decreasing water level changes the groundwater level in the former shore area of the Dead Sea. Freshwater enters salt inclusions and washes them out. Cavities are formed, collapse, and drag along whole houses in the worst case.

With the help of balloons and drones, the participants collected a number of data to characterize the sinkholes and their surroundings. These field studies were complemented by exercises and lectures by DESERVE scientists. Other topics covered potential climate changes induced by the decreasing water level and the seismic hazard in the region.

"The winter school does not only offer scientific training, but also is a nice opportunity for our doctoral students to explore the region," project coordinator Dr. Manuela Nied says. "Some participants have already been studying the Dead Sea for a long time, but have never been there." The costs for accommodation and catering were borne by the project. Thanks to a cooperation with the Graduate School for Climate and Environment, GRACE, some of the students received grants to cover their travel expenses.

Going Underground

Interim Storage of Heat in the Ground

The idea is appealingly simple: Excessive heat produced on hot summer days or by the operation of industrial facilities is stored in the ground until it is needed again. This process is referred to as aquifer storage. Its potential will be studied and evaluated by the team of Junior Professor Dr. Philipp Blum of KIT's Institute of Applied Geosciences (AGW) at eight locations in Baden-Württemberg over the next three years. "So far, this technology has hardly been used in Germany, although there are many regions, where geological conditions are favorable," Blum says.

Excessive heat is stored in underground, water-bearing layers, so-called aquifers. Among the locations to be studied for use of this technology are a public swimming pool in Hockenheim, the municipal hospital in Karlsruhe, and the city of Überlingen near Lake Constance. The GeoSpeicher.bw project is funded by the Baden-Württemberg Ministry of the Environment.

For this project, a multidisciplinary graduate school will be established. Eight doctoral students of different disciplines from KIT, the universities of Heidelberg and Stuttgart, and the Biberach and Offenburg Universities of Applied Sciences are to participate in the projects. Cooperation with municipal utility companies and the public is envisaged. "These demonstration projects are to enhance our outreach and to show that the technology is economically efficient and has a high carbon dioxide emission reduction potential," Blum says.

MORE INFORMATION:
www.agw.kit.edu/english/176_1633.php

The outdoor pool of the Waldsee-Therme, a thermal spa in Bad Waldsee. (Photo: Waldsee-Therme)

Scientists Explore the Geological Structure of Scandinavia

The geology of Scandinavia puzzles researchers: Why are the mountains of the Caledonides, a mountain range at the Western continental margin, so high? From the geological point of view, they appear much younger than they actually are. "Tectonic forces to uplift the mountains in the region ceased to be active a long time ago," Michael Grund of KIT's Geophyscial Institute (GPI) says. "By measuring seismic waves, we now try to find the causes of this phenomenon."

Many measurement stations of this type measure seismic waves. (Photo: Michael Grund)

130 temporary and 115 permanent stations measure seismic waves in Scandinavia under the international ScanArray project. GPI and the GFZ – Helmholtz Centre Potsdam German Research Centre for Geosciences are responsible for the German work package: LITHOS-CAPP (LITHOSpheric Structure of Caledonian, Archaean, and Proterozoic Provinces). For their measurements, the researchers of both centers installed twenty wide-band stations in Finland and Sweden from September 2014 to October 2016.

These stations record seismic waves running through the Earth after an earthquake somewhere in the world. "Depending on the structure and material of the underground, seismic waves propagate more quickly or more slowly or are deflected into various directions," Grund explains. "Based on our measurements, we can develop a tomographic model of the underground and better characterize the processes occurring there." The German contribution to the ScanArray project is planned to be completed next summer. Until then, the researchers hope to know more about why Scandinavia looks as it does.

Measurement stations in Scandinavia. (Photo: Michael Grund)

Models for Water Resources Management

Maximum Information with a Minimum Amount of Data

Worldwide, there are more than 100,000 reservoirs that do not only produce 20% of the energy consumed globally, but supply millions of people with freshwater. These reservoirs are anything but simple water collection ponds. They are subject to constant change, mainly in terms of water level and quality. Increasing urbanization of rural areas increases utilization pressure and frequently also pollutant input. A possible consequence is water scarcity. In many regions of the world, this situation is aggravated by climate changes that affect water availability.

To adequately manage water resources, models are required to forecast long-term development of water reservoirs. "There are countless models," says Dr. Stephan Fuchs of KIT's Institute for Water and River Basin Management. "But they all are very complex and need countless data. In many regions of the world, they are hardly usable for this reason."

Together with partners from Germany and Brazil, Fuchs wants to develop new, simplified models for global use. "We want to 'slim down' the models for them to require minimum amounts of data, but still supply decision-relevant forecasts." The required data are to be generated by remote sensing.

The Passauna reservoir near Curitiba – the investigation area in Brazil. (Photo: Mauricio Scheer, SANEPAR)

From satellite data, information on soil moisture, land use, or vegetation cover can be derived, Fuchs says.

As a starting point, the scientists will use data of the well-documented reservoir of the Große Dhünn river in West Germany. The models will then be verified and further adapted at two water reservoirs in Southeast Brazil. The "Multidisciplinary Data Acquisition as a Key to Globally Applicable Water Resources Management" project is funded under the BMBF funding program "Global Resource Water (GROW)." After the kickoff meeting of the German partners in May, first work is about to start. In autumn this year, the project will be launched officially in Brazil.

MORE INFORMATION:
www.ptka.kit.edu/wte/168_618.php
(in German only)

How Ozone Depletion in the Arctic Influences the Climate

Scientists involved in the POLSTRACC campaign are very busy at the moment. They evaluate measurement series, analyze and interpret data, and summarize the results for publications. "We are right in the middle of the harvesting phase," says Dr. Björn-Martin Sinnhuber of the Atmospheric Trace Gases and Remote Sensing Division of KIT's Institute for Meteorology and Climate Research (IMK-ASF). He coordinates the campaign to investigate the ozone layer above the Arctic together with his colleague Hermann Oelhaf.

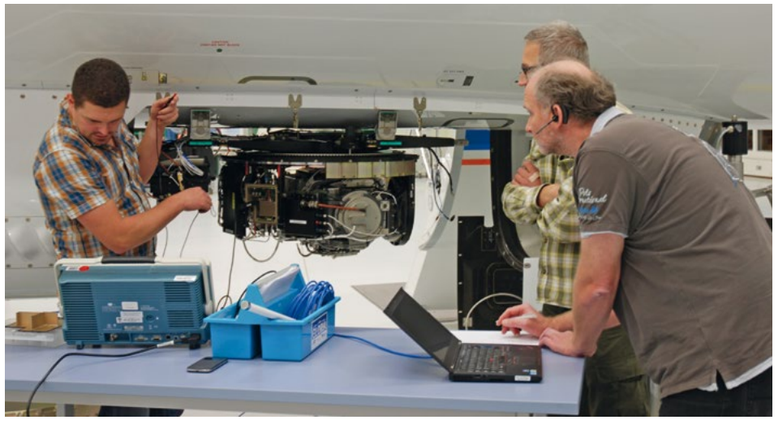
The measurement campaign proper of four months' duration in the Arctic took place more than one year ago in the Arctic winter of 2015/2016. It comprised 18 research flights of more than 150 hours in total. With three tons of equipment on board, the German research aircraft HALO started from Oberpfaffenhofen to the North Pole in December 2015. Between January and March 2016, flights were made from Kiruna in North Sweden.

With the help of numerous measurement instruments, the researchers studied chemical processes at eight to fifteen kilometers height. Using these measurements, remote sensing data collected by the aircraft, and measurements made on the ground and from satellites, the Arctic atmosphere was characterized. Now, the fruits of this hard work can be harvested. "We can already say that ozone depletion in the polar region was extraordinarily strong in that winter,"

HALO waiting for the start in Kiruna. On top of the fuselage, a number of air inlets for in-situ measurement instruments can be seen. The GLORIA infrared spectrometer is visible underneath.
(Photo: Björn-Martin Sinnhuber)

Sinnhuber says. "The reason is that the stratosphere at ten to 30 km height was extremely cold, colder than ever before."

When temperatures in this atmospheric layer decrease significantly, so-called stratosphere clouds develop. At the surface of these clouds, chemical reactions take place, which eventually result in a depletion of ozone. In the long term, scientists expect further temperature decrease in the stratosphere as a consequence of climate change: "While increasing greenhouse gas concentrations cause the temperature to increase in the layers near the ground, temperatures decrease in the stratosphere," Sinnhuber explains.



The GLORIA team working in the hangar. GLORIA is mounted underneath the fuselage.
(Photo: Björn-Martin Sinnhuber)

Since the conclusion of the Montreal Agreement in the late 1980s, emission of ozone-damaging chlorine- and bromine-containing chemicals, such as chlorofluorocarbons (CFC), has been prohibited. But these substances are long-lived and can still be found in the atmosphere. They have a particularly high ozone-depleting effect when it is very cold for a sufficiently long period of time. Measurements of the researchers revealed that about half of the ozone was destroyed in the extremely cold winter of 2015/16. While such processes are well-known for the much colder Antarctic, they are rather rare in the Arctic.

Did the researchers just happen to organize their campaign in an exceptionally cold year? Or do such extremes occur more frequently? And which effects do the changes measured have? These questions still remain to be answered. "The underlying chemical processes are already understood quite well," Sinnhuber says. "Now, we are interested in the climate effect of these changes." For this purpose, the researchers input the data measured in climate models and simulate potential consequences. One thing already is certain: The effects of Arctic processes are widely felt. Air from the Arctic flows into middle latitudes and influences the climate there, that is here in central Europe.

MORE INFORMATION:
www.polstracc.kit.edu

(Photo: © www.kit.edu)

Professor Dr. Johannes Orphal

Professor Dr. Johannes Orphal is winner of this year's Gentner-Kastler Prize granted by the German Physical Society and the Société Française de Physique every year to German and French physicists alternately. The Prize is named after the German Wolfgang Gentner and the French Alfred Kastler, two excellent physicists, who rendered outstanding services to the cooperation of France and Germany in physics research after the Second World War. "I accept this prize with great humbleness and gratitude," Orphal says, who heads the Atmospheric Trace Gases and Remote Sensing Division of KIT's Institute for Meteorology and Climate Research. "I will use this prize to foster cooperation between Germany and France in the area of atmosphere research."

(Photo: © www.kit.edu)

Professor Dr. Joaquim Pinto

In 2016, Professor Dr. Joaquim Pinto accepted the AXA Endowed Professorship for Meteorology at the Troposphere Research Division of KIT's Institute for Meteorology and Climate Research. "Work is aimed at systematically evaluating extreme weather events and the associated risks in Europe against the background of climate change," the meteorologist says. For this, Pinto and his team use observation data as well as computer models: "We want to find out whether and how weather hazards will change in the different regions of Europe over the next decades." This also is in the interest of insurance companies. "The AXA funds enormously increase our impact – with complete scientific independence," Pinto says about the commitment of the internationally active insurance group.

(Photo: © www.kit.edu)

Professor Dr. Jan Cermak

Professor Dr. Jan Cermak is building bridges. But no bridges to cross roads. Cermak is building bridges by linking both campuses of KIT, Campus North and Campus South, in his work: In spring, he took up the professorship for geophysical remote sensing that covers work at the Institute of Photogrammetry and Remote Sensing (IPF, Campus South) and at the Atmospheric Trace Gases and Remote Sensing Division of KIT's Institute for Meteorology and Climate Research (IMK-ASF, Campus North). His chair is funded under the so-called integration initiative of KIT that is aimed at creating precisely such synergies between competences of both parts of KIT. "This is of benefit to my research," Cermak says, "and was the main reason for me to come to KIT from Ruhr-Universität Bochum. Here, I have lot of opportunities to network in terms of contents and methodology."

Cermak's work mainly covers clouds. Cermak: "We study meteorological conditions under which clouds develop and, on the other hand, spatial and temporal variations of clouds and their properties. For this, we mainly use satellite data." Clouds are influenced strongly by smallest particles, so-called aerosols, for instance. These aerosols are produced partly by anthropogenic activities, such as traffic or industrial combustion processes, or may be released into air without man's interference, e.g. from vegetation or drifts.

On aerosols, water vapor in the atmosphere condenses to droplets. "A high aerosol concentration in the air may cause the formation of many small instead of a few large droplets," Cermak says. "Small droplets reflect sunlight very well. We are interested in the influence this has on the Earth's temperature."

To analyze such and similar problems, Cermak and his team use data collected by measurement stations in Germany, Portugal, and Namibia as well as with the help of satellites. "KIT offers best technical prerequisites," Cermak adds. "Here, I find many colleagues for exchanging scientific and methodological findings as well as students, who contribute to our research with their bachelor's and master's theses. This is an ideal combination." And a good reason to build bridges.

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. Philipp Blum
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:** PD Dr. Michael Kunz

Climate Change: People Are Interested in Scientific Facts!

By Professor Peter Braesicke

Newspapers, television, radio: All media relevant in the 1980s and 1990s painted rather gloomy and somber pictures: The ozone layer, our life-saving protection shield against hazardous UV radiation from the universe, disintegrates! Today, the ozone hole no longer is a big topic, at least not the headline on page 1. This is not due to the alleged short-windedness of the media. On the contrary, much was achieved in the past years for the protection of the ozone layer.

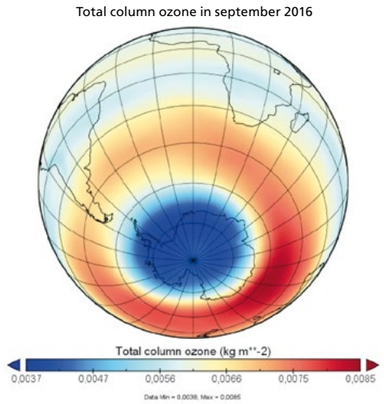
Growth of the ozone hole in the 1980s indeed was fast and alarming: Atmosphere researchers found that ozone concentration above the South Pole decreased strongly in the Antarctic spring. The area affected grew rapidly. But investigation of this phenomenon also advanced that rapidly and soon it became clear that chemical substances, including chlorofluorocarbons (CFCs), doubtlessly caused growth of the ozone hole.

In view of these clear facts, it was possible to forge an international alliance within a few years and to adopt the Montreal Protocol as early as in 1987. The signatory countries committed to taking measures to ensure protection of the ozone layer and stop production of CFCs, for instance.

Today, we see the successes of these joint efforts. Concentration of ozone-depleting substances in the atmosphere has decreased considerably. The ozone hole stagnates and the ozone layer slowly starts to recover. By the middle of this century, ozone values are expected to be comparable to those of the early 1980s again.

This shows that science, politics, civil society, and industry are quite capable of jointly changing course in a matter of vital importance to our planet. As a born optimist, I think that this can also be achieved in climate change, provided that we learn from the solution of the ozone hole problem.

What can we learn precisely for tackling the much bigger challenge of climate change? First, problems have to be broken down to a level tolerable to the people. In case of the ozone hole, this was relatively easy. It was caused by a clearly defined group of substances produced by a relatively small branch of industry and used in comparably closed substance cycles.



ECMWF reanalysis of the ozone hole in September 2016. (Figure: P. Braesicke, KIT)

As regards climate change and its main cause carbon dioxide, the situation is much more difficult. CO_2 is produced by nearly all economic activities. Every one of us produces CO_2. On the political level, it is therefore required to first address the big CO_2 sources, e.g. coal-fired power plants, in order to achieve visible success. It also must be made easier for the people to reduce their carbon footprint. Private transport is a potential field of action, but also the way how we consume. It may be necessary for us to forego using air travel, for instance. But with a smarter use of resources, we can stick to some cherished luxuries.

Complexity also is an important aspect. We have to even better understand the highly complex climate processes. In case of the ozone hole, we managed to do this quite well. Decreasing ozone concentrations above the Antarctic had a surprising impact on temperatures. The Antarctic peninsula warmed up strongly, while large parts of the inner Arctic cooled down rather than warmed up due to climate change.

Meanwhile, this effect can be explained well. This has shown that matters may not be as simple as initially expected. On the contrary, surprises are the rule. But we are capable of analyzing such unforeseen events and always learning something about the integrated system.

We have to effectively, that is understandably, communicate our findings on the complex climate system. And generally, we have to raise awareness of its complexity. It is my experience that man in the street is interested when we as scientists speak with him about such processes and scientific findings. We have to leave our institutes and go into the public, then we will succeed also in matters of climate change.

Politicians are as important as average citizens. Also they mostly are laypersons, but set the agenda for the future. Looking at this target group and having the experience gained from the Montreal Protocol, I can also say that they are interested. As co-author of the "Scientific Assessment of Ozone Depletion" report that is issued every four years, I constantly realize that publication of this paper is actively accompanied and followed by politics. And once published, the report leads to lively and constructive debates. Hence, most politicians are well aware of the problem and the need for action.

My conclusion is: We have to take average citizens along with us on the travel towards a stable climate! They are interested. We have to understandably communicate our scientific findings. Then, we will succeed in saving not only the ozone layer, but the climate.

KIT's Campus Alpine Joins Bavarian Climate Alliance

With an official ceremony in the presence of the Bavarian Minister of the Environment, Ulrike Scharf, and the Head of Division IV – Natural and Built Environment of KIT, Dr.-Ing. Karl-Friedrich Ziegahn, the Atmospheric Environmental Research Division of the Institute for Meteorology and Climate Research (IMK-IFU) in Garmisch-Partenkirchen joined the Bavarian Climate Alliance on February 03, 2017. Together with a number of other Bavarian partners, the Alliance wants to raise awareness of climate protection e.g. by supplying information and organizing actions for sustainable climate protection. With their scientific studies covering the interaction of climate, vegetation, soils, and water availability, scientists working on KIT's Campus Alpine, as members of the climate alliance, intend to bridge the gap between theory and practice.

Professor Hans-Peter Schmid (IMK-IFU, KIT), Ms. Ulrike Scharf, member of the Bavarian parliament (Bavarian State Minister for the Environment and Consumer Protection), and Dr.-Ing. Karl-Friedrich Ziegahn (KIT Division Head IV) signing the agreement on February 03, 2017. (Photo: Marco Schmidt)

Peter Braesicke Chairs the European Climate Research Alliance ECRA

During the meeting of the ECRA Executive Committee in early March, Professor Peter Braesicke of the Atmospheric Trace Gases and Remote Sensing Division of KIT's Institute for Meteorology and Climate Research (IMK-ASF) was elected chairman of ECRA. He succeeds Professor Lochte (AWI) who held the position in the past years. ECRA is a European platform for knowledge and information exchange among scientists studying climate change and its impacts on the environment. We cordially congratulate Mr. Braesicke.

Clouds and Storm Tracks

Which role do clouds play in atmospheric circulation of middle latitudes and which impacts does the interaction of clouds and circulation have on regional climate change? These are the questions studied by the BMBF young investigators group of Dr. Aiko Voigt of the Troposphere Research Division of KIT's Institute for Meteorology and Climate Research (IMK-TRO) since late 2016. The project with a planned duration of five years will mainly concentrate on investigating cloud-radiative interactions in the North Atlantic region.

The young investigators group is part of the Germany-wide research project HD(CP)2: High Definition Clouds and Precipitation for Advancing Climate Protection. It is supported largely by BMBF and FONA.

Forests Suffering from Heat Stress

Heat waves often bring along severe drought. It affects the carbon and water cycle of forests. With the help of this cycle, however, forests fulfill an important task in mitigating the effects of climate change. The more pronounced heat and drought are, the longer takes the regeneration process of forests. How does a reduced regeneration capacity of forests affect the carbon and water cycle and, hence, global warming? What are the underlying processes in trees and forests? These are the questions studied by the Emmy Noether Young Investigators Group of Dr. Nadine Rühr of IMK-IFU that started work in autumn 2016. The group pursues an integrated approach by coupling experiments with modeling from the cell to the ecosystem.

Pine "forest" in the greenhouse at Garmisch. (Photo: N. Rühr)

With GRACE to the Other Side of the Earth

The GRACE graduate school is an indispensable part of the KIT Climate and Environment Center (ZKU). Advertising is no longer required: Research proposals submitted by the ZKU refer to GRACE when underlining the quality of education of doctoral students. The high priority of the graduate school is also reflected by the decision of the KIT Presidential Committee to grant transition funding for the years from 2018 to 2020.

Hence, there is good reason for looking ahead: What about the future orientation of GRACE? "In the next years, we plan to expand GRACE's international relations and cooperation with other graduate schools," Andreas Schenk, scientific coordinator of GRACE, says. As a first success, a memorandum of understanding was signed by the University of Melbourne, Australia, and KIT. "We are presently developing a double degree (cotutelle) procedure for doctoral students of both universities."

Two doctoral students of KIT will head for Australia at the end of this year already. Their research stays for three months will serve to strengthen existing contacts and be funded by the Karlsruhe House of Young Scientists (KHYS).

Interdisciplinarity will continue to play an important role in GRACE. "This year again, we will organize a summer school on 'Future Cities – Research for a Sustainable Urban Development.' It will bring together young scientists of various disciplines, from engineering to social sciences," Schenk says.

One of the highlights of the five-day summer school from July 17 to 21 will be the Trifelser Gespräch (Trifels dialog). Experts of science, politics, and industry will discuss future-oriented mobility in the city and surroundings. Interested persons may register at www.grace.kit.edu.

Professor Dr. Dick Strugnell, University of Melbourne, (seated) and Professor Dr. Alexander Wanner, KIT Vice President for Higher Education and Academic Affairs, sign the Cotutelle Agreement.

MORE INFORMATION:
www.grace.kit.edu/english/index.php

Is the Utilization of Deep Geothermal Energy Environmentally Compatible?

In the future, geothermal facilities might be environmentally more compatible than most of the other "renewables." This is the conclusion of a team of scientists headed by Philipp Blum of KIT's Institute of Applied Geosciences (AGW) after they analyzed the lifecycle of deep geothermal energy.

Currently, only few commercial geothermal facilities equipped with the so-called EGS (Enhanced Geothermal Systems) technology exist. "According to estimates, however, EGS technology may supply 8.3% of the energy needed worldwide by 2050," Blum says. Hence, its CO_2 reduction potential is significant. But what about the environmental pollutions caused by the construction and later operation of such facilities? They can be assessed by means of so-called lifecycle analyses. So far, such analyses have been made occasionally only. Now, they have been re-evaluated by Blum and his team based on generally valid criteria.

The result: A rather big improvement potential exists with respect to environmental compatibility. If electric drills were used instead of diesel-driven systems for drilling water supply and discharge lines and if these drills were supplied with power from renewable energy sources, lifecycle balance would be improved significantly, say the scientists participating in the study.

Further development of drilling technologies gives rise to expectations that geothermal energy may also contribute to base load supply one day.

K. Menberg, S. Pfister, P. Blum, P. Bayer: A matter of meters. State of the art in the lifecycle assessment of enhanced geothermal systems. Energy & Environmental Science, 6, 9, 2720. DOI: 10.1039/c6ee01043a.

Imprint

Issued by:
Karlsruhe Institute of Technology
Kaiserstraße 12
76131 Karlsruhe, Germany

Edited by:
www.sciencerelations.de

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

Design, Layout by:
www.spezial-kommunikation.de

Translated by:
KIT Sprachendienst/
KIT Translation Service

Printed by:
dieUmweltDruckerei GmbH, Hannover

PDF (German/English) for Downloading:
www.klima-umwelt.kit.edu

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: +49 721 608 – 2 85 92
www.klima-umwelt.kit.edu

July 2017

Printed on 100% recycled paper with printing inks based on renewable resources, marked with environmental label "Blue Angel."

klimaneutral
natureOffice.com | DE-275-169227
gedruckt