Karlsruhe Institute of Technology

The KIT Climate and Environment Center

Research for a Future Worth Living in

Life on Earth needs an intact environment in which the vital resources of water, air, energy, raw materials, and food are available and of good quality - especially in times of growing impacts of climate change, population growth, and technical and economic progress.

The Earth is influenced by climate and environmental change. Living conditions in the 21st century are changing rapidly and drastically. Demographic, technical, and economic developments affect the availability and quality of vital resources, such as air, water, food, energy, and raw materials. This makes states and societies vulnerable and reveals that climate and environmental research is facing major new challenges.

The KIT Climate and Environment Center: Mission and Strategy

In future, it will be important to do more than just eliminate the causes of environmental problems. We have to increasingly adapt to changed natural and anthropogenically produced environmental conditions. It is, therefore, essential to acquire basic knowledge on underlying processes, their interactions at local, regional, and global levels, and climatological, ecological, and economic impacts. This interdisciplinary process is to give rise to applicable action strategies.

To cope with these challenges, researchers of the KIT Climate and Environment Center work on six scientific topics which reflect the unique combination of competencies in natural sciences, engineering, and social sciences at KIT. The topics "Atmosphere and Climate," "Water," "Georesources," and "Ecosystems" cover important environmental compartments. Current, application-oriented cross-cutting issues are in the focus of the topics "Urban Systems and Material Flow Management" and "Natural Hazards and Risk Management."

Knowledge Triangle

KIT relies on the combination of research, teaching, and innovation. Proximity to top research makes studies at KIT highly attractive. In line with the research strategy of the European Union, KIT uses its innovation potential in cooperating with industry. In this way, excellent research results are rapidly transferred to marketable products.

Man changes the composition of the atmosphere and, thus, affects the climate as well as the formation of clouds. This is measured by highly sensitive instruments on the ground or on board of aircraft and satellites.

TOPIC 1

Atmosphere and Climate

Without an atmosphere, life on Earth would not be possible. This gas layer that is very thin compared to the Earth contains carbon dioxide for the photosynthesis of plants and oxygen for breathing. It distributes fresh water and energy and protects life against radioactive radiation from the universe and UV radiation of the sun. And it is here, where weather and climate develop.

By emitting pollutants and greenhouse gases, man significantly changes the composition of the atmosphere – with far-reaching impacts on the climate, water availability and quality, ecosystems, and human health. To detect these often subtle changes in due time, researchers working on the "Atmosphere and Climate" topic of the KIT Climate and Environment Center monitor the atmosphere's composition with high spatial and temporal resolution. Using mobile and stationary measurement stations, they determine the concentrations of carbon dioxide and other important trace gases as well as of aerosols.

Measurements are complemented by process studies at the laboratory and in the field. These studies help analyze in more detail and better understand fundamental atmospheric processes, such as the formation of clouds or precipitation. Among the systems used are the mobile KITcube, the AIDA cloud chamber, or a boundary layer wind tunnel.

Data from measurement campaigns and laboratory studies are combined in computer models for comprehensive analysis. Model systems, such as COSMO, ICON or WRF, help determine the impacts of global changes on the regional scale. This is the basis for improved forecasts and risk studies, thunderstorm warnings, or long-term prognoses of climate changes.

Highly sensitive technology:
By means of liquid chromatography-tandem mass spectrometry, KIT researchers determine trace substances in water ecosystems.

Water is an indispensable basis for all life on Earth. And it is an endangered resource. Rising demand by a growing global population, climate change, or chemical and microbiological pollution threaten the availability and quality of water in many regions of the world. KIT's water research concentrates on developing solution strategies for these challenges and supplying innovative technologies for transfer to practice.

The "Water" topic pools competencies of natural sciences, engineering, and social sciences, as well as technology assessment and covers nearly the complete range of water research. The scientists involved study water and substance cycles in all environmental compartments, i.e. in surface waters and aquifers, in the ground zone, and in the atmosphere. A central research field is securing water resources. Scientists develop highly sensitive analytical instruments and methods to track pollutants, study their effect on the environment, and look for technologies to remove them from wastewater and other raw waters. In addition, they develop concepts to adapt water infrastructure to changing environmental conditions and demand, in particular in congested urban areas and arid regions.

Researchers always pay attention to the effect global change has on the water cycle and water infrastructure and to the adaptations required to mitigate potential damage.

The expertise of individual disciplines is pooled in integrated water resources management in particular. Especially in Southeast Asia, in the Jordan valley, in India, and in South America and Africa, scientists of KIT, mostly in cooperation with industry partners and local actors, conduct numerous projects to secure sustainable water utilization at the local level.

Assessing the resource potential in western Greenland: Mineable resources are enriched in the Earth’s crust by various geological processes. In-depth investigation of the rocks in the field often enables reconstruction of the processes, although they took place 1900 million years ago, as in this case. Western Greenland in the area of Upernavik is known for its Zn-Pb-Ag mineralization. Here, we study iron-rich rocks (rusty weathering) for indications of non-ferrous metal enrichment in the environment.

Georesources, i.e. the ground, water, and deep underground, are an indispensable basis of life of all human beings on Earth. They do not only supply raw materials, but influence our present and future living conditions by acting as sources or sinks of environmentally important and climate-relevant substances.

How can "georesources" be utilized responsibly and sustainably for future generations also being able to cover their demand? In view of the constantly growing global population and imminent overuse of resources, scientists search for answers more urgently than ever – also at the KIT Climate and Environment Center.

Within the "Georesources" topic, natural scientists, engineers, and social scientists study complex substance conversion and transport processes in the underground, from the molecular to the global scale.

Which substances are decomposed or converted, which are bound in rock? Detailed understanding of these processes is indispensable for the responsible use of georesources, i.e. when disposing of radioactive or chemical wastes, storing gas underground, using geothermal resources, extracting fossil or metallic resources, or developing remediation concepts.

Scientists develop analytical and numerical models to reproduce as realistically as possible the dynamics of transport and transformation processes in the underground. The impacts of changed climate and environmental conditions also are considered, as they may dramatically affect global material flows.

Not least, KIT's research into georesources covers the development of innovative technologies for the exploration and evaluation of underground storage systems as well as of techniques for long-term monitoring of underground facilities.

Plants, animals, and microorganisms interact in many ways with each other and with the ground, rock, water, and atmosphere. These mutual relationships are complex and not yet understood in all detail.

TOPIC 4 Ecosystems

Plants, animals, and microorganisms interact in various ways with each other and with the ground, rock, water, and atmosphere. These mutual relationships are complex – and not yet understood in all detail. But without them, life in its present form would not be possible.

Ecosystems, hence, represent the most important natural basis of human society. They secure food supply, influence the climate as well as the quality of air and water, they supply resources, and protect against diseases or natural disasters, to mention but a few services only. It is the common goal of researchers involved in the "Ecosystems" topic to comprehensively study ecosystems functions and processes. Research focuses on the question of how global change and ecosystems influence each other on various spatial and temporal scales. This includes climate change as well as changes of land use, global population growth, or urbanization of society. Apart from measurement-based ecosystems monitoring and experimental research, modeling and the development of scenarios play a central role.

Scientific analysis is complemented by socioeconomic aspects. It is of particular interest which impacts global change will have on the economic and social conditions of certain groups of the population and what feedbacks this will have on the ecosystems.

Greenhouse experiment in Ecuador to determine the sensitivity of tree species of tropical mountain rain forests to toxic aluminum.

Urban climate: Warming of air above Manhattan leads to cloud formation.

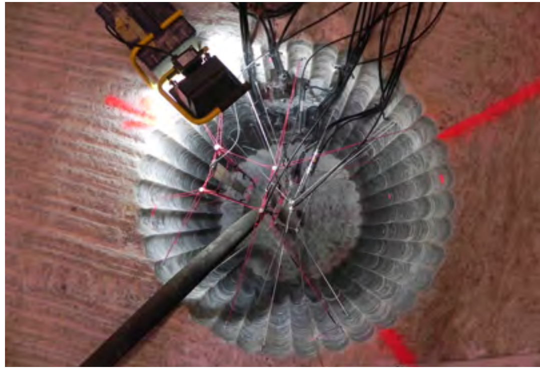
Mankind is in the middle of an urban revolution: More than half of the world's population lives in cities, and this proportion is still growing. About 75 percent of all material flows are turned over there. About 80 percent of the anthropogenic carbon dioxide is produced in cities. Health of urban population is threatened by environmental impacts and pollution.

Hence, the society faces a number of challenges. How can the quality of life in cities not only be maintained, but improved, and existing resources be utilized sustainably? The corresponding research activities are pooled in the topic "Urban Systems and Material Flow Management," in which scientists from more than 20 institutes of KIT are involved.

Apart from urban planning and development, a focus lies on the analysis of material flows, that is the turnover of gases, water, energy or resources in cities. For sustainable urban development, methods to more efficiently use e.g. the scarce resources are developed.

Another field of research is urban ecology. Scientists study how urban ecosystems work and can be integrated into urban development processes. Improving the urban climate and fighting air pollution are major tasks.

Moreover, technical and methodological instruments are developed to protect cities against climate change, demographic and economic changes, or natural disasters. This includes the design of adapted supply, accommodation, transport, or communication infrastructures, also in cooperation with other KIT Centers.



The topic pools expert know-how from social sciences to architecture to civil engineering to natural sciences in order to cope with the big challenges of urban planning at the national and global levels.

Emergency shelters after the severe earthquake in Nepal on April 25, 2015. During several field campaigns, researchers of CEDIM/KIT studied the situation of emergency shelters, the reasons why evacuations were not made, restoration of the infrastructure, and the population’s need for information after the earthquake.

Natural Hazards and Risk Management

Increased dependence on critical infrastructures, such as energy, transport or communication systems, and advancing globalization enhance the vulnerability of present societies to natural and technical risks. Political objectives, such as the energy transition in Germany or the change of mobility systems (electric mobility, autonomous driving), also represent major interferences with existing complex systems. Moreover, changing climate conditions can lead to extreme situations that are not or not adequately considered by existing protection concepts and risk management systems.

Work within the "Natural Hazards and Risk Management" topic is aimed at generating knowledge on natural and anthropogenic risks and developing adequate tools and technologies to enhance resilience. The complexity and diversity of the topic require an interdisciplinary approach.

Researchers of KIT study a large range of aspects relating to natural hazards and risk management. Within the framework of various projects, the complete process of natural hazards is studied, from the causes to the identification of new risks to their short-term and long-term impacts. Particular attention is paid to the vulnerability of critical infrastructures, in particular energy supply, mobility systems, and information and communications technologies. In the area of risk management, simulation systems are developed to analyze the course of disasters. Real-time information systems and tools are designed for decision support. Synergy effects result from combining methods for natural risks with methods for technologically induced risks.

Work relating to these aspects is pooled among others by the Center for Disaster Management and Risk Reduction Technology (CEDIM). This multidisciplinary institution of KIT focuses on disaster and risk management.

The KIT Climate and Environment Center goes international: Concepts for sustainable water resources management under extreme natural conditions – exploration of karst mountains in North Vietnam.

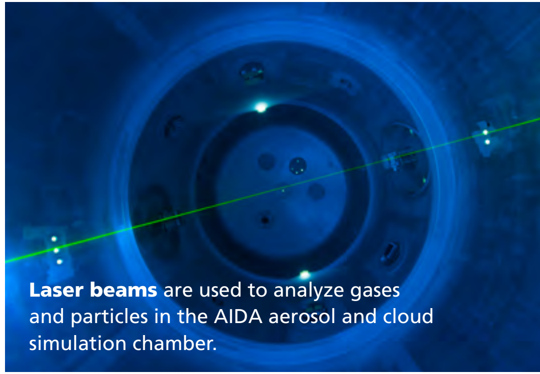
More than 700 scientists of 30 institutes of KIT cooperate in finding-oriented research at the KIT Climate and Environment Center and develop innovative and sustainable technical solutions for coping with the challenges of climate change and for the protection and use of our unique environment that is subject to dynamic change. For this purpose, we pool fundamental knowledge, technologies, and systems analyses to derive practically viable solutions taking into account socioeconomic conditions. Work is based on our internationally acknowledged competencies in studies of the Earth, i.e. its atmosphere, terrestric hydrosphere and biosphere, pedosphere, and lithosphere.

Strong Pillars of Climate and Environmental Research

The activities of the KIT Climate and Environment Center are based on well-established institutions of KIT, such as the Institute for Meteorology and Climate Research (IMK), the Center for Disaster Management and Risk Reduction Technology (CEDIM), several large-scale projects on integrated water resources management (IWRM), the Competence Center for Material Moisture (CMM), and many significant research projects. For our studies, big research infrastructures are available, such as the AIDA cloud chamber or the KITcube integrated atmospheric observation system. Some topics are closely related to topics of the KIT Energy Center, such as work at the State Research Center for Geothermal Energy.

GRACE Graduate School

The Graduate School for Climate and Environment (GRACE) of the KIT Climate and Environment Center supports interdisciplinary work and thinking and focuses on the needs of highly committed young scientists in climate and environmental research. The KIT Climate and Environment Center executes numerous projects in co-



Laser beams are used to analyze gases and particles in the AIDA aerosol and cloud simulation chamber.

operation with industrial enterprises. New perspectives result from interdisciplinary cooperation. Work focuses among others on the safe utilization of the underground, the development of measurement instruments and methods, consulting services on the extent of climate change or on risk assessment, numerical forecast models, and efficient software solutions (e.g. COSMO-ART).

Karlsruhe Institute of Technology (KIT)

KIT – The Research University in the Helmholtz Association creates and imparts knowledge for the society and the environment. It is the objective to make significant contributions to the global challenges of mankind in the fields of energy, mobility, and information. For this, scientists cooperate in a broad range of disciplines in natural sciences, engineering sciences, economics, and the humanities and social sciences, from fundamental research to applications.

KIT prepares its students for responsible tasks in society, industry, and science by offering research-based study programs. Innovation efforts at KIT build a bridge between important scientific findings and their application for the benefit of society, economic prosperity, and the preservation of our natural basis of life.

With about 9300 employees, of these more than 6000 in science and academic education, and 26,000 students, KIT is one of the big research and education institutions in natural sciences and engineering in Europe.

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