



Photo: FZ Jülich

Field measurements: FZJ researchers measure the gas exchange of plants

ON THE RIGHT TRACK

FOURTH OBSERVATORY COMES ONLINE

The Germany-wide Earth observation network TERENO continues to take shape. Three years since the project was launched work has begun at the fourth observatory which covers the region “North-East German Lowlands”. TERENO now unites climate and environmental research from the Alps to the Baltic coast. The necessary instrumentation to achieve this goal is at an advanced stage. The world’s largest lysimeter network, TERENO-SOILCan, became operational in 2010. Research is underway at all sites. This issue highlights some examples, including several projects which focus on water and material flows in the ground. In addition, collaborations with partners both in Germany and abroad are expanding further. The first signs of success are already visible.

CONTENTS

Editorial: Forging Ahead	2
Setting Up the Largest Lysimeter Network in the World.	2
“One of Our Most Important Research Projects”.	4
Extending the Network Further	5
A Good Combination	6
From a Snapshot to the Big Picture.	7
Cooperation Pays Off	7
Predicting the Future with Help from the Past.	8
Taking Night Calls.	9
Monitoring Evaporation.	9
Greenhouse Gas from out of the Ground.	10
Microwaves Tracing Water	11
“Like a Large Library Catalogue”.	12

SETTING UP THE LARGEST LYSIMETER NETWORK IN THE WORLD

SOILCan investigates effects of climate change on matter and water fluxes in the soil

The lysimeter network TERENO-SOILCan was established September 2010. In just six months, researchers have set up 126 lysimeter systems at 13 locations according to an uniform design (see newsletter 1/2010). "That makes TERENO-SOILCan the largest network of its kind in the world", says Dr. Thomas Pütz from the Agrosphere Institute at the Forschungszentrum Jülich (FZJ), who is coordinating the project.

Researchers are using the lysimeters—stainless steel cylinders that are open at the top and contain a soil core obtained by sinking the cylinder into the ground—to examine the effects of global change on matter and water fluxes in the soil. The starting point for the network was preliminary work undertaken at the TERENO observatory based in the Bavarian Alps and pre-Alps region by the Institute for Meteorology and Climate Research (IMK-IFU) at the Karlsruhe Institute of Technology (KIT). TERENO has extended the climate feedback model adopted by the IMK-IFU to include all of its observatories.

A need for global data

Researchers have exchanged soil monoliths—the term used to describe the soil cores in the lysimeters—throughout Germany along existing temper-

ature and precipitation gradients. The aim is to install the soil monoliths at locations which correspond to the predicted changes in climate at the TERENO observatories. "For example, soil monoliths at the installation destination are exposed to drier and warmer environmental conditions than at their original sites", explains Thomas Pütz.

SOILCan's goal is to collect long-term data on climate change related variations in terrestrial systems. This kind of data is lacking world-wide, but is absolutely crucial for the development and improvement of models for the exchange processes between the biosphere, atmosphere and hydrosphere.

Grassland in the can

The monolithic lysimeters have a surface area of one meter squared and are one and a half meters long. They have been integrated into the respective research sites of the TERENO observatories as intensive measuring devices. To this end, lysimeters have been prepared at areas of land used to cultivate arable crops as well as at grassland areas. Partly due to the nature of the sites in question, marred by such factors as rocky subsoil, filling up the lysimeters was no easy task. "Under those sort of conditions it's a good technique to prepare the soil monoliths in layers above ground", says the FZJ researcher. This

EDITORIAL



Photo: Chris Teubke

Forging ahead

Dear Readers,

TERENO is one of the Helmholtz Association's most important environmental research projects, as Dr. Jürgen Mlynek, President of the Helmholtz Association of German Research Centres, once again emphasizes in an interview for this issue. TERENO enters its third year with a spring in its step. The launch of the fourth observatory marks another milestone. The observatory "North-East German Lowlands" is not just an addition to our existing research areas. It extends the research spectrum by drawing on geological archives. The lysimeter network TERENO SoilCan, which was established in 2010 is also a great contribution. It is the largest network of its kind in the world. TERENO SoilCan is characterized by close collaboration and a division of labour between the participating facilities which works extremely well. The possibilities which such close collaboration can generate is evidenced by the Transregional Collaborative Research Centre 32 (TR32) "Patterns in Soil-Vegetation-Atmosphere Systems", funded by the German Research Foundation (DFG). The project's close collaboration with TERENO was a major factor in the decision to extend TR32 and provide it with extra funding. We want to encourage these types of collaborations with other research groups further. For example, data from the scheduled satellite mission Tandem-L, which is being co-organized by the German Aerospace Center (DLR) and NASA, will be made available to TERENO. In order to make the ongoing measurements taken at the various TERENO sites available to the wider research community as quickly as possible we are also continuing work on the data portal TEODOOR. It is set to come online before the end of this year.

I wish you enjoyable reading and all good things for 2011!

Harry Vereecken

TERENO-Coordinator

SOILCAN'S MAIN AREAS OF FOCUS

- Changes in the coupled cycles and storage of carbon and nitrogen (temporal dynamics)
- Biosphere-atmosphere exchange of climate-relevant trace gases.
- Changes in vegetation and biodiversity.
- Changes in all components of terrestrial hydrology, such as the water balance, evaporation, precipitation variability and water-retention capacity.
- Supplementary instrumentation of the experimental sites within the TERENO observatories.
- Bridging the gap in scale from the point-to the field scale (up-scaling).



Photo: DLR

A lysimeter being filled with soil

proved to be the only guaranteed way in which monolithic lysimeters could be filled.

Wireless data exchange

The stainless steel SOILCan cylinders are lysimeters which have a defined lower boundary condition. This means that the water balance of a lysimeter controls real location conditions via a tensiometer-controlled suction probe at the lower boundary of the lysimeter. Every SOILCan lysimeter is attached to three highly sensitive load cells that make it possible to monitor the

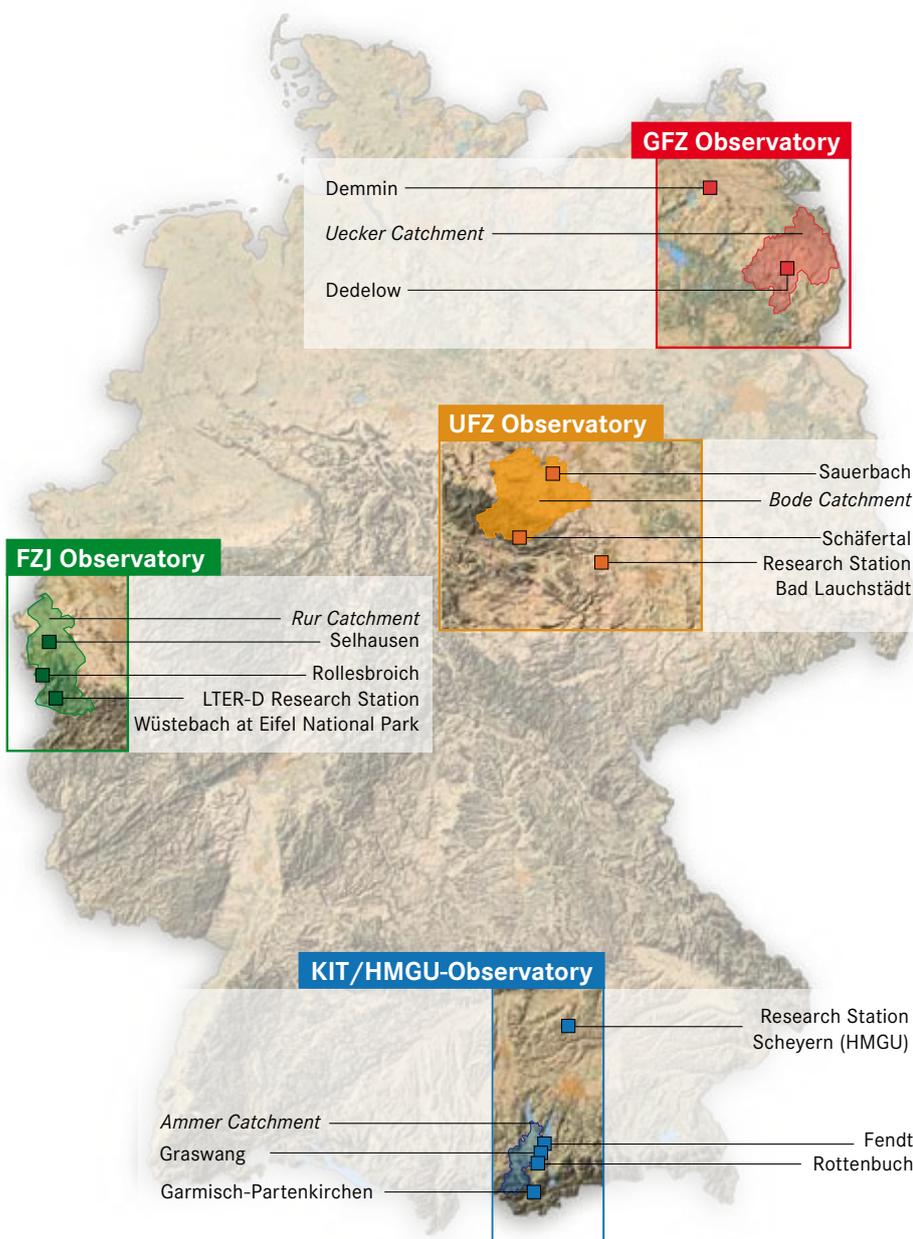
important components of the water balance, evaporation and precipitation, with high temporal resolution. In order to collect information about the soil in the lysimeters, researchers installed various sensors and probes to measure soil water content, matrix potential, temperature and carbon dioxide gas concentration.

The fully automated lysimeter systems are equipped with cutting-edge wireless-based technology for monitoring and data communication, so that a centralized system manager can take on the continued monitoring and functionality of

all systems. Following a thorough data verification process the lysimeter data are sent to the TERENO database for further scientific analysis.

In order to monitor local climatic characteristics weather stations have been erected within the immediate proximity of each station. The researchers are also keeping tabs on curious visitors such as mice, birds or even bigger animals with the help of a video camera which has been fitted out with a motion sensor. ■

TERENO SOILCAN LOCATIONS

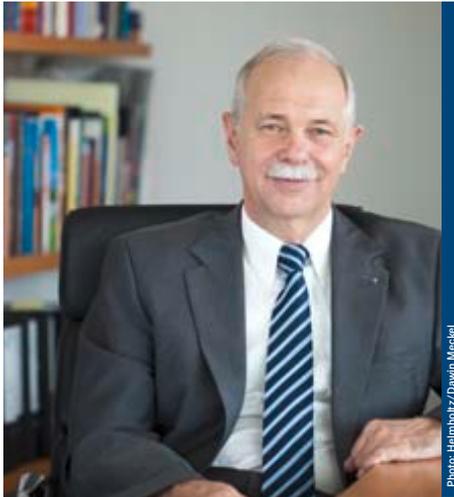


Six additional lysimeters are set up in a circle around every central measurement- and service shaft (top) Once the lysimeters have been set in place and the technology has been installed, the surrounding pit is filled in with soil (bottom)

- **Greater Leipzig-Halle Region**
Coordination: Helmholtz Centre for Environmental Research – UFZ
- **Eifel-Lower Rhine Valley**
Coordination: Forschungszentrum Jülich
- **Bavarian Alps and pre-Alps**
Coordination: Forschungszentrum Karlsruhe and German Research Center for Environmental Health
- **North-East German Lowlands**
Coordination: German Research Centre for Geosciences – GFZ

“ONE OF OUR MOST IMPORTANT RESEARCH PROJECTS”

An Interview with Jürgen Mlynek, President of the Helmholtz Association



Jürgen Mlynek

Dr. Jürgen Mlynek was initiated as President of the Helmholtz Association of German Research Centres—Germany’s largest research organisation—in September 2005. The physicist, born in 1951, was elected for a second term in 2009, which will run to 2015.

Work at the fourth and last of the TERENO observatories will start at the beginning of this year. How do you rate the progress which has been made so far?

TERENO is developing at a great pace and the participating centres are working together superbly. In particular, the division of labour is also proving successful. An experimental set up at any one site always benefits from the expertise of all participating partners. In this way TERENO is able to ensure series of high quality measurements that have a high degree of continuity.

What role does TERENO play in the Helmholtz Association’s Research Field “Earth and Environment”?

TERENO is one of our most important research projects in the field of environmental research. It is helping us to build a solid database over the long term for the core environmental topics such as regional climate change, water- and soil quality as well as biodiversity.

TERENO is scheduled to run for 15 years. But there is always the threat that valuable test series will be cut short, for example if funding runs out or equipment gets broken. What steps can be taken to ensure that long-term goals or expectations can be realized?

15 years is a long time for a research project. I am confident that we will already be able to make a lot of progress in this time frame. The essential structures will be set in place, and we will have already gained some important insights. The continuation of the series of measurements can be ensured by incorporation into the Helmholtz research programme. Of course the appropriate decisions will be made by a process of external review. The Helmholtz Association can continue its research agenda for decades as long as the science is of high quality.

Which aspects of environmental research will the Helmholtz Association focus on in the future?

We are committed to using our research to find solutions for the great challenges of the future. Of course global climate change is one such challenge, and our aim is to collect better data on the driving factors and to make more accurate predictions of the exact changes at a regional level so that adaptation measures can be taken in a timely manner. That’s why atmospheric research is such an important field of research, as well as the investigation of exchange- and feedback processes in the soil-vegetation-atmosphere system. The Helmholtz Association is also focusing on water and biodiversity. In addition, we intend to extend our risk research so that we are better at predicting and managing natural catastrophes.

How important is cooperation between Helmholtz centres and other research institutes and universities in environmental research?

There is often strength in numbers. There are lots of areas in which all of the various players complement each other beautifully. TERENO is a case in point. It is establishing an infrastructure with cutting-edge equipment which is not used exclusively by the Helmholtz centres. This can lead to some very productive collaborations, such as the close cooperation between the universities of Aachen, Cologne and Bonn within the framework of the Transregional Collaborative Research Centre 32 (TR32), funded

by the German Research Foundation (DFG). The success of the collaboration was one of the factors which led the DFG to extend the time frame of TR32 and provide additional funding.

The research initiative REKLIM, which focuses on regional climate change and is run by the Helmholtz Association, is actively trying to get universities on board. Without universities nothing is possible, they are our most important partners.

Do you think that more research institutes and universities will make joint appeals for funding in the future?

Wherever that’s possible, certainly. Some funding opportunities are only available to specific facilities however. For example, funding from the Helmholtz programmes is only available to Helmholtz centres. Be that as it may, TERENO and TR32 show that there are great opportunities for synergy effects. One exception is the Karlsruhe Institute of Technology (KIT), which is also involved in TERENO. As a result of the merger between the university and the Helmholtz research centre in Karlsruhe, the KIT is now also able to apply for funding from the German government’s Excellence Initiative.

Will the KIT remain an exception, or will there be a trend for more mergers between universities and other research institutes? Bearing in mind that there have also been critics of the two-tier system of university research and research undertaken outside of the universities.

This much vaunted concept of a “pillarization” of the German research landscape is a fallacy. We have always cooperated with numerous partners at universities and to this end we are developing new measures such as virtual institutes, the Helmholtz Alliances and now also Helmholtz institutes which are affiliated to universities. There are several ways to increase collaboration between any given research centre and a neighbouring university. The KIT, in which a research centre and university have merged, is just one option. For example the Forschungszentrum Jülich is working particularly closely together with the RWTH Aachen in various research fields, and that is also very productive. ■

EXTENDING THE NETWORK FURTHER

Advisory Board finds TERENO is on track

The third TERENO Advisory Board Meeting was held in the town of Schleiden at the end of September 2010. The Advisory Board, which is made up of 12 independent climate and environmental research experts from all around the world and provides TERENO with advice and support on scientific questions, gained an overview of the project's progress. The results were more than encouraging. The Advisory Board, chaired by the US hydrology expert Dr. Richard P. Hooper, placed particular emphasis on efforts to extend the TERENO network to include other research groups.

Schleiden is located in the heart of the North Eifel region, at the centre of the TERENO observatory in the Eifel/Lower Rhine Valley. During their stay, members of the Advisory Board gained insights into the region's characteristics: intensive farming and forestry, small- and medium-sized businesses and a moderately developed tourist industry.

Regional characteristics

On the first day attendees visited the TERENO research station "Wüstebach" in the Eifel National Park which is coordinated by the Forschungszentrum Jülich (FZJ). Dr. Michael Rööb from the Eifel National Park gave an introduction to the history of the North Eifel biosphere and answered questions about the further development of the national park, which is still in its infancy. Scientists from the FZJ and colleagues from the collaborating universities of Trier and Bonn presented their research programmes and the infrastructure and equipment made possible through TERENO funding. These included the SOILCan lysimeter system, SoilNet, one of the largest wireless soil moisture sensor networks in the world, as well as

the 34 metre-high measuring tower (see TERENO Newsletter 1/2009).

In a presentation the next day, TERENO coordinator Professor Harry Vereecken from the FZJ, together with other members of the Scientific Steering Committee, outlined –inter alia– the rise in cooperations with other networks. The list of partners includes LTER (Long Term Ecological Research), the EU project EXPEER (see TERENO Newsletter 1/2010) and ICOS (Integrated Carbon Observation System). TERENO observatories are also involved in current and scheduled space satellite missions, such as SMOS (Soil Moisture Ocean Salinity) and TanDEM-X.

Presenting data

Preliminary research results were also presented. Ph.D. student Ulrike Rosenbaum (FZJ) shared the first analyses of spatiotemporal patterns of soil moisture at the TERENO station Wüstebach. The results of a long-term study on nitrous oxide emissions in Scheyern were outlined by Professor Jean Charles Munch from the Helmholtz Center Munich (see page 10). Dr. Erik Borg from the German Aerospace Center (DLR) showed results of the monitoring of evaporation which were recorded with the help of satellite data for the DLR test site DEMMIN (Durable Environmental Multidisciplinary Monitoring Information Network), located in the observatory "North-East German Lowlands".

Among its recommendations, the Advisory Board placed an emphasis on the continued development of the data management structure so that measurements taken at TERENO sites can be made readily available to a wider research community. ■



Mike Schwank

NEW COORDINATOR

Dr Mike Schwank from the GFZ German Research Center for Geosciences has been coordinating work at the TERENO observatory in the North-East German Lowlands since September 2010. The 44-year old Swiss scientist previously worked at the ETH Zürich and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf. His research focus was on passive microwave remote sensing, with the aim of measuring soil moisture at a global scale. During this time the doctor of astrophysics was involved in the development of microwave hardware. The European Space Agency (ESA) currently uses this technology to review SMOS satellite data, which make it possible to deduce soil moisture at a global scale and are therefore extremely relevant for TERENO. ■

Contact: mike.schwank@gfz-potsdam.de

TERENO ON TV

The science magazine programme NANO produced by the television channel 3SAT covered the research project TERENO in October. In the roughly seven-minute piece titled "Climate on the Ground" viewers were introduced to the activities of TERENO, in particular the work being undertaken as part of TERENO SoilCan (see page 2). ■

Science magazine programme NANO

POOLING COMPETENCES

On November 1 the Forschungszentrum Jülich (FZJ) pooled its competences in bio- and geosciences in a new institute. The Institute for Bio- and Geosciences (IBG) also includes the Agrosphere Institute (now IBG-3), which coordinates the TERENO observatory in the Eifel-Lower Rhine Basin. The IBG is intended to provide direction and ideas for the future-oriented field of bioeconomics. For example, fundamental research is being done into how materials and chemicals, possible energy sources and food can be produced economically and sustainably. To this end the FZJ is establishing six additional professorships. ■

Gaining insights at first-hand: Members of the Advisory Board visit the TERENO research station "Wüstebach" in the Eifel National Park



A GOOD COMBINATION

Researchers at the UFZ predict soil moisture with very high accuracy

One of the TERENO observatories' most important tasks is to monitor near-surface soil moisture. "Knowing how water is distributed in the soil is vital to understanding the hydrological cycle", explains Dr. Steffen Zacharias, TERENO Coordinator at the Helmholtz Centre for Environmental Research (UFZ). The availability of water is a decisive factor in plant growth; it has an influence on species composition and influences the local climate through interactions with the radiation- and energy balance.

However, purely statistical or model-based measurements are not sufficient for researching the water cycle within a particular catchment area, for example, as the water is in constant motion and the weather and the ground are always changing. "That's why we also need to compile spatially distributed soil moisture information", says Marion Pause from the UFZ, scientific coordinator of the PLMR campaign. To this end, a procedure to measure near-surface soil moisture with the help of an empirical model which combines spectrometer and microwave radiometer data was tested at the TERENO observatory in the Harz/Mid-German Lowlands.



Photo: Marion Pause/UFZ



Photo: Sommer

Successful testing: Researchers from the UFZ are able to measure soil moisture with a PLMR sensor (left) by combining their recordings with vegetation data collected with a hyperspectral sensor on-board the microlight aircraft AISA Eagle (right)

The starting point was a measuring campaign in May 2008. A research aircraft fitted with a Polarimetric L-band Multibeam Radiometer (PLMR) sensor flew over numerous test sites at different TERENO observatories. The aim of this initial campaign was to determine whether or not PLMR is an effective tool for generating soil moisture data.

The method registers the natural emissions of microwaves in the so-called L-band – that is, of electromagnetic waves in a frequency range of 1.4 gigahertz. PLMR sensors make use of the fact that the emission of microwaves is highly dependent on the dielectric properties of the soil. This correlation is in turn directly influenced by the soil water content.

Vegetation as a disruptive factor

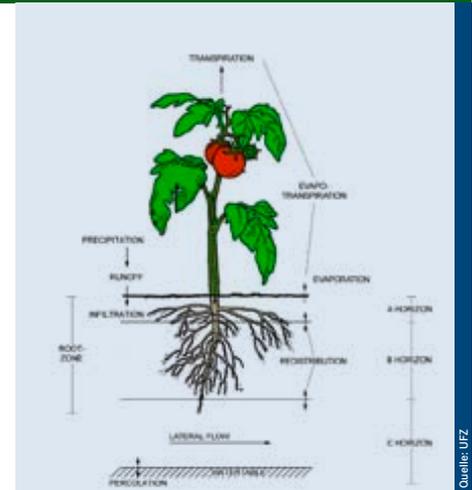
Nevertheless, the radiation temperature recorded by the radiometer does not represent a direct measurement of soil moisture. In addition to sensor-specific factors, such as the observation angle, the signal is particularly affected by dense vegetation. On the one hand it dampens the actual soil moisture signal, and on the other hand it adds its own signal to the mix. "These complex interactions between microwaves and vegetation make it much more difficult to calculate the actual soil moisture level", summarizes Marion Pause.

In addition, different types of vegetation cover affect the signal in different ways. As vegetation

cover varies from place to place, the researchers have to take exact note of the vegetation at the areas under investigation.

Combining various approaches

In order to make better use of the data generated by PLMR, researchers at the UFZ have come up with a new solution: they combine them with



Quelle: UFZ

How water cycles between the atmosphere, soil and plants

INTERFACE TO GROUNDWATER

Near-surface soil moisture significantly impacts the distribution of rain into surface runoff, evaporation and infiltration. In addition, it regulates microbacterial activity and biogeochemical transformation processes. It is at this interface that groundwater recharge and consumption is affected. It therefore has tremendous significance for agriculture, hydrology and meteorology. The determination and monitoring of soil moisture patterns provides important information about water distribution at lower-lying soil levels, which are highly significant for regional and indeed global water management. ■

vegetation data which they have collected with imaging spectrometers. With AISA Eagle und AISA Hawk, TERENO has two hyperspectral sensor systems which, when fitted to microlight aircraft, can take air-borne pictures from the land surface. Using this method, scientists at the UFZ have compiled soil moisture maps for cereal fields in the test area Großbardau in the observatory "Harz/Mid-German Lowlands".

"Thanks to the AISA Eagle data, we were able to use an empirical model to account for 92 percent of the spatially distributed soil moisture recorded by the PLMR data", emphasized Marion Pause. The researchers were therefore able to show that a combination of hyperspectral and passive microwave data provide very good results on very dry soil with little variability in moisture. As a result of the PLMR campaign's positive outcome the FZJ purchased a new PLMR sensor within the framework of TERENO. ■

FROM A SNAPSHOT TO THE BIG PICTURE

Scientists from the UFZ analyze matter fluxes in the Sauerbach catchment area



Photo: M. Rebeck

The Sauerbach creek mainly flows through arable land

The catchment area of the Sauerbach creek is located within the fertile Magdeburg Börde area. It spans almost two square kilometres about 35 kilometres west of the city of Magdeburg, and constitutes one of the main research areas in the Hydrological Observatory Bode, which is part of the TERENO Harz/Central German Lowland Observatory. Scientists at the Helmholtz Centre for Environmental Research - UFZ want to analyze in detail water and matter fluxes in soil, groundwater and surface water in the intensively agriculturally used catchment area. Work on the installation of various measurement systems began in spring 2010.

“The Sauerbach catchment area provides ideal conditions for developing measuring and observational approaches which could be applied to other, especially larger catchment areas”, explains Dr. Ute Wollschläger, who coordinates field work at the hydrological observatory. To reach this goal, scientists from various disciplines such as soil, water and biodiversity research, geophysics and remote sensing are working closely together. They are using a variety of measurement and analysis methods to collect comprehensive, long-term data on the dynamics of the water and its chemical composition. In the next step, re-

searchers want to use computer simulations in order to gain a better understanding of the processes which water- and matter fluxes undergo in this type of catchment area.

Understanding the dynamics better

For example, a multiparameter probe installed in the Sauerbach continually monitors important surface water properties such as temperature, oxygen- and nitrogen concentration. In addition, researchers regularly take samples from the surface water of the Sauerbach, from drainages and from the groundwater monitoring wells which have been set up in the area. “Our aim is to increase our understanding of the dynamics in the chemical composition of the surface water and to better estimate the contributions of the various inflows to the Sauerbach’s total runoff”, explains Dr. Ute Wollschläger. Furthermore, researchers have installed temperature probes at various points in the riverbed to monitor the exchange between surface water and groundwater at different sections of the Sauerbach.

Lysimeters are being used to investigate water dynamics in the upper soil zone. In summer 2010 researchers excavated twelve soil columns within the framework of the SOILCan project (see page 2). More lysimeters are being planned. ■

COOPERATION PAYS OFF

TR32 to run for 4 more years – DFG provides big funding boost

The German Research Foundation (DFG) announced in November that it would extend the Transregional Collaborative Research Centre 32 (TR32) “Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling and Data Assimilation” by an additional four years. TR32 Coordinator, Dr. Stefan Kollet from the University of Bonn attributes the project’s success to its close collaboration with TERENO (see TERENO Newsletter 2009).

Dr. Kollet, the DFG has increased its funding to around 12 million euros – almost double the amount for the initial research phase. The number of projects will expand from 15 to 25. What made your proposal so compelling?

Our measurement infrastructure is second-to-none in many areas. Our approach to data assimilation is to match up measurement data with models, in order to make existing models more realistic. This helps us to understand processes

better and to make more precise predictions. We have also made very good progress in developing new models for the integrated soil-vegetation-atmosphere system. The results have reached an international audience, for example through publications and presentations at conferences. In addition, the concept we put forward for the second phase was very well received.

What is TERENO’s role in this?

Both climate projects focus on the catchment area of the Rur River. We therefore discussed in detail exactly which measurements should be taken where. It’s a win-win situation: the TR32 benefits from the TERENO infrastructure. In turn, the TERENO project benefits from the data generated by our researchers. We are also working closely together with regards to monitoring. TERENO is directly or indirectly involved in 20 of our 25 projects. This collaboration was heavily emphasized in our proposal to the DFG. It was an important factor in the review process.



Photo: terbat

Stefan Kollet

What is the significance of this extension for research in the region?

TR32 is a collaboration between the three universities of Aachen, Bonn and Cologne as well as the Forschungszentrum Jülich. Extending the project lifespan, and giving it such an enormous financial boost, will provide an incredible stimulus for geosciences in the region. Of course TERENO will also benefit, as cooperating with universities is extremely important for TERENO’s success. ■

Transregional Collaborative Research Centre 32



The DEMMIN test site located within the observatory "North-East German Lowlands" is currently equipped with 16 climate stations (left, right). The study area also includes the predominantly agricultural Uckermark region (centre)

PREDICTING THE FUTURE WITH HELP FROM THE PAST

"North-East German Lowlands": The fourth TERENO observatory comes on line

The fourth TERENO observatory is set to start operating at the beginning of 2011. The observatory "North-East German Lowlands" (NE) closes what has, up to now, been a yawning gap in the map. It spans an area of Germany which is considered one of the regions most severely affected by climate change. "It marks an important contribution to the existing research areas in the Alps and pre-Alps region, Eifel Lower-Rhine Basin and Harz Mid-German Lowlands", explains NE observatory coordinator Dr Mike Schwank from the GFZ German Research Center for Geosciences in Potsdam.

In the course of the two-year foundation phase four thematic core areas have emerged which form the focus of research at the NE observatory: remote sensing, hydrology, geopedology and the reconstruction of climate dynamics and landscape evolution based on geological archives. Examples of the type of geological archives used include tree rings and lake sediments which provide information about the climate in recent centuries. Old chronicles and books which contain reports about past weather also have a role to play. The aim is to combine observations gathered from geological archives with data to be collected by researchers working within the framework of TERENO in order to create new climate models and make long-term climate predictions. "Introducing the use of geological archives at the four observatories in Germany constitutes an important thematic development for the whole research network. They make it possible for us to better distinguish between short-term changes in our environment and long-term, possibly climate-dependent trends", stresses Professor Achim Bauer, Head of the GFZ Section for Climate Dynamics and Landscape Evolution.

Tree ring revelations

The GFZ has attracted various external scientific cooperation partners to set up the observatory such as universities, Leibniz institutes, Helmholtz centres and government agencies. At the test sites in Dedelow and Demmin for example, scientists from the GFZ collaborate with colleagues from the Leibniz Centre for Agricultural

Landscape Research (ZALF) Müncheberg and the Neustrelitz site of the German Aerospace Center (DLR). The long-term test "Durable Environmental Multidisciplinary Monitoring Information Network" (DEMMIN) is thus one of four important research areas within TERENO-NE (see TERENO newsletter, October 2009).

Scaling environmental parameters in time and space

"Our strategy is to scale environmental parameters and their dynamics in time and space", says Mike Schwank. The researchers' approach includes comparing data which they have collected directly from the ground with aerial photographs and satellite images. This enables them to improve their analysis of remote sensing data, which in turn makes it possible to determine the environmental state of a specific target area with more accuracy than has hitherto been possible. In order to document changes over longer time scales the researchers run various long-term measurements at forest-, grassland- and farmland sites, for example on water evaporation from flora and soil surface. Within the framework of SoilCan (see page 2) work has also already begun at the Dedelow and Demmin sites on the instrumentation of lysimeters, which make it possible for the researchers to investigate the soil water balance and flows of material. The observatory's infrastructure is set to be extended further in the coming year.

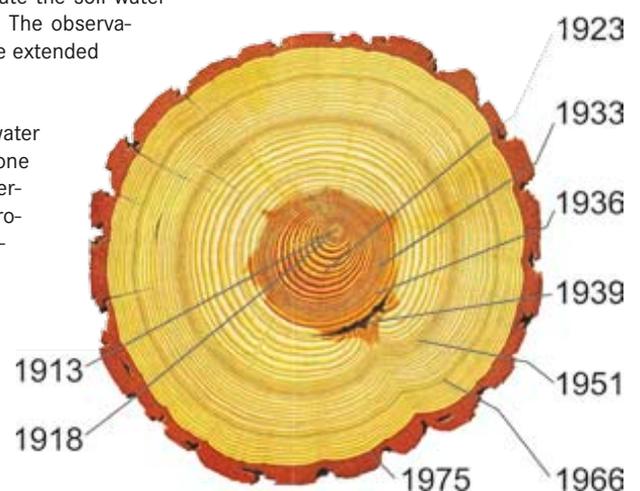
In addition to researching water balance, work is also being done on the material balance of different soils and their exchange processes with the atmosphere and hydrosphere. Above all, erosion processes and their interactions with the carbon balance of landscapes are at the centre of the research collaboration between the GFZ and ZALF. In particular, the partners would like to answer the significant

question for the global carbon dioxide (CO_2)-balance, whether erosion creates a (CO_2)-sink, that is storage for carbon dioxide, or whether it creates a (CO_2)-source.

New measuring system

Researchers also hope to gain new insights with the help of a novel measuring system which documents near ground carbon dioxide (CO_2)-concentration and which is currently under development at the GFZ. The advantage of the system, which works with laser spectrometers, lies in the fact that it doesn't just determine the concentration of the gas at a given spot. Instead, it can identify the distribution of the (CO_2)-gas concentration over a specific area. That brings researchers one step closer to a comprehensive carbon accounting of the ground and provides science with detailed insights into the carbon processes in humus. The novel measuring technology is also set to be deployed in cooperation with the University of Potsdam and deployed as part of a collaboration with the ZALF within the framework of the joint research project "CarboZALF". ■

Tree rings provide information about a tree's history. They do more than help date a tree's age. The thicker an individual tree ring, the better the climatic conditions





TAKING MEASUREMENTS TWICE FOR NASA

Worldwide, active radar systems are often used as a remote sensing tool to monitor soil moisture. These systems emit microwaves, for example, and then capture the reflected part of the signal. A radiometer by comparison is a passive measuring instrument. It doesn't emit a signal. Instead it simply detects existing radiation such as the reflection of the sky radiation on the Earth's surface. Scientists at the FZJ are currently testing a combination of both systems. "We hope to use these measurements to answer questions which will be of use to a future NASA mission titled SMAP (Soil Moisture Active Passive)", explains Dr. Lutz Weihermüller, a researcher at the FZJ. The researchers want to find out how the two measuring systems compare and if they could complement each other. ■

MONITORING EVAPORATION

State-of-the-art technology from Jülich calculates water content in arable land

In a field outside the village of Selhausen, not far from the town of Düren, researchers from the Institute of Bio- and Geosciences (IBG-3) at the Forschungszentrum Jülich (FZJ) have put up a 10-metre high platform. Perched on top is an L-band radiometer with the help of which the scientists want to get a better picture of the soil below – more specifically, soil brightness temperature and consequently water content. The research focus is on the effects of surface structure on soil evaporation. "Up to now there has been very little research into the processes which are involved", explains Dr. Lutz Weihermüller. "But especially for countries which suffer from water shortages, that's exactly the type of information which is needed so that evaporation from the ground can be better managed." The test site is part of the TERENO observatory in the Eifel/ Lower Rhine Valley which is coordinated by the FZJ.

Data matching with the ESA

The researchers from the FZJ also perform field measurements with a mobile L-band radiometer

on various areas under cultivation with crops such as sugar beet, wheat, rape, and corn. These data are being collected in the context of the SMOS (Soil Moisture and Ocean Salinity) satellite mission, a campaign run by the European Space Agency (ESA). While the team from Jülich monitors soil moisture according to their own methods, a satellite uses a radiometer to relay information on soil moisture and ocean salinity. Back in Jülich, the data generated in Selhausen are initially used for model calculations, the researchers then pass them on to the ESA in order to calibrate the satellite measurements. ■



Researchers from the FZJ investigate the relationship between surface structure and evaporation from the ground

TAKING NIGHT CALLS

Listening post for bats built in to TERENO measurement tower

Working at night is part and parcel of bat research. Not at the Eifel National Park however; the first place in Germany to boast a permanent bat listening post. Set up in the middle of the forest on top of the 34-metre high meteorological tower at the TERENO research station "Wüstebach" it plays the role of an automated colleague, taking over all of the night work. The listening post is maintained by the Forschungszentrum Jülich (FZJ)

in collaboration with the volunteer-run bat protection societies Aachen, Düren, Euskirchen from the three big nature conservation groups in North Rhine-Westphalia (NABU, BUND and LNU).

Continual bat monitoring

The permanent listening post covers the area around the tree tops and the forest's lower branch level around the tower with the help of specialized microphones set up at two different levels. A high-quality ultrasound recording device processes the signals, which are then stored on a computer. In order to limit the amount of data stored, recordings are only made from sunset to sunrise. In addition, the device is only activated when a predefined ultrasound level is reached.

"We didn't have particularly high expectations given that there are only spruce trees in the Wüstebach Valley, which doesn't make it a very attractive forest habitat for bats", says Dr. Henrike Körber from the bat protection society. After four months of continuous monitoring there was a big surprise in store. More than 320,000 data files had been recorded. As was to be expected

the lion's share of the ultrasound producing background noises were from the rustling of leaves, wind or the beating of metal, which were roughly sorted by filter software. The conservationists sifted through the remaining 58,000 data files with specialist software and were left with 2,500 data files that could be identified as bat calls.

"There were bats flying by one of the microphones almost every night, periods of bad weather notwithstanding", explains Holger Körber from the bat protection society. "We have been able to identify six species with certainty". That is a good result for a coniferous forest. 90 percent of the calls were from the adaptable pipistrellus species, first and foremost the common pipistrelle. According to the records, the bats only spend a few minutes around the tower, even on days when the weather is good. "The likelihood of getting a reading on a night-time spot check with a mobile detector would be very low", says Dr. Henrike Körber. The conservationists want to analyze the data further, for example, to examine whether the current transformation of the forest from a spruce to a deciduous forest affects the bats' flight behavior. ■



Native to the Eifel National Park: the noctule bat

GREENHOUSE GAS FROM OUT OF THE GROUND

Researchers in Scheyern look for strategies to reduce emissions of nitrous oxide



Photos: HMGU

The small-scale agricultural landscape typical to Bavaria is also included in the Research Station Scheyern

It is a prized anaesthetic, but it offers no relief at all to our climate: laughing gas or nitrous oxide, a chemical compound with the formula N_2O is deemed much more dangerous than the more infamous climate-killer carbon dioxide (CO_2). One tonne of N_2O is as damaging as around 300 times that amount of CO_2 . It is estimated that 145 million tonnes of N_2O enter the Earth's atmosphere every year, predominantly through agriculture. It takes about 120 years for the odourless and colourless greenhouse gas to gradually dissolve. During that time it contributes to the green house effect in the troposphere, thereby damaging the ozone layer and acting as a catalyst for its destruction. It's for these reasons that scientists within the framework of TERENO are working to develop models and strategies to keep nitrous oxide emissions in the atmosphere as low as possible without impacting on agricultural productivity.

The gas exists naturally in very small quantities in the atmosphere. On Earth it is predominantly found in the soil. In what quantities depends on, amongst other things, soil type, temperature, rate of precipitation, insolation and the type of vegetation. Another significant factor is the human interaction with the ecosystem, for example through agricultural use of the soil. That is why Dr. Jean Charles Munch from the Helmholtz Center Munich - the German Research Center for Environmental Health, is conducting long-term experiments to understand gas flow between the soil, plants and the atmosphere at the Prielhof research farm which is part of the Scheyern monastic estate, a large-scale research area for agricultural ecosystem research in Upper Bavaria. The project is run in collaboration with the Technical University Munich (TUM) within the framework of TERENO.

Fertilizers a Risk factor

"Nitrous oxide is synthesized naturally whenever plant residues are broken down by microorganisms, reintroducing nutrients into the

element cycle", explains Munch. They convert organic materials into mineral nitrogen and nitrate which are important plant nutrients. Under certain ecological conditions the microorganisms reduce nitrate that isn't absorbed by plants into nitrogen gas, which is released into the atmosphere, an important process within the context of global biogeochemical cycles. This process spans various intermediate stages, one of which is responsible for producing nitrous oxide. If there are high concentrations of nitrate in the soil, due to intensive use of fertilizers in agricultural land for example, or from vegetation residues such as roots after harvesting, coupled with a deficiency of oxygen, then the microorganisms skip the last of these stages. Instead of converting nitrous oxide into nitrogen gas, which is not harmful to the climate and an important part of our atmosphere, they prefer to take up fresh nitrate. As a result, the nitrous oxide which is accumulated is released into the air. "That explains why highly fertile soil which is so well supplied with nitrogen is a major source of nitrous oxide emissions", sums up the researcher.

Data spanning 18 years

Simply reducing the amount of fertilizer would not solve the problem as this could also lead to a reduction in yield. "But given that the global population will soon hit 9 billion there is a need for ever more food and for more high quality, protein-rich food from agricultural soil", explains Munch. One alternative is to change how and when fertilizers are used, for example by administering it in several applications when plants absorb the largest possible amount of nitrogen and leave small amounts in the soil. On the downside, this is a more expensive and work intensive option, causing eventually soil compaction. Nevertheless, today's researchers are working hard to increase nitrogen efficiency with the help of state-of-the-art technology including on-site analysis of plant stands.

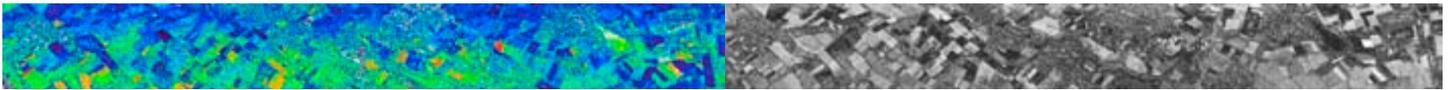
The amount of precipitation is also a factor in

determining how much nitrous oxide is released from the soil. Water-logged soil contains little oxygen, causing microorganisms to switch over to nitrate to maintain respiration, which leads to the release of large quantities of N_2O .

Researchers in Scheyern run different agrarian management systems, simulate climate conditions and measure nitrous oxide and other greenhouse gas emissions together with the soil factors that influence them. Analyses are performed for different crop rotations on different fields; fallow, ploughed or minimally tilled with different regimes of fertilizers. The research record of reliable data on the effects of atmospheric conditions and crop rotations spans some 18 years and is now being analysed. The aim is to develop predictive models which can be applied at a global scale and inform decision-making. ■

Researchers use containers which automatically open and close to measure gas exchange between the soil and the atmosphere (top). The soil is worked by tractor (bottom). It is also worked without a plough





MICROWAVES TRACING WATER

TERENO is taking off to measure soil moisture

If you want to get to the bottom of soil moisture, get high. That is, take a ride in a research aircraft like the Dornier Do228, which is operated by the German Aerospace Center (DLR) at their Oberpfaffenhofen location. The Dornier Do228 was already in service for TERENO research activities in 2008. Further flights are scheduled between April and June 2011.

The amount of moisture present in soil provides key information about the water cycle. It also plays an important role in regional weather development and the climate. "Our goal is to be able to measure soil moisture comprehensively and at a high repeat rate throughout Europe", explains Irena Hajnsek, a professor at the DLR Microwaves and Radar Institute in Oberpfaffenhofen. That wouldn't be achievable by taking measurements directly from the ground as it would require a comprehensive network of measuring stations.

One solution goes by the name of SAR, which stands for Synthetic Aperture Radar, a high-resolu-

tion method of remote sensing. An area is scanned by plane with microwaves while an on-board sensor measures how the waves are reflected by the soil, vegetation or built-up areas. Scientists can use the radar data to calculate soil moisture.

Comparisons with measurements from the ground

This method makes it possible to chart larger areas with a resolution of three times three metres. On the down side, other factors such as soil structure and vegetation also affect the radar signal. A first step in tackling this problem then, is to find an evaluation algorithm that extracts the correct soil moisture from the raw data. To this end, the Do 228 conducted a research flight over the Rur catchment area in 2008. It took around one hour to scan the in total three times 120 kilometres-long strip. Colleagues from the Forschungszentrum Jülich (FZJ) took direct measurements of soil moisture at selected sites within the strip in order to test the reliability of the ra-

dar readings. The tests are set to be continued in 2011. "We want to find out how vegetation influences the water balance of the underlying soil, and whether radar measurements can accurately document these variations", says Hajnsek, who is directing the flight campaign.

"An even easier and more cost-effective option with wider-ranging capabilities is afforded by satellite measurements", projects Irena Hajnsek. As yet, there is no high-resolution long-wave SAR mission which can measure soil moisture on a continual and qualitative basis. The DLR Microwaves and Radar Institute has issued a joint proposal for such a mission together with the NASA Jet Propulsion Laboratory. The primary mission objective of "Tandem-L" is to generate models of systematic and global dynamic processes on the Earth's surface with unprecedented accuracy and resolution. For example, this would include the generation of soil moisture-maps with a spatial resolution of 50 metres on a weekly basis. The scientists are very hopeful that such a mission will come to fruition. ■

Lift-off for science: A radar system on board the DLR's own Do 228 (bottom) measures how microwaves are reflected by soil and vegetation. The recorded data provides a soil moisture map with the help of an evaluation algorithm (top)



“LIKE A LARGE LIBRARY CATALOGUE”

Metadatabase at the heart of the TERENO data portal TEODOOR

From measurements recorded by weather radars and sensors to dissertations and publications: The goal is for every piece of data which is collected over the course of the TERENO project to be managed and made accessible through an integrative portal. To this end, the TERENO Coordination Team “Data Management” is developing the data portal TEODOOR. The portal will help scientists within the TERENO community, as well as external users, search, view and download data.

The data portal itself contains practically no data. “We have chosen a system of distributed databases, which means that the data are not all in one place. Instead, they are stored decentrally on various computers at the participating Helmholtz centres”, explains Dr. Ralf Kunkel from the Agrosphere Institute at the Forschungszentrum Jülich (FZJ), who heads up the coordination team. TEODOOR spans the network like an umbrella and provides integrated access to all data. This makes it possible for the system to expand and for new databases from other project groups, for example, to be integrated at any time.

“The challenge lies in the fact that the data are heterogeneous”, says Ralf Kunkel. Standardized data inputs and search tools are required in or-

der to access different databases. To ensure that this happens quickly and easily, TEODOOR uses the data exchange standard of the Open Geospatial Consortium (OGC). The international consortium for the development and standardization of geospatial data includes universities, businesses and institutions—NASA and Microsoft to name a few examples. The coordination team has built geospatial information systems, so called WebGIS, into the portal for the presentation of geospatial data. “You could call it Google for geospatial data”, explains the FZJ researcher.

Google for geospatial data

But it is really the metadata database that is at the heart of TEODOOR. “It’s like a large library catalogue listing where which data can be found”, explains Ralf Kunkel. Metadata are what make it possible for data records to be accessible at all: anywhere from 13 to 400 inscriptions describe the individual data records and specify where the data records can be found. The data portal is currently 70 percent complete. Work on the portal is set to be finished in the course of next year. ■

[TERENO Data Policy](#)

CONTACT | COORDINATION

Dr. Heye Bogena

Agrosphere Institute (IBG-3)
Forschungszentrum Jülich
Tel.: +49 (0)2461/61-6752
Email: h.bogena@fz-juelich.de

Prof. Dr. Hans Papen

Institute for Meteorology and
Climate Research (IMK-IFU)
Karlsruhe Institute of Technology
Tel.: +49 (0)8821/183-130
Email: hans.papen@kit.edu

Dr. Mike Schwank

Section 5.1 „Geoecology and Geomorphology“
German Research Centre for Geosciences GFZ
Tel.: +49 (0)331 288 28697
Email: mike.schwank@gfz-potsdam.de

Dr. Steffen Zacharias

Department of Monitoring and
Exploration Technologies
Helmholtz Centre for Environmental
Research (UFZ)
Tel.: +49 (0)341/235-1381
Email: steffen.zacharias@ufz.de

www.tereno.net

PUBLISHER

TERENO

Editorial Responsibility:

Christian Hohlfeld
www.trio-medien.de

Authors:

Henrike and Holger Körber,
Dr. Ursula Resch-Esser, Sabine Wygas

Translated by:

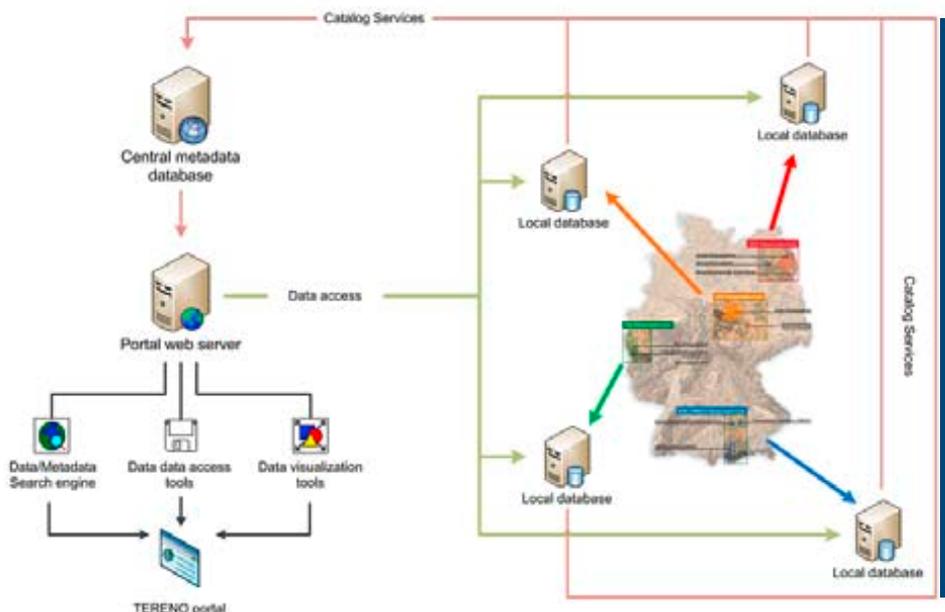
Christina Harrison

Graphic Design and Layout:

www.axeptDESIGN.de

FZJ Forschungszentrum Jülich (Coordination)
DLR German Aerospace Center
KIT Karlsruhe Institute of Technology
HMGU Helmholtz Zentrum Muenchen, German
Research Centre for Environmental Health
UFZ Helmholtz Centre
for Environmental Research
GFZ Helmholtz Centre Potsdam GFZ German
Research Centre for Geosciences

HOW DATA FLOW



Data collected within the framework of TERENO are not stored centrally on the data portal, but locally on different computers at the participating Helmholtz Centres. TEODOOR spans the network like an umbrella and provides integrated access to all data