Lofty heights: A new 50-meter high climate measurement tower at TERENO's "Hohes Holz" site enhances monitoring of water, energy and carbon dioxide exchange between vegetation and atmosphere.

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TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Newsletter 1/2015

CONTENTS

Better protection for a vital resource

The future of the Earth's soils is in our hands. But according to the "Bodenatlas 2015" published by BUND (Friends of the Earth Germany), some 24 billion tonnes of fertile soil are lost each year due to improper usage. To draw attention to this vital resource and increase the worldwide effort to protect it, the United Nations has declared 2015 the International Year of Soils (IYS). To better protect our soils, we first need to improve our understanding of their many functions – such as their role in water and material fluxes, or the exchange processes between soils, plants and the atmosphere. This requires that experts collaborate, share their knowledge and establish common standards across disciplines and national boundaries. TERENO engages in this effort by participating in various initiatives and conducting its own activities such as the TERENO International Conference.

HELMHOLTZ ASSOCIATION

NATIONAL INFRASTRUCTURE NETWORK

Establishing a national infrastructure platform for terrestrial research in Germany is one of the primary goals of the "Infrastructures in Terrestrial Research" working group, a five-year project set up by the Alliance of Science Organisations in Germany.

Members of the Alliance working group at the 2014 kick-off meeting in Bonn

Chaired jointly by the German Research Foundation (DFG) and the Helmholtz Association, the working group will promote more effective networking within the diverse and tradition-rich terrestrial research community in Germany. This includes identifying important themes for further development of the research field, for example by standardizing and harmonizing research, by improving the availability of data, and by better integrating German projects into international research initiatives. The working group intends to deliver a detailed concept plan with concrete implementation guidelines that will strengthen long-term interdisciplinary research in Germany. In the end, the goal is to strengthen working relationships and intensify collaboration with government authorities at the state and national level.

The working group, which began its work in early 2014, includes some 20 experts from different institutions, among them researchers from virtually every TERENO initiative partner. The establishment of the working group has its origins in the 2013 strategy paper "Long-Term Perspectives and Infrastructure of Terrestrial Research in Germany," in which the DFG, the National Committee for Global Change Research (NKGCF), and various other experts participated. The paper contains several ideas and recommendations for infrastructures in terrestrial environmental research at both national and international levels. ■

- Alliance working group "Infrastructures in Terrestrial Research"
- Strategy document "Long-Term Perspectives and Infrastructure in Terrestrial Research in Germany – a Systemic Approach"

Change of Coordinator

The TERENO observatory "Bavarian Alps/pre-Alps" has a new Coordinator: Dr. Ralf Kiese from the Institute of Meteorology and Climate Research (IMK-IFU) at the Karlsruhe Institute of Technology. Kiese replaces Prof. Hans Papen (also IMK-IFU), who entered retirement in early 2015. A hydrologist and head of the "Ecosystem Matter Fluxes" research group at IMK-IFU, Kiese has been Senior Scientist at IMK-IFU since 2003. His research focuses on the impact of global environmental changes on carbon and nitrogen fluxes in terrestrial ecosystems, as well as associated greenhouse gas emissions and nutrient depletion. ■

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New Member of the Advisory Board

Prof. Remko Uijlenhoet from Wageningen University in the Netherlands joined the TERENO Advisory Board in late 2014. An expert in hydrology and quantitative water management, Uijlenhoet's research focuses in particular on remote sensing of rainfall and the development of hydrological process models. A native of the Netherlands, Uijlenhoet has been a member of the scientific steering committee of HyMeX (Hydrological cycle in the Mediterranean Experiment) since 2008 as well as a member of the steering group for GEWEX (Global Energy and Water Cycle Exchanges Project), a core project of the World Climate Research Programme (WCRP), since 2014. ■

EDITORIAL

Networking on All Levels

"Networking networks" and "strength in numbers" are concepts that reflect well current activities in the area of terrestrial environmental research, where networks of researchers and research initiatives are growing, communicating and interacting at all levels. TERENO plays an important role in this trend to connect science across disciplines and infrastructures. Researchers at TERENO's participating institutions are involved, for example, in the working group "Infrastructures in Terrestrial Research" established by the Alliance of Science Organisations in Germany (see article on this page), in the Helmholtz Alliance "Remote Sensing and Earth System Dynamics" (see p. 8) and in the new EU project eLTER, which seeks to establish a European network of networks connecting long-term ecological research with Critical Zone Observatories and Critical Zone research (see p. 9). Today in Germany, preparations are underway to establish a national network of Critical Zone Observatories (CZO), and TERENO's observatories are considered possible candidates for this CZO network (see p. 8). In the US, the NSF launched its Critical Zone Observatory Program back in 2007 (see p. 8), and we can surely benefit from their experience over the last eight years. In the fall of 2014, the TERENO International Conference – the first large-scale event of its kind organized by the TERENO initiative – attracted participants across all disciplines, who exchanged ideas on how to advance the science of observation, and explored networking opportunities (see p. 4). We were impressed by the positive response to the TERENO conference. Some 100 lectures and 220 abstracts provided a broad spectrum of topics for in-depth discussions among the 250 participants, and various other activities provided participants with ample opportunity to make new contacts and deepen existing relationships.

I hope you enjoy this issue of the TERENO newsletter.

Sincerely, **Harry Vereecken**
TERENO Coordinator

SETTING THE BAR HIGH

New EU project eLTER to create unified European infrastructure – Interview with project coordinator Dr. Michael Mirtl

Austrian ecologist and environmental engineer Dr. Michael Mirtl is considered an expert in European environmental research infrastructure. As chairman of the European network for long-term ecosystem research (LTER Europe), Mirtl is working to establish a common research strategy and common standards for national networks across Europe. Dr. Mirtl is also coordinator of the EU's new eLTER project: European Long-Term Ecosystem and socio-ecological Research Infrastructure (see also p. 9).

Dr. Mirtl, the EU gave the eLTER project the maximum rating as part of its evaluation. It also described eLTER as an ambitious and urgently needed undertaking. What makes eLTER so important?
The EU is funding our project as part of a larger funding program "Integrating and opening existing national and regional research infrastructures of European interest". The goal of this program is to create a larger network of such infrastructures so that researchers throughout Europe can use them and benefit from them. This is a necessary step if we want to establish a European research area that is competitive internationally. With eLTER we are making our contribution to this in the area of environmental research. Our network, for example, unites the LTER research areas with "Critical Zone" research projects.

What exactly do you mean with 'unite'?
The main function of this kind of infrastructure is to provide services. As an example, a site might receive a request for certain data. In this case, the site operator needs to be able to deliver not only good quality scientific data, but must also have the technical capacity to process the specified data set and make it available in the desired format. We want to make sure all good sites are capable of delivering on this.


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Michael Mirtl heads the "Ecosystem Research & Environmental Information Management" department within Austria's Environment Agency. Mirtl is president of the Austrian Society for Long-Term Ecological Research (LTER-Austria), chairman of the European network LTER-Europe and, beginning September 2015, chairman of the global LTER network ILTER.

So you want to establish uniform standards?
If we want a system to manage and plan a truly European infrastructure, then we'll need to establish standards. These would apply, for example, to data collection methods in the field, quality assurance of measurements, data validation, and information technology. This can only work if there is a top-down process in place within a framework, such as eLTER, which defines the standards, ensures that the standards are complied with, and provides the necessary financing. We made a conscious decision to set high standards here. The risk of course is that things might not function as hoped, but we need to set the bar high if we want to find out where our weaknesses lie and learn from this.

Who develops the standards?
In LTER-Europe and the EU project eLTER we develop and test both services and standards. Through mechanisms and structures designed to facilitate cooperation, we gradually bring the European network to life. In eLTER, for example, we are working on a way to record up to one-hundred years' worth of data in such a way that it remains accessible and usable for future generations of researchers. The 5 million euros in EU funding also allows us to support sites that are not yet equipped with the equipment needed for such data exchange. One thing we do is create data nodes where site operators can store their data. The idea is to tailor the support according to each site's technical capabilities and needs.

Does that mean that you're gradually creating a centralized database for everyone?
No, centralized data storage is too cumbersome. Over the long term we want every site to have its own data node where data is stored and maintained according to standardized rules. The data is then accessed via a central access point which is supported with web services. The data pools of all eLTER partners within the community are then accessible to all – even beyond the fouryear term of the project.

What role does TERENO play in this?
As a source of high-quality data, the TERENO sites are an important component of this kind of European network. TERENO is a model example in several other respects as well: its hierarchical system for organizing field sites from small test areas up to entire regions, for example, or its exemplary infrastructure for data storage and access.

What were you able to take away from the TERENO conference?
I was able to deepen my understanding of a few of TERENO's technical aspects and was impressed by the size of the TERENO research community, and the wide range of disciplines it covers. I also found noteworthy the support that TERENO receives from the policy side and the fact that the exchange between researchers and the government research ministry is at a very high technical level already today. This certainly cannot be said of all European countries. I was also pleased by the very open discussion about the challenges TERENO faces when it comes to applying the results of their scientific research, i.e. how difficult it is to draw clear conclusions with regard to society and environment, or to make concrete action recommendations. But I hope that new scientific insights and initiatives such as eLTER will help us make progress on this front. ■

CONNECTING IDEAS AND INSIGHTS, BUILDING "ACTION KNOWLEDGE"

International TERENO-Conference
Sept. 29 – October 3, 2014
Bonn

250 researchers attend International TERENO Conference to discuss new ideas and approaches

Which innovative new methods will allow researchers more detailed and accurate measurements of evaporation and soil moisture? What are the latest findings on carbon dioxide exchange? How can existing data – on biodiversity, for example – be used more efficiently and effectively? This is just a small sample of the questions discussed at the TERENO International Conference held in Bonn, Germany from September 29 to October 3, 2014. "From observation to prediction" was the motto of the 2014 conference, which brought some 250 scientists together to discuss current developments and new approaches in terrestrial environmental research. Researchers presented their current projects with over 60 lectures and some 220 conference submissions (abstracts). In his opening remarks, TERENO Coordinator Prof. Harry Vereecken from Forschungszentrum Jülich summed up the challenges in terrestrial research today. "The goal is to continuously improve models and methods, to connect ideas and insights, and create stronger linkages between data sets in the area of hydrosphere, ground surface and atmosphere," said Vereecken. Wilfried Kraus from the Federal Ministry of Education and Research (BMBF) pointed out that policy makers are also interested in this. "Science delivers the knowledge – the 'action knowledge' – that policy-makers need to make the necessary decisions on how to deal with climate change," said Kraus.

Sold-out lecture hall: 250 scientists took part in the conference.

Evaporation as key mechanism

Prof. Dara Entekhabi from the Massachusetts Institute of Technology talked about a satellite mission to improve our understanding of evaporation, which is considered a key mechanism to connecting terrestrial water, energy and carbon cycles and improving our understanding of the Earth system. Today scientists still lack mature models and the data required for a more accurate understanding of the relationship between soil moisture and evaporation. Entekhabi, who is Science Team Leader of NASA's Soil Moisture Active and Passive (SMAP) satellite mission, wants to change this. Since January 2015, the SMAP satellite, in orbit some at 680 kilometers above the Earth's surface, is using both a radiometer (passive) and radar (active) to measure global soil moisture and its fluctuations at an unprecedentedly large bandwidth. Entekhabi plans to use this data to expand and enhance his evaporation model. The TERENO project is also involved in the SMAP mission (see p. 6).

Unexplained fluctuations in CO_2 levels

CO_2 is considered one of the most important greenhouse gases and contributors to global warming. Despite extensive research, however, scientists still disagree on how to predict fluctuations in CO_2 concentrations in the ecosystem. So far, these fluctuations appear to be quite random. One of the problems, according to Prof. Matt Williams from the University of Edinburgh, is that current models cannot yet describe the CO_2 exchange between soil and atmosphere with sufficient precision, and data available for developing models still consists largely of isolated measurements.

At the conference, Williams presented the CARDAMON project, which combines modeling with satellite observation data, data from eddy flux towers and plant-trait data as a way to "up-scale" data sets from the site to the to the regional level. Among other results, the project has generated a model that describes the CO_2 exchange between soil and atmosphere for the period 2001-2010.

A map of nitrous oxide emissions

Another greenhouse gas is nitrous oxide, also known as laughing gas. As part of the TERENO project, Prof. Klaus Schäfer from the Karlsruhe Institute of Technology and Dr. Daniel Weymann from Forschungszentrum Jülich are researching the nitrous oxide exchange between soil and atmosphere in various locations with the help of measurement instruments such as lysimeters (for fields) or underwater measuring tunnels. Their goal is to contribute to a comprehensive land registry, which would depict – similar to a map of the landscape – where greenhouse gases are emitted and in what concentration.

Another study on nitrous oxide was presented by doctoral candidate Shurong Liu from Forschungszentrum Jülich. Liu had investigated the formation of nitrous oxide in the soils of a Norwegian forest via nitrification, which involves the conversion of ammonia to nitrate by bacteria, as well as via denitrification, the process by which nitrate is reduced to molecular nitrogen. Liu's studies reveal not only the location of hot-spots, but also suggest that hydroxylamine, a colorless chemical intermediate, is useful for predicting nitric oxide emissions.

No lack of input for conference participants: Approx. 60 lectures and 220 conference submissions.

Standardizing data for a more accurate picture of biodiversity

"We know that we're losing them, but we still lack basic data." This was how Dr. Christoph Häuser from the Museum für Naturkunde in Berlin opened his TERENO conference lecture on biodiversity. The decline in species diversity among both plants and animals demonstrates the impact of climate change perhaps more shockingly than any other phenomenon. At the same time, research findings in the area of biodiversity remain surprisingly vague. A lack of data, according to Häuser, is not the problem. Satellite data combined with field observations are generating enough information. The problem is that the data is scattered across many databases and, for the most part, has not yet been standardized. The good news? Häuser sees a potential solution in two of today's key technologies. Smart phones, for one, provide a simple way for both researchers and lay people to gather standardized data; at the same time, big data technology makes it more and more possible to process large amounts of data.

Q & A: Conference lectures provided an opportunity to discuss new approaches and insights.

In his lecture on AgroScapeLabs, a large-scale project focusing on experimental biodiversity research in real landscapes, Prof. Gunnar Lischeid talked about the complexities of trying to understand biodiversity. As part of the AgroScapeLabs project, researchers investigated the relationship between land use and biodiversity at a 450 square kilometer test site within the Northeastern German Lowland TERENO observatory. Conducted over the course of several years, observations of flora, fauna, hydrology and soils revealed that the fields in northeastern Germany are by no means as homogenous as they seem, and that small differences, such as differences in the vegetation surrounding a pond, can have a significant impact on the biodiversity of the surrounding area. ■

Many participants used the poster sessions to get some valuable "face time".

Media coverage of the TERENO conference
German only

Bonn General-Anzeiger, Sept. 30, 2014

▶ Die Anamnese des Bodens

Deutsche Welle, Oct. 1, 2014

▶ Tereno – vom Waldboden lernen

Deutschlandfunk (radio report by Volker Mrasek), Oct. 2, 2014

▶ Moore – Hoher Methan-Ausstoß bei Wiedervernässung

Nearly all lectures and abstracts can be found on the conference website:

▶ International TERENO Conference 2014

TERENO insights

The conference concluded with a visit to TERENO's Wüstebach test site in the Eifel National Park, where researchers have been working since 2009 investigating water and material fluxes between soil, vegetation and atmosphere using a range of different measurement instruments. Dr. Heye Bogena (2nd from left) from Forschungszentrum Jülich shows visitors the measurement devices used to gather water budget data.

NEW METHOD FOR PREDICTING SUBGRID VARIABILITY OF SOIL WATER CONTENT

Soil water content can vary considerably even within the few square meters contained in a single model grid cell. Understanding this subgrid variability of soil water content is important to further improve prediction accuracy of water and energy fluxes. TERENO researchers in Jülich and Munich developed a new method which allows them to describe the water content variability using basic soil data, and presented their method in the prestigious journal Geophysical Research Letters.

Jülich researchers use a mobile drilling rig to collect soil samples and analyze soil properties. Sensors used to measure soil moisture are then installed in the bore holes.

Researchers from Forschungszentrum Jülich's Institute of Bio- and Geosciences (IBG) and the Helmholtz Center's Institute of Soil Ecology in Munich conducted a stochastic analysis of the unsaturated soil water flow based on the existing van Genuchten-Mualem (VGM) model. The parameterization of the VGM model was accomplished using basic soil information and so-called pedotransfer functions, which can be used to derive hydraulic parameters from information on soil texture, e.g. sand and clay content. The researchers used soil data from various test sites to confirm the effectiveness of their new method. This included data sets from three TERENO test sites (Rollesbroich, Wüstebach and Scheyern) gathered using TERENO's "SoilNet" wireless sensor network, as well as data from additional test sites in China and Australia.

▶ Wireless Sensor Network SoilNet

The new method makes it possible to estimate the small-scale spatial variability (subgrid variability) of soil hydraulic properties. In addition, the method could also be used to estimate subgrid variability of soil water content with the help of global soil maps, and to improve prediction accuracy of large-scale hydrologic, weather, and climate models. This information might also make it possible to estimate the uncertainty of global-scale remote sensing measurements of soil water content, including data from ASCAT (Advanced SCATterometer), ESA's SMOS (Soil Moisture and Ocean Salinity) mission and NASA's SMAP (Soil Moisture Active Passive) mission. ■

Wei Qu, Heye Bogena, Johan Alexander Huisman, Jan Vanderborght, Max Schuh, Eckart Priesack, Harry Vereecken. *Predicting sub-grid variability of soil water content from basic soil information*. Geophysical Research Letters, 42, 2015.

▶ DOI: 10.1002/2014GL062496

FOUR MORE YEARS FOR TR32

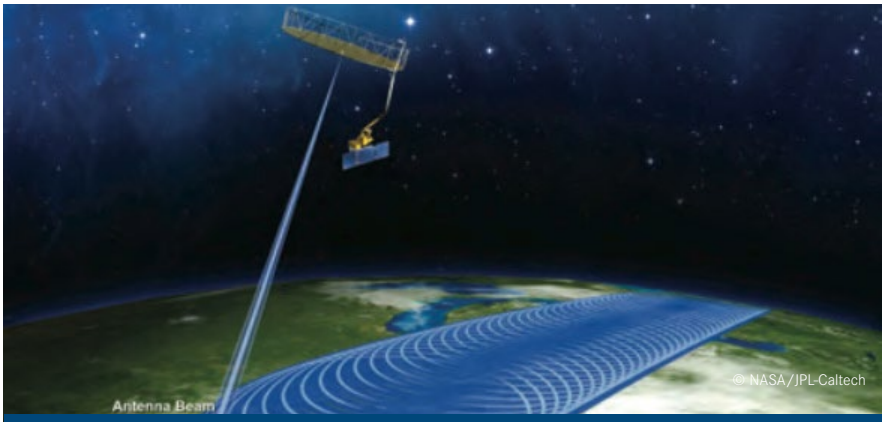
The German Research Foundation (DFG) has extended funding for its Transregional Collaborative Research Centre 32 (TR32) "Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling & Data Assimilation" for another four years through the end of 2018. First launched in 2007, TR32 thus reaches the maximum 12-year funding period for special research projects as defined by the DFG. TR32 will receive some 11.5 million euros in funding from the DFG for this third phase of the project.

▶ Transregional Collaborative Research Centre 32

An interdisciplinary collaboration between RWTH Aachen University, University of Bonn, University of Cologne and Forschungszentrum Jülich, TR32 investigates material and energy fluxes as well as the complex exchange processes between soils, plants and the atmosphere. TR32 researchers collaborate closely with TERENO, with two TR32 research areas – the Erkensruhr river catchment in the Eifel and the Wüstebach basin – located within the "Eifel/Lower Rhine Valley" TERENO observatory. This allows TR32 researchers to take advantage of TERENO's wealth of measurement tools and data. ■

SMAP SATELLITE PROVIDES FIRST SOIL MOISTURE DATA

TERENO researchers evaluate NASA measurements



To capture as large an area possible on each flyover, the satellite antenna rotates a full 360 degrees every four seconds.

The US space agency NASA has successfully launched its Soil Moisture Active & Passive (SMAP) mission. In January 2015 a carrier rocket brought the Earth observation satellite into orbit, which began providing data in April. SMAP combines active and passive microwave remote sensing into a single observation system to record global measurements of soil moisture, and is also focusing on soils in the higher latitudes where the soil makes the transition from the frozen to thawed state. Researchers hope to use the SMAP data to enhance their understanding of the processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models.

TERENO researchers are among the scientists eagerly awaiting the SMAP data. The Eifel/Lower Rhine Valley TERENO observatory is one of the official validation sites whose job is to evaluate the accuracy of the SMAP soil moisture products. For this, sensors in the upper 5cm of the soil provide online data for direct comparison with SMAP. The German Aerospace Center (DLR) together with the Agrosphere Institute of Forschungszentrum Jülich used data from an airborne campaign in 2013 to evaluate the current SMAP active and passive fusion algorithms (see TERENO Newsletter 2013/1).

TERENO researchers continue to advance these techniques. Combining active and passive signal types in this way is more effective than a single instrument when it comes to decoupling soil moisture effects from the effects of vegetation or roughness. “In a first study we concluded that the current SMAP baseline algorithm is more accurate than the alternative algorithm being discussed,” explains Jülich researcher Dr. Carsten Montzka. “It is better to first disaggregate the passive sensor data with the help of active microwave backscatter and then invert to soil moisture.” ■

▶ NASA’s SMAP mission

HGF ALLIANCE GROWS AND INTENSIFIES SCIENTIFIC EXCHANGE

The HGF Alliance “Remote Sensing and Earth System Dynamics” (EDA) continues to grow. Initiated in 2012 (see TERENO Newsletter 2013/1), EDA today involves more than 120 researchers from eight Helmholtz centers, eight universities and three non-university research institutions in the effort to develop innovative global bio/geo-physical satellite remote sensing products and integrate them in Earth system models. As the network continues to expand, a major component of EDA’s activities is to promote greater scientific exchange between the participating partner organizations – not only in HGF focus areas of biosphere, geosphere, hydrosphere and cryosphere, but beyond these areas as well. Several seminars, summer schools, workshops and joint field campaigns have been conducted over the past few years to help realize this goal, demonstrating that collaboration at established research areas can lead to valuable synergies between researchers of different work packages and research institutions. The TERENO test sites are good examples of this in the areas of biosphere and hydrosphere.

Participants in the 2nd Helmholtz “Alliance Week” in summer 2014 in Garmisch- Partenkirchen

Given EDA’s emphasis on networking and exchange, the “Alliance Week” has become a central event on its annual calendar. Over the past few years the event has evolved into an important forum for scientific exchange and for the planning of future projects. Some 100 researchers take part in the event each year, including representatives from the participating institutes, the HGF Alliance committees, and other international institutions. The next Alliance Week will take place in June 2015. ■

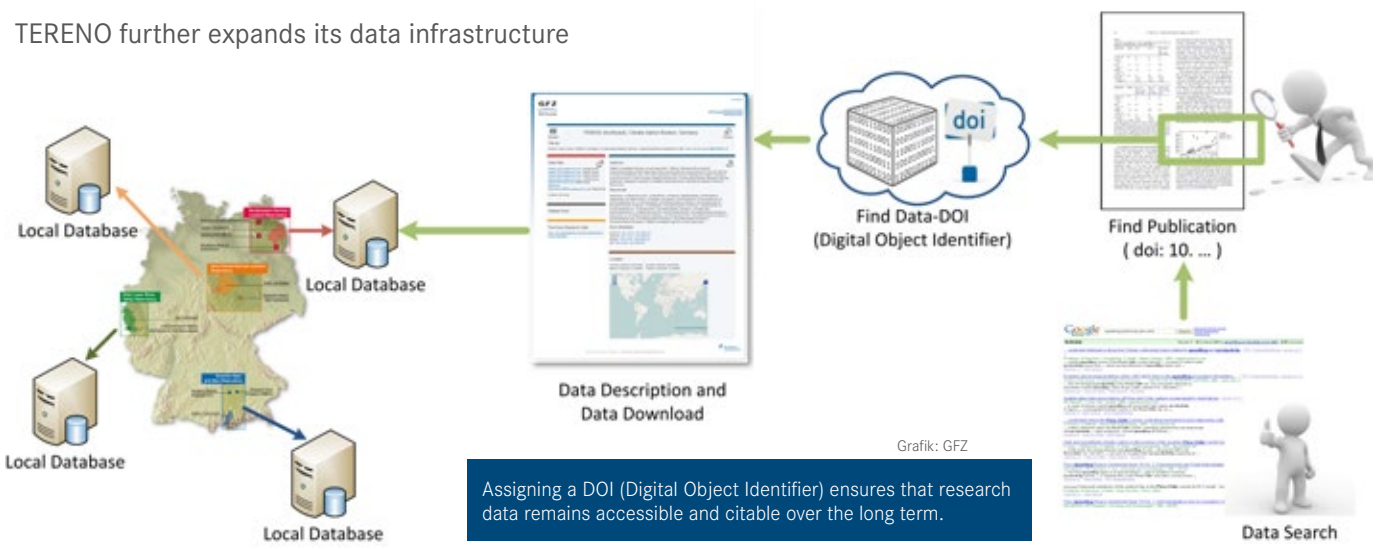
3rd HGF Alliance Week

June 22 – 26, 2015 Garmisch-Partenkirchen / Germany

▶ Helmholtz Alliance: Remote Sensing and Earth System Dynamics

A DOI FOR SENSOR DATA

TERENO further expands its data infrastructure



Grafik: GFZ

Assigning a DOI (Digital Object Identifier) ensures that research data remains accessible and citable over the long term.

The success of long-term, data-intensive projects such as TERENO depends a great deal on how the data is handled. Having a well-organized system for data storage, data access, and data exchange between project partners is key. Citability also plays an important role. Researchers, for example, should be able to explicitly reference any data set used or referred to in a publication. Members of TERENO's Data Management working group at the GFZ German Research Centre for Geosciences want to realize this with the help of the digital object identifier (DOI) – an unique identifier used mainly for online versions of academic journal articles.

"We are currently developing a method that will automatically describe data sets using a single, uniform system, and assign each data set a unique DOI," explains Vivien Stender from GFZ's Centre for GeoInformation Technology CeGIT. In this way, each data set receives a persistent identifier and becomes permanently accessible and citable.

Each of the four TERENO observatories uses its own data portal to bundle data. The Northeastern German Lowland TERENO observatory, for example, which is operated by the GFZ, comprises five different research areas. "The challenge lies in administering and processing the heterogeneous data sets," says Stender. "These are collected using various GFZ measurement technologies and are submitted by many different cooperation partners, including the University of Rostock, the Leibniz Centre for Agricultural Landscape Research (ZALF) and the German Aerospace Center (DLR), and all of this data must be provided in compliance with Open Geospatial Consortium (OGC) standards." The Public TERENO Data Portal was developed to facilitate the distribution of TERENO data and ease the search for relevant data sets (see TERENO Newsletter 2011/1). "This allows single access to all data contained in the portals of the different observatories," explains Dr. Ralf Kunkel from the Agrosphere Institute at Forschungszentrum Jülich. The TERENO data portal also provides tools for data access, recognition and visualization. ■

▶ TERENO Data Portal

WORKING TOWARDS AN INTERNATIONAL NETWORK OF CRITICAL ZONE OBSERVATORIES

Participants in the CZO workshop in Jena

A workshop held May 15-16, 2015 at the Max Planck Institute for Biochemistry in Jena focused on the development of a Germany-wide network of Critical Zone Observatories (CZO). More than 20 scientists in various fields from Helmholtz centers, universities, and other institutions discussed shared research goals and issues. The outer part of the Earth's crust is considered a "critical zone", where most of the Earth's exchange processes and metabolic cycles take place. The workshop's participants shared the view that a future network should cover land-use variability and climate variability in central Europe. Eight to ten potential sites were identified as locations which could be expanded to become CZOs, and six of these infrastructure sites are located within TERENO observatories. There was consensus that the CZO network in Germany should concentrate primarily on developed areas, and that research topics could include reaction, capacity, and rehabilitation of the critical zone. A further focus should be on the "anthroposphere" (humanity's living environment) and on consequences of land use. The next CZO meeting will be organized together with Chinese colleagues in September 2015 in Nanjing, China. This meeting will provide a good opportunity to exchange views and further the establishment of an international CZO network. ■

A NETWORK FOR ALL

National program in the U.S. leads the way in Critical Zone research

Research into the Earth's "Critical Zone" has rapidly gained in importance over the last several years. The U.S. has led the way in the field since 2007, when the country's federal funding agency, the National Science Foundation (NSF), launched the comprehensive Critical Zone Observatories National Program. Originally comprising three Critical Zone observatories (CZOs), the program today consists of a total of 10 CZOs distributed across the U.S., from California in the west to Puerto Rico in the east.

"The U.S. CZOs are community resources – serving as both infrastructure and collaboratory," explains Henry Lin, Co-Principal Investigator of the Susquehanna-Shale Hills CZO. "It funds individually formulated, long-term research projects that together form a larger network." Lin, Professor of Hydropedology/Soil Hydrology at Pennsylvania State University and member of the TERENO Advisory Board, is also co-investigator at Intensively Managed Landscape (IML) CZO. At each of the ten CZOs, interdisciplinary research teams investigate the interactions between rock, soil, water, air, and living organisms and how these interactions shape the Earth's surface. With a total program staff of 250, each of the CZOs has a different area of focus, determined mainly by different environments at each CZO site – from farmland to forests to mountain regions.

For all CZOs, however, the overarching goal remains the same: to quantify and better understand the complex processes in the Critical Zone. Based on the CZO's collective results, investigators are looking to develop new insights into the Critical Zone. At the same time, investigators are developing coupled models to help predict how human activity, climate change and geologic change impact the Critical Zone.

Pennsylvania State University students investigate a hole in the soil in the Susquehanna-Shale Hills Critical Zone Observatory. The metal plate is buried in the ground to help calibrate ground-penetrating radar.

The national-level CZO program ensures a common framework so that data, for example, can be shared between observatories or various monitoring programs aligned with one another. Access to the observatories and CZO-generated data, however, is not limited to the investigators directly involved in the program. One of the program's key objectives is to collaborate closely with research institutions and other programs – and to integrate graduate students, undergraduates and other young researchers into the investigation process.

International collaboration also plays an important role. For Lin, a partnership between the American CZOs and TERENO is a "very real possibility" given the many common areas of interest and investigation. ■

▶ Critical Zone Observatories
U.S. NSF National Program

EUROPEAN ENVIRONMENTAL RESEARCH CLOSES RANKS

Existing research sites united by the EU's new infrastructure project eLTER

Global challenges require joint international efforts, and this applies to ecological research as well. One such challenge is to better understand the complexity of ecosystems and the interplay between ecosystem functions. Bundling various networks into one common network is the order of the day, and the European Commission has now approved a project that takes on this challenge: the European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER), which is part of the EU's "Horizon 2020" framework program for research and innovation.

Nature provides us with vital raw materials, water and food. In addition, maintaining nature's productive and adaptive capacity is critical to our ability to adapt to climate change. Human societies are highly dependent on access to these ecosystem services, which is why ecosystem research is such a hugely important branch of research today. In Europe there are already numerous sites devoted to long-term ecosystem research. eLTER brings these test areas together into a common network so that researchers can make optimal use of the test sites in their effort to better understand Europe's most important ecosystems.

To this end, eLTER brings together the existing European LTER network (Long-Term Ecological Research) with the most important projects in the area of critical zone research – an area which has established itself in Europe over the last several years. The goal is to improve cooperation and alignment between research projects and approaches, to provide appropriate information technologies and platforms, and to facilitate further development of measurement tools and technologies for ecological observation and research. TERENO is an important project partner. Researchers at the Helmholtz Centre for Environmental Research and Forschungszentrum Jülich, for example, are involved in defining, developing and establishing methodological and technological standards for European ecological research, and are collaborating with project partners on developing a platform for integrated ecosystem models. ■

eLTER in numbers

28 partner institutions/facilities
162 test areas
22 countries
5 million euros in funding
4 year term (beginning mid 2015)

The new tower at the "Hohes Holz" site allows measurement of water and carbon fluxes.

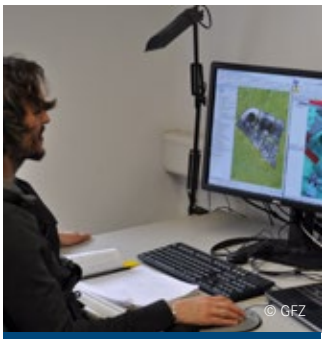
NEW CLIMATE MEASUREMENT TOWER IN THE BODE CATCHMENT

A new climate measurement tower was installed in June 2014 at TERENO's "Hohes Holz" research site operated by the Helmholtz Centre for Environmental Research – UFZ. Researchers at "Hohes Holz" have been measuring carbon and water fluxes since 2012. The 50-meter high measurement tower, which is maintained by UFZ researchers Dr. Corinna Rebmann and Dr. Matthias Cuntz, now expands the available research "toolset". Using the eddy covariance method, for example, researchers can conduct high temporal resolution measurements of the net exchange of water, energy and carbon dioxide between vegetation and atmosphere. They can also use the tower to monitor a number of other parameters important to understanding exchange fluxes – including air temperature and humidity, photosynthetically active radiation, wind speed and direction, as well as concentrations of CO_2 and hydrogen – at several different heights above the ground. The tower also features cosmic ray neutron sensors, which help measure water content of biomass and soil. Located in the Bode River catchment, the "Hohes Holz" forest research site is also part of the international research infrastructure network ICOS. ■

PRECISION FARMING GETS SUPPORT FROM OUTER SPACE

Soil pattern analysis at the field scale

Soil data with high spatial resolution becomes increasingly important as an enabler of environmentally sustainable land use. Since 2013, researchers at the GFZ German Research Centre for Geosciences working at the German Aerospace Center's calibration and validation test site DEMMIN, have analyzed soil patterns from satellite imagery to see what kinds of information these patterns can provide.



Visual analysis of soil patterns

Insight gained into the temporal-spatial variability of soil patterns can then be used to generate basic soil information maps for precision farming. The goal of precision farming is to understand and respond to differences in soil characteristics and soil productivity within a single field. The soil information maps make it possible to adjust the cultivation of the field according to these variations so that farmers can save on agrochemicals, fuel and labor.

Researchers first analyze time series from the satellite data to select appropriate bare soil images. The soil pattern analysis is based on 54 RapidEye satellite images with a spatial resolution of 6.5 meters. The respective soil reflectance patterns provide information on the spatial variability and temporal stability of detected soil patterns. Researchers were able to exclude temporal reflectance patterns – i.e. temporary variations that arise due to vegetation and land management practices – when generating the models and soil information maps. More than 700 soil surface samples were taken from the bare soil fields at the DEMMIN site in order to validate the reflectance patterns identified by the satellite images.

Soil samples from the demonstration site were analyzed in the lab for their humus and carbonate content, as well as grain size. "There's a particularly strong correlation between humus content and the soil's reflectance patterns," explains Gerald Blasch, doctoral candidate at the GFZ. "By combining analysis of soil samples and satellite images, we can identify precise patters of soil humus content across space and time. The method is currently being tested on other fields in the region. The goal is a regional forecasting model that does not require costly soil analysis." ■

Gerald Blasch, Daniel Spengler, Christian Hohmann, Carsten Neumann, Sibylle Itzerott and Herrmann Kaufmann. *Multi-temporal soil pattern analysis with multispectral remote sensing data at the field-scale*. Computers and Electronics in Agriculture Volume 113, April 2015, pp. 1–13.

▶ DOI: 10.1016/j.compag.2015.01.012

PROXY DATA INDICATE GREATER FLUCTUATION OF LAKE LEVELS

Proxy data provide new insight into lake-level dynamics

A diver takes samples from submerged tree remains on the lake bottom.

Researchers from the GFZ German Research Centre for Geosciences joined forces with colleagues from several other research institutions to systematically combine observational data with reconstructed data in an effort to better understand lake-level dynamics for two lakes in the Schorfheide area north of Berlin. This novel approach allowed the team to reconstruct the lake-level dynamics of the last 90 years.

Their findings revealed surprisingly large fluctuations within just a few decades, prompting the team to warn against landscape dynamics analysis and/or predictions without the benefit of historic data.

Determining the impact of climate and land-use changes on the regional water budget requires data on changing water levels in streams, rivers, lakes and aquifers. In many cases, however, data of this kind has been compiled only in recent decades, and a longer observational period is often required to accurately understand the causes of change. Researchers must therefore combine observational data with reconstructed data – so-called proxy data – which allows them to model continuous-time series for longer periods, including periods during which no observations were made.

For both lakes, researchers combined the use of gauging records, aerial imagery and map imagery with lake-level modeling and dendrochronological data on submerged tree remains. Lake levels for both of these closed lakes were found to have been several meters lower in the first half of the 20th century than they are today. Lake levels reached their maximum in the 1980's before falling significantly again by the mid-2000s. The research team considers these fluctuations across relatively short time periods to be closely related to weather changes. ■

Knut Kaiser, Ingo Heinrich, Iris Heine, Marco Natkhin, Ralf Dannowski, Gunnar Lischeid, Thomas Schneider, Johanna Henkel, Mathias Küster, Karl-Uwe Heussner, Oliver Bens, Jana Chmieleski. *Multi-decadal lake-level dynamics in north-eastern Germany as derived by a combination of gauging, proxy-data and modelling.* Journal of Hydrology, 2015.

▶ DOI:10.1016/j.jhydrol.2014.12.057

TERENO:ROVER FOR MOBILE SOIL MOISTURE MEASUREMENTS

The TERENO:Rover allowed researchers to create high-resolution soil moisture maps while "driving by".

The Helmholtz Centre for Environmental Research – UFZ has deployed a mobile Cosmic Ray Sensor system, the "TERENO:Rover" since summer 2014. Data from the Rover allows UFZ researchers to measure soil moisture patterns at larger scales. While on the move, the Rover measures at one minute intervals the average soil water content across an area of ca. 10-20 hectares at a depth between 10 and 70 centimeters. As with stationary Cosmic Ray Sensors already being used in the TERENO observatories, the Rover passively measures the number of neutrons in the air above the soil surface. The neutrons are generated by cosmic rays and then reduced by the presence of water.

During the TERENO International Conference 2014, the Rover also spent a day roaming TERENO's Eifel/Lower Rhine Valley Observatory. The Rover has also visited and calibrated all ten stationary Cosmic Ray Sensors positioned at this site from the lowlands to the southern mountain region. "Mobile measurements also make it possible to capture spatial patterns of water content between measurement sites. In this way the Rover helps to interpolate the data to the regional scale," explains UFZ researcher Martin Schrön.

For summer 2015 researchers plan to conduct comparative studies using different measurement instruments at TERENO's Peißenberg-Fendt site. Data delivered by TERENO:Rover has great potential to improve the parameterization of hydrological models. It could also be used in flood prevention as a way to estimate water retention potentials in catchment areas. ■

TERENO media coverage

Deutschlandfunk, Nov. 11, 2014

▶ Cosmic Ray Rover – Wie Sternenexplosionen bessere Bodenfeuchte-Messungen ermöglichen

TURNING SOURCES BACK INTO SINKS

Investigating the greenhouse gas balance in rewetted mires

Since 2013, researchers have been monitoring efforts to restore two mires contained within the Northeastern German Lowland TERENO observatory. The Helmholtz Young Investigator group TEAM (Trace Gas Exchange in the Earth-Atmosphere System on Multiple Scales) based at the GFZ German Research Centre for Geosciences, along with their partners from the Leibniz Centre for Agricultural Landscape Research (ZALF) and the University of Rostock, are investigating the exchange of climate-relevant trace gases.

Intact mires provide an effective natural sink for atmospheric carbon, but over the last two centuries, approximately 95% of Germany's mires have lost this sink function. Largely due to degradation resulting from intensive drainage efforts and agricultural usage, these former "sinks" have become, instead, "sources" of unwanted carbon. Extensive rewetting measures have been underway since the mid 1990s and scientists hope that raising water levels will help reduce emission levels and restore the mires' natural sink function as much as possible. There is a trade-off, however: the process involves a significant increase in methane emissions, if only temporarily. This is an undesirable outcome in terms of climate-protection and scientists do not yet know how long these methane emissions persist.

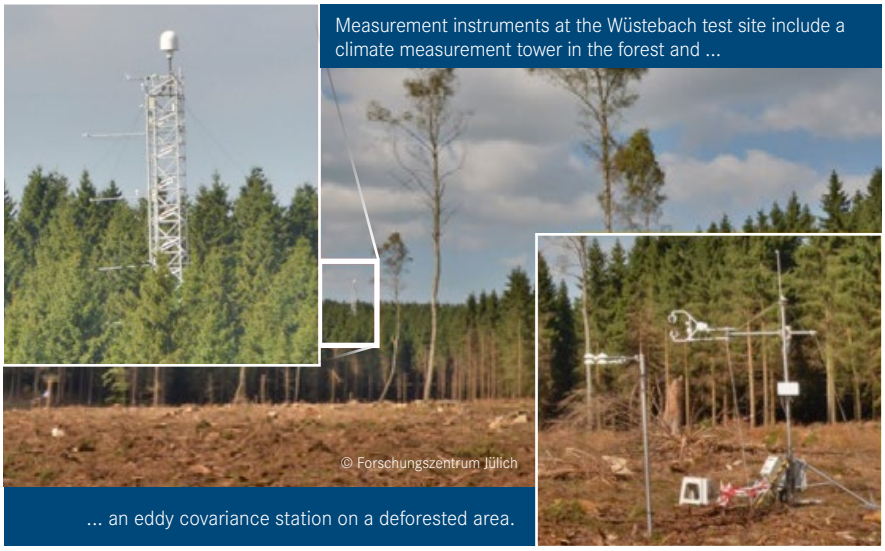
In response, researchers are conducting continuous, high temporal resolution monitoring of the exchange of climate-relevant trace gases between earth (soil, water, vegetation) and atmosphere at the two mires using the micrometeorological eddy covariance method. One of the core objectives of TERENO is to balance energy and matter fluxes in the earth-atmosphere system and achieve a better understanding of spatial and temporal patterns.

Eddy covariance measurement tower and automatic measurement chambers in the Peenetal wetland

The data from the first year of monitoring is currently being analyzed at the GFZ. "Along with the greenhouse gas balance we are mainly interested in the spatial variability of the carbon dioxide and methane exchanges within our investigation sites," explains Dr. Torsten Sachs, who leads the Young Investigator group. TEAM researchers want to better understand how different forms of vegetation differ from one another, how they differ from any remaining open water, and the impact of different environmental parameters on gas exchange. ■

▶ **TEAM – Trace Gas Exchange in the Earth-Atmosphere System on Multiple Scales**

EFFECTS OF DEFORESTATION ON WATER, ENERGY AND MATTER FLUXES



Measurement instruments at the Wüstebach test site include a climate measurement tower in the forest and ... ... an eddy covariance station on a deforested area.

In keeping with the core themes of the TERENO project, the investigators focused on the water, energy, and matter fluxes as well as the biological and physical drivers of these fluxes. The results of the Wüstebach experiment demonstrate that TERENO's terrestrial observatory concept allows for a detailed monitoring of changes in hydrological and biogeochemical states and fluxes triggered by environmental disturbances. The integrated hydrometeorological monitoring system, for example, was able to adequately capture different components of the local water balance during the observation period. The measured precipitation was nearly identical with the sum of actual evapotranspiration and runoff as measured by the researchers. ■

The Eifel National Park is currently transitioning the predominant conifer monoculture into near natural mixed-deciduous forest, which requires the removal of a significant proportion of spruce stands. This impacts the Wüstebach TERENO test site, which lies within the national park (see TERENO Newsletter 2013/2). Forschungszentrum Jülich is conducting ongoing investigations to determine the effects of such a disturbance on the forest ecosystem. In the academic journal SCIENCE CHINA Earth Sciences, the researchers and their colleagues from the University of Bonn and Trier University present the integrated observation system along with their first measurement results.

Heye Bogena, Roland Bol, Nils Borchard, Nicolas Brüggemann, Bernd Diekkrüger, Clemens Drüe, Jannis Groh, Nina Gottselig, Johan Alexander Huisman, Andreas Lücke, Anna Missong, Burkhard Neuwirth, Thomas Pütz, Marius Schmidt, Michael Stockinger, Wolfgang Tappe, Lutz Weihermüller, Inge Wiekenkamp and Harry Vereecken. *A terrestrial observatory approach for the integrated investigation of the effects of deforestation on water, energy, and matter fluxes.* Science China: Earth Sciences, 2015, Vol. 58, No. 1: pp. 61–75.

▶ DOI: 10.1007/s11430-014-4911-7

HOW OLD RIVER CHANNELS LIVE ON

Geophysical measurement method provides explanation for unexpected plant growth

A two-month drought period led to a surprising discovery in the vicinity of TERENO's Selhausen test site. Data from the RapidEye Earth observation satellite revealed the presence of riverbed channels many thousands of years old. The changes in vegetation caused by the drought made the structural patterns of the old channels clearly visible in the satellite images. Researchers at Forschungszentrum Jülich conducted a detailed investigation of the soil characteristics along the channel structures using electromagnetic induction (EMI), a non-invasive geophysical measurement method.

The research team mapped the electrical conductivity (ECa) of the soils up to a depth of 1.8 meters. The ECa data was then compared with the patterns revealed by the Leaf Area Index (LAI) data derived from the RapidEye satellite images. Researchers found that

Satellite image of TERENO's Selhausen test site. Growth anomalies along the old river channels are clearly recognizable within the circle below (dark shadows). The colored areas show the results of the EMI measurements. In the circle above, the red areas, which indicate higher electrical conductivity, reveal the bends in the old river bed. These areas were examined in detail by the Jülich researchers.

a strong correlation between ECa data and LAI patterns, which reflect plant growth, could only be established for deeper soil layers. "This could be due to the fact that the topsoil, as a result of agricultural activity such as plowed furrows, has undergone significant changes and been mixed with soils from surrounding areas," says Prof. Jan van der Kruk from the Agrosphere Institute at Jülich. The analysis of the soil probes confirmed that the old channels, which are today filled with high clay-content sediments, have a higher electrical conductivity (ECa) compared to the surrounding soils, which have higher sand and gravel content. "The higher clay content in the filled-in channels likely increases the water storage capacity, which could explain why these areas exhibit better crop development in drought periods compared to surrounding soils," says van der Kruk. ■

Sebastian Rudolph, Jan van der Kruk, Christian von Hebel, Muhammed Ali, Michael Herbst, Carsten Montzka, Stefan Pätzold, David Robinson, Harry Vereecken and Lutz Weihermüller (2015). *Linking satellite derived LAI patterns with subsoil heterogeneity using large-scale ground-based electromagnetic induction measurements.* Geoderma, Vol. 241, 2015, pp. 262–271.

▶ DOI: 10.1016/j.geoderma.2014.11.015

HILLSLOPE MOISTURE DYNAMICS

On this slope in TERENO's Schäfertal site, researchers investigated what influences water pathways.

Environmental processes can be studied in high temporal and spatial resolution by wireless sensor networks. A research group has used such a network on a section of a hillside near TERENO's Schäfertal test site to measure and model characteristic hillside hydrology. Scientists at the Helmholtz Centre for Environmental Research, Magdeburg-Stendal University of Applied Sciences, University of Freiburg and University of Tübingen were able to identify significant processes which determine water dynamics in low mountain range catchment areas. Using statistical analyses, the researchers identified relevant soil moisture dynamics over the course of a year, defined transitional phases, and identified main structural properties influencing the hydrology of such hillslopes. The results were published in the Vadose Zone Journal and the article was highlighted by the journal editors.

Soil moisture is an important variable in the water cycle. It has significant influence on plant growth, groundwater renewal, and evaporation (so-called evapotranspiration). Understanding the temporal and spatial dynamics of soil moisture is therefore important in many areas, for example in agriculture, water management, meteorology, and climate research. Wireless networks used to define the spatial variability of environmental parameters have become an important research tool in recent years, and can be found today at several TERENO sites. ■

Edoardo Martini, Ute Wollschläger, Simon Kögler, Thorsten Behrens, Peter Dietrich, Frido Reinstorf, Karsten Schmidt, Markus Weiler, Ulrike Werban, Steffen Zacharias. *Spatial and Temporal Dynamics of Hillslope-Scale Soil Moisture Patterns: Characteristic States and Transition Mechanisms.* Vadose Zone Journal 01/2015.

▶ DOI: 10.2136/vzj2014.10.0150

MOLECULAR KEYS TO THE CARBON CYCLE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For the geoecologist and environmental microbiologist Prof. Susanne Liebner, the Northeastern German Lowland TERENO observatory provides the ideal backdrop for conducting comparative ecological research. The 37-year-old Liebner has led the Helmholtz Young Investigators Research Group "MicroCene" at the GFZ German Research Centre for Geosciences since 2013. MicroCene focuses on microbial communities in peatlands, soils and sediments, and Liebner investigates the differences between surface and subsurface microbial communities, as well as the impact of the subsurface microsphere on carbon cycles. She is currently Junior Professor at the University of Potsdam.

Liebner's research on the peatlands of northern Germany is an excellent complement to her investigations in the Arctic. Using molecular methods, she and her team identify key organisms involved in the microbial methane cycle of various types of peatlands and characterize their ecology. This knowledge contributes not only to the further understanding of current trace gas fluxes, but creates the basis for interpreting the distribution and activity of microbial communities in several thousand-year-old peat core samples. ■

GREENHOUSE GAS EXCHANGE IN FLUX

The Earth's biosphere and atmosphere are constantly interacting in a busy give and take of substances such as carbon dioxide (CO_2), water vapor (H_2O), and nitrous oxide (N_2O). At the same time, human-induced environmental changes around the world are impacting concentrations of these gases. Man's use of fossil fuels, for example, increases the concentration of CO_2 in the atmosphere, which can act as a fertilizer for green plants, while changes in land use can change the way plants and soils absorb, store or emit carbon. Tracking and understanding these many interactions is the focus of Dr. Alexander Graf (40), landscape ecologist and staff scientist at Forschungszentrum Jülich, who also heads up the Young Investigator Group IDAS – GHG (Instrumental and Data-driven Approaches to Source-Partitioning of Greenhouse Gas Fluxes) sponsored by the German Federal Ministry of Education and Research. "To understand these changes, we need a simple and reliable way to measure photosynthesis and respiration processes on the ecosystem scale," says Graf. "This is also the prerequisite for developing global-level models that can predict ecosystem behavior and the net exchange of greenhouse


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gases." To this end, Graf and his team are comparing and improving various methods – and relying on measurement tools and data provided by TERENO. "We save a tremendous amount of time and money not having to establish our own infrastructure," says Graf. It's a symbiotic relationship that also benefits TERENO, as data from Graf's investigations flows into the larger TERENO database and is made available to other researchers. ■

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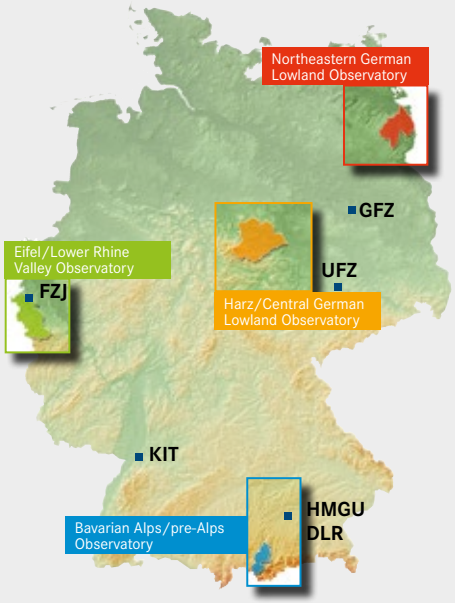

FZJ Forschungszentrum Jülich (Coordination)

DLR German Aerospace Center

KIT Karlsruhe Institute of Technology

HMGU Helmholtz Zentrum Muenchen, German Research Center for Environmental Health

UFZ Helmholtz Centre for Environmental Research

GFZ Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

IMPRINT

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