In the light chamber at the robot system at the TERENO site in Graswang, Dr. Rainer Gasche and his colleagues can continuously and automatically measure the greenhouse gas exchange between the soil and the atmosphere. LED technology is used to simulate sunlight usable by plants.

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TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Newsletter 3/2024

CONTENTS

A JOINT TASK

In climate and environmental research, data is the basis for a better understanding, better models and more precise predictions. In order to generate knowledge faster, data must be accessible and usable for everyone. The TERENO partners and other Helmholtz centers are enabling this with a common data infrastructure, including new tools for data management and uniform standards. See page 4.

HELMHOLTZ

EARLIER DETECTION OF CHANGES AND EXTREMES

Extreme drought: the river Elbe in Dresden 2018

The federal state of Saxony wants to prepare as early as possible for climate change and extreme weather. The MOWAX project enables this with better soil moisture information. The Helmholtz Center for Environmental Research - UFZ is leading the three-year cooperation between science and government authorities.

In recent years, climactic changes and extreme events such as floods, heatwaves and droughts have increasingly impacted life and infrastructures in Saxony. According to climate projections, this trend could intensify in the future. „In order to face these challenges and minimize the risks, we require more precise site measurements of the current situation and better spatial information. They are the scientific basis for more timely management decisions and measures," says UFZ researcher Dr. Martin Schrön, one of the MOWAX project leaders.

One key requirement is better monitoring, modelling, and communication of soil moisture, an important indicator of changes and extreme events. To this end, the MOWAX team is setting up an extensive soil moisture monitoring network with Cosmic-Ray Neutron Sensors (CRNS) to supplement existing sites. The solid database will enable better spatial soil moisture estimation. That will be used for model validation and calibration and enables an improvement of the mesoscale hydrological model (mHM), which is used for the drought monitor in Saxony.

An online visualization of observation and modelling data will be set up for near-real-time information dissemination. "In all these aspects, which form the basis for scientific recommendations, the project benefits greatly from the extensive experience gained within TERENO," emphasizes Martin Schrön.

The MOWAX project is made available by the European Regional Development Fund (EFRE) and by tax revenue on the basis of the budget approved by the Saxon state parliament (funding code 100702604). Participants in the project are the UFZ, the German Weather Service DWD, the Saxon State Forestry Administration, and the Saxon State Office for Environment, Agriculture and Geology.

▶ **MOWAX – Monitoring- and modelling concepts as a basis for water budget assessments in Saxony**

EDITORIAL

Creating the right framework conditions

Collecting long-term data is essential in order to understand the climate crisis and develop adaptation measures. However, collecting data is only one component. We also need to create the right framework conditions to deal with the ever-growing mountains of data in a sustainable way and to improve access and usability of data. TERENO relies on uniform standards and terminology, appropriate data management and tools for a shared data infrastructure. One current example is the new Sensor Management System (SMS) for metadata, a prime example of cross-center cooperation within Helmholtz (see page 4ff.). It will be an important component of the future digital ecosystem in the Helmholtz Research Field Earth and Environment.

The TERENO initiative is also set to develop further. We are delighted to have gained two excellent scientists, Prof. Dörthe Tetzlaff and Dr. Isabelle Braud, as new members of the Advisory Board (see page 9). They will help us to make TERENO even better - just as Prof. Ute Skiba, who stepped down this year, did before them. We would like to thank her most sincerely for her commitment and wish her all the best for the new phase in her life. In this issue, you can also read about new findings from the TERENO observatories and why the Swedish observation network SITES is also of interest to researchers from other countries.

I hope you enjoy reading, wish you a Merry Christmas and all the best for 2025!

Your Harry Vereecken
TERENO Coordinator

"ENVIRONMENTAL MONITORING MUST BE TAKEN SERIOUSLY"

Prof. Dr. Ute Skiba from the UK Centre for Ecology and Hydrology is an expert on greenhouse gas fluxes. In this interview, the outgoing member of the TERENO Advisory Board explains why well-equipped research infrastructures and close international cooperation are important.


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One of Ute Skiba's (r.) aims is to inform the public about environmental research and its importance. She and her colleagues from the UK Centre for Ecology and Hydrology regularly welcome visitors to the Easter Bush site and explain measuring instruments, research and the benefits of long-term measurements. The site is part of the British long-term monitoring network COSMOS-UK.

UTE SKIBA

Ute Skiba moved from Germany to England in 1977 to study. Via Bedford, Sheffield and Aberdeen, she ended up at the UK Centre for Ecology and Hydrology in Edinburgh – one of the four UKCEH Institutes (the others are Bangor, Lancaster and the headquarter Wallingford). UKCEH is one of the world's leading research institutions in ecology and hydrology. There, the biogeochemist studied greenhouse gas fluxes in temperate, tropical and arctic climate zones and their impact on the environment. Her research has taken her to various regions and countries, including Malaysia, India, Botswana and the Arctic.

Over the last 40 years, you have researched climate and environmental topics. Is there a significant difference in climate and environmental research between Germany and the UK?
When I compare the capabilities of TERENO observatories, research facilities in the UK are not as well supported especially in terms of equipment. The TERENO observatories are excellently equipped with instruments. We do not have the capacity in the UK. That makes me a little bit jealous.

Why does Great Britain not have these capacities?
It is all about money. In recent years, the UK did not spend enough funds to build such infrastructures. Brexit has not improved the situation. However, we hope that something will change after the incoming Labour government in the UK. Environmental monitoring must be taken seriously in the face of global challenges such as climate change, air pollution and biodiversity loss. Other countries, such as China have heavily invested in science. I believe China is now the leader in terms of equipment and infrastructures. However, international cooperation and policies are at least as important as investment in infrastructure.

What do you have in mind?
It would be great if European infrastructures could organise close collaboration across European Sciences (and beyond!), to harmonise instrument types and protocols: 'Who does what, what overlaps are there, how can we work together?

International cooperation is extremely important. The four TERENO observatories, for example, cover different topics, which is a good approach. However, other European countries, and within their regions, have different priorities. We need to bring together the different knowledge from different regions. To do this, we should take a whole system approach, i.e. record all relevant parameters at all locations.

What can TERENO contribute to this?
TERENO's collaboration with the French network OSCAR, for example, is an excellent combination. We must continue to expand this form of cooperation between infrastructures - and ideally extend it to the whole of Europe. The European infrastructure network eLTER is an excellent platform for this - also because in eLTER we are working on an important prerequisite for closer cooperation: uniform standards for measuring or handling data. It is important, for example, that everyone uses the same protocols so that data and results can be exchanged and compared. Thanks in part to TERENO, which plays a pioneering role in this standardization, we are well on our way in eLTER.

How do you see TERENO developing overall?
I've only been a member of the Advisory Board for around three years, so I was an observer in the early days, but not actively involved myself. Of course, TERENO has developed magnificently, as I said, the initiative is a role model for European environmental research in terms of equipment, a common approach to measurement and the harmonization of standards. But it will also be important for TERENO to receive sufficient research funding in the future. There will always be new research questions that need to be addressed and that require the infrastructure to be adapted.

You retired last year and are now also leaving the TERENO Advisory Board. Will you still be involved in research or what are your future plans?
I will be taking a step back, but not giving up science completely. I certainly will contribute to one or two outstanding projects and write one or two peer reviewed publications. I will contribute my scientific knowledge to society. For example, I plan to get involved in the local Greenpeace group.

Ms. Skiba, thank you very much for the interview.

SIMPLER, MORE EFFICIENT, MORE TRANSPARENT

TERENO partners have jointly developed a new tool for data management. The Sensor Management System (SMS) is not only part of a digital ecosystem for the Helmholtz Research Field Earth System Sciences, it could also become a new hit in technology transfer.

"Just a few years ago, we were still entering our data in Excel spreadsheets," recalls Dr. Christof Lorenz. The climate and environmental researcher is responsible for Scientific Data Management at the Campus Alpin of the Karlsruhe Institute of Technology (KIT). Today, he and his colleagues at the other Helmholtz centers involved in TERENO rely on special online tools - such as the new Sensor Management System (SMS), which was jointly developed by the Helmholtz Centre for Environmental Research - UFZ, the GFZ German Research Centre for Geosciences, Forschungszentrum Jülich and KIT.

The SMS can be used to manage metadata, especially from observation systems. Metadata provides important information additional to the actual measurement data and is essential for correct evaluation and interpretation. TERENO is concerned, for example, with the type of sensor used to measure long-term data such as temperature, soil moisture or greenhouse gas exchange, the exact location of a sensor and the accuracy of the measurements. It is also interesting to know whether a region has special features or whether the sensor is part of a measurement platform. Until now, scientists have usually passed on information by email or by calling out to those responsible for data management, who then update the databases or Excel tables. In future, researchers will enter everything directly into the SMS. The special feature: "The online tool not only allows sensors to be entered, but also the system information to be managed during operation," explains computer scientist Dr. Ulrich Loup from the Jülich Institute of Bio- and Geosciences (IBG-3). This means that, in addition to the information about the sensor, measurement platform and measurement region, all activities and changes are logged. For example, when a sensor is recalibrated, repaired or replaced, a software update is carried out or measurement campaigns or experiments are conducted.

> *"The online tool SMS not only allows sensors to be entered, but also the system information to be managed during operation."*
>
> *Dr. Ulrich Loup*

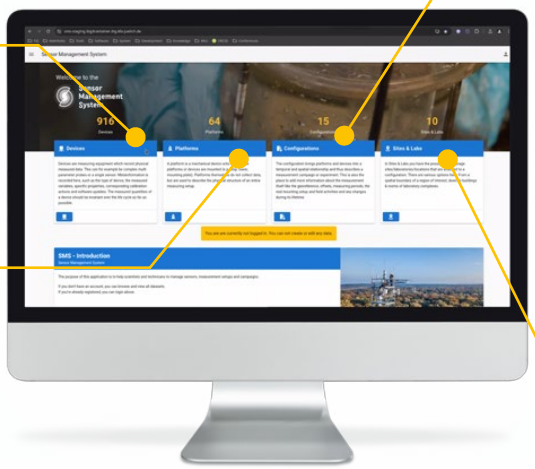
Managing metadata with the SMS Sensor Management System

1. Devices

- Sensors and measurement devices as well as their type, the parameters they measure and measurement specifics
- Software updates, calibrations, repairs

2. Platforms

- Static and mobile carrier systems such as measurement towers, tripods, ships or rovers



3. Configurations

- Setup of measurement systems connecting devices and platforms
- Information when, where and by whom a system is/was operated
- Any changes of device systems: assembly, disassembly, maintenance, exchange
- Measurement campaigns, experiments, and field activities (including measuring periods, georeference, ...)

4.Sites & Labs

- Localities of, e.g., an observatory or laboratory including maps, coordinates, web links

ADVANTAGES:

- simplified data acquisition
- acquisition of additional details such as changes of configuration
- standardized spellings and terms thanks to a controlled vocabulary
- uniform and consistent metadata

▶ **Sensor Management System (SMS)**

Retaining knowledge

In practice, such information is often lost. This is partly due to the constant change of personnel in science. As a rule, a postdoc or doctoral student sets up the device. As their contracts are temporary, many different people look after the measuring systems over the years. Everyone changes something, but not everyone has the same approach and work is often documented in different ways. Once the people are gone, their knowledge is often gone too. “If, for example, no one knows what is wired at a measuring station and how, it is no longer possible to trace the measuring parameters. In the worst case, data that has been collected for years is unusable,” explains Lorenz. The SMS enables such knowledge to be retained. In order to clearly assign an entry in the SMS to a device, each sensor and each platform can be assigned a unique key, a so-called Persistent Identifier (PID). This also makes it easier to keep track. “If, for example, a new location is to be equipped, I can immediately check in the SMS whether there are still unused sensors in the cabinet or whether I need to buy new ones. If the SMS is used consistently, it helps to save costs,” emphasizes David Schäfer, who is responsible for the further development of the SMS at UFZ.

And the SMS and the associated tools solve another problem that scientists often struggle with: different names for the same measured variables. For example, some use the term temperature in their data, others air temperature, and still others the German term ‘Lufttemperatur’. Some write terms in lower case, others in upper case. “As cross-center data management is a comparatively new task in our field of science, standards are not well established. As a result, centers, institutes or even research groups have developed their own approaches - and different terms are used,” explains the lead developer of the SMS Nils Brinckmann from GFZ. However, even different terminology can confuse results when merging and evaluating data. “However, it would take far too long if I had to read through the description of each data set to understand what was measured and how. We need a standardized language,” explains Loup.

Uniform vocabulary

The TERENO partners have therefore agreed on standardized terms for the SMS. For almost all input fields, users can only select predefined terms from a jointly developed vocabulary. Standardized terms are also used when logging activities. “This not only increases consistency and transparency, but also makes it easier to fill in,” emphasizes Loup. The vocabulary is also not set in stone. New terms can be suggested at any time and easily introduced after internal coordination.

Bringing Europe together

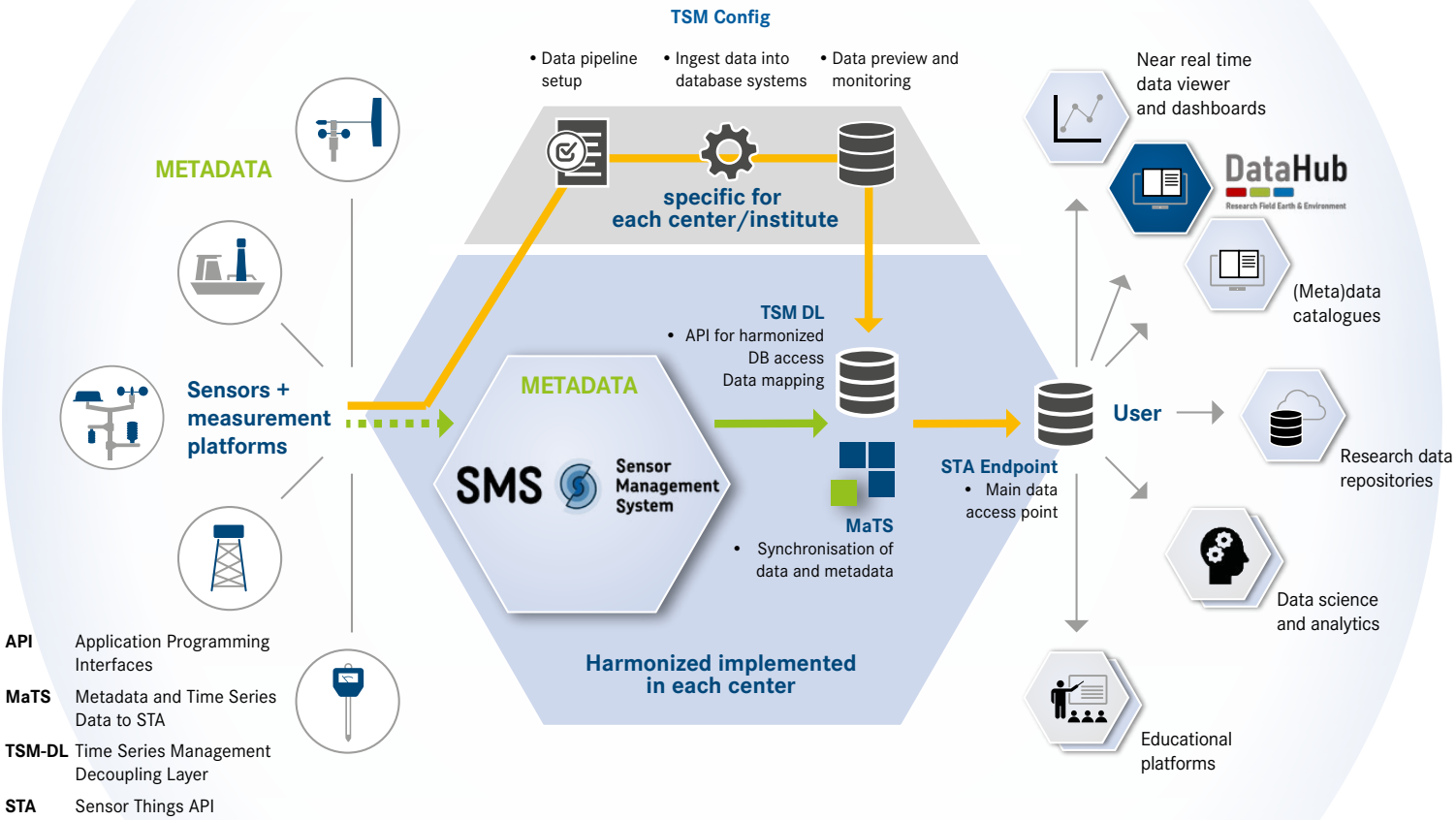
Such uniform standards - both for terms and for the collection, processing and storage of data - are extremely important in order to make proprietary data usable for everyone. This applies not only to TERENO, but also at a European level. “We are contributing our experience from TERENO to European networks such as the Integrated Carbon Observation System (ICOS), the Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research Infrastructure (eLTER RI) and the European Open Science Cloud (EOSC) - for example with the joint data management strategy for the four observatories, the common standards and uniform data processing. All of these things are also the basis that makes tools like the SMS possible,” says Lorenz.

It took four years to jointly develop and implement the SMS. “A single center does not have the resources. Unlike companies, the resources for developing tools like the SMS are very limited, as the centers often do not have dedicated departments for software development. It is not uncommon for something like this to be done alongside day-to-day work. For this reason alone, it is important that we Helmholtz Centers join forces here,” explains Lorenz. The Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) has also been operating a similar system for several years to manage the metadata of the measurement systems running there. “However, this system is designed more for the management of marine systems” says Lorenz. On the initiative of the UFZ and GFZ, the Helmholtz centers involved in TERENO then decided to jointly develop a suitable system.

The SMS could become an export hit

Even barely completed, there are already interested parties for the sensor data management system - not only from Germany, but also from the UK. To facilitate access by institutions outside Helmholtz, the partners have therefore converted the SMS to a European Open Source License (EUPL). First institutions from Germany and abroad have been given their own instances, such as eLTER RI and the British Oceanographic Data Centre. But the SMS is not only suitable for environmental research. “Energy science, for example, has very similar requirements. Our SMS is flexible enough to model both a climate station and a solar panel as a sensor - the decisive factor in both cases is the precise description of the metadata,” says Lorenz.

Time series data ecosystem of TERENO



CONTRIBUTION TO AN OPEN DATA LANDSCAPE

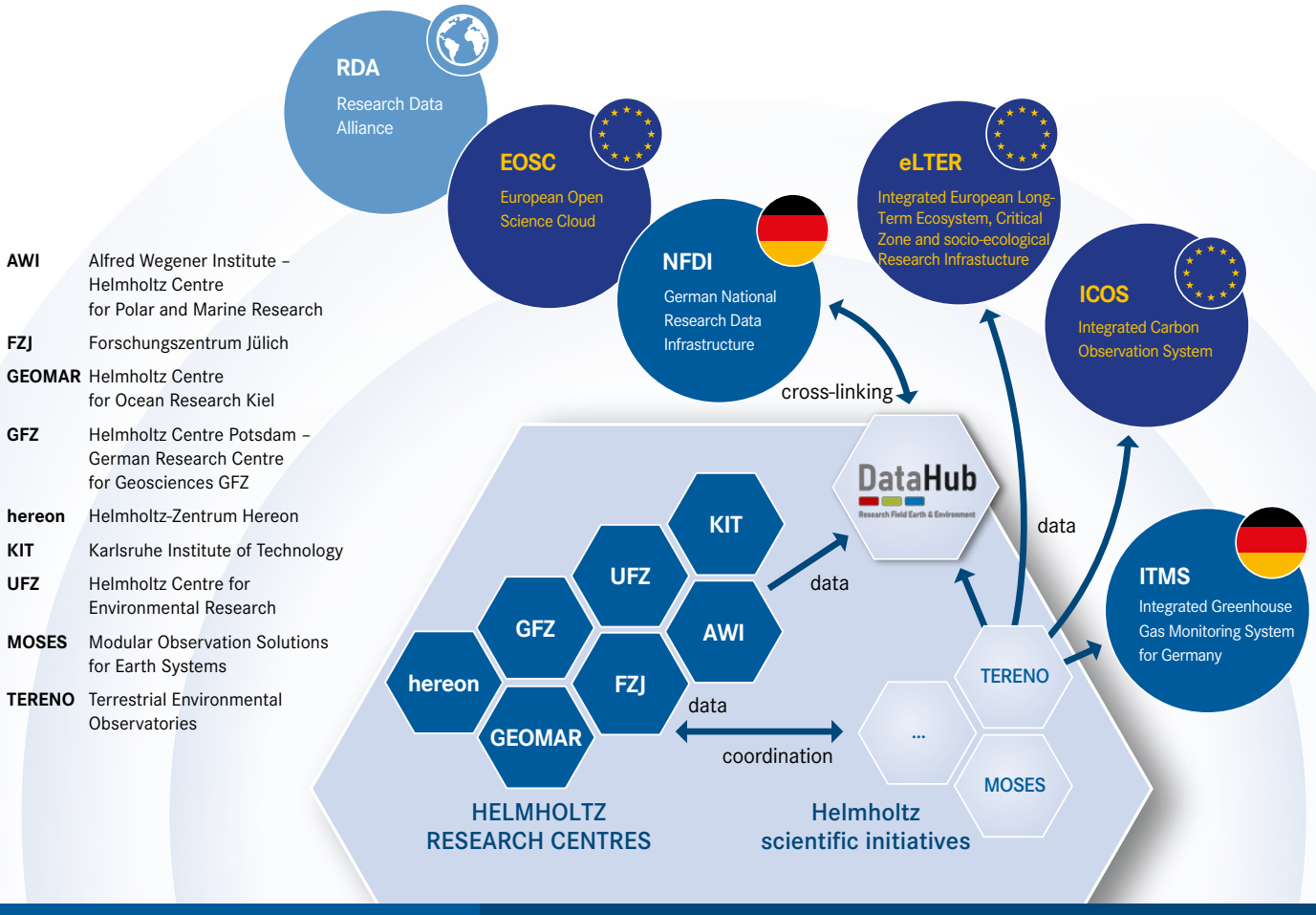
The TERENO data managers and their colleagues at the other Helmholtz Centers also have a lot planned within Helmholtz. “Currently, the infrastructure for research data is diverse - even within a center. We want to change that. The SMS is one of several building blocks of a uniform infrastructure for the Helmholtz Research Field Earth and Environment that we are currently developing,” reports David Schäfer. The core of the new digital ecosystem is the Helmholtz DataHub Earth and Environment. With this platform, the Helmholtz Association is also contributing to the development of the National Research Data Infrastructure in Germany. For the DataHub, the seven centers of the research field Earth and Environment are developing tools, guidelines and best practices to standardize the various research data and research data infrastructures. In particular, this should significantly simplify cross-center and cross-disciplinary collaboration and thus form the basis for new scientific discoveries and findings. In addition, the DataHub infrastructures enable researchers to increase their own visibility – for example, by making their research data accessible to others or integrating it into thematic data visualizations. Non-specialists should also be able to understand findings and correlations through appropriate viewers and presentations.

In addition to the SMS with its standardized vocabulary, this DataHub infrastructure includes, for example, the SaQC software contributed by the UFZ for automated quality control of measurement data, the use of the European EUDAT B2INST service for registering and generating a PID, the Earth Data Portal developed at the AWI for seamless exploration and presentation of data and metadata, and the Helmholtz AAI for controlling user rights and authentication. Some things are already online, others are still in the pipeline. “Here, too, it is important that we agree on common standards and languages. For example, we recently agreed on a uniform data interface, the SensorThings API (STA) from the Open Geospatial Consortium (OGC). It links everything, i.e. the entire interaction with the data,” reports Nils Brinckmann. Further standardization is on the way. The cloud infrastructure HIFIS that the Helmholtz Association is currently setting up also plays an important role here. The team around Brinckmann, Lorenz, Loup, and Schäfer would like to integrate their SMS into the Helmholtz Cloud as soon as possible. “At the moment, each of the participating Helmholtz centers is running its own instances of the SMS. It would be simpler and better to have a single central instance for all of them,” says Loup.

> *“The SMS and the Helmholtz DataHub show that collaboration works very well not only in scientific projects”*
>
> *David Schäfer*

The TERENO experts are convinced that the future of scientific data management belongs to such tools. It is equally clear to them that individual centers cannot handle such tasks. “The SMS and the Helmholtz DataHub, which is currently under construction, show that collaboration works very well not only in scientific projects, but also in the development of software tools and the establishment of a uniform data infrastructure - and with our systems we are making a significant contribution to an open data landscape from the environmental sciences - in line with the international FAIR principles, according to which data should be findable, accessible, interoperable and reusable,” Schäfer enthuses.

▶ DataHub Earth and Environment



BETTER DATA FROM FORESTS AND FIELDS

If we want to get a grip on global warming caused by humans, the first thing we need is precise data on greenhouse gas emissions. Jülich postdoc Dr. Theresa Boas is one of around 100 scientists who are enabling this in the ITMS project. They are developing an Integrated Greenhouse Gas Monitoring System (ITMS) for Germany that combines environmental observation with modeling and is intended to monitor the sources and sinks of the most important greenhouse gases in the future. (See TERENO Newsletter 2/24).

Boas has been working on the "Agri for Life" sub-project since May 2024. She is further developing models and providing high-resolution model data for agricultural and forest areas. Infrastructures such as ICOS and TERENO play an important role in this. "They provide the data needed to drive land surface models - for example weather data - and also data such as soil moisture, which I can use to check how well the model results match reality," reports the geoscientist, who completed her doctorate in the field of land surface modeling.

She completed her doctorate in the JUMPA program, a joint program offered by Forschungszentrum Jülich and the University of Melbourne. She found the dual concept - including a double defense of her work in Germany and Australia - very exciting. The only downer: the coronavirus pandemic prevented her from spending a year in Melbourne.

In the meantime, the Bonn native is concentrating on the Rhineland, where her family lives. Her postdoc position runs until the beginning of 2027, but it will be at least another three years before the IMTS is fully up and running. "It would be nice if the project was extended to a second phase and I could stay at the research center," hopes Boas.

Jülich postdoc Theresa Boas develops computer models.

DISCOVERING THE GREEN CLASSROOM

Charlie Periane explains to students how a band dendrometer works.

Since March 2024, the Plant Ecophysiology Lab at the Campus Alpin of the Karlsruhe Institute of Technology (KIT) has had a new task: the scientists take schoolchildren on a discovery tour through the forest.

"We are bringing research and environmental education together to raise children's awareness of the diverse functions of the forest," says Prof. Nadine Rühr, forest expert and head of the Plant Ecophysiology Lab. The project is a collaboration between KIT and the primary and secondary school Garmisch-Partenkirchen at Gröben. The school has its own school forest, and the area has been made available by the Bavarian State Forests. In the green classroom, the pupils explore nature, have lessons in open air, or can simply move around freely. With the help of Nadine Rühr and her colleagues Charlie Periane and Mathis Giese, they are now learning more about tree growth, what forest soils are like and what role trees play for people and the environment. To this end, they regularly meet with the scientists in the forest or in the classroom.

The children also take part in the research. For example, they measure with a band drendometer how the tree diameter or the height of trees changes. To do this, the researchers have attached additional measuring devices to more than a dozen coniferous and deciduous trees. The pupils are also involved in analyzing the data. In addition, they gain an insight into the connections between forests, the atmosphere and the climate - for example, that trees remove CO_2 from the atmosphere when wood grows and how extreme events such as droughts affect the forest.

"The project is a great success, the children are very enthusiastic about it. We are currently discussing whether other locations should also be equipped with measuring devices in order to learn more about the growth of forests in the Alpine region, which is at risk of climate change," reports Rühr.

NEW MEMBERS

Two experts from the field of hydrology have joined the TERENO Advisory Board: Prof. Dörthe Tetzlaff from Germany and Dr. Isabelle Braud from France. The Advisory Board consists of independent scientists and supports the work and further development of TERENO.

Dr. Dörthe Tetzlaff is Professor of Ecohydrology at Humboldt-Universität zu Berlin and Head of the Department of Ecohydrology and Biogeochemistry at the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB). She researches the ecohydrological effects of catchment areas. This involves, for example, how and for how long water is stored and released in landscapes.

© Kurt Steinhausen

Dr. Isabelle Braud


© Kurt Steinhausen

Dr. Dörthe Tetzlaff

Dr. Isabelle Braud is co-leader of OZCAR, TERENO's French partner organization, which operates long-term observatories for environmental monitoring in France and overseas. Isabelle Braud works in the RiverLy research and development unit, which focuses on the functioning of hydrosystems and is part of the French Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (INRAE). Isabelle Braud's research focuses on modeling, in particular hydrological processes and interactions between soil, vegetation and the atmosphere.

FROM ARCTIC TO WETLANDS

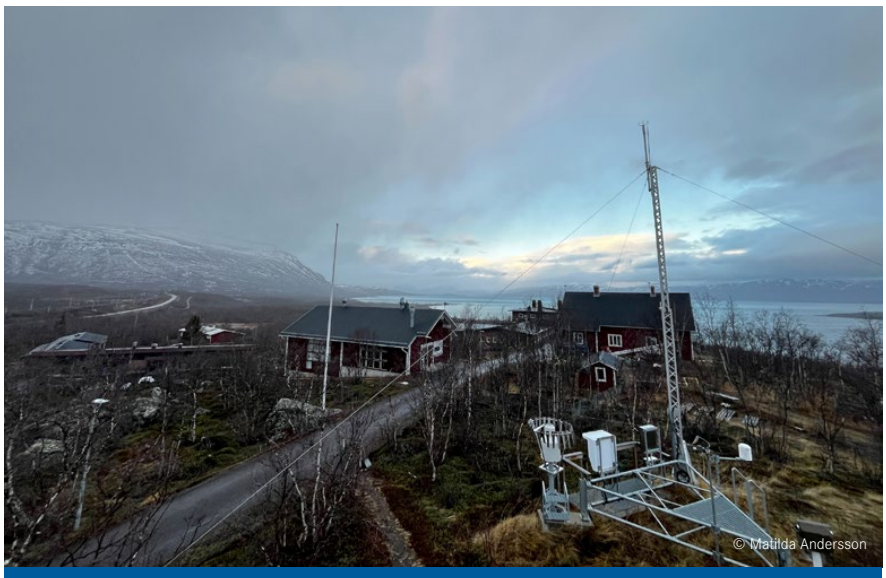
The Swedish Infrastructure for Ecosystem Science (SITES) is a network of nine stations that enables field-based ecosystem research. The vision of the research infrastructure is to support evidence-based approaches to sustaining the integrity of ecosystems in their own right and as a foundation of human well-being. “The quality and impact of the SITES field-based ecosystem research infrastructure should make it a compelling choice for use in new research initiatives,” says Prof. Kevin Bishop, director of SITES.

SITES focuses on terrestrial and freshwater ecosystems and recognizes the connectivity of elements within landscapes and between regions. The stations were selected to represent the range of climate, biodiversity and land use in Sweden, from the arctic to temperate forests, agriculture, lakes, streams and wetlands. Each station brings unique research foci, expertise, experiments, long-term monitoring and societal settings to the infrastructure built on shared scientific goals and methodologies.

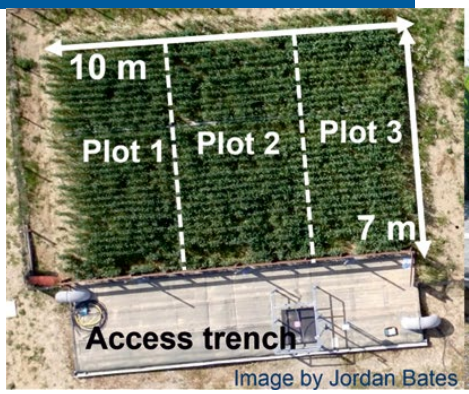
To help scientists develop and test theories against the observed realities of ecosystems in specific localities and landscapes, SITES facilitates access to these field stations. Context for new research is provided by long- term, standardized and openly available monitoring data, comprehensive documentation, as well as engagement with local residents and stakeholders. The stations also have on-site expertise to assist in the design and execution of scientific investigations that can span spatial and temporal scales as well as disciplinary boundaries. To facilitate comparison between climate zones, landscape elements and management systems, as well as to strengthen the collaboration within the network of stations, SITES stations participate in Thematic Programs focused on remote sensing, water monitoring and aquatic mesocosms. Open access to the infrastructure and data is emphasized to attract national and international scientists.

These features of SITES support national and international researchers who want to pursue research questions about how ecosystems function in response to anthropogenic pressures, natural variability and management efforts to achieve specific goals. “This has made SITES a highly valued, critically important infrastructure for research on Swedish ecosystems and landscapes, not least in the context of how the Earth System will respond to drivers of environmental change,” says Bishop.

▶ **SITES – Swedish Infrastructure for Ecosystem Science**


© Matilda Andersson

The Abisko Scientific Research Station, one of nine SITES stations, is located around 200 kilometers north of the Arctic Circle. The dominating ecosystems types are alpine forest, lakes, streams and wetlands.



Maize crops on the minirhizotron facilities at the TERENO site in Selhausen

WHAT ROOTS REVEAL ABOUT SOIL MOISTURE

How can plants be optimally irrigated and fertilized? Information on the distribution of crop roots and soil water content could help. This is indicated by a study conducted by Jülich scientists who analyzed data from ground penetrating radar measurements at the TERENO site Selhausen in a new way.

"Our results show that during the vegetation period of maize crops, both the root volume of the maize crops and the spatial variability of soil water content increased. We suspect that the presence of roots causes a redistribution of water within the soil and thus an increase in the variability in ground penetrating radar data" says the study's first author, Dr. Lena Lärm from Forschungszentrum Jülich. She and her colleagues see the results as an important step towards better understanding processes within the soil-plant continuum.

The researchers studied maize cultivation at the Selhausen site for three seasons. During this time, they repeatedly captured root images at six depths between 10 centimetres and 1.2 meters using two so-called minirhizotron facilities, each of which was installed in different soil types. For the same depths, the team determined the soil water content using a ground penetrating radar (GPR). "We use GPR measurements to determine the permittivity, from which we can derive the soil water content. We have analyzed the measurement data in a new way. This enabled us to investigate whether the presence of roots increases the variability of the soil's GPR permittivity," reports Lena Lärm.

The researchers' approach opens up new possibilities for combining non-invasive geophysical measurement methods such as GPR measurements with root information measurements. Based on this, models and agricultural management decisions, such as irrigation and fertilization, could be improved.

Lena Lärm et al. (2023). *Linking horizontal crosshole GPR variability with root image information for maize crops.* Vadose Zone Journal.
▶ DOI: 10.1002/vzj2.20293

RUNOFF PATTERNS: THE MOST IMPORTANT INFLUENCING FACTORS VARY DEPENDING ON THE AREA

In order to manage our water resources sustainably, it is crucial to understand the rainfall-runoff process in a catchment area. Many factors influence this process, such as soil moisture, climate or local geological characteristics. However, the influence of these factors can vary depending on the area, as a study by experts from Austria and Germany shows.

The study was conducted as part of the REPEAT project, in which researchers from the University of Natural Resources and Life Sciences, Vienna (BOKU) are investigating these factors in collaboration with TERENO and the Austrian Federal Agency for Water Management. The project, which is funded by the Austrian Science Fund FWF, aims to contribute to a better understanding of the rainfall-runoff process. "So far, it is not exactly clear how the various factors lead to the rapid mobilization of water that has been stored in the catchment area for a long time. To this end, we are looking for recurring patterns in the rainfall-runoff process to draw conclusions about the runoff generation," says project leader Dr. Michael Stockinger from BOKU.

This is where the high-resolution TERENO data comes into play. For the study, the researchers used data from two TERENO areas - the Wüstebach forest site and the Rollesbroich grassland site - and another area in Petzenkirchen (Austria) to identify recurring patterns in the runoff. They used a newly developed method for the analysis. "We were able to show that the factors influencing the recurring runoff patterns differed depending on the area. In the TERENO catchment areas, soil moisture had a greater influence, while precipitation played a more important role in the Austrian catchment," explains Adriane Hövel, PhD student in the REPEAT project.

In the future, the researchers want to use the method to better understand the rainfall-runoff process in other regions and thus draw conclusions about the influence of the prevailing climate, for example.

Installation of a hydrological measuring station in Rollesbroich

Adrinae Hövel et al. (2024). *Repeating patterns in runoff time series: A basis for exploring hydrologic similarity of precipitation and catchment wetness conditions.* Journal of Hydrology, 629.
▶ DOI: j.jhydrol.2023.130585

CHANGE TAKES TIME

Long-term data from the Zarnekow site in the TERENO's Northeast German Lowland observatory shows that methane and CO_2 emissions in the rewetted peatland area have fluctuated over the years, but the trend has been a steady decline. So-called emission factors, which are used to calculate the emissions of such peatlands, tend to represent this transition phase as an abrupt change. TERENO researchers argue that the factors should be better adjusted to the reality.

Measuring devices in the Polder Zarnekow record CO_2 and methane emissions in the peatland area.

Many peatlands have been drained in recent centuries, for example to use land for agriculture. But peatlands are important carbon reservoirs. If a peatland is drained, it changes from a sink to a CO_2 source. Rewetting reverses this process and is therefore considered an effective measure against the climate crisis. The Polder Zarnekow, part of the peatland along the river Peene in Mecklenburg-Western Pomerania has been undergoing this development since 2004. Since 2013, the GFZ German Research Centre for Geosciences has been operating measuring devices there in the TERENO's North-East German Lowland observatory. GFZ scientists have analyzed the data, they also used measurement series from 2007 to 2009.

The researchers found that it took until 2020 for the peatland to change from a CO_2 source to a sink after rewetting. “The trend of decreasing CO_2 and methane emissions is still continuing,” reports Dr. Aram Kalhori, first author of the study. The greatest influence on emissions was the water level, while vegetation cover also had great influence on CO_2, and soil temperature had the greatest influence on methane – except in extremely dry years such as 2018.

The researchers suggest adjusting the emission factors for rewetted peatlands used by the Intergovernmental Panel on Climate Change (IPCC) and in Germany's National Inventory Report for greenhouse gas quantification: instead of an immediate changeover, they recommend staggering them over time. “Of course, it takes several years for peatlands to fully exploit their climate protection potential. This makes it all the more important to make faster progress with rewetting and not losing time unnecessarily. Our results also show how important continuous long-term monitoring is for verifying the emissions reductions,” emphasizes Prof. Torsten Sachs from the GFZ.

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VALUABLE IMPETUS

At the beginning of November 2024, the TERENO initiative hosted its annual international workshop. Around 90 experts from various countries and scientific disciplines came to the Helmholtz Center for Environmental Research - UFZ in Leipzig to discuss the latest developments in terrestrial environmental research. The focus was on innovative approaches to observing and modeling environmental processes, interdisciplinary cooperation and the expansion of international networks. Inspiring presentations, intensive discussions and practical workshops promoted exchange and provided valuable impetus for future research projects.

The program also included two excursions: to the Leipzig branch of the German Meteorological Service (DWD) and to the Brandis lysimeter facility (right picture). The Brandis Lysimeter facility has been providing data on soil water balance since 1980 and is part of the monitoring network of the Saxon State Agency for Environment, Agriculture and Geology.

NO “STANDARD WORKING DAY”

The technical team at the Institute of Meteorology and Climate Research (IMK-IFU) at the Karlsruhe Institute of Technology is characterized by a special feature: It does not consist of technicians. Instead, the team at the Campus Alpin in Garmisch-Partenkirchen is made up of five university graduates, some of whom have also completed vocational training. Young people who are doing a voluntary ecological year (FÖJ) at the IMK-IFU provide valuable support in maintaining the measuring equipment. The technical team takes on two people every year.


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The range of activities is diverse – not only because the locations of the measurement sites range from the foothills of the Alps to high up in the mountains. In addition to everyday tasks such as maintaining and repairing equipment and calibrating sensors, the team also carries out accompanying investigations such as determining biomass or sampling soil composition. Quality control and processing of the raw data is also carried out by the technical team in close cooperation with the IMK-IFU data initiative.

“We therefore have no “standard working day”, says Dr. Ingo Völksch. The geoscientist forms the “team EC” together with environmental engineer Stefan Sellmaier, who studied automotive mechatronics after completing his training as an automotive mechatronics technician. Their main task is the operation and maintenance of the climate and eddy-covariance measuring stations in the TERENO's Pre-Alpine observatory.

Hydrologist Dr. Benjamin Fersch looks after a wide variety of sensors from the Zugspitze summit to the lowlands of the Alpine foothills, including the cosmic-ray neutron sensor network, the water levels and the wireless soil moisture network. For snow balance measurements, he sometimes has to go on ski or snowshoe tours lasting several hours. “Fortunately, calibration here only makes sense during constant conditions and good weather,” says Fersch.

Carsten Jahn, a trained electrician and environmental engineer, looks after the weather stations and devices for measuring precipitation. He is also in demand when work at height is required, for example on masts. Biologist Dr. Rainer Gasche is a scientific engineer responsible for fully automated and partly robot-supported measuring equipment. This includes lysimeters, for example, which record the parameters and processes of the water cycle and the exchange of greenhouse gases between the soil and the atmosphere.

What all team members are currently working on: upgrading the old system to make it future-ready. After more than 10 years in operation, some of the sensors and measuring devices are worn out and and data acquisition and transmission systems are no longer state of the art. Going forward, the technical team will surely never be short of work.

Above: the Campus Alpin technical team: Rainer Gasche, Stefan Sellmaier, Ingo Völksch, Carsten Jahn und Benjamin Fersch (from left to right) in front of the lysimeter facility in Graswang.
Below: Ingo Völksch (r.) und Stefan Sellmaier maintain a measuring mast in Schechenfilz.

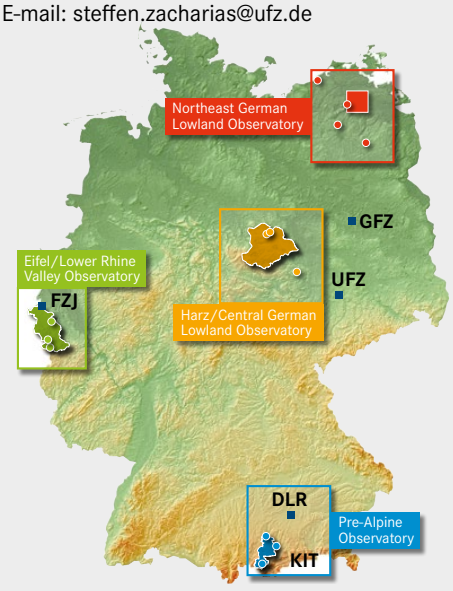
CONTACT | COORDINATION

Dr. Heye Bogena
Institute of Bio- and Geosciences – IBG-3: Agrosphere, Forschungszentrum Jülich, 52425 Jülich, Germany
Tel.: +49 (0) 24 61/61-67 52
E-mail: h.bogena@fz-juelich.de

Dr. Ralf Kiese
Institute for Meteorology and Climate Research, (IMK-IFU), Karlsruhe Institute of Technology
Kreuzeckbahnstrasse 19,
82467 Garmisch-Partenkirchen, Germany
Tel.: +49 (0) 88 21/1 83-1 53
E-mail: ralf.kiese@kit.edu

Dr. Gerhard Helle
Helmholtz Centre Potsdam – GFZ
German Research Centre for Geosciences,
Telegrafenberg, 14473 Potsdam, Germany
Tel.: +49 (0) 3 31/6264-13 77
E-mail: gerhard.helle@gfz.de

Dr. Steffen Zacharias
Department Monitoring and Exploration Technologies, Helmholtz Centre for Environmental Research – UFZ, Permoserstraße 15, 04318 Leipzig, Germany
Tel.: +49 (0) 3 41/2 35-13 81
E-mail: steffen.zacharias@ufz.de



FZJ Forschungszentrum Jülich (Coordination)

DLR German Aerospace Center

KIT Karlsruhe Institute of Technology

UFZ Helmholtz Centre for Environmental Research

GFZ German Research Centre for Geosciences

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