Good prospects: In the future, the Global Ecosystem Research Infastructure (GERI) will link infrastructures and data from five continents. TERENO sites such as the Hohes Holz forest area contribute to this.

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TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

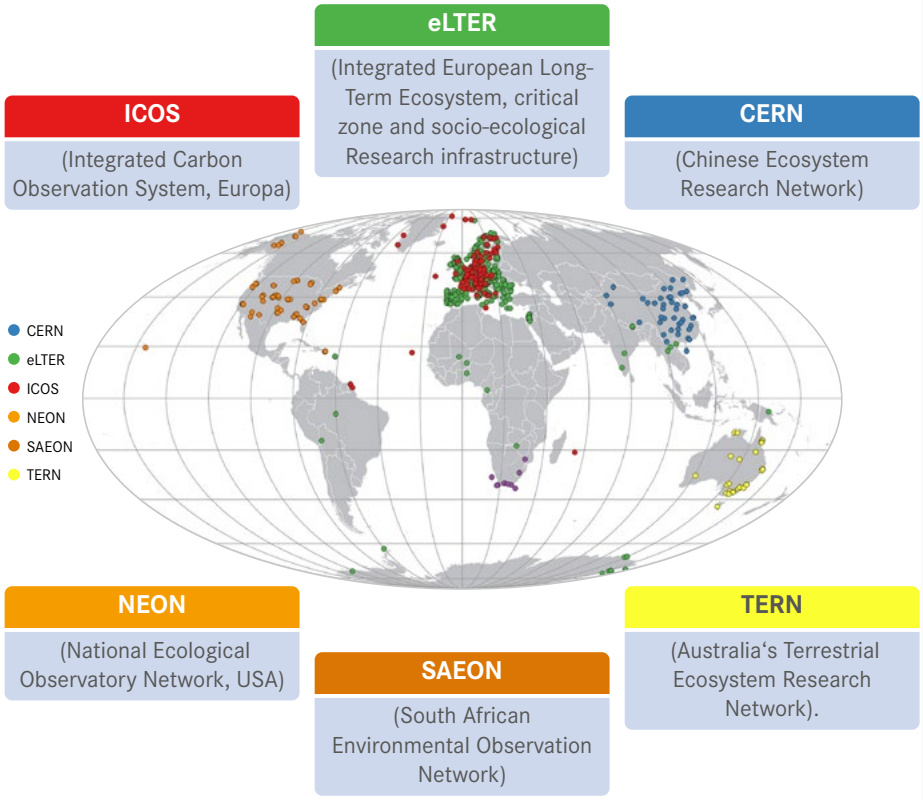
Newsletter 1/2022

CONTENTS

2ND TERENO-OZCAR CONFERENCE

25–28 September 2023 in Bonn, Germany

HELMHOLTZ ASSOCIATION



NEW NETWORK LINKS CONTINENTS

Global Ecosystem Research Infastructure (GERI) is intended to help generate new insights into global ecological relationships. TERENO is involved in the new network through two European infrastructures.

Over the past decade, major environmental research infrastructures have been established on every continent. With their help, scientists capture how ecosystems respond to human-induced environmental changes. This concerns biophysical and biogeochemical processes as well as the so-called biotic environment, i.e. processes and conditions that relate directly to living beings such as plants or animals. A major influencing factor here is globalization. An increasingly interconnected world has led to more and more influence on the flow and distribution of energy and materials in ecosystems, but also on animal and plant species.

"We want to better understand the concrete interconnections. This is easier said than done, because as a result of the growing influence of ongoing globalization, these interrelationships are changing rapidly and widely," says Dr. Steffen Zacharias of the Helmholtz Centre for Environmental Research - UFZ. Environmental research infrastructures provide the data necessary for research. Through GERI, infrastructures and data from five continents are now linked: from Africa, America, Asia, Australia and Europe. "By harmonizing data, we can reduce uncertainties in understanding processes, for example. But the collaboration offers much more: it enables broader, cross-continental research - in ways that have not been possible before. This will help us to better understand ecological processes across continents, time periods and disciplines," emphasizes the UFZ scientist, who was involved in establishing the network. New perspectives are also opening up for TERENO as a partner of the two participating European infrastructures eLTER and ICOS, for example in the expansion of international research collaboration.

Henry W. Loescher et al. (2022). *Building a Global Ecosystem Research Infrastructure to Address Global Grand Challenges for Macrosystem Ecology. Earth's Future, Volume 10, Issue 5.*
▶ DOI: 10.1029/2020EF001696

EDITORIAL

A farewell, and some perspectives for the future

The next meeting of the TERENO Advisory Board will be different: for the first time since TERENO was founded in 2008, it will not be chaired by Rick Hooper, who has stepped down at his own wish. TERENO owes him a great deal. Under his chairmanship, the Advisory Board not only accompanied the initiative's development, but played a key role in shaping it. It is also thanks to him that TERENO has become such a success story. In the interview, Dr. Hooper looks back once again and also tells us how important it is to generalize findings at individual locations and to combine data.

With the founding of GERI, a network of six research infrastructures from five continents, we want to follow precisely this path together with colleagues from South Africa, the USA, Australia, China and Europe. The expansion of joint activities with national and international partners is a theme that runs through almost all contributions to the newsletter: we are establishing a new TERENO site together with the Leibniz Center for Agricultural Landscape Research; we are involved in COSMOS-Europe, a new European network of cosmic-ray soil moisture sensors; and we are contributing our infrastructure and data to various research projects.

An important concern of all Helmholtz centers involved in TERENO is to inspire young talents to do science - be it through student labs or partnerships with schools. Work at the TERENO sites also plays a role. In this issue, we present what the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences and the Campus Alpin of the Karlsruhe Institute of Technology have to offer.

Happy reading!

Your **Harry Vereecken**

Coordinator TERENO

"INVESTMENT IN INSTRUMENTS PAYS OFF"

Interview with Prof. Richard "Rick" Hooper - the expert in hydrology was Chairman of the Advisory Board since TERENO's founding. He has recently retired from the role.

Prof. Hooper, what made you decide to chair the Advisory Board back when TERENO was founded in 2008?
In the environmental sciences, we have the problem that there is almost never sufficient funding for long-term innovative projects. TERENO offered a rare opportunity at that time to bring together the money needed for a large-scale Earth observation network. This will allow long-term environmental, social, and economic impacts of global change to be captured. In my view, this is extremely important research.

How do you assess TERENO's development so far?
Highly positive. To be honest, we were worried at the beginning whether we would find enough people to carry out investigations on site with the numerous measuring instruments. But then it worked out extremely well. Today, scientists from a wide range of institutions are conducting research in the four TERENO observatories, not only from the participating Helmholtz centers and not only from Germany.

What were the highlights from your point of view?
For example, the research at the Wüstebach site in the Eifel comes to mind. Since 2008, a group of researchers there has been studying the water and material cycles of a forest system with a stream before and after the clearing of spruce trees and the subsequent regeneration of a near-natural deciduous forest. In the process, a large amount of meteorological, soil and hydrological measurement data was obtained. Similarly important data has been collected at all TERENO sites. This shows that investments in instruments pay off. We can now better understand how individual terrestrial systems function at a given location. We have also made great progress from a technical point of view, for example, in terms of managing large amounts of data. It's very tedious, hard work, but it's worth it.

What do you wish for TERENO's further development?
As with any long-term endeavor, the main thing is to stay innovative and not do the same thing over and over again. Do we perhaps need to invest more heavily in technology again at some point? There is no right or wrong answer to this question; it is a discretionary decision that requires wisdom and foresight. In the long term, the main task will be to generalize the findings from measurements at individual locations: What do the findings from the Wüstebach mean for the Rhine or for other rivers? And we need models on a global scale. This requires systems that integrate data from a wide variety of sources - from weather stations and satellites to research infrastructures such as TERENO.

What are your personal plans?
I will enjoy my free time in retirement, but I won't be doing any more research. You can only do that completely or not at all. A little research doesn't really work. I can only imagine continuing to supervise students. I will no longer write funding proposals. My wife is German. We are looking forward to traveling more, visiting family members in Europe or just renting a house in Brittany for a month - all hopefully without Corona restrictions.

The interview was conducted by Janosch Deeg.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Richard Hooper studied Applied Mathematics and Ecosystem Ecology and earned a PhD in Environmental Systems Engineering. After serving as a hydrologist with the U.S. Geological Survey, he became Executive Director and President of the Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) in 2003. After retiring in 2017, he became a professor at Tufts University. In 2018, he received the Edward A. Flinn III Award from the American Geophysical Union.

A Man of Vision

Since the start of TERENO in 2008, Rick Hooper has served as the chair of the Advisory Board. In these 15 years, Rick supported and guided the development of TERENO from an unknown observational platform in Germany to a successful and internationally renowned research activity. His leadership and foresight contributed significantly to this success.

As chair, he and the members of the board addressed critical issues, but they also pointed the way to solutions, thereby keeping TERENO on track. The availability and accessibility of the data produced at TERENO and the interactions with stakeholders were of great importance to him, and it led to the development of the TEODOOR data platform, which provides quality-checked data to the scientific community and society in general.

During his period as Chairman, TERENO expanded from a national network to a platform that is integrated into European research initiatives like the Integrated Carbon Observation System ICOS and the Critical Zone Exploratory Network CZEN. TERENO served as a blueprint for the eLTER research infrastructure.

Rick left on his own initiative at the end of 2021. We thank him for his outstanding contribution to TERENO and wish him all the best for the future!

Harry Vereecken, on behalf of TERENO

IMPROVED WARNING AGAINST FLASH FLOODS

Floods and heavy rainfall can have devastating consequences, as demonstrated by the catastrophic floods on the River Ahr in 2021. This makes it all the more important to predict such hazards as accurately as possible. The RealPEP research unit, which has been funded since 2018 by the Deutsche Forschungsgemeinschaft (DFG), is developing an improved forecasting system for flash floods, using state-of-the-art measurements like polarimetric radar data to the fullest extent possible. TERENO is supporting the project.

To estimate the type and amount of precipitation, scientists and weather services so far have used mostly conventional, non-polarimetric radar measurements. Algorithms calculate from the data the current precipitation intensity, calculations whose accuracy can now be improved considerably with state-of-the-art radar. So-called 'nowcasting' methods make use of these precipitation estimates and are particularly good at predicting the development of the next two hours or so. For forecasts with longer lead times more complex methods are needed. Numerical forecast models calculate precipitation on the basis of physical laws - from a certain initial state up to several days in advance.

Providing data for better forecasts: the TERENO weather radar at Sophienhöhe

"In RealPEP, we want to link these methods more closely to improve the value and efficiency of warnings for small to medium-sized river basins in Germany," says Dr. Silke Trömel of the University of Bonn. She coordinates RealPEP, whose partners, in addition to the University of Bonn, include the Deutscher Wetterdienst, Freie Universität Berlin, Forschungszentrum Jülich and the Karlsruhe Institute of Technology. The scientists aim to combine information from precipitation estimates and nowcasting into numerical forecast models and then feed all the results into hydrological models. "In this way, we provide forecasts for water levels and runoff that incorporate additional information, for example about the condition of the soil," clarifies Silke Trömel. The development of the forecasting system is to be completed by 2024.

TERENO contributes data from its weather radar at Sophienhöhe in the Eifel/Lower Rhine Valley observatory, as well as soil moisture data from the SoilNet wireless sensor network and cosmic-ray neutron sensors. The data help to better estimate the initial conditions for the hydrological models of TERENO sites in catchment areas such as the Ammer, Bode and Ruhr rivers. The sites serve as test areas for RealPEP.

▶ **DFG Research Unit 2589**
Near-Realtime Quantitative Precipitation Estimation and Prediction (RealPEP)

WATER CYCLES ALREADY STRONGLY INFLUENCED?

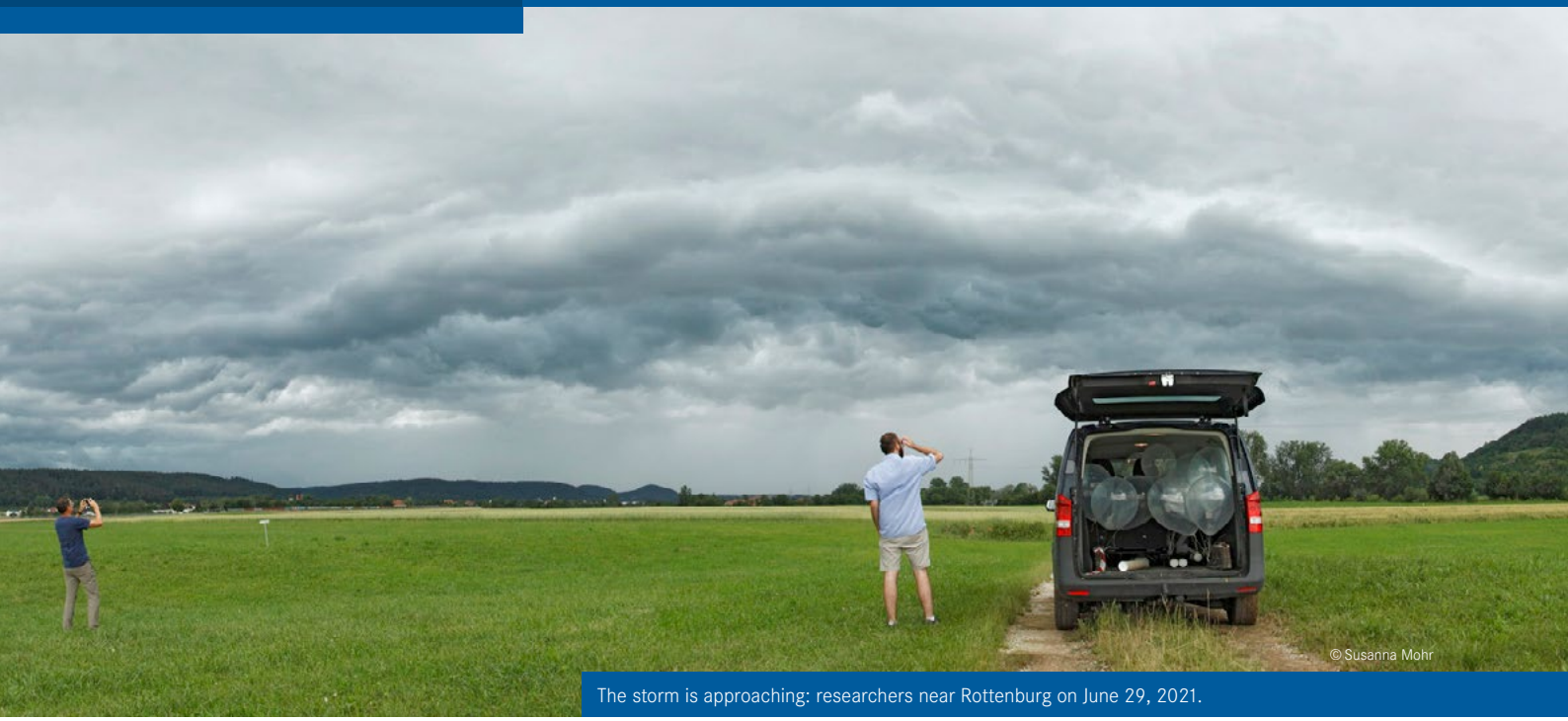
The TERENO site at Selhausen

Many regions are experiencing increasing precipitation, while others seem to be literally drying out. However, explanations such as "dry regions are becoming even drier and wet regions are experiencing more precipitation" are not satisfactory. Some changes cannot be explained by current climate models, either.

Have humans, through land use change and intensified water management, influenced the regional climate more than previously assumed? A new Collaborative Research Centre of the German Research Foundation, the CRC 1502 "Regional Climate Change: The Role of Land Use and Water Management" (DETECT), aims to investigate this hypothesis.

The researchers involved suspect that humans have already strongly influenced regional water cycles, contributing to changes in the atmospheric circulation of water that in turn affect atmospheric and terrestrial water balances in more remote regions. In the CRC, which is coordinated by the University of Bonn, researchers from different disciplines want to develop a model system that represents, in particular, the interactions of humans and climate which influence the continental water cycle. TERENO is contributing its environmental data, sites and the SoilCAN lysimeter network.

▶ **CRC 1502 DETECT**



The storm is approaching: researchers near Rottenburg on June 29, 2021.

TRACKING THE SUPERCELL

Thousands of lightning bolts, hailstones up to five centimetre diameter, extreme wind gusts, heavy precipitation: the hailstorm in the Neckar Valley on June 23, 2021, provided ample data for the "Swabian MOSES" measurement campaign, part of the Helmholtz initiative MOSES. Between May and September 2021, scientists from nine institutions, including the five TERENO partners, collected data on thunderstorms and heat waves in the Neckar Valley and the Swabian Jura. The evaluations are still ongoing, but the follow-up campaign is already being planned; below, an interview with tropospheric researcher Dr. Andreas Wieser from the Karlsruhe Institute of Technology, who led the measurement phase together with his colleagues Prof. Michael Kunz and Dr. Jannik Wilhelm in June 2021.

Dr. Wieser, what findings were you able to gather during Swabian MOSES?

Thousands of lightning bolts, hailstones up to five centimetre diameter, extreme wind gusts, heavy precipitation: the hailstorm in the Neckar Valley on June 23, 2021, provided ample data for the "Swabian MOSES" measurement campaign, part of the Helmholtz initiative MOSES. Between May and September 2021, scientists from nine institutions, including the five TERENO partners, collected data on thunderstorms and heat waves in the Neckar Valley and the Swabian Jura. The evaluations are still ongoing, but the follow-up campaign is already being planned; below, an interview with tropospheric researcher Dr. Andreas Wieser from the Karlsruhe Institute of Technology, who led the measurement phase together with his colleagues Prof. Michael Kunz and Dr. Jannik Wilhelm in June 2021.

Is it difficult to predict such supercells?

Yes, due to the chaotic nature of the atmosphere, it is still a big challenge. Floods, such as on the Elbe or Rhine rivers, or flood disasters after heavy rainfall, such as in the Ahr Valley in July 2021, can be reliably predicted several days in advance. When it comes to supercells, we can often predict them only a few hours in advance, and even then uncertainties remain. In the second half of June, we had forecasted deep convection almost every day, but heavy thunderstorms or supercells only developed on June 23 and then on June 28/29.

What is so special about a supercell?

Thunderstorms develop by so-called convection. The ground surface is heated by solar radiation, warm and humid air rises, reaches the level of condensation, and a thundercloud is formed in the atmosphere. Warm and humid air can also rise when air masses flow around mountains and converge behind again. Such thunderstorms last about half an hour, after which they run out of energy because the warm air flow ends suddenly. In supercells, the wind factor is added. Sometimes, when strong winds are blowing, the wind direction and speed are changing with altitude. This separates up- and downdraft areas and causes the air masses to rotate, which moves and intensifies the thunderstorm. Such a supercell can provide lightning, hail and heavy precipitation for about six hours.

Are supercells a common phenomenon?

Fortunately, they rarely occur in Germany. However, our study area in Baden-Württemberg, which roughly covered the area between Stuttgart and Donaueschingen, is considered a hotspot for supercells. Such extreme events occur here around eight times a year. In 2021, Sahara dust could have been an inhibiting factor.

Why Sahara dust of all things?

In the first half of June, we measured a lot of Sahara dust in the atmosphere. Strong air currents had carried it from Africa to Europe. Dust, that is, small particles in the air, absorbs radiation. In other words, it heats the air in the dust layer and reduces solar radiation at the soil. This inhibits the formation of convection and thus of supercells. We are currently trying to derive the exact relationships from the data.

A new campaign is scheduled for next year. What is planned?

In Swabian MOSES 2.0, we also want to add a focus on urban areas. We may adjust the geographical area of the study somewhat. Then the Fendt TERENO site would be included and we could use the equipment there, in addition to our measurement aircraft and various instruments like radiosondes, cosmic-ray sensors and energy balance stations. Also, more partners will probably be present. And since there were no heat waves in Baden-Württemberg in the summer of 2021, unlike in previous years, we may be able to collect more data on this in 2023.

▶ Measurement campaign Swabian MOSES 2021

ICOS CERTIFIES MEASURING WÜSTEBACH TOWER

The 38-meter high measuring tower at Wüstebach site

The European research infrastructure "Integrated Carbon Observation System", or ICOS for short, has certified the measurement tower at the TERENO site in Wüstebach as an "Associate Station". With this certification, ICOS ensures that stations record greenhouse gases in a high-quality manner and according to the same standards.

The ICOS network comprises 149 stations in 14 countries. They provide data, for example, on the exchange of greenhouse gases between soil, plants and atmosphere in Europe, especially of CO_2 and water vapor. They also record climate parameters such as precipitation, radiation and air and soil temperature. Plant population trends are also monitored. "By May 2022, 104 stations had been inspected and classified into one of the three classes: C1 (highest), C2, and 'associated', depending on the degree of standardization and the scope of the measurement program. In order to permanently guarantee the quality, the measurement data of the stations will be permanently monitored even after the certificate has been awarded," says Marius Schmidt, a researcher at Forschungszentrum Jülich and a member of the ICOS ecosystem program.

Now that the 38-meter high measuring tower at the Wüstebach forest site has successfully passed the demanding control program, all three ICOS sites of TERENO's Eifel/Lower Rhine Valley observatory are certified. The Selhausen arable site was classified in the highest possible class C1 in 2019, and the Rollesbroich grassland site was classified as "associated" in 2021. Also already certified are the TERENO sites Fendt (C1), Graswang (associated) and Schechenfilz (associated) in the pre-Alpine observatory as well as Hohes Holz (C1) and Großes Bruch (associated) in the Harz/Central German Lowland observatory. im Observatorium „Harz/Mitteldeutsches Tiefland".

All data are freely available via the ICOS data portal.

▶ ICOS data portal

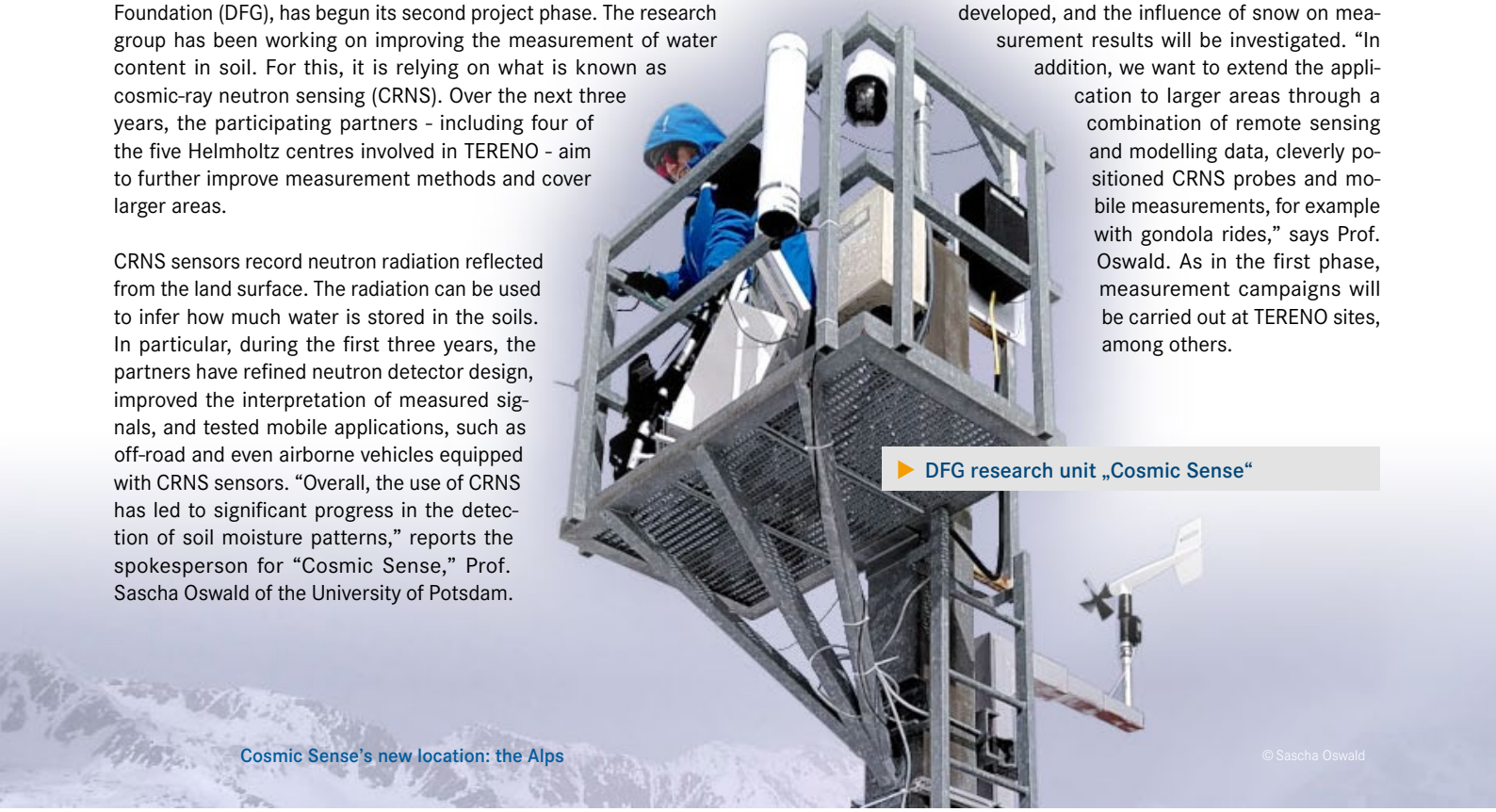
SECOND PHASE BEGUN

The "Cosmic Sense" research unit, funded by the German Research Foundation (DFG), has begun its second project phase. The research group has been working on improving the measurement of water content in soil. For this, it is relying on what is known as cosmic-ray neutron sensing (CRNS). Over the next three years, the participating partners - including four of the five Helmholtz centres involved in TERENO - aim to further improve measurement methods and cover larger areas.

CRNS sensors record neutron radiation reflected from the land surface. The radiation can be used to infer how much water is stored in the soils. In particular, during the first three years, the partners have refined neutron detector design, improved the interpretation of measured signals, and tested mobile applications, such as off-road and even airborne vehicles equipped with CRNS sensors. "Overall, the use of CRNS has led to significant progress in the detection of soil moisture patterns," reports the spokesperson for "Cosmic Sense," Prof. Sascha Oswald of the University of Potsdam.

In the second phase, the method will be further developed, and the influence of snow on measurement results will be investigated. "In addition, we want to extend the application to larger areas through a combination of remote sensing and modelling data, cleverly positioned CRNS probes and mobile measurements, for example with gondola rides," says Prof. Oswald. As in the first phase, measurement campaigns will be carried out at TERENO sites, among others.

▶ DFG research unit „Cosmic Sense"



Cosmic Sense's new location: the Alps

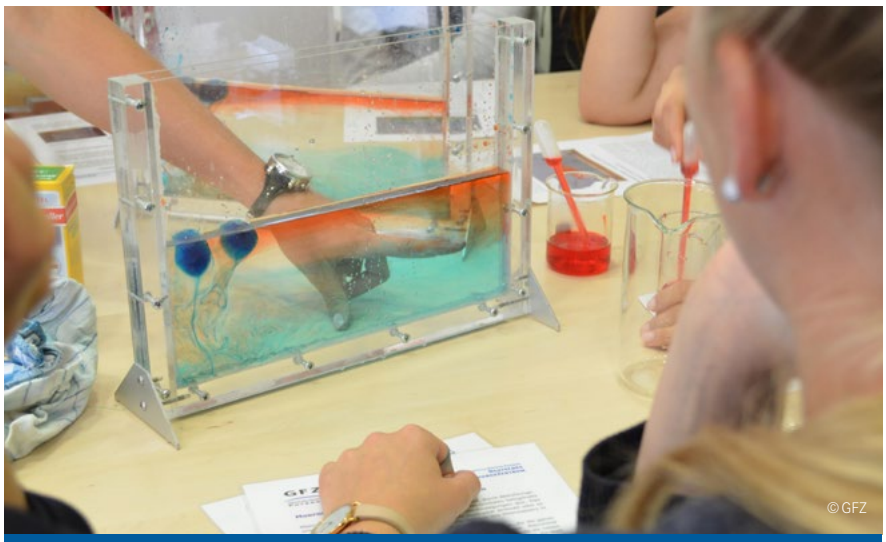
FROM THE SCHOOL BENCH TO THE LAB

Discovering the world of science, experimenting or even doing research yourself - in Germany there are numerous opportunities to get young people excited about science. They range from competitions such as "Jugend forscht" ("youth do research") to trial courses at a university, to student laboratories. The Helmholtz Centers participating in TERENO also regularly host students.

The Helmholtz Centre Potsdam GFZ - German Research Centre for Geosciences, for one, has its own student lab that offers courses for preschool and elementary school classes as well as for classes at secondary level I and II, among others. "Student labs, through their direct connection to a research facility, make it possible to communicate the latest scientific findings to schools. For example, we can offer environmental education at the cutting edge of research," says Manuela Lange, who is responsible for knowledge transfer to schools at the GFZ. The work done at the TERENO's Northeast German Lowland observatory (TERENO-NO) is also incorporated here. "We use it as a regional example to explain scientific working methods and knowledge processes," says Manuela Lange.

In the course "The climate system - on the trail of climate change," for example, the students learn about the usual data collection at the TERENO sites using various measuring instruments and measuring methods, as well as their analysis. "Among other things, we go into the role of peatlands in the exchange of greenhouse gases between soil, vegetation and atmosphere. Unfortunately, we can't do this on site in the field; Potsdam's physical distance from the sites would make it too time-consuming," the geoscientist explains.

In addition, secondary school students from one of the GFZ's cooperation schools receive an introduction to the research methods used in TERENO-NO to study lake sediments as geoarchives. They go through all the steps: from drilling in the lake bottom on site to laboratory investigations and data analysis at the GFZ. This knowledge helps them in their technical and seminar papers. A seminar paper on the topic of "External Influences on Artificial and Natural Waters" was even submitted for the state competition "Jugend Forscht" in 2022.



An important part of the courses at the GFZ student laboratory: practical exercises, for example on the influence of temperature on ocean currents

An unusual path

Schoolgirls from the Max-Josef-Stift Girls' High School in Munich can even do their own research thanks to the cooperation with the Campus Alpin of the Karlsruhe Institute of Technology. Since 2012, the KIT Institute for Meteorology and Climate Research (KIT/IMK-IFU) in Garmisch-Partenkirchen and the high school have been conducting joint projects. Participants of the propaedeutic science seminar in biology learn about scientific measurement methods and data evaluation for the quantification of greenhouse gases. Education and research benefit from this: the students understand what role ecosystems play in climate processes, whether they are sinks or sources of greenhouse gases, and what interdependencies lie behind them. And the research obtains cleanly collected data.

"At the beginning of the collaboration, we had deliberately chosen a rather unusual path. Two questions were crucial: Can school-research collaboration projects provide scientifically valid data? And, how must such projects be structured in order to be successful?" recalls Dr. Ralf Kiese of KIT/IMK-IFU. This developed into a kind of school-based Citizen Science, in which the schoolgirls independently measure greenhouse gases using a method established in the TERENO's Pre-Alpine observatory.

▶ GFZ student lab (in German)

Measuring and Analysing

After a briefing by the researchers, the students independently carry out manual chamber measurements on various agriculturally used soils in the area surrounding the school for several months during the vegetation period. During the measurements, the students have to take samples of the air trapped in the measurement chamber at 15-minute intervals within 45 minutes. The KIT/IMK-IFU laboratory then analyses the CO2, methane, and nitrous oxide concentrations of the samples. The students then use Excel spreadsheet to check the quality of the data and calculate the flux rates for the greenhouse gases. Finally, the students present the results of their seminar work to the scientists at a presentation at KIT IMK-IFU and learn about further topics and measurement methods of climate research during a guided tour.

"The data on greenhouse gas exchange of agricultural ecosystems collected in this school-science cooperation are absolutely valid; currently, the multi-year time series are being compiled in a publication," reports Dr. Kiese.

▶ School-research cooperation Max-Josef-Stift/Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research (in German)

COSMOS-EUROPE: LONG-TERM DATA ON SOIL MOISTURE PUBLISHED

Over the past decade, Europe has experienced the worst period of drought on record. In order to better monitor such changes and make predictions, a collection of harmonized long-term data sets are needed across the continent. COSMOS-Europe has released data providing a foundation for this approach, which relies on a European network of cosmic-ray neutron soil moisture (CRNS) sensors. The TERENO sites are part of the network.

“Such data sets are of particular importance for the analysis of extreme climatic events at the continental scale. For example, COSMOS-Europe data show that since 2018, soil moisture has been lower throughout the year, indicating a long-term downward trend in soil moisture”, says the lead author of the study, Dr. Heye Bogena from Forschungszentrum Jülich. The data set included measurements from 66 CRNSs operated by 24 institutions and distributed across the major climate zones in Europe. Twenty-six sensors are located in TERENO observatories.

“Data processing followed harmonized protocols and state-of-the-art methods to generate consistent and comparable soil moisture products,” explains Heye Bogena. He and his colleagues hope that the data will have a wide range of potential applications for environmental research: for example, remote sensing data validation, trend analysis, or model assimilation.

However, so far, COSMOS-Europe only covers central Europe; there are still large gaps in the more peripheral areas of Europe. The network therefore aims to motivate countries with few or no CRNS stations to set up additional stations. In addition, a global COSMOS network is envisioned, together with continental networks in the USA, Australia and India.

Heye Bogena et al. (2022). *COSMOS-Europe: a European network of cosmic-ray neutron soil moisture sensors. Earth System Science Data, Volume 14, pages 1125–1151.*

▶ DOI: 10.5194/essd-14-1125-2022

COSMOS-Europe dataset:

▶ DOI: 10.34731/x9s3-kr48

MAKING CITIES MORE SUSTAINABLE AND RESILIENT

Cities and urban areas are considered particularly vulnerable to environmental change and destructive natural events. The new Helmholtz initiative Resilient Urban Spaces aims to mitigate the risks to cities and make them more adaptive and resilient. TERENO supports the initiative.

“When we look at climate change, environmental changes and their consequences for the Earth system, we also have to consider urban areas,” says Prof. Bernd Hansjürgens of the Helmholtz Centre for Environmental Research – UFZ. Today, just over half of the people on our planet live in cities. According to United Nations estimates, this figure is expected to rise to two-thirds by 2030.

“In this context, we have to consider cities as both polluters and victims,” says the environmental economist. While cities are responsible for about 80 percent of global energy consumption and more than 70 percent of CO2 emissions, extreme weather events have a particularly strong impact on cities. During heat waves, for instance, temperatures are even higher in cities than in surrounding areas. The heat accumulation in the canyons of buildings has several causes: for example, dense building development, heat-storing surfaces made of concrete, glass or metal, and soil sealing.

Researchers from eight Helmholtz centers aim to identify ways to make cities more sustainable and resilient, and how people can live in cities under healthy environmental conditions despite climate change. To this end, they are currently setting up the Helmholtz initiative Resilient Urban Spaces. “As with environmental monitoring in the TERENO observatories, we need measurement networks to record conditions - from groundwater to air quality and interactions between urban structure and atmosphere, to resource and material flows,” explains Prof. Hansjürgens who coordinates the initiative jointly with Prof. Fabrice Cotton from Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences and Prof. Hans-Peter Schmid from Karlsruhe Institute for Technology (KIT). The researchers also want to investigate topics like food supply and urban-rural relationships.

“For many topics, the participating Helmholtz centers already have approaches. We want to bring them together,” says the UFZ scientist. The initiative has its sights set not only on German cities, but also Istanbul, Dar es Salaam or Santiago de Chile, for example.

Santiago de Chile is threatened by increasing heat and drought.

Hills and fields characterize the Quillow catchment area

AGROSCAPELAB QUILLOW WITH NEW WEBSITE

The catchment area of the Quillow in the Uckermark in one of the driest regions in Germany. Around 560 liters of precipitation per square meter fall there each year. The average nationwide in 2021 was 805 liters. The catchment area of about 170 km2 is part of the TERENO's Northeast German Lowland observatory. Focus of research in the area is the landscape laboratory AgroScapeLabQuillow (ASLQ) coordinated by the Leibniz Centre for Agricultural Landscape Research (ZALF). Long-term systematic and continuous measurements as well as process studies on landscape processes and landscape experiments are carried out at the ASLQ. The landscape is characterized by rolling hills and a large number of small standing waters, the sills. About two thirds of the area is used for agriculture. Intensive farming has led to severe soil erosion in recent centuries. A new website provides comprehensive information about the work in the ASLQ.

▶ AgroScapeLabQuillow

WATER RUNOFF: IN SEARCH OF RECURRING PATTERNS

The process is always the same: it rains, the water infiltrates into the soil, it runs off and enters water bodies, then evaporates, forms clouds, and at some point falls back to earth as precipitation. But does each individual step always follow the same pattern? For example, if the same amount of rain repeatedly falls on the ground in a region, does the water always run off in the same way? This is what Austrian researchers from the University of Natural Resources and Life Sciences, Vienna, in collaboration with TERENO, are trying to find out in the REPEAT project. The Austrian Science Fund is supporting the project.

"Specifically, we are investigating the so-called rainfall-runoff process, that means how rainfall is transported through a catchment area of a water body and generates streamflow," explains project leader Dr. Michael Stockinger. It is known that several factors influence this process - primarily topological and geological conditions, land use, and human influences. The problem: "It is not clear exactly how these factors influence the process. A reason for this is that water flow in the soil is invisible and currently impossible to measure with adequate spatiotemporal resolution to unequivocally answer the question of how exactly runoff is generated by rainfall," says Dr. Stockinger.

TERENO data as a basis

The extensive data from two TERENO sites, the Wüstebach forest site and the Rollesbroich grassland site, should help. The researchers aim to combine the TERENO data with artificially generated data. "First, we want to analyse the data to find out how similar rainfall patterns can be defined. If we know what belongs to such a pattern, we can look for similar patterns in hydrological data," explains Adriane Hövel, a doctoral student in the REPEAT project.

One essential component is the time spent by a water particle traveling through a catchment. Water travel times are also an important variable for assessing water quality. "It tells us something about the distribution of dissolved substances, which includes pollutants. This is because most dissolved substances are mainly transported by water," says Hatice Türk, another doctoral student in the REPEAT project.

That is why the researchers plan to use stable water isotopes as tracers. Isotopes are special types of atoms. The data will be incorporated into a hydrological model. "In this way, we want to explore the actual water flow in the soil and learn more about the factors that influence rainfall-runoff process. In the end, our results should help to develop better water management strategies," Dr. Stockinger summarizes.

Measuring station at TERENO site Wüstebach

EFFICIENT IRRIGATION

The number of people on our planet is growing continuously. The same cannot be said for our resources. Water, for example, will actually become scarcer in the coming decades as a result of climate change. "To feed everyone, we will have to produce more food with fewer resources in the future," says Dr. Cosimo Brogi, a postdoctoral researcher at Forschungszentrum Jülich. His interest in the topic of water scarcity and agriculture developed during his doctorate, for which he conducted research at the TERENO agricultural site in Selhausen.

Now the environmental engineer wants to help farmers at least partially compensate for potential water shortage through so-called precision irrigation.

In this process, each individual area of a site receives exactly as much water as is needed. This requires knowing as precisely as possible how dry each area is. Brogi uses innovative cosmic neutron sensors (CRNS) for this purpose. Together with his Jülich colleague Dr. Heye Bogena, he is exploring whether this works in practice in the EU project Agricultural Interoperability and Analysis Systems (ATLAS). The findings should help develop commercial products tailored to farmers' needs.

As a first step, the researchers installed two sensors in an apple orchard near Agia in Greece, close to a site of the European CRNS network COSMOS-Europe (see page 8). "Our preliminary results are very encouraging, but there are still some challenges to overcome," Brogi reports. For example, data must be delivered in near real-time to the platform that helps farmers manage irrigation timing and quantity. So far, little research has been done to determine whether CRNS is suitable for areas where soil moisture varies significantly - even within a small range.

TERENO WORKSHOP "FROM MEASUREMENTS TO MODELLING"

8–9 November 2022 in Garmisch-Partenkirchen, Germany

"From Measurements to Modelling" is the theme of the 8th TERENO Workshop hosted by the Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU). In presentations and dedicated workshops, researchers will present their work on integrating measurements made at TERENO observatories or other sites into hydrological, biogeochemical and biodiversity modelling activities. Topics include the application of process-based models and artificial intelligence applications at different scales (site, catchment, regional, national), and the translation of measurement and simulation results into decision support tools and products for stakeholders.

Venue:
Dorint-Hotel,
Garmisch-Partenkirchen, Germany

On 10 November, interested parties will have the opportunity to participate in a field trip to measurement sites of the TERENO's Pre-Alpine observatory.

Contact, and to register:
Dr. Ralf Kiese
Institute for Meteorology and Climate Research (IMK-IFU)
Karlsruhe Institute of Technology

Tel.: +49 (0) 88 21 / 1 83-1 53

▶ E-mail: ralf.kiese@kit.edu

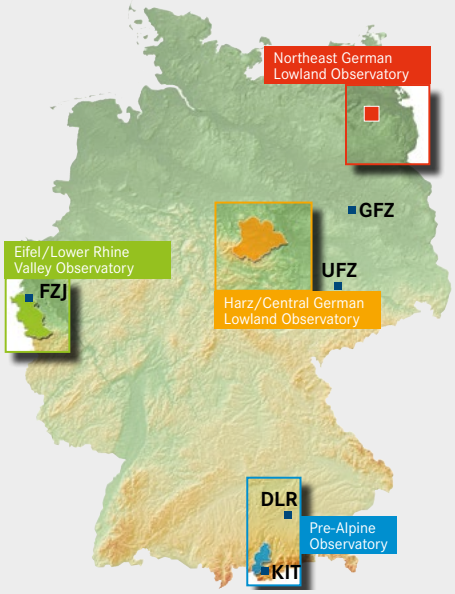
CONTACT | COORDINATION

Dr. Heye Bogena
Agrosphere Institute (IBG-3)
Forschungszentrum Jülich
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
Tel.: +49 (0) 88 21 / 1 83-1 53
E-mail: ralf.kiese@kit.edu

Dr. Markus Schwab
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences
Tel.: +49 (0) 3 31 / 2 88 1388
E-mail: markus.schwab@gfz-potsdam.de

Dr. Steffen Zacharias
Department of Monitoring and Exploration Technologies
Helmholtz Centre for Environmental Research – UFZ
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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