TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Newsletter 1/2024

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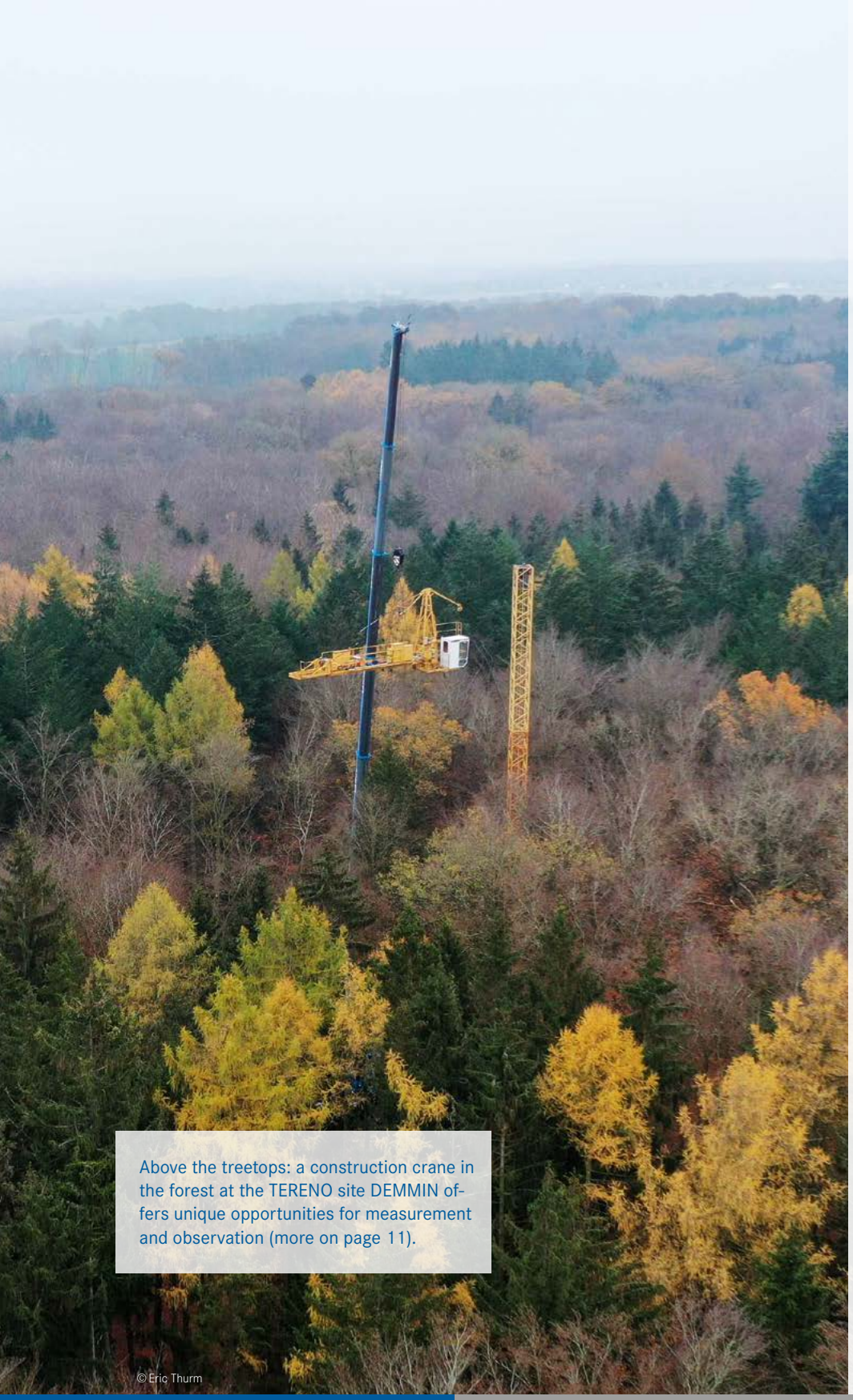

Above the treetops: a construction crane in the forest at the TERENO site DEMMIN offers unique opportunities for measurement and observation (more on page 11).

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SUCCESSFUL EVENT

The 2nd TERENO-OZCAR conference was a complete success. More than 80 lectures and 70 poster presentations provided plenty of material for exchange and discussion for the 170 scientists from 20 countries who came to Bonn at the end of September 2023. More from page 4.

HELMHOLTZ ASSOCIATION

PINIOS HYDROLOGIC OBSERVATORY RECORDS SEVERE STORM IN GREECE

In September 2023, Storm Daniel caused extreme rainfall and flooding in southeastern Europe and North Africa. One of the worst affected countries was Greece. Between September 4 and 7, numerous monitoring stations in the country logged new records for rainfall. More than a dozen people died, and around 200,000 livestock drowned. The Greek government estimated the damage caused by the water at around 2.5 billion euros. “There had never been such a extensive and destructive event in Greece before,” says Dr. Andreas Panagopoulos, research director at the Soil and Water Resources Institute of the Hellenic Agricultural Organization – DIMITRA (HAO).

Aerial view of the flooding in Agia

Panagopoulos is also responsible for the Pinios Hydrologic Observatory (PHO), which the HAO set up in 2015 together with Jülich agrosphere researchers based on the model of the TERENO observatories (see TERENO Newsletter 2/2016). The 53 square kilometer observatory near Agia is located in the Thessaly region, which was hit hard by the storm. In the agricultural area surrounding the PHO, rain and flooding of the Pinios River destroyed numerous fields and orchards. Damage was also caused to already stored produce, feed, and agricultural machinery and equipment.

The maximum daily rainfall in the PHO was recorded on September 5, exceeding 252 millimeters (mm). The highest rainfall intensity was 23.2 mm within 10 minutes, equivalent to 139 mm within one hour. “This shows how heavy some of the rainfall was,” says Dr. Vassilis Pisinaras of HAO. Between Sept. 4 and 7, a total of between 373 and 446 mm fell at the observatory's three meteorological stations. Other areas were hit even harder. According to the German Weather Service, in some cases around 1000 mm fell within three days. For comparison, the average annual precipitation of Hamburg is 800 mm.

The enormous amounts of rain also affected groundwater. One month after the storm, groundwater availability was eight times higher than before the extreme event. “Normally, this groundwater availability would be expected after a wet winter and spring season and around early to mid April. But even the groundwater availability estimated as of April 1, 2023, was still more than 30 percent lower compared to Oct. 3, 2023,” Pisinaras said.

EDITORIAL

Challenges are not getting any smaller

The second international TERENO-OZCAR conference was also a great success (p. 4-7). We are very pleased that scientists from over 20 countries participated. International exchange is enormously important in order to meet the challenges of global change. Moreover, the challenges are not getting any smaller. The EU's Copernicus climate change service reported that 2023 will be the warmest year globally since records began in the mid-19th century. At the same time, we are probably missing our climate protection targets. A UN report by the World Meteorological Organization (WMO) states that the greenhouse gas reductions recommended by countries would not be sufficient to achieve the goals of the Paris Climate Agreement.

Meanwhile, weather extremes caused disasters again in 2023, for example in Greece - our cooperation partners report on their extent (p. 2). An international team of researchers has shown how the global temperature rise could be mitigated: through a combination of CO_2 removal from the atmosphere by more plants and increased reflection of sunlight (p. 10). Another example of the necessary international cooperation is the teamwork with partners from Africa in the construction of measuring stations in West Africa. Unfortunately, a long-standing international partner is leaving us: the Danish hydrologist Karsten Høgh Jensen, who has been a member of the TERENO Advisory Board from the beginning, wants to make room for the next generation (p. 3). Many thanks to Karsten for his commitment and all the best!

I hope you enjoy this issue, and wish you all the best for 2024

Yours, Harry Vereecken
Coordinator TERENO

"IMPRESSED BY THE ACHIEVEMENTS"

At the end of the year, Prof. Karsten Høgh Jensen will leave the TERENO's Advisory Board at his own request. In the interview the Danish hydrogeologist looks back at his journey with TERENO.


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Karsten Høgh Jensen has been Professor for Hydrology at the University of Copenhagen since 2002. He is also director of the Danish Hydrological Observatory HOBE. In 2017, he received the Helmholtz International Fellow Award.

You have been an Advisory Board member from the very beginning. What did you think when you were approached for this role?

I was extremely honored and pleased to be invited as a member of the advisory board. I considered this as an excellent opportunity for exchange of knowledge and ideas between the TERENO observatories and the hydrological observatory HOBE in Denmark.

What was special about being a member of the Advisory Board?

I had an excellent opportunity to get detailed insight into the research accomplishments in TERENO and to meet the responsible scientists and coordinators of the project and also the young researchers affiliated with the project. I have met many students during the scientific sessions at the TERENO meetings. Knowledge sharing obtained during the meetings has been of great inspiration and significance for me.

Have your expectations been fulfilled?

My expectations have certainly been fulfilled. Our observatories have shared experiences with new instrumentation and modeling and shared knowledge about how catchments respond to temporal and spatial changes. Our close collaboration has been used to formulate and submit proposals to the EU to broaden the hydrological network in Europe – unfortunately, we have not been successful in this regard. However, we have developed a community driven European data platform of hydrological observatories, ENOHA, to make data from existing observatories available to the research community. Colleagues from TERENO have been the driving force for the establishment of the data platform. It is of pivotal significance that data collected at different sites are archived for the future and made available for other researchers. In addition, I would like to mention that TERENO and HOBE both are associated with the eLTER ecosystem network.

How do you assess TERENO's development so far?

I am deeply impressed by the achievements of TERENO. No other organization in Europe and beyond will have the financial and organizational resources in combination with the high scientific standing to develop and maintain such a comprehensive observational network. TERENO has been an immense inspiration to the hydrological scientific community in many regards. The initiative has developed and exploited new sensor technology to collect hydrological data for a range of temporal and spatial scales in combination with dedicated hydrological experiments. The data and findings have been analyzed by complex and integrated models using high performance computing. The research has been presented in numerous papers published in high-ranked international journals.

What recommendations do you have for the future of TERENO?

I am hoping that TERENO will continue for many more years. The hydrological scientific community needs long-term experimental infrastructures, which supply data that allow us to analyze the hydrological impacts of e.g. climate and land-use changes. I trust that the Helmholtz organization has the financial and organizational resources to make this happen.

What about your own future?

I have reached an age where it is time for the next generation of hydrologists to take over. Still, I am hoping to be able to make small contributions to hydrology here and there.

Prof. Jensen, thank you very much!


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ELECTED TO ACADEMY

The Austrian Academy of Sciences (ÖAW) has elected Prof. Achim Brauer of the German Research Centre for Geosciences (GFZ) as a Corresponding Member Abroad in its Mathematical and Natural Sciences Class. The head of the Climate Dynamics and Landscape Evolution Section at the GFZ was choosen by the ÖAW in particular for his research in the fields of paleolimnology and environmental and climate history.

THE 2ND TERENO-OZCAR CONFERENCE – A LOOK BACK

Even the sun cooperated. TERENO Coordinator Prof Harry Veerecken and OZCAR Coordinator Prof Isabelle Braud welcomed the participants to the 2nd TERENO-OZCAR conference in perfect late summer weather. 170 scientists from 20 countries came to the Gustav Stresemann Institute in Bonn at the end of September 2023. A further 50 took part online.

More than 80 lectures and 70 poster presentations on ten different topics (sessions) relating to the critical zone awaited them – ranging from fundamental questions on exchange processes between soil, vegetation and atmosphere to various approaches to long-term monitoring and new methods and modelling. Below, six examples give an insight into the variety of topics. Many of the lectures and poster presentations are available for download on the TERENO homepage (see p. 6).

The Gustav Stresemann Institute © Christian Hohlfeld

Improved model, improved understanding

Modelling is an important tool for researching the critical zone. Earth system models are the key to understanding and evaluating the effects of climate and land use on the functioning of the Earth system and its components. One problem with these models, however, is the quantification of water cycles and biogeochemical fluxes. "The best possible representation of these cycles depends on the ability of the models to correctly reproduce the precipitation distribution and the coupling between the land surface and the atmosphere," said Dr Cathy Hohenegger from the Max Planck Institute for Meteorology in her keynote speech in Session 8 "Water and biogeochemical cycles in Earth system models".

In her keynote speech, she presented a new Earth system model that was developed at the Max Planck Institute for Meteorology: ICON-Sapphire. "It is able to reproduce basic features of the precipitation distribution," emphasised Dr Hohenegger, who presented the results of a global, coupled simulation with a grid spacing of 5 kilometres over a complete annual cycle. Noteworthy, the coupling between soil moisture and precipitation tends to be weaker than what has been known from coarse-resolution earth system models, in better agreement with observations. This speaks for using km-scale earth system models for investigating questions related to climate over land, including carbon cycle.

Simplifications lead to biases in climate projections

Regional climate models are used to simulate the climate and its future development for certain regions. However, most of these models represent groundwater processes in a simplified way. "This can lead to biases when heatwaves are simulated," said Dr Liubov Poshyvailo-Strube from Forschungszentrum Jülich in her presentation "Groundwater in terrestrial systems modelling: a new climatology of extreme heat events in Europe". She is the lead author of a study in which the Terrestrial Systems Modelling Platform, or TSMP for short, was compared with an ensemble of EURO-CORDEX simulations for controlling climate change scenarios in the context of dynamical downscaling of global climate models. The difference between the two: TSMP uses a coupled regional climate system with a closed terrestrial water cycle, while the CORDEX ensemble works with simplified groundwater dynamics.

All simulations came up with a comparable number of heat events for the historical 30-year comparison period. However, there were statistical differences in the duration and the intensity of the heat events: compared to the CORDEX ensemble, TSMP simulated significantly fewer and less severe heat waves, i.e. heat events lasting 6 days or longer. "Our results show that taking groundwater into account in regional climate models could be a key to reducing biases in the simulation of heatwaves," summarises the Jülich researcher.

Understanding rivers better

Modelling also plays an important role in studies of watercourses, as the keynote speech by Prof. Julian Klaus from the University of Bonn in Session 7 “Extremes and the critical zone: Water and matter transport during floods and droughts, intermittent streams and processes at the groundwater-surface water interface” showed. In his presentation, Klaus dealt with the monitoring and modelling of watercourse processes. “In order to decipher these processes and their effects on the biogeochemistry and ecology of watercourses, it is crucial to understand the dynamics of the interactions between groundwater and surface water,” emphasised the Bonn-based researcher.

To improve this understanding, he and his team combined experimental techniques, hydrological modelling and observations of a network of wells. Using this combination, they investigated the processes in the hilly catchment area of the Weierbach, a well-equipped observatory in Luxembourg. A special feature: the team coupled their hydrological model with a so-called hydraulic mixed cell approach. This enabled the scientists to determine the sources and mixing of the surface water more precisely. “With the mix of observation and simulation, we were able to determine that it is not precipitation but the exfiltration of water from the subsurface that is the dominant source for the surface water in the bank areas and the stream runoff,” reported Klaus.

Floods and groundwater

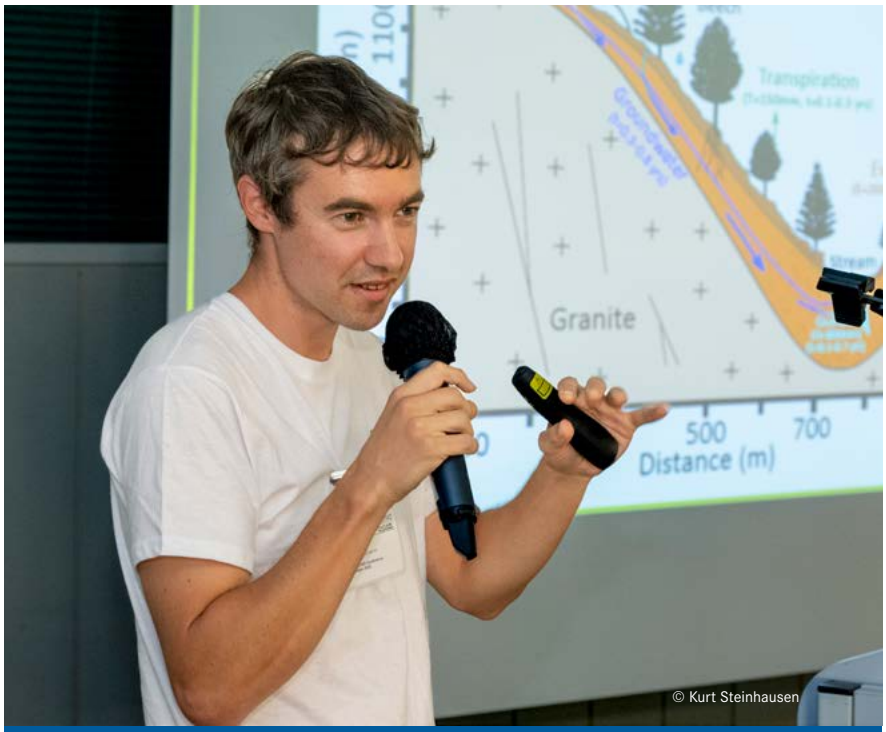
A frequently used method for analyzing watercourses is the so-called End-Member Mixing Analysis (EMMA). A team of French researchers has developed an EMMA method using the water conductivity as tracer to find out the groundwater contribution to the floods in small watersheds (less than 1 km^2). To this end, the team analysed floods between 2015 and 2020 in the Laval watershed in south-eastern France, which is part of the OZCAR Draix-Bleone observatory.
“We were able to discover seasonal patterns in the groundwater contribution to floods, that appear to be primarily linked to the meteorological characteristics of the catchment area,” reported Ophélie Fischer from the Institut des Géosciences de l'Environnement in Grenoble in her presentation “Study of the contribution of groundwater to floods in Mediterranean mountainous watersheds”. The team found that long-duration floods generated from low-intensity precipitations in winter and spring have high groundwater contributions, while short-duration floods generated by high-intensity storms in summer and autumn have low groundwater contributions. The link with sediment transfer was also analysed: results showed that the floods exporting the most sediments are the ones with the highest runoff contribution. “If we understand the processes that control erosion dynamics and sediment transfer within watersheds, we can also manage water and soil resources more sustainably,” emphasized Ophélie Fischer.

Coupled processes also important

Session 5 “Biogeochemical processes at the soil and catchment scale” focussed on the consequences of climate change, land use changes and agricultural practices on the biogeochemical cycle of water, carbon and nutrients and their exchange with the atmosphere, surface waters and groundwater. Long-term monitoring of catchment areas is essential in order to better understand and model the coupled biogeochemical and hydrological processes.

For their modelling, researchers from the French OZCAR network took three long-term observatories into account - the agriculturally dominated Kervidy-Naizin catchment in the AGRHYS observatory in north-west France, the Montoussé catchment in the south-west, which is also dominated by agriculture, and the Strengbach catchment, a forested low mountain region near the French-German border.

“Our investigations show that several processes that take place on different time scales are interconnected in controlling the hydrological functioning of water catchment areas. The long-term development of the critical zone and climatic influences determine the most important hydrological properties of the catchment areas,” reports Dr Julien Ackerer from the Institut des Géosciences de l’Environnement in Grenoble in his presentation “Integrated and ecohydrological modelling of the water cycle in three contrasting long-term observatories”. However, anthropogenic activities also have an influence. “They can weaken or exacerbate trends, as the effects of intensive agriculture and forestry on the current water cycle show,” says Ackerer.



Julien Ackerer from the Institut des Géosciences de l’Environnement

2. TERENO-OZCAR International Conference 2023

- https://www.tereno-conference2023.de
- Sessions, posters and impressions

Deforestation affects nutrient balance

Scientists from the Helmholtz Centre for Environmental Research – UFZ and Forschungszentrum Jülich investigated human intervention in nature: in 2013, the Eifel National Park cleared parts of the spruce forest at the Wüstebach TERENO site in order to convert the monoculture into a natural mixed beech forest. In their study, the researchers focussed on the effects of clear-cutting on the nutrient balance. "Deforestation can cause more nutrients to be washed out of the soil and end up in surface waters - which threatens ecosystems and drinking water supply," explains the lead author of the study, Annemarie Bäthge from the UFZ, in her presentation "The influence of clear-cut on nutrient dynamics in the Wüstebach catchment (Eifel, Germany) - Preliminary results from a modelling study".

After the clearing, increased levels of nitrate and organic carbon (DOC), for example, were detected in the Wüstebach. Using the HYPE model, Bäthge and her colleagues were able to break down how the additional nutrient losses came about. "Remains of the felled trees were the main driver. Their decomposition released additional nutrients into the soil," said Bäthge. Model calculations showed that the nitrate and DOC concentrations would have fallen without this effect. However, questions still remained about water runoff: "The model could not sufficiently reproduce the increase in fast flow components, so we were unable to evaluate its influence. But the model showed that regrowing vegetation has the potential to act as a nitrogen sink to shorten the period of nitrate loss after clear-cutting," says Bäthge.

Lively exchange

In addition to presenting and discussing new findings, getting to know each other and socialising are among the most important things at a conference. The 2nd TERENO-OZCAR conference also offered participants plenty of opportunities for this - and not just during the breaks between presentations, when the terrace and garden of the Gustav Stresemann Institute were an inviting place to chat. The conference programme also included excursions to the TERENO site in Wüstebach in the Eifel and to the Rur dam in Schwammenauel, a French-German science evening hosted by Samuel Pujade-Renaud from the French Embassy, and the conference dinner on the Rhine ship "Moby Dick".

After the successful second conference, we will await 2025, when the next conference will take place in Paris under the auspices of OZCAR.

MORE KNOWLEDGE IS NEEDED

Kevin Bishop is Professor of Environmental Assessment at the Swedish University of Agricultural Sciences (SLU), chair of the European Long-Term Ecosystem Research Interim Council (eLTER IC), and, since 2023, Director of the Swedish Infrastructure for Ecosystem Science (SITES). At the TERENO-OZCAR conference he gave the keynote speech of session 2 “Long-term environmental observation for understanding the Earth system in the Anthropocene”.

Prof. Bishop, what is the current state of international environmental monitoring?

We have undoubtedly made great progress. This starts with new methods, continues with open data and extends to the establishment of national structures and the expansion of international cooperation. But our work is far from over. Climate change and its effects are changing many things in the environment and this means we need to change how we monitor the environment.

What are the challenges?

One of the major challenges we face is green transition – the transformation of our economy and society to become more sustainable. Our task in environmental monitoring is to document how ecosystems are changing and understand why. This evidence base should help society in providing food, water and energy while protecting biodiversity, reducing greenhouse gases and adapting to climate change. But we need more knowledge about how ecosystems function to better utilize the evidence base provided by environmental monitoring.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How can we create more knowledge?

Knowledge is gained in the research observatories. Field research makes it possible to confront scientific theories with the complexity of reality. We can improve our knowledge of ecosystems in these observatories . When researchers come together and test their ideas, the result may not be what we expected, but it is likely to be just what was needed. As for national monitoring outside the specialized observatories, it is important to prioritize how resources are used to be most effective.

In Sweden, the field research infrastructure is a national task. What is special about SITES?

Established in 2013, SITES is run by a consortium of three universities and one national authority. The Swedish Research Council funds half of the infrastructure, with the other half coming from the consortium partners. Responsibility for each of the stations in the network lies with the partner who runs the station. SITES provide additional, long-term funding to each of the stations and coordinates network activities, including the data portal and thematic programs: SITES Water, Spectral and Aquanet. Like TERENO, SITES aims to promote high-quality research. Key elements of this mission include local support in the field, some long-term experiments, and open data from strategic environmental measurement time-series that provide context that a researcher might find useful. The research stations were chosen to represent important ecosystems in the country, e.g. agricultural lands, forests, lakes and tundra. Due to Sweden’s geographical location, SITES covers four climatic zones, ranging from the temperate climate in southern Sweden to the Arctic in the north.

What about international cooperation?

International cooperation is very important, and we aim to develop this further. SITES collaborates with research infrastructures and networks worldwide, for example, with ICOS, ACTRIS, eLTER, GLEON, and INTERACT (the International Network for Terrestrial Research and Monitoring in the Arctic). We are open to new partners and ideas. International conferences like the TERENO-OZCAR conference are perfect opportunities for exchanging ideas and intensifying contacts.

Prof. Bishop, thank you very much!

ENABLING SUSTAINABLE AGRICULTURE IN WEST AFRICA

Setting up measuring devices

The population of West Africa is growing rapidly. This has led to a strong intensification of agriculture - and thus to environmental damage, soil erosion and more greenhouse gas emissions. Climate change is increasing these problems. In the CONCERT project, partners from Germany, Ghana, Nigeria, and Niger are creating the conditions to make agriculture more sustainable and secure food supplies. The Federal Ministry of Education and Research is funding the project through the "WASCAL Research Action Plan 2.0" program.

"Both the intensification of agriculture and droughts and heavy rainfall have an impact on the water balance, soil moisture and nitrogen and carbon cycles. These effects can significantly impair crop cultivation and harvesting," explains Prof. Harald Kunstmann from the Institute of Meteorology and Climate Research (IMK-IFU) at the Karlsruhe Institute of Technology (KIT). In order to understand the interplay of the various factors, long-term climate observations are needed. These are the prerequisite for improving Earth system models and then being able to estimate future developments more accurately and develop adaptation measures.

So far, there have been few long-term climate observations in West Africa. To change this, KIT, the University of Augsburg, Forschungszentrum Jülich, the Kwame Nkrumah University of Science and Technology in Kumasi (Ghana) and WASCAL are working closely together to set up measuring devices at several locations in Ghana. "In 2022 and 2023, instruments were procured, prepared and successfully put into operation at a cost of around 300,000 euros," reports Frank Neidl from IMK-IFU, who was in charge of setting up the stations. The partners also want to use the instruments to record differences between rice-growing areas and undisturbed savanna soils and to measure methane fluxes for the first time. "Among other things, we contribute the experience we have gained over 15 years at the TERENO's Pre-Alpine Observatory to establish the instrument infrastructure," says Kunstmann.

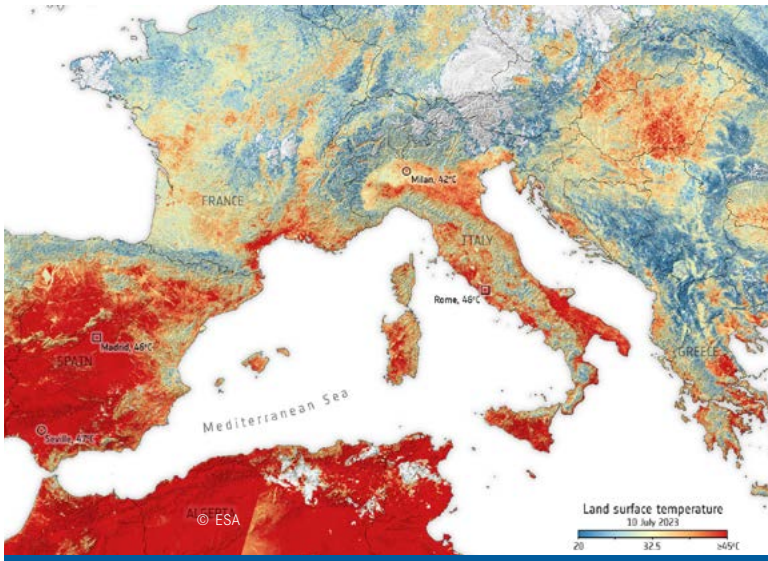
ONE SOLUTION FOR ALL

Seven Sentinel Earth observation satellites of the European Space Agency (ESA) are already in space. More are to follow. The EU project Copernicus Cal/Val Solution (CCVS), which was completed at the end of 2022, had the task of developing a holistic solution for calibrating all Sentinel satellites and validating the data products derived from them (Cal/Val). TERENO supported the project.

"With such a solution, synergies between the various missions can be identified, and by adapting the Cal/Val methods used, costs can be saved and the quality of the data products improved at the same time," says Bringfried Pflug from the German Aerospace Center (DLR), one of the partners of CCVS. In the first phase of the project, the partners carried out an inventory of available sources of reference data, for example in-situ measurements at permanent stations. TERENO sites were also included.

The existing Cal/Val methods and reference data were then compared with the requirements from the satellite missions. "We identified gaps in the process. We set out how these could be closed in our recommendations for research and development projects," reports Pflug. At the end of the project, the partners submitted their proposal for a Cal/Val strategy, including implementation, to the European Commission and the space agencies. They must now decide how to proceed.

The project partners also have recommendations for the TERENO network. "TERENO could create a hyperspectral network for measuring the spectral surface reflectance that is representative of the different cover types of the Earth's surface. It could provide data, including their uncertainties, that are traceable according to the International System of Units (SI) - i.e. SI-traceable reference measurements," says the DLR researcher.



Created with Sentinel data: land surface temperature across Europe on 10 July 2023

▶ Project reports of EU project Copernicus Cal/Val Solution (CCVS)

RZA: A UNIQUE SOCIO-ECOLOGICAL RESEARCH INFRASTRUCTURE

The “Réseau des Zones Ateliers” (RZA) is a French national research infrastructure (RI) for social-ecological systems. It brings together 15 so called Zones Ateliers, which are Long-Term Socio-Ecological Research (LTSER) platforms accredited by the French state research organisation “CNRS Ecologie & Environnement”. The French LTSER platforms are structured around a specific landscape such as a river and its watershed, a mountain range, a coastal zone, agricultural or urban areas. The research carried out aims to explore, understand, predict, and possibly transform the functioning and trajectories, past and future, of social-ecological systems (SES).

Some platforms have been in existence for 35 years, while the RZA network itself emerged in the 2000s. It became a research infrastructure in 2018. Since 2020, RZA has been working together with the “Observatoires de la Zone Critique: Applications et Recherche” (OZCAR), another French research infrastructure and Partner of TERENO, in the construction of the European eLTER-RI.

Developing a Systems Approach to SES

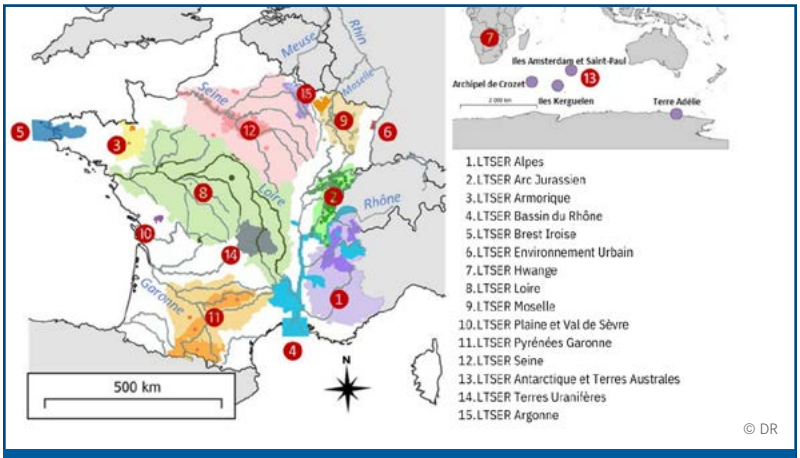
The RZA is working in the field of sustainability sciences, particularly in its transformative science branch. It benefits from a wide diversity of SES, providing an appropriate framework for addressing the complexity of each SES, and the scaling up through comparisons or testing of hypotheses along different gradients (climate, environment, intensity of anthropization, history of co-research with stakeholders...).

For this purpose, “Zones Ateliers” develop systemic approaches involving holistic interdisciplinarity among life, earth, engineering, human and social sciences, and strong transdisciplinarity. This includes cooperation with local stakeholders such as protected area managers, citizens, NGOs, decentralized state services, local authorities, and agencies.

The RZA provides a number of services for the scientific community, stakeholders, and decision-makers. The most important is the co-construction of knowledge, a synergy effect between research and practice that enables new insights for both. The RZA's working hypothesis is that co-construction is absolutely necessary to accompany territories in their transformation towards greater sustainability.

▶ The Zones Ateliers

The Zone Atelier Jura Arc



Overview of the current 15 Zones Ateliers: 13 are located in France, one in Zimbabwe in Africa (7) and one covers areas in the Indian Ocean and the Antarctica (13).

WAYS TO COOL DOWN

How can we mitigate climate change? One contribution might be to plant trees, since they remove CO_2 from the atmosphere. But more trees would reduce another cooling effect of the land surface: the reflection of sunlight, or albedo. An international research team shows why reforestation first leads to warming and how that can be avoided, at least for certain locations.

For their study, the scientists from 14 countries considered data on greenhouse gas, water and energy budgets, including reflection of sunlight, from 176 FLUXNET sites. FLUXNET is a global network of regional environmental monitoring networks, including TERENO. Using these data, the researchers computed what would happen if each site was redesigned to absorb the maximum amount of CO_2 possible. Their result: in the first 20 years, there is a moderate global net warming, before a strong cooling effect sets in.

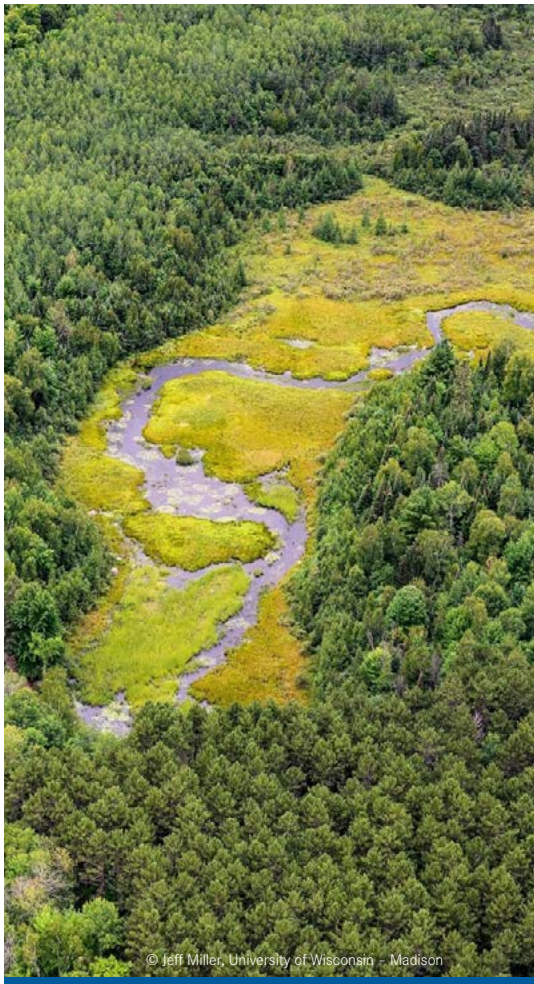
"In the first phase, the decline in albedo dominates. Forests, for example, reflect much less sunlight than most other land ecosystems. Instead, they absorb more light, which contributes to global warming," says the study's lead author, Dr. Alexander Graf of the Institute of Biological and Geosciences (IBG-3) at Forschungszentrum Jülich. But the most important factor is time. "This warming effect has a much faster impact than the cooling effect due to increasing CO_2 storage. This is because trees first have to grow in order to absorb larger amounts of CO_2," says the Jülich researcher.

But for many locations there are ways to avoid negative effects or even increase CO_2 uptake and albedo at the same time. "One example: many regions with intensive farming have a dark soil surface that lies fallow for part of the year. If cover crops are grown during the fallow period – where climate permits it –, we get a year-round vegetation cover that both increases albedo and CO_2 uptake," Graf explains.

Alexander Graf et al. (2023). *Joint optimization of land carbon uptake and albedo can help achieve moderate instantaneous and long-term cooling effects.* Commun Earth Environ 4, 298.

▶ DOI: 10.1038/s43247-023-00958-4

▶ **Behind the paper: reflect sunlight or use it to store carbon?**



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Study site near Lost Creek, USA

NEW DFG RESEARCH UNIT ON CLIMATE ADAPTATION OF FOREST TREES

The damaging effects of climate change on European forests have been clearly visible since the extreme droughts and heat waves of 2018 and 2019. It is still unclear how domestic forests can adapt in the face of such drastic and rapid environmental changes. An interdisciplinary research unit "PhytOakmeter" was founded to investigate this question over the next four years. It is funded by the German Research Foundation (DFG) and the Swiss National Science Foundation (SNSF).

© Ines Krieg

Oak trees and weather station at TERENO site Greifenhagen

The aim of the research unit is to understand the oak tree and its microbiome with regard to its reaction to environmental changes so well that they can be used as phytometers – that means as sensors for climatic and biotic stress. "To this end, we are using a clone of pedunculate oak – Quercus robur – that can be in-vitro propagated and later grown in soil for greenhouse and field trials. A clone means that the oaks are genetically identical and therefore our studies are not influenced by genetic variability of the host tree," says Prof. Mika Tarkka from Helmholtz Centre for Environmental Research – UFZ, one of the project partners. In this way, the researchers hope to decipher the role of the tree and its microbes to acclimation and adaptation processes.

PhytOakmeter uses both experimental and field platforms in its research. In nature, the clone is studied in 12 sites ranging from south-western France and southern Finland - for example, in Germany in the TERENO sites Greifenhagen, Harsleben, Pfeiffhausen and Bad Lauchstädt. "The oak trees were planted in these sites in 2014 and monitored ever since by us. The sites were arranged with online weather stations by the UFZ Research Data Management team," UFZ researcher Dr. Marie-Lara Bouffaud explains.

A GIANT IN THE FOREST

Near Demmin in the TERENO's Northeast German Lowland observatory, a construction crane has recently been erected in the middle of the forest. “The rotating crane offers unique opportunities to observe the tree crowns and to take measurements and samples,” explains Dr. Sibylle Itzerott from the German Research Center for Geosciences (GFZ). For more than 10 years, the 45 meter high giant stood at the edge of the forest, now it has moved on into the forest for the new research project FeMoPhys. In this project, the GFZ and its five project partners are continuously recording the condition and development of the main tree species in the mixed forest using remote sensing techniques. What is new is that not only spectral signals from the crane nacelle, the drone, the aircraft and the satellite are recorded, but are combined with tree physiology measurements and biomarker investigations on the needles and leaves to form an overall picture. In this way, it should be possible to concretely identify the physiological causes responsible for the expression and change of the spectral signal. “In the course of climate change, information on the vitality of forests is becoming increasingly important in order to better identify stress and stress signals,” says GFZ project manager Itzerott.

Floating above the forest in a gondola

The Rappbode Dam

DAM OBSERVATORY BECOMES JOINT PROJECT

The Rappbode Dam Observatory (TOR) in the TERENO's “Harz/Central German Lowland” Observatory will be run by three partners in the future. The Helmholtz Centre for Environmental Research (UFZ) has signed a corresponding cooperation agreement with the two co-operators, the Talsperrenbetrieb Sachsen-Anhalt (TSB) and Fernwasser Elbaue-Ostharz (FEO).

With a reservoir volume of more than 100 million cubic meters, Rappbode Dam is the largest drinking water reservoir in Germany. It supplies around one million people in the region. “With the instruments installed there, we record water quality, matter flows and ecosystem dynamics of the dam system and its inflows,” says Dr. Karsten Rinke, head of TOR and also of the UFZ's Department of Lake Research.

The water authorities use the TOR not only to monitor water quality in real time, but also to identify emerging problems at an early stage, for example high inputs of humic substances from the catchment area. Long-term issues are also tackled together, such as climate change, forest loss, and adaptation options for water management.

The cooperation agreement not only intensifies the existing collaboration, but also puts it on a sound basis for long-term operation as the partners will share the financial and human resources required to operate and maintain the observatory.

AWARDED AS BEST DOCTORAL THESIS

Dr. Ebuka Canisius Nwosu has received the Friedrich Robert Helmert Prize for his doctoral thesis on the lake Tiefer See in the TERENO's Northeast German Lowlands Observatory. The Association of Friends and Sponsors of the German Research Centre for Geosciences (GFZ), the GFZ Friends, awards the prize of 1,500 euros each year to the best doctoral thesis written at the GFZ. With the help of the DNA of cyanobacteria - also known as blue-green algae - Nwosu was able to prove that humans have been permanently altering their environment since the Bronze Age. He had extracted the genetic material of the bacteria from up to 11,000-year-old sediments of lake Tiefer See (see Newsletter 2/22).

EC system for determining trace gases in the undergrowth and soil

DROUGHT: IMMEDIATE AND DELAYED RESPONSE OF THE FOREST

In 2018, Germany suffered from a widespread drought. The drought and the subsequent proliferation of tree pests caused considerable damage to the forests. Researchers at the Helmholtz Center for Environmental Research - UFZ have found a way to distinguish between the immediate and delayed response of the forest to the drought.

To do this, the scientists analyzed eddy covariance data from the TERENO site Hohes Holz, a mixed deciduous forest in central Germany, from the period 2015 to 2020. They were able to identify patterns in the data that are related to the extreme drought. For example, the net ecosystem productivity of the forest – that means carbon sequestration - was around 16 percent higher in 2018 than in the years before the drought, followed by a sharp decline of around a quarter in 2019. “The decline in productivity cannot be explained by the hydrometerological conditions in that year alone,” says UFZ doctoral student Felix Pohl, lead author of the study. Models had in fact predicted a significantly higher productivity. “By including long-term drought information into our models, we were able to reduce overestimation error in productivity for 2019 by almost half,” reports the UFZ researcher.

He has also created a dataset for 101 eddy covariance locations in Europe, which enables the comparison of drought events across different climate regions and flexible temporal parameterization. “Since a wide range of definitions for extreme events are used in research, comparisons are often difficult. The published standardized approach makes this easier,” explains Pohl.

Felix Pohl et al. 2023. *Observational evidence of legacy effects of the 2018 drought on a mixed deciduous forest in Germany*. Sci Rep 13, 10863.

▶ DOI: 10.1038/s41598-023-38087-9

▶ Dataset

GROUNDWATER AS THE MAIN PATHWAY OF PHOSPHORUS

If too many nutrients such as nitrogen and phosphorus enter bodies of water, algae and aquatic plants grow excessively. One of the main causes of this eutrophication of streams, rivers and lakes are diffuse phosphorus emissions from the land into the water. These emissions are caused by intensive agricultural land use.

Researchers from the Helmholtz Centre for Environmental Research - UFZ have discovered that phosphorus can mainly enter a watercourse via the groundwater, especially under ecologically relevant low water conditions. Using the Schäfertalbach stream in the TERENO observatory “Harz/Mitteldeutsches Tiefland” as an example, they investigated the main pathways, sources and seasonal concentrations of a type of phosphorus that algae and plants can easily convert: soluble reactive phosphorus (SRP). “SRP concentrations can vary greatly throughout the year, often being highest in summer. But their main sources, their spatial distribution and their temporal dynamics are often unknown,” explains Prof. Michael Rode, first author of the study.

The researchers took samples along the entire length of the stream and carried out combined measurement campaigns during summer and winter low water conditions. In order to identify the SRP release processes, they carried out measurements of radiocarbon, dissolved organic carbon (DOC) and iron in the rising groundwater and in the streambed sediments, for example. “The SRP concentrations, the proportion of SRP in the total dissolved phosphorus and the radiocarbon age matched in the samples of stream water and groundwater that we had taken in the summer under low water conditions,” reports UFZ researcher and co-author of the study Dr. Andreas Musolff. It also turned out that a single short section in the upper headwaters was responsible for most of the SRP fluxes in the stream. The next step is to investigate whether the results can be transferred to sites with different conditions.

Michael Rode et al. 2023. *Seasonal variation and release of soluble reactive phosphorus in an agricultural upland headwater in central Germany*. Hydrology and Earth System Sciences, Volume 27, 1261–1277.

▶ DOI: 10.5194/hess-27-1261-2023


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NO OFF-THE-SHELF TECHNOLOGY

Diversity - this best describes the responsibilities of the nine technicians from the German Research Center for Geosciences Potsdam (GFZ) who work at the TERENO's Northeast German Lowlands observatory. Professionally trained as engineers, meteorologists, geoinformation scientists and physicists, they operate and maintain scientific instruments situated in agricultural fields, peatlands or forests, such as the forest crane near Demmin (see page 11). “Here, we are responsible for both sensors and cameras, as well as the overall operation of the crane. This includes legal considerations or the organization of training for researchers,” says Christian Budach, who manages the crane together with Christian Wille.

One ongoing task involves monthly lake monitoring, led by Sylvia Pinkerneil, who oversees equipment acquisition, maintenance, sample collection, and data quality assurance. Additionally, technicians may be involved in laboratory analyses or software development. There are often special assignments, such as Matthias Zöllner overseeing a specialized drone measuring system for greenhouse gas fluxes, and Alice Künzel at the Demmin site looking after the X-band weather radar. The technicians are often the face of TERENO Northeast regularly engaging with the community and local partners at the sites, for example with the employees of the Müritz National Park and local farmers.

Individual solutions required

What they encounter time and again: “There is no off-the-shelf technology for certain experiments or infrastructure, solutions have to be developed individually,” reports Markus Morgner. They and their colleagues Anke Saborowski and Jörg Wummel, provide essential expertise to researchers, for example giving specialist advice on equipment and solutions for conducting experiments in the field. Another regular task is to check measuring stations on site. In the forest, debris such as leaves, branches and collapsed trees or even animals can cause unwanted disturbances. “Consistent measurement series and high data quality must of course be guaranteed,” says Matthias Köppl.

However, TERENO's activities are only part of their work. Spread across four sections at GFZ and with almost all the Northeast Lowland technicians being funded by other projects, many can only allocate a portion of their working time to the observatory.

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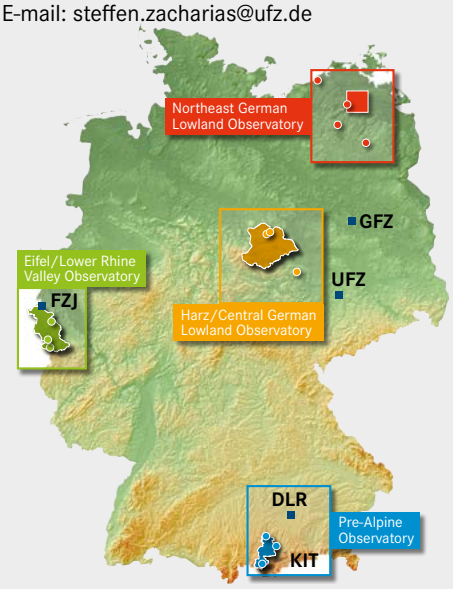

FZJ Forschungszentrum Jülich (Coordination)

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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