TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

NEWSLETTER

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A giver of life, soil plays a number of vital roles, providing habitat, nutrients and critical ecosystem services for the environment. Soils are also an important economic factor.

HIGH PERFORMANCE SOIL

THE DELICATE ALL-ROUNDER

Soil is full of life. A handful of soil will sometimes contain more living organisms than there are people on earth. Soil secures life. Humans obtain 90% of their food from the soil's uppermost layer. Soils not only provide animals, plants and other organisms with water and nutrients, they also filter out pollutants. As the earth's third-largest carbon pool, soils are also important for the climate. But soils are not just multi-talents, they are also delicate and highly complex, and today's climate and land-use changes are having a tremendous impact on the way they function. This poses a huge challenge to the scientific community, especially since we do not yet understand all of the processes involved. This is where TERENO plays a vital role – with research in soil function and changes in the soil over the long term.

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TERENO International Conference
29 September to 2 October 2014

A MORE INTEGRATED APPROACH TO MATERIAL AND WATER CYCLES

TERENO observatories apply new research strategies

TERENO provides the ideal platform for a cross-disciplinary approach to soil science research. While climate change and land-use changes are having a tremendous impact on terrestrial systems, research until now has focused only on subsystems such as topsoil, the carbon cycle, the nitrogen cycle, or near-surface aquifers. But in order to assess the effects of climate change, material cycles must be considered as interactive systems in connection with the water cycle.

In the coming years, global increases in nitrogen emissions will result in an increase in terrestrial nitrogen deposition by a factor of 2.5. As climate change causes nutrient levels to increase, scientists do not yet know enough about the relevant processes to assess the impact of these changes on soil productivity. This requires an integrated research approach, which regards the carbon, nitrogen and water cycles as an interconnected network.

Various activities in the TERENO observatories are designed to do just that. TERENO-SOILCan investigates the effects of climate change on soil function and soil water balance. At the SOILCan site in Dedelow/Uckermark, the German Research Centre for Geosciences (GFZ) and the Leibniz Centre for Agricultural Landscape Research (ZALF) are installing a second lysimeter hexagon complementary to the exisiting hexagon, which contains soils of different erosional states. The new hexagon will be filled with three strongly eroded soils and three colluvial soils, partly influenced by groundwater. Together, both hexagons will allow an analysis of pedogenesis and feedback processes as a result of erosion and deposition processes, which are most important for soil landscape dynamics in the Uckermark.

Water fluxes and soil shifts

The Helmholtz Centre for Environmental Research – UFZ together with ZALF have installed a "Vadose Zone Monitoring System" (VAMOS) at Dedelow. A prototype of this measurement concept installed at the Schäfertal site, which analyses vertical and lateral water fluxes in the unsaturated zone, has been providing interesting results for a year now.

This year, GFZ and ZALF have begun monitoring, reconstructing and conducting an impact analysis of soil shifts in small catchment areas in Germany's Uckermark region. At UFZ, the Soil-Landscape-Modeling (SLAM) is being developed as part of the integrated project "Water and solute fluxes in catchments". This involves the coupling of soil formation models with geophysics and remote sensing to estimate the continuous distribution of soils and their functional characteristics (see page 8). ■

Another lysimeter hexagon will be installed at the SOILCan site in Dedelow to investigate additional landscape soils, including eroded luvisol (r.) and colluvic gleyic regosol (l.).

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EDITORIAL

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It's time for action

The German government's Soil Protection Report published in June of this year sums it up well: even 15 years after signing the Kyoto Protocol, too little attention is being devoted to soils when developing climate-change protection and adaptation measures. This is an area where soil research needs to take action. In Germany, the various disciplines and research facilities within the terrestrial research community have already begun working together more intensively – due in no small part to the collaborative work facilitated by TERENO. In light of the challenges we face, we need to continue to push this kind of collaboration further. If we want to be able to assess the impact of current and future climate changes and to develop mitigation and adaptation strategies, for example, we will need an integrated research approach that considers the interactions and complex feedback mechanisms between the water, matter (e.g. carbon, nitrogen) and energy cycles in terrestrial systems and its management with a specific emphasis on the role of soils. We can only achieve this if all disciplines work together, which is already one of TERENO's strengths. In the coming year, TERENO will organise its first large international conference as a way to facilitate a dialogue between the various disciplines involved in observing terrestrial systems and predicting its changes (see page 4). Still, a team of experts recently concluded that soil research in Germany needs to do more (see page 3). This includes establishing a consensus on the most urgent research topics, achieving more expedient knowledge transfer and improving communication with the general public, so that everyone – not just the experts – becomes aware of the social and economic importance of soils. And we need to begin with this as soon as possible.

I hope you enjoy this issue of the TERENO newsletter.

Sincerely,

Harry Vereecken
TERENO Coordinator

A NEW STRATEGY FOR SOIL RESEARCH

Expert team recommends setting priorities – Interview with project head Prof. Franz Makeschin


© private

Franz Makeschin was Professor for Soil Science and Soil Protection at Dresden University of Technology (TU Dresden) until April 2013. An educated farmer, Prof. Makeschin is also Chairman of the Soil Protection Commission KBU of Germany's Federal Environmental Agency and a member of the Life, Environmental and Geo Sciences Scientific Committee of Science Europe.

Prof. Franz Makeschin is among Germany's leading scientists in the area of land use and soil conservation. With funding from Germany's National Academy of Science and Engineering (*acatech*), Prof. Makeschin has led a team of experts from the sciences, business, government and various associations in developing recommendations for the area of soil science and research. In the following interview, Prof. Makeschin (63) talks about the importance of soils and priorities for future soil research.

Professor Makeschin, what role do soils play today?
Soils are among the basic necessities of life. Soil supports plant life, which we then rely on for food and natural resources. Many people are unaware of the importance of soils – that they are in fact an important economic factor in Germany, much like the car industry. Soils also play an important role in the environment and perform vital ecosystem services.

Could you give us an example of these "services"?
Soils play an important role in the natural cycle of materials. Organisms in the soil ingest and decompose plant debris and turn it into humus. Humus contains many important nutrients such as nitrogen or phosphorous, which then sustain the growth of new plants. Soils play a protective role as well, for example, by filtering and transforming pollutants, which prevents pollutants from contaminating groundwater.

The team of experts under your direction has focused mainly on soil and land management. What are some of the main topics here?
The biggest challenges are climate change, resource scarcity, food security and material management. Climate changes affect the complex and delicate processes and material cycles in the soils, and this can negatively impact soil fertility. What we need are region-specific adaptation measures. At the same time, the demand for biomass continues to grow. We need to feed the growing population and satisfy growing energy needs, which is why we need to increase crop yields, establish sustainable land use practices and an efficient value chain.

How can soil research contribute to this?
Soil research – or soil-relevant research – needs to bundle its knowledge better. This includes not only soil science, but also disciplines such as hydrology, economics and biodiversity. These areas need to work together more than they have in the past. Until now, soil research in Germany has been too fragmented. Today, it should be aligning more on strategy and research priorities, while not restricting the freedom of basic research.

What should be the high-priority research topics?
In the *acatech* paper we defined 11 areas where we think we need to find interdisciplinary solutions – areas such as climate change, land use, land management, soil-water-plant interactions, biogeochemistry and material dynamics. This includes the development of innovative methods, sensor technologies and remote sensing techniques. The TERENO research platform is an important component of these efforts. We also need to be focusing on the interrelationships between soil, nutrition and health and on restoring degraded land, i.e. land with impaired soil function.

How impaired are our soils today?
Current estimates indicate that 20 million square kilometres of soil around the world are impaired, which is about ten percent of the available land surface. This is mainly due to soil erosion resulting from human activity – things like deforestation, overgrazing and one-sided soil management practices. But there are significant regional variations and some of these estimates are based on data that is over 20 years old. All the more reason to increase investment in research.

How does soil research in Germany fare in an international comparison?
We have outstanding individual researchers who have also established reputations internationally. But more than other countries, we need to make sure that we build bridges, for example between university and non-university research. Projects such as TERENO are excellent examples of this. We need to build on these networks, internationally as well. And we need to become more active – not only within the scientific community but also vis-à-vis society, i.e. the larger community.

What do you mean by that?
In the past, soil research has concentrated too much on purely scientific topics and problems. As a result, we have failed to communicate the social and economic significance of soils. So we need to make up some ground here. Part of this involves communicating interrelationships, problems and our approach to solving these problems in a way that non-scientists can understand. We want to give soil research a voice. We want to work together with the business community on this – and hope for political support on this front as well.

Georessource Boden – Wirtschaftsfaktor und Ökosystemdienstleister. Empfehlungen für eine Bündelung der wissenschaftlichen Kompetenz im Boden- und Landmanagement. *Published by the National Academy of Science and Engineering (acatech)*, December 2012 as part of the "acatech Position Paper" series.

A BETTER UNDERSTANDING OF PATTERNS AND STRUCTURES

International symposium on soil-vegetation-atmosphere systems

An important aspect of Earth Sciences research is to provide a better understanding of complex patterns and exchange processes within and between the biosphere, hydrosphere, pedosphere and atmosphere at various time and space scales. This requires a joint effort and multidisciplinary approach, facilitated recently by the international symposium "Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modeling and Data Assimilation" held last March in Bonn, Germany. Hosted by the German Research Foundation's Transregional Collaborative Research Centre 32 and Denmark's HOBE Center for Hydrology, the event brought together some 150 experts from Asia, the Americas, and Europe to discuss current approaches and latest developments.

Researchers reported on new developments and techniques in the area of non-invasive measurement methods such as Electrical Impedance Tomography, Electro Magnetic Interference, Spectral Induced Polarization and Nuclear Magnetic Resonance. Also featured were high-resolution optical remote sensing techniques for determining vegetation parameters such as sun-induced fluorescence. Additional core topics included Integrative Terrestrial Systems – modeling platforms which incorporate all major interactions between ground water, soil, vegetation and the atmosphere – as well as data integration across time and space scales.

Lectures by scientists such as Dr. Roni Avissar (University of Miami/USA), Dr. Tissa Illangasekare (Colorado School of Mines/USA) and Dr. Dani Or (ETH Zürich/Switzerland) led to numerous in-depth discussions on questions such as: What kind of information can we expect from geophysical measurements? Which uncertainties must be considered within the soil-vegetation-atmosphere system? How can we develop upscaling methods to better describe the exchange of matter, energy and momentum between soil, vegetation and the atmosphere across scales?

All lectures are available for downloading www.tr32meeting.uni-koeln.de


© TR32 / Karin Boessenkool

Poster presentation at the international symposium hosted by Transregional Collaborative Research Centre 32 and HOBE.

ICOS-Germany launched

ICOS-Germany (ICOS-D), established April 1, 2013, provides an observation network for monitoring greenhouse gases across Germany. Part of the European "Integrated Carbon Observation System" (ICOS) initiative, the network brings together observation facilities, including TERENO observatories, that had largely worked independently up until this year. The goal of ICOS is to gain an overall picture of CO2 and other climate-relevant trace gases across Europe through continuous, high-quality, standardised measurements.
As part of ICOS-D, new measurement instruments will be purchased for the individual sites and a central measurement and calibration laboratory will be established in Jena. The infrastructure expansion, made possible by approximately 15 million euro in funding from Germany's Federal Ministry of Education and Research (BMBF), is scheduled to be completed by 2016, by which time the current network of 13 institutions will be joined by additional research institutions and universities. www.icos-infrastruktur.de


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Conference venue: University of Bonn.

FROM OBSERVATION TO PREDICTION

TERENO International Conference 2014 discusses new research approaches

Climate and land use change are key factors influencing the terrestrial hydrological system which need to be managed by society in the coming decades. These changes act and provoke system reactions on different spatial and temporal scales, which result in immense challenges for environmental and hydrological research. Terrestrial environmental research has to tackle these challenges. The TERENO International Conference "From observation to prediction in terrestrial systems" brings together international researchers of all Earth science disciplines to discuss new research approaches and the latest developments. The conference will be held from 29 September to 2 October 2014 at the University of Bonn, Germany.

New approaches are needed to detect complex interaction and feedback mechanisms between the various compartments of the terrestrial system and to identify long-term trends in observed states and fluxes. Therefore, the development and implementation of large-scale, long-term, and integrated environmental research infrastructures has become more and more important during the last few years across all scientific disciplines.

TERENO solicits contributions from scientists dealing with the integrated subsurface-land surface-atmosphere system from the micro to the meso-scale. Particularly interesting are studies applying novel sensing technologies for terrestrial systems; methods and case studies for bridging the scale between management, model and observation scale; coupled processes in soil-plant-atmosphere systems; data assimilation approaches for predicting states and fluxes in terrestrial systems.

Contact: Dr. Heye Bogena, Forschungszentrum Jülich, h.bogena@fz-juelich.de

PREPARING FOR FUTURE CHANGE

WESS research cluster investigates water cycle and matter fluxes

At the interface between surface water and groundwater: geoelectric measurements of the flow field inside the gravel bar.

The water cycle and matter fluxes in water, soil and atmosphere are delicate systems, which are impacted by climate change, land-use changes and man-made pollutants. The Water and Earth System Science Competence Cluster (WESS) investigates changes in these three environmental compartments and the resulting impact on the water cycle and on transport and turnover of solutes. With the help of TERENO, WESS researchers are developing strategies for managing or even avoiding future environmental problems.

WESS researchers collect the necessary data at two contrasting catchment areas: the River Neckar in Baden-Württemberg, Germany and the River Bode Basin in the state of Saxony-Anhalt, which forms an important part of the "Harz/Central German Lowland" TERENO observatory. WESS benefits from the extensive TERENO infrastructure and data sets already available at the TERENO field sites, for example at the monitoring site on the Selke, a tributary of the Bode river.

Here, WESS studies exchange fluxes of water and solutes in the hyporheic zone, in the river water and sediments in neighboring areas. In addition, WESS researchers want to characterise the land surface at the small hydrological catchment scale, for example at the Schäfertal Catchment testing site, with the help of extensive field measurement campaigns and remote sensing data to quantify water and heat exchange fluxes.

The Schäfertal site is also the focus for the development of a scalable soil-landscape model. In the catchment areas of the Selke, Bode and Sauerbach (another TERENO site), WESS is also investigating the transport and concentration of environmentally hazardous polycyclic aromatic hydrocarbons in river water samples. Cross comparison of the results from the Neckar catchment sites will allow a better understanding of the water cycle in different landscapes and insight into how these landscapes respond to environmental pollution.

WESS

The Water and Earth System Science Competence Cluster (WESS) was launched in 2009 as a joint project of the University of Tübingen, the University of Hohenheim, the University of Stuttgart and the Helmholtz Centre for Environmental Research – UFZ. It is a member of the Helmholtz Water Science Network and the "Water Science Alliance" e.V. www.wess.info

IN THE CRITICAL ZONE

SoilTrEC seeks international partners to form a global network of Critical Zone Observatories for soil research

The 2.5 kilometre long Damma Glacier in Switzerland is one of SoilTrEC's four Critical Zone Observatories. Compared to its size in 1920, the glacier has shrunk approximately 400 meters.

Soil degradation is an international threat which requires an international response. The European Union identified priority research areas in its 2007 Thematic Strategy for Soil Protection. SoilTrEC (Soil Transformations in European Catchments) addresses these areas. The five-year, 9-million euro project – including 7 million euro contributed by the European Commission – researches soil processes and their function within Earth's Critical Zone (CZ). The CZ, which extends from the vegetation canopy to the bottom of aquifers, supplies most essential life-sustaining resources and is under tremendous pressure from the increasing demands of human population and wealth. One of SoilTrEC's objectives is to establish a global network of Critical Zone Observatories (CZOs) in cooperation with international partners.

SoilTrEC comprises four European CZOs, which represent key stages of the soil cycle. Understanding the evolution of soil processes through this life cycle provides new insights into soil research. The four SoilTrEC CZOs are integrated with additional EU, USA and Chinese field sites as the first global network of CZOs. Using a CZ integrated model, soil processes can be studied along environmental gradients at planetary scale providing a major evidence base for policy makers.

SoilTrEC Project Coordinator, Professor Steven Banwart at the University of Sheffield, stresses the need for international support in securing the success of the global CZO network and the management of the data collected. TERENO, with its long-term soil research experiments such as TERENO Soil-Can and SoilNet, and the data-sharing portal TEODOOR, is well-placed to make a significant contribution. Professor Banwart has already worked closely with scientists at the TERENO observatory "Bavarian Alps/pre-Alps", explains: "We collaborate with the TU Munich in our activities to build an international network of Critical Zone Observatories". Further partnerships are in the pipe-line. Professor Banwart is in frequent communication with TERENO Coordinator Professor Harry Vereecken: "We both see the potential for many networks of sites within Europe to link more proactively on terrestrial science."

www.soiltrec.eu

Steve Banwart. *Save our soils.* Nature, 2011, Vol. 474, Iss. 7350, pp 151–152. Doi: 10.1038/474151a

INSIGHT INTO RELATED INTERNATIONAL PROJECTS

2013 TERENO workshop in Garmisch-Partenkirchen

This year's TERENO workshop in Garmisch-Partenkirchen focused on the ongoing activities of the large-scale Helmholtz project as well as on the research approaches and activities of various other projects. Renowned national and international guest speakers presented numerous related projects and reported on their TERENO-relevant research. The two-day meeting was organised by the Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU) of the Karlsruhe Institute of Technology.

Dr. Henry Lin, Professor at Pennsylvania State University (USA) and member of the TERENO advisory board presented the Critical Zone Observatories in the USA. This network of observatories researches the transport of energy and materials in the Earth's so-called "Critical Zone", among other topics. Dr. Eva van Gorsel from Australia's Commonwealth Scientific and Industrial Research Organisation introduced the workshop participants to Australia's national-level Terrestrial Ecosystem Research Network, which monitors and studies Australia's entire ecosystem. Additional lectures presented research on carbon dioxide and ecosystems, the measurement and modeling of greenhouse gas emissions in urban regions, as well as carbon fluxes in the permafrost regions of the Arctic. Members of the TERENO coordination teams Data Management, Hydrology and Paleoclimate also reported on their current work. Other participants provided updates on projects such as ACROSS, REKLIM, ICOS, and UrbENO, as well as the new Helmholtz Alliance "Remote Sensing and Earth System Dynamics". In the evening doctoral candidates from TERENO-affiliated centres presented their posters, which featured current work at the four TERENO observatories.

The second day of the meeting was devoted entirely to new TERENO themes and topics. Three keynote speeches provided ample material for in-depth discussions. Speakers included Prof. Stefan Kollet from the Forschungszentrum Jülich (FZ Jülich), who spoke on the subject of "Integrated Modelling", Dr. Ellen Banzhaf from the Helmholtz Centre for Environmental Research – UFZ, who talked about the "Urban System" and Dr. Hannes Taubenböck from the German Aerospace Center (DLR) on the subject of "Remote Sensing Urban Spaces".

Workshop materials:
teodoor.icg.kfa-juelich.de/workshops-de

CONFERENCE REPORTS

Participants of the ICLEA workshop in Poland, with Czechowskie Lake in the background.

LANDSCAPE EVOLUTION IN NORTHERN CENTRAL EUROPE

How can we better understand climate dynamics and landscape evolution in the Baltic lowlands since the last ice age? Has anthropogenic climate change already had a significant impact? Or are the observed changes due to the natural variability of the Earth's climate – something that has accompanied human history throughout the millennia? These and other questions were the topic of discussion at the Helmholtz Virtual Institute of Integrated Climate and Landscape Evolution Analyses' (ICLEA) second annual international workshop held in the northern Polish village of Stara Kiszewa in late April 2013. The 75 participants in the workshop also collaborated to define future research topics and agree on comparative investigations. "The workshop marked a great step forward for international cooperation among different scientific disciplines," summed up Prof. Jörg F. Negendank, who is a member of ICLEA's international advisory board. The virtual institute, which is coordinated by the German Research Centre for Geosciences (GFZ), investigates long-term landscape evolution in the northern German and northern Polish lowlands. The German and Polish partners involved in the project make extensive use of the infrastructure provided by the TERENO observatory "Northeastern German Lowland".

Conference/workshop proceedings:
DOI: 10.2312/GFZ.b103-13047

EYE TOWARDS LONG-TERM CHANGE

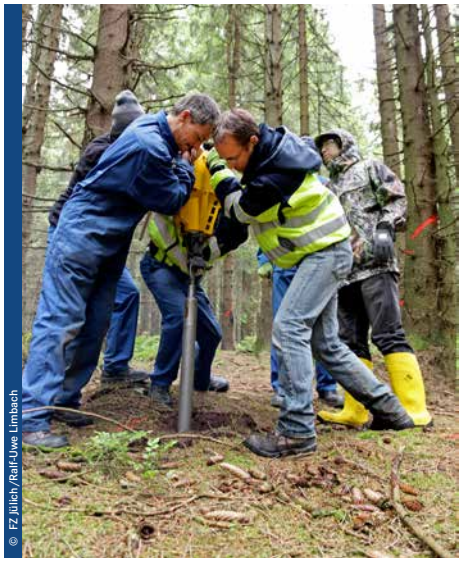
The working group on Palaeopedology of the German Soil Science Society (DBG) met for its annual conference in Klink/Müritz in early May 2013. Participants in the conference, all of whom study the long-term evolution of soils, considered the ways in which TERENO observatories have facilitated progress in the study of past soils and landscapes. The German Research Centre for Geosciences (GFZ) together with the University of Greifswald and the Müritz National Park invited participants to take part in two on-site visits to the TERENO observatory "Northeastern German Lowland". The soil and sediment sequences found at the Lake Fürstenseer See made clear to the excursion's 30 participating researchers that extreme hydrological events can be well reconstructed with the help of pedological-geomorphological analysis. The value of palaeopedological records was demonstrated by the beech forests near Serrahn, a UNESCO world natural heritage site, and the inland dunes at Lake Müritz. Research has shown that despite centuries-old tree populations, the soil and relief features in the national park across a large area are significantly impacted by former human activity.

www.dbges.de/wb/pages/working-groups/paleopedology.php

Close-up palaeopedological evidence: conference participants on a field trip in Müritz National Park.

A RETURN TO MIXED-DECIDUOUS FORESTS

TERENO supports natural restoration in the Eifel



Researchers collected roughly 1,250 soil samples in the spruce forest along the Wüstebach stream before the Eifel National Park began transforming it into a mixed deciduous forest (sampling with a percussion gouge).

This summer the Eifel National Park began efforts to transform the spruce forest along the Wüstebach stream into a mixed deciduous forest. The TERENO project team includes scientists from the Forschungszentrum Jülich (FZ Jülich), University of Bonn, University of Cologne and University of Trier. Together with the national park and regional water associations, the team will apply a continuous, long-term approach to investigate the impact of this restoration process. In June they began by taking 1250 soil samples at various depths, which will serve as the point of reference for analysing future samples.

Spruce trees were planted in the 19th and 20th centuries as a way of reforesting the logged areas of the Eifel. Today, the Eifel National Park wants to reintroduce native tree species to these areas. One benefit is the improved conditions for native animal species which, in some cases, have become rare or endangered. For soil scientists, the transformation is a very interesting process to observe. How will the environment react to the removal of approximately eight hectares of spruce forest? What will be the long-term impact on the water, carbon and nitrogen levels? No long-term research of this kind has been conducted up until now. The catchment of the Wüstebach stream, an important test site of the "Eifel/Lower Rhine Valley" TERENO observatory, is an ideal location for such a project. Numerous monitoring devices make it possible to measure changes in soil moisture, soil chemistry, soil physics, as well as the exchange of greenhouse gases between the soil and atmosphere – all at high temporal resolution. "Because the site is a self-contained catchment area, we are in fact able to balance water and material fluxes," explains Dr. Thomas Pütz from FZ Jülich.

The research findings are also relevant for international environmental and climate protection efforts. For example, Scandinavia and Russia continue to clear coniferous forests without fully understanding the consequences. At the same time, forests function as an important carbon sink and remain a significant factor for the global climate.

UNDERSTANDING EVAPORATION

Measurement campaign analyses temperature patterns in northeastern Germany

The July skies in Germany's northeastern corner: a helicopter from the German Federal Institute for Geosciences and Natural Resources (BGR) circles above Western Pomerania. Aboard the Sikorsky S-76B is a thermographic camera that provides information about the surface temperature of the landscape below. The measurement campaign is a joint project of the BGR and the German Research Centre for Geosciences (GFZ) in Potsdam. They hope to use the thermal remote sensing data to learn more about the climate-soil-vegetation system, focusing on evaporation.

For the campaign, the researchers identified two large observation areas in the DEMMIN testing area, each approximately four square kilometres in size. The large fields at the German Aerospace Center (DLR) research site, which serve as an important testing ground for the "Northeastern German Lowland" TERENO observatory, are ideal for the measurement campaign. The partners had already taken thermal-imaging photos from the air the previous year, but this summer the weather was far more cooperative. The conditions on three of the ten scheduled flying days were perfect for remote sensing data collection. Researchers were able to collect numerous images at different times of day and analyse the heat radiation of different objects as affected by solar irradiation levels.

Combining data

In order to collect thermal measurement data about the soil and plants at various spatial scales, the team also took thermal imaging photos from a platform 20 metres off the ground. A hyperspectral camera mounted on an aircraft also provided optical remote sensing data, including information on surface materials. Researchers also identified surface temperature, soil moisture levels and vegetation structure. Prior to the campaign, they had already taken several soil samples, analysed spectral characteristics of vegetation and soil, and prepared comprehensive documentation of the areas under investigation. "By bringing together various data sources, we want to better understand the relationships between temperature, soil moisture levels and evaporation," explains Dr. Sibylle Itzerott from the GFZ.

A German Federal Institute for Geosciences and Natural Resources (BGR) helicopter takes off to gather thermal-imaging data above the DEMMIN testing area.

MAPPING SOIL CHARACTERISTICS

SLAM enables better modeling

Every square inch of soil is different from the next, which is what makes it so difficult for researchers to accurately assess soil characteristics such as soil density, water availability or nutrient storage capacity at individual locations or across larger areas. Using soil landscape modeling (SLAM), scientists at the Helmholtz Centre for Environmental Research – UFZ are developing a concept that will make it possible to create a detailed "map" of functional soil characteristics.

TERENO provides ideal conditions for testing the SLAM concept, like at the Sauerbach intensive test site.

SLAM is part of the "Water and solute fluxes in catchments" project, which involves UFZ researchers studying different aspects of the soil at various resolutions across a wide area. As part of the project, available geological, topographical and land-use data are used to model the soil development in the context of landscapes. The researchers also carry out geophysical measurements and make use of remote sensing data from aircraft and satellites. While these different methods provide very different kinds of information, they are all relevant to understanding the spatial patterns of soils. "Together they provide us with the necessary foundation for forecasting soil distribution patterns in the landscape," explains Prof. Hans-Jörg Vogel, who is director of UFZ's Soil Physics department. Based on this "mapping", functional soil characteristics can then be identified, including water and solute flux. In this way, SLAM can provide parameters for modeling these fluxes. In the future, this will also improve forecasting of water and solute fluxes and make it easier to test and compare various model concepts.

TERENO provides the ideal framework for the further development of SLAM. Test sites such as the Schäfertal catchment of the TERENO observatory "Harz/Central German Lowland" feature highly instrumented soil monitoring networks. These intensive research sites make it possible to test and evaluate the SLAM concept directly – to determine, for example, the kind of data required for estimating soil patterns and the associated degree of uncertainty. The goal is to be able to apply the methods developed here to other areas and regions.

THE OAK AND ITS PARTNERS

"TrophinOak" project explores interactions with parasites, herbivores and fungi

In the test tube today, in the wild tomorrow: clones of the native pedunculate oak

A species does not function alone in an ecosystem. Together with other plants, insects and microorganisms, it forms communities characterised by complex systems of interactions with these partners. Scientists at the Helmholtz Centre for Environmental Research – UFZ, along with colleagues from five German universities, are analysing the effect of these various ecosystem partners on the oak tree. As part of the "TrophinOak" project, which has been funded by the German Science Foundation (DFG) since 2010, researchers are also investigating the role of changing climatic conditions on these various partner interactions.

The oak is one of the most important broadleaf trees in the northern hemisphere. With the oak in particular, its own functions and internal processes are influenced by interactions with so-called biotrophic partners – organisms that feed off living plant or animal substances. For their investigations, the "TrophinOak" researchers use an in-vitro propagated clone of the native pedunculate oak tree. Under strictly controlled laboratory conditions, they bring the plants into contact with bacteria, herbivores and mycorrhizal fungi and compare how gene activity is regulated during the individual interactions or how nutrients are distributed throughout the oak.

Phytometer system created

In order to test the lab results in the field, the research team has created a so-called phytometer system, which involves releasing standardised plants from the lab into the field along a predetermined climatic gradient – in this case within the TERENO observatory "Harz/Central German Lowland". TERENO sites offer the advantage of being equipped with numerous measurement instruments, which are also used by TERENO researchers to monitor vegetation, birds, butterflies and other insects. The "TrophinOak" lab and field tests are also investigating how climate change is impacting the oak trees and their various partner interactions. Climate researchers expect a warmer and drier climate in some parts of Germany and the oak tree – in contrast to conifer trees, for example – is considered to have a good chance of adapting to the changing conditions.

www.ufz.de/trophinoak/

POWERFUL COMBO

Assessing a new combination of soil-moisture measurement techniques

TERENO scientists conducted airborne measurements over the course of several weeks to test a combination of two soil moisture measurement techniques. By combining radar and radiometer measurements, they hope to generate more precise data. At the same time, the data provides important input for the SMAP (Soil Moisture Active and Passive) satellite mission to be launched by NASA in 2015 (see Newsletter 1/2013).

"The flights over the Rur River catchment area within the TERENO observatory "Eifel/Lower Rhine Valley" and the Bode River catchment area within the TERENO observatory "Harz/Central German Lowland" have demonstrated that we are making very good progress towards optimally combining the two measurement techniques," says Dr. Carsten Montzka from the Agrosphere Institute at Forschungszentrum Jülich. Because the water content of the upper soil layer influences the transfer of water and energy between the soil and atmosphere, more precise data on soil moisture could help to improve weather and flood forecasting, for example. The process involves deploying two different sensor types – radar and radiometer – in aircraft and satellites in an effort to more precisely measure soil water content. The TERENO researchers want to combine the two techniques and are developing, testing and analysing various algorithms to this end.

The radar emits microwaves, which are reflected differently off moist soil than off dry soil. The reflected signal thus provides an indication of the water content of the upper soil layer. Soil moisture is measured at a depth of 3 to 5 centimetres, depending on the soil. "Radar measurements are spatially very precise, but the data on soil water content depends very much on the roughness of the surface," explains Carsten Montzka. The radiometer does not emit a signal; instead, it receives electromagnetic radiation from the earth's surface. "While the spatial resolution is lower than radar, the radiometer allows us to determine more precise values for soil moisture," says Montzka.

The German Aerospace Center (DLR) provided the aircraft for the project: a Dornier Do228 fitted with the F-SAR radar system and PLMR2 radiometer. The researchers validated their airborne measurement data with ground-based moisture readings. The results are forwarded to NASA's SMAP mission, which will also rely on combined measurement techniques.

Radiometers provide precise data on soil moisture, but with low spatial resolution. Here, measurements are taken on a flight above the Blausteinsee lake near Jülich.

THE ROLE OF CLOUDS

Measurement campaign monitors spatial variations in solar radiation

Clouds and suspended particles, which can both mitigate and magnify solar radiation, have a significant effect on solar radiation levels on the ground. For the first time in Germany, scientists from the Forschungszentrum Jülich and the Leibniz Institute for Tropospheric Research (TROPOS) have investigated the spatial variation in solar radiation caused by clouds across a limited spatial region. In June and July of this year they conducted measurements in the region surrounding Jülich, Germany.

Every cloud not only looks different from the next, but also moves at a different speed across the sky. Individual clouds also change in shape and size as they move, which means that the solar radiation levels on the ground can vary within just a few metres and change within a short period of time. All of this has a significant impact on processes such as evaporation or the daily warming of the Earth and sky.

Thanks to the wealth of diagnostic tools available at the TERENO observatory "Eifel/Lower Rhine Valley" and the Transregional Collaborative Research Centre 32 (Transregio 32), researchers have been able to collect data on the most important cloud properties and material flows.

Near Jülich, TROPOS scientists installed roughly 100 pyranometers, which collect data on solar radiation levels.

100 pyranometers installed

Solar radiation data was collected by 100 special sensors provided by TROPOS, known as pyranometers, distributed across roughly 70 square kilometres (7 km x 10 km) southeast of Jülich. Researchers also installed several pyranometers in the TERENO forest test site Wüstebach in the Eifel National Park, where the trees – in contrast to open fields – affect the solar radiation levels on the ground by creating additional shade. The data is now being evaluated.

These investigations were a continuation of the HOPE project conducted this spring in Jülich as part of the ongoing "HD(CP)2 - Clouds and Precipitation Processes in the Climate System" project. HD(CP)2, which is also taking advantage of TERENO and Transregio 32 monitoring networks, investigates the role of clouds in the earth's radiation budget and climate system.

http://hdcp2.zmaw.de/

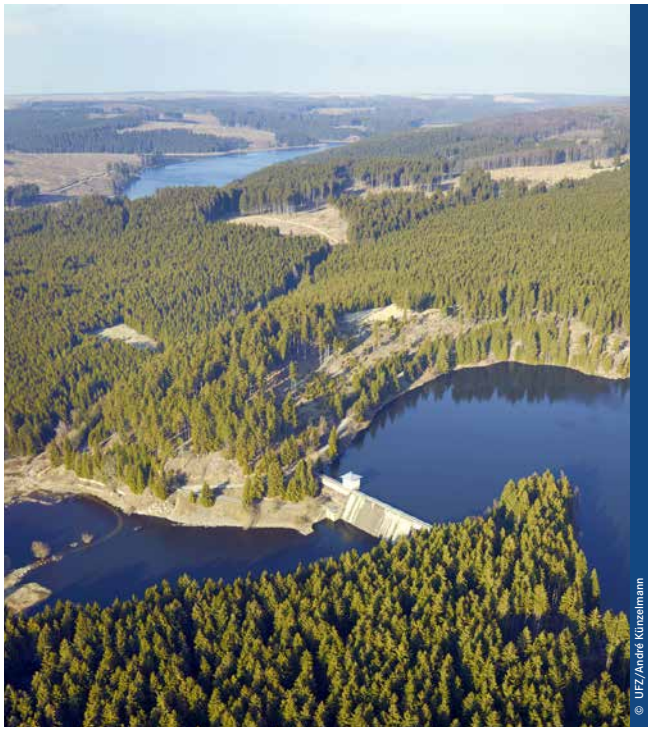
PUBLICATIONS

MATERIAL FLOWS AND WATER QUALITY IN RESERVOIRS

A reservoir's catchment area has decisive impact on the reservoir's water quality and its ecosystem dynamics, which is why these attributes provide important information about the biogeochemical and hydrological processes in the catchment. Within the TERENO project, scientists from the Helmholtz Centre for Environmental Research – UFZ have established an online monitoring system at Germany's largest drinking water reservoir, the Rappbode reservoir in the Harz Mountains region. The system is designed to monitor matter flows and water quality on a continuous basis. The TERENO Rappbode Reservoir Observatory (TOR) comprises a set of online sensors for the measurement of physical, chemical, and biological variables and is complemented by a biweekly limnological sampling schedule. TOR facilitates both scientific monitoring and process studies within the TERENO project, as well as reservoir management.

TOR researchers conduct high-frequency measurements in order to monitor short term dynamics. The advantage of this was demonstrated during a flood event in the summer of 2012, which mobilised high loads of dissolved organic carbon. The measurements revealed that the characteristics of the receiving reservoir changed from eutrophic to dystrophic within just a few days. The high-frequency measurement is also important for monitoring ecosystem dynamics such as oxygen production by algae or oxygen consumption by microorganisms. TOR also provides an excellent site for the application and further development of lake models and enables several links to other TERENO activities in the catchment area of the Bode River.

Karsten Rinke, Burkhard Kuehn, Serghei Bocaniov, Katrin Wendt-Potthoff, Olaf Büttner, Jörg Tittel, Martin Schultze, Peter Herzsprung, Helmut Rönicke, Karsten Rink, Kristine Rinke, Maren Dietze, Marco Matthes, Lothar Paul and **Kurt Friese**. *Reservoirs as sentinels of catchments: the Rappbode Reservoir Observatory (Harz Mountains, Germany)*. Environmental Earth Science, 2013, Vol. 69, Issue 2, pp. 523-536. Doi: 10.1007/s12665-013-2464-2.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The Rappbode Reservoir in the Harz Mountains region, is Germany's largest drinking water reservoir. UFZ scientists use an online monitoring system to continually monitor material flows and water quality.

LONG-TERM FLOOD DYNAMICS OF THE AMMER RIVER


© GFZ

Researchers gather sediment profiles from the bottom of Lake Ammersee with the help of a drilling platform.

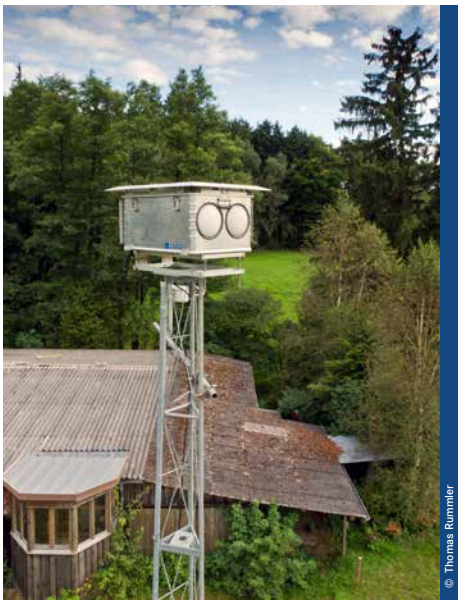
Sediment deposition at the bottom of a lake is an annual occurrence. With the help of new high-resolution analysis techniques, these stacked sediment layers provide the unique opportunity to create a long-term record of flooding events. Markus Czymzik, working at the TERENO observatory "Bavarian Alps/pre-Alps", created a 5,500-year record of flooding events for the Ammersee lake as part of his dissertation work with the German Research Centre for Geosciences (GFZ). Czymzik investigated two ten-meter sediment profiles and detected a total of 1,573 detrital layers marking flood events. The investigation is based on an innovative combination of microscopic analyses and high-resolution geochemical scanning techniques in the micrometer range. Comparisons of the flood layers with hydrological and meteorological data confirmed that flood layer deposition corresponds to summer flooding. The research indicates that the summer flood intensity for the Ammer River has increased over the last 5,500 years. The research team has determined that this increase was parallel to a gradual reduction in summer solar irradiation due to changes in the Earth's orbit around the sun. In addition, the research revealed significant variation in the frequency of flooding, by roughly a factor of 10 between flooding minima (2 flooding events in 30 years) and flooding maxima (20 flooding events in 30 years). These variations are attributed to climate changes as well as changes in solar activity.

Markus Czymzik, Achim Brauer, Peter Dulski, Birgit Plessen, Rudolf Naumann, Ulrich von Grafenstein, Raphael Scheffler. *Orbital and solar forcing of shifts in Mid- to Late Holocene flood intensity from varved sediments of pre-alpine Lake Ammersee (southern Germany)*. Quaternary Science Reviews, 2013, Vol. 61, pp. 96-110. Doi: 10.1016/j.quascirev.2012.11.010.

ESTIMATING HUMIDITY AND PRECIPITATION NEAR THE SURFACE

Near-surface water vapour and precipitation are central hydrometeorological observables which are still difficult to quantify accurately above the point scale. Both play an important role in modeling and remote sensing of the hydrologic cycle. Scientists at the Karlsruhe Institute of Technology and Technical University Munich have developed a new microwave transmission experiment that is capable of providing line integrated estimates of both humidity and precipitation near the surface. The system is located at the test site Fendt in the TERENO observatory "Bavarian Alps/pre-Alps" in southern Germany. Path length is kept short at 660 metres to minimise the likelihood of different precipitation types and intensities along the path. It uses a monostatic configuration with a combined transmitter/receiver unit and a 70-centimetre trihedral corner reflector.

The transmitter/receiver unit simultaneously operates at 22.235 gigahertz and 34.8 gigahertz with a pulse repetition rate of 25 kilohertz. An alternating horizontal and vertical polarization enables the analysis of the impact of the changing drop size distribution on the rain rate retrieval. Due to the coherence and the high phase stability of the system, it allows a sensitive observation of the propagation phase delay. On the basis of phase delay measurements, values for the line integrated refractivity of the atmosphere can be determined.This proxy is then post-processed to absolute humidity and compared to different station observations. In this article the authors present the design of the system and show an analysis of selected periods for both precipitation and humidity observations. The theoretically expected dependence of attenuation and differential attenuation on the drop size distribution was reproduced with experimental data. When detailed information about the drop size distribution was disregarded and only a fixed relation between attenuation and rain rate considered, a decreased correlation between the attenuation measurements and in-situ data was observed. Humidity data derived from the phase delay measurement correlated with in situ measurements.


© Thomas Rummler

The Fendt test site in the "Bavarian Alps/pre-Alps" TERENO observatory features a newly developed microwave measurement system, which can monitor air moisture and precipitation near the surface.

Christian Chwala, Harald Kunstmann, Susanne Hipp, Uwe Siart. *A monostatic microwave transmission experiment for line integrated precipitation and humidity remote sensing.* Atmospheric Research, 2013.
Doi: 10.1016/j.atmosres.2013.05.014.

IMPROVED MEASUREMENTS WITH TDR

Time domain reflectometry (TDR) is a standard method for measuring soil water content and soil electrical conductivity. In many applications, TDR probes are installed in soil columns or field setups, and TDR measurements are performed using a multiplexing system. Commercially available multiplexers share a common ground, which might lead to inaccurate TDR measurements when probes are installed close together or at sites with high electromagnetic noise. For this reason, researchers at the Forschungszentrum Jülich (FZJ) developed an eight-channel differential multiplexer (50C81-SDM) which allows communication with standard TDR equipment. In a first step, researchers tested the new multiplexer to analyse channel noise and channel-to-channel variability for open reflection coefficients and travel times. Second, the team tested the 50C81-SDM multiplexer using TDR probes installed in electrolyte solutions and a sand tank. In contrast to standard multiplexers, the 50C81-SDM multiplexer showed no interference of closely spaced TDR probes (spacing ranging from 5 to 95 cm). Measurements at the TERENO test site Selhausen also demonstrated the applicability of the 50C81-SDM multiplexer in environments with high electromagnetic noise.

Lutz Weihermüller, Johan Alexander Huisman, Normen Hermes, Stefanie Pickel and **Harry Vereecken.** *A New TDR Multiplexing System for Reliable Electrical Conductivity and Soil Water Content Measurements.*
Vadose Zone Journal, 2013, Vol. 12, No. 12.
Doi:10.2136/vzj2012.0194.

EVENTS

October 21-24, 2013 | Tucson, Arizona (USA)

Soil-mediated Drivers of Coupled Biogeochemical and Hydrological Processes Across Scales

In order to better quantify water and matter fluxes at the interfaces between neighbouring soil compartments, the interactions between hydrological and biogeochemical processes must be better understood. The American Geophysical Union's Chapman Conference is designed to bring together researchers from the soil sciences, hydrology and the biological and geological sciences to discuss current approaches to better understanding these processes. The event focuses on the significance of soils for hydrological and biogeochemical processes across various scales. Conference organisers include scientists from TERENO member institutions, including the Agrosphere Institute at the Forschungszentrum Jülich (FZJ) and the Karlsruhe Institute of Technology (KIT).

http://chapman.agu.org/soilmediated/

October 7-10, 2013 | Garmisch-Partenkirchen (Germany)

HGF Alliance Week: Remote Sensing and Earth System Dynamics

The partners of the new Helmholtz Alliance "Remote Sensing and Earth System Dynamics" will meet for the first time in October. Some 100 participants from 11 universities, 3 non-university research institutes, and the participating Helmholtz centres are expected to attend the Alliance Week. Led by the German Aerospace Center (DLR), the event will provide an overview of the project's goals and its four areas of research. The first recommendations of the External Advisory Board will also be developed at this time. The aim of the Alliance is to understand and quantify the complexity of the Earth system and its interaction processes. To this end, participating scientists plan to develop new biophysical and geophysical information products via satellite remote sensing.

www.hgf-eda.de

PROFILES: YOUNG RESEARCHERS AT TERENO

Bright future for data mining

Hendrik Paasche

TERENO observatory researchers gather vast amounts of data – from precipitation measurements, to soil temperature, to radar data. Dr. Hendrik Paasche, from the Helmholtz Centre for Environmental Research – UFZ, relies on data mining to process, evaluate and take full advantage of this wealth of information. "Using algorithms, we can process large amounts of different kinds of data automatically, quickly and objectively as a way of recognising structures and patterns. This is particularly helpful in the case of complex processes such as water budget or carbon fluxes, when a large number of different kinds of data need to be considered," explains the 37-year-old, who has headed up the UFZ working group "Data Integration and Parameter Estimation" since 2012. These methods have made tremendous progress possible in areas such as genome research. Using these kinds of analyses, soil researchers can determine with greater precision where to take samples in order to ensure the best quality data. "Our techniques also make it possible for scientists to include and evaluate data sets that might otherwise be outside their area of expertise," says Paasche, who earned a PhD in Geophysics from the Swiss Federal Institute of Technology in Zürich and conducted postdoctoral research at the University of Potsdam. TERENO was a big factor in Paasche's subsequent move to UFZ: "You can hardly get this kind of extensive and interdisciplinary data at any university," he says, believing that with data mining, it will be possible to supply environmental and climate models with more data and make it easier to adjust and improve models. ■

Soil moisture from microwave signals

François Jonard

Soil water content has a significant impact on water, carbon and energy cycles, and learning more about soil moisture requires a better understanding of the processes and dependencies between soil, vegetation and the atmosphere. One challenge is to determine the temporal and spatial variability of the soil water content as precisely as possible. To this end, Dr. François Jonard developed and tested new modeling techniques using active and passive microwave remote sensing data as part of his doctoral thesis at the Forschungszentrum Jülich with funding from the German Research Foundation's Transregional Collaborative Research Centre 32. Jonard, who has a Master's degree in Management along with a PhD in Environmental Engineering, used L-band radiometry and off-ground Ground Penetrating Radar (GPR). After completing his PhD in March 2012, Jonard has continued his research as a postdoc at Jülich. "Factors such as vegetation and soil surface roughness can often impair measurements of the soil water content from microwave signals, and we want to improve the process understanding for a better soil water content retrieval," explains the 34-year-old Belgian. Jonard and his Jülich colleagues want to investigate the use of these remote sensing methods for characterising crop canopies and water stress-related phenomena. TERENO is not the only beneficiary of Jonard's research. While pursuing his PhD, Jonard also spent three months in the USA to help prepare for NASA's Soil Moisture Active and Passive (SMAP) mission, which is scheduled for 2014. ■

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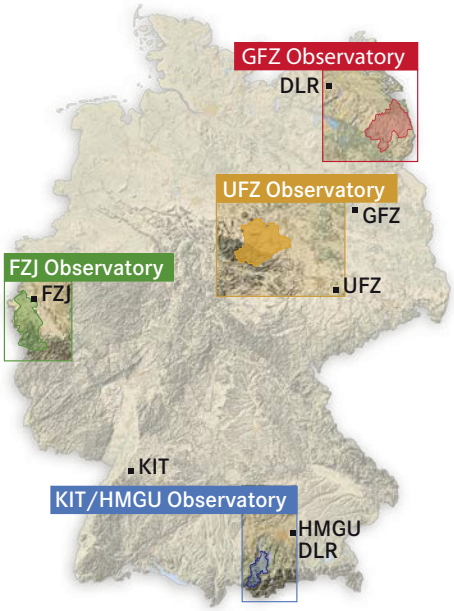

FZJ	Forschungszentrum Jülich (Coordination)
DLR	German Aerospace Center
KIT	Karlsruhe Institute of Technology
HMGU	Helmholtz Zentrum Muenchen, German Research Center for Environmental Health
UFZ	Helmholtz Centre for Environmental Research
GFZ	Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences