

Newsletter 1/2017

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In tow: a quad bike drags sleds installed with fixed-boom multi-coil electromagnetic induction systems for measuring integrated electrical conductivity over different soil depth ranges. The data allows researchers to determine soil physical properties, e.g. structure, moisture, and salinity at different depths.

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The “Critical Zone”

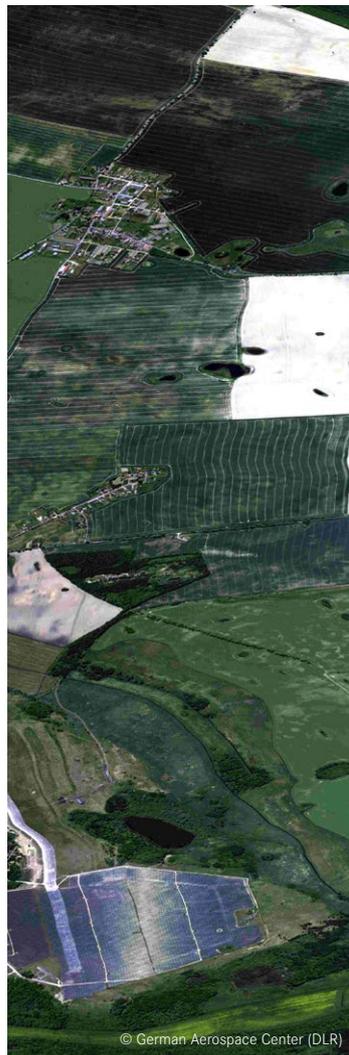
The uppermost layer of the Earth’s crust is home to most exchange and turnover processes associated with the Earth system. Because these processes are such a major factor for life on our planet, science refers to this “layer” as the Critical Zone. Understanding these Critical Zone processes is one of the more important tasks assigned to science today – not least because of the need to understand and adapt to climate change and its consequences. It is for this reason that TERENO operates six Critical Zone Observatories (CZO) in its observatories across Germany.

SOLAR INSTALLATIONS SUPPORT REMOTE SENSING

Remote sensing data is indispensable for today's climate and environmental research. To ensure the accuracy of this data, the remote sensors – in air and orbit – need to be calibrated. Scientists at the German Aerospace Center (DLR) and the Helmholtz Centre for Environmental Research – UFZ have developed a simple and reliable method for calibrating optoelectric sensors with the help of solar installations. These so-called in situ calibrations, which involve comparing sensor data with other measurements, are very time and cost intensive.

“Calibration methods in the lab and on board satellites are quite sophisticated and very reliable,” says DLR researcher Dr. Erik Borg from the German Remote Sensing Data Center (DFD). “But in situ calibrations are also quite common because current atmospheric conditions across time and space can vary, for example, and effect the quantitative analysis of the data.” But the disadvantage of in situ calibration is that it requires large and uniform reference areas, such as deserts, and this kind of homogenous expanse basically does not exist in Europe. “There is almost no way to calibrate sensors for Europe like this,” says Borg. “As a result we often have the problem that remote sensors do not account for the specific conditions here in Europe.”

This is also a problem for the TERENO initiative, which requires high-quality remote sensing data, for example, to develop climate change adaptation strategies. The hope is that this new method can achieve this level of quality for significantly less effort and cost. As the sensors fly over, they capture data on atmospheric conditions via solar installations. “The solar installations provide us with a measurement platform,” says UFZ researcher Prof. Peter Dietrich. “We then use the data generated to calibrate the sensors.” The researchers have applied for a patent for this new method, which will now be used in the TERENO observatories.



Solar field (silver area at bottom) near the TERENO site DEMMIN in northeastern Germany. Quick-Look photo without geometric and atmospheric correction taken on May 25, 2012 with the hyperspectral imager HySpex

TERENO INTERNATIONAL CONFERENCE 2018

From October 8–12, 2018 the Helmholtz Centre for Environmental Research – UFZ in cooperation with the other Helmholtz Centers engaged in the TERENO initiative will host the second TERENO International Conference. The event provides young scientists and international experts with a platform to come together and discuss recent progress and developments, strengthen the collaboration between data collection and data usage, and plan the future of international observatory networks. We cordially invite researchers from all disciplines of earth and environmental sciences.



EDITORIAL

Sharing knowledge



In the Critical Zone we are dealing with extremely complex processes between soil, rock, water, air and living organisms. Close collaboration between the wide-range of disciplines involved – from biology to meteorology to geology – is the only way to achieve effective Critical Zone research. For this we need observatories that allow researchers to observe the many processes in question. The USA was the pioneer in this area, establishing the first Critical Zone Exploration Network back in 2006 (see p. 5). Critical Zone research is also an important part of what we do at our TERENO observatories, as demonstrated by the six Critical Zone Observatories (CZO) that we have established (see p. 4).

And just as important as creating the CZOs is the process of networking i.e. establishing connections between observatories in the various countries, as well as with other environmental research networks, such as the European network for long-term environmental and ecosystem research (LTER-Europe). Only by exchanging and sharing knowledge will we be able to understand the complex processes involved – such as those between earth, atmosphere and land-use – and be able to develop solutions to address the effects of global environmental change.

We are promoting productive dialogue and exchange between colleagues across the widest spectrum of disciplines with the help of new projects and consortia, such as Danubius-RI (see p. 9), the European Hydrological Data Platform Initiative (see p. 9) or the International Modelling Consortium (see p. 10). And we are planning the next TERENO conference for 2018.

I hope you enjoy this issue of the TERENO newsletter.

Sincerely, **Harry Vereecken**

TERENO Coordinator

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BETTER UNDERSTANDING THE “CRITICAL ZONE”

The “Critical Zone”, a term first introduced by US scientist Dr. Gail Ashley in 1998, extends from the lower atmospheric boundary to the bottom of the groundwater. The complex processes that take place in this zone between soil, water, rock, air and living organisms are critical factors in determining matter fluxes and the formation of nutrients, soils and plants. Humans also live in and from the Critical Zone, but also impact the CZ through global change and/or changes in land-use, with consequences that are not always expected or foreseeable. All the more important, then, to improve our ability to understand, predict and manage these many Critical Zone processes.

Still, significant gaps in our knowledge of the CZ remain. As a result, many countries have created special Critical Zone Observatories (CZOs) over the last several years. Today a total of six CZOs can be found within TERENO’s four observatories, which provide the ideal setting for CZOs, since many of the areas important for Critical Zone research have long been the subject of TERENO research – whether atmosphere, hydrosphere, biosphere or pedosphere. TERENO scientists also work closely with colleagues from the Technical University of Munich (TUM), who have created their own CZO. The TUM CZO, which is located in TERENO’s “preAlpine” observatory, allows researchers to benefit from each other’s work at the Scheyern site, for example, or the Ammer River catchment.

Critical Zone Observatories (CZOs) in the TERENO research areas



“A MULTI-NATIONAL INTERDISCIPLINARY APPROACH IS REQUIRED”

Heading towards a worldwide network of Critical Zone Observatories – Interview with Dr. Timothy White, Coordinator of the US CZO National Office

In 2007 the US National Science Foundation funded the National Critical Zone Observatories (CZO) Program. The program serves the scientific community through research, infrastructure, data, and models. Nine CZOs have been established in the USA, and since 2010, Dr. Timothy White, geologist from The Pennsylvania State University, has been the coordinator of the CZO National office, working alongside Dr. Lou Derry, Cornell University. The office helps advance network-level Critical Zone science, education and outreach as tools for sustainability.



Dr. White, the US CZO national program was funded ten years ago. Germany is now establishing such a network. Is there any reason why it was established so much earlier in the US?

The international Earth surface and environmental science community began to organize around the concept of Critical Zone science in the early 2000s with funding support from the US NSF and the EC's SoilCritZone program. International scientists participated in many science-planning workshops. The US NSF had the foresight and leadership, primarily through the guidance of Dr. Enriqueta Barrera, to establish a formal program early on, shortly followed by the EC's SoilTrEC project. It's taken a little more time for the momentum to build in other nations, but we're seeing the concept spread, for example TERENO in Germany, the Critex project and the RBV network in France, and the new joint program between the Natural Environment Research Council (NERC) in the UK and the National Natural Science Foundation of China (NSFC) in China.

What are the main results of the US national program?

That's a difficult question to answer briefly. What I'll state is that the term "Critical Zone" is beginning to be broadly accepted in the Earth surface and environmental science communities, and in the US we are slowly beginning to introduce the term and concept into the mainstream lexicon of society. At our US CZO strategic planning meeting we defined three big ideas that have come from Critical Zone science as: revealing how the deep CZ varies across landscapes; predicting the spatial structure of the deep surface relative to the ground surface; and, observing that differences in energy inputs at the surface translate to differences in various characteristics at depth.

How could countries benefit from each other?

One beneficial approach that other countries could implement to help build a functioning global network of Critical Zone Observatories is to fill gaps in environmental gradient space that currently exist in the US CZO network. That is, help to address the science of the heterogeneous landscapes and climate change and land use impacts by studying those that are not studied in the existing US network.

Why is international cooperation important for Critical Zone research?

The Critical Zone is a complex and heterogeneous component of Earth's surface. To understand the full range of that heterogeneity and the full range of human impacts on it requires scientific inquiry

and observations from a range of landscapes and land uses that are not revealed in any single nation, or on no one continent. Further, the expertise, instrumentation, laboratories, and requisite funds cannot be found in one nation, thus a multi-national interdisciplinary approach is required. The community of nations needs a viable and sustainable mechanism for multi-national funding to establish a well functioning network of Critical Zone Observatories.

What is the US CZO community doing to strengthen international cooperation?

I am the Principal Investigator of a National Science Foundation project called CZO Science Across Virtual Institutes (SAVI). The project supports US students to travel abroad to work at international CZOs, laboratories and other field sites. The project has also supported a series of workshops in which international scientists have participated, and the 3rd International CZO Workshop will be held prior to the AGU meeting in New Orleans on December 10, 2017 to focus on developing a viable work plan and proposal for achieving CZ science across multiple international CZOs in 2018. Further, we now have an International CZO Planning Committee, with representatives from formally funded CZO networks in the U.S.A., France, Germany, United Kingdom and China, that should more effectively coordinate activities across the networks.

In August 2017 the USA submitted an official withdrawal from the Paris climate pact. The Trump administration is downplaying the human impact on climate change. What effect does the change of US climate and environmental policy have on your research and the National CZO Program?

So far, none that we are aware of beyond a drop in morale for those many scientists who have dedicated much of their research careers to understanding the consequences and impacts of ongoing climate and land use change. But the full impact remains to be seen as our Congress works through budget negotiations with the president – noting the administration's apparent goal of substantially cutting environmental science funding. Our CZO network will continue to pursue research to understand the functioning and resilience of the critical zone, including as influenced by climate and land use change.

Dr. White, thank you very much!

WATER QUALITY AND ECOLOGY OF TERRESTRIAL SYSTEMS

A look back at the 9th TERENO Workshop

More than 100 experts convened in October 2016 for the 9th TERENO Workshop held at the Helmholtz Centre for Environmental Research – UFZ in Leipzig with its focus on the ecology of terrestrial systems and water quality (“Forschung zur Ökologie terrestrischer Systeme und zur Wasserqualität”). TERENO’s annual workshop is a chance for TERENO researchers as well as guests from other research organizations to meet and discuss their latest projects and findings.

The 2016 workshop featured wide ranging lecture topics – from water quality analysis in lakes, to the use of dendrochronological studies for researching historical climate change, to the application of isotope analysis for understanding runoff processes in catchments. One of the main themes among the lecturers was aquatic ecosystems. Dr. Gretchen Gettel from UNESCO partner IHE Delft Institute for Water Education gave a lecture on the role of aquatic systems in greenhouse gas emissions.

President of Germany’s Federal Agency for Nature Conservation (BfN) and member of the TERENO advisory board Prof. Beate Jessel presented recent findings on ecosystem services of meadows and floodplain landscapes. Prof. Jeff McDonnell from the University of Saskatchewan, also a member of TERENO’s advisory board, spoke about the concept of ecohydrological separation and presented findings from his own experiments. Poster presentations also provided insight into some 40 projects, in particular those of young TERENO scientists.

Three different panel discussions focused on data management as well as new aspects of future research activity within the TERENO network. Participants discussed the concept of “Stichtagsbeprobung” as a way to achieve an integrated assessment of multiple influencing factors on the ecological and chemical quality of bodies of water. Also considered were ways to measure sources and sinks of matter transport in catchment areas.



Members of the TERENO advisory board and scientific steering committee take time during the workshop to visit the “Hohes Holz” site in the Harz/Central German Lowland observatory.

The independent scientists on the TERENO advisory board spoke highly of TERENO’s involvement in the eLTER project initiatives and suggested that TERENO’s very successful research could play a larger role on the European level.

WORKSHOP: DATA ASSIMILATION FOR IMPROVED FORECASTING

Data assimilation is considered a promising method for predicting fluxes – including water or carbon fluxes – in the atmosphere or ground. In September 2016 some 60 scientists from several different countries came together in Bonn to attend the “Data Assimilation in Terrestrial Systems” workshop and share with each other the latest insights and developments.



Participants in the workshop

“Data assimilation is the process by which computer simulation models are corrected with new measurement data on an ongoing basis,” explains Prof. Harrie-Jan Hendricks-Franssen, Forschungszentrum Jülich scientist and deputy spokesperson for DFG Research Unit 2131 “Data Assimilation for Improved Characterization of Fluxes Across Compartmental Interfaces”. Hendricks-Franssen helped organize the workshop, which featured guest lectures on data assimilation for atmospheric models, land surface models and subsurface models. Dr. Henrik Madsen from the Danish Hydraulic Institute presented a model including data assimilation that considers both land surface and subsurface.

Only a few working groups worldwide are currently focused on integrated data assimilation across the subsurface, land surface and atmosphere compartments. Researchers hope that such models can deliver significantly more accurate predictions. “Models that only consider the land surface in detail, for example, often simplify the effect of the atmosphere and subsurface on fluxes,” explains Hendricks-Franssen. “If in

addition calculations with such land surface models generate results that deviate from real measurement data, the only option is to make statistical adjustments.”

Hendricks-Franssen and colleagues from various other organizations are part of DFG Research Unit 2131, which is working on an integrated, cross-compartmental data assimilation model. This model takes into account actual physical relationships in such a way as to reduce highly complex processes as little as possible, i.e. model first principles as closely as possible (see TERENO Newsletter 1/2014). FOR 2131 also involves TERENO partners and relies on the extensive data provided by the TERENO infrastructure. Phase I of funding for the DFG research unit ended in spring 2017 after the initial three-year period. Now researchers expect to continue their work as part of Phase II.

▶ Workshop “Data Assimilation in Terrestrial Systems”

▶ DFG Research Unit 2131 “Data Assimilation for Improved Characterization of Fluxes across Compartmental Interfaces”

AN ID FOR EVERY SAMPLE

From taking samples to publishing results: TERENO’s approach to field data

The way to access the world of TERENO data is through its Data Discovery Portal (DDP). Through DDP scientists can access data gathered at TERENO’s four observatories on things like water and material fluxes, energy exchange processes, or changes in microorganisms, flora and fauna. A look at the SoilCan example reveals how exactly measurement data is gathered, managed and published.

TERENO’s SoilCan lysimeter network investigates how climate change effects soil processes and plant diversity. SoilCan measurements include both data collected automatically via in situ measurement stations, as well as samples taken by researchers out in the field. Along with soil and plant samples these mainly include water samples from surface waters, groundwater, precipitation and deposition samples, or the SoilCan lysimeters. In the Eifel/Lower Rhine Valley observatory, for example, researchers collect between 10,000 and 15,000 samples in this way each year. Given the sheer number of samples, researchers recognized the need for standardized procedures for gathering, analyzing and storing samples. To this end, Jülich scientists working with Dr. Ralf Kunkel, Tobias Korf and Jürgen Sorg developed the SAMPLIFY tool and integrated it into the time series management system TSM, which they also use to manage data collected automatically by the stations.

Gathering data via app

Every sample is labeled with a unique identifier; this ID, along with key meta data, is already assigned in the database before the sample is taken. Therefore, whoever takes the sample is also responsible for assigning an ID for the sample, a task accomplished using the JAVA program SAMPLIFY DESKTOP which can also be used to print sample labels and label series in various formats.

To support the sample-taking process out in the field, the team from Forschungszentrum Jülich has also developed the Android app SAMPLIFY-MOBILE. “For instance, if someone is collecting a water sample from surface water like a stream or a pond, the app allows them to enter the measured parameters digitally in the field and then synchronize them with the database later,” explains Ralf Kunkel. “This might include the exact time of sample collection, the water temperature or any comments and special information.”



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Labels for samples are created using the JAVA program SAMPLIFY DESKTOP. QR codes help identify each sample.



© Forschungszentrum Jülich / Ralf-Uwe Limbach

Jülich’s own Android app SAMPLIFY-MOBILE allows researchers to collect additional information for a sample, e.g. the exact time a sample was taken or the water temperature.



The TERENO Data Discovery Portal displays both the location of the measurement stations (green circles on the map) as well as time series for given parameters.

Identifying with QR codes

After collecting their samples, researchers can then use SAMPLIFY-DESKTOP to process the data collected either in the field or the lab. “The Program makes it easy to find data quickly using various search criteria such as project, measurement location, name or date,” says Tobias Korf. “But with any 2D-Barcode reading device, such as a smartphone, you can also read the sample’s QR code.” Furthermore, researchers can import the data directly into the TSM via MS-EXCEL or ASCII files or enter it manually for review, correction and publication.

Data from the water sample, for example, along with the associated analysis can then be published via DDP. “The platform also features helpful search functions,” says Jürgen Sorg. “From the main page you can quickly access all the measurement stations where samples were collected.” The stations are depicted as points on a map. When the user clicks on one of the points, a new window opens with time series for the various parameters – both for the measurement site as well as for individual samples; these can be visualized but also downloaded. In addition, users can search through the metadata for the samples in a detailed measurement-station view. “And of course that works not just with the SoilCan data,” adds Kunkel with a smile.

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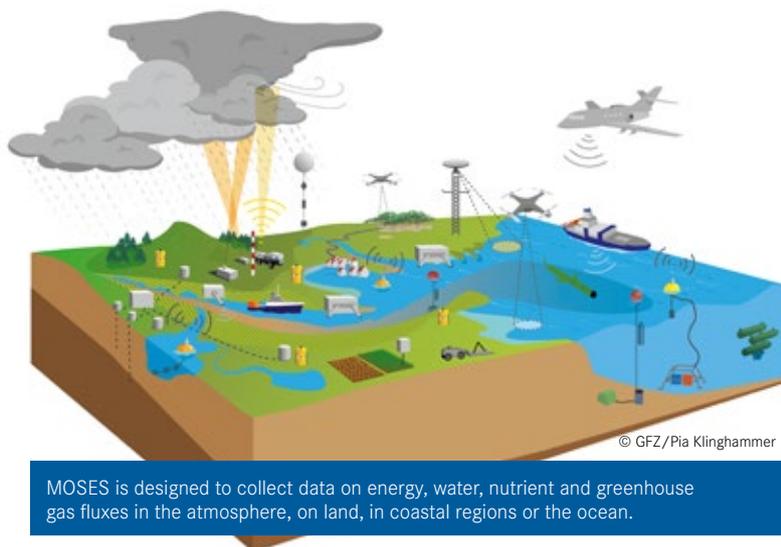
HEAT WAVES, FLOODS AND OTHER EXTREMES

The Helmholtz Association is creating a highly flexible, mobile earth observation system known as the Modular Observation Solutions for Earth Systems (MOSES). The system's 5-year launch phase began in 2017. Scientists want to use MOSES to investigate interactions between short-term dynamic events and the long-term development of earth and environment systems. The project draws on the expertise of nine Helmholtz centers, including all six TERENO partners.

MOSES is focused mainly on four types of events: heat waves, hydrological extremes, ocean eddies and the abrupt thawing of permafrost. "We want to better understand the significance these kinds of short-term dynamic events, which are limited both temporally and geographically, in the context of longer-term global changes," explains project head Dr. Ute Weber. "And we want to investigate their socio-economic effects." The project's infrastructure is designed as a "system

of systems". The centers involved in the project develop sensor and measurement systems that are combined into observation modules. These MOSES modules can then be used to gather data on energy, water, nutrient and greenhouse gas fluxes in various compartments, including atmosphere, land surface, coastal regions, the ocean, as well as in areas with snow and ice. By combining different modules, researchers can conduct closely linked cross-compartmental measurement campaigns.

Researchers involved in the planned MOSES campaigns will also rely on long-term observations over larger geographical areas, which are necessary in order to analyze the effects of these four types of dynamic events on larger earth/environmental systems. National



MOSES is designed to collect data on energy, water, nutrient and greenhouse gas fluxes in the atmosphere, on land, in coastal regions or the ocean.

and global-level monitoring networks can provide the relevant reference data. Helmholtz observatories, including the four TERENO observatories, deliver high-quality data pools, which makes them ideal testing areas for the development phase of the MOSES project and its later measurement campaigns. "The observatories and MOSES complement each other perfectly for this cross-compartmental and cross-scale observation concept," says Ute Weber.

Participating centers:

Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research ■ German Aerospace Center (DLR) ■ Forschungszentrum Jülich ■ GEOMAR Helmholtz Centre for Ocean Research Kiel ■ Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences ■ Helmholtz Zentrum Geesthacht Centre for Materials and Coastal Research ■ Helmholtz Zentrum München – German Research Center for Environmental Health ■ Helmholtz Centre for Environmental Research – UFZ ■ Karlsruhe Institute of Technology

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HIGHER RESOLUTION FOR BETTER FORECASTING

After focusing on Germany during its first funding period, the climate model ICON-LEM (Icosahedral non-hydrostatic core – Large Eddy Model), which scientists developed as part of the High-Definition Clouds and Precipitation for Advancing Climate Prediction program (HD(CP)), will now turn its attention to other parts of the globe, including tropical regions and the North Atlantic. Scientists involved in the program will also further adjust their model for supercomputer hardware. HD(CP) was awarded a second round of funding last year by Germany's Federal Ministry of Education and Research (BMBF); the second phase of the program will run until March 2019.

ICON-LEM is designed to predict cloud formation and precipitation distribution, which remains one of the biggest challenges and sources of uncertainty for climate models today. ICON-LEM allows researchers to forecast weather over several days and large areas, such as central Europe or parts of the Atlantic Ocean. The model is unique in that it calculates extremely small units of area – just 100 meters by 10-50 meters – whereas other models have offered only

highly simplified parameterizations for clouds and precipitation up until now. "With ICON-LEM and its extremely high resolution we're no longer limited in this way; this means significant improvements for weather forecasting," says Prof. Stefan Kollet from Forschungszentrum Jülich. "Still, the calculations required for these simulations are pushing even the largest supercomputer environments to their limits." Two TERENO partners – Forschungszentrum Jülich and the Karlsruhe Institute of Technology – are among the 17 organizations participating in the HD(CP) program.

Over the long term, researchers hope that simulations generated by such complex models can render real observations at least partially obsolete. But this is still a long way off. For now, scientists will continue observing and monitoring on the local level as they verify ICON-LEM results and further develop the model.

► **High-Definition Clouds and Precipitation for Advancing Climate Prediction – HD(CP)²**

FROM HEADWATERS TO ESTUARY

Europe is creating a new research infrastructure, named DANUBIUS-RI, to help scientists better understand river-sea systems and predict with greater accuracy how these systems develop over the long term, e.g. in response to factors such as global change. Organizations from 27 countries are involved in the pan-European project, including TERENO.

“DANUBIUS-RI is unique,” says Dr. Peter Heininger from the German Federal Institute of Hydrology (BfG), which coordinates Germany’s contribution to the project. The infrastructure will consider the entirety of river catchments – from headwaters to estuaries, including the contiguous coastal waters – and investigate the full range of factors impacting a hydrological system, including interactions with soils and agricultural areas, but also social and economic effects, such as the impact of urban areas. Researchers will have the possibility to focus on a variety of aspects related to river-sea systems, namely the hydrology, geo-hydromorphology, chemistry, biology, ecotoxicology, and hygiene.

“The infrastructure is essential,” says Heininger. “It’s like a lab or a workshop; we first need to build it before researchers can even begin conducting research.” The task now is to acquire devices and instruments for seven “supersites” – all exemplary natural environments in which small infrastructures already exist and upon which DANUBIUS-RI can build. The only supersite identified so far in Germany is the Elbe River Estuary, although additional sites in Germany might be added over time. “Another aspect of establishing this infrastructure is to develop common standards for things like research methods, data storage and data exchange,” says Heininger. These standards will be communicated later through training and educational programs, but first DANUBIUS-RI partners need to define their research agenda and establish common rules for collaboration. Another important element of the preparatory phase is to ensure that participating countries commit to financing the project over the long term.



© NASA Landsat, HZG

Satellite image of the Elbe River Estuary

TERENO is contributing to DANUBIUS-RI in two ways: first, with its expertise in water budget modeling and, second, with its extensive experience in creating and operating infrastructures used for long-term monitoring of ecosystems and water supplies. After completion of the preparatory phase in 2025, the DANUBIUS-RI infrastructure will serve scientists for at least another 20 years.

► **DANUBIUS-RI – The International Centre for Advanced Studies on River-Sea Systems**

NEW NETWORK UNITES HYDROLOGICAL OBSERVATORIES



Setting up the “Rollesbroich” hydrology monitoring station in TERENO’s Eifel/Lower Rhine Valley observatory

Today’s global-scale changes – whether it’s climate change, the impact of climate change on water supplies, or changes to ecosystems – pose complex challenges for terrestrial environmental researchers. As a result, interdisciplinary, integrated research at multiple temporal and spatial scales is in demand more than ever. This is precisely what prompted researchers of the Agrosphere Institute in Jülich to establish the European Hydrological Data Platform Initiative ENOHA.

Following its kick-off meeting in October 2016, ENOHA presented itself to a broader audience for the first time in April 2017 at the annual meeting of the European Geosciences Union in Vienna. “Our goal with ENOHA is to advance all fields of hydrological research,” explains Dr. Heye Bogena from Forschungszentrum Jülich. “To this end we are creating a European network of observatories that will monitor the subsurface environment, the land surface (including the biosphere), the lower atmosphere, as well as socioeconomic aspects.” ENOHA members have agreed to use the TERENO data portal TEODOOR (see p. 8) as a blueprint for their data portal, which will draw on selected ENOHA observatories. Along with the TERENO observatories in Germany, these include the Hydrological Open Air Laboratory (HOAL) in Austria and the Center for Hydrology (HOBE) in Denmark.

“Terrestrial systems are extremely complex, but models that consider climate and biosphere on a large scale often include only a simplified version of the hydrology,” says Bogena. “Changing this is one of the big challenges of terrestrial research.” The goal of the ENOHA network is to provide data that will help scientists improve their understanding hydrological processes. The observatories will deploy a range of measurement technologies, including remote sensing platforms, wireless sensor networks and hydrogeophysical measurement techniques.

► **European Hydrological Data Platform ENOHA**

ACROSS FUNDS NEW OBSERVATORY IN GREECE



© Andreas Panagopoulos

View of the Plain of Thessaly from the Pinios hydrologic observatory

With funding from the ACROSS initiative, the recently established hydrologic observatory in the Greek province of Thessaly has been further expanded (see TERENO Newsletter 2/2016). In early April 2017, Greek and German scientists set up a new monitoring station focused mainly on the area's water balance. Water is needed to irrigate the region's many fruit plantations, but a significant portion of water is not available for this purpose as it is taken up by another type of plant: the evergreen maquis scrubs typical of Greece's coastal mountains. One of the goals of the new monitoring station is to determine exactly how much water the maquis consumes.

The research area, in the vicinity of the town of Agia, spans some 50 square kilometers and is located in the eastern portion of the Pinios basin. The plain is home to apple, cherry, pear and peach plantations and is one of the most productive agricultural regions in Greece. The precipitation used for irrigation in summer falls in winter in the mountain areas. By way of various sub-surface runoff pathways, this water enters the alluvial aquifer system in the plain where it is stored before being accessed by the irrigation systems.

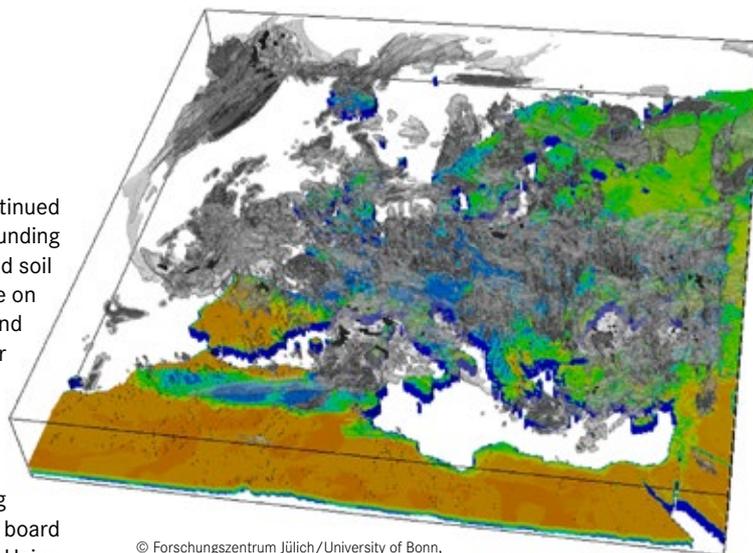
The job of the monitoring stations, installed by the team at an altitude of about 1,000 meters, is to determine how much water is "lost" to the thirsty maquis vegetation along the way. The fully equipped climate station, wireless soil moisture sensor network, and cosmic-ray sensors will also provide a portion of the data used to calibrate the water balance model mGROWA currently being used by the Greek/German research team. The researchers want to use their findings to simulate water balance and long-term available water resources in the entire Pinios basin. The data will also be made available to local agricultural and water management officials.

The Agia observatory is operated jointly by scientists from the Soil and Water Resources Institute of the Hellenic Agricultural Organisation along with agrosphere experts from Forschungszentrum Jülich. Funding comes from the Helmholtz initiative ACROSS. The observatory already participates in the International Long-Term Ecological Research (ILTER) network.

A GROWING COMMUNITY OF SOIL MODELERS

The International Soil Modeling Consortium (ISMC) has continued its steady expansion. Roughly one and a half years after its founding in March 2016, the consortium now consists of 270 registered soil modelers and features nearly 40 soil-related models available on the consortium website. In addition to initiating data sets and platforms for modeling studies, ISMC has joined with other groups to launch new research projects such as the Global Energy and Water cycle Exchanges (GEWEX) project and the Agricultural Model Intercomparison and Improvement Project (AgMIP). ISMC also collaborates with other international groups such as the Community Surface Dynamics Modeling System (CSDMS). In April 2017 ISMC introduced its current board members at the annual meeting of the European Geosciences Union in Vienna. The board consists of chairman Prof. Harry Vereecken (Forschungszentrum Jülich), deputy chairman Dr. Michael Young (University of Texas), Dr. Ana Tarquis (Universidad Politécnica de Madrid), Prof. Anne Verhoef (University Reading), Dr. Scott Painter (Climate Change Center Oak Ridge) and Dr. Umakant Mishra (Argonne National Laboratory).

ISMC was founded with the goal of promoting soil system modeling and improving the data used for modeling. Today ISMC is focused on three main thematic areas: the linking of data and observations to models, soil model intercomparison and development, and promoting a closer dialogue with the scientific community and general public.



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Simulation with the Terrestrial Systems Modeling Platform (TerrSysMP): cloud water content (grey) and soil moisture (color) in Europe, June 2013

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COMBINING STRENGTHS

ScaleX campaigns accelerate use of TERENO data



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 Researchers Jost Lavric (left) and Martin Kunz (center) of the Max Planck Institute for Biogeochemistry assist Purdue aeronautical engineering technology student Evan Flatt (right) with preflight preparations on an unmanned aerial vehicle used to measure nighttime air flow.

ScaleX campaigns, which involve scale-crossing, intensive observation activities, have been conducted at TERENO's preAlpine observatory since 2015. The campaigns combine the strengths of long-term observational research, as conducted by the TERENO initiative, with short-term intensive measurement campaigns. "This allows us to cover a broader range of spatial and temporal scales," explains ScaleX coordinator Dr. Matthias Zeeman. ScaleX combines ground-based in situ measurements with remote sensing methods, as well as mobile systems such as drones, multicopter and other aircraft. These activities are designed to improve not only measurement systems but also models of processes such as matter exchanges, precipitation and water drainage. Following the first two major measurement campaigns in 2015 and 2016, participating scientists from Europe and the USA have convened for several workshops to discuss the data generated by the campaign, its analysis, and to plan upcoming measurement campaigns. "The workshops are also a way for participants to get to know different approaches and topics," says Zeeman. "This allows us to identify common priorities and goals despite the fact that our research interests might differ." The measurement campaigns have already generated several papers and conference contributions. In addition, lessons learned from ScaleX can be carried over into new projects, such as a Federal Ministry of Education and Research (BMBF) project to develop an urban climate model. The next ScaleX workshop will take place in early 2018 in Garmisch-Partenkirchen, where the time and theme of the next intensive campaign will also be discussed.



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 Setup for monitoring wind-induced air pressure fluctuations: wind measurement and test of different pressure heads



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 A support structure is being readied by BSc student Kevin Wolz (Karlsruhe Institute of Technology) in order to suspend optical fibre for measurement of air temperature at high resolution.

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Benjamin Wolf et al. *The SCALEX Campaign: Scale-Crossing Land Surface and Boundary Layer Processes in the TERENO-preAlpine Observatory*. Bulletin of the American Meteorological Society. Published online on June 23, 2017.

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New measurement tower near Rollesbroich

TOWERING

Researchers from Forschungszentrum Jülich and Helmholtz Center Potsdam – German Research Center for Geosciences (GFZ) have installed an L-band microwave radiometer atop a new measurement tower rising 18 meters above an open field near Rollesbroich within TERENO's Eifel/Lower Rhine Valley observatory. "We wanted as much height as possible to make sure the radiometer covers as large an area as possible," explains Jülich researcher Dr. Lutz Weihermüller, who is managing the measurement campaign together with colleague Prof. François Jonard. The radiometer will measure the soil's microwave radiation across an area of about 100 square meters. This radiation allows them to determine soil moisture changes of the first cm of the soil profile, which is an important component in the water cycle. In addition to the tower-mounted radiometer, Jülich researchers have installed a wireless sensor network (SoilNet) on the field that monitors soil water content and soil temperature at hundreds of locations. "These measurements can differ significantly even within a single square meter of ground, which is why we need a large number of sensors," says François Jonard. Researchers hope these long-term measurements will help them better understand the impact of climate change on the regional scale. Scientists also use the data to verify soil-moisture measurements taken by passing satellites. Rollesbroich, for example, serves as a validation site for NASA's Soil Moisture Active Passive (SMAP) satellite mission.

WHEN FERTILE SOIL IS LOST

Soil erosion is one of the main causes of soil destruction. Heavy rains and strong winds can strip away soil particles, especially from arable fields on sloped terrain. Because it takes so long to create new soil, this results in a net loss of fertile farmland over time. It is largely unknown how soil erosion impacts water balance and carbon and nitrogen cycles. The Institute of Soil Landscape Research (BLF), which is part of the Leibniz Centre for Agricultural Landscape Research (ZALF) Müncheberg, wants to learn more about the effects of soil erosion, especially as they relate to climate change. To this end, ZALF maintains two SoilCan lysimeter hexagons at the Dedelow site in TERENO's Northeastern German Lowland observatory.



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The lysimeter installation (Hexagon 1) at the ZALF testing site in Dedelow (photo right); ZALF team members Marcus Herbrich, Jörg Haase and Dr. Horst H. Gerke (left to right) applying a bromide tracer solution to the surface of a lysimeter covered with lucerne grass (photo left).

"We're focused mainly on soil development in arable soil landscapes of the hummocky ground moraine," says ZALF researcher Dr. Horst Gerke. In the Earth's northern hemisphere, this kind of landscape covers an area of about 1 million square kilometers. Here, the combination of water erosion and erosion caused by tillage operations leads to what's called lateral soil transfer: material eroded from hummocks (convexities) and hillsides accumulates in topographic depressions (concavities), where it buries the soil. The lysimeters were filled with soil types found in these areas: pararendzinae (on hummocks), para-brown earths/Luvisols (on slopes) and Colluvic Regosols (in depressions).

Lysimeters can be used to measure water balance components, such as precipitation, evaporation and leaching, as well as to balance input and output of dissolved matter. Researchers want to use this data to develop mathematical models for water and matter dynamics during soil erosion. Researchers can then integrate these modelling results when conducting their agricultural field experiments, which also gather data on plant root development and lateral flows in the soil. Researchers also hope the information provided by the models will allow them to estimate biomass production or to improve remote sensing methods.

Marcus Herbrich, Horst H. Gerke, Oliver Bens, Michael Sommer. *Water balance and leaching of dissolved organic and inorganic carbon of eroded Luvisols using high precision weighing lysimeters.* Soil and Tillage Research 2017, 165, 144–160.

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MODELING REALITY



Weather forecasts are based on special computer models, which use measurement data and physical equations to calculate the current and future state of the atmosphere. Cornelius Hald, a PhD student at the Institute of Meteorology and Climate Research - Atmospheric Environmental Research in Germany's Garmisch-Partenkirchen, is working with one such model, the Weather Research and Forecasting model, which is used for local-level forecasting. The model's usual resolution is about one kilometer, but Hald is working to achieve a resolution of 30 meters, by which small scale motions in the atmosphere, such as turbulence, would be resolved. "This could make it possible to improve forecasts of energy and moisture fluxes," says Hald.

These kinds of calculations are important for predicting conditions in places where there is no measurement data available. Still, a resolution of one kilometer limits the accuracy of such predictions, since lower resolution enables only a simplified depiction of certain parameters such as wind, solar radiation and land surface variations. Hald hopes his modified model will change this, but he first needs to test how well the calculations correspond to reality. For this he relies on extensive data gathered by the ScaleX measurement campaigns in TERENO's "preAlpine" observatory in 2015 and 2016 (see p. 10). "I compare the measurement data with the model's calculations," explains Hald. "The calculations are based on data from global weather models, which comes from weather observations around the world – things like temperature stratification in the atmosphere and wind speed." All this requires tremendous processing power. Hald is analyzing a small area – just 15 x 15 kilometers – and the model needs an entire day to simulate just one hour of weather. This makes ensemble simulations or forecasts impossible, of course, but the model remains very well suited for case studies.

RAINFALL'S FINGERPRINT

We might know that it takes 23 hours and 56 minutes for the Earth to rotate around its own axis, or that the seed of a pine tree takes between two and three weeks to sprout. But we certainly don't yet understand all of nature's processes or know how long they take. Dr. Michael Stockinger, a hydrologist at Forschungszentrum Jülich, is focused on answering one such open question. His goal is to find out how long rainfall travels through a catchment before it reaches the river. So far scientists can't say for sure how long this takes. But knowing more about water travel times is an important piece of the puzzle when trying to determine, for example, whether climate change or land-use changes effect the rainfall flow paths of catchments. It is also relevant in the context of pollutants and other substances that travel through soil and groundwater before reaching rivers.

The challenge for Stockinger, 35, is that currently available technology cannot yet directly measure how fast water passes through a catchment. "No one knows what is actually going on below ground level," explains Stockinger. "Our knowledge of rainfall travel times is solely based on modeling results." Stockinger's approach



is to use stabile isotopes, i.e. non-radioactive isotopes that do not decay into other elements, to isolate the data he needs. Every element has various isotopes – some stable, some unstable, some light, some heavy. "Rainfall will always have a specific proportion of light and heavy stable isotopes – of hydrogen and oxygen, for example," says Stockinger. "This fingerprint can be captured when the precipitation falls and when it shows up again in the river." And this is exactly what Stockinger is investigating at TERENO's Wüstebach test site. Stockinger hopes that his results will provide a way to fact-check the data generated by computer models. "This is important for the future, because models often generate uncertain figures when it comes to rainfall travel times," says Stockinger.

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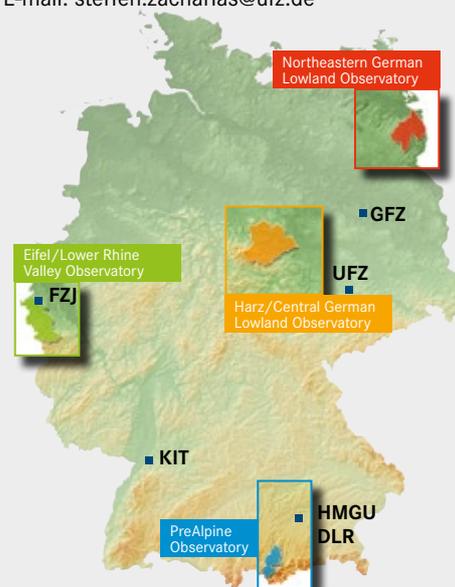
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FZJ Forschungszentrum Jülich
(Coordination)

DLR German Aerospace Center

KIT Karlsruhe Institute of Technology

HMGU Helmholtz Zentrum München, German Research Center for Environmental Health

UFZ Helmholtz Centre for Environmental Research

GFZ Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

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