Improving science through **environmental monitoring**

A Mediterranean monitoring and research alliance is using novel experimental approaches to observe hydrological processes and monitor global change. **Elisabeth Helen Krüger**, **Dr Steffen Zacharias** and **Professor Harry Vereecken** outline how this work will build upon its parent project in Germany



What ultimate impacts do you hope the 'Terrestrial Environmental Observatories in the Mediterranean' (TERENO-MED) project will have?

In the Mediterranean region there is a lack in availability of long-term data series, making it difficult to produce reliable scientific results regarding environmental trends and developments. We hope that the project will fill this gap for a region that is of high relevance to Europe as a whole. Also, we are hoping that TERENO-MED will serve as a nucleus for further scientific projects, involving the best researcher groups from the region, and beyond. Our vision is the creation of a strong Mediterranean alliance that will use its joint forces for tackling the problems concerning water scarcity and environmental degradation that pose a significant threat to economic development in the region.

Can you detail some of TERENO's Mediterranean activities?

Two Helmholtz Centres – the Helmholtz Centre for Environmental Research UFZ and Forschungszentrum Juelich – have decided that a monitoring network dedicated to providing essential knowledge for understanding the environmental system is urgently needed in a region that is facing major societal challenges. The Mediterranean is characterised by rapid population growth and urbanisation, and strong increases in water, energy and food demand, all of which is posing serious threats to the functioning of environmental ecosystems. Furthermore, the Mediterranean region is a hotspot of climate change with measurable decreases in precipitation and increases in temperature observed over the last decades.

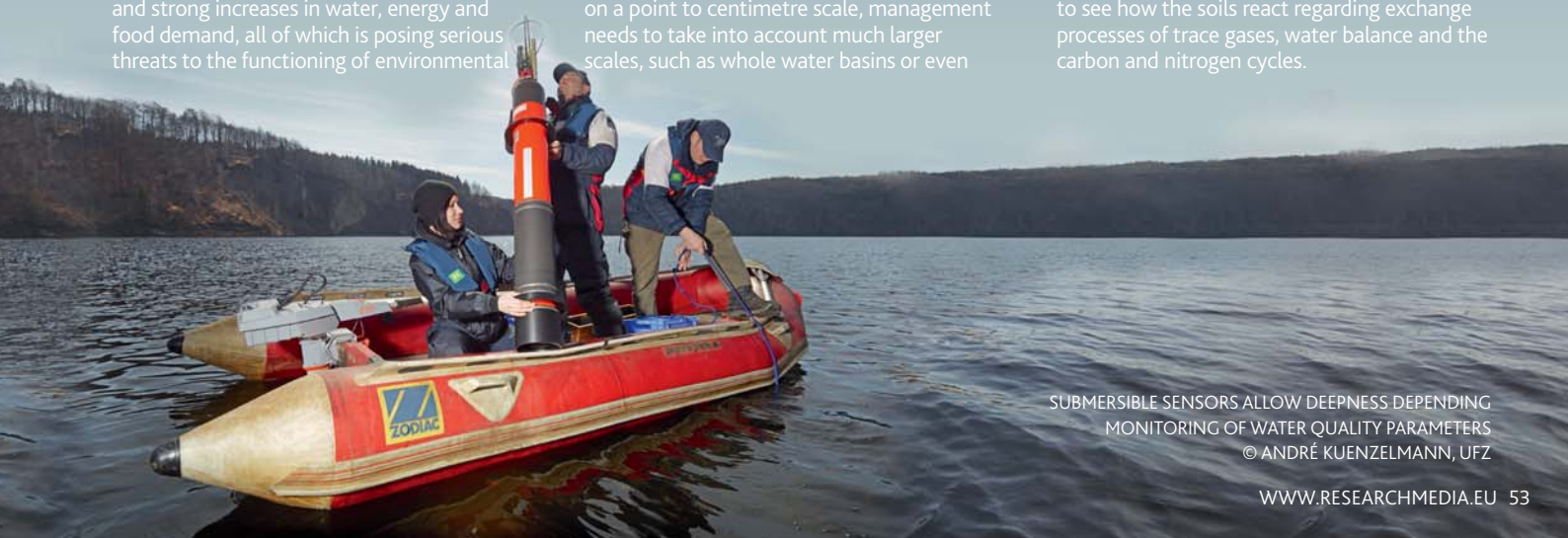
The idea of TERENO-MED is to set up a network of long-term environmental observatories with a focus on water resources in representative regions of the Mediterranean – the north, south and east. These observatories will be set up in collaboration with local scientific and administrative partners, who will also be involved in the long-term operation and maintenance of the sites. Joint research projects between German, European and Mediterranean partners are also planned. So far, we have been closely studying the Mediterranean in terms of environmental conditions, running projects in the field of water and water scarcity research, and appropriate partners for the TERENO-MED network. We are in the middle of negotiations about cooperation and TERENO-MED sites, and are visiting a number of potential sites around the Mediterranean. A general framework and scientific concept for the implementation has been developed. We will begin establishing the sites this year, and the set-up will continue over the next three to four years.

Could you highlight some of the technologies and methodologies that are used in TERENO and will be used for TERENO-MED?

A central problem of environmental research is the gap between measurements and management in both temporal and spatial scales. While measurements are usually done on a point to centimetre scale, management needs to take into account much larger scales, such as whole water basins or even larger regional units. Here, satellite-based Earth observations provide data to operate complex, cross-regional or global models. However, the effective use of this data is hampered due to the fact that ground-truth observations to calibrate satellite-borne data are sparse. Several emerging technologies for environmental monitoring are dedicated to address these obstacles and are important components of the TERENO infrastructure. For example, Cosmic Ray Soil Moisture probes allow the monitoring of soil moisture at an intermediate scale and close a gap between point measurements and remotely sensed proxies; novel easy-to-use weather radar systems enable a flexible, highly resolved detection of rainfall intensity in catchments; and mobile, geophysical platforms allow a fast and repeated survey of soil related parameters at the field scale.

Lysimeters are an element of the infrastructure used in your German TERENO network. How central is the role of lysimeters to your work?

Experimental approaches are an important complement to observational activities. Lysimeters can be described as containers filled with soil. They are open at the top and the idea is to observe how rain falling onto the soil infiltrates, evaporates from the vegetation growing in the soil, or percolates down to the groundwater underneath and mobilises solutes stored within the soil. With the SOILcan experiment TERENO has created the world's largest lysimeter network where 126 undisturbed soil monoliths have been excavated and moved to other climatic regions within Germany. Through this experiment we are 'mimicking' climate change and are able to see how the soils react regarding exchange processes of trace gases, water balance and the carbon and nitrogen cycles.



SUBMERSIBLE SENSORS ALLOW DEEPNESS DEPENDING MONITORING OF WATER QUALITY PARAMETERS
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Cataloguing global change in Europe and the Mediterranean

By uniting climate and environmental research from the Alps to the Baltic and Mediterranean coasts, **TERENO** – a multidisciplinary observation platform – aims to improve understanding of a changing regional climate

THE BACKBONE OF integrated natural resource management is the availability of robust data and solid environmental research. This element is absolutely essential to understanding and interpreting the impacts from anthropogenic activities, and a warming climate. The integration of environmental monitoring and research is becoming increasingly important, as countries across the globe struggle to adapt to climate change. In the Mediterranean region this is of particular concern, given the rampant population growth and rapid industrialisation.

Since its inception in 2008, an Earth Observation network spanning across Germany, from the North German lowlands to the Bavarian Alps, has been focused on building a robust dataset that catalogues the impacts of a warming climate and of land use changes on the environment, community and economy in Germany. Known as 'Terrestrial Environmental Observatories' (TERENO), the alliance of scientists and researchers hope that their work will improve understanding of what some of the most appropriate responses will be to this change. The scientific coordinator of TERENO, Professor Harry Vereecken, explains that a major task of this network is the observation of climate-induced changes on the terrestrial system and its different compartments: "TERENO provides the necessary long-term observation data covering multiple spatial and temporal scales. In addition, the necessary environmental models are being developed that will enable the use of this data to improve our understanding of climate and land use change impacts".

OBSERVING AND DOCUMENTING CHANGE

There are currently four observatories within the TERENO network. All of them include a river catchment, and a range of different land use types over an area of several thousand square kilometres. The Eifel/Lower Rhine Valley Observatory covers a range of land uses, including areas of intense urbanisation and agriculture, several important drinking water reservoirs and the Eifel National Park. This observatory is important for understanding soil- and groundwater processes and exchanges between soil and atmosphere at multiple scales. The Harz/Central German Lowland Observatory comprises a number of sites along steep temperature and precipitation gradients and hosts the largest drinking water reservoir in Germany. These sites are looking at water, soil, and biodiversity-related issues, including aquatic ecology and water quality issues. A network of sites focuses on species-environment relationships monitored over the long term. Within this observatory is the Global Change Experimental Facility, which allows scenario-based process analysis in a range of different agricultural land use types.

The Northeastern Lowland Observatory is situated in a region that endured a history of glacial and periglacial processes, and today the landscape is dominated by lakes and rivers connected to a shallow groundwater system. This Observatory is particularly important to understanding how sensitive the 'younger' landscapes are to climate change. The work at the fourth observatory, the Bavarian Alps/pre-Alps Observatory, is focused on understanding the effects of climate change on carbon and nitrate cycles as well as on the hydrology and how extreme precipitation events impact on the highly sensitive pre-alpine ecosystems.

TERENO CONTRIBUTES TO THE EUROPEAN RESEARCH INITIATIVE, INTEGRATED CARBON OBSERVATION SYSTEM (ICOS), SETTING UP A MEASUREMENT STATION TO MONITOR GREENHOUSE GAS FLUXES
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BUILDING AND FOSTERING STRONG LINKAGES

By joining the efforts of six Helmholtz Centres across Germany, an integrated observatory approach has been set up which is improving understanding of environmental processes and how they feed back into the larger systems. There are eight Coordination Teams, comprising Data Management, Environmental Sensing, Atmosphere, Pedosphere, Hydrosphere, Biosphere, Integrative Modelling and Palaeo Climate. Dr Steffen Zacharias, who is based at the Helmholtz Centre for Environmental Research and is coordinating the Harz/Central German Lowland Observatory, believes that the work they are doing on improving knowledge of how hydrological impacts differ between regions is absolutely essential for managing water resources in the future. Being able to fulfil the high scientific and analytical standards and the goals of TERENO means they need to maintain good links with respected national and international researcher groups and monitoring networks, such as, for example, the US CUAHSI network of universities in hydrological sciences. "TERENO receives external inputs not least through communicating its results at scientific conferences and in scientific journals. TERENO's researchers take on real-world challenges in close exchange with local stakeholders enabling a transfer of research results into practice," Zacharias observes.

THE CHALLENGE OF SUSTAINABILITY

As with any research project of this scale, TERENO has had to overcome a number of hurdles. Sustaining a monitoring network on a long-term basis is highly challenging, both with regard to the financial aspects but also regarding the scientific commitment and development of the project. Zacharias believes that to keep the TERENO infrastructure scientifically effective, it is absolutely essential to have permanent feedbacks between monitoring and modelling: "The Helmholtz Association is in the unique position to successfully manage both aspects, as the TERENO research is embedded into the development of the strategic, scientific programmes of the operating Helmholtz Centres". This means that the network can be regularly updated and adapted to respond to the evolving challenges.

TERENO-MED

After three years of intensive capacity-building and getting the infrastructure up and running, the TERENO collaboration is now happy to be in the position of producing data that will help to inform and develop the models they need. Vereecken says that the success of such a complex project is reliant upon how well data is managed and exchanged between all the different sub-projects, observatories and coordination teams, but he is confident this is something they have under control: "All the data collected in TERENO will be made accessible to the community via an integrative web-based data portal". As the first data is already available online, they expect the data base structure to be completed by 2013. "With the implementation phase of TERENO almost completed, we are now planning to set up an international TERENO network in the Mediterranean," highlights Elisabeth Helen Krüger, who is coordinating the new TERENO-MED study. This initiative will most certainly benefit from the knowledge and experience already gained by the TERENO team. The focus of this component is the reliability and development of water resources – specifically the quality and quantity of water that is available to support the rapidly growing population and economies in the Mediterranean region.

To assist coordination and communication between TERENO and TERENO-MED, a joint advisory board supports the scientific development of the two initiatives. Achieving good day-to-day communication is the responsibility of a number of scientists, all of whom have gained solid experience in developing the national TERENO or other research networks. Zacharias Krüger describes how an exchange of information will be supported by encouraging the Mediterranean partners to visit the German TERENO sites, by facilitating exchanges of scientists and by setting-up joint field schools: "Scientists from the participating Helmholtz Centres will be working on projects in the Mediterranean, and will therefore communicate their experiences with the Mediterranean partners and vice versa". One of the most important methods for ensuring consistency across the two networks is that the results gleaned from the field work at the Mediterranean observatory sites will be included in the TERENO database. Through this work the TERENO-MED collaboration hopes that it can fill the data gap in regards to long-term environmental trends and developments within the Mediterranean region, ultimately aiding policy development for global change adaptation and responses in Europe.

INSTALLATION OF WEATHER RADAR
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INTELLIGENCE

TERENO/TERENO-MED

TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

OBJECTIVES

To catalogue the long-term ecological, social and economic impact of global change at regional level. TERENO aims to establish an observation platform linking terrestrial observatories in different regions of Germany and the Mediterranean. The observatories will generate continuous datasets covering spatial and temporal scales.

PARTNERS

Helmholtz Centre for Environmental Research (UFZ) • Juelich Research Centre (FZJ • Karlsruhe Institute of Technology (KIT) • GFZ German Research Centre for Geosciences • The German Aerospace Centre (DLR) • Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)

FUNDING

Helmholtz Association

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ELISABETH HELEN KRÜGER joined the UFZ in 2008. Since 2010 she has coordinated UFZ's national and international water research activities including the set-up of the Mediterranean observatory network TERENO-MED.

STEFFEN ZACHARIAS studied Land Management and Environmental Protection at the University of Rostock, earning a PhD in Soil Physics in 1999. Since 2007 he has coordinated the TERENO observatory Harz/Central German Lowland at the UFZ.

HARRY VEREECKEN received a PhD in agricultural sciences from the Katholieke Universiteit Leuven, Belgium in 1988. Since 2000 he has been full professor at Bonn University, Faculty of Agriculture, and director of the Agrosphere (IBG-3), Forschungszentrum Jülich GmbH.

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TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATORIES
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