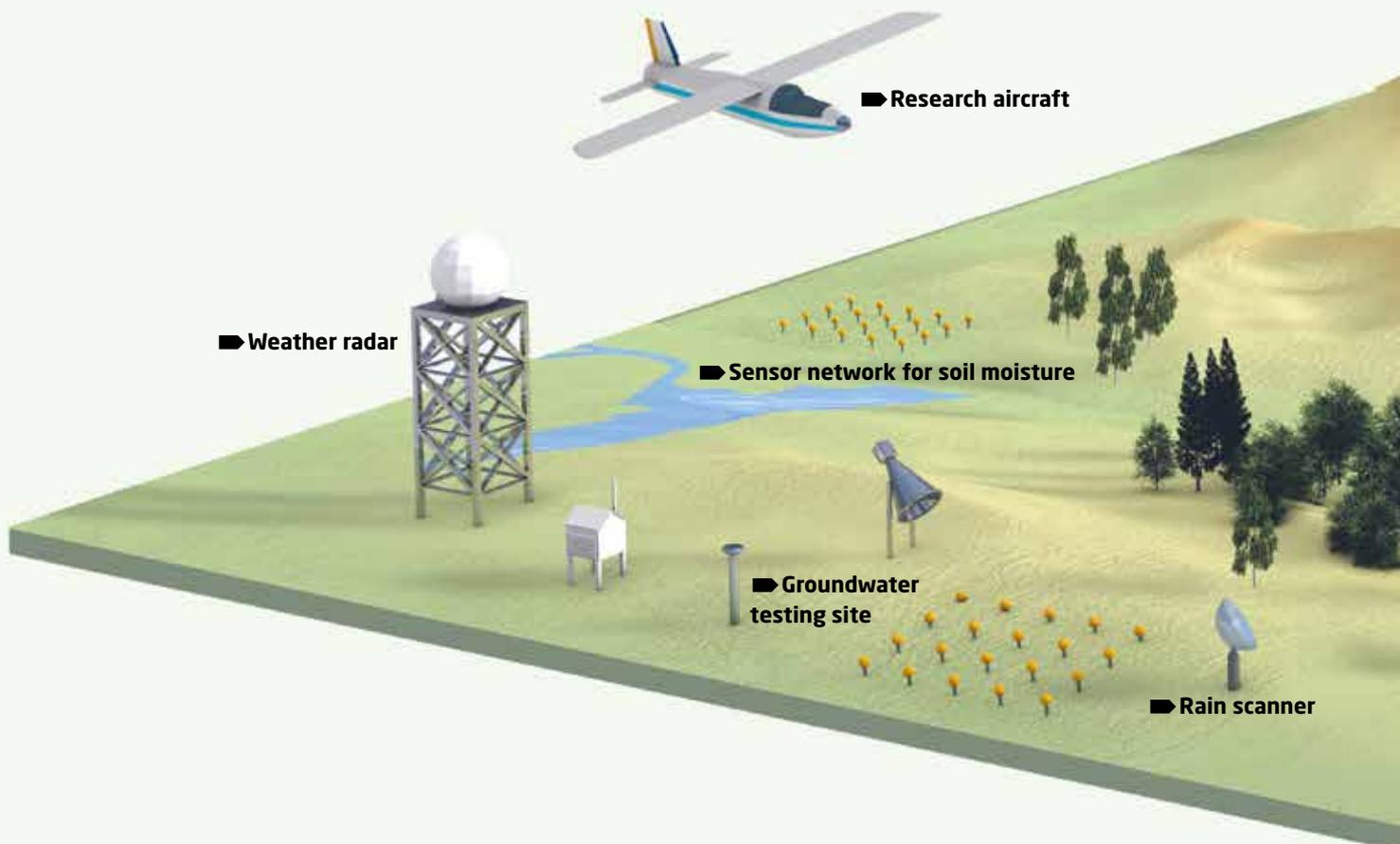




EVERY DETAIL MATTERS

How is climate change affecting Germany's meadows, forests and lakes? To help answer that question, ten years ago the Helmholtz Association established high-tech observatories in four key regions. Dubbed TERENO, this monitoring network has since become a role model for modern environmental research around the globe. REKLIM experts have actively supported the lighthouse project, and had successes at several levels to report this year, which marks TERENO's ten-year anniversary.



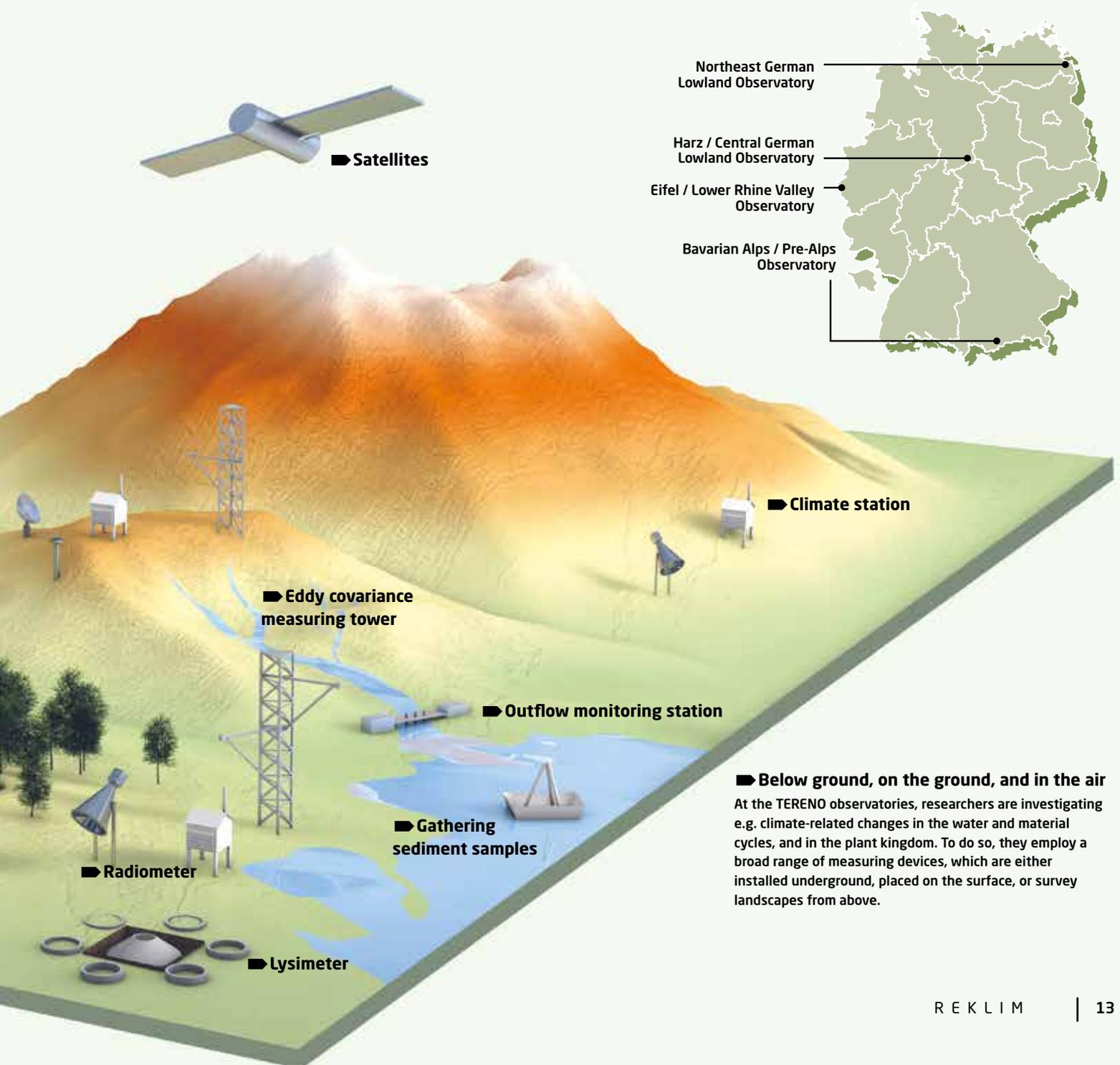
How is the heat affecting plants?

► TERENO has become our **most important research network** within Germany. For example, at the monitoring sites attached to the observatory in the pre-Alps, we're investigating how heat waves and droughts impact natural ecosystems and land used for agriculture. So we're addressing central questions like: how

much water does the soil provide for plants, and what stress reactions do they show during heat waves? These detailed studies wouldn't be possible without the stationary equipment at the TERENO observatories. They're at the core of our work, and are complemented by measurements taken with mobile devices.

PROF HANS PETER SCHMID

Climate researcher and Head of the Institute of Meteorology and Climate Research at the Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen



► **Below ground, on the ground, and in the air**
At the TERENO observatories, researchers are investigating e.g. climate-related changes in the water and material cycles, and in the plant kingdom. To do so, they employ a broad range of measuring devices, which are either installed underground, placed on the surface, or survey landscapes from above.

Developed for TERENO, used worldwide

► The TERENO observatories were and are the ideal testing grounds for new quality assurance methods for environmental data. For example, in the REKLIM climate initiative we have developed **software** that allows us to monitor our time series on carbon dioxide exchange

between the atmosphere and ecosystems. The software automatically scans our field data for errors, and similar algorithms, after being successfully tested in Germany, are now being used in the European carbon dioxide monitoring network ICOS, and in the USA.

DR MATTHIAS MAUDER

Atmospheric researcher
at the Karlsruhe Institute of
Technology (KIT)

Research with direct practical applications

► In addition to national and international scientific collaboration, TERENO has led to regular **exchanges with local actors** involved in agriculture, forestry and nature conservation. For example, we've met with farmers and agricultural advisors from southern Bavaria to discuss how we could prepare our findings on

optimised pasture management so that they provide the greatest benefit for farmers in their day-to-day work. These talks led e.g. to a practice-oriented research project in which we're jointly exploring the question of how much nitrogen from liquid manure is actually used by plants.

DR RALF KIESE

Biogeochemist at the Karlsruhe
Institute of Technology (KIT)

Our concept is setting new standards

► At our TERENO observatories, we've been combining cutting-edge monitoring technologies with innovative modelling approaches for the past ten years, and investigating for the first time all components of our environment - **a concept that has since been copied internationally**. For example, it forms the basis of the major European environmental observation

network 'eTLER', which is currently in the planning stage. In addition, our observatories collect data for the European carbon dioxide monitoring network ICOS. These and other successes have only been possible because everyone involved worked together closely. As such, for me TERENO is a prime example of collaboration within the Helmholtz Association.

PROF HARRY VERECKEN

Environmental researcher
at the Forschungszentrum
Jülich (FZJ)



Online connection for remote observatories

► Establishing the TERENO observatories confronted us with the challenge of finding **optimised data management solutions**, from the sensors' data acquisition, to automatic data transfer and archiving, to visualising the data online: a task

that created considerable added value, since we were able to apply the techniques and lessons we learned with regard to connecting geographically remote sites online in subsequent projects, e.g. in Ghana and Burkina Faso.

FRANK NEIDL

Head of the IT Department of the Institute of Meteorology and Climate Research at the Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen

Working hand in hand with universities

► The Europe-wide drought in the summer of 2018 showed how important soil moisture monitoring is for agriculture. At the TERENO observatories, we employ the new cosmic ray neutron sensing method to measure soil moisture, and are working together with experts from various universities to further refine it. Our

goal is to make the method more flexible and more universally applicable, so that **groundwater distribution on a regional scale** can be more frequently and, above all, more accurately measured. In this way, TERENO is also promoting scientific collaboration between different Helmholtz Centres and universities.

DR HEYE BOGENA

Environmental researcher at the Forschungszentrum Jülich (FZJ)

Extremely dry conditions weaken pines and oaks

► One of the most important tasks for the TERENO Observatory Northeast consists in comprehensive **environmental monitoring for the older tree populations** in Müritznational Park. In this regard, we're investigating how the weather and climate affect the trees' growth. For example, with the help of TERENO we were able to precisely trace the effects of the extreme summer in 2018

on various tree species. While the beech trees showed surprisingly good growth, the oaks and pines, contrary to our expectations, were characterised by significant drops in growth. Findings like these help us understand how trees grow under different types of conditions. In addition, we can now use the growth rings from older trees to accurately determine how the climate has varied over the past few centuries.

DR INGO HEINRICH

Dendrochronologist at the German Research Centre for Geosciences (GFZ) and Coordinator of TERENO's Northeast German Lowland Observatory