Portal Wissen

The Research Magazine of the University of Potsdam

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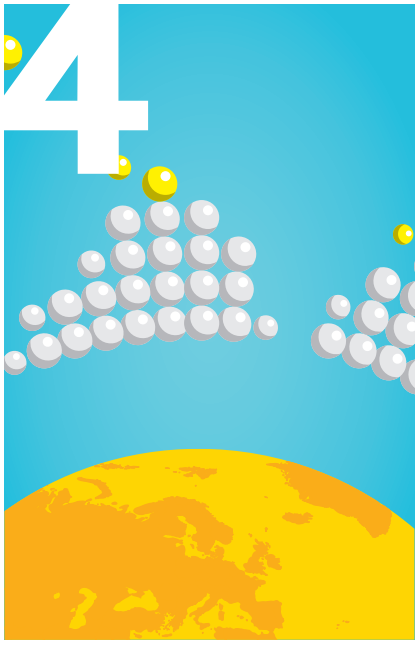
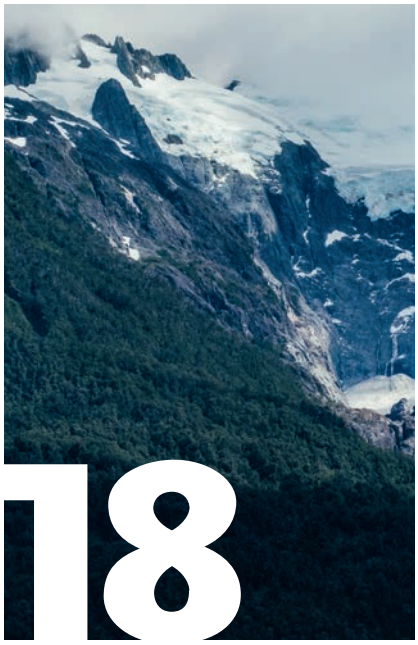
Universität Potsdam

DATA





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DATA

Data assimilation? Stop! Don't be afraid, please, come closer! No tongue twister, no rocket science. Or is it? Let's see. It is a matter of fact, however, that data assimilation has been around for a long time and (almost) everywhere. But only in the age of supercomputers has it assumed amazing proportions.

Everyone knows data. Assimilation, however, is a difficult term for something that happens around us all the time: adaptation. Nature in particular has demonstrated to us for millions of years how evolutionary adaptation works. From unicellular organisms to primates, from algae to sequoias, from dinosaurs ... Anyone who cannot adapt will quickly not fit in anymore.

We of course have also learned to adapt in new situations and act accordingly. When we want to cross the street, we have a plan of how to do this: go to the curb, look left and right, and only cross the street if there's no car (coming). If we do all this and adapt our plan to the traffic we see, we will not just safely cross the street, but we will also have successfully practiced data assimilation.

Of course, that sounds different when researchers try to explain how data assimilation helps them. Meteorologists, for example, have been working with data assimilation for years. The German Weather Service writes, "In numerical weather prediction, data assimilation is the approximation of a model run to the actual development of the atmosphere as described by existing observations." What it means is that a weather forecast is only accurate if the model which is used for its calculation is repeatedly updated, i.e. assimilated, with new measurement data.

In 2017 an entire Collaborative Research Center was established at the University of Potsdam, CRC 1294, to deal with the mathematical basics of data assimilation. For Portal Wissen, we asked the mathematicians and speakers of the CRC Prof. Sebastian Reich and Prof. Wilhelm Huisinga how exactly data assimilation works and in which areas of research they can be used profitably in the future. We have looked at two projects at the CRC itself: the analysis of eye movements and the research on space weather.

In addition, the current issue is full of research projects that revolve around data in very different ways. Atmospheric physicist Markus Rex throws a glance at the spectacular MOSAiC expedition. Starting in September 2019, the German research icebreaker "Polarstern" will drift through the Arctic Ocean for a year and collect numerous data on ice, ocean, biosphere, and atmosphere. In the project "TraceAge", nutritionists will use the data from thousands of subjects who participated in a long-term study to find out more about the function of trace elements in our body. Computer scientists have developed a method to filter relevant information from the flood of data on the worldwide web so as to enable visually impaired to surf the Internet more easily. And a geophysicist is working on developing an early warning system for volcanic eruptions from seemingly inconspicuous seismic data.

Not least, this issue deals with the fascination of fire and ice, the possibilities that digitization offers for administration, and the question of how to inspire children for sports and exercise.

We hope you enjoy reading – and if you send us some of your reading experience, we will assimilate it into our next issue. Promised!

THE EDITORS

Photo: AdobeStock/Oleksii

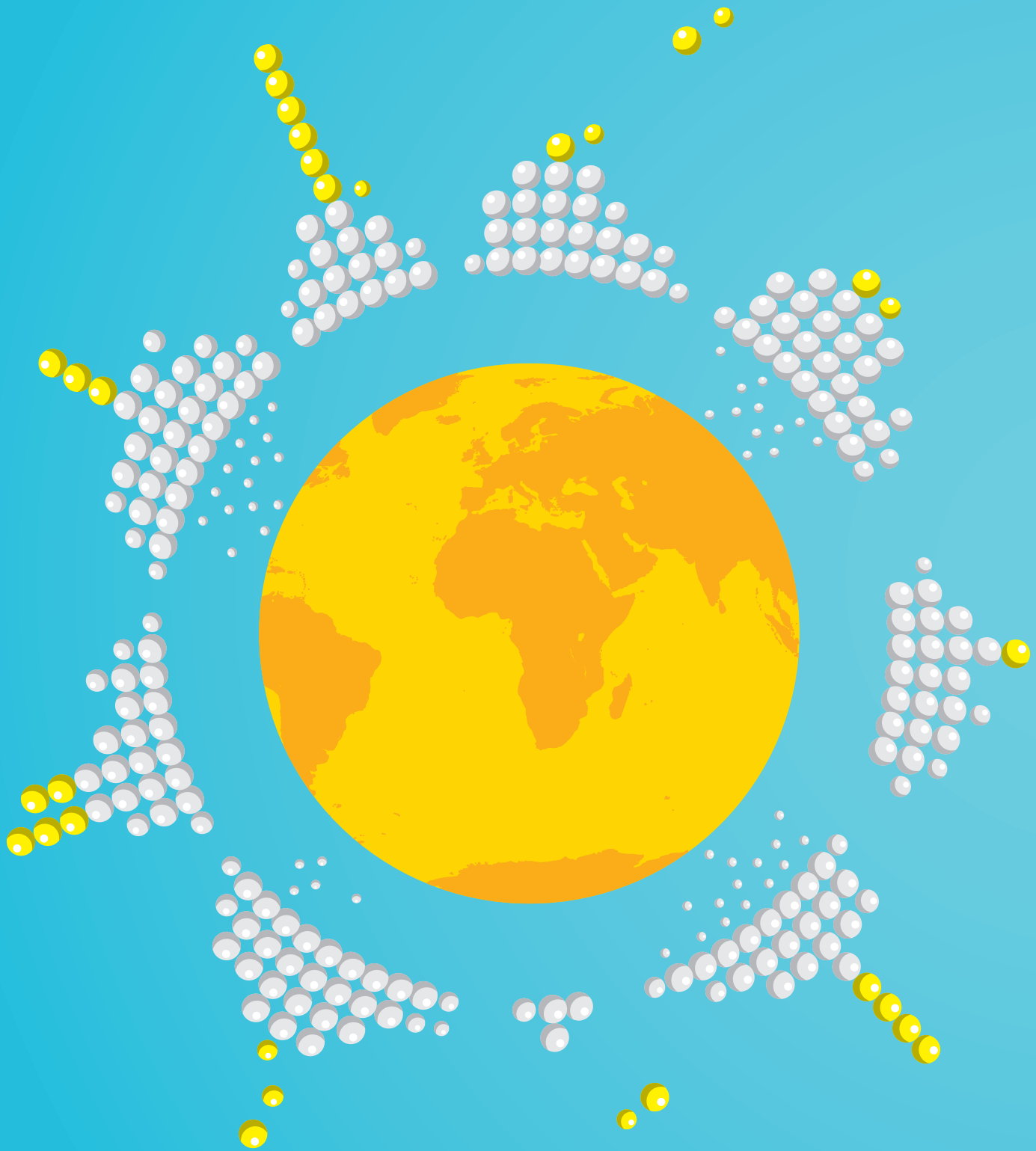


Illustration: Töpler, Andreas

“The Best of Both Worlds”

The Connection between the Weather, Amoebae, and the Human Gaze

Data is all the rage. Satellite images make the entire world available – in detail and around the clock. Humans, too, are being captured down to the last detail, from their genetic material to their heartbeat. Traffic flows, cell structures, internet flows – and that’s only the beginning. But the more data that is available, the more pressing becomes the question of how to arrange, analyze, and interpret them. Mathematical models provide a solution. They can structure large amounts of data and make them “readable”. Model and data, however, do not always come together easily. This is where the Collaborative Research Center (CRC) 1294 comes in. Its title says it all: “The seamless integration of data and models”. Matthias Zimmermann interviewed Prof. Sebastian Reich, speaker of the CRC, and his deputy Prof. Wilhelm Huisinga.

Data assimilation bridges theory – that is, the mathematical model – and practice – the measured data that should go into this model. How does this work?

Sebastian Reich: Thanks to modern computing technology, mathematical models can be simulated. Incidentally, this also creates data, in a way a reflection of the phenomenon that one wants to model. On the other hand, there is experimental data that you obtain from measurements. The goal of data assimilation is to bring these two worlds together and to use the experimental data to calibrate, validate, and compare models, verify model approaches and so on. You want to combine the best of both worlds, and this happens algorithmically through the assimilation of data in models.

Wilhelm Huisinga: May I disagree right away? (Laughs) I would say this “best of both worlds” does not exist as such. It only becomes possible as a result of the combination. Big data is often said to generate knowledge through large data sets. Here we would say: Collecting a lot of data does not necessarily yield new findings. It also takes innovative methods to turn this data into knowledge. And that is done through combining experiment and model. Principally, models contain our idea of the processes underlying the measured data. Only by combining models and data are you able to generate knowledge.

The **Collaborative Research Center (CRC) 1294** with the title **“Data Assimilation – The Seamless Integration of Data and Models”** focuses on the integration of large data sets into complex computational models. This is meant to facilitate a better understanding of underlying processes as well as more accurate predictions. In meteorology, hydrology, and the search for raw materials, data assimilation methods are already being used very successfully. In the future, new application areas in the fields of biology, medicine, cognitive and neurosciences are also expected to benefit. This urgently requires a theoretical foundation of the existing algorithms and development of novel ones for data assimilation.

The Collaborative Research Center 1294 comprises 11 scientific subprojects, a data infrastructure project, and a graduate college. In addition, it also includes a central administrative project. Of the 17 applicants of the CRC, two are from the Helmholtz Center Potsdam – German Research Center for Geosciences, one from the Weierstrass Institute Berlin, one from Humboldt Universität zu Berlin, two from the Technische Universität Berlin, and eleven from the Departments of Mathematics, Physics and Astronomy, Computational Science, and Psychology of the University of Potsdam.

www.sfb1294.de

Reich: Although this distinction is also quite subtle. Scientific models use principles for model design. But we also have projects where these principles are not necessarily known. Cognitive science, for example, is about discovering these principles in the first place – and for this, you also need data. You can suggest different models, but to decide which model is the more appropriate one, they have to be matched with data. This is done in data assimilation. It is the interface between statistics, which has historically dealt with how to model data, and applied mathematics, which is primarily devoted to the development of models and their analysis, but also to machine learning. The latter essentially also deals with the question of how models that fulfill certain tasks can be generated from data.

How did the field of data assimilation evolve in the first place?

Reich: In close relation to meteorology. Although we have a relatively good understanding of how weather phenomena occur, meteorology is about making predictions. The statistician George Box put it nicely when he said, "Essentially, all models are wrong, but some are useful." It means that you have to keep adapting models to reality. This also applies to weather forecasting models. In this context, data assimilation has made enormous progress. The availability of satellite data in the southern hemisphere, for example, has immensely improved the quality of forecasts. The CRC, however, deals not only with predictions. We also want to find models that can explain things.

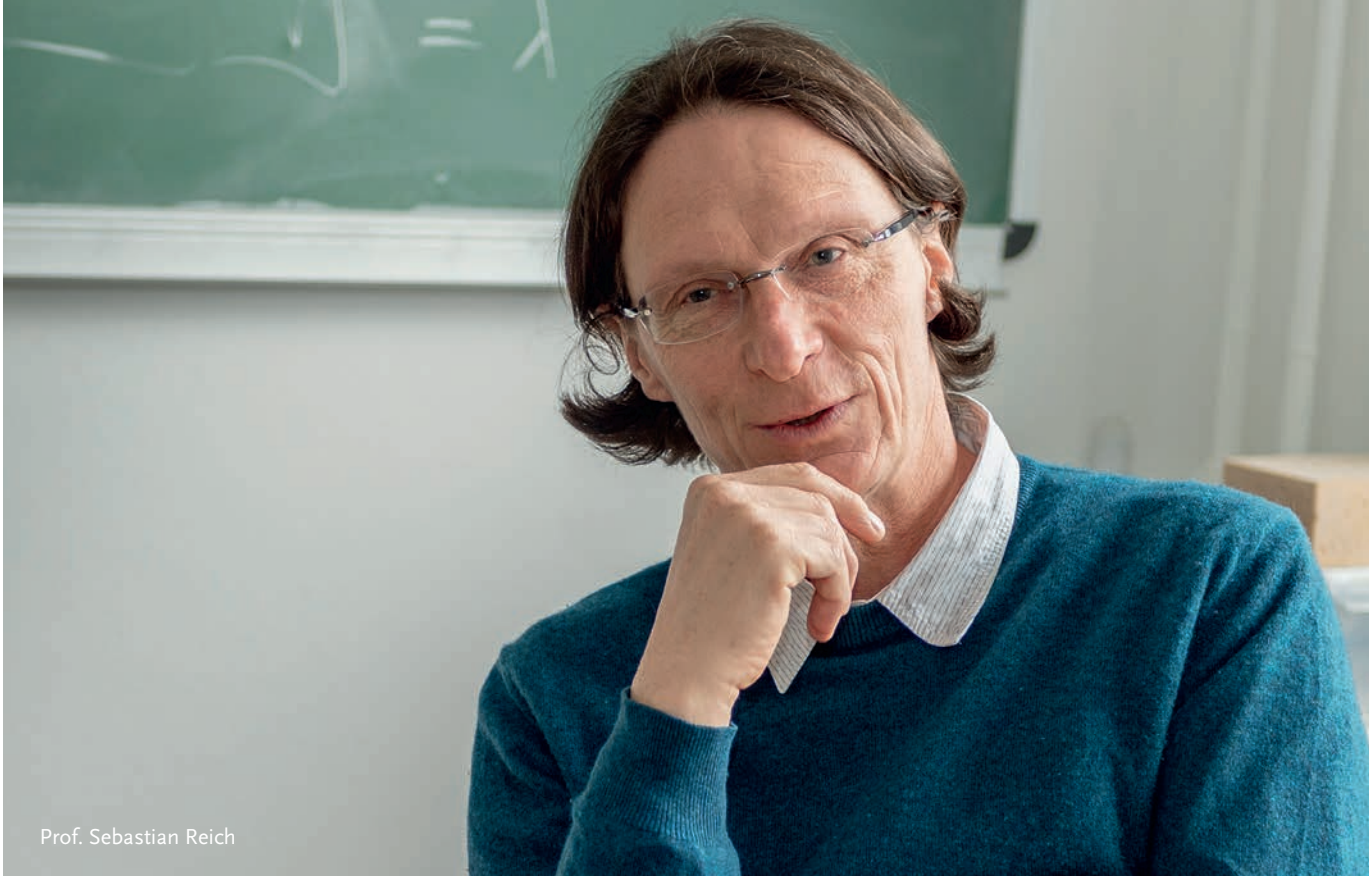
Huisinga: An example from the CRC: A subproject explores the question of how to determine whether a person has previously seen a picture they are looking at. Here, the mechanism of information retrieval in the brain and its impact on eye movement is not important. In other areas, we also want to develop an understanding of why something is the way it is. To Box's quote I would like to add: Actually, we should say that all models are approximations, i.e. methods of approximation. Some of them are useful, while others are completely futile so that you cannot do anything with them.

Reich: ... "Wrong" is, of course, a bit exaggerated. The models have an approximation quality, but errors occur, that's the important point. And these errors accumulate, for example when it comes to weather forecasts, so that the forecast quality is very low after seven days. Only a constant adaptation of the model to the data allows for repeatedly good predictions. This is how we have to interpret George Box's statement.

Huisinga: That's exactly why data assimilation is such a nice combination. One has an explanatory or even predictive model that seems off after a few days, and so you force the model to constantly respond to reality – through data assimilation.

Prof. Wilhelm Huisinga

Photo: Hopfgarten, Tobias



Prof. Sebastian Reich

Reich: This is like a learning process. The model is constantly learning through these data.

Are the "data assimilation algorithms" different from the mathematical models for simulating processes themselves?

Huisinga: I would say yes. In meteorology, to stick to the example, there are equations that describe the various processes and make a prediction for a specific time and place. When a measuring point is added, it needs to be correlated with the prediction. I would say that is a kind of statistical model which is based on the actual mechanistic model and assimilates data and models.

How does this work mathematically?

Reich: You can see it as a kind of feedback effect. The original model has an output, for example a prediction repeatedly compared to new observations, that is, to data. The model is adjusted based on this data. This feedback loop is relatively independent of the actual model. Therefore, Research Area A of the CRC deals with general algorithms of data assimilation as an independent mathematical problem. Research Area B deals with concrete applications, for which the algorithms have to be adapted: Which processes are behind all this? How can you achieve such feedback? What is the specific task: prediction, classification, or model verification? A good example, even if it is not yet relevant at the CRC, is autonomous driving. A self-driving car has many sensors that can discern the environment. The car has to react to its data. This requires a basic model defining what the vehicle does when and how. A feedback system takes into account the constantly incoming measured data. Similar questions will have to be addressed in personalized medicine.

Huisinga: The great thing about mathematics is that it's a kind of general language that can be used to describe phenomena – in an abstracting way. This shows that different application problems are based on the same mathematical questions or models. This is also the case in the CRC where the same mathematical process is important in two projects, even when one is on earthquake research and the other on the movement of amoebae. What's special about this process is that the occurrence of one event has a feedback on future events. A big earthquake entails many small earthquakes. Amoebae, in turn, move by creating coordinated protuberances of the membranes called pseudopodia. The probability of a pseudopodium forming is higher in the vicinity of existing ones. This is how the cell moves in one direction. This shows that earthquakes and amoebas are – mathematically – much closer than one might expect at first glance.

Reich: The other important aspect is that only mathematical modeling and modern computing technology have enabled us to extensively analyze, simulate, and even predict complex processes. Modern computers enable us to determine planetary orbits thousands of years in advance, or to predict the probability of earthquakes.

Is there anything like general algorithms for data assimilation?

Reich: Yes, there are certain basic principles. One of the "classics", the Kálmán filter, dates back to the 1960s. Rudolf Kálmán was a Hungarian mathematician who developed such an algorithm for data assimilation of linear models, i.e. a limited class of models. This played an important role in the Apollo program, for example. But there are other methods and different statistical techniques. Our CRC also wants to consolidate these a bit, derive principles and, in particular, develop new algorithms.

Huisinga: Another goal of the CRC is to bring data assimilation from classical applications, such as geosciences and meteorology, to new areas, such as cognitive science or biology. One of our application examples is on how to use these data assimilation techniques profitably in pharmacology.

Reich: For a long time, data assimilation was primarily developed by its users. Over the past decade, however, there has been a growing interest in understanding these things mathematically and analyzing what's actually going on. The CRC is expanding on these developments.

Huisinga: Ultimately, the users will also benefit from it. Especially in practice, you have to know when models are working and, even more importantly, when they are not, because the users will apply them to everything. Sometimes you may not realize that a surprising prediction is not a real phenomenon, but simply results from the fact that the math or the model does not hold up.

Reich: Meteorology, for example, is now reaching the limits of the algorithms that are used. As the models become ever more detailed and increasingly three-dimensional, new data assimilation algorithms are needed.

Has the "star of data assimilation" risen with the age of big data?

Reich: Mathematically, they overlap in many ways. The difference, in my view, is just that we are quick to speak

Illustration: Töpfer, Andreas

of "big data" when there are very large data sets. In other words, you have enormous amounts of data to find many parameters. For other applications, where there may not be as much data, more specific models need to be developed. That's a question of balance. Many algorithms used in data assimilation are increasingly being used in machine learning and vice versa.

For successful data assimilation, do you need a mathematician for the model, a scientist for the data collection, and a data scientist for its implementation?

Reich: It usually starts with a user saying, "I have a question...". Often, the users are mathematically well-educated and already have a model, which they also work with but which they don't know exactly. Then there is a mathematician who tries to analyze and improve the model. Ideally, this leads to a dialog during which they jointly develop an algorithm that is also practicable because the user needs a forecast at a specific time – the weather tonight and the earthquake warning before the quake.

Huisinga: At the CRC, the mathematicians are responsible for Research Area A and the users for Research Area B. The important thing is to bring them into conversation with one another.

Reich: Exactly. But looking at the B projects, it's clear that mathematicians and users always work on them together. That is also the exciting thing about the projects: As a specialist, you first have to understand the language and problems of others. Only then will you be able to create something together.

You have mentioned the two big areas of the CRC. Could you quickly explain what Research Area A does?

Reich: A lot of math. (Laughs) There are six subprojects ranging from statistical questions in connection with high-dimensional stochastic processes to statistical questions of inverse problems. For example, there are two projects that deal especially with the already mentioned aspect of learning, that is, with the continuous adaptation of models to data. Furthermore, Project A03 deals with the question of how to best make decisions, and Project A05 deals with point processes.

What applications does Research Area B focus on?

Huisinga: As mentioned, we are studying how amoebae move in a biophysical project. This is about model development as well as data collection. A second focus is earthquake research, a well-established field of research in Potsdam. The goal is to model earthquakes not only dispersed over time, but also over space. We have two projects in the field of cognitive sciences which we want to make available for data assimilation. One project creates cognitive models of movement, while the other examines, as mentioned, whether you look at a picture differently if you have seen it before.

Reich: The last project is about space weather. This refers to the influence of solar activities on the radiation belt that surrounds the Earth and is of great importance to satellites. All in all, the researchers at the CRC merge basic mathematical research for data assimilation with disciplines in which the University of Potsdam has proven itself strong in research – above all, biology and the cognitive and geological sciences. The exciting thing about such a CRC, however, is of course also the interaction between projects. Some do this, others that – but how do they come together? You could, for example, model amoebic motion via stochastic partial differential equations, and then you suddenly have an interaction between a rather application-driven and a mathematically motivated project. In such a context, it is much more likely that people get in contact with one another who might otherwise be able to get in contact, but wouldn't actually end up doing so.

TRANSLATION: SUSANNE VOIGT

THE RESEARCHERS

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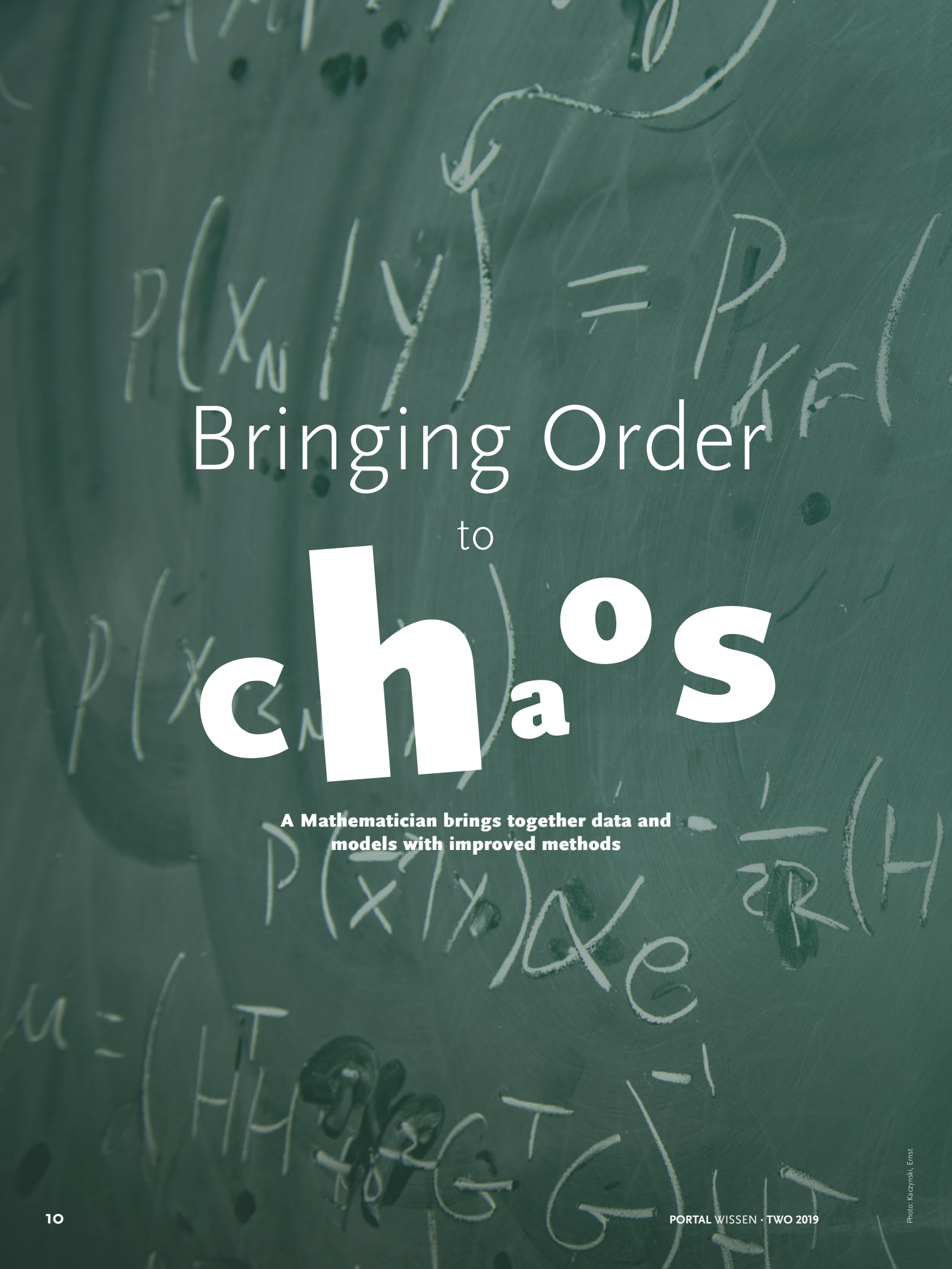
Photos: Hopfgarten, Tobias (2)



Bringing Order to chaos

A Mathematician brings together data and models with improved methods

Photo: Kaczynski, Ernst

Small variations can have big effects. This insight is part of Dr. Jana de Wiljes' everyday work life. The researcher works with mathematical models that allow predictions about the weather, earthquakes, and robot movements. The problem, however, is that even small deviations in the initial conditions that are fed into the models result in a large variability of the simulation results. In the Collaborative Research Center Data Assimilation, it is de Wiljes' task to mitigate these uncertainties.

The lines on the monitor of mathematician Jana de Wiljes form two interconnected ovals. The image is reminiscent of delicate butterfly wings but is actually the visualization of a mathematical model. It is the so-called "Lorenz Attractor", named after the meteorologist Edward N. Lorenz, who developed the model in 1963. Broadly speaking, it describes how liquids and air masses flow. This is important, for example for weather forecasts.

Research with toy models

What may look playful actually represents the dilemma of the researchers working with these and similar models: the Lorenz attractor depicts a system with chaotic behavior. It shows that long-term weather forecasts are nearly impossible because even very small changes lead to large deviations. Lorenz created the image of the butterfly effect in the context of chaos theory. This indicates, symbolically, that the flapping of a butterfly's wings can affect the weather in a faraway part of the world.

Jana de Wiljes uses the Lorenz attractor as a so-called toy model. "It's low-dimensional yet causes enough trouble," she explains. "It is not comparable to the big numerical weather models." The toy model, however, is well-suited to testing how best to combine models and data best to make the most accurate predictions possible.

"That's not easy," says the 33-year-old researcher. To bring together data and models, she has to develop new methods but also better understand existing ones. She scrutinizes and analyzes the mathematical assumptions behind the models and examines why certain methods are more successful than others. "Take, for example, a robot that is programmed to move in a certain direction in a room," de Wiljes says. "Due to small bumps on the ground, the robot moves completely differently than intended. These mistakes have to be fixed by collecting additional information." The researcher is basically looking for suitable filters to intelligently adapt models and data to each other.

Sometimes, a sheet of paper and a pencil are enough for that. She then juggles numbers, formulas, model parameters, and mathematically explores why one method works better than the other, simplifies equations and puts them into filters, analyzes assumptions, data, and results.

On other days, the mathematician uses a computer, writes codes for new filters, and initially tests them with simple simulations that gradually become more complex. "Many methods only work well when you run many simulations," she explains. This, however, is difficult with these complex, high-dimensional models. They require so much computing power that it would be too expensive to do hundreds of simulations. Fortunately, there are the mathematicians' toy models, which, although highly simplified, are still able to map the basic functions very clearly. Testing these models eventually leads the researchers to new findings. In the long run, the progress made can be applied to the larger models.

Data assimilation conquers new research fields

The Collaborative Research Center is not about weather forecasts, de Wiljes emphasizes, although the mathematics behind it are similar. Many researchers across different fields of expertise will ultimately benefit from the foundations that the mathematician is developing. "We collaborate closely with the application-oriented projects," she emphasizes. These investigate, for example, the space weather, earthquakes, and the effect of medication in patients. It is always about predictions – how intensely the next solar storm will affect the earth's magnetic field, how strong the next earthquake will be, or how individual people with clearly defined properties will react to certain active substances.

THE PROJECT

Within the Collaborative Research Center 1294 "Data Assimilation", the sub-project A02 researches the **theoretical foundations of data assimilation**. The researchers develop new filters for mathematical models and examine existing ones to better understand them. The sub-project B06 develops and tests **"Novel methods for the 3D reconstruction of the dynamic evolution of the Van Allen belts using multiple satellite measurements"**.

Duration: 2017–2021
Principal investigators: University of Potsdam, Technische Universität Berlin, GFZ Potsdam
www.sfb1294.de

Dr. Jana de Wiljes

Of course, mathematics is primarily thinking. But for her research, Jana de Wiljes seldom sits alone behind closed doors brooding over problems. “Mathematics is a team sport,” she says, something she learned as a child since both her parents were mathematicians. She discusses new ideas with colleagues, tests suggestions, or discusses possible solutions. Within the Collaborative Research Center, contact with scientists of other departments is also important. After all, the mathematician must understand what is behind the individual projects and which mathematical solutions could help.

In this way, mathematicians often venture into new territory with their instruments. While it is commonplace in meteorology or robotics to work with data and models, these methods are less common in biology and medicine. But for de Wiljes, this is an incentive rather than a deterrent. “New applications create new challenges, new methods, and new algorithms,” she says.

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

THE RESEARCHER

Dr. Jana de Wiljes studied mathematics at Freie Universität Berlin. Since 2014, she has been researching at the University of Potsdam.

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Prof. Dr. Yuri Shprits studied physics and applied mathematics in Moscow, meteorology in Oklahoma, oceanography at MIT, and space physics in Los Angeles, where he also earned his doctorate. He is Head of the Section Magnetospheric Physics at the German Research Center for Geosciences and Professor at the Department of Physics and Astronomy at the University of Potsdam.

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Storm in Space

How Data Assimilation Can Contribute to Forecasting Space Weather

They help us communicate over long distances, navigate unknown terrain, and predict the weather. Hundreds of satellites orbit the Earth servicing science, the media, the economy, and the military. Unsurprisingly, there is a great interest in protecting their sensitive technology from the particle radiation released by solar storms. In the future, data assimilation could contribute to predicting such negative effects of space weather.

Prediction and understanding of space weather is somewhat similar to the prediction of the terrestrial weather, says Yuri Shprits. With measurements from a single station we are not able to observe the entire weather system. To see a global picture we need a whole network of stations. "Similarly, for space, we get only local information from individual satellites," says the physicist. In order to be able to better understand the complex dynamics of the system and make predictions, it is necessary to include far more satellites and develop new methods to make the best use of the data.

Yuri Shprits is Head of the Section Magnetospheric Physics at the German Research Center for Geosciences and Professor at the Department of Physics and Astronomy at the University of Potsdam. His research of the near-Earth space environment and space radiation, which is dangerous for the aerospace industry, provides an interesting field of application for data assimilation, combining incomplete and inaccurate satellite observations with information from physical models. What has already led to meaningful and reliable simulations in meteorology, oceanography, and climate research, is now also supposed to contribute to understanding the weather in space.

Shprits explains how it works. "First, we make a prediction with our model and connect it with observational data. Then, this prediction, corrected through the observations, is used as an initial condition for a new prediction, which in turn is combined with new data." By comparing comparing the model predictions with the actual measurements, we can deduce what physical processes are still missing in the model to better quantify it. In this way, data assimilation is not only able to reconstruct the ongoing processes in the magnetosphere but can actually give precise clues as to the physics behind them, says the scientist, who was awarded the 2012 Presidential Early Career Award for Scientists and Engineers by Barack Obama.

Within the CRC "Data Assimilation," Shprits is collaborating with the mathematician Jana de Wiljes from the University of Potsdam to be able to apply this method to the specific field of space physics. "Jana de Wiljes not only tries to prove theories and develop abstract methods, but also to tailor them to practical problems," Shprits emphasizes. Although theoretical experiments may be promising, the developed methods must be tested on actual data and for real-life applications. Every field and every application has its own specifications. "Sometimes we try things that work well, but we still don't understand why. If we knew that, we would be able to optimize the methods, understand their applicability, and possibly transfer them into many other fields, such as biology, earthquake research, navigation, and climate research," Shprits says.

He and his team are currently focusing on the Earth's radiation belts and ring current: two donut-shaped regions that capture high-energy protons and electrons from the Earth's magnetic field. The researchers want to understand how the particles are accelerated and spread into the atmosphere, where they can influence the climate. "The data assimilation models help us create a global picture despite sparse measurements," Shprits says. "By comparing our analytic model with the collected data and assimilating that data, the new tools show us something that is not visible to the naked eye."

However, it is no less important to understand how these methods work. "Otherwise we cannot rely on them," says the physicist. "Only when we well understand them, will we know for sure that this is what really happens in nature."

ANTJE HORN-CONRAD

TRANSLATION: SUSANNE VOIGT

Photo: Courtesy of NASA/SDO and the AIA, EVE, and HMI science teams

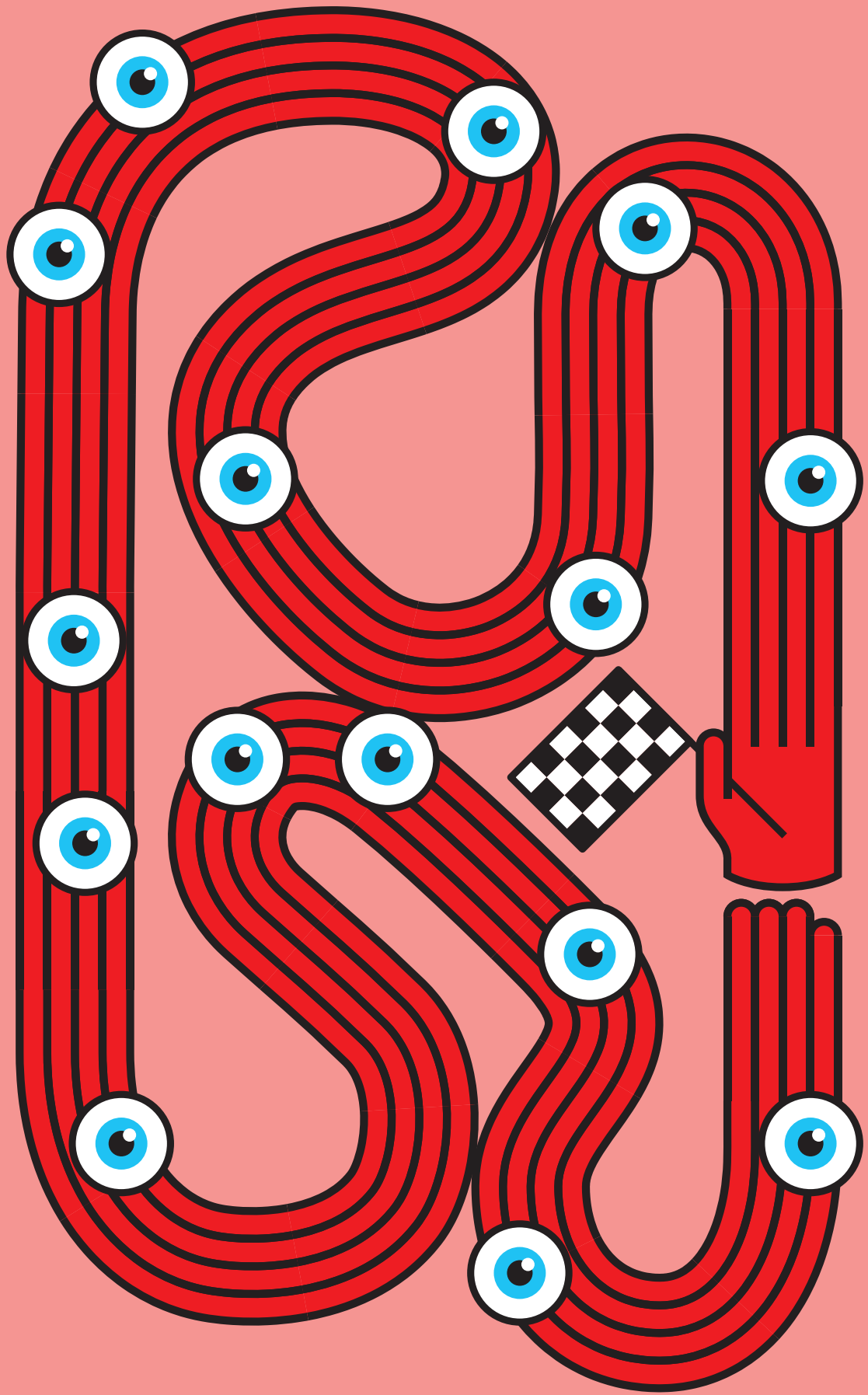


illustration: Topler, Andreas

I See What You See – And See Where You Look Next

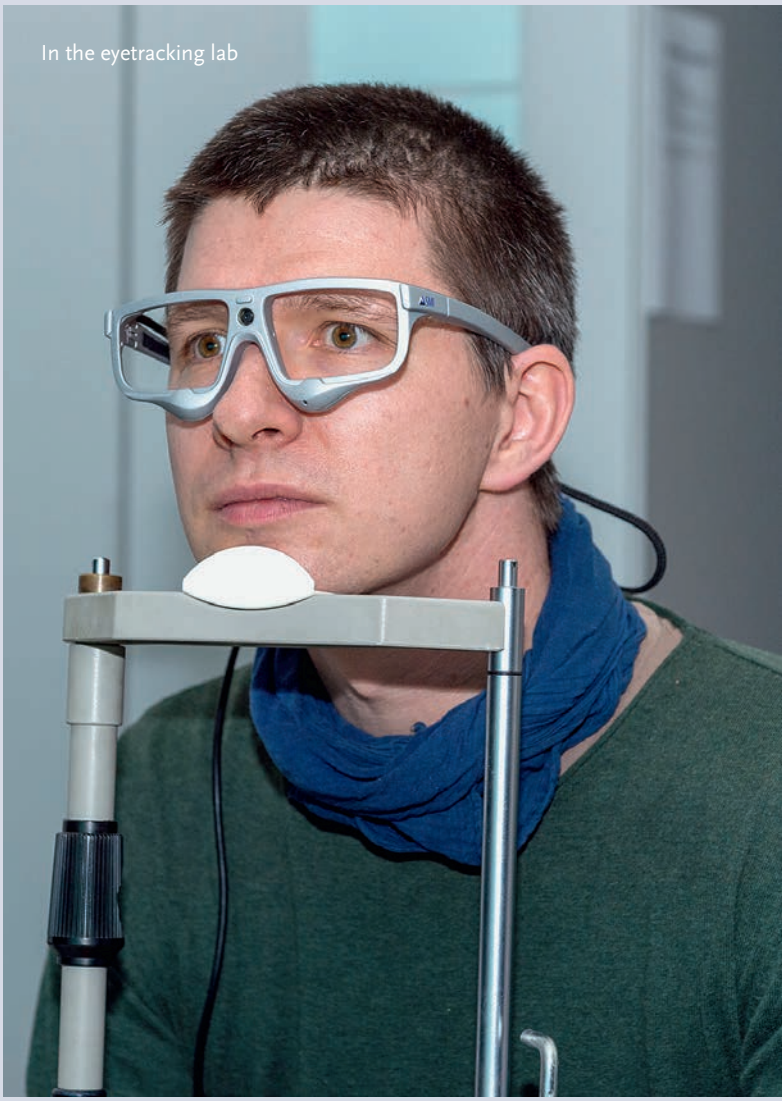
Potsdam cognitive scientists develop models for predicting eye movements

For some time, cognitive scientists have been focusing on the human gaze, especially when it comes to reading and viewing images and objects. We know more and more about why we look at a specific spot and how we grasp what we are looking at. Researchers have gone, however, a step further and investigate whether the movements of our eyes may also reveal what we are going to look at next. Matthias Zimmermann participated in a self-experiment on an eye-tracking analysis – and talked to cognitive scientist Prof. Ralf Engbert.

"Top left, right, down, up, bottom left, I have no idea." The symbols that appear on the screen about five meters in front of me are getting smaller and smaller. At some point I have to guess. I wonder if others can still recognize what has already become blurred before my eyes. When I think I have failed, the friendly colleague explains to me that my visual acuity is perfect. Lucky me! Actually, I am here today to participate in an experiment on eye movement measurement. But before we really get started, they will test if I am allowed to participate. This time, a cognitive test follows. I have to assign symbols and numbers to each other with a time limit and then do a vocabulary test. I feel a little bit like at school, but my ambition has been aroused and I give it all. The experiment itself, however, has not even begun. Then it's time for looking again! My eyes are thoroughly checked: focusing -okay, depth of focus- works, color vision – perfect, eye dominance – on the right. At some point I am completely registered, get a number for anonymization and then I'm ready to hold my eyes in the camera. But why? What the researchers will see, when they see what I see, I do not know yet. I hope I will find out soon.

"Eye movement measurements are a methodical tool that is versatile and can be used in different disciplines," says Ralf Engbert. The physicist is Professor of General and Biological Psychology and an expert on the mathematical modeling of eye movements and attention processes. "In Potsdam, we have established many scientific applications for eye movement analyses in psychology and linguistics."

It is therefore hardly surprising that Engbert is involved in the eye movement projects of two DFG Collaborative Research Centers. Within the CRC 1287 "Limits of Variability in Language", he and Prof. Shravan Vasishth investigate what eye movements reveal about language parsing processes. The project in the CRC 1294 "Data Assimilation" focuses on theoretical models that can describe eye movements for texts or pictures and how to predict where we look when we look at a scene. "There are already functioning models for static scenes," Engbert says. The advertising industry, for example, already uses heat maps, which document the areas of images, graphics, or websites we are



In the eyetracking lab

looking at particularly intensively. “We are working on dynamic cognitive models.” With their help, it should be possible not only to reconstruct on average but to intrinsically predict where someone will look next – and not only when looking at a photo but eventually in a real, changing environment. “The potential applications for such a prediction of eye movements in real time are enormous,” says Engbert. “Especially for human-machine interaction. An appropriately equipped assistance system in a car could warn you if you overlook the pedestrian on the side of the road because you are looking elsewhere.”

The laboratory looks unspectacular: a sober room, which is lined with black curtains, two computers, chairs, and inconspicuous gray plastic goggles. That’s it. I’m still not impressed. That changes when the experimenter, Daniel Backhaus, puts the goggles on my nose, which has no glasses but is wired, and turns it on. A program window opens on one of the screens and I see there what I see through the goggles. I shake my head and the live broadcast shakes as well. This is getting even more bizarre as I

THE RESEARCHER

Prof. Dr. Ralf Engbert studied physics at RWTH Aachen. Since 2008, he has been Professor of Experimental and Biological Psychology at the University of Potsdam.

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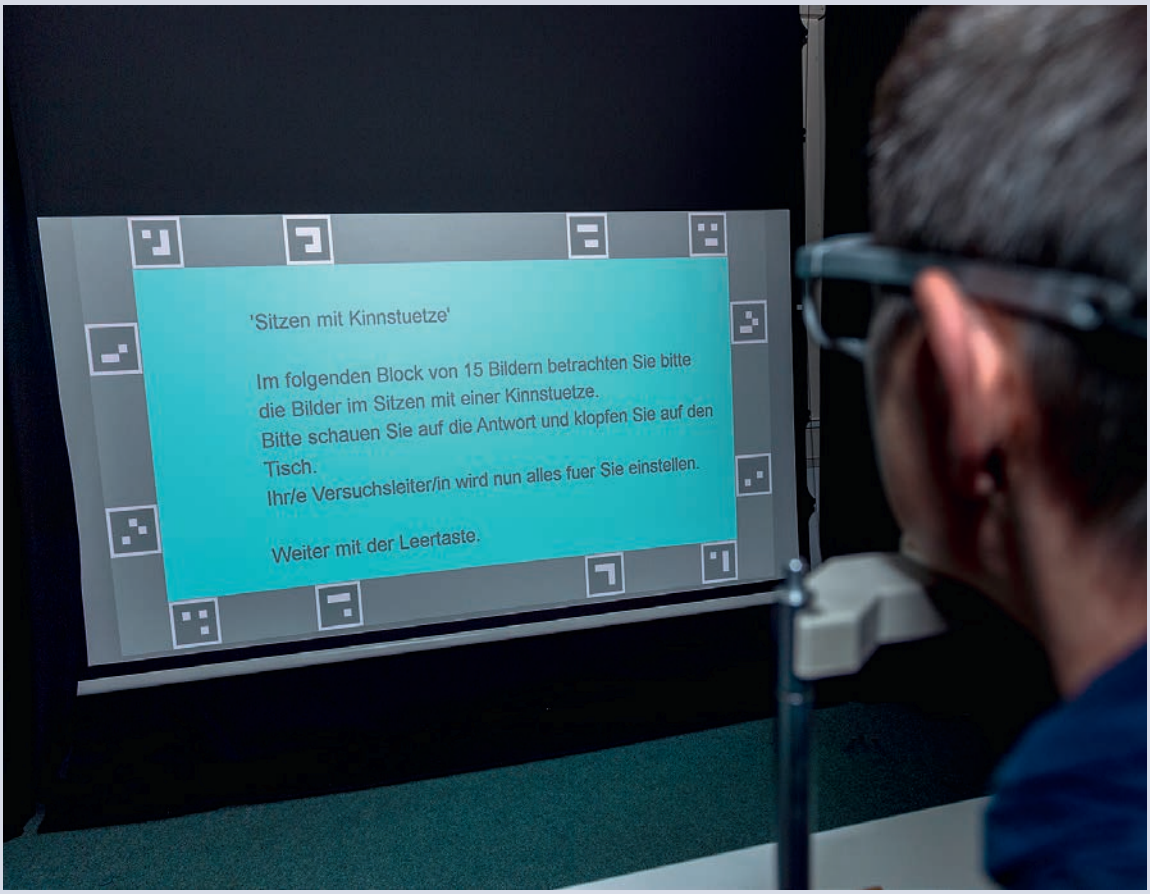
Photos: Hopfgarten, Tobias (4)



step closer and see the screen in the screen and another smaller one inside and one more and another until they are too small to identify. I feel reminded of a mirror cabinet. The goggles are calibrated before and also during the test series, altogether at least 20 times. For this I have to focus three consecutive black dots on a white background. Everything is adjusted to the millimeter. Even the canvas is adapted to my height, so I really look straight ahead and not up or down.

The eye-tracking glasses are the technical heart and the experiment's "all-seeing eye". They are equipped with several small cameras, some of which are aligned to the front and record what the subject sees. The others focus on the pupils and register their movements – down to the smallest detail and in real time. When they are combined, visual tracks are created that document where you look in the picture. The constantly repeated calibration ensures that the visual track and the viewed image ultimately fit together exactly.

Finally, the test begins. The experimenter places me on two so-called wobble boards, i.e. round plates that are mounted on a half ball so that I must constantly balance in order to not lose my balance – in other words, aggravated conditions. About three meters in front of me is a large, white canvas and directly above me a projector. Wobbly like a surfer when trying to stand on the board for the first time I have to look at 15 photos. I see landscapes, streets, houses – and in between, animals: elephants in the savannah, seagulls in the harbor, monkeys in the zoo, dogs, horses, sheep, sometimes single animals, sometimes masses. My job is to count how many animals I see in the photos. I have ten seconds for each picture. Then I can choose from three possible answers and must say my answer aloud. If I'm correct, the screen lights up in green and my "experiment account" is credited a few cents. If I am wrong, there is no nasty "eeh" as in a game show, but the screen turns red. Experiment or not: I cannot deny that I feel a bit under pressure. The number is often correct, but again and again I am wrong – and that annoys me.

Research on eye movement measurements has been around for some time, Engbert explains, but so far it has usually taken place under laboratory conditions. "Visual perception, however, serves as a preparation for

Photo: Hopfgarten, Tobias

Prof. Ralf Engbert

actions. We look at a cup and then pick it up; we look at things and reflect upon their function." Visual perception depends very much on the task and therefore can only be expediently examined in these contexts. "Our goal is to get the eye movement analysis out of the lab – without sacrificing scientific precision."

The researchers in Potsdam do this in two ways. On the one hand, it is now possible to simulate more natural conditions thanks to the latest technology. For a long time, permanently installed trackers were used for a long time, where you had to put your chin on a support and were not allowed to move your head during the experiment. The new tracking glasses offer more mobility. Standing or turning your head – all that is no longer a problem. "It is already possible to walk across the campus with an eyetracker on your head," says Engbert. "With this first step we make our subjects move within our different settings to create conditions that enable scientific conclusions about a natural behavior of ours."

On the other hand, the researchers simply "ensure" that the sight of the test subjects is meaningful by giving them a task. In this case it is counting animals. That makes their eye movements not only realistic but also comparable. This, in turn, is a prerequisite for a good model that they can feed with the datasets and then refine. Of course, experiments become increasingly complex when they are more realistic. That does not make it easier for researchers. "Natural conditions present challenges in many fields," says Engbert. He refers to the complexity of the models, for example. The more parameters that have to be taken into account in an experiment, the more data that is incorporated into the modeling. "The only thing that helps to take advantage of the wealth of data without getting lost in its everglade is good theory."

Finally, the first round is over and, relieved, I step down from my "surfboard". A short rest, but I am still far from completing the experiment. Another 45 pictures are in front of me. This time, I firmly stand on my feet for the next 15 pictures, so it's a piece of cake. Nevertheless, I cannot relax; the pictures are demanding. I search in vain for some animals. Again and again red screens,

Photo: Hopfgarten, Tobias

and in between, I remember that measuring eye movements is a bit like mind reading. Experimenter Daniel Backhaus sees exactly where I am looking – also my glimpse at the slowly growing "reward account", which I deny myself from now on. I am here to report on a research project and not to earn money. But then it crosses my mind: What if the whole experiment is a psychological study to find out who peers hard at money and who not? I pull myself together, I have to count animals. Eight sheep, none, three elephants. Wrong, damn!

Although the CRC 1294, which I am also contributing to with "my" experiment, was only started in autumn 2017, Engbert and his team of cognitive scientists have already achieved a lot in their subprojects. "Our mathematical models have improved considerably," he says with some pride. Thanks to data assimilation, the dynamic cognitive models, which he developed together with the project partners, are not only able to depict the sequential structure of vision. "With each new data point, we are better able to predict the next fixation point from the recorded sequences, that means the point in a picture where the viewer looks next."

But that's not all. Improved modeling through data assimilation has enabled them to make more accurate predictions with less data. "Up to now, measurement data from many subjects was needed to formulate relatively static and general statements about eye movements. We have already come to a point where we are able to make individual predictions with data sets from individual subjects."

Two more "photo rounds" are next. After all, I am allowed to sit now, first on a kind of bar stool and then on a chair at a table. I have to put my head on a small supporting frame – and must not move it. Therefore, I cannot say how many animals I see. Instead, I'm shown three answer options: I have to look at one of the numbers and then close my eyes for a moment – and that is how I show my decision. Two ducks -blinking – correct. I would like to order my food in the restaurant like this, I think, and wait for the next photo.

The fact that their work has been so successful is not least because of the particularly fruitful research climate at the CRC, says Engbert with enthusiasm. "People exchange their ideas over a long period of time – both on a theoretical and practical level." Sometimes it becomes evident that some model approaches have more in common than was previously thought, even though they may come from earthquake research and eye movement analysis. Ultimately, everyone benefits from the joint work of experienced researchers in various disciplines and young doctoral students and postdocs. "The joint supervision of two principal investigators ensures that you always deal with different perspectives and new questions. And when young, interested people are ready to try new things, we all end up learning something."

Finally, the test series is done, and I am completely exhausted. I am quite proud that I found so many animals, even if the task was actually just a sideline. Experimenter Daniel Backhaus finally asks me about my strategy for searching for the animals. I ponder. I scanned, looked for big fixed points, then looked at unclear spots more intensively, and then repeated everything again. In fact, after a few minutes, I had developed a procedure that seemed the most sensible to me for "animal searching in seconds". Did others do it the same way? I hope I will find out when the experiment has been evaluated.

MATTHIAS ZIMMERMANN
TRANSLATION: SUSANNE VOIGT

THE PROJECT

Ralf Engbert is involved in two subprojects of the collaborative Research Center 1294 "Data Assimilation". Project B03 – „Parameter inference and model comparison in dynamical cognitive models", that he heads together with mathematician Prof. Sebastian Reich, examines the data assimilation for dynamic cognitive models. The project focusses on improving mathematical models of eye movement control in reading, scene perception, and fixational eye movements. The goal is to develop efficient algorithms for data assimilation and model comparison to be able to predict eye movements in real time. Project B05 – "Attention selection and recognition in scene-viewing", that Engbert heads together with computer scientist Tobias Scheffer, develops algorithms and mathematical models that describe eye movements while considering the individual characteristics of the viewer. A second goal is to generate discriminative models from such generative models of fixation sequences that enable extracting the latent properties of the observer from the viewed fixation sequences. From the exact analysis of eye movements, it could be inferred whether the viewer is familiar with depicted persons or other images. In the long run, such models could be used in e-learning and in criminology.

www.sfb1294.de

Photo: AdobeStock/Daniel Berkmann

Germany, Norway, Belgium, Denmark, France, Spain, Estonia, Hungary, the United Kingdom, and the Netherlands – in all these countries, public administrations are facing digital reforms. And each of these countries responds to digitization differently. How do European governments use digital instruments for cooperation? And how do they use such tools to communicate with their citizens? Julia Fleischer and her team are researching this topic – together with experts from 10 European countries – as part of the TROPICO project. It was launched two years ago and will be completed in 2021 – so now is a good time to discuss first results.

"You can't win elections with administrative reforms in this country," says Julia Fleischer, Professor of German Politics and Government at the University of Potsdam. So it comes as no surprise that Germany is lagging behind the rest of Europe in the digitization of its public administration. "The Nordic countries, as well as Estonia, are more open to digital applications. You can virtually sense a reforming zeal there," Fleischer says. That does not, however, mean that it is problematic if a country – such as Germany – proceeds more slowly.

Often, there are good reasons for it. In Germany, public administration was developed based on Max Weber's not very flexible ideal-type bureaucracy. "Principles such as the requirement of the written form and written records are not easily adapted to the possibilities of digital instruments," Fleischer explains. Besides, data protection is of comparatively high importance to German civil society. And last but not least, in a federal nation the legal framework is very complex. "It's not easy to develop a common digitization

THE PROJECT

TROPICO – Transforming into Open, Innovative and Collaborative Governments

Duration: June 2017–May 2021
Participants: University of Potsdam, Central European University, Budapest (Hungary), University of Antwerp (Belgium), University of Bergen (Norway), Sciences Po Grenoble (France), Cardiff University (United Kingdom), Hertie School of Governance, Berlin, Erasmus University Rotterdam (Netherlands), KU Leuven (Belgium), Tallinn University of Technology (Estonia), Roskilde University (Denmark), University of Zaragoza (Spain)
The Potsdam team: Julia Fleischer, Nora Carstens, Andree Pruin, Camilla Wanckel
Funding: European Union/Horizon 2020
www.tropico-project.eu

Prof. Julia Fleischer (second from right) and her team

strategy that will work anywhere in the country – after all, it takes not only ideas and instruments, but an appropriate infrastructure as well."

Municipalities are developing exciting ideas for the utilization of online tools

For a number of years, German citizens have been able to submit their tax statements completely electronically. "In this respect, we do not differ much from other countries," Fleischer says. However, the very complex tax legislation and tax law make the electronic transmission relatively complicated. "I have lived in the Netherlands and in Norway, so I know what I am talking about," Fleischer says with a laugh. Sometimes, however, a reserved attitude towards digital services may turn out to be advantageous: "You don't always need to be among the frontrunners. This actually allows you to avoid mistakes."

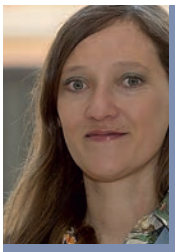
Especially since the Federal Government has indeed placed digital governance on its agenda. With the adoption of the Law on Online Access in 2017, the Federal Government, the federal states, and the municipalities have committed themselves to offering their administrative services – 575 in total – in digital form by the end of 2022. "Already, many exciting ideas have been developed, especially at the level of the municipalities and federal states. In our federal system, these are the ones mainly responsible for the provision of services such as day care nurseries, parental allowance – essentially all basic public services." Bremen is currently testing an app that can be used to apply for parental allowance. But it is not just ideas that matter. "They also have to be tested for legal certainty, so this is what slows the process down time and again." Besides, several authorities are involved in the granting of parental allowance, so not only the parents benefit from the new technology, but the authorities, too, because they start cooperating in a completely new way.

Close links between public administration and the legal system

The Potsdam team is specifically in charge of internal policy formulation: the way in which governments effect decisions, make regulations, or draft new laws. This also includes a comparison between European countries. So Fleischer and her team surveyed experts in law, politics, administrative sciences, and history from all over Europe on their views regarding the effect of digitization on policy formulation. "We found that the differences between European countries could partly be traced back to their administrative traditions. For instance, respondents in Estonia attributed a much higher impact to the dynamics of digital services than their colleagues in Germany did." For Fleischer, these differences mainly result from the different legal systems public administrations are closely linked with.

At the same time, the survey found that digitization may not only result in better and more efficient cooperation, but can also create some challenges, for instance regarding the delimitation of responsibilities and the cooperation between ministries or authorities.

Photo: Hopfgarten, Tobias



THE RESEARCHER

Prof. Dr. Julia Fleischer studied public administration at the University of Potsdam and the Complutense University of Madrid. She has been Professor of German Politics and Government at the University of Potsdam since 2017.

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Fleischer is looking forward to interviewing administrative officials in person in the second half of the project. The international team contrasted scientific opinion with qualitative case studies carried out in countries where digital instruments are used for internal policy formulation. In Germany, for instance, they looked at the electronic sustainability impact assessment, or eNAP. The Federal Government has committed itself to devoting more attention to the goals laid out in the United Nations' Agenda for Sustainable Development for its policy formulation. The web-based application eNAP is to ensure that these goals will be attained: It makes sustainability assessments easier for advisors. "Our main question is whether they use the portal at all and how it impacts their everyday work."

In addition, Fleischer and her team studied digital tools for climate protection in Hungary and an electronic platform by employees for employees in public administration in the Netherlands. "We want to understand how digitization affects the tension between politics and administration," Fleischer says. She and her team are researching in how far the European Union implicitly promotes the introduction of digital instruments. For instance, will a tool for measuring carbon emissions for environmental purposes that is tested and approved in one country be introduced more rapidly in another EU country? This is the type of question she hopes to find answers to.

Civil society, too, is increasingly using digital means to make its voice heard

Regarding policy implementation, the researchers studied online portals for citizens in Germany and Norway, respectively. In Berlin, they examined "mein-berlin.de" (my Berlin) and in Norway "minsak.no" (my cause¬). Both platforms allow citizens to get involved in urban planning processes.

According to Fleischer, one of the major challenges is that not all social groups are equally represented among the users of digital tools. "Just like analog communication with public administrative bodies, people with higher levels of education use the instruments of political participation more often than less-educated citizens." However, the researchers are less interested in how citizens use such offers and more in how the administration deals with them. How is the input processed – more quickly or more slowly than in analogous form? Are there any differences at all? And how do workflows and decision-making change? Currently, the researchers are still in the midst of their evaluation. Nevertheless, Fleischer has a provisional answer to these questions: "Things are not simply getting better or worse, the answer is: it depends."

DR. JANA SCHOLZ
TRANSLATION: MONIKA WILKE

Digital administration also means access to online services for citizens

Photos: Hopfgartner Tobias (top); AdobeStock/Sikov (bottom)

"Henrietta's school in motion" was developed to help children enjoy movement.

Illustration: Tina Vlachy (Berlin), Monika Bröse (Köln); Projekte & Spektakel GmbH/AOK Nordost

MAKING CHILDREN **MOVE**

The SMaRTER study at the University of Potsdam researches how regular remedial PE classes affect elementary school children

THE PROJECT

Testing the effects of remedial PE on the motor and cognitive development of elementary school children in the state of Brandenburg (SMaRTER study)

Funding: ca. EUR 172,000, by AOK Nordost – Die Gesundheitskasse
Duration: 2018–2022
Participants: Prof. Dr Urs Granacher, Fabian Arntz, Sophia Funk, Dr Kathleen Golle, Teresa Rymarcewicz, Prof. Dr Reinhold Kliegl

Children have a natural desire to move. They run, jump, and skip whenever they have the opportunity. But what if they prefer watching others doing sports rather than being active themselves? For quite some time, researchers have been observing an increase in motor deficits in school-aged children. To counteract this trend, the federal state of Brandenburg has launched various programs based on studies developed at the University of Potsdam. One of them is the SMaRTER study in which a team of researchers around Urs Granacher, Professor of Training and Movement Science, explores the influence of remedial PE classes on several parameters of young school children with motor deficits. Their research is part of the project "Henrietta's school in motion," initiated by the Brandenburg Ministry of Education, Youths, and Sports in 2017, together with the AOK Nordost, a public health insurance company, and the state sports association of Brandenburg, LSB.

"Imagine you are on a journey. Try to stand still on one leg for 60 seconds, or for as long as you can, with your eyes closed. You may move your upper body to keep balance, but keep your hands on your hips, and don't hop or change the position of your legs." This is one of many physical fitness tests in the SMaRTER study. Eight- and nine-year-olds from a total of 12 schools in Brandenburg completed this and other tests as part of their entrance test in February, and once again in June this year. In addition to testing their fitness and capturing their level of physical activity, the test battery also included methods to test body composition, cognitive function, and psychosocial well-being.

"Henrietta's school in motion" is a program for the promotion of exercise initiated by the Ministry of Education, Youths, and Sports of the state of Brandenburg together with the AOK Nordost, a public health insurance company, and the state sports association of Brandenburg, LSB, in 2018. It is meant to engage and inspire children and teenagers for whom sports is not very much fun yet. The first set of instructors have already completed their training provided by the LSB. The SMaRTER study is part of this program. For "Henrietta's school in motion," AOK Nordost and the staff at the division of training and movement science at the University of Potsdam have developed, among other things, 25 movement cards for teachers to use in PE classes, and for children to use at home.

Illustration: Tina Vladhy (Berlin), Monika Bröse (Köln): Projekte & Spektakel GmbH/AOK Nordost

The **EMOTIKON study** was developed at the University of Potsdam at the suggestion of the Ministry of Education, Youths, and Sports of the state of Brandenburg. The acronym stands for "Assessment of motor performance in year 3 for the continuous evaluation of PE classes and a diagnosis-based systematization of the promotion of exercise and movement".

Earlier studies have conclusively demonstrated a correlation between physical fitness, especially endurance, and cognition. It is assumed that there is also a link between coordinative performance and cognition. For this reason, Granacher's team also tests children's postural control. All children participate in the project voluntarily. Most of them were recruited through the so-called EMOTIKON study – a mandatory fitness test for third graders in Brandenburg. Those displaying deficits in physical fitness were invited to participate in the SMaRTER study.

First, the researchers compare the effects of remedial PE on children in the intervention group with that of the waiting group attending regular PE lessons. After a certain time period the groups switch, so that in the end all children have received remedial PE. Following the one-year intervention phase, the researchers trace the children's motor-cognitive development until they leave elementary school to find out whether the intervention has had a lasting effect. By now, all teachers involved in the project have been provided with teaching concepts for the intervention that takes place twice a week. The program comprises playful elements for increased strength, endurance, and coordination. Ball and relay games are included, as well as dance exercises, running, throwing, and jumping activities.

The entrance test has already shown that the children selected with the help of EMOTIKON indeed display motor deficits – and thus clearly represent the target group of the SMaRTER study. "They are the appropriate group with special educational needs," Granacher confirms. "In February we also saw that our tests work, and that they are valid and fun." For instance, the cognitive tests, for which team member Fabian Arntz developed an app, were very well received. "To take the test, each child was given a tablet PC," Granacher explains. "The tasks were mainly attention exercises to be completed under time pressure." He hopes that the new concept of remedial PE will not only have a positive effect on the physical activity and fitness level of the participating elementary school children, but on their cognitive function as well. "This

Illustration: Tina Vlachy (Berlin), Monika Bröse (Köln); Projekte & Spektakel GmbH/AOK Nordost

Prof. Urs Granacher

Studies show that the number of children and teenagers who get sufficient exercise is declining. Accordingly, the **trend and longitudinal study on the health of children and youths in Germany (KiGGS)** initiated in 2003 has found that the WHO's recommendations for physical activity – 60 minutes of moderate-to-vigorous physical activity per day – are adhered to insufficiently. In 2017, only 22 percent of girls aged 3 to 17 and 29 percent of boys in the same age group met these recommendations, with teenagers displaying a lower compliance rate than children. Besides, the compliance rate of the recommended daily minimum dose of physical activity for 7- to 10-year-olds fell from 31 percent in 2009–2012 to 26 percent in 2014–2017.

would be a great outcome," he says. "We are eagerly awaiting the post-tests that will enable us to precisely measure the effect of the intervention versus the control schools. This will certainly be the most interesting part of our study."

By contrast, some results of the EMOTIKON study worry him: For some time, the researchers have noticed a drop in endurance performance among third-graders in Brandenburg. Achievements in the six-minute run test have declined over the past years, particularly in the lowest performance group. "Perhaps this finding is an early warning sign of things moving in the wrong direction." Granacher can only speculate about the reasons. "We are living in an environment that doesn't promote physical activity. Often, children are driven to school by car or bus, rather than walking or biking. Increased media use may also play a role."

Photo: Fritze, Karla

Schools and sports clubs need to cooperate better

Before the SMaRTER study could launch, a lot of persuading had to be done. Granacher and Arntz had to bring on board schools, parents, and, above all, teachers – with the support of local politicians and the state sports association of Brandenburg. "We offer advanced training programs for remedial PE teachers," explains Eckhard Drewicke of the Ministry of Education, Youths, and Sports. As an advisor for PE at school, he has accompanied both the EMOTIKON and the SMaRTER studies from the very beginning. "This research is important for us as it provides information on what practical action needs to be taken to successfully reach children with physical fitness deficits." The idea is to include the experiences of teachers in the current remedial PE program into general recommendations, as plans are under way for a more extensive roll-out of the program in Brandenburg.

Now that the full-day program for elementary schools has been relaunched, the ministry places greater emphasis on relations between schools and sports clubs and sports associations. Here, it cooperates closely with the state sports association of Brandenburg which has just started to train 40 fitness instructors to work with children with physical fitness deficits, and to develop 40 respective offers. "We are discussing what these could be."

The studies performed by training and movement science researchers at the University of Potsdam go far beyond scientific measurements, comparisons, and conclusions: They are of social, and thus educational and political, relevance. And not only for Brandenburg – as deficits in physical fitness among children and youths are a common phenomenon in many modern industrialized countries.

PETRA GÖRLICH
TRANSLATION: MONIKA WILKE

THE RESEARCHER

Prof. Dr. Urs Granacher studied sport science, German studies, and English literature at the University of Freiburg. He has been Professor of Training and Movement Science at the University of Potsdam since 2012.

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Photo: Fritze, Karla (top); Illustration: Tina Vlachy (Berlin), Monika Brose (Köln); Projekte & Spektakel GmbH/AOK Nordost (bottom)

POWDERED WITH *ASH* OR COVERED IN *ICE*

Volcanic Eruptions and Meltwater Lakes

Photo: Korup, Prof. Dr. Oliver

Ash and ice are phenomena that the researchers around Prof. Dr. Oliver Korup and his Natural Hazards working group are equally fascinated by. Accordingly, they study volcanic eruptions in Chile and glaciers in the Himalayas. And their research has produced some surprising results.

Following the eruptions of two volcanoes in the south of Chile ten years ago, trees in the surrounding rain forests were covered by thick layers of ash. Years later, when hillslopes around the volcanoes began to slip, Korup and his team decided to take a closer look. For the first time, the geographers systematically accounted for these significantly delayed natural hazards caused by volcanic activity. The slopes in the volcanoes' vicinity were covered in such thick layers of ash that the trees had died. "We assume they have suffocated. The roots are rotting, and hundreds of tree skeletons with neither leaves nor branches dot the landscape," Korup says. Over time, with the roots dying, the soils are losing their stability. To those responsible for the safety of roads, infrastructure, and settlements in the area, this elusive natural hazard triggered by volcanic eruptions poses major challenges.

When a volcano erupts, the people living nearby have to leave the danger area as quickly as possible. Once the volcano has calmed down – often only after a few years – they are allowed to return. This is also what happened in Chaitén, a town some 10 kilometers from the volcano of the same name with a height of 1 122 meters. Its most recent eruptions took place between 2008 and 2009. Within just a couple of hours after the eruption had started in 2008, the first residents of the town and its surroundings were brought to safety. At first, it was not clear whether the area could even be made habitable again, because of the destruction caused by the mud flows. A few years later, initiatives formed to return former residents, which, of course, will take some time.

Volcanic ash devastates regions for many years

Most of the damage caused in the town and its surrounding areas was not due to the volcanic eruptions themselves, but the scattered ash. "The volcano ejects up to 1 cubic kilometer of ash into the atmosphere over several weeks to months, and the ash then forms thick layers in the range of centimeters or decimeters on the ground," Korup points out. These layers are washed away by rain, enter the river system, and bury entire forests, houses, and the infrastructure. For 10 years, the researchers have been monitoring developments in the field, particularly delayed mass flows and landslides. More recently, drones have also been used for comprehensive site measurements.

THE PROJECTS

Natural hazards in ecologically disturbed temperate rainforests in south Chile (coNIFER)

Duration: 2014–2016
Funding: Start-up support by the German Federal Ministry of Education and Research (BMBF)

Graduate School "NatRiskChange" (Natural Hazards and Risks in a Changing World)

Duration: 2015–2018
Funding: German Research Foundation (DFG)

Layers of ash ...

THE RESEARCHERS

Prof. Dr. Oliver Korup studied geography at the University of Würzburg and did his doctorate at Victoria University Wellington, New Zealand, in 2003. He has been Professor for Geohazards at the University of Potsdam since 2011.

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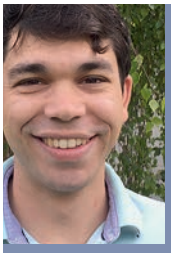


Georg Veh studied physical geography at the Catholic University of Eichstätt-Ingolstadt. Since 2015, he has been a PhD student at the Graduate School "NatRiskChange" (Natural Hazards and Risks in a Changing World) at the Institute for Environmental Sciences and Geography at the University of Potsdam.

✉ georgveh@uni-potsdam.de

The region is very well documented by satellite images, so the researchers are able to record and quantify damage to, and changes in, the vegetation – which has tended to play a secondary role in natural hazard management until now. "We find that the number of landslides has grown exponentially, especially where the layers of ash are thickest," Korup states.

... let trees die.

While a study on the eruption of Mount St. Helens in the southern part of the U.S. state of Washington in 1980 – one of the largest volcanic eruptions of the 20th century – is available, systematic research as performed by the Potsdam team who are documenting and analyzing the delayed consequences of volcanic eruptions is novel. To continue this research, Dr. Christian Mohr, who is a co-researcher in the project, has filed an application with the Emmy Noether Program of the German Research Foundation DFG. Using computer models, he intends to focus more on hydrological and mechanical aspects of the landslides around Chaitén.

Hazardous lakes at 5 000 meters

On the contrary, PhD candidate Georg Veh is interested in cold and ice. Glacial lake outbursts remain

Photos: Korup, Prof. Dr. Oliver (top, bottom right); privat (bottom left, 2)

a significant hazard, and have become the subject of particularly intense research recently. Veh is studying the natural hazards resulting from glaciers melting in the Himalayas, the highest mountain range in the world stretching across some 3 000 kilometers from Pakistan to Myanmar. When glaciers melt, lakes are forming. When they expand, moraines fed by glacier flows may collapse, as ice or debris break off and fall into the lakes, causing waves. Besides, landslides can also cause such outburst floods. As a result, a huge flood wave forms and rushes down the valley with a speed of several meters per second. In such events, people in the area have very little time to escape or protect themselves from the consequences of these natural hazards. Early warnings could be provided if there were only a few lakes to monitor – but there are around 5 000 lakes in the Himalayas, and new ones are forming each year. Measures for the protection of the population are difficult to implement as many of the lakes are located in remote areas. As glaciers are located at altitudes of between 4 000 and 5 000 meters, they are hard to reach, and the installation of an early warning system has been limited to few sites.

Using an automatic search algorithm that Georg Veh developed, he has analyzed more than 8 000 satellite images covering a period of 30 years. In this way, the researcher found that lakes shrink and disappear. “The pictures also tell us that broad sediment disturbances form below the lakes. They occur when water masses move down to the valley and deposit sediments there,” Veh explains.

More recent hypotheses have suggested that with the number of lakes increasing, the number of outbreaks will increase, too. Veh has been able to prove that this is not the case. “We searched the entire Himalayan arc for such outbreaks to find out how often glacial lake outbursts occurred. At least for the past three decades, there is no proof that the number or rate of outburst floods has been increasing,” Veh states.

Yet these findings should not be interpreted to mean that the hazard will remain unchanged. Some regions in the Himalayas are very seriously affected, others less so. The research done at Potsdam makes it very clear that, in times of climate change, precise and differentiated studies are crucial for reliable assessments of natural hazards.

DR. BARBARA ECKARDT
TRANSLATION: MONIKA WILKE

Photos: Korup, Prof. Dr. Oliver (4)

SEARCHING

Illustration: Topler, Andreas

FOR TRACES

NUTRITIONAL SCIENTISTS WANT TO FILL KNOWLEDGE GAPS ABOUT TRACE ELEMENTS

Iodine, zinc, iron, copper, selenium, and manganese are essential trace elements our body needs in tiny quantities. Yet basic knowledge about these micro nutrients is still scarce. In the DFG-funded research unit "TraceAge", researchers study complex interactions between trace elements as well as their role in the aging process and in diseases in older age.

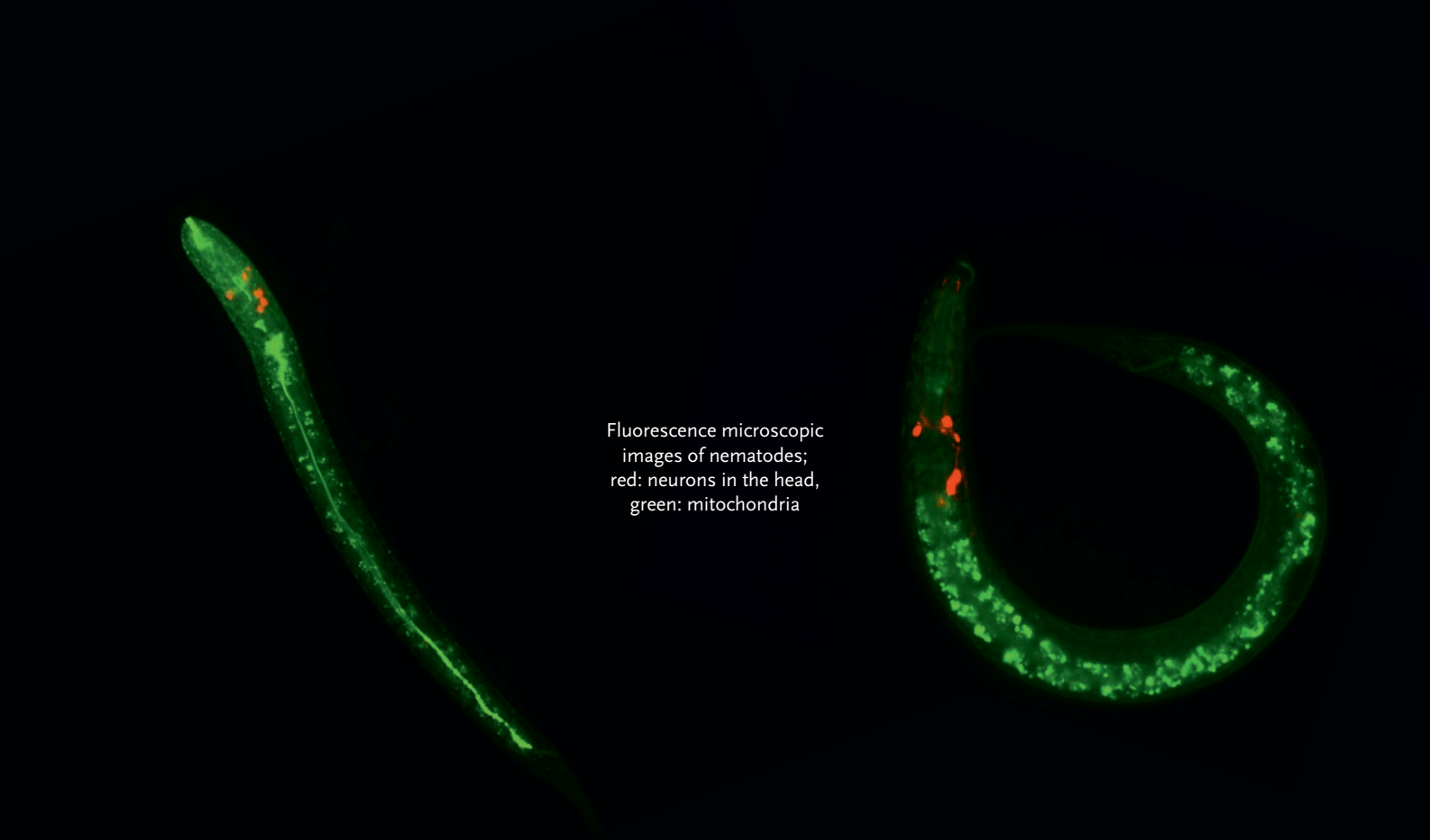
Lab worms live in the dark, but they don't mind. In their culture dishes in the incubator they have all they need: abundant bacteria to feed on, a pleasant temperature of 20 degrees centigrade, and many others of their own kind. The transparent nematode Caenorhabditis elegans is but 1 millimeter long. Originally a soil organism, it has been a common sight on agar plates in scientific laboratories all over the world since the 1960s.

Here, at the Institute of Human Nutrition, the worm is also well-known and used as a model organism. "It is very well-researched and easy to modify genetically," PhD student Jessica Baesler explains. Besides, nematodes are easy to keep, multiply rapidly, and are easy to examine. These properties make them a good choice for Baesler, too, who wants to find out how a specific diet affects the nematodes' development.

Consequences of under- and oversupply are little researched

The tests carried out by Baesler are part of the extensive study "TraceAge", in which 6 teams of 36 researchers from a variety of disciplines such as epidemiology, clinical medicine, toxicology, analytical chemistry, food chemistry, and nutritional physiology study the effects of certain substances in food on the health of elderly people. Their focus is on trace elements which the body needs only in very small quantities.

In "TraceAge", the researchers are looking at 6 of these micronutrients – selenium, iodine, copper, zinc, iron, and manganese – that are involved in the regulation of the immune system, the production of proteins, and the activation of hormones, for instance. "In order to be able to survive, humans have to take up trace elements," underlines Professor Tanja Schwerdtle who directs the study. But our knowledge of this is only a few decades old. Hence, research on the effects of micronutrients on health or aging is still in its infancy. "As yet, we know very little," Schwerdtle summarizes. But in general, the German population is comparatively well-supplied with trace elements, and acute deficiencies are rare.



Fluorescence microscopic images of nematodes; red: neurons in the head, green: mitochondria

THE RESEARCHER

Prof. Dr. Tanja Schwerdtle studied chemistry and food chemistry at the University of Karlsruhe. She has been Professor of Food Chemistry at the University of Potsdam since 2013.

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Some people – especially women – show mild symptoms of an iron-deficiency anemia. The researchers suspect an undersupply of selenium as well, since the soil in Germany is poor in selenium resulting in a low concentration of selenium in crops. "As for selenium, we don't know exactly what amount is really needed," Schwerdtle explains. An under- or oversupply might increase the risk of cardiovascular diseases, cancer, and diabetes. "It is a very sensitive issue, and only a few markers are known to indicate whether someone is sufficiently supplied," she says.

Better measuring methods and forecasts

The same applies to the other trace elements studied by "TraceAge". Above all, the researchers are interested in the interactions between micronutrients. "It doesn't make sense to look at them separately, since they interact," Schwerdtle explains. The researchers also want to develop more accurate ways of measuring trace elements and their effects. From the full picture of all parameters, a fingerprint of a person's health status will be created. For this purpose, so-called function markers have to be developed. These could be metabolic products, molecules, certain proteins, or hormones that can be found in blood serum and indicate how well the body is supplied with certain micronutrients. At the same time, these markers should allow for predictions of potential diseases resulting from under- or oversupply.

For the same purpose, Baesler puts nematodes under the microscope. They were put on a special diet to under- or oversupply them with one or several trace elements, and now their development is inspected: Do they produce more or fewer eggs? Do they wiggle

Photos: Schwerdtle, Prof. Dr. Tanja (top, 2); privat (bottom)

across the substrate as usual, or do they move differently? Do they show organ deformities or abnormalities? Baesler uses these parameters to understand whether the respective diet has been beneficial or detrimental to the worms.

Trace elements are associated with neurodegenerative disorders

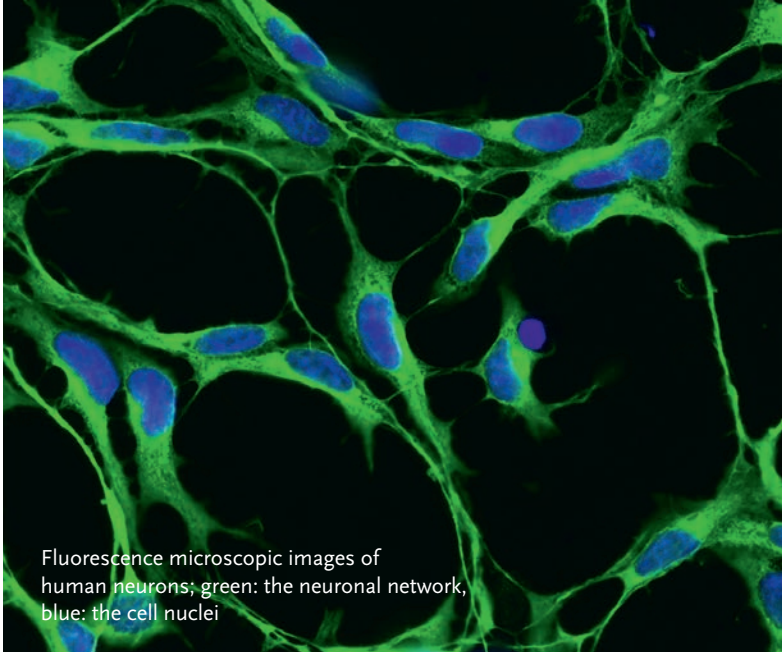
The way the nematodes move may also indicate whether their nervous system has been damaged. This aspect is particularly important in the research, as trace elements seem to be associated with neurodegenerative disorders such as Alzheimer's, Parkinson's, and Huntington's. The genome of some of the nematodes has been altered to make them more vulnerable to neuronal damage. If Baesler finds indications of, let's say, her "Alzheimer's nematodes" displaying more damage on certain diets, she may examine them once again at the molecular level using marked nerve cells of nematodes. In addition, she analyzes which genes are active, which proteins are formed, and in which cells and organs trace elements accumulate. Her results will provide insights into whether and how trace elements are associated with neurodegenerative disorders in humans, too.

The nematode model of the "TraceAge" researchers is just one of many levels at which the various questions are studied. The researchers also use cell cultures, mice, and the comprehensive data of the EPIC Potsdam study to get a holistic picture of how trace elements function. The wealth of data compiled in the EPIC long-term study – through which blood samples and data of thousands of test persons have been collected since the 1990s – has already produced some exciting results.

THE PROJECT

"TraceAge – Interactions of essential trace elements in healthy and diseased elderly" is an interdisciplinary research unit funded by the German Research Foundation (DFG). Spanning multiple disciplines, it investigates interactions of essential trace elements and their role in diseases and develops new measuring methods.

Participants: University of Potsdam, German Institute of Human Nutrition Potsdam Rehbrücke, Friedrich Schiller University Jena, Charité – Universitätsmedizin Berlin, Technical University Berlin
Duration: 2017–2019
www.uni-potsdam.de/traceage



Fluorescence microscopic images of human neurons; green: the neuronal network, blue: the cell nuclei

Photo: Schwerdtle, Prof. Dr. Tanja

With advancing age, the uptake of trace elements changes

Analyses of the serum of test subjects who had blood samples taken every 20 years confirm a hypothesis nutritional researchers have had for some time: With age, copper concentrations in serum increase, while zinc concentrations drop. Dietary changes in older age could have provided an explanation for this phenomenon. However, the "TraceAge" researchers were able to demonstrate in an experiment with mice that the zinc and copper concentrations in older mice changed even though they were on the same diet as younger mice. Tanja Schwerdtle suspects that, among other things, "physiological processes in the intestine change with age, making zinc absorption more difficult". This has consequences not only for the immune system, but also for aging processes, as many zinc-activated enzymes are involved in the repair of DNA damage.

While the researchers are still in the midst of their work, they are already planning the next major studies as the research area of trace elements is largely unexplored. Aside from neurodegenerative disorders, the spotlight will be on bone health. The analysis of measurements needs to be optimized and refined, and imaging techniques will be used to determine the brain regions or organs where trace elements accumulate. In addition to that, other age groups and the effects of micronutrients during pregnancy will be studied. Besides, the interactions between trace elements and vitamins have largely not been researched, either.

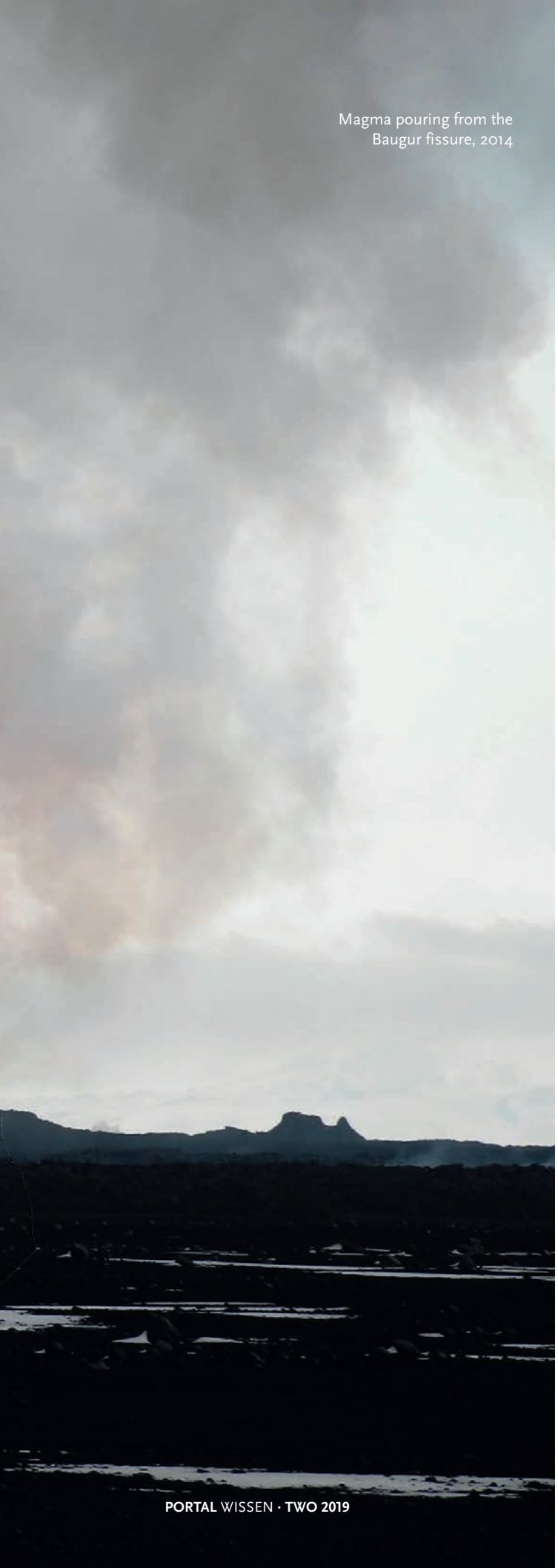
So there is still a lot of work to do for researchers and nematodes alike. The nematodes will probably take it easy: If food runs out in their incubator, they will turn stiff and survive hunger periods of up to three months as long-time larvae. Once food becomes available again, they will wake up and continue to grow.

HEIKE KAMPE
TRANSLATION: MONIKA WILKE

Iceland's Boiling Ground

HOW TO PREDICT VOLCANIC ERUPTIONS EARLIER

Photo: Eth. Prof. Dr. Eva



Magma pouring from the Baugur fissure, 2014

In August 2014, all of a sudden the earth in Iceland shook more often and more intensely than usual. The Icelandic Meteorological Office, which localizes and monitors all earthquakes and volcanic activity in real time, was immediately alarmed. Over a period of two weeks, the earthquakes moved from the glacier-covered Bárðarbunga volcano towards the Holuhraun plain. A volcanic eruption in the center of the country was imminent. On 29 August, the first lava fountains erupted from a fissure that was 2 kilometers long. The magma continued to flow for six months and formed a huge lava field spanning 85 square kilometers, an area the size of Manhattan. It was the strongest eruption in Iceland in 200 years. Throughout, the earth kept shaking. Volcanologist Eva Eibl, Assistant Professor of General Geophysics, was in the field and recorded the vibrations.

Iceland is known for its intense volcanic activity. Slowly the island is breaking apart as the Eurasian and North American Plates are drifting apart. This drift is forming a mid-ocean ridge that stretches around the globe. For the most part, it runs 2 kilometers below the surface of the sea. But due to a hotspot, Iceland juts out from the water. Consequently, the eruptions along the ridge are visible to the naked eye, and often in populated areas, too. Currently, there are 32 active volcanic systems in Iceland. Each one consists of a central volcano and a fissure system that may stretch over hundreds of kilometers northeast and southwest as the plates drift apart. Lava may erupt from both the central volcano and the fissure system. The Holuhraun plain is part of such a system with neighboring Bárðarbunga as its central volcano. “In the case of Holuhraun, the magma probably leaked out from a chamber below Bárðarbunga, and first moved laterally before reaching the surface,” Eibl explains.

The volcano below the ice

For two weeks, the earthquakes moved at a depth of 5 to 8 kilometers more than 50 kilometers north, while the ground was rising up. The vibrations were significantly more frequent than usual and reached up to a magnitude of 5. “For Iceland, these were very strong earthquakes,” Eibl says. It was evident that magma was moving and would likely surface. The situation was quite dangerous as the magma was mostly moving below a layer of ice. If it surfaced and got in contact with the ice, an eruption with an ash cloud could follow – as was the case with the Eyjafjallajökull eruption in 2010. The consequences would have been disastrous. After all, the Eyjafjallajökulls eruption lasted only a couple of weeks and produced earthquakes up to a magnitude of 2, whereas the significantly stronger Holuhraun eruption lasted for no less than

THE RESEARCHER

Prof. Dr. Eva Eibl studied geosciences and geophysics at LMU and TU Munich and earned her doctorate in volcanic seismology at the University College Dublin in Ireland. She has been Assistant Professor of General Geophysics at the University of Potsdam since September 2018.

✉ eva.eibl@uni-potsdam.de

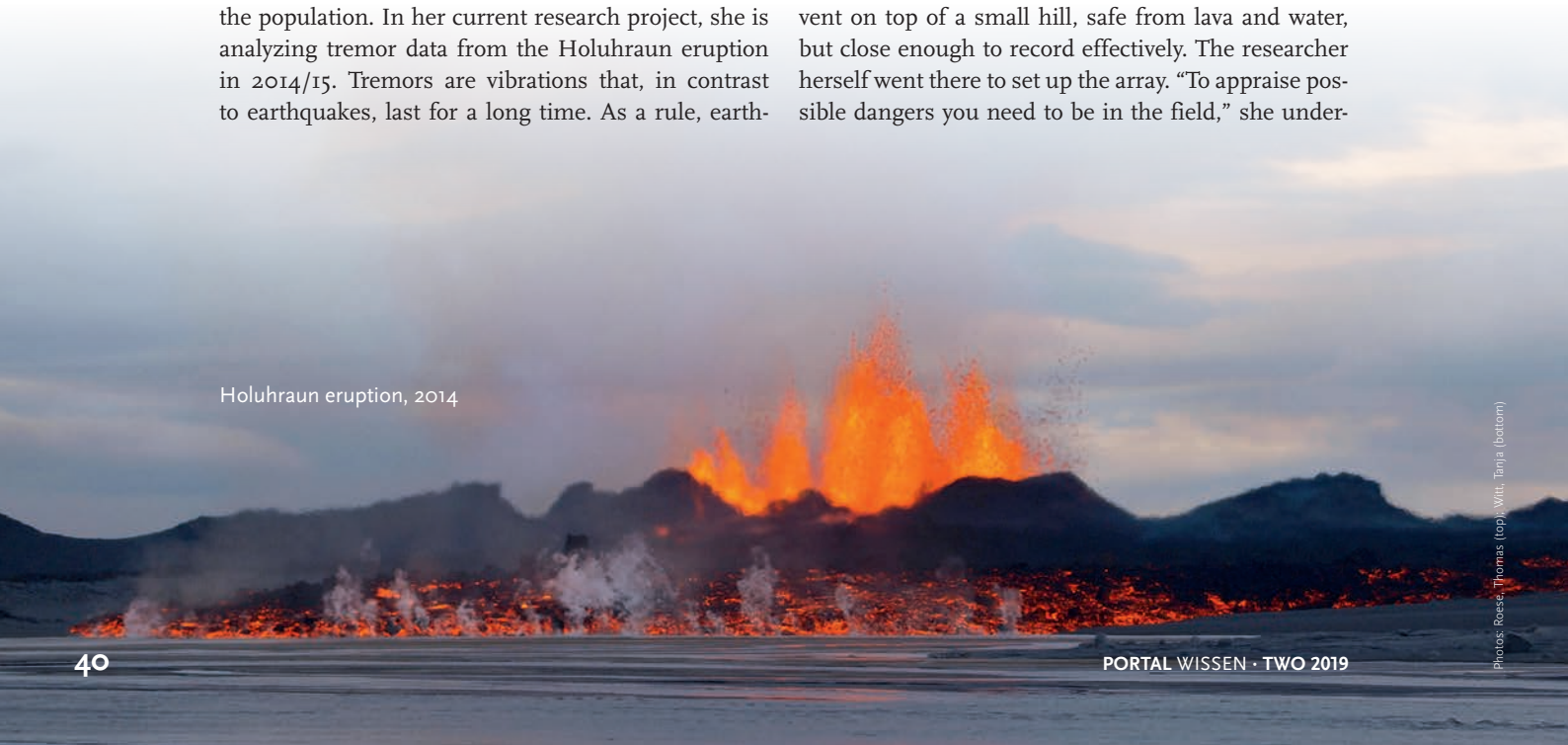
6 months. Fortunately, the magma surfaced some 10 kilometers north of the ice cover. On 29 August 2014 around midnight, lava erupted from the ground. The nocturnal spectacle continued until 4 o'clock in the morning. Some 24 hours later, the same 2 km long fissure opened up again. Within a few days, lava poured out of only 3 vents: one at the northern end, one at the southern end, and one in the middle of the fissure. The magma from the middle one, spontaneously named Baugur by Icelanders, lasted the longest und formed a huge lava field. The eruption produced eight times more lava than the eruption of Eyjafjallajökull had. Since the region is uninhabited, there were no human casualties. But toxic gases escaped and traveled as far as Sweden.

Volcano seismologist Eibl takes an interest in earthquakes occurring before and during an eruption. Her research examines where they happen and what they are caused by so as to facilitate better early warning. "When you consider how many people live near volcanoes these days, it is crucial that they can be warned as early as possible," Eibl says. In the event of a volcanic eruption, every hour counts for a timely evacuation of the population. In her current research project, she is analyzing tremor data from the Holuhraun eruption in 2014/15. Tremors are vibrations that, in contrast to earthquakes, last for a long time. As a rule, earthquakes are quite short and display a characteristic sequence of seismic waves travelling either through the earth or along its surface. There is a precise sequence of certain types of waves which is also used to localize earthquakes. By contrast, a tremor is a continuous signal which may last for months, as happened during the Holuhraun eruption. "For a tremor, there is no precise arrival time of waves, and the start is difficult to determine, which also makes it more difficult to localize than an earthquake," Eibl explains. While earthquakes – due to their high frequencies – can be both felt and heard, tremors go unnoticed.

The trembling of the volcano

Because tremor signals are so complex, volcanologists often disregard them and focus on earthquakes which are easier to analyze. But Eibl faces the challenge and wants to find out more about the origin of tremors. To this end, she analyzes tremors that occurred in Holuhraun at a depth of up to 2 kilometers. "The closer we get to the surface, more and smaller earthquakes occur, that we cannot tell apart. We think that the tremor consists of such earthquakes," Eibl says. She believes that tremor occurs not only during an eruption, but also prior to it, so she hopes they could be used as early warning signals. Since February 2019, she has been exploring, together with a team of researchers from Cambridge who also performed measurements in Holuhraun, whether tremor occurred before the eruption. Some results suggest that this could be the case. While there were still earthquakes after the eruption, the tremor ended when the magma flow stopped.

Eibl analyzed data from an array of 7 seismometers installed 300 to 1 000 meters apart from each other. The array was located 15 kilometers from the volcanic vent on top of a small hill, safe from lava and water, but close enough to record effectively. The researcher herself went there to set up the array. "To appraise possible dangers you need to be in the field," she under-



Holuhraun eruption, 2014

Photos: Roese, Thomas (top); Witt, Tanja (bottom)

Eva Eibl in the field ...

... and in front of the Baugur fissure, 2014

lines. A number of measuring devices were installed just a few meters from the fissure. "Some teams measured the escaping gases to be able to say whether or not too many toxic gases had entered the air – which would have meant evacuating the northeast of Iceland," Eibl says. Other teams drove around the lava field using GPS to measure and calculate its size and in which direction it was expanding. The whole time, there was the danger of an eruption below the ice cover triggering a flood wave that could have run over the researchers. Such flood waves or additional eruptions below the ice would have been indicated by tremors. However, with the conventional methods at the time of the eruption, it was impossible to determine the exact location of the tremor – an important piece of information that would have been essential to predict a flood wave.

Gaining a better understanding of volcanic activity

In the end, Eibl succeeded in locating the place of origin of the tremor by using a new method of interpreting her measuring results – it had originated below the ice; an important step forward for early detection of volcanic tremor. Due to the huge number of volcanic systems in Iceland, it is often not clear where and when the next tremor may occur. Therefore, Eibl is planning to test her method in a different place later this year. On the island of La Réunion, east of Madagascar, there is a volcano which erupts three or four times a year, providing ideal conditions to detect and record tremor data.

But Eibl does not want to say goodbye to Iceland yet. "Volcanoes in Iceland are still poorly understood since there are so many volcanoes and, by comparison, so few seismometers in the field," Eibl says. For instance, it is not known yet where or at what depth the magma chambers are and what their size is. And why the interval between volcanic eruptions changes, as in the case of the Hekla volcano, is not known either. So there is ample room for Eibl to find out more about the boiling ground of Iceland and volcanoes in all parts of the world.

CAROLIN KRAFZIK

TRANSLATION: MONIKA WILKE

Photos: Braiden, A. (top left); Eibl, Prof. Dr. Eva (top right)

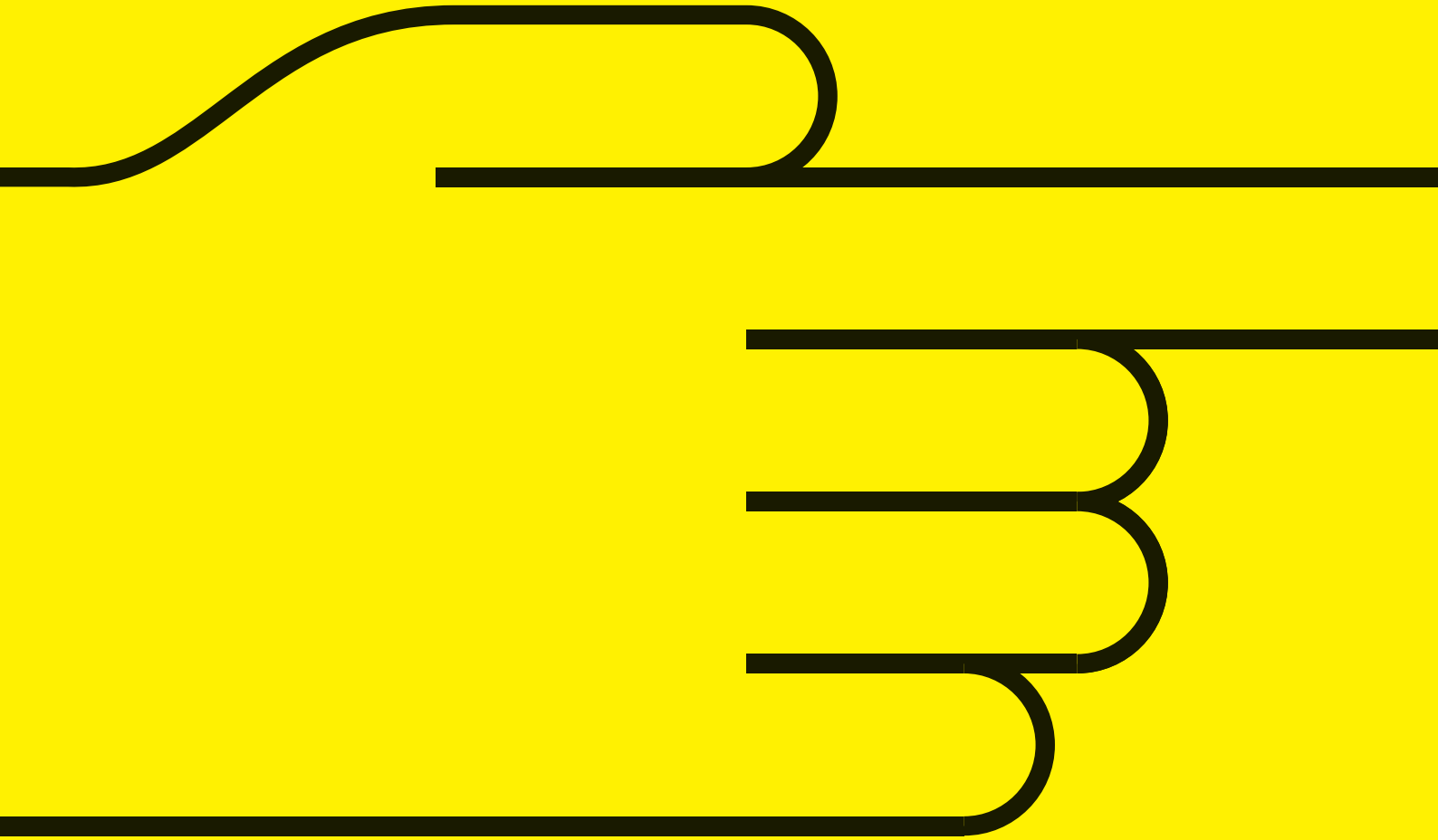


Illustration: Töpfer, Andreas

TACTILE WEB BROWSING

COMPUTER SCIENTISTS MAKE ONLINE SERVICES MORE ACCESSIBLE FOR THE BLIND

Quickly check your email, look up the weather forecast, or get the latest news in the morning – many people use web services daily to stay informed or communicate with others. The blind or visually impaired, however, face enormous challenges if they want to do the same. And the currently existing assistive devices are often impractical and expensive. Computer scientists are working to develop new instruments to make online services more accessible for the blind.

The male computer voice sounds robotic and monotonous. At a maddening speed, it reads out one word after the other with just a few short breaks in between. A torrent of words descends onto the user. Less experienced listeners will hardly be able to filter out the information they need.

A flood of information without navigation

But the blind and visually impaired depend on such text-to-voice programs for using the internet. A screen reader software reads out everything on the screen – text as well as structural information such as lists, input windows, logos, or links. While sighted people are able to identify all important information and structures at a glance and ignore the rest, the blind have to work their way through everything using their sense of hearing. "It is an almost endless torrent of information, without period or comma," says professor of computer science Ulrike Lucke. Navigation aids such as spacing or font sizes are nonexistent. "We follow optical patterns. Blind people can't," Lucke explains. In addition, screen readers are unable to interpret pictures, diagrams, drawings, or videos. Thus, even just logging into one's email account may turn into a bumpy ride, as the landing pages of major providers usually contain a lot of advertisements and entertainment.

Apart from the screen reader, there is another way for the blind to navigate the internet: by using their sense of touch. Special devices are connected to the user's computer or laptop and translate web content into braille. Tiny, electronically controlled pins move up and down on a refreshable braille display. Each braille letter consists of a pattern of dots, and to enable users to read them correctly with their fingertips, they require a certain size. So this technology has its limits, too. "It's like looking at the internet through a keyhole," Lucke says. Users of a braille display also have to work their way through a webpage from one section to the next.

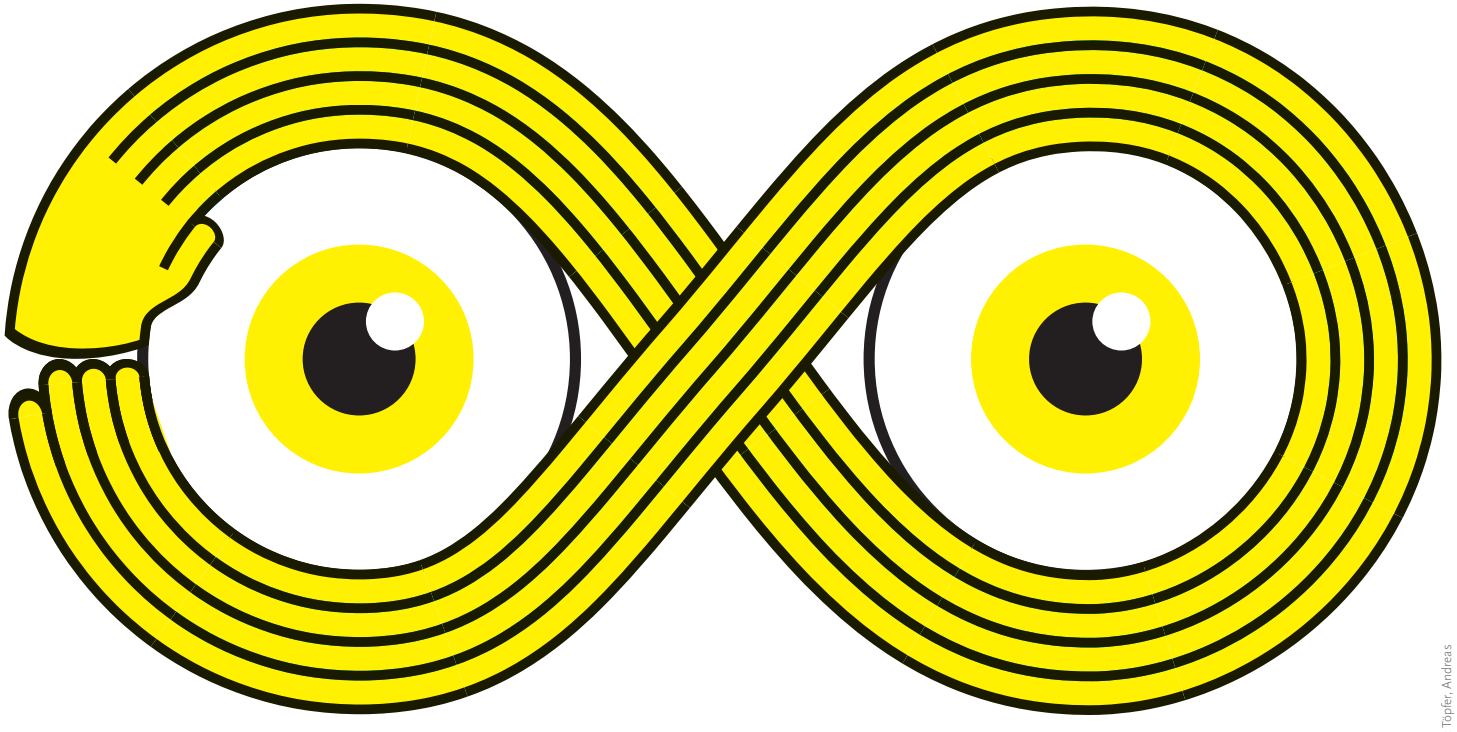


Illustration: Töpfer, Andreas

Prof. Ulrike Lucke

Using AI for orientation

Lucke and her team are striving to give blind people better tools for browsing the internet. To that end, the researchers first explored what web services were used most often. They found that music streaming, shopping, online banking, email, and social networks, as well as map services, and dating platforms were most frequently used. In total, the team is examining 40 groups of applications for blind users. First, they analyze the various functions of the sites and the controls that need to be found easily and quickly to make the service usable for the blind. Machine learning is used to identify such relevant fragments on the user interface.

THE PROJECT

In the project **"TactileWeb"**, researchers are developing software for a tactile braille display to give blind and visually impaired users faster and easier access to web services.

Duration: 2018–2019
Funding: Federal Ministry for Economic Affairs and Energy (BMWi)
Participants: University of Potsdam and metec AG Stuttgart

Next, a machine algorithm is repeatedly confronted with common websites and trained a thousand times with the information displayed there. Gradually, the AI develops a reliable program for the quick and systematic detection of certain elements like the login mask. "This is where we are now," explains Lucke. The enormous variety of information poses immense challenges for the researchers: "The internet is a huge haystack," says Lucke. And the important interfaces and controls are sometimes well hidden within.

The objective, in the end, is to enable the blind to navigate the internet faster and more systematically with the help of the developed software. At the same time, the computer scientists adapt the program to a hardware that can present much more information than a line of braille letters. The centerpiece of the project is a somewhat clunky device resembling a keyboard that needs to be connected to a computer. Instead of al-

Photos: Kaczynski, Ernst (2)

phabetic keys, the HyperBraille output device made by metec AG has many little pins on its surface.

As the pins move up and down, braille letters can be formed and read. The size of the tactile display allows the blind to read even graphs or diagrams with their fingers.

Eventually, the software developed by the Potsdam computer scientists and connected to the HyperBraille will connect via the web with AI every time a user connects to an online service. The AI will analyze and translate the website and leave out anything unimportant. Then, the actually relevant information will be played back and shown on the HyperBraille display.

More job opportunities for the blind

Devices like the HyperBraille make a real difference in the everyday and working lives of the blind – but unfortunately, they are also very expensive. "The current price is in the 5-digit range," Lucke explains. At universities and schools for the blind and visually impaired, such devices are already available, but in private homes, they are the exception. Yet the researchers are convinced that the demand will increase in line with expanded options for use and that prices will drop. "When a blind person is able to work with spreadsheets, read diagrams, or format text, this will result in better job opportunities," Lucke underlines.

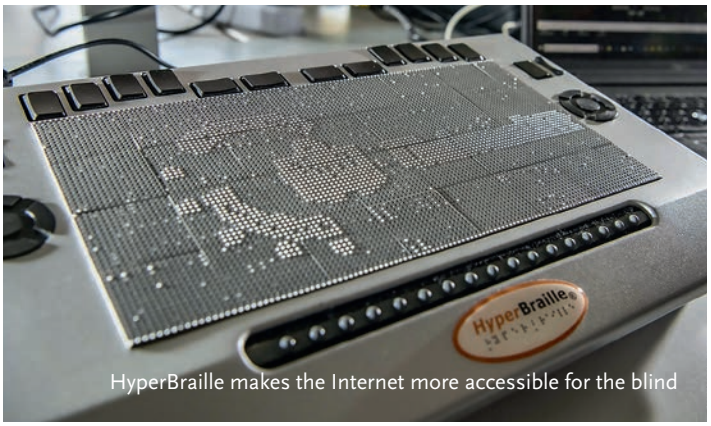
The prototype of the new system is supposed to be operational by the end of the year. Then, industrial partner metec AG from Stuttgart will take over and develop it into a marketable product. Lucke hopes that it will be as popular with users as another program developed by her team recently. This allows the blind to explore maps on the internet – also based on a tactile braille display. The desired route is traced by moving pins. "It was very touching to see the first blind person testing the map," Lucke remembers. "For the first time, she was able to put together a travel itinerary for herself on the internet without any help."

HEIKE KAMPE

TRANSLATION: MONIKA WILKE

THE RESEARCHER

Prof. Dr. Ulrike Lucke studied computer science at the University of Rostock. She has been Professor of Complex Multimedia Application Architectures at the University of Potsdam since 2010.



HyperBraille makes the Internet more accessible for the blind

Photos: Kaczynski, Ernst (3)

For our page SKETCHED, we asked graphic designer and illustrator Andreas Töpfer to interpret one of the research topics graphically. For this issue, he illustrated the concept of a "tactile internet", in other words, the technical implementation of a web browsing interface for visually impaired people. He also created the illustrations for the cover page and on the pages 4, 8, 14, 22, 30 and 31.

Illustration: Töpfer, Andreas

AWI sea ice researchers in front of the “Polarstern”

Through **Night and Ice**

Expedition to the “Epicenter” of Global Warming

Photo: Hendricks, Stefan

THE PROJECT

MOSAiC – Multidisciplinary drifting Observatory for the Study of Arctic Climate is an Arctic expedition with the German research icebreaker "Polarstern". A total of 600 people from 17 countries will participate in this expedition. Many more researchers are going to work on the collected data to raise climate and eco systems research to a new level. MOSAiC led by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).

Duration: September 2019 – October 2020

Shipwrecks, washed ashore on coasts of Greenland, once put the polar explorer Fridtjof Nansen on the right track: the remains of the navel exploration vessel "Jeannette", which had been crushed by pack ice and then sunk in 1881 north of the New Siberian Islands, could only have come so far west on a single route – with the ice drift. Would it be possible to take the same route by boat, passing the hitherto unreached North Pole?

Nansen's expedition is legendary. In 1893, he froze his research vessel "Fram", especially designed for this expedition, and drifted with his crew through night and ice. Although he just missed his dream goal, he was able to prove the existence of the transpolar drift ice current with his venturous journey.

Now, almost 130 years later, an international research team spearheaded by the Alfred Wegener Institute for Polar and Marine Research (AWI) ventures to relaunch the experiment with the MOSAiC Expedition, albeit in much larger dimensions. Starting in autumn, the German research icebreaker "Polarstern" will be frozen and then drift through the Arctic Ocean. Researchers from 17 nations will overwinter, temporarily north of the 87th latitude, in a region that is usually unreachable during the polar night. They will set up their research camp on an ice floe and surround it with a kilometer-wide network of measuring stations, thus being able for the first time to collect complete data in the ocean, ice, biosphere, and atmosphere. "Measurements that we urgently need if we want to better understand the influence of the Arctic on the global climate," says Markus Rex, who is Head of the Atmospheric Physics Section at the AWI and Full Professor for Atmospheric Physics at the University of Potsdam. He is leading and coordinating the international collaboration for this extraordinary expedition, which is associated with unprecedented challenges. After all, the team needs to be supplied by icebreakers and airplanes throughout the year.

The Central Arctic is considered the "epicenter" of climate change. Nowhere else does the atmosphere warm up as fast as in the far north, which in turn decisively influences the weather in our regions. Researchers are not yet able to say precisely how the rising temperatures and the melting ice will actually change the climate. The existing models vary between a 5 and 15-degrees higher temperature in the Arctic by the end of the century and between ongoing ice coverage and total loss of ice. "That is, if we do not achieve a very massive and rapid reduction in global greenhouse gas emissions," Rex sums up the problem. In order to collect the missing data and to be able to forecast more accurately, he and his colleagues from 60 institutes from all over the world will take on the hardships of overwintering in the cold and the dark.

Fridtjof Nansen's ship "Fram", 1894

Research icebreaker "Polarstern"

Photos: gemeinfrei (left); Mehrtens, Folke (right)

The "Polarstern" in the Weddell Sea

Filling the gap in the data network of climate research

As the "Fram" once offered shelter and living space to Nansen and his small crew, the "Polarstern" will carry the 100 scientists and crew members of the MOSAiC expedition safely through the ice. Filled to the brim with state-of-the-art technology, the ship will not only offer living quarters but also a laboratory connected to numerous outposts on the ice. A tethered balloon, deployed at a height of 1.5 kilometers, will permanently collect meteorological data. Balloon probes will rise into the atmosphere every day. In the opposite direction, drilling will provide information on the composition, thickness, deformation, and melting behavior of the ice. What happens when air heats up over cracks in the ice on the ocean and shoots far into the atmosphere? For Rex this is only one of many open research questions. The properties of Arctic clouds are still poorly understood. When do they cool or warm? How dense are the droplets, how high is the amount of ice crystals? And what are the effects of soot and suspended particles, the aerosols? In order to shed some light on these and other questions, the international research team will use everything it has to offer in terms of measuring instruments: It will use radar, laser, and microwave technology to fill the gap in the data network of climate research that spans the Central Arctic. Thanks to a runway built on the ice and fuel

Aurora borealis in the night sky above the "Polarstern"

Photos: Hendricks, Stefan (2)

tanks, even planes will be able to ascend to traverse the region at the North Pole during the winter months.

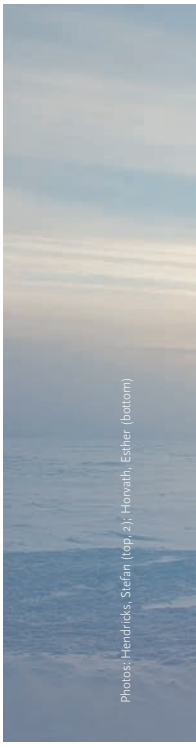
Although Fridtjof Nansen did not even remotely have such resources, he was the first to survey meteorological and oceanographic data in the high northern latitudes. He observed a wildlife that surpassed anything that was expected in this hostile environment. It therefore comes as no surprise that biologists will also be aboard the MOSAiC expedition to explore the animals and microorganisms under the ice. "Where ice breaks in the spring, life explodes and everything becomes green," knows Rex from previous trips. "But what do krill and plankton do in winter? How do they survive the complete darkness of the long polar night under the ice cover?" During the drift, the sun will not rise over the horizon for 150 days – time for the biologists to look below the ice surface and to find answers.

Germany joins the leading rank of big historical polar expeditions

While the crew of the "Fram" got rid of the monotony of the dark days with board games, music, and books,

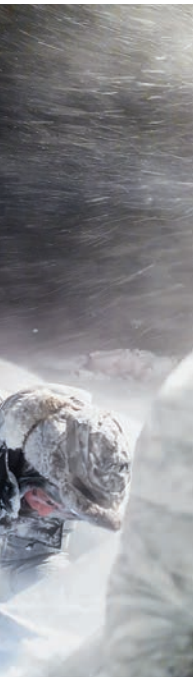
Experiments in the Arctic

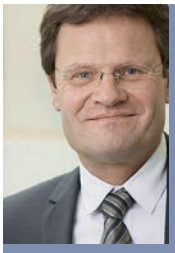
Collecting snow samples in the Arctic



Photos: Hendricks, Stefan (top, 2); Horvath, Esther (bottom)

intensive scientific activity will prevail on the "Polarstern". As an expedition leader, Rex coordinates the individual experiments and distributes the jobs on the ice around the ship. "It's like property management. We have to decide exactly who can sample how much ice, so that the floe will still have untouched areas for our research at the end of the year and not everything will have been perforated before," says Rex, who already managed several major international projects. MOSAiC, however, surpasses anything previously done. "I am aware of this all the time," says Rex with respect. His predecessor at the AWI, the atmospheric researcher Klaus Dethloff, had the idea for the expedition. It took years, however, to convince partners throughout the world, write applications, raise funds, and to pass rounds of evaluation. The expedition budget is over 140 million euros. It is funded by the participating partner nations but above all by the Helmholtz Association, and, i.e. more than 50 percent come from the Federal Ministry of Education and Research (BMBF). "That's a statement," says Rex. With MOSAiC, Germany is taking a leading position and steps from the second into the first rank of the major historical polar expeditions. (But) Rex is looking forward to working with all the partners without whom such a project cannot be managed. He sees the joint effort as a contribution to international understanding. "Of course, I will ensure a good atmosphere on board," he says with great anticipation, which increases, together with the tension, every day.





THE RESEARCHER

Prof. Dr. Markus Rex is Head of Atmospheric Physics Section at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) in Potsdam. At the Faculty of Science of the University of Potsdam, he is Full Professor for Atmospheric Physics.

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Launching a tethered helium-filled balloon

Photos: Pauls, Jan (topp); Horvath, Esther (bottom left); Schoen, Stephan (bottom right)

For half a year no icebreaker can reach the "Polarstern"

On the 20th September at 8 pm the time will have come. The "Polarstern" will then be seen off in Norway with a big farewell ceremony and leave the port of Tromsø for the Central Arctic. Before the polar night begins, the researchers must have found a suitable, at least 1.5-meter-thick floe on which they can build their research camp – a place with tents, paths, and lines – like a small town – which will be protected by six polar bear guards. "We have a sophisticated system and will withdraw to the ship when spotting a bear," Rex assures.

In total, the "Polarstern" will travel 390 days and cover 2,500 kilometers. During the ice drift, it is an average of seven kilometers per day. Icebreakers from Russia, China, and Sweden will call at the floe in the first and last months of the expedition to supply it with fuel and exchange staff. In between, the ice is so thick for about half a year that no icebreaker can reach the "Polarstern". The crew will change five times during the year. Six times new researchers will come on board before the ship returns to its home port in fall 2020 – loaded with data that will bring a long-lasting change tour understanding of the Arctic.

ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

Snapshots of Ice-cold Proteins*

Prof. Petra Wendler, Institute of Biochemistry and Biology

MONDAY:

We are freezing a protein complex to prepare it for cryo-electron microscopy. The complex controls the conversion of formic acid into CO_2 in bacterial cells. Maybe we will be able to change the complex in such a way that the reaction is reversed and fixes CO_2. Initially however, we have to understand how the different proteins work together in the complex. We need their three-dimensional structure. If you don't know what a protein machine looks like, it is hard to understand or change it. The frozen protein complexes are introduced into a ceiling-high electron microscope. If the sample looks okay, we will record images for the next four days, day and night, until we will have collected a data set of about one million images.

TUESDAY:

The microscope automatically collects lots of images and I can turn to the lab work. We have problems isolating a protein complex that is important for the catabolization of cytotoxins. Its structure is also still unknown. Mutations in this complex result in children dying within the first years of life. It is a rare disease and the pharmaceutical industry is not investing in research on it. If we know what effect the mutations have on the three-dimensional structure, we could develop drugs that counteract such mutations. After optimizing the purification process, we finally cleaned both proteins of the complex, but they do not interact. We will have no other choice but to laboriously test many different conditions to optimize complex formation.

WEDNESDAY:

The first images produced by the microscope are being copied to our server and we start evaluating them. To obtain a three-dimensional structure from the electron micrographs, we have to accurately determine for each of the one million images from which angle the complex was taken in the microscope. Fortunately, there are helpful computer programs. With several terabytes per data set, it is nevertheless important not to lose track. Our server with four of the most advanced and largest graphics cards available will be calculating for several weeks before we will know the atomic structure of the protein complex.

THURSDAY:

I received the peer reviews for the publication I'm writing together with a colleague from Toronto. There is not much to change, but I will have to rework some of the images. If I am able to manage this in the morning, I can continue working on the application for the German Research Foundation in the afternoon. Together with a colleague from Cologne, I want to apply for funds for a new project. At 5 pm, I am on my way to a lecture in Berlin at the Cluster of Excellence Unisyscat. Without inspiration from the outside, you would stew in your own juice.

FRIDAY:

We're back at the microscope. We finish collecting data and transfer all remaining images to our server. In the meantime, we have found two conditions under which the proteins isolated on Tuesday could form a complex. We are checking it quickly on a smaller electron microscope. The pictures do not look good. Instead of complexes, we only see a disordered accumulation of proteins. We have to keep on looking ... Happy Friday!

TRANSLATION:
SUSANNE VOIGT

* A typical week of my daily research routine. It is fictitious because it does not include any administrative and teaching activities.

Photos: Hopfgarten, Tobias (2)

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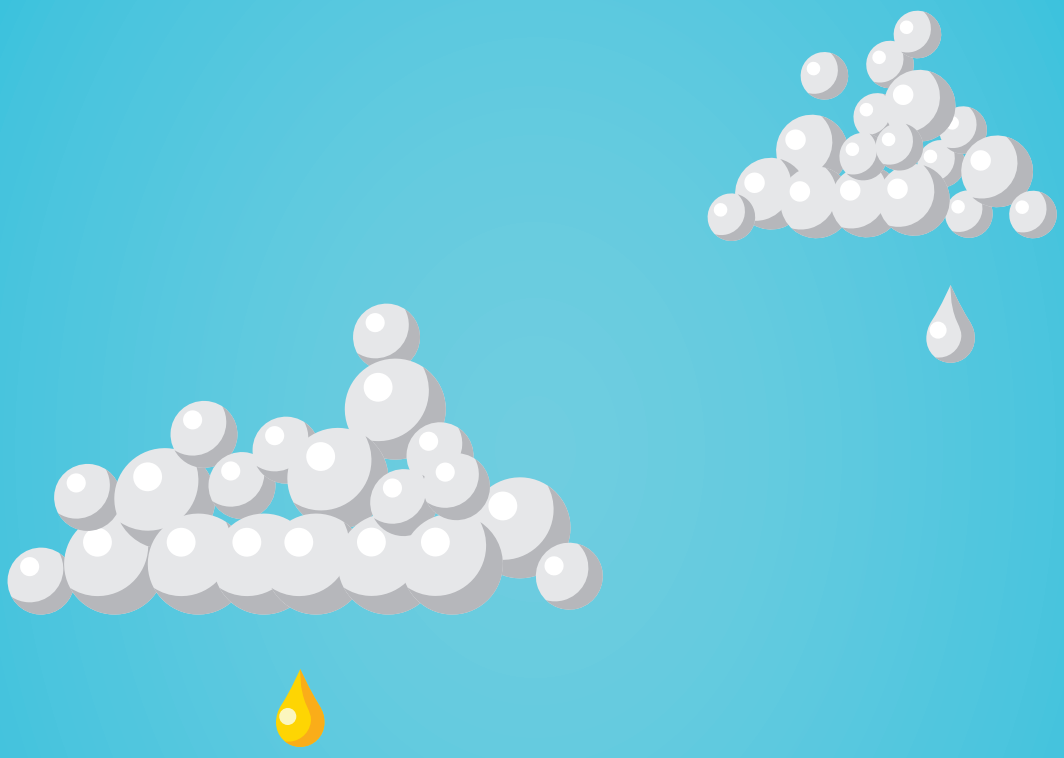

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