in2science

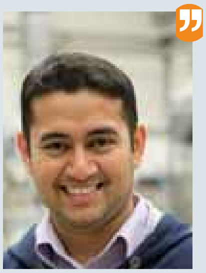
The Magazine About People with Ideas

#7

The Hall of the Multi-Talented • Research in the Arctic
Iron Catchers in Action • The Beamline Scientist •
Magnesium – The Raw Material for Ideas

Helmholtz-Zentrum
Geesthacht
Centre for Materials and Coastal Research

We asked HZG scientists:
What are your hopes in your research field for 2019?



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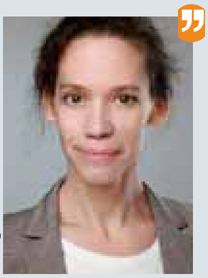
Dr Mushfequr Rahman
(Institute of Polymer Research)

My research is focussed on investigating the structure-property relationship of polymeric membranes for gas separation and water treatment. It is important to understand the impact of the chemical and morphological characteristics of the membranes on mass transport phenomenon and the separation mechanism. Such fundamental knowledge enables us to unlock the doors to design new membranes with high separation efficiency. In the coming years, I would like to explore different strategies to fabricate nanofiltration membranes for potable water and waste water treatment. I want to contribute to the enrichment of fundamental knowledge regarding the separation mechanism of the membranes, which is indispensable to reduce the energy demand of the currently used membrane-based water treatment processes. It is my utmost wish to secure funding for this project by obtaining a research grant in 2019.



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Dr Tanja Blome
(Climate Service Center Germany)

2018 was a year in which climate change perception and interest in the issue clearly increased. The hot summer and the pronounced drought in Germany as well as numerous other extreme global events have sensitised people to weather and climate. The publication of the IPCC Special Report on 1.5°C global warming has made clear how vital it is that greenhouse emissions be rapidly lowered on a massive scale. The report deals, for example, with different scenarios that would lead societies to a world that is 1.5°C warmer: which economic and technological routes must be taken to prevent us from crossing this warming threshold? I hope that linking various fields of knowledge as well as transferring this knowledge into political decisions and practical application in 2019 will improve even more so that the challenges concerning climate protection and adaptation can be addressed.

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Dr Götz Flöser
(Institute of Coastal Research)

What I hope for in my own research field is that, in collaboration with my colleagues in biogeochemistry and hydrodynamics, we can resolve the issues concerning size, temporal evolution and composition of suspended matter in the Wadden Sea and the German Bight. In order to do so, I have a large data set from various measurement equipment that I want to analyse and understand, and we also have the opportunity to address open questions through targeted field experiments. For coastal research as a whole, I hope that with our incredible potential we will be able to undertake a suitable topic (e.g., what impact do wind farms have on the North Sea?) and find a solution by utilising a combination of measurements, modelling, biogeochemistry, hydrodynamics and remote sensing. This would have the internal effect of strengthening departmental collaboration and demonstrating externally what we can do, namely tackling considerable challenges and providing solutions.

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Claudia Richert
(Institute of Materials Research)

My dissertation is concerned with the mechanical properties of nanoporous gold. In my work, I use for example tomography data to create computer models. Using these simplified and rapidly calculating simulation models, I would like to determine what influence the structure imposes on the mechanical properties of the nanoporous gold. I find application of machine learning here totally exciting.

I prepare example data sets that I subsequently feed into an artificial neural network. This network recognizes links in the data and can apply what is learned at any time to other, new data sets.

I look forward to further researching these links and hope the research is pushed forward using this new method. This can give rise to entirely new approaches for the connection of experimental and theoretical knowledge.

Dear Readers,

"Are you indifferent to climate change? Same goes for him." This is what it reads on a Hamburg electricity company poster, depicting the St Michael's church tower sinking. For us and for many colleagues at the HZG, climate change doesn't leave us cold. Quite the contrary. Researchers at the Climate Service Center Germany have spent many of their working hours on a report for the Intergovernmenal Panel on Climate Change. GERICS director, Prof Daniela Jacob, was one of the lead authors of the Special Report on Global Warming of 1.5°C.

This publication shows that the Earth's warming can be limited to 1.5°C compared to the preindustrial period. The knowledge and technology to achieve this target are present within societies. Now it's up to political willingness to halt global warming. You'll discover more in the magazine about how the IPPC report came to life and about the encouraging results.

Conserving resources using new technology: colleagues from the Solid State Joining Processes Department show you how this can be done. Millions of rivets could be conserved in aerospace engineering through their innovative joining methods. This would make aircraft lighter and would require less fuel.

The infographic in the centre of this volume explains the route of materials development, from basic research to application. In addition, the interview with Henning Scheel demonstrates how polymer research from Geesthacht is used in the commercial sector. Way up in the north, two coastal researchers go about studying the spread of organic pollutants in the Arctic. Their expedition report, with fabulous pictures, shows once again how much our world is worth protecting.

In the Portrait sections, this time we find out more about beamline scientist Dr Jörg Hammel and Institute Director Prof Regine Willumeit-Römer.

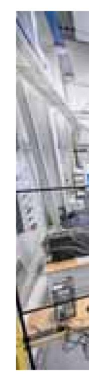
Extra tip: Using the web links in the edition, you can discover more about people with ideas at the Helmholtz-Zentrum Geesthacht.

Have fun reading, viewing and listening,

Gesa Seidel Heidrun Hillen

We are pleased to present the seventh issue of in2science

A call for submissions:
Employed at the HZG and have an exciting story or outstanding collaboration you'd like to share? Then please get in touch with our editors. We look forward to your ideas, praise and criticism. Simply write to us at in2science@hzg.de



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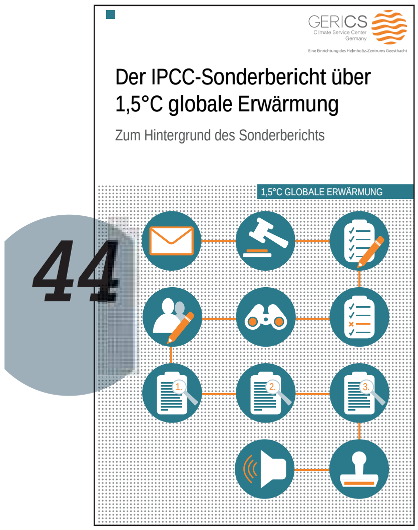
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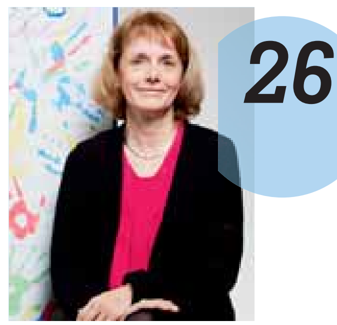
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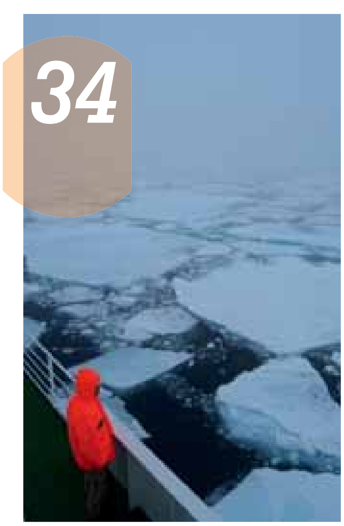
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The Hall of the Multi-Talented

The most improbable composites are researched here: metal with plastic, carbon with aluminium or titanium with steel.

The fuselage of a modern aircraft consists of a mix of aluminium and fibre composite structures, which are often lighter and more durable than those of pure metallic construction. Conventional joining processes, such as sheet metal riveting, are not optimal for new engineering methods.

These approaches can be replaced with special weight-reducing welding processes. This is what the joining specialists are researching at the Helmholtz-Zentrum Geesthacht. The scientists have developed and patented various methods in the field of friction stir welding. Today, for example, they're joining carbon fibre and metal or aluminium with steel. No melting, no adhesive, no trouble.

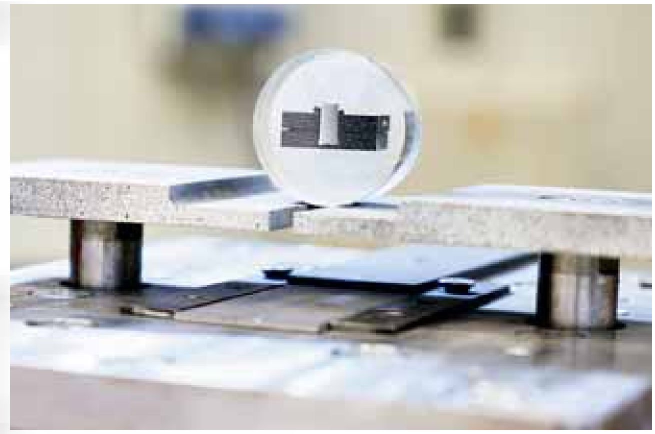
The advantage of their methods: low heat generation, the most diverse materials can be joined, no pre- or post-processing of the joint, no welding filler, no toxic vapours or other by-products.

On the following pages, we show you how the approximately forty members of staff in the Solid State Joining Process Department, led by Dr Jorge dos Santos, are always making strong connections.

FricRiveting

This is what doctoral candidates Natascha Zocoller (large photo) and Mihaela Malita research. While Zocoller connects metal with carbon fibre, Malita joins plastics. Although rivets only penetrate a few centimetres deep, they still require large machines, as the rivet is applied with a compressive force of up to 20 kilonewton pressure and 10,000 revolutions per minute. In comparison: 20 kilonewton corresponds to a weight of approximately two tons.

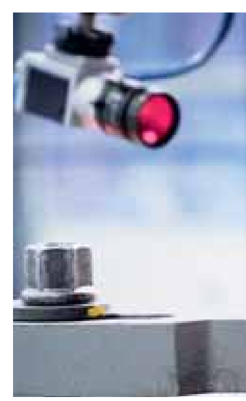
Photos: ©HZG/Christian Schmid



A cylindrical, metallic rivet penetrates through the upper material under rotation and pressure into the underlying plastic. Anchoring formed at the rivet tip and adhesion between the materials to be joined with the rivet results in a firm connection. (Image: above)

Application of the innovative joining process in aerospace engineering was researched in depth by Geesthacht scientists. One example is the following publication on www.sciencedirect.com:
Direct-Friction Riveting of Polymer Composite Laminates for Aircraft Applications.

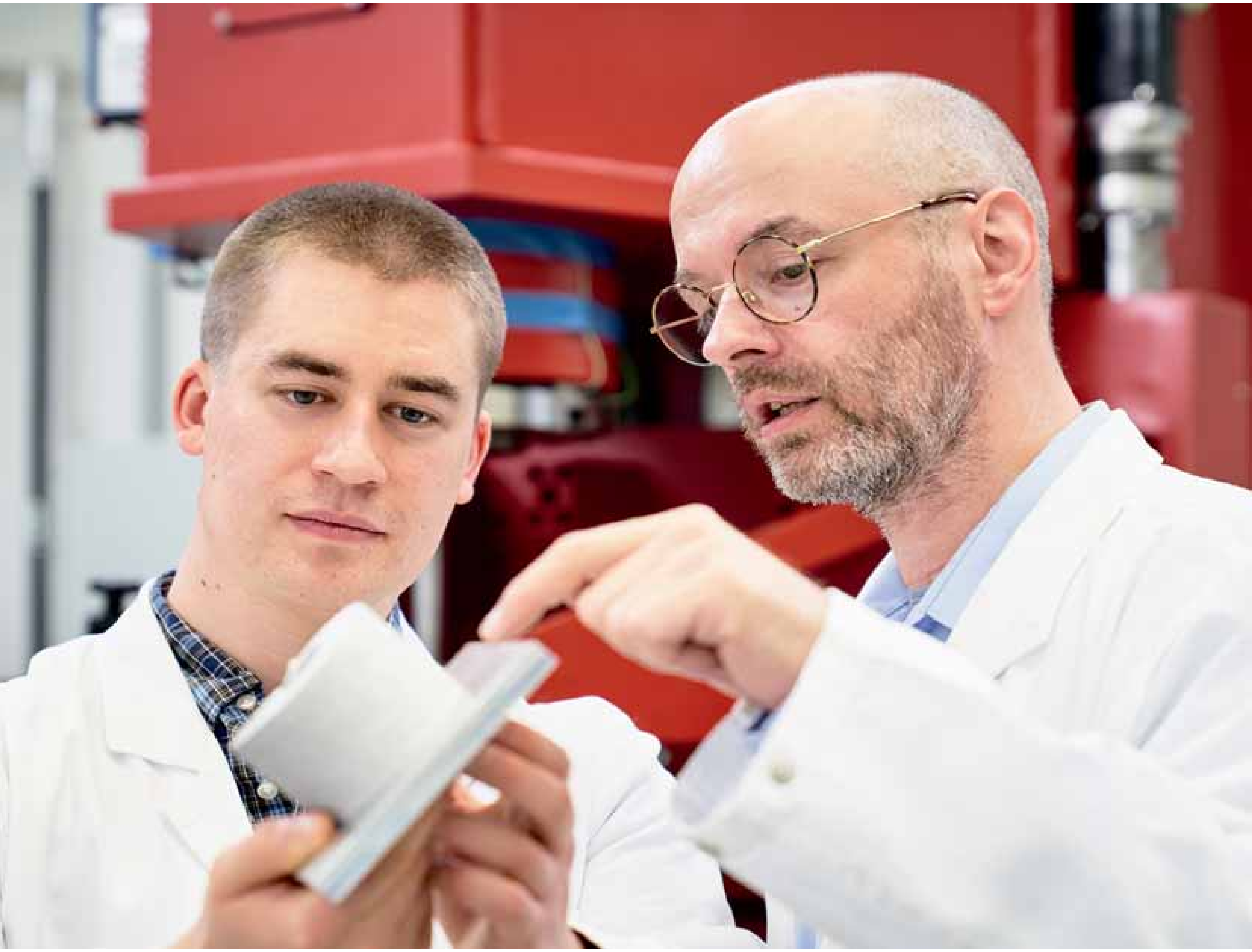
Link to publication: **doi.org/10.1016/j.matlet.2017.12.033**



Photos: ©HZG/Christian Schmid

Friction surfacing

Dr Arne Roos (front) and graduate student Lars Rath apply a metallic material to another component using their machine. This, for example, can be used for corrosion protection and protection against wear, or for repairing components.



The metal to be applied is pressed onto the base material in cylindrical form, similar to a 3D printer – but with metal.

Photos: ©HZG/Christian Schmid

Friction Spot Joining

Doctoral candidate Natalia Manente researches a method that provides an environmentally friendly alternative for joining carbon fibre (CFRP) with metal. This is possible, as no adhesive is utilised.

The principle: the metal is made selectively malleable, which leads to mechanical anchoring in the CFRP. A rapidly rotating sleeve only penetrates into the metal layer. The metal becomes soft from frictional heat and the CFRP at the surface becomes fused. When the sleeve plunges downwards, the aluminium deforms slightly into the CFRP.

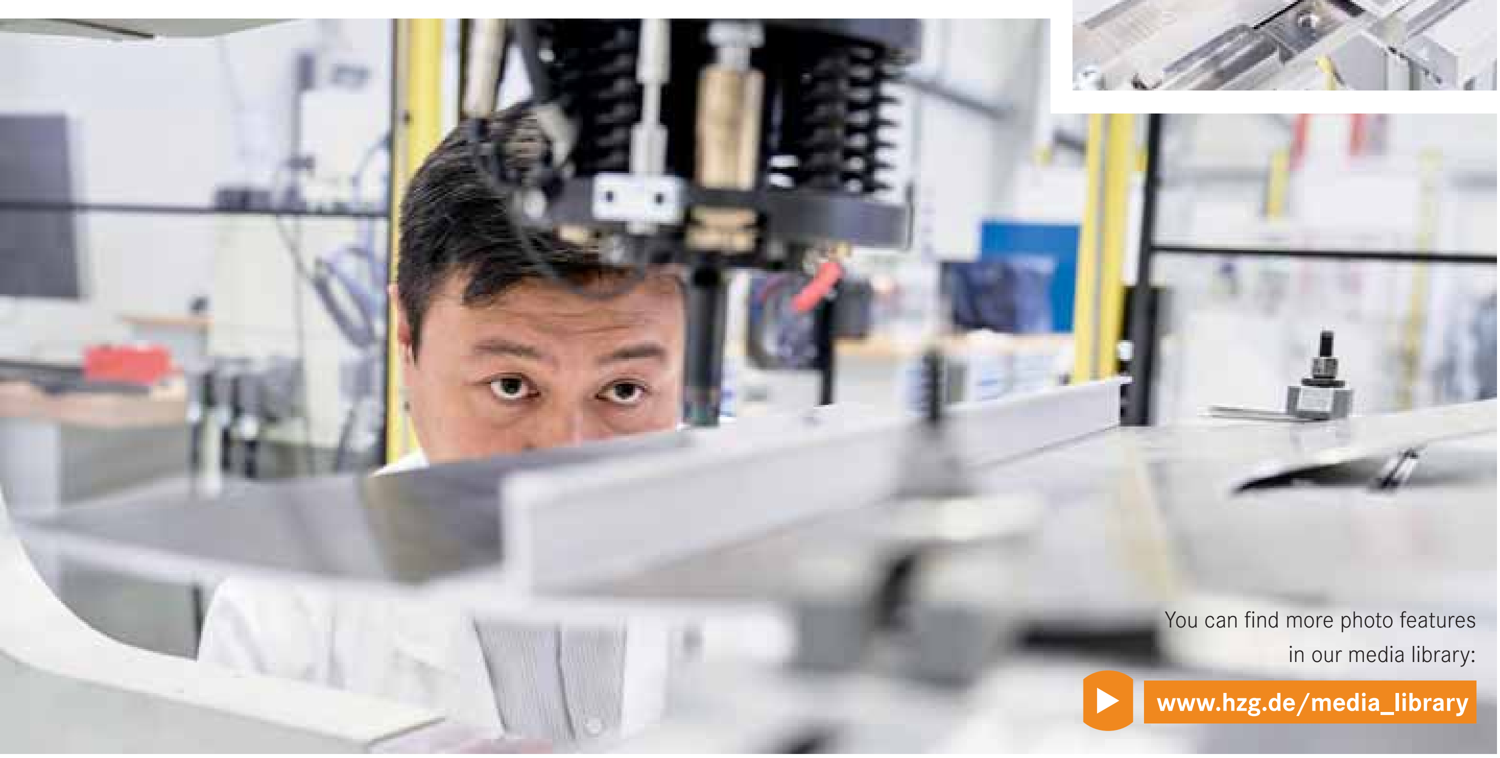
Current publication in the *Journal of Adhesion:*
Composite Surface Pre-Treatments: Improvement on Adhesion Mechanisms and Mechanical Performance of Metal-Composite Friction Spot Joints with Additional Film Interlayer
The Metal Polymer research group recently studied the influence of various surface pre-treatments on mechanical properties of the friction spot joining method.

You can find the publication here:

doi.org/10.1080/00218464.2017.1378101

Refill Friction Stir Spot Welding

Materials are joined at specific points using this method. Rotating tool components perform a coupled motion: the material is first pressed out of the joint and then pressed in again. Dr Uceu Suhuddin observes the process.



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Where the Water Flows

Using complex computer models and modern radar technology, researchers explore ocean currents. These researchers are now able to generate increasingly precise forecasts – something from which rescue teams and scientists alike can benefit.

A shipping container has gone missing and is at risk of entering a channel that sees high traffic. An oil slick might enter the protected Wadden Sea. A surfer who is unable to manoeuvre is careening out into the open waters. It is during emergencies like these when rescue teams wish to know in what direction the tides, wind and sea conditions are driving the water. Which ships, for example, must be warned of the stray container? How many coastal towns should prepare for an impending oil spill? And where exactly must the rescue helicopter fly to save the surfer?

Jochen Horstmann: Drifters are always recording interesting phenomena on currents for us.

Scientists could only imprecisely answer such questions for quite a long time: little was known concerning ocean currents, which are known as drift. Forecasts were correspondingly flawed.

Researchers have been attempting to explore patterns of movement in the sea for centuries – sometimes using surprising methods. Experts from the German Naval Observatory in Hamburg, for example, threw hundreds of bottles into the sea about 150 years ago. The form tucked inside each bottle asked those who made the discovery to inform the Naval Observatory of the bottle's location when found. This is how they would determine drift pathways. This was a first in scientific research – if an extremely imprecise approach. And a lengthy one at that: one of the bottles from Hamburg reached the coast of Australia only this spring. After 132 years at sea.

The site in Hamburg now owns the largest “message in a bottle” collection in the world. The methods have, nevertheless, been heavily refined since these beginnings: researchers have meanwhile been able to predict with increasing precision where the person, particle or object will drift. Reverse calculations are also possible now: where did the algae come from that suddenly appeared along the coast? Which ship carried the packet of cocaine that washed ashore there? And who illegally dumped paraffin into the sea a few hours ago, which is now drifting toward land? Scientists and government bodies are now able to find answers to such questions concerning the past more precisely than ever before.

Two main drivers of drift have been identified: on the one hand, the fixed sequence of ebb and flow creates ocean currents, while on the other hand, the constantly fluctuating weather drives the surface water. In addition, local factors come into play, such as in estuaries or near land barriers – for example, islands.

Heavily fragmented regions, such as the German Bight, with all the islands and tributaries, are therefore particularly interesting research regions for marine scientists: for analysing drift in the German North Sea alone, an entire network of experts has joined forces, including researchers from the Helmholtz-Zentrum Geesthacht. At the Institute of Coastal Research, for example, oceanographers measure how wind and sea state affect drift; mathematicians reconstruct the weather for the past sixty years through simulations in order to recognise typical current patterns; biologists observe where plankton and other marine creatures drift over the course of seasons; and technicians release small transmitter stations – called surface drifters – which are pulled along by the water in the North Sea and regularly transmit information back to land pertaining to their location.

Dr Jochen Horstmann has been heading the Radar Hydrography Department at the HZG's Institute of Coastal Research since 2013.

Dr Ute Daewel has been employed as a scientist in the Matter Transport and Ecosystem Dynamics Department at the Institute of Coastal Research since 2016.

"Drifters are always recording interesting phenomena on currents for us," explains Jochen Horstmann, head of the Department of Radar Hydrography at the HZG. "Their data, however, hardly allows us to draw conclusions on structures of currents on a large scale." This is therefore taken care of by the institute's radar facilities instead: high-frequency radar equipment with a range of approximately one hundred kilometres is located on the islands of Sylt and Wangerooge as well as on the coast of Büsum. The antennae measuring three metres high are constantly receiving data. The surface currents in the German Bight are calculated from this data every twenty minutes. These currents, with a resolution of up to two kilometres, are also considered an important corrective for the purely mathematical models with which researchers also work.

The marine radar possesses an even narrower focus: ocean currents within a radius of three kilometres are measured aboard ships, and this information is transmitted to the screen on request with only a slight time delay. Every two seconds a new image of the surface is received, with a resolution of 7.50 metres. This makes waves of different lengths visible: pulsating, their crests scurry across the monitor, and surface films emerge as dark shadows.

Ute Daewel : The current carries the eggs along after spawning – in unfavourable cases, in regions with a great number of predators, insufficient food supply or unfavourable environmental conditions.

When Horstmann requires data with considerably higher spatial resolution, he releases a drone into the air – this is fitting, for example, near estuaries or harbour areas, as it is there that the current varies a great deal. "The seawater in the vicinity of the coast often moves at speeds of one or more metres per second and the current direction also changes quite suddenly," explains the oceanographer. It is usually more sluggish, however, on the open sea: there it usually flows at speeds considerably less than one meter per second.

Researchers must be familiar with this mosaic of calm and extremely agitated zones if they want to correctly interpret local phenomena. Ute Daewel, for example, marine researcher at the Institute of Coastal Research, is interested in how drift affects fish populations. The current carries the eggs along after spawning – in unfavourable cases, in regions with a great number of predators, insufficient food supply or unfavourable environmental conditions. According to Daewel, "This can lead to a sharp decline in the population of certain species."

If the population of an otherwise typical species of fish suddenly decreases in a region, the experts must then not only check whether this is due to an environmental problem or if fishing could be the underlying reason. The current can also severely affect animals seasonally – we only need to remember last year's "shrimp crisis". The animals had become so rare along the German coasts that shrimp rolls in some beach resorts reached a record price of €11.50. Researchers such as Daewel assume that unfavourable current conditions could have been responsible for the decrease at the time. The animals manage comparatively better in the face of climate change.

The expert works with computational models for her studies. These models allow her to precisely track where eggs and larvae drift and how they develop, depending on water temperature and food supply. Herring, for example, typically spawn off the eastern coast of England. The current usually carries the eggs from there to the southeast, to zones with abundant food supplies along the German coast. Herring, however, spawn in winter, when the prevailing cold causes the eggs to mature even slower. If temperatures then still drop drastically, there is a risk that the larvae only hatch when, with the drift, the eggs have long since passed the nutrient-rich regions – after all, the North Sea in the German Bight is constantly turning in a counter-clockwise direction.

Drift researchers also bring up important arguments concerning environmental issues. Using what are known as dispersants in Germany, for example, is controversial: if this chemical is sprayed onto a drifting oil slick, it dissolves into many tiny droplets that mix with the seawater and sink. The toxic slick disappears from the water's surface before it reaches land and can threaten its ecosystem. The oil particles are instead distributed in the water, penetrating all the way to the seabed and possibly seeping into the sediment, where they in turn could harm the organisms living there. “Various risks on land and at sea must be weighed before we can come to a decision on the use of dispersants,” explains Ulrich Callies, who leads the Modelling for the Assessment of Coastal Systems Department.

He has been refining the models for drift phenomena at the HZG for many years and is particularly interested in the behaviour of oil at sea – especially in regard to possible oil spills. “Each type of oil reacts differently when it comes into contact with air and salt water – one evaporates quickly, while others rapidly clump. The effectiveness of an applied dispersant depends heavily on the type of oil present,” explains Callies.

Dr Ulrich Callies heads the Modelling for the Assessment of Coastal Systems Department at the Institute of Coastal Research.
He has been employed at the research centre in Geesthacht since 1988.

Where is the message in a bottle drifting?
Where does the garbage on the beach come from?
Oil Spill! Which sections of beach are threatened?

Want to find out? Try the HZG “Drift” app! With the help of mathematical models, scientists at the Institute of Coastal Research have reconstructed shifting wind, current and sea state conditions in the North Sea region for a certain period. In the game, you can launch rubber ducks, messages in bottles, oil particles and fish larvae on a journey. You can choose any day from the past six decades. You can discover where objects wind up drifting and where they originated.
The drift paths for particular weather events, such as for the flood of 1976 or for Hurricane Kyrill, which caused a stir in 2007, can be tracked playing the game.

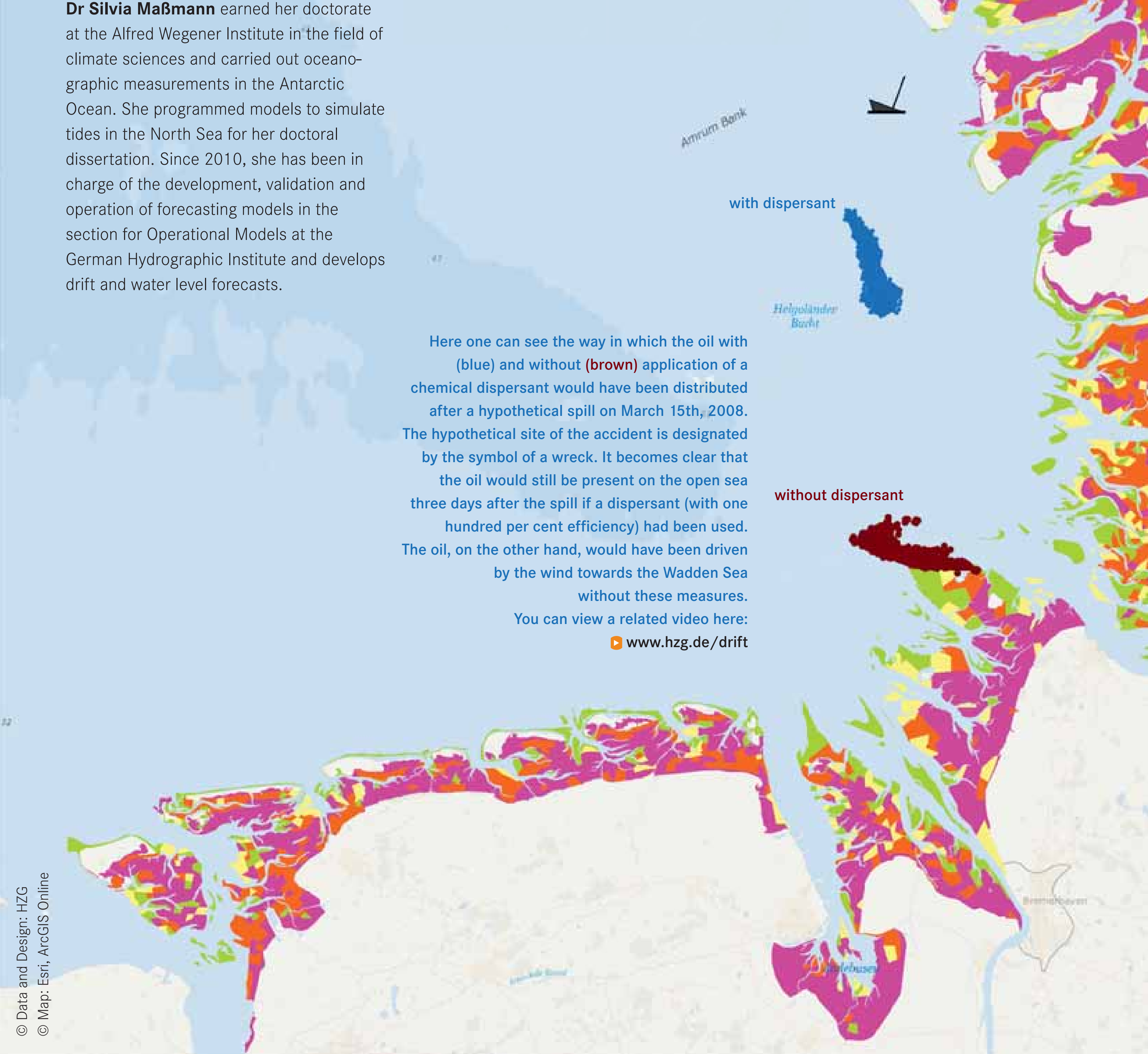
After spawning, some fish species are dependent on the currents to transport their eggs to other regions, where the young fish can mature.

Ulrich Callies: Each type of oil reacts differently when it comes into contact with air and salt water – one evaporates quickly, while others rapidly clump. The effectiveness of an applied dispersant depends heavily on the type of oil present.

It is all the more difficult to predict whether the use of dispersants is actually advisable to prevent an oil spill from polluting the coast or the sensitive Wadden Sea. Callies and his colleagues therefore use computer simulations that enable them to continuously release oil into the North Sea – millions of times and during the most varying weather conditions as well as at any location. The simulations have demonstrated that if a tanker leaks directly off the coast, the dispersants no longer help against extreme contamination – the tidal movement alone would push the oil rapidly into the Wadden Sea. Far out at sea, on the other hand, conventional methods for combating oil spills are usually sufficient due to the long periods of time available. This renders any use of additional chemical pollutants in the sea unnecessary. The use of the chemical additives in a predefined corridor along the coast would be of interest: if oil leaks at a distance of twenty to forty kilometres from land, the chemical additives may often effectively prevent the oil slick from drifting into the Wadden Sea. In addition, the fact that the water depth in these zones already reaches values of around twenty metres speaks in favour of spraying. The water column is thus large enough for dispersants and oil particles to at least be heavily diluted. "Limited use in this area is therefore advisable to prevent worse situations from unfolding," says Callies.

The expert is regularly in contact with the governmental bodies responsible for combatting oil at sea, such as the German Federal Maritime and Hydrographic Agency (BSH). The forecasting service there keeps an eye on the North Sea currents day and night, including with the help of HZG data. The staff can utilise the BSH model data with a few clicks of the mouse to produce drift forecasts for the next

Dr Silvia Maßmann earned her doctorate at the Alfred Wegener Institute in the field of climate sciences and carried out oceanographic measurements in the Antarctic Ocean. She programmed models to simulate tides in the North Sea for her doctoral dissertation. Since 2010, she has been in charge of the development, validation and operation of forecasting models in the section for Operational Models at the German Hydrographic Institute and develops drift and water level forecasts.



Here one can see the way in which the oil with (blue) and without (brown) application of a chemical dispersant would have been distributed after a hypothetical spill on March 15th, 2008. The hypothetical site of the accident is designated by the symbol of a wreck. It becomes clear that the oil would still be present on the open sea three days after the spill if a dispersant (with one hundred per cent efficiency) had been used. The oil, on the other hand, would have been driven by the wind towards the Wadden Sea without these measures.
You can view a related video here:
www.hzg.de/drift

forty-eight hours. They can subsequently track down environmental polluters by calculating which path the particles last took due to the currents.

“Our team responds to fifty such requests from police and rescue personnel per year,” explains Silvia Maßmann, who supervises the drift model at BSH. “Pressing issues are handled by the on-call water level forecasting service, even in the middle of the night, while we respond to others as quickly as possible within twenty-four hours.” She and her colleagues receive all requests that concern, for example, buoys that have broken loose during a storm, or missing persons who were last spotted at sea. Once she was contacted about a drifting naval mine near the coast – her ”most unusual case,“ according to Maßmann. A fisherman had pulled the unexploded bomb from World War II on board, and then he threw it back into the water out of fear. He immediately contacted the waterways police, who asked Maßmann for assistance. “Luckily our forecasts at the time corresponded very precisely with the actual course so that the rescue team could quickly retrieve the bomb.”

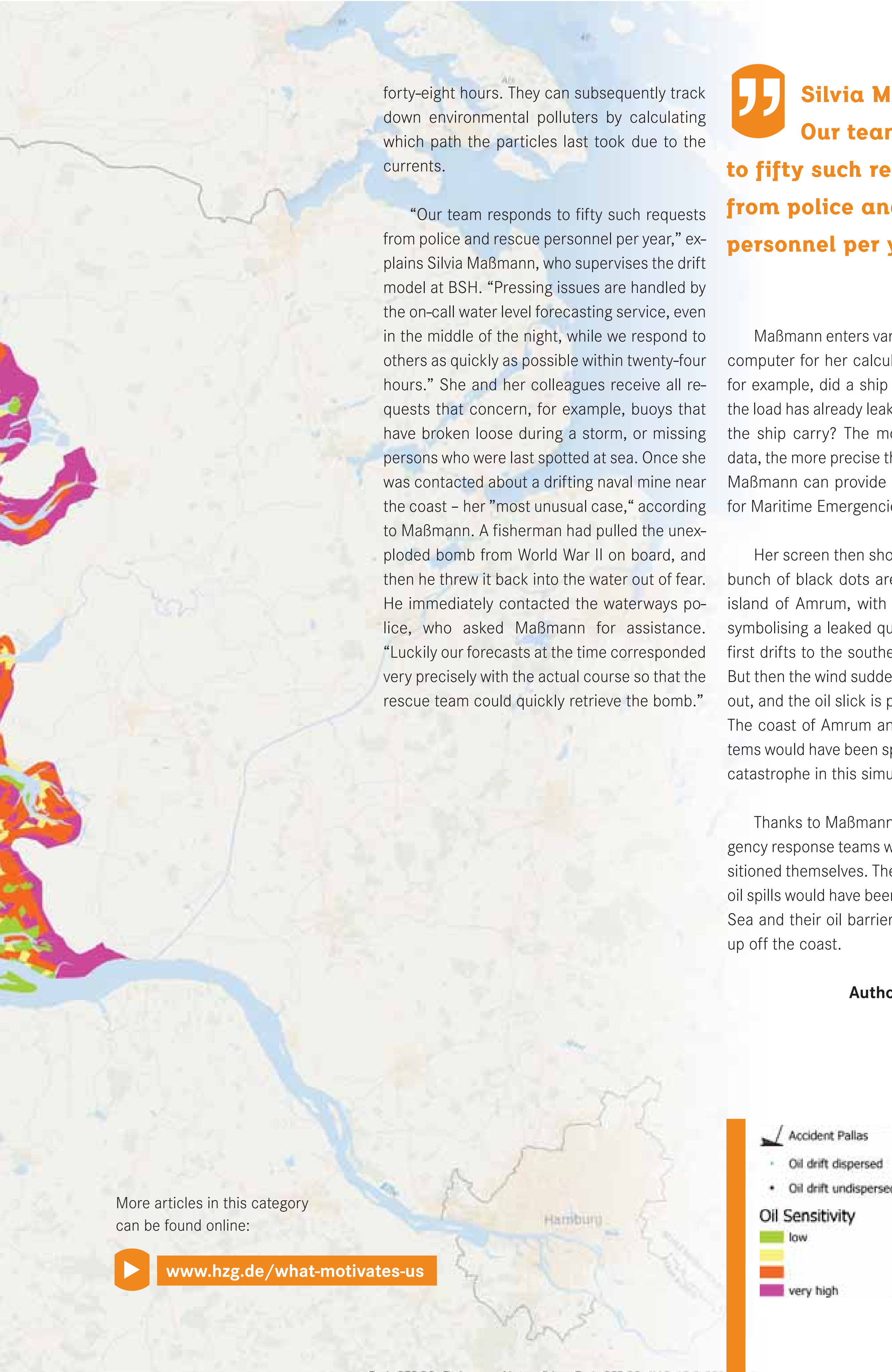
Silvia Maßmann: Our team responds to fifty such requests from police and rescue personnel per year.

Maßmann enters various parameters on the computer for her calculations. Where exactly, for example, did a ship leak oil? How much of the load has already leaked? What type of oil did the ship carry? The more detailed the initial data, the more precise the forecasts will be that Maßmann can provide the Central Command for Maritime Emergencies.

Her screen then shows, for example, how a bunch of black dots are set in motion off the island of Amrum, with each splash of colour symbolising a leaked quantity of oil. The cloud first drifts to the southeast, toward the island. But then the wind suddenly shifts, the tide goes out, and the oil slick is pulled out to the ocean. The coast of Amrum and its sensitive ecosystems would have been spared an environmental catastrophe in this simulation.

Thanks to Maßmann’s forecasts, the emergency response teams would have correctly positioned themselves. Their ships for combatting oil spills would have been deployed to the North Sea and their oil barriers would have been set up off the coast.

Author: Jenny Niederstadt



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The Beamline Scientist

How to look after a ninety-metre microscope

Dr Jörg Hammel

works in the Division for X-ray Imaging with Synchrotron Radiation at the Institute of Materials Research.

Petra III, sector 4, P05 – we are at the brightest storage ring X-ray source in the world. It's noon on a Thursday. Dr Jörg Hammel worked until two in the morning yesterday. He nevertheless seems completely euphoric as he discusses his work at the beamline.

In this room with us are five work stations, all outfitted with several computer screens. Experiments can be controlled and observed from here, and it is here that the data is displayed and everything is checked.

Jörg Hammel is a beamline scientist. Together with his colleagues he maintains the P05 beamline, which is connected to the PETRA III storage ring in Hamburg. The entire facility is located on the DESY campus, and the beamline belongs to the HZG.

We're virtually working with a ninety-metre-long microscope to look at miniscule samples – it's crazy!

The samples are of the most varying kind. Hammel says, "We've already investigated the melting of magnesium alloys, the formation of a corrosion layer on biodegradable implants, the connection of the human Achilles tendon to the bone, sand-lime brick deposits, and shark bones – and those are just a sampling of what we've studied." Emitted from the ring is an X-ray beam that is focussed on the sample to be examined. "We have a field of view measuring seven by seven millimetres. If we want to examine larger samples, we need to take various measurements and then add those together."

Jörg Hammel grew up in Schwäbisch Hall, near Stuttgart, where the scientist, who is now thirty-eight years old, studied technical biology. "I quickly noticed that basic research is what motivates me. It's so exciting when you can pursue new ideas." He then attained his doctorate at the Friedrich-Schiller-University in Jena in the field of zoology. The topic of his dissertation: marine sponges. "These are the simplest multi-celled organisms that we know of – they have neither nerves nor muscles. They can nevertheless react to neuroactive substances and can move on their own. They were extremely exciting objects to research," he says. "What lies hidden behind things had already piqued my interest back then. How does it work? Why is it like that? And how can we make even more improvements in how we study it?" Today he lives with his wife and two children in Hamburg. "The proximity to the water offsets the lack of mountains," he says with a smile.

While we're talking, a colleague enters with a quick request. Hammel turns toward the monitor, where we can glimpse around seven different windows with numbers and commands. What the monitor also shows is what the camera is recording at the beamline. "Right now we're studying the respiratory organs of insects. Here you can see the organs from a type of cricket," he explains to me. A few clicks and his colleague is satisfied. Things can proceed.

During his graduate studies, Hammel had already forged connections to P05 and the scientists working there. The beamline itself was set up in 2009 and he was amongst the users when the first experiments were carried out. "The high-quality technology here had fascinated me even back then," he says. "There are so many possibilities for further development – and we have the opportunity to drive this development forward, which is terrific!" After short research stays in Amsterdam and Jena, the scientist seized his chance when a position opened in 2014. "They were searching for someone who was familiar with the facility and who came from the field of life sciences. It fit me perfectly."

The measuring time at the beamline is heavily regimented. Eighty per cent is assigned to external users. These users can submit requests, which then go through an assignment system and an expert committee. The applicants receive a maximum of one week at the beamline. That time is fully utilised: those granted only seventy-two hours for their project will sleep as little as possible. Jörg Hammel and his colleagues look after the external projects and also remain on call. "Fortunately we can manage a lot from home through the PC, as calls at 2:30 in the morning are not unusual," he points out. The remaining twenty per cent of the operational time is assigned internally. This time is used for starting up the facilities, further development and their own projects.

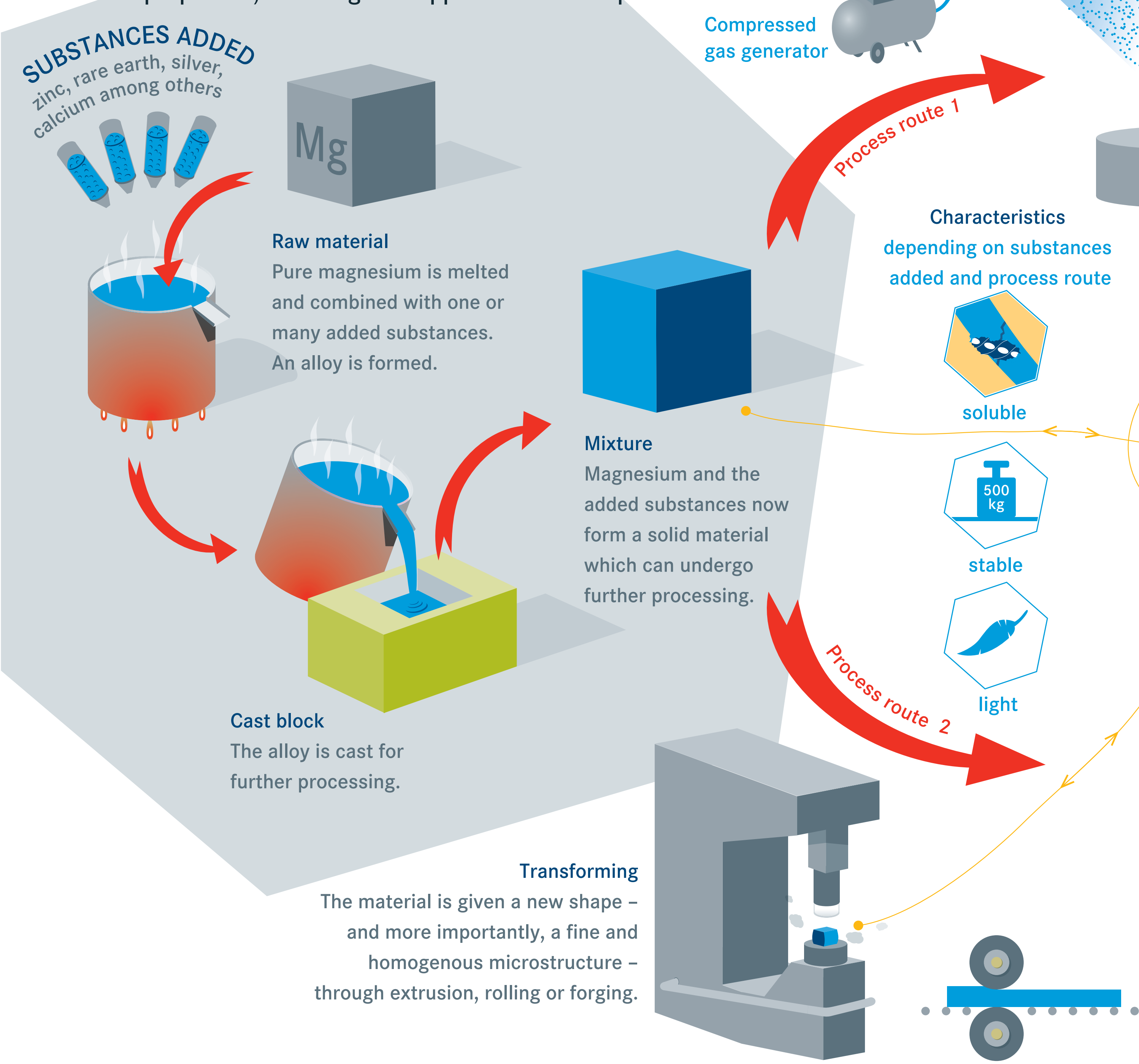
We're working at the limit of feasibility here.

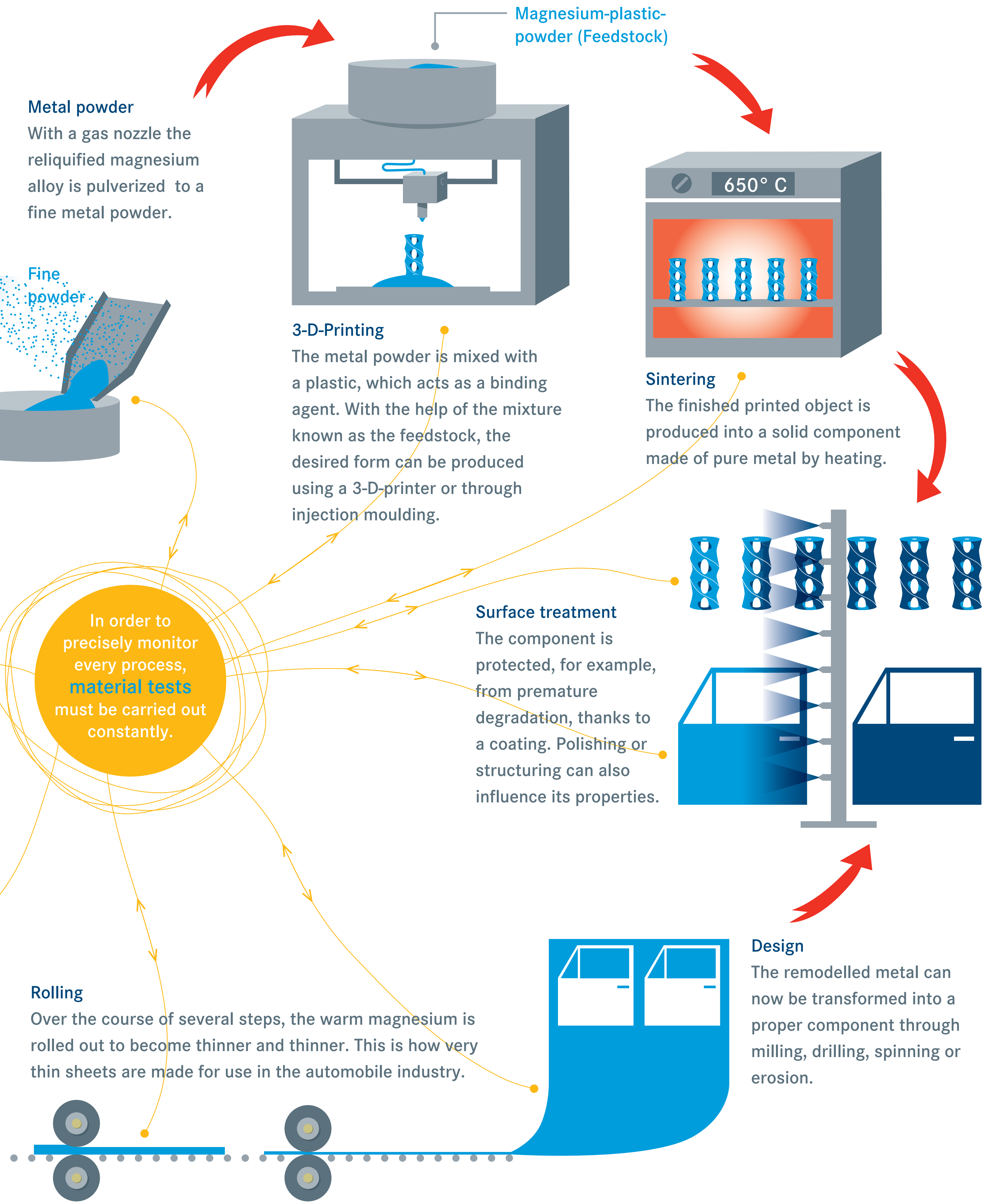
"Soon we'll have a weekend with measuring time just for us – my colleagues and I are ecstatically looking forward to it! We're working on time-resolved measurements at the moment, basically 4D. It's like 3D but the temporal evolution is also included. We can then observe dynamic processes and movements," says Hammel. At the moment, they're managing to create twenty-second recordings in very high quality using the technology. This, however, only works with good teamwork. Four scientists cooperate with engineers here. There is a great deal of collaboration with the HZG's Central Technology Department. "Much of the equipment is not at all standard; we are, after all, undertaking cutting-edge research."

Author: Gesa Seidel (HZG)

Magnesium – the raw material for ideas

The light weight of magnesium makes it the metal of the future. Depending on the substances added, the manufacturing process or surface treatment, the end product can be particularly stable, or dissolved in the body in a controlled way, for example, as a bone screw. Scientists at the Helmholtz-Zentrum Geesthacht are giving the material new properties, revealing new applications in the process.




Metal powder
With a gas nozzle the reliquified magnesium alloy is pulverized to a fine metal powder.
Fine powder
Magnesium-plastic-powder (Feedstock)
3-D-Printing
The metal powder is mixed with a plastic, which acts as a binding agent. With the help of the mixture known as the feedstock, the desired form can be produced using a 3-D-printer or through injection moulding.
650° C
Sintering
The finished printed object is produced into a solid component made of pure metal by heating.
In order to precisely monitor every process, material tests must be carried out constantly.
Surface treatment
The component is protected, for example, from premature degradation, thanks to a coating. Polishing or structuring can also influence its properties.
Design
The remodelled metal can now be transformed into a proper component through milling, drilling, spinning or erosion.
Rolling
Over the course of several steps, the warm magnesium is rolled out to become thinner and thinner. This is how very thin sheets are made for use in the automobile industry.

Conversations Between Body and Metal

What drives physicist Prof Regine Willumeit-Römer?

Find more portraits online:

www.hzg.de/portraits

Prof Regine Willumeit-Römer

leads the Metallic Biomaterials Division at the Institute of Materials Research

Life sometimes takes us down strange roads. Prof Regine Willumeit-Römer moved into a new building at the HZG with her division in autumn of 2018. It is there with her team that she researches how magnesium implants behave in our bodies. What happens at this border between physics and biology, where metal meets human cells?

At the beginning of her career, however, she wasn't interested in the microscopically small, but in the opposite: "Outer space fascinated me as a child. My father had explained to me back then that light needs years to reach Earth. That's something I wanted to understand better. So I started to read books on astrophysics." As a school student, she travels from her home in Westphalia to the trade fair in Hannover and visits the DESY booth. She wants to discover more about the place where researchers simulate the Big Bang. She makes contacts, snags a student internship at the particle accelerator in Hamburg – a rare opportunity at the time – for which she sacrifices her entire summer. "There I met people from all over the world," explains Willumeit-Römer. "They got together over coffee and discussed new theories. I thought to myself: wow, that's the way work can be! You make a difference as a team. I knew then that I wanted to do this later too!"

So after she finishes secondary school, she heads to Hamburg to study physics. Sure, mathematics and biology were her main courses in secondary school – not bad preparation. But she had dropped physics in school, of all subjects.

> **Calculating parallelograms of forces and free fall – I found that completely boring. That wasn't the type of physics that interested me.**

In her first semester, however, she came up against these very things again, and Willumeit-Römer soon thought of giving up. "I had the papers for un-enrolling on my desk and had even celebrated a farewell party with my friends. But the others convinced me to keep going. We even tore up the papers the same evening." Willumeit-Römer holds on and finishes her degree. "As a lone fighter," she says, "I never would have made it on my own." She obtains a doctoral student position at the GKSS in Geesthacht, where she studies proteins. She said goodbye to astrophysics – a fruitless art – long before that.

"I really wanted to leave university research after my dissertation. There was already a lucrative offer from the commercial sector," she says. Again, it was external motivation that changed everything: her department head received a call from abroad – the institute director asked Willumeit-Römer if she would like to be his successor. "That meant several steps ahead in my career all in one go. So I accepted."

Why did they choose her? "As a doctoral candidate earlier I had led guided tours for visiting groups. I wanted to know what the other departments at the centre were actually doing. In hindsight, it really helped me. This was because suddenly I knew a great number of colleagues and I wound up in a role as a sort of mediator. My institute leader said at that time: 'You're the only one who can explain to me what is going on in your department.'"

She initially researched a new form of antibiotics in her small department. She returned to metal again through a mixture of coincidence, teamwork and communication: on the recommendation of her institute director, Willumeit-Römer developed titanium implant coatings and studied the biological reaction.

> **I noticed at a certain point that magnesium is a much more exciting material for such experiments.**

This is because magnesium degrades, unlike titanium, in the human organism.

Today Willumeit-Römer's institute division researches magnesium implants, such as screws that hold broken bones together. Because they dissolve, this spares the patient a second surgery in which the implant would need to be removed. This, for example, is the case with children, whose bones are still growing – but their metal prostheses are not. They cannot, therefore, remain inside the body. The costs of such subsequent surgeries in Germany alone are more than a billion Euros per year.

Regine Willumeit-Römer describes the interaction of the biochemical reactions between magnesium and human cells as a "conversation", as "communication". This dialogue, she says, ends only when the screw has completely degraded within the body. There are at present only a few approved magnesium implants on the market, and the surgeons are closely observing how the material performs in the patient. Willumeit-Römer's hope for the fifteen remaining years of her career? "That magnesium will at some point be well established as a material utilised in osteosynthesis." She views this as a "ninety per cent chance of happening." To achieve this, she'll do what she's always done. Working hard. Talking to a great number of people. Remaining a curious team player. And continuing to listen to the secret dialogues between bone and metal.

Author: Jochen Metzger

Measured Separation

Interview with Henning Scheel, Business Development Manager at Flowserve SIHI in Itzehoe

Tailor-made production for membrane plants: a view into the production hall of Flowserve SIHI in Tönning, Schleswig-Holstein.

There are essentially two fields of application. Systems for the recovery of reusable materials and exhaust purification.

The company where Henning Scheel works produces membrane systems that include functions such as recovering valuable solvents and trapping harmful exhaust gases. He has been collaborating for many years with the Helmholtz-Zentrum Geesthacht on this subject: the experts at the Institute of Polymer Research have developed the basic technology and regularly support Flowserve SIHI in developing their products.

Mr Scheel, how do the membranes that you use in your systems work?

The membranes are made of special polymers. You shouldn't imagine these as sieves with tiny pores through which molecules of the right size can slip. Instead, these molecules are dissolved in the membrane and can pass through it. The different substances in a gas mixture can be separated as a result. A prerequisite is a pressure gradient: there must be high pressure on the side of the membrane where the gas mixture is located. On the other side, where the molecules to be separated should accumulate, lower pressure is needed. Our firm produces the necessary compressors and vacuum pumps – our core business – which is ideally supple-

The brand new system is assembled in the factory. The membranes from Geesthacht are in the high white containers on the right picture.

Photos: ©HZG/Christian Schmid

mented by the membranes. The fundamentals for the membranes were researched by the Helmholtz-Zentrum Geesthacht. This is why the HZG receives licensing revenue from us for every membrane system sold – and has been since the early nineties.

The fundamentals for the membranes were researched by the Helmholtz-Zentrum Geesthacht.

In which fields are your membrane systems used?

There are essentially two fields of application. On the one hand, the systems are used for recovering reusable materials. One example lies in the production of a particular type of polyethylene, one of the most commonly produced plastics in Germany, where a certain method uses large quantities of the solvent hexane. A portion of the hexane evaporates and normally gets lost during the process. This can lead to losses of up to 18,000 US dollars in large factories – keep in mind, this is per day! Our membrane systems can recover 99.9 per cent of this solvent. They therefore pay for themselves in a short period of time, after merely a few months. In concrete terms, the gas to be separated – a mixture of nitrogen and hexane – is initially condensed using compressors. It then flows through a condenser into cylinder modules. Each of these modules contains up to thirty square meters of membranes in the form of envelopes. The gas flows on a zigzag course through the module and over these pockets. The hexane molecules are dissolved in the membrane and are thus separated from the nitrogen, then subsequently conveyed back to the suction side of the system and liquefied in the condenser. The hexane obtained in this way can then again be used for polyethylene production. The purified nitrogen can also be used again. An exhaust gas enters the system and two recycled materials are extracted.

And the second field where the systems are used?

This lies in exhaust purification. A good example can be found in gasoline vapors, which inevitably form in a tank farm: a portion of the petrol in a tank evaporates, especially when there are high temperature fluctuations. Previously, these vapours were simply blown into the air through pressure relief valves. Today, operators must comply with legal limits and remove the petrol from the air. In order to do so, they use our membrane systems: they separate the petrol from the air, the vapours are liquefied in the system and are returned to the tank. These systems also pay for themselves over time for the operator.

How does your collaboration with the Institute of Polymer Research look in concrete terms?

The technology has been constantly improving over the course of time; the membranes in particular have become considerably more selective. The Helmholtz-Zentrum Geesthacht has contributed quite a bit in this regard. We're collaborating on several levels right now. If a client, for example, asks us whether a membrane can be utilised for a certain process, we first compile a feasibility study especially for this application scenario. If we do not know precisely how well a membrane under the required temperature and pressure conditions works, or how effectively a certain material can be separated using a membrane, we discuss these issues with the experts at HZG and outline solutions together. We can then judge what is possible and what is not.

We also utilise software tools developed in Geesthacht. We can thus realistically mimic the membrane's behaviour in a process simulation – the basis for accurately designing and creating the dimensions for a system. This software module is constantly under development at the Institute of Polymer Research, whereby our calculations have become increasingly more accurate over time. And lastly, the HZG has measured numerous materials in the laboratory over the years. These measured values serve as a basis for our calculation of a membrane. If we are dealing with a new substance, we sometimes commission the institute to undertake the measurements. It's therefore extremely helpful that I worked in Geesthacht earlier for a number of years. I know the current department head, Dr Torsten Brinkmann, from my time spent there. This helps in communicating – we're speaking the same language.

Have there already been joint research projects?

Yes, for example, in the area of CO_2 separation. Within the framework of the "MemKoR" project, supported by the Federal Ministry for Economic Affairs and Energy, the HZG developed a two-stage membrane system that filters the CO_2 from coal power plant flue gases. One could, in principle, use this CO_2 as the basis for polymers. In our production hall in Tönning (Schleswig-Holstein), we created this system, including monitoring and analytics, on behalf of the HZG and then later modified it. It is being tested in a power plant in Karlsruhe, among other places.

We are always looking for new fields of application for our systems.

About:

Chemical engineer **Henning Scheel** has worked at Flowserve SIHI GmbH in Itzehoe since 2001. SIHI was founded in 1920 and produces vacuum pumps and compressors in Itzehoe, mainly for the chemical and petrochemical industries. Today the company is part of the US group Flowserve. As Business Development Manager, Scheel oversees the planning, development and manufacturing of membrane systems for material separation. He therefore collaborates regularly with HZG's Institute of Polymer Research. His professional roots also lie in Geesthacht: just before his career move to SIHI, Scheel had completed his master's degree at the then GKSS at the end of the nineties and was extensively involved in membrane technology even at that early stage.

Photos: ©HZG/Christian Schmid

The membrane systems are manufactured as the customer requests. HZG polymer researchers optimize the membranes and support the search for solutions.

We were also collaboration partners in a research project supported by the Federal Ministry of Education and Research called “Mixed Matrix Membranes for Gas Separation”. In basic experiments, the HZG observed that membrane selectivity increases when activated carbon is mixed in the membrane polymer. Within the context of the BMBF project, we wished to determine, together with the TU Berlin and the activated carbon manufacturer Blücher, to what extent this effect could be implemented in an industrial pilot plant. Our part consisted of calculating the process and testing it at an industrial firm.

What were the results of this project?

The results actually showed that certain hydrocarbons can better be separated from each other than with conventional membranes. For example, higher hydrocarbons such as butane can in principle be separated more effectively from a gas mixture to obtain a gas with the highest amount of methane for combustion in a gas engine. You do, however, need relatively high pressures for this, something that limits the field of application at present. But should an area of application be found, we would be very interested as a company in utilising these new membranes in our systems.

In your view, where do the future markets for membrane technology lie? What could be possible with the new, improved membranes?

We're always essentially searching for new fields of applications for our systems. There are, for example, materials that cannot be separated using current membranes because they simply dissolve the polymers. In this regard, we’re hoping for developments that would make the membranes more stable – then we could also separate components that still cannot be processed today. It would also be interesting if we could make the membranes more stable with regard to temperature and pressure. Here we also hope for vital inspiration in the future from the Institute of Polymer Research in Geesthacht.

The interview was conducted by science journalist and physicist Frank Grotelüschen in the production hall of Flowserve SIHI.

You can find more interviews online:

www.hzg.de/interviews

Ten Litres of Snow and Twenty-Four Hours of Air: Research in the Arctic

July 2018. The sea is calm. Everyone is going about their business on board. We're in the laboratory of a research ship. Suddenly there are shouts, and many people run on deck. Finally, after more than two weeks, the POLARSTERN is surrounded by ice. Then everything becomes very calm. Only the sound of the ice breaking apart can be heard as we move through slowly. It is a moment of awe for everyone.

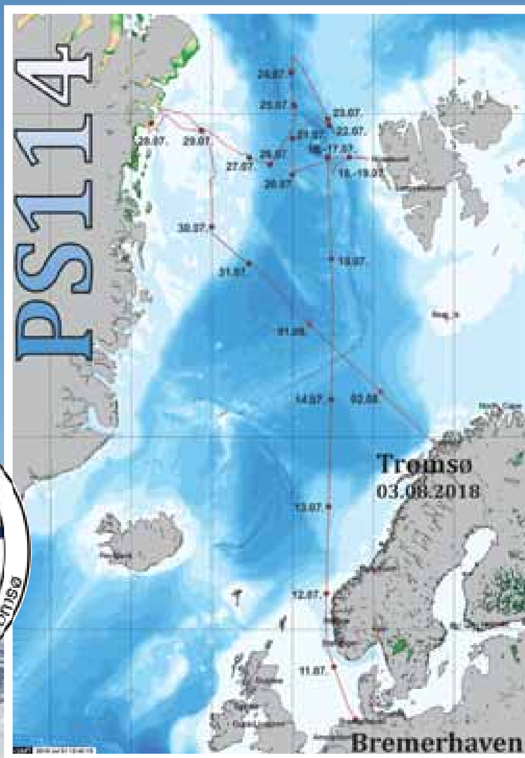
An expedition report by Hanna Joerss and Zhiyong Xie; transcribed by Gesa Seidel (HZG).

About

Dr Zhiyong Xie is involved in the study of biogeochemical cycling of classic and emerging organic pollutants in the coastal, oceanic and polar ecosystems. He moved to Germany in 2002 after studying analytical chemistry in China. Xie successfully earned his doctorate in 2005 at the HZG. Since then he has been employed as a scientist in the Department for Environmental Chemistry at the Institute of Coastal Research. Expeditions to remote areas are part of life for him as a scientist: 2018 marks his fourth time to the Arctic on the POLARSTERN.

10th of July. The day had finally come. The PS 114 expedition began in Bremerhaven aboard the German research vessel POLARSTERN. We stood on the ship deck and watched the people on land grow smaller. After a long period of preparation for the journey and the numerous bureaucratic details that needed to be taken care of, it seemed almost unreal – but then you realise: here we go.

The POLARSTERN belongs to the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). In the beginning, we had to cover quite a distance. We travelled past Norway, initially in the direction of Spitsbergen. The research area we aimed to reach was the Fram Strait between Spitsbergen and Greenland.



©AWI

About

Hanna Joerss is currently working on her doctorate at the Institute of Coastal Research in the Department for Environmental Chemistry. The 31-year-old's research topic concerns per- and polyfluoroalkyl substances. Before she came to Geesthacht in 2016, she completed her studies in food chemistry at the University of Münster and took her second state examination as a food chemist. She then worked for two years in an analytical laboratory focussing on ultratrace analysis of pollutants. This expedition to the Arctic was the first for Hanna Joerss.

The subject of our research. The aim of our journey was to study the occurrence, distribution and fate of emerging organic pollutants along potential transport pathways, from the European continent to the Arctic. To do so, we collected water, air and snow samples. Long-living and slowly degradable chemical compounds are called persistent organic pollutants or POPs. These environmentally hazardous chemicals are regulated in the Stockholm Convention, which came into force in 2004 and was ratified by 182 parties. Production and use of some substances is restricted in the convention, and others are completely banned. In addition to the regulated "classic" pollutants, new contaminants are always appearing. These, for example, can be substances that are introduced into the market by the industry to replace prohibited materials, or those that can only be definitively determined by using new analytical methods and novel sampling strategy after the substances have entered the environment.

To be included in the Stockholm Convention, substances must meet the following criteria: they must be persistent; bioaccumulative and toxic; and transport over long distances. Our results on the occurrence of emerging problem substances in remote regions can be integrated into the assessment as to whether they should be included in the Stockholm Convention or whether they should otherwise be regulated by law.

©HZG/Zhiyong Xie

©HZG/Hanna Joerss

The samples are processed in the laboratory.

Hanna Joerss:
That was pretty exciting. It was the first big expedition for me. So far, I've always sailed with the HZG's ship, the LUDWIG PRANDTL. The large POLARSTERN, in contrast, seemed like a floating village to me. I'm happy that Zhiyong was there. He already knew the ship and could point out and explain a lot to me.

©HZG/Hanna Joerss

We also ask ourselves how climate change impacts pollution. When the ice melts in the polar regions, contaminants that were previously stored within the ice can be released. What routes they take, however, is still unclear. That is why we have taken water, air and snow samples.

Water samples. Two types of water samples were important for us: one was the surface water, which is well established. The POLARSTERN has a pump under the keel that can draw the water directly into our laboratory. The pipes are made of stainless steel so as to avoid contamination. Using a rosette water sampler, seawater can be obtained from varying water depths. The sample containers, which are initially open, close at different depths and sample the water at those locations. We took samples at six stations on the journey and from ten different depths at each station: ranging from near the seafloor, which in some locations is more than three thousand metres deep, up to surface waters.

Taking samples from the air. Atmospheric transport plays a considerable role for volatile chemicals. Air samples are therefore also vital for us. We brought two devices with us on board and installed them up on the top deck. There they run continuously, taking samples during the entire journey. Within the devices is an adsorption material to trap the pollutants. The air flows through for twenty-four hours, then Zhiyong changes the sample. The samples are stored at -20°C as we can only fully analyse them in Geesthacht.

Air sampling on the top deck.

Zhiyong Xie:

Even if I've already taken part in several expeditions, each trip is incredibly exciting. At the same time, it was lovely to gain new insights about the Arctic on a familiar ship. I really look forward to sharing my experience with other scientists from all over the world.

RV *POLARSTERN*

Length: 118 metres
Width: 25 metres
Cruising speed: 10.5 knots
Maximum draught: 11.20 metres
Range: 19,000 nautical miles / 80 days
Personnel: Up to 55 researchers and 43 crew members
Area of Operation: Arctic and Antarctic Waters
Lead time for travel suggestions: 3-4 years

The research ship RV POLARSTERN has been designed especially for polar research. The fields of biology, geology, geophysics, glaciology, chemistry, oceanography and meteorology can therefore be covered. The Federal Ministry of Education and Research (BMBF) owns the ship and the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven operates the vessel.

More information on the POLARSTERN and other German research vessels can be found here:
www.portal-forschungsschiffe.de


©AWI/M.Hoppmann

Hanna Joerss: “It was an overwhelming moment when we were surrounded by the ice for the first time. When the POLARSTERN breaks the ice and it begins to crack, you hear and sense the power of this ship.”

At last – snow sampling. Pack ice. Everywhere. It’s unbelievable how many different colours ice can take. It was very foggy on many days and you could barely see anything. On a few days, the sun was shining all the more brightly from the blue sky. Visibility was especially critical when Zhiyong was taking snow samples. Despite the foggy weather over a long period of time, we could take snow samples from four stations.

The principle always remains the same: we need to fill a steel bucket with ten litres snow. The question is always simply: how do we get from the ship to the snow?

One day we merely travelled in a small boat to one location where we could get onto the ice easily and therefore could get to the snow. Twice, we used what is known as the mummy chair to reach the snow. The mummy chair is nothing but a box in which people can be transported. It is lifted overboard with a crane and placed on the ground safely. One of the two people must then be secured by rope and get out to take the snow sample about ten metres away from the location, as we want to avoid contaminating the sample. The other person remains in the box, keeping an eye on the surroundings.

The 28th of July was a very special day. We were on the coast of Greenland and after weeks of struggling in the fog, the sun came out – we could take a helicopter ride!

For us that meant detailed safety instruction, putting on survival suits, oxygen vests, helmets – and then off we went. On board there are two helicopters; a second is always ready to go in case of emergency. We had ten minutes time to fill our buckets with snow at our station on the sea ice. The helicopter engines were running, so we needed to walk about one hundred metres to avoid contamination. Then it was already time to head back.

©HZG/Hanna Joerss

The mummy chair in operation.

Helicopter flights are only possible during highest visibility.

Back on board, we could enjoy the view of the impressive glaciers along Greenland's cliffs – we could even observe a polar bear, a walrus and a whale. It's amazing to see how everything seems to be in harmony here.

Laboratory work on a ship. There are various laboratories on the POLARSTERN: for example, wet lab, dry lab and chemistry lab. These rooms, however, don't resemble those laboratories we find at our research facilities. On board, they are completely empty, as the laboratories can be equipped according to research needs. This means that each group carefully considers beforehand what equipment and other resources they require on the expedition. These articles naturally include sampling vessels, pipettes and similar devices, but also consumables such as gloves, paper towels and other items. We packed twenty-nine boxes altogether at the HZG and loaded them onto the POLARSTERN. In the laboratory, we then unpacked what we needed at the time and, most importantly, fastened everything down. We were lucky in that we encountered relatively calm seas during the entire trip so we were able to get good work done.

The journey home. Then it was all over on the 3rd of August – our adventure ended in Tromsø, Norway. We packed all of our samples well – the snow and air samples even at -20°C. They remained on the POLARSTERN until the ship returned to Bremerhaven in mid-October. We could then unpack our twenty-nine boxes and begin investigating and analysing.

One day on the *POLARSTERN:*

07:30	Breakfast
07:50	Weather briefing
	Sampling / laboratory work
12:00	Lunch
	Sampling / laboratory work
15:30	Coffee break
	Sampling / laboratory work
17:30	Dinner
	Science Meeting
	Sampling / laboratory work

You see, you never get bored on the ship – the days here are completely structured. You work around the clock. When we arrived at a certain measurement station, we needed to take samples even if it was 2 AM. It’s unusual for us that it’s light during both day and night, so you don’t think that much about sleeping. There are also many events to provide structure to our days. Each evening we held a “science meeting”. The expedition’s chief scientist provided the news of the day; we talked about the weather forecasts for the following day, and every evening a different group discussed their project. It’s really exciting. There were forty-seven scientists on board and we do research in very different fields. We, however, don't take only scientific input with us, as we're all coming from the most varying countries and cultures. It was great to meet the people we have: an oceanographer from Mexico who could write backwards, a helicopter technician from Spain who is also a sports enthusiast, a weather technician from the former GDR who told us about how he experienced German unification from the Antarctic – just to name a few.

After the nearly four-week journey, the samples and data must now be analysed. This means months of work in the laboratory, analyses and calculations. The results that Zhiyong Xie and Hanna Joerss obtained and whether they could detect pollutants in the Arctic will be covered in the next issue of In2Science.

©HZG/Hanna Joerss

Iron catchers in action

HZG researchers are making progress in the development of a magnesium battery

Mikhail Zheludkevich picks up a metal block of magnesium. Its surface is visibly corroded, rough and porous like a sponge. “We tested this block as an electrode in sea water for 24 hours,” says Zheludkevich, head of the Department of Corrosion and Surface Engineering at the Helmholtz-Zentrum Geesthacht and professor at the University of Kiel. “After that, it displayed this clearly visible corrosion damage.” The chemist then takes another, equally-sized magnesium electrode - it looks new. “This one was in our electrochemical test rig for one week and shows little damage.” The reason for the difference lies in special additives, which the researchers added to the salt water: The additives prevent the corrosion of magnesium. This new process is a significant advance towards an interesting type of battery - the magnesium battery.

“Essentially, it is an old type of battery. It has been around for more than 100 years,” explains Zheludkevich. “In principle, its advantages are high storage capacities and power densities. On top of that, the concept is simple and robust.” Because the anode - the negative pole of the battery - is made of normal magnesium, sea water can act as an ordinary electrolyte. However, the concept shows one drawback that has hindered its widespread use so far: during operation, the magnesium anodes corrode too quickly, which greatly reduces battery performance and durability.

Iron specifically contributes to this process. It is a common magnesium impurity which acts as a veritable corrosion accelerator. “Even the tiniest quantity of iron suffices to drastically accelerate the dissolution of magnesium,” emphasises Zheludkevich. When the iron is released, it can coat the surface of the magnesium - experts refer to this process as redeposition.

Prof Mikhail Zheludkevich leads the Corrosion and Surface Technology Department at the Magnesium Innovation Centre MagIC.

Even the tiniest quantity of iron suffices to drastically accelerate the dissolution of magnesium.

Mikhail Zheludkevich and his team carry out series of tests in his laboratory on the third floor of the Magnesium Innovation Centre.

But how can this phenomenon be curbed and possibly be prevented? To address this, experts add small amounts of additives to the electrolytes. These additives act as regular iron chelators, preventing re-deposition of the iron, thereby removing one of the major corrosion culprits. “Originally, we had developed such additives as corrosion protection for lightweight magnesium alloy materials,” explains the Belarusian-born scientist. “That sparked the idea of transferring the concept to the development of magnesium batteries - a transfer of knowledge from one field to another.” To achieve this goal, the team had to adapt the additives to batteries and study their effects in detail in the laboratory.

Here, Mikhail Zheludkevich points to containers filled with salt water, in which wired electrodes are immersed - systematic test series, which sometimes take weeks to perform. At a testing facility next door, the team is examining these pivotal processes on a microscale: electrodes in the micrometre diameter range scan material samples, recording current flows and pH levels. “This is a very unique technique that combines different detection methods and allows us to record several measurement variables simultaneously,” explains Zheludkevich. “This gives us a detailed picture of what happens on the electrode surface. A type of high-resolution map of the sample surface.”

The results are promising and have recently been described by the working group in an article published in the prestigious scientific journal *Scientific Reports*. A mixture of two different additives turned out to be particularly promising: in addition to the “iron chelators”, a second type of additive prevents the formation of a harmful layer of magnesium hydroxide. “By combining these two approaches, we were able to dramatically improve battery performance, efficiency and durability,” says Zheludkevich.

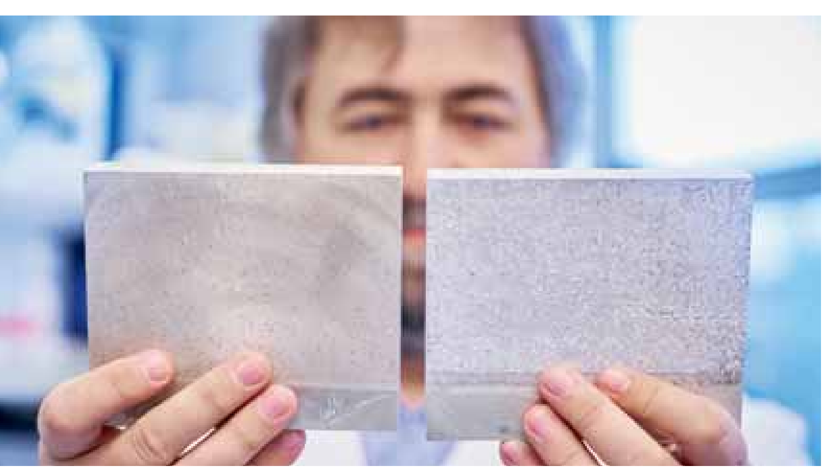
The first application of these novel findings may well be in the depth of the ocean - as a power supply for autonomous monitoring systems in oil and gas production or for scientific measuring stations. Lithium batteries are currently used for these applications, but they are expensive and not always reliable. Magnesium batteries promise significant advantages over lithium batteries: since sea water is an abundant electrolyte, this novel technology should be much more robust and more affordable.

Experts now want to develop a working prototype for deep-sea deployment within the framework of the EU MarTERA programme. The recently approved project "SeaMag" (High-Performance Sea Water Magnesium Batteries for Marine Application) aims to build a battery with a capacity of 25-kilowatt hours, which lasts at least five years. In addition to the Helmholtz-Zentrum Geesthacht and the Hamburg-based company develogic GmbH, industry partners and research institutes from Norway and Belarus are also involved in this three-year project.

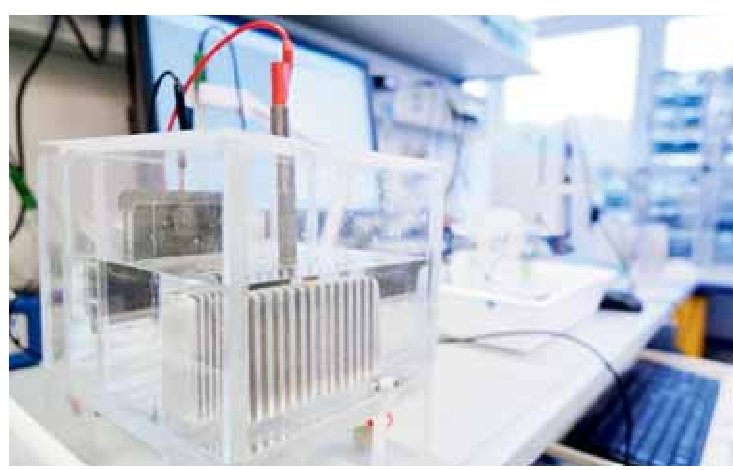
And there are additional ideas for other applications down the line: as energy boxes conceivable for deployment in disaster situations, when power supply has been disrupted by an earthquake for example. A magnesium cell would simply require salt water to be poured over it to provide ample power. Potentially novel applications can also be conceived for electric vehicles: instead of recharging conventional lithium batteries with a cable as we do today, the battery could be refreshed simply by replacing the magnesium anode - this clearly is a much faster process. “These anodes could also be manufactured using the excess power produced from wind farms and solar plants and therefore have a positive impact on climate change,” says Mikhail Zheludkevich. “And unlike lithium, magnesium is distributed evenly around the globe, making it available to everyone.”

Author: Frank Grotelüschen

This is a very unique technique that combines different detection methods and allows us to record several measurement variables simultaneously.



The comparison shows that the electrode without additives on the right displays corrosion damage – the left electrode, in contrast, looks like new.



Due to the lamellar structure, this electrode clearly possesses a considerably larger surface.

Limiting Global Warming to 1.5°C – The World's One-time Chance

The Special Report on Global Warming of 1.5°C (SR15) brings everyone up to date: limiting warming to 1.5°C is technically feasible, but will require unprecedented changes. Nine colleagues from the Climate Service Center Germany (GERICS), an organisational entity of HZG based in Hamburg, have contributed in various capacities to the report.

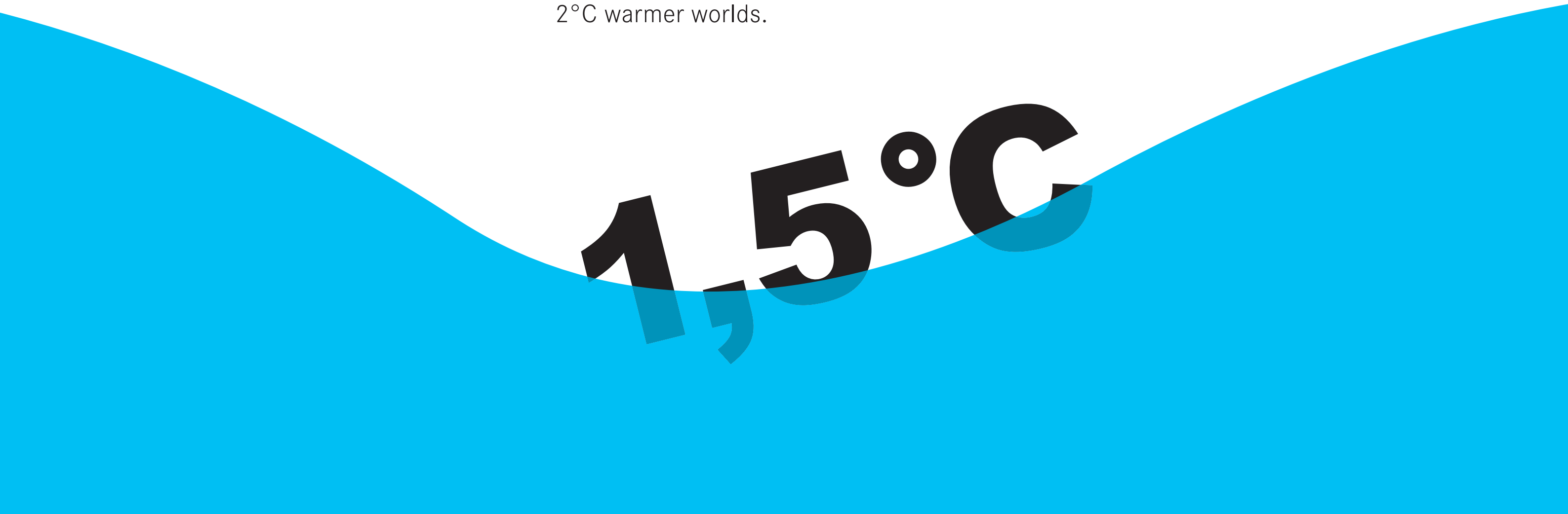
Prof Daniela Jacob, director of the Climate Service Center Germany, GERICS, played a significant role in the development of the report. As the only German coordinating lead author, she helped coordinate Chapter 3, "Impacts of 1.5°C of Global Warming on Natural and Human Systems", together with colleagues from Jamaica and Australia. Fifteen lead authors and seventy contributing authors were involved in the preparation of the chapter.

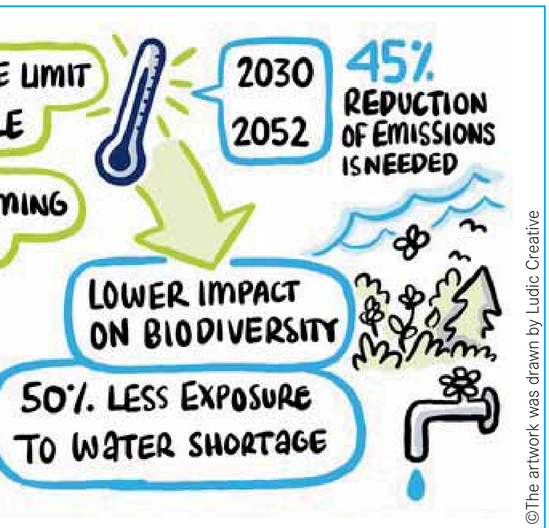
SR1.5 summarises the up-to-date knowledge gathered from the literature and describes how limiting global warming to 1.5°C can be achieved, and what the projected risks are. The experts convened in South Korea in October 2018, and the government representatives of the Intergovernmental Panel on Climate Change (IPCC) approved SR1.5 amidst tremendous public attention.

Prof Daniela Jacob and GERICS staff member Tania Guillén were actively involved in the approval session in Korea. Commenting on the SR1.5 proceedings, Daniela Jacob stated, "The world experienced a historical week in Korea. The adoption of the report represents a unique opportunity. It shows that a 1.5°C limit in global warming is feasible and that the risks for humans and nature can be considerably reduced."

In 2015, the Paris Climate Agreement had already officially recognised that the consequences of climate change, such as droughts and sea level rise, are especially a threat to poorer nations. Following this, the Conference of the Parties (COP21) of the UN Framework Convention on Climate Change (UNFCCC) invited the IPCC to prepare SR1.5. The report therefore first arose from the wishes of the parties in the UNFCCC, where it was hoped that the SR1.5 would elucidate the risks and opportunities that may exist in 1.5°C and 2°C warmer worlds.

The SR1.5 now provides participants of the next Conference of the Parties (COP24) of the UNFCCC a basis for discussion. The meeting took place beginning 2 December in the Polish city of Katowice. Among other topics, it is to constructively impact what is known as the "Talanoa dialogue". This dialogue serves to revise national climate plans previously presented by the countries to the UNFCCC. The report's scientific findings could therefore directly influence national climate policy decisions.





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Daniela Jacob presented the IPCC Special Report on 1.5°C Global Warming in Belgrade at the Climate Europe Festival 2018 in October. This is a sketched summary of the presentation.

> **Daniela Jacob:**
> **The world experienced a historical week in Korea. The adoption of the report represents a unique opportunity. It shows that a 1.5°C limit in global warming is feasible and that the risks for humans and nature can be considerably reduced.**

One of the most important statements in SR15 is that it is technically feasible to limit global warming to 1.5°C, but would mean unprecedented changes for humanity. However, all the scenarios described in SR1.5 show that in addition to a significant reduction in greenhouse gases, carbon dioxide must also be directly removed from the atmosphere. This means that ”negative emissions“ are necessary, which include, for example, reforestation, or technical and/or chemical CO_2 storage. The longer it takes for efficient climate mitigation measures to be implemented, the more heavily we will rely on the success of these technologies to achieve the climate goals set in Paris. These technologies, however, are still under development.

2°C

2°C is too high

A further important statement in SR1.5 is that there is a considerable difference in the impacts between a 1.5°C or 2°C warmer world. Daniela Jacob explains, “Never before has the scientific evidence for the impacts that climate change has already had, and what may await us in 1.5°C or 2°C warmer worlds, been so clearly confirmed. Until now, we researchers didn’t know exactly how different the risks between 1.5°C and 2°C worlds actually would be.”

For example, the report shows that at 1.5°C warming, global mean sea level rise is projected to be 10 cm lower than at 2°C, and as a result ten million fewer people living in coastal areas would be directly affected. Limiting global warming to 1.5°C, rather than 2°C, would expose several hundred million fewer people to climate risks and the associated threat of poverty. A further example can be seen in fish nurseries – the large warm-water coral reefs – that would shrink by nearly one hundred per cent at 2°C warming. At least a portion would survive at 1.5°C.

Tania Guillén adds, "The special report confirms the need to take immediate and ambitious action to mitigate climate change so as to avoid increasing negative impacts on numerous human and natural systems. It also highlights the need to develop and implement adaptation measures to face current impacts and future risks, for which developing climate services at different stages is crucial."

What each individual can do is well known and does not necessarily mean sacrifice, but rather it can also mean an increase in quality of life. We can, for example, purchase regional products when shopping, consider cycling more often or using public transportation, and also consider whether the use of technology such as videoconferencing can reduce the need to travel.

Daniela Jacob points out: "What is in high demand are creative ideas, innovative and dynamic concepts, good coordination and positive attitudes to reduce climate change together and to create a shift toward a sustainable lifestyle, which also reduces poverty, combats dangers and equalises development opportunities."

Author: Heidrun Hillen

About:

Prof. Dr. Daniela Jacob

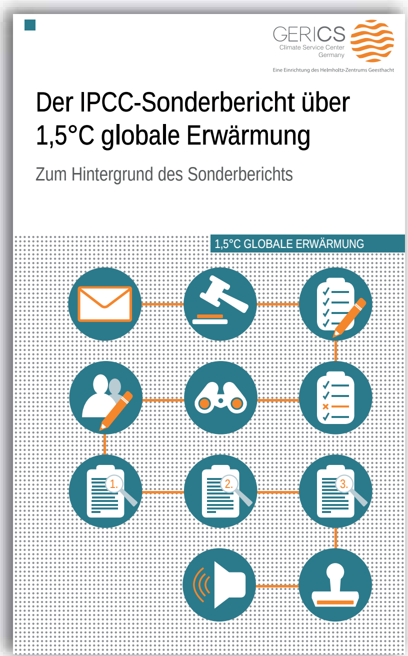
Prof Daniela Jacob is director of the Climate Service Center Germany (GERICS) and guest professor at Leuphana University in Lüneburg. She is one of the coordinating lead authors of the Special Report on Global Warming of 1.5°C (SR1.5). She has organised endeavours such as the international research project IMPACT2C, which studied the impacts of 2°C Celsius global warming on different sectors. She serves on several committees and is ex officio member of the "Earth League", an international alliance of prominent scientists. Daniela Jacob is also editor-in-chief of the journal *Climate Services*, published by Elsevier.

About:

Tania Guillén Bolaños

In addition to her work for the IPCC's Special Report on Global Warming of 1.5°C (SR1.5), Tania Guillén Bolaños supports GERICS activities in regard to the implementation of climate policy tools. She was previously a recipient of the Alexander von Humboldt Foundation's International Climate Protection Fellowship for Young Climate Experts from Developing Countries. She graduated from the Central American University (UCA) in Nicaragua in environmental engineering and completed her master's degree in "Technology and Resource Management in the Tropics and Sub Tropics" at the TH Köln.

IPCC (Intergovernmental Panel on Climate Change)



Information on GERICS activities pertaining to the Special Report on Global Warming of 1.5°C are compiled here:
www.gerics.de/IPCC-SR1.5

We asked HZG scientists:
What are your hopes in your research field for 2019?

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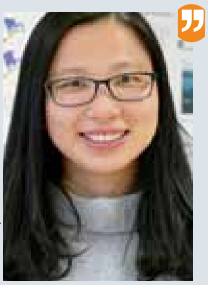
Prof Benjamin Klusemann
(Institute of Materials Research)

New challenges and opportunities are arising for me as a result of my upcoming transfer to the Department Solid State Joining Processes. In addition to the increased activities in the experimental field of solid state processing and related process simulations, I hope to be able to look intensively into the mechanisms at the microscale in the future in order to understand why the material behaves in such a way during the processes as we observe it experimentally. Here I hope to develop models that provide meaningful predictions in regard to experimental results so that they can subsequently be used for the experiment in a beneficial way. In addition, I hope that we can establish a new process in the department in 2019 that will facilitate new strategic partnerships on the one hand, while on the other, new interesting questions arise in regard to materials process development in following years.



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Dr Feifei Liu
(Institute of Coastal Research)

I am a postdoc working on North Atlantic and Arctic ecosystem dynamics, particularly decadal prediction. This means I am trying to understand how the lower level trophic system will behave in those regions in the coming years, even up to the next decade if we know the current status of the system, for instance, the nutrient distribution and the primary production, which serve as the foundation for the entire food chain in marine ecosystems. A question like this can be investigated by numerical decadal prediction experiments. Through my work, together with collaboration with other colleagues, I hope in 2019 we can achieve the goal of learning whether variations in the North Atlantic and Arctic ecosystems can be depicted in decadal prediction simulations. And if so, to what extent is the ecosystem predictable?

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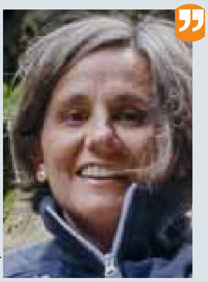
Dr Armin Aulinger
(Institute of Coastal Research)

My main wish is for my research to be taken seriously and that the results will be discussed critically. A model is always a simplification of a complex reality and can never provide one hundred per cent accurate predictions. Models nevertheless provide us with insights into possible future scenarios and furnish us with information on how we can influence this future in one way or another. I would also like to see my results on atmospheric pollution viewed in an overall context with other pressures on humankind and the planet. I believe that environmental protection measures often have a synergistic relationship with other measures, and I'd find it unfortunate if these were pitted against each other. Environmental research makes sense for me only if it leads to sustainable improvement in human living conditions, or at least prevents these conditions from worsening.



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Dr María Máñez Costa
(Climate Service Center Germany)

My special wishes for 2019 are related to the capability of advancing science for adaptation to climate change. In some cases, this requires an increased input on capacity development to be able to understand adaptation needs society might face and also to co-design adaptation pathways society wishes to follow to become more resilient. This will imply further development of modelling capabilities in order to incorporate the best climate science available in the decision making processes. 2018 has shown us that some possible impacts of climate change, such as the long dry summer in northern Europe, will pose an extra burden on institutions and governance structures. I hope to be able to give some insight on how to accurately respond to such “unknown risks”.

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