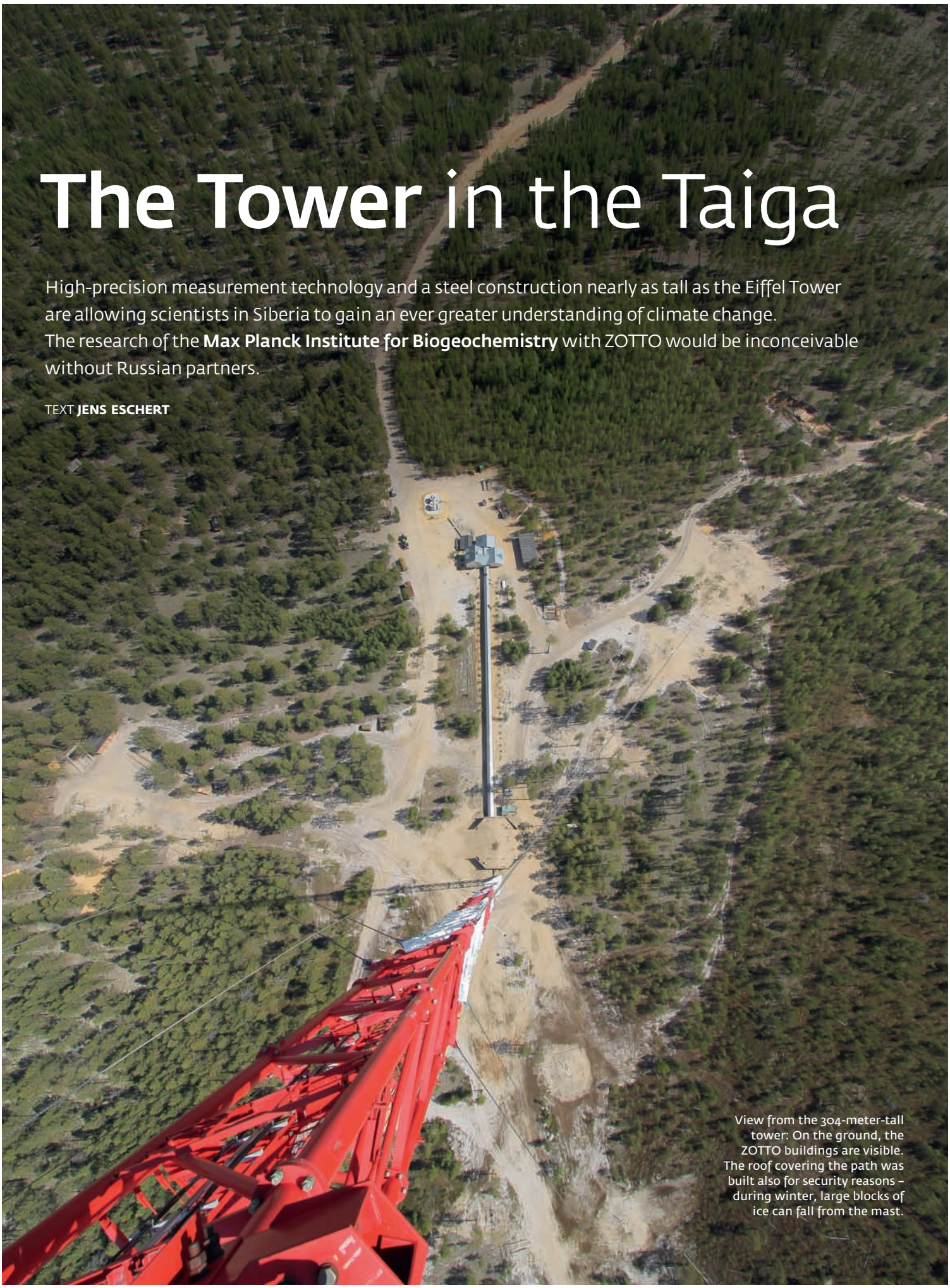
The Tower in the Taiga

High-precision measurement technology and a steel construction nearly as tall as the Eiffel Tower are allowing scientists in Siberia to gain an ever greater understanding of climate change. The research of the **Max Planck Institute for Biogeochemistry** with ZOTTO would be inconceivable without Russian partners.

TEXT **JENS ESCHERT**



View from the 304-meter-tall tower: On the ground, the ZOTTO buildings are visible. The roof covering the path was built also for security reasons – during winter, large blocks of ice can fall from the mast.

The mighty Ural truck carries him piggy-back up the last stretch, lumbering over dirt tracks – trails in the Siberian wilderness. The fact that it takes the vehicle a full one and a half hours for the barely 20-kilometer journey into the depths of the taiga has long since ceased to bother Jošt Lavrič. After all, the Group Leader from the Max Planck Institute for Biogeochemistry in Jena has already been on the road for three days as his longest business trip now approaches its goal: ZOTTO, or the *Zotino Tall Tower Observatory,* named after the nearest town, Zotino.

There, scientists use a 304-meter-tall tower to continuously measure the amount of greenhouse and other trace gases and aerosols in the atmosphere. "Of course it's a strain, no doubt about it. But the research we can carry out there with our Russian partners is crucial to understanding the mechanisms and consequences of climate change," says Lavrič, a geochemist.

The boreal and arctic land masses of Siberia are, after all, a so-called hotspot – a place that has a relatively strong influence on the global climate and, at the same time, where the effects of change can have a particularly strong impact. "Such locations show very clearly that the entire climate system, with all of its factors, is dependent on both positive and negative feedback," says Lavrič.

To name one example: The Siberian coniferous forests comprise around 10 percent of the carbon stored in vegetation and soils worldwide. In addition, more than half of the Siberian forests are located in the permafrost, where, in turn, massive amounts of carbon are stored. And it is a known fact that the average temperature in large parts of Siberia in summer has risen by up to 2 degrees Celsius in the past 45 years.

"But then there are many unanswered questions – such as how the temperature increase affects the carbon sinks in the region: Does the warming climate lead to additional carbon storage in more rapidly growing forests due to longer vegetation periods? Or is more soil carbon released to the atmosphere due to faster microbial decomposition," asks Jošt Lavrič.

Because of its special location, the ZOTTO tower, which was jointly constructed by the Max Planck Institute for Biogeochemistry and the partners from the Sukachev Institute of Forest of the Russian Academy of Sciences, takes measurements at six different altitudes. The first sensors are below the treetops. "This allows us to better understand and describe the local signals," says Lavrič.

UNDERSTANDING A HOTSPOT OF GLOBAL CLIMATE PROCESSES

But because the researchers are interested in the interactions with the atmosphere and the processes that occur there, they had to set their sights quite high: one has to go up to an altitude of about 300 meters to reach air layers that are free from local influences and permit conclusions regarding climate processes of much larger regions. It is this spectrum of high-precision measurements of greenhouse gases such as carbon dioxide and methane, but also of the oxygen content and general meteorological indicators, that offer research the decisive extra value.

To even more accurately detect the influence of the vegetation in the interaction with the atmosphere, the scientists from the institute in Jena additionally set up two small sibling towers in the taiga in recent years. These register the so-called carbon fluxes of the forests and of the swamp areas. "The two measurement approaches – that of the large tower and that of the smaller stations – complement each other. Taking all of the data together gives us a detailed picture and can put the local processes in a larger context," says Lavrič.

ZOTTO has been in operation since 2006. The first studies have been published, providing facts that replace the earlier suppositions. For instance, the question of whether the Siberian forests are, on annual average, rather a source of carbon or a carbon sink, or in other words, whether they take up more carbon than they release: "The data shows that the picture varies. When summers are very dry, the vegetation activity can slow down so much that almost no more photosynthesis takes place. If this is then compounded by fires, we see special effects that have a major impact," says Lavrič.

But there are also other years in which the forests contribute to a positive annual result, or in other words, when they store more carbon than they release. "The longer the recordings run, the smaller the error indicators in this calculation become," says the researcher.

And that is the scientific core of the high-precision measurements: The numbers illustrate concrete climate situations. For the modelers trying out the widely varying scenarios, this is important information. After all, this is what makes it possible to better describe the causes of climate change, forecasts become more precise. That is why stationary atmosphere monitoring has become established around the world, more and more stations are being built. The goal is to create a global measurement network that covers all relevant regions of the world.

This is a task for the entire community, and the Max Planck Institute for Biogeochemistry is involved. The Jena-based institute recently commissioned an observatory in Namibia, and Jošt Lavrič's group, which belongs to Max Planck Director Martin Heimann's department, runs a total of five measurement stations worldwide.

Another Max Planck project, the construction of ATTO, a similarly tall tower in the Amazonas region, is being

Photo: MPI for Biogeochemistry – Michael Hielscher

In the Siberian wilderness: The ZOTTO tall tower station is located about 600 kilometers northwest of Krasnoyarsk. Technicians and scientists of the Max Planck Institute for Biogeochemistry go there twice a year on working campaigns. On such occasions they meet their Russian partners – as here in the group picture taken in the summer 2012.

headed by the Max Planck Institute for Chemistry in Mainz. Together with the Max Planck Institute for Meteorology in Hamburg and the Potsdam Institute for Climate Impact Research, these institutes make up the core of the Earth System Research Partnership (ESRP) and form international networks with leading research institutes.

ZOTTO is a German-Russian project of the International Science and Technology Center (ISTC). The groundwork was financed largely by the Max Planck Society, but both sides are now involved in the operation. "Our research would be inconceivable without local partners," stresses Lavrič – already because the team from his group or the institute engineers working with Olaf Kolle can seldom be on site. The Russian partners from the Institute of Forest, in contrast, are permanently at the station. They conduct their own research, but they also maintain the measuring instruments and ensure, for instance, that the diesel generators supply constant electricity for continuous delivery of the measurement data. The scientists in Jena then retrieve the data via a server in Krasnoyarsk.

NEW COLLABORATIVE PROJECTS WITH RUSSIAN EXPERTS

"We're over there no more than two or three times per year," says Lavrič, but he is regularly in touch with the coordinator at the Institute of Forest, Alexey Panov. There are also additional projects being conducted on the Russian side – such as an independent measuring station for detecting ozone locally, run by the Moscow Institute of Atmospheric Physics of the Russian Academy of Sciences.

According to Jošt Lavrič, there are additional plans for future collaborative projects. Beginning in summer, the group led by Mathias Göckede at the Max Planck Institute for Biogeochemistry will build a new observation station near Chersky, in northeastern Siberia. This region lies above a deep permafrost near the arctic tree line. In cooperation with the Northeast Scientific Station (NESS) of Sergey and Nikita Zimov, they will study how climate change impacts the immense carbon stores in this ecosystem.

This is about more than just rising temperatures: by systematically dewatering one part of the measurement area, they aim to record the influence of changes in the water cycle. Through this experiment, the researchers are essentially opening a "window to the future," allowing them to measure the suspected consequences of climate change now.

In fall of this year, Jošt Lavrič wants to once again take his team on his longest business trip. This will take him from Jena to Berlin, flying from there to Moscow, then another plane to Krasnoyarsk. There, Lavrič will transfer to a minibus and head north along the Yenisei River. After an overnight stay, he will then get on a speedboat that will take him on an eight-hour ride to the village of Zotino, where that final stage of the journey in the Ural truck begins.

No, he is not particularly looking forward to the trip itself. But then, actually being there – that is something special. Of course there is always a lot of strenuous work. This affects him and his colleagues alike, who in recent years had to lay cables through the middle of the swamp in order for the small measuring towers to be able to transmit their data to the station. "That is a feat in itself, with thick copper cables, especially in 30-degree heat, with insects everywhere," says Lavrič. The conditions were oppressive for him, too – but nevertheless: "The landscape is an absolute treasure. There, you experience an incredible sense of vastness." ◀

Photos: MPI for Biogeochemistry – Martin Heimann (above), MPI for Biogeochemistry – Steffen Schmidt (below)