Newsletter

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CzechGlobe

Global Change Research Institute CAS

CZECHGLOBE IN THE TIME OF CORONA VIRUS

It was supposed to be an exceptional year, not only for its magical number 2020, but also for the fact that GCRI commemorates ten years of the CzechGlobe Center of Excellence. We had been planning a number of events to celebrate this anniversary since June last year. But fate wanted it otherwise.

From the beginning of the year, we had been watching, from a seemingly safe distance, the situation in China, where a previously unknown virus began to spread and started to attack thousands of people with great force in a short time. At that time, the rest of the world was rather focused on burning Australia, where record breaking fires escalated after a spell of great drought. They left the local fauna immensely damaged as they killed almost a billion animals.

Nevertheless the worst for the whole world was yet to come… The worldwide COVID-19 pandemic came, which, according to experts, should have been expected, but it seems that no one could have anticipated it to such an extent. In connection with the spread of the epidemic, collective life in the Czech Republic (CR) and CzechGlobe came to a halt in mid-March, but event after event was cancelled already from the beginning of the month. In the second week of March, the internal annual conference of the SustES project took place, but then we "stayed at home" as the government's instructions and the motto of the past days advised. Fortunately, scientific work allows us to do some quality work even in the home office regime. In addition to that, the restrictions came at a time when projects are usually submitted to the GA CR, so from this point of view, researchers had more time to focus on writing their projects. In the end, we submitted 24 projects to the GA CR. Our colleagues joined the CAS initiative "Science at Home" and their two streamed lectures devoted to the effects of climate change and drought had over 30,000 views.

After two months, the anti-epidemiological measures began to loosen and everyone hopes that society will return to "normal mode" with some time.

The fact that COVID-19 is a global problem became evident on the state of the entire planet. In connection with the lockdown of factories in China's most affected region, emissions of NO_2 and CO_2 fell by 25%. A reduction in NO_2 was also recorded by the ESA satellite over northern Italy. Smog has been cleared in India, and in the United States such dramatic reductions in car traffic have reduced CO_2 emissions to the point that the United States would be able to meet and even exceed the goals of the Paris Climate Agreement. Almost zero air traffic in the world will certainly continue to contribute to the reduction of CO_2 emissions. So far, the data from the Hawaiian Mauna Loa observatory from the end of May have shown a new record of CO_2 concentration in the atmosphere. News related to such improvement in the environment would normally be very encouraging, but regrettably we cannot appreciate it so much in the current situation. The cost of hundreds of thousands of lives and gigantic economic losses is too high a toll. In addition, the global economic downturn and the ambition to get it started as quickly as possible may lead to some countries not having the desire and will to participate in the new EU "European Green Deal" strategy and to contribute to the sustainable transformation of the European economy so that Europe can reach climate neutrality in 2050. Due to these concerns, CzechGlobe researchers wrote an open letter to our political representation urging them not to overlook or reject commitments already made as well as efforts to mitigate and adapt to the causes of global climate change in a push to address the economic and social situation.

From January, the course of winter suggested that we could expect another drought this year. This manifested itself in full force already in April. Our colleagues from the InterSucho project issued a report in which they talk about a mega-drought that our country had not witnessed for more than 500 years. Over the last five years, the soil has been lacking an average of almost 500 mm of rainfall. Although rainfall in May and June at least mitigated surface drought and helped some farmers save their crops, hydrological drought continues to worsen. The torrential June rains, which caused devastating flash floods particularly in Central Moravia, and the subsequent persistent rains, which in several places in the CR raised river levels to flood levels and caused rivers to overflow their riverbeds, are not big game-changers either as far as drought is concerned. The long-awaited precipitation thus did more harm than good and mostly drained away. After six years, there is now enough water in the soil, but the hydrological drought still continues. Of course, the issue of drought has once again come to the forefront of political interest. At a time when 98% of the territory of the CR was affected by agricultural drought, the National Coalition for Combating Drought came together. Shortly before, the Ministry of Agriculture published a new plan presenting 31 new protected sites for the construction of water reservoirs in the future. This intention, provoked a sharp discussion among the supporters of the construction of water reservoirs and the promoters of the ecological solution of water retention in the landscape. Although the construction of some water reservoirs, primarily to provide drinking water in long drought-stricken areas, is basically not disputed, environmental experts, including colleagues from CzechGlobe, clearly believe that just water reservoirs do not solve the problem of drought and water retention in the landscape needs to be supported by focusing on the protection of agricultural land and the appropriate composition of forests. -mš-

Introducing the Department of Ecosystem Trace Gas Exchange

OUR RESEARCH IS A NEVER-ENDING CHALLENGE AND LIFE MISSION,

says Dr. rer. nat. Mgr. Kateřina Macháčová. She is the head of the Department of Ecosystem Trace Gas Exchange. She got her degree in Biology focusing on plant physiology at the Faculty of Science, Charles University in Prague. During her Master's degree, she spent a year in Germany at the Faculty of Biology, University of Freiburg. She completed her doctoral studies at the same university at the Faculty of Forest and Environmental Sciences. The theme of her doctoral thesis elaborated at the Chair of Tree Physiology was the research of emissions of methane (CH_4) and nitrous oxide (N_2O) as significant greenhouse gases from various tree species. Throughout her studies, she was a member of the Graduate School "Environment, Society and Global Change" belonging to the above-mentioned university, namely in the field of "Adapting Forest Ecosystems to Global Change". Since 2012 she has been working at the Global Change Research Institute (GCRI) of the CAS, first as a junior scientist and research assistant at the Laboratory of Ecological Plant Physiology, and since 2018 as the head of the newly established Department of Ecosystem Trace Gas Exchange. Kateřina Macháčová cooperates with foreign research institutions and universities and spends a significant part of the year on research stays abroad. She specializes in the study of the natural cycle of trace gases in forest ecosystems, i.e. gases occurring in the atmosphere in low concentrations.

With you joining CzechGlobe, you brought a new topic in the field of greenhouse gas fluxes research. To this point, as far as greenhouse gases are concerned, mainly CO_2 fluxes had been studied. How did you get to research this still rather new discipline during your studies?

Since 2008, my doctoral studies in Germany and the theme of my doctoral thesis have led me to a new, gradually emerging scientific field of research, i.e. into the fluxes of less known but important greenhouse gases CH_4 and N_2O from trees and forest ecosystems. At that time, globally, we were just a handful of enthusiastic scientists who were trying and are still trying to convince the general scientific community about the ability of trees when it comes to exchange of CH_4 and N_2O with the atmosphere, as well as the need to take into account the share of trees regarding CH_4 and N_2O forest balance estimates and greenhouse gas inventories. Unfortunately, this balance is often inaccurate and primarily based on long-term research of CH_4 and N_2O fluxes from the soil, i.e. between the soil surface and the atmosphere. However, woody plants are still very much neglected players in estimates of CH_4 and N_2O exchange in forest ecosystems, despite the fact that we already have a convincing body of scientific data adverting to the important role of trees in CH_4 and N_2O exchange with the atmosphere.

Over the years, the scientific community in our field has gradually expanded, and with it the measurement of CH_4 and N_2O fluxes from woody plants in forest ecosystems around the world is also increasing. These measurements are accompanied by detailed studies of the processes and mechanisms of production, consumption, transport, emissions and intake of these greenhouse gases within the entire soil - tree - ecosystem - atmosphere system. Seasonal changes in their fluxes and the influence of a number of environmental factors on these fluxes are also intensively studied. We find that the exchange of CH_4 and N_2O within the entire forest ecosystem is far more complex than we expected and involves a whole lot of processes running in parallel. The new scientific direction is thus slowly but surely becoming a life mission not only for one generation of enthusiastic scientists. I dare say that our new field of science has found its place in the scientific world.

How did you manage to progress your career and the field within CzechGlobe?

The successful defense of my doctoral thesis in 2012 opened a free scientific world for me and offered a lifelong sphere of action. In the same year, I joined the Global Change Research Institute, where it was possible for me to transfer my professional experience from Germany and establish my own new research topic on CH_4 and N_2O exchange by trees (and gradually also other important trace gases such as carbon dioxide, nitrogen dioxide and ammonia) within the Laboratory of Ecological Plant Physiology. To establish a new research direction required several years of demanding work associated with the gradual acquisition of funds and purchasing of the necessary instrumentation, the never-ending process of developing, testing and improving functional prototypes of our measuring systems, creating and modifying measuring methods and protocols. Of course, all this was connected with the development of existing international cooperation and the establishment and deepening of new cooperation with excellent scientists and research organizations, especially in Europe. Since 2013, my team and I have carried out a number of intensive measurements of the dynamics of CH_4 and N_2O fluxes in various tree species, soils and forests in the boreal, hemiboreal, temperate and tropical climate zones, which have brought valuable new findings.

In May 2018, a new Department of Ecosystem Trace Gas Exchange was established. This happened based on the convincing results, which we had managed to publish in prestigious journals. Although my position within the GCRI has changed and there are a lot more activities and tasks regarding the department management, nothing has changed as far as our research and the way we are working is concerned, and we continue pursuing our truly detective work with the same motivation and we always discover something new. Thanks to the new nature of the scientific field, there are always new things to be discovered. When conducting experiments, with every question answered there are a number of new questions waiting to be clarified. That is why our research is a never-ending challenge and our life mission.

What does the work on your experiments entail?

We focus on measuring gas fluxes directly in the field, i.e. directly in forest stands. We quantify CH_4 and N_2O fluxes from individual forest components (trees - trunk, leaf, root; soil; other vegetation; the whole ecosystem) and we study their temporal and spatial variability as well as the influence of environmental parameters on these fluxes. We estimate the forest balance of CH_4 and N_2O and the contribution of individual forest components to this balance. We determine whether the given ecosystem is, in the end, a source or a recipient

DEPARTMENT OF ECOSYSTEM TRACE GAS EXCHANGE

Within the GCRI organizational structure, the Department of Ecosystem Trace Gas Exchange is incorporated in the Domain of Environmental Effects on Terrestrial Ecosystems. It investigates the exchange of important greenhouse gases (GHGs) – methane (CH_4) and nitrous oxide (N_2O) – in different tree species and forest ecosystems of different climate zones and it seeks to clarify the role of woody plants in greenhouse gas exchange, which is key to provide correct estimates of the forest ecosystem balance of greenhouse gases and thus for the inventory of CH_4 and N_2O fluxes.
The department employs four researchers and one doctoral student.

of CH_4 and N_2O. Thanks to an interdisciplinary approach and the interconnection of various methods, we try to find in forest ecosystems the missing resources and recipients of the gases we study.
We study CH_4 and N_2O fluxes on adult subjects of various tree species, in soil and forest ecosystems. The principle of measuring the exchange of gaseous substances is the same for all forest components. For our measurement we use various types of static chamber systems, which we develop ourselves. For example, if we measure the gas exchange between a tree trunk and the atmosphere, we close parts of the trunk bark surface in the chamber. This results in a change in the concentration of gaseous substances in the air in the chamber. We are able to measure this concentration either with portable greenhouse gas analyzers directly in the field, or by taking gaseous samples from the system and subsequent analysis of such samples in the laboratory using a gas chromatograph. If an increasing concentration of a certain gaseous substance is detected in the chamber air, it means that the substance is emitted from the stem into the atmosphere, while a decreasing concentration indicates the uptake of the substance by the stem from the atmosphere.
Field measurements are followed by weeks and months of data processing and analyses, which lead us to acquire the flux speed of the substances we study within forest ecosystems. We then further evaluate the gas flux rates and relate the results to other studied parameters. We successfully publish the results of our research in prestigious journals such as *Nature Communications* and *Scientific Reports* belonging to the group of *Nature* journals.

What results have you achieved and how they can be used?

Our rather young scientific discipline is based on basic research in order to understand the natural fluxes of CH_4 and N_2O, their mechanisms, processes and dynamics, namely within forest ecosystems across geographical and climatic gradients. The outputs of our research will be used for accurate estimates of the greenhouse gas balance of forest ecosystems and thus for the inventory of greenhouse gas fluxes at the global level. In the future, our outputs will be able to be used to plan the planting of new forests with regard to changing environmental conditions, to establish and expand new protected areas and, for example, to address the issue of water pollution from agricultural activities. During my scientific work at GCRI, we have gained a number of new and unique findings. For example, we were the first to show that different tree species of the boreal, temperate and tropical zones can be not only significant emitters of CH_4 and N2O into the atmosphere, but also recipients of these greenhouse gases from the atmosphere. We do not yet know the mechanism of intake and the fate of the gases received, but we believe that what may lie behind the intake are photoautotrophic organisms living on the surface of trunk bark, such as algae, fungi, mosses and lichens, or microorganisms in plant tissues involved in the "consumption" of CH_4 and N_2O. We also found that, in addition to tree trunks, it is also foliage that plays a significant role in CH_4 and N_2O fluxes.

You mentioned an interdisciplinary approach. Based on what do you choose partners to cooperate?

We are the only team in the Czech Republic studying CH_4 and N_2O fluxes from woody plants. Other teams working in our field are spread across Europe and the world. We regularly meet at international conferences and scientific meetings and we develop and establish new international cooperation. These make it possible to study new forest ecosystems in various climatic zones and to involve other interdisciplinary approaches in the measurement, for example from the field of soil biology, hydrology and ecophysiology. It is the interconnection of narrowly specialized fields studying the given issue from their perspectives into one unit that will enable us to understand the cycle of trace gases in forest ecosystems in the future.
For our measurements we use various forest experimental stations of our cooperating partners in various countries. Due to the need for certain technical, infrastructural and methodological background and equipment of experimental stations (e.g. the presence of a system of stable towers for measurement in the crowns of adult trees) and the need for continuous measurement of necessary support parameters (environmental parameters, ecosystem fluxes of CH_4, N_2O and CO_2, other ecophysiological measurements) the selection of experimental stations is not easy. We lack suitable stations in certain forest ecosystems and climate zones. We therefore try to find and use suitable existing experimental stations at the international level and establish and deepen new international collaborations enriching our research with new measurement sites and new fields of expertise (e.g. close collaboration with soil biologists, hydrologists or atmospheric physicists) and in general with a new perspective on our issues.

After all that has been said above, it is clear that you attach great importance to international cooperation and this also reflects in the composition of the team…

Yes, our team at CzechGlobe is truly international. You will find colleagues from the University of Tartu (Estonia) and the University of Freiburg. We complement each other both on a human and professional and scientific level. We are experts in ecophysiology, soil biology, environmental technology and ecosystem exchange of greenhouse gases. In addition to the two institutions mentioned above, we cooperate with a number of other international scientific institutes and universities. I can name at least the University of La Réunion (France), the University of Helsinki (Finland), the Swedish University of Agricultural Sciences, the Federal Office and Research Center for Forests (Austria) and the Technical University of Munich (Germany). In addition to working on joint projects and experiments, we help motivated scientists from these institutions to establish similar measurements of CH_4 and N_2O exchange from trees in different types of forest ecosystems. Our help consists in transferring knowledge and experience, in lending our own developed measuring systems and in their installation and testing, we also help with data processing and evaluation of results. Our scientific community is also successfully expanding thanks to our leisure work in spreading awareness of our scientific field and through the organization of successful subject field sections (since 2016) at the annual international conference EGU (European Geosciences Union General Assembly) in Vienna. Thanks to these activities, more and more enthusiastic scientists are setting up measurements at their home experimental stations around the world. And our mission is to support these "newcomers" in their efforts in the name of science and to show them the way. And later on, to learn from them, too. This is the endless cycle of science….

FORESTS AND DROUGHT: HANGING BY A THREAD?

GOT OUR ATTENTION

Owing to the development of weather in recent years combined with the consequences of climate change, drought in the Czech Republic is becoming a more and more relevant problem. Increasingly, we can observe the effects of drought in the surrounding landscape. Not so long ago, the idea prevailed that especially native natural forest ecosystems have a relatively high degree of adaptability to both ongoing and expected climate change. However, a new study published in the journal *Science* (Brodribb T.J. et al. 2020) summarizing new findings on the general functioning of forest ecosystems have fundamentally changed this view.

Forest ecosystems absorb approximately one quarter of anthropogenic carbon dioxide (CO_2) emissions globally, and therefore any changes in their carbon storage capacity are important for the overall carbon balance. If this ability of forests is to be maintained, it must remain in good condition. Drought resistance in trees is determined by many interacting factors. From an evolutionary point of view, it is in principle a competition between better growth and better drought resistance. Therefore, for example, fast-growing plants naturally have greater water consumption and are more vulnerable to drought. We used to be rather optimistic regarding the growing resistance of plants to drought because in plants with the predominant type of metabolism, where the first intermediate of metabolism is sugar containing three carbon molecules and this metabolism occurs in up to 95% of plants, increasing CO_2 concentration allows to achieve a given rate of photosynthesis with less water loss due to a lower need to open stomata. In the last decade, however, this view has been gradually changed by findings about the influence of rising temperatures on the drying up of leaves and soil. It turns out that the positive effect of higher CO_2 concentration on plant water management is outweighed by the negative effect of increased evaporation due to higher temperature. Higher evaporation rates cause increasing tension in tree tissues (xylem). It is defined as a negative water potential. When its critical limit is reached, the water column is disrupted and the so-called cavitation occurs, i.e. air enters the xylem cells and the tissues are irreversibly damaged. Although not all trees die as a result of such an acute phase of drought, understanding the laws and critical limits of cavitation of different tree species explains their spatial distribution and mortality relatively well. Nevertheless, the consequences of acute drought may be seen in ecosystems for months and sometimes even years after its maximum effects have subsided. The authors of the new paper, where a tree growth model was used, showed that even a small change in the setting of the cuticular leakage parameter (Fig. 1) leads to diametrically different prognoses in the strength of carbon sink in forest ecosystems. On the assumption that stability of the protective layer of cells (cuticle) is temperature-dependent, tree mortality in warmer climate conditions can be up to twice as high as previously supposed. It seems that we will have to abandon the idea of "highly adaptable" natural ecosystems that can cope even with a rapid climate change. After all, the relatively massive deaths of so far mainly economic and monocultural even-aged spruce, pine and other forest stands are a warning signal that the resistance of plants has been overestimated. This paper again demonstrates how important it is to mitigate climate change, i.e. to reduce anthropogenic greenhouse gas emissions.

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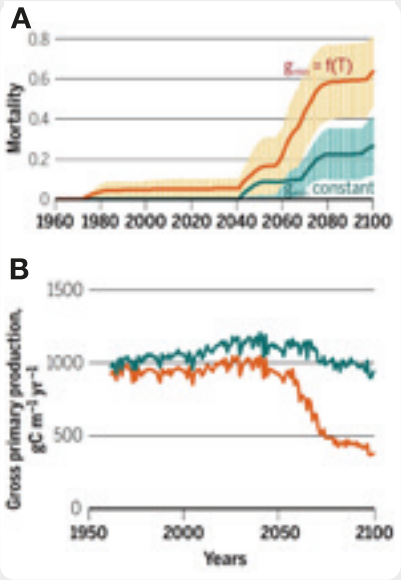

Fig. 1: *Forecast of the development of mortality of a typical temperate zone coniferous tree assuming a static (green) and more realistic temperature-dependent cuticular leakage (orange) (A) and a corresponding development of gross primary production (B).*

Reference:
Brodribb T.J. et al., 2020, Science: https://science.sciencemag.org/content/368/6488/261/

WHAT´S NEW

Preparing the cooperation with the National University of Mongolia

From 13th till 14th January 2020, the Dean of the School of Engineering and Applied Sciences of the National University of Mongolia, prof. Baatarbileg Nachin, visited GCRI and Mendel University in Brno. Both Czech institutions are preparing long-term research cooperation with Mongolian partners in the field of forestry and climate change, namely in the field of deforestation, impacts of climate change on ecosystems, adaptation and mitigation. This cooperation with Mongolian institutions was supported during last autumn's visit to Mongolia by the President of the Czech Academy of Sciences, prof. Eva Zažímalová.

Meeting of the InterSucho portal collaborators

On 3rd February 2020 in Větrný Jeníkov, the GCRI, together with Mendel University, the Agrarian Chamber and the State Land Office, organized another meeting of the InterSucho portal respondents. The discussion meeting, which included the seminar called "Limiting the Impacts and Predicting Agricultural and Forest Drought in the Czech Republic", was attended by 180 guests, including representatives of the Ministry of Agriculture of the Czech Republic, the Agrarian Chamber, the Agricultural Association of the Czech Republic and the Association of Private Farming of the Czech Republic. Representatives of the InterSucho team also presented the newly prepared Agrorisk portal that will serve to predict biotic and abiotic risks threatening agricultural crops.

Signing the Memorandum on the reduction of CO_2 emissions

On 6th March 2020, GCRI together with 28 other companies operating in Brno signed the Memorandum on the reduction of CO_2 emissions. This happened as part of the Festival of Architecture, which is traditionally held during the Building Fair. The GCRI thus undertakes, among other things, to use renewable resources, low-emission or other environmentally friendly means of transport, to save water and build retention areas or reservoirs, and to apply the principles of circular economy.

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