# Newsletter

2/2023

CzechGlobe

Global Change Research Institute CAS

## WILL EXTREME CLIMATE EVENTS BECOME THE NEW NORMAL?

Kerberos and Charon are not just the names of mythological demons of the underworld, but after the past year we will mainly associate them with anticyclones, which literally scorched Europe in July and thus fulfilled the forecasts that a hot summer awaits us. Already June was the hottest on record globally. Not to mention July... Temperatures records were broken in France, Spain, Italy and Sardinia – where even historical records were rewritten.

Europe was not the only place facing extreme temperatures. At the same time, the southwest of the USA – i.e. a region accustomed to temperatures of more than 40 degrees – was also struggling with a record-breaking heatwave. This time it lasted several weeks straight. The Death Valley almost even broke a record set in 1913, when the highest temperature ever recorded on Earth was 56.7 °C. This time it held, but judging by the temperatures measured over the last decade, it seems it won't last very long.

In America, climatologists are even beginning to use the term 'new normal' in reference to the frequent climate extremes (currently one event every 8 days), which this year include devastating forest fires, floods and extremely high sea and ocean temperatures off the coast of Florida, in addition to extreme heat. I guess there's something to that, unfortunately...

Even in the Czech Republic, we felt the influence of anticyclones. Although the heat was not record-breaking and, fortunately, it was not prolonged either, but in connection with the long-lasting drought, we received an unprecedented highest level warning for the extreme fire danger. It should be noted that the FireRisk application for predicting fire weather is the brainchild of our climatologists, and this time, we delve into the topic of wildfires in an interview with Markéta Poděbradská.

Not only has the world experienced the hottest summer on record globally, but September and October have also been labelled the hottest months on record. It was already clear in advance that the year 2023 as a whole will again be record-warm. November 18 was then the first day in the history of measurements when the average daily global temperature was 2.0 °C or more above the reference average given by the IPCC for the period 1850-1900. While this is a one-day anomaly, and the long-term average remains below +1.5 °C, the question is, for how long?

From the perspective of CzechGlobe's activities, the past summer or actually the entire half year was hectic. The year was swarming with big events. First, the Department of Remote Sensing organized an international workshop of the SCERIN regional network (under the umbrella of NASA), which brings together scientists and experts in the field of Earth system observation from South-Eastern and Central Europe. Among other things, the workshop established a working group on urban agglomeration observations – an area where our colleagues from the Department of Remote Sensing are very active.

In July, CzechGlobe organized two international conferences – FLUXNET and TRANSFORMATIONS (we report on both events in more detail in this newsletter). In September, a meeting of the European Copernicus program was held in Brno, in which our climatologists are also significantly involved. At the meeting, scientists collecting satellite data, environmental and climate change data and also the users of this data discussed how to further improve the annual outputs of the program and the use of the data. Scientists from CzechGlobe play a significant role both in the annual reports on the state of the climate and in the use of satellite data (e.g. in precision agriculture for crop yield estimation or in forestry for monitoring bark beetle calamity).

At the beginning of August, we received important and fortunately favorable piece of news that we had eagerly awaited. No wonder, the success of the project "Advanced Methods of Greenhouse Gases Emission Reduction and Sequestration in Agriculture and Forest Landscape for Climate Change Mitigation - AdAgriF" in the competition of the Operational Programme Jan Amos Komenský (OP JAK) provides CzechGlobe and two co-researchers with a total of almost 500 million Czech crowns for the next five years. This funding should help the international team of top scientists in the project to create the prerequisites for the transformation of the Czech landscape into an effective, sustainable and resilient tool for reducing greenhouse gas emissions, while preserving and perhaps even strengthening its other functions so that the transformation is sustainable. Almost immediately after the announcement of the results, the project was launched and a kick-off meeting took place in Brno already in early November.

Another important milestone in the context of international cooperation was the December signing of an agreement between CzechGlobe and the European research infrastructure AnaEE-ERIC on the hosting and support of the AnaEE-ERIC Interface and Synthesis Centre. The Center will help integrate results from AnaEE's experimental platforms and process them so that they can be used by various stakeholder groups to lobby for new research programs and to facilitate communication between scientists, policy makers, industry representatives and society.

Considering that the essence of AnaEE is a network of distributed experimental facilities through which ecosystems can be exposed to a range of controlled conditions, focusing on understanding the impact of climate change on ecosystem functions, including agricultural ones, it is crucial news that we completely renovated the cultivation chambers in Domanínek early in the summer.

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Meet one of us

# Markéta Poděbradská, Ph.D.

**graduated in Applied Ecology at the Faculty of Environmental Sciences of the Czech University of Life Sciences in Prague, where she also received the Dean's award for her outstanding bachelor thesis. During her undergraduate studies, she was awarded a one-year-long scholarship at the University of Nebraska-Lincoln, where she returned a year later for postgraduate studies with a full scholarship. She obtained her Ph.D. in Natural Resource Sciences with a specialization in climate assessment and climate impacts in 2021, and at the same time received the Distinguished Alumni Award from the Faculty of Natural Resources. During her studies, she collaborated on research with the National Drought Mitigation Center. Since 2021, he has been working as a postdoctoral fellow researcher at the GCRI of the Czech Academy of Sciences, focusing primarily on assessment of drought, the occurrence and behavior of wildfires and the classification of fire risk for the early warning system against wildfires, and since 2022 also at the Mendel University in Brno. In her free time, Markéta enjoys rock climbing and high-altitude hiking.**

**You spent your studies and professional career to date in the USA. What were your beginnings, and how did you professionally specialize?**

I first visited the USA, specifically Lincoln in the state of Nebraska, during my bachelor's studies. I always wanted to experience studying abroad and was looking for the most efficient and cost-effective way. I discovered the annual scholarship program called Robitschek Scholarschip, which is intended for Czech and Slovak university students. The main advantage is that the student can choose any bachelor courses that are taught at the university, and in addition, this program covers all expenses from tuition fees, through plane tickets, to accommodation and meals. During my year on the "Roubíček," as everyone calls the program, I had the opportunity to work as an intern at the National Drought Mitigation Center (NDMC), focusing on drought research. Apparently, they were satisfied with my work because, at the end of my internship, they offered me the chance to continue my Master's and Doctoral studies at the University of Nebraska in Lincoln under their guidance and financial support. I accepted this offer and began to explore the spatial analysis of drought impacts on vegetation. I have always liked Remote Sensing technologies, so in my dissertation thesis I combined them with ecology and climatology to create a model estimating forage production for the Great Plains and Western United States. With the support of a grant from the U.S. Geological Survey, this model evolved into a web application that can be used by ranchers as an early warning system for the impacts of drought on cattle forage production.

**How did you learn about the opportunity to work at CzechGlobe? Was it known at American institutions, or did you "discover" it only after returning to the Czech Republic?**

CzechGlobe was known at the National Drought Mitigation Center (NDMC). My thesis supervisor, former NDMC director, Mike Hayes, had worked with Mirek Trnka, my current supervisor, for several years. I had even met some of my current colleagues from CzechGlobe in Lincoln during my student internship in 2015, and later had met some during my doctoral studies. During my studies, I already knew that I wanted to return to the Czech Republic, so I was exploring opportunities for my employment here. Mike Hayes recommended that I contact Mirek Trnka and apply for a postdoc position in his team. Mirek welcomed the idea and was very supportive. He suggested that even before my return, we could try to prepare a Marie Curie programme project on wildfires. At that time, I didn't know anything about fires, so while completing my doctorate, I studied the issue of wildfires and searched for a topic for the fire project. The project didn't work out, but thanks to the already ongoing big projects, I was still able to join Mirek's team, contributing to both new research on wildfires as well as drought.

**What are you currently working on at CzechGlobe?**

There are more of those topics. On the one hand, I am still involved in the study of drought and its effects on vegetation, and I also coordinate the international project Clim4Cast, in which CzechGlobe is the key partner. However, my primary focus is on wildfires and assessing the associated risks. Within the team, we have developed and we operate the FireRisk.cz portal, monitoring the risk of wildfire occurrence and spread. These layers are also calculated globally and are available on the Windy.com application. Apart from assessing fire danger and risks, we also engage in modeling fires and determining landscape susceptibility related to fires. Within this topic, we cooperate with the Institute of Forest Ecosystem Research, with the administration of the national parks of České Švýcarsko and Šumava, and with the Fire Rescue Service. In the Czech Republic and in Central Europe, this research topic is still relatively new, so we gain a lot of experience through international collaboration.

**Is there a difference in addressing the topic of fires here and in the USA, where they are more accustomed to them?**

I didn't deal with wildfires during my studies in the US, so it's hard for me to compare. However, I delved into the topic of fires last year during two internships in the USA, where my colleagues and I visited the renowned U.S. Forest Service facility in Missoula, Montana. For researchers at the Missoula Fire Sciences Laboratory, the study of wildfires is a primary focus and has a long-standing tradition. This is due to the fact that much larger fires occur in the relatively sparsely populated American landscape compared to ours. At the same time, wildfires have been an inherent part of the American landscape for centuries. The natives used them mainly for hunting, and various ecosystems are adapted to wildfires. Therefore, their knowledge and, above all, field experience with fires is completely incomparable to the situation in the Czech Republic, and I am very grateful that CzechGlobe has enabled me to gain this knowledge through internships abroad.

**In North America, they fight fires through controlled burning…**

It's exactly like that. From approximately the 1950s to the 1960s, wildfires were largely excluded from the American landscape. However, this caused biomass to

accumulate in the landscape, which would otherwise be burned by a relatively low-intensity fire. This exclusion of wildfires is also one of the reasons why the United States has experienced such large and intense fires in recent years. Land owners, whether private or state-owned, have realized this fact and are trying to combat it through mechanical removal of excess biomass and controlled burning, which is a highly effective tool. Controlled burning takes place under very specific conditions, when ground vegetation can burn, but at the same time the conditions are not favorable for rapid spread, ensuring that the fire remains under control. Volunteer firefighters are on site and all planned controlled fires must be reported and approved in advance to avoid a situation where air quality is compromised. The entire process usually involves several years of preparation, often including prior partial mechanical removal of excess vegetation.

**Has the perception of the danger of wildfires changed in the Czech Republic after the largest fire in České Švýcarsko in 2022? Do you feel supported in your activities?**

From my point of view, yes. Overall, interest in this topic has increased both from the side of the state administration, e.g. the Fire and Rescue Service, national parks, Forests of the Czech Republic, as well as from the general public and the media. However, I have personally been involved in this issue for a relatively short time, so I cannot evaluate it entirely and objectively. However, I would also compare it to other natural threats and disasters, where there is always heightened interest after a significant event. In my opinion, we should seize the opportunity that fires have started to be discussed after last year and try to propose appropriate measures.

**Do you leverage the acquired international experience and does your cooperation continue?**

Certainly yes. The experience I gained in the USA during last year's internships is absolutely crucial for me and I continue to draw on it. The collaboration with the Missoula Fire Sciences Laboratory continues, which is also great. They are highly regarded experts. This year, we submitted a project on behalf of CzechGlobe in the INTER-ACTION programme under the Ministry of Education, Youth, and Sports, which could support further bilateral collaboration. I really hope we will be successful.

# CZECHGLOBE HOSTED THE ANNUAL FLUXNET CONFERENCE

From July 11 to 14, 2023, CzechGlobe, in cooperation with MENDELU in Brno, organized the annual conference of the global FLUXNET network. FLUXNET, through the regional networks ICOS, AmeriFlux, OzFLUX, SAEON and AsiaFlux, brings together a community of scientists working on measurements of carbon fluxes, water vapor and energy exchange between the atmosphere and ecosystems using eddy covariance techniques. Natalia Kowalska provided professional endorsement for the conference on behalf of CzechGlobe, which is a founding member of the European ICOS (Integrated Carbon Observation System) network. The ICOS – ERIC consortium financially supported the conference.

More than ninety participants of the event, along with online attendees, were introduced to the latest findings from carbon fluxes research through plenary lectures, lightning talks, discussions, posters and lectures by representatives of companies producing measuring technology. Natascha Kljun (Lund University), Philippe Ciais (Institute Pierre Simon Laplace), Markus Reichstein (MaxPlanck Institute for Biogeochemistry) and Tonatzin Tarin (National Autonomous University of Mexico) provided the main keynote lectures. An interesting topic of the conference was the advanced tools and innovative approaches that are being developed to make measurements using eddy covariance techniques more widely applicable. These include technologies used by scientists in the field of Remote Sensing, such as geostationary satellites, terrestrial laser scanning or hyperspectral spectroscopy, which enhance measurement resolution on towers. The use of various models also allows for a more precise representation of ecological interactions and nuances.

One of the goals set by the FLUXNET network is to create common procedures for data standardization from all regional networks by 2025. It is because a standardized data product is needed for summary comprehensive studies. By far not all locations where fluxes are measured currently meet the basic requirements for eddy covariance measurements, and the sensors may not always be in optimal condition either. Standardized data processing will thus serve as a means to increase the comparability of data collected at different locations and facilitate data sharing.

Part of the conference program was also an excursion to the Lanžhot ecosystem station, which represents a floodplain forest and is an ICOS-ERIC certified station.

# TRANSFORMATION 2023 CONFERENCE IN PRAGUE

From July 12 to 14, 2023, CzechGlobe hosted the international conference Transformation 2023 at the headquarters of the Academy of Sciences and the United Nations Information Center in Prague. The conference is held every two years by the global Transformations Community, bringing together scientists, practitioners and artists, and with a focus on creating transformative changes for sustainability. Its intention is to connect various insights and diverse knowledge, reflected in the conference's highly interactive format, including discussion meetings, panels, world cafés, and workshops.

These conferences are held all over the world to allow people from different regions to participate. However, this year's conference was unique. For the first time since the conference in Chile in 2019, it was supposed to take place again in a face-to-face format, namely in Sydney, Australia.

For many interested attendees from Europe, due to the distance and the associated carbon footprint, attending the conference in person was "unthinkable ". Even online participation did not seem to be an ideal solution due to the significant time difference. That is why scientists from CzechGlobe, led by prof. Julia Leventon came up with the idea of offering the Transformations Community to host a small European HUB through which participants could join the conference in Sydney online and at the same time engage in discussions. The proposal received a positive response, so in addition to the face-to-face and online conference in Sydney, the conference of the European hub took place in Prague simultaneously. It was followed by a workshop at the North American Center in Portland, Maine. The global theme of all events was "Transformative Partnerships for a Better World" and participants exchanged ideas and initiatives to support a sustainable, regenerative and equitable future.

The Prague conference was successful, bringing together 100 participants. The overall success of the event was underlined by excellent keynote speakers, chosen by the organizers to emphasize the importance of bringing the perspectives of Central and Eastern Europe closer together. Also thanks to the daily guided tours of the city with the theme of transformation and a joint reception in Vila Lanna, the organizers made the location really famous. Additionally, the participants were enthusiastic about the conference format and it seems that the HUB model will continue to be utilized in the future, reducing travel while maximizing the connection to the conference location.

# CAN PLANTS STORE MORE CARBON THAN EXPECTED?

GOT OUR ATTENTION

One of the dominant uncertainties in predicting the evolution of climate change is the response of plants. The variance of carbon sequestration scenarios is comparable to the uncertainty associated with cloud response, which is among the largest in non-living nature. Some studies assume that the carbon sequestration capacity will be only half of what it is today by 2050, while other indicate a slight increase even in the second half of the century. A study published in the journal *Science Advances* suggests that gross primary production (GPP) (i.e. the total amount of carbon sequestered in the process of photosynthesis over time, excluding losses through respiration) may be significantly higher by the end of the century than previous analyses have suggested.

The GPP indicator is one of the key indicators of the terrestrial carbon cycle. Nevertheless, its representation in terrestrial biosphere models (TBM) does not reflect existing knowledge of plant physiology. Specifically, these models assume a static response of photosynthesis to surrounding conditions, infinite mesophyll conductance, and consequently a higher availability of $CO_2$ for photosynthesis than is actually the case. The way in which such simplified models circumvented the discrepancy between the measured data and the initial assumptions consisted in correcting the model outputs with the measured values. While this approach is sufficient for achieving relatively good results under current climatic conditions, future forecasts for models calibrated in this way are not reliable. Therefore, in their study, the authors included more realistic physiological processes in the models. That is, the acclimation (adaptation) of photosynthesis to the change in temperature, the final mesophyll conductivity and the optimization of photosynthesis through the redistribution of nitrogen in the leaves. This is the first work to refine the TBM models in this way in a single step. The authors then used the updated model to predict future conditions using two extreme climate scenarios, i.e. RCP2.6 (warming below 2 °C in 2100) and RCP8.5 (warming of 5 °C in 2100).

While the effect of photosynthetic acclimation (except for Africa and South America) and optimization of nitrogen distribution resulted in a decrease in GPP, the effect of mesophyll conductivity was positive in most areas (Fig. 1). Most importantly, the combined effect of these three factors on GPP was significantly positive practically worldwide, with the most pronounced effect observed in the cooler regions of North America and Asia. If these results are confirmed by further analyses, it will represent a significant shift towards a better understanding of the effect of climate change on the carbon cycle. Higher GPP values are usually also associated with a higher rate of carbon storage in plant ecosystems. The overall adaptation and mitigation potential of vegetation could thus be more significant than some other studies suggest. The authors show that a more significant increase in GPP compared to TBM models can also be estimated from seasonal changes in $CO_2$ concentration and data from direct measurements of carbon fluxes using eddy-covariance techniques. In conclusion, the authors state that further experiments with increased $CO_2$ concentration (+550 ppm) and higher average temperatures (+2 °C) are needed to properly validate the models. -aa-

*References:*
*Knauer J. et al. Higher global gross primary productivity under future climate with more advanced representations of photosynthesis. Science Advances, 2023: https://www.science.org/doi/10.1126/sciadv.adh9444*

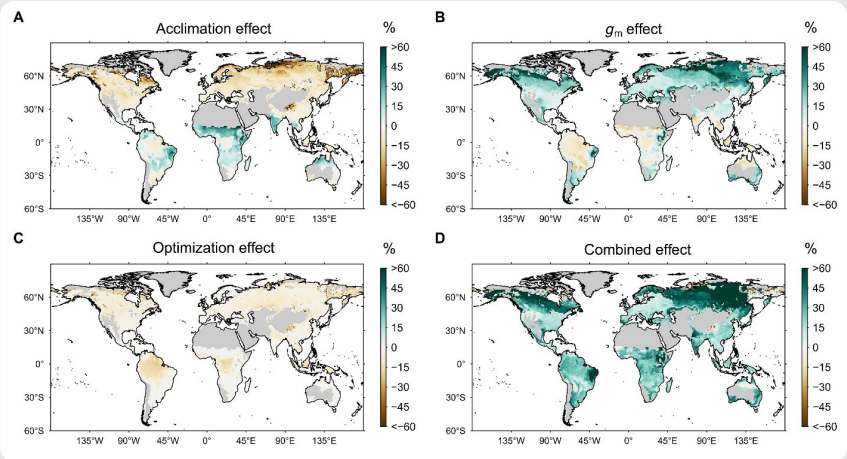


**Fig. 1:** *Graphs showing relative spatial changes (in %) of GPP according to individual parameters. A) temperature acclimation of photosynthesis; B) explicit mesophyll conductance; C) photosynthetic optimization; D) all factors combined. GPP changes are calculated for the period 2070-2099 using the RCP8.5 climate scenario relative to the reference period 1976-2005.*

# WHAT´S NEW

## Visit of the President of the Czech Academy of Sciences

On September 21, 2023, a delegation from the Academy Council of the Czech Academy of Sciences, led by the President of the Academy, Prof. Eva Zažímalová, visited CzechGlobe. During a working meeting with the leadership and scientists from CzechGlobe, representatives of the Academy of Sciences were introduced to the current state and strategy of the Institute, international activities, selected research activities related to global change, and some suggestions for addressing the conditions of scientific work.

## Discussion of the Czech-German Climate Dialogue

On October 18, 2023, a public discussion on the topic "The Significance of Forests in the Era of Climate Change and Biodiversity Loss: Experience from the Czech Republic and Germany" took place in Brno. This event was organized within the framework of the Czech-German Climate Dialogue by the Embassy of the Federal Republic of Germany and CzechGlobe. It was the first of five autumn events held throughout the Czech Republic, addressing questions such as: What measures against climate change and biodiversity loss have been adopted in recent years? How successful are the Czech Republic and Germany in fulfilling international commitments? Where is the potential for strengthening Czech-German cooperation in this area?

## Lecture Afternoon in Mušov

On October 14, 2023, at the Visitors Centre Mušov – Gateway to the Roman Empire, CzechGlobe, in collaboration with the Institute of Archaeology of the Czech Academy of Sciences, organized a lecture afternoon on the topic "Climate Change and Agriculture – History, Opportunities, Adaptation." This series of educational and popular science lectures intended for farmers, winemakers, and the general public showcased how climate conditions in the Roman era influenced the settlement of Moravia by Romans and Germans. The lectures also covered what agricultural crops reveal about Roman legions and Germanic tribes, how stable isotopes are used to reconstruct past climates, how the climate for agriculture has evolved in the previous 2000 years, and what conditions it might bring, and that soil conservation and regenerative agriculture are suitable tools for agriculture to adapt to climate change. The event also demonstrated how different scientific disciplines, such as archaeology and biological-ecological scientific disciplines can collaborate effectively in research.

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**The appendix of Newsletter 2/2023 presents a selection of interesting publications and applied results of CzechGlobe employees published in 2023.**

Tang, A. C. I., Flechard, C.R., Arriga, N., Papale, D., Stoy, P.C., Buchmann, N., Cuntz, M., Douros, J., Fares, S., Knohl, A., **Šigut, L.**, Simioni, G., Timmermans, R., Gruenwald, T., Ibrom, A., Loubet, B., Mammarella, I., Marchesini, L. B., Nilsson, M., Peichl, M., Rebmann, C., Schmidt, M., Bernhofer, C., Berveiller, D., Cremonese, E., El-Madany, T. S., Gharun, M., Gianelle, D., Hörtnagl, L., Roland, M., Varlagin, A., Fu, Z., Heinesch, B., Janssens, I., **Kowalska, N., Dušek, J.,** Gerosa, G., Molder, M., Tuittila, E. S., Loustau, D. Detection and attribution of an anomaly in terrestrial photosynthesis in Europe during the COVID-19 lockdown. *Science Advances* 2023, 9(35), 166149.

The study Tang et al. (2023) investigates how the effect of the 2020 spring lockdown due to COVID-19 and the resulting improvement of air quality impacted plant $CO_2$ uptake at the European scale. The presence of pollutants in the atmosphere can affect plants both directly through damage of plant tissues or indirectly due to the atmosphere brightening resulting in more light available for photosynthesis. Detecting such small effects is a challenge, particularly as $CO_2$ uptake is influenced by other meteorological drivers and management practices. The study utilized data from 44 ecosystem stations submitting data to the Integrated Carbon Observation System (ICOS), including three Czechglobe sites. When compared to a refence period 2015-2019, we observed significant changes in spring $CO_2$ uptake at 34 sites in the spring of 2020. Among these, 14 sites showed an increase in $CO_2$ uptake associated with higher incoming light, 10 sites had lower $CO_2$ uptake linked to atmospheric and soil dryness, and seven sites were subjected to management practices. The remaining three sites were affected by atypical spring meteorological conditions. The ozone ($O_3$) concentration remained relatively unchanged at the research sites, making it unlikely that $O_3$ exposure was the dominant factor driving the $CO_2$ uptake anomaly. In contrast, incoming light increased by 9.4 % at 36 sites, suggesting enhanced $CO_2$ uptake possibly due to the atmosphere brightening and reduced cloudiness. Our findings indicate that air pollution and cloudiness may weaken the terrestrial carbon sink by up to 16 %.

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Airborne laser scanning data obtained by our scientific infrastructure FLIS (https://olc.czechglobe.cz/flis/) and methods for estimating aboveground biomass of forest stands developed within the successfully completed NAZV project (QK1910150) were part of three studies on a local, European and global scale:

Araza, A.B., Herold, M., Bruin, S.D., Ciais, P., …, **Brovkina, O.**, **Novotný, J**., et al. Past decade above-ground biomass change comparisons from four multi-temporal global maps. *Int. J. Appl. Earth Obs. Geoinformation* 2023, 118, 103274.

Monitoring of above ground biomass (AGB) is needed to understand the role of forests in mitigating the climate change. The study cross-compared four recent global multi-date maps of AGB changes and compared them with National Forest Inventory (NFI) data and local maps of AGB from airborne lidar. The comparisons revealed that LiDAR data compared most reasonably with the maps, while the comparisons using NFI only showed some agreements at aggregation levels <10 km. The study identified large disagreement between the maps in key forest regions such as the Amazon basin.

Turubanova, S., Potapov, P., Hansen, M.C., … **Brovkina, O., Navrátilová, B., Novotný, J.**, et al. Tree canopy extent and height change in Europe, 2001–2021, quantified using Landsat data archive, *Remote Sensing of Environment* 2023, 298, 113797.

Changes in tree canopy height across Europe from 2001 to 2021 were studied using the multidecadal spectral data from the Landsat archive and calibration data from airborne and spaceborne GEDI lidars. It was found that the European tree canopy extent area increased by nearly 1% overall from 2001 to 2021, with the largest increase observed in Eastern and Southern Europe, and the British Isles. However, the tree canopy extent in Europe declined after 2016. The highest reduction was observed in Fennoscandia. The continental extent of tall tree canopy forests (≥ 15 m height) decreased by 3% from 2001 to 2021, which indicates reduction in forest carbon storage capacity in Europe.

Tebaldini, S., d'Alessandro, M. M., Ulander, L. M. H., …. **Hanuš, J., Novotný J.**, et al. TomoSense: A unique 3D dataset over temperate forest combining multi-frequency mono- and bi-static tomographic SAR with terrestrial, UAV and airborne lidar and in-situ forest census. *Remote Sensing of Environment*, 2023, 290, 113532.

TomoSense experiment funded by European Space Agency supported development of forest assessment methods based on Synthetic Aperture Radar (SAR), with special focus on the use of tomographic SAR. Unique combination of tomographic SAR and multi-scale lidar data (terrestrial, UAV and airborne based) allows for direct comparison of canopy structural metrics including vertical profiles of canopy wood and foliage density, and per-tree and plot-level above ground biomass (AGB). We developed reference maps of forest AGB from airborne lidar data and comparison with tomographic SAR showed good agreement for forest with AGB above 200 t/ha.

**Findurová, H., Veselá, B.**, Panzarová, K., Pytela, J., Trtílek, M., **Klem, K.** Phenotyping drought tolerance and yield performance of barley using a combination of imaging methods. *Environmental and Experimental Botany*. 2023, 209(May), 105314.

Drought is one of the factors significantly limiting agricultural production and crop yields. In addition, due to climate change, droughts are expected to become more frequent and longer. To ensure the stability of agricultural production, it is necessary to adopt some strategies to limit these negative impacts. These strategies also include the selection of suitable varieties with higher resistance to drought, which is most often carried out using the so-called phenotyping. It is a method in which selected plant properties are determined and recorded, e.g. leaf temperature, plant colour, or photosynthesis rate. Thanks to modern technologies, it is then possible to carry out fully automated high-throughput phenotyping, where a large number of plants are monitored at once using various sensors, which makes it possible to evaluate, for example, the different behaviour of different varieties of the investigated crop. For this technology, to allow us to correctly assess the resistance of plants to drought, it is crucial to choose the appropriate methods and parameters to be monitored. In this study, 6 barley varieties were exposed to a drought period, during and after which a side-projected leaf area, an RGB plant image, a chlorophyll fluorescence image, and a thermal image (leaf temperature) were recorded. Plants were grown until harvest. Grain yield and the amount of above-ground biomass, which correspond to the effects of drought in agricultural production, were subsequently correlated with the measured parameters from the period of drought stress and subsequent re-watering, and the ability of individual parameters to express the plant's resistance to drought was compared. The observed parameters were found to have different sensitivities in different drought phases. Of all the methods examined, sensitivity to drought was best expressed by RGB imaging, with the highest correlation with relative yield found for dark green and khaki colours during the re-watering phase. The side-projected leaf area also expressed drought sensitivity the best in the re-watering phase. On the contrary, the first responding parameter was the leaf temperature, but in the later stages, the differences between the varieties disappeared. Differences between varieties were then worst reflected by the maximum quantum yield of photosystem II, which reached maximum sensitivity at the end of the drought period. In conclusion, it can be said that by monitoring an appropriate parameter in an appropriate period (beginning of drought/end of drought/re-watering), information can be obtained on how the yield of a given barley variety will be affected by drought. For experiments of shorter duration, it is then advisable to choose fast-reacting parameters (e.g. leaf temperature), while for longer experiments, RGB imaging will serve well.

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**Daněk, J.,** Blättler, L., **Leventon, J., Vačkářová, D.** Beyond nature conservation? Perceived benefits and role of the ecosystem services framework in protected landscape areas in the Czech Republic. *Ecosystem Services* 2023, 59(Feb), 101504.

Protected Landscape Areas (PLA) are large areas that focus not only on the protection of species and habitats, but also landscapes and local cultural values. The use of the ecosystem services (nature's contributions to people) framework in the analysis of interviews with managers of PLA confirms the key role of these areas in nature and biodiversity conservation. The most frequently mentioned category of benefits was habitat creation and maintenance. In terms of the comparison between different groups of benefits (regulating, material and non-material), cultural or non-material benefits were the most frequently mentioned group of benefits. These findings underline the importance of PLA in people's relationship with nature and landscape, particularly as an environment enabling recreation, education and as a place with cultural heritage values. The study also identified existing synergies or conflicts in the provision of particular ecosystem services in PLA. In particular, some types or approaches to agricultural and forestry management have negative effects on the provision of specific benefits (e.g. habitat creation and maintenance or supporting identities). Although the use of the ecosystem services framework in PLA practice was very limited (at the time of the research), respondents suggested that it has great potential to support conservation goals and decision-making in PLA, e.g. in the form of additional arguments explaining the values of nature and the reasons for its protection, or by raising awareness on the benefits of nature to society more generally. This study confirms the societal importance of large-scale protected areas in the Czech Republic, which, in addition to their crucial role in nature and landscape protection, bring a number of specific, especially intangible benefits to people.

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**Červený, J.**, Malaník, P., **Tinka, J.**, Drahanský, M. Illumination cultivator - microalgae collector. Global Change Research Institute of the Czech Academy of Sciences, p. r. i., 2023. Prototype optimALga_bioreactor.

In collaboration with the Brno-based company TrendBit s.r.o., the Department of Smart Biotechnologies at the Global Change Research Institute, Czech Academy of Sciences, has developed a prototype of an automated illumination cultivator that will ensure the expansion and innovation of the existing infrastructure. By utilizing advanced algorithms, including artificial intelligence methods, which are being developed in the department to optimize production processes and accelerate comprehensive multifactorial analysis of cultivation environments, microbial growth in an environment that allows for simulating both future climate scenarios and complex industrial processes will be effectively studied. The result of such optimization is not only new knowledge about the studied biological system but also significant savings in equipment and human resources compared to traditional methods, making the research results promising for implementation in real biotechnological applications. The new cultivator was developed with a focus on integration with a unique digital platform for data management and analysis (www.optimalga.com), which was developed in collaboration with DataFriends s.r.o. as part of a joint grant application.