Newsletter

2/2018

CzechGlobe

Global Change Research Institute CAS

THE ICOS CONFERENCE DEALT WITH THE FULFILLMENT OF THE OBLIGATIONS OF THE PARIS AGREEMENT

The research in CzechGlobe is largely focused on the fieldwork and scientists sometimes spend weeks on measurement campaigns. This summer, however, was a bit different because, instead of focusing on local permanent research areas and monitored plots, part of our colleagues with all the unique technical infrastructure moved abroad to work with international teams on significant projects. Therefore, our Airborne Laboratory of Remote Sensing, i.e. the CESSNA aircraft literally packed with the very best that you can imagine in the domain of sensors, was most of the season flying over Europe and capturing images of Italy, Spain, France, Germany and Switzerland for the FLEX SENSA campaign. The team of the new Department of Ecosystem Trace Gas Exchange spent a month on the island of Reunion where, for a case study on the determination of greenhouse gas emissions in tropical rainforest, measured the fluxes of nitrous oxide and methane from the tree trunks of typical tropical trees. This does not mean that scientists from CzechGlobe would not normally go abroad for measurements, on the contrary actually. E.g. the team around prof. Kindlmann studying biodiversity, traditionally carry out most of their research in exotic countries such as Papua New Guinea, Nepal, or the Latin American countries. The Department of Matters and Energy Fluxes involves themselves a lot in Africa, Vietnam, Panama, and we would be able to find many more examples. The difference consists in the fact that in these former two cases we are speaking about rather young teams that started developing rapidly not sooner than with the very establishment of the Center, and especially our own aircraft equipped with top-notch instrumentation and professional staff has taken our Remote Sensing Department to the absolute top within the European community. Besides that, we have also strengthened our international position when the eLTER Research Infrastructure associating the field workplaces covering the European ecological zones, including ours, was included in the ESFRI Road Map.

In the previous issue we regretted the fact that we are slowly beginning to face an issue with the acquisition of PhD students and young scientists. This trend manifests itself also in other European countries where it could potentially lead to a loss of competitiveness in some key research areas. In an attempt to prevent this from happening, the EC introduces in the domain of science the principles of strategic human resources management, known under the mark HRS4R (Human Resources Strategy for Research). In addition to improving the working environment for scientists, it also becomes a certain quality guarantee of the research organization, and in some programmes it can also bring financial benefits. It is, therefore, logical that CzechGlobe also strives for this award.

The fact that CzechGlobe already represents the well-established and quality brand has been demonstrated many times. Of course, the best opportunity to showcase its strengths is via active participation in international conferences or via direct organization, as it was the case at the end of the summer when CzechGlobe participated in the organization of the „Third ICOS Scientific Conference 2018". It took place from 11th to 13th September in the premises of the Czech University of Life Sciences in Prague. ICOS (Integrated Carbon Observation System) is a European Research Infrastructure, one of the first to proudly gain the legal subjectivity of the ERIC, focusing on the observation of greenhouse gases in the atmosphere and in terrestrial and ocean ecosystems. CzechGlobe has been a member of the ICOS consortium from the very beginning, and probably also thanks to the many years of good experience, we were entrusted with

the conference organization. The conference was attended by over 250 international scientists, including many of the world's leading masterminds in the field of bioclimatology, atmospheric physics and many other biological disciplines. They dealt with thirteen thematic segments, some of which were very specific, such as working with data and models, while others tackled topics of broad societal significance. Such a topic was, for example, the mitigation of the consequences of climate change, which was dedicated to the commitments of the Paris Agreement and how to reach the determined emission limit. This later proved to be extremely topical, because at the beginning of October, the Intergovernmental Panel on Climate Change (IPCC) published a worrying report stating that, even at the current pace of introducing measures to reduce emissions, averting warming by even 2°C by the end of this century is unrealistic. We could see what the reality feels like during this year's record breaking warm, and in the Czech Republic also extremely dry, years. -mš-

Introducing the Department of Biogeochemical and Hydrological Cycles

CURRENT DROUGHT DOES NOT CORRESPOND TO MODEL PREDICTIONS VERY MUCH,

says prof. RNDr. Jakub Hruška, CSc., the Head of the Department of Hydrological and Biogeochemical Cycles at the GCRI. He graduated from the Faculty of Science at Charles University in Prague. Since 1990 he has been working for the Czech Geological Survey, where he deals with the impact of atmospheric deposition on forest ecosystems, especially soil and water, and biogeochemical modeling of changes in ecologically important elements in connection with acidification, eutrophication and climate change. From 1997-1999 he worked at the Swedish University of Agricultural Sciences in Umea. In 2016 he was appointed Professor of Environmental Sciences (Faculty of Science, Charles University in Prague). Since 2011 he has been the Head of the Department of Hydrological and Biogeochemical Cycles at the GCRI. He is a member of Scientific Councils of the Faculty of Science at Charles University in Prague and Faculty of Environmental Sciences at Czech University of Life Sciences Prague, a member of the Panel of the Government Council for Sustainable Development, the Šumava NP Council and the Krkonoše National Park Council and the Czech representative in the Convention on Long-range Transboundary Air Pollution in Europe within the United Nations Economic Commission and the national coordinator of the Long-Term Ecological Monitoring Network (ILTER).

Your team was formed within the Czech Geological Survey (CGS). How did its incorporation within CzechGlobe come about?

When CzechGlobe was forming, we, together with prof. Moldan, who had been working for CGS for years, and Michal Marek agreed that our specialization, i.e. measurement of material fluxes in small forest basins could be both new and beneficial to the emerging CzechGlobe center. As a matter of fact, there is a relationship between the events in the atmosphere, i.e. when the climate, precipitation, temperatures change, and how these changes affect ecosystems - in terms of not only carbon fluxes, but also biogeochemistry of nitrogen and carbon, phosphorus, basic cations of other elements in forest soils and surface waters (streams).

What does your team's benefit particularly lie in?

Since the early 1990s, we have been running a network of small basins called GEOMON, where we continuously measure hydrology and chemistry of precipitation, soil waters, soils and runoff. In hydrology, however, many basins have much longer time series of measurements, so it is a great tool how to document the climate change (CC). The network originally served mainly to study the effects of acid rain on waters and soils. We successfully managed to document, but subsequently also use in model predictions, the decrease of sulfur and nitrogen deposition, changes in the deposition of basic cations and acidic precipitation, the change in acidity of soils and streams. All of this can be used to quantify the CC that came to Central Europe after acid rains, so we reverted a bit from the acidic deposition, which has subsided substantially, to how ecosystems deal with CC at the moment.

The name of your department includes the term biogeochemical cycles. Can you clarify what they mean?

In nature, biogeochemical cycles (BGCs) are very important. Under normal circumstances, ecosystems seek to retain nutrients and important elements. The moment when excessive amount of one of the key elements such as phosphorus, nitrogen, calcium, magnesium starts to leak out of the system, it means that something that is not supposed to be happening is actually happening. It is indeed biogeochemistry that describes changes in the chain of atmospheric deposition - soil - surface and underground waters – vegetation, which determines in forest basins how the elements flow between the individual parts of ecosystems, where they are held back and where they are, in some situations, released. E.g. when the forest declines, the trees release quite a large number of elements into the soil where these elements behave in a certain way and proceed to e.g. surface waters and subsequently run out from the ecosystem.

Are these cycles affected by the CC?

While acidic deposition does not depend much on the climate, BGC - particularly of carbon and nitrogen in forest soils, are quite dependent on the CC because the increase in temperature leads to the acceleration of some chemical reactions and thus the mineralization of organic matter increases. At the same time, the growing season is prolonged, so trees and soil microorganisms have a longer time to either incorporate or release these elements. Now, the biggest problem, however, lies in the loss of water available in ecosystems, both in soils and consequently in streams. The drought has largely caused the current bark beetle gradation in spruce forests. That significantly changes the BGC, because humus will begin to mineralize, there will be plenty of available nitrogen, and the basic cations, which were previously unavailable, will become available again by dying of trees and the biomass begins to decompose. What is happening with the elements in ecosystems therefore mainly lies with the CC today.

What are the most important elements of BGC in ecosystems?

It is carbon, although it does not apply in terms of nutrition, availability of nutrients and water chemistry. In the mentioned cases the most important elements are nitrogen, phosphorus, calcium, magnesium, potassium, or the released toxic elements in the ecosystem, such as aluminum. As for carbon, it is said that essentially everything revolves around the robust carbon cycle, but it is not as important in terms of nutrient balance of the ecosystem.

Besides BGC, you also deal with hydrological cycles. How do they change in relation to the CC?

As I have mentioned above, the CC's key manifestation is the loss of water in ecosystems. Over the last five years, we have detected a 40% reduction in surface water runoff in our basins. In these basins, we continuously measure the amount of falling precipitation, interceptions and the amount of water flowing in the streams, so we have a hydrological balance for all 14 basins. In addition to these measurements, we further model the future development of the hydrological balance and element budget. Here we cooperate a lot with the prof. Trnka's team, who provide us with the scenarios of the development of climatic parameters for individual river basins, and we then secondarily use them to fill in hydrological models. I have to say that the dry period we have witnessed over the past five years is not exactly what the hydrological models had predicted. According to the models, the current state means a certain fluctuation in the long-term trajectory, which leads to the fact that the waters in the ecosystem, as temperatures rise, will decrease anyway. In our view, however, this is a short-term fluctuation, and it is not going to be typical weather in Central Europe. We think it will return to „normal" again, although the long-term trajectory until 2100 shows that years are likely to look like this in the second half of the 21st century, but they should not look like that right now. According to older data, such a dry period was, for example, in the late 1850s. The climate of Central Europe is changeable and unpredictable at short intervals, e.g. individual years. We are simply able to track the paths of future development, but we cannot model what the hydrological balance will look like next year, and neither anyone else in the world can.

Besides precipitation, is the hydrological cycle in terms of the CC influenced in other ways as well?

Within the CC, the hydrological cycle, especially in forests, is not influenced by other variables very much. The cultivation of monoculture forests with a large number of trees which then brings higher demands on water for transpiration, is a certain influence. What is also missing in forests is dead wood, which can „retain" certain amount of water for some time. What you cannot do in forests, however, are measures for better water retention, as can be done in agricultural landscapes. What we can most do is to mechanically stop forest meliorations at the places where they are carried out - and there are many in the Czech Republic. Nevertheless, this is the only thing that can be done promptly at this stage. Of course, considering the CC, the forest structure can be changed. Cultivation of spruce monocultures is considered an unacceptable way of management in the future. With regards to the CC we should consider a change in the species composition of forests. We need more deciduous forests and those that are suitable for a drier warmer climate, i.e. to focus more on oaks than on spruces and other mountain species. But this is a task for decades.

Is your research focused solely on the forest environment?

In principle, we are focusing only on forest basins, even though we have started to consider reviving some field basins too, because it is a very important component of material fluxes today. In addition to that, CGS used to operate small field basins in the Bohemian-Moravian Highlands in the 1970s and these sites still exist. But so far, it is only at the stage of considerations.

Can you briefly describe how you work?

We work in several levels. The basis consists in long-term monitoring, which then serves as a base for everything else (e.g. for modeling). That is, we collect monthly samples of rainfall and runoff, on the forest plots we collect monthly samples of soil waters. In intensively monitored basins we take surface runoff samples on a weekly basis, or within some episodes during spring or summer floods. The samples are brought in, and subsequently pH, conductivity, alkalinity is measured. They are then submitted for analysis to laboratories where a large spectrum of anions and cations are measured, and the data are filled in databases and the annual balances are calculated. It's a certain routine job that we are used to doing. We also work in campaigns, i.e. once every 5 to 10 years we thoroughly take soil samples in each basin. We carry out soil analyzes (both chemical and physical) so that we can cover all river basins in terms of the structure of stands and soil types and species. The third area we have been recently dealing with is the monitoring of vegetation. We carry out dendrological studies and phytocenological images so that they cover or characterize the entire basin as a whole. These images should serve in the future to identify vegetation changes in the basins. We are also working on the research plot Načetín, which is a typical forest research „bi-plot" of spruce and beech, where apart from monitoring also experiments are carried out. At the moment, for example, we are simulating the acidification that used to be here before, and we „water" the soil with sulfuric

DEPARTMENT OF BIOGEOCHEMICAL AND HYDROLOGICAL CYCLES

In the CzechGlobe structure, the department is integrated into the Domain of Ecosystems Analysis. The department deals with the study of changes in biogeochemical and hydrological cycles related to climate change. In particular, it focuses on the monitoring of small forest basins, the measurement of concentrations and calculation of material fluxes of ecologically important elements, field experiments, the use of hydrological and biogeochemical models to predict the development of forest ecosystems depending on the expected development of the climate change.

At present, the department consists of eight scientists, one doctoral student and four technicians.

acid, nitric acid and ammonia, and we observe not only the chemical response but also the response of microbial communities to individual treatments in both stands.

Does your research also include biodiversity studies?

Together with The Norwegian Institute for Water Research (NIVA), we have conducted a study on the biodiversity of sessile algae in watercourses. The results were surprising and showed that species diversity correlated more with acidification than with nutrients, although the opposite was assumed. So, basins that have a lot of phosphorus but are very acidic at the same time, are not rich in species, but on the contrary - poor. I forgot to mention that we have been dealing with acidification and changes in Šumava lakes for a long time. We have been working on that with colleagues from the University of South Bohemia in České Budějovice. While they are focusing on the biodiversity component, we are focusing on the modeling of chemism.

How do you cooperate with other CzechGlobe teams?

It has already been partially said above. We cooperate the most with the group around Mirek Trnka, with Tomáš Kolář and dendrochronologists. We have been working with Pavel Cudlín for 20 years on matters relating to mycorhize and forest physiology. Since this year, I also have had a joint project with Ota Urban's team on forest growth and productivity based on nitrogen and carbon isotopes. Another project that is set up on the data of the GEOMON Forest Basin Network is a project by Lucie Homolová studying the use of remote sensing techniques to detect stress of forest stands and estimate the amount of nutrients in biomass and soils. Cooperation within CzechGlobe is also efficient thanks to the newly built laboratory for soil and water analysis in Brno. It is shared with the GEOTEST company and provides analyses for other departments of CzechGlobe as well.

You've mentioned foreign cooperation with NIVA, do you have more?

Yes, we have a lot of them. In addition to NIVA, it is the Swedish Environmental Institute, the UK's Center for Hydrology and Ecology in Wallingford and Bangor. In the USA we cooperate a lot with the University of New Hampshire and recently we have been working a lot with TU Dresden.

This year, the European eLTER network, where you are one of the partners, has succeeded to get to ESFRI's Road Map for Research Infrastructures. Can you specify this network and the territory it covers?

The network includes locations where typical long-term environmental research is carried out, and it does not really matter in which field it is. As for our part, we have the GEOMON network of small forest basins, but also e.g. Sokolov dump and other sites. This shows you that environmental research can be carried out in a national park as well as on a dumping ground. Other partners in the network have their locations e.g. with long-term botanical observations or primaeval forests. From the position of the national eLTER network coordinator, I can say that the inclusion in the ESFRI Roadmap promises mainly funding on a longer-term basis, sustainability and also infrastructure development.

And what other interesting projects have you solved lately?

We have solved major projects funded by the Norwegian funds, which ended the year before last year as well as last year. Regularly we solve 3-4 projects of the Czech GA. Our colleague, Filip Oulehle, within the Marie Skłodowska-Curie Actions, has attended a post-doctoral internship in the UK, which is a pretty prestigious thing. Recently, we have also acquired a commercial project from CEZ which I value and appreciate very much. Within the project, we evaluated the forests' response to long-term acid deposition.

GLOBAL CHANGE REDUCES THE AVAILABILITY OF NITROGEN FOR PLANTS

GOT OUR ATTENTION

Scenarios on climate development are burdened with a great deal of uncertainty. The great uncertainty, right after the socio-economic factors and uncertainty associated with changes in the cloud amount, is related to the response of plants. Climate models differ widely when forecasting to what extent will terrestrial ecosystems, particularly forest ecosystems, be able to continue absorbing increasing CO_2 from the atmosphere. A new study suggests that factors related to global change reduce the availability of nitrogen, which is one of the key elements for plants to continue acting as atmospheric CO_2 sink. The phenomenon of excessive use of nitrogen, especially in agriculture, with the resulting deterioration in the quality of water resources, eutrophication of rivers and lakes, and the creation of dead zones in ocean coastal waters is rather well-known and fairly well-described. However, in contrast to these long-term trends, there is a contradictory issue of an increase in nitrogen deficiency. An international team of 38 authors led by Joseph Crain used for their research the existence of herbaria in combination with isotopes analysis of nitrogen ^{15}N in tree rings. The researchers also analyzed the database of chemical composition of leaves of several hundred plant species collected worldwide from 1980 to 2017. More than 43,000 samples were analyzed

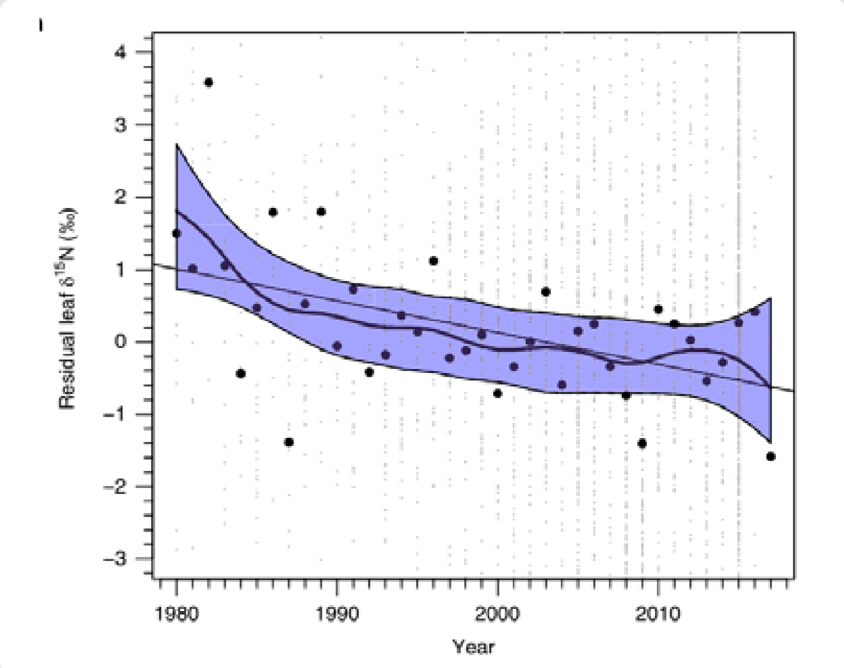

Fig. 1: Development of the content of nitrogen isotope (^{15}N) in plant leaves worldwide after the correction of climate influence and mycorrhizal type between 1980 and 2017. The black dots represent the average for the given year and the gray dots for the given location. The black line shows a regression and the black bold line shows the smoothed average together with 95% confidence interval.

in total, which makes it the broadest study of its kind so far. Scientists have demonstrated a global trend in the decline in nitrogen availability in natural, i.e. unfertilized, ecosystems (see Fig. 1), which is in agreement with other evidence such as a decrease in nitrogen content in tree leaves, reduced protein intake in cattle on pasture, reduced protein content in pollen grains or a higher carbon / nitrogen (C: N) ratio in soil. These results also correlate with a decrease in ^{15}N isotope content in natural forest and grass ecosystems over the past 75 to 150 years.
Although the paper was not able to identify the very causes of the observed decrease in nitrogen content, the most likely is the increase in the CO_2 concentration in the atmosphere as well as the extension of the vegetation period due to higher average temperatures. Anthropogenic impacts, on the one hand, reduce the availability of nitrogen in natural ecosystems (oligotrophication) and, on the other hand, they are disproportionately increasing it by direct fertilization using predominantly artificial fertilizers in agricultural ecosystems (eutrophication). -aa-

Reference: Crain et al., 2018, Nature Ecology and Evolution, https://www.nature.com/articles/s41559-018-0694-0

WHAT´S NEW

Photo exhibition of ICOS infrastructure

From 10th till 24th September 2018, an exhibition of photographs by the acclaimed Finnish photographer Konsta Punkka took place in the Chamber of Deputies of the Parliament of the Czech Republic as a side-event programme of the „Third ICOS Science Conference 2018“. For the ICOS consortium, the author created a set of photographs of its monitoring stations in all twelve member-countries involved in the infrastructure. The exhibition entitled „Towers for Carbon“ was also complemented by the photographs of Czech stations included in the ICOS network taken by Marian Pavelka, Gabriela Vítková, Vlastimil Hanuš and Jiří Duška from GCRI.

The Science and Technology Week

From 5th till 12th November 2018, was held the Science and Technology Week, which this year was included among the events dedicated to the 100th anniversary of the foundation of Czechoslovakia. For this jubilee, the GCRI prepared a popularization lecture called „How the ecosystem ecophysiology research has changed in the Czech Republic since 1989“. Traditionally, also the Doors Open Day was held at the Brno Global Change Research Institute, which, besides the tour of laboratories, also tempted the visitors with a cycle of popularization lectures on global climate change, the future of spruce in our climate conditions, the Remote Sensing over time and the issues of chemical pollution of the environment.

Josef, Marie, and Zdeňka Hlávka Foundation Award given to Jan Květ and Adam Emmer

On 16th November 2018, the Hlávka Foundation Awards were granted. Among this year‘s laureates for the Josef, Marie and Zdeňka Hlávka Foundation Awards were also two of our colleagues from GCRI. The naturalist, botanist and ecologist Jan Květ received the Josef Hlávka Medal for long-term, targeted and active research on wetland ecosystems. Adam Emmer won the Josef Hlávka Award given to the best students and graduates of Prague public universities, Brno universities of technology and young talented employees of the Czech Academy of Sciences.

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Also this year's winter issue of the Newsletter (2/2018) contains an appendix dedicated to selected articles of our colleagues that were published in 2018.

Büntgen, U., Wacker, L., Galvan, D., Arnold, S., Arseneault, D., Baillie, M., Beer, J., Bernabei, M., Bleicher, N., Boswijk, G., Brauning, A., Carrer, M., Ljungqvist, F. C., Cherubini, P., Christl, M., Christie, D. A., Clark, Peter W., Cook, E.R., D'Arrigo, R., Davi, N., Eggertsson, O., Esper, J., Fowler, A. M., Gedalof, Z., Gennaretti, F., Griessinger, J., Grissino-Mayer, H., Grudd, H., Gunnarson, B., Hantemirov, R., Herzig, F., Hessl, Amy, Heussner, K. U., Jull, A. J. T., Kukarskih, V., Kirdyanov, A. V., **Kolář, T.**, Krusic, P. J., Kyncl, Tomáš, Lara, A., LeQuesne, C., Linderholm, H. W., Loader, N. J., Luckman, B., Miyake, F., Myglan, V. S., Nicolussi, K., Oppenheimer, C., Palmer, J., Panyushkina, I., Pederson, N., **Rybníček, M.**, Schweingruber, F. H., Seim, A., Sigl, M., Churakova (Sidorova), O., Speer, J. H., Synal, H.-A., Tegel, W., Treydte, K., Villalba, R., Wiles, G., Wilson, R., Winship, Lawrence J., Wunder, J., Yang, B., Young, G. H. F. Tree rings reveal globally coherent signature of cosmogenic radiocarbon events in 774 and 993 CE. *Nature Communications* 2018, 9, 3605. ISSN 2041-1723.

The published study presents the results of analyzes of 487 tree rings coming from different locations on both the Northern and Southern hemispheres, as well as from various altitudes (up to 4000 m a.s.l.). These rings were formed between the years of 770-780 and 990-1000 A.D. The results of the analysis of the content of ^{14}C radioactive carbon isotope in the rings show that there were two significant decreases in its content in the mentioned periods. These anomalies varying from the line of 11 years of average values were recorded in the years 774 and 993 on both hemispheres. In these 2 years, the Earth was probably exposed to strong solar proton radiation. This statement is supported by contemporary records from proxy archives, according to which red polar glow was witnessed in these years. These findings have, among other things, significance in determining the frequency and repetition of past events in the space which the Earth was exposed to, and in assessing the threat of space weather to humanity.

Cienciala, E., Altman, J., Doležal, J., Kopáček, J., **Štěpánek, P.**, Ståhl, G., Tumajer, J. Increased spruce tree growth in Central Europe since 1960s. *Sci. Total Environ.* 2018, 619–620: 1637–1647. doi:10.1016/j.scitotenv.2017.10.138.

Tree growth response to recent environmental changes is of key interest for forest ecology. This study addressed the following questions on Norway spruce in Central Europe: Has tree growth accelerated during five decades since 1960s? What are the main environmental drivers of the observed growth changes? Using a nationwide dendrochronological sampling of spruce (1246 trees, 266 plots) within the network of CzechTerra landscape inventory, novel regional age-restricted tree-ring width chronologies were assembled. They represented 40(±10)- and 60(±10)-year old trees within the study period (1961-2013). Data were averaged across three elevation zones (break points 500 and 700m) and analyzed with correspondingly averaged environmental drivers (climate, nitrogen deposition, CO_2). The results show that spruce tree radial stem growth has responded strongly to the changing environment since 1960s, with a mean tree ring width increase of 24 and 32% for the 40- and 60-year old trees, respectively (excluding suppressed trees). The indicative correlative analysis suggests that the contributing factors included spring air temperature (March-May), precipitation during the vegetation season, N-deposition in interaction with elevation, as well as CO_2 effect (direct or indirect by increased water use efficiency). The regression models explained 55-57% of the variability in the two age-restricted tree ring width chronologies. Discussion details the likely effect of forest management and other factors. While the increased growth was robustly supported by the study, discerning the specific contribution of environmental factors remains to be studied further. The results also offer an interesting interpretation of a long-term growth trend and increasing limitation by drought (see the sister study Tumajer et al. 2017, Agric. For. Meteorol. 247:56-64) leading to the current severe decline of spruce in the region.

Oulehle, F., Tahovská, K., Chuman, T., Evans, C.D., **Hruška, J.**, Růžek, M., Bárta, J. Comparison of the impacts of acid and nitrogen additions on carbon fluxes in European conifer and broadleaf forests. *Environ. Pollut.* 2018, 328: 884-893.

Forest soil acidification and nutrient degradation (due to the excess of nitrogen) are global threats caused by SO_2, NO_x and NH_3 emissions from industry, transportation and agriculture. In a five-year-long experiment conducted in two typical forest types in Central Europe (spruce monoculture and natural beech forest) we tested response of soil C cycle to soil pH and N availability manipulations.

Consistently in both forest types the increases of soil acidity caused decrease of dissolved organic carbon (DOC) concentration in soil solutions, decrease of soil microbial biomass and overall decrease of soil respiration of about 10%. All effects caused by soil pH decreases were more substantial in spruce forest. Effects on C balance caused by changes in acid-base status of forest soils dominated over the impacts of enhanced N availability.

Acidification of forest ecosystems is an ongoing threat in SE Asia, whereas in Europe and North America forest ecosystems have been recovering from acidification since 1990s. Our study demonstrated that soil pH could influence soil C balance by slow-down of C cycle under soil acidification and by acceleration of C cycling when soils are regenerating from acidification. In both cases, soil C is not in a steady state. This could have implications for appropriate assessment of climate change effects on C cycling in forested ecosystems, especially in areas under historical or current stress caused by anthropogenic acidification.

Hlaváčová, M., Klem, K., Rapantová, B., Novotná, K., Urban, O., Hlavinka, P., Smutná, P., Horáková, V., Škarpa, P., **Pohanková, E.**, Wimmerová, M., **Orság, M., Jurečka, F., Trnka, M.** Interactive effects of high temperature and drought stress during stem elongation, anthesis and early grain filling on the yield formation and photosynthesis of winter wheat. *Field Crops Research* 2018, 221, MAY: 182-195. ISSN 0378-4290.

Increasing frequency of extreme weather events such as heat waves or drought spells will be expected in the future. Such extreme events will also be more frequent during the growing season, including the critical periods for the growth and development of winter wheat as the most important cereals in the territory of the Czech Republic and also throughout the whole Europe. However, in order to ensure sustainable agricultural production in future climatic conditions, it is very important to know the limits for growing the main crops, including the responses of individual genotypes to the extreme weather events and as well as their sensitivity at different growth stages. This will allow agronomists to carry out a qualified selection of the most appropriate varieties of a specific crop for given growing conditions. In order to evaluate the response of the contrasting winter wheat varieties (morphological, developmental and main use) to high temperatures and water scarcity, two varieties – Bohemia and Tobak – frequently cultivated in the Czech Republic were exposed to high temperatures (for 3 and 7 days) combined with a water scarcity. The experiment was conducted under controlled conditions of growth chambers. Plants of both varieties were exposed to these conditions in three growth stages (beginning of stem elongation – DC 31, beginning of flowering – DC 61, milk ripe – DC 75). Daily temperature peaks were graded in the range of 26–38°C, and half of the plants were exposed to water scarcity. Within the study, the effects of stress factors on plant photosynthetic parameters (CO_2 assimilation rate and stomatal conductance) and yield parameters such as the number of grains per spike, spike productivity and the thousand grain weight were evaluated. While the duration of stress factors did not play a significant role in the yield formation, photosynthetic parameters were significantly affected by the exposure time, and the highest reduction was observed in the combination of high temperature and water scarcity. Compared with other growth stages, plant photosynthetic parameters were least affected in the flowering stage. From the combined effects of high-temperature stress and water scarcity on photosynthetic parameters, the Tobak variety appears to be more tolerant. It can be concluded that both varieties of winter wheat can compensate for short-term effects of high-temperature stress and water scarcity (up to 7 days) on yield, even though these conditions have a major impact on photosynthetic parameters.

Lorencová, E., Whitham, Ch., Bašta, P., **Harmáčková, V.Z., Štěpánek, P., Zahradníček, P., Farda, A., Vačkář, D.** Participatory climate change impact assessment in three Czech cities: The case of heatwaves. *Sustainability* 2018, 10, 1906. ISSN 2071-1050.

Three quarters of European inhabitants live in urban areas that are often vulnerable and insufficiently prepared for impacts of changing climate such as heatwaves, water scarcity, drought or floods. Apart from the population, a high proportion of socio-economic activities and greenhouse gas production is concentrated in the urban areas. Increasing risks associated with climate change affect urban vulnerability and can have negative impacts on human well-being as well as on the national economy, urban ecosystems and natural capital.

Due to the changing climate, days with extreme temperatures (heatwaves) are expected to become more numerous, which could be particularly important for urban areas where the urban heat island (UHI) phenomenon is observed.

The aim of this study is to illustrate, on the example of larger Czech cities (Prague, Brno, Pilsen), a methodical approach for integrating participatory approaches into the assessment of the potential climate change impact of heatwaves. In addition to the current state of heatwave impacts, the study also focuses on the future outlook (2030), in terms of future climate scenarios RCP 4.5 (medium variant of increasing greenhouse gases) and RCP 8.5 (high emission trajectory). Moreover, outcomes from stakeholder participatory assessment are included in the analysis.

Potential climate change impacts were mapped at two levels describing “in-city” and “inter-city” comparison. When comparing the potential impact of heatwaves across the three cities (“inter-city”), the most affected city is Brno, with 10.5% of its area in the very high impact category for the baseline and both RCPs. The “in-city” comparison shows the differences between the baseline and future scenarios of each city. The assessment of heatwaves’ impacts was further used to support urban adaptation planning.

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In collaboration with colleagues from the University of Technology Sydney, we studied the limitations of photosynthesis in the biotechnologically promising microalga *Nannochloropsis oculata. Nannochloropsis* is perceived as an organism suitable for industrial applications particularly due to its ability to produce polyunsaturated fatty acids, including omega-3 fatty acids. During *Nannochloropsis* cultivation in an industrial setup, however, the biomass production may become reduced because of limited inorganic carbon availability: instead of direct CO_2 fixation, *Nannochloropsis* uptakes the HCO_3- ion. After CO_2 fixation from the HCO3- ion, OH- is released into the environment and the pH of the cultivation medium increases, shifting the carbon balance towards CO_3^{2-}. As microalgae are unable to uptake the CO_3^{2-} ion, carbon limitation occurs. Our study has demonstrated that the reduced biomass production in *Nannochloropsis* under carbon limitation is directly related to reduction of both photosynthetic activity and capacity. Combining biophysical and biochemical methods, we have also described compensation mechanisms in photosynthetic apparatus as well as changes in *Nannochloropsis* metabolism during growth in carbon limited environment. The study also provides an overview of applicability and feasibility of particular methods for investigating carbon limitation in microalgae.