Newsletter
2/2015

CzechGlobe
Global Change Research Centre CAS, v. v. i.

CLIMATE FROM ALL ANGLES

Undoubtedly one of the most important topics of the past year was a record-breaking heat wave and consequently also drought. In addition to that, world agencies published reports from meteorologists and climatologists from the US National Oceanic and Atmospheric Administration NOAA saying that this year is, in terms of the history of measurement, the ever warmest year on Earth. Also in the Czech Republic, thermometers were on the verge of hitting forty degrees Celsius and there were records of the highest temperatures since the beginning of the monitoring, which date back more than 200 years ago. In addition, since spring there has been very little rain and we have suffered the biggest drought in last 15 years. This gave worries to water managers, farmers and it also made many people's lives miserable.

It might seem that an institution dealing with the consequences of global change will be happy that the development of the weather "plays into our hands". We could clearly show all the naysayers and those who call us ecoalarmists that our work is meaningful and justified. Yet, despite the situation, we did not jump on the cheap wave of populism, even though that our workers were invited to various talk shows on television and radio more often than usual in those days, and our work became the subject of many coverage and newspaper articles.

The course of these events very well coincided (we cannot control the weather) with the publication and a gala book launch „Sucho v českých zemích: minulost, současnost, budoucnost" (Droughts in the Czech Lands: Past, Present and Future,) written by a team of authors from different scientific institutions under the guidance of prof. Brázdil and prof. Trnka of the GCRC. The book is the result of years of research and the completion of the INTERSUCHO project, whose aim was to create a top interdisciplinary international scientific team researching drought. This was successfully accomplished and thanks to the present-day topic and their outcomes, the team received funding from the Strategy AV21 of the Academy of Sciences and its activities can therefore continue. In November, a system for daily forecasts of agricultural drought was successfully launched for the Czech Republic and subsequently also for Slovakia. In the future, the team aspires to create a Central European center for monitoring drought.

This year's event that is highly anticipated worldwide and for many reasons very interesting for us as well is the just ongoing World Climate Change Conference in Paris. Despite the bloody events of recent days it is held with the participation of top senior representatives of all developed countries and most developing countries. All participating countries prepared their national action plans as a basis for negotiations. What is expected is that the countries will conclude a new globally binding agreement on reducing CO_2 emissions to replace the Kyoto Protocol of 1997. Its adherence should contribute to reducing global warming. Shortly before the conference, the World Meteorological Organization (WMO) published data on the record breaking levels of the main greenhouse gases of carbon dioxide and methane in the atmosphere, which shows that the average monthly concentration of CO_2 in the spring of this year has already exceeded the value of 400 ppm. CzechGlobe, as a respected research institution dealing with climate change research, provided the data and opinions for the Czech National Action Plan. And what is more, prof. Marek and dr. Ač are by virtue of being members of the Scientific Council of the Minister of the Environment, or more precisely, Chairman of the Czech National Committee Geosphere – Biosphere, members of the delegation of the Minister of the Environment.

The autumn months are traditionally marked by a number of conferences and workshops. In terms of their organization, also CzechGlobe was very fruitful as we inform you in other pages of the Newsletter. From mid-October to early November another phase of the evaluation of research teams was carried out at the GCRC, it consisted in presentations of teams before the evaluation committee. Nevertheless, as far as the results are concerned, we will have to wait until the first month of the upcoming year.

Finally, it behooves us to inform you that after years of effort, we will hopefully follow through to finalize the organizational change of the GCRC, which will then be divided into two parts. The Department of Nanobiology and Structural Biology in Nové Hrady will become part of the Institute of Microbiology CAS and Global Change Research Institute CAS will become the new successor of the GCRC. We wish everyone good luck, not only in 2016. **-mš-**

WE ARE INTRODUCING THE DEPARTMENT OF IMPACT EXPERIMENTS

OUR PLANTS ARE TASTING FUTURE CLIMATE

says Ing. Karel Klem, Ph.D., the Head of the Department of impact experiments at the Global Change Research Centre of the Academy of Sciences CR. He graduated from Phytotechnics at the Faculty of Agronomy, Mendel University in Brno. Then he pursued his doctoral studies in General Plant Production at the Faculty of Agrobiology, Food and Natural Resources at the Czech University of Life Sciences in Prague. He worked at the Agricultural Research Institute Kromeriz, for the company Agrotest fyto and since 2009 he has been working for the GCRC. In addition to that he is a lecturer at the Mendel University in Brno.

Your department dates back relatively recently, but its research activities have been carried out in the GCRC for quite a long time. Is it so?
That is true, impact experiments, or in other words, experiments evaluating the global change effects on plants and terrestrial ecosystems were together with the monitoring of carbon fluxes the foundation of the Laboratory of Ecological Plant Physiology. We began with the so-called open top chambers for the evaluation of the impact of increased CO_2 concentrations in spruce individuals, and then subsequently a unique experimental facility, the so-called cultivation lamellar mini-domes, was developed. These domes are still used for long-term monitoring of the impact of elevated CO_2 concentration on forest ecosystem. Thanks to the development and performance of these experiments we were able to engage in a number of European projects, for example ECOCRAFT, MERCI etc.

The experimental facilities have brought a number of interesting results and valuable scientific publications. Nevertheless, increasing demands on monitoring the factors associated with global change in mutual interactions, and a sufficient number of repetitions as well as the requirements for monitoring physiological and biochemical responses inevitably led to designing new experiments. Their implementation was made possible thanks to the OP RDI project, which allowed us to build a whole new set of experimental facilities, purchase top instrumentation and employ more experts and professionals. With such a range of experiments it was just logical to create a separate department focusing solely on experiments investigating the effects of global change on plants and ecosystems. Therefore, in 2010 we became the Department of Impact Experiments.

What exactly do you deal with then?
If I should summarize it in one sentence, our endeavor is to find the answers to the question, what will be the impacts of the anticipated global change on terrestrial ecosystems. For doing that we use various types of experiments in which we simulate environmental conditions anticipated based on various climatic models within a period of next 50 to 100 years. We can simply say that the plants within these experiments are tasting the future climate. In particular it is increased concentration of carbon dioxide in the atmosphere, elevated temperature, drought, varying intensity and quality of the solar radiation including ultraviolet radiation. The impacts of these factors are not observed just individually but also in combination, since a joint effect of several environmental conditions may accumulate, or, contrariwise, one factor may mitigate the effect of another. We are also interested in how the impacts of future conditions can be affected by farming methods, such as plant nutrition, interventions affecting the vegetation structure, use of growth regulators and the like.

What do such experiments look like in practice?
Most new experiments focus on three basic sets of questions. The first one is to understand the mutual interactions of the effects of more global change factors, e.g. the effect of elevated CO_2, drought and increased temperature. To do this we need an experiment where we can automatically and simultaneously simulate the change of multiple environmental conditions which is possible thanks to the new experimental field station in Domanínek with its 24 automatically controlled growth chambers. These chambers provide us with the possibility to evaluate the effect of the combination of elevated CO_2 concentration, temperature, drought, UV radiation and mineral nutrition. In the past three years we have focused on experiments with field crops and short-term experiments with European beech. However, we monitor similar combined effect of several environmental conditions in other experiments as well. At this point I would like to mention the experiment regarding the effect of drought on a mountain meadow ecosystem. The experiment is currently being modernized - the original passive rain-out shelters capturing rainfall have been replaced with an automatic system for simulating drought and increased temperature. In this experiment, we will cooperate with the Department of Matter and Energy Fluxes. Our colleagues will automatically measure respiration. The second group of experiments serves the understanding of the mechanisms of plant response and adaptation to the changed conditions. Despite the fact that we partly use field experiments for studying the mechanisms, the thing that is crucial for us here is a cluster of growth chambers called phytotrons that allow us to completely control the growing conditions from temperature, light, air humidity up to the concentration of CO_2 in the air. In these experiments, we find absolutely crucial to be in connection with the Laboratory of Ecological Plant Physiology as well as the Laboratory of Metabolomics and Isotope Analyses, because together we are able to explain the physiological and biochemical nature of plant response to changing conditions.

The last type of experiments stems from the requirements for the specification of models estimating the impacts of global change on ecosystems, particularly in terms of production. We partly use the results of long-term experiments, but the main emphasis is put on experiments that allow us to evaluate the dependence of plants response on individual environmental conditions. Such experiments require monitoring the influence of factors on a number of various

levels, often in interaction with another factor. Obtained dependencies between one or more environmental factors and production or quality parameters will allow more accurate estimates of the impact of global change, e.g. on crop yields or their food quality.

Within the range of the above-mentioned experiments we also endeavor to develop methods useful in remote sensing for the evaluation of processes like carbon assimilation or early diagnosis of drought stress impacts or nutrient deficiency. In the future, these methods should allow monitoring of, for example, the impact of drought episodes on ecosystems in much larger spatial scale allowing estimation of the influence of soil conditions, or terrain topography on the effect of not only this factor but also other ones.

You have described how experiments are carried out. Could you also tell us how you select plants for your experiments?

Although a substantial portion of the experiments are still focused on forest ecosystems and woody species, especially on European beech and Norway spruce, which are the most common trees in the country, new experimental facilities have allowed us to expand the sphere of interest on the meadow ecosystem, where we study various grass and herb species. For model experiments, which are used to understand the processes of adaptation to changing conditions, we use rockcress (Arabidopsis).

Lately, thanks to collaboration with colleagues from the Faculty of Agronomy of the Mendel University in Brno and shared grants we have been more and more devoting ourselves to field crops, where we focus mainly on winter wheat and spring barley. It turns out that changing climatic conditions not only affect crop production itself but also its food quality. For instance increased CO_2 concentration reduces not only the total amount but also relative proportions of proteins in the grain of wheat, which may be reflected on the quality of pastries, but it can also influence the occurrence of gluten intolerance allergies. Disastrous impacts on quality can also be created by drought or, conversely, by heavy rainfall during the ripening of grains. Nevertheless, the interaction of the effects of the amount of precipitation together with increased CO_2 concentration on quality has not been studied yet.

Listening to the list of your activities, I assume that you have certainly managed to achieve a lot of results. Could you mention the most interesting ones?

It is difficult to pick only a few from a variety of results, but the most interesting results are surely the ones focusing on the role of protective substances from the group of flavonoids which are induced mainly by ultraviolet radiation. Flavonoids protect plants against excessive radiation or during drought. I can also mention the results that show that the increased CO_2 concentration reduces food quality of wheat, which is primarily due to lower protein content and its composition. We also pursue the understanding of the mechanism of plant adaptation to elevated CO_2 concentration, and we have confirmed the key role of the sink - the accumulation of sugars - and nitrogen in terms of the feedback regulation of photosynthesis at elevated CO_2 concentration.

I would like to mention our innovation activities as well. It's the task we have in the international project European Plant Phenotyping Network (EPPN), where we found interesting possibilities for the selection of genotypes in terms of tolerance to drought, low temperatures, deficiency of nitrogen, attacks by fungal diseases, etc. Doing that, we employ the imaging methods based on chlorophyll fluorescence, spectral reflectance or thermal imaging and we combine those with advanced mathematical methods and methods of artificial intelligence when we use e.g. neural network or combinatorial imaging. This approach makes the selection of new genotypes significantly more accurate and allows earlier detection of tolerance to abiotic and biotic stress factors.

Besides this project, are you cooperating within any other international platforms as well?

Despite our relatively short history, we have managed to engage in several international projects like COST, ESFRI infrastructure projects as well as EU framework projects. What I consider key is the COST activity ClimMani focused on cooperation in the area of experiments monitoring the effects of climate change. Essential for us is also our integration into the European Research Infrastructure ESFRI, namely within the project AnaEE (Analysis and Experimentation on Ecosystems) where we are a founding member, and we assume that apart from our experiments, also the Isotopic and Metabolomic Laboratory and the Remote Sensing Laboratory will get involved as a compact infrastructure that provides data for the evaluation of the impacts of climate change across all Europe.

We also participate in the already mentioned project of the EU Framework Programme called European Plant Phenotyping Network (EPPN) focused on phenotyping of plants for the selection and cultivation of new plant genotypes. Our task in this project is to develop a system for scanning and developing a 3D model of chlorophyll fluorescence at the level of the whole plant. This unique sensor inclusive of software for the evaluation has already been developed and is now being tested in Jülich in Germany. As part of this project, another task of ours is to develop new optical methods used for the rapid noninvasive detection of plants' tolerance to abiotic and biotic stress. First and foremost, we develop methods based on chlorophyll fluorescence, spectral reflectance and thermal imaging.

DEPARTMENT OF IMPACT EXPERIMENTS

The Department of impact experiments falls within the Domain of impact studies and physiological analyzes of the GCRC. It focuses on understanding the impact of global change on both plant and ecosystem level, especially in view of unknown or little explored interactions with potentially limiting or stimulating factors such as the level of water, nutrients and light supply. Its endeavor is to find adaptation and regulatory mechanisms of plants and to evaluate species and genotype differences, phenotypic response and variability of different provenances.

The Department currently employs six researchers, three PhD students and the operation of experimental facilities is taken care of by one technician.

GLOBAL CHANGE MAY EXCEED A THRESHOLD FOR HUMAN ADAPTABILITY

GOT OUR ATTENTION

Jeremy S. Pal, Elfatih A. B. Eltahir

Some of the means helping to solve global change are adaptation measures. By this we mean all measures that lead to the mitigation of its negative consequences. Adaptation, i.e. adaptation of organisms to the environment, is a common ingredient as well as experience throughout life and it is an essential requirement for successful survival. Global changes in the past caused by natural factors shaped genetic memory of organisms and largely determined the threshold within which organisms can adapt to changes. The key in this regard is the speed at which global change occurs. From the past, we have plentiful evidence that many organisms are unable to adapt to very rapid changes. A new study published in the journal Nature Climate Change has shown that the threshold of adaptability, in some parts of the world, will be exceeded even in the case of humans (Fig.1).

The human body adapts to high temperatures mainly through evaporation of sweat (perspiration). The problem with this method of cooling occurs in a situation where a high temperature is combined with high humidity. The threshold for the survival of „apparent temperature" is 35°C. Several hours outdoor when this value of "apparent temperature" is exceeded causes health problems even for a young, healthy individual. Even moving to a shaded or well-ventilated area does not help. The published study has shown that the adaptability threshold will be exceeded especially in the Persian Gulf region. This is the first work ever which has shown that if the rise in greenhouse gas emissions continues, we will reach the limits of physiological adaptation of the human body by the end of the century. The fact that these model outputs cannot be taken lightly has been demonstrated this year. On 31 July in the Iranian city Bandahr Mashrahr the perceived temperature was as high as 34.6°C for almost one hour. The real problems occur in a situation where similar conditions will persist for several hours. The conditions that the people of the Middle East experience in the summer once every 20 days nowadays will become a normal summer day in the future. The most vulnerable cities are Doha, Qatar, Abu Dhabi and Dubai in the United Arab Emirates or Bandar Abbas in Iran.

Current heat waves, which occurred in Europe in 2003 and in Russia in 2010, have threatened especially the elderly and children so far. The anticipated heat waves, however, will mean an increased risk of death for all population, regardless of age or health. Air temperatures around 45°C will become common and maximums will reach values of up to 60°C by 2070. The study is important from two perspectives. It showed that the impacts of an increase in temperature and the resulting heat waves will be more serious than previously expected, and it also identified which areas will suffer the earliest and most. –aa-.

Source: Jeremy S. Pal, Elfatih A. B. Eltahir, Future temperature in southwest Asia projected to exceed a threshold for human adaptability, Nature Climate Change, 2015.

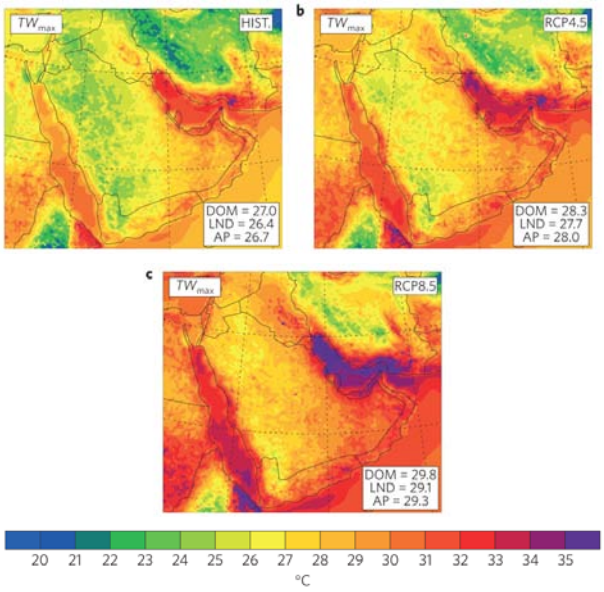

Fig. 1.: *Spatial distribution of apparent temperature. The mean estimate (Ensemble average) of the 30-year (2071-2100) maximum of apparent temperature for historical observation (a), moderate climate scenario (b) and climate scenarios without limiting the emissions of greenhouse gases (c). The most impacted zone will be the area around the Persian Gulf.*

WHAT´S NEW

14th CEPB and 13th SDEPB

From 7th to 11th September 2015 GCRC together with the Mendel and Masaryk Universities held the 14th Conference of Experimental Plant Biology (CEPB) and 13th Student Days of Experimental Plant Biology. This gathering of the community of scientists who are engaged in plant biology is traditionally held under the auspices of the Czech Society of Experimental Plant Biology and Slovak Botanical Society. Both of the events, with their 11 expert sections, were attended by more than 200 participants. What was new this year was the prof. Nátr Prize that was donated by GCRC and awarded for the best student presentation.

Workshop of the ICOS project

From 14th to 16th September 2015 an international workshop of the representatives of the ecosystem stations within the ICOS project (Integrated Carbon Observation System) was held in Brno. The workshop was aimed at creating a unified measurement protocol binding for all stations in order to ensure maximum possible accuracy and mutual comparability of the measured values.

Conference on gender equality in the academia

From 14th to 15th October 2015 GCRC organized a conference on „Gender Mainstreaming in STEM and Global Change Sciences" under the auspices of the president of the Academy of Sciences, prof. Jiří Drahoš. The conference was one of the planned events of the European project EGERA, which GCRC - as one of the partners - has been solving for the second year already and through which it seeks to systematically introduce gender equality in the academic environment.

Brno Adaptation to Climate Changes II

On 3rd December 2015 GCRC organized a workshop of the Norwegian funds project UrbanAdapt that was focused on the potential impacts of the climate change in pilot cities and accordingly also on the preparation of adaptation strategies of towns and cities as well as suggestions for suitable adaptation measures. One of these pilot cities is Brno as well. The seminar introduced the participants to the identified major issues related to climate change, to the analysis of key players in the city and to the economic evaluation of adaptation measures.

Newsletter CzechGlobe

Issue VI., number 2/2015

Published by: Global Change Research Centre CAS, v. v. i.,

Bělidla 4a, 603 00 Brno, tel.: +420 511 192 211

centrum@czechglobe.cz, www.czechglobe.cz

Design, layout and print by: Studio Palec, www.palec.net

Photo credits: Publisher's Archive

This Newsletter was supported by the Ministry of Education, Youth and Sports of CR within the National Sustainability Program I (NPU I), grant number LO1415.