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BOKU
DEPARTMENT FÜR WASSER-ATMOSPHÄRE-UMWELT

CONTENTS

Excellence in research through Responsible Research and Innovation

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The term Responsible Research and Innovation (RRI) has gained increasing EU policy relevance in the last years in the context of the Horizon 2020 Strategy. Responsible Research and Innovation is an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation. RRI implies that societal actors (researchers, citizens, policy makers, business, third sector organisations, etc.) work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society.

The aim of the presentation is to provide an overall understanding of RRI and its different pillars (public engagement, open access, gender equality, science education, ethics, and governance) and to prepare participants for the future FP9 Framework and its social-ethical requirements.

The initiative is organized as part of the NewHoRRIzon Project and its Social Lab focusing the on the Spreading Excellence and Widening Participation Work Programme. Social labs are not workshops. They are intensive, experimental interventions. They bring together people from across the system to seek root causes behind their problems and then collaborate on devising and testing solutions aimed at key leverage points. This work continues in the “lab” of the real world – over time and in context.

Doctoral School towards Knowledge Based Society

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Doctoral education, doctoral programmes and doctoral schools are the third cycle of the higher education and at the same time constitute the first phase of a young researcher's career. Doctoral training is markedly different from the first and second cycle of higher education (undergraduate and master's education). Its main characteristic, which makes it specific, is that a doctoral candidate has to be led and trained to advance her/his knowledge through original research. Therefore, the doctoral education constitutes the main link between Higher Education Area and Research Area.

Institutional reforms of the doctoral education in the XXI millennium. The reorganization of doctoral training, from being a very individual work focused on a specific topic, towards structured programmes and training in a wide range of transferable skills, have received considerable attention. Such a reform is imposed by changing contexts in the knowledge society and the globalised world. It is a result of the growing awareness of the importance for Europe of increasing its research potential and providing the unique environment in which young researchers are trained by, and through, research.

Recommendations based on rich tradition of doctoral education and challenges of the modern society**.** Salzburg Principles from 2005 of the European University Association and subsequently Salzburg II Recommendations from 2010 have advocated and paved the way for a new paradigm of doctoral education. The core recommendations are: advancement of knowledge through original research; embedding in institutional strategies and policies; rich diversity of doctoral programmes, including joint doctorates; doctoral candidates as early stage researchers to be recognized as professional; new practice of supervision, assessment and shared responsibilities; achieving critical mass to be able to develop different new types of innovative practice; limited duration (3-4 years full-time); interdisciplinary training with transferable skills, increasing mobility, appropriate funding.

We have undertaken an extensive comparative study of the main ideas, notions, and goals of the doctoral education in Europe and Serbia within the Tempus project "Doctoral School towards European Knowledge Society" (2008-2009), details are available at http://cms.uns.ac.rs/deuks/ The main outcome has been the doctoral programme "Applied Mathematics" at the Faculty of Technical Sciences, University of Novi Sad. The focus of the programme is cutting-edge research, interdisciplinary training, application, internationalization and mobility.

New challenges are faced in the continuous implementation of reforms in doctoral education building on these recommendations:

- Research integrity and research ethics
- Digitisation, open science, big data, online learning
- Global research synergy.

Knowledge Based Society. Doctoral education has a great potential in engaging with other stakeholders as a link between universities (academia) and society (non-academia). The mobility of doctoral candidates between academia and private companies or public sector develops collaboration between these society pillars. The aim is to increase the number of graduated students to find employment in non-academic jobs in order to bring cutting edge knowledge to society. To this end, it is crucial to raise awareness and interest of non-academia in highly-educated specialists who will bring forward the companies and the society in general, with their innovative thinking, creative ideas and practical cutting-edge knowledge.

Agricultural meteorology and climatology - presentation of new textbook

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"Agricultural Meteorology and Climatology" is a text book for courses of Meteorology and Climatology at agricultural faculties and courses of Agrometeorology and Agroclimatology at all other faculties with this subject in their curricula. Additionally, book is useful source of information for agronomist and all people interested in different aspects of weather and climate impact on agricultural production.
Respecting the fact that knowledge and practical experience increase exponentially, "Agricultural Meteorology and Climatology" design leaves open access to new information by extending its content out of book cover and including, on line available, numerical examples and additional reading material. The last two are in the form of easy-editing work sheets and text files which can be continuously improved.
In order to capture reader's attention, the book is divided in three sections: Basics, Application and Agrometeorological measurements with numerical examples.

Basics section discusses the atmosphere, its causes and the consequences of its behaviour. The origin of the Earth is the cause of atmospheric content. Together with incoming solar radiation and surface characteristics, the composition of the atmosphere determines the Earth's heating and cooling, the major forces behind almost all atmospheric processes determining weather and climate. Since soil and plants, with atmosphere, complete list of main pillars of climate system, their interactions and feedbacks are clearly presented in separated sub chapters of each chapter.

Application section addresses impact of weather and climate on plant phenology, extreme weather events and consequent risk management. Since agricultural production is weather dependant activity, impact of climate change on agriculture, including modelling techniques as well as mitigation and adaptation measures from global to farm scale, are presented with particular attention.

Agrometeorological measurements with numerical examples should encourage readers to apply gained knowledge in solving practical problems. No matter if they prefer to organize micrometeorological measurements or to use remotely sensed data, information about meteorological instruments principle of work, data assimilation and management will for sure meet reader's needs.

Internationalization of higher education through joint training and exchange of guest lecturers. SEF as a case study

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At the 2017 Gothenburg Summit, EU leaders outlined a vision for increasing policy attention in Europe to education and culture. In the conclusions adopted, leaders highlighted that «*education and culture are key to building inclusive and cohesive societies, and to sustaining our competitiveness. In Gothenburg we expressed a willingness to do more in these areas, in which the EU plays an important supplementing and supporting role*».

In this context, EU is calling to specific initiatievs, such as 'European Universities' that must be a game changer in higher education. The idea is that, building on excellent examples such as Erasmus Mundus and Marie Skłodowska-Curie Actions, Europe must make a step forward. Driven by high quality, these European Universities would attract the best students, teachers and researchers, making use of the most innovative pedagogies and digital technologies.

This is a very ambitious and promising objective in Europe, but what is the experience on the ground? Are we able, as representative of the european research, to take this step? Which is the real impact of the internationalization of higher education? WHich are the limits and the potential?

Serbia for Excell wanted to contribute to the international debate and wanted to go towards the direction identified by EC in therms of internationalization, knowledge and skills upgrading not only of students but also of the reseachers.

To this aim, Serbia for Excell used two powerful tools: Expert trainings and Guest lectures. In particular, expert trainings were dedicated to knowledge and skills upgrading, in the case of senior and young researchers, while guest lectures were aimed both at researhcers (mobility) and at university students.

In this presentation, the main characteristics, strenghts and weakeness of such initiatives were identified and described with the help of ad hoc interwiewes to people that really participated to the internationalization process.

Internationalization of higher education through harmonised curricula and joint student's books

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Internationalization of higher education, transfer of students and university staff, knowledge and methods is old as old are universities worldwide. During the last 50 years and particularly during XXI century whole process is intensified due to more efficient transfer of people, improved communication techniques and, recently social networks.

It seems that less developed countries and universities can and should benefit from that processes. However, there are different opinions about subject which should be taken into account. For example, according to Knight (2003) the internationalization of higher education is "the process of integrating an international, intercultural, or global dimension into the purpose, functions or delivery of postsecondary education". On the other hand, Khorsandi Taskoh (2014) pointed out that internationalization of higher education is "the process of commercializing research and postsecondary education, and international competition for the recruitment of foreign students from wealthy and privileged countries in order to generate revenue, secure national profile, and build international reputation."

One of important goals of H2020 TWINN SERBIA FOR EXCELL project is strengthening research, innovation and societal capacities particularly within university students and staff through internationalization of education in all participating countries. Harmonization of curricula and development of joint text book are good steps toward realization of project goals but also EC goals formulated during 2017 Gothenburg Summit when European Council make a call for "…strengthening strategic partnerships across the EU between higher education institutions and encouraging the emergence by 2024 of some twenty 'European Universities', consisting in bottom-up networks of universities across the EU which will enable students to obtain a degree by combining studies in several EU countries and contribute to the international competitiveness of European universities" (https://ec.europa.eu/education/european-universities-initiative_en).

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Small Study Group Activity

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Task from the project:

Small study groups (SSG). At least one student from each partner institution, will be invited during one year to participate to one SSG. At least two SSG will be organized during the project. Since some parts of, for example, Agrometeorology/Meteorology courses are the same at UNSFA, BOKU and UNIFI students will prepare the same lectures and afterwards solve same tests. Parts of lectures will be exclusively presented to each partner students and it will be presented to all others. It will initiate communication among students and produce necessity to work together in order to solve problem. At the end we will discuss with students their impressions about joint study work. **SSG** students from partner countries will be invited to SS1 and SS2 and will have opportunity to meet in person.

Realization summary

As explained in the previous report, the project team has came to a conclusion that it is difficult to assemble small study group from undergraduate students since they are not focused on a specific subject (they have many subject to follow, and those are diverse between institutions). Therefore, this task was accomplished due to the joint activities of Ph.D. students from all partner institutions.

During 2017 and 2018 one small study group was formed in each year from Ph.D. students from all partner institutions. On the occasion of Summer school 2 students presented the results of SSG2017 and during Workshop they will present their work in the frame of SSG2018.

SSG in 2017

The title of choice for the common work was **Climate change-induced abiotic stress affects agriculture** and the participants were: Jorge Alvar-Beltrán (UNIFI), Leonardo Verdi (UNIFI),
Sabina Thaler (BOKU), Milena Daničić (PFNS).

During their work, the students prepared joint text of the paper and Power Point presentation.

The contents of the paper are: General introduction, Drought stress, Main drought effects on crops, 2) Heat stress, Main heat stress effect on crops, Strategies to mitigate heat stress, EU strategies to mitigate drought and heat stresses, Conclusion, 3) NaCl and heavy metal impact on crops, Main NaCl and heavy metal (HM) effects on crops, Mitigation strategies of plants induced by salt and HM stress, Conclusion, 4) N deficiency stress on crops, Nitrogen deficiency effects on crops, Factors affecting N dynamics, Strategies to mitigate, N deficiency in plants, Combination of N/ water deficiency effect on crops, Combination of N/salinity deficiency on crops, Conclusion, 5) Overall conclusion, 6) References

SSG in 2018

The title of the joint work was **Impact of climate changes on plant growth and nutrition** and the participants were: Carolina Fabbri (UNIFI), Milena Daničić (PFNS), Tijana Narandžić (PFNS), Lukas Koppensteiner (BOKU), Thi Mai Anh Tran (BOKU).

During their work, the students prepared joint text of the paper and Power Point presentation.

The contents of the paper are: General introduction, 1) Spectral measurements and selected vegetation indices in plant production and climate change, 2) Climate change and crop growth, 3) Climate impact on xylem tissue in woody plants, 4) Managing nitrogen for sustainable development and its role in climate change, 5) Impact of the environment on uptake of micronutrients, 6) Conclusion and 7) References.

Science for Education and education for science

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As a part of WP3, we organized several events. In cooperation with elementary school "Tvrdjava" from Novi Sad, we organized four events as a part of "Children's university". In 2017, two events took place: one with younger (8-10 years old) and older (11-13 years old) group of children. Lecture for the younger group was focused on global warming and its influence on sea level rise. After the short introduction, kids were divided in groups of two, and each group used modeling clay, two food storage boxes, water and ice cubes to simulate how location of ice formations dictate the amount of rise in sea level.
Lecture for the older group was focused on greenhouse effect and solar radiation. After the short introduction, kids were divided in groups of two, and each group used a computer model to explore how solar radiation interacts with components of Earth's surface and atmosphere, and learn how greenhouse gases warm Earth's atmosphere.
In 2018, we organized "ice melting" activity with the new generation of 8 year kids. With older group we discussed erosion, its mechanisms and consequences. Practical activity was based on comparing effect of water and vinegar on chalks that were immersed into them. Kids were again divided into groups of two, and they started the experiment at the beginning of the event. Near the end of the lecture, they were instructed to remove their chalks from water and vinegar and observe and comment the results.
For all groups, practical activity also teaches them to practice some of the steps involved in a science investigation. To emphasize that part, we ended activities with short discussion about the basics of the scientific methods and scientific practice.
We also organized three round tables during 2018. The topic of the first one was "Education and/or critical thinking" which took place in UNSAF, Novi Sad. Attendants were UNSAF PhD students, prof. Dušan Petrić, prof. Branislava Lalić, while the round table was moderated by Dr. Igor Balaž. Main topics were: What is the critical thinking; Does usual education practice nurture critical thinking; If not, or not enough, what would be the case; Risks and benefits of critical thinking. Although we planned that the round table take about one hour, actual duration was 2 hours. Two remaining round tables were organized in cooperation with two grammar schools from Novi Sad: Jovan Jovanovic Zmaj (3rd year students) and Zivorad Jankovic (4th year students). The structure of both round tables was similar: as a starting point we presented two opposite sides from the climate changes debate (alarmist vs. denialist). We went through several prominent arguments from both sides and analyzed how and to what extend they distort scientific facts. In the second part of the discussion we moved towards general critical thinking skills: what are they and how they can be applied. Within that topic we discussed how mass media treat scientific claims and how to recognize differences between scientific skepticism versus two opposing extremes: uncritical belief and denialism.

Problem solver challenge and its efficiency

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Discussion and creative thinking in Serbian educational system is not encouraged, from student's initial schooling onward. System is more focused on learning and reproduction. In the frame of project "problem solver" challenge was created to attract young people to think creatively, i.e. to observe environment, to identify problems (related to plant development, agricultural production, physical processes of the atmosphere, ecophysiology and environment), to analyze causes and consequences and to offer solutions which include their knowledge from science (physics, chemistry, biology, agronomy) and mathematics. Students of all levels and young researches were invited to participate. They could write the problem and solution (up to 1500 characters) in English, Serbian, German, Italian. Problem solver was intended to be a place for discussion and offering of solutions or to leave a problem and wait for solution. Formally, it was very easy just to register through project web page and leave a "Problem solver note". Unfortunately, all the problems were not visible on the web page of the project, and the participants were encouraged to concomitantly describe the problem and to offer the solution. In order to make “problem solver” activity more attractive for young people, small contest to win the title "Problem solver of the month and year" was organized. Once a month the best "problem solver" was awarded with tickets to popular social events (movies, theatre, concert, sport event, …). The winner of the year contest was in both 2017 and 2018 granted tickets for Exit music festival and opportunity to participate in the Summer school 2 and Workshop organized by the project. Rewords for contest winners could have been reworded for places and events in partner institutions alike (BOKU and UNIFI).

Advertising of the "problem solver" challenge was made through the project web page, public presentations of the project by participants and during the regular courses at universities and high school students. Many announcements were displayed in rooms attended by bachelor, master and Ph.D. student. Announcements were also placed in grammar schools. In various ways, we tried to attract the attention of students to this challenge, but awards were often not enough motivating. Only students of undergraduate studies, in the frame of the course of Ecotoxicology and environmental protection (PFNS) responded to the task. About 35 problem solver items were sent during the 2017 and 61 during 2018, until now, all from Serbia. Students in Serbia typically fear from public presentations of their opinions, since they fear condemnation from the environment. However, if they are given a concrete task in the frame of the study course, they will do it readily and on time. This is exactly how we obtained results in the frame of this project activity.

Partner institutions (BOKU and UNIFI) did not get any positive response from their students. They did not get any contribution to this activity, even though they advertised and promoted it. They concluded that students at BOKU and UNIFI do not consider such extracurricular opportunities, which is a general problem that they have met also on other occasions. Possible reasons for such attitude are: scarce skill in

English language, low scientific attitude/interest, low level of interaction, especially with different realities, consideration of University as a prolongation of high school instead of a real research/scientific high-level environment (thinking that they are here to receive something, not to contribute).

Faculty of Agriculture, Novi Sad - strategic plan in research and education (2018-2021)

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In the 21st Century higher education institutions around the world have been struggling under two different types of pressure: the first is financial, as the provision of public funds has been decreasing. The second refers to the political, economic and social demands on higher education, which have been increasing. Thus nowadays they are taking on more responsibility for their own future planning and they need to further strengthen their capacity for strategic performance.

This strategic plan represents values and characteristics that define Faculty of Agriculture, Novi Sad (FANS) and ambition to create a great competitive research driven faculty with modern management that will be able to relate education to world of business, create better conditions for learning and research and improve graduate employability. Socio economic environment supported comprehensive approach and development of courses designed to provide students with the knowledge in environmentally friendly agricultural production. The aim is to be recognised locally, nationally and internationally as a wide-ranging, multidisciplinary faculty that delivers inventive and outstanding research. At the same time we are committed to stimulate research initiatives, to incubate entrepreneurship and to support enterprise development programmes. Our principal function, as a research driven faculty, is to motivate and support individuals and groups to generate research ideas, explore and engage in research funding, to create new knowledge and in particular publish papers in highly ranked journals. Conduct fundamental and applied research at the high levels of excellence, promote science awareness to stakeholders, and release ideas and technologies which will promote economic growth of the region. FANS is committed to improve the quality of research activity and outputs and to provide a stimulating environment and enabling infrastructure to allow staff to achieve their highest potential. Having in mind that research and education are inseparable entity both task must be equivalent and balanced. Applying the highest academic standards we enable students to acquire competences based on the newest scientific knowledge, for the benefit of the society.

Key performance indicators in next four-year period are: to ensure the efficiency of the organization and management of the faculty, financial commission in strategic investments, accreditation of the teaching process, increasing number of students (permanent and strategic promotion), to develop scientific excellence, innovation in research and collaboration with business sector, develop collaboration with strategic partners and Internationalization.

MosqDyn project results

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WHO estimates that vector-borne diseases account for more than 17% of all infectious diseases with more than half of the world's population at risk. Every year, more than one billion people are affected of which a large proportion is due to diseases transmitted by mosquitoes. More than 2.5 billion people are at risk of contracting dengue alone, and malaria causes 600,000 deaths every year globally. The main objectives of this project were: (1) Optimised spatio-temporal efficiency of sampling techniques and strategies; (2) Field identification of pest species using loop-mediated isothermal amplification of DNA; (3) Forecasting pest population dynamics at various scales; (4) Optimise the use of low cost meteorological sensor networks. Very high resolution (VHR) satellite images were used in combination with supervised classification techniques for the development of a stratified sampling design. A stage-structured deterministic model was constructed to simulate mosquito population dynamics for *Culex* and *Aedes* species. The model uses a system of ten ordinary differential equations with temperature dependent development and mortality parameters to simulate the different life stages within the mosquito life cycle. Specifically, three aquatic stages (Egg, Larva and Pupa) and three adult stages (Bloodseeking, Gestating and Ovipositing) for parous and nulliparous adult females were considered. A wireless sensor network (WSN) was used to inform the link between environmental drivers and mosquito development parameters at a finer scale. An optimal set of meteorological predictors was identified considering the mosquito population as the dependent variable. These predictors included large scale averages as well as local screen level variables in the planetary boundary in the areas of interest. The most important meteorological variables were temperature and precipitation. Relative humidity was considered however did not improve the model when compared to the reference run. A high-resolution physiographic dataset called ECOCLIMAP was used within the RMI numerical land surface module (SURFEX) to compute the time evolution of the meteorological variables taking into account different physiographic characteristics. SURFEX was run with a 1-km resolution in order to fully exploit the details of the ECOCLIMAP data base. Accurately modelling the abundance of the vector population in local environments is a pressing issue. Model outputs can be used in assessing the risk of disease transmission which is positively correlated with mosquito abundance and seasonal activity.

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CO_2 exchange dynamıcs ın agrıcultural ecosystem: a case study of wheat

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Agricultural land and forests have an extremely important share for the global greenhouse gas budget. Agricultural and forest areas are different from the other regions in terms of greenhouse gas emissions due to being both source and sinks. In terrestrial ecosystems, greenhouse gas exchanges are measured and tracked for a long time, often with forest-based flux measurement systems and their associated flux networks. Measurements in agricultural areas are fewer and shorter when compared to the forests. However, studies involving the interaction of plants with agricultural products, including CO_2, CH_4, N_2O as important greenhouse gases and their interaction with the atmosphere, are not only important for the environment but also countries' carbon footprint studies. Unfortunately, flux studies including carbon exchanges using micrometeorological methods, are not very common in developing countries. Thus, the results obtained for some crops grown in our country will be shared as a result of measuring and calculating the variation of greenhouse gas emissions and sinks from agriculture by a micrometerological method widely used in the world.

Potential of photographs digitalization and thermal imaging for plant studies

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Digitalization of photographs has been used by many scientists for determinations of canopy closure and LAI in canopies. It has also been used for phenological studies. Still the techniques and algorithms show some uncertainties. Thermal camera systems allow to determine canopy and leaf temperature.
The leaf temperature is an important indicator as to the stress status of a plant. Leaf temperature increases when plants close their stomata which may be an indication of drought stress of the plant. One important index for the determination of drought stress is the Crop water stress index (CWSI) which uses the difference between air temperature and leaf temperature.
In the present study, we used tomato plants (Solanum lycopersicum) with different types of water amount treatments to characterize CWSI. Treatment 1 (L1) was well watered (900 ml/d), treatment 2 (L2) was imposed a medium water stress (600 ml/d) and treatment 3 (L3) was grown with a strong water stress (300 ml/d). The amount of water was decided in account to a recommended watering of 1000 – 1500 ml/d for tomato plants. Additionally, we wanted to charaterize an extreme treatment level of no watering. Therefore, three plants standing almost the whole day in shade weren't watered for one day.
Infrared and visible photographs of the plants were taken four times per day. 27 tomato plants, potted in a 5 l pot, had a distance of 40 cm to each other and covered an area of 7 m² in a glass house whereby the walls were metal grids.
First results show a clear signal that stressed tomato plants become warmer than the air temperature the less water they got. Leaves of L1 had an average temperature difference of -0.43 °C, leaves of L2 had a temperature difference of 0.83 °C and leaves of L3 had a difference of 1.65 °C compared to the ambient air temperature (values from meteoblue) in shade over the whole two days. The extreme drought treatment level got even an average temperature difference of 3.01 °C.

Use of different timescale weather forecasts in the field of plant disease predicting

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Growing population requires food production on the potential level. That amount of food produced means that the agricultural production needs to be free of environmental, pest and disease risks. The appearance of the plant diseases is always a result of both biotic (presence of specific bacteria, fungi, viruses, i.e.) and abiotic (temperature, precipitation, light, pH, etc.) factors specific to the current environment. The details about factors influencing disease appearance and infection intensity are the basis on which adequate protective measures and control programs can be developed. This extensive knowledge, collected in the field and laboratory experiments, is the base for the development of mathematical models which can calculate plant disease (or pest) development dynamics or on the other hand the effects of disease (or pest) on the crop development (e.g. crop yield).

Downy mildew (*Plasmopara viticola*) has been the cause of massive yield loss in Serbian and Austrian vineyards. Introducing more spraying has resulted in moving production away from the organic and cost effective. Introduction of plant disease specific modelling tools, into integrated disease management can significantly reduce number of spraying and increase their efficacy. Calibrated and validated model for the specific location can be used for early alarm of disease appearance based on observed *in situ* meteorology but it can also be used for forecasting.

Recently, a wide spread of different time and space scale weather data has been collected and generated for the past, present and the future conditions. We have used different time and space scale forecasts and BAHUS model to investigate how well the prediction of downy mildew can be in Serbia and Austria agroecological condition.

Further plans in this field are including other disease, particularly fire blight and apple scab, appearance forecasting.

A new gap filling approach

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Automatic weather stations (AWS) are in everyday use in agriculture. Data usability is often reduced because of existing gaps in measurements caused due to different reasons. There are plenty of well known ways to recreate missing data by using simple interpolation and extrapolation techniques but they can be used only for short gaps. To recreate longer gaps we suggest use of other reliable weather data sources such as weather reanalysis. Such datasets are available for long historical periods for wide geographical areas and are of acceptable accuracy.

In this research ERA5 reanalysis dataset from European Centre for Medium-Range Weather Forecasts (ECMWF) was used to fill gaps in temperature time series. Simple insertion of reanalysis data into gaps will cause new problems. Strong bias in ERA5 data series compared to AWS can disrupt statistical characteristics of longer time series and can diminish data homogeneity. Reanalysis data have poor horizontal resolution and distance between AWS and nearest grid point in reanalysis dataset can be significant. Often we can recognize the influence of the measurement site on weather observations. For one AWS we have noticed that temperature amplitudes are greater in observations dataset than in reanalysis dataset. For the other AWS we observed significant difference between AWS elevation and elevation of nearest reanalysis point which was reason for strong bias. In order to reduce bias and other site measurement effects we have developed a new gap filling approach. Existing data from the time before the gap was used to calculate bias between ERA5 reanalysis dataset and AWS dataset and learned bias relations were applied to ERA5 dataset for the period of missing observations. We relay on known features of variable and use linear regression as measure of bias between AWS observations and reanalysis data. Root mean square error (RMSE) was used to calculate achieved scores.

First results gained with new methodology showed that our approach was better than simple substitution of ERA5 data for most cases. Differences in results for different geographic areas were also noticed. It remains to examine the cause of bad results for individual events which can help us learn more about relations between observations and reanalysis data and to look for possible improvements which can be applied in future work.

The effect of ionic liquids on germination and physiological traits of wheat and barley

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One of the most prominent topics in the field of green chemistry is synthesis of the environmentally friendly solvents. Popular strategy is synthesis of new classes of ionic liquids (ILs) due to their extraordinary physiochemical properties. ILs are considered as innovative solvents of 21st century with a wide range of potential applications. However, Ils are very heterogeneous group of liquids which cannot be considered a priori benign. Therefore, it is necessary to evaluate their potential effect on living organisms and overall environment. At the first part of experiment of the present PhD research we investigated the effect of five different imidazolium based ionic liquids: 1-(2-oxybutil)-3-methylimidazolium chloride, 1-(2-oxypropyl)-3-methylimidazolium chloride, 1-(3-hydroxypropyl)-3-ethylimidazolium chloride, 1-(3-hydroxypropyl)3-methilimidazolium chloride, 1-(2-hydroxyethyl)-3-methylimidazolium chloride, together with commercial 1-butyl-3-methylimidazolium chloride and synthetized protic imidazolium chloride, on early development of wheat and barley. The concentrations of ILs used in the experiment were 10, 100 and 1000 mg L^{-1}.The addition of polar groups (in form of hydroxide and/or ether group) in the alkyl side chain of the imidazolium cation and their influence on the reduction of ILs toxicity was investigated also in the present research. The results indicate that germination of barley was more sensitive to the presence of ILs in comparison to wheat. In general, effect of investigated ILs on plant seedlings growth (root and shoot) was not pronounced at lower concentrations (10 and 100 mg L^{-1}), but under higher IL (1000 mg L^{-1}), the adverse effect of ILs on plant seedling growth was observed. Furthermore, negative impact on growth was more pronounced in barley. Toxicity of oxygen functionalized ILs was significantly lower against wheat when compared to non-functionalized analogues. Results showed that alkylation in the position N-3 atom of the imidazole declined the toxicity of the cation.

In the next phases of research, the potential effect of different synthetized and commercial ILs on germination and growth of cucumber and tomato are going to be tested. Physiological responses of plants (e.g. malonyldialdehyde (MDA) concentration, free proline content in different parts of the plants (root, stem and leaf), leaf area, fresh and dry biomass, and root area) will be assessed.

Environmentally related cherry root xylem plasticity

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The general aim of this research was to determine whether the cherry root cambium posses the similar water-stress adaptation ability as the scion does. Specifically this study aimed to determine whether there is a shift in root xylem structure due to precipitation fluctuations and temperature increase during the growing season in two contrasting root systems – deep, vertically oriented in *Prunus fruticosa* (Pall.) versus shallow in *Prunus cerasus* (L.) ecovar. Oblačinska. Cherry rootstock breeding at the Faculty of Agriculture, Novi Sad, Serbia is the ongoing project focused on vast biodiversity of genus *Prunus*, its collection, evaluation and conservation both *in situ* and *ex situ*. During 2010 root systems of more than 40 cherry genotypes belonging to *P. fruticosa* (locality Fruška gora) and *P. cerasus* 'oblačinska' (localities Prokuplje and Dešilovo) were morphologically and anatomically evaluated for the selection purposes. Although sampling methodology was identical throughout the survey, some roots of the same age showed more than one ring-like formations across the wood sections, characteristic only for stems. Occurrence of ring-like formations in secondary roots collected from in vivo mother plants, and their absence in clonally propagated plants of the same age and genotypes required in dept analysis of meteorological data in the time of formation. For these purposes data regarding temperatures and precipitation during vegetation of 2010 were obtained from ERA 5.

Assumed environmentally related cherry root xylem plasticity in this study was fortified by occurrence of false rings and alterations in conduit sizes in secondary roots collected from in vivo mother plants and their absence in clonally propagated plants' roots of the same age and genotypes. Under environmental signals both investigated species altered their radial root growth imprinting stops and starts in cambial activity that resulted in intra-annual false rings occurrence. Along the false rings European ground cherry followed the usual early-late wood pattern, while oblačinska sour cherry produced larger vessels as an alternative to smaller cross-sections and weaker shallow root system. Changing environmental conditions triggered the shifts of large and small vessels throughout the false rings, but their size seemed to be mainly genetically controlled. Taking into consideration all the above, genotypes with moderate vessel lumen area – lesser or around 1200 μm^2 in the inner zone, as well as no greater than 1500 μm^2 in the outer zone – are presumed to be both size-controlling and stable upon the drought events. Thus, further field trials will be focused on SV2 European ground cherry genotype and OV13, OV32 and OV34 oblačinska sour cherry genotypes.

With the changing environment rootstock breeding selection goals are to be changed accordingly. If un-irrigated, preferred rootstocks should to be able to cope with uneven precipitation distribution and increased temperatures during late spring and summer months. For future breeding purposes and size-

controlling prediction models of an equal importance will be the assessed environmentally related xylem plasticity as well as genetically controlled conduit size. Investigated cherry genepool indicated the ability to optimize its inta-annual anatomical architecture to the specific environment, adjusting both secondary wood and secondary cortex characteristics, which should be further investigated inter-annually.

The effect of cover crops on soil water balance in rain-fed conditions

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Cover crops are usually considered as beneficial crops, due to positive effect on increased soil organic matter, reduced erosion, improved uptake of nutrients etc. However, there is a concern among farmers for the cover crops use in crop rotation as they can reduce the soil water availability for the subsequent main crop. The aim of this study was to determine the influence of winter cover crop water uptake on soil water content and water balance for the cash crop. Standardized Precipitation Index (SPI) was calculated for 1, 3 and 9 months in order to identify and to analyze intensification of drought. The field experiment was conducted between 2011 and 2013 at three locations in the Vojvodina Province, north part of the Serbia (Novi Sad-Rimski Šančevi, Sombor, and Senta in rain-fed conditions. The experiment was set up as a random block design with three replicates and included winter cover crops used as green manure - common vetch sole crop (*Vicia sativa* L.), triticale sole crop (x *Triticosecale* Wittm. ex A. Camus) and their mixture, two N rates (N_1 80 kg N ha^{-1} and N_2 160 kg N ha^{-1}) and a control. The control was unfertilized plot and without cover crop during winter and was performed with ploughing in autumn followed by bare fallow. Winter cover crops were planted in the first half of October of 2011 and 2012 and ploughed-in in May 2012 and 2013, when the mineral N fertilizers were also applied. After the cover crops were ploughed-in, silage corn was sown. From each location, soil samples were taken in four soil layers: 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm at the beginning of growing period and after the winter period (March), after cover crops ploughing-in (end of May) and after harvest of silage corn (September/October). Based on the meteorological data and SPI values, it can be concluded that 2012 was extremely dry year, while in 2013 weather conditions was near the average but with favourable distribution of the precipitation. The difference in the soil water content (0-120 cm) between treatments with cover crop and bare fallow was more than 100 mm. The results indicated that winter cover crops had significant influence on the soil water content and therefore on the silage corn yield.

Greenhouse gas and ammonia emissions from soil: the effect of organic matter and fertilization method

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Greenhouse gas emissions (GHGs) into the atmosphere derived from the use of fertilisers represent a serious issue for the sustainability of agricultural systems, also considering the growing global demand for food requires an increasingly productive agriculture. In addition, it is also important to consider that emission dynamics are affected by a wide range of factors as soil texture, soil organic matter content, fertilization method and fertilizers type, agricultural management strategies and climate. These factors are strictly connected among them and interactions play a key role on the emission dynamics from soils. In the present experiment authors evaluated the effect of soil organic matter and fertilization techniques on the emissions of greenhouse gases and ammonia emissions. Liquid fraction of digestate from pig slurries, compost from organic fraction of municipal solid wastes, and urea were applied on bare soil with two levels of organic matter (OM1: 1.3% and OM2: 4.3%). Emissions were directly monitored by a static chamber system and a portable gas analyser. Chambers were composed by two parts: the lid and the anchor system to be inserted into the soil. The gas analyzer uses NDIR for NH3 detection and electrochemical technology for CO2, CH4 and N2O. Samplings were performed once a day during the first week after fertilizers spreading and twice a week during the following weeks by holding the sensor inside the chamber for 1 minute immediately after chamber closing and then repeated at 1 hour intervals. Gas fluxes were calculated starting from gas concentration into the chamber, chamber dimensions (area and volume), closing time and molecular weight of each gas. As temperature had a similar trend inside each chamber, the whole experiment was assumed to be at standard temperature and pressure (STP) conditions and the molar volume of the air is assumed as 22,4 liters. Results shows that soil organic matter as well as the composition of the fertilisers affect greenhouse gasses emissions. Emissions of methane (CH4) produced by digestate and compost during experimental period were higher in correspondence of lower organic matter content (0.58 – 0.49 kg CH4 C/ha/ day and 0.37 – 0.32 kg CH4 C/ha/day for digestate and compost respectively), contrary to what was observed for urea. For all fertilisers, carbon dioxide (CO2) and nitrous oxide (N2O) emissions were higher in correspondence of higher organic matter level. In particular, CO2 emissions were 11.05%, 67.48% and 82.84% higher in OM2 than OM1 for digestate, urea and compost respectively. Likewise, N2O emissions were 87.45%, 68.97% and 92.11% higher in OM2 than OM1 for digestate, urea and compost respectively. The obtained results show that the content of organic matter in soils plays a key role on the emissions of GHGs, generally enhancing the levels of gas emissions.

In addition, a bachelor thesis was wrote from an Italian student of DISPAA with the support of PFNS on the topic of intercropping.
As a future perspective, a scientific publication is in progress between DISPAA and PFNS on the topic of Nitrogen emission losses and Nitrogen Use Efficiency from different cover crops.

The establishment and productive characteristics of sainfoin (*Onobrychis viciifolia* Scop.) in intercropping

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Sainfoin (*Onobrychis viciifolia* Scop.) is a perennial legume usually considered as a potential substitute for alfalfa (*Medicago sativa* L.). It is a protein-rich tanniniferous crop with non-bloating effect on ruminants, well adapted to drought conditions and calcareous soils. In a temperate region, the spring establishment of perennial legumes is often followed by intensive weeds infestation and reduced yield and intercropping can be used to overpass these difficulties. This research aimed to determine the suitability of field pea (*Pisum sativum* L.) as a companion crop for sainfoin establishment and to determine the appropriate cultivar and pea density that provides the best yield and impact on the undersown crop. A trial was set up at the Experimental field of the Institute of Field and Vegetable Crops, Novi Sad, during 2010-2014. The trial was established in four sowing years as a random block design with three replications and included two morphologically different pea cultivars (Jezero-afila leaf type and Javor-reduced leaflet) and three pea densities (30, 60 and 90 plants m^{-2}). The sainfoin pure stand and a mixture with oat (*Avena sativa* L.), as a traditional way of sowing perennial legumes with cereals, were used as control treatments. The dry matter yield, yield components, weed proportion and physiological parameters of sainfoin in the first cut was measured. The analysis also included the sainfoin annual dry matter yield and dry matter yield of the first cut in the following year. The weather conditions significantly influenced obtained results. On average, the sainfoin pure stand had the lowest dry matter yield in the first cut (2.1 t ha^{-1}), while the highest obtained sainfoin with oat (6.5 t ha^{-1}) due to a significant share of the first yield. In the establishment year, field pea as a companion crop had a better impact on sainfoin development, while in the following year companion crops had minimal impact on sainfoin dry matter yield. Concerning pea cultivars, a higher dry matter yield was obtained with cultivar Jezero. It was concluded, there were no significant differences between obtained yield with 60 and 90 pea plants m^{-2}, giving an economic advantage to the lower seeding rate. The weed proportion was lower in intercropping compared to the sainfoin pure stand. The sainfoin leaf area index decreased with the increase of pea density in the stand. Intercropping and weather conditions had a significant impact on pigment content in sainfoin leaves. The results have shown that sainfoin can be successfully established with field pea in intercropping. This practice can be considered as a reliable and ecological way for sainfoin growing, which ensures the stable and high-quality yield of the first cut, with no negative effect on sainfoin yield in subsequent cuts.

Simulation of production of rainfed and irrigated spring barley (*Hordeum vulgare* L.) under future climate scenarios

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During the last decades of 20th century, public concern with regard to climate change has increased. The effect of climate change on agriculture, especially in developing countries such as Serbia, is of the highest importance in terms of sustainable production, due to economic situation. There is a long history of climate-crop models which can estimate the impact of climate change scenarios and adaptive agricultural practice. Advances in climate prediction increased interest in forecasting crop yields as a means of improving farm management in a way that reduces risks and enhances food security. Therefore, the aim of this work was to assess whether implementation of irrigation of typically rain-fed crops, such as barley, may significantly affect yields and be cost-effective under predicted climate conditions in the following 8 decades.

Barley (*Hordeum vulgare* L.) is widely cultivated crop and it can be successfully grown in a wide range of environmental conditions. It is the fourth most important crop in the world and the second most cultivated small grain crop in Serbia, where it is traditionally grown in rainfed conditions.

The AquaCrop model developed by Food and Agriculture Organisation (FAO), will be used in the present research to forecast barley production under rainfed and irrigated conditions. Furthermore, the economic analysis of irrigation costs will be conducted. Three-year data of spring barley yield produced in Vojvodina will be used in calibration of the model, while the 5-year data will be used in validation. In addition, 9 years of observed meteorological parameters will serve as an input for the model for calibration, while predicted climate scenarios for two future periods (2018-2030 and 2071-2100) will be incorporated in the simulations.

The outcome of the simulations will give information on differences between rainfed and irrigated spring barley production under future climate scenarios, as well as economic feasibility of irrigation.

Increase of Nitrogen Use Efficiency of barley: a precision farming approach

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Nitrogen is an essential element for life, as much as potentially harmful. In fact, it is the base for crop's fertilization, as it is able to increase yields. However, excessive intake of nitrogen on the soil may leads serious consequences in terms of environmental pollution, due to volatilization, leaching, surface runoff and denitrification. Therefore, crops response to nitrogen supply and its use efficiency have to be monitored properly to obtain the highest and sustainable yields. Hence, the development of more sustainable agricultural management strategies is essential to ensure the best nitrogen use efficiency. Precision farming is a challenge to achieve these results, through the use of different technologies as spectroradiometric meters. These tools allow the identification of the real needs of crops, by developing vegetative nutritional indexes. Therefore, they guide the farmers towards a variable management of the fertilization, to improve nutrients use efficiency. The most important and studied index is definitely the Nitrogen Different Vegetation Index (NDVI), that is able to assess green biomass or nitrogen content. According to NDVI values, it is possible to define the best moment and the amount of nitrogen needed by crops. The PhD project aim is to implement new precision farming techniques to achieve higher nitrogen use efficiency and reduce environmental impacts of fertilization.

The first step of the PhD project was focused on the comparison between conventional and variable rate fertilization on barley. The experimental field was located at ITASR (Istituto Tecnico Agrario Statale), Florence, Italy. The experiment was organized on specific tanks, with volume of 1 m^3, where the same soil conditions were reproduced. The test was organized on 9 tanks: 3 control (no fertilization), 3 high N level (150 kg N ha^{-1}) and 3 variable N level (based on NDVI analysis). NDVI was monitored from spectroradiometric measurements on barley during the vegetative stages; measurements were conducted with an active spectroradiometer (Greenseeker) and NDVI values were calculated through the "Fertilizer Estimation Chart". Furthermore, additional non-destructive measurements were conducted with a passive spectroradiometer; the secondary aim was to make a comparison between instrument's measurement results. Moreover, an additional experiment was conducted to evaluate the correlation between NDVI, from spectroradiometers, and chlorophyll content values, from Spad measurements.

Finally, measurements of environmental impact of fertilization were conducted. In particular, emissions of N_2O and N leaching were evaluated. Emissions were directly monitored by a static chamber system and a portable gas analyser.

Preliminary results show low NDVI values in control tanks during the vegetative stages. Instead, the results were comparable for the high and variable N treatments. From the preliminary results we observed as a lower N amount, than conventional fertilization, is needed by barley, if it's spread in the high-request moment for the crop. In conclusion, crop monitoring during vegetative season represent a key factor to reduce environmental impacts of fertilization and provide economic benefits for farmers.

The influence of different cherry rootstocks on sweet cherry properties

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The most important goal while raising a fruit plantation is to achieve both high production and reduction of costs. Production of sweet cherry (*Prunus avium* L.), a candidate for one of the most profitable fruit tree, depends vastly on proper rootstock selection, right choice of variety and orchard management. In high density cultivation systems, tree size is of major importance, which emphasizes the value of size-controlling rootstocks. Beside vigor control and simplification of agro and phyto techniques due to reduced tree size, varieties grafted on such rootstocks enter into fruiting earlier and have higher productivity, which means an earlier return of investment. Greatest number of existing fruit plantations are raised on very vigorous rootstocks, including mazard (*Prunus avium*) and mahaleb (*Prunus mahaleb*), producing large trees difficult to maintain. On the other hand, dwarfing rootstock Gisela 5, although very productive and precocious for intensive sweet cherry growing, is characterized by poor adaptability in semi-arid climate. Due to those constrains during the last decade great efforts have been made to the selection of potential dwarf genotypes in a frame of autochthonous cherry germplasm. During that process, 'Oblačinska' sour cherry (*Prunus cerasus*), ecotype that expanded and spreaded around the village Oblačina, Serbia, was selected for further research, as well as ground cherry (*Prunus fruticosa*). 'Oblačinska' sour cherry genotypes were selected as the result of positive clone selection within the range of its' origin and the highest prevalence. Selection of ground cherry came as a result of individual positive selection, i.e. selection was conducted based on noticed unique and rare properties important for the breeding objectives' realization.

Vegetation performance is strongly affected by global climate change. In order to attain high production levels and to produce high quality fruits, environmental challenges must be conquered. Research aim is to propose sweet cherry rootstocks that are both drought tolerant and precocious, which will contribute to Serbia's competitiveness on cherry market, along with constant work on improving of assortment that can attain European quality standards. Sweet cherry variety 'Summit', grafted on different rootstocks, is being researched as perspective cultivar that can meet above specified requirements. Assessment of its performance regarding fruit properties in stressed conditions without irrigation, shows promising results when grafted on investigated rootstocks. Better fruit quality was obtained in sweet cherry trees grafted on 'Oblačinska' sour cherry and ground cherry, with emphasis on fruit weight and its dimensions, compared to the variants where sweet cherry was grafted on reference rootstocks.

STARC - Impact

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Full title of the STARC- Impact project is "Supporting the Austrian Research Community in using recent Climate Change Projections for Climate Impact Studies". The Austrian Climate and Energy Fund (klien) supports this project. Project leader is University of Graz, Wegener Center for Climate and Global Change (WEGC); two partners are a) the Central Institute for Meteorology and Geophysics (ZAMG), Climate Research Department and b) University of Natural Resources and Life Sciences, Institute of Meteorology (BOKU-Met).

Project background is the availability of the ÖKS15 climate scenarios for Austria. These scenarios represent the latest generation of regional climate projections employing the latest emission scenarios, the Representative Concentrations Pathways (RCPs) (Van Vuuren et al., 2011; Moss et al., 2010). The data sets enable to analyze climate change in Austria throughout the 20th and 21st centuries in a probabilistic manner. They are based on long-term high quality and highly resolved (1 km x 1 km grid spacing, daily bases) gridded observational data.

The STARC-Impact project team assesses the strengths and limitations of the ÖKS15 dataset. The specific BOKU-Met tasks are 1) to exemplify climate change impacts on regional crop production and their sensitivity against uncertainty in emission scenario and climate models based on the ÖKS15 projections and 2) concerted establish guidelines for the Austrian Climate Research Community for selecting and using the ÖKS15 data with a specialized focus on limitations, uncertainties, and differences from different climate model generations and emission scenarios.

The tools used by BOKU-Met have been the crop growth model DSSAT (Jones et.al, 2003) and the agro climatic risk model AGRICLIM (Trnka et al, 2011). The sensitivity with regard to the climate input data (1981-2010) and spatial resolution of the model data (1, 5, 11, 21 km). Within Austria three regions with each three different soil types were chosen to evaluate actual status and future projections.

Response of maize yield under different climatic and production conditions

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Maize (Zea *mays* L.) is the second most important cereal crop in Vietnam as well as in the study area, a province in the North of Vietnam. Maize is nowadays even more important than ever because of increasing population, and therefore increasing demand for food. However, the climate variability in Vietnam in recent years has driven various challenges on maize production such as flooding and drought which are two main abiotic stresses on maize production in Vietnam.

In order to detect the influence of climate variabilities on maize production, the study used DSSAT-CERES maize model version 4.5 to simulate the maize growth. Data requirements for run the model included three main individual elements which were weather, soil and agronomic management data in combination with experiment field data which were used for calibration of crop parameters to ensure the simulation accuracy. To validate the model, the averages of annual observed maize yield data in the period of 15 years (2000-2014) were used to compare with simulated maize yields. The simulated and validated results afterwards were analyzed by Normalized Root Square Error (NRMSE). The NRMSE values proved that DSSAT-CERES Maize model was a useful tool to simulate crop growth, however showing the better performance of DSSAT model in simulation of maize in spring than in winter.

To simulate the perspective of maize production in 2100, the study applied DSSAT-CERES model under climate change scenarios, Representative Concentration Pathways RCP 4.5 and RCP 8.5, which are stabilized to limit radiative forcing at 4.5 and 8.5 Wm^{-2}, respectively. The results show that maize yields in the far future are generally lower than in the past, especially in spring crops. This result mainly correlated positively with the number of dry days under RCP 4.5 and RCP 8.5 scenarios which measured by AGRICLIM.

Keywords: Climate variability, maize production, DSSAT-CERES, RCP 4.5, RCP 8.5.

Effects of nitrogen source on production potential of intercropped fenugreek and buckwheat

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Best agricultural management practices implemented in agricultural production systems can help to achieve efficient crop nutrient use as well as improve crop diversity in the landscape. A relatively new intercropping system is a cereal intercropped with a leguminous medicinal plant, which possesses multiple uses for food, feed and health. Soil nutrient management is an important practice to achieve high yields from both sole and intercropped fenugreek. Using mineral fertilizer only, however, may impair environment and soil health. Application of organic manure is an important strategy to maintain soil fertility and reduce dependence on industrially manufactured fertilizers.
In order to determine the effects of nitrogen source on production potential of intercrops of fenugreek with buckwheat, field experiments were conducted at the research farm, College of Agriculture, Shahrekord, Iran during 2014 – 2015. Treatments included sole cropping of fenugreek (F), sole cropping of buckwheat (B) and three intercropping ratios (F:B = 1:2 (one row of fenugreek + two rows of buckwheat), 1:1 (one row of fenugreek + one row of buckwheat) and 2:1 (two rows of fenugreek + one row of buckwheat)) as the first factor, and the second factor was fertilization source with 3 levels, i.e. chemical fertilizer (CF), integrated fertilizer (IF) and broiler litter (BL). In both years, fenugreek-buckwheat intercrops with organic fertilizer (IF and BL) in both F and B increased above ground dry matter (AGDM), macro and micro nutrients concentration and uptake, nutrient use efficiency, land equivalent ratio (LER), photosynthesis pigments, canopy radiation interception (at flowering stage), radiation use efficiency (RUE) and CO_2 flux from soil compared to the sole cropping and chemical fertilizer tratments. In both years, the highest numbers of yield components, total yield, harvest index and hectoliter weight were observed in intercropping systems treated with organic fertilizers (IF and BL). In overall, this study showed a potential benefit of intercropping for production of fenugreek (legume) and buckwheat (non-legume) medicinal plants supplied with organic fertilizers (IF and BL), which proved to be a suitable alternative for chemical fertilizers. Therefore, the strategy of intercropping and organic fertilizers application, in addition to increase of product quantity and quality of fenugreek and buckwheat medicinal plants, increasing of fertilizer efficiency, reducing nutrient losses from the soil and producing healthy food, reducing the environmental risks can successfully contribute to improving the quantity and quality of the subsequent crops in a rotation and decrease chemical fertilizer requirement as well.

Spectral measurements and selected vegetation indices in plant production and climate change

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In the course of conducting “spectral measurements” the radiation reflected by a given vegetation cover is detected. They allow the non-destructive, remote collection of data, which is then used to calculate algorithms called “vegetation indices” (VIs). VIs have shown the ability to provide information concerning plant production, for instance plant properties (e.g. plant nutrition, plant water status and plant developmental stage), prediction of yields, resource use efficiency (e.g. water, fertiliser and energy) as well as detection of weeds, diseases and pests. In the context of climate change, VIs are used to investigate the effects of climate change trends and extreme weather events on yields and crops in general.

In the course of this SSG 2018 contribution, important aspects, benefits, disadvantages and the practical applicability of spectral measurements and selected vegetation indices in plant protection and climate change research are discussed.

First, general information on the topic “radiation” is provided (e.g. overview of the electromagnetic spectrum, definition of the term “reflectance” and factors influencing reflectance). Moreover, the spectral characteristics of plant canopy are discussed. Second, important aspects of different platforms for conducting spectral measurements, i.e. satellites as well as aerial and proximal systems, are addressed (e.g. altitude, spatial resolution as well as potential applications for the different platforms). Third, the selected vegetation indices NDVI (Normalised Difference Vegetation Index), NDRE (Normalised Difference Red Edge) and CCCI (Canopy Chlorophyll Content Index) are discussed (e.g. definition, important aspects and potential applications of the different VIs). Fourth, an overview of the current project at the University of Natural Resources and Life Sciences Vienna (BOKU) on the prediction of plant nitrogen concentration using a selected vegetation index (CCCI) is given. Fifth, exemplary applications of vegetation indices in climate change research are summarised. Finally, the challenges and opportunities of spectral measurements and vegetation indices in plant production are addressed.

All in all, spectral sensing systems still feature disadvantages, as many factors can have an influence on spectral measurements (e.g. soil conditions, crop management, plant development as well as abiotic and biotic stresses). Moreover, many agricultural applications of vegetation indices are costly and require cultivar and site-specific calibrations. However, if the mentioned shortcomings can be improved in the future, these applications will become essential elements of modern farming and change the way of agricultural production permanently.

Avia-GIS

Els Ducheyne[1]

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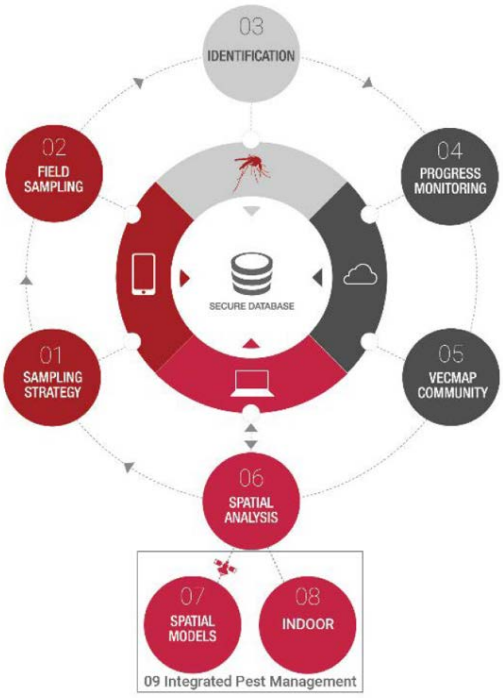
Avia-GIS NV is a Belgian SME founded in 2001 that specializes in the collection, processing and analysis of spatial information as a basis for the development of software products for risk mapping and integrated pest management applied to human, veterinary and plant health, with a focus on (emerging) vector-borne diseases (VBDs). Our main flagship is VECMAP, a one-stop-shop for species distribution modelling that offers the full suite of tools required to go from planning field data collection over lab data entry to the production of risk maps that will assist the decision maker in reducing the risk of disease transmission. Avia-GIS is now expanding the software suite to include components for integrated pest management.



In addition to these software products, we offer a range of Consulting and Contract research services to the industry, international organisations, governmental agencies, and research teams: organisation of on-site clinical trials to test products against VBDs in the tropics, development of tailored SDSS and mobile applications; coordination of multidisciplinary research projects and networks, and à la carte on-site / on-line capacity building. Avia-GIS has been coordinating the medical and veterinary entomology network, VectorNet and its predecessors for the last decade.

Avia-GIS NV has a unique market position. Only few companies operate in our domain and none developed such close contacts with the industrial, decision support and academic world. As a result, we have a clear view on user needs and requirements, on the state of the art, and on how this can be translated into cost-efficient operational tools.

PIS – Concept and activities

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In the process of agricultural production in order to obtain a high-quality and health-safe product, the protection of crops from pests and diseases is very important. Information on the necessary and justifiable measures in plant protection have been reported for the past eight years by the System of the Forecasting and Warning Service of Plant Protection of Serbia (PIS). The System gives recommendations on measures of control of harmful organisms for the most important plant production on the territory of the whole country.

Each recommendation is complete information that contains data on the stage of development of the host plant, the detected harmful organism and its stage of development, the measure to be applied, and the timing of application of the given measure. In order for the recommendation to be consistent and that each of the segments has the correct information, every year the PIS organizes an extensive monitoring of the economically most important plant productions (crop, vegetable, fruit and grapes), the most important harmful organisms on them and conditions in which productions take place and harmful organisms develop. Tools of monitoring include pheromone traps, light traps, visual examination of pathogens, visual examination of pests, visual examination of host plants, spore catchers, automatic weather stations (AWS), trials and laboratory analyzes. Reading of catches on pheromon traps and light traps is carried out daily. Visual examination of pathogens, pests and host plants are carried out according to the unique methodology at continuous intervals. Using AWS located in field and vegetable crops in orchards and vineyards, production conditions are monitored. In the territory of Serbia, the most important meteorological parameters (air temperature, soil temperature, relative humidity, precipitation, duration of leaf wetness) are recorded every hour at over 120 AWS. A very important role in the decision on the implementation of chemical protection measures play trials by which thresholds of harmful organisms and biological facts are determined and by which excessive protection measures are avoided. In the PIS Laboratory, identification of harmful organisms is carried out which provides the correct selection of control measures. Monitoring is carried out on over 150 harmful organisms, in 36 different crops and over 2000 positions on the territory of Serbia. By connecting the biological and meteorological data obtained by monitoring, information, which is important for operational use, is provided. On the basis of this information, decisions are made about taking protective measures that are given through recommendations.

Each of the recommendations is only a segment of the protection model that is defined for the most important agricultural production, based on the principles of biologically justified pesticide application, an anti-resistant strategy in their application, while respecting the maximum number of treatments and prescribed withdrawals.

The final users of the recommendations are agricultural producers, agronomists and all interested participants in agricultural production. The recommendation can inform about the condition of the specific production for some of the 29 regions in the country, and all biological information and thresholds of harmful organisms given in the recommendation can help them make decisions about taking protective measures on their fields.

Dissemination of data on occurrence and movement of harmful organisms and control measures is done through the PIS Portal on the Web (www.pisvojvodina.com or www.pissrbija.com), SMS messages, TV programs, lectures and seminars.

With this concept of work in the PIS it is possible to establish rational and justified use of pesticides in the territory of Serbia. All PIS activities are focused on the principle of integrated management of harmful organisms and integrated agricultural production.

Austrian system for drought monitoring

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Although most regions of Austria are humid or semi-humid, main important crop production regions are frequently and with an increasing trend over the past decades affected by agro-meteorological droughts (often combined with heat stress), where water deficit and/or heat effects leads to significant yield decrease of various crops. Crop model studies show that these conditions will accelerate under future climate scenarios in Central Europe including Austrian crop production. Based on the lack of an operational drought monitoring and forecasting system specifically designed for the needs of agriculture in Austria the main project goal was therefore the development of such a tool supporting management and mitigation of drought/heat impacts on crops.

The project included 5 Work Packages (WP). WP1 was dedicated to establish an Austrian data base on model inputs such as weather and soil conditions and crop drought impacts used in WP2 for adaptation, calibration as well as validation of models and algorithms for crop drought stress and yield impact detection. WP3 established and adapted weather forecasting products implemented in the drought forecasting procedure. WP4 implemented the developed methods of WP2 and WP3 into an operational GIS drought monitoring model and tool for 4 agricultural crops and grassland and WP5 was dedicated to test the drought/heat monitoring and forecasting system with stakeholder participation.

In the project a high resolution GIS based crop drought monitoring and forecasting system was developed and designed for operational application. To reach that aim, a crop water balance and a crop phenology model combined with drought and heat stress and yield impact indicators for five main important crops in Austria (grassland, maize, winter wheat, spring barley and sugar beet) were adapted/developed and tested based on collected Austrian data sets. Further, the spatial INCA product of daily weather data (including forecast) was adapted for daily input use. A Web-portal was developed demonstrating the operational use and presentation of the GIS model outputs for Austria. A test of the model in the year 2015 demonstrated good performance regarding detected yield impacts of drought and heat stress, considering a certain uncertainty range based on deviations of underlying inputs from real site conditions at small scales (especially on soil, crop, weather parameters).

The ADA (AgroDroughtAustria) drought monitor is available as a GIS based software for operational use. It was successfully tested in the extreme year 2015 showing good performance of results. However, the test of the system on real conditions and data sets including the extension for other weather based cropping risks is continued in the further project COMBIRISK. The project consortium is also active in finding and supporting an optimum way to implement the ADA system for operational use to be fully available for stakeholders.

More information at ADA project webpage: https://ada.boku.ac.at/

„Innovative Food Product Development Cycle: Frame for Stepping Up Research Excellence of FINS“ (FOODstars) H2020-TWINNING

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Innovative Food Product Development Cycle is defined as a framework for stepping up scientific excellence of the Institute of Food Technology (FINS) and at the same time intended to bring together experts from academia, industry, decision making and consumers. New product development is recognized to be a key activity to boost the innovativeness in global food industry and includes the complete process of bringing a new product to market. It is known that consumers' demands keep changing over time. Emerging knowledge from food science and research in the synergy with consumers has the potential to increase the innovation rate and competitiveness of food industry. FOODstars project offers the researchers from FINS the opportunity to improve the existing knowledge concerning all aspects of new product development through training events to renowned research institutions in Ireland (Teagasc - Agriculture and Food Development Authority) and Italy (University of Bologna, Italy), summer schools, workshops and study visits.

The FOODstars project receives funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 692276.

Drought Risk in the Danube Region – project DriDanube

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DriDanube - Drought Risk in the Danube Region is an international project that involves drought monitoring and management institutions from 10 countries in the Danube region (hydrometeorological services, universities, research institute, organizations specialized in state-of-the-art IT and remote sensing techniques). The aim is to strengthen capacities at all levels of the drought management cycle (political, professional, end-users), their mutual cooperation and to improve the process of drought emergency response. In addition to the preparation of a cross-border Drought Risk and Impact Assessment Methodologies, Strategy to Improve Drought Emergency Response, the project will also prepare an interactive online drought monitoring tool that will enable more accurate and efficient drought early warning. Utilizing state-of-the-art technologies and processing large amounts of remote sensing data from satellites, this tool will be used by both, experts and end-users (e.g. farmers). The project has begun on January 1, 2017 and will end on June 30, 2019.

Presentation of "COMBIRISK and POLICY FIT" projects

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Examining and identifying the regional, site specific cropping risks under climate change conditions is crucial for the assessment and recommendations of meaningful adaptation measures, especially at the farm level. This is still a big challenge for many European crop production regions. Research has mainly focused on average impacts, such as average changes in temperature and precipitation, and less so on extreme events, which can damage production resources (e.g. loss of soil from erosion events) and push farms beyond resilient states. Apart from bio-physical impacts of climate change, a more complete picture on farming systems is required. It includes both the options for farmers to adapt to changing climate conditions as well as the risks from cumulating changes in their production environment, such as combinations of extreme climate events and market changes. Bio-economic farm models are an appropriate tool to analyze such relationships. They can represent the farming system, such as the interlinkages between plant and livestock production on a farm, farm resource conflicts such as labor and capital constraints and are able to integrate bio-physical impacts of climate change in economic farm decision making. Stochastic versions of such models have proven to be valuable tools to analyze weather related uncertainty and production risks.

The approach of identifying and mapping the potential weather based cropping risks in selected agricultural production regions by using adequate agroclimatic indicators is applied in COMBIRISK. There is also still no consolidated data base in Austria on reported or measured weather related crop damages or failures, including all potential risks at the relevant sites and regions. This hampers model improvement by aggravating calibration and validation. Therefore a data base on documented and measured crop specific responses (i.e. yield loss) and economic damages caused by adverse weather conditions is established. Reported damages are related to measured weather conditions (statistical screening on significant relationships) and are expressed in calibrated crop specific indicators subject to available data. As a main outcome of COMBIRISK is an indicator model of combined abiotic and biotic weather related risks, established and applied on current conditions over Austria and ensemble climate change scenarios in two main crop production regions in Austria. A GIS-implemented version of the model based on the already established operational drought monitoring system AgroDroughtAustria is used for mapping risks (Agricultural Risk Information System, ARIS) and will additionally allow extended operational monitoring and forecast applications in response to changing climatic conditions. In order to demonstrate the development of regional tailored farm adaptation measures the indicator model will be applied in combination with a bio-economic farm model at two case study regions.

More information at COMBIRISK project webpage: https://combirisk.boku.ac.at/

Based on COMBIRISK and other past and ongoing projects, further proposals are developed currently. The overall objective of **POLICY-FIT** (Agricultural POLICY assessment toolbox - FITting decision making

through modelling multiscale impacts and interactions on natural resources and sustainability of agricultural systems) proposal in frame of RUR EU call is the development and demonstration of a flexible, modular and interactive decision-support system. It aims to support evidence-based policy and decision making at different spatial and temporal scales in agriculture and related sustainable food production, natural and renewable resource management and ecosystem services.

H2020 - EVO-NANO project overview

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EVO-NANO stands for "Evolvable platform for programmable nanoparticle-based cancer therapies". It is a Horizon 2020 FET Open project that will start on October 1, 2018. The long term vision of the project is to create an integrated platform for the artificial evolution and validation of novel drug delivery systems for cancer treatment using nanoparticles (NP). Nanoparticles are increasingly being studied in cancer research for their ability to improve diagnosis accuracy and/or deliver tailored treatments directly to tumors. However, their effective biodistribution is still a major limitation. The challenge is to discover how to program collective behavior of the trillions of NP interacting in a complex tumor environment. Finding effective NP designs that give rise to desired outcome will require a new class of evolutionary algorithms that can simultaneously 1) generate novel NP-based anti-cancer strategies, 2) search over a large space of solutions, and 3) adapt to a wide variety of scenarios. Our novel evolutionary approach will be integrated with the NanoDoc simulator that reproduces realistic NP motion and interactions within the tumor environment and with other NP. The most promising NP designs will then be synthesized and tested *in vivo* and *in vitro* on breast and colon cancer stem cells using mouse cancer xenografts and microfluidic testbeds featuring cancer microenvironments. To promote translation of the platform from early stage research into a commercialized product for patients, we will work with industrial partner ProChimia Surfaces, organize „Industry Open Days" for potential investors and develop a translation strategy.

EVO-NANO is a multidisciplinary project that will create an entirely novel NP design platform for new cancer treatments, capable of autonomously evolving both innovative and adaptive solutions. The proposed platform has the potential to be at the forefront of cancer nanomedicine by enabling much faster development and assessment of new cancer treatments, than is done today. The project will generate concrete tools for the predictive design of nanomedicines that could be applied in other clinical fields.

LOVCEN project and AIM-COST Action

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The HERIC-CRDS LOVCEN ("Surveillance of invasive and native mosquito vectors and pathogens they transmit in Montenegro") project promoted training of young scientists, standardization of methods, integration of knowledge between disciplines, and knowledge transfer to policy-makers all in the field of vector mosquitoes and mosquito-borne pathogens. The project achievements provided further improvement of the Montenegro Consortium Members (MCM) research and innovation capacities through collaborative research with prestigious Europeans centers, exchange of experience and knowledge, strengthening of human, infrastructural and material resources, establishing the strategic international research partnerships on RTD in vector/pathogen surveillance and control, monitoring and climate change impact modeling.

The LOVCEN project combined a diverse set of activities: (a) Collaborative research on native/invasive mosquitoes and pathogens they transmit in Montenegro and development of non-chemical control measures; (b) Twinning through the exchange of know-how and experience and dissemination activities; and (c) Acquisition of research equipment and innovation capacity building. The cutting-edge, innovative research provided the ground for (a) application of SIT in invasive mosquito control –Montenegro is the second country in Europe to adopt this technology; (b) mobile phone application for community involvement in surveillance of invasive and indigenous mosquito species; (d) implementation of novel non-chemical, biodegradable materials for control of mosquito larvae; (d) modeling of climate changes impact on mosquito vectors; (e) policy recommendation on direction of the research in vector-borne disease prevention.

The *Aedes* Invasive mosquitoes (AIM) COST Action focused on the *Aedes* mosquitos that cause >100 million symptomatic cases/year of viral diseases (such as dengue, yellow fever, chikungunya and Zika), and thousands of deaths in tropical areas. With increasing trade and travel, several *Aedes* species have been introduced into Europe and are now spreading spectacularly rapidly becoming a significant public health risk, as testified by recent cases of autochthonous chikungunya and dengue transmission. Transboundary risks require sound surveillance, risk assessment, and vector control, requiring collaboration between the normative, research, public health, commercial and civil society sectors at international, national and local scales which is not happening. Despite the range of institutional guidelines available, current mitigation activities are mostly uncoordinated, and implemented piecemeal

nationally or locally, reducing cost-effectiveness and impact with no efficient dissemination of information and guidance to stakeholders.

AIM Cost Action will build a gender, age and geographically balanced network from critical stakeholder sectors. The Action will assess and review current surveillance, control and analysis practices, develop best practice guidelines and protocols ensuring consistency across Europe. It will facilitate the development of new tools and identify priority research topics. Recommendations to standardise and streamline entomological and spatial analysis will promote enhanced risk assessments needed for reliable targeting and planning. Critical elements maximising impact will be involvement of civil society and citizen scientists, as well as collaborative dissemination ensuring that technical outputs and guidelines are customised at different geographical scales for each operational stakeholder group. Lessons learned will be transferable to other emerging vector-borne diseases worldwide.

Assessment of climate change effects on agricultural soil and water environment in the Loess Plateau of China and Serbia and corresponding solutions

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Background for collaboration between Faculty of agriculture, Novi Sad and Northwest A&F University, Yangling is the Alliance "Silkroad Agricultural Education and Research Innovation Alliance" which was established at the University of Yangling, China in November, 2016. Convention was organized to found the Consortium, comprising institutions (universities and research institutes) from Eurasian countries, along the "New Silk Road" aiming at improved international collaboration in research and higher education. One of the first results of collaboration within Alliance is bilateral project between Serbia and China: Assessment of climate change effects on agricultural soil and water environment in the Loess Plateau of China and Serbia and corresponding solutions. The project is supported Chinese Academy of Sciences (CAS). Duration of the project is two years with budget over 100 000 US dollars.

The project comprises following research topics:
-Analysis of mechanism how agricultural soil and water respond to climate change. With long-term observation, field experiment and modeling, this section will investigate the relationships between climate change and some factors related to soil and water, such as soil erosion, soil water, soil carbon pool, soil nutrients and microbiology. The results will present fundamental information about how climate change influences agricultural soil and water.
-Impact assessment of historical climate change on agricultural soil and water. This section will identify the best models for simulation of hydrology, soil erosion, soil carbon, soil nutrients and crop, and then calibrate the model as the tool to evaluate the impacts of climate change on agricultural soil and water.
-Scenario analysis of future climate change impacts on agricultural soil and water. Downscale GCMs with dynamic and statistical methods to project the changes in mean state and extremes of climate in future 50 years. Use the downscaled climate as inputs of hydrological or erosion models to evaluate impacts of climate change on agricultural soil and water.
-Adaptation of agricultural soil and water to climate change. Assemble different kinds of management practices for agricultural soil and water and evaluate the sensitivity of different practices to climate change. Develop the best countermeasures for efficient utilization of soil and water resources under changing environment.

"Climate Smart Urban Agriculture" COST initiative

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COST, European Cooperation in Science and Technology, is an association that funds pan-European, bottom-up networks of scientists and researchers across all science and technology fields. These networks, called 'COST Actions', promote international coordination of nationally-funded research.
COST aims to enable breakthrough scientific developments leading to new concepts and products. It thereby contributes to strengthening Europe's research and innovation capacities. In order to achieve its mission, COST endeavours to:

- Build capacity by connecting high-quality scientific communities in Europe and worldwide
- Provide networking opportunities for Early Stage Researchers (ESR)
- Increase research impact on policy makers, regulatory bodies and national decision makers as well as on the private sector

COST does not fund research itself, but provides support for networking activities carried out within COST Actions. They are bottom-up science and technology networks open to researchers and stakeholders , with a four-year duration and a minimum participation of seven COST Member States.
People can participate to COST Actions in two ways:

1) Be proposer or co-proposer of a new Action (Open call twice per year)
2) Apply to join an existing Action

As one of the main aim of Serbia for Excell was to encourage the collaboration and cooperation through the set up of new joint projects and initiatives, we decided to apply for a new COST Action together with PFNS and BOKU. The main topic of the proposal was the assessment of the impacts (positive and negatives) of urban agriculture on cities resilience to climate change and on ecosystem services, by combining the different skills (climatology, agronomy and crop physiology, modelling) offered in the framework of the running Twinning project.
Even if finally the Action was not approved, the high score received by the evaluators should be taken as an encouragement to strenght the collaborations, enlarge the network and apply with an improved proposal.
In this sense, Serbia for Excell can be considered as a starting point to grow up at the international level.

European Centre for Medium range Weather Forecast public datasets, availability and use

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The European Centre for Medium-Range Weather Forecasts (ECMWF) is an independent intergovernmental organization supported by 34 states, based in Reading, UK. It was established in 1975. ECMWF is both a research institute and a 24/7 operational service, producing and disseminating numerical weather predictions to its Member States. This data is fully available to the national meteorological services in the Member States. The Centre also offers a catalogue of forecast data that can be purchased by businesses worldwide and other commercial customers.

A big amount of public datasets is provided on ECMWF web pages, work on adding more data and forecasts from different origins is in progress. Access to these datasets is provided free of charge. Terms and conditions may apply for individual dataset, instructions and manuals are easy to follow on the web site http://apps.ecmwf.int/datasets/.

Public datasets cover:

- global reanalysis,
- regional reanalysis,
- multi model seasonal forecast,
- multi model medium range forecast,
- archived data,
- observation feedback.

Procedure for retrieving data is very simple – after registration and accepting terms and conditions the user writes a request, submits it and retrieves a file(s) with requested data. Python script for data request is provided on web pages. Data are in grib or netcdf format.

Most meteorological data (observation and forecast) for use in agriculture are in excel files or csv format, there are user friendly tools developed for this purposes.

This presentation intend to go step by step through process of requesting data, downloading and converting to usable format. We will choose parameter, reanalysis, time period and show the final result as a table, excel file or plot.

Activities of the Croatian Agrometeorological Society

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The idea of establishing the Croatian Agrometeorological Society (HAgMD) has imposed itself six year ago. The number of experts who deal with agrometeorological activities is very small compared to the broader scientific community. It is very important to bring together scientists and experts of meteorological, agricultural and forestry profession and focus their unique actions toward the same goal: the promotion and advancement of all branches of agrometeorological science. The main mode of action is that the experts help different users in agrometeorological training; furthermore, to spread the knowledge to the public for the purposes of food production and the protection of forests against fire. Therefore, in the frame of the programme “Agrometeorology in the Service to the Users“ HAgMD organized the 41 agrometeorological seminars for students, five agrometeorological workshops for farmers, agronomists, firefighters and foresters, and two round tables for scientists and journalists about impact of the climate change in agriculture and potential risks of wildfires and how to adapt and mitigate their consequences. Agrometeorological information of research, which direct users get, will pay on multiply times for the general welfare of development in food production, the protection of forests, conservation of nature and environment which would in turn improve the tourist offer and initiated economic development, and thus improved quality of life. Such results will not come overnight. Only with diligent efforts of agrometeorological experts as well as knowledge of users the gained from the workshops apply in practice, will lead to the desired result. Also, of great importance is exchange of views between experts and users since only with direct communication, experts get feedback how agrometeorological products (eg. agrometeorological forecasts, drought monitoring, warnings of sudden natural disasters and forest fires, etc.) are usable to users in practice. Thus, this project improves agricultural production and protection of forests and also improves the usefulness of agrometeorological information to directly users. Any forest fire prevention or mitigation of its consequences, which usually cause great economic losses, leads to savings in the budget. One of the preventive measures is good training on the causes and consequences of wildfires. The most common cause of forest fires is negligence of adults, and adult man is often difficult to reeducate. That is why we started from the youngest in the frame of the program “Agrometeorological Mosaic for Youth“. HAgMD produced the educational animated film and comic book “Fire is no joke“ because the animated film is children's most popular medium. Members of HAgMD hold the 68 Little Schools “Fire is no joke” in different parts of Croatia and about 4000 children attend them. Kids fascinated us with their knowledge of wildfire causes but they were always surprised with the long-term restoration of the forest. In the end they knew exactly to repeat the motto of the movie "Don’t play with flames and smoke, fire is no joke!" HAgMD has also support from the international community, particularly by the Global Federation of Agrometeorological Societies and World Meteorological Organization.