Book of abstracts

6th PannEx Workshop

Organised by the

**Babes-Bolyai University, Faculty of Geography,
Research Centre for Sustainable Development**

in partnership with the

**University of Agriculture Sciences and Veterinary Medicine
in Cluj-Napoca,**

INDECO Soft

and the

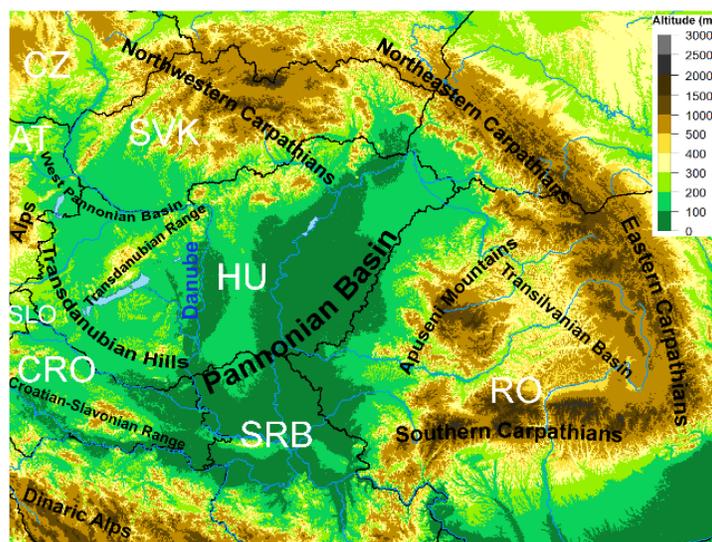**PannEx consortium network**

Cluj-Napoca,

20-21 June, 2022

Regional environmental challenges in the Pannonian basin

Workshop
Climate Services for a Sustainable Agriculture

Edited by
Adina-Eliza Croitoru,
Csaba Horváth, Bela Kobulniczky

Cluj-Napoca,

20-21 June, 2022

The workshop was organized under the framework of the research project **Redefining agro-climatic suitability zones for maize and winter wheat crops towards a smart climate change-oriented agriculture in Romania (AGROCLIMRO)** financed by the Executive Unit for the Financing of Higher Education, Research, Development and Innovation (UEFISCDI) in Romania.

Background

PannEx (Pannonian Basin Experiment) is a Regional Hydroclimate Network of the Global Energy and Water Exchanges project (GEWEX) which aims to achieve a better understanding of the Earth system components and their interactions in the Pannonian Basin. The international efforts involve the international research community in an integrated approach towards identifying and increasing adaptation capacity in the face of climate change in the Pannonian Basin.

Objectives

The 6th workshop is dedicated to introduce the ongoing and planned research on climate change in extreme weather events and adaptation, and to discuss the cooperation possibilities for research projects. The workshop is intended to strengthen & organize the work of the PannEx Task Teams and develop a new iteration of the Science and Implementation Plan. More details are available in the *White Book* at: https://www.wcrp-climate.org/WCRP-publications/2019/WCRP-Report-No3-2019-PannEx-WB.pdf

The workshop is organized as a side meeting of the workshop *Climate Service for a Sustainable Agriculture* organized within the framework of the research project **AGROCLIMRO** (www.agroclim.ro).

Topics of the 6th workshop follow the structure of the PannEx Task Teams and include

- Agroclimatological and Agrobiological Systems;
- Energy Production;
- Special Observations and Data Analysis;
- Ecosystem Services;
- Urban Climate and Air Quality; Outreach and Education; Micrometeorology and Agronomical Process Modelling;
- Water Balance at Basin Scale;
- Modelling from Climate to Flash Floods.

Scientific Committee

- Mónika Lakatos – OMSZ, Hungary
- Danijel Jug – University of J.J.Strossmayer in Osijek, Croatia
- Branka Ivančan-Picek – DHMZ, Croatia
- Adina-Eliza Croitoru – Babes-Bolyai University, Romania
- Ivan Güttler – DHMZ, Croatia
- Vladimir Djurdjevic – University of Belgrade, Serbia
- Tamás Weidinger – Eötvös Loránd University at Budapest, Hungary
- Andrej Ceglar
- Joan Cuxart – University of the Balearic Islands, Palma, Mallorca, Spain
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Citizen science in service of the climate change adaptation

Eric Dobrivoje Lale, Tanja Adnadjevic,

Marjana Brkic, Marija Cvetinovic, Mirjana Utvic ✉ ·

"The H2020 TeRRIFICA project has developed an innovative approach to science communication open to individuals and groups to take an active part and influence climate change institutional, governmental and policy adaptations. In a system defined by RRI policy, SDGs, citizen science and climate adaptation and mitigation measures, TeRRIFICA operates in six European regions with very distinctive challenges. A practical outcome of this co-creation process is locally focused but globally empowered climate actions, based on the collected and visually represented data. TeRRIFICA crowd-mapping tool demonstrates actual geographical spread of climate changes by showcasing effects which citizens encountered and marked on a daily basis.

TeRRIFICA's unique approach will be showcased together with potential applicability of this innovative science communication tool. Taking into account external perspectives and knowledge, the idea is to provide an overview of aspirations and opportunities to incorporate such data into local decision-making processes at all scales, from bottom-up to top-down. The goal is to broaden the discussion to include diverse external challenges and local experiences in order to inspire and encourage outside parties to join the debate, advocate for innovative climate actions to tackle growing climate change crisis and influence the constitution of decision-making processes in the cities of tomorrow.

Center for the Promotion of Science (CPN) acts as a regional project hub and coordinator of activities across South-East Europe – from Croatia to Romania and from Albania to Hungary. Together with local partners belonging to diverse professional and social groups, the CPN has been organising numerous project presentations, advocacy meetings, educational activities, etc, with a goal to define common regional framework and foster future partnerships and joint actions. This

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presentation will also announce further activities and announce collaborative opportunities at the regional level, including an experimental, mobile and modular platform entitled Climate Capsule."

droughts within the South of Ukraine is not homogeneous. For various meteorological stations and hydrological posts, the situation has changed from ""mild"" to "severe"" drought, in some cases no drought at all in recent years. The analysis shows that drought indices are an additional tool for analyzing the situation in the studied river basins, as well as forecasting water trends using model values of temperate and precipitation. It should also be noted that the agrometeorological drought index, together with the well-known SPI, can also be used as an indicator of the total humidity of the territory, and has prospects for use in forecasting methods."

Analysis of the impact of weather conditions in 2010-2019 on the formation of flash floods in the north-western Black Sea region

Valeriya Ovcharuk, Galina Borovskaya, Natalia Kichuk 🔲 .

"Modern climate change is accompanied by increasing recurrence of dangerous hydrometeorological phenomena, including heavy rainfall. During the warm period in the study area there are heterogeneous weather conditions, which are due to the alternation of hot air masses and atmospheric fronts, resulting in high temperature contrasts in the area. Almost every year on the territory of the north-western Black Sea coast, heavy rains can be observed, which sometimes become catastrophic and lead to flash floods. This is how the downpour rain on September 12, 2013 in the Kohylnyk River basin can be characterized, where the maximum daily precipitation was 196.9 mm at the Tarutino weather station and caused significant damage throughout the basin.

Similar weather conditions developed in the first decade of August 2019, which led to significant rainfall in the study area. According to the UkrHMS in the first decade of August 2019 in Ukraine there was unstable weather with large fluctuations in air temperature. During the first decade of August, several active atmospheric fronts and cyclones moved through the territory of Ukraine, accompanied by heavy rains, squalls and hail. The greatest amount of precipitation was observed on August 3-4 in the southern and eastern regions during the movement of the active cyclone from southwest to east. On August 4, 2019, in the city of Belgorod-Dniester, as a result of the disaster, traffic was disrupted, agricultural and basement buildings were flooded, certain areas were flooded, sewer manholes were destroyed, and trees were felled.

In some areas of these regions there were heavy rains, when the amount of precipitation reached 130-220% of the monthly norm, in Khorly (Kherson region) - 105 mm, Zaporozhye (according to AMWS) - 121 mm, Belgorod-Dniester (Odesa region) - 126 mm, which was about three monthly norms and met the criterion of a spontaneous meteorological phenomenon III (red) level of danger.

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In normative documents, the formation of rain floods is associated with the daily values of precipitation Hm. The observed values of Hm in recent years range from a fairly wide range - from 52 mm (Korotne) to 196.9 mm (AMWS Tarutino), but, as the analysis shows, belong to different years. Generalized data on the frequency of maximum daily precipitation showed that most often daily maxima were observed in the range of 80 - 100 mm (56.7%). In the last ten years, significant daily precipitation occurred in only 12.7% of their total.

The analysis of the presented data also shows that for the last 5 years no significant amount of precipitation was observed in any of the watersheds where stationary hydrological observations are conducted, which caused significant floods."

Strategy for the Adaptation of the Capital City of Prague to Climate Change - the climatological point of view

Michal ZAK ⬚ ·

"The capital city of the Czech Republic, Prague, has a significant urban heat island. Its development is increasing partly due to the city enlargement and increase of build-up fraction area, partly due to climate change. Therefore, there was a pressure to prepare Adaptation strategy to climate change. It has to deal especially with increasing frequency of heat waves (and warm nights) and irregularities of precipitation regime. The presentation will provide overview of the principles and measures of the adaptation strategy, partly from the climatological point of view. Future plans including cooperation with the climatologists will be described and discussed in the presentation, too."

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Expected future potential natural vegetation of Hungary under climate change scenarios

Imelda SOMODI, Ákos BEDE-FAZEKAS[⊡]·

"The potential natural vegetation (PNV) is a concept that represents the environment's capacity to foster certain vegetation types under the environmental conditions of a specific period. PNV, if estimated by models and applied to future time horizons, helps to assess the range of vegetation suitability, which support adaptation plans and helps to predict the future of ecosystem services.

We developed PNV models describing contemporary vegetation suitability over the full area of Hungary and applied them to two climate change scenarios. The models describing the current conditions are based on gradient boosting models of 47 habitat types. Hydrologic, edaphic, topographic and climatic parameters were used as predictors. The two scenarios were assessed by two regional climate models (i.e. 4 combinations) for the period of 2071–2100.

We found that the future environment will likely be less suitable for mesic, closed forests of low mountains, while more suitable for open, xeric oak forests and steppic habitats. However, contraintuitively, wetlands habitats of lowlands seem to profit from the changing climate probably due to a projected increase in annual precipitation sum.

In conclusion, the environmental suitability of currently known natural habitats of Hungary will shift closing tensions for existing stands and shaping the feasibility of future restorations. Most of the shift will favour open and dry habitats, but wetlands appear to present exceptions."

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Data-driven crop yield forecasting in the Pannonian Basin and its skill in years of severe drought

Emanuel BUEECHI, Milan FISCHER, Laura CROCETTI,

Miroslav TRNKA, Aleš GRLJ, Wouter DORIGO [·]

The Pannonian Basin has experienced several droughts in recent decades, which heavily affected agricultural production. The already challenging conditions for crop production are expected to worsen due to climate change. Hence, decision-makers need support while facing these challenges. Data-driven crop yield forecasting has proven being a vital tool in that respective. However, such forecasts often get less reliable in years of severe drought and, therefore, require thorough validation. In this study, we develop a machine-learning based crop yield forecasting system for the Pannonian Basin and examine its skill, with special focus on drought years. The crop yield forecasting system developed here predicts yearly yield anomalies of maize and winter wheat for various administrative districts in that area. The forecasts are calculated using a random forest model with 18 predictor datasets of vegetation, weather, and soil moisture based on Earth Observation, in-situ measurements, meteorological reanalysis, and seasonal weather forecasts of precipitation and air temperature. Monthly forecasts are made for each growing season, starting with a lead time of three months before the usual harvest. The results show that the estimates of the crop yield anomalies in the two months preceding the harvest have the best performance (correlations from 0.45 to 0.67 of observed and predicted crop yield anomalies over all years and regions). In years of severe droughts, the correlations decrease to 0.33 to 0.47. This is related to the generally worse performance of forecasts of regional variations of the yields within a season and the low number of considered drought years, respectively. The analysis of the feature importance of the model shows that wheat yield is generally limited by temperature, while for maize moisture availability is key. Overall, the method presented here forms a basis to provide stakeholders with forecasts of crop yield anomalies and potential losses on a country-scale.

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Evaluation of the surface layer stability functions for momentum, heat and water vapour in a semi-arid location

B. MARTÍ, D. MARTÍNEZ-VILLAGRASA, J. CUXART ·

"The Surface-Energy Budget station at the Campus of the University of the Balearic Islands has been running continuously since 2015. It is located in a wide flat area 8 km away from the coast and at the foothills of the Tramuntana range. In consequence, the meteorological regime is dominated at midday by the sea breeze in the warm period of the year (blowing from the South) and by katabatic flows in the middle of the night (blowing from the North). 2020 was an extremely wet year and most of the time (excepted a few weeks in summer) the upper soil had a substantial amount of water. Instead 2021 was a very dry year and the upper soil had low water content values most of the time.

In this presentation we assess for these two years the goodness in the daytime of the classical approaches of Businger and Dyer, in the form synthesised by Hogstrom (1988) for our site in moderately complex terrain and arid conditions in summer. The momentum flux is computed in two ways, with one level of wind and the prescription of a monthly-varying roughness length or with 2 levels of wind. The sensible and latent heat fluxes are computed using two levels of temperature and humidity (2m and 0.36 m above the ground). The stability functions for momentum and heat display a good behaviour with an exception for moist soils under high solar irradiation. Instead the stability function for moisture shows a dependency on the value of the Bowen ratio, and needs modification for very dry conditions."

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Evolution of the air and soil temperature profiles near the surface during a clear summer night in Szeged (PABLS'15 experiment)

Z. Szabó, J. Cuxart, T. Weidinger, B. Wrenger, G. Simó, B. Matjacic ⊡ ·

"The Pannonian Atmospheric Boundary Layer Study consisted in a two-step program: one in the cold season (PABLS'13, Nov-Dec 2013) and one in summer (2015), both held in the Aerodrome of Szeged, in Southern Hungary, in the center of the Pannonian Basin. While PABLS'13 took place along two weeks, PABLS'15 was a longer time surface layer deployment (about 4 months, end of June to end of September) including a Special Observation Period in July, which included 4 Intensive Observation Periods (IOPs) focused in the nighttime. During these IOPs, available profiling systems were operating, either tethered balloon systems or multicopter profilers.

For this work we have chosen IOP3 of PABLS'15, between noon July 15th and noon July 16th. During this IOP we dispose of the whole surface-layer and soil instrumentation installed at the Szeged Aerodome by ELTE, supplemented with a column of termistors by UIB. In the vertical we have access to the operational radiosondes of OMSZ (Hungarian Meteorological Service) at 12 and 00 UTC and the vertical profiles of temperature and humidity produced by the TH-OWL multicopter which operated the whole night at approximatively half-hourly intervals. Finally we have access in this analysis to the outputs of the ECMWF model as supplied by DHMZ (Croatian Meteorological and Hydrological Service).

IOP-3 started with a well-developed windy convective boundary layer leading to a windy evening transition with sustained cooling. Later on, as the wind calmed down, we had a clear night with very weak winds and almost constant temperature at 2m. Finally the morning transition conduces to a classical Convective Boundary Layer with weak winds. In order to understand the lack of cooling during the calmed part of the night, the evolution of the air temperature profile between the surface and 2 m, and of the soil temperature profile between the surface and -20 cm are analyzed. The analysis is supported by the inspection of the surface energy budget and of the radiation budget."

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Representation of clothing in the human thermal bioclimate models

Ferenc ÁCS, Zsófia SZALKAI, Erzsébet KRISTÓF ✉ ·

"Human modelling is the central issue in the science of human thermal bioclimate modelling. Human modelling involves modelling of a) clothing, b) metabolic heat flux density related to the activity and c) human thermal perception. Among issues mentioned modelling of clothing seems to be most simple task, but this opinion is also deceptive. In this study, we will focus on the issue of modelling of clothing in human thermal bioclimate models. In these models, clothing is represented by its thermal insulation rate (hereafter clothing resistance). There are models (the majority), in which this basic information is used as input variable, but there are also models (less), which simulates this variable and use it as model output. No one has compared these methods so far.

The aim of this study is to compare three clothing resistance parameterization methods. In one method, clothing resistance is ouput variable; the clothing resistance calculated by the other two methods is to be used as the input variable. The results show that clothing resistance values calculated by different methods can differ significantly and systematic differences were also recorded, especially in extreme weather situations. The results also show that clothing resistance can vary over a wide range, which can cause great uncertainty in simulating human thermal load."

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A preliminary analysis regarding the impact of rainfall erosivity on irrigated and non-irrigated arable land in Romania

Bela KOBULNICZKY ·

"Rainfall erosivity is most often highlighted in the development of soil erosion assessment models (RUSLE, WEPP, SWAT, AnnAGNPS, and others). Agricultural productivity must be closely linked to the impact of rainfall erosivity on arable land that can be exploited. Two important data sets are relevant for this analysis: the Land Copernicus land use database and the European Soil Data Center database on rainfall erosivity rates created at the European level. To continue such a preliminary analysis, it is necessary to address the phenophases of crops that are affected by severe climate change and increase their resilience."

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Analysing the urban heat island of Budapest during summer heatwaves

Rita PONGRACZ, DEZSO Zs., Judit BARTHOLY ·

"On the one hand, the urban heat island results in less energy demand during winter, thus it can be considered as a positive anthropogenic impact. On the other hand, summer heat waves affect human health adversely due to the heat stress. Therefore, the artificial surface covers may interfere and strengthen the adverse effect. The main aim of this study is to evaluate the urban heat island of Budapest using surface temperature products available from NASA's Terra and Aqua satellites, from 2001 up to date. We analysed the spatial distribution, inter-annual variability, and 20-year trends of the urban surface heat island of Budapest for the late spring and summer months, with a special focus on heat waves. Despite extremely high surface temperature values in daytime, heat wave events tend to produce relatively lower heat island intensities because of the more intense warming of the surrounding areas outside the capital compared to the densely built-in districts of the city center. This appears as a consequence of the lower latent heat content of the energy balance above natural surfaces during the hot, dry weather situations."

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Analysing the detected and projected trends of extreme precipitation indices over the Pannonian plains

Judit BARTHOLY, Rita PONGRACZ, Alexandra BERENYI ·

"The main goals of this study are (i) to analyse the spatio-temporal changes in extreme precipitation indices for the past since 1950, (ii) to validate the available historical simulations of the Euro-CORDEX regional climate models from this specific point of view, and (iii) to evaluate the projected trends of extreme precipitation indices for the plain area of the Pannonian basin using scenario runs for the 21st century from the Euro-CORDEX database in a fine, 0.11° grid resolution. The research compares the Pannonian basin to other plain regions of Europe. Altogether 17 climate indices were calculated including both the excessive precipitation and drought related indices, most of them defined by the Expert Team of Climate Change Indices (ETCCD). Our results show that the occurrence and intensity of extreme precipitation events increased, while the trends of duration and frequency of dry spells show both intra- and inter regional variability across the plains. "

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Micrometeorological measurement program for analysing foggy situations at Budapest and near Lake Balaton (2018-2021)

WEIDINGER Tamás, GANDHI Arun, GYÖNGYÖSI András Zénó, TORDAI Ágoston Vilmos, KRÁMER Tamás, TORMA Péter, REHÁK András, HORVÁTH Ákos, PAPPNÉ FERENCZI Zita, HORVÁTH Gyula, IMRE Kornélia, GERESDI István [□]·

"The evolution of fog is a complex phenomenon, governed by radiation, phase transition, cooling, microphysical and turbulent exchange processes. Low wind speed, stable stratification, and radiation cooling at the top of the fog layer are inherent characteristics of foggy weather. Fog dissipation is usually the consequence of strengthening wind (therefore mechanical turbulence) and increasing irradiation. We are analysing the micrometeorological data were observed at the synoptic station of Pestszentlőrinc (12843) and in the Sió Valley (Siójut) close to the Lake Balaton near Siófok (12935). Instrumentation of six performed measurement campaigns (in the winter half years between 2018 and 2021) is presented. Structure of the near-surface and planetary boundary layers in foggy events are discussed using case studies. The surface energy budget components, vertical profiles and time series of relative humidity and temperature are evaluated in each case. The start and duration of fog events are determined using visual observations, data from present-weather sensors and ceilometer data. The beginning and dissipation of fog could not be always determined by observed relative humidity. We also provide information about the quality control process accompanying the development of the micrometeorological database. Analysis of hourly air pollutants concentrations (O3, NOx, SO2, CO, PM10, PM2.5) observed in Budapest are provided. "

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Construction of common database, quality control and data processing procedures for micrometeorological measurement campaigns

TORDAI Ágoston Vilmos, WEIDINGER Tamás, TORMA Péter, REHÁK András, MÉSZÁROS Róbert, GANDHI Arun, BRANISLAVA Lalic ⊠·

"In the past 8 years (2015-2022), the Department of Meteorology at Eötvös Loránd University took part in numerous micrometeorological field measurement campaigns. The unification of data structure and metadata formats became an increasingly important task. Also, the overview of the applied quality control process for distinct phases of the measurement campaigns (from preparations to the actual field measurements and data post-processing) is an important task.

We present the measurement programs and highlight the importance of metadata (e.g., detailed description of stations, instrumentation, measurement heights, photographs, geolocation, used constants and calibrations). The calibration of the used instruments with standard reference instruments, the field calibrations, adjustments, and their proper documentation are priority tasks for quality assurance. We assess the issue of harmonization of different contributing institutions' measurements at various locations. We present an example of post-field (follow-up) calibration by a case study from the micrometeorological fog measurement campaign at Budapest (12843) showing relative humidity and temperature time series. We also show deviations in the measurements that can be explained by physical reasons, the methods of their detection and suggested corrections.

More agrometeorological stations and data loggers are installed each year e.g., in orchards, vineyards, high-value crop fields, etc. Through these measurements, we assess an important question regarding the added value of these stations compared to standard synoptic stations.

The presented measurement campaigns and data-processing procedures are fitted to the frameworks of the COST action CA20108 - FAIR NEtwork of micrometeorological measurements

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(FAIRNESS) program (https://www.cost.eu/cost-action/fair-network-of-micrometeorological-measurements). The main goals of the program are "to improve standardization and integration between micrometeorological measurements established for special purposes, create a transboundary network of researchers and stakeholders, and establish a knowledge sharing platform." We present this program's connection points with our database development process as well."

A country scale assessment of the heat hazard-risk in urban areas

Sorin CHEVAL, Alexandru DUMITRESCU, Vlad AMIHĂESEI, Adrian IRAŞOC, Monica-Gabriela PARASCHIV, Darren GHENT ⊡.

"The connexion between the regional climate and urban environment produces local changes in most climate features and exacerbates the magnitude and frequency of the extreme events. Heat hazards are particularly related to urban climate and global warming will amplify the associated risks in vulnerable areas and their environmental impacts. This paper presents the results of interdisciplinary environmental research aiming to provide a country scale perspective of the heat hazard-risk (HHR). We have used a risk matrix approach combining elements of thermal hazard, derived from land surface temperature (LST), and vulnerability metrics, derived from population density and urban fabric. The study informs about the overall factors that control the HHR across 77 cities in Romania, such as the environmental and climate settings, the city size and structure. The results show that the urban HHR is higher during the daytime, in warmer climates and in densely populated cities. The use of the methodology at a country scale is innovative, and demonstrates clear potential for applications in other regions, mainly for national strategies and plans aiming to mitigate the urban HHR within the climate change context. "

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Next generation of space-based observation systems and geo-information products for water and agriculture

Espen VOLDEN

"The European Space Agency has launched a set of activities focusing on enhancing the retrieval from Earth Observations of different critical parameters describing the terrestrial component of the water cycle. Activities include studies aimed at enhancing estimates of precipitation, soil moisture, evapotranspiration, irrigation, river discharge, and run-off. They aim at providing such parameters at spatial and temporal resolution compatible with decision-makers needs. Efforts are being done to produce sets of data products that are consistent and to move towards closing the balance of the water cycle. Other activities have developed systems and tools for producing dynamic crop masks and crop type maps and advanced towards more reliable yield estimation and prediction. Enabling platforms for scientific collaboration and provision of services in the domain of agriculture have been established and are being improved. Examples of results will be highlighted as well as opportunities for the future."

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Detecting changes in sub-daily precipitation for the PannEx region

Monika LAKATOS 📧·

The investigation of the sub-daily precipitation can help understanding of the nature and drivers of precipitation extremes.

A set of hydroclimatic indices have been produced in the INTENSE project is in correspondence with the World Climate Research Programme (WCRP)'s Grand Challenge on 'Understanding and Predicting Weather and Climate Extremes' and the Global Water and Energy Exchanges Project (GEWEX) Science questions. Some of the indices defined in INTENSE describes the maximum rainfall totals and timing, the intensity, duration and frequency of heavy precipitation, frequency of rainfall above specific thresholds and some of them is related to diurnal cycle. Selected indices are analyzed in this paper to assess the general climatology of the short-term precipitation in the Pannonian basin. The following indices are illustrated on maps and graphs: the annual mean and maxima of 1-h, 3-h and 6-h sums, the count of 3-hr periods greater than 20 mm thresholds, the maximum length of wet hours, the timing of wettest hour and the 1-h precipitation intensity. The seasonal trends of the 1-h precipitation intensity were tested from 1998 to 2019. Analysis of sub-daily precipitation has been limited by the availability of data on a global or a regional scale. The international effort made in this work through collaboration in the PannEx initiative contributes to enlarging the data availability for regional and global analysis of sub-daily precipitation extremes.

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Development of a representative database for the study of the climate of the Carpathian Basin

Beatrix IZSÁK, Mónika LAKATOS, Olivér SZENTES, Zita BIHARI ⊡.

"Climate studies, in particular those are related to climate change, require long, high-quality, controlled data sets that are representative both in space and time. Homogenization of the data series raises the problem that how can we update the earlier homogenized data series without starting from beginning. Another question is how to homogenize together the long and short data series, since in the last decades the meteorological observation system was upgraded significantly. It is possible to solve these problems with method MASH (Multiple Analysis of Series for Homogenization, Szentimrey), since it is based on adequate mathematical principles for these purposes. MASH is based on hypothesis testing, so we can examine the null-hypothesis of homogeneity of the new system by statistical tests.

The homogenized station data series are interpolated to the whole area of Hungary on a regular grid. The MISH (Meteorological Interpolation based on Surface Homogenized Data Basis; Szentimrey and Bihari) software was developed at the Climate Department of Hungarian Meteorological Service (OMSZ) specifically for interpolation of climate elements. The software consists of two major parts: the modelling of climate statistical parameters and the interpolation subsystem. A good quality modelling requires long homogenized data sets, but the representativity of the station system is also very important. Therefore, as many measurements as possible should be considered in the modelling process. The interpolation error can also be reduced by using homogenized data from stations beyond our borders in the modelling process.

The MASH and MISH methods were used during the implementation of the CarpatClim project (http://www.carpatclim-eu.org). The PannEx WS provide a good opportunity to discuss the possible update of the CarpatClim in the future. "

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Seasonal climate forecast for European agriculture - can crop producers benefit from it?

Andrej CEGLAR, Andrea TORETI □.

"Skill and reliability of seasonal agro-climate predictions are assessed. We show how seasonal climate forecast can provide useful information for decision-making processes in the European winter wheat-producing sector. For example, flowering time can be reliably predicted already at the beginning of the growing season in central and eastern Europe, which could support effective variety selection and timely planning of agro-management practices. The predictability of climate events relevant for winter wheat production is strongly dependent on the forecast initialization time as well as the nature of the event being predicted. Overall, regionally skillful and reliable predictions of drought events during the sensitive periods of wheat flowering and grain filling can be made already at the end of winter. On the contrary, predicting excessive wetness seems to be very challenging as no or very limited skill is estimated during the entire wheat growing season. "

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Analysis of temperature-related climatic events in winter and spring - attribution to anthropogenic climate change

Rita PONGRÁCZ, Péter SZABÓ, Zsófia BARNA, Anna MRÁZ, Judit BARTHOLY ⬚·

"The anthropogenic global warming is evident by now, however, it is also a valid question how much the anthropogenic activity contributes to various climatic events, e.g., the occurrence of frost days, the start of vegetation period, the date of late frost in spring. For the analysis, several data sources are used: (1) an ensemble of CMIP6 global climate model simulations of both natural-only forcings and historical runs, (2) an ensemble of regional climate model simulations from Euro-CORDEX, including both RCP4.5 and RCP8.5 scenarios, (3) HUCLIM, a fine-resolution, homogenized observation-based gridded data compiled by the Hungarian Meteorological Service. We addressed seasonally relevant extremes and general climatic events, from which temperature related indices are analyzed here. The focus of the study is on Hungary, however, it is possible to extend the evaluation to the entire Pannonian region for both the past and the future. "

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Seasonal forecasting in Croatian agriculture

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"Seasonal forecasts are of great importance to support decision-making in various sectors, such as agriculture and energy. Although the performance of seasonal forecasts is generally limited in Europe, it has improved in recent past as a result of better representation of different physical processes in models, higher spatial resolutions, and display of initial conditions. Consequently, seasonal forecasts are increasingly used in Europe, but also around the world, as a tool to help farmers make decisions about choosing the right agro-technical measures in agricultural production. As previous research on seasonal forecasts in Croatia has not focused on the agricultural sector, a review of literature and results from Europe and the region will present the concept of methodology for applying the ensemble of seasonal forecasts of the European Center for Medium-Range Weather Forecasts (ECMWF) in agrometeorological modeling of crop yields. Furthermore, connection of yields with sources of predictability, such as the EL Nino South Oscillation and the North Atlantic Oscillation will be shown at the regional level. "

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Climate change detection based on long-term historical meteorological data in the Carpathian Region

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"High quality observational time series has double role in climate research; on the one hand based on observations past climate processes can be directly analysed, on the other hand long-term observations are necessary to validate climate information obtained from climate models, or other proxy data. In the study we consider the historical climatological time series available in the meteorological yearbooks of the Royal Hungarian Institute of Meteorology and Geomagnetism first published in 1871. Data quality improvement of historical data includes the homogenisation process with outlier checks and data gap filling applying the Multiple Analysis of Series for Homogenization (MASH) software developed by Szentimrey (2008). We investigated 13 stations from the Carpathian Region having the most complete monthly temperature and precipitation time series for the period of 1871-1918, namely Arad, Bistrița (Beszterce, Bistritz), Miercurea Ciuc (Csíkszereda, Szeklerburg), Cluj-Napoca (Kolozsvár, Klausenburg), Baia Mare (Nagybánya, Frauenbach), Sibiu (Nagyszeben, Hermannstadt) (RO); Budapest, Debrecen (Debrezin), Pecs (Fünfkirchen), Szeged (Segedin) (HU); Uzhhorod (Ungvár, Ungwar) (UA), Kosice (Kassa, Kaschau) and Hurbanovo (Ógyalla, Altdala) (SK). First, statistical tests were elaborated to compare the main statistics of the historical data sets (1871–1918) with current data (1971–2020). The source of the current data are the National Meteorological Administration of Romania (stations in RO), and the European Climate Assessment & Dataset (other stations). Furthermore, we performed trend analysis to detect possible changes in climate over the past 150 years. The results show significant changes between the two periods. Temperature are moving towards higher values in terms of means and in terms of extremes. Even if some local trends can be detected in the historical periods (e.g. Cluj-Napoca), significant changes are much more characteristics in the recent period for all stations in the region, which indicates a large-scale climate change detected in the last few decades."

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PannEx is in its way to become a Regional Hydroclimate Project (**RHP**) of the World Climate Research Programme (**WCRP**) Global Energy and Water Exchanges Project (**GEWEX**). The GEWEX aims to observe, understand and model the hydrological cycle and energy fluxes in the Earth's atmosphere and at the surface. It proceeds by means of an integrated program of research, observations and science activities that focuses on the atmospheric, terrestrial, radiative, hydrological, coupled processes and interactions that determine the global and regional hydrological cycle, radiation and energy transitions, and their involvement in climate change. The almost closed structure of the Pannonian basin makes it a very good natural laboratory for the study of the water and energy cycles, focusing on the physical processes of relevance.

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