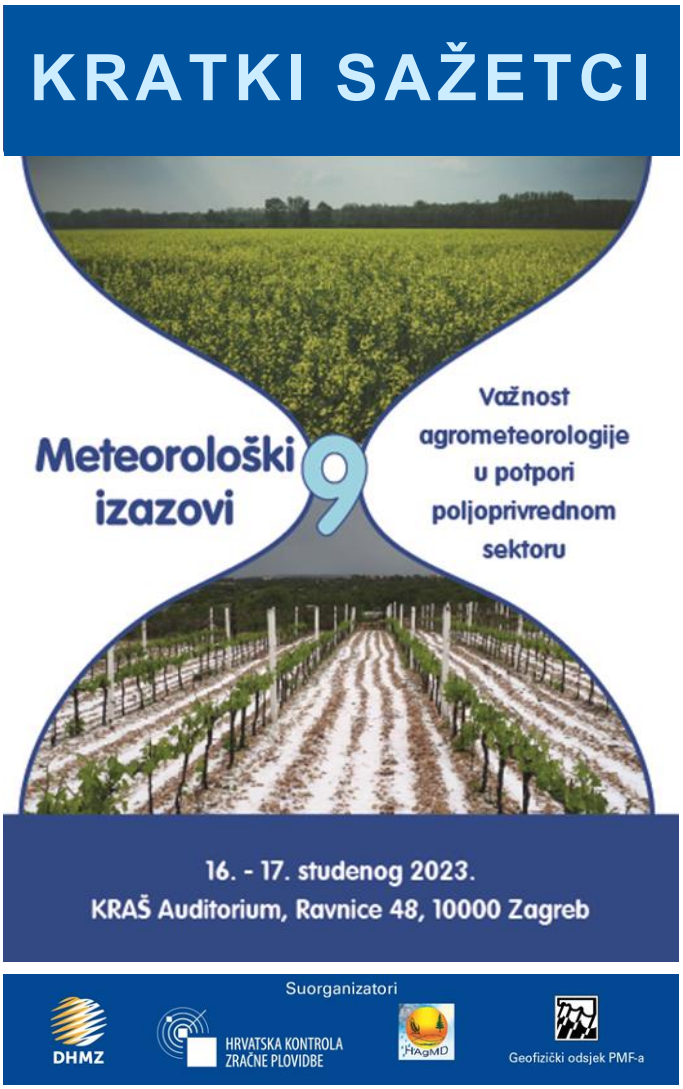
KRATKI SAŽETCI



Klimatske promjene i ekstremne vremenske prilike velik su izazov u održivoj proizvodnji hrane, što potvrđuju i sami poljoprivrednici. Stoga im je pravodobna i pouzdana informacija o očekivanim vremenskim prilikama od nekoliko dana, tjedana i mjeseci unaprijed od iznimne važnosti za ostvarivanje dobrih prinosa.

Ciljevi skupa su: diskutirati načine na koje agrometeorologija, kao važna karika u proizvodnom lancu, može svojim specijaliziranim meteorološkim produktima odgovoriti na potrebe poljoprivrednika da im omogući uspješnu proizvodnju hrane; razmijeniti znanja i najnovije rezultate znanstvenih istraživanja iz meteorologije, klimatologije, sinoptičke meteorologije, numeričkog modeliranja i ostalih srodnih područja; ojačati komunikaciju znanstvene zajednice s korisnicima meteoroloških podataka i produkata, općom javnošću i medijima te promicati i popularizirati meteorologiju.

Skup je otvoren za sve korisnike i pružatelje meteoroloških informacija.

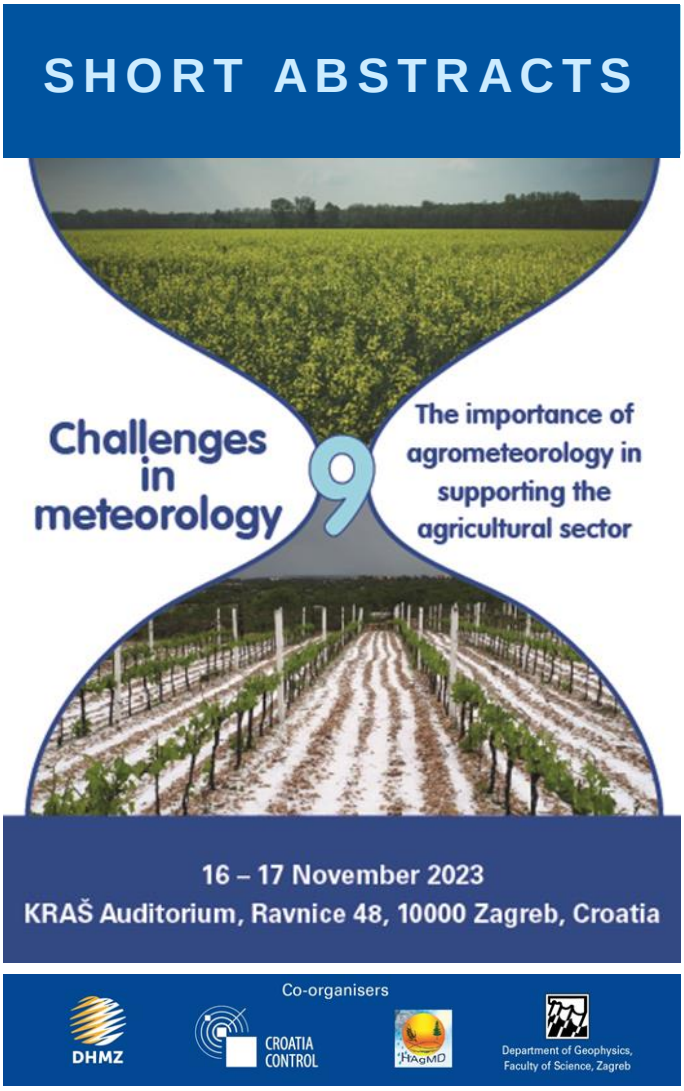
Očekivani rezultati skupa su bolja interdisciplinarna suradnja meteorologa s korisnicima iz svih područja društvenih i gospodarskih djelatnosti s fokusom na podršku poljoprivrednom sektoru te razvijanje svijesti o važnosti jačanja komunikacije među svim relevantnim dionicima.

Pozvani predavači su: Joan Cuxart Rodamilans (University of the Balearic Islands, Mallorca, Španjolska) i Željka Stone (NMT, Climate and Weather Consortium, New Mexico).

Generalni pokrovitelji: Ministarstvo poljoprivrede RH, Ministarstvo znanosti i obrazovanja RH

Sponzor: Altium International d.o.o.

SHORT ABSTRACTS



Farmers will agree that extreme weather and climate change are a major challenge in the sustainable food production. Therefore, accurate and reliable information about the expected weather conditions in the coming days, weeks and months is extremely important to them, in order to achieve a successful food production.

The goals of the conference are: to discuss the ways in which agrometeorology, as an important link in the production chain, with its specialized meteorological products can respond to the needs of farmers in efficient food production; to exchange the latest scientific achievements in the fields of meteorology, climatology, applied meteorology, environmental protection and sustainable development; to strengthen the communication with users of meteorological data and products, the general public and the media and to promote and popularize meteorology.

The conference is open to all users and providers of meteorological information.

The expected results of the conference are closer interdisciplinary cooperation between meteorologists and users from all areas of social and economic activities focused on supporting the agricultural sector, as well as developing awareness of the importance of strengthening communication among all relevant stakeholders.

Invited speakers are Joan Cuxart Rodamilans (University of the Balearic Islands, Mallorca, Spain) and Željka Stone (NMT, Climate and Weather Consortium, New Mexico).

Under the auspices of: Ministry of Agriculture, Ministry of Science and Education.

Sponsor: Altium International d.o.o.

PREDAVANJA
PRESENTATIONS

CONTRASTING EVAPOTRANSPIRATION OVER DIFFERENT IRRIGATED AND NON-IRRIGATED CROPS DURING THE *LIAISE 2021 CAMPAIGN*

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The Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) project aims to improve our understanding of the impact of anthropization on the water cycle in terms of land-atmosphere-hydrology interactions, and the limitations of models to represent all aspects of the terrestrial water cycle in a semi-arid environment on the Iberian peninsula. An experimental effort took place in summer 2021 in the Ebro valley, with a two-week Special Observing Period (SOP) focused on documenting the contrast in the atmospheric boundary layer between an extense irrigated area and the surrounding rainfed landscape. Several surface energy budget stations were deployed and further boundary layer measurements were obtained with radiosondes, remote sensing devices, UAVs and aircraft.

A comparative study of the evapotranspiration in the study area for the SOP will be shown in this presentation. The data used are from eddy-covariance measurements at noon and at midnight over 5 well-watered surfaces (shallow lake, corn, alfalfa, apple orchard and grass) and 3 rainfed parcels with dominancy of dry bare soil in summer (almond orchard, natural vegetation and vineyard). Large differences between nearby observations will be shown and tentative explanations given. Standard approaches such as Penman-Monteith or Priestley-Taylor will be assessed with observations over well-watered surfaces. The performance of two numerical weather prediction models (Meso-NH and UK Unified Model) in reproducing the observed evapotranspiration over the different surfaces will also be discussed.

TOPSOIL DROUGHT INDICATOR IN THE *DROUGHT METER* ONLINE PORTAL

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The frequency of droughts in Slovenia has been increasing in recent decades. In the last twenty years we have recorded 7 droughts that affected Slovenia on the scale of a natural disaster, with the most recent one in 2022 causing around 148 million euros of direct damage to agriculture. Droughts have been occurring with increasing intensity, and in areas and seasons where they have not been a problem in the past.

In Slovenia, the main indicator used to determine drought conditions in the topsoil layer is surface water balance, which presents the difference between the amount of precipitation and the amount of water evaporated from a reference surface over a selected time period. In recent years, the indicator has been used both for near real time monitoring and detection of drought conditions as well as for analysing past drought events.

The aim of this talk is to show how this indicator is used 1) in operational work for determining near real time water balance conditions in the topsoil layer for the *Drought meter* online portal, and 2) for the purpose of analysing past topsoil drought events, with drought 2022 as an example.

For the purpose of detecting drought conditions in near real time and informing the public about these, Slovenian Environment Agency has developed the *Drought meter* online portal where estimated drought conditions in three parts of the water cycle (topsoil layer, surface water, groundwater) are published on a weekly basis throughout the year. For each part of the water cycle, drought conditions are monitored at its representative stations using its specific indicator; in case of topsoil layer, the surface water balance for the past 30 days is used. Regional estimation of drought conditions is then determined based on a percentile analysis of the indicator at representative stations, which gives information on how often in the past similar conditions have occurred in the selected time period.

When analysing past droughts, surface water balance when aggregated over different time windows proved to be a suitable indicator for identifying periods of wet/dry conditions. In our talk, we provide an overview of the surface water balance conditions in three distinct time windows throughout 2022 based on percentile analysis at representative stations. The unfavourable weather conditions created and intensified drought from autumn 2021 to September 2022 and caused significant damage to agricultural crops due to drought stress.

The *Drought meter* online portal represents a progress in providing information on drought conditions in Slovenia, since near real time drought information for all three parts of the water cycle is available in one place and on a uniform spatial and temporal scale. In 2022, estimated drought conditions in *Drought meter* were also the basis for the competent authorities to determine the onset of the period for assessing damage to agricultural crops due to drought.

ALTERNATIVNE METODE IZRAČUNA EVAPOTRANSPIRACIJE U HRVATSKOJ

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Evapotranspiracija, kao vrlo važna komponenta hidrološkog ciklusa, ima važnu ulogu u poljoprivrednoj praksi zbog održavanja vodne ravnoteže, posebno kod utvrđivanja potreba za optimalnim navodnjavanjem poljoprivrednih površina. Jednako tako, evapotranspiracija je i među ključnim komponentama agrometeoroloških modela, čiji je cilj odrediti prinose s obzirom na dane meteorološke, biološke i pedološke uvjete. Kako bi se dobio što pouzdaniji konačni rezultat, nužno je što više smanjiti ulazne pogreške i nepouzdanosti. Kod korištenja sezonskih prognoza kao ulaznog meteorološkog parametra za izračun evapotranspiracije, potrebno je voditi računa o vještini predviđanja više meteoroloških varijabli. U slučaju preporučene Penman-Monteith metode, procjene bi se oslanjale na vještinu predviđanja temperature zraka, tlaka zraka, brzine vjetra i globalnog sunčevog zračenja.

Korištenje smanjenog broja ulaznih varijabli za procjenu referentne evapotranspiracije moglo bi smanjiti sveukupno oslanjanje na ograničenu vještinu sezonskih predviđanja vjetra, tlaka zraka i globalnog sunčevog zračenja. Iz tog razloga ovaj izvorni istraživački rad istražuje usporedbu različitih alternativnih metoda za izračun referentne evapotranspiracije, ETo, s referentnom Penman-Monteith metodom, u različitim klimatskim područjima Hrvatske korištenjem meteoroloških podataka iz nacionalne mreže Državnog hidrometeorološkog zavoda i uspoređujući ga s paneuropskim skupom podataka EOBS te AgERA5 skupom podataka. Ovo istraživanje ima za cilj ispitati koja alternativna metoda s ograničenim podacima je najpogodnija za pojedinu regiju i koji skup podataka je najpogodniji za izbor referentnog skupa u daljnjim istraživanjima. Budući da u Hrvatskoj ne postoji sveobuhvatno istraživanje referentne evapotranspiracije, ovo istraživanje popunjava prazninu znanja na lokalnoj i globalnoj razini.

SIMULATING THE DAILY SOIL TEMPERATURE OF EGYPT USING A HIGH-RESOLUTION REGIONAL CLIMATE MODEL: SENSITIVITY TO SOIL MOISTURE AND TEMPERATURE INITIAL CONDITIONS

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In this study, a high-resolution regional climate model (RegCM4) was used to forecast the daily soil temperature at 40 cm of depth (hereafter ST40). The RegCM4 was downscaled by the Global Forecast System (GFS) of one degree horizontal resolution to 25 km grid spacing. To examine the sensitivity of the ST40 to different initial conditions of the soil moisture and temperature, four experiments were conducted and grouped in two cases. The first case considered the comparison between initialling the RegCM4 from bare soil and from the global satellite soil moisture product (ESACCI). On the other hand, the second case examined the influence of initializing the soil temperature from the Century reanalysis product (Century) versus initializing from zero values.

The results showed that initializing the RegCM4 with the ESACCI has a notable impact on the simulated ST40 with respect to the bare soil. Additionally, when the RegCM4 is initialized with the Century product, the simulated ST40 is improved in the sense that the ST40 trend becomes smoother than when the RegCM4 is initialized with zero values. In comparison with a reanalysis product, the RegCM4 shows a good performance when it is initialized with the ESACCI and Century products.

In conclusion, the RegCM4 can give a reliable forecast of the ST40 when it is initialized with the ESACCI satellite soil moisture and Century reanalysis soil temperature products especially in scarce-data regions.

ANALYSIS OF TEMPERATURE CONDITIONS NEEDED FOR WINTER WHEAT CULTIVATION AND THE IMPACT OF TEMPERATURE CHANGE ON ITS PRODUCTIVITY IN THE DELTA OF EGYPT

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Winter wheat is one of the most important strategic crops for Egypt food sector; therefore, successful understanding of the effect of temperature on crop production is crucial for supporting future planning and decision-making, especially with climate change and temperature increase which is projected in this region [1]. To this aim, in the present work, we analyzed temperature variables: monthly mean temperature, monthly maximum temperature, and monthly minimum temperature, in addition to the number of heatwaves during 20 cultivation seasons, from 2001 till 2020 to determine the temperature variables that the wheat crop can resist. Those variables were analyzed during seasons with yield 10% greater than mean yield (+yield) and years with yield 10% less than mean yield (-yield) through the 20 years of the study to determine the best and worst temperature conditions. Also, to assess the possible impacts of climate change on the agricultural sector, the expected winter wheat productivity was predicted for 1-year intervals during the period between 2025-2050 using the CORDEX data with the RCP4.5 and RCP8.5 scenarios, and the World Food Studies Simulation Model (WOFOST).

The results showed that years with yield less than average were probably associated with heat waves striking the Delta of Egypt in February and March with monthly mean temperatures higher than monthly mean temperature above normal (1.5–2.5°C), whereas years with yield above average where associated with no heat waves in February and March and with monthly mean temperature below normal (1.5–2.5°C) Moreover, it was found that when mean temperature increased, wheat yield, total biomass, and straw were observed to decrease by around 6, 6.5, and 6.8%, respectively. Also, the opposite was true for temperature decrease. Results of the analysis of the projected CORDEX data with the two scenarios pointed out to an expected increase in mean temperature that will probably decrease winter wheat productivity.

[1] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

EUMETSAT SATELLITE PRODUCTS IN SUPPORT OF AGROMETEOROLOGY

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Satellite data and products have a growing impact in the provision of agrometeorological information and effective services. Information on soil moisture, temperature, evapotranspiration and precipitation, among other variables, is essential for assessing soil conditions and makes an important contribution to crop planning models, enabling early prediction of agricultural production. From the beginning of the 1980's, polar orbiting and geostationary satellites have provided data and products to characterise and monitor land surface properties, such as land surface temperature, vegetation cover, solar radiation and others. Satellite information combined with medium-range and seasonal weather forecast, crop models and geographical information systems have been emerging as decision making tools to support early warning applications for drought, floods, pests/diseases etc. and evolution of regional agrometeorological information systems.

EUMETSAT with its Satellite Application Facilities for Land Surface Analysis (LSA SAF) and Hydrology and Water Management (H SAF) offer a range of products that can be used in support of Agrometeorology and can respond to the growing interests among agricultural and meteorological scientific community as well as weather related service providers for agricultural monitoring and decision making.

Precipitation and soil moisture products from the H SAF as well as LSA SAF products on Land Surface Temperature, Vegetation and Evapotranspiration are developed to provide the insight into soil conditions in real-time. Long term high quality data records, as those provided by the Climate Monitoring Satellite Application Facility (CM SAF) can be used to assess the impact of climate change.

The presentation will give an overview of the current status and further developments of the satellite products for agrometeorology as well as information about the data access and processing facilities of EUMETSAT.

AGROMETEOROLOGY IN ACTION: CHALLENGES AND OPPORTUNITIES IN THE OPERATIONAL USE OF AGRO-METEOROLOGICAL DATASETS FOR EARLY WARNING AND CROP YIELD FORECASTING BY DIVERSE STAKEHOLDERS

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Through its MARS (Monitoring of Agricultural ResourceS) activity, the Joint Research Centre (JRC) of the European Commission contributes to the more efficient management of agricultural commodity markets within the European Union's Common Agricultural Policy (CAP). The JRC provides timely and independent information on growing conditions and early estimates of crop yields of the major staple crops grown in Europe and its neighbourhoods. This is achieved through agrometeorological risk analytics and crop yield modelling that provide fundamental inputs for the monthly JRC MARS Bulletins on crop yield forecasting. The JRC MARS team has also been providing expertise to international actors concerned with global agricultural monitoring, food security assessment and response, climate change impact studies, as well as international aid and assistance policies. The MARS activity looks back to more than 30 years of CAP support.

The JRC crop yield forecasting activities and infrastructure are underpinned by the JRC MARS Meteorological Database, which contains near-real time weather station observations from national meteorological services and relevant organisations, subjected to rigorous quality control procedures. These are interpolated currently on a 25-km spatial grid and daily time step from 1979 to present, covering the European Union and neighbouring countries. Tools for inter-comparison and performance evaluation of the gridded dataset alongside alternative weather datasets are under development. Together with a range of data sources and geo-spatial analysis tools, including earth observation, bio-physical models, and crop yield statistics, this infrastructure provides the MARS team with value-added gridded datasets developed to support the analyses and operational monitoring of agricultural resources. In the process, the activity provides a unique perspective of continuously re-assessing our role as user of data by national meteorological services, striving to produce quality value-added data and services, publicly shared thanks to the EU Open Data Policy, while at the same time reaching out to diverse actors from farmers to policy makers.

In this talk, we would like to draw an overview of the challenges and opportunities in agrometeorology from the 30+ years long MARS programme with examples from the core activity of crop yield forecasting to supporting studies on agrophenology and the length of the crop growth cycle, agrometeorological risk analysis for high-value crops (e.g. fruit trees), impact analysis of extreme weather events such as droughts, heatwaves, and frost-kill risk, use of seasonal weather forecasts in agrometeorology, and not the least, energy demand studies to anticipate heating/cooling requirements.

FENOLOŠKA MOTRENJA U DRŽAVNOM HIDROMETEOROLOŠKOM ZAVODU

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Fenologija kao znanstvena disciplina proučava povezanost fenoloških ciklusa s vremenom i klimom, i fenofaze koje se prate kao razvojne faze u životu biljaka i životinja. Govoreći o fenologiji, načelno se misli na biljnu fenologiju, obzirom da je ona razvijenija od životinjske fenologije.

U Državnom hidrometeorološkom zavodu fenološka motrenja obavljaju se od 1951. godine. Broj fenoloških postaja mijenjao se kroz godine, a danas ih je aktivno šezdeset i dvije. U sklopu fenološke mreže nalaze se još i međunarodni i domaći fenološki vrt u Križevcima, osnovan 1959. godine. Međunarodni fenološki vrt u Križevcima dio je europske mreže od 90 fenoloških vrtova, a podaci prikupljeni u njemu pohranjuju se u europsku bazu podataka. U vrtu su posađene ekološki i ekonomski najznačajnije kontinentalne vrste drveća i grmlja. Sadnice biljaka osigurava IPG (International Phenological Gardens of Europe) iz Ingolstadta, koji u svom rasadniku razmnožava klonove biljaka, te ih zatim šalje u fenološke vrtove diljem Europe. Klonovi osiguravaju genetski identičan materijal u svim vrtovima, što daje mogućnost praćenja utjecaja klimatskih čimbenika na razvoj biljke neovisno o nasljednim osobinama same biljke. Biljke obuhvaćene fenološkim motrenjem grupirane su u nekoliko skupina: samonikle zeljaste biljke, šumsko drveće i grmlje, djeteline i livadne trave, ratarske kulture, voćke i vinova loza. Pored toga, prati se početak i kraj poljodjelskih radova, te medenje na lipi i bagremu.

Motrenje na fenološkim postajama obuhvaća sljedeće fenofaze: početak listanja, početak cvatnje, opća cvatnja, pojava prvih zrelih plodova, opće žućenje lišća i opadanje lišća. Motritelji bilježe datume nastupa pojedinih fenofaza te ih u realnom vremenu upisuju u digitalnu fenološku bazu podataka, koju je izradio Informatički odjel DHMZ-a. Ovakav način unosa predstavlja napredak u odnosu na raniju praksu, kada su motritelji kvartalno slali papirnata fenološka izvješća. Unošenje podataka u realnom vremenu otvara prostor za pravovremenu kontrolu i eventualne ispravke prikupljenih podataka. Valja napomenuti da su u digitalnoj bazi objedinjeni podaci prikupljeni od 1951. godine do danas. Podaci o nastupu fenofaza koriste se za istraživanje klimatskih promjena, i to je najveći značaj fenologije. Biljke su organizmi koji milijune godina opstaju i prilagođavaju se životu na Zemlji, a promjene u njihovim životnim ciklusima odraz su klimatskih promjena.

Ovogodišnje fenološke aktivnosti uključuju: obilazak terena, kako bi se utvrdilo stanje fenoobjekata unutar fenološke mreže Hrvatske, prisustvovanje PEP725 međunarodnom fenološkom sastanku u Beču te početak obnove međunarodnog fenološkog vrta u Križevcima. Planovi za sljedeće razdoblje uključuju izradu ažuriranog naputka za fenološka motrenja, izradu kataloga fenoloških postaja, dovršetak obnove međunarodnog fenološkog vrta u Križevcima i osnivanje mediteranskog fenološkog vrta u Rovinju.

ANALIZA FENOLOŠKIH KARAKTERISTIKA VINOVE LOZE UPOTREBOM STICS MODELA RAZVOJA BILJAKA

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Brojni radovi pokazali su kako se promjenom temperature zraka mijenjaju i datumi nastupa fenoloških faza. Vinova loza ima veliku socioekonomsku ulogu, kako u Hrvatskoj, tako i nad cijelim Sredozemljem. *Graševina* i *Plavac mali* najzastupljenije su sorte u Hrvatskoj stoga je naglasak u ovom istraživanju upravo na njima na četiri različite lokacije: Daruvar, Križevci, Hvar i Lastovo. Uz *Graševinu* i *Plavac mali*, promatrale su se i internacionalne sorte *Chardonnay* i *Merlot*.

STICS je model razvoja biljaka koji simulira odnose tlo-biljka-atmosfera na temelju ravnoteže vode, ugljika i dušika potrebnih kod rasta različitih vrsta usjeva bilo jednogodišnjih i/ili višegodišnjih, zeljastih i/ili drvenastih.
Prilikom mjerenja model STICS pokazao je zadovoljavajuće rezultate na tri od četiri promatrane postaje. Model STICS primijenjen je i na izlazne rezultate klimatskog modela koji je dao rezultate u dva razdoblja: 1999. – 2009. godine te 2043. – 2053. godine. Navedeni model pokazao se učinkovitim i samim time primjenjivim za simulaciju nastupa fenoloških faza. Uz navedeno, simulirao je i raniji nastup fenofaza u budućoj klimi za gotovo sve postaje.

U radu su korišteni fenološki i meteorološki podaci Državnog hidrometeorološkog zavoda te rezultati COSMO klimatskog modela.

FROST RISK

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Many studies showed a significant impact of frost on crop reduction. In 2016 in Croatia, according to the data from the Ministry of Finance, more than 50% of economic losses were caused by frost. There is no unique method for forecasting frost, and different methods to describe frost in the present and future climate are found in research. Five such methods are tested for frost detection in Croatia. In addition, new five frost estimation methods that use measurements of daily minimum temperature (T_{min}) and dew point temperature (T_d), calculated using T_{min}, relative humidity (RH), and Clausius Clapeyron equation are introduced in this research.

Methods that introduce additional variables outperform ones that rely solely on temperature. The method that classifies a day as having frost using T_{min} threshold of 3 °C and T_d threshold of 0 °C (using T_{min} and daily mean RH) is proven to capture the most frost days with the least amount of error. Using this method, results show a decrease in number of days with frost in the period 2001–2020 compared to the 1981–2000 period in coastal areas, as well as in the eastern part of Croatia. In these areas, it is evident that, in the recent period, we have 10–20 days with frost less. In the coastal area, the last spring day with frost occurs mostly by mid-March. The risk of spring frost is higher in the continental area, where, despite the reduction in the recent period 2001–2020, the last day with frost in spring most often occurs in mid-April. Further reduction of 15–40% of days with frost, in regards to the period 1971–2000, is expected in the future, and an additional shift of last spring frost day up to 20 days in certain areas.

Although the reduction in number of days with frost is good news for some farmers, these changes in the occurrence of frost do not have such an effect on reducing the risk of damage caused by frost on some fruits. Due to the earlier onset of budding and flowering, some fruit trees could have an even greater risk of a reduced yield due to frost in the future.

KVARNEREXTREM I TUCHKO
DOBAR SPOJ ZA POLJOPRIVREDNIKE KVARNERA

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KvarnerExtrem, punog naziva "Primjena inovativnih tehnologija za odgovor na krizne situacije nastale pojavom ekstremnog vremena" projekt je kojeg je realiziralo Hrvatsko meteorološko društvo (HMD) s partnerom udrugom Eko Kvarner u razdoblju od 6. 12. 2021. do 6. 3. 2023. Projekt vrijedan 63.965,38 eura (481.947,13 kn) financiran je iz Europskog socijalnog fonda (85 %) i Vlade Republike Hrvatske (15 %). Ciljevi projekta su: jačanje razumijevanja utjecaja ekstremnih pojava (prvenstveno tuče i jake kiše) na lokalnu zajednicu; jačanje suradnje s lokalnom zajednicom (lokalne vlasti, zadruge, pravne i fizičke osobe) i povezivanje s ciljanim skupinama (vinogradari, maslinari, voćari te ostali poljoprivrednici, sudionici u prometu, informacijski kanali, tijela javne uprave i intervencijske službe) na području Kvarnera.

Tijekom projekta uspostavljen je sustav mjerenja tuče i jake kiše na Kvarneru. Sustav se sastoji od digitalnih tučomjera i mobilne aplikacije Tuchko.

Digitalni tučomjer je novi instrument koji registrira pojavu tuče i jake kiše u realnom vremenu, a informacije se prikupljaju u elektronskom obliku i arhiviraju te se mogu koristiti odmah ili za kasnije analize. U sklopu projekta KvarnerExtrem prvi puta je postavljena mreža od sedam digitalnih tučomjera koji su postavljeni na poljoprivrednim površinama na otocima Krku (Vrbnik i Malinska), Cresu (Cres i Martinšćica), Rabu (Lopar) i Pagu (Lun) te u Novom Vinodolskom.

Tuchko je besplatna mobilna aplikacija za pametne telefone koja korisnicima u realnom vremenu (minutu do dvije nakon početka ekstremnog vremena) šalje obavijest o pojavi tuče ili jake kiše.

Sustav omogućava 1) informiranje poljoprivrednika i ostalih korisnika o pojavi tuče i jake kiše u realnom vremenu, što doprinosi kontroli šteta u poljoprivredi i održavanju kvalitete poljoprivrednih kultura, 2) praćenje šteta na fotonaponskim panelima, 3) veći stupanj pripravnosti sudionika u prometu, javnih i interventnih službi i njihovu bolju koordinaciju što rezultira smanjenjem nezgoda u prometu i manjim opterećenjem zdravstvenog sustava na hitnom prijemu, 4) mogućnost lakšeg dokazivanja štete u poljoprivredi te krivnje u prometu pred osiguravajućim društvima.

Tijekom projekta formirana je baza od 93 volontera, održane su: radionica za poljoprivrednike i volontere (Krk), konferencija predstavljanja projekta nakon postavljanja digitalnih tučomjera (Vrbnik), konferencija puštanja cijelog sustava u pogon (Krk), radni sastanak s tijelima lokalne uprave i interventnim službama (Krk) te završna konferencija (Zagreb); izrađeni su informativni materijali za širu javnost u tiskanom obliku (uključujući i brošure na Brailleovom pismu za slijepe osobe) i u elektronskom obliku; izrađena je podstranica projekta na internetskim stranicama HMD-a.

KvarnerExtrem je bio pilot projekt uspostave sustava praćenja ekstremnih vremenskih pojava (tuče i jake kiše) i diseminacije informacija krajnjim korisnicima na području Kvarnera. Iskustva stečena radom na projektu mogu se primjeniti na bilo koje područje Hrvatske ili izvan nje.

AGROMETEOROLOGIJA U SLUŽBI KORISNIKA: *BILJKE KOJE KAZUJU VRIJEME*

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Hrvatsko agrometeorološko društvo objavilo je 2020. godine svoju prvu knjigu *Biljke koje kazuju vrijeme* meteorologa Marka Vučetića u okviru projekta popularizacije znanosti *Agrometeorologija u službi korisnika*. Objavljivanje knjige podržali su Hrvatska akademija znanosti i umjetnosti, Primorsko-goranska županija i Hvarski vodovod. Predstavljanja knjige održana su u Križevcima, Hvaru i Zagrebu 2021., Rabu 2022. te u Hrvatskom botaničkom društvu u Zagrebu 2023.

Osebujnost knjige daje isprepletenost antičkih mitova, pučkih vjerovanja sa znanstvenom spoznajom o vremenu i biljkama. Pred čitateljima otvara se jedinstvena, unikatna pa čak i začarana priča o biljkama koje kazuju vrijeme, a potiče ih na promatranje biljaka drugim očima kako nisu navikli. Pisana je pitko i razumljivim jezikom. Obuhvaća osam poglavlja i sve je popraćeno bogatim fotografijama, njih 260, na 203 stranice. Svakom poglavlju prethodi uvodni meteorološki dio s kojima su biljke povezane. Knjiga započinje najnježnijim godišnjim dobom – proljećem i buđenjem vegetacije i proljetnicama. Zatim se nadovezuju poglavlja o važnosti sijanja Sunca, toplini te vodi na Zemlji i reakciji biljaka na njih (suncokret, smilje, zlatna i plava kiša itd.). Slijede biljke koje se povijaju vjetru (trstika, šumarica itd.). Vrhunac knjige su munje i gromovi i biljke kojima se ljudi pokušavaju zaštiti od te strašne nepogode (čuvarkuća, čempres itd.). Kako prognozirati vrijeme je pretposljednje poglavlje. Biljka vremenokaz nadmašila je sve svoje srodnike u predviđanju vremena pa se zasluženo nalazi na naslovnici. U posljednjem poglavlju opisane su ružmarin, planika i nešpola koji ne mare za godišnje doba.

Umjetničku dušu knjizi utjelovio je rapski umjetnik Mladen Šćerbe koji je dizajnirao i grafički pripremio knjigu te obradio fotografije. Autor knjige se potrudio da snimi biljke u raznim godišnjim dobima, a kada neku biljku nije uspio uhvatiti u određenom trenutku u pomoć su mu priskočili Joško Vučetić i Mladen Šćerbe. Stoga knjiga obiluje fotografijama poznatih i manje poznatih biljaka pa će sigurno i vizualno privući radoznale čitatelje.

Svojim kritičkim okom recenzenti prof. dr. sc. Vladimir Hršak, prof. dr. sc. Željko Španjol i dr. sc. Višnjica Vučetić doprinijeli su u stručnom dijelu, a za pravopis pobrinula se lektorica Ksenija Trajbar. Recenzent prof. dr. sc. Željko Španjol je istaknuo: „…Knjiga *Biljke koje kazuju vrijeme* autora Marka Vučetića naći će se u rukama znanstvenika i ljubitelja prirode kao vrijedan izbor zaboravljenih informacija. Ona naprosto otima iz zaborava ono što smo zanemarili, one spoznaje i promišljanja koje čovjeka vezuju za prostor u kom živi, a koje proizlaze iz čovjekove želje i nagona da pronikne u tajne prirode, da ih razotkriva i tumači…“

RELATIONSHIP BETWEEN CORN AND BEAN YIELD, CLIMATE CHANGE INDICES AND CLIMATIC TELECONNECTIONS IN GUATEMALA

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This study addresses the influence of climate on the annual yield of corn and beans in Guatemala, considering climatic relationships and the climate change index. Agriculture is highly vulnerable to climate variability, and understanding how climatic factors affect crops is crucial for food security. Yield data from FAO and climatic data from the average of 48 local weather stations in Guatemala are used in the study. The methodology is based on Principal Component Analysis (PCA) to reduce the dimensionality of climatic data. Correlation analyses are conducted, identifying long-distance relationships between climatic variables and crop yields. Subsequently, multinomial logistic regression models are constructed to predict the category of beans and corn (high, medium, low) based on representative climatic variables and the first principal components.

Correlation analysis reveals significant long-distance associations between climatic variables and corn and bean yields. Corn shows a positive correlation with variables like the Atlantic Multidecadal Oscillation (AMO) and various temperature measures, while beans exhibit a negative relationship with the 10^{th} percentile minimum temperature and a positive correlation with other temperature measures and AMO. The contribution of each principal component is analyzed, showing that around 4 to 5 components explain the phenomenon. PC1, contributing 38.8%, includes variables like AMO, global mean temperature, 90^{th} percentile low temperature, and Tropical North Atlantic (TNA) index, while PC2, contributing 15%, encompasses precipitation variables such as ENSO (El Niño Southern Oscillation) – precipitation index, SDII (Simple Daily Intensity Index), Rx5day (maximum 5-day precipitation), and annual total precipitation. The multinomial logistic regression model based on annual average minimum temperature demonstrates that as the average minimum temperature increases, the probability of low and medium categories decreases. Analysis of variance (ANOVA) suggests no significant difference in fit between the temperature-based model and the first principal component-based model.

Results underscore the link between climate and corn and bean yields in Guatemala. Both long-distance climatic connections and climate change indices impact crop cultivation. The multinomial logistic regression model reveals that climatic variables, particularly the annual mean minimum temperature, predict bean and corn categories. Comparison between models indicates that both approaches provide similar data fit. These findings contribute to understanding factors affecting crucial crop yields in Guatemala and can guide agricultural decisions in the face of climate variability.

AGROCLIMATIC INDICES AND THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN SLOVENIA

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Under climate change, the food system is becoming increasingly more vulnerable and consequently, food supply, especially at the regional level, plays an important role in the development of the system's resilience. According to the latest report of the Intergovernmental Panel on Climate Change (IPCC), rising global temperatures are already changing weather patterns, increasing the risk of extreme weather events such as droughts, heat waves, floods and occurrence of new parasitoids. In order to assess the impacts of climate change on agriculture, defining a set of agroclimatic indicators that represent the relationships between meteorological variables and crop production is of crucial importance. The set of agroclimatic indicators is based on thorough scientific literature review and individual consultations with experts for various fields of agricultural production in Slovenia. Recently, the occurrence of frost events in Slovenia has been increasing steadily, therefore negatively affecting fruit production. Therefore, the project research is also focused on an appropriate indicator of frost occurrence for Slovenia. An analysis of the chosen set of agroclimatic indicators is currently in progress. The analysis of frost risk for Slovenia is based on historical meteorological data from the E-OBS database and climate model projections for the 21st century, in particular regionally downscaled EURO-CORDEX projections. The frost risk analysis is made for an ensemble of 6 regionally downscaled model projections for scenarios RCP4.5 and RCP8.5. The analysis of the chosen set of temperature and precipitation based agroclimatic indicators is based on E-OBS data for the period of 1951–2022.

The frost risk analysis results showed that the probability of frost events occurring after budburst (for grapevine) or flowering (for apple and sweet cherry) in Slovenian grapevine, apple and sweet cherry varieties increases throughout the 21th century in the case of the RCP4.5, as well as the RCP8.5 scenario. We identified the period of 2071–2100 as the period when the majority of Slovenian fruit-growing regions will be most prone to frosts, whereas during 2011–2040 and 2041–2070 the probability of frost occurrence might vary.

The presentation will focus on some of the preliminary results of the project. In the scope of the presentation, an agroclimatic indicator of frost risk in Slovenia will be presented for the examples of grapevine, sweet cherry and apple fruit tree varieties. On the other hand, several other temperature and precipitation based indicators, relevant for agriculture will be presented, as well as the first results based on historical data.

UTJECAJ I POSLJEDICE VREMENSKIH EKSTREMA NA ŠUMSKI EKOSUSTAV HRASTA LUŽNJAKA (*QUERCUS ROBUR L.*)

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Hrast lužnjak (*Quercus robur L.*) predstavlja jednu od najzastupljenijih i gospodarski najvrijednijih vrsta drveća u Hrvatskoj i u Europi. U Hrvatskoj šume hrasta lužnjaka nalazimo na površini od oko 210.000 ha, gdje sudjeluju sa 48 milijuna m³ drvne mase (12 %), dok je tečajni godišnji volumni prirast 1 milijun m^3. Stanište hrasta lužnjaka u prvom redu je na području velikih rijeka (Save, Drave i Kupe) gdje se unatoč periodičnim poplavama, dobro održava i odlično razvija, uglavnom na nadmorskoj visini od 80 do 120 m u različitim fitocenozama. Najvrijednije šume hrasta lužnjaka nalazimo u istočnom dijelu Republike Hrvatske, na području Spačvanskog bazena koji obuhvaća površinu od 40.000 ha što čini jednu petinu svih lužnjakovih šuma u Hrvatskoj te predstavlja jedan od najvećih suvislih kompleksa nizinskih lužnjakovih šuma u Europi. Cilj je gospodarenja šumama hrasta lužnjaka formirati takvu strukturu sastojine koja će osigurati njezinu stabilnost, produktivnost i sposobnost prirodnog pomlađivanja. Većina šuma hrasta lužnjaka (oko 95 %) nastala je prirodnom obnovom odnosno prirodi bliskom gospodarenju šumama primjenom oplodnih ili postupičnih sječa. Oplodna je sječa takva stručna šumarska operacija kojom se fruktifikacija hrasta lužnjaka uspijeva pretvoriti u novu mladu šumu, putem više sječnih zahvata, uglavnom triju: pripremni, naplodni i dovršni sijek uz prethodnu pripremu tla. Na onim lokalitetima gdje nisu postojali povoljni uvjeti za oplodnu sječu, ondje je nova šuma podignuta sjetvom žira ili sadnjom biljaka. Prirodna obnova ovih šuma u kontekstu klimatskih odstupanja postaje sve zahtjevniji proces.

Sve brojniji okolišni pritisci izravno i neizravno otežavaju mogućnost zadovoljavajuće prirodne obnove. Uz navedeno, pojava vremenskih ekstrema stvara dalekosežne posljedice na hrastove šume u ekološkom i gospodarskom smislu. U radu je opisan jedan takav nesvakidašnji događaj čije posljedice na terenu se još evidentiraju i saniranje nastalih šteta moglo bi potrajati godinama. Olujno nevrijeme 19. srpnja 2023. godine zahvatilo je prvo zapadni dio Hrvatske i nastavilo je prema istoku Hrvatske. Na svom putu ostavilo je katastrofalne posljedice u većim kompleksima nizinskih šuma od Kutine, Lipovljana sve do najekstremnijih šteta na području Spačvanskog bazena. Prve procjene, prema podacima poduzeća „Hrvatske šume“ d.o.o, ukazuju na štete od čak 2,7 mil. m^3 drvne mase, samo na području UŠP Vinkovci u svih 12 šumarija, a procijenjena vrijednost iznosila bi cca 200 milijuna eura. Štete su zabilježene i u UŠP Zagreb, UŠP Bjelovar, UŠP Nova Gradiška i UŠP Požega. U ovim ekstremnim uvjetima šumski ekosustavi su izravno ugroženi, a obnova hrastovih šuma bit će iznimno zahtjevna i dugotrajna i vrlo neizvjesna uvažavajući dosadašnje probleme s prirodnom obnovom uz eventualnu veću pojavu štetnika i biljnih bolesti.

THE SPLIT WILDFIRE AND INITIAL COUPLED FIRE-ATMOSPHERE SIMULATIONS

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The Split wildfire in July 2017 was the most severe fire event and the most demanding firefighting intervention in Croatian history. The first part of this research analyses meteorological conditions behind this fire event. The Split wildfire was beforehand reconstructed using radio logs, digital photographs, media and firefighting reports and interviews with firefighters, firefighting pilots and eye-witnesses. The reconstruction presented four distinct phases of fire progression which were afterwards related to weather conditions. The wildfire was characterized by rapid downslope fire runs towards the highly populated coastline with the most extreme fire behaviour including extensive spotting and fire whirls. As the wildfire burnt along the complex terrain surrounded with mountain and hills it created highly complex atmospheric dynamics in the area. This was confirmed by the firefighting aviation which could not approach the fire site due to severe turbulence in the lower atmosphere.

Synoptic analysis showed that high pressure gradient between the Azores anticyclone and a cyclone over southeastern Balkans dominated the region. At the upper level there was the deep shortwave trough extending from the northern Europe to the Adriatic Sea. The surface analysis showed that the wildfire was driven by a strong north-easterly bura wind in the first 30 hours of ignition. North easterly flow brought cool and dry air that resulted in an air temperature drop and lowest relative humidity in July. The simulations of the enhanced-resolution operational model identified a low-level jet in the area when wind subsided and moved downslope, which is known to be closely related to turbulent fire behaviour. The bura flow with mid-to-low level gravity wave breaking and turbulent mixing also caused the dry air subsidence from the upper troposphere and therefore rapid surface drying, all of which influenced the fire ground.

The second part of this research included implementation of the WRF SFIRE coupled fire-atmosphere model for the first time in Croatia. Beforehand prepared meteorological analysis and reconstruction of the Split wildfire provided an opportunity to validate coupled simulations in this case. Additionally, the model's option to include and exclude energy fluxes that are exchanged between the fire and the atmosphere gave an option to determine whether and how a simulated fire might affected the local atmosphere. This method resulted in the first numerical evidence of fire-atmosphere interactions occurring in a fire event along the Adriatic coast. Altogether, the research contributes to Croatian fire weather research and knowledge and lays the groundwork for future fire weather forecasting and fire management improvement.

AGROMETEOROLOŠKI MOZAIK ZA MLADE: *MALA ŠKOLA "POŽAR NIJE ŠALA"*

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Znanstvena istraživanja pokazuju da klimatske promjene uzrokuju sve veći broj katastrofalnih šumskih požara, a projekcije u budućnost upozoravaju na još drastičniju situaciju. Jedna od preventivnih mjera je dobra izobrazba o uzrocima i posljedicama požara raslinja. Najčešći uzrok šumskih požara je nehaj i nepažnja odraslih, a odraslog čovjeka je često puta teško preodgojiti.

Stoga je Hrvatsko agrometeorološko društvo u okviru projekta popularizacije znanosti *Agrometeorološki mozaik za mlade* pokrenulo *Malu školu "Požar nije šala"* – izobrazbu najmlađih od 4 do 11 godina o zaštiti šuma od požara kako bi im podigli svijest o promišljenom pristupu korištenju prirodnih vrijednosti, ali upozorili i odrasle o opasnim radovima koji uzrokuju požare raslinja. Požari ne poznaju granice ni gradova ni županija već je važno da na vrijeme obrazujemo najmlađe naraštaje. Nužno je poticati očuvanje krajobrazne, mikroklimatske, biološke i georaznolikosti sa svrhom unaprjeđenja prirodnih vrijednosti pa ovaj projekt ima prvenstveno obrazovnu i odgojnu notu. Temi zaštite šuma od požara pristupilo se cjelovito s meteorološkog, ekološkog, šumarskog i vatrogasnog gledišta u suradnji meteoroloških i šumarskih stručnjaka i znanstvenika. *Malu školu* podržalo je Ministarstvo znanosti i obrazovanja u okviru projekta popularizacije znanosti, područne i lokalne zajednice Dubrovačko-neretvanske, Splitsko-dalmatinske, Primorsko-goranske i Istarske županije, te gradovi Dubrovnik i Zagreb. Partner na projektu je Javna ustanova za upravljanje zaštićenim dijelovima prirode Dubrovačko-neretvanske županije, a projekt je ostvaren u suradnji s Geofizičkim odsjekom Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu.

Djeci slika može najzornije dočarati opasnosti šumskog požara i njegove posljedice na prirodu: stradavanje biljnog i životinjskog svijeta, ogoljivanje tla, uništavanje krajobraza i dugotrajnu obnovu šume i raslinja. Budući da je animirani film danas sveprisutan u dječjim životima i njima najpopularniji medij, sve je to vizualno i vrlo slikovito predočeno u kratkometražnom animiranom filmu i dječjem stripu *Požar nije šala* scenarista i režisera filma Ivana Đuričića, filmskog animatora i ilustratora stripa Ivana Šivaka i skladatelja glazbe Marka Jurage. Djeca i učenici su obavezno tražili ponovo prikazivanje filma nakon žive rasprave u kojoj su nas oduševili svojim odgovorima o vatrogascima i zrakoplovima za gašenje požara kanaderima, o vjetru koji pogoduje razvoju požara, te su suosjećali sa životinjama koje su izgubile svoj dom u požaru. No, ostala su iznenađena s katastrofalnim posljedicama nakon požara o kojima nitko ne govori i dugotrajnoj obnovi šume. Od rujna 2016., kada je započeo projekt, održane su 163 Male škole u 52 mjesta i grada diljem Hrvatske u kojima je sudjelovalo oko 7700 djece i učenika. Animirani film *Požar nije šala* prikazan je i na agrometeorološkim radionicama odraslima na kojima je obuhvaćeno oko 850 osoba te u inozemstvu u Ljubljani, Novom Sadu, Budimpešti, Beču i Sidneyu. Iz ovog filma djeca, kao i odrasli, trebali bi izvući pouku: „Vatru ne pali, jer požar se ne šali!“ što je ujedno i slogan filma i stripa.

Mala škola je trajni projekt i cilj je nastaviti s predavanjima i projekcijama animiranog filma i podjelom dječjeg stripa *Požar nije šala* djeci u predškolskim i obrazovnim ustanovama te na raznim manifestacijama i skupovima na području Hrvatske, a englesku verziju filma prikazivati i izvan naših granica.

STUDYING HURRICANES WITH AIRBORNE DATA

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The basic conditions for hurricane development have been known for decades. However, in similar conditions such as high sea surface temperature, low shear and low or mid-level vortex, some tropical storms become hurricanes while others do not. The path to the rapid intensification is even a bigger mystery. This is where numerical models struggle the most.

Tropical Cyclone Rapid Intensification (TCRI) project 2020–2024 was funded by Office of Naval Research, US Navy, to study physical processes behind rapid intensification. We used NOAA's aircraft Gulfstream IV and two WP-3D aircraft to fly into hurricanes. Data sets that we collected were high-altitude dropsondes and radar observations. Those aided with ground radar network, satellite images and satellite-detected lightning strikes make for an impressive hurricane data base. We use them to apply theoretical knowledge about tropical cyclone intensification developed over the last two decades in search for something new.

Using the combination of datasets described above, my research group analyzes the thermodynamic and kinematic structure and evolution of 2020–2024 hurricanes prior to and during their rapid intensification. In some we observe the development of a pronounced mid-level vortex and a subsequent alignment in vorticity profiles. We show this is due to regeneration of the lower level vortex via vorticity convergence as a consequence of convection associated with the mid-level vortex. In others alignment is achieved early on due to favorable environment conditions. Our analysis highlights the importance of the thermodynamic environment in modulating the structure of the convection to promote bottom-heavy mass flux profiles, low-level spin-up, vortex alignment, and the onset of rapid intensification.

In this talk I will describe how we collect data, present the highlights of 2020-2024 season hurricanes, talk about theories behind the rapid intensification and application of those to numerical models.

COMBINED USE OF MULTIPLE DROUGHT INDICES FOR EVALUATION LONG-TERM CHANGES IN THE CHARACTERISTICS OF DRY AND HOT-DRY EVENTS IN SYRIA

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In this study, we conduct a comprehensive analysis of the arid and arid-hot climatic conditions in Syria within the context of climate change. We achieve this through the utilization of various indices derived from contemporary climate data (WorldClim 1.4) at a spatial resolution of 30 seconds (~1 km²) and 2.5 minutes (~21 km²) covering the period from 1960 to 2018. Additionally, historical data from 55 synoptic stations spanning 1950 to 2020 are employed. To characterize drought, we perform separate assessments based on three standardized drought indices at a 12-month scale: the Standardized Precipitation Index (SPI), the Standardized Precipitation Evapotranspiration Index (SPEI), and the Reconnaissance Drought Index (RDI). Further analyses involve the application of the Self-Calibrating Palmer's Drought Severity Index (SC-PDSI) and the Rainfall Anomaly Index (RAI).

Our investigation encompasses shifts in drought attributes, encompassing frequency, seasonal occurrence, and spatial and temporal coverage, along with an evaluation of concurrent hot-dry conditions. These latter conditions are assessed through the integration of SPI and the Standardized Temperature Index (STI) across various time scales. Employing descriptive statistics, the Mann-Kendall test, the Pettitt approach, Pet linear regression, and analysis of variance, our findings reveal a substantial downward trend in yearly and seasonal precipitation during winter and spring, while a minor positive trend is identified for autumn and summer. Furthermore, a noteworthy upward trend is identified in mean annual and seasonal temperatures throughout Syria. Across all drought indices, our analysis suggests a period of increased aridity across the entire country, with the most pronounced rise in drought frequency occurring between 1999 and 2020. Notably, the period from the late 1990s to the mid-2000s, as well as the late 2010s, emerges as persistent and severe dry intervals, with a significant shift in the mean annual values in 1999.

The study uncovers the occurrence of severe droughts in Syria between 2008 and 2012, likely attributed to human-induced climate change. Moreover, the mid-2000s are identified as a substantial mega-drought event spanning over 70 years in northeastern Syria. Our results also indicate that indices based on temperature prove more effective than solely precipitation-based indices in evaluating drought conditions within Syria. Notably, the years 1999, 2010, and 2020 stand out due to their extensive spatial coverage characterized by simultaneous hot and dry conditions, affecting approximately 40% and 35% of Syria's land area, respectively.

CHANGES IN THE SEASONAL CYCLE OF HEATWAVE, DRY AND WET SPELLS OVER WEST AFRICA USING CORDEX SIMULATIONS

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Heatwaves are generally defined as lethal phenomena having spatial and temporal extension. They mainly depend on many factors such as the research application or activities sectors (health, infrastructure, agriculture) and the geographic and climatic conditions and thresholds. On the other hand, studies of heatwaves are not documented over the region of West Africa and did not analyse the phenomenon with other climate extremes.

This study analyses the potential response of changes in the seasonal cycle of heatwave (HWDI) and other climate extremes such as dry (CDD) and wet (CWD) spells indices over West Africa for the near (2031-2060) and the far (2071–2100) future periods, under RCP4.5 and RCP8.5 forcing scenarios using the COordinated Regional climate Downscaling EXperiment (CORDEX) simulations. Although some relative biases in comparison to Climate Prediction Centre (CPC) observation data (underestimation of 30% for CDD; overestimation about 60% for CWD and overestimation about 50% for HWDI) in general during the historical period (1976–2005), the CORDEX simulations and their ensemble mean outperform the seasonal variability of the above indices over three defined sub-regions of West Africa (i.e., Guinea gulf, west and east Sahel).

They have shown significant correlation coefficients (0.9 in general) and less Root Mean Squared Errors (RMSE). They project an increase (about 10 and 20 days) in heatwave days for both near (2031–2060) and far (2071–2100) future periods over the whole West Africa region under both Representative Concentration Pathways (RCPs) scenarios. In addition, the Sahel regions will particularly face a decrease (about 5 days) in wet spells days from March to November, whereas, the Gulf of Guinea will face a decrease (about 3 days) during the whole year, except CCCLM simulation which indicates an increase (about 5 days) during the retreat phase of the monsoon (October to December). The results also have shown an increase (about 80%) in dry spells over Sahel regions, more pronounced during March–November period, whereas, over the Guinea gulf, the increase (about 40%) is observed over the whole year. On the other hand, the months of increasing dry spells and decreasing wet spells coincide, suggesting that countries in these regions could be exposed simultaneously to dry season associated with a high risk of drought and heatwave under future climate conditions. Consequently, many sectors like agriculture, infrastructure, economy, etc., will be vulnerable. Hence, agricultural practices, food security and human health are in the great risk in West Africa by the advent of heatwave effects.

IMPACT OF TROPICAL SSTs ON THE LATE-WINTER SIGNAL OVER THE NORTH ATLANTIC-EUROPEAN REGION AND CONTRIBUTION OF MIDLATITUDE ATLANTIC

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The impact of tropical sea surface temperatures (SSTs) on the signal of geopotential heights (GH200) over the North Atlantic-European (NAE) region is analyzed from the aspects of seasonality, the contribution of individual tropical basins and midlatitude North Atlantic, ENSO effect and spatial pattern of the atmospheric response. For this purpose, ensembles of targeted numerical simulations with SST forcing prescribed in various ocean basins are performed and examined.

A clear atmospheric response is obtained in the late winter months. A weak signal appears even without any SST forcing, but tropical SSTs considerably strengthen it. The strongest signal is linked to ENSO events during late winter. The competitive influences of individual tropical basins are indicated. At the same time, the superposition effect of the extratropical North Atlantic SSTs, which is established through the modulation of storm tracks, is demonstrated. Both, the modelled signal and the NOAA-CIRES-DOE 20th Century Reanalysis variance reveal the ENSO signature as a pattern in the North Atlantic projecting onto the East Atlantic pattern.

THE RESULTS OF THE APPLIED COST733 ACTION PRODUCTS IN CROATIA

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The only weather type classification that has been in operational use in Croatia since 1965 is subjective Poje's classification. This classification consists of 29 weather types determined after the distribution of surface pressure and is defined for relatively small and diverse areas. Therefore, the motivation of the presented study is to improve previous knowledge and practice and to make the whole classification process automatized. To achieve this, the results of the COST733 action "Harmonization and Applications of Weather Types Classifications for European Regions" were applied to the Croatian area. Firstly, the COST733 catalog was applied. Based on the obtained results and conclusions from that analysis, further analysis is done by running COST733class software for different settings. This analysis aims to determine the most suitable combination of main classification parameters such as domain size, number of types, input variables and classification methods to develop a classification that is intended to be the most appropriate to capture precipitation variability in Croatian regions. For this purpose, Croatia is divided into five regions to acknowledge the orography and climate diversity of the Croatian area which lead to different weather conditions within the same atmospheric circulation. Two regions belong to the continental part of Croatia (Eastern and Central Croatia), while the rest, including mountainous parts, are placed along the Adriatic Sea (North, Middle and South Adriatic).

The efficacy of different objective classifications obtained using the COST733 products is examined utilizing ERA5, E-OBS and Croatian meteorological station data. For evaluating the discriminative power (synoptic skill) of the classifications and the relevance of specific settings several statistical metrics are used. The results from the analysis using COST733 catalog have shown better classification performance for optimization and threshold based methods among other methods, hence GWT (GrossWetterTypes) and DKM (dkmeans) methods are applied in the analysis using COST733class software. Results for all different settings have shown better classification performance along the Adriatic coast and in the mountainous parts than in the more continental parts. Further, some results show that classifications based on DKM methods perform better when using eg. standardized input data instead of raw input data and that domain size and position should be tailored for each input variable. Also, the improvement of classification is found when including some of the additional variables together with the main variable (usually mean sea level pressure), but is not always apparent with an increase in the number of types.

DATA RECOVERY AND RESCUE OF NATIONAL CLIMATE OBSERVATIONS IN THE REPUBLIC OF SLOVENIA

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In Climatology as well as Agrometeorology, the climate observation data is the one we need to give special attention to because:

– Good quality and long-time series of climate data is crucial.
– To investigate past climate it is necessary to prolong data time series back into the past as far as possible.
– The very climate change with extreme weather events and other natural disasters are a threat to archives of climate records.
– Historical documents on paper fade away by time.
– The collection and preservation of climate data for future generations are the essential tasks of every National Meteorological Service.

These are reasons that the Slovenian Environment Agency (ARSO) runs activities regarding rescuing and recovering climate records.

The first step of rescue activities is to make an electronic inventory of paper holdings. Inventorying of the logbooks and reports is done. In ARSO archives there are almost 3 million pages of different climate reports from 1850–2020. Diagrams, such as pluviograms, heliograms etc., and documents with metadata are not included in the mentioned figure because inventorying them is still in process.

The second step is to image all documents with climate data and metadata and organise them in a document base. Document imaging with metadata is in process while we do it by students. Climate reports and logbooks will image professionals. The digital document base is still in plan.

After imaging, logbooks and reports will be transferred to the National archives.

Digitization of historical climate records, performance of quality control and homogenisation is the fourth step. Trained and qualified experts and students, led by the experts, perform the digitalisation of the logbooks and reports manually. The actual meteorological reports, pluviograms and heliograms are digitised regularly. The majority of climate records from 1950 to today have been digitised and quality-controlled. They are easily accessible on the ARSO web page. Yet, we still have to digitise more than 90% of hourly data and 30% of daily climatological and precipitation data. The digitization of metadata is in process.

For storage backup of the digital document base and relational database, ARSO must find two additional distant locations.

Due to turbulent Slovenian history, some Slovenian historical climate reports are still in Italian, Austrian and perhaps Hungarian and Serbian archives. Slovenia put a lot of effort into recovering climate records in foreign Archives as a participant and member of international data recovery and rescue activities.

In cooperation with Italian (ISPRA), Austrian (ZAMG – GeoSphere) and Hungarian (OMSZ) colleagues, some historical climate reports, metadata, and yearbooks have been found and imaged.

It is made the list of missing climate reports and published on the EUMETNET – DaRe Lost&Found web page and the I-DARE International data rescue portal.

The main hindrances to recovery and rescue activities are financial issues, lack of adequate employees and time-consuming work.

HOMOGENISATION AND INTERPOLATION OF DAILY PRECIPITATION TIME SERIES FROM SLOVENIAN METEOROLOGICAL STATIONS IN THE PERIOD OF 1950–2020

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Slovenian Environment Agency has recently renewed and upgraded homogenisation and interpolation of station climate series. This work has been done as a follow-up of a project Climate Variability in Slovenia in 1961–2011, covering longer time span (1950–2020) and using also the data from automatic weather stations, especially for temperature.

Homogenisation and data imputation of time series of precipitation sum were based on the monthly time series of 268 precipitation sites data. The underlying daily data has been quality controlled, aggregated in monthly sums and homogenised using Homer software tool. Homogenisation corrections on monthly data are almost equally positive and negative, with a negligible network annual mean of less than 0.5 mm throughout the majority of the period. Monthly corrections from homogenisation were applied to daily data, whereas missing daily data has been spatially interpolated using an advanced regression method.

The seasonal trend in homogenised and interpolated precipitation amount is significant only in summer in some parts of southern and western Slovenia, where it is negative and below –4% per decade. On annual level, the trend magnitude is mostly below 1% per decade and insignificant almost everywhere. The trend in extreme daily rainfall is less spatially homogenous and more inclined towards increase than total precipitation amount trend. For example, the trend in spring and annual extreme daily rainfall is statistically significant and positive at some stations in northeastern and western Slovenia, respectively. The trend in extreme two day rainfall is more homogenous, positive almost everywhere and statistically significant in north-western Slovenia.

Preliminary comparison of our homogenised and interpolated precipitation dataset with ERA5 reanalysis reveals significant subperiod and trend differences between the datasets, i.e. pointing to probable inhomogeneities in the reanalysis. These differences underpin the importance of establishing good-quality precipitation time-series in order to properly assess long-term changes and variability. The presented dataset of daily precipitation in Slovenia may serve and was served as a basis for calculation of climate normals of the latest climate period (1991–2020) and analysis of climate change in Slovenia in last decades as well. It also served as the input data to the agency's new spatial interpolation of monthly precipitation and precipitation indices in the period from 1950.

URBAN HEAT LOAD IN A SMALL MEDITERRANEAN CITY IN RECENT, EXTREME AND FUTURE CLIMATE CONDITIONS

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Mediterranean cities are very vulnerable to the impacts of climate change. Karst relief, scarce precipitation and vegetation make them extremely challenging for tackling the consequences of climate change.

In this paper, the urban heat load (UHL) of Dubrovnik, a small town located in the complex terrain of the eastern Adriatic coast, was investigated. In this study, UHL is quantified in terms of climate indices, hot days and tropical nights. Using the urban climate model MUKLIMO_3, three experiments mimicking different climate conditions were made: recent climate (1981–2010), hypothetical extreme climate (constructed from 10 warmest years in the period 1961–2021) and the future climate (2041–2070). Also, the possible benefits of certain UHL mitigation measures (including changes in the albedo of the roofs, the fraction of built-up, low vegetation and impervious surfaces) were examined.

The results indicate that in all experiments the strongest UHL is associated with built-up parts of the city. In both future and extreme climates, UHL strengthens over the entire domain, but not uniformly. Additionally, results indicate that the average UHL in the future climate is approximately equal to that obtained for some of the historically warmest years. Although urbanized parts are still the warmest, vegetated areas exhibit a stronger UHL increase and therefore the difference between the UHL of built-up areas and vegetated areas decreases. This change manifests itself differently for hot days and tropical nights depending on the type of vegetation. Generally, the difference in UHL between built-up and vegetated areas is reduced during the night. It has been shown that mitigation measures can reduce UHL somewhat, but their effect is mostly local and depends on the part of the day (daytime and nighttime) and the characteristics of certain parts of the city. However, the mitigation effect is not enough to completely mitigate the consequences of global climate change, which are significantly stronger than those associated with interventions in the urban environment. It has been shown as well that it is extremely challenging to investigate the climate characteristics of a city squeezed between the hills and the sea. Due to the terrain complexity, the selection of a representative rural area is questionable, and therefore the determination of the urban heat island.

This study indicates that the projected future climate of Dubrovnik is similar to the hypothetical extreme climate. Considering relatively weak vegetative cooling, reduction of high urban vegetation efficiency and possible strengthening of climate extremes, it is likely that the Mediterranean cities will suffer from an extremely high heat load in the future.

HOW THE RISK OF HEAT WAVES WILL CHANGE IN THE FUTURE DECADES IN CROATIAN CITIES?

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After the well-known Western European heat wave during August 2003 that caused as many as 70.000 excess deaths, many countries started to build heatwave early warning systems. In Croatia, the system is operational since 2012, and it warns about the level of possible risk for eight main regions in the country. Monitoring of the past 20 years regarding issued warnings, but also heat wave risk estimated by measured temperatures clearly indicates that the level of risk is increasing.

The aim of this work is to analyse what can we expect, regarding the intensity of heat waves in Croatia, in the future. For that purpose, we will use regional climate simulations from EURO-CORDEX data set. Simulations will cover a set of projections on 12.5 km horizontal resolution, taking into account several RCP scenarios. The future climate will be considered for three 20-year time slices.

The operational criteria used in the Croatian heat wave early warning system will be applied to the projected daily minimum and maximum temperatures. Historical climate risk simulated by models will be compared with issued warnings in order to evaluate simulations. The difference between projected and historical climate risk will be analysed by the level of risk, its duration and spatial distribution.

DROUGHT MONITORING IN CROATIA – CURRENT STATUS AND PERSPECTIVES

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Several droughts during the last decade seriously affected large parts of Europe, including Croatia, causing significant economic losses. In Croatia, agriculture is the most vulnerable sector to droughts since crop yields may be diminished or completely ruined during extreme drought events. The current drought monitoring system provided by the Croatian Meteorological and Hydrological Service has relied mainly on drought indices based on precipitation amounts at different time scales, from daily to monthly and multi-monthly scales. However, when precipitation deficit is accompanied by high air temperatures, particularly during the warm period of a year, it may further intensify drought and its negative effects. Such was the case in 2022 when long dry spells in Croatia were accompanied by several heat waves.

In this study, climatological drought monitoring with the Standardized Precipitation-Evapotranspiration index (SPEI) was analyzed. The five theoretical distributions were fitted to the water balance in Croatia comprising different time scales, from one to 24 months. Water balance is defined as a difference between precipitation amount (R) and potential evapotranspiration (PET), where PET was calculated by the Hargreaves-Samani formula. Time series of monthly precipitation amounts and air temperatures were used from 31 main meteorological stations for the period 1961–2022.

The results revealed that a three-parameter generalized logistic (GLO) distribution was found as the most appropriate one. According to the SPEI values, different drought parameters in terms of duration, frequency and intensity were compared in the two climate periods, 1961–1990 and 1991–2020. A tendency toward longer dry spells was found in the recent period for time scales from one to nine months while for longer time scales, a decrease prevailed in the whole country. However, the number of dry spells and frequency of extreme drought events occurrence was increased across the country for all time scales. Drought 2022 monitored by the SPEI index confirmed its ability to detect drought earlier than only precipitation-based indices, since extreme air temperature was recorded in June.

Since further increase in air temperature is expected in future with drying summer trends, an increase in fire weather conditions may increase. Therefore, the Interreg Central Europe project Clim4Cast started in 2023 gathering seven EU countries. The aim and main goals within its three-year lifetime will be also presented.

OVERVIEW OF PROJECTED CLIMATE CHANGES OVER CROATIA BY THE MIDDLE OF THE 21ST CENTURY

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According to the latest IPCC report, the broader Mediterranean area is projected to undergo persistent air temperature increases, along with an increase in the frequency and intensity of warm and wet extreme events, while also expecting a decrease in the overall annual precipitation amount These shifts are likely to result in more frequent agronomic and ecological droughts, coupled with an increase in the occurrence of flash floods, particularly in the northern Mediterranean. To gain a more comprehensive insight into these expected changes and their spatial variability, particularly concerning the broader Croatia and Adriatic area, our analysis focuses on examining both mean air temperature and precipitation amount changes, as well as a wide range of extreme air temperature and precipitation indices.

To estimate the climate change signal for the middle of the 21st century (2041–2070) compared to the historical period (1981–2010), we employ the "moderate" greenhouse gas concentration scenario RCP4.5. Our ensemble comprises 12 EURO-CORDEX simulations conducted at a horizontal spatial resolution of 12.5 km. Notably, three regional climate models (RegCM, RCA4 and CCLM4) have been driven by four global climate models (CNRM-CM5, EC-EARTH, MPI-ESM and HadGEM2).

The focus of our analysis is the assessment of mean annual and seasonal changes in air temperature and precipitation indices. Through this comprehensive approach, we will give a quantitative evaluation of the projected shifts in climate conditions over the broader Croatia and Adriatic areas. Overall, our study aims to provide valuable insights into the complex dynamics of climate change in this region, aiding policymakers and stakeholders in formulating effective adaptation strategies and mitigating the impacts of these projected changes.

CLIMATE CHANGE PROJECTIONS FOR SLOVENIA OVER THE 21ST CENTURY

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Knowledge of past climate variability and estimation of future climate conditions are crucial for preparing expert basis for adaptation to climate change in Slovenia. In addition to changing average conditions, estimates of the frequency, severity and duration of extreme weather and weather-related phenomena that have the greatest impact on us, our environment and our activities are of particular importance. Projections of changes in air temperature and precipitation conditions, including extreme events, serve as a basis for developing climate change adaptation policies.

The focus of the project Climate Change Projections for Slovenia over the 21st Century are climate change projections and corresponding changes in extreme weather and hydrological events, such as heat waves, droughts, extreme precipitation events, frost, high water conditions and their impact on the water cycle and energy potential of climate dependent resources.

For this purpose, we followed a common approach utilizing RCM simulations from the EURO-CORDEX project, based on CMIP5 global climate model (GCM) simulations, and different Representative Concentration Pathway (RCP) scenarios. We selected two RCM simulations from the model ensemble for RCP2.6 and six for RCP4.5 and RCP8.5. Bias adjustment of RCM simulations was performed for daily mean, minimum and maximum air temperature at 2 m, precipitation amount and reference potential evapotranspiration, where national gridded homogenized observational data for the period 1981–2010 was used as a reference. For precipitation we used the non-parametric quantile mapping using the empirical quantiles with linear extrapolation. All other variables were adjusted using the quantile delta mapping method, taking into account the dependence of the considered variable on the amount of precipitation. The outputs are available in 12 km spatial resolution on a daily basis for the period 1981–2010.

The use of climate model ensemble can lead to a wide range of climate change estimates. The multitude of results does not always reveal at first glance whether it is possible to draw unambiguous conclusions from the projections, so we introduced an indicator called the *reliability of the change*, which estimates the coherence of the climate ensemble and tells us whether the ensemble members show similar changes. The indicator is based on the statistical significance of the calculated changes and is presented at three levels: high reliability, low reliability and no change.

The graphical representation of the ensemble of climate model projections mainly consists of maps and region-averaged plots with different information (median change, reliability). Most of the maps and plots were prepared on an annual and seasonal scale and are publicly available in the Atlas of climate projections (https://meteo.arso.gov.si/uploads/probase/www/climate/OPS21/Priloge-app/).

EFFECT OF CLIMATE CHANGE ON WATER TEMPERATURE AND STRATIFICATION OF LAKE KOZJAK

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Climate change is introducing significant effects and serious threats to aquatic systems worldwide. As closed systems, lakes are extremely vulnerable. Their responses to climate change are complex and associated with a combination of meteorological factors, as well as globally escalating anthropogenic pressure. Studies have shown that while surface water temperatures have exhibited a globally increasing trend, deep water temperatures do not follow this consistent trend and show high variability in both sign and value across lakes, thus an incoherence in the stratification patterns has been recognized. This findings point to the need for further investigation of the behavior of individual lakes. This study focuses on Lake Kozjak, Croatia, a small lake belonging to the Plitvice Lakes system. This system represents a unique hydrogeological karstic phenomenon, closely dependent on a delicate biochemical balance necessary for tufa formation. Understanding its response to climate change is crucial for effective management and conservation of the lakes and their associated ecosystems.

We apply a simple one-dimensional model, SIMO v.1.0, to predict future water temperature at Lake Kozjak under three different future scenarios (RCP2.6, RCP4.5 and RCP8.5) from 2006 to 2100. The model was calibrated using measured water temperature profiles and meteorological data from a nearby station. In addition to analyzing the average temperatures of the epilimnion, hypolimnion and the whole lake, we also studied the surface and bottom layer temperatures and their relation to specific forcing parameters. The Schmidt stability index was used as a quantitative indicator to assess lake stability and stratification phenology.

The simulation results indicate average lake water temperature increase of 0.51, 1.41 and 4.51 °C per 100 years for RCP2.6, RCP4.5 and RCP8.5, respectively. The temperature increase was more significant in the epilimnion than in the hypolimnion. The projected trend of the extension of the stratification period in the baseline RCP8.5 scenario was 47 d 100 y^{-1}, in RCP4.5 scenario 27.7 d 100 y^{-1}, and even in RCP2.6 scenario there is a significant lengthening trend of 16.1 d 100 y^{-1}. No significant trend was detected in the yearly average thermocline depth, but the maximum thermocline depth value increases at a rate of 7.3 m 100 y^{-1} in scenario RCP8.5 and 3 m 100 y^{-1} in scenario RCP4.5. Substantial increase in the average stratification strength, evaluated based on the Schmidth stability index, was observed only in case of the baseline scenario RCP8.5. Namely, due to the relatively low depth of Lake Kozjak, there is significant warming of the deep layers through heat diffusion and convective mixing, which does not allow for more significant increase in stratification strength.

The predicted water temperature increase and prolonged stratification period carry serious ecological and environmental implications. The obtained results provide a foundation for future studies in various fields, such as lake biology, geochemistry, sedimentology, and others.

PLANIRANJE MONITORINGA U LUCI RIJEKA ZBOG OČUVANJA BIORAZNOLIKOSTI, GOSPODARSTVA I LJUDSKOG ZDRAVLJA – PROJEKT *PROTECTAS*

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Svjedoci smo svakodnevnog utjecaja ljudskih aktivnosti i klimatskih promjena na prirodne procese i okoliš koje imaju, uglavnom, nepovoljan utjecaj na sav živi svijet, a time i na morski ekosustav. U morskom okolišu jedan od učinaka je povećavanje vjerojatnosti uspješne prilagodbe unesenih alohtonih (stranih) vrsta u novim područjima što može rezultirati i povećanjem broja invazivnih vrsta. Balastne vode jedan su od glavnih vektora prijenosa organizama između morskih regija, stoga su pomorske luke značajno žarište unosa stranih vrsta. Uspostavljanjem i provedbom monitoringa luka omogućilo bi se rano otkrivanje stranih vrsta, procjena njihovog utjecaja na temelju iskustava u drugim područjima i pravovremena primjena mjera za sprječavanje negativnih utjecaja koje bi mogli izazvati. Negativni učinci odražavaju se na bioraznolikost, morske resurse i gospodarstvo, posebice ribarstvo, ali i zdravlje ljudi konzumacijom morskih plodova kao i tijekom izloženosti prilikom bilo kakvih aktivnosti povezanih s morem. Stoga, važnost monitoringa luka je neupitna.

U svrhu izrade smjernica za monitoring luka u sklopu projekta „Razvoj sustava kontrole i obrane luka od unosa stranih vrsta – *ProtectAS*“ (KK.05.1.1.02.0013) provedeno je interdisciplinarno istraživanje u dvjema hrvatskim lukama Rijeka i Ploče. Na izradi smjernica sudjelovao je tim stručnjaka iz područja biologije, zdravstvene ekologije, pomorstva i građevinarstva (hidrotehnike). U samom su projektu provedene brojne aktivnosti vezane uz pregled postojeće zakonske regulative vezane uz tematiku brodskih balastnih voda i stranih vrsta, opsežna terenska istraživanja na uzorkovanju i laboratorijskoj analizi sastava planktonskih zajednica, zatim mjerenju morskih struja u dvjema lukama te izradu numeričkih modela. Jedna se komponenta numeričkog modeliranja odnosi na uspostavu združenoga trodimenzionalnog (3D) hidrodinamičkog modela cirkulacije mora i pronosa mikroorganizama u luci Rijeka. Temeljna podloga ovoga združenog modela njegova je hidrodinamička komponenta pri čemu je kalibracijom i verifikacijom (na temelju mjerenja brzina morskih struja) utvrđena zadovoljavajuća pouzdanost što omogućuje korištenje za daljnja istraživanja i analize kao što je dinamika širenja planktonskih zajednica. Pri uspostavi modela pronosa korišteno je modeliranje zasnovano na agentima (eng. Agent based modelling, ABM) kao relativno novi modelski pristup koji može poslužiti pri analizi kompleksnih adaptivnih sustava kojeg čine jedinke i okoliš u kojem se nalaze zajedno sa svim procesima koji ih povezuju.

Ovim će se radom prikazati dio rezultata numeričkih simulacija pronosa planktonskih zajednica (dijatomeja i dinoflagelata kao predstavnika fitoplanktona i kopepoda kao predstavnika zooplanktona) spomenutim akvatorijem. Pri tome, odabrane su karakteristične situacije djelovanja vjetra koje koincidiraju s trenucima unosa modelskih čestica tijekom ispuštanja balastnih voda u luci Rijeka. Pojam karakterističnih situacija odnosi se na odabir uvjeta cirkulacije mora pri pojavi najučestalijih smjerova vjetra, vjetra s najvećim brzinama te kompleksnijih vjetrovnih situacija koje ukazuju na izrazitu varijabilnost smjera i intenziteta vjetra u razdoblju razmatranja rezultata. Rezultati modela podrška su odabiru postaja za monitoring luke, i ukazuju na nužnost uključivanja meteoroloških podataka u planiranju monitoringa luka kao dio prilagodbe na klimatske promjene.

AGRICULTURE RISK METRICS

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Croatian agriculture is affected by the increase in extreme air temperatures and consequently extreme weather events. Data from the Damage Register of the Ministry of Finance show that the highest economic losses are caused by hail, drought and frost. Literature shows that the effects of climate change are reflected in changes in product quality, decreasing yields, higher costs, and fluctuating agricultural incomes.

The aim of this paper is to present an innovative risk management tool Agricultural Risk Metrics (ARM). Using ARM as a case study, we discuss how digital and granular agrometeorological data can support the work of risk managers and the insurance industry to model climate change impacts and add value to agriculture.

The ARM seeks to provide answers and/or help decision makers faced with the question of how to obtain better data for data-based analysis and decision-making for crop risk management and insurance in times of climate change. The ARM has a collaborative infrastructure. All the data you need is in one place, structured, secure, accessible and reliable. Data management and reporting are user-friendly. ARM is an analysis tool that provides the foundation for a virtual research environment that supports collaborative data analysis, modeling, and sharing of results.

Other challenges that ARM seeks to help insurance and agricultural decision makers address include a strong need for a lean ecosystem that enables digital climate risk research in agriculture. Application of sound data governance and data usage guidelines in the rapid digitization of agricultural systems (digital twin of agriculture).

In agriculture, ARM could play an important role in developing innovative risk management tools from the Common Agricultural Policy toolbox. It could also help design innovative business models and measure the potential stress of such models. However, adoption of ARM requires a good understanding of farmers' risk behavior and the frequency with which they adopt innovations in agriculture.

MOŽE LI KONZERVACIJSKA POLJOPRIVREDA BITI UČINKOVIT ALAT U PRILAGODBI KLIMATSKIM PROMJENAMA?

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Zbog sve većih negativnih učinaka klimatskih promjena, poljoprivredna se proizvodnja u današnje vrijeme susreće sa sve većim izazovima. Na temelju predviđanja kako će se u budućnosti utjecaj klimatskih promjena i dalje intenzivirati, očekuje se njihov sveobuhvatniji i učestaliji utjecaj na sve segmente poljoprivredne proizvodnje, odnosno proizvodnju hrane općenito. Budući da biljna proizvodnja, kao primarni proizvođač, predstavlja ishodišnu točku poljoprivredne proizvodnje, nameće se logično pitanje kako osigurati istovremeno dovoljnu količinu i zadovoljavajuću kvalitetu primarnih poljoprivrednih proizvoda na održiv način. Pravo je pitanje može li se poljoprivreda i u kojoj mjeri, uz minimalan negativni učinak na okoliš oduprijeti, odnosno prilagoditi klimatskim promjenama?

Danas na globalnoj razini postoji više različitih platformi koje temelje provedbu biljne proizvodnje na okolišno prihvatljiv i održiv način, odnosno na način da njihov okolišni otisak bude što je moguće bliže nuli. Jedna od najučinkovitijih platformi ili modela je Konzervacijska poljoprivreda koja se izvorno temelji na nekoliko postulata i prihvatljiva je, uz određene prilagodbe, u primjeni na globalnoj, regionalnoj i lokalnoj razini. Implementirani postulati koji omogućavaju njenu uspješnu provedbu baziraju se na primjeni:

- minimalnog narušavanja tla obradom,
- kontinuiranoj pokrivenosti proizvodne površine biljnim ostacima i
- pravilnoj rotaciji uzgajanih usjeva.

Budući da klimatske promjene uvećavaju, a u određenim slučajevima i višestruko multipliciraju "uobičajene" degradacijske procese u agrosferi (tlo, voda, zrak), primjenom načela konzervacijske poljoprivrede ovi se procesi u značajnoj mjeri stabiliziraju pa čak u određenoj mjeri i smanjuju. Primarni okolišni elementi biljne proizvodnje (svjetlo, voda, zrak, toplina) ovim se pristupom mogu vrlo uspješno balansirati, i to na održiv način: smanjivanjem intenziteta evaporacije odnosno konzervacijom vlage tla (biljni ostaci), povećanjem infiltracijske sposobnosti tla, ublažavanjem dnevnih i sezonskih temperaturnih oscilacija, intenziviranjem pozitivnog evapotranspiracijskog učinka, intenziviranjem (agro)biorazno-likosti, umanjivanjem ili sprječavanjem vodene i vjetrene erozije tla, intenziviranjem sekvestracije organskog ugljika i dr.

Na temelju istraživanja koja se provode u okviru Projekta HRZZ-a (ACTIVEsoil), utvrđen je pozitivan učinak primijenjenih agrotehničkih mjera, koja se odnose na umanjivanje degradacijskih procesa u tlu u uzgoju usjeva i prilagodbu na okolišne uvjete uzgoja, koji se uobičajeno promatraju u okviru klimatskih promjena. Tako su na tretmanima konzervacijske obrade tla (kao integralnog dijela konzervacijske poljoprivrede), u usporedbi s konvencionalnim (neodrživim) sustavima, utvrđene značajno manje dnevne temperaturne varijacije, kao i veći udio vlage tla. Samo navedeni parametri (ali i niz drugih promatranih parametara) pozitivno su utjecali na povećanje prinosa, što ujedno ukazuje i potvrđuje

pozitivan potencijal mjera konzervacijske poljoprivrede koje se provode kao odgovor na klimatske promjene.

Napomena
Ovaj je rad financirala Hrvatska zaklada za znanost projektom "Procjena konzervacijske obrade tla kao napredne metode uzgoja usjeva i prevencije degradacije tla – ACTIVEsoil" (IP-2020-02-2647)

PREDSTAVLJANJE PROJEKATA "PRILAGODBA POVRTNIH KULTURA NOVIM AGRO-METEOROLOŠKIM UVJETIMA U SLAVONIJI" I "ZELENO POVRĆE ZA ZELENI PLAN“

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Projekt „Prilagodba povrtnih kultura novim agrometeorološkim uvjetima u Slavoniji“ (AVACS) provodio je Biotehnički odjel Sveučilišta u Slavonskom Brodu kroz tri godine (2020. – 2023.) u partnerstvu s Institutom Ruđer Bošković te Institutom za fiziku iz Zagreba. Cilj projekta bio je provedba primijenjenog istraživanja prilagodbe povrtnih kultura (zelena salata i paprika) na klimatske promjene u najranijoj fazi razvoja. Provedena su mjerenja morfoloških pokazatelja rasta kako bi se utvrdila razlika između presadnica tretiranih PAW vodom (plazmom aktivirana voda) i netretiranih u uzgoju na otvorenom i u zaštićenom prostoru te se mjerila i suha tvar. Nakon provedenih pokusa i potrebnih mjerenja te statističkih analiza utvrđeni su bolji rezultati u svim mjerenim morfološkim karakteristikama kod biljaka uzgajanih u zaštićenom prostoru (plasteniku). Rezultati istraživanja pokazali su statistički značajan utjecaj PAW vode na početku rasta presadnica te pozitivan utjecaj na suhu tvar kod salate i paprike, međutim utvrđena je potreba za dodatnim istraživanjima.

Radi daljnjih neophodnih istraživanja u uvjetima klimatskih promjena a koje će utjecati na poljoprivrednu proizvodnju prijavljen je i odobren projekt „Zeleno povrće za Zeleni plan“ čiji je cilj nastaviti „zelena istraživanja“ kako bi se utvrdio utjecaj PAW vode na morfološka, kvalitativna i kemijska svojstva te prinos poljoprivrednih povrtlarskih proizvoda (salate i špinata), s ciljem doprinosa i poticanja perspektivnih inovacijskih niskougljičnih tehnoloških rješenja za postizanje visokih prinosa uz smanjenje upotrebe dušičnih gnojiva i emisiju CO_2. U ovom projektu uz ostala inovativna rješenja u poljoprivredi osigurana je suradnja s Državnim hidrometeorološkim zavodom iz Zagreba s ciljem korištenja računalnog agrometeorološkog modela AquaCrop koji bi trebao na temelju ulaznih podataka vremena, tla i razvojne faze biljke odrediti optimalne prinose salate i špinata.

THE CHANGING CLIMATE AND OLIVE GROWING: STATE-OF-THE-ART AND PERSPECTIVES

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As a climate change hotspot where the changes are accelerated for about 20% compared to global values, the Mediterranean is already now recording the climate-induced hazards at an unprecedent rates in both atmosphere and ocean. Heat waves, extreme precipitation events, long-lasting droughts, wind storms, fast-spreading wildfires, etc., are endangering in coastal regions, among others, safety of the Mediterranean food production and sustainability of crops, like olive (*Olea europaea L.*). The big question is: do we really know the level of effects of climate changes to olive tree physiology and olive growing in the Mediterranean region? Or, in other words, how much we are confident in present-level climate models for projections of changes in key olive variables, like air temperature and precipitation amount, at the local level?

In this presentation, the research at the state-of-the-art in countries that are known for their extensive production of the Mediterranean crops (like Spain, Italy and Greece) will be presented, targeting to olives as the one of key crops upon which the Mediterranean identity is formed. Zooming on the Croatian coastline will follow, on which less negative impact on olives is foreseen as exhibiting less warm climate with more precipitation than at the most productive regions in the south. We will also present plans for the future research for which high-resolution climate models and advanced clustering methods are now available, with the ultimate goal of building a crop-production climate model that will reliably quantify these changes at high resolutions in both space and time.

PHYTOCHEMICAL ADAPTATIONS OF CHINESE CABBAGE TO FLOODING AND DROUGHT

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Environmental conditions play a pivotal role in shaping the production of bioactive compounds in plants. Extreme climate changes, including abiotic stresses such as flooding and drought, are increasingly common factors affecting plant growth and development. These conditions can trigger metabolic adaptations in plants, leading to changes in their nutritional potential and biological effects of their extracts.

In scope of this work, we assessed the effect of different soil water content on the nutritional potential of young Chinese cabbage (*Brassica rapa ssp. pekinensis*). Drought increased total phenolic acids, which suggests that Chinese cabbage responds to water scarcity by producing more phenolic compounds, which can act as antioxidants and protect the plant from oxidative stress. Both drought and flooding increased the levels of soluble sugars. This response is common in plants facing environmental stress, as sugars can serve as osmoprotectants to help maintain cell turgor and osmotic balance. Both types of stress reduced the total tannin content in Chinese cabbage. Tannins are a group of polyphenolic compounds, and their decrease under stress conditions may be due to altered metabolic priorities.
Drought led to higher levels of L-ascorbic acid (vitamin C) in the plants compared to the control group. Vitamin C is an antioxidant, and its increase under drought stress may be a protective response to oxidative damage. This condition also resulted in reduced ferulic acid and quercetin, two phytochemicals with antioxidant properties.
On the other hand, flooding increased the amount of sinapic and ferulic acid. Flooding had a more significant negative impact on photosynthetic pigments, leading to a reduced amount.
However, chlorophyll b concentration was notably higher in plants grown under drought conditions. This suggests that photosynthetic pigments, particularly chlorophyll b, respond differently to flooding and drought stress. Chinese cabbage grown under flooding conditions had reduced levels of porphyrins, compounds involved in various metabolic processes, including photosynthesis, compared to plants grown under normal and drought conditions.

In summary, the findings indicate that Chinese cabbage undergoes various biochemical and phytochemical changes in response to drought and flooding stress. Understanding these responses is valuable for both plant biology research and agriculture, as it can help in developing strategies to improve crop resilience and nutritional quality under different environmental conditions. With the joint approach of meteorologists, biologists and farmers, an introduction of climate-smart farming practices would be much easier.

LULUCF SEKTOR U KLIMATSKOJ POLITICI EUROPSKE UNIJE

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Republika Hrvatska kao dio Europske unije (EU) dijeli klimatsku ambiciju Europske komisije iskazane u Europskom zelenom planu kojim se želi osigurati razvoj EU-a do 2050. s neto-nula emisija stakleničkih plinova, a do 2030. smanjenje emisija stakleničkih plinova za 55 % u odnosu na emisije iz bazne (1990.) godine kako bi u skladu s Pariškim sporazumom zadržali ograničenje porasta globalne temperature do 20 °C. Navedeni ciljevi trebaju se postići u sektorima unutar EU sustava trgovanja emisijama stakleničkih plinova (EU ETS) (npr. velika energetska postrojenja) i izvan tog sustava (non-ETS) (npr. poljoprivreda, otpad) kao i u sektoru Korištenja zemljišta, prenamjene zemljišta i šumarstva (engl. kratica LULUCF). Za sektore izvan EU sustava trgovanja emisijama stakleničkih plinova državama članicama Europske unije utvrđuju se godišnje emisijske kvote i te kvote države članice ne smiju prekoračiti. Osim toga, svaka država članica Europske unije mora osigurati takve uvjete da od 2021. do 2030. godine emisije stakleničkih plinova u sektoru LULUCF ne premašuju njihova uklanjanja. U okviru ciljeva "Spremni za 55" LULUCF Uredbom 2023/839/EU postavljen je cilj da se do 2030. godine na razini EU uklanjanja moraju povećati na -310.000 kt CO_2eq, a svakoj članici EU utvrđeno je koliko treba doprinijeti u ostvarenju tog cilja. Za Republiku Hrvatsku taj cilj u 2030. godini iznosi -5.527 kt CO_2eq. Ispunjavanje obveza o smanjenju emisija države dokazuju izradom Izvješća o inventaru emisija stakleničkih plinova (engl. National Inventory Report, NIR) koji se priprema na godišnjoj razini sukladno smjernicama propisanima od strane UNFCCC (engl. 2006 IPCC Guidelines for National Greenhouse Gas Inventories). Proračunom su obuhvaćene emisije koje su posljedica ljudskih djelatnosti i koje obuhvaćaju direktne stakleničke plinove. Izvori emisija i uklanjanja stakleničkih plinova podijeljeni su u pet glavnih sektora: Energetika, Industrijski procesi i uporaba proizvoda, Poljoprivreda, Korištenje zemljišta, prenamjena zemljišta i šumarstvo i Gospodarenje otpadom. Prema IPCC metodologiji u sektoru poljoprivrede promatraju se emisije CH_4 i N_2O do kojih dolazi zbog uzgoja stoke, upotrebe gnojiva i procesa povezanih s degradacijom tla, dok se u LULUCF sektoru promatraju odlivi/emisije ugljika u šest pohraništa i koji su usko povezani s načinima gospodarenja pojedinom kategorijom zemljišta (npr. obradom tla). U budućoj EU politici predviđa se povezivanje ciljeva o smanjenju emisija iz sektora LULUCF i sektora poljoprivrede u ciljeve za jedan sektor, AFOLU (eng. Agriculture, Forestry and Other land use) u kojem se prate emisije do kojih dolazi provedbom praksi gospodarenja na pojedinoj kategoriji zemljišta LULUCF sektora i provedbom aktivnosti uzgoja stoke i primjene gnojiva.

Ministarstvo gospodarstva i održivog razvoja i Fond za zaštitu okoliša i energetsku učinkovitost pokrenuli su različite projekte u svrhu istraživanja mogućnosti za smanjenje emisija i zadržavanje/povećanje uklanjanja CO_2 u sektoru LULUCF-a, kako bi se pravilno definirale mjere koje će se provoditi na pojedinoj kategoriji zemljišta i time osiguralo da sektor LULUCF u Republici Hrvatskoj doprinese klimatskoj neutralnosti, što je tema ovog predavanja. Međutim, postizanje cilja u LULUCF sektoru mora biti u ravnoteži s ostalim ciljevima kao što su zaštita biološke raznolikosti i proizvodnja hrane tako da je povezivanje i suradnja dionika različite nadležnosti ključno za planiranje i provedbu budućih mjera.

ANALYSIS OF FACTORS CONTRIBUTING TO FOG DEVELOPMENT AT ZADAR AIRPORT

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In air traffic the occurrence of fog represents a major problem as it elevates safety concerns. Long-lasting fog events at airports can cause significant flight delays due to poor visibility and low cloud ceiling. Climatologically days with fog are more common for the continental part of Croatia, particularly at Zagreb Airport which has category due to ICAO standards and EU regulation resulting in installation of instrumental equipment that enables operations during low visibility conditions. However, an increase of low visibility days at Zadar Airport have been identified particularly during recent years in October.

Detailed analysis of meteorological conditions, including available visibility and RVR measurements at Zadar Airport have been conducted. Also, the results of NWP models (WRF, ALADIN etc.) were used to analyze contributing factors and mechanisms behind the fog formation and an evaluation of model performance is provided using different parametrization schemes in WRF. Accurate fog forecasts at airports are still challenging and of major importance for airlines and the aviation industry as a whole.

This work represents the first systematic approach to studying fog climatology at Zadar Airport with aim to: (i) analyze climatological features of fog events at Zadar Airport, (ii) provide operational forecasters with statistical data to improve fog forecasting and (iii) analyze and improve model performance.

KLIMATSKE PROMJENE – CIVILNO-VOJNA GLEDIŠTA I MOGUĆA SURADNJA

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Klimatske su promjene jedan od velikih izazova za NATO s kojim se Savez mora suočavati ne samo danas, nego i u budućnosti. Klimatske promjene i učinci povezani s klimom, uključujući uništavanje okoliša, gubitak biološke raznolikosti, ekstremne vremenske uvjete, oskudicu vode i hrane, onečišćenje zraka i prirodne katastrofe, pridonose izbijanju sukoba ili kriza i već prijete lokalnoj, regionalnoj i međunarodnoj sigurnosti, stabilnosti i miru. Također, klimatske promjene, čije su posljedice već evidentne i za koje se predviđa da će srednjoročno i dugoročno eskalirati, postaju sve dominantniji multiplikator rizika, u smislu da mogu pogoršati određene već postojeće čimbenike krize i da, zajedno s hibridnim i kibernetičkim prijetnjama predstavljaju novi sigurnosni izazov ne samo za zemlje članice Saveza nego i za sve ostale. Kao Savez koji ima zadaću pružiti visoku razinu sigurnosti svojih članica, NATO mora procijeniti taj izazov, prilagoditi mu se i pridonijeti ublažavanju njegovih učinaka uvijek održavajući vojnu učinkovitost. Prema riječima glavnog tajnika NATO-a Jensa Stoltenberga, za NATO i saveznike imperativ je da nastave jačati nacionalnu i međunarodnu otpornost, uzimajući u obzir utjecaj klimatskih promjena.

Klimatske promjene značajno utječu na sposobnosti svih grana oružanih snaga; kopnene vojske, zrakoplovstva, mornarice, svemirskih snaga i kibernetičkog ratovanja. Zbog toga oba strateška zapovjedništva NATO-a, Savezničko zapovjedništvo za operacije i Savezničko zapovjedništvo za transformacije, iniciraju i provode istraživanja projekcija klimatskih promjena. Meteorološkom i oceanografskom potporom na strateškoj razini bavi se Radna skupina za meteorologiju i oceanografiju pri Vojnom odboru NATO-a (Military Committee Working Group, MCWG(METOC)) u čijem radu sudjeluju i predstavnici Republike Hrvatske. MCWG(METOC) je stručni autoritet za izradu strateških i doktrinarnih dokumenata koji reguliraju geografsku, meteorološku i oceanografsku potporu vojnim operacijama. NATO nema politiku djelovanja protiv klimatskih promjena. Umjesto toga, NATO pokazuje *poseban interes* za njih i tretira ih kao *umnoživač prijetnji (threat multiplier),* koji unosi dodatan operativni rizik. Sve ove aktivnosti predviđaju intenzivnu međunarodnu civilno-vojnu suradnju za čiju realizaciju procjenjujemo kako postoje interesi na nacionalnoj razini, a time i dobri preduvjeti za njeno ostvarenje.

Kroz povijest su primjenjivane brojne tehnologije utjecaja na vremenske prilike u ratovanju, a vrhunac su doživjele u prvoj polovici Hladnog rata, sve do sredine 70-ih godina i donošenja UN-ove Konvencije o zabrani vojnih ili bilo kojih drugih štetnih utjecaja na okoliš (Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, ENMOD). U međuvremenu su nekadašnje vojne tehnologije utjecaja na okoliš prešle u civilnu domenu, prvenstveno u poljoprivredu i šumarstvo. Njihova nekontrolirana primjena dovodi do velikih šteta i izaziva međunarodne incidente. Konvencija UN-a o zabrani utjecaja na okoliš predviđa mehanizme za zaustavljanje tih štetnih aktivnosti i pokretanje pregovora pod pokroviteljstvom UN-a. Prednosti potpisivanja Konvencije su brojne, no izuzetno složena politička situacija u regiji otežava provedbu optimalne strategije, sazivanja regionalnog potpisivanja i ratifikacije Konvencije.

U ovoj prezentaciji ukratko će se prikazati izravni i neizravni utjecaji posljedica klimatskih promjena na obranu i sigurnost. U drugom dijelu ukratko će se predstaviti dosad korištene mogućnosti umjetnog utjecaja na vremenske uvjete s naglaskom na tehnologije koje su u međuvremenu doživjele primjenu u agrarnoj proizvodnji, za povećanje prinosa ili anuliranje učinaka klimatskih promjena. U trećem dijelu prezentacije predstavit će se Konvencija koja bi trebala regulirati sve aktivnosti utjecaja na okoliš budući da ga nije moguće ograničiti unutar granica država.

VERIFICATION OF THE ANALOG-BASED METHOD AND KALMAN FILTER

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Post-processing of wind speed and wind gust variables using the analog-based method has been thoroughly analyzed at Croatian Hydrological and Meteorological Service (DHMZ) for a long time, including a few improvements upon the most simple variation that show very promising results. Besides the analog-based approach, the method inspired by the Kalman filter has also been tested and the results have shown that the method comes with its own set of advantages (e.g., no need for long training). This recursive algorithm is often used as a bias correction method for predictors. Finally, these two post-processing methods could even be combined, producing the best overall results in some cases.

Destination Earth (DestinE) is an initiative of the European Commission to develop a digital model of the Earth on a global scale, including extreme weather and climate adaptation. As a collaborator in a work package focused on the energy sector, DHMZ established partnership to analyze wind and energy data from an onshore wind farm in Croatia. In addition, data from a few meteorological stations are also included in the analysis. Two of the already mentioned methods are put to the test primarily for the wind speed at hub height. The continuous verification focuses on the overall forecast quality, while the categorical approach can also determine the forecast performance for more extreme events. The most promising analog-based method variation includes predictor weight optimization and a correction for high wind speed, exhibiting the best results for both common and more extreme events. It is also shown that the variation of the *r* parameter in the Kalman filter approach shows the possibility of improving the results for more extreme events. Future work includes analyzing the effect of different post-processing setups directly on wind energy production.

PARAMETERIZING DISSIPATION RATE OF TURBULENCE KINETIC ENERGY

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One of the very important issues in agrometeorology, which is the main subject of this conference, is dispersion and turbulent diffusion of fine particles including pollen, pesticides, herbicides, dust, droplets and more. While the first order turbulence parameterization schemes, regardless of their local or non-local type, are usually only (over)diffusive and without a true dynamical prognostic component, higher order schemes offer a generally more consistent treatment of turbulent processes that affect transport and dispersion of pollutants. One of the key terms in the turbulence kinetic (and potential) energy, TKE, prognostic equation is the dissipation rate of TKE, ε.

Based on: 1.) the assumption that small scale turbulence becomes progressively more homogeneous and perhaps isotropic, and 2.) the „Hockey Stick“, HOST, hypothesis, we parameterize ε independently for low and high wind speed conditions. This approach suggests two different TKE's dissipation mechanisms at various wind speeds. That can be important not only for agrometeorology, but also for betterment of weather forecasting and climate projections in general.

DESTINATION EARTH ON-DEMAND EXTREMES DIGITAL TWIN

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Destination Earth (*DestinE*) aims to develop on a global scale – a highly accurate digital model of the Earth to monitor and predict the interaction between natural phenomena and human activities. As part of the European Commission's Green Deal and Digital Strategy, *DestinE* will contribute to achieving the objectives of the twin transition, green and digital. *DestinE* will allow users to access thematic information, services, models, scenarios, simulations, forecasts and visualisations. Underlying models and data will be continuously assessed to provide reliable and actionable scenario predictions.

The main components of the *DestinE* system are:
1) The Core Service Platform which will provide a user-friendly entry point for *DestinE* users,
2) The Data Lake, a consolidation of pre-existing European data holdings from Copernicus, ESA, EUMETSAT and ECMWF, and other sources, like the Internet of Things (IoT) and socio-economic data, and
3) The Digital Twins / digital replicas of the highly complex Earth systems. ECMWF will, in coordination with its Member States, among which DHMZ, develop the Digital Twin Engine, the complex software and hardware environment needed for the next generation of very high-resolution prediction models.

Presentation provides overview of Croatian team efforts from DHMZ and IRB on developing on-demand configurable digital twin engine for forecasting of environmental extremes at the sub-km scale. The core of the solution is to provide an on-demand workflow with co-design of high-resolution predictions about extreme weather events combined with decision making support for impact sectors including hydrology, air quality and energy meteorology, with use of a physics-based and data driven model system and computationally-intensive data-flow organized on the EuroHPC high performance computer platform.

TEMPERATURE POSTPROCESSING OF ALADIN-HR40

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Postprocessing has become an integral part of the NWP process in recent years. Although the NWP has progressed greatly since its introduction in the mid-20th century, many sources of errors are still present. This results in forecasts with systematic biases and insufficient accuracy. Postprocessing aims to improve raw NWP forecasts after they have been produced by utilizing available observations.

At Croatian Meteorological and Hydrological Service (DHMZ), we are actively developing an analog-based method. The analog-based method forms, using the current forecast and its analogs in the past, an ensemble of past observations for the Location of Interest (LoI). Using historical observations instead of forecasted values eliminates many systematic errors (e.g., representativeness errors). The results are very satisfying and include improving the accuracy of air temperature forecasts by 20% on average. Currently, analog-based forecasts are produced for air temperature, wind speed, and wind gusts for locations for which observations of sufficient quality are available.

However, many locations of interest do not have any observations. For this reason, we have developed a novel method for air temperature postprocessing which does not need any observations and can work for any location in the model domain. The method consists of several steps: i) finding the closest model point to LoI; ii) forming a neighbourhood ensemble around LoI and calculating the air temperature lapse rate from it – lapse rate is calculated by doing linear regression between neighbouring points height and air temperature; iii) applying this lapse rate on all neighbouring points to obtain height-corrected air temperatures and iv) calculating ensemble mean from the height-corrected neighbourhood ensemble which is then the final postprocessed forecast for this LoI. The method was thoroughly tested and validated using a 2-year period and 55 surface stations in Croatia. Results are encouraging and show an increase in forecast accuracy of about 10% on average.

IMPROVEMENTS AND CHALLENGES OF WIND NWP AT DHMZ

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At the Croatian Meteorological and Hydrological Service (DHMZ), the wind forecast has been operationally adapted to the 2 km horizontal grid by dynamical adaptation method (HRDA) from ALADIN-HR numerical model configuration since 2011.

From the beginning of February 2023, the improved ALADIN-HR20 (HR20) configuration has been run operationally, whereby the model settings have been optimized and the HR20 has been upgraded from the dynamic adaptation mode to a full model configuration with non-hydrostatic dynamics. Finally, in the test operational configuration, post-processing of HR20 forecasts using the analog-based method (HRAN) is performed for wind speed and gusts, with previously optimized settings.

The results of the mentioned update are compared with the results of the previously used HRDA operational configuration. The aim is to evaluate the performance of the operational forecast system after the upgrade, pointing out the main differences that can be expected, and to assess the potential for the operational application of post-processing at the tested locations.

The first step in the evaluation of the updated forecasting system is to compare the overall performance of wind speed predictions. The results show that variability is underestimated throughout the year and that HR20 has a larger bias of the mean than HRDA. The latter is reduced by HRAN. Furthermore, HR20 exhibits lower dispersion error and RMSE than HRDA throughout the year, whereas HRAN improves results even further. The differences between HRDA and HR20 are the most pronounced at coastal stations, including the reduction of bias of the mean and dispersion error in favor of HR20. The HRAN improves HR20 results even further, due to reduction of dispersion error and bias (if present). The results for wind gusts are consistent with the wind speed.

All wind speed categories are affected after the update, improving the results for common wind events, whereas the scores for high wind speed events yield mixed results. Even so, the effect on rare event forecasts is further considered using case studies, especially in complex terrain prone to high wind speed (e.g., bura and jugo wind). Large errors mostly occur due to small time or space shifts, especially during bura events.

PROHUJALO S *VIHOROM*: ŠTO SE PROMIJENILO U PROGNOSTIČKOM SUSTAVU ALADIN-HR?

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ALADIN-HR je operativni numerički prognostički sustav Državnog hidrometeorološkog zavoda koji omogućuje satni izračun prognoze do 72 sata unaprijed (izračun se osvježava svakih 6 sati). Operativno se izračun radi za dvije modelske konfiguracije, ALADIN-HR40/ALADIN-HR20, koje se prvenstveno razlikuju po razlučivosti modela (4 km/2 km horizontalno, 73/87 vertikalnih nivoa) no postoje i druge značajne razlike: ALADIN-HR40 početne uvjete dobiva iz sustava asimilacije podataka (ALADIN-HR20 koristi interpolirane podatke ALADIN-HR40 modela); ALADIN-HR40 koristi hidrostatsku dinamičku jezgru dok je ona kod ALADIN-HR20 konfiguracije nehidrostatska. ALADIN-HR20 konfiguracija namijenjena je za poboljšanje kvalitete prognoze vjetra čije karakteristike su na području Hrvatske u velikoj mjeri određene utjecajem orografije, koja je bolje opisana u modelu manjeg horizontalnog koraka mreže.

Početkom 2023. godine u operativnu primjenu uvedene su nove inačice ALADIN-HR modelskih konfiguracija te je izračun prognoze premješten na novo superračunalo „Neverin“. Novo superračunalo predstavlja značajan iskorak u vidu dostupnih računalnih resursa (~12.000 računalnih jezgri u odnosu na ~300 računalnih jezgri na superračunalu *Vihor*). Nove inačice modelskih konfiguracija koriste najnoviju preporučenu verziju numeričkog modela (cy43) te su unaprijeđene u još nekoliko aspekata. Za ALADIN-HR40 konfiguraciju, unaprijeđena je asimilacija podataka proračunom nove ansambl B matrice te uključenjem doprinosa velikih skala globalnog modela u proces asimilacije. Također se koristi unaprijeđeni paket fizikalnih parametrizacija (ALARO-1) te je dodatno izvršeno ugađanje parametara modela što je na kraju rezultiralo poboljšanjem prizemne temperature zraka i brzine vjetra (izraženije tijekom zime) te naoblake u ljetnom periodu. Nova verzija modela je omogućila i izradu novih produkata: vidljivosti i tipa oborine.

Izračun prognoze vjetra na 2km horizontalnoj mreži modela prije ove promjene radio se metodom dinamičke adaptacije. Metoda dinamičke adaptacije podrazumijeva pojednostavljeni izračun modela s ciljem smanjenja potrošnje računalnih resursa, a opet uvažavanjem bolje razlučivosti orografije te posljedično bolje prognoze prizemnog vjetra. Budući da su na novom superračunalu računalni resursi znatno veći, ALADIN-HR20 konfiguracija sada predstavlja puni proračun nehidrostatske verzije modela. Također je poboljšan opis podloge u modelu korištenjem novije baze podataka bolje reprezentativnosti te je napravljeno ugađanje parametara modela povezanih s prognozom vjetra. Verifikacija ALADIN-HR20 konfiguracije biti će prikazana u zasebnoj prezentaciji.

REVIEW OF SEVERE CONVECTION IN JULY 2023

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Thunderstorms are not uncommon during the summer in Croatia, but in terms of convective activity, the month of July this year was indeed special. Following a prolonged heatwave over the Mediterranean region, all the necessary ingredients for the formation of very intense and dangerous storms came together multiple times. Apart from the very warm and humid air mass that had built up under the stable ridge conditions, a strong upper-level flow was present over most of the period. Such flow generates strong vertical wind shear, which is a crucial component for organizing storms into supercells and linear convective systems. These storms are often accompanied by extreme wind gusts, large hail, tornadoes and flash flooding.

In these conditions, the only missing element was an upper-level trough or a frontal system to help release all the accumulated energy. When such disturbances approached, severe storms usually formed in northern Italy or Slovenia and then moved over Croatia.

The record-breaking supercell storm in Europe, in terms of duration and distance traveled, formed on July 13, 2023, in Slovenia, around midday. Over the next 14 hours, it covered a distance of about 1200 km to the east, crossing through Croatia, Serbia, and Romania before dissipating over the Black Sea. It left behind a trail of damage from large hail (up to 13.5 cm in diameter in Slovenia, 9 cm north of Zagreb, and around 10 cm further east) and additional damage from strong wind gusts towards the east.

This storm narrowly missed Zagreb, but on July 19, luck was not on the city's side. That morning, a line of storms formed on the Switzerland-Italy border, intensified as it crossed Slovenia due to favorable conditions, and reached Zagreb around 14 UTC. Such linear convective systems, also known as squall lines, are usually associated with very strong wind gusts, and in this case, the favorable conditions contributed to particularly extreme gusts. The consequences were three lost lives (two in Zagreb and one in Slavonia), over 100 injuries, and extensive damage from wind, as well as flash flooding in some parts of the city. At Zagreb Airport, the highest recorded wind speed was 32 ms^{-1}, and at Maksimir station 25.5 ms^{-1}.

At the southern end of this storm system, an embedded supercell produced hail with a diameter of 13 cm in the Karlovac area. As this storm system continued eastward, it caused extensive damage along its entire path through Croatia, Bosnia and Herzegovina, Serbia, Romania, and Bulgaria. There were also fatalities and injuries reported in Slovenia, Bosnia and Herzegovina, and Romania.

In addition to these significant convective events, in July there were many other similar events with extensive damage, caused by either supercell storms or linear convective systems. For example in the morning 30 July Rijeka airport was hit by a storm with severe wind gusts of 36 ms^{-1}.

In this presentation we will explore meteorological conditions which lead to formation of those severe storms and also show some of their consequences.

SEMINARI U HKZP-U

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Hrvatska kontrola zračne plovidbe (HKZP) pruža meteorološke usluge za zrakoplovstvo. Prognostičari izrađuju prognoze i upozorenja za zračni prostor, a motritelji motrenja na zračnim lukama. Od 2007. godine organiziraju se redovni seminari za meteorološko osoblje.

Radi potrebe neprekidnosti pružanja usluga, održavaju se redovno u dvije grupe u sjedištu tvrtke. Zadnjih godina prognostičari u pravilu imaju proljetni i jesenski seminar, a za motritelje se nastoji održati jedan seminar godišnje. Trajanje je obično dva do tri dana po jednoj grupi. Glavna instruktorica za meteorologiju u HKZP-u mr. sc Katarina Stanković, seminare je prvotno osmislila kao seminare osvježenja znanja za operativno osoblje. S vremenom seminari postižu sljedeće sadržaje: usvajanje novih znanja i vještina, vježbe, razmjene iskustava, upoznavanje s novim procedurama ili produktima te sastanak s nadređenima. Planiranje, organizacija, dogovori, pripreme i održavanje zahtijevaju mnogo truda i vremena. Procjenjuje se da za jednu održanu prezentaciju od sat vremena, predavač i koautori utroše većinom od dva do dvadeset puta više vremena (nekad i više). Nedavna iskustva održavanja seminara preko mrežnih platformi, zbog pandemije ili bolesti, pokazuju da su u nemogućnosti drugih uvjeta dovoljno dobra, premda se ograničava komunikacija među sudionicima (razmjena iskustava, timska atmosfera). Snimane prezentacije zbog bolesti sudionika (ili predavača u nekoj grupi) mogu pomoći da se naknadno ipak omogući prenošenje sadržaja.

Osobitost edukacija za prognostičare u Hrvatskoj je različitost tema koju je potrebno pratiti u operativnom radu zbog bogatstva vremenskih i klimatoloških prilika. Prognostičari se suočavaju s izazovima i detaljima u prognoziranju konvekcije, zimskih oborina, bure i turbulencije, magle i niskih oblaka, ali i tercijarnom cirkulacijom (npr. vremenom nastupa maestrala). Navedene teme su naravno povezane u meteorologiji, ali i iznimno različite. Stoga se u edukaciji koristi glavni tim predavača iz podrške operativnim odjelima, ali predavanja održavaju i sami prognostičari i voditelji postaja za motritelje. Također u manjem dijelu, predavači su i vanjski partneri – stručnjaci iz DHMZ-a i s fakulteta Geofizičkog odsjeka PMF-a za meteorološke teme dok za zrakoplovne održavaju kolege iz HKZP-a.

Na nekim seminarima sudjelovali su i prognostičari DHMZ-a te zrakoplovni prognostičari iz Slovenije, Bosne i Hercegovine, Srbije, Crne Gore, Kosova i Sjeverne Makedonije, koji većinom nemaju tako razređene seminare. Naša predavanja su tematski korisna i drugima, a uz to se znatno poboljšava komunikacija koja je potrebna kod izrade koordiniranih prognoza i upozorenja u zrakoplovstvu.

Za pojedini održani seminar, bitna je ravnoteža između teorijskih sadržaja i prakse. Vježbe su uvijek dobro primljene kod operativnog osoblja. Iskustva pokazuju da je u jednom danu maksimalno trajanje predavanja do 5 odnosno 6 sati za motritelje odnosno prognostičare. Također, određenu temu potrebno je tijekom godina ponoviti ili obraditi s drugog gledišta. Na kraju svakog seminara sudionici ispunjavaju ankete koje služe kao povratna informacija koja se koristi u planiranju za naredne godine.

Seminari nisu cilj sami po sebi, već njihovo kontinuirano održavanje na duljoj vremenskoj skali služi poboljšanju i održavanju osnovnog znanja i vještine osoblja, koje može pružiti bolju uslugu za korisnika.

MESOSCALE MODELING USING A NEW METHOD FOR EDDY DIFFUSIVITY PARAMETERIZATIONS

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A new scheme for the parameterization of vertical diffusion applicable under convective conditions is developed using Large eddy simulation (LES) data. The novelty mainly relies on non-local contributions to the turbulent transport of heat and momentum as well as the contribution of the entrainment layer to the mixing intensity that are now explicitly included in the model. The proposed scheme includes the implementation of universal empirical coefficients that are independent of stability providing an easy-to-use solution for the parameterization of heat and momentum fluxes. This is an important result pointing to the straightforward applicability of the method in air quality and climate models and the improvement of turbulence parametrizations in the boundary layer. The method is implemented in a WRF-Chem model and validated against mast-mounted measurements in a complex terrain as well as against aviation measurements.

The results indicated improvement in modeling performance in terms of the near-surface wind speed and generally decreased applied statistical measures: BIAS, root mean square error (RMSE), and normalized mean square error (NMSE) which is an important step in understanding and improving the performance of numerical models.

NUKLEARNO-BIOLOŠKO-KEMIJSKA KONTAMINACIJA POLJOPRIVREDNIH ZEMLJIŠTA – PRIJETNJE I ODGOVORI

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Unatoč velikom naporu međunarodne zajednice, suvremene sukobe i krize u velikoj mjeri i dalje obilježavaju prijetnje oružjima za masovno uništenje (nuklearno, biološko i kemijsko) kao i velikim kontaminacijama nastalim zbog razaranja gospodarskih objekata koji sadrže velike količine opasnih tvari, ali i oružja koje sadrže toksične ili radionuklidne tvari. Zbog toga su Oružane snage Republike Hrvatske (OS RH) razvile sposobnost nuklearno-biološko-kemijske obrane (NBKO) i imaju u pripravnosti bojnu NBKO (bNBKO) koja „osigurava potporu cjelokupnim OS RH u nuklearno-biološko-kemijskoj zaštiti kroz zadaće KBRN motrenja, izviđanja i dekontaminacije, obučavanje pripadnika roda nuklearno-biološko-kemijske obrane te ostalih pripadnika OS RH po funkcionalnom području." Osim zadaća u krizi ili ratu, bNBKO, u skladu sa Zakonom o obrani, pruža potporu vojno-civilnim strukturama u saniranju posljedica prirodnih i tehničko-tehnoloških katastrofa. Bojna NBKO pruža zaštitu svim osobama (civilnim i vojnim) koje se nalaze u kontaminiranim zonama, kao i objekata i opreme. Dekontaminacija agrarnih, šumskih i ribolovnih područja nije primarna zadaća bNKBO, no dugoročno gledano oružane snage mogu dati značajan doprinos u sagledavanju i saniranju šteta.

U prezentaciji će biti predstavljena bNKBO te NKB laboratorij u Centru za obrambene i strateške studije „Janko Bobetko“ na Hrvatskom vojnom učilištu. Također, bit će predstavljena računalna aplikacija NBC Analysis u kojoj se koriste NATO standardni modeli disperzije onečišćenja. Na kraju će biti predložena daljnja civilno-vojna suradnja kroz korištenje postojećih materijalnih resursa i razvijenih sposobnosti, u svrhu potpore NBKO operacijama dekontaminacije agrarnih, šumskih i ribarskih područja.

Bojna NBKO je obučena i opremljena po NATO doktrini AJP-3.8 „Allied joint doctrine for comprehensive chemical, biological, radiological and nuclear (CBRN) defence“ iz 2018. godine koja uključuje standarde za samostalnu detekciju i modeliranje disperzije onečišćenja. To su: AEP-45 „Warning and Reporting and hazard prediction of chemical, biological, radiological and nuclear incidents (reference manual)“ iz 2018. godine, te ATP-45 „Warning and Reporting and hazard prediction of chemical, biological, radiological and nuclear incidents (operator's manual)“ iz 2023. godine. Oba NATO standarda uključuju meteorološku potporu NBK operacijama te ujednačavaju formate ulaznih i izlaznih podataka.

NATO je kao standardnu računalnu aplikaciju za predviđanje KBRN opasnosti odabrao NBC Analysis kojeg koriste i OS RH. NBC Analysis je računalni alat za prikupljanje podataka iz mreže senzora na terenu (Sensor Connectivity Information Management, SCIM) za izradu zajedničke operativne slike (Common Operational Picture, COP) kao NATO standardnog sloja za umrežene GIS alate, za analizu učinaka tijekom vremena dok traju učinci kontaminanata te za simuliranje KBRN operacija u obuci i vježbama.

NBC Analysis nema u sebi model disperzije onečišćenja, ali se razmjenom standardnih formata podataka, može uvezati na dva modela koji se koriste u obrambeno-sigurnosne svrhe. To su: Hazard Prediction and Assessment Capabilities (HPAC) američke Defense Threat Reduction Agency (DTRA) i danski Risø Mesoscale PUFF model (RIMPUFF). Modeliranje i kontaminacija agrarnih, šumskih i ribarskih područja pružaju priliku za uspostavu trajne civilno-vojne suradnje i buduća istraživanja. Pritom se postojeće NBKO sposobnosti na nacionalnoj razini mogu značajno poboljšati bez potreba za preustrojima i velikim ulaganjima u postojeće nadležne organizacije.

POSTERI
POSTERS

AGROMETEOROLOGICAL CONDITIONS FOR GROWING LAVENDER PLANTATION IN CENTRAL BULGARIA

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Three varieties of lavender, traditional for the Bulgarian selection were studied for a period of three years. The Hemus variety as one of the early varieties, the Sevtopolis variety as one of the most plastic, both for obtaining lavender oil and the Karlovo variety with a direction for dry lavender flowers.

Biometric indicators have been determined to characterise the growth and development of lavender plants. The agrometeorological indicators for the temperature and humidity conditions for the different phases of development during the short growing season of the lavender plantations were established, depending on the climatic conditions during the years. The influence of temperatures during the growing season and their influence on the accumulation of the essential oil and its quality have been established. The quantity and quality of the essential oil is most intensively influenced by the observed annual climatic conditions during the studied period.

THE ROLE OF AGROMETEOROLOGY DEPARTMENT OF CROATIAN METEOROLOGICAL AND HYDROLOGICAL SERVICE IN SUPPORTING AGRICULTURAL SECTOR

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The fundamental role of Croatian Meteorological and Hydrological Service (DHMZ) is to monitor the state of the atmosphere, make risk assessments of individual weather disasters, and develop a system for forecasting and warning of storms and other extreme weather events. In this direction, within DHMZ, Agrometeorology Department has been supporting the agricultural sector with his activities for 70 years. During that period, numerous studies were conducted and forecasts for farmers were introduced as early as 1958. Constant investment in research and development in cooperation with associated partners and institutions enables continuity of progress in providing quality information to farmers.

At the end of 2021, we published the first Agroclimatic Atlas of Croatia for the period 1991–2020 and 1981–2010 which contains maps and tables with data on important agroclimatic parameters, which can be used to determine the temperature regime of air and soil, water balance, and the determination of the plant fire hazard index.

To review the situation, there is agrometeorological data that offers a monthly and weekly overview of the agrometeorological situation, as well as a weekly overview of soil and air temperature, temperature sums, forest fire danger index, either in tabular or graphical display. One can find specialized agrometeorological four-day forecasts with implications for agricultural work, as well as weather outlook.

All this information can be used collectively by the farmer in his daily decisions in the management of the agricultural economy. We will continue to introduce new products, listening to the needs of farmers, in order to provide them with valuable information and provide support in mitigating damages.

AGROCLIMATIC ASSESSMENT OF THE CLIMATE CHANGE INFLUENCE ON SUNFLOWER CROP GROWING CONDITIONS AND PRODUCTIVITY IN THE SOUTHERN STEPPE OF UKRAINE

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Global climate change creates new conditions in all economic areas, including agriculture, in the world as well as in Ukraine. It influences the agro-climatic conditions for growing crops, in particular sunflower. Therefore, the necessity of these conditions assessment is relevant, because they are critical to consider the potential adaptation of sunflowers to climate change, and profitability of its cultivation in certain agro-climatic zones of Ukraine.

The main objective of the study was to determine the degree of climate change impact on sunflower production in the Southern Steppe of Ukraine. The modern climate change scenarios (RCP2.6 – moderate level of greenhouse gas emissions; RCP4.5 – average level of greenhouse gas emissions) were used for assessment the impact on sunflower production. RCP2.6 and RCP4.5 scenarios were used for researching changes of climate conditions for the period 2021–2050. The period 1980–2010 is used for comparative analysis of previous meteorological data. The research of sunflower production was carried out using the mathematical model assessment of agro-climatic resources for the formation of crop productivity adapted for sunflower culture.

In this work the main agro-climatic characteristics such as photosynthetically active radiation, average air temperature, amount of precipitation, average hydrothermal index for the period, evapotranspiration and moisture supply were used. The influence of agro-climatic conditions on the main indicators of sunflowers production such as leaf area, yield of sunflowers vegetative organs, roots and seeds was modeled.

It has been established that in the south of Ukraine, in actual average long-term data, sunflower sowing begins in early April, in RCP2.6 climate change scenario sowing starts 11–14 days earlier, while in RCP4.5 scenario 4–5 days later.
It should be noted that due to both scenarios, in the period from sowing to the beginning of flowering, agroclimatic conditions will be more favorable than actual ones. It will contribute to more intensive growth of leaf area. However, especially dry conditions during the flowering–ripening period will contribute to a decrease in both photosynthetic potential and sunflower yield, to a greater extent under the RCP4.5 scenario.

Thus, if both scenarios are realized, an increase in climate aridity will be observed in the south of Ukraine, which will contribute to a decrease in the yield of sunflower seeds. To preserve the acreage of sunflower in this natural and climatic zone, it is necessary to reconsider the technology of its cultivation.

POLJOPRIVREDA: PRILAGODBA NA KLIMATSKE PROMJENE I MOGUĆNOSTI NJIHOVOG UBLAŽAVANJA

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Klimatske promjene predstavljaju jedan od najvećih izazova s kojima se čovječanstvo danas susreće. Utjecaj klimatskih promjena vidljiv je u svim dijelovima svijeta. Klimatske promjene očituju se u promjeni hidroloških ciklusa i temperaturi zraka/tla/oceana, pojačanom intenzitetu i učestalosti elementarnih nepogoda poput oluja, suša, poplava, toplinskih valova i sl., promjeni razine mora, smanjenju biološke raznolikosti, povećanju pojave bolesti i štetnika, narušenoj kvaliteti tla i voda, itd. Tri najranjivija sektora zahvaćena klimatskim promjenama su poljoprivreda, šumarstvo i turizam. Poljoprivreda, osim što predstavlja žrtvu klimatskih promjena, također je i njihov uzročnik. Stoga je u poljoprivredi potrebno poduzeti osim mjera prilagodbe na klimatske promjene, također i mjere ublažavanja klimatskih promjena.

Najznačajnije mjere prilagodbe na klimatske promjene obuhvaćaju prilagodbu datuma sjetve/sadnje/žetve, izbor sadnog materijala, uzgoj novih sorata poljoprivrednih kultura, osiguravanje navodnjavanja poljoprivrednih površina, izgradnju zaštićenih prostora poput staklenika i plastenika te prilagođene agrotehničke zahvate i održive prakse gospodarenja tlom.

Ublažavanje klimatskih promjena u poljoprivredi moguće je na dva načina, a to su: 1.) smanjenje emisija stakleničkih plinova iz sektora Poljoprivreda i 2.) povećanje uklanjanja ponorima unutar sektora Korištenje zemljišta, prenamjena zemljišta i šumarstvo (eng. Land Use, Land Use Change and Forestry: LULUCF).
Smanjenje emisija stakleničkih plinova iz sektora Poljoprivrede prvenstveno obuhvaća smanjenje emisije iz poljoprivrednih tala, emisije uzrokovane unutarnjom fermentacijom preživača i gospodarenja stajskim gnojem.
Uklanjanje ponorima moguće je u poljoprivredi biološkom sekvestracijom ugljika. Naime, ugljik kruži između atmosfere, biosfere i pedosfere u relativno kratkim vremenskim razdobljima. Biljke asimiliraju atmosferski ugljik procesom fotosinteze, sekvestriraju ga u svoju biomasu koja nakon odumiranja biljke završava u tlu gdje podliježe procesima razgradnje te se jedan dio ugljika ponovno otpušta u atmosferu procesima disanja tla, a jedan dio ugljika ostaje trajno vezan u tlu. Ovisno o biotskim i abiotskim faktorima te poljoprivrednim praksama i načinu gospodarenja tlom, poljoprivredna tla mogu predstavljati izvore, ali i ponore stakleničkih plinova.

EXPECTED CLIMATE CHANGES IN CROATIA BY THE MIDDLE OF THE 21ST CENTURY

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According to the latest IPCC report, the broader Mediterranean area is projected to undergo persistent air temperature increases, along with an increase in the frequency and intensity of warm and wet extreme events, while also expecting a decrease in the overall annual precipitation amount. These shifts are likely to result in more frequent agronomic and ecological droughts, coupled with an increase in the occurrence of flash floods, particularly in the northern Mediterranean. To gain a more comprehensive insight into these expected changes and their spatial variability, particularly concerning the broader Croatia and Adriatic area, our analysis focuses on examining both mean air temperature and precipitation amount changes, as well as a wide range of extreme temperature and precipitation indices.

To estimate the climate change signal for the middle of the 21st century (2041–2070) compared to the historical period (1981–2010), we employ the "moderate" greenhouse gas concentration scenario RCP4.5. Our ensemble comprises 12 EURO-CORDEX simulations conducted at a horizontal spatial resolution of 12.5 km. Notably, three regional climate models (RegCM, RCA4 and CCLM4) have been driven by four global climate models (CNRM-CM5, EC-EARTH, MPI-ESM and HadGEM2).

The focus of our analysis is the assessment of mean annual and seasonal changes in temperature and precipitation indices. Through this comprehensive approach, we will give a quantitative evaluation of the projected shifts in climate conditions over the broader Croatia and Adriatic areas. Overall, our study aims to provide valuable insights into the complex dynamics of climate change in this region, aiding policymakers and stakeholders in formulating effective adaptation strategies and mitigating the impacts of these projected changes.

KLIMATSKE PROMJENE U BiH
POREĐENJE NIZA 1961. – 1990. I 1990. –2020. I TRENDOVI

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Klimatske promjene su globalna pojava i srednja temperatura čitave planete Zemlje neprestano raste. Štaviše, taj se proces neprestano ubrzava. Dok je početkom ovog milenija povećanje iznosilo 0,6 °C za sto godina, sada to povećanje iznosi preko 1 °C. Primjer Sarajevskog stogodišnjeg niza pokazuje da se ti procesi odvijaju i u BiH. Što se tiče padavina, imamo stagnaciju ili lagano povećanje suma padavina što je utješno, medjutim promjena režima padavina koja je posljedica sve učestalijih vremenskih ekstrema, prije svega poplava i suša uzrokuje sve lošije vodne bilanse. Bosna i Hercegovina je potpisnik Pariškog sporazuma o klimatskim promjenama. U pogledu primjene njegovih odredaba naša zemlja nije daleko odmakla, i to je veoma štetno. Naime, Pariški sporazum pretpostavlja dvije vrste obaveza glede klimatskih promjena. Prva je sprječavanje klimatskih promjena, a druga je prilagodba istim. Naša zemlja nema velike obaveze u pogledu sprječavanja klimatskih promjena, jer nema velike emisije stakleničkih plinova, ali što se tiče prilagodbe tu može samo dobiti, jer prilagodjavanje prije svega podrazumjeva umanjenje šteta koje nastaju usljed povećanih ekstrema i smanjenje broja ljudskih žrtava.

SNIJEG U HIONOFILNIM ŠUMSKIM EKOSUSTAVIMA NA VELEBITU

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U gorskom i pretplaninskom vegetacijskom pojasu znatan dio zimskih oborina pada u obliku snijega. Hionofilne šume su šume koje se razvijaju u predjelima s mnogo snježnih oborina. Snijeg je u njima po mnogočemu koristan, ali može u određenim okolnostima izazvati i štete na šumskom drveću.

Cilj ovog istraživanja je bio analiza broja dana sa snijegom te maksimalne visine snijega (cm) na području gorskog i pretplaninskog vegetacijskog pojasa na Velebitu, analiza trenda broja dana sa snijegom i maksimalnih visina snijega te usporedba srednjeg broja dana i maksimalnih visina snijega s prijašnjim podacima iz opisa klime ovog područja. Istraživanje je provedeno na tri meteorološke postaje unutar dva vegetacijska pojasa na sjevernom i srednjem Velebitu. Gorski je vegetacijski pojas na području Dinarida na nadmorskim visinama od 800 do 1100 m. Unutar ovog vegetacijskog pojasa nalaze se acidofilne jelove šume, acidofilne smrekove šume i dinarske bukovo-jelove šume. Pretplaninski vegetacijski pojas uključuje šumske ekosustave na nadmorskoj visini od 1100 do 1700 m nad morem. U ovom pojasu nalaze se pretplaninske bukove šume, borealne jelove i smrekove šumske zajednice i klekovima planinskog bora s kozokrvinom. S obzirom na nadmorske visine, dvije meteorološke postaje (Baške Oštarije i Oltari) su smještene u gorskom vegetacijskom pojasu. Meteorološka postaja Zavižan je smještena u pretplaninskom vegetacijskom pojasu. Podaci o broju dana sa snijegom i maksimalne visine snijega su preuzeti od Državnog hidrometeorološkog zavoda Republike Hrvatske za razdoblje 1981. – 2021. Za podatke o broju dana sa snijegom i maksimalnim visinama snijega napravljena je deskriptivna statistika podataka. Analiza trenda broja dana sa snijegom i maksimalnih visina snijega je napravljena Mann-Kendall trend testom. Single T testom su uspoređeni broj dana sa snijegom i maksimalne visine snijega s podacima iz opisa klime vegetacijskih pojasa 1948. – 1960. godine.

Povećanjem nadmorske visine, povećavao se broj dana sa snijegom i maksimalne visine snijega. Prosječni broj dana sa snijegom u gorskom vegetacijskom pojasu na meteorološkoj postaji Baške Oštarije je iznosio 66 dana (≥ 1 cm), 44 dana (≥ 10 cm), 22 dana (≥ 30 cm) i 6 dana (≥ 50 cm). Na meteorološkoj postaji Oltari broj dana sa snijegom je iznosio 91 dan (≥ 1 cm), 63 dana (≥ 10 cm), 29 dana (≥ 30 cm), 12 dana (≥ 50 cm). Prosječan broj dana sa snijegom u pretplaninskom vegetacijskom pojasu je iznosio 158 dana (≥ 1 cm), 141 dan (≥ 10 cm), 113 dana (≥ 30 cm) i 90 dana (≥ 50 cm). Maksimalna visina snijega u gorskom pojasu je prosječno iznosila 60,09 cm, odnosno 78,25 cm dok je u pretplaninskom pojasu iznosila 165,04 cm. Za meteorološke postaje na području gorskog vegetacijskog pojasa nismo ustanovili statistički značajan trend broja dana sa snijegom i trend maksimalnih visina snijega. Na području pretplaninskog vegetacijskog pojasa je ustanovljen statistički značajan trend smanjivanja broja dana sa snijegom i maksimalnih visina snijega. Prema rezultatima single T testa broj dana sa snijegom (> 1 cm) i maksimalne visine snijega (cm) su značajno manje na području oba vegetacijska pojasa u odnosu na razdoblje 1948. – 1960. godine.

PREDICTING THE POTENTIAL IMPACT OF EXTREME RAIN EVENTS ON PLANTS AND THEIR ASSOCIATED SOIL MICROBIOME

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In addition to a number of signs of global climate change, we are witnessing more frequent fluctuations in weather conditions and increasing instances of extreme weather disasters. According to the UN Office for Disaster Risk Reduction report, extreme weather events will dominate the disaster landscape in the 21st century. Extreme rain events have produced more rain and become more frequent in many regions of the world, and these trends will increase as the planet warms. Assessment guidelines published in the "Seventh National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC)" identify the agricultural sector as a climate-related "vulnerable sector" that is expected to suffer the greatest damage as a result of climate change in Croatia. The expected decline in future crop yields could threaten food security, quality and price stability. Against this background, there is an urgent need to develop novel approaches to crop adaptation to a rapidly changing climate.

In the project entitled "Potential of the rhizosphere microbiome in the adaptation of agriculture to climate change (PERSPIRE)", funded by the EU Regional Development Fund, we focused our research on the effects of water retention (flooding) in agricultural fields on the health of the plant as a holobiont, i.e. on both the plant (changes in morphology and physiology), its associated microorganisms (changes in structure, function, and plant-promoting properties), and the soil compartment (nutrient status). We conducted our experiment in a greenhouse and used cabbage (*Brassica oleracea var. capitata f. alba*) as a model plant. The experiment lasted 57 days from sowing to the complete end. Plants (triplicate trials) were exposed at different developmental stages to either one (72 h duration) or two short-term floods (72 h duration, 10 days recovery between floods). At different time points (day 0, post-flood, and post-recovery), whole plants and soil were removed from the pots and prepared for subsequent analyzes.

Our results suggest that long-term, repeated flooding has negative effects on the plant and soil compartments, with changes observed in plant morphology and nutrient status, as well as in the production of stress metabolites. Soil and rhizosphere microbial community structure and plant growth-promoting bacteria and fungi (PGP) populations also changed under flooded conditions, with 11 strains selected as potential bioinoculum strains. Through a variety of mechanisms, PGP microorganisms provide plant growth and biocontrol benefits and could be important for plant development under different climate change scenarios. We believe that a comprehensive understanding of the effects of climate change on the plant as a holobiont could be a first step toward potential crop adaptation to climate change.

A CASE STUDY OF CHARACTERISTICS AND VULNERABILITY POWER AND AGRICULTURAL LOSSES DUE TO TROPICAL CYCLONE IN THE BAY OF BENGAL AND THE ARABIAN SEA IN 2018

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The coastal area of Bay of Bengal (BoB) and Arabian Sea (ARS) is one of the mostly populated area in the world (more than 2.31 billion). The huge costal line of more than 11,146 km is very much affected by the tropical cyclone occurred in these regions of BoB and ARS several times in a year.

In this paper we have studied the vulnerability power and property losses of different category of depression (wind speed above 25 kt hr^{-1}.) in 2018 in Indian Ocean area. There were 14 such events occurred in the year 2018 in BoB and ARS. From those depression seven of them become Cyclonic Storm (CS) with the wind speed above 40 kt hr^{-1}. The attempt has been made to categorize the Tropical cyclones (TC) of *Mekunu*, *Luban* and *Sagar* occurred in ARS and *Daye*, *Titli*, *Gaja* and *Phethai* occurred in BoB. From these seven storms *Mekunu*, *Titli*, *Gaja* and *Phethai* become very severe cyclonic storms (VSCS).

Here we have also studied the characteristics of all depressions including the devastating power of them. Also it has been done that the estimated damage of agriculture and property losses in socio economic aspect during these events.

ANALYSIS OF BIOMETEOROLOGICAL CONDITIONS USING UTCI (UNIVERSAL THERMAL CLIMATE INDEX) IN DIFFERENT CLIMATIC REGIONS OF SLOVENIA DURING THE SUMMER TIME IN THE PERIOD 2000–2021

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Due to more frequent and intense heat waves, the risk of heat stress has been increasing recently among different population groups, including workers in agriculture. The aim of study was the analysis of biometeorological conditions in different climatic regions of Slovenia during the summer, using UTCI (Universal Thermal Climate Index). Stations used from Submediterranean climate region were Bilje and Portorož, from Subcontinental climate region Črnomelj, Ljubljana, Maribor and Novo mesto, from Moderate climate of hilly region Postojna and Slovenj Gradec, and from Subalpine climate region Rateče. A correlation analysis was performed between UTCI and water loss index (SW) and accepted level of physical activity (MHR) to assess the number of unsafe working days in agriculture due to heat.

The proportion of summer days in the period 2000–2021 within strong or very strong heat stress varies considerably according to the location, from a third to even more than half in Submediterranean and Subcontinental climate region. In recent years there have been increased number of the UTCI values around 44 and 45, which means approaching the limit values for extreme heat stress conditions. The correlation between UTCI and MHR or SW was high and statistically significant for all stations. At the same time as UTCI and SW increase, MHR decreases, calculated values showed that on average conditions in the middle of a summer day are not suitable for moderate or heavy level of workload in agriculture.

FENOLOŠKA BAZA PODATAKA DHMZ-a

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Državni hidrometeorološki zavod ima dugu tradiciju fenoloških motrenja. Podaci se prikupljaju od 1951. godine. Kao i uvijek kada se prikupljaju velike količine podataka glavni zadatak je kvalitetno skladištiti podatke, te će ovdje biti naglasak na fenološku bazu podataka, no potrebno je prvo ukratko reći o kakvim se podacima radi.

• Što su fenološka motrenja i čemu služe?
Fenološka motrenja obuhvaćaju praćenje pojava na biljkama i/ili životinjama koje su u vezi s vremenskih prilikama, što može pomoći u praćenju klimatskih promjena. Neki od primjera fenoloških faza koje se motre u Državnom hidrometeorološkom zavodu su početak listanja, početak cvjetanja, pojava zrelih plodova, opadanje lišća, te mnoge druge. Bilježe se u obliku datuma kada je nastupila određena fenološka faza, za određenu biljku i lokaciju. Postoje također i neke pojave koje se bilježe kod pčela ili poljodjelskih radova.

• Što i gdje se motri?
Predmet motrenja naziva se fenološki objekt. U fenološkoj bazi podataka DHMZ-a fenološki objekti su podijeljeni u skupine:
Samonikle zeljaste biljke (npr. visibaba)
Šumsko drveće i grmlje (npr. obična breza)
Djeteline i livadne trave (npr. crvena djetelina)
Ratarske kulture (npr. ozima pšenica)
Voćke (npr. jabuka, kruška)
Vinova loza (npr. frankovka, graševina…)
Pčela
Opći poljodjelski radovi
Mediteranski dio (npr. oleandar)

Opseg motrenja se mijenja kroz godine pa je ovdje izdvojen samo kratak prikaz za posljednje razdoblje:
Broj fenoloških objekata u posljednjih 20 godina: >700 (tu se ubrajaju i sve motrene sorte jedne vrste, npr. može biti više sorti jabuka, šljiva, vinove loze…)
Broj fenoloških faza u bazi podataka: 44 (npr. početak listanja, početak cvjetanja itd.)
Broj trenutno aktivnih fenoloških postaja: 64

• Najstariji podatak u fenološkoj bazi?
Najstariji podaci datiraju iz 1951. godine, te je tako najstariji podatak u našoj bazi podataka – početak cvjetanja obične lijeske na lokaciji Topusko, koji je zabilježen 11. 1. 1951.

• Kako se čuvaju podaci?
U prošlosti su se podaci čuvali na različite načine, od papirnatih izvješća, do zapisa u datoteke, a danas se podaci čuvaju u relacijskoj bazi podataka.

• Gdje je izrađena fenološka baza podataka DHMZ-a?
Fenološka baza podataka u potpunosti je izrađena u Državnom hidrometeorološkom zavodu, u Službi za informatiku, gdje se i održava. Izrađena je u suradnji i prema naputcima fenoloških stručnjaka DHMZ-a. Relacijska baza je tipa PostgreSQL.
Uz samu bazu podataka, u Službi za informatiku izrađene su i sve programske aplikacije za pristup bazi, unos podataka, katalog fenoloških objekata, katalog fenoloških faza, program rada fenološke postaje, program motrenja za svaku biljku, te ispis i prikaz fenoloških podataka.

• Sadržaj fenološke baze podataka i unos podataka u bazu
U fenološkoj bazi se nalaze svi podaci od 1951. godine do danas.
Arhivski podaci prebačeni su iz datoteka, te iz papirnatih izvješća, što je bio vrlo opsežan posao.
Aktualni podaci unose se redovito na svim fenološkim postajama.
Motritelji na fenološkim postajama unose podatke u bazu putem browsera, te su podaci odmah dostupni u bazi.
Zaduženi djelatnici DHMZ-a ažuriraju katalog fenoloških objekata, te program rada fenološke postaje.

• Pristup fenološkoj bazi podataka
Fenološkoj bazi podataka pristupa se putem browsera. Mogu joj pristupati djelatnici DHMZ-a koji za to imaju privilegije. Za pristup bazi potrebno je korisničko ime i lozinka.

• Međunarodna razmjena podataka
Jedan dio podataka iz naše fenološke baze šalje se u međunarodnu fenološku bazu podataka PEP725.

• Budući razvoj fenološke baze podataka
Pred nama je zadatak da se izradi softver za kontrolu podataka u bazi, što je izazov i kod nas i kod drugih institucija koje imaju fenološke podatke.
Također, prema potrebi izradit će se i novi programi za prikaz fenoloških podataka.

OPTIMIZATION OF TD-GC/MS METHOD FOR DETERMINATION OF BTEX IN AIR

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In the last decades, volatile organic compounds such as benzene, toluene, ethylbenzene, and isomeric xylenes (BTEX) have become of particular interest in ambient and indoor air quality. Since people spend an average of about 90% of their time indoors, attention is increasingly being paid to indoor air in addition to outdoor air pollution. BTEX in the environment occur as components of naphtha and its derivatives and at room temperature and atmospheric pressure they are colorless liquids with a characteristic smell and relatively low boiling temperature, and high vapor pressure. They are widespread in the atmosphere by burning solid and liquid fuels and household heating. Consequently, the primary source of BTEX in urban air is vehicular traffic, and in the indoor air the sources of BTEX are smoking, furniture, domestic products, cleaning products, cooking, and renovation. Benzene is classified by the World Health Organization as a carcinogenic compound due to its high toxicity, and for toluene, ethylbenzene, and isomeric xylenes the same properties are researched. The average annual concentration of benzene in the air is regulated by European Union Directive 2008/50/EC at 5 μg m^{-3}, while indoor air quality legislation does not exist yet.

The objective of this study was to develop and optimize an analytical method for the determination of benzene, toluene, ethylbenzene, and m-, p-, o- xylenes in indoor air. For this purpose, thermal desorption coupled with gas chromatography and mass spectrometry (TD-GC/MS) was used. Manual analytical sample preparation has been replaced by multi-bed tubes for thermal desorption. TD tubes were packed with a combination of porous polymer, graphitised carbon black, and carbonised molecular sieves (Markes, Llantrisant, United Kingdom). Conditioned TD tubes were spiked with a standard mix (CRM4877, Supelco) containing BTEX and the retention times of BTEX peaks on the chromatogram were confirmed by individual standards (Sigma-Aldrich). Spiked tubes were heated in a desorber up to 320 ºC, and a helium flow rate of 50 mL min^{-1} was applied. For separation, a DB-624 UI capillary GC column (6% cyanopropyl/phenyl, 94% polydimethylsiloxane, 60 m, 0.32 mm internal diameter, 1.80 μm film thickness, 60 m length, Agilent Technologies, Santa Clara, CA, USA) was used. Method parameters such as MS temperature, hold time, and carrier gas flow were optimized. The optimized TD-GC/MS method could be used for parallel determination of BTEX in ambient and indoor air.

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SEKCIJA VI: PRIMIJENJENA METEOROLOGIJA
SESSION VI: APPLIED METEOROLOGY

100 GODINA ZRAKOPLOVNOG METEOROLOŠKOG MOTRENJA U HRVATSKOJ

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Ove godine obilježava se 100 godina od početka meteoroloških motrenja u zrakoplovstvu. Najstarija zračna luka u Hrvatskoj bila je u Zagrebu na Selskoj cesti, gdje je u razdoblju od 1. studenog 1923. do 1. svibnja 1927. postojala i meteorološka postaja. Ona bi se mogla smatrati prvom zrakoplovnom meteorološkom postajom (Penzar I., Sijerković, 1998.).

U radu će se prikazati razvoj meteoroloških motrenja od prvih dana do danas kada su razvijeni moderni tehnički sustavi, te će se dati i pogled u budućnost zrakoplovne meteorologije.
