Book of Abstracts

Osijek, Croatia, 9-11 November 2015

GEWEX WORKSHOP ON THE CLIMATE SYSTEM OF THE PANNONIAN BASIN

Organized by: Meteorological and Hydrological Service (DHMZ)
Faculty of Agriculture in Osijek

Supported by: Global Energy and Water Exchanges Project (GEWEX)

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Josip Juraj Strossmayer University of Osijek
Faculty of Agriculture in Osijek

GEWEX Workshop on the Climate System of the Pannonian Basin

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Edited by

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GEWEX Workshop programme

Venue:

University of J.J. Strossmayer in Osijek, Faculty of Agriculture in Osijek

(Vladimira Preloga 1, 31000 Osijek, Croatia)

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Session 1. Moderators: D. Jug, T. Halenka

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09:15 B. Grisogono, M. Telišman Prtenjak, B. Ivančan-Picek and K. Horvath: Relevant atmospheric circulations for the Pannonian basin

09:45 Coffee break

10:15 I. Güttler, K. Cindrić Kalin and A. Croitoru: Climatological characterization of the Pannonian basin

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11:15 A. Jeričević and G. Gašparac: Episodes of high PM concentrations during stable atmospheric conditions in the Pannonian basin

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17:15 C. Briese, W. Wagner, G. Bloschl, J. Paraika, N. Pfeiffer and G. Mandelburger: use of remote sensing for hydrological applications

17:45 S. Rozsa, J. Adam, I. Juni, T. Tuchband, A. Kenyeres, T. Weidinger, J. Bartholy and A.Z. Gyongyosi: Remote sensing of the atmospheric water vapour using GNSS observations

18:15 T. Weidinger, F. Ács: Surface-vegetation-atmosphere interface: experimentation and modelling

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09:00 C. Briese and W. Wagner: Earth observation data center on water resources monitoring

09:30 D. Komatina: The International Comission for the Sava river

10:00 L. Lestinska: The WMO Regional instrument centre - Slovak hydrometeorological institute

10:30 Open discussion

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11:45 T. Halenka, M. Belda and Z. Klukova: The EUROCORDEX and CECILIA projects (regional climate modeling and impacts)

12:15 M. Lakatos, Z. Bihari, T. Szentimrey and S. Szalai: Analysis of the observed trends in temperature and precipitation extremes in the Carpathian Region based on homogenized and harmonized gridded dataset

12:45 G. Pejanovic and V. Djurdjevic: The South Easteuropean Virtual Climate Change Center

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13:30 Lunch Break

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Moderators: J. Polcher, J. Cuxart

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G. Pejanovic and V. Djurdjevic: The South Easteuropean Virtual Climate Change Center

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Andreina Belušić, Ivan Güttler and Maja Telišman Prtenjak: Evaluation of near-surface wind characteristics obtained by an ensemble of RCM simulations over the Pannonian region

Petra Sviličić and Višnja Vučetić: Trends of soil temperature in eastern Croatia in the periods 1961 – 2010 and 1981 – 2010

Martin Klaić, Maja Telišman Prtenjak, Joan Cuxart, Marko Kvakić, Karmen Babić, Darko Koračin and Amela Jeričević: Numerical simulations of fog formations over the Zagreb area

Tomislav Stilinović, Ivana Herceg-Bulić and Ksenija Cindrić: The Effects of Arctic, North Atlantic and East Atlantic/West Russia Oscillation on Precipitation in Croatia Considering the Standardized Precipitation Index

Branislava Lalic, David R. Fitzjarrald and Ana Firanj: Impact of Seasonal Variations of Forest Structure on Eulerian Length Scale and Mixing Length

Ana Firanj and Branislava Lalic: Exchange of greenhouse gasses between biosphere and atmosphere

Martina Ćurić, Tomislav Stilinović, Maja Telišman Prtenjak and Vinko Šoljan: Analysis of atmospheric instability indices based on radio sounding and ALADIN data, weather types and lightning detection

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Yaohui Li, Ping Yue and Hongsheng Zhang: Comprehensive observation experiment for drought/arid land-surface process and atmospheric boundary-layer characteristics

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Abstracts

The GEWEX Hydroclimatological Panel and previous regional experiments

Jan Polcher and Jason Evans

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The GEWEX Hydroclimatology Panel (GHP) aims to understand and predict continental to local-scale hydroclimates for hydrologic applications. GHP concentrates on improving our understanding of environmental water and energy exchanges at the regional scale and from an integrated perspective. Addressing the water cycle at the regional scale allows us to better understand the many components of the system, from its physical to economic to social aspects. There are three types of projects within GHP that allow us to do this. Regional Hydroclimatological Projects (RHPs) are an essential tool in understanding and predicting hydroclimates as they bring together various disciplines on water-related issues. Cross-Cutting Projects allow GHP to propagate knowledge from one region to another and synthesize results at the global scale. They also facilitate the development and testing of applications derived this new understanding. Global Data Centers collect and distribute important hydrology-related data.

Relevant atmospheric circulations for the Pannonian basin

Grisogono Branko, Telišman Prtenjak Maja, Ivančan-Picek Branka, Horvath Kristian

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Strong seasonal dependency of the relevant atmospheric circulations over the Pannonian basin appears to be due to the typical continental mid-latitude position of the basin. General circulation usually imposes gradually changing overall conditions that typically end up in four basic groups of baric configurations over the basin. These tropospheric formations are: low-pressure (cyclone and trough) and high-pressure systems (anticyclone, high pressure ridge and bridge), zero-pressure gradient field (small regional pressure gradient with very weak regional flow) and transitional synoptic states with advection from almost any direction. Arguably, all those synoptic situations can be organized in a few tens of weather types; such a classification was previously done for Croatia using 29 weather types. Much of vigorous weather situations pertain to cyclones and blocking. Anticyclone weather types, under stable tropospheric stratification, having relatively light winds and weak turbulent exchange processes, dominate in either the cold part of the year or in nighttime conditions. The corresponding weather includes fog or/and low cloudiness, although it can be sunny in the sporadic highlands and the Basin's surrounding mountains. Nevertheless, winters are also characterized by rapid cold air outbreaks from N and NE inducing strong winds. Most of the impinging flows are to some degree modified by the surrounding mountains. Cold air of maritime origin typically streams into the Basin from NW while cold air of continental origin flows in from NE. The flow of warm and moist air usually arrives from S into the Basin. Temporarily, however, alterations in large scale flows may allow for various secondary circulations, i.e., mesoscale and local flows such as drainage flows, thermal lows, mesoscale convective systems, etc. Those flow types depend regularly on the underlying surface properties (orography, moisture, etc.) and air masses in play. Deep moist organized convective activities, often related to vigorous showers, lightning and hailstorms in the warm part of the year occur with the SW (the most often) and NW or NE (less often) upper-level flow. The corresponding lower-level flow then usually belongs to either weak or non-gradient pressure. Other flow structures also occur over the Basin. For example, summertime blocking situations often yield to heat waves and droughts, while certain weak pressure gradient conditions may promote significant trans-boundary transport and dispersion of air-pollution including airborne pollen (e.g., ragweed).

Climatological characterization of the Pannonian basin

Ivan Güttler, Ksenija Cindrić Kalin, Adina Croitoru

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The European Climate Assessment and Dataset (ECA&D) gridded dataset E-OBS is used to estimate mean seasonal 2 m air temperature (T2m) and total precipitation amount (R) over the Pannonian basin and neighbouring regions. We have analysed two historical periods: 1961-1990 and 1981-2010 using gridded data at the horizontal resolution of 25 km. Comparison against national climate atlases based on higher resolution data is also provided. The same E-OBS data is used to estimate trends in the mean seasonal and annual T2m and R time series over the entire available period (i.e. 1950-2014) at the location of the major cities in this region. Again, references against high resolution national climate products are provided where possible. Finally, several extreme meteorological events over this region (e.g. 2003 heat-wave, 2012 drought, 2014 flooding) are put into the context of the observed climatology and climate trends.

Regional climatological modelling

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Model RegCM is a 3-dimensional, sigma-coordinate, primitive equation model, originally developed by Giorgi et al., and currently available from the ICTP (Abdus Salam International Centre for Theoretical Physics) in Trieste. The newest model version is adapted with the ultimate aim of providing climate projection for the Pannonian region with 10 km horizontal resolution. For this purpose, first, coarse resolution reanalysis data and global climate model outputs are used to drive 50 km resolution model experiments covering a larger European domain, from which the outputs are used to provide necessary boundary conditions for the fine scale model runs. We use the mosaic-type subgridding option in order to take into account subgrid processes. Longer experiments were preceded by a sensitivity study to determine the most appropriate configuration of available model parameterizations. In the framework of the model validation process we tested three different cumulus convection schemes (i.e., Kuo, Emanuel, and Grell schemes with different closure methods). Our conclusions suggest that combined use of the Emanuel scheme over ocean and Grell scheme over land with Fritsch and Chappell (1980) closure results the best performance of RegCM simulations for the Carpathian Region. Besides the historical runs (for the period 1981-2005), RCP4.5 and RCP 8.5 scenario runs are also planned for the 21st century (for the period 2006-2100). These experiments are essential since they form the basis of regional, national, local climate and adaptation strategies by providing detailed regional scale climatic projections and enabling specific impact studies for various sectors.

Episodes of high PM concentrations during stable atmospheric conditions in the Pannonian basin

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Air quality in the Pannonian basin was analysed with the focus on stable atmospheric conditions using available observed data and EMEP and WRFChem model results. This work presents the continuation and exploration of the research of episodes of relatively high particulate matter (PM) concentrations over Pannonian basin which occurred during persistent stable meteorological conditions. The scope of the research encompassed regional and high resolution air quality (AQ) model as well as the analysis of the observed data. Air pollution due to high PM concentrations was investigated at rural background and urban stations within Pannonian basin during 2011. Seasonality of the PM observations at different types of sites was analyzed for the whole year. Furthermore, few particular situations during periods with increased concentrations were selected for additional analysis with online coupled AQ model WRF Chem to evaluate the contribution of local sources as well as the meteorological conditions on areas where peak values occurred. Various tests were also made with different model parameterization and the emission input data sets. EMEP model was used to determine transboundary transport of air pollution and establish the background PM levels. Using complex atmospheric chemistry model it was possible to analyze and describe the main processes contributing to the relatively high PM concentrations on regional and local scale.

Temporal and spatial variability of stable isotope compositions and air moisture sources for precipitation in Hungary

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This study evaluates the regional differences in stable isotope compositions of precipitation in the Pannonian Basin based on the hydrogen and oxygen isotope analyses of daily rainwater samples collected in seven distinct meteorological stations in Hungary since April 2012. Thus, this work provides the first "comprehensive map" of isotopic composition of precipitation for Hungary. Additionally, we determined the air moisture source regions for each location during the studied period by running the NOAA HYSPLIT trajectory model and by calculating the specific humidity along the trajectories. Five possible moisture source regions for precipitation were defined: Atlantic, North European, East European, Mediterranean and continental (local/convective). Stable isotope variations show systematic and significant differences between the regions, especially large differences in the local meteoric water line were observed between the stations in West and East Hungary. The variability of moisture source shows also systematic distribution. Interestingly, the most dominant among the identified source regions in all stations is the Mediterranean area; while the second is the Atlantic region. The ratio of the precipitations originated in Eastern and Northern Europe seem to correlate with the geographic position of the meteorological station. Additionally, the ratios of the different moisture sources show intra annual variability. In each location, the amount weighted d-excess were calculated for the identified moisture sources. It seems that the precipitation originated in the Mediterranean regions has systematically higher d-excess than those originated in the Atlantic sector independently from the absolute value which apparently changes from station to station.

Determination of the water budget at the basin level

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With the ongoing climate change water budgets of river basins may change dramatically. Recent efforts of specifying basin-scale evapotranspiration (ET) from meteorological variables combined with satellite remote sensing data are crucial for predicting future runoff changes in such watersheds. Here we present a simple approach of predicting basin-scale ET from basic meteorological variables with or without the aid of remotely sensed data.

River discharges changes and use of GIS in hydrological studies

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The proposed presentation aims to: 1) highlight some aspects on the river discharges changes in the context of climate changes in Romania, and 2) present possibilities for GIS use in hydrological approaches. The presentation is structured into 2 parts, corresponding to the two mentioned objectives. In the first part, after a brief presentation of the changes observed in the last 5-6 decades in the variability of the main climatic parameters controlling the river flow, some case studies on the river discharges changes, observed and predicted by models, are presented. The second part is focused on GIS application in hydrological studies, namely in hydrological modeling. This relies on accurate catchment-based models in terms of spatial representation (lumped and distributed) or process representation (black-box, grey-box, white-box). In the GIS analysis the role of DTMs is vital for surface features (slope, aspect, and altitude), drainage system (watershed, sub-catchment, stream network) and for the quantification of the catchment variables (flow accumulation, flow tracing, flow width, flow times, stream power indices, transmissivity, catchment response). Other key catchment variables considered for an accurate scenario are: soils (type and association, derived characteristics), geology, land use (vegetation cover, management practices) and artificial drainage system. GIS-based catchment models use data layers to represent the above-mentioned flow control variables and use advanced procedures to represent relationships between them, to model processes and to predict response.

Hydrological modelling for the Sava basin in Croatia

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Croatian Meteorological and Hydrological Service with Croatian Waters and DHI have developed combined hydrological-hydrodynamic MIKE11 pilot model of the Sava river from the Slovenian border to the confluence with Kupa river at town of Sisak. The next modelling phase will cover the rest of the Sava basin in Croatia.

Fully integrated dynamic hydrology modelling

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Numerical hydrologic modeling has achieved limited success in the past due to lack of adequate input data. Over the last decade, data availability has improved substantially; high-resolution data on topography, river routing, and land cover have meanwhile become available. At the same time, the quality and resolution of quantitative precipitation predictions have also improved significantly. Today there is a variety of hydrology modeling approaches, ranging from conceptual and kinematic methods to more complex dynamic methods. The most complex models include full dynamic governing equations in which momentum equations, along with the equation of mass continuity, are used in their full extent. Such approach permits appropriate representation of different hydrology scales ranging from flash floods to flows of large slow river watersheds. The implementation of such full dynamic systems is however not straightforward since the vanishing of surface water of a model causes numerical instability. This presentation describes a fully dynamic model for lateral hydrology which has been successfully run under conditionally stable conditions. This model has been also integrated with a hydrostatic atmospheric model in a two-way coupled manner. An example of assessment of regional hydrology conditions at multi-decadal scale using such integrated model will be shown.

Vegetation and agriculture status and challenges

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Pannonian basin are recognized as region with a potentially rich plant production. Very heterogeneous area and very divergent agroecological conditions influenced on yield levels from year-to-year in wide scale. This variation primarily depends on climate aberrations but also because of many other problems, which every single or/and all together lead to reduction of production and low productivity. Conservation soil tillage as a component of conservation agriculture represent one of main technology operations in crop production which proper application could significantly improve yields. In Pannonian basin this technology is still used very occasionally and in small areas, with rarely examples in practice, but with tendency to grow in last fifteen years. Main encouragement to adoption conservation approach in crop production are positive financial effect, and unfortunately, the other positive effects arising from the application of conservation production/tillage systems are still in the background (reduction of soil erosion, increase biogenity and quality of soil, less traffic and soil compaction alleviation, nutritional status an quality traits of crops, weed infestation etc.). Main reasons for this situation can be divided on two different group: Economic and social development (knowledge, tradition, technics, technology, science implementation etc.) and Agro-ecological conditions (climate, soil, water, crop, biology etc.). Climatic changes, with primary changes in water and temperature regime, have large and perhaps the greatest impact on crop production. Regarding this, the soil tillage is necessary to be changed in order to achieve a safer and more stable production. Simplified, cheaper and more rational conservation soil tillage is one of the possibilities of overcoming the upcoming unfavorable climate (all the more extreme vegetation years), economic, market, organizational, socio-economic and other changes. Conservation agriculture/soil tillage is a result of serious scientific research and practical testing, and it is the result of better and more comprehensive observation and understanding of the natural environment.

The use of remote sensing for hydrological applications

Christian Briese, W. Wagner, W. Dorigo, N. Pfeifer and G. Mandlburger

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Remote sensing techniques, such as laser scanning, photogrammetry or radar, allow to observe geometric and physical processes at different scales that are relevant to several hydrological applications. Sensors mounted on terrestrial or airborne (manned or unmanned aerial vehicles) platforms allow one-time data capturing on the reach or catchment scale in very high resolution. The resulting dense point clouds are used as the basis for deriving accurate digital terrain models and roughness measures for hydraulic modelling (flood simulations, sediment transport, river restauration, hydro-morphology, habitat modelling). On the national scale, high resolution digital elevation data from remote sensing are used to derive the entire river network of a country or to improve the existing networks. Satellite platforms, in turn, allow to capture hydrological relevant data on a global, multi-temporal manner. In both cases the validation with in-situ reference data is essential. This talk focuses on recent research results in the area of laser bathymetry and radar remote sensing. While multi-temporal laser bathymetry results demonstrate the high resolution capabilities to map the underwater surface geometry and relate changes in the morphology to flood events, satellite based radar remote sensing products map surface soil moisture data globally and in a continuous manner. Furthermore, the talk presents the International Soil Moisture Network established at TU Wien which is a centralized platform for collecting and distributing in-situ soil moisture and hydrometeorologic data worldwide.

Remote sensing of the atmospheric water vapour using GNSS observations

Szabolcs Rozsa, Jozsef Adam, Ildiko Juni, Tamas Tuchband, Ambrus Kenyeres, Tamas Weidinger, Judit Bartholy, Andras Zeno Gyongyosi

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The atmospheric water vapour plays an important role in many meteorological applications. It is used for numerical weather predictions as well as for climatic studies, since the water vapour is one of the most significant greenhouse gases. Atmospheric water vapour content is measured by radiosondes, microwave radiometers and some meteorological satellites, too. This paper focuses on a relatively new technique: the atmospheric remote sensing with the Global Positioning System (or more broadly with the Global Navigation Satellite Systems - GNSS). GNSS measures the propagation time of satellite signals. Since the propagation of microwave signals are affected by the water vapour content of the atmosphere, the determenination of the signal delays enables us to estimate the water vapour content of the atmosphere. The paper introduces satellite based and ground based methods for the remote sensing of atmospheric water vapour. These methods include the near realtime estimation of integrated water vapour, the tomographic reconstruction of water vapour density and the satellite based radio-occultation methods. The strength and weaknesses of these approaches are studied and state-of-the-art databases are introduced to exploit these data sets for meteorological applications.

Surface-vegetation-atmosphere interface: experimentation and modelling

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In Hungary, beside standard meteorological and hydrometeorological network (~250 automatic stations) long term and expeditionary micrometeorological measurements have been also performed aim to do investigation. High quality measurements of radiation budget components, eddy covariance fluxes, state variable profiles (temperature, humidity, wind speed) up to 10 m height, soil temperature, moisture and heat fluxes have been done at the Agrometeorological Observatory in Debrecen. Similar measurements combined by flux calculations of trace gases closing energy budget as well as possible have also been carried out at stations Bugac (EU7 ECLAIRE program) and Szeged. Standardisation of energy budget measurements and parameterizations above water surfaces (e.g. lake Balaton) is also important field of investigation. All these micrometeorological measurements could also be used as boundary conditions in SVAT (Soil Vegetation Atmosphere Transfer) model applications. Independently from above mentioned measurements, modelling campaigns focusing on the Carpathian Basin were also performed. They deal with both the biogeophysical and biogeochemical aspects of vegetation-atmosphere relationship, with biogeophysical aspects being in the majority. Among biogeophysical treatments more attention is paid for investigating processes of evapotranspiration as well as of its effect on shallow and deep convections. Processes of shallow and deep convection are analyzed in terms of the diurnal change of planetary boundary layer height and the spatial distribution of daily convective precipitation. The surface-dependent region-distinctiveness of these two phenomena have been recognized, at the same time the strength of the relationships have not yet been quantified. The results also suggest the basic importance of soil moisture content in the summer period.

Operational atmospheric observational network and special observations

Joan Cuxart, B. Matjacic

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An integrated view of the operational observational network for the Pannonian Basin will be given, by exploring the basin national networks. As a first step, observations entering every day the global observing network system will be listed, mainly SYNOP (regular station), METAR (aeronautical report) and TEMP (sounding report). Other observations like satellite data or meteorological reports from commercial aviation will be also described. The supplementary observation networks at the national level will also be explored, through contact with the National Weather Centers and other public services. They may include Automatic Weather Stations for different purposes (air-quality, road monitoring, etc) and human-managed stations with a climatological purpose. This approach will allow to check the current coverage of meteorological information for the basin. Finally, special observation means will be explained, belonging to Met. Services, Research Centers or Universities. Fixed installations will first be listed, such as meteorological radars, high towers or atmospheric profilers. Mobile equipement apt for campaigns will be identified, such as micrometeorological instrumentation or research-intended remote- sensing devices. The ensemble of the information should allow a sounded discusion on what can be done with the present means of observation if used in a coordinated and efficient mode, and where to concentrate efforts if needed.

Earth Observation Data Centre for Water Resources Monitoring

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This talk presents EODC, the Earth Observation Data Centre for Water Resources Monitoring GmbH. It is a public private initiative that focuses on a cooperation model in order to foster the research and exploitation of big earth observation (EO) data. In this cooperation model, partners from the private and the public sector work together in different communities, e.g. on infrastructure, on joint software developments, or on scientific method development. In these communities EODC facilitates and promotes cooperation. EODC aims to establish fully automatic, end to end, EO data processing chains built upon collaborative software development processes. Based on the Big Data infrastructure, EODC offers a range of services that allow collaborative software development as well as operational EO processing. The services can be broadly categorized in four different service types: (i) community building services, (ii) data services, (iii) software services and (iv) platform services. EODC takes full advantage of cloud computing by providing, an on demand, self-service access to a shared pool of computing resources. The infrastructure components include (i) a platform for 24/7 processing, (ii) a virtual environment for collaborative algorithm development, (iii) Petabyte storage, and (iv) access to the Vienna Scientific Cluster 3 (VSC-3, ranked 85th in the November 2014 worldwide TOP500 supercomputer list). EODC together with its partner TU Wien focuses on an operational processing chain for generating soil moisture products from Sentinel 1A data. Sentinel 1A is the first of several satellites of the European Space Agency launched for operational monitoring of the Earth.

International Commission for the Sava River Basin

Dejan Komatina

International Commission for the Sava River Basin

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The Sava River Basin is a major drainage basin of the South-Eastern Europe and the second largest Danube sub-basin by area, while the Sava River is the largest Danube tributary by discharge. Given high environmental and socio-economic values of the Sava River Basin, a well-balanced approach is necessary for the use of the economic potential along with the preservation of the existing environmental values. Following the geopolitical changes in the region in the 1990-ies (i.e. decay of the former Yugoslavia), the Sava River was turned from the biggest national river into an international river. Consequently, a new, international framework became necessary for the water resources management on the basin level. To respond to these challenges, the Framework Agreement on the Sava River Basin (FASRB) has been created as the only transboundary water cooperation framework for any European basin d dealing with both protection (water, environment) and development issues ((e.g. navigation, river tourism). Subsequently, the International Sava R River Basin Commission (ISRBC) has been established as the implementing body of the FASRB. The FASRB is the first development-oriented multilateral agreement concluded in the region in the post-conflict period, after the agreements on peace and succession. With its strategic goal to ensure sustainable development of the Sava River Basin through transboundary water cooperation in the basin, it integrates all aspects of water resources management, and thus provides the ISRBC with the broadest scope of work a among international basin organizations in Europe. The presentation explains the legal and institutional framework for the water cooperation in the Sava River Basin (FASRB and ISRBC, respectively), as well as the ISRBC approach to integrated water resources management, and its achievements and ongoing activities. Although rather demanding in terms of human and financial resources, good cross-sectoral cross-sectoral coordination and permanent joint efforts of the Parties, the transboundary water cooperation based on the FASRB yields considerable benefits for the Parties, making the FASRB a good basis for the progress towards the achievement of the key objective – sustainable development of the Sava River Basin.

The WMO Regional instrument centre - Slovak hydrometeorological institute

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In meteorology, as in all scientific fields, there is a great need to provide an accurate and precise data. One of the essential tools to ensure high quality data is calibration of the measuring devices. Many meteorological services now have their own calibration laboratories and they are able to perform calibrations of their measuring instruments. Still, there is an increasing need for international cooperation. This is one of the reasons why Regional instrument centres (RICs) were established by World meteorological organization (WMO). Some of the basic RICs functions, assigned by WMO, are: to assist members of the region with calibrations, give members instrument-related advice, cooperate with other RICs etc. Slovak hydrometeorological institute (SHMU) is one of the Regional instrument centres in RA VI region – Europe. Other two are located in Toulouse (France) and Ljubljana (Slovenia). The Calibration Laboratory of SHMU was established in early sixties as part of the Division Meteorological Services and at the time it solely served for internal purposes. Now it performs calibrations for both SHMU and external customers. The Calibration Laboratory is accredited in accordance with the International Standard ISO/IEC 17025 for the calibration of the following instruments: classic liquid-in-glass thermometers, PRTs platinum resistance thermometers, thermographs, mechanical and electronic hygrometers, hygrographs, electronic barometers, anemometers, automatic rain gauges; and for calibration of air pollution analysers. The Calibration Laboratory regularly and successfully takes part in the International Interlaboratory Comparisons with other meteo services in the region.

The ALADIN model consortium and participation in HyMeX

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Numerical weather prediction since long relies on intensive international cooperation among national meteorological centers, as well as academia. Since 1996, Croatia has been involved in the ALADIN project, whose goal has been to develop and implement a high-resolution mesoscale numerical weather prediction model for producing more accurate, reliable and timely short-range weather forecasts. To address this challenge in the central Europe, Regional Cooperation for Limited Area modelling in Central Europe (RC LACE) focuses on developments in data assimilation, physics, dynamic and coupling, and predictability. As a result, deterministic short-range weather predictions in Croatia are performed operationally using both hydrostatic version of the ALADIN model at 8 km horizontal grid spacing with 3D-Var data assimilation and a non-hydrostatic convection-permitting version of the ALADIN model at 2 km grid spacing. RC LACE consortium also developed limited area ensemble forecasting system (ALADIN-LAEF), while post-processing, such as e.g. Kalman filter and analogue ensemble for the case of Croatia, are done individually in each country. These developments lead to both higher forecast accuracy and an estimation of forecast uncertainty that together contribute to higher efficiency of the early warning system for severe weather phenomena. Improved numerical weather prediction also provides data needed for improving the efficiency in all economic sectors, for the rational use energy and natural resources, and for improving environmental protection and quality of life in general. In recent years, an international project Hydrological cycle in Mediterranean Experiment (HyMeX) was launched to achieve a better general understanding of natural water cycle and improve hydrometeorological forecasts. Reasons for launching the Hymex project lie in the fact that the Mediterranean is one of hot spots for regional climate change. The Mediterranean area also concentrates the major natural risks related to the water cycle, including heavy precipitation and flash-flooding during the fall season, severe cyclogenesis associated with strong winds and large sea waves during winter, and heat waves and droughts accompanied by forest fires during summer. The Hymex project has focused on conducting both special observation periods (SOPs) and long-term observation periods (LOPs). An important goal of the project is also to advance state-of-the-art numerical models within a coupled atmosphere – sea – land modelling system across all weather and climate scales. Therefore, the project aims to improve the capability of predicting high-impact weather events, which remains moderate due to contribution of very fine-scale processes and their non-linear interactions with the larger-scale processes. On climate scales, in addition to

temperature increase, a large decrease in the mean precipitation and an increase in precipitation variability are expected during dry (warm) season in future. Due to comparable amplitudes of climate change and internal climate variability, assessing regional climate evolution in the Mediterranean still remains a principal challenge.

The EUROCORDEX and CECILIA projects (regional climate modeling and impacts)

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Project EC FP6 CECILIA – Central and Eastern Europe Climate Change Impact and Vulnerability Assessment studied the impact of climate change in complex topography of the Central and Eastern Europe in high resolution for applications in agriculture, forestry, hydrology and air-quality. Resolution of regional climate simulation is an important factor affecting the accuracy of dynamical downscaling of the global changes in local scale. Especially the extremes are strongly dependent on the terrain patterns like shape of orography or land use, which can contribute to extreme temperatures or precipitation occurrence. Similar activity is running under EuroCORDEX initiative within the framework of WCRP CORDEX action in broader scope of RCMs participating as well as GCMs driving conditions and climate change scenarios, covering ful Europe. The reliability of the RCMs in reproducing climate conditions and extremes has been studied in the experiments with the perfect boundary conditions with further different kinds of validations. The benefits of high resolution (10 km, 0.11°) are analysed in comparison to lower resolution simulations (0.44°) together with the problems of data available for this assessment. Examples of impacts assessment are shown based on CECILIA project with the perspective of use the EuroCORDEX data for similar studies and climate services provision in the Pannonian basin.

Analysis of the observed trends in temperature and precipitation extremes in the Carpathian Region based on homogenized and harmonized gridded dataset

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The harmonized data derived in CarpatClim (2010-2013) project has enabled the presentation of the most comprehensive picture of climate change in the Carpathian Region. The CarpatClim investigates fine temporal and spatial structures of the climate in the Carpathian Mountains and the Carpathian basin with unified methodology. The results are 0.1°(~10 × 10 km) resolution, freely available, gridded, daily time series of various basic meteorological variables and several climate indicators on different time scales from 1961 to 2010. The target area is partly includes the territory of Czech Republic, Slovakia, Poland, Ukraine, Romania, Serbia, Croatia, Austria and Hungary. Uniform process of data homogenization was crucial due to the fact that significant differences might be occurred between the measurements and data handling in the examined fifty-year-long period. The commonly used method for data homogenization and quality control in the project was the MASH (Multiple Analysis of Series for Homogenization; Szentimrey) procedure. The gridding of the homogenized time series was accomplished by applying the MISH (Meteorological Interpolation based on Surface Homogenized data basis; Szentimrey and Bihari) method specially developed for interpolation of meteorological data. More information about the methods and the project results can be found on the project page: http://www.carpatclim-eu.org/pages/home/ A set of climate change indicators derived from daily temperature and precipitation data, focus on extreme events, were computed and analysed on the dataset derived in the CarpatClim. Annual and seasonal extreme indices for the period 1961–2010 are examined. Trends in the gridded fields are calculated, mapped and tested for statistical significance. Results show significant changes in temperature extremes associated with warming throughout the Carpathian Region.

The South East European Virtual Climate Change Center

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The growing evidence of the impact of climate change in the South East European (SEE) region has contributed to the promotion of the climate change issue to a higher level on the agenda of the governments. The result was launching of the so-called Belgrade Initiative, adopted by the UNECE Ministerial Conference in 2007. Within the Belgrade Initiative, the sub-regional SEEVCCC hosted by the Republic Hydrometeorological Service of Serbia was established. The action in setting up the main SEEVCCC functions proceeded simultaneously in two directions: through intensive implementation of the Belgrade Initiative, and through participation in the activities of the WMO Regional Climate Centre Network (RA-VI) to support the NMHSs in the region. The RA-VI RCC consists of three nodes: climate data, climate monitoring and long range forecasting. Within first node (Lead: KNMI/Netherlands), the SEEVCCC provide regional climate projections data covering SEE and the Mediterranean area. Within second node (Lead: DWD/Germany) operational issuing of monthly and three-monthly climate monitoring maps for SEE region is performed. Within third node (Lead: Météo-France&Roshydromet) the SEEVCCC performs the seasonal predictions for 7 months ahead for SEE, which are produced by dynamical downscaling of ECMWF LRF system. All products are available from the web sitehttp://www.seevccc.rs. In addition, SEEVCCC/RHMSS support RCOF mechanism by hosting SEECOF meetings. In pursuing with the highly recommended functions related to R&D the SEEVCCC is particularly interested in application and development of a NCEP non-hydrostatic NMM-B model designed for global to sub-regional and local scales.

Heat stress and agriculture in Croatia: past, present and future

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The study analyzed consecutive days with maximum daily air temperatures above 30°C in Croatia. The data was taken from 81 meteorological stations and 110-, 50-, and 30-year periods were analyzed. The aims of this study were to show the spatial distribution of affected areas due to heat stress and using the regional climate model (RegCM) to gain insight into the future climatic conditions on the Panonian plain in Croatia. Heat stress was defined as at least ten consecutive days with maximum daily air temperature equal to or higher than a certain critical temperature. The critical temperature was taken from a range of temperatures from 30°C to 34°C per 1°C. Vulnerability of an area due to heat stress in agriculture was defined by the existence of at least 6 years with heat stress during a 30-year period. Results show a sudden increase of the number of days with maximum daily air temperature above the critical maximum daily air temperatures, and increase of the number of periods with heat stress in Croatia in past three decades when compared to the reference period 1961–1990. Results also show the expansion of the zone affected with heat stress for the critical temperatures in the range from 30°C to 32°C. Analyses based on numerical simulation of maximum daily air temperature until 2070 show expansion of area affected with heat stress from Adriatic coast to the Pannonian plain. Thus, the irrigation system will need to be introduced for the crops that we still do not irrigate.

Evaluation of near-surface wind characteristics obtained by an ensemble of RCM simulations over the Pannonian region

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This study focuses on the evaluation of the characteristics of near-surface wind obtained from the latest generation of the regional climate models (RCMs). While model domains include all of Europe, an area of particular interest is the Pannonian Plain. Bordered by the Alps in the northwest, the Dinaric Alps in the southwest and by the Carpathians in northeastern direction, the Pannonian Basin is divided into two parts by the Danube river. South of the Danube, which includes the Croatian part of the Pannonian Plain, sporadic mountains have "insular" character with altitudes up to 1000 m above sea level contributing to the area complexity. Daily climate model data for near-surface (i.e. 10 m) wind were taken from the EURO-CORDEX archive (CLMcom-CCLM4-8-17, DMI-HIRHAM5, IPSL-INERIS-WRF331F, KNMI-RACMO22E, SMHI-RCA4, DHMZ-RegCM4) and compared against surface station observations. All simulations were forced by ERA-Interim reanalysis. For the evaluation, data from 1996-2008 period have been used on account of the length of available observed time series. Various methodological aspects related to the interpolation techniques when comparing RCMs and observations (or RCMs at two different resolutions) are discussed. The study reveals strong sensitivity of the simulated wind flow and wind pattern to the RCM horizontal resolution (12.5 km vs. 50 km). Furthermore, a measures-oriented approach (e.g. mean-square error or Brier skill score) and a distributions-oriented approach (e.g. Perkins skill score) disclosed both season and location dependence.

Trends of soil temperature in eastern Croatia in the periods 1961 – 2010 and 1981 – 2010

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Soil temperature has been more and more recognized as an important factor within the climate system. In this paper, trends of soil temperature were analyzed on seasonal and annual scales at depths of 2 cm, 5 cm, 10 cm, 20 cm, 30 cm and 50 cm at 5 sites in the eastern region of Croatia, Slavonia, for periods 1961 – 2010 and 1981 – 2010. The Theil Sen's slope estimator was used to detect the slope of possible trends in annual and seasonal maximal, mean, and minimal soil temperature and statistical significance of trends at the 0.05 level was determined with the non-parametric Mann-Kendall test. The results show a general warming in all seasons and depths for mean and maximal temperatures in both observed periods, while only at some locations for minimal soil temperature. Warming is more pronounced in the spring and summer season in the second period. Significant trends of maximal, mean and minimal soil temperature in both observed periods range from 0.4 to 3.3°C/decade, from 0.1 to 1.3°C/decade, and from -0.5 to 1.3°C/decade respectively. The magnitude of trends generally decreases with depth, but some exceptions were detected in deeper layers, especially in the autumn season, where significant magnitudes of trends increase in relation to the above layers. These results are of great importance for the development of local agriculture.

Numerical simulations of fog formations over the Zagreb area

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This study investigates fog development over a wider Zagreb area. According to the climatological data, haze and fog occur frequently over the Zagreb-airport area and cause severely low visibility that can last for several days. Zagreb airport is located in a flat terrain south of Zagreb near the Sava river at a height of 108 m above sea level (asl). To the north, the city of Zagreb (~120 m asl) is a main source of urban pollution including condensation nuclei. There are heavy traffic roads around the airport which also generate pollutants. North of Zagreb, the Medvednica mountain rises up to 1000 m asl in a relatively short distance of about 10 km, with a very well defined downslope forest area. We focus on a case study of a long-lasting fog event that took place during 6-8 November 2013 to understand of the dynamic processes of fog development and fog persistence. The selected case was analyzed by means of available measurements and numerical simulations performed by the WRF-ARW high-resolution numerical model in several model setups. The model was able to reproduce this fog event with small differences among the various model runs. The results revealed the roles of: (i) the downslope wind which usually occurred over city when the net radiation over the Medvednica slopes becomes negative and (ii) the effect of urban Zagreb area which adds pollution to the downslope flow and consequently decreases fog duration over the city. The effect of the downslope flow was not apparent in the surface layer over the airport because it occurred above the thermal inversion contributing to the fog persistence. The influence of the Sava river has been also estimated and discussed. This comprised an additional calculation of backward trajectories and simulations of the water vapor dispersion (a passive scalar in the atmosphere) by the FLEXPART Lagrangian particle dispersion model driven by the WRF output.

The Effects of Arctic, North Atlantic and East Atlantic/West Russia Oscillation on Precipitation in Croatia Considering the Standardized Precipitation Index

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The Arctic Oscillation (AO), North Atlantic Oscillation (NAO) and East Atlantic/West Russia Oscillation (EA/WR) are global modes of climate variability with a strong influence on European climate. Therefore, the climate variability of Croatia is affected by them as well. This study investigates a possible influence of AO, NAO and EA/WR on precipitation over the Croatia considering correlation between respective indices and standardized precipitation index (SPI), a quantity that has been widely used in drought assessments. A possible time-delayed impact of these oscillations on SPI is also considered. It is shown that there is a noticeable impact of wintertime (JFM) NAO, AO and EA/WR on precipitation in Croatia that may be reflected in SPI values. All three modes exert the strongest influence on SPI1 during the first overlapping month (January), with AO showing the strongest correlation. Results also indicate time delayed impact of wintertime NAO, AO and EA/WR on SPI3 calculated for subsequent seasons. The influence increases in magnitude towards the spring season, reaching its maximum in FMA season (for AO) and MAM season (for NAO and EA/WR). The correlation between EA/WR and SPI indices shows a time lag compared with NAO and AO correlations having a longer influence. Besides, results indicate that strength and duration of investigated impacts are spatially dependent.

Impact of Seasonal Variations of Forest Structure on Eulerian Length Scale and Mixing Length

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The Eulerian length scale, Lw, a measure of the characteristic turbulent eddy size within and just above a forest canopy is affected by canopy density and structure that varies seasonally and interannually. Nearly continuous measurements of turbulent and radiative fluxes above and below the canopy of a red oak forest at Harvard forest (42.53° N, 72.19° W, north central Massachusetts USA) were used to obtain the Eulerian time and length scales Tw and Lw using the observed standard deviation of vertical velocity, w (Lw=w Tw). The Eulerian autocovariance function of wind velocity, Rww was computed from three-dimensional wind velocity measurements made within and above the forest crown for 2002-2011. The mixing length, lm is length scale associated with turbulent transfer mechanism. Within the forest, lm is affected by drag coefficient of each canopy element, Cd and the canopy density, LAD(z). Using measured PAR albedo and occasional LAI measurements, seasonal variations of LAI and LAD(z) were calculated; seasonal variations of Cd were obtained through the u*2/U2 relation. The Eulerian length scale, Lw and mixing length, lm analyses yielded two interesting findings: 1) Mean midday values during spring-autumn period are quite similar, indicating a common origin for the behaviour of each parameters; 2) The clearly exerted seasonal variation indicates decrease of both length scales during the leaf emergence in spring, almost constant values during fully leafed canopy in the summer followed by an increase once autumn defoliation starts.

Exchange of greenhouse gasses between biosphere and atmosphere

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In the light of anthropogenic greenhouse gasses (GHG) production, climate change and rapid concentration jump of all GHG one question staid "How will nature respond to these conditions?"Answer to that question require extensive knowledge of processes, their hierarchy on different time and space scales, which can have an effect on present GHG concentration and exchange. The exchange of GHG between biosphere and atmosphere is the most intense in the contact area where are most of the sinks and/or sources of mass and energy located. The concentrations and fluxes of reactive and non reactive GHG in the land-atmosphere system are controlled by complex interactions between emissions, turbulent transfer, dry deposition and chemical transformations. All these processes are highly dependent on the contact area characteristics homogeneity and isotropy, as well as morphological, aerodynamic and thermal characteristics. Since forests are one of the biggest sinks and sources of the mass and energy on the land, it is important to describe their influence on generation, degeneration, segregation and exchange processes of GHG in numerical models on physically correct manner. For the correct numerical interpretation of physical and chemical processes, their interaction and influence on GHG exchange within biosphere-atmosphere system, we have developed MLC-LAPS Soil-Vegetation-Atmosphere Transfer (SVAT) model. Model was used to calculate GHG fluxes and to assess influence of the different forest crown shapes on intensity of gas exchange. Important finding is crown shape which can act as maximal GHG sink.

Analysis of atmospheric instability indices based on radio sounding and ALADIN data, weather types and lightning detection

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A use of the instability indices of the atmosphere has a long tradition in the forecasts of deep convection by displaying a convective activity through a single number. A calculation of the instability indices can be done either from radiosoundings, numerical atmospheric models or on the basis of satellite data. Here we have used radiosounding data for 7 stations (Zagreb, Zadar, Vienna, Budapest, Szeged, Udine and San Pietro Capofiume) in a 7-year period (1st January 2007 – 31st December 2013), trying to estimate instability indices thresholds (by stations, season and time of day) and correlate them with measured lightning. The instability thresholds (for LI, CAPE, CIN, KI, TT, SI, SWEAT, BRN, TPW) are found using the frequency distribution method. We have found acceptable probabilities for successful convection prediction using noon sounding data (e.g., for LI <1°C, KI>27°C, TT >46°C, SI <3°C). The most typical weather regimes associated with lightning are the precipitation regime and almost non-gradient pressure field (NG). Regimes which include high pressure formations are relatively rarely associated with convection. The most common flow type for days with lightning is the SW wind associated with large SWEAT index (> 161). While the largest average values of CAPE, LI, KI and TPW indices occur within NG, the greatest average values of the SWEAT index have been found during the precipitation regime. An additional comparison between radiosonde and ALADIN model for increased set of indices showed that the ALADIN model has been successfully predicted indices that are mainly derived from temperature and wind at significant levels. Weaker results were obtained for the indices that are dependent on the specific levels, e.g., the level of condensation.

Modeling Water Balance Components in Eastern Croatian by Palmer method

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Eastern Croatian regions are leaders in agricultural productions and simultaneously exposed to various atmospheric impacts. Although stormy weather damages crops locally or floods wider areas, the lack of precipitation combined with high temperatures are usually the key factor destroying crops and plantations in the entire region during the second half of the vegetation period. Either the excess or the lack of precipitation/water negatively influences the agriculture and the life in general. As in any aspect of the nature, the balance is critically needful. We have witness many dry periods even droughts one the one side and severe weathers and floods on the other. There are many technological solutions available and could be developed to ease the consequences of such extreme weather phenomena that occurs more and more on the regular basis. In order to interfere and mitigate the uneven time and spatial distribution of water, first of all we need to understand water circulation and balance and to model it. I used Palmer's method in order to quantify water balance components in the eastern Croatian region. I refined method by setting into the account more corrective factors in order to include influence effects of the wind and specific soil type. Constrained by the meteorological data availability, I will focus on getting three products: one hundred years' time series of water balance components showing the trends at one meteorological station; comparison of components of two climatological periods on few stations; and spatial distribution map of the components for the region.

Comprehensive observation experiment for drought/arid land-surface process and atmospheric boundary-layer characteristics

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Drought is one of the main natural disasters in China. The lack of scientific understanding of land-surface process and PBL characteristics during dry-humidity or humidity-dry conversion periods as well as complete procedure of drought are often exposed due to the sparse observation site and sufficient high spatial-temporal resolution observational data. So, a national major scientific research project of Public Welfare industry (Meteorology), China Drought/Arid Meteorology Scientific Research Program (CDMSRP), has been started. And the first phase of this project -- Drought Related Process and Disaster Caused Mechanism in North China (GYHY201506001), in which set the comprehensive observation and experiment for drought/arid land-surface process and PBL characteristics, is conducted by Institute of Arid Meteorology, CMA, Lanzhou. Based on the project, a 'V' type layout design of major experiment area were set along the direction of 'NW-SE' (winter monsoon) and 'NE-SW' (summer monsoon) in north China. The comprehensive observation and experiment will be carried out at 3 key stations, 10 primary stations and several weather stations in this "V" type region to improve and examine the parameterization scheme of LSM and regional climate model. Therefore, the accuracy of drought monitoring and prediction will be improved through the scientific understanding of the land- surface processes and boundary layer characteristics based on the drought/arid comprehensive experiments. Keywords: Drought/arid comprehensive experiment; 'V' type layout design for observation area; Land-surface and PBL characteristics; Arid and semi-arid regions of North China.

Land-surface–atmosphere relationships: The Hungarian perspective

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The Pannonian Plain, as the largest Intra-Carpathian Plain, is the lowland part of the Carpathian Basin. It includes all of Hungary as well as peripheral areas of Slovakia, Ukraine, Romania, Serbia, Croatia, Slovenia and Austria. The natural vegetation has a typical mosaic-like structure with many Pontian and endemic floral elements instead of classic zonal arrangements because of different climatic influences and the sheltered position owing to the surrounding mountains. Beside the vegetation the soil is also specific, that is, it unequivocally differs from the soils outside of the region. These region-specific land-surface features induce such shallow and deep convection processes, which are also, to some extent, region-specific, at least in terms of the diurnal change of planetary boundary layer height and the spatial distribution of convective precipitation. In our presentation, the above given statement is documented by results obtained by WRF (Weather Research and Forecasting) modeling system. These numerical simulations refer to shallow and deep convection events occurred during last summers in the Carpathian Basin. We showed the fundamental role of soil moisture content and evapotranspiration in regulating land-surface–atmosphere feedback processes.

A basin-wide cold pool in the Pannonian Basin: a study using ECMWF analyses

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The Pannonian Basin is a large structure of about 600 km of diameter, comprising a large flat plain surrounded by well defined mountained ranges, that results in an almost closed structure. Between autumn and spring, anticyclonic situations favor the formation of a stagnant mass of air within the limits of the Basin, that often leads to fog events over the whole area. In this work, we analyse some events of relatively persistent anticyclonic conditions over the Basin using data form the analyses of the ECMWF, at a horizontal scale of 0.16°. We use two late autumn cases in 2011 and 2013 to follow the evolution every 6 hours of the air mass confined in the basin, focusing in the establishment of a cold pool that grows in height until almost the top of the surrounding mountain ranges. We compare these results to a summer 2015 anticyclonic case. The development of barocline flows close to the surface within the basin during these events are also inspected. Comparison of the analyses to the available surface layer data shows that the ECMWF analyses miss the near-the-ground circulations in some particular conditions.

Multicopter measurements in the PABLS15 campaign

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The PABLS15 campaign in July 2015 was dedicated to the dinocturnal cycle of the stable atmospheric boundary layer (ABL) in the Pannonian plane near Szeged (Hungary), close to the Serbian border. The setup of the campaign included surface budget stations, a tethered balloon and two multicopter remotely piloted aerial systems (RPAS). During 4 IOPs, the balloon was operated either with its own sensor package (T, RH) or with an Graw radiosonde from Hungarian Meteorological Service. The multicopter RPAS sensor packages provide fast thermocouple temperature sensor and RH sensor (OWL multicopter), and standard T and RH sensors (BHS multicopter). Several test flights were also done using BHS multicopter and Graw sonde. During the IOPs, we studied the boundary layer evolution for the evening transition (IOP 1, IOP 4) or for the evening and morning transition including the night (IOP 2, 3) with up to 24 flights per night. Multicopter RPAS are used for ABL investigation since 2011 by HSOWL and it has been demonstrated that they are capable of sampling meteorological and air chemical parameters from close to the ground up to several hundred meters above ground level if operated in a suitable way. Our multicopters use four propellers driven by electrically powered motors. The total power consumption is about 150-250 W for normal flight patterns and moderate wind conditions. Depending on the capacity of the battery and the system setup, flight times up to 45 min are possible. In the PABLS15 campaign, we were flying vertical profiles only with a vertical speed of 1-2 m/s depending on the response time of the sensors, resulting in flight times of less than seven minutes per flight. Night time operation of the RPAS is made possible due to suitable illumination which allows the identification of the multicopter's orientation, if required. All flights were supervised by a safety pilot. One advantage if compared to tethered balloons is the multicopter's capability of flying horizontal flight patterns and really vertical profiles even in windy conditions. On the other hand, the disadvantage of the propellers' downwash mixing the air has to be taken into account. It can be coped with suitable flight patterns, as can be shown by simoultaneous flights of tethered balloon and multicopter or by comparing the results with other, e.g. remote sensing sensors or a meteorological mast. We will show preliminary results showing clearly the evolution of the boundary layer during the IOPs. (1) University of Applied Sciences Ostwestfalen-Lippe, Höxter, Germany (HSOWL), (2) Eötvös Loránd University, Budapest, Hungary (ELTE), (3) Bolyai High School, Senta, Serbia (BHS), (4) University of the Baleares, Palma de Mallorca, Spain (UIB).

Impact of Kopački rit water area on climate conditions

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Previous study of climate conditions of the broader area of Kopački rit Nature Park showed rather evident spatial diversities. Distances from the large Kopački rit water area determine most of the diversities. This study shows some of them which are the most impressive. For that purpose analysed are climate conditions at the closest main meteorological station in Osijek (Čepin) during 1981-2010 climate period, as well as the conditions in Osijek, Tikveš (station Kopački rit) and Grabovac (station Brestovac Belje) over shorter period (2004-2013) which is the only one with overlapping of the work time of all three local meteorological stations. For better understanding of the influence of Kopački rit water area on microclimate needed are long-term data (thirty years long) and meteorological monitoring established as close to the location of interest as possible. On the other hand, for the research of microclimate of Kopački rit itself, meteorological measurements at few more specific and prevailing types of terrain inside the Nature Park would be useful.

Measurement of soil CO_2 emissions in Croatia

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The agricultural sector is a source of greenhouse gas emissions that directly affect the global problem of climate change. Soil-plant-atmosphere interactions i.e. the boundary between the pedosphere and atmosphere is site of carbon exchanges. The studies have shown that factors such as agrotechnical measures, agroclimatic factors, crop presence, crop type and soil properties have influence on soil CO_2 emissions. Irregular and irresponsible agricultural practices, such as excessive tillage and improper fertilization often leads to soil carbon loss and increased CO_2 emissions to the atmosphere. It is important to remark that soil has major role in the fight against climate change as soil is the second largest carbon reservoir, containing twice as much of carbon in relation to the atmosphere and three times more than vegetation, and is also an important sink of atmospheric CO_2. The reduction of CO_2 emissions by soil carbon sequestration is of primary importance as agricultural and forestry practices could remove atmospheric carbon by sequestration and thus mitigate the climate change by maintaining and/or increasing the amount of carbon stored in the soil and plant material. Due to the lack of research and national data related to the soil respiration, a research under the project "Influence of Different Land Management on Climate Change" was conducted in natural agro-climatic conditions in the vicinity of Daruvar and Sisak. The impact of different tillage methods and applied mineral fertilizer doses, in different seasons (seasonal variations) and different crop types (wheat, corn, triticale / triticale, double-crop soybeans in hot barley) was studied. CO_2 concentrations were measured near the soil surface, by in situ method with static chambers, which, to our knowledge, has nobody so far in Croatia studied.

Climate and climate change of the twentieth century in Hungary

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Climate and climate change of the twentieth century in Hungary were investigated using Feddema's (2005) climate classification method. The method was applied in two ways. In the first case, we used its original form, which is suitable for global scale analysis (F-GS). In the second case, the criteria of the method were slightly modified in order to mesoscale classification purposes (F-HU). In both version, the potential evapotranspiration was calculated using McKenney and Rosenberg's (1993) formula. We used monthly precipitation and temperature data from the Climatic Research Unit (CRU TS 1.2) database. The spatial resolution of the dataset is 10' (approximately 18 km). The climate of period 1901-1930 and 1971-2000 and the deviation of these two terms in global and mesoscale were examined. We determined that the mesoscale structure of the climate and the climate change process could be more successfully reproduced using the F-HU method than the F-GS method. We also showed that the most intense climate change in Hungary appears in Mecsek and Villány Mountains (parts of region Transdanubia), in Bükk Mountains (part of North Hungarian Mountains) and in the so called Danube Bend area.

Summer temperature extremes over Europe obtained from an ensemble of regional climate models

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European summer temperature extremes from simulations of six EURO-CORDEX regional climate models are analysed for the 20-year period, 1989-2008. The models were driven by ERA-Interim reanalysis at 50 and 12.5 km horizontal resolutions. Three categories of extreme temperature indices - absolute, percentile and duration - are derived from daily data. The results are compared with extreme temperature indices calculated from the gridded daily E-OBS data over Europe and for Croatia, where the indices are derived from daily observations at 20 Croatian meteorological stations. The ensemble spread is large, but the biases at 12.5 km simulations are smaller than at 50 km. When compared with validation data, model simulated temperatures and their percentiles are mostly overestimated over southern Europe and underestimated over northern Europe. Over Croatia, spatial distribution of indices at 12.5 km is closer to observed distribution than at the 50 km resolution.

Components of the operational flood forecasting system of the Kupa and Upper part of Sava river

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Meteorological and Hydrological Service of Croatia (DHMZ), Croatian Waters (CW) and Danish Hydraulic Institute (DHI) have developed operational flood forecasting system of the Kupa and Upper part of Sava river in Croatia downstream to Sisak including tributaries to these two rivers. Model runs automatically hourly on the MIKE11 platform (DHI) at Division for Hydrological Forecast within DHMZ. It is provided by real time data from hydrological and meteorological stations, forecasted data from NWP models ALADIN-HR and ECMWF, and Slovenian upstream data of the Sava river as inputs. The model results of water level and discharge flow (forecast) are issued automatically each hour for the next 4 days for the hydrological stations according to the State flood defense plan (Croatian gazette, 84/2010) and The main implementation plan of flood defense (CW, 07/2015).

Projected climate change consequences in extreme runoff characteristics

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Projected changes in regional climatological conditions are likely to modify the different processes of the whole hydrological cycle (especially runoff), and may result in various environmental and socio-economic hazards (e.g., floods, landslides, droughts, water scarcity, sustainability of food production). In order to decrease the overall exposure to potential future damages, it is essential to estimate and evaluate future climatic trends and prepare detailed assessments of hydrologic responses, with special regard to the runoff extremes. Thus, this study focuses on impacts of climate change on runoff extremes over a relatively small catchment area. The applied methodology is shown for the Zagyva catchment located in the northern part of Central Hungary. For the investigation the DIstributed WAtershed (DIWA) hydrological model is used, considering several aspects i.e., topography, land use, soil type. Historical meteorological and runoff data are available for 30 years to analyze trends in the recent past. Future climate simulations are provided by the RegCM4 regional climate model (taking into account RCP scenarios) adapted for the Pannonian Region. First, calibration and validation of DIWA distributed hydrological model are completed for the joint watershed after the confluence of the two small Hungarian rivers (until the cross-section located in Jásztelek, Hungary at 47.5°N 20.0°E) using historical meteorological and runoff data. After that, characteristics of extreme hydrological events in the past and in two future time periods for 30 years are assessed. Finally, statistical analysis based comparison of observed-past, modelled-past and modelled-future runoff data is evaluated for the catchment of Zagyva.

Relation of radar and hail parameters in the continental part of Croatia

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Continental part Croatia is exposed, mainly in the summer months, to the frequent occurrence of severe thunderstorms and hail. In the 1960s, aiming to protect and reduce the damage, a operational hail suppression system was introduced in that area. The current protected area is 26800 km2 and has about 580 hail suppression stations (rockets and ground generators) which are managed with 8 radar centres (S-band radars). In order to obtain objective and precise hailstone measurement for different research studies, hailpads were installed on all this stations in 2001. Additionally the dense hailpad network with the dimensions of 20 km x 30 km (1 hailpad per 4 km2), was established in the area with the highest average number of days with hail in Croatia in 2002. This paper presents analysis of relation between radar measured parameters of Cb cells in the time of hail fall with physical parameters of hail (max. diameter, number of hail stones and kinetic energy) measured on hailpads in period 2002 -2014. In addition are compared radar parameters of Cb cells with and without hail on the ground located at the same time over the polygon area.

Pannonian Atmospheric Boundary Layer Studies (PABLS): some findings of the 2013 and 2015 campaigns

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Two experimental campaigns exploring the characteristics of the Atmospheric Boundary Layer have taken place in the Aerodrome of Szeged, a city very centrally located in the Pannonian plain. The 2013 experiment happened in late autumn, with special instrumentation displayed during two weeks, which included surface layer and soil measurements, and with few days of intensive observation using soundings and UAVs. That first campaign is under analysis and has already produced several interesting results that will be summarized in the poster: study of the relation of local and elevated turbulence with recorded infrasound, successful use of UAVs as sounding devices, cold air intrusions in clear calm nights, and the combined use of data and model to explore the time-space evolution of the Pannonian basin scale cold pool. Much more recently, in summer 2015, a similar display was repeated during the months of July and August, that included one week of intensive observations with soundings and UAVs between July 10 and July 17. These particular days allowed to measure several canonical episodes of windy convective boundary layers, weakly stable nights, and evening and morning transitions, compiling a nice set of likely reference cases. The following weeks had several episodes of high pressure systems over the region, that allowed well defined summer diurnal cycles to be sampled with the instrumental display left there by some of the participating institutions. They will be used in further data analysis and combined with numerical model outputs.

A New Micrometeorological Research Facility at the New Maslenica Bridge

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While bora macro-scale and even meso-scale features have been intensively investigated in the past few decades, there are only few papers in the literature addressing the bora related turbulence. One of the reasons for this inadequacy is the lack of measurements suitable for micro-scale investigations. Those are high-frequency measurements of in situ wind speed and temperature in space (e.g., aircraft measurements) and in time (single point ground based measurements on e.g., meteorological towers/masts). Therefore, Department of Geophysics at the University of Zagreb conducted several projects in the past ten years within which high-frequency measurements of the wind speed and temperature along the eastern Adriatic coast have been performed. These are single point measurements at the town of Senj, Vratnik Pass and Pometeno Brdo (hinterland of the city of Split). However, all of those measurements were performed using sonic anemometers mounted on the towers/masts 10 m and higher above the ground, leaving the turbulence structure of the bora wind below 10 m unknown. Here we present a new state-of-the-art micrometeorological tower installed 200 m at the front of the new Maslenica Bridge. The tower is 10 m tall and is equipped with three levels of Gill WindMaster ultrasonic anemometers (2, 5 and 10 m) gathering the 3D wind speed and sonic temperature with the sampling rate of 20 Hz.

Assessment of net radiation from routine measurements in the Panonian Region

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The aim of this work is to discuss several different procedures for calculating radiation from routine weather measurements and observations. First of all, we compared estimated and measured solar and net radiation using the long term dataset from the climate reference station near Debrecen (Hungary). Afterwards, we compared estimated and measured long wave radiation. Than we recalculated net radiation from the sum of global radiation, long wave down-welling radiation, reflect solar radiation and up-welling longwave radiation. The measurement program of the reference climate station includes (i) standard meteorological variables (as synoptic station), (ii) profile measurements (wind speed, temperature and moisture at different heights from 0.5 up to 10 m above ground level), (iii) high accuracy radiation budget components, (iv) infra-red surface temperature, soil temperature and moisture profiles and soil energy budget measurements, (v) determination of energy budget components using the eddy covariance (tau, H, LE) and/or the Bowen ratio methodologies. We believe that our contribution i) can become significant for data quality control and ii) may help in understanding and bridging differences between point measurements and atmospheric models for all radiation components, SLP, as well as state variables, especially temperature and wind, in our region.

Short Summary

The GEWEX-promoted workshop on the Climate System of the Pannonian Basin took place at the Faculty of Agriculture of the University of Osijek during 2.5 days (Monday 9 Nov to Wednesday 11 Nov 2015). It was organized by the University of Osijek, the Croatian Meteorological and Hydrological Service, and the Geophysical Institute of the University of Zagreb. 56 scientists of the Pannonian region attended the workshop, that had 23 keynote talks (54 authors) and 24 poster presentations (75 authors), followed by a discussion session on Wednesday.

The first day talks made a review of the current state-of-the-art of the different relevant research subjects for the workshop, namely atmospheric circulations, climatological characterization and modelling, air quality issues, hydrological monitoring and modelling, and agricultural practices and needs.

On Tuesday the status of the observational networks was discussed, as well as the review of some of the research infrastructures of the area. The research and operational past recent and current consortia were also introduced to the audience. In the afternoon, after an inspiring lecture by Prof. Mesinger, a poster session was held where some of the most recent research efforts could be discussed among participants.

Wednesday morning saw a two-step discussion session. In the first part a diagnosis of the current status of the research and operations related to the Pannonian Climate System was made, and it was concluded that the community has the necessary size, scientific level and will to undertake a supranational action at the scale of the Pannonian Basin. This action may be organized as a Regional Hydroclimate Project (RHP) under the umbrella of the GEWEX Hydroclimatological Panel. This initiative, with the acronym "Pannex", was seen as a good opportunity to foster cooperation between the different institutions and exchange of data, knowledge and expertise between partners, as well as a platform to obtain funding for the related activities.

The second part of the discussion aimed to establish the main flagship science questions and cross-cuts to define a framework for this collaboration. Five main topics and three cross-cut actions were defined that may give room to most of the scientific and operational activities while providing outputs of interest for the society. These subjects are listed as annex I to this short summary.

Finally, some agreements to proceed further were taken. A Pannex White Book (PWB) that develops the ideas expressed in the workshop must be prepared. A first draft of this PWB will be discussed in a meeting to be held in Budapest in the second half of June 2016, hosted by the Department of Meteorology of the Eötvös Loránd University at Budapest. A core group, namely the International Planning Committee (ICP), was proposed to manage the first steps of this

action (members listed in annex II). The outcome of this workshop was to be reported to the GHP meeting at Endebbe (Uganda) in the following week for discussion. Once the PWB is under way, an implementation plan shall be defined. The status of the action must be reported by a representative of the ICP to the GHP general meeting in fall 2016 at Paris.

The workshop was closed at noon, the attendees expressing their gratitude to the organisers for the great work made.

(Summary written by JC, dated Nov 23rd 2015)

Annex I

Flagship Questions (FQ) and Cross-cut actions (CC)

FQ1: Adaptation of agronomic activities to weather and climate extremes

* Weather scale predictions of yields and plant phenology
* Response to climate change (farming practices, crop types, pests and diseases)
* Water management and irrigation
* Land and soil use changes
* Perception of agricultural stakeholders and evolution of European policies
* Preserving ecological services

FQ2: Understanding of air quality under different weather and climate conditions

* How does a warmer climate affect air quality and human health
* Interaction of air quality and water cycle
* Interactions with agricultural practices (sol, water and air)
* Physics and chemistry of the boundary layer; improving forecasts
* Refinement of emission inventories
* Perception of populations, urbanization

FQ3: toward a sustainable development

* Preserving ecological services
* Hydropower potential evolution
* Wind and solar energy potential
* Biomass production and conflict with agronomic needs
* Building the infrastructure for forecasting and coordination of the energy production
* Evolution of the energy needs (cooling and heating) in a warmer climate

FQ4: water management, droughts and floods

* Evolution of precipitation and temperature (weather) extremes and risk assessment
* Understanding the water cycle of the Pannonian basin (hydrological perspective)
* Hydrometeorological forecasting and early warning systems
* Anthropogenic influence (dams, reservoirs...) on the hydrological cycle
* Agronomic and environmental practices: water quality and usage
* Regulation of Danube and tributaries: management of floodplains
* Aquifers: sustainability and current usages

FQ5: Education, knowledge transfer and outreach

CC1: Data and knowledge rescue and consolidation

CC2: Process modelling

* Quantifying surface energy and water budgets

* Atmospheric chemistry
* Land-atmosphere interactions
* Precipitating systems
* Crop modelling
* Hydrological modelling

CC3: Development and validation of modelling tools

* Large-scale circulation: from weather to seasonal
* Climate change: decadal to centennial

Annex II

Proposed International Planning Committee

Branka Ivančan-Picek (DHMZ, Croatia)

Mónika Lakatos (OMSZ, Hungary)

Adina-Eliza Croitoru (Babes-Bolyai University, Romania)

Danijel Jug (University of Osijek, Croatia)

Vladimir Djurdjevic (University of Belgrade, Serbia)

Tamás Weidinger (Eötvös Loránd University at Budapest, Hungary)

Ivan Güttler (DHMZ, Croatia)

PannEx webpage: https://sites.google.com/site/projectpannex/