Abstracts

Climate Change and Local Level Adaptation Strategies in Hungary

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At the Institute for Sociology, Hungarian Academy of Sciences, I have been studying climate programs since 2003. From September 2004 to June 2005 I was a guest of the British Academy in the United Kingdom where I studied local-level climate change activities in this country. After returning to Hungary in 2015 I created the "Climate-friendly Municipalities" research project which was subsidized by the Institute. The aim of this project was to study the social and economic factors that act to promote or hinder local-level social resilience. I used action research as a method of inquiry.
The first steps of the "Climate-friendly Municipalities" programme were successful and with five municipalities we formed the Hungarian Association of Climate Friendly Municipalities in 2007. The Association had 30 members in 2015, located in different parts of Hungary.
Five municipalities with the support of the Institute and in collaboration with local inhabitants, who formed new NGOs, called "Climate circles", have prepared their local-level climate change strategies and related action plans. The "Climate circles", cooperating with the local leaders, was an important social innovation of this program. In this way they undertook about 30 different activities, most of them were part of the adaptation strategy. For instance: emission calculation, green transport program, introduction of a local currency, heat and UV alarm plan, bicycle path, local food markets, climate friendly shops.
After ten years research I concluded that current social and economic conditions are robustly hindering local-level social resilience. Most of the local leaders know very well, that the municipalities have to be prepared for natural changes, but they did not see real possibilities to take the necessary steps.
In my presentation I will speak about the reasons of this special situation, which are true not only in Hungary but for all consumer societies.

Keywords: *local level adaptation, climate circles, social and economic conditions*

Comparison of ERA-20C and ERA-Interim reanalysis datasets

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To battle climate change it is really important to monitor as precisely as possible the potential scenarios of the future. To meet this need reanalyses were improved in the 1990s. By using reanalyses we have the opportunity to verify the results of previous numerical models with the available new technologies. In this way now it is possible to get a more accurate picture of the atmosphere's past and by this its future state as well. Reanalyses not only help to represent the conditions of the atmosphere more precisely, but they also help to recognize the errors of the numerical models. All these progresses are the basics of getting precise results of global climate models. Thanks to the innovation of data-assimilated methods and further technical developments several reanalysis projects were improved in the last decades.

In our current studies we are making a proper, comparative study between the two most modern ECMWF reanalysis datasets (ERA-Interim, ERA-20C). In the first step we assigned three periods of ERA-20C (1901–2000, 1901–1950 and 1951–2000) where we examine several selected parameters. We also assigned a collective period from both ERA-Interim and ERA-20C (1981–2010). Four different meteorological parameters – 500 hPa height, 850 hPa temperature, mean sea level pressure, and ice coverage in the Arctic- Circle regions were investigated in our study. Emphasis is also placed on extreme weather situations. Firstly we are monitoring the detectability and the changes in frequencies of rapid cyclones in the period 1981-2010 collectively in both reanalysis datasets. Besides we examine some selected cyclones' frequency and spatial location in three periods of ERA-20C (1901–2000, 1901–1950 and 1951–2000).
By the results we can recognize the strengths and weaknesses of the two reanalyses. It is a great benefit for all the reanalysis users, such as climate researchers, and the developers of climate modelling and reanalysis, because as our results point out these miscalculations and uncertainties, they support the development of new reanalysis products.

Getting across our message about climate change

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Climate change has implications for weather-related risks and changed climatic conditions are expected to affect our society over a broad range of sectors. An optimal decision-maker shows an appreciation for a changing baseline, but our experiences suggest a resistance to new insights about climate change and its consequences. There are a number of challenges, which may be linked to problems concerning communication, prejudice, education, psychology, and perception of importance. There are also some decision-makers who do recognise the value of impact assessments based on meteorological data in different sectors. We raise the question for the need of training, education of decision makers and increased co-operation. Could that entail outreach through media or involvement in the professional society "Tekna"? Such activities also need to account for the perspective of a decision maker. Traditional approach has been to produce sets of data, but most decision-makers need answers and information rather than data itself. Two-way dialogue and co-production of knowledge have been proposed as the best way of sharing knowledge, and we can point to an example of "distillation" from CORDEX-ESD workshop in Cape Town 2015 where representatives from ministries of the Tanzanian government brought with them a set of issues: building of dams, agriculture and flooding. Other examples include a report commissioned by The Arctic Council (Adaptive Actions in a Changing Arctic; AACA) work associated with hydropower production as well as projects like ClipC, EU-Circle, and COST-VALUE.

Estimation of the extreme meteorological and hydrological conditions in Slovenia in the future

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Successful climate change mitigation and adaptation require the knowledge of the change of extreme weather events in the future. The average changes of meteorological variables due to climate change are usually not enough for this kind of future planning. At the Climatology department of the Slovenian Environment Agency we have already analysed how the weather will change on the average. The analysis was based on regional climate models simulations over Slovenia in the period

2012–2050 that became available through the ENSEMBLES project. We focused mainly on future temperature and precipitation projections. Uncertainties of the future climate were estimated with the analysis of the ensemble of the climate models. Model results in 25 km resolution were downscaled to 1 km resolution with empirical methods. Requests from our clients initiated our effort to estimate the change in the future extreme weather events. Agency has just started a project for estimating extreme meteorological and hydrological conditions in the future, up to the year 2100. The meteorological part of the project comprises downloading and preparation of the daily regional climate data from the ensemble of models simulations of the Euro-Cordex project, bias correction of the regional models results, estimation of the future regional climate, drought indices, change in extreme precipitation and estimation of the change in future extreme precipitation events. All analysis will be done for two representative concentration pathways (RCP 4.5 and 8.5) on a daily models data. The data is going to be the basis for the future drought and flood analysis. Our poster will present the basic results of the previous climate change estimation and our goals for the ongoing project of estimating the change in extreme weather events.

The Hungarian CRIGiS project

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CRIGiS and two other projects were initiated to extend the National Adaptation Geo-information System (NAGiS) to further sectors. The aim of these projects was on one hand to develop a methodology which can be used to objectively quantify the effects of climate change in exposure, vulnerability and adaptation capacity for various sectors, on the other hand the integration of data layers prodeced by the new methodology into NAGIS database. CRIGIS project focused on three main areas: healthcare, critical infrastructure and tourism.
Our specific objectives were as follows:

- Studies on increased mortality caused by the heat waves;
- Analysis of the impacts of extreme weather conditions on the road accidents;
- Examinations of the effects of climate change on tourism.

The purpose of the project was to develop indicators according to above mentioned aspects. In the framework of the project climate indicators characterizing direct exposure were identified (extreme temperatures, extreme weather events). Indicators were also developed to measure the impact of weather events (surplus mortality, the number of accidents).The indicators provide important assistance in the development of health and tourism services, and planning for road safety purposes.
The indicators are based on data with different spatial resolutions: meteorological data uses 0.1x0.1° resolution grid, while the data connected with effects mostly refers to NUTS regions or roads. The basic data of NAGiS are also available on a 0.1x0.1° resolution grid, the additional data and some indicators had to be connected with layers representing different levels of aggregation in order to fulfill user demands. The indicators were calculated based on the present climate measurements, as well as the climate model estimations for future using earlier NAGiS data format as a standard. As a result, the prepared datasets are compatible with NAGiS system, and they can help in impact assessments, vulnerability and resilience tests related to climate change in new sectors as well. The climate model results were provided by the ALADIN-Climate regional climate model (RCM) applied at OMSZ.
The project was realised by the coordination of Hungarian Meteorological Service together with the participation of the National Public Health Center, the National Directorate General for Disaster Management and the Department of Climatology and Landscape Ecology, University of Szeged.

Environmental indicators of climate change impacts in the Carpathian Basin

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Climate change strongly affects the Carpathian Basin having clearly observed complex environmental impacts. Several environmental indicators were applied to show and estimate the rate and the frequency of the observed changes in the last decades. The long-term changes in water resource is an important indicator of climate trends and human impacts. The drier period from the beginning of the 1980s until the mid-1990s caused significant decline of groundwater resources mainly in the Danube-Tisza Interfluve. Low water periods became more frequent and decreasing discharge values are detected for lowland Hungarian rivers. Vegetation is also an important indicator of climate impacts. For example, the reduction of biodiversity and wetland habitats, and the transformation of habitats were observed in many places, in addition, agriculture faces serious yield loss in drought years. The environmental changes also influence the phenology, the spatial pattern and the distribution of vegetation. Hydrological changes also influence soil conditions. Dusting and decreased fertility of good quality chernozems can be identified in the Hungarian Great Plain. The observed aridification process can contribute to secondary salinization, and the increasing irrigation demand can result in the changes of the critical groundwater level.
Climate change and the observed environmental impacts contribute to increasing rate and frequency of natural hazards—e.g. drought, inland excess water, soil erosion and wind erosion — causing social, economic, and environmental problems. The problems are mostly related to the changing hydrological conditions. The lack of water during drought periods is harmful to all living organisms and results in reductions in agricultural yields. Excess water affects damages to agriculture, soil structure, and inundated urban areas. Due to the projected warming and the changing precipitation conditions, wind erosion on arable lands has become also an important natural hazard.
According to regional climate model simulations, Carpathian Basin will be exposed to increasing drought hazard, which will make this hazard probably the most serious hazard of the region. The changes in wind erosion and inland excess water hazards show less definite trends. Because of the projected increase in climatic extremes, high fluctuation of the hazards can be expected.

Keywords: *climate impact, environmental indicators, environmental hazards*

The effect of climate change on heatwave related excess mortality in Hungary at small area (NUTS4) level, 2021–2050 and 2071–2100

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According to the 5th Assessment Report of IPCC the greatest health impact of climate change will be heat related excess mortality. Therefore the prediction of future effects is an important tool in the adaptation process.
In order to assess the climate change related excess mortality, the daily mean temperature data at NUTS4 level based on the climate model in the National Adaptation Geo-Information System "NAGiS" and its extensions for the future periods 01.05.-30.09. of 1991–2020, 2021–2050 and 2071–2100, were provided by the Hungarian Meteorological Service. The Central Statistical Office gave the daily mortality data for the period of 01.05.-30.09., 2005–2014.
As we found difference between the frequency distribution of measured temperature and the present period of the climate model, therefore a correction was done assuring that the yearly sums of

excess heat contributing to excess mortality were the same in the observed and modelled present period. Based on the corrected threshold values of the modelled present period the changes in the future could be predicted.
According to the climate model the number and intensity of heat wave days will increase in relation to the present situation. The range of increase will be between 107% and 182%. Assuming the same level of sensitivity, this increase of heat wave days and intensity will predict the same level of increase of excess mortality, which will increase approximately 2.6-fold causing 2030 excess death cases compared to the period of 1991–2020.
The climate model predicts an increase of excess mortality in the range of 531% and 668% regarding exposure, meaning a 7.4-fold increase at national level, which corresponds to a yearly increase of excess death cases to 5800 compared to the 1991–2020 period.
The NAGiS database will help stakeholders prepare adaptation measures.

Keywords: *heat waves, climate model, climate change related excess mortality, small area level*

The seasonal prediction activities of the Copernicus Climate Change Service

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The Copernicus Climate Change Service will include a range of products derived from seasonal forecasts. This presentation describes the concept this service will be based on, its building blocks, the plans for development and a time line for the phase preceding implementation into operations.

Society, economy and climate change: lessons from the Long-term socio-economic forecasting for Hungary project

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Within the Adaptation to Climate Change Programme in Hungary financed by the EEA Grants, one of the sub-projects was to provide information on future socio-economic trends and its spatial variations for the National Adaptation Geo-Information System (NAGiS). This paper summarises some of the main epistemological, ontological and methodological challenges of building these data layers from the social sciences perspective.
On the epistemological level, current literature in social sciences has emphasised the situatedness of knowledge on climate change, i.e. how knowledge reflects different aspects of the social realities from which it comes. This also means that "lay" knowledge or spatially variegated local practices of people affected by climate change is as much important, as "expert" knowledge is. Spatial data layers on willingness to act against climate change has thereby become an important feature of our NAGiS development.
On the ontological level – i.e. what is climate change –, it is important to look at appearances of climate change as at the same time natural (physical) and social phenomena: nature does not exist outside society, and vice versa. In a geographical information system which aims to help strategic planning and the adaptation to climate change this understanding shall be reflected by the combination of certain data layers, inter alia. Also part of the ontological questions, the political ecology approach in social sciences has called for concentrating on political-economic processes in order to act against environmental injustice in connection to climate change.

Methodologically, it is highly important not to limit ourselves to one possible world view on present and future climate change and its socio-economic impacts. As we built NAGiS data layers it was not self-evident how much variety of the models we would like to show for users, or whether it is legitimate to offer more than one, significantly different datasets about the future, thereby making the work of climate adaptation planning more complicated.

Keywords: *climate change, NAGiS, social sciences*

Homogeneous tropospheric path delays from GNSS re-processing by Geodetic Observatory Pecny

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EUREF Permanent Network (EPN) was established in 1996, initially for the maintenance of the European Terrestrial Reference System (ETRS). Since that time it has grown up to 250 GNSS continuously operating stations and its utilization became much wider. A contribution to a climate research exploiting the tropospheric products could be one of future applications. However, it requests a long-term homogeneously processed data in order to avoid any interruptions or jumps in the tropospheric parameter time-series.
Recently, the 2nd reprocessing campaign was completed in support of a new realization of ETRS. Using global precise products, the EUREF reprocessing is closely linked to the similar re-processing coordinated by the International GNSS Service (IGS). Geodetic Observatory Pecny (GOP) performed the reprocessing of the whole EPN network and the period of 1996-2014 which was additionally aimed to support a climate research within the COST ES1205 (GNSS4SWEC project). GOP provided several variants with special focus on tropospheric estimates - VMF1 and GMF mapping functions were used together with different elevation cut-off angles and setting of horizontal tropospheric gradients. The processing strategy was enhanced in several aspects: 1) combining tropospheric parameters in midnights, 2) careful handling of the weekly coordinates of all stations when substituted for estimating tropospheric parameters and 3) providing a procedure to filter problematic stations (based on a consistency of combined coordinates). Results of the GOP reprocessing, including all available variants, will be described and evaluated using the powerful GOP-TropDB database system for an intra- and inter-technique tropospheric and meteorological parameter comparisons.

Adaptation support to forest management considering climate change information – results and challenges

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Recurrent droughts of the last decades have led to severe impacts in forestry in the sensitive and vulnerable low-elevation regions of Southeast Europe. Observed impacts are very likely to occur with increasing probability under projected climate conditions throughout the 21st century. Therefore the importance of complex, long term management planning and of land use optimization is increasing. In Hungary, silvicultural technologies and species preferences are prescribed by binding

regulation based on climate conditions that are assumed to be constant over time. Severe droughts and observed tree mortality shed light on the need to rethink forest management planning.
In order to suggest options for adaptation and mitigation, a GIS-based Decision Support System is under development in the frame of the joint EU-national research project "Agroclimate". Considering site conditions with special focus on the changing climate conditions, future distribution of the forest climate zones is determined and suggestions are made for the tree species selection. Reliable projections of health status, production, growth, and yield are also part of the system that are essential for the next decades in order to decide about sustainable forest tree species preference and to assess the economic impacts of possible species changes.

Keywords: *regional climate modelling, climate impact assessment, forestry, adaptation, decision supporting*

Introduction of Biome-BGCMuSo model

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The process-based biogeochemical model Biome-BGC was enhanced to improve its ability to simulate carbon, nitrogen and water cycles of various terrestrial ecosystems under contrasting management activities. Biome-BGC version 4.1.1 was used as base model. Improvements included addition of new modules such as the multilayer soil module, implementation of processes related to soil moisture and nitrogen balance, soil moisture related plant senescence, and phenological development. Vegetation management modules with annually varying options were also implemented to simulate management practices of grasslands (mowing, grazing), croplands (ploughing, fertilizer application, planting, harvesting), and forests (thinning). New carbon and nitrogen pools have been defined to simulate yield and soft stem development of herbaceous ecosystems. The model version containing all developments is referred to as Biome-BGCMuSo (Biome-BGC with multi-layer soil module). Case studies on a managed forest, cropland and grassland are presented to demonstrate the effect of model developments on the simulation of plant growth as well as on carbon and water balance.

Keywords: *model development, Biome-BGC, biogeochemical model, management, soil water content, drought stress*

Evaluating the impact of climate change based on the National Adaptation Geo-information System

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The National Adaptation Geo-information System (NAGiS) is a multipurpose geo-information system that has been developed to support policy-making, strategy-building and decision-making processes related to the impact assessment of climate change in Hungary. This tool aims to provide a sound basis for the elaboration of adaptation strategies and measures, as it contains reliable, objective information. The NAGiS has been established with the financial support of Iceland, Liechtenstein and Norway through the EEA Grants and the REC.
The three main parts of the NAGiS Portal (nagis.hu) are: a) a map-visualization system (with a resolution of 10×10 km, containing hundreds of layers which show the way different aspects of

climate change can affect certain areas of the country); b) a database (GeoDat) containing the calculation results based on modelling (exposure, sensitivity, expected impact, adaptive capacity and vulnerability); c) a meta-database facilitating navigation through different kinds of information (a sort of "data-map" about what to find and where).

The ERA5 reanalysis of the Copernicus Climate Change Service (C3S)

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ECMWF is in the production of a new reanalysis called ERA5 to replace the previous ERA40 and ERA-Interim reanalyses. ERA5 uses the latest ECMWF model version and data assimilation systems and has increased spatial resolution as compared to its predecessors. On top of the observations assimilated in ERA-Interim several reprocessed satellite observations are going to be used too. ERA5 is using a 4DVAR data assimilation system combined with an Ensemble of Data Assimilations (EDA) component for computing the flow-dependant background errors for the reanalysis system. EDA will also provide uncertainty estimation of the reanalysis products. The presentation is going to give an overview of the details of ERA5 and its promises for the users.

Experiences of co-operation with decision makers at the Norwegian Centre for Climate Services

Hans Olav Hygen
Norwegian Centre for Climate Services

Climate services have to be tailored towards the user needs, and there is only one way to get the user needs: Close interaction with the users. In Norway the main provider of background data for climate adaptation is the Norwegian Centre for Climate Services (NCCS). NCCS is a co-operation between The Norwegian Meteorological institute, The Norwegian Water Resources and Energy Directorate, and UNI-Research/Bjerknes Center.
As main user groups, NCCS has targeted governmental institutions and authorities from national to municipality level; road and railway authorities, as well as decision makers in important sectors like energy, buildings, health and primary industries. NCCS role in working with these groups is mainly structuring and tailoring the data for them and co-develop indices based on the users' needs and background knowledge. To provide counties and municipalities with updated information on local challenges in climate adaptation in different sectors, NCCS provides "Climate Profiles" for each of Norway's 19 counties. To improve methodologies for establishing tailored climate data and products for climate adaptation in collaboration with users, NCCS has initiated several projects with user involvement.
The presentation will highlight Norwegian experiences of co-operation with decision makers in municipalities with different competence in dealing with climate adaption; examples of tailored climate products, and prospects for enhanced background data for climate adaptation through novel projects funded by the Norwegian Research Council.

The application of RCM-driven hydrological model to the Uppest-Tisza basin

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Hydrology-related events are certainly sensitive to climate change. Since extreme hydrological conditions (e.g. long-lasting droughts, large floods, intense flash floods, low and high runoff characteristics) often result in severe socio-economic impacts, it is essential to estimate future tendencies in order to build adaptation strategies in time. For these estimations, cooperation of experts in hydrology and climate modelling is a key step.
To analyse the hydrological consequences of climate change, the DIWA (DIstributed WAtershed) hydrological model is driven by the RegCM4 regional climate model. DIWA, which is a physically-based, distributed model, considers several aspects, e.g. topography and its relevant derivatives (slope, aspect, local drain directions, etc.), characteristics of the streambed, land cover, three soil layers and their hydraulic properties, interception, snow accumulation and melt, infiltration, evaporation and transpiration, furthermore, surface and stream runoff. To run DIWA, meteorological time series of precipitation, minimum and average temperature are provided by the observation-based CARPATCLIM dataset (for calibration/validation) and RegCM4 simulations taking into account the new RCP scenarios (for prediction).
In this study, the methodology of coupling the hydrological and climatological models is presented for the Uppest-Tisza basin. First of all, the calibration (01.05.2000–30.04.2002) and the validation (01.05.2002–30.04.2004) of model DIWA are necessary for the target basin. For this purpose, discharge time series are evaluated at the Tiszabecs discharge station using historical meteorological data. The preliminary results, based on the CARPATCLIM database and RegCM4 simulations, are compared for the past. Our ultimate aim is to run the calibrated DIWA model for the future and compare the runoff characteristics of the two time periods (i.e. past and future). The final results can be used to provide recommendations for decision makers in order to mitigate climate change induced hydrological hazards.

Keywords: *hydrology, DIWA, RegCM4*

Modelling the impacts of climate change on shallow groundwater conditions in Hungary

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Global climate change is impacting on groundwater resources through the modification of water balance. Rainfall and temperature changes have direct influence on recharge and evapotranspiration, and indirect influence on groundwater withdrawals.
The goal of this study was to develop a methodology for the assessment of direct climate impact on shallow groundwater resources and to apply this methodology for the country-scale investigation of groundwater conditions in Hungary. The applied modular modelling methodology included the delineation of climate and recharge zones, calculation of water balances using hydrological models and the simulation of groundwater table with numerical models for various climate scenarios.
Natural-state conditions were simulated based on measured climate parameters and historical groundwater level calibration data. Predictive modelling was undertaken using regional climate model projections for three time intervals.

Regional climate model projections indicate rising annual average temperature and decreasing annual rainfall rates in Hungary until the end of the century.
Based on model simulation results, recharge rates are expected to decreased by up to 50 mm/year in mountainous areas. Predictive simulations also indicate significant water level drops in elevated areas such as the Alpokalja, Mecsek, Transdanubian and Northern Mountain Ranges. A more subtle water level drop was simulated along foothill areas, the Kisalföld, the Tiszántúl, and the Duna-Tisza interfluve.
The presented outputs are representative of groundwater conditions at the regional scale. The introduced methodology is valid for modelling climate impact on shallow groundwater resources at various scales.

Keywords: climate change, groundwater, recharge, modelling

Heating period features in Ukraine till the middle of the 21st century based on ensemble and individual RCM projections

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Information about climate change and its potential impact become an important component in the planning of sustainable development of any country. Currently, climate products are used in various sectors of the economy: agriculture, energy, transport, recreation, construction, etc. The increasing dependence on meteorological factors in modern society requires intensive development of applied climate research.
The aim of the presented study was to enhance the use of climate information for planning the development of the energy sector and to work out a methodology for using regional climate models (RCM) for calculating the special climatic characteristics, such as length and average temperature of heating period when the daily mean surface air temperature is less then 8°C, temperature of the coldest and the warmest 5-day periods, etc. All estimations were performed on the basis of individual and ensemble projections of 10 RCMs for five consequent decades from 2001 to 2050. In addition change of the same characteristics were examined for 30-year periods: standard 1961-1990, modern 1981–2010 and middle-future projection 2021–2050. Verification of RCMs against E-Obs dataset was performed for all periods till 2010, particularly for the first decade 2001–2010 verification showed that ensemble of 10RCMs in average for Ukraine gives less mean temperature (-0.19°C) and longer (+1.6 days) heating period, that considering as an allowable errors.
The expected increase in surface air temperatures in the first half of the 21st century will certainly lead to a change in the characteristics of the relevant regulatory duration of the heating season in Ukraine. Its shortening for 10-23 days in 2021–2050 compared to of Building Climatology Norms of 1961–2005 is projected in Ukraine. At the same time, more detailed in time and verified projection of 10 RCM ensemble showed that in the current period 2011–2020 compared to the first decade of the 21st century significant decrease in the average temperature and length of the heating period is not expected: space-averaged characteristics for Ukraine are -0,16°C and +8 days respectively. The alteration to the opposite trend held for temperatures starts in the period 2021–2030 and for the duration of the period only in 2031–2040. The average temperature of heating season is expected to increase everywhere in the country, mostly (> + 1°C) in the northern region, the Carpathians and the far east in the period 2041–2050 compared with 2001–2010. The duration of the heating period, excluding the High Carpathians, reduced by an average of 5 days, maximum - more than 14 days in the southern region.

Features of the presented special climatic characteristics were averaged for all 25 administrative regions of Ukraine and recommended for use in the development of new norms of heat consumption and long-term planning of energy development at the national and regional level.

Keywords: *climate change, heating period, RCM projection, energy sector, Ukraine*

Gridded observations for climate change studies in Hungary

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Understanding the recent climate trends is possible with analysis of high quality and representative climate data in time and space alike. The majority of long term series are inhomogeneous, using them for climate search purposes results in false outcomes. However neglecting the inhomogeneous series causes a huge loss of valuable information. The only way is homogenizing of the data series before using them in climate change purposes. Application of MASH (Multiple Analysis of Series for Homogenization, Szentimrey) guarantee the homogeneity of long term series used for climate monitoring in Hungary. The MASH was developed at the Hungarian Meteorological Service for quality control, homogenization and data completion.
The gridded data provide high resolution spatial information for climate change studies. The interpolation/gridding of climate data is carried out by method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis, Szentimrey, Bihari) at our Service. The MISH interpolation procedure is based on the principles that: gridded data can be created (interpolated) with higher quality if we know certain climate statistical parameters; the long climate data series make possible to model these statistical parameters.
The countrywide annual and seasonal temperature and precipitation changes are interpreted as the averages of trend values over the grid covering the territory of Hungary. Confidence intervals are also added to the point estimation of the linear trends. The tendencies of the temperature and precipitation extremes are presented on trend maps of several predefined extreme climate indices. An outlook to the Carpathian Region based on the results of CARPATCLIM project is presented too.
CARPATCLIM is an example of high quality, homogenized and harmonized gridded observational dataset. The project resulted in daily gridded dataset in 0.1°(~10 × 10 km) spatial resolution for 13 basic variables and 37 derived climate indicators (amongst several drought indices) in the period of 1961 to 2010 for the Carpathian region (cca. 500 000 km^2). The same methods were executed by each country participated in the project: the MASH for homogenization, quality control and data completion; and the MISH for gridding. The freely available gridded dataset with the description of metadata, the data rescue activity and the methodology can be found here: http://www.carpatclim-eu.org/pages/home. The project was led by the Hungarian Meteorological Service and supported by the JRC.

Impact of climate change on the forest fire nature of Ukraine

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The article presents the assessment change of climate factors, responsible for emergence and spread of natural fires in Ukraine. Defined the change of high and extremal fire danger level maximum duration, its regional and seasonal features and significance of this change. Research is based on daily data obtained from 187 meteorological stations for period 1981–2010.
Assessment of the influence of thermal, moisture regimes and weather events changes on quantity and area of wildfires, its possible changes and consequences until 2050 relatively to actual climate period using A1B scenario and estimation of uncertainty of these changes. Analysis performed on the most vulnerable to wildfire Kherson region.
It was found that the number and area of forest fires in Kherson region is largely dependent on the thermal regime, moisture and wind regime. The influence of temperature is decisive on the area of the fire and much less on their number. For example, the increasing of annual / summer average temperatures by 1°C can lead to an increase in the average area of the fire near 110% and 90% respectively. Increasing the number of days with atmospheric drought and heat (maximum temperature above 30°C) for 10 days can cause increase in average area of fires 130% and 80%. At the same time, air temperatures in September and October closely related to number of fires: increasing of month air temperature by 1°C can lead to 20% increasing of number of fires.
As a result of climate change analysis in Kherson region was found that over the past decade in the region has changed significantly thermal mode, moisture, wind frequency of weather phenomena that affecting the number and area of forest fires. These changes led to increase fire risks in the region. Evaluation of possible changes in these characteristics to the middle of the XXI century showed that the under SRES A1B scenarios could be expected further increase in temperatures throughout the year, growth in the number of hot days and sultry duration period. Since these processes are accompanied by increasing duration drought period, these changes significantly affect the fire risk increase - the number of forest fires and their area by the middle of the XXI century in Kherson can significantly increase.

Keywords: *climate change, impact climate change on the forest fire nature, increase forest fire frequency and area*

Climate impacts and adaptation challenges in hilly regions of NE-Hungary

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The presentation intends to provide an overview on a few related topics investigated in the recent years. They include statistical analyses of solar and wind energy potential, wine quality and quantity, fruit phenology and urban pollution in connection with variability and change of climate. All statistical estimates are motivated by a priori knowledge of relevant references.
For renewable energy potential empirical trends are established in a 30 years long warming period, based on validated series of CarpatClim data basis. Wine series are multi-correlated to various station-based and also gridded data to interpret potential of temporally and spatially resolved data. Fruit phenology observations are compared to inter-annual climate variations with the aim to establish driving variables. Urban pollution data are compared to circulation classification with background information of their frequency changes.

Keywords: *impact, Hungary, solar energy, wine quality, urban air pollution*

The study of heat wave related excess mortality in Hungary at small area (NUTS4) level, 2005–2014

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One of the major goals of the 2nd National Climate Strategy is to establish a National Adaptation Geo-Information System. Its special task is the assessment of heat related excess mortality at NUTS4 level in the present period (2005–2014).
The Central Statistical Office provided the daily mortality data for the period of 01.05.-30.09., 2005-2014. The daily mean temperature data for the same period at NUTS4 level were provided by the Hungarian Meteorological Service.
The heat wave related excess mortality was modelled by the 90th percentile of the frequency distribution of the daily mean temperatures, defined as threshold temperature. The excess mortality on days over the threshold was computed by extracting the mean daily mortality of cool days from the number of deaths on "hot days". The sum of effective temperature causing excess mortality was also calculated as the excess temperature on days over the threshold and the excess mortality/1°C increase of temperature was computed at NUTS4 level.
During 2005–2014 the range of daily mean temperature belonging to the 90th percentile was between 22.3°C and 27.2°C at NUTS4 level. Higher values were observed in the Great Plain. During the heat waves the mean values of excess temperature over the threshold were in the range of 1.45-1.82°C. The daily mean death cases were 1.89. Less than one death/day occurred in 67 small areas. The mean excess mortality was 15.8% during the heat wave days at NUTS4 levels. Besides some areas with no excess mortality, there were areas with excess mortality over 40%. At national level, daily mortality was higher by 51 cases on heat wave days than on cool days, which corresponded to an excess of 783 death cases. While the „baseline" mortality showed a characteristic spatial distribution, there was no typical spatial pattern of heat related excess mortality.

Keywords: *heat waves, excess mortality, small area level*

Decadal and centennial scale climate projection for the Carpathian Region taking into account RCP4.5 scenario

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Hungarian national climate and adaptation strategies have been revised, and a National Adaptation Geo-information System (NAGiS) has been established. This platform serves as a central data collection for various end-users, impact researchers, and decision makers on national level in Hungary. Simulations were carried out with the RegCM model at 10 km horizontal resolution at the Eötvös Loránd University and were incorporated into NAGiS. RegCM is a 3-dimensional, sigma-coordinate, primitive equation model, originally developed by Giorgi et al. Currently, it is available from the ICTP (Abdus Salam International Centre for Theoretical Physics).
In the framework of the RCMGiS project a continuous run has been completed for the 21st century assuming the RCP4.5 scenario. The corresponding CO2 global mean concentration level by 2100 is estimated at 650 ppm, which can be considered a moderate increase of atmospheric CO2 but still implies the exceedance of doubled preindustrial level. This presentation analyzes the temperature and precipitation outputs of RegCM simulation, and the temporal and spatial aspects of projected changes – both in the mean and extreme conditions – on annual, seasonal, and monthly scales throughout the 21st century.

The mean temperature is projected to increase in all time scales, also, a significant increase is projected in the number of warm extremes, while frost days tend to become less frequent. Changes in precipitation are more uncertain – when compared to our previous results, or other model simulations – but a restructuring of annual precipitation distribution is probable.

Keywords: *RegCM, RCP4.5, temperature, precipitation*

Education of and by climate change

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The presentation reviews a few different investigations performed on the media reflection of climate change and various possibilities for education of climate change, as well as applying climate change related topics to emphasise other issues of the various subjects of natural sciences. Media appearance of the anthropogenic climate has been investigated for six months in 2014, including the electronic media and internet. Very poor reflection of the topic and especially of the reality of the reasons and implications had been established. Education of climate change includes topics of the university education in Eger, as well as an extended experiment in three elementary schools. Results of the education (before, after and 1.5 year later) are quantified establishing that about the half of the additional knowledge remained in the head of the pupils. For education by climate change there are lists of topics biology, geography and physics, as well as of the so called key competences which can be developed by using (broadly understood) climate change topics. Also a newly initiated experiment based on personal contacts with the pupils will be introduced.

Vulnerability of natural landscapes to climate change – a case study of Hungary

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Hungary is at the interface of the forested and the steppe biome hosting the forest steppe biome as well. This leads to a highly variable and rich natural landscape composition. Thus the change in temperature and precipitation conditions expected due to climate change will likely greatly influence the location of border of these biomes and thus the composition of natural landscapes.
We identified natural habitats likely to be most sensitive to climate change by bioclimatic modelling based on their current distribution and the abiotic characteristics of their locations. Potential impact given two regional climate models have been estimated by applying the models for future climate conditions. Two time periods were considered: 2021–2050 and 2071–2100. Additionally, adaptation capacity was estimated based on current patterns in the landscape. A vulnerability assessment of natural landscapes has been carried out to assess the spatial variation in climate change impacts within the country.
Highest vulnerability was found for mountains and in general in the western part of Hungary, while Eastern Hungary and particularly the Great Hungarian Plain appeared to be less vulnerable. This can be associated with the current landscape composition. Landscapes where forests dominate are more vulnerable, because the potential impact is higher and adaptation capacity lower. Grasslands may even benefit from climate change leading to lower vulnerability of the lowlands hosting them.

We can conclude that climate change is likely to greatly influence our landscapes by differentially affecting habitats from the forest and grassland biome, shifting potential vegetation towards grasslands.

Keywords: adaptive capacity, forest, grassland, natural habitats, potential impact

Mission possible: cooperation with climate model data users

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The regional climate modelling group at the Hungarian Meteorological Service has been involved in a number of co-operations with the community of climate model data users in the last ten years. These liaisons were mostly realized within the framework of international projects. However, until the recent years experience with the users only sporadically occurred in Hungary, and exclusively in a few sectors. With the establishment of the National Adaptation Geo-information System last year, a better cooperation started with the users through a coordinated adaptation system. There is definitely a place for improvement in the system, in the communication of usability and the data served. In the presentation we put emphasis on the expertise provided within mainly the recent RCMGiS and CRIGiS national projects, which confirmed our earlier conclusion that every user needs an individual solution how their requests could or could not be satisfied.

Educating Climate – A Guide for Climate-adaptive Urban Planning

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In the current EU planning period (2014–2020) urban regeneration projects based on climate adaptation receive big emphasis. Besides we have a wide knowledge considering urban climate, urban heat island. Researches have also proven the effectiveness of urban parks, green facades and roofs in providing shade and shelter for the urban dwellers and in also having an important role in creating cooler microclimate mainly during crucial summer period. These days there is an indisputable need for connecting the knowledge of researchers with that of the planners, to ensure the realisation and practical application of severe research results. Urban planners seem to have a lively interest towards climate-conscious planning, but they have to face a lack of information regarding the climate-adaptive tools and their microclimatic effects. In spite of that climatologists have been involved in the topic many years now; it hasn't come to the point to develop an articulate, easy-to-use planning system for architects and urban planners. Considering climate-related issues hasn't been a requirement in planning instruments in Hungary so far.
Here comes the importance of dissemination and education in order to increase climate awareness and competence of urban planners and decision makers. Our work therefore aims to set up a system of climate-adaptive planning instruments and their impact on urban microclimate – converting the results of theoretical researches – which could help urban planners in everyday planning routine. The guide should help the detailed calibration of green infrastructure elements and nature-based solutions in urban environment. After creating the guide for climate-adaptive planning a

testing among urban planners is needed in order to have adequate feedback and for being able to improve the quality and usefulness of the system of indicators. The guide should be available for a circle of students and planners, so they are able to use the guide in practice. The testing period must have a double use: on one hand planners are encouraged to take climate-related issued in consideration while planning and on other hand the competence of a number of planners will be increased too.
In our work we present a work-in-progress version of a guide which can be used both for planners and as planning criteria in the EU-funded urban public space development projects.

Keywords: *climate-adaptive urban planning, planning guidelines, urban microclimate*

How can a newspaper help? – Practical examples from the GazMag online magazine

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One of the main topics of the International Climate Change Workshop is the communication. The GazMag online magazine has some projects about this theme.
The GazMag is a monthly online published free magazine in Hungary. The main topics are economy and sustainable development, but you can find several other topics in articles. Most of our journalists are young experts and university students. The operation of this magazine is non-profit. In this research (what started in 2012) you can meet with the ecological footprint of the editorial. It is important, because the magazine try to present a good practice to the readers. It contributes to change of attitude. There other things what can help in the adaptation, like the subject of the articles.

Keywords: *communication, sustainable development, ecological footprint*

Gridded observation data for Climate Services

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High resolution gridded observation datasets of surface climate elements are an important background for describing past, current and future climate. Based on in-situ observations and robust spatial interpolation methods they often bridge traditional climatology with climate descriptions from climate models and atmospheric re-analyses. One advantage of high-resolution gridded data products is that they compared to modelled data sets represent the local climatology better since they usually are based on a more observations and derived by methods with less smoothing than the physical atmospheric model approaches.
MET Norway has a long tradition in developing, producing and providing long term gridded climate data sets with 1 x 1 km spatial resolution based on in-situ observations for climate monitoring. These data have become widely used as input variables to spatially distributed models, especially hydrological models.
The gridded data also form the basis for several climate indicators such as degree days, frequency over thresholds etc. that are relevant for assessing climate variability and climate change in several disciplines.
Gridded observation data, given that they are derived from a representative observation network and by robust interpolation methods, probably provides the best spatially continuous historical

representation of the climate. They are therefore an invaluable reference for bias adjustment of the output from regional climate models. They thus provide a better basis for e.g. assessing the impact of climate change by applying distributed spatial hydrological models to study future changes in runoff, floods and snow conditions.
We will present examples of different climate indicators developed by applying gridded climate data describing past and future climate.

Trends in heat-related cardiovascular mortality in urban population of the Czech Republic

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The study resumes previous research that found significant effects of hot spells on increased mortality in highly urbanized regions of the Czech Republic, and declining trends in heat-related mortality in the Czech population as a whole. We analyze severe hot spells during 1994–2013 and temporal changes of their effects on total and cardiovascular mortality in several urban regions with a different overall socioeconomic level (city of Prague, city of Brno, Ostrava region). Mortality data were standardized to account for different population structure and its changes over time. The mortality baseline for each region was determined using a generalized additive model. Although declining trends in the mortality impacts of hot spells prevail in most regions in spite of rising temperature trends, the magnitude of the mortality decline was different with respect to the overall socioeconomic level and development of the regions. The results suggest that trends in heat-related mortality depend on the level of socioeconomic deprivation of population. It is essential to better understand the risks of climate change in different parts of population with respect to their adaptability.

Urban climate projections for Central European cities and modelling tools for urban planning

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Cities are one of the critical areas where the climate change is expected to have severe impacts. One of the well-known problems is the excess in heat due to the Urban Heat Island (UHI) effect caused by the modification of energy balance in the built-up environment. With global and regional warming, as well as continuous urbanization, the negative effects of the urban climate can be amplified in the future. Understanding and evaluating possible changes occurring in the local climate is important in the perspective of sustainable urban development and climate sensitive urban planning. In the past years the ZAMG (Zentralanstalt für Meteorologie und Geodynamik) is investigating the climate change on urban scale by modelling the urban climate of the cities in Austria under current and future climate conditions. Additionally, the effectiveness of the climate adaptation strategies such as green and blue infrastructure and reflective surfaces is analysed in various simulations with potential modifications in the urban environment. The modelling tool used for this purpose is the urban climate model MUKLIMO_3 developed by the DWD (Deutscher Wetterdienst). The same modelling approach was implemented in the project "Urban climate in Central European cities and global climate change", funded within the framework of the International Visegrad Fund's, to evaluate the expected heat load increase in five Central European cities (Vienna, Austria; Krakow, Poland; Bratislava, Slovakia; Brno, Czech Republic and Szeged, Hungary). The urban climate projections were calculated based on the EURO-CORDEX model simulations.

The applicability of the MUKLIMO_3 model is being extended to cover short-range forecasts and it is tested in combination with the HARMONIE modelling system. Recently funded H2020 project STORM–"Safeguarding Cultural Heritage through Technical and Organisational Resources Management", will provide new investigation on impacts of different extreme weather events and climate change conditions on historical structures and buildings on selected cultural heritage sites, which is expected to offer improved and effective adaptation and mitigation strategies, systems and technologies for preservation of European Cultural Heritage.

Keywords: *urban climate, climate projections, urban modelling, UHI effect, cultural heritage*

Modelling of climate change induced urban climate with SURFEX land surface model

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Cities in a warming climate are considered to be highly vulnerable and exposed to the changes due to their specific climate modifying effect and high population density. Currently, fine scale regional climate models are applied to estimate future climate change over a region or country in detail, and to serve as a fundamental basis for quantitative impact studies. At the Hungarian Meteorological Service (OMSZ) we conduct urban climate investigations using the SURFEX land surface model over Hungarian cities (Budapest and Szeged) on 1 km resolution, including the TEB parametrization scheme for urbanized areas. SURFEX is coupled one-way to the ALADIN-Climate regional climate model adapted at OMSZ.
Test of the model settings and coupling methods, validation of each member in the model chain are inevitable in order to set-up a proper tool for our objectives and to explore the model's skills and weaknesses on climate scale. These preceding steps may lead to reasonable impact studies based on future climate projections.
Short-term simulations are being performed for testing the effect of different coupling strategies, such as different vertical heights and different temporal update of the atmospheric forcings. For validation we are investigating the 2-m temperature results on 1991-2000 for Szeged and Budapest. Szeged is especially favorable to study the urban climate processes and the performance of SURFEX itself, since it locates on a flat area and its climate is warm and dry. On the other hand Budapest is a metropolitan city, but modelling its local climate is challenging thanks to its relatively complex topography. Thus in the second case study we pay special attention on the skill of the regional climate model and its influence on the performance of the land surface model.
The presentation is going to show our methodology and concept to perform urban climate impact studies and some results upon model validation and set-up experiments.