Creation of the FORESEE database to support climate change related impact studies

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Abstract – Regional climate model (RCM) based scenarios are fundamental tools for the estimation of climate change effects on the environment, ecosystems and society. Our aim was to create RCM-based climate scenarios that contain daily meteorological data (precipitation, maximum and minimum temperature) to support climate change related impact studies. We utilized the results of ten RCM experiments that were produced and made accessible within the framework of the ENSEMBLES FP6 project. We performed bias correction using the cumulative distribution functions fitting technique, which allowed for correcting the systematic errors in the RCM results. In case of precipitation both the intensity and the frequency of precipitation was corrected. The resulting database – the so called FORESEE database – contains daily meteorological data based on the ten RCM results for 2010-2100, and observation based data for the period 1951-2009 interpolated to 1/6×1/6 degree spatial resolution grid. Central Europe is the target area of the FORESEE database.

Keywords: impact study / FORESEE database / daily meteorology / bias correction

1. INTRODUCTION

Despite significant efforts, anthropogenic greenhouse gas emission is not expected to be reduced to the desired level (for current trends see PETERS ET AL. 2012), and thus mankind cannot reduce the strength of climate change significantly. In order to mitigate the potential damage caused by the changing environmental conditions we have to estimate the impacts of climate change and develop adaptation strategies (IPCC 2007a). Increasing demand on impact studies calls for reliable climate data feeding the impact models (DOSIO AND PARUOLO 2011). As many natural and socio-economic systems are affected by the meteorological conditions, reliable meteorological data are substantial for the investigation of both past and future effects on climate on such systems. For the past, direct measurements or observation-based gridded datasets are available, while climate model results can be used for the decription of future climates (IPCC 2007b).

In the past, many research organisations developed and ran climate models, and disseminated their results freely via the Internet to provide the support for climate change impact studies. Such data has been broadly used in many fields of research; however, not everybody is aware of the availability and characteristics of climate model outputs. Climatologists recognize that outputs of any climate model contain systematic errors (CHRISTENSEN ET AL. 2008). Fortunately, these systematic errors are quite stable in time

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(MARAUN 2012), thus the errors are not causing problems if only the expected changes are examined. However, problems may arise when such data are to be used for climate change related impact study, which generally requires realistic daily meteorology.

For these reasons, our aim was to create a database providing the scientific community with essential daily meteorological data suitable for impact studies in various sectors in Central Europe.

2. MATERIALS AND METHODS

We used observation based datasets and climate model results to create a daily meteorological database for the period 1951-2100 for Central Europe **(**Figure 1**)**, which contains minimum/maximum temperature and precipitation time series.

For the past (1951-2009) the daily E-OBS database (created within the framework of the ENSEMBLES FP6 project; HAYLOCK ET AL. 2008) and the monthly CRU TS 1.2 (Climatic Research Unit, University of East Anglia, UK; MITCHELL ET AL. 2004) high resolution gridded dataset were used. For practical reasons, we used version 3.0 of E-OBS for 1951-1961, and a newer version (precipitation: version 5.0; temperature: version 7.0) for the period 1961-1990. We found that the CRU based data provides better estimates for Hungary than the E-OBS database on the monthly time scale. Thus, we first corrected the E-OBS database using the monthly CRU TS 1.2 dataset, and such data set has been used for the bias correction and for the reconstruction of past meteorological conditions.

Table 1. Bias corrected models included in the FORESEE database

model ID	model name (RCM-GCM)	Developing institute
1	ALADIN-ARPEGE	National Centre for Meteorological Research (CNRM)
2	CLM-HadCM3Q0	Swiss Federal Institute of Technology Zürich (ETHZ)
3	HadRM3Q0- HadCM3Q0	Hadley Centre for Climate Prediction and Research (HC)
4	HIRHAM5-ARPEGE	Danish Meteorological Institute (DMI)
5	HIRHAM5-ECHAM5	Danish Meteorological Institute (DMI)
6	RACMO-ECHAM5	Royal Netherlands Meteorological Institute (KNMI)
7	RCA-ECHAM5	Sweden's Meteorological and Hydrological Institute (SMHI)
8	RCA-HadCM3Q0	Sweden's Meteorological and Hydrological Institute (SMHI)
9	REGCM-ECHAM5	The Abdus Salam International Centre for Theoretical Physics (ICTP)
10	REMO-ECHAM5	Max-Planck-Institute for Meteorology (MPI)

For future climate description, we selected ten RCM-GCM (Regional Climate Model – Global Climate Model) couplings (Table 1; data is provided by the ENSEMBLES FP6 project; VAN DER LINDEN ET AL. 2009), and we executed a state-of-the-art bias correction on the daily meteorology fields for the period 1951-2100.

All RCMs used were driven by the A1B greenhouse gas emission scenario (a balanced emphasis on all energy sources; IPCC 2000). As there were differences between the datasets (i.e., regarding the used calendar and coordinate system), all RCM results were converted to a 365-day calendar. Then all of the data were interpolated to a common 1/6×1/6 degree horizontal resolution grid using an inverse distance interpolation technique.

For the bias correction the period 1951-2009 was selected as a reference. This is the longest period for which both observation-based data and RCM results are available. The applied bias correction method is based on the cumulative density function fitting technique. First, the climate model results and the observation based datasets were compared for the reference period, and correction factors were defined based on the monthly comparison. These correction factors were then applied to the daily climate model results for the past and also for the future. In case of the temperature the correction is a shifting, while in case of rate of precipitation it is a multiplication.

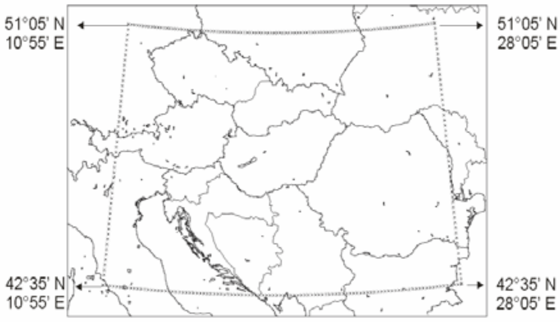

Figure 1. The target area of the FORESEE database (dotted rectangle) containing climatic data for the period 1951-2100. The data are distributed in 5,408 (104×52) grid cells organized in 1/6×1/6° regular grid.

The correction of precipitation was done using more complicated procedure as monthly precipitation is not just characterized by the sum but also the frequency of precipitation. In order to adopt a state-of-the-art bias algorithm we corrected not just the rate but also the frequency of precipitation (DÉQUÉ 2007; INES AND HANSEN 2007).

The methodology is described in detail in DOBOR ET AL. (2012).

3. RESULTS

Bias correction was performed on ten RCM results retrieved from the database of the ENSEMBLES project (Table 1). The final daily time series cover the period 1951-2100. As the corrected RCM results are consistent with the observations used for the correction, in the period 1951-2009 the RCM results were replaced by the CRU corrected E-OBS database. This is a necessary requirement of scientists performing impact studies as they generally validate their models using observations. Validation would be impossible if the RCM results were used, as they differ from the realization of the past weather.

Figure 2 shows a so-called thermopluviogram (temperature-precipitation plots using long term averages) based on the ten bias corrected RCM results for the whole target area. This type of plot can be used for fast visual investigation of relations between the RCMs, and can support the selection of models used for impact studies. In Figure 2 the green colour represents the mean annual temperature and precipitation amount for the period 1961-1990. The blue and the red colours show the 30-year means for the ten RCM-GCM couplings for the periods 2021-2050 and 2071-2100, respectively. Some properties of model results could be clearly seen in the thermopluviogram. The dashed lines show the average of the ten models for the given time slice. The model mean represents a drier and warmer climate for the future. Each model reveals a warming tendency, while course of change in precipitation differs among models.

We assume that some of the fortcoming impact studies will not use all ten models in the database, for example because of the high computation time. The users can select different strategies to choose a subset of models from the whole ensemble using the presented chart. For example, the use of models close to the all-models average seems advisable for first simulation runs.

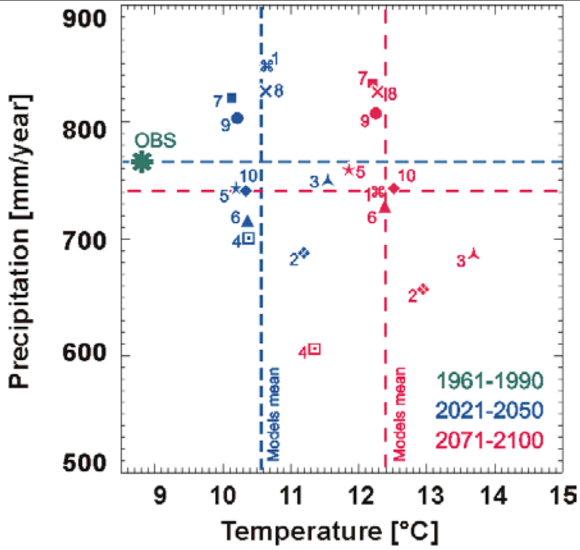

Figure 2. Thermopluviogram for the ten corrected RCMs for the near (2021-2050) and the distant future (2071-2100). The numbers represent models' ID (see Table 1). The dashed lines represent the all-models average in the two periods investigated. OBS represents the reference period (1961-1990)

Here we present two extreme and one representative model results to demonstrate the range of projected changes in climate (especially concerning precipitation) as indicated by the ten RCMs used. In this context representative model means a single model that is close to the all-models average. The three selected models are REMO-ECHAM5 (close to the average; representative model), RCA-ECHAM5 (model indicating inreasing precipitation), and CLM-HadCM3Q0 (model indicating decreased precipitation) with model IDs 10, 8 and 2, respectively. Figure 3 shows the expected annual precipitation and annual mean maximum and minimum temperature changes according to these models.

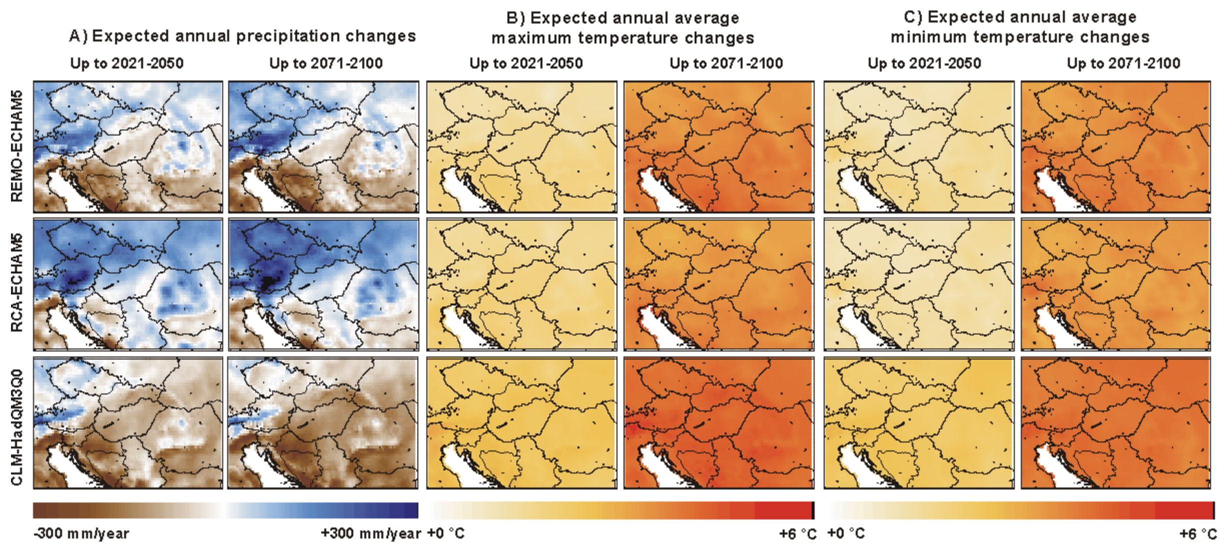

Figure 3. The projected changes in annual precipitation (A), mean maximum (B) and mean minimum (C) temperature according to three climate models for the near (2021-2050) and distant future (2071-2100) relative to the reference period (1961-1990)

Figure 3 suggests that the Mediterranean is expected to become drier according to all three models, while inside the land area the annual precipitation rates decrease to a smaller extent or even increase. The line between expected precipitation increase and decrease is usually oriented southwest-northeast and it is located north to the Carpathian Basin. In case of the temperature changes, each model estimates warming for the future, as has also been indicated by the thermopluviogram in Figure 2.

3. CONCLUSIONS

We introduced a new database that was created to support climate change related impact studies in Central Europe as well as to provide the essential daily meteorological data for studies concentrating on the past 60 years in this region. The database is called the FORESEE database (Open Database FOR ClimatE Change Related Impact Studies in CEntral Europe). The motivation for this work came up from our experience on needs of impact studies, and the fact that – up to our knowledge – there is no such database available for Central Europe. Specifically, the database should reflect the general needs of climate change impact studies, where the methodology of database construction is transparent, and all characteristics of the model results are described in detail. In the present study – due to length constraints – we could only provide a brief description of the main characteristics of the database. In the future we plan to further analyze the data and to provide climate maps for all models, and intra-annual characteristics of all ten models will be discussed.

We intend to create an open website for the dissemination of the FORESEE database, where the users will have easy access to the complete database, or alternatively to subsets of the data. Due to the high political and scientific pressure on estimating the anticipated impacts of the changing environment, we believe that construction and dissemination of the FORESEE database will be useful for the scientific community. Presently, the FORESEE database is available from the authors upon request (e-mail: doborl@nimbus.elte.hu; bzoli@elte.hu).

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CONFIRMATION

I have proofread the paper *Creation of the Foresee Database to Support Climate Change Related Impact Studies* by Laura Dobor et al. and hereby I confirm that it has been written in appropriate academic English, and so it is acceptable for publication in the proceedings of the International Scientific Conference for PhD Students.

Budapest, 31 December, 2012.

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