RCM ALADIN-Climate/CZ simulation of 2020-2050 climate over the Czech Republic

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1. Introduction

Model ALADIN is being developed in an international consortium of several European and North African countries led by France. Primarily, it is being used as a tool for short time weather forecast but since recently it has been used for climate research purposes, too. It is a barocline, fully three-dimensional regional model of atmosphere based on integration of semi-implicit semi-Lagrangian advection scheme. As such, it has been tested and utilized for climate research purposes at CHMI (as well as at some other institutes) and proved to be useful and sufficiently well performing yielding reliable information on climate in the Central Europe for the experiments dealing with contemporary and past time periods.

The regional climate model ALADIN-Climate/CZ is employed within the frame of the EU FP6 project CECILIA to provide high-resolution information on future climate conditions over the region of Central Europe. The regional climate model (RCM) is driven by GCM ARPEGE with the IPCC A1B emission scenario. Here we present the preliminary investigation of the scenario run results with emphasis on the region of the Czech Republic. The obtained results are compared to both 1961-1990 control run outputs and the present time climatological observations from available datasets, including the set of station data transformed into grid points of the model.

2. Model configuration and integration parameters

The RCM ALADIN-Climate/CZ is based on semi-lagrangian semi-implicit two-level scheme and derived from the NWP version of ALADIN model used in operational practice at CHMI. It is a different model than the RCM ALADIN-Climate/FR developed by Meteo-France.

Integration domain size (C, lat. × lon.)	74 × 148 points	
Horizontal resolution	10 km	
Vertical resolution	43 levels	
Time step	450 s	
Integration period	1. 1. 1960 – 31. 12. 1990	1. 1. 2021 – 31. 12. 2050
Input data	GCM ARPEGE-Climat	GCM ARPEGE-Climat

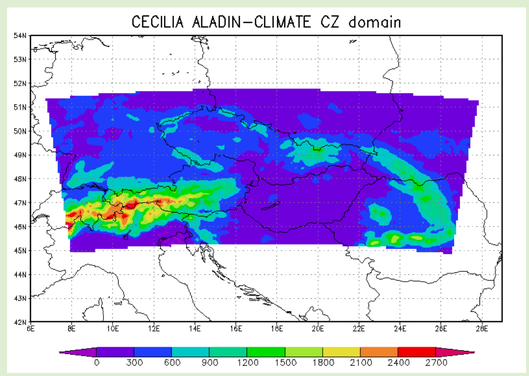

Fig. 1. Central Europe integration domain (left) and the model's 10 km orography with 789 model's grid points covering the territory of the Czech Republic (right)

3. Methodology

To validate model results against station data, a new **gridded dataset** of comparable spatial resolution, based on records stored in the CHMI climatological database, was created (for period 1961-2007). Before processing, input station data were **quality controlled and homogenized** in daily scale. The daily data of four meteorological parameters (mean, maximum, minimum temperature and precipitation) were then taken and recalculated to the model's grid (see Fig. 1). Daily station measurements in a vicinity of each grid point were first reduced on the grid point's (model's) altitude by a local linear regression and then weighted averaged to a grid point location according to their distance from the grid point . The inverse distance (1/d) factor was used as a weight for air temperature ($1/d^3$ for precipitation).

Before time slice 2021-2050 analysis, the **model** data were **corrected** according to validation results carried out for the period 1961-1990. Gridded dataset of station observations was compared with RCM simulations in each grid point and according to relationship between the two datasets, outputs of scenario run were corrected applying an approach of Déqué (2007) based on variable correction using individual percentiles. After the correction, the model outputs are fully compatible with station (measured) data.

The gridding and all data processing including analysis were done by **ProClimDB** database software for processing climatological datasets. The software was developed by one of the authors and can be download for free from: http://www.climahom.eu

4. Model Validation

Period used for the model validation was 1961-1990. Negative (positive) biases dominate in the transient (main) seasons (Fig. 2). The negative spring bias is associated with snow accumulation by ALADIN during winter and its slower melting in spring. Positive summer and autumn bias in the southeast is an extension of the warm feature over the Pannonia basin.

The annual course of air temperature in the Czech Republic is well reproduced by the model (Fig. 4). Differences of seasonal air temperatures between the model and station data are smaller in transient seasons than in main seasons for air temperature.

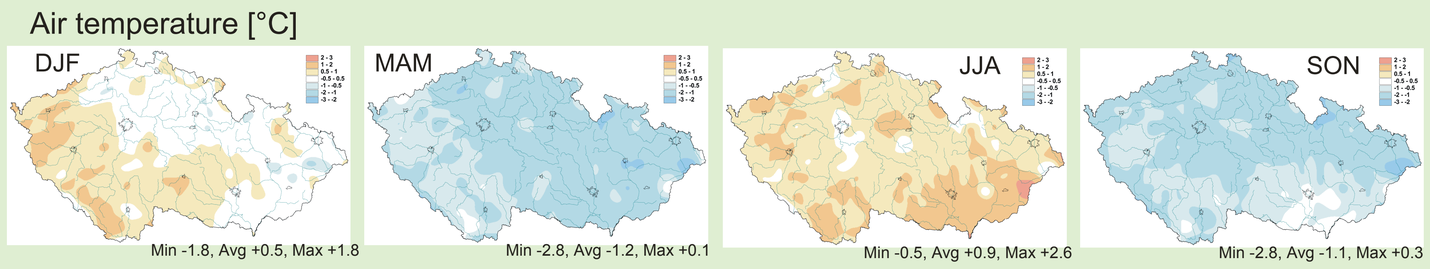

Fig.2. Seasonal mean air temperature in RCM ALADIN driven by GCM ARPEGE for the period 1961–1990 compared to the gridded station data over the Czech Republic

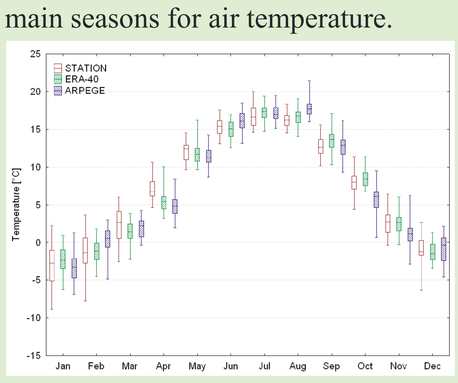

Fig. 4. Annual cycle of air temperature (left) in the Czech Republic for the period 1961–1990. Median, upper and lower quartiles, maximal and minimal monthly values are indicated for station data as well as the model ALADIN driven by driven by ERA-40 re-analyses and GCM ARPEGE.

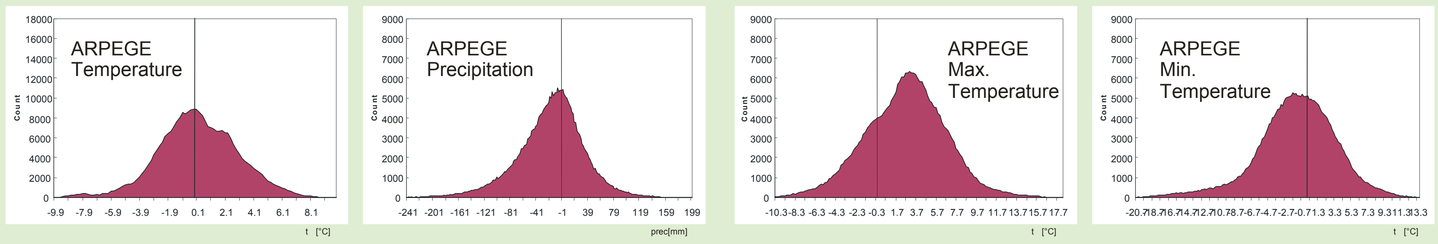

Fig 3. Histograms of all monthly - mean temperature, - sum of precipitation, - maximal and minimal temperature differences between the station data and the model driven by GCM ARPEGE for 789 model's grid points over the Czech Republic within the period 1961–1990

5. Comparison of current and future climate

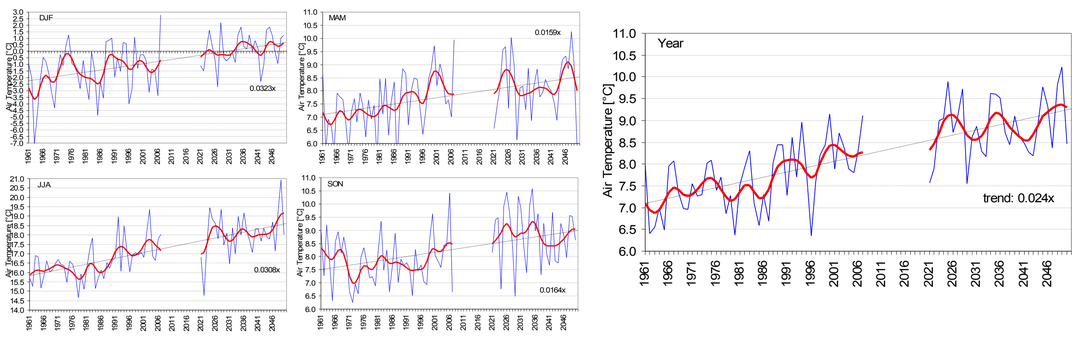

Fig.5. Fluctuations of averaged air temperature for the Czech Republic calculated from gridded dataset of station observations and corrected scenario model runs (789 model grid points), 1961-2007 and 2021-2050, for individual seasons and year. Smoothed by Gaussian low-pass filter for 10 years.

Spatial patter of absolute maximum temperature per decades 1991-2000 and 2041-2050 is compared in Fig. 6. Mean difference for the whole area is 2.6°C, but there are some areas with considerably higher differences, especially in Bohemia and higher altitudes. The highest temperatures reached in the late years of scenario model runs are around 44°C.

After correction of scenario runs, the model outputs have been analyzed together with gridded dataset of station observations in the periods 1961-2000 and 2021-2050. Fluctuations of annual averages of daily mean temperature are given in Fig. 5. Linear trends are only positive and for the averaged series of the Czech Republic are statistically significant (confidence level 0.05) for year and all seasons. Values of linear trend for annual averages of daily mean, maximum and minimum temperature are the same (0.24°C / 10 years), while for individual seasons they slightly differ. The highest values are reached in winter (0.32°C per decade) and summer (0.31°C), the lowest values are encountered in spring (0.16°C for daily means) and autumn (0.16°C).

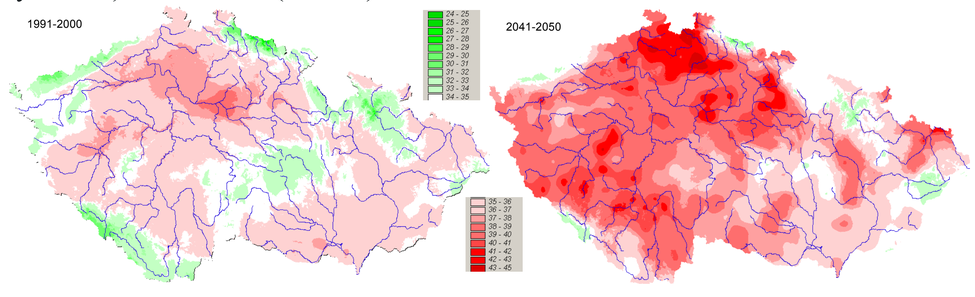

Fig.6. Absolute maximum temperature [°C] for decade 1991-2000 (left) and 2041-2050 (right) for the area of the Czech Republic.

6. Conclusions

The presented results of the first evaluation of the historic run experiments performed with the RCM ALADIN-Climate/CZ confirm the findings of previous studies made with the model under a coarse resolution (e.g. Farda et al., 2007) that the model is well capable to capture the main features of the present-time climate in the region of the Central Europe and is working well even over the smaller areas with a rather complex orography represented here by the territory of the Czech Republic.

To validate the model under the high resolution of 10 km we have created the gridded dataset of the station observations. Our next step in its development will be an extension of the dataset to cover the region of the common CECILIA target area, more detailed investigation of the gridding technique and how it affects the quality of the final dataset.

From the corrected future climate simulations (the regional climate model driven by GCM ARPEGE with the IPCC A1B emission scenario) and comparison with the period 1961-2007 it e.g. follows, that compared to 90s of the 20th century, in 40s of 21st century we can expect temperatures higher by 1°C. Increase in temperature is expected especially in winter and summer and less in spring and autumn, both in daily mean, maximum and minimum temperature. Higher increase of temperature is expected in Bohemia then in Moravia and in higher altitudes.

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