Project No. 037005

CECILIA

Central and Eastern Europe Climate Change Impact and Vulnerability Assessment

Specific targeted research project

1.1.6.3.I.3.2: Climate change impacts in central-eastern Europe

D7.2: Key species concentrations from the European runs for 4 * 10 years with 50 km resolution based on CBM-IV chemistry with sulphur, analysis of the output of the offline chemistry AQMs for future projections and for the control period.

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Start date of project: 1st June 2006 Duration: 36 months

Lead contractor for this deliverable: Aristotle University of Thessaloniki (AUTH)

Revision [final]

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

CECILIA WP7 DELIVERABLE D21 (or D7.2)

Lead partner for deliverable: AUTH

Contributing partners: AUTH, BOKU

January 11, 2008

1 Introduction

After the completion of the coupling of the air quality models (AQMs) used within CECILIA to the output of the regional climate models (namely RegCM and ALADIN) (Deliverable D7.1) the goal of Deliverable 7.2 was the performance of 4x10 years simulation of RegCM3/CAMx for present and future climate in the European domain with 50 km x 50 km resolution by BOKU and AUTH. For this purpose the regional climate model simulations of RegCM3 were used to drive off-line the air quality model CAMx for 4 decadal runs namely a) 1990-2001 with ERA-40 to drive RegCM3, b) 1991-2000 with ECHAM5 to drive RegCM3, c) 2041-2050 with ECHAM5 to drive RegCM3 and d) 2091-2100 with ECHA5 to drive RegCM3. All the RegCM3 simulations for these time slices have been carried out by ICTP and provided to both AUTH and BOKU. However there was a delay for the future simulations of RegCM3 which has a consequence on the CAMx simulations for the future decades. It should be noted that the transfer of all the necessary RegCM3 fields for the CAMx simulations has been completed by mid-December 2007.
In particular, the following work was done:

- Both AUTH and BOKU performed a ten year simulation of RegCM3/CAMx for the period 1990-2001 using as lateral boundary for RegCM3 the ERA-40 meteorological fields.
- AUTH carried out a validation study of the RegCM3/CAMx model results with respect to the EMEP observed data for the period 1990-2001. Similar comparisons with EMEP data were performed by BOKU.
- Both AUTH and BOKU performed a ten year simulation of RegCM3/CAMx for the period 1991-2000 using as lateral boundary for RegCM3 the meteorological fields from the General Circulation Model ECHAM5.
- Both AUTH and BOKU perform a ten year simulation of RegCM3/CAMx for the period 2041-2050 using as lateral boundary for RegCM3 the meteorological fields from the General Circulation Model ECHAM5 for scenario A1B. This task is in progress at AUTH and it is anticipated to be completed by end of February 2008. BOKU has completed these calculations already.
- Both AUTH and BOKU performed a ten year simulation of RegCM3/CAMx for the period 2091-2100 using as lateral boundary for RegCM3 the meteorological fields from the General Circulation Model ECHAM5 for scenario A1B. This task is in progress at AUTH and it is anticipated to be completed by end of March 2008. These calculations are in progress at BOKU and will be completed before the end of January 2008.

2 Detailed description of the work done

2.1 Model runs RegCM3/CAMx for present and future

2.1.1 Meteorological runs with RegCM

The regional climate model RegCM3 (http://www.ictp.trieste.it/~pubregcm/RegCM3/) was used to simulate the time period 1960-2002, forced by the ERA-40 reanalysis fields of ECMWF for a large European domain (similar to the common domain of the EU Project ENSEMBLES) with a grid resolution of 50 km x 50 km. Furthermore RegCM3 was used for a transient simulation for the period 1950-2100, forced by the general circulation model ECHAM5 under the A1B future scenario. These two long-term simulations of RegCM3 were carried out at ICTP within the framework of the ENSEMBLES EU project.

2.1.2 Photochemical runs with CAMx

The above mentioned simulations of RegCM3 were used to drive offline the air quality model CAMx for the following time slices:

- A simulation of RegCM3/CAMx for the period 1990-2001 using as lateral boundary for RegCM3 the ERA-40 meteorological fields.
- A ten year simulation of RegCM3/CAMx for the period 1991-2000 using as lateral boundary for RegCM3 the meteorological fields from ECHAM5.
- A ten year simulation of RegCM3/CAMx for the period 2041-2050 using as lateral boundary for RegCM3 the meteorological fields from ECHAM5 for scenario A1B.
- A ten year simulation of RegCM3/CAMx for the period 2091-2100 using as lateral boundary for RegCM3 the meteorological fields from ECHAM5 for scenario A1B.

2.1.2.1 Runs at AUTH

Species concentrations were produced for the time period 1990-2001 over Europe with spatial resolution 50 km x 50 km. The domain's vertical profile contained 12 layers of varying thickness, extending up to 450 hPa. The meteorological fields were derived from RegCM runs received from ICTP. Hourly anthropogenic emissions of gaseous and particulate pollutants were compiled and provided by BOKU. Biogenic emissions were calculated using the RegCM-CAMx interface in a 6-hour basis. Biogenic and anthropogenic emissions were combined with AddEmiss software developed by BOKU. All emissions were treated as surface area emissions. Initial and boundary (top and lateral) conditions corresponded to concentrations of clean air.

The chemistry mechanism invoked was Carbon Bond version 4 (CB4). Photolysis rates were derived for each grid cell assuming clear sky conditions as a function of five parameters: solar zenith angle, altitude, total ozone column, surface albedo, and atmospheric turbidity. A file containing information on albedo, ozone column density and turbidity for the CAMx domain was also provided as input file (AHOMAP file) containing spatial and temporal distribution of the above mentioned parameters. These parameters are essential for photochemical simulations as they determine variation of photolysis rates.

Model results were validated with measurements from the EMEP database for several European stations. The statistical scores that were used were the fractional gross error (FGE) and the modified normalized mean bias (MNMB). Figure 1 shows how the chemical model performed in the decade 1990-2001 with respect to FGE and MNMB. FGE ranges in the majority of stations between 10-35 % while MNMB ±20 %. 'Satisfactory' model performance is usually considered within the ranges of ± 15-20 % for normalized bias and 30-35 % for gross error according to US-EPA regulations (US EPA, 1991). Thus, we can conclude that our model results reproduce successfully the observations.

Concerning the concentration fields of the major photochemical species, O3 and NOx, the model seems to reproduce the expected spatial features for the monthly averages calculated with the whole dataset (1990-2000): increased NOx emissions over urban/industrial regions and respective minima in the same regions for O3 due to destruction of O3 with NO. O3 has a clear seasonal variability with increased values during summer months due to intense photochemistry. The Mediterranean basin exhibits in warm months O3 monthly mean concentrations up to 70 ppb, while over European mainland monthly mean concentrations are lower: 50 ppb for southern Europe and around 35 ppb for northern Europe. NOx monthly mean concentrations are higher during winter months, probably due to higher anthropogenic emissions. Figure 2 shows NOx and O3 contours over Europe for mean January and July of the period 1990-2000.

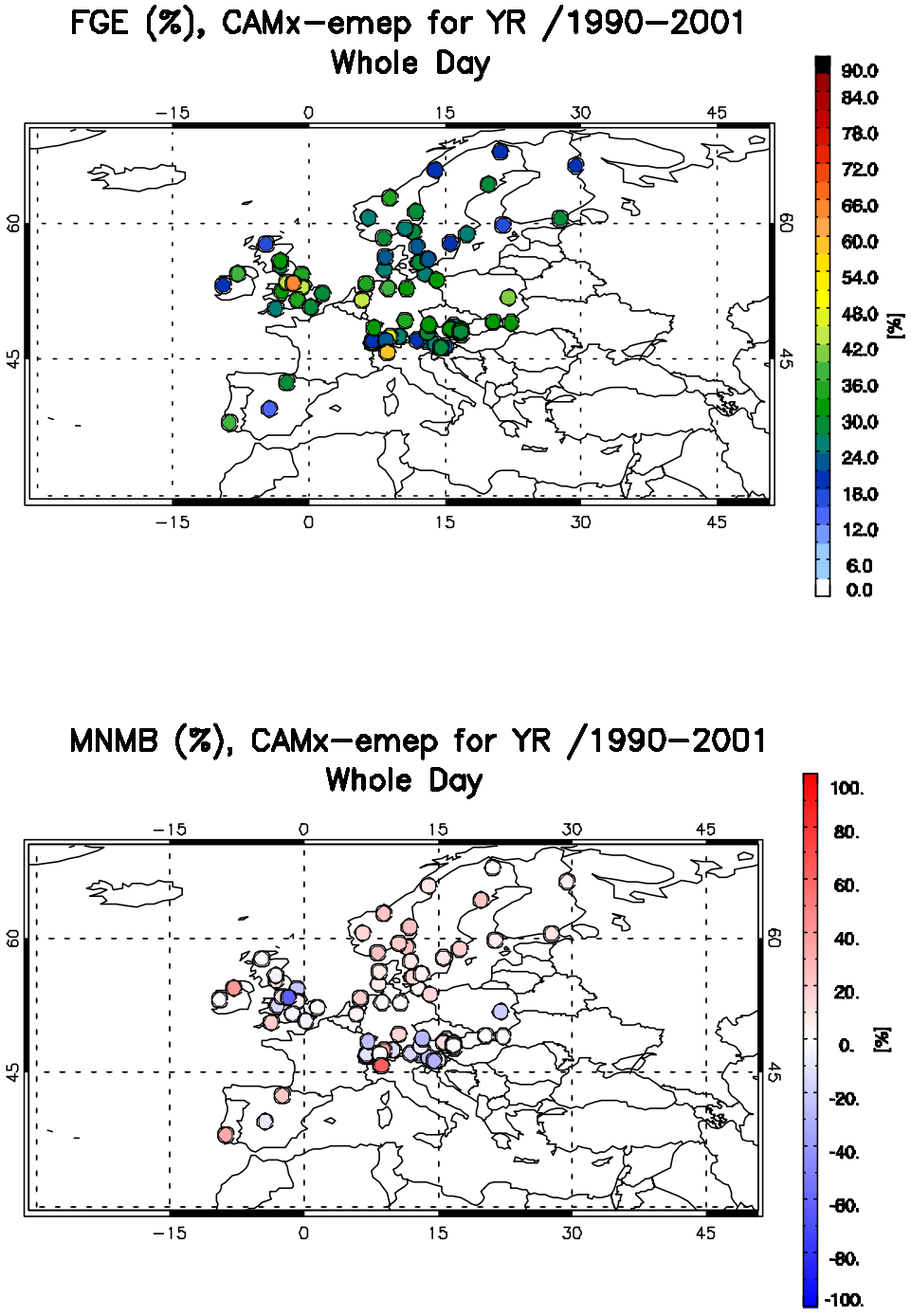

Figure 1: FGE (upper panel) and MNMB (bottom panel) for CAMx model performance for the period 1990-2001.

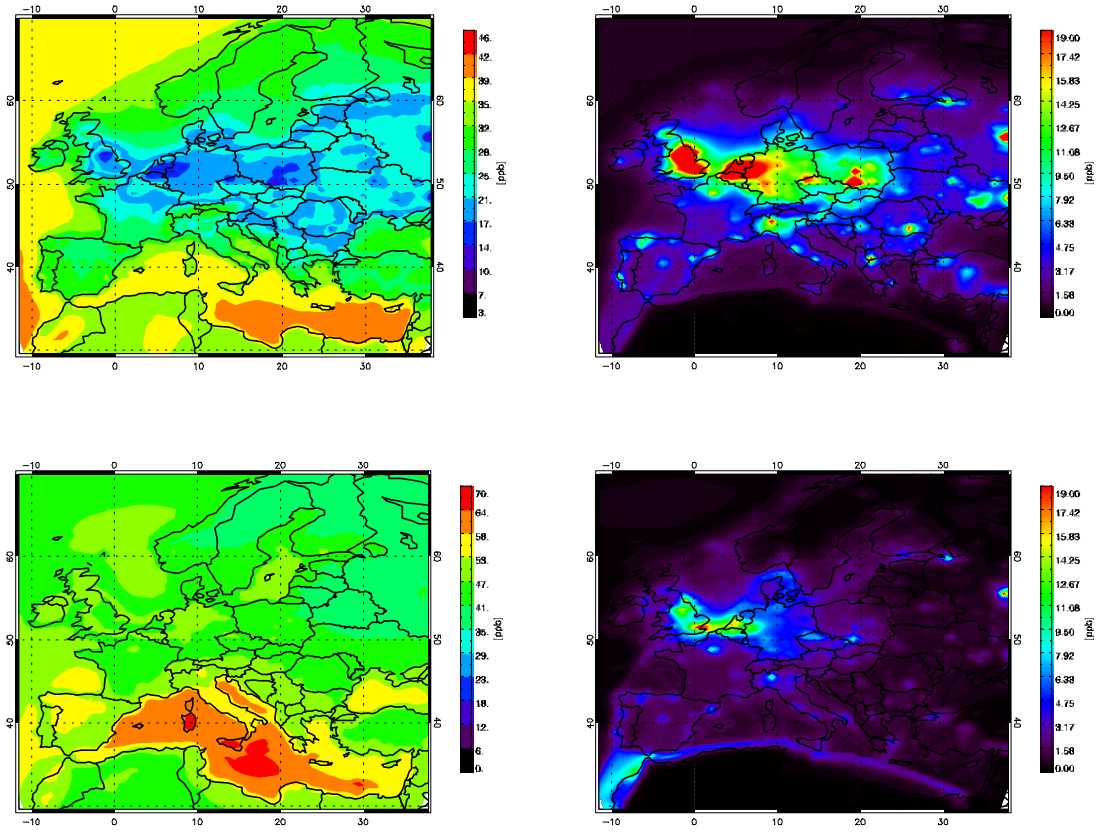

Figure 2: O3 (left panel) and NOx (right panel) monthly mean concentration fields for January (upper panel) and July (lower panel) over the period 1990-2000.

2.1.2.2 Runs at BOKU

At BOKU photochemical model runs with CAMx were performed for the same time slices as in the model runs by AUTH. Also the same model setup (CBM-IV mechanism with aerosols) and the same input data were used. These included the “clean air” boundary concentrations, the same albedo, total ozone column and turbidity files provided by AUTH and the same anthropogenic emission files provided by BOKU as well as the RegCM meteorological fields from ICTP. Except of the meteorological fields the same data were used for every time slice in order to distinguish the signal of climate change clearly in the pollutant concentrations. At the time of the submission of this report, the last decade (2090-2100) was in work.

The results of the ERA40-runs were also compared with EMEP ozone measurement stations and showed resonabable agreement. A first intercomparison between the results from AUTH and from BOKU indicated no significant differences. Hourly data of 33 trace species on 12 model levels were stored on LTO tape for further use. Finally data of 45 years (1990-2001, 1990-2000, 2040-2050, and 2090-2100) will be collected. Together with the input data this sums up to an amount of about 9 TB.

As a first evaluation of the data the 90 % percentiles of the daily maxima of ozone in all grid cells covering the various countries were calculated in a monthwise manner for each time slice. The results are shown in Figure 3 for four countries within the CECILIA target area. Comparing the simulation driven by the ERA40 reanalysis and the control run, the ERA40 results are higher, in particular in the more northern countries Austria and Hungary. The difference between the control run and the mid-century run (2040-2050) is small, while the end-century run shows higher ozone, mainly in the second half of the year in the northern countries and all year except winter in the southern countries Romania and Bulgaria. However, in this preliminary evaluation just two years of the end-century decade are considered, and the result may change for the full decade.

An interpretation of these results together with comparisons of various other quantities and considering the climate differences between the time slices will follow in the further work for CECILIA.

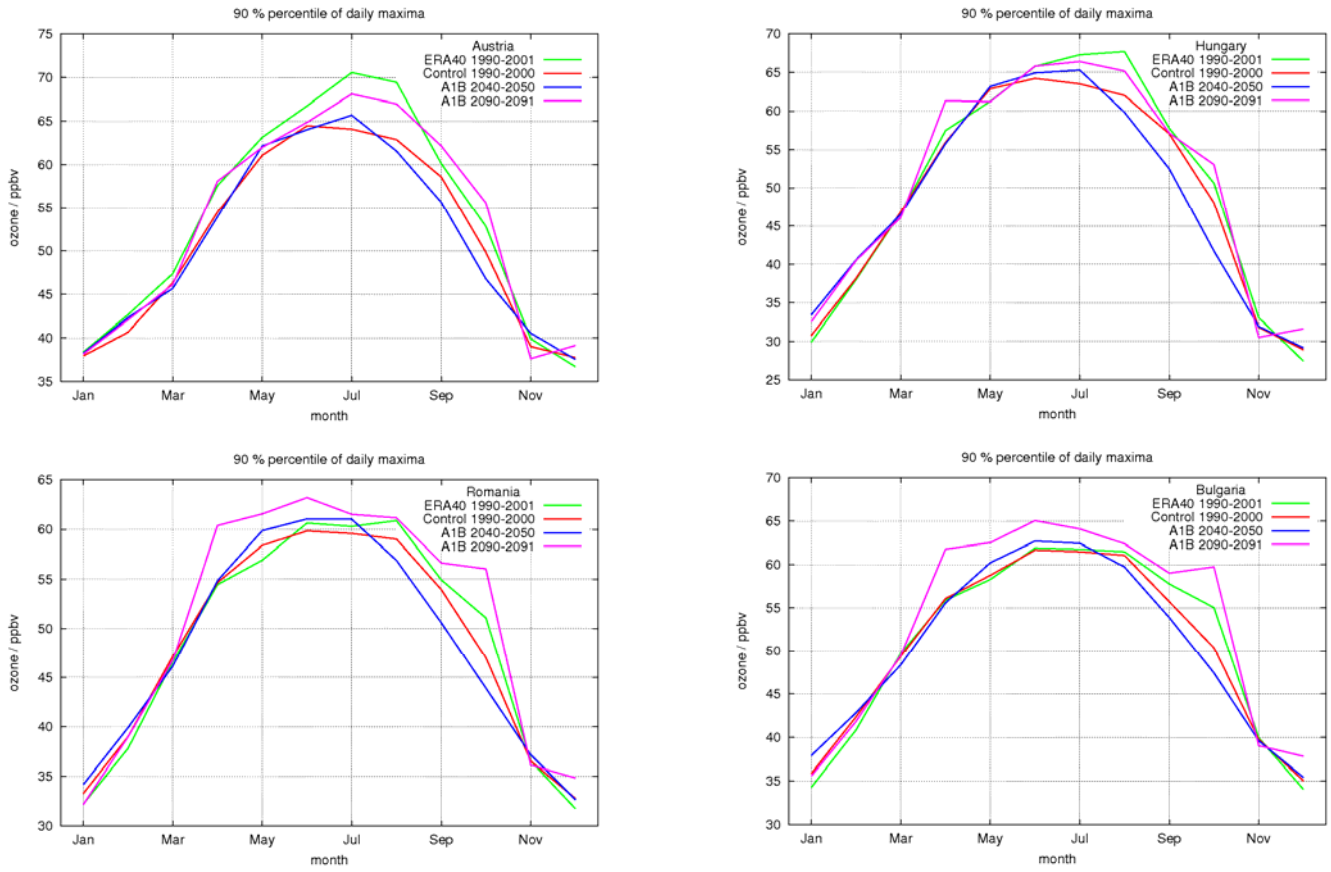

Fig. 3: Monthly variation of the 90 % percentiles of the daily maxima of ozone in all grid cells covering a country for each time slice for Austria, Hungary, Romania, and Bulgaria.

3 Summary

For the second deliverable of Workpackage 7 of the CECILIA project, the air quality model CAMx driven by RegCM3 meteorological fields run successfully for decadal simulations for present and future climate in the European domain with 50 km x 50 km resolution by BOKU and AUTH. All the RegCM3 simulations for these time slices have been carried out by ICTP and provided to both AUTH and BOKU. However there was a delay for the future simulations of RegCM3 which has a consequence on the CAMx simulations for the future decades. It should be noted that the transfer of all the necessary RegCM3 fields for the CAMx simulations has been completed by mid-December 2007 which as a consequence led to a delay of the starting the future decadal simulations with CAMx. Currently two decadal runs at AUTH and one decadal run at BOKU are in progress. The first preliminary evaluations of the results look promising.

4 References

US EPA, 1991. Guideline for Regulatory Application of theUrban Airshed Model. US EPA Report No. EPA-450/4-91-013. Office of Air and Radiation, Office of Air QualityPlanning and Standards, Technical Support Division. ResearchTriangle Park, NC, USA.