CityZen

megaCITY - Zoom for the Environment

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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)	

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Report on improved emission inventories including scenarios, spatial scale-bridging model systems and the systematic observational evidence

1 Summary

1.1 Purpose

The main activity of Task 4.5 in CityZen, as stated in the Description of Work, has been to ensure that the documentation of the improved emission inventories including scenarios, spatial scale-bridging model systems and the systematic observational evidence would be published in an appropriate way on web sites (and through other channels) in order to ensure easy access to data, models and documentation, especially for support of policy. Institutions, as for example met.no, NILU and INERIS, with a long-term mission to support applications of science, would adopt key methodological and data advances achieved in the project, into their (semi)operational routines. This report gives and overview of improved emission inventories and scenarios, spatial scale-bridging model systems and the systematic observational evidence gained during CityZen and provides links or references to relevant websites and publications. In addition it gives brief descriptions of major advances and of relevant data that have not yet been described elsewhere. The main scientific results from CityZen have been summarized for the present and recent past in CityZen deliverable report D1.1.6, while input to and results from future simulations have been described in multiple deliverable reports for CityZen, and will not be repeated here.

1.2 Emission data in CityZen

Several emission data sets have been compiled and/or used within the CityZen project, some of them created specifically for CityZen. The main sources of emission data for CityZen have been the EMEP data base (http://www.emep.int and http://www.ceip.at/), the RCP scenarios (http://www.iiasa.ac.at/web-apps/tnt/RcpDb/ and *van Vuuren et al.*, 2011), and the Global Energy Assessment (GEA) scenarios provided by IIASA (http://www.iiasa.ac.at/Research/ENE/GEA/). In addition, several finer-scale emission data sets have compiled, e.g. for Istanbul (to be described in this deliverable report), the Rhine-Ruhr area (provided by the German authority Landesamt für Natur, Umwelt und Verbraucherschutz LANUV, and used, e.g. in deliverable report D4.1.2 and in Hodnebrog et al., 2011), and China (CityZen milestone M1.7.2 and available on the CityZen wiki page). An overview of the final data sets for the present has been given by CNRS in deliverable report D3.2.2, while the future emissions have been described in deliverable report D3.3.4 (IIASA).

Emission data from CityZen are publicly available (e.g. the MACCity data at the ECCAD database, http://ether.ipsl.jussieu.fr/eccad), with the exception of the GEA emissions described in deliverable report D3.3.4. The availability of the GEA emission data is pending on the publication of the GEA report during autumn 2011.

Inverse modelling to improve emission data has not been persued within CityZen, but the comprehensive data set provided from satellite observations for CityZen gives hints regarding major emission sources. In particular, *Konovalov et al.* (2010) have used satellite observations to narrow down emission estimates for several megacities and emission hot spots.

CityZen partners ULeic and CNRS have used VOC measurements to refine the VOC speciation in emission data sets (see Section 4 of CityZen deliverable report D3.2.2).

1.3 Modelling tools and results

The study of the environmental impact of megacities necessitates model systems that can investigate different scales. Deliverable report D1.3.2 has identified and described various scale-bridging approaches that have been pursued during CityZen. The figures and technical details of these approaches will not be repeated in this report. In addition to D1.3.2, two publications have been submitted to the peer-reviewed literature, investigating the nudging and the zooming techniques, respectively (Maurizi et al., 2011; Siour et al., 2011).

Model results of trend analyses and future mitigation strategies have been or will be published in the peer-reviewed literature (see list of publications in CityZen deliverable report D1.1.7 and deliverable report D3.4.1). Model results for future climate/chemistry interactions have been included in policy briefs issued by CityZen, and first publications have become available (see deliverable D4.2.1). They have also been reported to the UN LRTAP convention, as will be described in more detail in this report.

1.4 Observational data

Ground-based observational data have been compiled from a comprehensive data base hosted by NILU (http://ebas.nilu.no/), while comprehensive satellite data are available at the IUP (University of Bremen) servers. Measurement networks have been analysed and partly maintained for CityZen in the Eastern Mediterranean hotspot (D1.4.1, D1.4.2, D1.1.6), the Po Valley (D1.6.1), London (D1.1.6), the BeNeLux area (D1.5.1) and the Pearl River Delta (D1.7.1). The long-term observations have been used to get further insight into trends (see deliverable report D1.1.6), but also for detailed source allocation studies (e.g. Kocak et al., 2010a, Kocak et al., 2010b).

1.5 Dissemination

The CityZen coordinator, met.no, has created two websites for CityZen (as explained in more detail in CityZen deliverable report D4.7.2), one of them is now using novel software capabilities to vizualize model results interactively (see CityZen deliverable report D4.3.2). For example, the results from the comprehensive trend study of Colette et al. (2011) can be viewed conveniently on the CityZen wiki site at http://www.cityzen-project.eu/toolkit .

The representative of the CityZen coordinator, Michael Gauss, has also acted as coordinating lead author in the upcoming IGAC/WMO report on megacities. CityZen partners have contributed to the European section (e.g. FRIUUK for the BeNeLux area, ULeic for the London megacity and ECPL for the Eastern Mediterranean region). The report is meant for scientists but also for policy makers and city planners, as a review of the current scientific basis in the research of megacities.

Main findings have also been translated into local languages (e.g. deliverable report D1.6.4). Further efforts will be made to convey the main scientific messages to local authorities through translation into local languages. For example, it has been agreed to translate the policy briefs from CityZenm, which are being prepared for the revision of EU Air Quality legislation, into Turkish (Alper Unal, ITU, pers. comm.).

2 Present emissions in CityZen

2.1 The MACCity data set

Within CityZen, a global dataset as well as a regional emissions dataset were developed. Since Deliverable report D3.1.1 was delivered in May 2010, no changes have been implemented in the regional inventory (called INERIS-EMEP). INERIS-EMEP was created by CityZen Partner INERIS by downscaling 50x50 km^2 data to 10x10 km^2 resolution, keeping the emissions per EMEP 50x50 km^2 grid cell fixed. Independently of this effort, CityZen partner CNRS developed a global data inventory (called MACCity). This inventory has been developed in cooperation with the FP7 MACC (Monitoring Atmospheric Composition and Climate, http://gmes-atmosphere.eu) project. It was therefore decided to choose for this dataset the acronym MACCity. The global MACCity and the regional INERIS-EMEP inventories developed within CityZen have been evaluated through comparisons with other publicly available datasets (see Deliverable report D3.2.2). The INERIS-EMEP inventory has also been implemented in the MACCity inventory through a merge of the INERIS emissions for Europe into the global inventory: the resulting dataset, MACCity_INERIS has been used for several model simulations within CityZen (e.g. Colette et al., 2010).

The MACCity emissions have been developed as an extension of the ACCMIP emissions dataset developed for the on-going IPCC AR5 assessment. In 2008-2009, a group of international scientists developed a new emissions dataset covering the 1850-2000 period, based on the combination and harmonization of published and publicly available datasets (Lamarque et al., 2010). The new 1850-2000 harmonized emissions dataset is called ACCMIP (Emissions for Atmospheric Chemistry and Climate Model Intercomparison Project). The year 2000 was chosen as the reference year, since 2000 emissions represent a combination of the best information available on existing regional and global inventories in the years 2008-2009 when the inventory was built. For each emission type, 10 emission sources were specified for 40 regions. ACCMIP emissions for historical years were drawn on the basis of several of the emission inventories discussed below and will therefore agree closely with some of them. For example, ACCMIP emissions at the global scale up to 2000 represent a combination of the HYDE, RETRO, PNNL and the Bond inventories described below. For ozone precursors, the ACCMIP emissions are based on a combination of the GAINS and REAS emissions for Asia, on the EMEP emissions for Europe and on the EPA inventory for the USA. For SO2, ACCMIP uses EPA data as a basis for the emissions in the USA. Details on the methodology used to generate the ACCMIP emissions are given in Lamarque et al., 2010.

The dataset provides distributions of emissions of sectoral, gridded anthropogenic and biomass burning emissions covering the historical period (1850–2000) in decadal increments at a horizontal resolution of 0.5° in latitude and longitude. Anthropogenic emissions are given as yearly averages, while biomass burning emissions are given on a monthly basis.

The data set has been evaluated carefully against other data sets that are widely used in the scientific community, e.g. EDGAR, HYDE, RETRO, GAINS, ACCMIP and many others. Table 1 shows the spread in emission estimates for different components and different years. It thus gives a measure of scientific uncertainty connected to these estimates, which are crucial input to modeling studies. For further details about the MACCity data set and the emission evaluation study the reader is referred to CityZen deliverable 3.2.2. The MACCity data set, along with documentation and visualization tools is also publicly available at the ECCAD website http://ether.ipsl.jussieu.fr/eccad. The registration at this data base is easy and a large number of emission data can be downloaded free of charge.

		1980	1990	2000	2005
BC anthropogenic					
	Global	1.53	1.52	1.13	1.28
	Western Europe	2.08	2.04	1.59	1.34
	Central Europe	2.45	2.50	1.92	1.76
	USA	2.38	2.74	1.53	1.48
	China	1.64	1.32	2.12	1.29
	India	1.99	1.95	1.78	2.27
BC biomass burning					
	Global	1.53	1.36	1.74	1.28
	Africa	2.94	2.65	1.50	1.57
	South America	1.49	1.60	3.18	1.42
CO anthropogenic					
	Global	1.27	1.31	1.28	1.09
	Western Europe	1.34	1.55	1.65	1.28
	Central Europe	1.43	1.56	1.58	1.73
	USA	1.87	1.67	1.69	1.66
	China	1.34	1.54	1.43	1.15
	India	1.31	2.01	1.97	2.00
CO biomass burning					
	Global	1.56	1.84	1.68	1.19
	Africa	2.89	2.78	1.51	1.85
	South America	1.35	1.36	3.04	1.20
NO_x anthropogenic					
	Global	1.13	1.18	1.17	1.15
	Western Europe	1.15	1.28	1.15	1.18
	Central Europe	1.32	1.24	1.16	1.23
	USA	1.27	1.41	1.15	1.33
	China	1.91	1.66	1.31	1.32
	India	2.17	2.11	1.68	1.39
SO_2 anthropogenic					
	Global	1.19	1.27	1.40	1.32
	Western Europe	1.25	1.49	2.33	2.36
	Central Europe	2.04	1.32	2.08	2.73
	USA	1.23	1.26	1.24	1.47
	China	1.54	1.66	1.78	1.68
	India	1.59	2.09	1.95	1.70

Table 1: Ratio between the lowest and highest emissions estimate for each species and each region for the different periods considered in the CityZen emission evaluation study (for further details, see Deliverable report D3.2.2). Numbers lower than 1.3 appear in green, values between 1.3 and 1.7 are in yellow, and values higher than 1.7 are in red.

2.2 Fine scale emissions for Istanbul

A new anthropogenic emissions inventory has been developed for the Istanbul extended area on a 2 km spatial resolution. The development of this inventory has started prior CITYZEN then, during evaluation *(Im et al., 2010)*, the need for improvement has been revealed and this has been achieved and the inventory has been finalized in the frame of the project. The inventory covers all the major sources including energy production, residential and industrial combustion, road transport, local and international shipping and solvent use. The emissions of CO, NO_x, SO_2, non-methane volatile organic compounds (NMVOCs), NH_3, PM_{10} and $PM_{2.5}$ are estimated in the inventory. The NMVOC emissions are speciated into 23 species based on the *Oliver et al. (2001)* and *Visschedijk et al. (2007)* sectoral profiles while the PM emissions are speciated based on CARB (2007) profiles. The results (see Table 2 from *Kanakidou et al., 2011* and references therein) show that on-road traffic is a significant sector, contributing to 83% of CO, 80% of NO_x and 45% of NMVOC emissions, annually. Regarding SO_2, the important sources are residential combustion by 15%, industrial combustion by 23%, 17% for cargo shipping and energy production by 26%. Solvent use is another significant contributor to NMVOC emissions by 30%. Regarding PM_{10} emissions, 65% originates from industrial activities, whereas 17% comes from on-road traffic. Residential combustion contributes to 12% of $PM_{2.5}$ while industrial activities accounts for 44% and traffic for 30%.

Table 2 Contribution of major emission sectors to CO, NO_x, SO_2, NMVOC and PM anthropogenic emissions from Istanbul, Cairo and Athens in the East Mediterranean as reviewed by *Kanakidou et al., Atmos. Environ., 2011* (see references therein).

Anthropogenic emissions from Istanbul (reference year 2007: Markakis et al., 2009), Athens (reference year 2003; Markakis et al., 2010a,b) and Cairo (reference year 2005; van Aardenne et al., 2009; Doering et al., 2009; # Cairo inventory concerns $PM_{2.5}$ emissions) greater areas.

	Residential combustion %	Industry %	Fuel extr./distribution %	Solvent use %	Road transport %	Off-road %	Maritime %	Waste %	Energy %	Total ktons/yr
CO										
Istanbul	10.8	3.7	–	–	83.1	–	0.3	0.7	0.7	437
Athens	8.0	3.2	–	–	75.6	13.0	0.2	–	–	473
Cairo	28.8	31.2			35.5			2.2	2.4	285
NO_x										
Istanbul	2.1	2.4	–	–	79.4	2.8	9.5	–	3.2	305
Athens	3.1	22.4	–	–	51.0	17.8	3.1	–	2.6	78
Cairo	4.0	50.2			11.4	3.37		0.12	30.9	222
SO_2										
Istanbul	14.7	23.2	2.3	–	2.3	4.1	17.6	–	35.6	91
Athens	14.9	29.1	8.4	–	3.2	7.2	11.3	–	25.9	31
Cairo	7.6	71.5			4.4					135
NMVOC										
Istanbul	2.6	0.5	–	29.8	44.8	0.4	0.6	20.4	0.2	77
Athens	3.2	2.1	2.0	13.8	70.6	5.7	0.5	–	2.1	93.2
Cairo	11.0	2.6		43.8	36.9			0.8		62.3
PM_{10} #										
Istanbul	7.1	64.9	0.1	–	17.4	3.9	3.1	1.7	1.8	61
Athens	18.0	62.7	–	–	13.0	0.8	1.9	3.6	–	21
Cairo #	53.4	4.3			35.9			4.4		6.4

Insights from observations

Results consistent with this inventory have been obtained from source apportionment of PM pollution in Istanbul by *Kocak et al. (2010a).* These authors employed positive matrix factorization (PMF) analysis based on measurements by *Theodosi et al. (2010)* of the chemical composition of PM_{10} in Istanbul (Bosporus University site) covering a period from November 2007 to June 2009. They calculated a contribution up to 29% of traffic to the PM_{10} levels, which is comparable with the 17% that is estimated in the emission calculations considering that the traffic cluster of the PMF analysis also includes re-suspended dust. They also calculated a contribution of up to ~39% from all sorts of incineration that is comparable with the 38% calculated as the sum of residential, industrial and energy production emissions.

Evaluation by adopting in mesoscale modeling

The Istanbul emission inventory has been used in mesoscale WRF/CMAQ modeling by Im et al (2011a,b) and has been successfully evaluated for its ability to reproduce observed O_3 (Figure 1) in Istanbul in summer 2004. The model is also able to reproduce reasonably well aerosol levels and composition in the East Mediterranean (Table 3; from Im et al., 2011b). Further evaluation of this inventory for 2008 year around is ongoing.

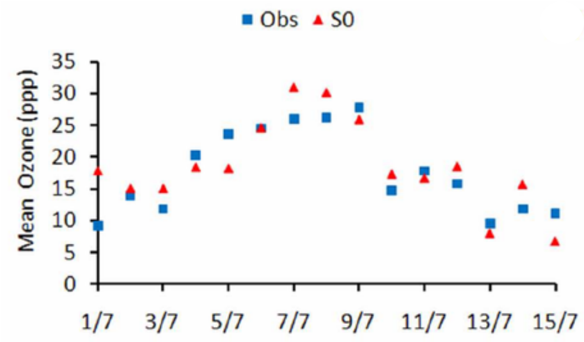

Figure 1. Observed (square) and modelled (triangle) surface daily mean ozone mixing ratios at Istanbul in July 2004 (Im et al., 2011a).

Table 3. Comparison of the PM_{10} composition (ug m^{-3}) calculated in the present study with previous studies in the region. Parentheses show the standard deviation (one number) or the minimum and maximum values (two numbers), if available (Im et al., 2011b and references therein).

Location	Period	nss-SO_4^{2-}	NO_3^-	$NH4^+$	Na^+	EC	OC	Reference
Istanbul	1-31/7/08	3.4 (1.1)	0.7 (0.2)	0.3 (0.2)	3.1 (0.6)	2.5 (1.2)	4.8 (1.8)	Theodosi et al., 2010 (Obs.)
	1-15/7/04	**6.4 (1.2)**	**0.8 (0.5)**	**2.1 (0.3)**	**0.4 (0.4)**	**2.6 (0.9)**	**6.9 (2.3)**	**This study**
Athens	29/8-16/9/94	5.5 (3-10)	2 (1-5)	1.5 (0.5-4)	0.5			Eleftheriadis et al., 1998 (Obs.)
	24/6/98	5.8 (1)	0.4 (0.4)	1 (0.5)	0.8 (0.2)			Athanasopoulou et al., 2008 (Model)
	2/6/03-21/7/03	8.2 (1.1)	1.8 (0.7)	2.4 (0.4)		2.0 (0.5)	14.1 (1.9)	Sillanpaa et al., 2006 (Obs.)
	1-15/7/04	**7.3 (1.4)**	**0.6 (0.2)**	**1.8 (0.4)**	**0.5 (0.4)**	**1.2 (0.5)**	**1.6 (0.5)**	**This study**
Thessaloniki	7/97-7/98	7.2 (5.8)	3.4 (1.9)	3.5 (2.3)	0.6 (0.5)			Tsitouridou et al., 2003 (Obs.)
	24/6/98	13.4 (2.8)	0.2 (0.3)	2.2 (0.9)	0.6 (0.2)			Athanasopoulou et al., 2008 (Model)
	6/07-9/07	6.2 (1.7-13.6)	1.3 (0.3-4.1)	1.3 (0.2-4.2)	0.3 (0-1.8)	2.8 (1-7.7)	6.5 (2.8-23.7)	Terzi et al., 2010 (Obs.)
	1-15/7/04	**6.6 (1.4)**	**0.4 (0.3)**	**1.8 (0.4)**	**0.1 (0.1)**	**0.3 (0.1)**	**1.0 (0.2)**	**This Study**
Finokalia	13-16/7/00	4.2	3.4	1	4.1			Smolik et al., 2003 (Obs.)
	26-30/7/00	8.2	2	3.7	0.6			Smolik et al., 2003 (Obs.)
	10-31/7/00 7-14/1/01	6.9 (1.0)	2.8 (0.4)	2.4 (0.4)	2.0 (0.3)	(0.1-0.7)	(0.3-2.2)	Bardouki et al., 2003 (Obs.)
	24/6/98	5.3 (1)	0.9 (0.3)	0.4 (0.1)	2.3 (0.8)			Athanasopoulou et al., 2008 (Model)
	12-16/7/04	8.1	2.1	2.3	1.1	0.6 (0.1)	4.7 (1.2)	Koulouri et al., 2008 (Obs.)
	12-15/7/04*	**6.5 (1.4)**	**0.6 (0.3)**	**1.0 (0.2)**	**0.5 (0.4)**	**0.3 (0.1)**	**0.8 (0.2)**	**This Study**
	1-15/7/04	**6.8 (1.1)**	**1.1 (0.4)**	**1.1 (0.2)**	**1.2 (0.8)**	**0.3 (0.1)**	**0.9 (0.2)**	**This study**

*12-15/7/2004 period of our simulation is extracted from the 15-day simulation period in order to be compared with Koulouri et al. (2008).

2.3 Emission improvement through satellite observations

Techniques have been developed that use satellite observations to derive emissions in various hotspots (Konovalov et al., 2010). Figure 2 shows this at the example of the Ruhr agglomeration. The technique can be used also to identify non-linear trends in emissions. The study of Konovalov et al., 2010 has been communicated by CityZen to the EMEP Centre responsible for emission data under the LRTAP convention.

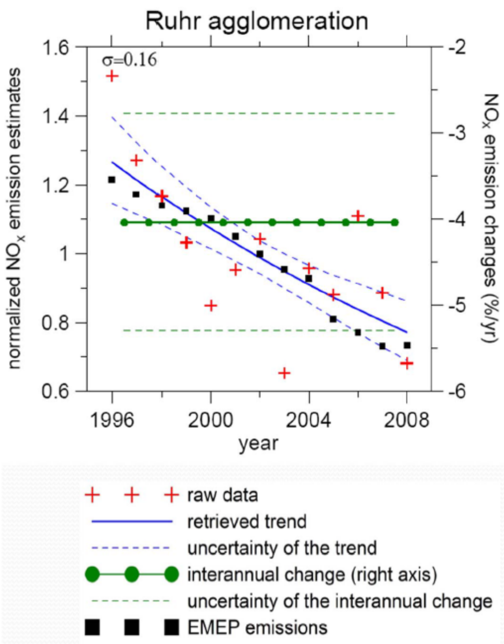

Figure 2. Trends in NOx emission estimates using satellite data, compared to EMEP data in the Ruhr agglomeration in Germany. From Konovalov et al., 2011.

3 Future emissions in CityZen

3.1 GEA

Coordinated by the International Institute for Applied Systems Analysis (IIASA) the Global Energy Assessment (GEA) is led by some of the world's leading energy experts, in research, academia, business, industry and policy, representing both the developed and the developing world. GEA is the first ever fully integrated energy assessment analyzing energy challenges, opportunities and strategies, for developing, industrialized and emerging economies. It is supported by government and non-governmental organizations, the United Nations System, and the private sector.

GEA involves specialists from a range of disciplines, industry groups, and policy areas in defining a new global energy policy agenda, one that is capable of transforming the way society thinks about, uses and delivers energy and to facilitate equitable and sustainable energy services for all, in particular the two billion people who currently lack access to clean, modern energy.

Published by Cambridge University Press, the Global Energy Assessment final report will be released in autumn 2011. The report will be accompanied by a series of policy briefs and White Papers addressing specific areas of the energy policy agenda.

The data set have been described in more detail in CityZen deliverable reports D3.3.2 and D3.3.4. The emission data will be available after the publication of the Final report.

IIASA has provided GEA gridded global emission data sets for different datasets, three of which have been used extensively by CityZen modellers, mainly to model Air Quality changes up to the year 2030, but also to model climate change up to year 2050. The scenarios are based on different assumptions on technological development and air quality/climate change policy.

3.2 Mitigation scenarios

In order to investigate climate friendly air quality measures in more detail, IIASA has provided ratios by which the reference scenario from GEA can be multiplied in order to mimic these measures. The measures and the rationale behind the ratios are described in detail in CityZen deliverable report D3.3.4. In brief, the measures are selected so that air quality is improved while at the same time not leading to global warming. Figure 3 shows an example for ratios in different countries, when the selected climate-friendly air quality measures are implemented.

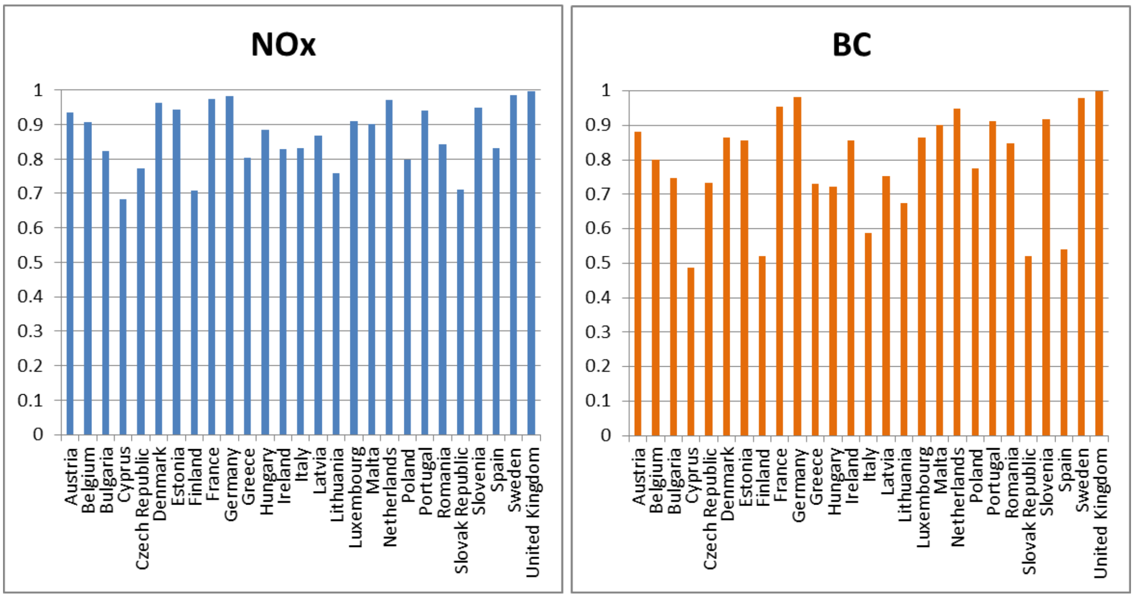

Figure 3: Ratios, by which reference emissions for 2030 have to be multiplied to mimic the climate-friendly air quality measures selected from GAINS. Road transport sector for NOx and BC. EU-27 countries.

For CityZen, different cases were defined:

[1] GEA high CLE

[2] GEA high CLE with IIASA ratios in megacity areas

[3a] GEA high CLE with IIASA ratios everywhere

[3b] GEA high CLE with same emission delta per country as in [2] evenly distributed over the country

[4] GEA low CLE

The GEA scenarios ‘GEA high CLE’ and ‘GEA low CLE’ mentioned in section 3.1 and described in more detail in deliverable report 3.3.2, are gridded and can be used conveniently by models. The mitigation scenarios, with IIASA scenarios, were converted by CityZen partner INERIS into files that are readable for regional and global modellers. Figure 4 shows examples for three of the cases.

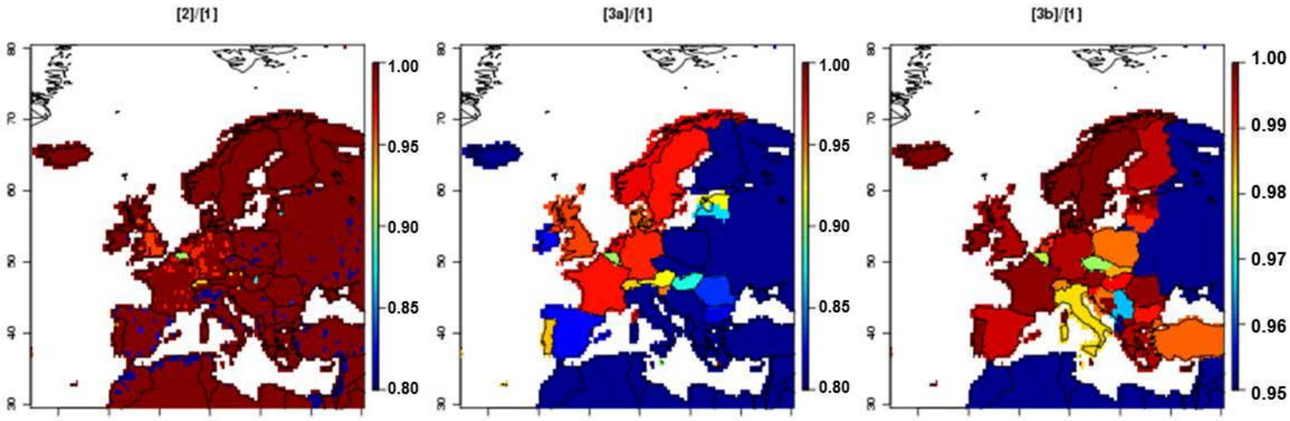

Figure 4: Change in emissions with respect to ‘GEA high CLE’ for cases [2], [3a], and [3b]. Values below 1 mean a decrease. Courtesy A. Colette, INERIS.

4 Model results

Model results from CityZen have been disseminated as they became available. For example results on the impact of climate change on air quality, as calculated by the HIRLAM model, have been reported to CLRTAP in 2010 (Nyiri et al., 2010).

The study exploited synergies between the European EUCAARI and CityZen projects, as acknowledged in the EMEP report. While in the EUCAARI project the focus was on the 2040s, in CityZen also the period 2025-2035 was chosen. Figures 5 and 6 thus show changes in climate and resulting changes in ozone and particulate matter. The main features, as described in other CityZen deliverable reports (D2.3.1), are an increase in ozone over large parts of Europe (mostly connected to a temperature-induced increase in biogenic VOC emissions) and an increase in particulate matter over the Mediterranean region, probably caused by the decrease in precipitation.

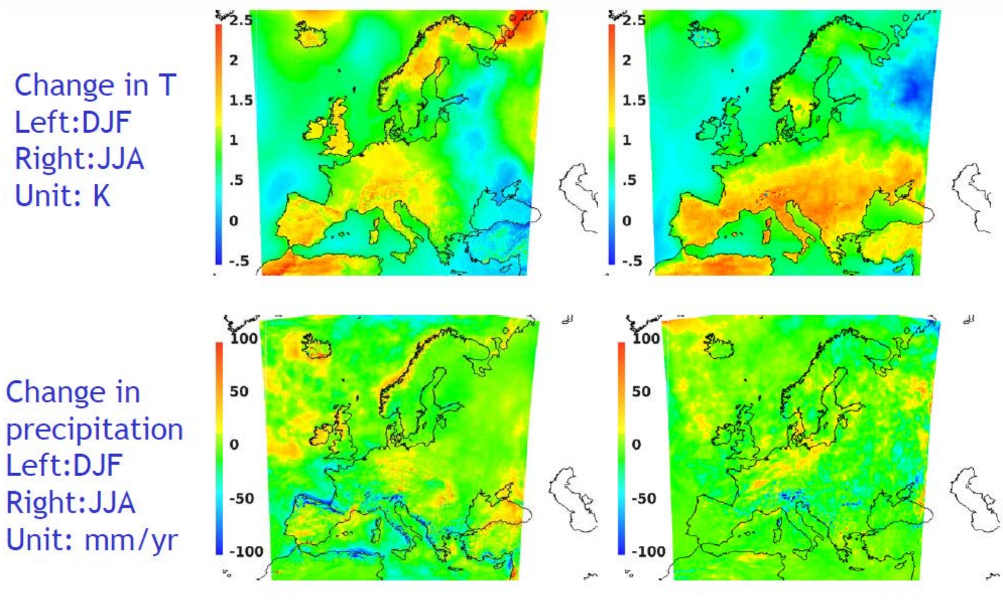

Figure 5: Change in temperature and precipitation between 2005 and 2030, in the summer and winter seasons, according to the HIRHAM model (CityZen partner met.no). Red colors indicate an increase, blue colors a decrease. Figure taken from A. Nyiri, met.no presentation at CityZen 2nd Annual Meeting in Istanbul, 2010.

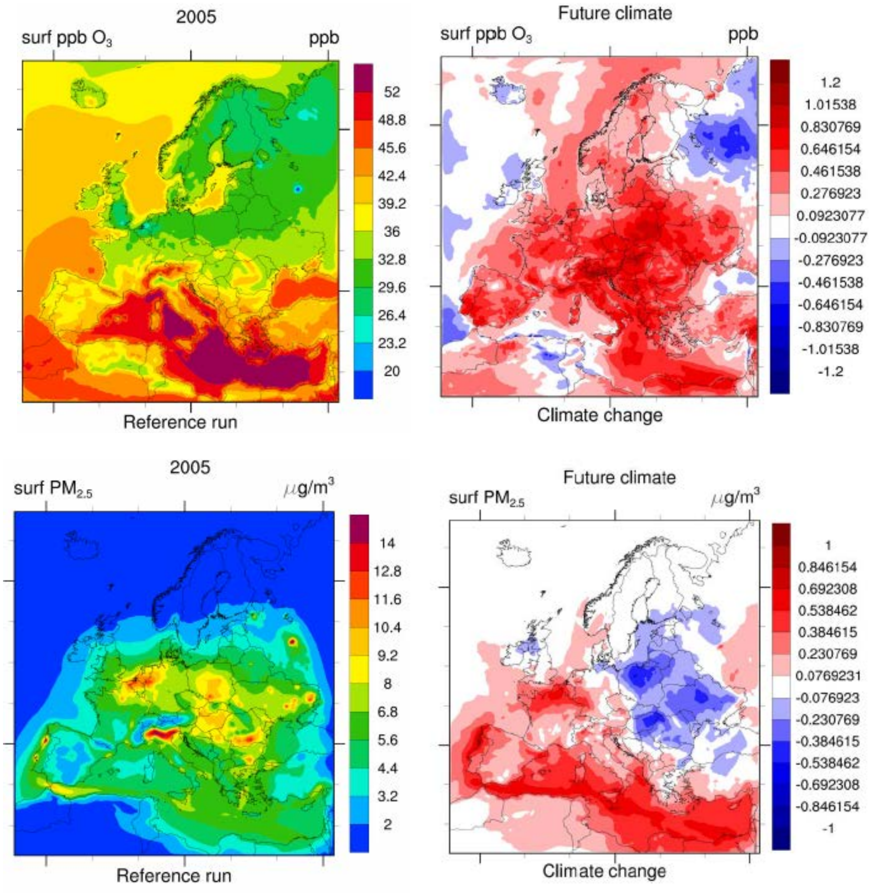

Figure 6: Surface concentrations of ozone (upper left) and PM2.5 (bottom left), compared to changes that are due to climate change only (right panels), modelled by the EMEP model (CityZen partner met.no). Figure taken from A. Nyiri, met.no presentation at CityZen 2nd Annual Meeting in Istanbul, 2010.

For what concerns the impact of emission changes in the various hotspot regions defined in CityZen, Figure 7 shows examples from the EMEP model. It is interesting to note the different response in, e.g. the BeNeLux and the Po Valley areas, reflecting a very different chemical regime.

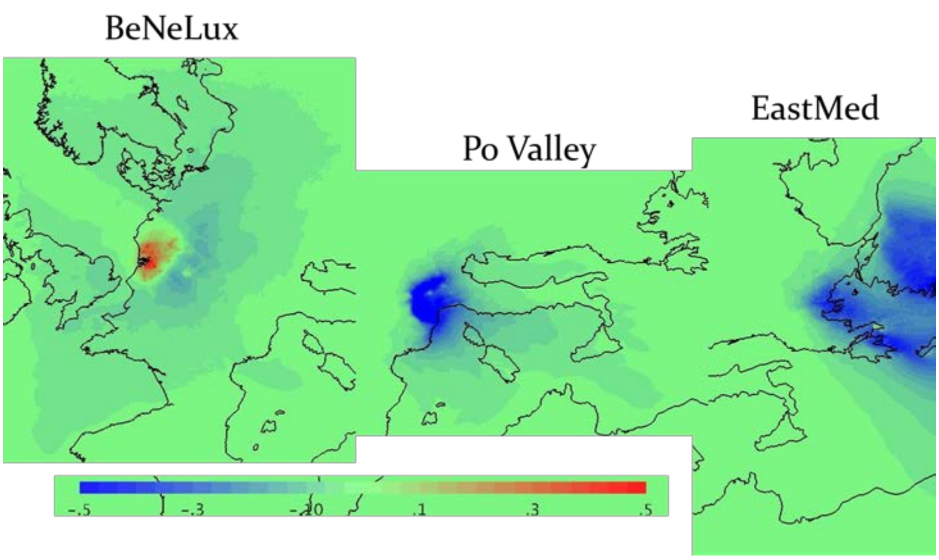

Figure 7: Change in ozone, resulting from a 10% decrease in ozone precursor emissions in the summer season (JJA), averaged over the time period 1998-2007.

The Po Valley is characterized by high concentrations of VOCs so that a NOx increase will lead to ozone increase in summer. In the BeNeLux area, high concentrations of NOx will lead to titration in heavily polluted area and the decrease in ozone is transported beyond the city limits. The figure shows the reverse case, where emissions are reduced, so that the ozone signal becomes positive in the BeNeLux region and negative in the Po Valley region in summer.

5 Observational evidence

Ground-based observational data have been compiled from a comprehensive data base hosted by NILU (http://ebas.nilu.no/) for the use by CityZen modelers, while satellite data are available at the IUP (University of Bremen) servers. The satellite data have been described in detail in the deliverable reports of Tasks 1.1 and 2.1, looking specifically at NO_2, CO_2, methane, glyoxal and aerosols. As an example Figure 8 shows trends in aerosol optical depth derived for the period 1997-2008 from SeaWiFS measurements (Yoon et al., 2011). Downward trends in AOT are found over the BeNeLux area, the Po Valley, and to lesser degree also over Eastern Europe. In contrast, an upward trend in AOT is apparent over the Pearl River Delta. These tendencies in AOT are in agreement with expectations and are explained by decreasing anthropogenic emissions in Europe, in particular in the highly industrialised BeNeLux and Po Valley regions and the rapid economic development in China which leads to large increases in aerosol levels.

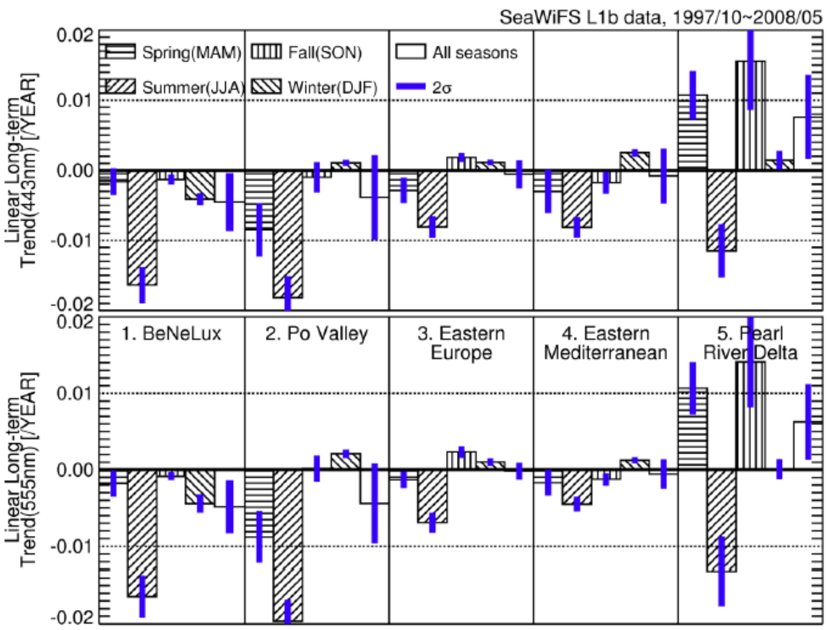

Figure 8: Linear trends in AOT at two wavelengths as derived from SeaWiFS data from October 1997 to May 2008 using the BAER algorithm. Trends are separated by season and shown for 5 regions. The upper panel is for AOT at 443 nm, the lower at 555nm. (Figure from Yoon et al., 2011.)

Ground-based measurement networks have been analysed and partly maintained for CityZen in the Eastern Mediterranean hotspot (D1.4.1, D1.4.2, D1.1.6), the Po Valley (D1.6.1), London (D1.1.6), the BeNeLux area (D1.5.1) and the Pearl River Delta (D1.7.1). The long-term observations have been used to get further insight into trends (see deliverable report D1.1.6), but also for detailed source allocation studies (e.g. Kocak et al., 2010a, Kocak et al., 2010b).

6 Conclusions and outreach

There have been made substantial improvements within CityZen beyond state-of-the-art, especially in satellite observations, the Eastern Mediterranean hotspot and coordinated model trend studies for the recent past. Major advances have also been made in emission inventories and the collection of ground-based data. Many partners of CityZen are in contact with their local authorities to make major scientific results available. Although it is always challenging to distil messages from scientific results that can be used directly in policy, CityZen has been successful in issuing policy-relevant messages from the project. During the third year of the project a policy flyer was created and disseminated amongst authorities. Preparations for an EC meeting in October 2011 about the revision of the European Air Quality legislation are still ongoing. Consolidated policy messages will be presented at that meeting and also be disseminated through the CityZen websites. A detailed study on mitigation options is also in preparation (based on the results presented in deliverable D3.4.1 and an ongoing analysis).

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