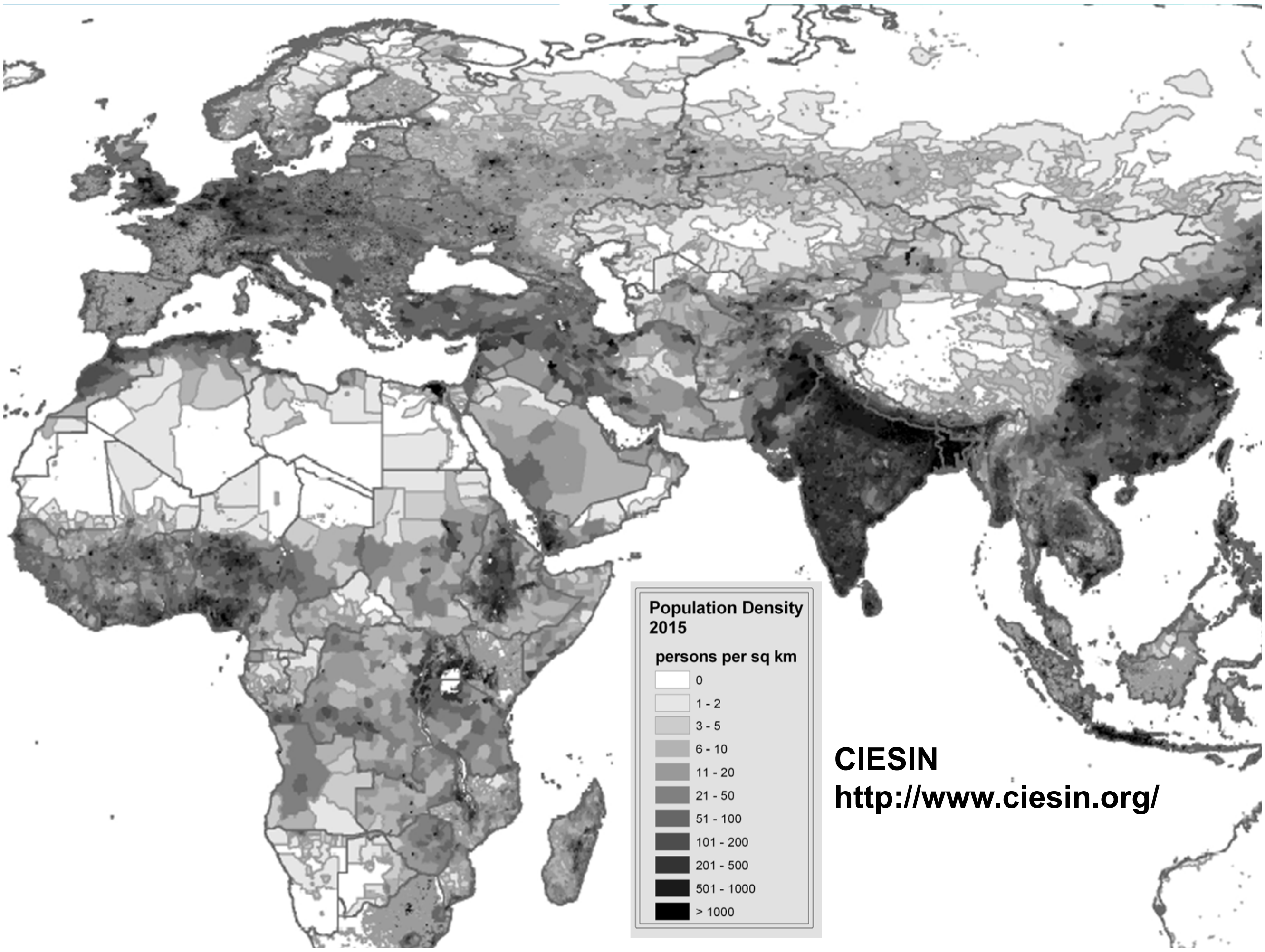
CityZen - a European Union FP7 project focusing on environmental problems arising from Megacities

Michael Gauss
& The CityZen Team

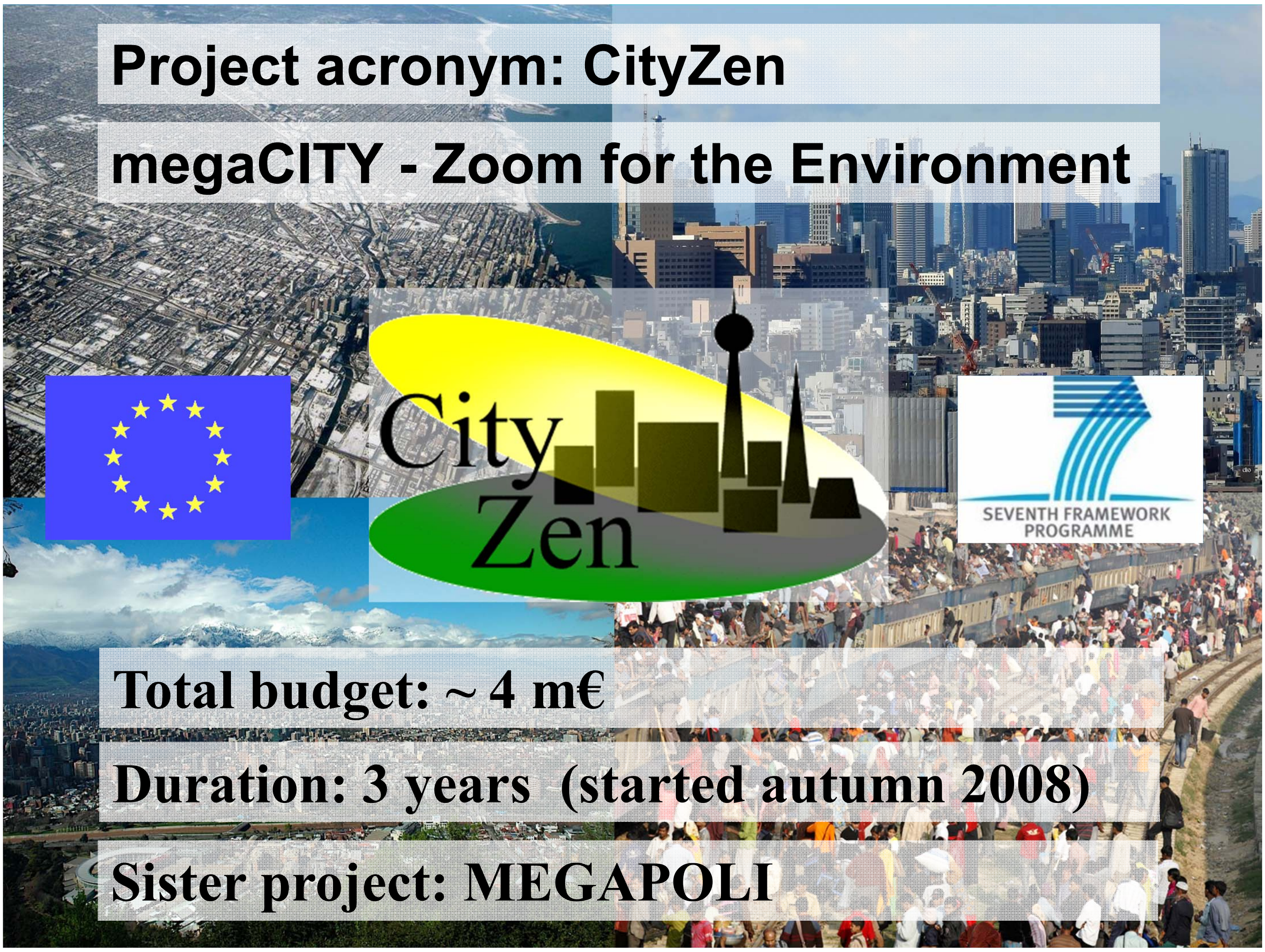
EGU Splinter Meeting MEGAPOLI/CityZen/MILAGRO, 05 April 2011



Rank	Name	English Name	Country	Population	Remark
1	Tōkyō	Tokyo	Japan	34,200,000	incl. Yokohama, Kawasaki, Saitama
2	Guangzhou	Canton	China	24,900,000	Northern Pearl River Delta incl. Dongguan, Foshan, Jiangmen, Zhongshan
3	Seoul	Seoul	Korea (South)	24,500,000	incl. Bucheon, Goyang, Incheon, Seongnam, Suweon
4	Delhi	Delhi	India	23,900,000	incl. Faridabad, Ghaziabad
5	Mumbai	Bombay	India	23,300,000	incl. Bhiwandi, Kalyan, Thane, Ulhasnagar
6	Ciudad de México	Mexico City	Mexico	22,800,000	incl. Nezahualcóyotl, Ecatepec, Naucalpan
7	New York	New York	United States of America	22,200,000	incl. Newark, Paterson
8	São Paulo	São Paulo	Brazil	20,800,000	incl. Guarulhos
9	Manila	Manila	Philippines	20,100,000	incl. Kalookan, Quezon City
10	Shanghai	Shanghai	China	18,800,000	
11	Jakarta	Jakarta	Indonesia	18,700,000	incl. Bekasi, Bogor, Depok, Tangerang, Tangerang Selatan
12	Los Angeles	Los Angeles	United States of America	17,900,000	incl. Riverside, Anaheim
13	Ōsaka	Osaka	Japan	16,800,000	incl. Kobe, Kyoto
14	Karāchi	Karachi	Pakistan	16,700,000	
15	Kolkata	Calcutta	India	16,600,000	incl. Haora
16	Al-Qāhirah	Cairo	Egypt	15,300,000	incl. Al-Jizah, Hulwan, Shubra al-Khaymah
17	Buenos Aires	Buenos Aires	Argentina	14,800,000	incl. San Justo, La Plata
17	Moskva	Moscow	Russia	14,800,000	
19	Dhaka	Dacca	Bangladesh	14,000,000	
20	Beijing	Beijing	China	13,900,000	
21	Tehrān	Tehran	Iran	13,100,000	incl. Karaj
22	İstanbul	Istanbul	Turkey	13,000,000	
23	London	London	Great Britain	12,500,000	
23	Rio de Janeiro	Rio de Janeiro	Brazil	12,500,000	incl. Nova Iguaçu, São Gonçalo
25	Lagos	Lagos	Nigeria	12,100,000	
26	Paris	Paris	France	10,500,000	
27	Chicago	Chicago	United States of America	9,850,000	
28	Shenzhen	Shenzhen	China	9,450,000	
29	Krung Thep	Bangkok	Thailand	9,400,000	
30	Lima	Lima	Peru	9,200,000	
30	Wuhan	Wuhan	China	9,200,000	
32	Kinshasa	Kinshasa	Congo (Dem. Rep.)	9,150,000	

Largest *agglomerations* of the world
01-01-2011

Source: *Thomas Brinkhoff: City Population*
http://www.citypopulation.de



The 16 partners of CityZen

13 partners from EU

3 partners outside the EU: China, Turkey, and Egypt

Objectives of CityZen

- Quantify and understand current air pollution in and around selected megacities
- Development of tools to estimate interactions between different spatial scales
- Estimate how megacities influence air quality and climate, locally and globally
- Estimate how megacities are responding to climate change
- Estimate the impact of future emission change, including mitigation options
- Provide technical underpinning of policy work

Issues within air pollution and climate change research addressed by CityZen

- Scale interactions
- Emission data sets and scenarios
- Observing and modelling trends
- Modelling future development
- Aerosol-cloud interactions

- Mitigation options and links to policy making

CityZen publications

- Gerasopoulos, E., Amiridis, V., Kazadzis, S., Kokkalis, P., Eleftheratos, K., Andreae, M. O., Andreae, T. W., El-Askary, H., and Zerefos, C. S.: Three-year ground based measurements of aerosol optical depth over the Eastern Mediterranean: the urban environment of Athens, Atmos. Chem. Phys., 11, 2145-2159, doi:10.5194/acp-11-2145-2011, 2011. Link to online version.
- Hatzianastassiou, N., A. Gkikas, N. Mihalopoulos, O. Torres, B. D. Katsoulis: Natural versus anthropogenic aerosols in the eastern Mediterranean basin derived from multi-year TOMS and MODIS satellite data, J. Geophys. Res., 114, D24202, doi:10.1029/2009JD011982, 2009.
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- Kanakidou, [illegible] poulos, E. Dermitzaki, A. Unal, M. Koçak, K. Markakis, D. Melas, G. Kouvarakis, A. F. Youssef, A. Richter, N. Hatzianastassiou, [illegible] s, A. Ladstaetter-Weissenmayer, H. Moubasher, Megacities as hot spots of air pollution in the East Mediterranean, Atmospheric Environment, doi:10.1016/j.atmosenv.2010.11.048, 2010.
- Koçak, M., Theodosi, C., Zarmpas, P., Im, U., Bougiatioti., A., Yenigün, O., Mihalopoulos, N.: Particulate matter (PM10) in Istanbul: Origin, source areas and potential impact on surrounding regions, Atmos. Environ., doi:10.1016/j.atmosenv.2010.10.007, 2010.
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- Lamarque et al., Historical [illegible] ass burning emissions of reactive gases and aerosols: methodology and application, Atmos. Chem. Phys., 10, 7017–7039, 2010. Link to online version.
- Reuter, M., Buchwitz, M., Sch[illegible], and Burrows, J. P., A method for improved SCIAMACHY CO2 retrieval in the presence of optically thin clouds, Atmos. Meas. Tech., 3, 209-232, 2010. Link to online version.
- Reuter, M., Bovensmann, H., Buchwitz, M., et al., Retrieval of atmospheric CO2 with enhanced accuracy and precision from SCIAMACHY: Validation with FTS measurements and comparison with model results, J. Geophys. Res., 116, D04301, doi:10.1029/2010JD015047, 2011.
- Schneising, O., Buchwitz, M., Burrows, J. P., Bovensmann, H., Bergamaschi, P., and Peters, W., Three years of greenhouse gas column-averaged dry air mole fractions retrieved from satellite - Part 2: Methane, Atmos. Chem. Phys., 9, 443-465, 2009. Link to online version.
- Song, Y., D. Chang, B. Liu, W. Miao, L. Zhu and Y. Zhang: A new emission inventory for nonagricultural open fires in Asia from 2000 to 2009, Environ. Res. Lett. 5, doi:10.1088/1748-9326/5/1/01[illegible], 2010. Link to online version.
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- von Schneidemesser, E., P. S. Monks, C. Plass-Duelmer: Global comparison of VOC and CO observations in urban areas, Atmos. Environ., 44, 5053-5064, 2010. Link to online version.
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Scale interactions and model resolution

Measuring trends in emissions

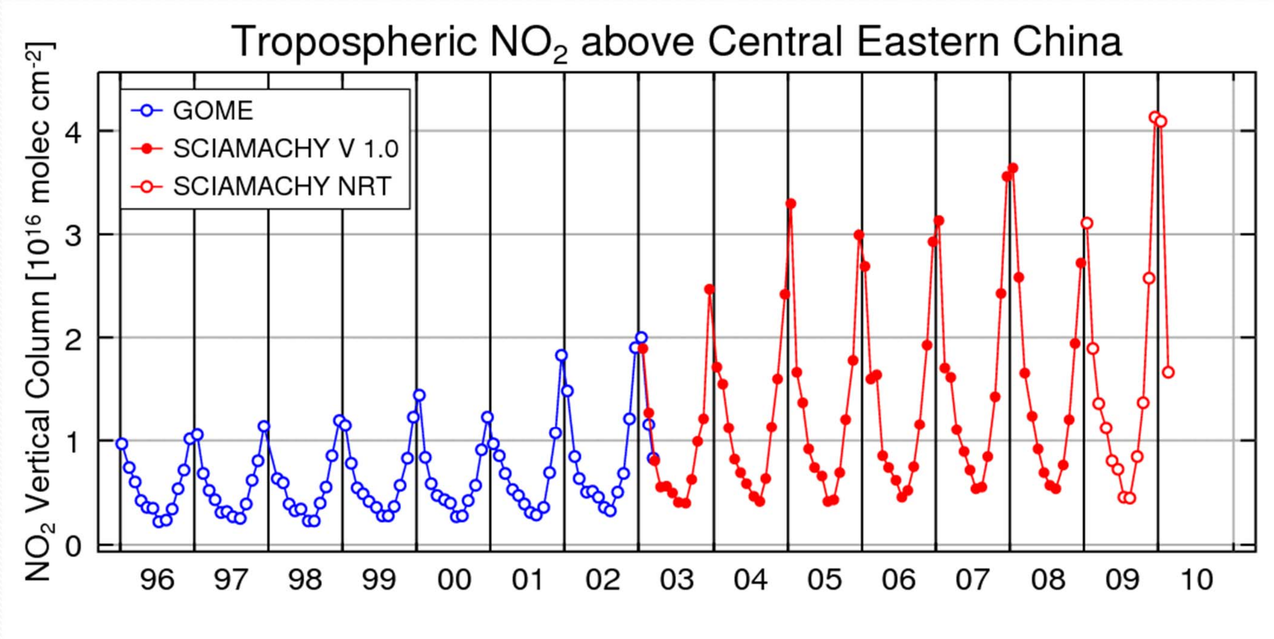
Source attribution of air pollution

Analysis of air quality trends

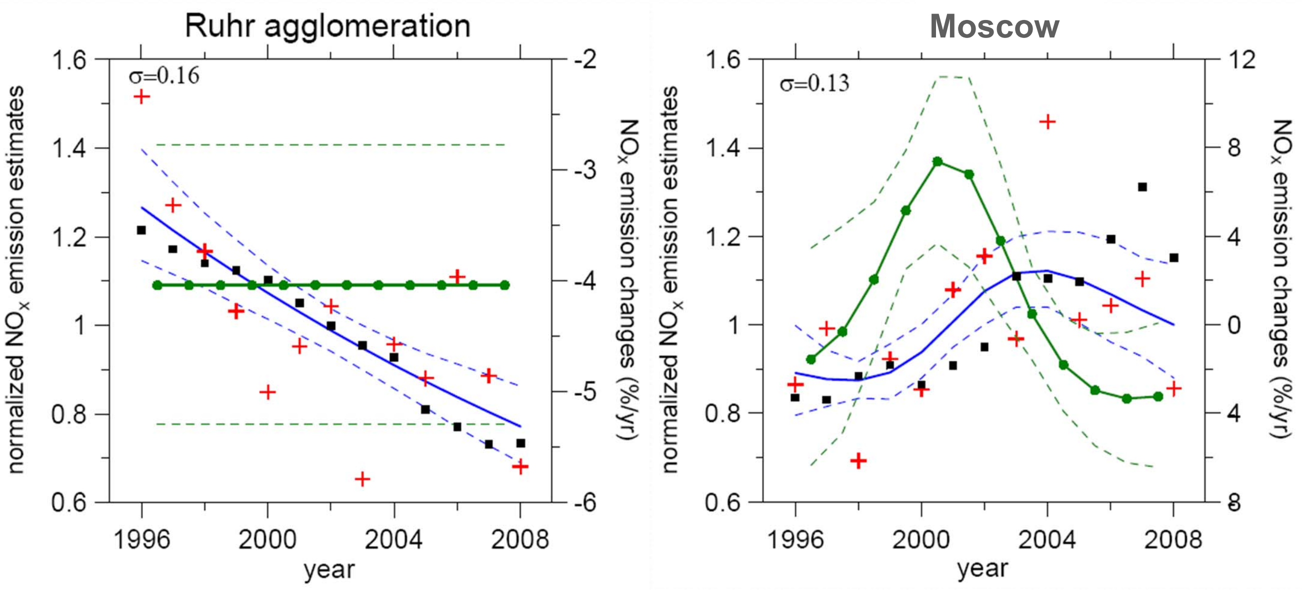
Measuring and modelling air pollution in megacities

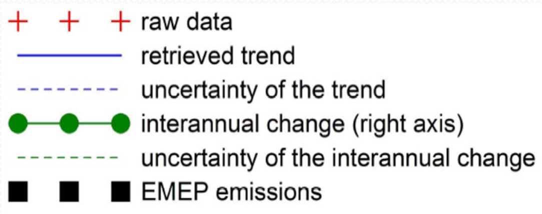
VOC speciation

Studies focusing on the present and recent past



Time series of tropospheric NO_2 above Central Eastern China observed from satellite (GOME and SCIAMACHY instruments) from 1996 to 2010. Source: CityZen partner University of Bremen.

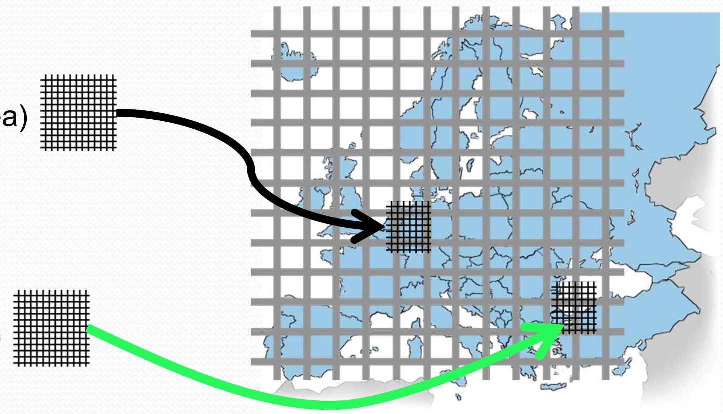




CityZen partner IUP-UB
Konovalov et al., 2010

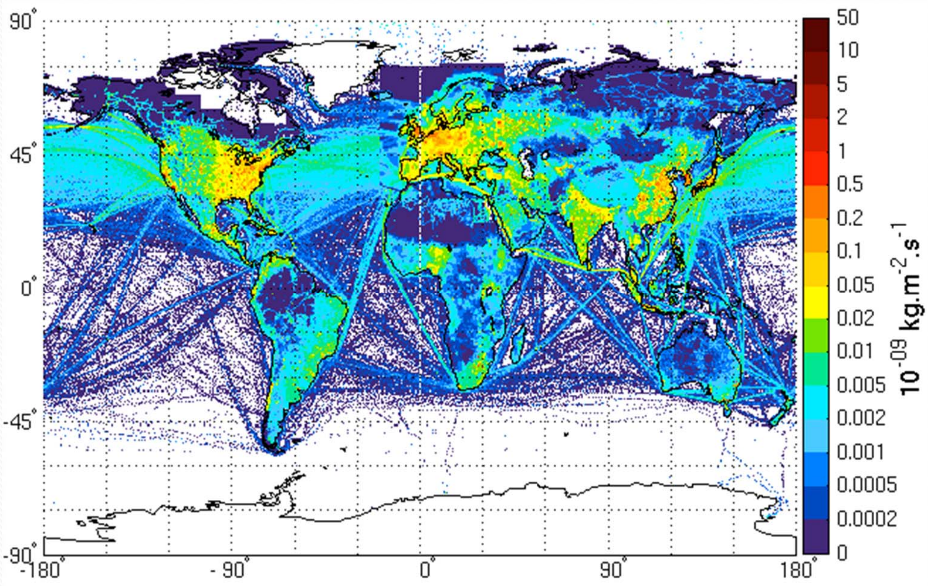
CityZen emission inventories (present)

- 1998-2007 **Europe**: EMEP (50×50 km^2) spatially regridded to 10×10 km^2 using GLOBCOVER data: INERIS (→ "INERIS-EMEP")
- Merging fine-scale data sets into large scale data sets:
  - LANUV (Rhine/Ruhr area)
  - AUTH, Istanbul TU, and Boğaziçi Univ. (Istanbul)



- 1998-2007 **global**: based on the RCP scenarios produced for IPCC-AR5 (0.5°×0.5°) and 'MACC-TNO': CNRS ("MACCity")

Merging regional and global emission data

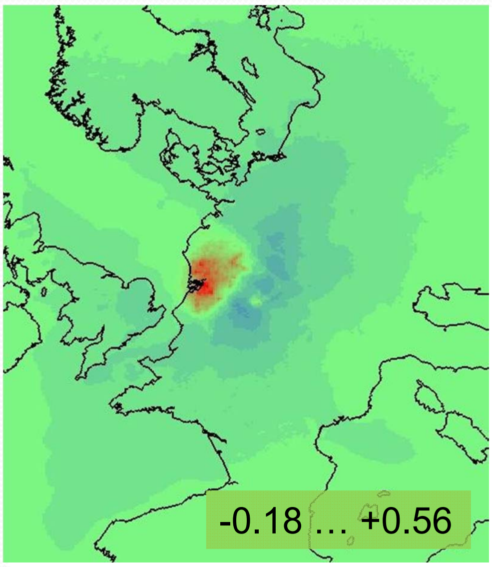


CityZen – anthropogenic emissions of NO in 1998 (EMEP/RCP)

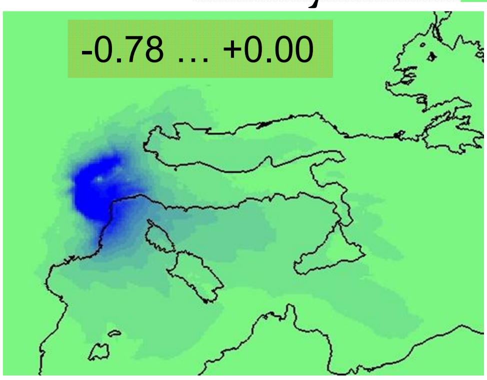
C. Granier et al, CityZen partner CNRS

EMEP results

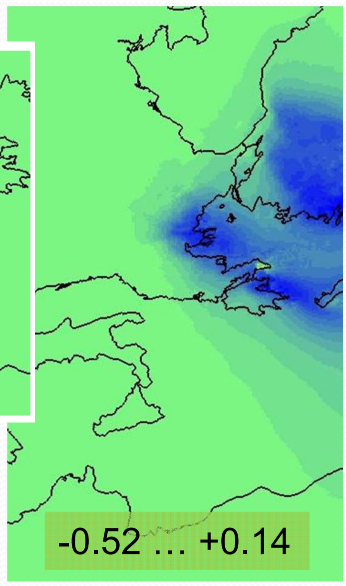
BeNeLux

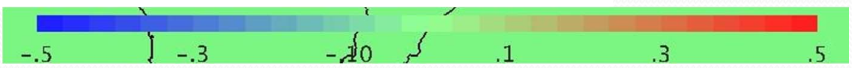


Po Valley



EastMed





Effect of a 10% emission reduction.

Surface ozone summer seasonal mean (change in ppbv).

Multi-Model decadal AQ assessment

Why?

- Are current models able to represent Air Quality trends in European pollution hotspots ?
- Identify contribution of Emissions / Meteorology / Boundary conditions

How?

- Ensemble of CTMs (Bolchem, Chimere, CTM2, Emep, Eurad, Mozart)
- Consistent set of emissions (EMEP/INERIS)
- Some degree of variability amongst models (forcing, BC, etc...)

Who?

- INERIS: A. Colette, F. Meleux, B. Bessagnet, L. Rouïl
- CNR/ISAC : A. Maurizi, F. Russo, F. Tampieri, M. D'Isidoro
- FRIUUK: H. Jakobs, M. Memmesheimer
- Met.no: A. Nyiri, M. Gauss,
- UiO: Ø. Hodnebrog, F. Stordal,
- CNRS: C.Granier, A. D'Angiola
- NILU: S. Solberg

INERIS maîtriser le risque pour un développement durable

Studies focusing on the future (2005-2030-2050)

IIASA Global Energy Assessment

Emission scenarios for 2005-2050

- *GEA Frozen Legislation (unrealistic)*
  - no change in pollution policies relative to 2005
  - no change beyond year 2005 technologies
  - no change in energy access policy
- GEA *Reference case with CLE ("CLE high")*
  - no specific policies on climate change and energy access, but full implementation of all current and planned air pollution legislation world-wide

International Institute for Applied Systems Analysis
IIASA

- GEA *Sustainable policy with CLE ("CLE low")*
  - full implementation of all current and planned air pollution legislation world-wide
  - moderate energy access policy (clean energy)
  - stringent climate policy (limit to 2-degree global temperature increase by 2100)
  - gives an indication of co-benefits of combining policies on climate change, energy access and air pollution

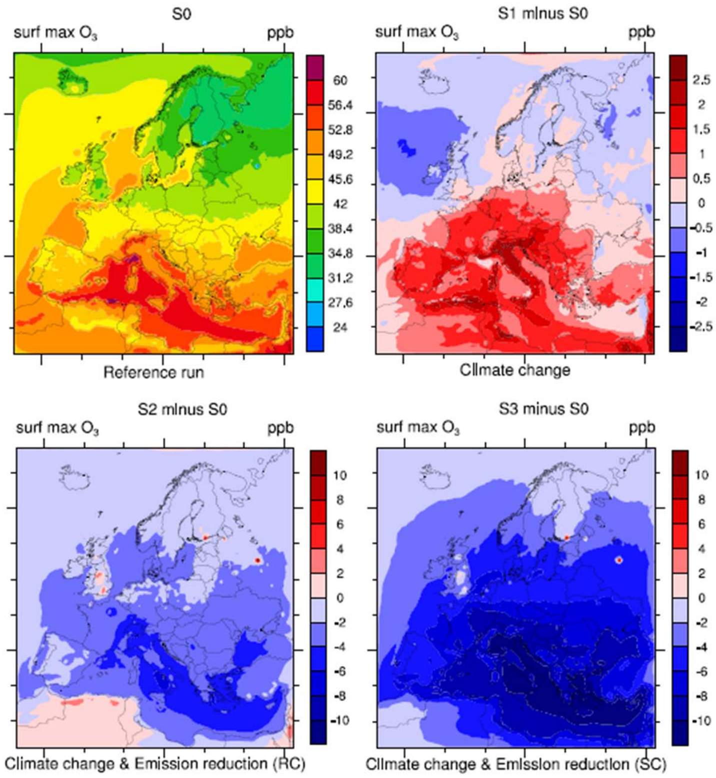
International Institute for Applied Systems Analysis
IIASA

Changes in ozone

Left: Daily maximum surface ozone, 2000-2010.

Right: Change until 2040-2050, Effect of climate change only.

… effect of climate change **and** emission change (left: GEA high CLE, right: GEA low CLE)



Norwegian Meteorological Institute *met.no*

Examples of climate-friendly Air Quality measures

Technical measures for black carbon mitigation

1. Replacing **traditional coke ovens** with modern recovery ovens, including the improvement of end-of-pipe abatement measures (in developing countries)
2. Replacing **traditional brick kilns** with vertical shaft kilns and Hoffman kilns where considered feasible (in developing countries)
3. Introduction of **improved biomass cook stoves** in developing countries
4. Wide-scale introduction of **pellets stoves and boilers** in the residential sector (in industrialized countries)
5. **Diesel particle filters** for road vehicles and off-road mobile sources (excluding shipping)
6. Particle control at **stationary engines**

IIASA International Institute for Applied Systems Analysis

Model experiments with ‘IIASA ratios’

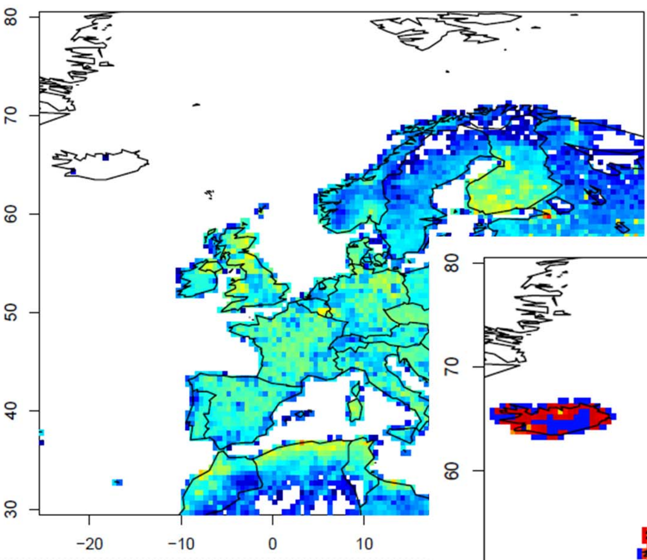
[1] GEA high CLE

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

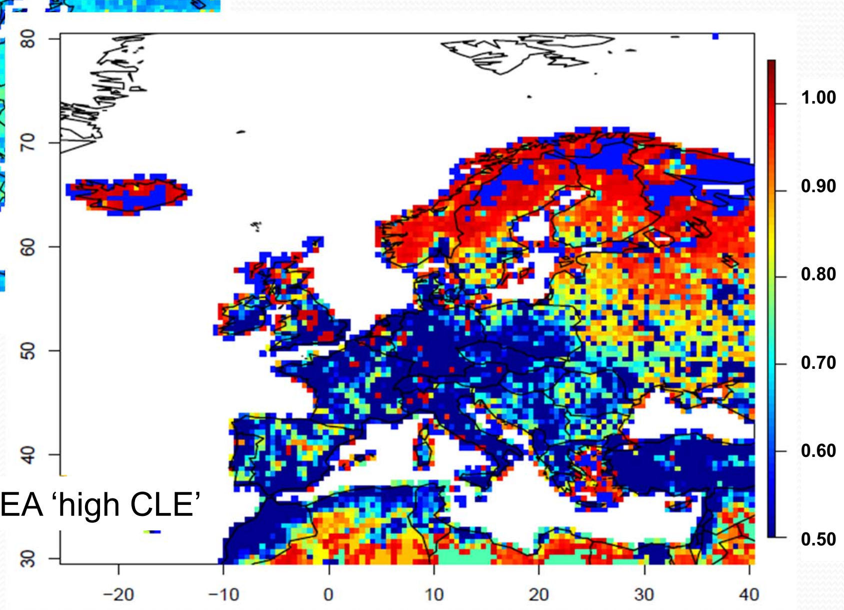
[3a] GEA high CLE with IIASA ratios everywhere

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

[4] GEA low CLE

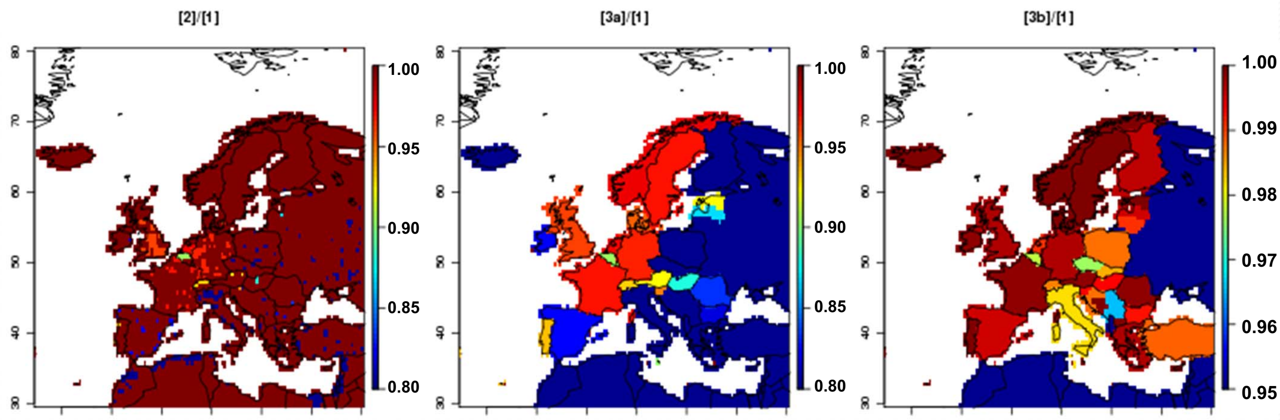


Pattern of NOx emissions in the GEA “high CLE” case in 2030

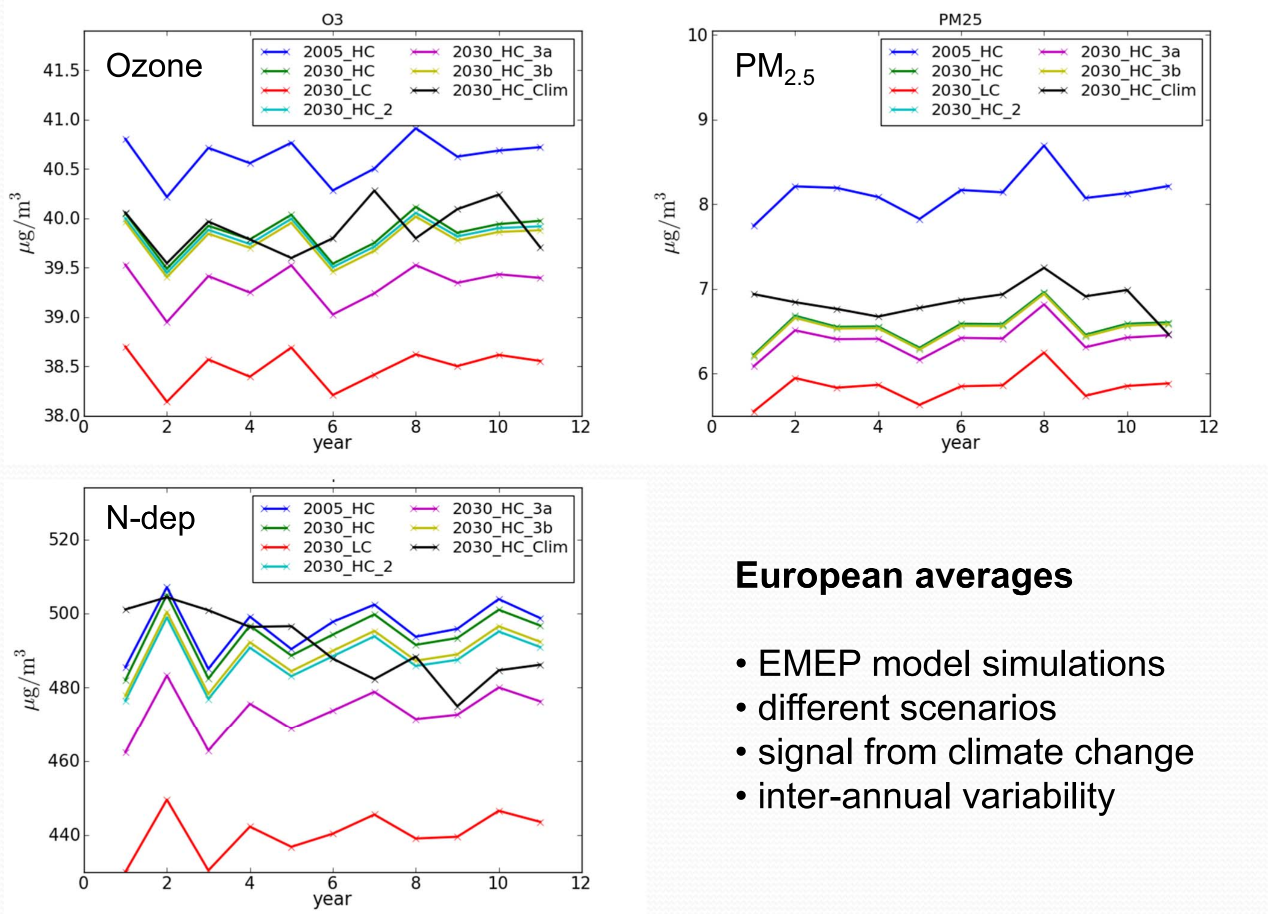


CityZen partner INERIS

Applying the emission ratios
(zoom on Europe)



Augustin Colette, CityZen partner INERIS



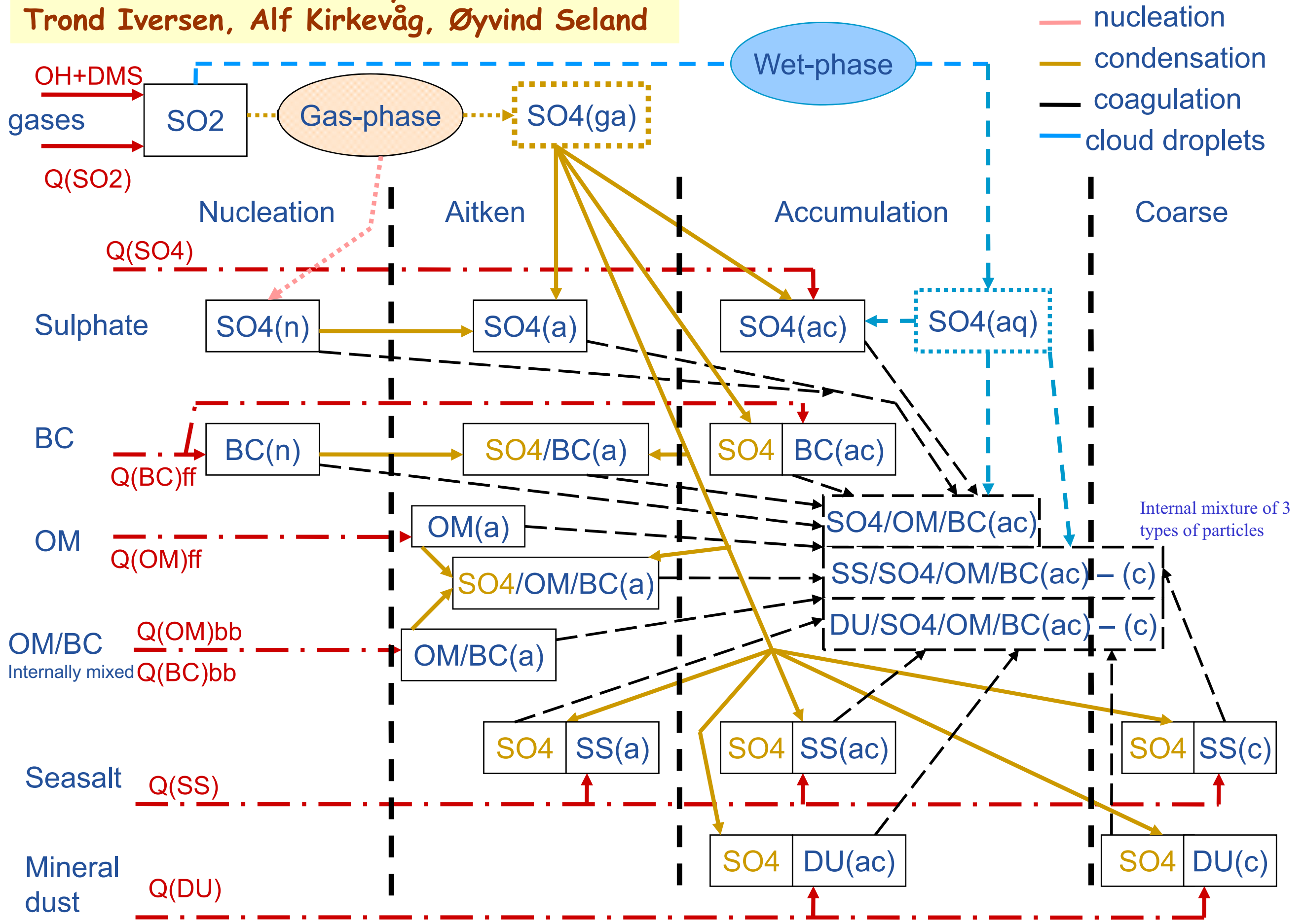
European averages

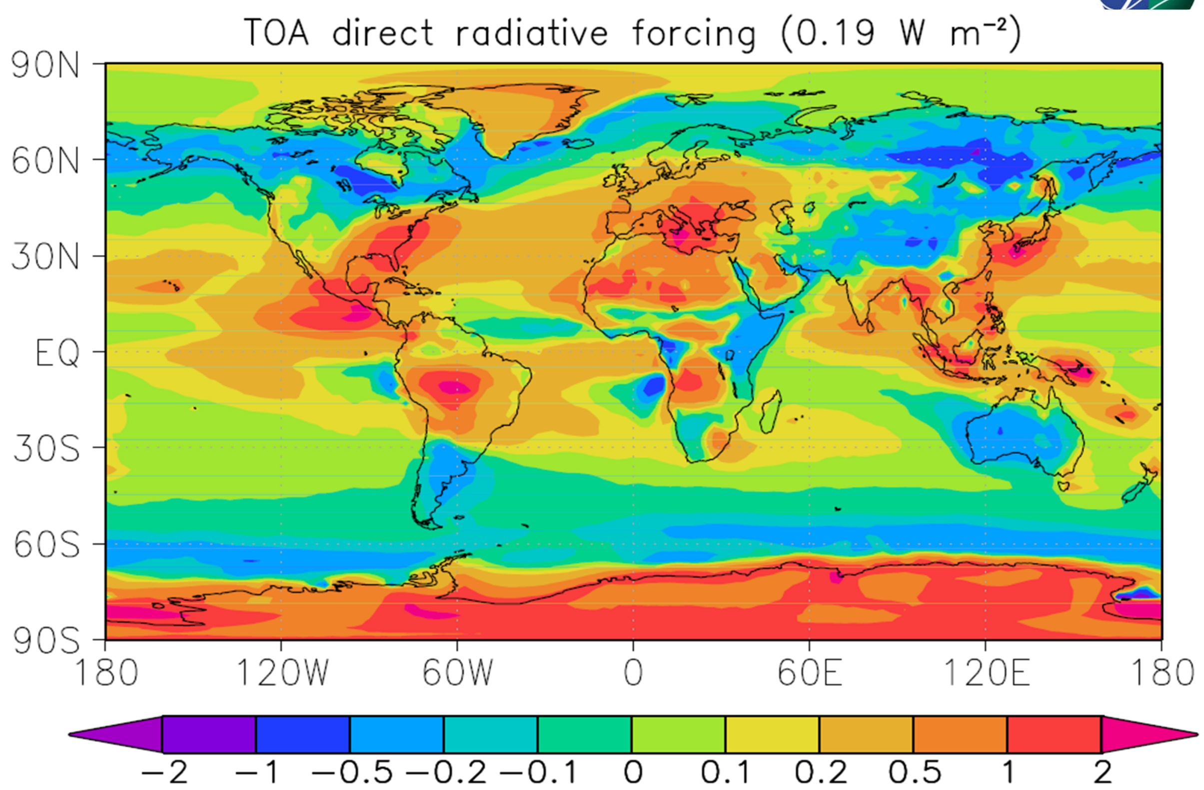
- EMEP model simulations
- different scenarios
- signal from climate change
- inter-annual variability

'hot off the press'

Agnes Nyiri, met.no

CAM-Oslo - Aerosol lifecycle schematic – Trond Iversen, Alf Kirkevåg, Øyvind Seland





Øyvind Seland

New experiments

- What if there were no emission hot spots? (but still the same activity level)
  - redistribute emissions of *particles* and *particle precursors* from fossil fuel use evenly within 40°S and 60°N over land areas after 1980 and compare to a CMIP5 'best simulation' (1850-2100), to be done in April
- **What about mitigation options?**
  - **run at least two IIASA scenarios, 'GEA low CLE' and 'GEA high CLE'**