CityDelta:
Objectives, methodology, Results

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Science for Global Insight

EUROTRAC 2

Presentation Overview

- Background
- Methodology
- Interpretation of the results
  - Emission Inventories
  - Model Validation
  - Deltas Interpretation
  - Key Findings
- Functional Relationships
- Conclusions

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CAFE: Clean Air For Europe

Launched in 2001 by the European Commission, CAFE is a programme of technical analysis aiming at the development of a long-term, integrated policy advice to protect against negative effects of air pollution on human health and the environment

***Question**: Which measures will lead to a cost-effective reduction of air-pollution health-related problems in European Cities? In particular for O3 and PM*

CityDelta Objective

How to include sub-grid effects into an Europe-wide health impact assessment for PM/Ozone?

CityDelta

A model inter-comparison exercise for urban-regional dispersion models focusing on 8 European cities to identify:

- the systematic differences (delta's) between rural and urban background AQ ("*Scale*"),
- how these delta's depend on emissions ("*Emissions*"),
- how these delta's vary across cities *("Cities"),*
- how these delta's vary across models *("Models"*)
- how these delta's vary for PM and O3 ("*Pollutants*").

Driving force:

WHO Review of health impacts from air pollution

- **Largest damage from long-term exposure to PM2.5**

  - ✓ Not yet possible to distinguish potency of individual PM components
  - ✓ No threshold can be identified
  - ✓ Thus larger health benefits from large-scale reductions of low concentrations than from peak concentrations at hot spots

  ⟹ CityDelta Indicator: Annual PM2.5 mean

- **New evidence for mortality effects from ozone**

  - ✓ No firm evidence for no-effect level, but larger uncertainties for effects at low concentrations
  - ✓ Thus also low ozone days are relevant

  ⟹ CityDelta Indicator: SOMO35 (*)

(*) Sum of max daily 8-hour mean O3 concentrations over 35 ppb, calculated over the entire year

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15 Modelling teams: 7 regional-scale 11 urban-scale

Model	# of levels	Level	Domain	Resolution
CALGRID	11	10m	CITYDELTA	5-10
CAMx	11	10m	CITYDELTA	5-10
CHIMERE local	6: surface-700hPa	SL (50m)	CITYDELTA	5
CHIMERE regional	6: surface-700hPa	SL (50m)	Europe	50
EMEP Unified Model	20: surface-100hPa	1m	EMEP	50
EMEP-v.1	20: surface-100hPa	45m	EMEP	50
EPISODE	6: 25-2500m	2m	CITYDELTA	10
EUROS	4	25m	CITYDELTA	10-50
LOTOS local	3: 0-3500m	ML	CITYDELTA	5-10
LOTOS régional	3: 0-3500m	ML	Europe	50
MOCAGE	47: surface-5hPa	1st level (0-50m)	Paris, Milano	10-50
MUSCAT	22: 0-4400m	1st level (0-33m)	CITYDELTA	10
MUSE	5	10m	CITYDELTA	10
OFIS	2	ML	CITYDELTA	5
REM3 local	4: 0-3000m	SL	CITYDELTA	5
REM3 regional	4: 0-3000m	SL	Europe	50
STEM-FCM	11	10m	CITYDELTA	5
TRANSCHIM	10	50m	CITYDELTA	5-10

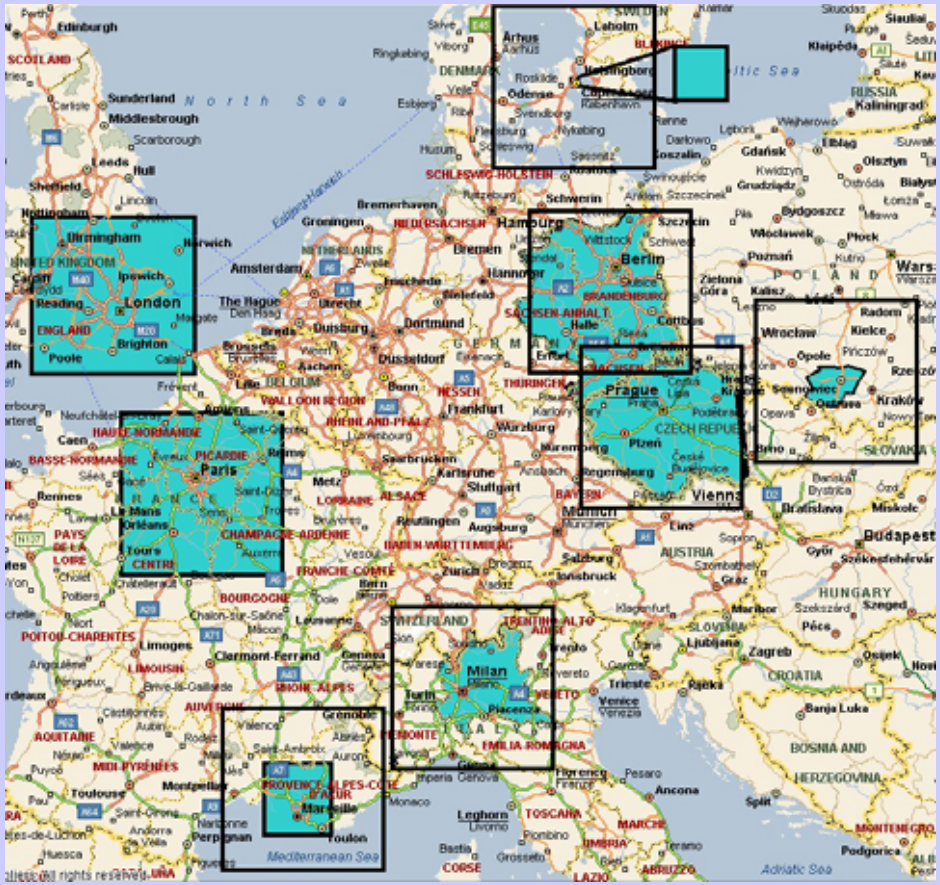
8 Cities:

London

Paris

Prague

Berlin



Copenhagen

Katowice

Milan

Marseille

8 Emission Scenarios

0 --- 1999

1 --- 2010 CLE: Current Legislation

2 --- 2010 NOx MFR: Maximum Feasible Reduction

3 --- 2010 NOx (CLE+MFR)/2

4 --- 2010 VOC MFR

5 --- 2010 NOX and VOC MFR

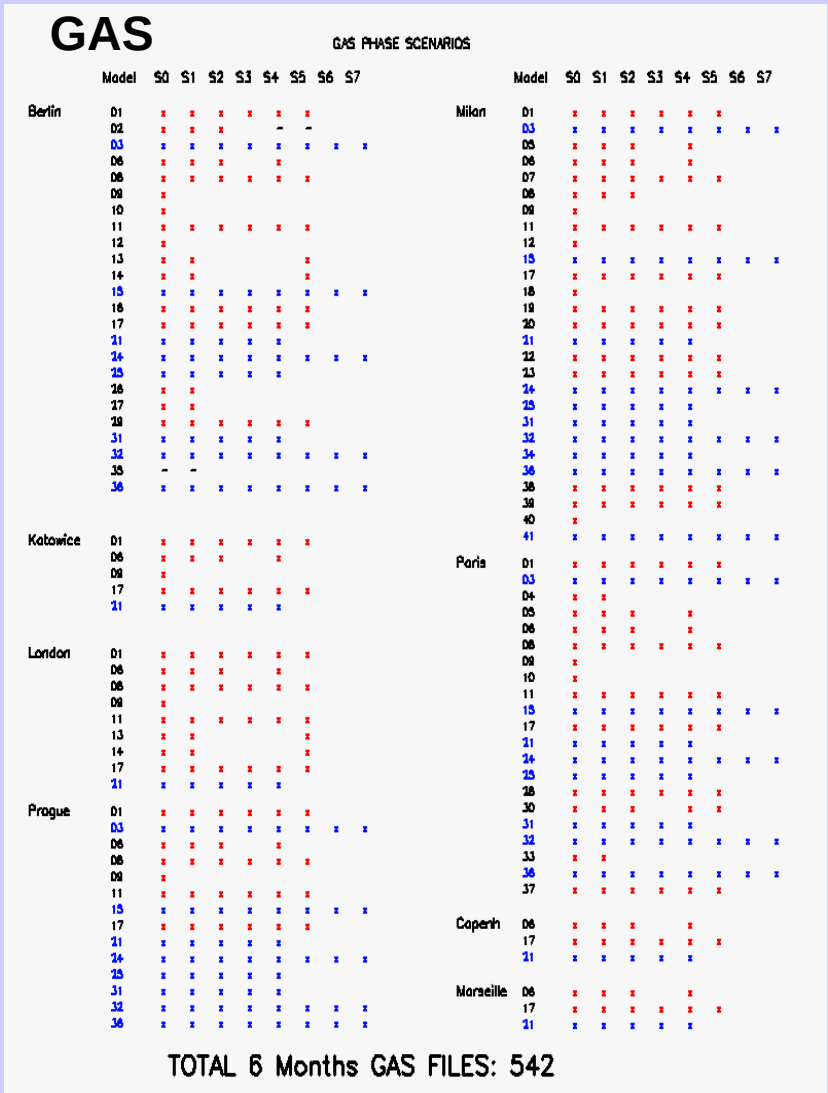
6 --- 2010 PMcoarse MFR

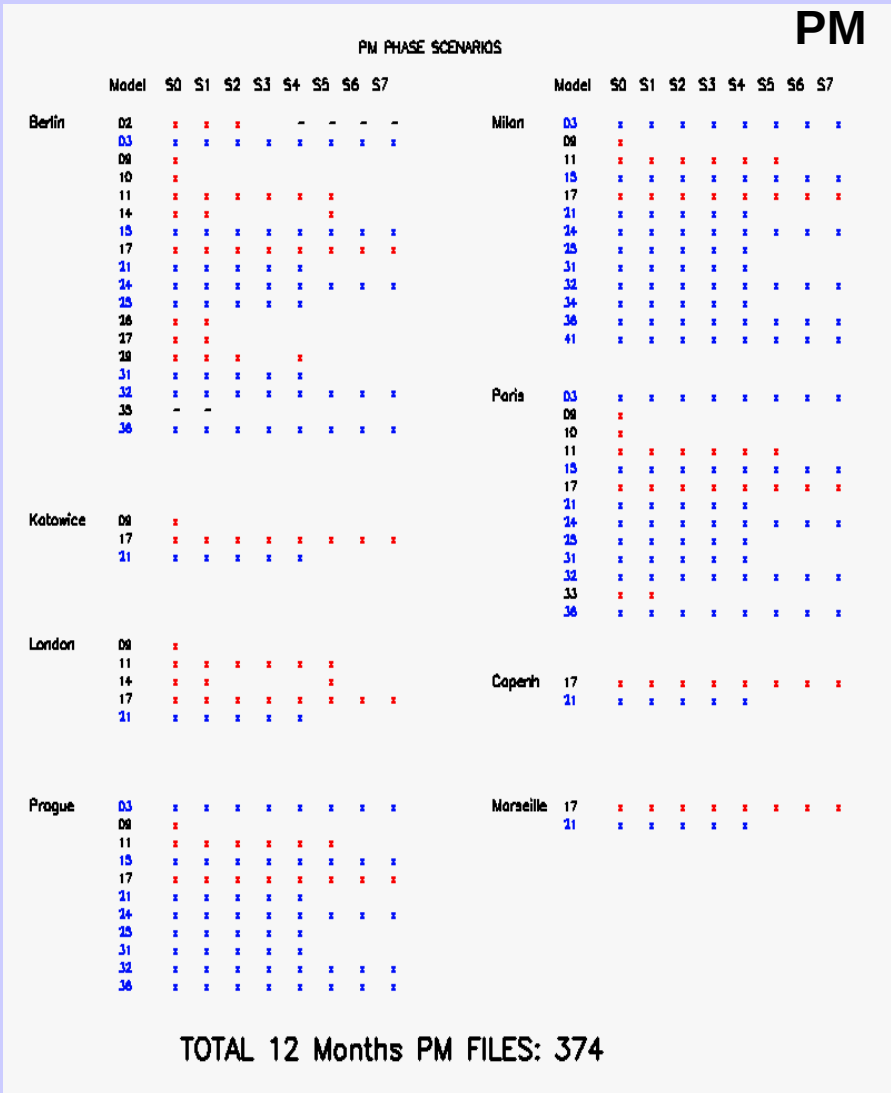
7 --- 2010 PM2.5 MFR

NOx	CLE-1999	MFR-1999
Prague	-34%	-62%
Milan	-36%	-53%
Paris	-42%	-65%
Berlin	-38%	-50%

- Meteo: 1999 provided by Meteo-France (Aladin 10 km) or calculated.
- Boundary conditions: provided by EMEP or calculated.
- Long term simulations: full year for PM, 6 months for O3
- Outputs delivered with resolution of 5-10 or 50 km

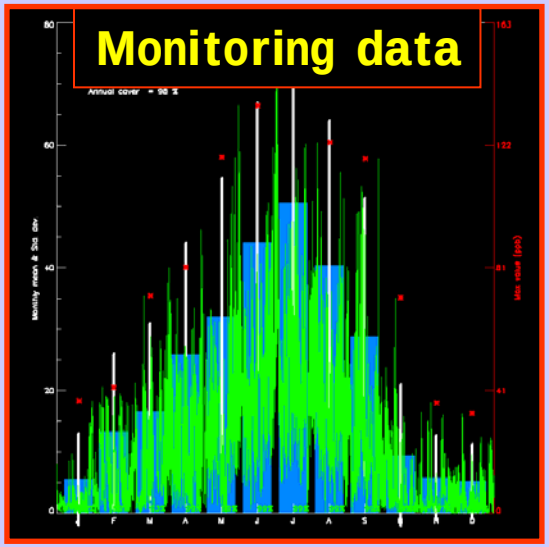
Delivered Output





Visualisation tool

Monitoring data



Monit --> View Monitoring Data

Valid --> Model/Observation comparison

Delta --> Scenario model results

Plane --> 2-D surface model results

Emis --> City vs EMEP emissions

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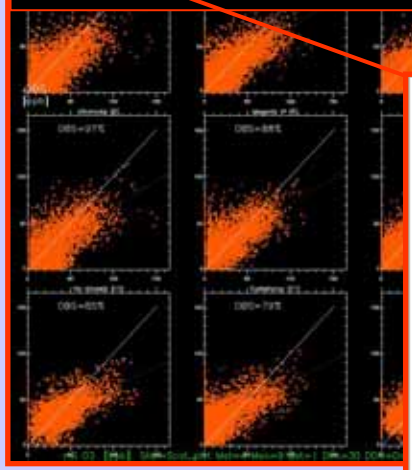
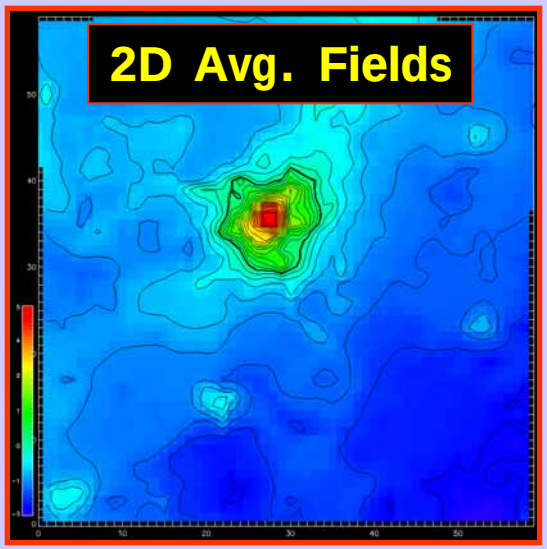
Validation with Obs.

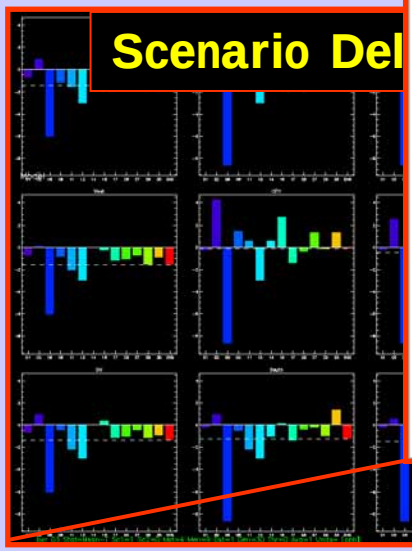


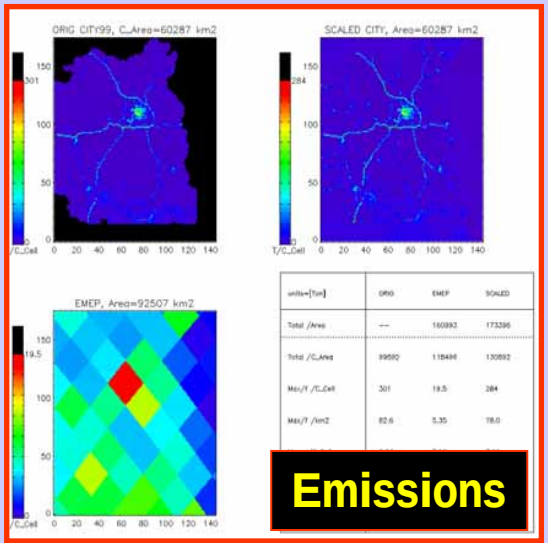
- Time series
- Max-ddn
- Min-ddn
- Mean-ddn
- Max-ddnT
- Min-ddnT
- Max-T
- Mean-T
- Stddev-T
- NMSE-T
- RMSE-T
- CRMSE-T
- Scat_plot
- Corr_coef
- SigM/SigO
- Bias-T
- NBias-T
- FBias-T
- NBias
- NBias_abs
- FBias
- FBias_abs
- Foex-T
- Freq_A
- Freq_A_Err
- Exc days
- AOTx
- Taylor

2D Avg. Fields



Scenario Del





Emissions

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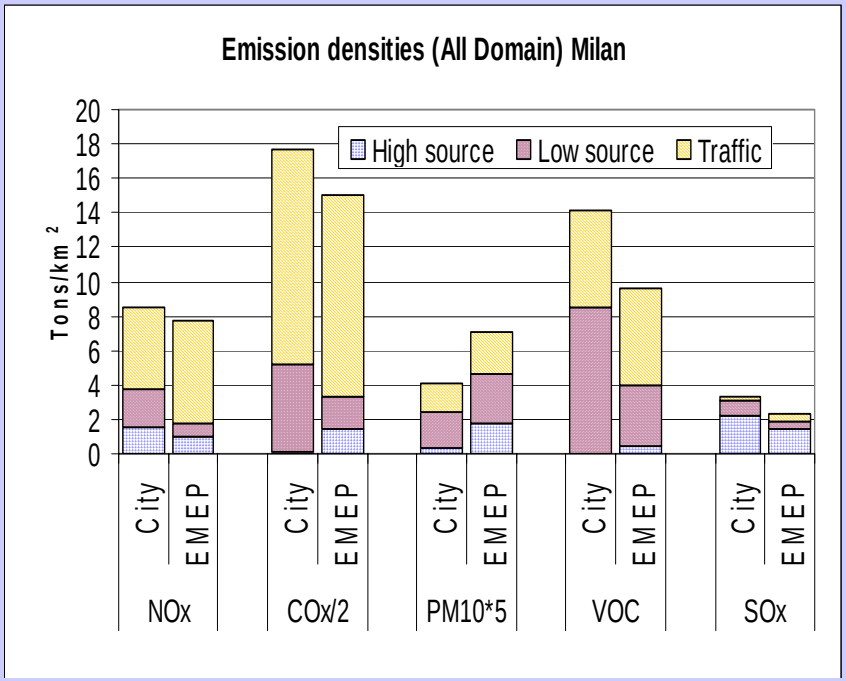
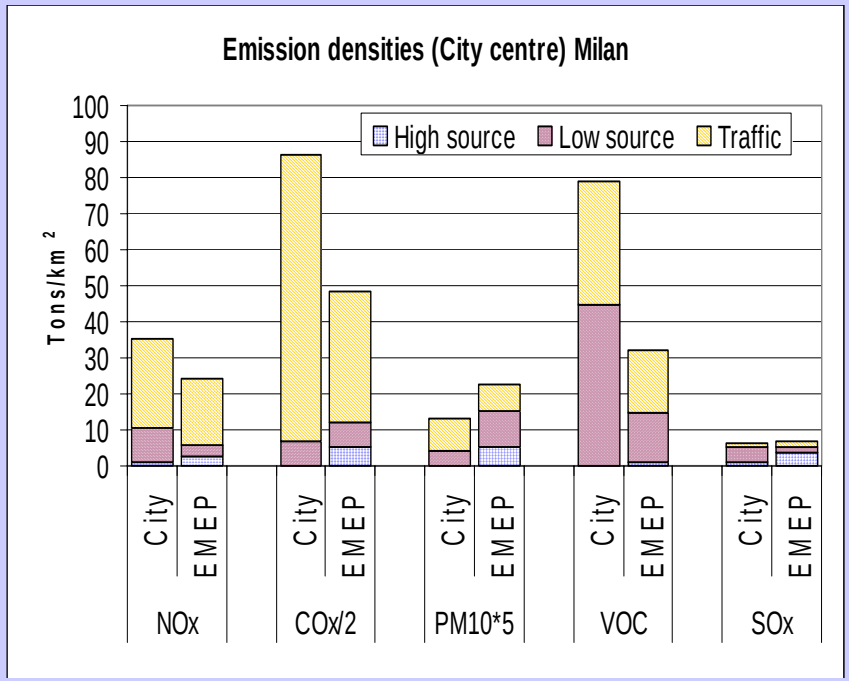
I: Emission Inventories: Local vs Regional

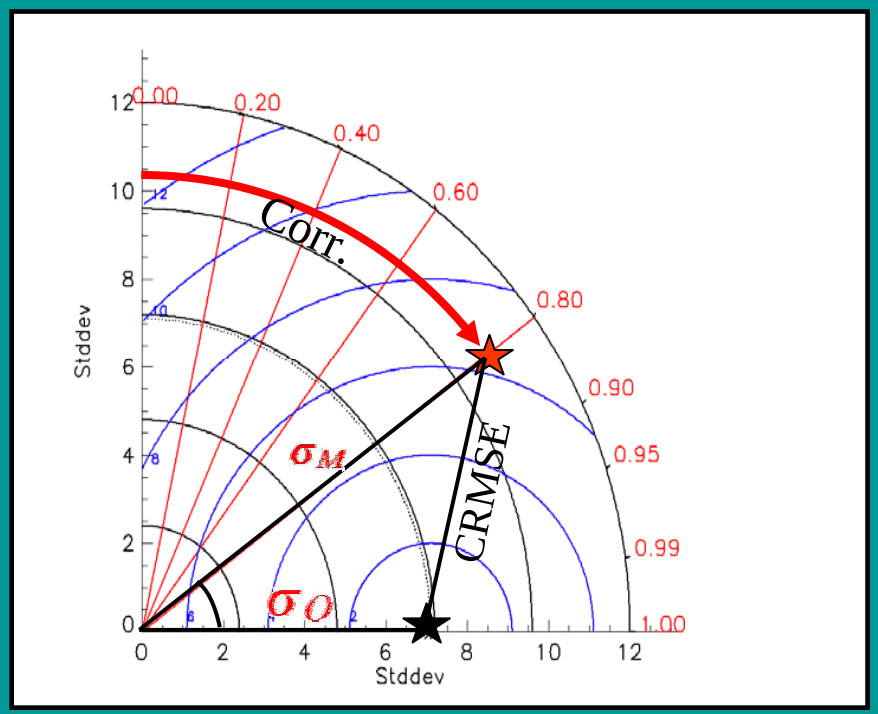




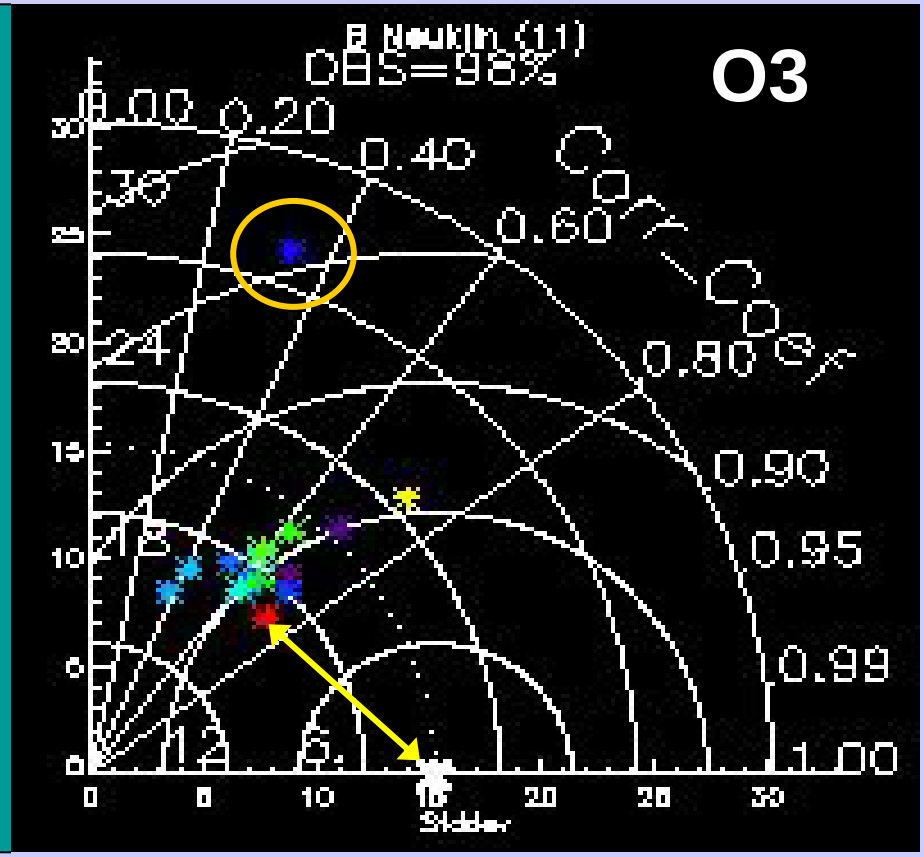
- ✓ NOx, CO, SOx estimates seems quite robust
- ✓ PM estimates show 40-50% differences.

➔ CITY DELTA has also contributed to a considerable revision of the regional emission data

II: Model Validation: - The “Taylor” plots
- The “Ensemble” model



K.E.Taylor, 2001, JGR, 106, 7183-7192

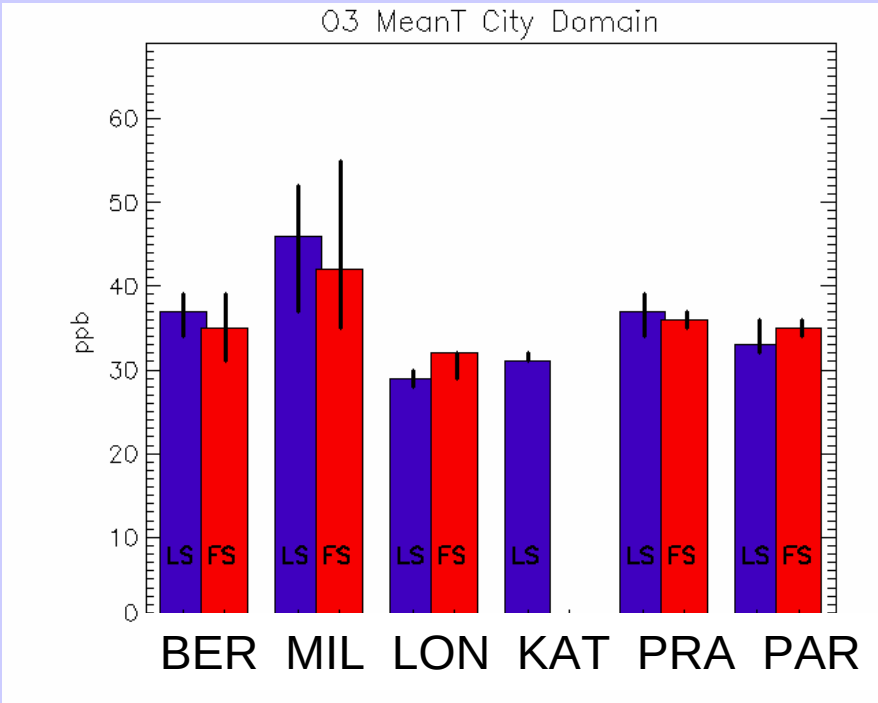


Summary of model validation

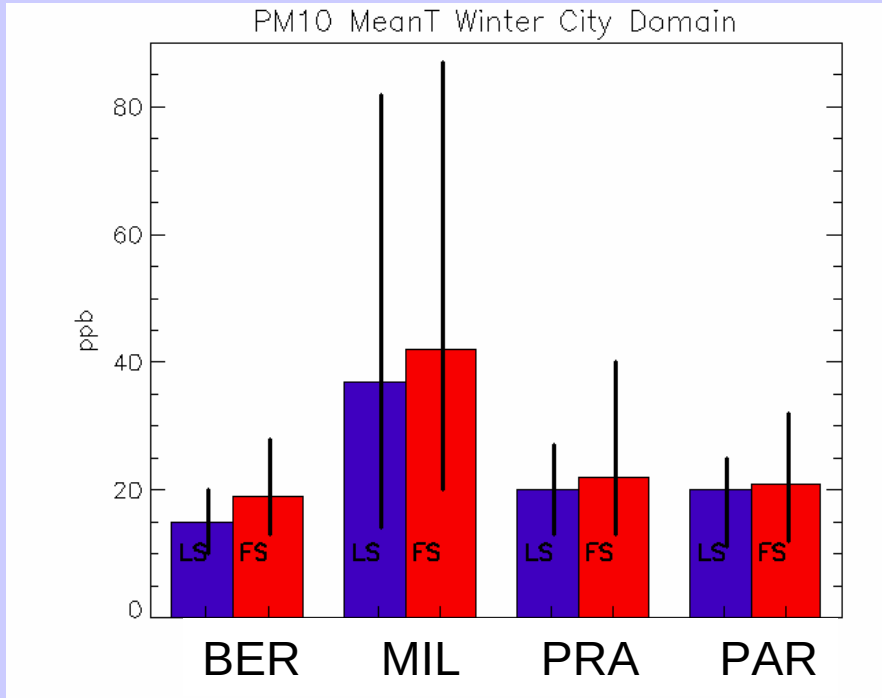
	Concentration levels		Correlation
	Deviation from mean	**Difference between coarse and fine scale models**	**Range**
O3	+/- 20 %	Differences due to some additional titration in FS	0.4-0.8
NO2	0 to -80%	Strong underestimates disappear with FS	0.2-0.6
PM10	-20 to -50%	Stronger underestimation from LS	0.4-0.75

III: “Delta” Interpretation (1)

O3 Summer Mean



PM10 Winter



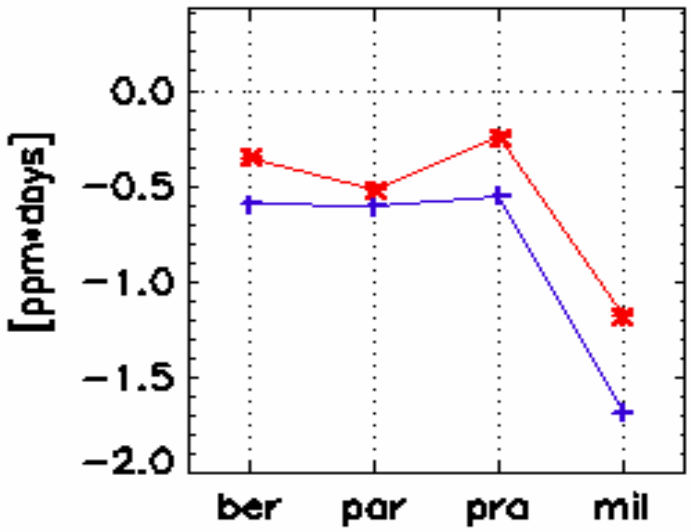
Fine scale Ensemble

Large scale Ensemble

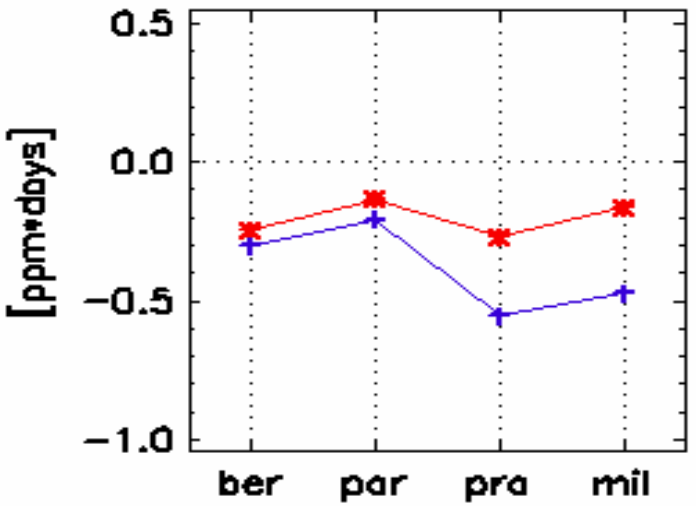
III: “Delta” Interpretation (2)

SOMO35:

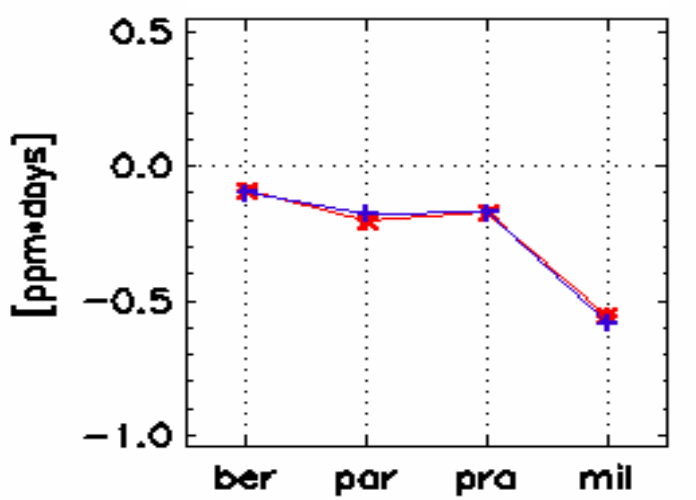
CLE-2000



NOx Reduction



VOC Reduction



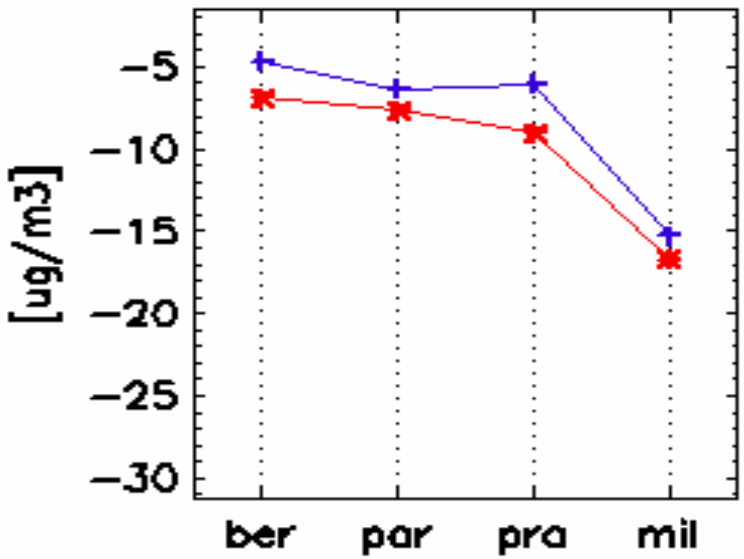
Fine scale Ensemble

Large scale Ensemble

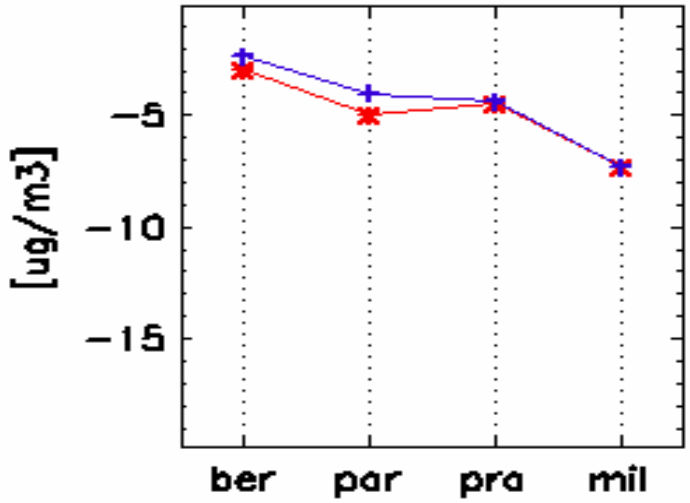
III: “Delta” Interpretation (3)

PM10:

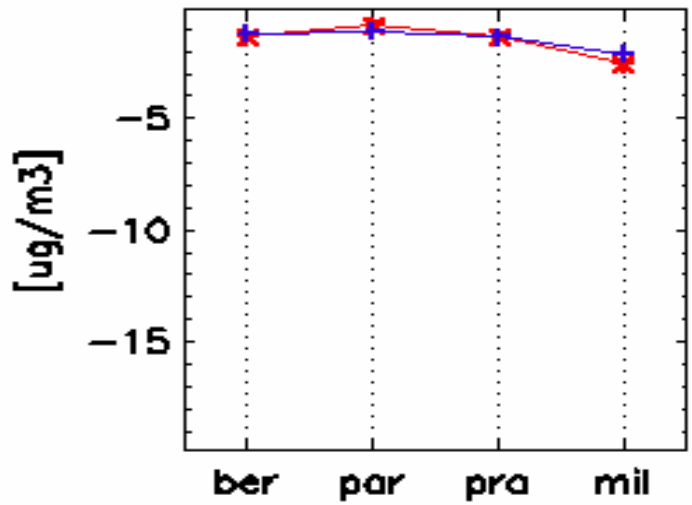
CLE-2000



NOx Reduction



VOC Reduction



Fine scale Ensemble

Large scale Ensemble

IV: Key Findings

O3

- ✓ Models reproduce well the present situation and agree on changes from CLE in 2010. There is also agreement on relatively little scope for further improvements from emission controls beyond CLE.
- ✓ Fine-scale models are able to show important sub-grid effects, which are not captured by regional scale models.
- ✓ Models agree more on the response to VOC emission controls than on the effects of NOx cuts.

PM

- ✓ Models agree that a large part of PM found in urban background originates from the regional background.
- ✓ Validation of PM is hampered by the lack of observations
- ✓ All models underestimate total PM mass, probably due to a limited understanding of sources and processes.

- ✓ The use of the ENSEMBLE model response provides a robust tool for analyzing the impacts of emission reductions

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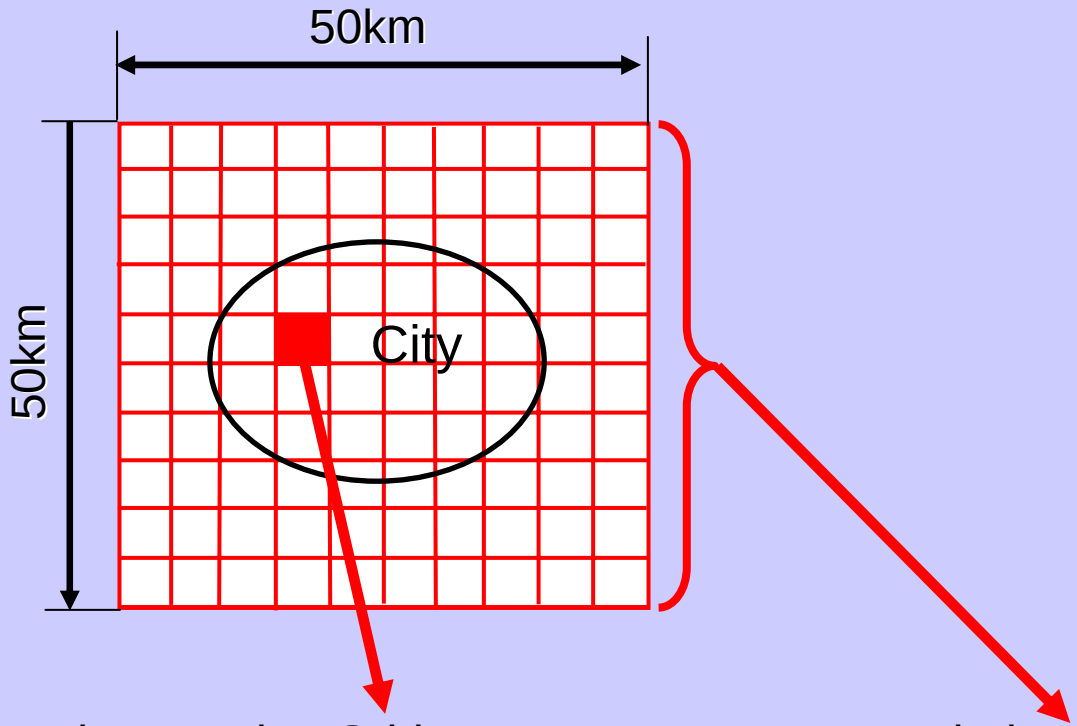
Functional relationships: Basic Approach



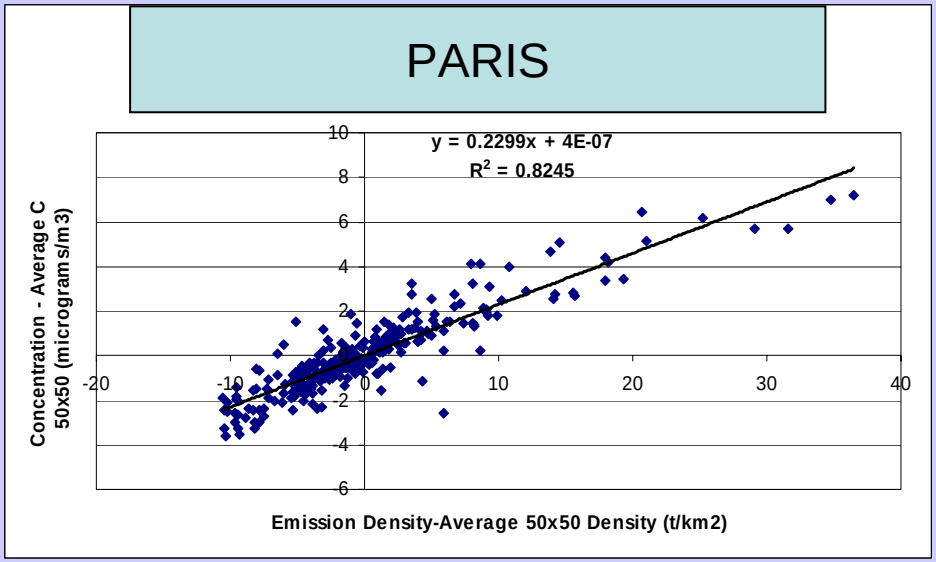
Delta Conc = PM_{conc} in a given 5x5km Grid - Average PM_{conc} over whole Domain

Delta Emis = ED in a given 5x5km Grid - Average ED over whole Domain

Correlate: Delta Concentration vs Delta Emission Density

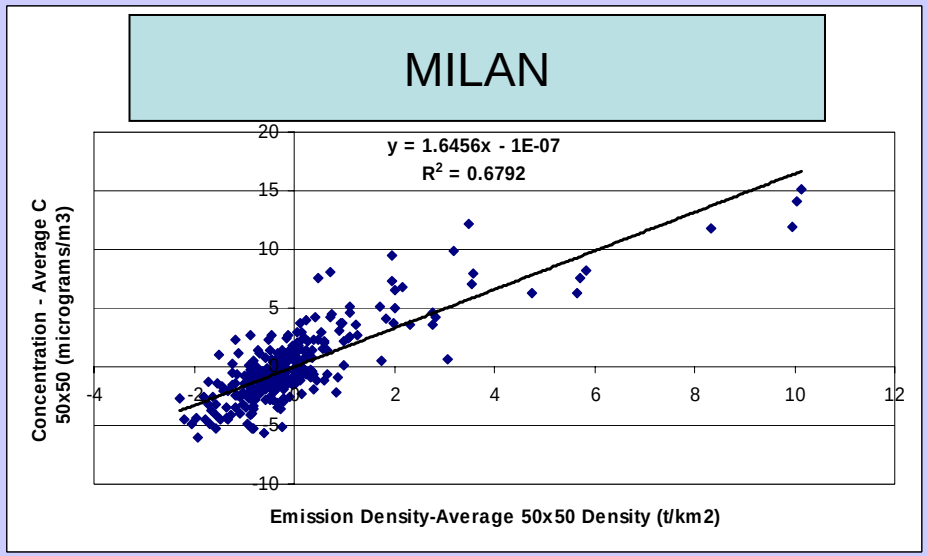
ENSEMBLE Base Case, CLE and MFR

"ΔConc - ΔEmis" correlations for PPM2.5 low level sources

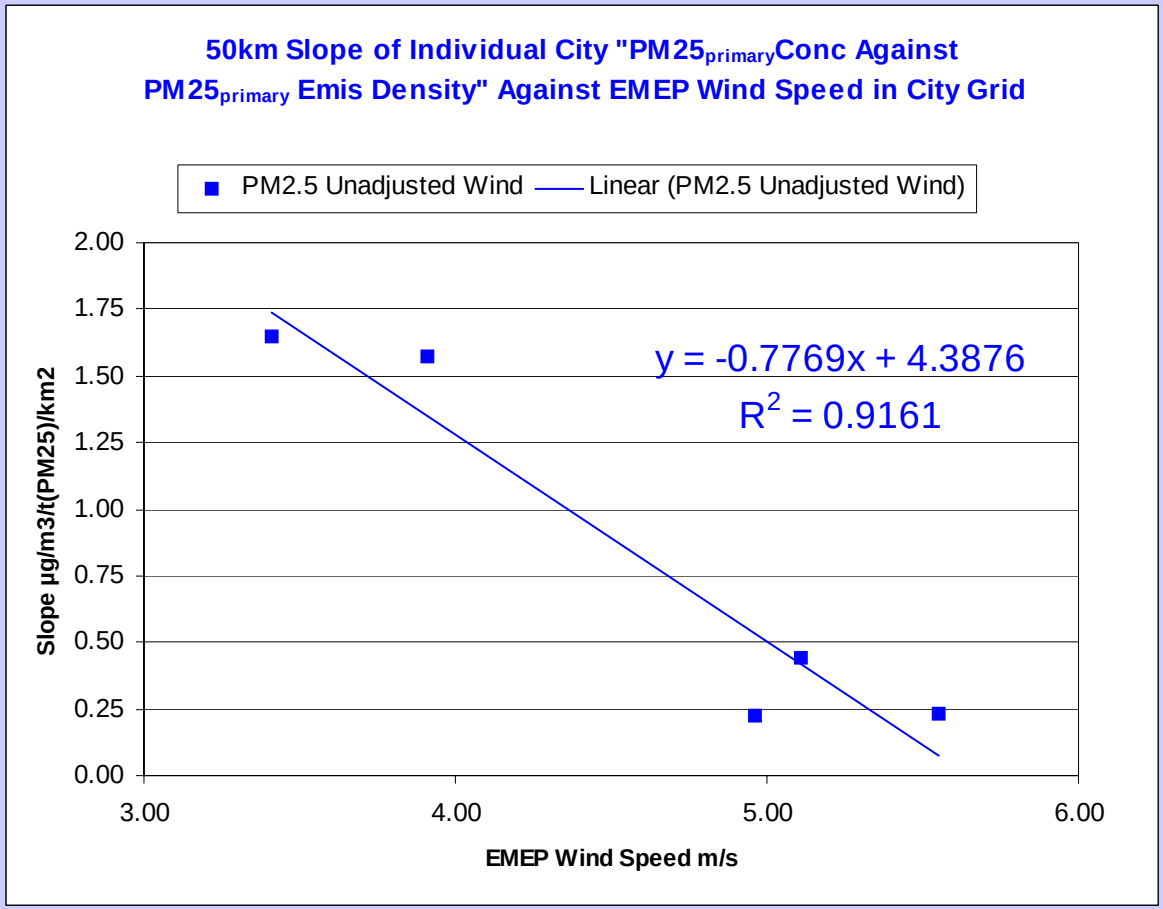


Paris: Slope = 0.23
R2 = 0.82

Milan: Slope = 1.64
R2 = 0.68



Slopes of individual cities against EMEP wind speed in city grid



Functional relationship for PM

$$\Delta PM_{sub\text{-}grid} = (ED_{sub\text{-}grid} - ED_{EMEP}) * (k1 - k2*V_{wind})$$

$\Delta PM_{sub\text{-}grid}$	..	Difference in PM concentration between sub-grid (urban/rural) area and EMEP grid average
ED_x	…	Emission density for low sources
V_{wind}	…	Annual mean wind speed in EMEP grid cell
k1, k2	…	City-Delta Parameters from ensemble model

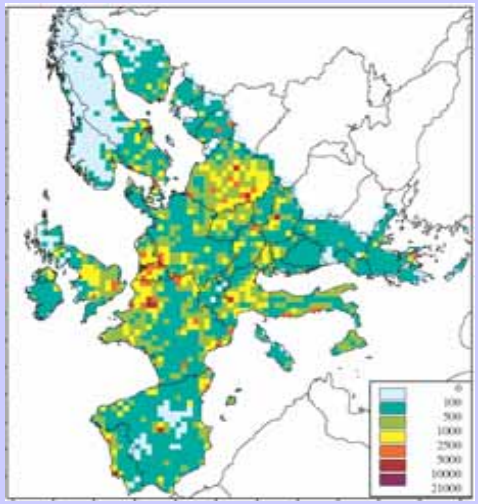
↓

$$\Delta PM_{sub\text{-}grid} = ED_{EMEP}(ED_{sub\text{-}grid} / ED_{EMEP} - 1) * (k1 - k2*V_{wind})$$

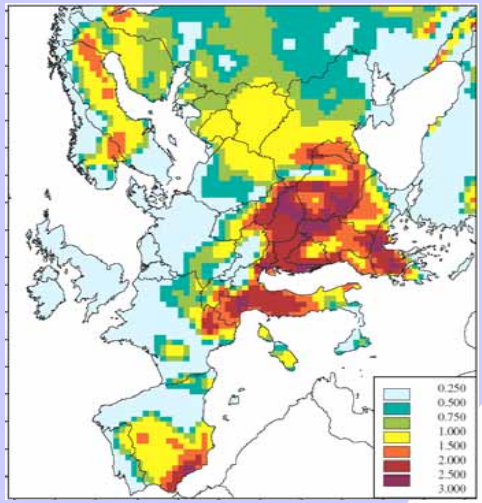
↓

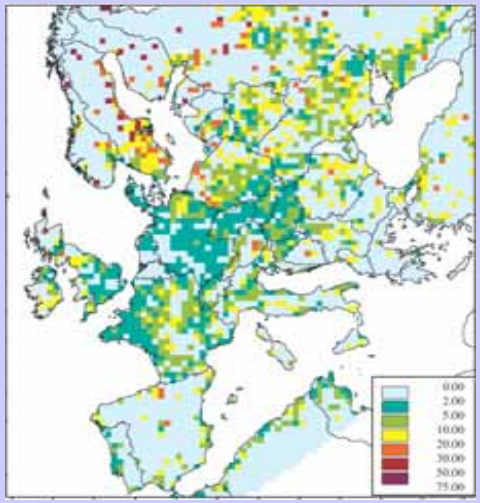
$$\Delta PM_{sub\text{-}grid} = ED_{EMEP}(PD_{sub\text{-}grid} / PD_{EMEP} - 1) * (k1 - k2*V_{wind})$$

Emission densities



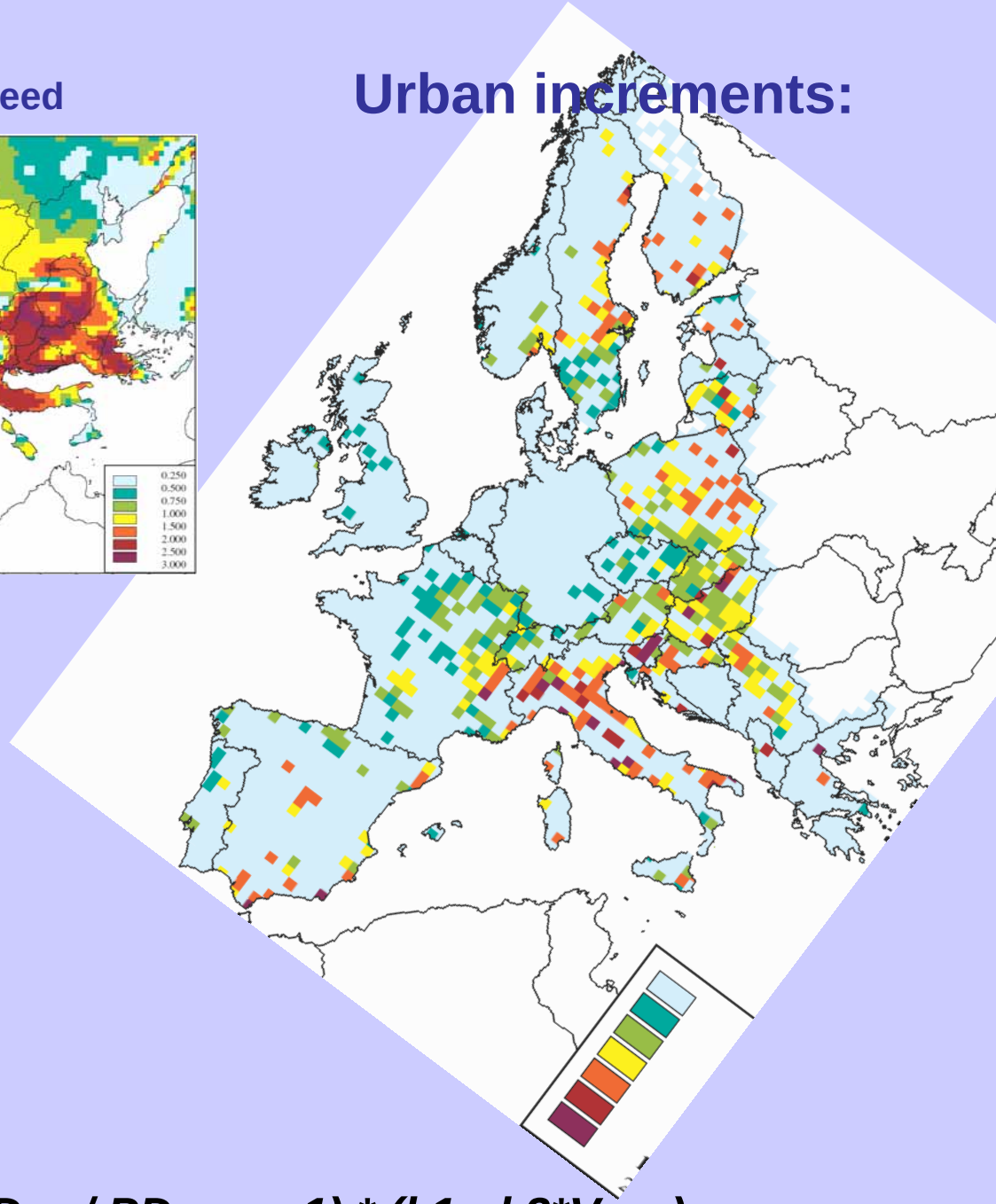
Wind speed





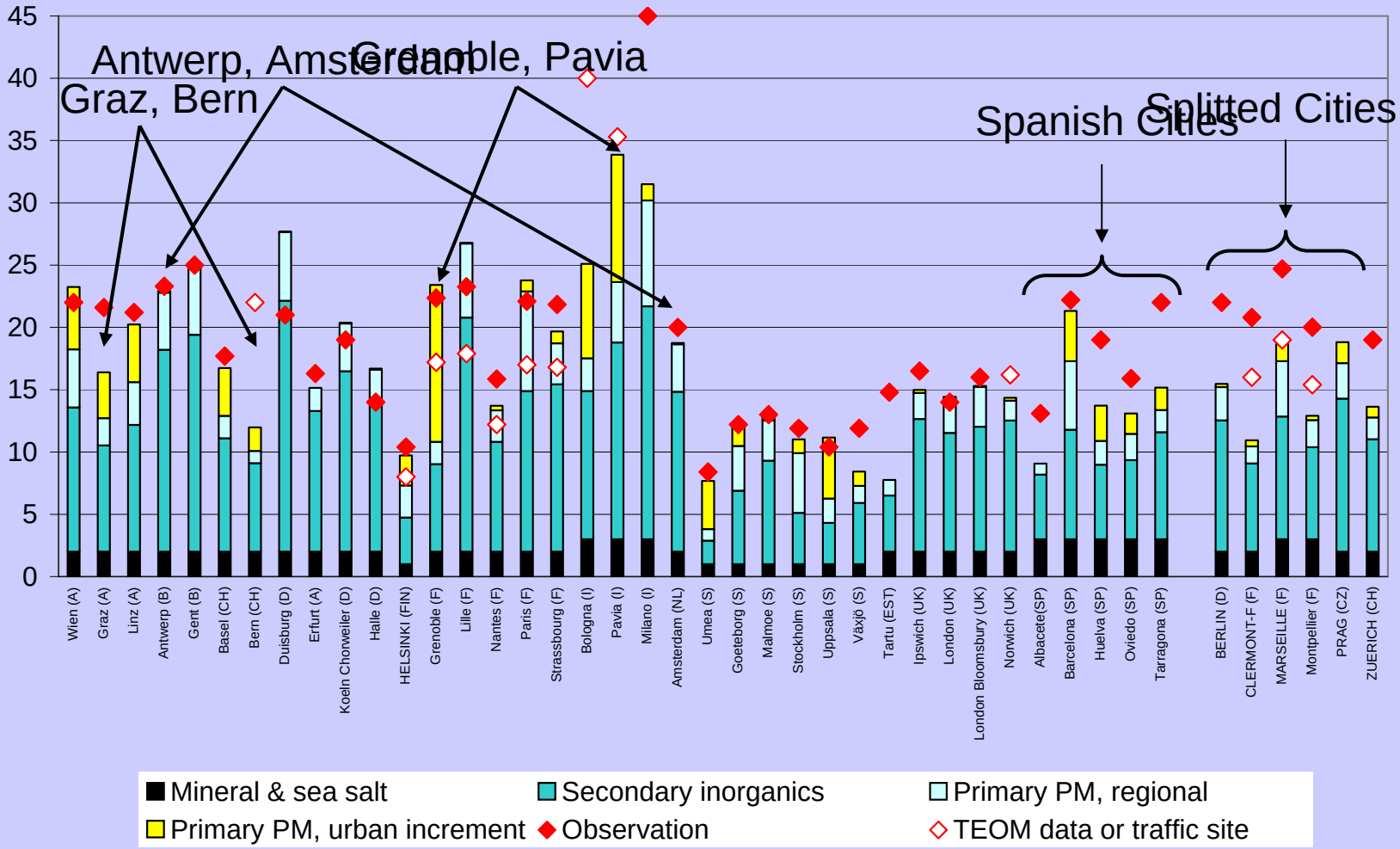
Population density ratios

Urban increments:



$$PM_{urb} = PM_{EMEP} + ED_{EMEP}(PD_{urb} / PD_{EMEP} - 1) * (k1 - k2*V_{wind})$$

Validation against observations
Urban background PM2.5 [µg/m³]



Discussion

- Urgent need for validation with monitoring data, hampered by lack of PM2.5 twin sites.
- Presently, grid average wind speed used. No consideration of topography. City-specific wind speeds should improve.
- Which emission/population density is representative for a city (how to draw city borders)? This determines directly the size of the urban increment.

Conclusions

- A first approach for addressing urban air quality for Europe-wide health impact assessment has been developed and implemented – based on observations and City-Delta results
- First results are promising, further refinement is necessary
- More PM2.5 monitoring data is necessary for validation
- Uncertainty and sensitivity analyses not yet performed

EuroDelta

A project to evaluate uncertainty in source-receptor relationships used in air quality policy

- 6 regional models: EMEP, MATCH, REM3, CHIMERE, LOTOS,TM5
- 28 different emission scenarios in 2000, 2010 and 2020 with area specific reductions
- Use of the ENSEMBLE approach
- Objectives : - Source-receptor variability
  - Spatial variability
  - Meteorological variability
  - Confidence limits in policy modelling: EMEP vs Ensemble

http://rea.ei.jrc.it/netshare/thunis/citydelta

http://rea.ei.jrc.it/netshare/thunis/eurodelta