A European model-intercomparison study
in support to the CAFE programme

organised by

JRC-IES, CONCAWE, IIASA, EMEP, TNO-MEP

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**Objective:**
To explore changes in air-quality (DELTA) in cities (CITY) due to changes in emission as predicted by atmospheric models with different scales, i.e:

- Identify differences between regional and urban model answers (scale delta)
- How are these differences depending on emissions (emission delta)
- How these deltas vary across cities (city delta)
- What is the range of variability in model answers? (model delta)

**Goal:** Implementation of urban signal into the RAINS model

**Focus:**
The focus is on the integrated assessment of the impact on human health and ecosystems.

WHO recommendations: Long term exposure to O3 (6 month hourly) and PM (12 months daily)
Cities:

Comparisons are conducted for a number of European cities with distinct differences in climatic conditions, geographical settings, and emission densities.

London
Paris
Prague
Berlin
Copenhagen
Katowice
Milan
Marseille
Input Data:

Monitoring data:
For the 8 cities delivered by the city-authorities:
O3, NO2, PM2.5, PM10

Meteorological data:
Provided to CityDelta by Meteo-France, or by the modelling group themselves for reference year 1999.

Emission inventories:
• High-resolution (1 km to 5 km) city-emission inventories
• Low-resolution (50 km) EMEP-TNO emission inventory

Boundary conditions:
Provided by EMEP, or by the modelling group themselves
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

<table>
<thead>
<tr>
<th>NOx</th>
<th>CLE-1999</th>
<th>MFR-1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prague</td>
<td>-34%</td>
<td>-62%</td>
</tr>
<tr>
<td>Milan</td>
<td>-36%</td>
<td>-53%</td>
</tr>
<tr>
<td>Paris</td>
<td>-42%</td>
<td>-65%</td>
</tr>
<tr>
<td>Berlin</td>
<td>-38%</td>
<td>-50%</td>
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</table>
**Output requested:**

- Hourly values for O3 (and NO2) for 6 months  (Summer)
- Daily values for PM2.5 and PM10 for 12 months

<table>
<thead>
<tr>
<th>Model Configuration</th>
<th>Institution</th>
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<tbody>
<tr>
<td>CALGRID</td>
<td>Univ. Brescia (Italy)</td>
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<tr>
<td>CAMX</td>
<td>Ag. Mobilita Ambiente (Italy)</td>
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<td>THOR</td>
<td>NERI (Denmark)</td>
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<tr>
<td>TRANSCHIM</td>
<td>CORIA (France)</td>
</tr>
</tbody>
</table>

40 different model configurations
Delivery

GAS PHASE SCENARIOS

PM PHASE SCENARIOS

TOTAL 6 Months GAS FILES: 542

TOTAL 12 Months PM FILES: 374
Interpretation of the results

• First, each modelling group evaluates its own model results before submission to JRC using its own tools based on personal criteria

• Second, intercomparison is performed of all results with a common graphical visualisation tool on a preselected data sub-set

  1. Same selection of locations, indicators,…

  2. Each group can compare its results against others

• Third, city/model overviews are constructed through specific approaches (Ensemble, Taylor, …)
The JRC tool

Monitoring data

Monit → Year Monitoring Data
Valid → Model/Observation companion
Delta → Scenario model results
Plane → 2D surface model results
Emis → City vs EMEP emissions

2D Avg. Fields

Emissions

Validation with Obs.

Time series
Max-diff
Min-diff
Mean-diff
Max-diffT
Min-diffT
Max-T
Mean-T
Std-dev-T
NRMSE-T
RMSE-T
CRMSE-T
Scat_plot
Corr_coef
Sigma/Sigma
Bias-T
NBias-T
FBias-T
NBias
NBias_abs
FBias_abs
FBias_abs
Foex-T
Freq_A
Freq_A_Err
Exc_days
AOTx
Taylor

Joint Research Centre

Garmisch-Partenkirchen

9th Harmonisation Conference
O3 Taylor plots

K.E. Taylor, 2001, JGR, 106, 7183-7192
**ENSEMBLE**: O3 mean daytime in City Centre

O3 exceedance days over 60 ppb
ENSEMBLE: O3 WHO 35 Indicator

City Centre

Whole domain

\[ \text{WHO}_{35} = \sum_{365\text{days}} \max [O_3 \text{ av8} - 35; 0] \]

- Red: Fine S models
- Blue: Coarse S models
O3 Delta Overview: daily mean in Milan

Whole domain

City Centre

RES = 50km

RES << 50km

ppb
Conclusions

- Emission inventories are crucial. Local inventories are not always compatible with regional emissions.

- Consistent pattern of difficulties in night time: model predictions are too high, especially LS models in the city area. Day time predictions show less variability between models.

- LS models tend to underestimate the impact of VOC emission reductions and to overestimate the impact of NOx emission reductions on O3.

- Impacts of emission reductions from 1999 to CLE are significantly larger than those from MFR to CLE.

- Milan shows the largest differences between LS and FS models.

- Further scenarios were required for PM deltas to be analysed (CityDelta Phase 2). Under review.

- Final CityDelta workshop: 14-15/10/2004, Ispra.
K.E. Taylor, 2001: Summarizing multiple aspects of model performance in a single diagram
JGR, 106, 7183-7192

\[ \text{CRMSE}^2 = \frac{1}{N} \sum_{n=1}^{N} \left( (M_n - \bar{M})^2 + (O_n - \bar{O})^2 \right)^2 \]

\[ \text{CRMSE}^2 + \text{BIAS}^2 = \text{RMSE}^2 \]

\[ \text{CRMSE}^2 = \sigma_M^2 + \sigma_O^2 - 2 \sigma_M \sigma_O R \]

\[ c^2 = a^2 + b^2 - 2ab \cos \Phi \]
Delta in O3 exceedance days over 60 ppb
ENSEMBLE: PM10 daily mean

![Graphs showing PM10 daily mean with various models and regions: Berlin (ber), Paris (par), Prague (pra), and Milan (mil).](image)
O3 Taylor Plots + Bias

BERLIN

MILAN

PARIS

PRAGUE

CRMSE

CRMSE

CRMSE

CRMSE

Bias

Bias

Bias

Bias

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