33rd meeting of the Task Force on Integrated Assessment Modelling

Prague. 3 May, 2007

National Integrated Assessment activities:

Sensitivity analysis of City Delta calculations for several Spanish cities

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Department of Chemical and Environmental Engineering
INTRODUCTION

SENSITIVITY ANALYSIS

CONCLUSIONS
Evaluation of City Delta results in some Spanish cities using national estimations
City Delta calculations (IIASA Interim Report IR-07-001)

\[
CD = \alpha \cdot \Delta Q \cdot \frac{1}{\sqrt{U}} \cdot \left( (1 + \beta \frac{d}{365}) \cdot \frac{\sqrt{D}}{A_c} - \frac{4\sqrt{A_E}}{A_E} \right)
\]

Where:
CD → concentration increment computed with the 3 models
\(\alpha, \beta\) → regression coefficients
D → city diameter
U → wind speed
\(\Delta Q\) → change in emission fluxes
d → number of winter days with low wind speed
\(A_c\) → “Urban shape” area
\(A_E\) → EMEP grid cell area
INTRODUCTION

SENSITIVITY ANALYSIS

CONCLUSIONS
Sensitivity analysis for the two largest cities in Spain

(Madrid & Barcelona)
**Sensitivity parameters analysed**

- Area:
  - Calculation method
  - Surface considered
- Population
- Emissions
- Meteorological data:
  - Wind speed
  - Number of low wind speed days during winter
Areas (Madrid)

Urban shape = 1488.17 km²
Urban shape diameter = 39.8 km
Calculated area = 1244.5 km²
City area = 605.8 km²
Region area = 8022 km²

CORINE Land Cover 2000

E-W | N-S
--- | ---
20.7 | 16.9
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Sensitivity analysis of CD for Spain

- CD (µgm⁻³)

- Area (km²)

- Baseline vs New calculation vs Different Distances (D=15 km, D=30 km, D=50 km)

- Percent change from baseline for different distances.
Areas (Barcelona)

- Urban shape = 603.47 km²
- Urban shape diameter = 23.3 km
- Calculated area = 426.8 km²
- City area = 98.21 km²
- Region area = 7728 km²

CORINE Land Cover 2000

<table>
<thead>
<tr>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>
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Sensitivity analysis of CD for Spain

- Base
- New calculation
- D=10 km
- D=20 km

Area (km²) vs CD (µgm⁻³)

- Area (km²) vs CD (µgm⁻³)

% change from base:
- New calculation
- D=10 km
- D=20 km
Population

- IIASA value: 4.575.586
- Official region population (2004): 5.964.143

![Population and CD graphs]
Population

- IIASA value: 2,859,713
- Official city population (2004): 1,593,075
- Official region population (2004): 5,226,354
Emissions

- Sensitivity analysis of CD for Spain

![Bar chart showing emissions and CD (µgm⁻³)]

- Comparison between base, official emissions, and own estimations.

![Bar chart comparing official emissions and own estimations](CD µgm⁻³)

- Percent difference analysis:
  - Official Emissions: -7%, -6%, -4%, -11%, -12%, -16%, -18%, 14%
  - Own estimations: 0%, 5%, 10%

- Graphs illustrating emissions and CD (µgm⁻³) for base and official estimations.
## Wind speed

<table>
<thead>
<tr>
<th>MADRID</th>
<th>Alcob</th>
<th>Alcalá</th>
<th>Alcor</th>
<th>Cosl</th>
<th>Fuen</th>
<th>Get</th>
<th>Leg</th>
<th>Móst</th>
<th>Bar</th>
<th>Average</th>
<th>BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>3.2</td>
<td>3.2</td>
<td>1.8</td>
<td>2.8</td>
<td>3.5</td>
<td>1.8</td>
<td>2.1</td>
<td>3.6</td>
<td>2.9</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td># days &lt;1.5</td>
<td>21</td>
<td>9</td>
<td>126</td>
<td>2</td>
<td>1</td>
<td>134</td>
<td>219</td>
<td>3</td>
<td>0</td>
<td>112</td>
<td>62.7</td>
</tr>
<tr>
<td># winter days &lt;1.5</td>
<td>0</td>
<td>8</td>
<td>50</td>
<td>1</td>
<td>1</td>
<td>39</td>
<td>35</td>
<td>2</td>
<td>0</td>
<td>52</td>
<td>18.8</td>
</tr>
</tbody>
</table>

![Graph showing wind speed and CD (µg/m³) for different scenarios](image)
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Sensitivity analysis of CD for Spain

<table>
<thead>
<tr>
<th>BARCELONA</th>
<th>El Prat</th>
<th>CMT</th>
<th>Areyns</th>
<th>Fabra</th>
<th>Average</th>
<th>BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>4.1</td>
<td>2.6</td>
<td>1.2</td>
<td>3.9</td>
<td>2.9</td>
<td>3.53</td>
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<tr>
<td># days &lt;1.5</td>
<td>3</td>
<td>44</td>
<td>266</td>
<td>8</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td># winter days &lt;1.5</td>
<td>1</td>
<td>5</td>
<td>58</td>
<td>3</td>
<td>34.0</td>
<td>0.365</td>
</tr>
</tbody>
</table>

Changes in wind speed for Barcelona

Changes in number of low wind speed days for Barcelona
## Increment intervals for Madrid

<table>
<thead>
<tr>
<th>MADRID</th>
<th>Urban shape</th>
<th>City emissions</th>
<th>Wind speed</th>
<th># low wind speed days</th>
<th>City Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Diameter</td>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>4,575,586</td>
<td>39.8</td>
<td>1488.2</td>
<td>6766.8</td>
<td>2.88</td>
</tr>
<tr>
<td>Highest CD</td>
<td>4,575,586</td>
<td>15.0</td>
<td>706.9</td>
<td>6766.8</td>
<td>1.79</td>
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<tr>
<td>Intermediate CD</td>
<td>4,575,586</td>
<td>30.0</td>
<td>176.7</td>
<td>6766.8</td>
<td>1.79</td>
</tr>
<tr>
<td>Lowest CD</td>
<td>4,575,586</td>
<td>50.0</td>
<td>1963.5</td>
<td>5497.0</td>
<td>3.56</td>
</tr>
</tbody>
</table>

### Extreme City Deltas for Madrid

- **Base CD**
- **Highest CD**
- **Intermediate CD**
- **Lowest CD**
# Increment intervals for Barcelona

<table>
<thead>
<tr>
<th>BARCELONA</th>
<th>Urban shape</th>
<th>City emissions</th>
<th>Wind speed</th>
<th># low wind speed days</th>
<th>City Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Diameter</td>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>2,859,713</td>
<td>23.3</td>
<td>603.5</td>
<td>4126.0</td>
<td>3.53</td>
</tr>
<tr>
<td>Highest CD</td>
<td>2,859,713</td>
<td>10.0</td>
<td>78.5</td>
<td>9204.1</td>
<td>1.21</td>
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<tr>
<td>Lowest CD</td>
<td>2,859,713</td>
<td>23.3</td>
<td>603.5</td>
<td>4126.0</td>
<td>4.07</td>
</tr>
</tbody>
</table>

**Extreme City Deltas for Barcelona**

![Graph showing the extreme city deltas for Barcelona](image)
INTRODUCTION

SENSITIVITY ANALYSIS

CONCLUSIONS
Comparison to Mar-2007 NECPI document (NEC Scenario Analysis Report Nr. 3)

- Assumed mineral and sea salt
- Urban increment
- Regional background
- AIRBASE monitoring data for urban background 2004

- Reported for (sub)urban background stations
- Reported for traffic background stations
- Reported for regional background stations
Comparison to lowest CD

- Assumed mineral and sea salt
- Urban increment

- Reported for (sub)urban background stations
- Reported for traffic background stations
- Reported for regional background stations

AIRBASE monitoring data for urban background 2004
Comparison to other CD

- Reported for (sub)urban background stations
- Reported for traffic background stations
- Reported for regional background stations

![Graph showing comparison of PM2.5 concentrations across different stations, with color-coded bars representing assumed mineral and sea salt, urban increment, regional background, and AIRBASE monitoring data for urban background 2004. The graph indicates concentrations ranging from 0 to 35 micrograms per cubic meter, with notable spikes exceeding 100.](image-url)
Conclusions (1)

- It was necessary IIASA support to reproduce calculations
- Current computed urban concentrations do not match with PM\textsubscript{2.5} measurements for Madrid and Barcelona
- CD computation is:
  - very sensitive to geometric and meteorological parameters
  - little sensitive to emissions
  - unsensitive to population
- Sensitivity is city-dependent:
  - relatively robust to input changes in Madrid (CD ranging from 0.6 to 9.3 mg/m\textsuperscript{3})
  - highly sensitive to input changes in Barcelona (CD varies from 1.8-100.9 mg/m\textsuperscript{3})
Conclusions (2)

- It is necessary to obtain improved values from countries, especially regarding:
  - Wind data (both wind speed and number of low ws days)
  - “Urban shape” area
- Since there is large variability between monitoring stations, it appears critical to have comparable criteria among countries to select the monitoring stations:
  - for meteorological input data
  - for PM\textsubscript{2.5} concentration comparison