Contribution to:
9th INTERNATIONAL CONFERENCE ON HARMONIZATION
WITHIN ATMOSPHERIC DISPERSION
MODELLING FOR REGULATORY
GARMISCH-PARTENKIRCHEN, GERMANY, JUNE, 1-4, 2004

AIR QUALITY IMPACT ASSESSMENT TOOL FOR LARGE INDUSTRIAL
AND POWER PLANTS FOR
REAL-TIME AND FORECASTING OPERATIONAL OBJECTIVES

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OBJECTIVES:

1. To develop a tool to evaluate the air quality impact of industrial plants.
2. The tool should be valid for historical and forecasting modes.
3. PC oriented computer platform.
4. State of the art air quality modelling systems.
5. Meteorological models (non-hydrostatic): MM5 (PSU/NCAR), RSM (NOAA), etc.
6. Air quality modelling systems: CMAQ (Community Multiscale Air Quality Modelling System, EPA, USA)
THE MM5-CMAQ MODELLING SYSTEM

THE MM5 MODEL

INTERPB

GRAPH

TERRAIN

REGRID

RAWINS

MM5

INTERPF

NESTDOWN

Garmisch-Partenkirchen

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THE MM5-CMAQ MODELLING SYSTEM

EMISSIONS, METEOROLOGICAL MODELLING AND CMAQ SYSTEMS

MM5

MCIP
Meteorology-Chemistry Interface Processor

LUPROC

ICON and BCON

JPROC

CMAQ Chemical Transport Model (CIM)
- Governing equations
- Transport algorithms
- Gas-Phase Chemistry
- Plume in grid treatment
- Aerosol Chemistry and Dynamics
- Cloud Chemistry and Dynamics

MEPPS

ECIP
Emission-Chemistry Interface Processor

THE CMAQ MODEL

Process Analysis

Aggregation
THE CMAQ MODELLING SYSTEM: NESTING APPROACH

The static Nesting Approach in CMAQ
THE CMAQ MODELLING SYSTEM: MM5-CMAQ LINKING

Input phase  Processing  Output phase

Met. Domain  Extended CMAQ Domain  CMAQ Domain  Boundary
‘F’-arrays  ‘X’-arrays  Dot & Cross  Domain

NROWS

NCOLS
LAND-USE DATA (I)

- Eurasia Land Cover Characteristics Data
  - Base Lambert Azimuthal Equal Area Projection
  - EURASIA-CMAQ-DOMAIN Lambert Conformal Conic

- Africa Land Cover Characteristics Data
  - Base Lambert Azimuthal Equal Area Projection
  - AFRICA-CMAQ-DOMAIN Lambert Conformal Conic
LANDUSE DATA
USGS Land Use/Land Cover System
Legend (Modified Level 2)

USGS LANDUSE 1KM RESOLUTION

1  Urban and Built-Up Land
2  Dryland Cropland and Pasture
3  Irrigated Cropland and Pasture
4  Mixed Dryland/Irrigated Cropland and Pasture
5  Cropland/Grassland
6  Cropland/Woodland Mosaic
7  Grassland
8  Shrubland
9  Mixed Shrubland/Grassland
10  Savanna
11  Deciduous Broadleaf
12  Deciduous Needleleaf Forest
13  Evergreen Broadleaf
14  Evergreen Needleleaf Forest
15  Mixed Forest
16  Water Bodies
17  Herbaceous Wetland
18  Wooded Wetland
19  Barren or Sparsely Vegetated
20  Herbaceous
21  Wooded Tundra
22  Mixed Tundra
23  Bare Ground Tundra
24  Snow or Ice

USGS Land Use/Land Cover System

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EMISSION MODEL: EMIMO

EMIMO (EMISSION MOdel).

- Generation of large scale emission maps.
- The whole world application.
- Hourly estimations for pollutants:
  - Anthropogenics: SO2, NOX, NMVOC, CO
  - Biogenics: Aerosols, Isoprene, biogenic VOC, biogenic NOX
- Geographic projection output.
- Cell size between 1 and 0.1 degrees.
- Graphic interface.
ANTHROPOGENIC ANNUAL EMISSIONS

DCW  USGS  CGEIC  CIESIN

Distribution Variables

EMISSION FACTORS

Spatial Distribution

EDGAR EMISSIONS

GEIA EMISSIONS  EMEP EMISSIONS  EDGAR EMISSIONS

Reference Map

Adjust to Reference Map

ANTHROPOGENIC ANNUAL EMISSIONS

Environment Software and Modelling Group http://artico.lma.fi.upm.es
Variable distribution: multiple regression process

9 distribution variables:

- **3 Roads:**
  Digital Chart of the Word (Pennsylvania State University)

- **4 Land uses:**
  USGS (U.S. Geological Survey)

- **2 Population:**
  - CIESIN (Centre of International Earth Science Information Network)
  - CGEIC (Canadian Global Emission Interpretation Centre)
EMISSION DATA

EMIMO V2.0

EMIMA V2.0

EMISSION DATA
Latitude-Longitude Projection

EMISSION DATA
UTM Projection

GRASS-GIS

EMISSION DATA
Lambert Conformal Projection

ECIP

FORMAT

EMISSION DATA
Lambert Conformal Projection (ECIP Format)
THE MM5-CMAQ MODELLING SYSTEM

NESTING APPROACH FOR A SPECIFIC COMBINED CYCLE ELECTRIC POWER PLANT ENVIRONMENTAL IMPACT ASSESSMENT STUDY

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Differences = portion of air concentrations due to industrial emissions
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METHODOLOGY: OPANA V3 (MM5-CMAQ)

ARCHITECTURE DESIGN

MODELLING PERIODS SELECTION: L282/69 EU COMISSION DECISION

INDUSTRIAL EMISSIONS: ON SCENARIO

RUN OPANA V3: ON AND OFF SCENARIOS

AUTOMATIC SCRIPT PRODUCTION: 3000 – 6000 GRAPHICS PER SIMULATION

POST-PROCESSING ANALYSIS: ON-OFF / %
<table>
<thead>
<tr>
<th>Geometry / emission characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diameter</strong>: 6.5 m</td>
</tr>
<tr>
<td><strong>Height</strong>: 60 m</td>
</tr>
<tr>
<td><strong>T</strong>: 377 K</td>
</tr>
<tr>
<td><strong>Velocity (gases)</strong>: 21.59 m/s</td>
</tr>
<tr>
<td><strong>Flux</strong>: 716,38 m3/s</td>
</tr>
</tbody>
</table>
MM5-CMAQ PERFORMANCE

MM5-CMAQ MODEL:
OCTOBER, 7-11, 2002
MADRID, NESTING LEVEL 3
(3 KM SPATIAL RESOLUTION)
COMAPARISON BETWEEN MODELED DATA AND OBSERVED DATA
NO2
MM5-CMAQ PERFORMANCE

MM5-CMAQ MODEL:
OCTOBER, 7-11, 2002
MADRID, NESTING LEVEL 3
(3 KM SPATIAL RESOLUTION)
COMPARISON BETWEEN MODELLED DATA AND OBSERVED DATA
PM10
MM5-CMAQ PERFORMANCE

MM5-CMAQ MODEL:
OCTOBER, 7-11, 2002
MADRID, NESTING LEVEL 3
(3 KM SPATIAL RESOLUTION)

COMPARISON BETWEEN MODELLED DATA AND OBSERVED DATA
SO2

Environmental Software and Modelling Group http://artico.lma.fi.upm.es
MM5-CMAQ PERFORMANCE

MM5-CMAQ MODEL:
OCTOBER, 7-11, 2002
MADRID, NESTING LEVEL 3
(3 KM SPATIAL RESOLUTION)
COMPARISON BETWEEN MODELED DATA AND OBSERVED DATA

O3

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Percentile 99.8 for the average value of the average hourly differences of NO2 for 1200 hours period for the 1 km spatial resolution modelling domain in the ON-OFF scenario.
DATA SET: datos.1.03torret

X: -12000 to 12000
Y: -12000 to 12000

MM5-CMAQ OS (%) ONA-OFF [X Y] 11-15/11/2002
OPERATIONAL SYSTEM

PENTIUM IV 2.4 Ghz.

- 3451' (57 h 31') CPU TIME
- 6 NODE CLUSTER >>>>>>>> 3-4 TIMES FASTER
- >>>>>>>>> 16 HOURS, CPU TIME
SPLITTING DOMAINS: EXAMPLE WITH 6 NODES

6 NODES
DOMAIN 45*45
SPLITING 2*3
COLS 1:23
24:45
ROWS 1:15
16:30
31:45
CONCLUSIONS:

1. We have implemented the MM5-CMAQ Air Quality Modelling System.
2. We have used three different nesting levels up to 1 km spatial resolution.
3. One power plant.
4. The system shows an excellent performance with a high sensitivity.
5. The system can be used to take actions in real-time based on 72 hours forecasts under daily basis.
6. The system can identify in time and space the exceedances of the EU limits and establish the optimal industrial emission reduction to avoid those exceedances.
CONCLUSIONS:

7. An INTERNET web interface is designed to report to the industrial partner and/or environmental authorities.
8. Several industrial emission reduction strategies can be applied based on the capacity of the computer cluster.
9. PC computer cluster are an optimal solution for real-time and forecasting air quality modelling system simulations.
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2. Environmental Protection Agency (U.S.A) for providing access to the CMAQ code.

3. D.W. Byun for his continuous help to implement the CMAQ modelling system.

5. EUREKA programme (EU). TEAP project.