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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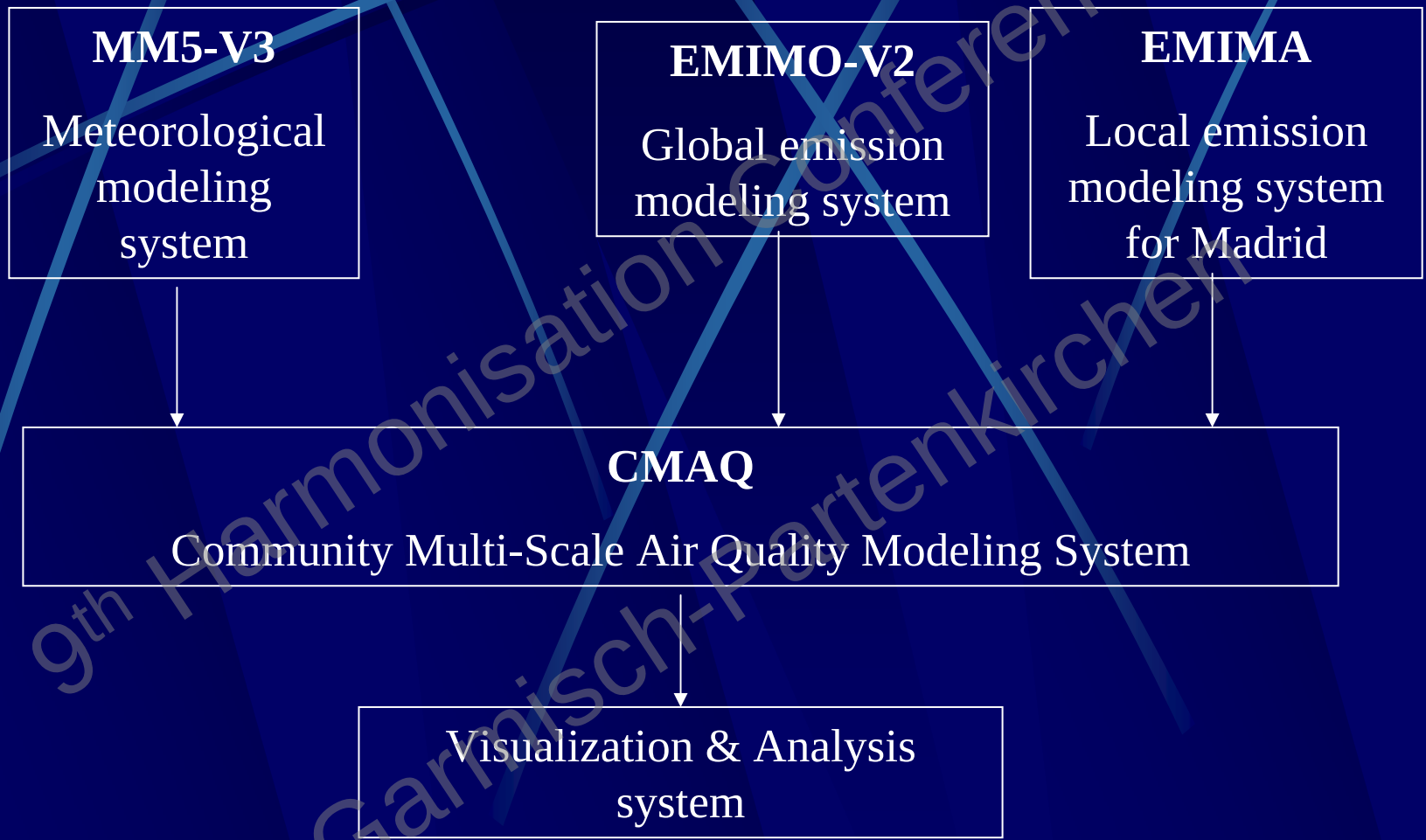
TEAP

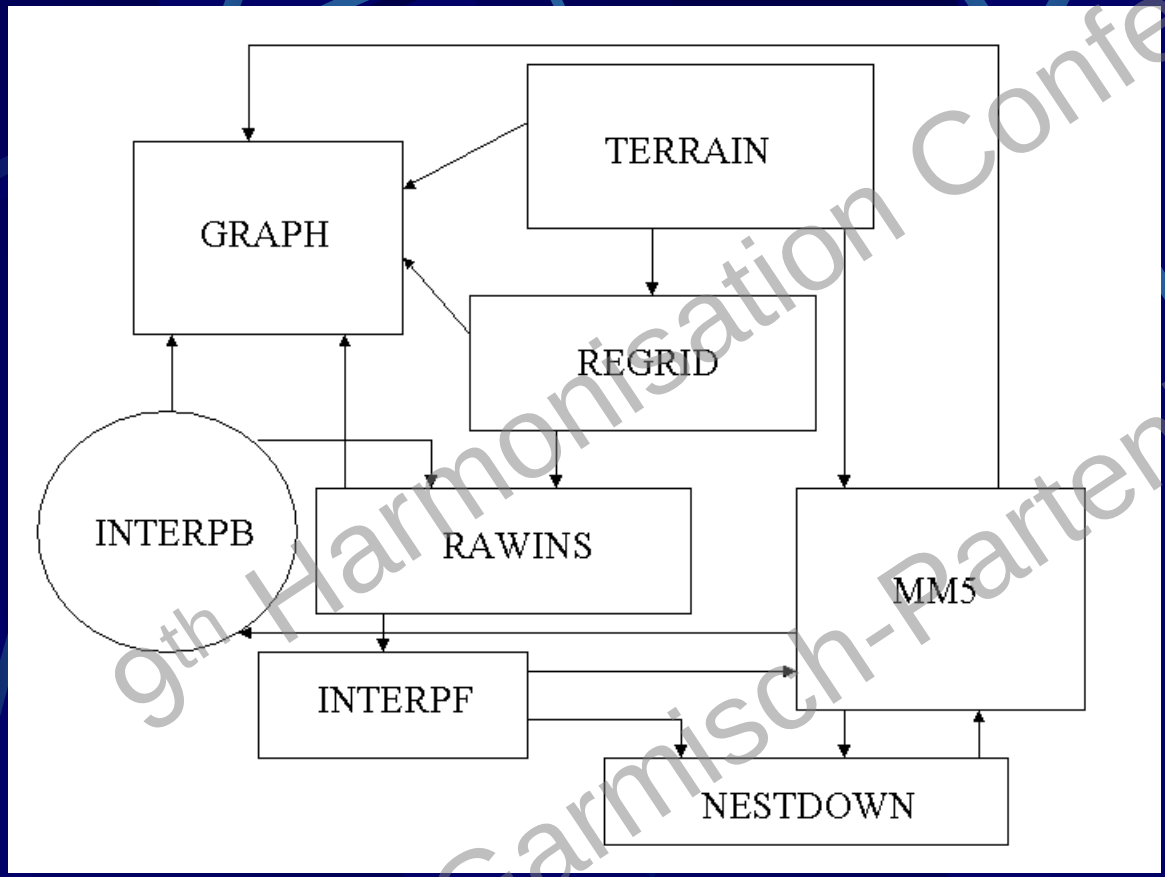
OBJECTIVES:

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)

MM5-CMAQ MODELLING SYSTEM



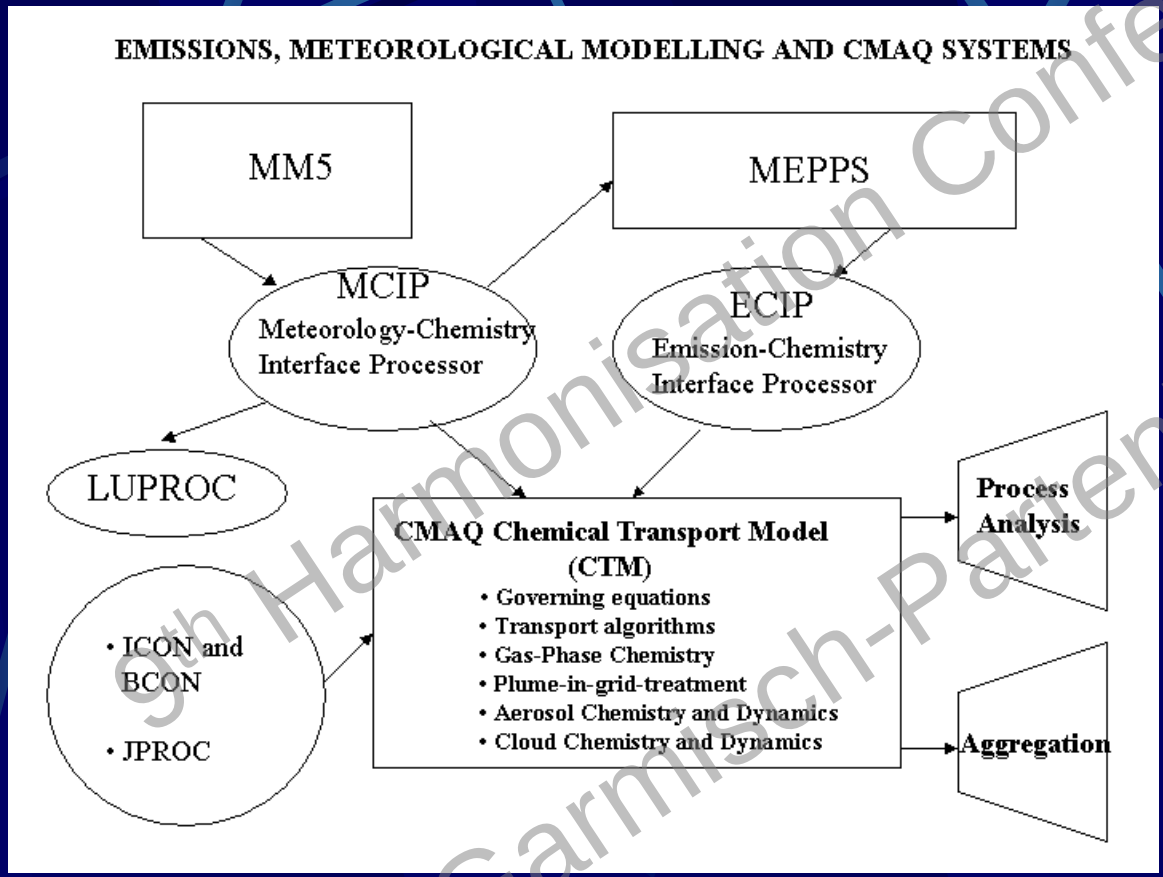
THE MM5-CMAQ MODELLING SYSTEM



THE MM5 MODEL

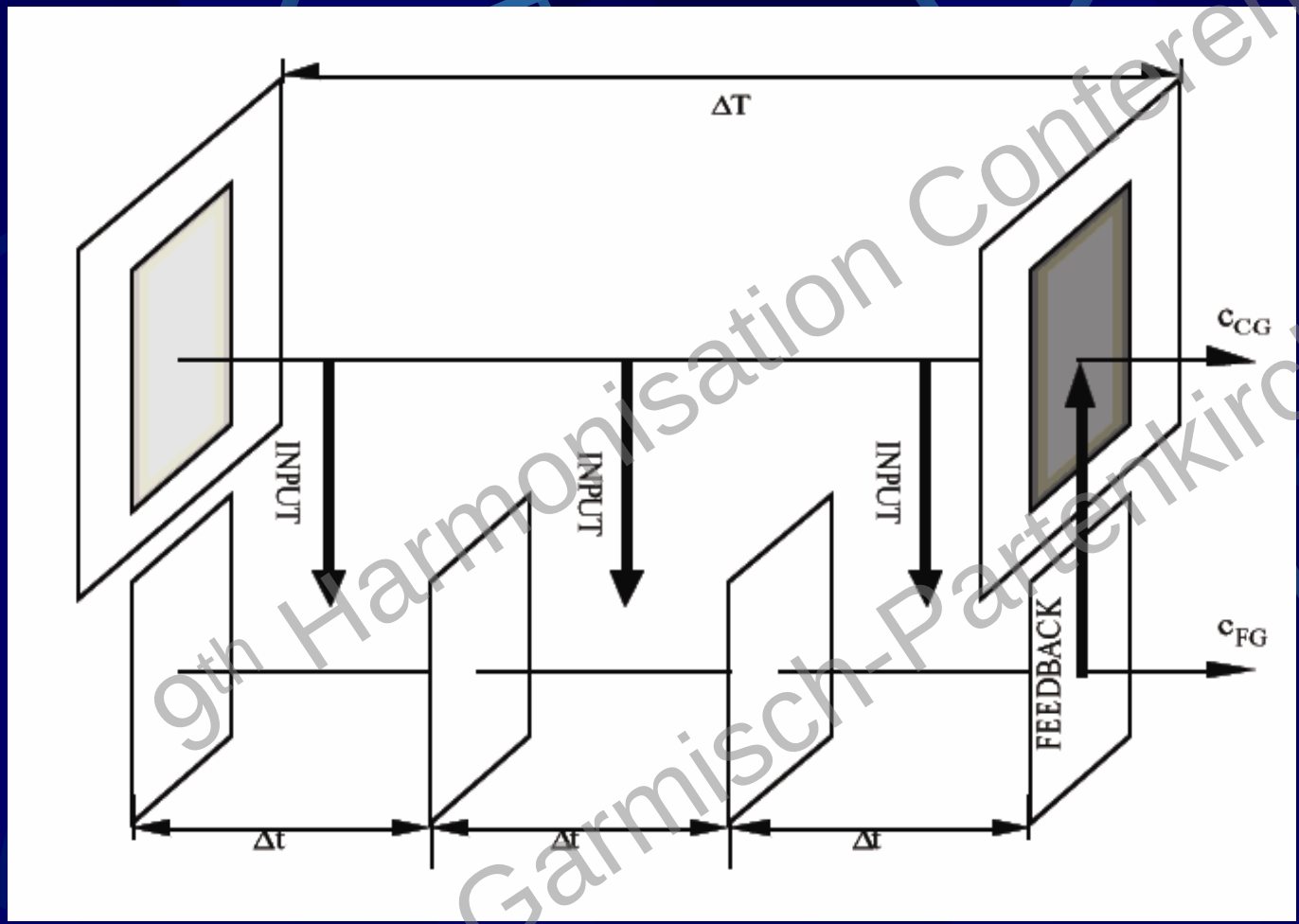
THE MM5-CMAQ MODELLING SYSTEM

Models 3
EPA's Third Generation Air Quality Modeling System



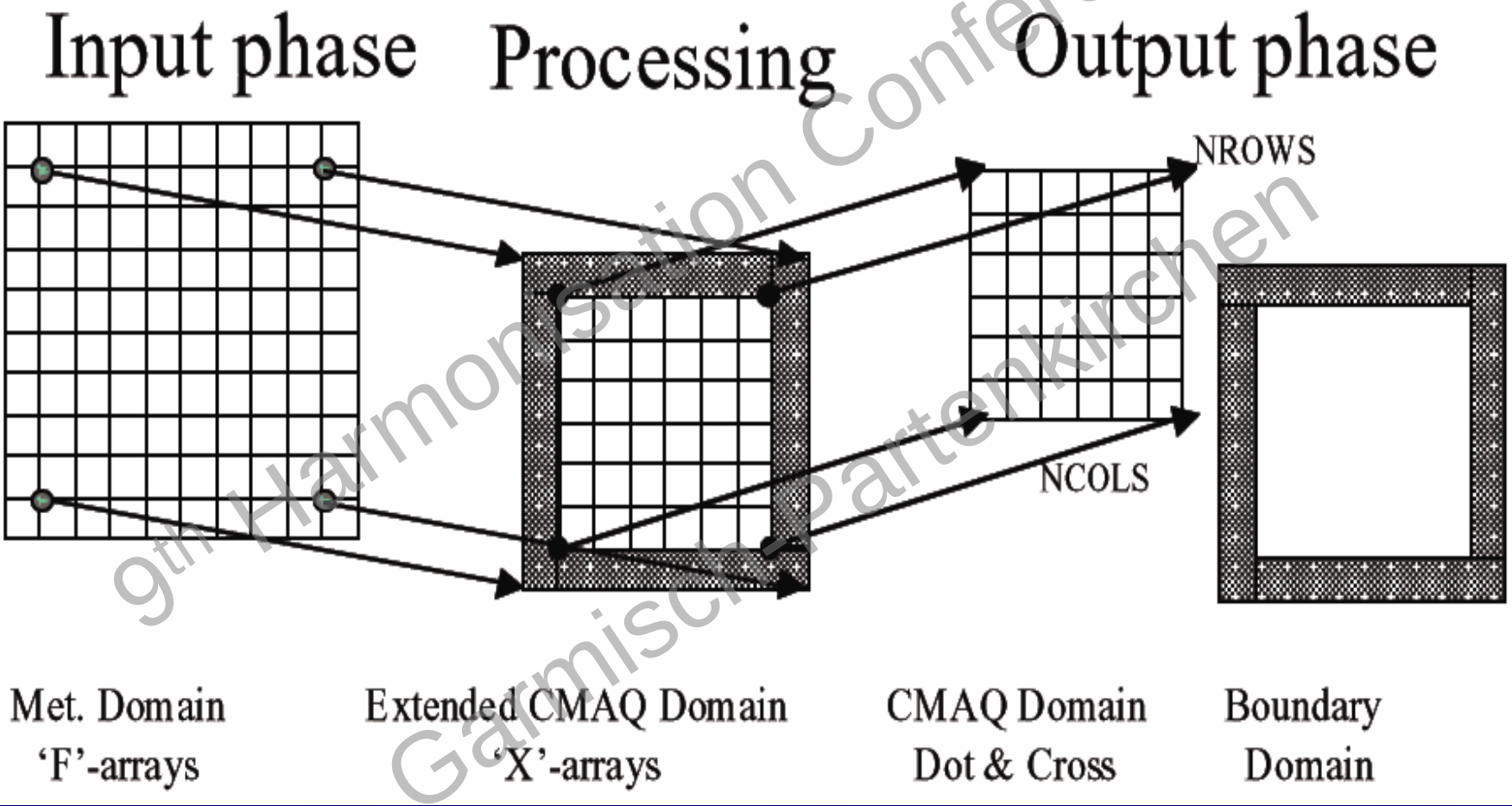
THE CMAQ MODEL

THE CMAQ MODELLING SYSTEM: NESTING APPROACH



The static Nesting Approach in CMAQ

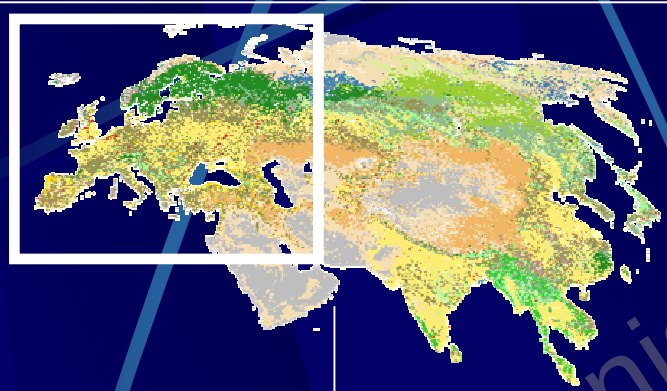
THE CMAQ MODELLING SYSTEM: MM5-CMAQ LINKING

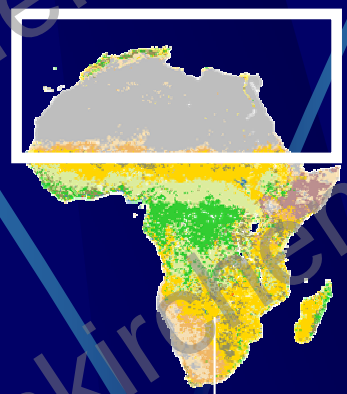


LAND-USE DATA (I)

Eurasia Land Cover Characteristics Data Base Lambert Azimuthal Equal Area Projection

Africa Land Cover Characteristics Data Base Lambert Azimuthal Equal Area Projection





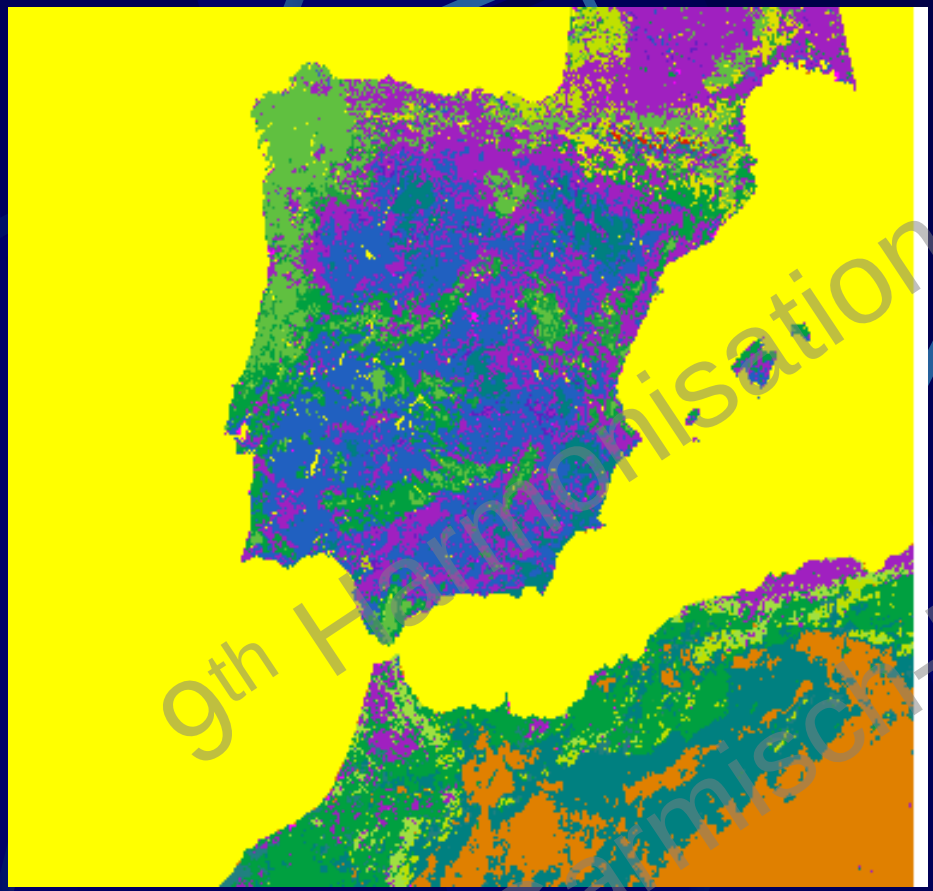
ARC/INFO → **GRASS** ← **ARC/INFO**

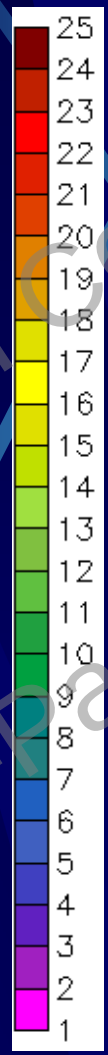
EURASIA-CMAQ-DOMAIN Lambert Conformal Conic

AFRICA-CMAQ-DOMAIN Lambert Conformal Conic

LANDUSE DATA

USGS Land Use/Land Cover System
Legend (Modified Level 2)





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

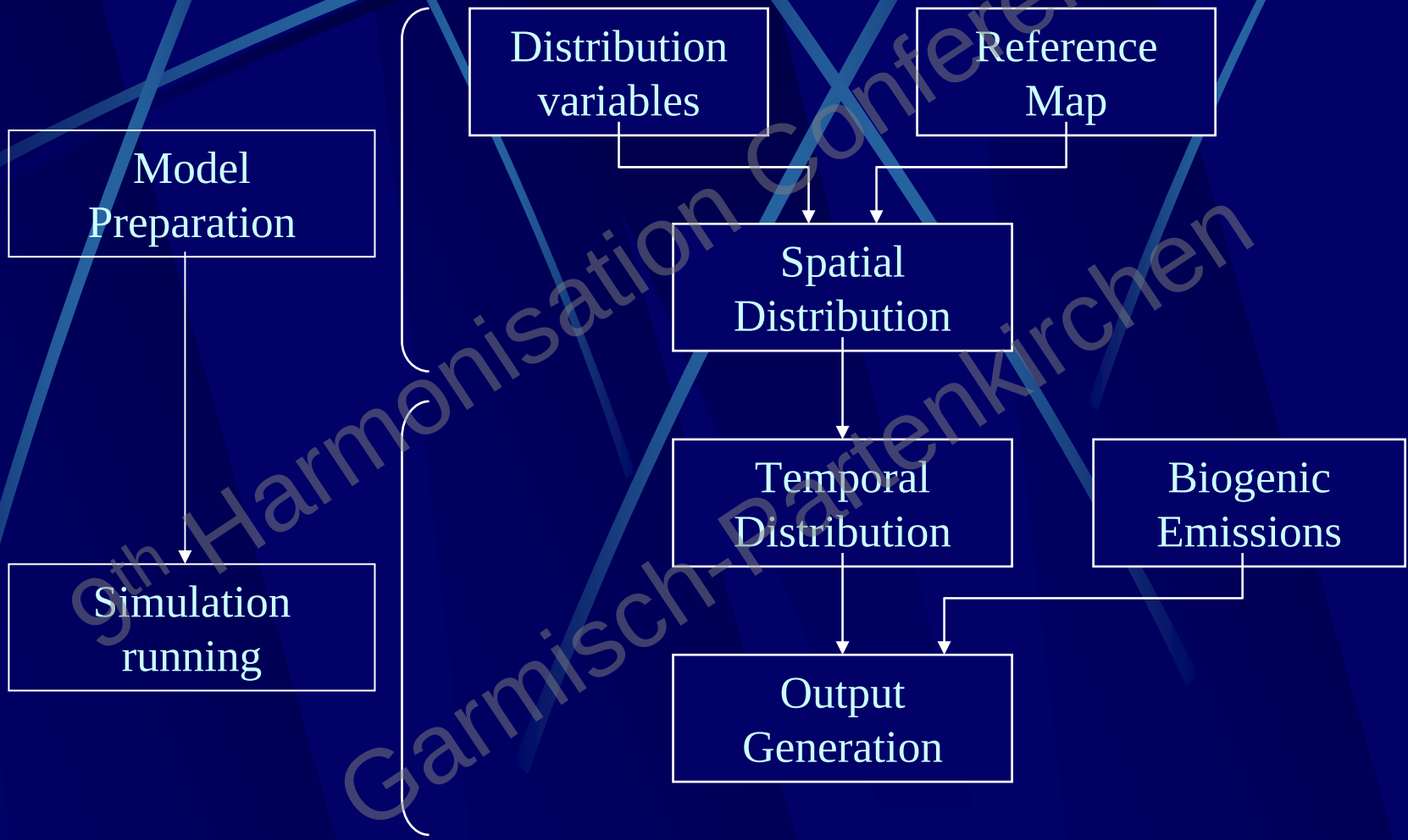
USGS LANDUSE 1KM RESOLUTION

EMISSION MODEL: EMIMO

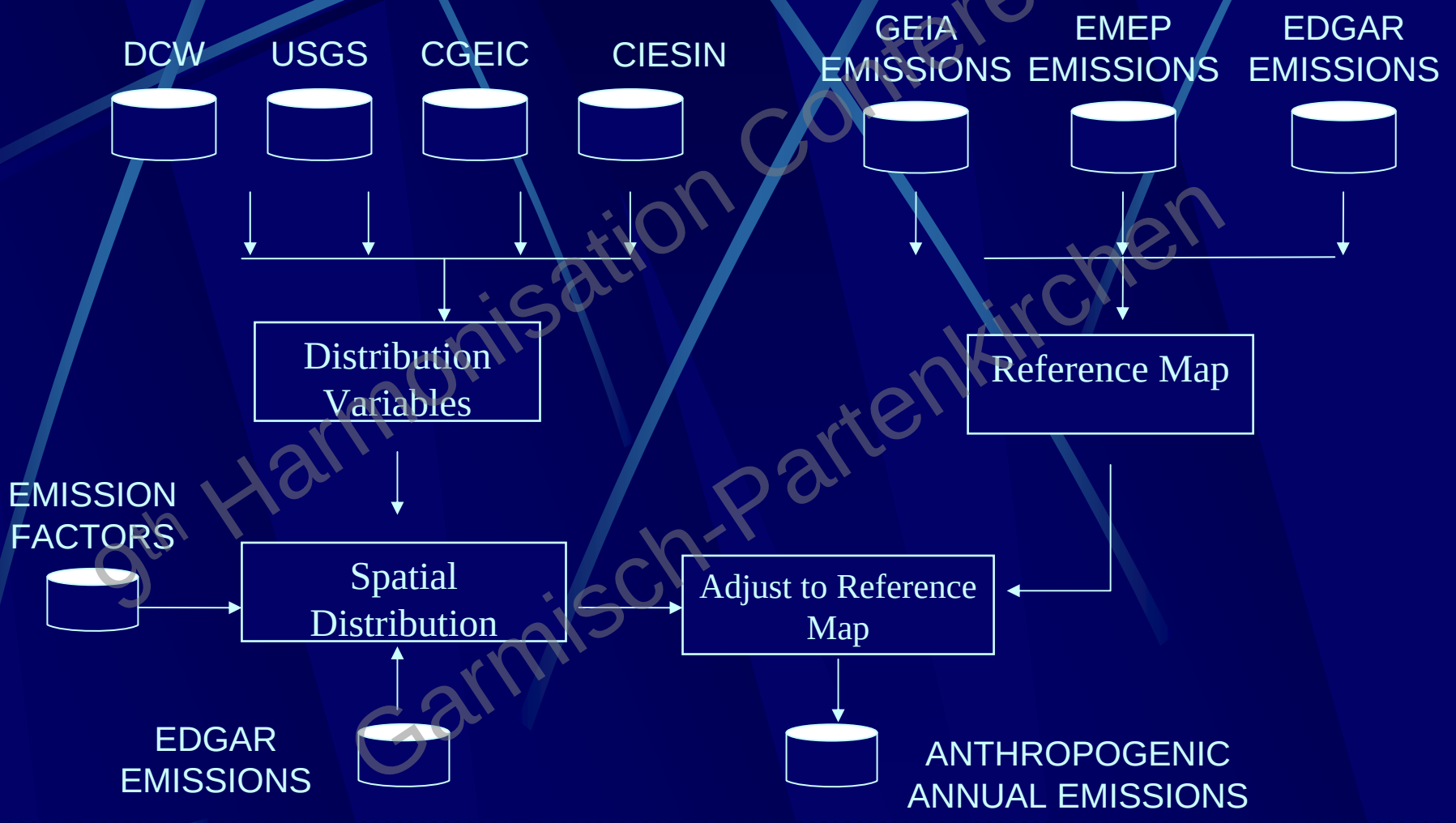
EMIMO (EMIssion MOdel).

- 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.

EMIMO: MODEL DIAGRAM



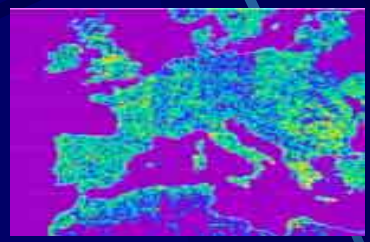
ANTHROPOGENIC ANNUAL EMISSIONS



Variable distribution: multiple regression process

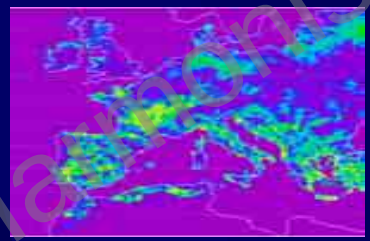
HIGHWAYS

ROADS

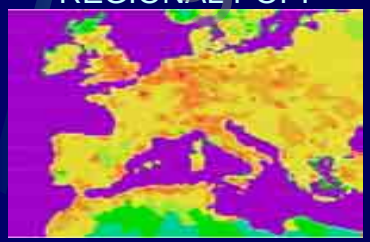


URBAN USE

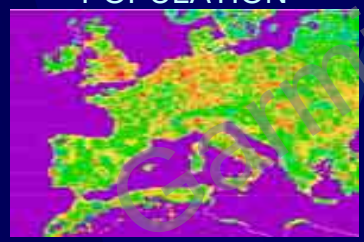
AGRICULTURAL USE



REGIONAL POP.



POPULATION



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

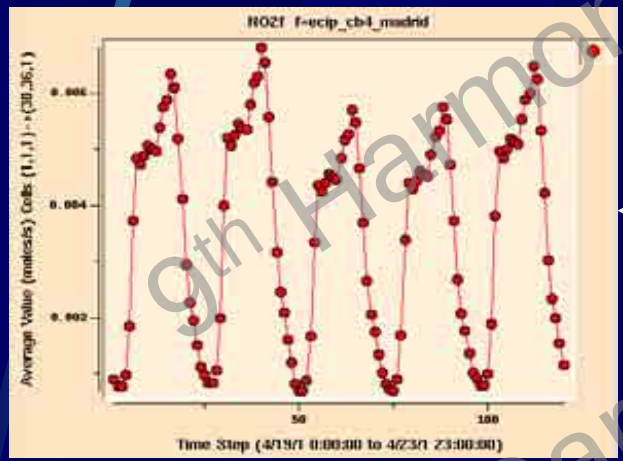
EMISSION DATA Latitud-Longitude Projection

GRASS-GIS

EMIMA V2.0

EMISSION DATA UTM Projection

EMISSION DATA Lambert Conformal Projection

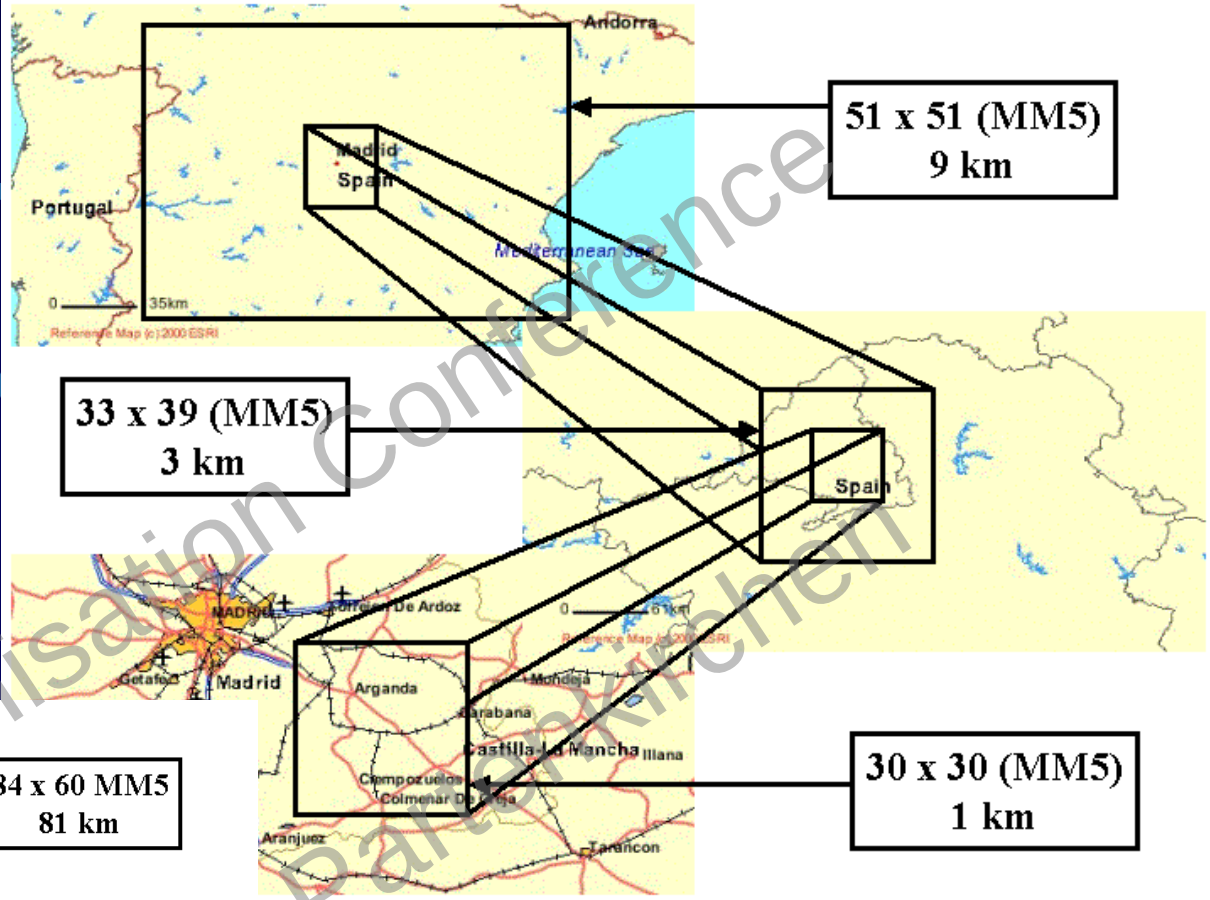


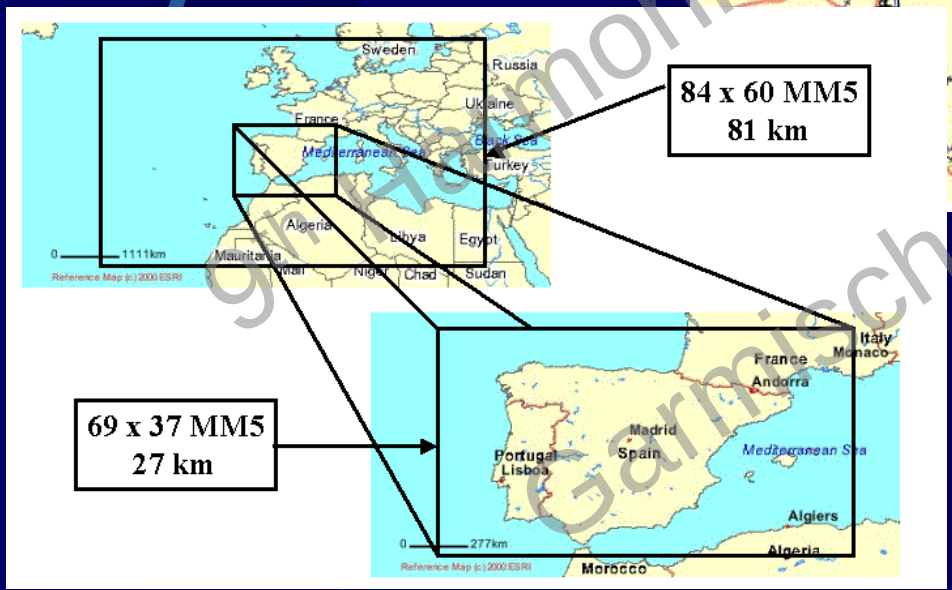
ECIP

FORMAT

EMISSION DATA Lambert Conformal Projection (ECIP Format)

THE MM5-CMAQ MODELLING SYSTEM





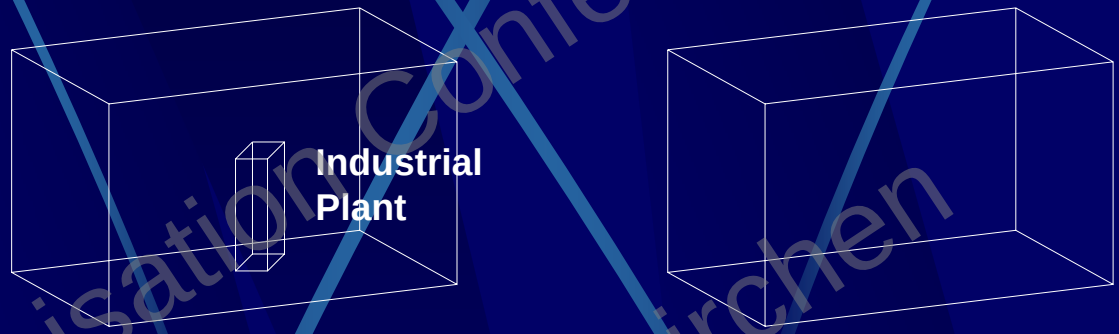
NESTING APPROACH FOR A SPECIFIC COMBINED CYCLE ELECTRIC POWER PLANT ENVIRONMENTAL IMPACT ASSESSMENT STUDY

TEAP

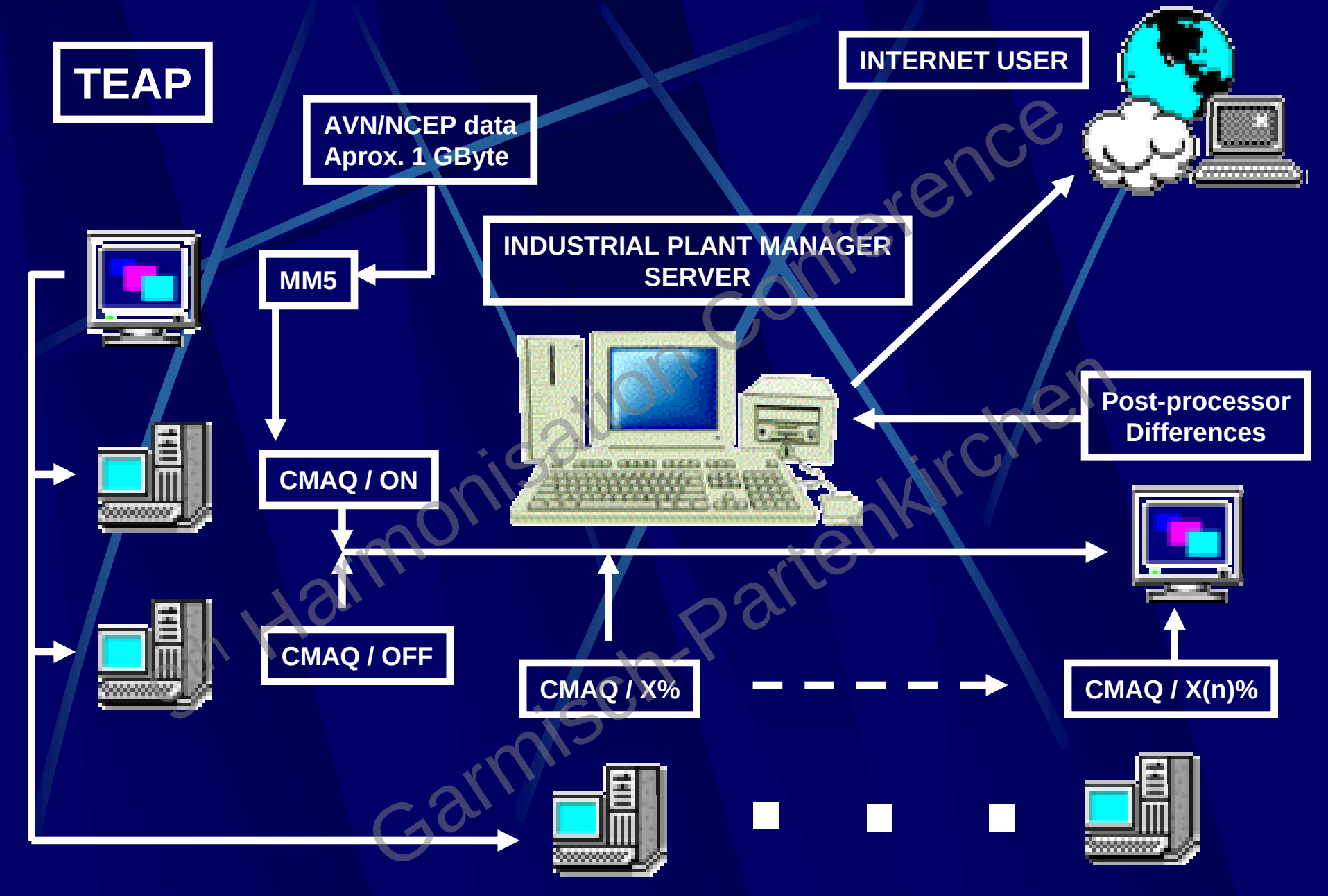
Taking decisions

ON

OFF



Differences = portion of air concentrations due to industrial emissions



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

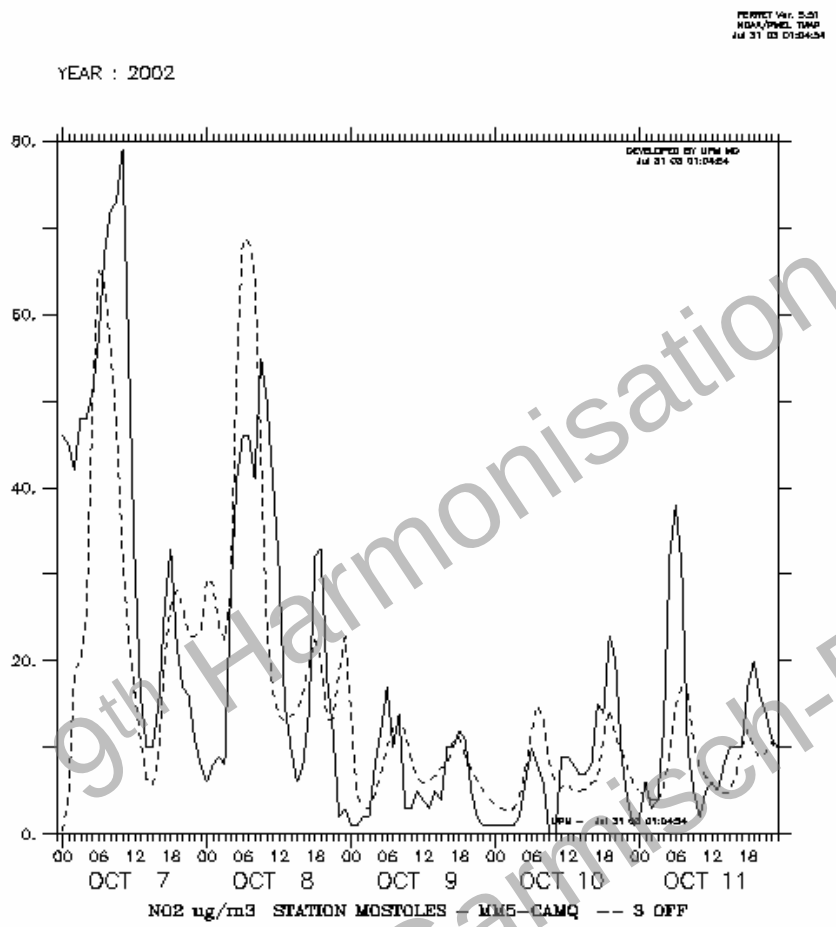
AUTOMATIC SCRIPT PRODUCTION: 3000 – 6000 GRAPHICS PER SIMULATION

POST-PROCESSING ANALYSIS: ON-OFF / %

Geometry / emission characteristics

Diameter: 6.5 m	PM: 1,9 g/s (ON)
Height: 60 m	VOC: 2,4 g/s (ON)
T: 377 K	CO: 8,9 g/s (ON)
Velocity (gases): 21.59 m/s	NOx: 34,56 g/s (ON)
Flux: 716,38 m3/s	SO2: 2,07 g/s (ON)

MM5-CMAQ PERFORMANCE



MM5-CMAQ MODEL:

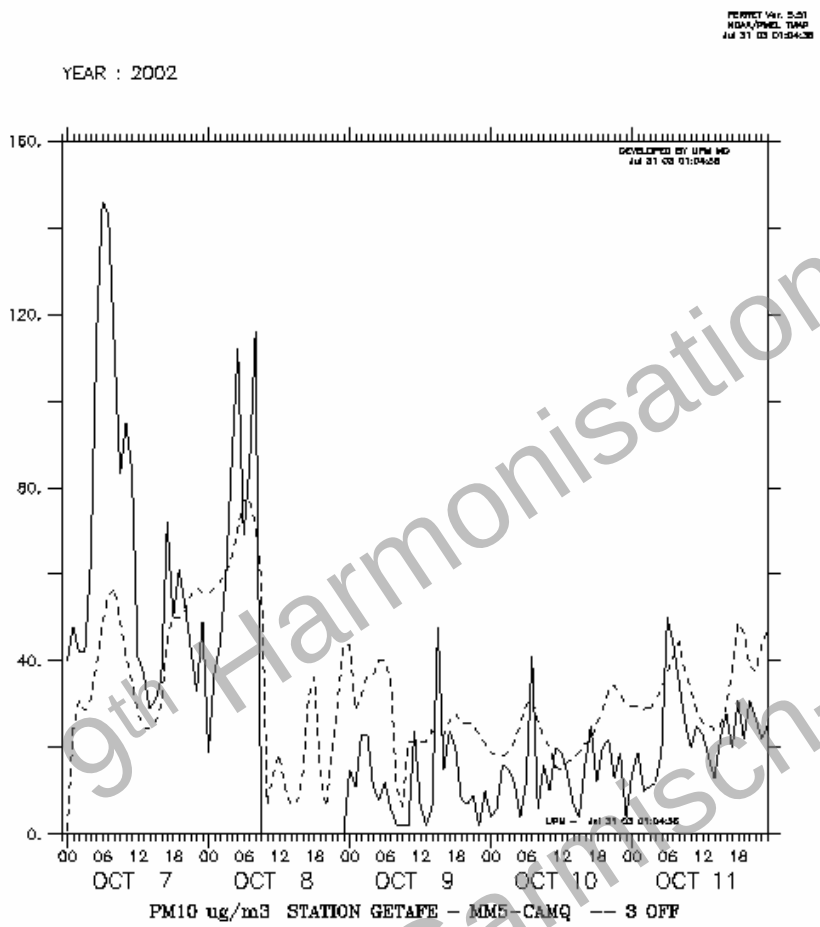
OCTOBER, 7-11, 2002

MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)

COMAPARISON BETWEEN MODELLED DATA AND OBSERVED DATA

NO2

MM5-CMAQ PERFORMANCE



MM5-CMAQ MODEL:

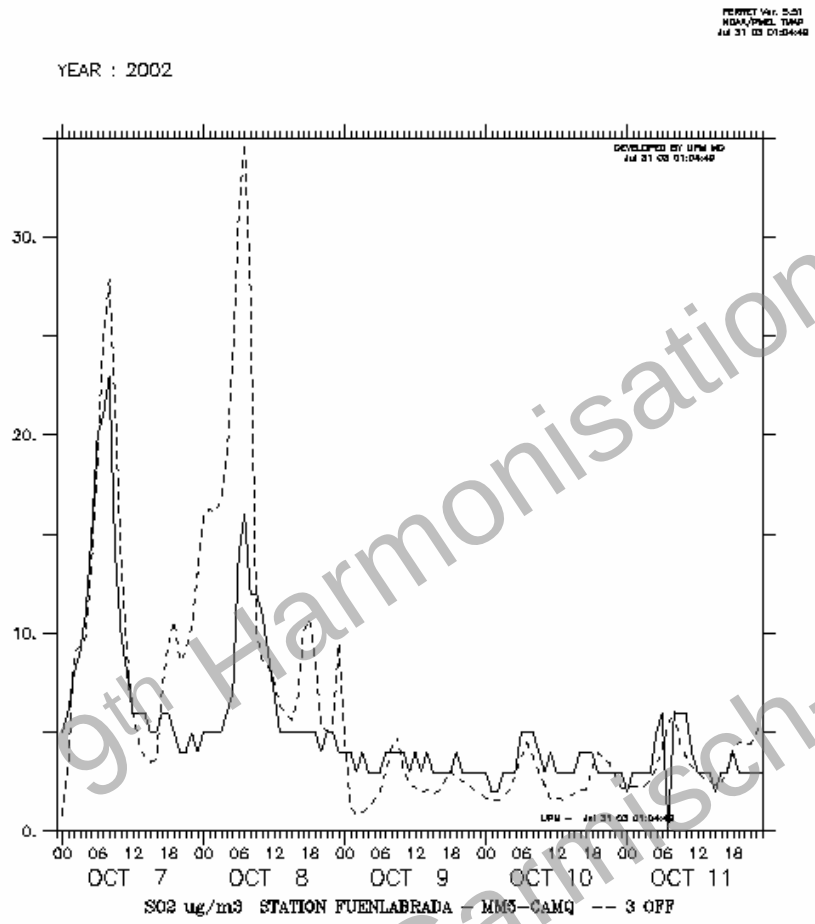
OCTOBER, 7-11, 2002

MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)

COMPARISON BETWEEN MODELLED DATA AND OBSERVED DATA

PM10

MM5-CMAQ PERFORMANCE



MM5-CMAQ MODEL:

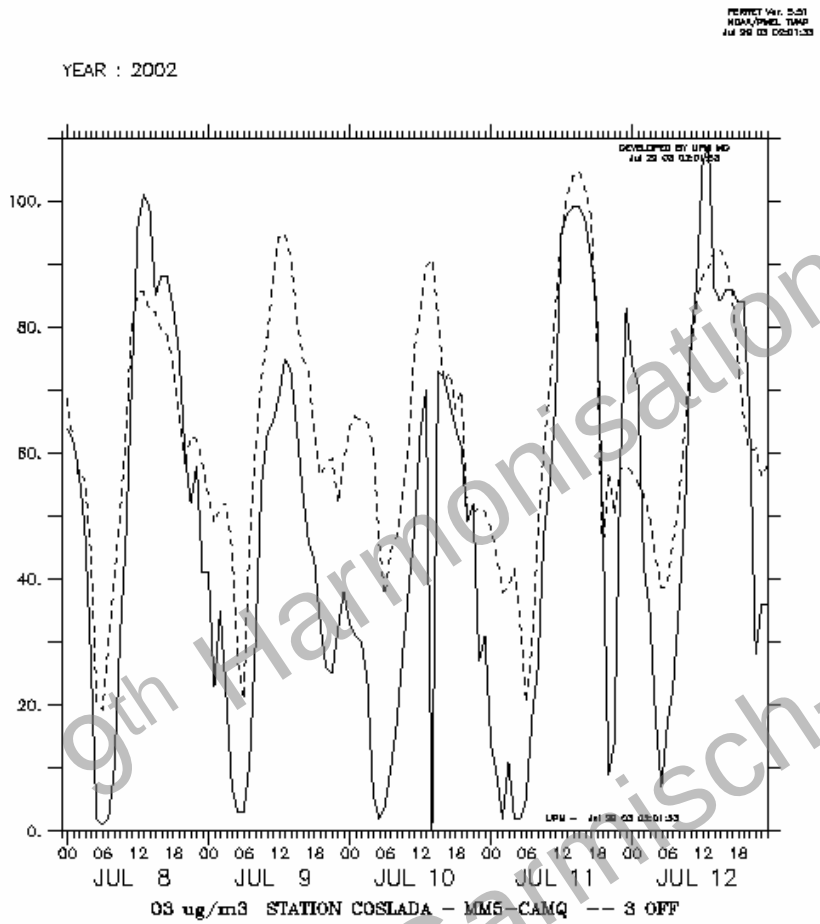
OCTOBER, 7-11, 2002

MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)

COMPARISON BETWEEN MODELLED DATA AND OBSERVED DATA

SO2

MM5-CMAQ PERFORMANCE



MM5-CMAQ MODEL:

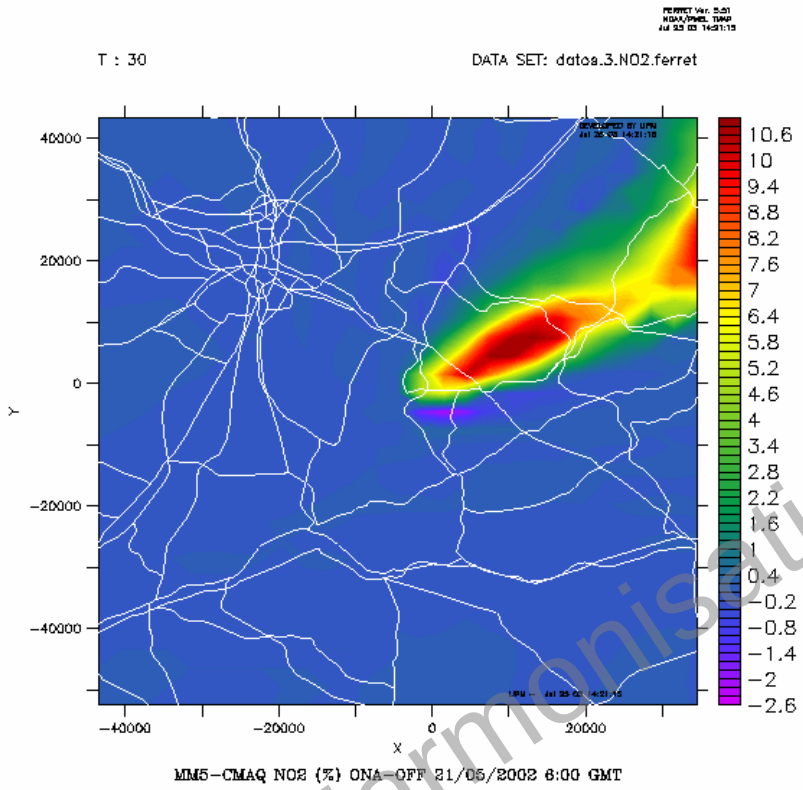
OCTOBER, 7-11, 2002

MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)

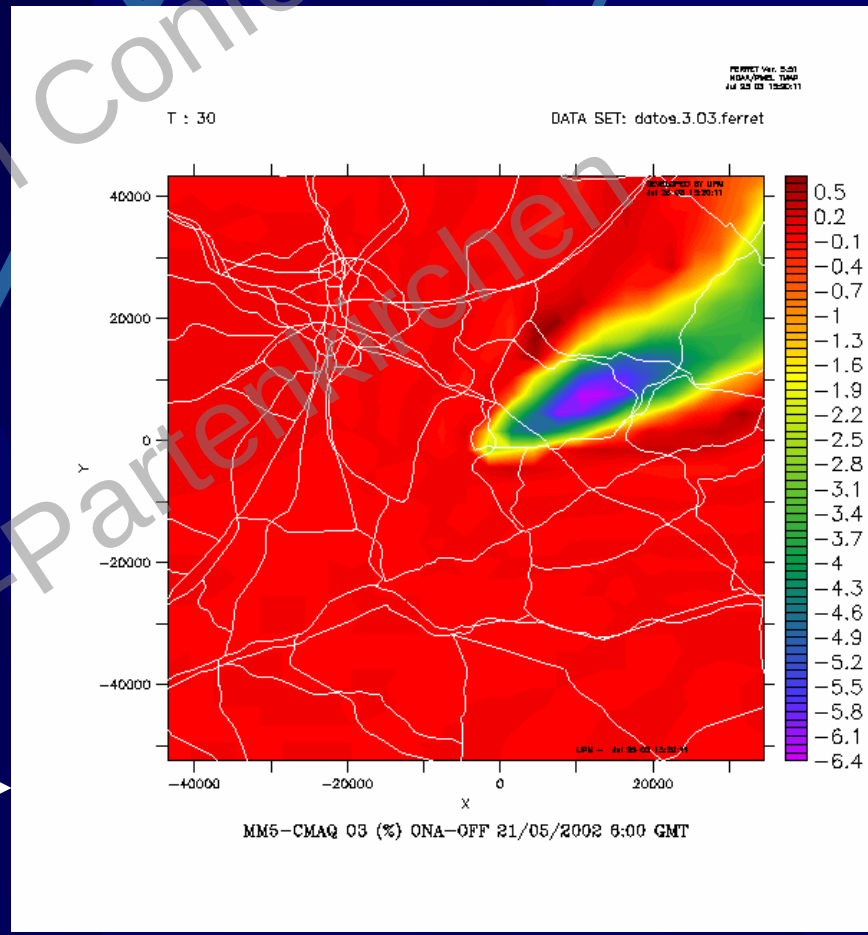
COMPARISON BETWEEN MODELLED DATA AND OBSERVED DATA

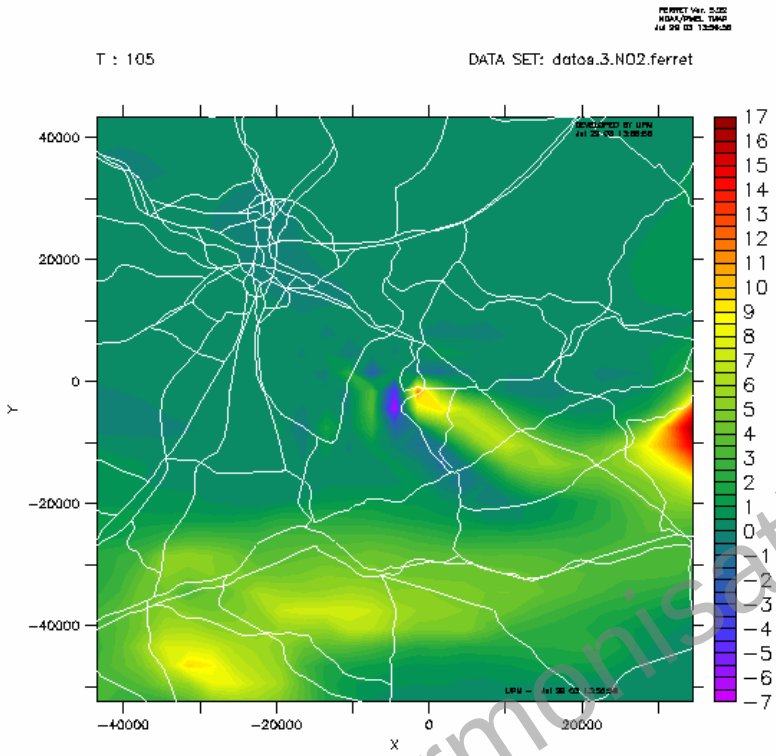
O3

MM5-CMAQ NO2 (%) ONA-OFF
21-05-2002 6H00 GMT



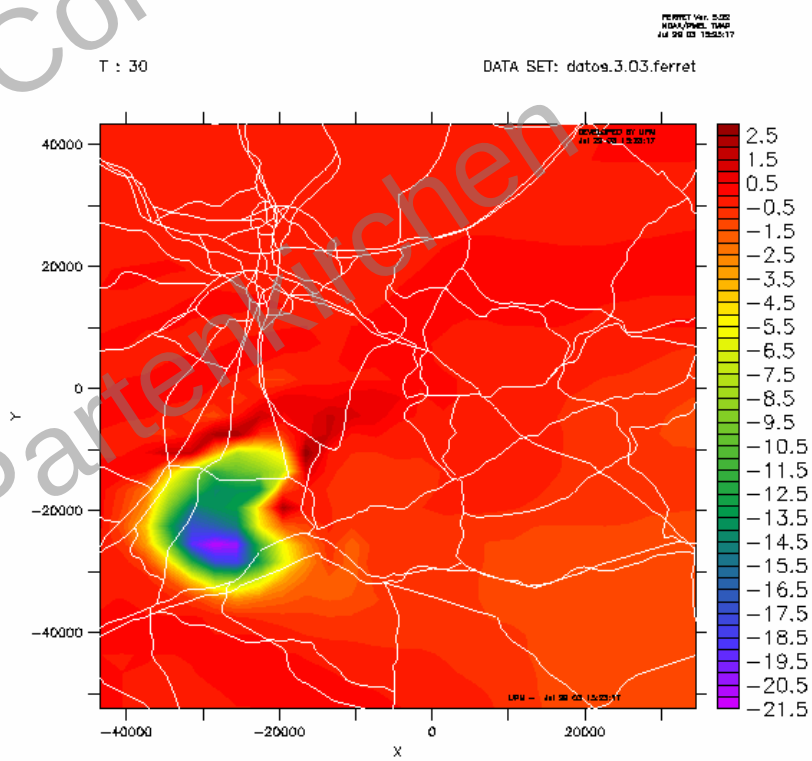
MM5-CMAQ O3 (%) ONA-OFF
21-05-2002 6H00 GMT

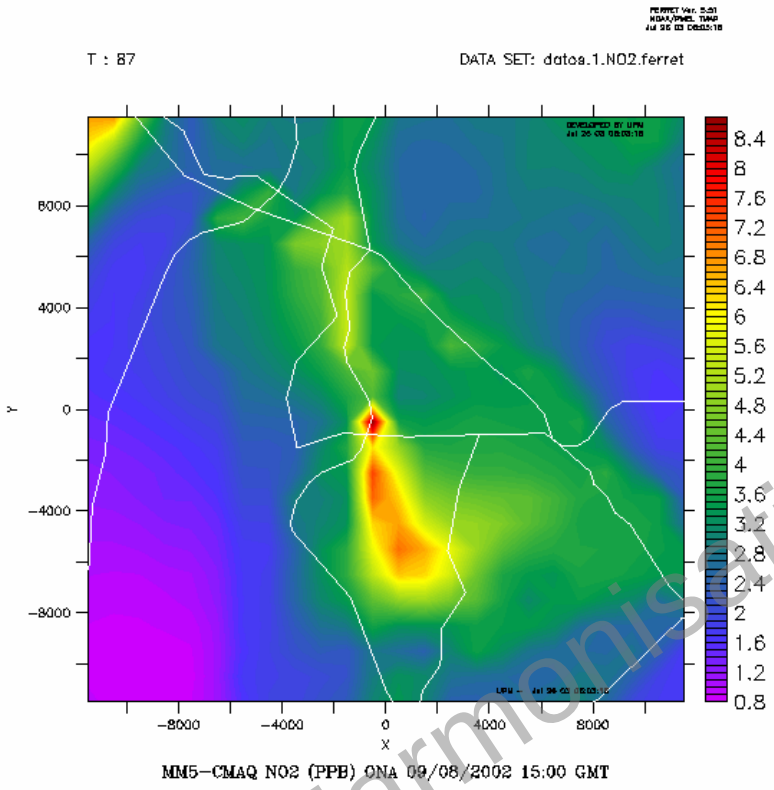




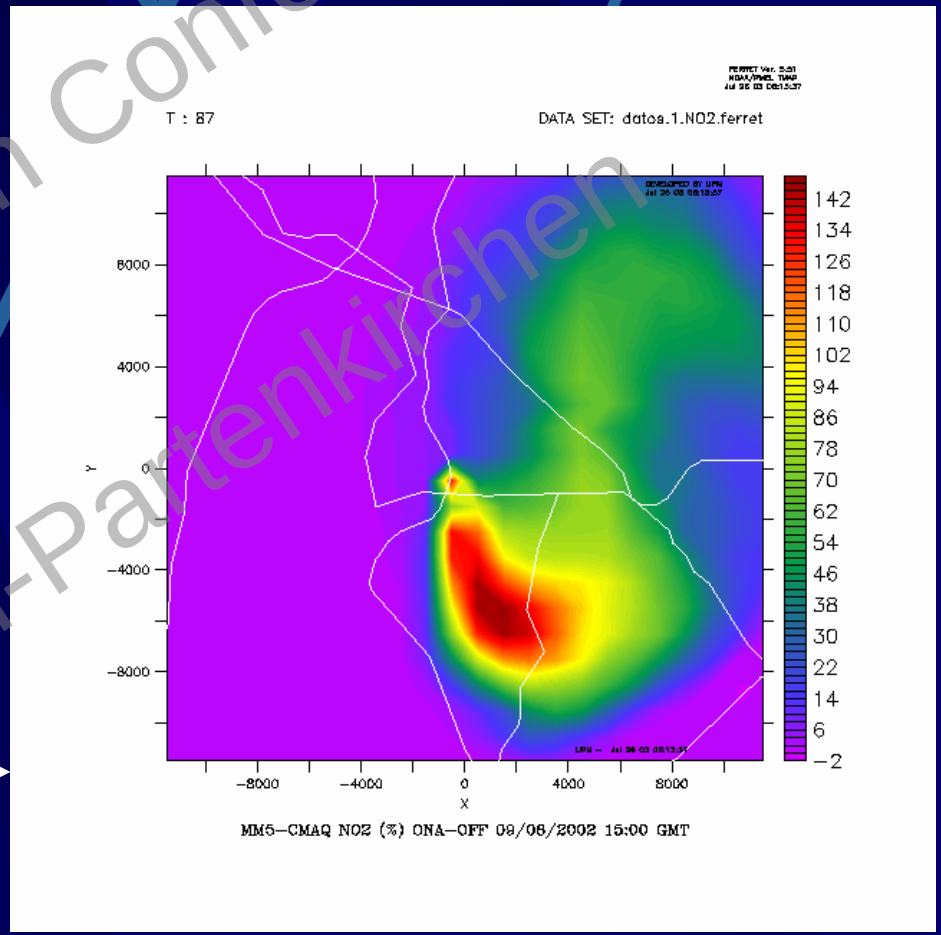
MM5-CMAQ NO2 (%) ONA-OFF
5-03-2002 9H00 GMT

MM5-CMAQ O3 (%) ONA-OFF
2-03-2002 6H00 GMT

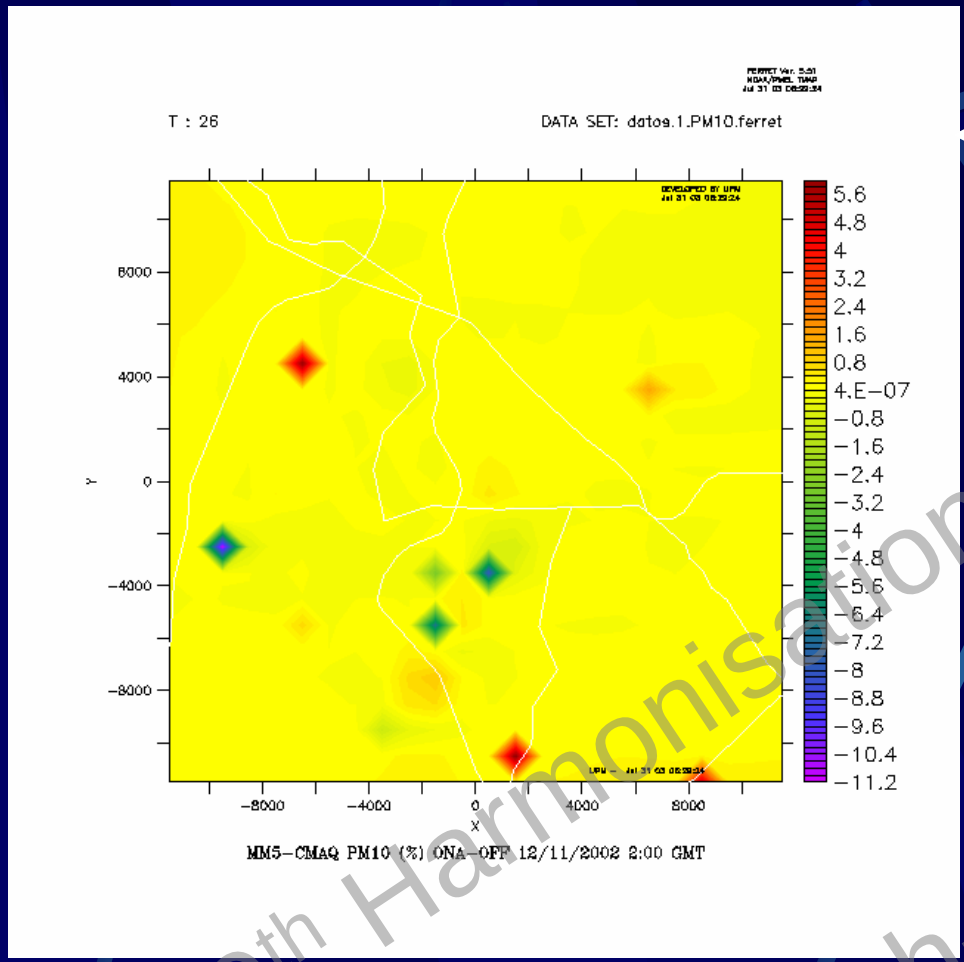




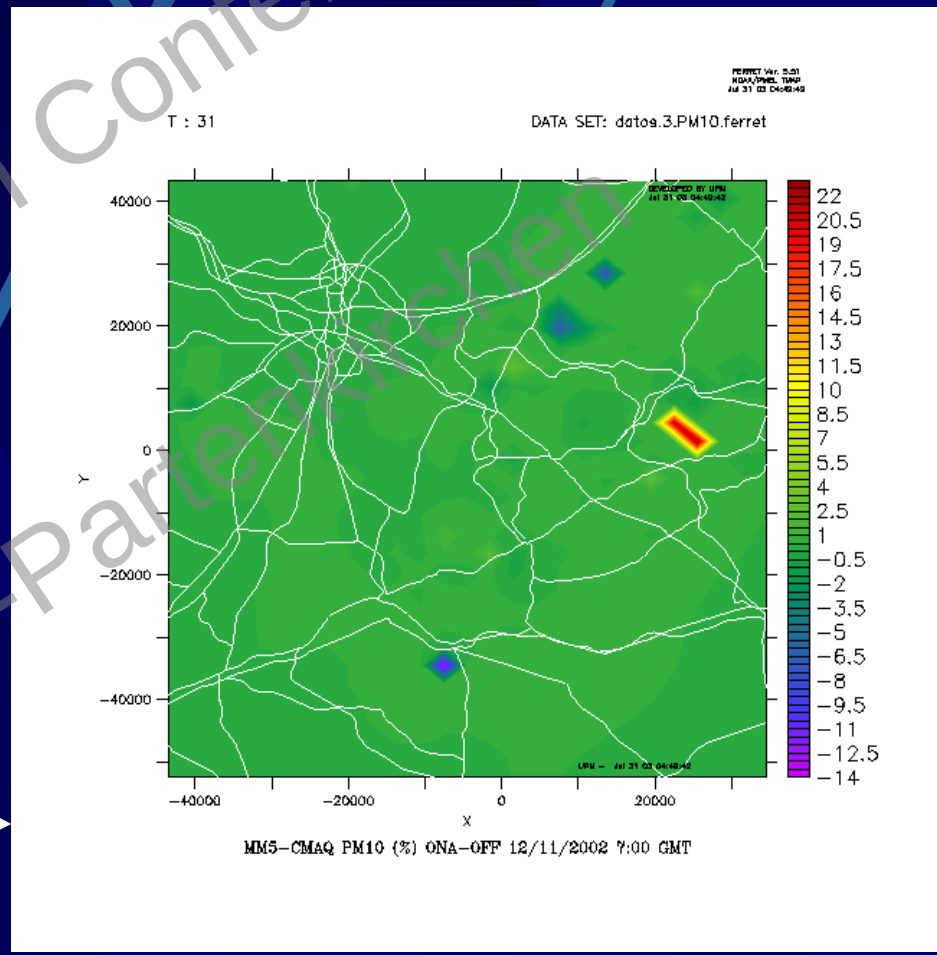
MM5-CMAQ NO2 (ppb) ONA
9-08-2002 15H00 GMT



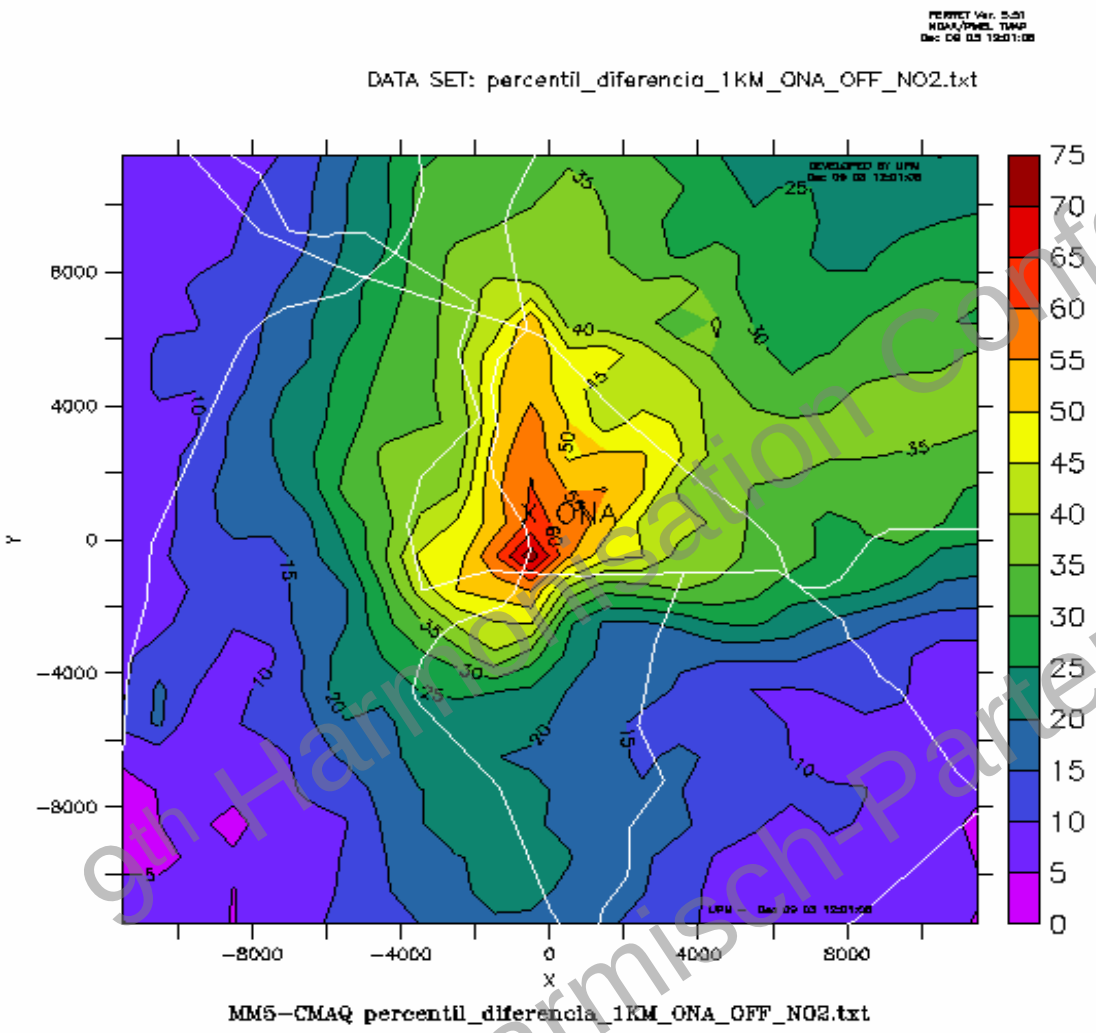
MM5-CMAQ NO2 (%) ONA-OFF
9-08-2002 15H00 GMT



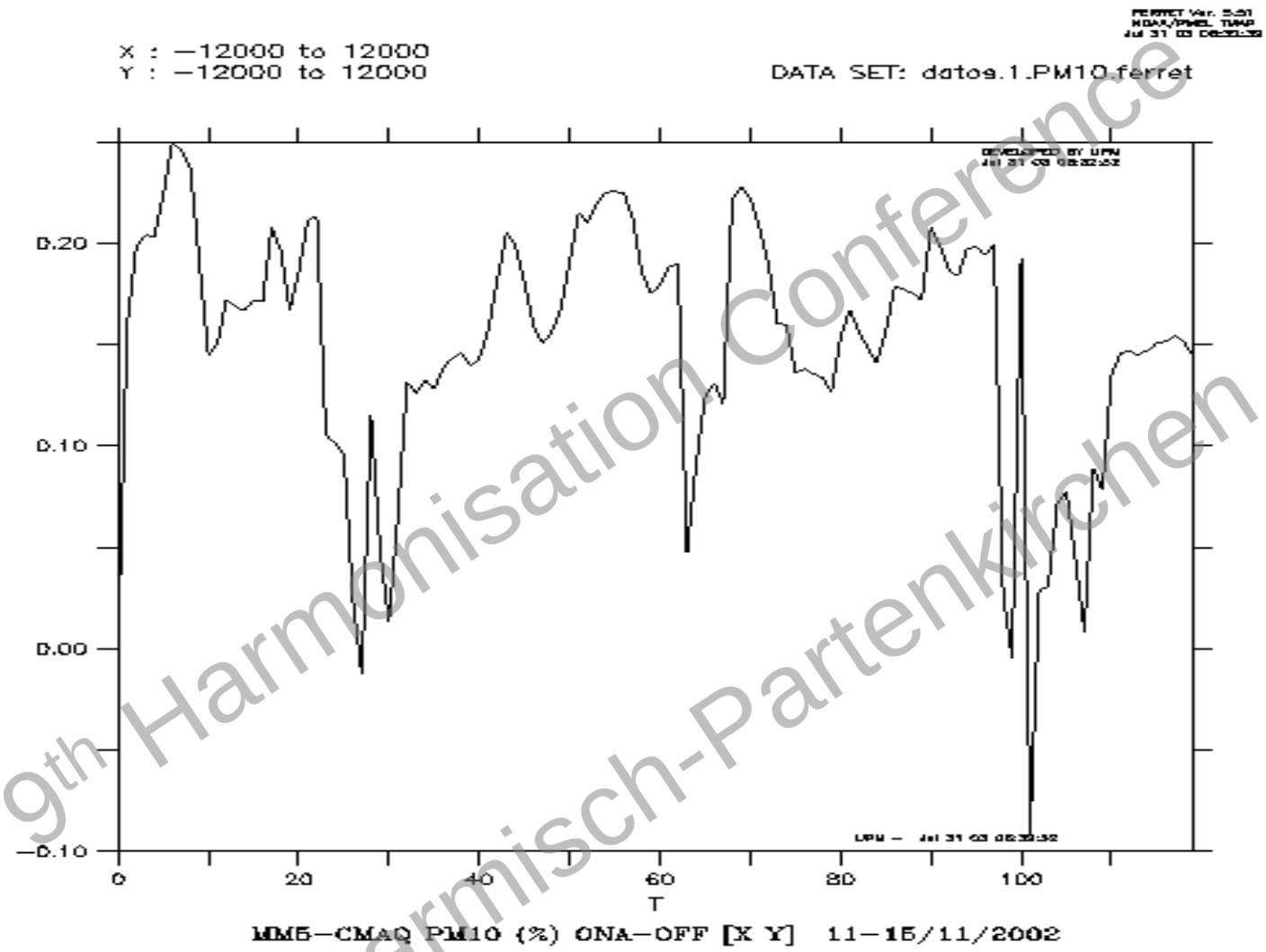
MM5-CMAQ PM10 (%) ONA
12-11-2002 02H00 GMT

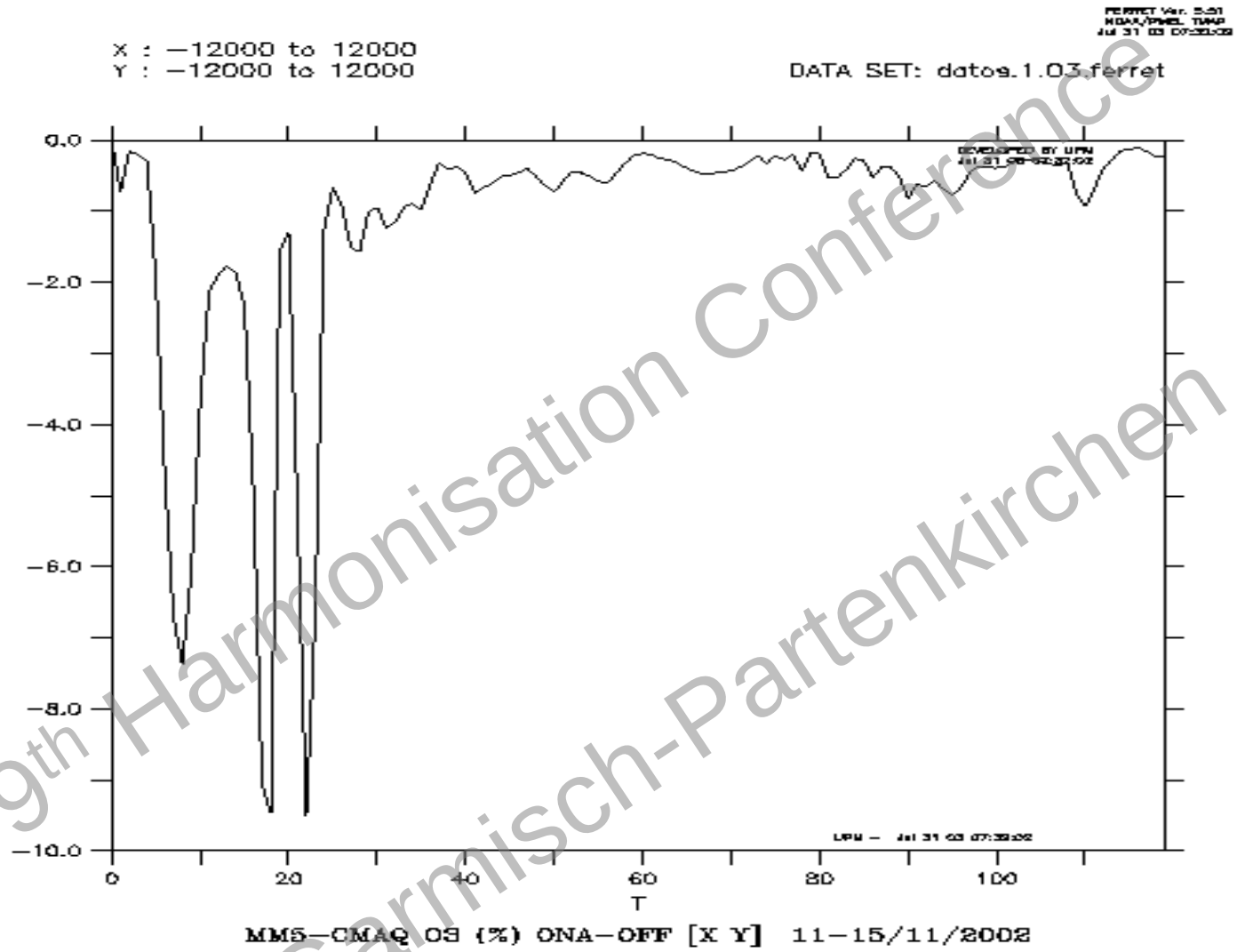


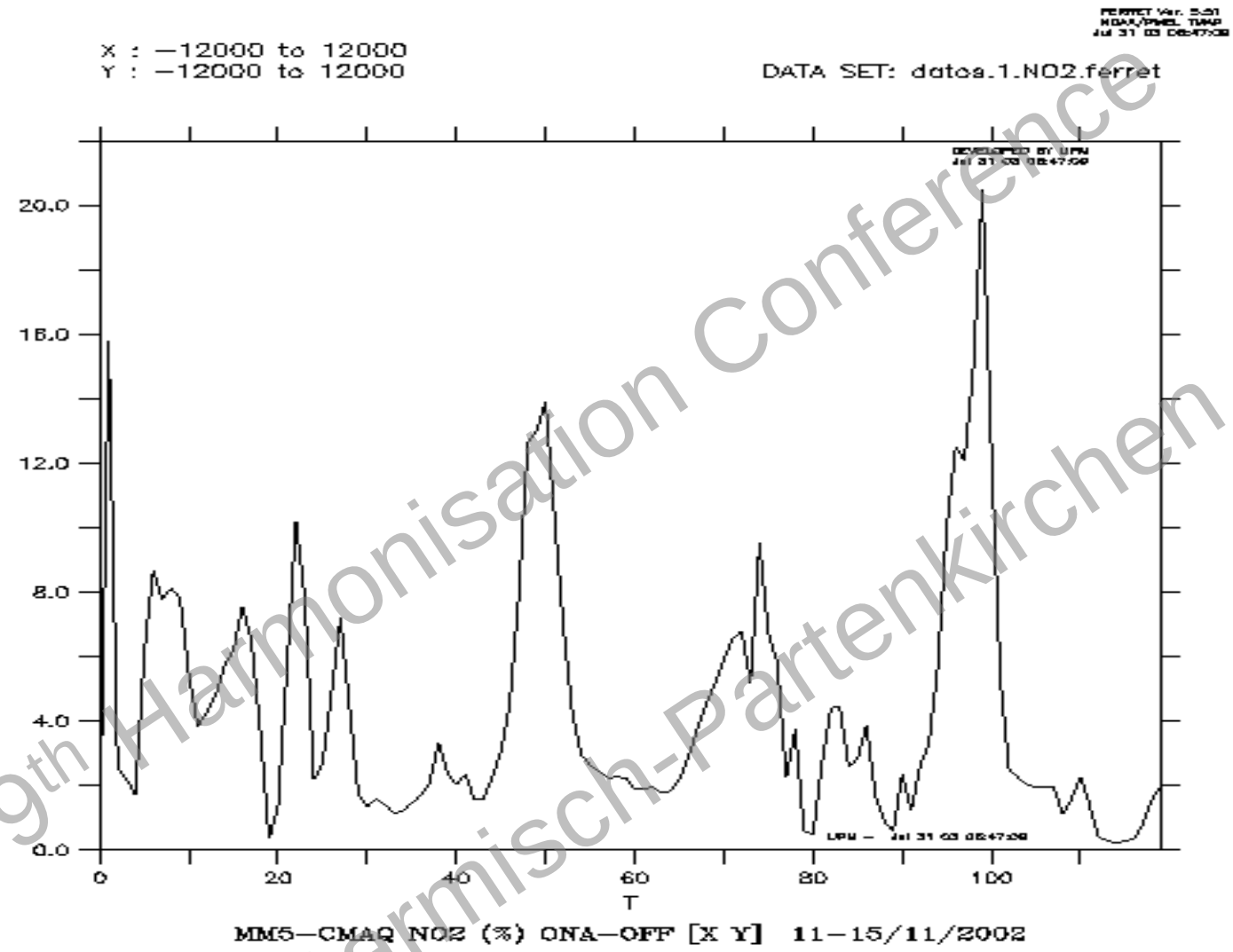
MM5-CMAQ PM10 (%) ONA-OFF
12-11-2002 07H00 GMT



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







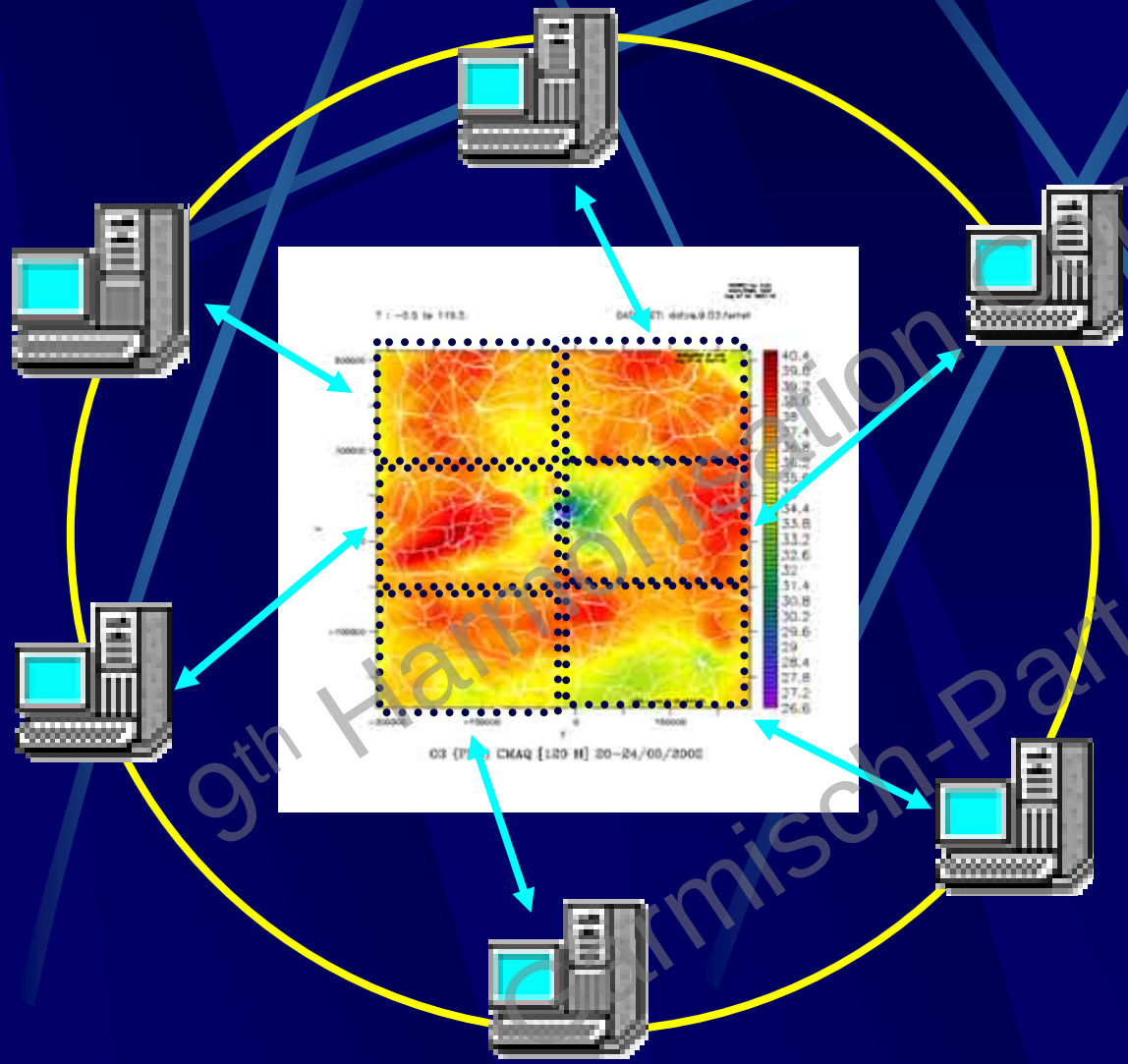
OPERATIONAL SYSTEM

PENTIUM IV 2,4 Ghz.

- **3451’ (57 h 31’) CPU TIME**
- **6 NODE CLUSTER >>>>>>> 3-4 TIMES FASTER**

>>>>>>>>> 16 HOURS, CPU TIME

SPLITING DOMAINS: EXAMPLE WITH 6 NODES



6 NODES

DOMAIN 45*45

SPLITING 2*3

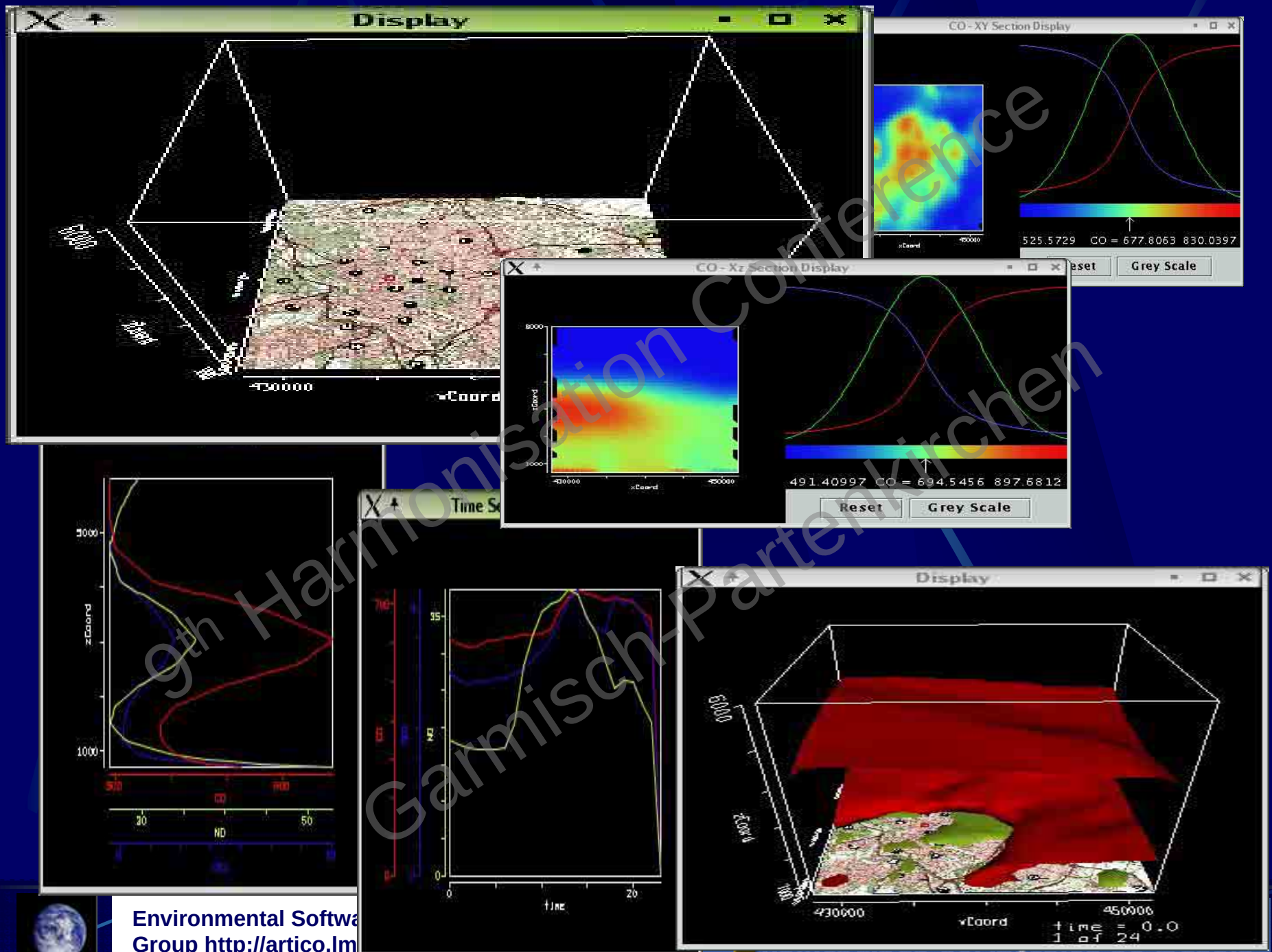
COLS 1:23

24:45

ROWS 1:15

16:30

31:45


Display
CO - XY Section Display
525.5729 CO = 677.8063 830.0397
Reset
Grey Scale
CO - Xz Section Display
491.40997 CO = 694.5456 897.6812
Reset
Grey Scale
Time S
Display
430000
xCoord
450000
time = 0.0
1 of 24
time
zCoord
9th Harmonisation Conference
Garmisch-Partenkirchen

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 sstem simulations.

ACKNOWLEDGEMENTS:

1. Pennsylvania State University and NCAR (USA) for providing access to MM5 source code.

2. Environmental Protection Agency (U.S.A) for providing access to the CMAQ code.

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

5. EUREKA programme (EU). TEAP project.