Contribución a:
RED IBERICA PARA LA INVESTIGACION Y DESARROLLO DE APLICACIONES EN BASE AL MODELO ATMOSFERICO MM5

# EXPERIENCIA DEL GMSMA (FI-UPM) EN LA EJECUCION NACIONAL DEL MODELO MM5 Y OTROS

R. San José

*Environmental Software and Modelling Group*
*Computer Science School – Technical University of Madrid*
*Campus de Montegancedo – 28660 Madrid (Spain)*

http://artico.lma.fi.upm.es

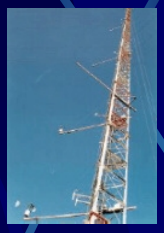


## 1980-1989

- Ph. D at CIBA (Centro de Investigaciones de la Baja Atmosfera) (Low Atmospheric Research Center)

University of Valladolid (Spain) and Spanish Meteorological Institute.

- Micrometeorology
- Spectral studies
- Deposition modelling

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upm UNIVERSIDAD POLITECNICA DE MADRID

Environmental Software and Modelling Group started on February, 1993 at the Computer Science School of the Technical University of Madrid




1989: Max Planck Institute for Meteorology (Hamburg, Germany) (mesoscale modelling).

1990-92: IBM-Bergen Environmental Sciences and Solution Center (Barcelona Olympic Games Modelling Studies).

1992-96: Deposition Measurement studies (EU projects) and MEMO+SMVGEAR Development.

1996: OPANA model V 3.0 (REMEST + SMVGEAR)

1997-98: OPANA model V4.0 (REMEST+VGEAR+AVN/MRF)

1999: RSM Model

2000-01: MM5 Model

2002: MM5-CMAQ Modelling System

## OPANA MODEL V3.0 (I)

• The OPANA model is a visual interface (Tcl/Tk) developed to manage the Meteorological and dispersion (chemical) Modules.

• 1996 (version 3.0) adapts MEMO model (REMEST) and SMVGEAR (CHEMA) to create one FORTRAN-77 and 90 Code where SMVGEAR is a subroutine of MEMO (REMEST).

• This is an on-line (chemical solver is solved for every meteorological time step) version. The operational version Solves the chemistry every 1800 s.

• Biogenic emissions and off-line in the operational version.



## OPANA MODEL V3.0 (II)

• MEMO model is a limited area model so that general fluid partical differential equation system is solved without taking into account earth curvature.

• MEMO initialization is done by vertical meteorological soundings.

• In this version we used the upper-air observed meteorological data from Barajas International Airport in Madrid for the first 24 hours.

• For another domains, surface meteorological data was extrapolated up to 6000 m by using Monin-Obukhov theory.

EU projects supporting the Operational AQMS applications:

- EMMA: Integrated Environmental Monitoring Forecasting and Warning Systems in Metropolitan Areas.
Funding: DGXIII- (IST) European Union.
Period: 1995-98.

2. Electronic Services for a Better QUAlity of Life (EQUAL).
Funding: DGXIII- (IST) European Union.
Period: 1998-2000.

3. APNEE: Air Pollution Network for Early warning and on-line information Exchange in Europe.
Funding: IST-European Union.
Period: Jan, 2000 – Dec. 2001.



EU projects supporting the Operational AQMS applications:

4. APNEE-TU: Air Pollution Network for Early Warning and on-line information Exchange in Europe – Take-up.
Funding: IST-European Union. Period: April, 2002 – March, 2004.

Other co-lateral European Union projects:

1. DECAIR : Development of an Earth Observation Data Converter with Application to Air Quality Forecast.
Funding: DGXII-(Environmental Research) European Union.
Period: July, 1999 – July, 2002.

2. Optimised Expert System for Conducting Environmental Assessment of Urban Road Traffic (OSCAR).
Funding: Environment Programme – European Union.
Period: September, 2002 – September, 2005

Applications:

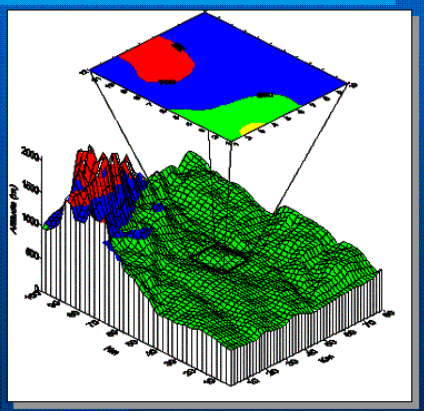
1. Madrid City (EMMA and City Funding)
2. Madrid Community (EMMA)
3. Madrid Community (Internet Service Summer, 2000).
4. Asturias (Spain) domain: Community of Asturias funding.
5. Las Palmas de Gran Canaria (Cannary Islands, Spain): City Funding (OPANA V5.0: MM5 -CMAQ). (on-line).
6. Bilbao (Spain) (EQUAL project)
7. Leicester City Council (U.K.) (EQUAL project)
8. Leicester City Council (U.K.) (Internet service)



Applications:

9. Andalucia (Spain) APNEE-TU European Project
10. Canary Islands Community (7 islands) APNEE-TU Project
11. Quito (Ecuador) (World Bank) 1998-2000.

# EMMA Domain Topography



**URBAN MODEL (EMMA_U)**

Area = 10x12 km

Grid = 10x12 cells

Resolution = 1 km

**REGIONAL MODEL (EMMA_R)**

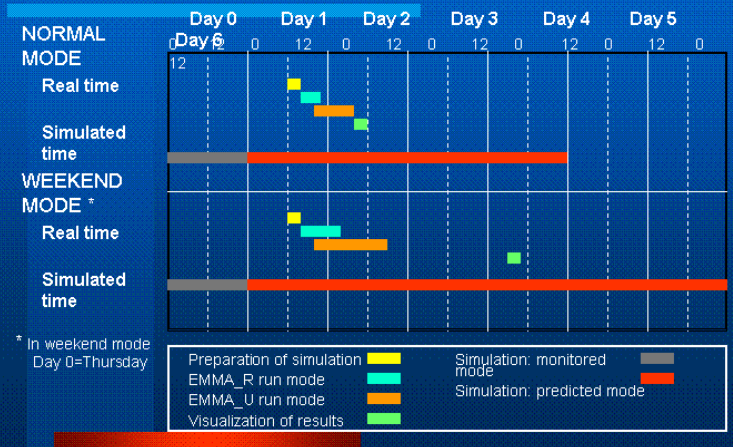
Area = 80x100 km

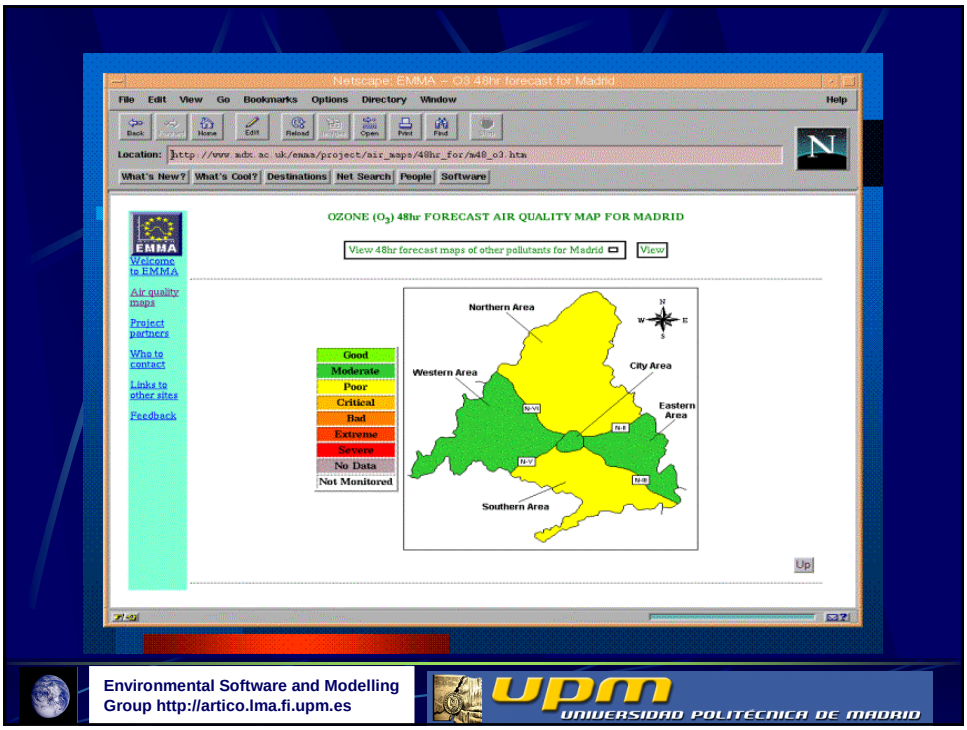
Grid = 8x10 cells

Resolution = 10 km



# EMMA Operational Mode




Netscape: EMMA – O3 48hr forecast for Madrid
File Edit View Go Bookmarks Options Directory Window Help
Location: http://www.mdx.ac.uk/emma/project/air_maps/48hr_for/m48_o3.htm
What's New? What's Cool? Destinations Net Search People Software
EMMA
Welcome to EMMA
Air quality maps
Project partners
Who to contact
Links to other sites
Feedback
OZONE ($O_3$) 48hr FORECAST AIR QUALITY MAP FOR MADRID
View 48hr forecast maps of other pollutants for Madrid
View
Good
Moderate
Poor
Critical
Bad
Extreme
Severe
No Data
Not Monitored
Northern Area
Western Area
City Area
Eastern Area
Southern Area
Up
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
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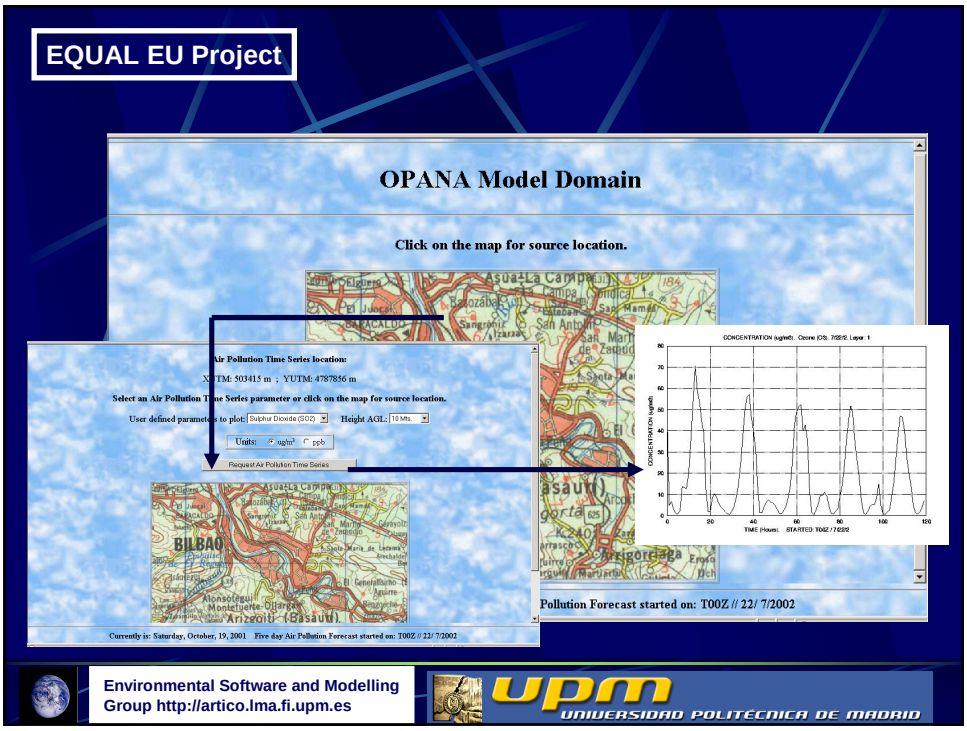
EQUAL EU Project
EQUAL Spain
Museums
Libraries
Education
Parking
Public transport
Traffic
Environment
Other local services
Questionnaire
Leicester
Site Developed By: Environmental Software and Modelling Group
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
upm
UNIVERSIDAD POLITECNICA DE MADRID


EQUAL EU Project
OPANA Model Domain
Click on the map for source location.
Air Pollution Time Series location:
Select an Air Pollution Time Series parameter or click on the map for source location.
Request Air Pollution Time Series
BILBAO
Pollution Forecast started on: T00Z // 22/ 7/2002
Currently is: Saturday, October, 19, 2001 Five day Air Pollution Forecast started on: T00Z // 22/ 7/2002
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
upm
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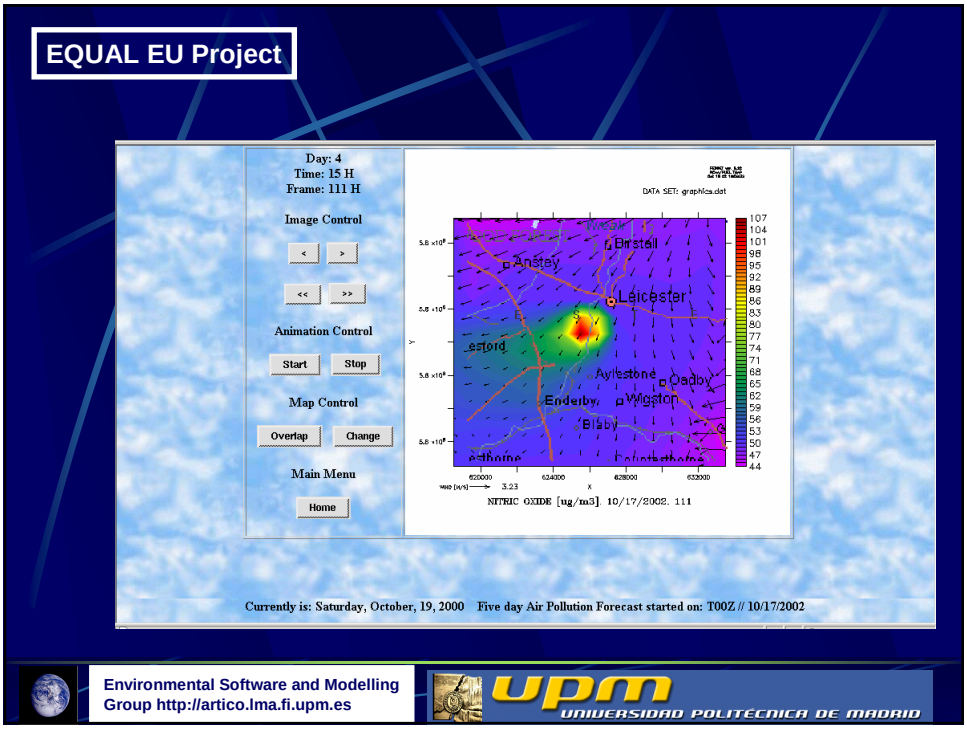
EQUAL EU Project
Day: 4
Time: 15 H
Frame: 111 H
Image Control
Animation Control
Start
Stop
Map Control
Overlap
Change
Main Menu
Home
DATA SET: graphics.dat
Bristell
Anstey
Leicester
Aylestone
Oadby
Wigston
Enderby
Blaby
NITRIC OXIDE [ug/m3] 10/17/2002. 111
Currently is: Saturday, October, 19, 2000 Five day Air Pollution Forecast started on: T00Z // 10/17/2002
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upm
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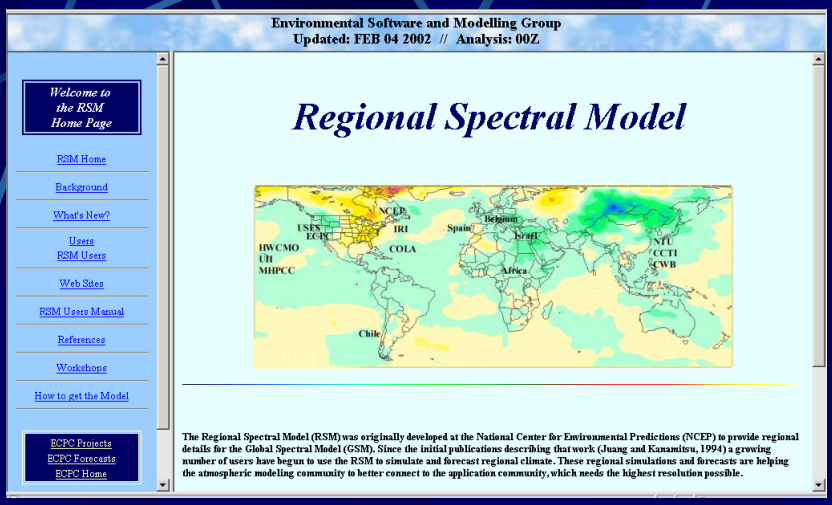
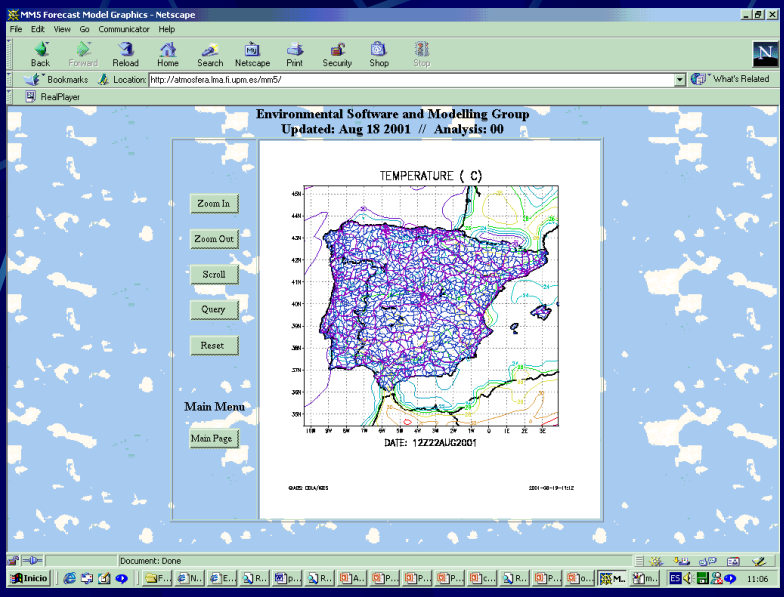
## Regional Spectral Model



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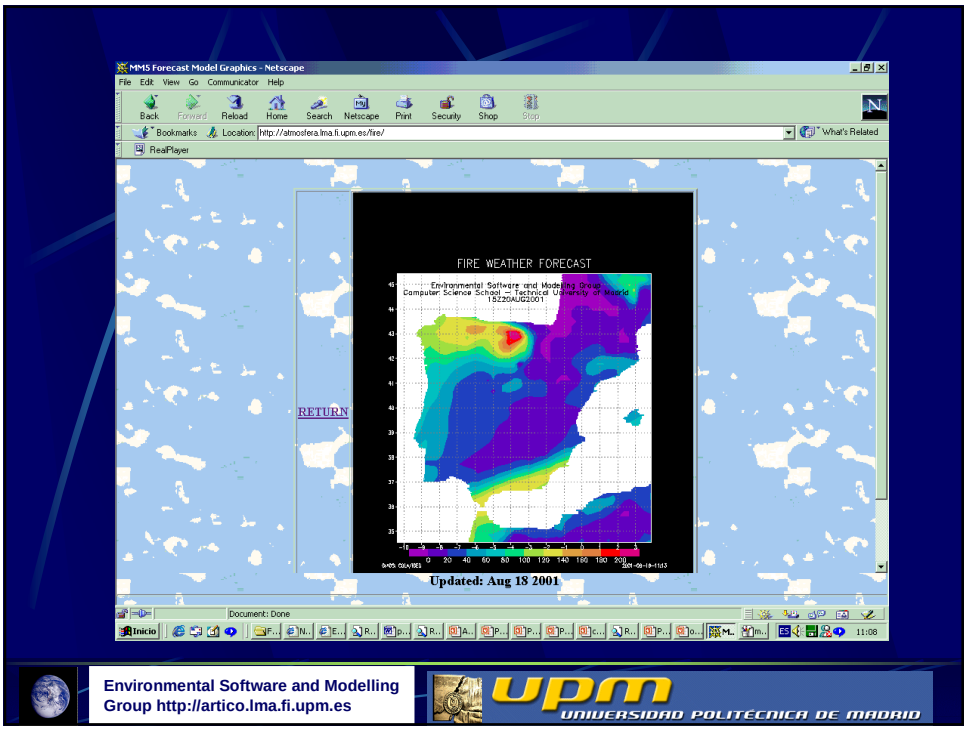
MM5 Forecast Model Graphics - Netscape
FIRE WEATHER FORECAST
RETURN
Updated: Aug 18 2001
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
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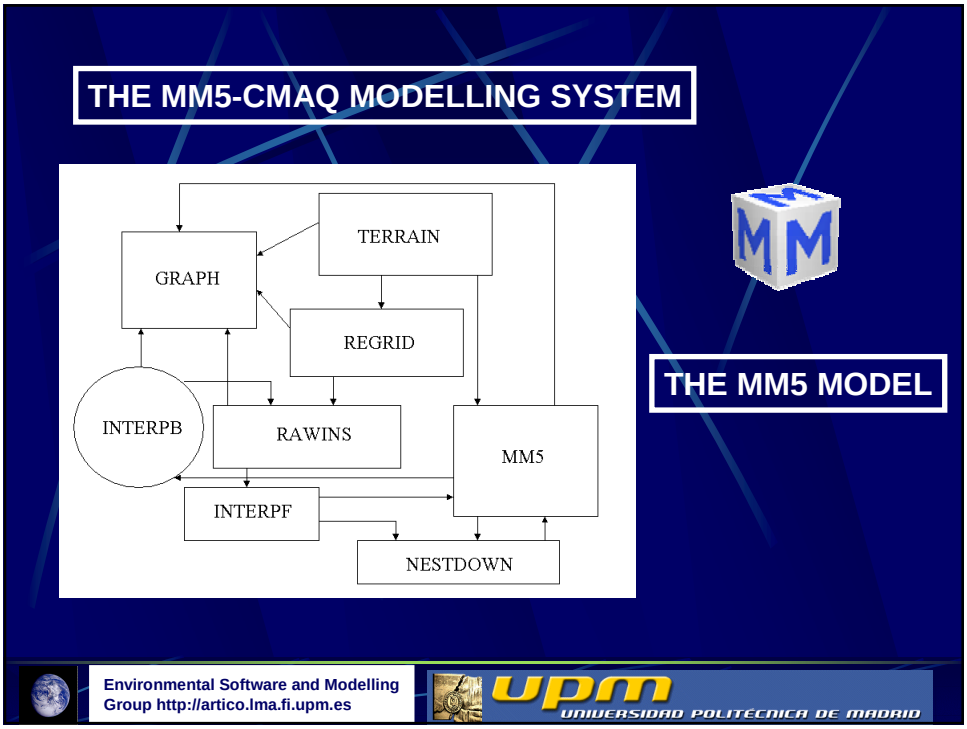
THE MM5-CMAQ MODELLING SYSTEM
TERRAIN
GRAPH
REGRID
INTERPB
RAWINS
MM5
INTERPF
NESTDOWN
THE MM5 MODEL
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
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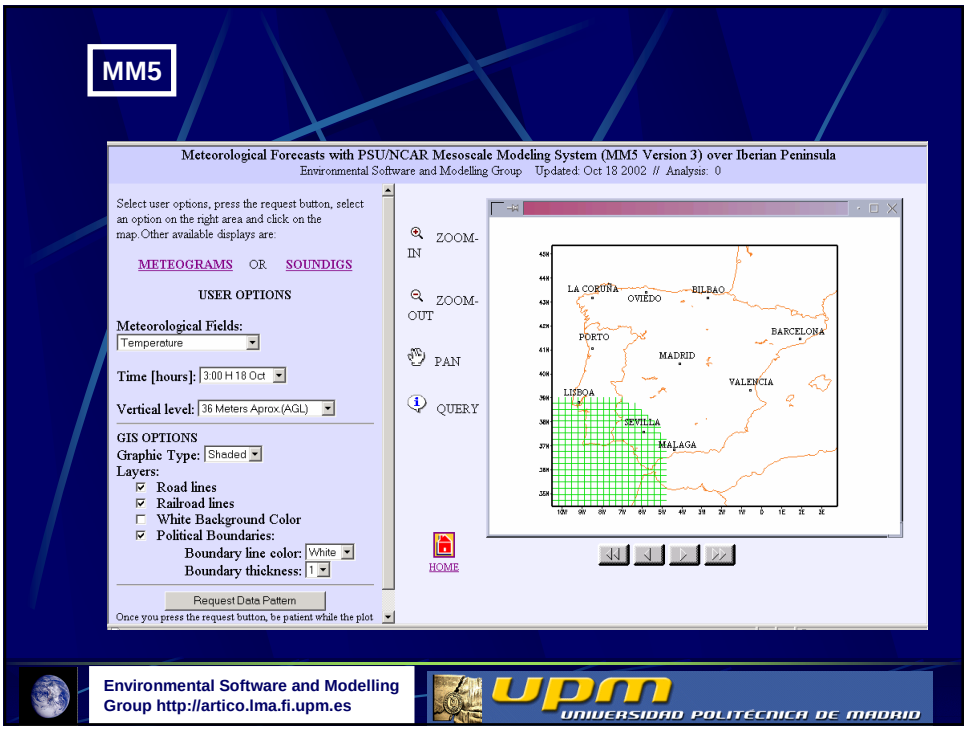
MM5
Meteorological Forecasts with PSU/NCAR Mesoscale Modeling System (MM5 Version 3) over Iberian Peninsula
Environmental Software and Modeling Group Updated: Oct 18 2002 // Analysis: 0
Select user options, press the request button, select an option on the right area and click on the map.Other available displays are:
METEOGRAMS OR SOUNDIGS
USER OPTIONS
Meteorological Fields:
Temperature
Time [hours]: 3:00 H 18 Oct
Vertical level: 36 Meters Aprox (AGL)
GIS OPTIONS
Graphic Type: Shaded
Layers:
Road lines
Railroad lines
White Background Color
Political Boundaries:
Boundary line color: White
Boundary thickness: 1
Request Data Pattern
Once you press the request button, be patient while the plot
ZOOM-IN
ZOOM-OUT
PAN
QUERY
HOME
LA CORUÑA
OVIEDO
BILBAO
PORTO
MADRID
BARCELONA
VALENCIA
LISBOA
SEVILLA
MALAGA
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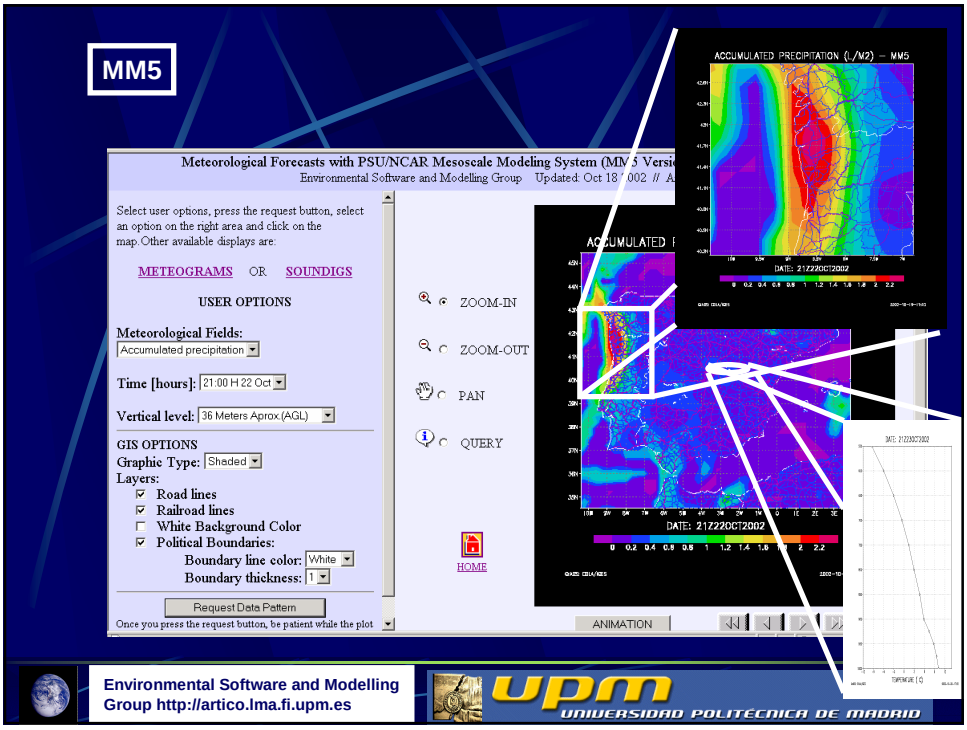
MM5
Meteorological Forecasts with PSU/NCAR Mesoscale Modeling System (MM5 Versi
Environmental Software and Modeling Group Updated: Oct 18 002 // A
Select user options, press the request button, select an option on the map.Other available displays are:
METEOGRAMS OR SOUNDIGS
USER OPTIONS
Meteorological Fields:
Accumulated precipitation
Time [hours]: 21:00 H 22 Oct
Vertical level: 36 Meters Aprox (AGL)
GIS OPTIONS
Graphic Type: Shaded
Layers:
Road lines
Railroad lines
White Background Color
Political Boundaries:
Boundary line color: White
Boundary thickness: 1
Request Data Pattern
Once you press the request button, be patient while the plot
ZOOM-IN
ZOOM-OUT
PAN
QUERY
HOME
ACCUMULATED PRECIPITATION (L/M2) — MM5
DATE: 21Z22OCT2002
ANIMATION
Environmental Software and Modeling Group http://artico.lma.fi.upm.es
upm
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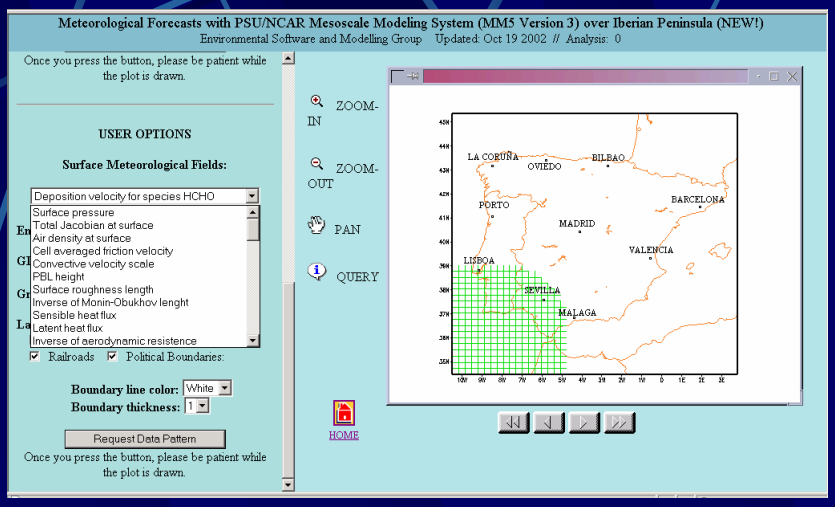
## MM5: MCIP

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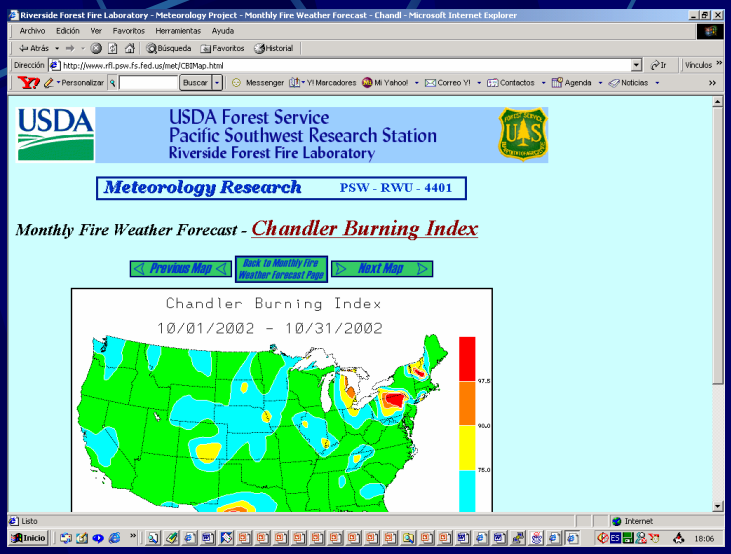
## Chandler Burning Index

http://www.rfl.psw.fs.fed.us/met/CBIMap.html

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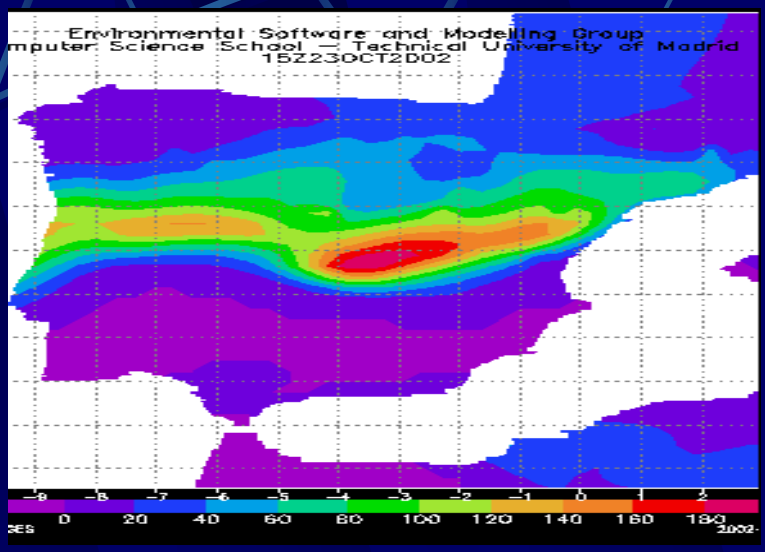
## Chandler Burning Index

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## APNEE EU – IST PROJECT 2000-01


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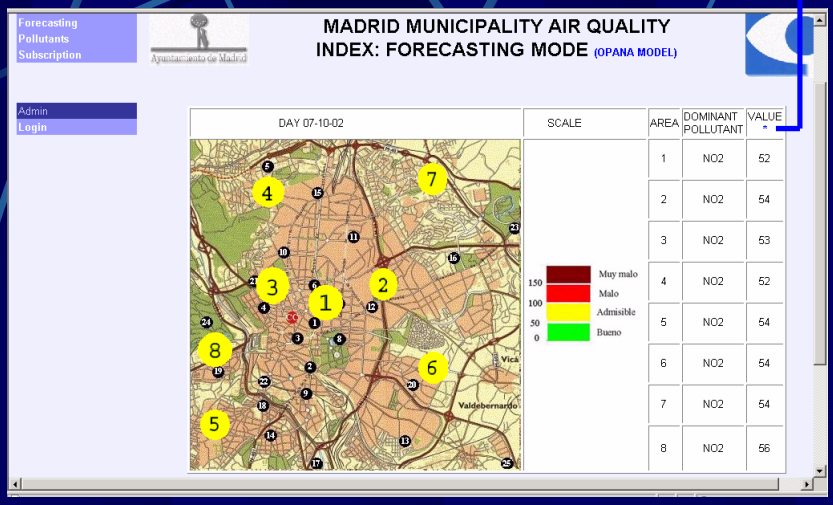
## APNEE EU – IST PROJECT 2000-01

**Adaptation of EU Directives to Spain**

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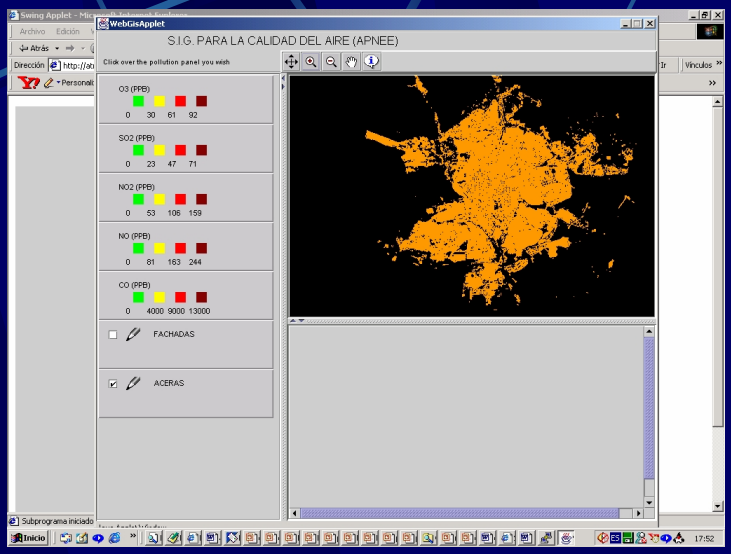
## APNEE EU – IST PROJECT 2000-01

**WEB/GIS (I)**

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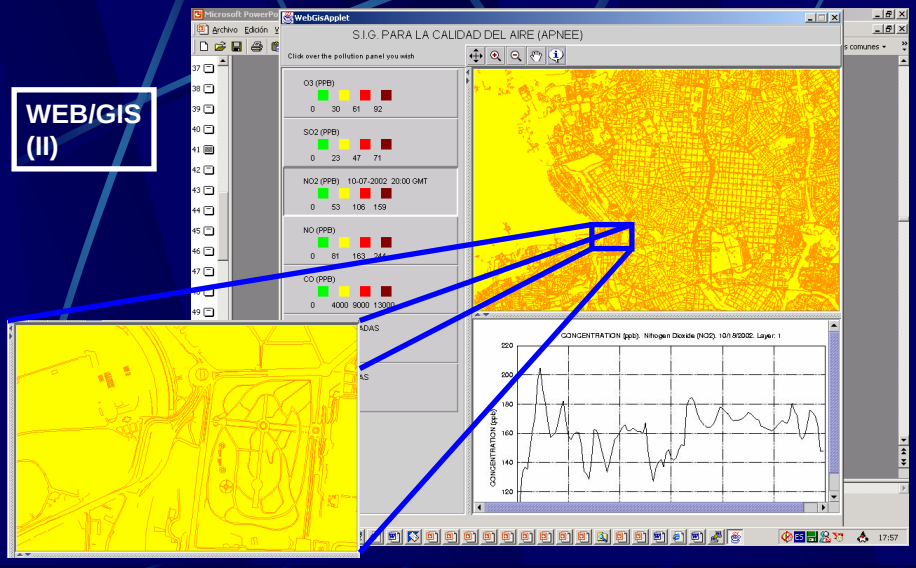
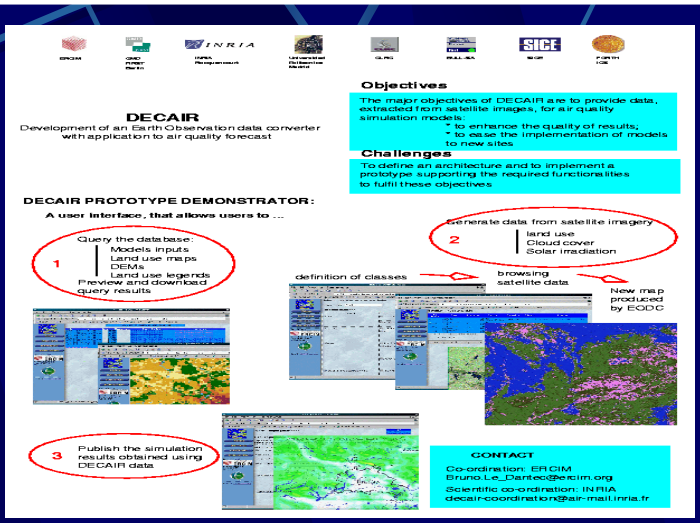
## APNEE EU – IST PROJECT 2000-01

**WEB/GIS (II)**





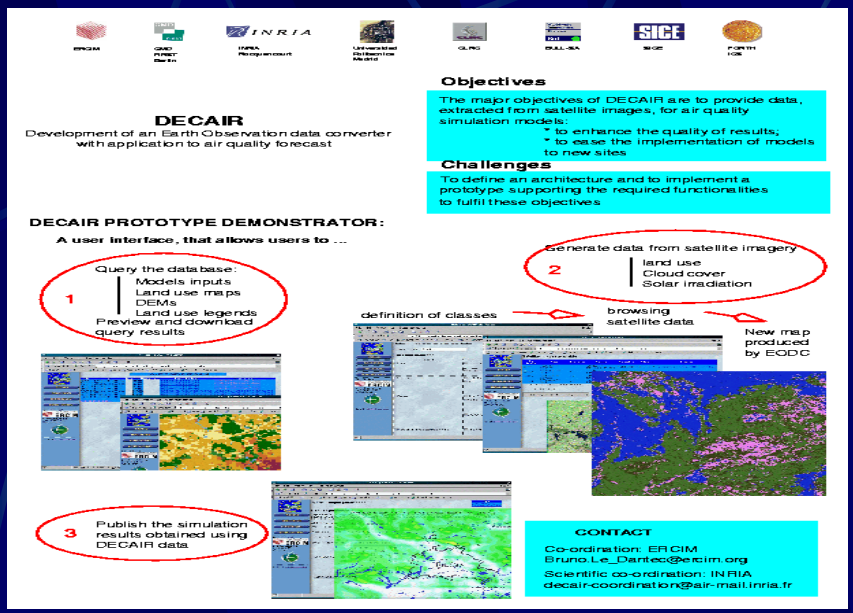

## DECAIR EU PROJECT: CEO (CENTRE FOR EARTH OBSERVATION) 2000-02



## OSCAR: OSTIMISED EXPERT SYSTEM FOR CONDUCTING ENVIRONMNTAL ASSESSMENT OF URBAN ROAD TRAFFIC (2002-2005)

(1) University of Hertfordshire ("The Coordinator")
(2) Westminster City Council
(3) TRL Ltd
(4) Finnish Meteorological Institute (FMI)
(5) Helsinki Metropolitan Area Council (YTV)
(6) Norwegian Institute for Air Research (NILU)
(7) Municipality of Oslo Department of Public Health (ODPH)
(8) National Centre for Scientific Research 'Demokritos' (NCSRD)
(9) Universidad Politecnica de Madrid (UPM)
(10) Sociedad Iberica de Construcciones Electricas S A (SICE)
(11) Netherlands Organisation for Applied Scientific Research (TNO)
(12) City of Utrecht



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## MM5-CMAQ MODELLING SYSTEM

**MM5-V3**
Meteorological modeling system

**EMIMO-V2**
Global emission modeling system

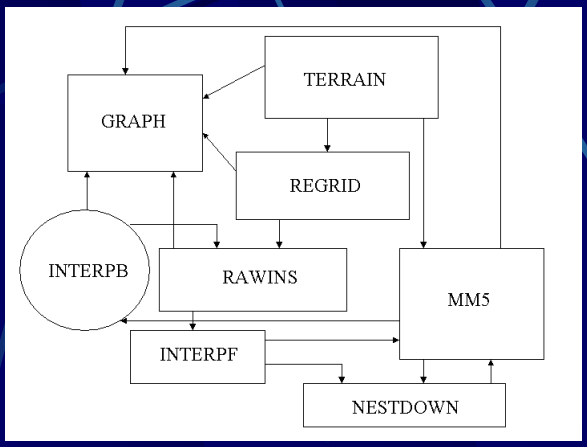
**EMIMA**
Local emission modeling system for Madrid

**CMAQ**
Community Multi-Scale Air Quality Modeling System

Visualization & Analysis system



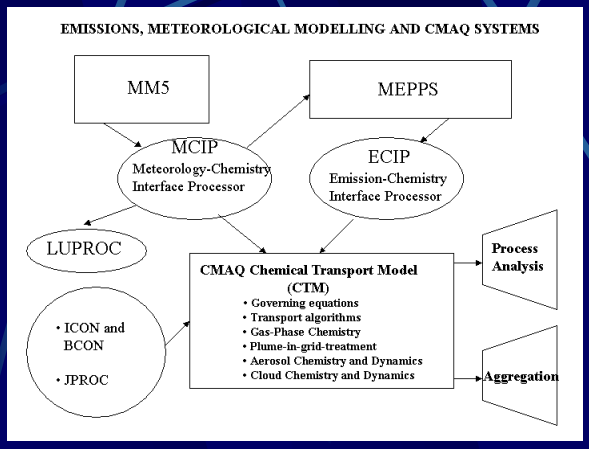
## THE MM5-CMAQ MODELLING SYSTEM




## THE MM5 MODEL

## THE MM5-CMAQ MODELLING SYSTEM

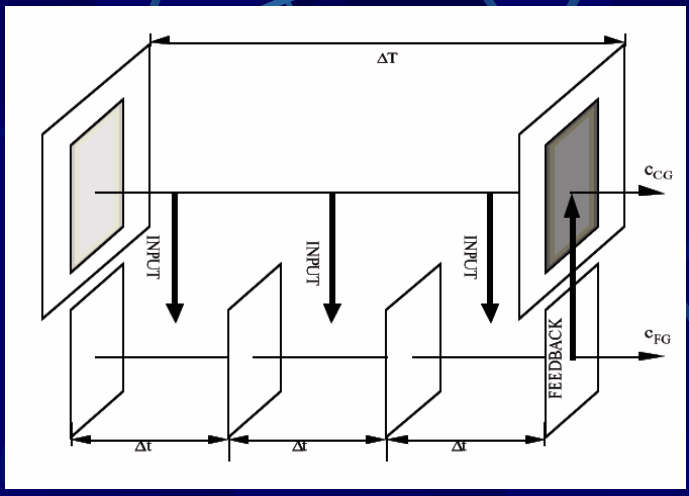
Models 3
EPA's Third Generation Air Quality Modeling System




THE CMAQ MODEL

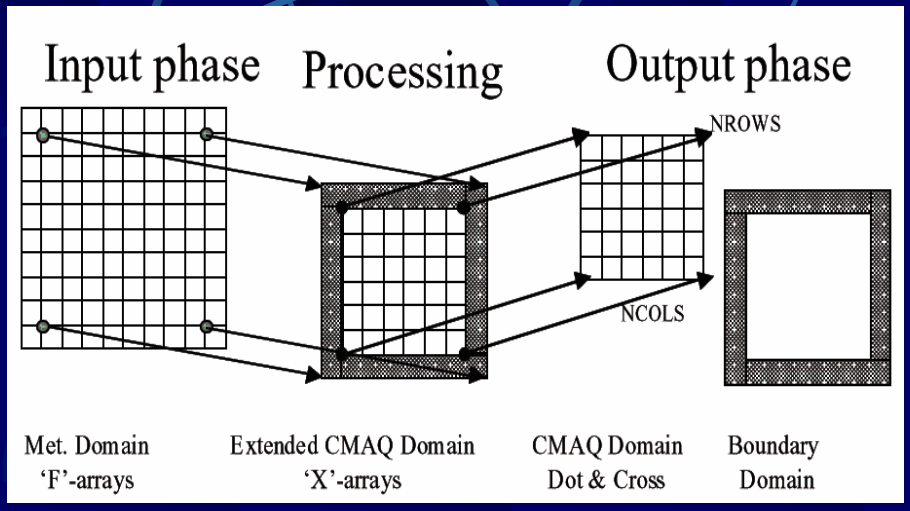


## THE CMAQ MODELLING SYSTEM: NESTING APPROACH



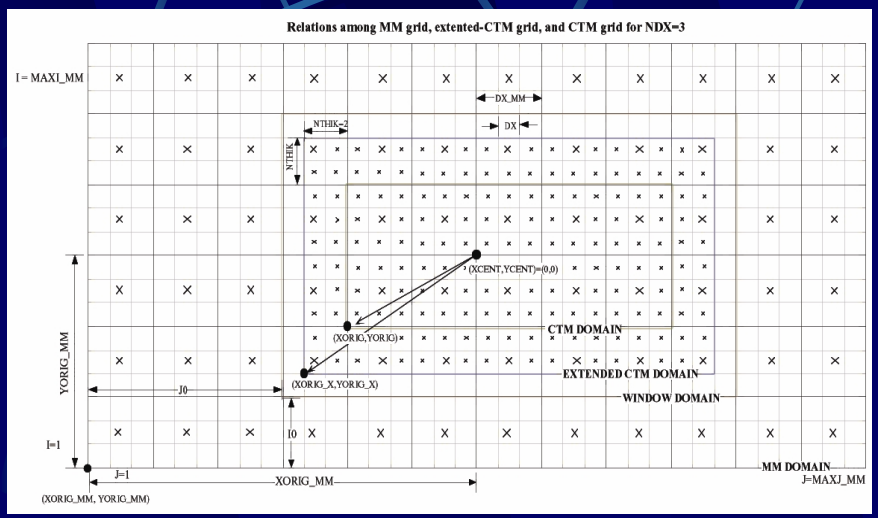

The static Nesting Approach in CMAQ

## THE CMAQ MODELLING SYSTEM: MM5-CMAQ LINKING



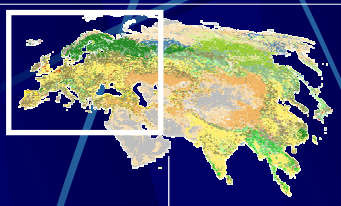



## THE CMAQ MODELLING SYSTEM: MM5-CMAQ LINKING



# LAND-USE DATA (I)

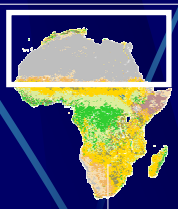
Eurasia Land Cover Characteristics Data Base Lambert Azimuthal Equal Area Projection



ARC/INFO

EURASIA-CMAQ-DOMAIN Lambert Conformal Conic

Africa Land Cover Characteristics Data Base Lambert Azimuthal Equal Area Projection



ARC/INFO

AFRICA-CMAQ-DOMAIN Lambert Conformal Conic



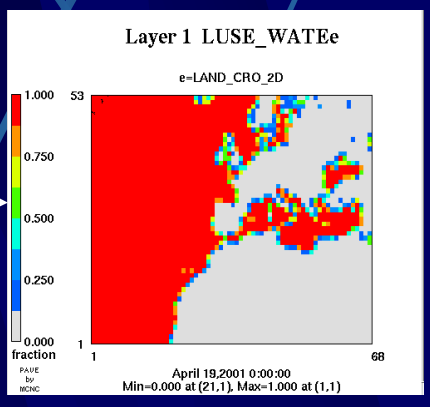
# LAND-USE DATA (III)

EURASIA-AFRICA-CMAQ-DOMAIN

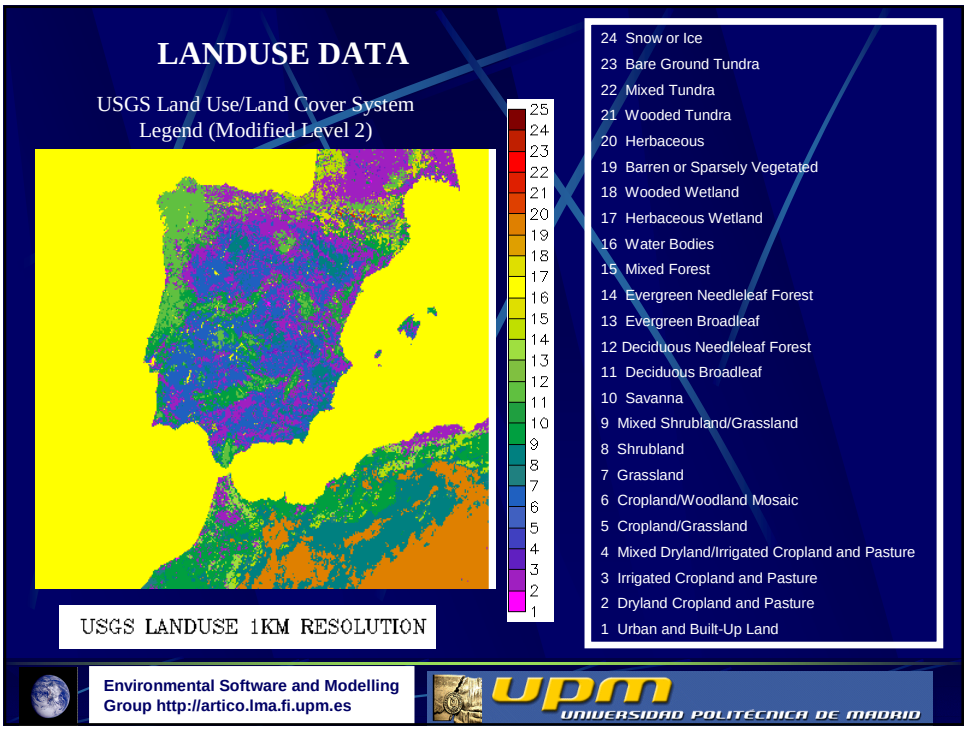
Lambert Conformal Conic.

Resolution = 4000m

LUPROC




Water Land-Use


LANDUSE DATA
USGS Land Use/Land Cover System
Legend (Modified Level 2)
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
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
Environmental Software and Modelling Group http://artico.lma.fi.upm.es
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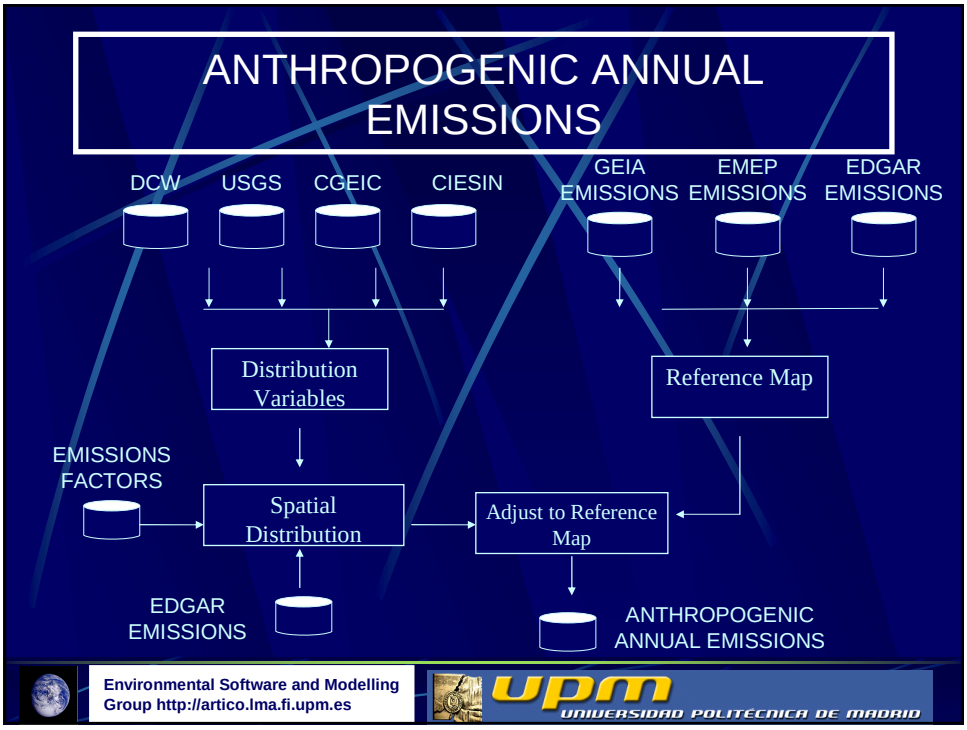
ANTHROPOGENIC ANNUAL EMISSIONS
DCW
USGS
CGEIC
CIESIN
GEIA EMISSIONS
EMEP EMISSIONS
EDGAR EMISSIONS
Distribution Variables
Reference Map
EMISSIONS FACTORS
Spatial Distribution
Adjust to Reference Map
EDGAR EMISSIONS
ANTHROPOGENIC ANNUAL EMISSIONS
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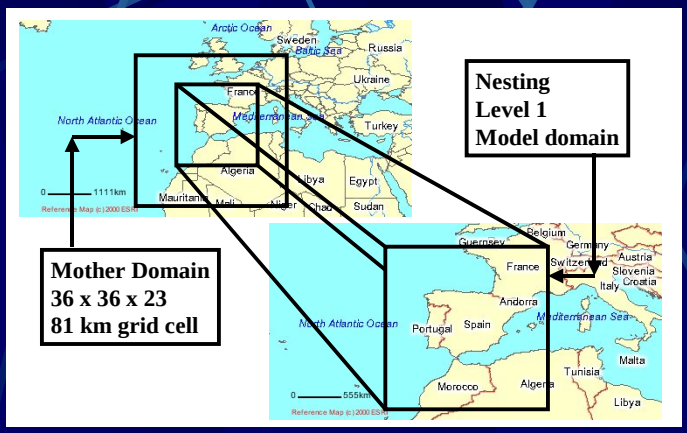
## THE MM5-CMAQ MODELLING SYSTEM




**Nesting Level 1:**

**69 x 66 cells**

**27 km Spatial resolution**



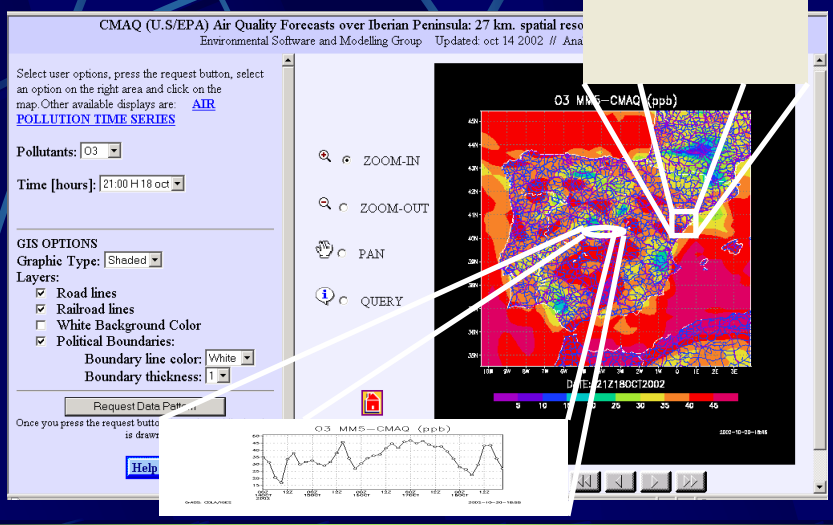
## THE MM5-CMAQ MODELLING SYSTEM

**Nesting level 2: 54 x 54 x 23 (9 km)**

**Nesting level 3: 33 x 39 x 23 (3 km)**

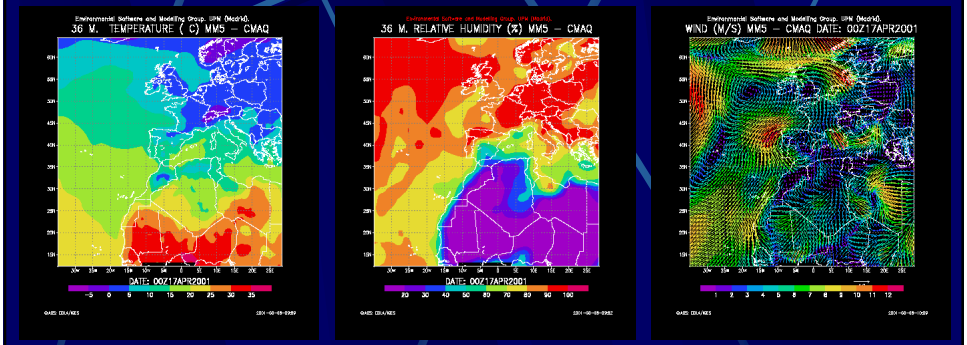

**MM5-CMAQ Process Analysis**

## MM5-CMAQ (INTERNET)

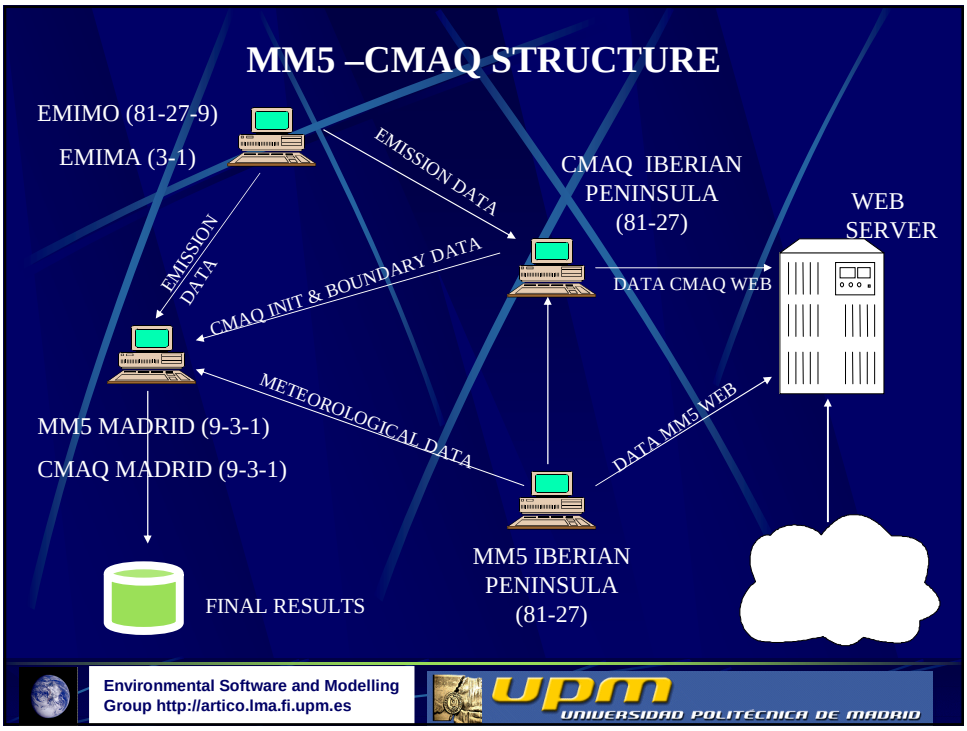





## THE MM5-CMAQ SYSTEM




**Temperature, relative humidity and surface winds produced by MM5 at 0Z, April, 17, 2001 (32 m above Sea level)**


MM5 –CMAQ STRUCTURE
EMIMO (81-27-9)
EMIMA (3-1)
EMISSION DATA
CMAQ IBERIAN PENINSULA (81-27)
WEB SERVER
EMISSION DATA
CMAQ INIT & BOUNDARY DATA
DATA CMAQ WEB
METEOROLOGICAL DATA
DATA MM5 WEB
MM5 MADRID (9-3-1)
CMAQ MADRID (9-3-1)
FINAL RESULTS
MM5 IBERIAN PENINSULA (81-27)
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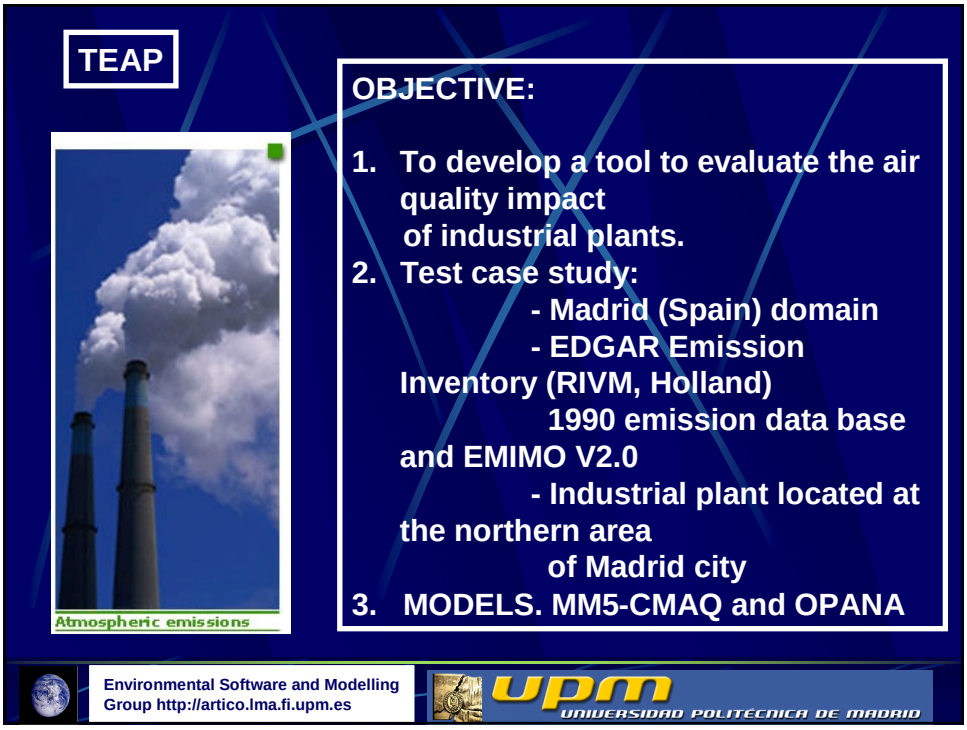
TEAP
OBJECTIVE:
1. To develop a tool to evaluate the air quality impact of industrial plants.
2. Test case study:
- Madrid (Spain) domain
- EDGAR Emission Inventory (RIVM, Holland) 1990 emission data base and EMIMO V2.0
- Industrial plant located at the northern area of Madrid city
3. MODELS. MM5-CMAQ and OPANA
Atmospheric emissions
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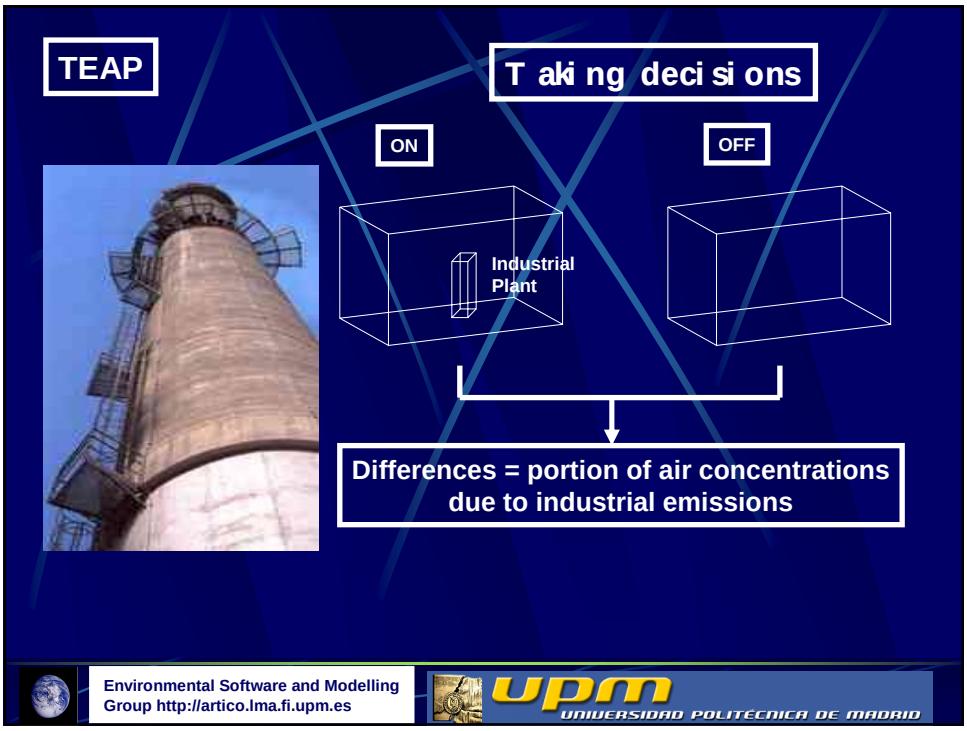
TEAP
T aki ng deci si ons
ON
OFF
Industrial Plant
Differences = portion of air concentrations due to industrial emissions
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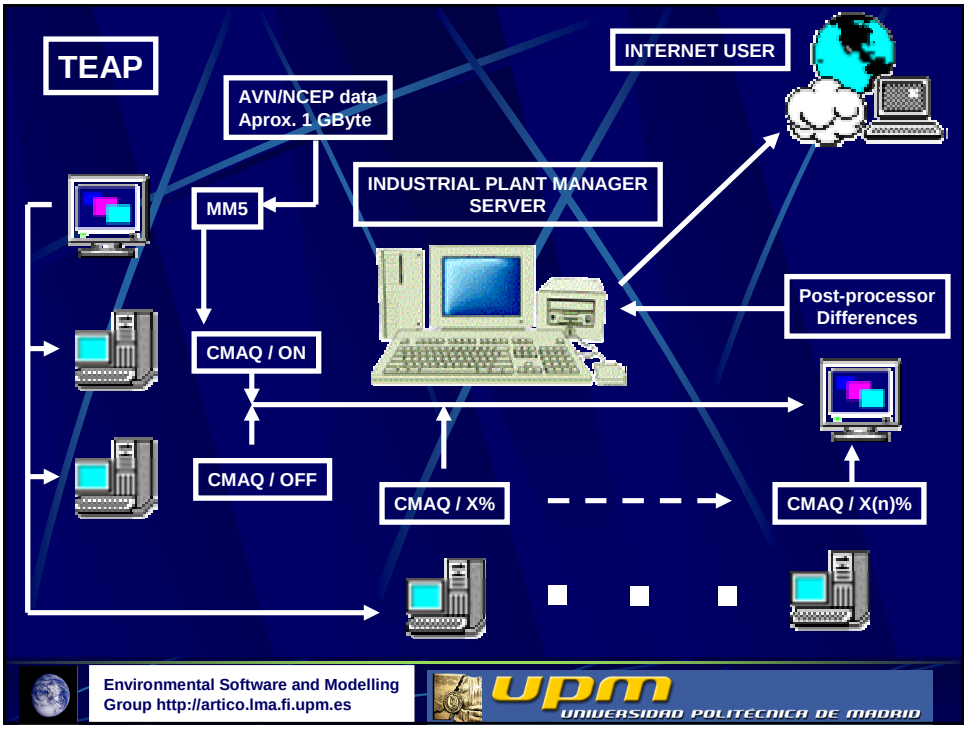
TEAP
INTERNET USER
AVN/NCEP data
Aprox. 1 GByte
MM5
INDUSTRIAL PLANT MANAGER SERVER
Post-processor Differences
CMAQ / ON
CMAQ / OFF
CMAQ / X%
CMAQ / X(n)%
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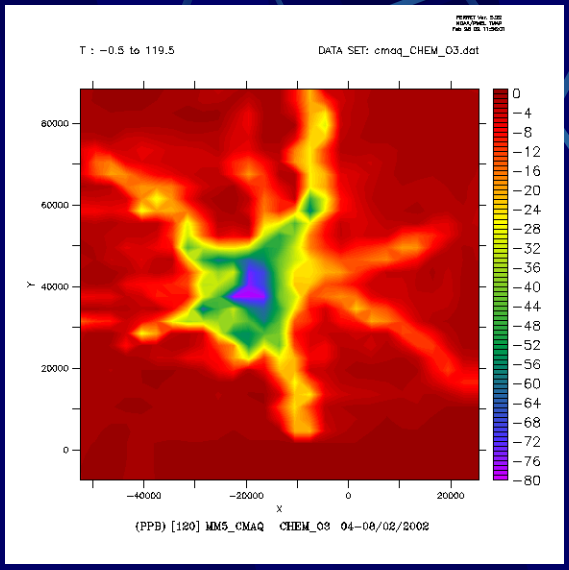
## MM5-CMAQ PROCESS ANALYSIS




**MM5-CMAQ PROCESS ANALYSIS:**

**FEBRUARY, 4-8, 2002**

**MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)**

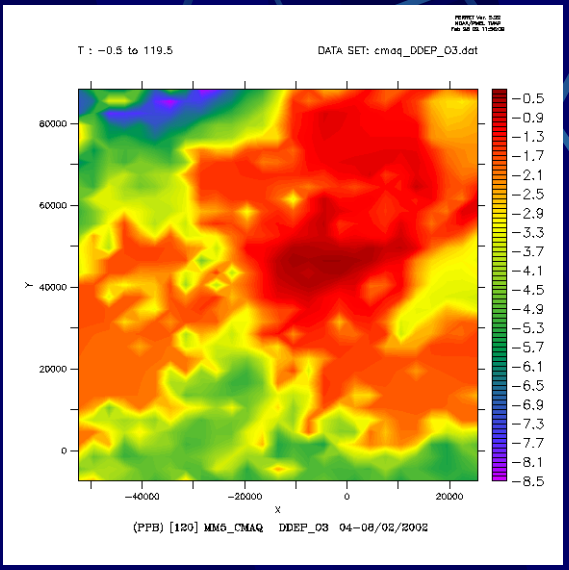
**AVERAGE OVER 120 HOURS**

**CHEMICAL PROCESS ON O3 FORMATION**

**CHANGE IN OZONE CONCENTRATIONS CAUSED BY CHEMICAL PROCESSES**



## MM5-CMAQ PROCESS ANALYSIS




**MM5-CMAQ PROCESS ANALYSIS:**

**FEBRUARY, 4-8, 2002**

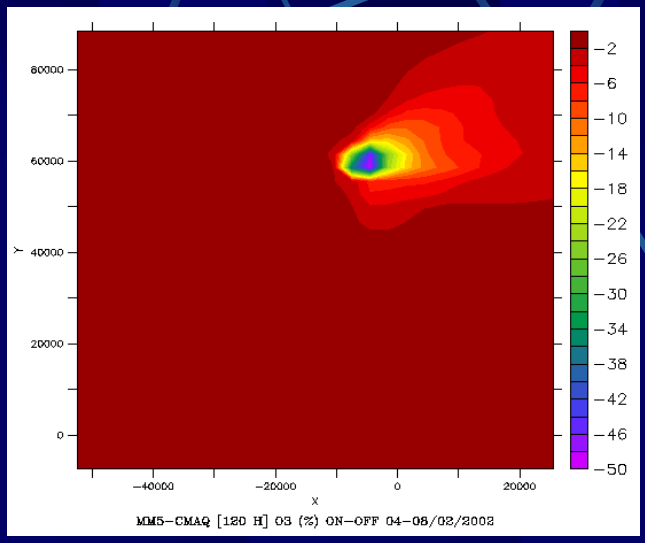
**MADRID, NESTING LEVEL 3 (3 KM SPATIAL RESOLUTION)**

**AVERAGE OVER 120 HOURS**

**DRY DEPOSITION PROCESS ON O3 FORMATION**

**CHANGE IN O3 CONCENTRATIONS CAUSED BY DRY DEPOSITION**

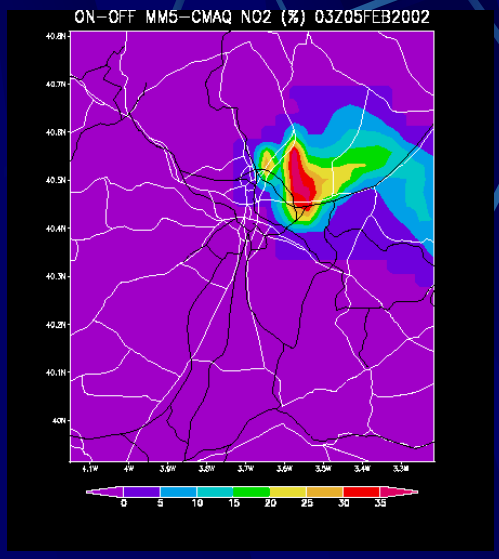
## TEAP




**120 hour average for the differences between simulation with industrial plant (ON) and simulation without the industrial plant (OFF) with the MM5-CMAQ model**

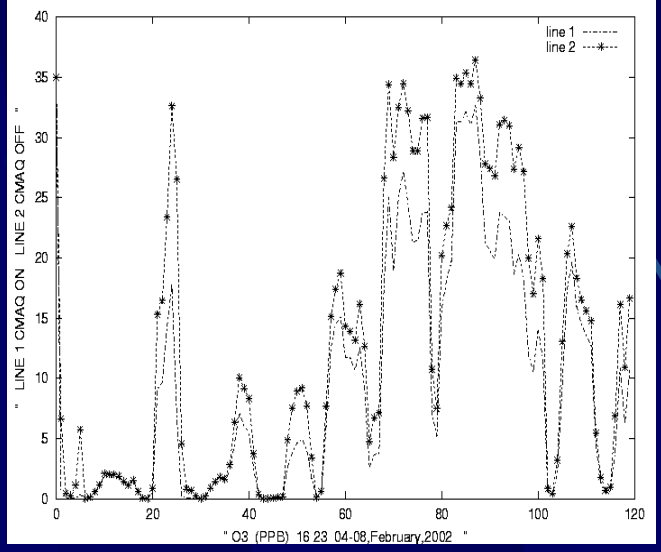


## TEAP




**NO2 percentage impact by the industrial source at 03h00 on February, 5, 2002 with MM5-CMAQ modelling system over the Madrid domain**

TEAP




**MM5-CMAQ Ozone concentrations at industrial plant cell (3 km) with and without industrial emissions**

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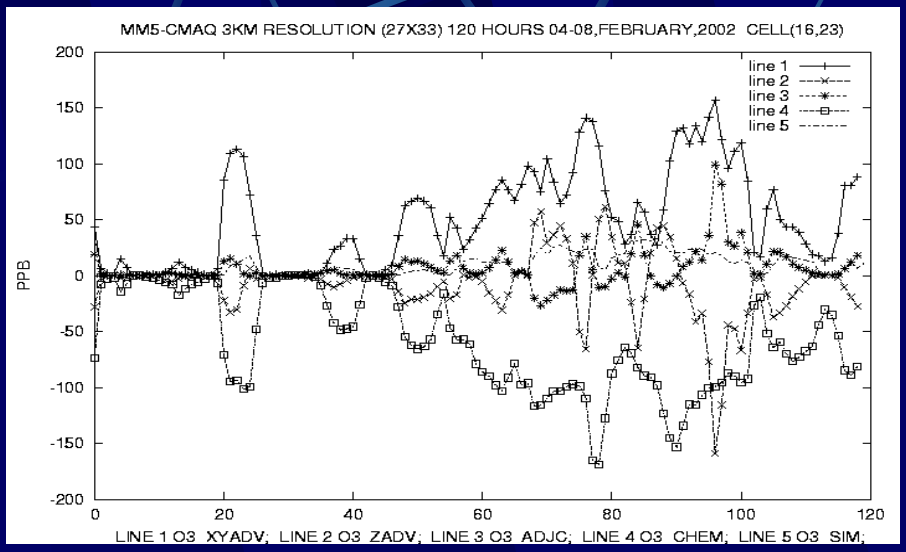


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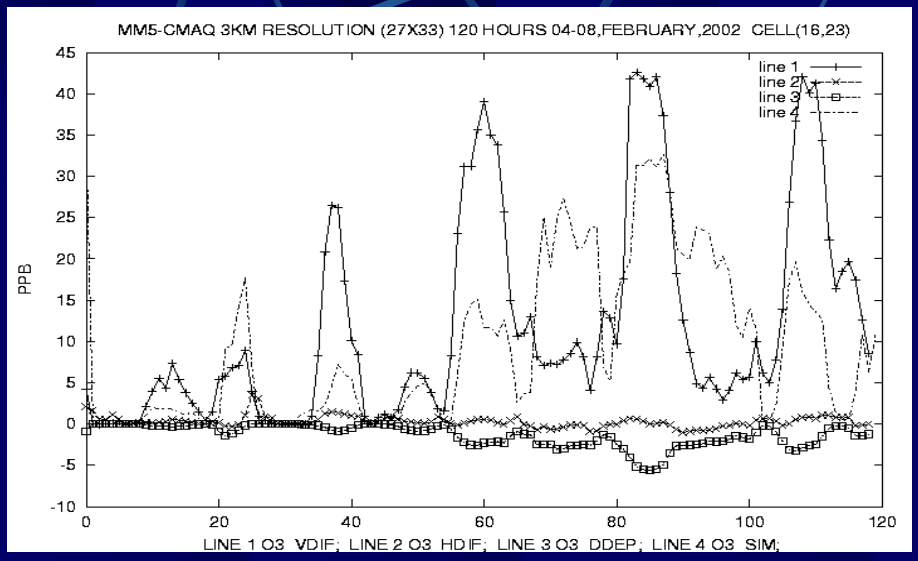


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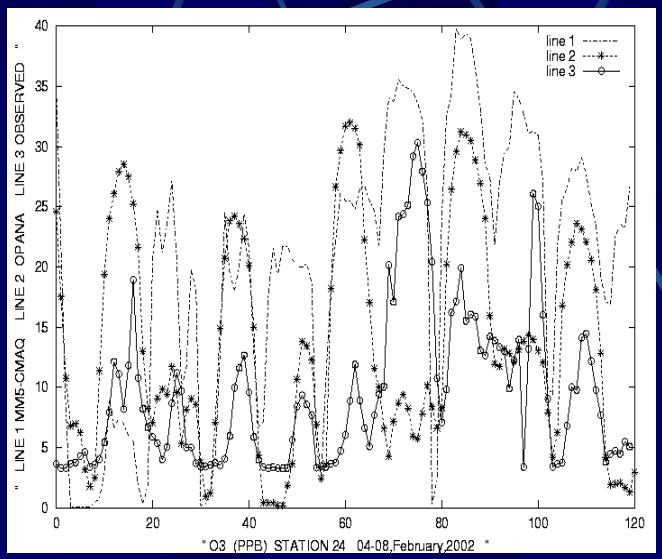


**OPANA, MM5-CMAQ and observed Ozone concentrations at Casa de Campo monitoring station**

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