16th Annual International Emission Inventory Conference

Emission Inventories: "Integration, Analysis, and Communications"

Raleigh. May 15, 2007

Integrated assessment modeling in Spain

R. Borge, J. Lumbreras, E. Rodríguez

UNIVERSIDAD POLITÉCNICA DE MADRID

Department of Chemical and Environmental Engineering

INTRODUCTION

EMISSION PREPARATION FOR MODELING

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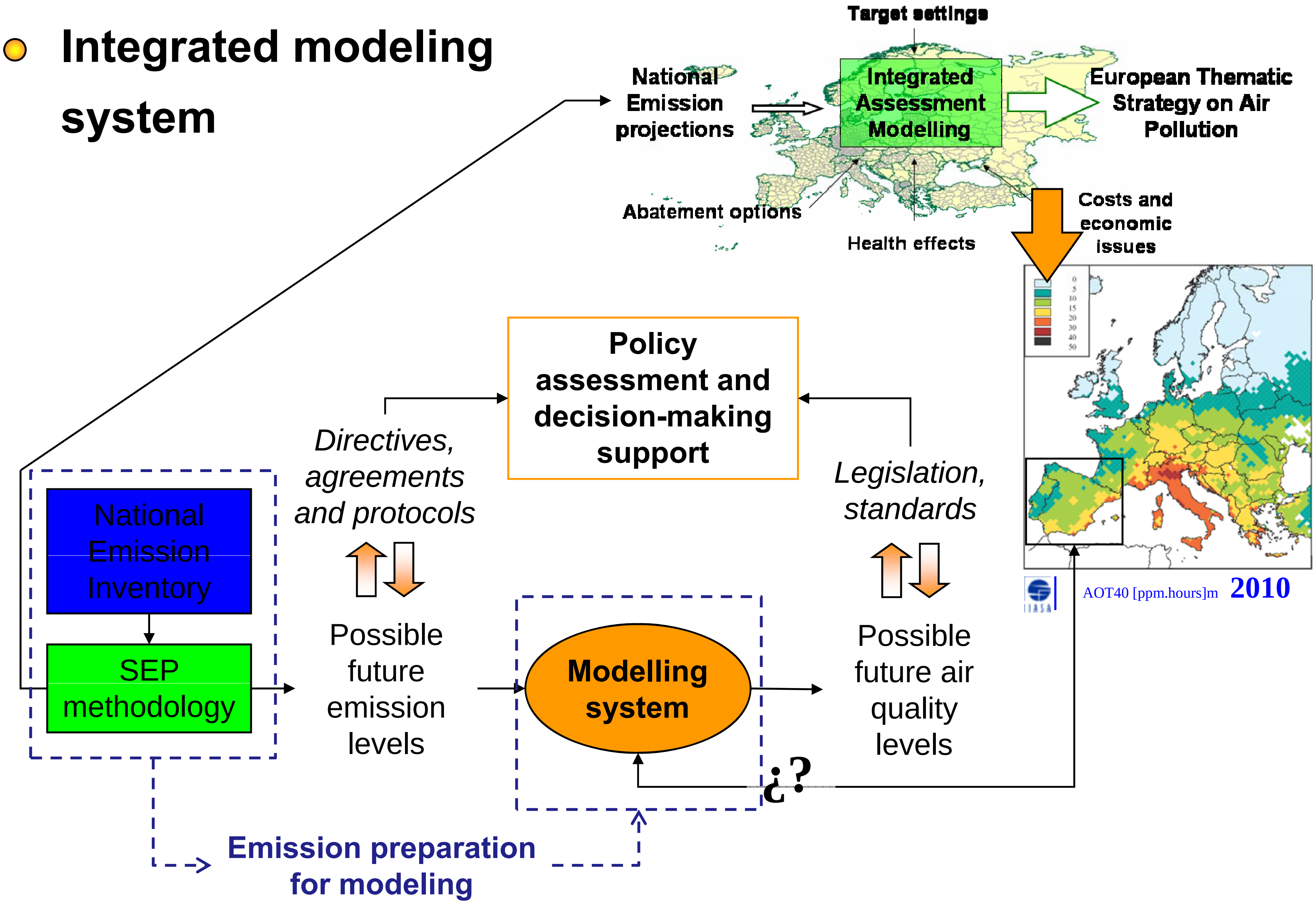
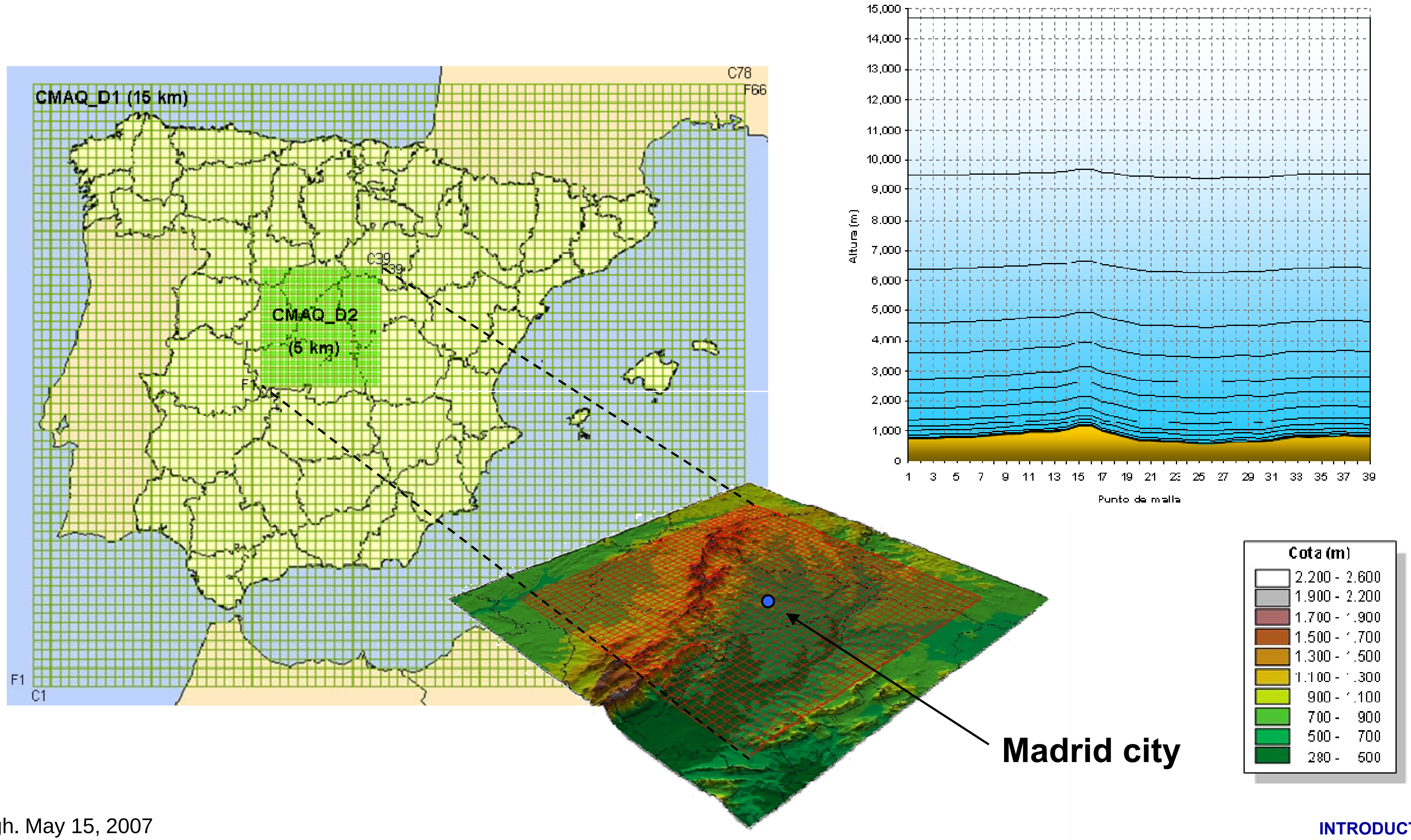
- **Integrated modeling system**



- Assessment and comparison of environmental policies and control strategies
- Based on national projections from the Spain's Emission Projection (SEP) project, funded by the Spanish Ministry of Environment
- Still a work in progress (SIMCA project)
- Some results for tropospheric ozone simulations over the Grater Madrid Area (2010)

- Two nested domains (15 and 5 km resolution)
- Meteorology from MM5 (25 vertical levels)



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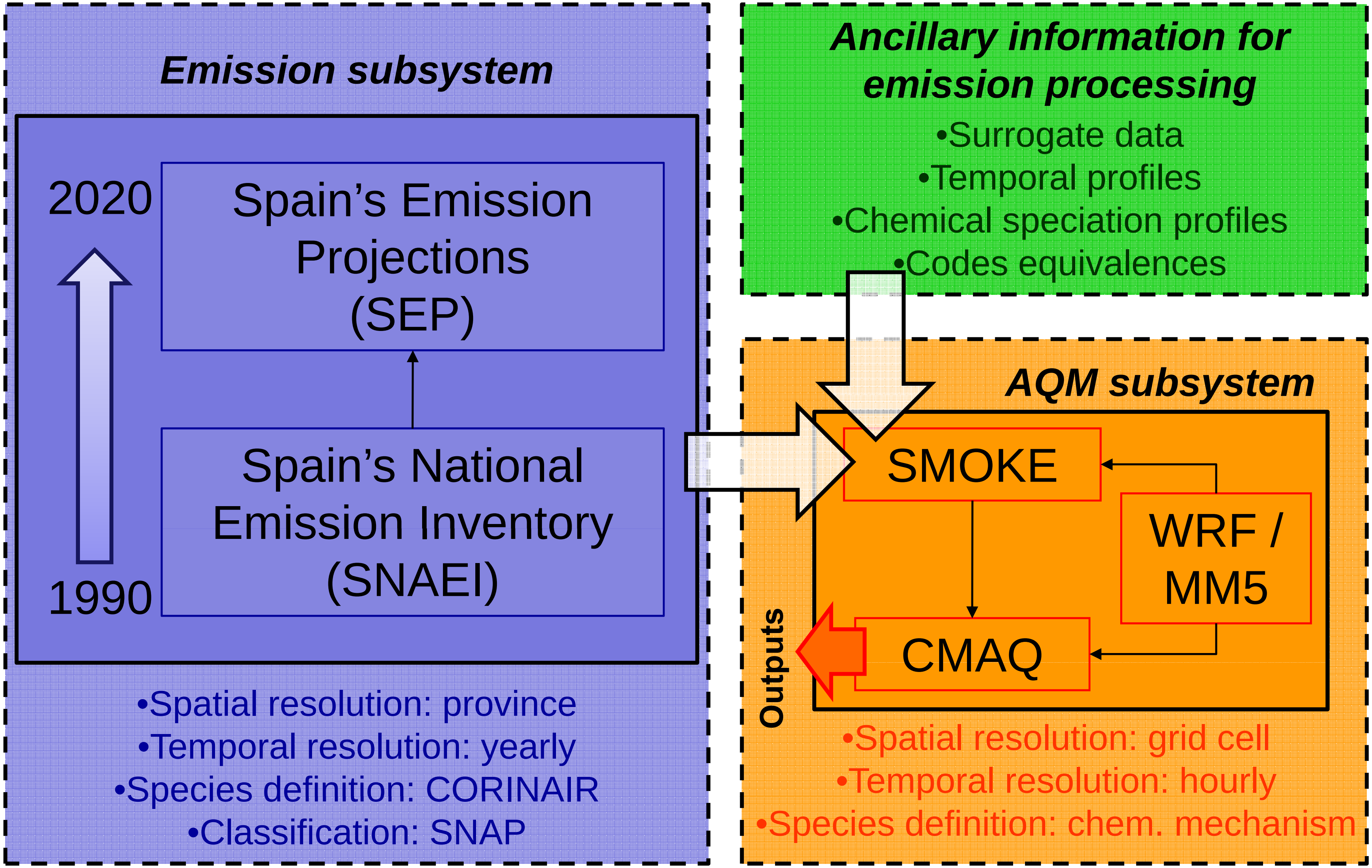
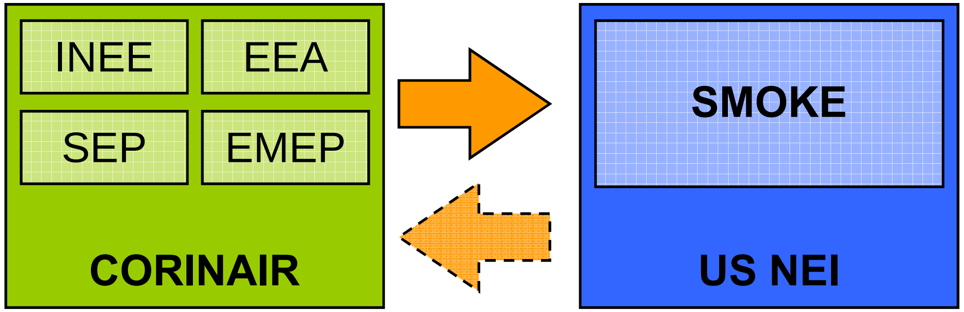
System's major components

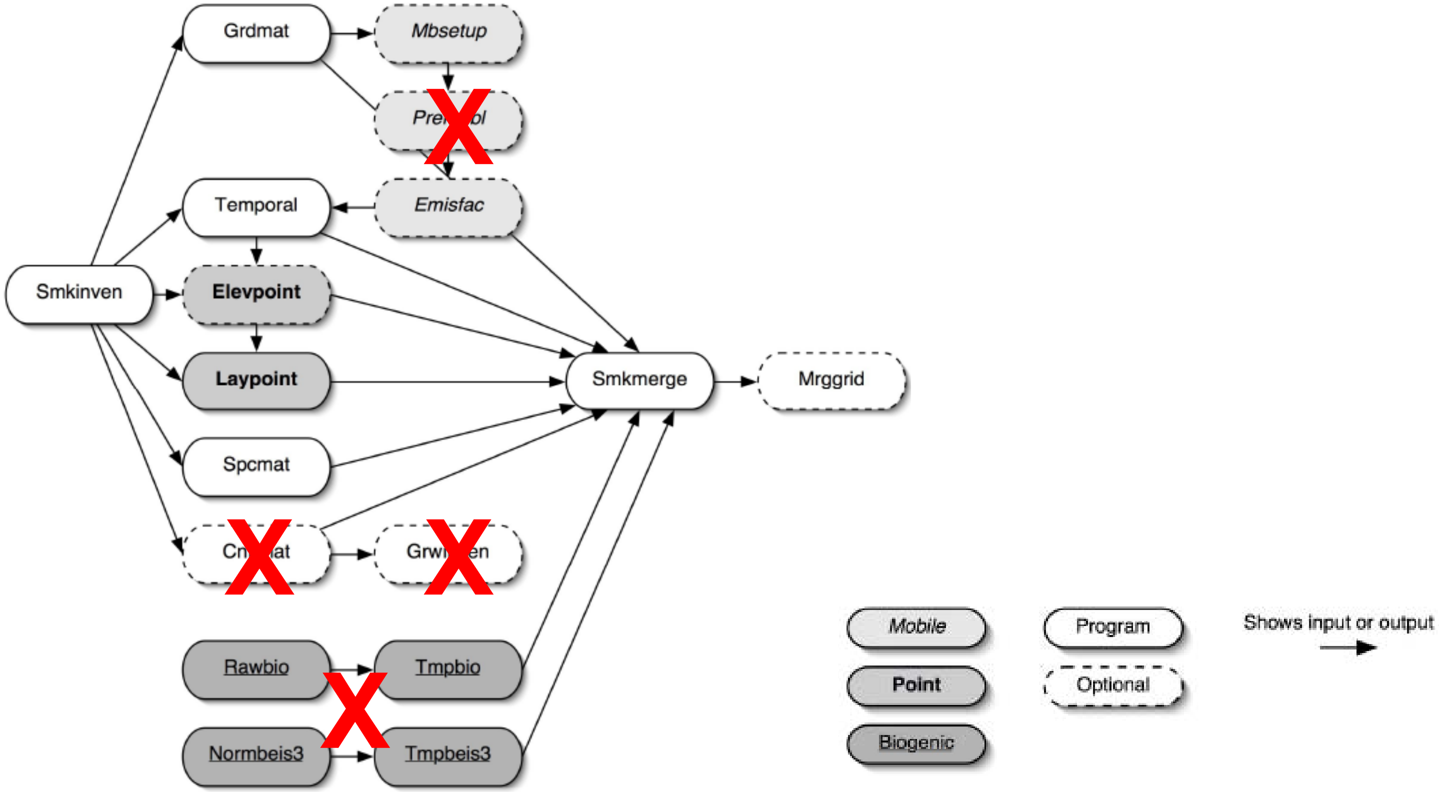


SMOKE approach

- SMOKE is designed to process US emissions in the framework of the US National Emission Inventory
- However, it is flexible enough to process any other emission data. The most important constraint is the information availability (emissions, ancillary data)
- More than modifying the model, this approach is based on the development of an interface between the US NEI and EU CORINAIR data and procedures



- In order to guarantee consistency with CORINAIR methods, SMOKE has been used only for emission processing



- Emission projections have been supplied as independent inventories

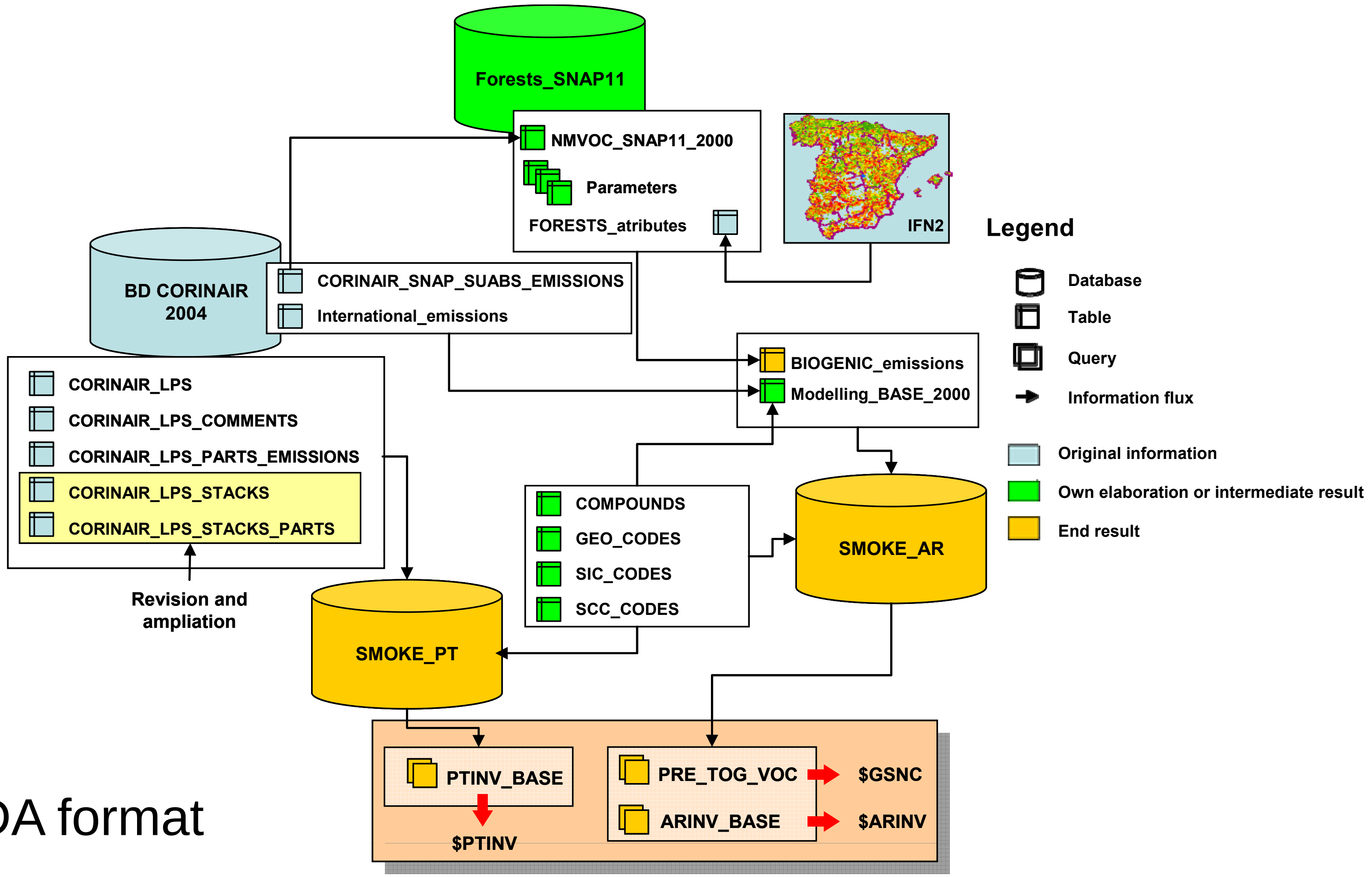
Source types

- Only two types:
  - "point sources": all the LPS according to the CORINAIR methodology and any other source included in the Spain's CORINAIR DB (e.g. SNAP 030103 "*Combustion industrial combustion plants < 50 MW (boilers)*")

    (group + subgroup + activity + 2-digit code)
  - "area sources": all activities typically labelled as area sources (agriculture, residential combustion) plus all types of mobile sources (on and off road) and biogenic sources

    (group + subgroup + activity + 4-digit code)

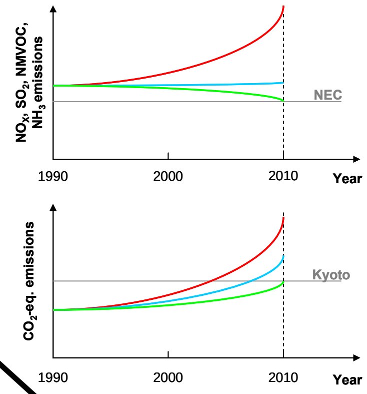
Inventory files



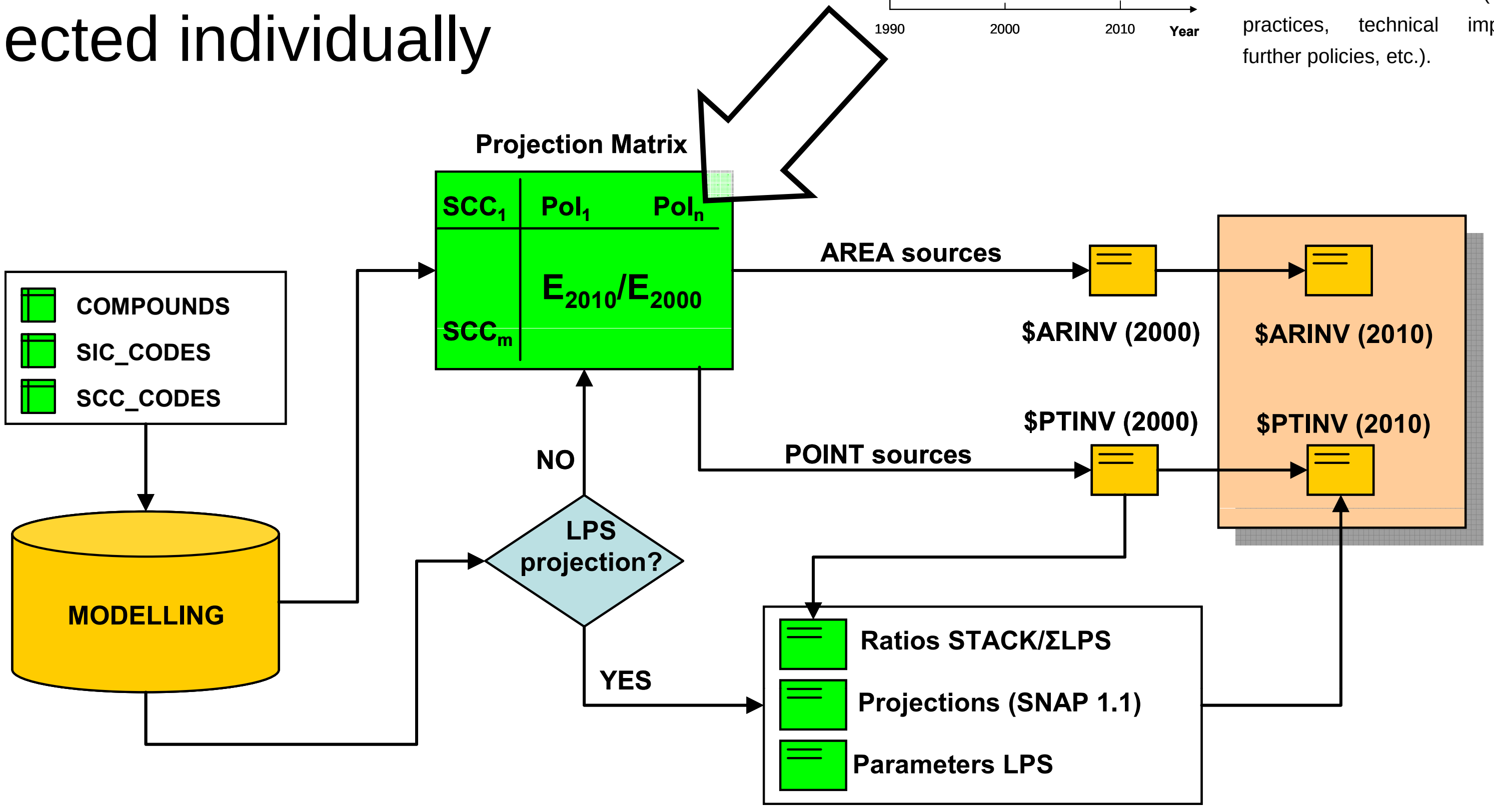
- IDA format

Inventory files (emission projections)

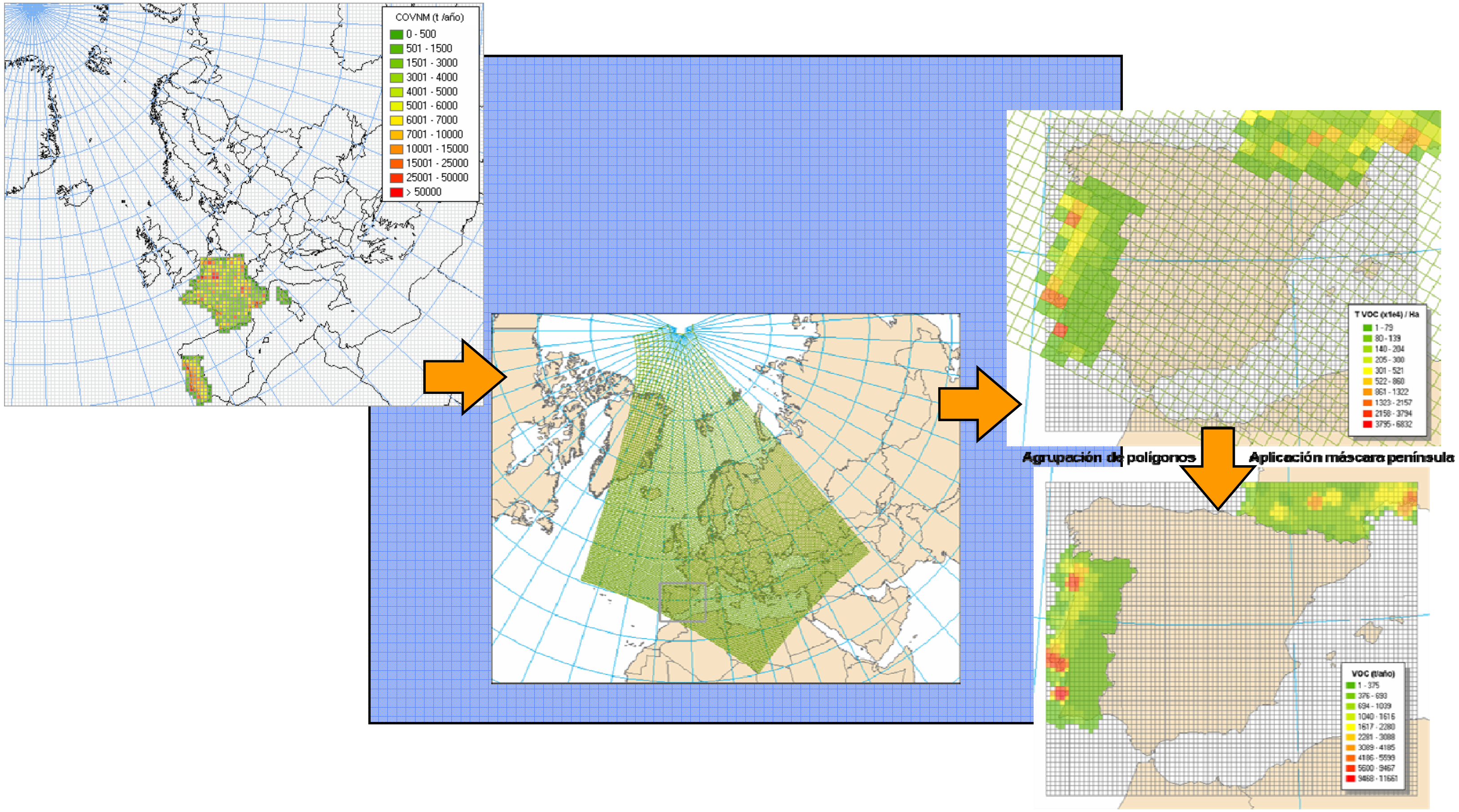
- Projection ratios from SEP (SNAP-3 level)
- Some point sources projected individually



- **Business As Usual (Tendencial):** reference scenario without any measure taking into account the past emission trends.
- **Baseline (Base):** the more likely future situation considering the enacted legislation and adopted plans, measures and policies.
- **Target (Objetivo):** the environmental objectives are reached through additional measures (e.g. good practices, technical improvements, further policies, etc.).



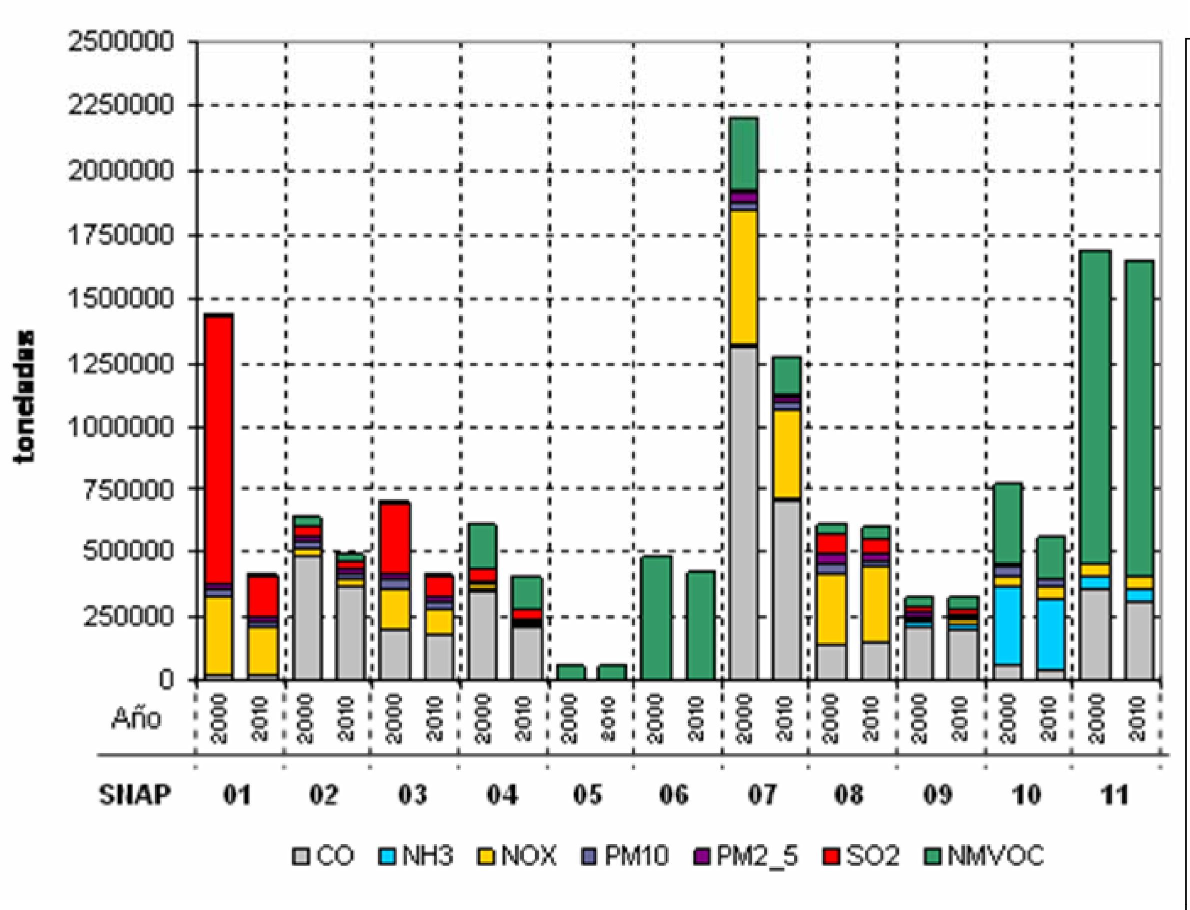
International emissions



- Past and future emissions outside Spain are taken from EMEP 50x50 km gridded estimates

- Emissions for the case study:

SNAEI 2000 Vs SEP 2010 (Baseline scenario)



- **Group 01** Combustion in energy and transformation industries
- **Group 02** Non-industrial combustion plants
- **Group 03** Combustion in manufacturing industry
- **Group 04** Production Processes
- **Group 05** Extraction and distribution of fossil fuels and geothermal energy
- **Group 06** Solvent and other product use
- **Group 07** Road transport
- **Group 08** Other mobile sources and machinery
- **Group 09** Waste treatment and disposal
- **Group 10** Agriculture
- **Group 11** Other sources and sinks (Nature)

emissions for modelling by SNAP group (tonnes)

Chemical speciation

- NMVOC, NO_X and $PM_{2.5}$ emissions have been broken down into CB-4 mechanism species (*CB4_AE3_AQ*)

- The SNEI does not include information regarding chemical speciation

- SNAP3-level chemical profiles have been generated from EMEP/CORINAIR guidebook and EPA references

  – 87 VOC chemical profiles

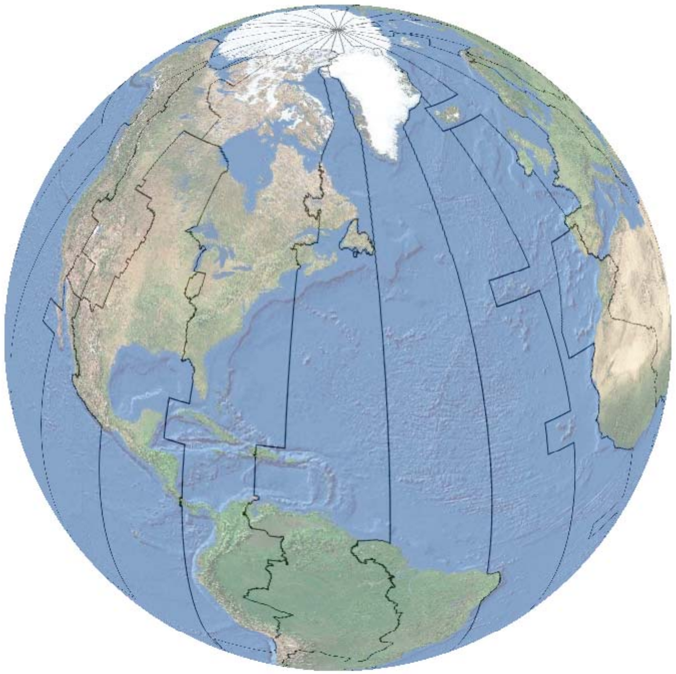
  – 54 PM2.5 chemical profiles

- VOC/TOG ratios for inventory species conversion for each SNAP activity must be provided ($GSCNV file)

Temporal allocation

- Hourly emissions allocation has been performed through SNAP3-level temporal profiles
  - 208 monthly profiles
  - 48 weekly profiles
  - 212 diurnal profiles (with different allocation patterns for weekdays and weekends)
- Domain-specific holidays calendar have been provided. Those days are processed as if they were a Sunday
- For some activities, province and/or pollutant-specific profiles have been developed

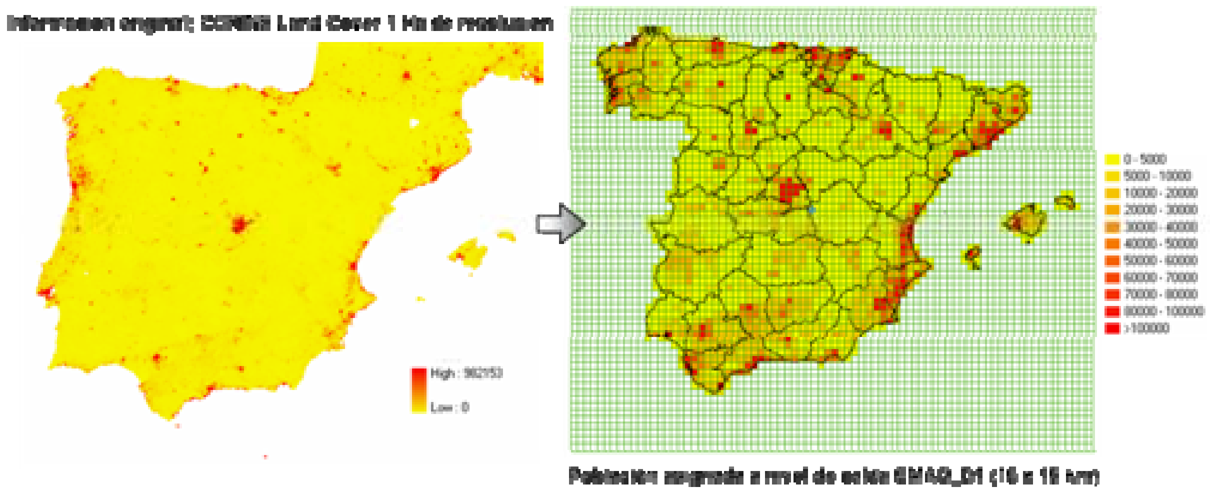
- Information to construct representative temporal profiles taken from official statistics, EIs, EMEP/CORINAIR guidebook, EPA, etc.
- Output files are referred to GMT=UTC ($OUTZONE=0), since this is what CMAQ expects
- All temporal inputs consider GMT as local time (SMOKE is not intended to operate in the east hemisphere; GMT+)



- SMOKE (I/O API 2.2) does not support daylight saving time in European regions

Spatial allocation

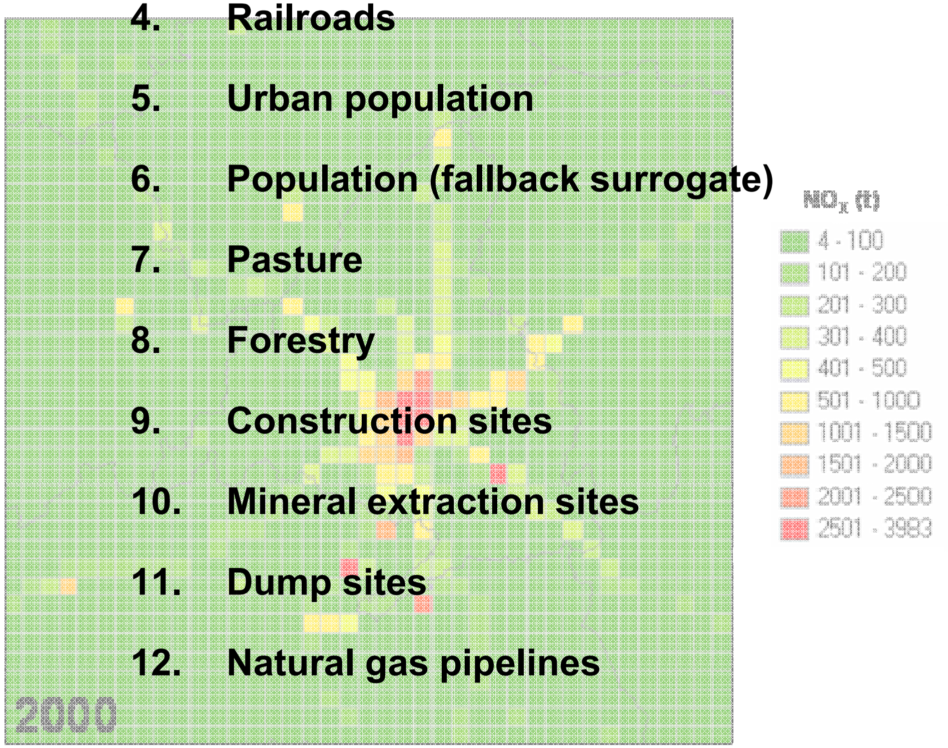
- Area source emissions are allocated to the grid cells by means of spatial surrogates
- The generation of these spatial ratios is based on the best information available regarding population distribution, land-use (CORINE land cover 2000), transport infrastructure, etc.

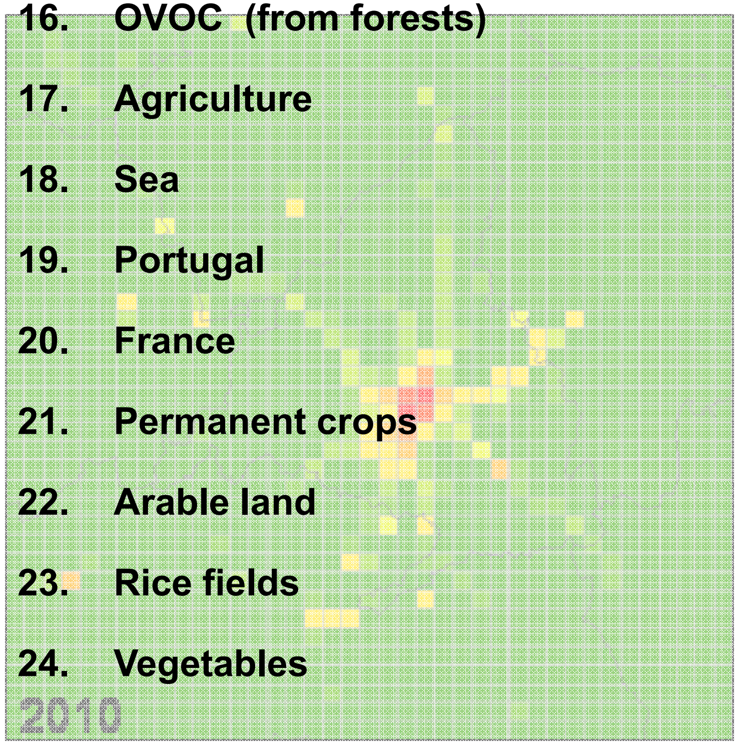


Surrogate example (CMAQ_D1): population

- Spatial surrogates generated (for both, 15 and 5 km domains where applicable):

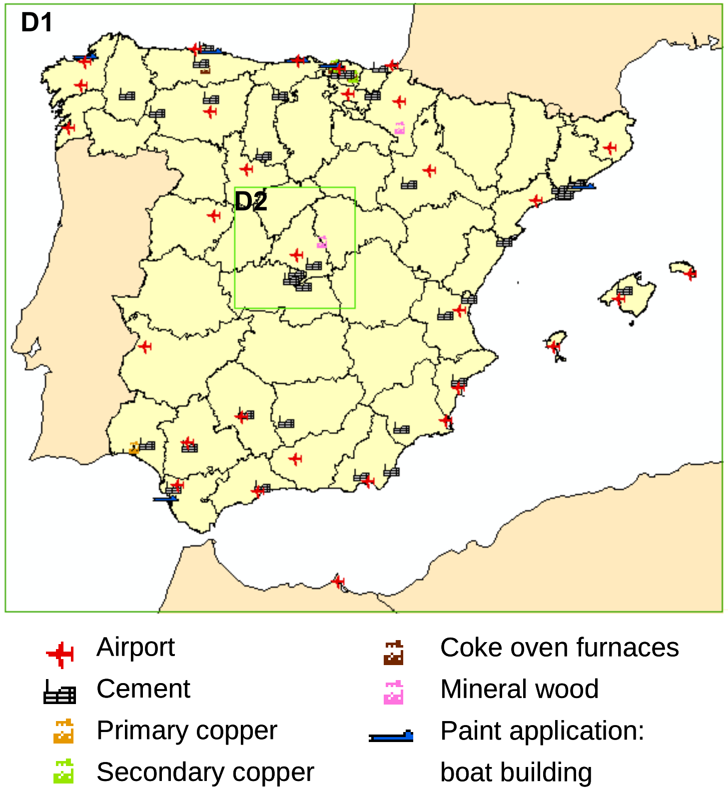
1. **Highways**
2. **Rural roads**
3. **Industrial and commercial units**
4. **Railroads**
5. **Urban population**
6. **Population (fallback surrogate)**
7. **Pasture**
8. **Forestry**
9. **Construction sites**
10. **Mineral extraction sites**
11. **Dump sites**
12. **Natural gas pipelines**
13. **Petroleum pipeline**
14. **ISOP (from forests)**
15. **MONO (from forests)**
16. **OVOC (from forests)**
17. **Agriculture**
18. **Sea**
19. **Portugal**
20. **France**
21. **Permanent crops**
22. **Arable land**
23. **Rice fields**
24. **Vegetables**



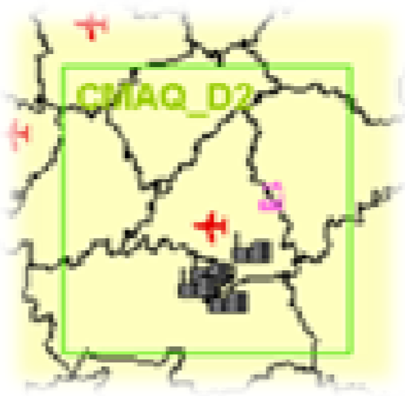


- Area-to-point algorithm (area sources spatially allocated by user-defined coordinates):
  - coke oven furnaces
  - primary and secondary copper production
  - ! cement
  - mineral wool
  - paint application: boat building
  - airport traffic (LTO cycles<1000m)

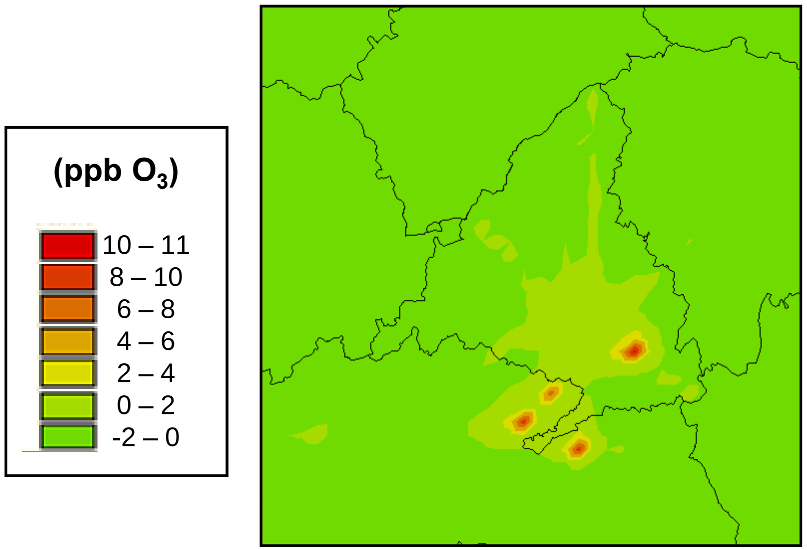
30 airports and 54 industrial facilities

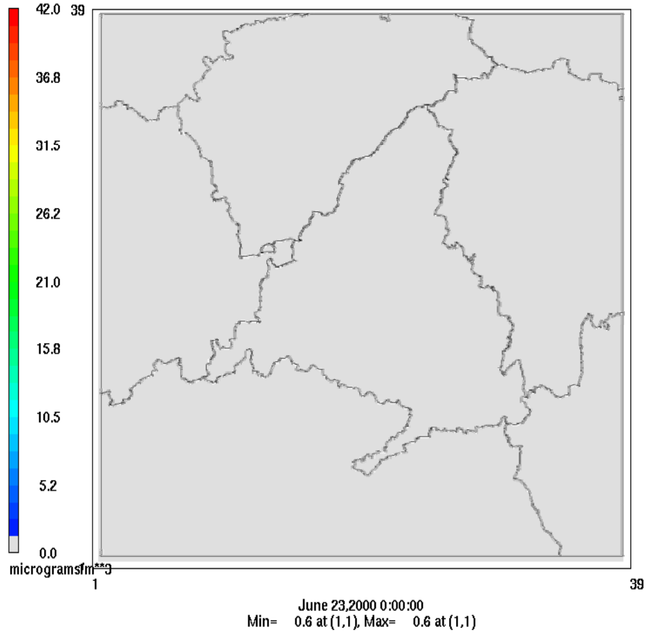


The location of many EU-15 industrial plants can be found in the European Pollutant Emission Register, EPER (http://www.eper.cec.eu.int/eper/)



- Cement plants are large emitters of NO_X and PM and should be included in the point source inventory





2010 – 2000 average ground-level ozone

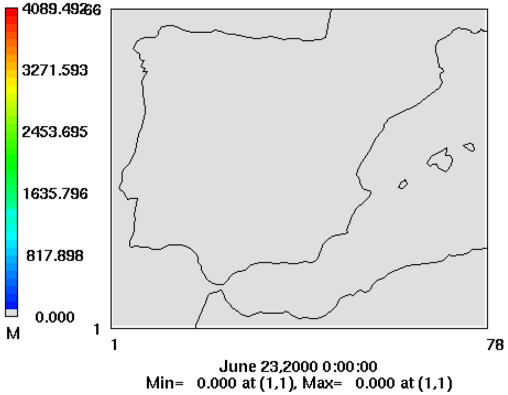
PM_{10} simulation

Layer assignment

- A proper processing of point sources is important for AQ modelling:
  - magnitude of their emissions (e.g. SO_2, 74% total national emissions)
  - special release conditions (thermal and kinetic momentum)
- Point source emission inventory file ($PTINV) included:
  - 107 LPS, 661 stacks in 2000
  - 116 LPS, 681 stacks in 2010
- All LPS have been treated as potential “elevated sources”

- No PING (Plume IN Grid) was selected (intended for coarser resolutions)
- Emission files are based on 10 layers (SMK_EMLAYS = 10)

Meteorology



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Emissions, stack parameters

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$$\Delta h_m = 3.0\,\frac{V_s d_s}{u}$$

$$\Delta h = 2.6\left(\frac{F_b}{u\,s}\right)^{1/3} \text{ with}$$

$$F_b = g\,\frac{T_s - T_a}{T_s}\,\frac{V_s d_s^2}{4}, \quad s = \frac{g}{T_a}\,\frac{\partial\Theta}{\partial z}$$

$$\Delta h = 1.2\left(\frac{F_b}{u u_*^2}\right)^{3/5}\left(h_s + 1.3\,\frac{F_b}{u u_*^2}\right)^{2/5}$$

$$\Delta h = 30\left(\frac{F_b}{u}\right)^{3/5}$$

$$F_r = \frac{u_1 \Delta z_p u_*^2}{2.664}\left(\frac{\Delta z_p}{h_s + \frac{2}{3} z_p}\right)^{2/3}$$

$$F_r = \frac{u_1 s \Delta z_p^3}{59.319}\; F_r = u_1\left(\frac{\Delta z_p}{30}\right)^{5/3}$$

SMOKE elevpoint plume-rise algorithms

emissions vertically allocated for the chemical-transport model computation

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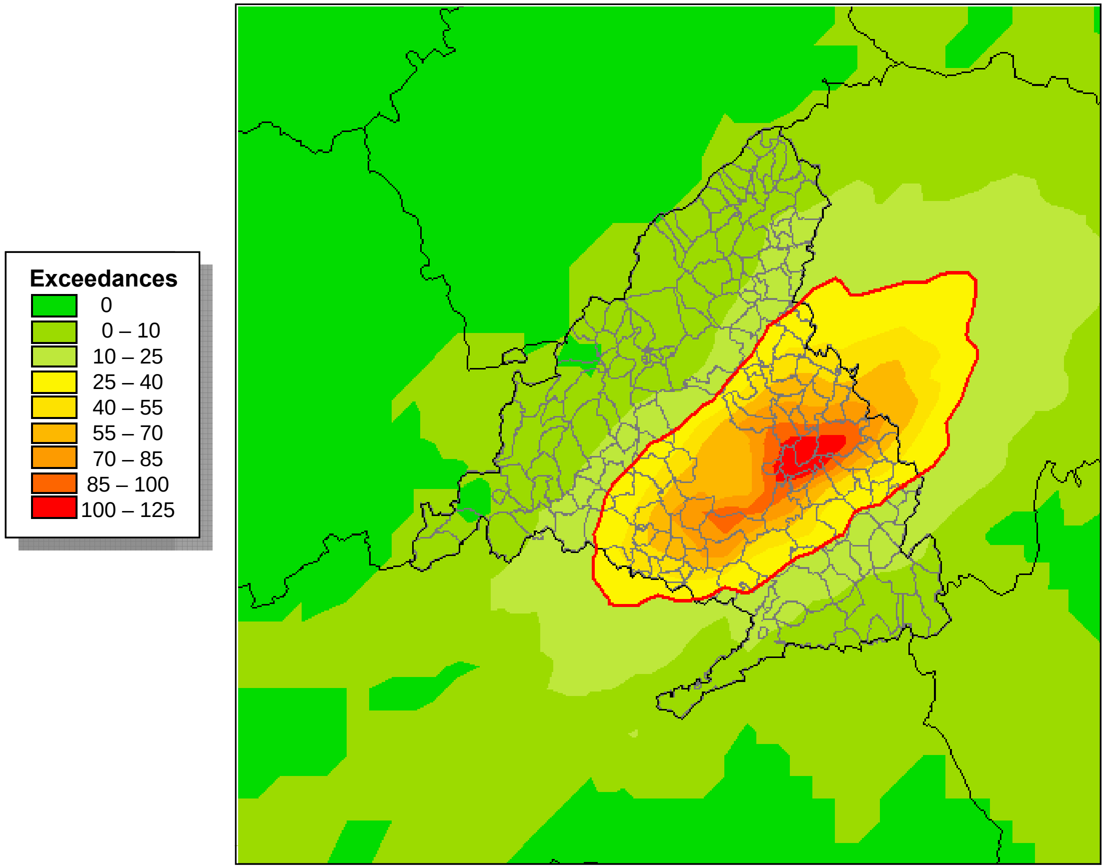
Legislation compliance

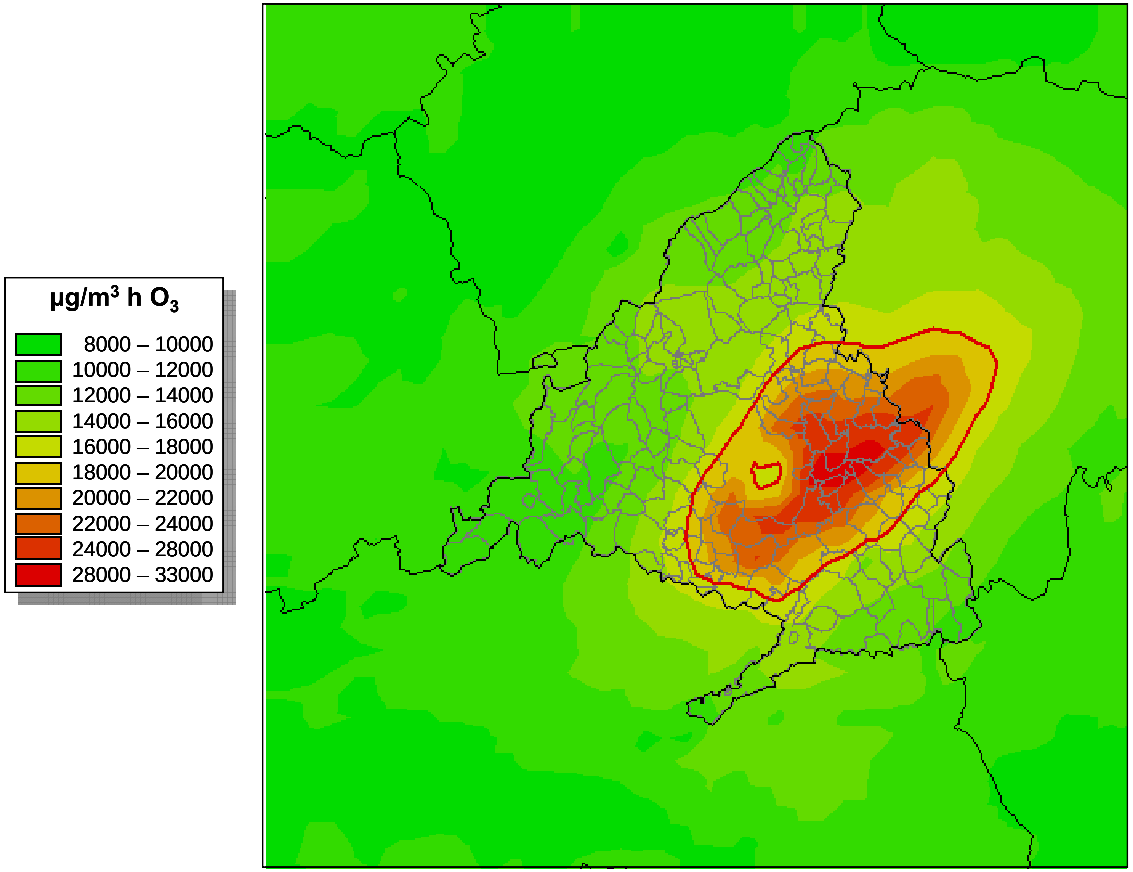
- Assessment of the fulfillment of the 2002/3/EC Directive in the Greater Madrid Area (GMA)



Maximum daily 8-hour mean < 120 µg/m3 not to be exceeded on more than 25 days per calendar year

Target values for the protection of human health

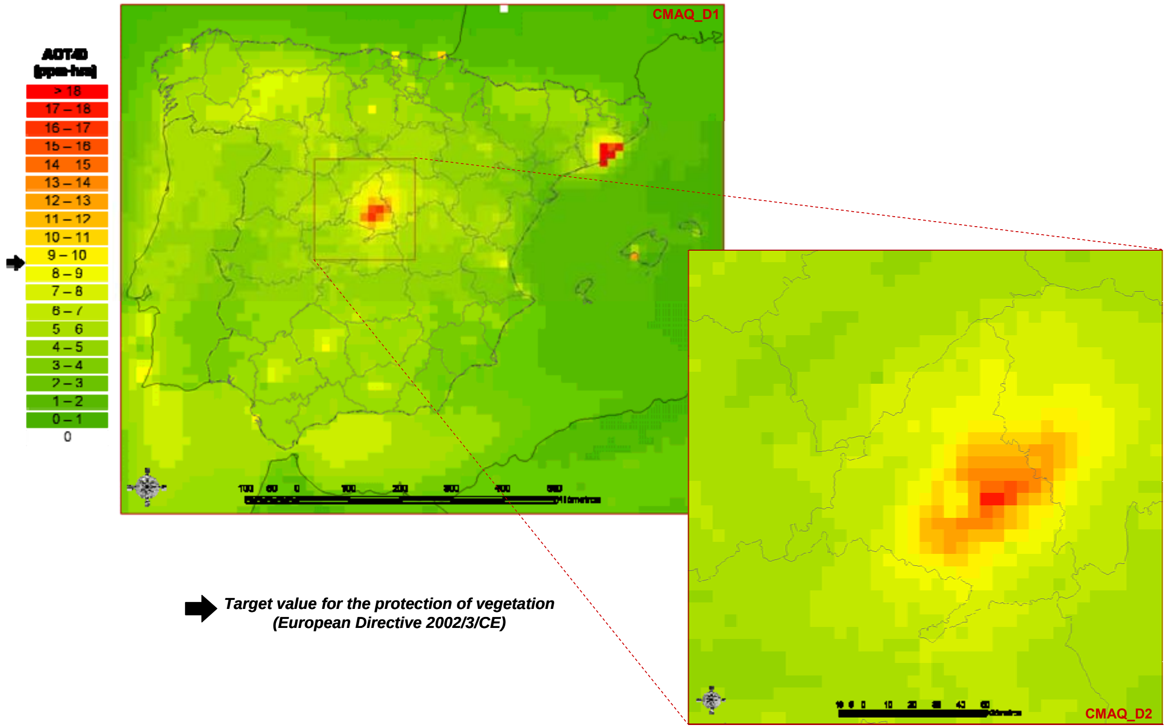
- Assessment of the fulfillment of the 2002/3/EC Directive in the Greater Madrid Area (GMA)

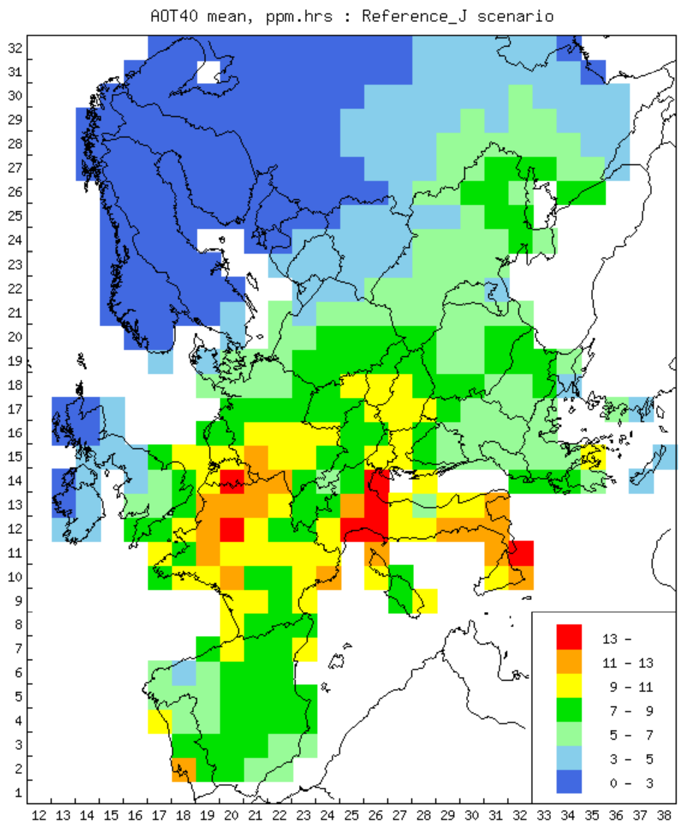


AOT40 calculated from 1h values from May to July < 18000 µg/m³·h

Target values for the protection of vegetation

Comparison with EMEP-RAINS (example: AOT40)





National (regional) modelling results

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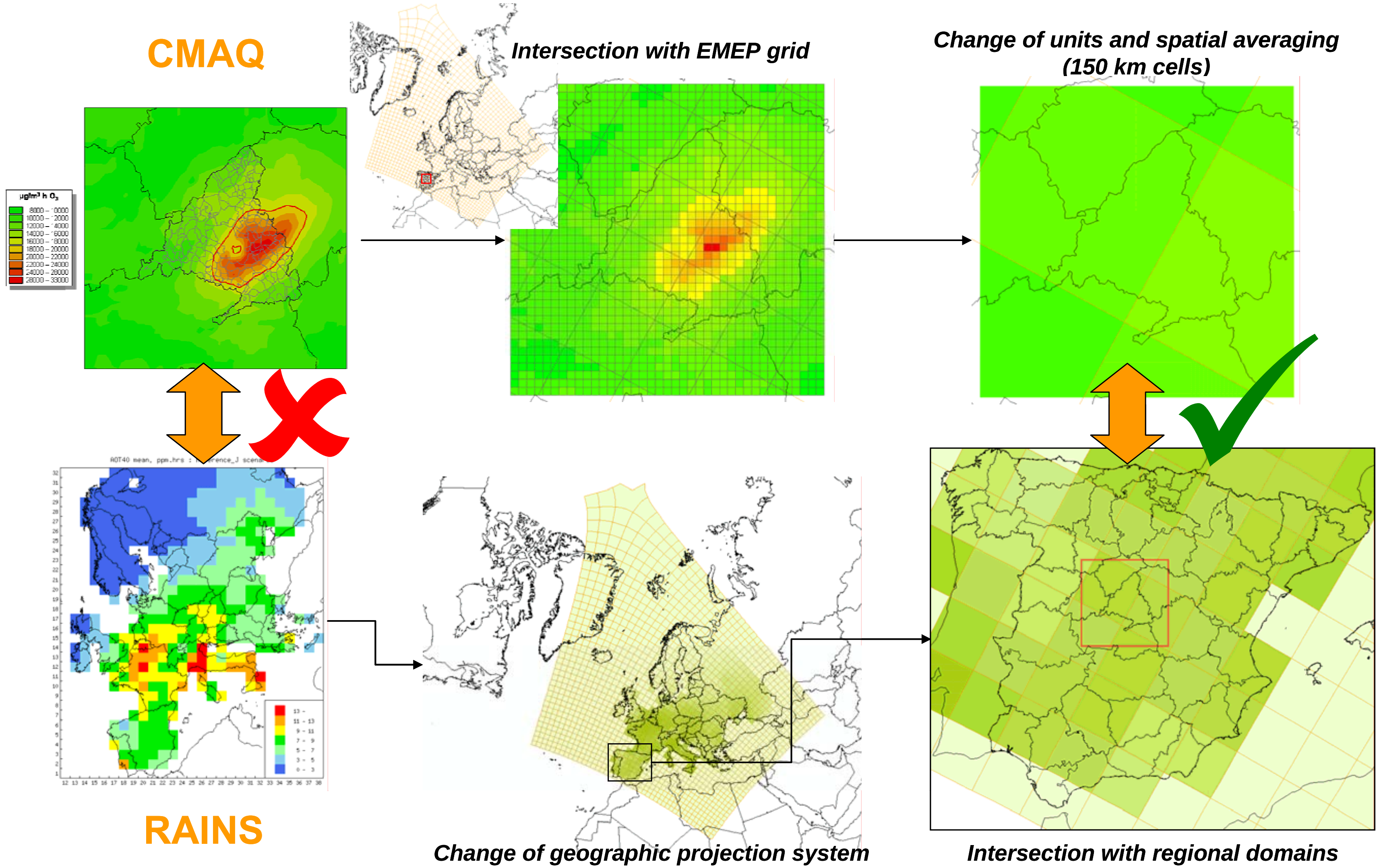
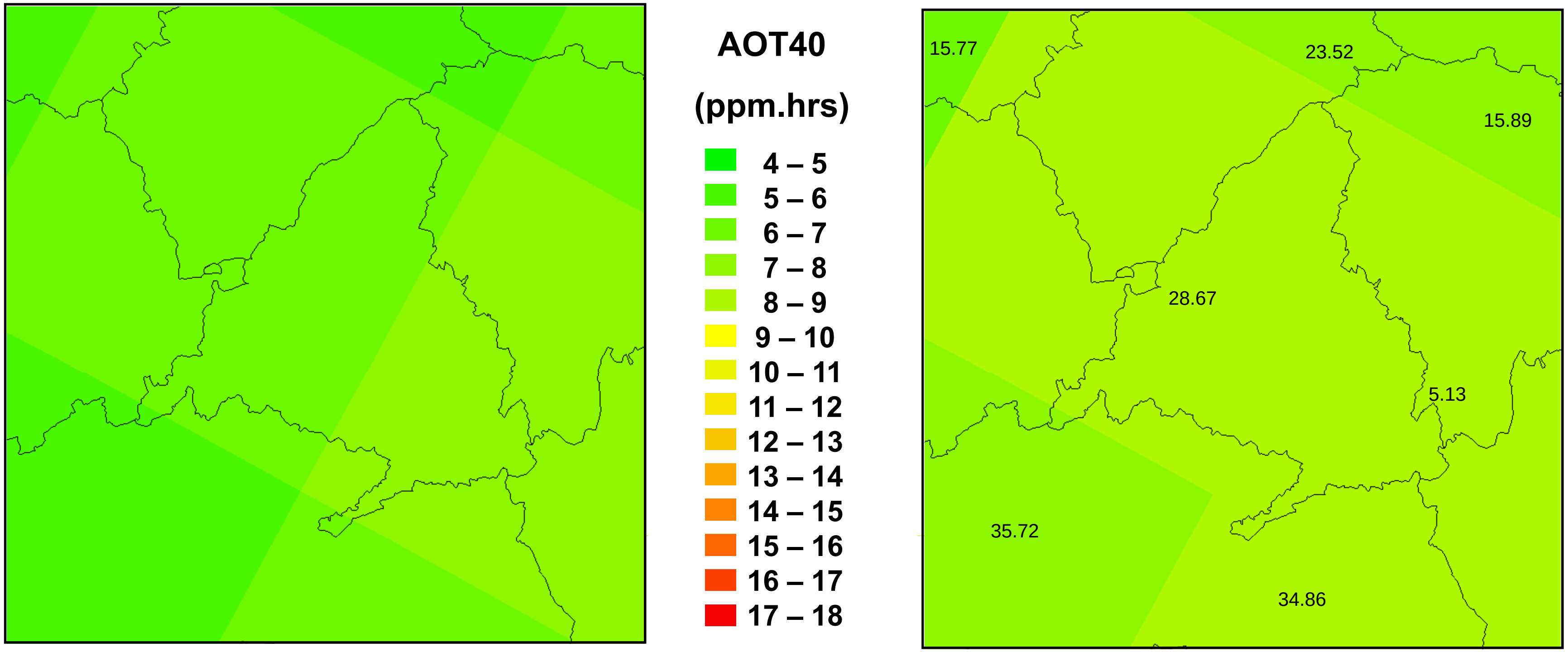
RAINS (150 km) modelling results

- Reduction to a common basis



Model performance

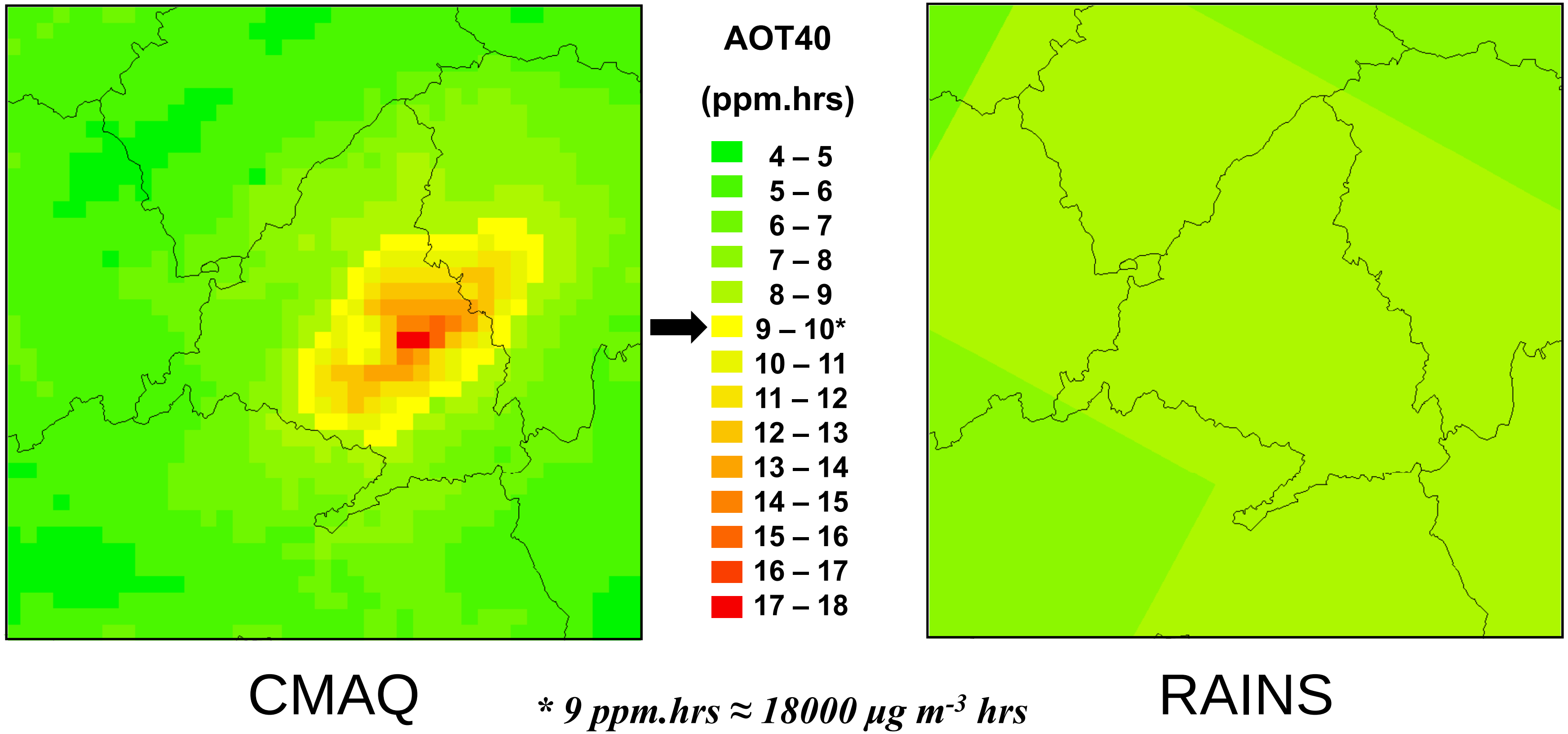


CMAQ RAINS

Mean normalized Bias: 22.46%

- Reasonable agreement

Reference scale limitations



***** 9 ppm.hrs ≈ 18000 μg m^{-3} hrs*

(Target value for the protection of Vegetation. Directive 2002/3/EC)

- It is not feasible to reproduce some (important) regional issues for low spatial resolution (150 km, 50 km)

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- The MM5-SMOKE-CMAQ modelling system can be used as a part of an integrated assessment modelling system, useful to policy assessment and decision-making support in Spain
- The emission subsystem is one of the most important components of the modeling framework. Official emission estimates are taken from the SNAEI and the SEP and processed by the SMOKE system
- SMOKE is strongly US-oriented, but it is flexible enough to accommodate and process European emission inventories based on the CORINAIR methodology

- Besides generating emission input information for the CMAQ model, this software provides a valuable platform for emission scenario analysis and may assist in the definition and design of abatement measures and environmental strategies.
- The main constraints in the application of the SMOKE system are related to the lack of meaningful information regarding chemical speciation or allocation patterns
- Future efforts must be oriented to improve ancillary information regarding these issues

Thank you for your attention!

rborge@etsii.upm.es