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HARMO 15 - 15th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

Development and Implementation of an Air Quality Integrated Assessment Model for the Iberian Peninsula

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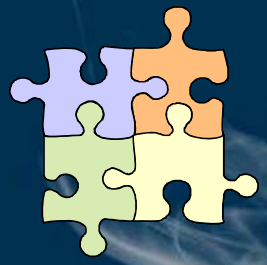
Outline

1. Introduction.
2. AERIS – Atmospheric Evaluation and Research Integrated system for Spain.
3. Model testing and evaluation.
4. Results.
5. Conclusions.
6. References.



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Introduction

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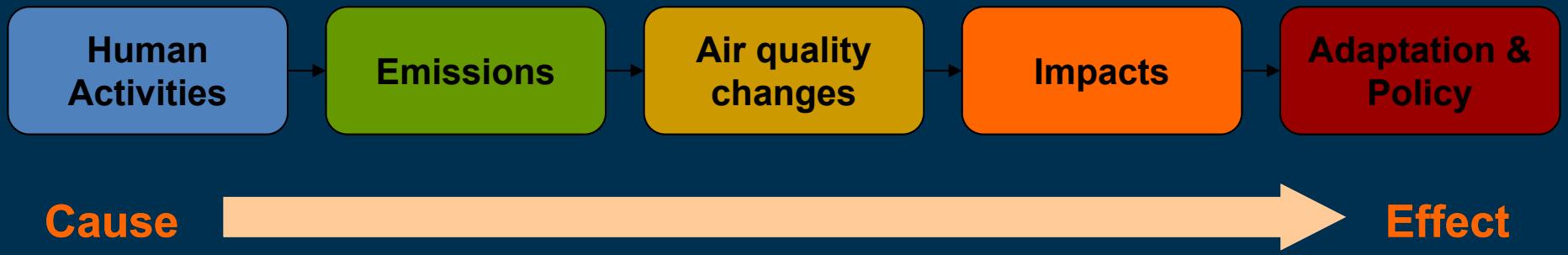
Integrated Assessment Modeling



- Provides a holistic description of environmental problems under a policy-driven framework.
- Methodology for gaining insight about the complex interactions between phenomena.
- Intended to satisfy the needs of a wide range of stakeholders. Assuming CPU time for quick questions??
- Broader scope – description of phenomena is simplified.

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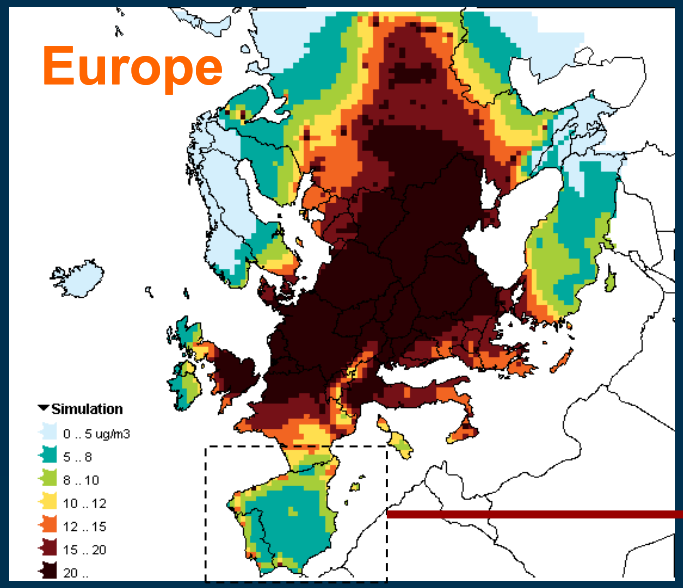
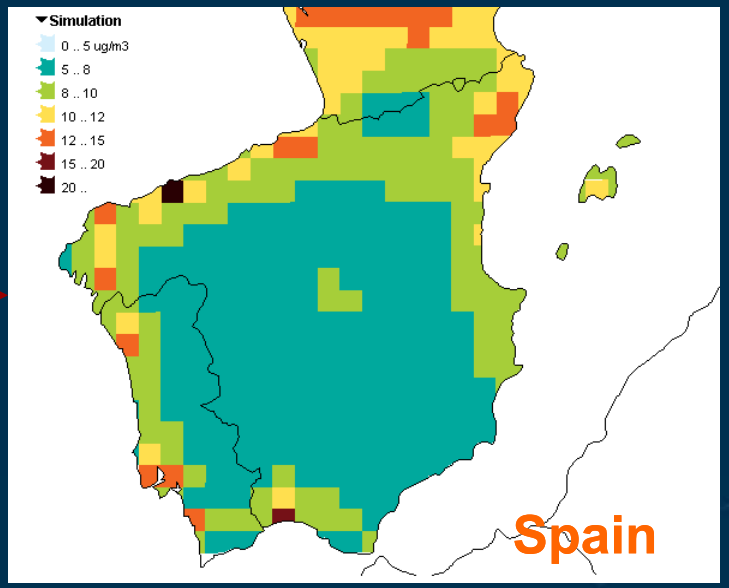
Why is GAINS not enough?





- European scale poorly catches local level phenomena.
- Not designed to support national policy – making.
- Relies on an emission inventory with a limited detail.
- Spain does not have an air – quality IAM so far.

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AERIS

Atmospheric Evaluation and Research Integrated model for Spain

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What is AERIS?

- **AERIS** is an air pollution Integrated Assessment Model conceived for Spain and the Iberian Peninsula.

- Addresses **air quality variations** (policy-relevant indicators) as a function of **percentual variations** in **emissions** against a **reference scenario**.

- **Multi – pollutant** approach: SO_2, NO_2, NH_3, PM_{10}, $PM_{2.5}$. Describes formation of O_3 and secondary particles.

- Based in the SIMCA – SERCA modeling system: **WRF – SMOKE – CMAQ** (Borge et al., 2008).

- Constructed with emissions from the **2007** National Emission Inventories of Spain and Portugal. **Reference scenario. Activity peak.**

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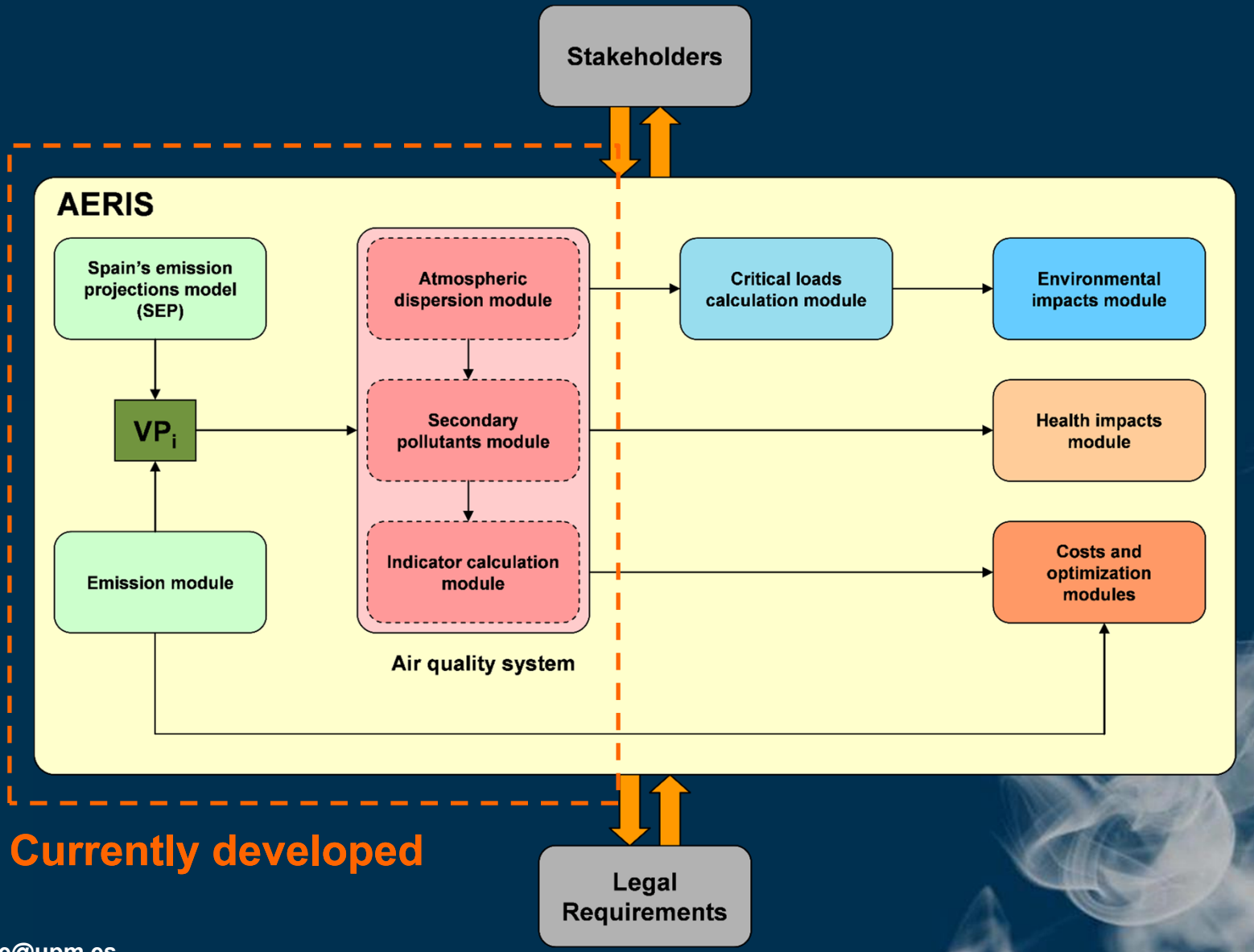
Structure of AERIS



Currently developed

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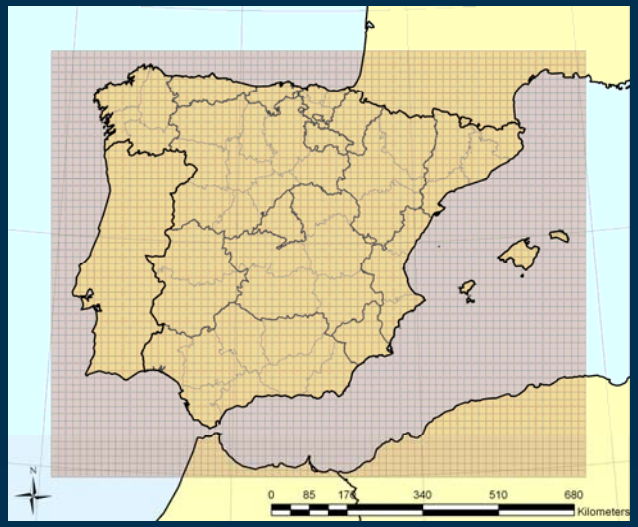
Modeled domain



- **Domain size:** 960 × 1200 km.
- **Cell size:** 16 km. 4500 cells.
- **Domain center:** 40°N, 3°W
- **Spain** and **Portugal**. Parts of France, Morocco and Algeria.
- Spain – **NUTS3** (province).

Emission Inventories

MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

SNEI
Spain

GOVERNO DE PORTUGAL

PNEI
Portugal

emep

Emissions
Other countries

EMEP/CORINAIR
SNAP

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Emission sectors

SNAP code	Description	NO_2	SO_2	PM_{10}	$PM_{2.5}$	NH_3
010000	Coal - fired power plants $\geq 300\ MW$	•	•			
020202	Residential plants $< 500\ MW$	•	•	•	•	
030000	Combustion in manufacturing	•	•			
040000	Production processes		•			
070101	Passenger cars - highway driving	•		•	•	
070103	Passenger cars - urban driving	•		•	•	
070201	Light - duty vehicles - highway driving	•		•	•	
070203	Light - duty vehicles - urban driving	•		•	•	
070301	Heavy - duty vehicles - highway driving	•		•	•	
070303	Heavy - duty vehicles - urban driving	•		•	•	
0707/08	Break, tire and road abrasion			•	•	
080500	Airports (air traffic)	•				
080600	Agriculture (machinery)	•	•	•	•	
080800	Industry (machinery)	•	•	•	•	
100101	Culture w/ fertilizers - permanent crops					•
100201	Culture w/ fertilizers - arable land crops					•
100500	Other agricultural activities					•
110000	Other sources and sinks					•

Specific transfer matrices developed for AERIS

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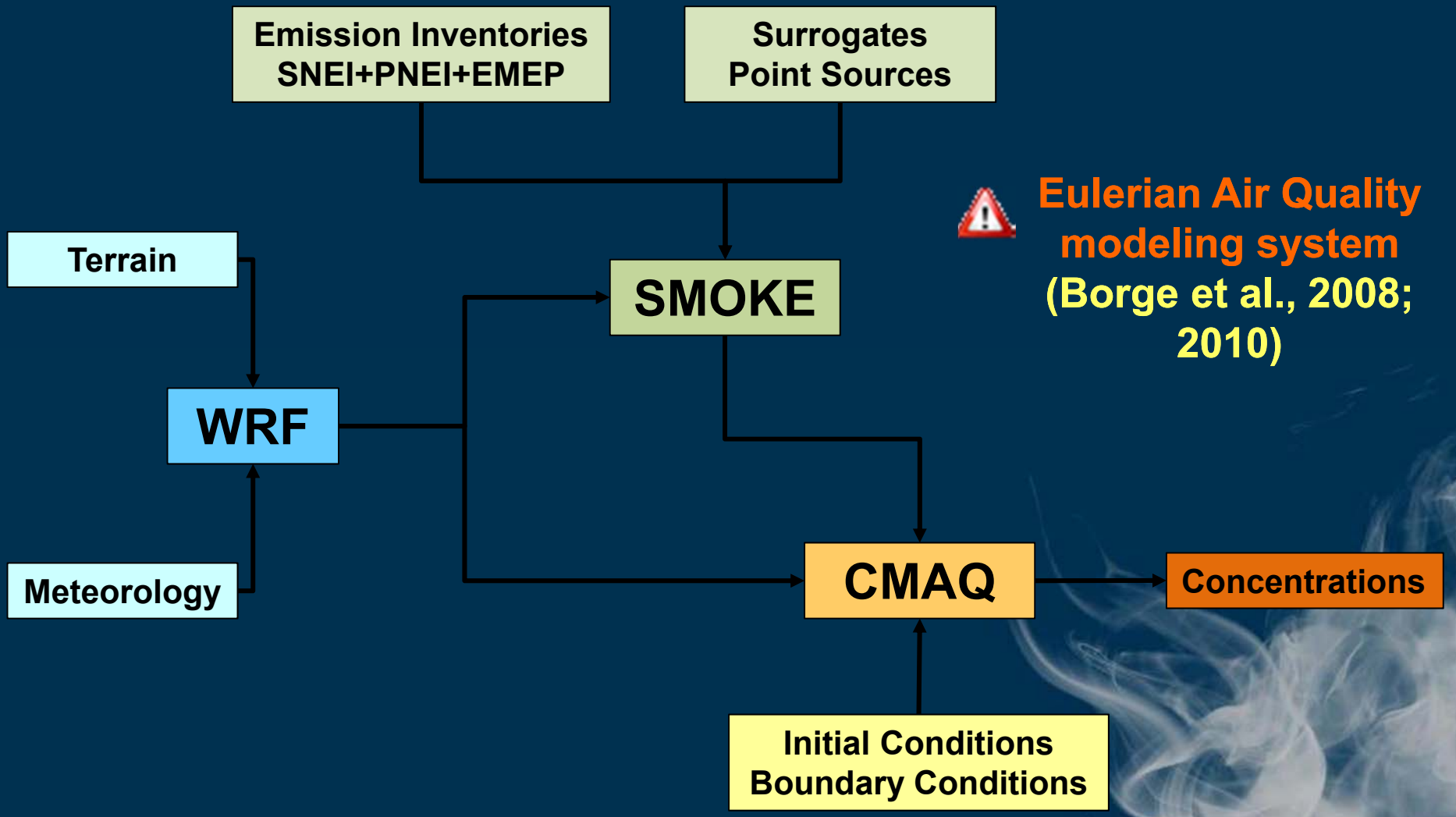
Air Quality Model



Eulerian Air Quality modeling system (Borge et al., 2008; 2010)

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Construction of AERIS

- AERIS is based on a parameterization of the AQM system – use of transfer matrices.

- For primary pollutants, air quality levels are proportional to changes in emissions (Economidis et al., 2008). Linearity. Systematic perturbations – linear regression.

$$[C_i]_{n\times m} = [G_{i,j}]_{n\times m} \cdot p_{i,j} + [C_i]^0_{n\times m}$$

- Changes in emissions were always referred to the baseline scenario (year 2007).

- Transfer matrices were constructed according to Bartincki (1999) and Amann et al., (2011).

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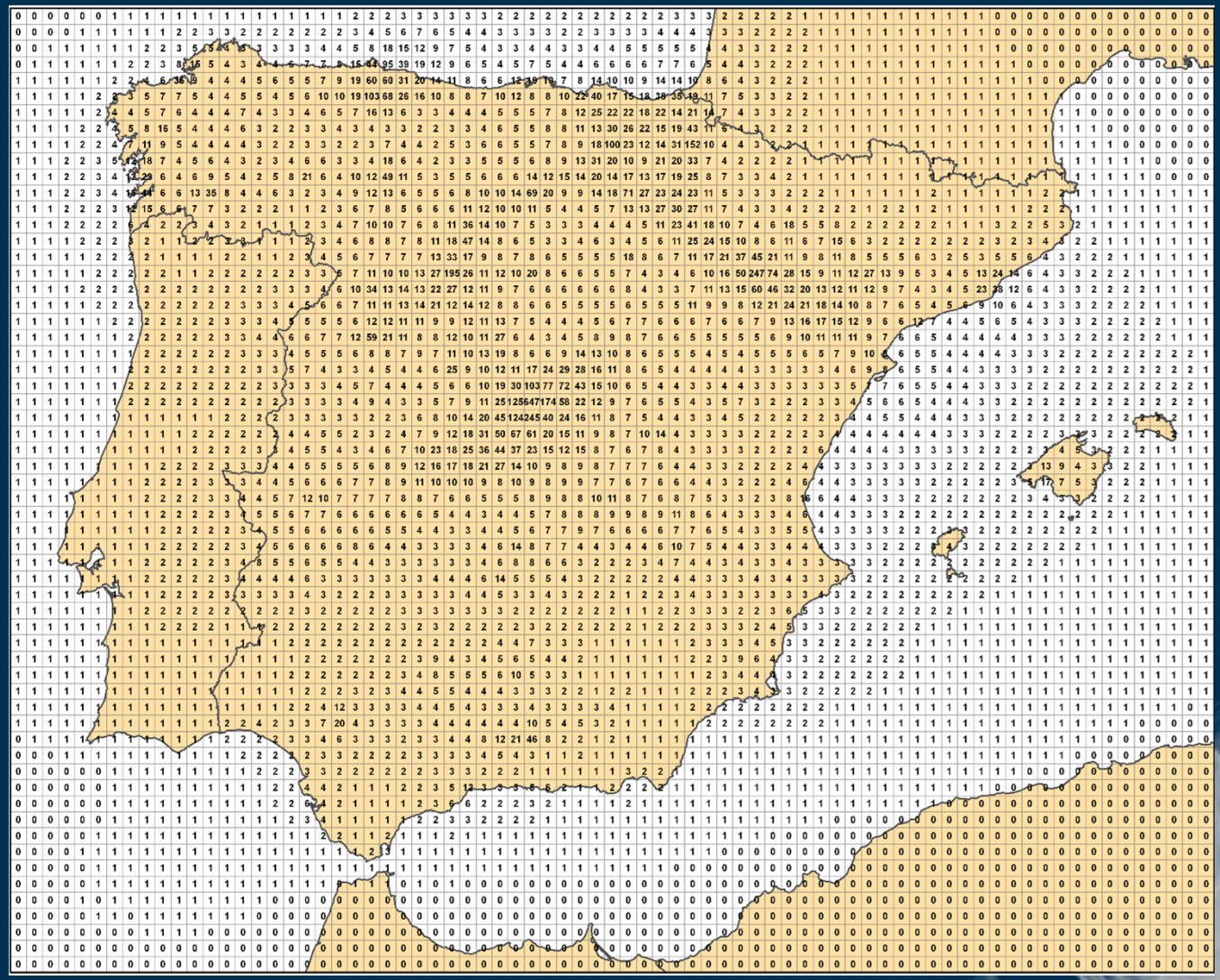
Transfer Matrix: Example



Transfer Matrix of SO_2 for SNAP 020202

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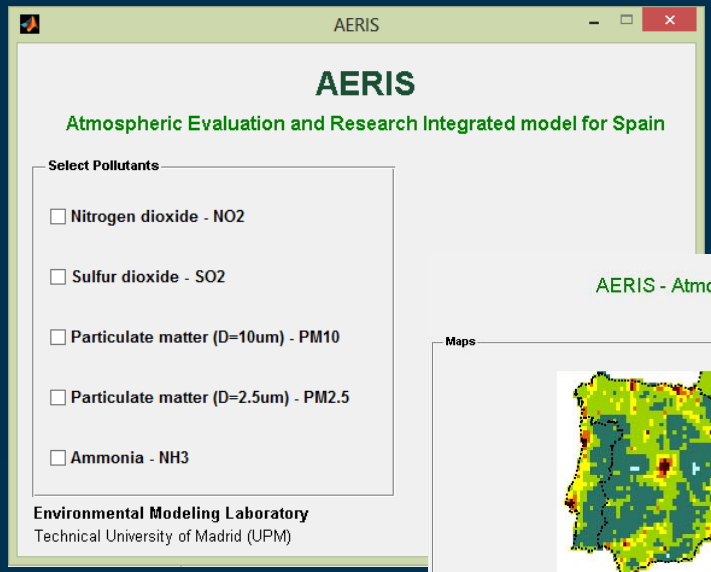
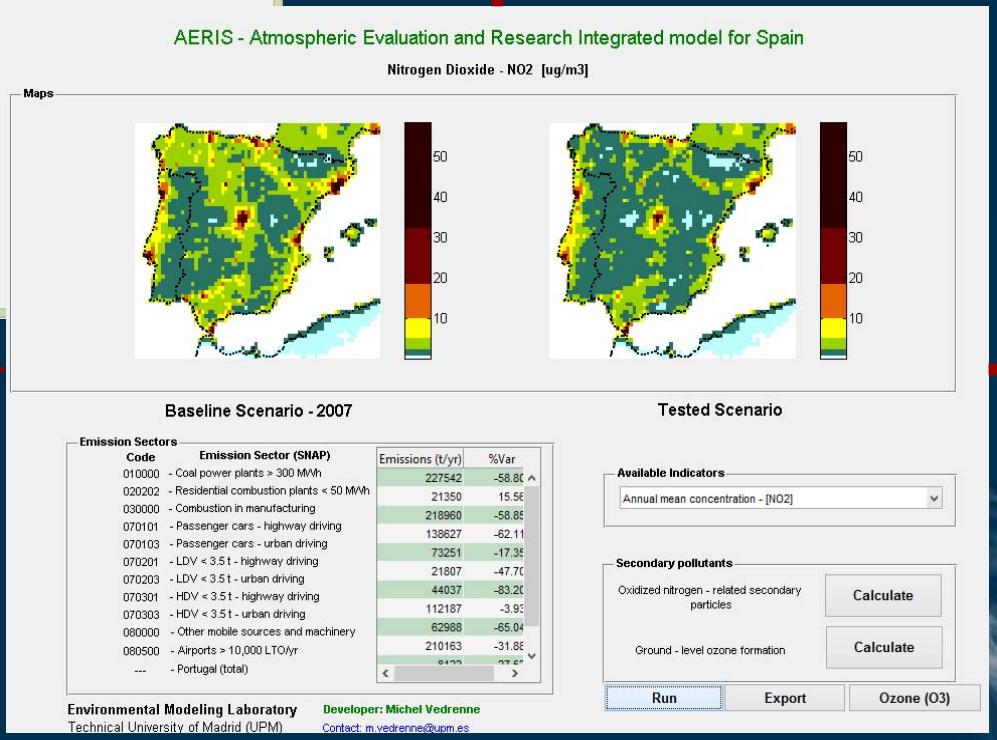
AERIS: an application





Arc GIS ESRI

Desktop applications

TXT
CSV
1,2,3

Input text files

Matlab – based GUI

MATLAB

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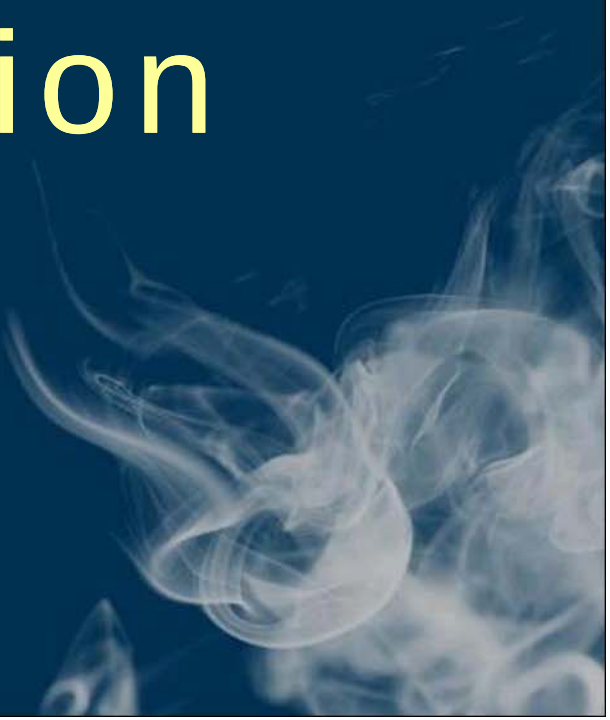
Model testing and validation



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Scenario definition

- **Hypothetic scenario (HS)** – Emissions likely to occur in Spain in year 2014. **Nine** sectors were altered (feasible).

- **Baseline scenario (BS)** – Emissions reported for year 2007.

- Hypothetic scenario created with the **Spain's emission projection model** (Lumbreras et al., 2008).

- Four pollutants were followed: SO_2, NO_x, PM_{10}, and NH_3. O_3 was also simulated. **Annual means**.

- The hypothetic scenario was also processed with the SIMCA ensemble. Results – **reference** for comparison.

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Scenario definition

Emissions at the hypothetic scenario (HS) as a variation percentage of the reference scenario (RS)

SNAP Code	Activity name	SO_2		NO_x		PM_{10}		NH_3	
		E_{RS}[a]	$\%_{HS}$	E_{RS}	$\%_{HS}$	E_{RS}	$\%_{HS}$	E_{RS}	$\%_{HS}$
010101	Combustion plants ≥300MW	805700	-88.6%	235331	-58.8%	17632	0.0 %	0	0.0 %
020202	Residential plants <50MW	12544	-59.7%	24648	15.5%	23461	-5.74%	0	0.0 %
030000	Combustion in manufacturing	83069	-33.0%	225942	-58.8%	27676	0.0 %	0	0.0 %
070101	Passenger cars: highway driving	599	0.0 %	135466	-62.1%	5387	-48.2%	5225	0.0 %
070103	Passenger cars: urban driving	571	0.0 %	75670	-17.3%	8052	-67.5%	473	0.0 %
070301	HDV >3.5 t: highway driving	605	0.0 %	111414	-9.9%	4564	-69.1%	339	0.0 %
070303	HDV >3.5 t: urban driving	324	0.0 %	72325	-65.0%	4049	-88.6%	226	0.0 %
0707/08	Road, tire and break abrasion	0	0.0 %	0	0.0 %	11621	-17.5%	0	0.0 %
100102	Cult. with fertilizers: arable lands	0	0.0 %	8361	0.0 %	736	0.0%	110927	-20.4%
-	Portugal (total)	22918	0.0 %	145250	0.0 %	80563	0.0%	48970	0.0%

[a] Emissions are presented in annual metric tons ($t \cdot yr^{-1}$)

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Evaluation criteria

Evaluation through indicators for model benchmarking (Thunis et al., 2011). IAM Prediction vs. AQM Prediction.

Emissions at the hypothetic scenario (HS) as a variation percentage of the reference scenario (RS)

Indicator	Definition	Units	Range
Mean Bias (MB)	$MB = \frac{1}{N} \cdot \sum_{i=1}^{N} (P_i - M_i)$ [b]	µg/m³	-∞ – ∞
Mean Error (ME)	$ME = \frac{1}{N} \cdot \sum_{i=1}^{N} \lvert P_i - M_i \rvert$	µg/m³	0 – ∞
Normalized Mean Bias (NMB)	$NMB = \sum_{i=1}^{N} (P_i - M_i) \Big/ \sum_{i=1}^{N} M_i$	%	-100 – ∞
Normalized Mean Error (NME)	$NME = \sum_{i=1}^{N} \lvert P_i - M_i \rvert \Big/ \sum_{i=1}^{N} M_i$	%	0 – ∞
Correlation coefficient (r)	$r = \left(\sum_{i=1}^{N} P_i \cdot M_i - N \cdot \overline{P} \cdot \overline{M} \right) \Big/ (N-1) \cdot s_P \cdot s_M$	dimensionless	0 – 1

[b] *P*-AERIS results, *M*-AQM results, *N*-number of cells of the domain, *s*-standard deviation of the dataset

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Results

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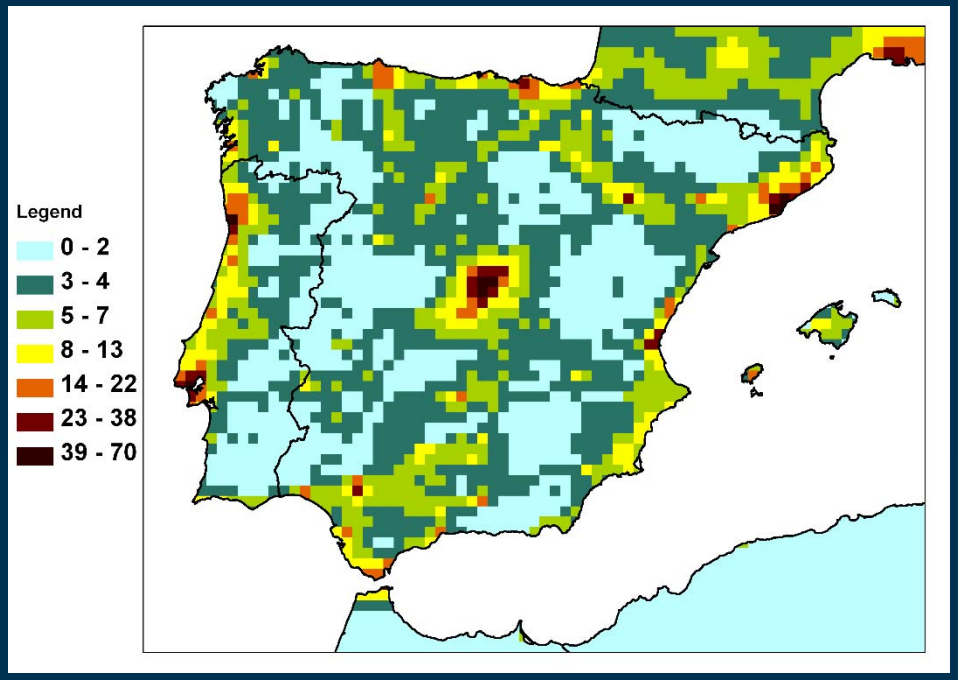
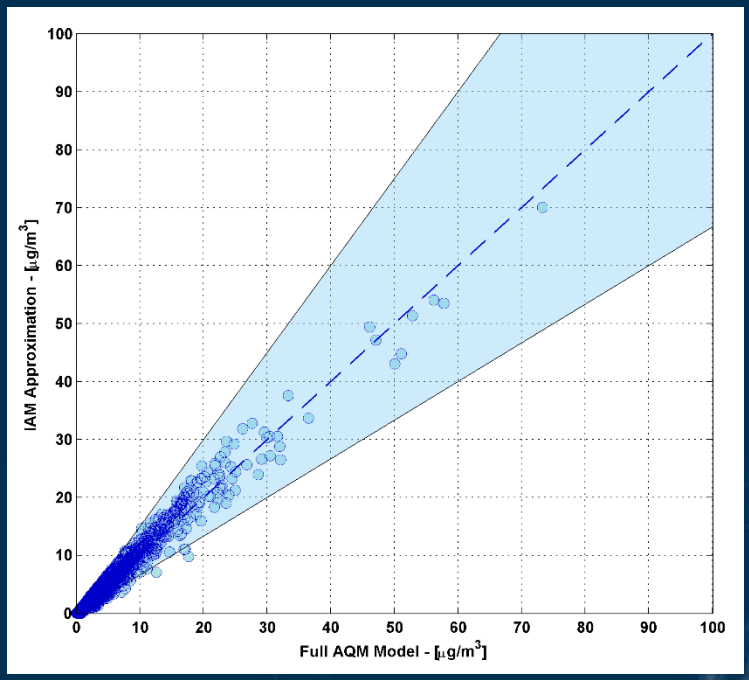
Performance for NO_2



NO_2 concentrations for the HS (µg/m³)



Scatterplot for NO_2 concentrations

Statistic Indicators:

MB = 0.95 µg/m³
ME = 0.48 µg/m³
MFB = 4.15 %
MFE = 13.11 %

r = 0.9841

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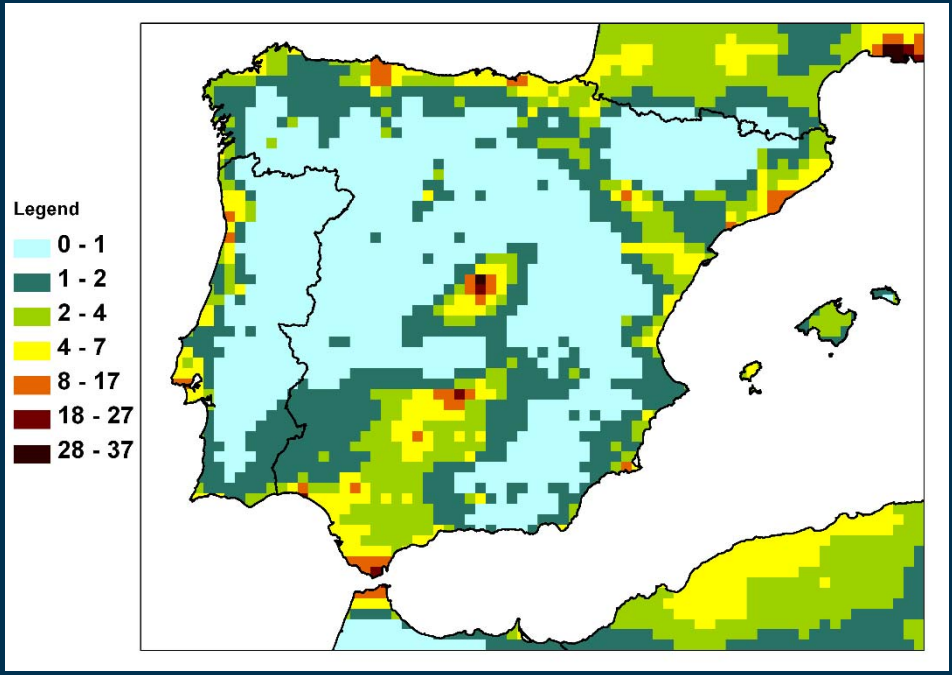
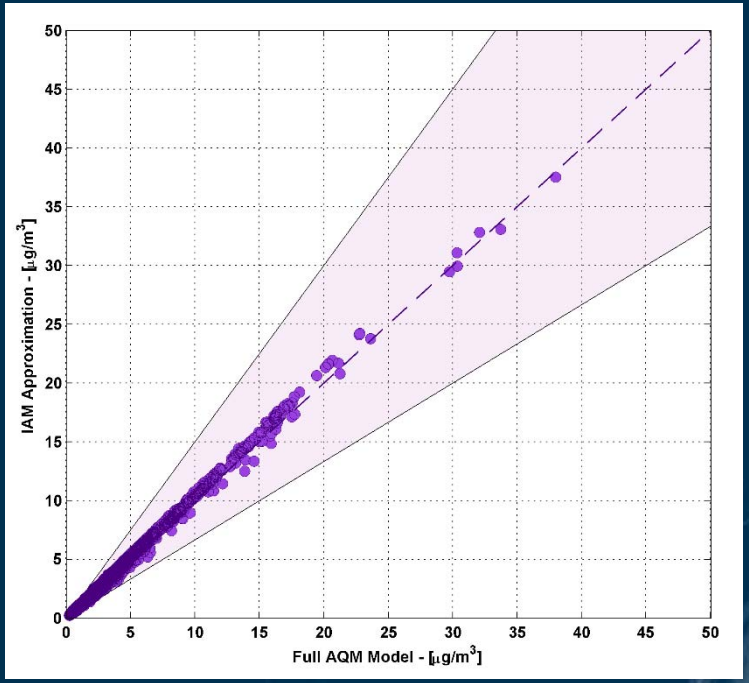
Performance for SO_2



SO_2 concentrations for the HS (µg/m³)



Scatterplot for SO_2 concentrations

Statistic Indicators:

MB = 0.09 µg/m³

ME = 0.14 µg/m³

MFB = 3.35 %

MFE = 4.97 %

r = 0.9986

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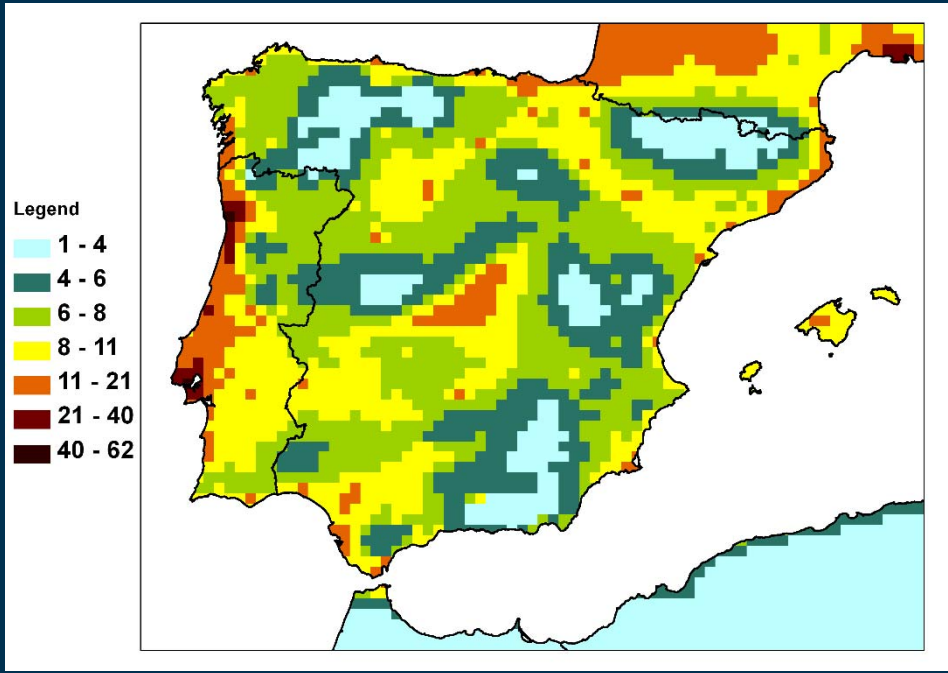
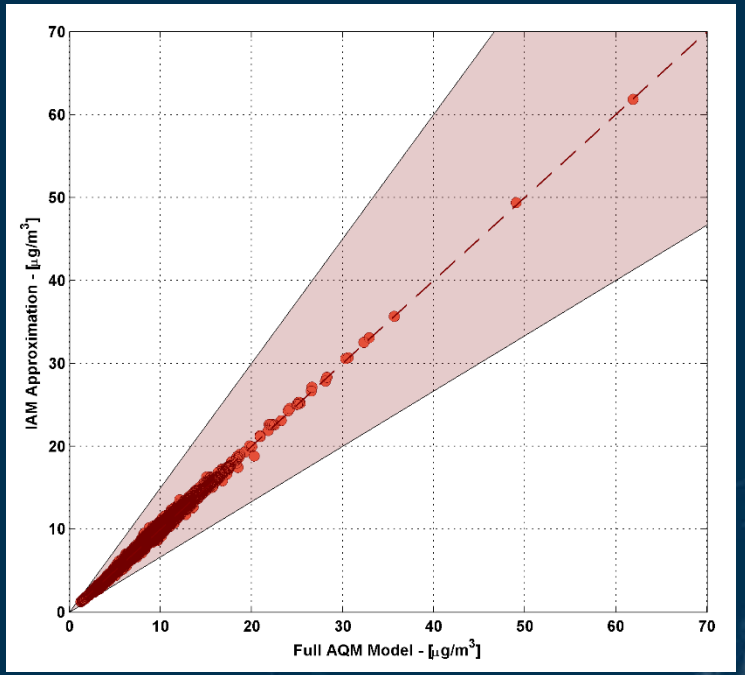
Performance for PM_{10}



PM_{10} concentrations for the HS (µg/m³)



Scatterplot for PM_{10} concentrations

Statistic Indicators:

MB = 0.08 µg/m³
ME = 0.22 µg/m³
MFB = 1.04 %
MFE = 2.37 %

r = 0.9966

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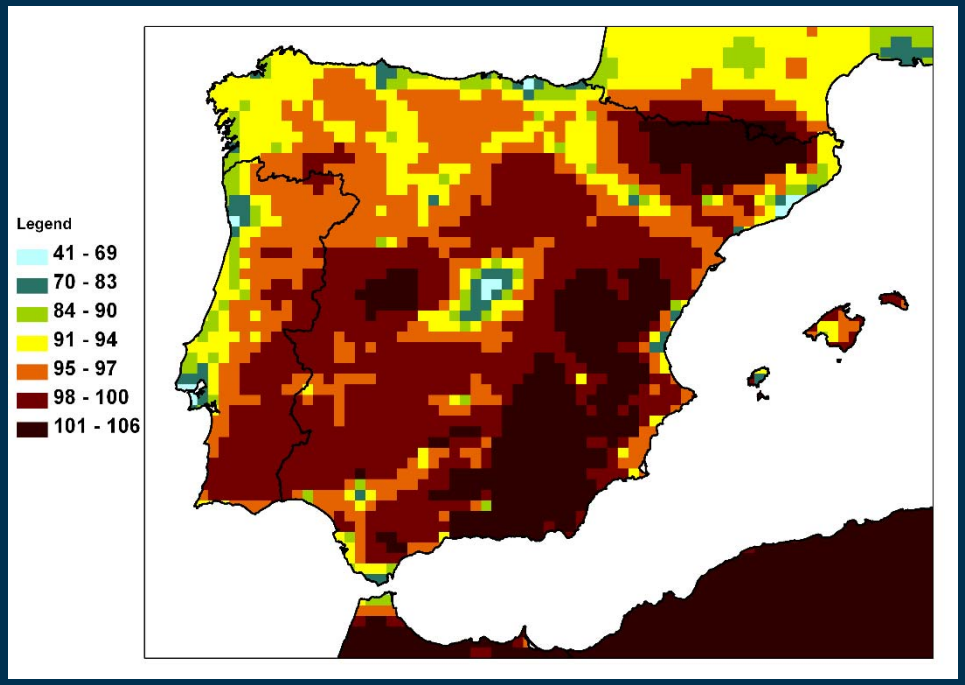
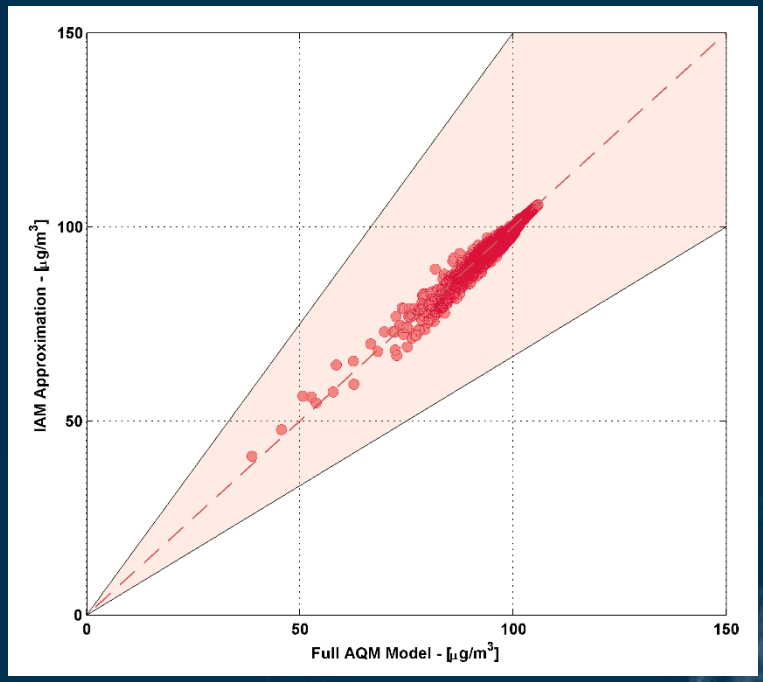
Performance for O_3



O_3 concentrations for the HS (µg/m³)



Scatterplot for O_3 concentrations

Statistic Indicators:

MB = -0.59 µg/m³

ME = 0.82 µg/m³

MFB = -0.61 %

MFE = 0.86 %

r = 0.9810

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Conclusions

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Conclusions

- Although simplified, AERIS performs similarly to the ordinary air quality model.
- Good correspondence levels of model benchmarking indicators.
- Small scale phenomena are catched by AERIS (i.e. cities). Finer scales and high-quality emission inventories.
- Uncertainty analysis is difficult to carry out. However, these are being evaluated.
- AERIS does not intend to replace AQMs. It is only a screening tool for answering "what if?" scenarios.

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Next steps

- AERIS is still under development. New modules are being constructed and tested. Full version to be delivered in 2014.
- New transfer matrices for sectors and pollutants are being developed.
- Create a stand – alone version of the AERIS application.
- Circulate AERIS among stakeholders and policy developers for feedback.
- Possibly reduce scale and create a version for Madrid.

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END

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