ANALYSIS OF THE IMPACT OF MODEL RESOLUTION ON O_3 - NO_2 PREDICTIONS OVER SOME AREAS IN SPAIN

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INTRODUCTION

- Air quality modelling is a very important tool for:
  - assessment
  - impact estimate
  - forecasting
  - management and planning
- Good performance of the AQ models needs:
  - good representation of the atmospheric processes
  - correct programming
  - high quality inputs.
  - **suitable model set-up.**

INTRODUCTION

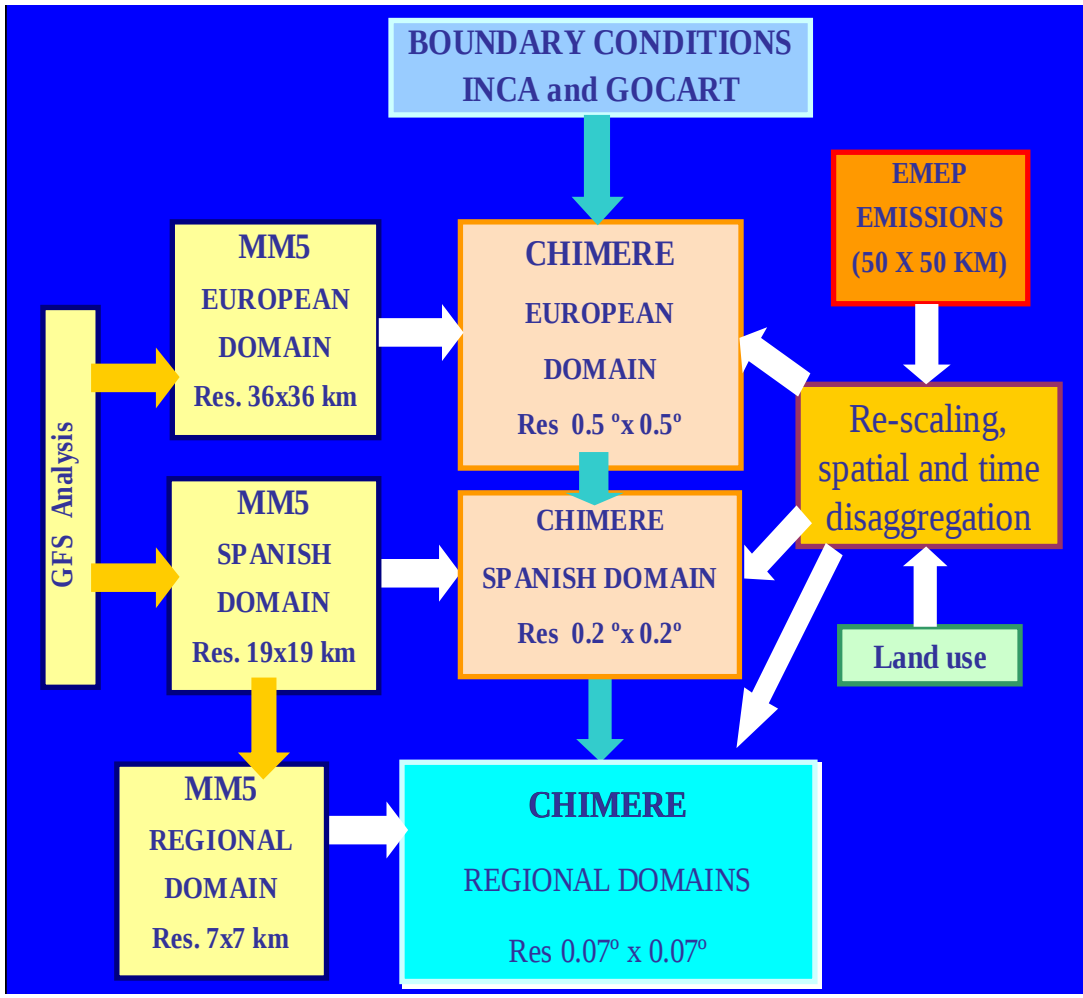
- Concerning the model set-up, the spatial resolution is an import factor to deal with.
- A general rule should be that AQ model resolution has to be similar to the scale of the most important atmospheric process affecting pollutant concentration in the area to be studied.
- This scale is affected by:
  - topographical features,
  - how emissions is distributed,
  - what is the required scale of the outputs, i.e., concentrations at rural background or urban or street scale, for example.

OBJECTIVE

- To determine the impact of spatial resolution three different areas in Spain
- To analyse whether higher-resolution simulations improve CHIMERE ozone predictions when using the same emissions database (50x50 km^2 EMEP emissions database adapted to a higher resolution according to land use information).
- To investigate the impact of

METHODOLOGY

- Simulations of photochemical compounds for 2004 carried out using the regional CHIMERE V200603par-rc1 version.
- Meteorological input from MM5 with GFS analysis data.
- Boundary conditions for gases concentrations for the coarsest domain provided from monthly concentrations estimated with the LMDz-INCA model (Hauglustaine et al., 2004).
- Emissions derived from the annual totals of the EMEP database for 2004 (Vestreng et al, 2006) disaggregated with land use information (GLFC-NASA) for finer resolution.

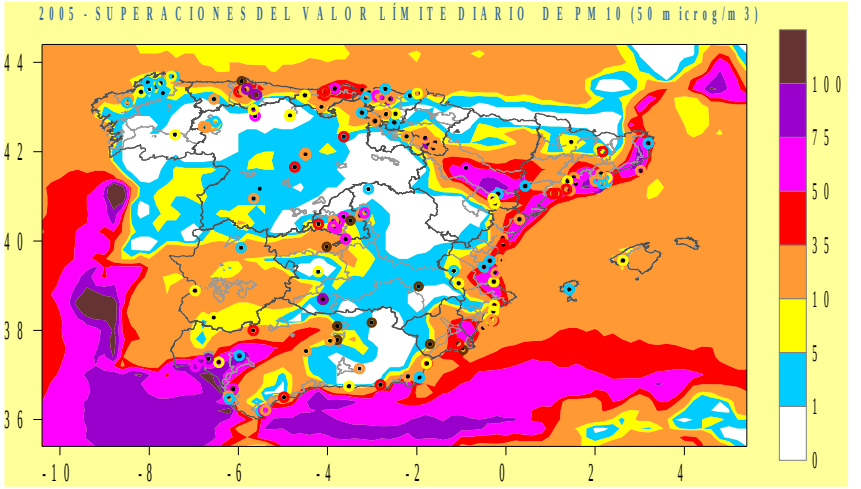


METHODOLOGY

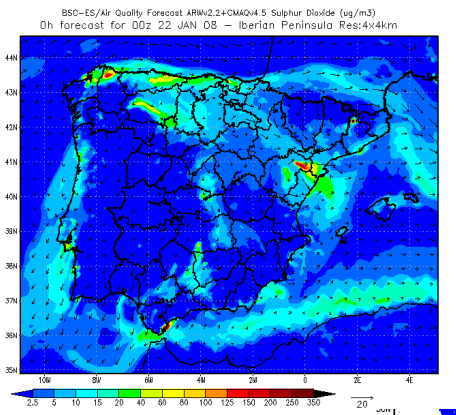
- The CHIMERE model is an air quality model widely used for the last years over Europe, specially over Mediterranean countries (Schmidt et al., 2001; Bessagnet et al., 2004; Vautard et al., 2003; Derognat et al. 2003; Hodzic et al., 2005, Monteiro et al. 2005).
- In Spain, an evaluation of the model performance at a 0.2º x 0.2º resolution for O_3 and NO_2 has been shown in Vivanco et al. (2008). O_3 predictions are in a reasonably agreement to observations recorded at rural sites.
- The capability to reproduce PM10 and PM2.5 has also been evaluated in Vivanco et al. (2007).

METHODOLOGY

- CHIMERE used in **air quality assessment** complementing observed data from air quality stations in Spain (Martín et al., 2003, Vivanco et al. 2007).

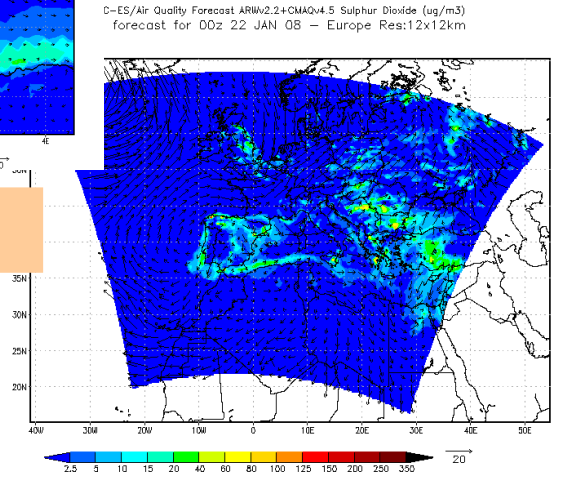


- CHIMERE is being included in the Spanish air quality forecast system (**CALIOPE**) along with CMAQ model (Baldasano et al., 2008)



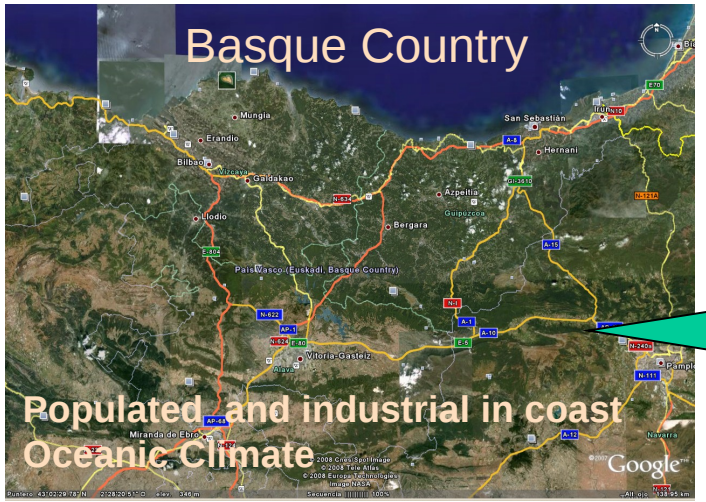
SO_2 Spain

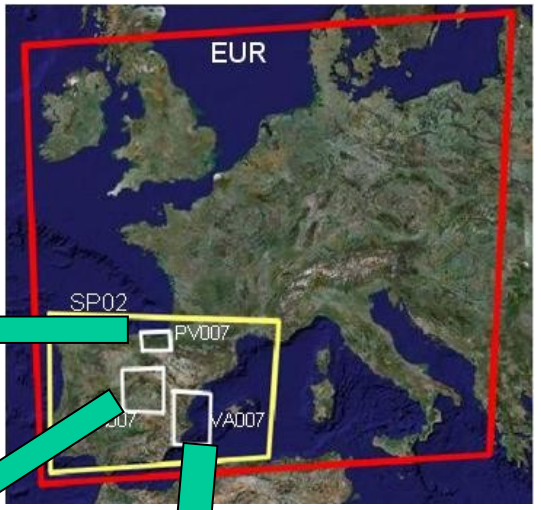
SO_2 Europe

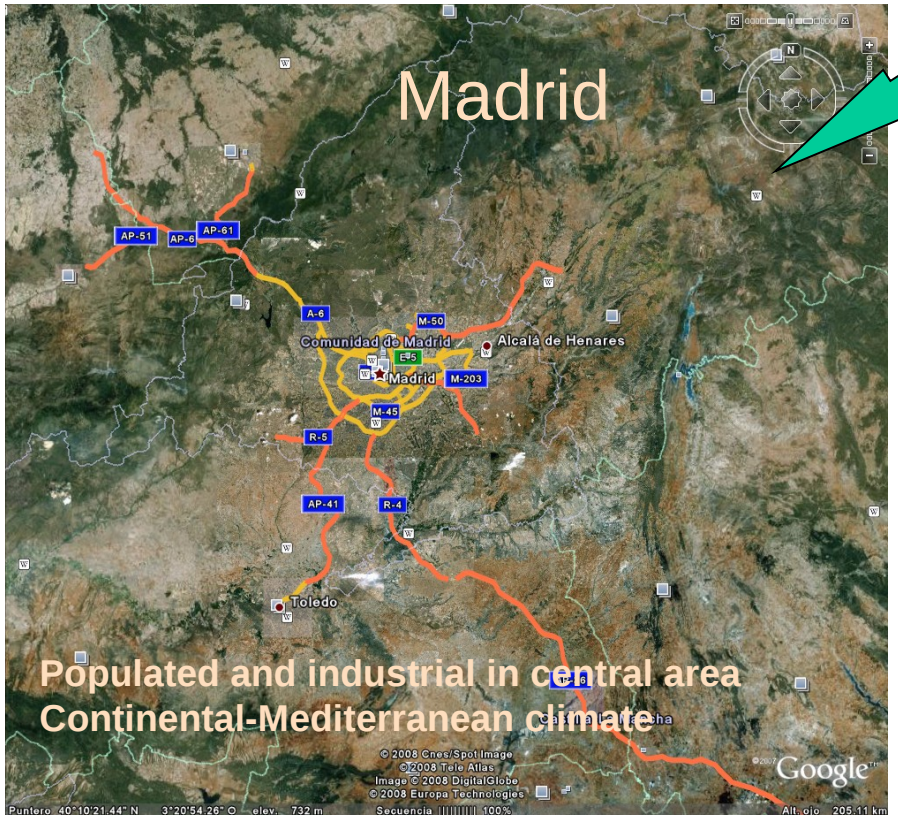


CALIOPE

METHODOLOGY







RESULTS & DISCUSSION

- Hourly O_3 and NO_2 for 2004.
- Cut-off of 80 μgm^{-3} for O_3 and 5 μgm^{-3} for NO_2.

Mean bias	$MB = \frac{1}{N}\sum(M_i - O_i)$
Mean normalized bias	$MNB = \frac{1}{N}\sum(\frac{M_i - O_i}{O_i})$
Mean normalized absolute error	$MNAE = \frac{1}{N}\sum(\frac{\lvert M_i - O \rvert_i}{O_i})$
Root mean square error	$RMSE = \left[\frac{1}{N}\sum(M_i - O_i)^2\right]^{\frac{1}{2}}$
Root mean normalized square error	$RMNSE = \left[\frac{1}{N}\sum\left(\frac{M_i - O_i}{O_i}\right)^2\right]^{\frac{1}{2}}$

RESULTS & DISCUSSION

Results for hourly 0_3 concentrations. Cut-off 80 µgm^{-3} .

0.5º 0.2º 0.07º

MADRID

	EUR	SP02	MA007
Mean bias (µg m-3)	-7.76	-9.61	-8.9
Mean normalized bias (%)	-6.25	-7.79	-6.97
Mean normalized absolute error (%)	16.46	15.81	14.46
Root mean square error (µg m-3)	21.19	21.3	20.03
Root mean normalized square error (%)	20.22	19.35	17.75

VALENCIA

	EUR	SP02	VA007
Mean bias (µg m-3)	14.21	10.87	7.82
Mean normalized bias (%)	16.57	13.03	9.78
Mean normalized absolute error (%)	22.46	19.29	17.15
Root mean square error (µg m-3)	23.84	20.6	18.43
Root mean normalized square error (%)	26.55	22.67	20.18

BASQUE COUNTRY

	EUR	SP02	PV007
Mean bias (µg m-3)	10.4	6.64	6.85
Mean normalized bias (%)	12.2	8.19	8.43
Mean normalized absolute error (%)	16.75	14.36	14.64
Root mean square error (µg m-3)	18.01	15.7	16.06
Root mean normalized square error (%)	20.3	17.53	17.92

RESULTS & DISCUSSION

Results for hourly NO_2 concentrations. Cut-off 5 μgm^{-3} .

0.5º 0.2º 0.07º

MADRID

VALENCIA

BASQUE COUNTRY

	EUR	SP02	MA007
Mean bias (µg m-3)	-40.3	-33.1	-30.1
Mean normalized bias (%)	-61.2	-52.2	-47.7
Mean normalized absolute error (%)	69.8	61.2	57.8
Root mean square error (µg m-3)	50.2	42.2	39.8
Root mean normalized square error (%)	74.5	67.2	64.6
	EUR	SP02	VA007
Mean bias (µg m-3)	-26.06	-26.17	-24.4
Mean normalized bias (%)	-42.07	-48.86	-43.66
Mean normalized absolute error (%)	69.16	65.96	64.41
Root mean square error (µg m-3)	35.89	34.62	33.32
Root mean normalized square error (%)	80.94	74.46	75.02
	EUR	SP02	PV007
Mean bias (µg m-3)	-18.92	-16.06	-15.22
Mean normalized bias (%)	-48.59	-38	-34.52
Mean normalized absolute error (%)	62.19	59.82	60.15
Root mean square error (µg m-3)	25.21	23.35	22.99
Root mean normalized square error (%)	69.37	69.93	72.1

RESULTS & DISCUSSION

Results for hourly NO_2 concentrations. Cut-off 5 μgm^{-3} .

- The improvement in NO_2 predictions with the finest resolution is notable in Madrid and Valencia.
- For Basque Country area:
  - Few differences between the results of 0.2º and 0.07º resolution domains.
  - ¿Is not the 0.07º resolution (roughly 7 Km) enough to simulate properly the atmospheric circulations with MM5?.

RESULTS & DISCUSSION

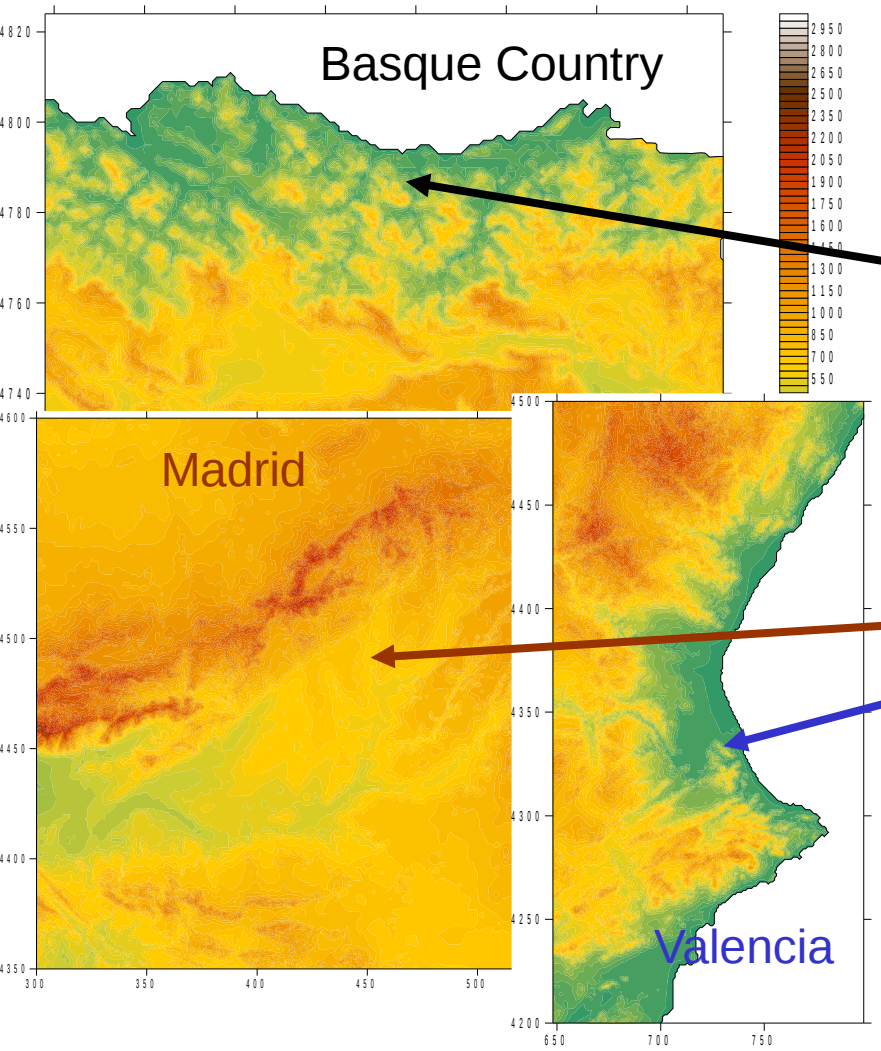
BASQUE COUNTRY - STATISTICS OF MM5 VALIDATION

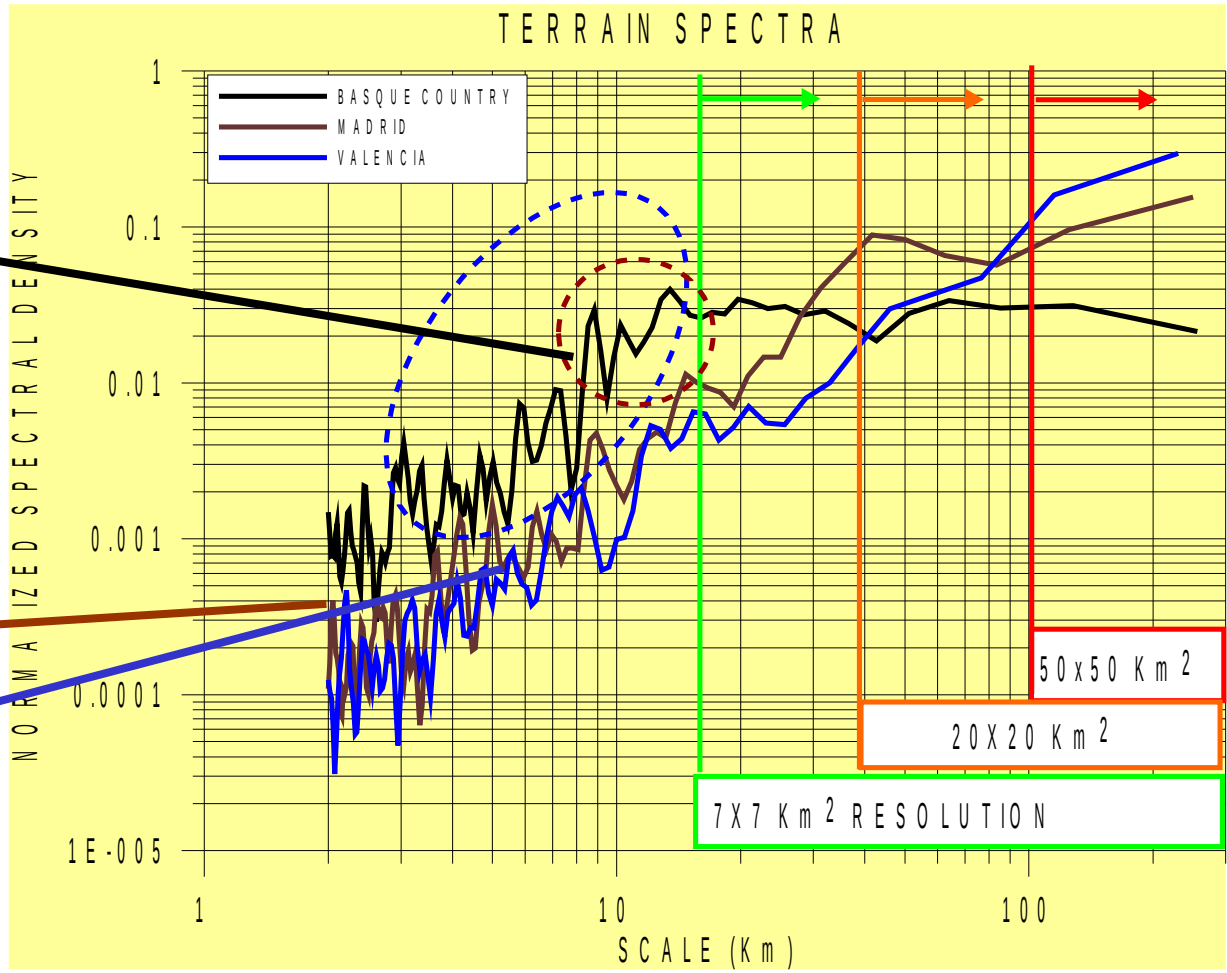
STATISTIC	TEMPERATURE			WIND SPEED			WIND DIRECTION		
	EUR	SPAIN	BASQUE	EUR	SPAIN	BASQUE	EUR	SPAIN	BASQUE
MNAE	0.014	0.015	0.009	64.2	49.7	23.8	0.984	0.764	0.661
RMNSE	0.018	0.018	0.011	217.7	171.3	92.2	2.114	1.663	1.437

- For temperature and wind speed, best results are in 0.07ºx0.07º res. domain.
- For wind direction, few differences between 0.2ºx0.2º and 0.07ºx0.07º domains.

RESULTS & DISCUSSION

Topography spectra of the domains

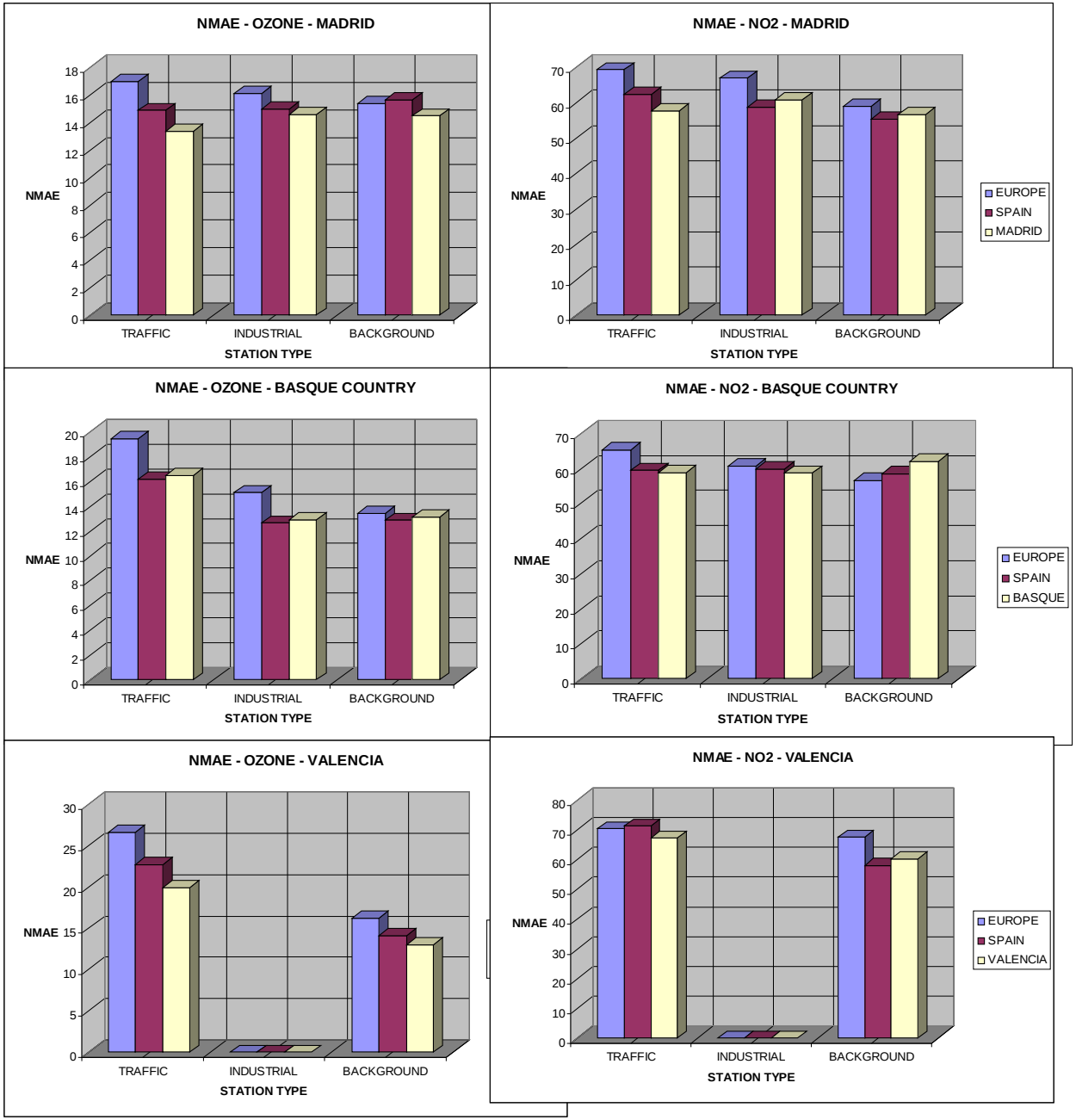




In Basque, very hilly and complex terrain (more in the coast) suggesting that a finer resolution is needed.

RESULTS & DISCUSSION

- The effect of model resolution is not the same for each station.
- Most of the stations present better predictions for higher-resolution simulations in Madrid and Valencia areas, but not in Basque Country.
- Higher improvements are observed in traffic stations.



SUMMARY & CONCLUSIONS

- Comparison between 2004 hourly CHIMERE model predictions and observations indicate that higher resolution simulations drive to a better agreement.
- This improvement for O_3 and NO_2 was observed for the statistics using all the 2004 hourly values in Madrid and Valencia areas.
- But for the Basque Country, finest resolution (0.07x0.07º) does not provide better results.
  - Meteorological simulations with MM5 model do not show the expected improvement for wind direction,
  - It can be related with the very complex topography with many topographical structures being in scales below 14 Km scale.
  - Higher resolution is clearly needed for the Basque Country.

Future work

- Simulations to a finer resolutions, at least 4x4 o 3x3 Km^2.
- Extending study to other pollutants and Spanish regions.

ACKNOWLEDGEMENTS

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THANK YOU