Differential photometric study of the European light emission to the space

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Grupo para la Protección del Cielo

STARLIGHT
A COMMON HERITAGE

European light emission

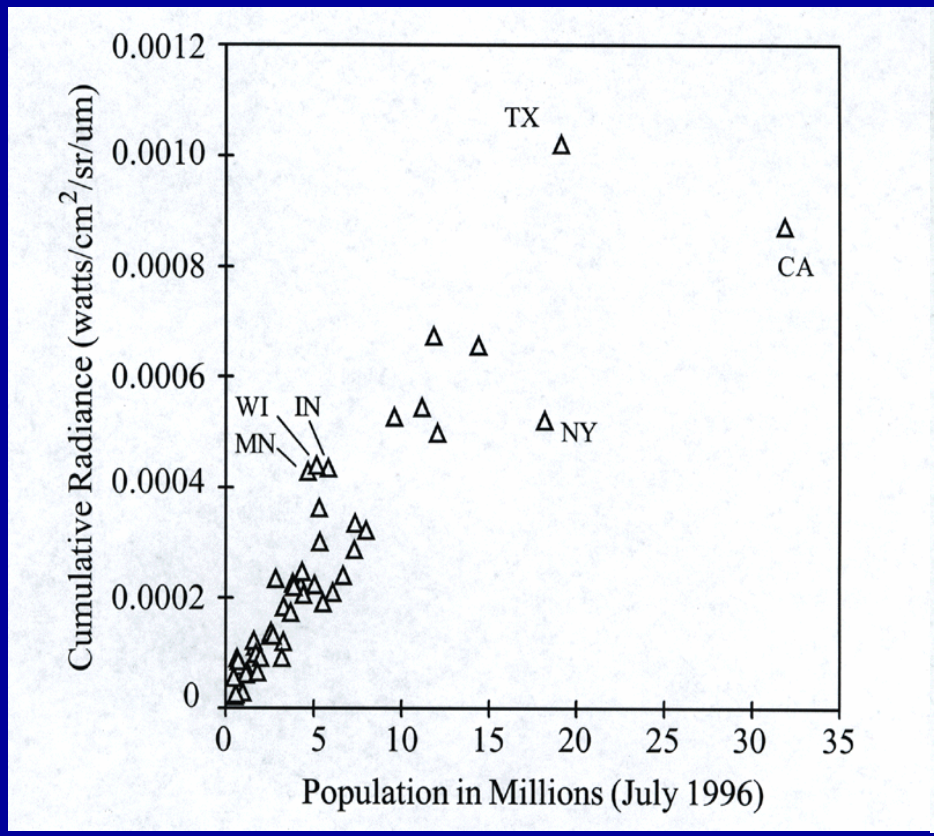
- Data acquisition and treatment
- Data analyses
- Countries comparison
- Conclusions and future work

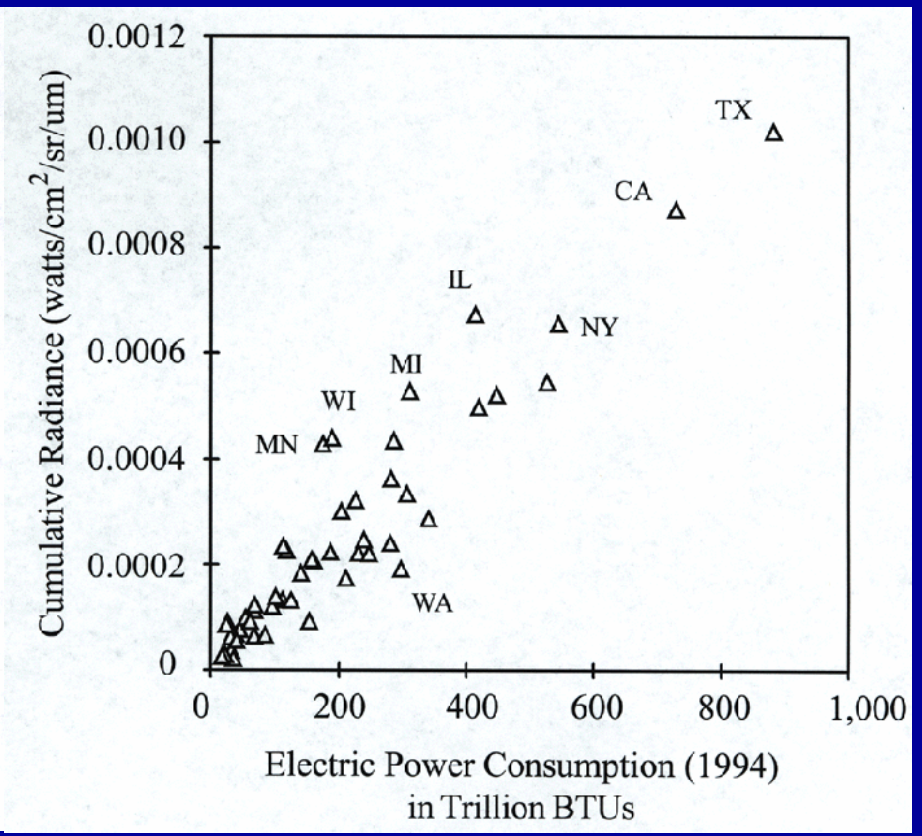
Objectives

- Search of the parameters that define the illumination quality based on satellite images.
- Study sources of light pollution and its evolution
- Spain case analysis

Precedents

Dr. Christopher Elvidge
325 Broadway E/GC2
Boulder, Colorado 80305





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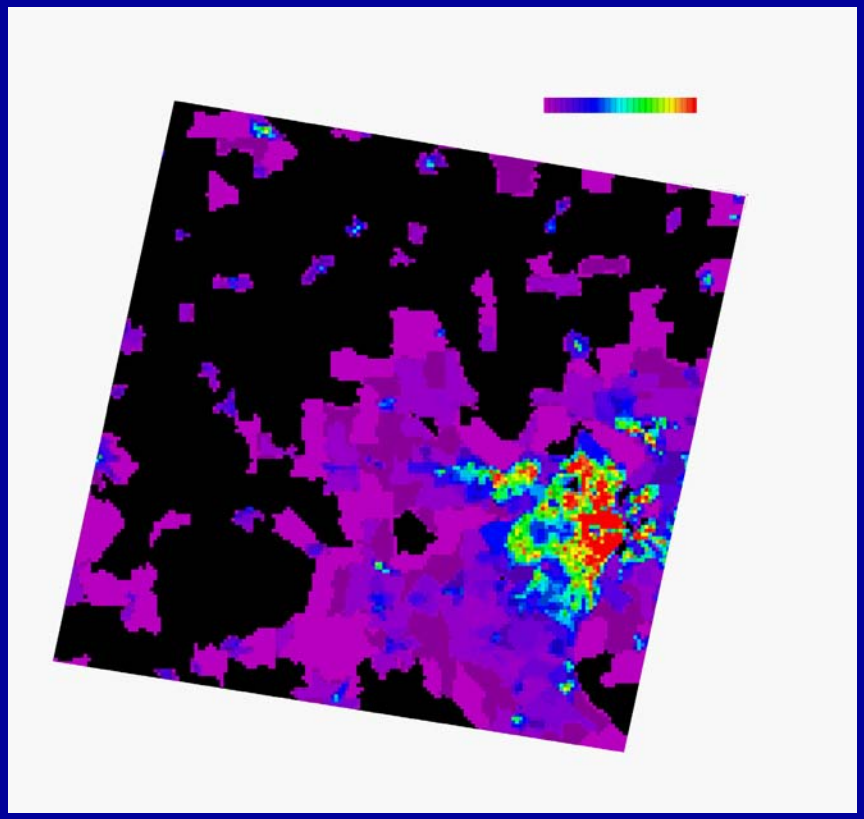
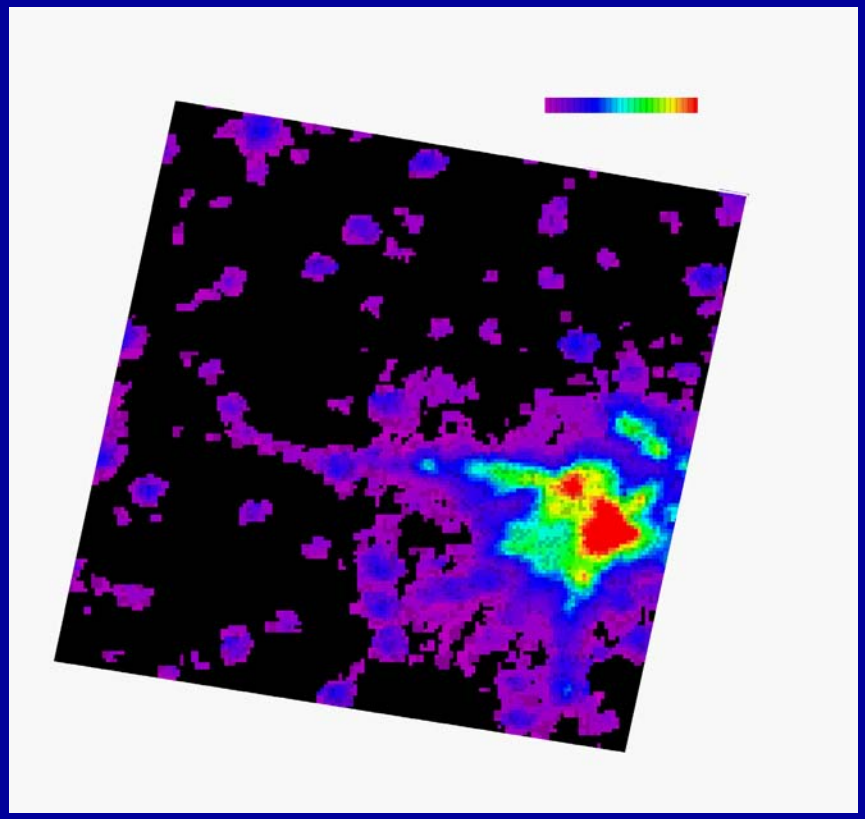
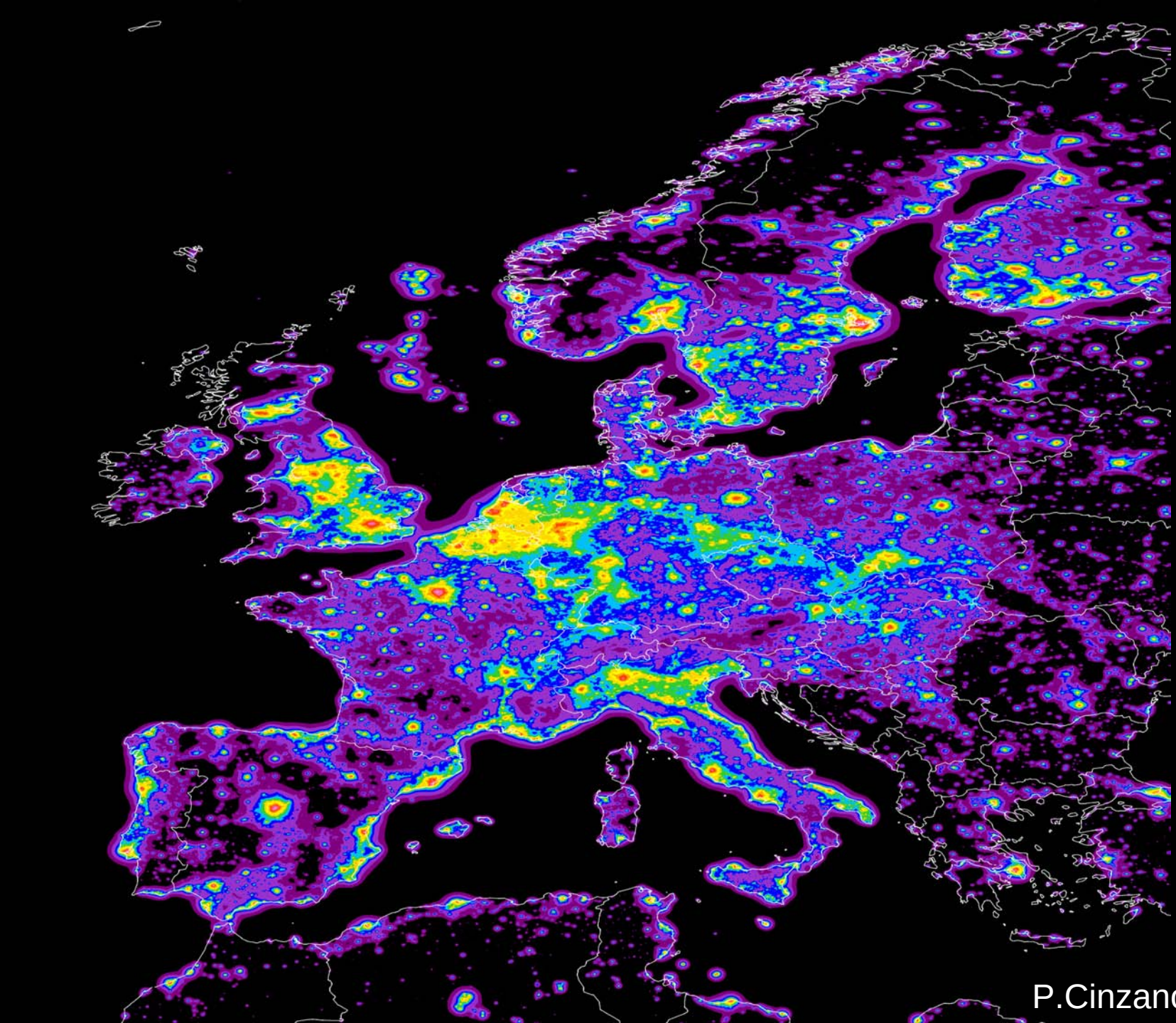


Population density

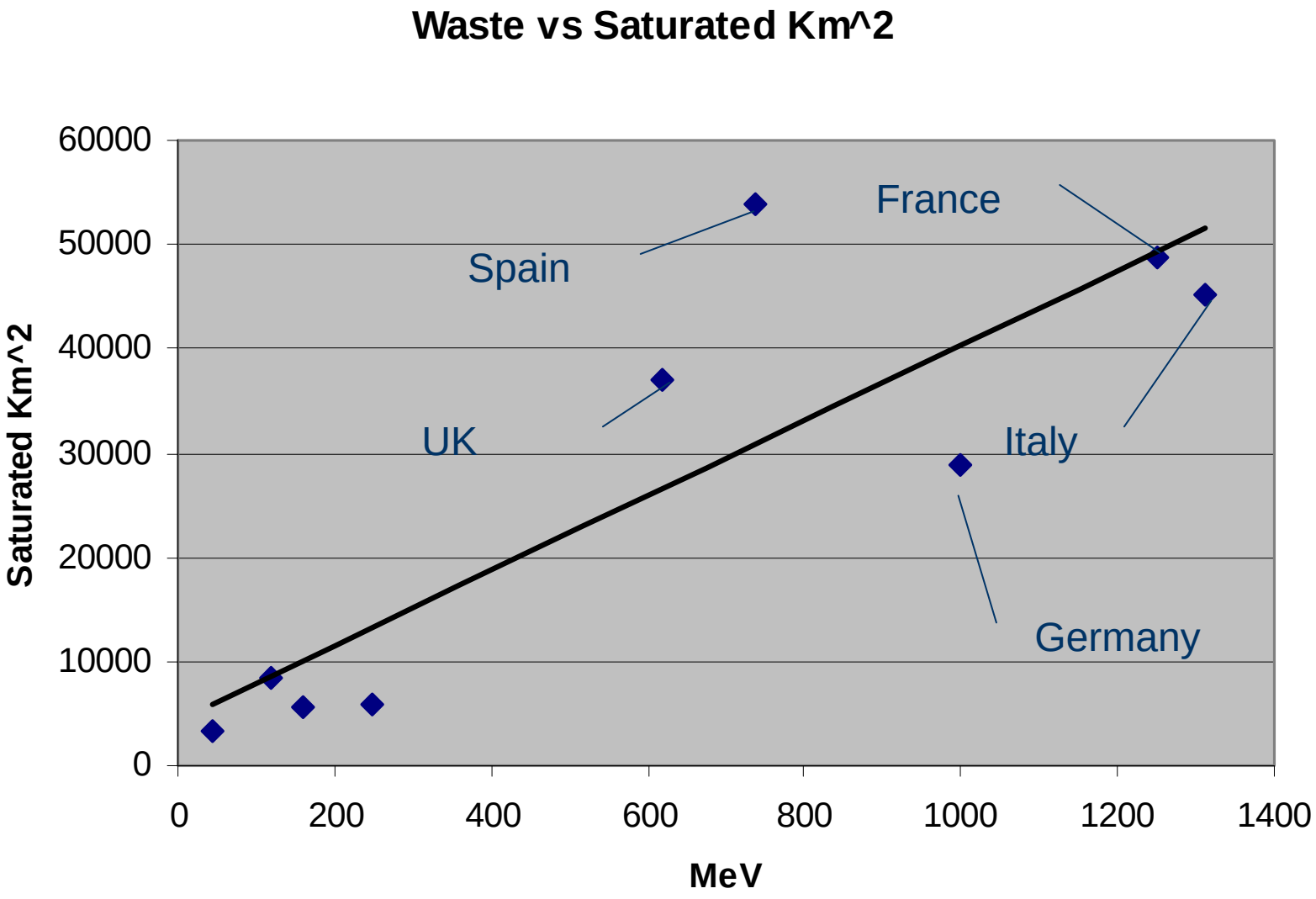


Intensity

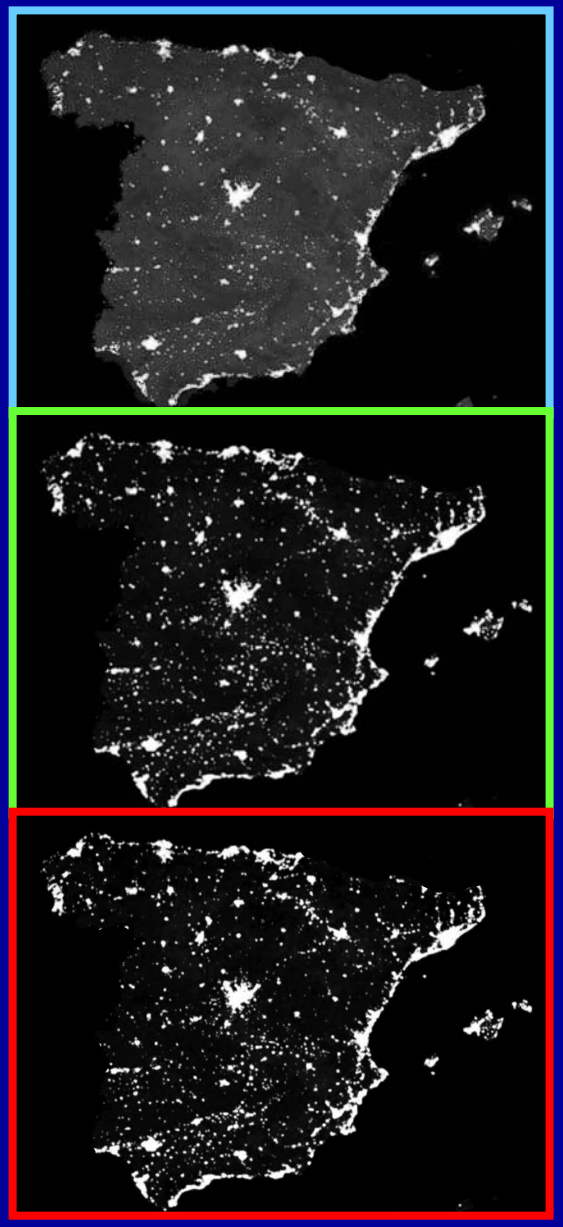


P.Cinzano et al 2000

Precedents


Waste vs Saturated Km^2
Saturated Km^2
60000
50000
40000
30000
20000
10000
0
0
200
400
600
800
1000
1200
1400
MeV
France
Spain
UK
Italy
Germany

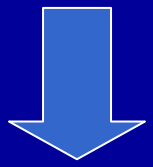
Data acquisition



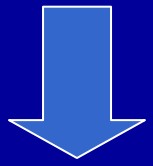
Data analyses

Comparison among Countries

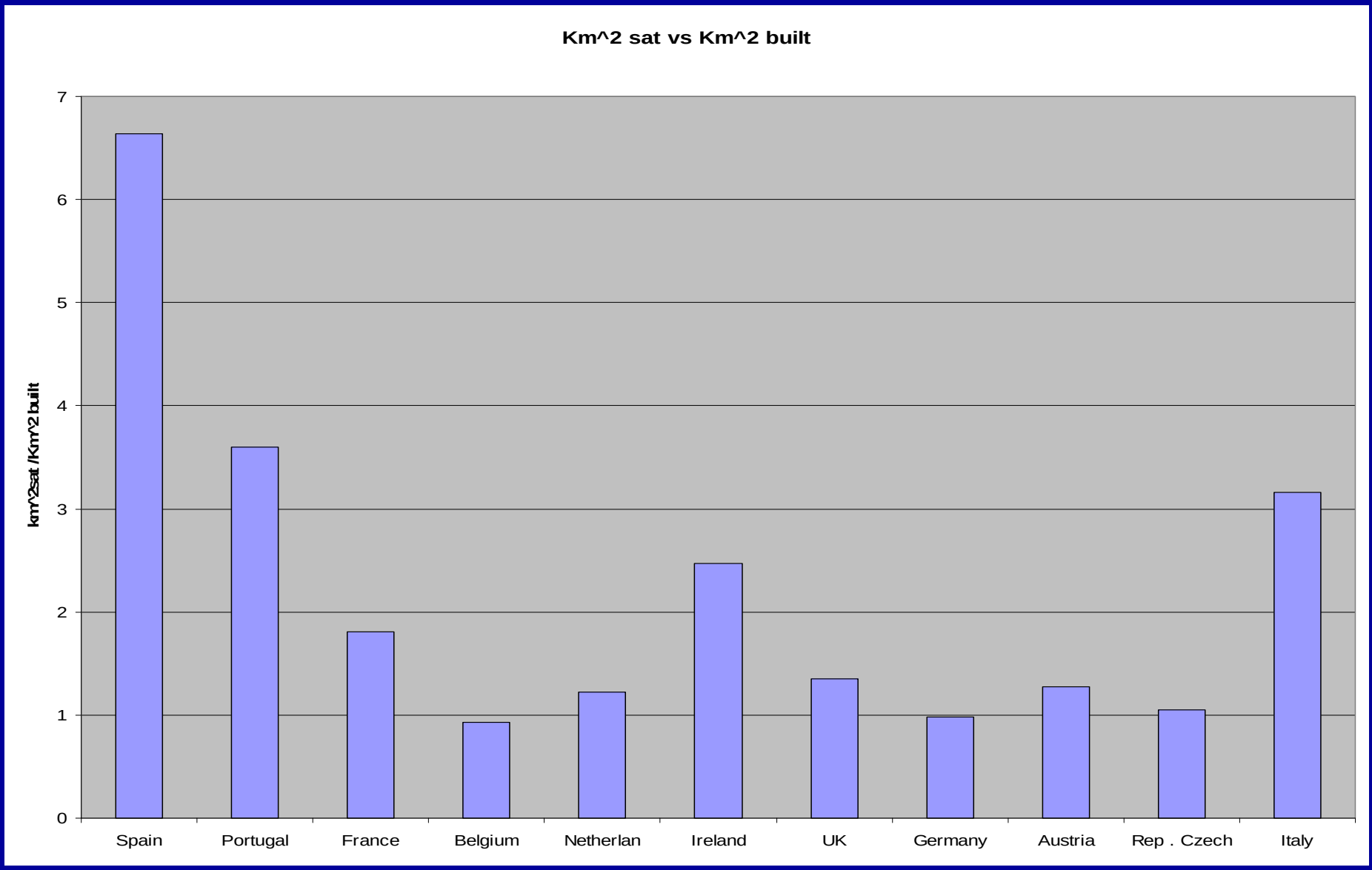
- Estimate demographic effects

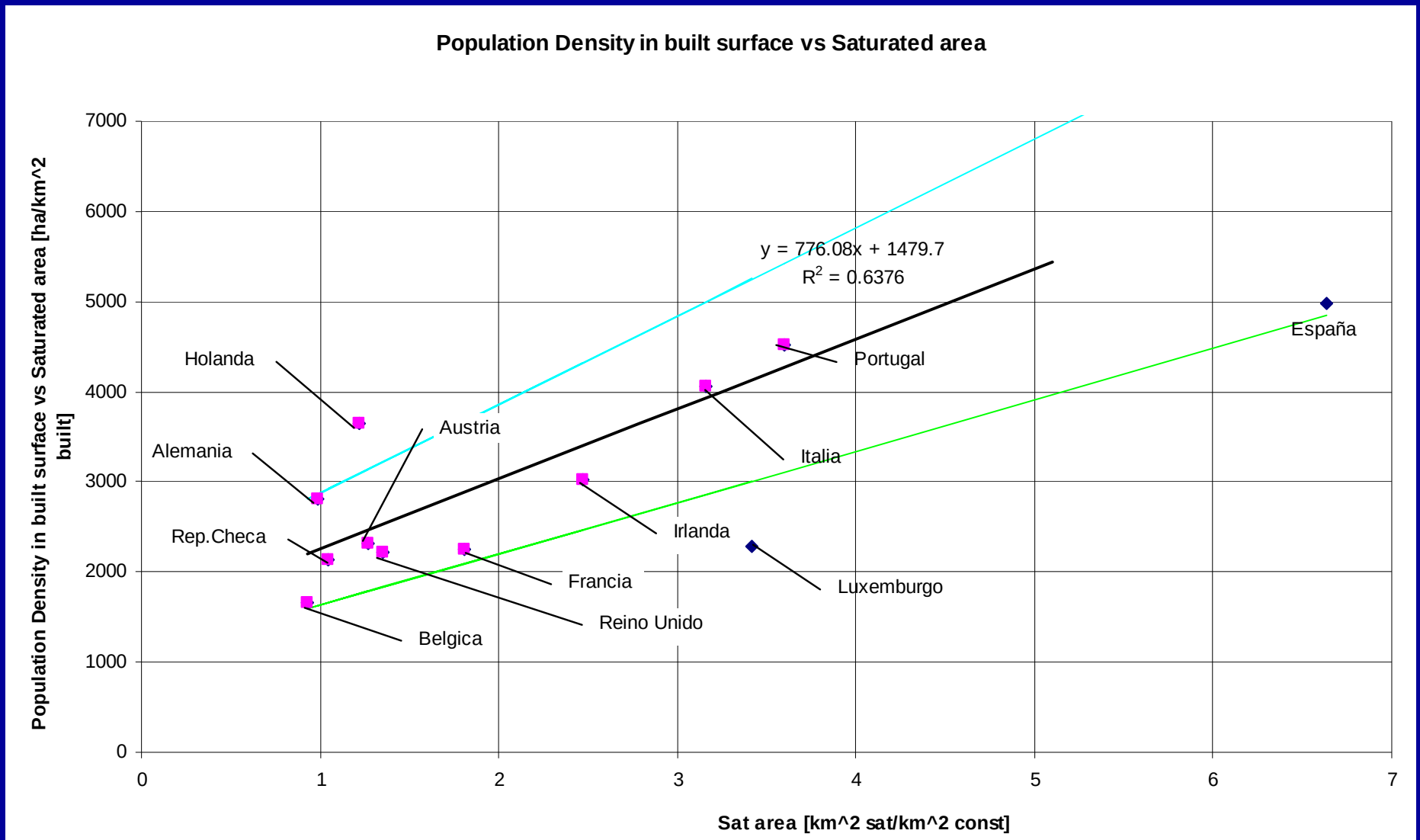


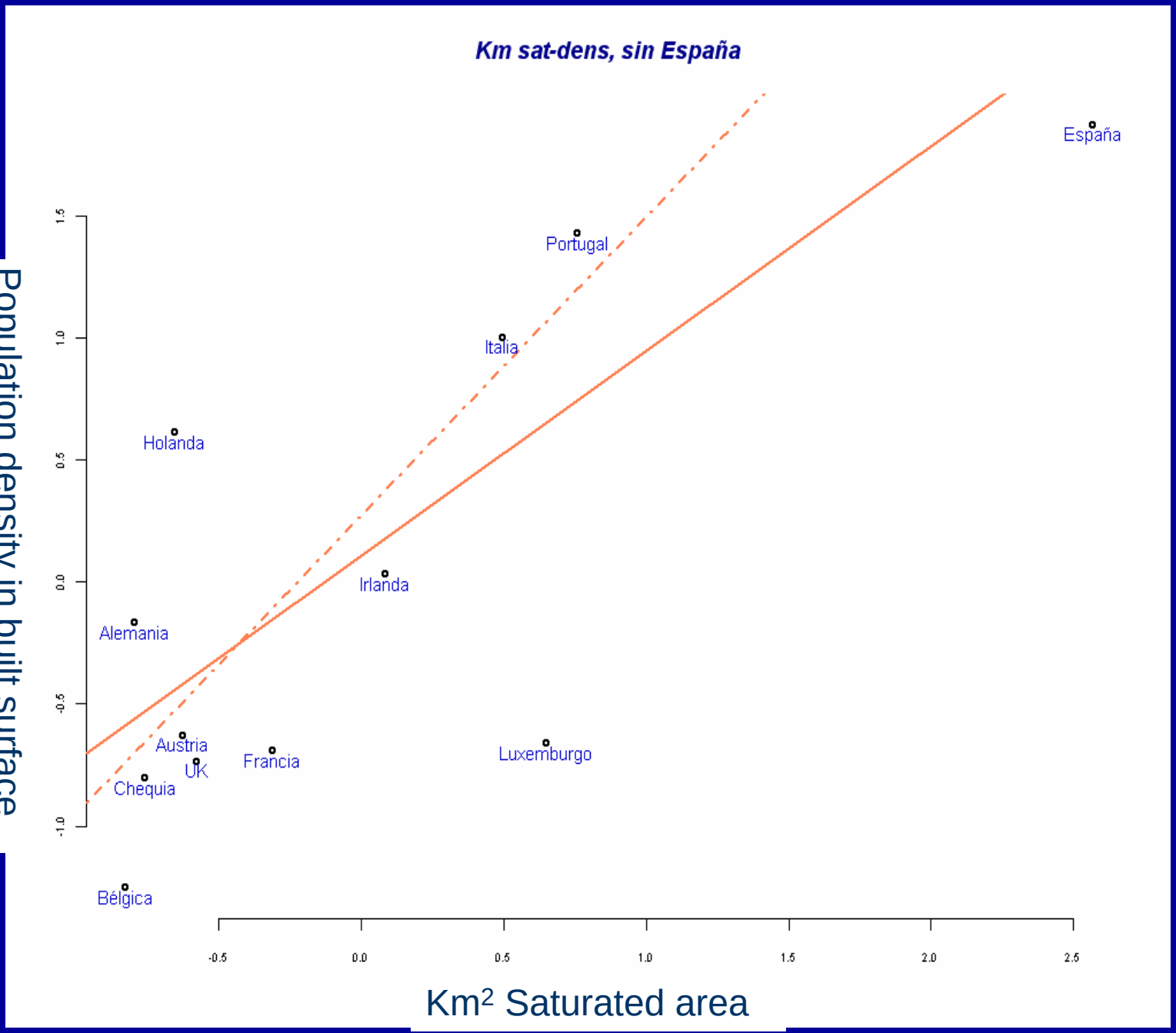
- Use of intensive parameters

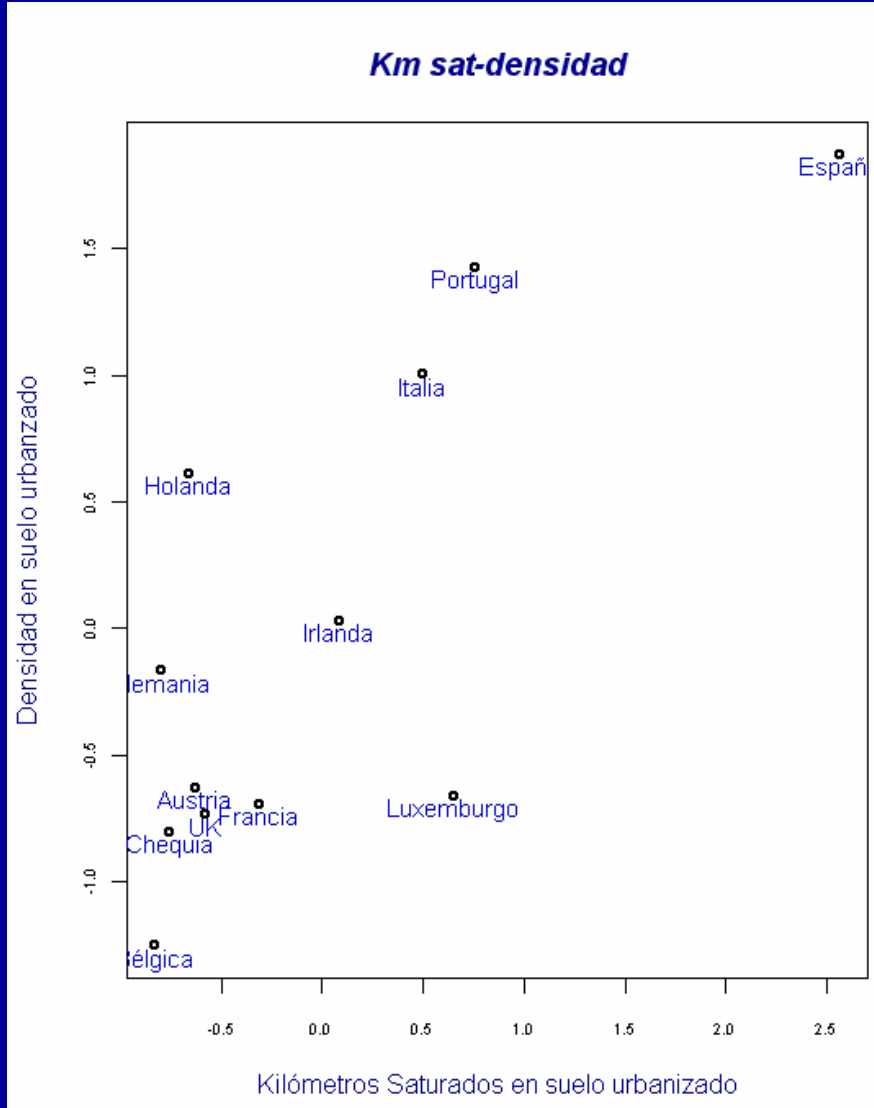


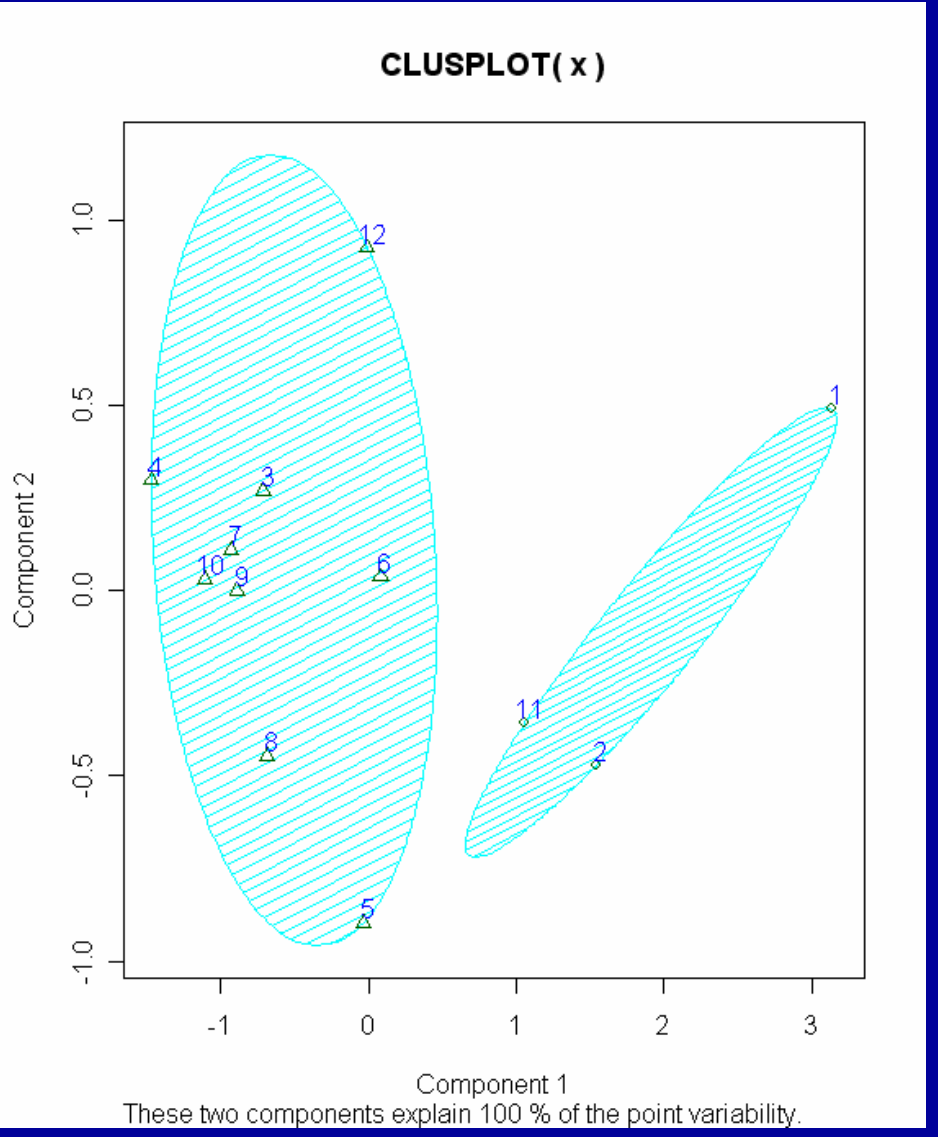
- Employment of parameters as: built area, population, power use and illumination.

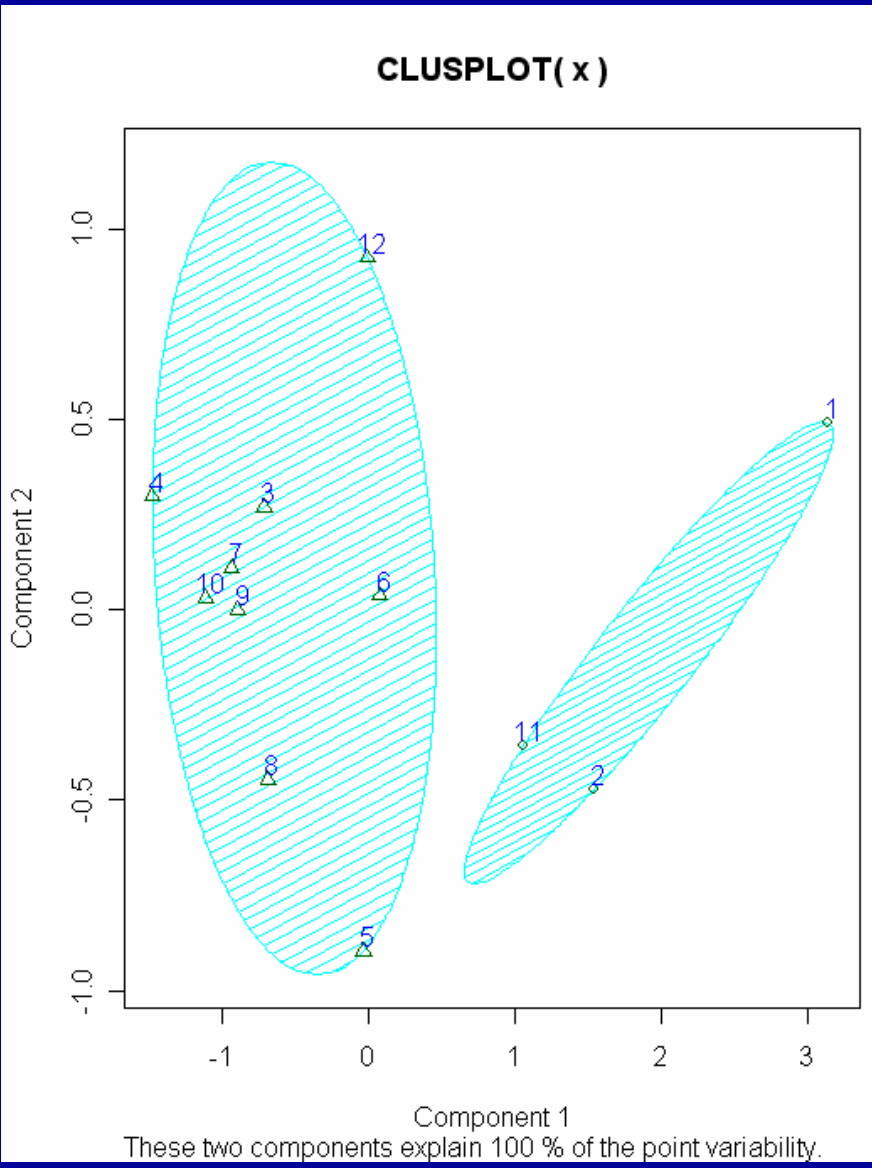

Km^2 sat vs Km^2 built
km^2sat /Km^2 built
0
1
2
3
4
5
6
7
Spain
Portugal
France
Belgium
Netherlan
Ireland
UK
Germany
Austria
Rep . Czech
Italy

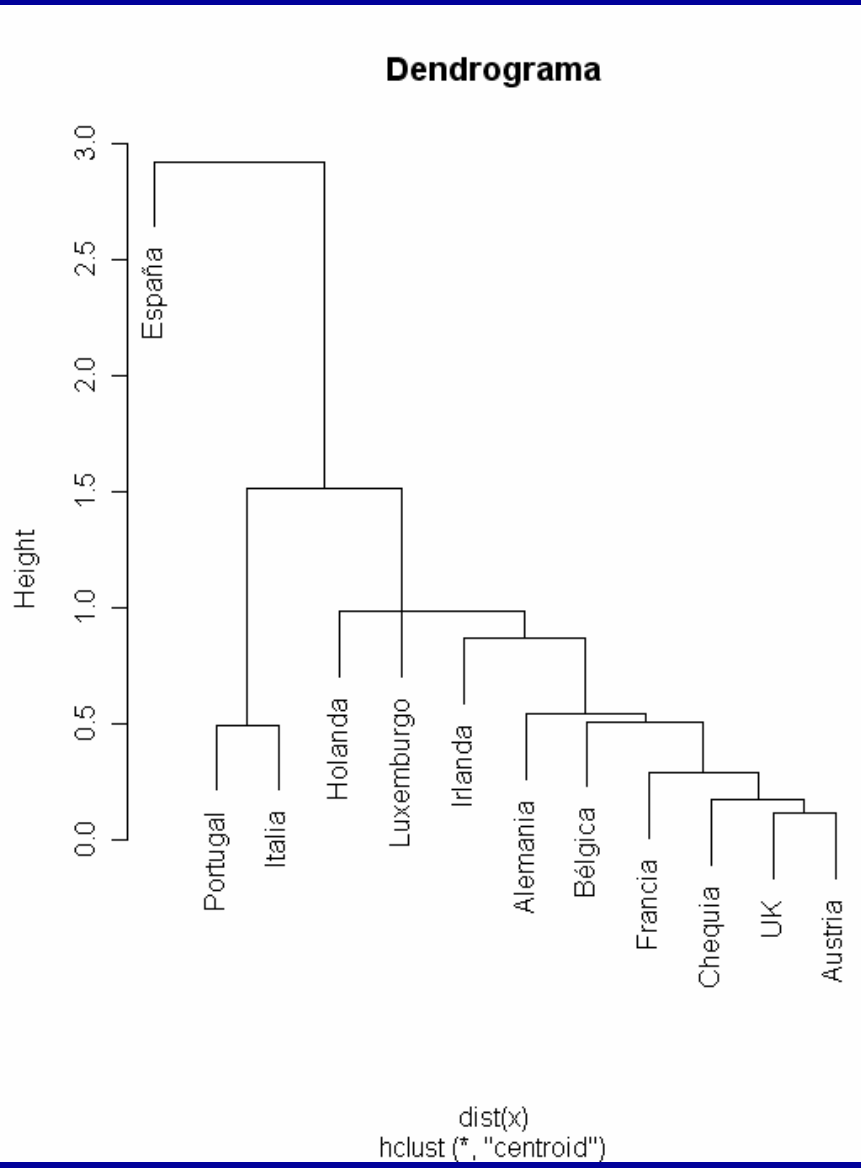

Population Density in built surface vs Saturated area
Population Density in built surface vs Saturated area [ha/km^2 built]
Sat area [km^2 sat/km^2 const]
y = 776.08x + 1479.7
R2 = 0.6376
Holanda
Austria
Alemania
Portugal
Italia
España
Rep.Checa
Irlanda
Francia
Luxemburgo
Reino Unido
Belgica
0
1000
2000
3000
4000
5000
6000
7000
0
1
2
3
4
5
6
7


Km sat-dens, sin España
España
Portugal
Italia
Holanda
Irlanda
Alemania
Austria
UK
Chequia
Francia
Luxemburgo
Bélgica
1.5
1.0
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Population density in built surface
Km2 Saturated area

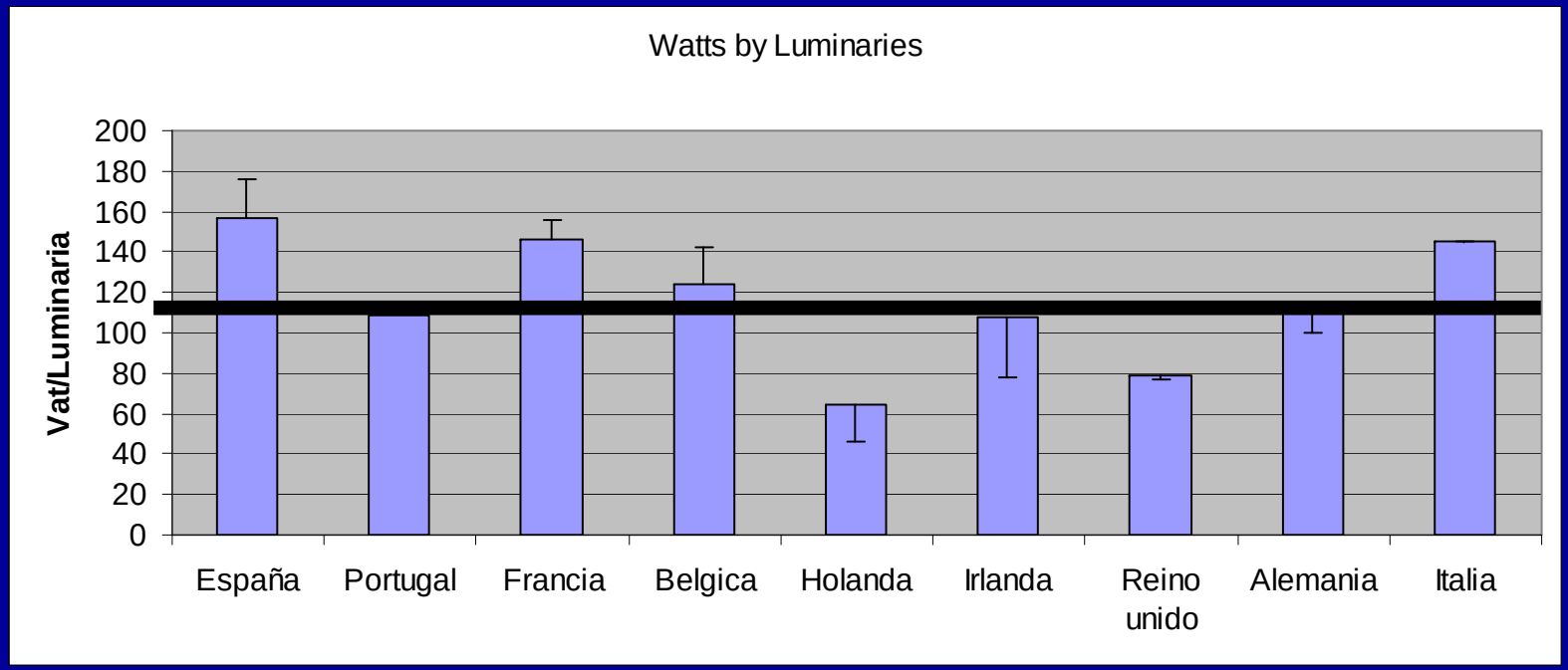

Km sat-densidad
Densidad en suelo urbanizado
Kilómetros Saturados en suelo urbanizado
Españ
Portugal
Italia
Holanda
Irlanda
lemania
Austria
UK
Francia
Chequia
Luxemburgo
élgica
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
-1.0
-0.5
0.0
0.5
1.0
1.5

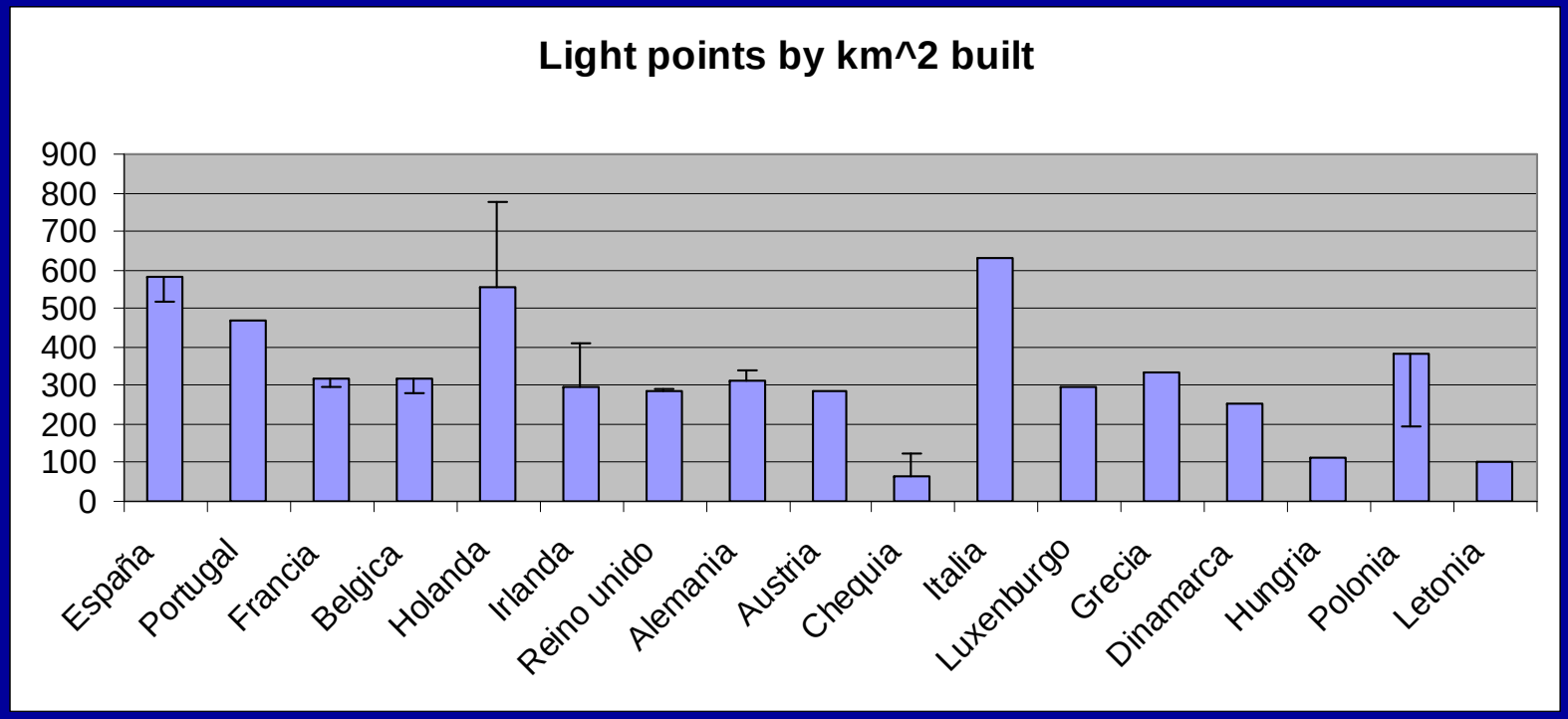

CLUSPLOT(x)
Component 2
Component 1
These two components explain 100 % of the point variability.
12
1
4
3
7
10
9
6
11
8
2
5
-1.0
-0.5
0.0
0.5
1.0
-1
0
1
2
3

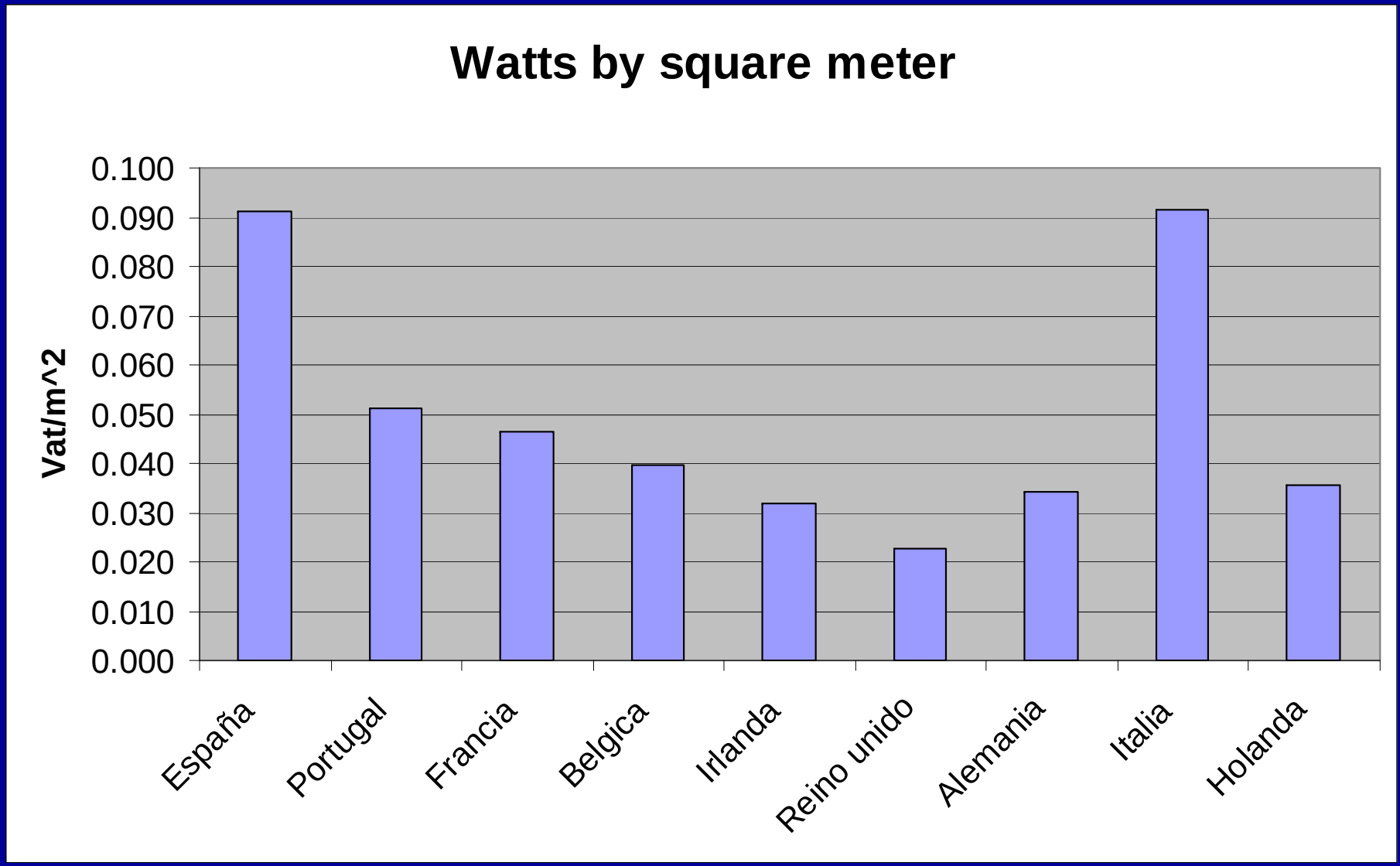

CLUSPLOT(x)
Component 2
Component 1
These two components explain 100 % of the point variability.
1
2
3
4
5
6
7
8
9
10
11
12


Dendrograma
Height
dist(x)
hclust (*, "centroid")
España
Portugal
Italia
Holanda
Luxemburgo
Irlanda
Alemania
Bélgica
Francia
Chequia
UK
Austria

Test of the results by other methods


Watts by Luminaries
Vat/Luminaria
200
180
160
140
120
100
80
60
40
20
0
España
Portugal
Francia
Belgica
Holanda
Irlanda
Reino unido
Alemania
Italia

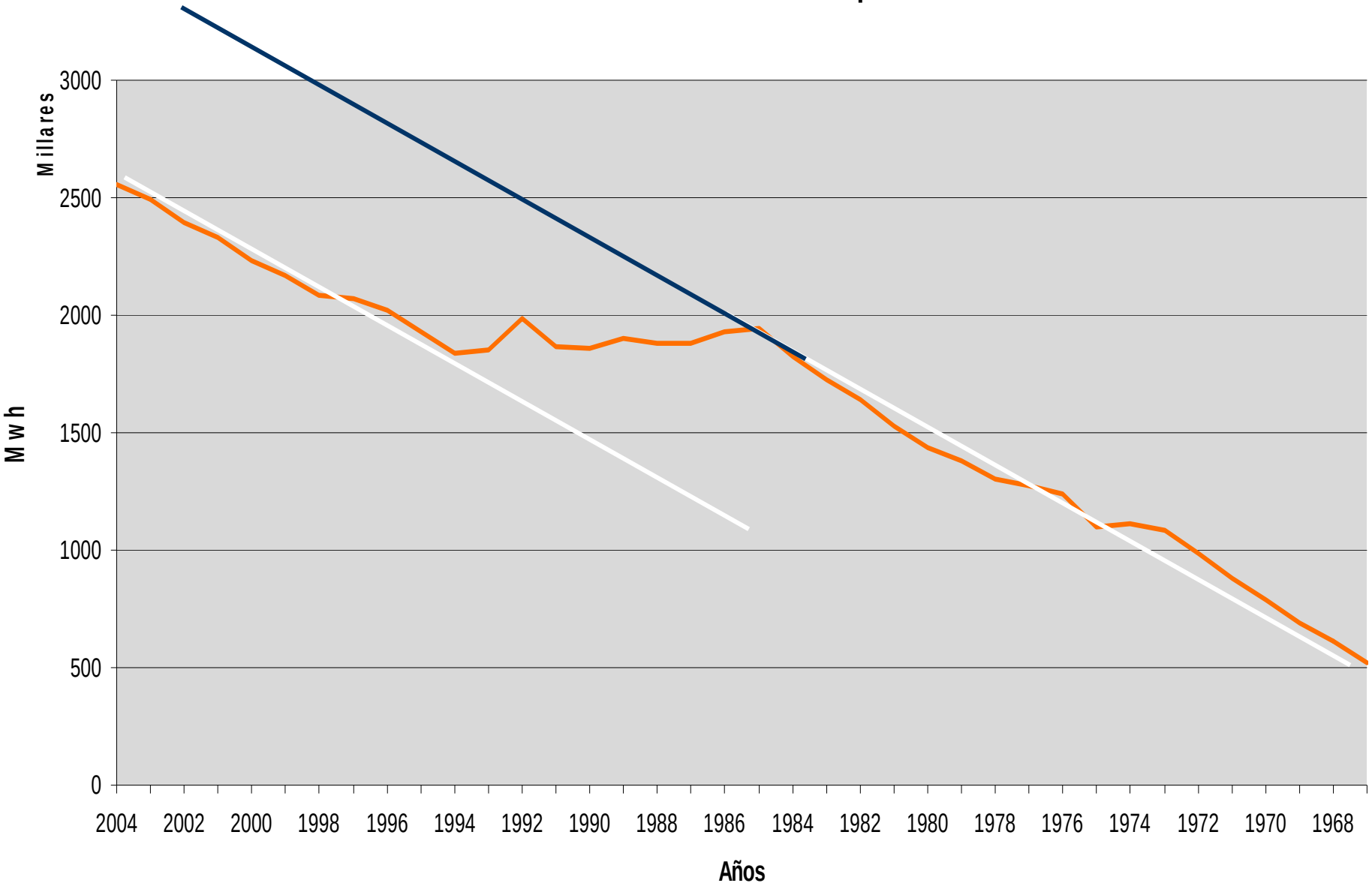

Light points by km^2 built
900
800
700
600
500
400
300
200
100
0
España
Portugal
Francia
Belgica
Holanda
Irlanda
Reino unido
Alemania
Austria
Chequia
Italia
Luxenburgo
Grecia
Dinamarca
Hungria
Polonia
Letonia

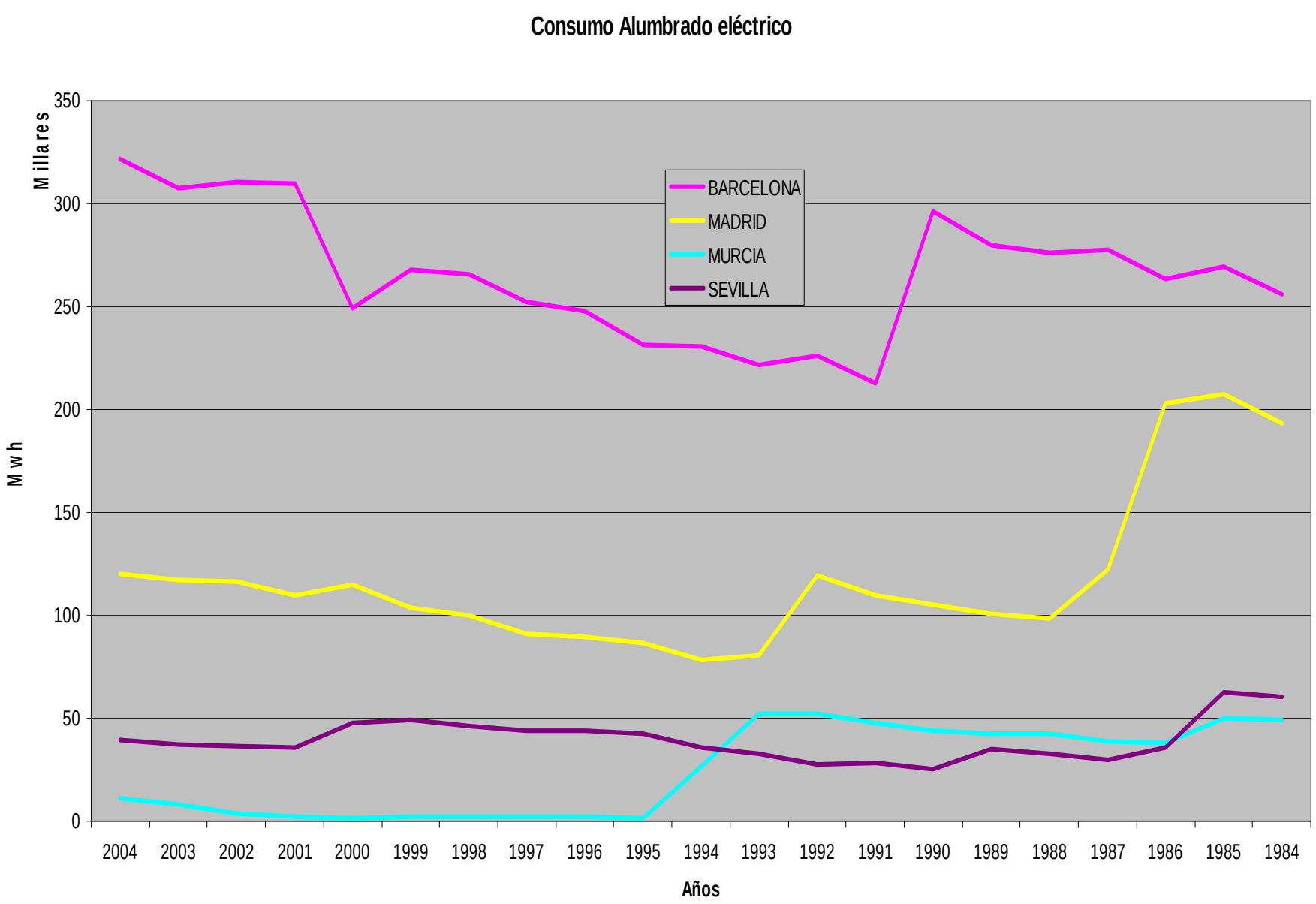

Watts by square meter
Vat/m^2
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
España
Portugal
Francia
Belgica
Irlanda
Reino unido
Alemania
Italia
Holanda

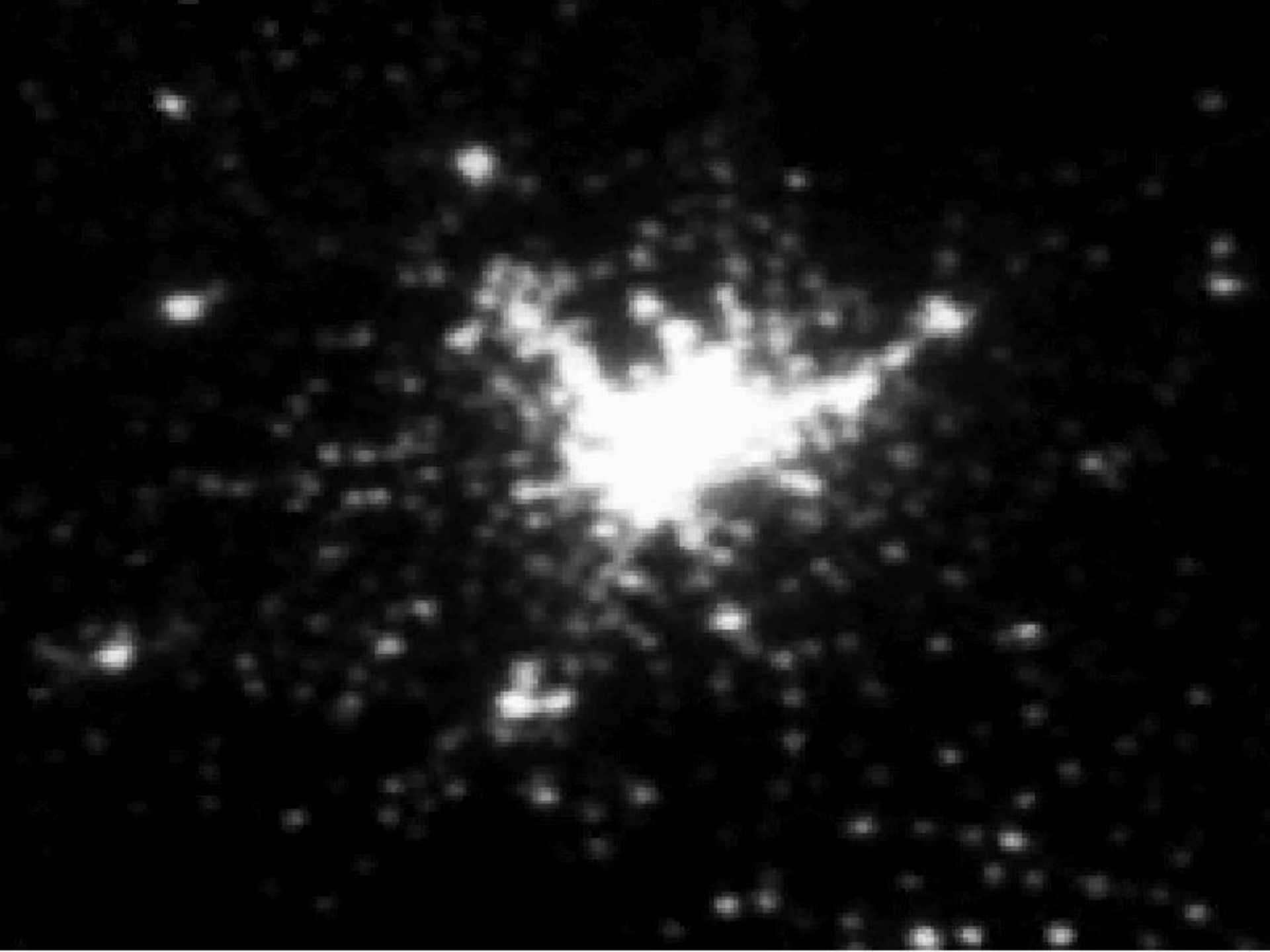
	España	Portugal	Francia	Luxenburgo	Belgica	Holanda	Irlanda	Reino unido	Alemania	Austria	Chequia	Italia
Área total construida	2%	3%	5%	75%	21%	13%	2%	11%	8%	4%	6%	5%
nº de farolas	4700000	1100000	8570000	61000	2005000	2500000	401000	7851000	9120000	1000000	300000	9000000
Farolas por habitante	0.12	0.10	0.14	0.13	0.19	0.15	0.10	0.13	0.11	0.12	0.03	0.15
Farola/km^2	580	468	318	32	321	552	299	286	311	284	63	629
km^2/farola	0.011	0.008	0.006	0.012	0.003	0.002	0.008	0.005	0.003	0.004	0.017	0.005
Área sat/persona	0.0013	0.0008	0.0008	0.0015	0.0006	0.0003	0.0008	0.0006	0.0003	0.0005	0.0005	0.0008
Área Saturada Porcentage	11%	9%	9%	27%	19%	16%	5%	15%	8%	5%	6%	15%
Km^ssat/km^2 urb	6.64	3.60	1.80	0.37	0.93	1.22	2.47	1.35	0.98	1.27	1.05	3.16
CO2 (1)	6.9	5.8	6	18.9	9.9	8.8	10.9	9.5	9.7	7.5	11.6	7.4
Vatios por luminaria	157	111	145		124	61	108	76	110			145
IEE*	0.911	0.510	0.463		0.398	0.356	0.320	0.226	0.341			0.915
Wat/m^2	0.091	0.051	0.046		0.040	0.036	0.032	0.023	0.034			0.091
Vatios Por persona	18.27	11.31	20.53		23.99	9.76	10.59	10.21	12.13			22.53

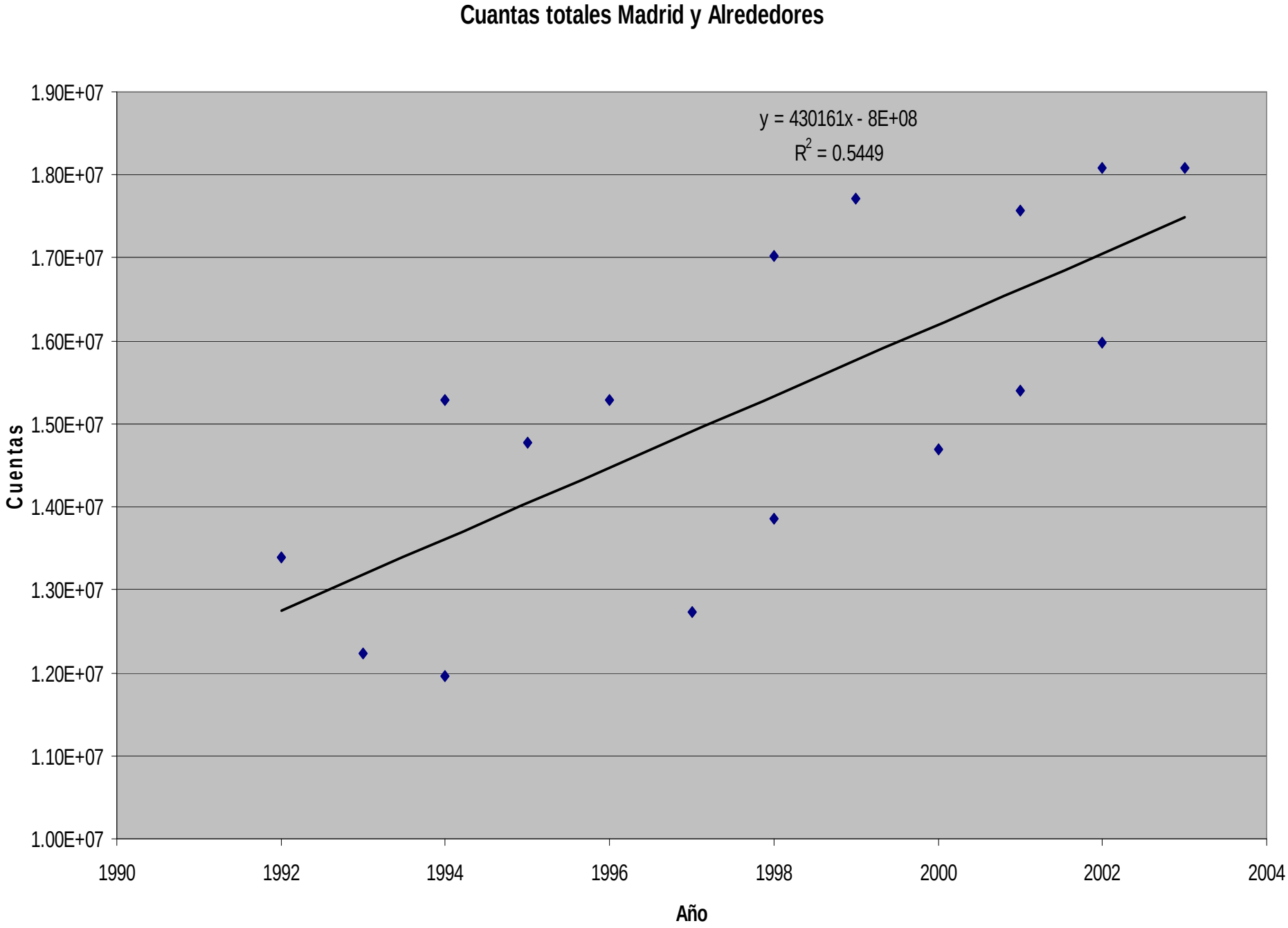
Spain analyses

Consumo en Alumbrado público




Consumo Alumbrado eléctrico
Millares
Mwh
350
300
250
200
150
100
50
0
BARCELONA
MADRID
MURCIA
SEVILLA
2004
2003
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990
1989
1988
1987
1986
1985
1984
Años




Cuantas totales Madrid y Alrededores
y = 430161x - 8E+08
R2 = 0.5449
1.90E+07
1.80E+07
1.70E+07
1.60E+07
1.50E+07
1.40E+07
1.30E+07
1.20E+07
1.10E+07
1.00E+07
Cuentas
1990
1992
1994
1996
1998
2000
2002
2004
Año

Resumen situación de España

- Crecimiento suelo artificial 27.9 % en 10 años.
- Crecimiento de la potencia instalada 39 % en 10 años.
- Crecimiento del la señal 34 % en 10 años.
- Según los últimos modelos de C.L. la difusión secundaria es muy importante. Implica que el efecto de las fuentes indirectas es mucho más importante.
- (**M. AUBÉ 2007**)

Conclusions and future work

Conclusions

- With the present data Spanish illumiation can not be explained by demographic causes.
- There is important evidence of excessive waste in Italy.
- The population density in built land as intensive data is the best global parameter in order to represent the saturation of a country.
- An appropriate ilumination can be shown in satellite images.

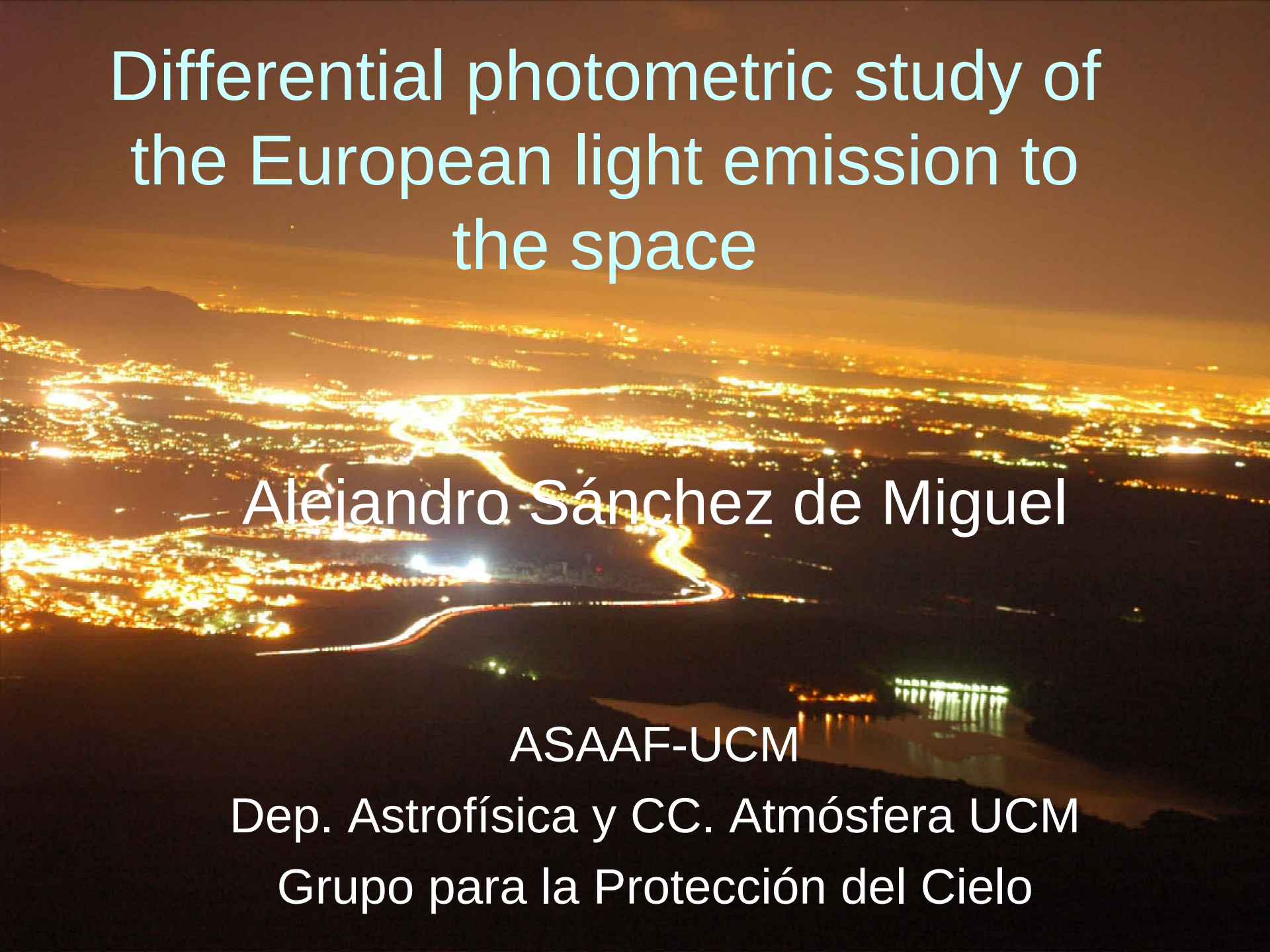
Future work

- It is needed further data of all the countries considered in the study. ¡¡¡¡¡HELP US!!!!!

- Extend this study to all European countries, EEUU and Japan.
- Search of an illumination model useful to countries in development.

- Discussion of hypothesis about the type of light polluting sources.

Differential photometric study of the European light emission to the space



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