



Vulnerability Assessment to Extreme Heat in the Lisbon Metropolitan Area - an attempt of spatial modeling.

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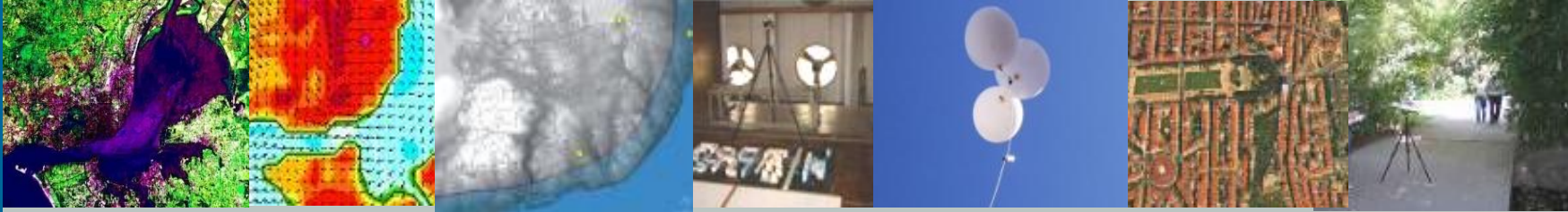


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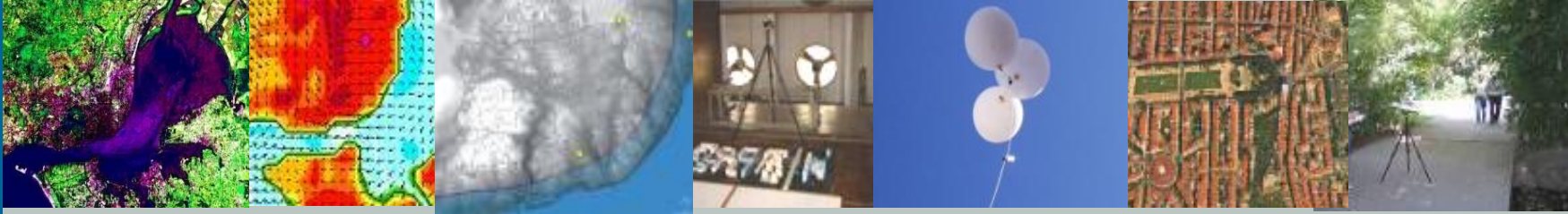


Center for Geographic Studies
and Spatial Planning



Presentation outline

- 1 – Introduction: Extreme Heat and Mortality**
- 2 – Thermal Extremes Risk Conceptual Model**
- 3 – Modelling Vulnerability to Heat:**
 - Mortality Rates**
 - Standard Mortality ratios**
- 4 – Conclusions**



1 – Introduction: Extreme Heat and Mortality

Severe impacts of heat waves on mortality

During 2003 Europe heat-wave:

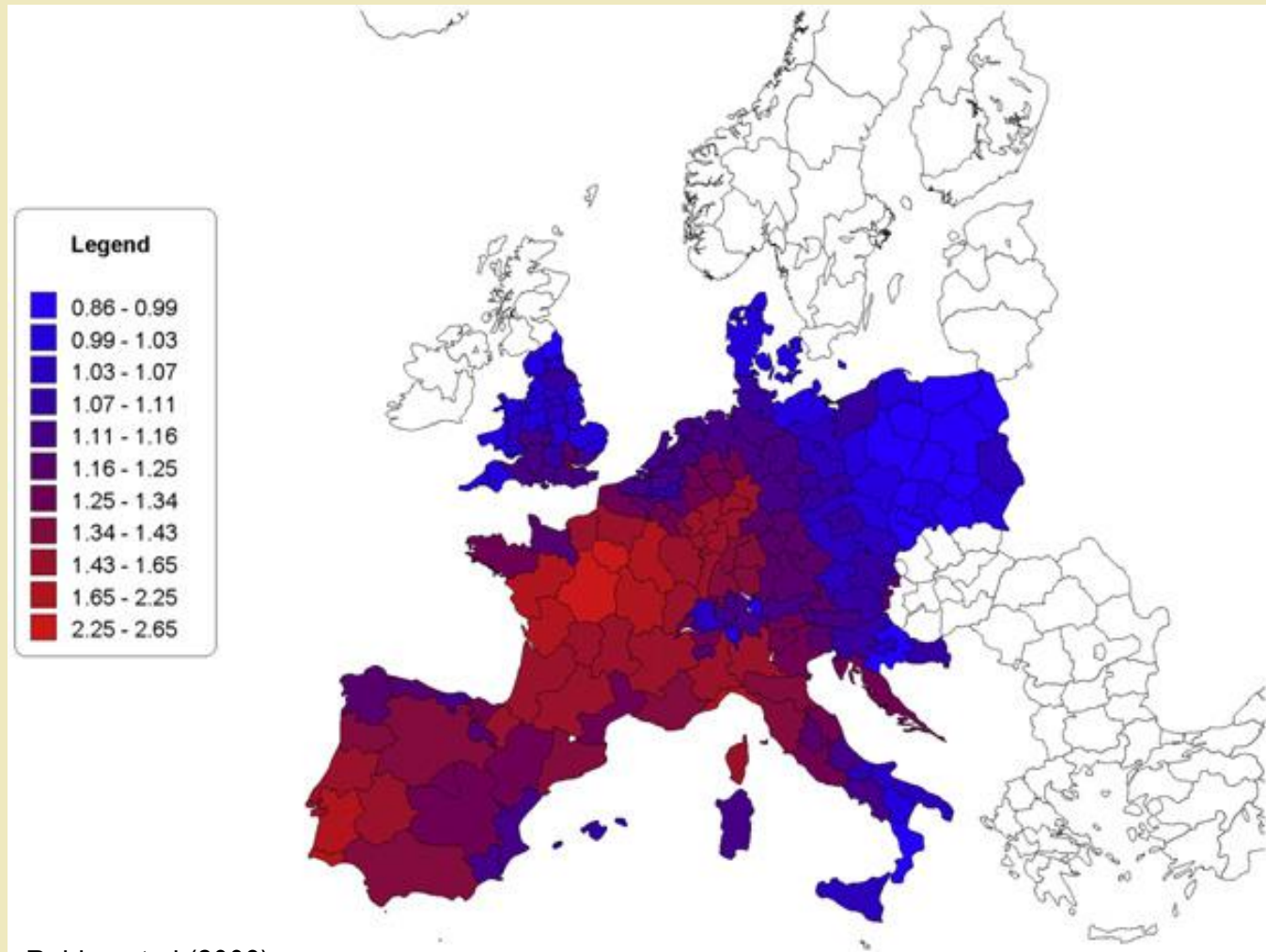
- More than 70 000 deaths attributed to heat (Robine et al 2008)**

In Portugal:

- More than 2100 deaths**

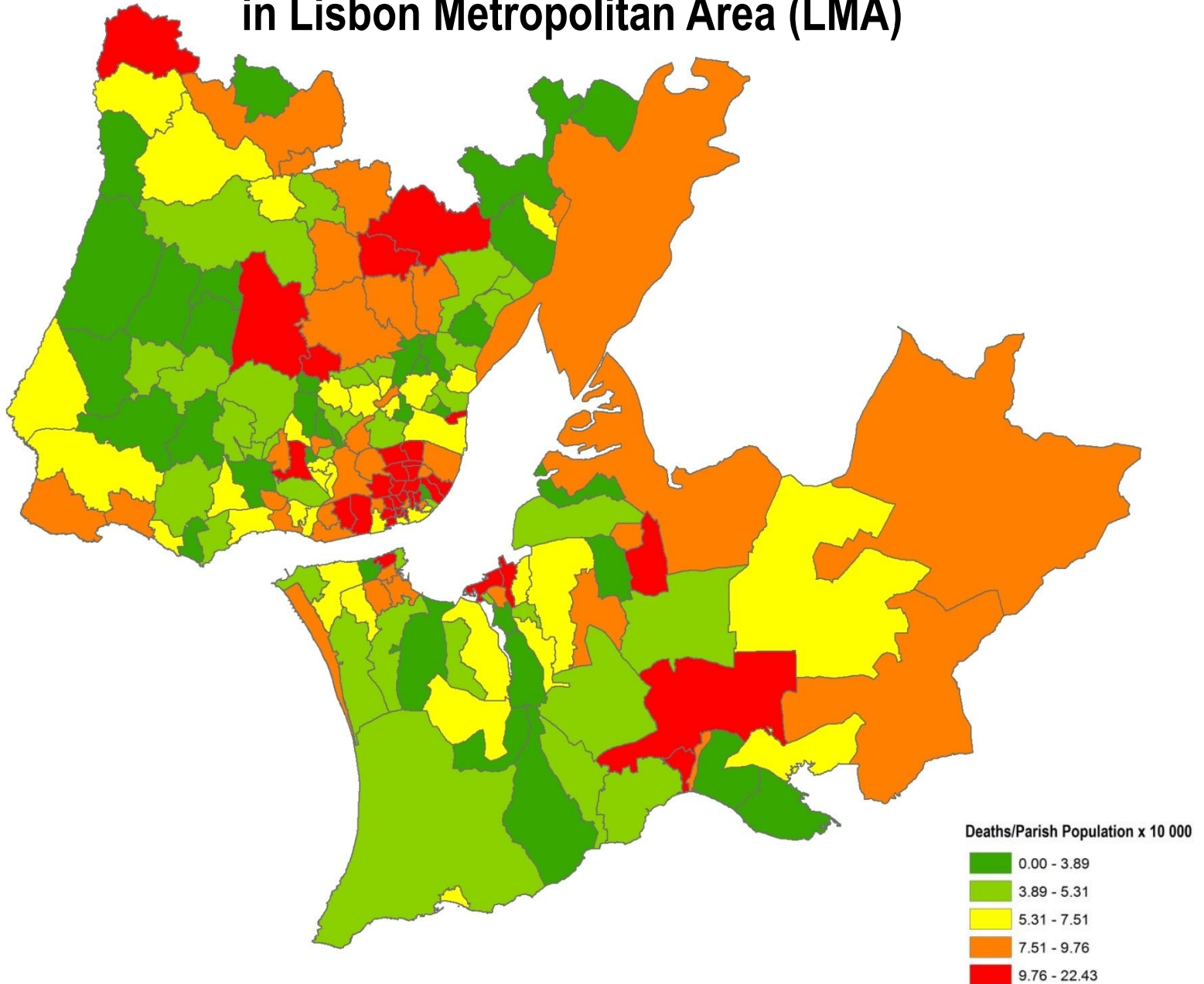
But the spatial distribution of mortality was not uniform...

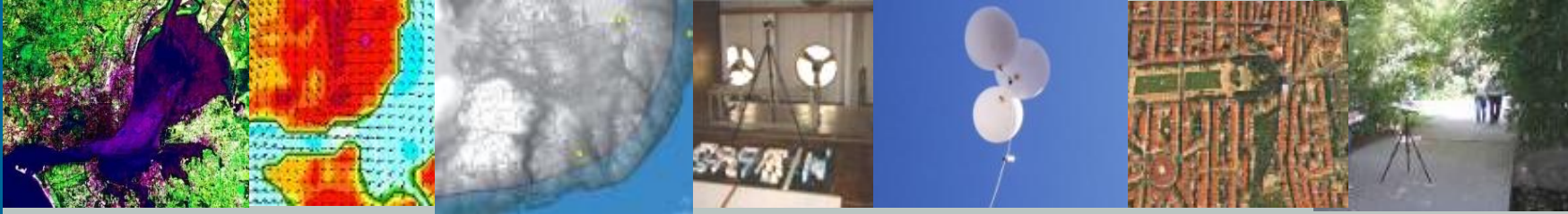
Mortality in Europe during the heat wave of 2003



Robine et al (2008)

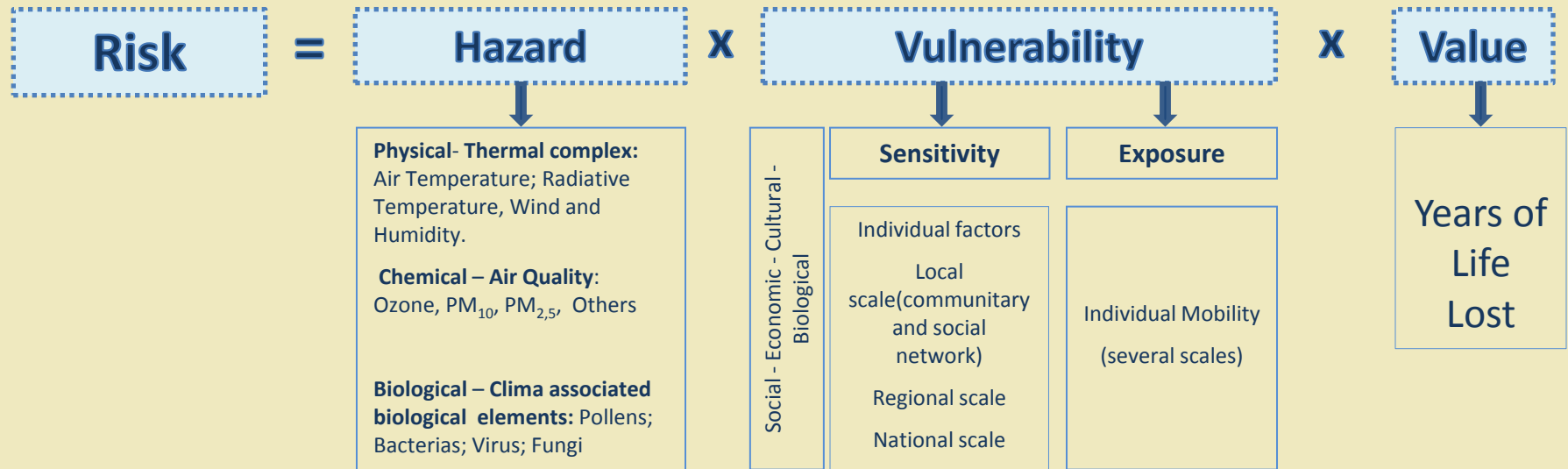
Mortality ratio during August 2003 heat wave in Lisbon Metropolitan Area (LMA)





2 – Thermal Extremes Risk Conceptual Model

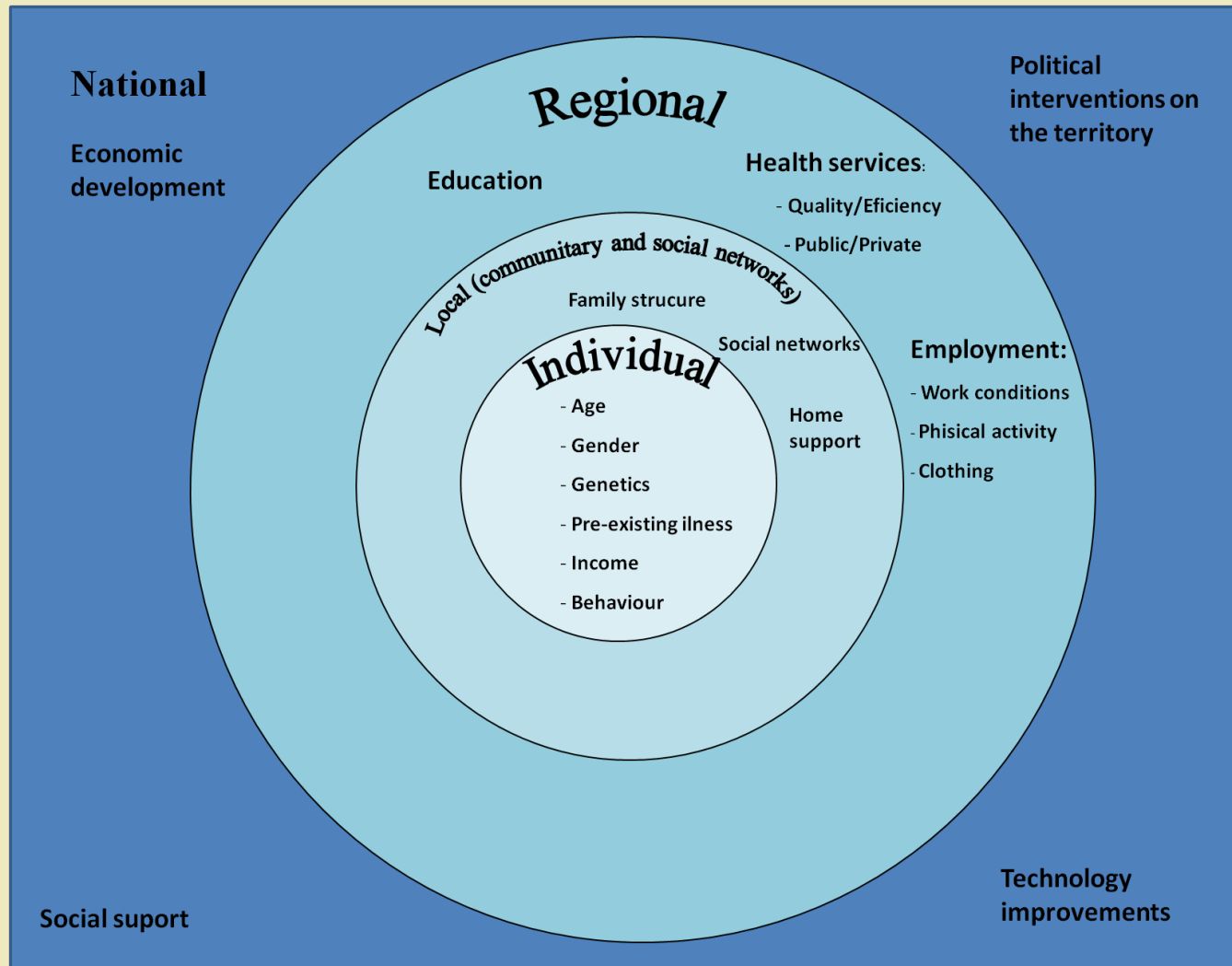
Thermal Extremes Risk Conceptual Model



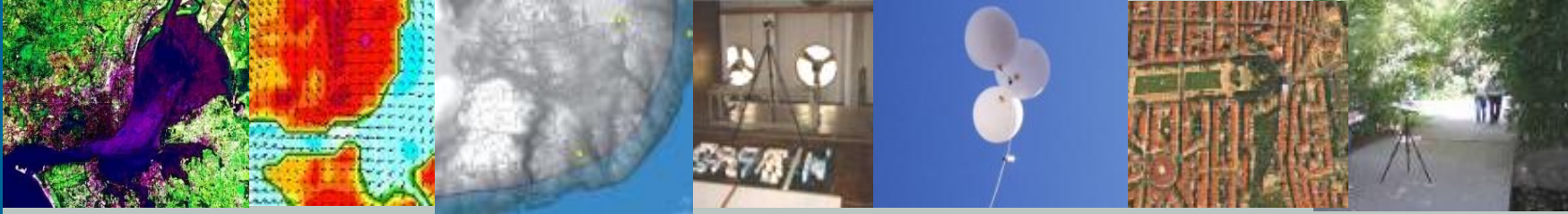
(Zêzere et al, 2008; Canário, 2010)

- Current situation and future projections

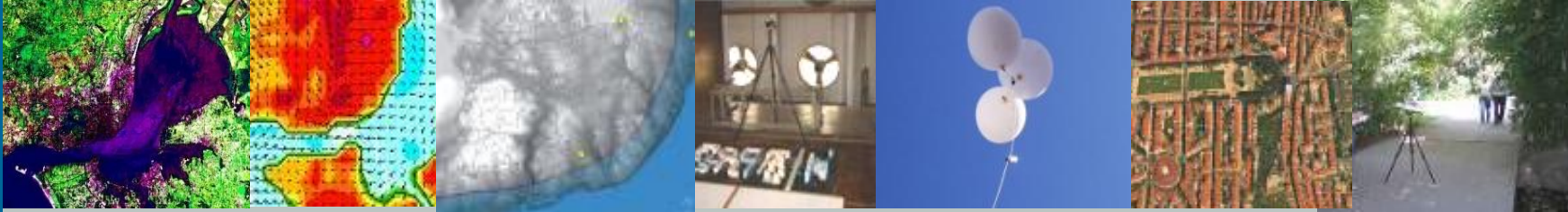
Vulnerability: Sensitivity assessment



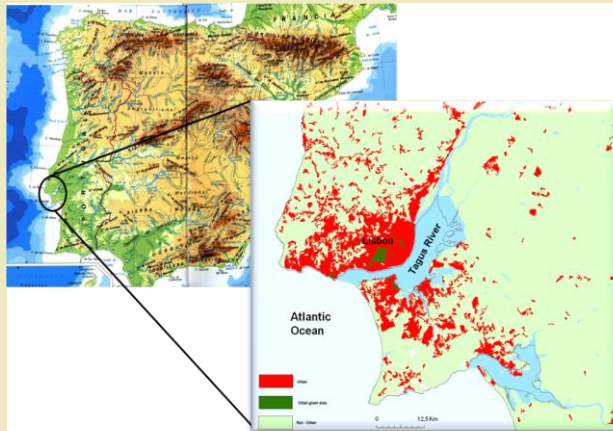
- Building personal indexes (physical, psychological and behavior features)
- Building socio-economic and demographic indexes integrating different variables at different scales



3 – Modelling Vulnerability to Heat

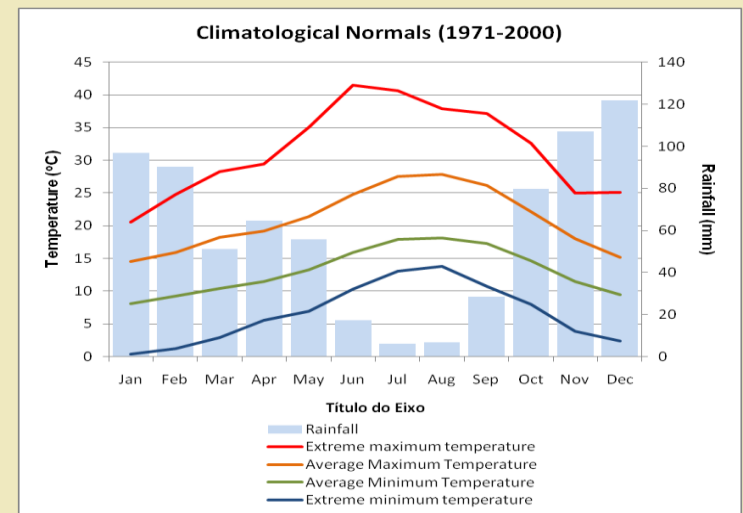


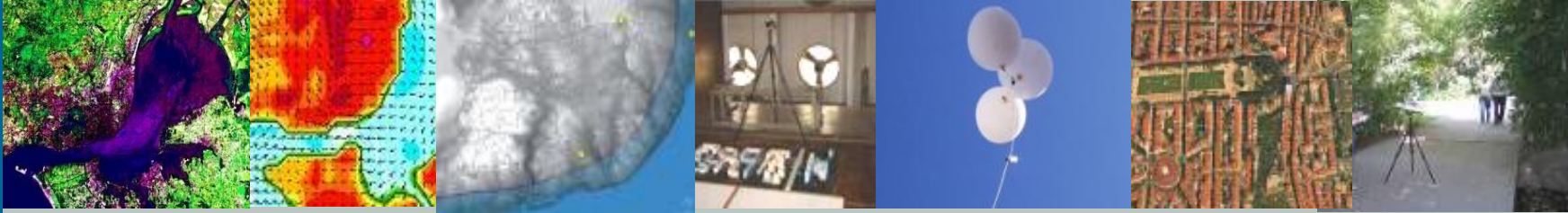
Lisbon Metropolitan Area



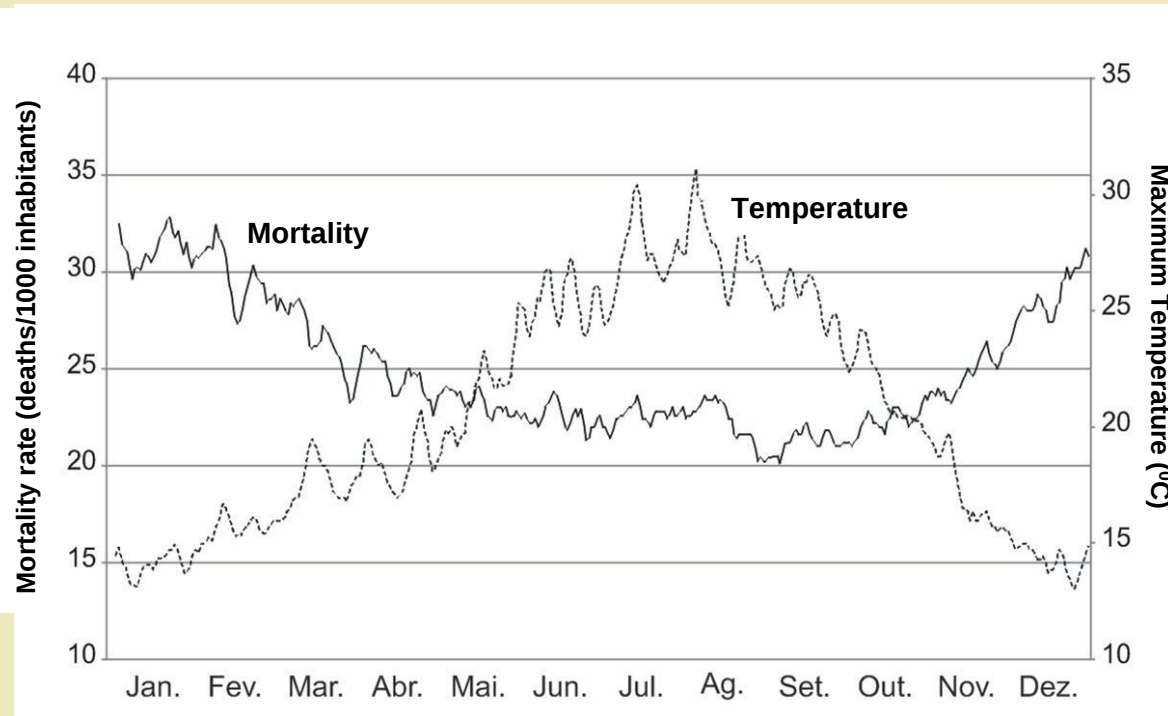
The Lisbon Metropolitan Area (LMA) is located in the central western region of Portugal, surrounding the estuary of Tagus river. It's an administrative region encompassing eighteen municipalities with a population of about 2 800 000 inhabitants. A progressive population ageing has been registered since the last two decades (17.6% are over 65 years of age).

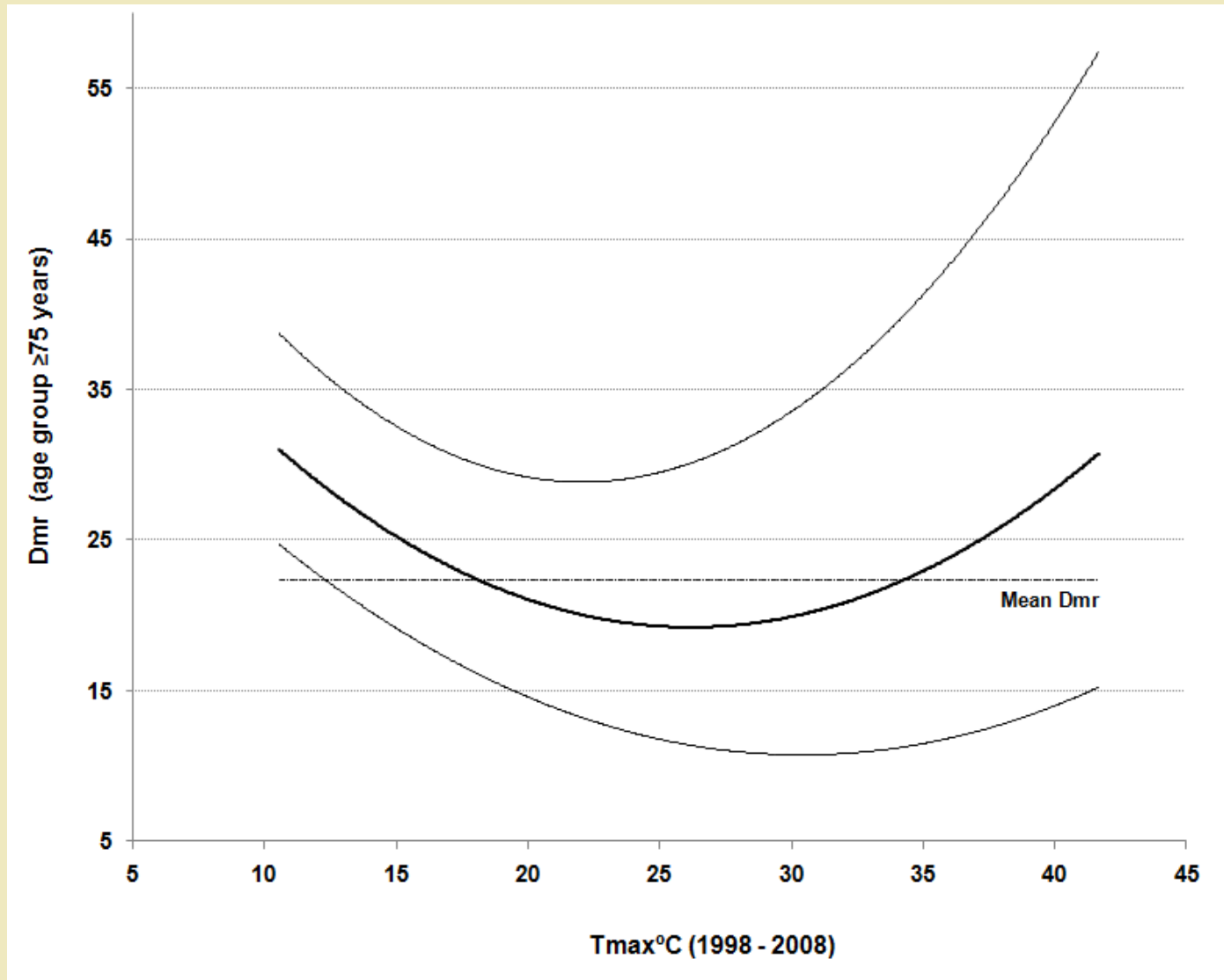
LMA has a Mediterranean climate, with mild winters and hot and dry summers. Mean maximum temperature of the hottest month (August) is 27.8°C and mean minimum temperature of the colder month (January) is 8.1°C (Climatological normals 1971-2000, IM).





Lisbon Metropolitan Area



Plot of mortality for elderly (≥ 75) against maximum temperature (1998 – 2008)

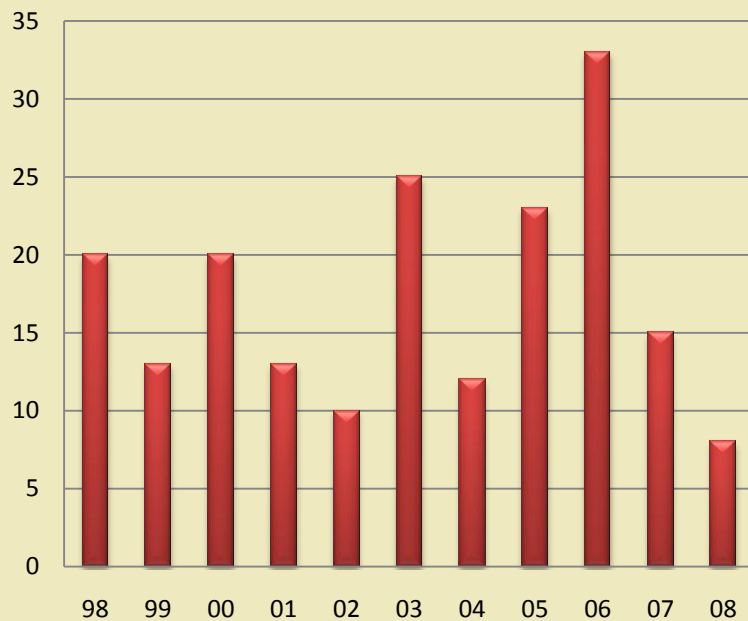
$$Txmort = 4.171 - 0.0531t_{max} - 0.0442t_{min} + 0.0136DMTm + 0.0450Dif2semtmi + 0.0013T_{max}^2$$

Source: INE

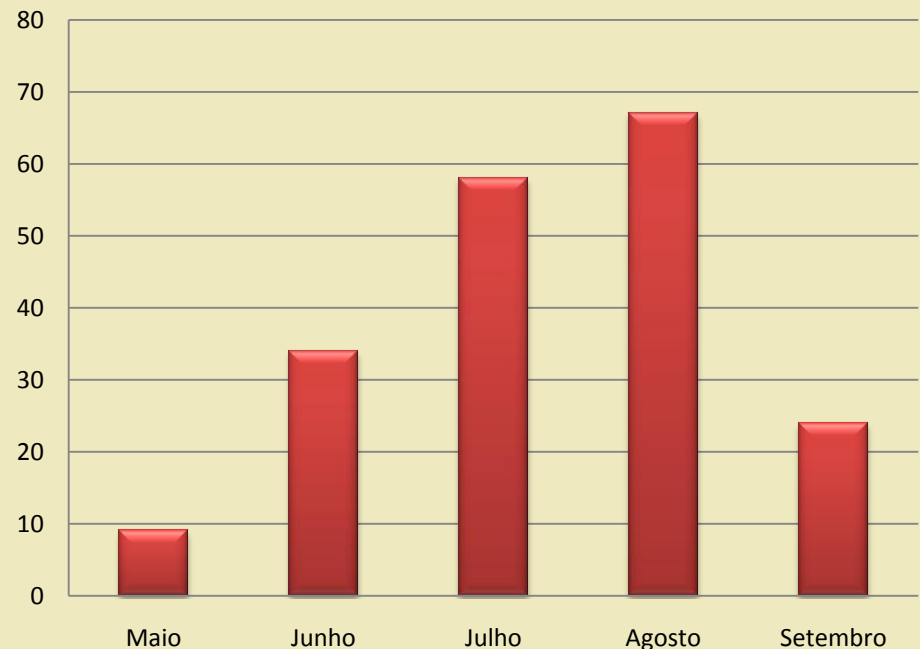
Vulnerability assessment

- 192 days with T.Máx > 32°C were selected in Lisboa/Gago Coutinho - May to September (Nogueira e Paixão, 2008)

Days with T.Máx > 32°C



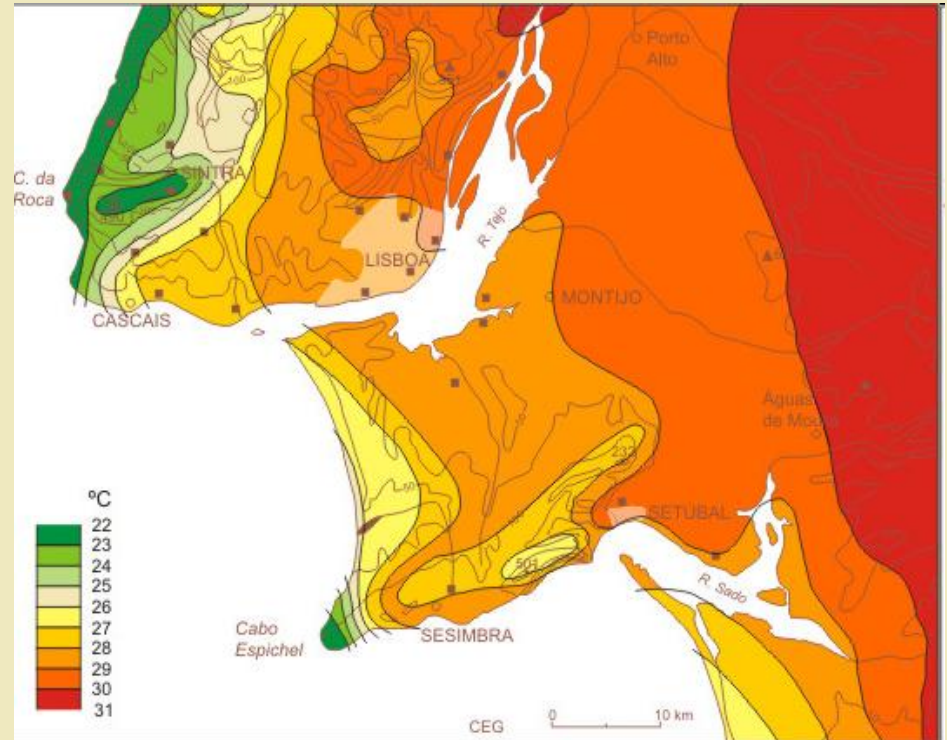
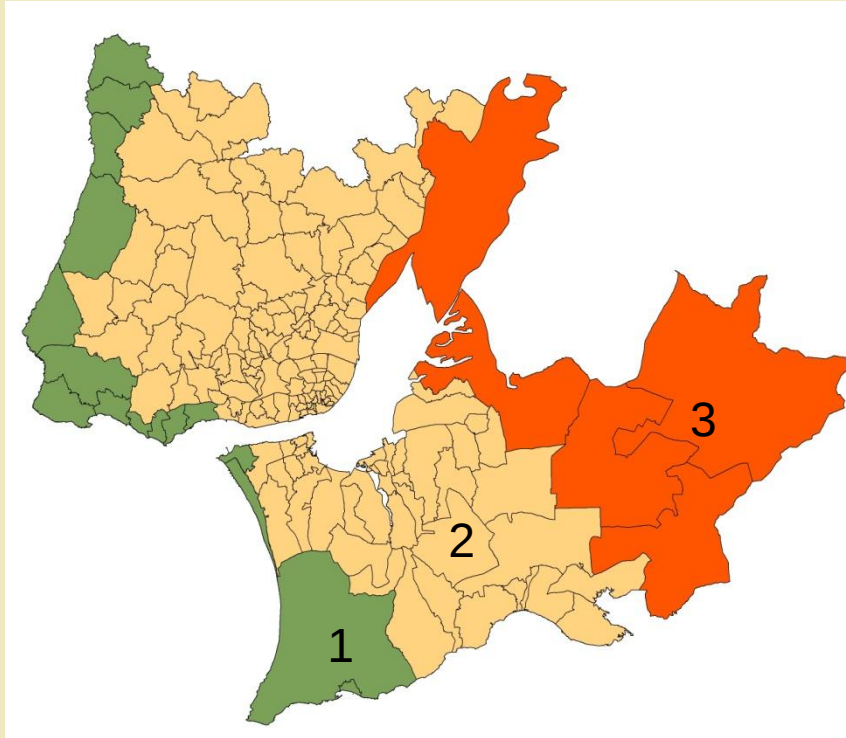
Days with T.Máx > 32°C



Higher T.Máx = 41.7 °C (01/08/03)

Daily average excess mortality of 6 deaths

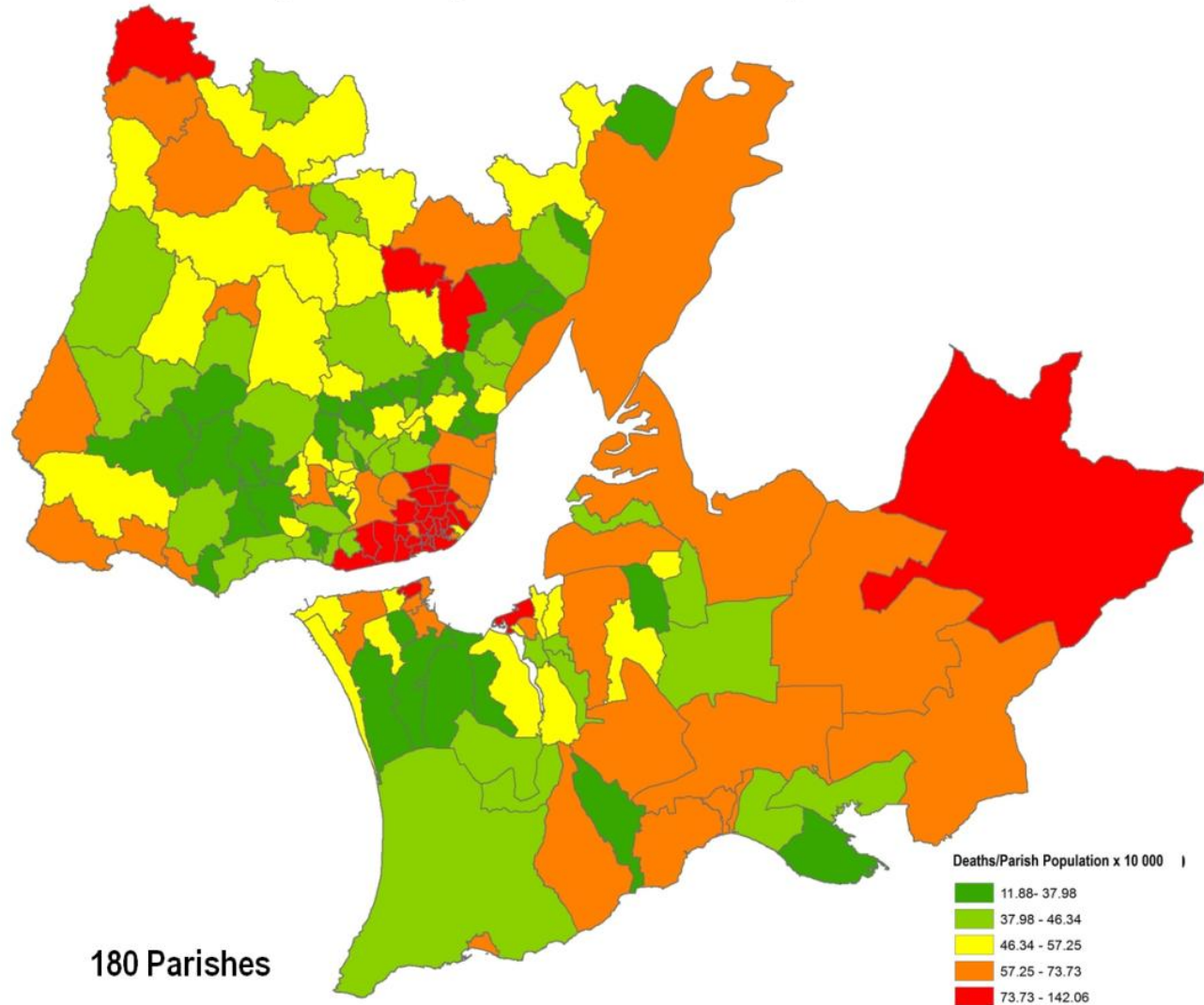
Thermal bands



Average maximum temperatures (1961-1990)
(Alcoforado e Dias, 2002)



Mortality rates – days with maximum temperature $> 32^{\circ}\text{C}$



Vulnerability assessment*

- Demographic indicators (% elderly , % widowed, population density, etc)
- Educational Indicators(iliteracy rate, %pop. with college degree, etc).
- Socio-ecomic indicator (average income, % people living in institutions, % people living in the dependency of social support, % % more socially valued professions, sociomaterial deprivation index – Nogueira, 2007).
- Urban indicators(building density, building age).
- Health indicators (distance to hospitals, etc).



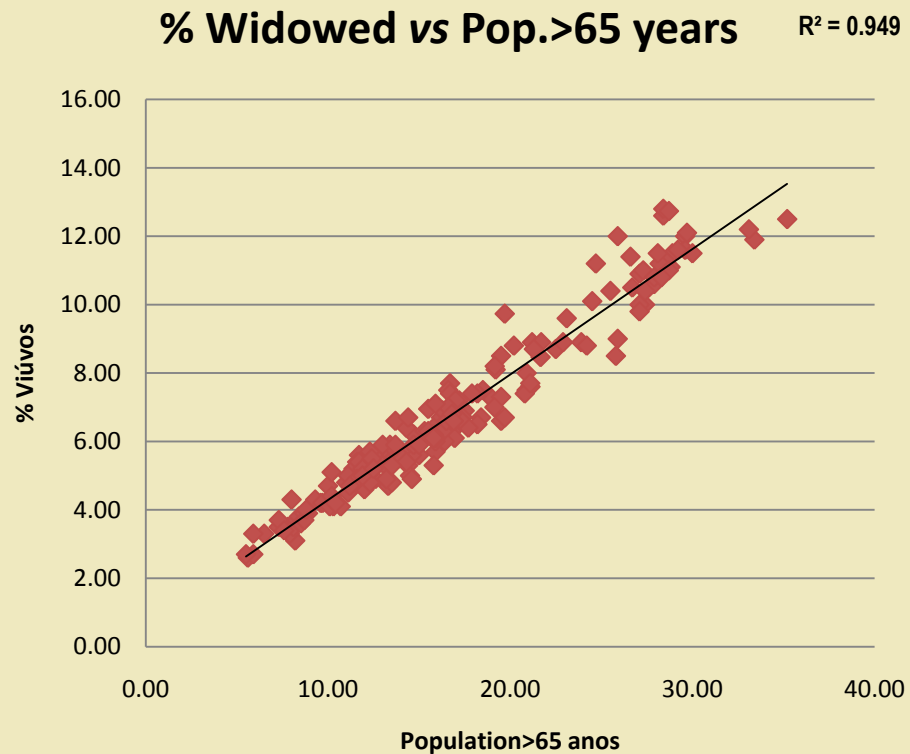
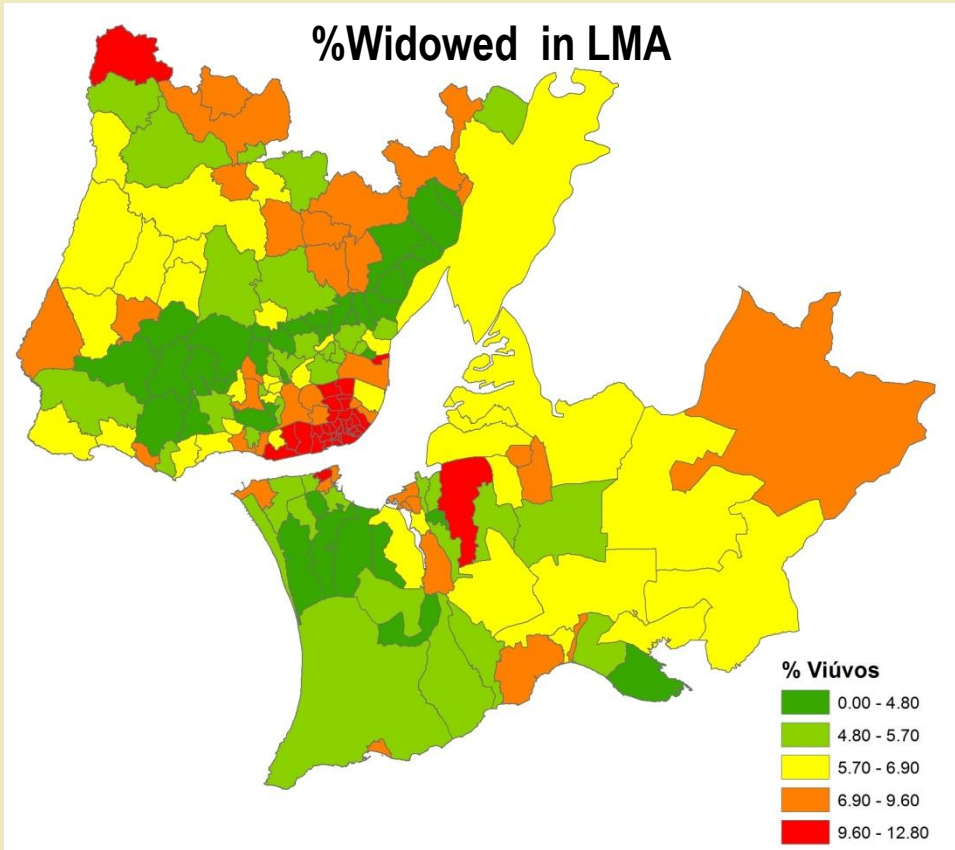
Multiple regression – Mortality rate vs Indicators

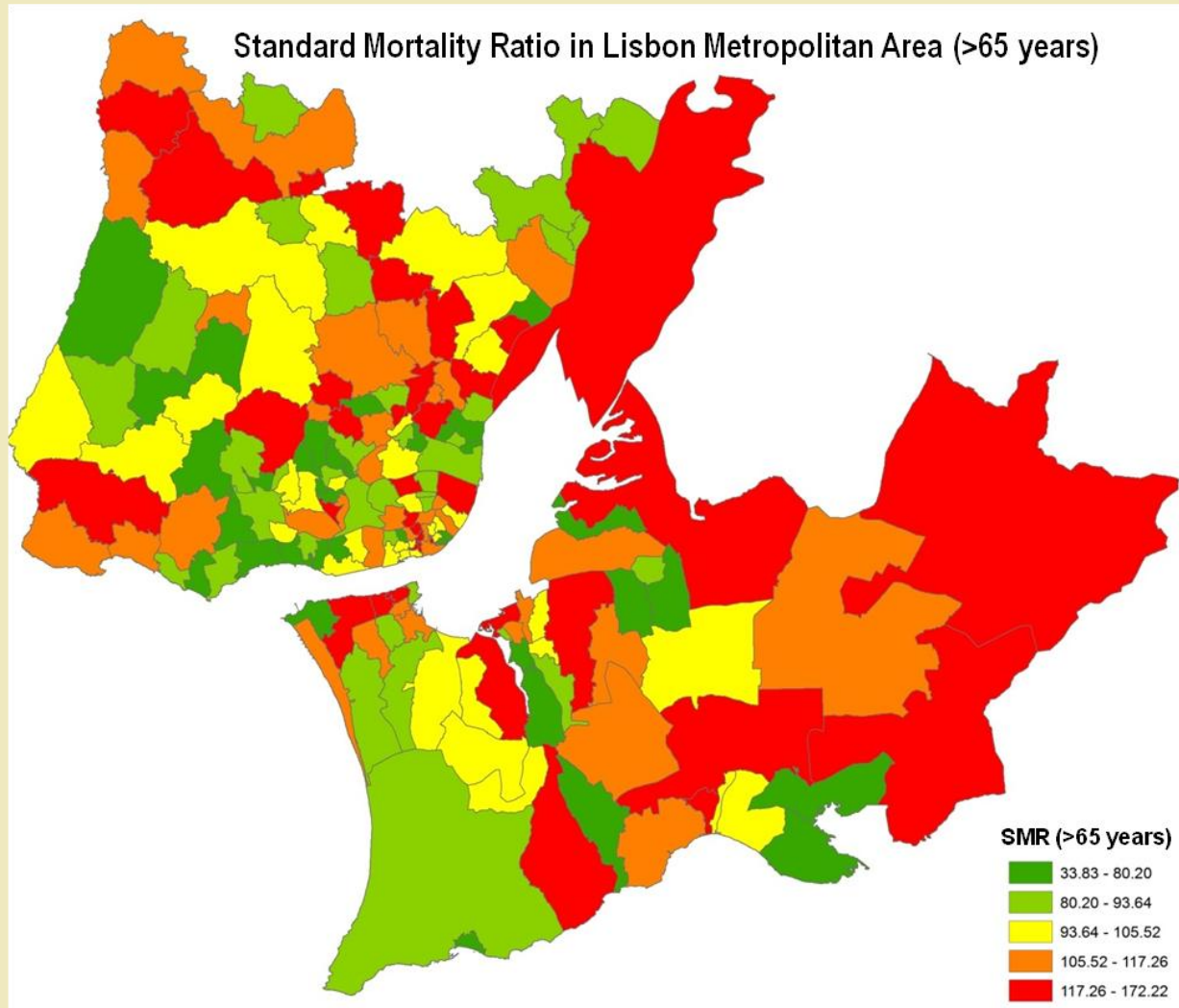
- 23 indicators tested

Regression Summary for Dependent Variable: Mortality Rate
 $R = .89214337$ $R^2 = .79591979$ Adjusted $R^2 = .78247738$

	Beta	p-level
% Widowed	0.454066	0.021752
Density of buildings (n°/km ²)	0.392278	0.000037
Population Density (hab/km ²)	-0.293228	0.005125
% Institutionalized population (social support and health)	0.080330	0.041112

Distribution and relationship of widowed population and elederly population in LMA





$$SMR = (O_r / O_{er}) \times 100$$



Discriminant Analysis

- SMR values classified in three classes:

High Mortality - a	SMR > 110
Average Mortality - b	110 > SMR > 89
Low Mortality - c	SMR < 89

	c	b	a	All Grps
% Institutionalized	0.66	1.47	1.36	1.16
Sociomaterial deprivation index	-0.13	-0.52	0.61	-0.02
Thermal ranges	1.87	1.93	2.02	1.94
Distance to hospital (min.)	6.87	7.67	8.10	7.54
Buildings aging index	222.68	561.77	399.20	394.52
Average income (Euros)	1048.53	994.78	1024.49	1022.59

Discriminant Analysis:results

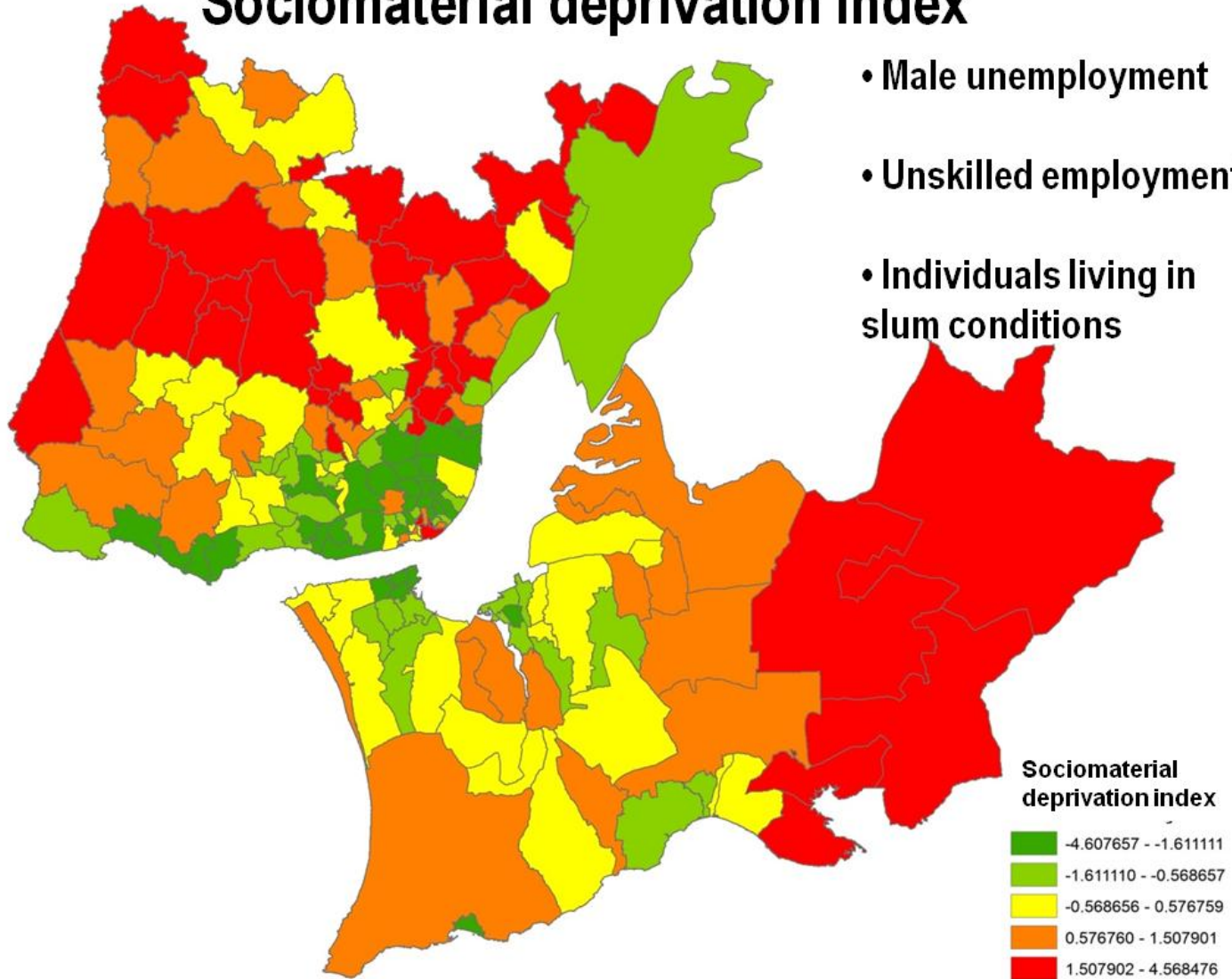
	Wilks' Lambda	p-level
% Institutionalized	0.847792	0.004487
Sociomaterial deprivation index	0.836678	0.013865
Thermal ranges	0.823638	0.053115
Distance to hospital (min.)	0.821551	0.065978
Buildings aging index	0.815743	0.121023
Average income (Euros)	0.807386	0.291904

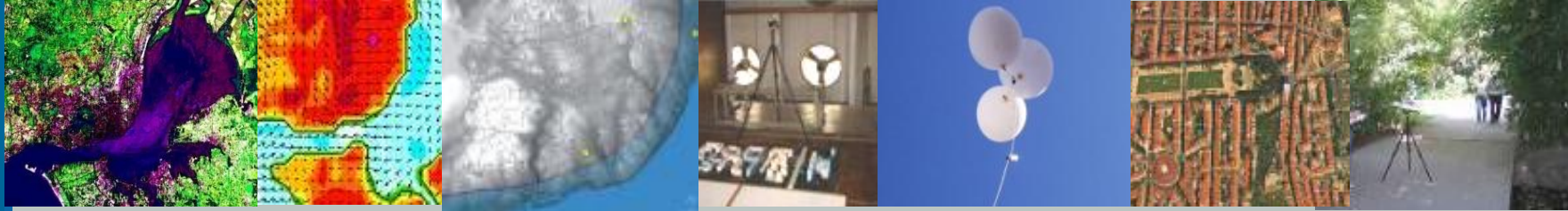
	Percent correct	a p=.32961	b p=.33520	c p=.33520
High SMR	48.33333	29	14	17
Average SMR	51.66667	12	31	17
Low RPM	66.66666	10	10	40
Total	55.55556	51	55	74



Sociomaterial deprivation index

- Male unemployment
- Unskilled employment
- Individuals living in slum conditions





4 – Conclusions



- **Mortality rates inLMA:**

- % Widowed (age structure and isolation)
- Population and buildings density
- Institutionalized population (health and social support institutions)

- **Standardized Mortality Ratios – low mortality civil parishes with:**

- less institutionalized population
- low sociomaterial deprivation index
- Proximity to the ocean (mild temperatures)
- Proximity to hospitals



Main limitations:

- Unfinished hazard spatialization**
- Time lag between mortality records and vulnerability indicators records.**

Ongoing Investigation



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