Heat Waves during the last century at Porto (1900-2006):

how mitigate the most severe damages?

A.Monteiro, C. Sousa, J.Sousa

Introduction

Heat kills by challenging the human body beyond its abilities.

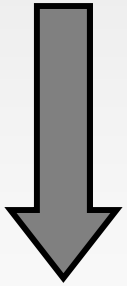
No one can know:

i) how many more deaths are advanced by heat wave weather;

ii) how many diseased or aging hearts surrender that under better conditions would have continued functioning;

iii) how cities contribute to increase heat stress or to mitigate it
(urban heat islands vs air conditioning)

How do our body communicate with the environment?



Focus: **Thermal Environment**

Background information

We know that

human bodies dissipate heat { by varying the rate and depth of blood circulation,

by losing water through the skin and sweat glands,

↓

The heart begins to pump more blood

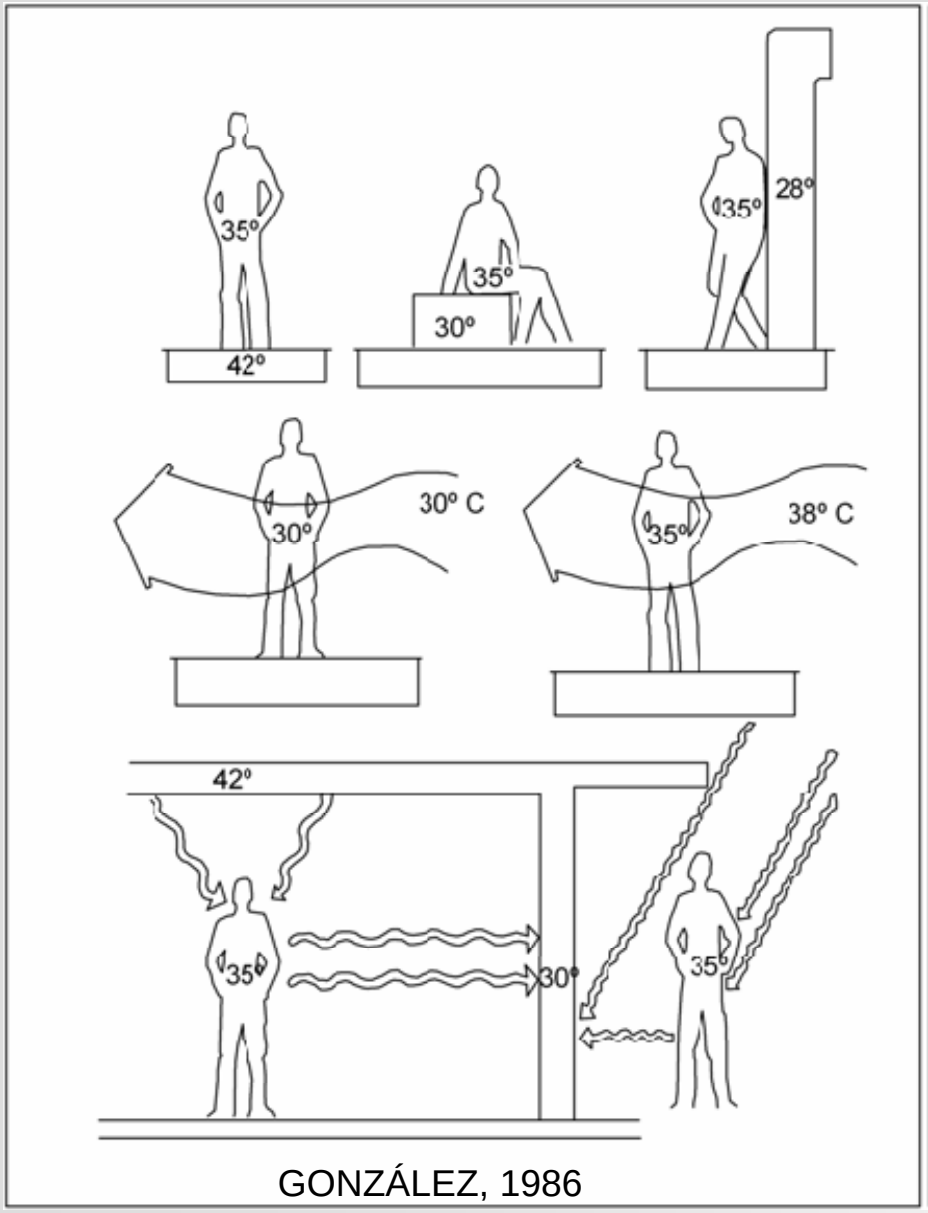
blood vessels dilate to accommodate the increased flow,

and the bundles of tiny capillaries threading through the upper layers of skin are put into operation.

↓

The body's blood is circulated closer to the skin's surface, and excess heat drains off into the cooler atmosphere.

Background information



GONZÁLEZ, 1986

Heat transference by conduction

Heat transference by convection

Heat transference by radiation

Background information

At the same time…..

water diffuses through the skin as perspiration.

The **skin** handles about 90% of the body's heat dissipating function.

Sweating, by itself, does nothing to cool the body, unless the water is removed by evaporation, and high relative humidity retards evaporation.

The heat energy required to evaporate the sweat is extracted from the body, thereby **cooling it.**

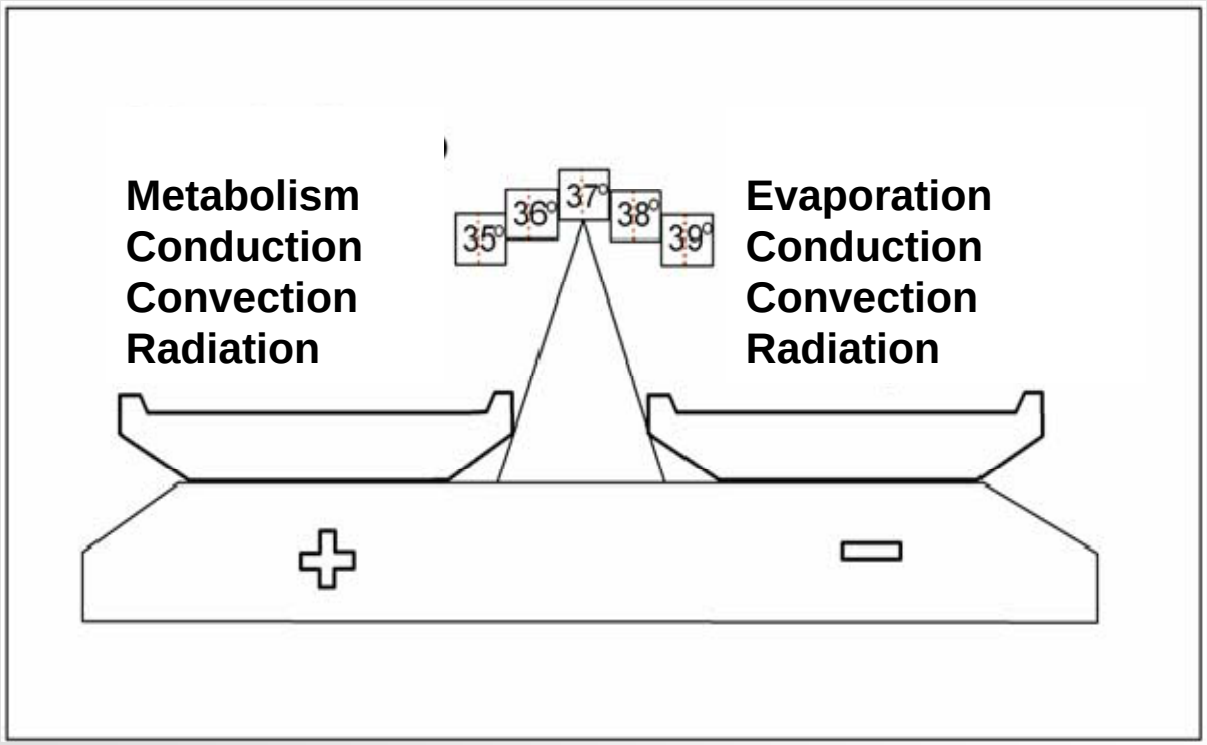
So, ⇩

Under conditions of **high temperature** and **high relative humidity**,

the body is doing everything it can to maintain 37ºC inside.

Background information

The body will do everything it can to maintain 37ºC inside



Under conditions of **high temperature**, **high relative humidity** and **no wind**

The heart pumps a torrent of blood through dilated circulatory vessels

The sweat glands pour liquid
(including essential dissolved chemicals, like sodium and chloride onto the surface of the skin)

Heat disorders

have to do with

a reduction or collapse of the body's ability to shed heat by:

- circulatory changes
- sweating

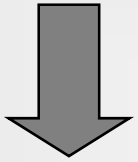
a chemical (salt) imbalance caused by too much sweating.

Background information

When heat gain exceeds the level the body can remove

or

when the body cannot compensate for fluids and salt lost through perspiration



the temperature of the body's inner core begins to rise

and

heat-related illness may develop.

Background information

Heat disorders share common features:

the individual has been **overexposed**

the individual has been **over exercised** for his age and physical condition

in the existing thermal environment.

Sunburn, with its ultraviolet radiation burns, can significantly retard the skin's ability to shed excess heat.

Reasons for doing this

Do we feel the same under equal thermal environments?

Thermal Comfort

i) **Diet** - habits that affect the metabolism and justify the differences of diet between different geographic areas;

ii) **Age** - the more aged prefer warmer environments;

iii) **Sex** - the women present an inferior metabolism than men (produce little heat, so they prefer warmer environments);

iv) **Body form** - the relation between volume and surface influences in the thermal preference;

v) **Body fat** – fatness act as a thermal insulator;

vi) **Health state** - a sick person can have its comfort limits narrowed;

vii) **Clothes** - thermal exchanges filter;

viii) **Acclimatization** - the time of permanence of a human being in one determined climatic context tends to produce metabolic alterations and increase thermal adaptation.

Why

Porto?

Urban Environment?

Cities pose special hazards

Reasons for doing this

21 July 2006

“Heat wave kills in Portugal” – emergency rooms occurrences increase 25%

25 July 2008

“..in 2003 we had more than 2000 deaths due to heat waves, in 2004 about 100, in 2005 about 400 and in 2006 about 1400……”, Costa Alves

“…Heat waves are, in Portugal, the natural hazard that kills more people after the earthquake of 1755….”, Costa Alves

Reasons for doing this

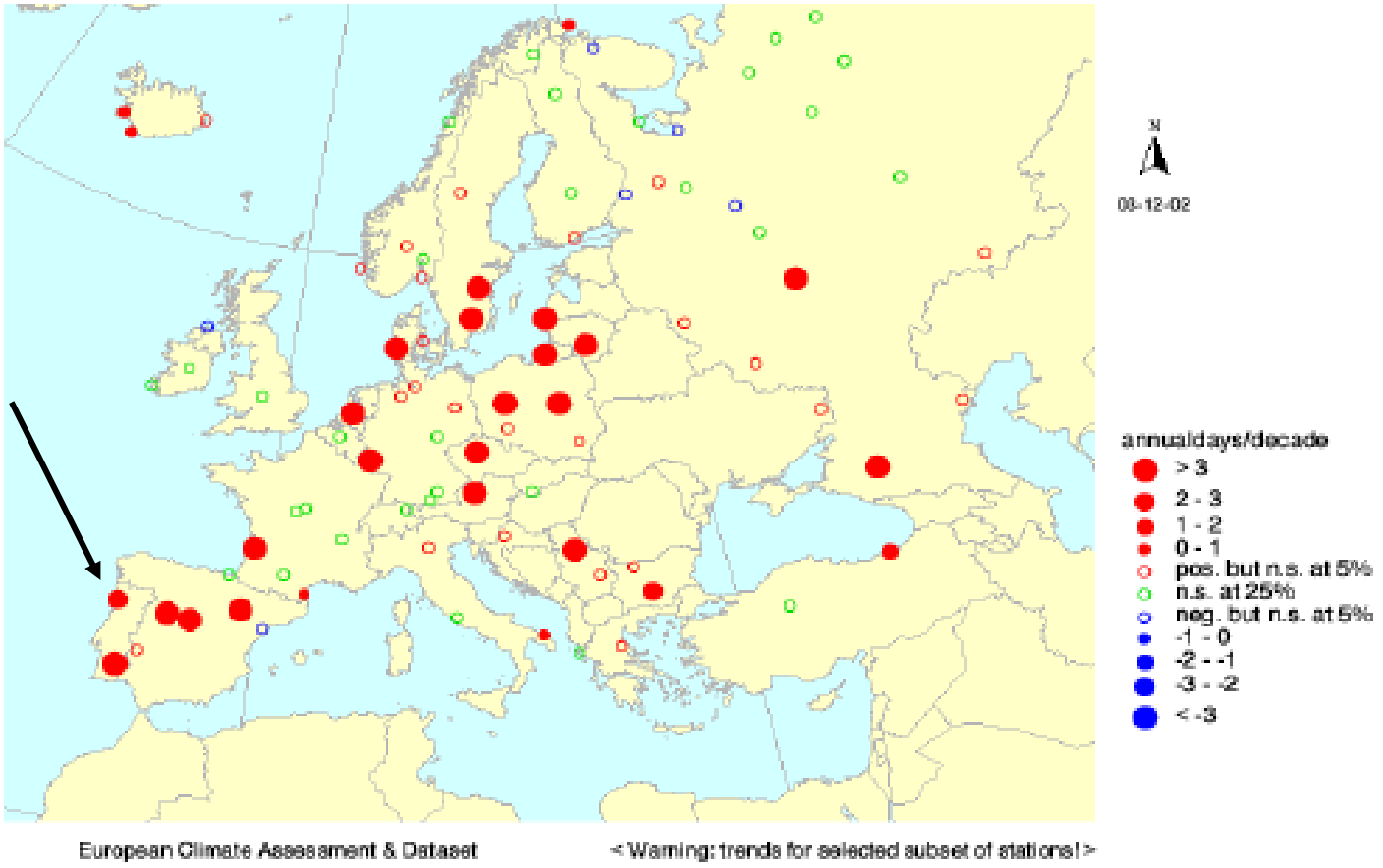
WORLD HEALTH ORGANIZATION

EUROPE

Extreme weather and climate events and public health responses

Report on a WHO meeting
Bratislava, Slovakia
09–10 February 2004

Reasons for doing this



Alteration of the frequency and/or intensity of extreme weather and climate events have a number of implications for health if appropriate response strategies are not formulated, including

- possible increases in heat-related mortality especially amongst sectors of the population that are unable to protect themselves against heat stress, such as the elderly and the urban poor;

WHO, Bratislava, 2004, p.13

Reasons for doing this

In urban areas

Threats

high number of persons

high population density

high social and economic diversity

high inequality in housing conditions

severe local and regional impacts on climatological context (*urban heat island*)

Chances

more air conditioning equipment

more private and public places with thermal indoor comfort conditions

more leisure activities

Reasons for doing this

In urban areas

The stagnant atmospheric conditions of the heat wave trap pollutants

and

add the stresses of severe pollution

to

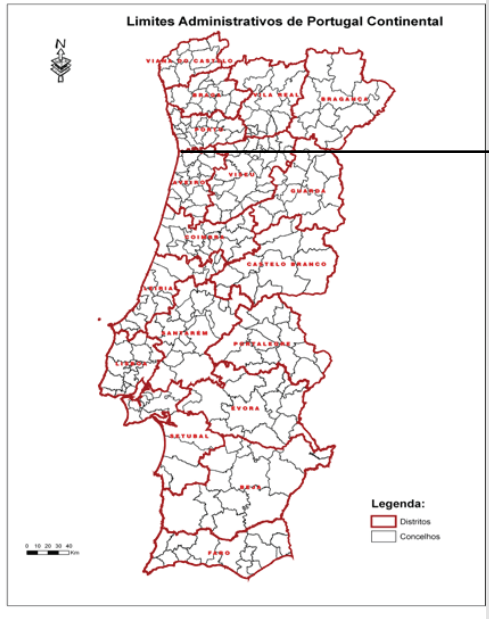
the dangerous stresses of hot weather

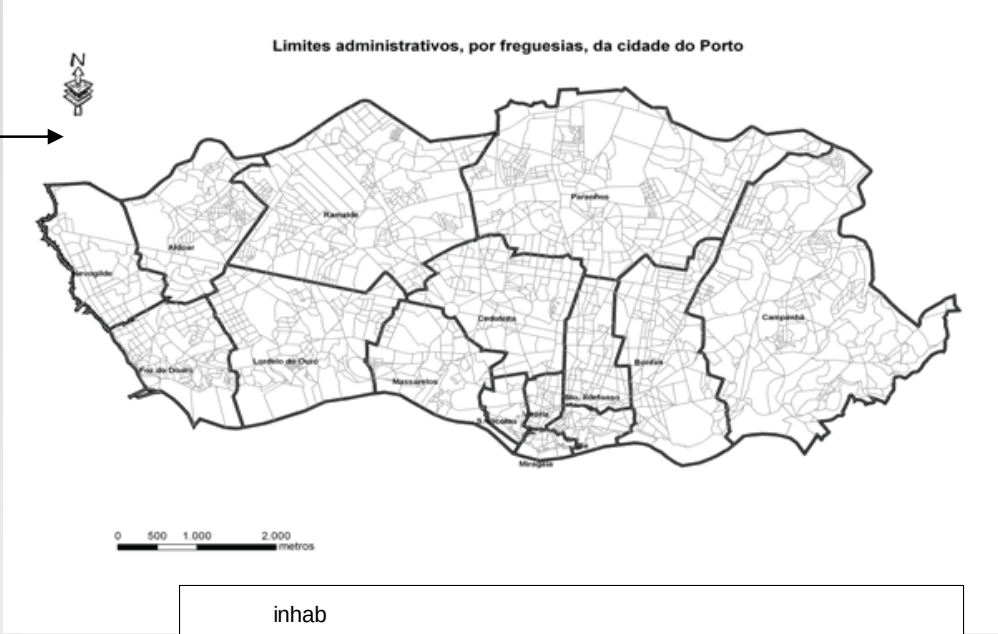
creating a bigger health problem

Reasons for doing this

Why Porto?

Why looking to heat waves through the last century?





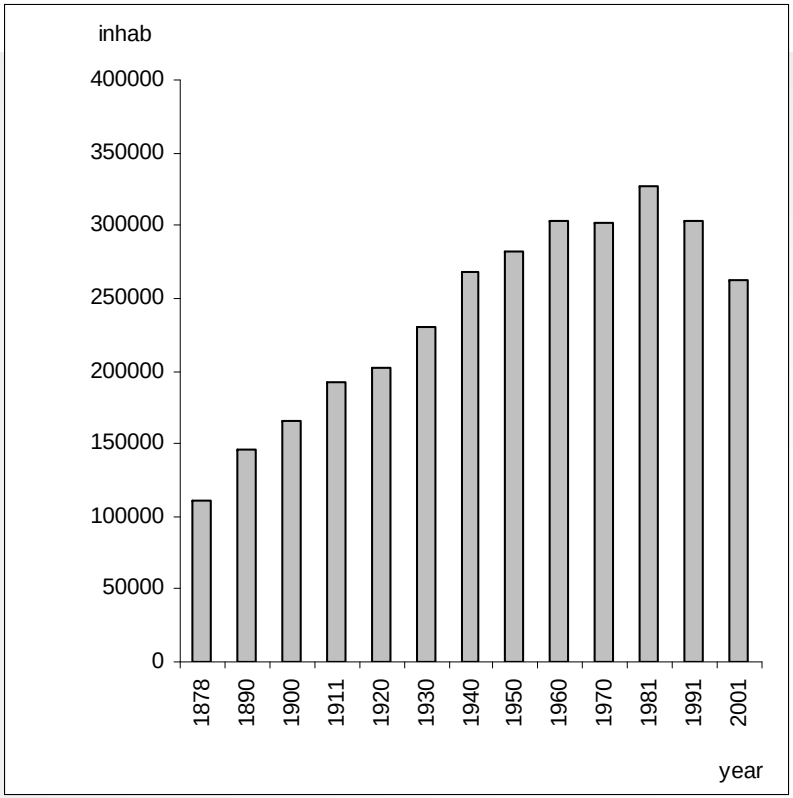
Porto

2nd most important Portuguese city

250 000 inhab.
(in a metropolitan area of 1million)

600 veihcles/1000 inab.

400 000 vehicles/day

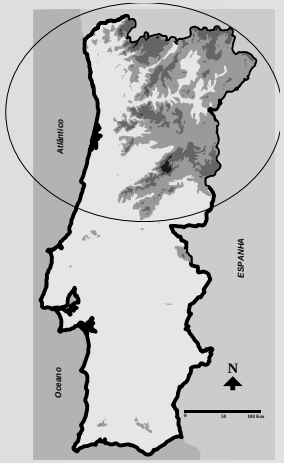


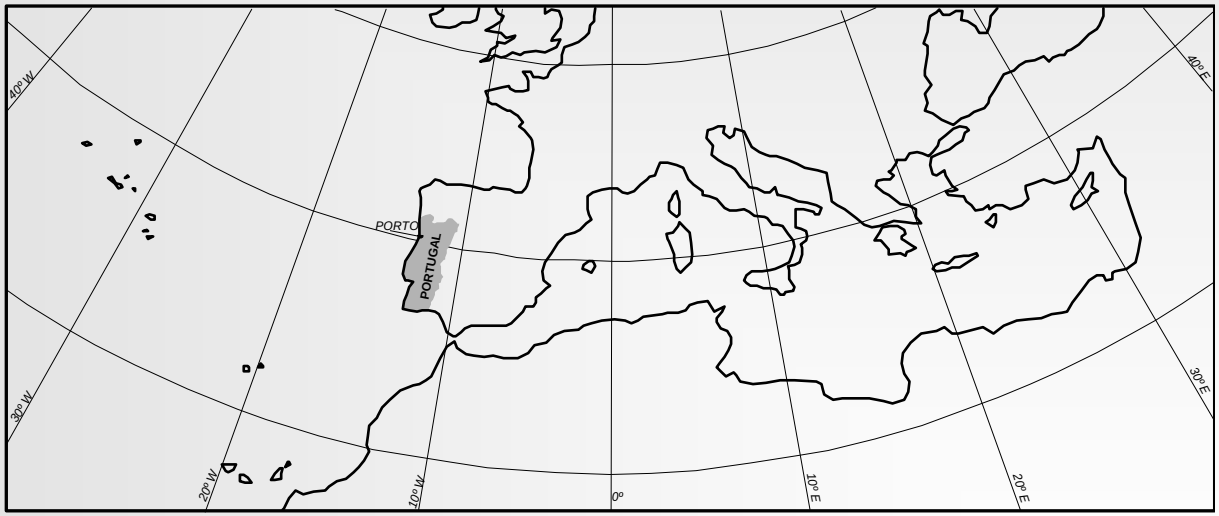
Porto is a *medium-size* city (at a global scale) – 250 000 inhab.

West coast city

On the way of the polar front routing

The 1st continental obstacle found by the west flux after crossing Atlantic Ocean

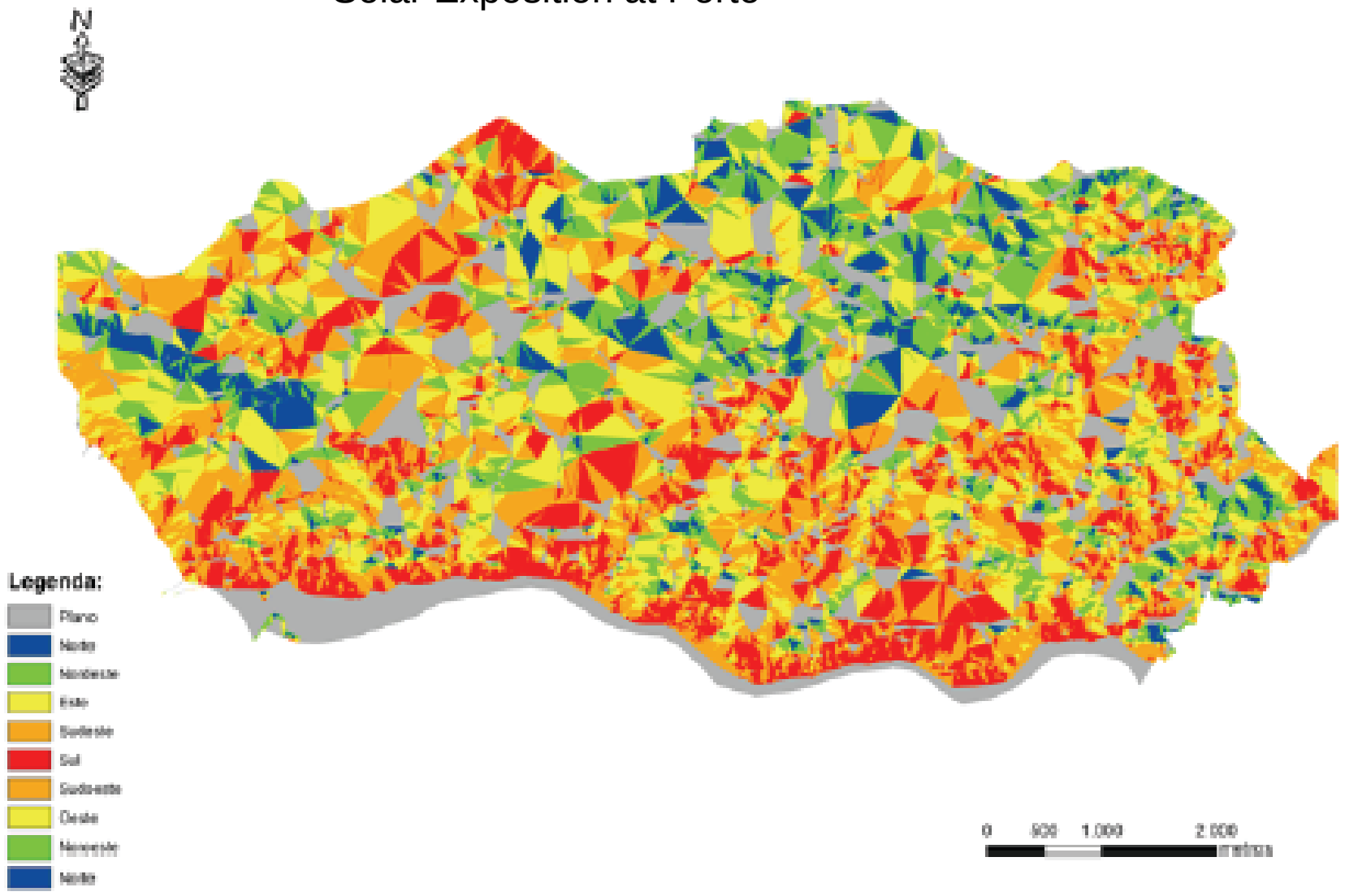




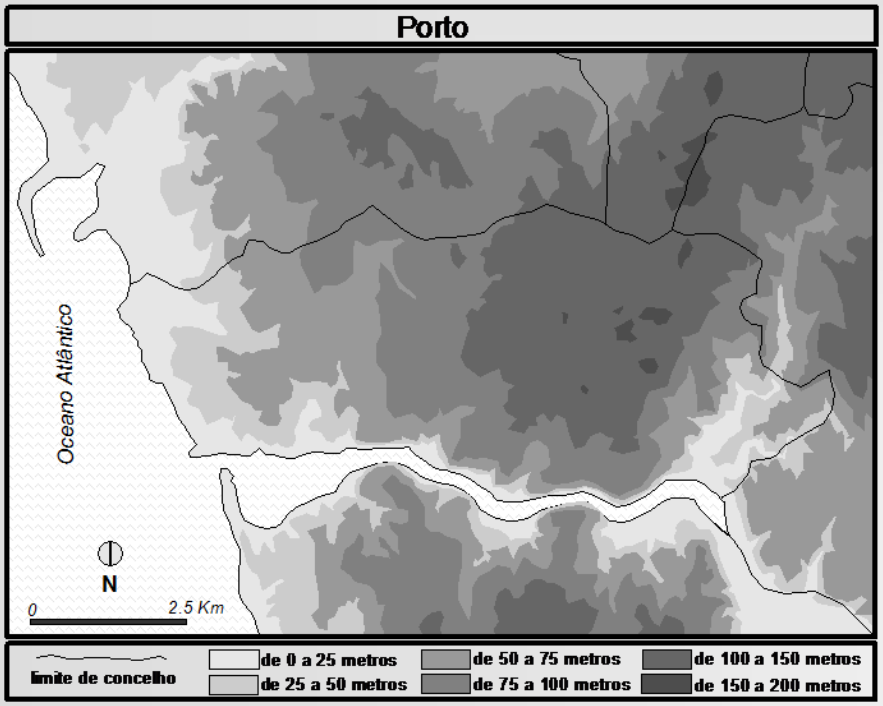
Urban Heat Island + Global Warming ?

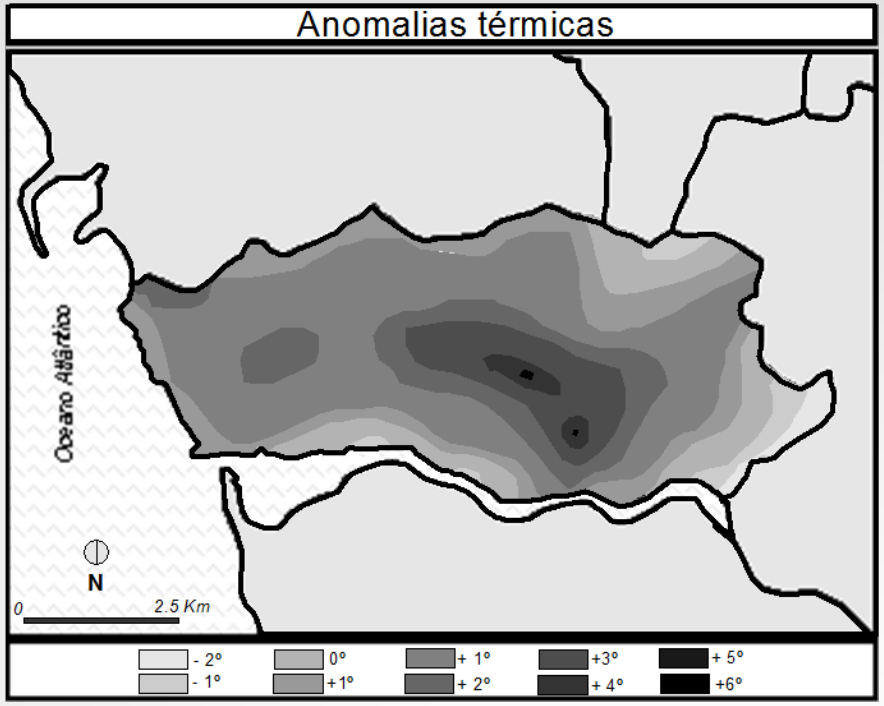
Built density (%) at Porto

Solar Exposition at Porto

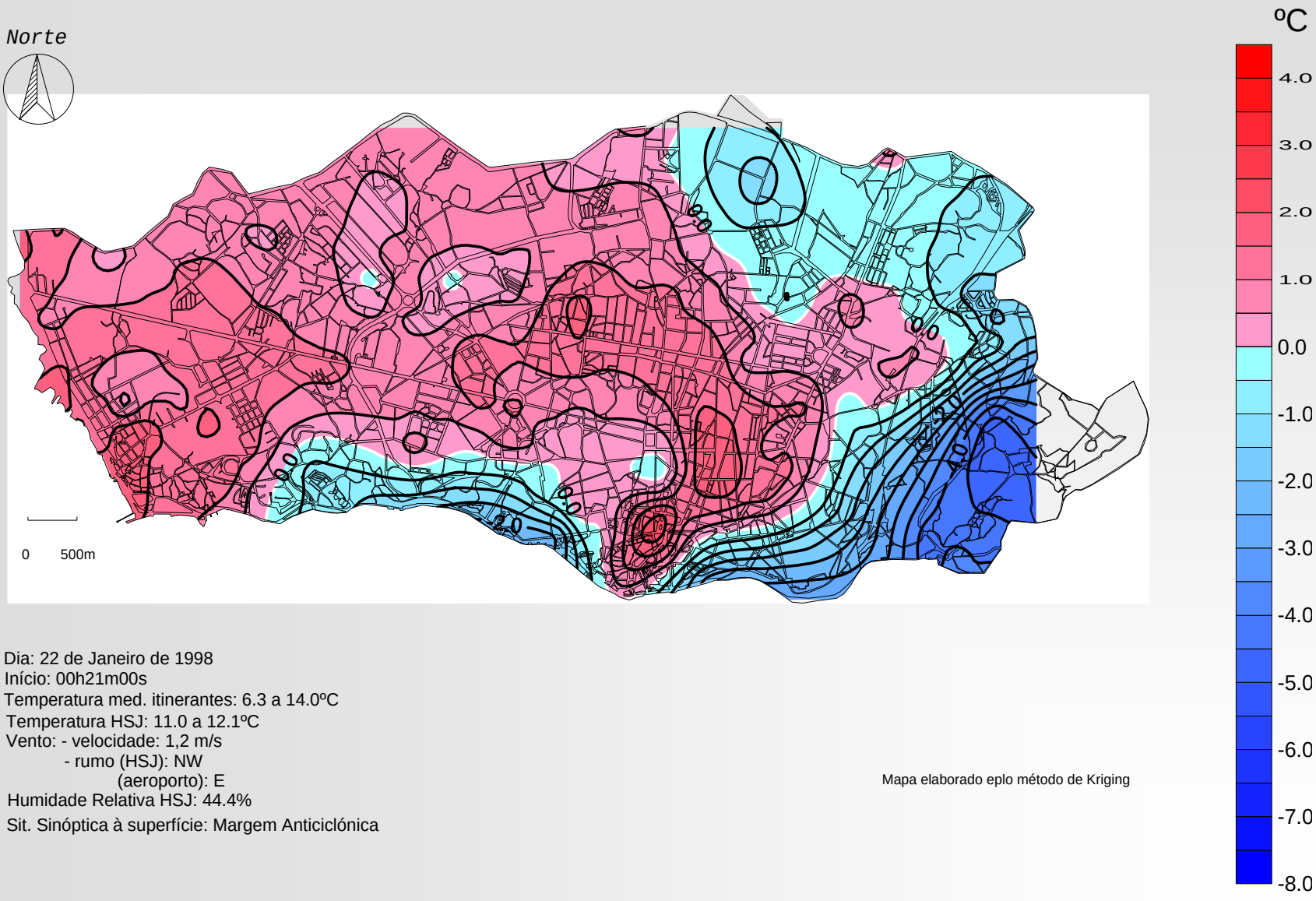


Urban Heat Island
4ºC-6ºC





Urban heat island with several forms and magnitudes



Dia: 22 de Janeiro de 1998
Início: 00h21m00s
Temperatura med. itinerantes: 6.3 a 14.0ºC
Temperatura HSJ: 11.0 a 12.1ºC
Vento: - velocidade: 1,2 m/s
- rumo (HSJ): NW
(aeroporto): E
Humidade Relativa HSJ: 44.4%
Sit. Sinóptica à superfície: Margem Anticiclónica

Mapa elaborado eplo método de Kriging

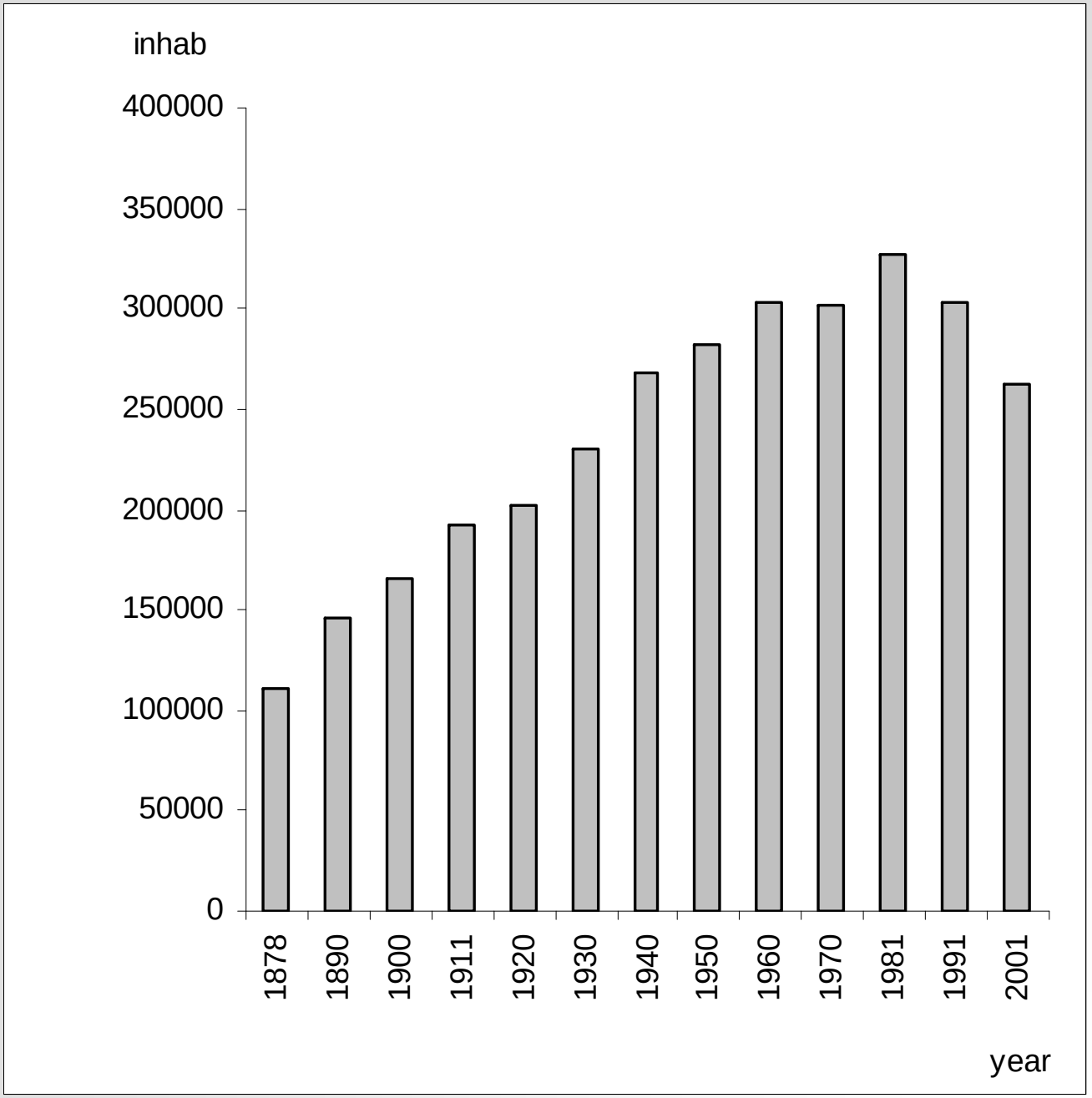
Effects

of urbanization

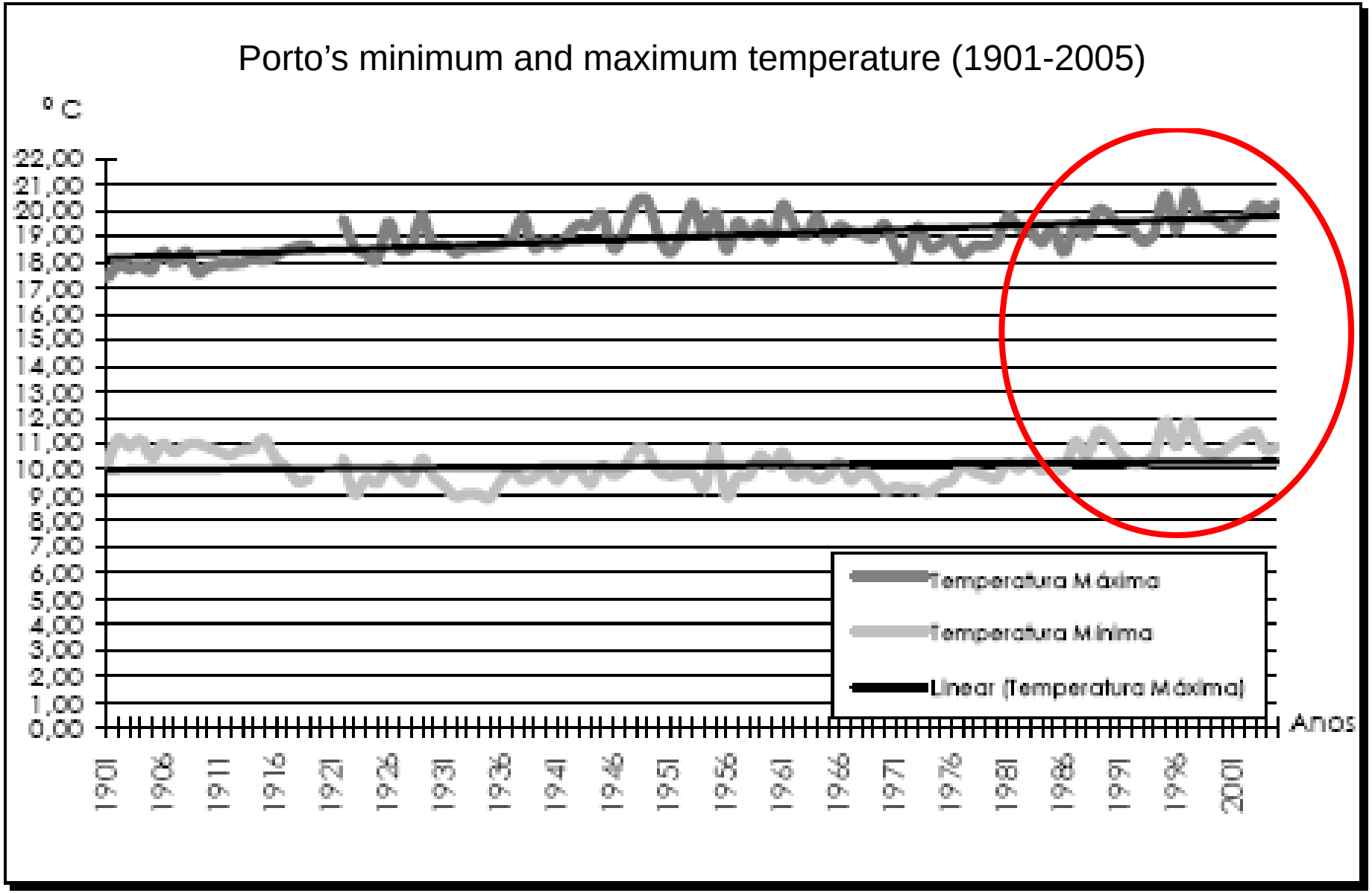
on

climate

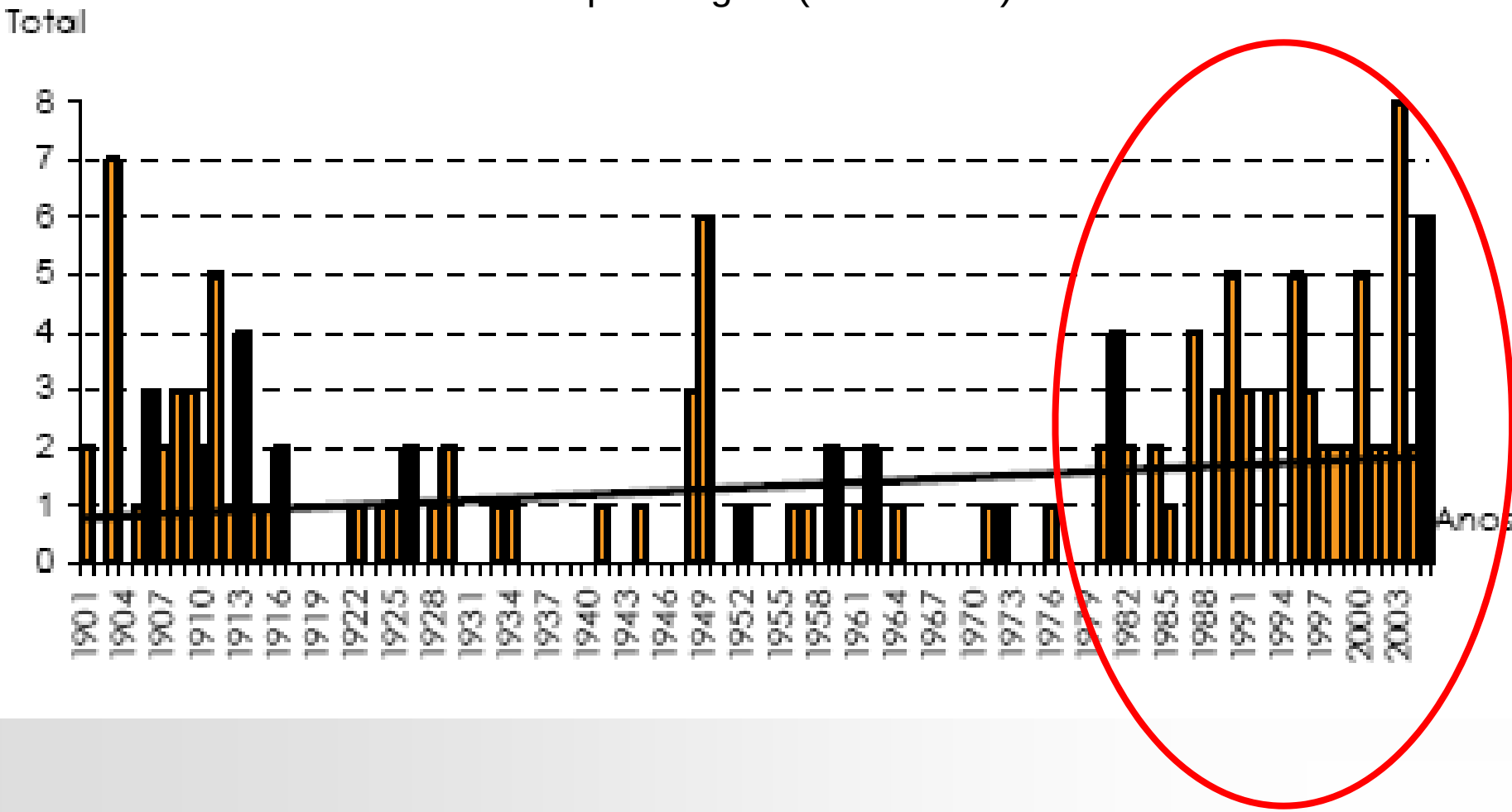
PORTO's population



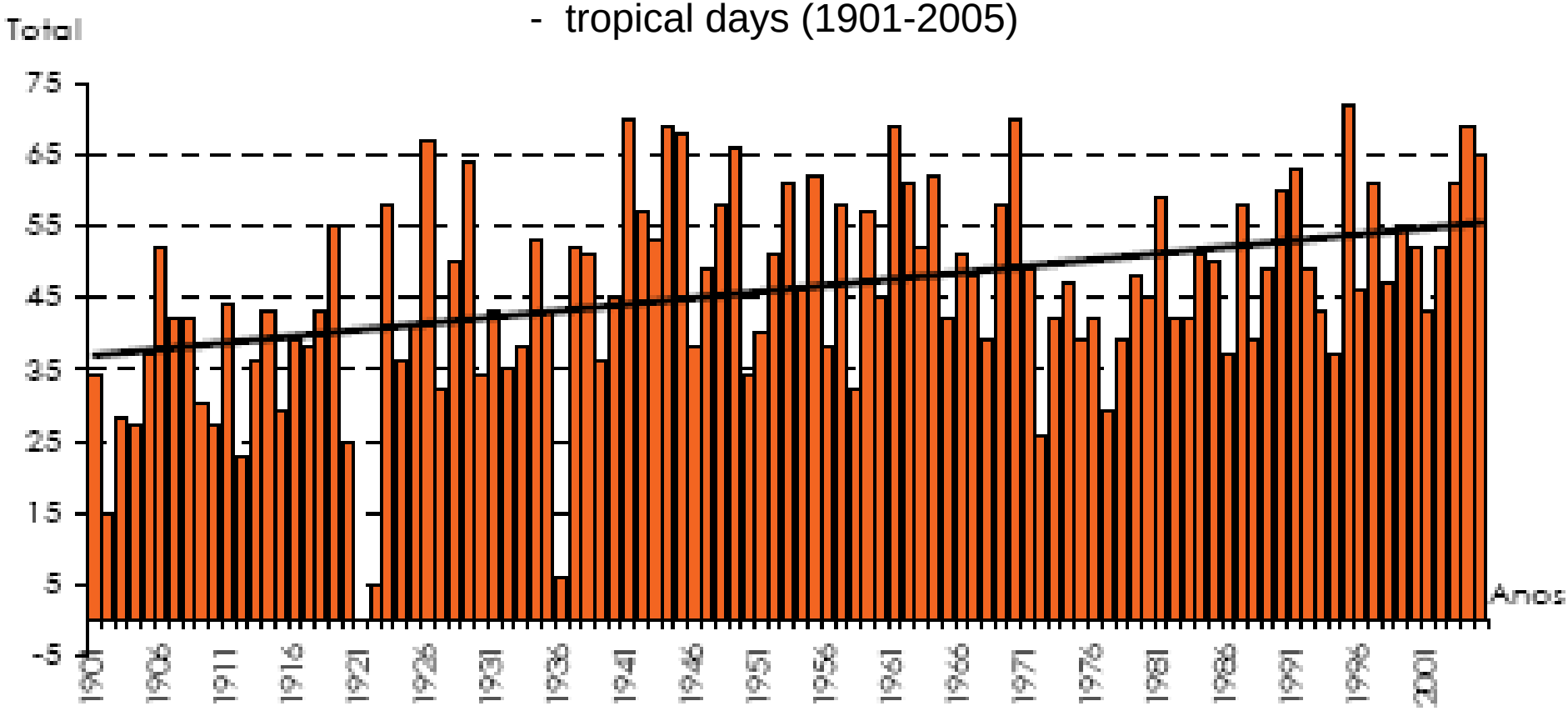
Porto's minimum and maximum temperature (1901-2005)



Number of days with minimum temperature above 20ºC
- tropical nights (1901-2005)



Number of days with maximum temperature above 25ºC
- tropical days (1901-2005)



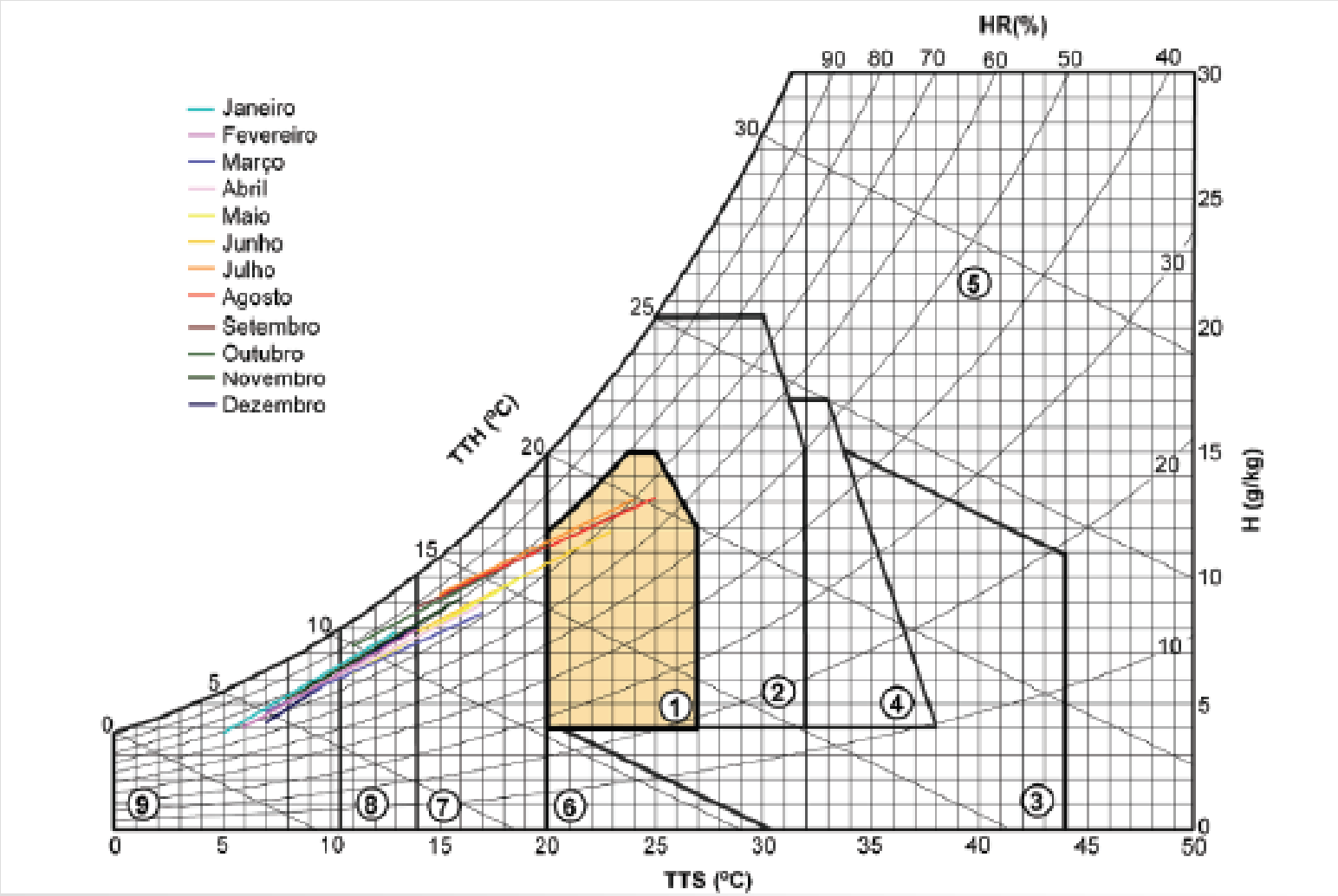
Porto bioclimatic needs (Givoni)

	1	2	3	4	5	6	7	8	9
Janeiro	0,0	0,0	0,0	0,0	0,0	0,0	0,0	32,5	67,5
Fevereiro	0,0	0,0	0,0	0,0	0,0	0,0	0,0	44,2	55,8
Março	0,0	0,0	0,0	0,0	0,0	0,0	30,3	35,4	34,4
Abril	0,0	0,0	0,0	0,0	0,0	0,0	33,9	39,5	26,6
Maio	0,0	0,0	0,0	0,0	0,0	0,0	38,2	61,8	0,0
Junho	33,0	0,0	0,0	0,0	0,0	0,0	67,0	0,0	0,0
Julho	44,4	0,0	0,0	0,0	0,0	0,0	55,6	0,0	0,0
Agosto	50,0	0,0	0,0	0,0	0,0	0,0	50,0	0,0	0,0
Setembro	40,3	0,0	0,0	0,0	0,0	0,0	59,7	0,0	0,0
Outrubro	0,0	0,0	0,0	0,0	0,0	0,0	66,7	33,3	0,0
Novembro	0,0	0,0	0,0	0,0	0,0	0,0	25,3	43,4	31,3
Dezembro	0,0	0,0	0,0	0,0	0,0	0,0	0,0	50,7	49,3
Total	*15,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*36,9*	*27,2*	*20,9*

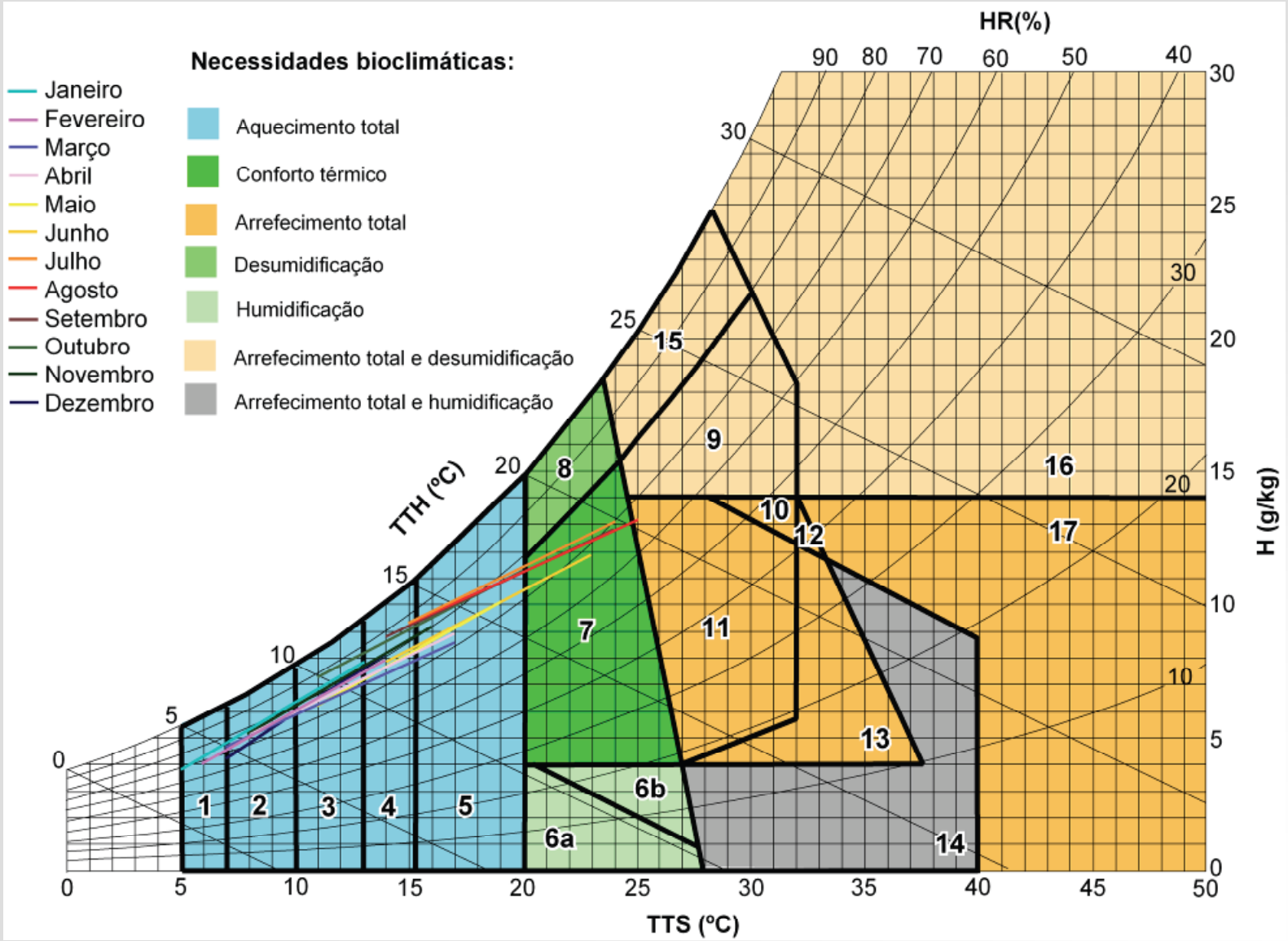
1- comfort zone
2- ventilation
3- cooling by evaporation
4- thermal inertia
5- artificial cooling
6- wetness
7- thermal inertia
8 – passive solar heating
7- artificial heating

At Porto the problem is with cold spells and not with heat waves!

Porto bioclimatic needs (Givoni)

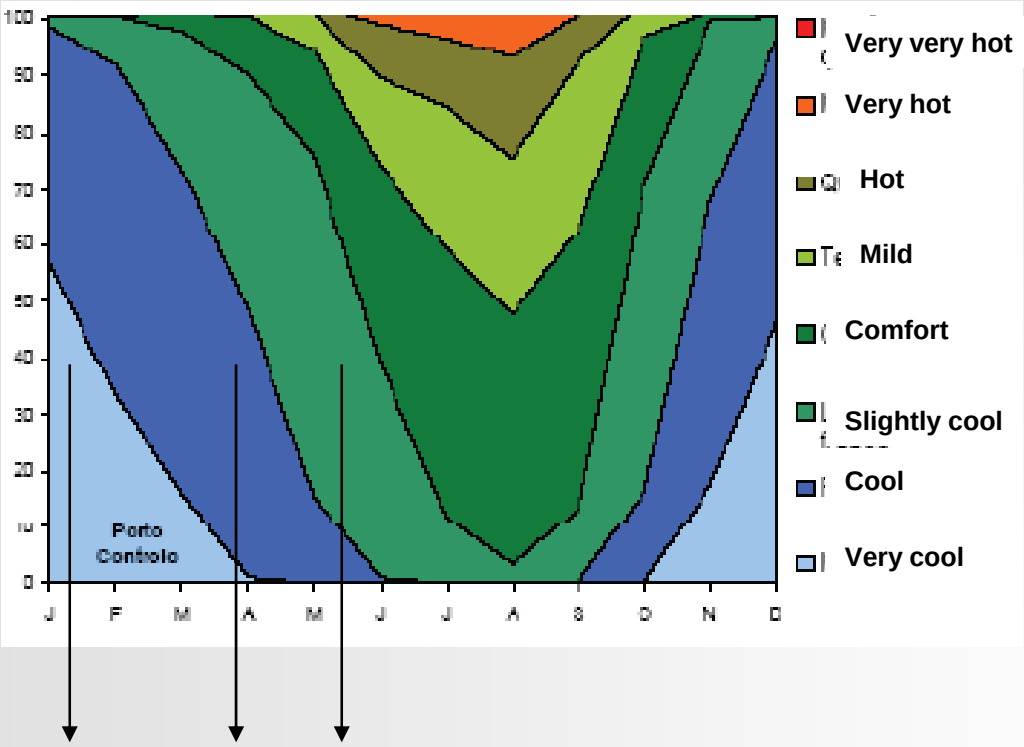


Porto bioclimatic needs (Watson & Labs)



PET index to Porto

thermal index PET (physiological equivalent temperature)



When we approach this heat wave issue

we must have in mind

the acclimatization of Porto's inhabitants

vulnerability

Heat wave ?

Criteria ?

Option → WHO

maximum temperature 5ºC above the average (≥30 years)
for a sequence of more than 5 days

HWDI – Heat Wave Duration Index, WCDMP-No.47, WMO-TD No. 1071

Reasons for doing this

Heat waves at Porto (1900-2006)

Number	Heat Waves recorded at Porto SP (1900-2006)											
Year	1925	1926	1930	1936	1940	1949	1960	1961	1966	1972	1981	1995
N° ocorrências	1	1	1	1	1	1	1	1	1	1	1	1

using the WMO criteria

2000 ?...
2003?...
2004?...
2005?...
2006?...

Heat Waves

Why not 2003?

2003							
Julho/ Agosto	25	26	27	28	29	30	31
	22,8	23,9	24,4	27,2	35,8	35,6	31,2
	1	2	3	4	5	6	7
	37,3	35	26,6	27,1	30,3	37,7	39,5
	8	9	10	11	12	13	14
	34,1	24,5	25,2	32,1	35,8	26,1	26,5
	15	16	17	18	19	20	21
	24,7	23,7	26	25,2	25,8	25,4	24
	22	23	24	25	26	27	28
	26,8	30,1	22,4	25,2	24,5	22,5	22,7
	29	30	31				
	23,2	25,5	25,3				

Because it was a sequence of:

- 5 days
- not
- 4 days
- not

HEALTH (comfort)?

vs

criteria

How assess the real effect of climate on health

at Porto?

still great gaps….

estimate….

TABLE 1

Total and daily average number of deaths registered in participant civil Registrars' offices during the period of the heat wave for all 3 comparison periods, Portugal, 2003

	Heat wave period 30 July - 18 August	Period 15-28 July	Period 1-14 July	Period 1-28 July
Total no. of deaths	1966	1427	1454	2881
Daily average no.	140.4	101.9	103.9	102.9

The excess deaths estimates varied slightly for the three comparison period

TABLE 2

Number of expected deaths, excess of deaths and proportion of the expected deaths, in the period of the heat wave, in the counties of participant civil Registration Offices, according to the used reference periods, Portugal, 2003

	Deaths expected in the heat wave period (30 July-12 August)		
	Period 15-28 July	Period 1-14 July	Period 1-28 July
No. of expected deaths (E)	1427	1454	1440.5
Excess of deaths (Observed-Expected) (O-E)	539	512	525.5

http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=553,
PJ Nogueira, J M Falcão, MT Contreiras, E Paixão, João Brandão, I Batista *Mortality in Portugal associated with the heat wave of August 2003: Early estimation of effect, using a rapid method* , Observatório Nacional de Saúde – Instituto Nacional de Saúde Dr. Ricardo Jorge, Lisboa, Portugal

Delta between the number of deaths observed during 2003 and the average number of deaths noted during the five years of the reference period and the excess mortality ratio compared with the same 1998-2002 reference period (expressed as a percentage) for various periods in 2003 (before the summer, during the summer and after the summer) and for various countries.

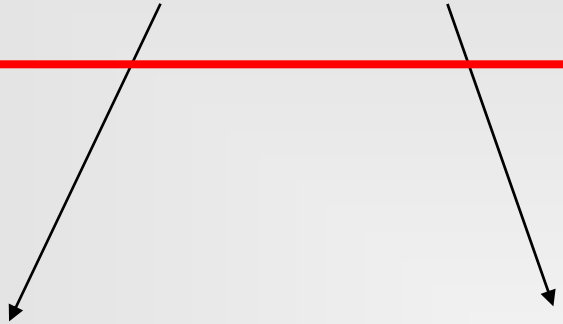
	Before summer		Summer										After summer		Total of the year	
			June		July		August		September		Total					
	Nb	Ratio	Nb	Ratio	Nb	Ratio	Nb	Ratio	Nb	Ratio	Nb	Ratio	NB	Ratio	Nb	Ratio
Countries involved in the August 2003 excess of mortality																
Belgium	-4	-0.01	139	1.72	162	1.97	438	5.31	436	5.57	1175	3.62	1356	5.11	2528	2.41
Switzerland	92	0.34	253	5.30	187	3.89	469	9.81	130	2.75	1039	5.45	-148	-0.93	984	1.58
Germany	9290	2.55	642	0.98	1159	1.73	7296	10.97	259	0.40	9355	3.56	-5760	-2.69	12885	1.53
Spain	-1464	-0.90	4268	15.49	2751	9.64	6461	22.86	1611	6.21	15090	13.68	7249	7.95	20875	5.74
France	-3977	-1.70	1482	3.60	1706	4.06	15251	36.93	1051	2.62	19490	11.84	3415	2.53	18928	3.55
Croatia	882	3.95	193	4.85	157	3.98	269	6.83	169	4.49	788	5.04	5	0.04	1675	3.29
Italy	5575	2.24	5274	12.12	4318	9.72	9713	21.81	783	1.94	20089	11.63	-2487	-1.76	23177	4.12
Luxemburg	69	3.47	33	10.81	27	9.29	75	25.00	34	12.22	170	14.34	79	7.85	318	7.95
Netherlands	304	0.50	78	0.71	11	0.10	578	5.24	297	2.79	965	2.20	503	1.42	1771	1.26
Portugal	-2068	-4.26	220	2.83	100	1.28	2196	27.75	179	2.44	2696	8.73	2072	7.76	2699	2.54
Slovenia	351	4.30	13	0.87	62	4.21	144	9.93	70	4.86	289	4.96	74	1.55	714	3.81
England & Wales	-5695	-2.41	-1080	-2.64	-504	-1.21	1987	4.90	-103	-0.26	301	0.18	2025	1.44	-3369	-0.62
Total	3355	0.23	11516	4.50	10137	3.88	44878	17.34	4917	1.99	71449	6.99	8382	0.99	83186	2.50
Countries used as controls																
Austria	706	2.12	-42	-0.71	172	2.86	159	2.63	57	0.99	345	1.45	-645	-3.30	406	0.53
Czech Republic	2406	5.17	207	2.43	190	2.18	58	0.67	-37	-0.43	418	1.22	-335	-1.20	2491	2.29
Poland	1916	1.21	-487	-1.71	-543	-1.85	-918	-3.21	-652	-2.29	-2600	-2.26	-3436	-3.60	-4119	-1.12
Denmark	-113	-0.44	-43	-0.95	-92	-1.95	-49	-1.04	14	0.31	-170	-0.92	92	0.61	-191	-0.32
Total	4920	1.86	-365	-0.77	-273	-0.56	-750	-1.56	-618	-1.31	-2006	-1.05	-4325	-2.74	-1411	-0.23

Source: European Union Project Etude de l'impact de la canicule d'août 2003 sur la population européenne

Discussion

It is still very difficult to establish the relationship

Health – Heat waves



Databases quality

Criteria
Background conditions

Heat waves have increased?

Vulnerability has increased?

DIscussion

We know that….

Elderly persons,

small children,

chronic invalids,

and persons with weight and alcohol problems

are particularly susceptible to heat reactions especially during extreme warm episodes (heat waves?) in areas where a moderate climate usually prevails.

But

how mitigate the most severe damages

at Porto?

Better heat wave period definitions

appropriate to each place

taking into account several social, economic and biological profiles

DIscussion

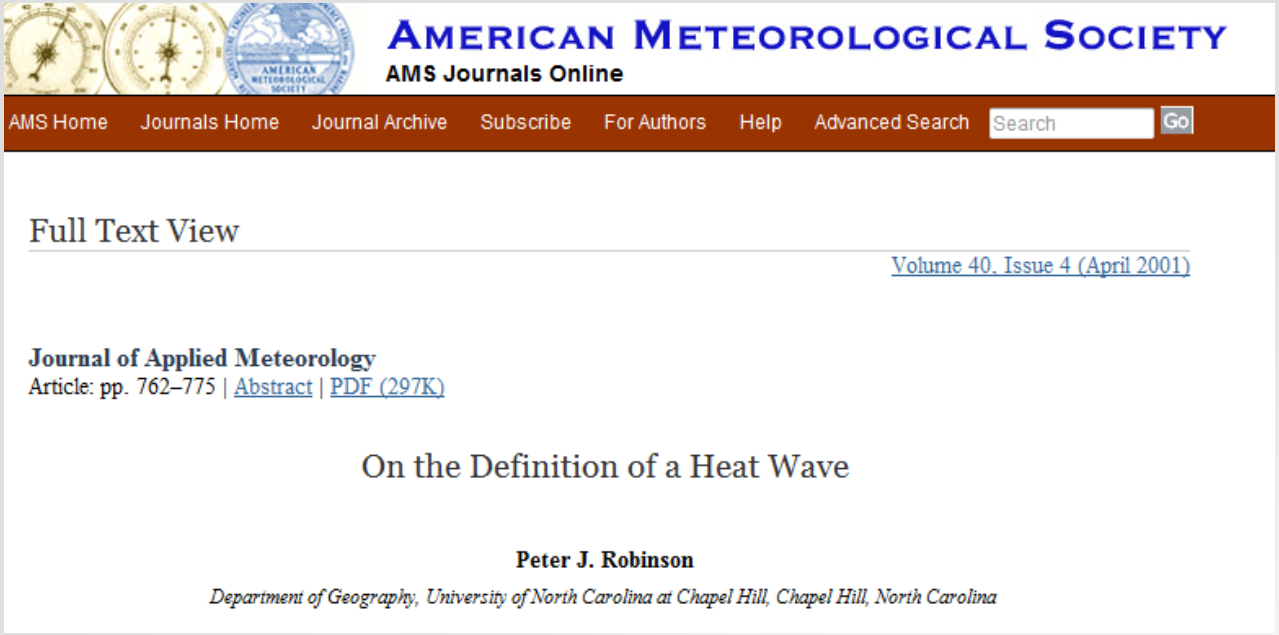
Health Risk

Demographic sensitivity	Behavioral choice	Regional and local factors
Physical constraints	Wearing inapropriate clothing	Geographical location
Mobility constraints	Failing to get adequately hidrated	Urbanization
Cognitive impairments	Consuming alcohol	Urban design
Economicconstraints	Engaging outdoor activities	Resident location
Social isolation	Eating inapropriate meals	Social isolation

EHE Notification and Response Programs,USA, 2007.

There are already several experiences done with success….

ex:



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Volume 40, Issue 4 (April 2001)

Journal of Applied Meteorology
Article: pp. 762–775 | Abstract | PDF (297K)

On the Definition of a Heat Wave

Peter J. Robinson

Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

. Average number of heat waves per decade as a function of length of event, and number of stations with events of specified length at any time during the 1951–90 period

Length (days)	1*	1.5*	2	2.5	3	3.5	4	4.5	5	5.5	6	>6
						1% threshold						
Avg No. events	4.68	3.36	1.18	1.03	0.52	0.49	0.37	0.34	0.33	0.28	0.27	0.35
No. stations	137	123	111	99	70	56	41	36	19	15	12	17
						2% threshold						
Avg No. events	7.02	5.41	2.01	2.01	0.94	0.86			0.39	0.35	0.32	0.51
No. stations	137	123	111	100	73	77	61	57	33	36	22	41

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* These lengths do not qualify as heat waves but are included for comparison purposes.

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