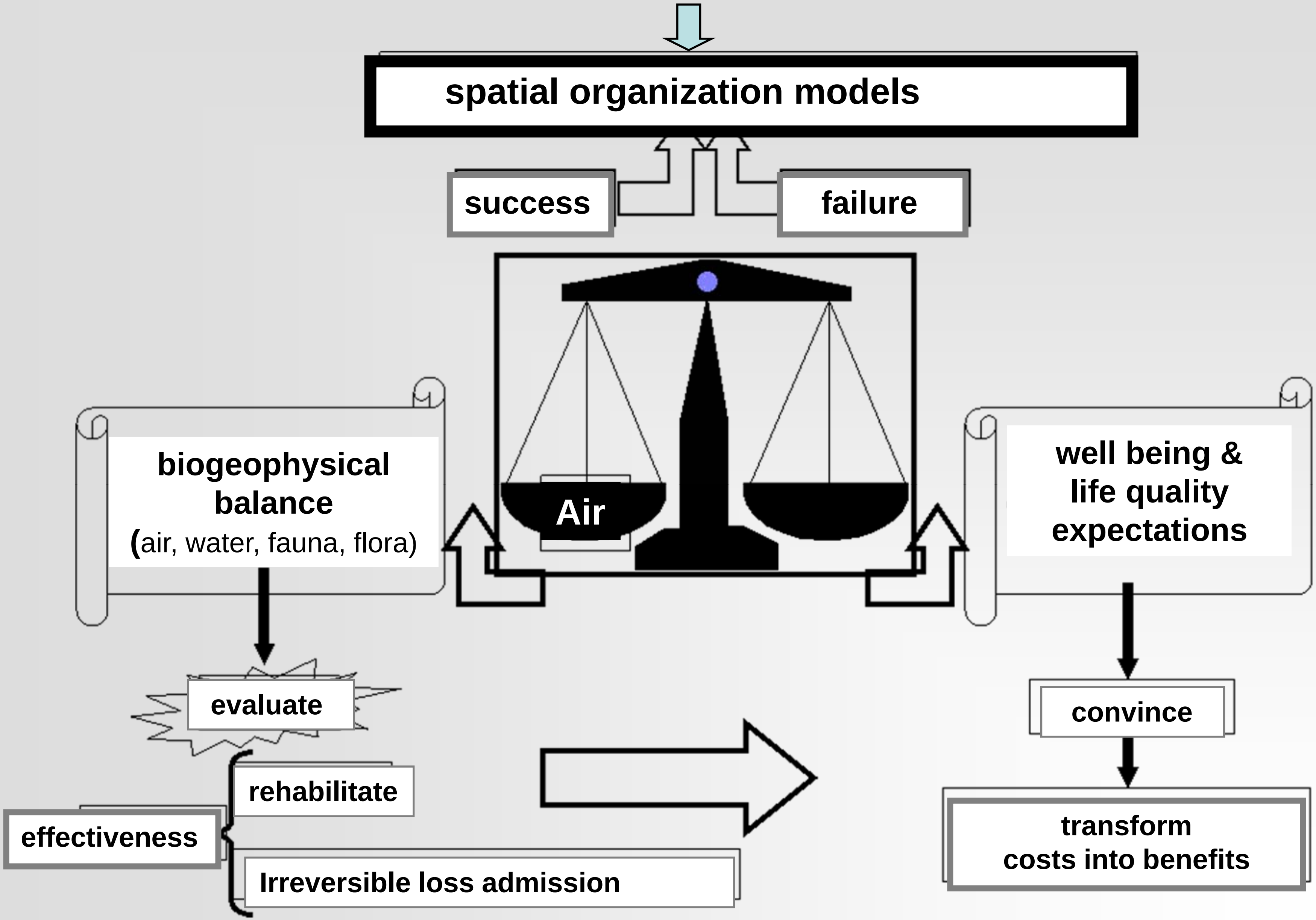
Urban impact of a medium size city

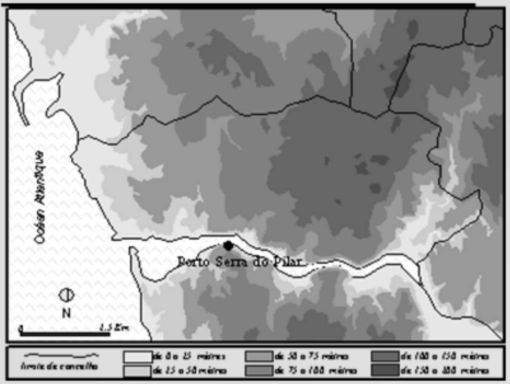
an overview of Porto century climatological data (1900-2005):

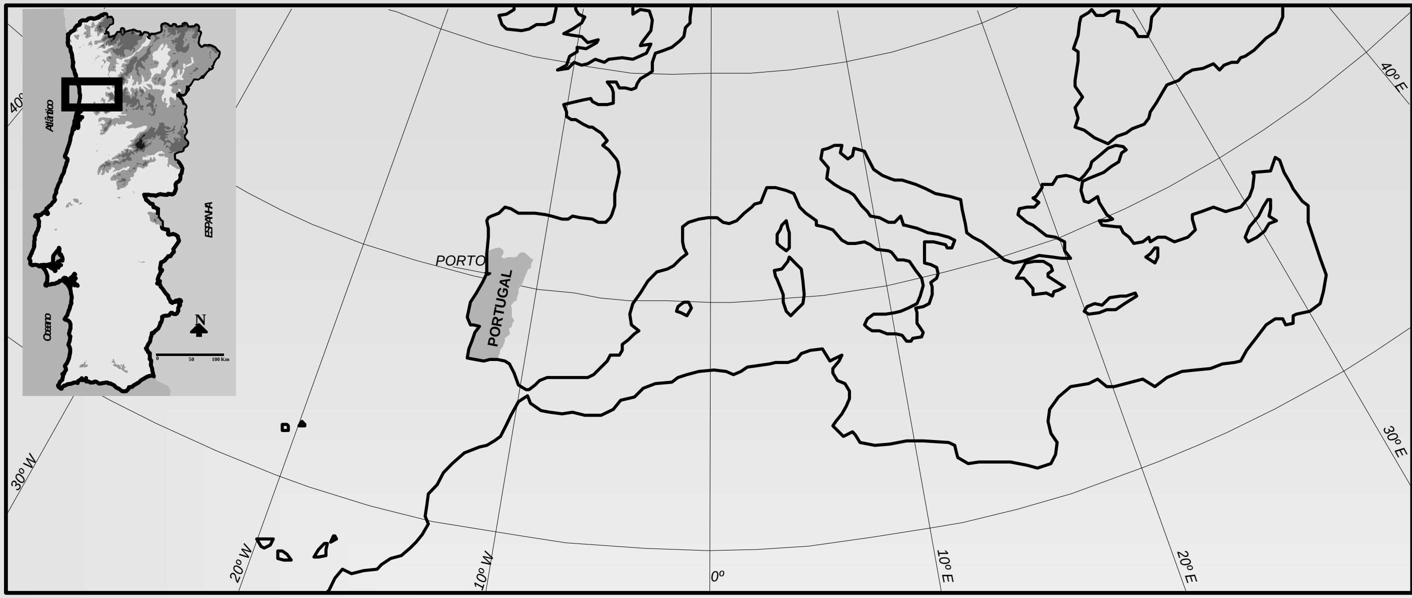
Ana Monteiro

GEOGRAPHY Object



INTRODUCTION





Porto is a north-west coast portuguese city

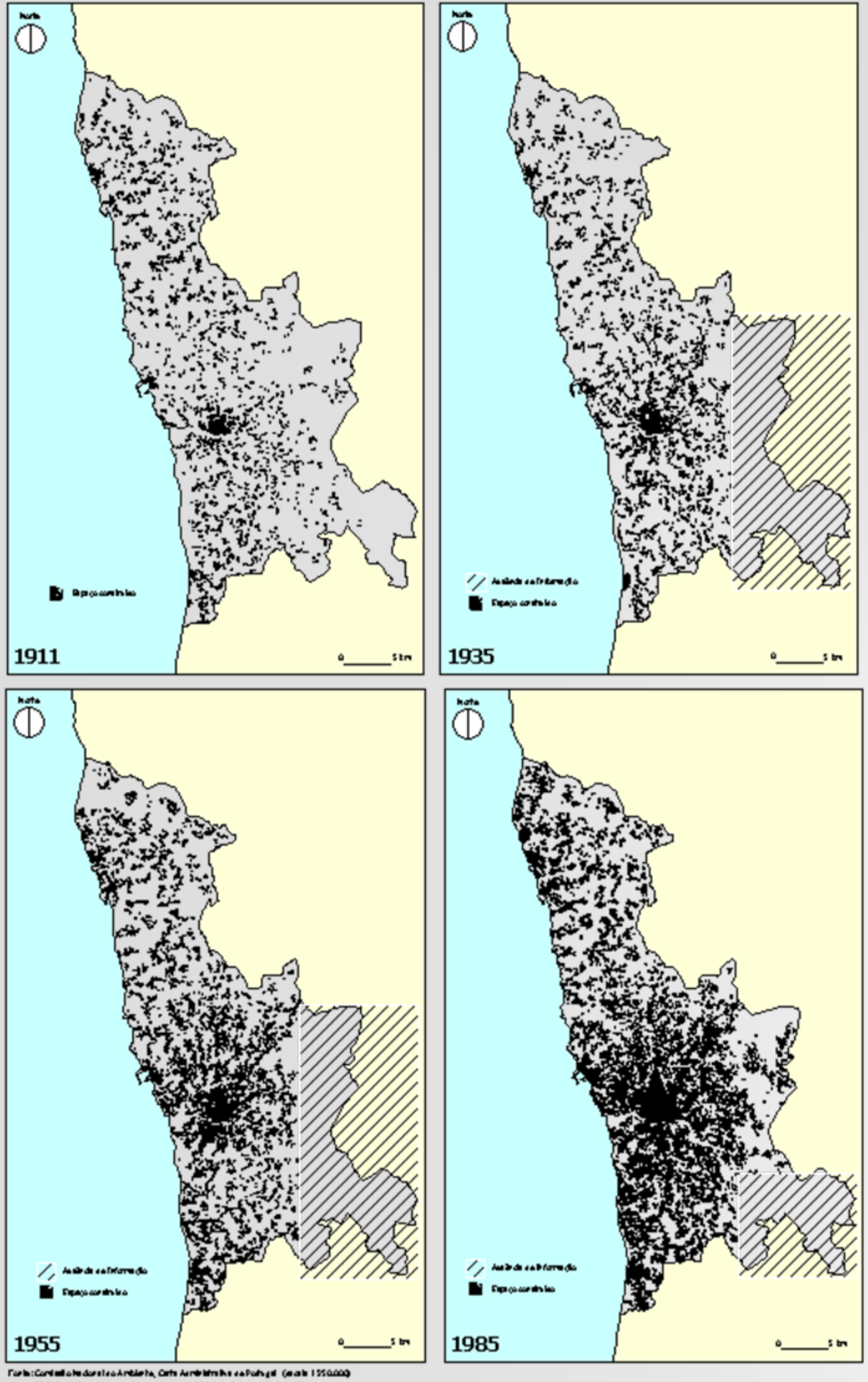
an enormous economic growth during the last 3 decades

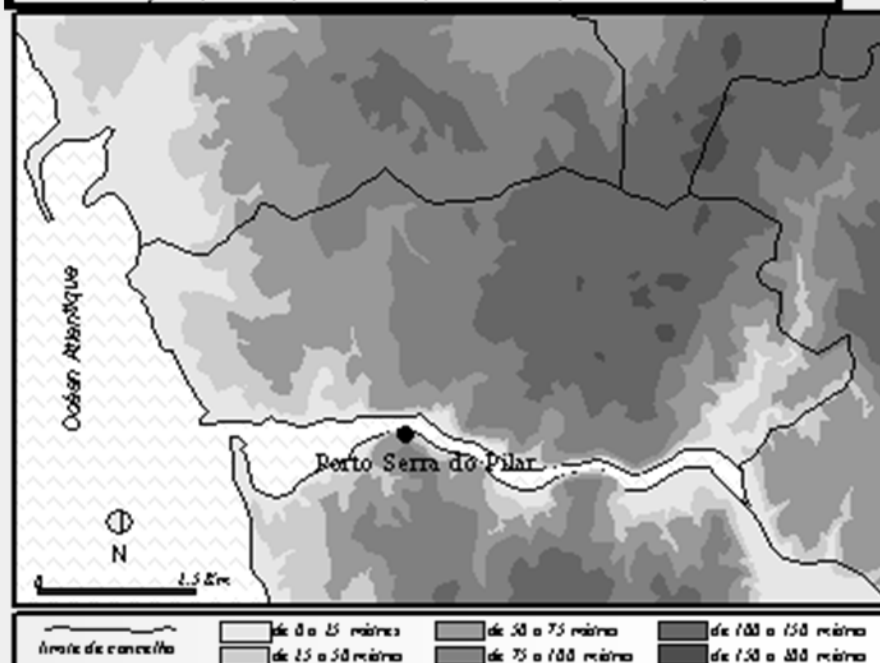
Porto's industrial and commercial location patterns and accessibility → changed

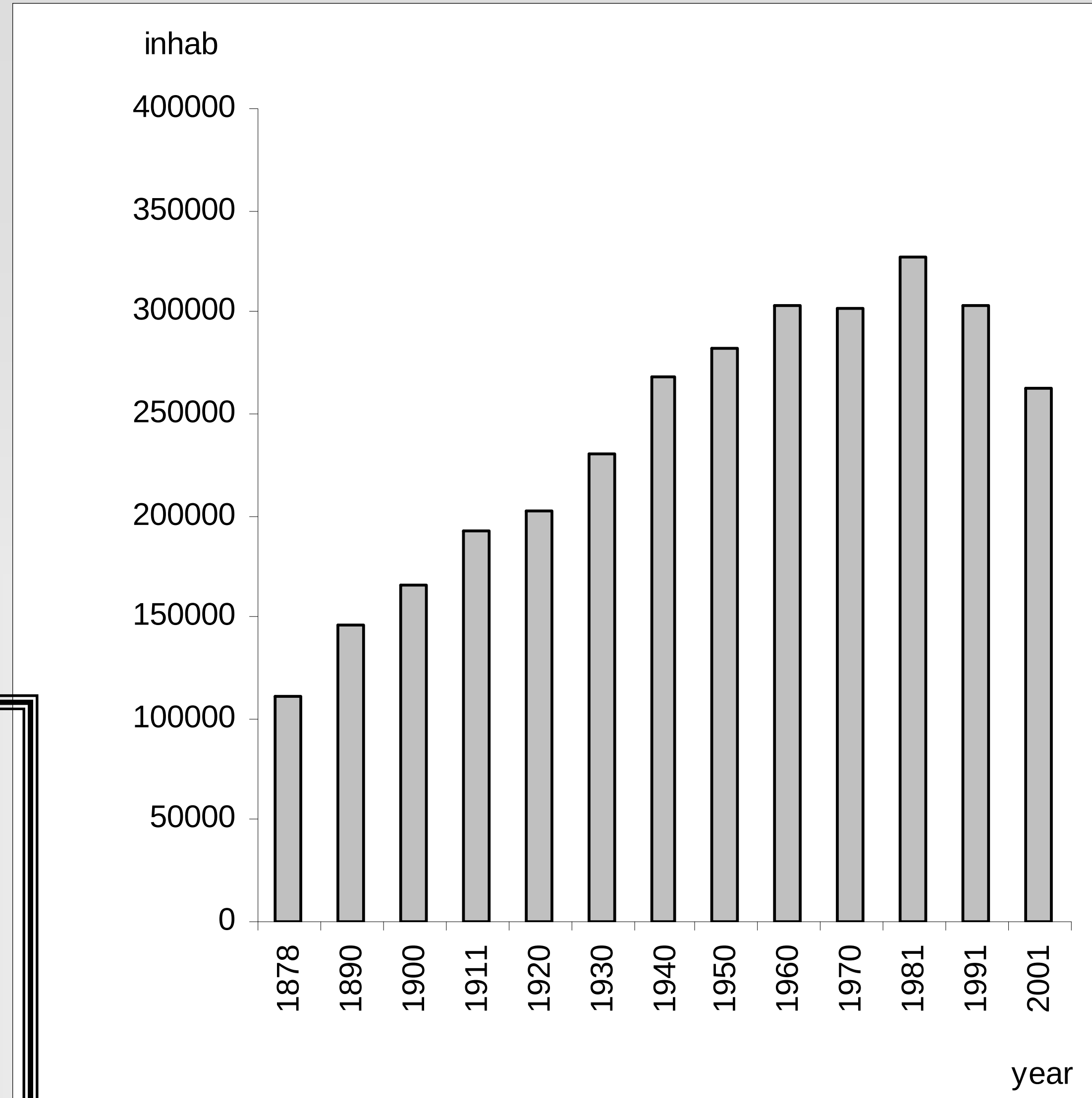
and were closely followed by the already expected reflexes in behavior and mentalities

Population
Human density
Impermeable area

→ **increase**







Porto

2nd most important Portuguese city

250 000 inhab.
(inside a 1million metropolitan area)

600 veihcles/1000 inab.

>300 000 vehicles/day

Urbanization stress

More people

More buildings

More traffic

More activities

Less visible water

Less green areas

more traffic

Air Quality → Atmospheric filter properties change

City	Nº Vehicles/day	Speed (km/h)	Emissions Estimation (kg/km done)			
			CO	CxHy	NOx	SO_2
PORTO	300 000	35	6 300	780	540	9. 900
		100	4 800	540	1 140	9. 300

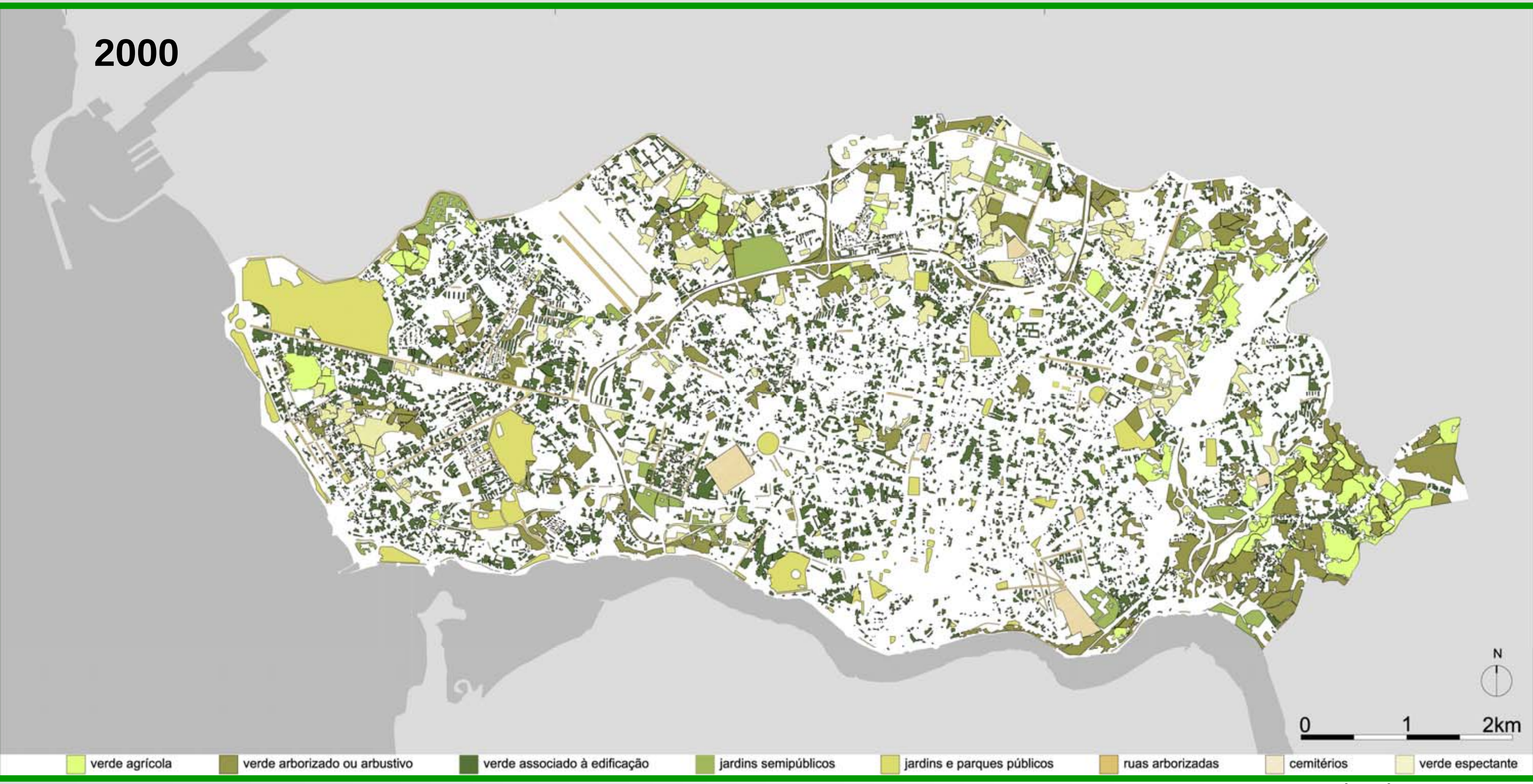
↓

Traffic fluidity

green areas loss

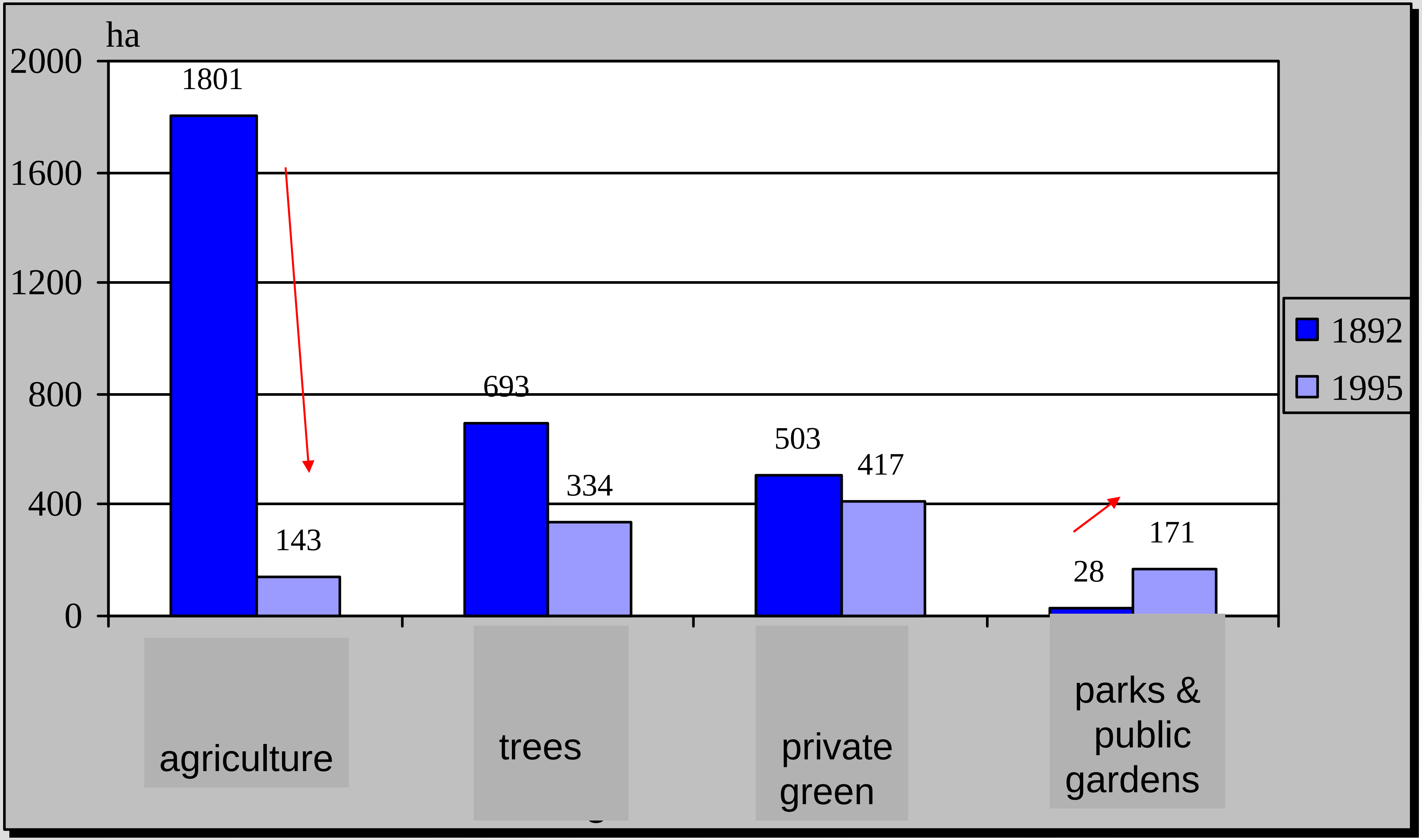
Madureira, H, 2001

green areas loss



Madureira, H, 2001

green areas loss



Madureira, H, 2001

Reason for doing this

Have we good reasons

to expect evidences of

Porto’s impact on climate?

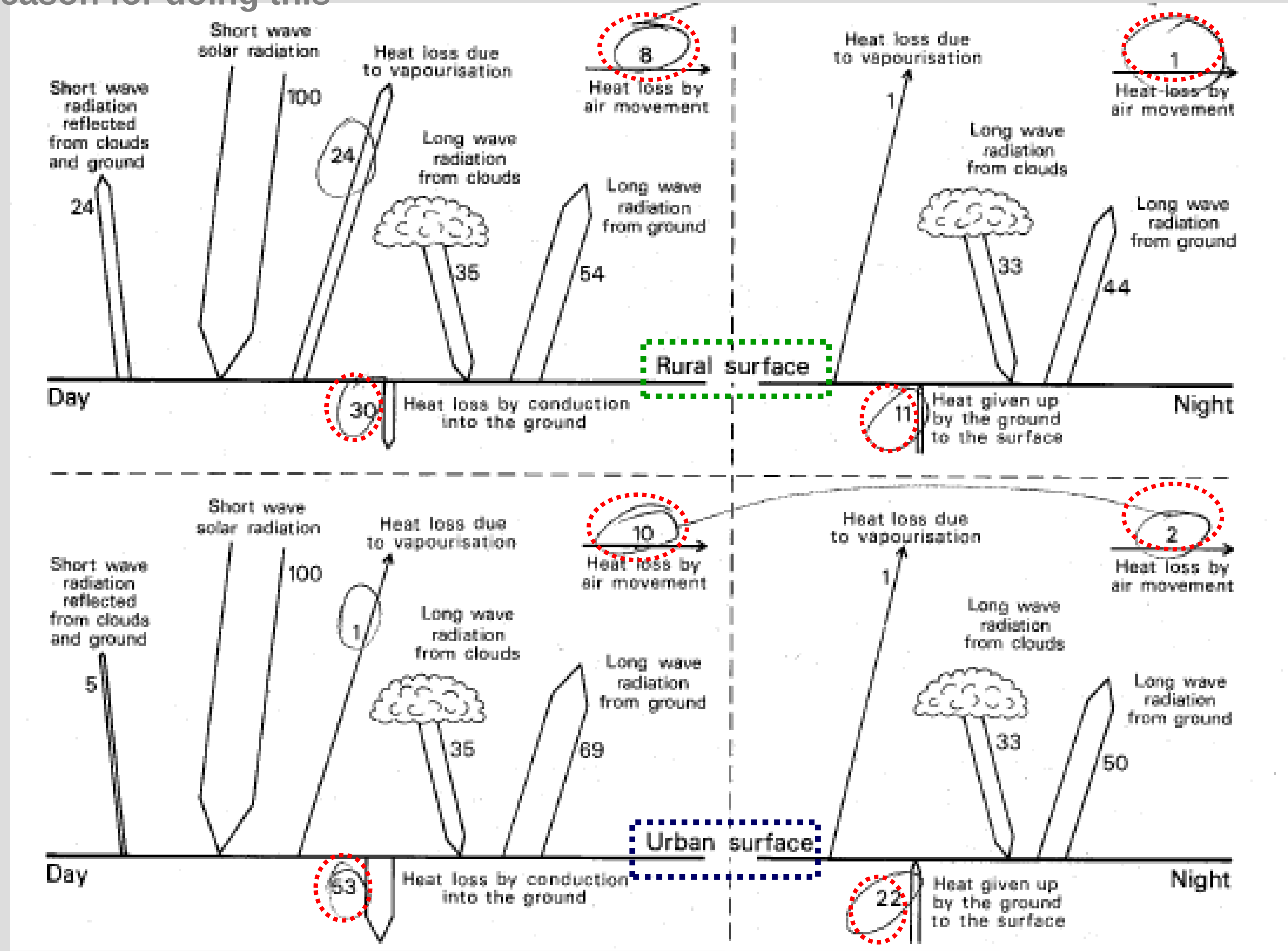
Urban energy budgets

in $\boxed{Qs+Qf+Qi = Ql+Qg+Qe}$ out

Qs - rate of radiant energy from sun
Qf - rate of generation of heat due to combustion, metabolism and disssipation machinery
Qi – rate of heat arrival fro the earth's interior

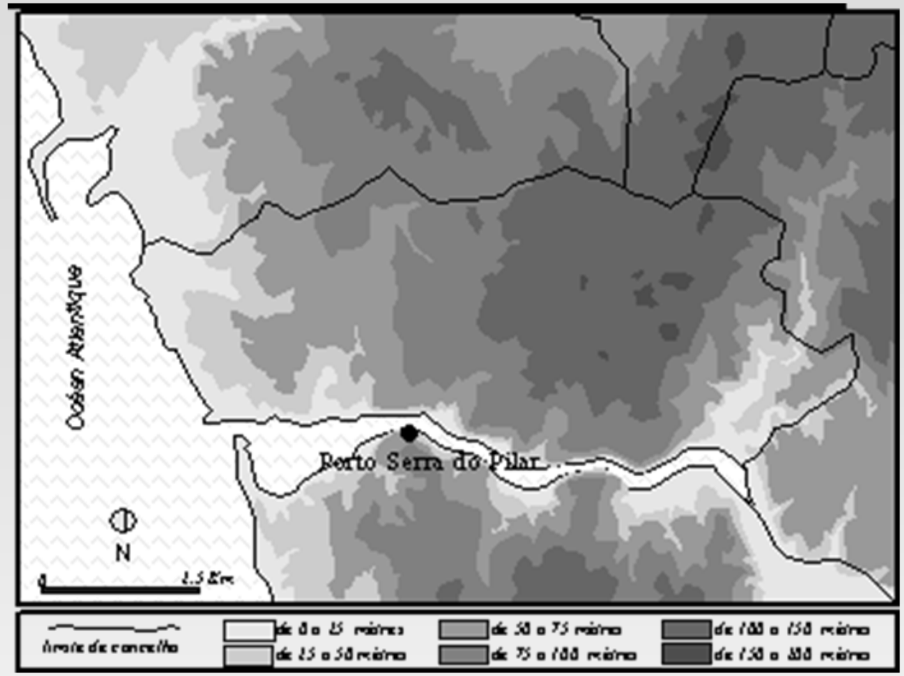
Ql – rate of loss of heat by evaporation
Qg – rate of loss of heat by conduction to soil, buildings, roads, etc.
Qe – rate of loss of heat by radiation

Reason for doing this



Landsberg, 1979

Reason for doing this



Porto's geographical context is very complex.

Confined by the Atlantic Ocean on the west

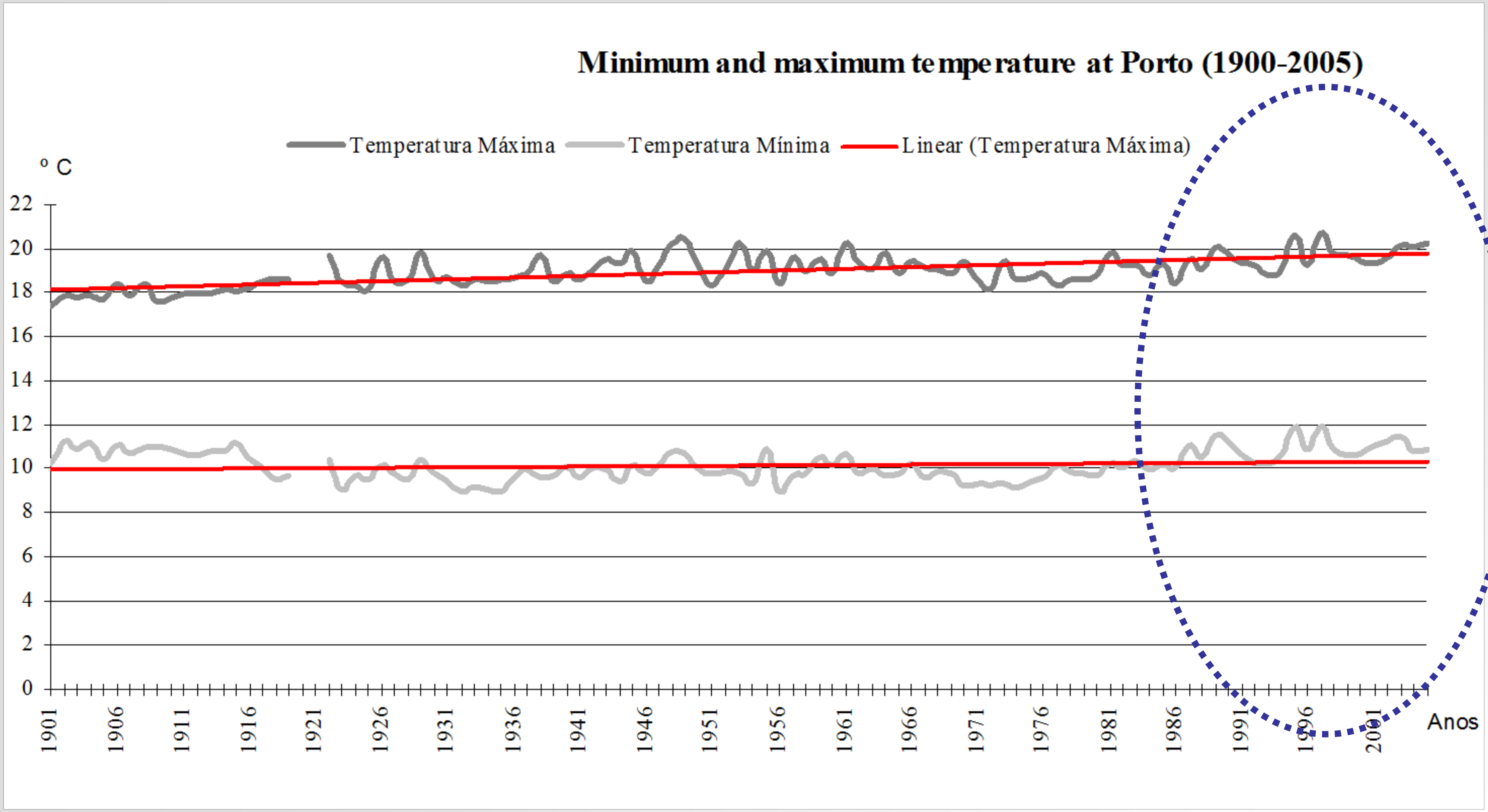
and to the south by the Douro's River

and with some important orographic barriers on the east,

and the climate?.....

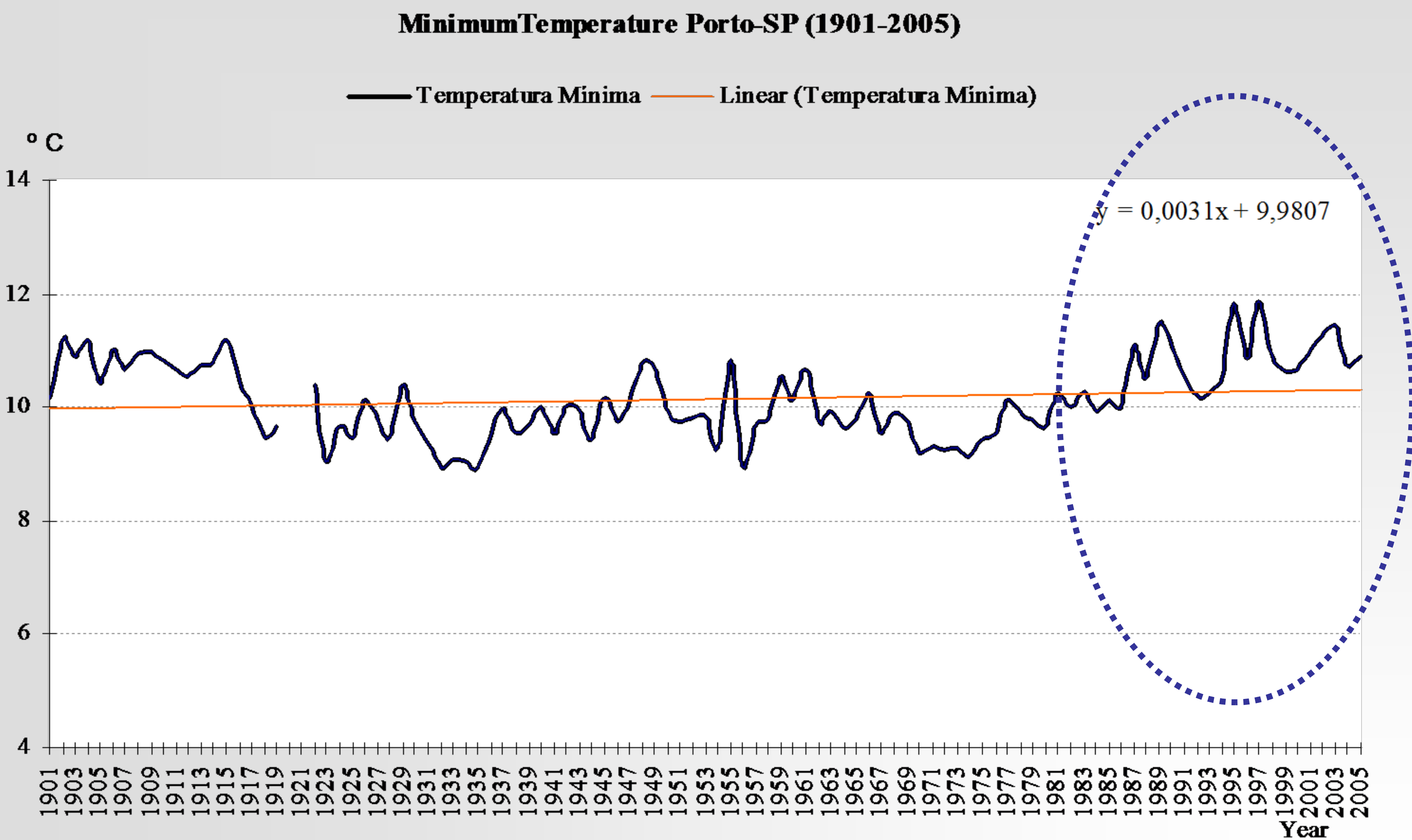
evidences of urbanization impacts on climate?

RESULTS



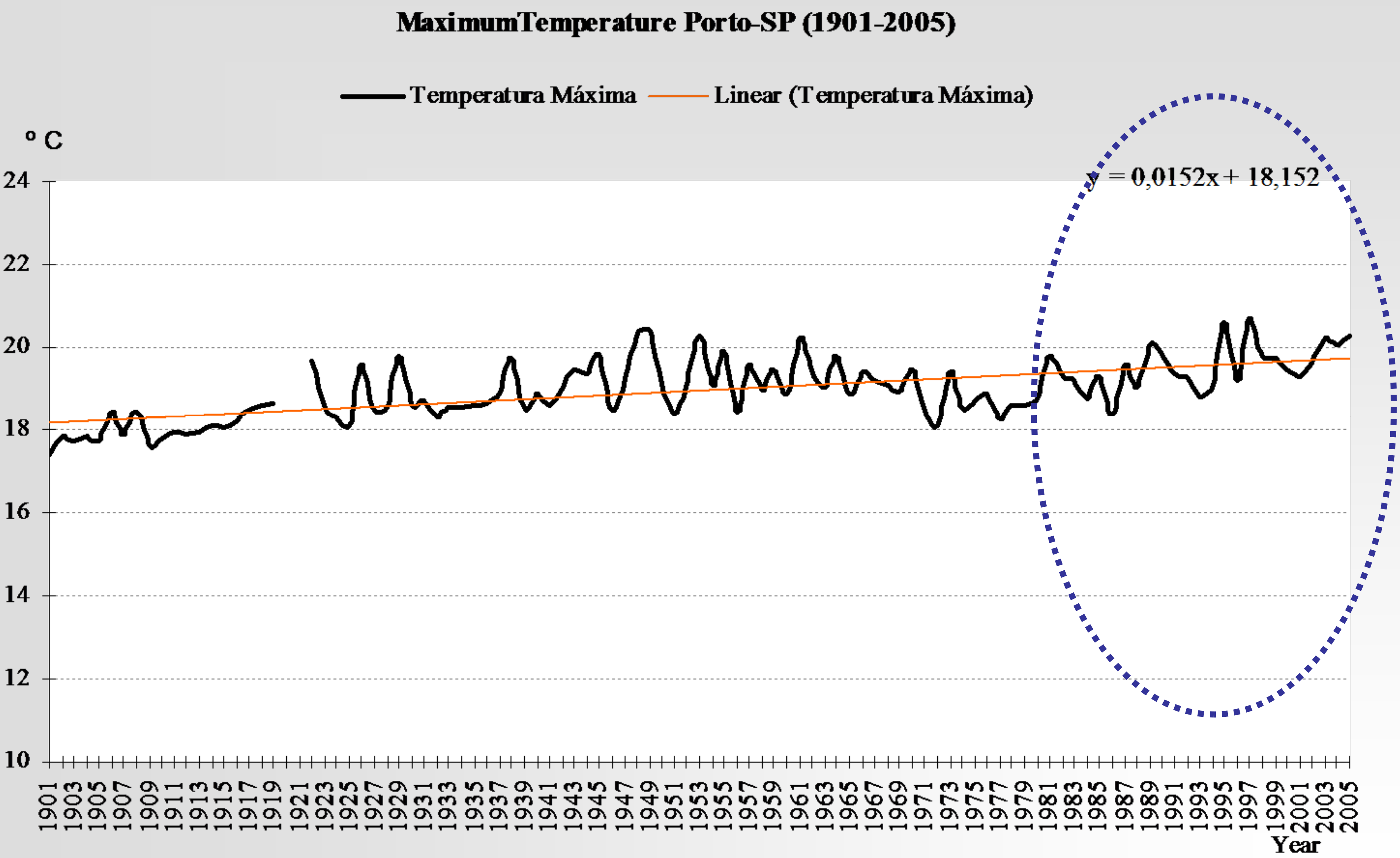
upward trend
especially evident in the minimum temperatures and during the colder season.

RESULTS



MinimumTemperature Porto-SP (1901-2005)
Temperatura Minima
Linear (Temperatura Minima)
° C
y = 0,0031x + 9,9807
14
12
10
8
6
4
Year

RESULTS



MaximumTemperature Porto-SP (1901-2005)
Temperatura Máxima
Linear (Temperatura Máxima)
° C
y = 0,0152x + 18,152
24
22
20
18
16
14
12
10
1901
1903
1905
1907
1909
1911
1913
1915
1917
1919
1921
1923
1925
1927
1929
1931
1933
1935
1937
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1991
1993
1995
1997
1999
2001
2003
2005
Year

RESULTS

We conclude that exists a steady increase

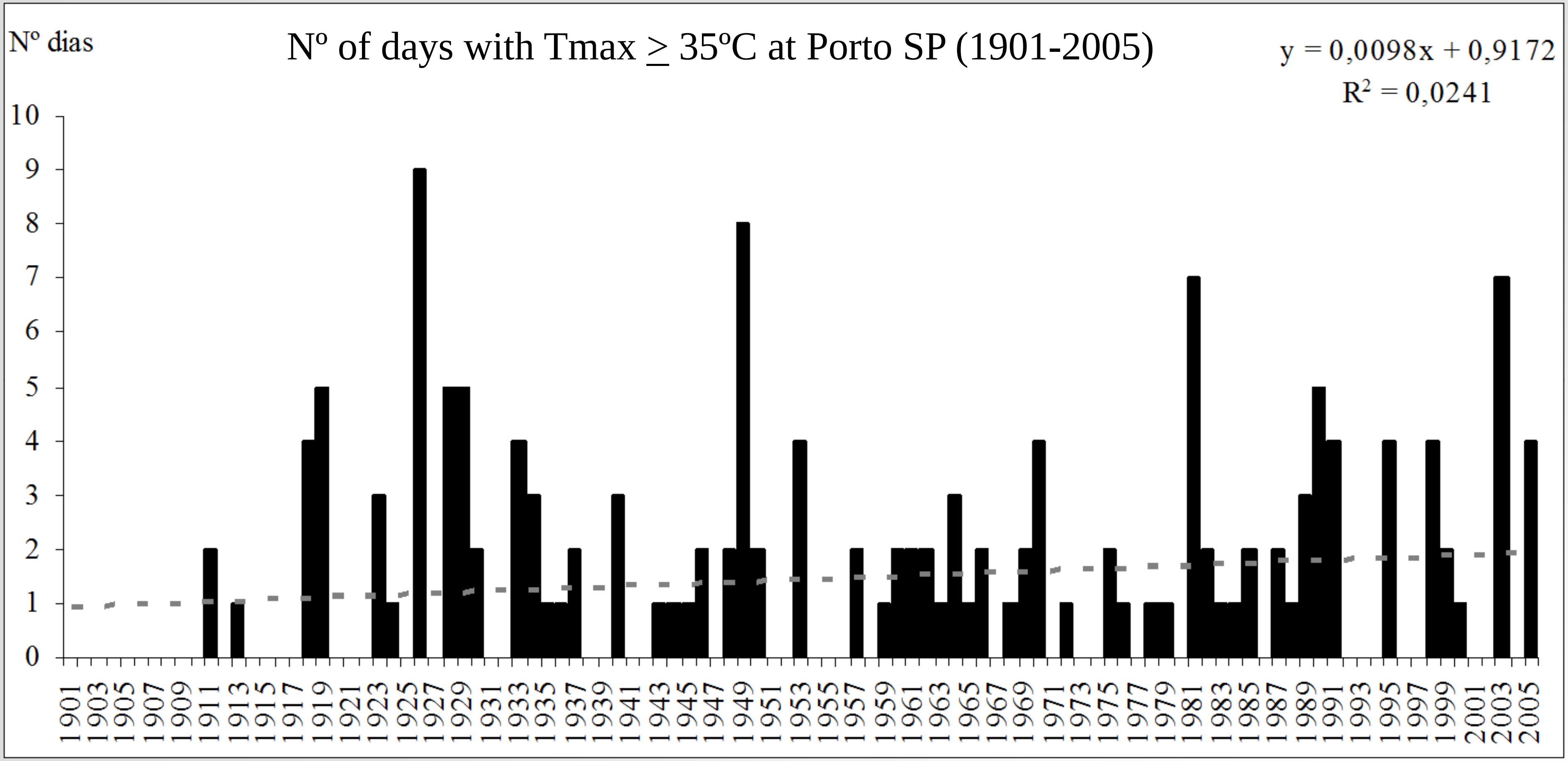
especially in the winter minimum temperatures,

that

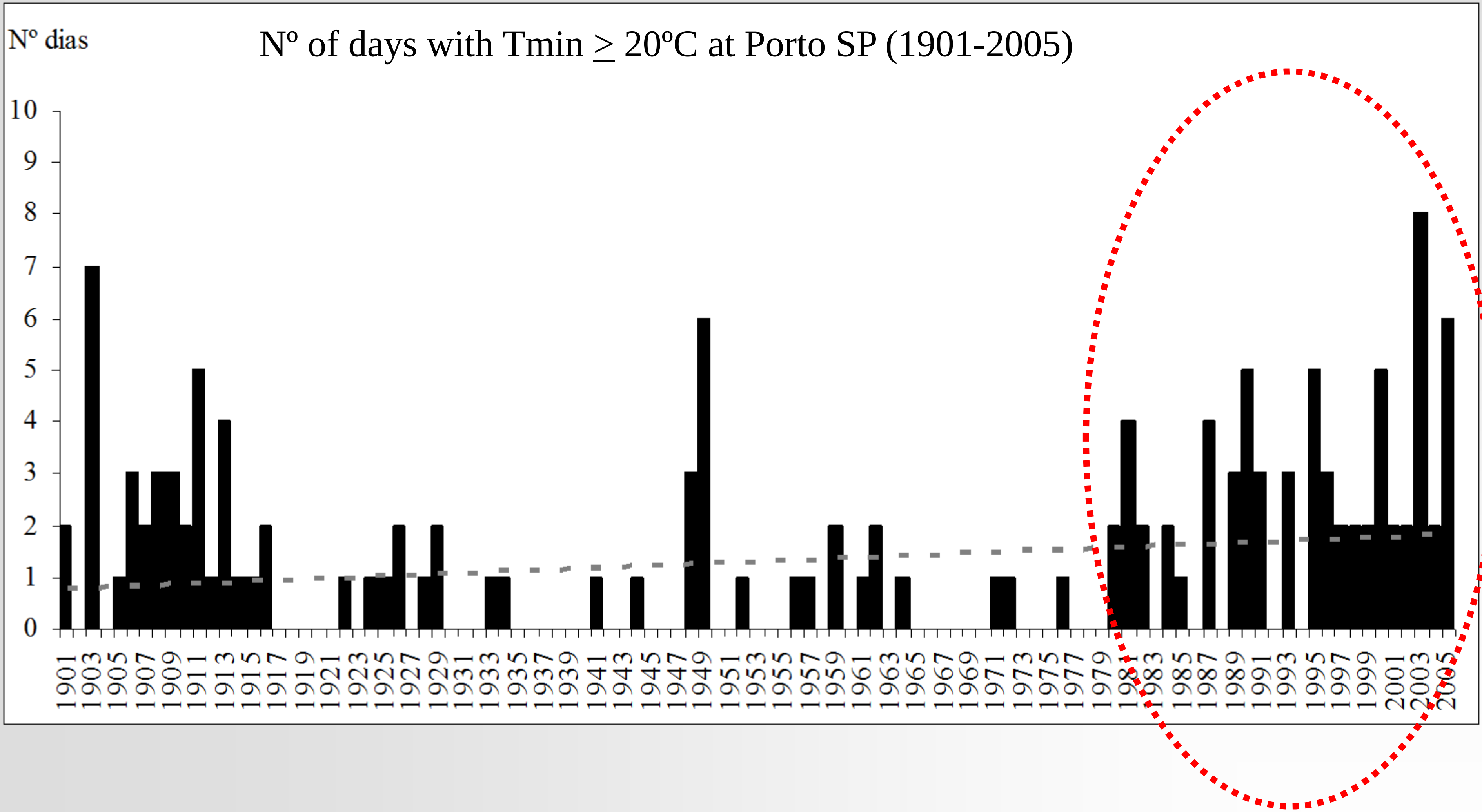
can not be merely interpreted as the result of intrinsic climatic variability

It should be viewed as a short-term temporary answer to the uncountable human interferences in the *climatic system*

RESULTS


Nº dias
Nº of days with Tmax ≥ 35ºC at Porto SP (1901-2005)
y = 0,0098x + 0,9172
R² = 0,0241
10
9
8
7
6
5
4
3
2
1
0
1901 1903 1905 1907 1909 1911 1913 1915 1917 1919 1921 1923 1925 1927 1929 1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005

RESULTS


Nº dias
Nº of days with Tmin ≥ 20ºC at Porto SP (1901-2005)
0
1
2
3
4
5
6
7
8
9
10
1901
1903
1905
1907
1909
1911
1913
1915
1917
1919
1921
1923
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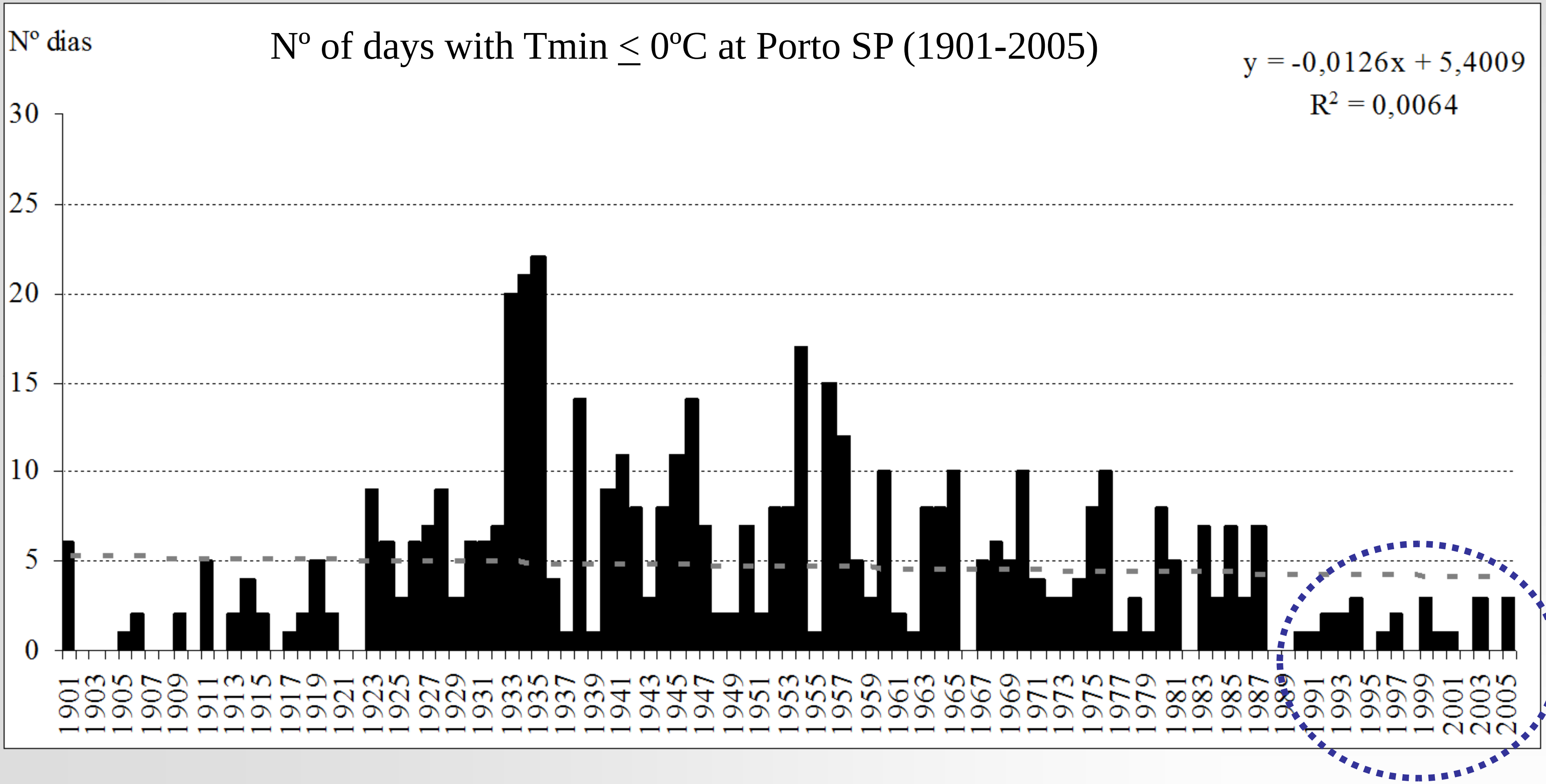
1997
1999
2001
2003
2005

RESULTS



Nº dias
Nº of days with Tmin ≤ 0ºC at Porto SP (1901-2005)
y = -0,0126x + 5,4009
R² = 0,0064
30
25
20
15
10
5
0
1901 1903 1905 1907 1909 1911 1913 1915 1917 1919 1921 1923 1925 1927 1929 1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005

We conclude that exists a steady increase

of

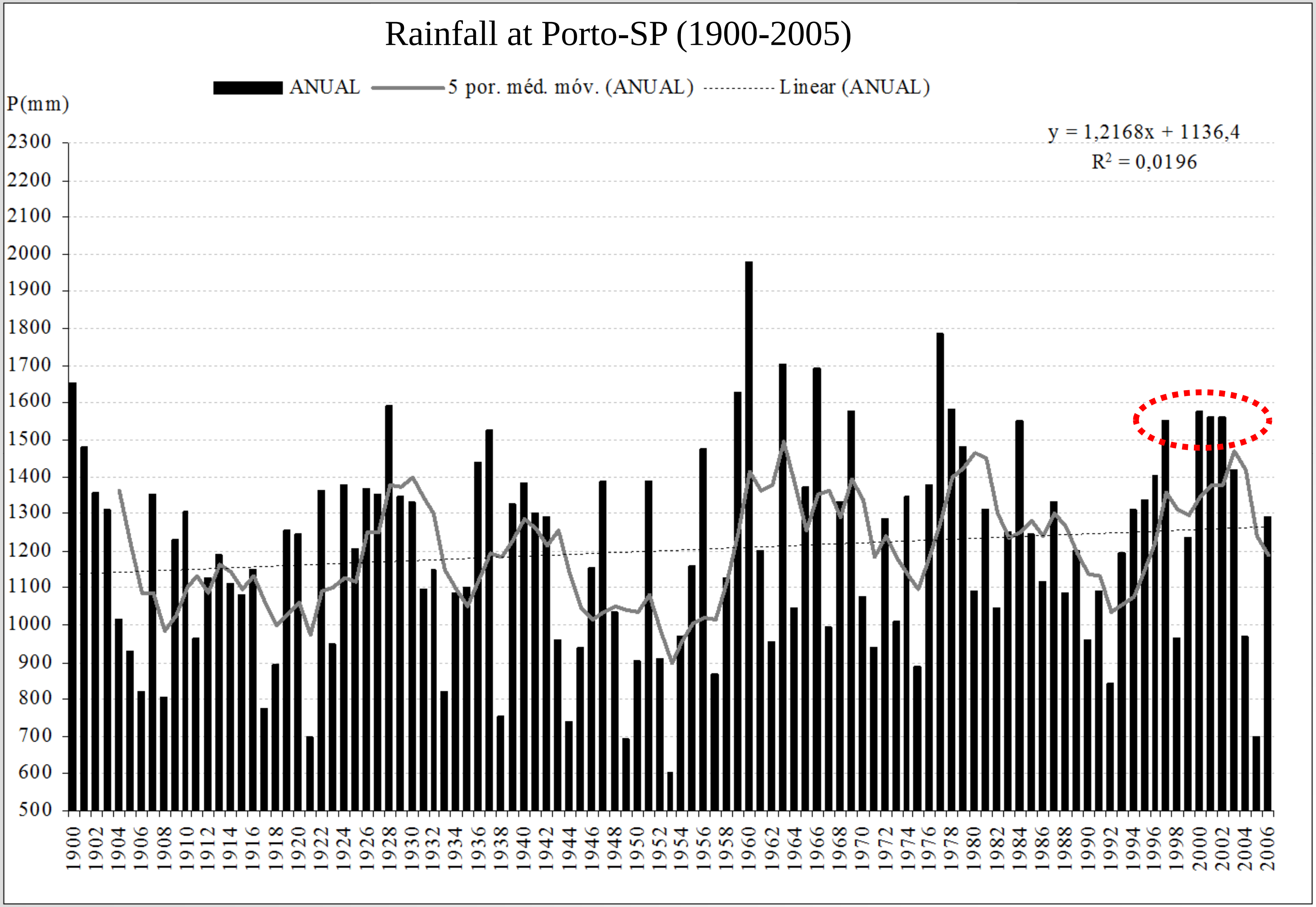
tropical nights and very hot days

We conclude that exists a steady decrease

of

frost during nights

RESULTS



Rainfall at Porto-SP (1900-2005)
ANUAL
5 por. méd. móv. (ANUAL)
Linear (ANUAL)
P(mm)
y = 1,2168x + 1136,4
R² = 0,0196
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
1900
1902
1904
1906
1908
1910
1912
1914
1916
1918
1920
1922
1924
1926
1928
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1932
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1966
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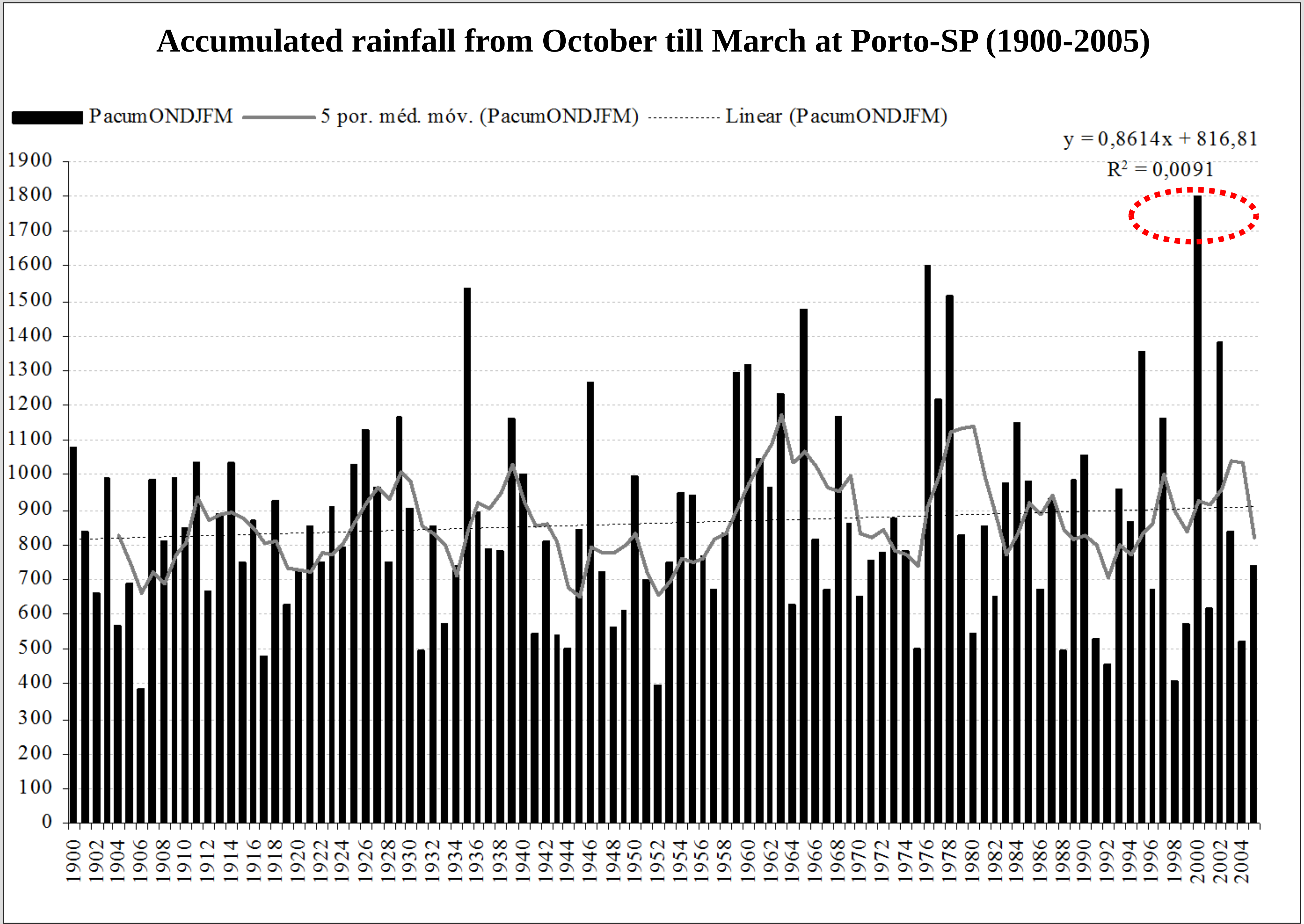
1996
1998
2000
2002
2004
2006

RESULTS



Accumulated rainfall from October till March at Porto-SP (1900-2005)
PacumONDJFM
5 por. méd. móv. (PacumONDJFM)
Linear (PacumONDJFM)
y = 0,8614x + 816,81
R² = 0,0091

Rainfall data shows

a seasonal disorganization

Why ?

Local? Regional? Global?

Global Warming effect?

Urbanization effect?

Urbanization effects on regional climate

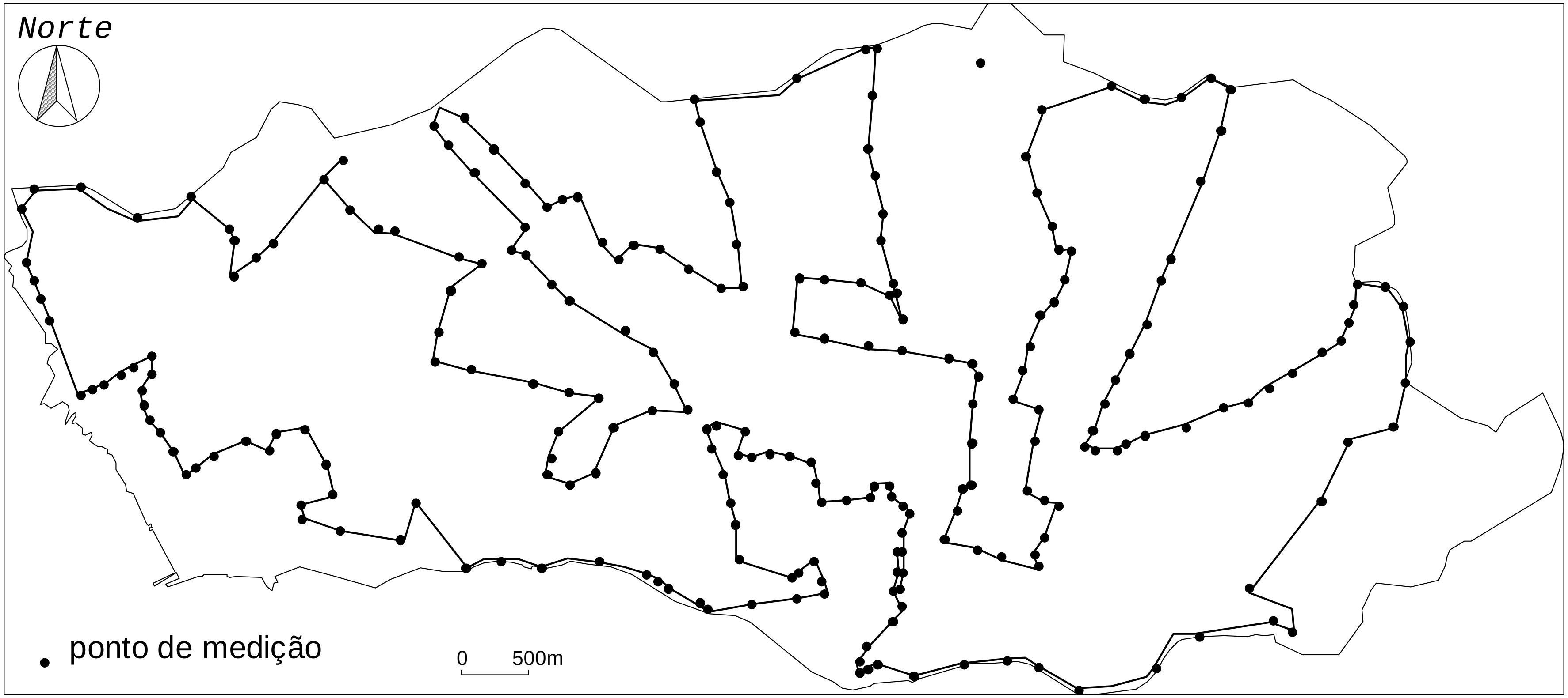
with the predicted formula of Oke, T.R. (1973)

relating **population size** and ***urban heat island* intensity**

CITY	INHABITANTS	T(u-r)measured	PREDICTED	AUTOR
LONDON	8500000	10°C	9.9°C	CHANDLER, 1965
BERLIM	4200000	10°C	9.3°C	GRUNOW, 1936
VIENA	1870000	8°C	8.5°C	SCHMIDT, 1927
SHEFFIELD	500000	8°C	11.5°C	GARNETT, 1966
MALMO	275000	7.4°C	7.4°C	LINDQVIST, 1972
LISBON	830000	4°C-5°C	7.8°C	ALCOFORADO,1988
COIMBRA	98000	5°C	6.0°C	GANHO, 1992
PORTO	300000	**6.0°C**	**6.9°C**	MONTEIRO, 1993

Oke, T.R. formula: DTu-r (max.) = 2.01 log. pop.- 4.06

Urban climate monitoring


Norte
ponto de medição
0
500m

PORTO

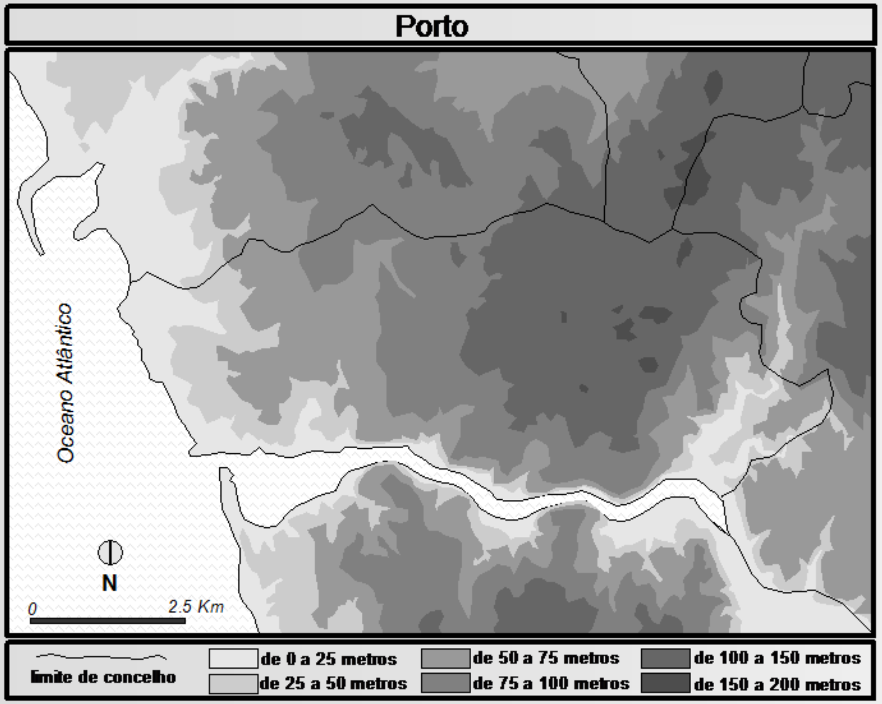
Dimension - 42 km^2

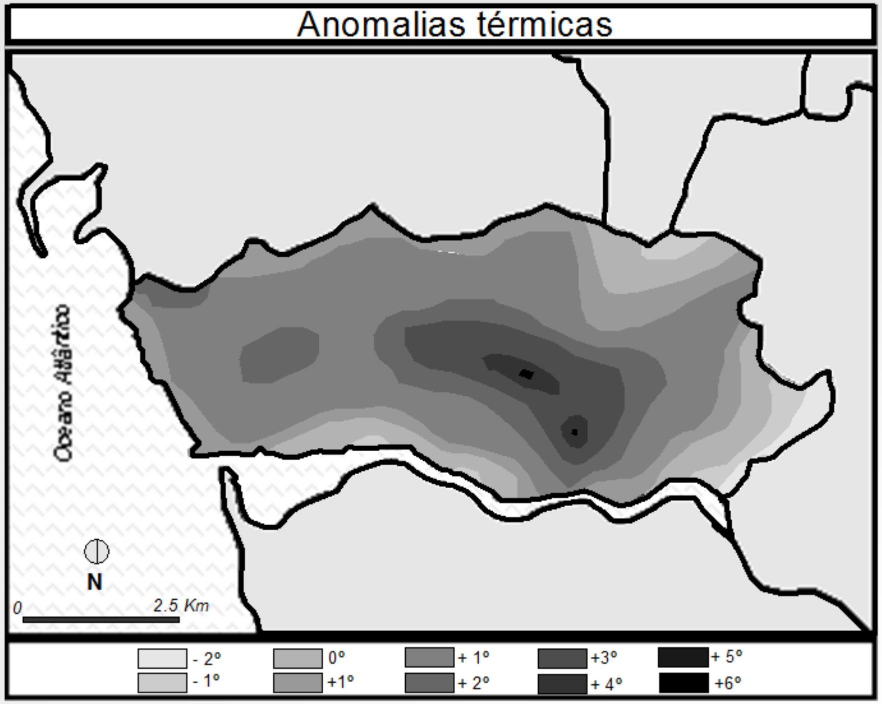
Population - 270 060

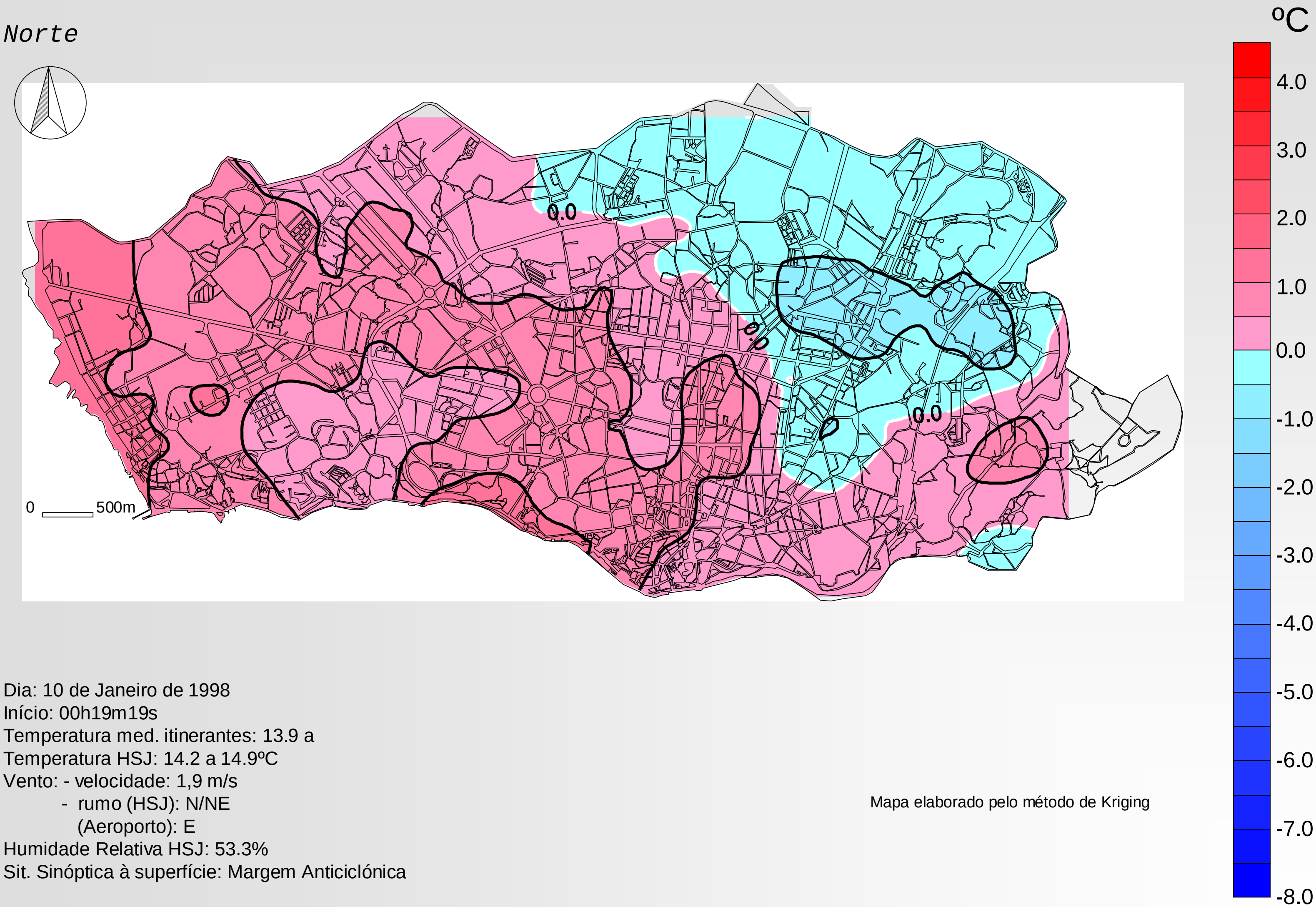
Motorisation rate - 596 vehic. /1000hab

Vehicles/day- > 300 000

Urban heat island 6 a 8ºC

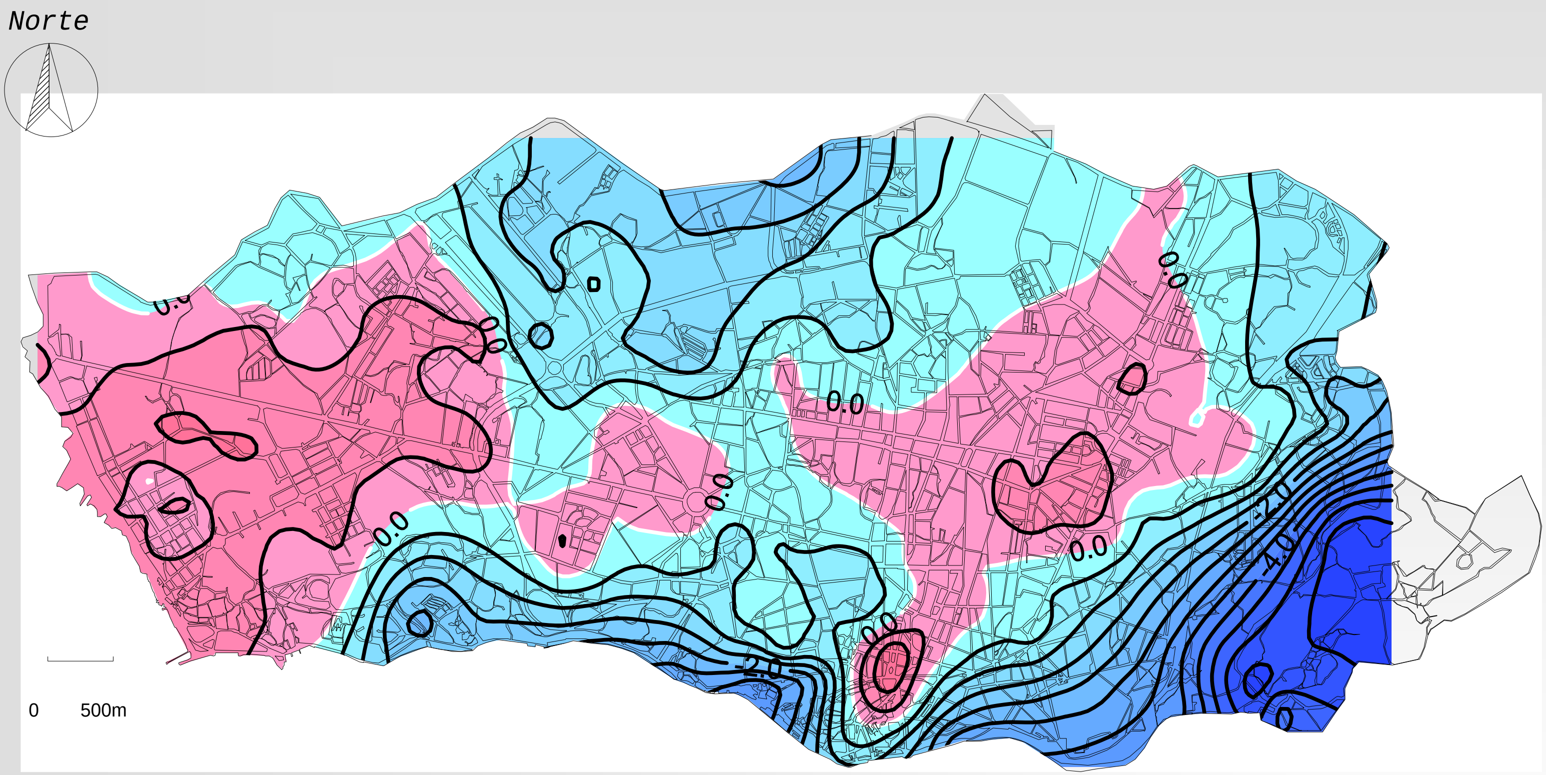


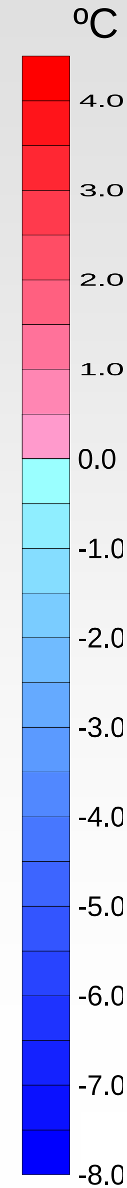




Dia: 10 de Janeiro de 1998
Início: 00h19m19s
Temperatura med. itinerantes: 13.9 a
Temperatura HSJ: 14.2 a 14.9ºC
Vento: - velocidade: 1,9 m/s
- rumo (HSJ): N/NE
(Aeroporto): E
Humidade Relativa HSJ: 53.3%
Sit. Sinóptica à superfície: Margem Anticiclónica

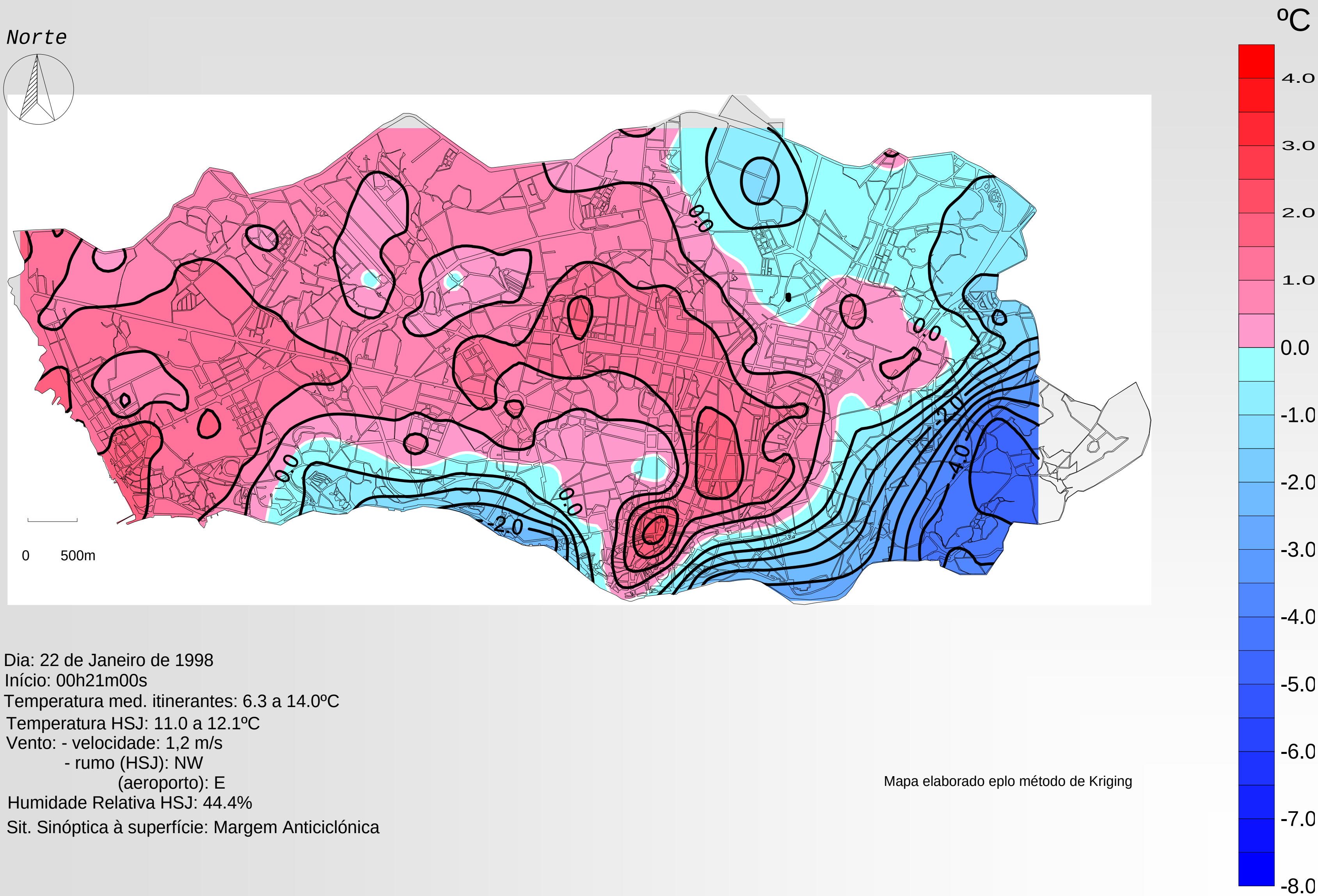
Mapa elaborado pelo método de Kriging





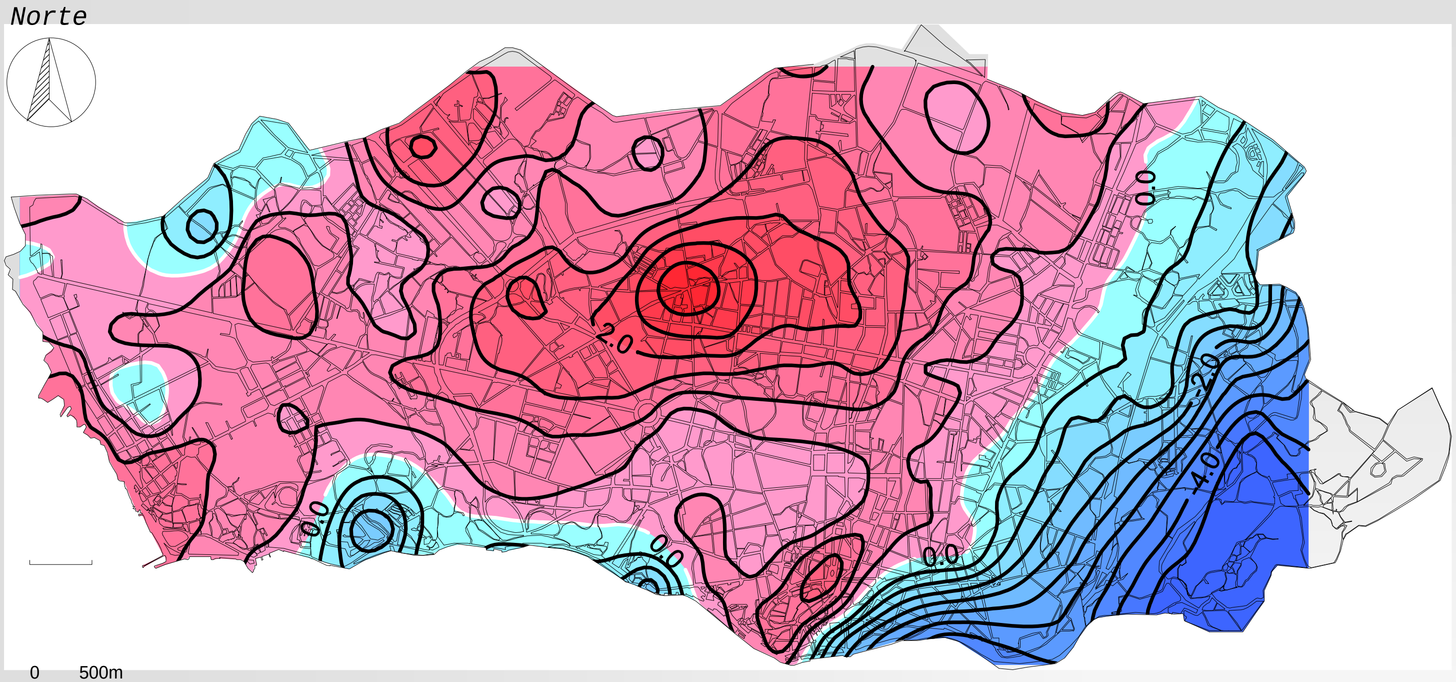
Dia: 22 de Janeiro de 1998 (2º percurso)
Início: 00h43m38s
Temperatura med. itinerantes: 5.3 a 12.6ºC
Temperatura HSJ: 11.1 a 12.1ºC
Vento: - velocidade: 1,4 m/s
- rumo (HSJ): NW
(aeroporto): E
Humidade Relativa HSJ: 44.4%
Sit. Sinóptica à superfície: Margem Anticiclónica

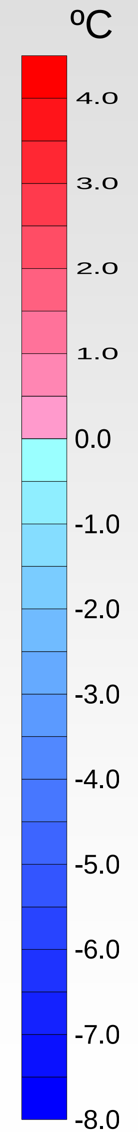
Mapa elaborado pelo método de Kriging



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





Dia: 19 de Junho de 1998
Início: 00h08m03s
Temperatura med. itinerantes: 19.9 a 27.3ºC
Temperatura HSJ: 24.0 a 25.2ºC
Vento: - velocidade:0.4 m/s
- rumo (HSJ): E
(aeroporto): E
Humidade Relativa HSJ: 53.1%
Sit. Sinóptica à superfície: Anticiclone Atlântico Subtropical

Mapa elaborado pelo método de kriging

The resolution process in *Oporto’s climatic subsystem*

under generically similar synoptic situations

were **quite diverse**.

The Oporto’s thermal nocturnal pattern denoted great vulnerability,

in relation to the different types of synoptic situation,

as well as

in relation to small *nuances* within the same type of synoptic situation.

“heat-island” was specially evident

on days of

great stability, weak barometric gradient, weak wind and frequent **periods of calm**.

Conditions normally associated with the presence of anticyclonic situations, but which, as we saw, can arise under the influence of situations of depression, when the ascendant movement of the air is conditioned by the presence, in altitude, of a “cold drop”, or when caused by a strong base heating.

The **shape** and **intensity** of the Porto ***urban heat island*** changed a lot

from one day to another

according with the weather type prevalent.

The wind velocity and direction, the type and the vertical structure of the atmosphere

have an effective control upon the thermal pattern within the city favourable to some factors more than others.

The **thermal pattern of Porto** is the **instantaneous result of 3 main vectors**:
the distance to the atlantic ocean and/or to the Douro's river,
the altitude
and the intensity of the site urbanization phenomena.

But….

Neither the E-W topographic differentiation, nor the proximity of two important mosaics of water (the ocean and the Douro River),

nor, much less,

the repercussions in terms of the diversity of area occupation, inherent to its more than eight centuries of history,

are sufficient

to dissimulate the impacts of the **urban metabolism**,

at least, at the level of its **energetic balance**

So,

We should **downscale** our speech about climate change

It is very easy to demonstrate the mechanics involved in:
the human performances → urban climate
(local and regional scale)

It is very difficult to demonstrate and convince people of
the human performance → global warming
(zonal and global scale)

Thank you