Day and Night Heat Waves in the City of Barcelona. 1971-2020

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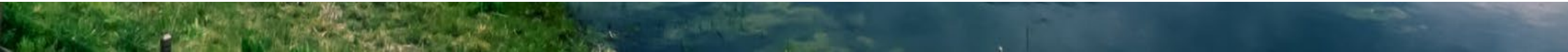
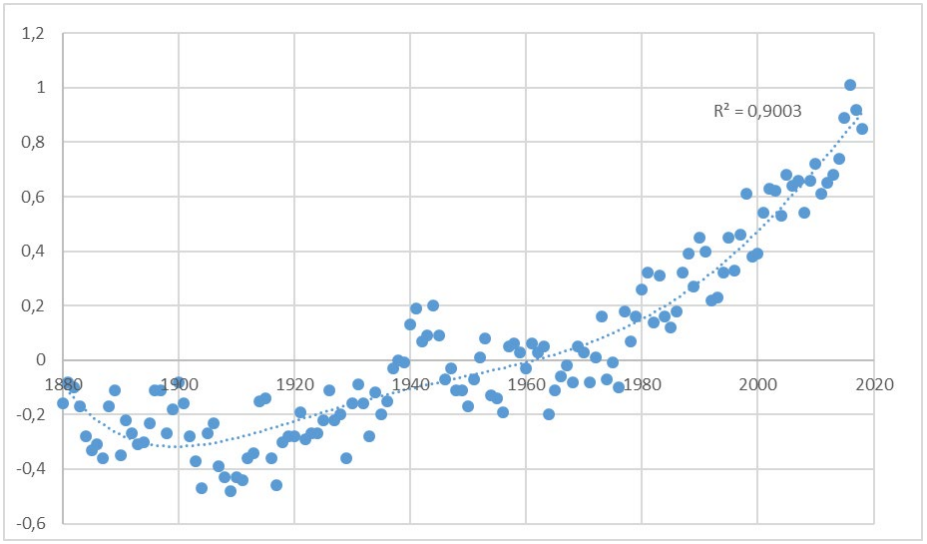
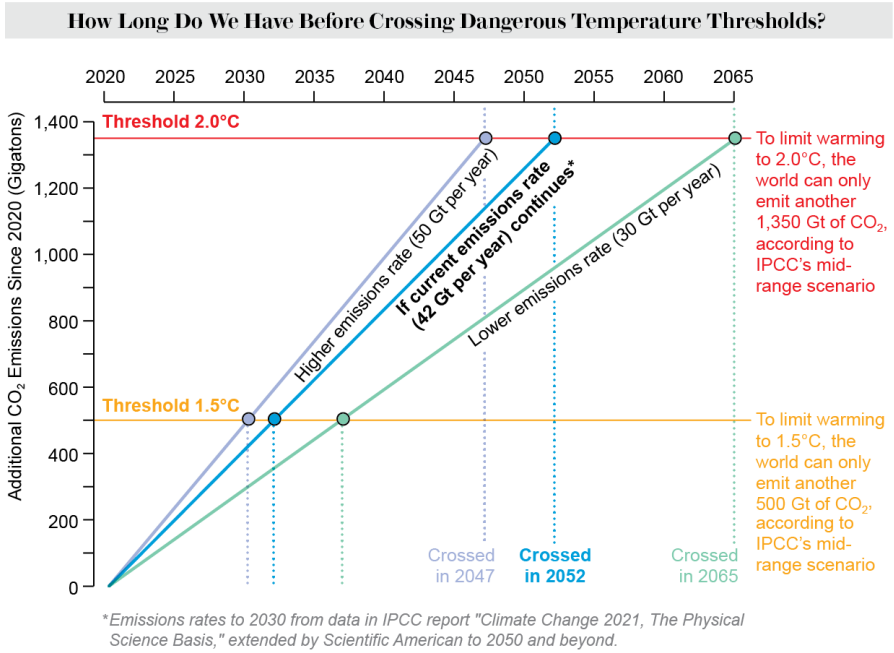


Global Warming

Global temperature has risen by nearly 1.1 °C since the industrial revolution.

Despite the effort of Cop 26 of limiting global warming to less than 1.5 Celsius degrees, reaching that level would still bring violent storms, deep flooding, gripping droughts and problematic sea-level rise; but it would avert even more severe consequences.

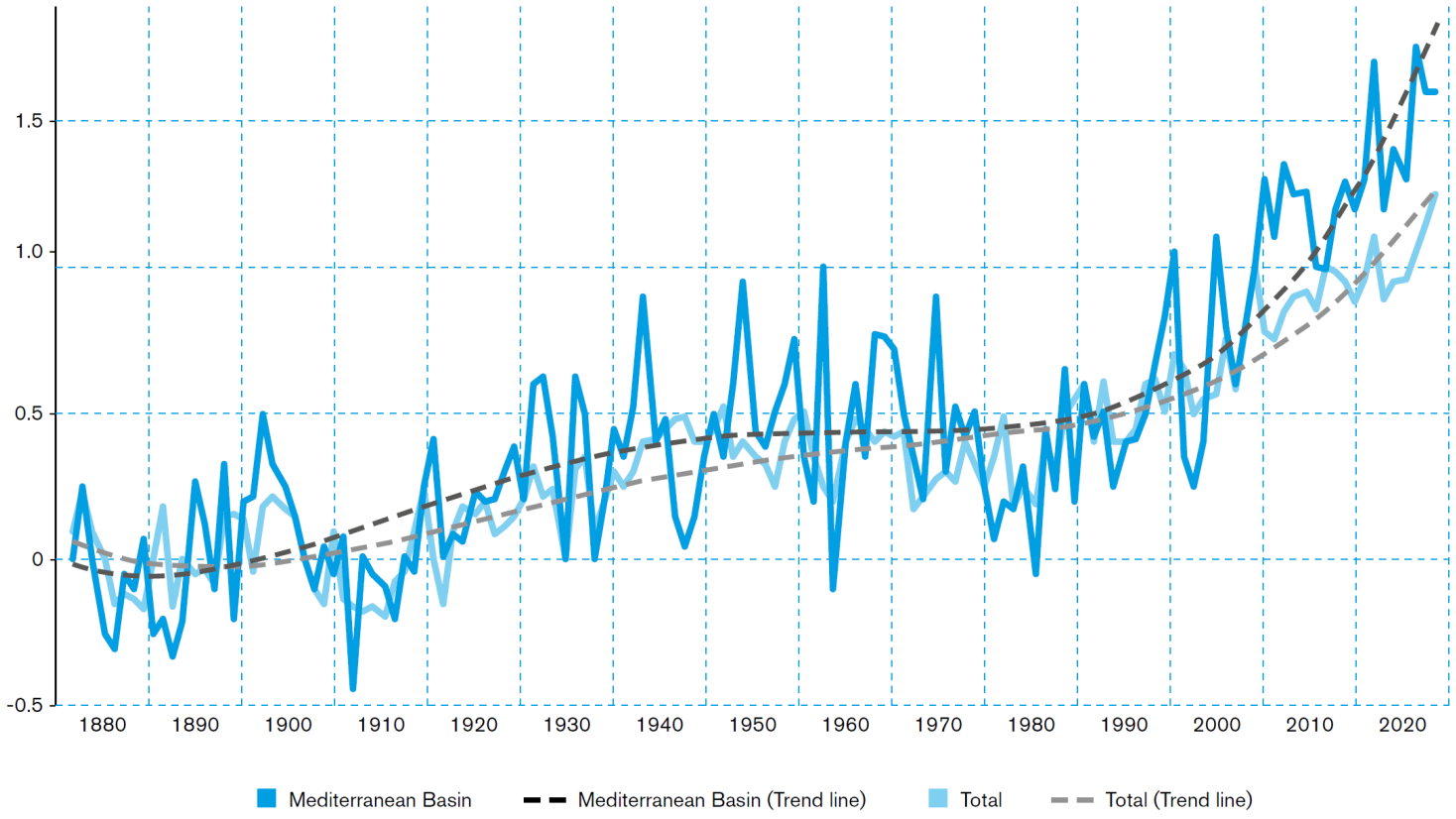




To avoid that threshold, the world can only emit a set amount of CO2 from now into the future. This quantity is known as the Carbon Budget.

Nations have about 11 more years at current emissions rates —2032— before exhausting the budget.

Global Warming in Mediterranean Area

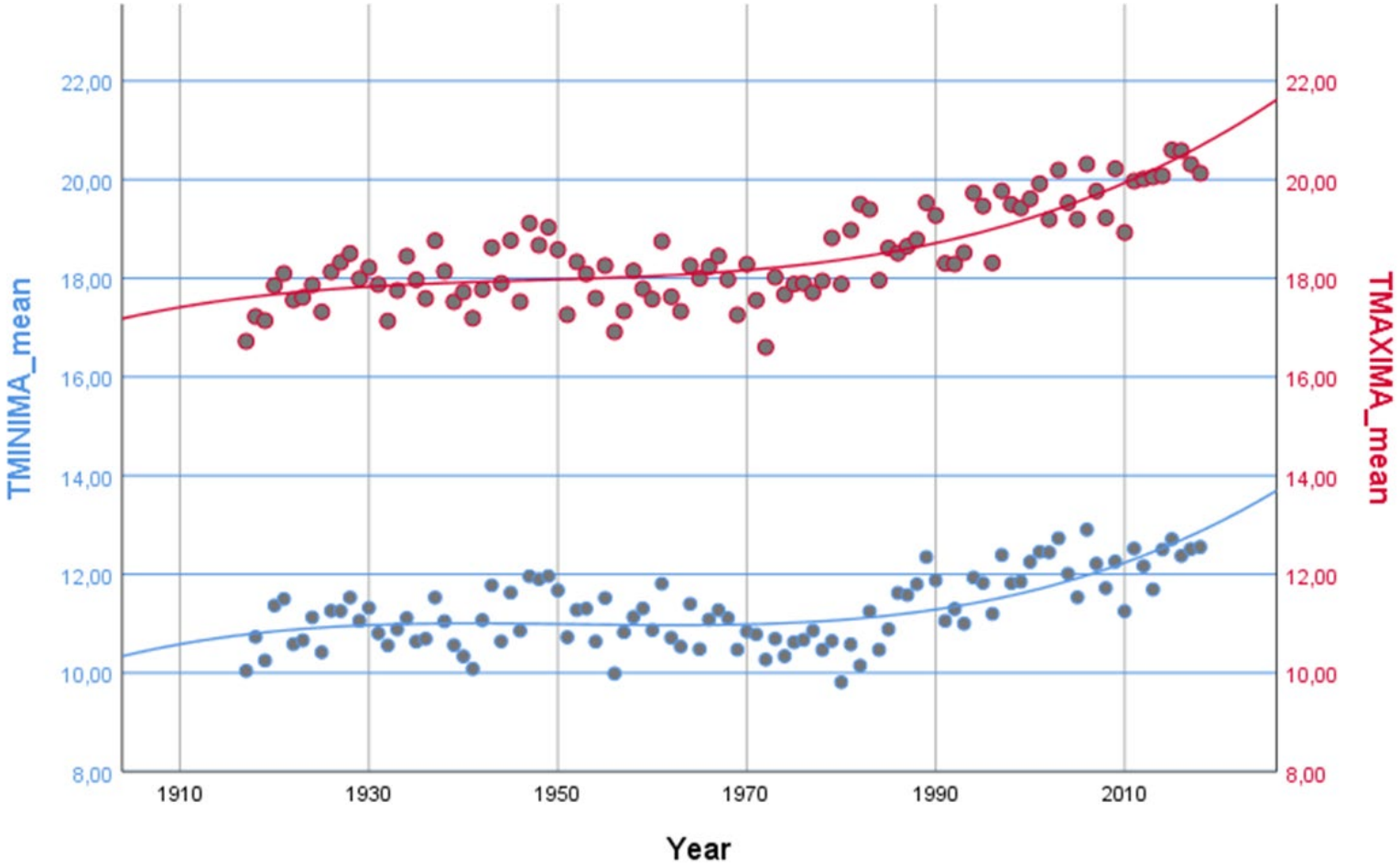


Mean Temperature Anomalies

The **Mediterranean** is expected to be one of the most vulnerable climate change 'hotspots' of the 21st century

The mean temperature over the Mediterranean has higher increasing than the global average

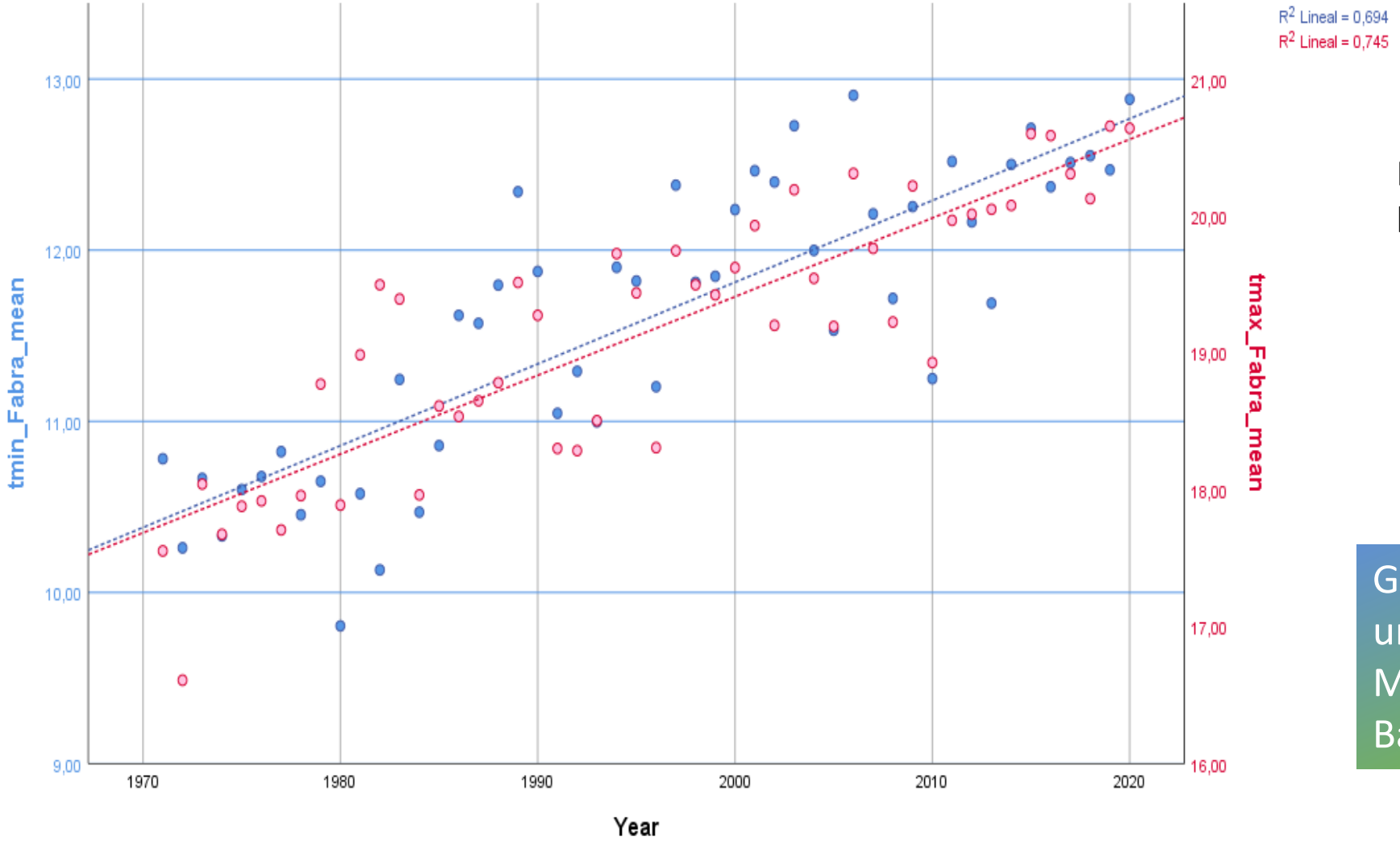
Global Warming in Barcelona



Fabra Observatory Historical Temperature Records

In Barcelona, the temperature increase since the pre-industrial era has exceeded 2 degrees

Air Temperature (1971-2020)



Fabra Observatory Data

Maximum average temperature have increased 2.82°C

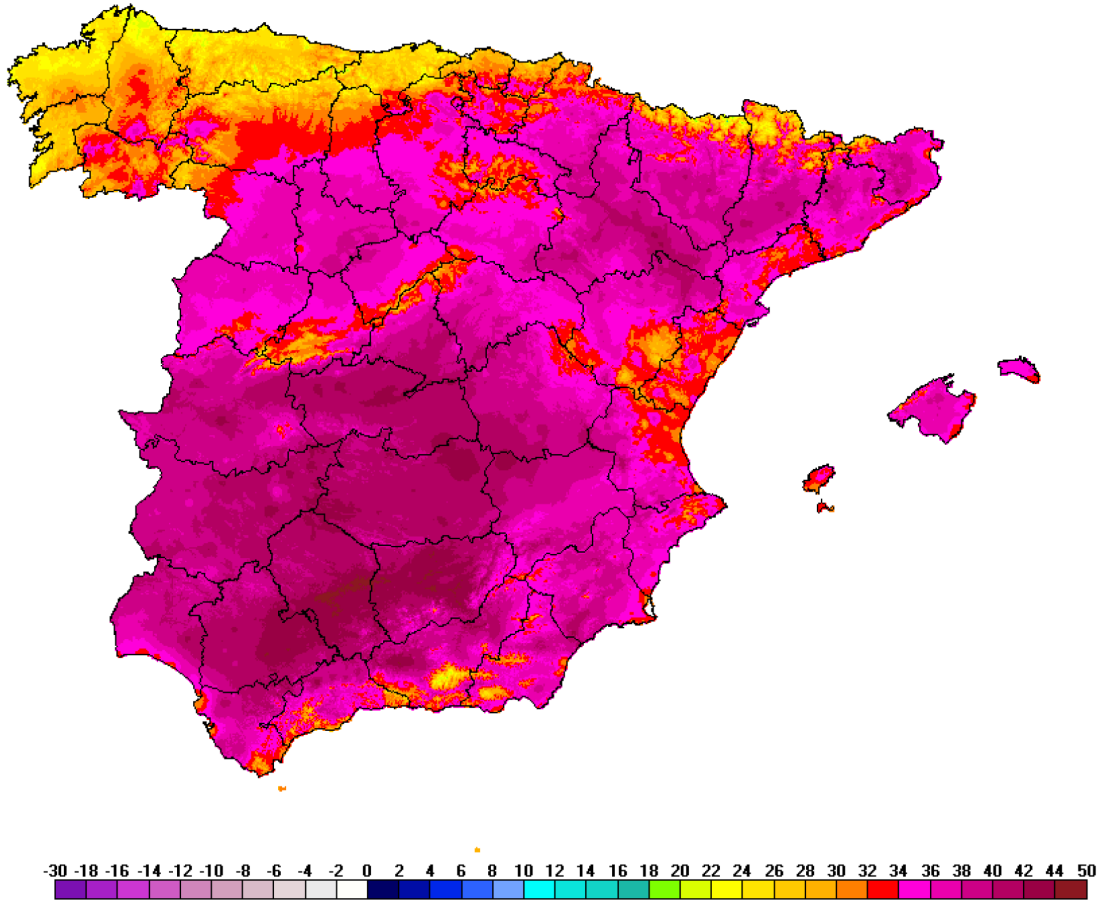
Minimum average temperature have increased 2.34°C

Global warming is an uncontroversial reality in the Mediterranean area in which Barcelona City is located.

Heat Wave

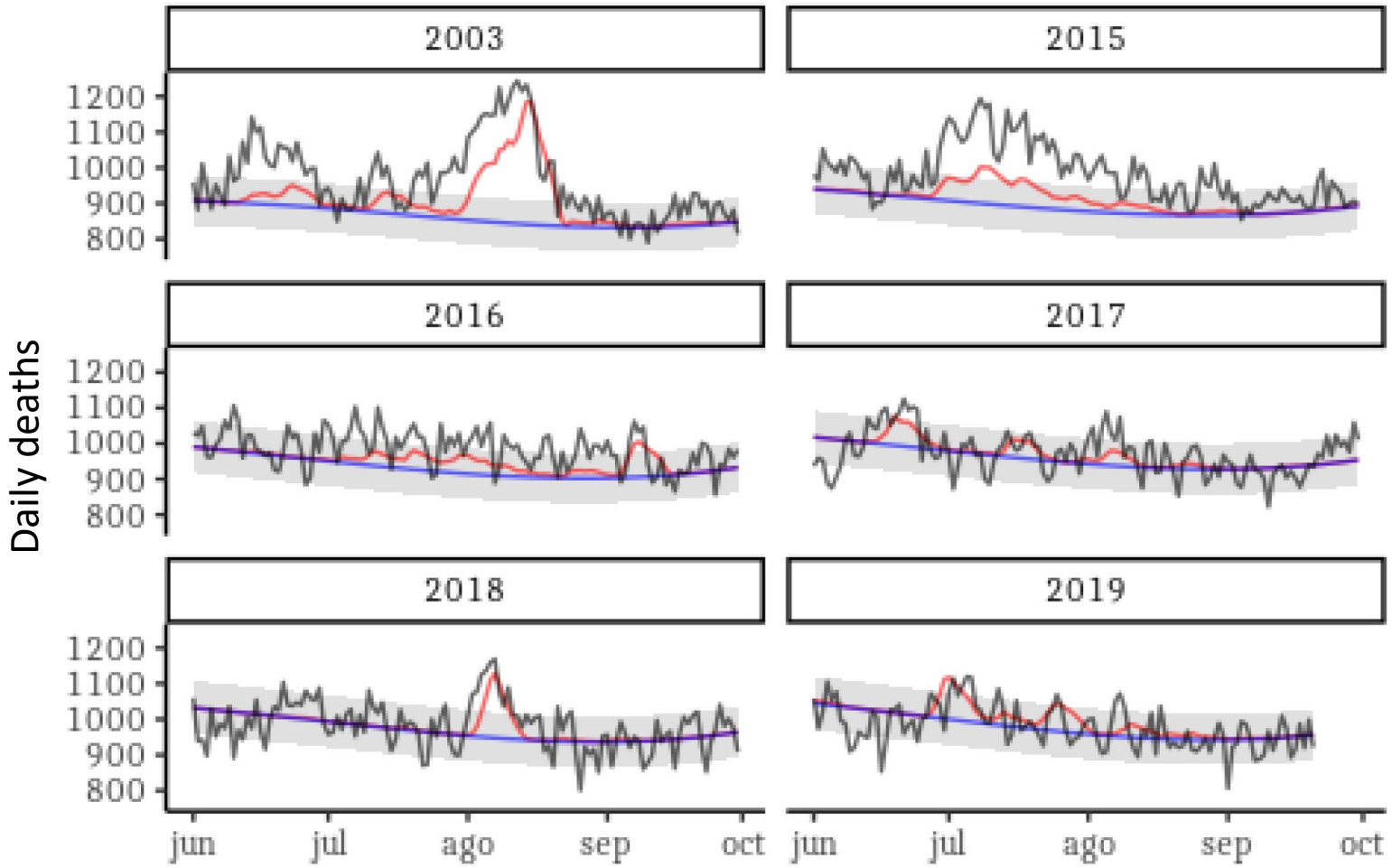
There is no universal definition of a heat wave, but such extreme events, associated with particularly hot sustained temperatures, have been known to produce notable impacts on human mortality, regional economies, and ecosystems.

The main element to define a heat wave is the presence of periods (more than 3 days) with extremely hot weather, in which there is no significant relief from the minimum temperatures and could have significant impacts on people's health.



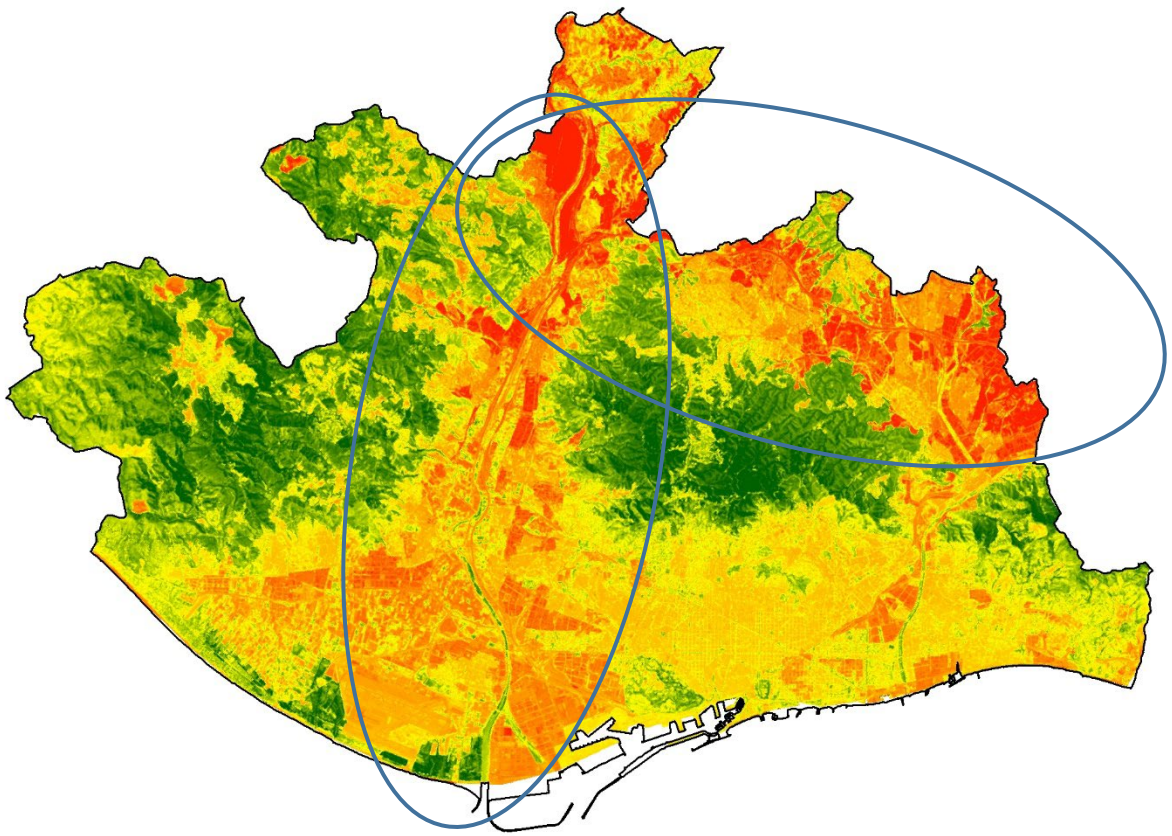
Maximum temperature in the Heat Wave in 2015

Health and Heat Waves

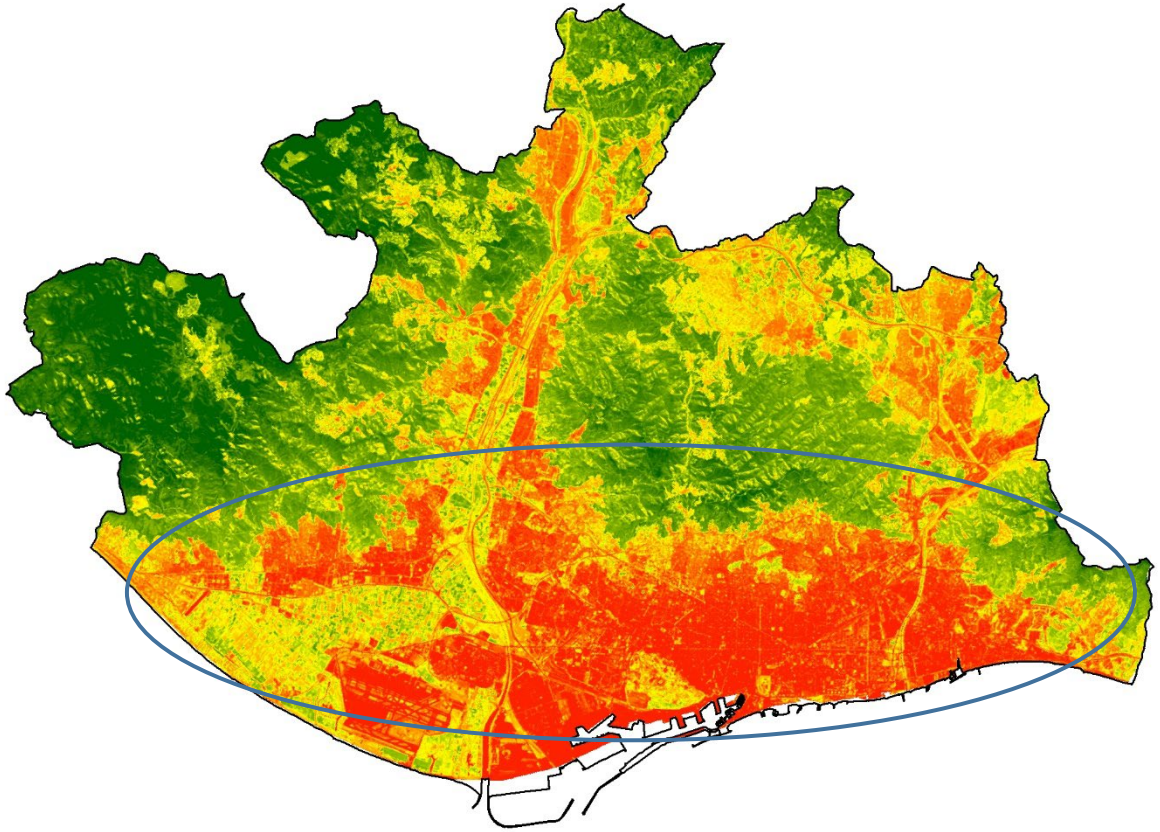


The graphics clearly show the increase in mortality with increasing high temperatures

Daytime and nighttime Urban Heat Island



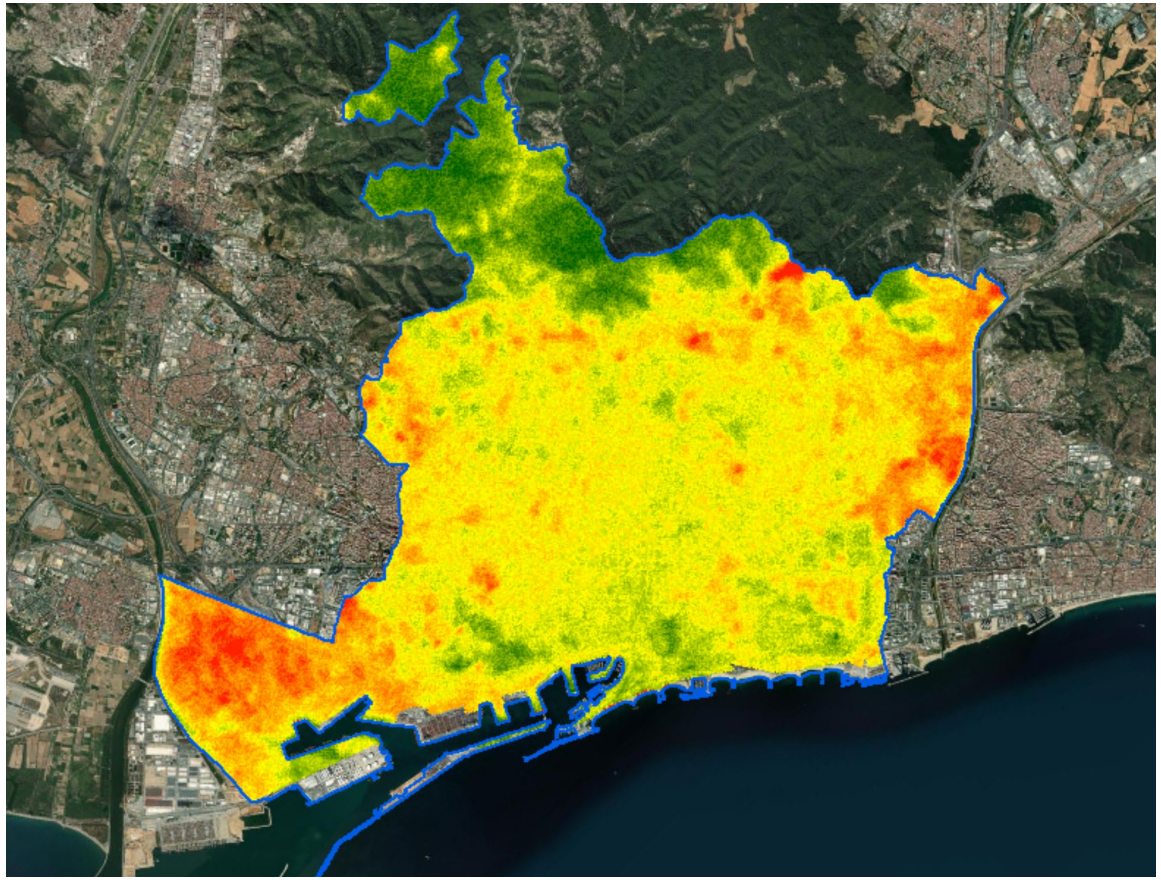
Day



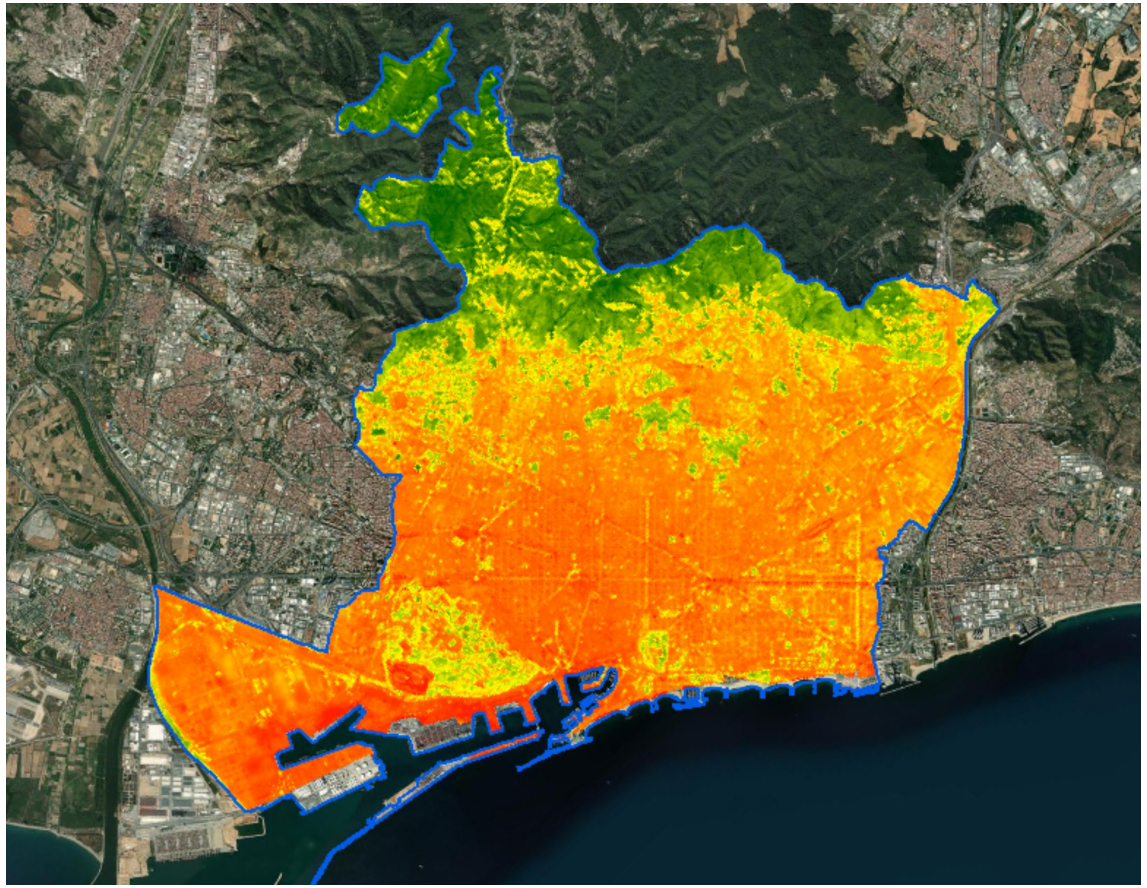
Night

The Urban Heat Island (UHI) increases the effects of Heat Waves, representing a serious inconvenience to human health and comfort.

Urban Heat Island in Barcelona City



Daytime UHI



Nighttime UHI

General Objective

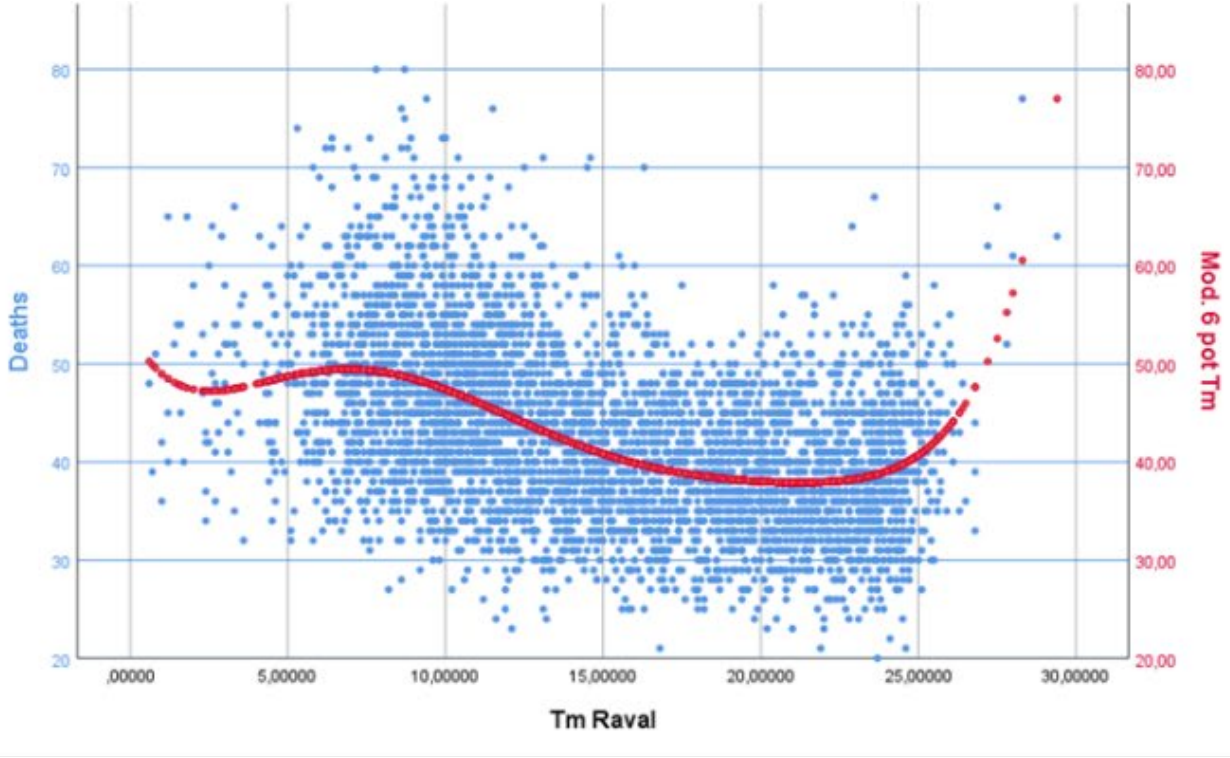
Study extreme heat events in the city of Barcelona between 1971 and 2020

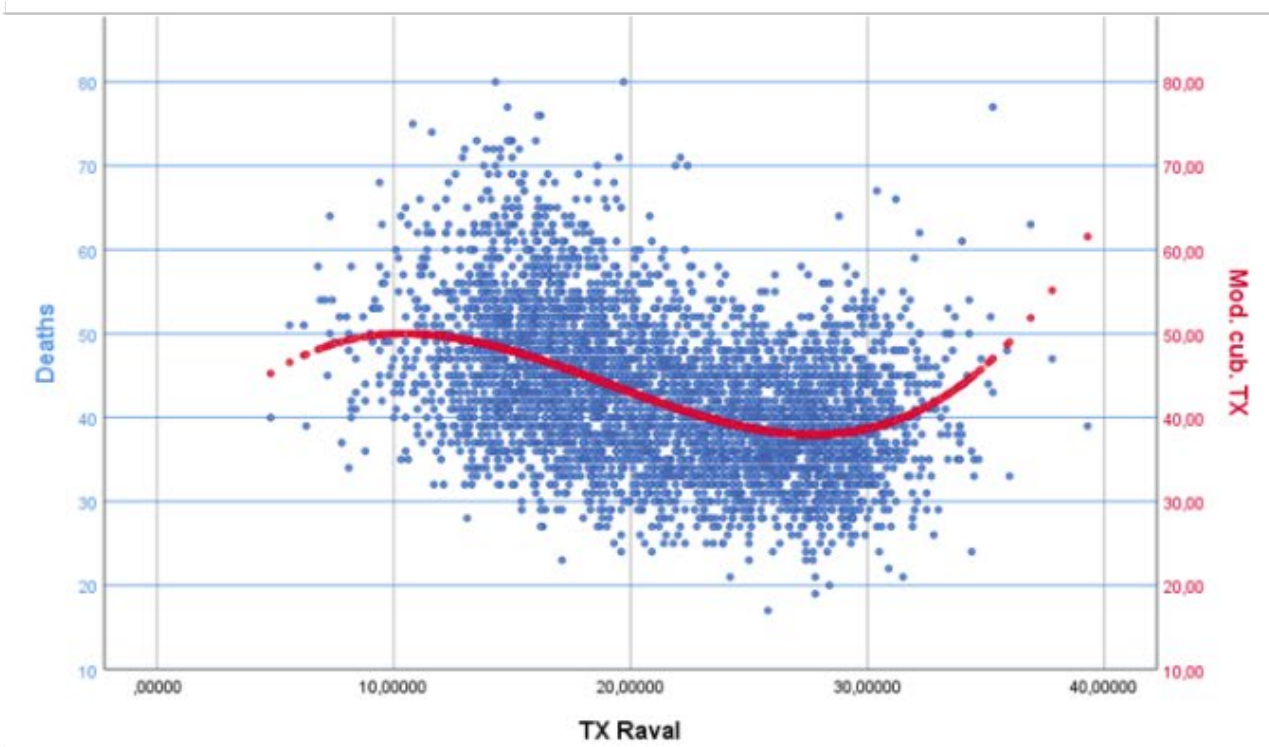
Since the urban climate presents a marked spatial variation, taking into account the geographical characteristics of the territory, as well as the spatial distribution of the island of urban heat, the research is carried out based on the information provided by four representative meteorological stations of the study area: Fabra Observatory, CMT at the Olimpic Villa, Raval and Barcelona Airport

Due to the variety of physical and morphological characteristics of the city (altitude, distance from the sea, density, green areas...), the city center shows a climatic behavior that is quite different from that experienced at the Fabra Observatory, which is located at more than 400 meters above sea level, and surrounded by the natural area of the Collserola Park

The research is based on the hypothesis that, it is essential to differentiate heat waves during the day (DHW) from those at night (NHW), since the latter are becoming more numerous and longer in Barcelona, affecting people's health more widely

Temperature & Mortality in Barcelona





Between 2007 and 2018 the city have experienced 852 days with night temperatures above 21.3 degrees. That has represented an increase in mortality that can be estimated in 995 additional deaths

In Barcelona there is a clear increase in mortality with high temperatures not only during the day but especially at night.

Heat Wave

Concept of heat wave used in the Spanish Meteorological Agency (AEMET):
A 'heat wave' is considered an episode of at least three consecutive days, in which at least 10% of the stations considered register maximums above the 95% percentile of their series of maximum daily temperatures for the months of July and August from the period 1971-2000

This definition has an important limitation: **it refers only to maximum temperatures, not minimum ones**. As indicated, it is the high minimum temperatures that mainly make the difference in health

Maximum temperatures can have serious consequences, especially "heat strokes“, but health effects are more pronounced in the case of night heat, where the inability to rest (especially in homes without air conditioning as occurs mainly in Spain) can cause a significant worsening of respiratory and cardio-vascular diseases that produce premature deaths

For this reason, **in this work we will differentiate the Heat Waves during the day (DHW) and at night (NHW), emphasizing the NHW**

Weather Stations

Given the difference in location of the meteorological stations in the study area, we will mainly use the data from the stations located in the city of Barcelona, and very specifically fourth of them: Fabra Observatory, CMT, Drassanes, Raval and, as a complement to the previous ones, the meteorological information of the Barcelona Airport will also be used, which, despite being in another municipal area, is less than 10 km from the city center

Station	Longitude	Latitude	Altitude	Dist_Sea	Orientation	Slope
Barcelona Airport	2,07	41,292778	4	1802,41	-1	0
CMT	2,2	41,390556	6	185,5	225	1,18
Drassanes	2,173889	41,375	5	357,9	-1	0
Fabra	2,123885	41,418432	411	6527,97	230,31	50,89
Raval	2,167751	41,383899	33	1324,86	0	1,67

Global Warming in Barcelona (1971-2020)

The realization of an OLS model, with the maximum and minimum daily (average) temperatures of the last 50 years, of the different studied weather stations (Fabra, Airport, Raval and CMT), and using year, month and calendar day (cd *) as explanatory variables, shows the warming process in Barcelona

The maximum temperature (TX) increased 2.43°C between 1971 and 2020.
The minimum (Tm) increased 2.86°C and the average temperature (Tm) 2.65°C.

Modelo		B	Desv. Error	Beta	t	Sig.
1	(Constante)	-76,102	1,950		-39,034	,000
	Year	,049	,001	,113	49,739	,000
	Month	-,260	,004	-,145	-65,036	,000
	cd	8,098	,019	,929	415,494	,000
	Raval	1,476	,047	,073	31,164	,000
	CMT	,375	,038	,023	9,794	,000
	Aeroport	1,261	,029	,098	43,092	,000

TX

Modelo		B	Desv. Error	Beta	t	Sig.
1	(Constante)	-101,443	1,799		-56,375	,000
	Year	,057	,001	,136	63,545	,000
	Month	-,196	,004	-,112	-53,133	,000
	cd	7,780	,018	,908	432,441	,000
	Raval	2,487	,044	,125	56,917	,000
	CMT	2,295	,035	,143	64,945	,000
	Aeroport	,318	,027	,025	11,794	,000

Tm

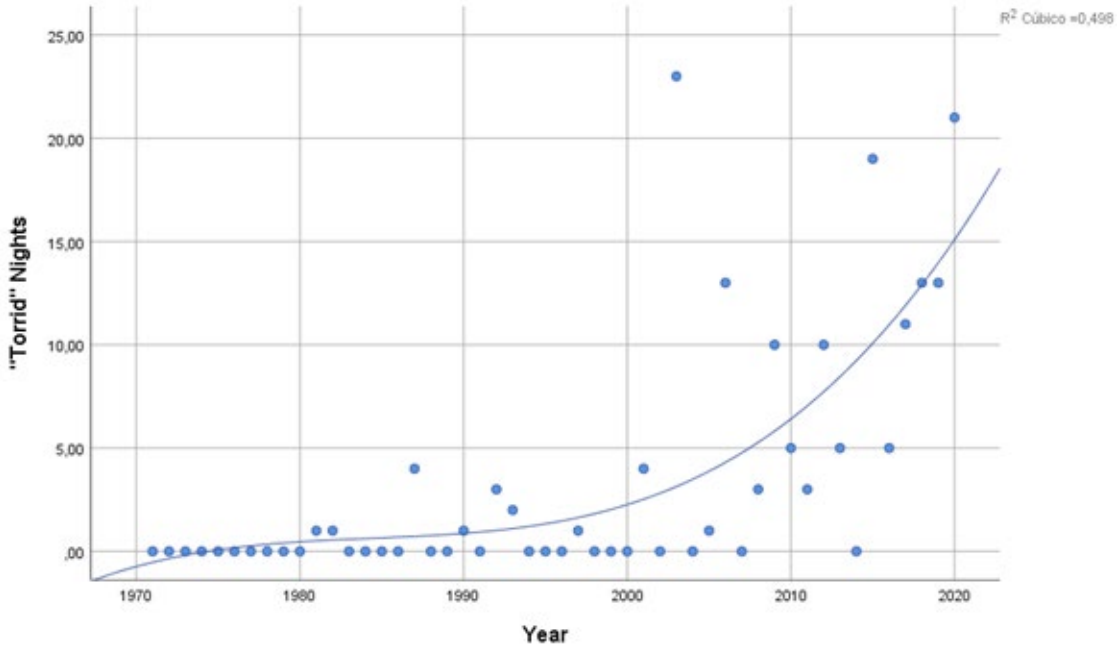
Hot Days & Nights (1971-2020)

The Copernicus program of the European Union highlights two climatic indicators: the so-called "summer days", where temperatures exceed 25 degrees Celsius, and the "tropical nights", when the minimum temperature does not drop below 20 degrees

- For the entire period 71-20, Raval is the weather station with the highest number of “summer days” per year: 114. **Almost 4 months per year of summer days.**

- **“Tropical Nights” more than 2 months in the city**

Weather Station	Tropical Nights (1970-2000)
Raval	67
Fabra Observatory	19
CMT Olimpic Villa	76



- **“Torrid Nights” Tm >= 25º have grown exponentially in the last 20 years,** representing serious health problems

Old Town (Raval) Daytime and Nighttime Heat Waves (1971-2020)

Heat waves in Barcelona means a thresholds of 32.5° Celsius by day and 23.8° Celsius by night

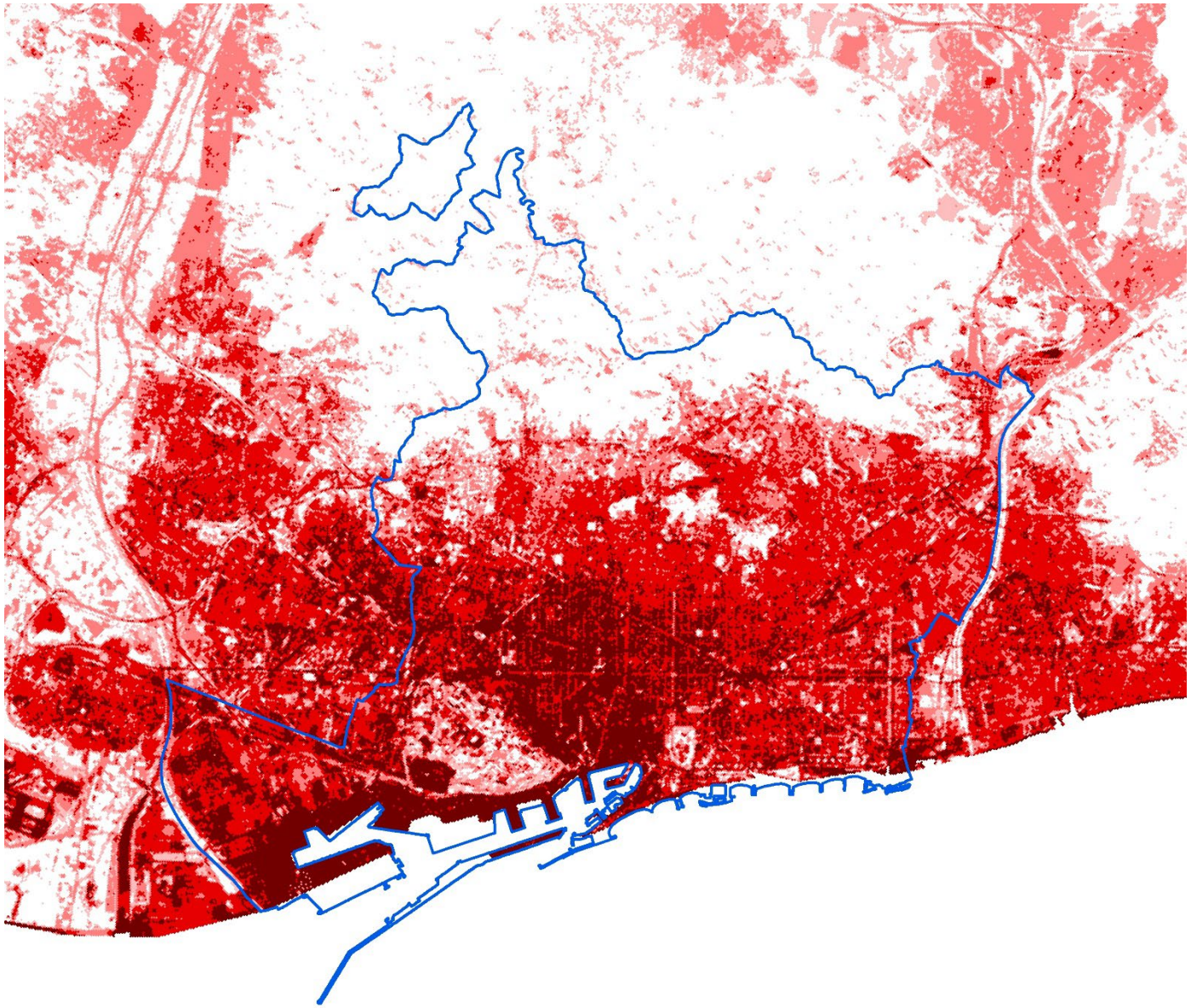
Applying these thresholds, between 1971 and 2020 Barcelona have had:

Years	NHW	HN
1971-1980	0	3
1981-1990	4	28
1991-2000	8	66
2001-2010	24	192
2011-2020	34	288
Total	70	577

- 18 Daytime Heat Waves, with 76 extremely hot days (TX > 32.49º)
- 70 Night Heat Waves, with 577 extremely hot nights (HN,Tm > 23.86º)

Night Heat Waves (NHW) and extremely hot nights (HN) have increased exponentially: the first from 0 (1971-1980) to 34 (2011-2020), and the second on from 3 (1971-1980) to 288 (2011-2020). Growth, which if it continues at the current rate, could lead to 140 extremely hot nights per year in Barcelona in 2050.

Nighttime temperatures and Health Risk

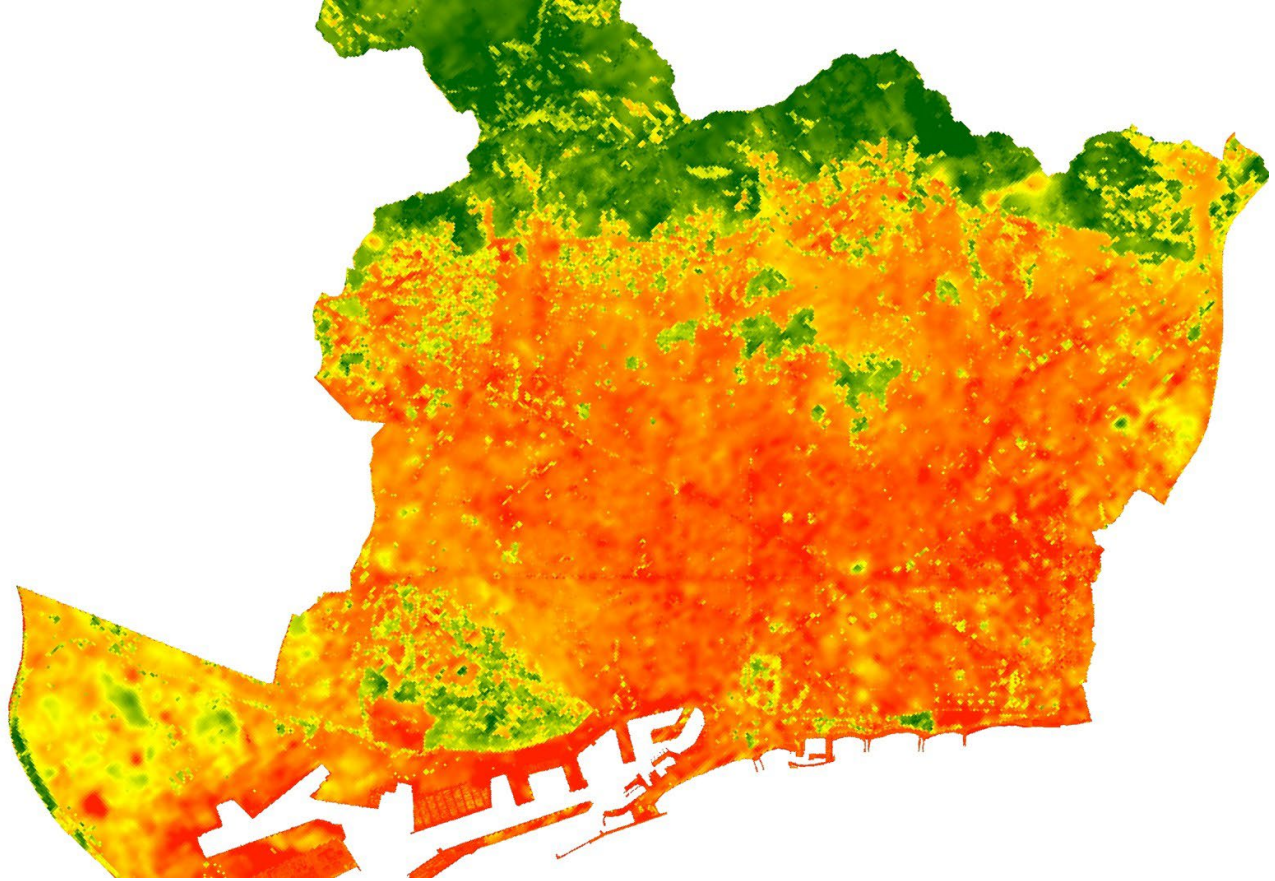


In dark red, the areas with the greatest health risk during Nocturnal Heat Wave event ("torrid" night)

In white, the areas without heat stress health risk (with a temperature equal to or less than 20°C)

Conclusions

- Global Warming is a clear reality in the Mediterranean area in which Barcelona is located.
- Barcelona shows greater warming (> 2º) than the Mediterranean area as a whole (1.5º), experiencing increasingly extreme temperature events that affect comfort and health
- The research shows a remarkable difference in extreme heat events between different urban locations. Proximity to the sea, altitude, different urban density and the quantity and quality of urban greenery have a determining effect on daytime and nighttime heat waves.
- The city center experiences the highest number and intensity of heat waves
- The most harmful effects on health are those derived from nocturnal heat waves. The City Center is the urban space with a higher degree of heat stress; especially at night, with more than 30 heat waves and almost 300 nights of extreme heat per decade
- The trend towards the increase of nighttime temperatures seems to continue in the coming decades



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Thanks for your attention and take care!

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