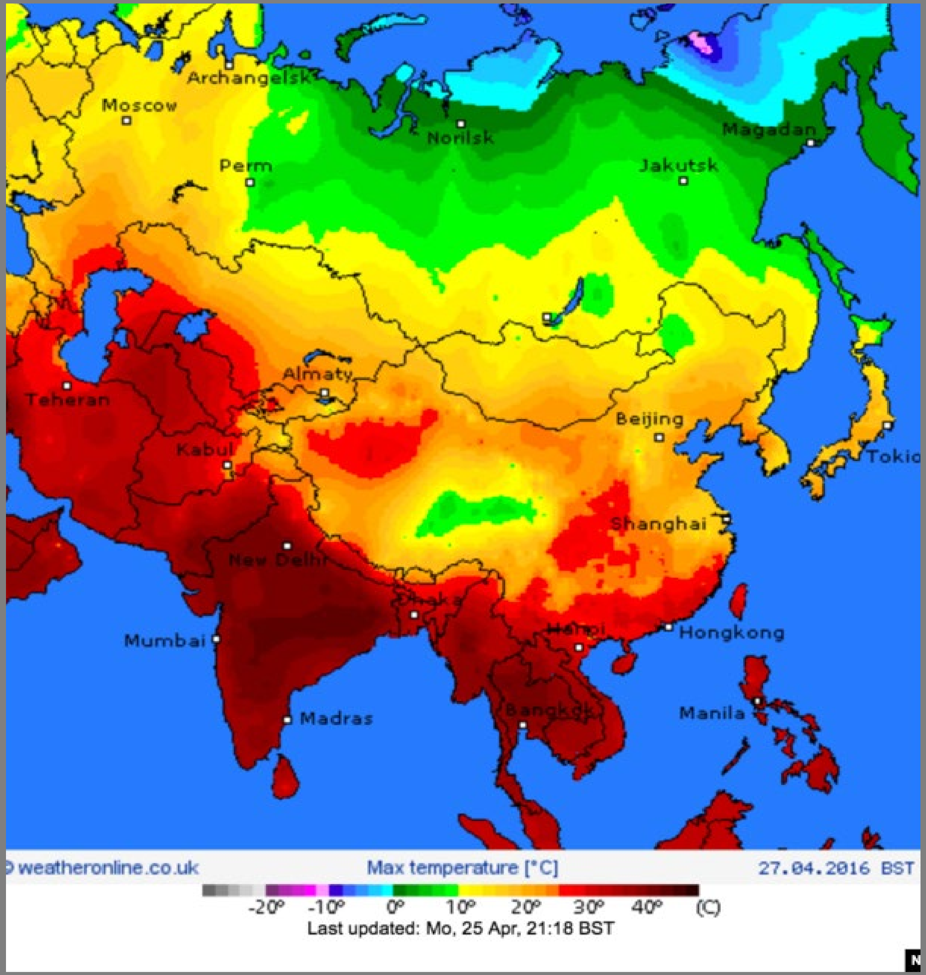
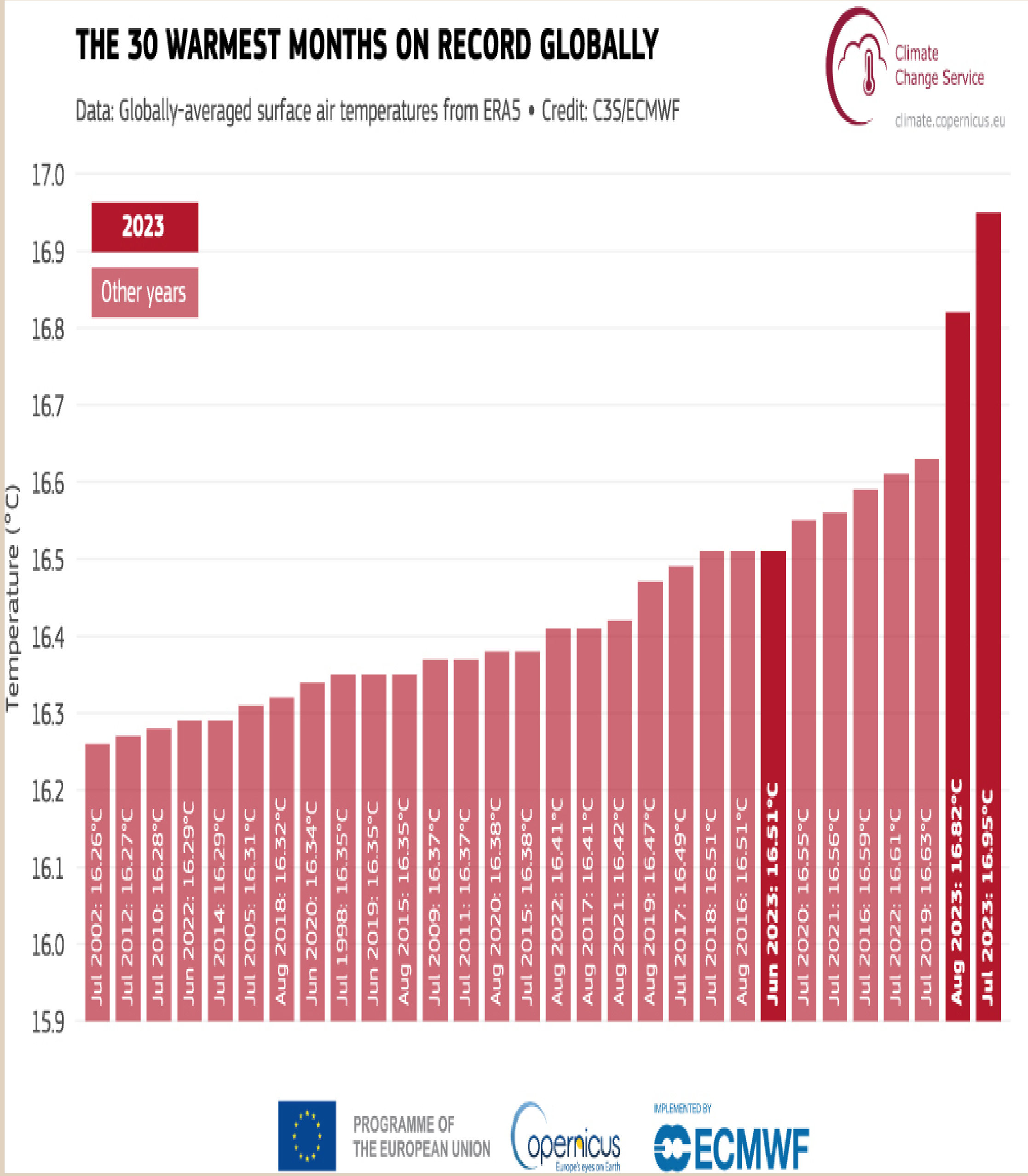


Starting in April 2023, a record – breaking heat wave has affected many Asian Countries, Including India, Bangladesh, Cambodia, China, Laos, Thailand, Malaysia, Singapore and Thailand

Several regional temperature records have been set. The heat wave has caused many deaths due to heat stroke and has prompted health warnings and power outages across multiple countries

A recent study by the World Weather Attribution found that the heat wave was made at least 30 times more likely by climate change in India and Bangladesh, and that climate change raised temperatures by at least 2 C in many parts of Asia.



Though Warming has not be uniform across the planet the upaward trend in the globally averaged temperature shows that more areas are warming than cooling.

According to NOAA's 2023 Annual Climate Report the combined land and ocean temperature has increased at an average rate of 0.06 C per decade since 1850.

The rate of warming since 1982 is more than 3 times as fast, 0.2 C per Decade

World view

By Gavin Schmidt

Why 2023's heat anomaly is worrying scientists

Climate models struggle to explain why planetary temperatures spiked suddenly. More and better data are urgently needed.

When I took over as the director of NASA's Goddard Institute for Space Studies, I inherited a project that tracks temperature changes since 1880. Using this trove of data, I've made climate predictions at the start of every year since 2016. It's humbling, and a bit worrying, to admit that no year has confounded climate scientists' predictive capabilities more than 2023 has.

For the past nine months, mean land and sea surface temperatures have overshot previous records each month by up to 0.2 °C – a huge margin at the planetary scale. A general warming trend is expected because of rising greenhouse-gas emissions, but this sudden heat spike greatly exceeds predictions made by statistical climate models that rely on past observations. Many reasons for this discrepancy have been proposed but, as yet, no combination of them has been able to reconcile our theories with what has happened.

For a start, prevalent global climate conditions one year ago would have suggested that a spell of record-setting warmth was unlikely. Early last year, the tropical Pacific Ocean was coming out of a three-year period of La Niña, a climate phenomenon associated with the relative cooling of the central and eastern Pacific Ocean. Drawing on precedents when similar conditions prevailed at the beginning of a year, several climate scientists, including me, put the odds of 2023 turning out to be a record warm year at just one in five.

El Niño – the inverse of La Niña – causes the eastern tropical Pacific Ocean to warm up. This weather pattern set in only in the second half of the year, and the current spell is milder than similar events in 1997–98 and 2015–16.

However, starting last March, sea surface temperatures in the North Atlantic Ocean began to shoot up. By June, the extent of sea ice around Antarctica was by far the lowest on record. Compared with the average ice cover between 1981 and 2010, a patch of sea ice roughly the size of Alaska was missing. The observed temperature anomaly has not only been much larger than expected, but also started showing up several months before the onset of El Niño.

So, what might have caused this heat spike? Atmospheric greenhouse-gas levels have continued to rise, but the extra load since 2022 can account for further warming of only about 0.02 °C. Other theories put forward by climate scientists include fallout from the January 2022 Hunga Tonga–Hunga Ha'apai volcanic eruption in Tonga, which had both cooling effects from aerosols and warming ones from stratospheric water vapour, and the ramping up of solar activity in the run-up to a predicted solar maximum. But these factors explain, at most, a few hundredths of a degree in warming (Schoeberl, M. R. *et al. Geophys. Res. Lett.* **50**, e2023GL104634; 2023). Even after taking all plausible explanations into account, the divergence between expected and observed annual mean temperatures in 2023 remains about 0.2 °C – roughly the gap between the previous and current annual record.

There is one more factor that could be playing a part. In 2020, new regulations required the shipping industry to use cleaner fuels that reduce sulfur emissions. Sulfur compounds in the atmosphere are reflective and influence several properties of clouds, thereby having an overall cooling effect. Preliminary estimates of the impact of these rules show a negligible effect on global mean temperatures – a change of only a few hundredths of a degree. But reliable assessments of aerosol emissions rely on networks of mostly volunteer-driven efforts, and it could be a year or more before the full data from 2023 are available.

This is too long a wait. Better, more nimble data-collection systems are clearly needed. NASA's PACE mission, which launched in February, is a step in the right direction. In a few months, the satellite should start providing a global assessment of the composition of various aerosol particles in the atmosphere. The data will be invaluable for reducing the substantial aerosol-related uncertainty in climate models. Hindcasts, informed by new data, could also provide insights into last year's climate events.

But it seems unlikely that aerosol effects provide anything close to a full answer. In general, the 2023 temperature anomaly has come out of the blue, revealing an unprecedented knowledge gap perhaps for the first time since about 40 years ago, when satellite data began offering modellers an unparalleled, real-time view of Earth's climate system. If the anomaly does not stabilize by August – a reasonable expectation based on previous El Niño events – then the world will be in uncharted territory. It could imply that a warming planet is already fundamentally altering how the climate system operates, much sooner than scientists had anticipated. It could also mean that statistical inferences based on past events are less reliable than we thought, adding more uncertainty to seasonal predictions of droughts and rainfall patterns.

Much of the world's climate is driven by intricate, long-distance links – known as teleconnections – fuelled by sea and atmospheric currents. If their behaviour is in flux or markedly diverging from previous observations, we need to know about such changes in real time. We need answers for why 2023 turned out to be the warmest year in possibly the past 100,000 years. And we need them quickly.

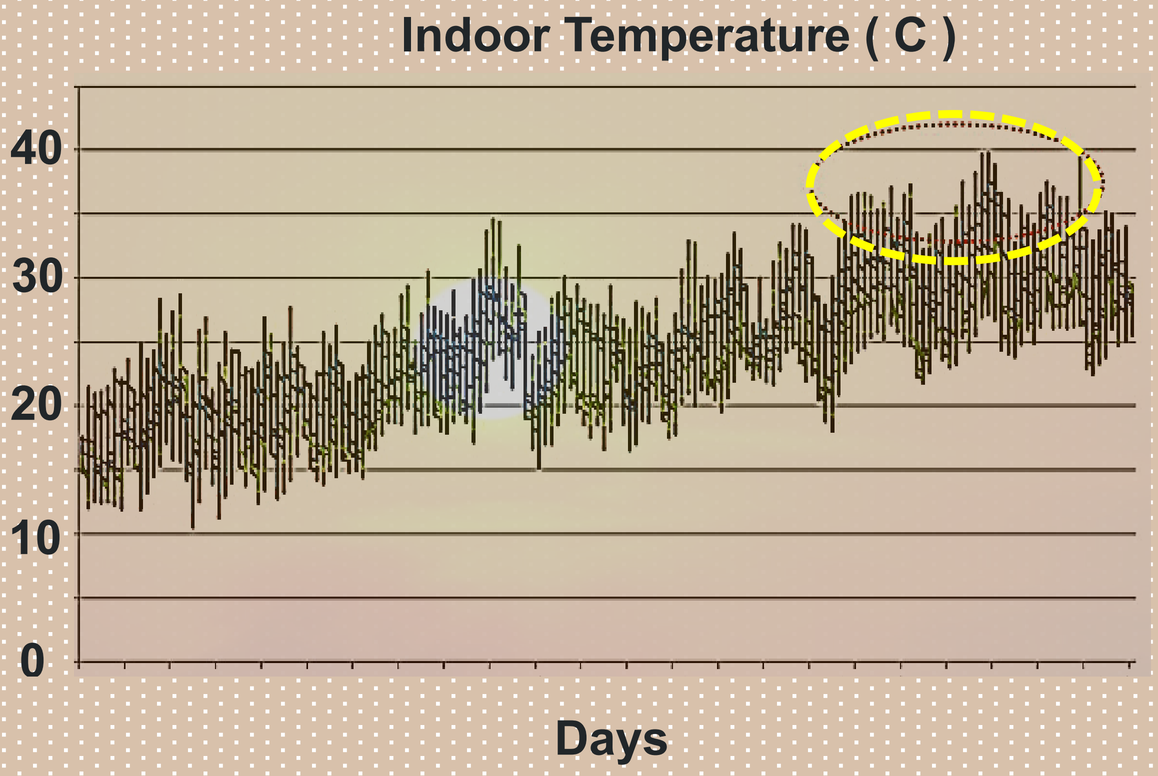
> **"If the anomaly does not stabilize by August, then the world will be in uncharted territory."**

Gavin Schmidt is a climatologist and director of NASA's Goddard Institute for Space Studies in New York City. e-mail: gavin.a.schmidt@nasa.gov

WILLIAM D. HRYBYK

'For the Past Nine Months, Mean land and sea surface temperatures have overshot previous records each month by up to 0.2 C - a huge margin at the planetary scale'

'If the anomaly does not stabilize by August, then the world will be in Uncharted waters'



Rich experimental data exist in the developed countries regarding the indoor environmental quality of low-income houses during the period of high ambient temperatures.

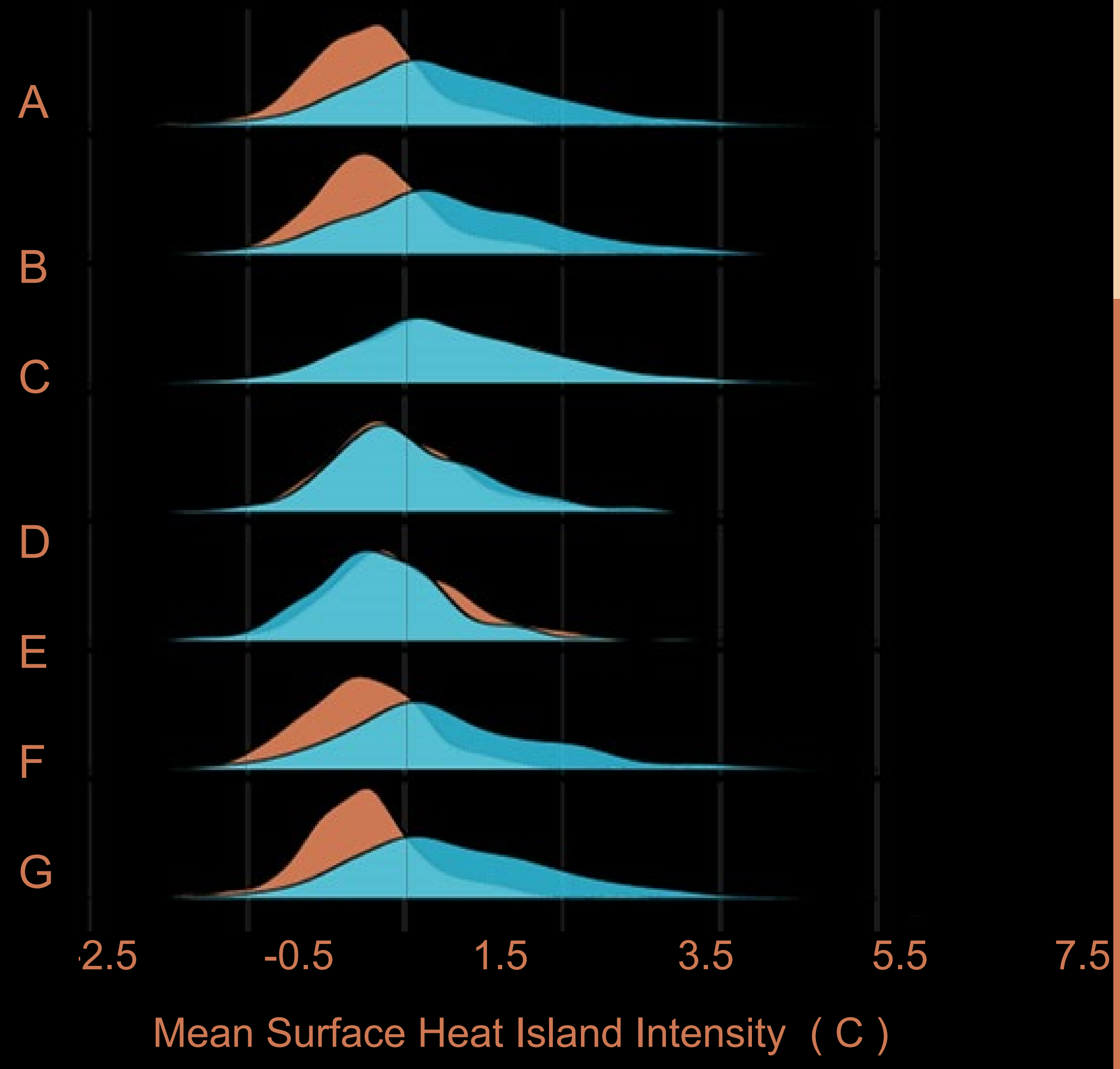
Continuous measurements of the indoor ambient temperature and CO_2 concentration, are performed in 110 low-income buildings in Western Sydney and rural NSW, for about 12 months.

It is found that during the summer period and not during a heat wave, indoor temperature was close to 40 C.

In parallel, the indoor concentration of CO_2 was up to 4 times higher than the threshold acceptable levels.

During the winter period, indoor temperature was as low as 5-7 C.

Shamila Haddad, Riccardo Paolini, Afroditi Synnefa, Lilian De Torres, Deo Prasad, Mattheos Santamouris : Integrated assessment of the extreme climatic conditions, thermal performance, vulnerability, and well-being in low-income housing in the subtropical climate of Australia, Energy and Buildings, 272, 112349, 2022



Results from 175 cities in USA correlating the magnitude of the surface Urban Heat Island against social and demographic characteristics, shown that immigrants, black and Hispanic population and vulnerable groups live in urban zones presenting a much higher UHI Intensity

A :Non Hispanic whites vs all people in color

B : Above vs Below Poverty

C : Below Poverty against all people in color

D : Over 5 vs under 5

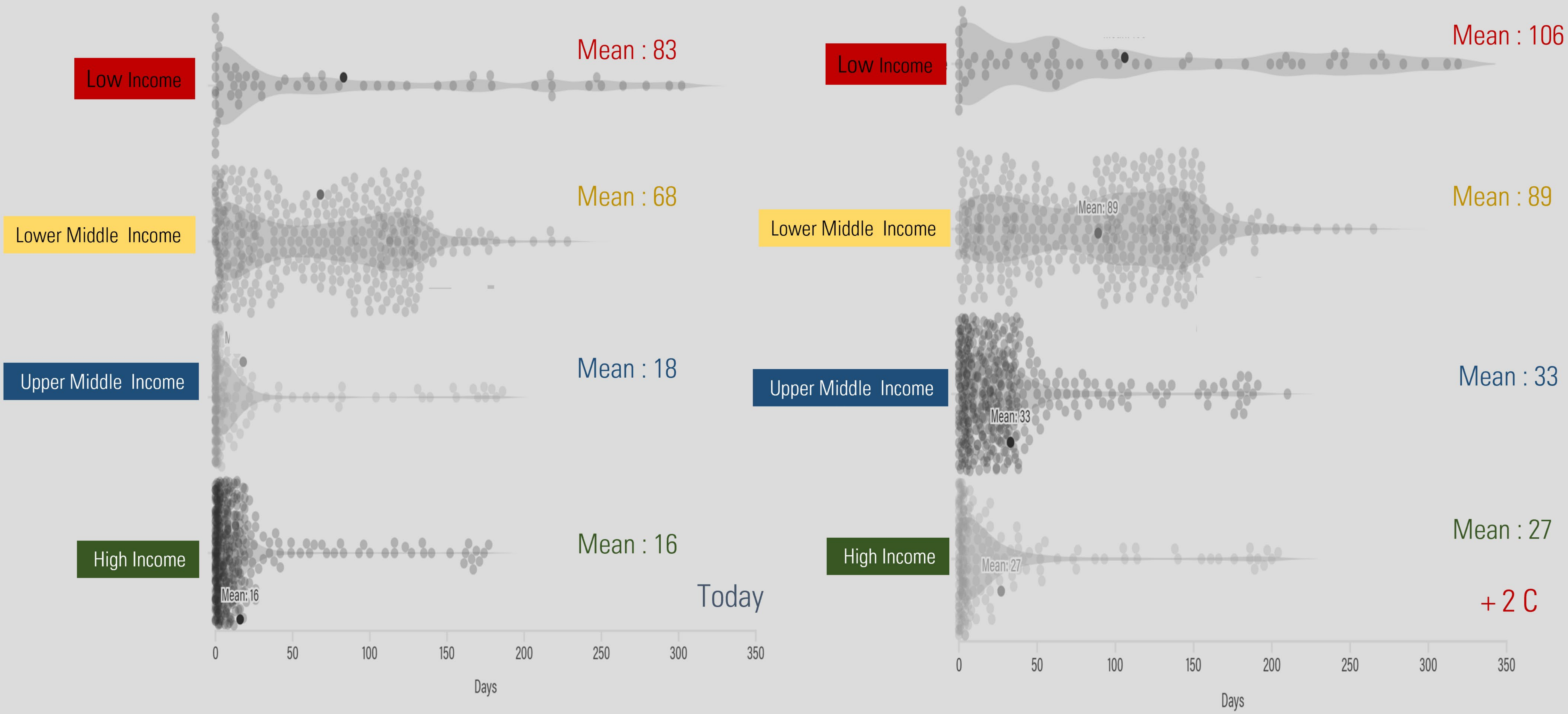
E : Over vs Under 65 y old

F : Over 65 White against all people in color

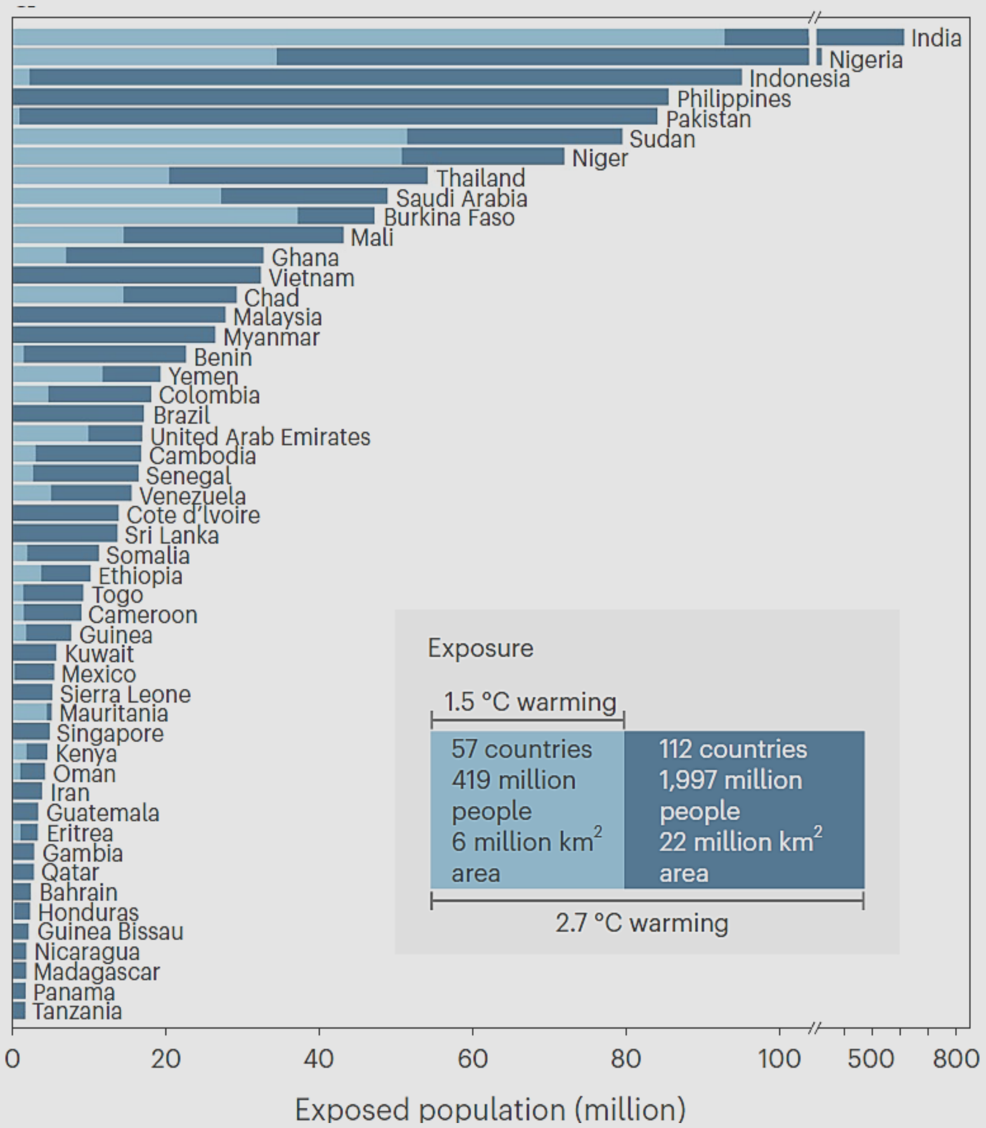
G : Under 5: Non Hispanic whites vs all people in color

A. Hsu et al : Disproportionate Exposure to Urban Heat Island intensity across Major US cities, Nature Communications,

Days per Year that Max Temperature Exceeds 35 C by City



Source: WRI analysis from IPCC Interactive Atlas, Bias Adjusted TX35 from CMIP6.



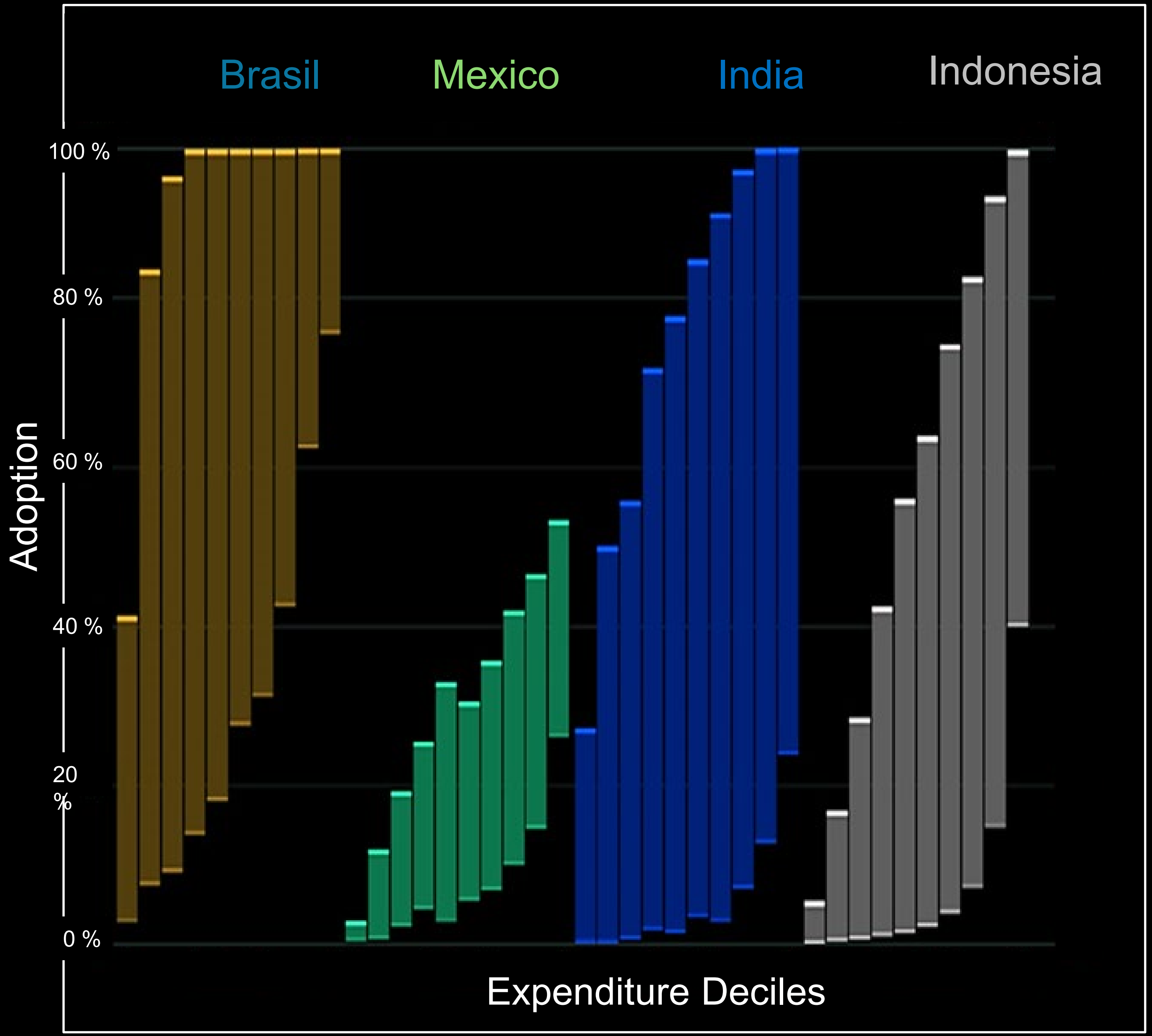
The 'human climate niche' is defined as the historically highly
conserved distribution of relative human population density with respect to mean annual temperature.

Climate change has already put ~9% of people (>600 million)
outside this niche

Country-level exposure to unprecedented heat (MAT ≥29 °C) at 2.7 °C and 1.5 °C global warming in a world of 9.5 billion people (around 2070 under SSP2).

Population exposed for the top 50 countries ranked under 2.7 °C global warming (dark blue) with exposure at 1.5 °C global warming overlaid (pale blue).

Timothy M. Lenton , Chi Xu, Jesse F. Abrams, Ashish Ghadiali, Sina Loriani, Boris Sakschewski, Caroline Zimm, Kristie L. Ebi, Robert R. Dunn, Jens-Christian Svenning & Marten Scheffer: Quantifying the human cost of global warming, Nature Sustainability, 2023

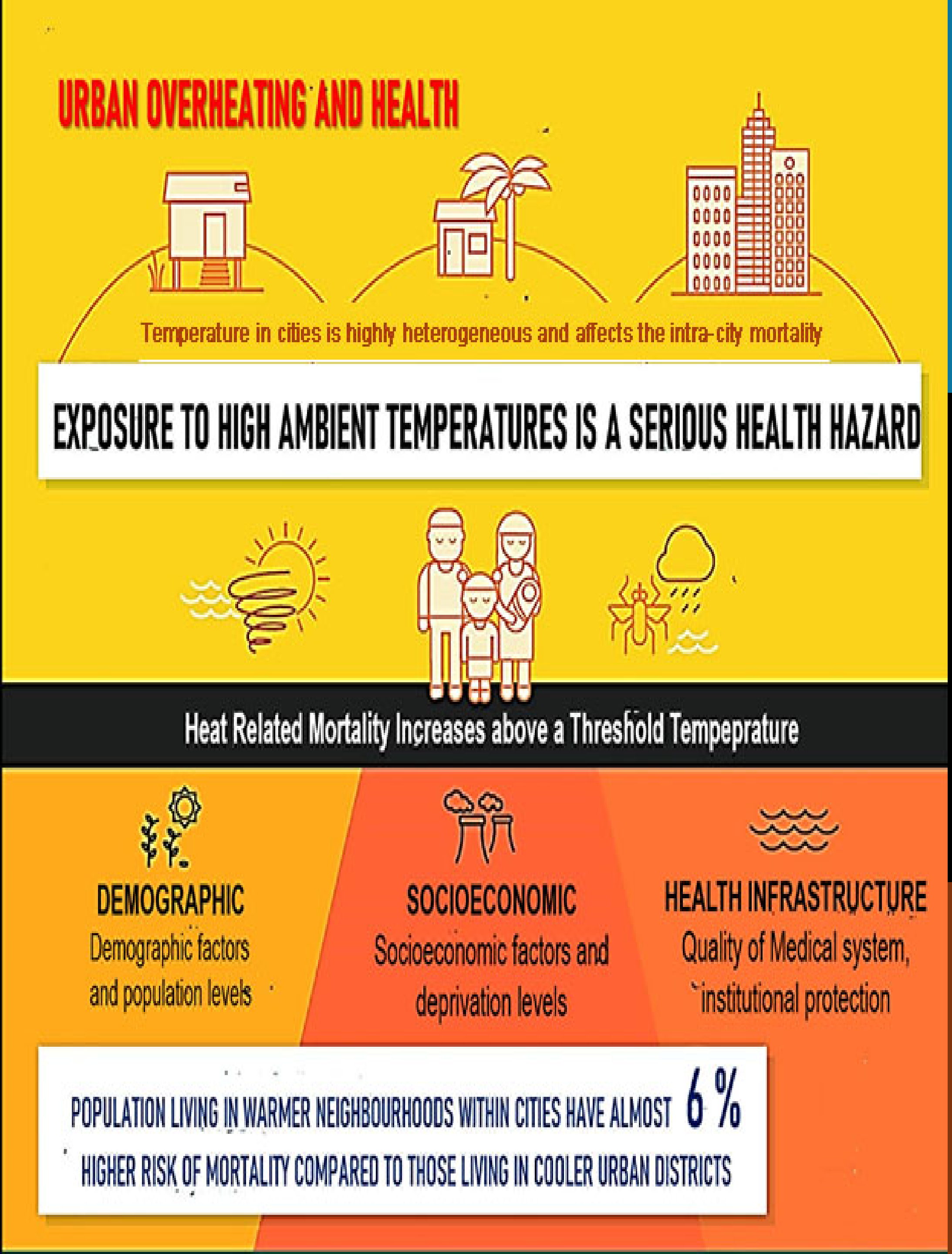


The Current and Future Penetration of A/C in Emerging Economies per Income Group demonstrates that low income population will not have access to air conditioning.

By 2040, a nonnegligible fraction of the population will be left behind.

On 2040, between 64 and 100 million households out of the total number of households living in the four countries considered in the latest waves of 343 million will face an adaptation cooling deficit

NATURE COMMUNICATIONS | (2021) 12:6460 | https://doi.org/10.1038/s41467-021-26592-2 | www.nature.com/naturecommunications



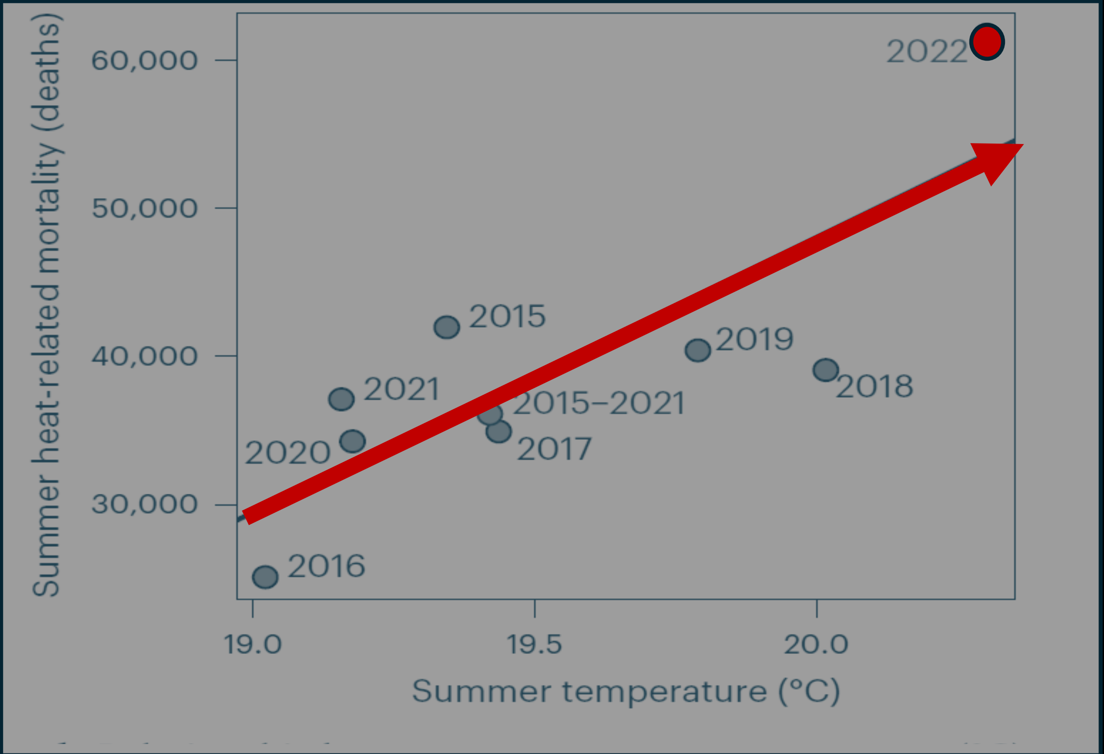
When exposed to temperature beyond a certain threshold, the human thermoregulation system cannot offset the impact of extreme heat resulting in increased global mortality and morbidity

Heat related morbidity and mortality caused by the local climate change, is highly alarming, and it seems to be one of the current and future peak scientific topics .

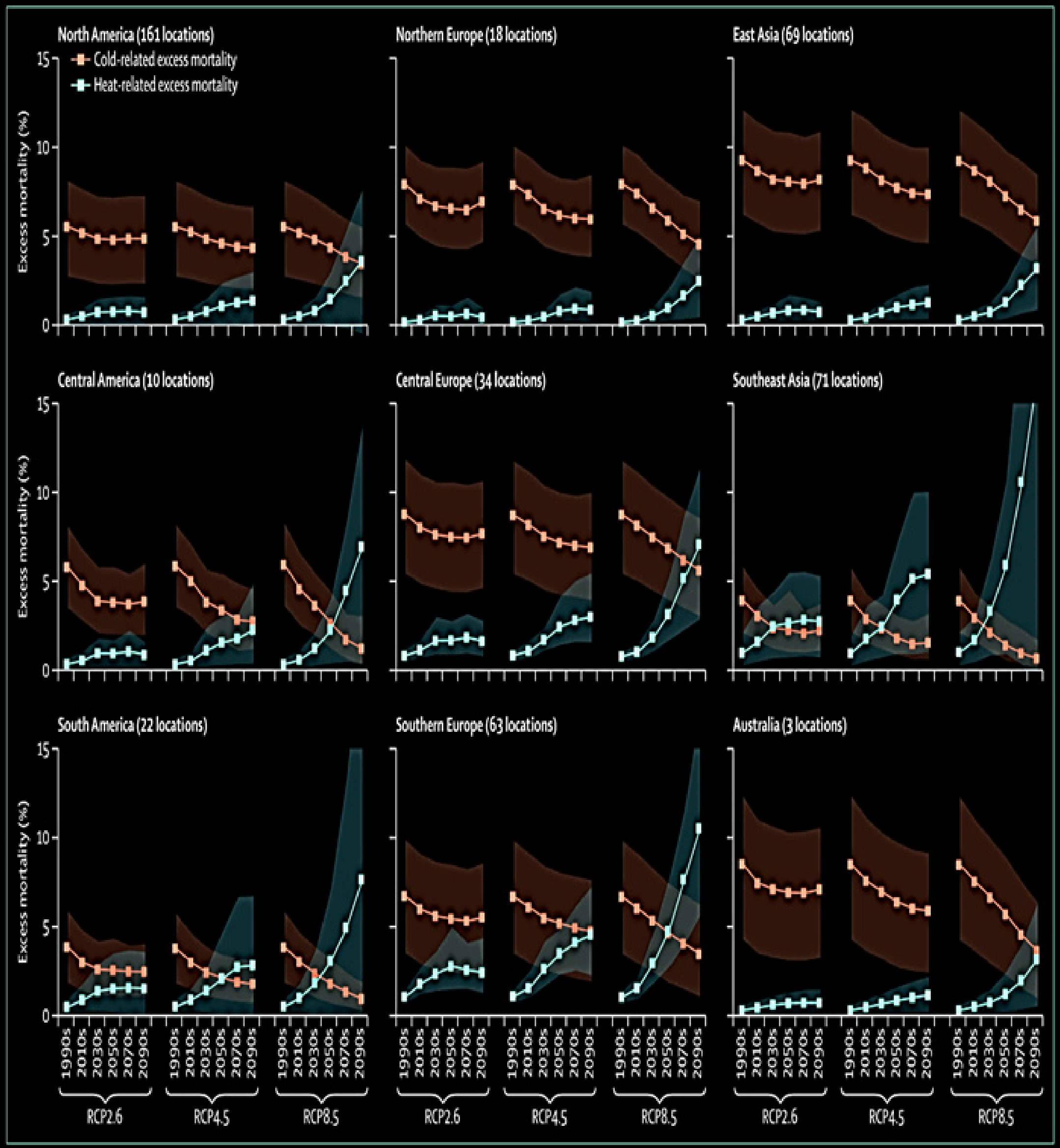
Elderly is the most vulnerable population group
Those with preexisting health problems like respiratory, cardiovascular, or mental health problems
Those using medication that affects thermoregulation, and
Those 'lacking in economic assets and access to public support systems, with diminished physical or cognitive capacities to respond to warnings and missing strong and enduring social support systems like social isolated people, and those living in hazardous places'

According to the existing epidemiological records almost 59,114 people passed away between 2000 and 2007 during 52 extreme heat events around the world

Temperature and Heat Related Mortality in Europe



Country	Attributable number (deaths)			Attributable rate (deaths per million)		
	Overall	Women	Men	Overall	Women	Men
Albania	352 (97, 586)	186 (39, 336)	80 (4, 155)	117 (32, 195)	125 (26, 225)	53 (2, 102)
Austria	419 (109, 741)	274 (−55, 570)	199 (66, 332)	47 (12, 83)	60 (−12, 125)	45 (15, 75)
Belgium	434 (−26, 911)	264 (−68, 558)	159 (−26, 341)	38 (−2, 79)	45 (−12, 95)	28 (−5, 60)
Bulgaria	1,277 (549, 2,072)	678 (138, 1,145)	556 (239, 867)	176 (75, 285)	182 (37, 307)	157 (68, 245)
Switzerland	302 (48, 557)	255 (54, 433)	93 (20, 161)	35 (6, 64)	58 (12, 99)	22 (5, 37)
Cyprus	101 (24, 173)	56 (6, 110)	47 (17, 75)	113 (27, 193)	123 (13, 240)	107 (38, 171)
Czechia	279 (−25, 607)	290 (37, 520)	38 (−45, 122)	26 (−2, 56)	53 (7, 95)	7 (−8, 23)
Germany	8,173 (5,374, 11,018)	3,925 (1,656, 6,403)	2,771 (1,333, 4,149)	98 (64, 132)	93 (39, 152)	68 (32, 101)
Denmark	252 (42, 468)	119 (−51, 274)	59 (−19, 136)	43 (7, 80)	41 (−17, 93)	20 (−7, 47)
Estonia	167 (26, 296)	113 (7, 214)	39 (−5, 83)	123 (19, 217)	157 (9, 297)	61 (−8, 129)
Greece	3,092 (2,217, 3,915)	2,076 (1,551, 2,586)	822 (448, 1,186)	280 (201, 355)	367 (274, 457)	153 (83, 220)
Spain	11,324 (7,908, 14,880)	7,190 (4,426, 9,478)	4,250 (2,825, 5,633)	237 (166, 312)	295 (182, 389)	181 (121, 241)
Finland	225 (−94, 562)	278 (−15, 551)	30 (−14, 71)	40 (−17, 100)	98 (−5, 194)	11 (−5, 26)
France	4,807 (1,739, 8,123)	2,424 (−473, 4,964)	2,584 (1,237, 3,889)	73 (26, 124)	71 (−14, 146)	81 (39, 122)
Croatia	731 (346, 1,069)	469 (198, 708)	212 (72, 344)	172 (82, 252)	213 (90, 322)	104 (35, 168)
Hungary	513 (−126, 1,207)	529 (74, 915)	129 (−131, 396)	51 (−13, 121)	101 (14, 175)	27 (−27, 83)
Ireland	26 (−168, 199)	38 (−90, 174)	0 (0, 0)	5 (−34, 40)	15 (−35, 69)	0 (0, 0)
Iceland	0 (0, 0)	0 (−2, 3)	0 (0, 0)	0 (0, 0)	2 (−12, 17)	0 (0, 0)
Italy	18,010 (13,793, 22,225)	11,917 (8,078, 15,148)	6,268 (4,619, 7,817)	295 (226, 364)	379 (257, 482)	211 (156, 264)
Liechtenstein	1 (−2, 3)	1 (−1, 3)	0 (0, 0)	19 (−42, 73)	41 (−56, 143)	0 (−10, 11)
Lithuania	381 (158, 618)	157 (−13, 309)	190 (94, 282)	128 (53, 208)	99 (−8, 194)	138 (68, 204)
Luxembourg	44 (−1, 91)	25 (−1, 51)	7 (−7, 20)	69 (−2, 144)	79 (−3, 162)	22 (−21, 62)
Latvia	105 (−33, 242)	42 (−69, 144)	46 (−20, 111)	52 (−16, 120)	39 (−63, 133)	49 (−21, 120)
Montenegro	50 (−12, 108)	31 (−17, 83)	7 (−8, 21)	81 (−19, 173)	100 (−55, 262)	22 (−26, 69)
Malta	76 (−2, 150)	41 (−11, 90)	43 (12, 72)	147 (−5, 290)	166 (−43, 363)	160 (43, 270)
Netherlands	469 (−8, 981)	326 (−117, 727)	155 (−49, 357)	27 (0, 56)	37 (−13, 82)	18 (−6, 41)
Norway	30 (−32, 86)	8 (−43, 58)	28 (−2, 57)	5 (−6, 16)	3 (−16, 22)	10 (−1, 21)
Poland	763 (−283, 1860)	559 (−417, 1446)	259 (−73, 576)	20 (−7, 48)	28 (−21, 73)	14 (−4, 31)
Portugal	2,212 (1,703, 2,679)	1,227 (761, 1,618)	828 (592, 1,064)	211 (162, 255)	222 (138, 293)	166 (119, 214)
Romania	2,455 (1,201, 3,797)	1,130 (56, 2,145)	1,323 (779, 1,837)	122 (60, 189)	110 (5, 209)	135 (79, 187)
Serbia	574 (226, 955)	465 (244, 651)	253 (89, 415)	81 (32, 135)	129 (68, 180)	74 (26, 121)
Sweden	40 (−104, 200)	46 (−100, 181)	9 (−30, 50)	4 (−10, 19)	9 (−19, 35)	2 (−6, 10)
Slovenia	154 (−24, 307)	100 (−4, 209)	58 (−4, 119)	73 (−12, 146)	96 (−4, 200)	55 (−3, 112)
Slovakia	365 (62, 676)	164 (−5, 314)	128 (−12, 267)	66 (11, 123)	58 (−2, 111)	48 (−4, 99)
United Kingdom	3,469 (370, 6,676)	Not available	Not available	52 (6, 100)	Not available	Not available
Europe	**61,672 (37,643, 86,807)**	**35,406 (21,576, 46,634)**	**21,667 (14,684, 27,998)**	**114 (69, 160)**	**145 (89, 192)**	**93 (63, 120)**



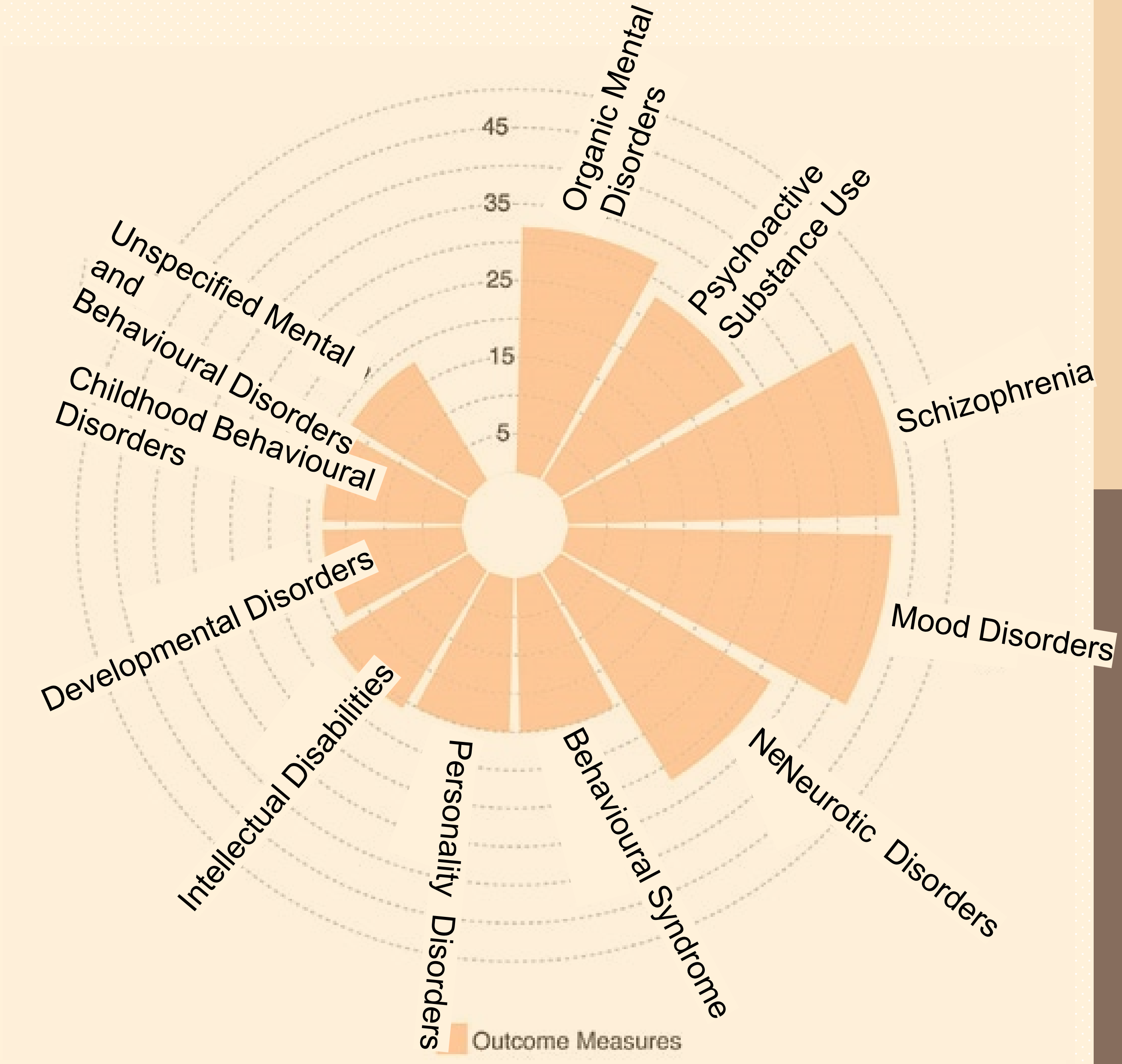
Lancet has published an extended epidemiological investigation on the potential health effects of higher ambient temperatures under various climate change scenarios, socioeconomic and demographic conditions , public health status and levels of economic development.   services.

‘The study indicates that, in high-emission scenarios, most regions are projected to experience a steep rise in heat-related mortality that will not be equaled by a reduction in cold-related deaths, resulting in a substantial positive net increase in mortality.

However, the potential impact varies across areas, and populations living in warmer and potentially poorer regions are expected to sustain an increased burden.

Furthermore, the increase in temperature-related excess mortality would be substantially reduced in scenarios involving mitigation strategies to limit greenhouse gas emissions and further warming of the planet, and stricter mitigation approaches are associated with larger benefits’.

www.thelancet.com/planetary-health Vol 1 December 2017



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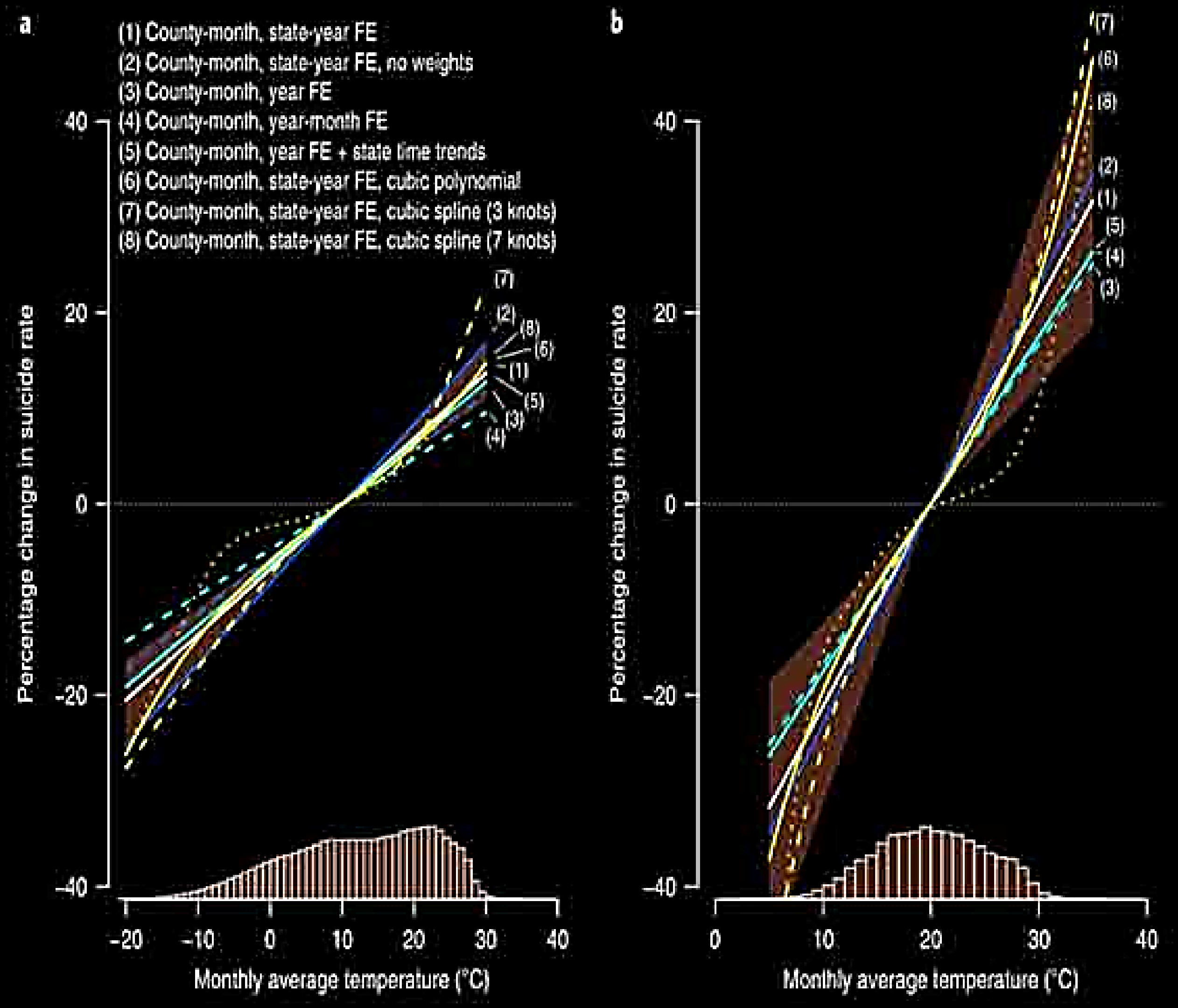
10.

Numerous studies have revealed critical associations between temperature extremes, and mental illness Three types of climate-related events (acute, subacute, and long-lasting changes) on mental health are identified. Extreme heat events that occur in summer could pose a serious risk to human mental conditions.

Meta-analysis showed that heatwaves and extreme high temperatures were associated with higher risk of schizophrenia, mood disorders, neurotic disorders.

A strong association between increases apparent temperature and elevated risk of Mental Behavioral Disorders.
A 99th percentile high temperature was associated with increased schizophrenia risk

D.Li et al: Climatic and Meteorological Exposure and Mental and Behavioural Health. A systematic Review and Metanalysis. Science of the Total Environment, 2023.

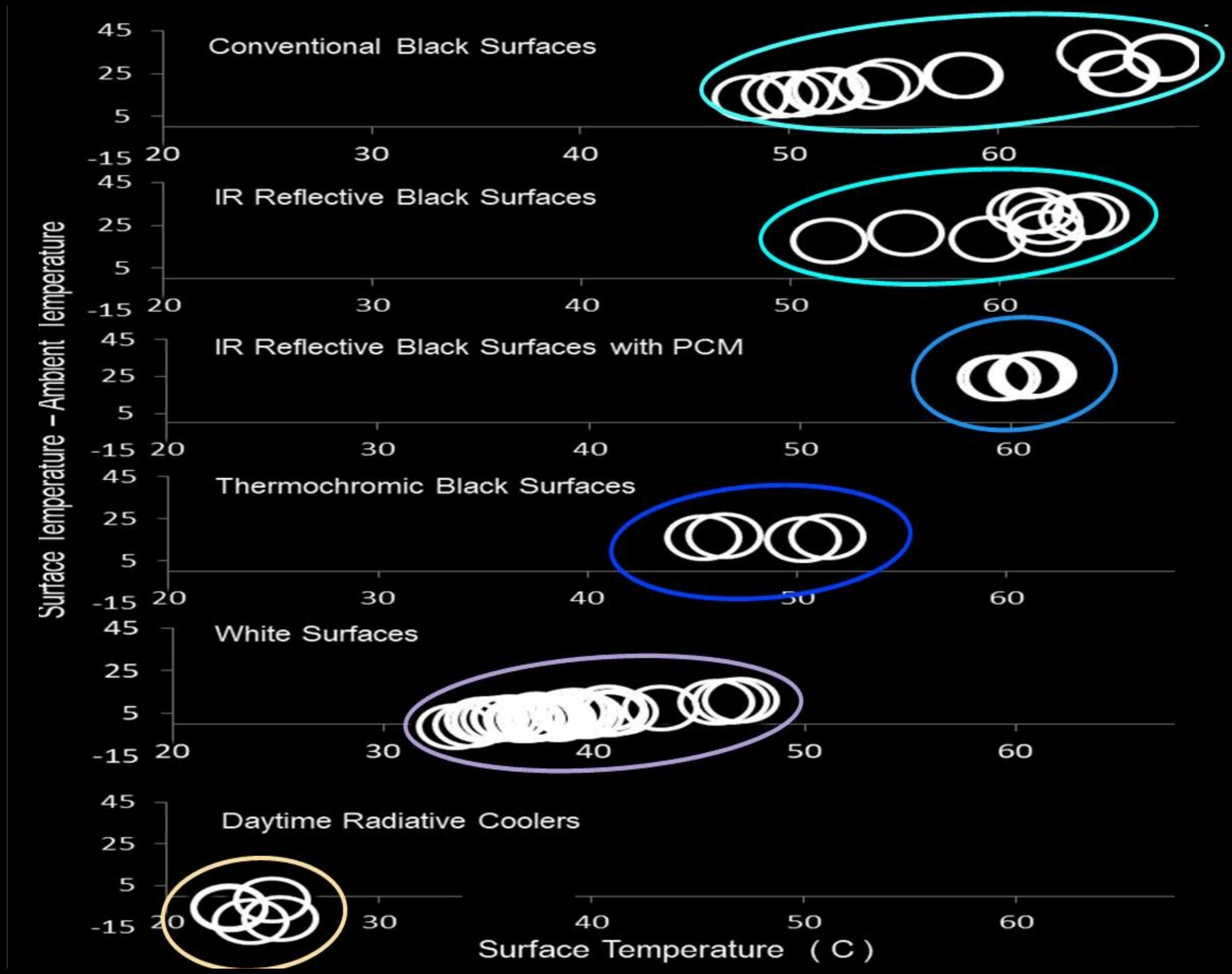


Using comprehensive data from multiple decades for both the United States and Mexico, it is found that suicide rates rise 0.7% in US counties and 2.1% in Mexican municipalities for a 1 °C increase in monthly average temperature.

This effect is similar in hotter versus cooler regions and has not diminished over time, indicating limited historical adaptation.

In contrast to all-cause mortality, suicide increases at hot temperatures and decreases at cold temperatures; also unlike all-cause mortality, the effect of temperature on suicide has not decreased over time and does not appear to decrease with rising income or the adoption of air conditioning.

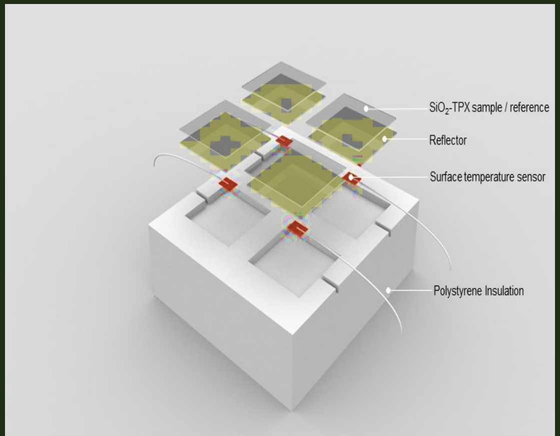
Burke et al : High Temperatures Increase Suicide Rates in the USA and Mexico, Nature Climatic Change 2018

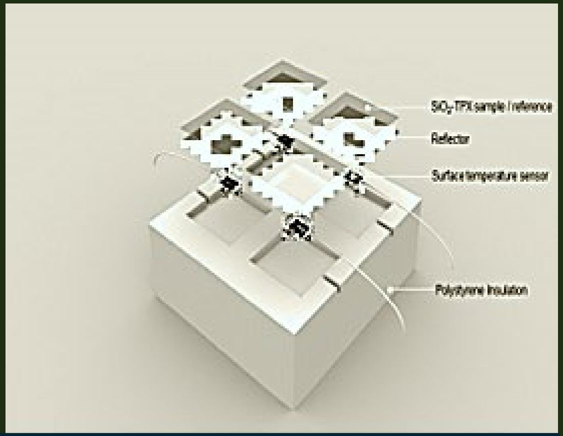


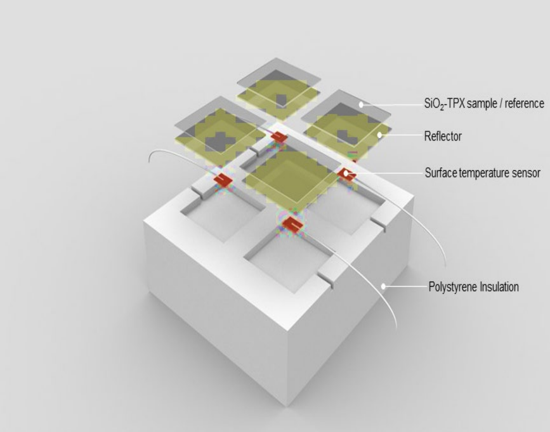
Comparative outdoor assessment of the main types of coatings for the built environment carried out under similar climatic conditions demonstrated the important progress in terms of cooling mitigation potential.

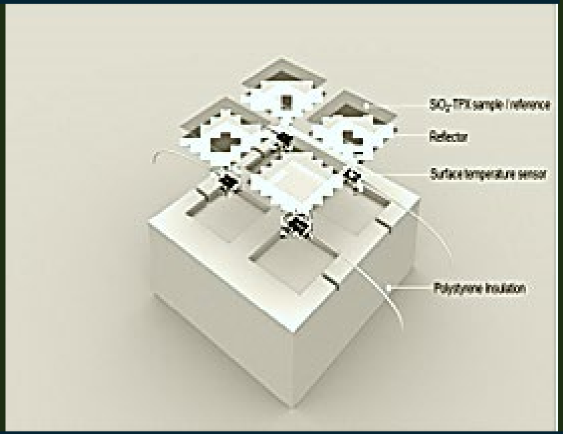
It is found that Super Cool Materials present almost 10-15 C lower surface temperature than the conventional reflecting white coatings.

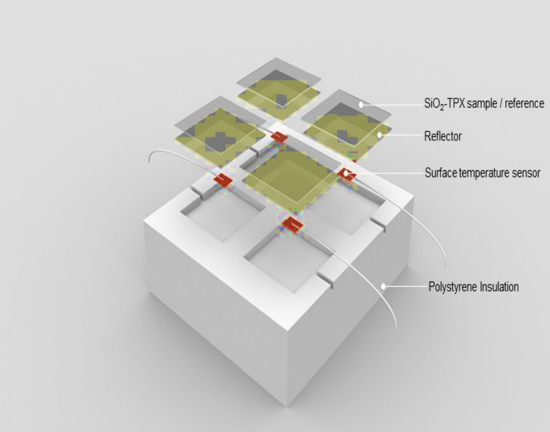
In parallel, the use of Super Cool Materials can decrease the surface temperature of dark color cities up to 30 C

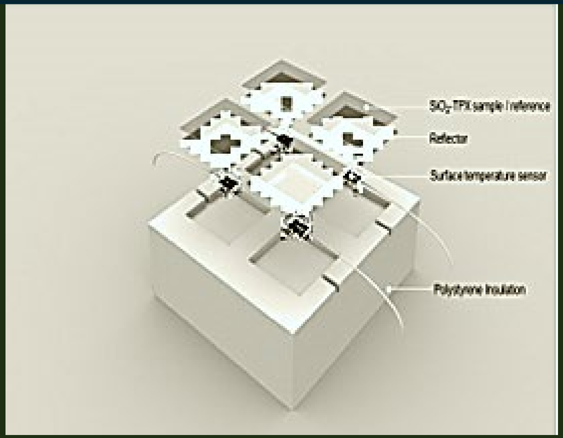










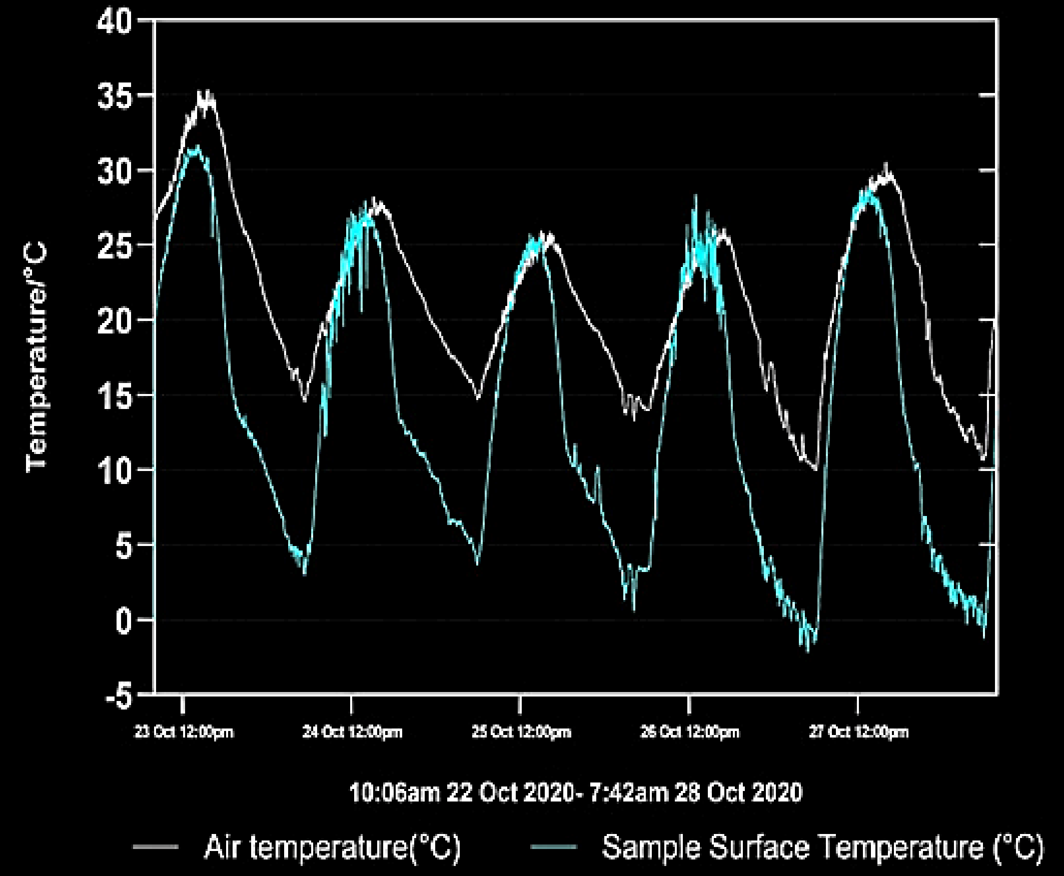


TPX Polymethylpentene (PMP) is a lightweight, functional polymer with a unique combination of transparency, heat and chemical resistant properties

We optimized the influence of the silica sphere's radius, sphere volume fraction, and silica-TPX layer thickness on the material's optical properties and cooling efficiency using theoretical predictions, (FDTD

Jie Feng, Kai Gao, M. Santamouris, K.W. Shah and G. Ranzi : Dynamic Impact of Climate on the Performance of Daytime Radiative Cooling Materials, Solar Energy Materials and Solar Cells, Volume 208, May 2020, 110426
Jie Feng, M. Santamouris and K. Gao :The Radiative Cooling Efficiency of Silica Sphere Embedded Polymethylpentene (TPX) Systems, Solar Energy Materials and Solar Cells, , Volume 215, 15 September 2020, 110671
Jie Feng , A, Khan and M, Santamouris : The heat mitigation potential and climatic impact of super-cool broadband radiative coolers on a city scale Cell Reports Physical Science, 100485 July 21, 2021
Feng J Kai Gao Yue Jiang Giulia Ulpiani Djordje Krajcic Riccardo Paolini Gianluca Ranzi and M. Santamouris : Optimization of Random Silica-Polymethylpentene (TPX) Radiative Coolers Towards Substantial Cooling CapacitySolar Energy Materials and Solar Cells Volume 234, January 2022, 11141

Silica TPX Sample + ESR + Silver Pet Film



Testing has been carried out during five consecutive days.

Day time ambient temperature varied between 25 to 35 C

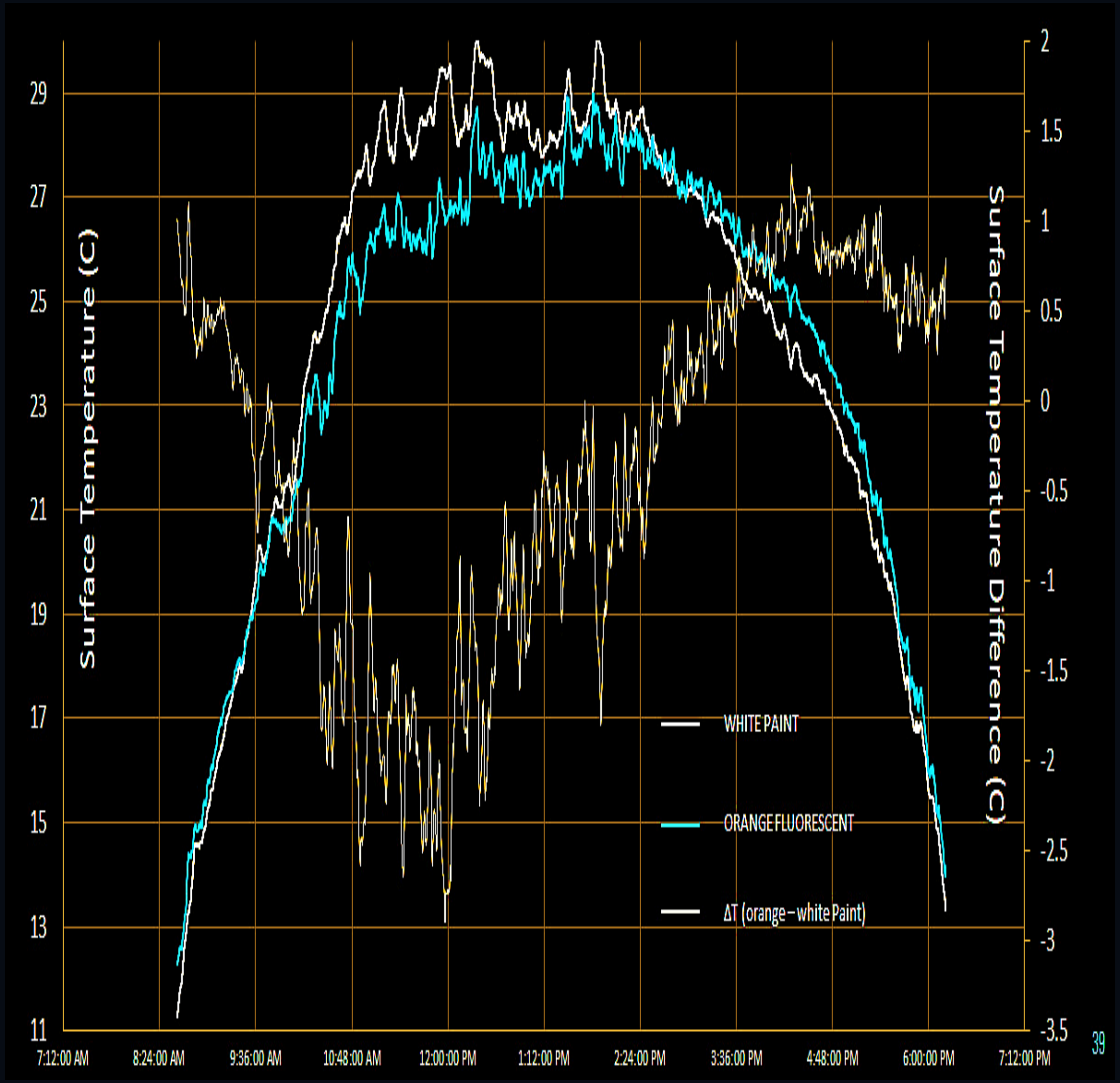
The peak solar Radiation intensity was between 800 to 100 W/m2

During the Day Time:

The Surface temperature of the developed Super Cool Materials was in average 6 C lower than the ambient one while during the peak ambient temperature the cooling of the SCM was 3-4 C.

During the Night Time:

The Surface temperature of the SCM was almost 10 C lower than the ambient one.



25/5/2023 – Alice Springs- Orange Fluorescent SC Material against conventional white paint.

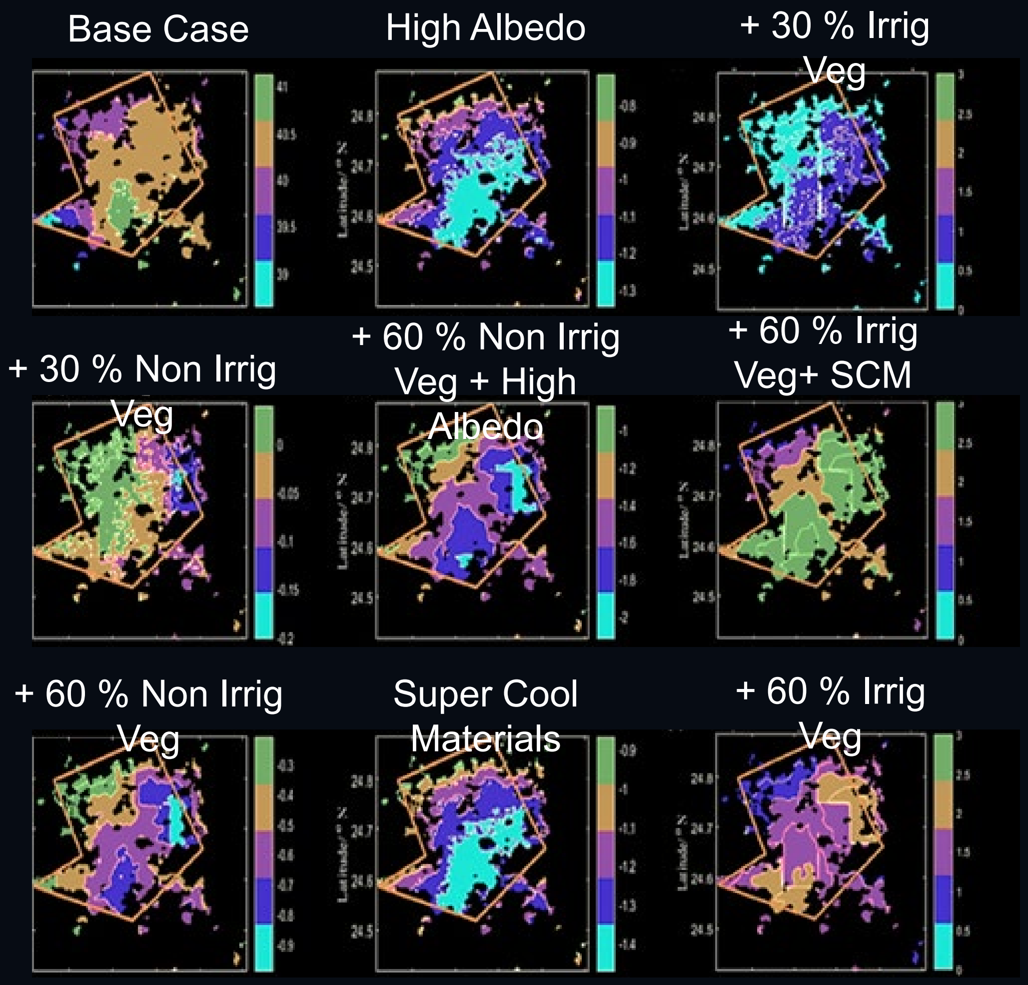
Max Amb. Temp : 27.4 C
Max SR : 740 W/m2
RH (noon) : 20 %,
Max Atm Rad : 370 W/m2

Comparison of the Colored against Conventional White Paint

During day time the average temperature of the white paint was 24.6 C

while of the Orange SCM was 24.1 C

During noon time the orange Super Cool material was almost 3 C of lower surface temperature than the white paint.



The developed Super Cool Materials have been considered as the primary heat mitigation strategy to decrease the ambient temperature and reduce the energy consumption of buildings in numerous cities.

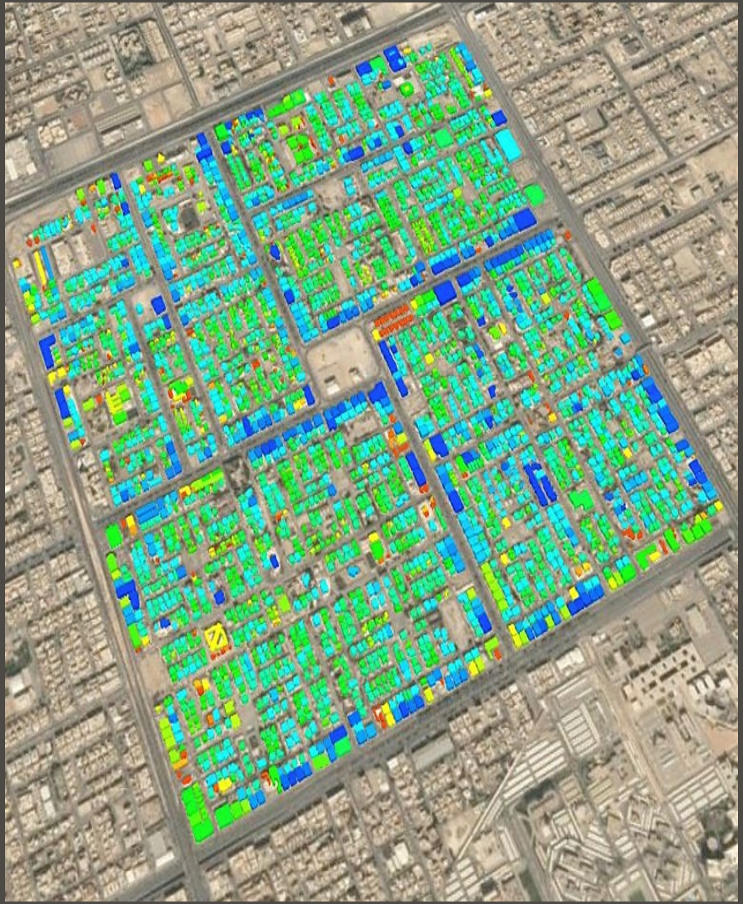
Results from the Heat Mitigation Study in Riyadh, KSA

- Use of white super cool materials in the roofs of the city, can reduce the peak daytime summer temperature up to 2.8 C

- Combined use of white SCM on the roof of buildings, with well irrigated greenery, can reduce the peak day summer ambient temperature up to 4.6 C

- Increase of the albedo in the city by 0.4 can reduce the peak daytime ambient temperature up to 1.5 C.-

S. Haddad et al : **Quantifying the Energy Impact of Heat Mitigation Technologies at the Urban Scale,** Nature-Cities, 2024



The combined use of white super cool materials on the roofs of buildings with well irrigated additional greenery provides serious energy benefits during the summer period and decreases considerably the cooling demand of buildings. .

Results from the Heat Mitigation Study in Riyadh, KSA

- Use of white super cool materials in the roofs of the city, can reduce the cooling demand of buildings up to 10 %

- Combined use of white SCM on the roof of buildings, with well irrigated greenery, can reduce the cooling demand of buildings up to 17 %.

- Combined use of white SCM on the roof of buildings, with well irrigated greenery and energy adaptation measures can reduce the cooling demand of buildings up to 35 %.

S. Haddad et al. **Quantifying the Energy Impact of Heat Mitigation Technologies at the Urban Scale,** Nature-Cities, 2024