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YSSP Report
Young Scientists Summer Program

Future cooling gap in the Shared Socioeconomic Pathways

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Approved by

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Abstract

Lack of access to cooling is and will become an even more prominent challenge to climate change adaptation as heat stress continues to rise. Here we analyze the socio-economic dimensions of adaptive capacity to deal with heat stress, and find that income, urbanization and inequality are factors that correlate with adaptation against heat stress. Using the scenario space of the Shared Socioeconomic Pathways, we estimate future trajectories of the cooling gap, which measures the difference between the population exposed to heat stress and population with access to a cooling device. Depending on the scenario, total population affected by the cooling gap could vary between 3.7 to 1.4 billion people in 2050, and between 0.1 and 4.8 billion at the end of the century. Our analysis shows vast regional inequalities in the capacity to adapt to one of the most common manifestations of climate change and underscores the need for considering the temporal evolution of adaptive capacity in assessments of climate change impacts.

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Introduction

Exposure to abnormal heat can cause various adverse effects on human health, from thermal discomfort to lethal outcomes in the worst case [1]. Heat stress also negatively affects economic activity by reducing labor productivity [2]. Impacts on human health occur through extreme events such as heat waves or droughts, but also through gradual changes in average temperatures. Recent scientific advances have attributed heat impacts on health to anthropogenic climate change [3,4] and there is ample evidence that these impacts will become even more prominent under more amplified global warming [5,6].

A way to alleviate the impacts of heat stress is to adjust indoor temperatures with the use of a cooling device. As the heat impacts increase, so will the need for adaptation to heat. But owning a cooling device is not only dependent on climate, but also on socio-economic factors, primarily enough income to be able to afford a cooling device. Inequality in socio-economic conditions and in exposure to climate hazards create hotspots of climate impacts around the world [7] and scenarios of future developments of societies and of climate allow us to analyze under what conditions societies will be more or less adapted.

Previous research focused mostly on the implications of the uptake of cooling strategies on energy demand and on modelling what this increase in demand entails for climate change mitigation [8–10]. Here we take a different angle and focus instead on understanding the adaptation challenge in response to heat stress. To this end, we analyze elements that constitute the capacity to adapt to heat, under the assumption that adaptation to heat stress is not only contingent on the climate but also a range of socio-economic factors that prevent or enable adaptation. We use air conditioning (AC) to proxy adaptation to heat, seeing it as one of the most straightforward implementable options on the household level and taking advantage of the fact that its implementation can be traced through census data and other country-level sources. We link the socio-economic adaptive capacity to cooling with the climate-induced need for cooling, and use the concept of *cooling gap*, which expresses the difference between the population exposed to heat stress and the population with the capacity to adapt through the use of AC [11].

This paper builds on previous research [8,10,11], by providing a temporal perspective on the cooling gap over the course of the 21st century and by adding a methodological nuance to how cooling gap and heat stress are calculated by using a substantially larger sample of countries and testing for different threshold metrics of heat stress. Using the scenario framework of the Shared Socioeconomic Pathways (SSPs) and the Representative Concentration Pathways (RCPs), we are able to estimate country-level projections of future population exposed to heat stress and future socio-economic dimensions of adaptive capacity to deal with heat stress. Our approach intends to motivate analyses of other gaps between adaptation needs and adaptative capacity in the broader research community of integrated climate change adaptation and mitigation assessments, by quantitatively illustrating the extent of challenges to adaptation that depends on scenarios of socio-economic development. An insight into a temporal and spatial evolution of adaptive capacity within the framework of SSPs is important for consideration in climate impact models. Constraining the expected uptake of adaptation in those models would contribute to more precise estimates of impacts of climate change when meeting different socio-economic conditions.

Because of the contribution of the use of AC to the increase in greenhouse gas emissions [12], which in turn creates a positive feedback with the global mean temperature and thereby the need for even more adaptation in the future, AC is a contested adaptation option and has even been termed maladaptation [13]. These are important interlinkages to understand, both for anticipating future energy demand and for shedding light on how large the need for adaptation will be in the future or what must be considered in adaptation planning. But, even if speculative, the assumption that the energy mix of the future is dominated by renewable energies, would mean that powering ACs would not be as consequential for emissions. Setting the potential mitigation challenge aside, here we use AC and the cooling gap that arises from unequal access to cooling as a heuristic tool to showcase adaptation gaps that will arise in the future as a result of vulnerable populations exposed to an increasing climate hazard, but with adaptive capacity constrained by levels of socio-economic development.

Within the broader spectrum of sustainable development, lack of access to cooling is also a dimension of energy poverty, which in turn has implications for the global sustainability agenda such as the Sustainable Development Goals (SDGs), in particular SDG 7 on Energy Access [14]. Providing a temporal perspective on how this dimension of energy poverty evolves can inform these efforts about what the necessary socio-economic conditions are if the targets of the SDGs are to be met.

Methods

Box 1: Definitions of key concepts

Cooling Degree Days (CDD) represent the sum of degrees above a set point temperature and population density of more than 10 persons per km^2.
Climate maximum saturation is the maximum share of air conditioning in a given climatic zone. It is modelled on the United States, which spans different climatic zones (proxied by CDDs) and where uptake of air conditioning is assumed to be unconstrained by income.
Availability of air conditioning is typically expressed as a function of income. Here we test for other socio-economic factors too.
Air conditioning saturation is expressed as a product of availability of air conditioning and climate maximum saturation.
Population exposed to heat stress is calculated as the median population exposed to at least 50, 100, 200 and 400 CDDs per year calculated with the upper bound of set point temperatures used throughout this analysis (daily average temperatures of 22°C and 24°C).
Cooling gap is calculated as the difference between population exposed to heat stress and population with access to air conditioning (proxied by AC saturation).

AC data

In this analysis we focus only on the AC ownership on the household level. However, it has been shown that residential and commercial AC ownership goes hand in hand [12].Data for AC ownership is gathered from several sources which together cover 61 countries, a substantially larger sample than in previous research which used similar approaches. Most of the additional coverage comes from the Global Data Lab [15] which provides subnational census data on the ownership of electrical appliances,

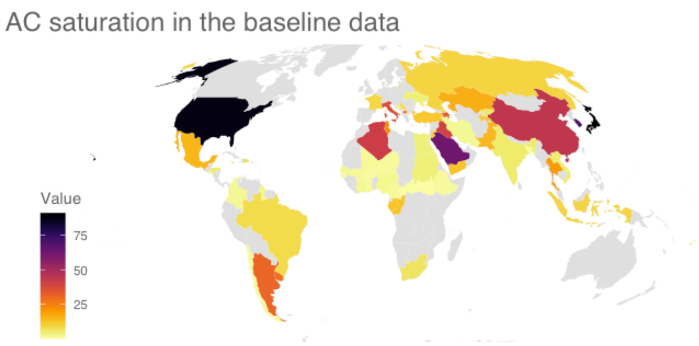

Figure 1: Countries covered in the sample and their rates of AC saturation in the year 2010.

here aggregated to the national level for a cross-country analysis. The full sample covered here can be seen in Figure 1.

For a better overview, most of the results in the rest of this study will be presented with the countries from our sample grouped in eight geographical regions. An overview of countries in each region can be found in the Supplementary Table 2.

Cooling Degree Days (CDDs)

To calculate CDDs, we use population-weighted (w_g) average by grid cell (g_i) within each country (i), of the annual sum of the positive difference between the average daily temperature and the set point temperature:

$$CDD_i = \frac{1}{pop_{tot}} \sum_{\forall g \epsilon i} pop_g \left(\sum_{d=1}^{365} pop_g \left(T_{d,g} - T_{sp} \right)^+ \right)$$

Where $T_{sp} \in$ (18°C, 20°C, 22°C, 24°C).

Shared Socioeconomic Pathways (SSPs)

Shared Socioeconomic Pathways provide a scenario space to explore the range of possible changes in socio-economic conditions over the next century. They can be thought of as "what-if" scenarios of implications of the socio-economic parameters for challenges to climate change adaptation and mitigation. SSPs quantify five different narratives of socio-economic futures to operationalize them for climate change research [16] – they are a widely used tool in climate research community, indispensable for integrated assessments of the dynamics between socioeconomic and climate change variables, and are also the scenario framework used in the Sixth Assessment report of the Intergovernmental Panel on Climate Change (IPCC).

SSP1, the 'sustainability' scenario, is characterized by low challenges to mitigation and adaptation, a result of increased investments in education, health, renewable energy sources and declining inequalities between and within countries, thus limiting impacts and increasing adaptive capacity. SSP2, the 'middle of the road' scenario, maintains premediated challenges to adaptation and mitigation, and is a pathway of uneven and slower socioeconomic progress, compatible with the continuation of historical trends. SSP3 is characterized by high challenges to both mitigation and adaptation, which are a product of a growing divergence between economies, weak international cooperation and increase in internal and international conflicts. SSP4, the scenario of 'inequality', leads to low challenges for mitigation, due to technological advancements in high income countries, but high challenges for adaptation, because of an unequal distribution of advancements and resources across countries. Finally, SSP5 is similar to SSP1 in the fast socioeconomic progress on all fronts, but with the major difference of the progress being powered by fossil fuels, which produces substantially higher emissions and resulting climate impacts.

For expressing the AC availability as a function of socio-economic factors in the following regression analysis, we here use GDP as an indicator of income [17], Gini coefficient as a measure of inequality [18]and urbanization rate, expressed as a share of population living in urban areas [19]. Future population trajectories used for estimates of exposure to heat stress are also taken from the SSP framework [20,21].

Model

To estimate the future uptake of air conditioning, we build on the two-stage modeling approach used in the seminal papers [8,10,22] that established the relationship between climate conditions, AC availability and AC saturation. This approach expresses AC coverage as a product of AC availability and a climate parameter. AC availability is normally expressed as a function of income, but here we will add urbanization and inequality as other dimensions of the socio-economic profile that might influence the uptake of AC.

The climate parameter (climate maximum saturation) defines the level of AC coverage if it would not be constrained by income and is a function of the CDDs. We use the parametrization of the relationship between climate maximum saturation and CDDs from McNeil and Letschert (2007). They derived the functional relationship on the sample of the census divisions in the United States, under the assumption that they span many different climatic zones, but that AC ownership is largely unconstrained by income.

The relationship between climate maximum saturation and CDDs is found to be an exponential function. The set point temperature for which CDDs are calculated is based on the estimate of the temperature at which the energy use is at the minimum (neither cooling nor heating). In previous studies, CDDs were routinely calculated with the set point temperature of 18°C which is the estimate based on the minimum energy use in the US and Europe [8]. Set point temperature reflects preferences for indoor temperature, which are a result of different factors such as thermal history (longer term experience with pervious thermal conditions) and thermal comfort zone [23], lifestyle factors [24], and infrastructural factors such as prevalent building characteristics [9].

Since these factors vary around the world, and here we use a sample with countries beyond the US and Europe, we analyze the AC ownership for the set point temperature thresholds of 18°C, 20°C, 22°C and 24°C. For orientation, Argentina would currently have 898 (162) population weighted CDDs with the set point temperature of 18°C (24°C), Italy would have 654 (116), Nigeria 3356 (1391), or the United States 956 (254).

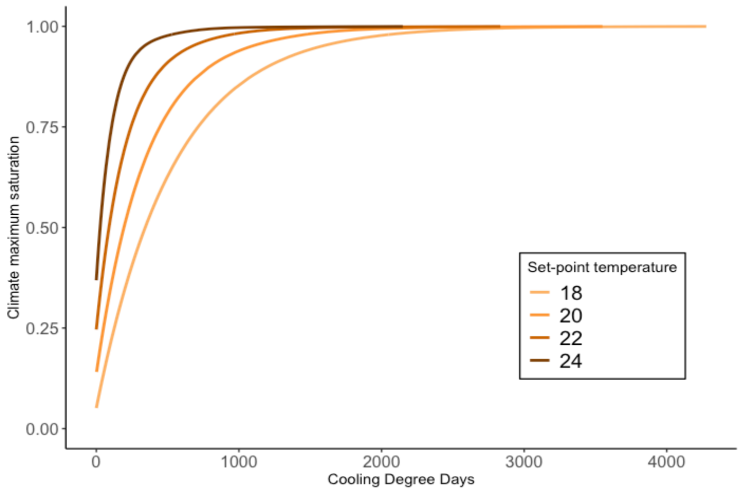

Figure 2: Climate maximum saturation for different set point temperatures

We adjust the climate maximum saturation curves for the different set point temperatures. To do so, we fit a spline function to the relationship between CDDs for 18°C and each of the other four set point temperatures we show here. We then use the coefficient estimate for the temperature-specific covariate to calculate CDD_{18} equivalents for other set point temperatures and calculate their respective climate maximum saturation curves as shown on Figure 2.

AC availability and AC saturation

We used the beta regression which is suitable for regressions in which the dependent variable takes values in the interval between 0 and 1. We used GDP, urbanization and inequality as socio-economic covariates to enhance the explanatory power of the regression model. Income (here proxied by GDP per capita) has been used in most previous studies and is which is the most straightforward determinant of whether an air conditioning device can be purchased or not. But here we also controlled for urbanization, with the assumption that AC will be more in demand in urban areas, and for inequality, with the assumption that the more equitably the income is distributed, the higher share of population will be able to afford residential air conditioning. Regression results are provided in Supplementary Table 1.

We use the terms AC ownership and AC saturation interchangeably. The data from the original sources are on AC saturation, which means that it must be divided with climate maximum saturation to obtain AC availability, which will then be used for the regression analysis of the initial conditions, For projections of future AC saturation, we use different set point temperature for different countries, based on the minimum residual in the cross-sectional regression of the initial conditions, which explains the relationship between AC availability and socio-economic factors. This improves the model accuracy and the projections.

The statistical model for the observational period rests on the following equation:

$$AC\ Availability_{i,t} = \beta_0 + \beta_1 GDP_{i,t} + \beta_2 Inequality_{i,t} + \beta_3 Urbanization_{i,t} + \varepsilon_{i,t}$$

Coefficient estimates obtained from the beta regression model are then imposed on projections of GDP [17], inequality [18] and urbanization [19] which, based on the same equation, calculate future values of AC availability in the five SSP scenarios.

Using the estimates of AC availability, we calculate AC saturation:

$$AC\ Saturation_{i,t} = AC\ Availability_{i,t} \times Climate\ Maximum\ Saturation_{i,t}$$

For future projections of Climate Maximum Saturation, we use CDDs in three Representative Concentration Pathways (RCPs): 2.6, 4.5 and 6.0.

Finally, to calculate the cooling gap, we calculate the difference between population exposed to heat stress and the share of population with AC (AC saturation).

$$Cooling\ gap = Population\ exposed\ to\ heat\ stress\ \times (1 - AC\ saturation)$$

Population exposed to heat stress is calculated by coupling the estimates of population weighted CDDs, with population projections to estimate future exposure to heat stress. For the upper bound of set point temperatures used throughout this analysis (22°C and 24°C) we aggregate the population in areas with at least 50, 100, 200 and 400 CDDs. Population exposed to heat stress is then defined as the median value of the combinations of the CDDs at two set point temperatures and their minimum counts. Limiting the estimates to this upper bound is a conservative approach, meaning the estimates of heat exposure would be even higher if we considered areas where cooling is demanded at lower CDD thresholds. By taking a conservative approach to estimating heat stress, our results reflect the minimum conditions for thermal comfort and are indicative of the extent of energy poverty by showing where and to what extent the population will not be able to adapt to heat stress.

Results and discussion

Projections of AC availability and AC saturation

On Figure 3, we show projections of future AC availability and AC saturation, with available country-level estimates averaged on the level of eight geographical regions, RCP 4.5 - the middle scenario used here. High AC availability reflects high levels of income and urbanization and on average low levels of income inequality. AC saturation is a product of this availability but adjusted for the actual need for AC as defined by the climatic conditions.

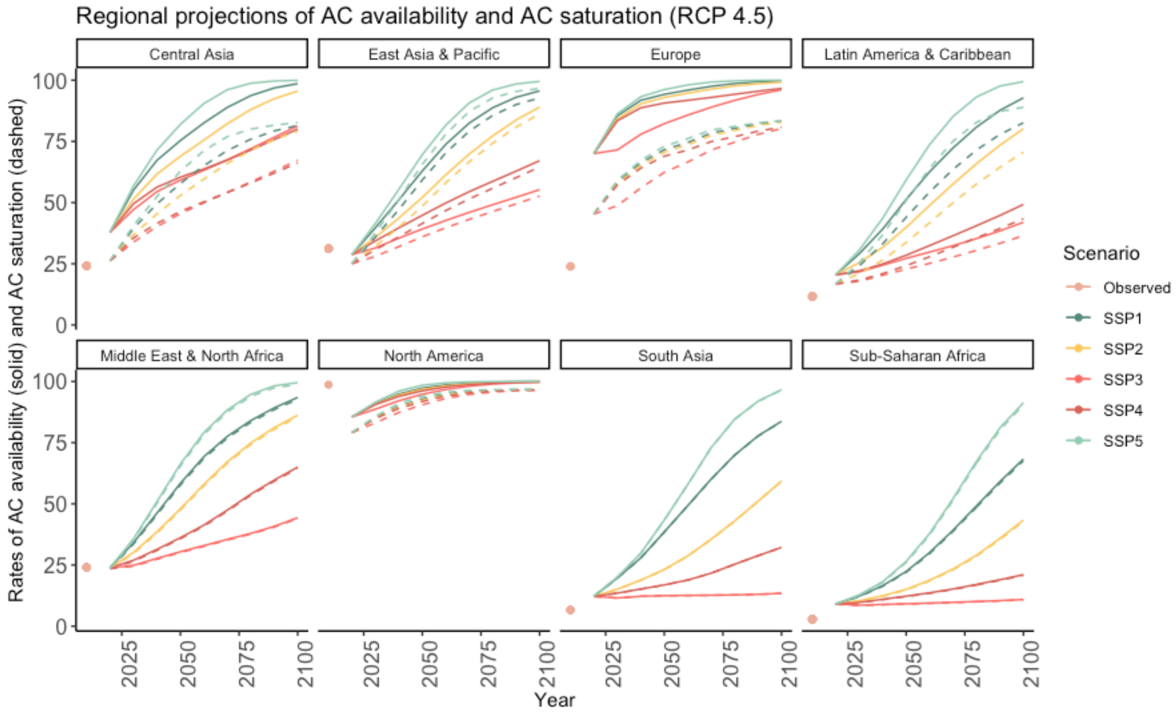

Figure 3: Observed and projected rates of AC availability (solid line) and AC saturation (dashed line) for eight large geographical regions. The climate scenario for future CDDs is RCP 4.5.

Figure 3 shows that Europe and Central Asia show respectively 25 and 10 percentage points differences between AC availability and AC saturation, which means that AC saturation in these regions is relatively strongly moderated by climatic conditions. In the Middle East and North Africa region, South Asia and Sub-Saharan Africa, estimates for AC availability and saturation overlap entirely, signaling that the climatic conditions require all of the available air conditioning, at which point AC saturation is also a product only of socio-economic conditions.

North America has by far the highest rates of AC saturation with more than 90% of the households covered by AC. Because this region is an outlier, the statistical model underestimates its observed rate by about 20 percentage points. Conversely, for Europe the model overestimates the observed rate by about 20 percentage points. However, both North America and Europe display little scenario difference, implying that adaptive capacity for this specific option is high, and will remain high in the future in the scenarios that we considered here.

Other six regions display a good model fit, but they differ substantially in the degree of scenario dependence. The difference is the largest for South Asia and Sub Saharan Africa, which in scenarios of low and sluggish socio-economic development (SSP3 and 4) see a stagnation or a marginal increase to about 25% of AC saturation by the end of the century, in the middle-of-the-road scenario SSP2 reach about 60% and 40% respectively by 2100, and in scenarios of fast socio-economic developments, reach saturation rates between 75% and 100% over the same time period. East Asia and the Pacific, Latin America and the Caribbean, Middle East and North Africa also display scenario differences, with about a 50-percentage point spread between scenarios at the end of the century. AC saturation in Central Asia is expected to increase in all scenarios, with difference in 2100 between the "worst" and "best" case scenario of 25 percentage points.

Heat stress exposure

Many different metrics of heat stress can be found in research. A large body of work has focused on the impacts of *extreme* heat stress (e.g. heat waves), which can have much more severe and adverse impacts on human health from the heat stress metric that is underlying this analysis. CDDs are calculated based on the average daily temperature and sum all degrees above that set threshold per year. Accounting for other parameters that determine the severity of heat stress, such as the deviation from the monthly mean, humidity, number of consecutive days of heat stress or the diurnal period (i.e. difference between daily maximum and daily minimum temperature which would allow for insights on the recovery period from heat) is beyond the scope of this analysis but would be a valuable contribution in future applications.

Figure 3 shows that in 2020, population in the southern hemisphere is disproportionally affected by heat stress, with much of the Sahel region, Sub-Saharan Africa and most of South Asia having over three quarters of their populations exposed to heat stress. Going towards mid-century in mid-range scenarios for both population growth and climate (SSP2 and RCP 4.5), increasing shares of population in the northern hemisphere are affected, and in 2100, almost entire populations in all countries except for Scandinavia and Great Britain are exposed to heat stress in these two scenarios. Estimates for 2050 and 2100 for RCPs 2.6 and 6.0 are available in the supplementary material.

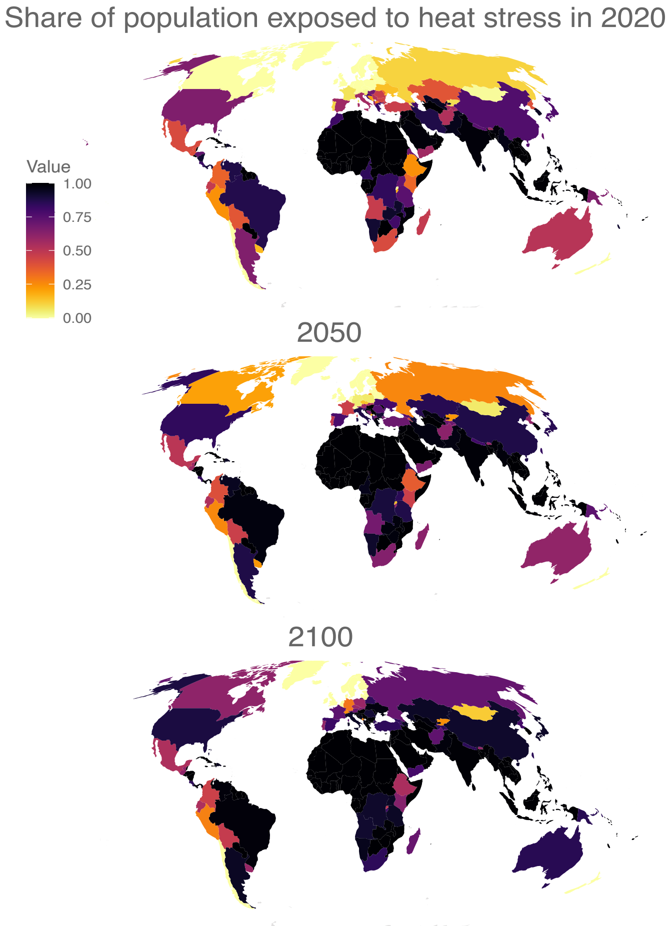

Figure 4: Population exposed to heat stress in 2020 and over the 21st century. Increase in population is based on SSP2 scenario and CDDs increase is in RCP 4.5.

Cooling gap projections

In Figure 4 we show absolute population affected by cooling gap – people in need of AC, but without access to it. We focus on two time slices: mid-century and end of century, for emissions scenario RCP 4.5. In 2050, South Asia (consisting in this sample of Bangladesh, India and Pakistan) stands out as a region with the largest population affected by cooling gap, with the scenario spread between 650 million in SSP5 and almost 1800 million people in SSP3. The second most affected region in Sub-Saharan Africa, followed by East Asia & Pacific. By the year 2100, the number of people affected by cooling gap substantially reduces for scenarios SSPs 1, 2 and 5 across all regions. Meanwhile, due to population growth and poor socio-economic development in SSPs 3 and 4, the number of people affected by cooling gap increases even further, reaching almost 2500 million in South Asia and 1500 million in Sub-Saharan Africa.

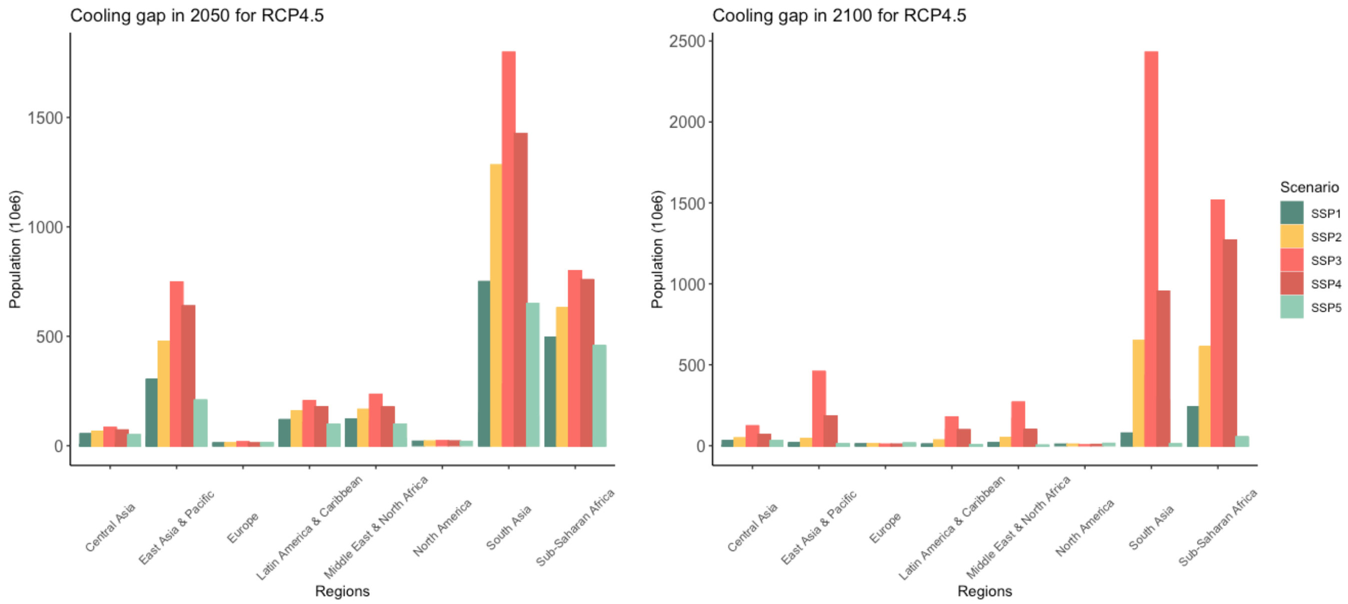

Figure 5: Absolute population estimates affected by cooling gap in 2050 and 2100. Heat stress underlying this estimate follows RCP 4.5. The bars are grouped in eight geographical regions and shown for each of the five SSP scenarios.

When cooling gap is regarded in relation to the total population of these regions, the picture becomes different, with Sub-Saharan Africa now having the highest shares of population affected by cooling gap across all scenarios and in both time periods. The region affected the least is North America (in the sample represented only by the United States). As shown on Figure 3, North America already is and will remain unconstrained in terms of its adaptive capacity and can adapt to heat stress as measured here, and its population will stagnate or even shrink in most scenarios. In the worlds of SSP3 and 4, over 75% of people in South Asia and Sub-Saharan Africa would be exposed to heat

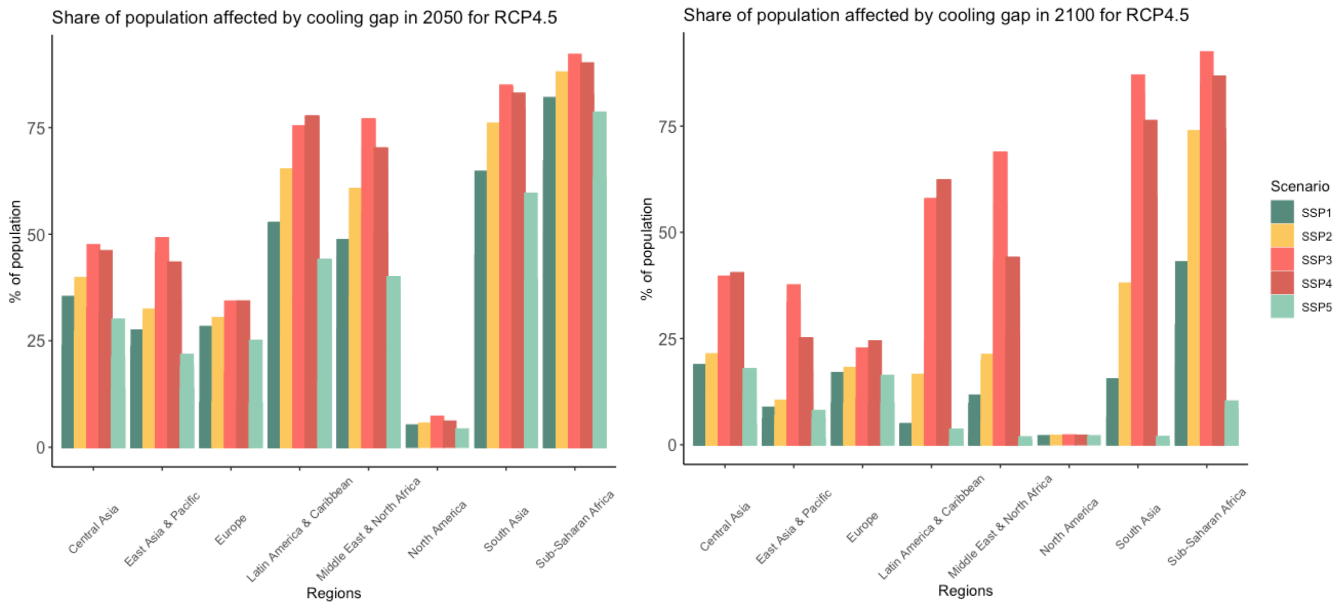

Figure 6: Share of population affected by cooling gap in 2050 and 2100. Heat stress underlying these estimates follows RCP4.5. The bars are grouped in eight geographical regions and shown for each of the five SSP scenarios.

without the adaptive capacity to deal with it, both in mid-century and in the long run. The access to AC can be improved by mid-century in scenarios of faster income growth, urbanization and reduced inequality, but only at the end of the century these regions are projected to display similar levels of cooling gap to today's rich countries of Europe and North America. Somewhat smaller, but still substantial portions of people are going to be affected in these scenarios also in Latin America and the Caribbean, and in the Middle East and North Africa regions. Significant improvements can be brought about in the pathways of SSP1 and 5, but only at the end of the century.

Figures 5 and 6 show median heat stress estimates based on the different calculations of CDDs and show results only for RCP4.5. Boxplots with the spread of the heat stress estimates, and for all emissions scenarios can be found in the Supplementary Figures 3 and 4. The main insight from different emission scenarios is that the spread of heat stress becomes smaller the warmer it gets, because all heat stress threshold used for sensitivity analysis here are eventually crossed. Because of the nature of the three RCP scenarios used here, the climate signals become significantly pronounced only in the second half of the century, which is the reason for seeing more drastic impacts of the changing emissions scenario only on graphs for 2100. However, for the most affected regions of South Asia and Sub-Saharan Africa, the way we measure heat stress makes very little, if at all, difference to the outcomes in terms of population affected.

Even though the most affected regions here are consistently in the Southern Hemisphere, previous research finds that a growing number of households in Europe is struggling to meet their needs for cooling [25]. Spatial resolution of our research does not allow for analyses on that level, but it is important to keep in mind that even in the regions portrayed here as best-off, there could still be portions of populations affected by cooling gap or energy poverty in a broader sense.

This analysis could be further elaborated upon with several additional considerations. Firstly, although we cover – to our best knowledge – the biggest sample of country-level data on AC saturation, 60 countries is far from a full global coverage which would yield even more precise estimates. Secondly, we consider only one type of a cooling option, whereas other devices such as fans are also used for cooling, and do not consider type of buildings whose quality of insulation might reduce the need for indoor cooling. Finally, population exposed to heat stress could be derived with the use of other heat stress metrics, or consider heat extremes and their duration which would also have disproportionately negative effects on the poor [26].

Conclusion

This study presents a toolkit for analyzing adaptive capacity across countries and over time on the example of AC use as an adaptation option to heat stress. Our analysis finds the availability of AC to correlate with income, urbanization and income inequality, which goes beyond the approach routinely used in for similar analyses which focus only on income. The combination of these socio-economic factors is indicative of what forms adaptive capacity for indoor cooling.

With projections within the framework of SSPs, we show future estimates of AC availability and AC saturation. Coupling these projections with estimates of future heat stress based on CDDs produce estimates of future cooling gap. Depending on the scenario of future socio-economic development, total population affected by the cooling gap could vary between 3.7 to 1.4 billion people in 2050, and between 0.1 and 4.8 billion in 2100. Future adaptive capacity in countries in the Global South depends greatly on the socio-economic dynamics or factors such as income, urbanization and inequality, while the developed countries of the sample in this instance only show dependence on the climatic conditions.

These estimates of future cooling gap point at vast regional inequality in future adaptive capacity, in all but most progressive scenarios of socio-economic development. Even in the most optimistic scenarios of the SSP framework, some of the vulnerable regions will not reach the same levels as in rich countries. Fast population growth that is not followed by socio-economic development would expose more than three quarters of populations to unabated heat stress in some of the world's most populous regions, like South Asia, Sub-Saharan Africa and Latin America.

As an important dimension of energy poverty, the extent of cooling gap and its scenarios presented here can be used for informing the attainability of sustainable development pathways or SDGs that depends on the broader socio-economic dynamics.

The perspective of adaptive capacity as a function of different socio-economic factors is an important consideration for future projections of impacts of climate change, which currently do not explicitly account for different degrees of the potential for adaptation to happen in the first place. Accounting for variation in adaptive capacity would contribute to better-constrained estimates of climate impacts and further enhance the identification of hotspots of climate hazards and socio-economic vulnerability.

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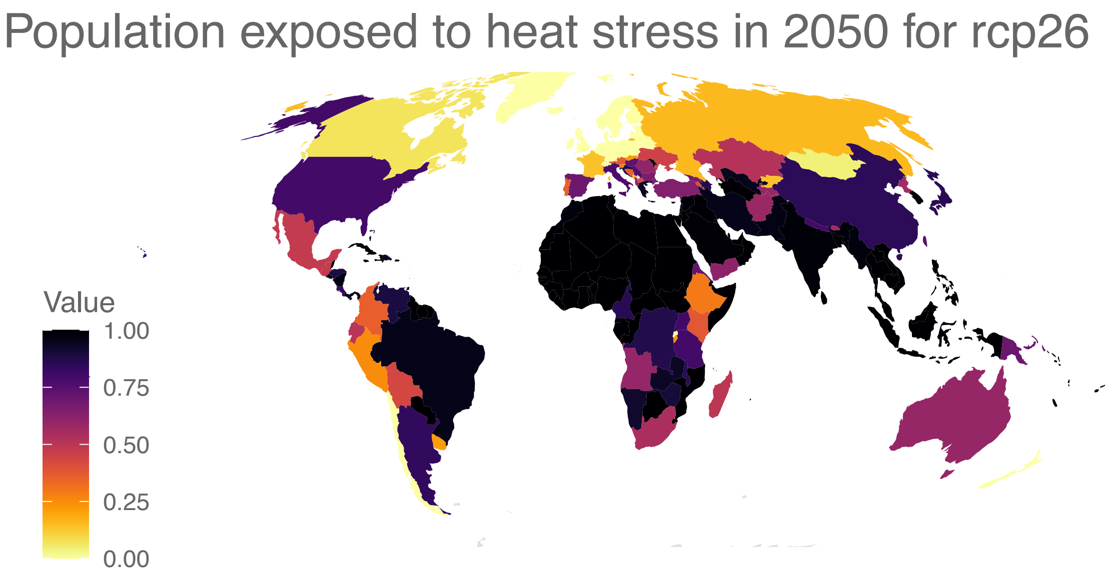
Supplementary Material

Table 1: Regression results

	Dependent variable:		
	Air conditioning availability		
	(1)	(2)	(3)
GDP per capita	0.0001***	0.0001***	0.0001***
	(0.00001)	(0.00001)	(0.00001)
Inequality		-0.037**	-0.047***
		(0.015)	(0.015)
Urbanization			0.014**
			(0.007)
Constant	-2.180***	-0.730	-1.047*
	(0.173)	(0.618)	(0.631)
Observations	61	61	61
R^2	0.567	0.611	0.655
Log Likelihood	61.780	64.397	66.517
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 2: Countries grouped in eight geographical regions

Region	ISO3 Country code	Region	ISO3 Country code
Central Asia	ARM	Middle East & North Africa	DZA
Central Asia	AZE	Middle East & North Africa	EGY
Central Asia	BIH	Middle East & North Africa	IRN
Central Asia	KAZ	Middle East & North Africa	IRQ
Central Asia	KGZ	Middle East & North Africa	JOR
Central Asia	MKD	Middle East & North Africa	SAU
Central Asia	RUS	Middle East & North Africa	TUN
Central Asia	SRB	Middle East & North Africa	YEM
Central Asia	TJK	North America	USA
Central Asia	TUR	South Asia	BGD
East Asia & Pacific	CHN	South Asia	IND
East Asia & Pacific	FJI	South Asia	PAK
East Asia & Pacific	IDN	Sub-Saharan Africa	BFA
East Asia & Pacific	JPN	Sub-Saharan Africa	CAF
East Asia & Pacific	KOR	Sub-Saharan Africa	CIV
East Asia & Pacific	LAO	Sub-Saharan Africa	CMR
East Asia & Pacific	THA	Sub-Saharan Africa	COG
East Asia & Pacific	VNM	Sub-Saharan Africa	ETH
Europe	FRA	Sub-Saharan Africa	GAB
Europe	ITA	Sub-Saharan Africa	GHA
Europe	UKR	Sub-Saharan Africa	GMB
Latin America & Caribbean	ARG	Sub-Saharan Africa	GNB
Latin America & Caribbean	BRA	Sub-Saharan Africa	MLI
Latin America & Caribbean	CHL	Sub-Saharan Africa	NER
Latin America & Caribbean	COL	Sub-Saharan Africa	NGA
Latin America & Caribbean	DOM	Sub-Saharan Africa	SDN
Latin America & Caribbean	GUY	Sub-Saharan Africa	SEN
Latin America & Caribbean	HND	Sub-Saharan Africa	ZAF
Latin America & Caribbean	JAM		
Latin America & Caribbean	MEX		
Latin America & Caribbean	SLV		
Latin America & Caribbean	URY		


Population exposed to heat stress in 2050 for rcp26
Value
1.00
0.75
0.50
0.25
0.00

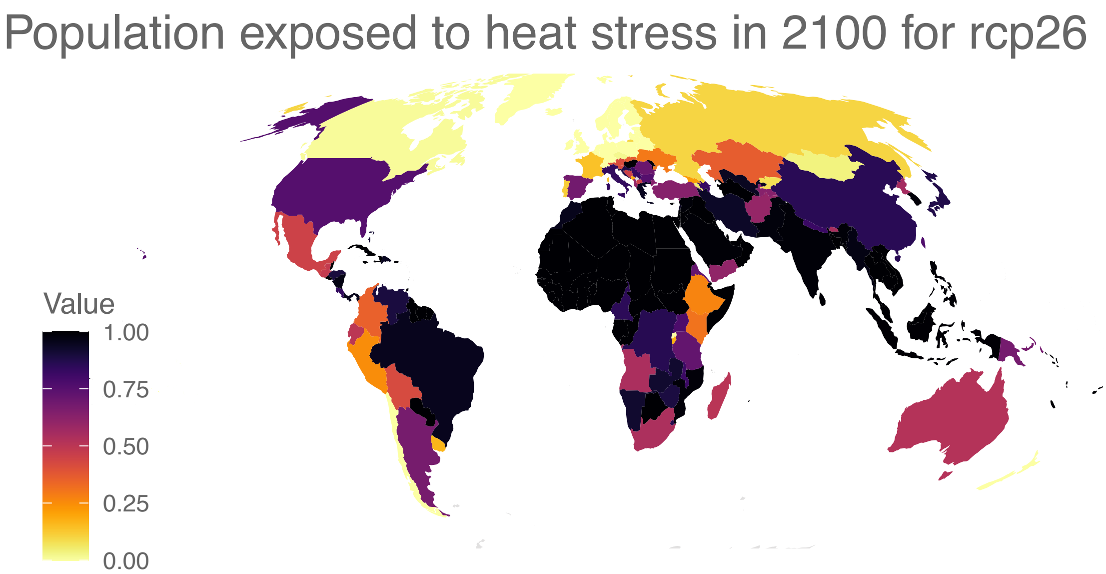
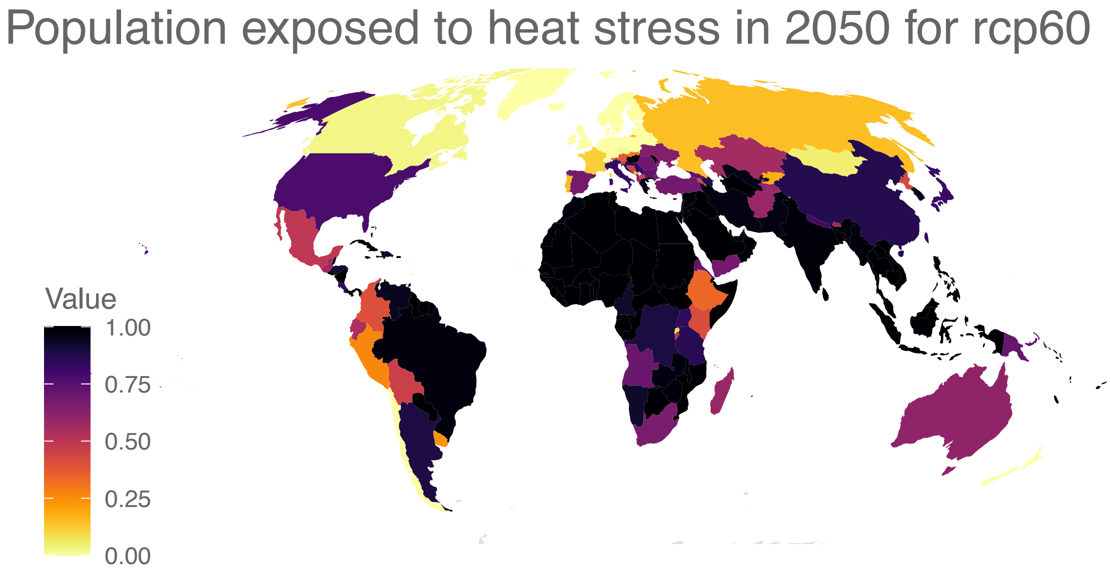

Population exposed to heat stress in 2100 for rcp26
Value
1.00
0.75
0.50
0.25
0.00

Figure SM1


Population exposed to heat stress in 2050 for rcp60
Value
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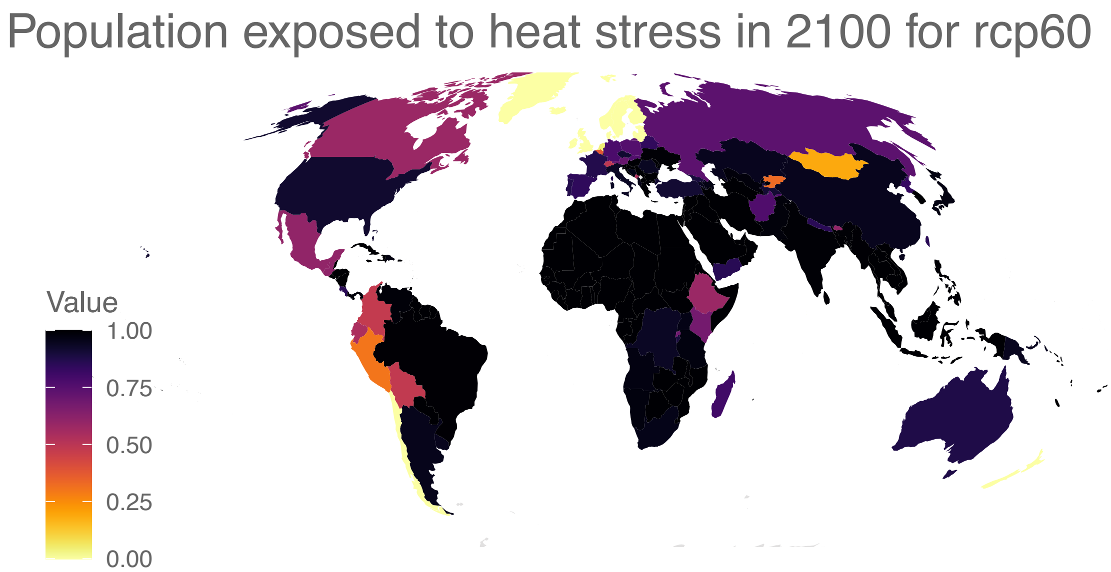
0.75
0.50
0.25
0.00


Population exposed to heat stress in 2100 for rcp60
Value
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0.75
0.50
0.25
0.00

Figure SM2

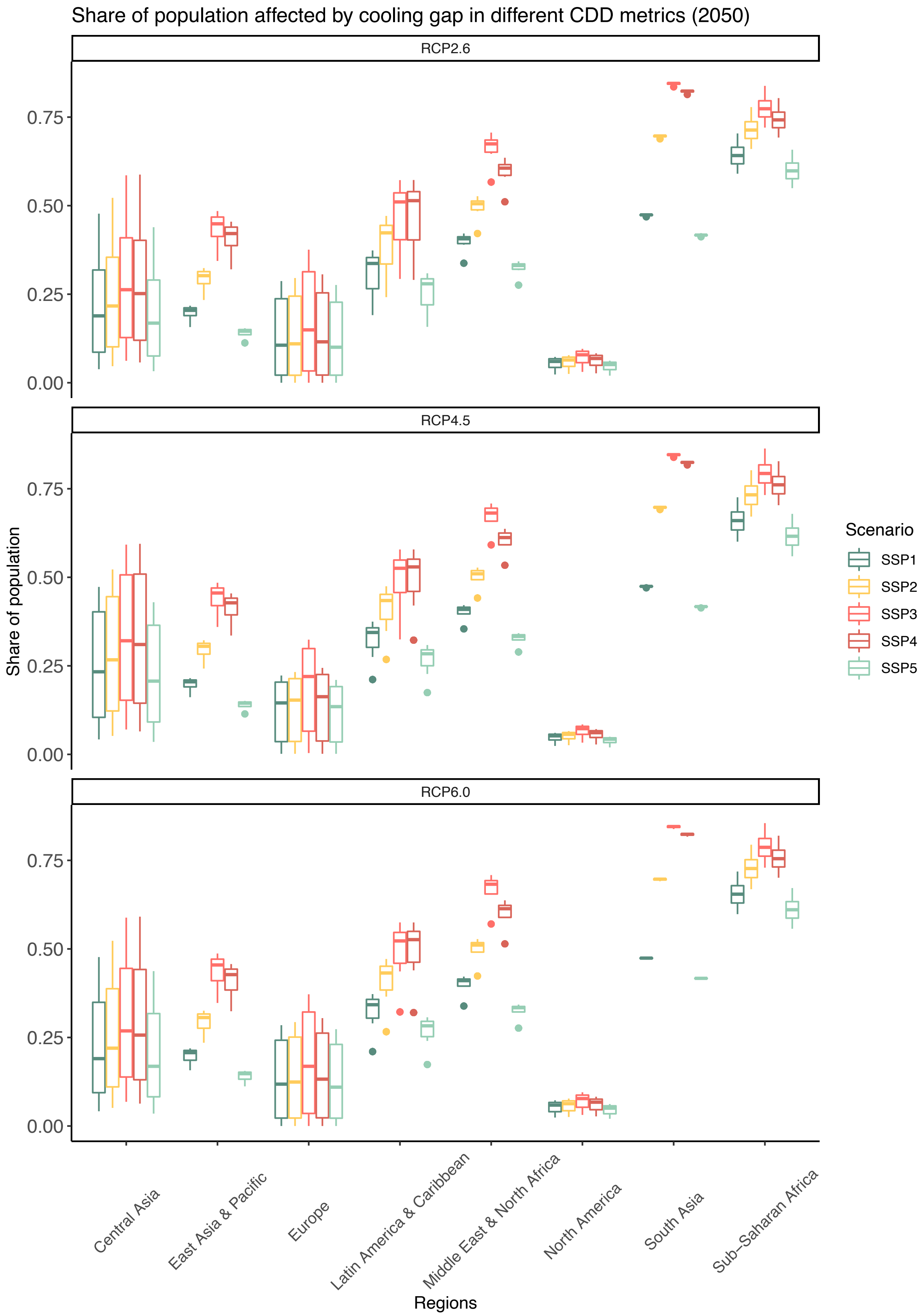
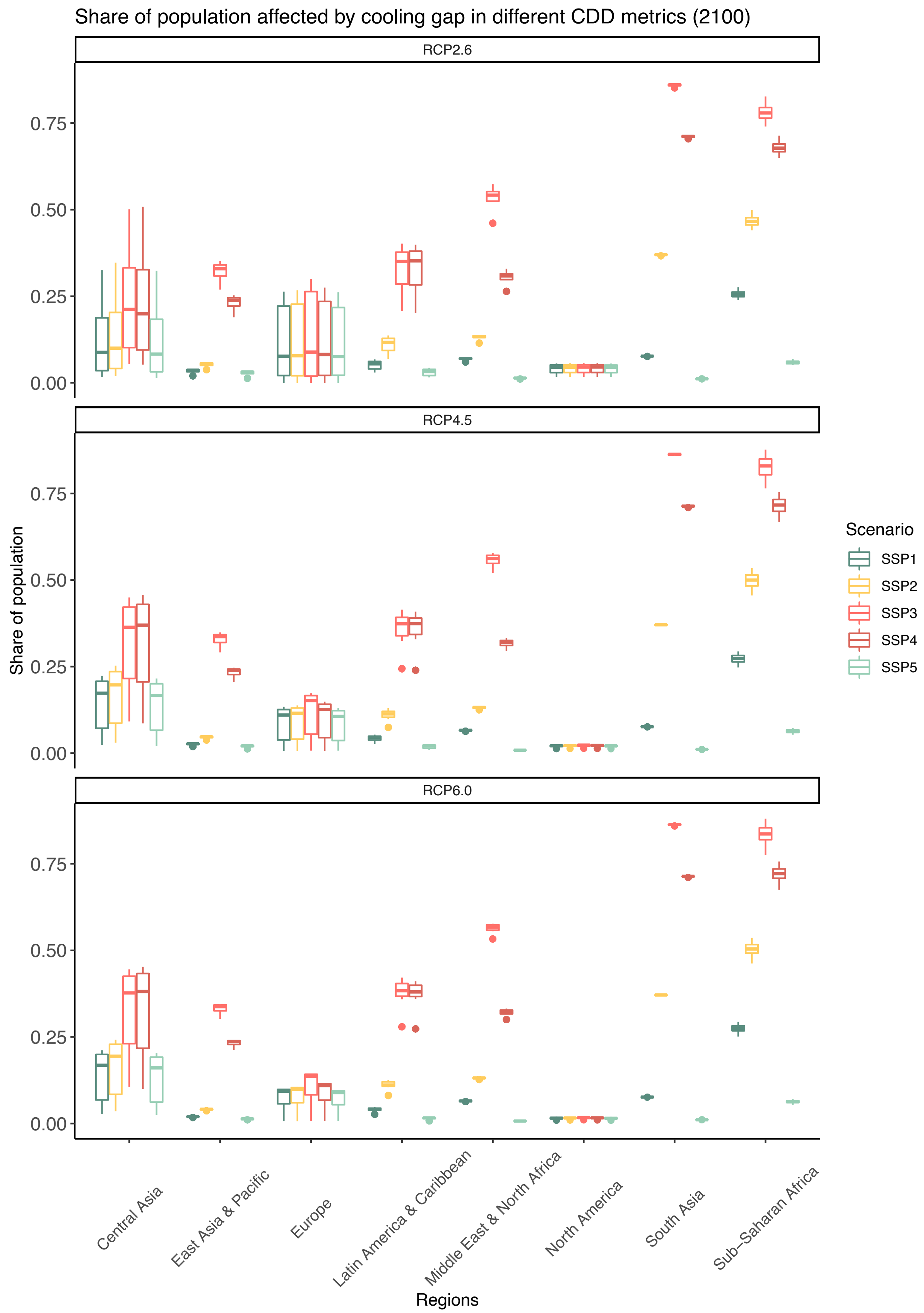

Share of population affected by cooling gap in different CDD metrics (2050)
RCP2.6
RCP4.5
RCP6.0
0.00
0.25
0.50
0.75
Share of population
Scenario
SSP1
SSP2
SSP3
SSP4
SSP5
Central Asia
East Asia & Pacific
Europe
Latin America & Caribbean
Middle East & North Africa
North America
South Asia
Sub-Saharan Africa
Regions

Figure SM3



Share of population affected by cooling gap in different CDD metrics (2100)
RCP2.6
RCP4.5
RCP6.0
0.75
0.50
0.25
0.00
Share of population
Scenario
SSP1
SSP2
SSP3
SSP4
SSP5
Central Asia
East Asia & Pacific
Europe
Latin America & Caribbean
Middle East & North Africa
North America
South Asia
Sub-Saharan Africa
Regions

Figure SM4