SIXTH ASSESSMENT REPORT
Working Group II – Impacts, Adaptation and Vulnerability

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Workshop on Climate Information for Risk Assessment and Regional Adaptation from Global Scale Climate Projections to Local Scale Climate Hazards

Trieste, Italy, 5-9 June 2023

Heat and Health: impacts, risks, solutions
From IPCC Sixth Assessment Report (AR6)

Guéladio Cissé (Swiss TPH, Switzerland)[1], Robert VAUTARD (IPSL, France)[2]
[1]Coordinating Lead Author WGII/ Chapter 7
[2]Coordinating Lead Author, WGI / Chapter

Objectives of the session

1. Present the WGII perspective on heat as one of the Representative Key Risks (RKR) for health, some major challenges and the range of solutions (heat related adaptation options)

2. Present the WGI perspective on heat-related climate changes, and provide a focus on humid heat, and the example of WWA South Asia heatwave attribution done

3. Discuss with participants possible important points to consider in the IPCC Cycle #7

Overview

1. **WGII** perspective and some highlights from the **SYR**
2. **WGI** perspective and case study

   including some non-IPCC highlights
3. Discussion points

PART 0

Questions

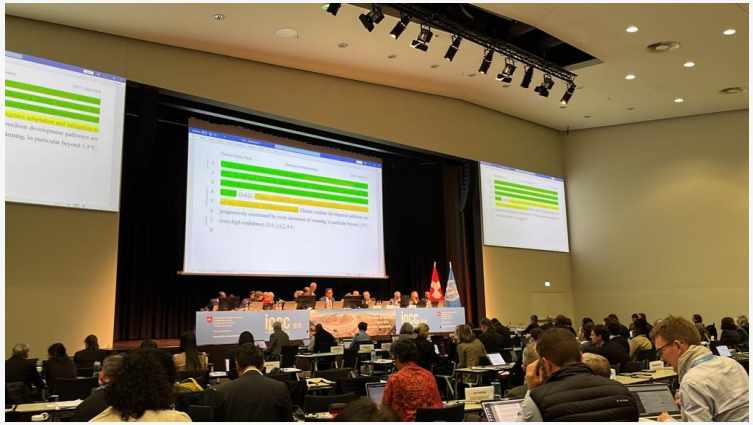
General reminders

Heat
Starting Questions

- *What words come to your mind when you hear “heat”?*
- *What words describe the most relevant climate actions on “heat”?*
- *What maximal temperature in your country could occur in the near-term (e.g. next 5 years)?*

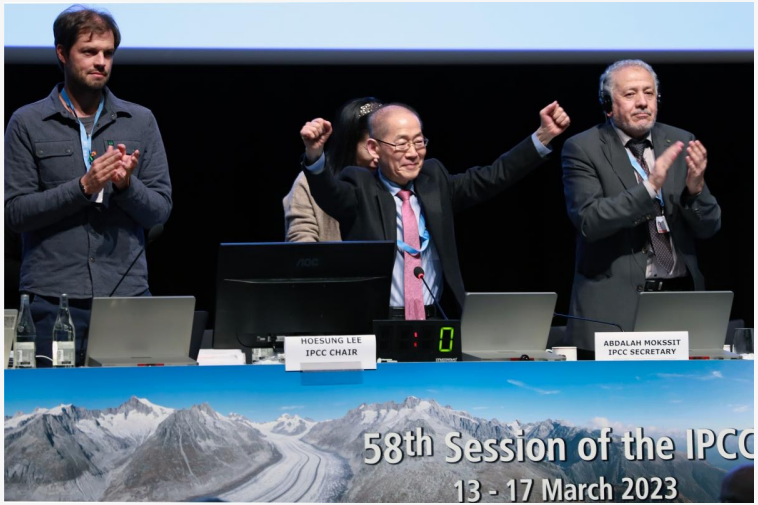
PART 1

WGII perspective and Highlights from the Synthesis Report



IPCC session for

SYR Approval by governments



Plenaries, working groups, night sessions, authors …

End: 19 **March 2023**!

WGII "Impact, Adaptation, Vulnerability"

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WGII AR6 LAM 1 Durban, January 2019

WGII AR6: 18 Chapters
(Intro, 7 Sectors, 7 Regions, 3 Syntheses)
+ 7 cross chapter papers
Summary for Policy Makers

WGII AR6 SPM release : February 2022
#8 years after AR5 (2014)

Working Group I – Health and Wellbeing Global

Extreme heat thresholds relevant to agriculture and health are projected to be exceeded more frequently at higher global warming levels ***

Levels of confidence:
**** *Very high*; *** *High*; ** *Medium*; * *Low*

AR6 WGI SPM C2.1

Hazards, Exposure, Vulnerability, Risks

Working Group II

Risks result from the superposition of climate **hazards**, **vulnerability** and **exposure** of human systems, ecosystems and their biodiversity

IPCC WGII AR6, 2022

VULNERABILITIES – Health and wellbeing

Working Group II

Increased vulnerability to climate impacts on health and well-being is experienced by specific groups and locations

WGII AR6 Chapitre 7

Vulnerability

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3.3 – 3.6 billion people live in hotspots of high vulnerability to climate change.

Overlapping challenges

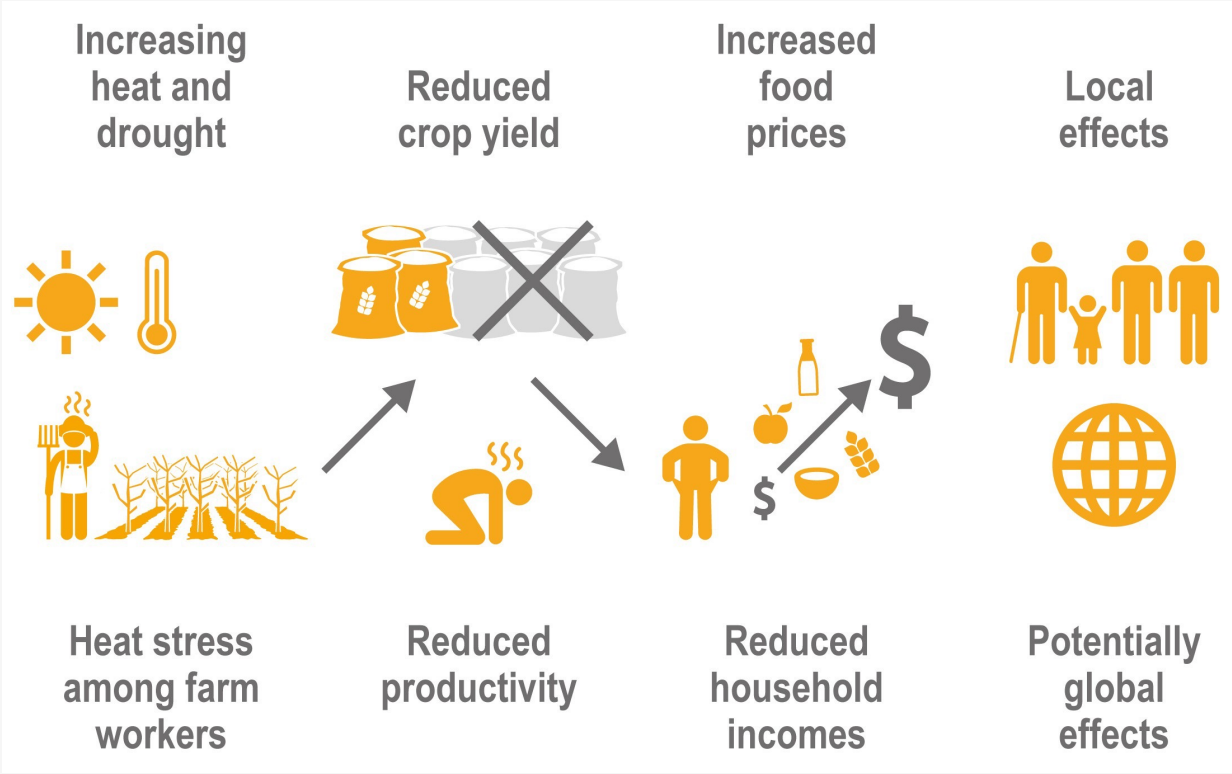
- Limited access to water, sanitation and health services
- Climate-sensitive livelihoods
- High levels of poverty
- Weak leadership
- Lack of funding
- Lack of accountability and trust in government

[Denis Onyodi / KRCS CC BY-NC 2.0]

Simultaneous extreme events compound risks

Multiple extreme events that compound the risks are more difficult to manage

Cascading effects



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Vulnerabilities – Health and wellbeing

Particular Impacts of Heat

- **Women and girls: pregnancy, maternal status**
- **Children: immature physiology and metabolism**
- **Elderly: disproportionately vulnerable**
- Socioeconomically marginalized populations
- People with disabilities
- Vulnerable populations in urban, coastal and rural areas

WGII Chapitre 7

OBSERVED IMPACTS – Health and Wellbeing Global

Working Group II

Climate change has adversely affected physical health of people globally ** and mental health of people in the assessed regions ****

HEAT

Levels of confidence:
**** *Very high*; *** *High*; ** *Medium*; * *Low*

WGII AR6 SPM B1.4, Chapitre 7

Working Group II

Observed Impacts – Non-communicable diseases and others

- **Extreme heat events human mortality and morbidity******
- Mental health challenges***
- Climate-sensitive cardiovascular and respiratory distress**
- More: diabetis

- Health services disrupted by extreme events***

Levels of confidence : **** *Very High* ; *** *High* ; ** *Medium* ; * *Low*

WGII AR6 SPM B1.4, chapitre 7

Projected Risks – Health and Wellbeing Global

Climate change and related extreme events will significantly increase ill health and premature deaths from the near- to long-term ***

HEAT

Levels of confidence:
**** *Very high*; *** *High*; ** *Medium*; * *Low*

AR6 SPM B1.4, Chapitre 7

Working Group II

Projected risks – Non-communicable diseases

- Population exposure to heatwaves: increase with additional warming, strong geographical differences in heat-related mortality ****

- Mental health (incl. anxiety and stress): increase in assessed regions ****

Levels of confidence : **** *Very High* ; *** *High* ; ** *Medium* ; * *Low*

WGII SPM B4.4

PNUE, Shutterstock

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Projected Risks

An excess of approximately 250,000 deaths yr^{-1} dominated by

- increases in deaths due to **heat** (**94,000**, mainly in Asia and high-income countries),
- **childhood undernutrition** (85,000, mainly in Africa but also in Asia),
- **malaria** (33,000, mainly in Africa) and
- **diarrhoeal disease** (33,000, mainly in Africa and Asia)

WGII Chapter 7, Figure 7.8

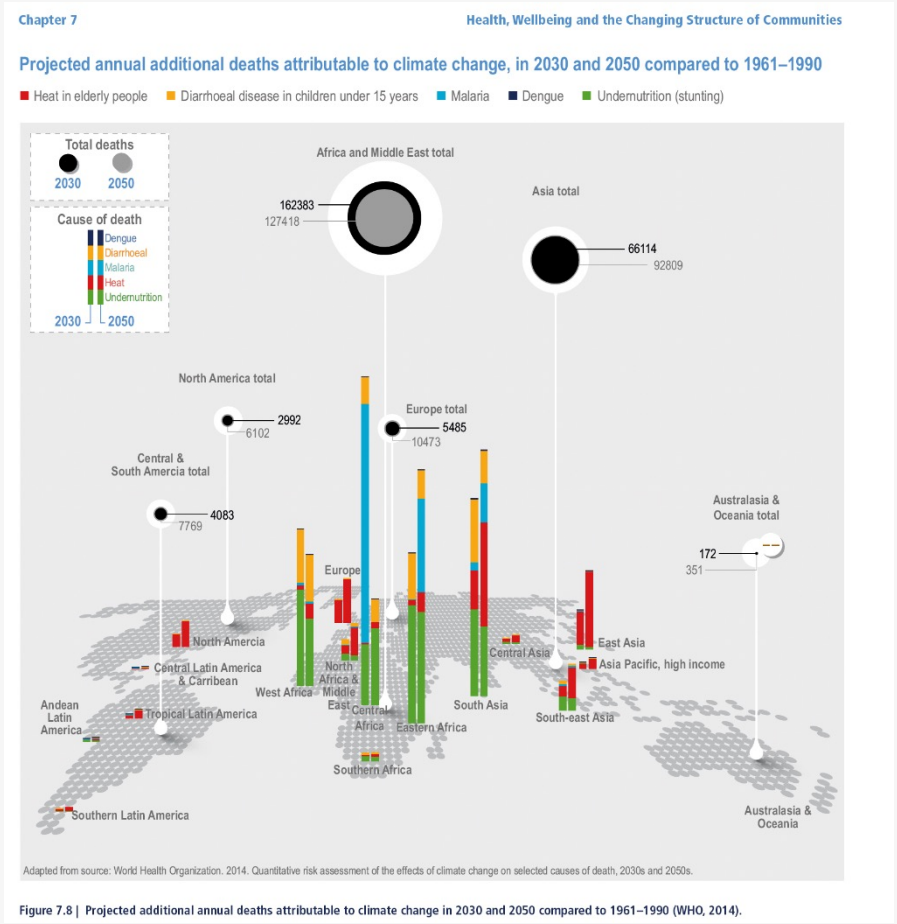
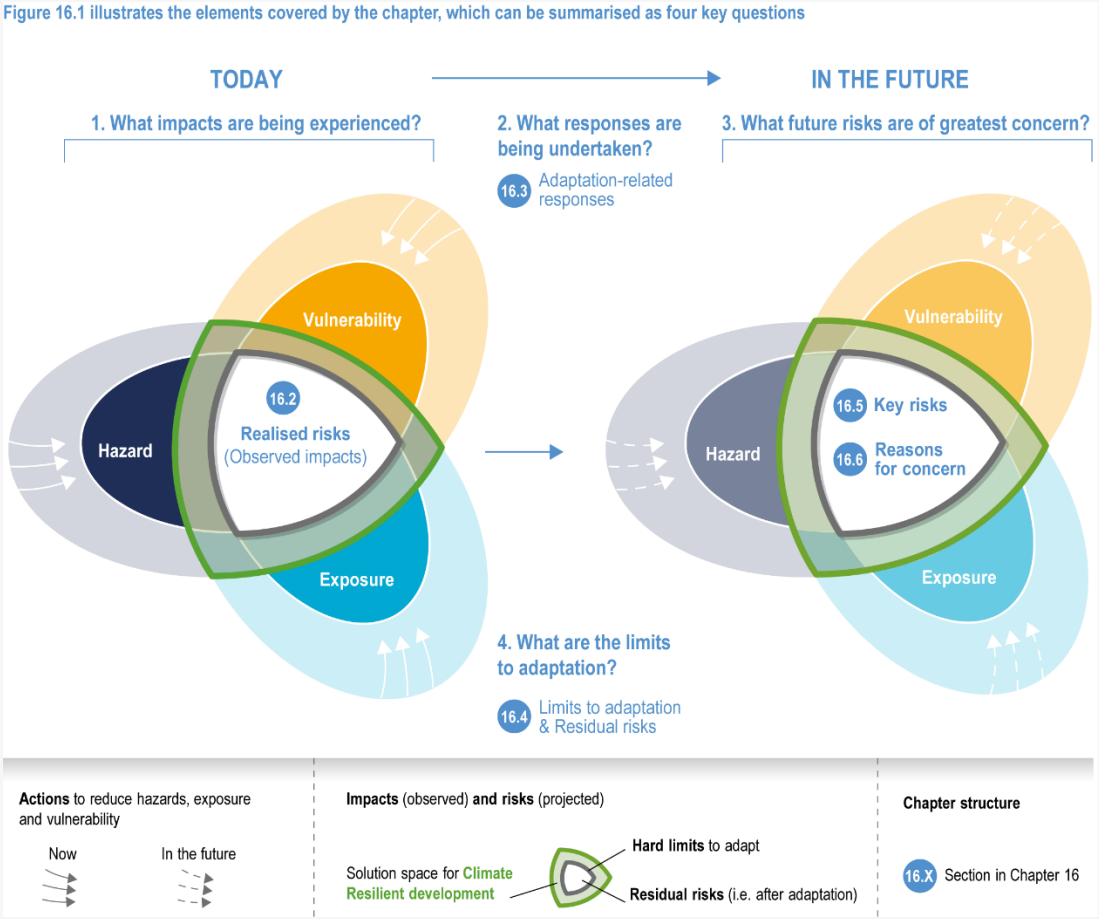


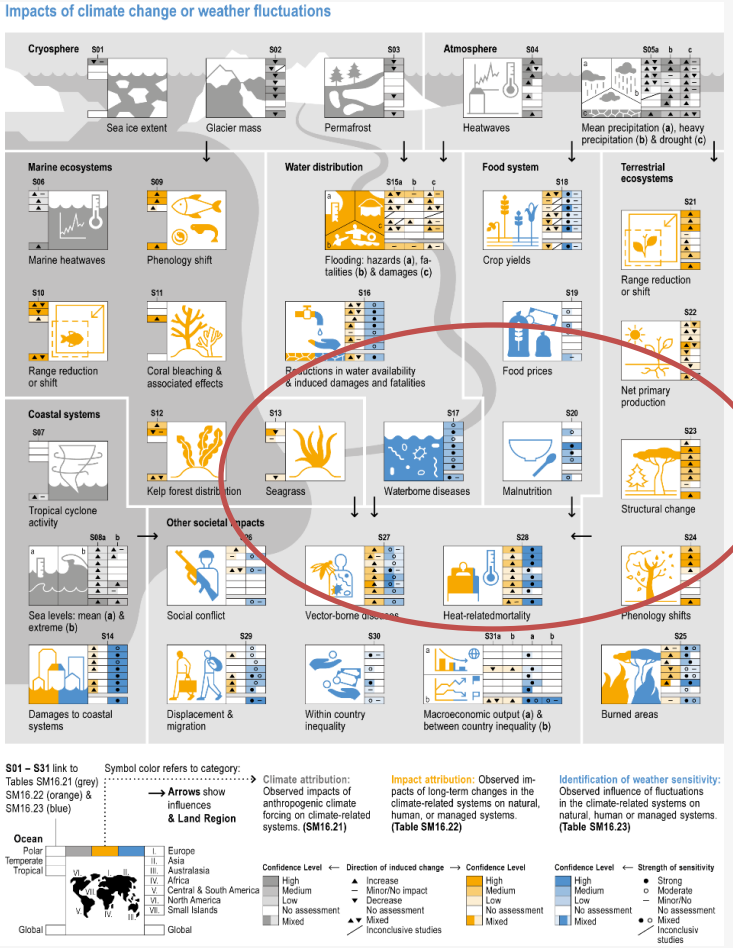
Figure 7.8 | Projected additional annual deaths attributable to climate change in 2030 and 2050 compared to 1961–1990 (WHO, 2014).

Chapter 16

- 120 key risks (KRs) : severe under particular conditions (hazards, exposure, and vulnerability).
- Eight so-called Representative Key Risks **(RKRs)** including: human health; food security; water security (high confidence).

Figure 16.1 illustrates the elements covered by the chapter, which can be summarised as four key questions





Chapter 16

For most Representative Key Risks (RKRs), potentially **global and systemically pervasive risks become severe in the case of high warming,** combined with high exposure/vulnerability, low adaptation, or both *(high confidence).*

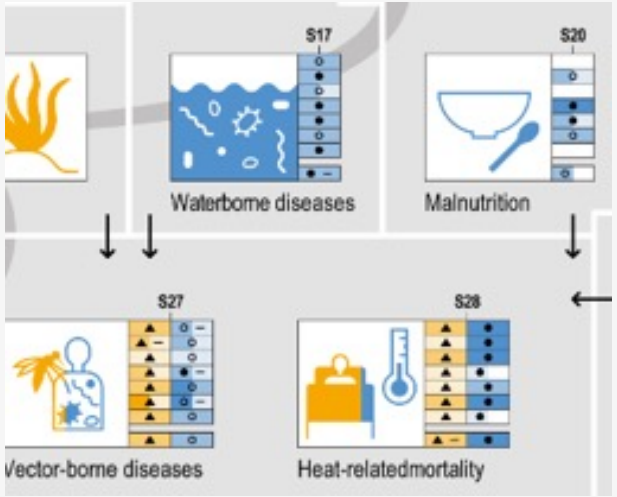
Health RKRs

Waterborne

Vector-borne

Heat-related mortality

Malnutrition

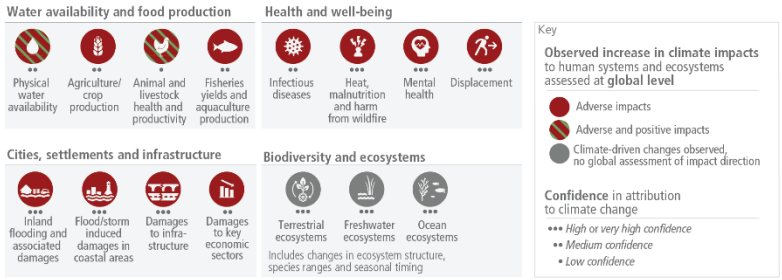


Heat Highlights

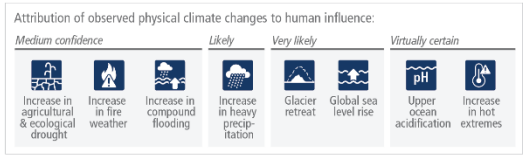
- There is nearly an universal evidence that non-optimal ambient temperatures increase mortality *(high confidence)*
- Increases in sea surface temperatures over recent decades as well as during recent summer heatwaves are linked to increased concentrations of Vibrio bacteria in coastal waters and an associated rise in environmentally acquired Vibrio infections in humans.
- Hazards and associated risks expected in the near-term include an increase in heat-related human mortality and morbidity (*high confidence*)
- Hundreds of local losses of species have been driven by increases in the magnitude of heat extremes (*high confidence*) with mass mortality events recorded on land and in the ocean (*very high confidence*).

Adverse impacts from human-caused climate change will continue to intensify

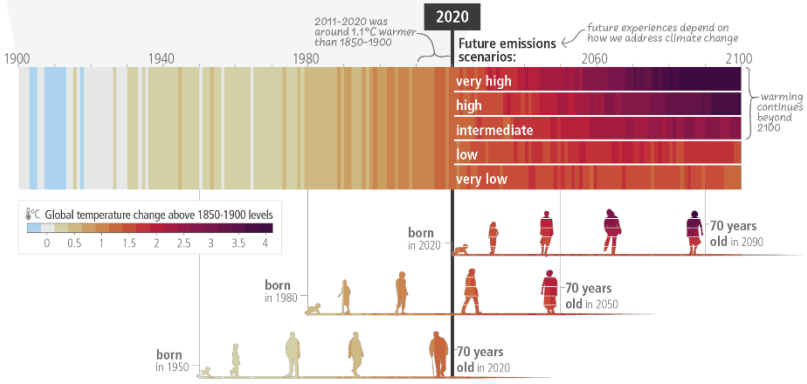
a) **Observed widespread and substantial impacts and related losses and damages attributed to climate change**



b) **Impacts are driven by changes in multiple physical climate conditions, which are increasingly attributed to human influence**



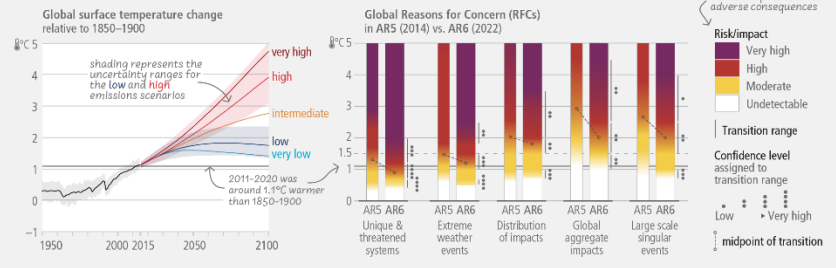
c) **The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near-term**



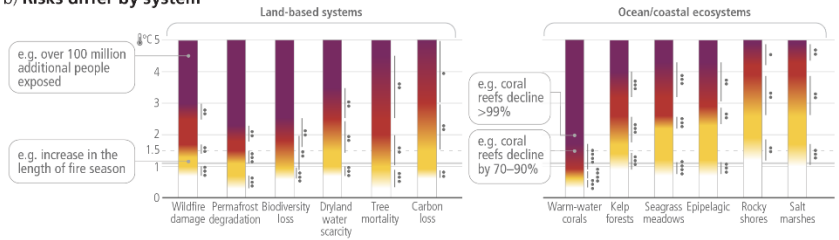
SYR
INTERGOVERNMEN

Risks are increasing with every increment of warming

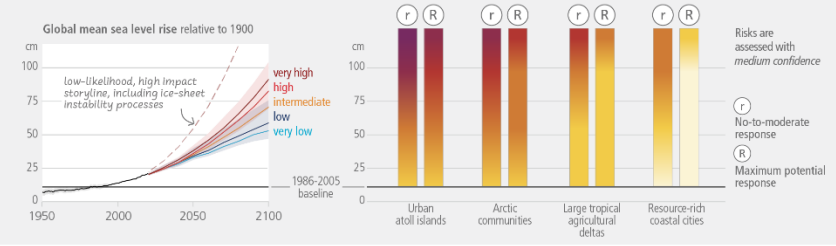
a) **High risks are now assessed to occur at lower global warming levels**



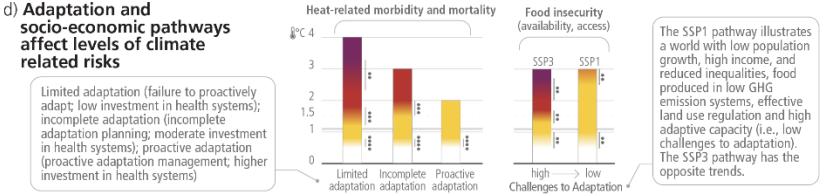
b) **Risks differ by system**



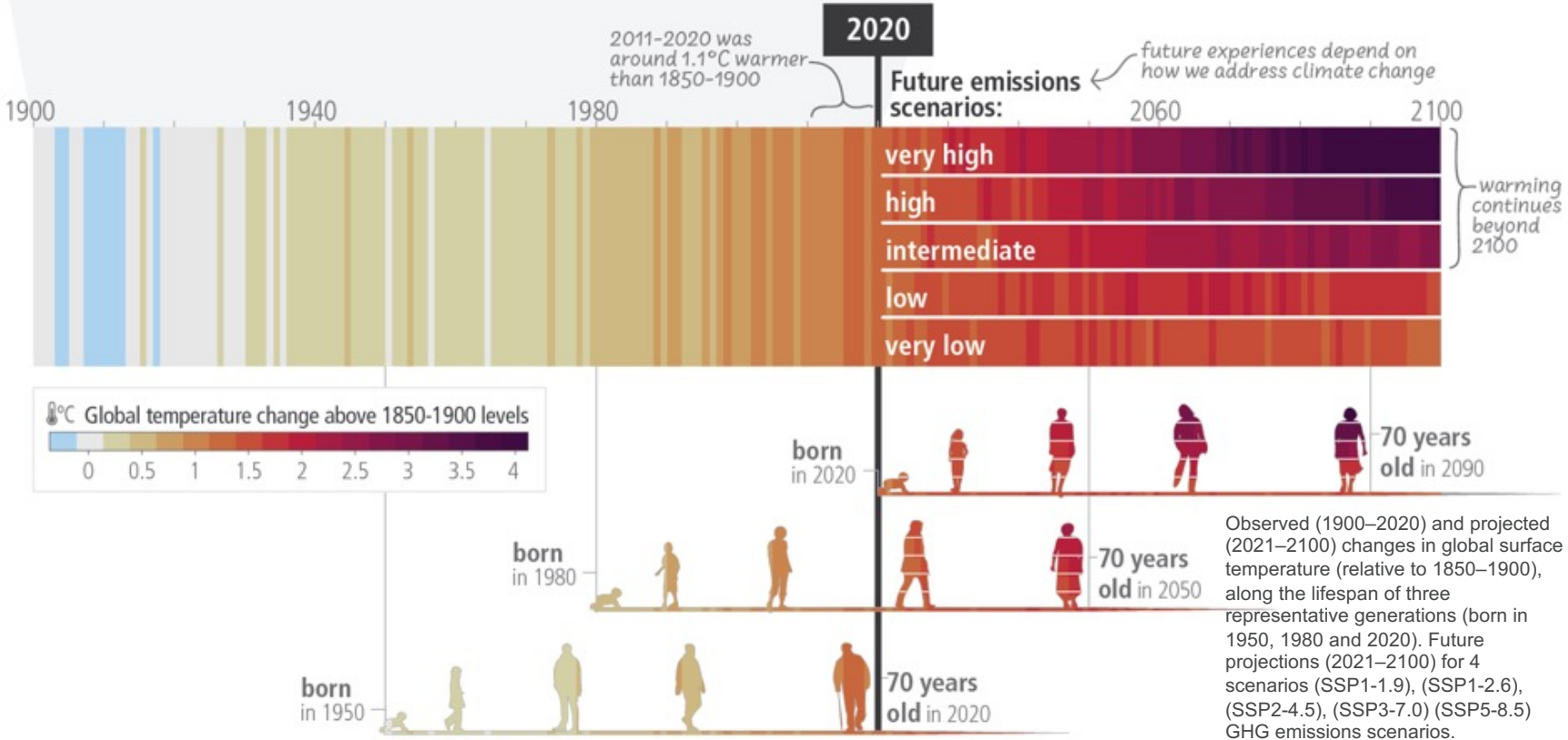
c) **Risks to coastal geographies increase with sea level rise and depend on responses**



d) **Adaptation and socio-economic pathways affect levels of climate related risks**



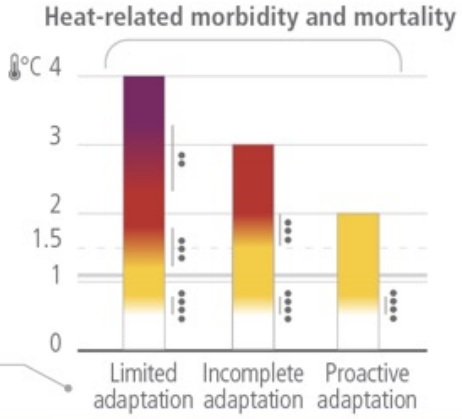
c) The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near-term

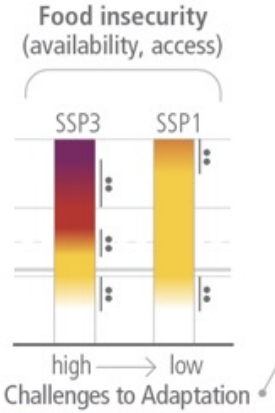


Observed (1900–2020) and projected (2021–2100) changes in global surface temperature (relative to 1850–1900), along the lifespan of three representative generations (born in 1950, 1980 and 2020). Future projections (2021–2100) for 4 scenarios (SSP1-1.9), (SSP1-2.6), (SSP2-4.5), (SSP3-7.0) (SSP5-8.5) GHG emissions scenarios.

d) Adaptation and socio-economic pathways affect levels of climate related risks

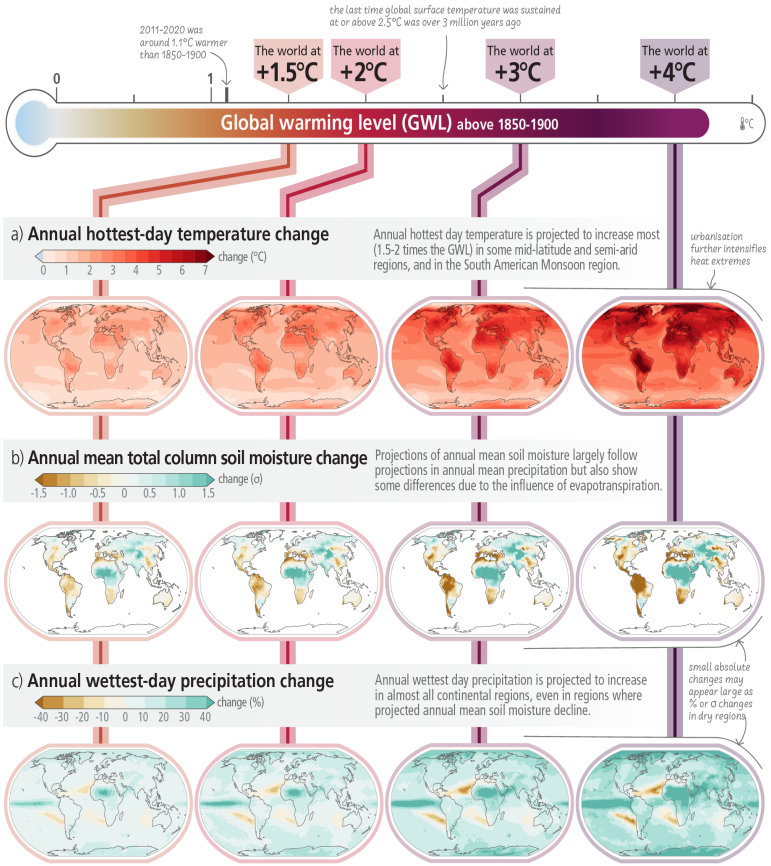
Limited adaptation (failure to proactively adapt; low investment in health systems); incomplete adaptation (incomplete adaptation planning; moderate investment in health systems); proactive adaptation (proactive adaptation management; higher investment in health systems)





The SSP1 pathway illustrates a world with low population growth, high income, and reduced inequalities, food produced in low GHG emission systems, effective land use regulation and high adaptive capacity (i.e., low challenges to adaptation). The SSP3 pathway has the opposite trends.

With every increment of global warming, regional changes in mean climate and extremes become more widespread and pronounced



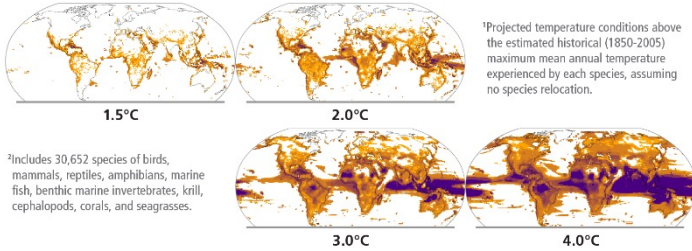
Future climate change is projected to increase the severity of impacts across natural and human systems and will increase regional differences

Examples of impacts without additional adaptation

a) Risk of species losses

Percentage of animal species and seagrasses exposed to potentially dangerous temperature conditions[1, 2]

0% 0.1 1 5 10 20 40 60 80 100

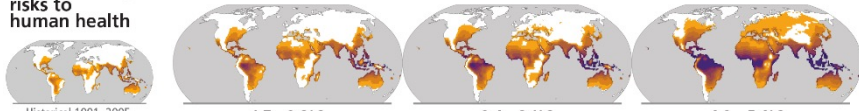


[1]Projected temperature conditions above the estimated historical (1850-2005) maximum mean annual temperature experienced by each species, assuming no species relocation.

[2]Includes 30,652 species of birds, mammals, reptiles, amphibians, marine fish, benthic marine invertebrates, krill, cephalopods, corals, and seagrasses.

b) Heat-humidity risks to human health

0 days 1 10 50 100 150 200 250 300 365 days



Days per year where combined temperature and humidity conditions pose a risk of mortality to individuals[3]

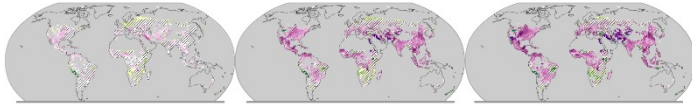
[3]Projected regional impacts utilize a global threshold beyond which daily mean surface air temperature and relative humidity may induce hyperthermia that poses a risk of mortality. The duration and intensity of heatwaves are not presented here. Heat-related health outcomes vary by location and are highly moderated by socio-economic, occupational and other non-climatic determinants of individual health and socio-economic vulnerability. The threshold used in these maps is based on a single study that synthesized data from 783 cases to determine the relationship between heat-humidity conditions and mortality drawn largely from observations in temperate climates.

c) Food production impacts

-35% -30 -25 -20 -15 -10 -3 +3 +10 +15 +20 +25 +30 +35%

c1) Maize yield[4]

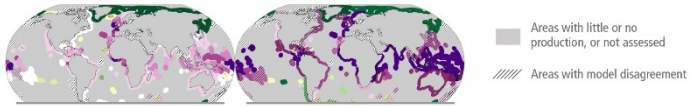
Changes (%) in yield



[4]Projected regional impacts reflect biophysical responses to changing temperature, precipitation, solar radiation, humidity, wind, and CO_2 enhancement of growth and water retention in currently cultivated areas. Models assume that irrigated areas are not water-limited. Models do not represent pests, diseases, future agro-technological changes and some extreme climate responses.

c2) Fisheries yield[5]

Changes (%) in maximum catch potential



[5]Projected regional impacts reflect fisheries and marine ecosystem responses to ocean physical and biogeochemical conditions such as temperature, oxygen level and net primary production. Models do not represent changes in fishing activities and some extreme climatic conditions. Projected changes in thea Arctic regions have low confidence due to uncertainties associated with modelling multiple interactin drivers and ecosystem responses.

With every increment of global warming, regional changes in mean climate and extremes become more widespread and pronounced

2011-2020 was around 1.1°C warmer than 1850-1900

the last time global surface temperature was sustained at or above 2.5°C was over 3 million years ago

0 1 The world at +1.5°C The world at +2°C The world at +3°C The world at +4°C

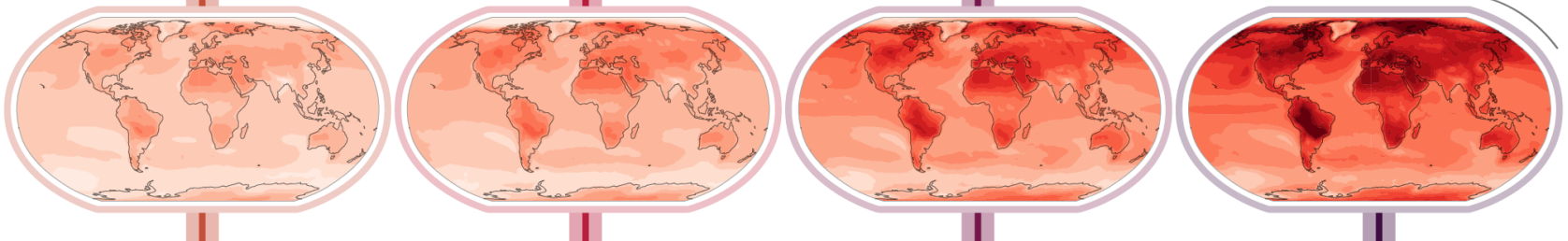
Global warming level (GWL) above 1850-1900 °C

a) Annual hottest-day temperature change

change (°C)
0 1 2 3 4 5 6 7

Annual hottest day temperature is projected to increase most (1.5-2 times the GWL) in some mid-latitude and semi-arid regions, and in the South American Monsoon region.

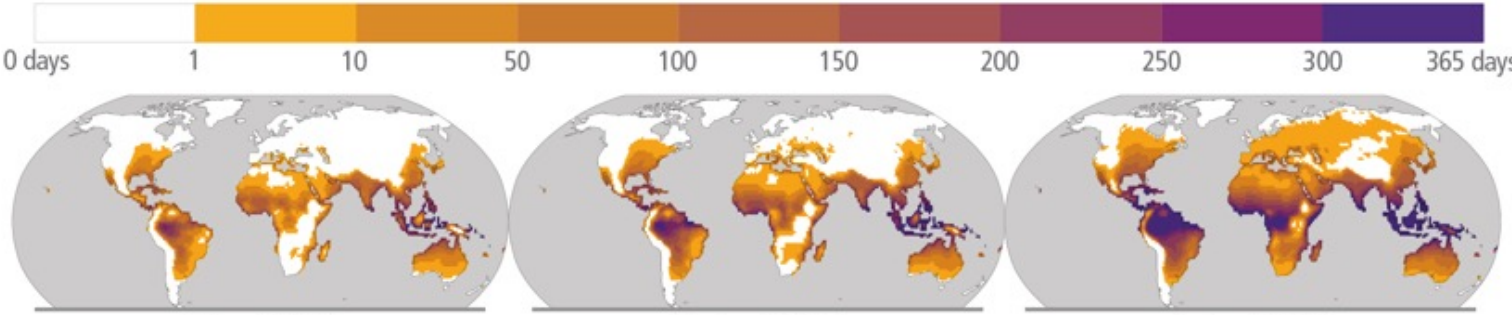
urbanisation further intensifies heat extremes



b) Heat-humidity risks to human health

Historical 1991–2005

Days per year where combined temperature and humidity conditions pose a risk of mortality to individuals[3]



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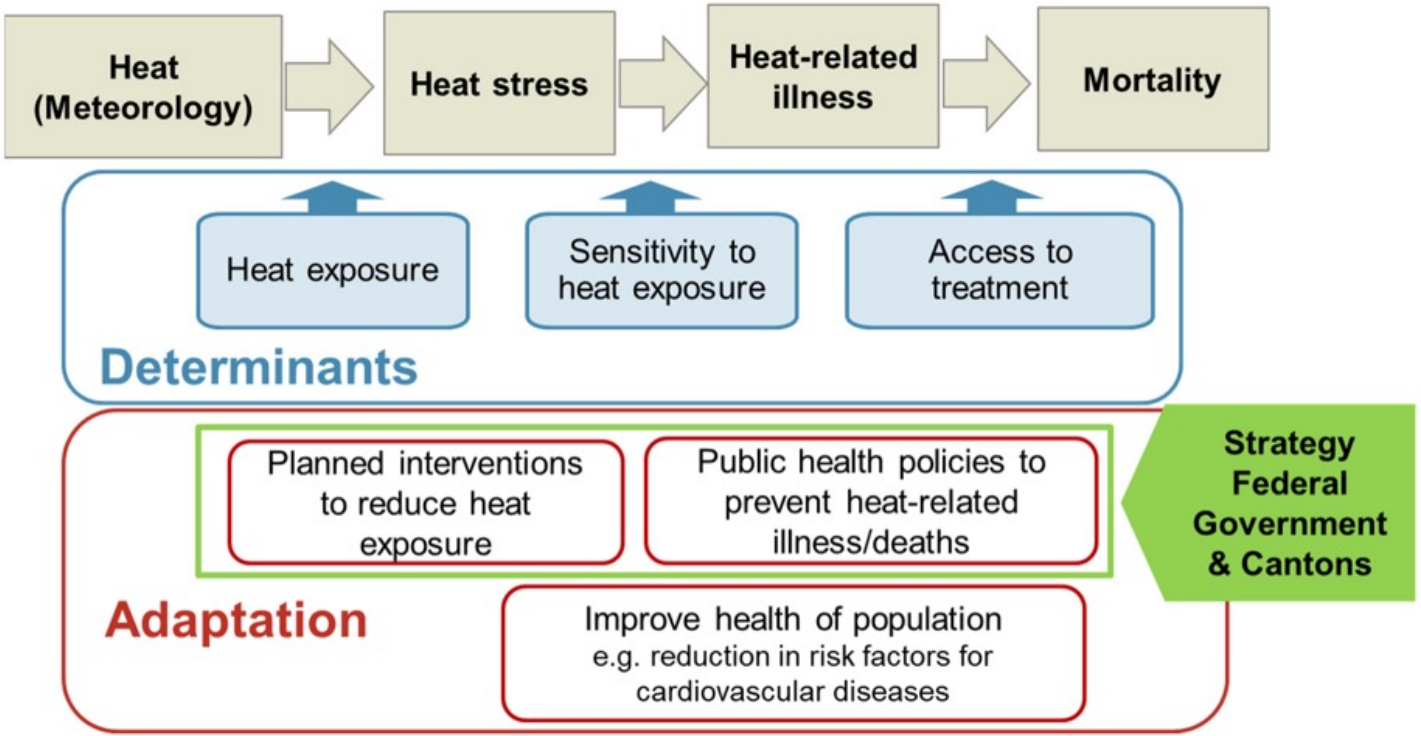
Heat
Range of solutions

- Adaptation options for future extreme heat risks include heat action plans (HAPs) that incorporate:
  - early warning and response systems for urban and non-urban settings;
  - tried, tested and iteratively updated response strategies targeting both the general population and vulnerable groups such as older adults or outside workers;
  - and effective stakeholder communication plans (*high confidence*).
  - These short-term responses can be complemented by longer-term urban planning and design, including nature-based solutions (NbS) that mitigate urban heat island (UHI) effects *(high confidence)* (Sections 7.4.1, 7.4.2, 7.4.3).

Heat
Range of solutions

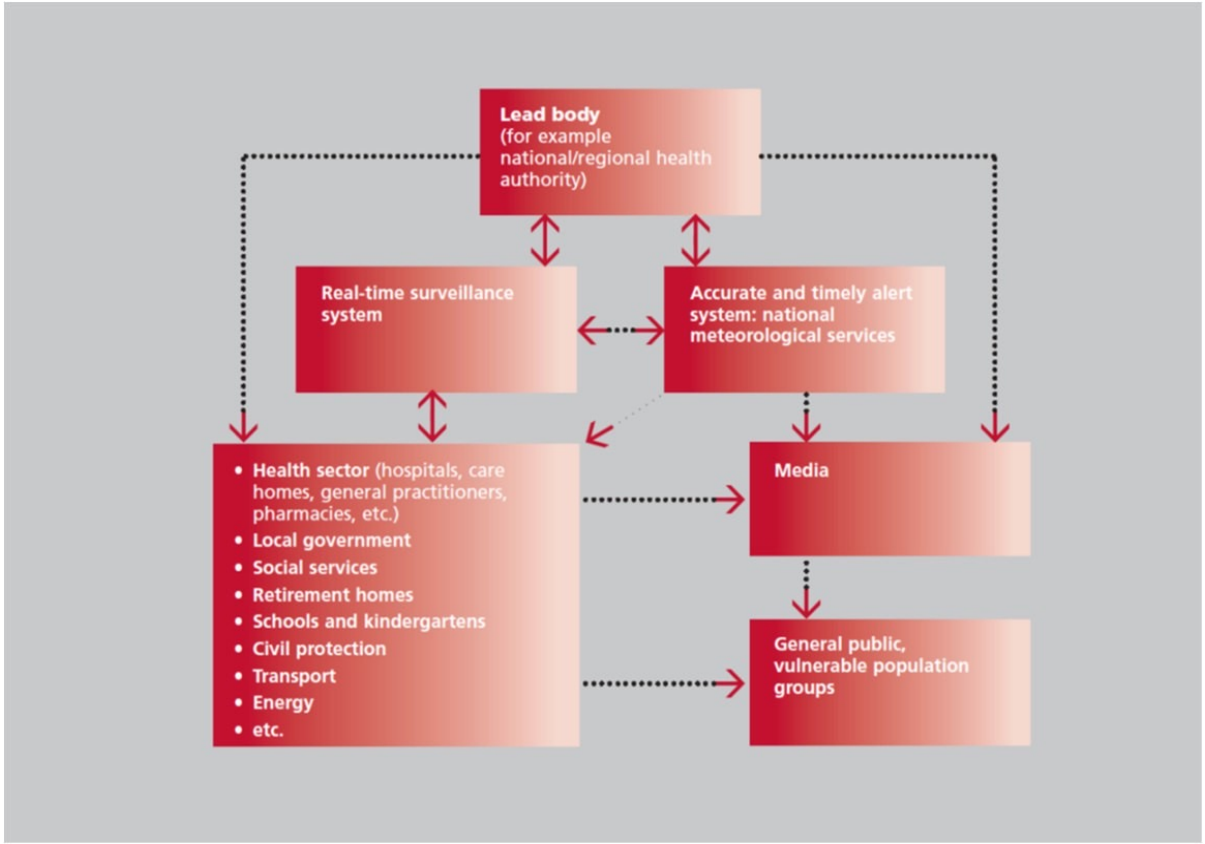
- Effective health adaptation options include strengthening public health programs related to climate-sensitive diseases, increasing health systems resilience, improving ecosystem health, … and Heat Health Action Plans that include early warning and response systems (*high confidence*).
- Ecosystem-based adaptation approaches such as urban greening, restoration of wetlands and upstream forest ecosystems have been effective in reducing flood risks and urban heat (*high confidence*).

How to adapt to a warmer climate?



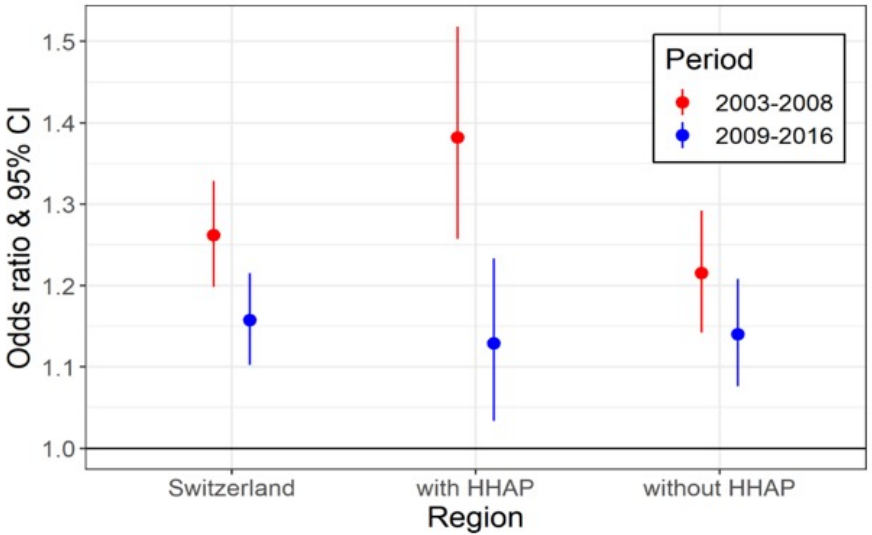
M. Ragettli

Early Warning Information System Flow from Central level to Local level

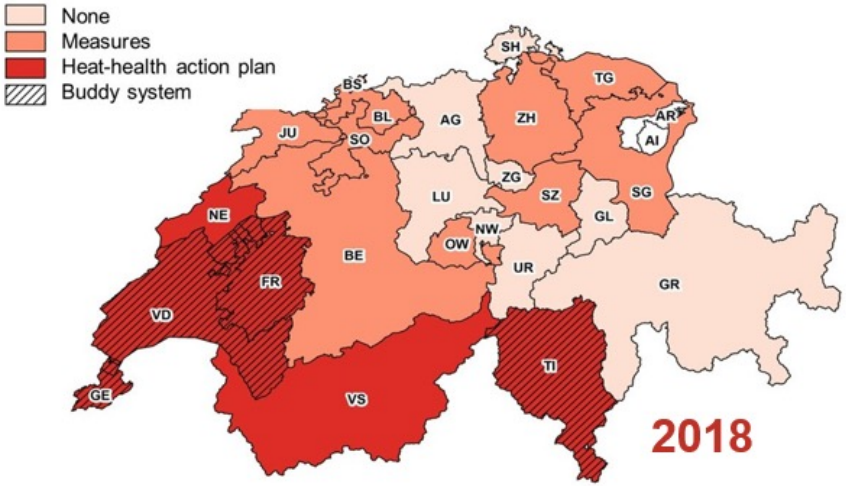


M. Ragettli

Strongest decrease in the region that introduced heat-health action plans (HHAPs) between 2004 and 2008.

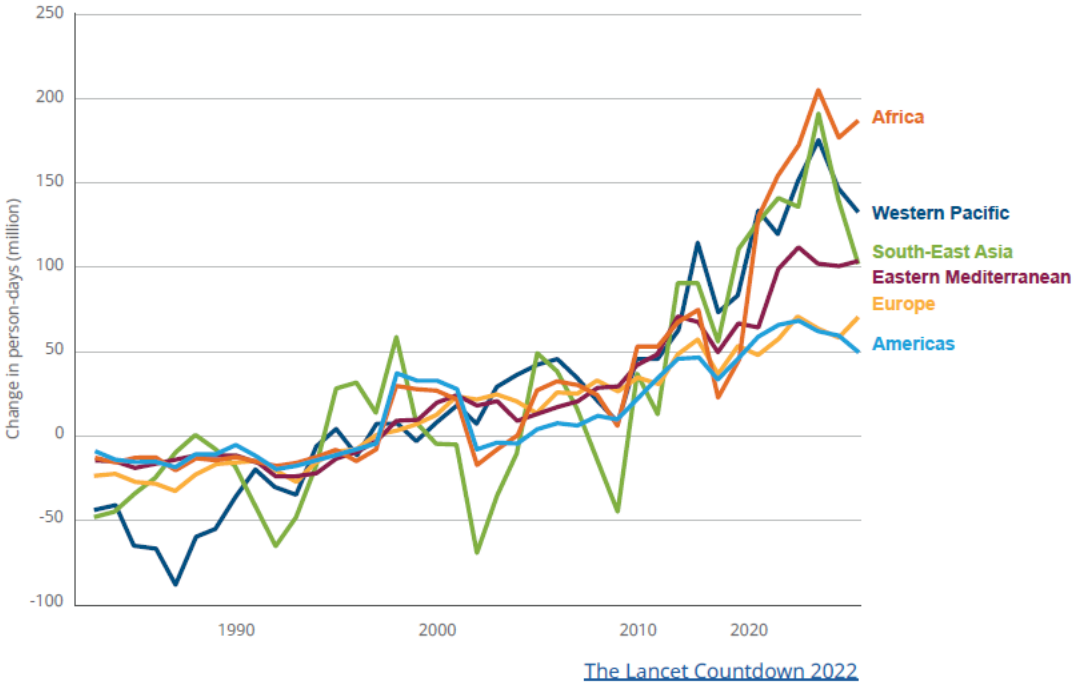


Odds Ratios (ORs) of mortality at daily maximum temperature of 33°C in relation to minimum mortality temperature.



Public health measures in Switzerland 2018 (Ragettli & Röösli 2019)

Climate change is causing more heat waves, and children will be increasingly exposed



The Lancet Countdown 2022

In 2019 alone, **308,000 deaths** were attributable to exposure to high temperature

IHME

In 2020, around 740 million children (1 in 3 globally) lived in countries with 83.54 or more days per year exceeding 35 oC.

Child exposure to extreme high temperatures is **highest in Africa and Asia** currently and will also be highest in these two regions by 2050.

While only 10 per cent of children in Africa are exposed to high heatwave frequency currently, **this will rise dramatically to 100 percent by 2050 under both scenarios explored.**

2022 UNICEF Report: Coldest Year of Their Lives

UNICEF 2022

THANK YOU

[Guéladio CISSÉ]
[Swiss Tropical and Public Health Institute/ University of Basel].
[gueladio.cisse@swisstph.ch, gueladio.cisse@unibas.ch, +41799381198]

For more information:

www.ipcc.ch

IPCC Secretariat: ipcc-sec@wmo.int

IPCC Press office: ipcc-media@wmo.int

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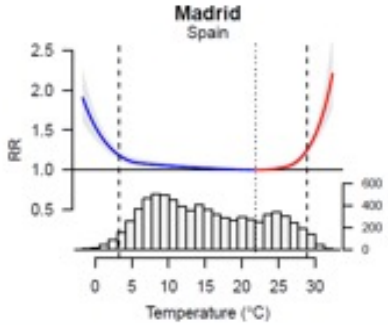
Highlights Epidemiology

Case study Switzerland

1. Excess mortality

- Difference between observed and expected number of deaths

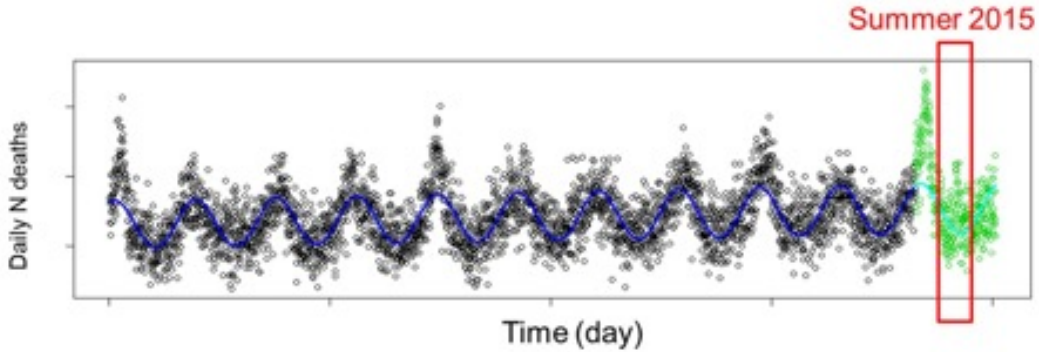


2. Time-series analysis

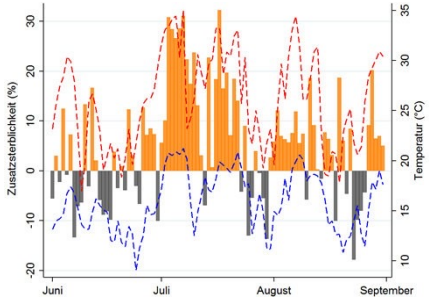
- Exposure-response functions
- Attributable deaths

$$Excess\ Deaths = Observed\ Deaths - expected\ Deaths$$

$$Excess\ mortality\ in\ \% = \frac{\sum Excess\ Deaths}{\sum Expected\ deaths}\ x\ 100$$



Calculation of excess mortality



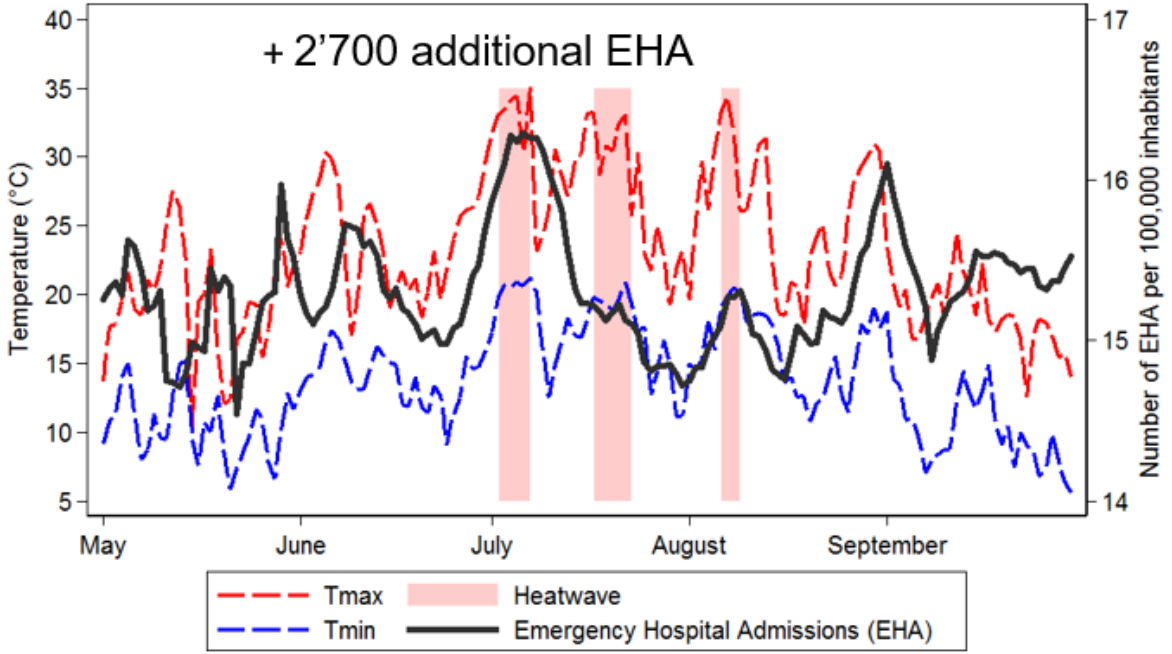
Advantages:

- Relatively cheap and fast method
- No temperature data is needed
- Easy to understand and communicate
- Provides relatively quickly estimates of the impact of a heatwave
- Very useful for assessment of extreme events

Disadvantages:

- No exposure-response association
- With climate change it becomes difficult to estimate a the expected mortality without heat effect.
- Difficulty to assign excess mortality to heat in case of more than two events that affect mortality.

Summer 2015: Heatwaves increased emergency admissions to Swiss hospitals by 4% in July



Most frequent causes & diseases:

- Infectious diseases
- Pneumonia
- Genitourinary system
- Digestive system

Other causes than for heat-related mortality

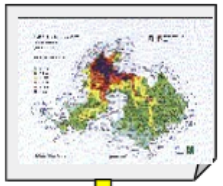
Ragettli et al. 2019

Attributable Fraction / Attributable Cases

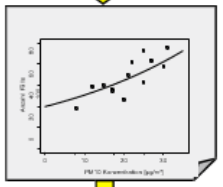
- Attributable fraction (AF) is the proportion or percentage of cases in the study population that can be attributed to the exposure.
- AF is calculated via the relative risk (RR) which represents the increase in the risk of mortality resulting from the temperature increase.

$$AF = \frac{RR - 1}{RR}$$

1. Exposure assessment



2. Exposure response function



3. Attributable cases =Exposure x Exposure-response x Disease frequency

Perez, L., Künzli, N., 2009. From measures of effects to measures of potential impact. International Journal of Public Health. 54, p45.

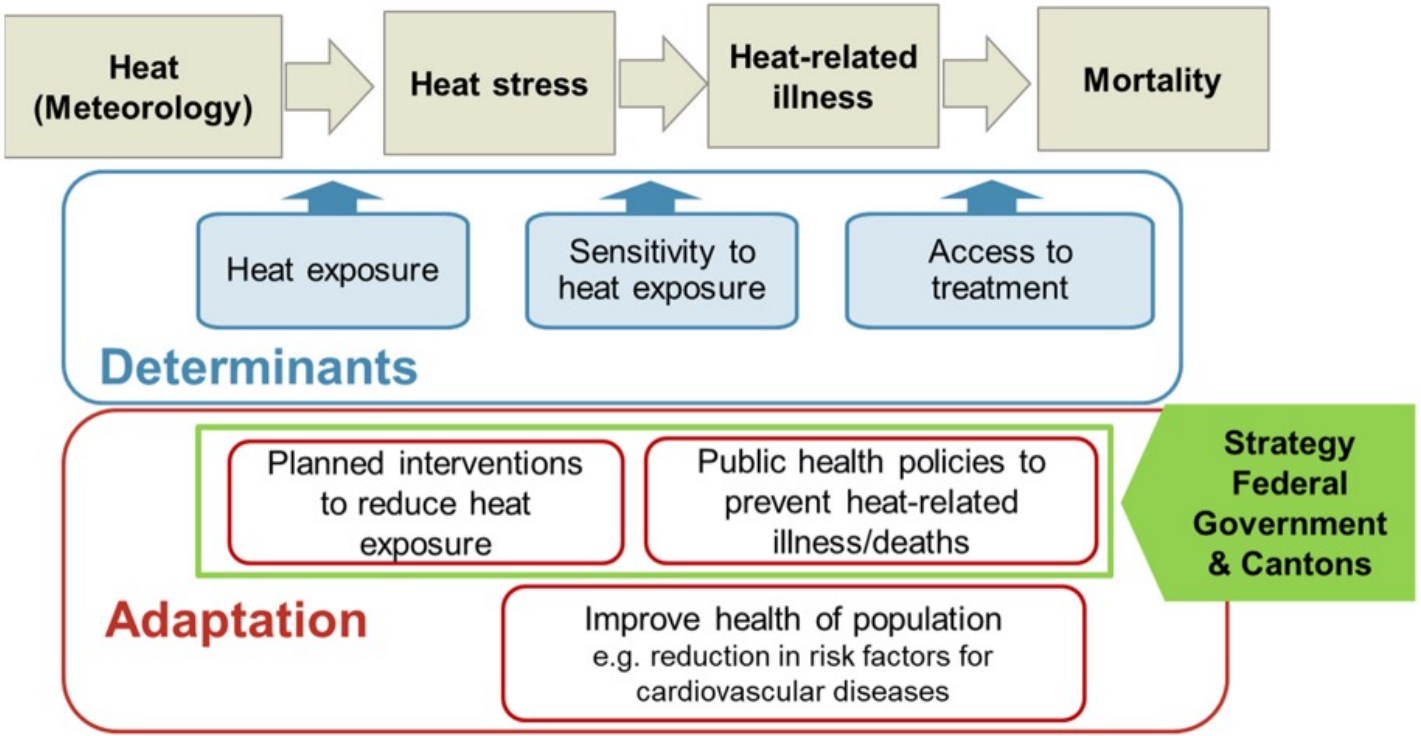
A new heat warning system from MeteoSwiss (since 2021)

What is new?

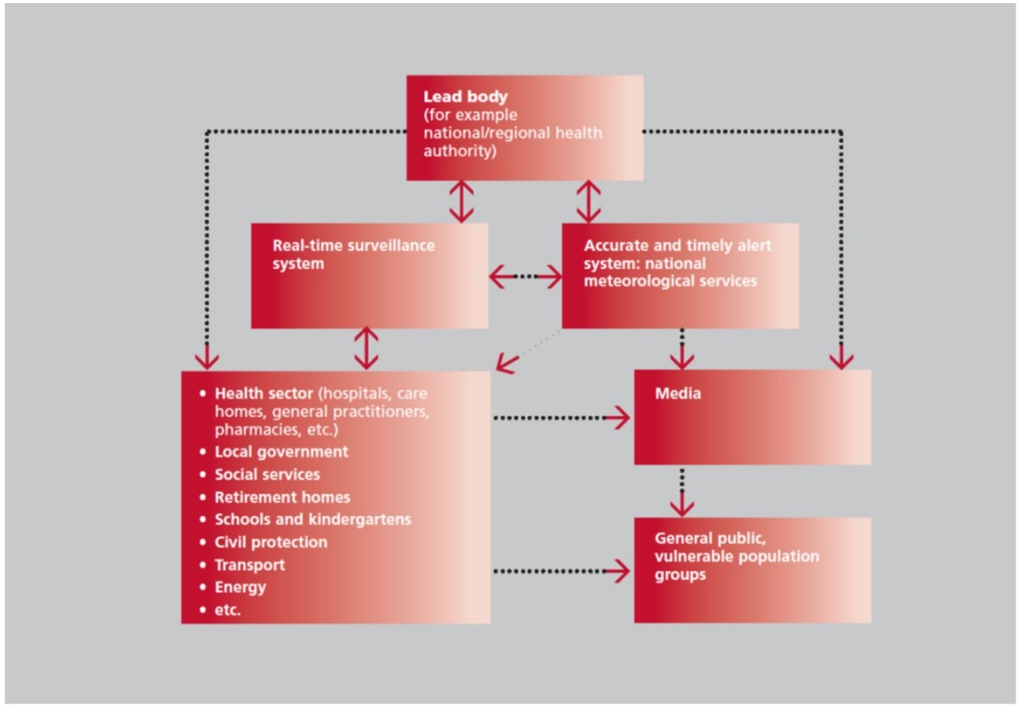
- Meteorological parameter: Daily mean temperature (Tmean) (average of 24h)
- Additional warning level 2: To warn short and intense periods of hot weather
- New thresholds
- Focus on heatwave intensity rather than heatwave duration

Level		Threshold	Duration
Level 1	minimal or no danger	Tmean <25°C	
Level 2	moderate danger	Tmean ≥25°C	at least for 1 or 2 days
Level 3	significant danger	Tmean **≥25°C**	at least 3 days
Level 4	severe danger	Tmean **≥27°C**	at least 3 days

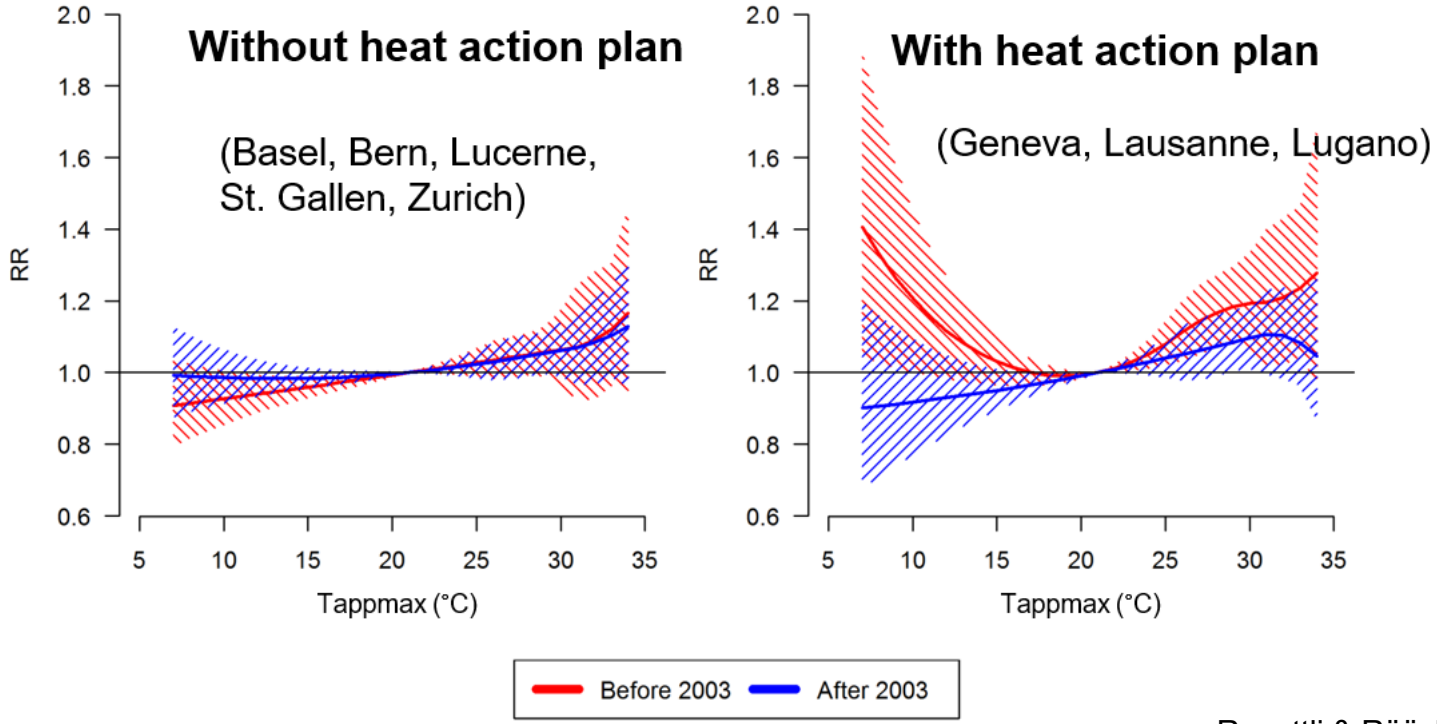
How to adapt to a warmer climate?



Early Warning Information System Flow from Central level to Local level

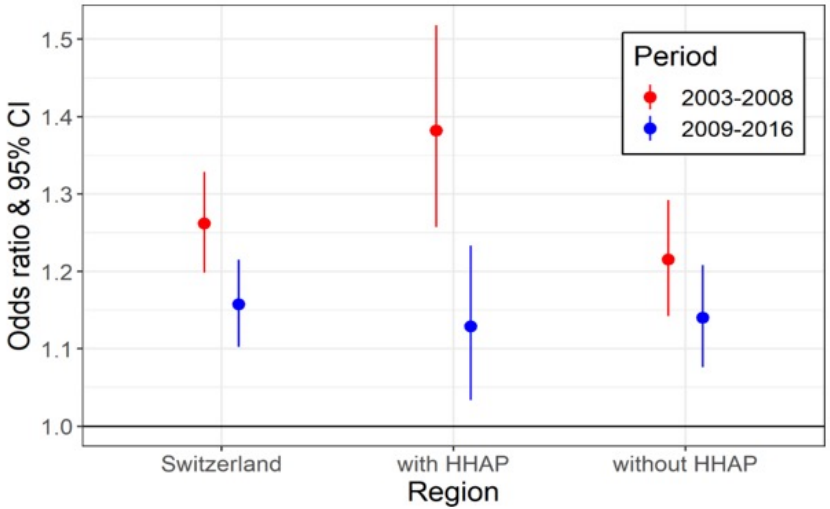


Before and after 2003: Reduction of heat-related mortality risk in cities with heat action plans (data: 1995-2013)

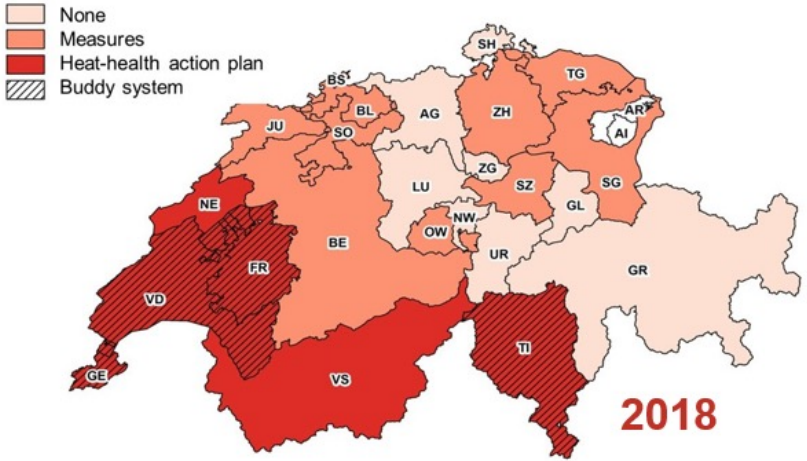


Ragettli & Röösli 2019

Strongest decrease in the region that introduced heat-health action plans (HHAPs) between 2004 and 2008.

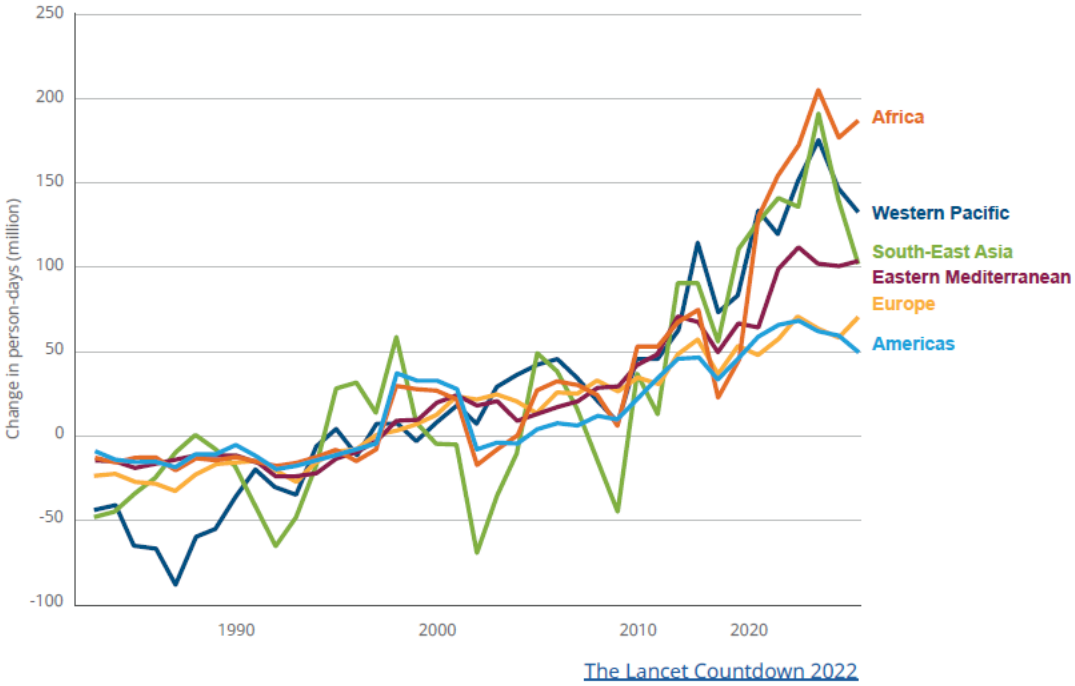


Odds Ratios (ORs) of mortality at daily maximum temperature of 33°C in relation to minimum mortality temperature.



Public health measures in Switzerland 2018 (Ragettli & Röösli 2019)

Climate change is causing more heat waves, and children will be increasingly exposed



The Lancet Countdown 2022

In 2019 alone, **308,000 deaths** were attributable to exposure to high temperature

IHME

In 2020, around 740 million children (1 in 3 globally) lived in countries with 83.54 or more days per year exceeding 35 oC.

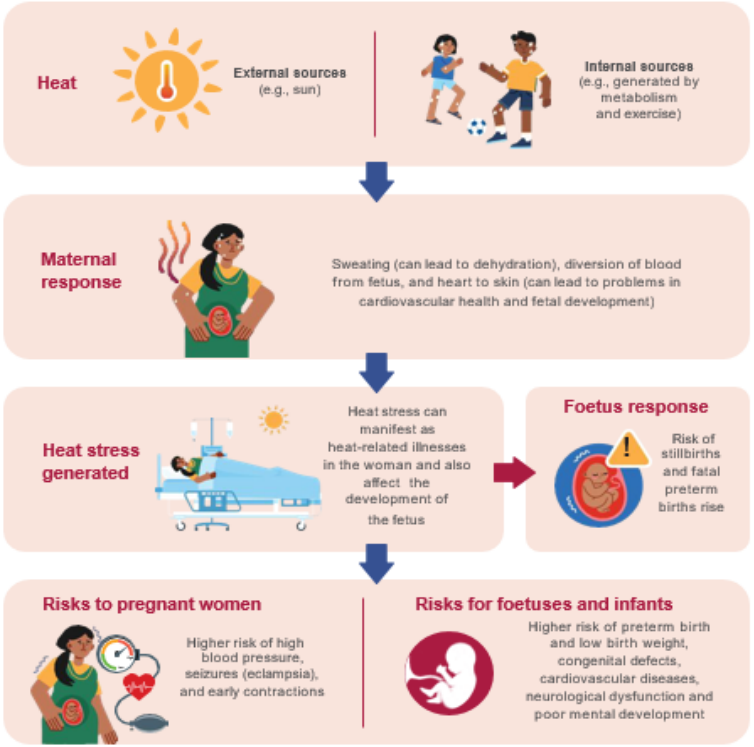
Child exposure to extreme high temperatures is **highest in Africa and Asia** currently and will also be highest in these two regions by 2050.

While only 10 per cent of children in Africa are exposed to high heatwave frequency currently, **this will rise dramatically to 100 percent by 2050 under both scenarios explored.**

2022 UNICEF Report: Coldest Year of Their Lives

UNICEF 2022

Children are uniquely vulnerable to heat stress



(adapted from The Lancet)

Infants and children are uniquely affected by heat stress compared to adults, leaving them more vulnerable to its short- and long-term effects because of:

- **Higher** heat production
- **Greater** body surface area
- **Lower** levels of sweat production
- **Poorer** practice of fluid replenishment
- **Underdeveloped** immune systems
- **Slower** adjustment to changes in weather
- **Protein modification** via foetal heat strain