Climate change and extreme heat: systematic review

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Improving health worldwide

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Background

- The impacts of very high temperatures on individuals and society due to climate change is a major concern, as higher rates of warming become more likely.
- There is a need to quantify current and future impacts to support climate change decision making

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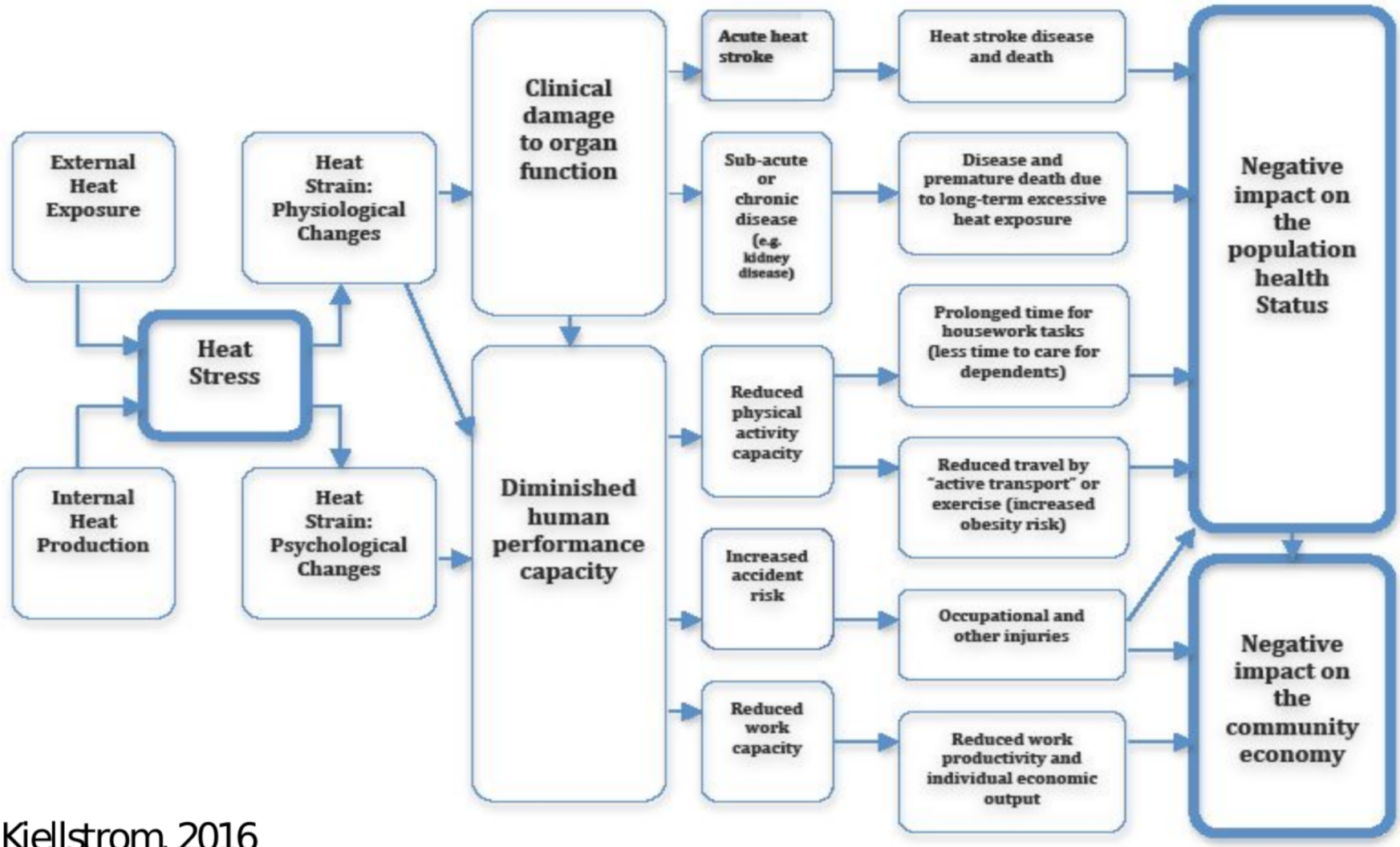
Health and social effects of heat stress



Kjellstrom, 2016

Heat impacts

Effect	Evidence; where described	References (examples; further references can be added)
Death from heat stroke at work	South African mine workers; USA agricultural workers; (and media reports from China, India and other countries)	Wyndham, 1965, 1969; MMWR, 2008; media reports (add Sawka and Manos)
Specific serious heat stroke symptoms; heat exhaustion	Many hot workplaces around the world	Parsons, 2003; Zhao et al., 2009 (add Nag studies, Bernard and GHA)
Clinical damage of organs	Heart overload and kidney damage; US military, El Salvador sugar workers	Schrier et al., 1967; Garcia-Trabanino, et al., 2005; Kjellstrom et al., 2010
Injuries due to accidents	Increased accidents in heat; Europe	Ramsey et al., 1983 (add Folgeman et al.,)
Mood/behaviour/mental health	Heat exhaustion; South African mine workers; Australian farmers	Wyndham, 1969; Kjellstrom, 2009b; Berry et al., 2010 (add Hancock)
Work capacity and economic loss	Low work capacity; lowered productivity in low and middle income countries; heat impact on GDP	Nag and Nag, 1992; Kjellstrom et al., 2009a Kjellstrom et al., 2009b; Dell et al., 2009 (add Sahu et al., and Tawatsupa et al)

Rintamäki et al. 2014. Inst Occup Health, Finland. Literature Review.

Deaths in construction workers

Deaths in Qatar (foreign workers)			
	2011	2012	2013
Indian	239	237	241
Nepali	162	169	191
Total	401	406	432
Source: ITUC			

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Definitions

- Survivability
- Habitability
- "Liveability"
  - Liveable cities
- Workability
- Economic viability

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Habitability

- Habitability can be defined as the intrinsic environmental capability of an area to sustained occupation (habitation) by a species.

- Define limits in context of modifying factors
  - without air conditioning,
  - where habitability is defined as the ability to sustain a productive economy, including the livelihoods of the poor

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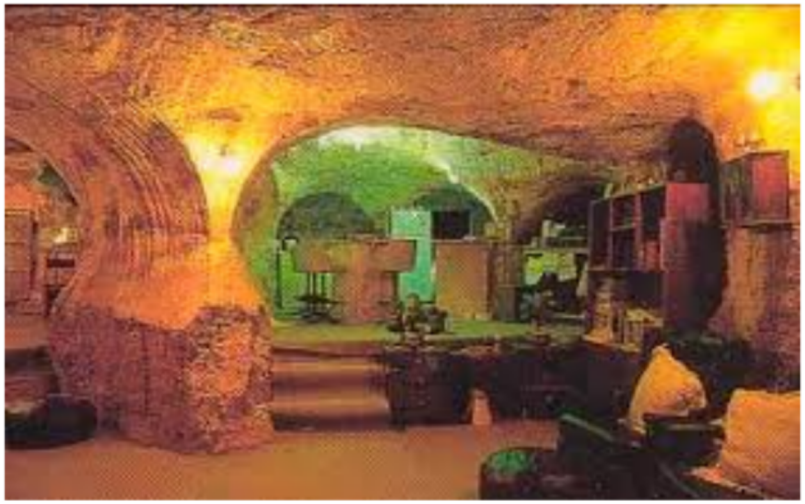
Coober Pedy

- Coober Pedy is a small outback town in northern South Australia, where opal mining is the dominant industry.
- Desert climate (BWh).
- Most residents live in caves excavated into the hillsides to avoid the harsh summer temperatures and work underground in mine shafts.



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Objectives

To assess:

- what physiologically-based heat indices have been used;
- how have these indices been quantified using weather and climate data (variables, temporally, spatially);
- how have these indices been related to the limits of human tolerance in relation to (a) habitability and (b) survivability, and what is the evidence supporting these relations; and,
- which climate and socioeconomic projections were used and how, if at all, was adaptation modelled?

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Search terms

Concepts	Keywords
Climate change	climate change or global warming OR greenhouse effect OR general circulation model OR climate model* OR climate project*
Extreme heat stress	"heat stress" OR "heat injury" OR "heat stress" OR "heat exhaustion" OR "heat stroke" OR "extreme heat" OR "thermal stress" OR "extreme temperature" OR "thermal comfort"
Physiologically-based heat index	heat index* OR heat indice* OR wet bulb OR wetbulb OR wbgt OR universal thermal climate index OR utci OR physiological equivalent temperature OR heat stress metric* OR apparent temperature OR physiological strain index OR heat stress index OR heat stress indi* OR corrected effective temperature OR thermal work limit OR predicted heat strain OR effective temperature OR required sweat rate OR temperature humidity index OR environmental stress index OR humidex OR modified discomfort index OR thermal humidity comfort index OR thermal humidity physiology index

Results

Main categories of papers.

- Extreme exposures relating to limits of habitability/ survivability
  - Global, regional
- Workability
  - Global, regional, national

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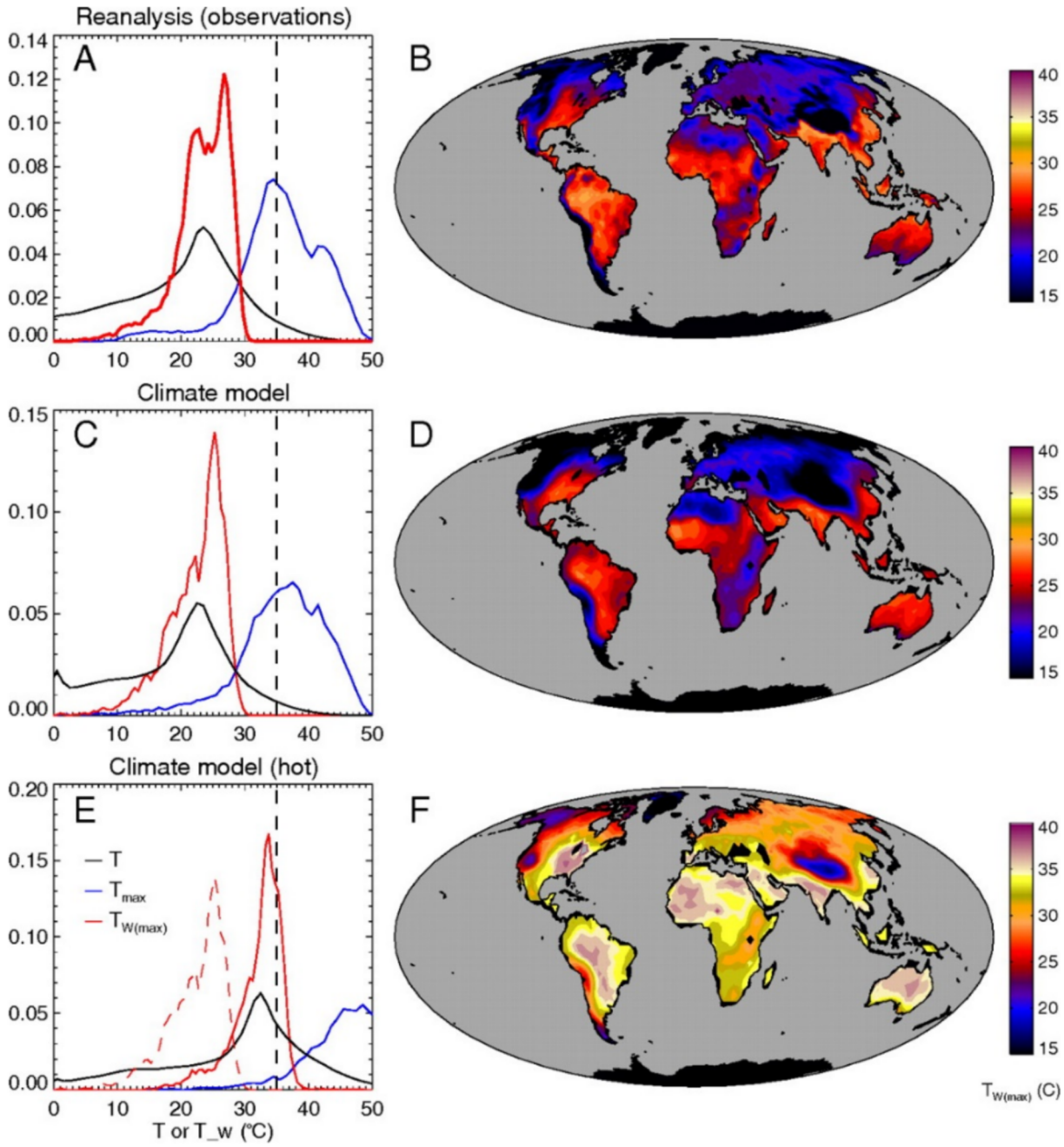
Examples of definitions in the literature

Concept Limits of….	Definition	Temp and duration thresholds	Reference.
Survivability	Where nobody lives now. ?	WBGT 34°C and UTCI 46°C	Kjellstrom
	"intolerable"	WBGT>35	(Sherwood and Huber 2010)
	a limit of survivability for a fit human under well-ventilated outdoor conditions [lower for most people]	WBGT 35◦C.	(Pal and Eltahir 2015)
Habitability	limits of habitability without air conditioning, where habitability is defined as the ability to sustain a productive economy, including the livelihoods of the poor.	WBGT 30°C and UTCI 38°	Kjellstrom

Histograms of 2-meter T (Black), Tmax (Blue), and TW (Red) on land from 60S–60N during the last decade (1999–2008).

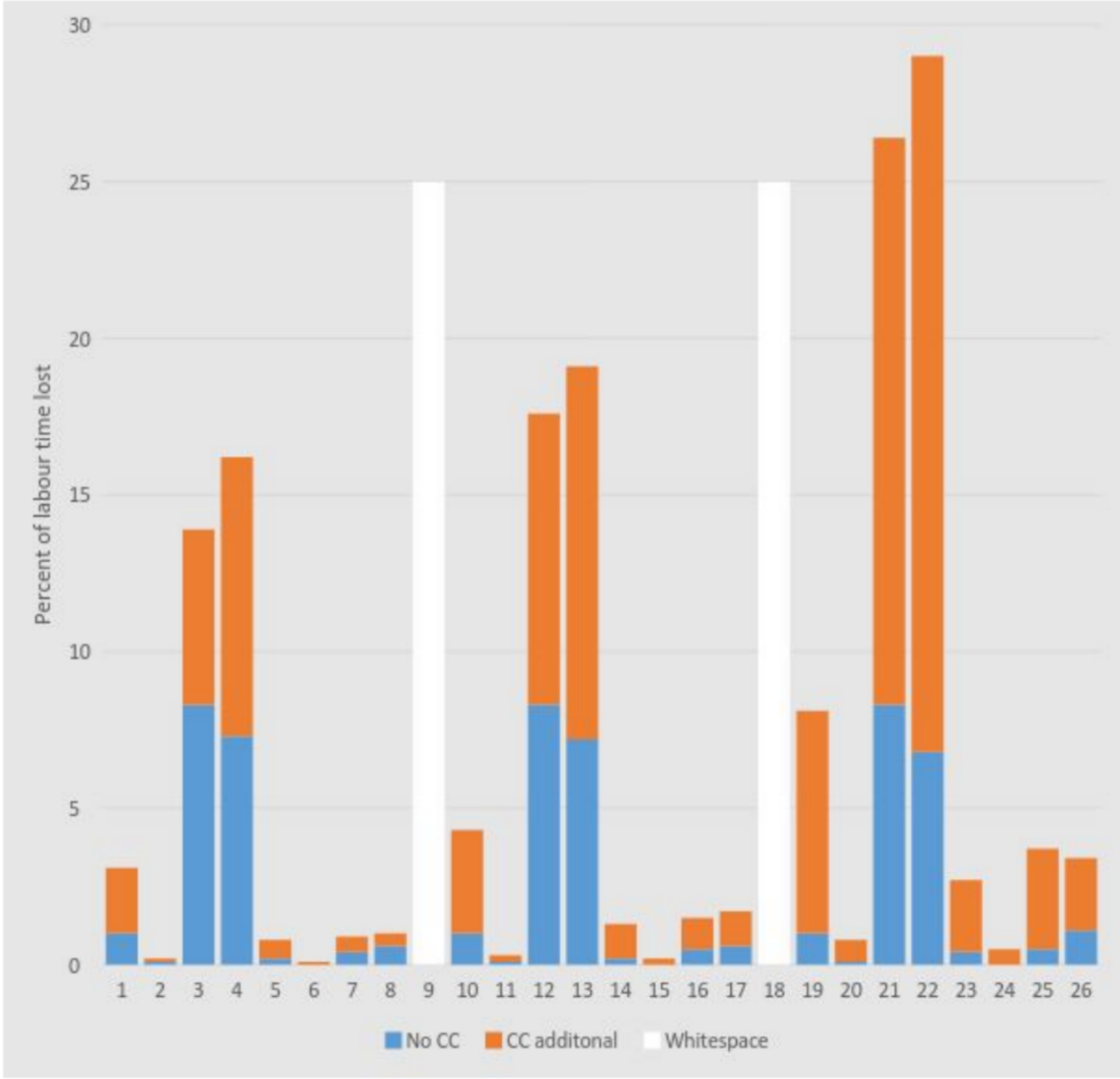
Maps = 10 °C global-mean warming relative to the last decade



Sherwood, and Huber PNAS 2010;107:9552-9555

- % of labour time lost in the working age population (15 to 64 years)
- without climate change [blue] and as additional with climate change [orange]
- No adaptation,
- for the thee climate scenarios in the 2080s,

Lloyd et al. 2016



Conclusions

- Systematic reviews are a valuable tool for assessing the strength of evidence for observational studies
  - But limited when we are looking at extreme conditions/exposures
- Systematic reviews are essential to compare across model studies
  - But are limited when similar model/ assumptions are used.
  - Formal criteria for the quality of models need to be developed.
- Extreme heat studies use similar methods
  - Sensitive to the assumptions regarding universal thresholds
  - Limitations in extrapolating from individual acute exposures to population level indicators.
  - Limitations for climate data in space and time.

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