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Assessing the Risk of Heat-stressed Mortality due to Global Warming Using Multi-GCM Approach

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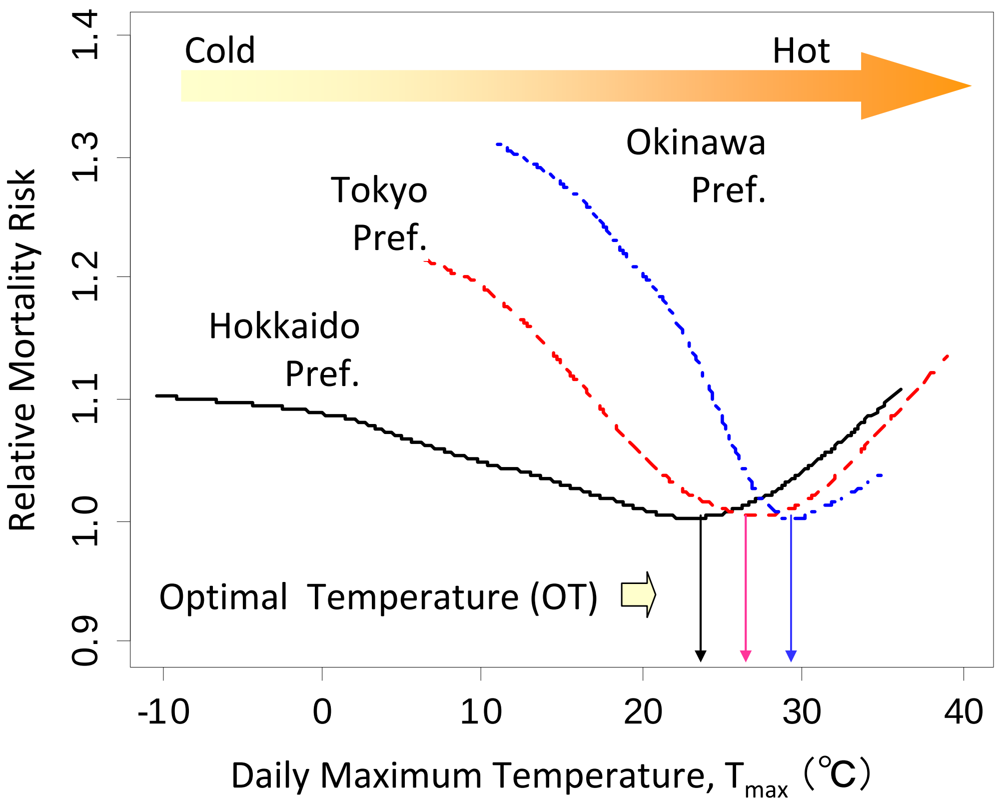
Introduction

- **Warming impact on heat-stressed mortality**
  - Climate change and variability will bring the higher death probability of heat-stressed mortality
  - V-shape relation with daily T_{max} and mortality rate
- **Heat-stressed impact assessment using Multi-GCMs**
  - Representing the level of confidence in impact caused by GCM predictions
  - Finding the responses of impact to climate change and variability
  - Finding the risk probabilities with different future
  - Finding the threshold temperature for assessing adaptation capacity

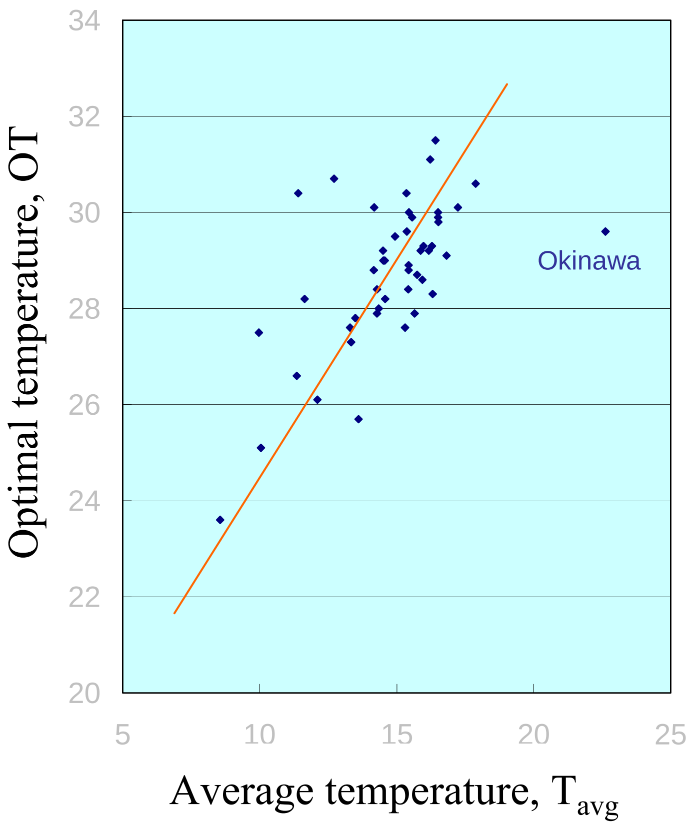
Daily T_{max} vs. Heat Mortality (1)

- "V"-shaped relation between daily T_{max} and Mortality (Honda et al. 1998, 2006)
- Using daily mortality data of 47 prefectures in Japan during 1972-1995

Relative mortality vs. OT

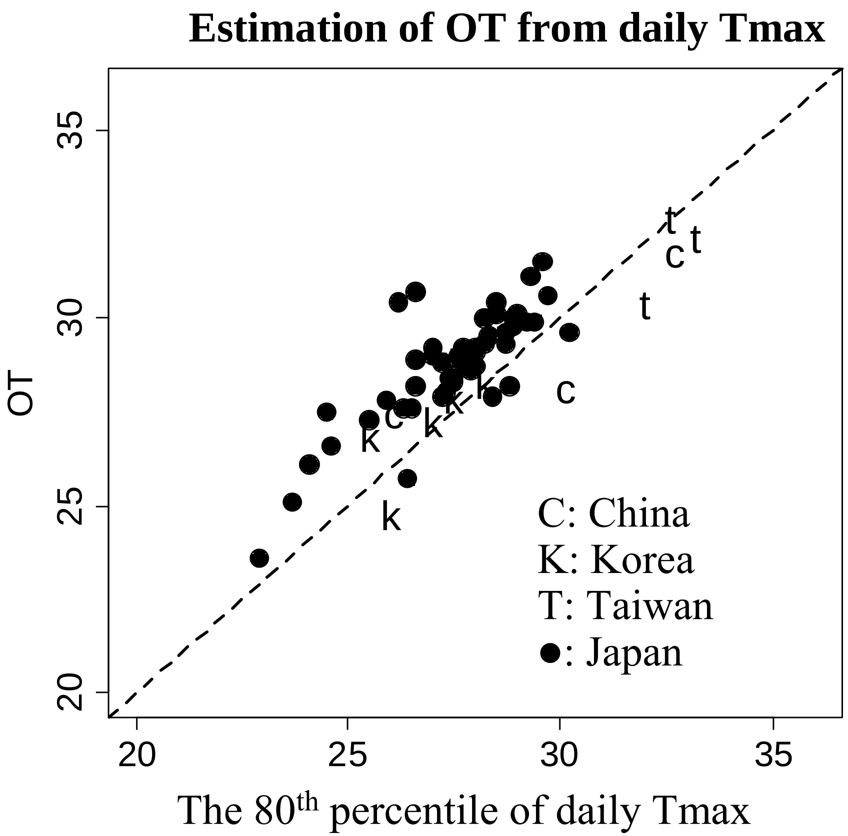


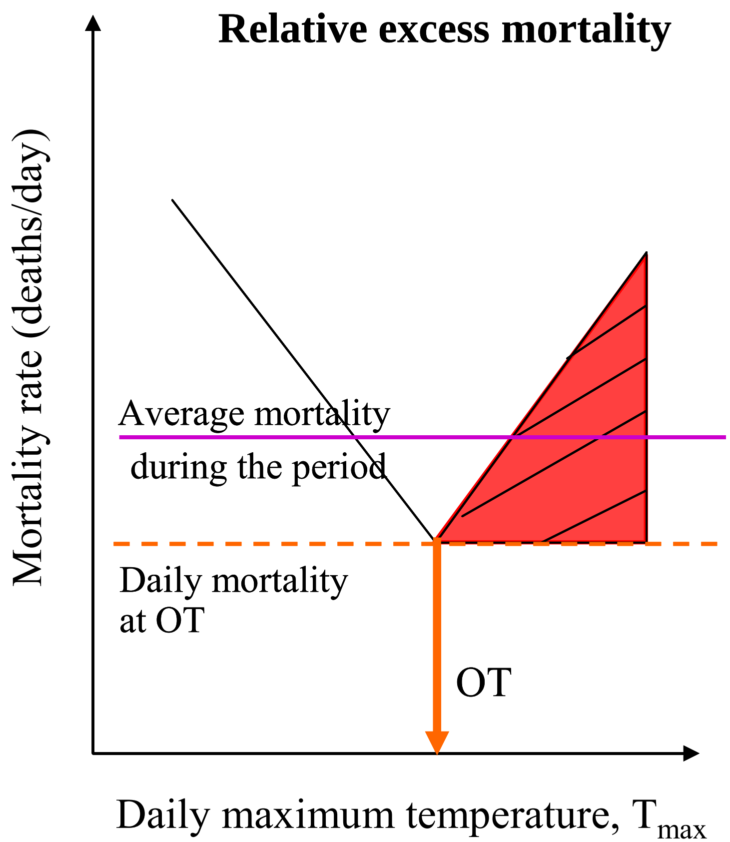
T_{avg} vs. OT (47 pref. in Japan)



Daily T_{max} vs. Heat Mortality (2)

- OT in East Asian countries (the 85th percentile of daily T_{max} as OT)
- Define relative excess mortality using 30-yr (1971-2000) daily T_{max} for base period





Daily T_{max} vs. Heat Mortality (3)

- Defining excess mortality, (Takahashi et al., 2007):

$$DenADNE_{grid,y} = DenPN_{grid} \times RelADNEADNO_{grid,y} \times RelADNOADN_{base} \times ADR_{cnt}$$

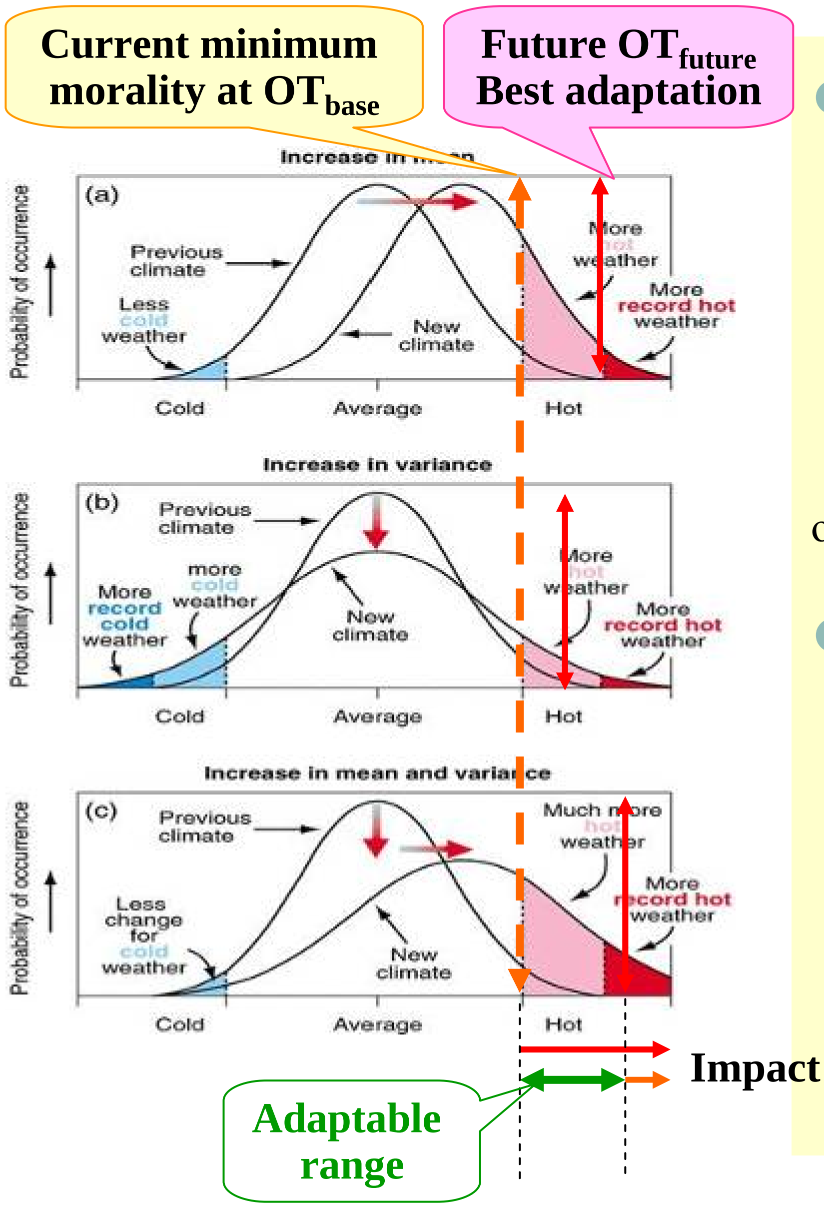
$$= (a1 \times N1 + a2 \times N2)/365$$

$$\left[\frac{deathpop}{km^2 \cdot yr}\right] = \left[\frac{persons}{km^2}\right] \text{ x } \frac{\overset{ADNE}{\left[\frac{deathpop}{yr}\right]}}{\underset{DDNO}{\left[\frac{deathpop}{day}\right]} \times \left[\frac{365day}{yr}\right]} \text{ x } \frac{\overset{OPT_{base}}{\left[\frac{deathpop}{pop \cdot day}\right]}}{\underset{ANL_{base}}{\left[\frac{deathpop}{pop \cdot day}\right]}} \text{ x } \left[\frac{deathpop}{pop \cdot day}\right] \text{ x } \left[\frac{365day}{yr}\right]$$

DenPN: Population density
RelADNEADNO: Relative excess mortality
DDNO: Daily mortality at TO
ADNE: Annual sum of daily excess mortality, DDNE
RelADNOADN: Ratio of mortality at TO to the annual average mortality of Japan
OPT_{base}: Daily mortality at TO in Japan
ANL_{base}: Annual average daily mortality in Japan

ADR: Annual average mortality of the country
N1: Annual number of days on which T_{max} > TO and T_{max} < TO+5 (℃)
N2: Annual number of days on which T_{max} > TO+5 (℃)

Extreme CC Effect on Mortality



- **Changes in distribution ?**

$$\mu^{o.f} = \mu^{m.f} + \left(\mu^{o.p} - \mu^{m.p}\right)$$

$$\sigma^{o.f} = \sigma^{m.f} \frac{\sigma^{o.p}}{\sigma^{m.p}}$$

o: observation,　m：model, f：future　p：present

- **Bias correction:**
  - Statistical method (Piani et al.2009)
  - Quintile mapping (Wood et al.2004)
  - Morphing (Belcher et al.,2005)
  - Rank matching, histogram equalization, daily scaling, delta method, relative ratio etc.

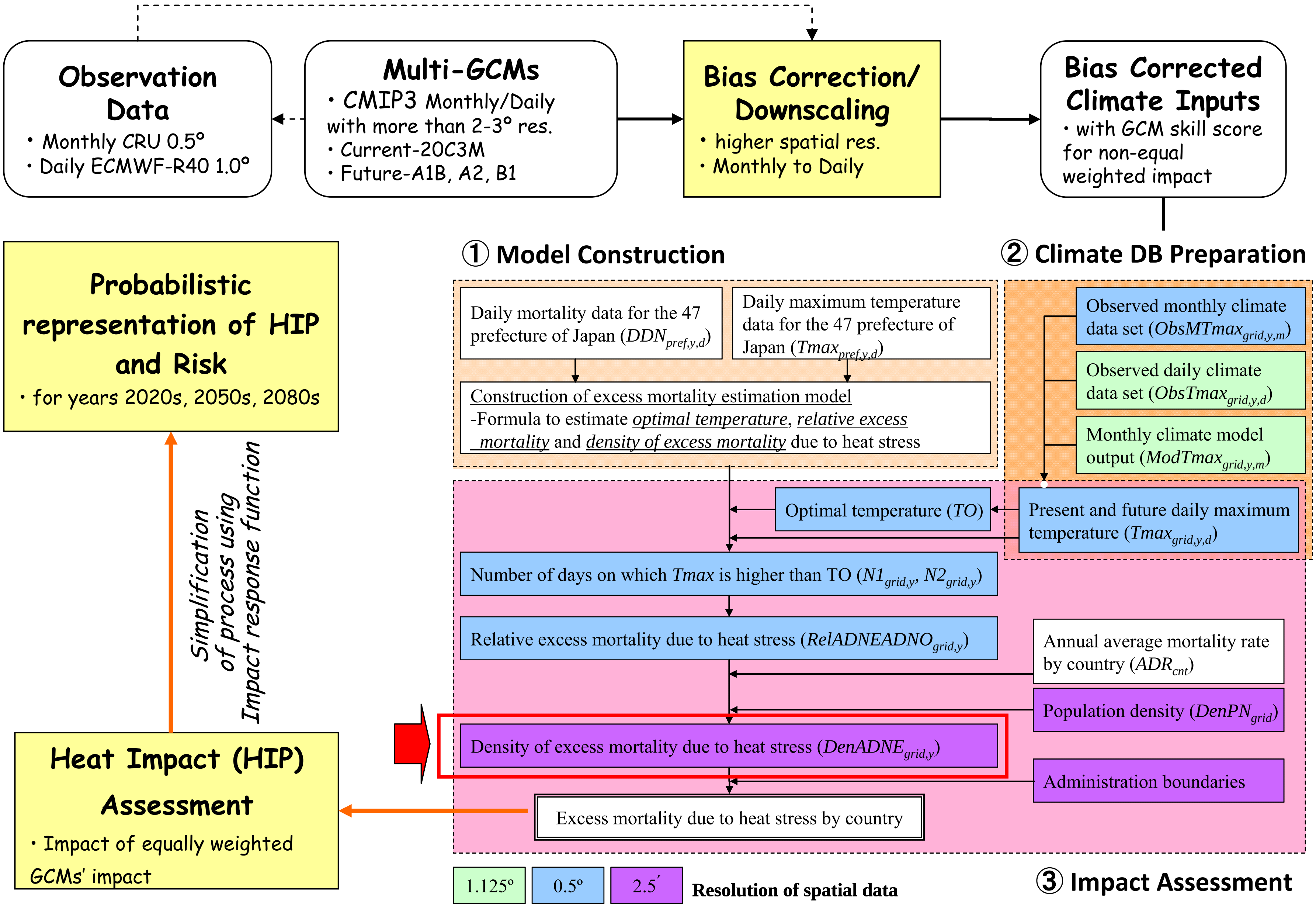
AR4 Climate Projections

- **Downscaling of monthly T_{max} with Morphing method**
  - ‘shift’ (μ change) and ‘stretch’ (σ change) of monthly CMIP3
  - c: 1980s(1971-2000): Monthly CRU (0.5) + Daily ECMWF_ERA40 (1.0)
  - f: **2080s(2071-2100)**, [2020s (2011-2040), 2050s(2041-2070)]

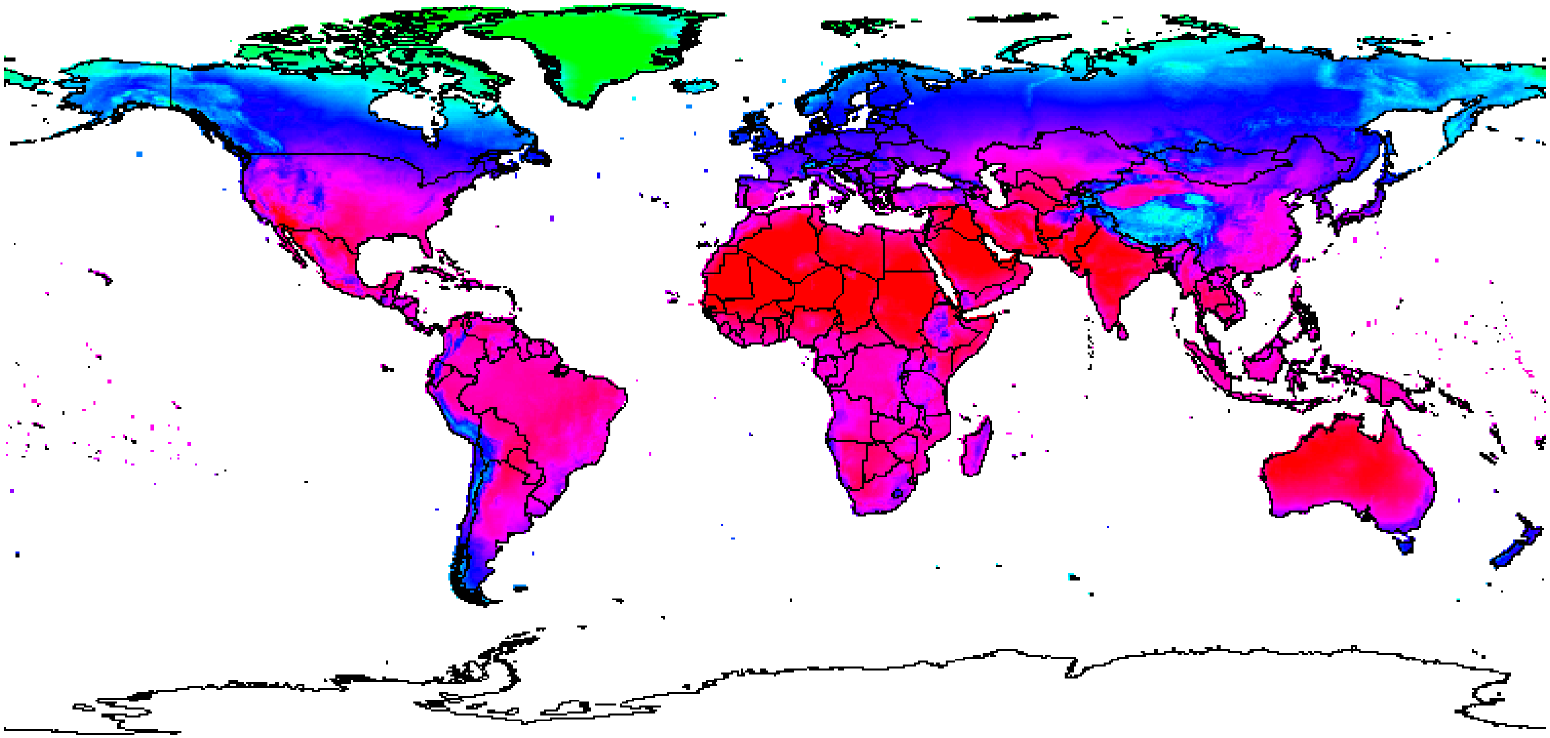
$$T_f(d) = \overline{T}_o(m) + [\overline{T}_f(m) - \overline{T}_c(m)] + \frac{\sigma_f}{\sigma_c} \cdot [T_o(d) - \overline{T}_o(m)]$$

GCM		Scenario		
Originating group(s)	Model name	A1B (20 GCMs)	A2 (17 GCMs)	B1 (20 GCMs)
Beijing Climate Center	BCC-CM1	-	O	O
Bjerknes Centre for Climate Research	BCCR-BCM2.0	-	O	O
Canadian Centre for Climate Modelling & Analysis	CGCM3.1 (T47)	O	O	O
Canadian Centre for Climate Modelling & Analysis	*CGCM3.1 (T63)*	O	-	O
Me´ te´ o-France/Centre National de Recherches Me´ te´ orologiques	CNRM-CM3	O	O	O
CSIRO Atmospheric Research	CSIRO-Mk3.0	O	O	O
US Dept. of Commerce/NOAA/Geophysical Fluid Dynamics Laboratory	GFDL-CM2.0	O	O	O
US Dept. of Commerce/NOAA/Geophysical Fluid Dynamics Laboratory	GFDL-CM2.1	O	O	O
NASA/Goddard Institute fr Space Studies	*GISS-AOM*	O	-	O
NASA/Goddard Institute fr Space Studies	*GISS-EH*	O	-	-
NASA/Goddard Institute fr Space Studies	GISS-ER	O	O	O
LASG/Institute of Atmospheric Physics	*FGOALS-g1.0*	O	-	O
Institute for Numerical Mathematics	INM-CM3.0	O	O	O
Institut Pierre Simon Laplace	IPSL-CM4	O	O	O
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	*MIROC3.2 (hires)*	O	-	O
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	MIROC3.2 (medres)	O	O	O
Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, and Model and Data	ECHO-G	O	O	O
Max Planck Institute for Meteorology	ECHAM5/MPI-OM	O	O	O
Meteorological Research Institute	MRI-CGCM2.3.2	O	O	O
National Center for Atmospheric Research	PCM	O	O	O
Hadley Centre for Climate Prediction and Research/Met Office	UKMO-HadCM3	O	O	O
Hadley Centre for Climate Prediction and Research/Met Office	UKMO-HadGEM1	O	O	-

Research Framework



Optimal Temperature



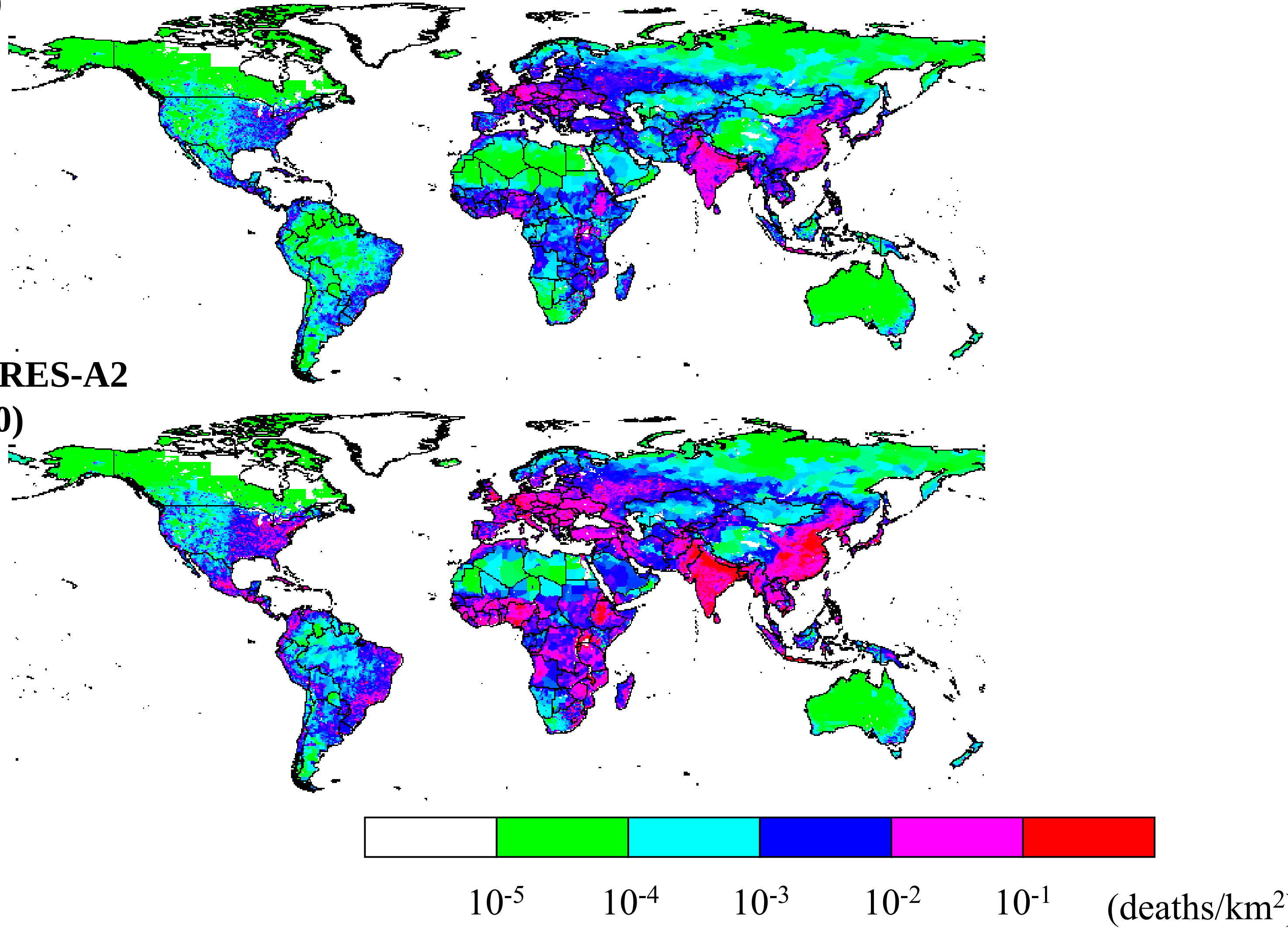
(85th T_{max} during 1971-2000)

0 10 20 30 40 (ºC)

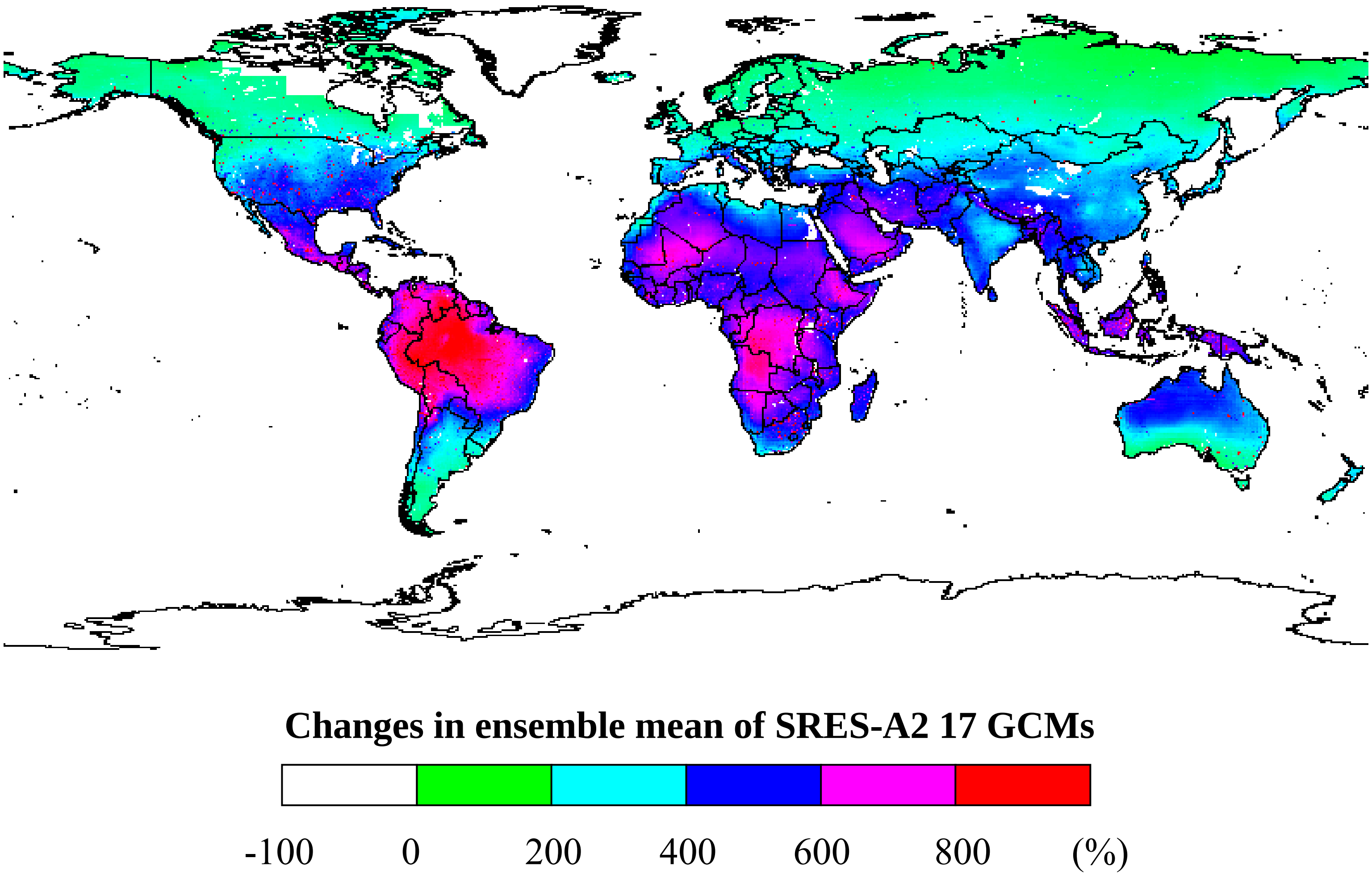
Excess mortality density due to heat stress in the existing condition (upper) and the future (lower)

Current (1971-2000)

Ensemble mean of SRES-A2 17 GCMs (2071-2100)

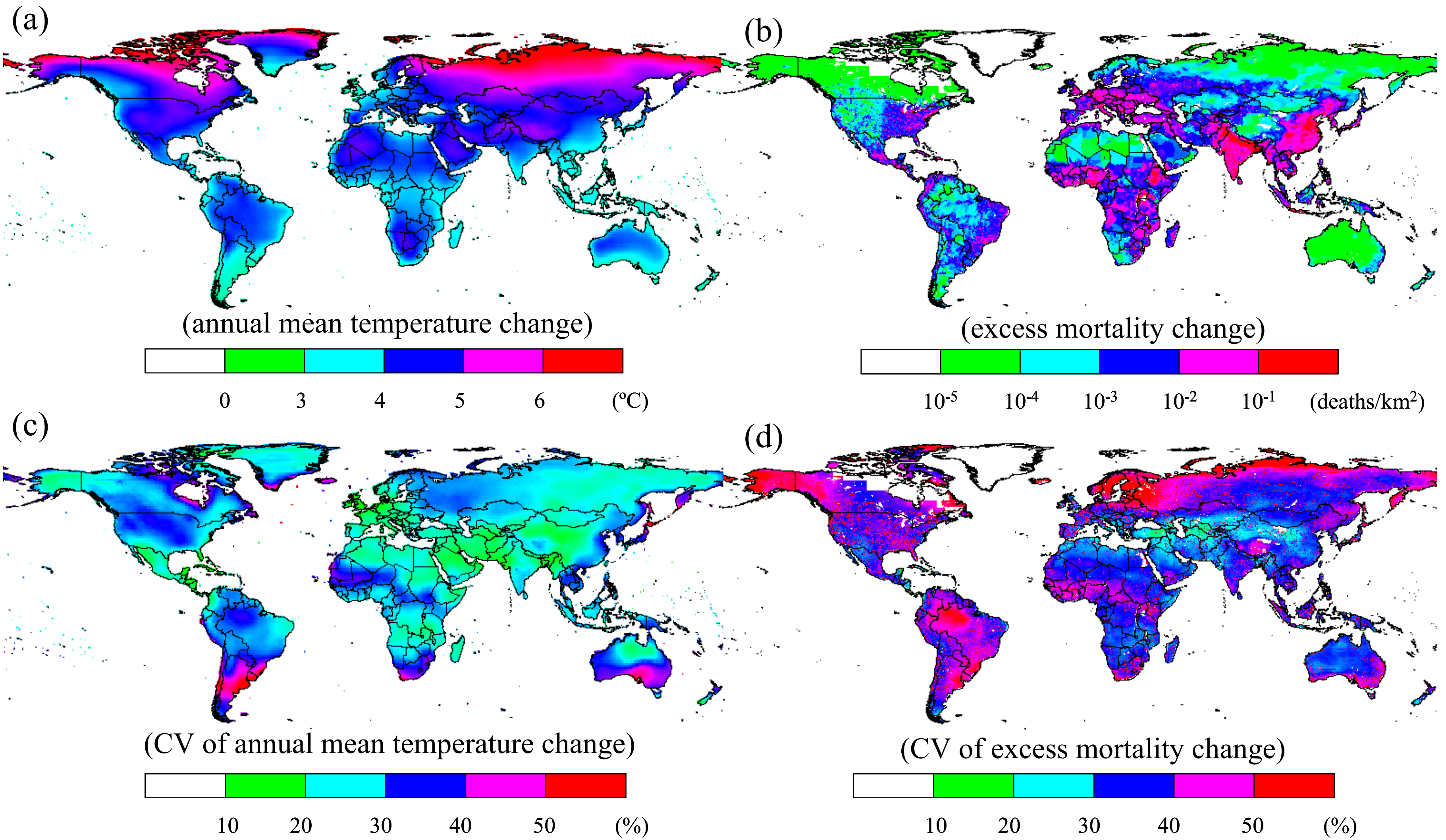


Rate of change of excess mortality due to hear stress (SRES-A2, 2071-2100)



Ensemble mean and normalized dispersion
(Mean and Coefficient of variation, CV)

Changes in annual mean daily maximum temperature and excess mortality years
from the existing condition (1971-2000) to the future (2071-2100) using the SRES A2 scenario (17 GCMs)



Future Consideration

- Assessing the extreme effect of temperature on impact
  - Comparison of **BCDS methods** to produce the daily extremes of Tmax
  - Comparison of **AR4-GCMs mean and variability** effects on mortality

- Defining the impact responses with GCM uncertainties
  - Uncertainty of GCM projections (AR4) and scenarios (SRES A1b A2, B2)
  - Defining skill of GCMs and scoring for impact with changes in mean and variation of Temperature.
  - Transfer GCM uncertainty to impact and Skill scoring

- Defining the risk by using the probabilistic distribution of impact
  - Developing the impact response function with uncertainty
  - Defining the adaptability (risk threshold) based on OT
  - Producing the impact probability and assessing the risk