A global assessment on temperature, climate and health

Results from the MCC Project

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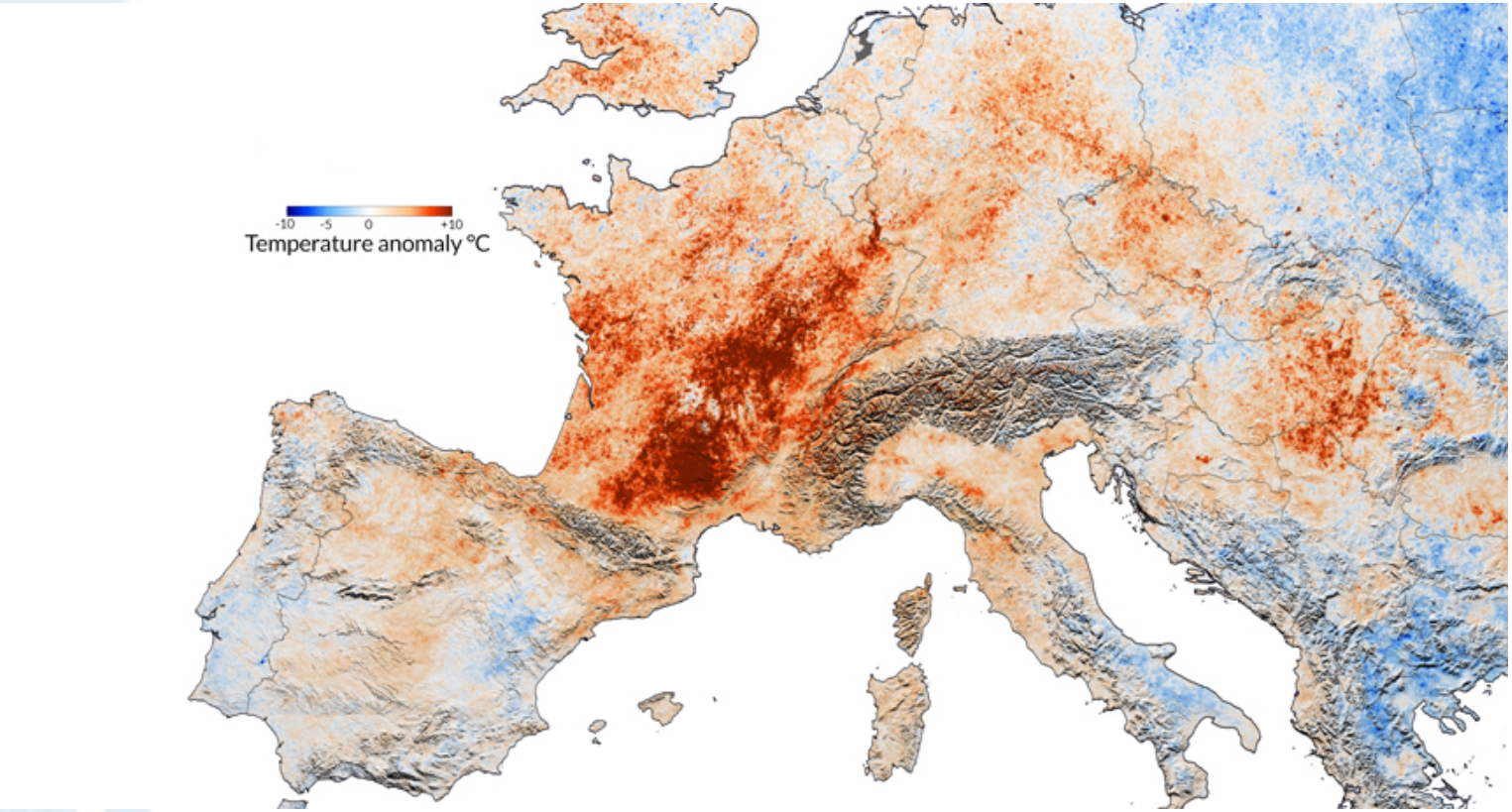
Outline

1. Epidemiological research on temperature
2. The MCC Network
3. Modelling framework
4. Future impacts: RCPs
5. Future impacts: Paris Agreement
6. Discussion

July/August 2003 heat wave in Europe



[From NASA Earth Observatory]

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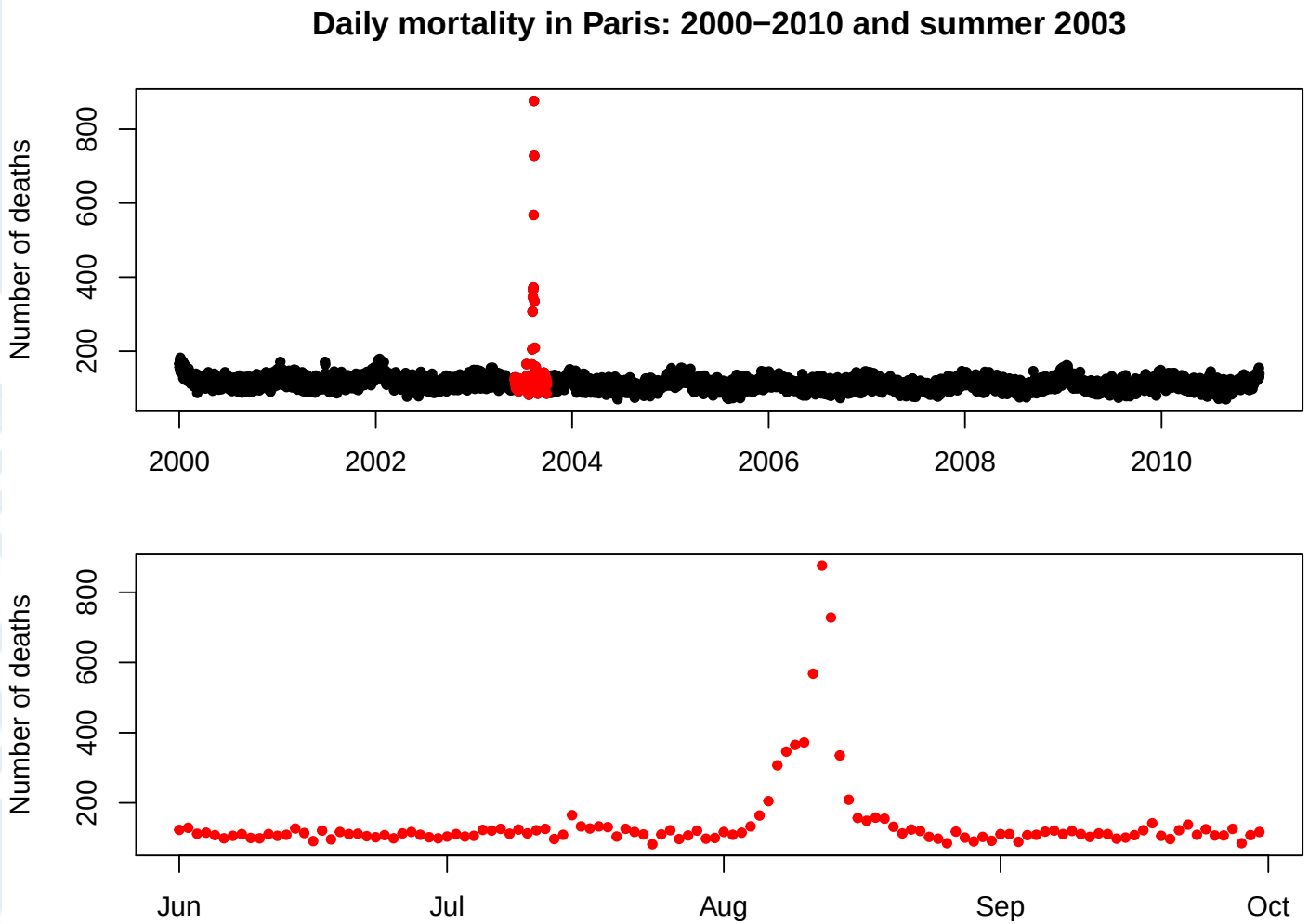
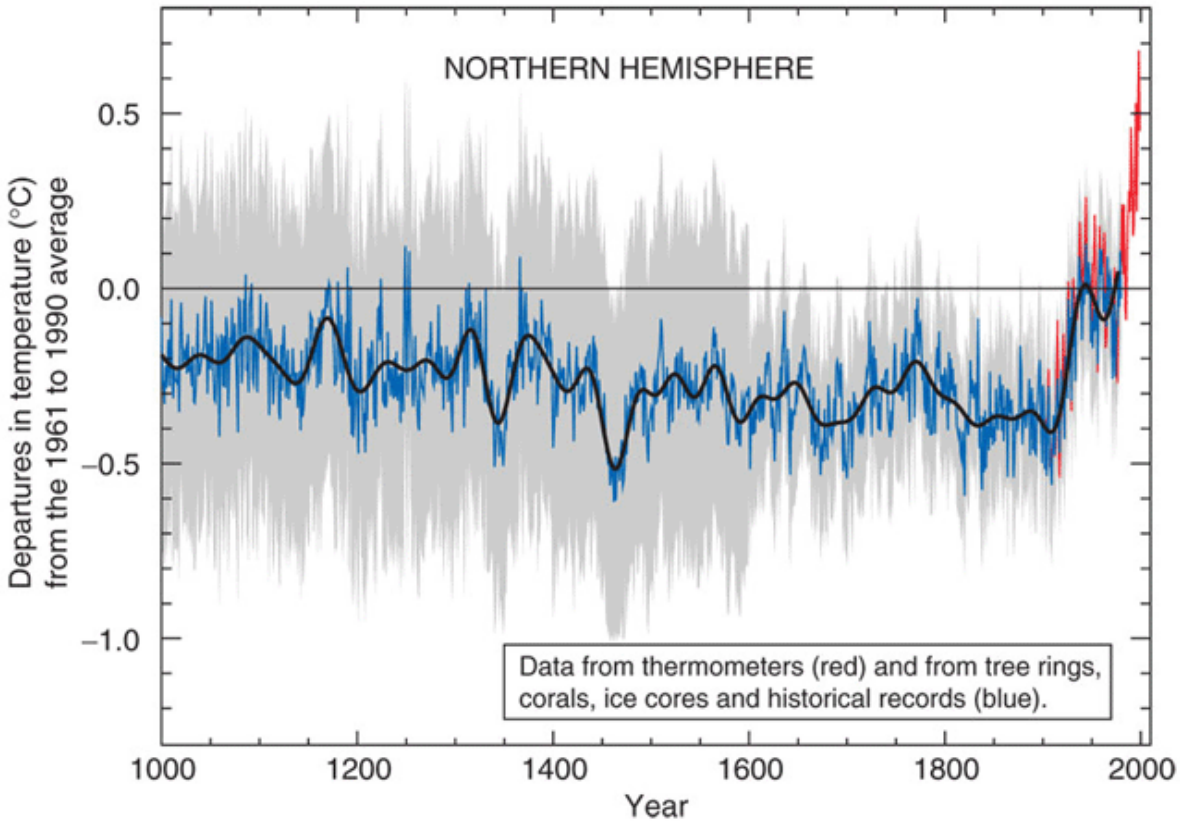
Impact on mortality in Paris



Climate change: the 'hockey stick'



[Adapted from Mann et al, *Geo Res Lett* (1999)]

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Limitations

- **Complexities in modelling** temperature-health relationships: non-linearity, lagged effects, pooling multi-parameter estimates
- **Geographical heterogeneity**: little information on susceptibility factors responsible for modifying the risk, difficult to compare estimates from different areas
- Poor knowledge about **key aspects** of the relationship, such as adaptation and acclimatization
- **Limited statistical power** in location-specific assessments

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The MCC Network

The **Multi-City Multy-Country (MCC) Research Network** is an international collaboration aiming at producing epidemiological evidence on associations between weather and health

Advantages:

- **Global perspective**: data from multiple locations within several countries, including populations with different characteristics and exposed to various climatic conditions
- **Flexible modelling framework** allowing non-linear/lagged responses, separation of effects due to cold/heat and moderate/extreme temperature, and assessment of effect modification

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MCC participants and funding

Participants:

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- Ariana Zeka
- Patrick Goodman
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The MCC dataset

Largest dataset ever collected: data from **512 locations** in **26 countries** within the period 1972–2012, including **105 million** deaths

Countries: Australia, Brazil, Canada, Chile, China, Colombia, Czech Republic, Finland, France, Iran, Ireland, Italy, Japan, Mexico, Moldova, Philippines, South Africa, South Korea, Spain, Sweden, Taiwan, Thailand, UK, USA, Vietnam

Daily time series of mortality counts (all-cause, CVD, respiratory, others), temperature (mean, min, max), humidity, air pollution (PM_x, O_3, NO_x, SO_2, CO)

Location-specific **meta-variables** on climatological, geographical, infrastructural, demographic, socio-economic characteristics

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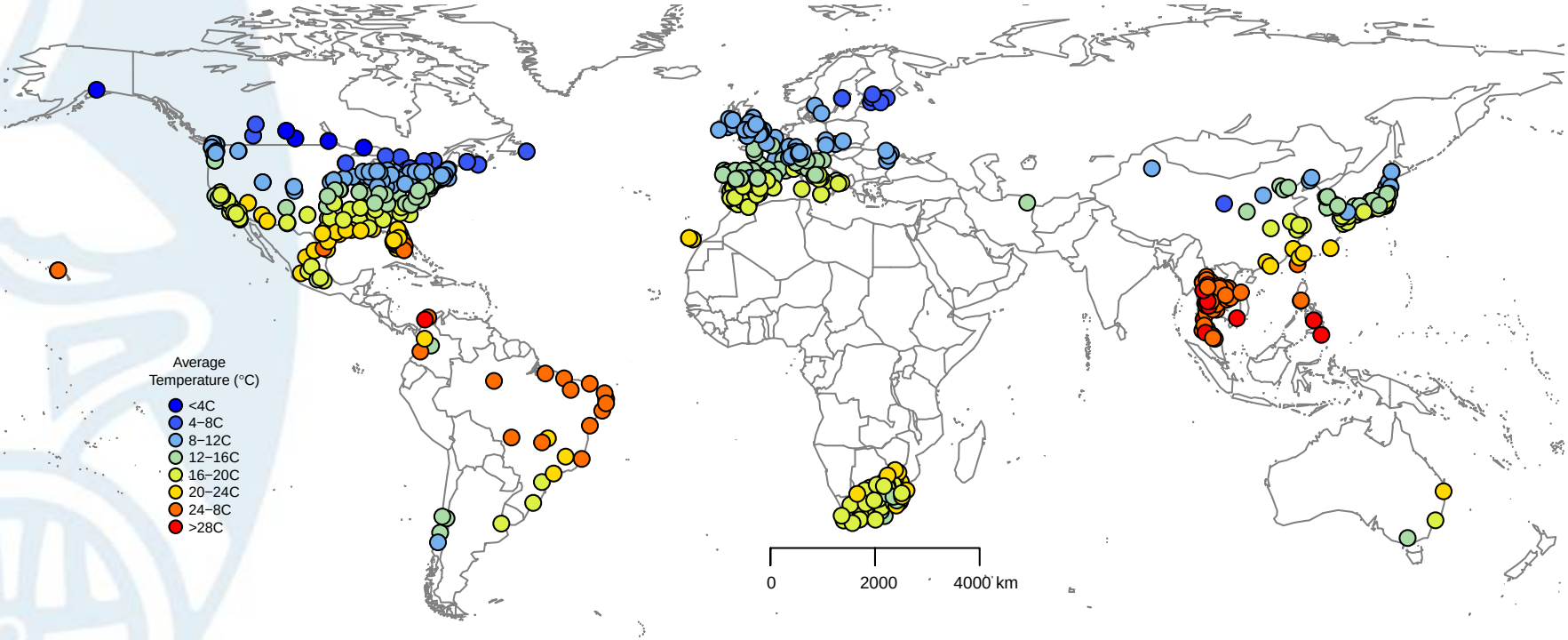
Map of MCC locations



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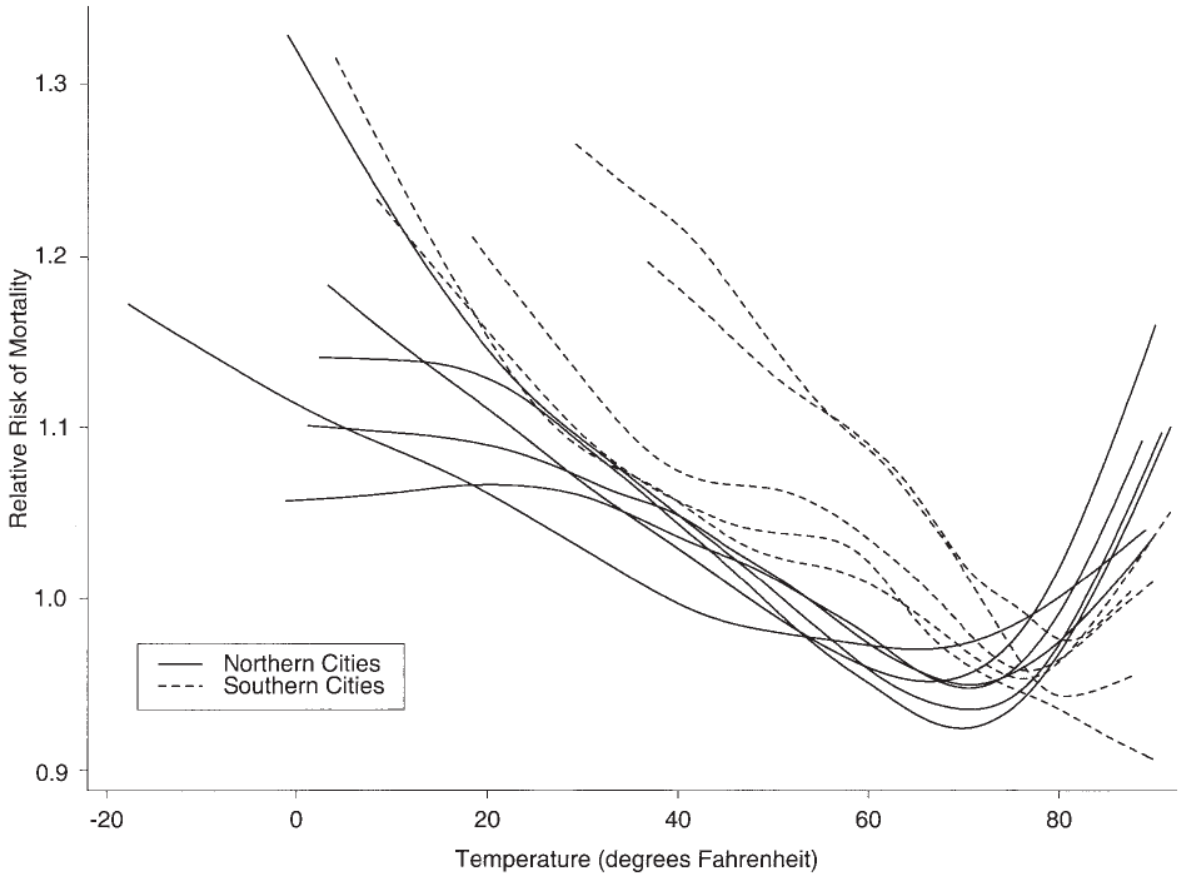
Complex temperature-health relationships



[From Curriero et al, *AJE* (2002)]

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New methodological issues

- **Complexities in modelling** the exposure-response relationships: non-linearity, lagged effects, pooling multi-parameter estimates
- **Geographical heterogeneity**: little information on susceptibility factors responsible for modifying the risk, difficult to compare estimates from different areas
- **Adaptation and acclimatization**: evidence of temporal changes, however little info on its timescale or drivers

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Modelling framework

1. **Two-stage time series analysis** to derive historical temperature-mortality relationships using observed data:
   - First-stage quasi-Poisson GLM with **distributed lag non-linear model** (DLNM) expressing a bi-dimensional *exposure-lag-response*
   - Second-stage **multivariate meta-regression** to pool estimates while accounting for location-specific characteristics
2. Computation of historical **excess mortality** for total and cold/heat components in each location, then aggregated by area and period
3. Derivation of **future daily temperature and mortality series** projected in the next decades
4. Projection of **future health impacts** and associated uncertainty

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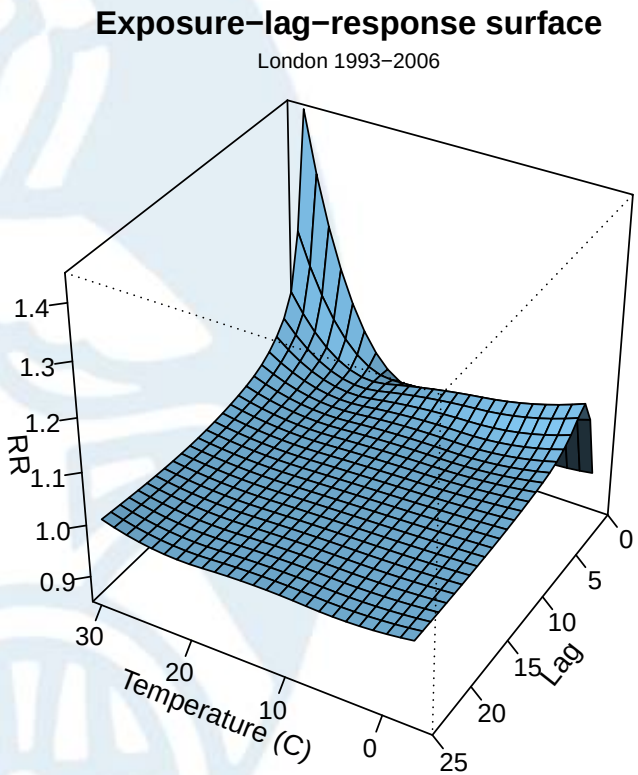
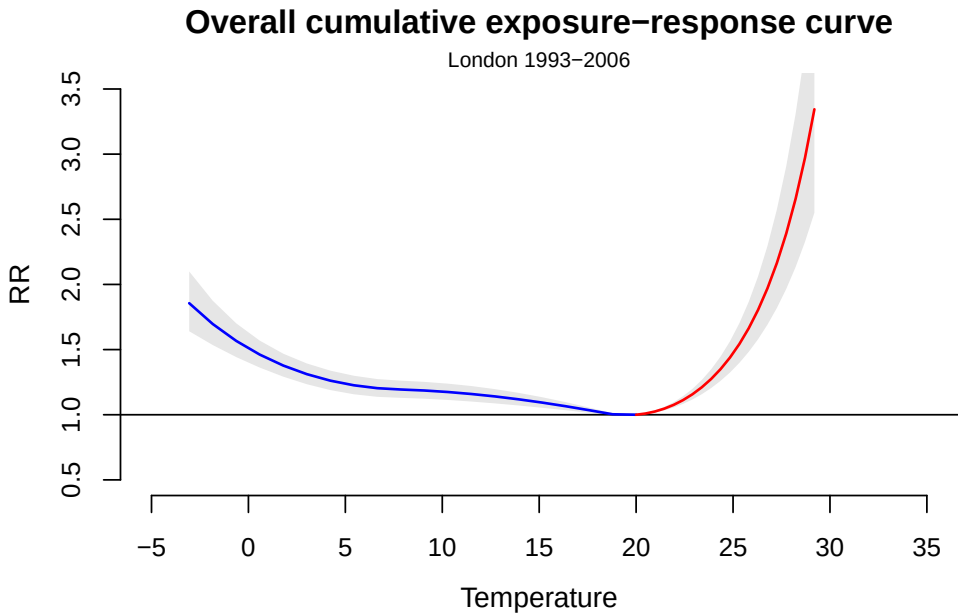
Exposure-lag-response associations





ISI-MIP dataset

- Global simulation dataset of daily meteorological variables including historical (1860–2005) and projection (2006–2100) periods
- Simulations from 5 **global climate models** (GCM) (HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, GFDL-ESM2M, and NorESM1-M) from the CMIP5 archive of IPCC, under 4 **emission scenarios** (RCP2.6, RCP4.5, RCP6.0, and RCP8.5)
- Downscaled over a $0.5^\circ \times 0.5^\circ$ grid through bias correction using re-analysis temperature data

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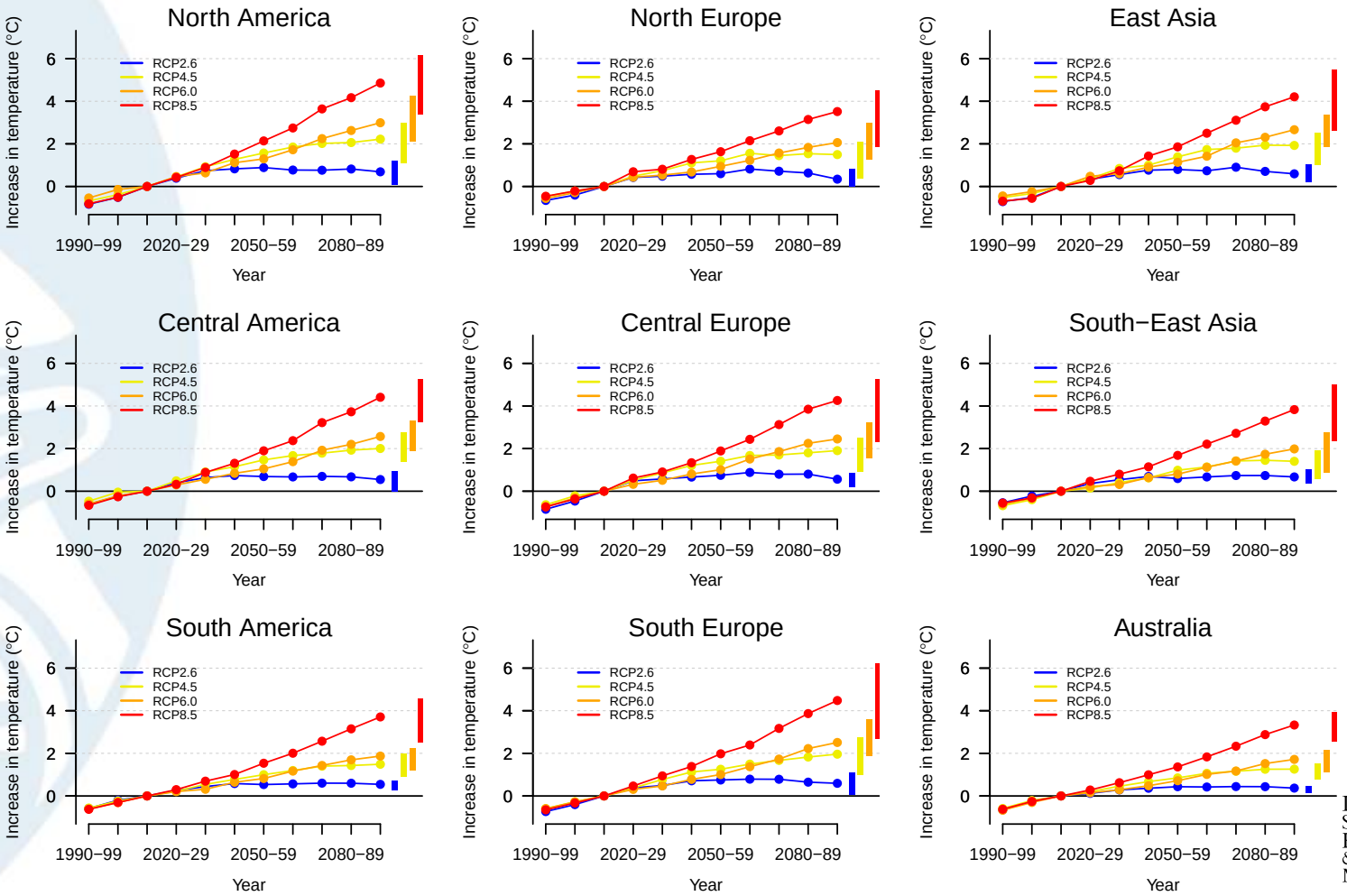
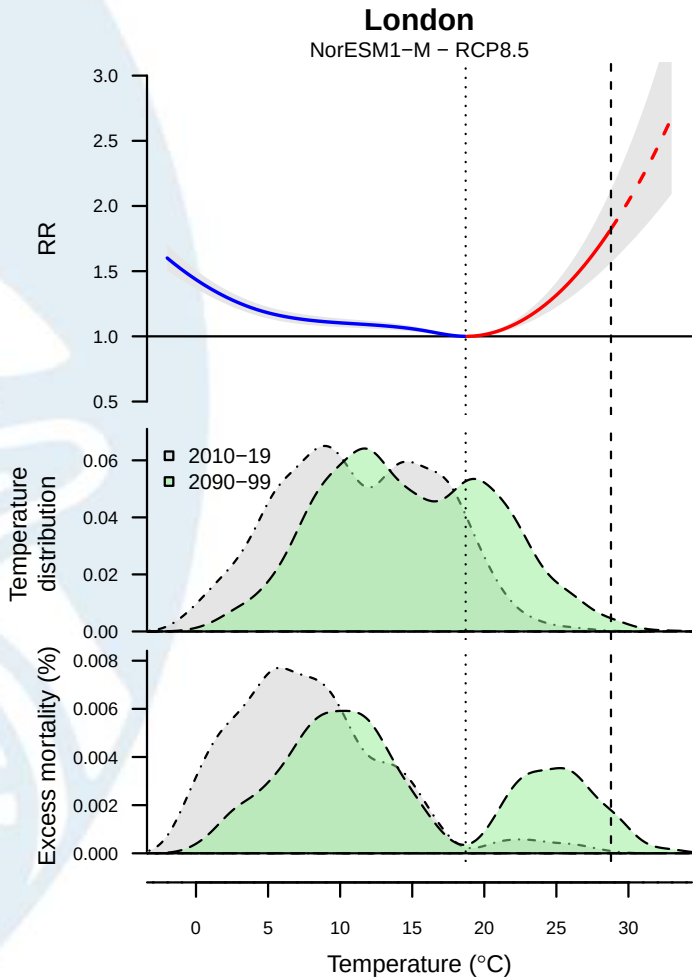
Scenarios of global warming

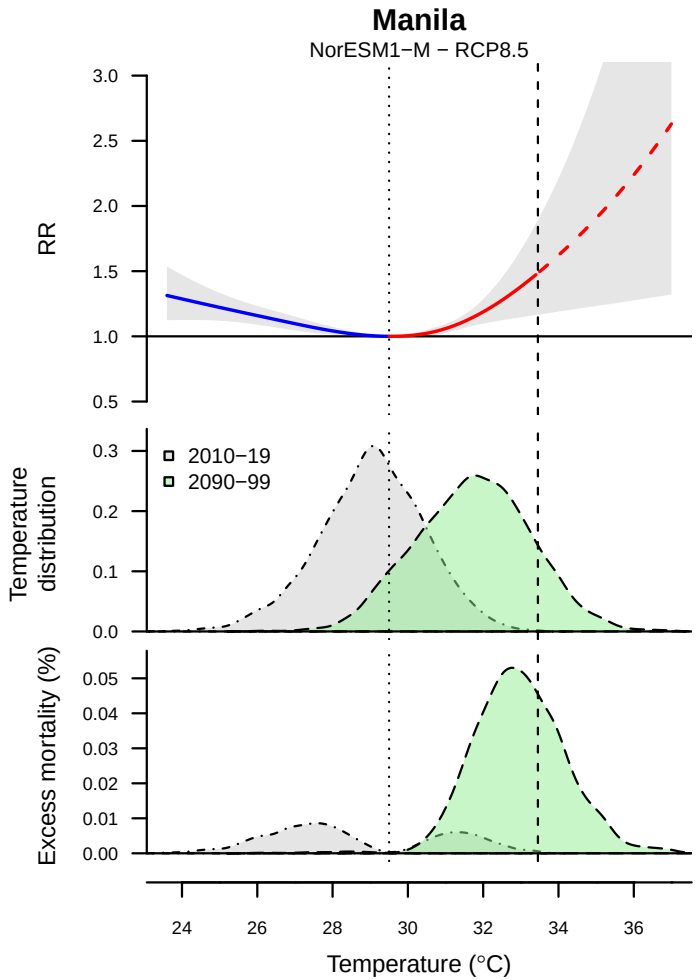
Gasparrini et al, in submission



Example with two cities

Gasparrini et al, in submission





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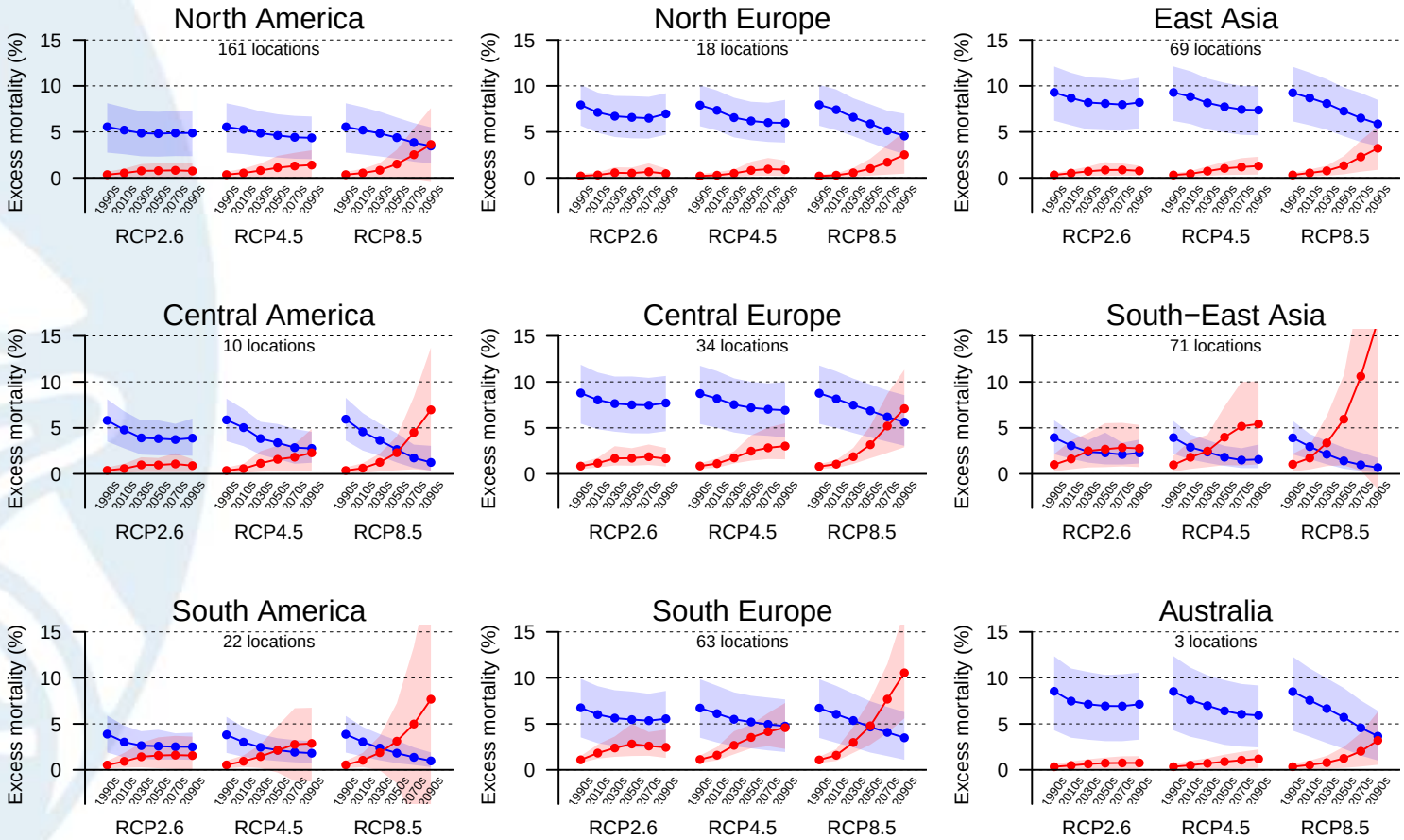
Projections under RCPs

Gasparrini et al, in submission



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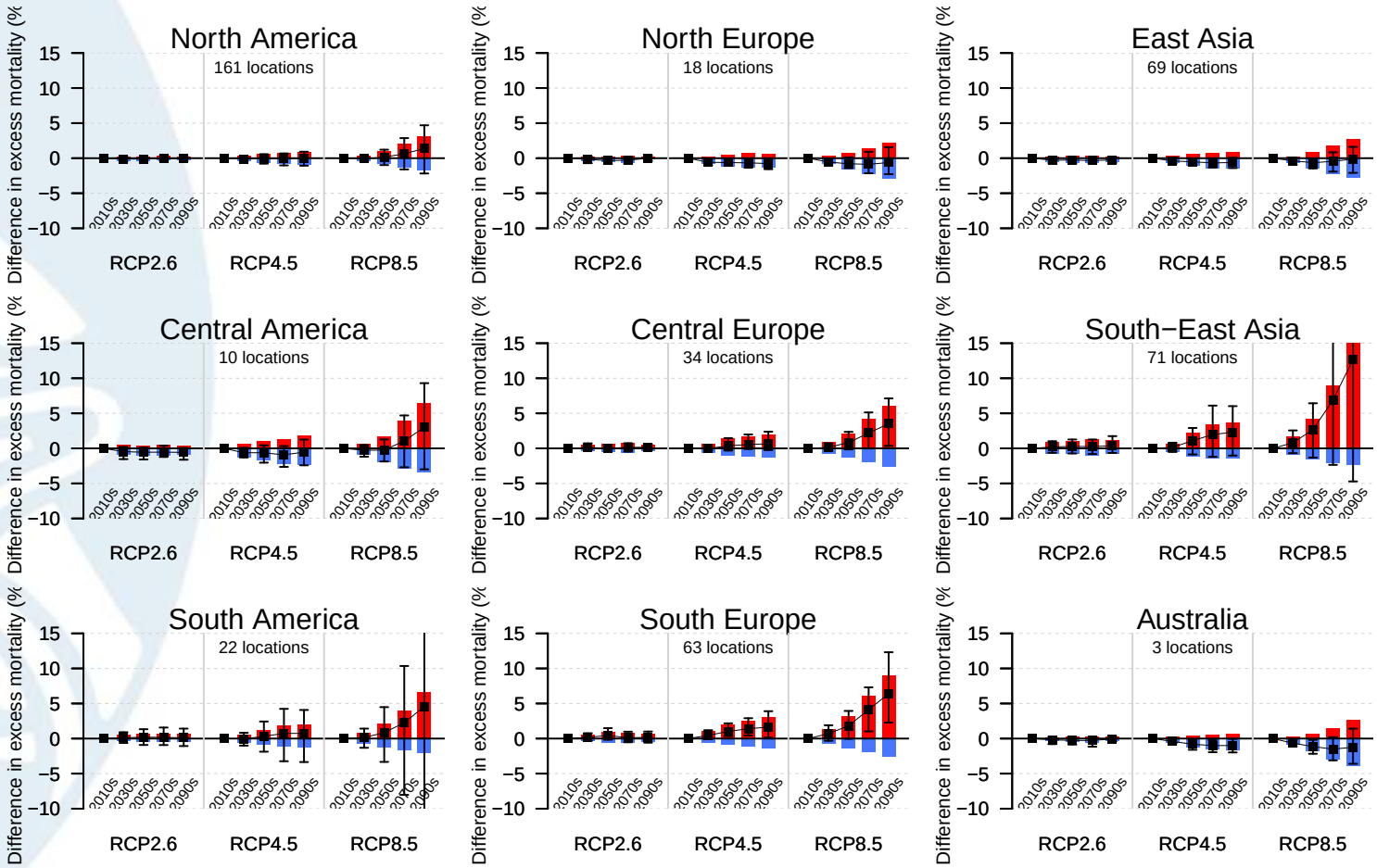

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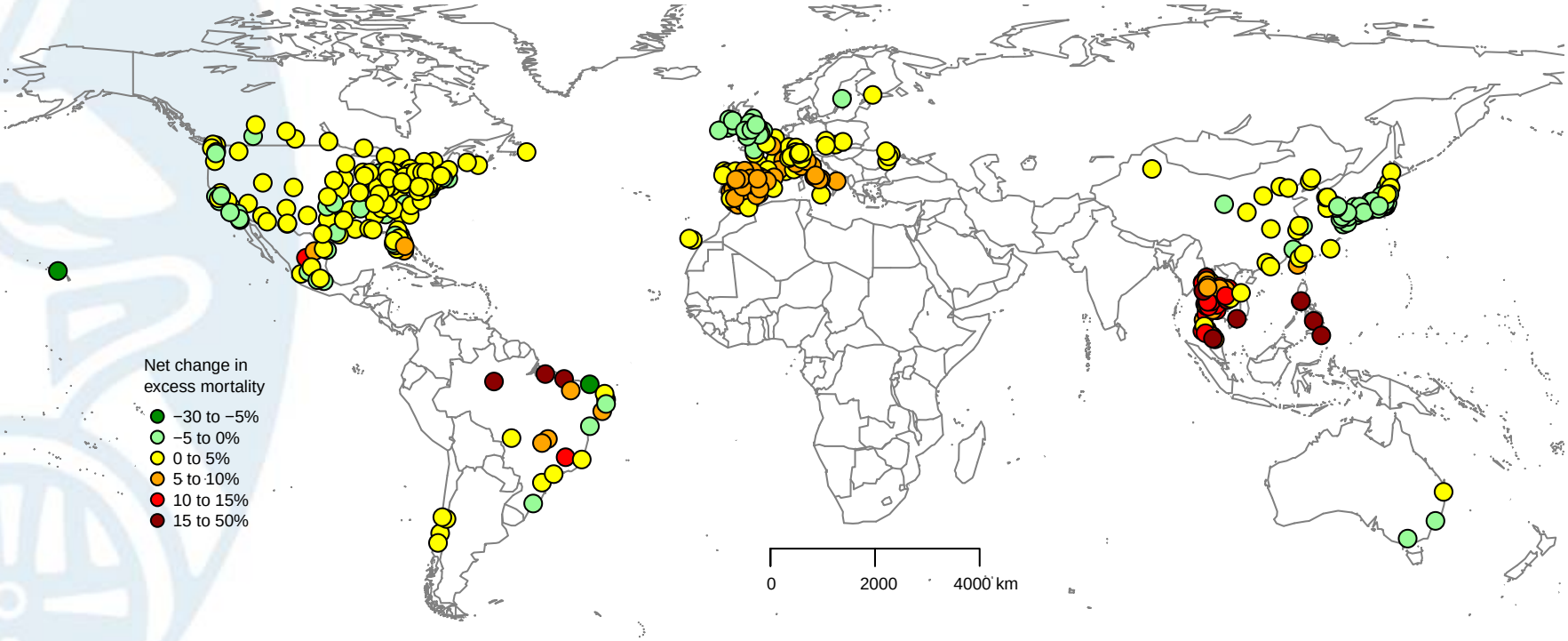

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Scenarios: 20-year windows

Warming level	Global Circulation Models		
	HadGEM2-ES	IPSL-CM5A-LR	MIROC-ESM-CHEM
1.5°C	2010 - 2029	2016 - 2035	2010 - 2029
2.0°C	2022 - 2041	2029 - 2048	2022 - 2041
3.0°C	2042 - 2061	2047 - 2066	2041 - 2060
4.0°C	2059 - 2078	2064 - 2083	2058 - 2077

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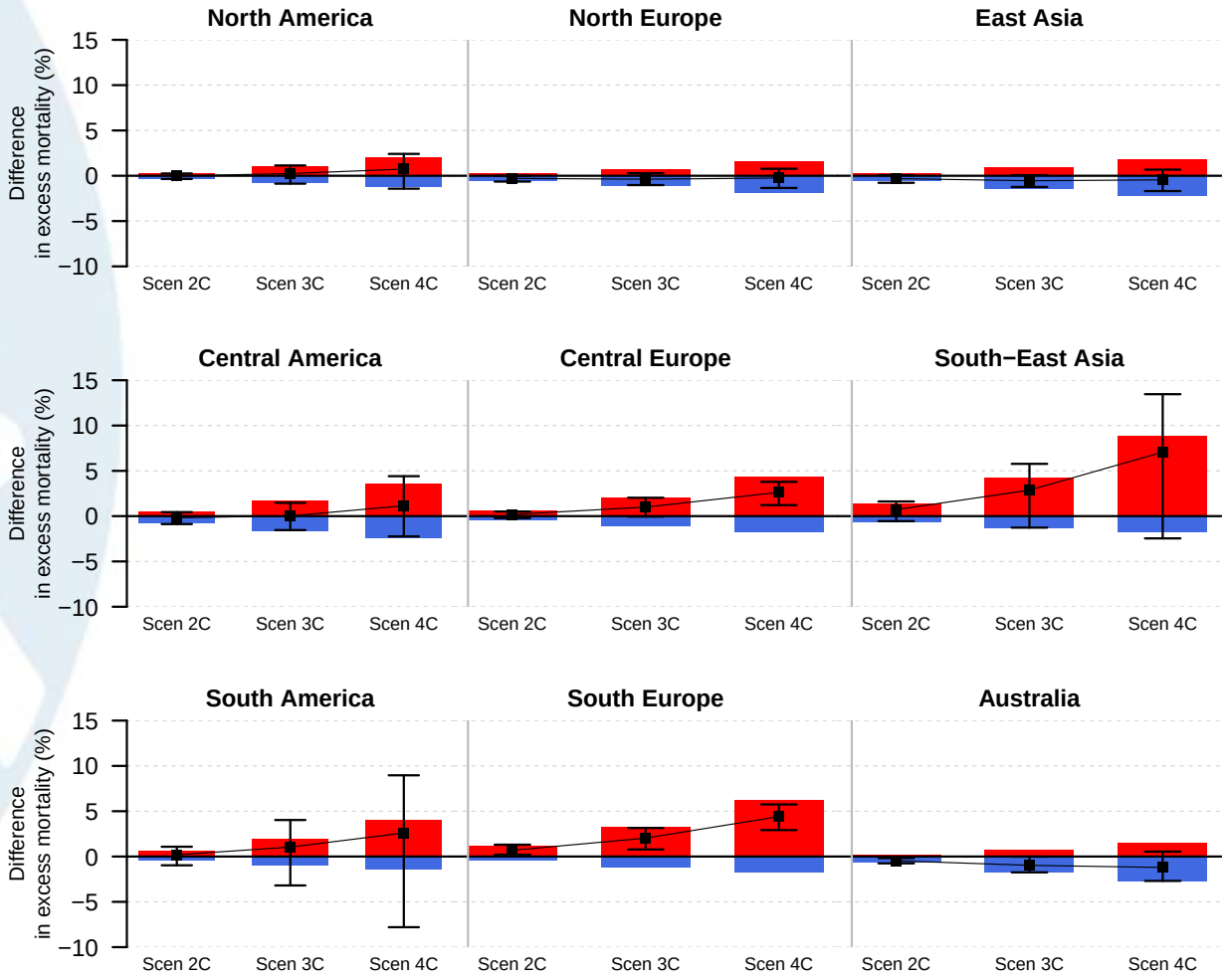
Projections under Paris Agreement

Vicedo-Cabrera et al, in submission



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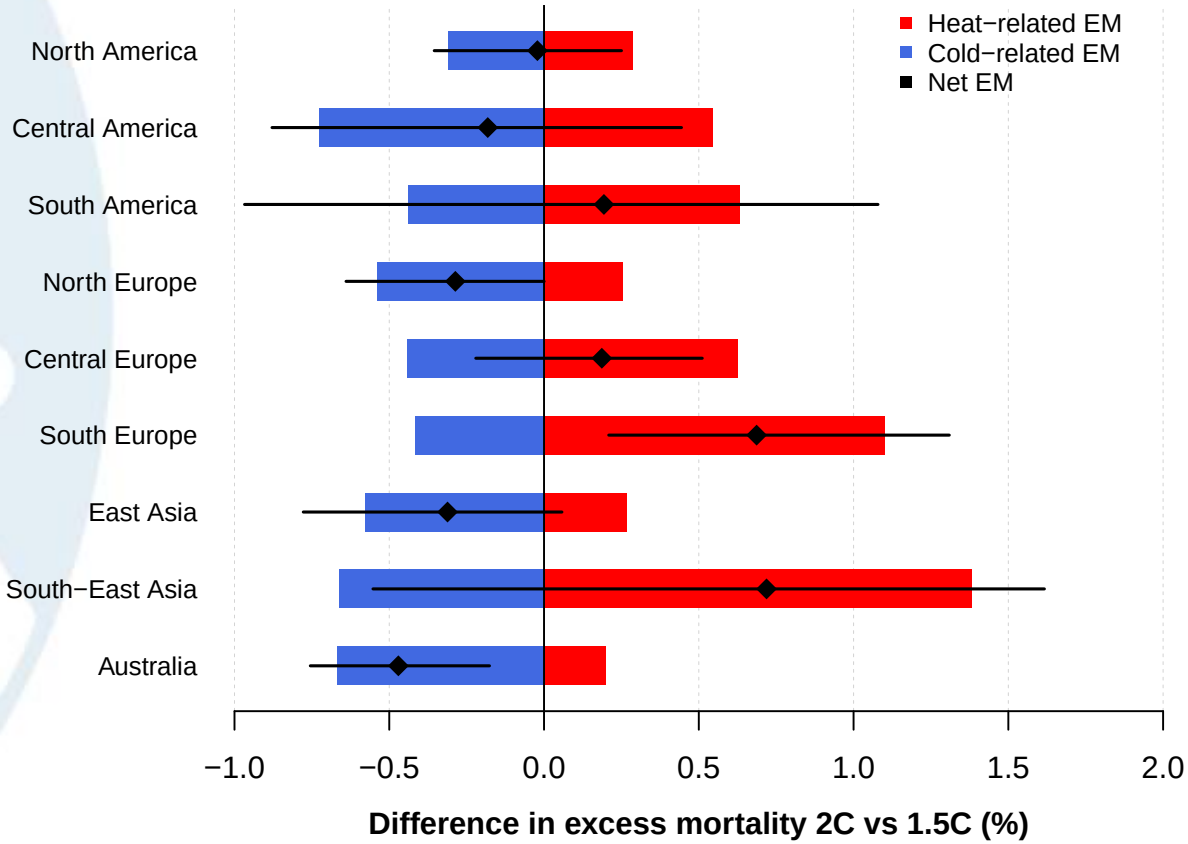

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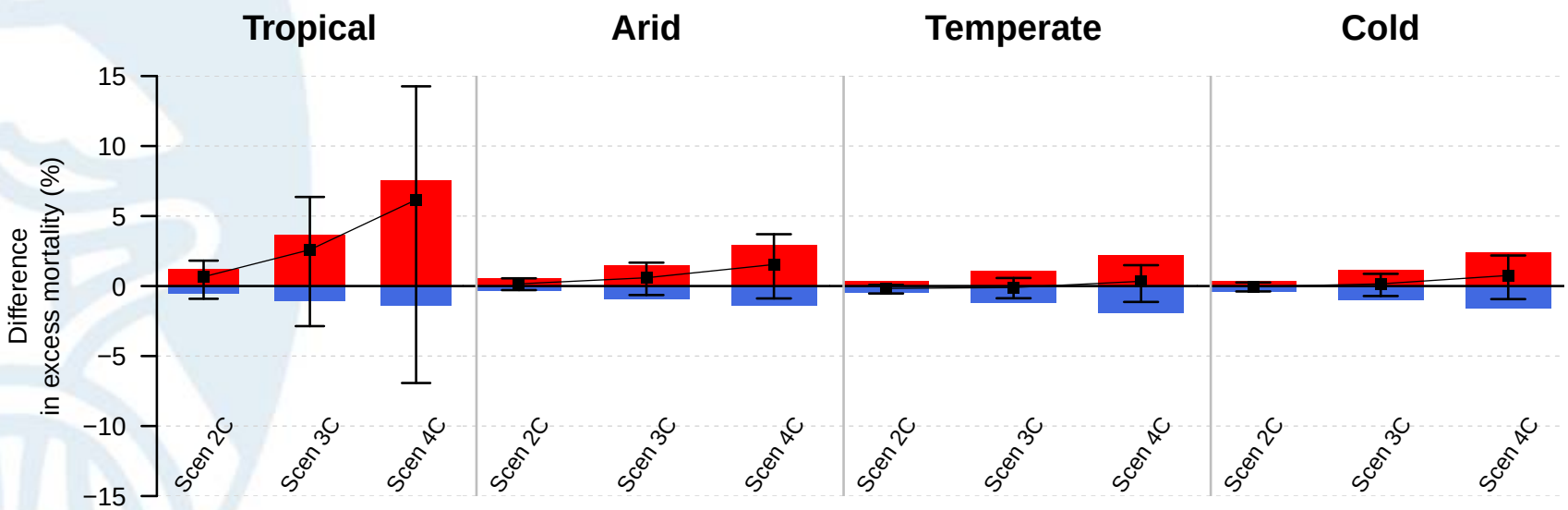

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Discussion

This represents the **largest epidemiological study** on health impact projections under climate change scenatior, covering **hundreds of locations** in various regions

Results show a **general pattern of increase** in temperature-related excess mortality, especially under more extreme scenarios, but with important **geographical differences**

Impacts are much **reduced under milder global warming scenarios**, confirming the benefits of the implementation of mitigation policies to reduce GHG emissions

Plan to expand the data and analysis to areas not covered in the current study, such as Africa and the Middle East, to attempt a **global assessment**

Need to extend the analysis to **less simplistic scenarios** including **adaptation** and changes related to pathways in socio-economic, demographic, infrastractural characteristics

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