

Deaths attributable due to the urban heat island effect in a megacity of Vietnam:  
green space can alleviate UHI impact

**Tran Ngoc Dang, MPH, PhD**

**The University of Medicine and Pharmacy, Ho Chi Minh city, Vietnam**

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# Motivation

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- **"Urban Heat Island"** (UHI) refers to the tendency for a city or town to remain warmer than its surroundings.

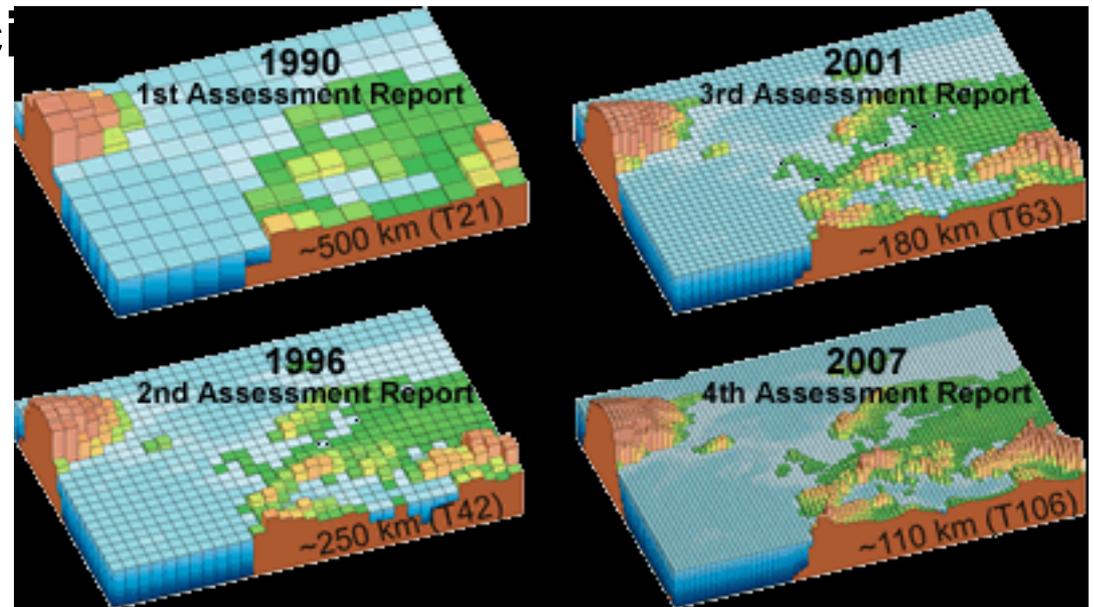


people in urban/inner cities exposure to excessive heat

- **From health perspective, UHI is a concern:**
  - increases the heat-related mortality and morbidity
  - UHI effects will be amplified:
    - Urban population increase (expected to 85% by 2100)
    - Climate change

# Research gaps

- Few studies directly quantify the magnitude of UHI impact on mortality, and they are in-sufficiently:
  - Lack of district-specific temperature (1-3)
  - or district-specific mortality (4)
- Global temperature-mortality projecting models neglect UHI impact → **assume that mortality-temp relation is the same within a city**



Credits: Image courtesy of the IPCC

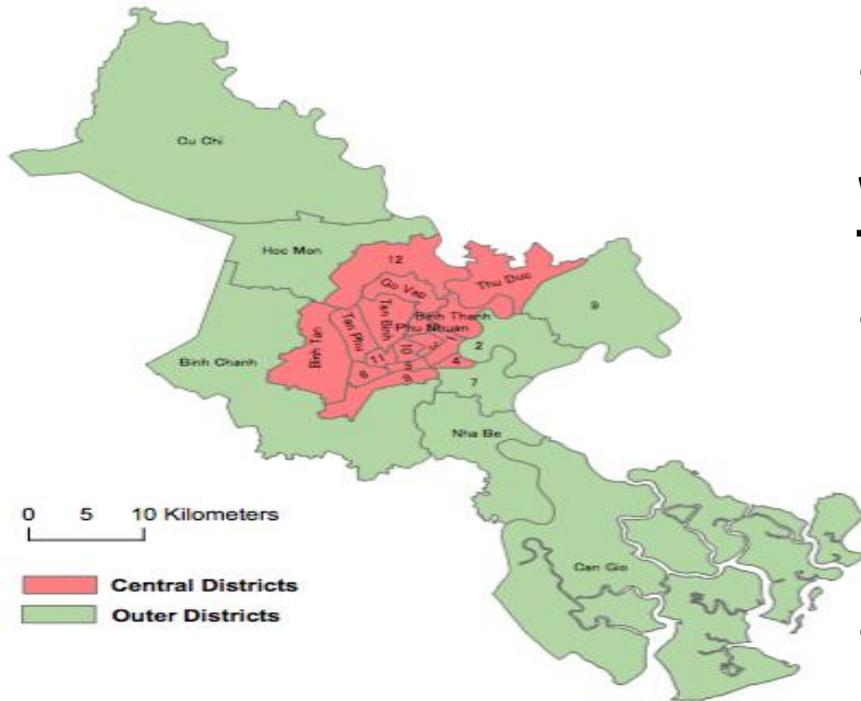
# Purpose of study

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- (1) To compare temp-mortality relation between center and outer areas in Ho Chi Minh City
- (2) To calculate the attributable number (AN), and fraction (AF) of mortality due to UHI
- (3) To determine the degree can planting of trees / green space prevent heat-related deaths?

# Study setting

- Population ~ 7 million in 2012 (8.4%)
- Pop density= 2660/km<sup>2</sup>



## Mortality data:

- A6 national mortality system
- 24 districts in HCM city
- 101,897 deceased persons

## Weather data:

- Dynamic downscaling with a regional weather model (2x2km) ~ district specific
- observed data: 7 stations

tropical, mega, most populous, rapid urbanization city in Vietnam

# Data analysis steps

1. For each districts, examine temp-mortality relation using 2 stage-model
2. Calculate district-specific mortality attributable fraction (AF), and number (AN) due to total heat, extreme-heat, mild-heat (Antonio method)

$$AF_x = 1 - \exp(-\beta x)$$
$$AN_x = n * AF_x$$

3. AF due to UHI:

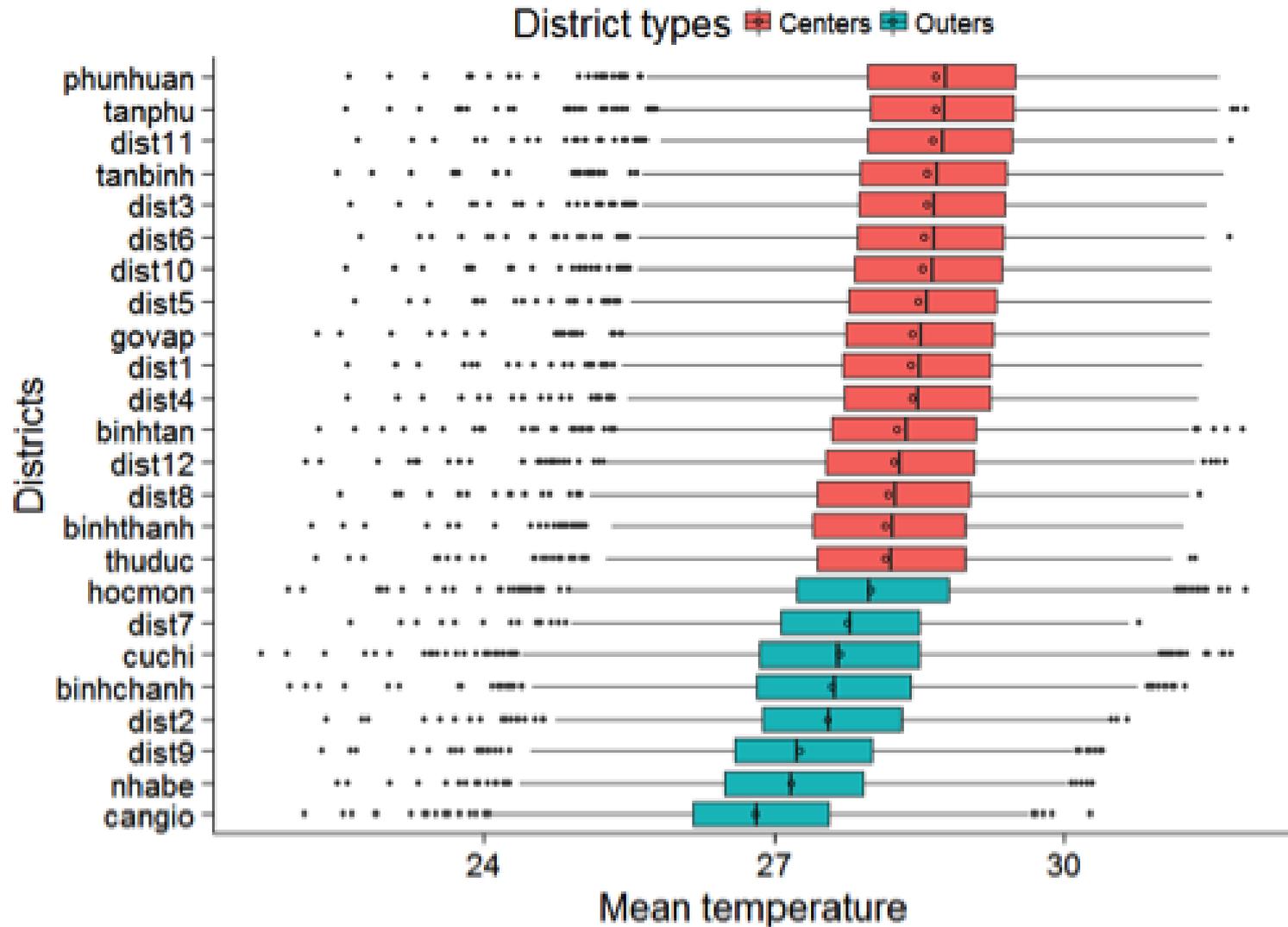
- $AF_i = \alpha_1 + \beta_1 * UHI$  (centers vs. outers)

4. AN due to heat can be prevented by green space:

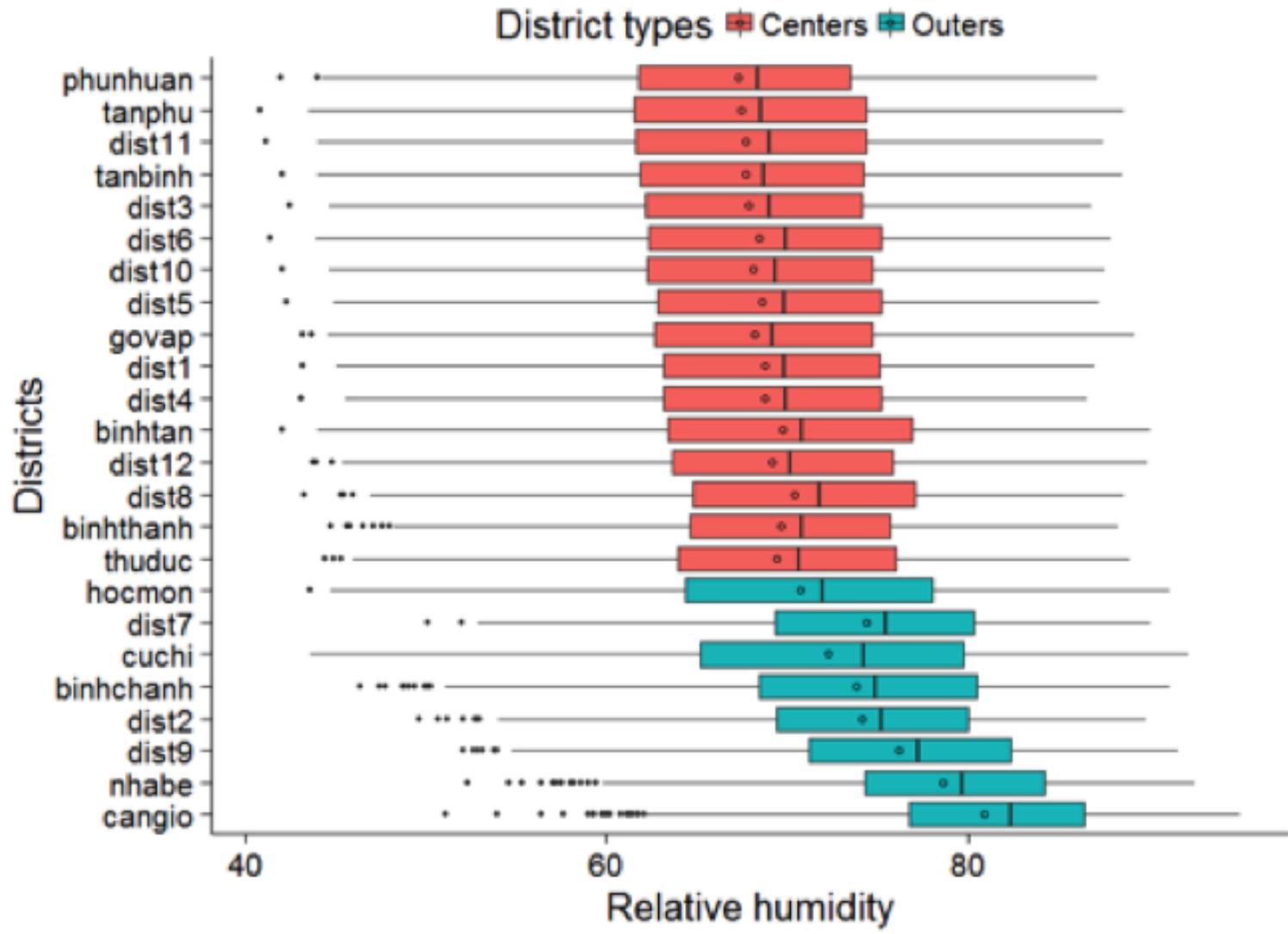
- $AN_i = \alpha_2 + \beta_2 * \text{green space}_i\%$  (satellite image)

# Results

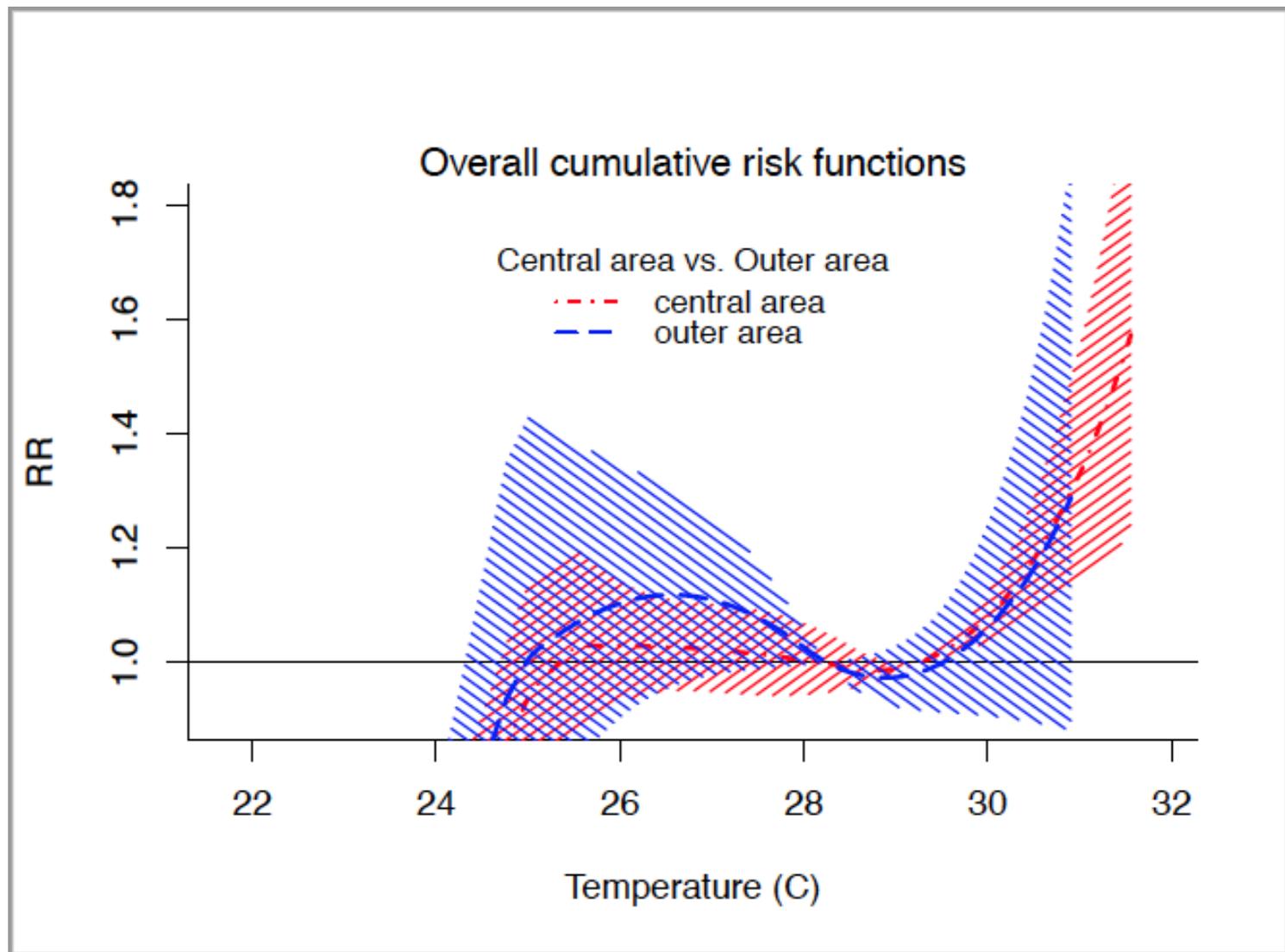
# Weather by Dynamic downscaling



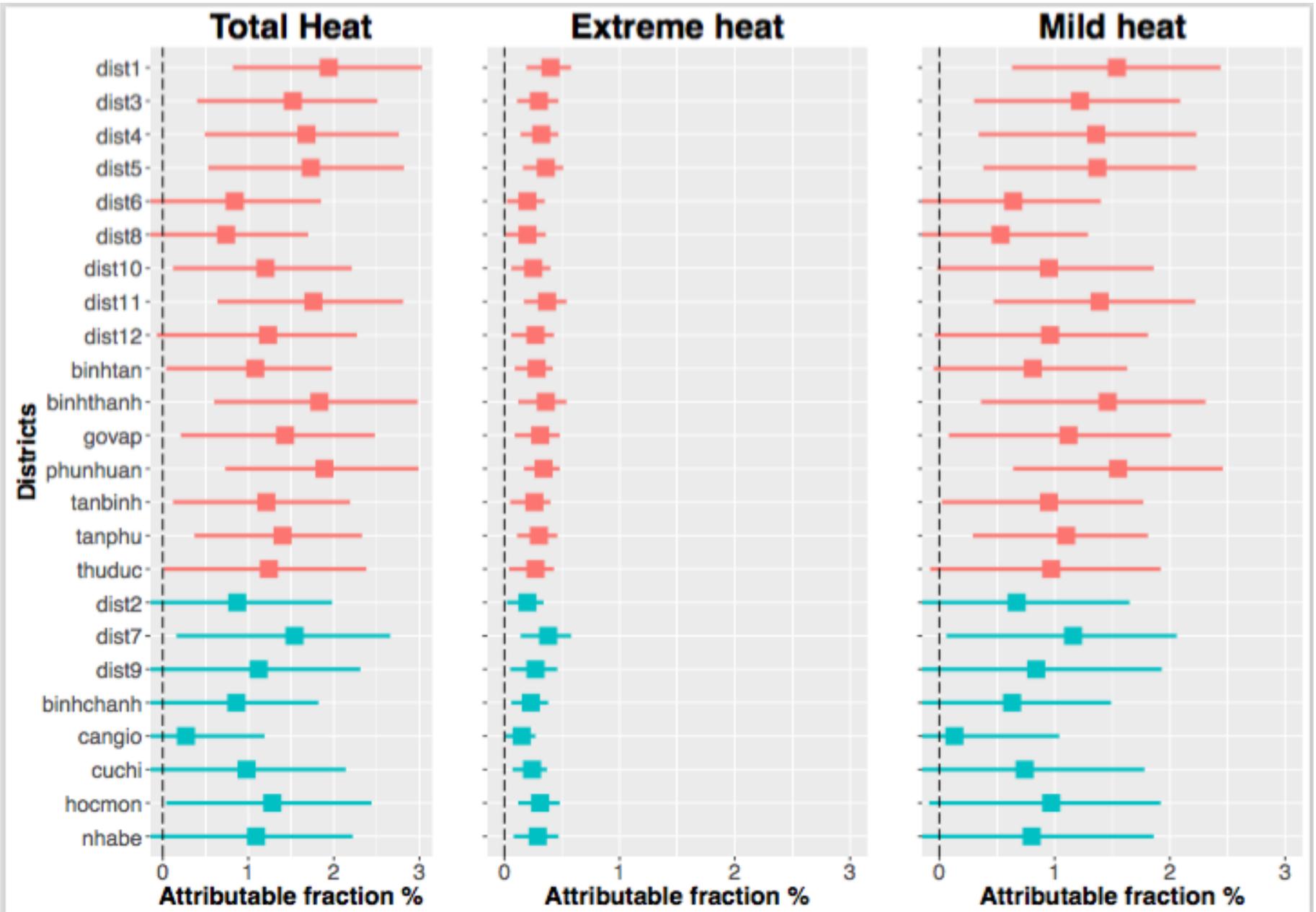
Central districts were hotter...



...and drier



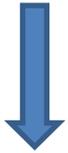
**Figure.** The heat-related mortality risk functions between central vs. outer area in Ho Chi Minh City from 2010-2013. The red line is the pooled estimate for the central districts, the blue line is the pooled estimate for the outer districts. The shaded area is the 95% CI.



**Figure. Attributable fraction (%) and its 95% empirical CI of districts grouping by centers and outers. Central districts are in red, and outer districts are in blue**

# AFs due to UHI

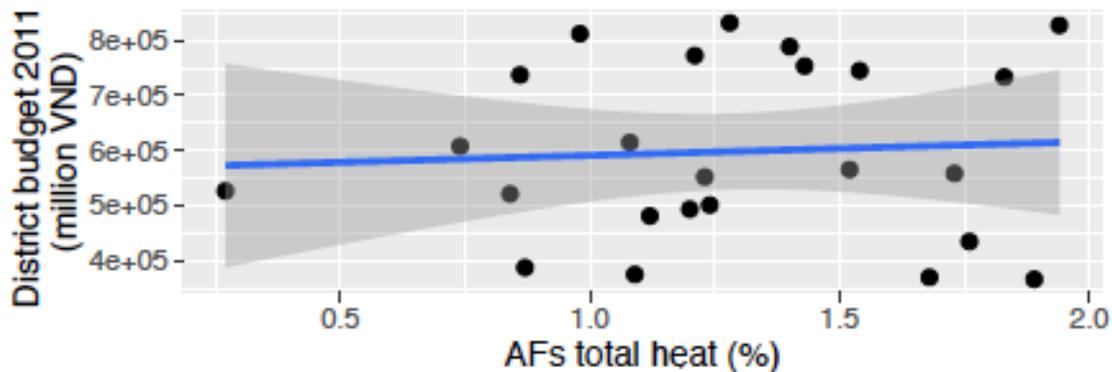
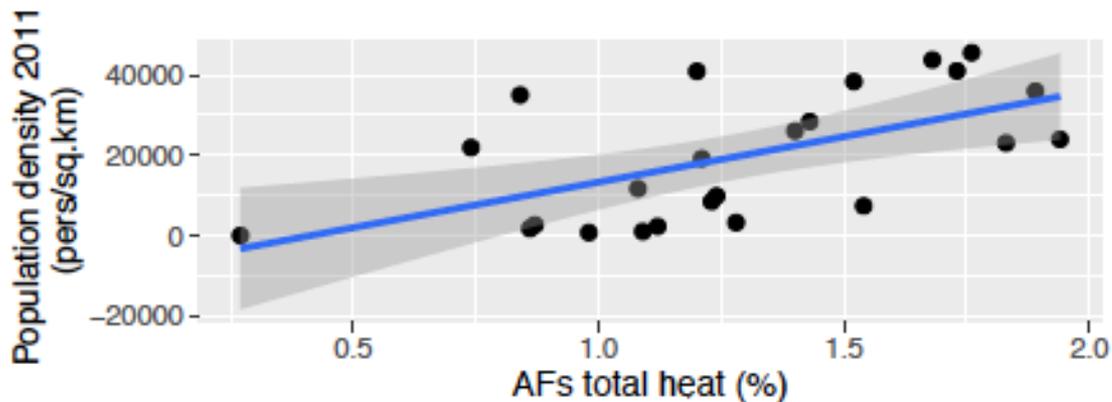
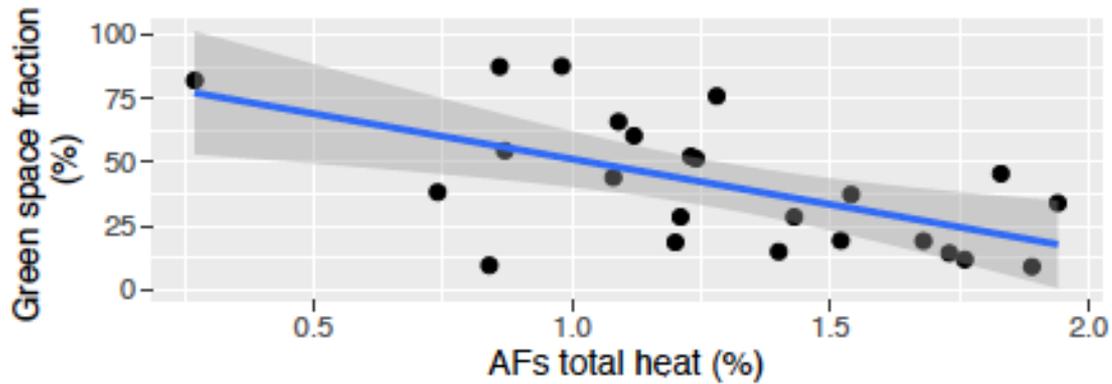
	AFs total heat	AFs extreme heat	AFs mild heat	IS surface	Green space	Green + Water surface
Centers	1.42%	0.3%	1.12%	72.62%	27.37%	27.37%
Outers	1.00%	0.26%	0.74%	19.47%	68.88%	80.53%



AFs due to UHI =  $1.42 - 1.00 = 0.42\%$

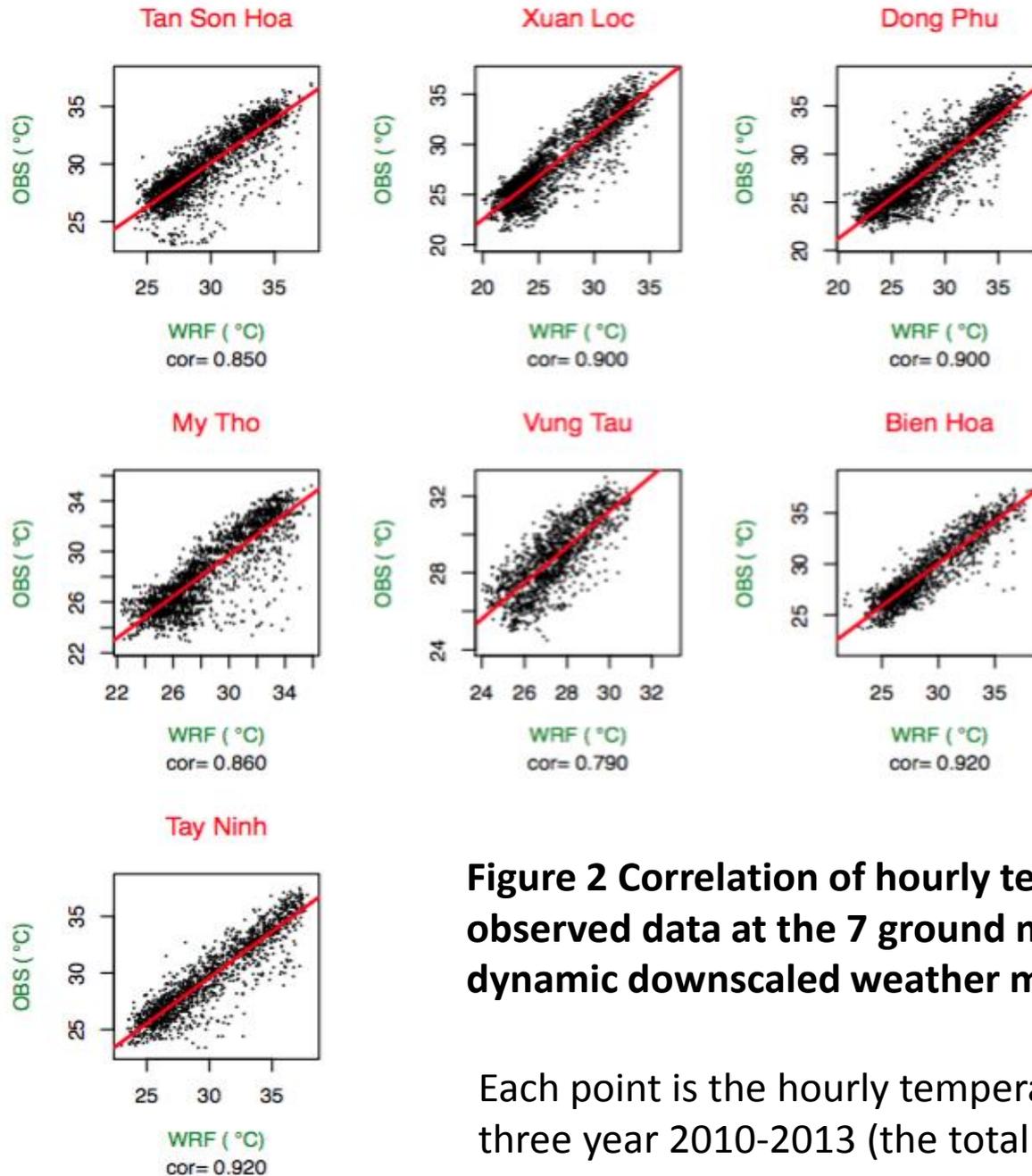
AFs =  $1.42 - 0.42 * \text{UHI}$  (p value = 0.015)

# AFs and green space



Every increase in 1 km<sup>2</sup> green space per 1,000 people will prevented 7.4 people deaths attributable to heat

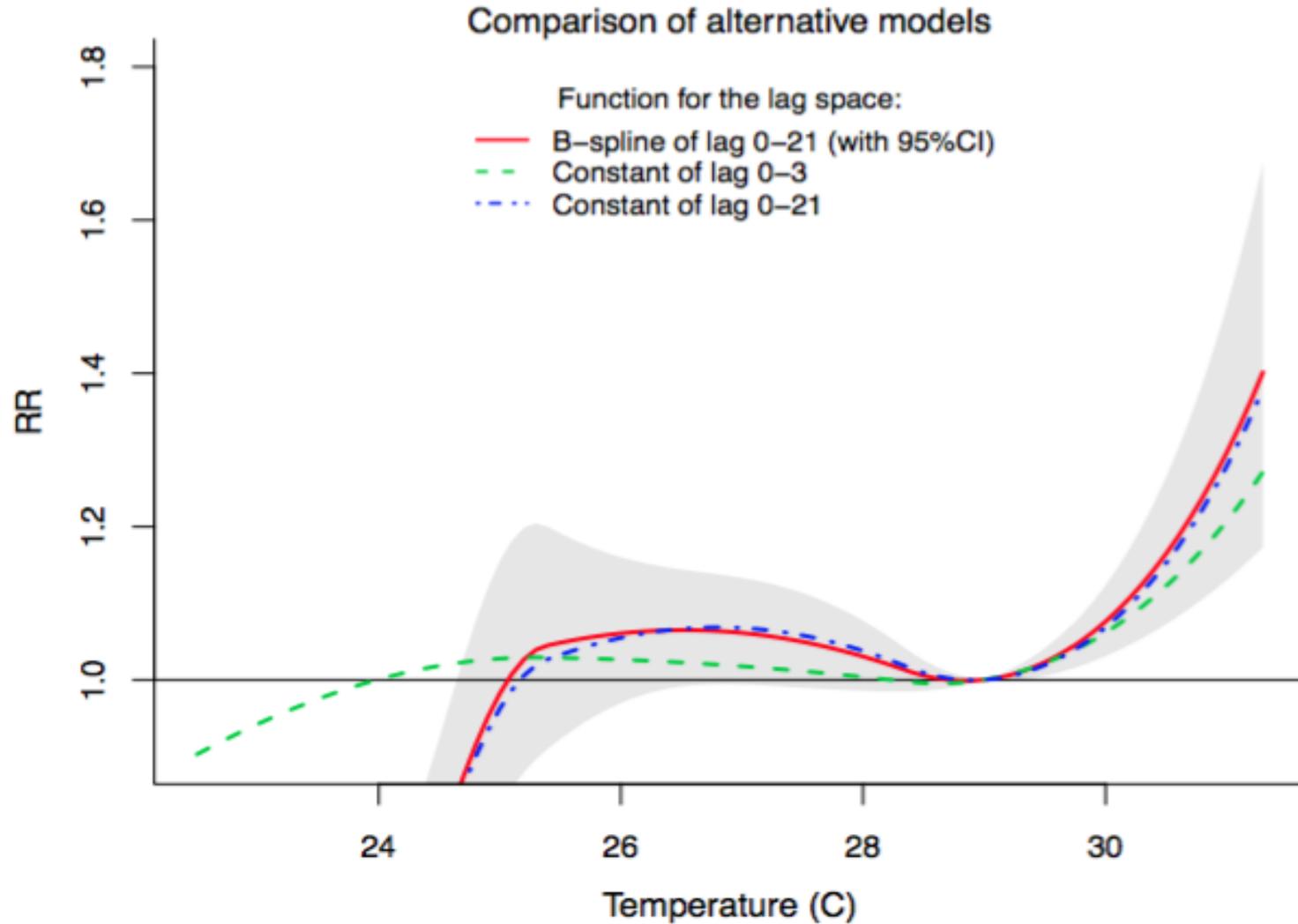
# Sensitivity 1



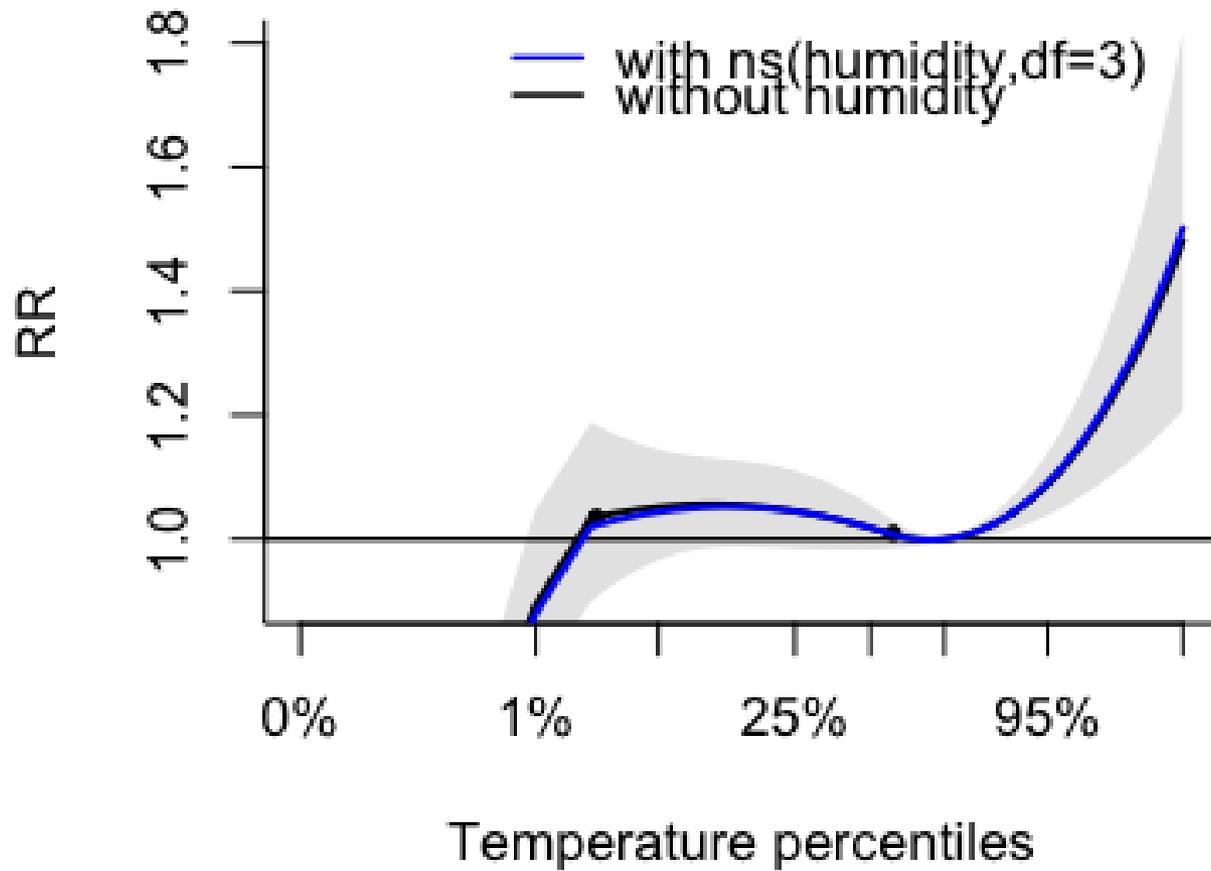
**Figure 2 Correlation of hourly temperature between observed data at the 7 ground monitoring stations and dynamic downscaled weather model data**

Each point is the hourly temperature of 30 days in April of three year 2010-2013 (the total number of point is 24x30x3)

# Sensitivity 2



# Sensitivity 3



# Discussion

- **Strengths:**

- first study uses both district-specific temperature and mortality
- AF, and AN is more understandable → policy implications

- **Limitations:**

- generalizability
- exposure misclassification (i.e. people moving around areas, and location of deaths)

# Summary- Policy implications

- Heat-slope is identical between centers and outers. The differences in temperature distribution induces the difference in AF total heat.
- Green space can alleviate the impacts of UHIs, though future studies conducting a health economic evaluation of tree planting are warranted

# Thank you!

- **Tran Ngoc Dang**, Doan Quang Van, Xerxes Seposo, Hiroyuki Kusaka, Yasushi Honda: **Green space and deaths attributable to the urban heat island effect in Ho Chi Minh City**. *American Journal of Public Health* 2017 (accepted on August 31<sup>st</sup> 2017)
- Yuming Guo, Antonio Gasparrini, Ben G. Armstrong, Benjawan Tawatsupa, Aurelio Tobias, Eric Lavigne, **Dang TN** *et al*: **Heatwave and mortality: a multi-country multi-community study**. *Environmental Health Perspective* 2017, **125**(8).
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2. Goggins WB, Ren C, Ng E, Yang C, Chan EY. Effect modification of the association between meteorological variables and mortality by urban climatic conditions in the tropical city of Kaohsiung, Taiwan. *Geospat Health* 2013;8(1):37-44.
3. Goggins WB, Chan EYY, Ng E, Ren C, Chen L. Effect Modification of the Association between Short-term Meteorological Factors and Mortality by Urban Heat Islands in Hong Kong. *PLoS ONE* 2012;7(6):e38551.
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