Impact of Temperature Extremes on the Excessive Mortality Rate from Cardiovascular Diseases of Elderly in Taipei: From Health Warning System to Potential Climate Change Impact Assessment

（極端溫度對大台北地區老年人心血管疾病死亡率增加的影響：從健康預警系統到氣候變遷的影響潛勢評估）

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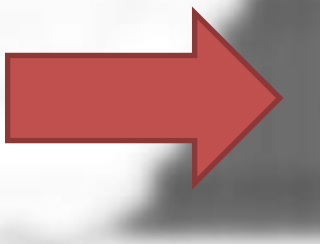
Background: CWB

Presentation Outline

Introduction

Methods & Results

Summary



Part 1: *Finding thresholds and constructing health warning system*

Part 2: *Sustained anomalous temperature*

Part 3: *Distribution of mortality in anomalous cold and hot events*

Part 4: *Assessment of climate change and its impact*

Background: Rey et al. (2007)

Introduction

Introduction

- Exposure to **anomalous** hot/ cold temperature => excessive deaths, especially **the elderly**.
- Ability to maintain temperature balance ↓ => risk of death↑ => death
- The **cardiovascular disease** of **the elderly** in **Taipei metropolitan**(Taipei City+ New Taipei City)

- Separated into 4 parts:

Part 1: *Finding* ***thresholds*** *and constructing* ***health warning system***

Part 2: ***Sustained(continuing)*** *anomalous temperature*

Part 3: ***Distribution*** *of mortality in* ***anomalous*** *cold and hot events*

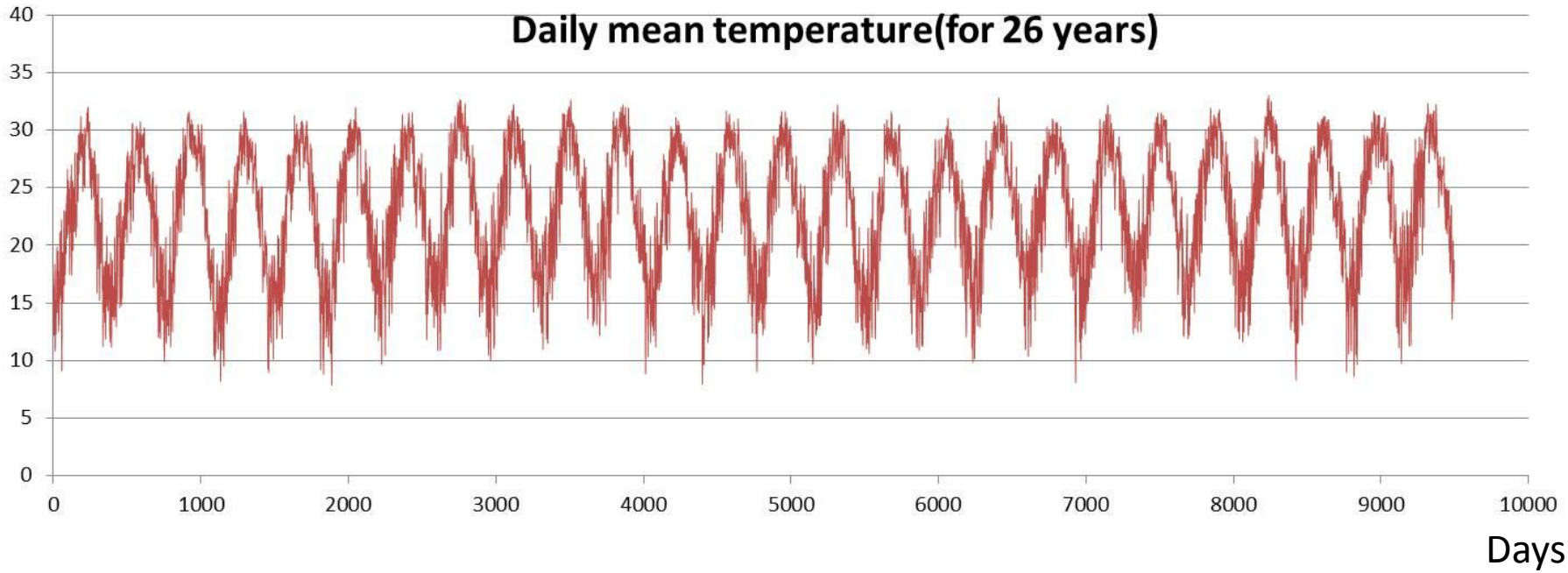
Part 4: ***Assessment*** *of climate change and its impact*

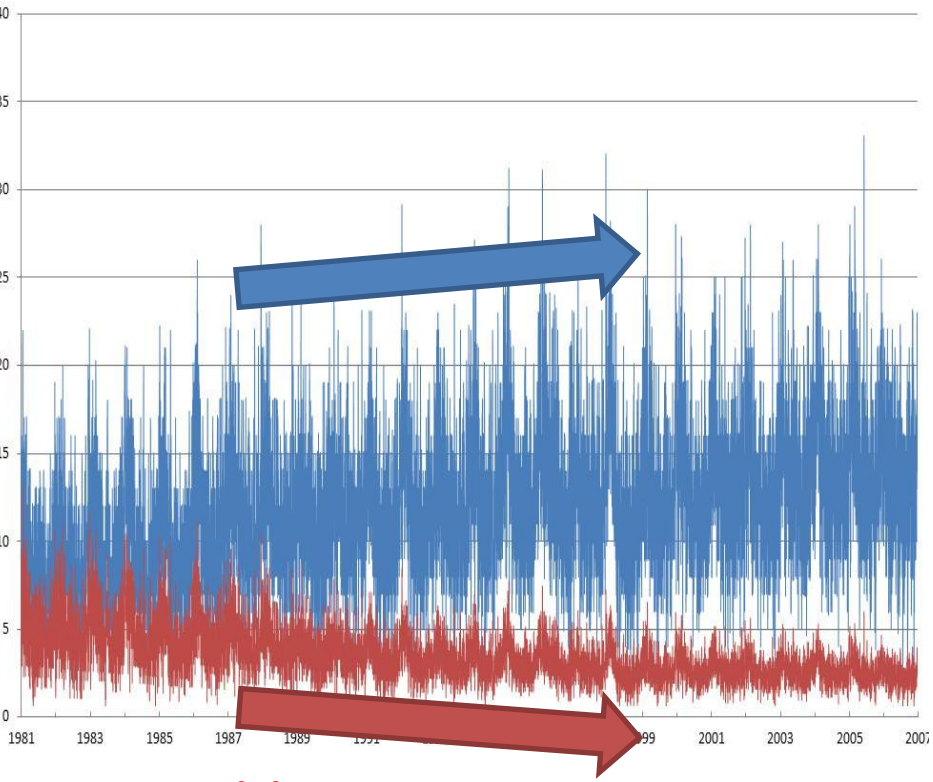
Methods & Results

Methods & results

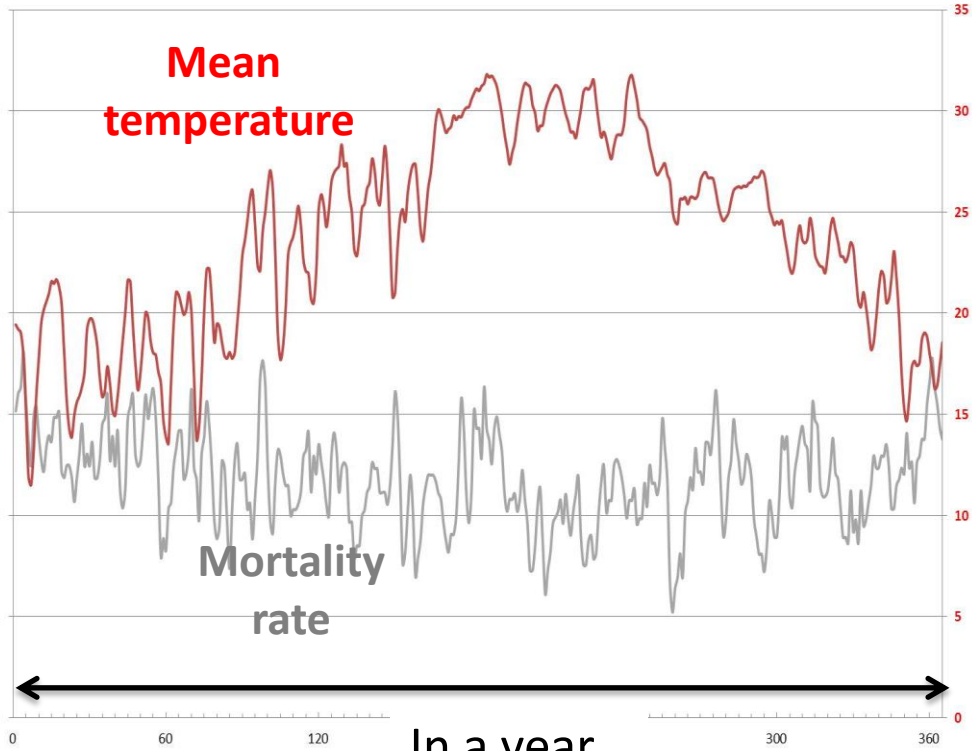
Data (from 1981 to 2006)

- ✓ Daily population and deaths due to cardiovascular disease of the elderly in Taipei
- ✓ Daily maximum and minimum temperatures at Taipei station





(1) Long-term trend of mortality rate



In a year

(2) Seasonal cycle of mortality rate

- Mortality anomaly ratio $= \dfrac{\text{Observed(actual) mortality rate}}{\text{Expected mortality rate}}$

- **Anomalous** hot/ cold temperature <=> excessive deaths?

★ Consider the contribution of long-term trend and seasonal cycle to mortality ratio as "common condition" (as expected)

Long-term trend + Seasonal cycle + **extreme temperature**

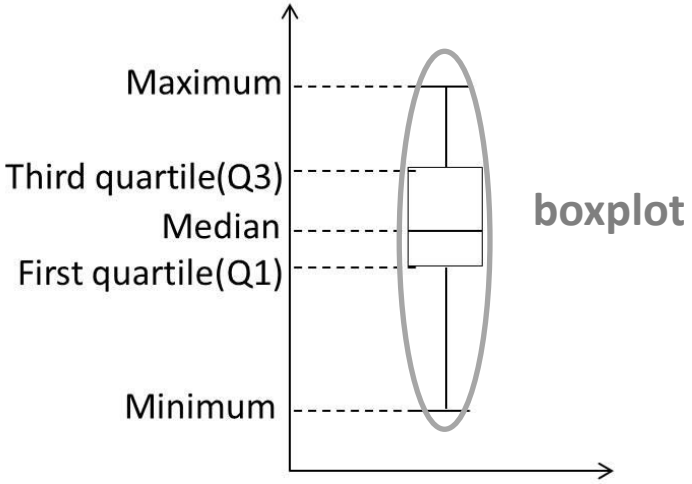
- Mortality anomaly ratio $= \dfrac{\text{Observed(actual) mortality rate}}{\text{Expected mortality rate}}$

Long-term trend + Seasonal cycle

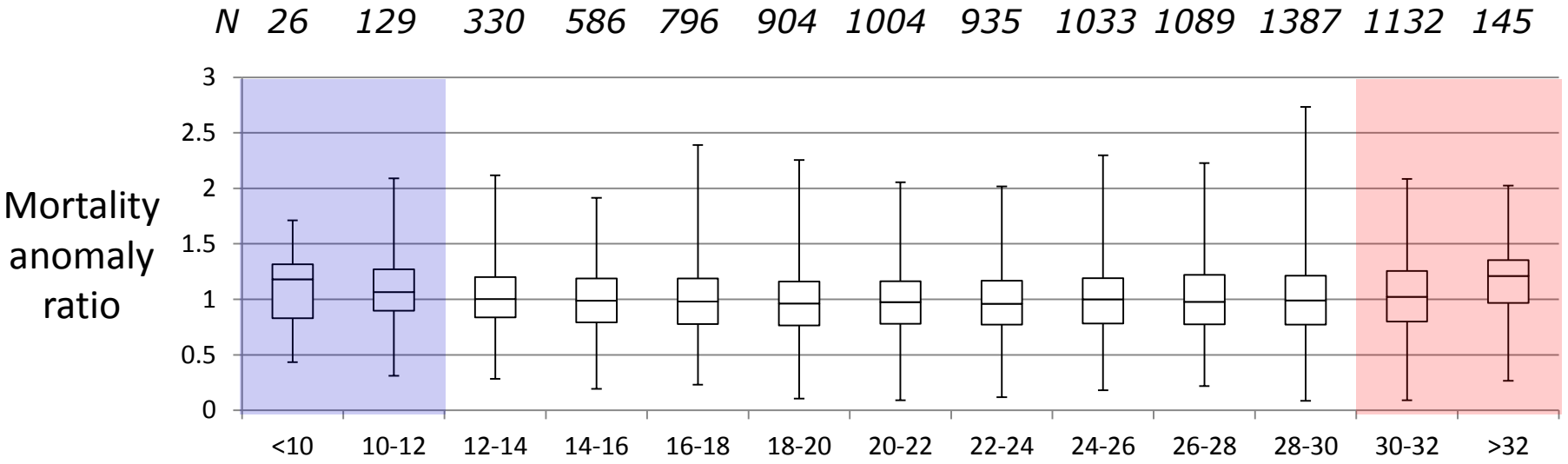
- Mean temperature $= \dfrac{\text{Yearly T}_{\max} + \text{Yearly T}_{\min}}{2}$

Part 1: Finding thresholds and constructing health warning system

- Methods
  - ✓ Put mortality anomaly ratio into different temperature bins to produce boxplot (inclueds mean T, Tmin, and Tmax)
  - ✓ Apply Mann-Whitney test (two ratio dstrb.)to find thresholds
  - ✓ Construct a threshold-based health warning system



- Results- Mean temperature (*calculated from yesterday's Tmax and today's Tmin*)



Mann-Whitney test :

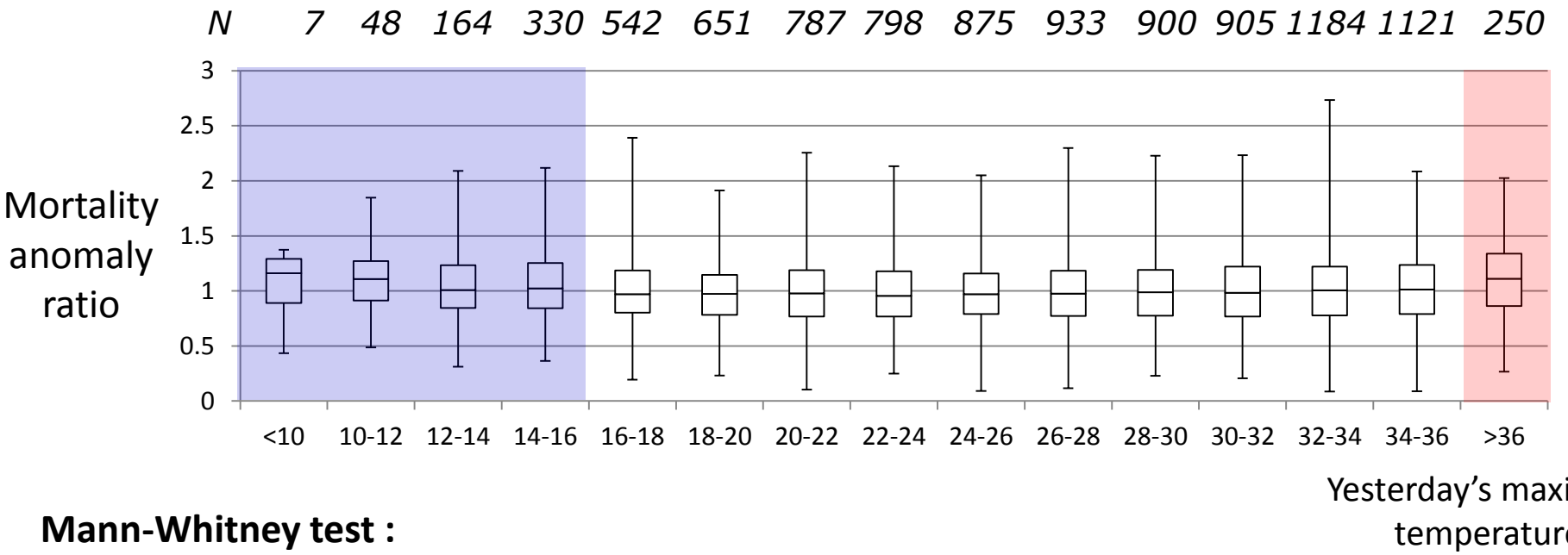
✓ Upper threshold: $30^{\circ}C$ (p=0.033<0.05). Excessive deaths per year: ~42 people

✓ Lower threshold: $12^{\circ}C$ (p=0.048<0.05). Excessive deaths per year: ~82 people

✓ Excessive deaths= (per year) [+ % of median when T>30] X [Avg. mortality rate] X [Population] X [Days of T>30 per year]

(1981-2000) (2010) (1981-2000)

- Results- Yesterday's maximum temperature



Mann-Whitney test :

✓ Upper threshold: $36^{\circ}C$ (p=0.0002<0.05). Excessive deaths per year: ~128 people

✓ Lower threshold: $16^{\circ}C$ (p=0.01<0.05). Excessive deaths per year: ~33 people

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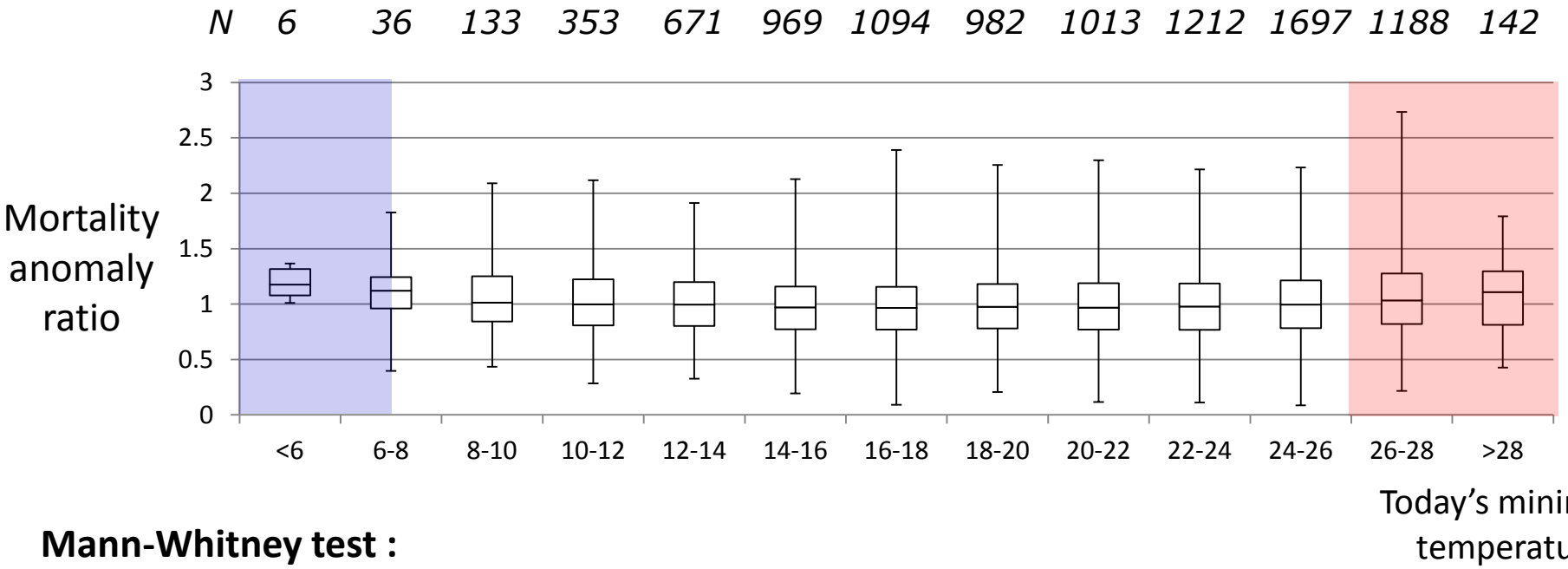
- Results- Today's minimum temperature



Mann-Whitney test :

✓ Upper threshold: $26^{\circ}C$ (p=0.002<0.05). Excessive deaths per year: ~44 people

✓ Lower threshold: $7^{\circ}C$ (p=0.033<0.05). Excessive deaths per year: ~132 people

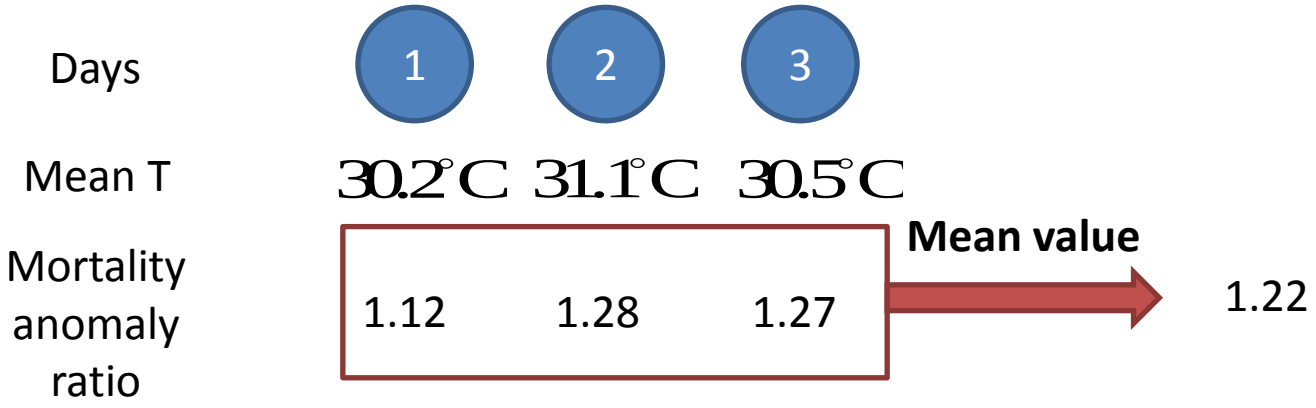
- Results- Health warning system

	Upper threshold	Lower threshold
Mean temperature	30°C	12°C
Yesterday's maximum temperature	36°C	16°C
Today's minimum temperature	26°C	7°C

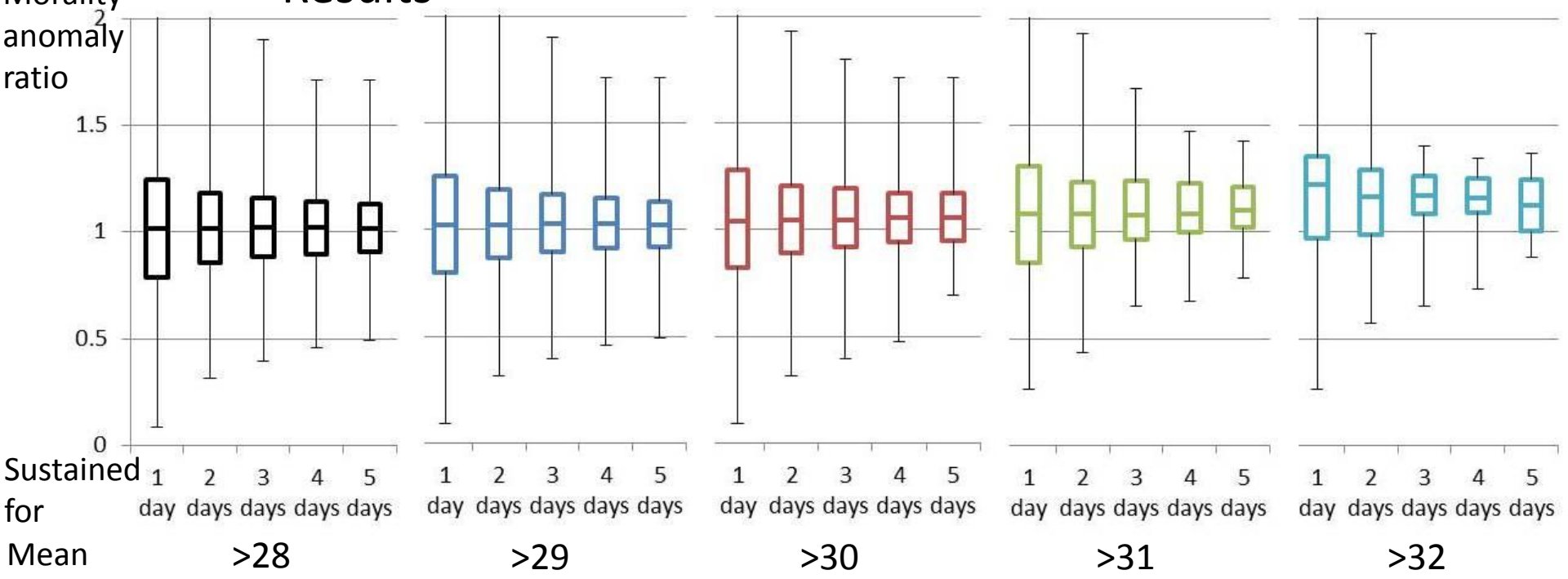
✓ To prevent from being sick or even dead

Part 2: Sustained(continuing) anomalous temperature

- Methods
  - ✓ Analysis on sustained cold condition isn't available.
  - ✓ Sustained hot condition:
    - T range: $28^{\circ}C$ to $32^{\circ}C$
    - Sustain for: 1day to 5 days
  - ✓ Example: Sustained for 3 days under T> $30^{\circ}C$



Part 2 ● Results



Increase % of median from expected mortality rate

	>28°C	>29°C	>30°C	>31°C	>32°C
1day	+1.4%	+2.2%	+3.8%	+8.4%	+22.4%
2days	+1.3%	+2.3%	+4.2%	+8.6%	+16.7%
3days	+1.9%	+2.5%	+4.7%	+7.7%	+17.3%
4days	+2.0%	+2.5%	+5.4%	+8.6%	+16.1%
5days	+1.8%	+2.2%	+5.8%	+10.0%	+12.6%

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Part 3: Distribution of mortality in anomalous cold and hot events

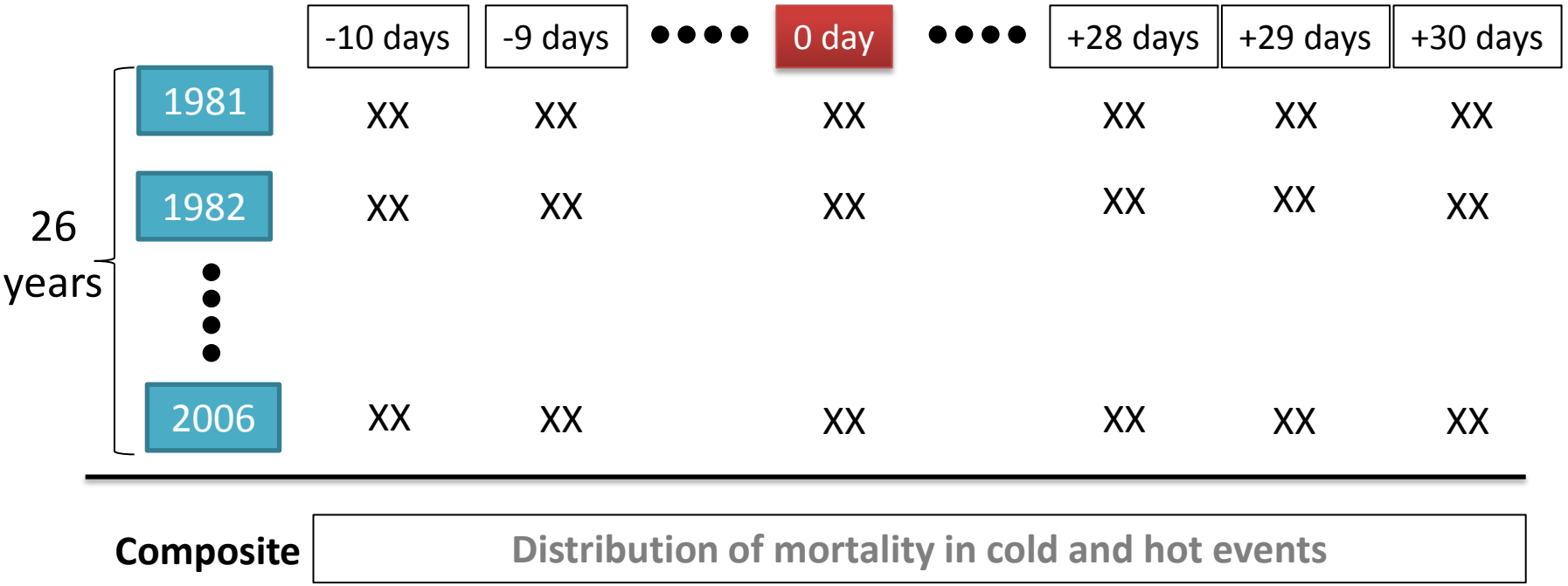
- Methods

(From 1981 to 2006)

✓ Pick up the day with highest and lowest mean T in each year→day 0 ("0 day"), ratio is known

✓ -10 days to +30 days

XX=(Mean T, ratio)



Composite Distribution of mortality in cold and hot events

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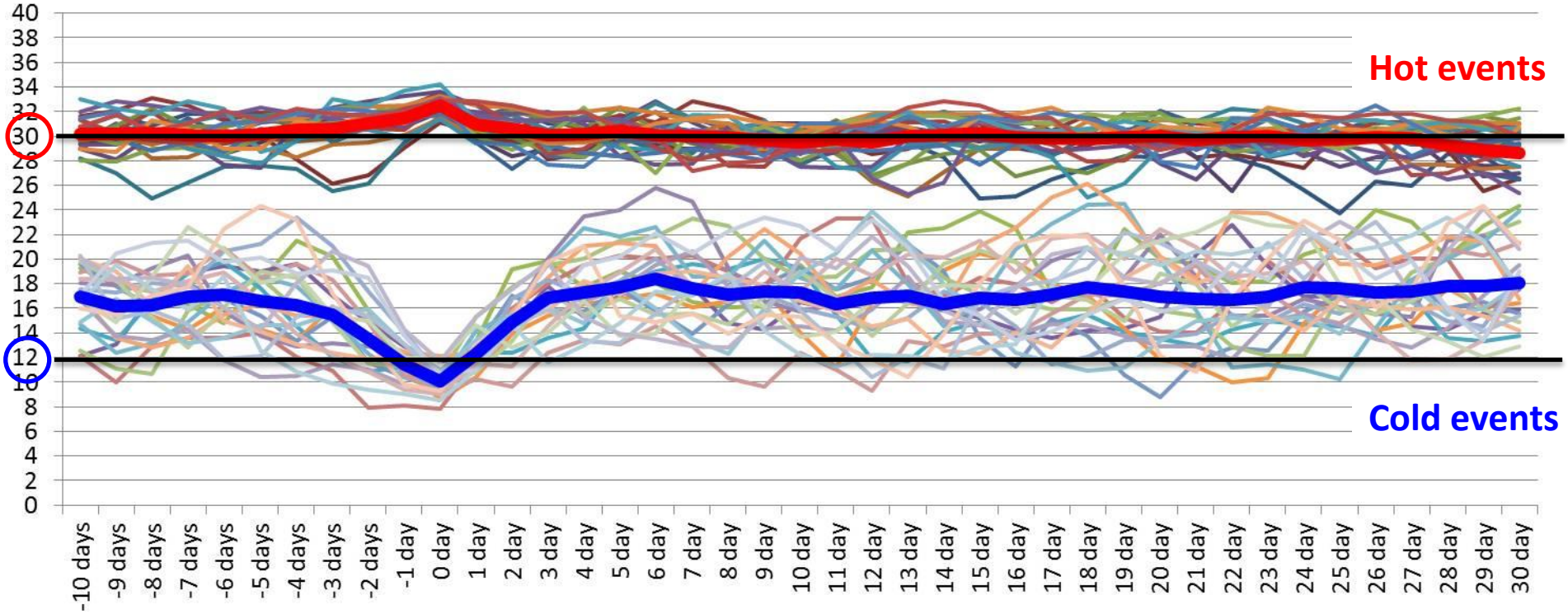
Mean T

Mean temperature profile



- Thresholds of mean T: $30^{\circ}C$ and $12^{\circ}C$
- **Hot events**: 46% of days, mean T> $30^{\circ}C$ (19/41)
- **Cold events**:5% of days, mean T< $12^{\circ}C$ (2/41)

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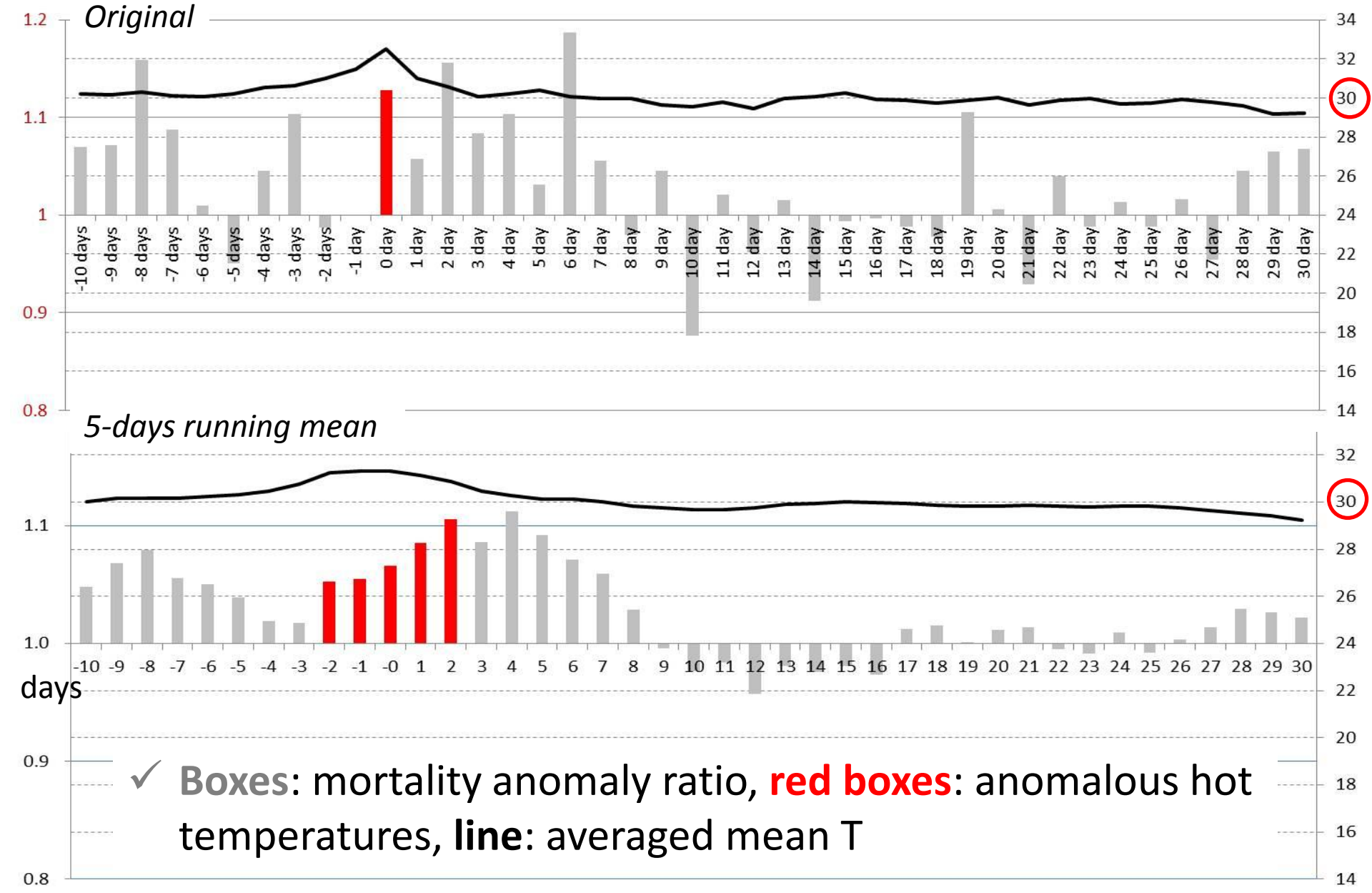
● Results- **annual hot events**



- ✓ **Boxes**: mortality anomaly ratio, **red boxes**: anomalous hot temperatures, **line**: averaged mean T

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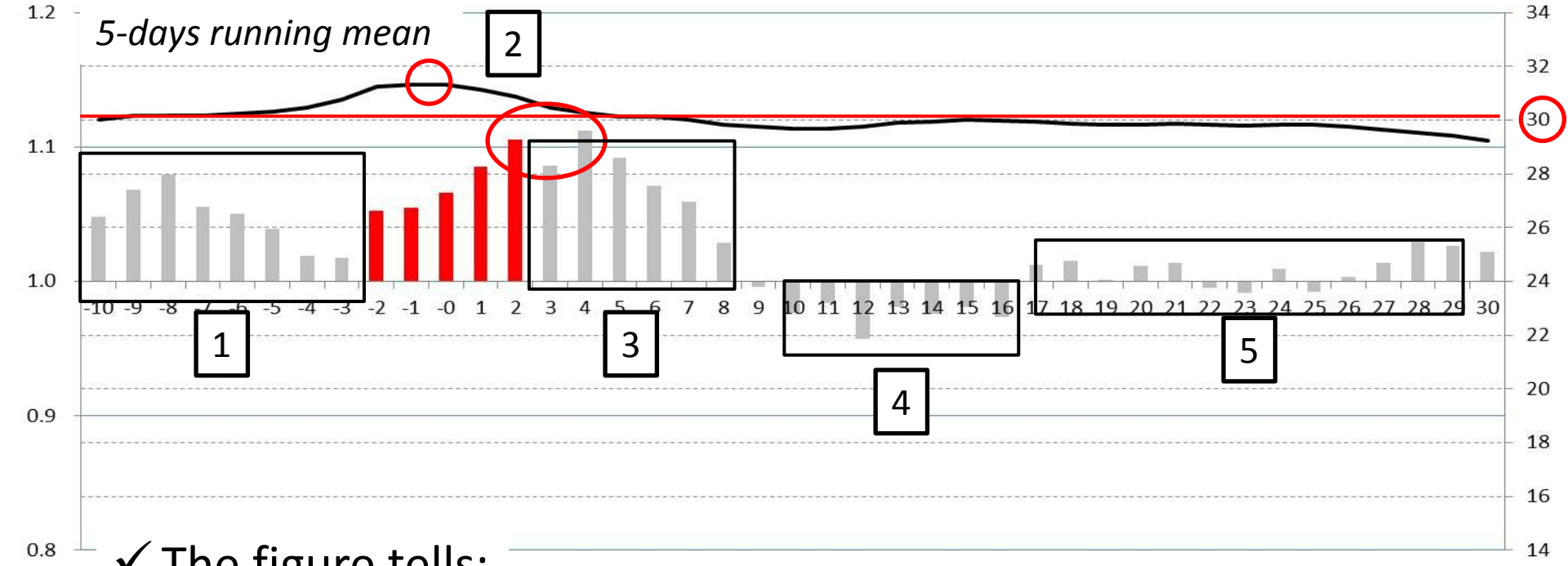

✓ The figure tells:

1. Ratio already >1 before "0 day" (which means highest T)
2. Max ratio lags behind max mean T for ~ 2 or 3 days
3. Ratio still >1 after highest T for ~7 days, but decreasing
4. Ratio remained <1 (~a week after highest T) for ~7 days
5. Ratio ~1

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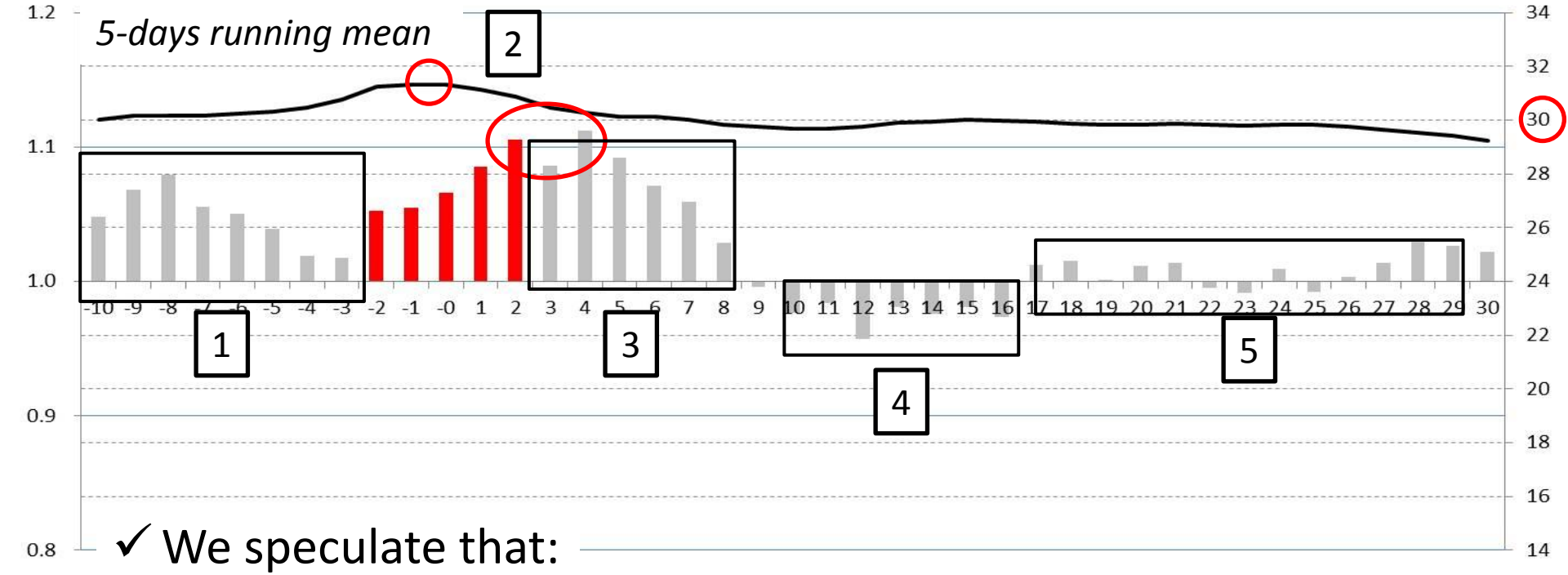

✓ We speculate that:

1. T already passed threshold($30^{\circ}C$) before highest T

2. (a) Regulation system needs some time to react (b) Good health service

3. (a)T remained high (b)Health condition varies with different people

4. ***Displacement effect*** (just a little): Advancement of mortality, rather than additional mortality, i.e. they died earlier as expected.

5. T falls below threshold($30^{\circ}C$)

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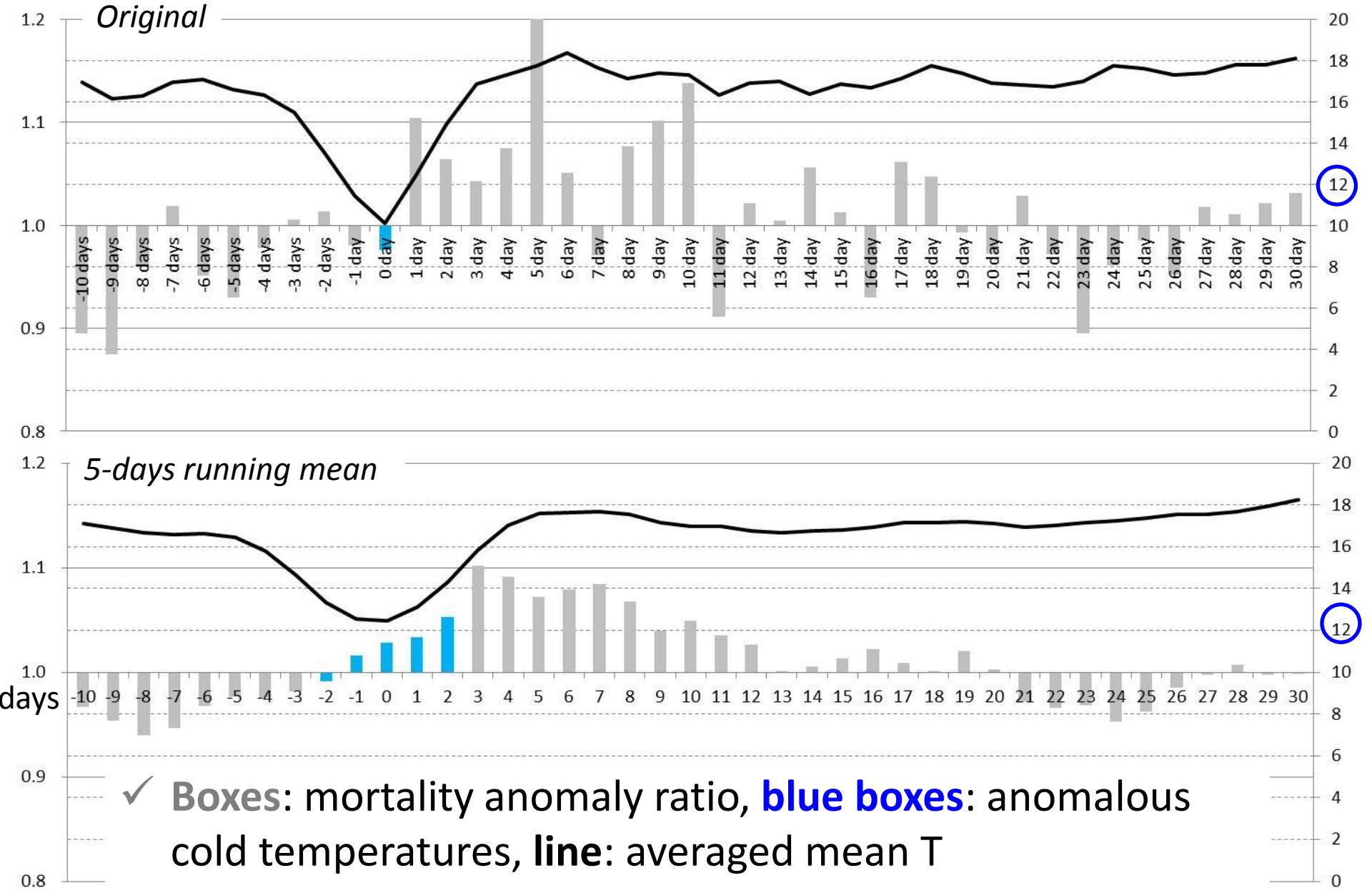
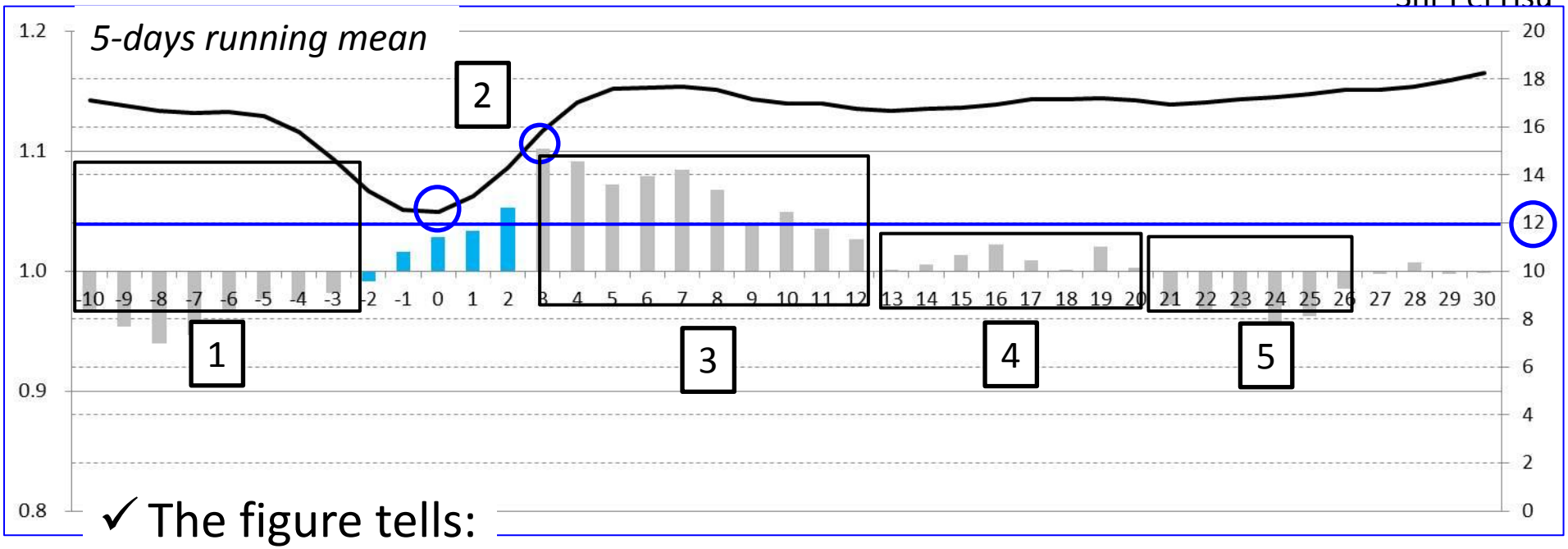
● Results- **annual cold events**



- ✓ **Boxes**: mortality anomaly ratio, **blue boxes**: anomalous cold temperatures, **line**: averaged mean T



✓ The figure tells:

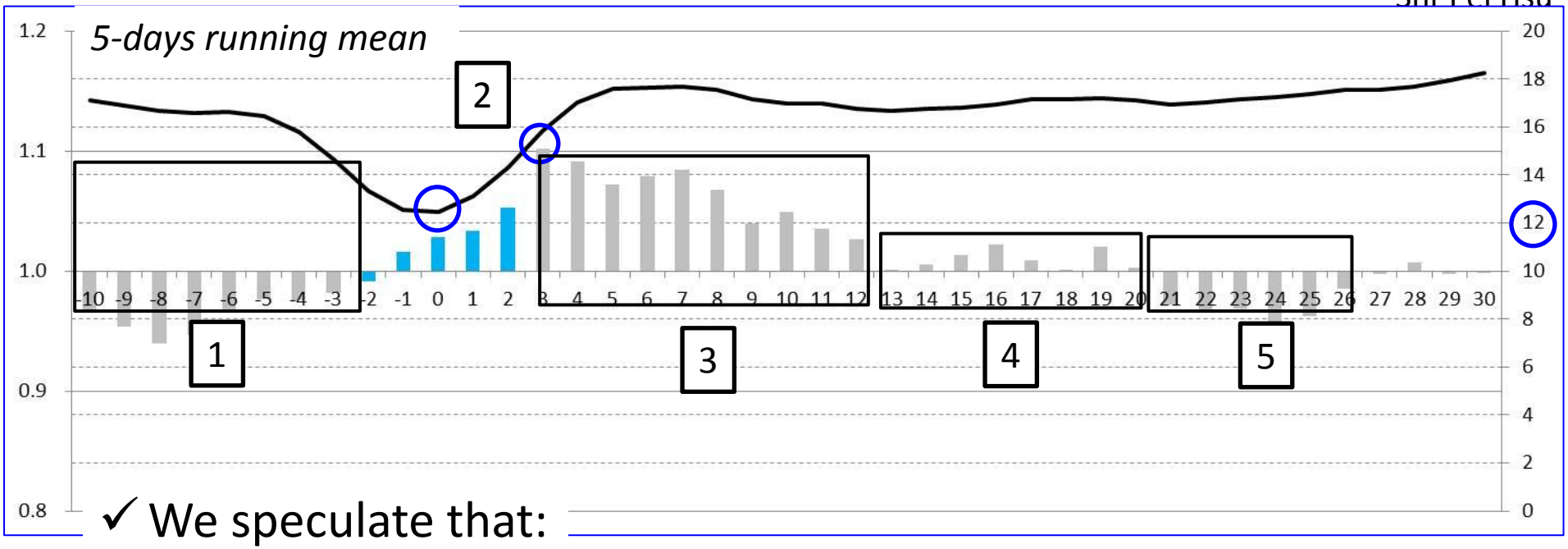
1. Ratio <1 before "0 day" (which means anomalous T)

2. (a) Ratio begins to rise when T gets anomalous cold
   (b) Max ratio lags behind min T for ~3 days

3. Ratio still >1 for ~10 days even when T went optimum, but decreasing

4. Ratio ~1

5. ***Displacement effect*** (just a little)



✓ We speculate that:

1. Under optimum T

2. (a) Regulation system needs some time to react (b) Good health service

3. Health condition varies with different people

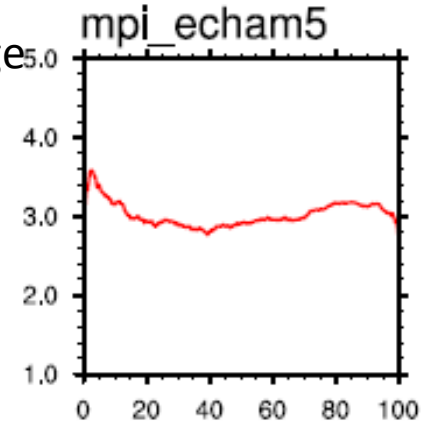
4. T went moderate for some days

5. ***Displacement effect*** (just a little): They died earlier as expected

Part 4: Assessment of climate change and its impact

- Goal: Under impact of climate change, estimate excessive deaths
- Methods

T change



At the end of this century
2080~2100

✓ **Present** climate: Pct of $30^{\circ}C$: ~87th => ~13% chance of T>30 ~47 days/year

✓ **Future** climate: Pct of $30^{\circ}C$: ~69th => ~31% chance of T>30 ~113 days/year

✓ Excessive deaths= (per year under climate change)

Excessive deaths per year (in present climate) X $\frac{\text{Population' (future)}}{\text{Population (present)}}$ X $\frac{\text{Days' of T>30 (future)}}{\text{Days of T>30 (present)}}$

Climate change + population ↑

- Results *(2080-2100)*

model ID	Pct of 30C	Chance of T >30	Days of T>30 per year	Additional days of T>30 per year	Excess deaths per year
bccr_bcm2_0	0.72	0.28	102	55	274
cccma_cgcm3_1_t63	0.695	0.305	111	64	298
cnrm_cm3	0.71	0.29	106	58	283
csiro_mk3_0	0.743	0.257	94	46	251
csiro_mk3_5	0.693	0.307	112	65	300
gfdl_cm2_0	0.662	0.338	123	76	330
gfdl_cm2_1	0.664	0.336	123	75	328
iap_fgoals1_0_g	0.725	0.275	100	53	269
ingv_echam4	0.723	0.277	101	54	271
miroc3_2_hires	0.622	0.378	138	91	370
miroc3_2_medres	0.664	0.336	123	75	328
mpi_echam5	0.666	0.334	122	74	327
mri_cgcm2_3_2a	0.69	0.31	113	66	303
Average	**0.691**				**303**

Climate change VS Growth of pop.

Pop 2010: ~646500
Pop 2090: ~1946500

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Condition	**Present(2010)**	**Future (2080-2100)**		
Consider…	(For all, if T>30)	Only population ↑	Only climate change	Climate change + population ↑
Excessive deaths per year	42	127	91	274
	42	127	99	298
	42	127	94	283
	42	127	83	251
	42	127	100	300
	42	127	110	330
	42	127	109	328
	42	127	89	269
	42	127	90	271
	42	127	123	370
	42	127	109	328
	42	127	108	327
	42	127	101	303
Average	**42**	**127**	**100**	**303**

Summary

Summary

Part 1: Finding thresholds and constructing health warning system

	Upper threshold	Lower threshold
Mean temperature	30°C	12°C
Yesterday's maximum temperature	36°C	16°C
Today's minimum temperature	26°C	7°C

- ✓ These are the thresholds we've found, if temperature reaches these thresholds, mortality rate increases significantly (in statistics).
- ✓ When predicted temperature reaches the thresholds above, health warning system is responsible to give warning to the elderly before anomalous temperature occurs.

Part 2: Sustained(continuing) anomalous temperature

Excessive deaths per year in present climate (people)

	> 28°C	> 29°C	> 30°C	> 31°C	> 32°C
1 day	+16	+26	+44	+97	+260
2days	+15	+27	+49	+100	+194
3days	+22	+29	+54	+89	+201
4days	+23	+29	+63	+100	+187
5days	+21	+26	+67	+116	+146

- ✓ For the same threshold, the excessive deaths increases with sustained days
- ✓ Excessive deaths increases substantially when mean temperature reach above threshold, i.e. 30C

Part 3: Distribution of mortality in anomalous cold and hot events

	Annual hot events	Annual cold events
Before anomalous T	• Ratio >1	• Ratio <1
During anomalous T	• Ratio begins to rise. • Max ratio lags highest T ~2 to 3 days.	• Ratio begins to rise. • Max ratio lags lowest T ~2 to 3 days.
After anomalous T	• Ratio remains >1 for ~ 7 days	• Ratio remains >1 for ~ 10 days
Displacement effect	A little. Occur ~20 days after anomalous hot T	A little. Occur ~10 days after anomalous cold T

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Part 4: Assessment of climate change and its impact

- ✓ **Present** climate: Pct of $30^\circ C$: ~87th => ~13% chance of T>30 ~47 days/year
- ✓ **Future** climate: Pct of $30^\circ C$: ~69th => ~31% chance of T>30 ~113 days/year

Condition	Present(2010)	Future (2080-2100)		
Consider…	(For all, if T>30)	Only population ↑	Only climate change	Climate change + population ↑
Averaged excess deaths	**42**	**127**	**100**	**303**

- ✓ At the end of this century, excessive deaths per year will be 7.14 times as large as the one in present due to climate change and growth of population of the elderly
- ✓ Compare the influence of *growth of population* and *climate change*, the former (3.02 times) is larger than the latter (2.38 times

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Thanks for your attention