



Changes in heat-attributable deaths in Prague, Czech Republic, over 1982–2019

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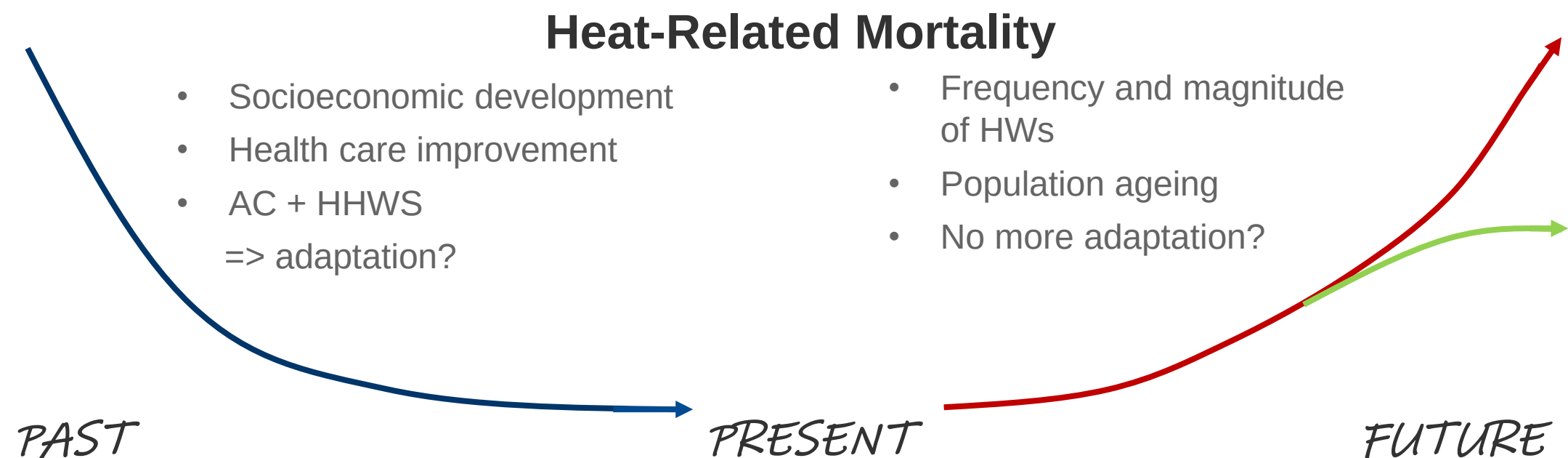
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Motivation – heat-related mortality paradox

- Heatwaves represent one of the major atmospheric hazard regarding the impacts on human health.
- In association with the climate change, increased frequency and magnitude of heatwaves are projected in Europe for the 21st century
- Paradox between observational and future-modelling studies



Data and goals

- **DATA:**
- 38 years of daily all-cause mortality data in Prague (1982–2019)
- Daily temperature (T_{avg}) records from Prague-Ruzyně airport
- **GOAL:**
- to analyse temporal changes in heat-related mortality over almost 4 decades
- 5 warmest months (May–September) in 1980s, 1990s, 2000s, 2010s

Methods – R-package *dlnm*

- Conditional Poisson regression in Distributed Lag Non-linear Model (**DLNM**):

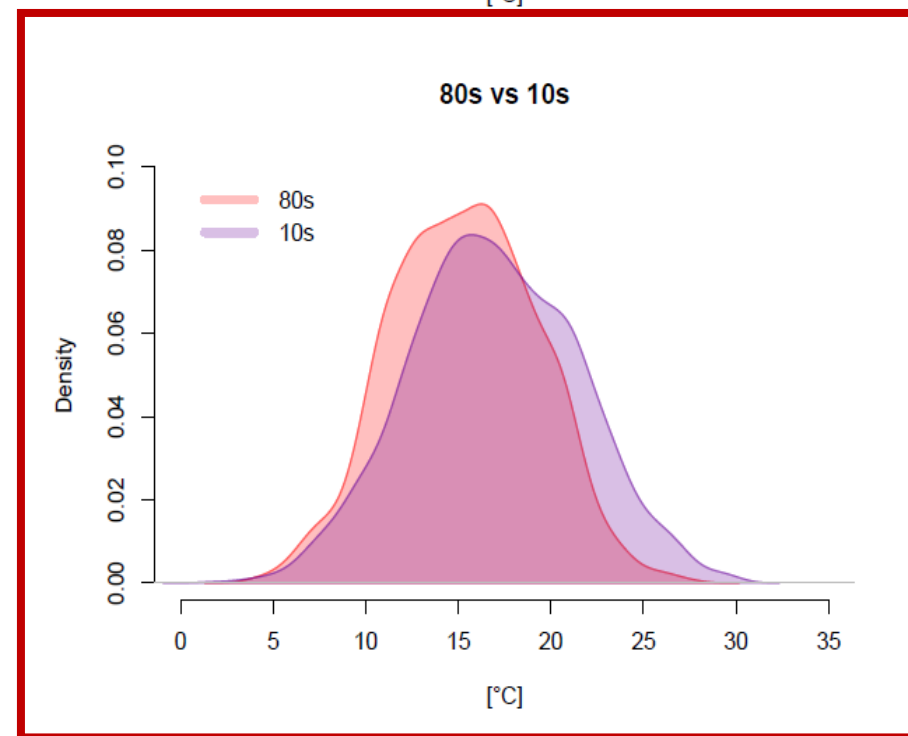
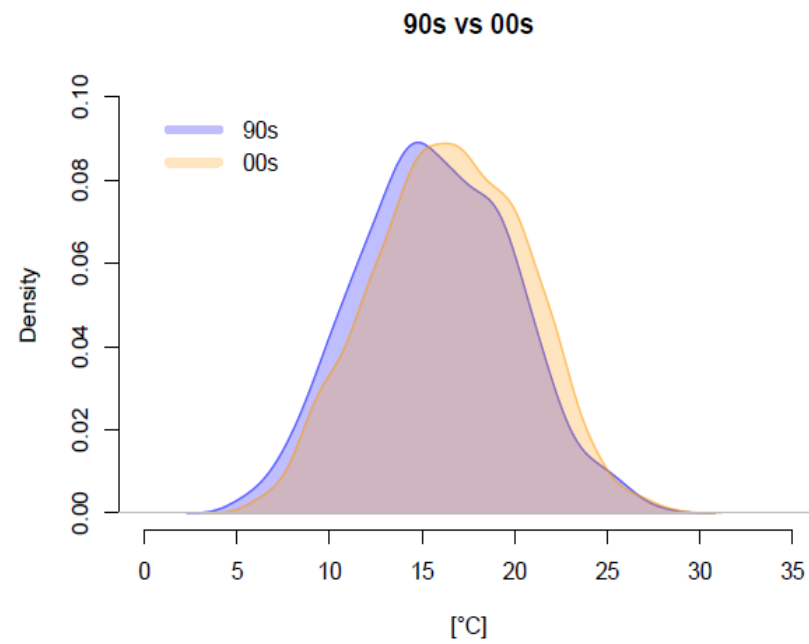
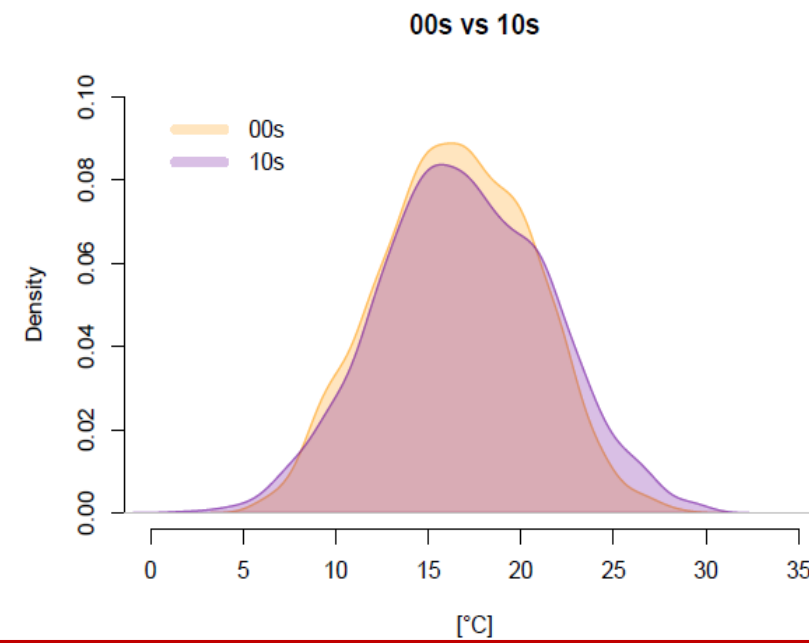
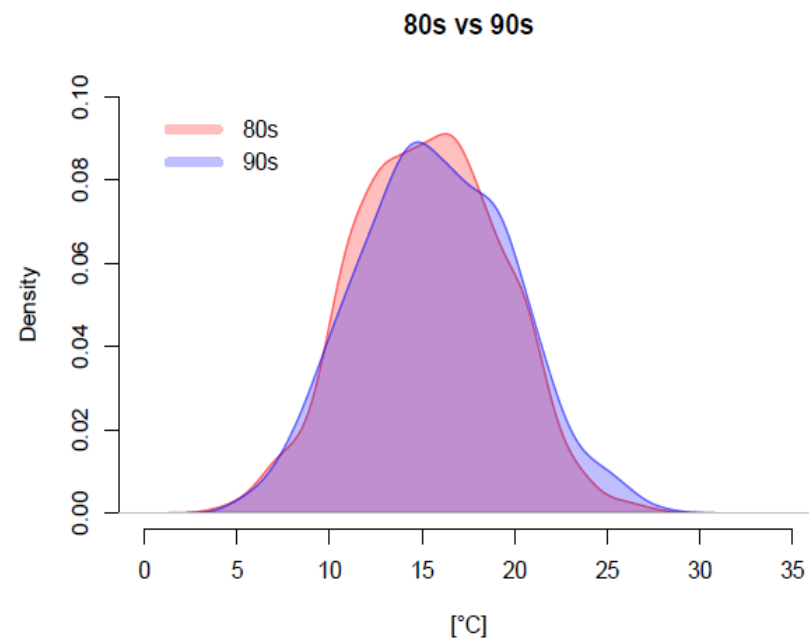
$$\text{Log}(\mu_t) = \alpha + \beta \text{Crossbasis} + \lambda \text{Stratum}_t$$

- *Crossbasis* = the non-linear and delayed effect of temperature (Gasparri et al. 2015)
 - Tavg – a quadratic B-spline with one internal knot placed at the 75th percentile of season-specific temperature distributions.
 - Lag variable – a natural cubic B-spline with two internal knots placed at equally spaced values in the log scale; 10 day lag.
 - **Calculates the relative risk (RR) of mortality considering the lagged effect of Tavg up to 10 days**
- *Stratum* = indicator variable composed of year, month, and day of the week (Year:Month:DOW) to control for long-term and seasonal trends (Fonseca-Rodriguez et al. 2020)

Methods – R-package *FluMoDL*

- From RRs - attributable number of deaths (ADs) and the attributable fraction (AF %) of total May–September deaths on hot days were calculated for each decade and each year.
(Gasparri and Leone 2014)
- **Hot days** - daily mean temperature larger than the 95th percentile of the May–September Tavg distribution.
- Heat Wave Index (**HWI**) – sum of temperature deviations above the 95th percentile on hot days

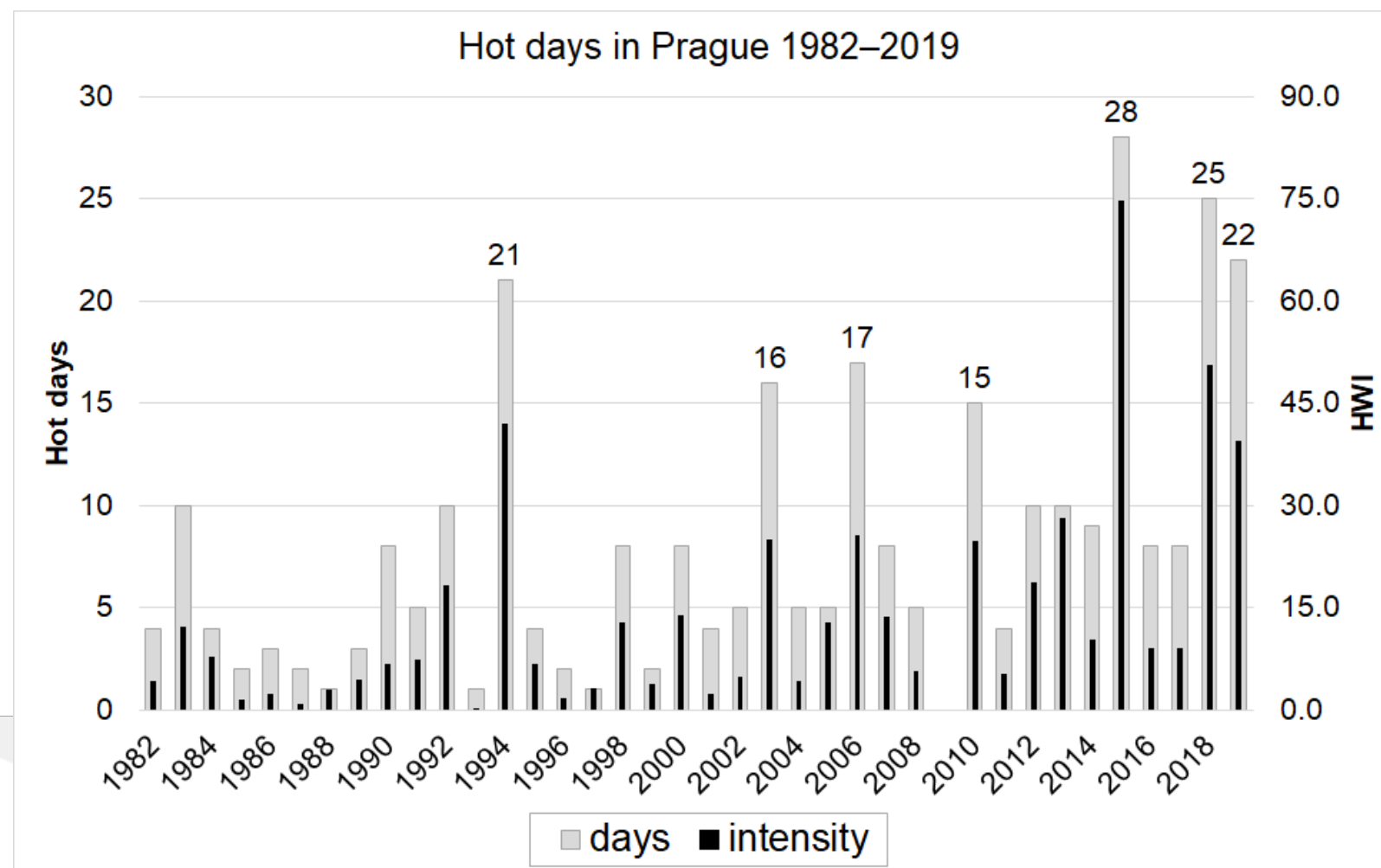
Results – Tavg distribution in Prague (May-Sept)



Results – frequency and intensity of heatwaves

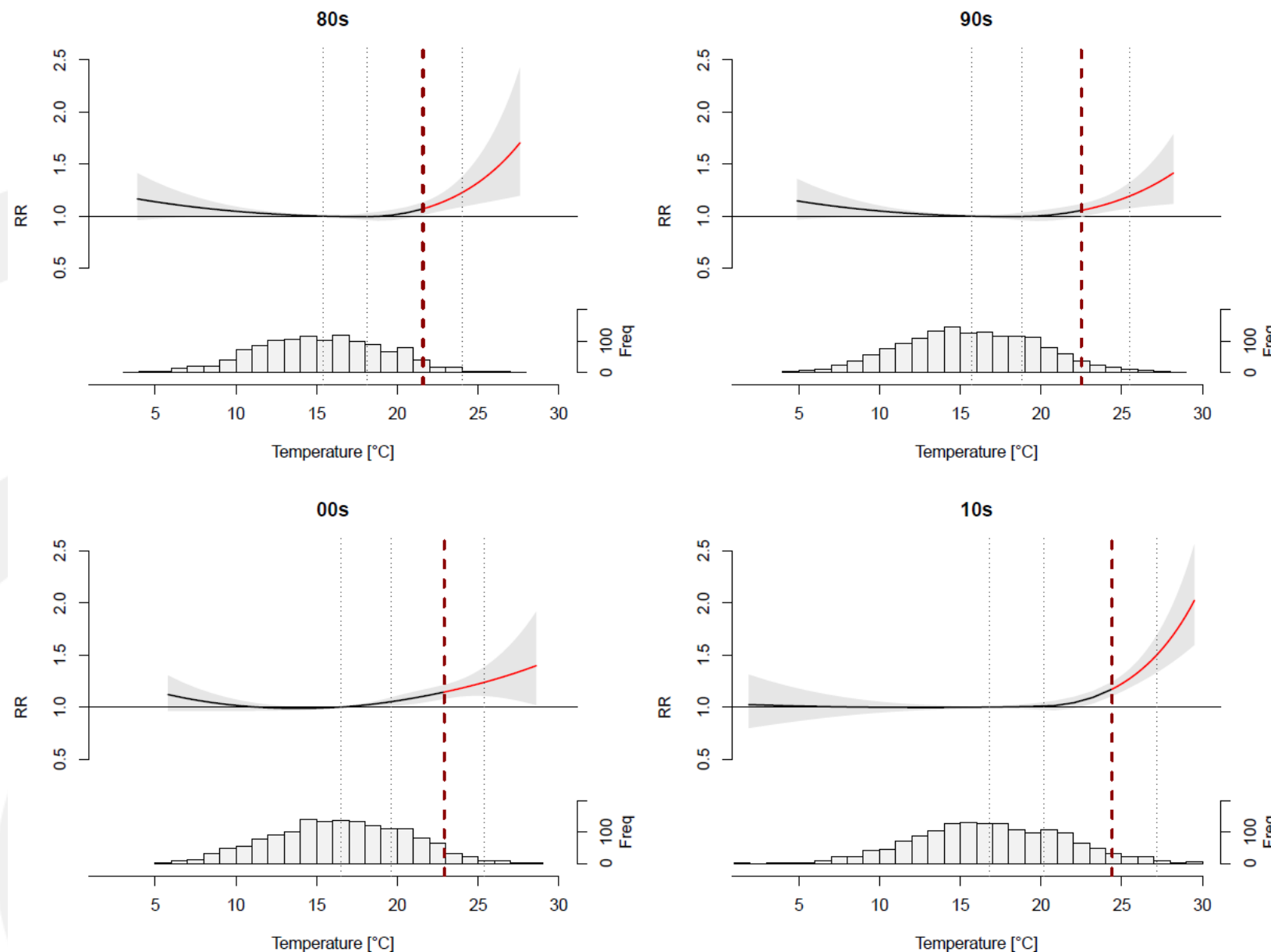
- Hot day – 95th percentile of T_{avg} in May–September 1982–2019
- HW = at least 2 consecutive hot days

	Hot days	Mean HW duration (days)	Mean HW number	T_{summer} (°C)	HWI per year
1980s	29	2.6	1.3	15.3	4
1990s	62	5.1	1.9	15.7	9
2000s	73	5.1	1.9	16.5	9
2010s	139	11.0	3.3	16.9	25



Results – temperature-mortality relationships

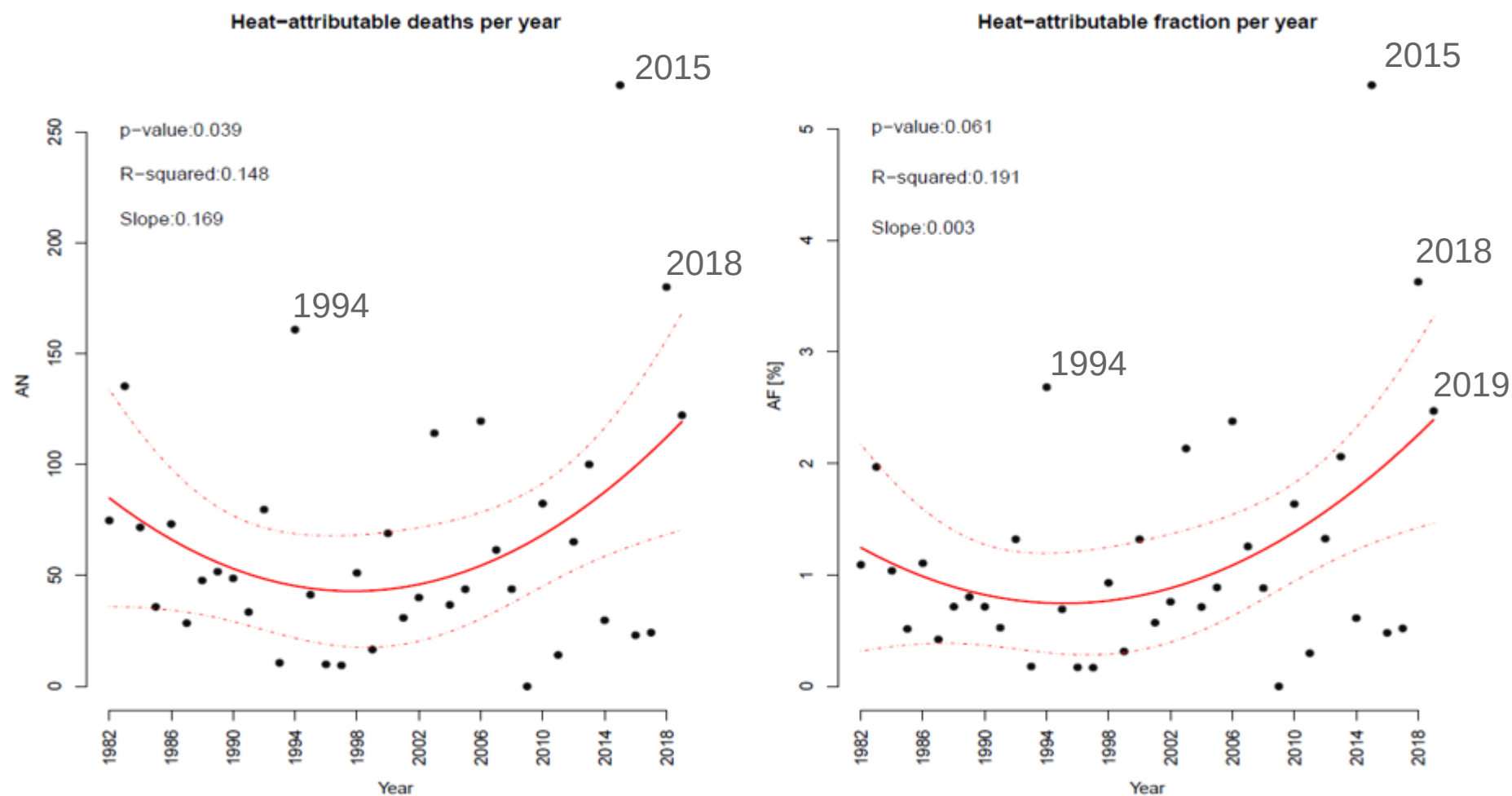
decade-specific temperature thresholds!



- Associations between RR centred at the 50th percentile of the temperature distribution.
- Histograms represent the daily mean temperature distribution in May-September.
- Grey vertical lines denote the 50th, 75th and 99th percentile of the temperature distribution.
- **Dark red vertical** lines denote the **95th percentile** of the temperature distribution.

Results – trends in heat-attributable fraction

- Heat-attributable deaths (AN) and attributable fraction (%) of total May-September deaths on hot days in each year
- Hot days defined according to the decade-specific thresholds!



Results – summary

Hot days defined for each decade separately!

RR difference

	hot days	Tmean	HWI per year	RR (Q99)	AN	AN per year	AF (%)
1980s	62	23.1	12	1.22 (1.09, 1.37)	487	61	0.90
1990s	79	24.3	15	1.19 (1.08, 1.32)	434	43	0.73
2000s	79	24.4	12	1.24 (1.11, 1.39)	526	53	1.03
2010s	88	25.8	16	1.50 (1.33, 1.69)	856	86	1.75

Decades	p-value
90s vs 80s	0.83
00s vs 80s	0.80
10s vs 80s	0.06
00s vs 90s	0.55
10s vs 90s	0.04
10s vs 00s	0.08

- Quadratic trend in the number of deaths attributable to heat
- Maximum in the 2010s and minimum in the 1990s
- The total number of heat-attributable deaths increased from ≈ 60 to almost 90 per year between the **1980s** and the **2010s**
- corresponds to the fraction of **0.90** and **1.75** %, respectively, of the total number of deaths in the May–September season.
- Reversal of heat-attributable mortality?

Thanks for your attention!



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