Understanding heat related mortality

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Motivation

- This project is about building the evidence and technological base for a future climate service for the health sector.
- The need for this service is clear. Around 9% of total mortality in the UK can be attributed to non-optimal temperatures (Gasparrini et al., 2015, doi:10.1016/S0140-6736(14)62114-0).
- Currently this mortality is predominantly associated with cold weather, but by 2050 many studies anticipate a doubling or tripling in heat-related mortality (e.g. Hajat et al., 2013, 10.1136/jech-2013-202449)

As we move through the presentation emphasise new capability/datasets

Dissemination – EPHSS (Environmental Public Health Surveillance System)

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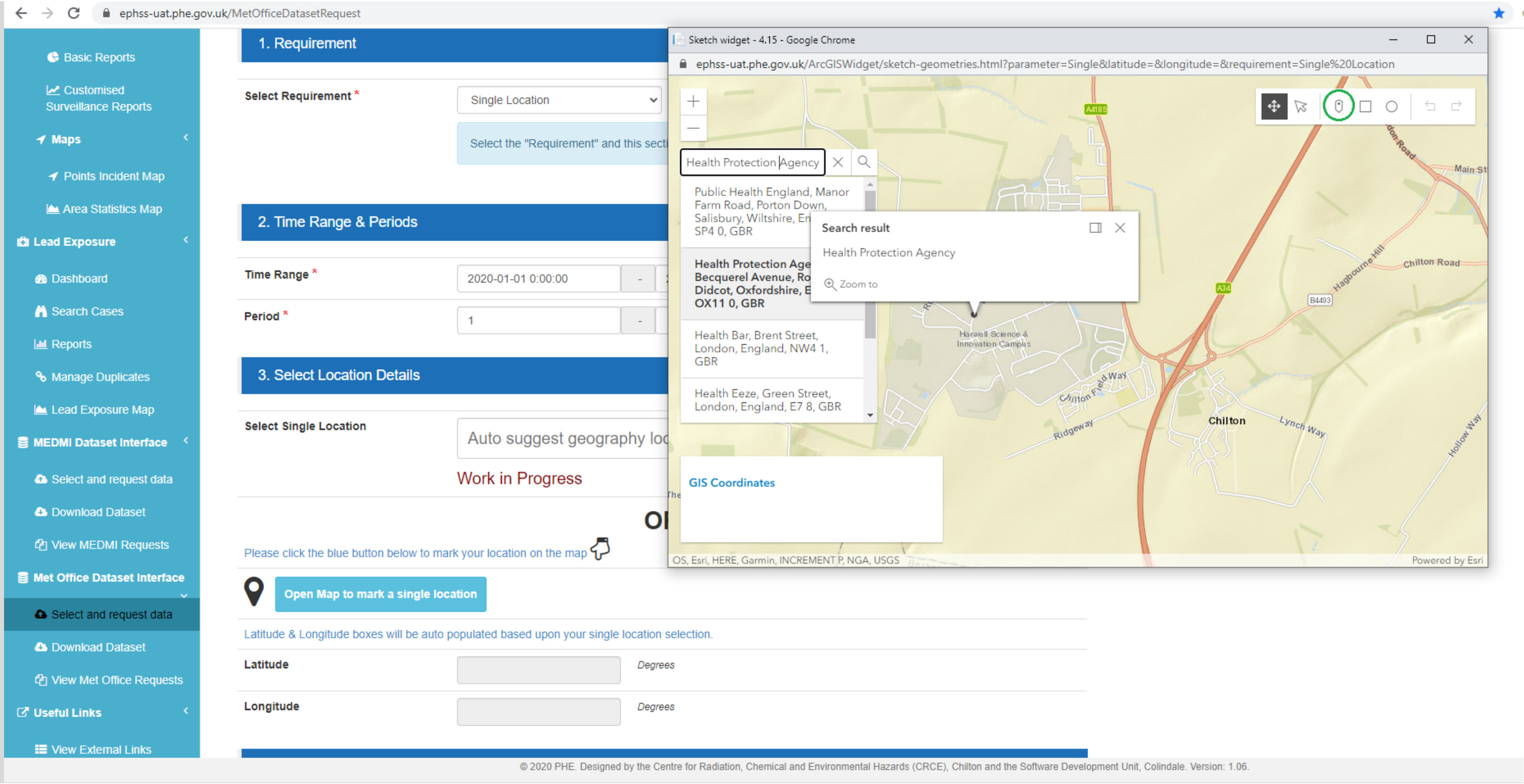
Public Health England (PHE) and Met Office **joint national capability** for the dissemination of climate data:

- A graphical interface
- Development due to be completed end 2020
- Access open to other public health agencies and researchers 2021

https://www.gov.uk/government/publications/environmental-public-health-surveillance-system/environmental-public-health-surveillance-system-ephss



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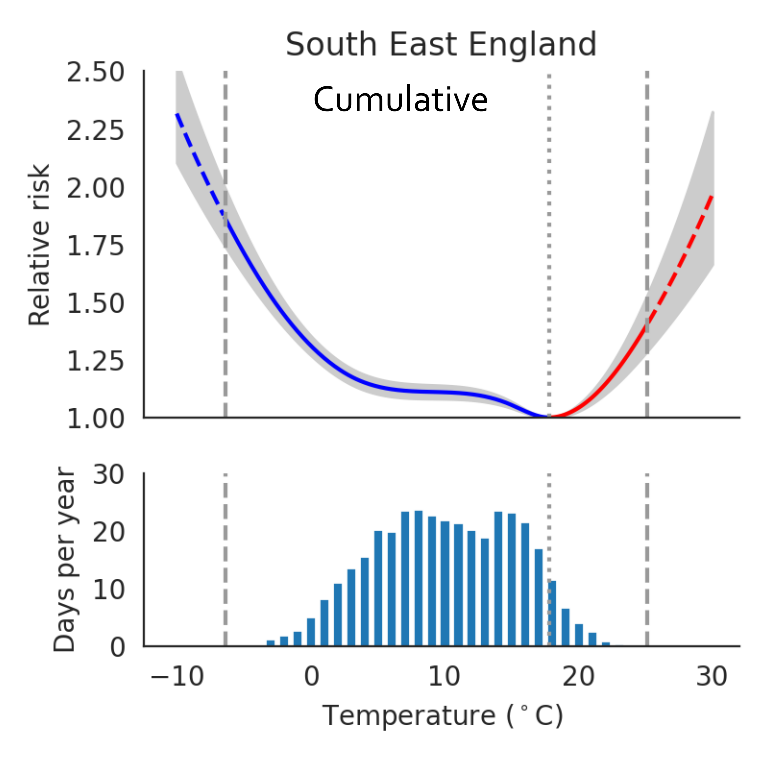
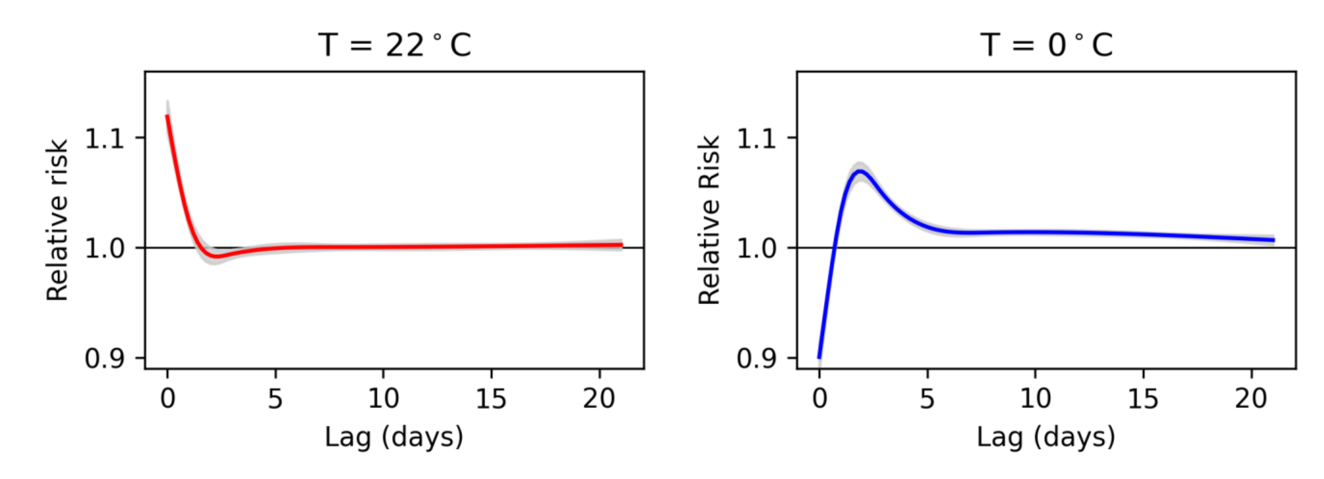
Temperature-lag-mortality model



- Distributed lag non-linear model (21 days lag)

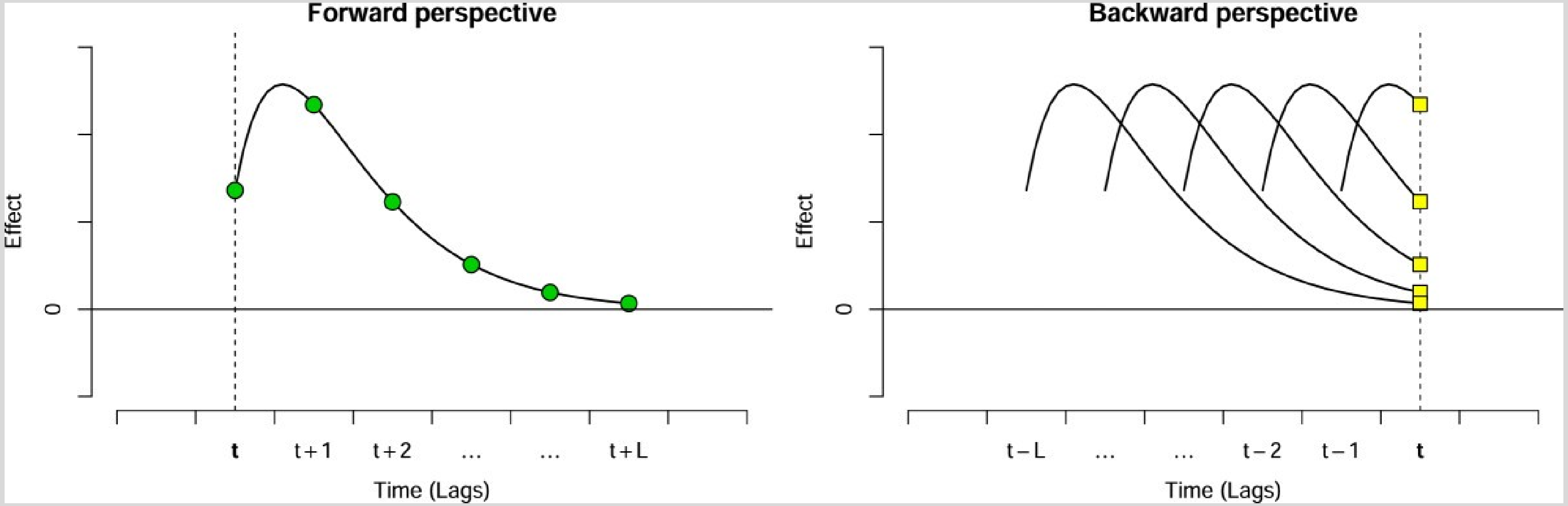
(e.g. Vicedo-Cabrera et al. 2019, doi: 10.1097/EDE.0000000000000982)

- 1991-2018
- Analysed on a UK regional basis (9 in England + Scotland, Northern Ireland, Wales)



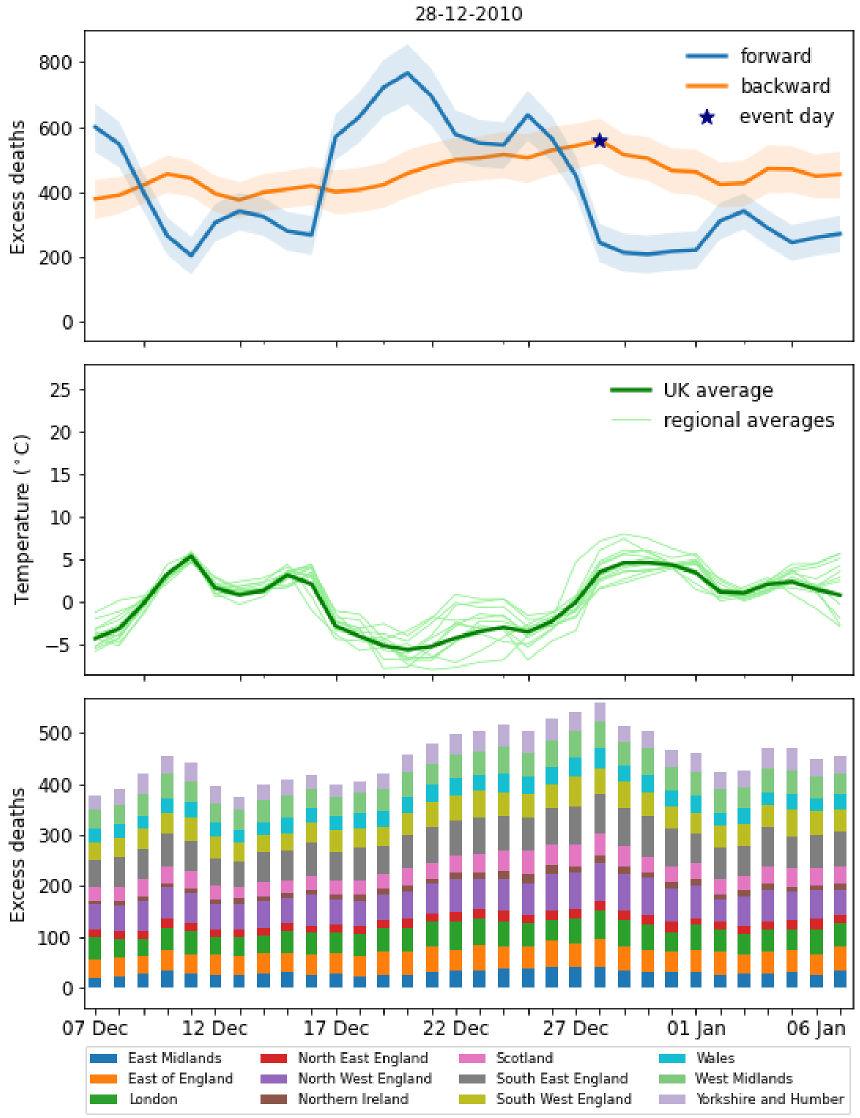
Forward vs. backward perspectives

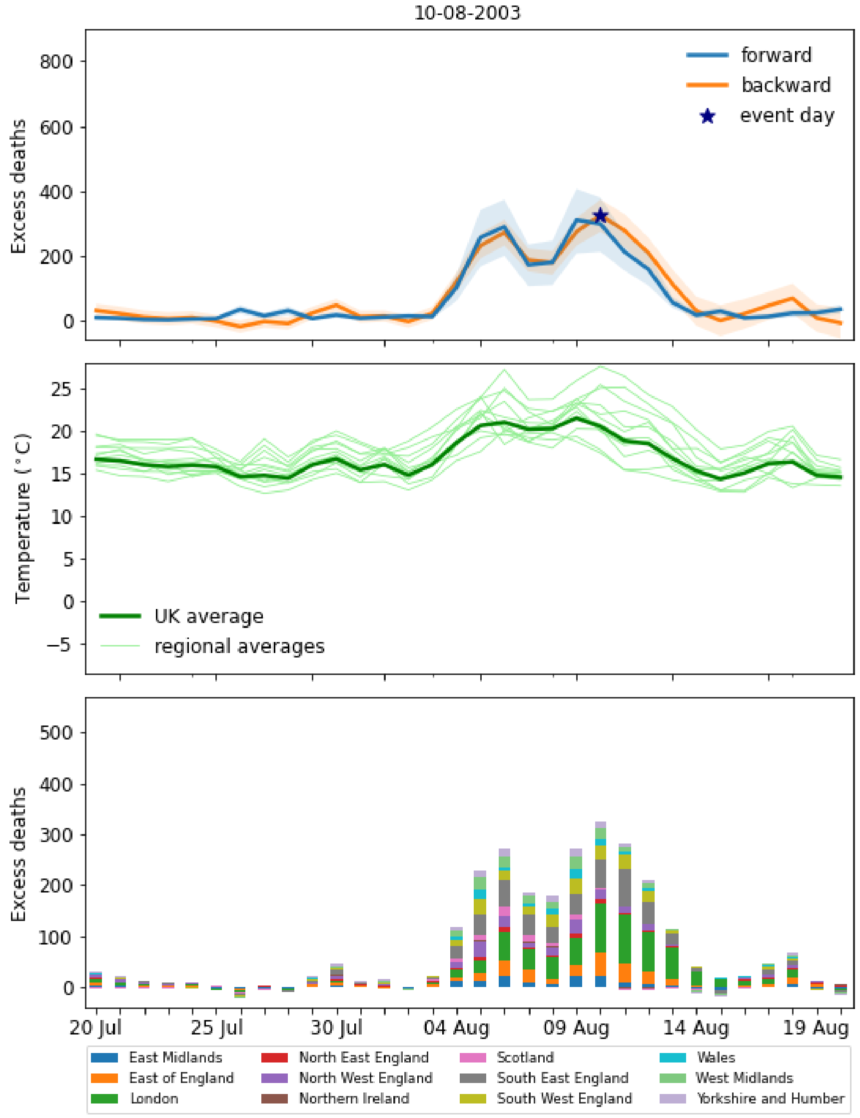
- **Forward**: present and future deaths associated with this day's temperature exposure (i.e. cumulative risk)
- **Backward**: deaths on this day associated with past and present temperature exposures



From Gasparrini and Leone, 2014, doi: 10.1097/EDE.0000000000000982

Example mortality events



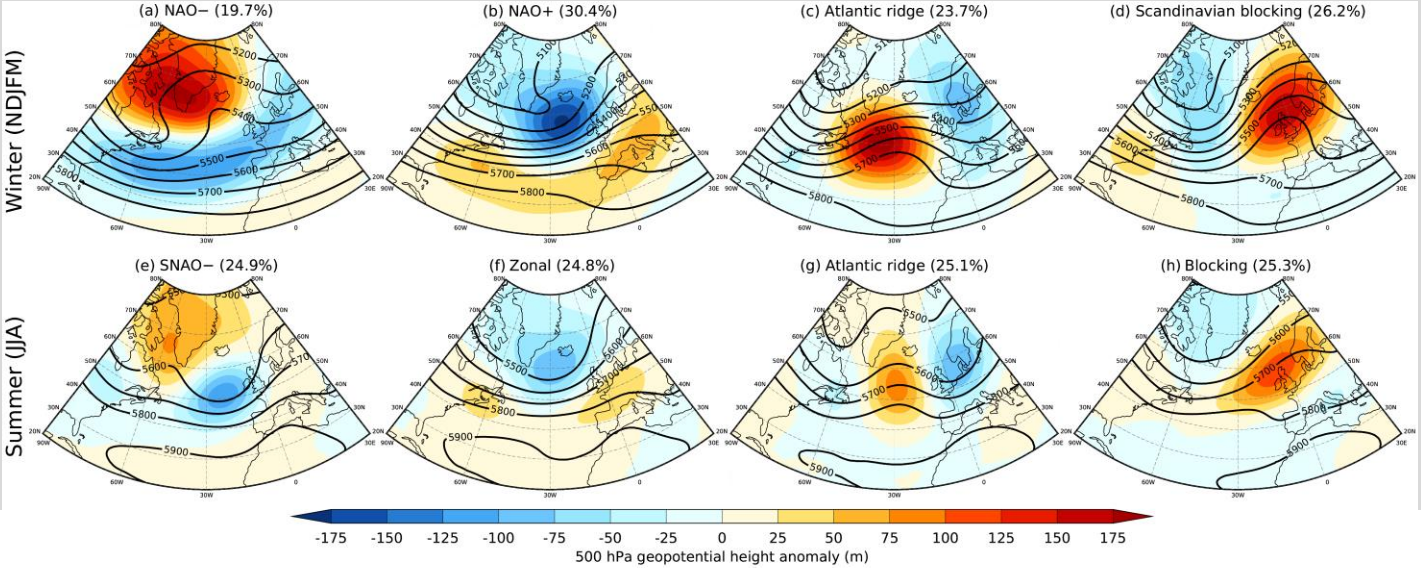


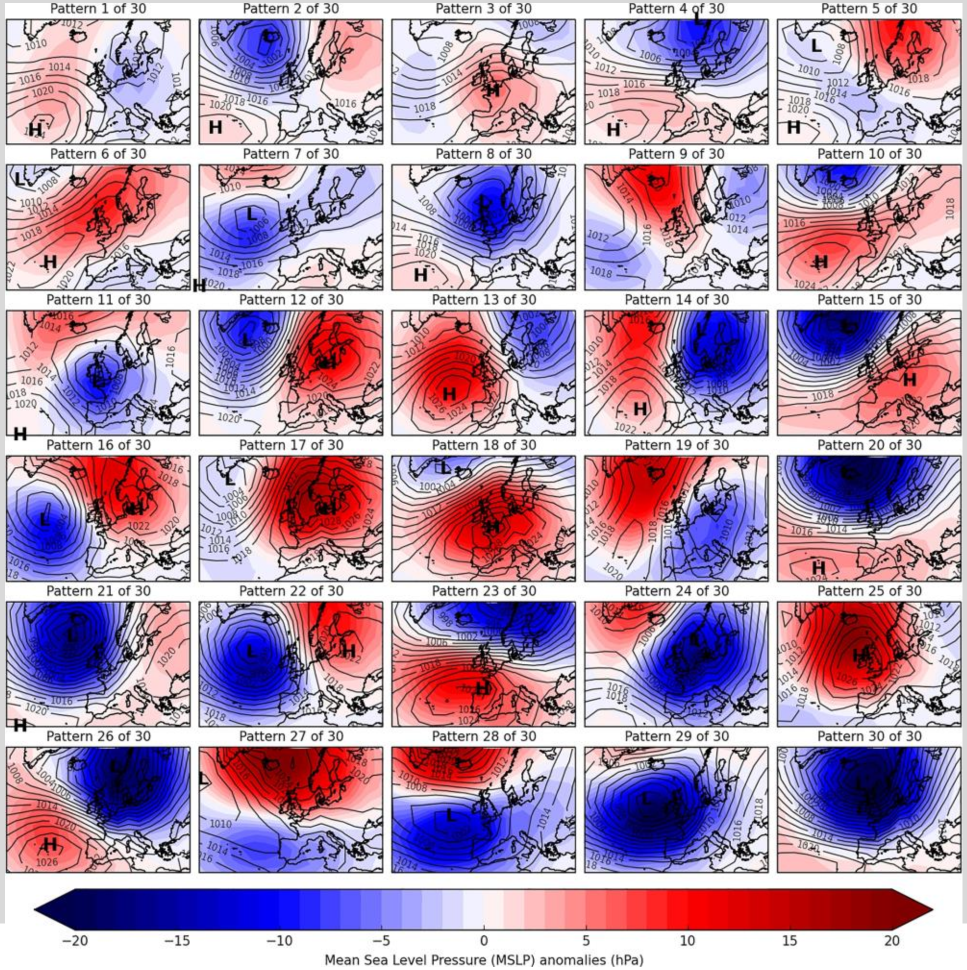
Project outputs

- Regional timeseries of forward and backward attributed mortality and hospital admissions and linked regional temperature
- Digest of most extreme events (from a mortality context)
- Linked to weather regimes/patterns (see next slides)

Weather regimes

- **4 weather regimes**: *k*-means clustering of the first 14 EOFs of the 500hPa geopotential height anomaly
- **30 weather patterns**: *k*-means clustering of mean sea level pressure anomaly

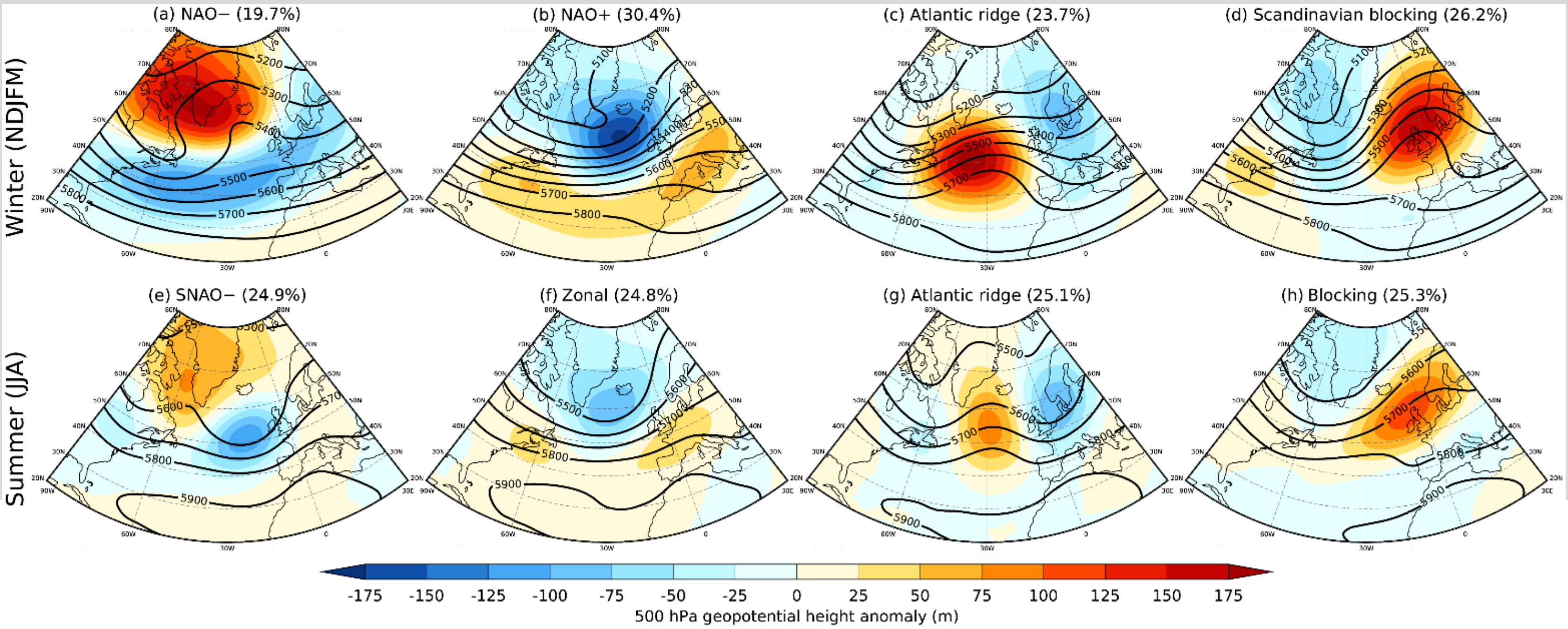


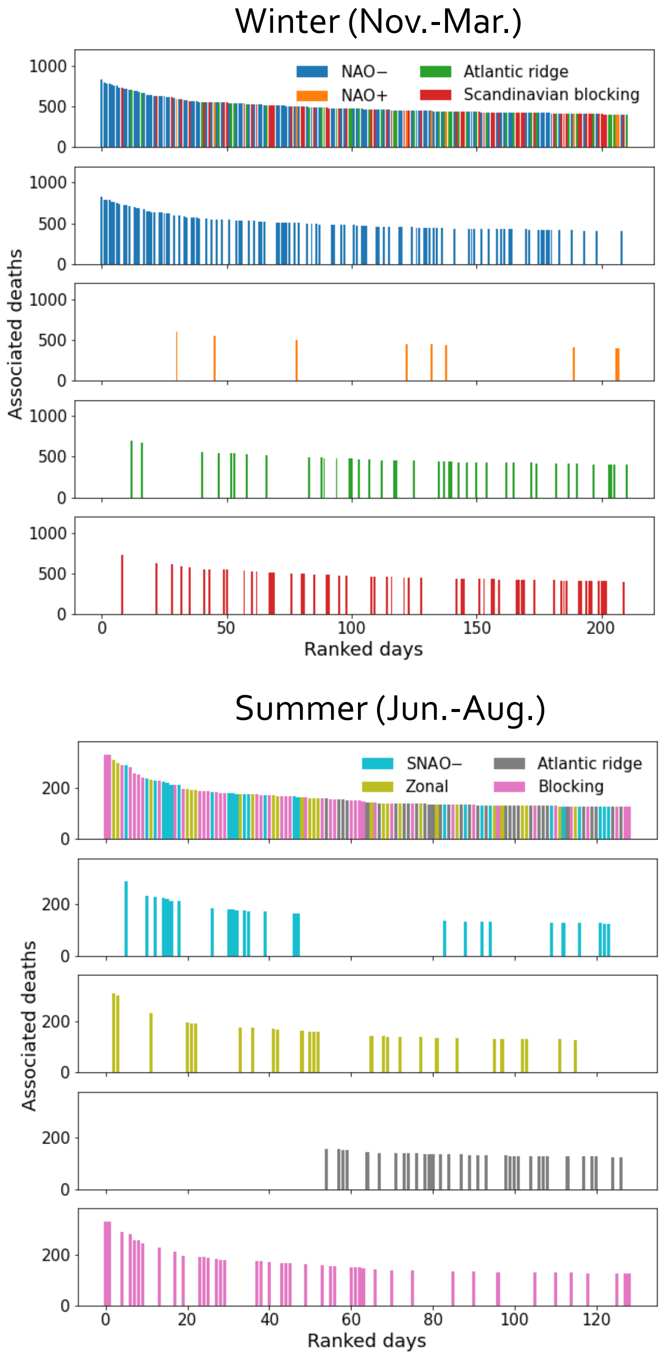


Neal et al. (2016)

Weather regimes and mortality

- In the deadliest 5% days 1991-2018:
  - Winter: 53% NAO- regime
  - Summer: 36% Blocking regime (49% of top 5% hot days)





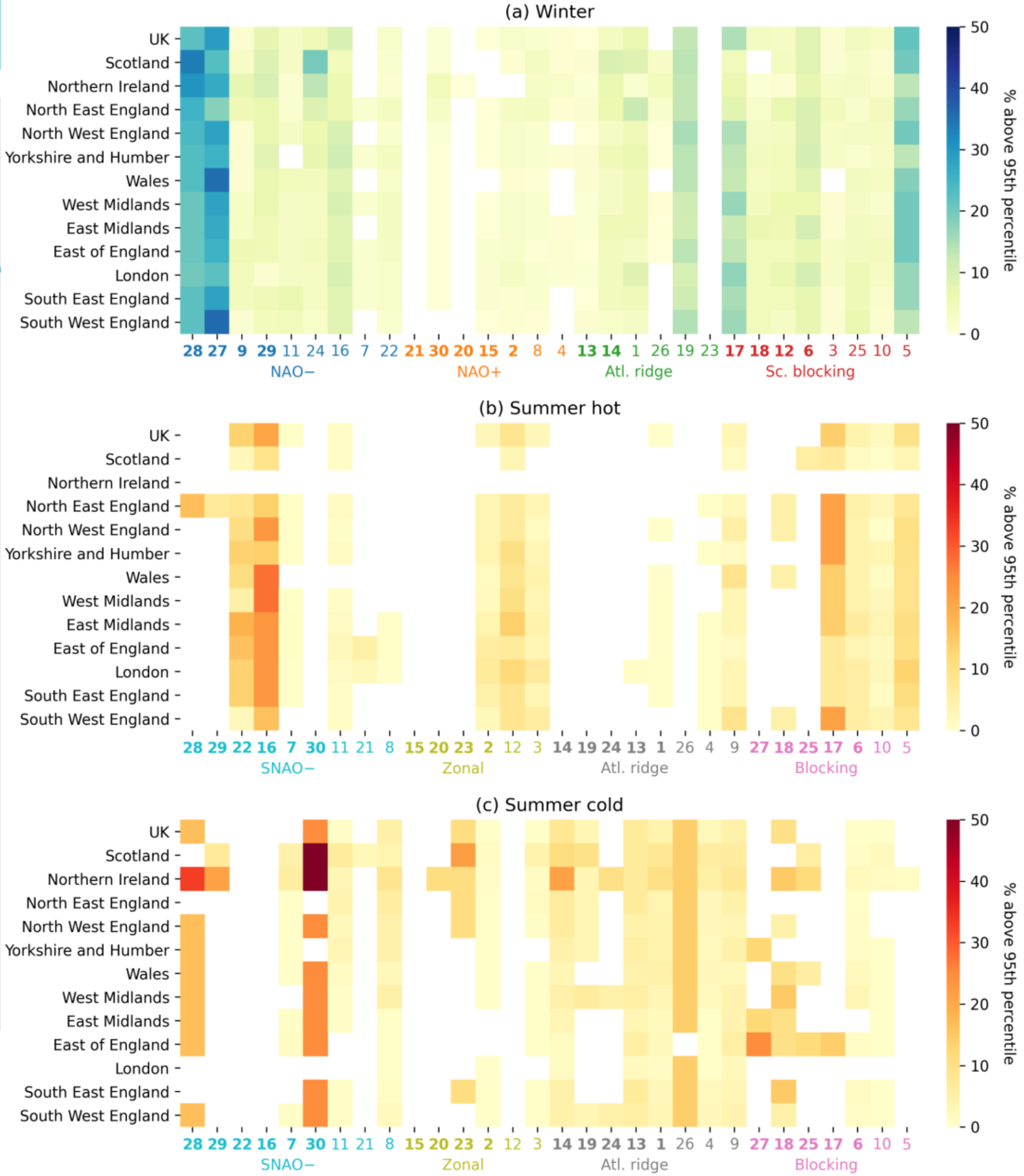
Weather patterns

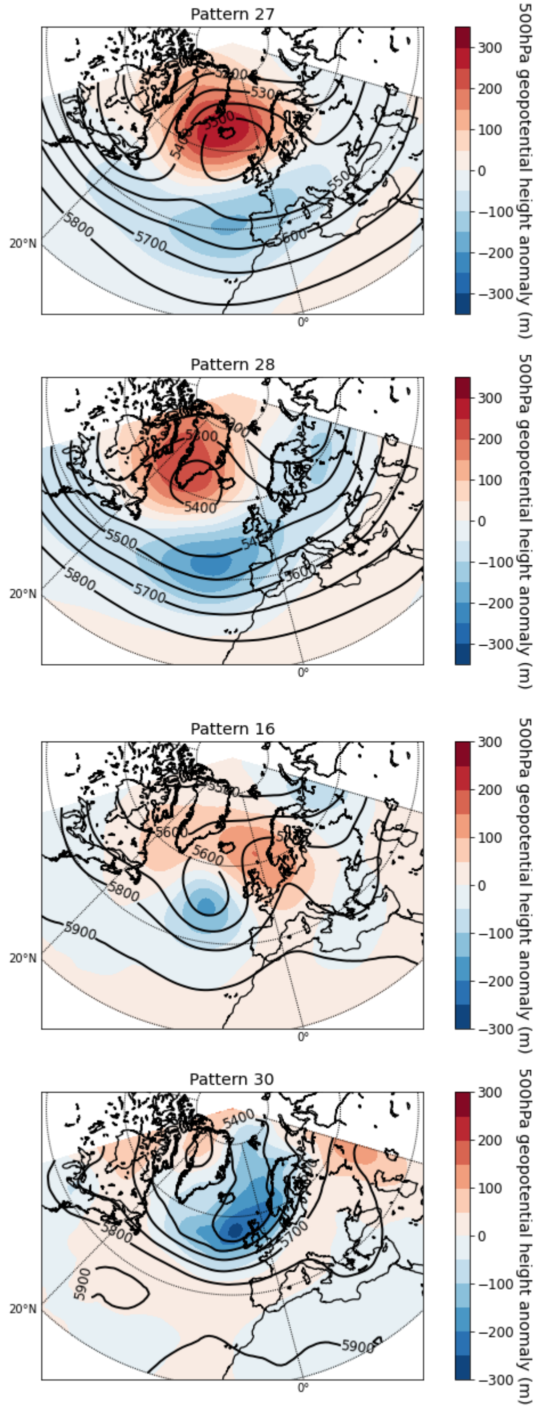
Weather patterns most likely to be above the seasonal 95th percentile

Winter:
the strongest NAO- type weather patterns (28 & 27)

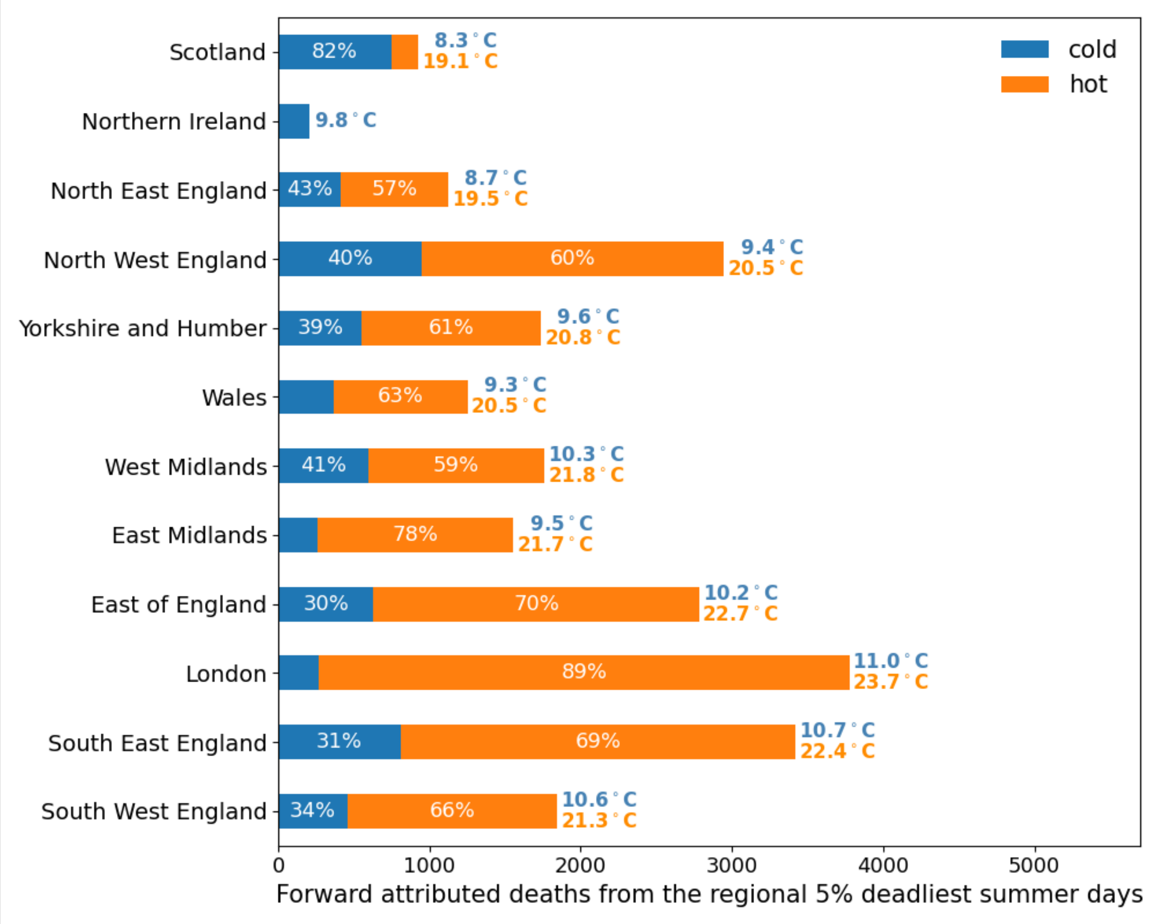
Summer:

- Hot patterns with a high pressure anomaly over the North Sea (16 & 17: clear sunny days)
- Cold pattern rarely found in summer (30: showery weather)

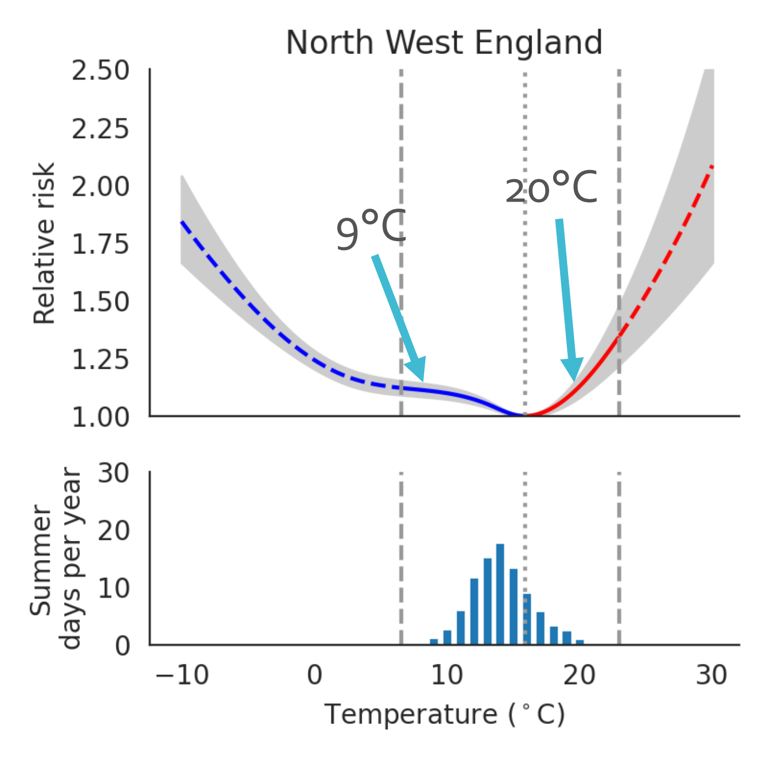




Summer cold days



- Extreme heat events are not very common in the UK observational record, such that the deadliest 5% summer days include substantial number of cold days



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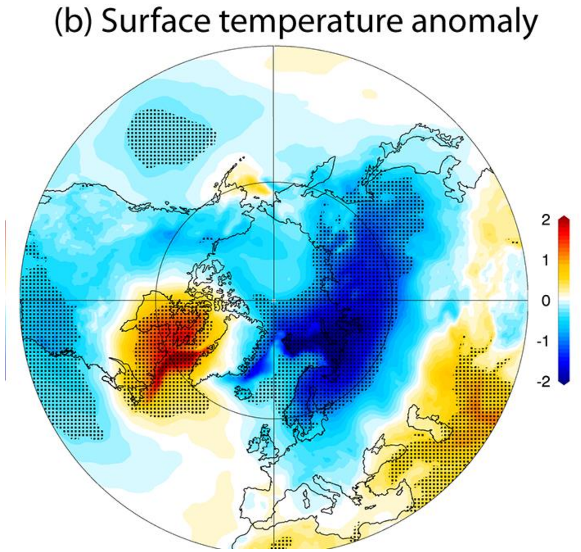
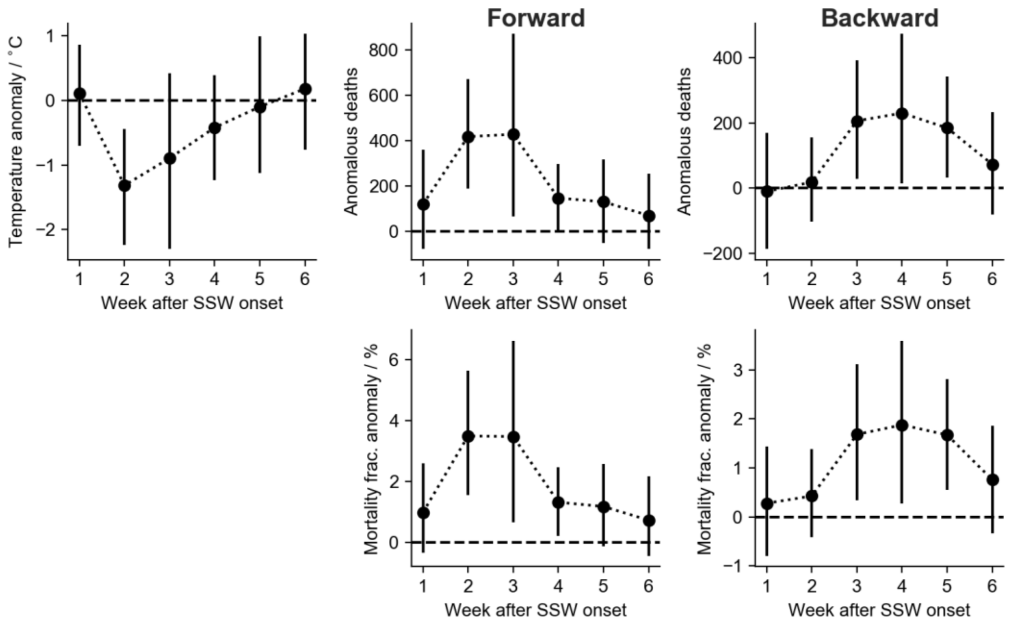
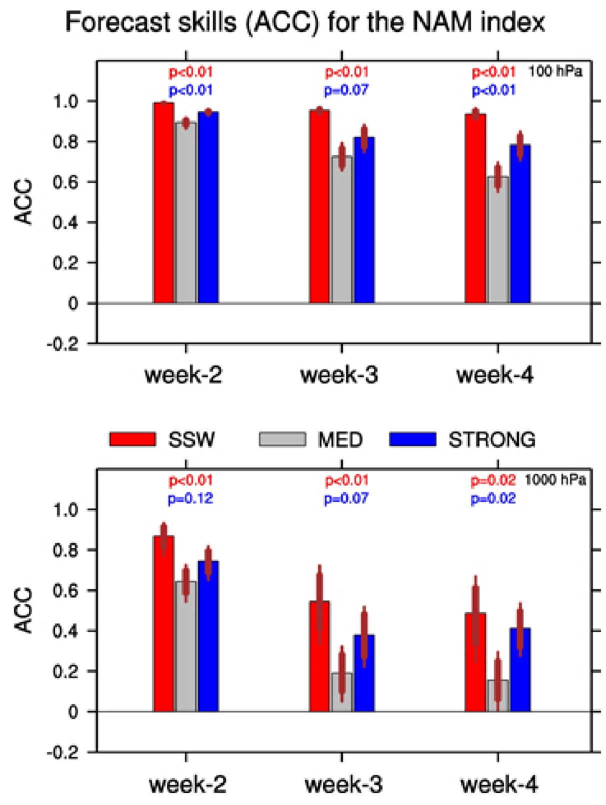
Stratospheric Warming Events



Major, long lasting disruptions to the stratospheric vortex lead to enhanced cold weather in Europe



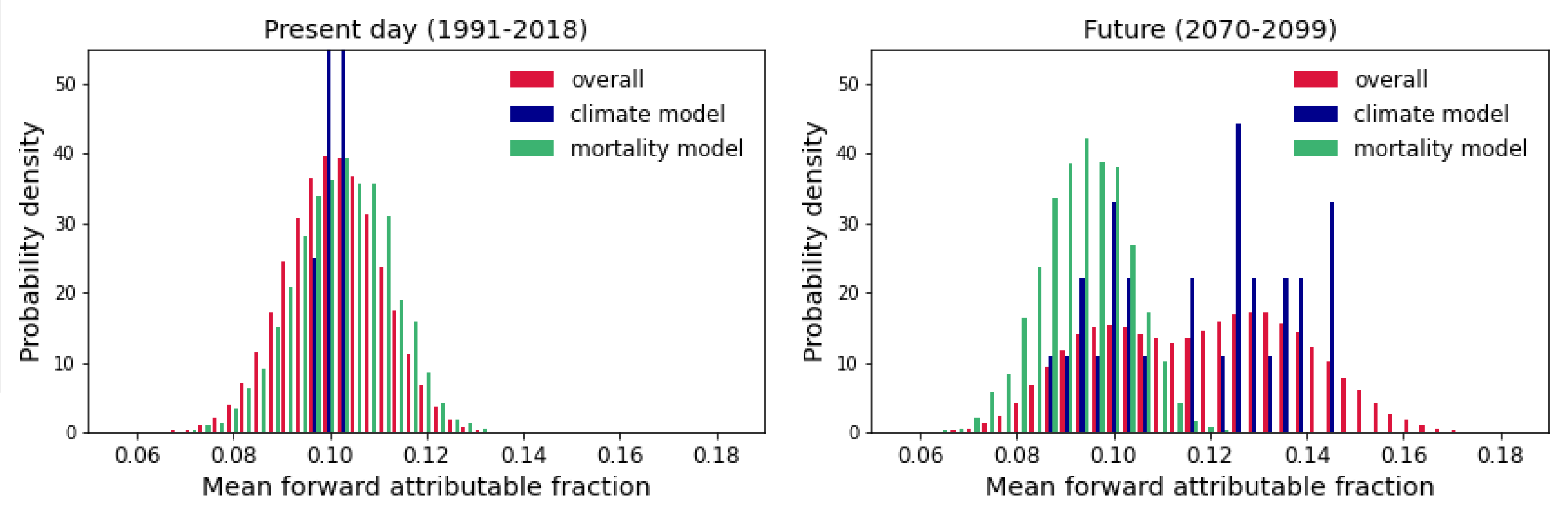
Measurable mortality effects (600 additional deaths weeks 3-5 after stratospheric event)



SSW effects are predictable and increase overall skill in weeks 3 and 4

Future changes: methodology

- UK climate projection 2018 (UKCP18) global model projections:
  - 28 global climate model simulations spanning 1900 to 2099
  - RCP 8.5
- Bias correction:
  - Correct present-day model monthly mean temperature and variance to match the observation
- Accounting for uncertainty
  - Climate projection: 28 global climate models
  - Temperature-mortality relationship: 5000 Monte Carlo resampling per model



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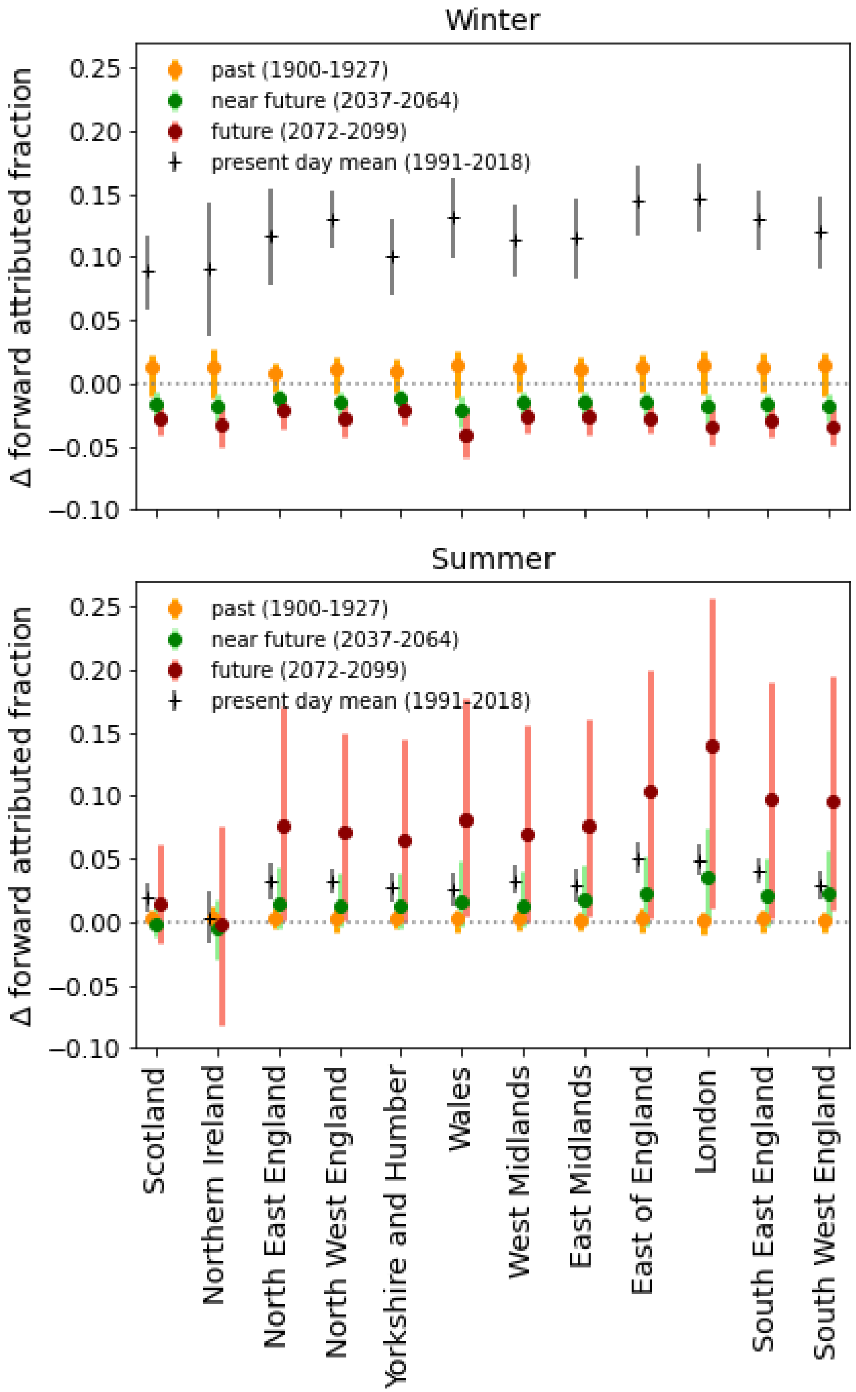

Future changes in average attributed fraction

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- Winter:
  - Decrease over time as climate warms (change mostly within -0.05)
  - Stronger changes in western regions of the UK
- Summer:
  - Decreases in cold/increases in hot weather mortality fraction
  - Dominated by increases in heat-related mortality fraction (roughly double by ~2050)
  - Great uncertainty in end-of-century changes due to uncertainty in climate projections

Project outputs

- Regional timeseries of forward and backward attributed mortality fraction for each of the 28 climate model simulations
- Monte-carlo samples of the same simulations to explore uncertainty due to exposure-temperature relationship.

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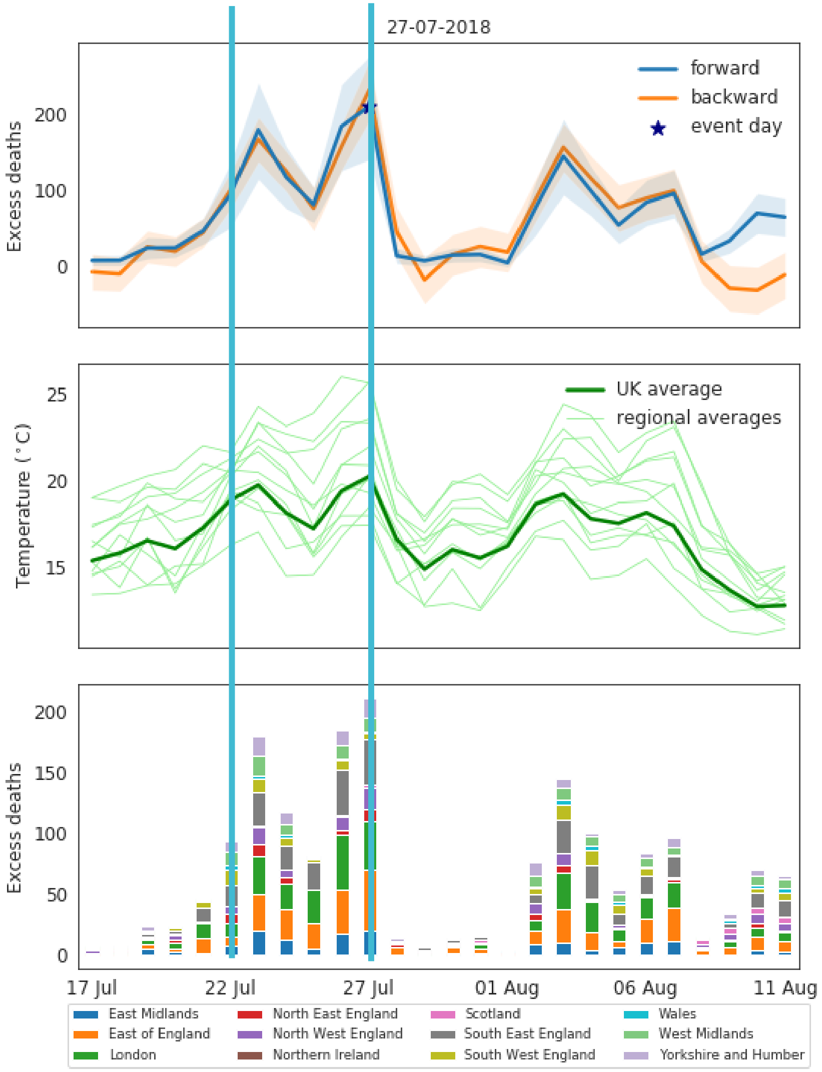
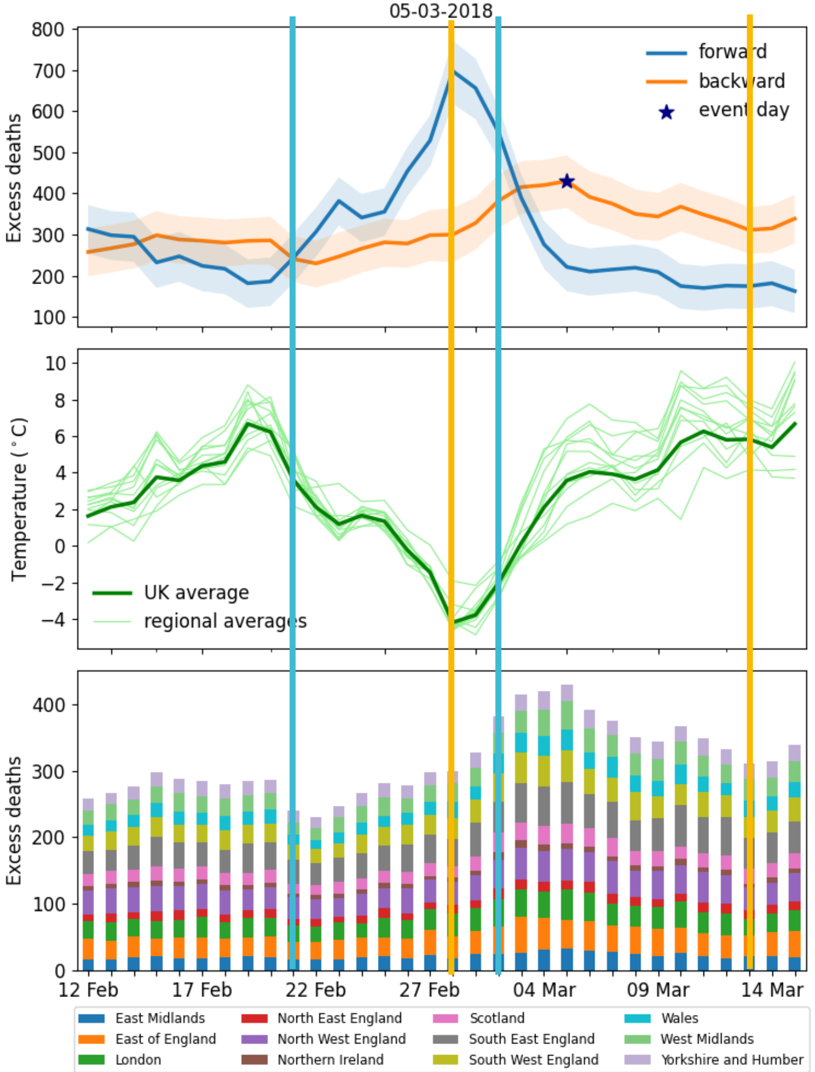
Example events in an Urban area – 2018, London

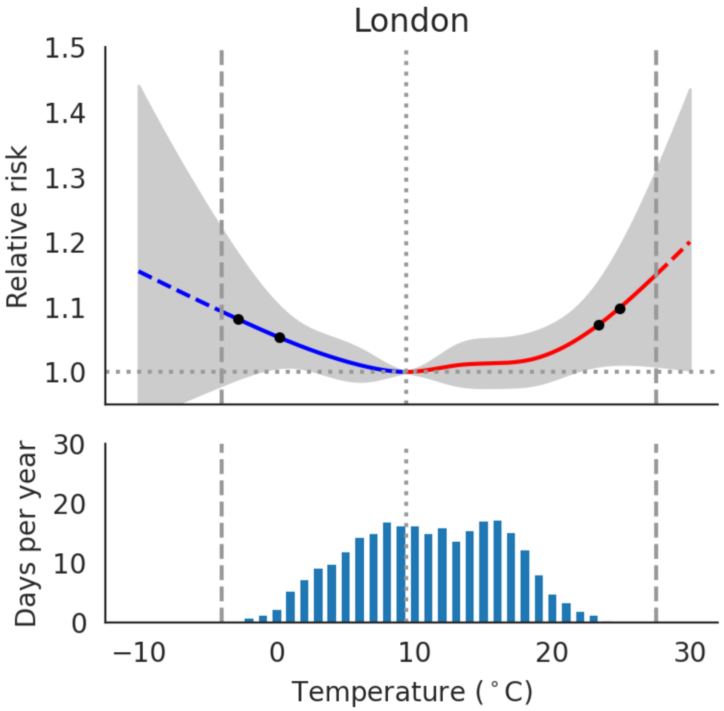
2018 heatwave



2018 cold spell



Fixed London-wide temperature-admissions relationship

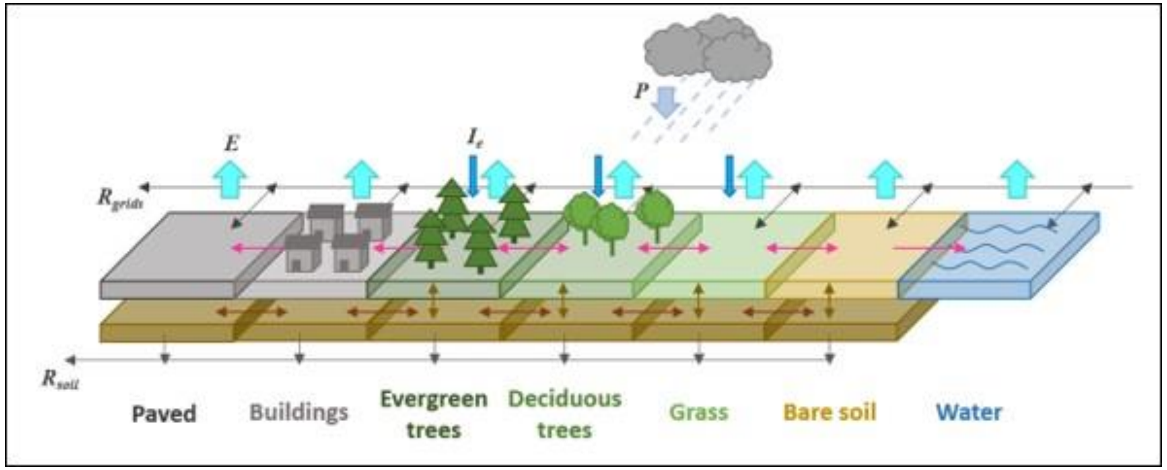


Urban Land Surface Model: SUEWS

Surface Urban Energy and Water Balance Scheme

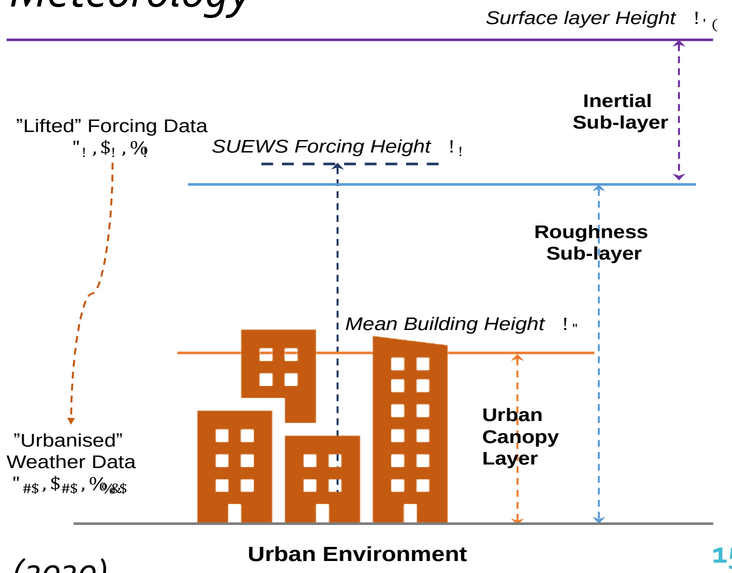
- Taking account for urban surface heterogeneity (land cover, morphology, etc.)
- Modelling anthropogenic emissions to represent human activities (building operation, traffic)
- Diagnosing near surface meteorology (air temperature, humidity and wind speed) for urban climate services (health, energy, etc.)

Urban Surface Heterogeneity

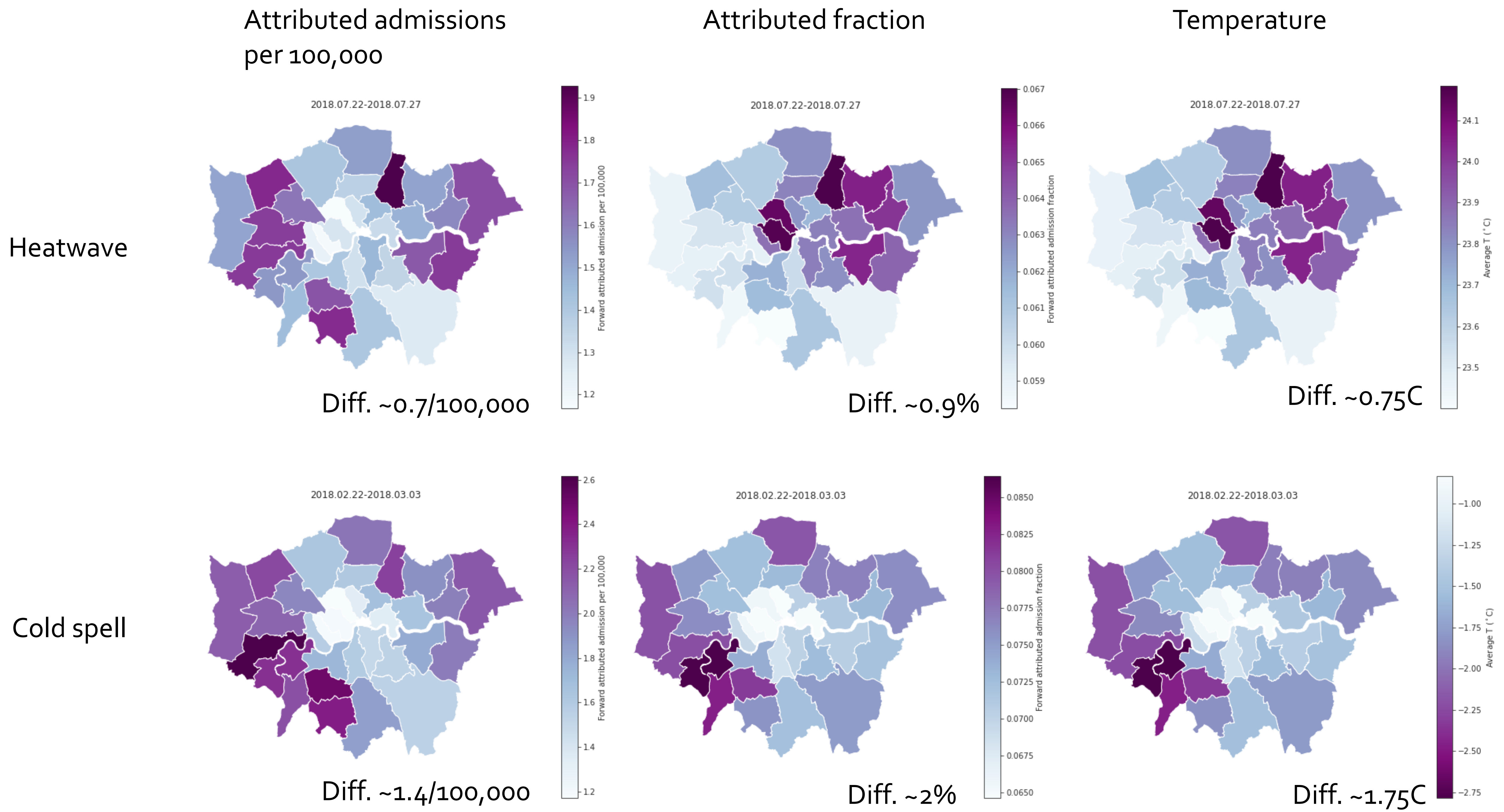


Järvi et al. (2011)

"Urbanised" Meteorology



Tang et al. (2020)


Attributed admissions per 100,000
Attributed fraction
Temperature
Heatwave
Cold spell
2018.07.22-2018.07.27
2018.02.22-2018.03.03
Forward attributed admission per 100,000
Forward attributed admission fraction
Average T (°C)
Diff. ~0.7/100,000
Diff. ~0.9%
Diff. ~0.75C
Diff. ~1.4/100,000
Diff. ~2%
Diff. ~1.75C

Summary

- Project has combined existing epidemiological ideas and models with best estimates of past and future UK temperatures.
- Result is data series and model fits that can be used to explore drivers of past and future ill-health due to temperature.
- Aim is to provide these through a new climate service, disseminated via EPHSS
- By understanding meteorological drivers of temperature-related mortality hope is to be able to enhance predictive capacity for impactful events on multiple timescales.
- Future service also needs to incorporate measures of vulnerability to temperature-driven ill-health, focus of final phase of the project and recent series of webinars and one-to-one interviews with end-users.

Contact details

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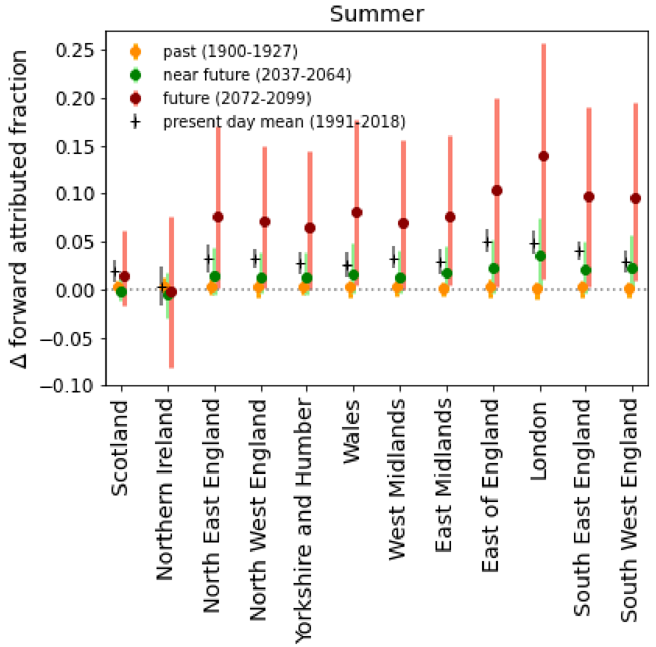
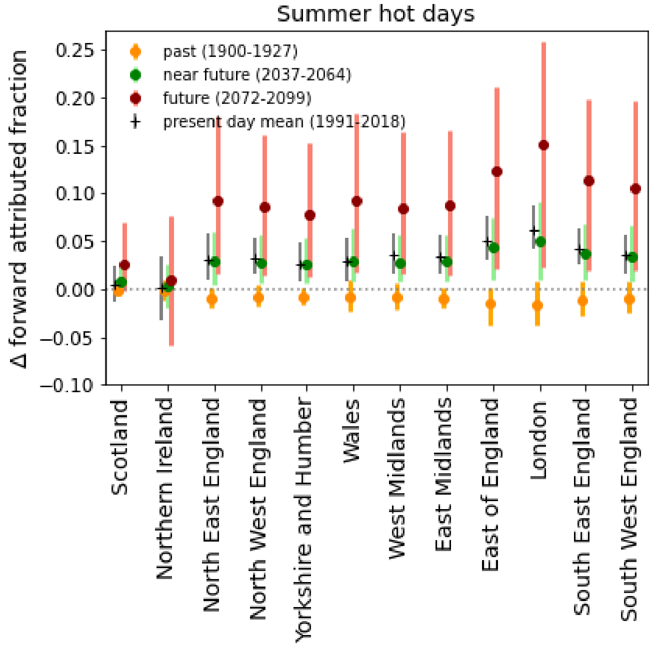
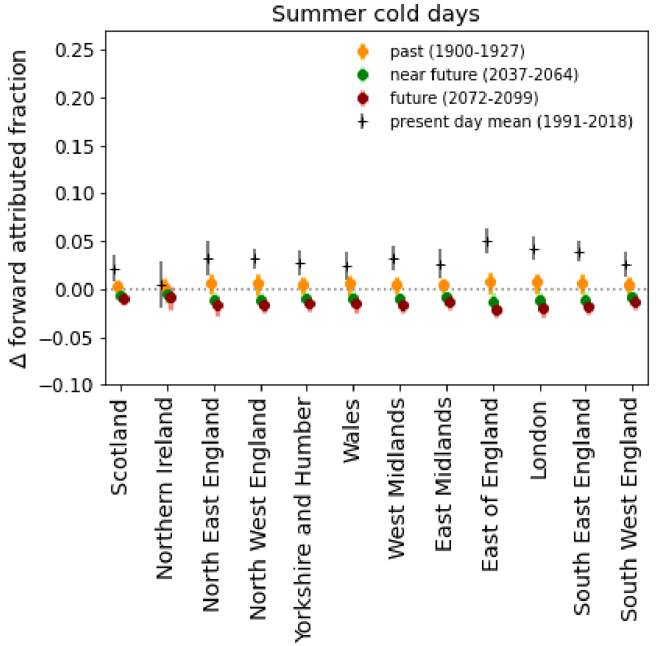
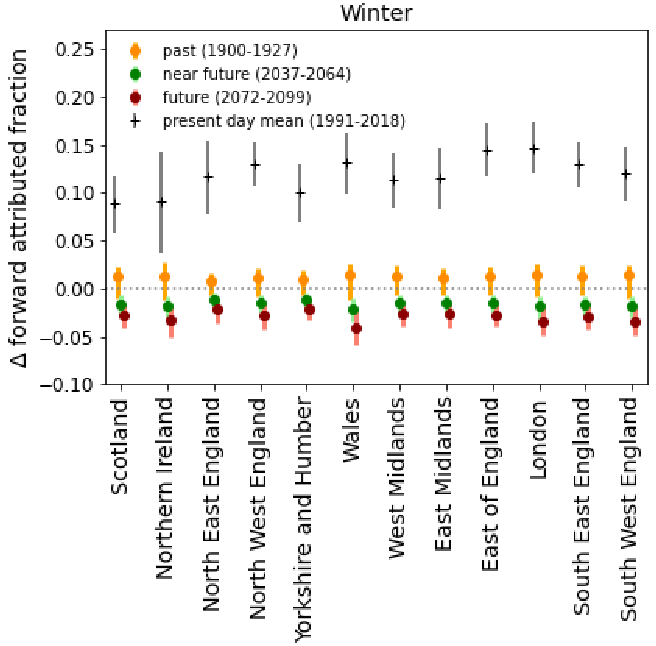
The UK Climate Resilience programme is supported by the UKRI Strategic Priorities Fund.
The programme is co-delivered by the Met Office and NERC on behalf of UKRI partners AHRC, EPSRC, ESRC.









Changes in forward attributable fraction compared to the present day period (1991-2018); error bars denote the 95% confidence interval

- Winter decrease significant by 2050 for all regions
- Further decrease by the end of the century; generally within a decrease of 0.05 compared to present day
- Statistically significant increase in attributable fraction from hot days and slight decrease from cold days for all regions except Scotland and Northern Ireland, notable already by ~2050
- Changes in Scotland and Northern Ireland not significant, except for summer cold days for Scotland, where the confidence interval lies fully in the negative

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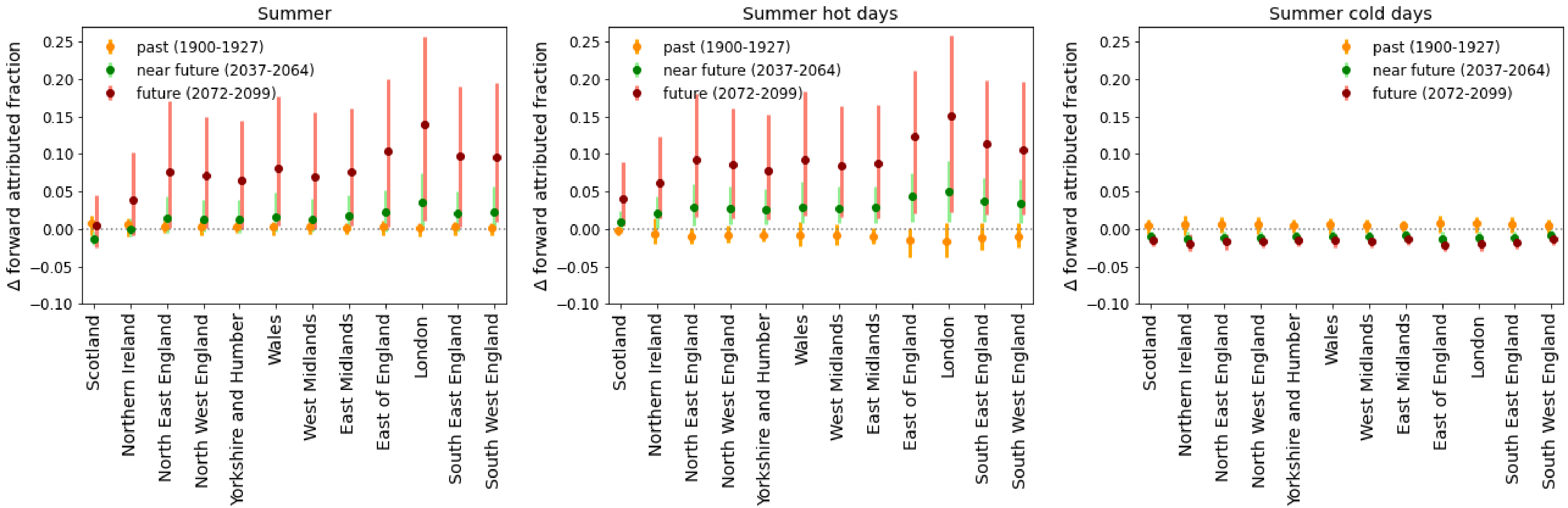
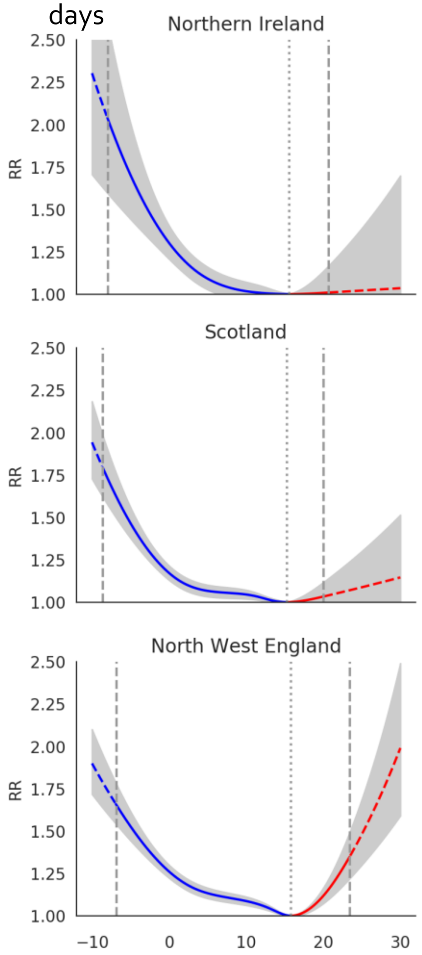


Cumulative risk across lag days



Temperature-mortality model for Scotland and Northern Ireland replaced by that of North West England

- More consistent increase in hot-temperature attributable fraction in the future in Scotland and Northern Ireland compared to other regions
- Magnitude of increase generally lower than more southern regions
- Using North West England's temperature-mortality relationship model also results in stronger decrease in attributable fraction from summer cold days for Scotland and Northern Ireland
  - Due to higher sensitivity to moderate cold temperatures in North West England
- As a result, overall change in associated fraction in summer is still not significant (only more so by the end of the century for Northern Ireland, but even then the confidence interval includes members with negative change)
  - Higher sensitivity to changes in summer cold days because the majority of present day summer associated mortality are related to cold days

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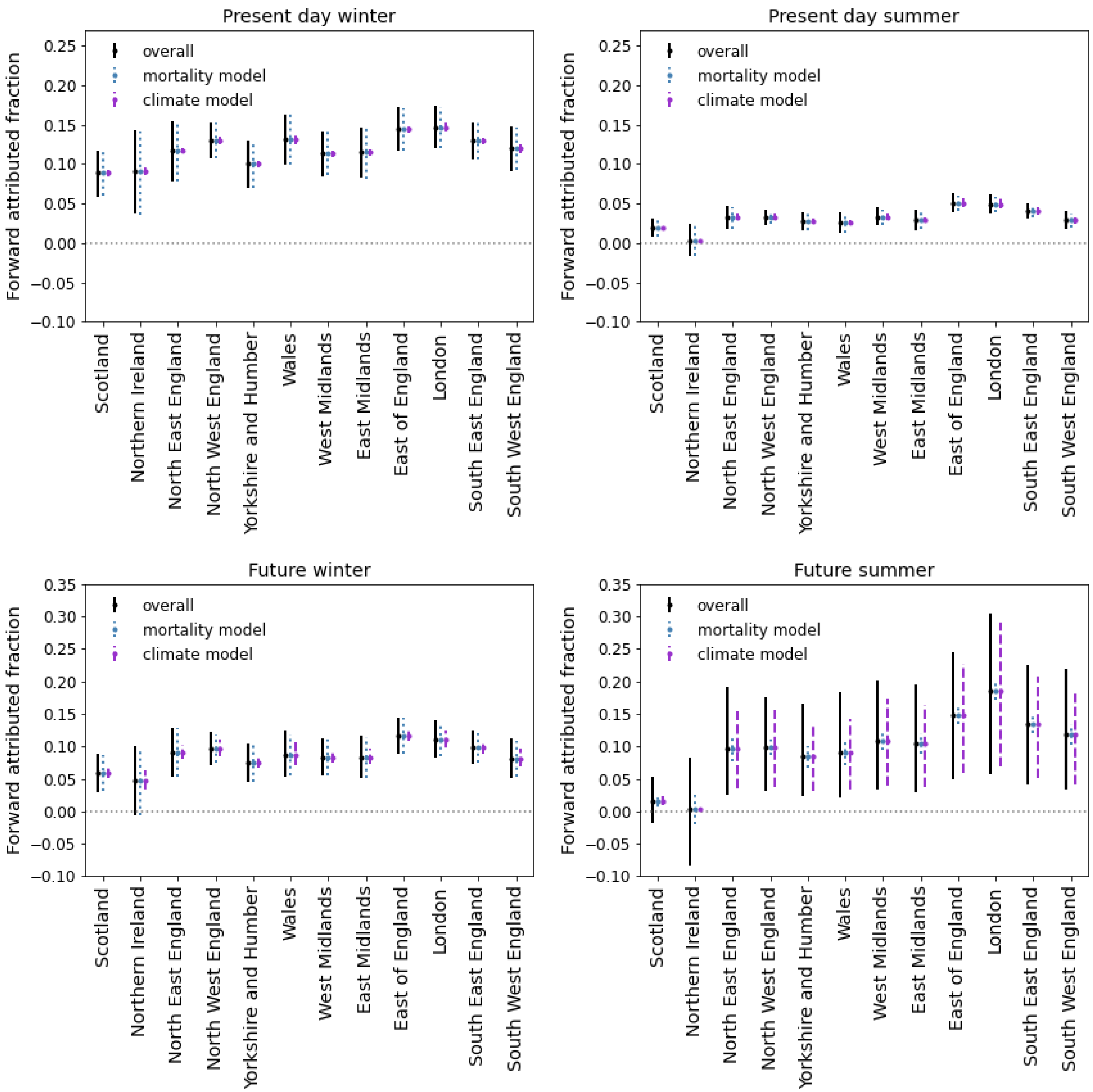
Sources of uncertainty



- Present day: mortality model accounts for nearly all uncertainty
- Future (end of century):
  - Winter: mortality model accounts for more of the uncertainty
  - Summer: climate projection accounts for the majority of the uncertainty

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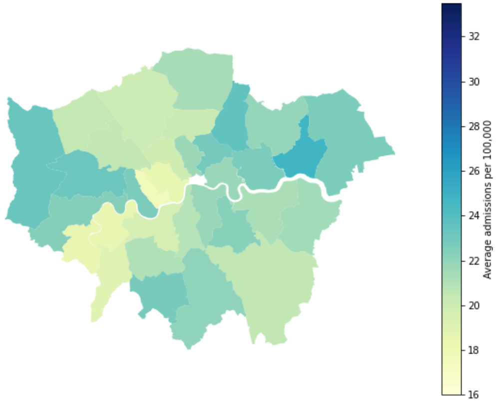
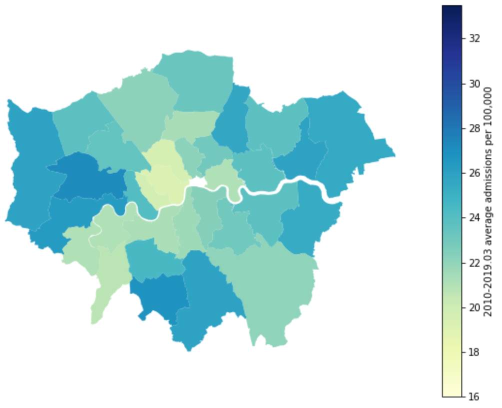
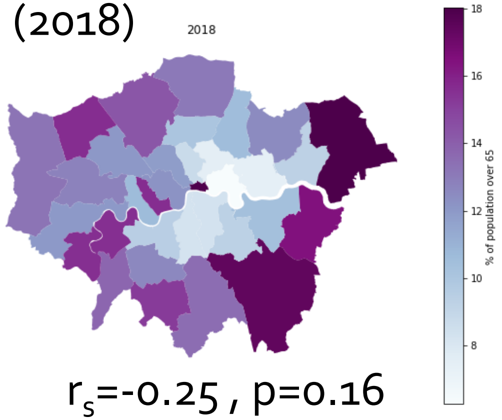
Average emergency hospital Admissions (1999-2019Mar)



Average emergency hospital Admissions (2010-2019Mar)

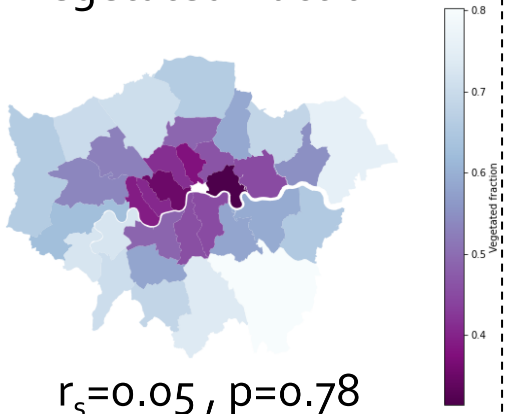


% population over 65 (2018)



r_s=-0.25 , p=0.16
r_s=0.15 , p=0.42
r_s=0.26 , p=0.16*
r_s=0.42 , p=0.02

Vegetated fraction



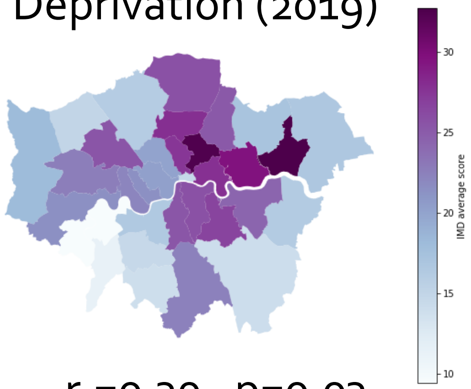
r_s=0.05 , p=0.78
r_s=0.37 , p=0.04
r_s=0.47 , p=0.006
r_s=0.64 , p=9e-5

2018 seasonal average admissions show similar correlations as the events, except for *-marked ones: % population over 65 vs. 2018 summer adm.: r_s=0.34, p=0.058, and IMD vs. 2018 winter adm.: r_s=-0.28, p=0.12

Spearman's correlation to:

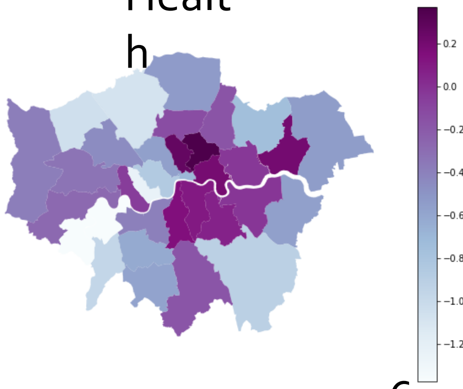
Overall 1999-2019Mar average admissions
2010-2019Mar average admissions
Heat event forward attributed admissions
Cold event forward attributed admissions

Index of multiple Deprivation (2019)



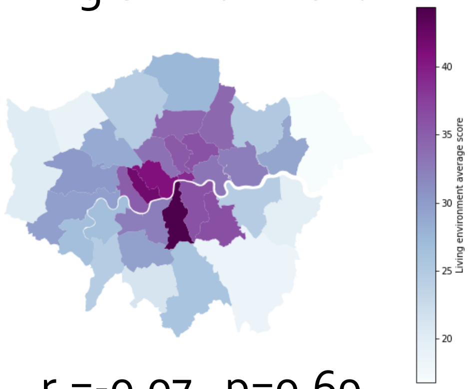
r_s=0.39 , p=0.03
r_s=0.02 , p=0.91
r_s=-0.19 , p=0.29
r_s=-0.42 , p=0.02*

Healt h



r_s=0.57 , p=0.0006
r_s=0.20 , p=0.28
r_s=-0.11 , p=0.56
r_s=-0.27 , p=0.13

Living environment



r_s=-0.07 , p=0.69
r_s=-0.41 , p=0.02
r_s=-0.53 , p=0.002
r_s=-0.59 , p=0.0004

Barriers to housing

r_s=0.38 , p=0.03
r_s=0.27 , p=0.14
r_s=0.15 , p=0.41
r_s=-0.04 , p=0.83

* City of London excluded from correlation analysis

Average admissions

2018

1999-2019