Anomalously warm temperatures are associated with increased injury deaths:

Extended Data

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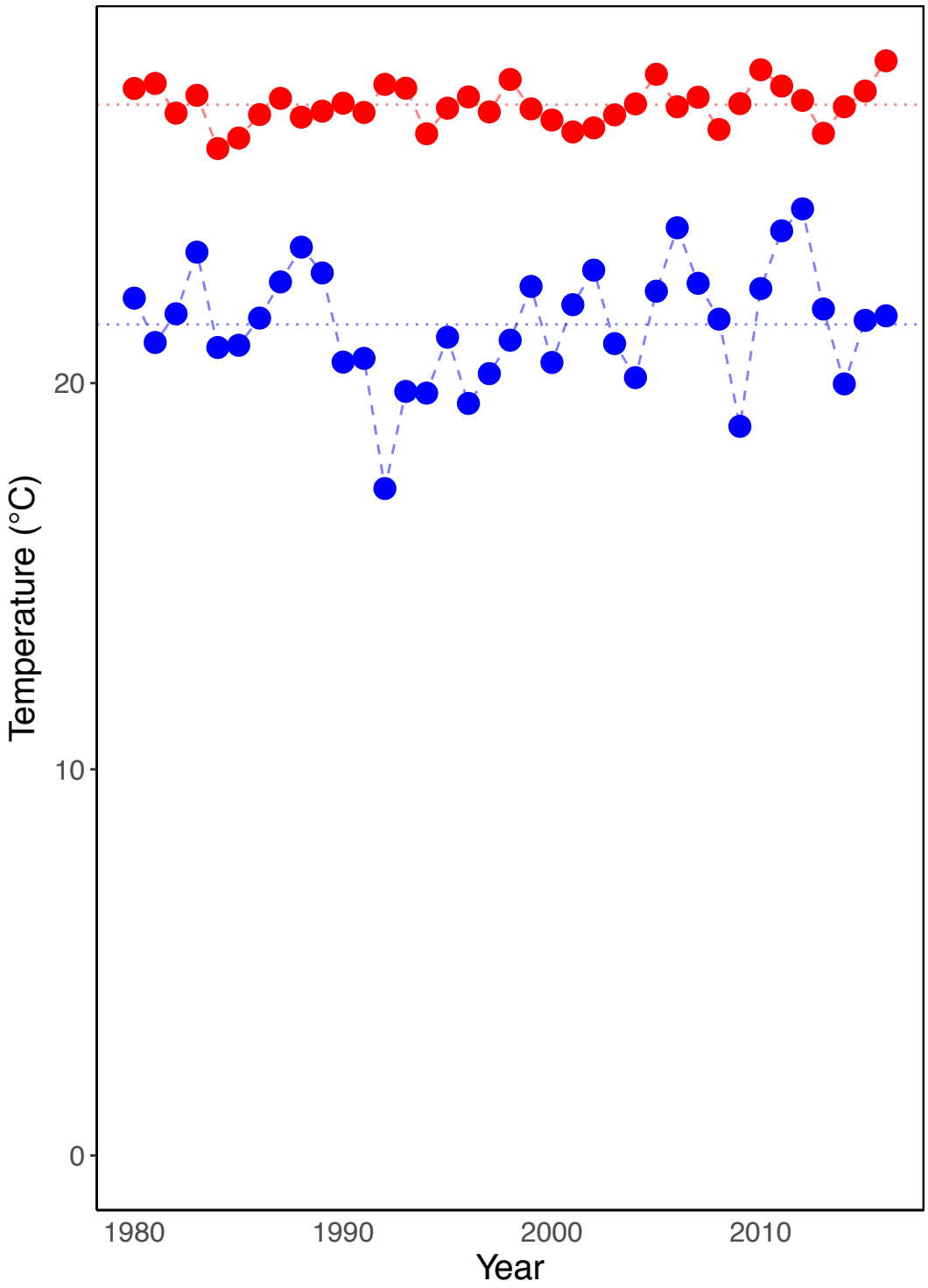
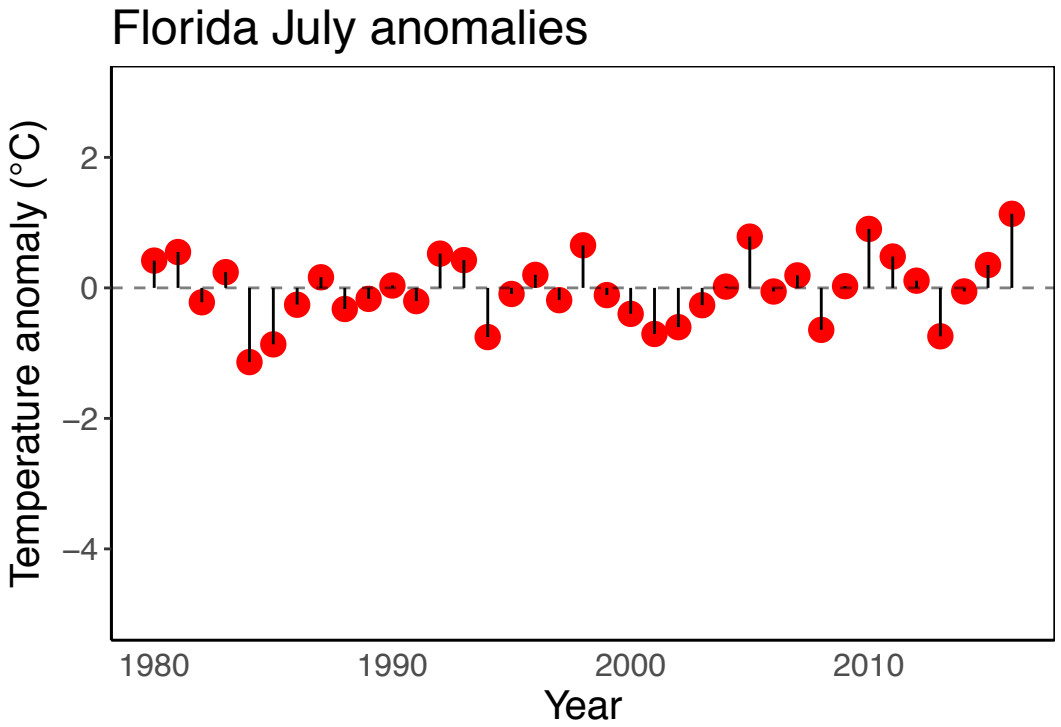
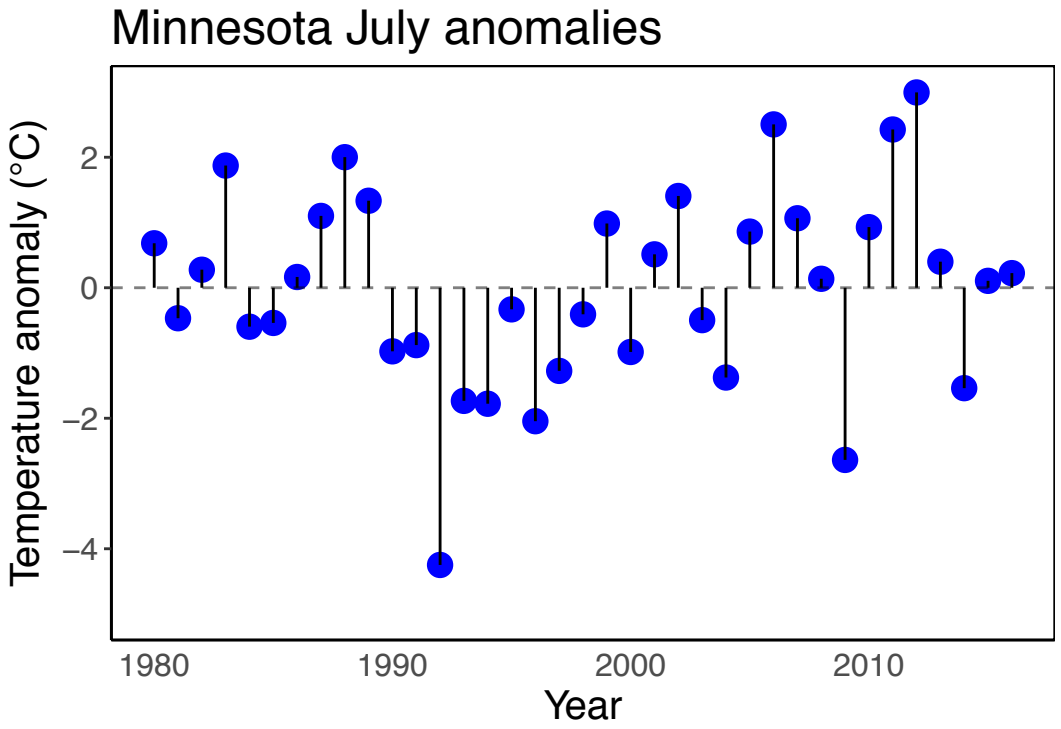
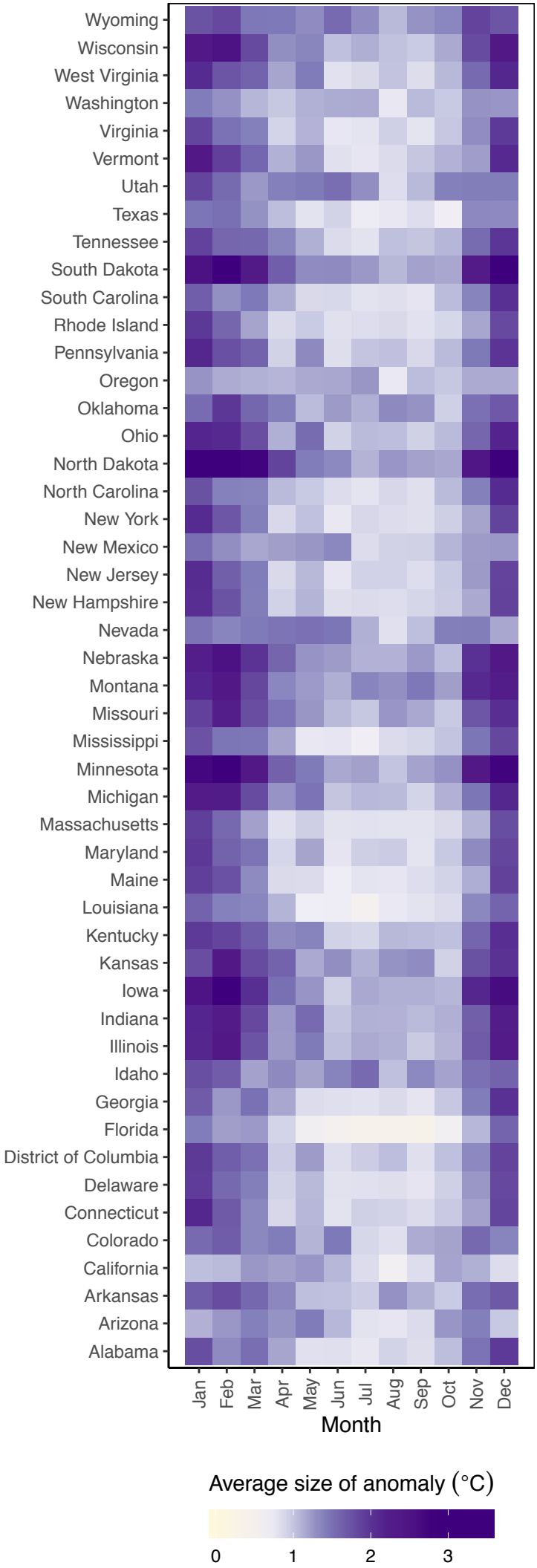
Extended Data Figure 1. Graphic representation of temperature anomaly measure used in the analysis. The graph shows how monthly temperatures in July two example states (Florida in red and Minnesota in blue) (left panel) for 1980-2017 are used to calculate temperature anomalies. As seen, a warmer state like Florida (top right) can have a smaller inter-annual variation in a particular month (here, July) compared with a cooler state like Minnesota (bottom right).


Temperature (°C)
20
10
0
1980
1990
2000
2010
Year

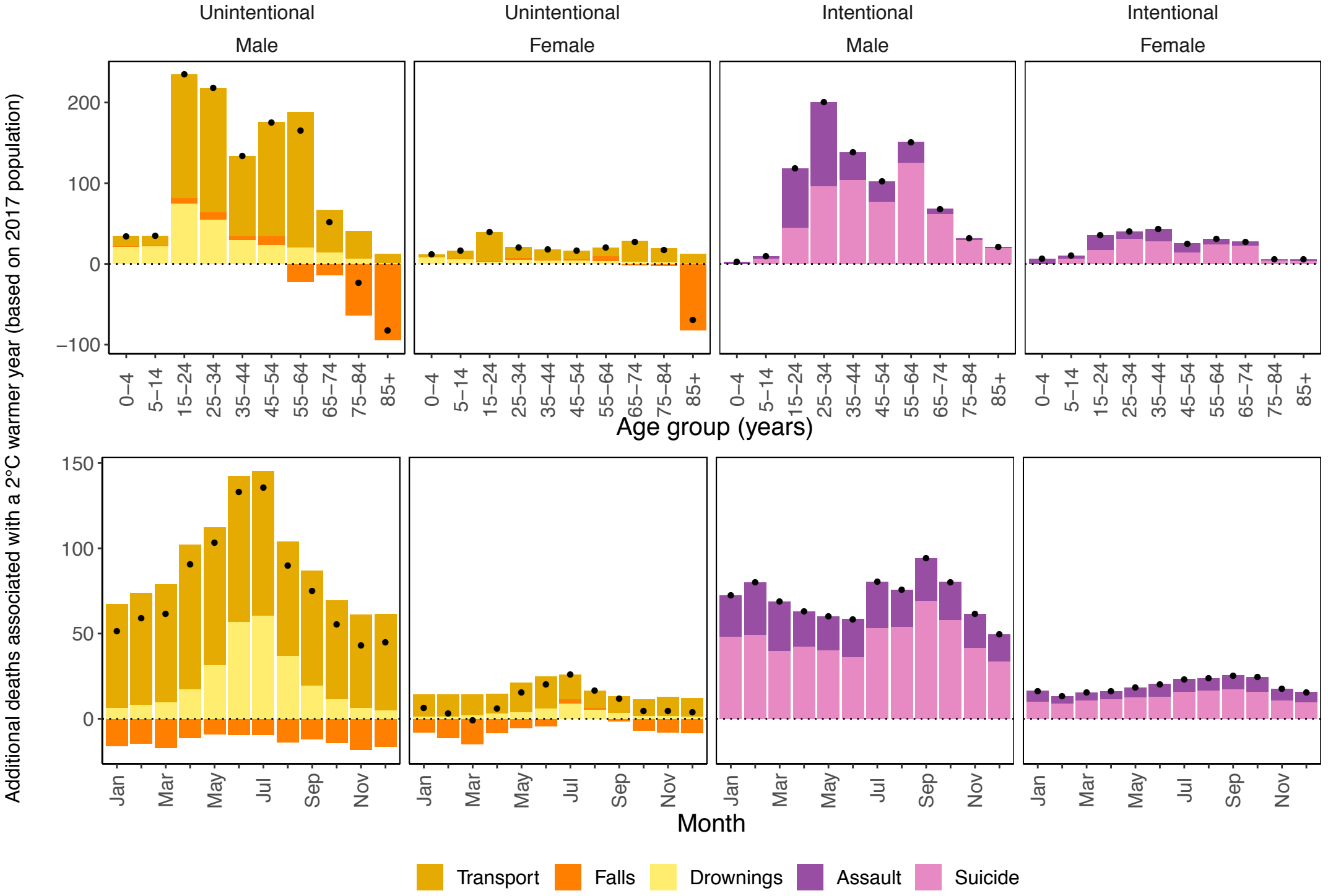

Florida July anomalies
Temperature anomaly (°C)
2
0
−2
−4
1980
1990
2000
2010
Year


Minnesota July anomalies
Temperature anomaly (°C)
2
0
−2
−4
1980
1990
2000
2010
Year

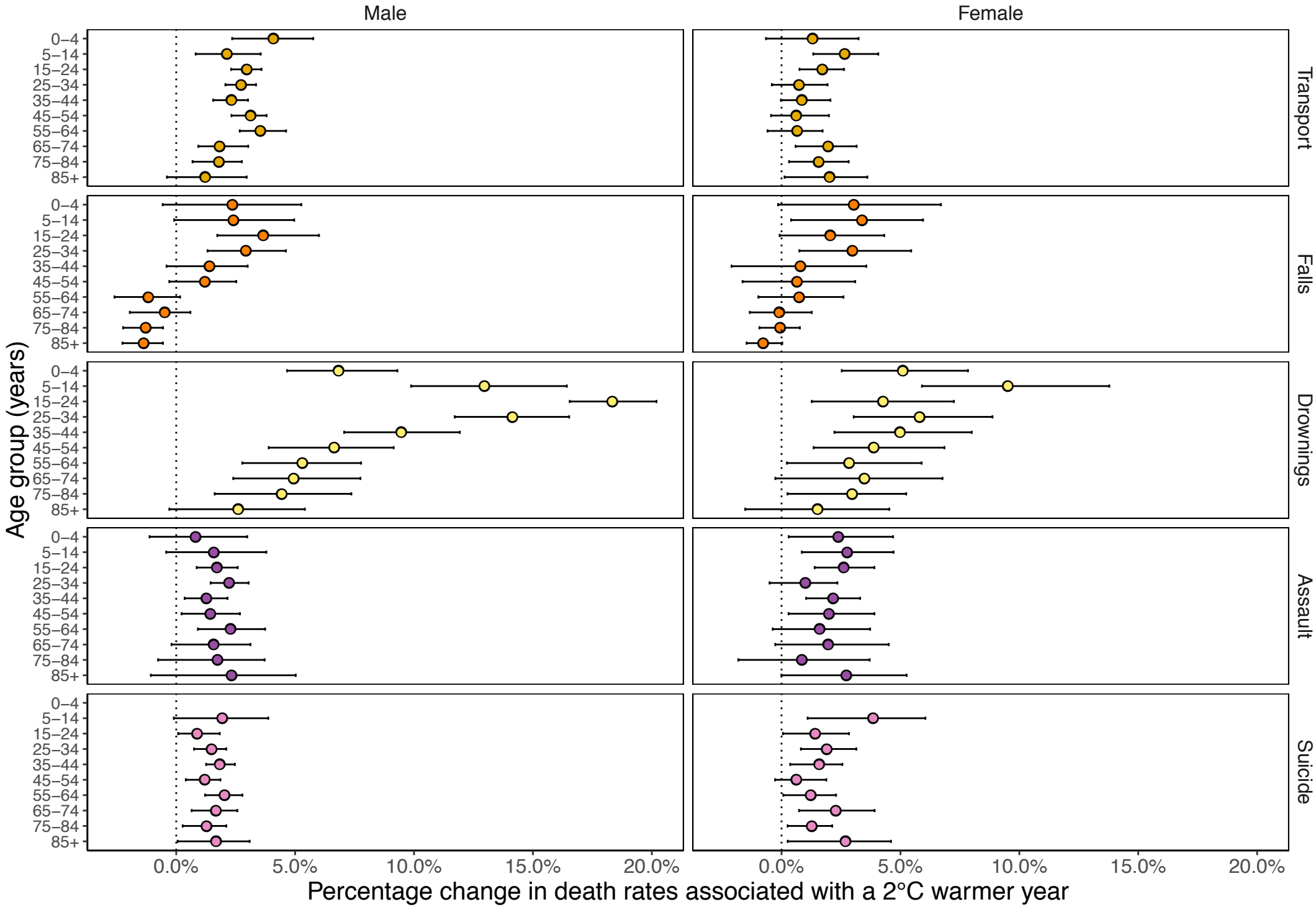
Extended Data Figure 2. Average size of temperature anomaly (°C) from 1980 to 2017, by state and month. The value for each state and month is the mean of the absolute size of anomaly, be it cold or warm, and hence gives an indication of the scale of anomalies around the local average temperatures.

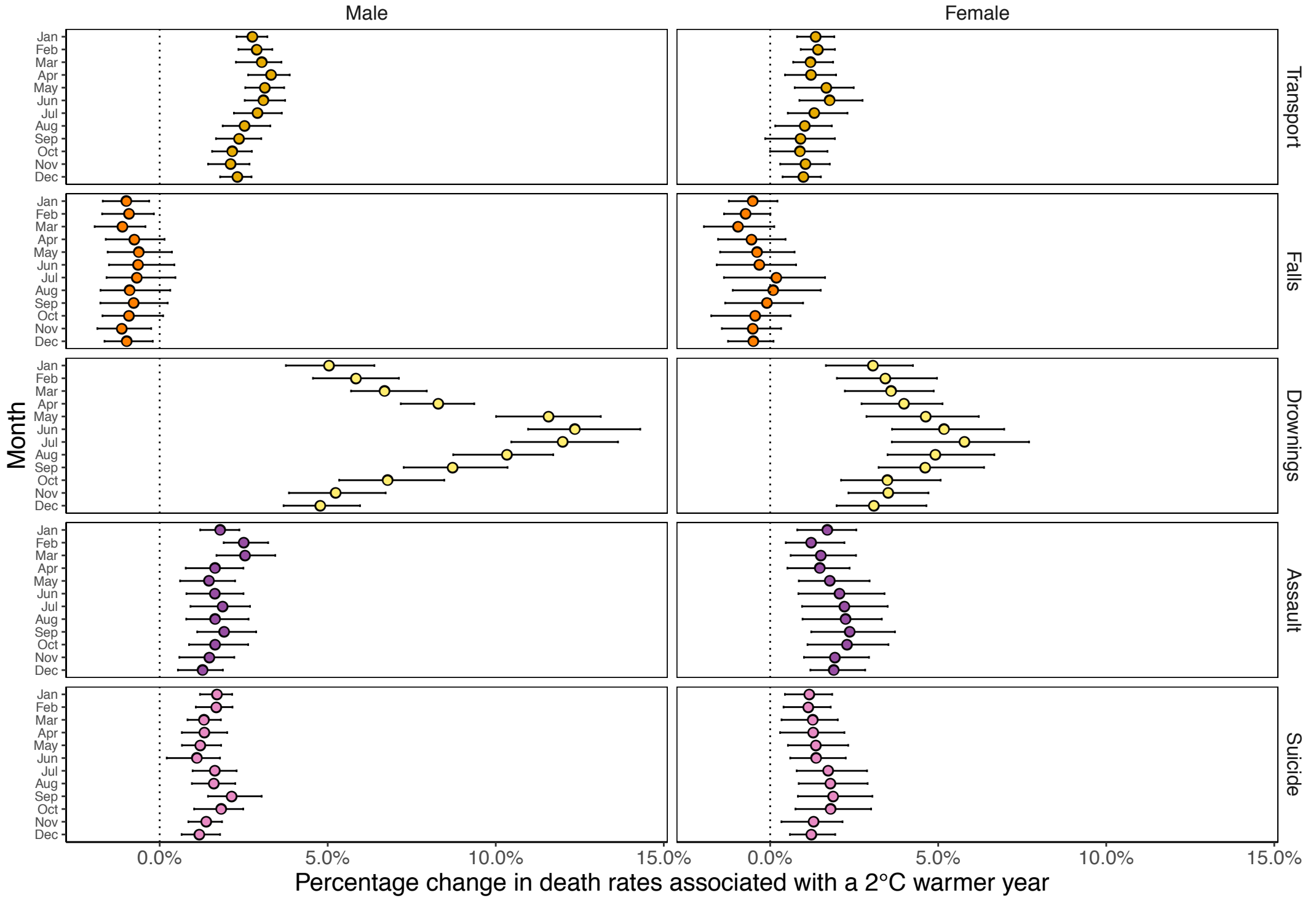

Wyoming
Wisconsin
West Virginia
Washington
Virginia
Vermont
Utah
Texas
Tennessee
South Dakota
South Carolina
Rhode Island
Pennsylvania
Oregon
Oklahoma
Ohio
North Dakota
North Carolina
New York
New Mexico
New Jersey
New Hampshire
Nevada
Nebraska
Montana
Missouri
Mississippi
Minnesota
Michigan
Massachusetts
Maryland
Maine
Louisiana
Kentucky
Kansas
Iowa
Indiana
Illinois
Idaho
Georgia
Florida
District of Columbia
Delaware
Connecticut
Colorado
California
Arkansas
Arizona
Alabama
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Average size of anomaly (°C)
0
1
2
3

Extended Data Figure 3. Additional annual injury deaths for the 2017 US population in year in which each month was +2°C warmer compared with 1980-2017 average temperatures. The top row shows breakdown by type of injury, sex and age group. The bottom row shows the break down by type of injury, sex and month. Black dots represent net changes in deaths for each set of bars.

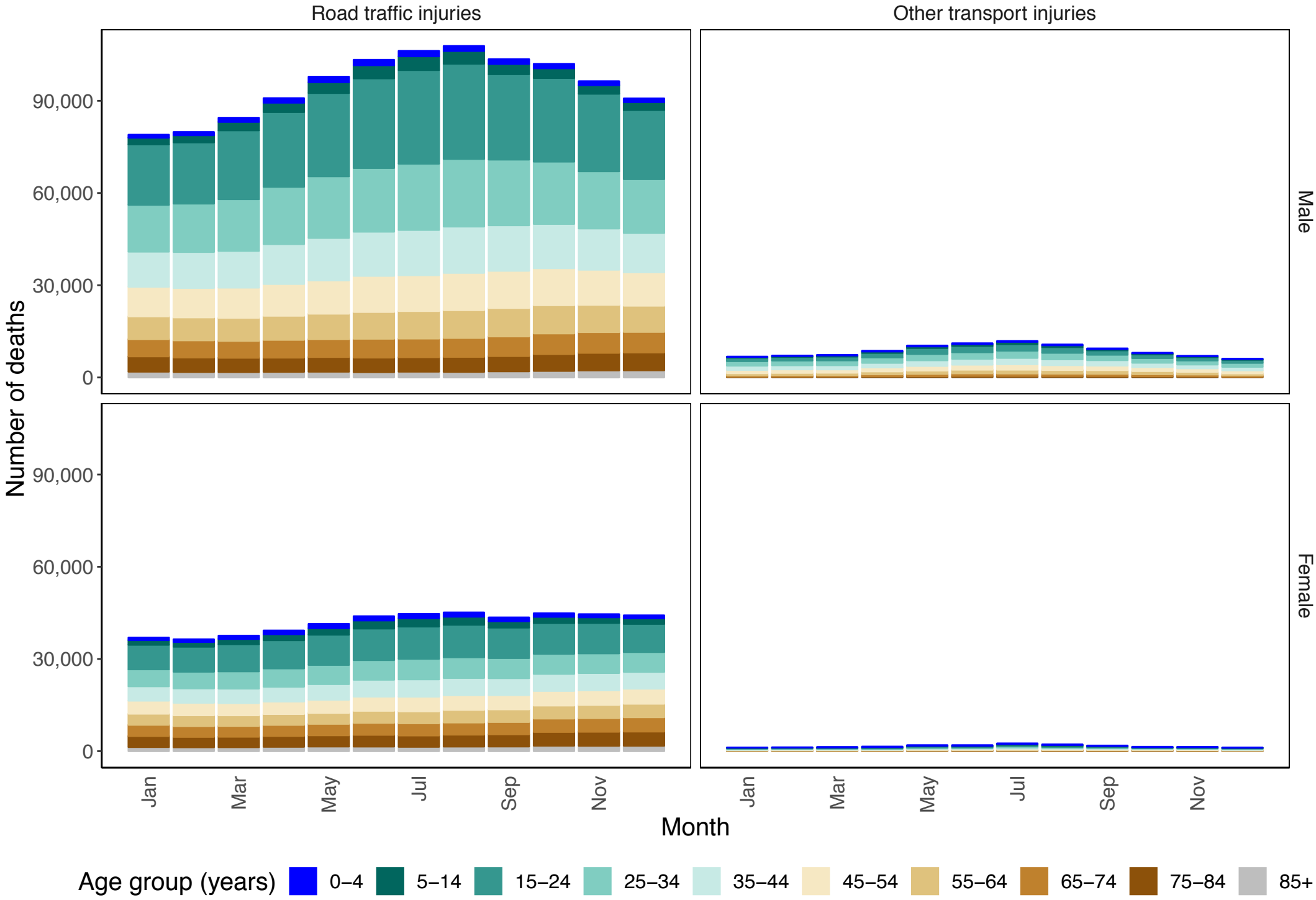

Unintentional
Male
Unintentional
Female
Intentional
Male
Intentional
Female
Additional deaths associated with a 2°C warmer year (based on 2017 population)
200
100
0
−100
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
Age group (years)
150
100
50
0
Jan
Mar
May
Jul
Sep
Nov
Month
Transport
Falls
Drownings
Assault
Suicide

Extended Data Figure 4. Percent change in death rates in year in which each month was +2°C compared with 1980-2017 average temperatures by type of injury, sex and (A) age group or (B) month.


Male
Female
Transport
Falls
Drownings
Assault
Suicide
Age group (years)
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
0.0%
5.0%
10.0%
15.0%
20.0%
Percentage change in death rates associated with a 2°C warmer year


Male
Female
Transport
Falls
Drownings
Assault
Suicide
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0.0%
5.0%
10.0%
15.0%
Percentage change in death rates associated with a 2°C warmer year

Extended Data Figure 5. Number of deaths by type of transport injury, month, sex and age group in the contiguous United States for 1980-2017.


Road traffic injuries
Other transport injuries
Male
Female
Number of deaths
90,000
60,000
30,000
0
Jan
Mar
May
Jul
Sep
Nov
Month
Age group (years)
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+

Extended Data Table 1. Injury groups used in the analysis with ICD-9 and ICD-10 codes.

Injury type		ICD-9	ICD-10
Unintentional	Transport	E800-E849	V01-V99
	Falls	E880-E888	W00-W19
	Drownings	E910	W65-W74
	Other unintentional (not analysed)	E850-E869, E890-E909, E911-E928	W20-W64, W75-X59
Intentional	Suicide	E950-E959	X60-X84
	Assault	E960-E969	X85-Y09
Intention undetermined (not analysed)		E980-E989	Y10-Y34
Legal intervention and operations of war (not analysed)		E970-E979, E990-E999	Y35-Y36
Complications of medical and surgical care (not analysed)		E870-E879, E930-E949	Y40-Y84
Sequelae of external causes (not analysed)		E929	Y85-Y89

Extended Data Table 2. Number of deaths and population over the study period (1980-2017) for injuries included in the analysis.

Sex	Age group (years)	Transport	Falls	Drowning	Suicide	Assault	Population (millions)
Male	0-4	19,263	1,828	14,110	0	14,137	379.6
	5-14	42,669	1,324	11,158	7,748	8,974	759.5
	15-24	316,862	8,801	26,335	147,423	180,145	801.9
	25-24	243,115	12,592	18,433	183,075	168,401	806.3
	35-34	175,783	17,389	13,617	175,251	98,664	748.8
	45-44	144,482	26,760	10,941	162,956	56,557	646.6
	55-54	110,084	36,343	8,420	126,006	29,811	508.0
	65-74	78,582	51,674	6,027	91,763	14,365	342.9
	75-84	62,262	95,526	4,136	70,682	6,531	176.4
	85+	23,756	103,976	1,596	25,633	1,861	49.9
Female	0-4	15,366	1,040	7,499	0	11,357	362.7
	5-14	25,912	489	3,517	2,971	5,894	725.1
	15-24	114,825	1,372	2,773	29,346	33,585	768.3
	25-24	75,607	2,096	2,756	43,114	39,843	797.5
	35-34	64,139	3,996	2,757	53,786	29,759	759.6
	45-44	55,040	8,301	2,737	56,141	17,900	672.5
	55-54	47,243	15,337	2,443	40,004	10,302	555.5
	65-74	47,478	34,426	2,213	22,261	7,572	417.0
	75-84	46,699	96,857	2,270	12,705	6,086	266.9
	85+	18,243	176,591	1,171	4,573	2,620	112.0

Extended Data Table 3. Correlation coefficients between monthly anomalies generated from daily mean temperature and daily maximum and minimum temperatures. Each correlation coefficient was calculated in each state for each month for 1980-2017, then averaged over all states for each month.

Month	Mean daily temperature and maximum daily temperature	Mean daily temperature and minimum daily temperature
January	0.98	0.98
February	0.98	0.98
March	0.97	0.97
April	0.97	0.96
May	0.96	0.94
June	0.95	0.92
July	0.97	0.94
August	0.96	0.93
September	0.93	0.91
October	0.91	0.93
November	0.96	0.97
December	0.97	0.98

Extended Data Table 4. Correlation coefficients between anomaly of mean daily temperature and measures of extreme anomalous temperature described in Methods. Each correlation coefficient was calculated in each state for each month for 1980-2017, then averaged over all states for each month.

Temperature variables	Anomaly of mean (main analysis)	Anomaly of 90th percentile	Number of days above long-term 90th percentile	Number of 3+ day episodes above long-term 90th percentile
Anomaly of mean (main analysis)		0.79	0.75	0.6
Anomaly of 90th percentile	0.79		0.89	0.77
Number of days above long-term 90th percentile	0.75	0.89		0.86
Number of 3+ day episodes above long-term 90th percentile	0.6	0.77	0.86	