National Future Extreme Heat Scenarios for Assessment of Climate Impacts on Public Health

Development of National Future Extreme Heat Scenario to Enable the Assessment of Climate Impacts on Public Health

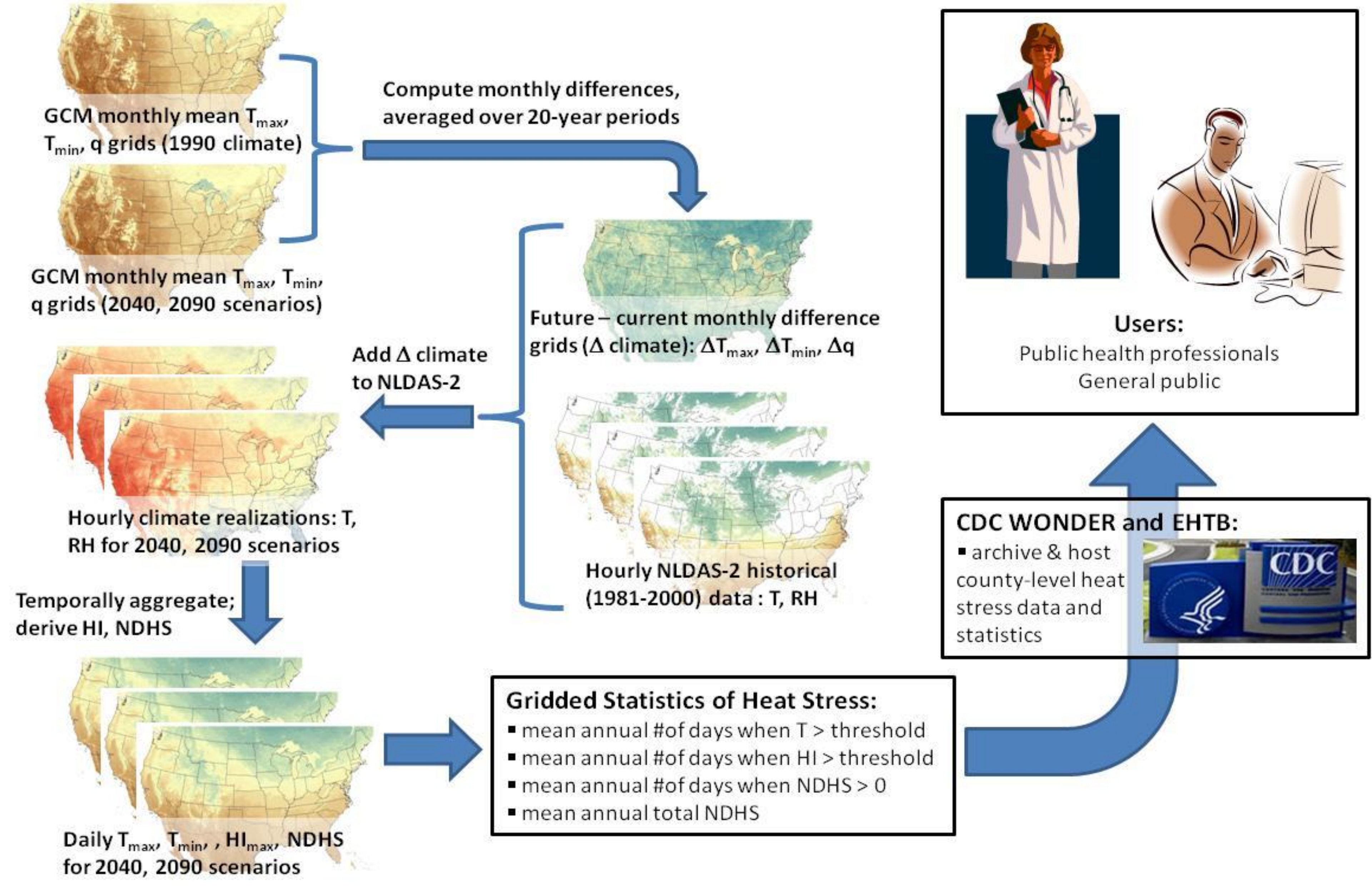
Dale A. Quattrochi
NASA Earth Science Office
Marshall Space Flight Center
Huntsville, AL
And
William L. Cresson
Mohammad Z. Al-Hamdan
Maurice G. Estes
Universities Space Research Association
National Space Science & Technology Center
Huntsville, AL

National Future Extreme Heat Scenarios for Assessment of Climate Impacts on Public Health

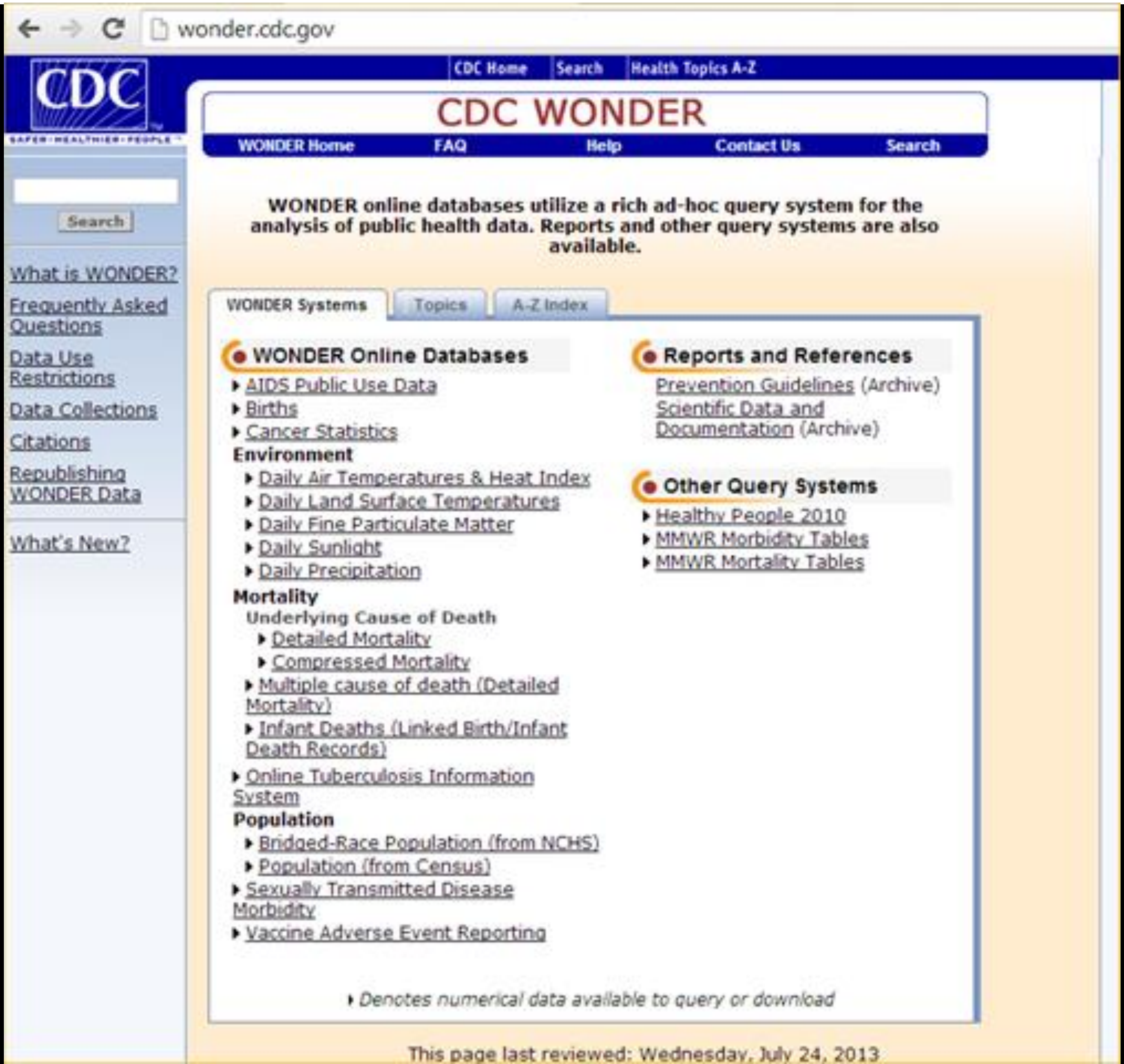
Project Objective: **To provide historical and future measures of climate-driven heat events to enable assessments of heat impacts on public health over the coterminous U.S.**

- The project's emphasis is on providing assessments of the magnitude, frequency and geographic distribution of EHEs to facilitate public health studies.
- We focus on the daily to weekly time scales on which EHEs occur, not on decadal-scale climate changes.
- There is, however, a very strong connection between air temperature patterns at the two time scales and long-term climatic changes will certainly alter the frequency of EHEs.

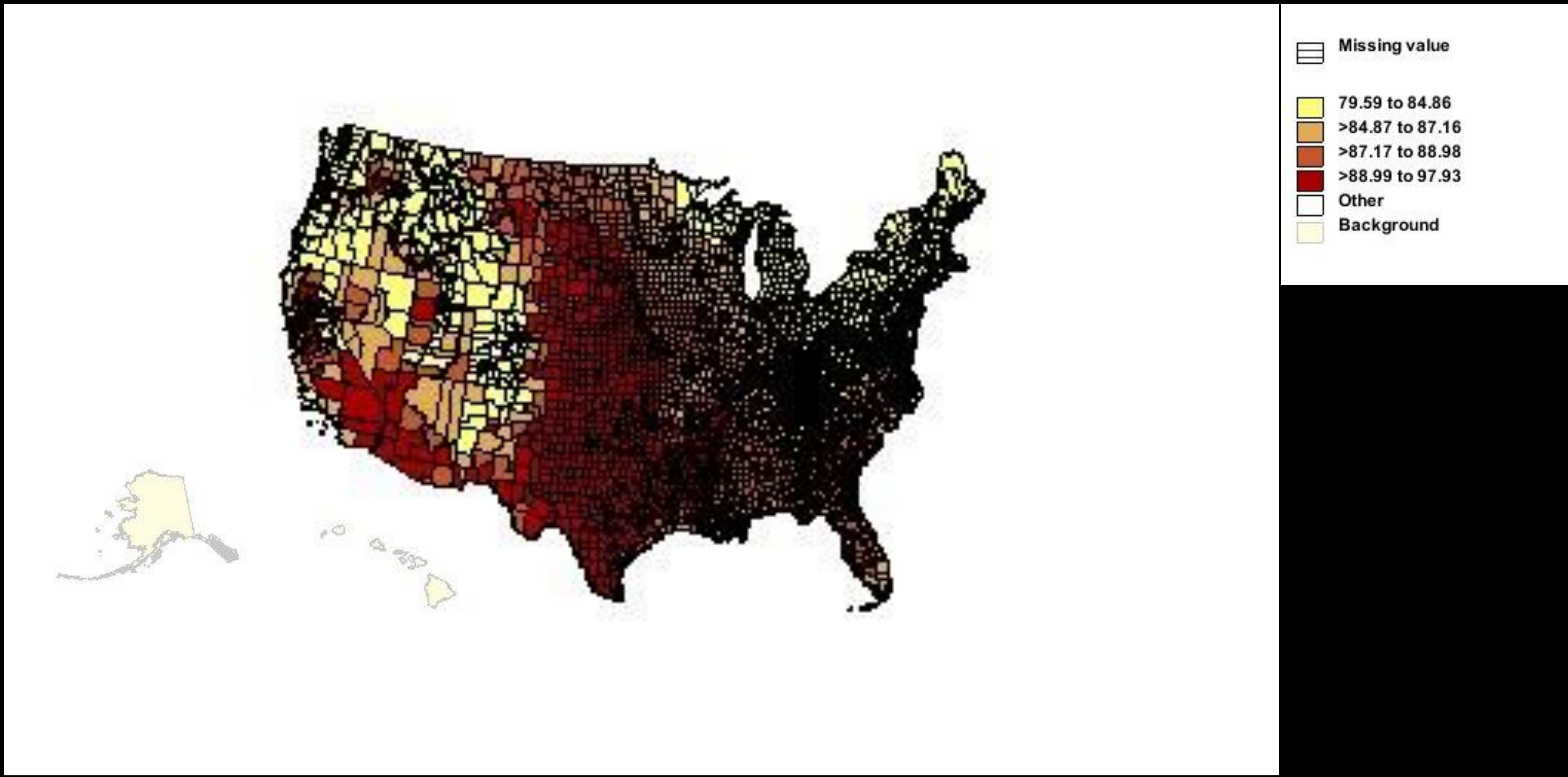
National Future Extreme Heat Scenarios for Assessment of Climate Impacts on Public Health



CDC WONDER DATABASES



CDC WONDER OUTPUT EXAMPLE



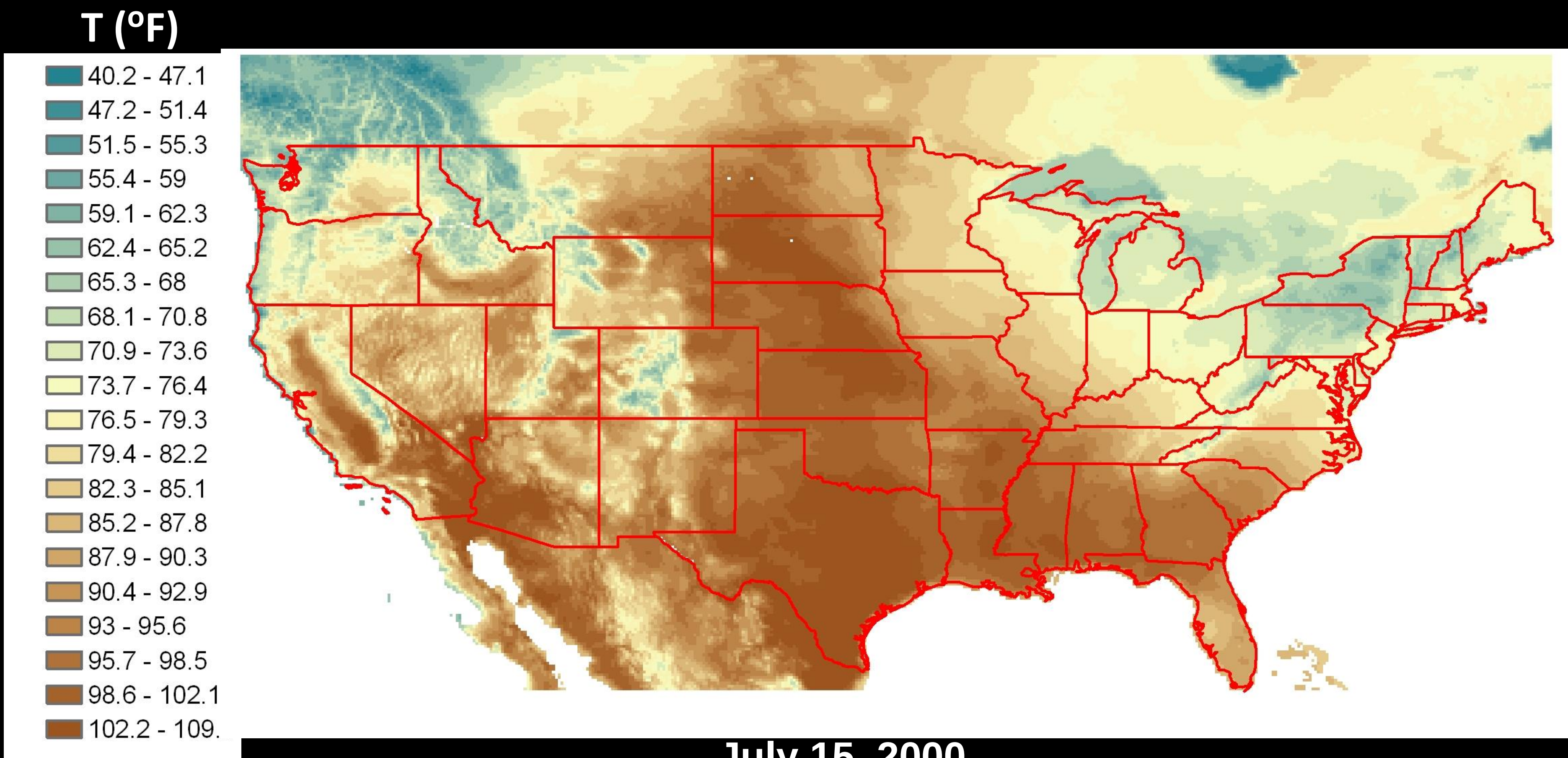
US Average Maximum Daily Air Temperature - 2000-2011

Metrics of Excessive Heat

1. Daily Maximum Air Temperature

- Daily maximum air temperature, the highest temperature recorded at an observation site between midnight and midnight local standard time, is a traditional measure of heat, and one with which everyone is familiar.

We used NLDAS data to calculate daily maximum air temperature.

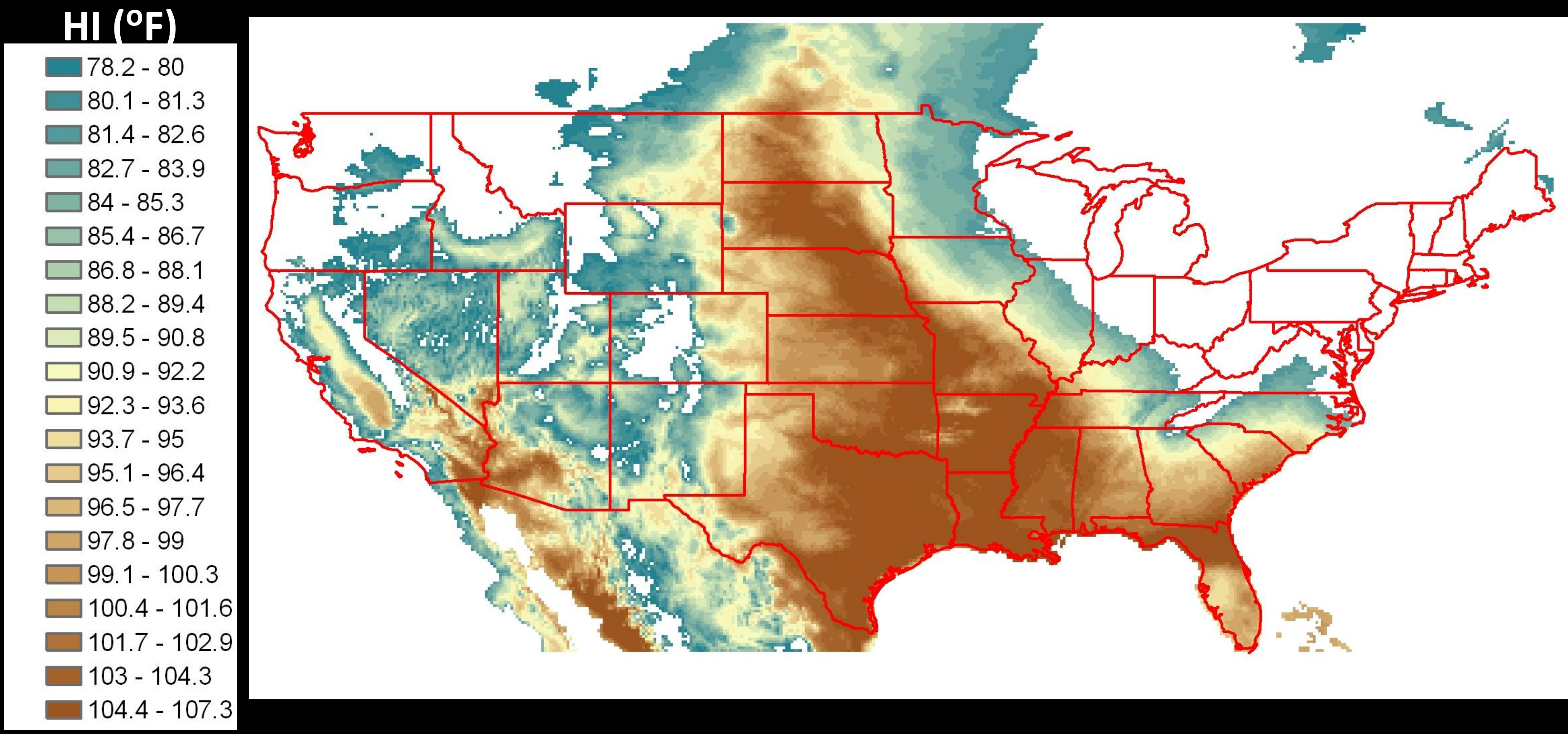


July 15, 2000

Metrics of Excessive Heat

2. Heat Index (HI)

We used NLDAS data to calculate daily maximum Heat Index (HI).



July 15, 2000

Metrics of Excessive Heat

3. Net Daily Heat Stress (NDHS)

Net Daily Heat Stress is a new heat variable that gives an integrated measure of heat stress (and relief) over the course of a day, defined as:

$$NDHS = \Sigma(HI_i - HI_{hot}) - \Sigma(T_{cool} - T_i)$$

where the summations are over the hours in a day, but only positive terms are included. In other words, the first sum, the 'heat stress', is only calculated when $HI_i > HI_{hot}$, where HI_{hot} is a threshold above which HI is considered a stressor, set to 90^o F.

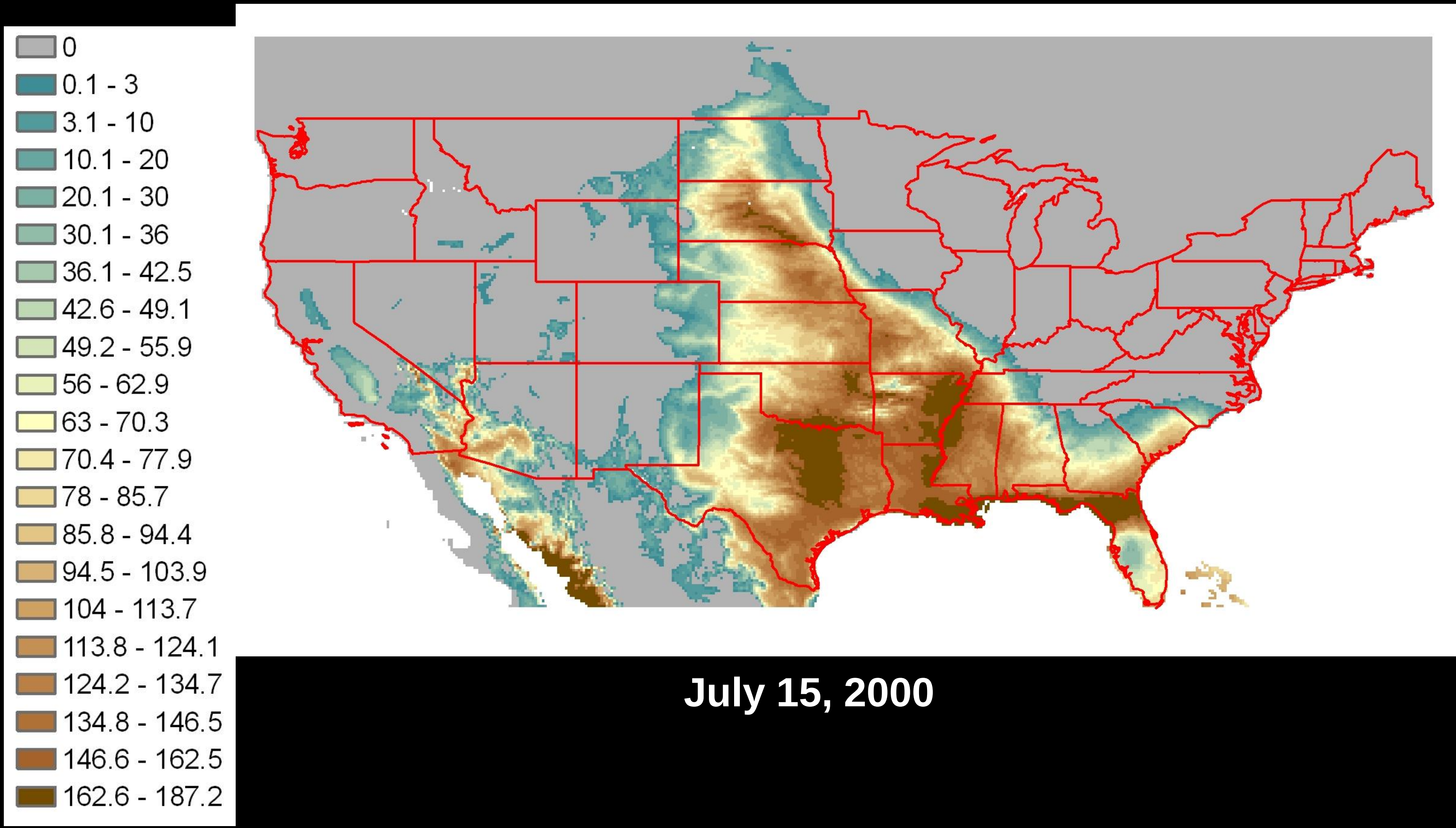
The second term, 'heat relief', is only computed when $T_i < T_{cool}$, a temperature below which relief from heat occurs, set to 75^o F. This term is based on air temperature since HI is only defined when T > 80^o F.

If heat relief is greater than heat stress, NDHS is set to 0.

Metrics of Excessive Heat

3. Net Daily Heat Stress (NDHS)

NDHS (degree-hours)



July 15, 2000

GCMs

We obtained GCM output of monthly mean minimum and maximum daily temperatures and monthly mean specific humidity.
Source: Coupled Model Intercomparison Project (CMIP3) Multi-Model Dataset Archive at Program for Climate Model Diagnosis and Intercomparison (PCMDI). This activity was in support of the 4th Assessment Report (AR4).

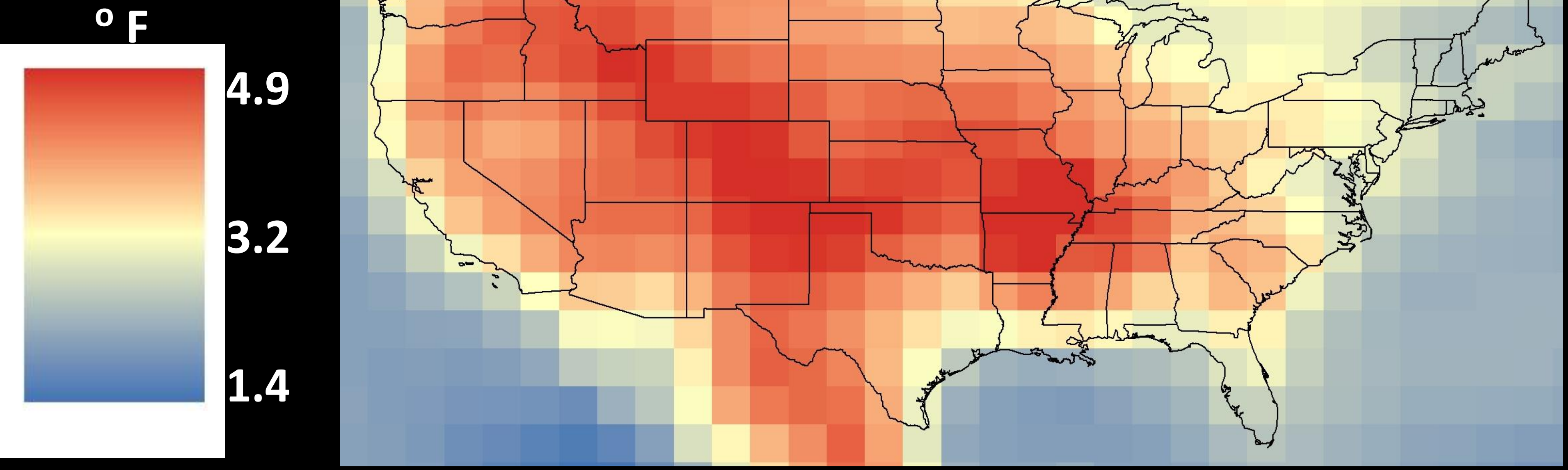
Scenarios:
20th Century Climate for 1980 -1999
SRES A2 for 2030-2049 (2040) and 2080-2099 (2090)
SRES A1B for 2030-2049 (2040) and 2080-2099 (2090)

	Model	# Ensemble members used
1.	CCSM3 (NCAR)	2
2.	CSIRO-MK3.0 (Australia)	2
3.	CSIRO-MK3.5 (Australia)	3
4.	BCCR-BCM2.0 (Norway)	1
5.	INM CM3.0 (Russia)	1
6.	MIROC 3.2 Med. Res. (Japan)	3

Means of each variable were computed across ensembles, then across models.

Mean Maximum Temperature Difference - August

2040 – 1990, Average of all models, all ensemble members, A2 scenario

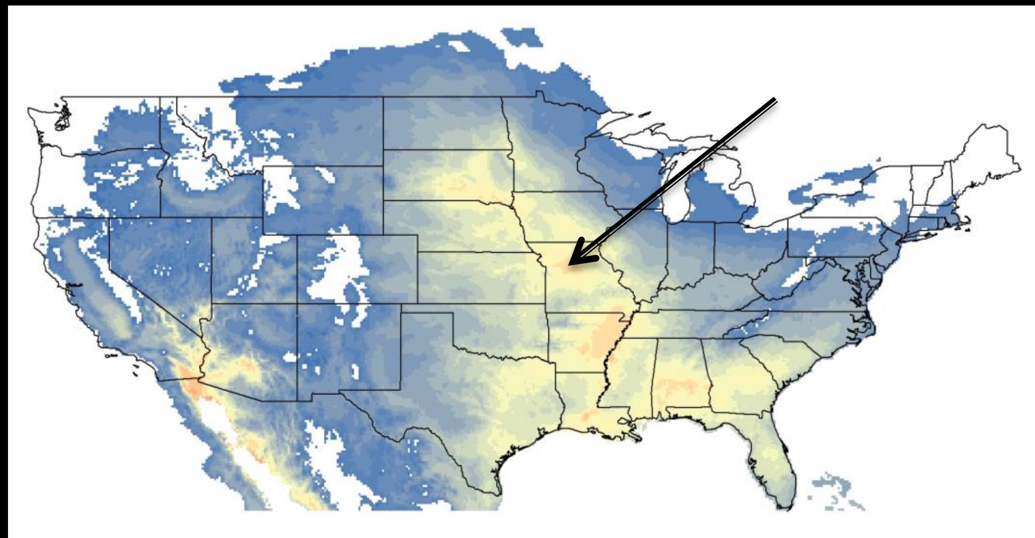


Example of current and future climates

Daily maximum Heat Index, A2 scenario

Heat Index (ºF)

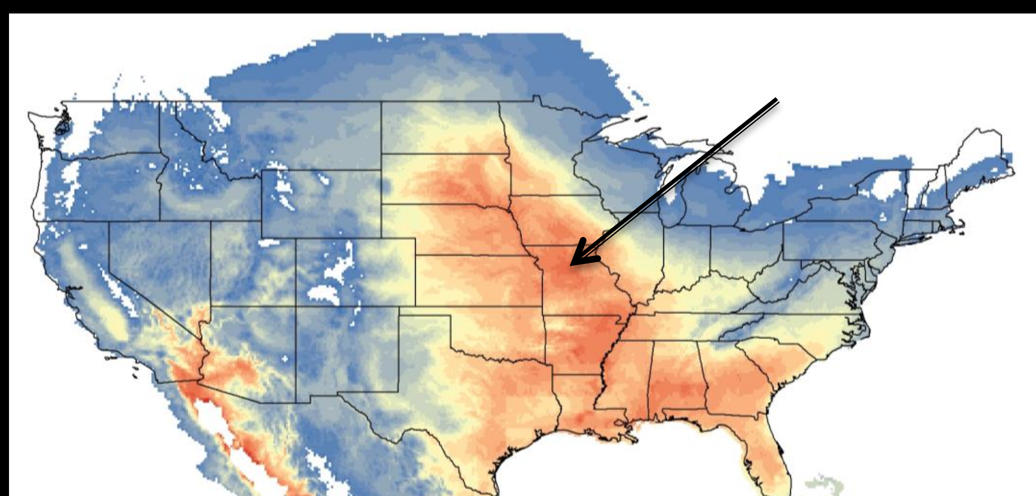
- 78 - 80
- 80 - 84
- 84 - 88
- 88 - 92
- 92 - 96
- 96 - 100
- 100 - 102
- 102 - 104
- 104 - 106
- 106 - 108
- 108 - 110
- 110 - 112
- 112 - 114
- 114 - 116
- 116 - 118
- 118 - 120
- 120 - 122
- 122 - 124
- 124 - 126
- 126 - 128



= 111 ºF

Daily maximum Heat Index August 13, 2007

Add 2040-1990 Δ-climate (temperature & humidity) to obtain HI projections:

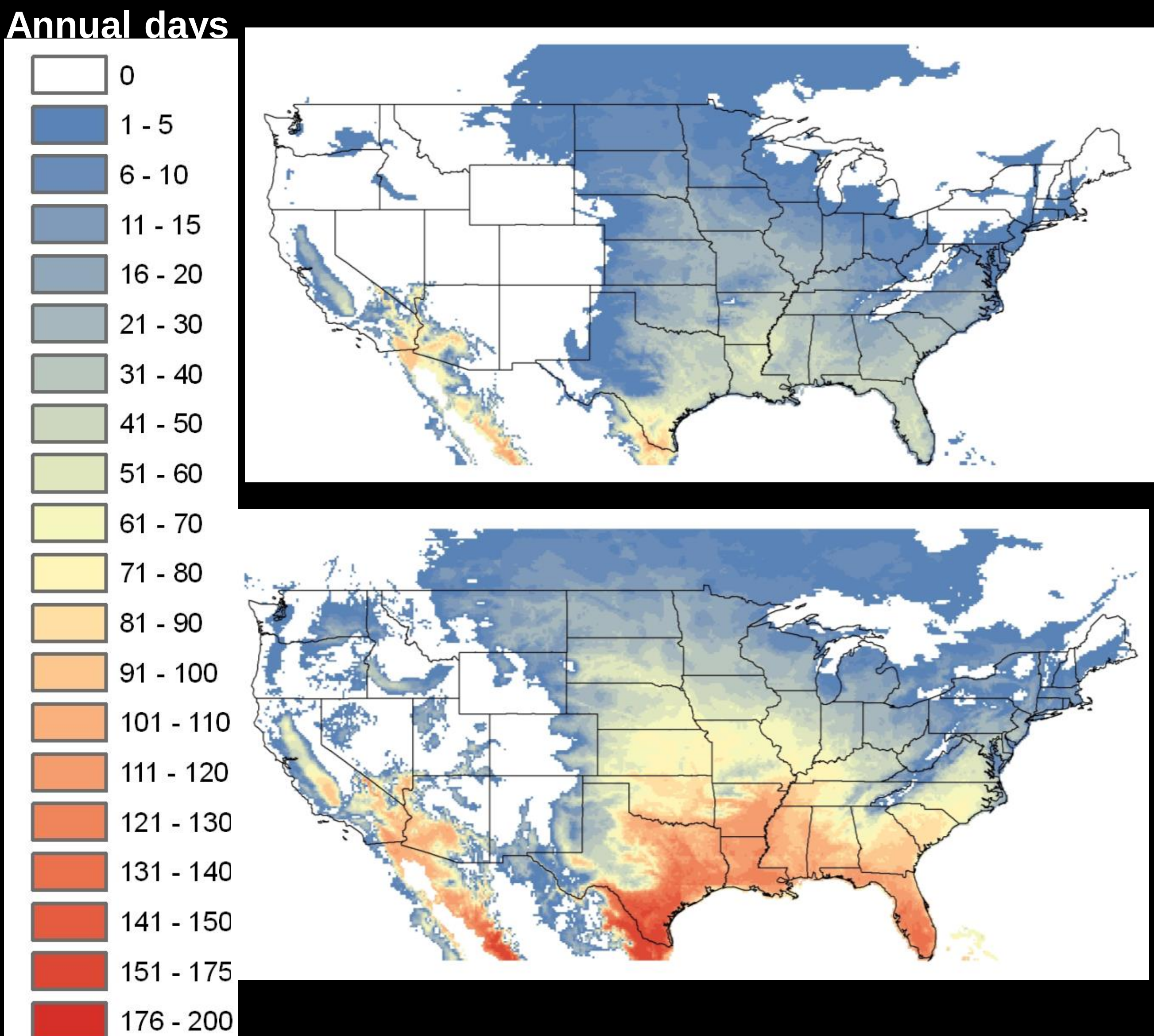


= 121 ºF

Daily maximum Heat Index August 13, 2007 analog in 2041-2060 climate

Example of current and future climates

Number of annual days when Heat Index exceeds 100 ºF, A2 scenario

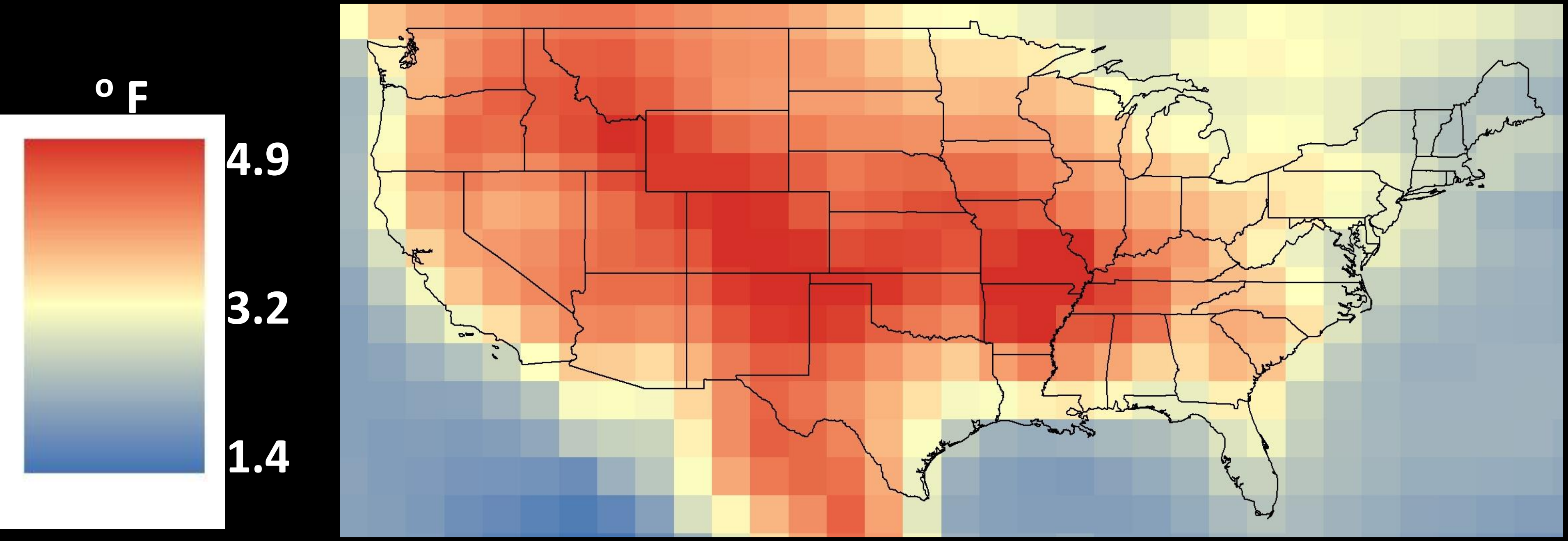


Number of days Heat Index exceeded 100 ºF 2007

Number of days Heat Index to exceed 100 ºF 2007 analog in 2041-2060 climate

Mean Maximum Temperature Difference - August

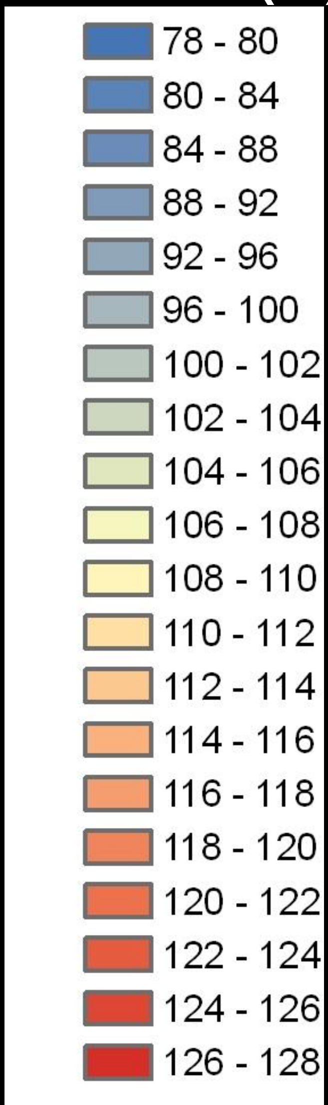
2040 – 1990, Average of all models, all ensemble members, A2 scenario

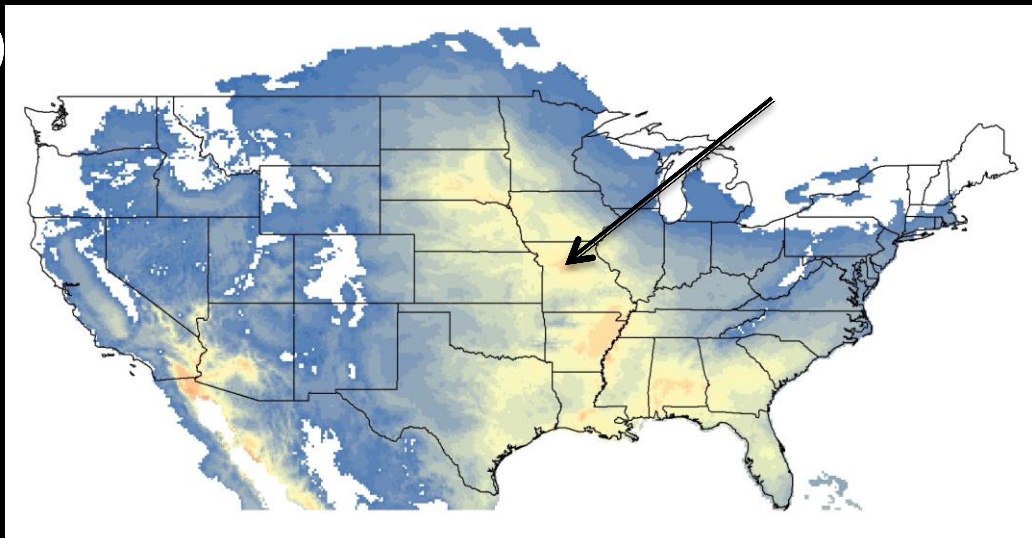


Example of current and future climates

Daily maximum Heat Index, A2 scenario

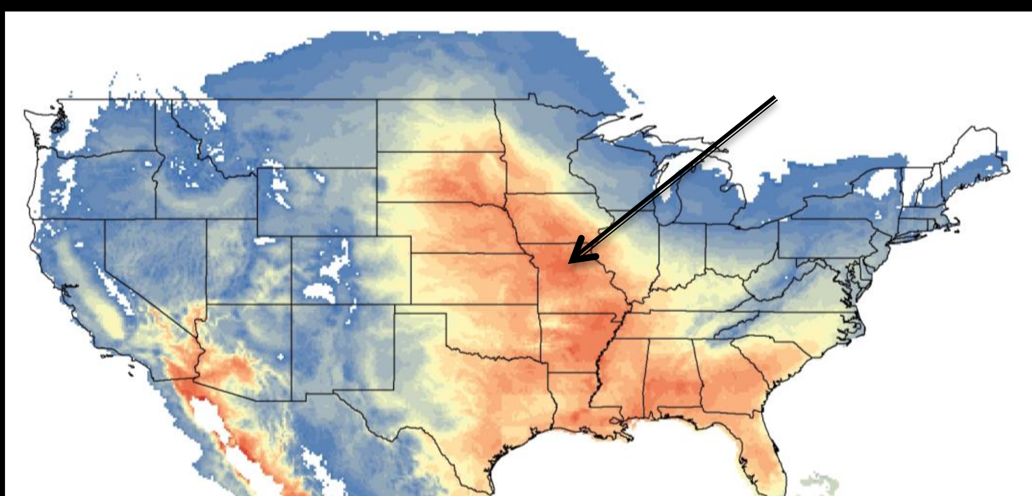
Heat Index (°F)





= 111 °F

Daily maximum Heat Index August 13, 2007



= 121 °F

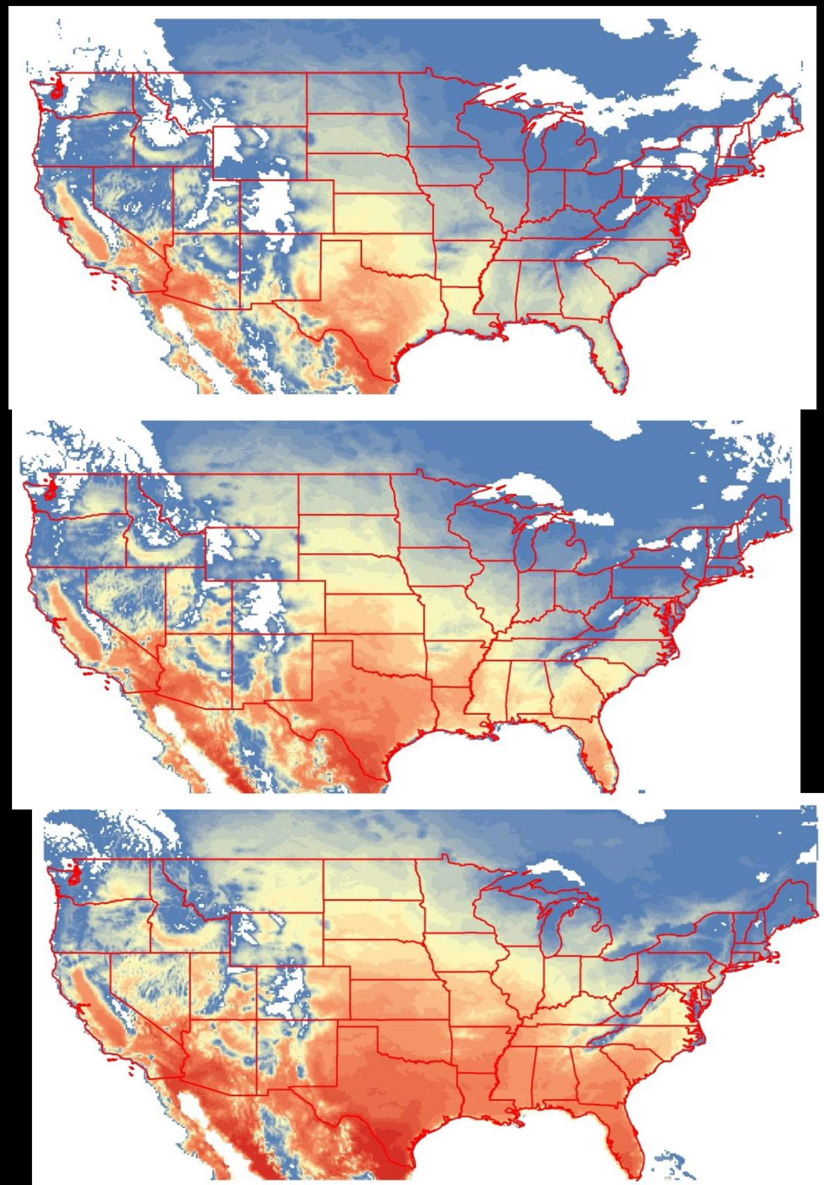
Daily maximum Heat Index 50 years later

Example of current and future climates

Number of annual days when air temperature exceeds 90º F, A2 scenario

Annual days

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 90
- 91 - 100
- 101 - 110
- 111 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- 201 - 225
- 226 - 260



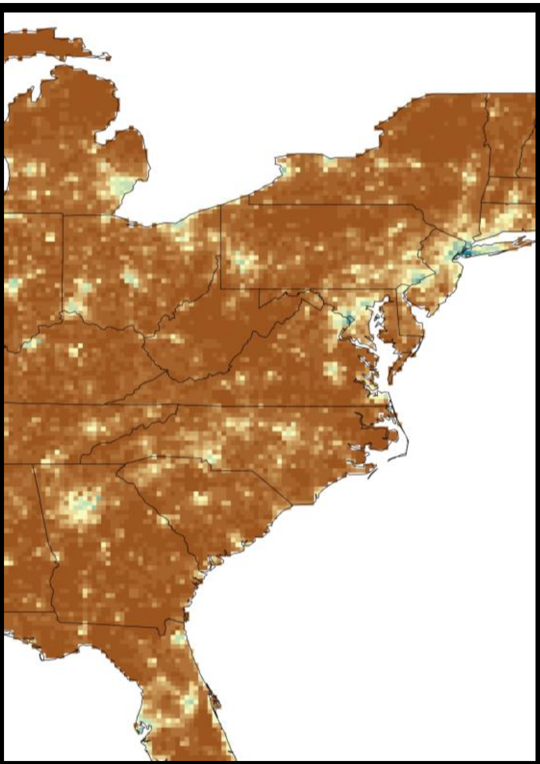
1981 - 2010

2031 – 2060
A2 Scenario

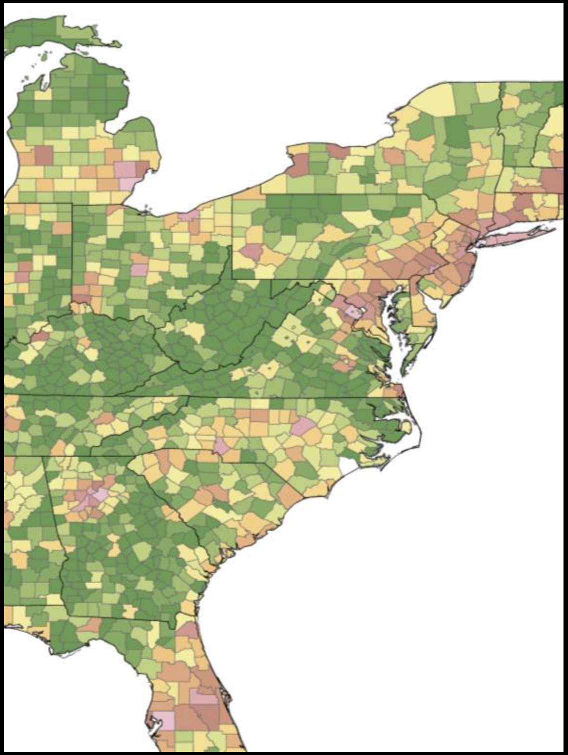
2081 – 2110
A2 Scenario

Population projections

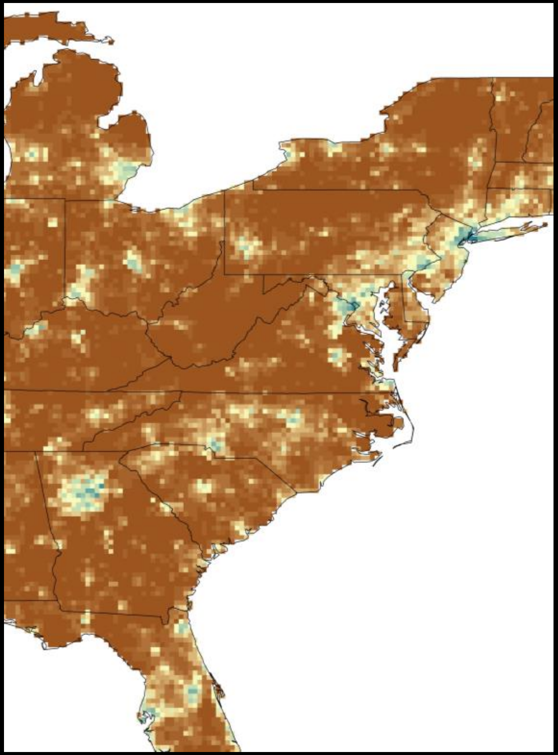
Combine current gridded population estimates with county-level projections



2010 Population
NLDAS Grid



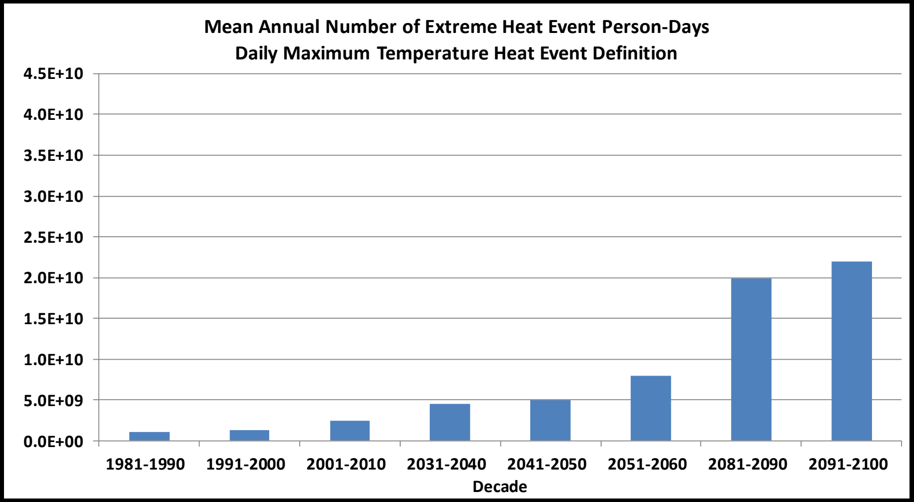
2050 County Projections
(EPA-ICLUS)

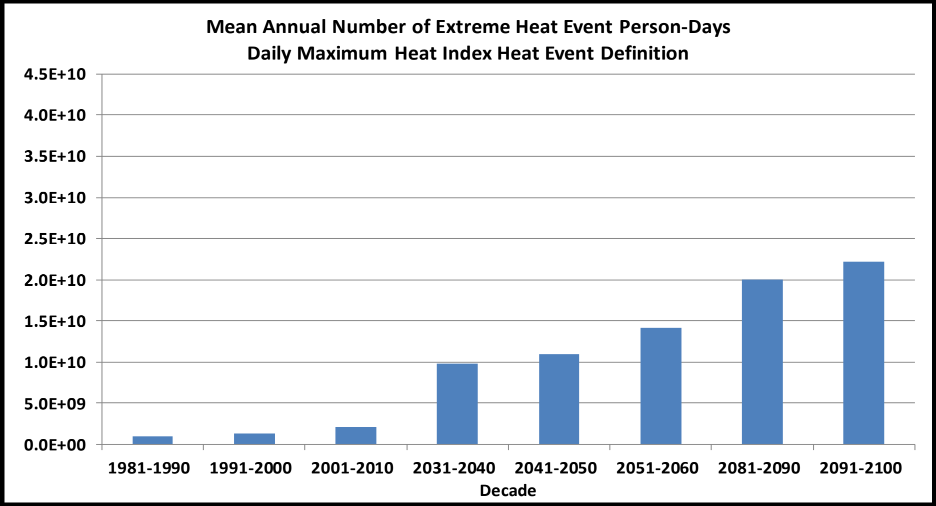


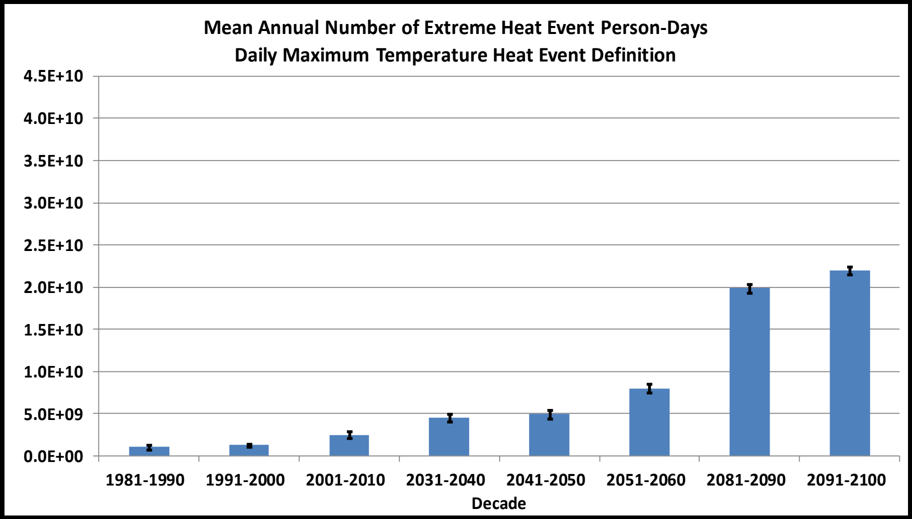
2050 Population
NLDAS Grid - A2 Scenario

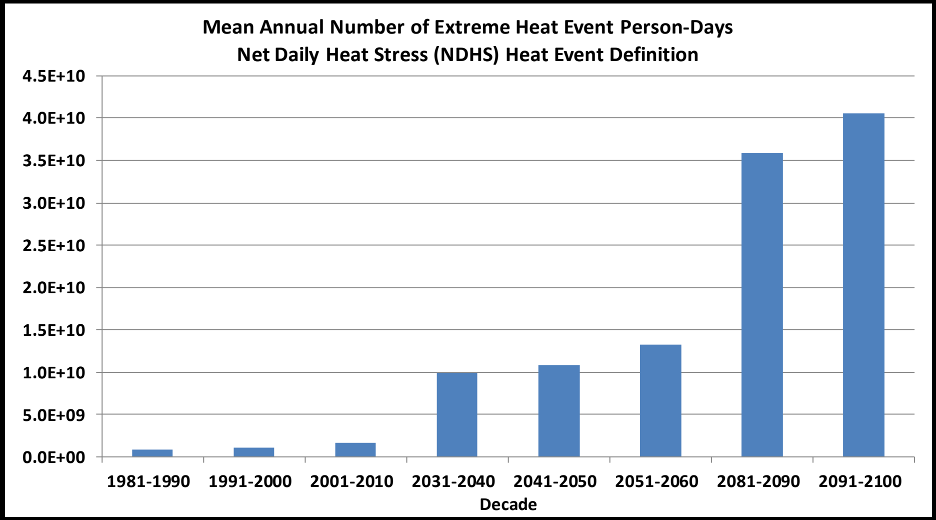
- 2010 5 km Gridded Population of the World (GPW-3) aggregated to 12 km NLDAS grid.
- Distribution of population across NLDAS grids within each county determined from 2010 county populations (EPA-ICLUS).
- Projections made using county-level estimates (EPA-ICLUS), keeping in-county distribution constant.

Population-Weighted Heat Wave Days Index
i.e. Mean Annual Number of Person-Days Experiencing Extreme Heat





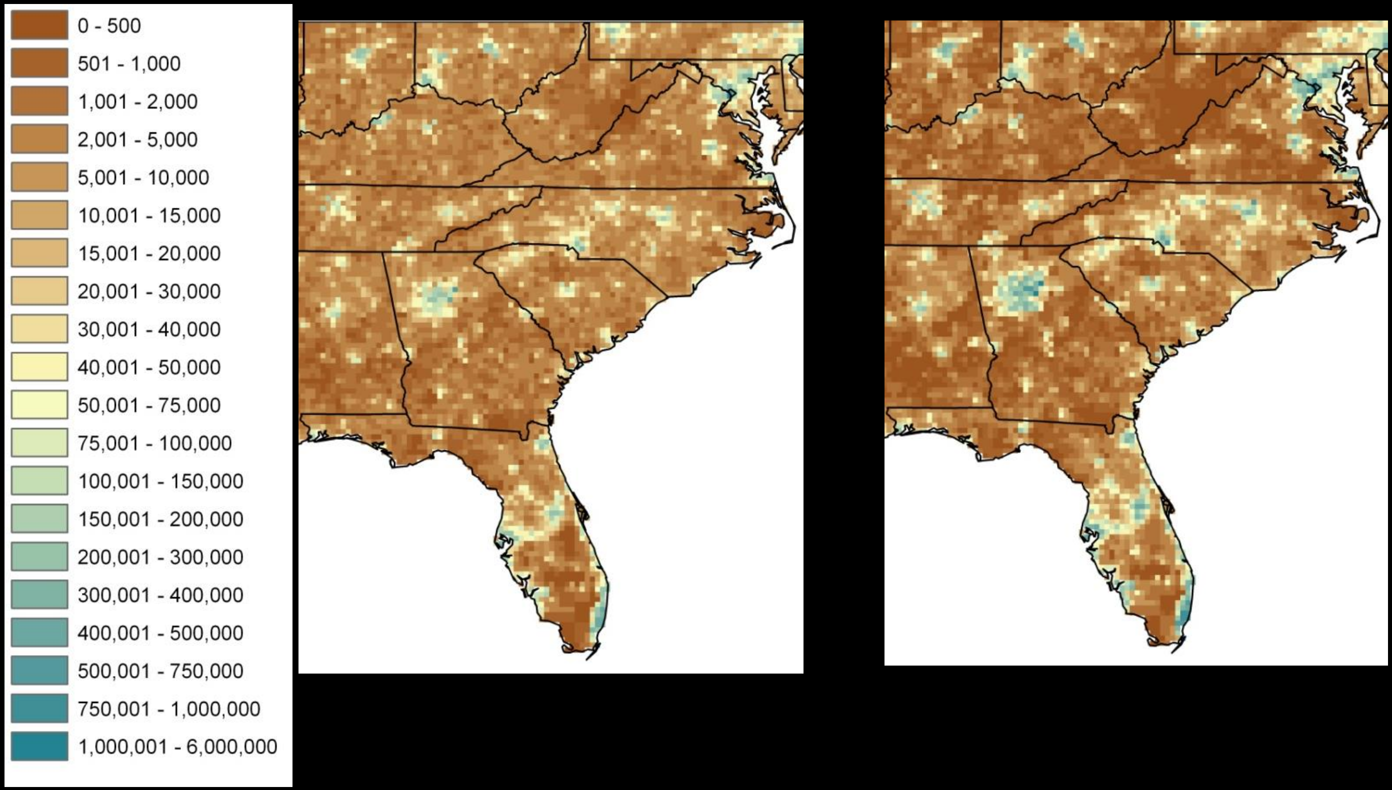




These graphs show the mean annual number of EHE person-days by decade, based on three EHE definitions.

Bottom left is same as top left except with bars showing the standard error of the means.

Population on the NLDAS grid

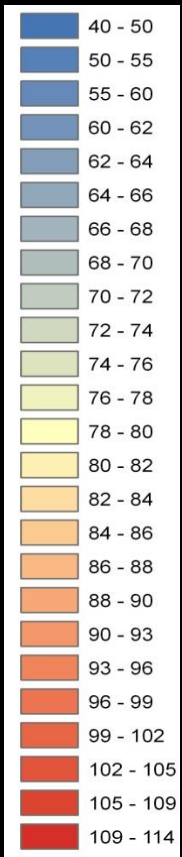


Procedure for projecting population on the NLDAS grid

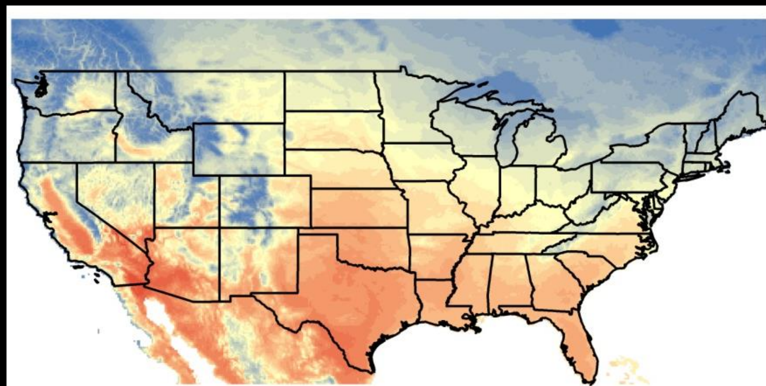
- Population on the NLDAS grid were determined from 2010 U.S. Census populations at the Census Tract level.
- County populations were determined by aggregating the NLDAS grid populations.
- The proportion of the county population within each NLDAS grid cell was computed by dividing the grid cell population by the respective county population.
- Populations in 5-year intervals to 2100 were estimated using projected county populations from EPA-ICLUS (Integrated Climate and Land Use Scenarios), keeping in-county distribution constant. The A2 climate scenario projections were used here.
- The 5-year projections were interpolated to create annual projections.

May – September mean daily maximum temperatures

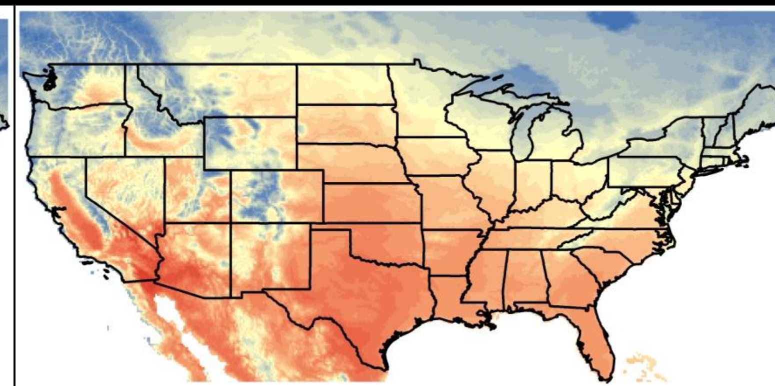
ºF



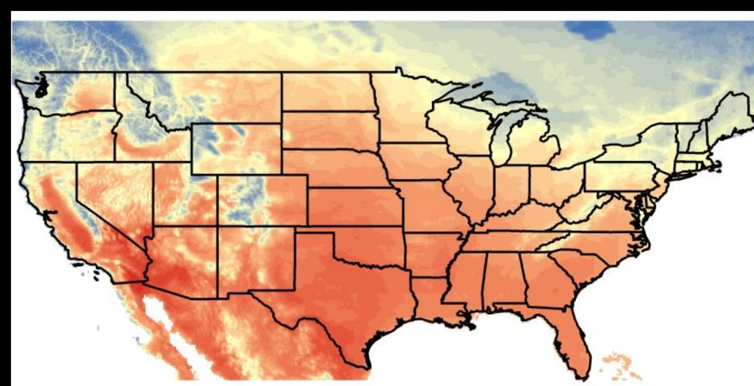
1981-2010



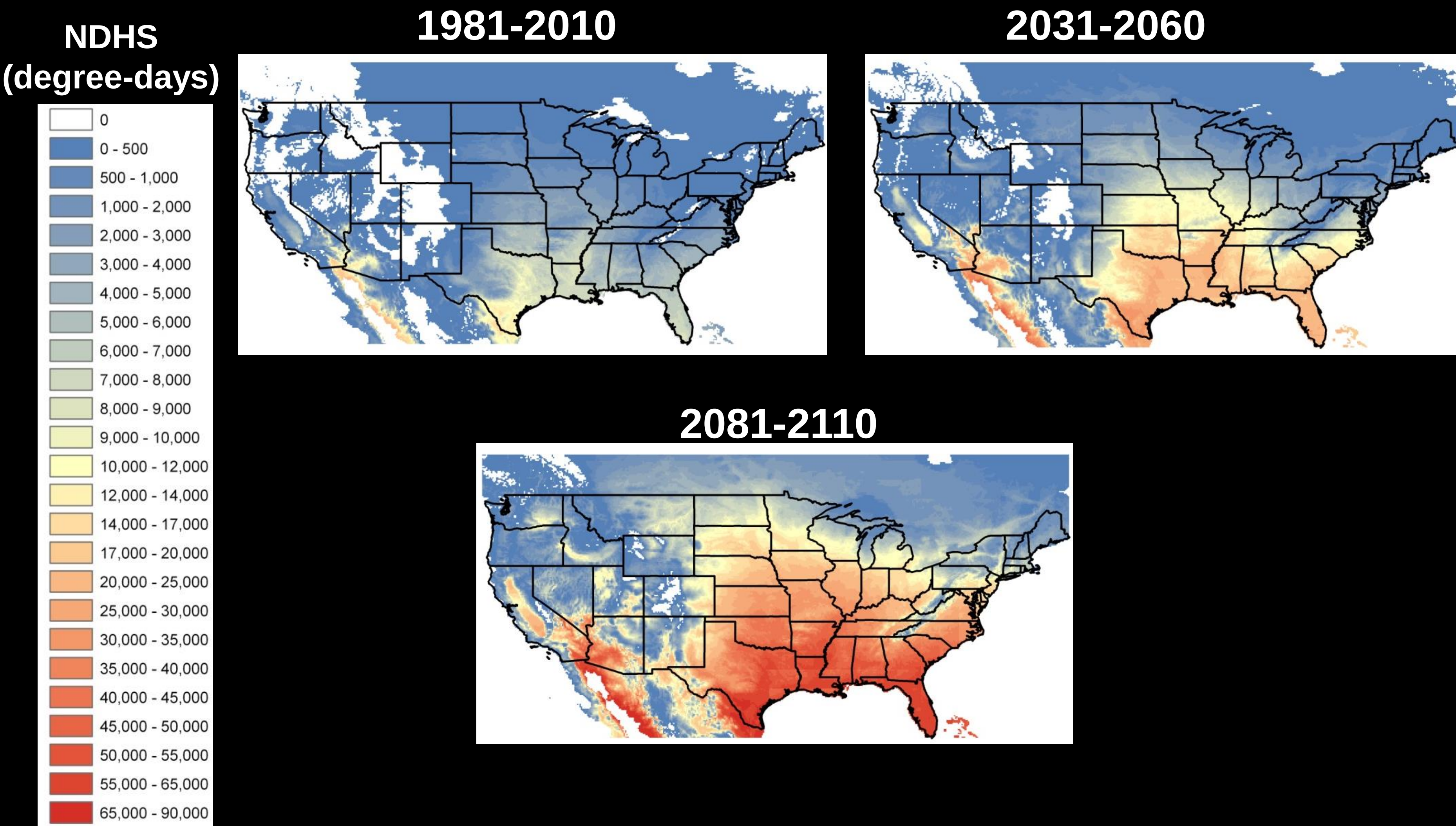
2031-2060



2081-2110

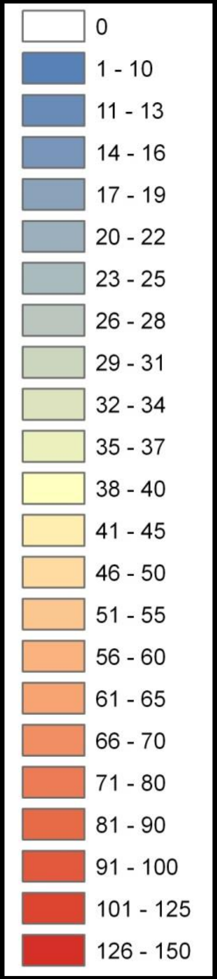


May – September mean total Net Daily Heat Stress

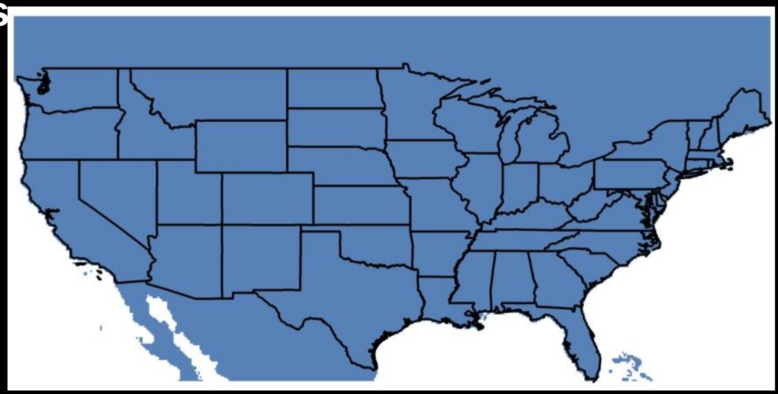


May – September Mean Number of Extreme Heat Event Days
Maximum Temperature Definition

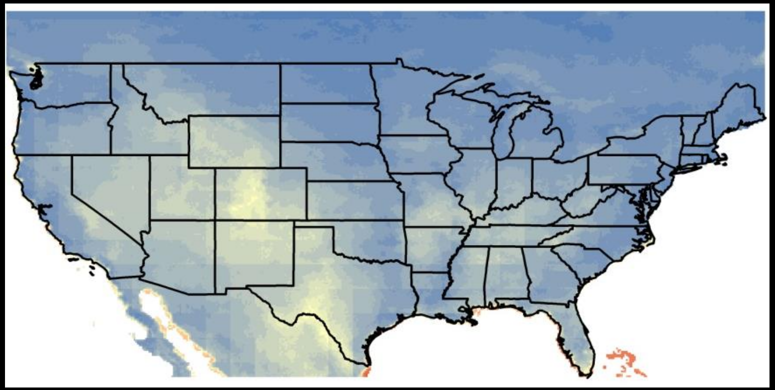
Number of days



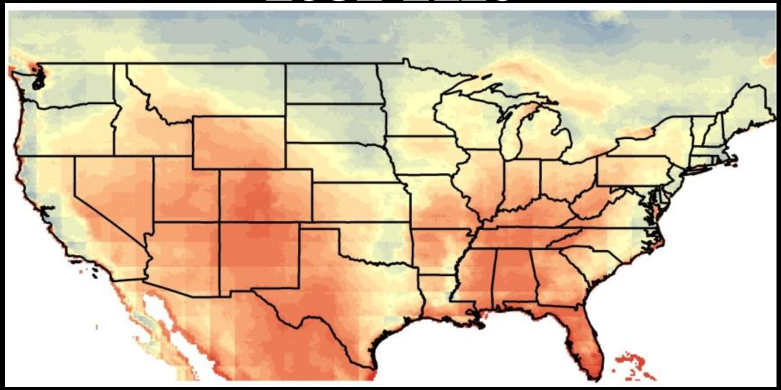
1981-2010



2031-2060



2081-2110

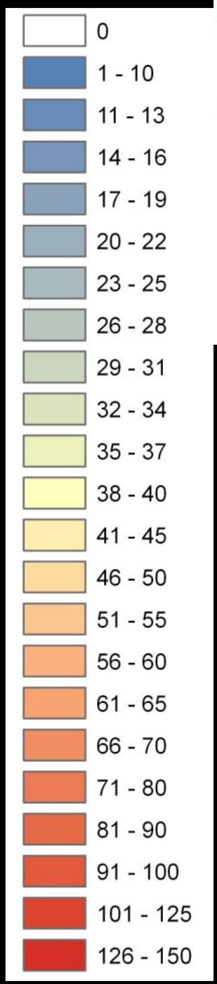


Note: Since EHE days are based on days exceeding percentiles for the local climate, the number of EHE days for the baseline period (1981-2010) is nearly uniform across the country, at about 6 days per year.

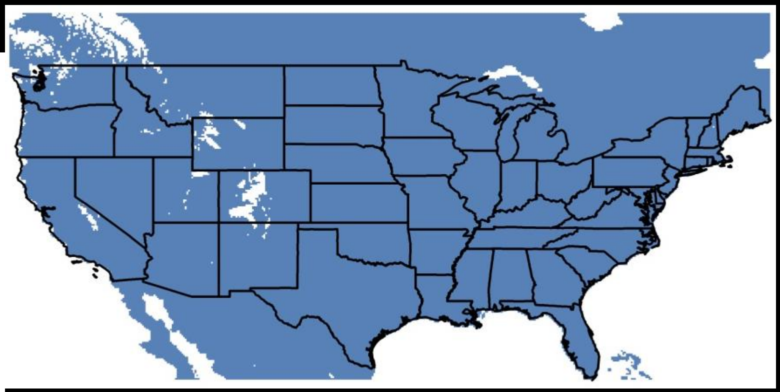
Based on the Maximum Temperature EHE definition, the mean annual number of EHE days rises to 20-40 for much of the country by mid-century , and to 50 – 100+ by the end of the century.

May – September Mean Number of Extreme Heat Event Days
Maximum Heat Index Definition

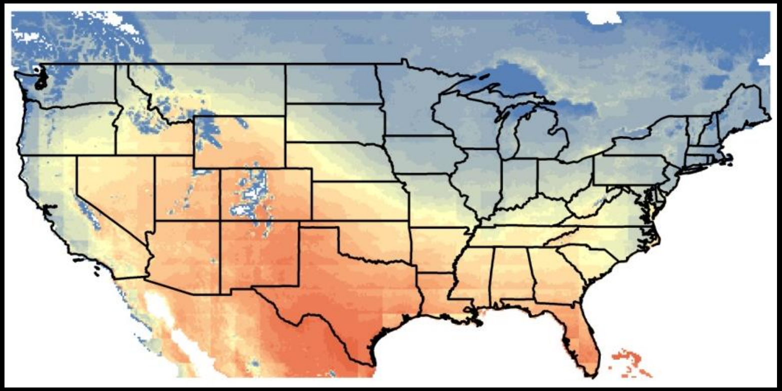
Number of days



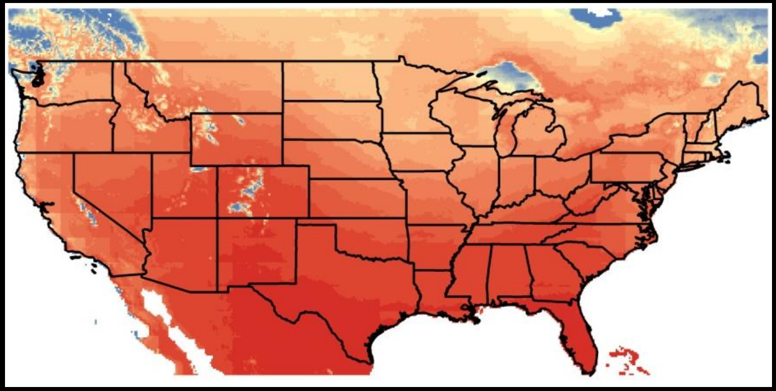
1981-2010



2031-2060



2081-2110



Based on the Maximum Heat Index EHE definition, the mean annual number of EHE days rises to 30-60 for much of the country by mid-century , and to 60 – 150 by the end of the century.

Summary

- GCM-scale monthly climatologies of max/min air temperature and specific humidity for the historical period 1981-2000, and future changes relative to this period.
- NLDAS-scale daily max/min temperatures, maximum heat index and Net Daily Heat Stress for historical period.
- NLDAS-scale statistics over 20-year past and future periods of heat stress measures.
- County-level heat stress measures to enable assessments of heat impacts on public health.
- Population-weighted NDHS for coterminous U.S.