Heat exposure of U.S. agricultural workers in a warming climate

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BACKGROUND

Heat is the leading cause of weather-related mortality in the U.S. (NWS, 2017), with more than 600 deaths per year attributed to extreme heat (Roelofs, 2018). Crop workers are particularly vulnerable to environmental heat exposure: heat-related mortality rates are 20x higher than in the general working population (CDC, 2008).

Climate change threatens to increase the risk of heat-related illness in ag workers, but no nation-wide evaluation of the expected change in heat exposure has been conducted. Here we estimate baseline and future exposure of crop workers in the main U.S. growing regions to extreme heat.

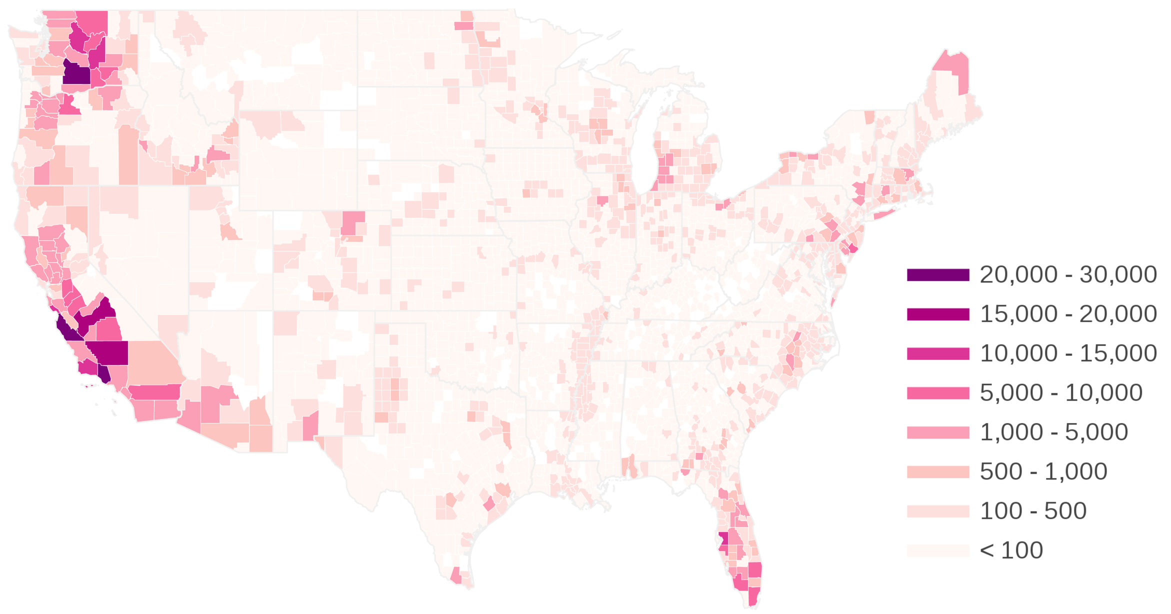


Fig. 1 Number of crop production workers in month with highest employment; 2008-2017

METHODS

We obtain 6-h temperature and relative humidity data from the **NCEP North American Regional Reanalysis** for 1979-2013 and calculate various percentile levels for daily min, mean, and max temperature and humidex ($H = T + (0.5555 * (e - 10))$) during the crop season (MJJAS).

For future projections, we regress monthly temperature change in the **CMIP5 RCP8.5 runs** against annual global mean temperature and add the multi-model mean change in climatology for **2 and 4°C global warming** to the reanalysis variability.

Crop worker statistics are obtained from the **BLS Quarterly Census of Employment and Wages**.

PRESENT-DAY LEVELS

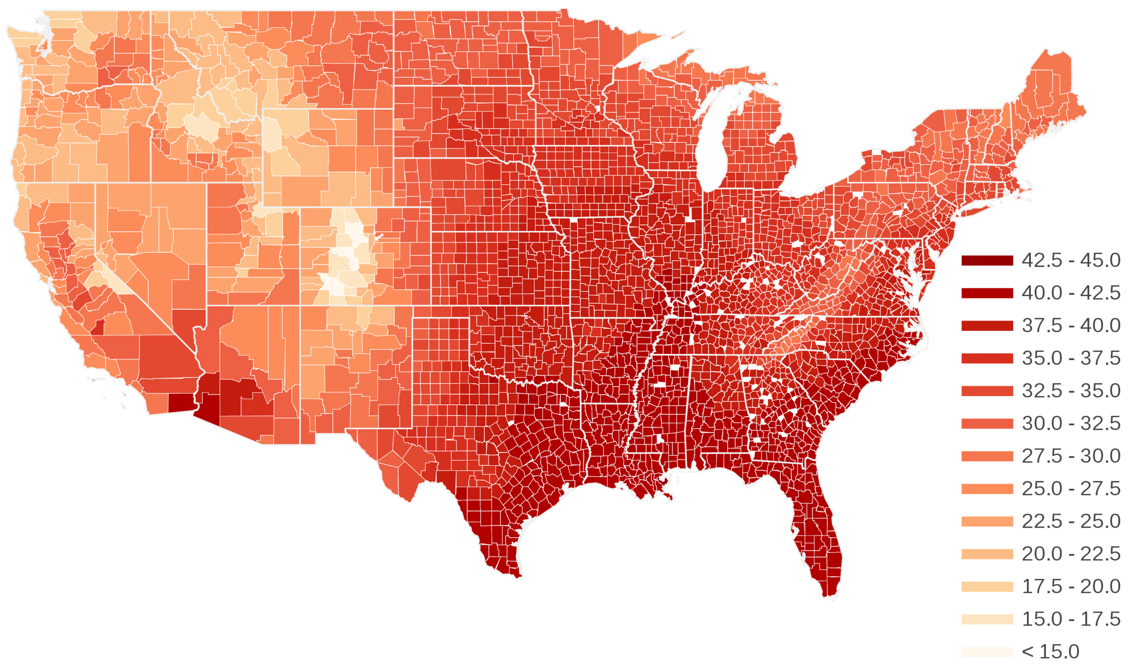


Fig. 2 95th-percentile of 1979-2013 daily mean summer (MJJAS) humidex

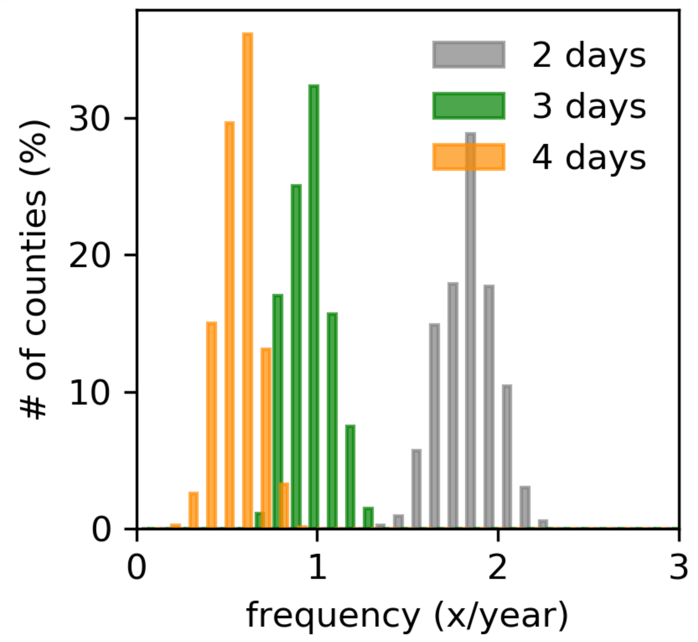
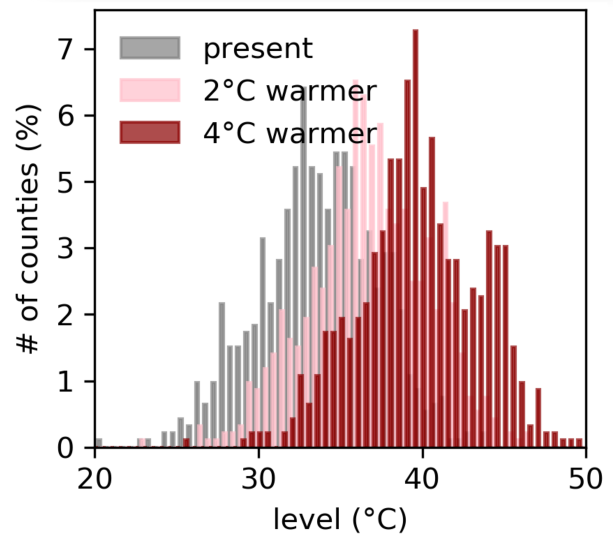


Fig. 3 Average frequency of threshold exceedance for 2, 3, or 4 days in counties with >100 workers

There is substantial geographic variability in exposure to heat extremes (measured by the 95th-percentile of humidex), suggesting varying levels of worker acclimatization. Multi-day heatwaves above this level of >4 days typically occur less than once a year.

FUTURE EXPOSURE



The mean 95th-percentile max temp in counties with >100 crop workers is projected to increase from 33.6°C to 36.2°C with 2°C warming and 39.8°C with 4°C warming.

Fig. 4 95th-percentile of max daily summer (MJJAS) temp in counties with >100 workers

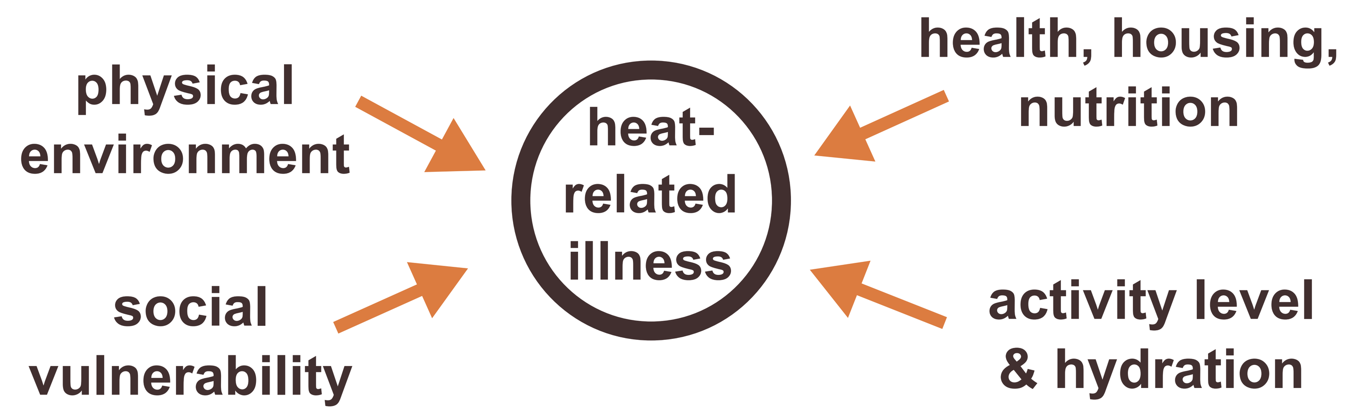
county	95th-percentile MJJAS T_{max}			times/year level exceeded for >4 days		
	present	+2°C	+4°C	present	+2°C	+4°C
Fresno County, California	36.0	39.0	41.9	0.9	3.4	6.1
Kern County, California	39.6	42.3	45.1	0.9	3.4	5.9
Monterey County, California	34.0	36.4	38.8	0.5	3.2	6.1
Santa Barbara County, California	31.9	34.1	36.3	0.7	3.3	5.8
Santa Cruz County, California	33.4	35.8	38.1	0.4	2.0	4.4
Tulare County, California	34.8	37.7	40.8	0.7	3.8	5.4
Ventura County, California	34.3	36.6	39.0	0.5	3.0	5.9
Chelan County, Washington	26.3	29.9	33.5	0.7	3.2	5.3
Grant County, Washington	35.7	39.4	43.2	0.6	3.1	4.8
Yakima County, Washington	30.1	33.8	37.5	0.7	3.2	5.3

In the ten counties with the most crop workers, the 95th-percentile of max temp is projected to rise well above safe levels. Multi-day heat waves above historical extremes are projected to occur multiple times each year.

Table 1 Historical and projected heat extremes (as measured by 95th-percentile of max temp) and frequency of historical threshold exceedance in ten counties with most workers.

DISCUSSION

Our results suggest that crop workers are already regularly subject to unsafe heat exposure in the present (Mix et al., 2018), and that future conditions will become severe. Better estimates of this exposure should include future changes in variability (Papalexiou et al., 2018) and humidity.



Ag worker heat standards exist in just 3 U.S. states. The vulnerability of ag workers is exacerbated by factors such as economic capacity, language barriers, immigration status, and access to health care (Liebman et al., 2013). Our results support the need for more comprehensive crop worker protections that address all factors contributing to heat risk.

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