# The HumanIndexMod and New Calculations Demonstrating Heat Stress Effects All Aspects of Human Life Through Industry, Agriculture, and Daily Life.

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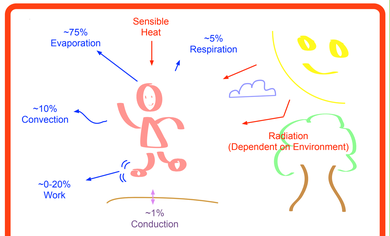
## Abstract

- The HumanIndexMod calculates 13 heat related metrics using meteorological inputs of temperature, pressure, and moisture. The heat stress metrics are commonly used metrics around the world. The module is implemented into the CLM4.5, which is a component model of CESM, and is maintained by NCAR. Instantaneous moisture-temperature covariance is calculated every model time step. The heat stress metric changes show that many portions of the world switch from moderate levels for the top 3 days of a year to severe heat stress for the top 3 days of a year.




## What is Heat Stress?

- Heat stress is the measure of thermal load on humans (and animals). For mammals, there are 4 methods for dissipating heat: Convection, Conduction, Radiation, and Evaporation. In hot climates, ~75% of heat dissipation occurs through Evaporation. For humans, a sustained change of 3˚C in core temperature in humans can be lethal (Simon, 1993). Heat dissipation may not be in equilibrium.

## Methods

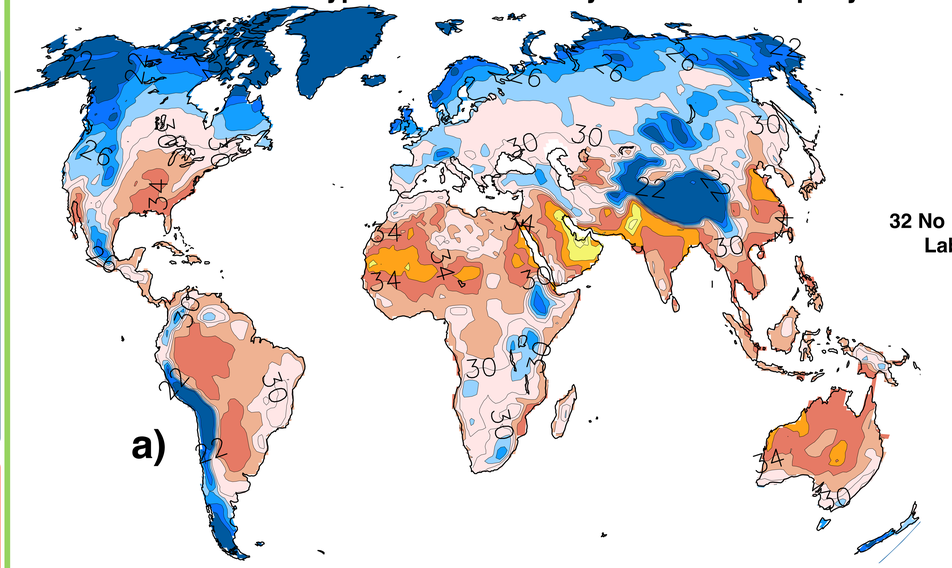
- We use CESM RCP8.5 (Taylor et al., 2012) output to drive the Community Land Model 4.5 (Oleson et al., 2013) (CLM4.5).
- We implemented the HumanIndexMod into CLM4.5 to calculate 13 different metrics; 4 moist thermodynamic variables and 9 heat stress metrics.
- We used 1°x1° resolution, and years 2005-2100, to output 4x daily and analyze the characteristics of the Simplified Wet Bulb Globe Temperature (sWBGT).

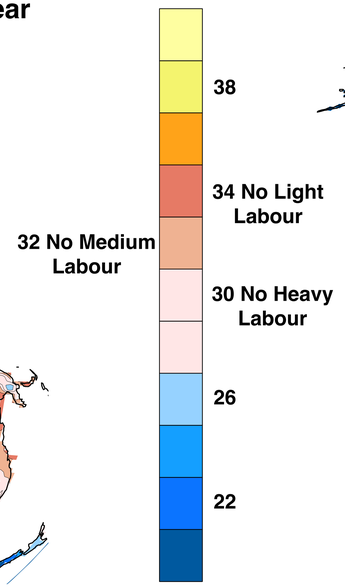
## Future Work

- Implementation of additional heat metrics (WBGT temperature of humans).
- Dynamically downscale results for EPSCoR Ecosystems and Society Project.

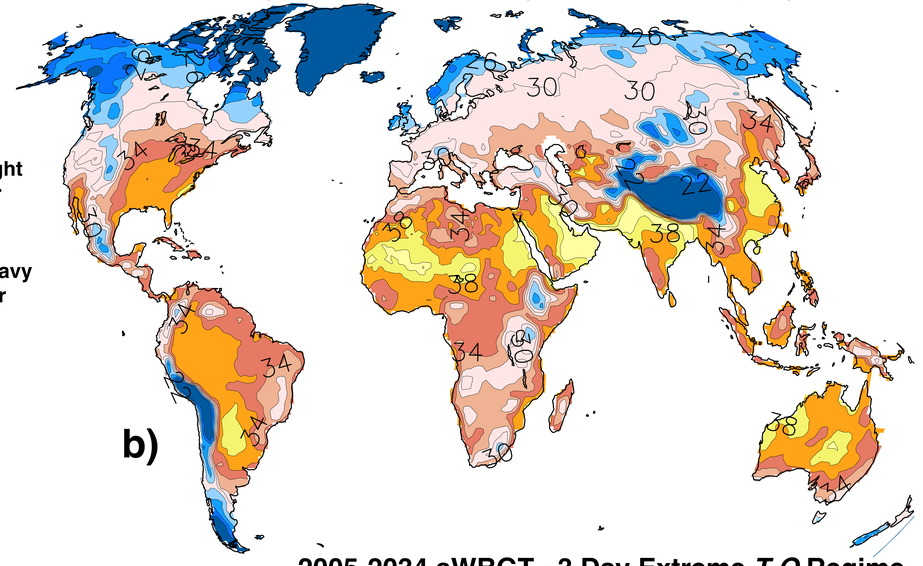
## 2005-2034 (a) and 2071-2081 (b) Simplified Wet Bulb Globe Temperature (sWBGT) ~3 day extreme event per year

### 2005-2034 Typical Hottest ~3 Day sWBGT Event per year



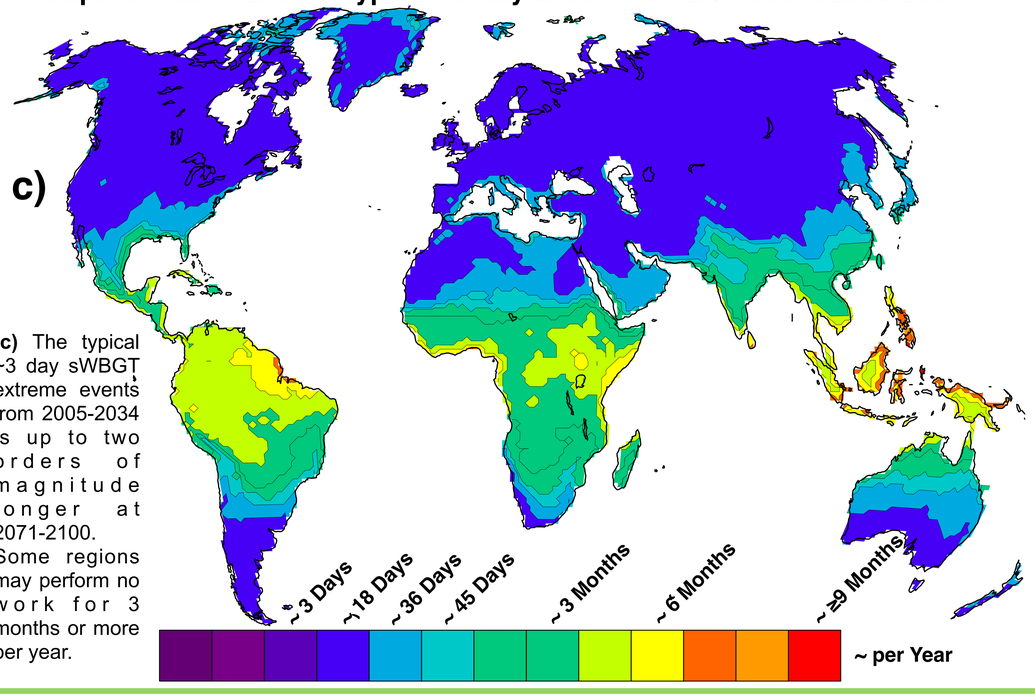




### 2071-2100 Typical Hottest ~3 Day sWBGT Event per year



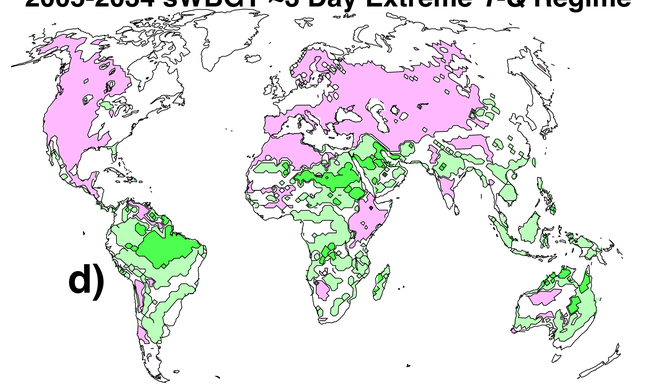

- sWBGT exceeds 33 for the majority of the world **(b)** as compared to **(a)**.
- 33 is a limit for labor capacity (Dunne et al., 2013).

### Time spent in 2071-2100 at typical ~3 day extreme sWBGT event 2005-2034

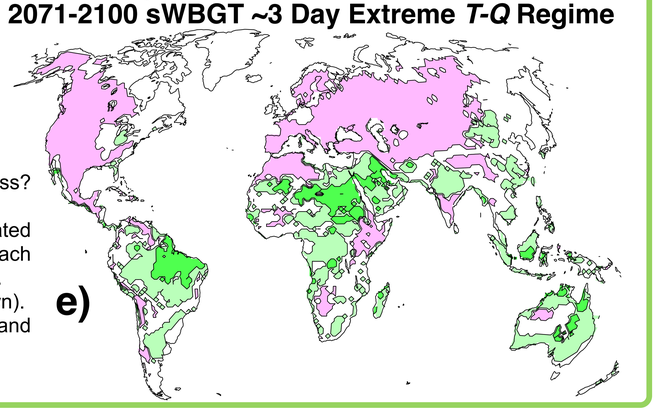



- **(c)** The typical ~3 day sWBGT extreme events from 2005-2034 is up to two orders of magnitude longer at 2071-2100.
- Some regions may perform no work for 3 months or more per year.

### 2005-2034 sWBGT ~3 Day Extreme *T-Q* Regime




### 2071-2100 sWBGT ~3 Day Extreme *T-Q* Regime




***Temperature (T)* Percentile**

| *Humidity (Q)* Percentile | <66.6 | 66.6<83.3 | 83.3<90 | 90<99 | ≥99 |
|---|---|---|---|---|---|
| <66.6 | | | | | Extreme T |
| 66.6<83.3 | | | | | |
| 83.3<90 | | | | | |
| 90<99 | | | | | |
| ≥99 | Extreme Q | | | | |

***Temperature-Humidity (T-Q)* Regimes Conditioned on sWBGT ~3 Day Extremes**

- **(d)** and **(e)** What causes peak heat stress? We calculate conditional regime maps.
- All temperatures and humidities associated with heat events are compared to each other via their climatological percentiles.
- Results are metric dependent (not shown).
- Results are largely robust between **(d)** and **(e)**.

## References

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