Influence of Solar and Thermal Radiation on Future Heat Stress Using CMIP5 Archive Driving the Community Land Model Version 4.5

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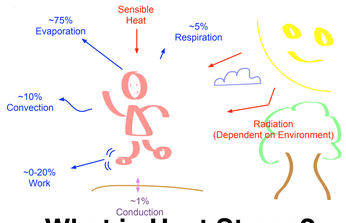
Abstract

- The summer of 2015 has experienced major heat waves on 4 continents, and heat stress left ~4000 people dead in India and Pakistan. The International Organization for Standardization (ISO) uses Wet Bulb Globe Temperature (WBGT)—an empirical metric this is calibrated with temperature, humidity, and radiation—for determining labor capacity during heat stress. Unfortunately, limited number of studies use the combination of temperature and humidity. Recent global assessments use WBGT, yet omit the radiation component without recalibrating the metric.

Sally Heat Stress



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. A sustained change of 3˚C in core temperature in humans, can be lethal. Heat dissipation may not be in equilibrium.

Methods

- We use 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 wet bulb temperature (Buzan et al., 2015), and also implement solar and thermal radiation fluxes to calculate globe thermometer.
- We used 1°x1° resolution, and years 2005-2100, to output 4x daily and analyze the characteristics of the full Wet Bulb Globe Temperature (WBGT).

Future Work

- Explore sensitivity to each CMIP5 model 2026-2045 baseline.
- Dynamically downscale results for EPSCoR Ecosystems and Society Project.

WBGT Above Vegetation Ensemble Mean

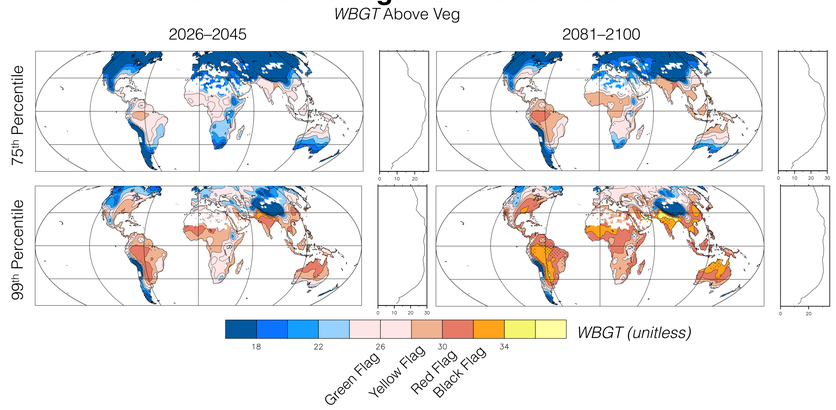


Figure 1: Ensemble mean with zonal average of WBGT Above Veg for two . Stipple pattern is inter-model spread greater than ±2.

WBGT Above Vegetation Change Scaled by Global Mean Surface Temperature Change (Slope Parameter Γ)

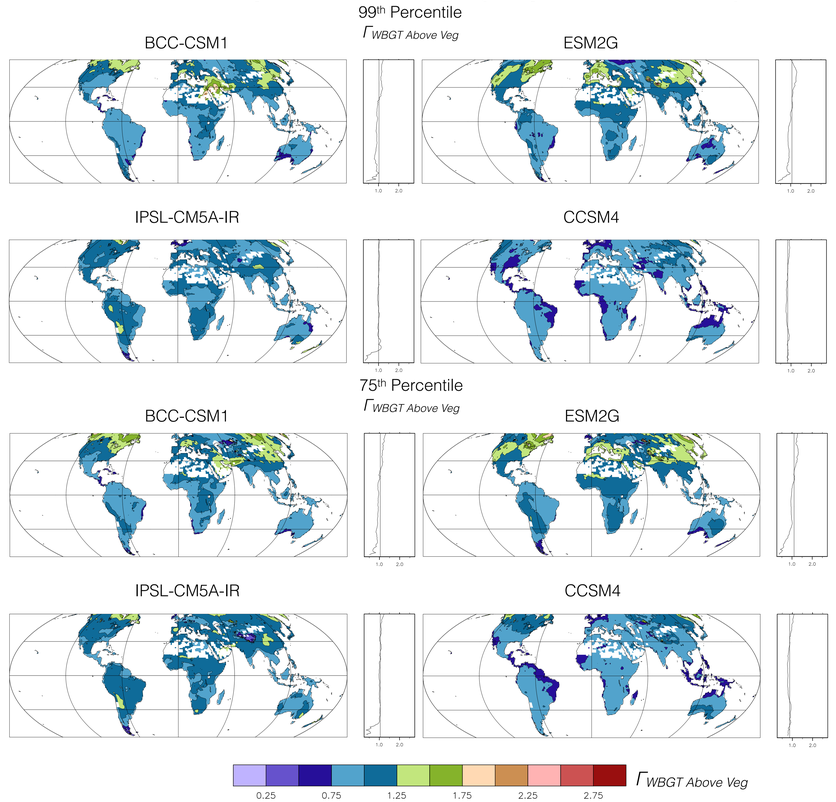


Figure 2: Slope Parameter and zonal average for 99th and 75th percentile threshold WBGT Above Vegetation and zonal means.

Labor Capacity at 75th WBGT Above Vegetation Scaled by $\Gamma_{WBGT\ Above\ Veg}$

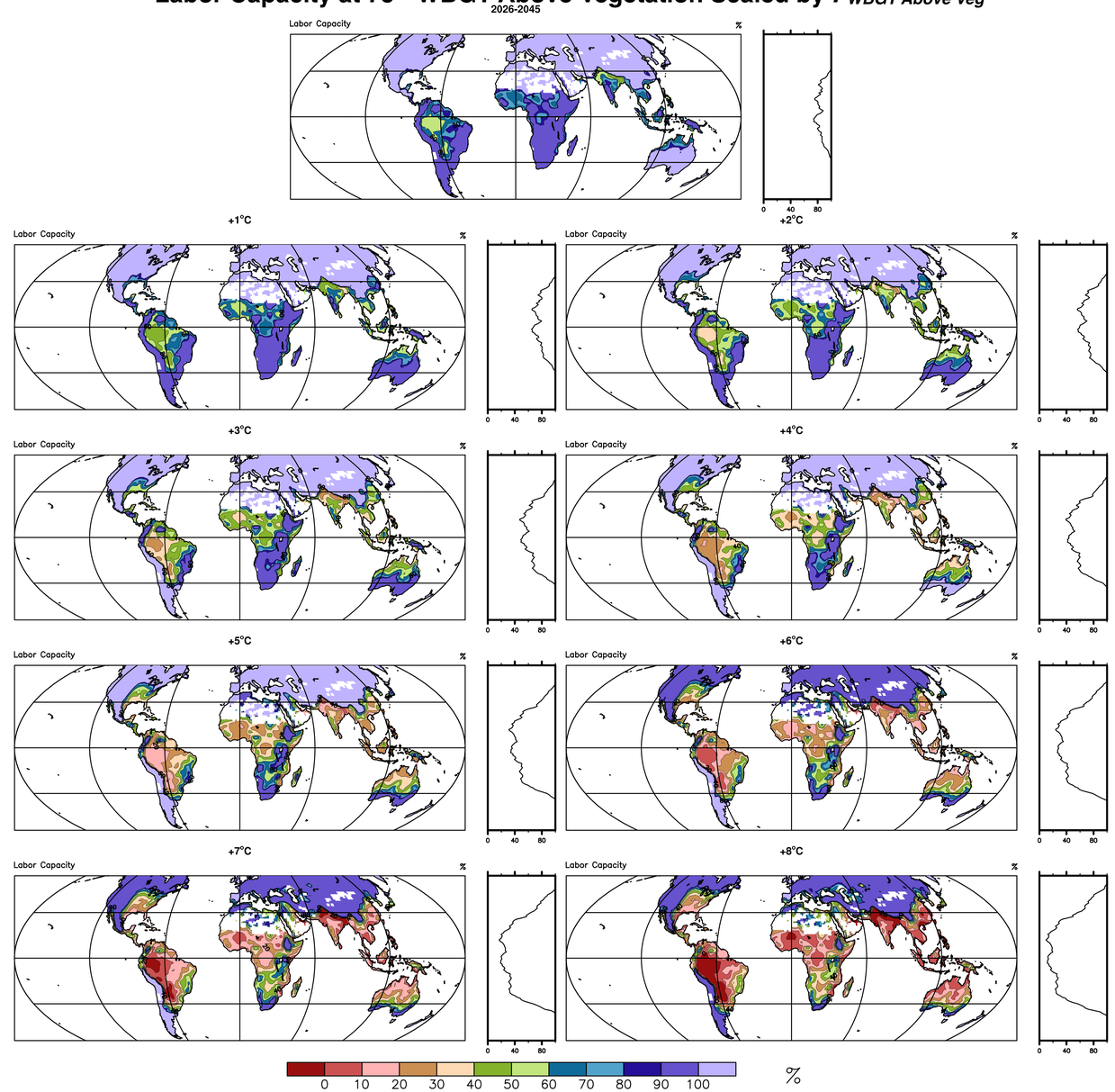


Figure 3: Labor capacity (Dunne et al., 2013) at 75th WBGT Above Veg scaled by global mean surface temperature change using the $\Gamma_{WBGT\ Above\ Veg}$ for CCSM4. Reference values of 2026-2045. Global mean surface temperature changes are +1°C – +8°C.

Discussion

Ensemble mean inter-model spreads are small (figure 1), and spatial patterns are nearly identical between time slices for each threshold. Slope parameters are spatially uniform except for the Middle East for both thresholds (figure 2). Spatially uniform slope parameters, and small inter-model spreads are consistent with quasi-equilibrium theory. This allows global calculations of labor reductions that are dependent on global mean surface temperature uncertainties, not inter-model uncertainties (figure 3).

References

- Dunne, J. P., R. J. Stouffer, and J. G. John (2013), Reductions in labour capacity from heat stress under climate warming, *Nature Climate Change*, doi:10.1038/nclimate1827.
- Oleson, K.W., D.M. Lawrence, G.B. Bonan, B. Drewniak, M. Huang et al., (2013), Technical Description of version 4.5 of the Community Land Model (CLM), 1–435, doi:DOI: 10.5065/D6RR1W7M.
- Taylor, K., R. Stouffer, and G. Meehl (2012), An overview of CMIP5 and the experiment design, *Bulletin of the American Meteorological Society*, 93(4), 485–498.
- Buzan, J. R., K. Oleson, and M. Huber (2015), Implementation and comparison of a suite of heat stress metrics within the Community Land Model version 4.5, Geosci. Model Dev., 8(2), 151–170, doi: 10.5194/gmd-8-151-2015.

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