Scaling of Livestock Heat Stress with Global Mean Surface Temperature Change

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Abstract

Heat stress impacts humans and animals in significant ways. In the summer of 2015, the India heat wave killed 2500 people *(Kopp et al., 2015, NYTimes)*. In May of that heat wave, an estimated 17 million chickens were culled. Trends in global heat stress show distinct regional scale variations. These variations are related to various local factors. But, nonetheless, we show that heat stress is robustly and fundamentally tied to the global mean surface temperature. Heat stress measures accounting for humidity are tied to maximum buoyancy of the atmosphere, and thus, quasi-equilibrium convection theory *(Williams et al., 2009)*.

In this study, we conducted Community Land Model version 4.5 simulations to calculate heat stress in future climate projections with Representative Concentration Pathway 8.5 greenhouse gas forcing (from CAM4). We use the HumanIndexMod *(Buzan et al., 2015)* to map heat stress in livestock.

Methods

- We take 30 year climatologies of 2005-2034 and 2071-2100, and calculate percentiles analyze the distribution of heat stress events (Figure 1).
- Next, we compare 2005-2034 to the 2071-2100 distribution to show relative changes in duration of heat stress events (Figure 2).
- Finally, we normalize the heat stress changes by the global mean surface temperature change between time slices (Figure 3; see Eq. 1).

$$\Gamma_{X_{yy}} = \frac{\Delta X_{yy}}{\langle \Delta T \rangle} \qquad (1)$$

- ΔX is the change in heat stress metric.
- yy is the distribution percentile.
- $\langle \Delta T \rangle$ is the globally averaged surface temperature change between time slices.
- Γ_{Xyy} is the normalized heat stress metric, i.e. the slope parameter.

Conclusions

- Substantial increases to THI heat waves magnitude by 2100.
- Heat wave duration increases by 18 days in high latitudes, and greater than 9 months at low latitudes, per year.
- Most regional THI experience increases of 1.5 units/°C global mean surface temperature changes.
- Coastal regional THI increases of 1-1.25 units/°C global mean surface temperature changes.
- Pacific Northwest THI increases of 1.75-2 units/°C global mean surface temperature changes.
- These results imply substantial infrastructure enhancements over the leading decades *(Gates et al., 1991)*.

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Figure 1. Temperature Humidity Index (THI)

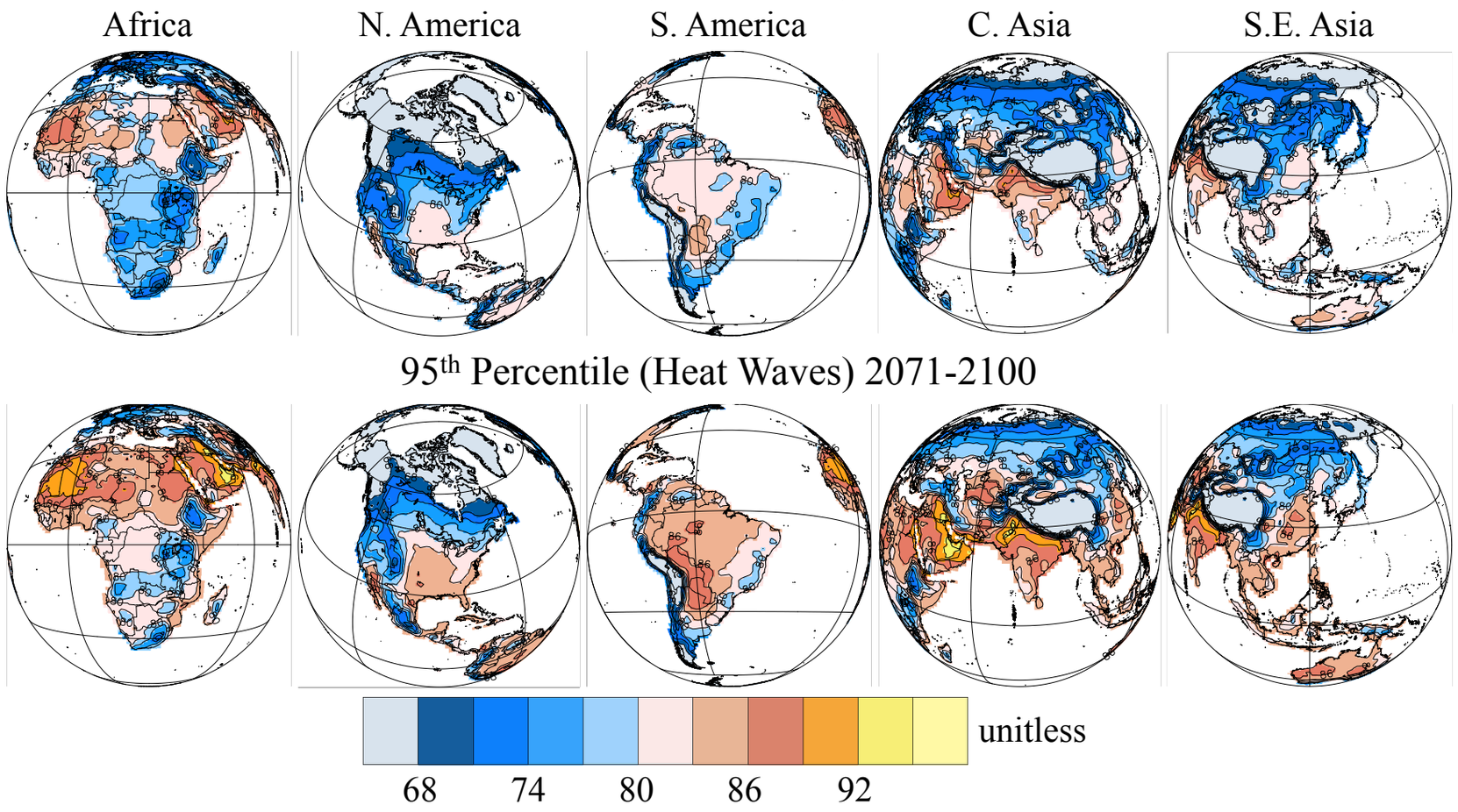


Figure 2. Approximate duration of 95th Percentile 2005-2034 THI at 2071-2100

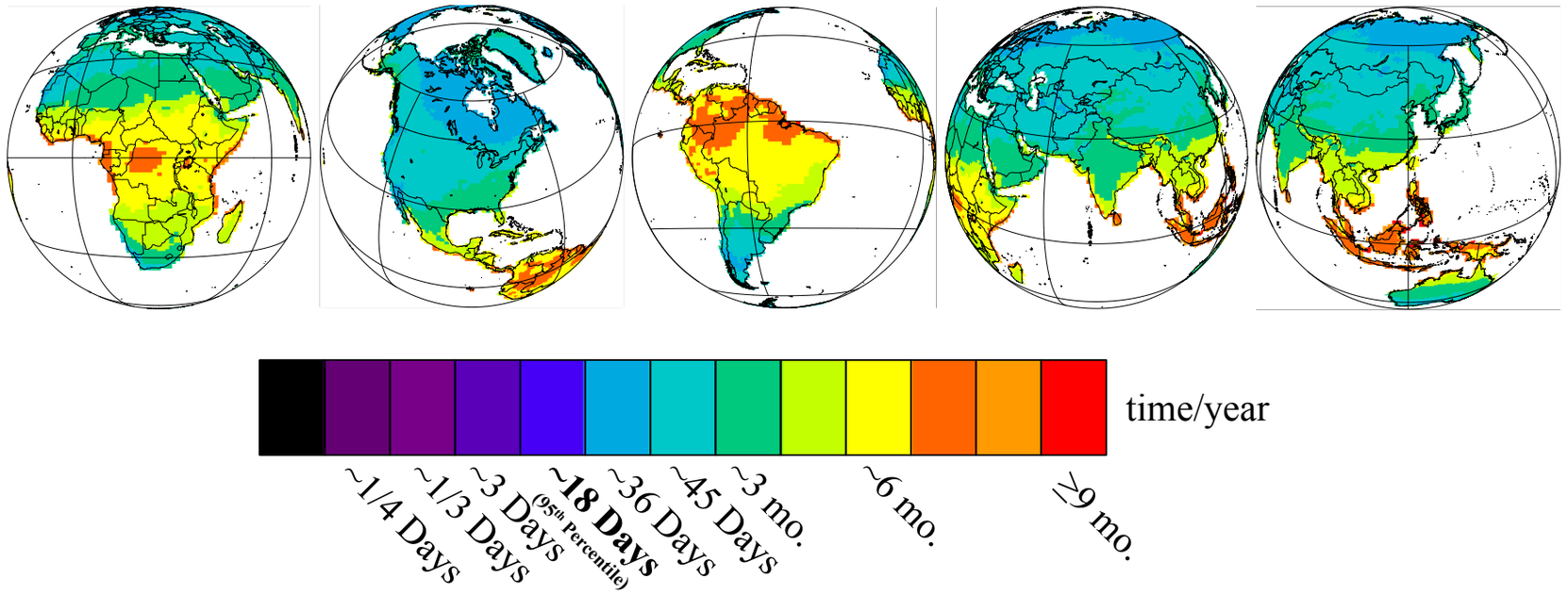
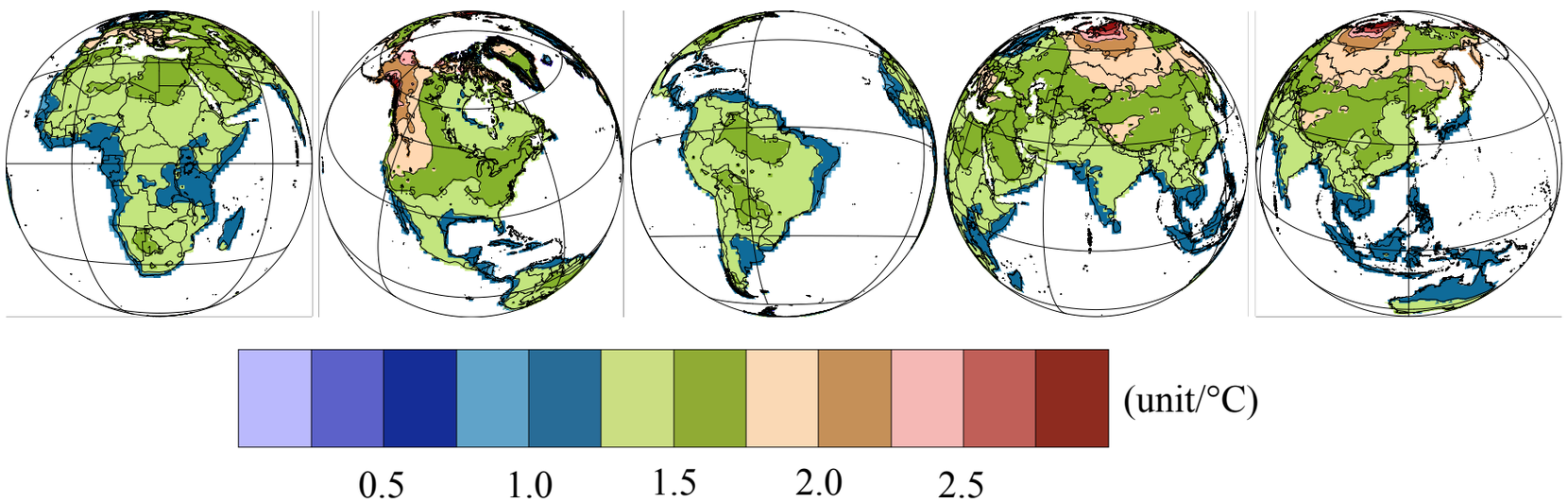


Figure 3. Γ_{THI95}



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