Widespread reductions in human labor capacity after 1.5 °C warming

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Motivation: Onset of Humid Heat

Temperatures rising due to climate change → extreme heat and associated health risks → worsened by high humidity

Wet-bulb globe temperature used to measure overall heat stress

Expansion of hot regions:

Expansion of hot + humid regions:
Motivation: Reductions in Labor Capacity

Increased WBGT $\rightarrow$ longer rest periods $\rightarrow$ decreased labor capacity $\rightarrow$ economic losses

(Dunne et al., 2013)

Goals:

- Use ESMLEs to estimate time of first emergence for significant labor capacity reductions in vulnerable regions
  - Inform “timing of action” for adaptation efforts
- Characterize uncertainty in time of first emergence stemming from:
  - Climate model design
  - Internal climate variability

(Dunne et al., 2013)
Methodology

Earth System Model data
- GFDL-ESM2M (RCP 8.5) and CESM2 (SSP 3-7.0)
- 30 ensemble members each
- Daily mean metrics

Compute labor capacity
- Calculate daily mean WBGT
- Convert to monthly mean labor capacity

Define ToFEs
- Time of First Emergence
- First year with summertime capacity reduced by X% relative to historical baseline
- Thresholds: 25%, 50%
31-44% of global land area expected to have experienced moderate reductions by 2100.

Larger affected areas and earlier ToEs (~12 years) in CESM2.
Results: Uncertainty from Internal Climate Variability

- 48-76% of vulnerable locations convergent within 30 years
- Hotspots of internal variability in yellow/orange

Expected/mean ToFE: \( \text{ToFE} = 2070 \)
Possible range: 2050 - 2090
Results: Ensemble Spread of “City” ToFEs

- High confidence: first occurrence of moderate reduction before 2060
- In general, significant internal variability at local scale

Each bar = one ensemble member
Results: Ensemble Spread of Regional Average ToFEs

- Population-weighted average of grid cell ToFEs
- Internal variability uncertainty decreases at:
  - Larger spatial scales
  - Higher reduction thresholds
Results: Progression of Labor Capacity Reductions

- 2100: 5670% of global population affected by moderate reductions
- Rapid onset of labor capacity reductions
## Takeaways

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<tr>
<th>Impacts</th>
<th>Uncertainty</th>
<th>Implications</th>
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<tr>
<td>• Large populations threatened by labor capacity reductions over course of 21st century</td>
<td>• Internal variability uncertainty</td>
<td>• Possibility of sudden + severe labor capacity reductions past 1.5°C of warming: importance of mitigation</td>
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<td>• Rapid onset within vulnerable regions, starting as early as 2040s</td>
<td>○ Significant locally; decreases at larger spatial scales</td>
<td>• Developing nations disproportionately at risk: require precautionary measures (e.g. workplace air conditioning)</td>
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<td>• Model uncertainty reduces when normalizing by temperature</td>
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Thank you!

Questions?