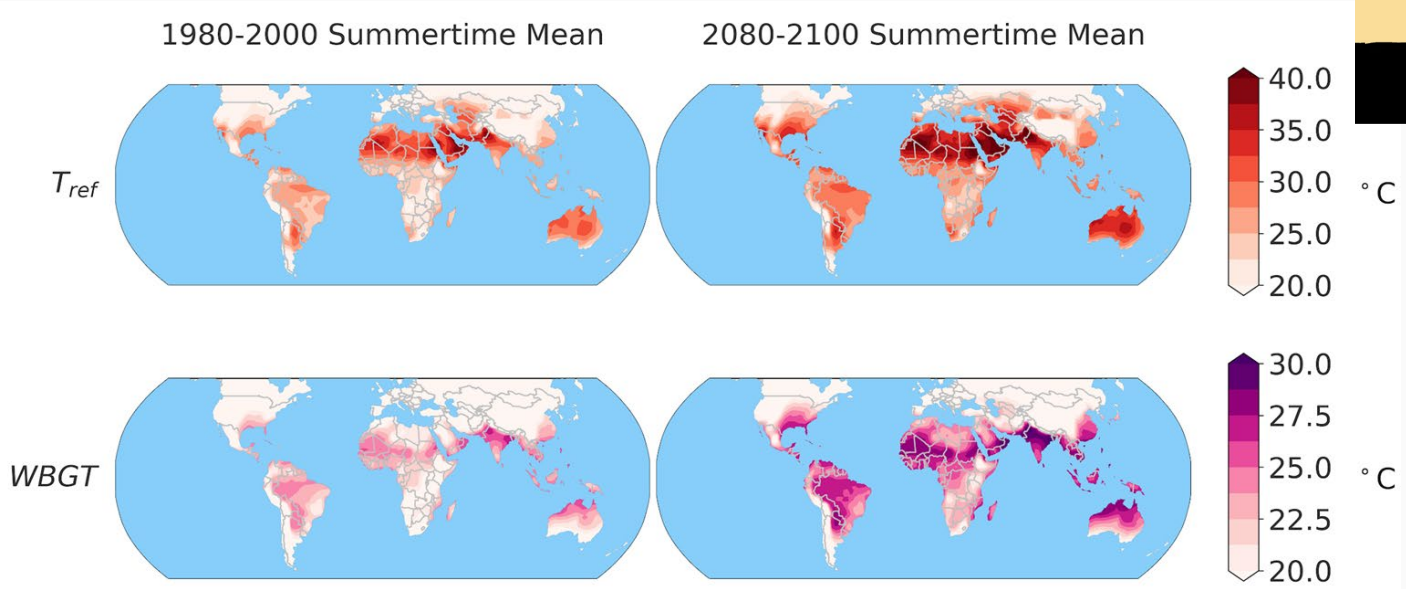
Widespread reductions in human labor capacity after 1.5 °C warming

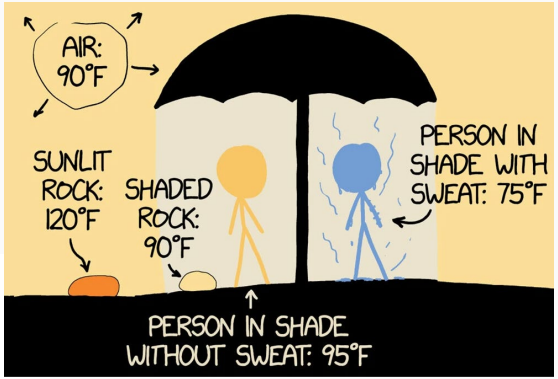
Karena Yan
Princeton University

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



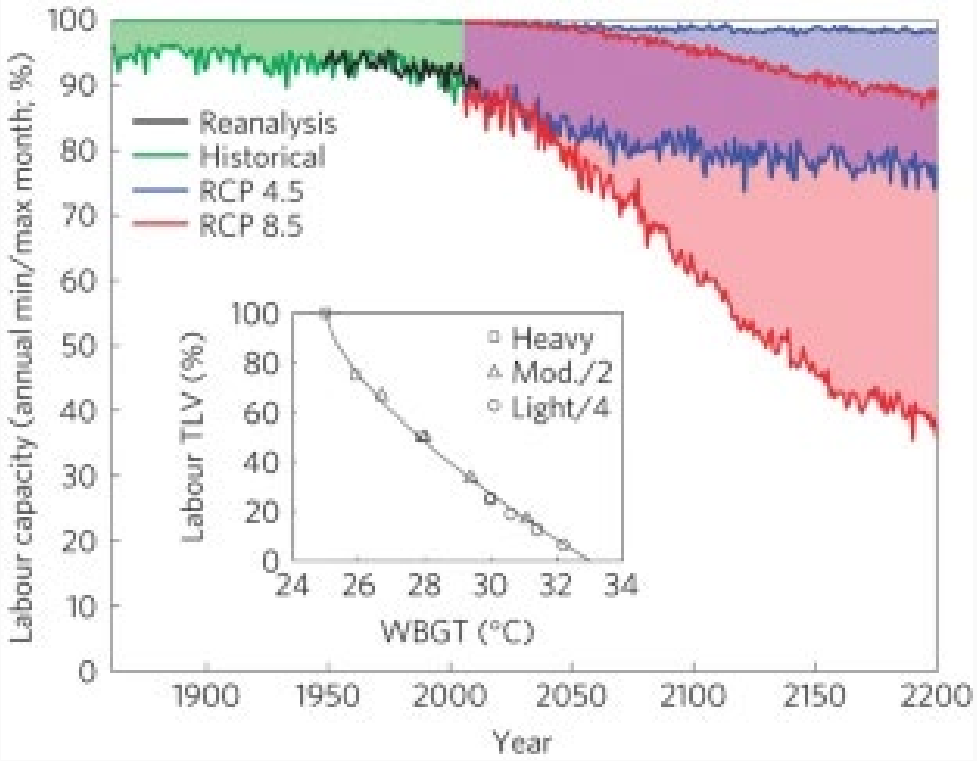


Expansion of **hot** regions:

Expansion of **hot + humid** regions:

Motivation: Reductions in Labor Capacity

Increased WBGT → longer rest periods → decreased labor capacity → 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

Methodology

Earth System Model data

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

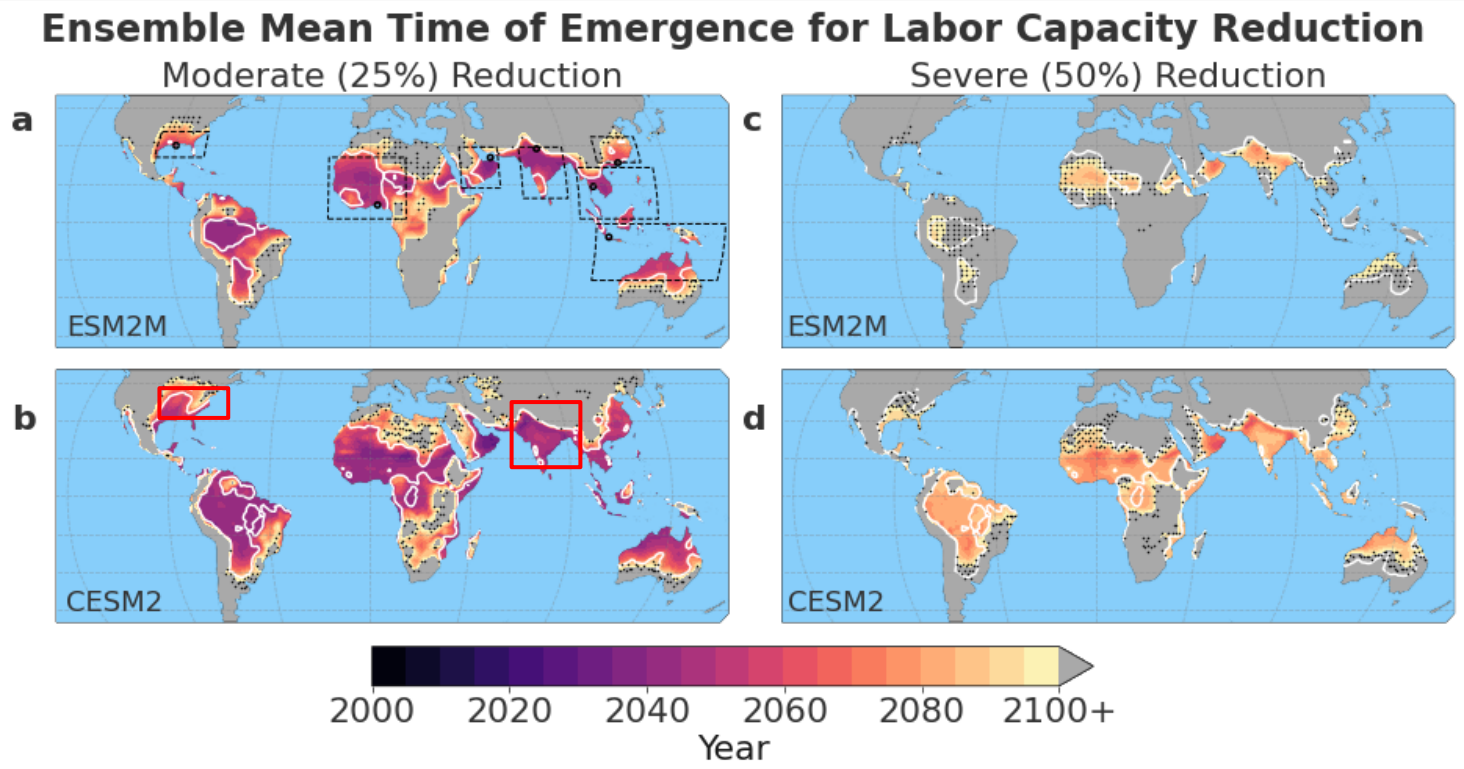
Compute labor capacity

- Calculate daily mean WBGT
- Convert to monthly mean labor capacity
- Split into historical (1980-2000) and future (2000-2100)

Define ToFEs

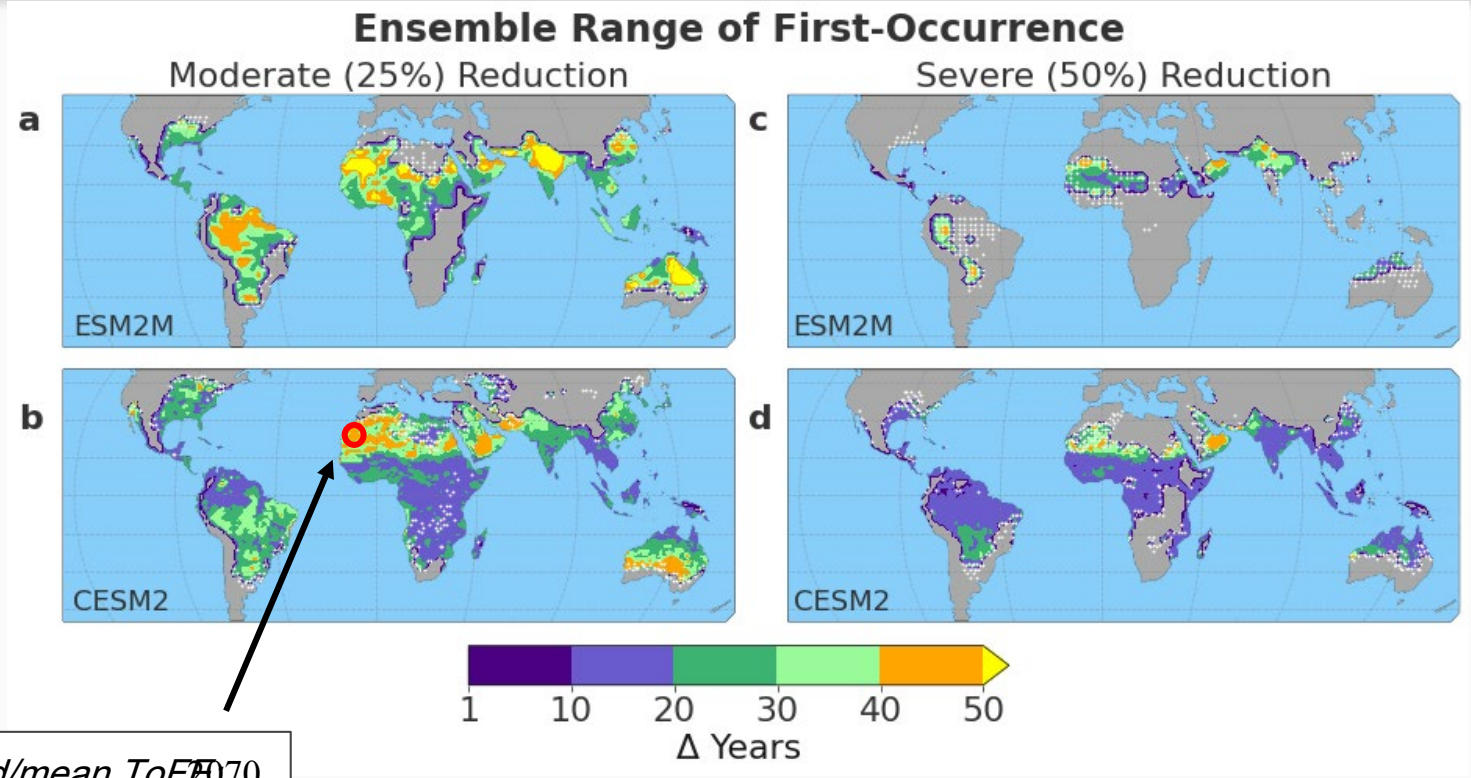
- Time of First Emergence
- First year with summertime capacity reduced by X% relative to historical baseline
- Thresholds: 25%, 50%

Results: Ensemble Mean Time of First Emergence



- 31-44% of global land area expected to have experienced moderate reductions by 21
- Larger affected areas and earlier ToEs (~12 years) in CESM2

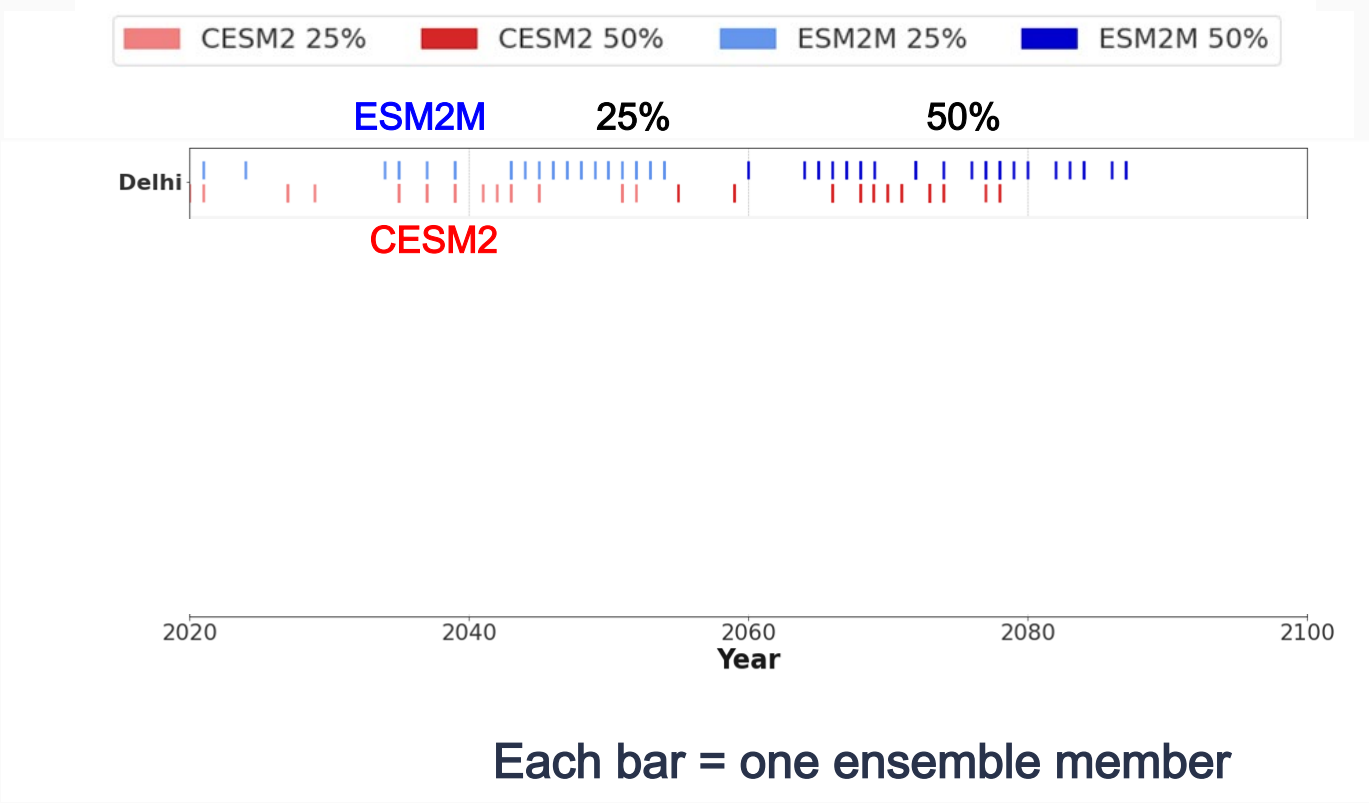
Results: Uncertainty from Internal Climate Variability



Expected/mean ToFE 2070
Possible range 2050 - 2090

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

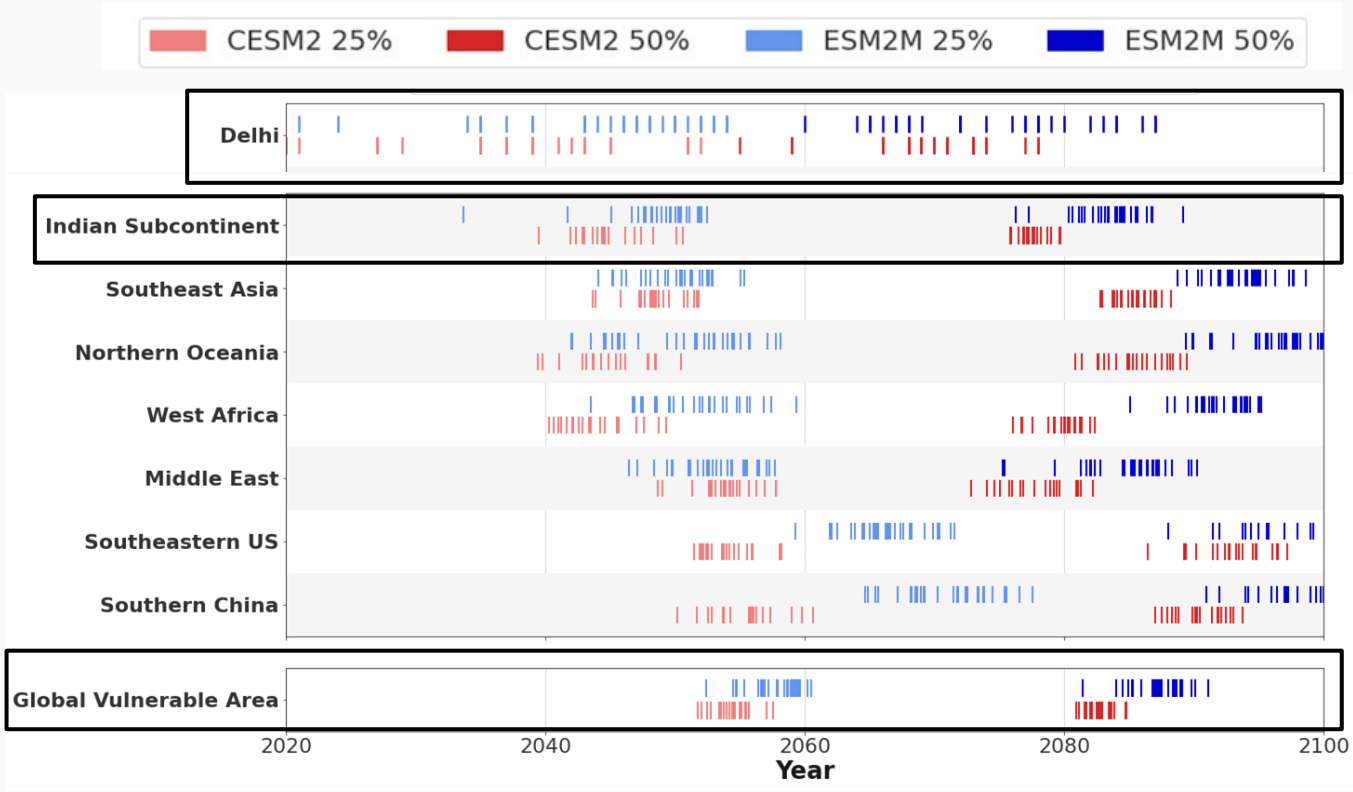
Results: Ensemble Spread of “City” ToFEs

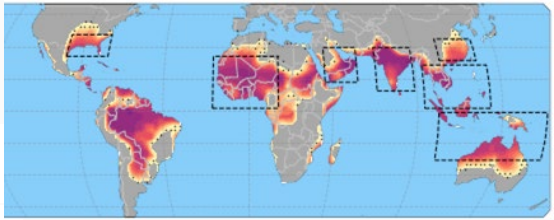


Each bar = one ensemble member

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

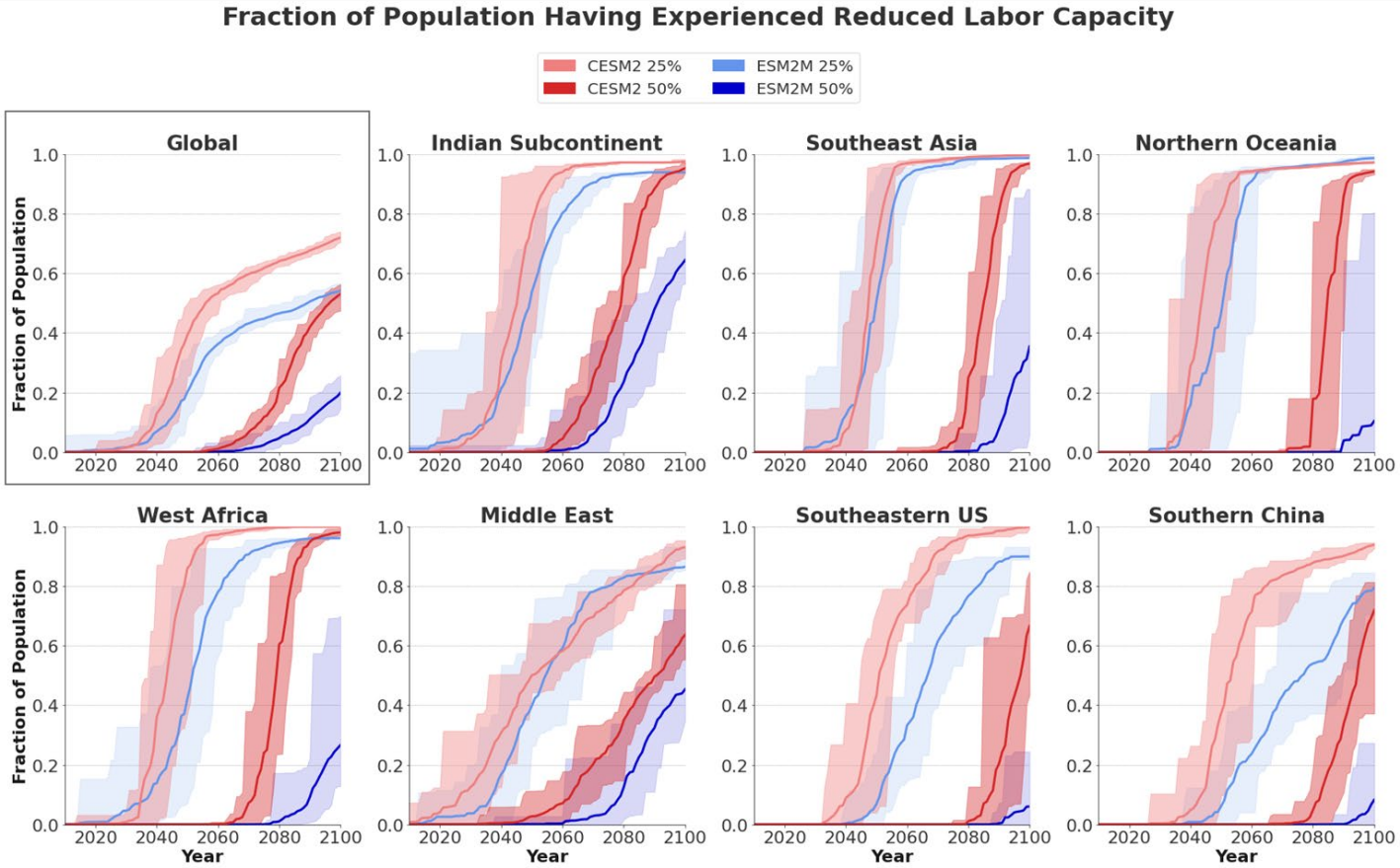
Results: Ensemble Spread of Regional Average ToFEs





- 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: 50-70% of global population affected by moderate reductions
- **Rapid onset** of labor capacity reductions

Takeaways

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

Thank you!

Questions?