# Importance of damage persistence for climate change costs:

# New evidence from lower-frequency temperature variability

NAVIGATE Workshop

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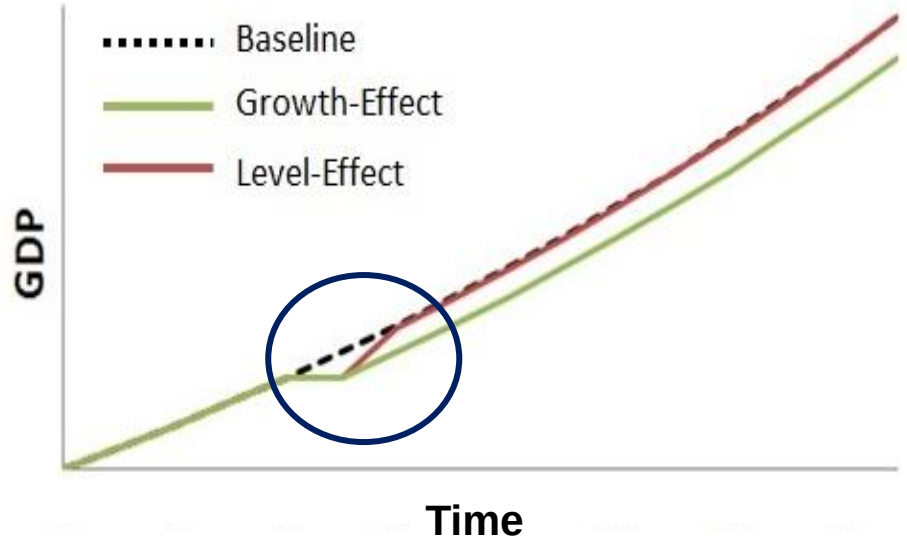
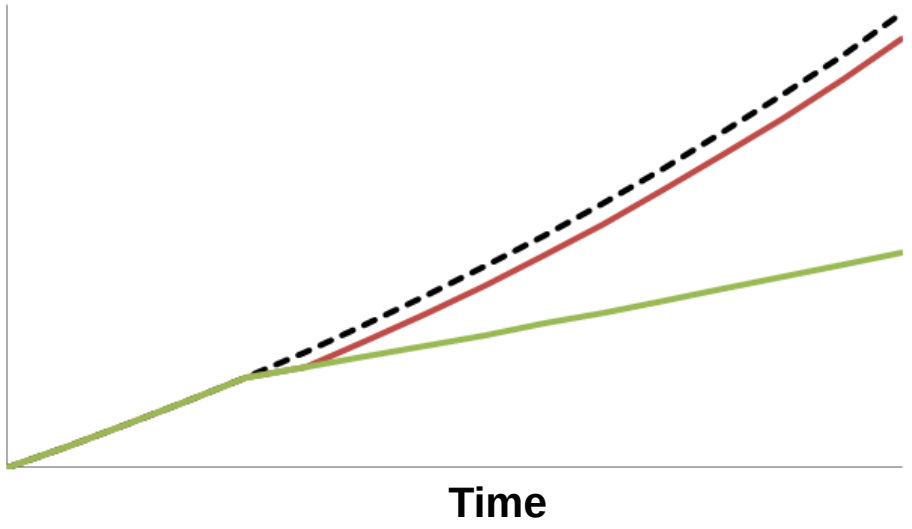
# Damage Persistence and Aggregate Climate Change Costs

- The question of how climate change affects macro-economic growth rates is of first-order importance for aggregate climate change costs
- Original integrated assessment models (IAMs) assumed climate change had no direct effect on growth rates
- This assumption is key in driving policy recommendations from these models

# Damage Persistence : Levels vs Growth Effects





# Damage Persistence: Levels vs Growth Effects

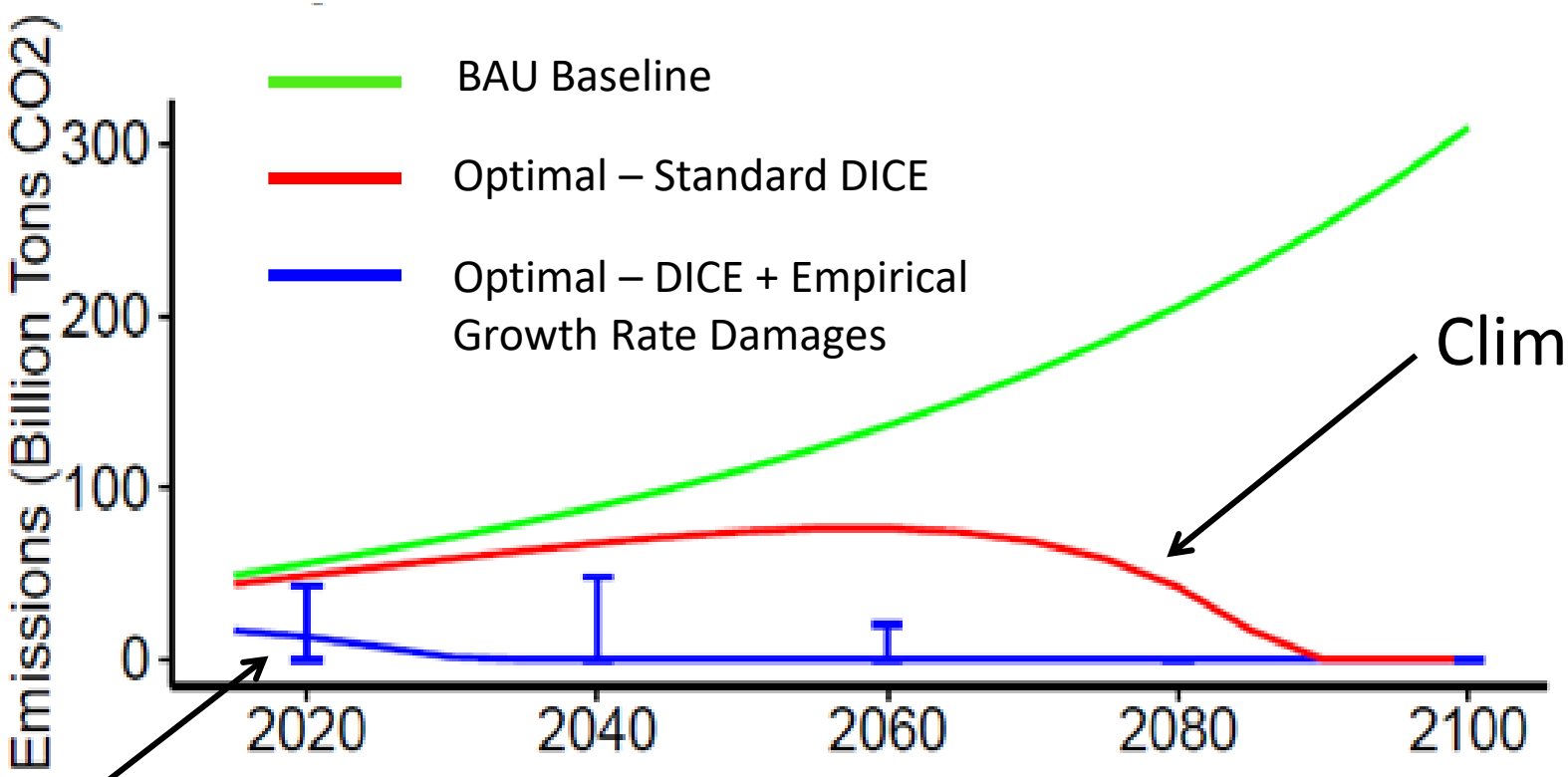
**Growth Impacts**

- Damage to capital stock from extreme events
- Disruption to social-economic institutions (e.g., political instability due to conflict)
- Slower technological change due to diversion of resources to respond to climate change extremes
- Slower accumulation of human capital due to disrupted learning

**Levels Impacts**

- Lower agricultural output due to heat damage
- Increased cooling loads
- Lower worker productivity in hot temperatures
- Disruption to production from extreme events

# Damage Persistence is of First-Order Import for IAM Results




Climate 'Policy Ramp'

Early and Stringent Mitigation

Error Bars = 68% Confidence Interval  Moore and Diaz, 2015

# Damage Persistence is of First-Order Import for IAM Results

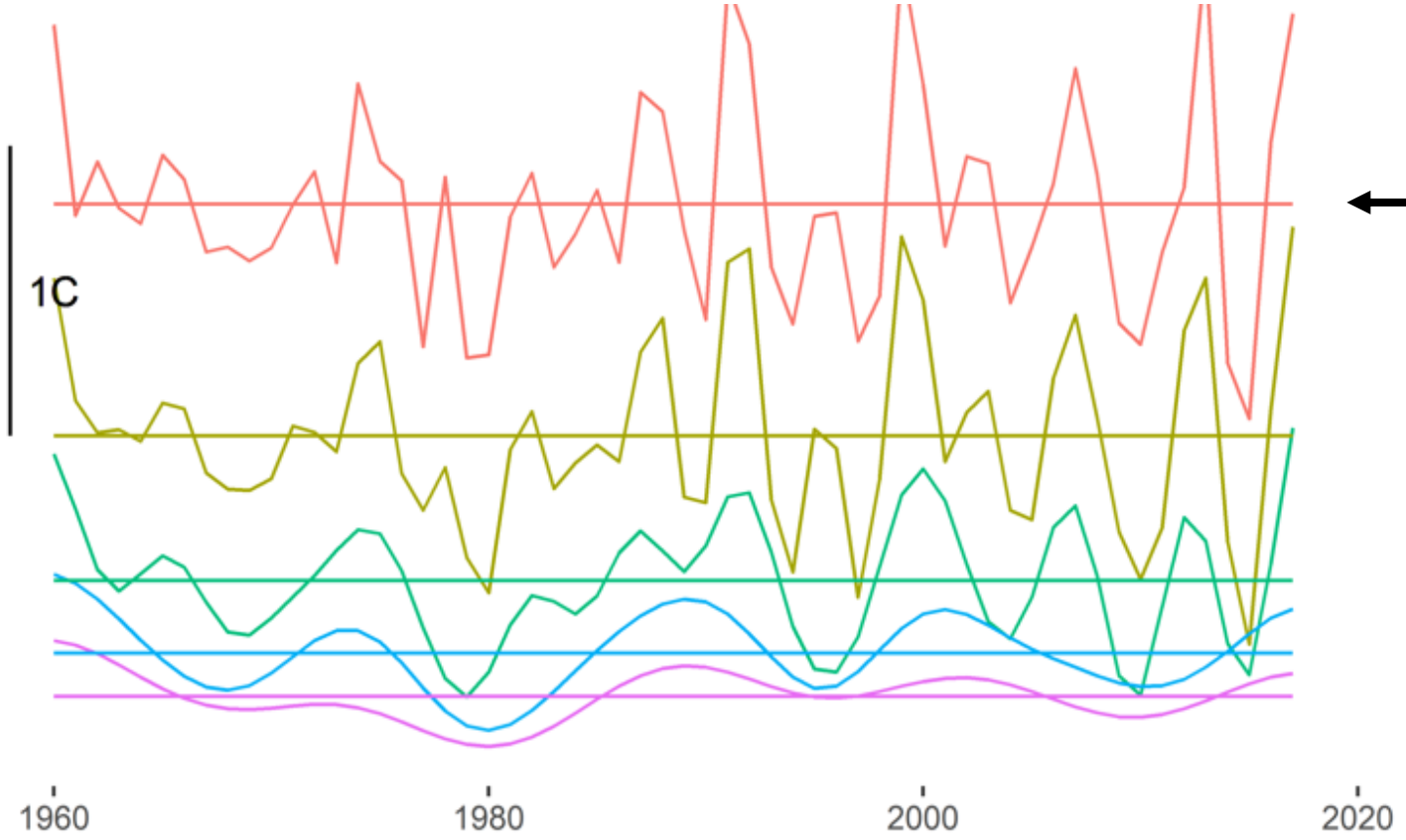
"Including an empirical estimate of damage persistence demonstrates that even minor departures from the assumption that climate shocks do not affect GDP growth have major economic implications and eclipse most other modeling decisions"

Kikstra et al., 2021

# Empirical Evidence of Damage Persistence is Suggestive but Uncertain

- Some empirical evidence from country-level data of persistent negative effects of higher temperatures on GDP in poorer / hotter countries (Dell, Jones and Olken 2012, Burke, Hsiang and Miguel, 2015)
- Subnational data gives mixed evidence for persistence (Kalkuhl and Wenz, 2020; Colacito et al. 2019)
- Uncertainty bounds on persistent effect from summing lagged regression terms are large and overlap zero (Burke, Hsiang and Miguel, 2015)
- Out of sample cross-validation unable to distinguish between levels and growth effects (Newell, Prest and Sexton, 2021)

# Using Lower-Frequency Temperature Variation to Identify Damage Persistence

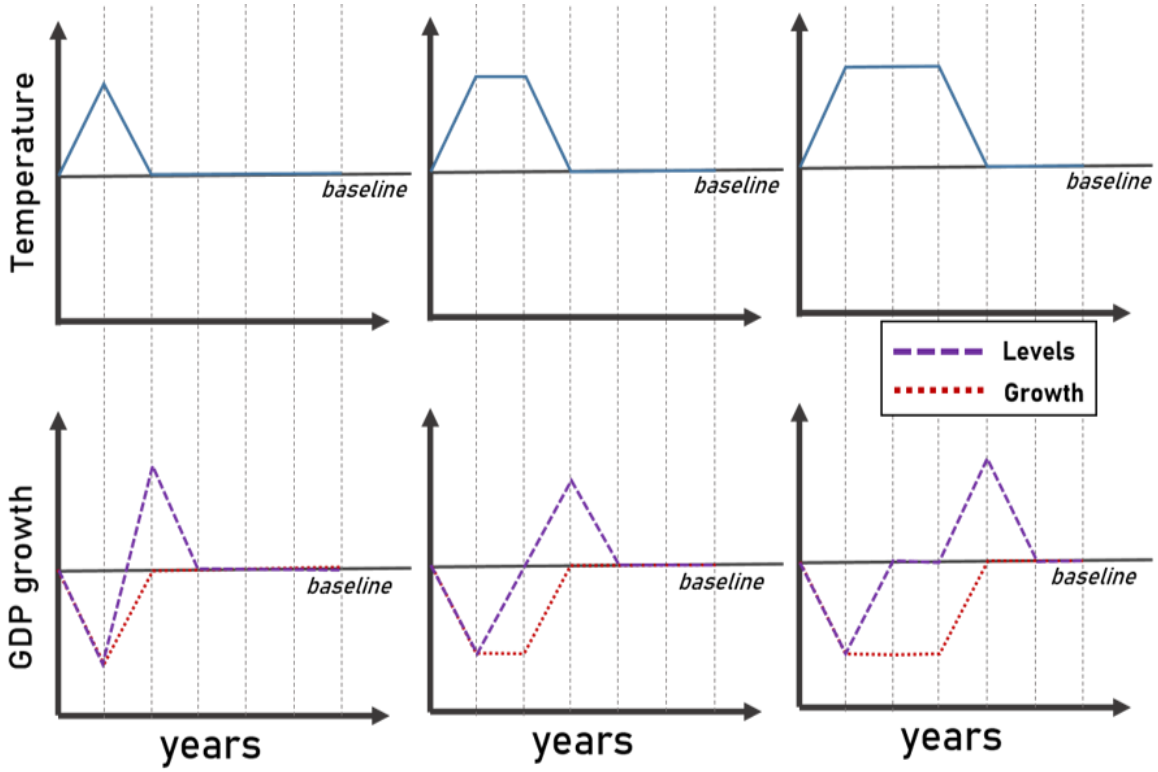



US Temperature Time Series

Temperature Time Series After Filtering Higher-Frequency Variation

Bastien-Olvera and Moore, in review

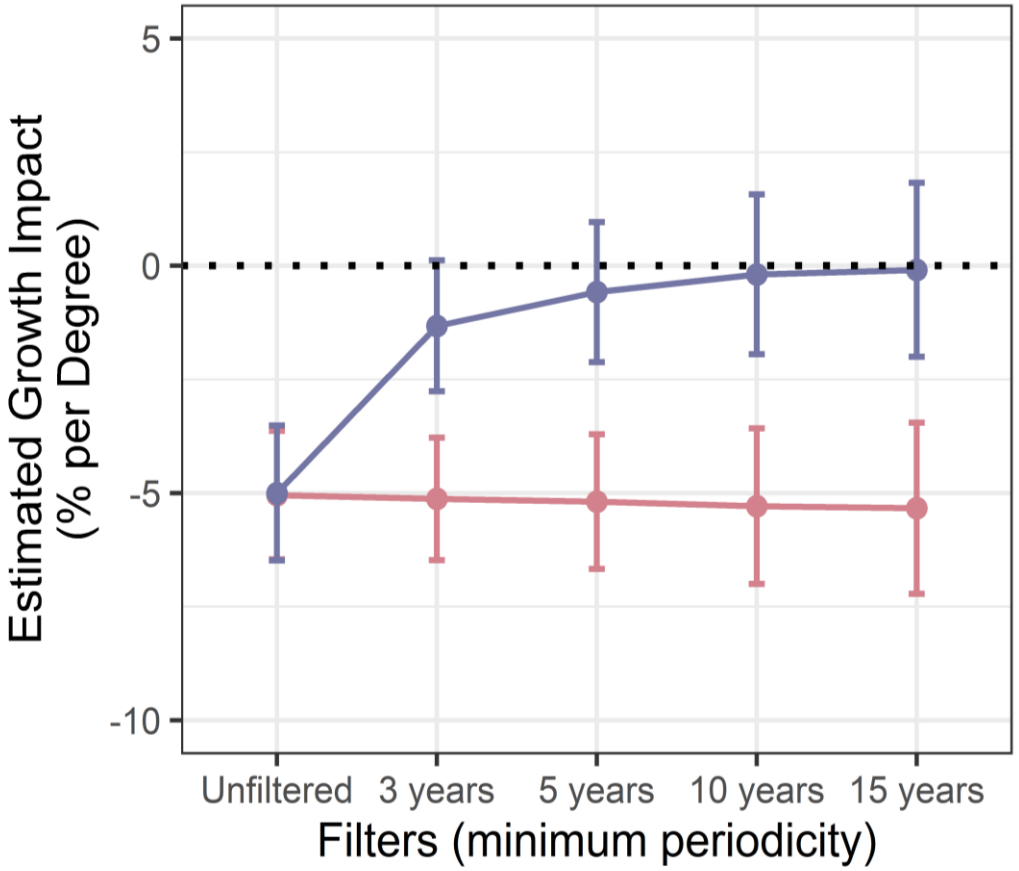
# Using Lower-Frequency Temperature Variation to Identify Damage Persistence




Bastien-Olvera and Moore, in review

- Different frequencies of variation can be used to identify damage persistence
- Lower-frequency variation has the same effect as higher-frequency variation under growth impacts
- But effects of lower-frequency variation are smaller than high-frequency variation under levels impacts

# Using Lower-Frequency Temperature Variation to Identify Damage Persistence




Declining regression coefficient with increased filtering under levels damages

Constant regression coefficient with increased filtering under growth damages

**Simulation:** Diverging Effects of Regression Estimates With Increasing Frequency Filters Under Levels vs Growth Damages

Bastien-Olvera and Moore, in review

# Empirical Application

$$g_t = \theta_f T_{t,f} + \pi_f P_{t,f} + \epsilon_t$$

GDP Growth-Rate in Year t

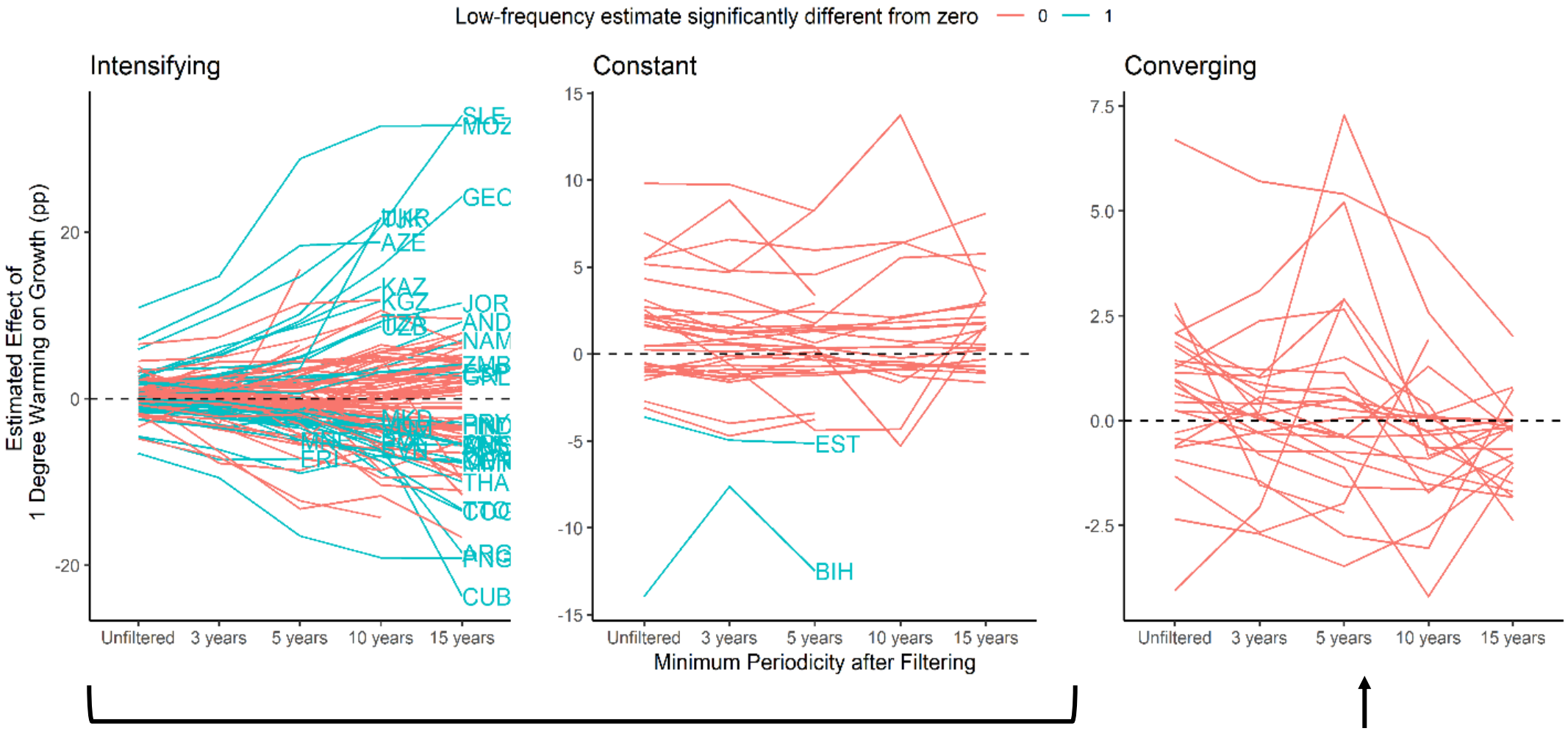
Effect of Temperature Variation at Frequency Filter f
Hypothesis: $|\theta_f| \to 0$ as f increases

Population-Weighted Temperature and Rainfall in Year t and Frequency-Filter f

**DATA:**

- World Bank annual GDP data for ~200 countries, 1961-2020
- Temperature and Rainfall Data from University of Delaware

# Findings




>85% of Countries Show Constant or Increasing Temperature Effects at Higher Filtering Levels, Consistent with Persistent Impacts

Very Few Countries Show Declining Impacts Consistent with Non-Persistent Impacts

# Summary

1. Persistence of temperature impacts is of first-order importance for aggregate climate change damages
2. Empirical evidence is suggestive of some persistence, but large uncertainties persist
3. Temperature variation at different frequencies can be used to distinguish persistent from non-persistent impacts
4. Vast majority of countries show evidence for strong persistence
   - Robust to multiple alternate GDP growth data sets
5. Global, population-weighted effect of low-frequency variation is a reduction of 0.8pp per degree warming