# When the Climate Changes the Odds

## Actuarial Insights from Attribution Science



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# About the Academy



**Mission:**
To serve the public and the U.S. actuarial profession

**Community:**
Serving over 20K MAAAs & public stakeholders for 60 years

**Standards:**
Setting qualification, practice, and professionalism standards

**Impact:**
Delivering over 300 insight-driven publications & resources annually

Visit www.actuary.org to learn more.

# About the Speakers

- Seong-min Eom, MAAA, FSA—Chairperson, Climate Change Joint Committee
- Nate Luketin, MAAA, FCAS—Member, Climate Change Joint Committee
- Dorothy Andrews, MAAA, ASA, PhD—Member, Climate Change Joint Committee

# The American Academy of Actuaries Climate Change Joint Committee



- **Purpose:** Provides actuarial insight on how climate change affects insurance, the actuarial profession, and the broader financial system through evolving climate risks and uncertainties.
- **Cross-Practice Collaboration:** Brings together actuaries from all practice areas (e.g., property & casualty, health, life, pension, and risk management) to address climate change as a systemic risk.
- **Policy & Public Engagement:** Develops nonpartisan resources (issue briefs, webinars, etc.) to inform policymakers, regulators, and other stakeholders on climate-related financial risks.

# The American Academy of Actuaries Climate Change Joint Committee



Recent Relevant Publications:

- Policy Paper:  Actuarial Perspectives on Quality, Challenges, and Effective Risk Quantification
- Issue Paper: Climatic Events, Inequities, and Risk Mitigation
- ORSA Climate Scenarios
- Attribution Science

Ongoing work due to be released soon

- Insurance Affordability



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# Agenda

- Why does it matter?
- Map of Changes
- What about overfitting?
- Concerns regarding attribution science
- Individual Event Attribution
- Actuarial Application
- Conclusion

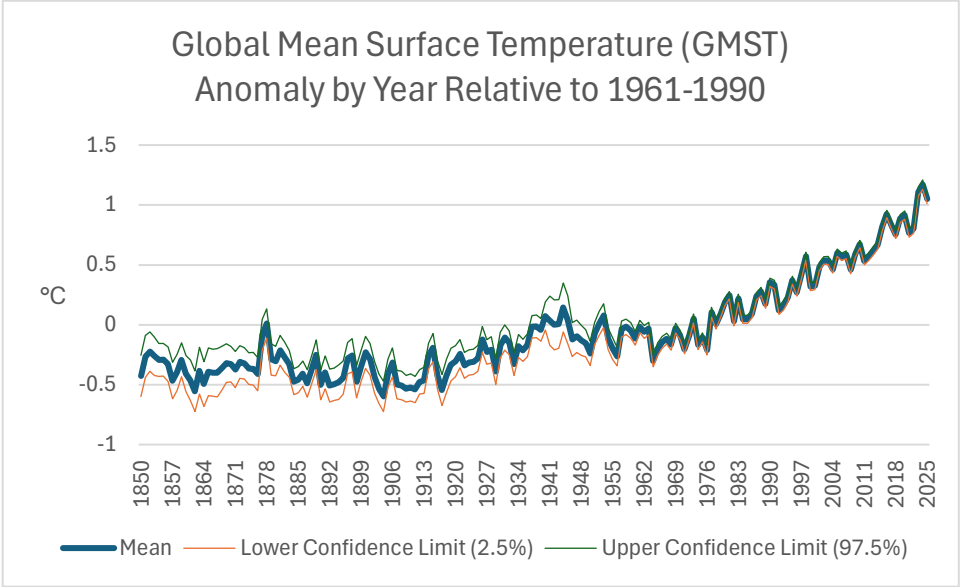
# Intergovernmental Panel on Climate Change (IPCC)

- Created by the UN and World Meteorological Organization
- Provides scientific information to support climate policy and negotiation
- Scientists are nominated by governmental bodies
- Produces Assessment Reports (AR) reviewing thousands of scientific papers

# Data Shows GMST Increasing

This measure of GMST…

- Measures ‘anomalies’
- Averages land and sea
- Uses 5° x 5° grids
- Estimates uncertainty




Source: Met Office Hadley Centre’s hadCRUT.5.1.0.0 Analysis (infilled)



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# Scientists Use Attribution Science to Assess D rivers

"**Attribution** is defined as 'the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence'."

(Bindoff et al., 2013, p. 872)



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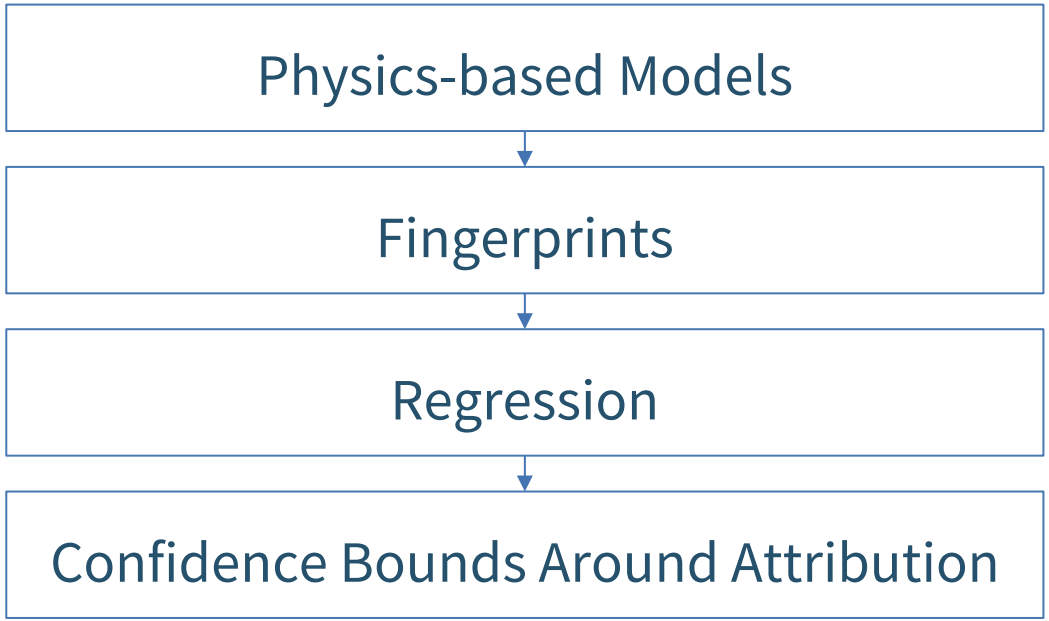
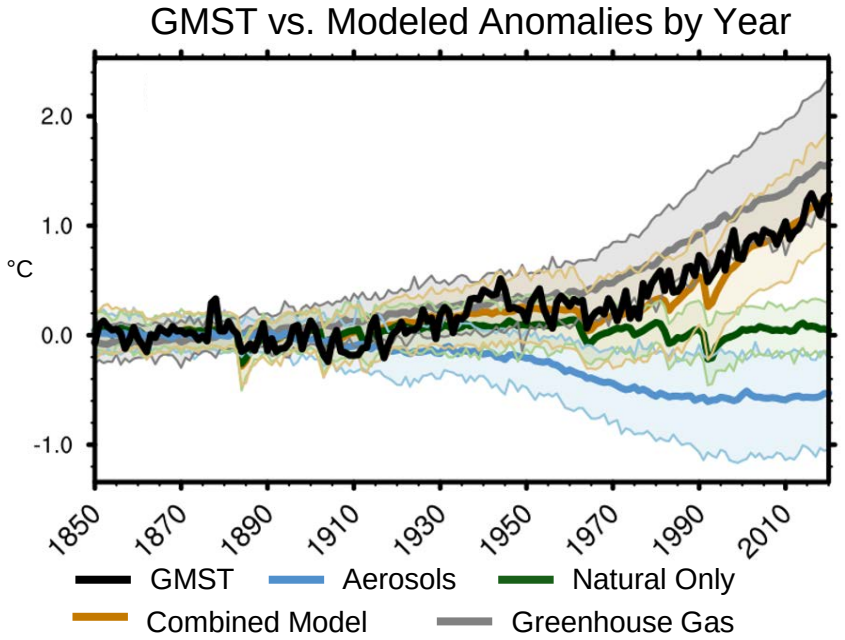
# Attribution Science Is Rooted in Physics



# There Could Be Multiple Contributing Factors

- Solar Variability
- Volcanic Eruptions
- Orbital Variations (Milankovitch Cycles)
- Internal Climate Variability
- Greenhouse Gas Emissions
- Land Use
- Aerosols

# Climate Models Measure Impact via Fingerprinting




Models perform:

- Control runs
- Counterfactual runs
- Historical runs



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# Attribution Is a Statistical Estimation Problem

- Models use a linear combo of forced signals and variability

$$Output = \sum (Forced\ Response) + Variability$$

- Scale factors are fit in regression

$$Observation = \sum (Scale \times Forced\ Response) + Variability$$

- A confidence interval is assigned to the scale factor
- If the confidence interval excludes zero, conditional attribution is made

# Risk of Overfitting Is Relatively Low

- There are few predictors
- Predictors are physics based
- Scale factors are estimated, not imposed
- Different models are used
- Output consistency is observed across different dimensions

# Event Attribution Can Assess Change in Risk

- Determine a specific event type (e.g., drought)
- Compare historical and counterfactual natural only results
- Estimate:

$$Risk\ Ratio\ (RR) = \frac{P_{Actual}}{P_{Counterfactual}}$$

$$Fraction\ of\ Attributable\ Risk = \frac{P_{Actual} - P_{Counterfactual}}{P_{Actual}}$$

- Change in Return Periods and Intensity

# Attribution Science Is Not Perfect

- There is inherent model risk
- Early period historical data is sparse
- Confidence varies when looking at a regional level
- Confidence varies for different climate impacts
- Confidence is lower for event attribution

# Integrating Attribution Science for Actuaries



## Best Practices for Reporting and Communication

- Establishing Clarity and Transparency
- Contextualizing Results: Uncertainty and Drivers
- Setting Priorities in Actuarial Work Products
  - Definitions
  - Full disclosure
  - Quantification of uncertainty

# Integrating Attribution Science for Actuaries



## Establishing Clarity and Transparency

- Specificity Defining the Scope of Analysis
  - Event Class Under Review
  - Define Peril – Pluvial v. Fluvial Flooding
  - Identify Geographic Regions
  - Temporal Duration
- Methodological Transparency
  - Documentation: Models, Ensembles, Assumptions
  - “World Without Climate Change”




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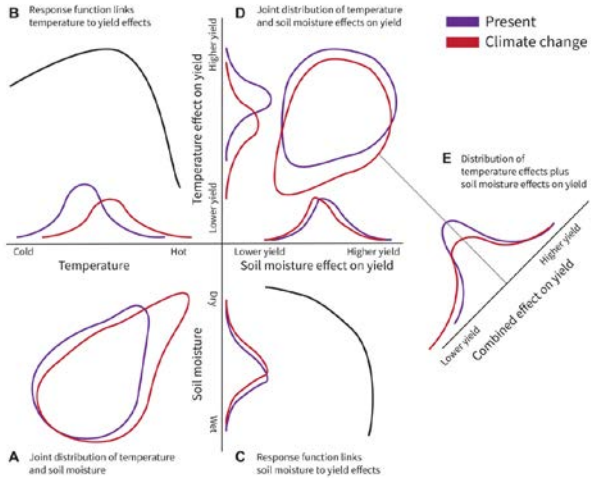
# Integrating Attribution Science for Actuaries



## Contextualizing Results: Uncertainty and Drivers

- The Quantification of Uncertainty
  - Confidence Intervals
  - Analysis of Sources of Variance
    - Observational Limitations
    - Sampling Variability
    - Model Structure Uncertainties
  - Disentangling Root Causes of Rising Losses
- Quantify Climate-Driven Hazard Attribution




Source: https://www.science.org/doi/10.1126/sciadv.ady3575



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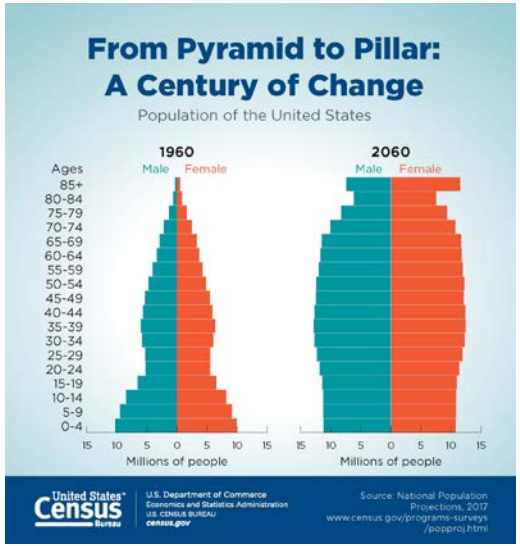
# Integrating Attribution Science for Actuaries



## Contextualizing Results: Uncertainty and Drivers

- Drivers of Climate Driven Hazard Attribution
  - Urban Development
  - Shifting Demographics
  - High-Consumption Lifestyle
  - Social & Community Inequalities
- Disaggregate Socioeconomic Physical Climate Factors
  - Targeted Adaptation Strategies
  - Equitable Public Policies



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# Integrating Attribution Science for Actuaries



## Setting Priorities in Actuarial Work Products

- Adopting a robust framework setting prioritizes
  - Definitions
  - Full Disclosure
  - Quantification of Uncertainty

*"A robust framework enables the transformation of complex scientific outputs into reliable financial metrics for stakeholders."*

# Integrating Attribution Science for Actuaries



## Applications in Actuarial Practice and Public Policy

- Insurance Applications: Integrating Attribution into Core Functions
  - Refine the traditional actuarial feedback loop
  - Augment historical averages with a forward-looking view of risk
  - Calibrate climate-adjusted rates perils like floods and convective storms
  - Incorporate "climate loads" into mortality & morbidity premium components
  - Improve interpretation of recent frequency & severity loss experience
  - Increase rigor of stress testing and scenario analysis—ORSA
  - Improve assessment of solvency v. “tail risk” using counterfactual modeling
  - Innovative solutions triggered by attribution-defined hazard thresholds

# Integrating Attribution Science for Actuaries

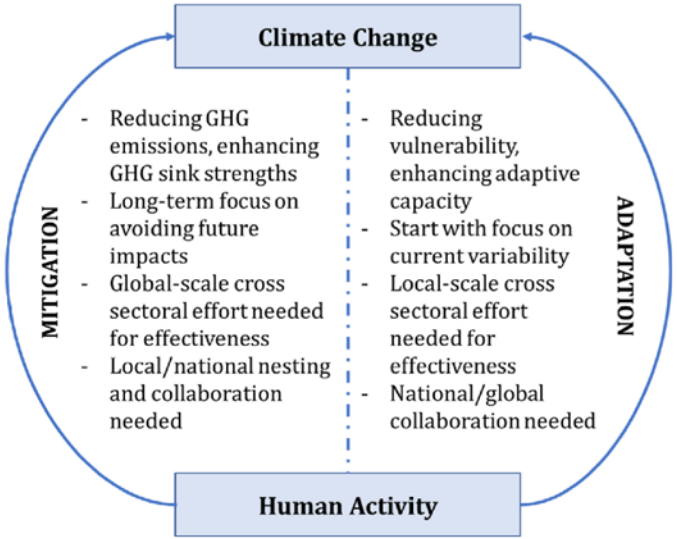


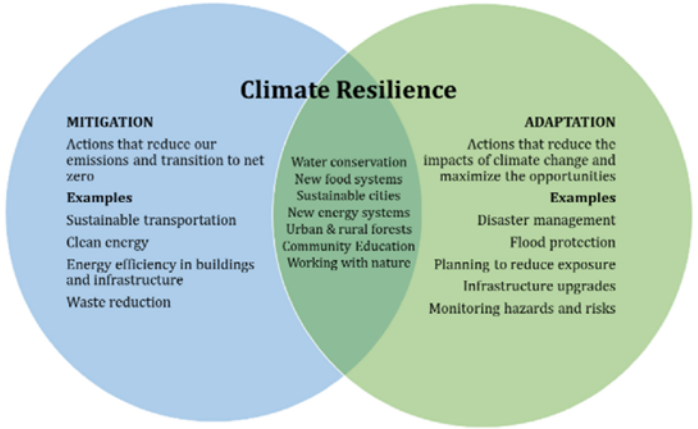
## Applications in Actuarial Practice and Public Policy

- Public Policy and Regulatory Implications
  - Quantify evidence for effective public policy and regulatory frameworks
  - Support rigorous financial reporting standards:
    - Task Force on Climate-related Financial Disclosures
    - International Sustainability Standards Board
  - Provide auditable, quantitative evidence of physical risk exposure
  - Establish causal links between emissions and damages in legal proceedings
  - Guide land-use planning and building codes through risk apportioning
  - Justify climate resilience adaptions using cost benefit analyses

# Climate Resilience Adaptations






Source: https://share.google/ys9Zftcea870J76hP

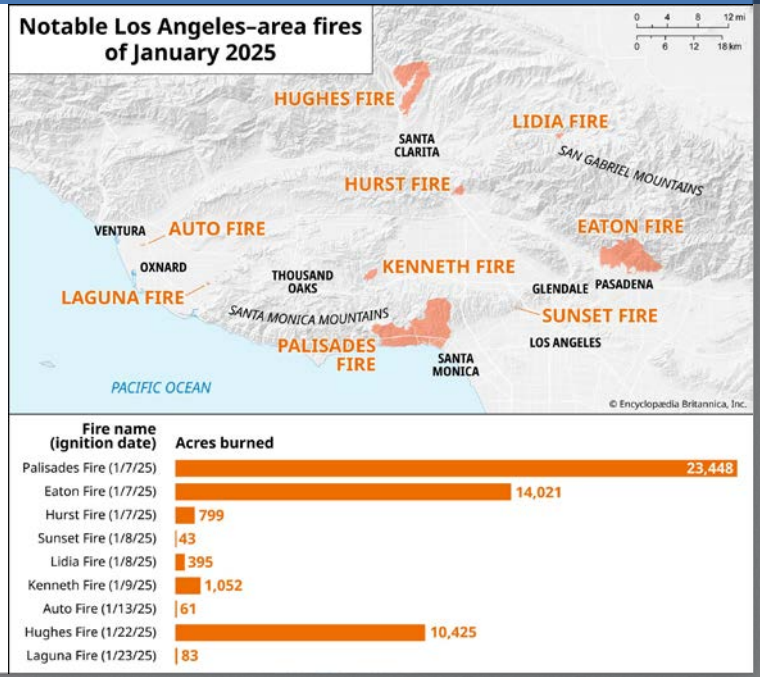
# Conclusion: The Way Forward



## Los Angeles Wildfires 2025

*Ranked among the top 10 costliest disasters to strike the United States*

- Causes and contributing factors
  - Careless use of NYE fireworks
  - Precursor event reignited
  - Palisades Fire became a conflagration
  - Eaton and Hurst fires source electrical
  - Causes of other fires remained unclear
  - Kenneth Fire believed intentionally set
  - Auto and Lidia fires under investigation




Source: https://www.britannica.com/event/Los-Angeles-wildfires-of-2025



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# Conclusion: The Way Forward



## Institute for Business & Home Safety


Roof age is the primary factor in conventional asphalt shingle performance at low to moderate hail severity.


A two-tiered approach that guards against embers and guards against flame exposure is needed to mitigate wildfire risk.


Little progress improving the wind resistance of asphalt shingles between Hurricane Charley (2004) and Hurricane Ian (2022).


Interior water damage to residential construction remains one of the most consistent and ever-present sources of insurance claims and losses.



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# Conclusion: The Way Forward



## Institute for Business & Home Safety





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# Conclusion: The Way Forward



**Institute for Business & Home Safety**

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Center for Risk & Insurance Research

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## Performance of IBHS Fortified Home Construction

**Table 9:** Potential Savings from Fortified

| | (1) Amount Reported In Data Call | (2) If All Houses Fortified Roof | (3) If All Houses Fortified Gold |
|---|---|---|---|
| Policyholders | | | |
| Deductibles Paid | $53,626,226 | $21,030,275 | $19,000,748 |
| Percent Saved | 0% | 61% | 65% |
| Insurers | | | |
| Claims Paid | $149,338,287 | $49,405,293 | $37,515,912 |
| Percent Saved | 0% | 67% | 75% |

*Notes*: Column (1) is the amount reported in the data call. Column (2) is the estimated amount if all the conventional houses had been built to the Fortified Roof standard. Column (3) is the estimated amount if all the houses had been built to the Fortified Gold standard.
*Sources*: ALDOI data call and IBHS



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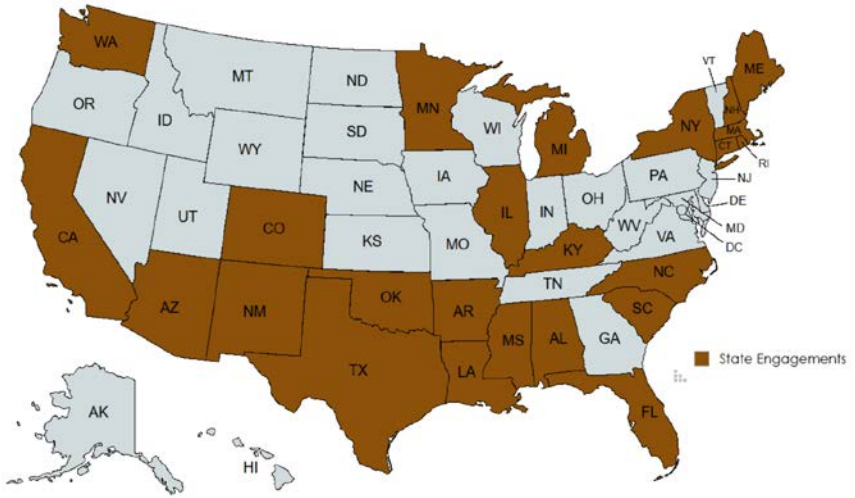
# Conclusion: The Way Forward



## Institute for Business & Home Safety

**State Embracing**
**"Culture of Resilience"**
**February 20265**

**Establishment of Retrofit Grant / Resilience Program**



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# Conclusion: The Way Forward



## Institute for Business & Home Safety


Insurance Partners



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# Conclusion: The Way Forward



## An Interdisciplinary Framework

- Property & Casualty, Life & Pension, and Health
  - A powerful interdisciplinary framework for climate risk quantification
  - Meteorologists provide the rigorous scientific attribution of climate signals
  - Actuaries quantify signals insured losses, longevity, & healthcare costs
  - Link extreme event probabilities to financial exposures & social outcomes
  - Integration promotes a comprehensive approach to climate risk quantification
  - Benefits of approach:
    - Strong Resilience Planning
    - Optimal Capital Allocation
    - Informed Regulatory Framework
    - Society Adaptation Support

# References


- Bindoff, N.L., P.A. Stott, K.M. AchutaRao, M.R. Allen, N. Gillett, D. Gutzler, K. Hansingo, G. Hegerl, Y. Hu, S. Jain, I.I. Mokhov, J. Overland, J. Perlwitz, R. Sebbari and X. Zhang, 2013: Detection and Attribution of Climate Change: from Global to Regional. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

# Questions?



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