American Academy of Actuaries

Connecting the Insurance Industry and Academia on Catastrophe and Climate Modeling Webinar Series

May 15, 2023

Welcome from the American Academy of Actuaries On behalf of the Academy, NOAA, and NSF

Lisa A. Slotznick, MAAA, FCAS

President-Elect

Chairperson, Climate Change Joint Committee

American Academy of Actuaries

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Agenda

Welcoming Remarks, Background, and Goals	Lisa Slotznick, American Academy of Actuaries
Announcement	Sarah Kapnick, NOAA
Panel Kick Off	Matt Chamberlain, Milliman
1	James Done, National Center for Atmospheric Research
2	Tom Delworth, NOAA/OAR/Geophysical Fluid Dynamics Laboratory
3	Kelly Hereid, Liberty Mutual
Audience Questions and Dialogue	Moderators Sarah Kapnick and Matt Chamberlain

Goals and Intentions

- Today's webinar will focus on the state of the science, model inputs, resolution, variables of interest, and the expression of uncertainty from the perspectives of climate modelers, and those using climate models.
- The prior webinars in this series have focused on catastrophe models and insurance industry usage of these models.
- These webinars are intended to support a broader effort NOAA and NSF are undertaking to connect industry partners and academic colleagues to make meaningful improvements to NOAA's climate services.

Additional goals include:

- Enabling all stakeholders, including industry partners, to incorporate NOAA's climate data into their decision-making.
- Another goal is to provide ideas and partnerships to academic cat and climate modelers to submit proposals to NSF later this year on the topics broached here.
- Finally, these dialogues also support the Academy's on-going efforts to examine climate change and climate risk.

Maximize Your Viewing and Engagement Experience

- The individual windows are resizable and moveable, so please feel free to move them around to get the most out of your desktop space.
- You may expand your slide area and the media player by clicking on the arrows in the top right corner of those windows.
- If you have any questions for our speakers, you may submit them through the Q&A engagement tool.
- You may find slides for today's webinar in PDF format in the Slides and Resources tool. For answers to some common technical issues, visit Help at the bottom of your screen.
- We invite you to share your feedback on today's webinar on the "Take Survey" tool on your screen.

Sarah Kapnick, Ph.D., Chief Scientist, NOAA

Sarah Kapnick, Ph.D. is Chief Scientist for NOAA. In this role, Dr. Kapnick is responsible for advancing policy and program direction for NOAA's science and technology priorities. Most recently, Dr. Kapnick served as a Managing Director at J.P. Morgan in the role of Senior Climate Scientist and Sustainability Strategist. Previously, Dr. Kapnick was a Physical Scientist and Deputy Division Leader at NOAA's Geophysical Fluid Dynamics Laboratory. Dr. Kapnick received a Ph.D. in Atmospheric and Oceanic Sciences with a Certificate in Leaders in Sustainability from UCLA, and an A.B in Mathematics with a Certificate in Finance from Princeton University.

Joint NSF-NOAA Funding Opportunity

via an NSF Dear Colleague Letter

NSF 23-106

GEO-SBE-NOAA Call for Proposals for: Modeling of Catastrophic Impacts and Risk Assessment Due to Climate Change

https://www.nsf.gov/pubs/2023/nsf23106/nsf23106.jsp

James Done, Ph.D.
Willis Senior Academic Fellow
Director of the Capacity Center for Climate and Weather Extremes
National Center for Atmospheric Research

James Done,PhD, is Director of the Capacity Center for Climate and Weather Extremes at the National Center for Atmospheric Research. He is also Senior Academic Fellow of the WTW Research Network. His climate research extends across a range of extreme weather and climate phenomena and connects with risk managers to strengthen the science and ensure business relevance. In recognition of his scientific leadership, he testified before the U.S. Congress on extreme weather in a changing climate. Dr. Done received his PhD in Meteorology from the University of Reading, UK in 2003.

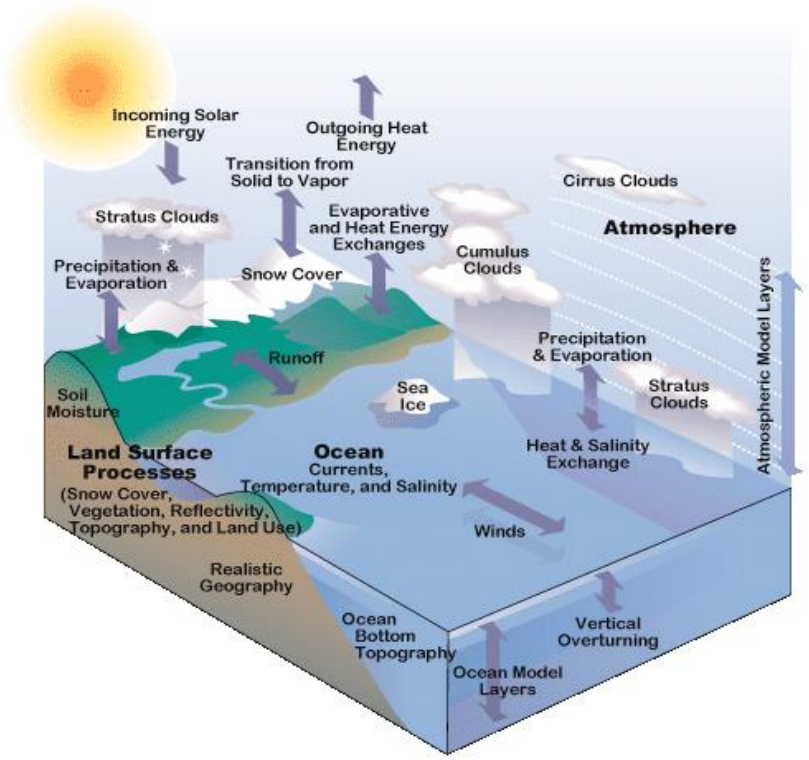
NCAR | NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

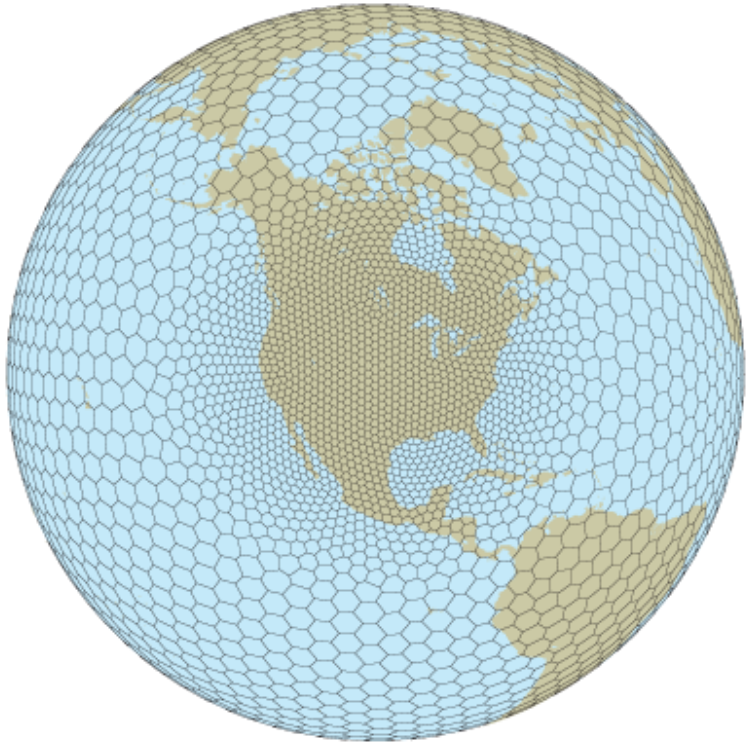
Climate Modeling for Risk Assessment

James Done
Willis Senior Academic Fellow,
National Center for Atmospheric Research

(Background image: NOAA)

Weather and climate models are based on physical laws of the Earth System

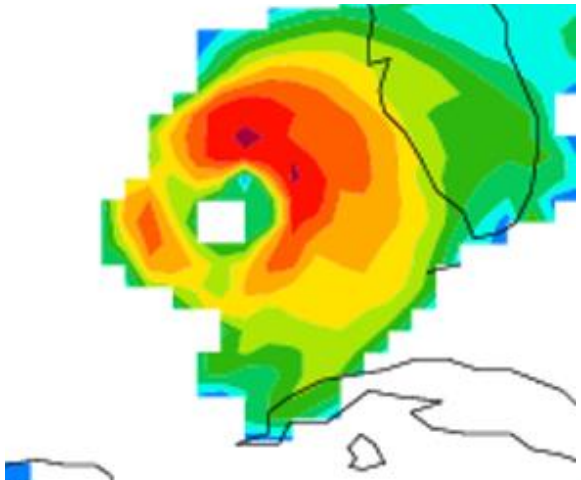




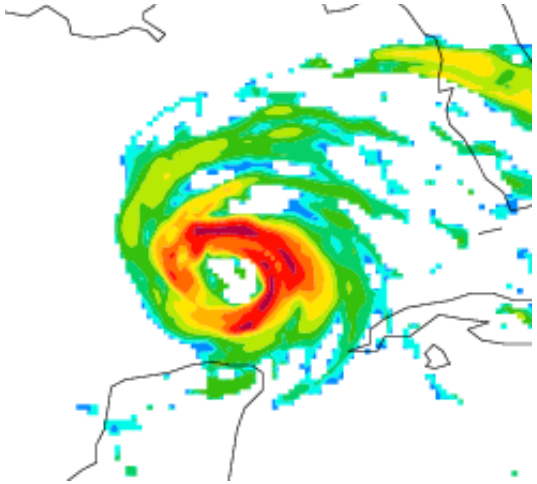
Built to understand weather and climate

Finer scale hazard features captured at increasingly finer resolution

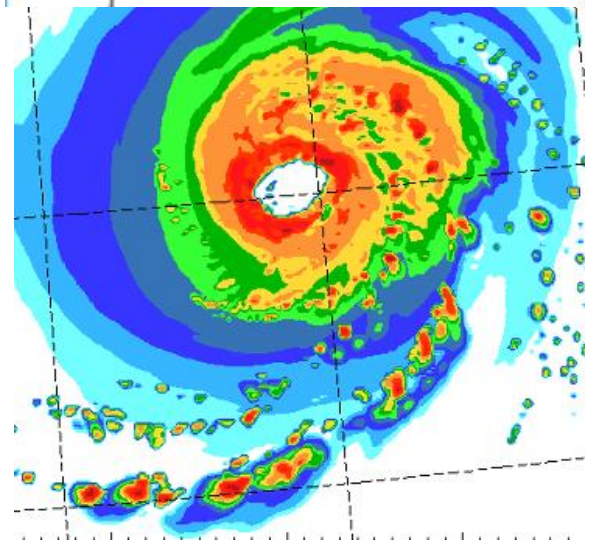
36 km



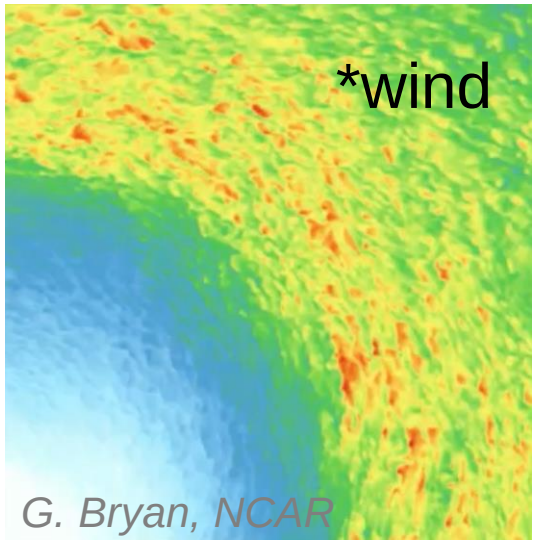
12 km



4 km

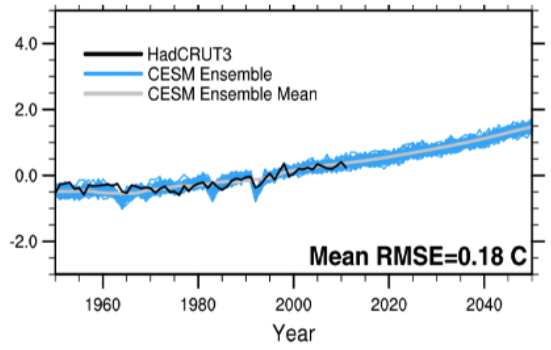


32 m

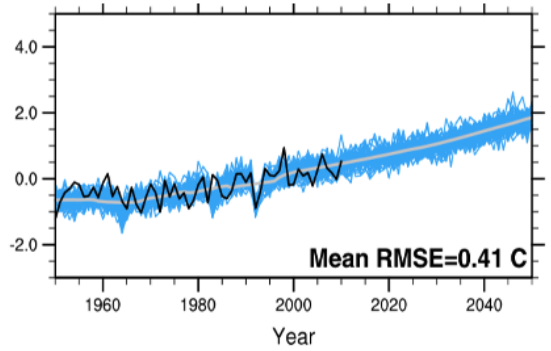


Climate projection uncertainty increases at smaller scales

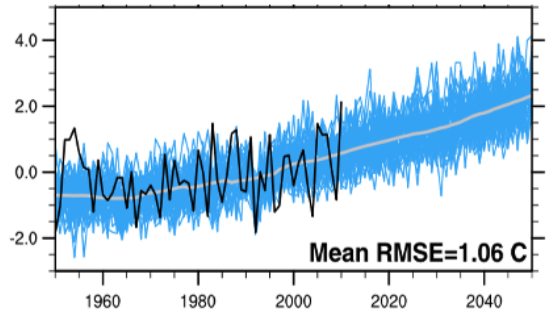
N. Hemisphere



United States



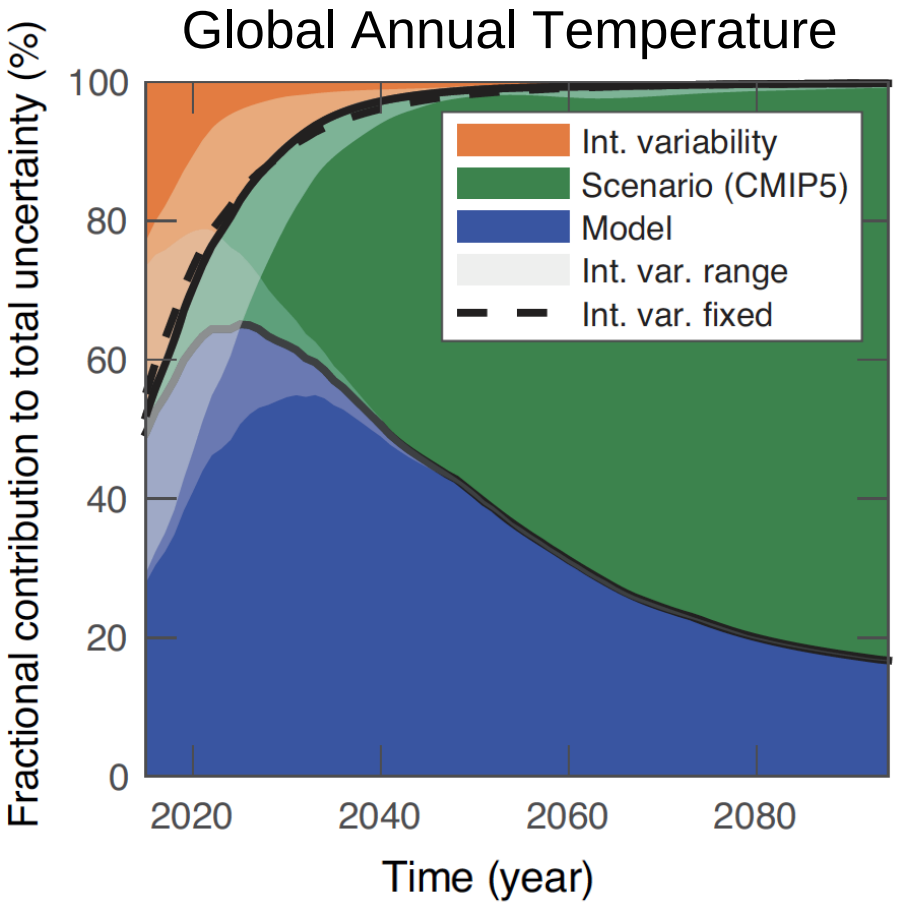
Midwest

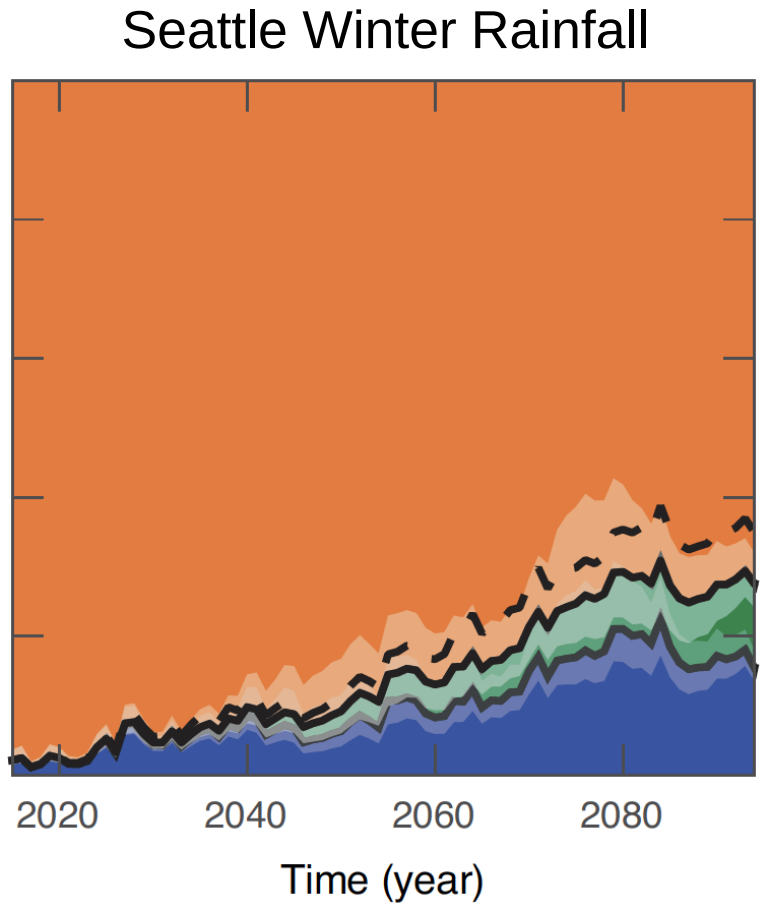


Temperature Change (C)

Deser et al. (2012)

Climate projection uncertainty sources depend on scale and variable





Lehner et al. (2020)

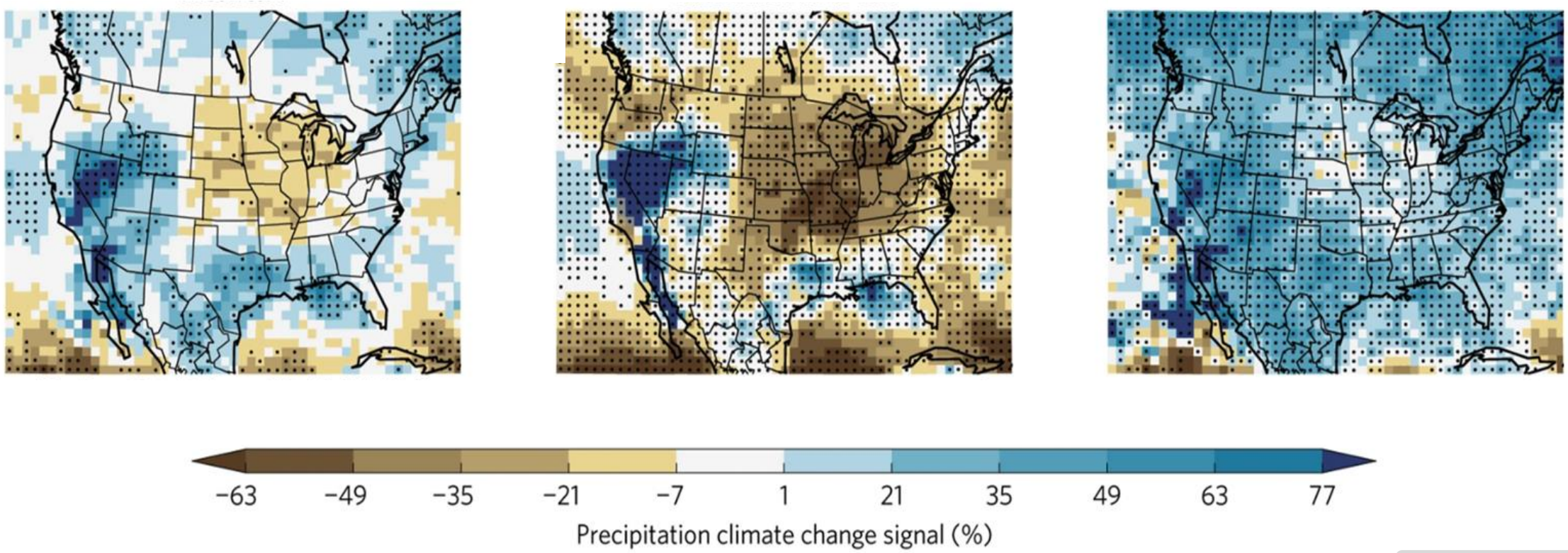
There can be some certainty in the tail

Recent trends in hourly precipitation

Summer mean

97.5 percentile

99.95 percentile

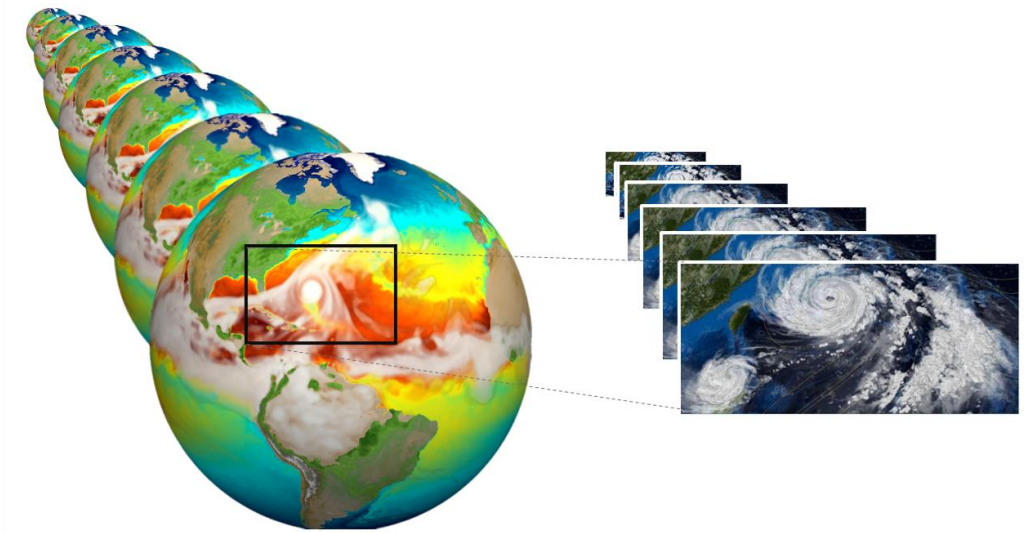


Prein et al. (2017)

Getting creative with climate models: Creating 1% probability events

Motivation: Do cat models contain all possible events?

Approach:
1) Scan through 1000s of years of CESM data for signatures of extreme events.
2) Zoom in on event details using WRF



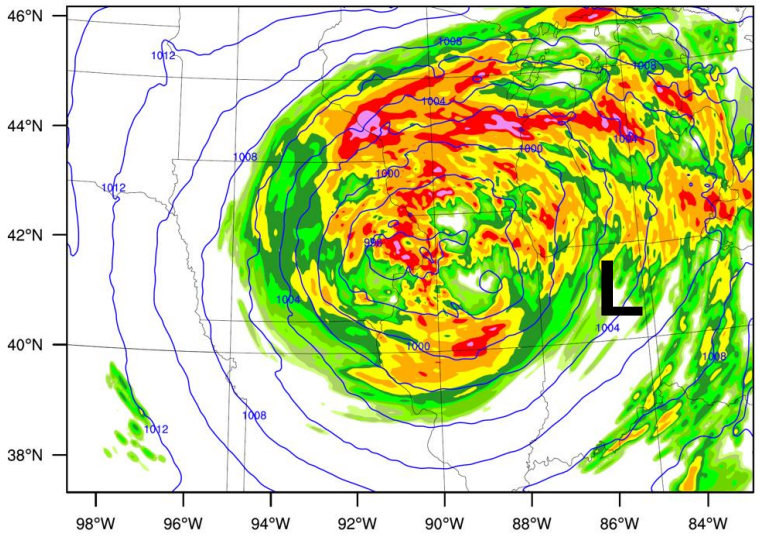
Benefits:
- Computationally efficient.
- Sees beyond the historical record.
- Climate change included.
- Adaptable to any hazard.

- Provides physical storylines.
- Test inclusion in risk models.

Example: 200-year Mid-West rainfall

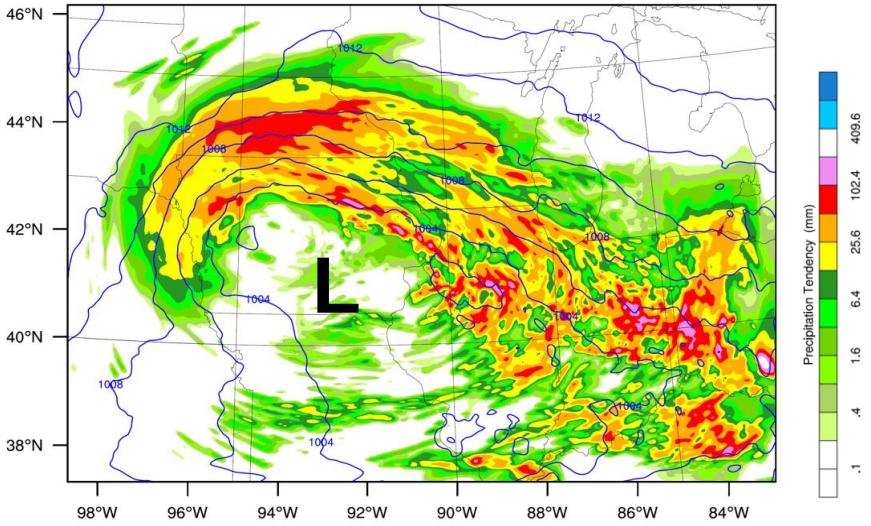
Collaborative work with WTW and Gallagher

Current climate event



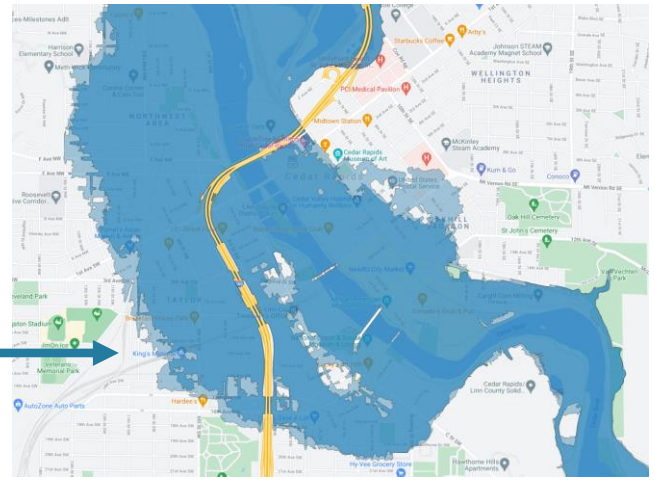
Thundery cyclone
~ 2 feet of rain.

Future climate event



Slower cyclone
~2.2 feet of rain

- Translated to flood and flood losses
- Losses increase 5 times faster than the rainfall.



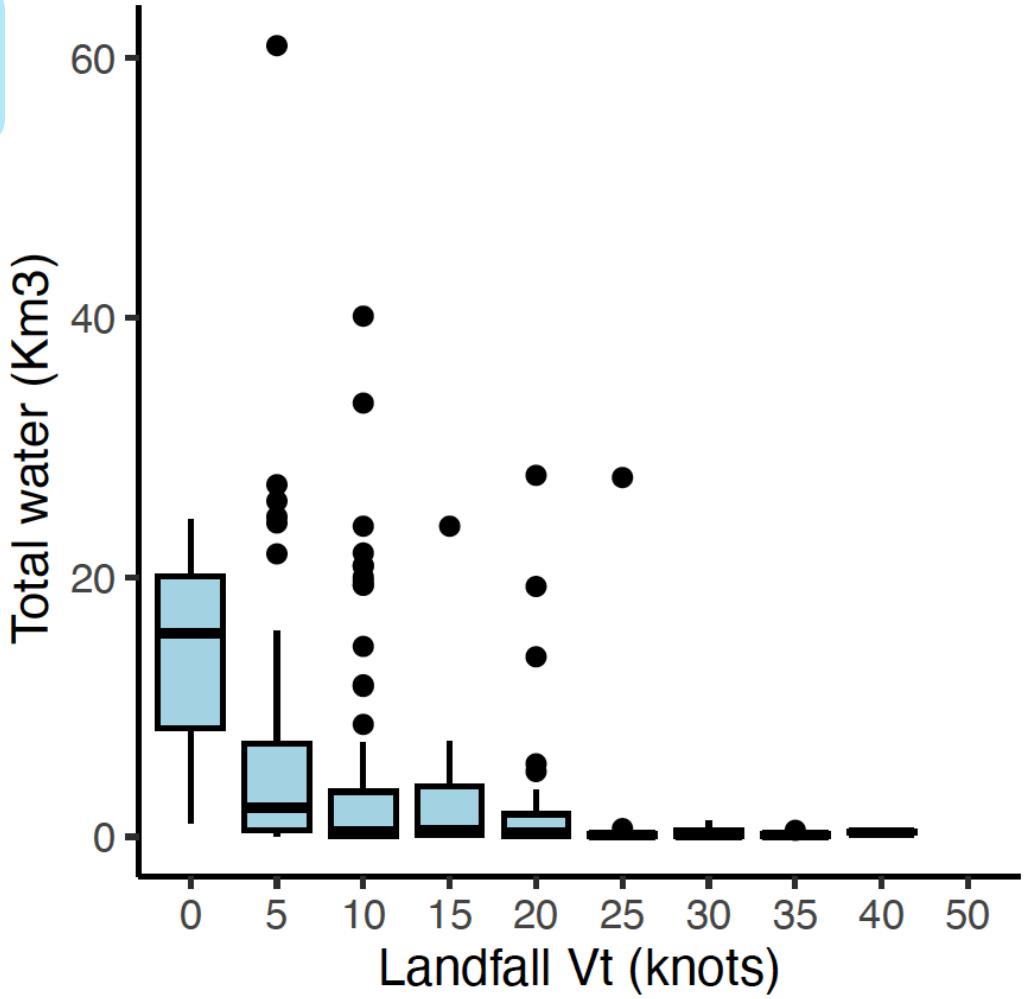
Source: Gabriele Villarini (U. Iowa)

Understanding TC Wind-Rain Relationships

Collaborative work with AXA XL

Motivation:
Understand TC loss contribution from flood.

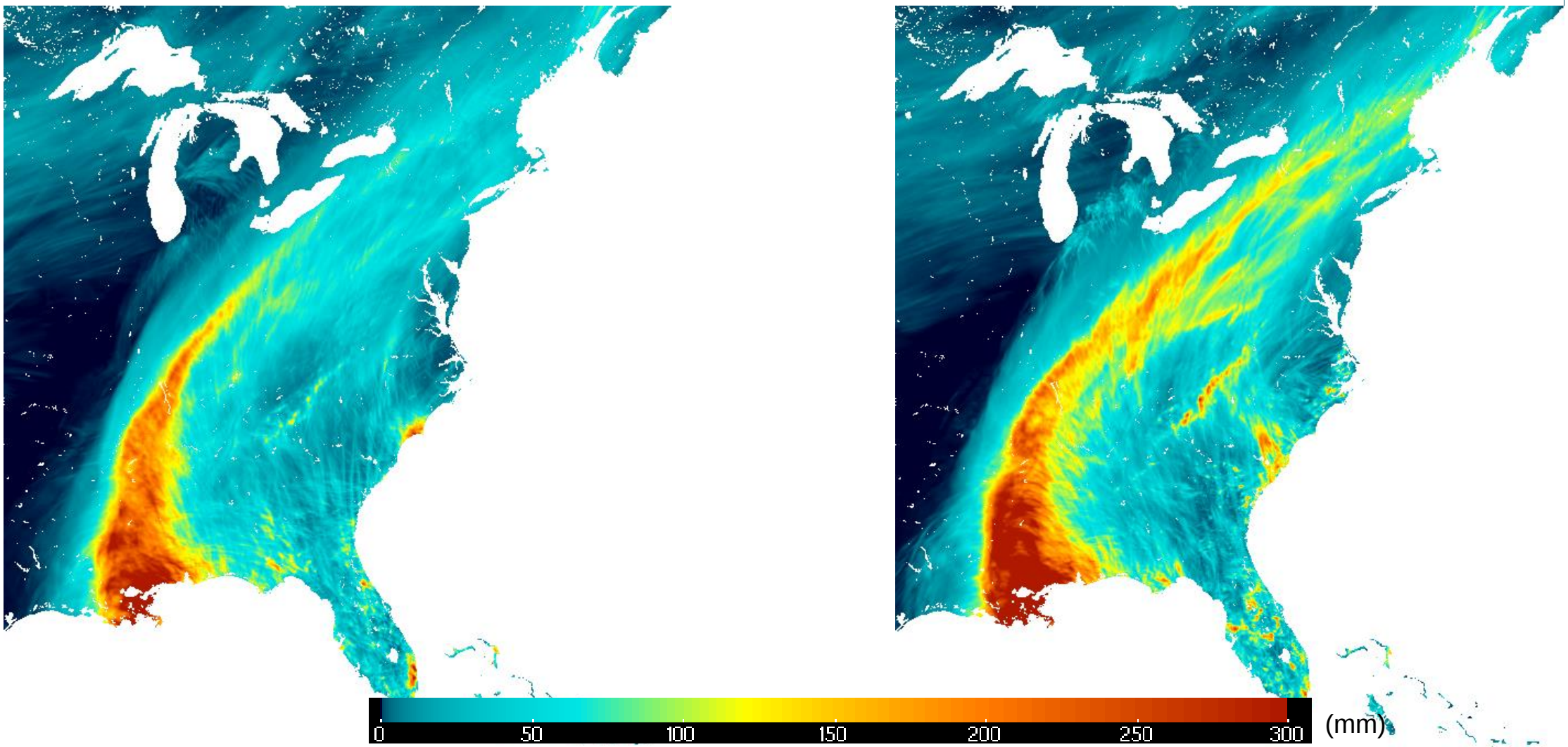
Slower storms are wetter in observations



Using climate models to project relationships

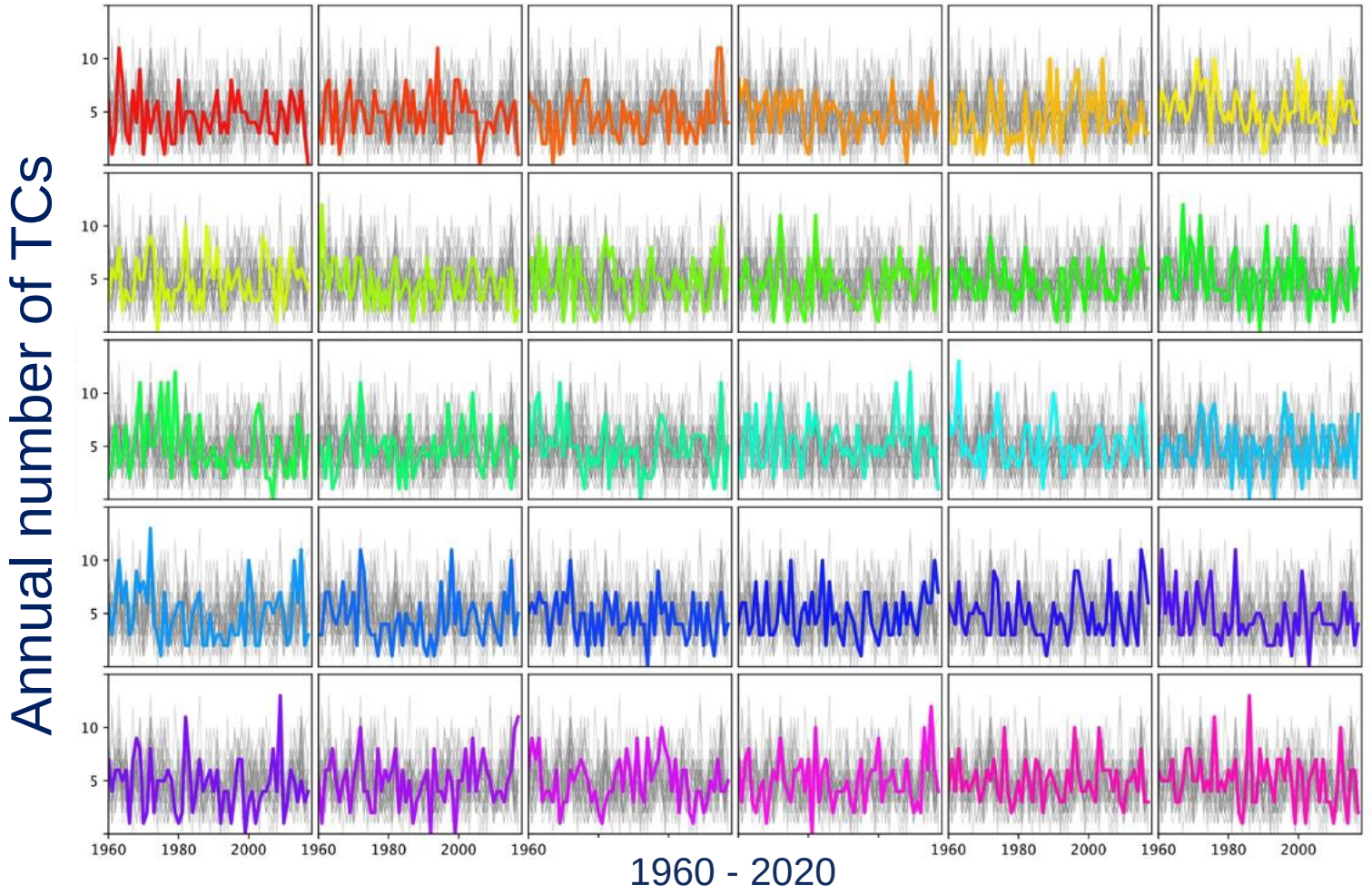
Total rainfall for Isidore (2002)

Isidore in a future climate



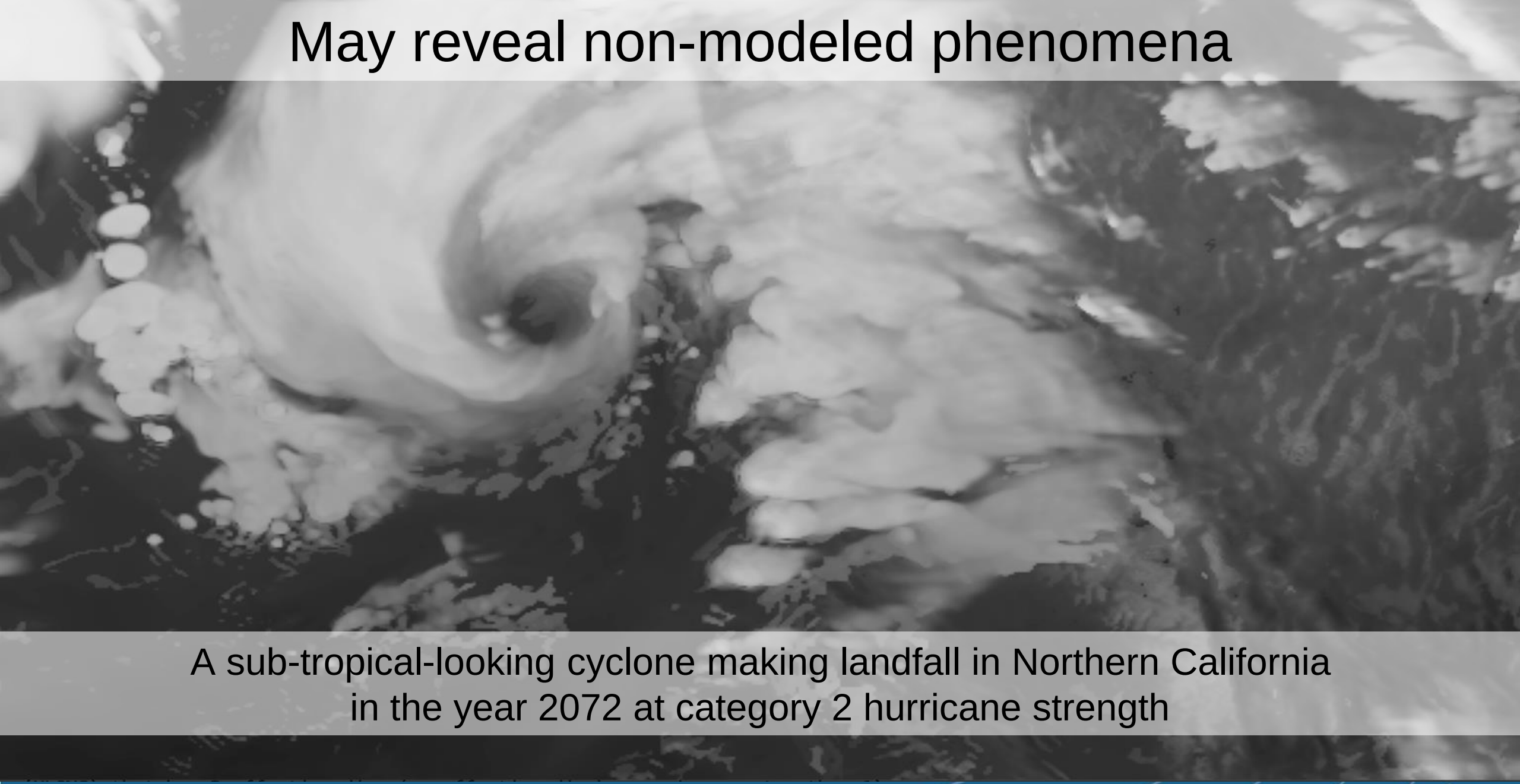
Understanding TC history along Australia's East Coast

Collaborative work with Insurance Australia Group



Bruyère et al. (2022)

May reveal non-modeled phenomena



A sub-tropical-looking cyclone making landfall in Northern California
in the year 2072 at category 2 hurricane strength

Key Takeaways

1. Integrating climate modeling and catastrophe modeling promises to transform our understanding of risk.

2. Get creative with climate modeling

2. Prioritize uncertainty sources

2. Collaboration is an opportunity to pursue new fundamental and usable science.

Thomas Delworth, Ph.D.
Senior Scientist, Geophysical Fluid Dynamics Laboratory
Division Leader, Seasonal to Decadal Variability and Predictability

Thomas Delworth, PhD is a Senior Scientist at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) and the Division Leader for Seasonal to Decadal Variability and Predictability. Dr. Delworth's research focuses on climate variability, predictability and change on time scales from seasonal to multi-decadal. His research foci include the role of the oceans in climate, decadal scale changes in regional hydroclimate and extremes, including drought, and predictability of the ocean-atmosphere-land system on seasonal to decadal scales. He has led efforts at GFDL to build a succession of state-of-the-art climate models. Dr. Delworth has served on numerous national and international scientific research committees, has authored over 190 papers for scientific journals and books, and is a Highly Cited Researcher (top 1% most cited in Geosciences) as identified by Web of Science. He is a Fellow of both the American Meteorological Society and the American Geophysical Union. He earned his PhD from the University of Wisconsin.

Seamless climate prediction and projection from seasonal to multidecadal time scales

Thomas L. Delworth
Geophysical Fluid Dynamics Laboratory/NOAA

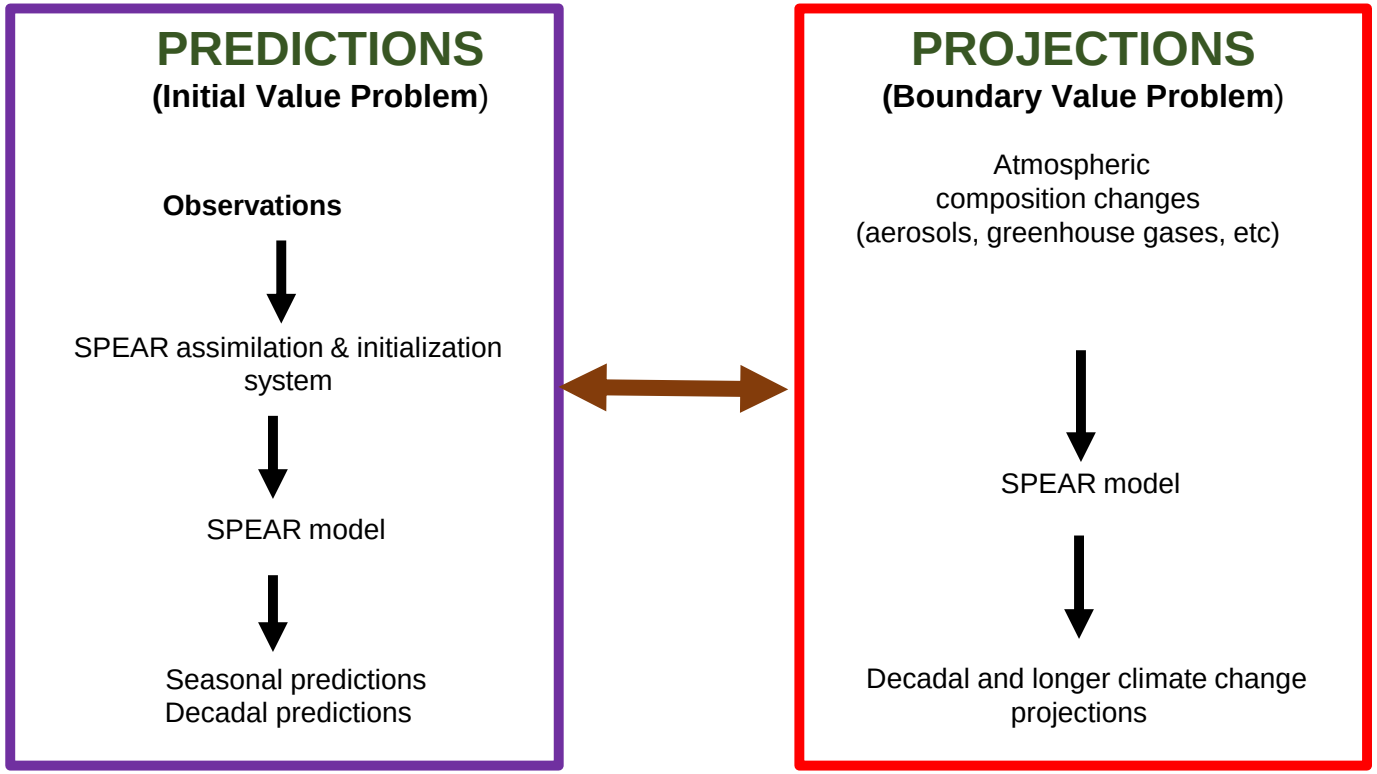
What are the likelihood and characteristics of changes in climate and extremes …

- *next month*
- *next season*
- *next year*
- *next decade*
- *50 years from now*
- *100 years from now*

Connecting the Insurance Industry and Academia on Catastrophe and Climate Modeling
Webinar Series May 15, 2023

”Seamless” Seasonal to Decadal Prediction and Projection of Climate & Extremes

- **Predictions**: How tropical Pacific ocean temperature (El Nino) will evolve in coming months and years
- **Projections:** How the statistics of Pacific ocean temperatures (El Nino) will change in response to increasing greenhouse gases



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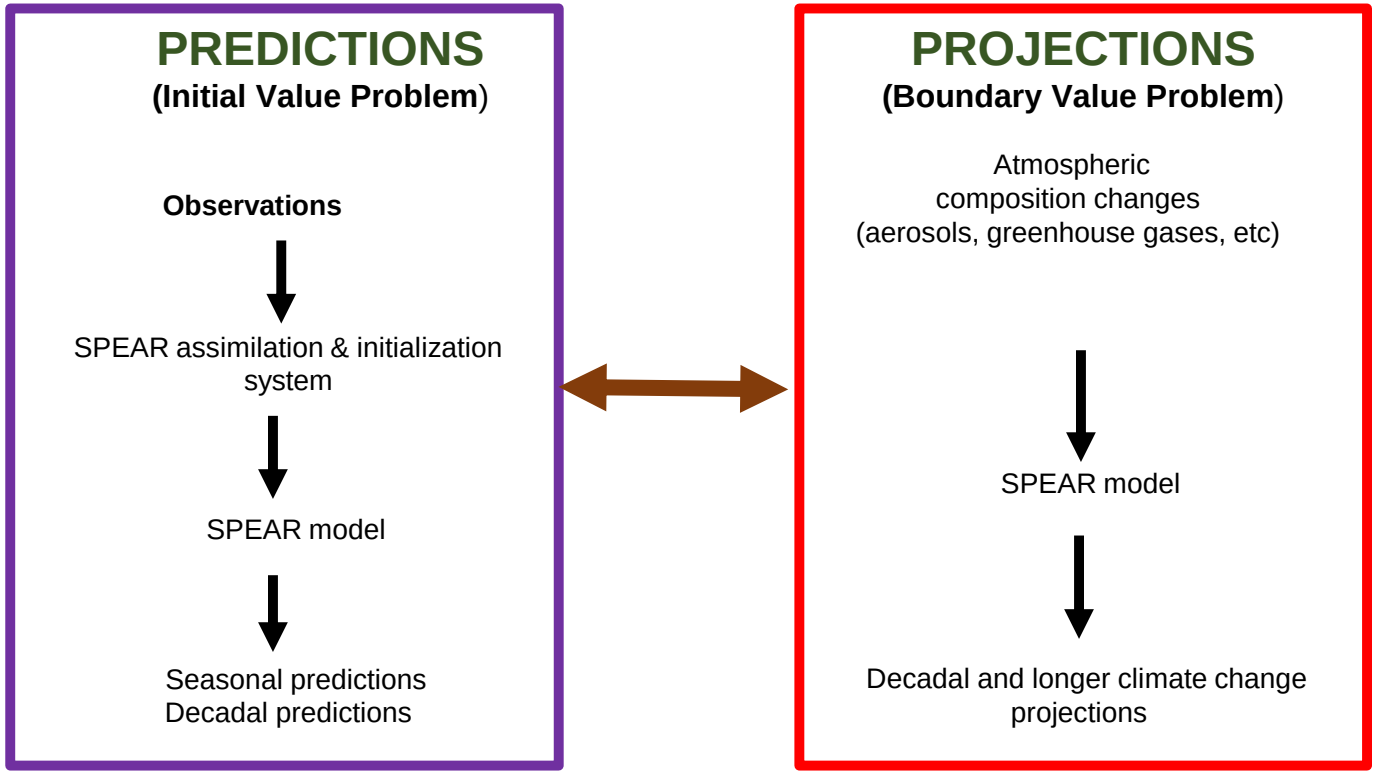
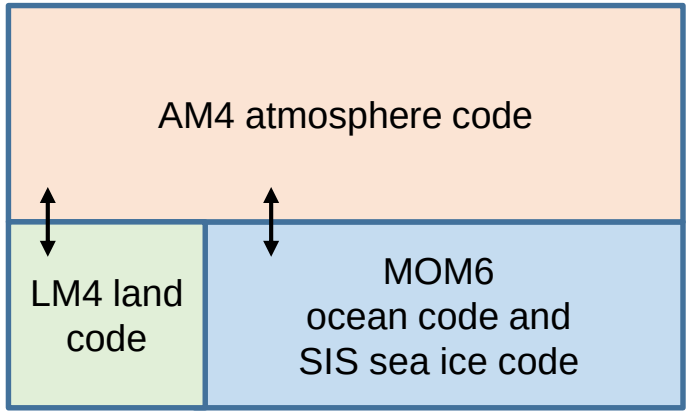


GFDL SPEAR:

Seamless system for **P**redictions and **EA**rth system **R**esearch



Predictions and projections “seamlessly” from seasonal to multidecadal scales

	Atmos resolution	Ocean resolution
SPEAR_LO	100 km	100 km
SPEAR_MED	50 km	100 km
SPEAR_HI	25 km	100 km
SPEAR_HI_25	25 km	25 km

Pushing the frontiers of seasonal extreme weather prediction

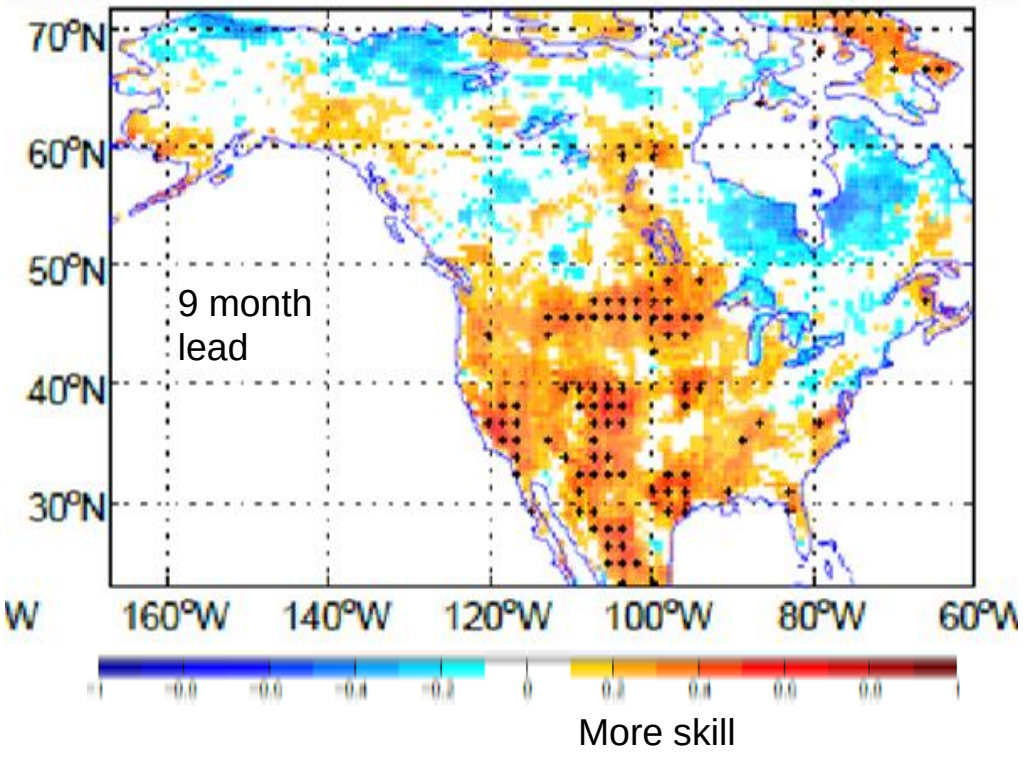
RESEARCH HIGHLIGHT | 07 April 2022

Scorching summers can now be predicted months earlier

Sophisticated global climate model offers as much as nine months notice of extreme heat in some parts of North America.

***Nature* highlight of Jia et al. (2022)**

SPEAR forecast skill of JJA temperature extremes



Emerging foci:

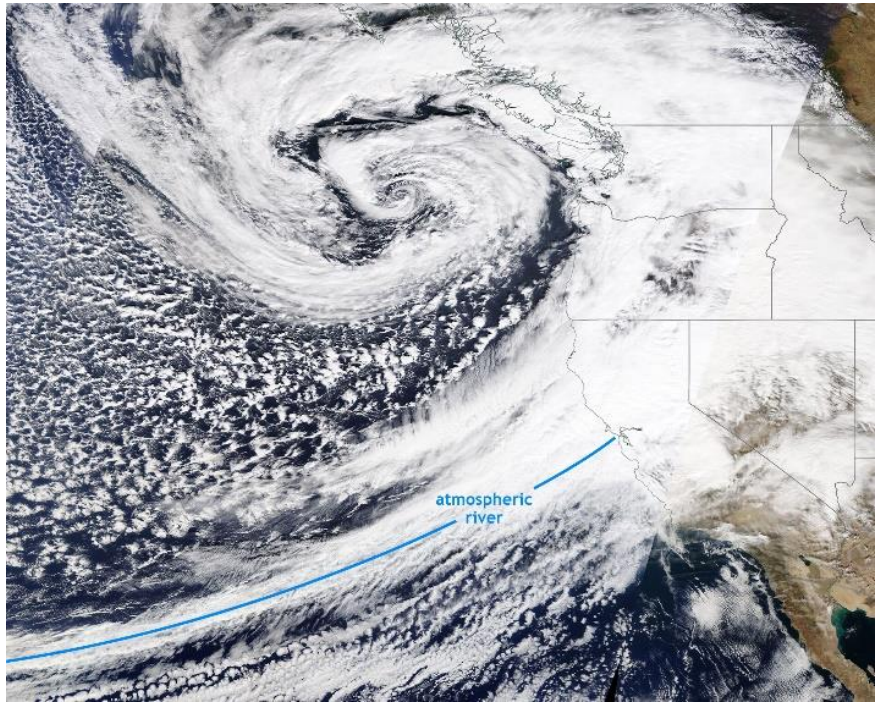
seasonal extreme weather prediction

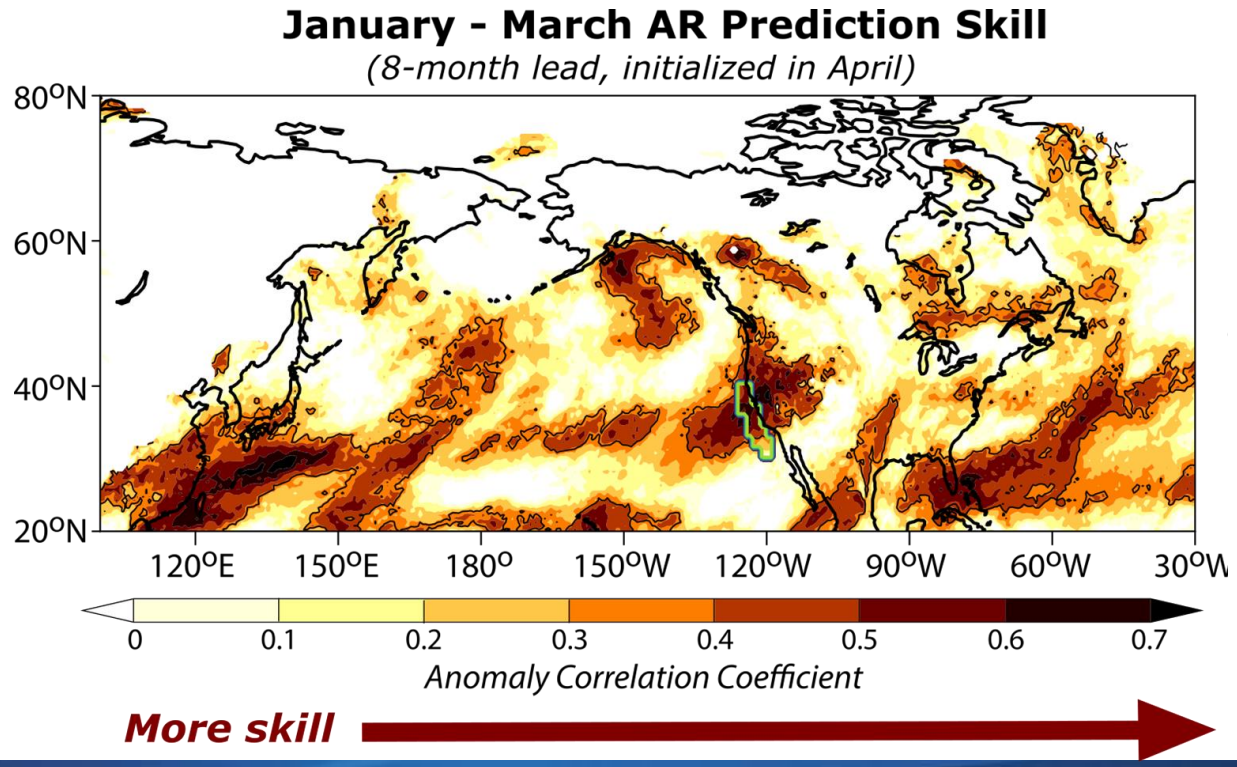
- *Seasonal tornadic activity prediction over US (skill up to 11 months in advance)*
  (Tseng and Johnson, in preparation)
- *Seasonal prediction of wind energy*
  (Yang et al, in preparation)
- *Seasonal prediction of Atlantic hurricanes*
- *Seasonal prediction of fire weather characteristics*
- *Seasonal prediction of extreme cold*
- *Multiannual prediction of extreme sea level along the US East Coast*
  (Zhang et al, in preparation)

Pushing the frontiers of seasonal extreme weather prediction

- **Atmospheric rivers (ARs)** cause damaging floods and destructive winds but also are a critical water resource, particularly for the western US.

- SPEAR can skillfully predict winter atmospheric river activity **up to 9 months in advance**.





We use the same modeling system to seamlessly project changes in AR activity due to greenhouse gases.

Source: Tseng et al. (2021, Geophysical Research Letters)

Understanding the changing risks of extreme weather in a warming climate

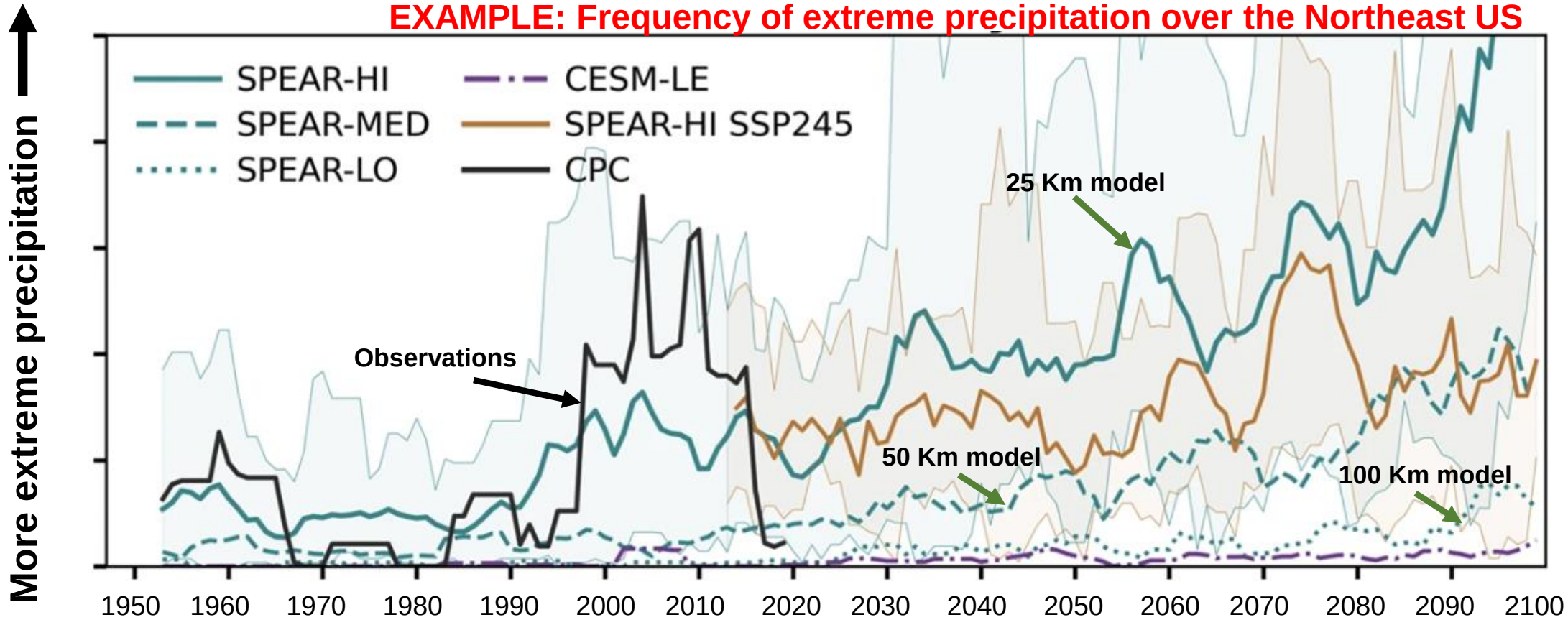
SPEAR Large Ensembles

Run SPEAR model many times, generating different possible future climate trajectories

Allows quantification of “climate risk” – changes in extremes (precip, wind, storms, etc)

KEY POINT: Realistic simulation of precipitation extremes requires high resolution.

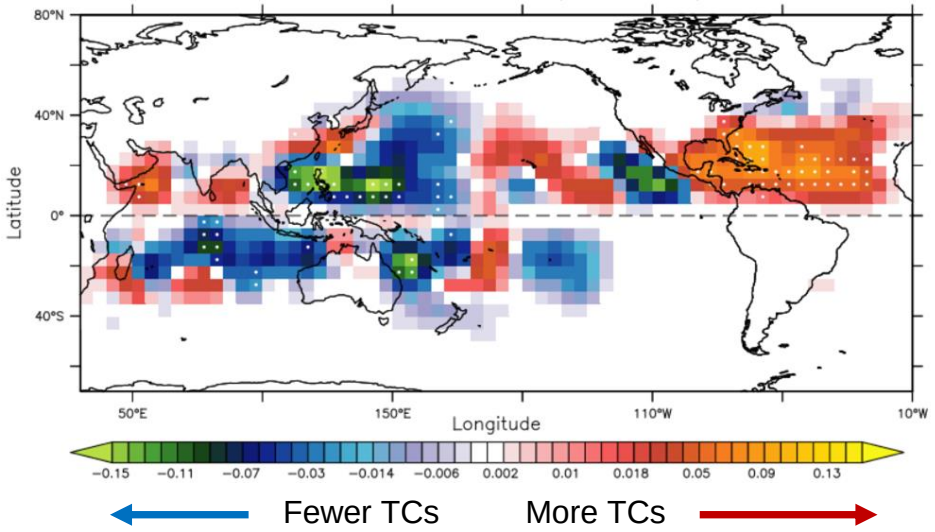
EXAMPLE: Frequency of extreme precipitation over the Northeast US



Understanding past Tropical Cyclone (TC) changes improves confidence in future projections

Q: What caused the historical changes in global TCs over the past 40 years?

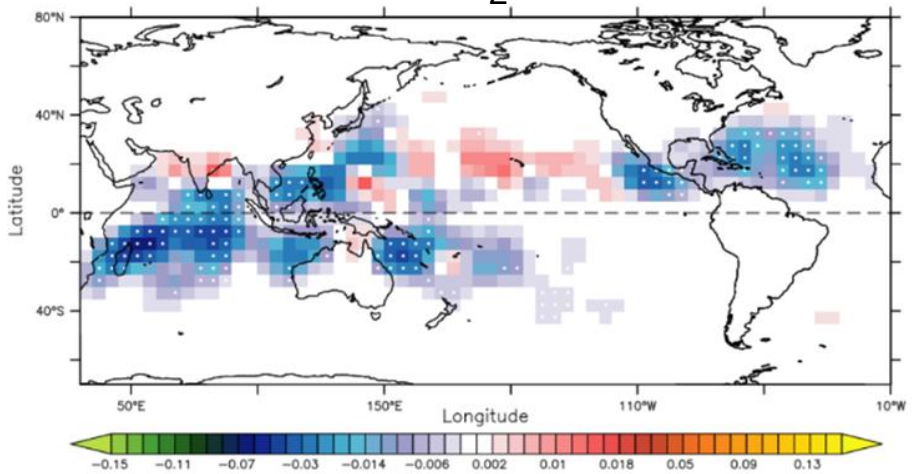
Observed changes (1980-2018)



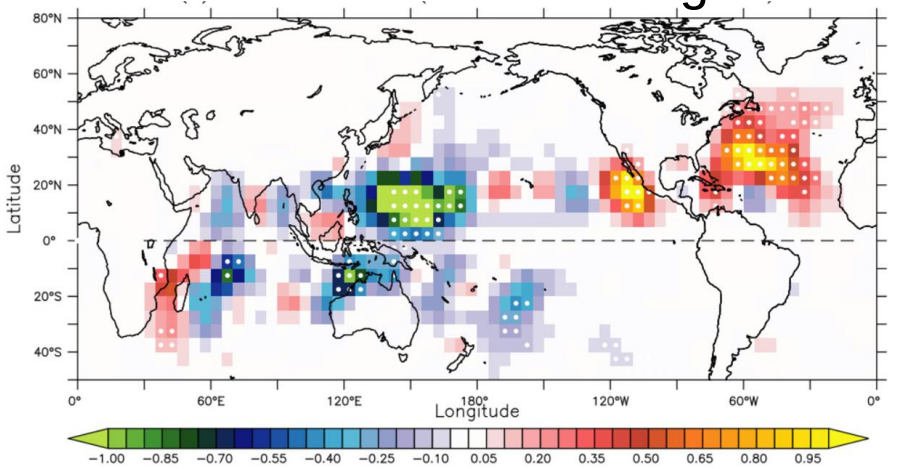
CO_2 increases only

aerosol changes only

Effect of CO_2 increase



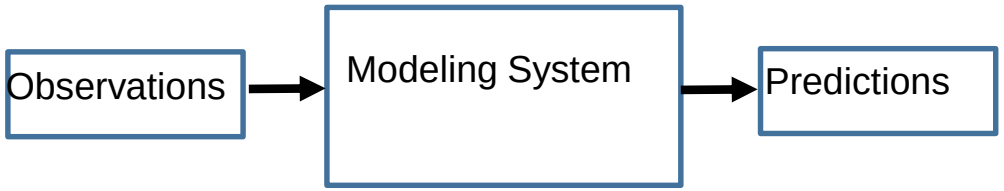
Effect of aerosol changes



SEAMLESS: Use same model for seasonal predictions and long term climate change projections

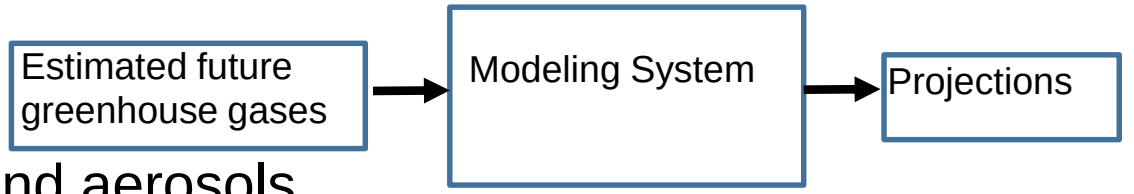
Sources of Uncertainty

Seasonal to Interannual Predictions



- Observational uncertainties or incompleteness
- Absolute limits on predictability (weeks in the atmosphere, years in the ocean)
- Model fidelity and resolution; ability to make use of observations

Decadal to Multidecadal Climate Change



- Estimates of future changes in greenhouse gases and aerosols
- “Realism” of model response to changing greenhouse gases and aerosols
- Interplay of natural climate variability and climate change from increasing greenhouse gases

Summary and a look down the road

Key points

- Seamless systems provide new capabilities for predicting and projecting climate and extremes across scales
- IPCC models typically use coarse resolution (~100 km grids). Difficult to explicitly simulate some extremes.
- Higher spatial resolution of models is critical for quantitative simulation of extremes.
- Modeling Centers face tradeoffs – with finite computing, how to best "spend" computing resources

Looking forward

- Now and next several years … new generation of global coupled climate models with resolution of 25 km or finer provide more powerful tools for predicting and projecting changes in extremes on regional scales.
- Next wave … global 3 km models used for climate change studies will be a quantum leap in simulating changes in extremes. Important phenomena at finer scales will be explicitly resolved.

Kelly Hereid, Ph.D., CCRMP
Director of Catastrophe R&D
Corporate Enterprise Risk Management group
Liberty Mutual

Kelly Hereid, Ph.D., CCRMP, is the Director of Catastrophe R&D at Liberty Mutual in the Corporate Enterprise Risk Management group. Prior to joining Liberty in 2020, she spent 8 years as a research scientist at Chubb with both the reinsurance and primary business. She specializes in climate change and emerging risks.

Dr. Hereid is a board member of the International Society of Catastrophe Managers (ISCM), member of the Reinsurance Association of America (RAA) Catastrophe Management Conference planning Committee and serves on the Advisory Council for the University of Texas – Austin Geology Foundation. She also represents Liberty externally in a variety of research forums, including the Insurance Development Forum (IDF Risk Modelling Steering Group) and European Insurance and Occupational Pensions Authority (EIOPA Technical Expert Network on Catastrophe Risks).

Dr. Hereid is a Certified Catastrophe Risk Management Professional (CCRMP). She has a Ph.D. in geological sciences from the University of Texas – Austin, focusing on climate science, and a B.A. in geology and biology from Carleton College in Minnesota.

Liberty Mutual INSURANCE

Integrating Climate Modeling into Risk Management

Kelly Hereid, Ph.D.

Director, Catastrophe R&D

Corporate ERM

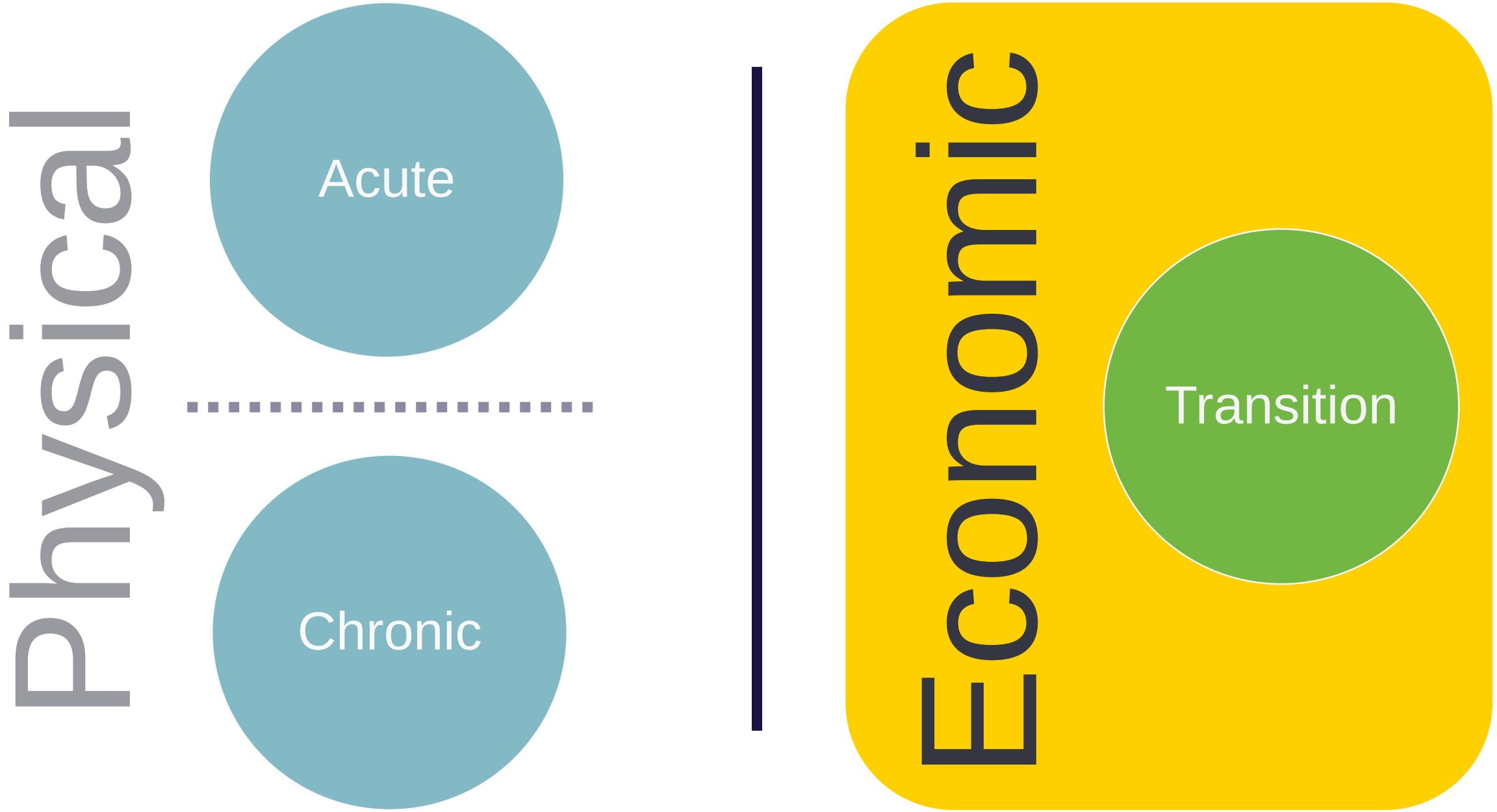
Key Points

Bottom-up catastrophe modeling complements top-down physical risk assessments

Make progress exploring chronic physical risk impacts on extremes

Good decisions in the built environment


Physical
Acute
Chronic
Economic
Transition


Physical
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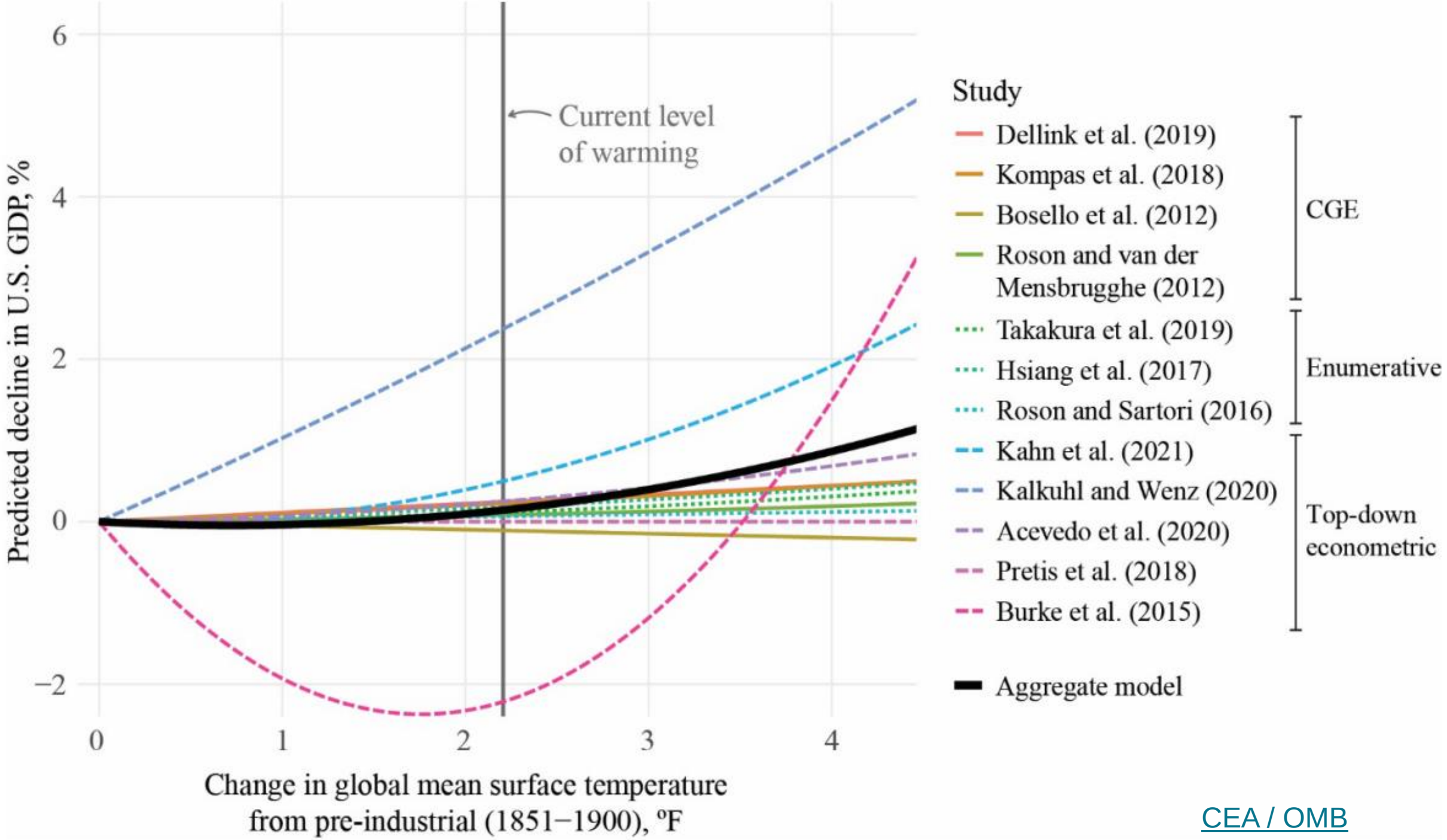
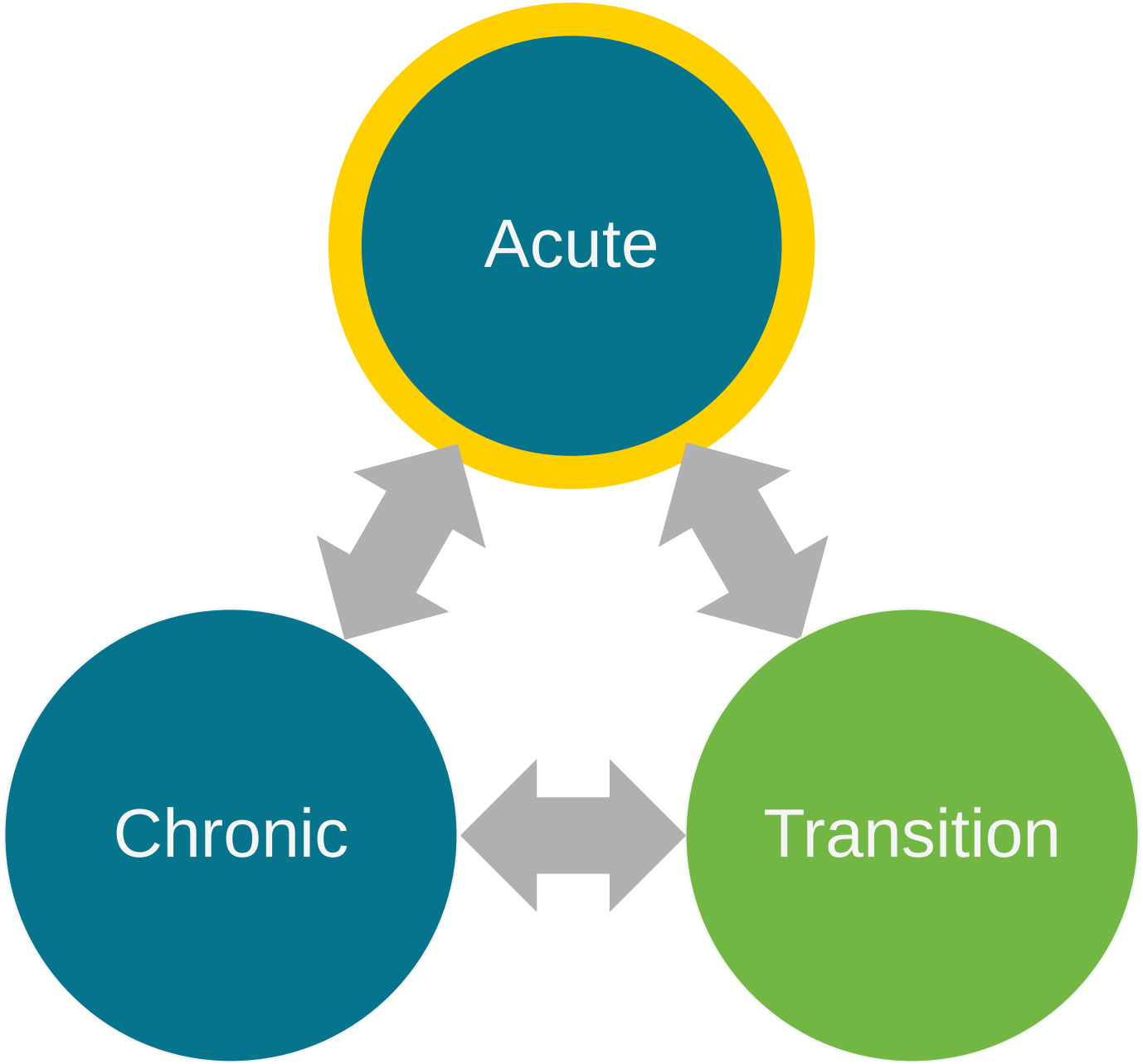

Predicted decline in U.S. GDP, %
6
4
2
0
−2
Current level of warming
0
1
2
3
4
Change in global mean surface temperature from pre-industrial (1851−1900), ºF
Study
Dellink et al. (2019)
Kompas et al. (2018)
Bosello et al. (2012)
Roson and van der Mensbrugghe (2012)
CGE
Takakura et al. (2019)
Hsiang et al. (2017)
Roson and Sartori (2016)
Enumerative
Kahn et al. (2021)
Kalkuhl and Wenz (2020)
Acevedo et al. (2020)
Pretis et al. (2018)
Burke et al. (2015)
Top-down econometric
Aggregate model

CEA / OMB

“…if [financial stress tests and macroeconomic modeling] tell you you are resilient at 4°C, that doesn’t mean you’ll be ok. **It means your analysis is crap.**”

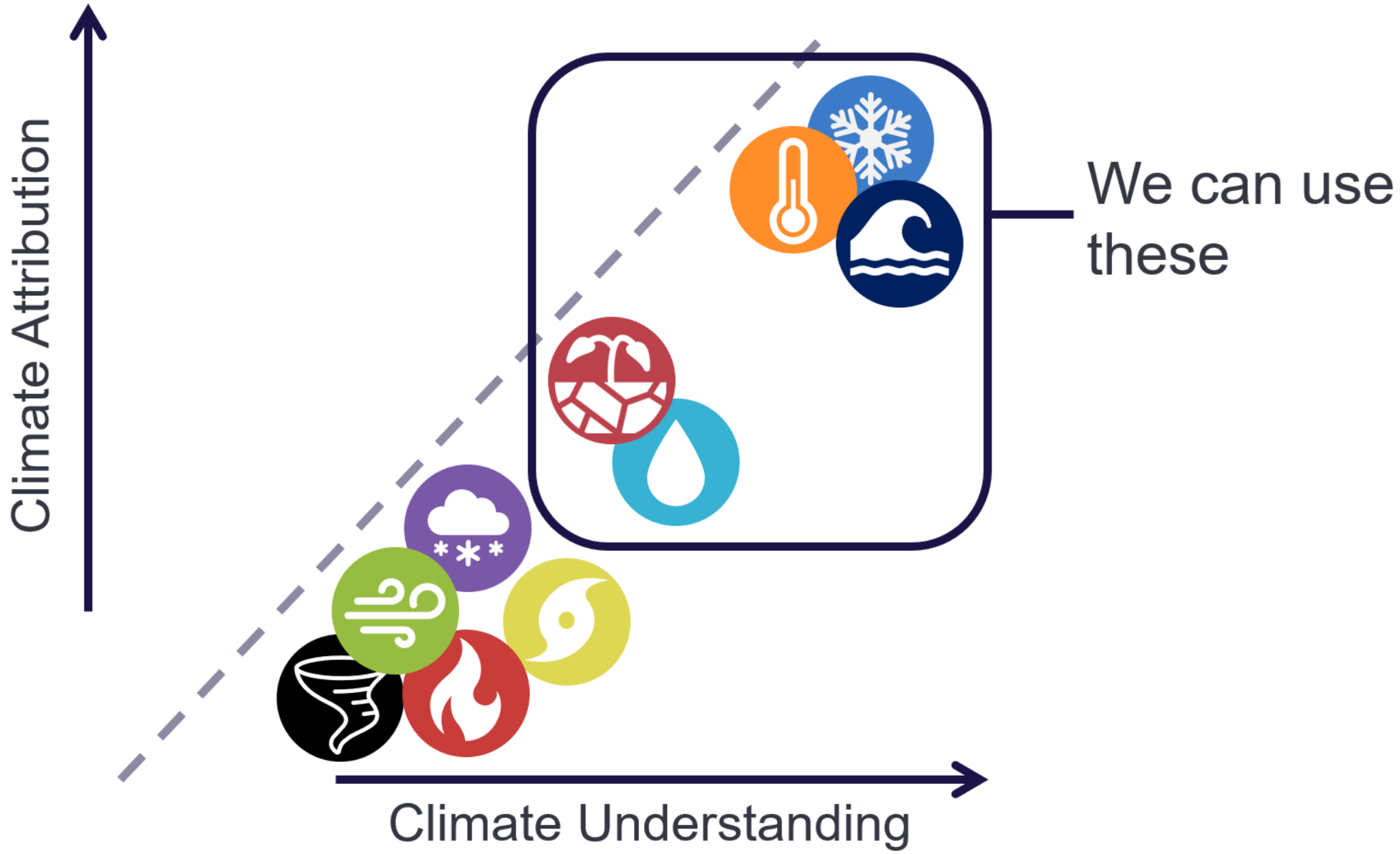
Andy Pitman, professor of climate extremes quoted in Bloomberg

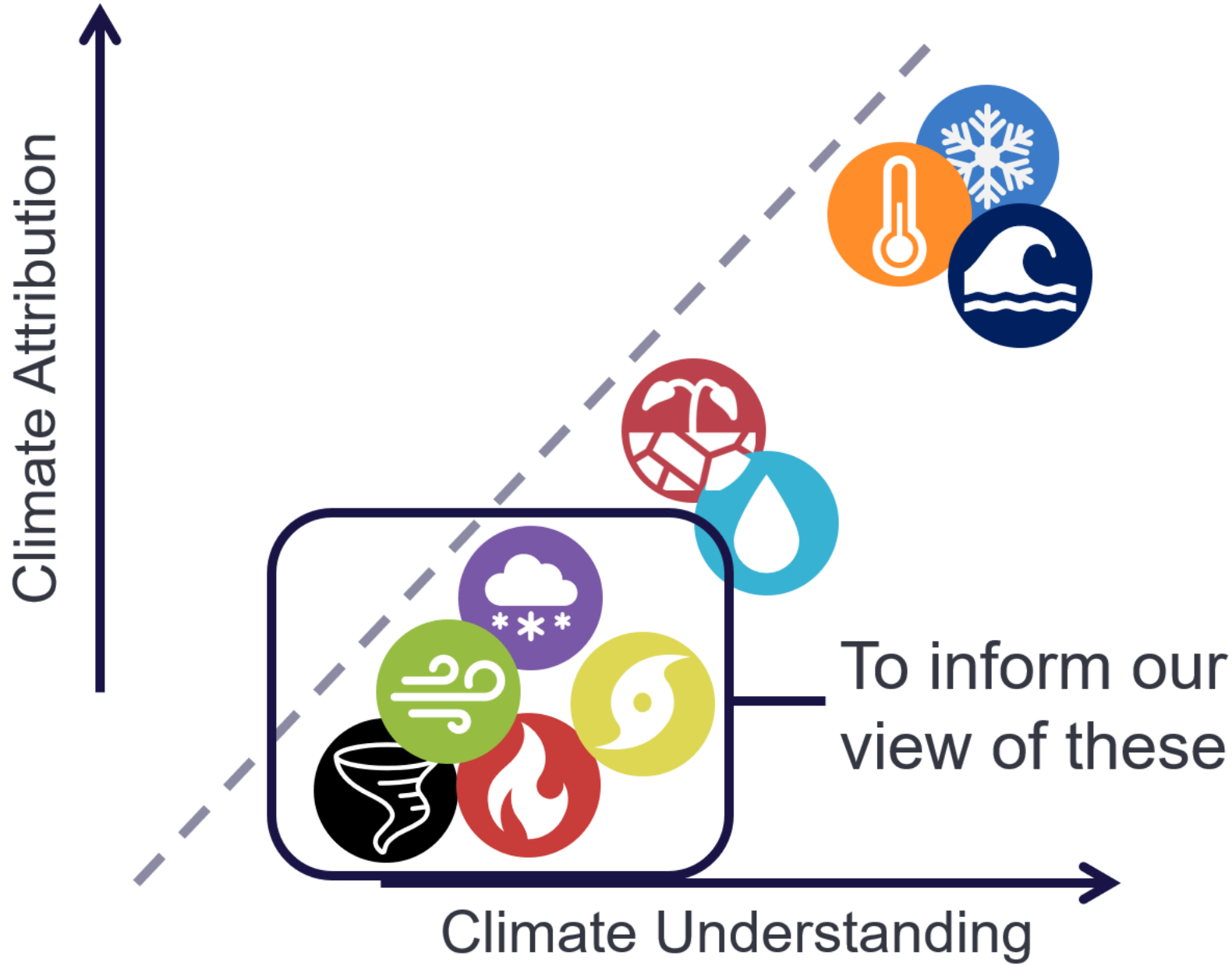

Acute
Chronic
Transition

Pilot Climate Scenario Analysis: 6 US Banks

Pathway (2050)	Event (NE Hurricane)	Insurance coverage
SSP2-4.5 / RCP4.5	100 yr return period	Yes
SSP5-8.5 / RCP8.5	200 yr return period	Yes
SSP5-8.5 / RCP8.5	200 yr return period	No

- Requires assumptions about frequency, intensity, storm location, rainfall, storm surge, sea level rise, rapid intensification, …
- Extrapolating from historical events likely insufficient
- Widely varying uncertainty from climate science side


Climate Attribution
Climate Understanding
We can use these


Climate Attribution
To inform our view of these
Climate Understanding

Deploy a flexible toolbox for managing uncertainty

Direction + Magnitude ⟷ Neither Direction / Magnitude

Scenario: Storm surge

Sensitivity: Rainfall

Normative: Frequency

Critical Thresholds

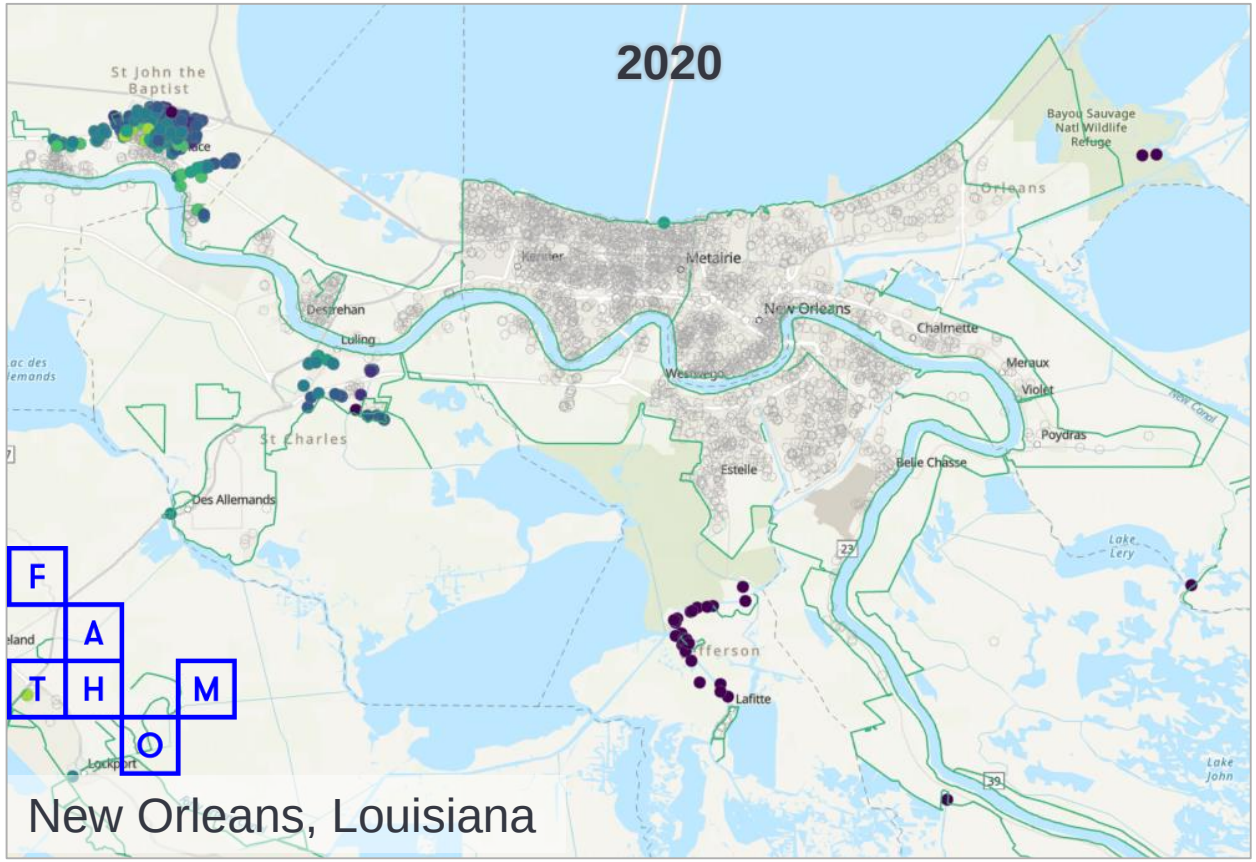
Levee Locations

Exposure Locations

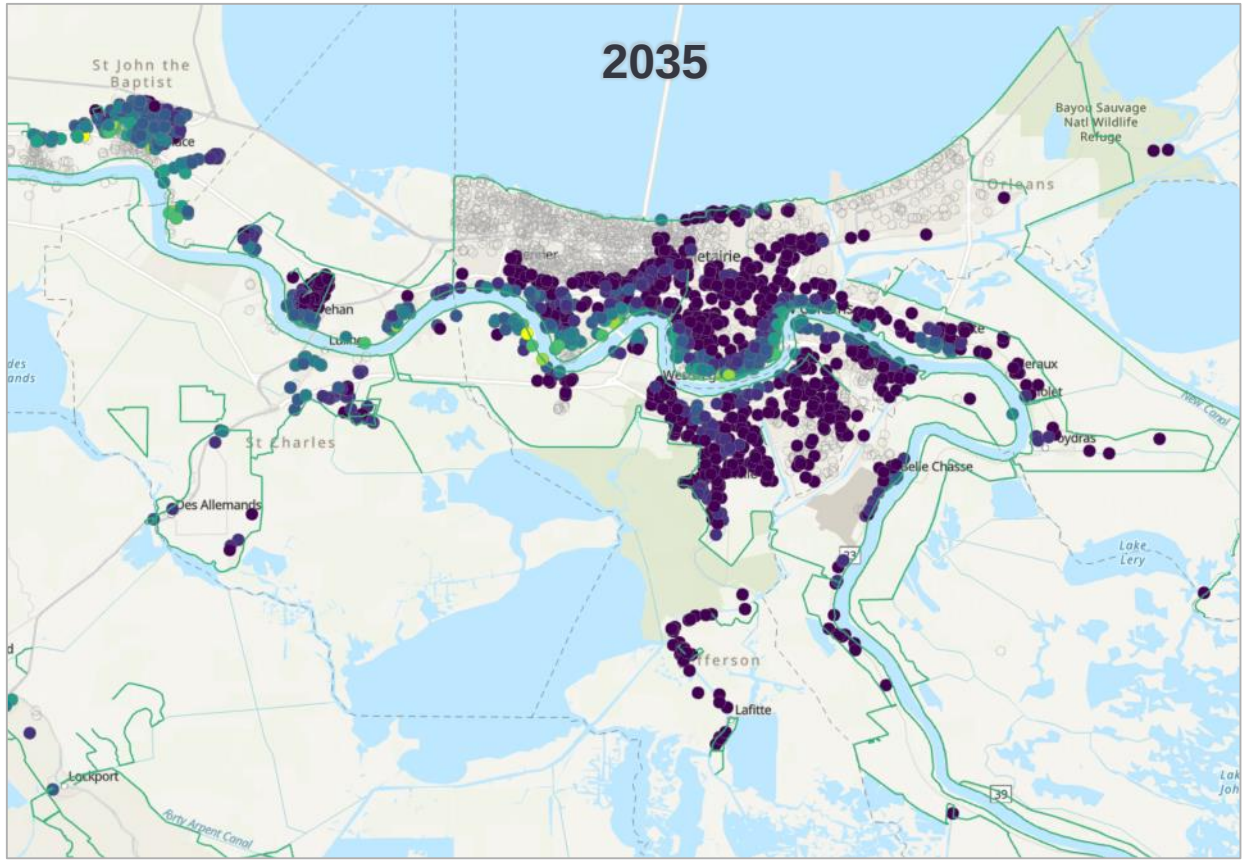
Flood Depth (ft)

- < 1 in
- 1 - 6 in
- 6 in - 1 ft
- 1 - 2- ft
- 2 - 4 ft
- 4 - 6 ft
- 6 - 8 ft
- > 8 ft

1 in 100 year Return Period Depths

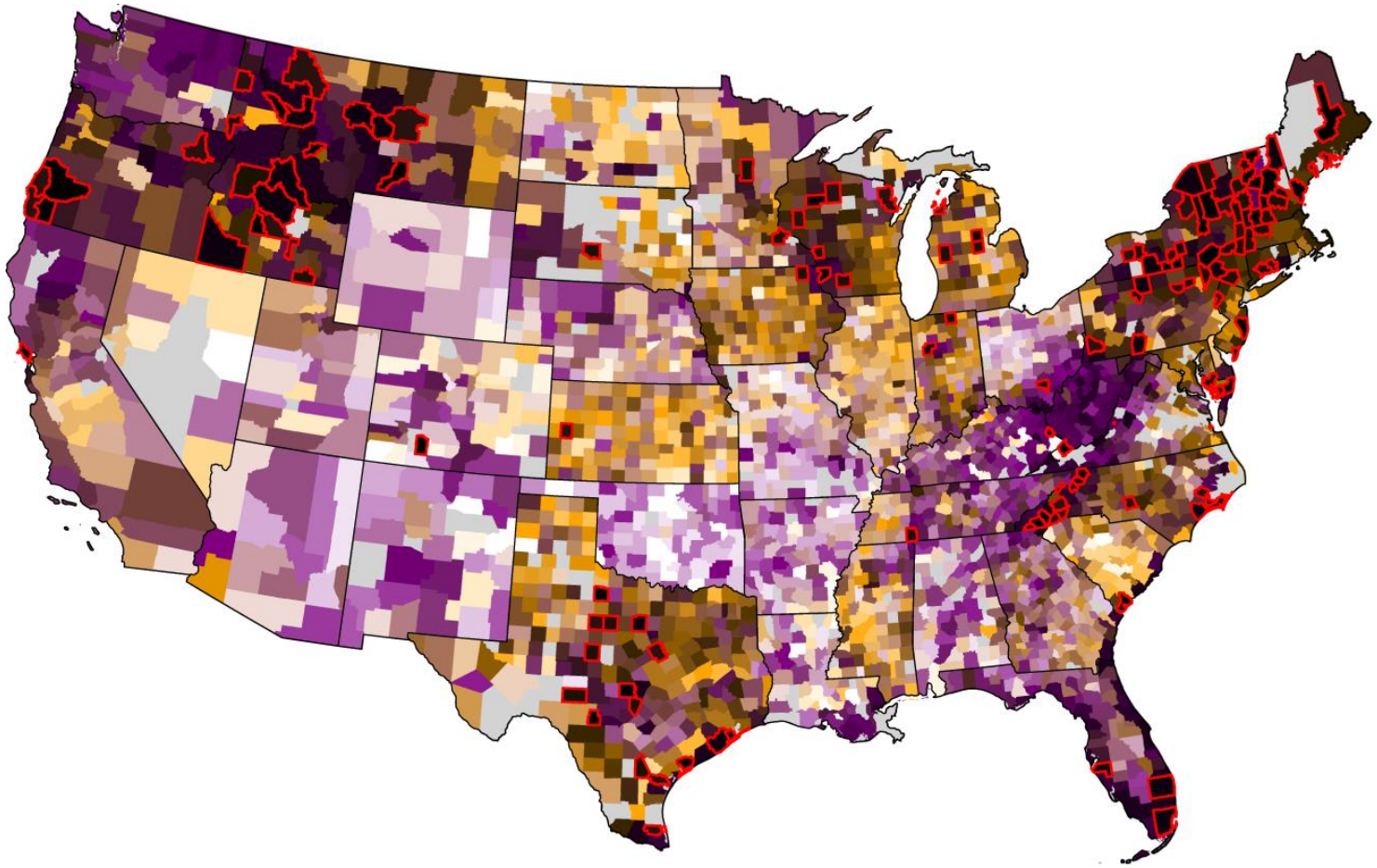


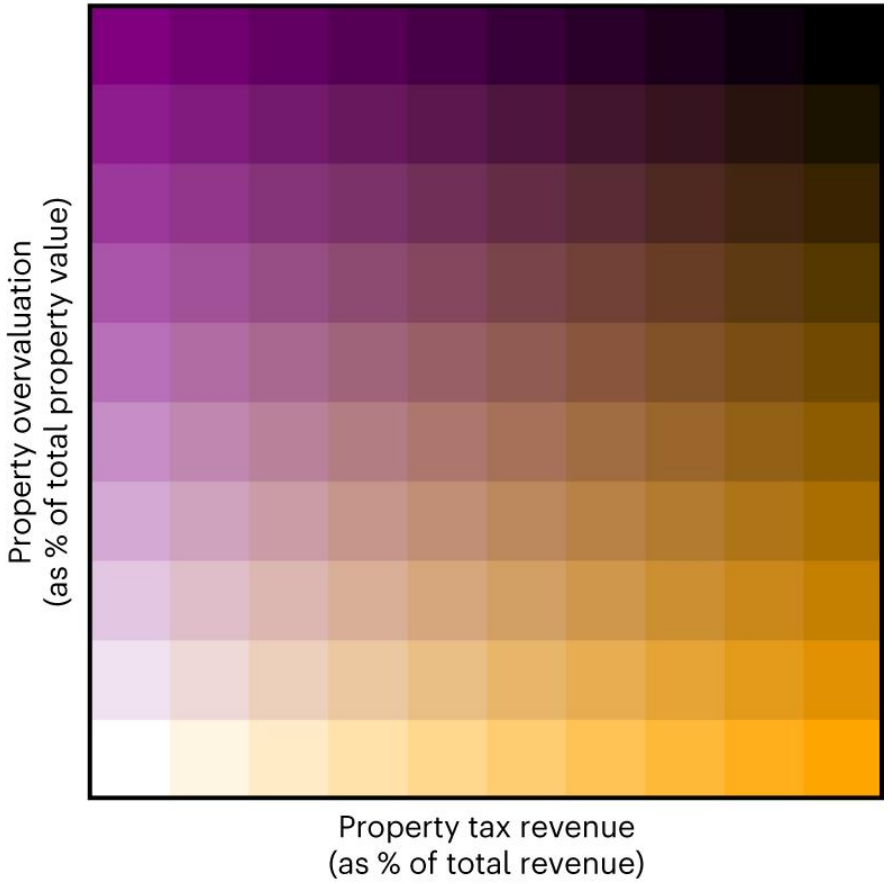
New Orleans, Louisiana




Justin Hobbs

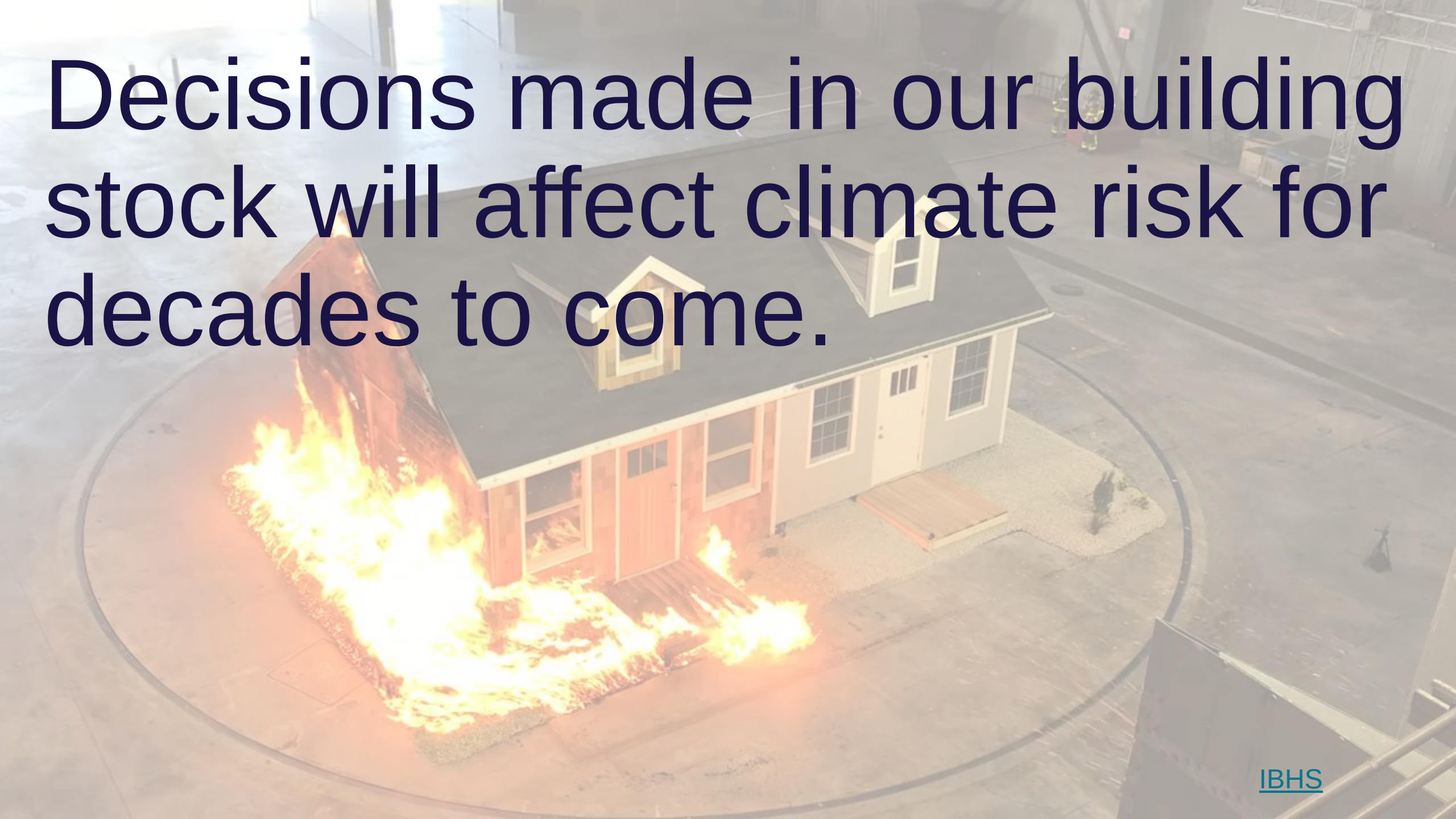
Capture risk to municipal finances





Gourevitch et al., 2023

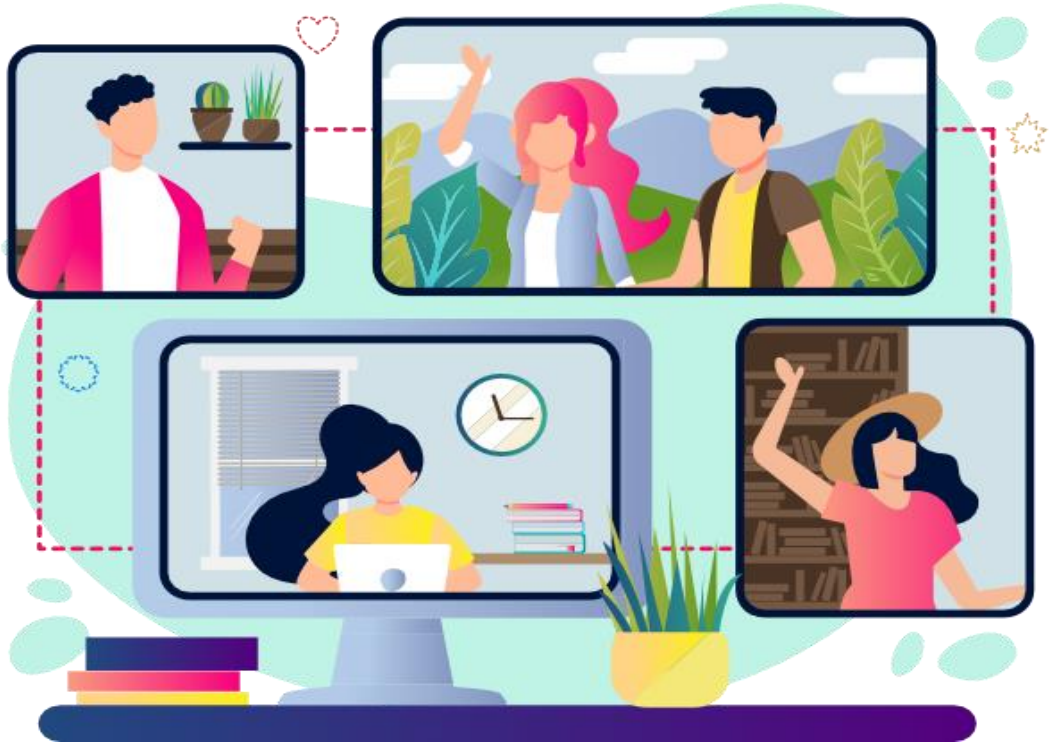
Decisions made in our building stock will affect climate risk for decades to come.



IBHS

Dialogue

Please enter your questions in the “Ask A Question” box on your screen



Joint NSF-NOAA Funding Opportunity

Industry-University Cooperative Research Centers (IUCRCs)

An IUCRC is a coalition of universities with faculty and students wanting to engage with industry to bring new knowledge and innovation, and to overcome hurdles in developing new products/services.

Next Steps for Universities:

- Read the IUCRC solicitation NSF 20-570 and discuss with your university administrators and faculty colleagues within your institution AND with possible partner institutions.

- Contact NSF (bransom@nsf.gov) if interested in starting an IUCRC - for timing of info/Q&A sessions and strategies for developing successful proposals - scheduled to start in June.

- Start talking to industry reps to understand their needs and develop a compelling value proposition and use-inspired research thrusts for your Center.

- Start IUCRC proposal submission process late 2023.

Joint NSF-NOAA Funding Opportunity

Industry-University Cooperative Research Centers (IUCRCs)

The role of industry in an IUCRC is to serve on an advisory board that identifies, for faculty participants, the most crucial needs of the targeted economic sector. The Board includes voting, and non-voting, members who review faculty-generated research projects that will best overcome industry obstacles.

Next Steps for Industry and Interested Non-Academic Entities:

- Contact NSF (bransom@nsf.gov) if interested in talking to academic entities formulating an IUCRC for climate risk and improved decision making.
- Talk to interested academic teams working to understand your top obstacles so they can construct the most impactful and compelling research thrusts and proposal.
- Explore internally whether your organization would like to be a voting* (or non-voting member of an IUCRC.

*This requires paying a membership fee and signing the standard NSF membership agreement.

Recording Available

This webinar series has been recorded and is accessible on the website using the QR Code below:

http://www.nrcc.cornell.edu/workshops/insurance/insurance.html

Joint NSF-NOAA Funding Opportunity

Questions?

Interested in knowing more?

Interested in starting a Center? (universities)

Interested in possibly joining a Center? (private and gov. entities)?

Please Contact:

Barbara Ransom, bransom@nsf.gov

Thank You

For more information, please contact:

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