April 20, 2012

Extreme Weather & Climate Change

Understanding the Link & Managing the Risk

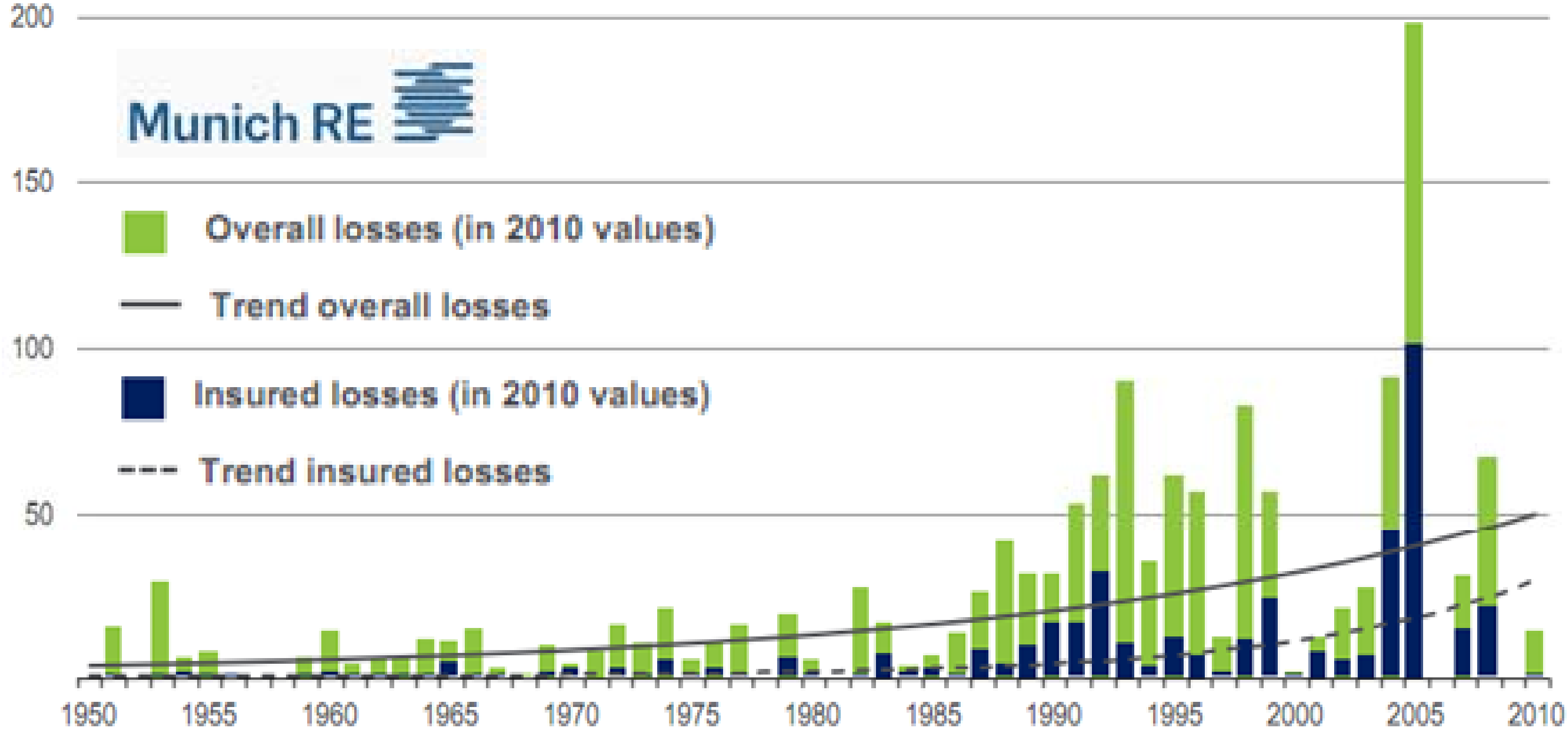
Jay Gulledge, Ph.D.
Senior Scientist
C2ES

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

C2ES.ORG

Extreme Weather: Costs Are Rising

Adjusted Economic Losses from 'Great Weather Catastrophes' Worldwide



Climate Change? No Single Event…

- Climate is the average of many weather events over a span of decades
- Single *events* lack useful information about *trends*

Should we ignore individual events?

No! They teach us about our vulnerabilities and help us price risk correctly.

Uncertainty is Unavoidable

"The scientific community has not done the right thing in that we've all been caught up in this mantra that we must reduce uncertainty. [Instead] what we do … is ask more questions and, in many cases, that increases uncertainty."

A. Janetos, 2010

- The future is inherently uncertain
- No point in waiting for certainty
- Assess and manage risk instead

Risk Management/Reduction

"Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation…"

IPCC 2007

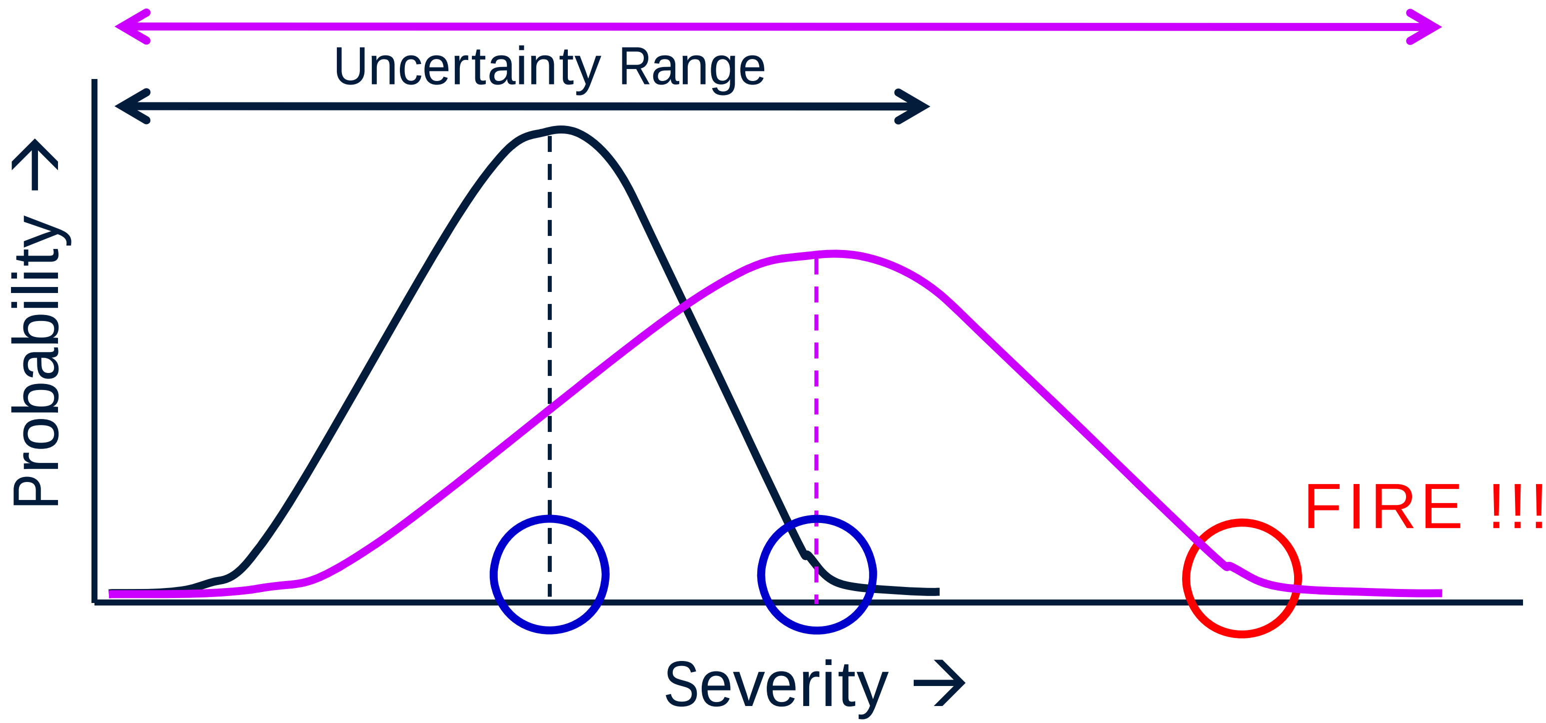
Risk: Severity of outcome X probability

Risk management:

- Actions to reduce probability (***mitigation***)
- Actions to reduce potential severity (***adaptation***)

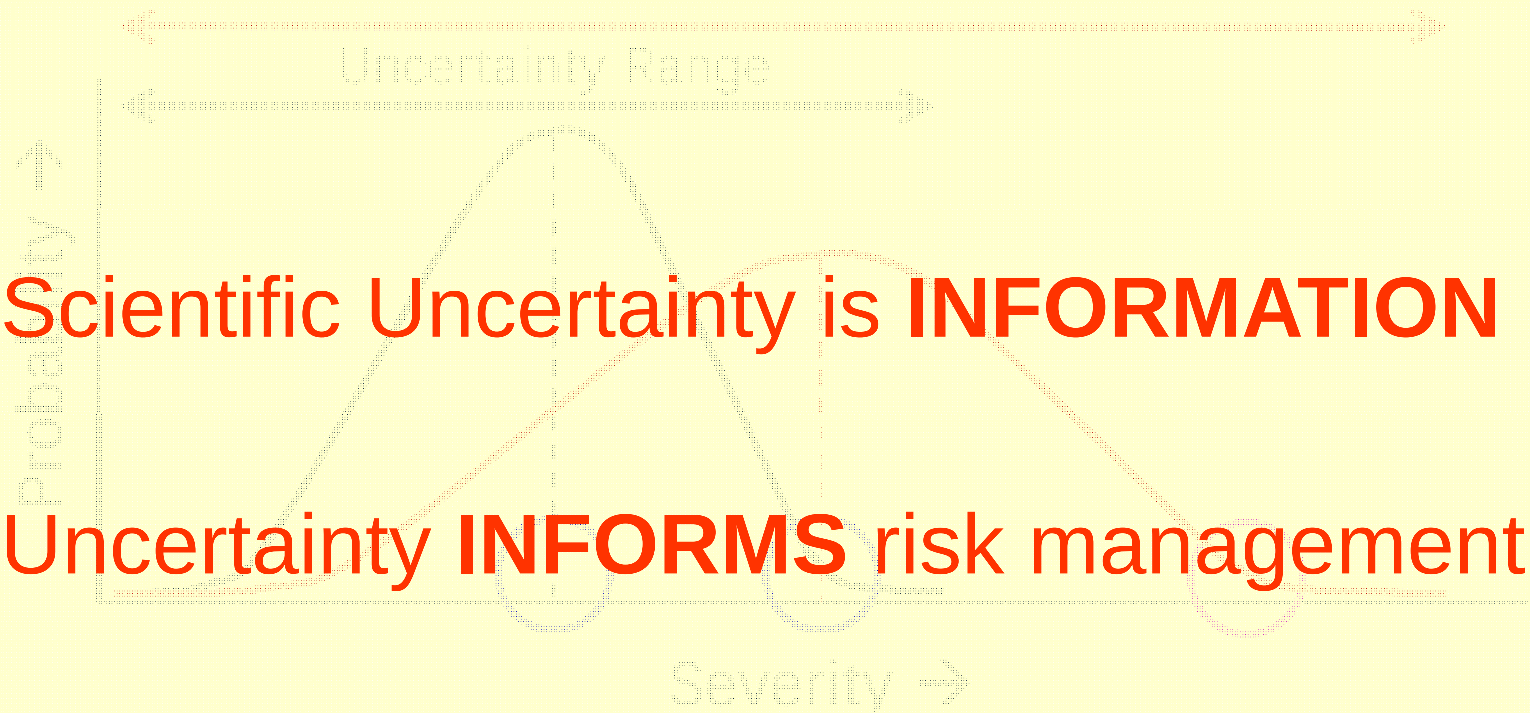
Uncertainty and Risk

- Risk = Probability X Severity
- Risk can be significant when uncertainty is large
- Risk can be catastrophic when probability is low



Uncertainty and Risk

- Risk = Probability X Severity
- Risk can be significant when uncertainty is large
- Risk can be high when probability is low (house fire)



- Scientific Uncertainty is **INFORMATION**
- Uncertainty **INFORMS** risk management

Multiple Risk Factors

As with heart disease, there are multiple ‘risk factors’ for extreme weather

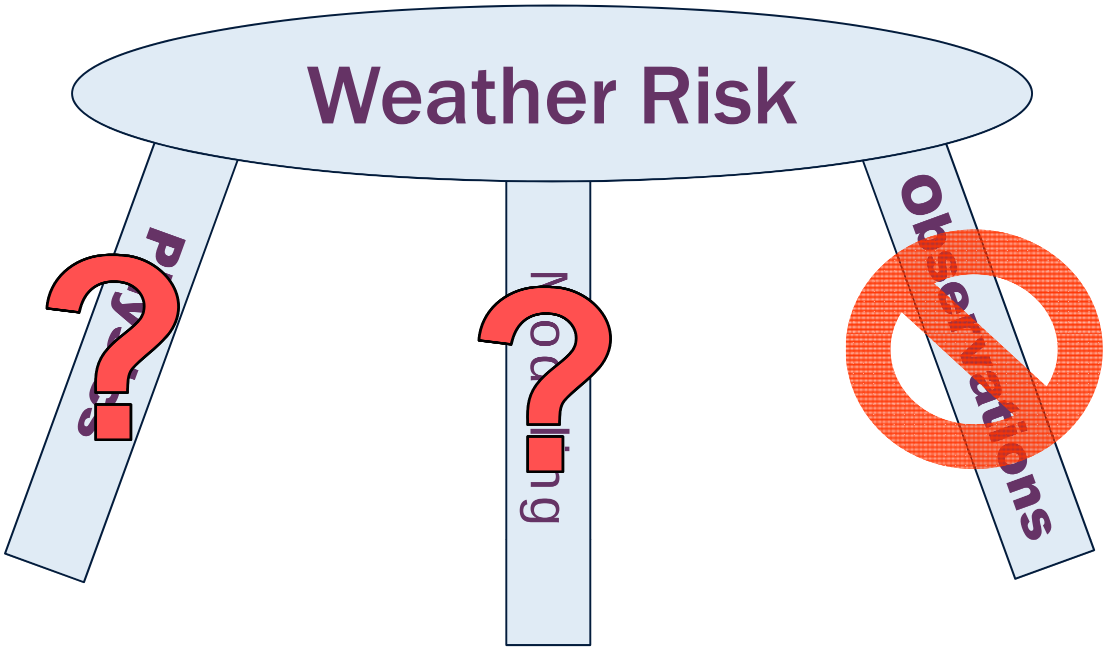
Heart Disease

- Heredity
- Poor diet
- Smoking
- Lack of exercise
- Stress

Extreme Weather

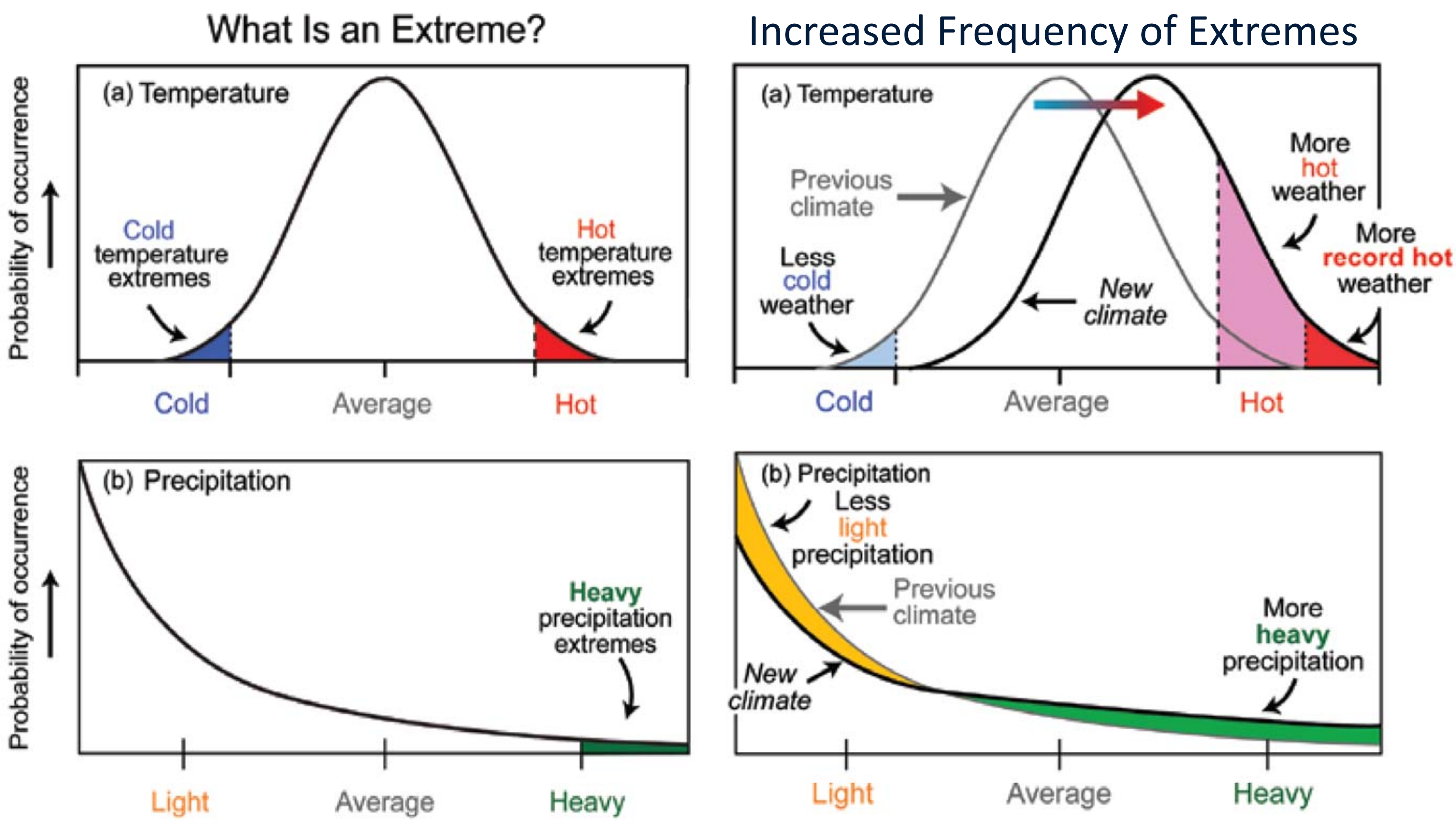
- People/structures in harm’s way
- Seasonality
- Natural climate oscillations (e.g., La Nina/El Nino)
- Global warming/climate change

Three-Legged Risk Assessment



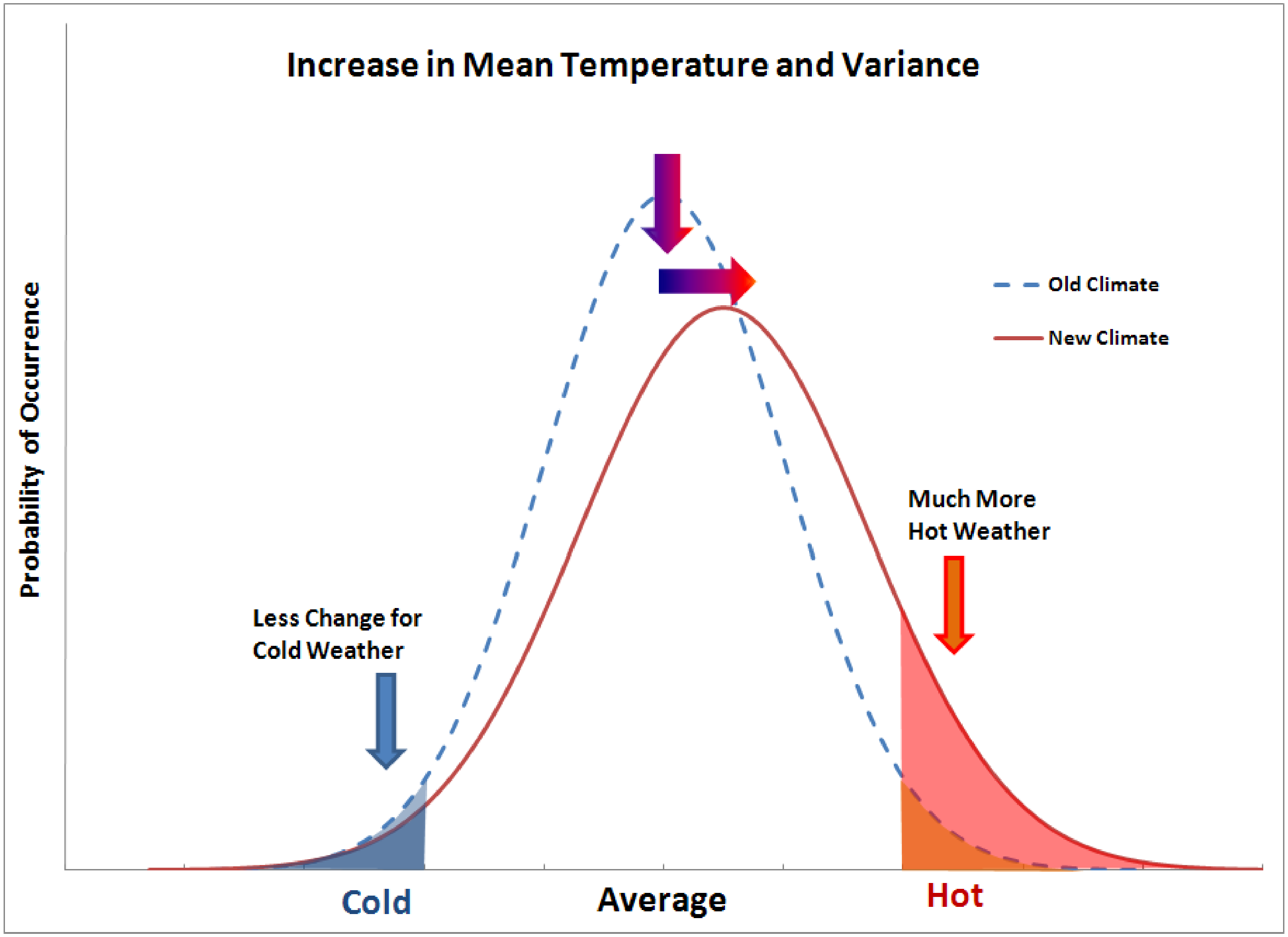
- Hurricanes: Two legs (likely future risk)
- Hail, lightening, tornadoes: 1 leg???

Physical Understanding



US GCRP SAP3.3 – Weather & Climate Extremes

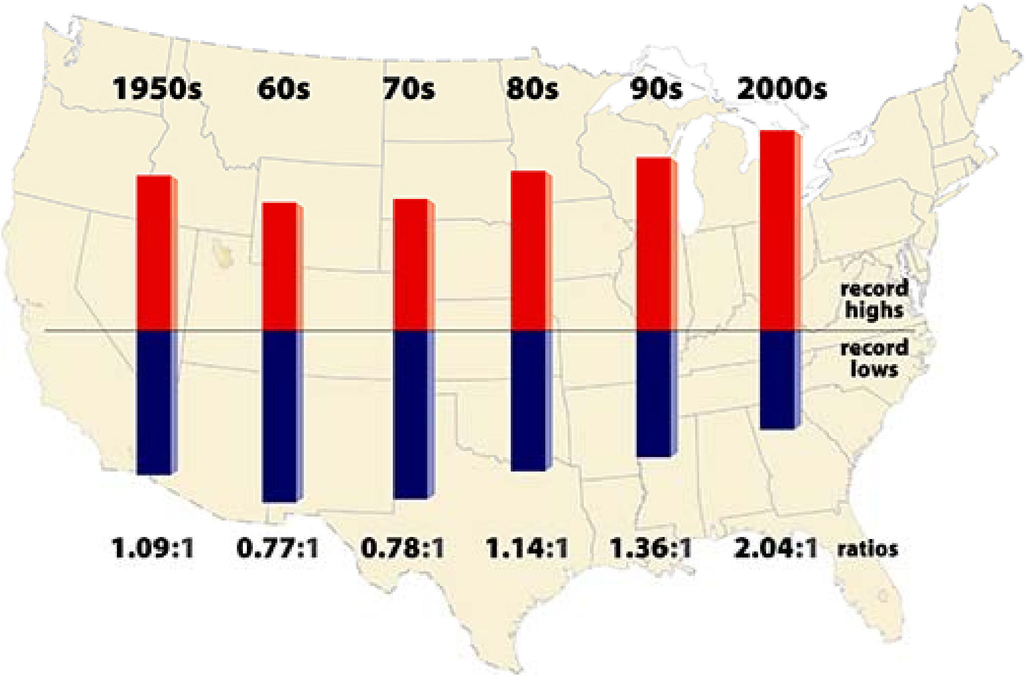
Asymmetric shifts in Probability



If 200-year events become 50-year events, most people will experience catastrophes within their lifetimes.

Observations: Extreme Heat

- Record highs now twice as common as record lows
- Increase in nighttime temperatures
- Increase in high humidity heat waves
- Elevated risk to public health

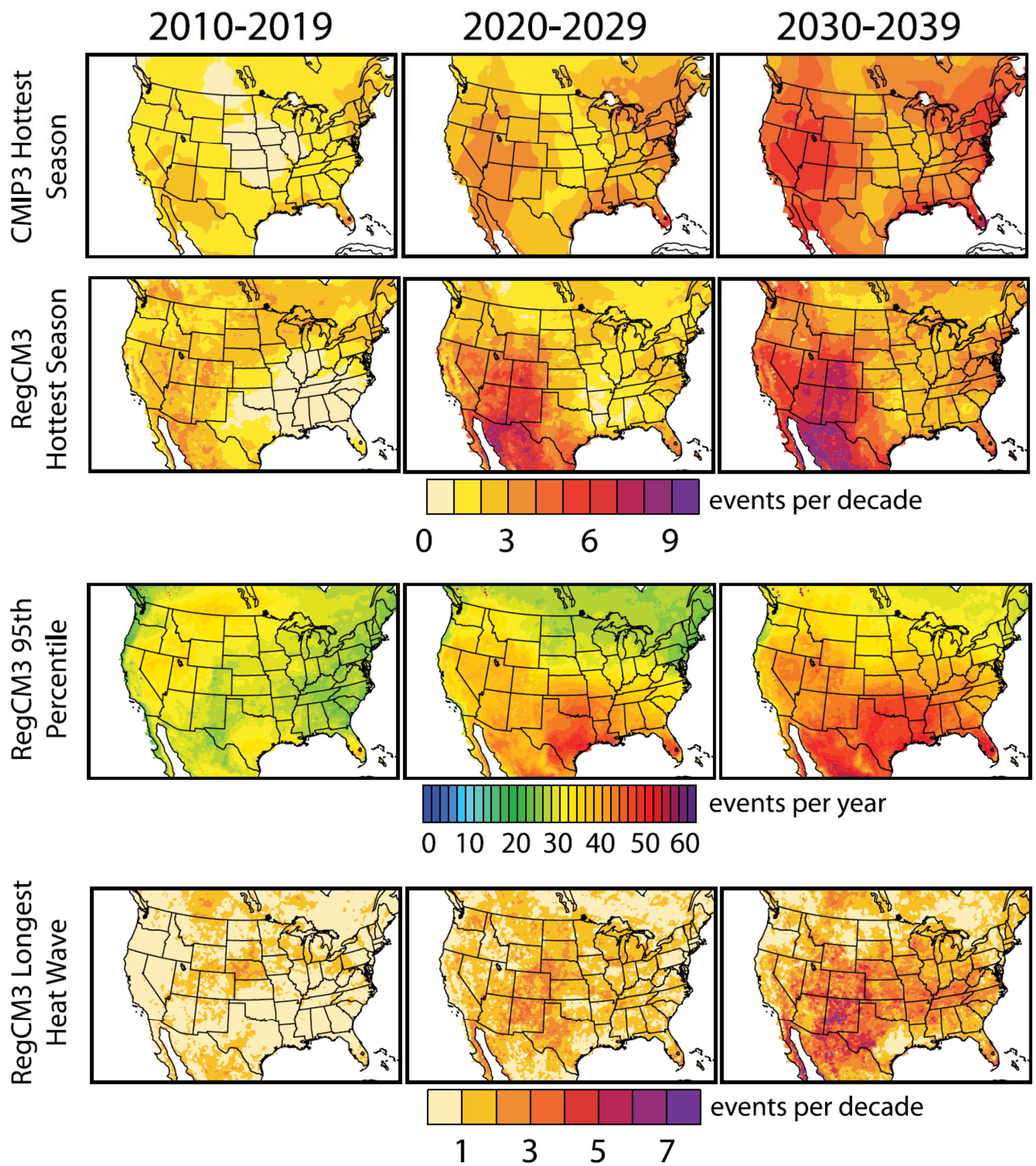


Modeling: Extreme Heat Risk

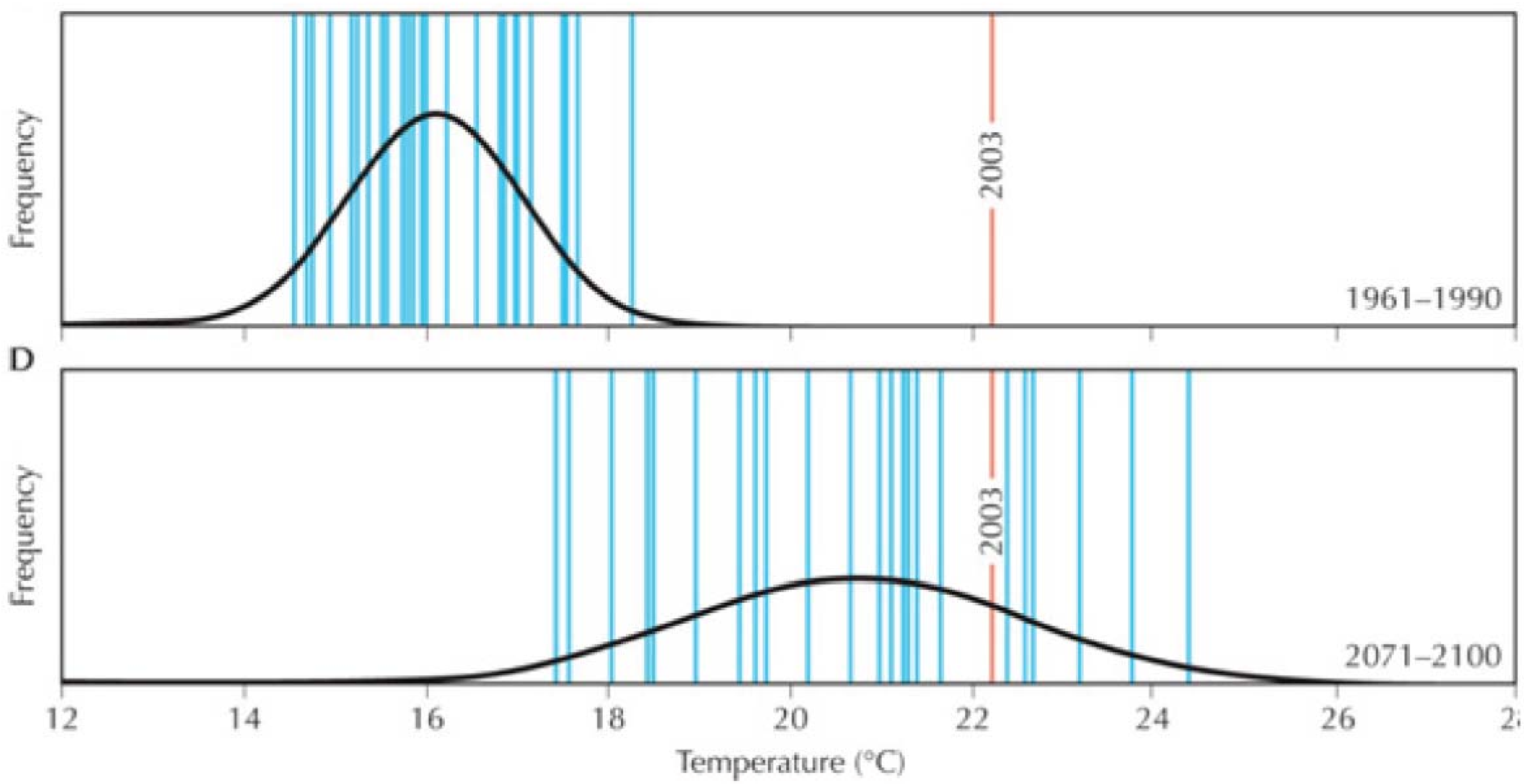
"Substantial intensification of hot extremes could occur within the next three decades"

"Intensification of hot extremes could result from relatively small increases in greenhouse gas concentrations"

Diffenbaugh, 2010 (*PNAS*)

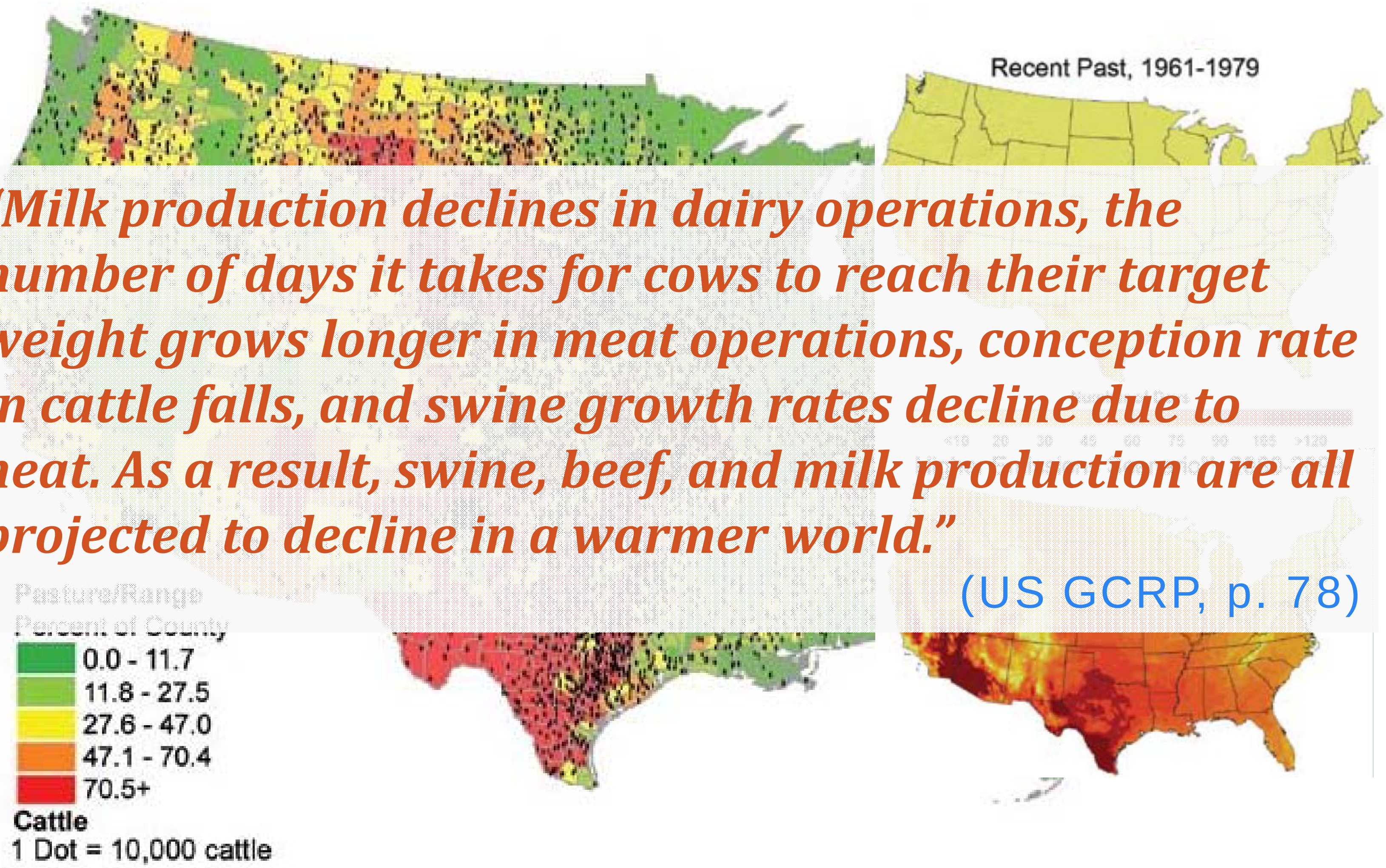


Modeling: Heat Wave Risk



Schar et al., 2010 (Nature)

Modeling: Livestock Heat Stress Risk



"Milk production declines in dairy operations, the number of days it takes for cows to reach their target weight grows longer in meat operations, conception rate in cattle falls, and swine growth rates decline due to heat. As a result, swine, beef, and milk production are all projected to decline in a warmer world."

(US GCRP, p. 78)

US GCRP Climate Impacts Report

Modeling: Labor Supply Risk

Temperature and the Allocation of Time: Implications for Climate Change

Joshua Graff Zivin, Matthew J. Neidell

NBER Working Paper No. 15717
Issued in February 2010
NBER Program(s): EEE HE LS

The NBER Bulletin on Aging and Health provides summaries of publications like this. You can sign up to receive the NBER Bulletin on Aging and Health by email.

In this paper we estimate the impacts of climate change on the allocation of time using econometric models that exploit plausibly exogenous variation in daily temperature over time within counties. **We find large reductions in U.S. labor supply in industries with high exposure to climate and similarly large decreases in time allocated to outdoor leisure.** We also find suggestive evidence of short-run adaptation through temporal substitutions and acclimatization. Given the industrial composition of the US, the net impacts on total employment are likely to be small, but significant changes in leisure time as well as large scale redistributions of income may be consequential. In developing countries, where the industrial base is more typically concentrated in climate-exposed industries and baseline temperatures are already warmer, employment impacts may be considerably larger.

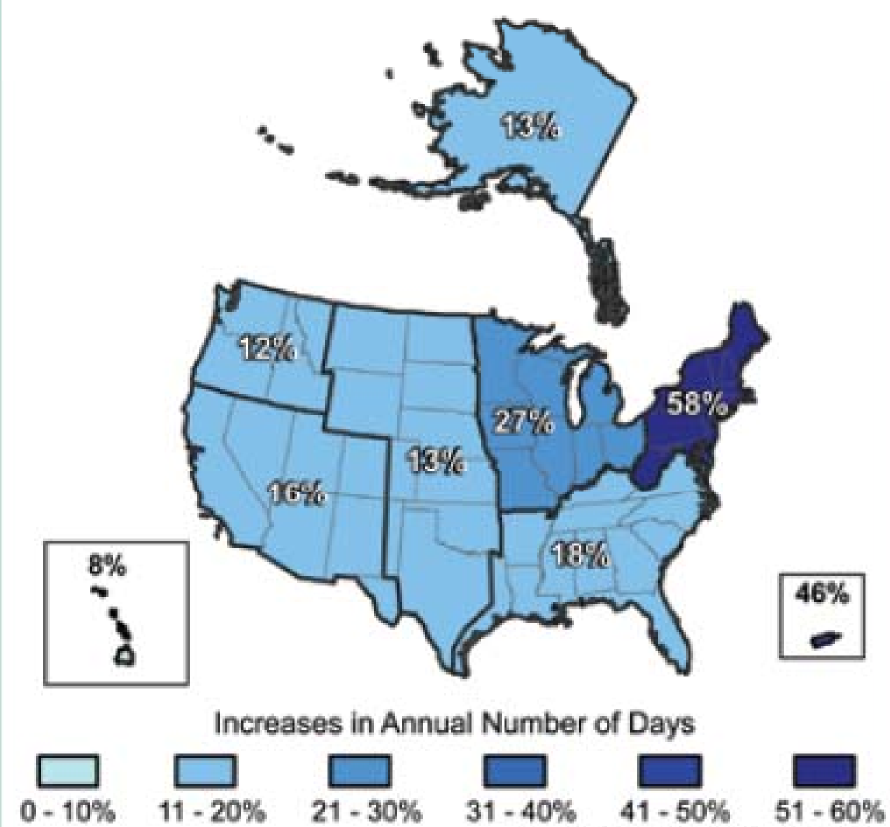
You may purchase this paper on-line in .pdf format from SSRN.com ($5) for electronic delivery.

Information about Free Papers

Observation: Heavy Precipitation

- Total rainfall is up 7% globally
- Top 1% heaviest events drop 20% more rain
- Days with very heavy precipitation increased 58% in the Northeast since 1958

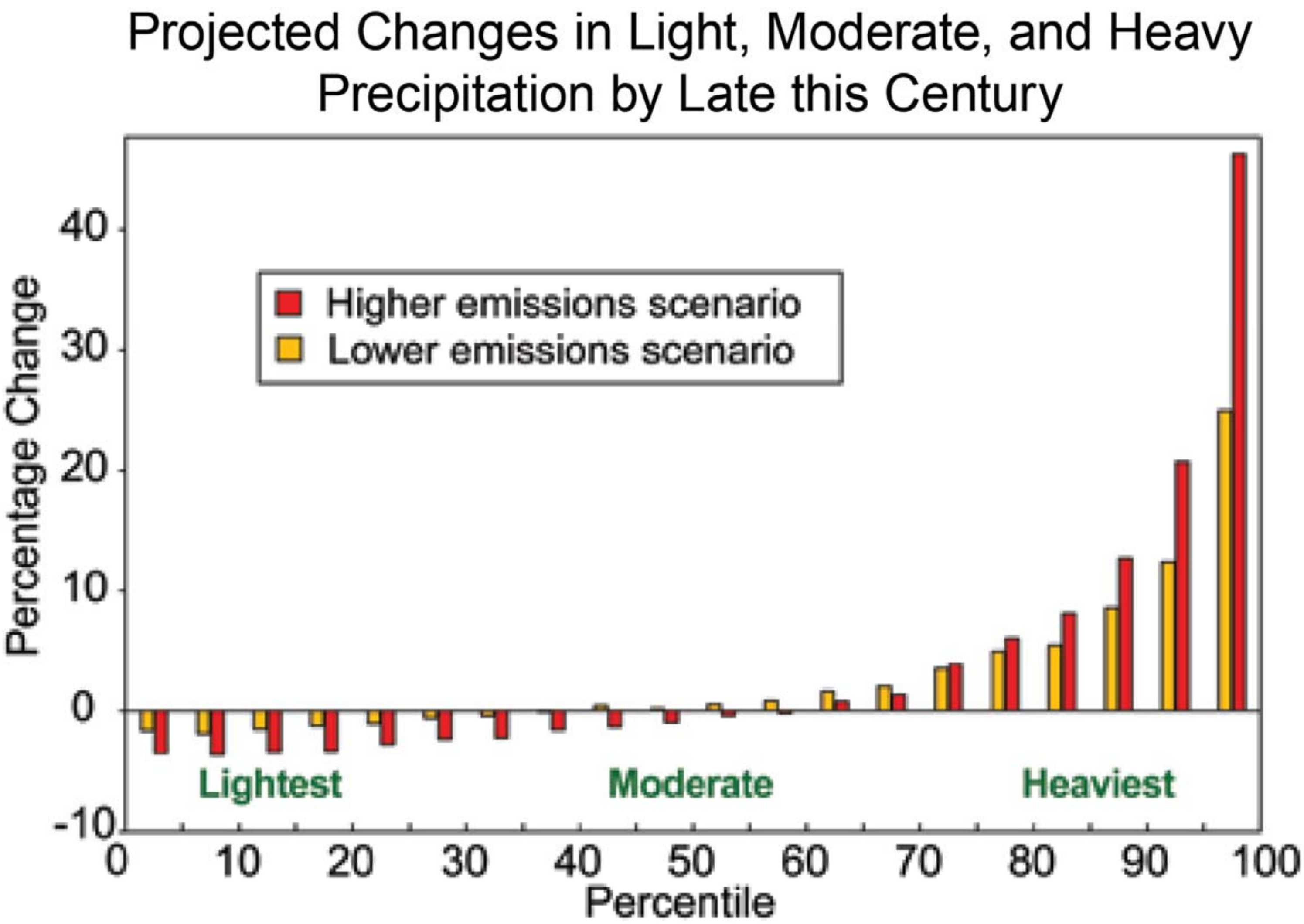
Increases in the Number of Days with Very Heavy Precipitation (1958 to 2007)



Updated from Groisman et al.[145]

The map shows the percentage increases in the average number of days with very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2007 for each region. There are clear trends toward more days with very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

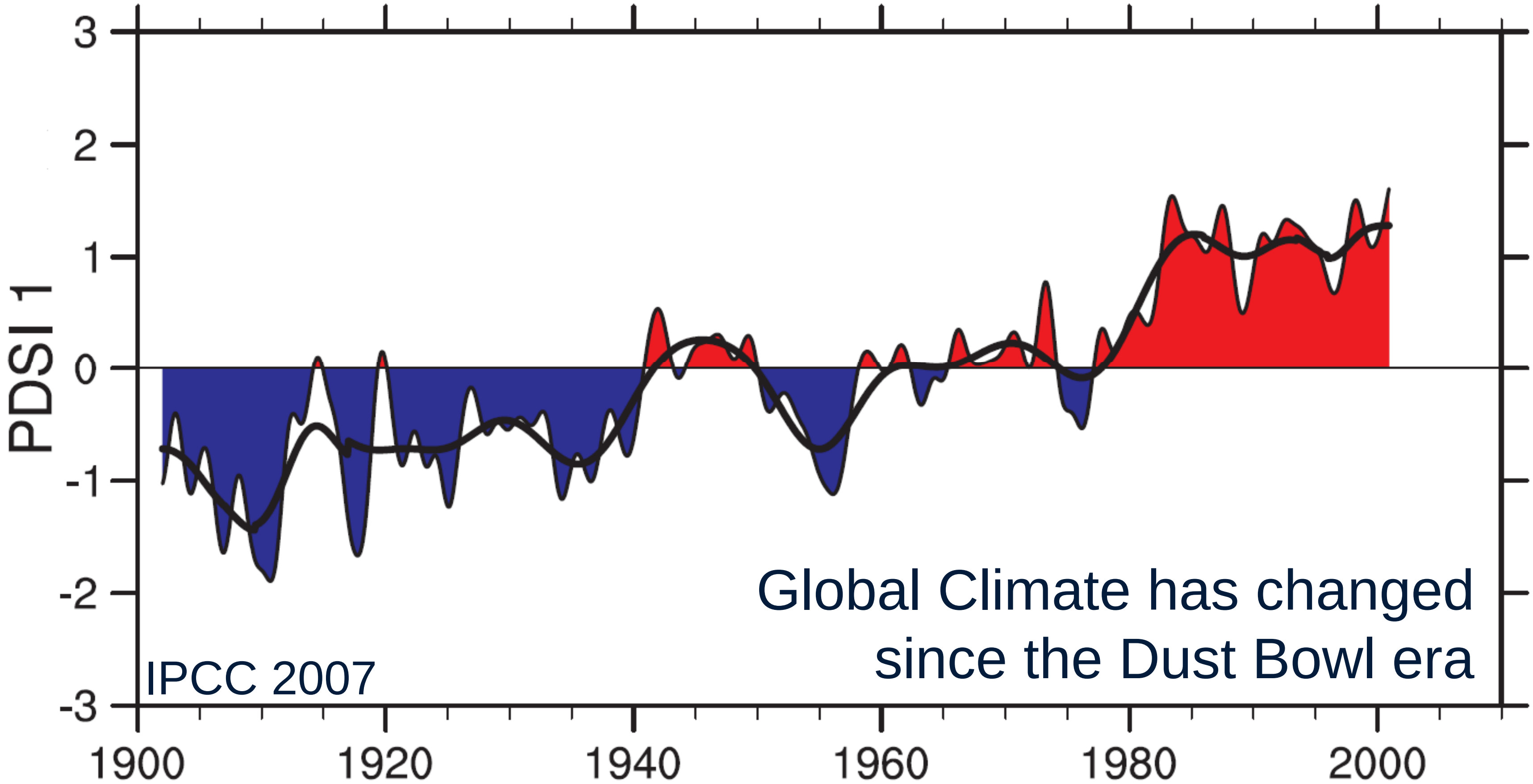
Modeling: Heavy Precipitation Risk



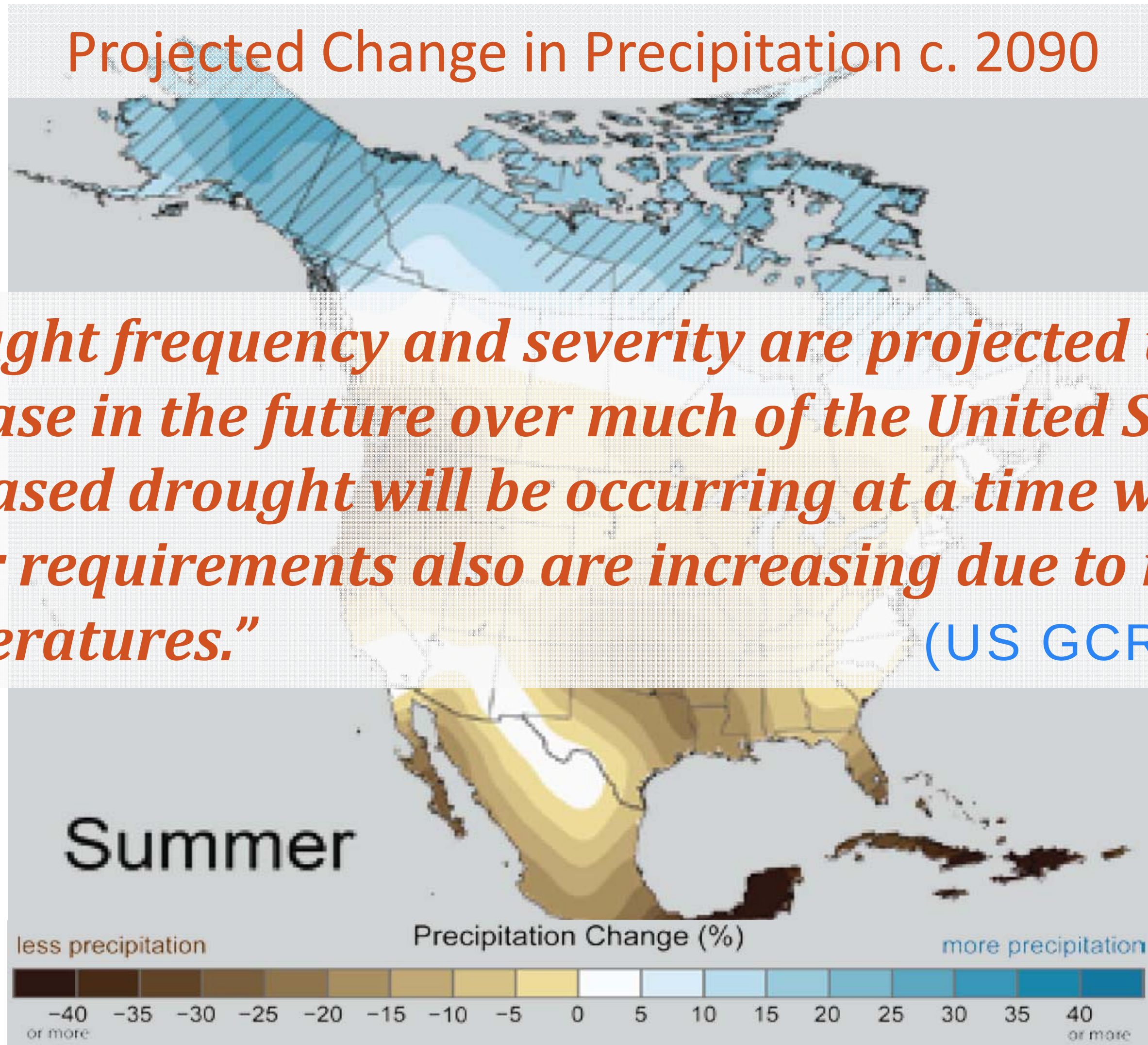
US GCRP Climate Impacts Report

Observation: Drought

Global Variability in Drought Severity during the 20th Century



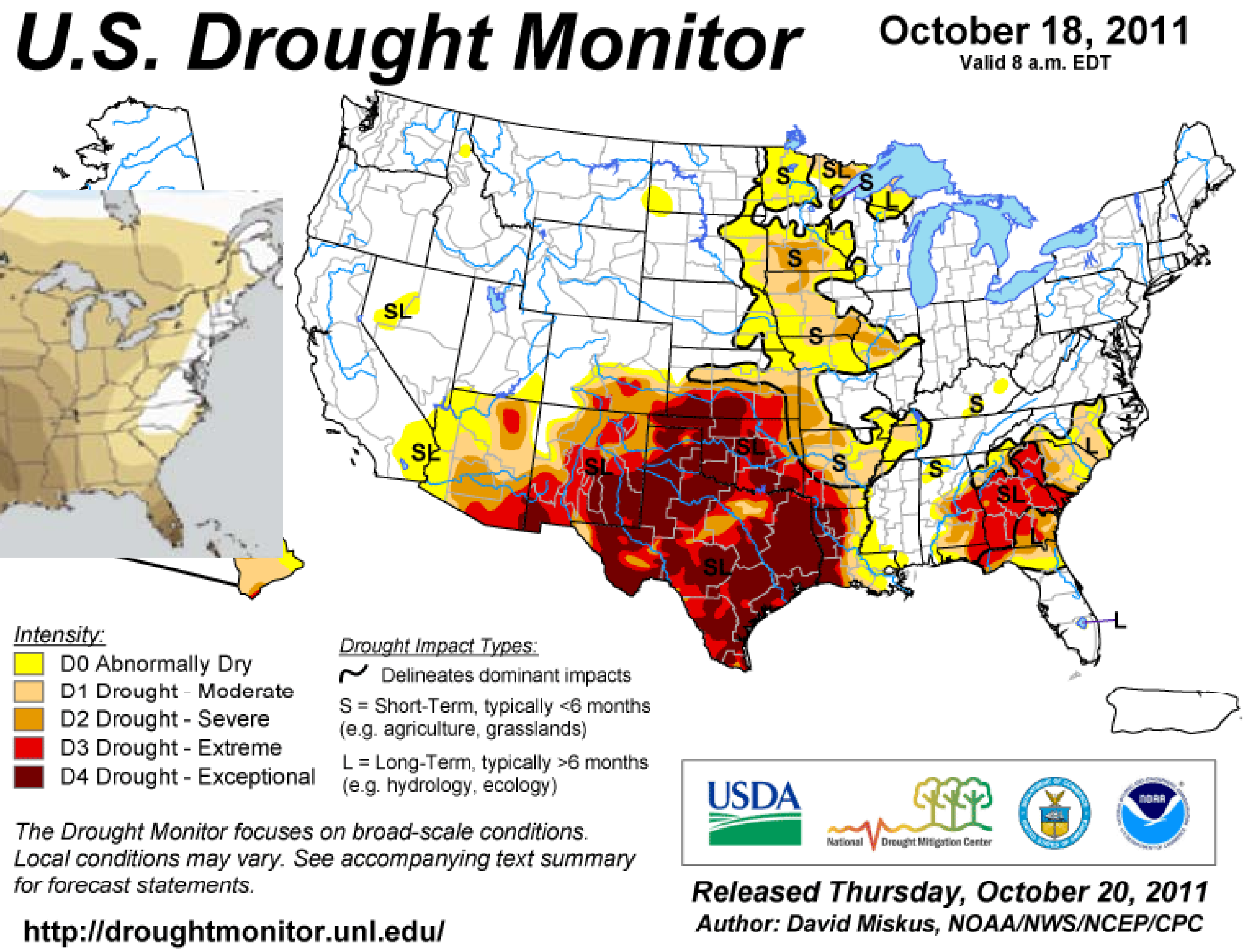
Modeling: Drought Risk

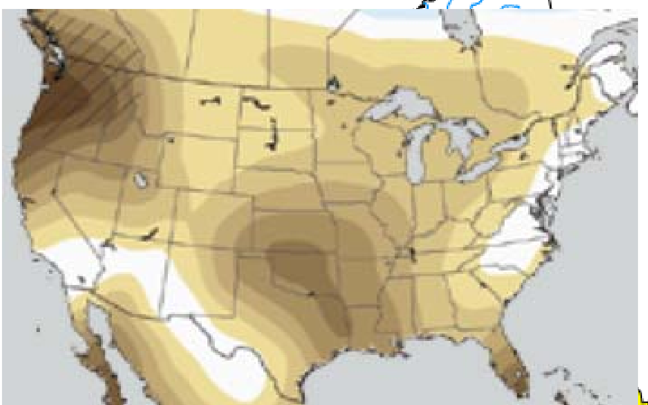


"Drought frequency and severity are projected to increase in the future over much of the United States... Increased drought will be occurring at a time when crop water requirements also are increasing due to rising temperatures." (US GCRP, p. 75)

US GCRP Climate Impacts Report

Modeling: Drought Risk





Multiple Risk Factors: Texas Drought

Texas State Climatologist John Nielsen-Gammon:

"…the impacts of the drought were enhanced by global warming, much of which has been caused by man."

Contributors to 2011 TX drought intensity

- La Nina, 79%
- Atlantic Multidecadal Oscillation, 4%
- Global Warming, 17%

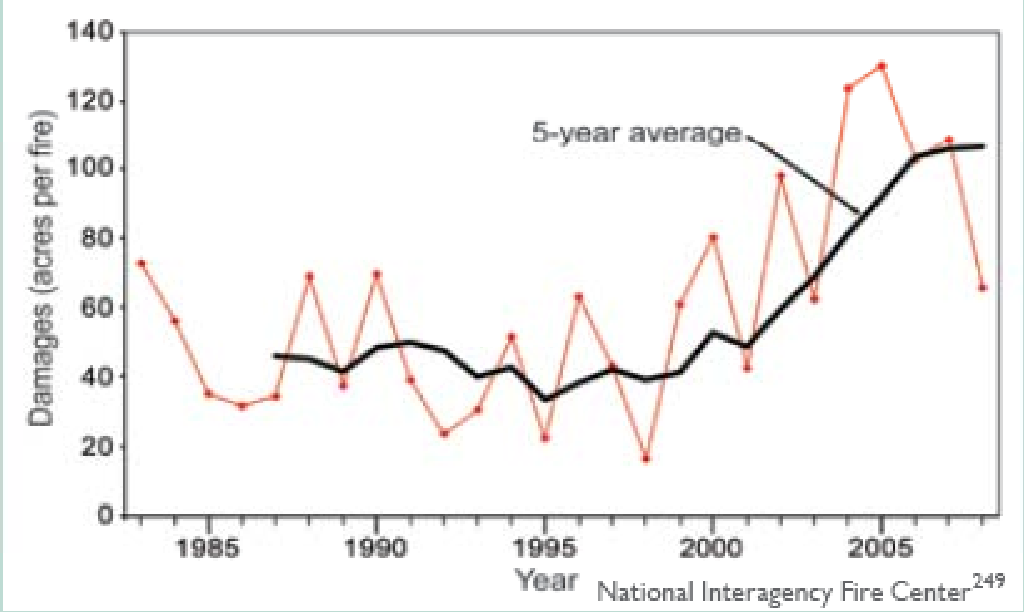
JNG: ***"Global warming accounted for about 1 F of excess heat. Warmer temperatures lead to greater water demand, faster evaporation, and greater drying-out of potential fuels for fire."***

Observation: Wildfire

Since the 1980s:

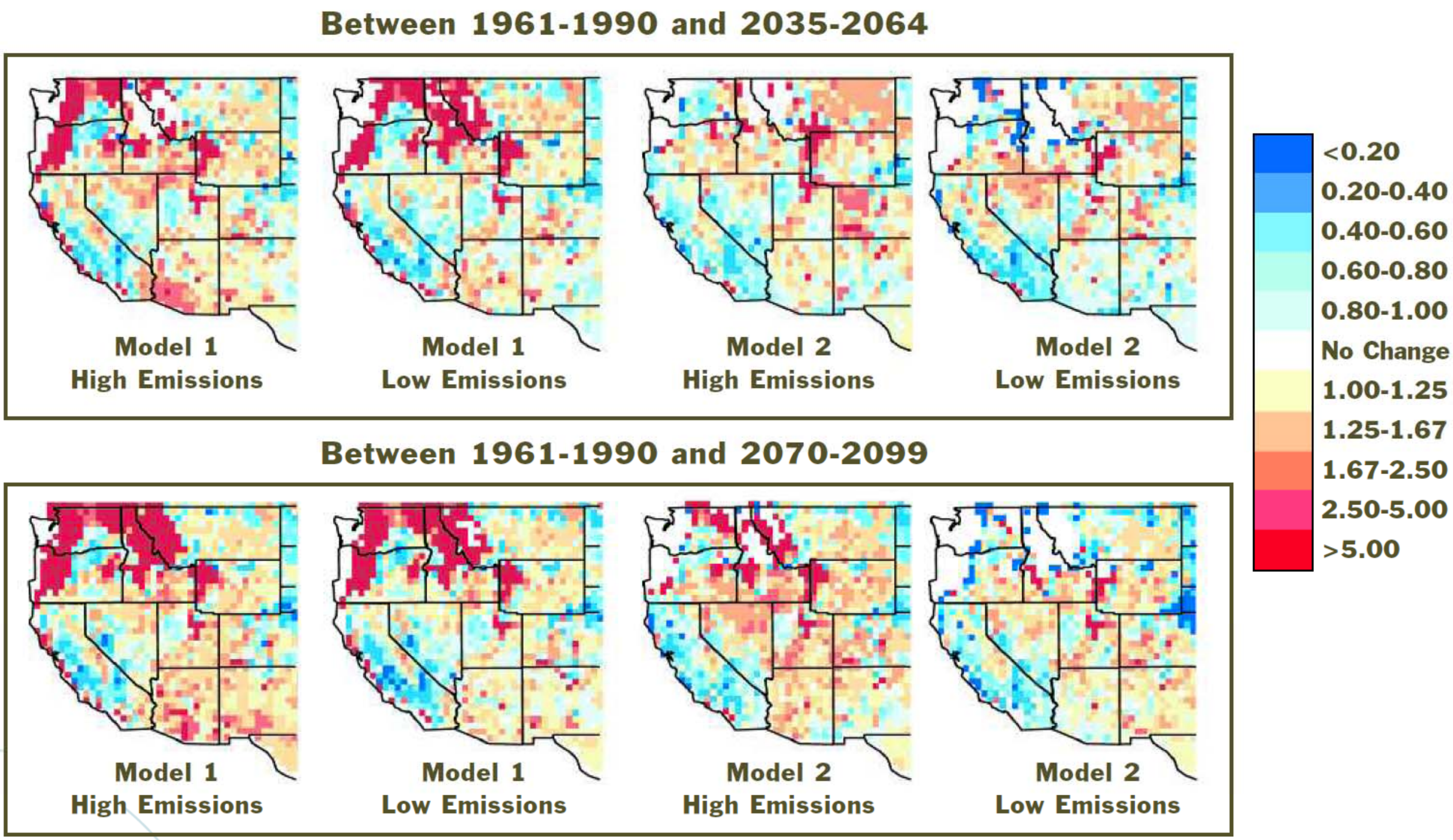
- Length of wildfire season increased by 78 days
- Number of large fires increased fourfold
- Large fires burn a full month longer
- Area burned increased sixfold
- Changes most evident in forests with no change in management practices

Size of U.S. Wildfires, 1983 to 2008



Data on wildland fires in the United States show that the number of acres burned per fire has increased since the 1980s.

Modeling: Wildfire Risk



Bachelet et al., 2007 (Pew Center)

Response to Elevated Risk

Learn about our vulnerabilities and
adapt to the *unavoidable*...

Risk: Severity of outcome X probability

- After the 1995 Chicago heat wave, the city improve preparation for future heat waves
- The 2003 European heat wave exposed the vulnerability to intense heat
- Hurricane Katrina showed that a major American city could be paralyzed for weeks
- Floods from earlier this year can teach us where we are vulnerable to extreme rainfall

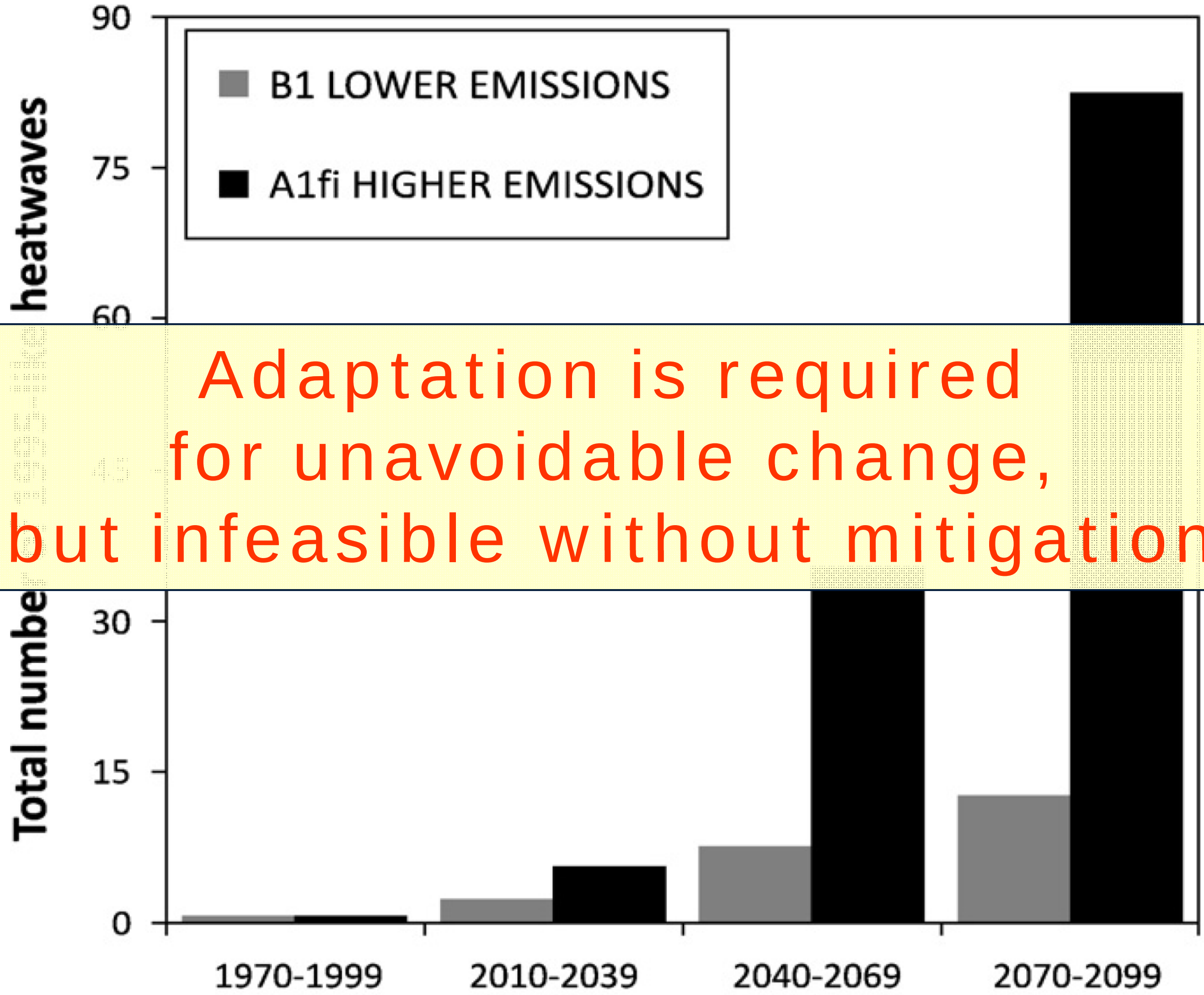
Response to Elevated Risk

… and *mitigate* GHG emissions to avoid the *unmanageable*.

Risk: Severity of outcome X probability

- Reducing greenhouse gas emissions reduces the probability of occurrence
- Limiting CO_2 in the atmosphere reduces the magnitude of climate change, and is therefore effective at reducing nonlinear changes in risk.
- In the long run, adaptation is infeasible, and in the short run, mitigation is too slow. Both responses must be pursued to minimize risk

Benefits: Manageable "Expected" Damages

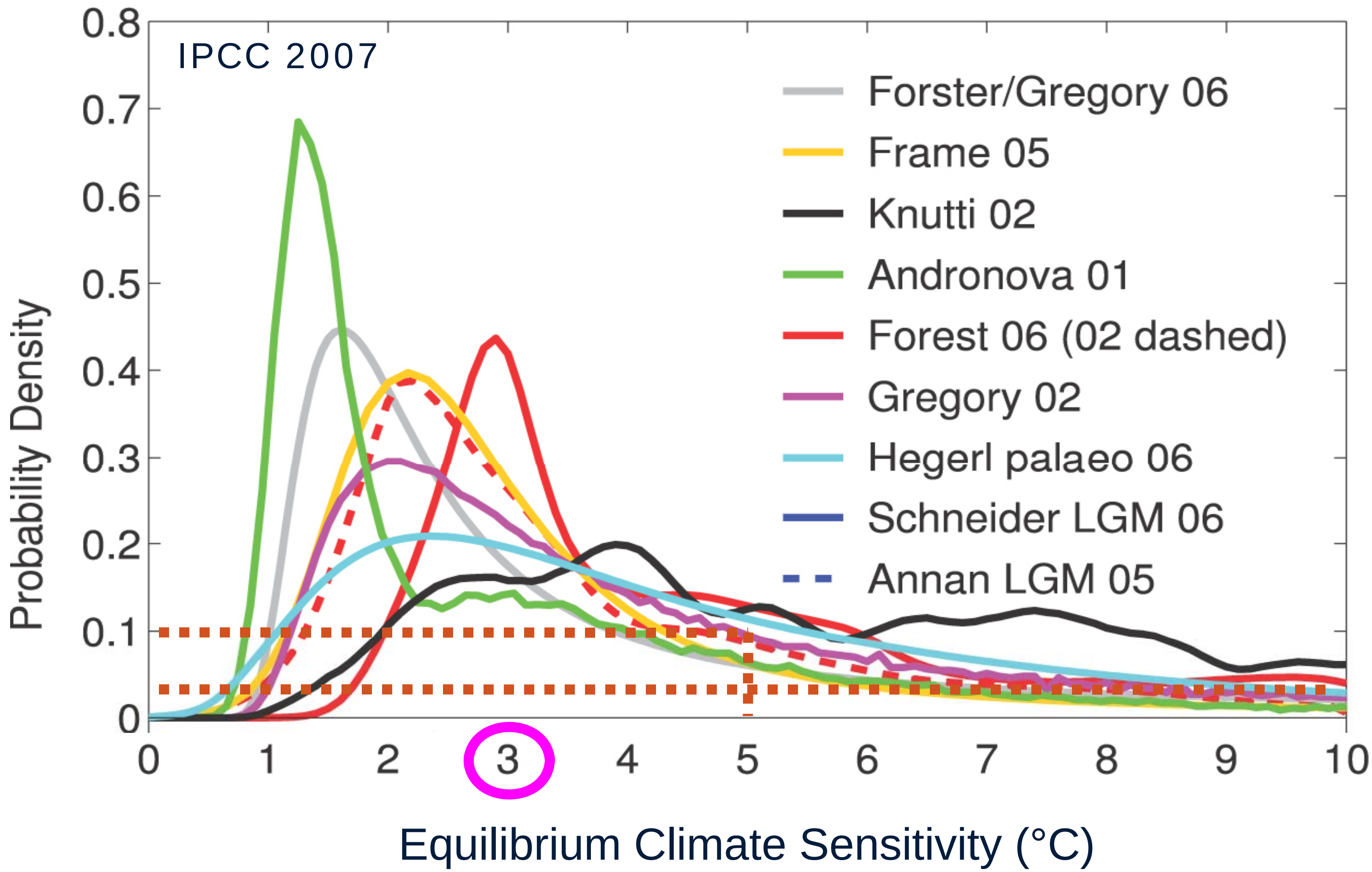


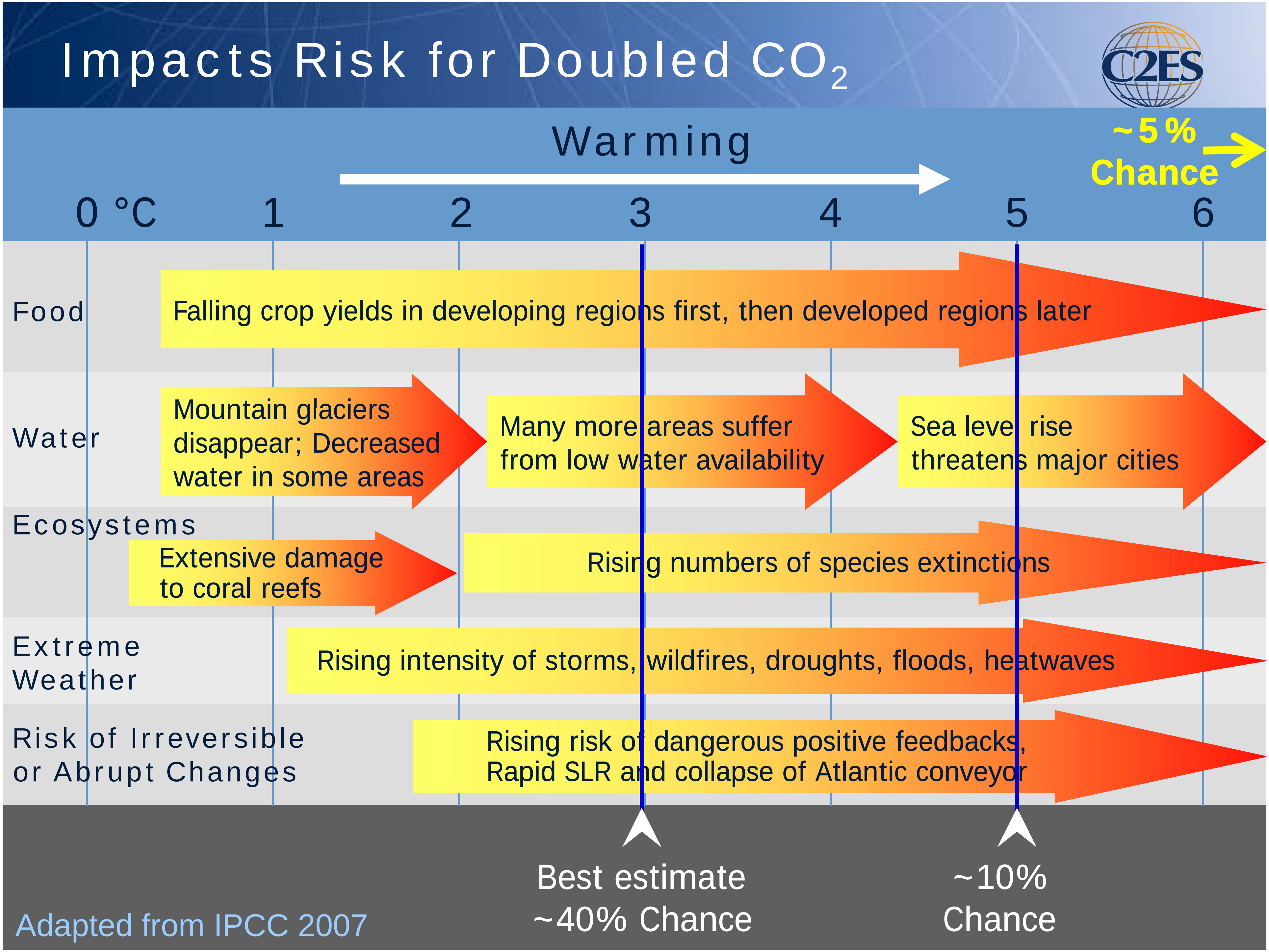
Adaptation is required
for unavoidable change,
but infeasible without mitigation

Hayhoe, 2010

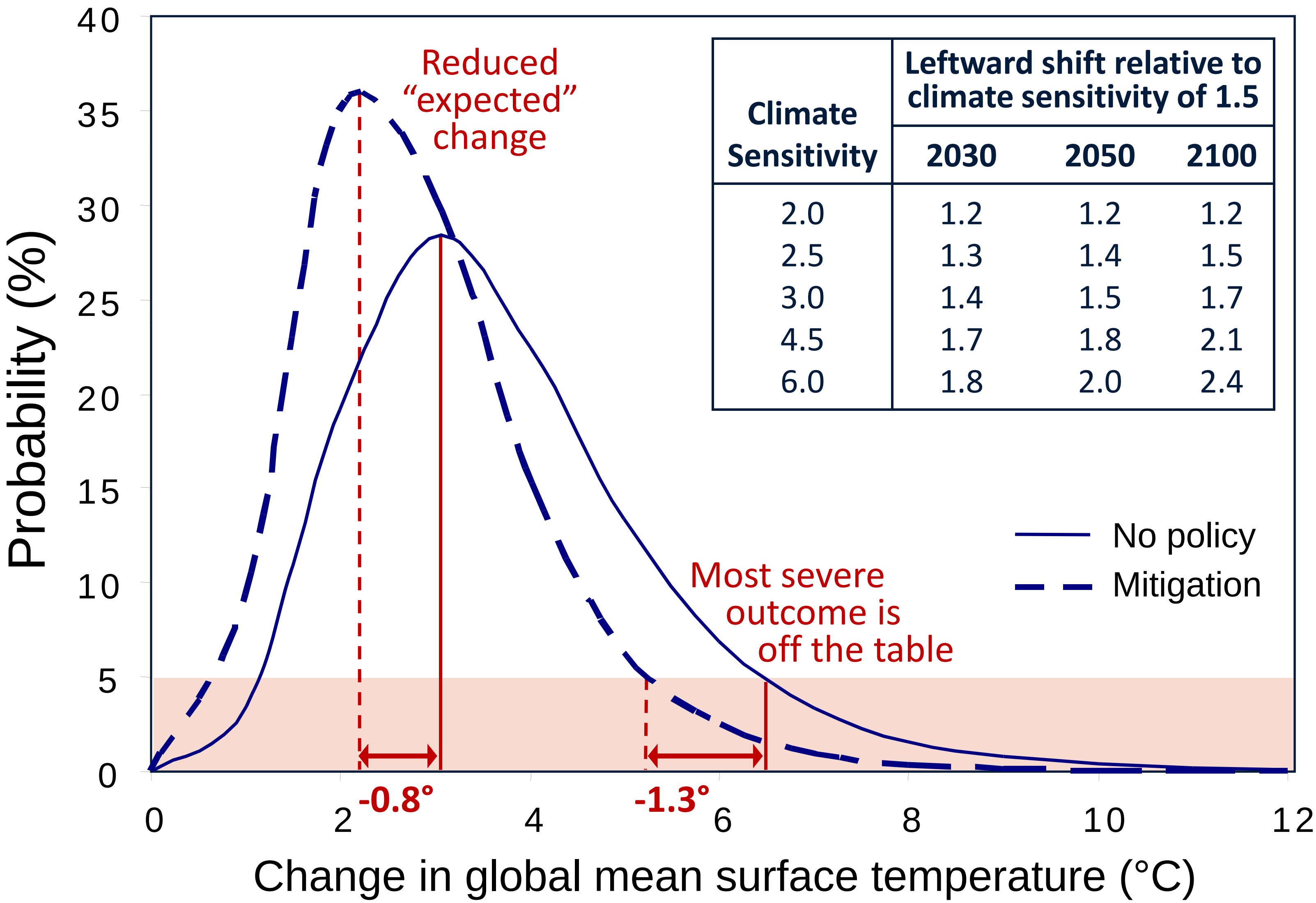
Slide: courtesy R. Bierbaum

Uncertainty and Risk: Climate Sensitivity




Impacts Risk for Doubled CO_2
C2ES
Warming
~5% Chance
0 °C
1
2
3
4
5
6
Food
Falling crop yields in developing regions first, then developed regions later
Water
Mountain glaciers disappear; Decreased water in some areas
Many more areas suffer from low water availability
Sea level rise threatens major cities
Ecosystems
Extensive damage to coral reefs
Rising numbers of species extinctions
Extreme Weather
Rising intensity of storms, wildfires, droughts, floods, heatwaves
Risk of Irreversible or Abrupt Changes
Rising risk of dangerous positive feedbacks, Rapid SLR and collapse of Atlantic conveyor
Best estimate ~40% Chance
~10% Chance
Adapted from IPCC 2007

Policy Benefits: Flat Tails, Not Fat Tails



Climate Sensitivity	Leftward shift relative to climate sensitivity of 1.5		
	2030	2050	2100
2.0	1.2	1.2	1.2
2.5	1.3	1.4	1.5
3.0	1.4	1.5	1.7
4.5	1.7	1.8	2.1
6.0	1.8	2.0	2.4

Rose, 2010

Change is unavoidable but manageable

- **Managed Change (policy/proactive)**
  - “Expected” damages are reduced
  - Unavoided change is more manageable
  - Reduced risk of unpredictable catastrophes
- **Unmanaged Change (no policy/reactive)**
  - “Expected” impacts are higher
  - Unavoided impacts are harder to cope with
  - No insurance against catastrophe

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

FOR MORE INFORMATION

C2ES.ORG

GulledgeJ@c2es.org