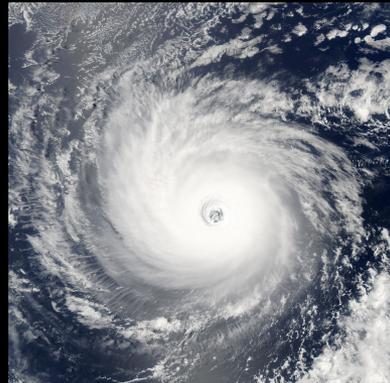


Weather Going Wild: Will Global Warming Lead to More Extremes?



Connecting the Dots: The Climate, Energy, Food, & Water Nexus
Stanford University

18 April 2014

Deepti Singh & Daniel Horton



Perhaps you've heard of Global Warming?

by far the most terrifying film
you will ever see.

an inconvenient truth

A GLOBAL **WARNING**

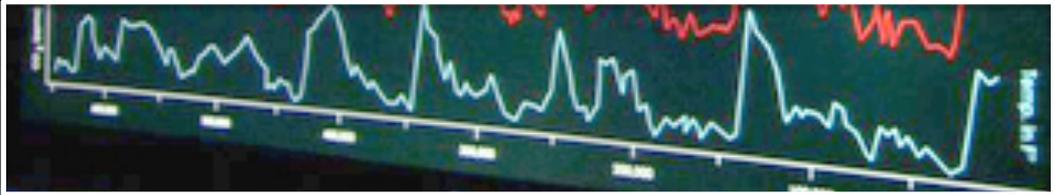
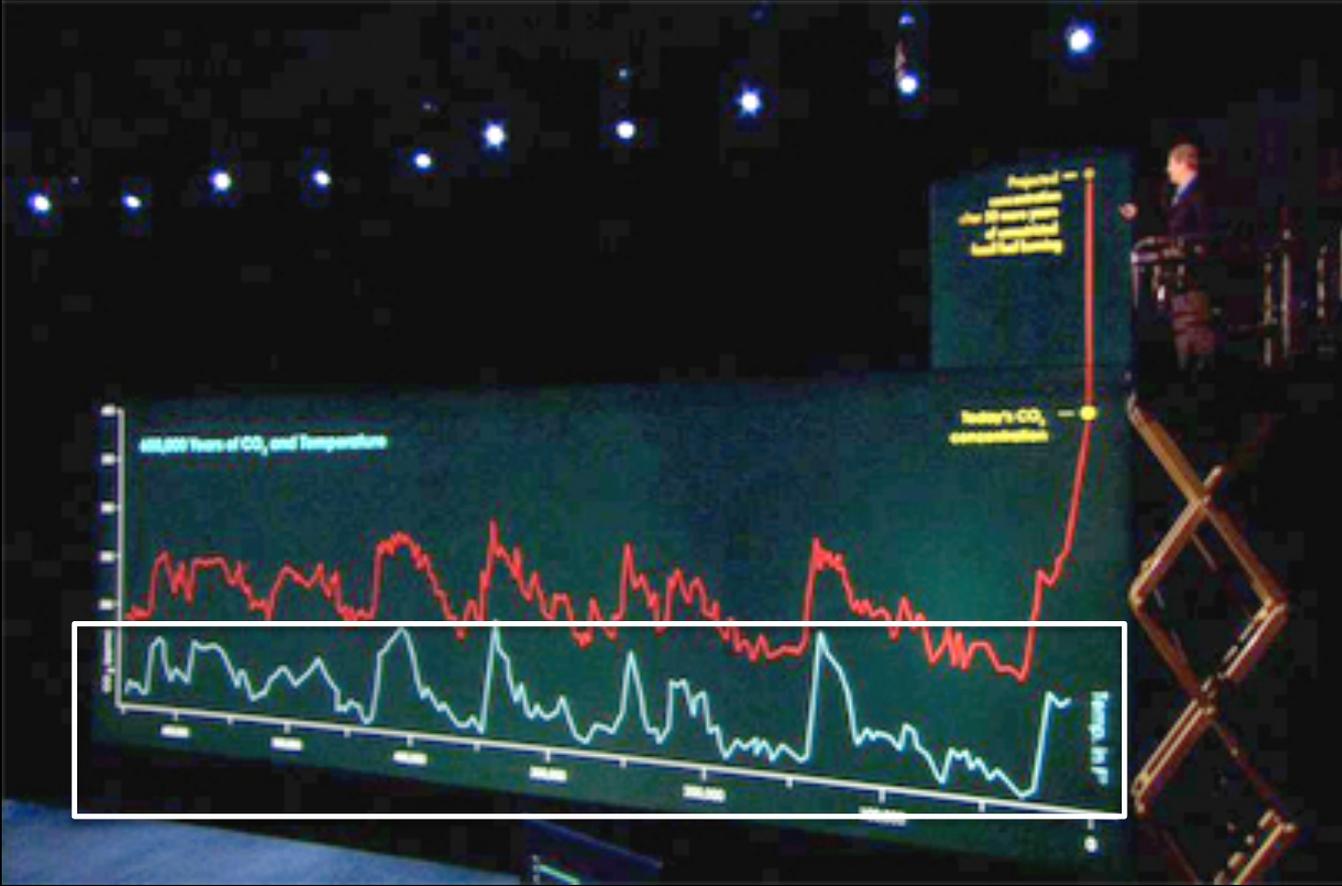
now playing in select theaters

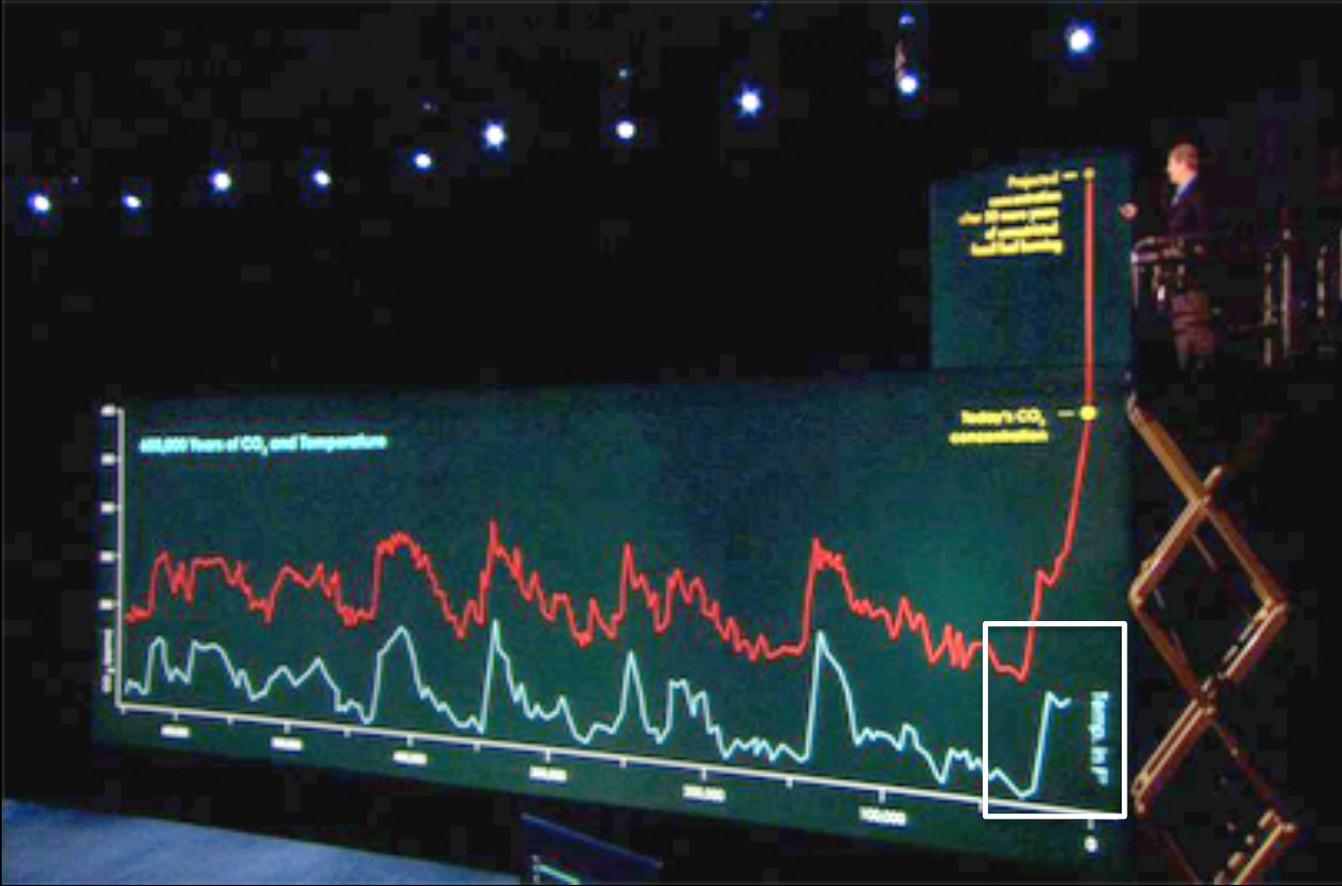
Copyright © 2009 by PARAMOUNT CLASSICS, a Division of PARAMOUNT PICTURES. All Rights Reserved.

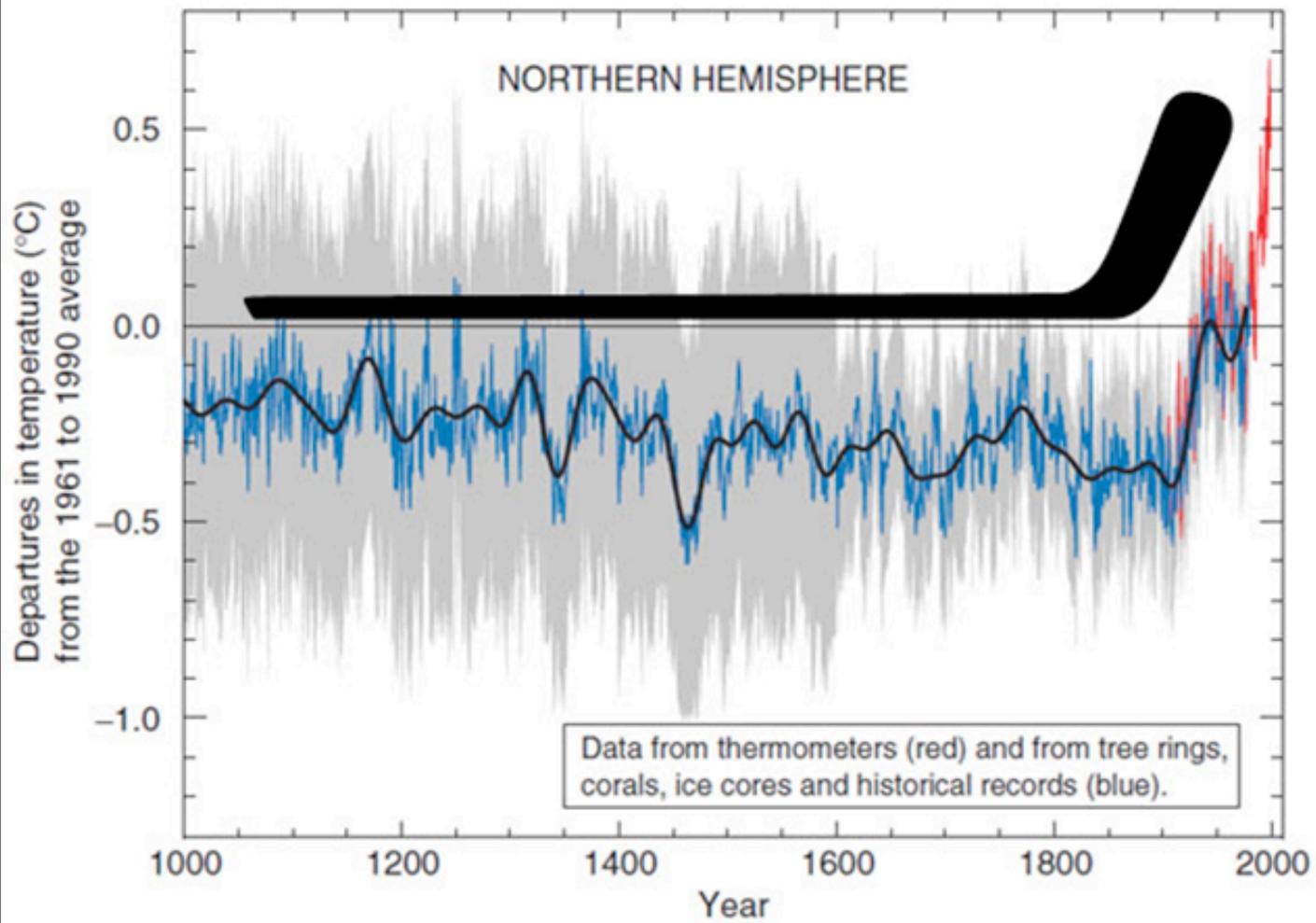
PARTICIPANT
PRODUCTIONS

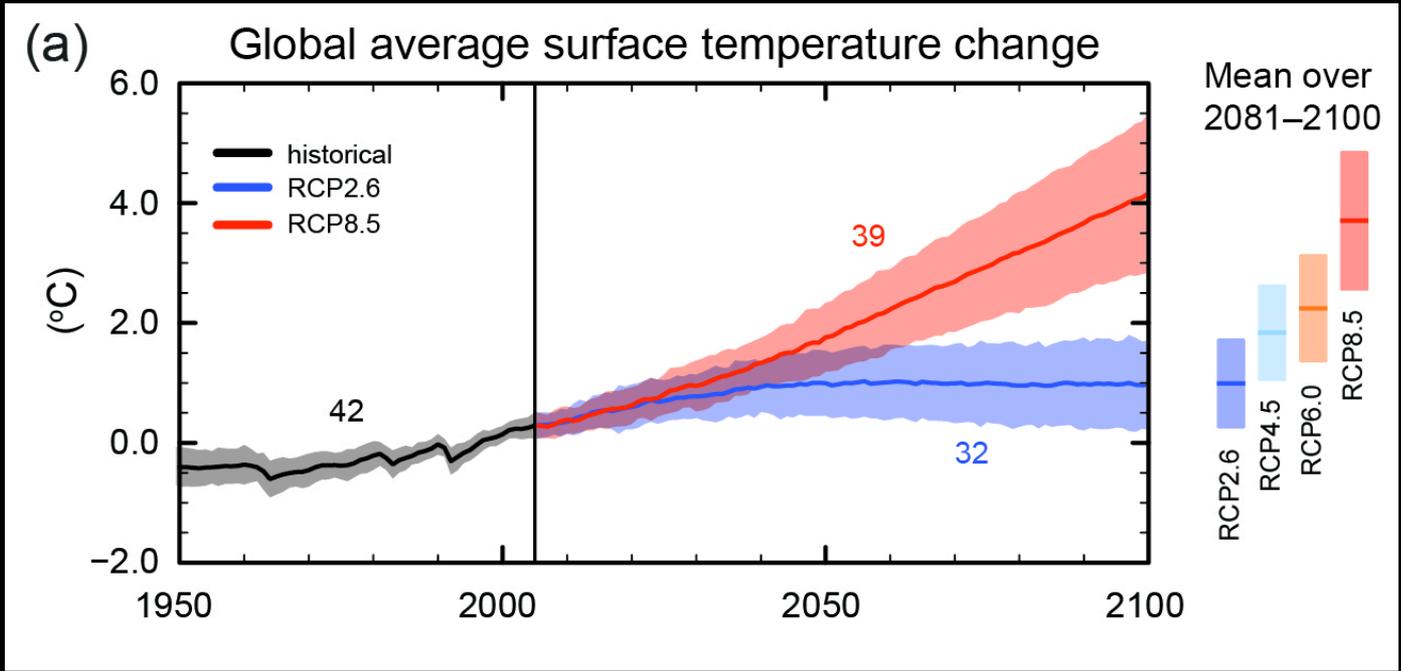




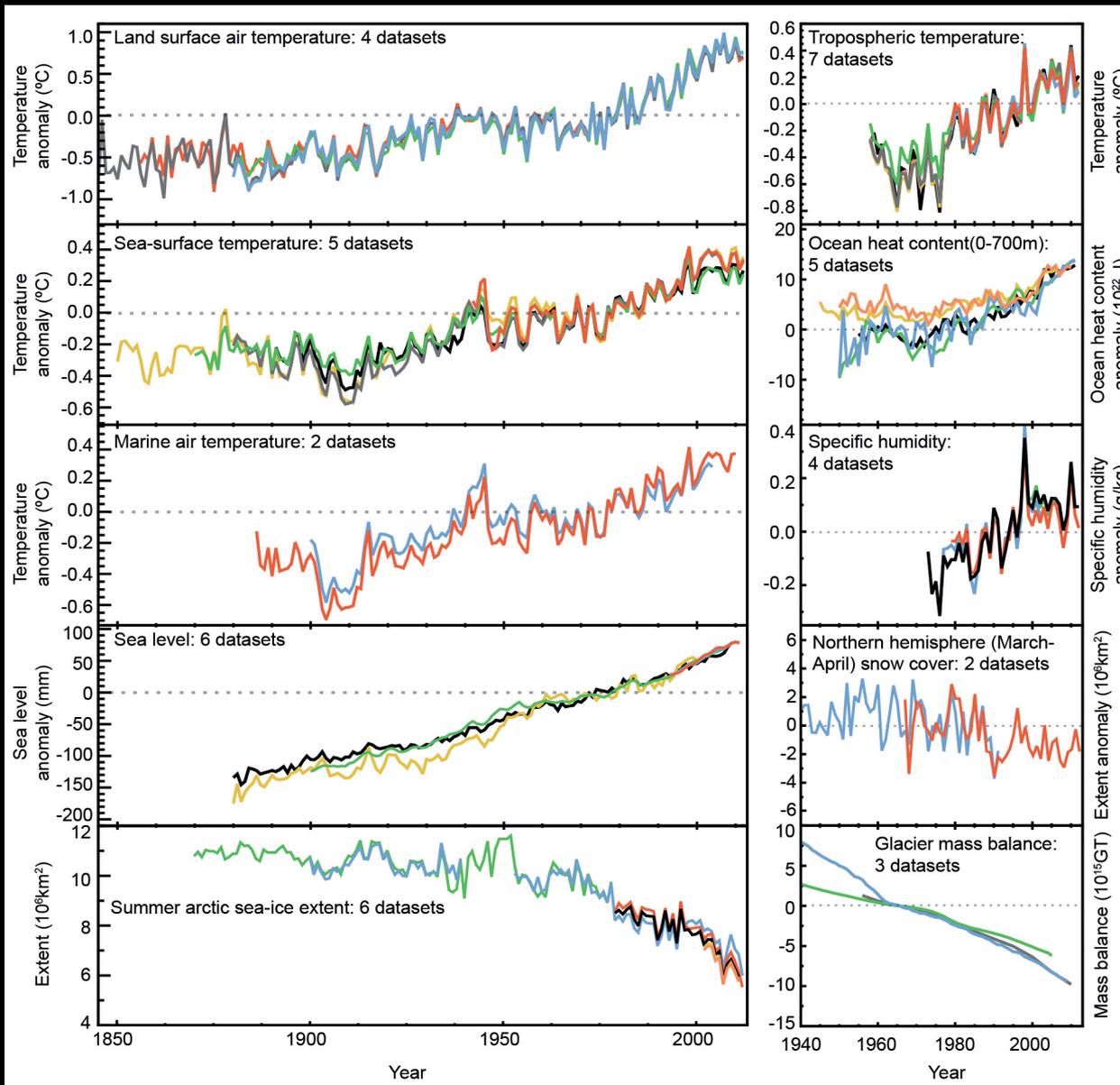




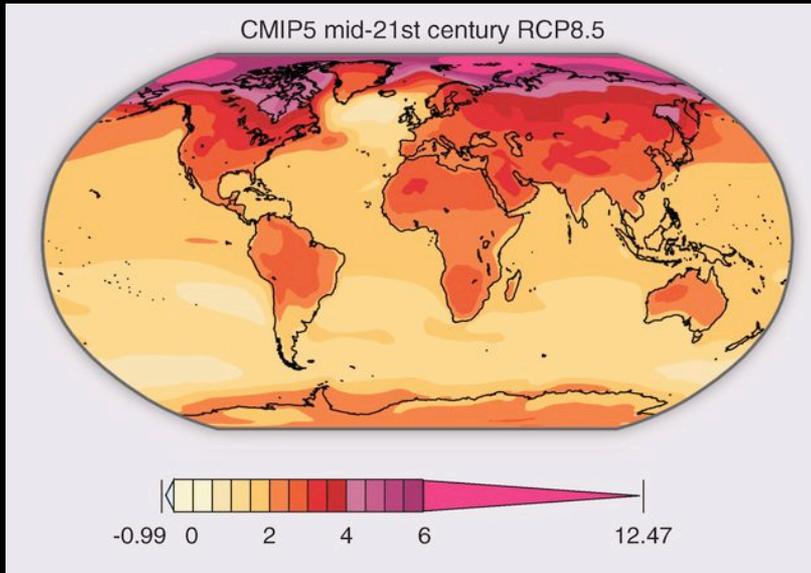




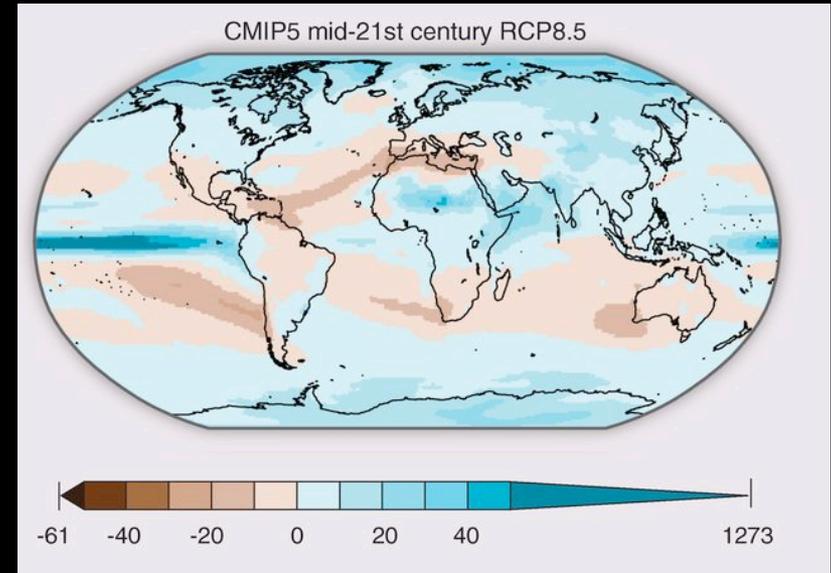
But Global Average Temperature Change is kind of abstract...



Temperature Change



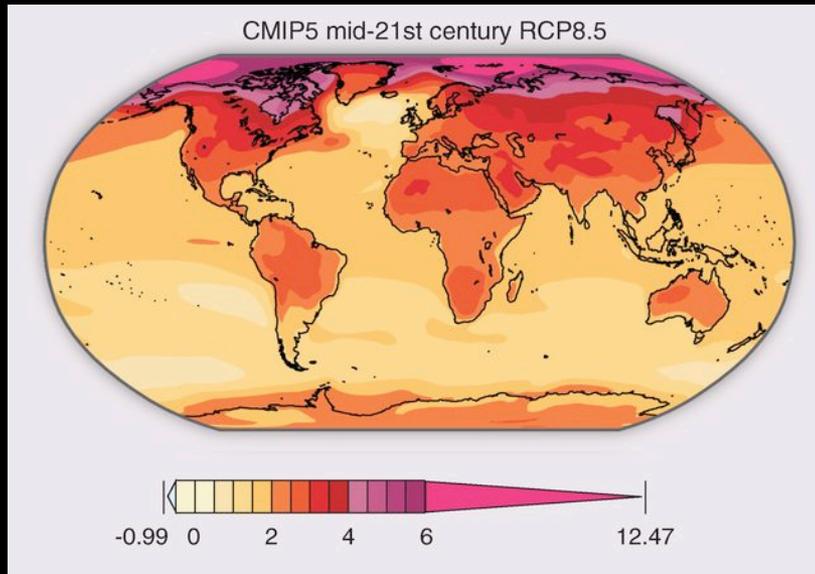
Precipitation Change



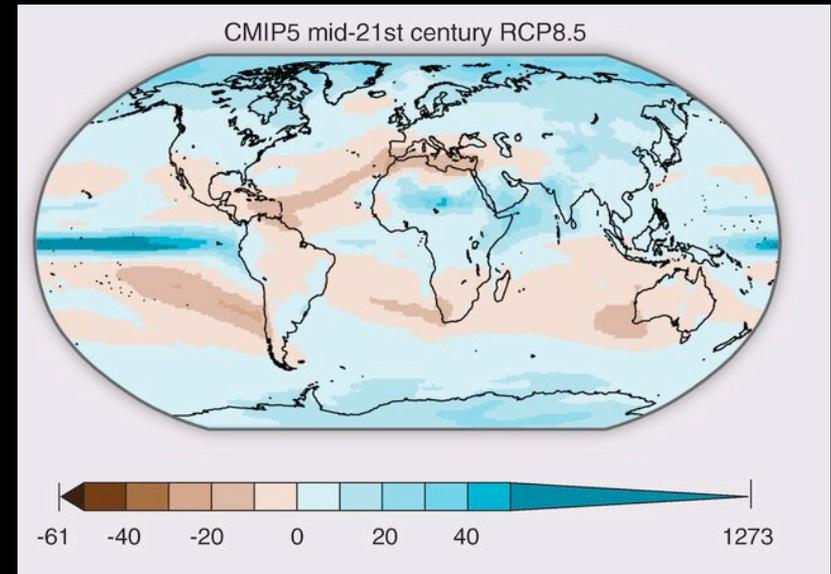
CA: 2 °C by mid-century

20% by mid-century

Temperature Change



Precipitation Change



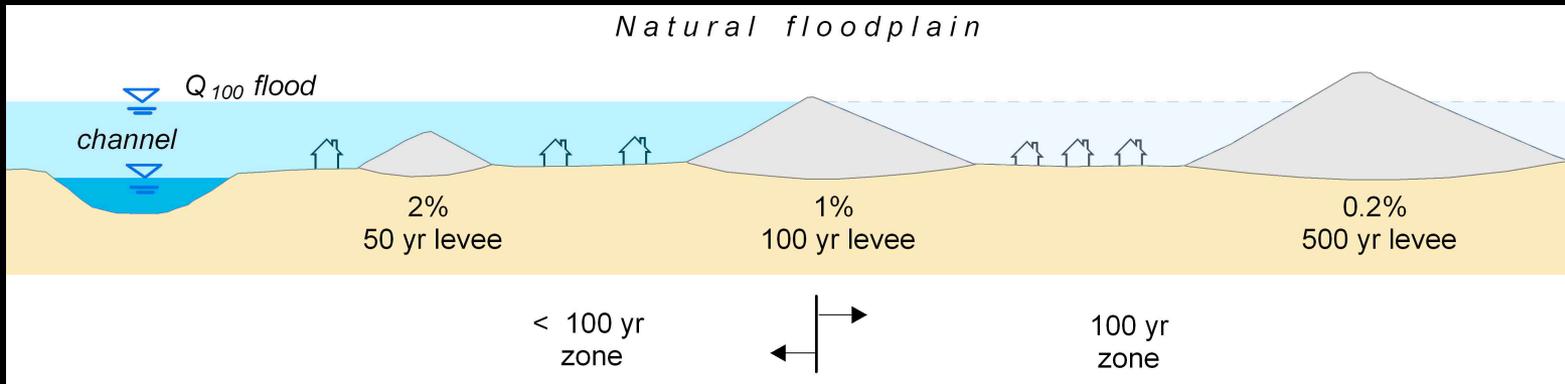
Less abstract, but...

The National Heatwave Plan – A Brief Evaluation of Issues for Frontline Health Staff

JANUARY 13, 2014 · RESEARCH ARTICLE



- When Public Health officials plan for heat waves
 - They don't plan for average temperatures
 - They prepare for extreme events



- When civil engineers design flood protection
 - They don't think about average precipitation
 - They build for extreme events at a chosen level of risk

Crowdsourcing Extremes

What makes an event “extreme”?

What’s an example of an extreme event?

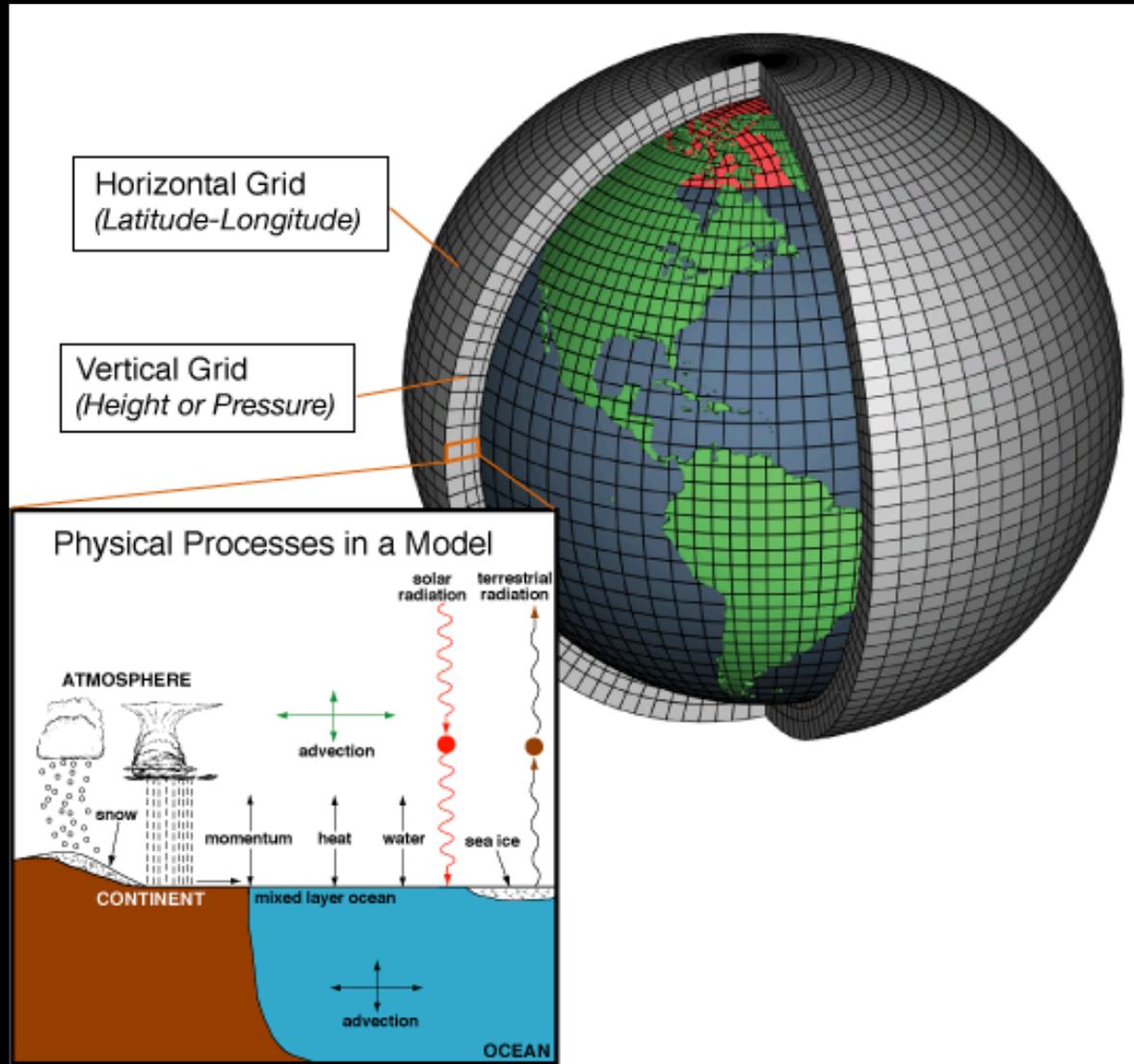


Weather Going Wild: Will Global Warming Lead to More Extremes?

1. What is an “extreme” weather event?
2. How does global warming influence extremes?
3. What does the IPCC say?

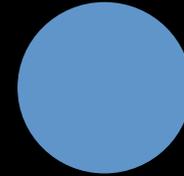


Tools to study extremes



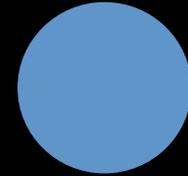
IPCC Likelihood Statements

Let's pretend this is a Climate Model:



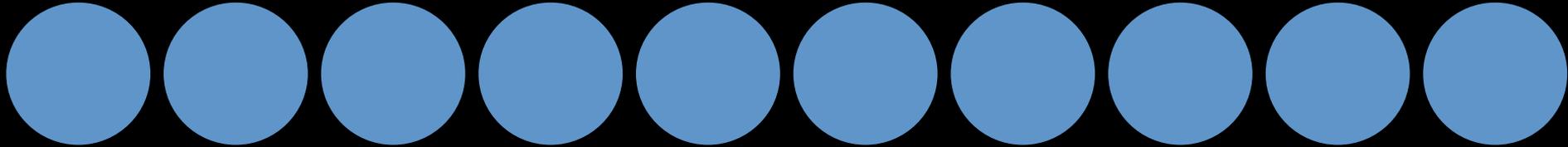
IPCC Likelihood Statements

Let's Build a Climate Model Ensemble



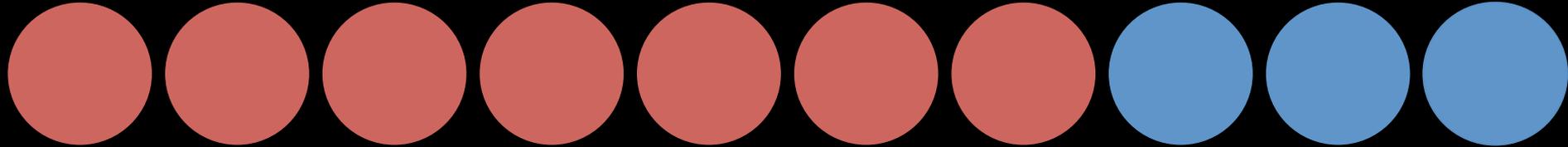
IPCC Likelihood Statements

Let's Build a Climate Model Ensemble



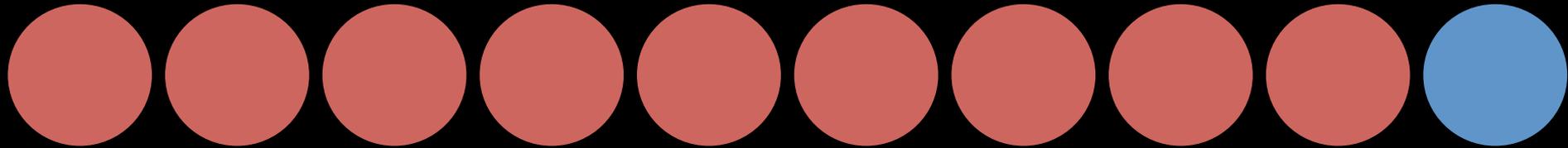
IPCC Likelihood Statements

Likely



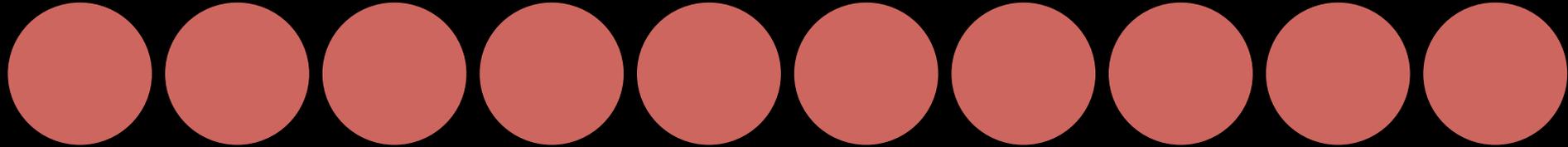
IPCC Likelihood Statements

Very Likely

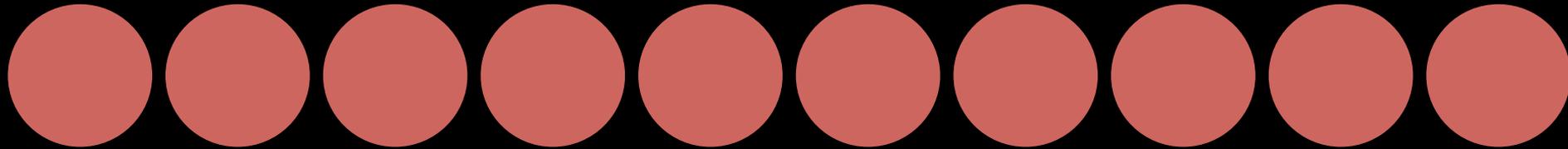


IPCC Likelihood Statements

Virtually Certain



IPCC Likelihood Statements



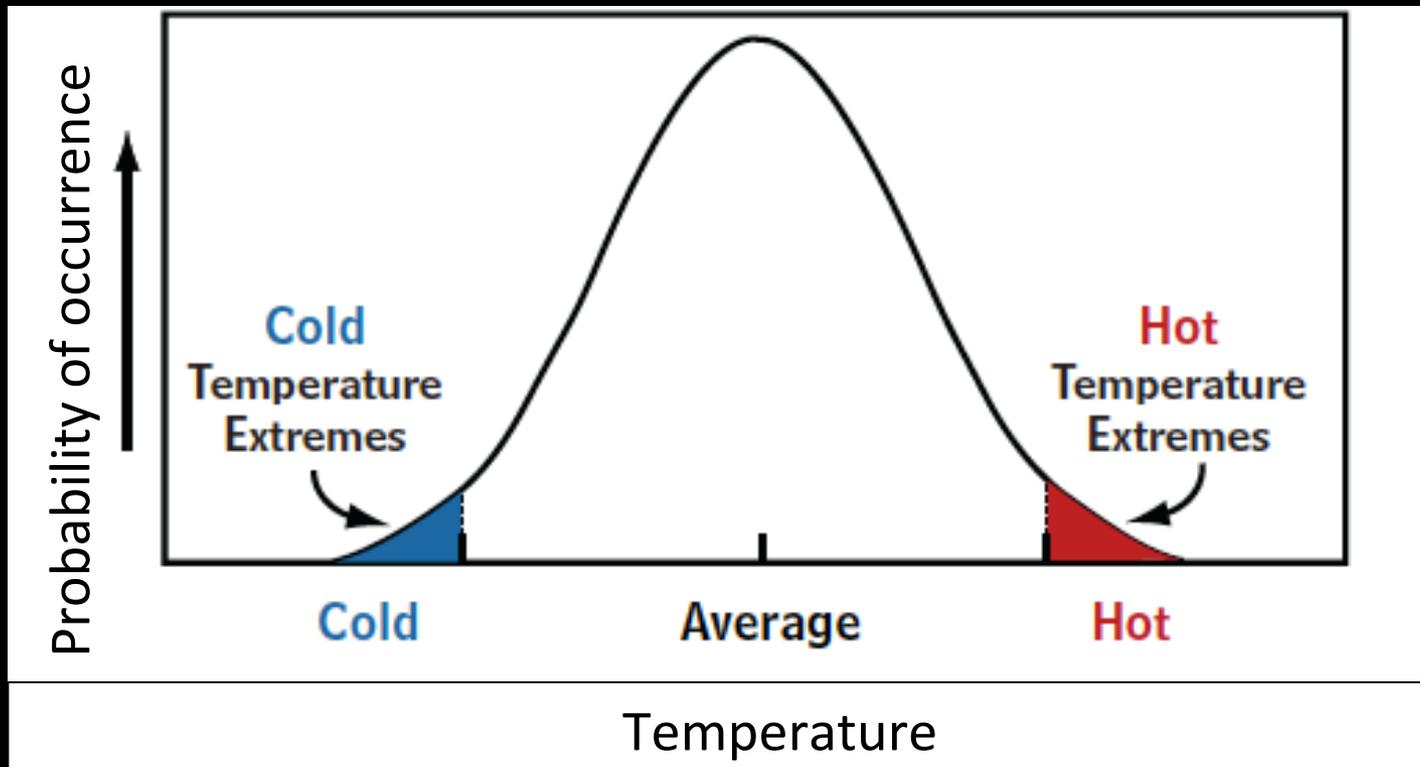
Confidence Statements

Agreement ↑	<i>High agreement Limited evidence</i>	<i>High agreement Medium evidence</i>	<i>High agreement Robust evidence</i>
	<i>Medium agreement Limited evidence</i>	<i>Medium agreement Medium evidence</i>	<i>Medium agreement Robust evidence</i>
	<i>Low agreement Limited evidence</i>	<i>Low agreement Medium evidence</i>	<i>Low agreement Robust evidence</i>
	Evidence (type, amount, quality, consistency) →		

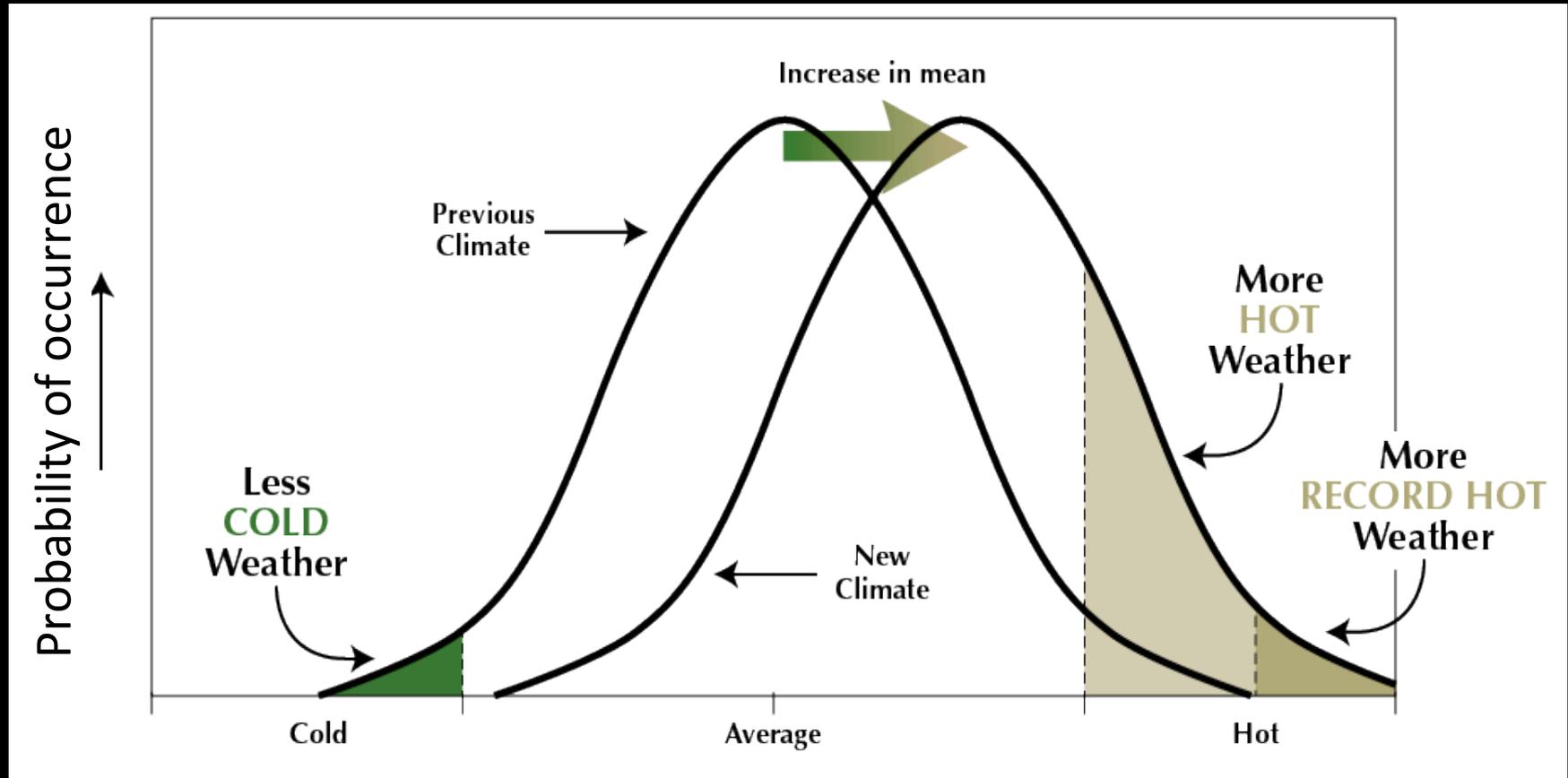


What is an extreme climate event?

IPCC definition “the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable”



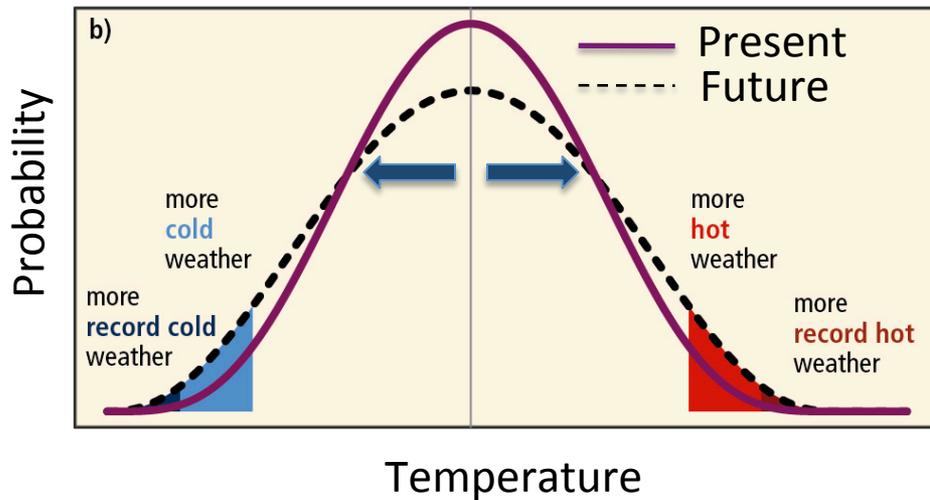
Temperature extremes in a changing climate



IPCC: "It is very likely that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights, at the global scale"

Temperature extremes in a changing climate

Increased variability



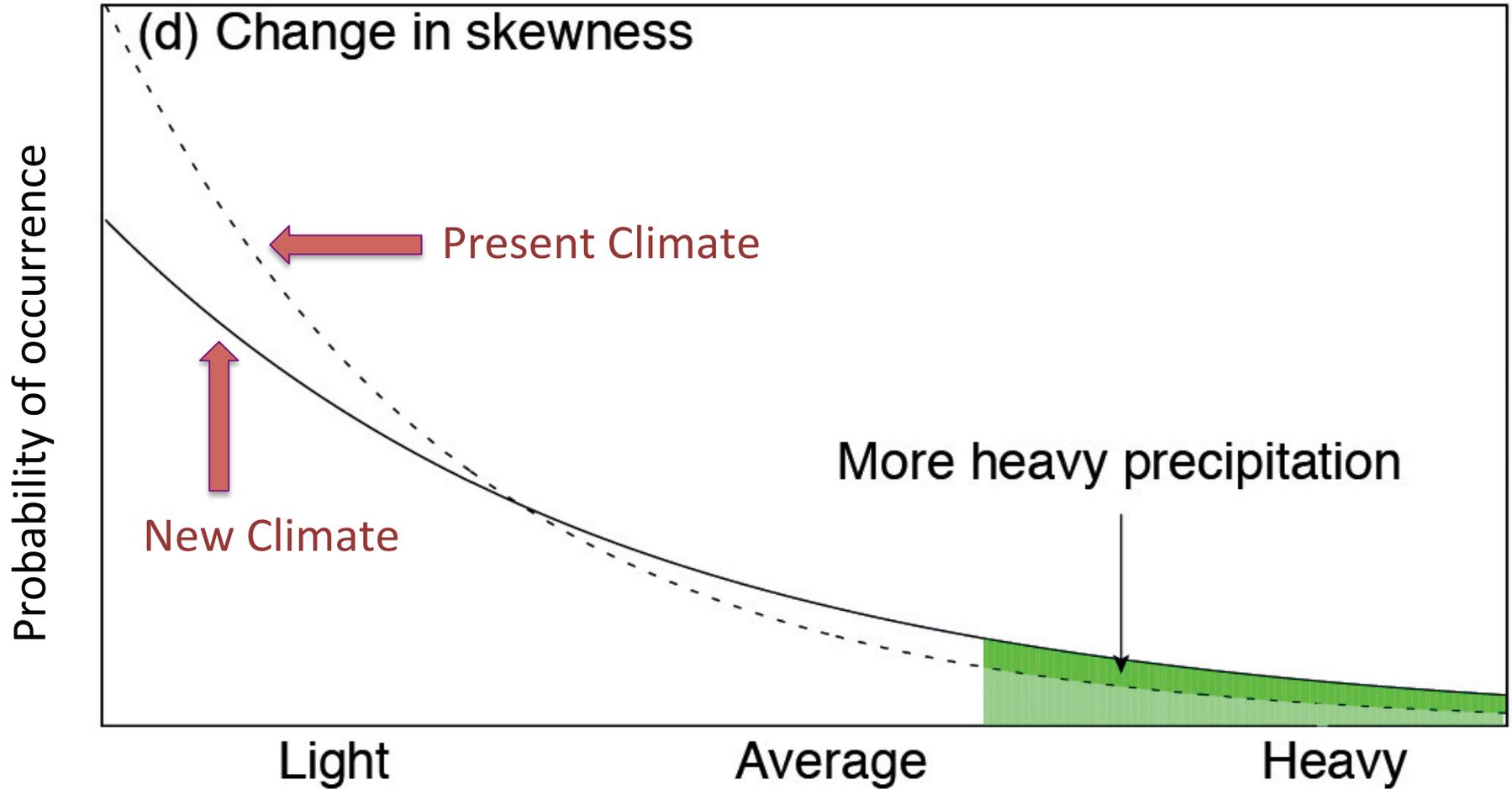
Temperature extremes in a changing climate



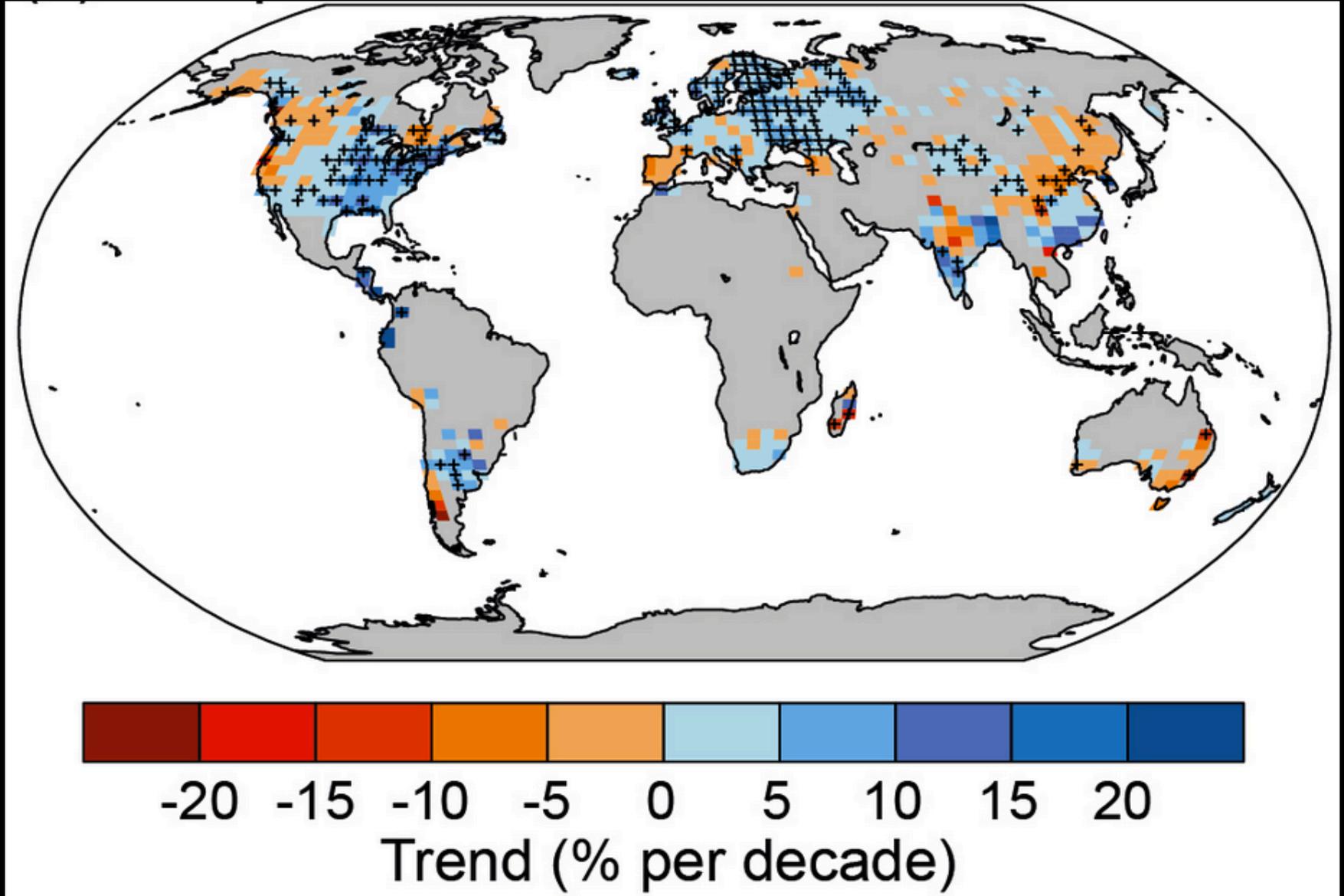
Russian heat wave, 2010

IPCC: "there is medium confidence that globally the length and frequency of warm spells, including heat waves, has increased since the middle of the 20th century"

Precipitation Extremes



Trends in heavy precipitation (1951-2010)



Daily-scale precipitation extremes



AFP Pakistan
Today

Pakistan Floods 2010

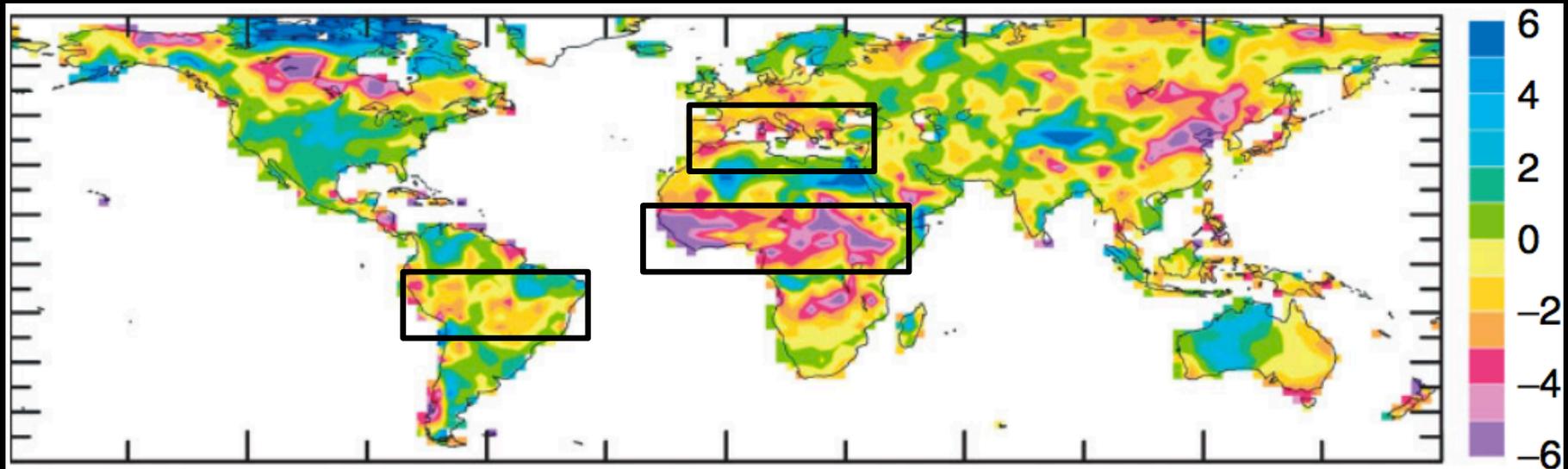


Rafiq Maqbool/AP

Northern India Floods 2013

IPCC: *Likely* increase in extremely heavy precipitation events over most land regions

Observed trends in drought measure



Red – regions getting drier
Blue – regions getting wetter

Seasonal-Annual Droughts



East African Drought 2010-2012



Central India Drought 2013

IPCC: medium confidence in a projected increase in duration and intensity of droughts in some regions of the world

Compound events:

Example : Tropical Cyclones/typhoons



increasing wind speeds

warmer sea-surface temperatures

rising sea-levels

Compound events:

Example : Tropical Cyclones/typhoons



Cyclone Phallin



Typhoon Haiyan

It is very likely that mean sea-level rise will continue to increase

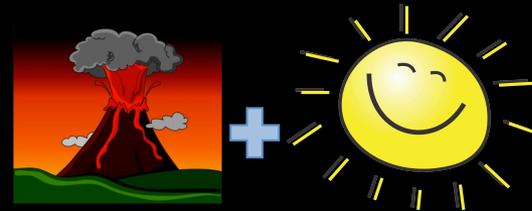
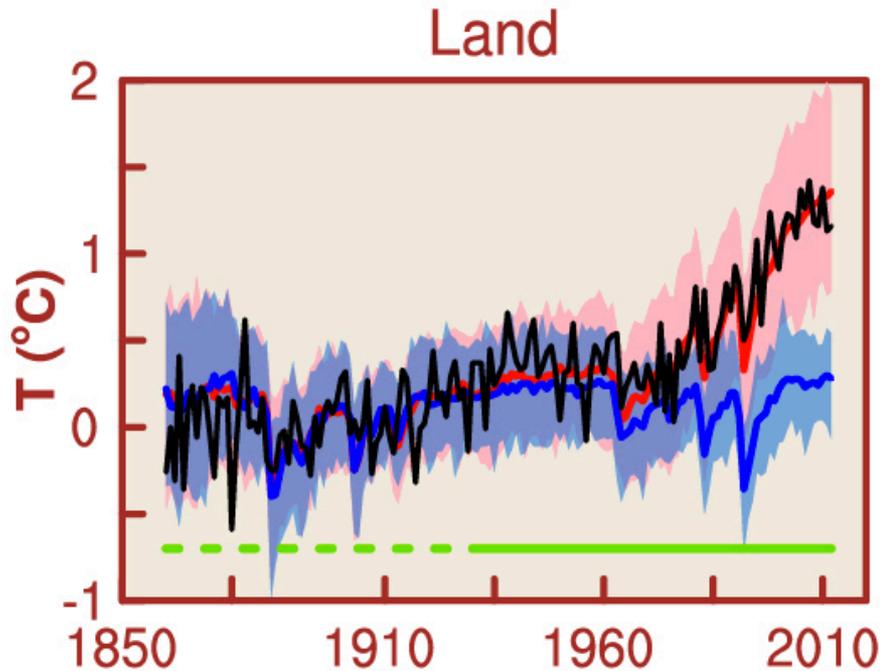
IPCC:

Likely increase in maximum tropical cyclone wind speeds

Likely increase in heavy rainfall from tropical cyclones

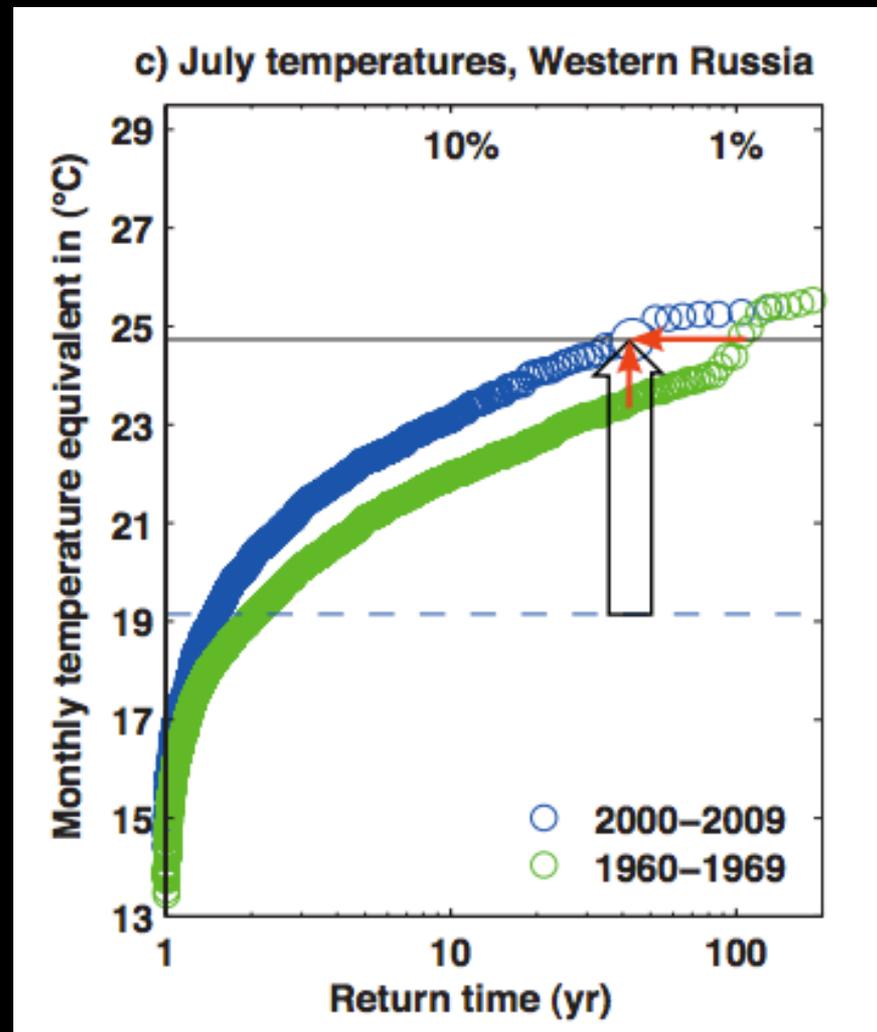
Likely decrease or no change in frequency

Influence of human activities

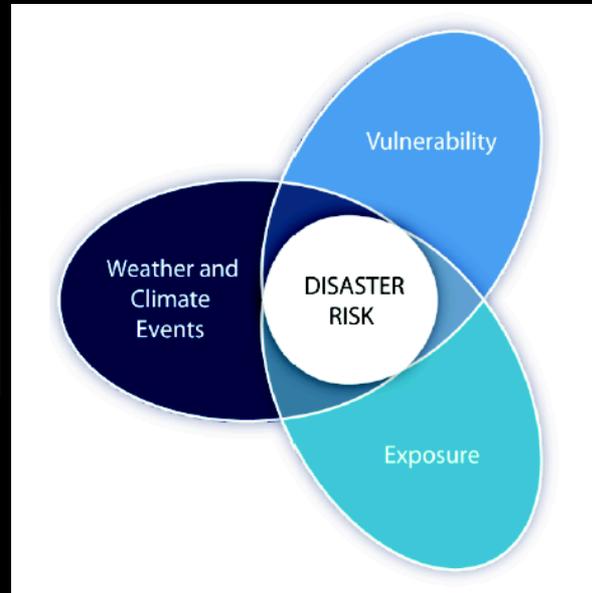


- Observations
- Models using only natural forcings
- Models using both natural and anthropogenic forcings

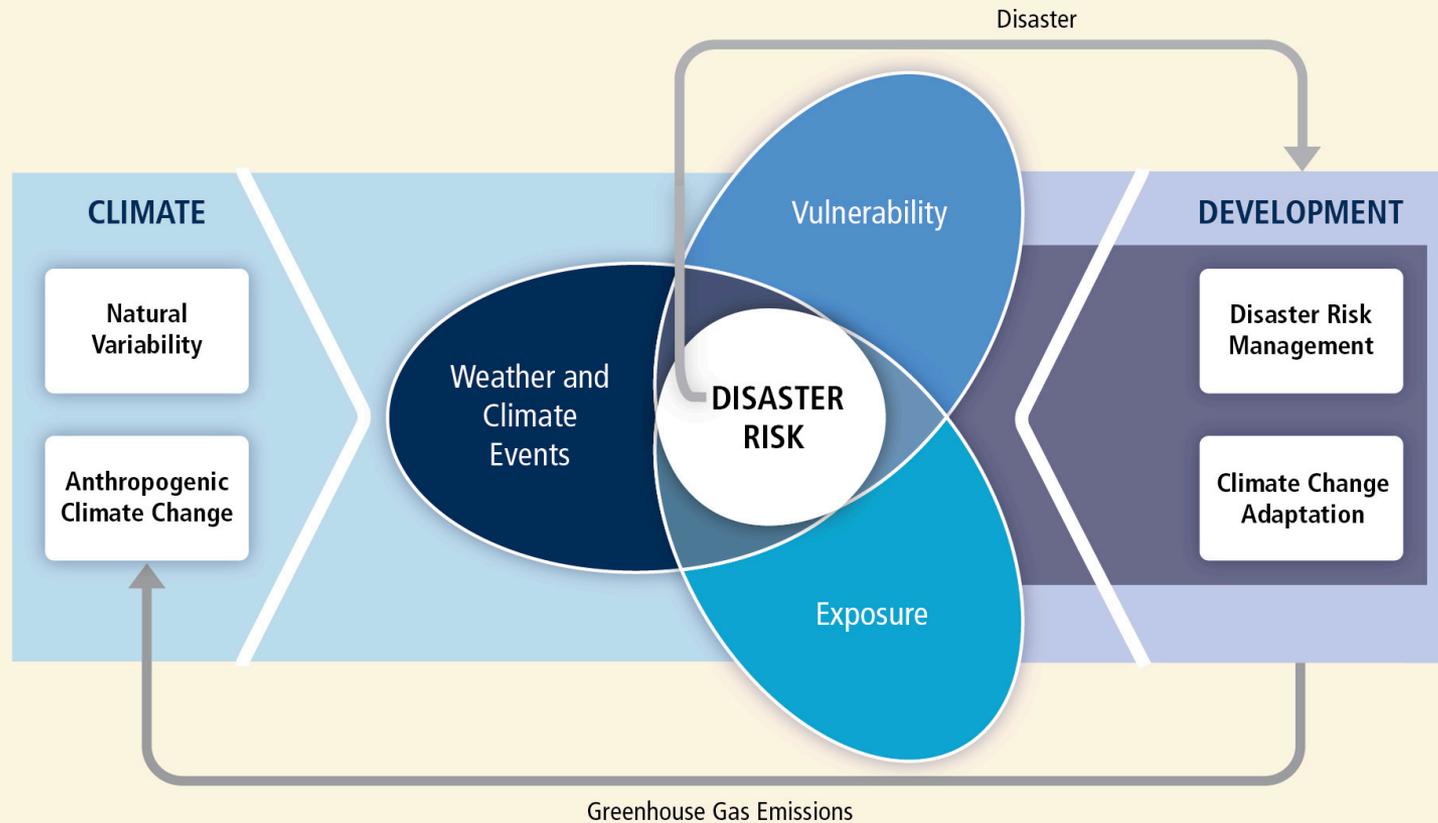
Extreme event attribution: Russian Heat Wave



Climate - Vulnerability - Exposure



Opportunity



Guided Discussion Topics:

Obvious & not-so-obvious impacts of extreme events

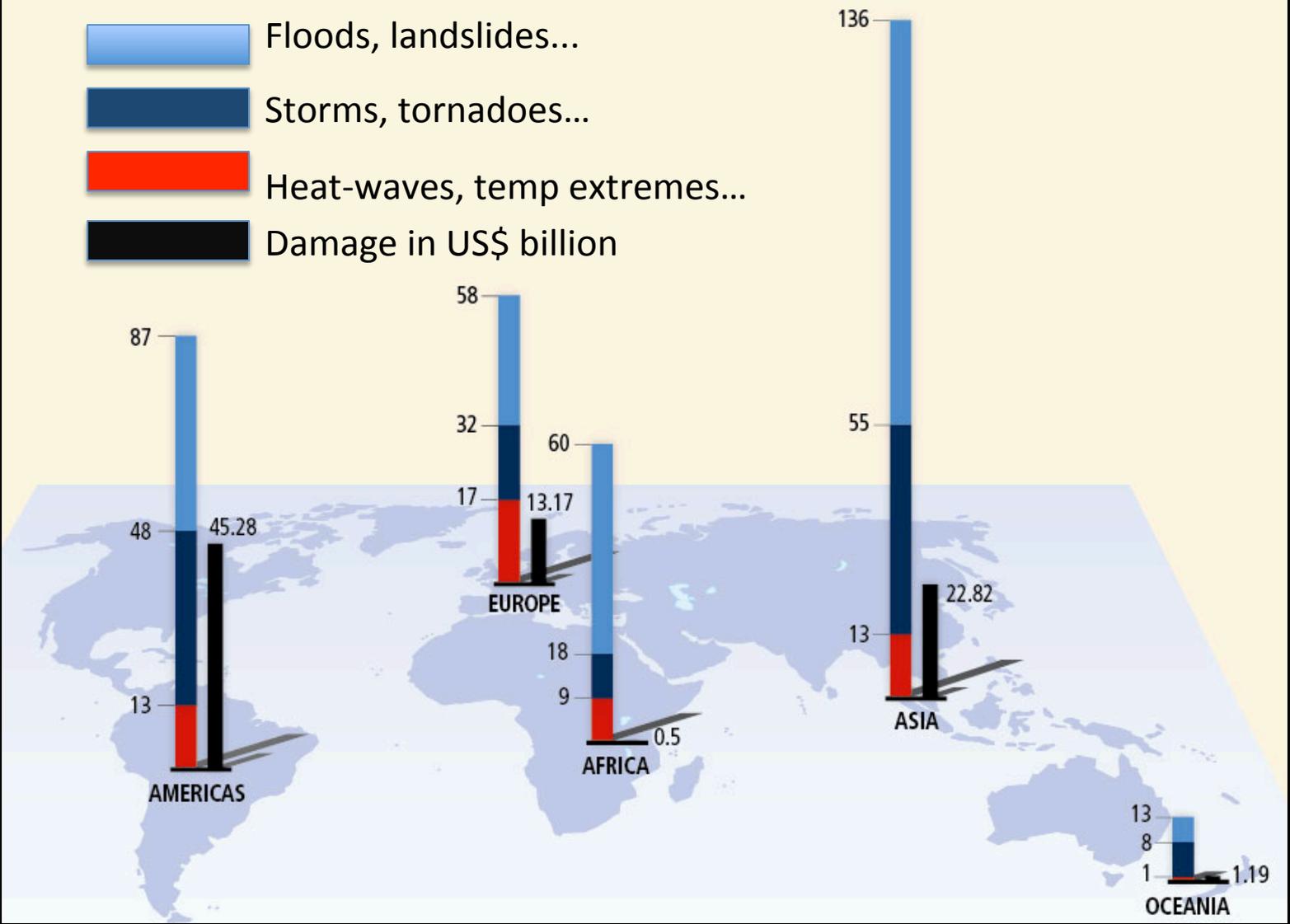
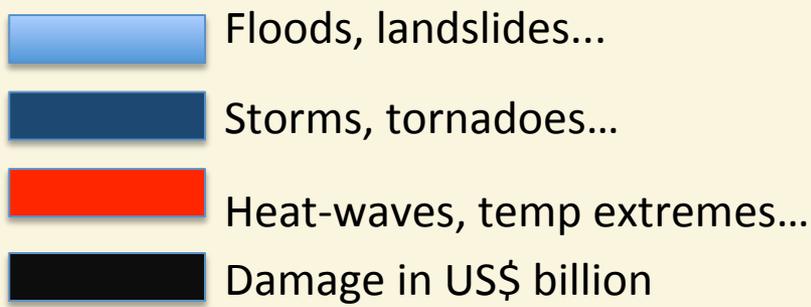
- How might extreme events affect your field of study or occupation?

Framing attribution – an on-going debate

What do people care about?

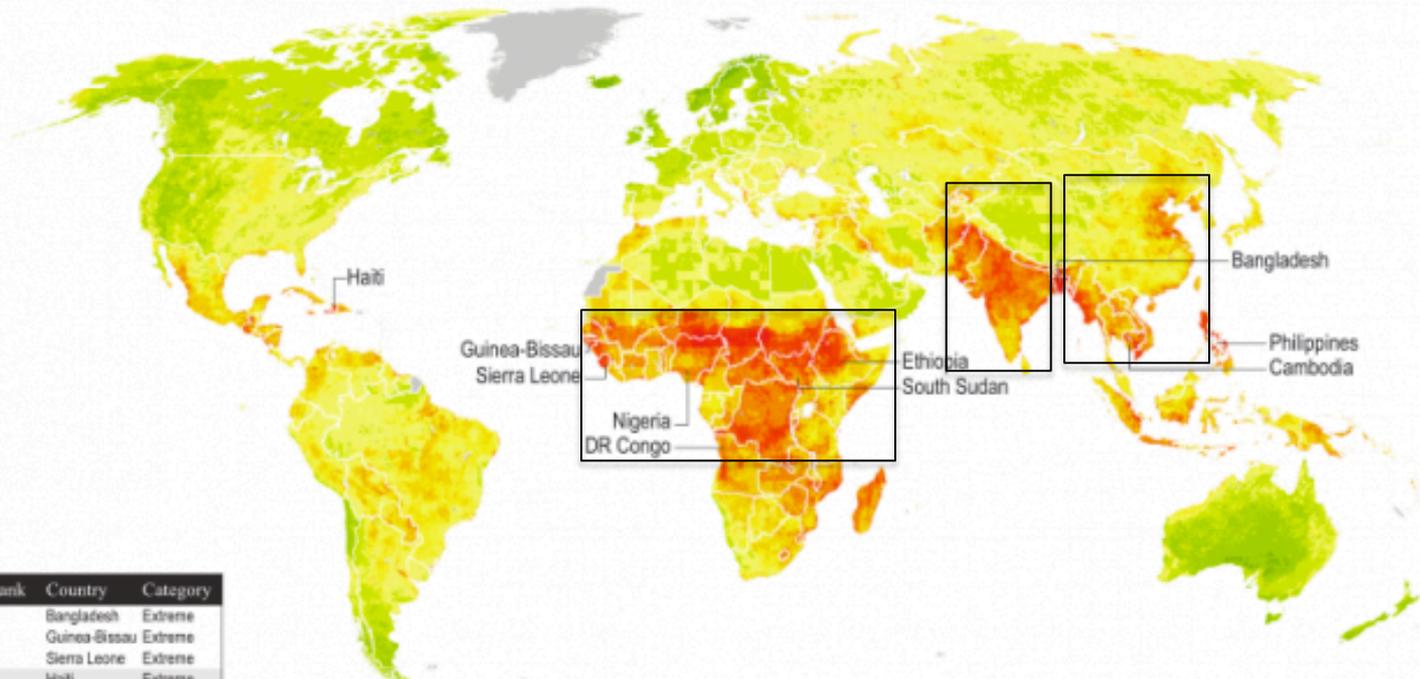
- The role of emotion in climate change discussions
- survival <---> recreation

Current Disaster Risk



Increase in Vulnerability

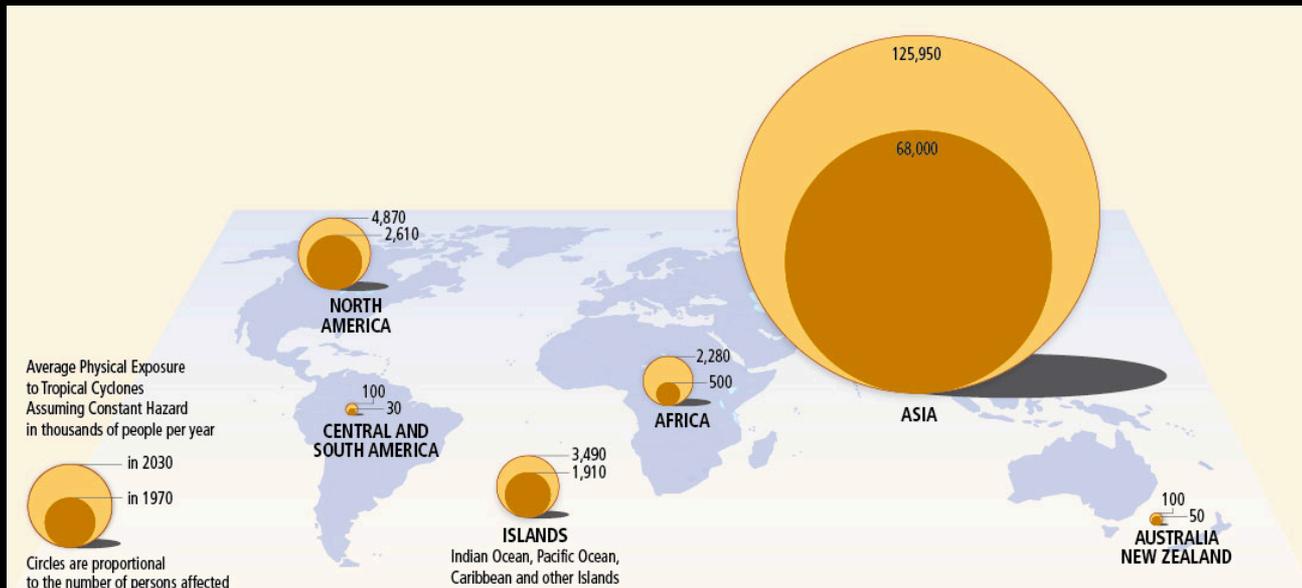
Climate Change Vulnerability Index 2014



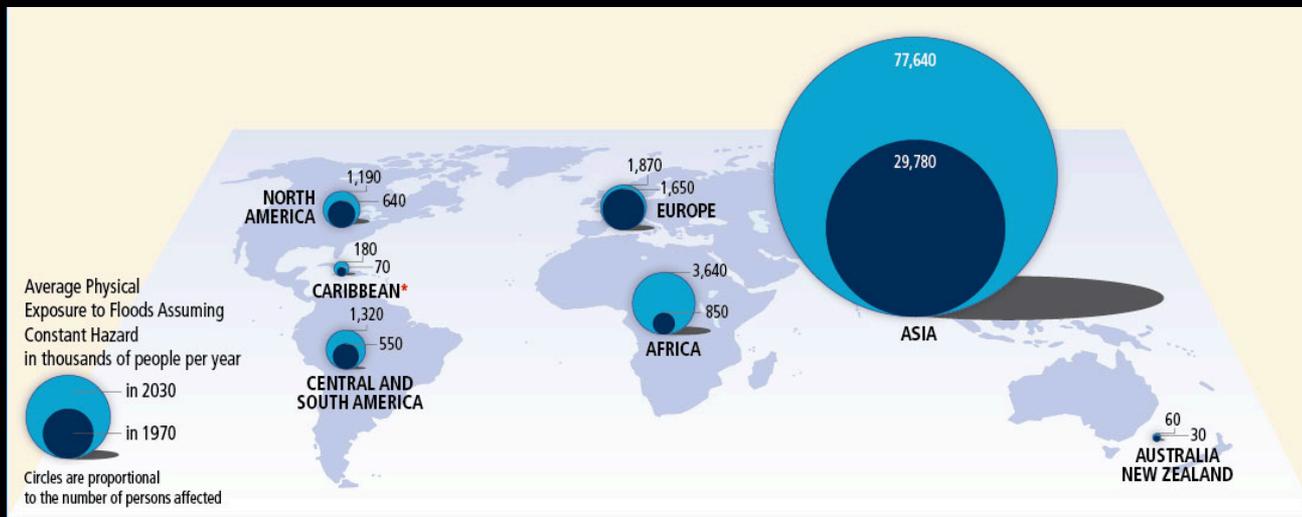
Rank	Country	Category
1	Bangladesh	Extreme
2	Guinea-Bissau	Extreme
3	Sierra Leone	Extreme
4	Haiti	Extreme
5	South Sudan	Extreme
6	Nigeria	Extreme
7	DR Congo	Extreme
8	Cambodia	Extreme
9	Philippines	Extreme
10	Ethiopia	Extreme



Increase in exposure

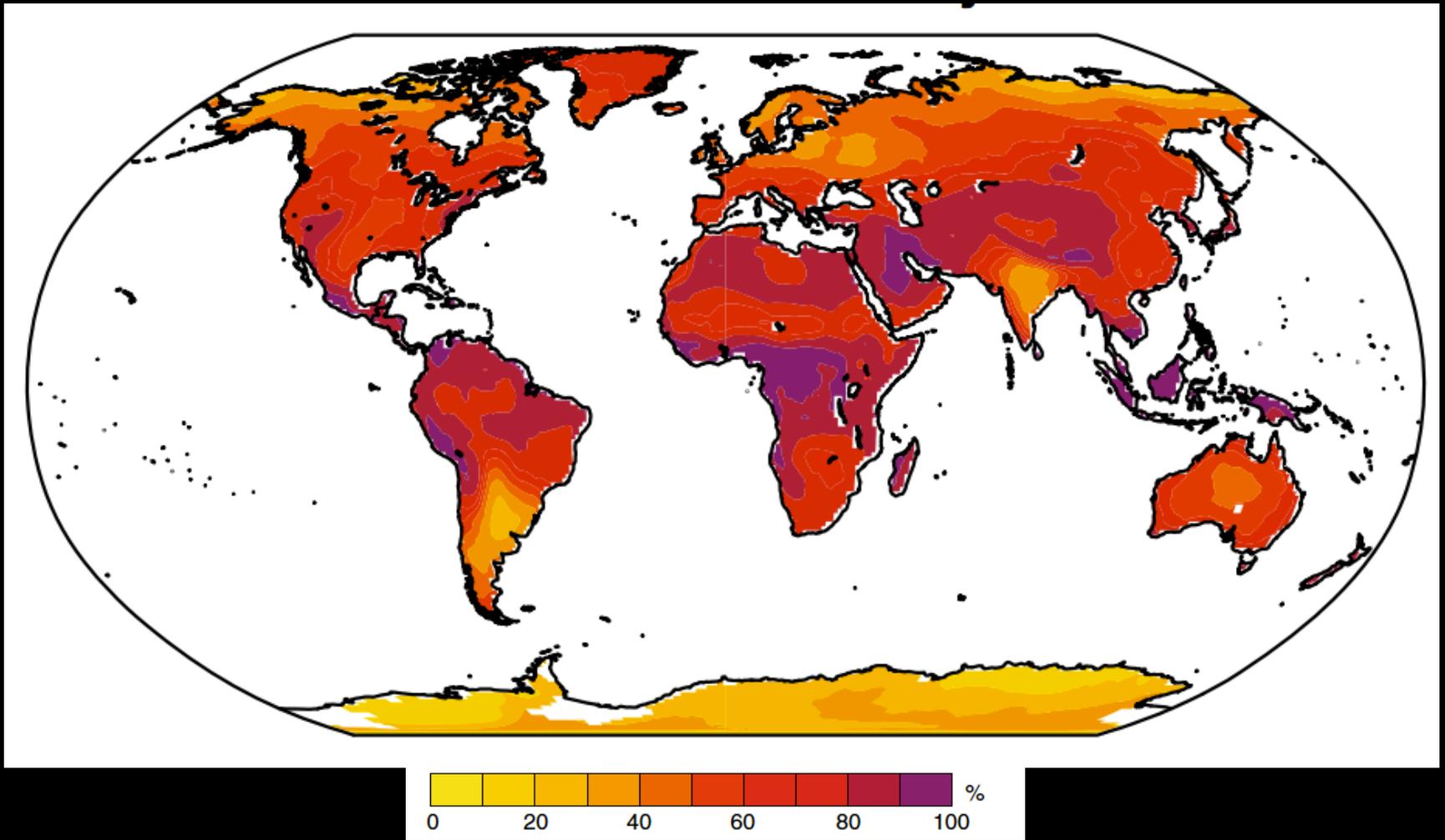


Exposure to tropical cyclones



Exposure to floods

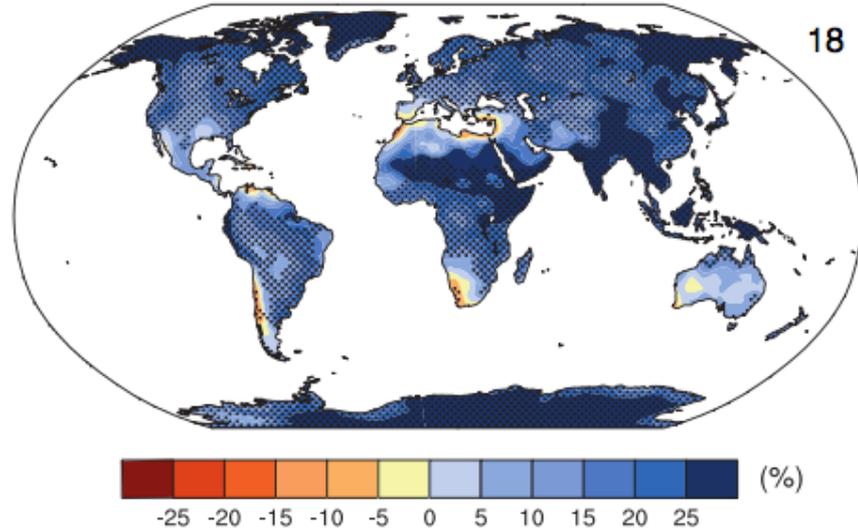
Mid-21st century summer temperatures



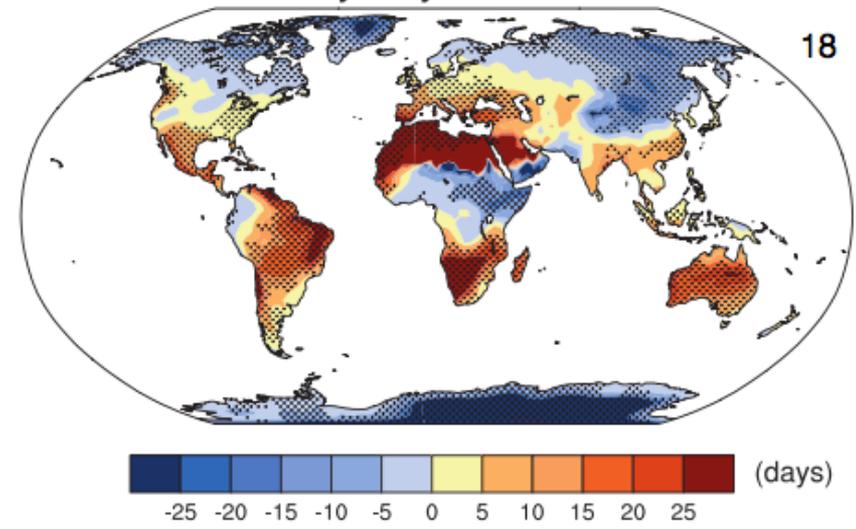
Percent of years exceeding the warmest season in late-20th century

Late-21st century precipitation projections

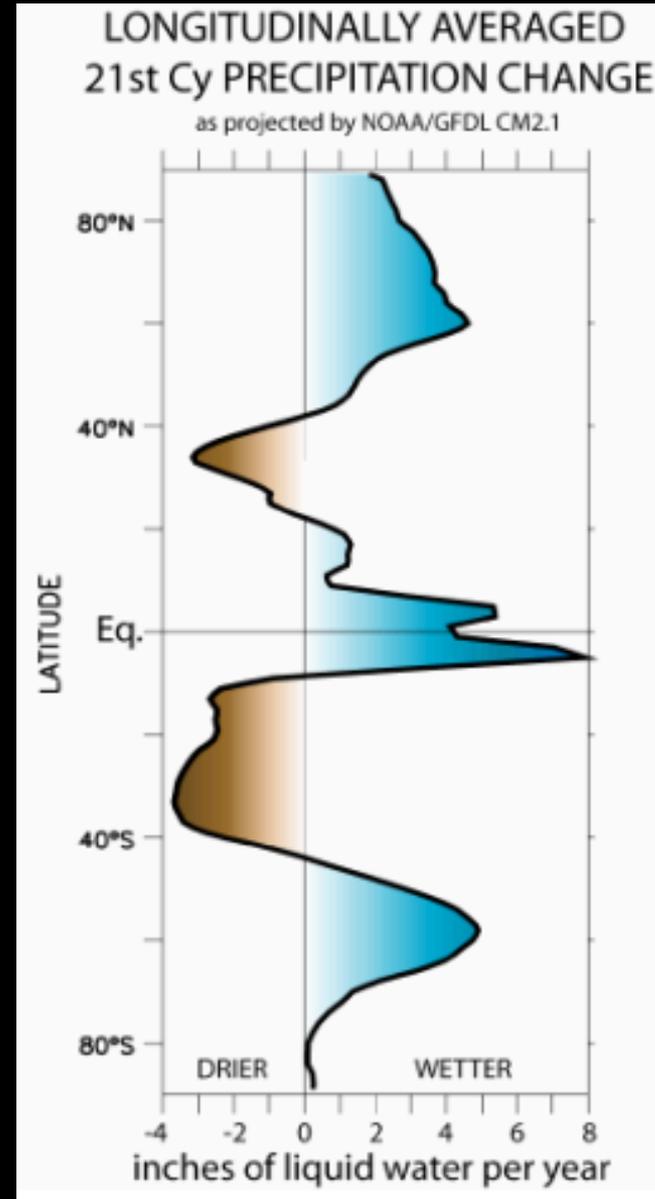
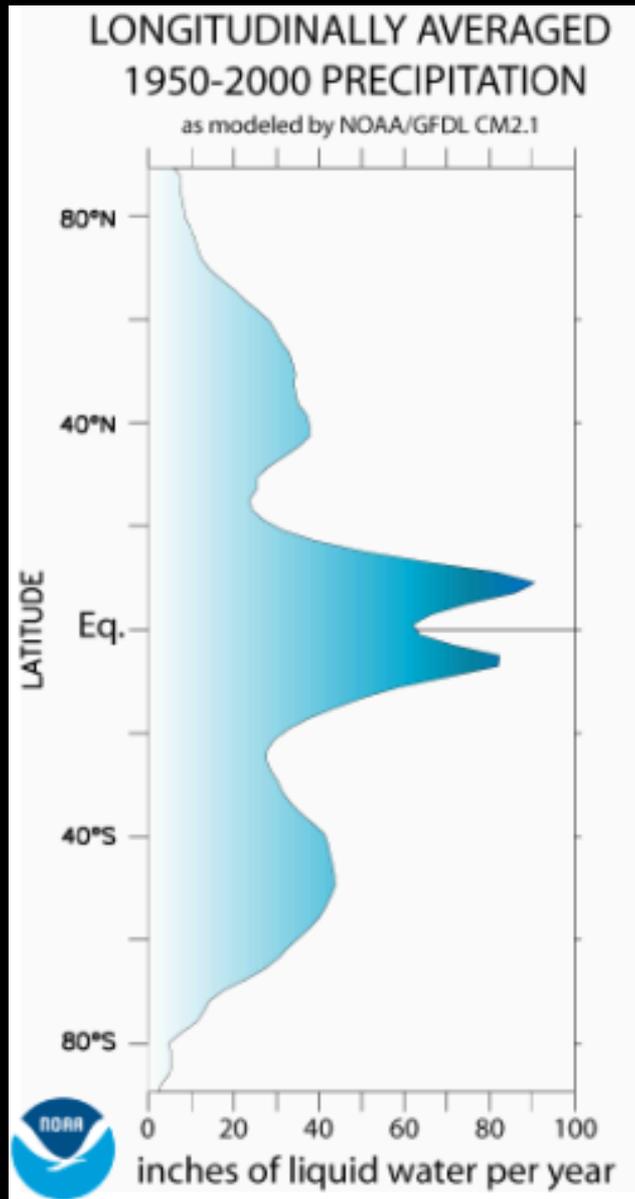
b) max. 5 day precip RCP8.5: 2081-2100



c) Consecutive Dry Days RCP8.5: 2081-2100



Precipitation changes: *Wet gets wetter and dry gets drier*

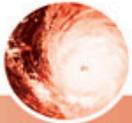


EXTREME WEATHER & CLIMATE CHANGE

→ Strongest Scientific Evidence Shows Human-Caused Climate Change Is Increasing Heat Waves and Coastal Flooding



TORNADOES



HURRICANES



SEVERE
DROUGHTS



EXTREME
PRECIPITATION
EVENTS



COASTAL
FLOODING



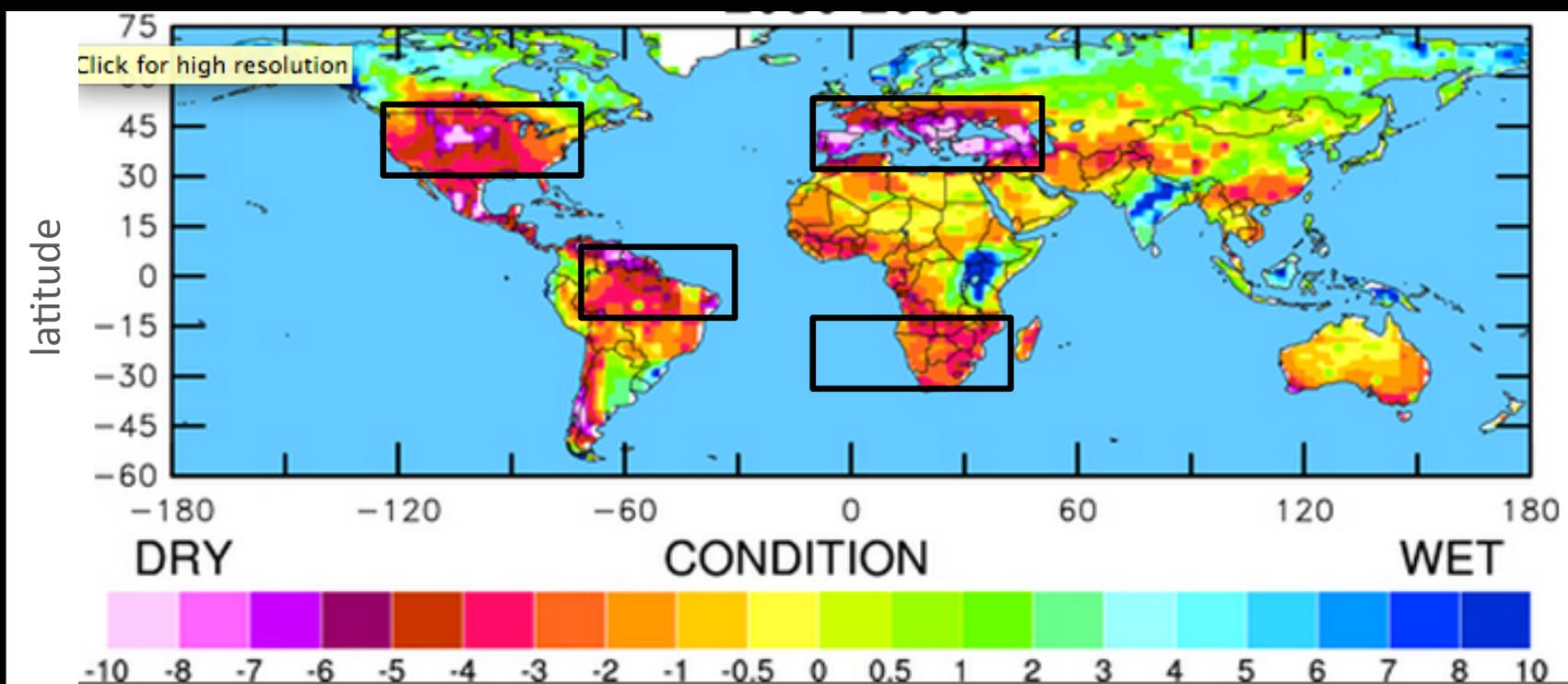
HEAT
WAVES

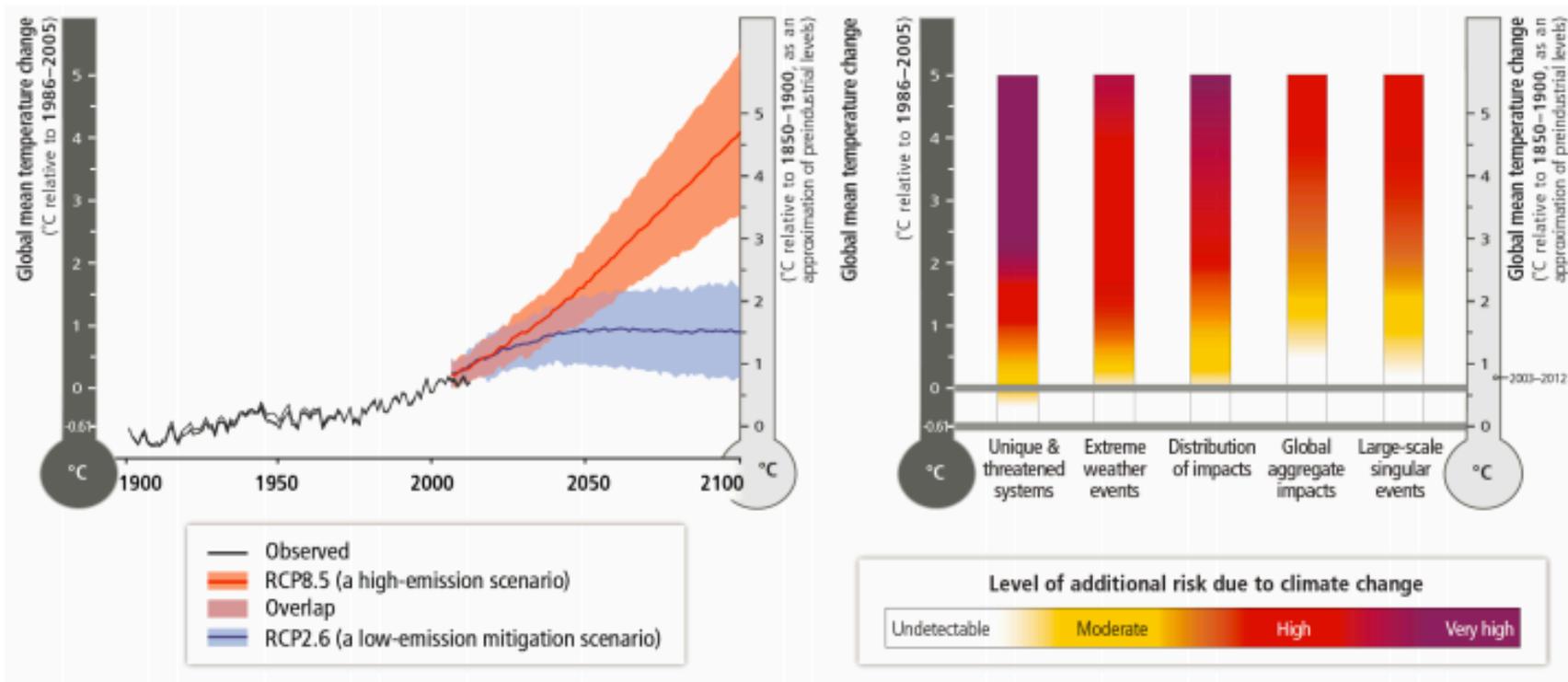
Limited
Evidence

Strong
Evidence

Strongest
Evidence

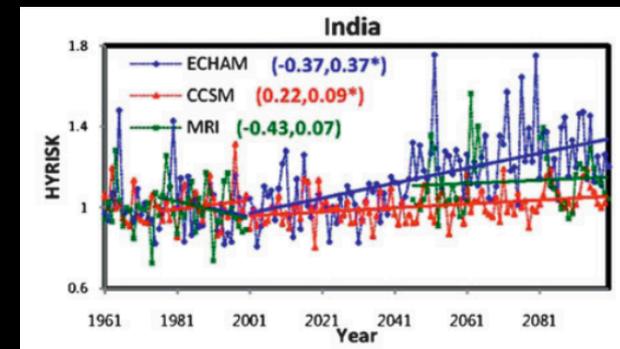
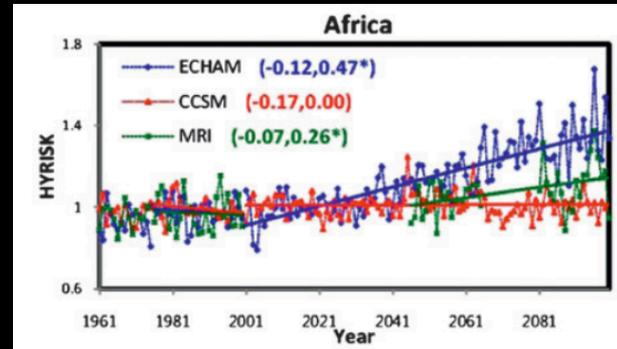
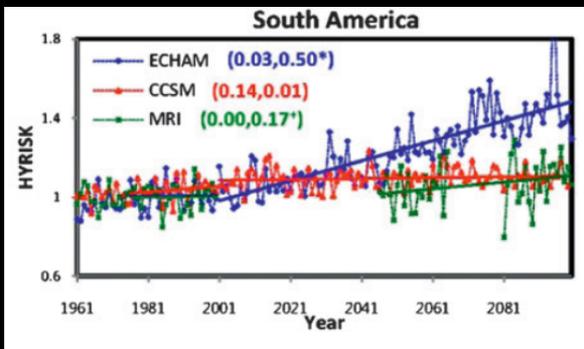
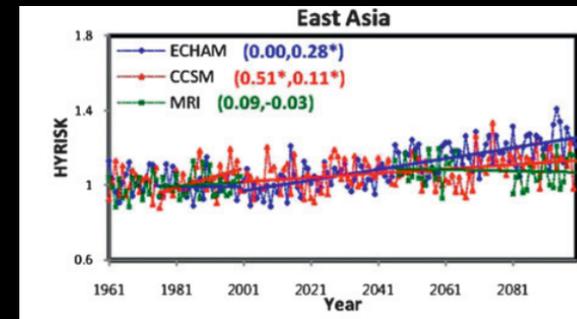
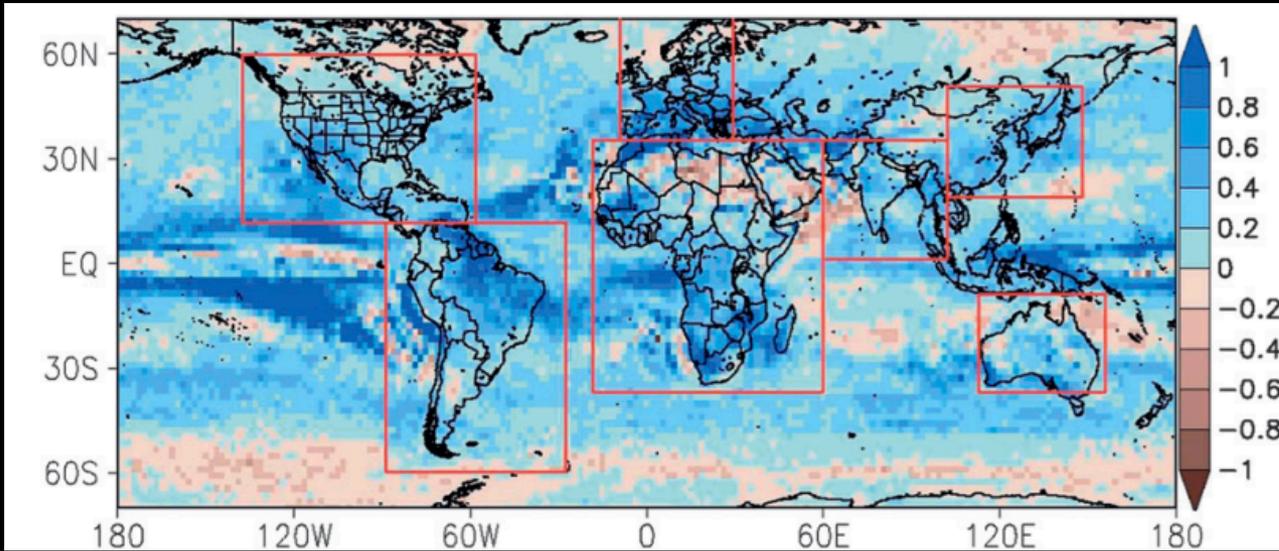
Mid-21st century drought projections





Assessment Box SPM.1 Figure 1.

HYDROCLIMATIC INTENSITY



Measure of tropical cyclone strength

Theory and some modeling studies suggest increase in stronger storms

