U.S. Global Change Research Program

Fourth National Climate Assessment, Vol II —

Selected Materials from Chapters 1, 2, 3, 28 & 29:

Overview, Changing Climate, Water, Adaptation and Mitigation

With additional materials from other sources, including IPCC SR-15

Which future?

Projected climate change in the coming decades

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1 Introduction: NCA4 Vol II

- Earth's climate is now changing faster than at any point in modern civilization
- These changes are primarily the result of human activities, the evidence of which is overwhelming and continues to strengthen
- The impacts of climate change are already being felt across the country, and climate-related threats to Americans' physical, social, and economic well-being are rising
- Americans are responding in ways that can reduce risks, build resilience, and improve livelihoods
- However, neither global efforts to mitigate the causes of climate change nor regional efforts to adapt to the impacts currently approach the scales needed to avoid substantial damages to the U.S. economy, environment, and human health and well-being over the coming decades

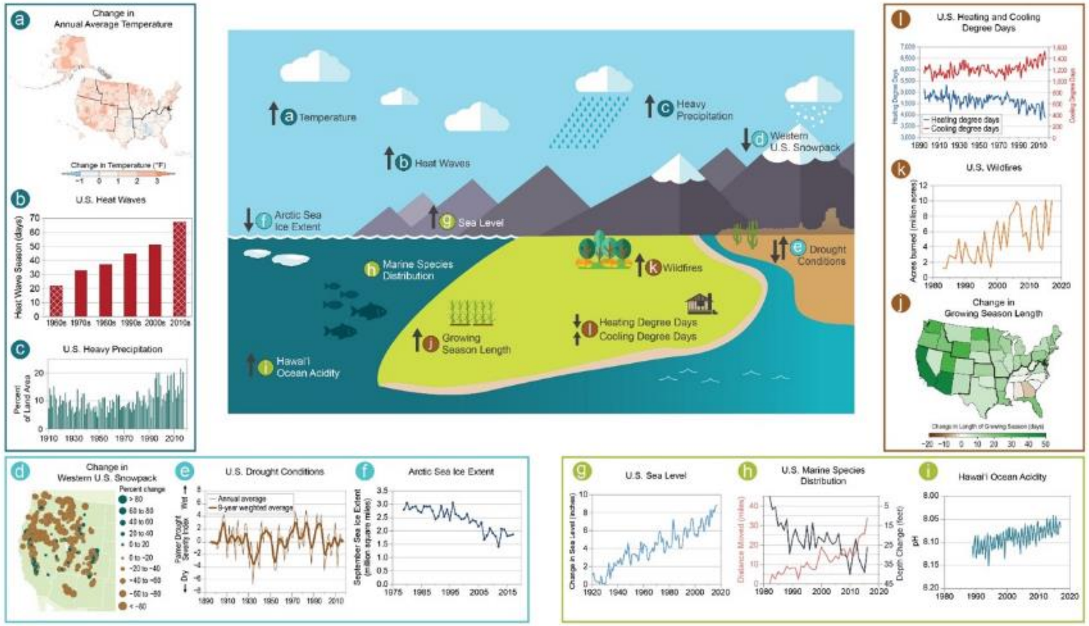


Fig. 1.2: Climate Change Indicators

Long-term observations demonstrate the warming trend in the climate system and the effects of increasing atmospheric greenhouse gas concentrations *(Ch. 2: Climate, Box 2.2)*. This figure shows climate-relevant indicators of change based on data collected across the United States. Upward-pointing arrows indicate an increasing trend; downward-pointing arrows indicate a decreasing trend. Bidirectional arrows (e.g., for drought conditions) indicate a lack of a definitive national trend. For a detailed description of each panel, view the full figure caption online at https://nca2018.globalchange.gov/chapter/1#fig-2. *Sources: (a) adapted from Vose et al. 2017, (b) EPA, (c–f and h–l) adapted from EPA 2016, (g and center infographic) EPA and NOAA.*

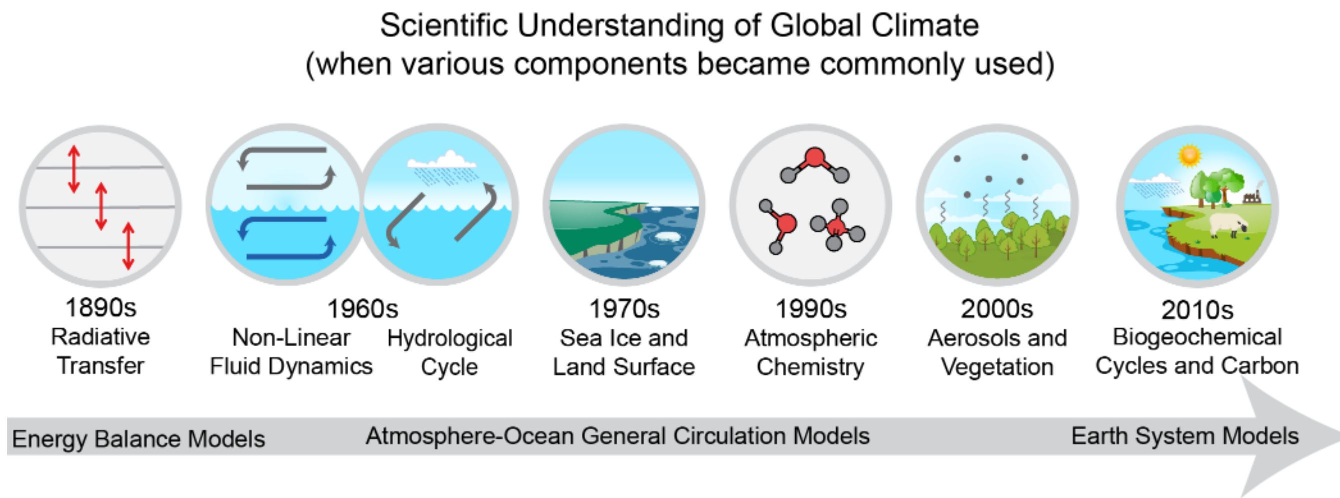


Fig. 2.10: Scientific Understanding of Global Climate

As scientific understanding of climate has evolved over the last 120 years, increasing amounts of physics, chemistry, and biology have been incorporated into calculations, and eventually, models. This figure shows when various processes and components of the climate system became regularly included in scientific understanding of global climate and, over the second half of the century as computing resources became available, formalized in global climate models. *Source: Hayhoe et al. 2017.*[24]

Fig. 2.1: Human and Natural Influences on Global Temperature

Both human and natural factors influence Earth's climate, but the long-term global warming trend observed over the past century can only be explained by the effect that human activities have had on the climate.

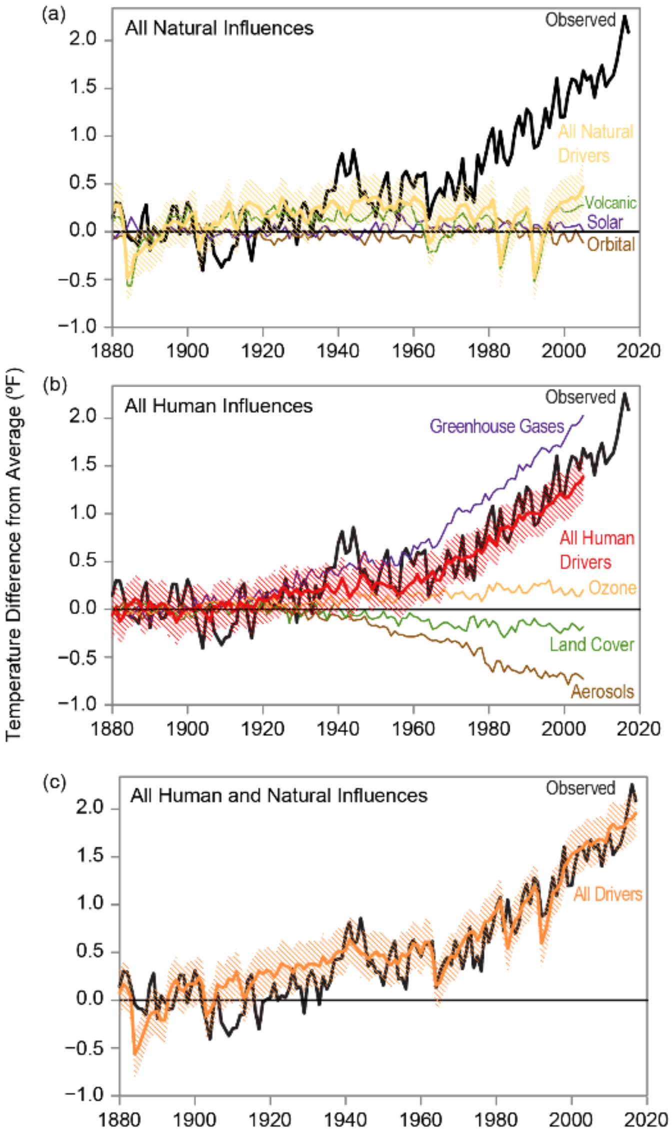
Sophisticated computer models of Earth's climate system allow scientists to explore the effects of both natural and human factors. In all three panels of this figure, the black line shows the observed annual average global surface temperature for 1880–2017 as a difference from the average value for 1880–1910.

The top panel (a) shows the temperature changes simulated by a climate model when only natural factors (yellow line) are considered. The other lines show the individual contributions to the overall effect from observed changes in Earth's orbit (brown line), the amount of incoming energy from the sun (purple line), and changes in emissions from volcanic eruptions (green line). Note that no long-term trend in globally-averaged surface temperature over this time period would be expected from natural factors alone.[10]

The middle panel (b) shows the simulated changes in global temperature when considering only human influences (dark red line), including the contributions from emissions of greenhouse gases (purple line) and small particles (referred to as aerosols, brown line) as well as changes in ozone levels (orange line) and changes in land cover, including deforestation (green line). Changes in aerosols and land cover have had a net cooling effect in recent decades, while changes in near-surface ozone levels have had a small warming effect.[18] These smaller effects are dominated by the large warming influence of greenhouse gases such as carbon dioxide and methane. Note that the net effect of human factors (dark red line) explains most of the long-term warming trend.

The bottom panel (c) shows the temperature change (orange line) simulated by a climate model when both human and natural influences are included. The result matches the observed temperature record closely, particularly since 1950, making the dominant role of human drivers plainly visible.

Researchers do not expect climate models to exactly reproduce the specific timing of actual weather events or short-term climate variations, but they do expect the models to capture how the whole climate system behaves over long periods of time. The simulated temperature lines represent the average values from a large number of simulation runs. The orange hatching represents uncertainty bands based on those simulations. For any given year, 95% of the simulations will lie inside the orange bands. *Source: NASA GISS.*



How well do climate models work?

- Additional non-NCA4 materials
- Climate Models Results
- Climate Extremes

Simulation of Global Surface Temperature Anomalies

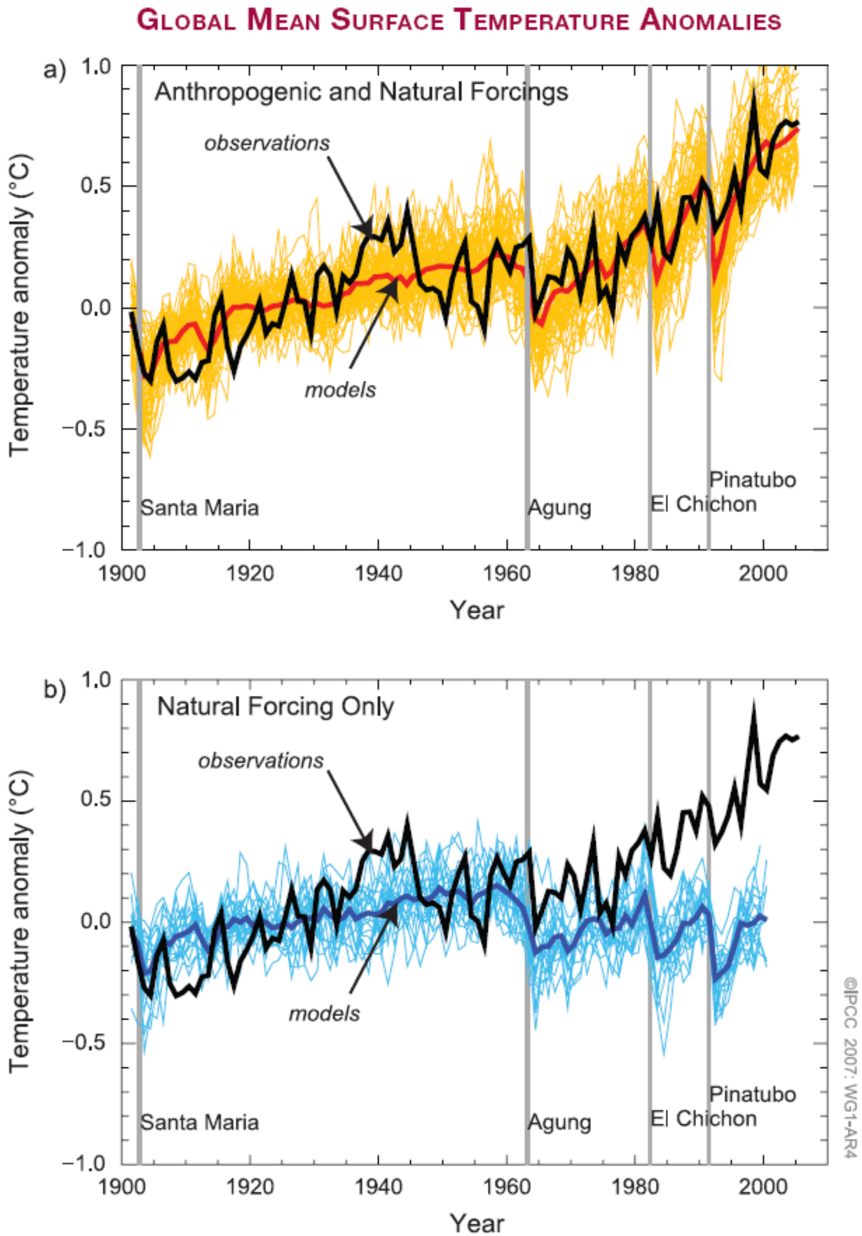


Figure TS.23. *(a) Global mean surface temperature anomalies relative to the period 1901 to 1950, as observed (black line) and as obtained from simulations with both anthropogenic and natural forcings. The thick red curve shows the multi-model ensemble mean and the thin yellow curves show the individual simulations. Vertical grey lines indicate the timing of major volcanic events. (b) As in (a), except that the simulated global mean temperature anomalies are for natural forcings only. The thick blue curve shows the multi-model ensemble mean and the thin lighter blue curves show individual simulations. Each simulation was sampled so that coverage corresponds to that of the observations. {Figure 9.5}*

- Ensemble comparison of model results with the observational record (IPCC 2007 Report).
- Models were run twice:
- Once with all forcing including anthropogenic CO_2 inputs.
- Second time without anthropogenic CO_2 inputs.

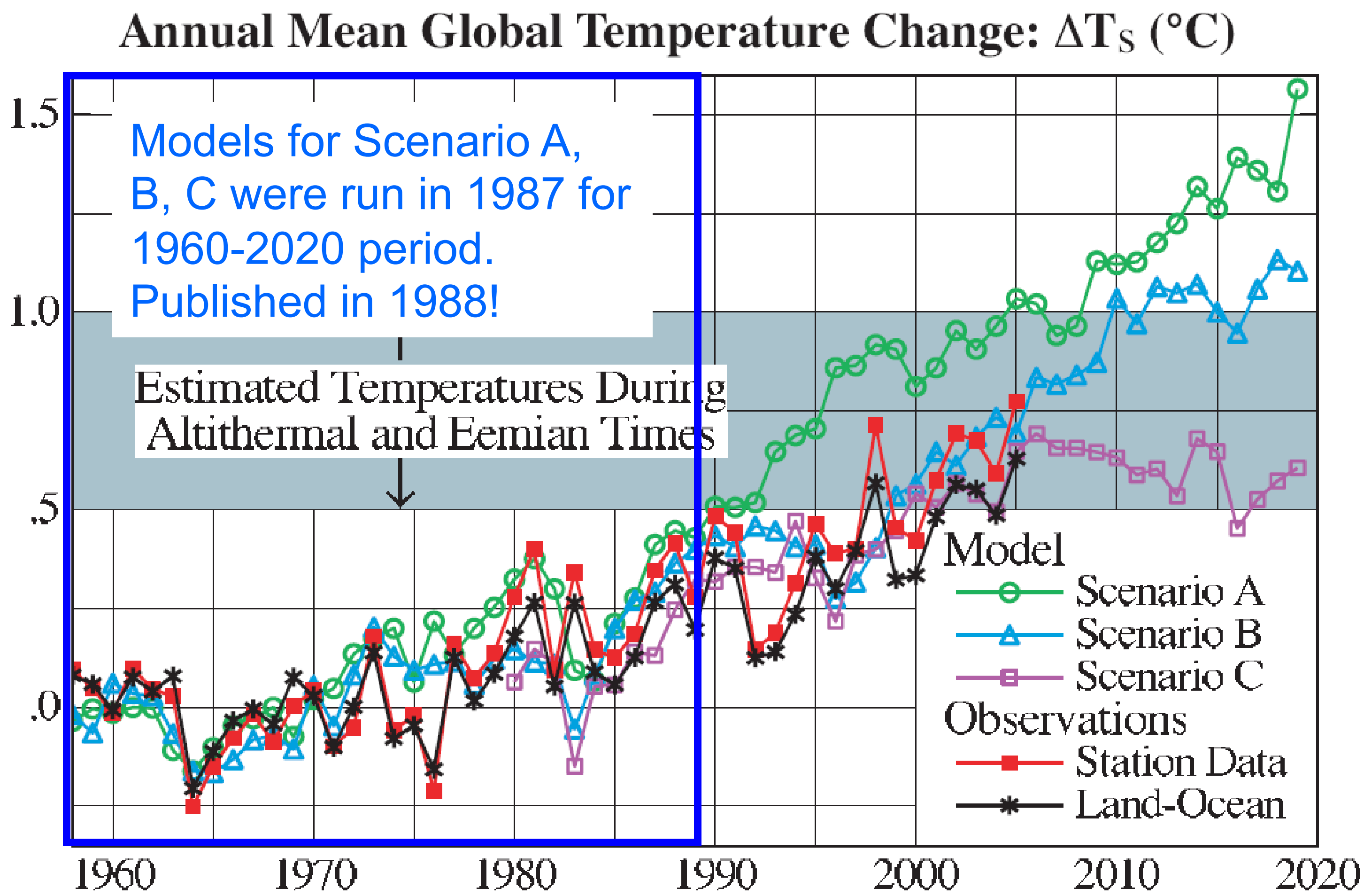
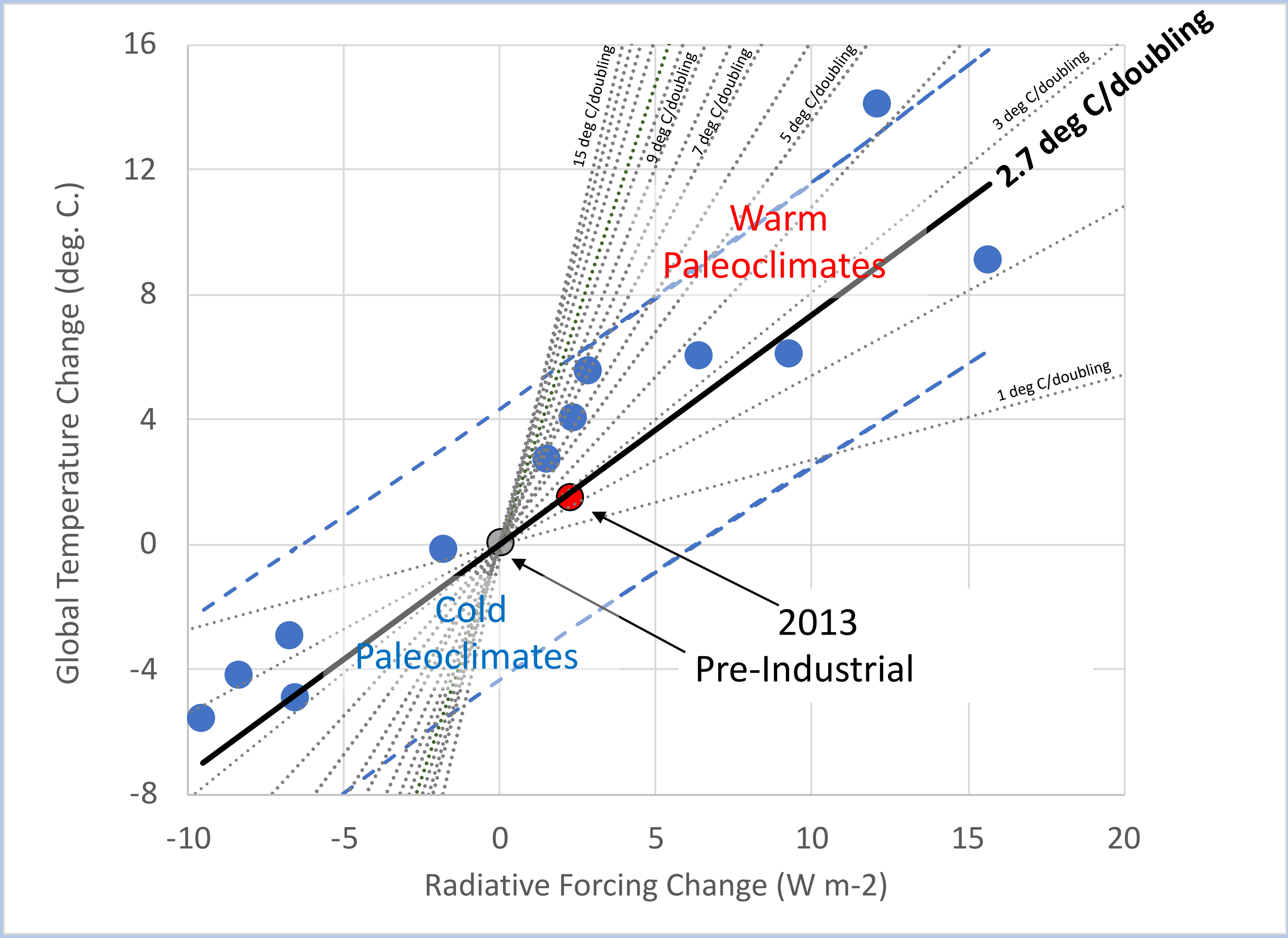


Fig. 2. Global surface temperature computed for scenarios A, B, and C (12), compared with two analyses of observational data. The 0.5°C and 1°C temperature levels, relative to 1951–1980, were estimated (12) to be maximum global temperatures in the Holocene and the prior interglacial period, respectively.

Click for animated model vs. data comparisons

Earth’s Climate sensitivity



After: *Skinner, Science, 337: 917-919 2012*

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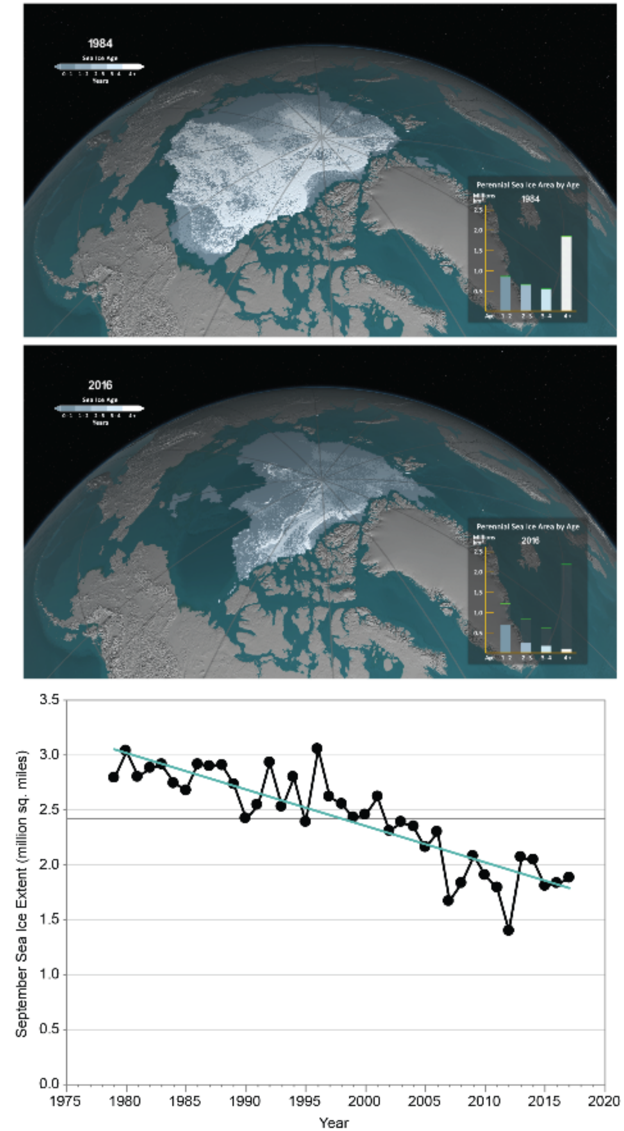
Fig. 2.7: Diminishing Arctic Sea Ice

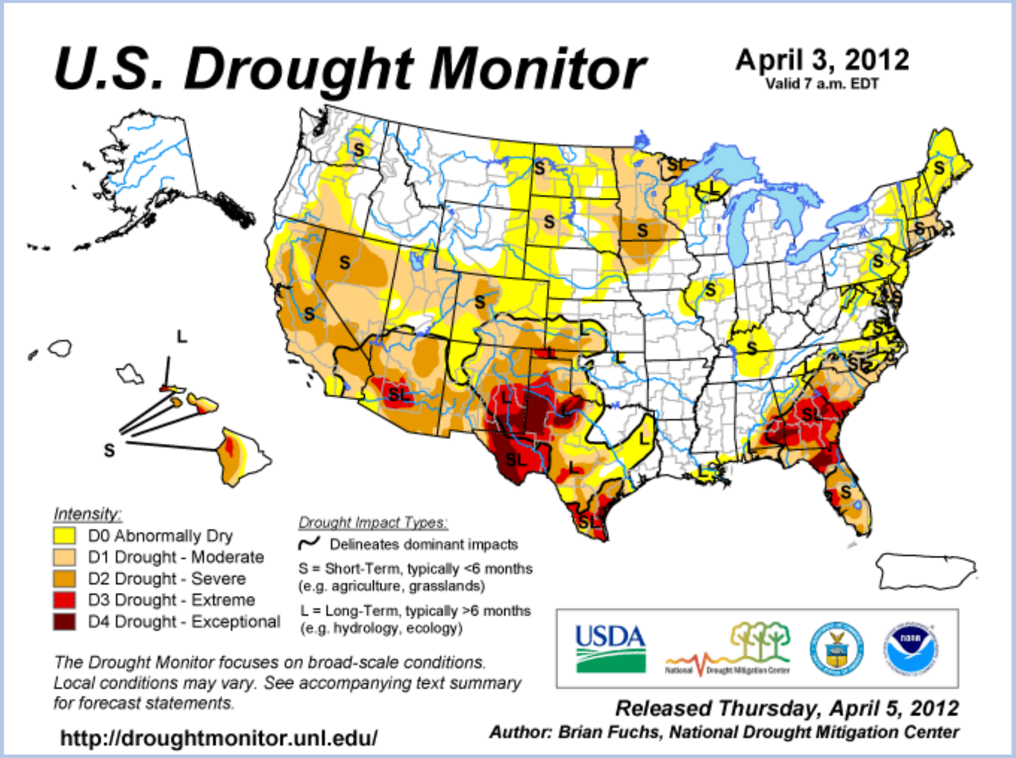
As the Arctic warms, sea ice is shrinking and becoming thinner and younger. The top and middle panels show how the summer minimum ice extent and average age, measured in September of each year, changed from 1984 (top) to 2016 (middle). An animation of the complete time series is available at http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4489. September sea ice extent each year from 1979 (when satellite observations began) to 2016, has decreased at a rate of 13.3% ± 2.6% per decade (bottom). The gray line is the 1979–2016 average. *Source: adapted from Taylor et al. 2017.*[122]



Let’s consider extreme events and how they are shifting...

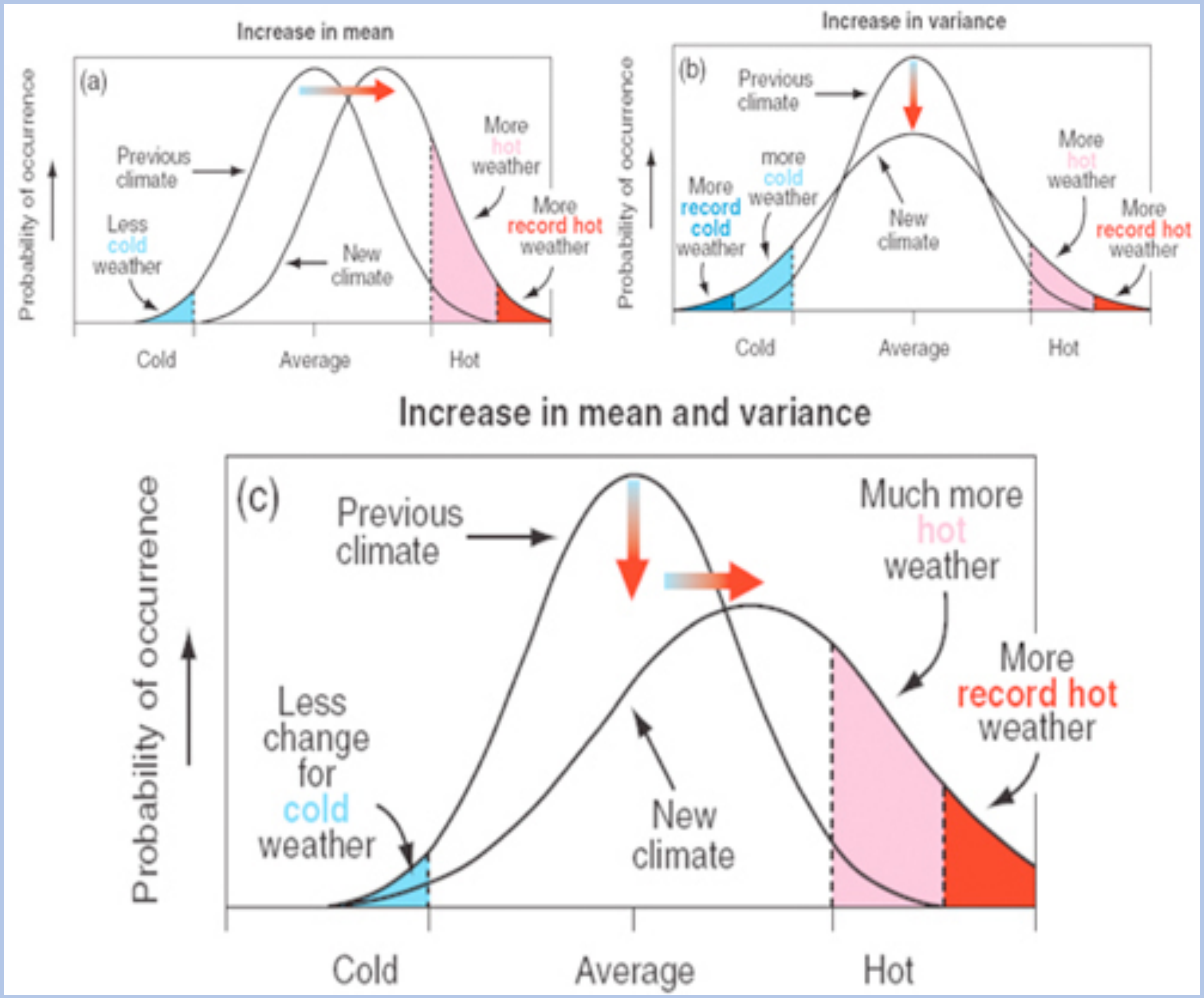
Extreme Events

- A warmer atmosphere is a more energetic atmosphere
- Increasing mean and variance can translate into greater climate extremes



Source NOAA: http://www.ncdc.noaa.gov/img/climate/research/2012/mar/usdm-120403.gif

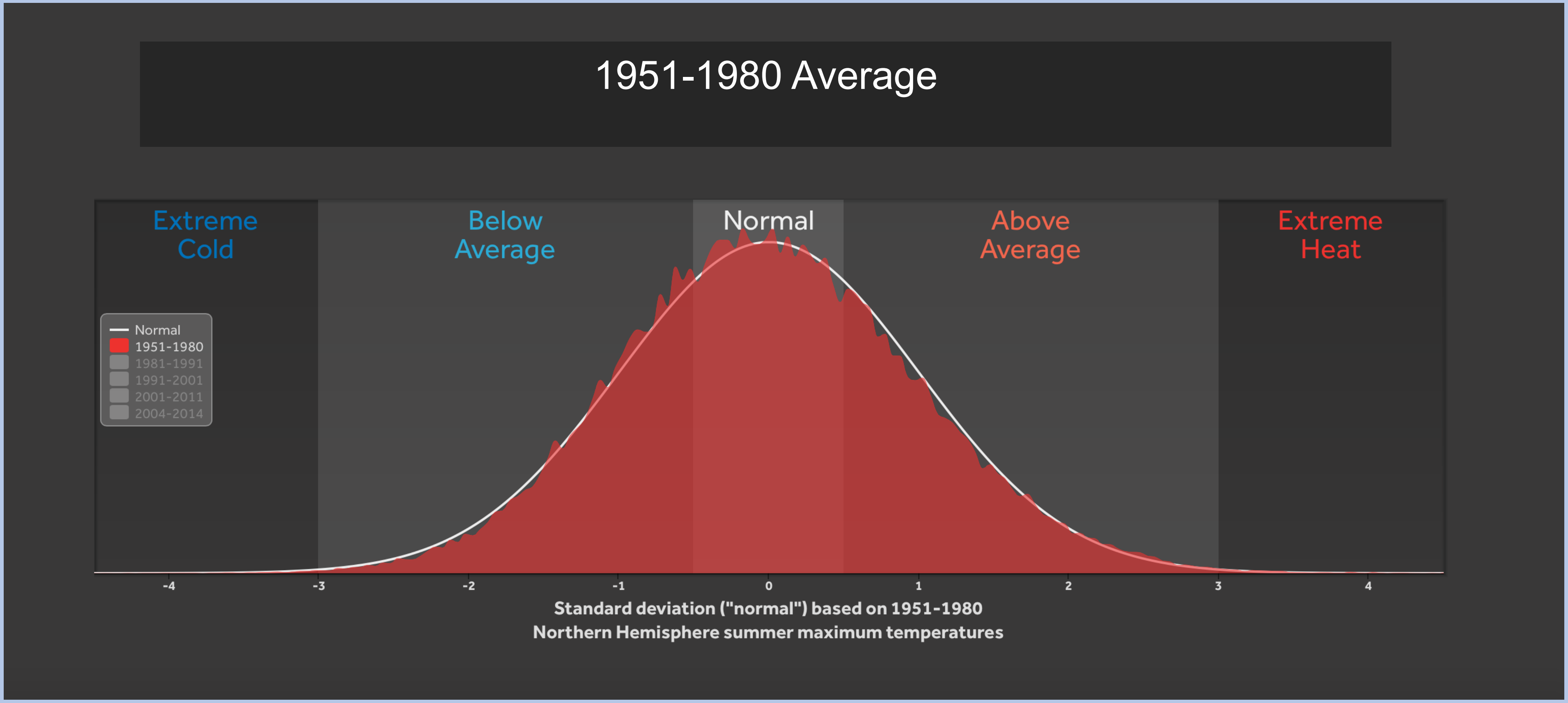
Shifting climate alters frequency of extreme events



Source: Minnesota SeaGrant

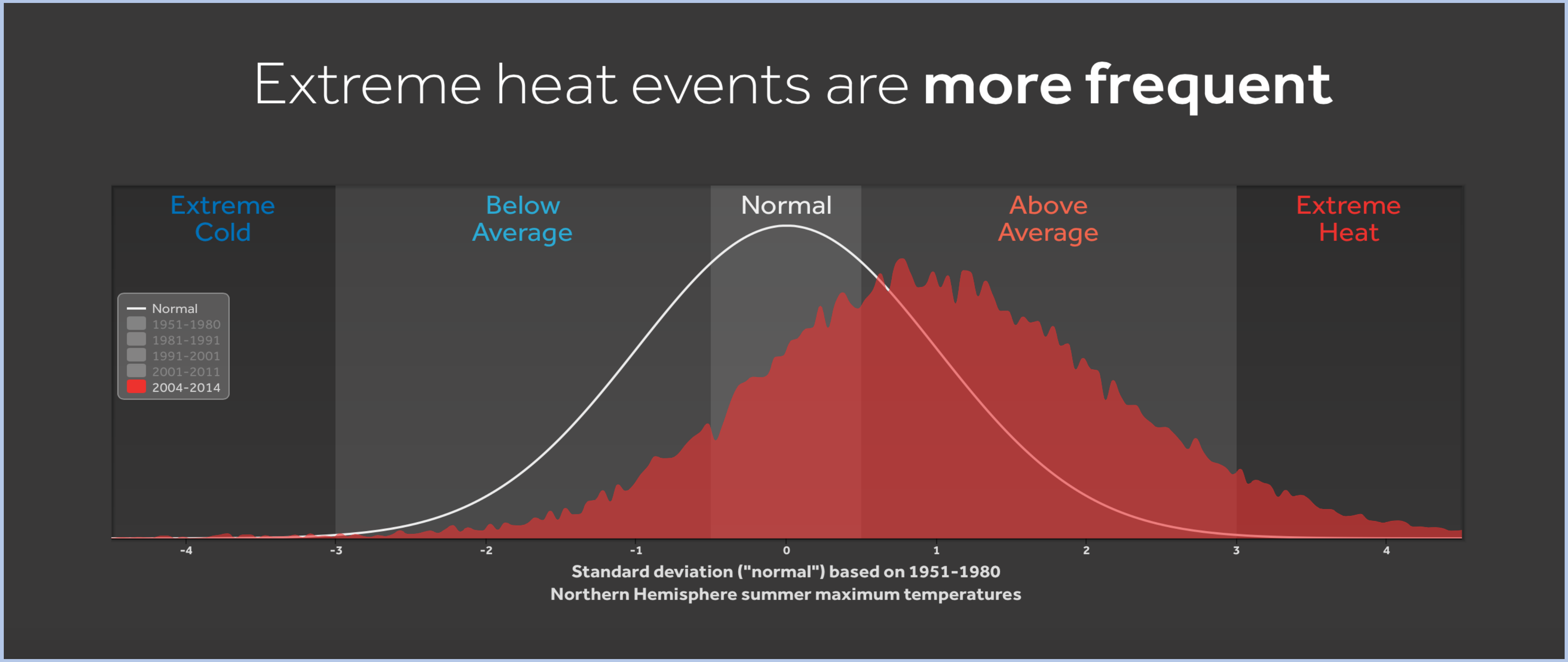
http://www.seagrant.umn.edu/climate/expect

Northern Hemisphere Summer Maximum Temp 1951-80 vs. 2004-14



Source: Climate Central, WxShift project
http://wxshift.com/climate-change/climate-indicators/extreme-heat

Northern Hemisphere Summer Maximum Temp 1951-80 vs. 2004-14



Source: Climate Central, WxShift project
http://wxshift.com/climate-change/climate-indicators/extreme-heat

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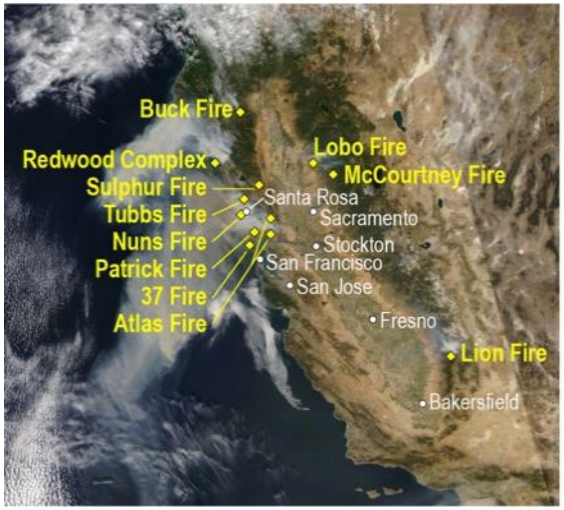


Fig. 1.5: Wildfire at the Wildland-Urban Interface

Wildfires are increasingly encroaching on American communities, posing threats to lives, critical infrastructure, and property. In October 2017, more than a dozen fires burned through northern California, killing dozens of people and leaving thousands more homeless. Communities distant from the fires were affected by poor air quality as smoke plumes darkened skies and caused the cancellation of school and other activities across the region. (left) A NASA satellite image shows active fires on October 9, 2017. (right) The Tubbs Fire, which burned parts of Napa, Sonoma, and Lake counties, was the most destructive in California's history. It caused an estimated $1.2 billion in damages and destroyed over 5,000 structures, including 5% of the housing stock in the city of Santa Rosa. *Image Credits: (left) NASA; (right) Tubbs Fire burn area by Master Sgt. David Loeffler, U.S. Air National Guard.*

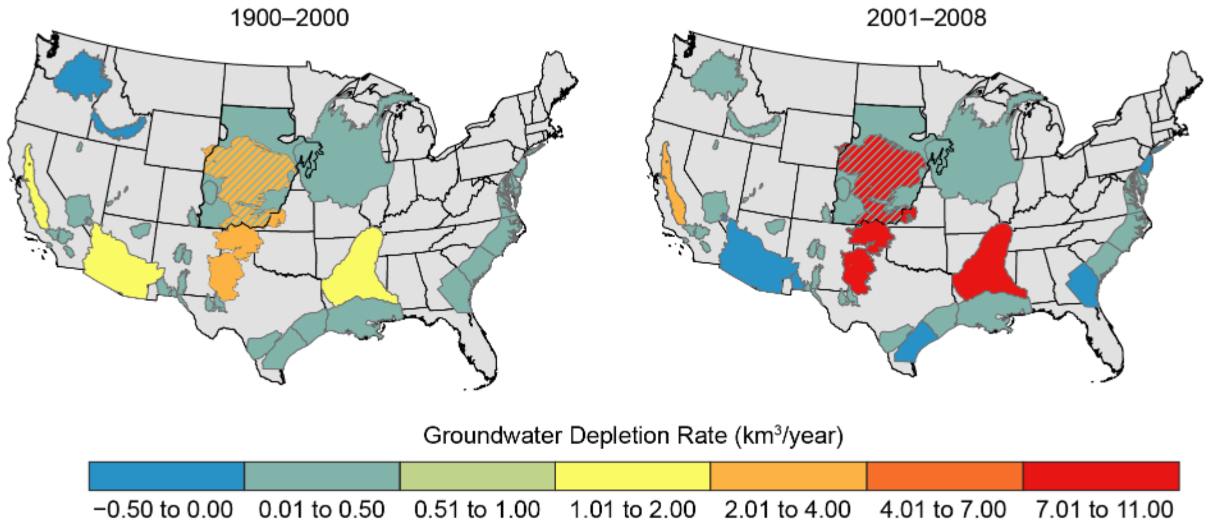
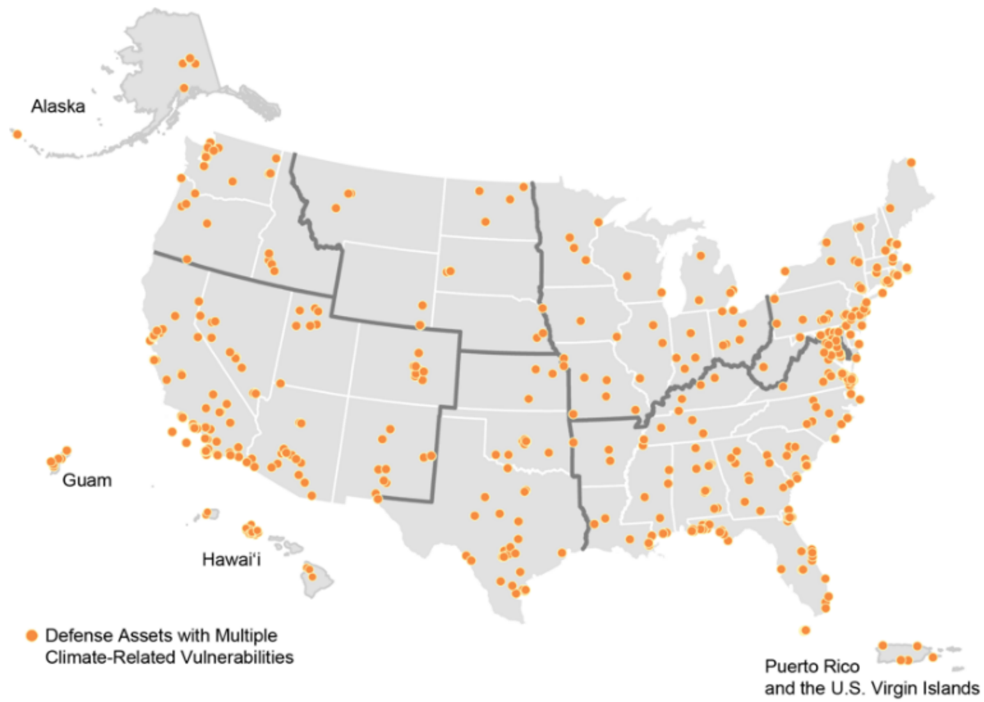


Fig. 3.2: Depletion of Groundwater in Major U.S. Regional Aquifers

(left) Groundwater supplies have been decreasing in the major regional aquifers of the United States over the last century (1900–2000). (right) This decline has accelerated recently (2001–2008) due to persistent droughts in many regions and the lack of adequate surface water storage to meet demands. This decline in groundwater compromises the ability to meet water needs during future droughts and impacts the functioning of groundwater dependent ecosystems (e.g., Kløve et al. 2014[3]). The values shown are net volumetric rates of groundwater depletion (km^3 per year) averaged over each aquifer. Subareas of an aquifer may deplete at faster rates or may be actually recovering. Hatching in the figure represents where the High Plains Aquifer overlies the deep, confined Dakota Aquifer. *Source: adapted from Konikow 2015.[4] Reprinted from Groundwater with permission of the National Groundwater Association. ©2015.*

Fig. 1.9: Weather and Climate-Related Impacts on U.S. Military Assets

The Department of Defense (DoD) has significant experience in planning for and managing risk and uncertainty. The effects of climate and extreme weather represent additional risks to incorporate into the Department's various planning and risk management processes. To identify DoD installations with vulnerabilities to climate-related impacts, a preliminary Screening Level Vulnerability Assessment Survey (SLVAS) of DoD sites worldwide was conducted in 2015. The SLVAS responses (shown for the United States; orange dots) yielded a wide range of qualitative information. The highest number of reported effects resulted from drought (782), followed closely by wind (763) and non-storm surge related flooding (706). About 10% of sites indicated being affected by extreme temperatures (351), while flooding due to storm surge (225) and wildfire (210) affected about 6% of the sites reporting. The survey responses provide a preliminary qualitative picture of DoD assets currently affected by severe weather events as well as an indication of assets that may be affected by sea level rise in the future. *Source: adapted from DOD 2018 (http://www.oea.gov/resource/2018-climate-related-risk-dod-infrastructure-initial-vulnerability-assessment-survey-slvas).*



1 Climate Change in the United States: *Current and Future Risks*

- Climate change presents growing challenges to: (1) the economy and our Nation's infrastructure, (2) the natural environment and the services ecosystems provide to society, and (3) human health and quality of life
- Risks posed by climate variability and change vary by region and sector and by the vulnerability of people experiencing impacts
- This report characterizes specific risks across regions and sectors in an effort to help people assess the risks they face, create and implement a response plan, and monitor and evaluate the efficacy of a given action

1 Natural Environment & Ecosystem Services

- Climate change threatens many benefits that the natural environment provides to society: safe and reliable water supplies, clean air, protection from flooding and erosion, and the use of natural resources for economic, recreational, and subsistence activities
- Valued aspects of regional heritage and quality of life tied to the natural environment, wildlife, and outdoor recreation will change with the climate, and as a result, future generations can expect to experience and interact with natural systems in ways that are much different than today
- Without significant reductions in greenhouse gas emissions, extinctions and transformative impacts on some ecosystems cannot be avoided, with varying impacts on the economic, recreational, and subsistence activities they support

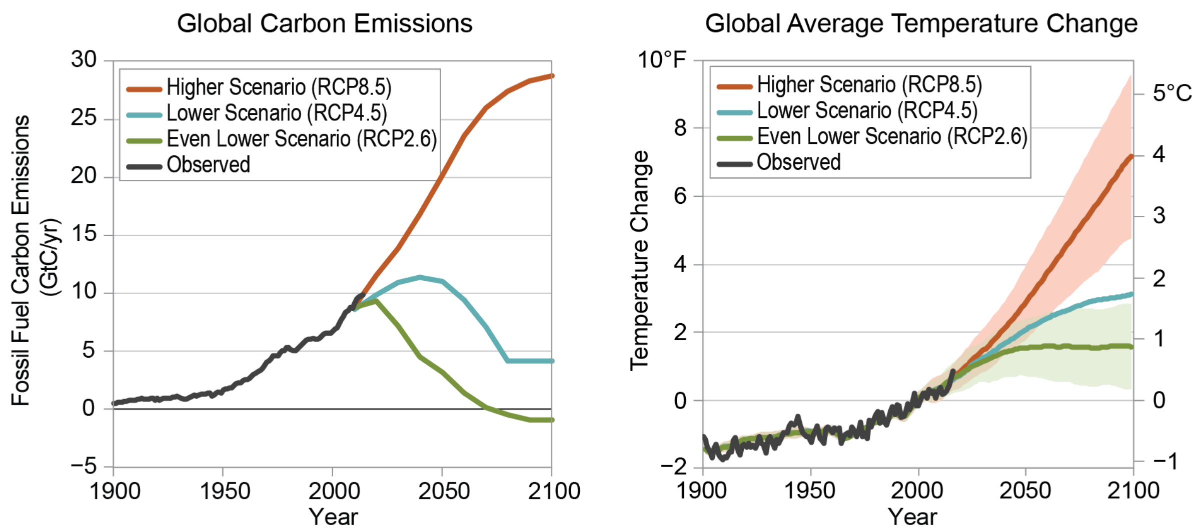


Fig. 2.2: Observed and Projected Changes in Carbon Emissions and Temperature

Observed and projected changes in global average temperature (right) depend on observed and projected emissions of carbon dioxide from fossil fuel combustion (left) and emissions of carbon dioxide and other heat-trapping gases from other human activities, including land use and land-use change. Under a pathway consistent with a higher scenario (RCP8.5), fossil fuel carbon emissions continue to increase throughout the century and by 2081–2100, global average temperature is projected to increase by 4.2°–8.5°F (2.4°–4.7°C; shown by the burnt orange shaded area) relative to the 1986–2015 average. Under a lower scenario (RCP4.5), fossil fuel carbon emissions peak mid-century then decrease, and global average temperature is projected to increase by 1.7°–4.4°F (0.9°–2.4°C; range not shown on graph) relative to 1986–2015. Under an even lower scenario (RCP2.6), assuming carbon emissions from fossil fuels have already peaked, temperature increases could be limited to 0.4°–2.7°F (0.2°–1.5°C; shown by green shaded area) relative to 1986–2015. Thick lines within shaded areas represent the average of multiple climate models. The shaded ranges illustrate the 5% to 95% confidence intervals for the respective projections. In all RCP scenarios, carbon emissions from land use and land-use change amount to less than 1 GtC by 2020 and fall thereafter. Limiting the rise in global average temperature to less than 2.2°F (1.2°C) relative to 1986–2015 is approximately equivalent to 3.6°F (2°C) or less relative to preindustrial temperatures, consistent with the aim of the Paris Agreement (see Box 2.4). *Source: adapted from Wuebbles et al. 2017.*[10]

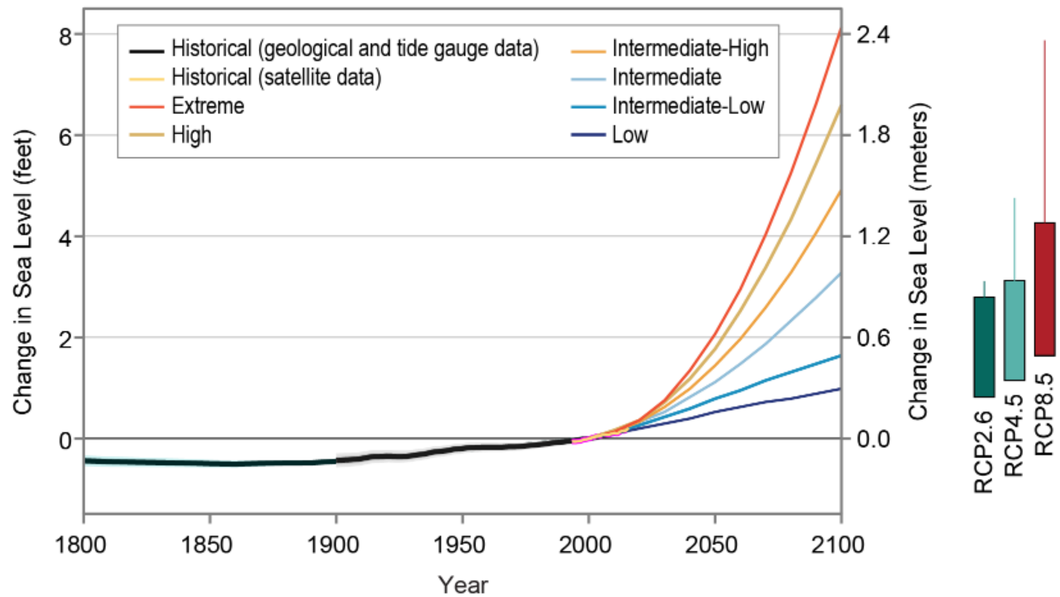


Fig. 2.3: Historical and Projected Global Average Sea Level Rise

How much global average sea level will rise over the rest of this century depends on the response of the climate system to warming, as well as on future scenarios of human-caused emissions of heat-trapping gases. The colored lines show the six different global average sea level rise scenarios, relative to the year 2000, that were developed by the U.S. Federal Interagency Sea Level Rise Taskforce[76] to describe the range of future possible rise this century. The boxes on the right-hand side show the *very likely* ranges in sea level rise by 2100, relative to 2000, corresponding to the different RCP scenarios described in Figure 2.2. The lines above the boxes show possible increases based on the newest research of the potential Antarctic contribution to sea level rise (for example, DeConto and Pollard 2016[80] versus Kopp et al. 2014[77]). Regardless of the scenario followed, it is *extremely likely* that global average sea level rise will continue beyond 2100. *Source: adapted from Sweet et al. 2017.*[57]

Fig. 2.5: Observed and Projected Change in Seasonal Precipitation

Observed and projected precipitation changes vary by region and season. (top) Historically, the Great Plains and the northeastern United States have experienced increased precipitation while the Southwest has experienced a decrease for the period 1986–2015 relative to 1901–1960. (middle and bottom) In the future, under the higher scenario (RCP8.5), the northern United States, including Alaska, is projected to receive more precipitation, especially in the winter and spring by the period 2070–2099 (relative to 1901–1960 for the contiguous United States and 1925–1960 for Alaska, Hawaiʻi, Puerto Rico, and the U.S. Virgin Islands). Parts of the southwestern United States are projected to receive less precipitation in the winter and spring. Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where changes are small and relatively insignificant. *Source: adapted from Easterling et al. 2017.*[94]

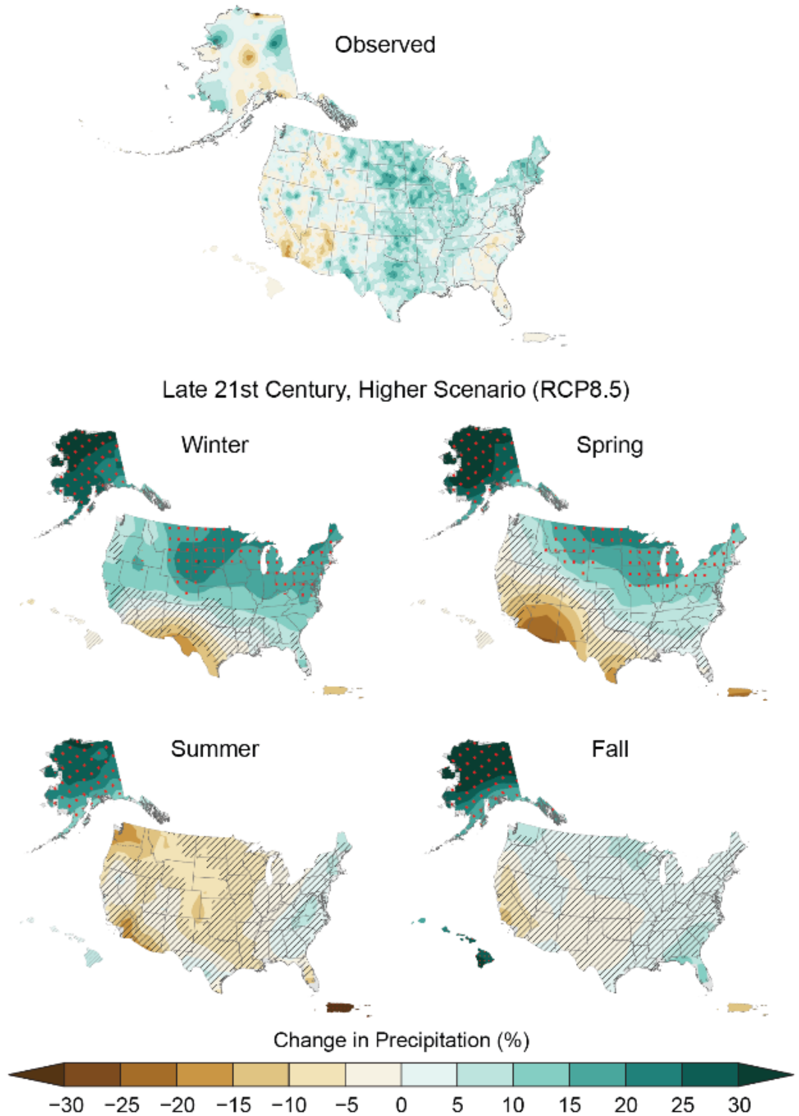
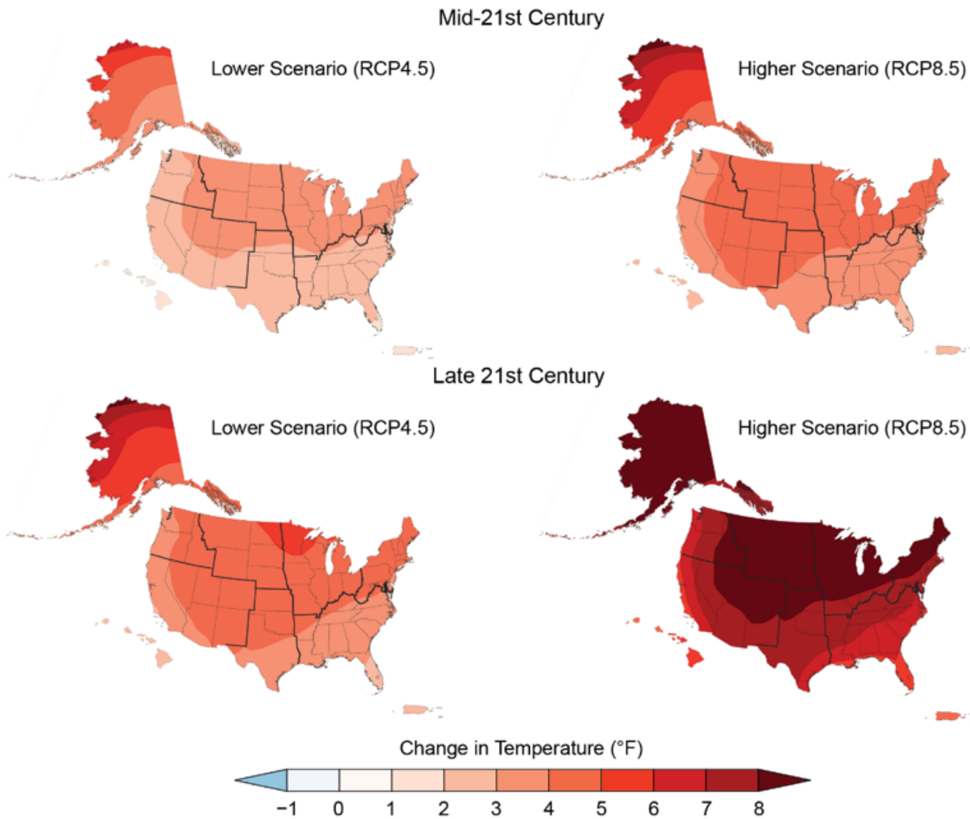


Fig. 1.3: Projected Changes in U.S. Annual Average Temperature

Annual average temperatures across the United States are projected to increase over this century, with greater changes at higher latitudes as compared to lower latitudes, and under a higher scenario (RCP8.5; right) than under a lower one (RCP4.5; left). This figure shows projected differences in annual average temperatures for mid-century (2036–2065; top) and end of century (2071–2100; bottom) relative to the near present (1986–2015). *From Figure 2.4, Ch. 2: Climate (Source: adapted from Vose et al. 2017).*



1 Economy & Infrastructure

- Many extreme weather and climate-related events are expected to become more frequent and more intense in a warmer world, creating greater risks of infrastructure disruption and failure that can cascade across economic sectors
- Regional economies and industries that depend on natural resources and favorable climate conditions, such as agriculture, tourism, and fisheries, are increasingly vulnerable to impacts driven by climate change
- Some aspects of our economy may see slight improvements in a modestly warmer world. However, the continued warming that is projected to occur without significant reductions in global greenhouse gas emissions is expected to cause substantial net damage to the U.S. economy, especially in the absence of increased adaptation efforts

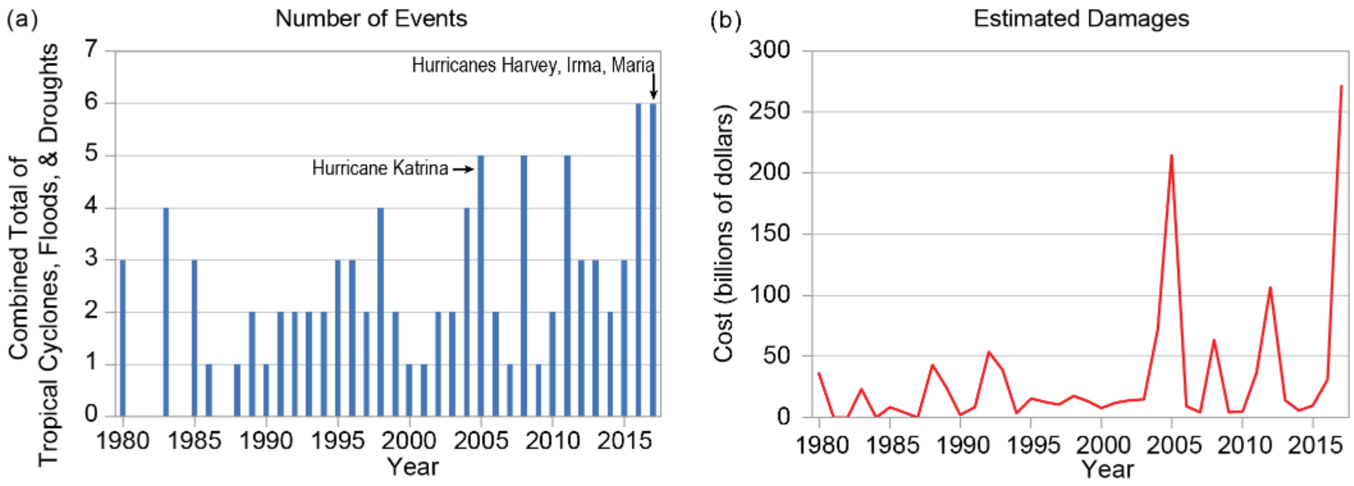


Fig. 3.1: Billion-Dollar Weather and Climate Disaster Events in the United States

The figure shows (a) the total number of water-related billion-dollar disaster events (tropical cyclones, flooding, and droughts combined) each year in the United States and (b) the associated costs (in 2017 dollars, adjusted for inflation). *Source: adapted from NOAA NCEI 2018.*[19]

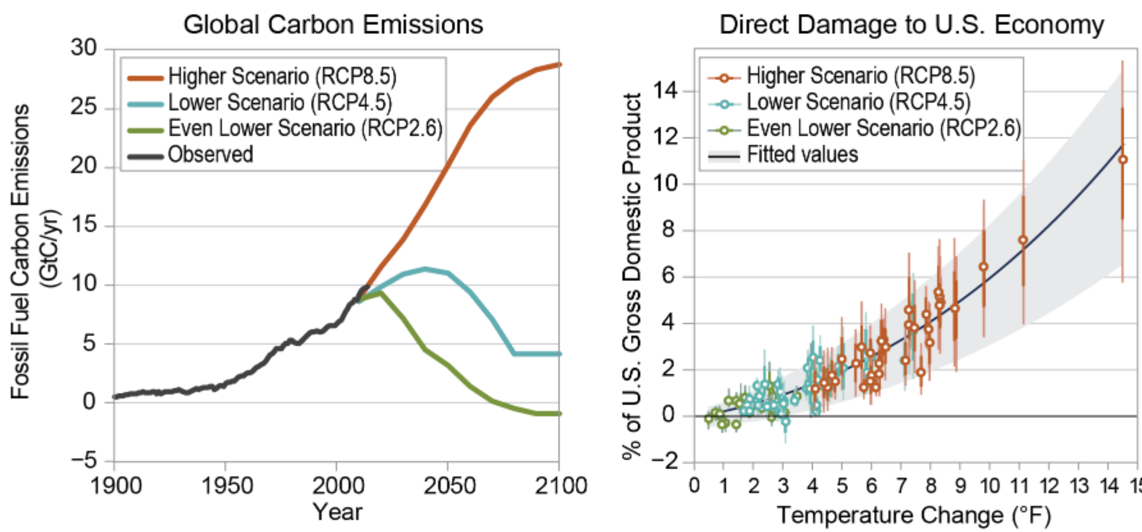


Fig. 29.3: Estimates of Direct Economic Damage from Temperature Change

The left graph shows the observed and projected changes in fossil fuel and industrial emissions of CO_2 from human activities (emissions from land-use change do not appear in the figure; within the RCPs these emissions are less than 1 GtC per year by 2020 and fall thereafter). The right graph shows projections of direct damage to the current U.S. economy for six impact sectors (agriculture, crime, coasts, energy, heat mortality, and labor) as a function of global average temperature change (represented as average for 2080–2099 compared to 1980–2010). Compared to RCP8.5, lower temperatures due to mitigation under either of the lower scenarios (RCP2.6 or RCP4.5) substantially reduce median damages (dots) to the U.S. economy while also narrowing the uncertainty in potential adverse impacts. Dot-whiskers indicate the uncertainty in direct damages in 2090 (average of 2080–2099) derived from multiple combinations of climate models and forcing scenarios (dot, median; thick line, inner 66% credible interval; thin line, inner 90%). The gray shaded area represents the 90% confidence interval in the fit (black line) to the damage estimates. Damage estimates only capture adaptation to the extent that populations employed them in the historical period. *Sources: (left) adapted from Wuebbles et al. 2017;*[83] *(right) adapted from Hsiang et al. 2017*[3] *and republished with permission of American Association for the Advancement of Science.*

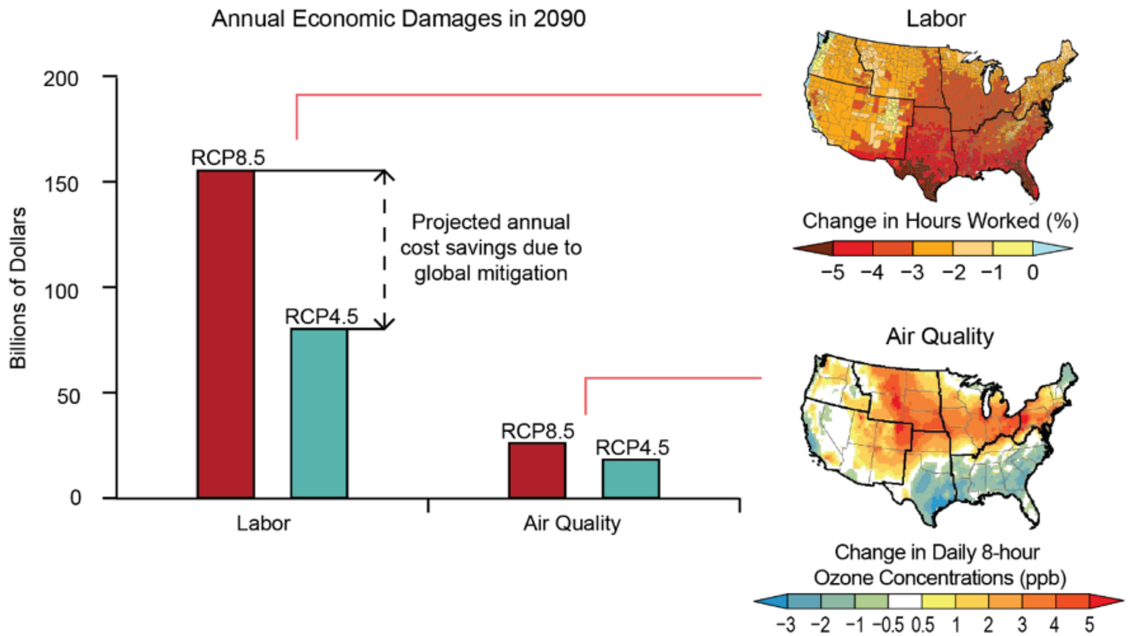


Fig. 1.21: New Economic Impact Studies

Annual economic impact estimates are shown for labor and air quality. The bar graph on the left shows national annual damages in 2090 (in billions of 2015 dollars) for a higher scenario (RCP8.5) and lower scenario (RCP4.5); the difference between the height of the RCP8.5 and RCP4.5 bars for a given category represents an estimate of the economic benefit to the United States from global mitigation action. For these two categories, damage estimates do not consider costs or benefits of new adaptation actions to reduce impacts, and they do not include Alaska, Hawai‘i and U.S.-Affiliated Pacific Islands, or the U.S. Caribbean. The maps on the right show regional variation in annual impacts projected under the higher scenario (RCP8.5) in 2090. The map on the top shows the percent change in hours worked in high-risk industries as compared to the period 2003–2007. The hours lost result in economic damages: for example, $28 billion per year in the Southern Great Plains. The map on the bottom is the change in summer-average maximum daily 8-hour ozone concentrations (ppb) at ground-level as compared to the period 1995–2005. These changes in ozone concentrations result in premature deaths: for example, an additional 910 premature deaths each year in the Midwest. *Source: EPA, 2017. Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment. U.S. Environmental Protection Agency, EPA 430-R-17-001.*

1 Reducing the Risks of Climate Change

- Many climate change impacts and economic damages in the United States can be substantially reduced through global-scale reductions in greenhouse gas emissions complemented by regional and local adaptation efforts
- Since the Third National Climate Assessment (NCA3) in 2014, a growing number of states, cities, and businesses have pursued or expanded upon initiatives aimed at reducing greenhouse gas emissions, and the scale of adaptation implementation across the country has increased
- However, these efforts do not yet approach the scale needed to avoid substantial damages to the economy, environment, and human health expected over the coming decades

Fig. 1.1: Americans Respond to the Impacts of Climate Change

This map shows climate-related impacts that have occurred in each region since the Third National Climate Assessment in 2014 and response actions that are helping the region address related risks and costs. These examples are illustrative; they are not indicative of which impact is most significant in each region or which response action might be most effective. *Source: NCA4 Regional Chapters.*

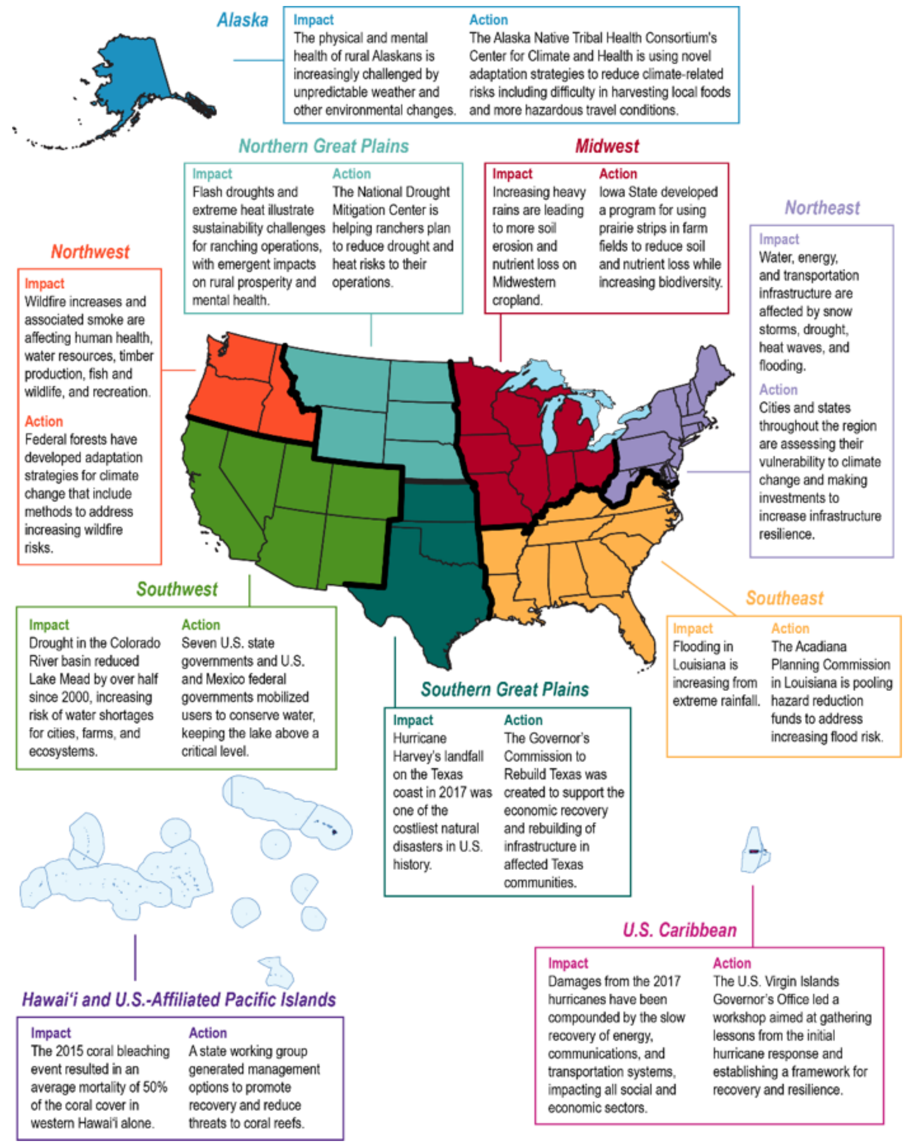


Fig. 1.10: Conservation Practices Reduce Impact of Heavy Rains

Increasing heavy rains are leading to more soil erosion and nutrient loss on midwestern cropland. Integrating strips of native prairie vegetation into row crops has been shown to reduce soil and nutrient loss while improving biodiversity. The inset shows a close-up example of a prairie vegetation strip. *From Figure 21.2, Ch. 21: Midwest. (Photo credits: [main photo] Lynn Betts; [inset] Farnaz Kordbacheh).*

Fig. 1.17: Community Relocation – Isle de Jean Charles, Louisiana

(left) A federal grant is being used to relocate the tribal community of Isle de Jean Charles, Louisiana, in response to severe land loss, sea level rise, and coastal flooding. *From Figure 15.3, Ch. 15: Tribes (Photo credit: Ronald Stine).*

(right) As part of the resettlement of the tribal community of Isle de Jean Charles, residents are working with the Lowlander Center and the State of Louisiana to finalize a plan that reflects the desires of the community. *From Figure 15.4, Ch. 15: Tribes (Photo provided by Louisiana Office of Community Development).*

Fig. 1.19: Mitigation-Related Activities at State and Local Levels

(top) The map shows the number of mitigation-related activities at the state level (out of 30 illustrative activities) as well as cities supporting emissions reductions; **(bottom)** the chart depicts the type and number of activities by state. Several territories also have a variety of mitigation-related activities, including American Sāmoa, the Federated States of Micronesia, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands. *From Figure 29.1, Ch. 29: Mitigation (Sources: [top] EPA and ERT, [bottom] adapted from America's Pledge 2017).*

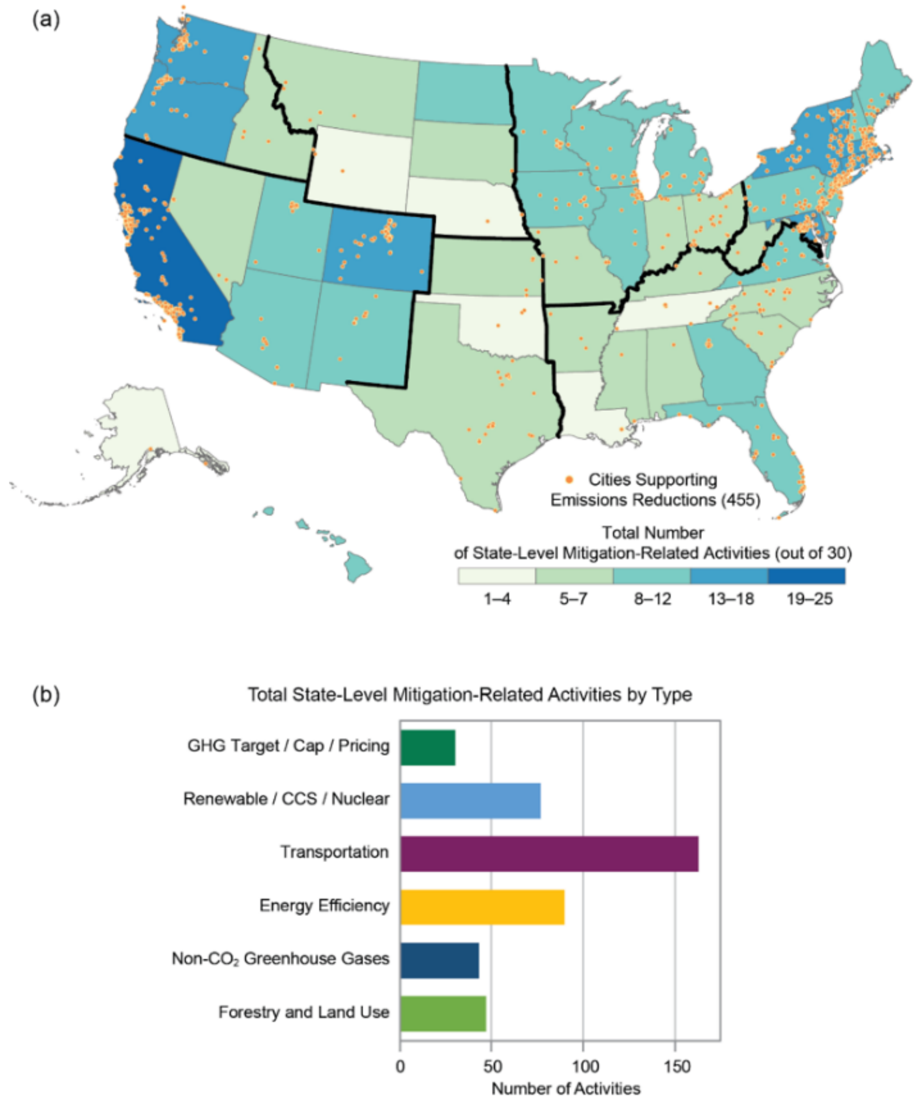


Fig. 29.1: Mitigation-Related Activities at State and Local Levels

The map (a) shows the number of mitigation-related activities at the state level (out of 30 illustrative activities) as well as cities supporting emissions reductions; the chart (b) depicts the type and number of activities by state.[36] Several territories also have a variety of mitigation-related activities including American Sāmoa, the Federated States of Micronesia, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands.[42,45] *Sources: (a) EPA and ERT, Inc.; (b) adapted from America's Pledge 2017.*[36]

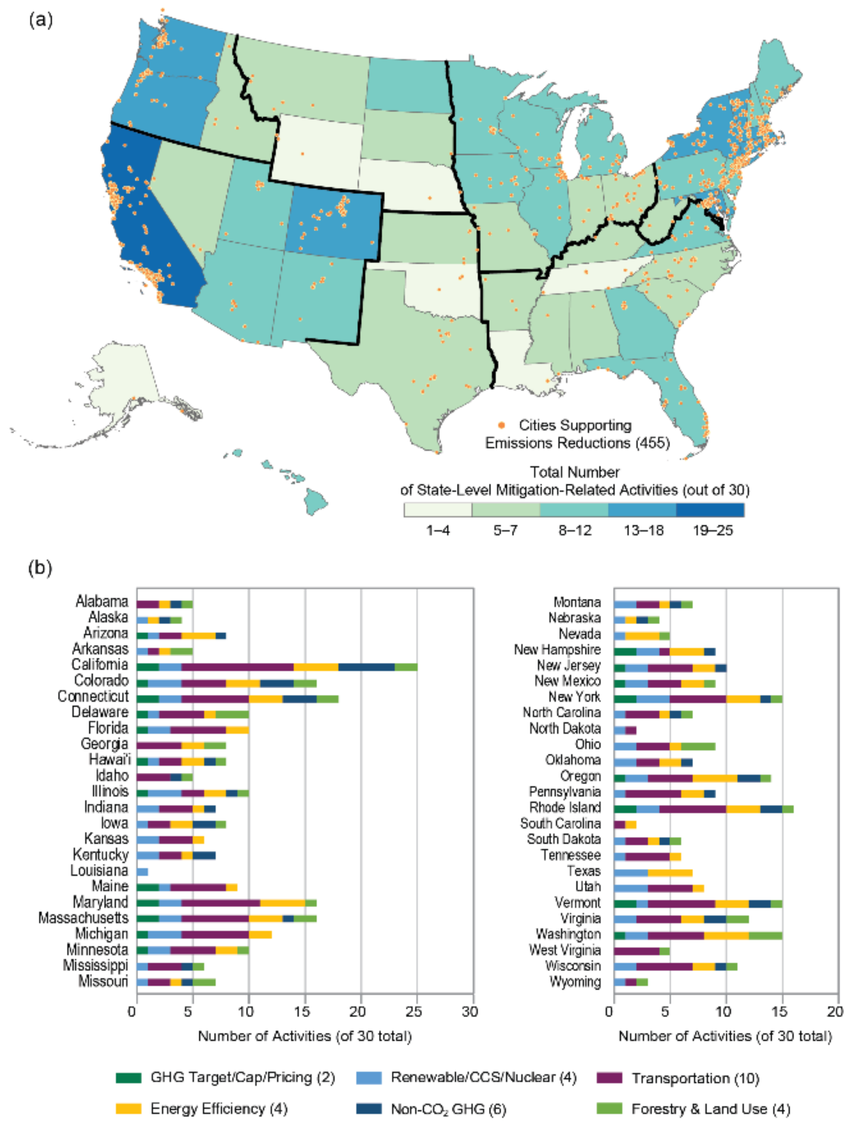
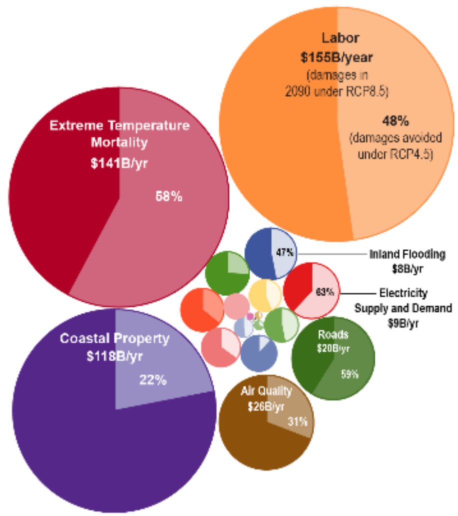


Fig. 29.2: Projected Damages and Potential for Risk Reduction by Sector

The total area of each circle represents the projected annual economic damages (in 2015 dollars) under a higher scenario (RCP8.5) in 2090 relative to a no-change scenario. The decrease in damages under a lower scenario (RCP4.5) compared to RCP8.5 is shown in the lighter-shaded area of each circle. Where applicable, sectoral results assume population change over time, which in the case of winter recreation leads to positive effects under RCP4.5, as increased visitors outweigh climate losses. Importantly, many sectoral damages from climate change are not included here, and many of the reported results represent only partial valuations of the total physical damages. See EPA 2017 for ranges surrounding the central estimates presented in the figure; results assume limited or no adaptation.[2] Adaptation was shown to reduce overall damages in sectors identified with the diamond symbol but was not directly modeled in, or relevant to, all sectors. Asterisks denote sectors with annual damages that may not be visible at the given scale. Only one impact (wildfire) shows very small positive effects, owing to projected landscape-scale shifts to vegetation with longer fire return intervals (see Ch. 6: Forests for a discussion on the weight of evidence regarding projections of future wildfire activity). The online version of this figure includes value ranges for numbers in the table. Due to space constraints, the ranges are not included here. *Source: adapted from EPA 2017.*[2]



Annual Economic Damages in 2090		
Sector	Annual damages under RCP8.5	Damages avoided under RCP4.5
Labor	$155B	48%
Extreme Temperature Mortality◊	$141B	58%
Coastal Property◊	$118B	22%
Air Quality	$26B	31%
Roads◊	$20B	59%
Electricity Supply and Demand	$9B	63%
Inland Flooding	$8B	47%
Urban Drainage	$6B	26%
Rail◊	$6B	36%
Water Quality	$5B	35%
Coral Reefs	$4B	12%
West Nile Virus	$3B	47%
Freshwater Fish	$3B	44%
Winter Recreation	$2B	107%
Bridges	$1B	48%
Munic. and Industrial Water Supply	$316M	33%
Harmful Algal Blooms	$199M	45%
Alaska Infrastructure◊	$174M	53%
Shellfish*	$23M	57%
Agriculture*	$12M	11%
Aeroallergens*	$1M	57%
Wildfire	−$106M	−134%

SR-15 Materials
(IPCC Special Report on Global Warming of 1.5 deg. C)

- Modeling a transition to a carbon neutral future

Other Sources:

- Renewable vs. Fossil fuel future
- Current costs of Energy production

SR-15 Fig 1a

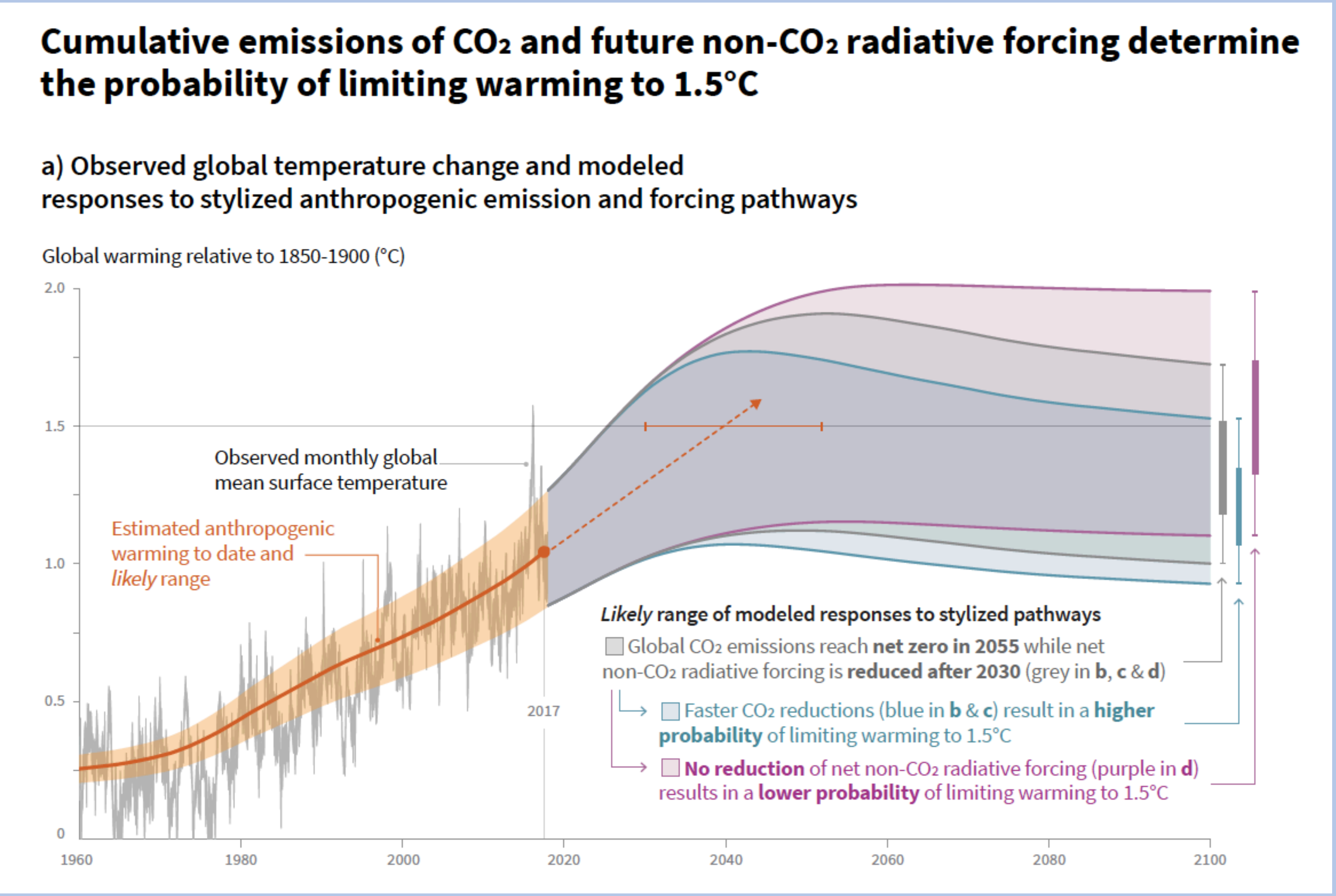
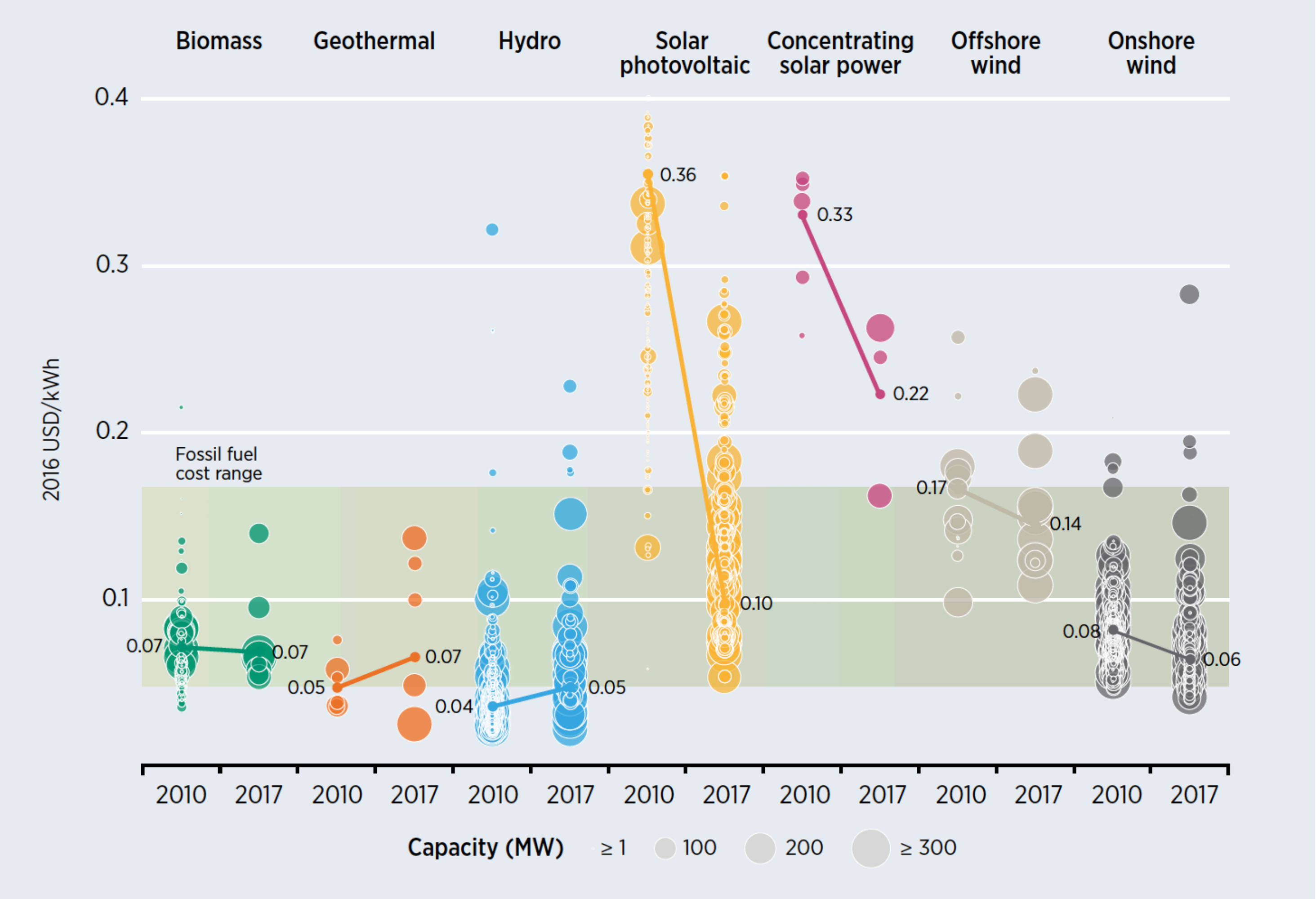

Cumulative emissions of CO₂ and future non-CO₂ radiative forcing determine the probability of limiting warming to 1.5°C
a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways
Global warming relative to 1850-1900 (°C)
2.0
1.5
1.0
0.5
0
Observed monthly global mean surface temperature
Estimated anthropogenic warming to date and likely range
2017
Likely range of modeled responses to stylized pathways
Global CO₂ emissions reach net zero in 2055 while net non-CO₂ radiative forcing is reduced after 2030 (grey in b, c & d)
Faster CO₂ reductions (blue in b & c) result in a higher probability of limiting warming to 1.5°C
No reduction of net non-CO₂ radiative forcing (purple in d) results in a lower probability of limiting warming to 1.5°C
1960
1980
2000
2020
2040
2060
2080
2100

Figure ES.1 Global levelised cost of electricity from utility-scale renewable power generation technologies, 2010-2017



Source: IRENA Renewable Cost Database.

Note: The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE value for plants commissioned in each year. Real weighted average cost of capital is 7.5% for OECD countries and China and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.

Source: IRENA (2018), Renewable Power Generation Costs in 2017, International Renewable Energy Agency, Abu Dhabi. ISBN 978-92-9260-040-2