

Taiwan September, 2014

Our Changing Climate: The IPCC AR5 and U.S. National Climate Assessments

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IPCC WGI Assessment

Summary for Policymakers
ca. 14,000 Words

14 Chapters
Atlas of Regional Projections

54,677 Review Comments
by 1089 Experts

2010: 259 Authors Selected

2009: WGI Outline Approved

ipcc

INTERGOVERNMENTAL PANEL ON climate change

CLIMATE CHANGE 2013

The Physical Science Basis

WG I

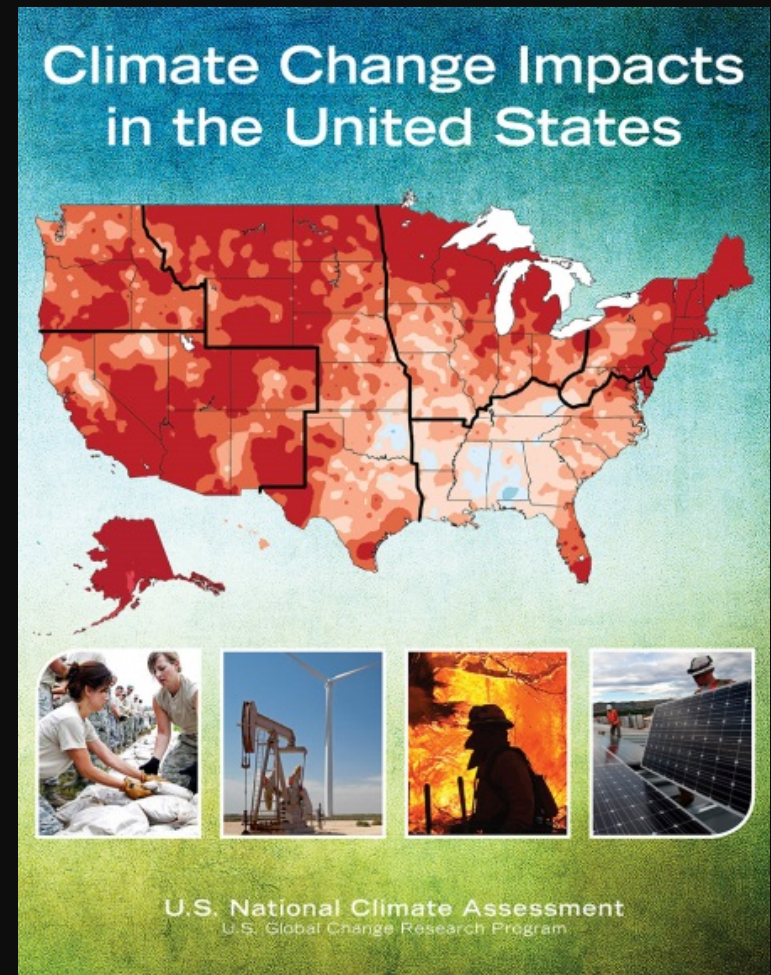
WORKING GROUP I CONTRIBUTION TO THE
FIFTH ASSESSMENT REPORT OF THE
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



The U.S. National Climate Assessment

Assessment is required every 4 years by Congress through the 1990 Global Change Research Act

This assessment is the most comprehensive analysis ever of how climate change is affecting our nation now and how it could affect it into the future



Read online or download at:
<http://nca2014.globalchange.gov>

The NCA Process

Inclusive, broad expertise

300 authors

60 member Federal Advisory Committee

Public engagement

Listening sessions around the country

Request for information, input reports

Extensive Review

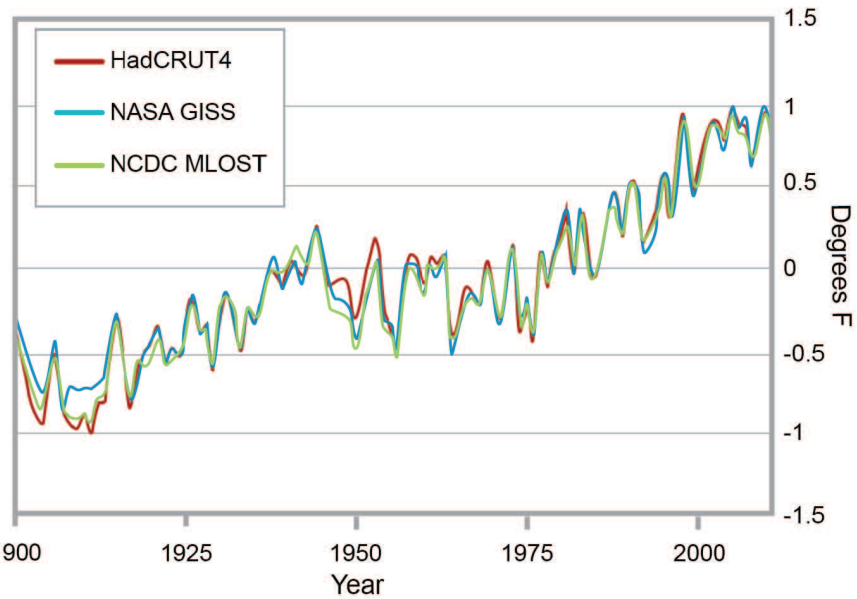
National Academy of Sciences (2x),
agencies, public and expert review;
we responded to all comments

Human-induced climate change has moved firmly into the present.

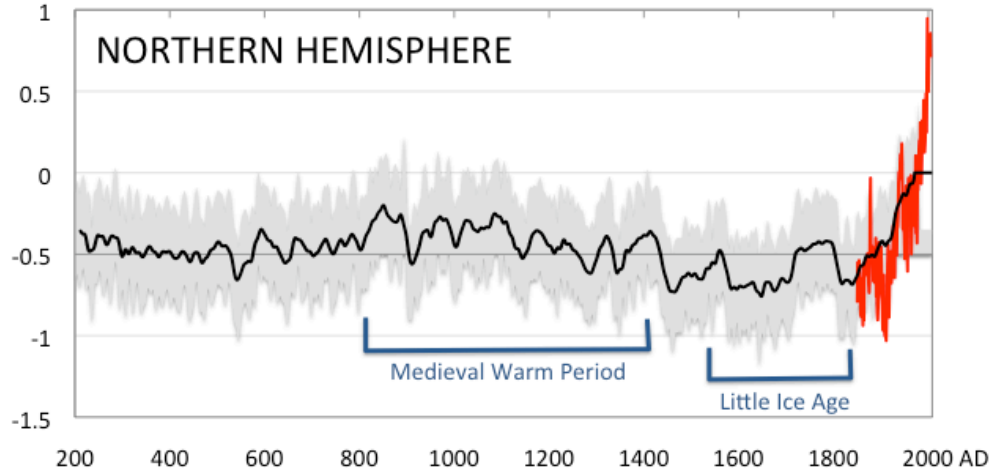


© Dave Martin/AP/Corbis

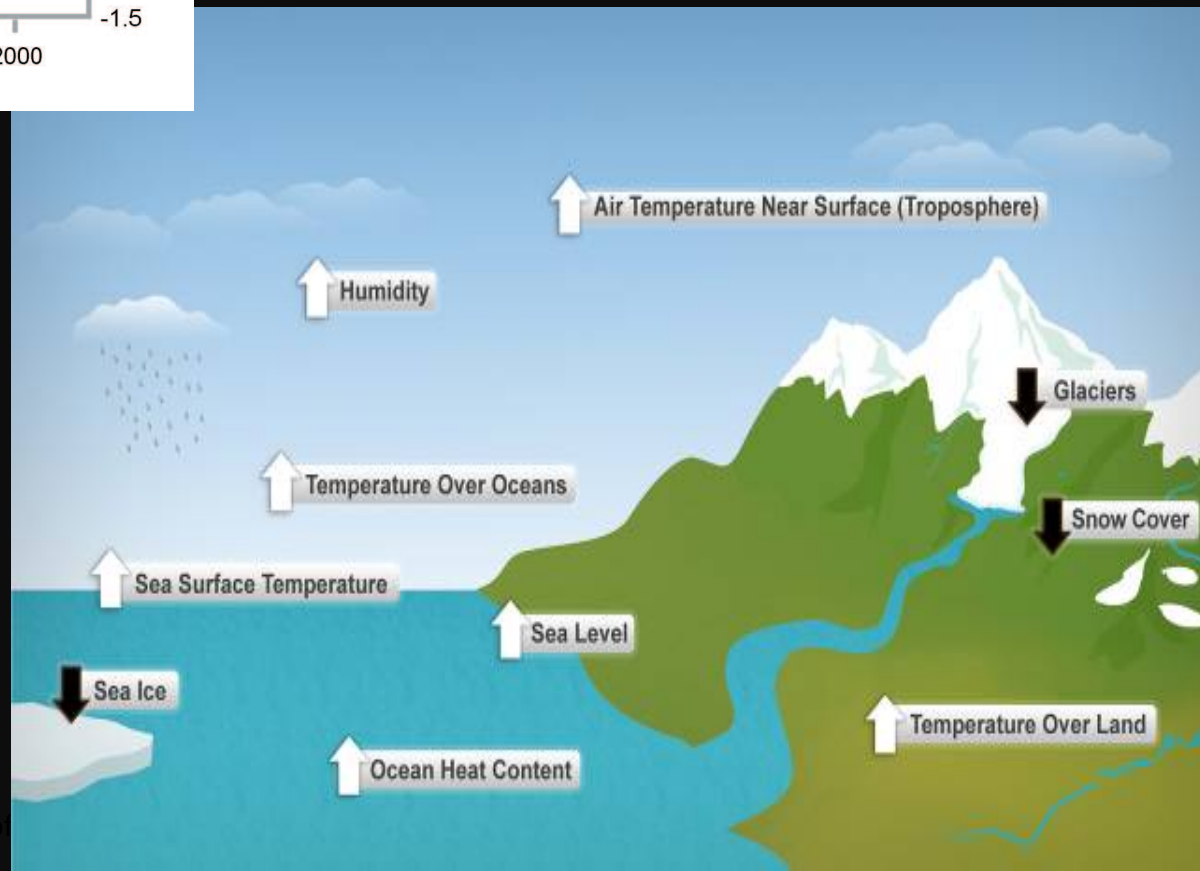
Changes in Observed Global Average Temperature



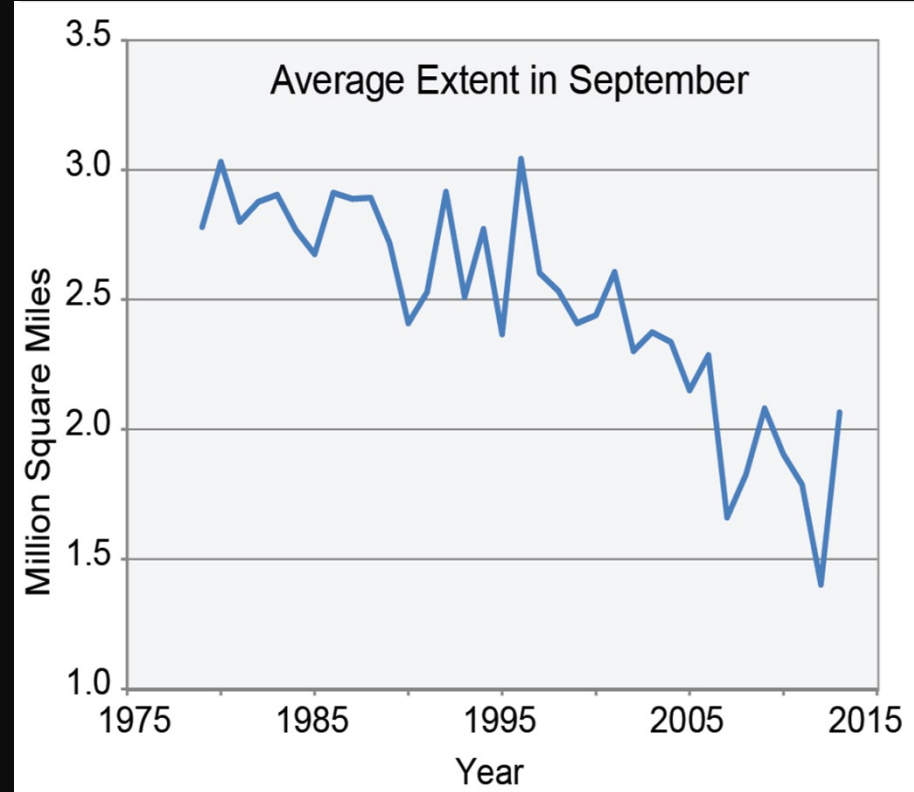
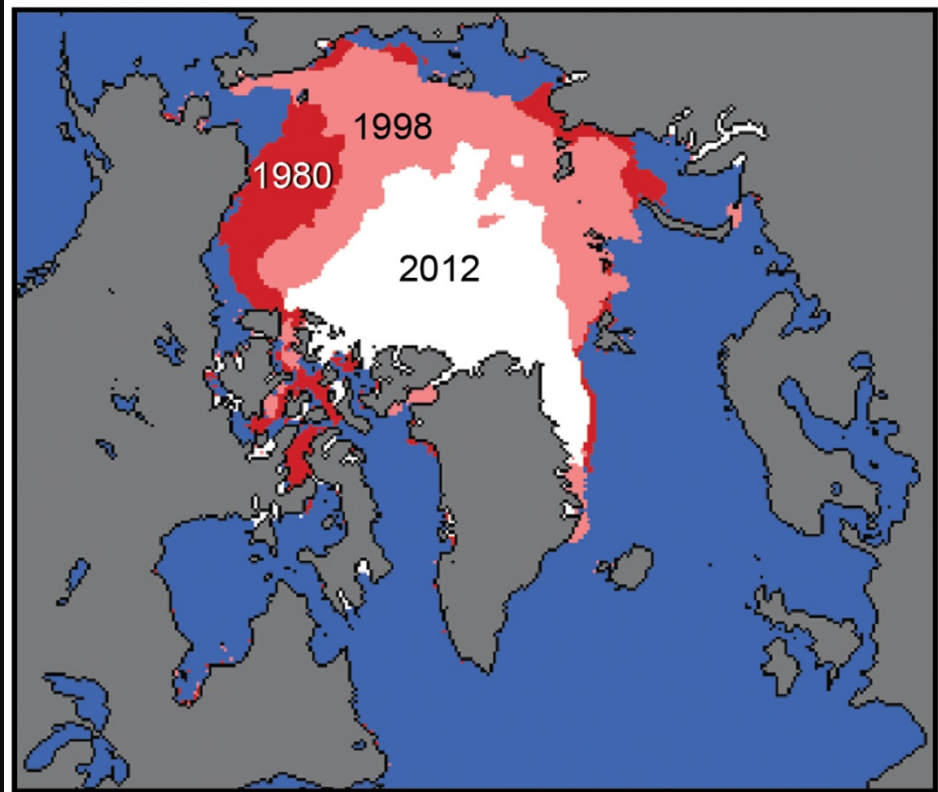
Temperature difference relative to 1961-1991 (°F)

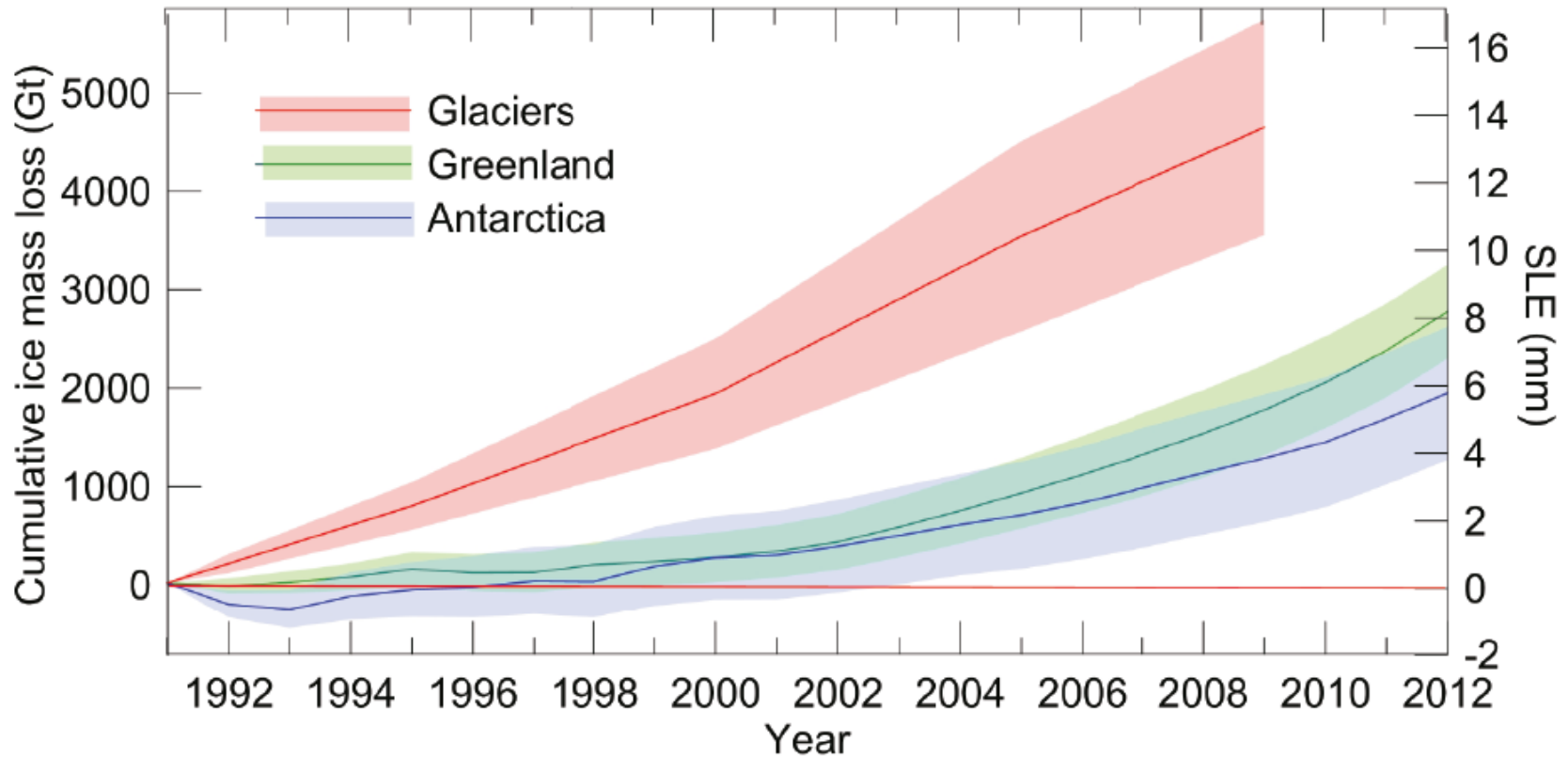


**Observational
Records Clearly
Indicate a
Changing Global
Climate**



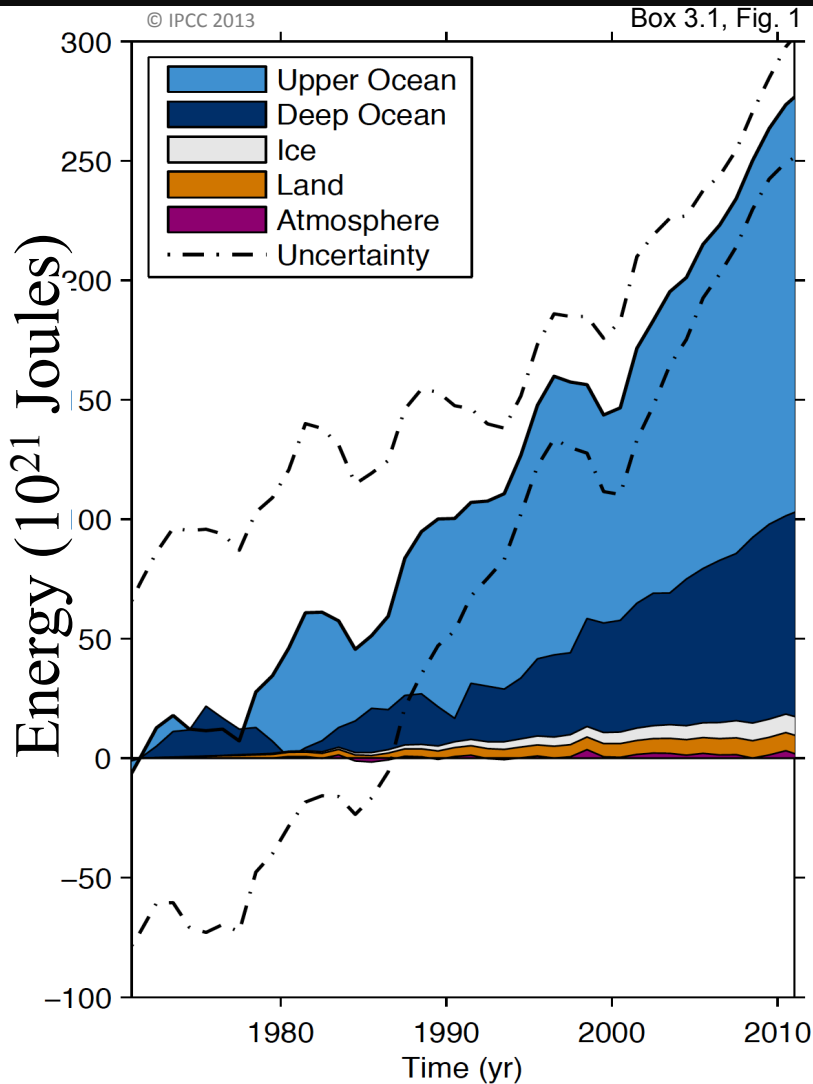
Arctic Sea Ice Decline





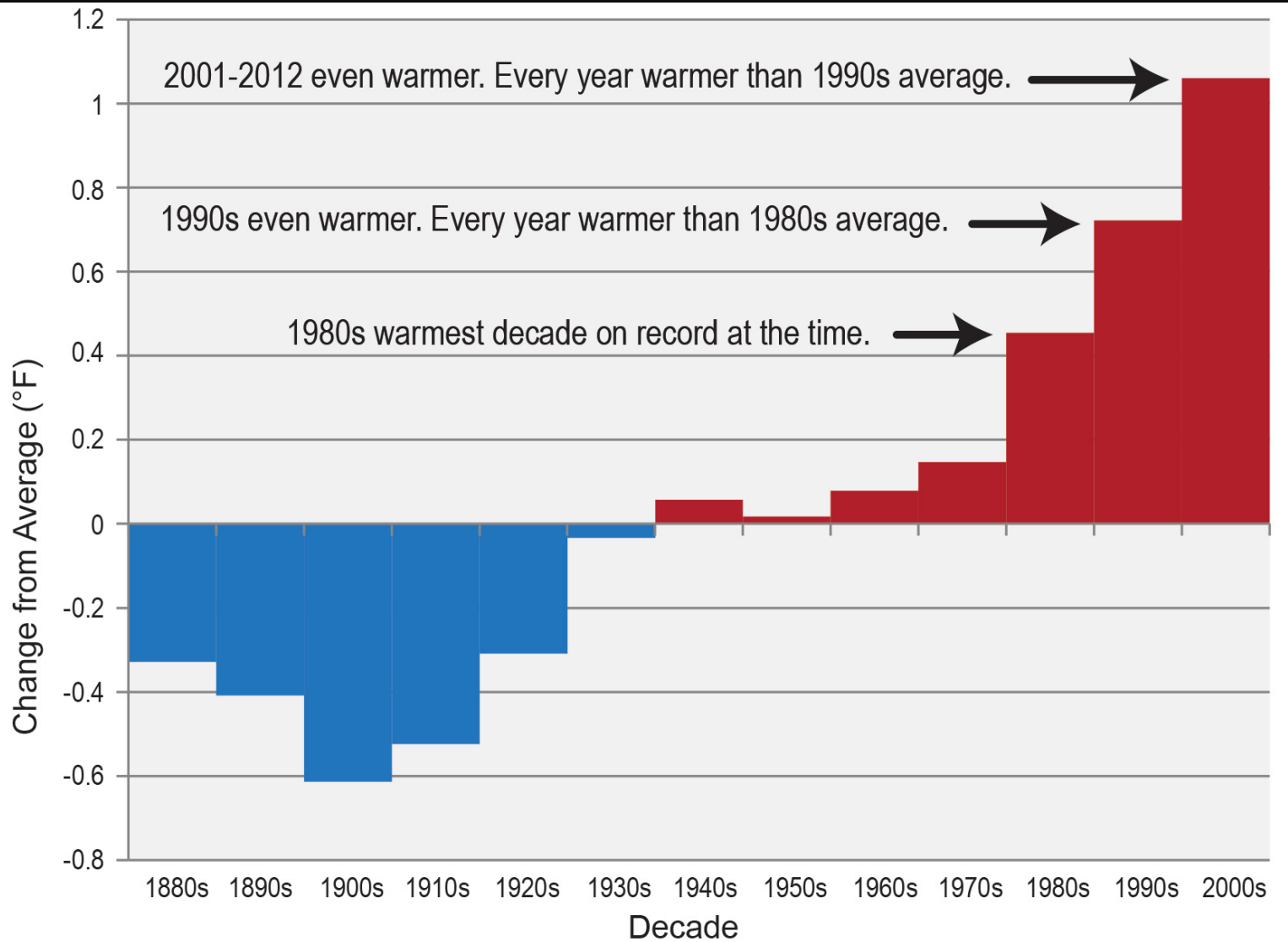
Ice loss from	Glaciers	226 ($\pm 60\%$) Gt yr ⁻¹	(1993-2003)
	Greenland	215 ($\pm 25\%$) Gt yr ⁻¹	(2002-2011)
	Antarctica	147 ($\pm 50\%$) Gt yr ⁻¹	(2002-2011)

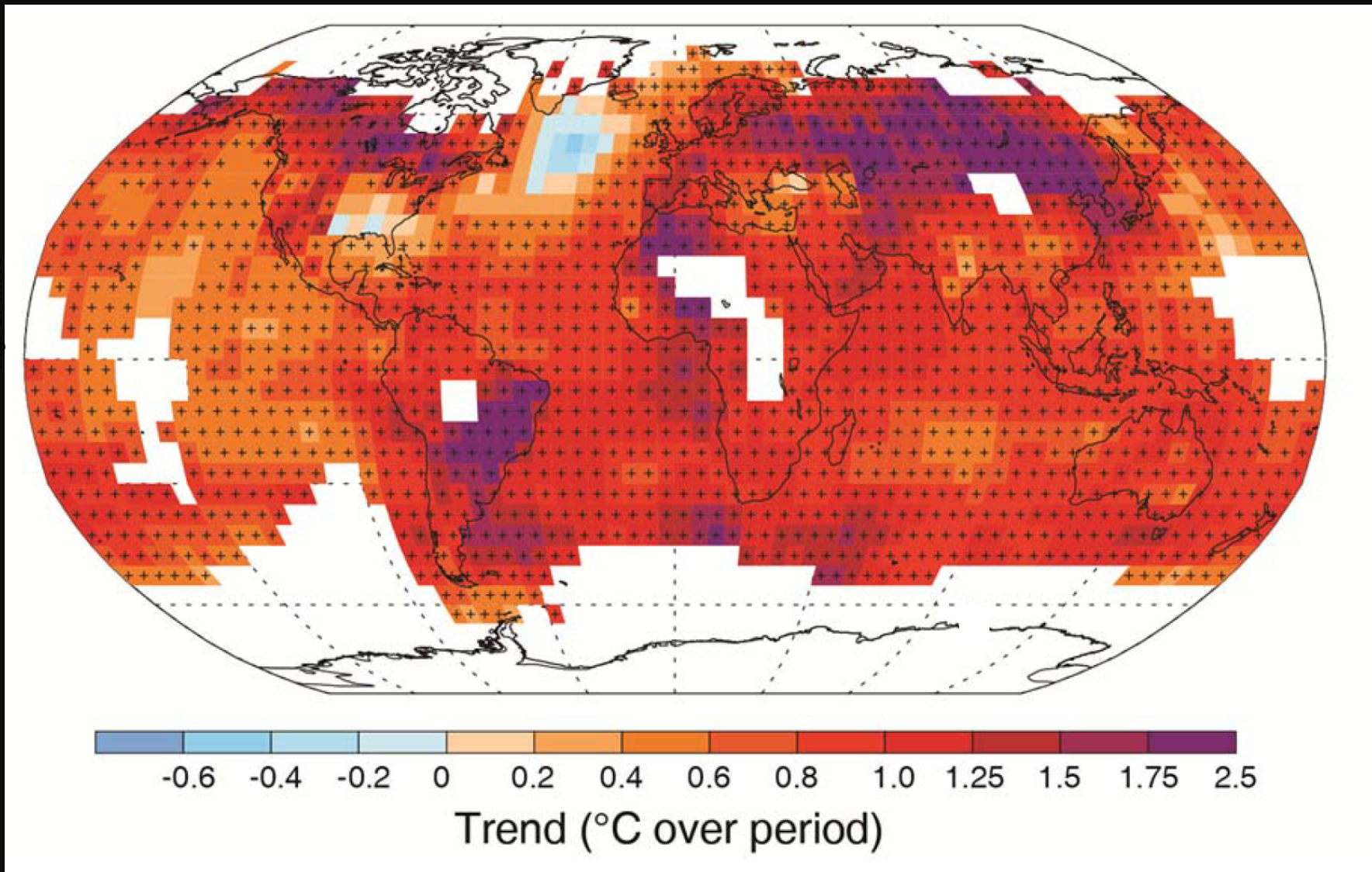
100 Gt yr⁻¹ of ice loss corresponds to 0.28 mm yr⁻¹ of global mean sea level rise



Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (*high confidence*).

Temperature Change by Decade





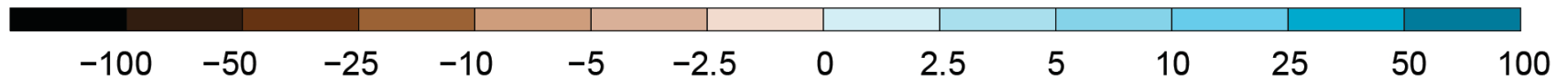
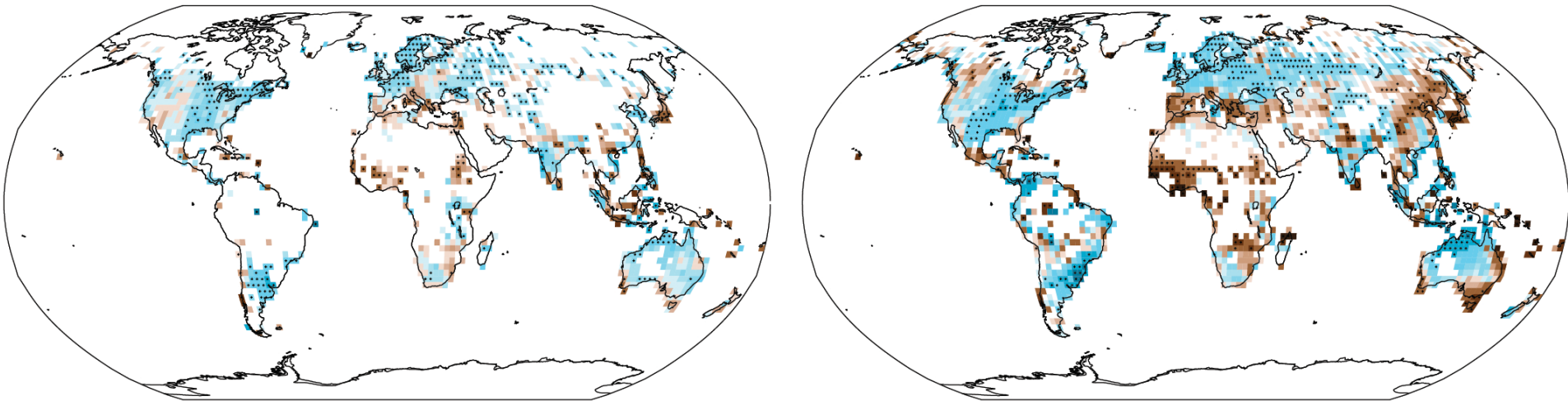
Temperature Difference 1901 to 2012 based on trend (°C)

Global Trends in Precipitation

Observed change in annual precipitation over land

1901–2010

1951–2010



(mm yr⁻¹ per decade)

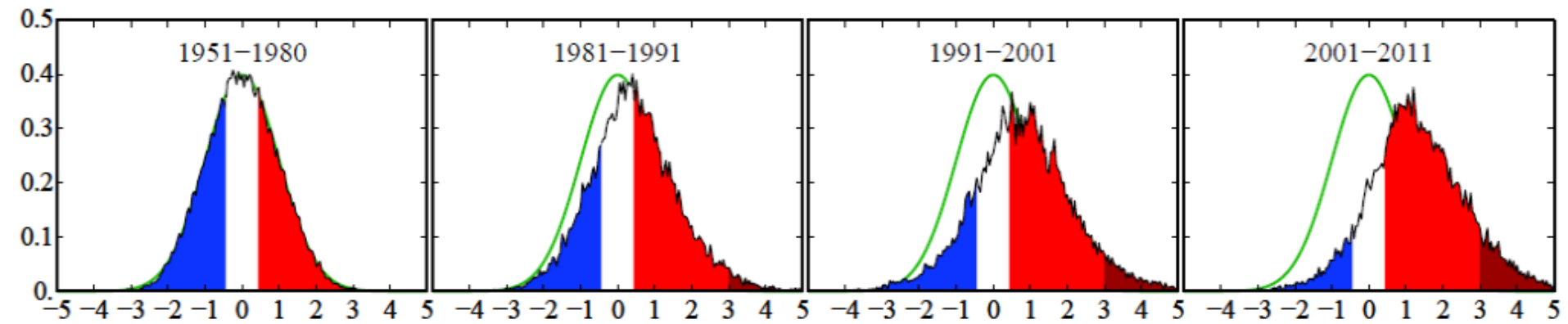
Certain Types of Extreme Events Show Important Trends

- Heat waves are generally increasing; will likely become longer and more severe.
- Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods in some regions (NE, MW).
- Droughts increasing in some regions (SW, SE).
- Increasing intensity of Atlantic hurricanes is likely.

These trends are likely to continue.

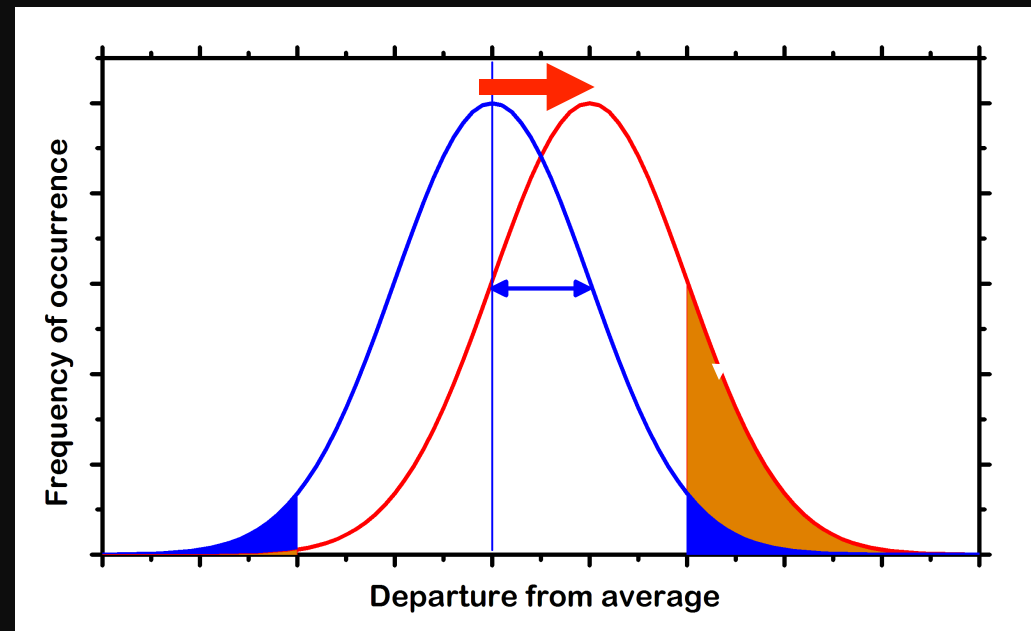
Observed Trend in Extreme Temperatures (Global)

Shifting Distribution of Summer Temperature Anomalies



Frequency of occurrence of local June-July-August temperature anomalies (relative to 1951-1980 mean) for Northern Hemisphere land in units of local standard deviation.

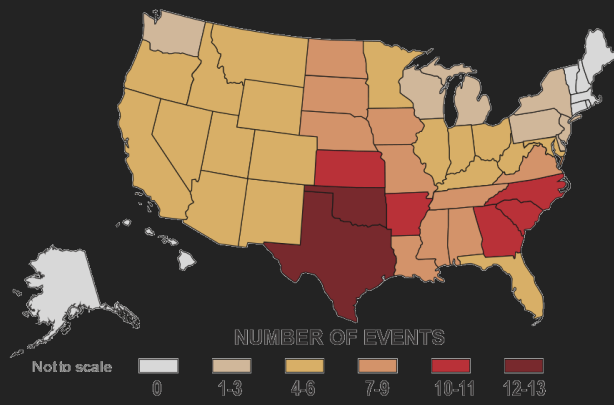
Source: Hansen, J., Sato, M., and Ruedy, R., *Proc. Natl. Acad. Sci.*, 2012.



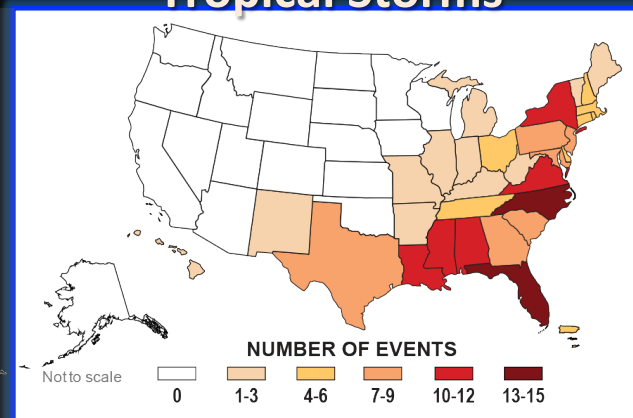
The United States Is Climate-Conscious

NOAA: U.S. Billion-Dollar Weather and Climate Disasters: 1980 – 2013*

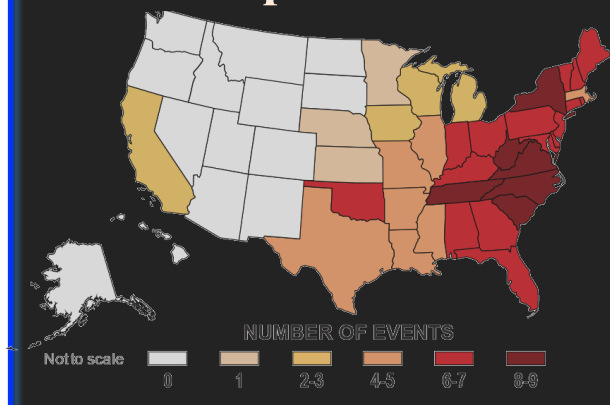
Drought and Heatwaves



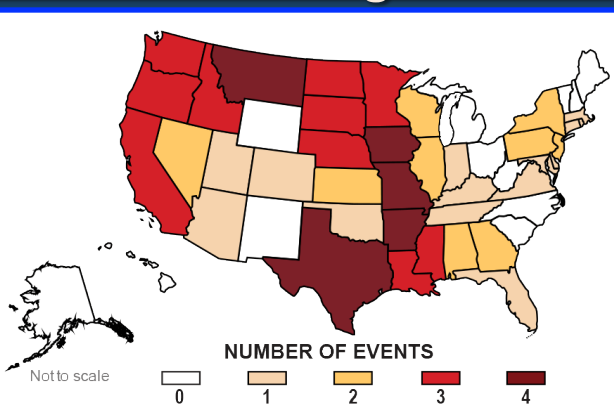
Hurricanes and Tropical Storms



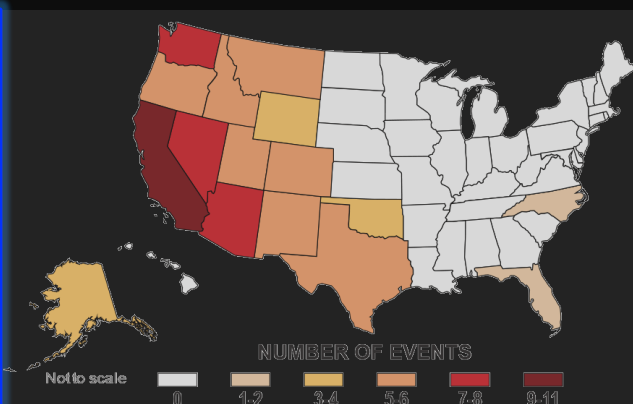
Winter Storms and Crop Freezes



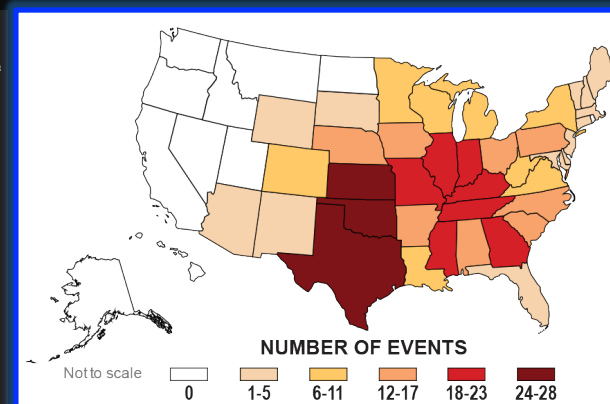
Flooding



Wildfires

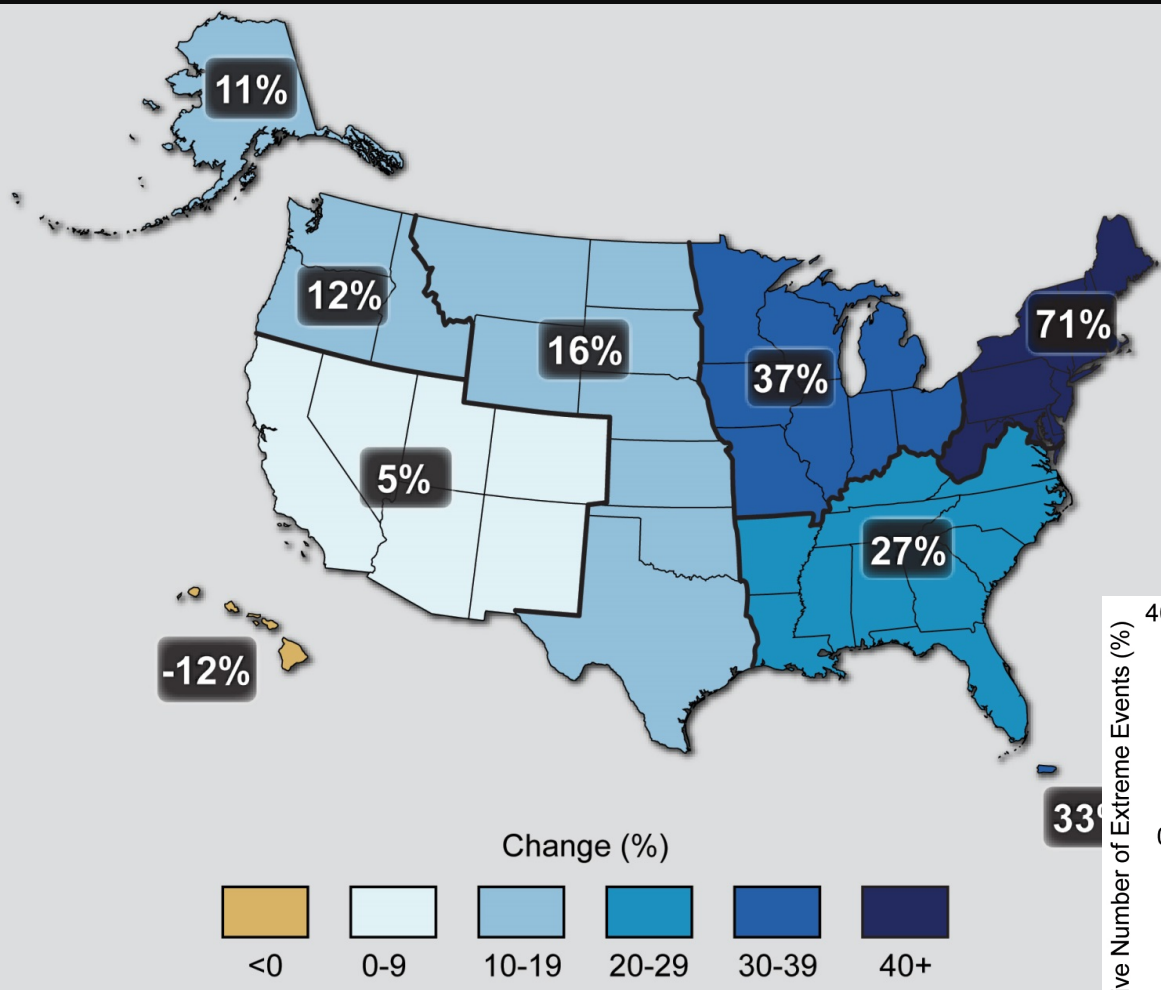


Severe Local Storms

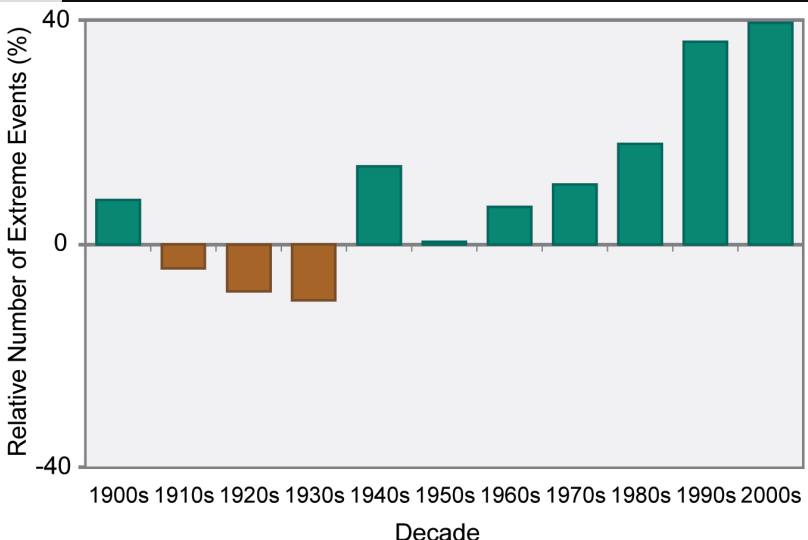


*151 weather and climate disasters reached or exceeded \$1 billion during this period

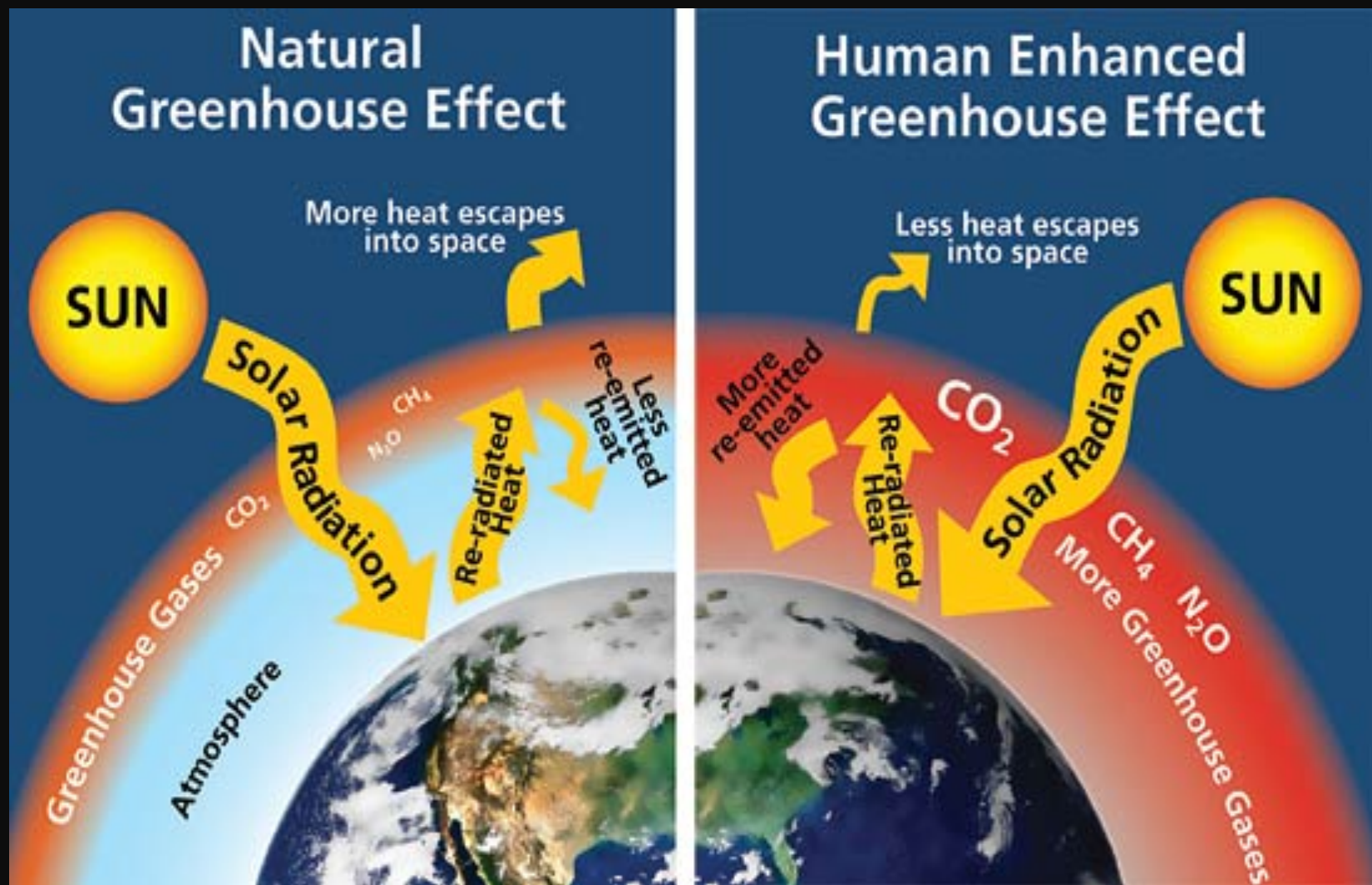
Observed U.S. Trends in Heavy Precipitation



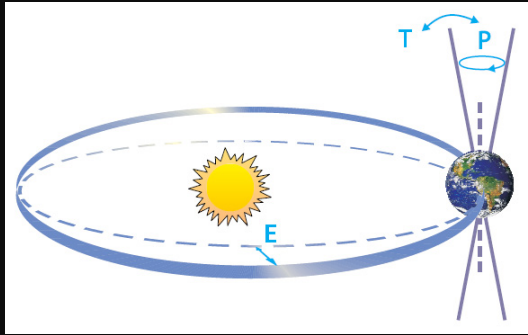
Two-day precipitation total that is exceeded on average only once in a 5-year period



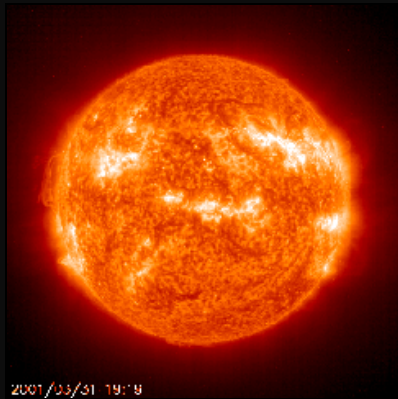
The Greenhouse Effect: Sustains Life on Earth, but being Affected by Human Activities



Natural Drivers of Climate



Variations in the Earth's orbit (Milankovitch effect)



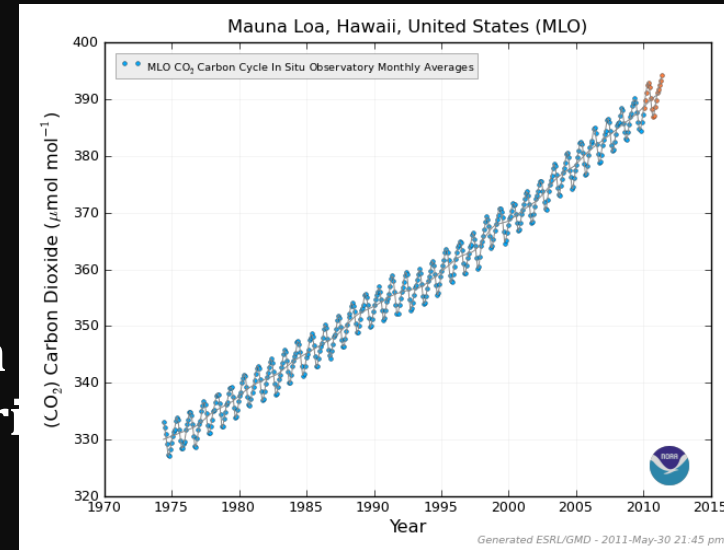
Variations in energy received from the sun



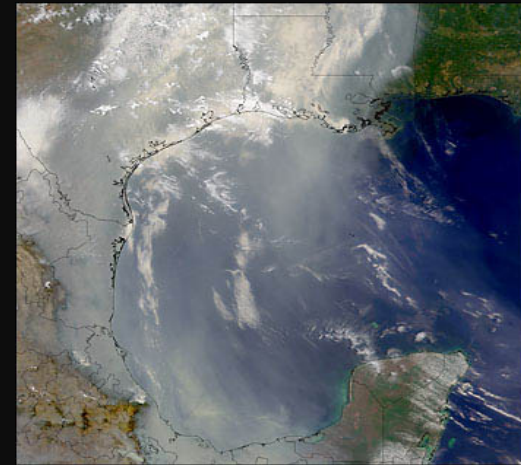
Stratospheric aerosols from energetic volcanic eruptions

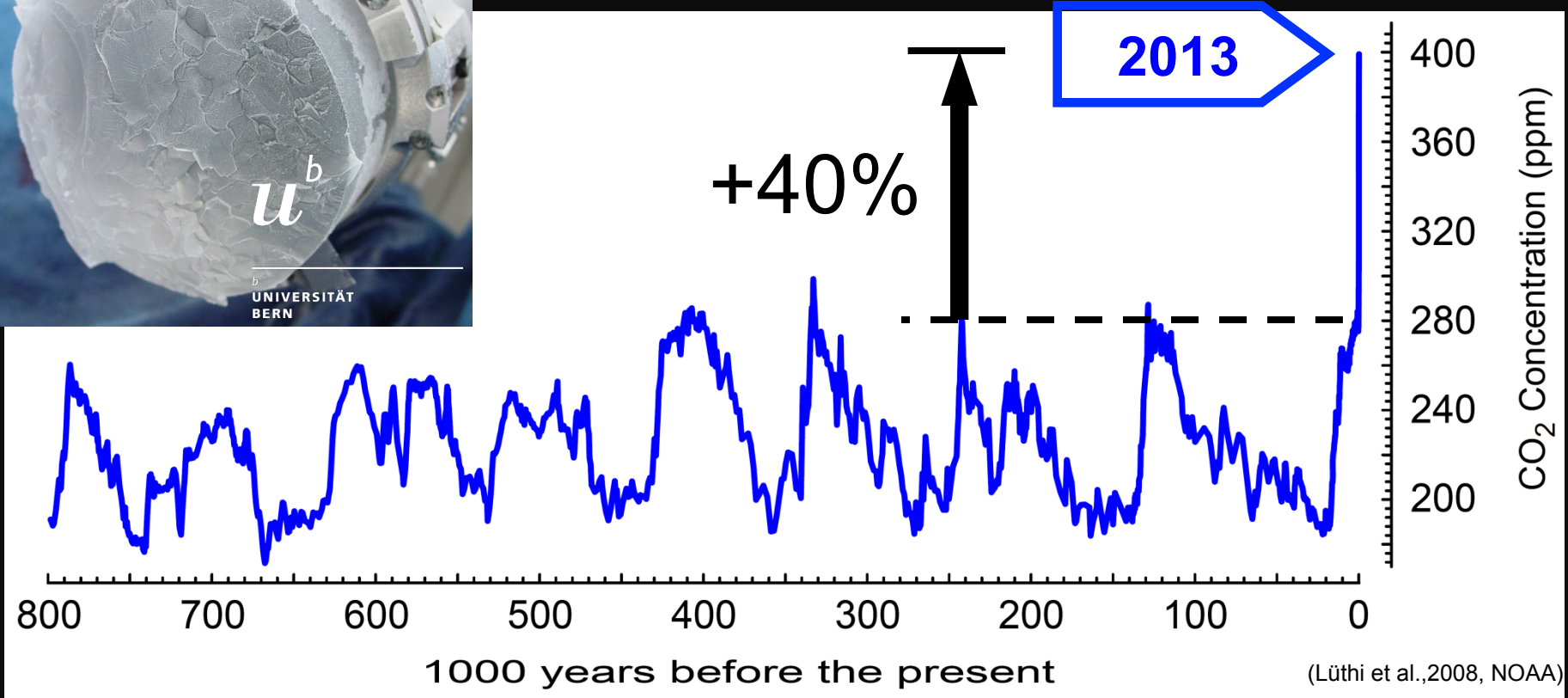
Human Factors in Climate

Changes in atmospheric gases



Changes in particles from burning fossil fuels and biomass





The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.

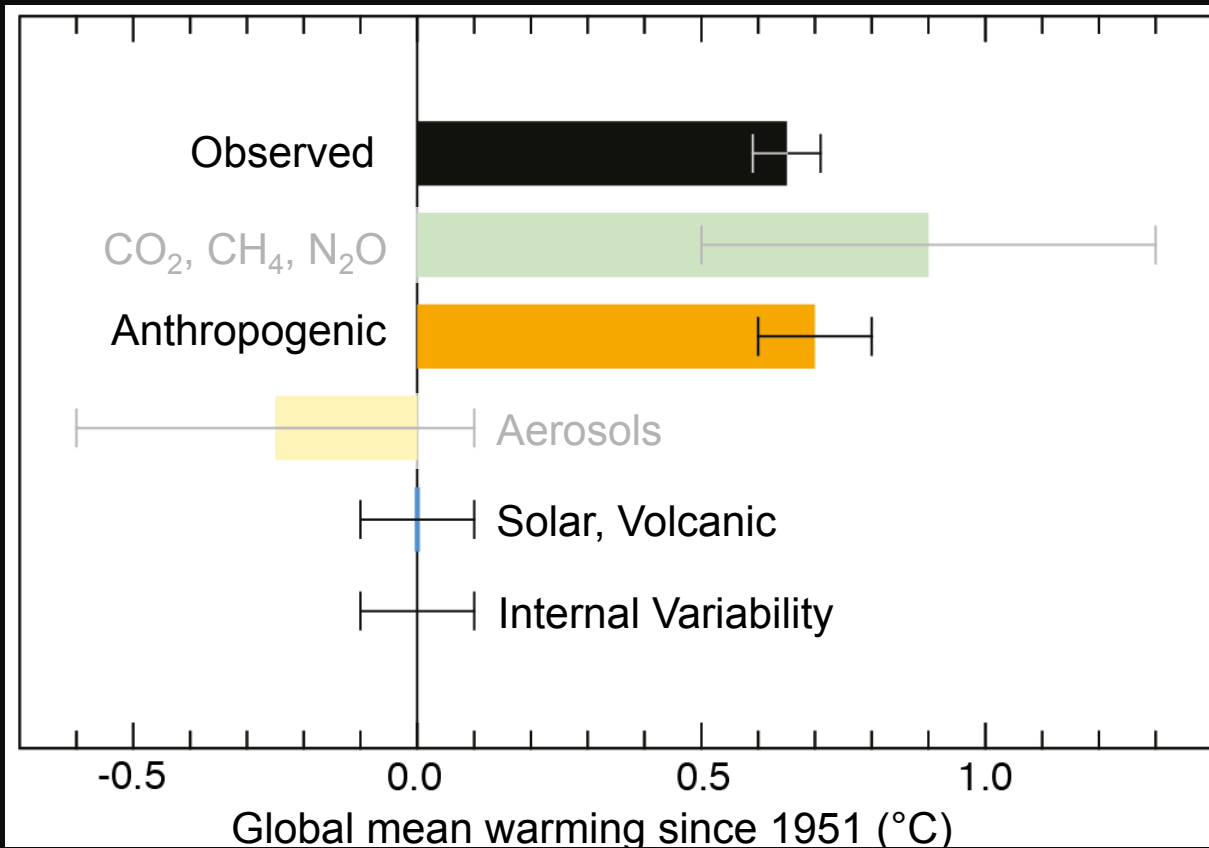


Fig. TS.10

The observed warming 1951–2010 is approximately 0.6°C to 0.7°C.

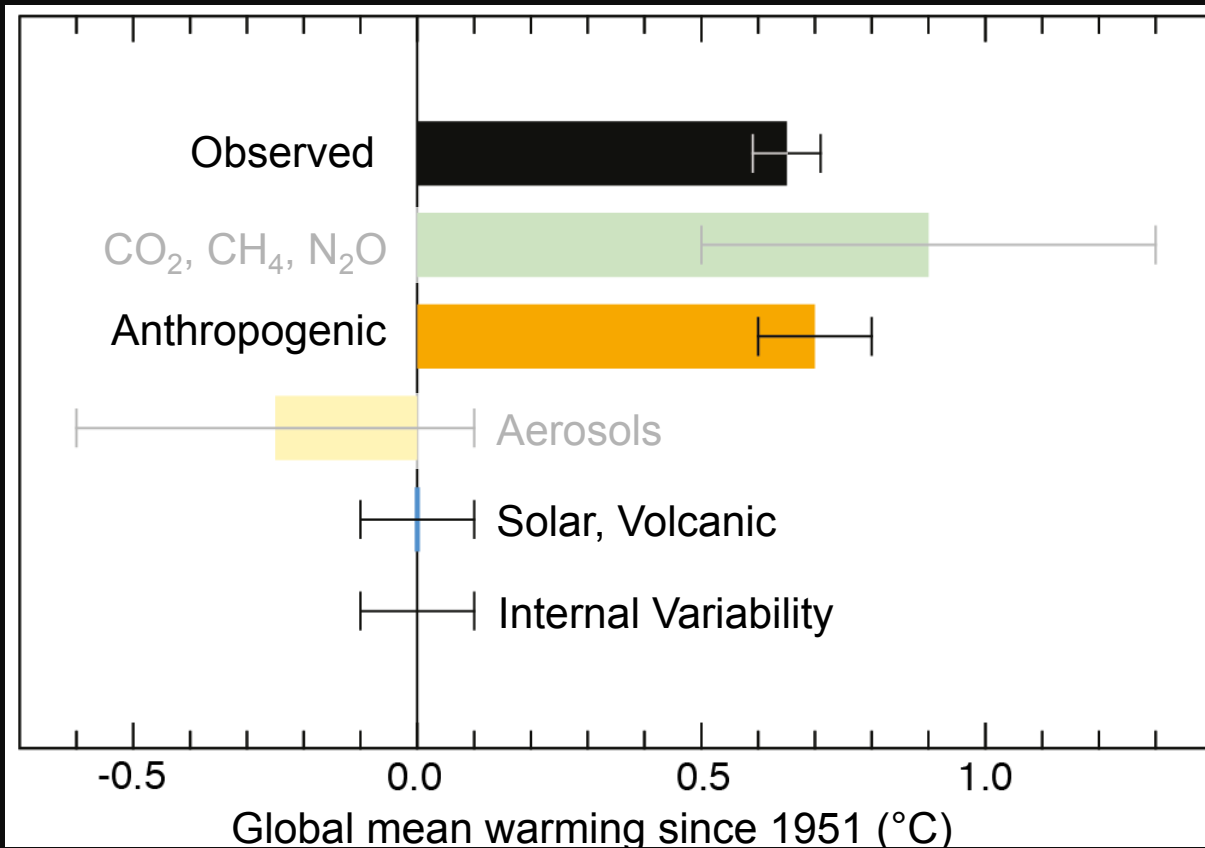
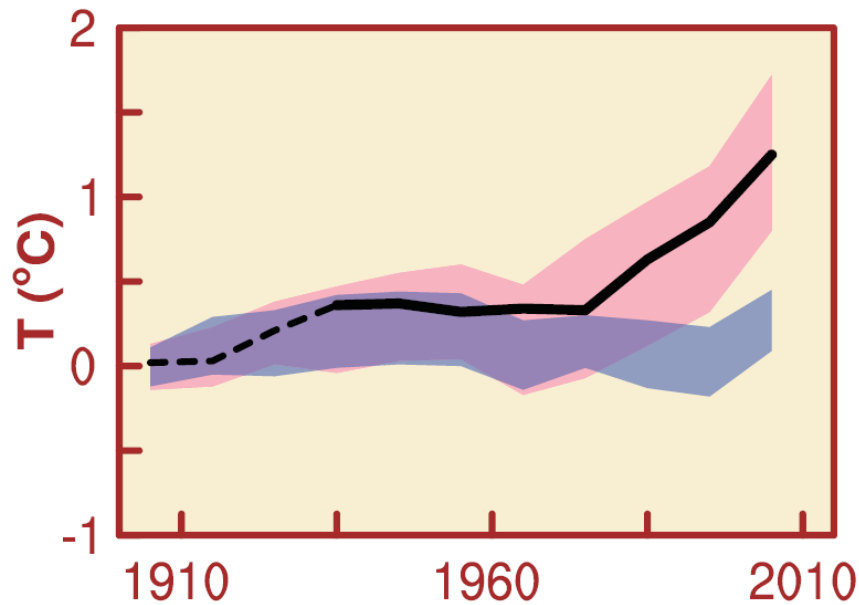


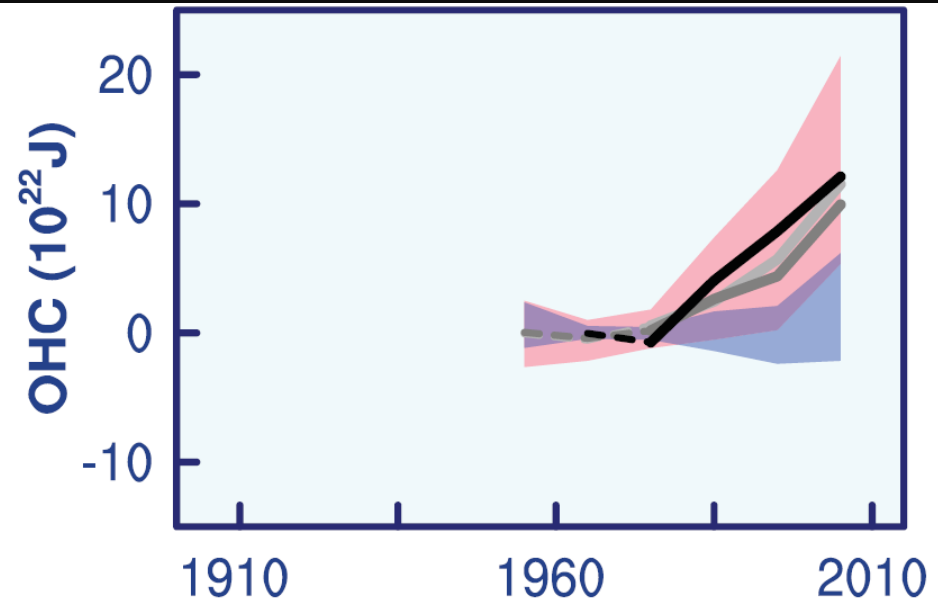
Fig. TS.10

It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Global Surface Temperature

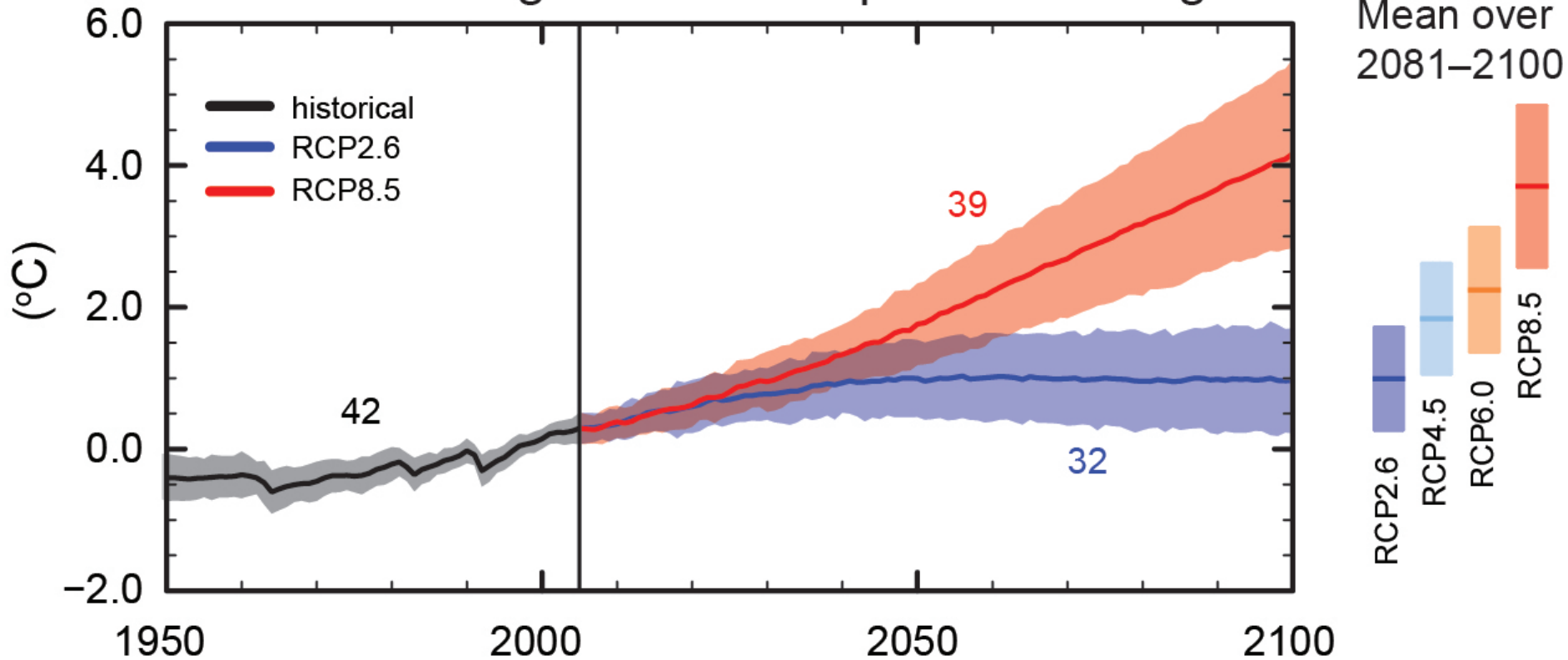


Ocean Heat Content

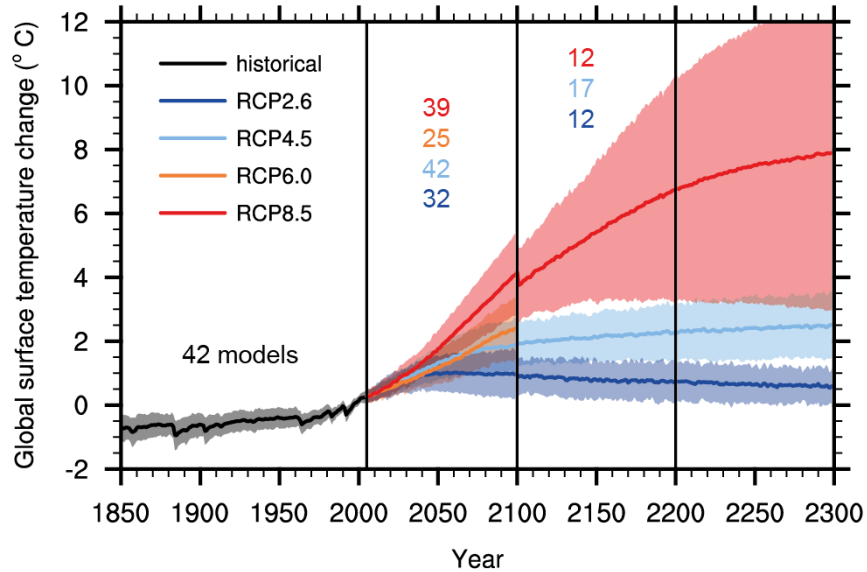
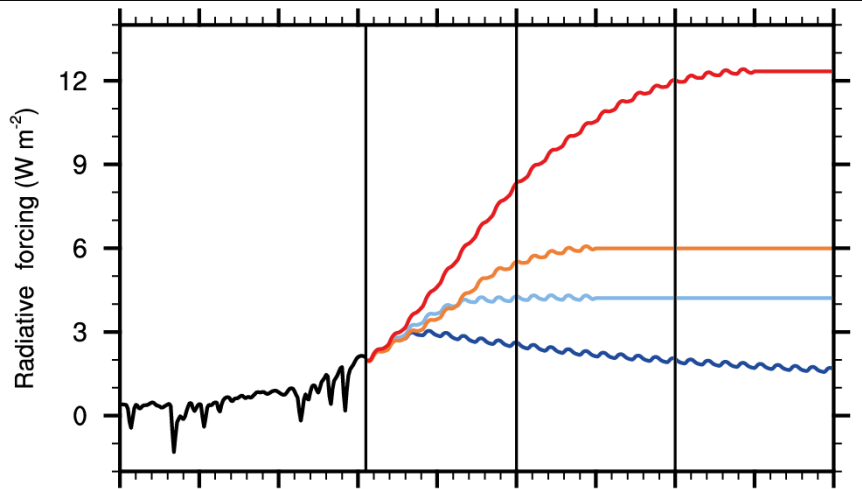


Human influence on the climate system is clear

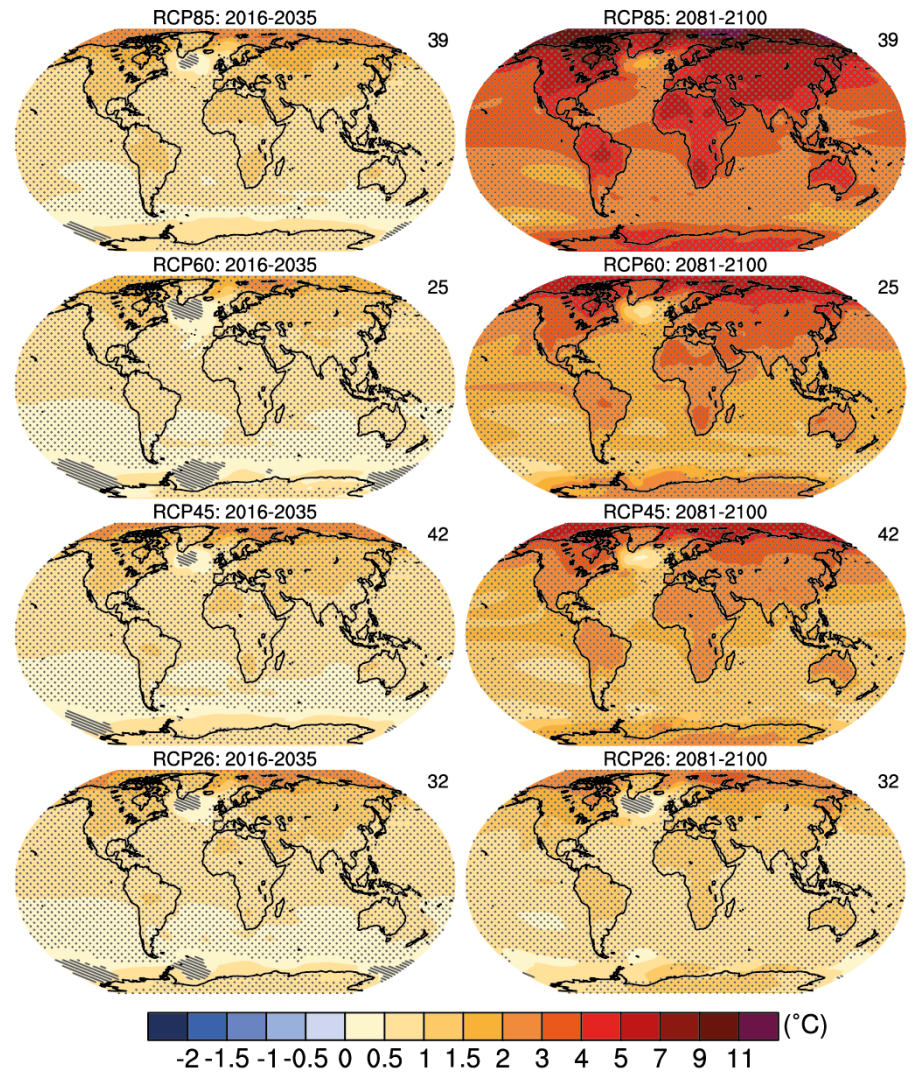
Global average surface temperature change



Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850–1900 for all scenarios except RCP2.6.

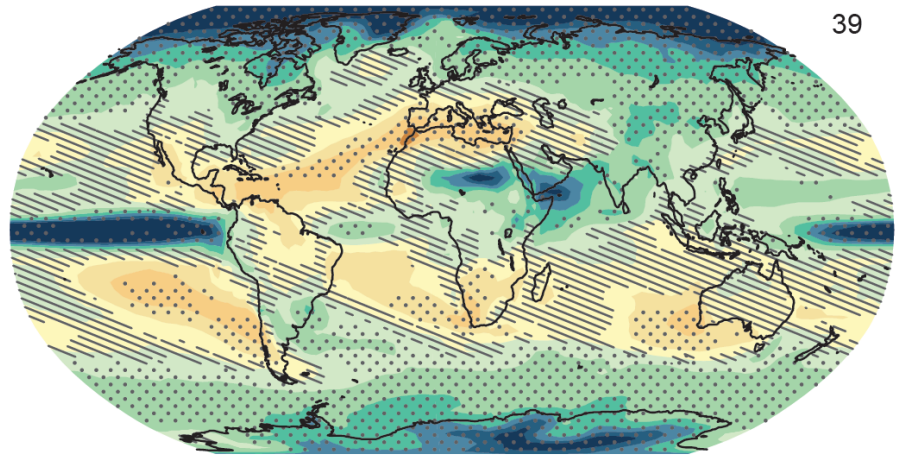
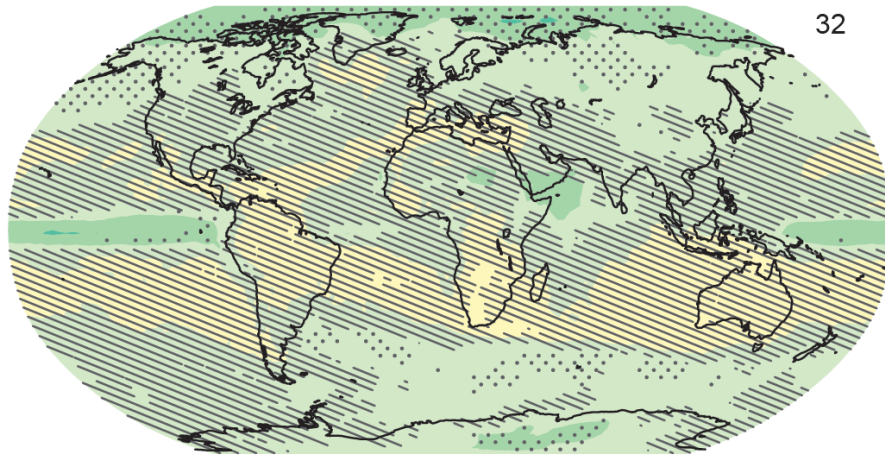


Annual mean temperature change



(b)

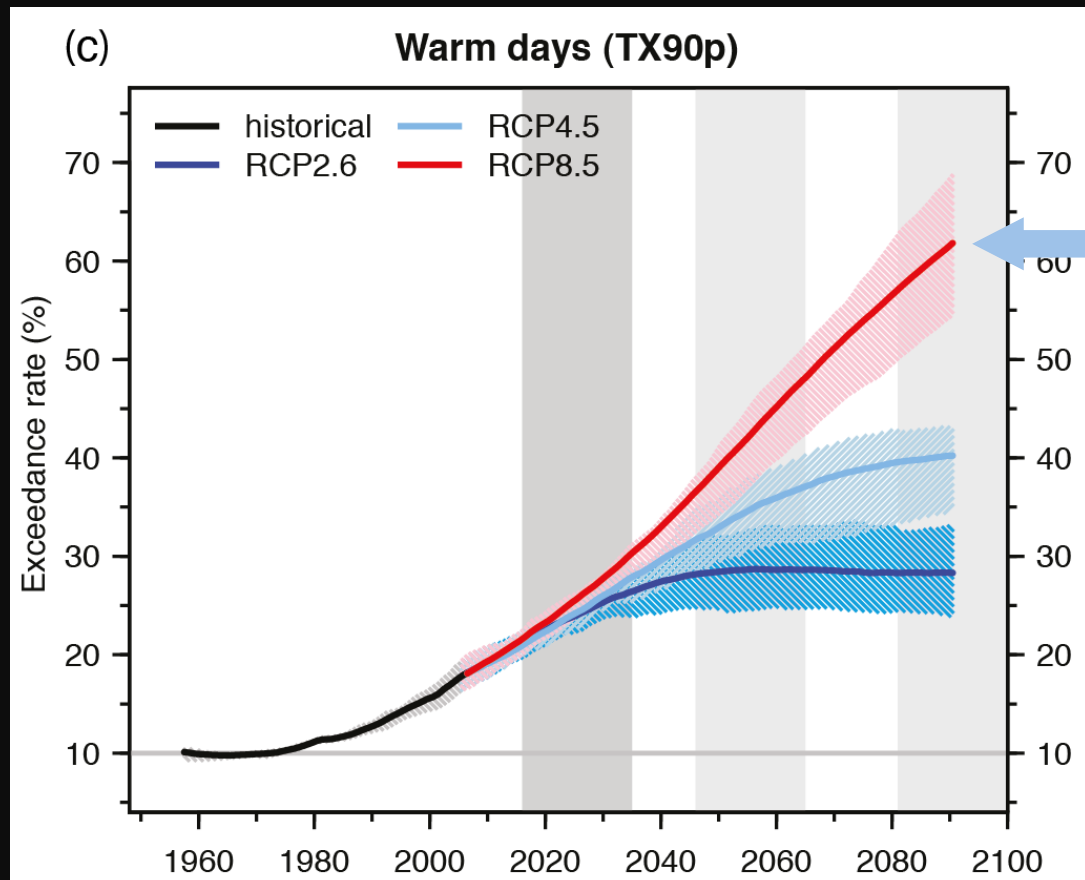
Change in average precipitation (1986–2005 to 2081–2100)



RCP2.6 Low Scenario

RCP8.5 High Scenario

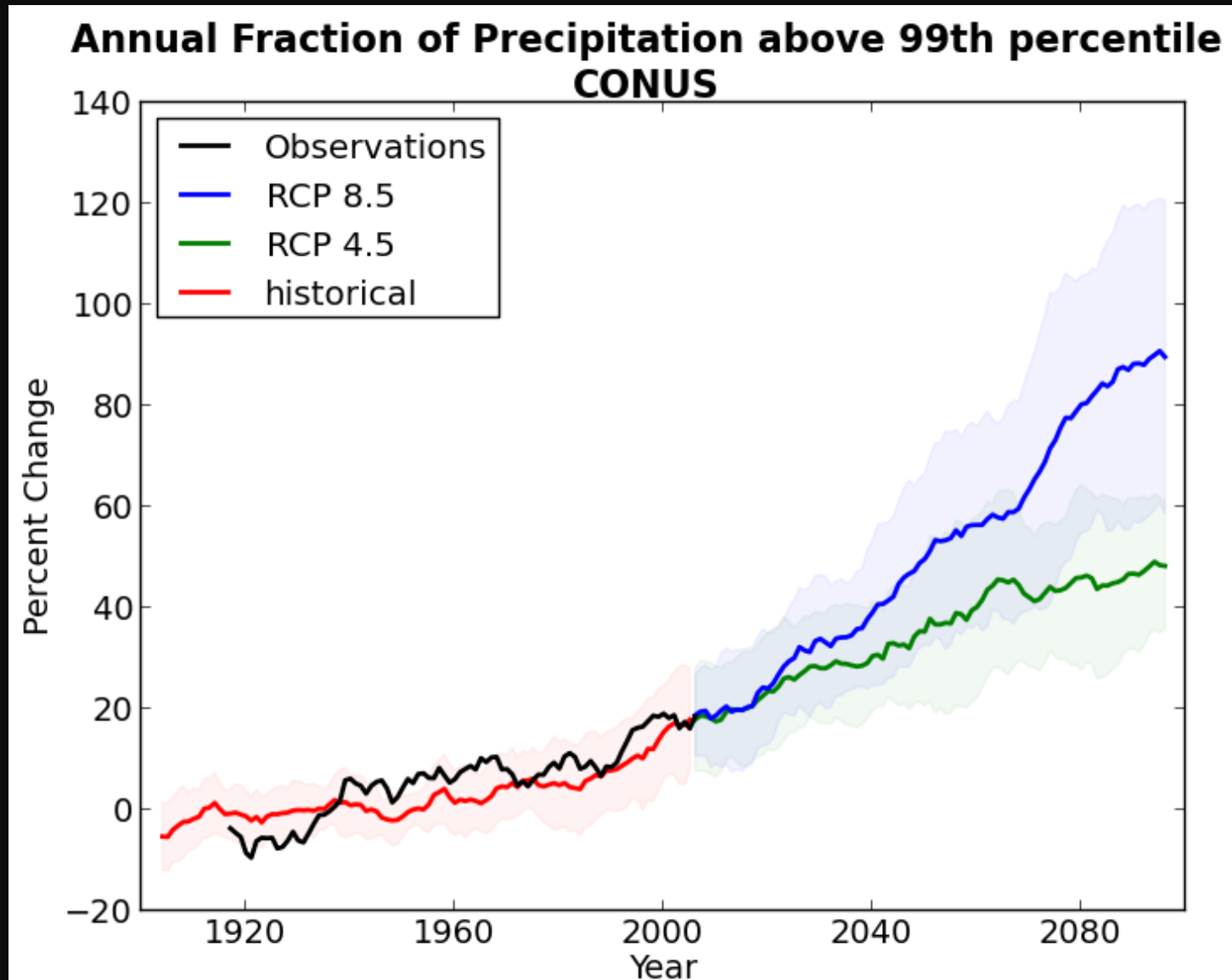
The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, [...]

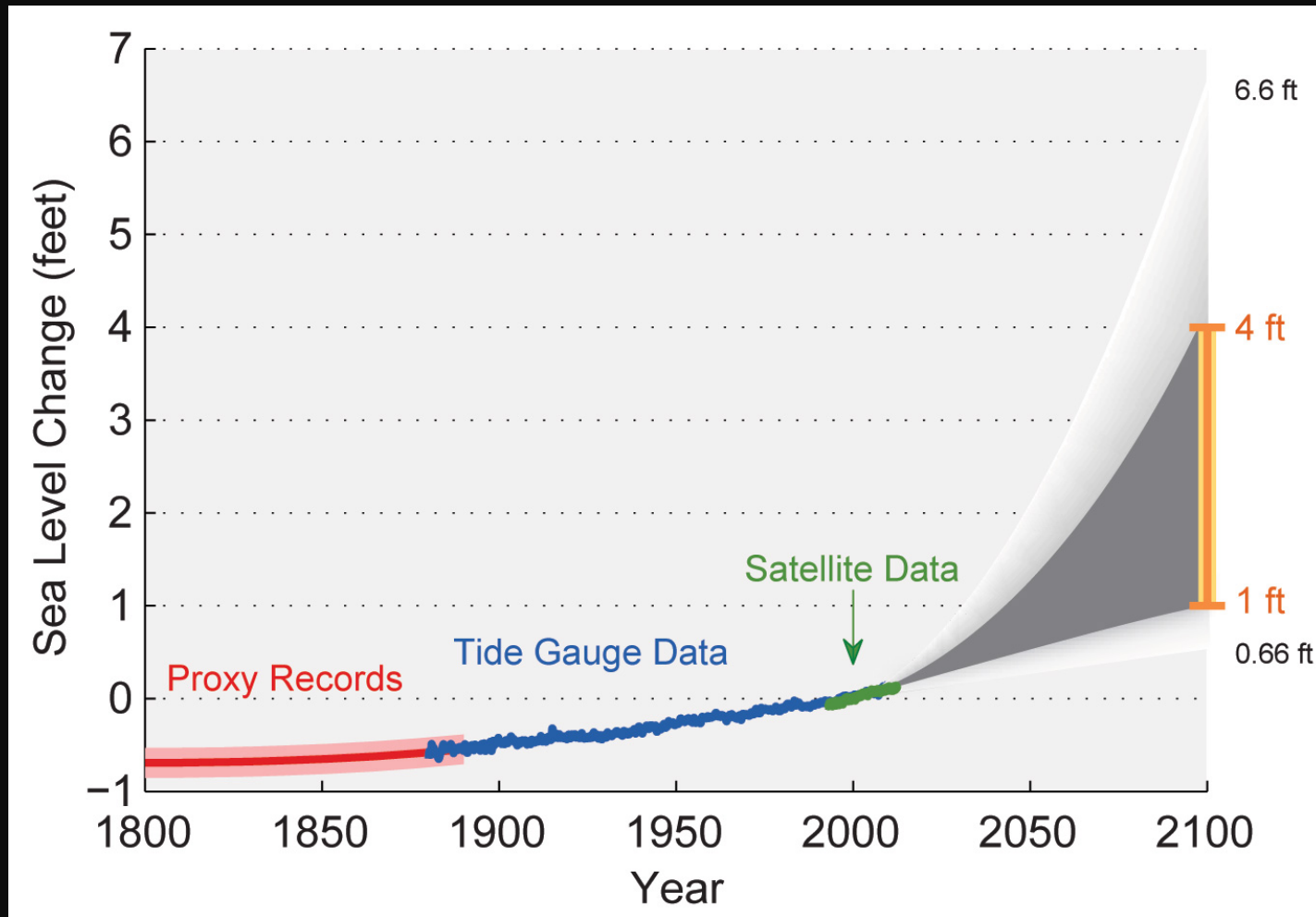


Over 6 times
more
frequent

It is *very likely* that heat waves will occur with higher frequency and duration. Occasional cold winter extremes will continue to occur.

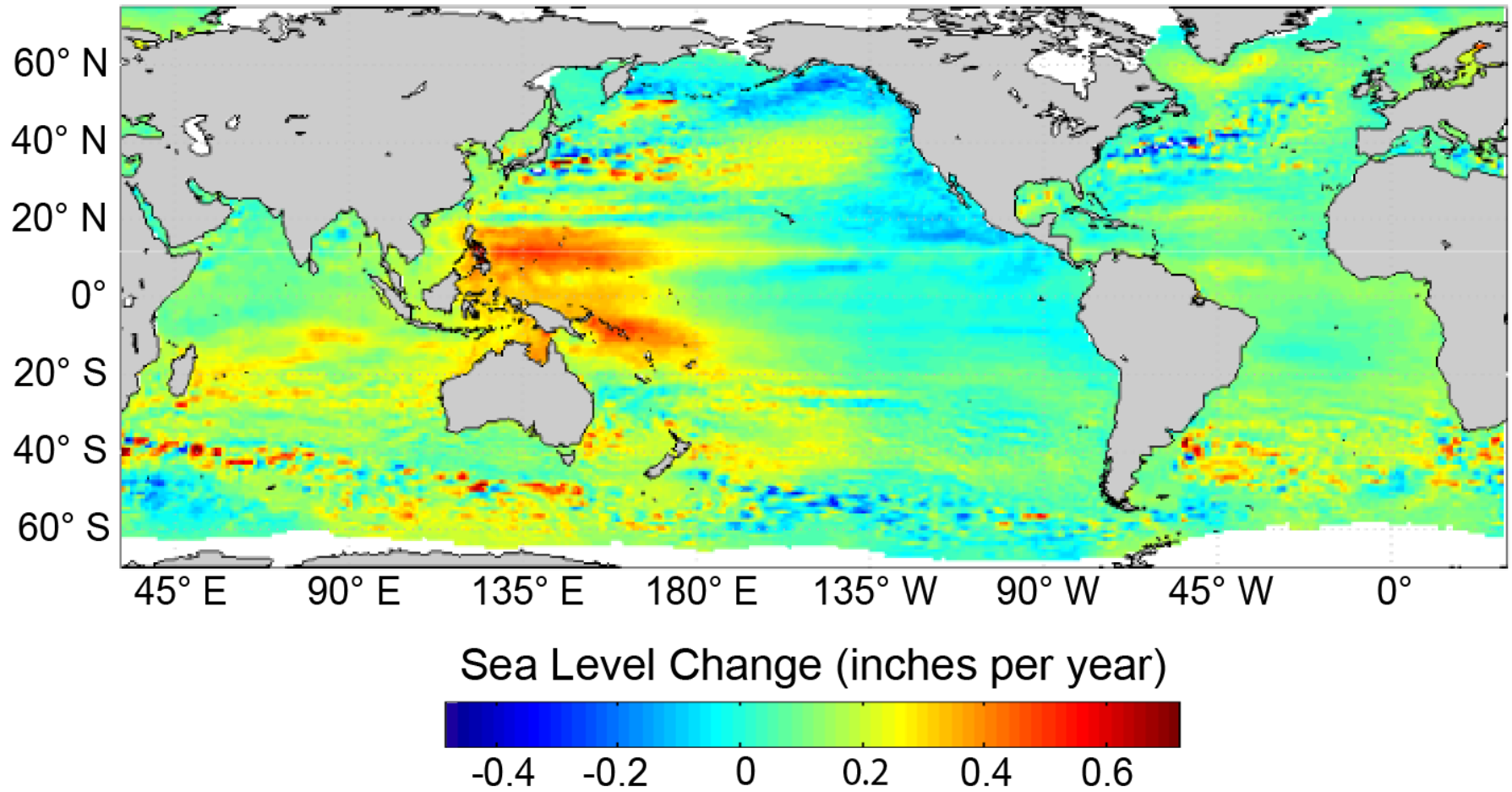
Trends in Heavy Precipitation likely to Continue



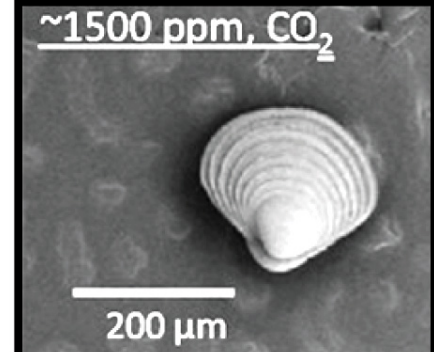
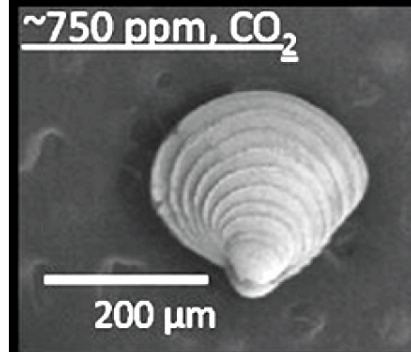
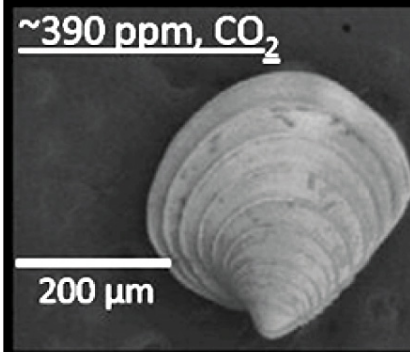
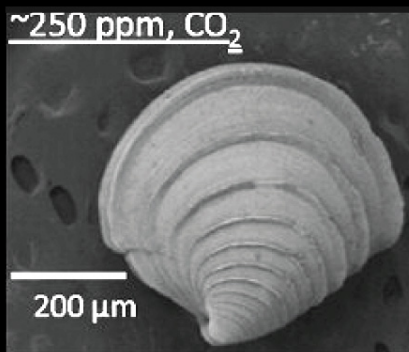
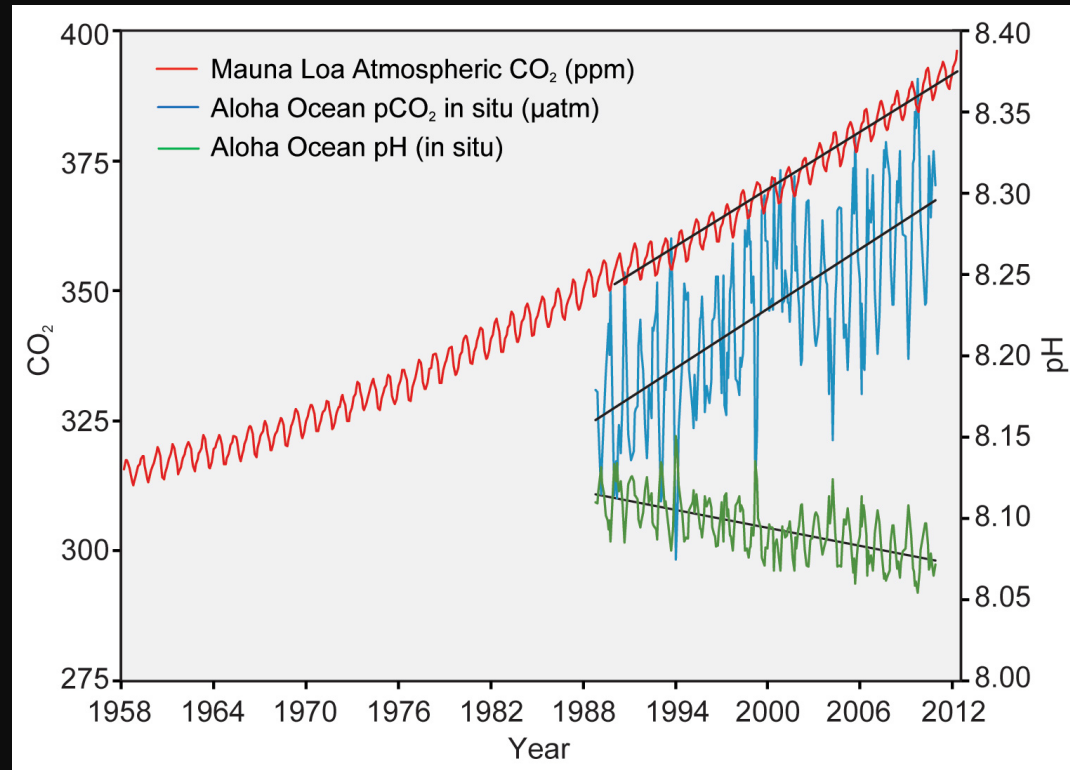


The global ocean will continue to warm during the 21st century. Global mean sea level will continue to rise during the 21st century.

Higher Sea Level Rise in Western Pacific



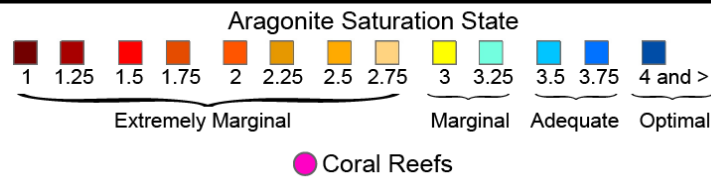
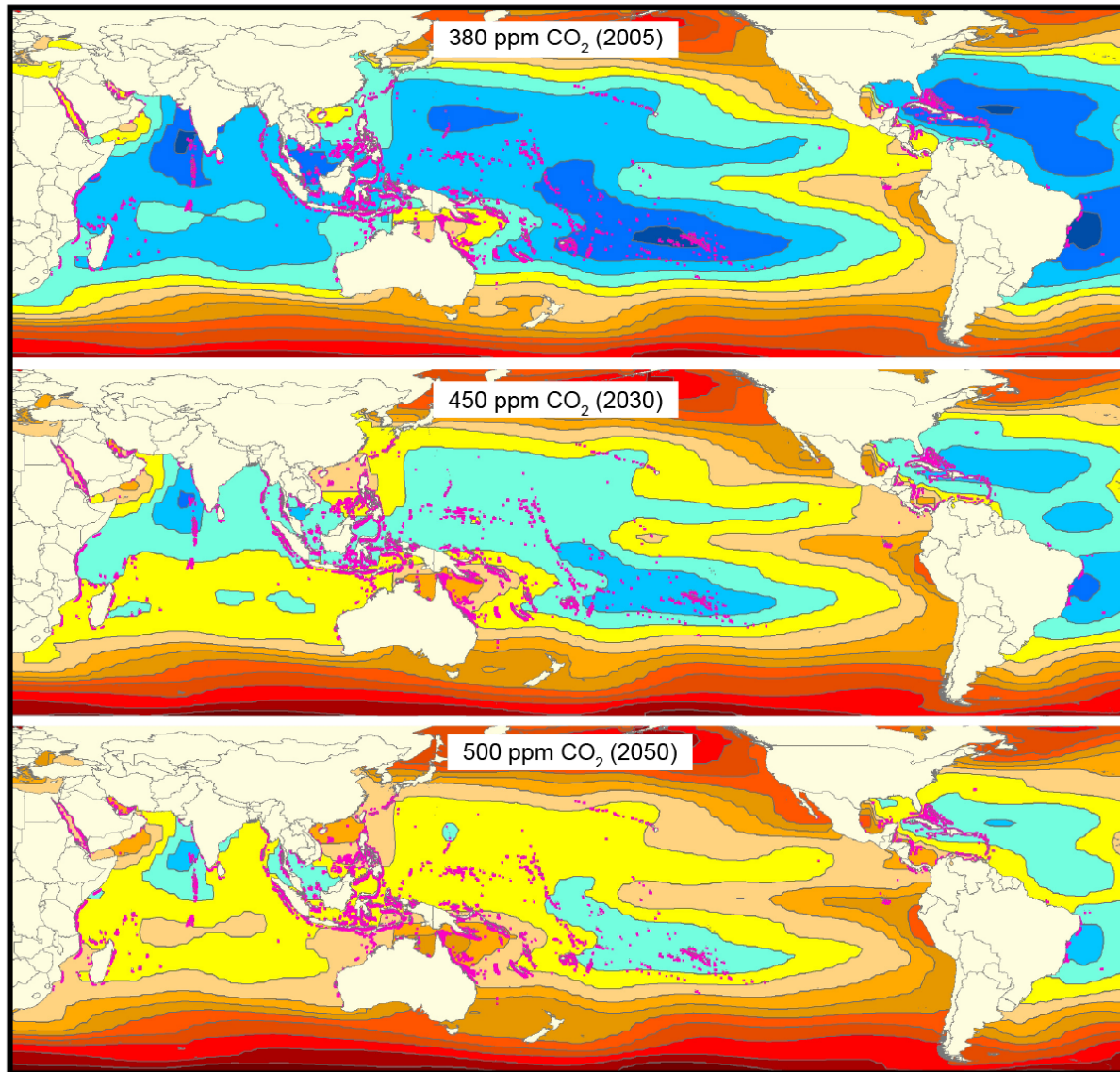
As Oceans Absorb CO₂ They Become More Acidic and is Affecting Ocean Life



Date

Name of Meeting

Increased Acidification Decreases Suitable Coral Habitat



Impacts are apparent in important sectors including health, water, agriculture, energy, and more.

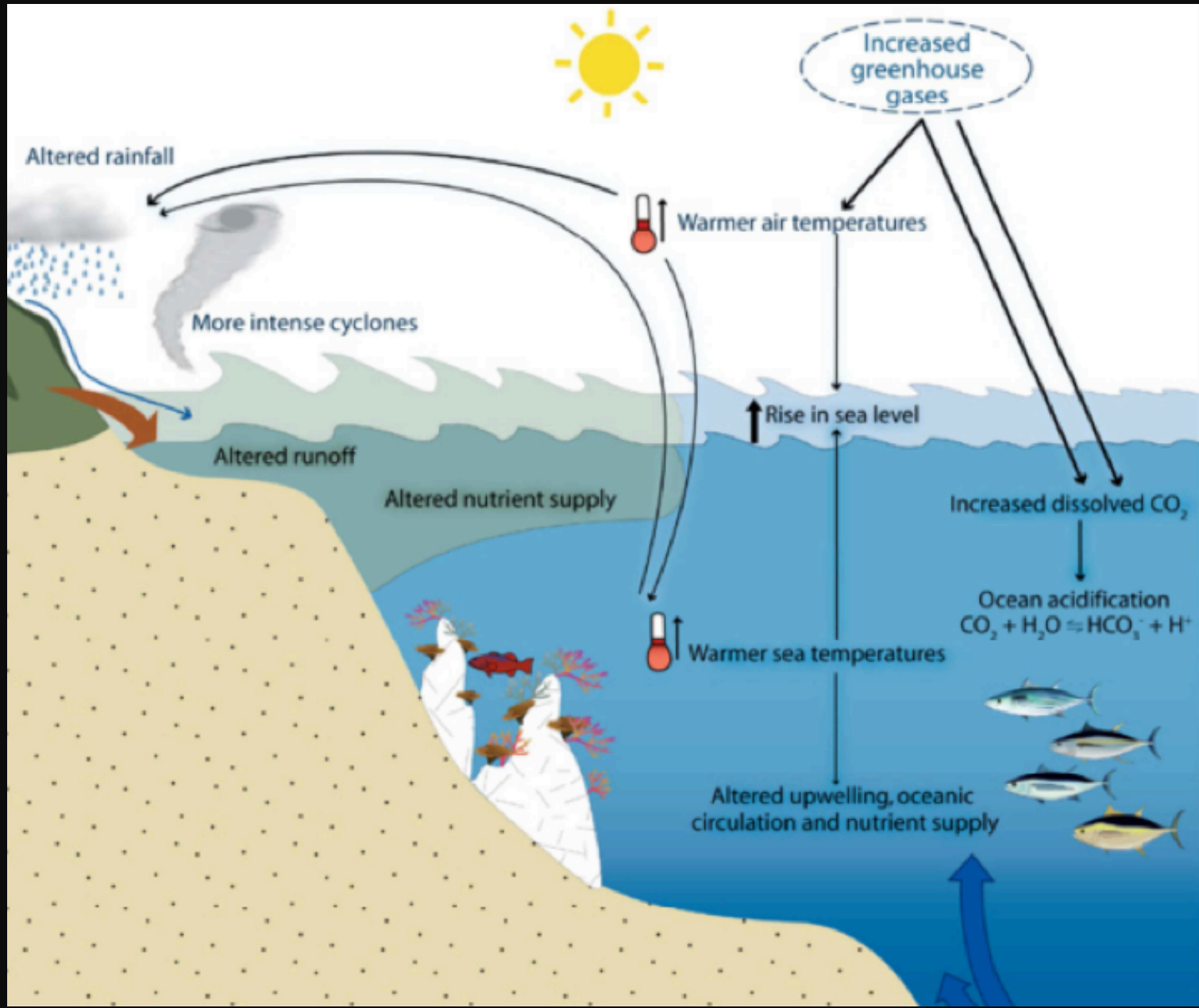


© Scott Olson/Getty Images

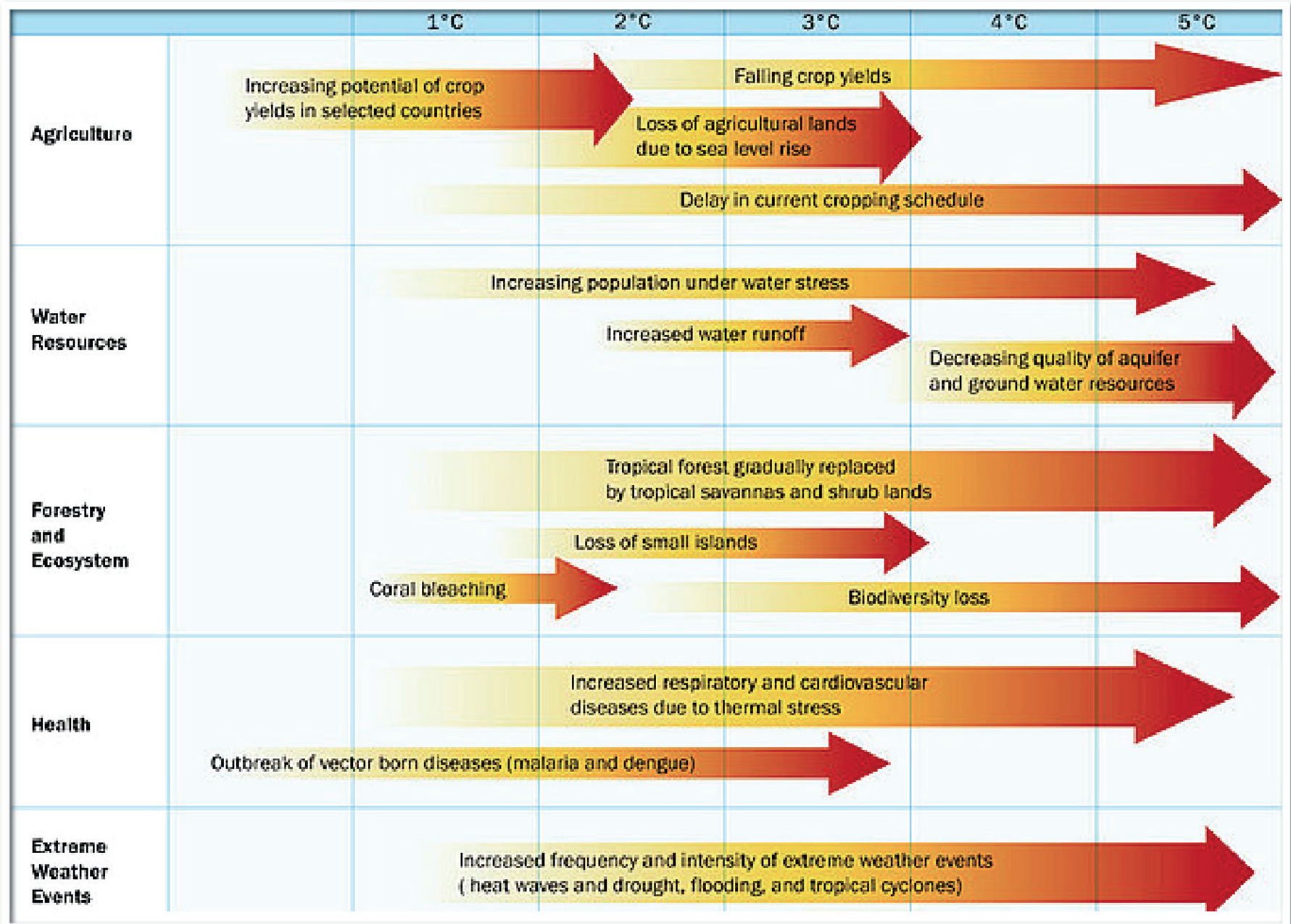
Saltwater Intrusion Destroys Crops



Impacts: Ecosystems in Tropical Pacific



Risks Increase with More Climate Change



Future Climate Change Depends Primarily on Emissions Levels



© Jim West/Imagebroker/Corbis

There are many actions we can take to reduce future climate change and its impacts and to prepare for the impacts we can't avoid.



©Dennis Schroeder, NREL



©Proehl Studios/Corbis

Mitigation



© Jerome Levitch/Corbis



© Dennis Schroeder, NREL



© Najlah Feanny/Corbis

Adaptation



©Esperanza Stancioff, UMaine Extension and Maine Sea Grant

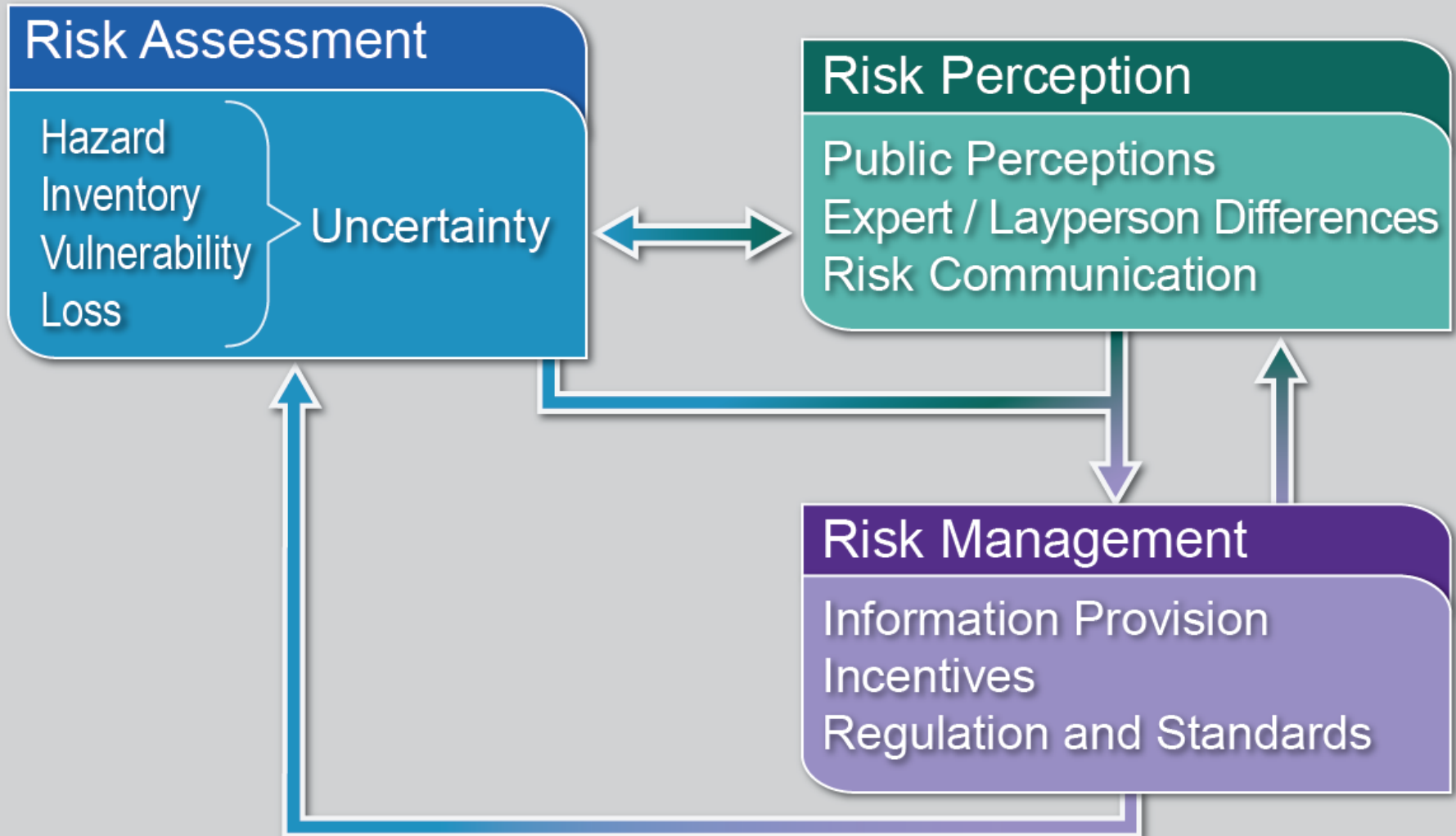


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FEMA photo by Wendell A. Davis Jr.

Linking Risk Assessment and Risk Perception with Risk Management of Climate Change



Adaptation is Not a Choice

- 1. In the U.S., substantial adaptation planning is occurring in all sectors and at all levels of government; however, few measures have been implemented and many currently are incremental .**
- 2. There is no “one-size fits all” adaptation, but there are similarities in approaches across regions and sectors. Sharing best practices, learning by doing, and iterative and collaborative processes including stakeholder involvement, can help support progress.**
- 3. Climate change adaptation actions often fulfill other societal goals, such as sustainable development, disaster risk reduction, or improvements in quality of life, and can therefore be incorporated into existing decision-making processes.**
- 4. Vulnerability to climate change is exacerbated by other stresses such as pollution, habitat fragmentation, and poverty. Adaptation to multiple stresses requires assessment of composite threats as well as tradeoffs among costs, benefits, and risks of available options.**

General Patterns in the Adaptation Process

Adaptation Process



Conclusions: A Sense of Hope

- The Earth's climate is changing, it's changing rapidly, and changing because of human activities.
- Our future depends on how we act to limit climate change.
- Adaptation is not a choice – our choice is whether to adapt proactively or respond to the consequences.
- Adaptation requires a paradigm shift, focusing on managing risks. Planning is important.
- As humans, we can draw on our long history of responding to changing conditions in facing the challenges of climate change.

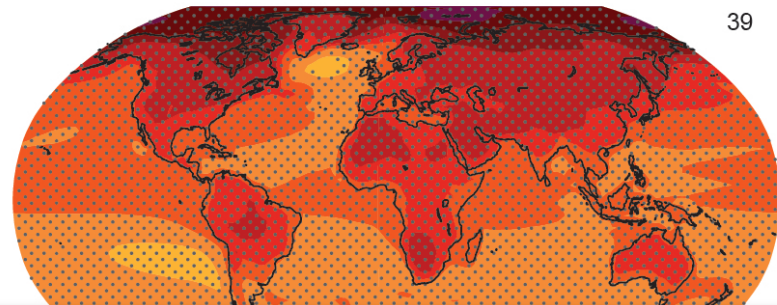
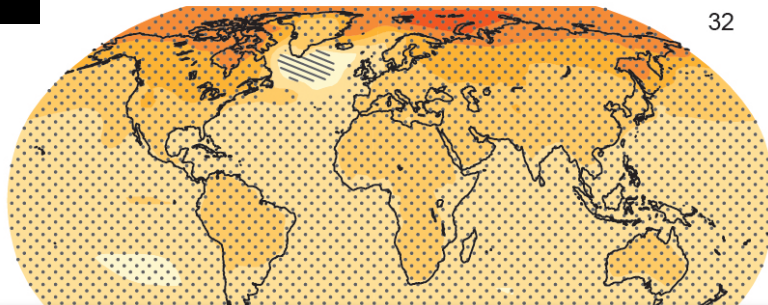
RCP2.6

$\text{CO}_{2\text{eq}} = 475 \text{ ppm}$

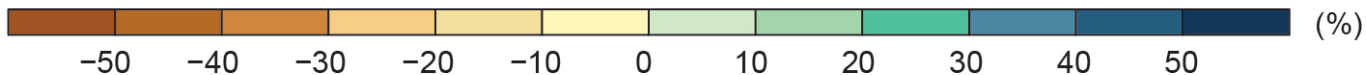
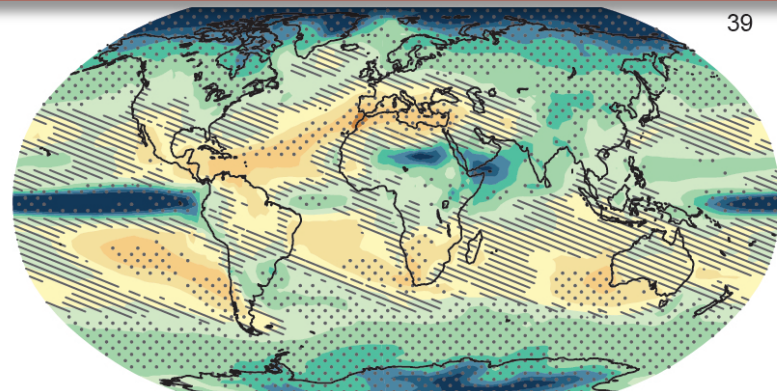
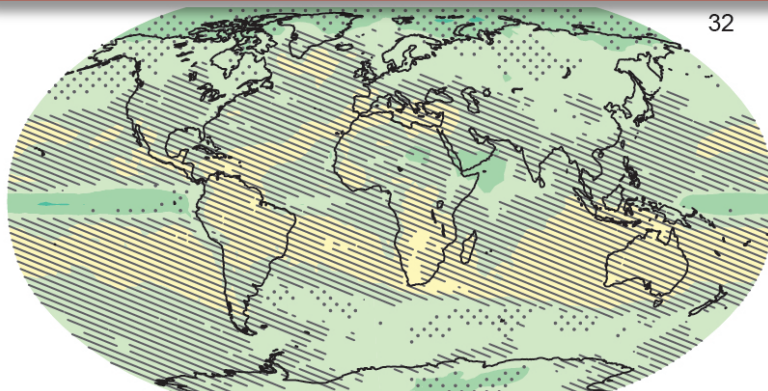
RCP8.5

$\text{CO}_{2\text{eq}} = 1313 \text{ ppm}$

Change in average surface temperature (1986–2005 to 2081–2100)



We have a choice.



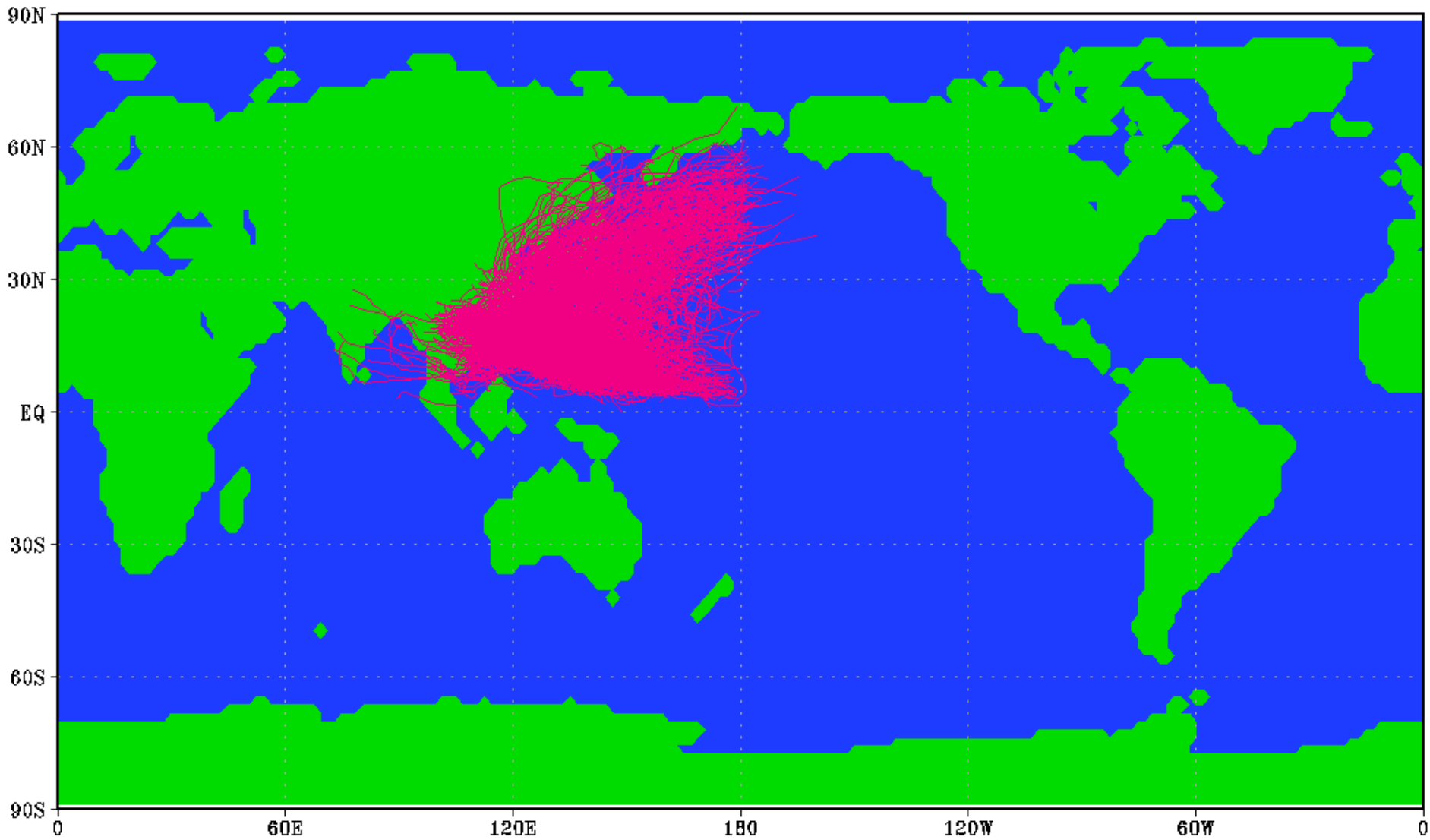
Adaptation to Changes in Precipitation Extremes due to Global Warming

Shaw Chen Liu

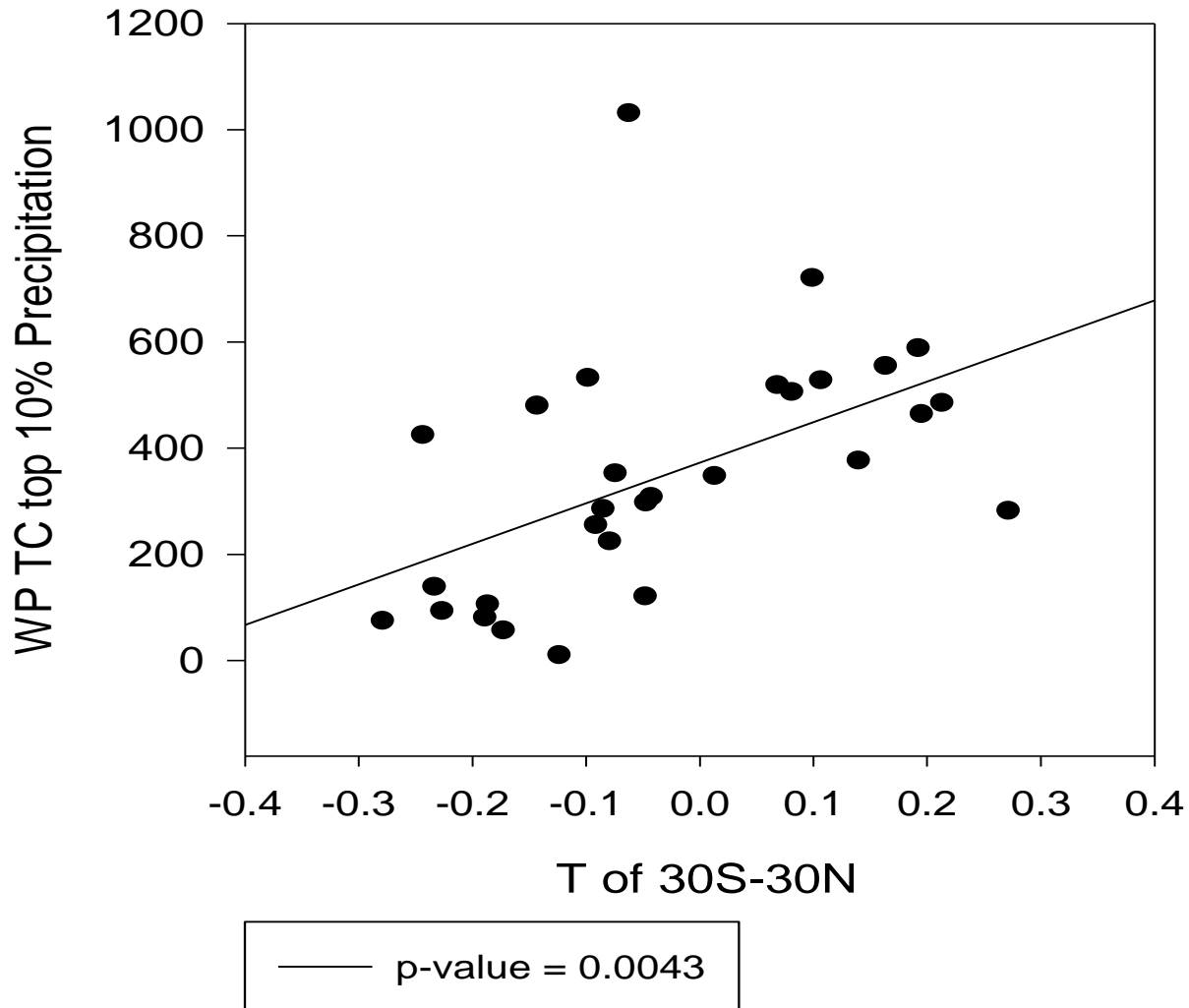
Research Center for Environmental Change
Academia Sinica

The 1st Pan Pacific International Conference on
Climate Change Adaptation
Sept. 29 – Oct. 1, 2014

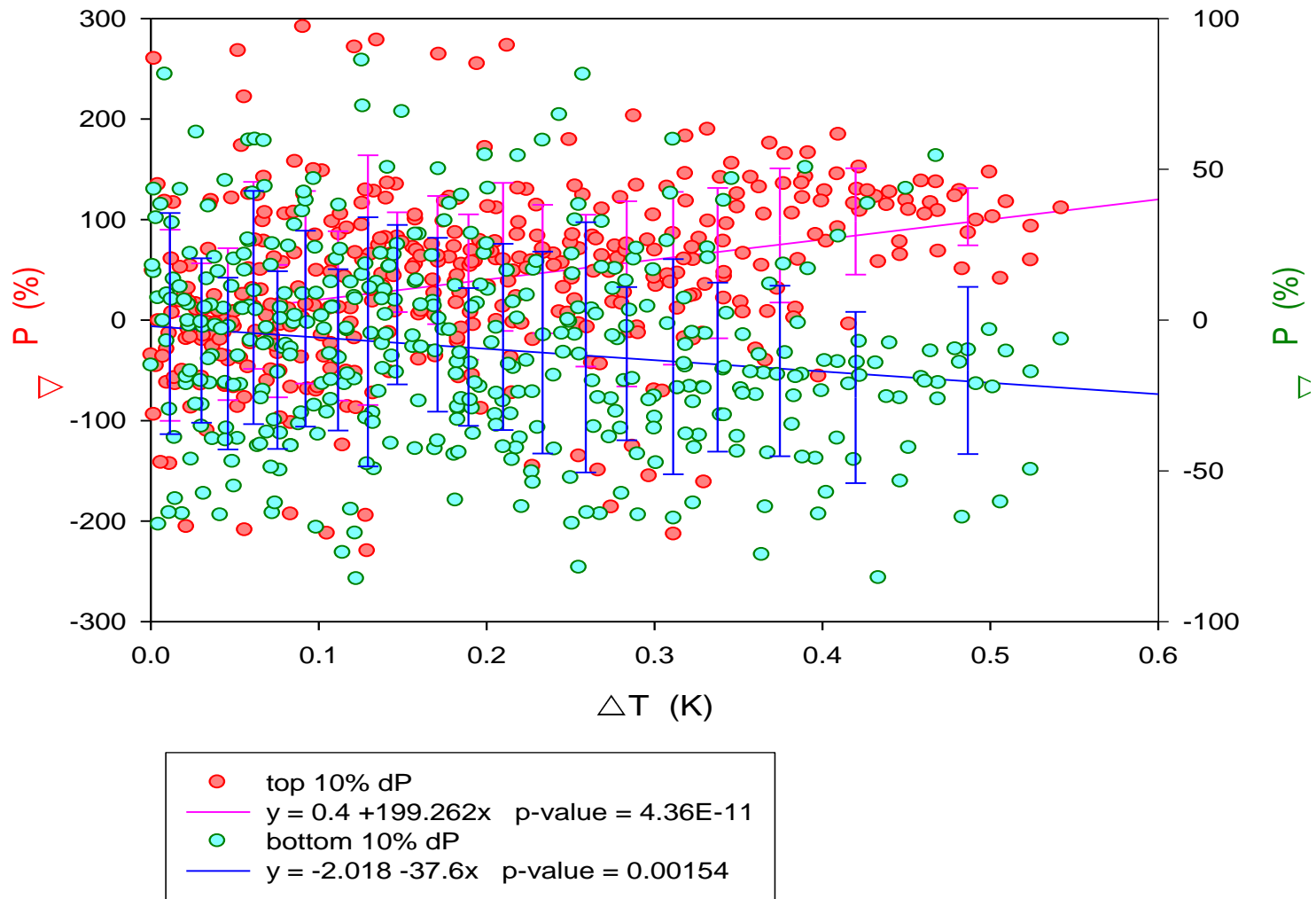
Storm in West Pacific 1979~2007



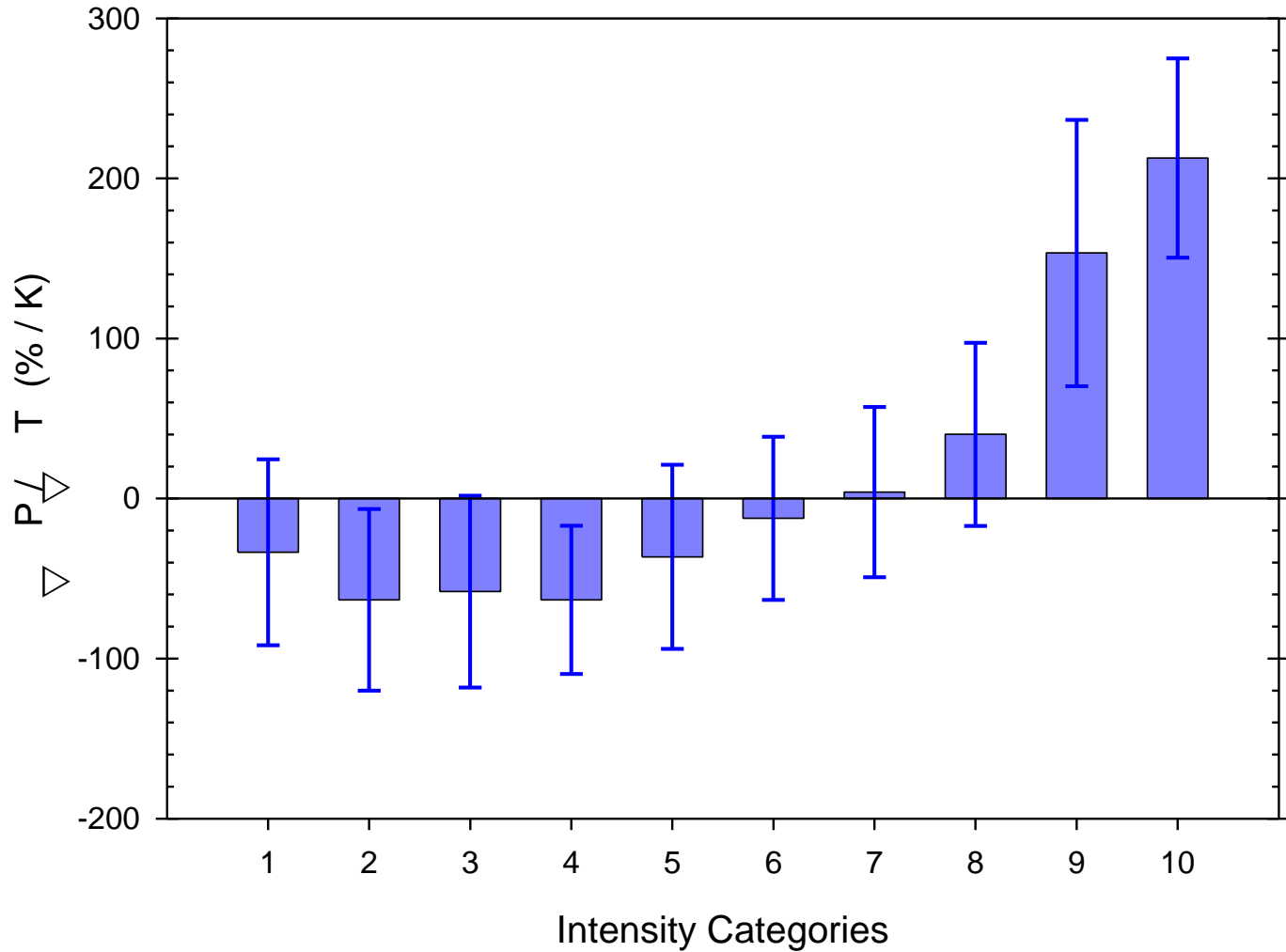
Correlation between the top 10% precipitation of TCs in the northwestern Pacific and temperature in 30S-30N



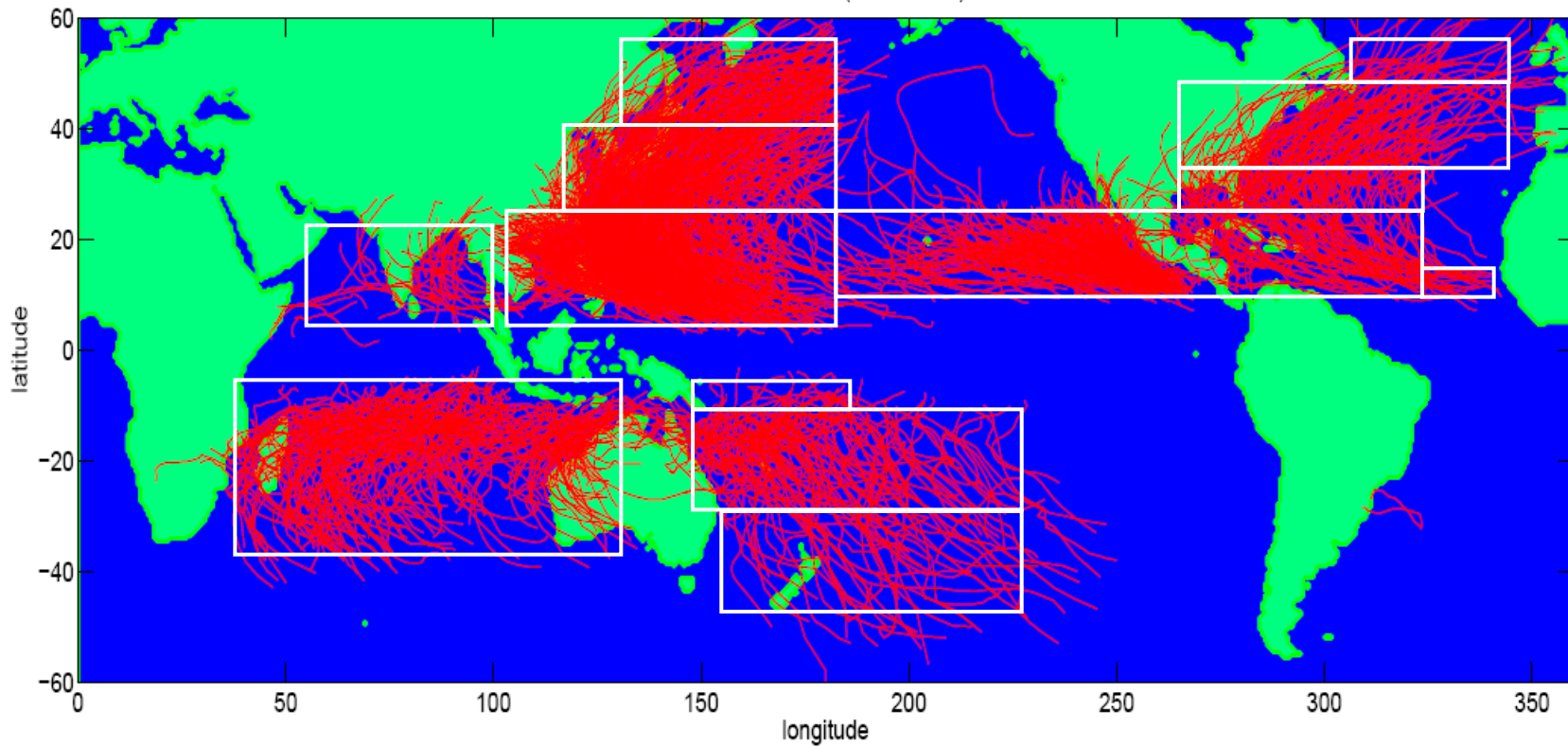
Correlation between the inter-annual difference of precipitation of TCs in the northwestern Pacific and the corresponding difference of temperature of 30S-30N



Western North Pacific Typhoon Precipitation
GPCP PENTA v1.0 & IBTrACS-WMO v03r04 data
1979~2007 (Not normalize)

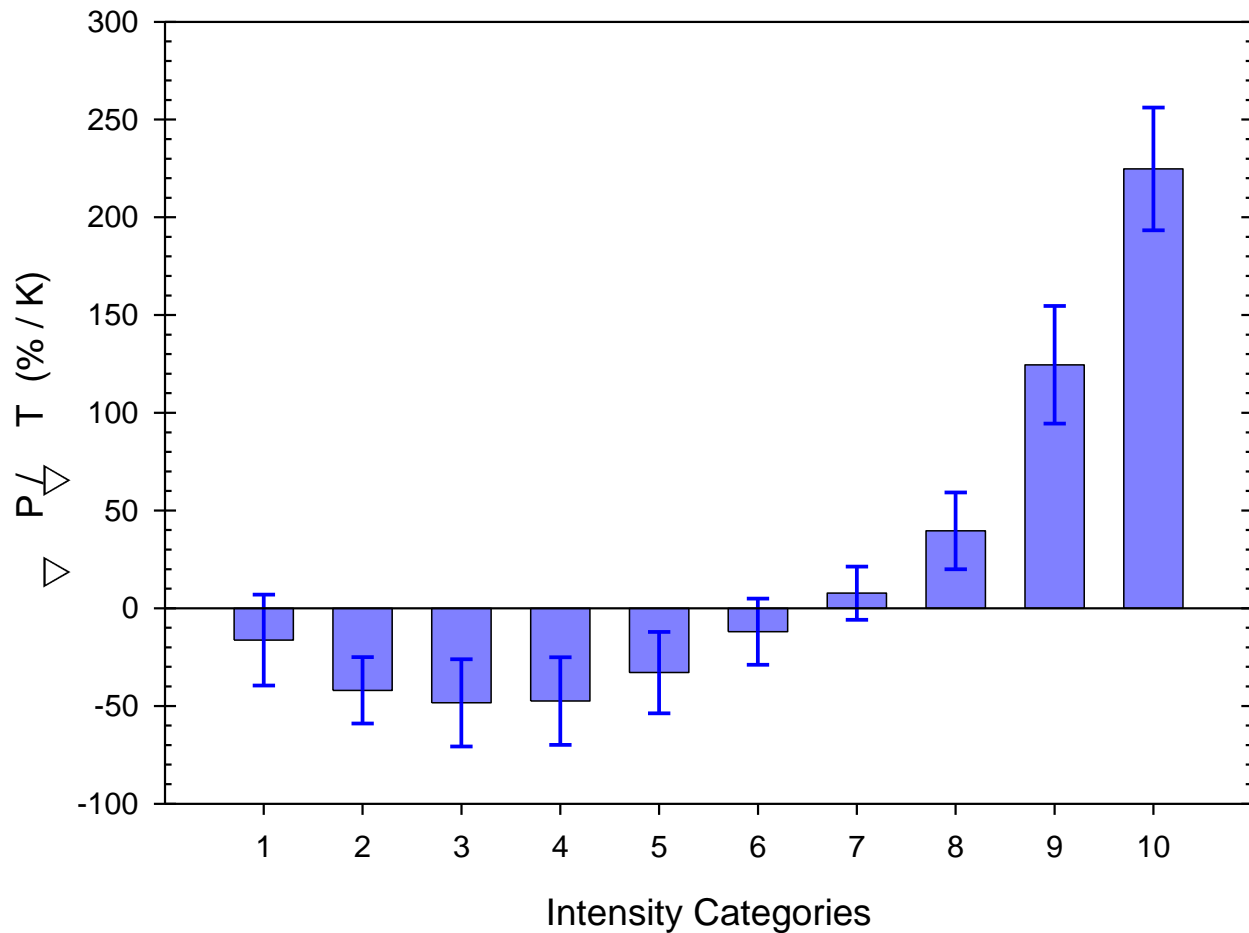


observed tracks (1981-2005)

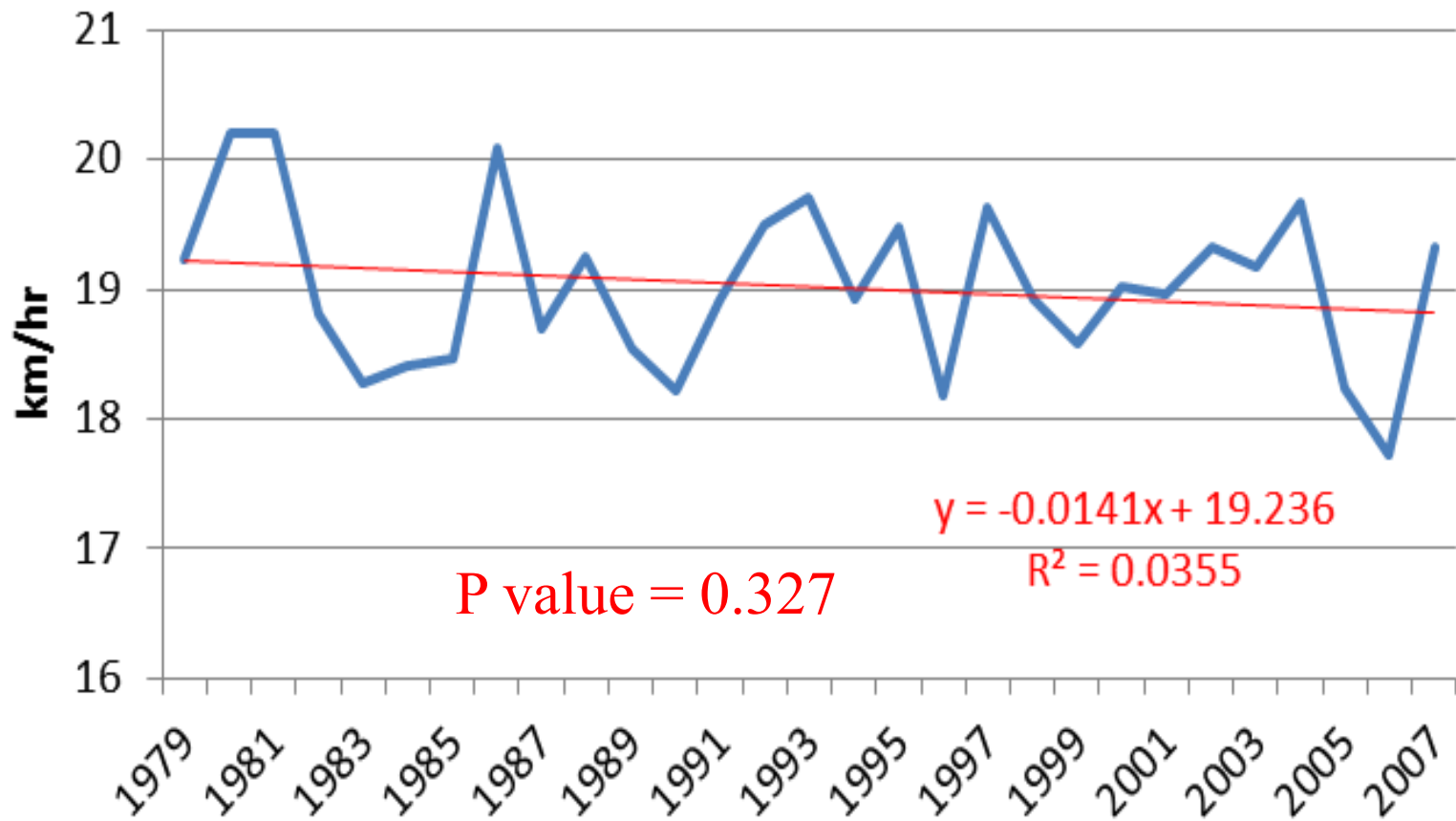


Trends in precipitation intensity of global TCs

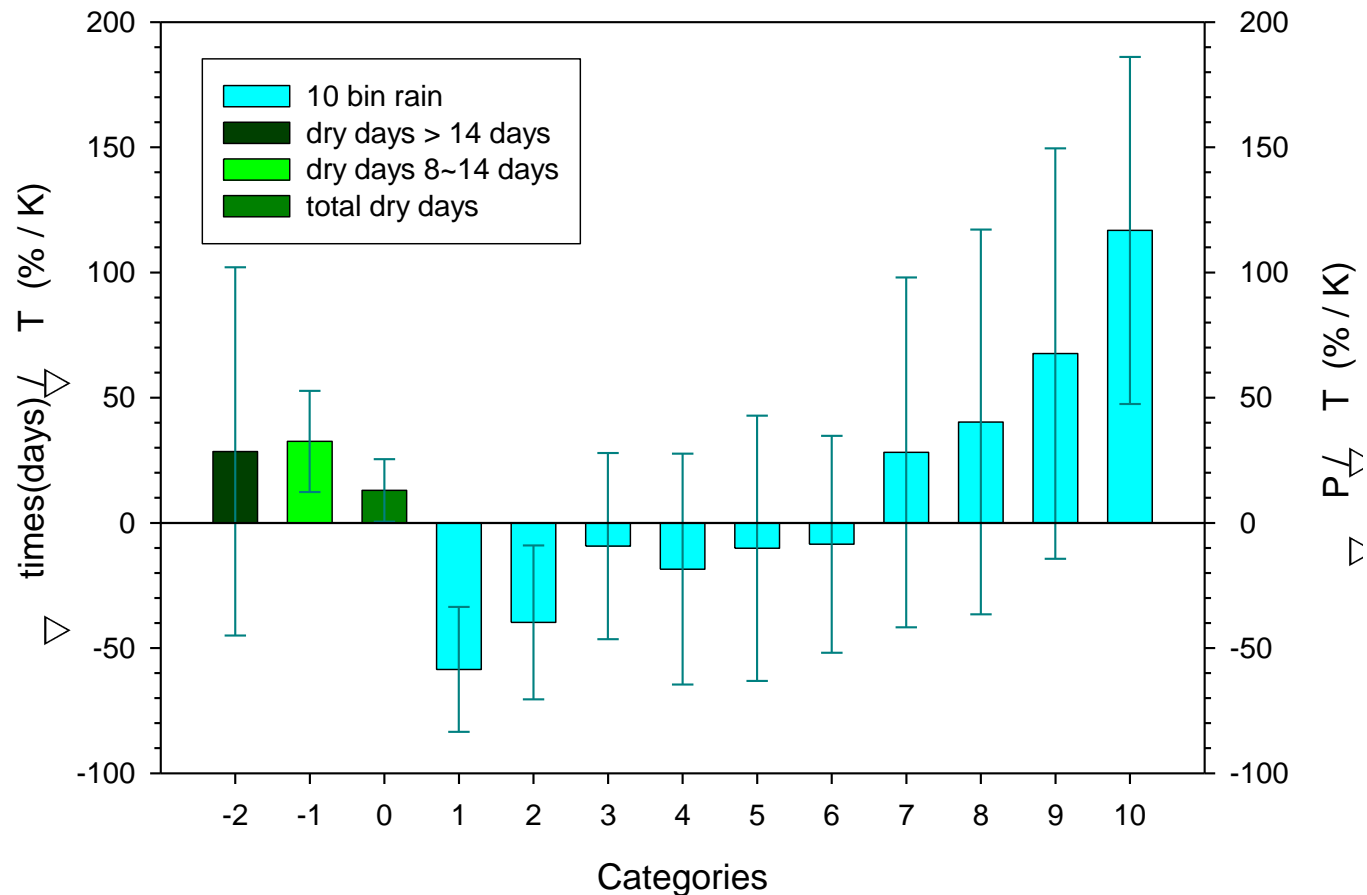
TYPHOON PRECIPITATION
GPCP PENTA v1.0 & IBTrACS v03r04 data
1979~2007

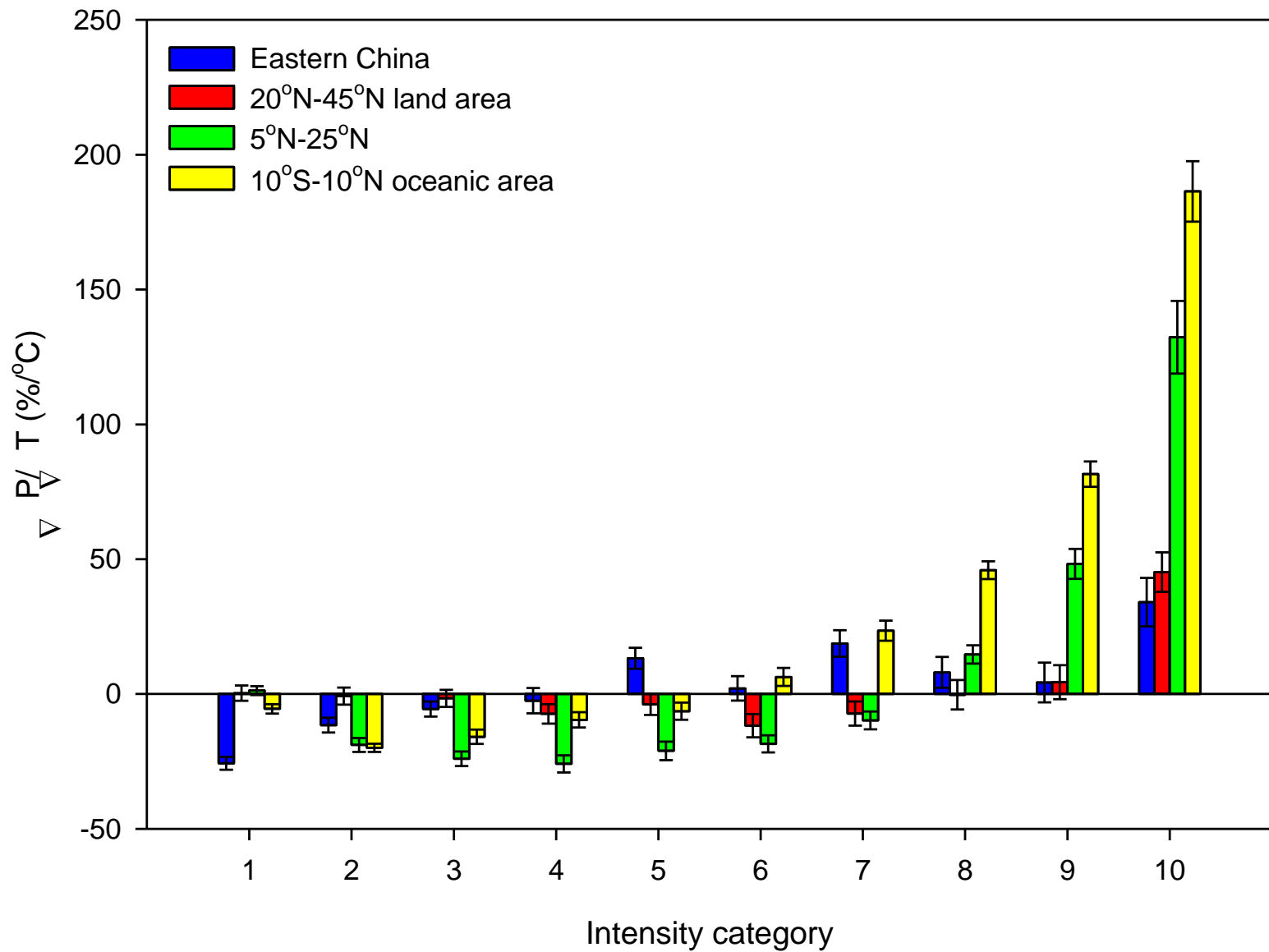


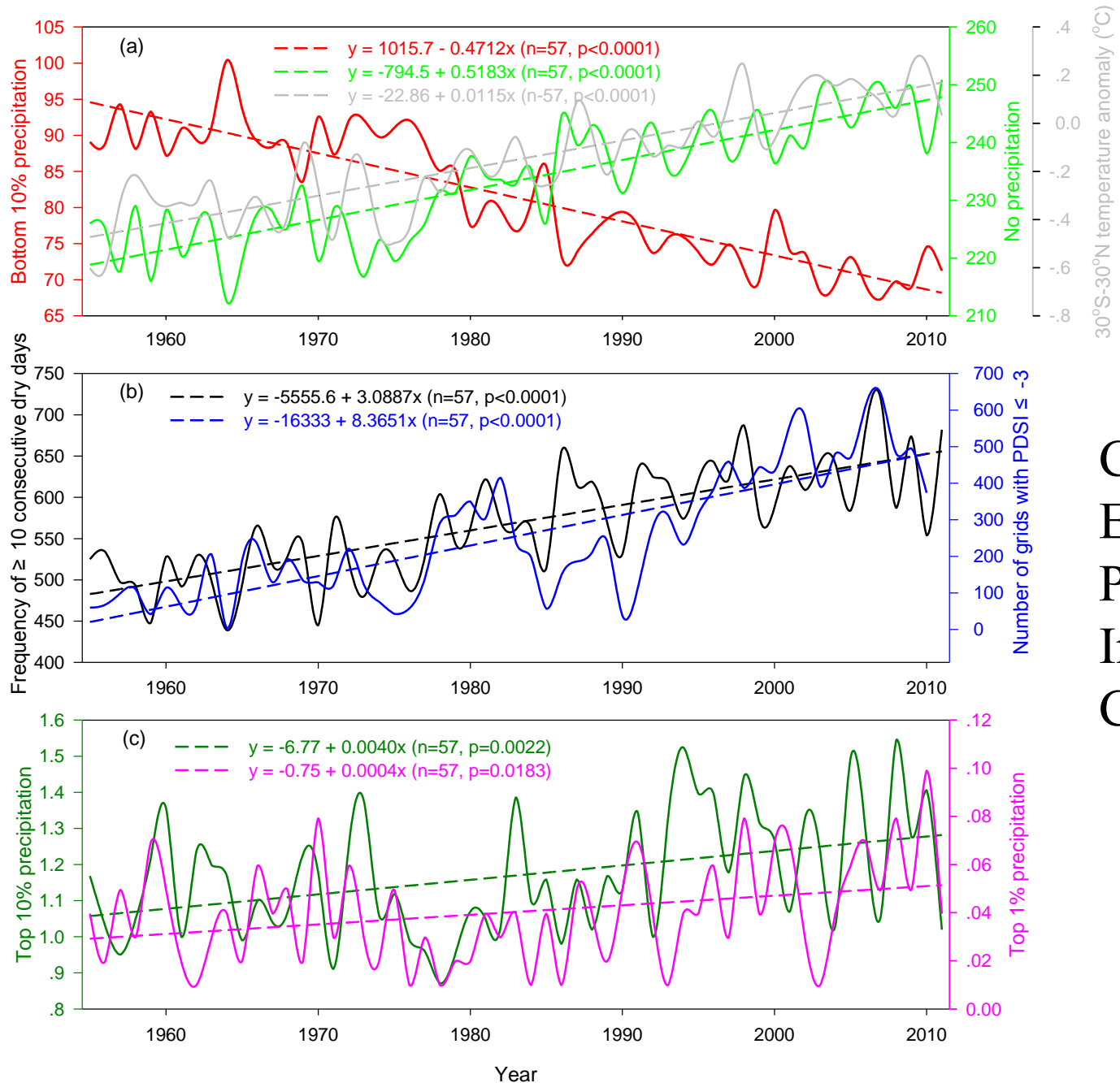
Changes in annual average translational speed of storms, 1979-2007



Changes (%) in precipitation intensity (10 blue bins) and consecutive dry days in Taiwan for each degree warming in global temperature
 (Based on Liu et al. GRL2009)







Changes in Extreme Precipitation In eastern China

Conclusions (1)

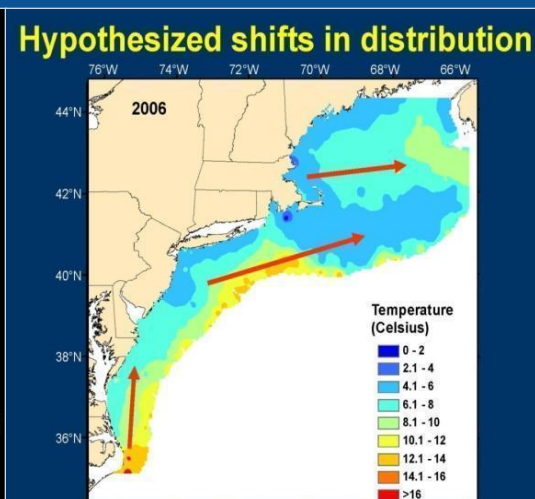
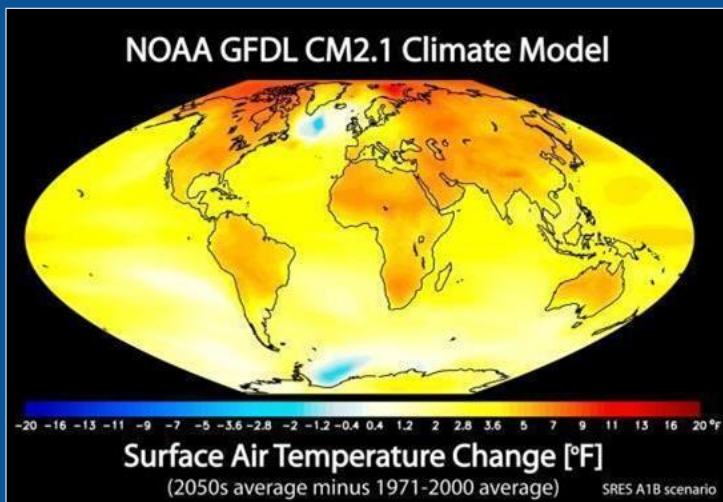
- During 1979-2007, the annual top 10% heavy rain of global tropical storms increased by about 90%. Similar changes are found for tropical storms in the NW Pacific and near Taiwan. These changes are consistent with the global warming theory summarized by Trenberth et al. (2003).
- No significant change has been detected in the translational speed of global tropical storms.

Conclusions (2)

- Light and moderate precipitation has decreased and dry days have increased significantly in eastern China and Taiwan in 1960-2010. There is an indication that this is a worldwide phenomenon, and a result of the robust water vapor/lapse rate climate feedback effect.
- **Both increased dry days and reduced light and moderate rain can increase the risk of droughts.**
- Adaptive actions such as flood and drought prevention, water resource management and land-use adjustments are imperative.

Thank you!

NOAA's Role in Providing Science and Services to Enhance Adaptation Action

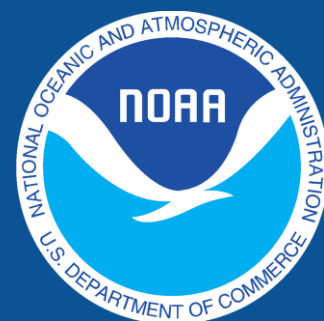


Dr. Wayne Higgins

U.S. National Oceanic and Atmospheric Administration

Director, Climate Program Office

September 29, 2014

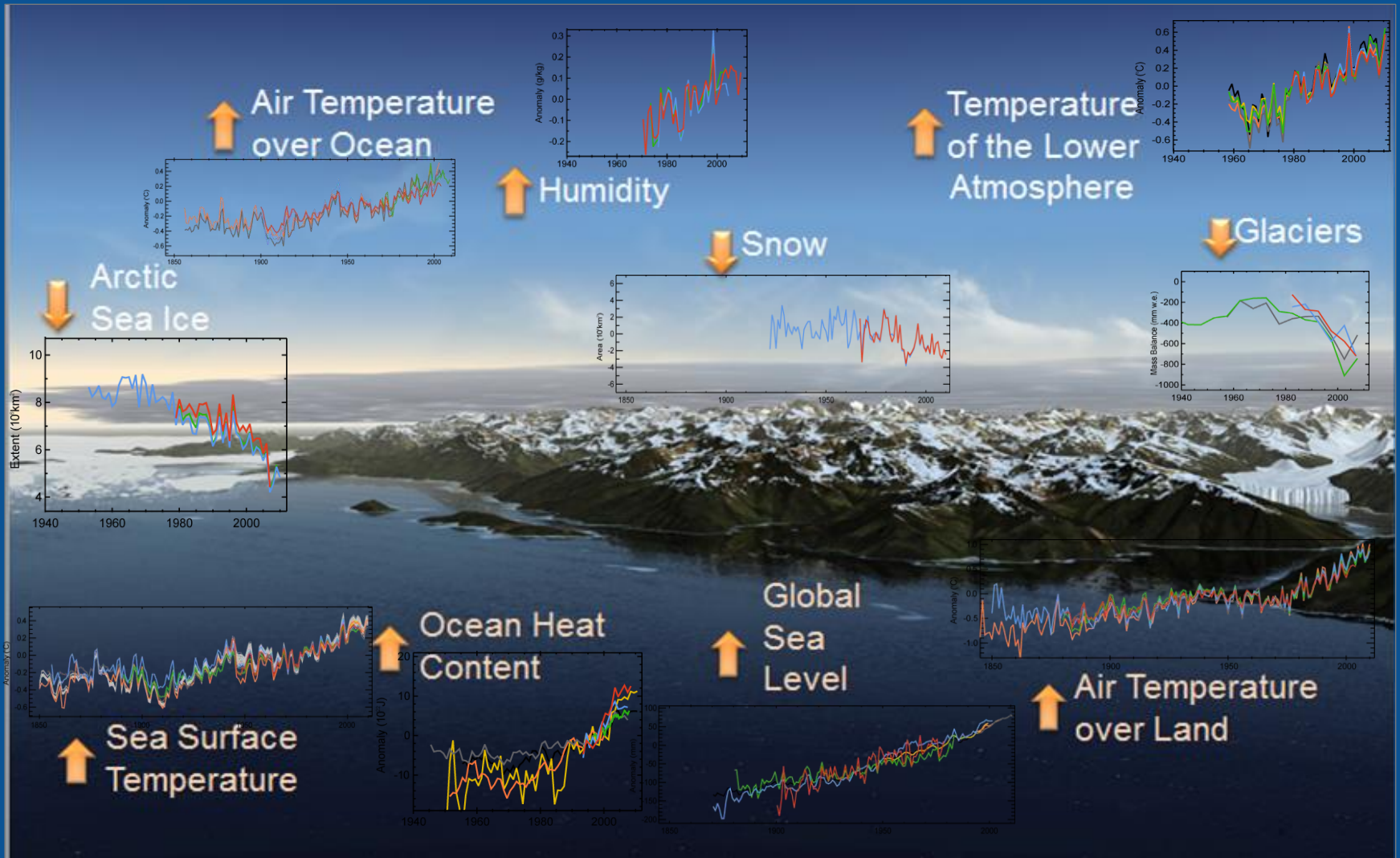


Outline

- A Changing Planet Means Changing Conditions
- The U.S. President's Climate Action Plan (PCAP)
- NOAA's Role in Climate Adaptation and Resilience
- NOAA's Contributions to the PCAP
 - *Domestic*
 - *International*
- NOAA's Societal Challenges
- Partnerships
- Concluding Remarks

What do we know?

Ten Indicators of Changing Conditions:



Why do we care?

Economies and Livelihoods are at risk



Life and Property



Aviation



Maritime



Space Operations



Forests



Emergency Management



Commerce



Ports



Energy



Hydropower



Reservoir Control



Infrastructure



Construction



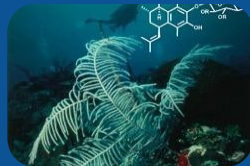
Agriculture



Recreation



Ecosystems



Health

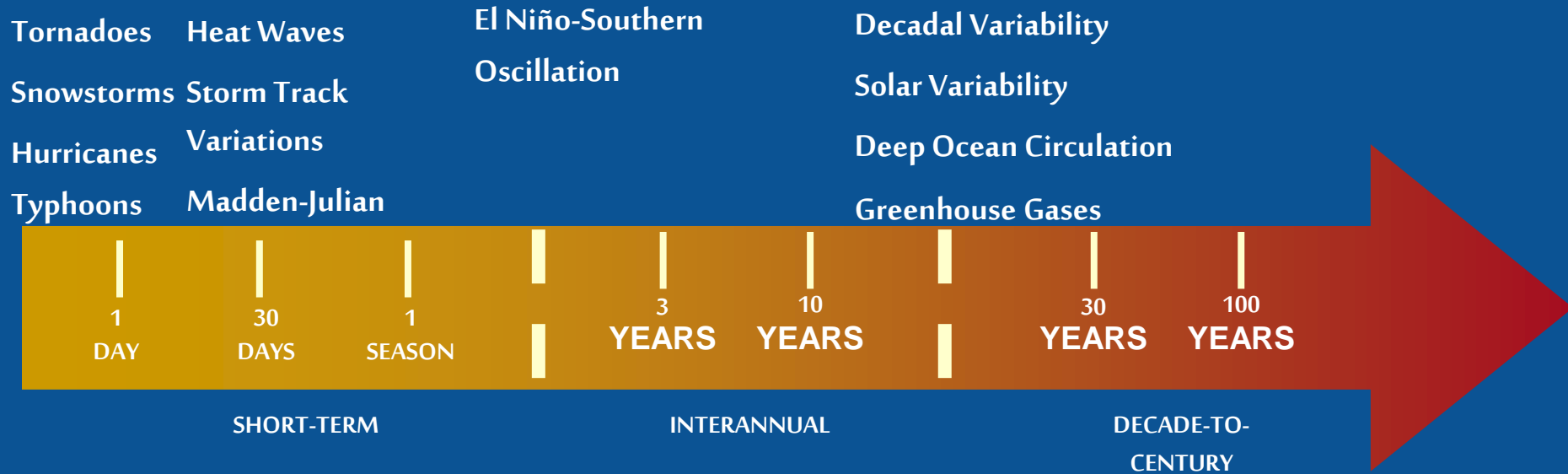


Environment

Careful preparations are required to seize opportunities, and minimize risks and vulnerabilities

What Climate Phenomena do we work with?

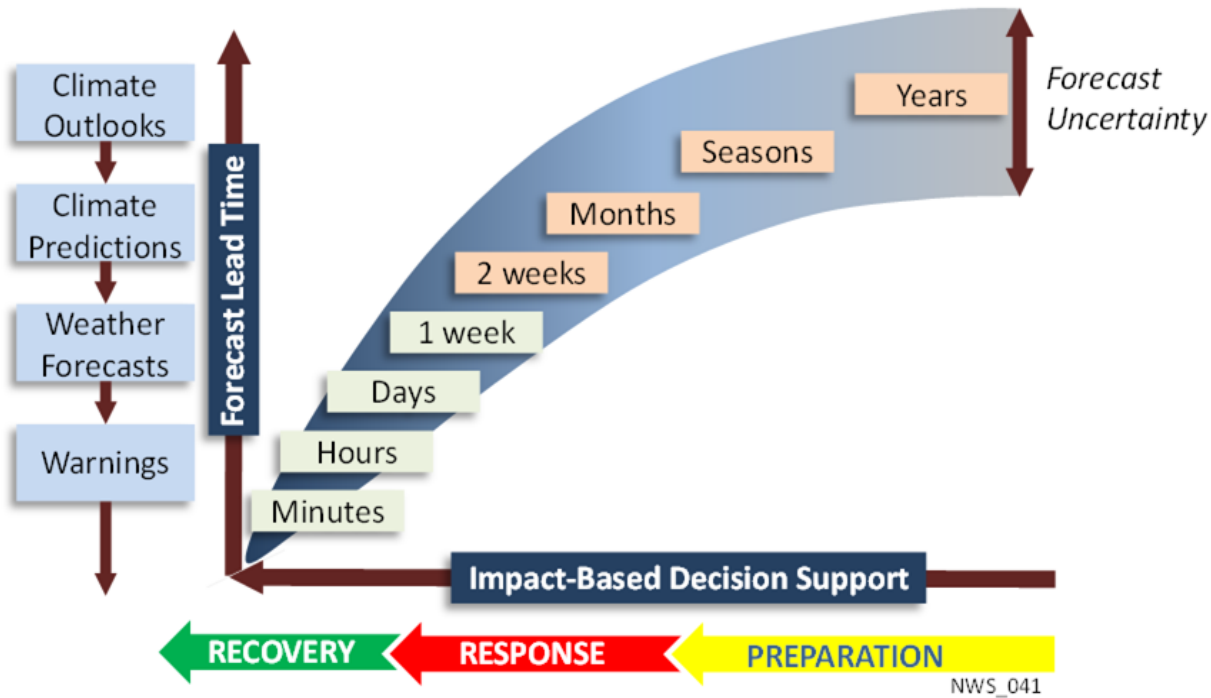
Climate Variability and Change are Linked



And Weather to Climate is a Continuum.....

What information is needed for decisions?

Timely, credible, useful - across all time scales



e.g. Disaster management planning and response

e.g. Crop Selection, Water management

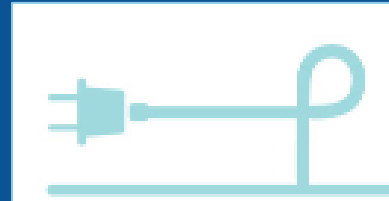
e.g. Infrastructure development

How can the U.S. meet the growing demand? President's Climate Action Plan

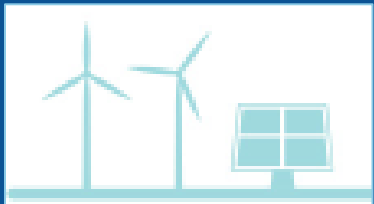
Pillar 1: Cut Carbon Pollution in America



Reducing Carbon
Pollution From Power
Plants



Cutting Energy
Waste in Homes,
Businesses, and
Factories



Accelerating Clean
Energy Leadership



Reducing other
Greenhouse Gas
Emissions



Building a 21st Century
Transportation Sector



Federal
Leadership

How can the U.S. meet the growing demand? President's Climate Action Plan

Pillar 2: Prepare the U.S. for the Impacts of Climate Change

Assess the Impacts of Climate Change (NCA)



Support Climate-Resilient Investments

Rebuild and Learn from Superstorm Sandy



Launch effort to Create Sustainable
and Resilient Hospitals



Maintain Agricultural Productivity
Provide Tools for Climate Resilience
Reduce Risk of Droughts and Wildfires

How can the U.S. meet the growing demand? President's Climate Action Plan

Pillar 3: Lead International Efforts to Address Global Climate Change

- Enhance multilateral engagement
- Combat short-lived climate pollutant
- Expand clean energy use
- Lead efforts to address climate change through international negotiations
- Expand bilateral cooperation
- Reduce emissions from deforestation
- Negotiate global free trade in environmental goods / services
- Mobilize climate finance



**** Work with other countries to strengthen global resilience to climate change ****

What is the Role of NOAA?

NOAA provides essential environmental information



Observations Monitoring Assessment Modeling Forecasts and Products



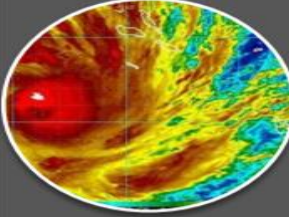


TOP PRIORITIES FOR 2014–2016

- 1 Make communities more resilient
- 2 Evolve the Weather Service
- 3 Invest in observational infrastructure
- 4 Achieve Organizational Excellence







Putting environmental information into the hands of people who need it

What is the role of NOAA?

End-to-End capabilities to enhance climate resilience

 <p>National Weather Service (NWS)</p>	 <p>Oceanic and Atmospheric Research (OAR)</p>	 <p>National Environmental, Satellite, Data, & Information Service (NESDIS)</p>	 <p>National Ocean Service (NOS)</p>	 <p>National Marine Fisheries Service (NMFS)</p>
-------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------

NOAA
Line
Offices

	Observing Systems, Climate Monitoring, and Data Stewardship	Research
	Understanding and Modeling	
	Predictions and Projections	
	Assessments	
	Informing Decisions	
	Communication and Education	
		Services

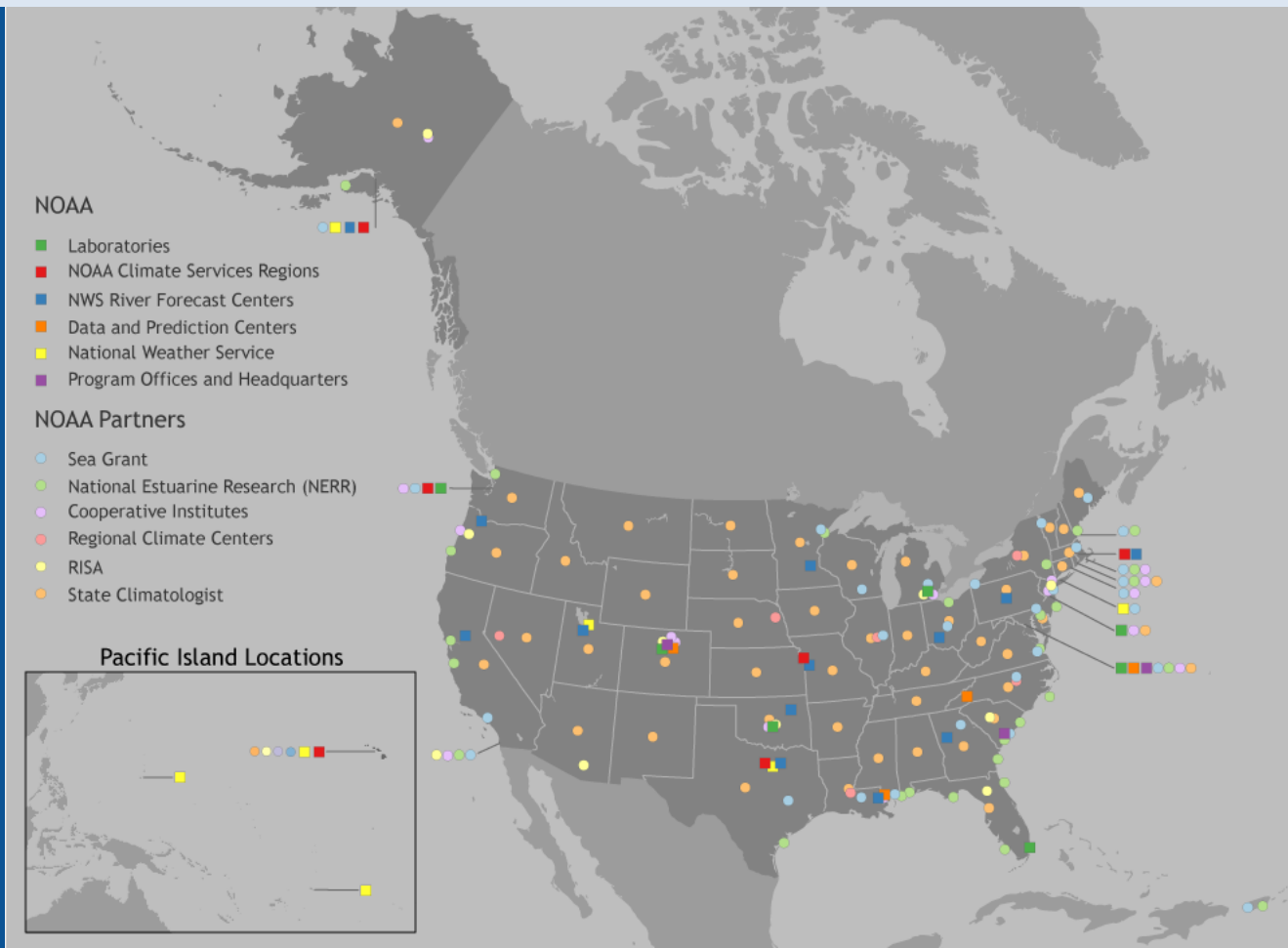
What is the role of NOAA?

NOAA Works Internationally because Climate is Global ...



And Climate Change is a Global Issue.....

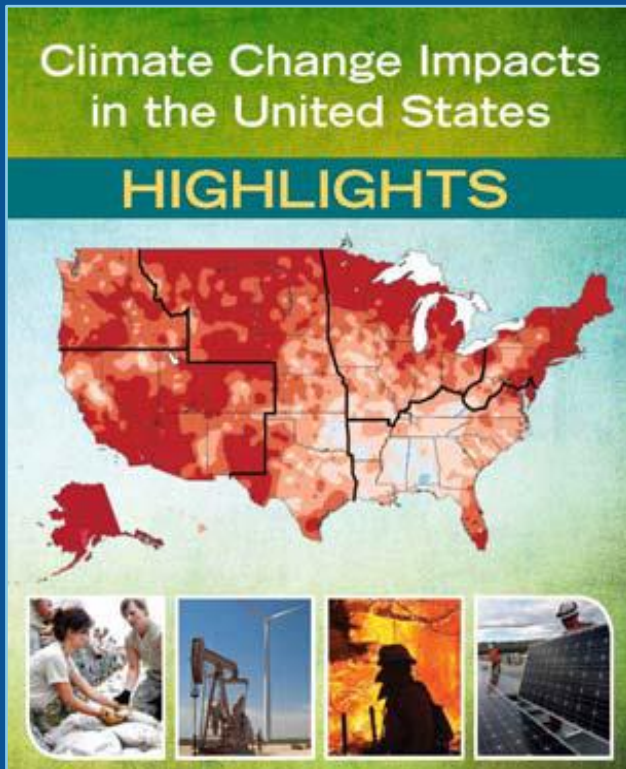
But most decisions related to adaptation are local NOAA invests in regional networks



NOAA is well positioned nationally and internationally to make data and information actionable. Most climate decisions are regional or local, and NOAA is structured to have multiple entry points at regional, state, and local levels.

How does NOAA implement the Climate Action Plan?

Example: Support the 3rd National Climate Assessment



- A comprehensive & authoritative scientific report about climate changes that are happening now in the U.S. and that can be expected throughout this century.
- The report - a key deliverable of President Obama's Climate Action Plan— confirms that climate change is affecting every region of the U.S and key sectors of the national economy.
- NOAA's science and observations are an integral part of global efforts to monitor Earth's climate, and have greatly informed the 3rd NCA
- White House/OSTP documents on "globalchange.gov" and "whitehouse.gov"

How does NOAA implement the Climate Action Plan?

Example: 2014 NCA - Resources for Educators:

National Climate Assessment (NCA) Teaching Resources
Learning Pathways to Help Educators Uncover Key Concepts and Authentic Data from the National Climate Assessment

The National Climate Assessment offers a wealth of actionable science about the causes, effects, risks and possible responses to human-caused climate change. NOAA, USGCRP NCAnet Education Affinity Group and members of the CLEAN Network have developed a series of guides for educators that focus on the regional chapters of the Assessment Report, helping to unpack the key messages of each region and point to related, high-quality online resources.

Explore the NCA Report Findings
[Click here to see them all »](#)

Regional support pages

Regions:
Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawaii and Pacific Islands, Coasts, Ocean

Overview support pages
What is the National Climate Assessment (NCA)?
Additional National Climate Assessment Resources for Educators
The National Climate Assessment and the Next Generation Science Standards

- The Climate Program Office's Climate.gov Education team along with collaborators from inside and outside of Government, has released new digital guides that connect educators to relevant findings of the NCA for each U.S. region.
- Link: <http://www.climate.gov/teaching/2014-national-climate-assessment-resources-educators>
- NOAA, [USGCRP NCAnet Education Affinity Group](#) and members of the [CLEAN Network](#) have developed this series of guides for educators

How does NOAA implement the Climate Action Plan? Example: Climate Resilience Toolkit (CRT)

U.S. Climate Resilience Toolkit

Get Started Taking Action Tools Topics Expertise

About Contact Funding Opportunities Help

Search

Meet the Challenges of a Changing Climate

The Climate Resilience Toolkit provides resources and a framework for understanding and addressing the climate issues that impact people and their communities.

- 1 Identify the Problem
- 2 Determine Vulnerabilities
- 3 Investigate Options
- 4 Evaluate Risks & Costs
- 5 Take Action

Taking Action to Build Resilience

- Dune Migration and Shoreline Protection [Watch Video >>](#)
- Pollen and Poison Ivy [Watch Video >>](#)
- Climate Outlooks Inform Water Management [Watch Video >>](#)
- Louisiana's Front Line-Defense from Storm and Surge [Watch Video >>](#)

Data Interaction Tool: Climate Explorer

The Climate Explorer is an interactive web application that presents national and regional maps of climate-related parameters, and location-specific time series of historical temperature and precipitation data.

Get Started

Featured Tools

- CanVis**
A visualization program used to "see" potential impacts from coastal development or sea level rise. Users can... [read more >>](#)
- COMET-Farm**
Enables farmers and ranchers to estimate carbon sequestration and greenhouse gas emissions related to annual crop production... [read more >>](#)
- Sea Level Rise and Coastal Flooding Impacts Viewer**
Being able to visualize potential impacts from sea level rise is a powerful teaching and planning tool, and the Sea Level... [read more >>](#)

A site designed to help people

- ✓ find and use tools, information, and expertise from across the U.S. federal government via one easy to use location:

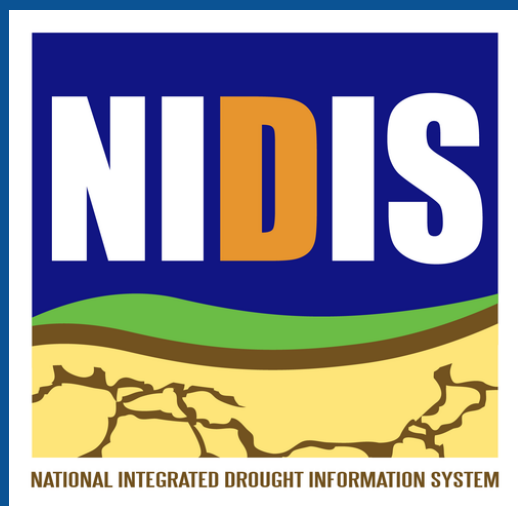
<http://climate.gov>

- ✓ *understand and manage* their climate-related risks and opportunities

- ✓ make their communities and businesses more *resilient*

How does NOAA implement the Climate Action Plan?

Example: NIDIS/National Drought Resilience Partnership



National Integrated Drought Information System:
Public Law 109-430; reauthorized in 2014 to

- “provide effective drought early warning”
- communicate drought forecasts, conditions, and impacts to decision makers, private sector, public

Information sharing and collaboration across all levels of government to promote drought preparedness & planning



How does NOAA implement the Climate Action Plan?

Example: Climate Data Initiative

A collaborative effort, led by NASA and NOAA, to spur innovation and advance awareness of climate variability & change. It includes:

- A catalog of climate-related datasets and data <http://climate.data.gov>
- Workshops with data users and data innovators to solve mutual problems
- Seeking commitments from private sector companies and civic innovators

The screenshot displays the Data.gov website interface. At the top right is a search bar labeled "Search Data.gov" with a magnifying glass icon. Below the search bar is the Data.gov logo, which includes the American flag and the text "DATA.GOV". To the right of the logo is a navigation menu with the following items: "DATA", "TOPICS" (with a dropdown arrow), "APPLICATIONS", "DEVELOPERS", and "CONTACT". Below the navigation menu is a blue banner with a sun and bar chart icon and the word "CLIMATE". Underneath the banner is a sub-navigation menu with the following items: "Coastal Flooding", "Updates" (with a dropdown arrow), "Data", "Tools", "Maps", "Challenges", "Resources", and "Feedback".

How does NOAA implement the Climate Action Plan?

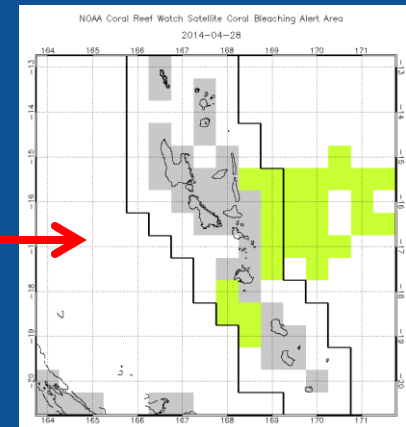
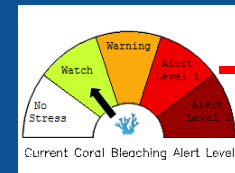
Example: Supporting Adaptation in the Pacific Islands

Focus Area Coordination Teams (FACTS):

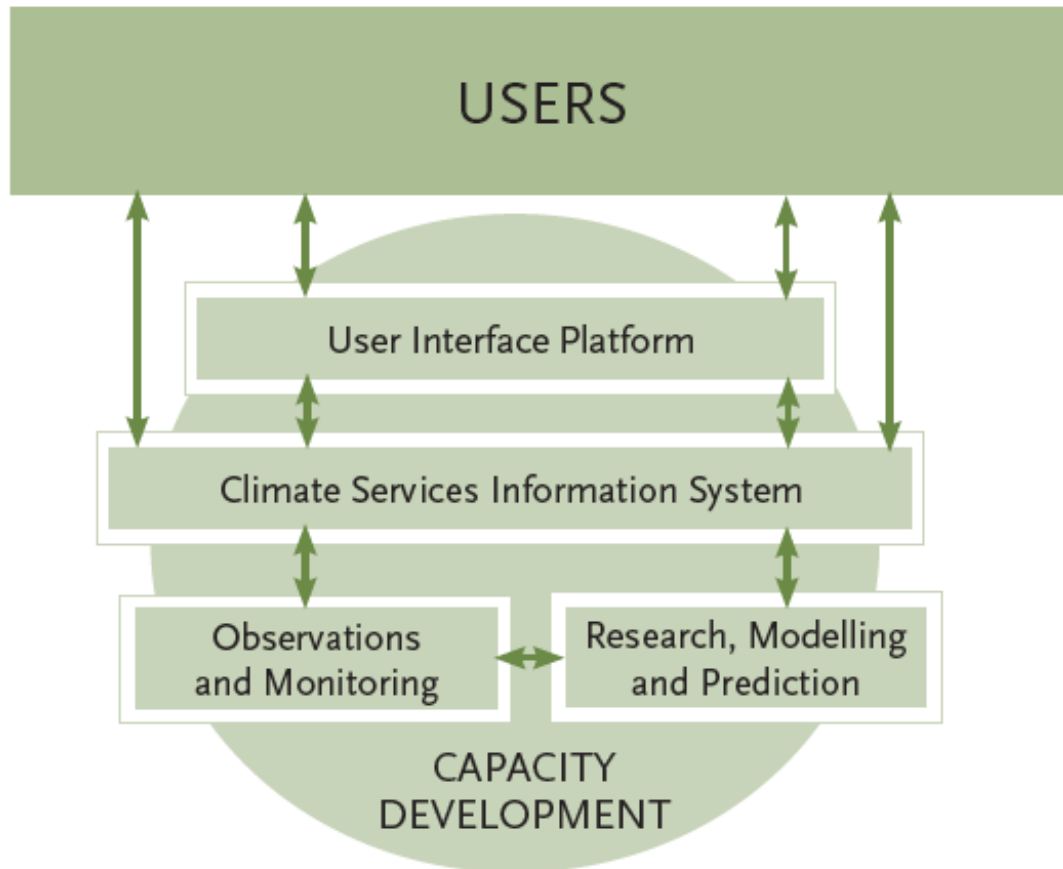
- Generating, transforming and transmitting information to ensure that it is understood and accessible.
- Grounding product and service development and delivery in the iterative 'co-production of knowledge' to ensure appropriateness and relevance.



NOAA Coral Reef Watch
Coral Bleaching Alert



How does NOAA implement the Climate Action Plan? Example: The Global Framework for Climate Services



Four Priority Areas:

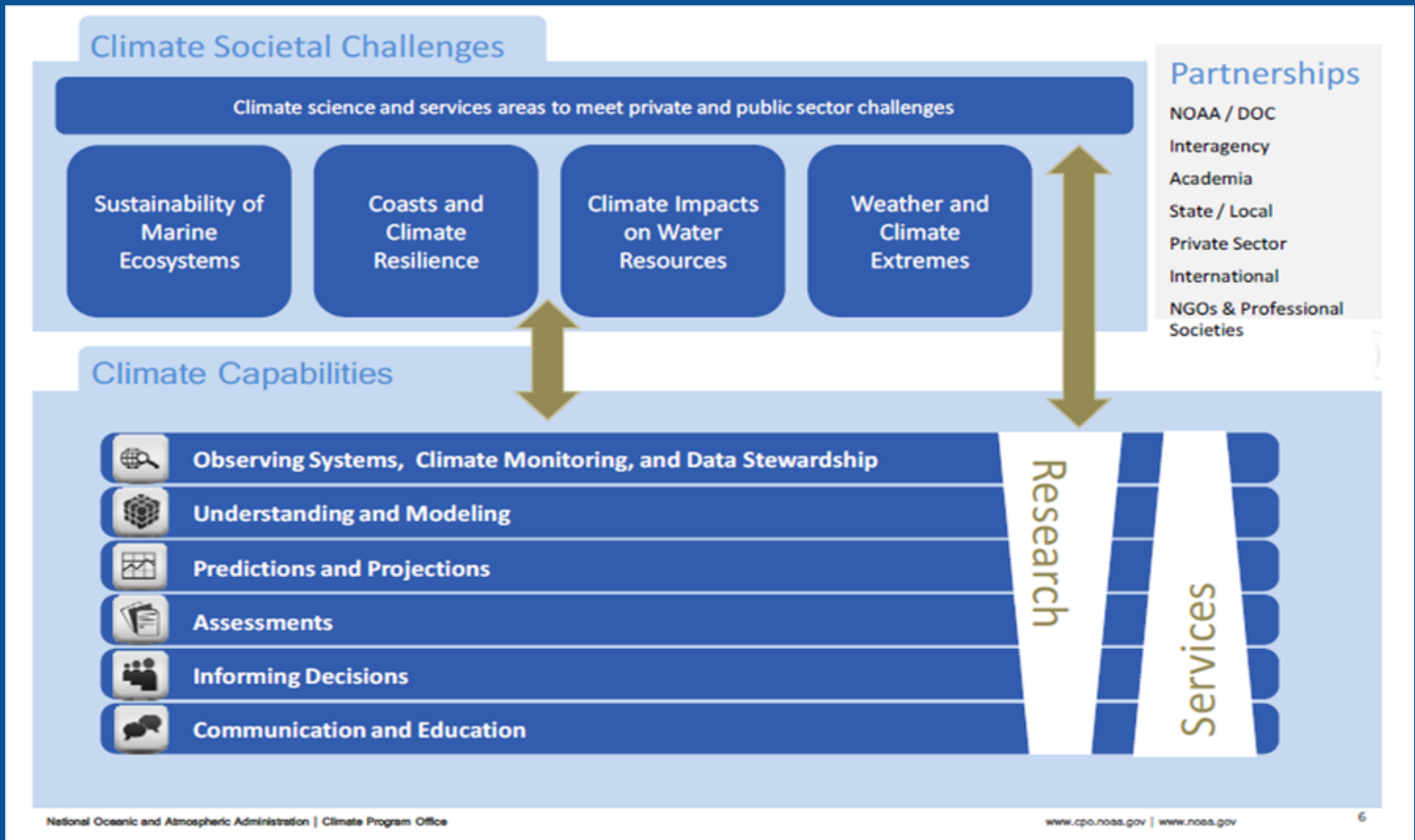
- Water Resources
- Food Security/Ag
- Human Health
- Disaster Risk Reduction

NOAA engagement

- Global Observations and Research
- Regional Climate Outlook Fora
- Capacity building for forecasters

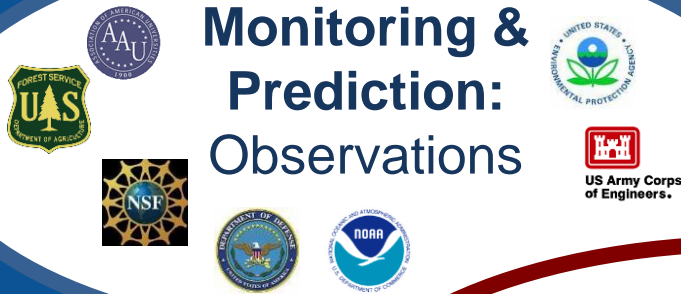
How does NOAA meet society's big challenges ?

Key thematic areas with an end-to-end approach



NOAA Priority: Integrated Information Systems across four (initial) societal challenges

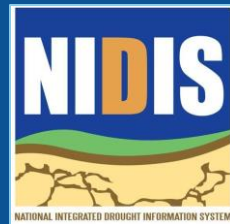
Monitoring & Prediction: Observations



Interdisciplinary research, applications, and assessments:



Integrated Information Systems: Preparedness and Adaptation



Communication and Outreach



Engaging Preparedness & Adaptation Communities:



Partnerships are essential

MUTUAL PRIORITIES supported, leveraged and pursued



Regional Priorities

- Drought
- Aging water infrastructure
- Knowledge gaps
- Evolving conditions
- Assessment



Competitive Research

- Mutual priorities
- Science policy innovations
- Focused, traceable projects



National / International Priorities

National Priorities

- Mission/Mandate
- Core capabilities
- Funding
- USGCRA



NOAA has a long history of supporting climate adaptation Capacity Building, Knowledge Exchange, Co-Production

NOAA
International
Training Desks
established
(1988)

The International
Research Institute for
Climate and Society (IRI) is
created with Columbia
University (1995)

International training desks
are expanded to include a
'Monsoon' Desk and a
'Pacific' Desk (2012)

Regional Climate Outlook
Fora (RCOFs) are
developed (1997)

International Research and
Applications Program
(IRAP) established with
USAID (2013)

1980

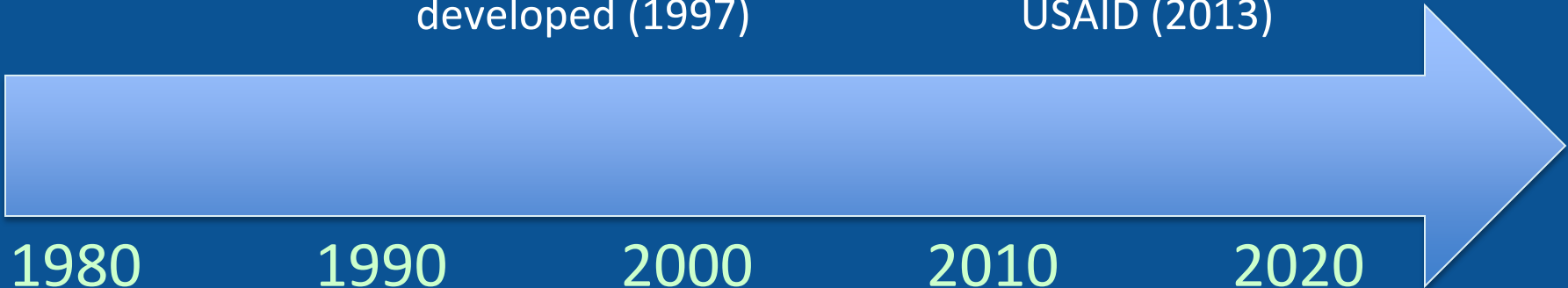
1990

2000

2010

2020

?



NOAA has a long history of supporting climate adaptation

The International Research Institute for Climate and Society



- IRI established at the **1995 *International Forum on Forecasting El Niño***
- IRI helps build capacity from advances in climate prediction through applications in food security, human health, etc
- IRI's partnerships integrate diverse institutions in addressing climate resilience, including those involved in research, risk and resource management

Concluding Remarks

- NOAA provides science and services that enhance adaptation action.
- The U.S. is working to meet the growing demand for climate information through the President's Climate Action Plan.
- NOAA contributions to the PCAP are both national and international in scope:

National Climate Assessment

National Integrated Drought Information System

Climate Resilience Toolkit

Climate Data Initiative

Global Framework for Climate Services

Adaptation Activities in the Pacific Islands Region

- Partnerships are essential to ensure that mutual priorities can be supported and advanced.



Partnerships are essential

MUTUAL PRIORITIES supported, leveraged and pursued

**Monitoring &
Prediction:**
MAPP, Climate
Observations

**Interdisciplinary research,
applications, and
assessments:** RISAs,
SARP, IRAP

**Integrated Information Systems:
Preparedness and Adaptation**

**Communication and
Outreach:**
RCSDs, NWS

**Engaging Preparedness &
Adaptation Communities:**
RCCs, Coastal Services,
RISAs, NMFS Habitat