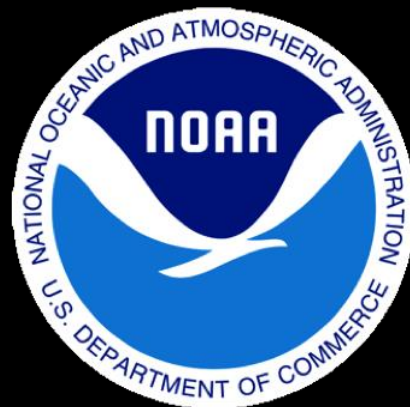


Adapting to Changes in Weather & Climate Extremes: NOAA Products for Water Utilities



Wayne Higgins, Ph.D.

Director, NOAA Climate Program Office

April 7, 2014

AMWA 2014 Water Policy Conference

Outline

Part 1: Climate Change Review

Part 2: Trends in Weather & Climate Extremes

Key Issues: Temperature

Precipitation

Coastal Vulnerability

Part 3: NOAA's Climate Strategy

Part 4: NOAA's Climate Products

Part 5: Informing Decisions

Part 6: Take Away Messages

PART ONE

Climate Change Review



Climate Change: What is it?



Source: LuAnn Dahlman/NOAA

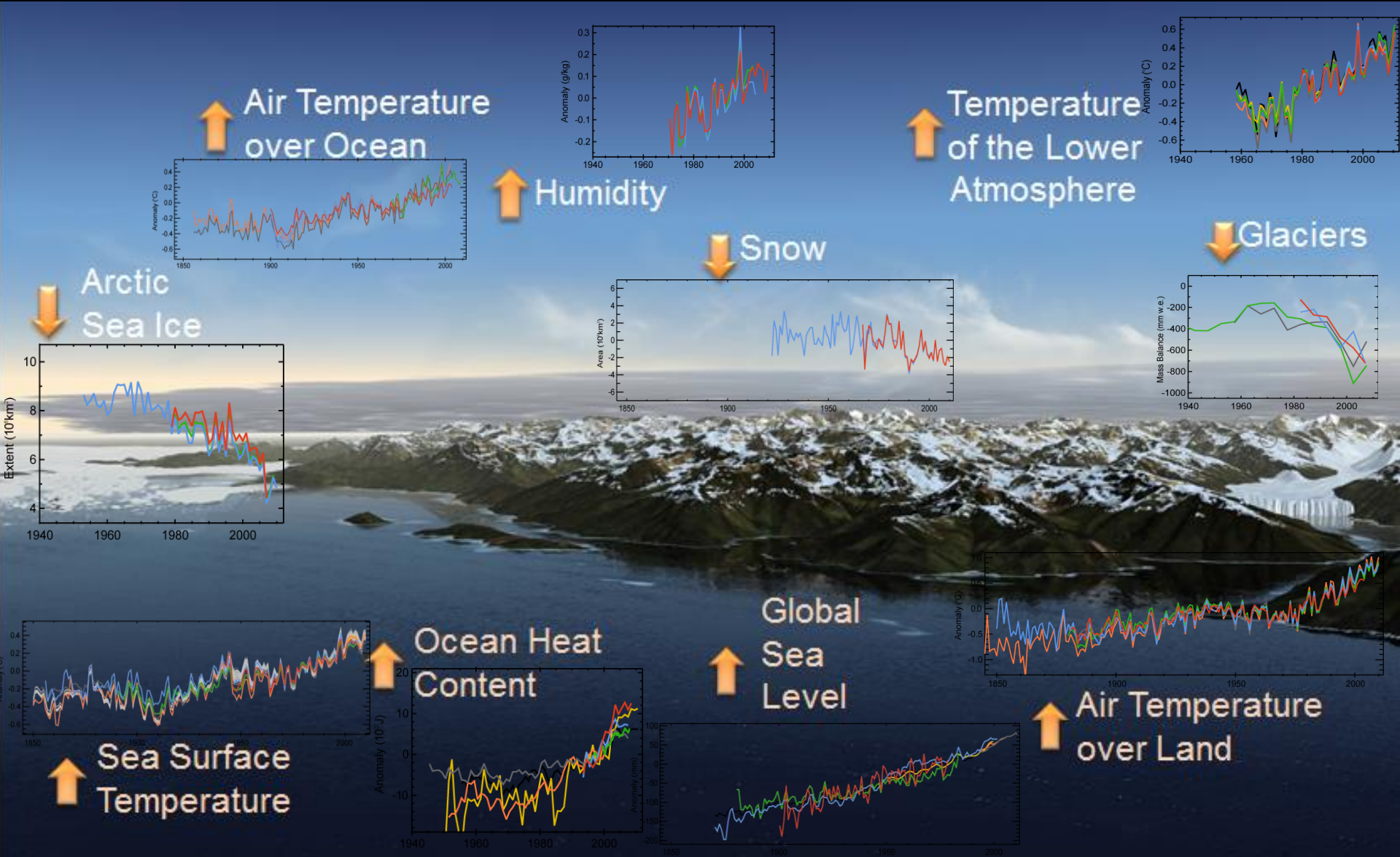
Climate Change is the departure from the expected average (or "normals") for a given place and time of year. In contrast with extreme events, such as Superstorm Sandy, Climate Change is the long-term shift in the average weather.

Global Warming: What is it?



- Global warming is one of many kinds of climate change.
- The term refers to the observation that the atmosphere near the Earth's surface is warming, without any implications for the cause or magnitude. It implies warming across the entire globe.

Key climate indicators confirm Earth is warming

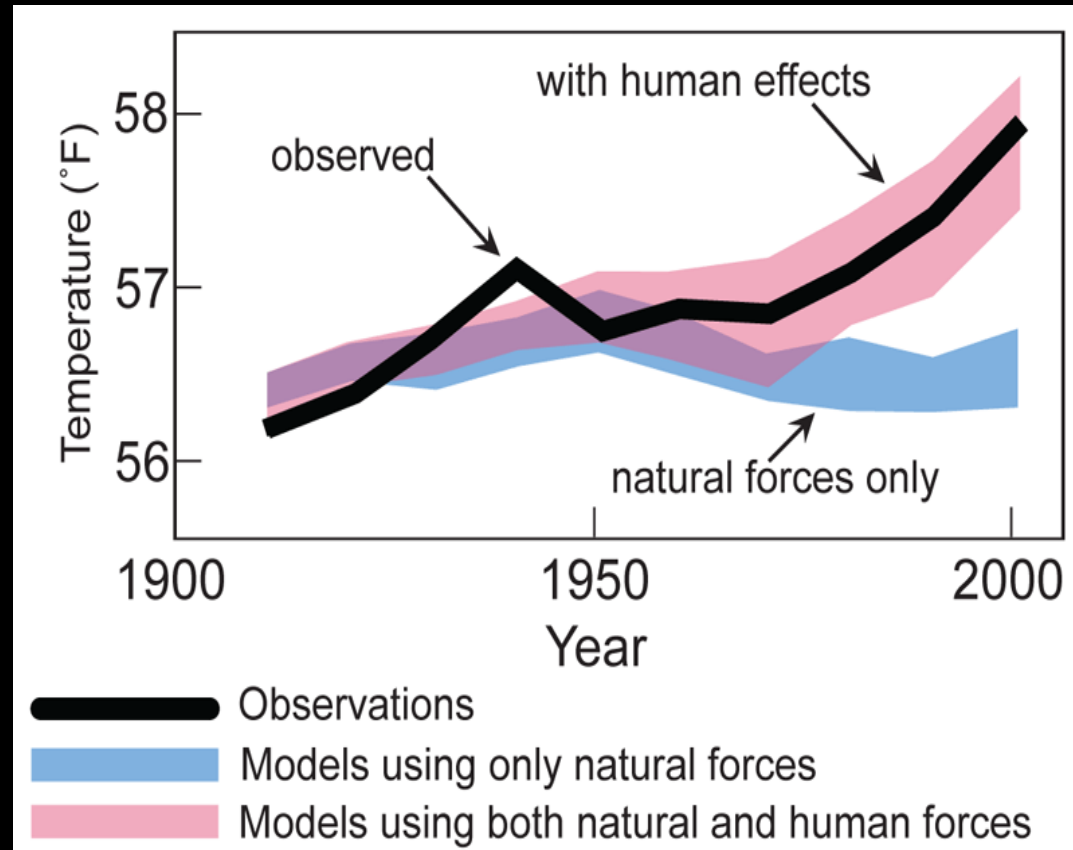


How do we know humans are the primary cause of the warming?

Both natural & human factors can lead to climate change.

- Natural (e.g. solar cycles; volcanoes)
- Human (e.g. greenhouse gases)

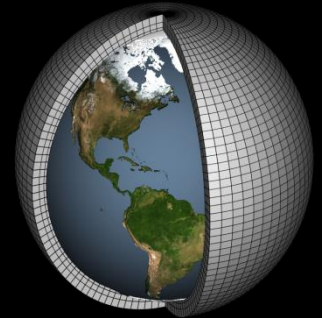
Model evidence helps confirm that the observed warming over the last half-century is primarily due to human factors.



Source : IPCC 2007

What can we expect in the future?

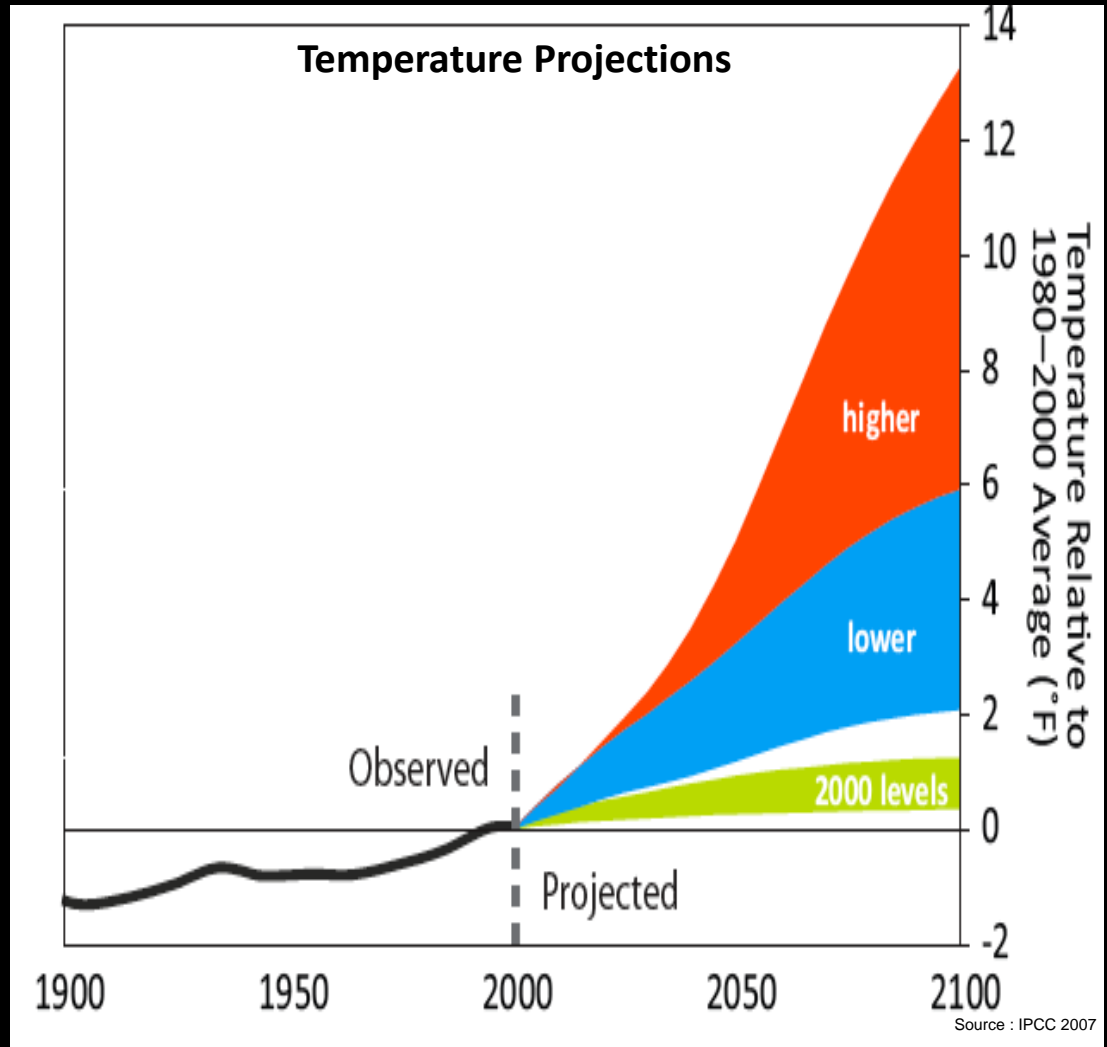
- Future scenarios use **Climate Models** to project future climates by changing certain parameters, such as the concentration of greenhouse gases, to understand how the climate would change in response.
- To credibly project a parameter (such as temperature) into the future, a **Climate Model** must credibly treat it in the past.



Future changes depend on near term choices

100-year temperature projections for 3 emission scenarios.

The climate models are run many times, and the cones indicate the growth of uncertainty based on the growth of model errors.



Reducing Uncertainty: A Climate Modeling Priority

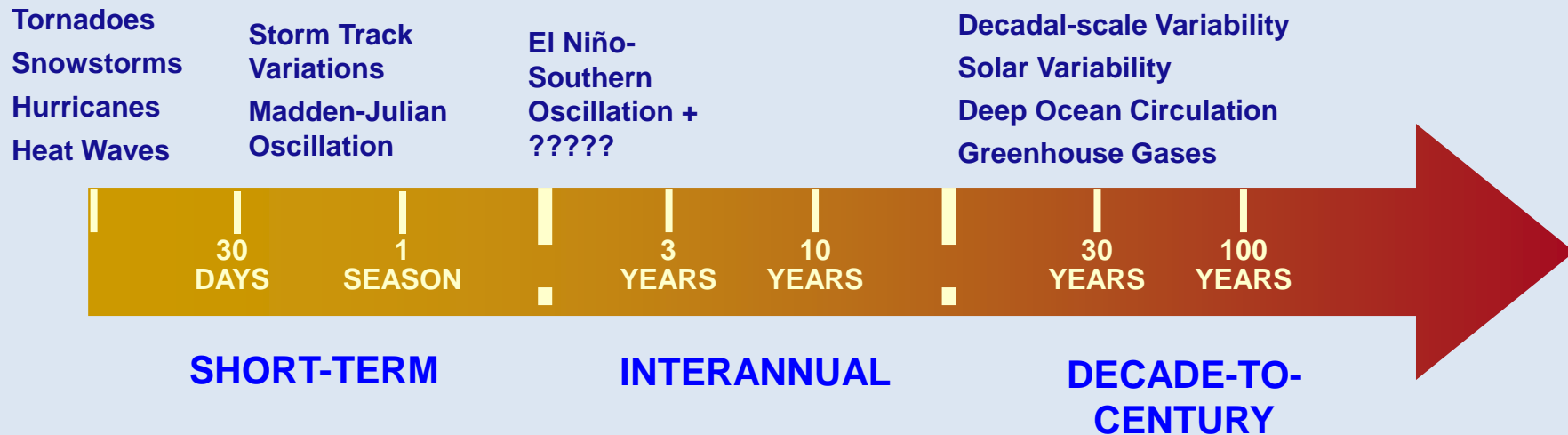
- All of us make decisions with varying degrees of uncertainty (i.e. a measure of how well something is known).
- At NOAA, reducing uncertainty in climate models helps us answer key climate questions with increased confidence.
 - How much warming has occurred due to anthropogenic increases in greenhouse gases?
 - How much warming will occur in the future? How fast will it take place?



PART TWO

Trends in Weather and Climate Extremes

From Weather to Climate Extremes -> A Continuum



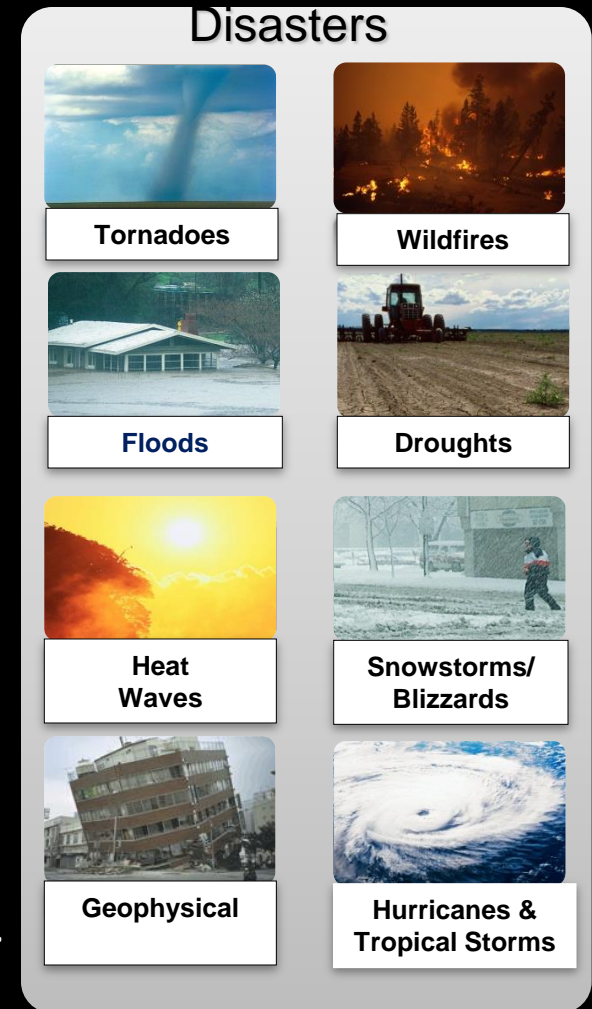
Weather & Climate Extremes

Extremes matter

- They have profound impacts and consequences.

Rising demand for information on extremes

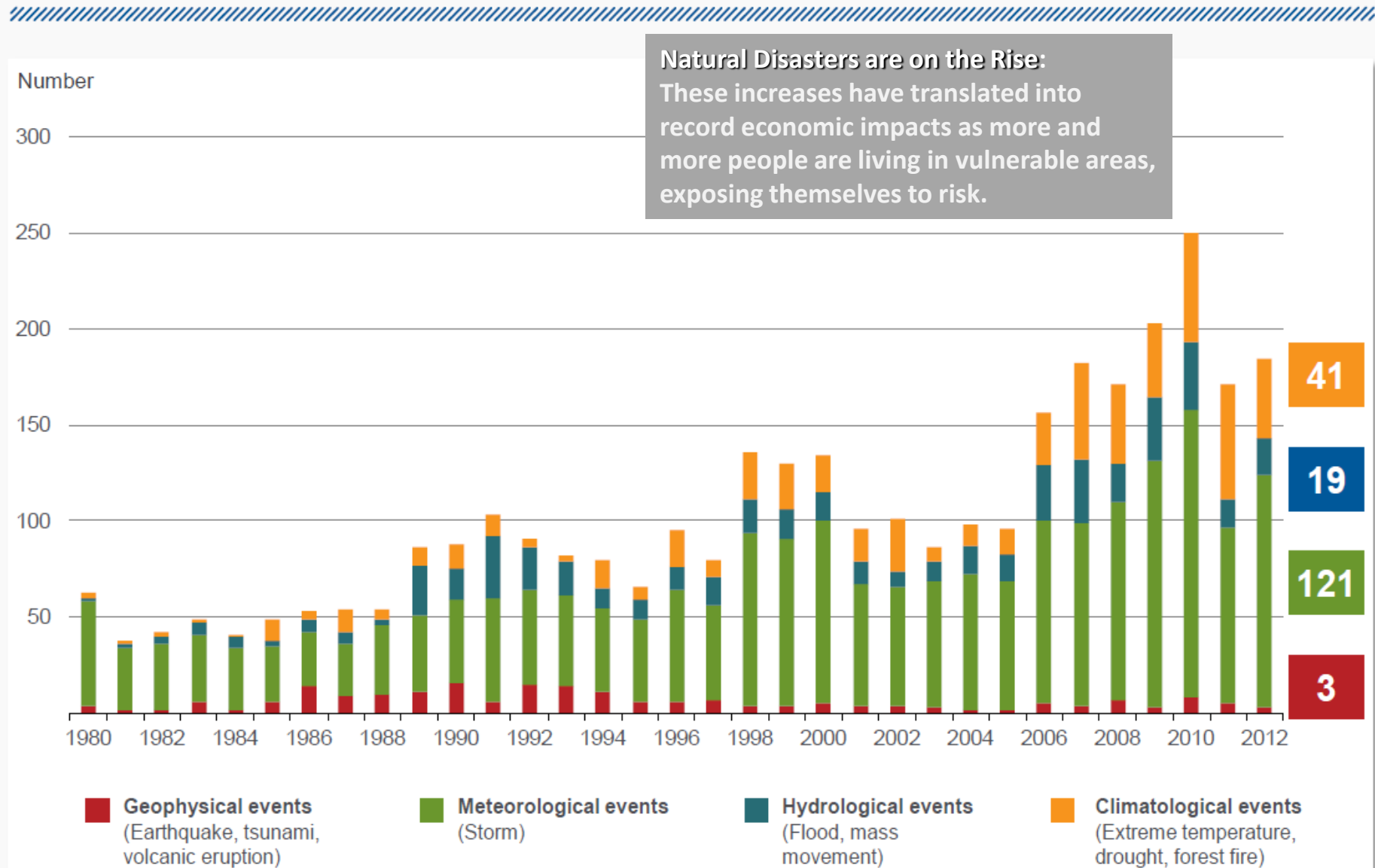
- Compelling scientific evidence that the nature of extremes is altered by climate variations & change.
- Decision makers are demanding improved information.
- Answers will provide a better basis for making decisions that affect our lives, livelihoods, businesses & the ecological systems that support us.



Source: NOAA Climate Adaptation Portfolio

Natural Catastrophes in the USA 1980 – 2012

Number of events

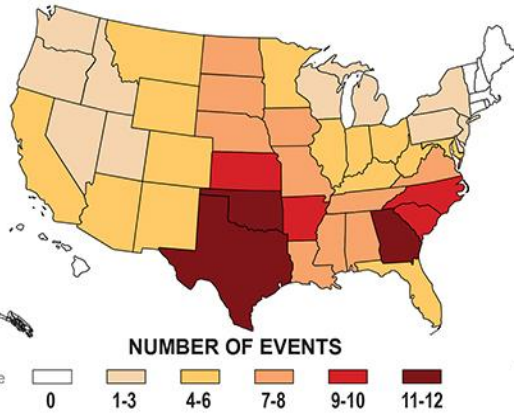


Source: http://www.munichreamerica.com/webinars/2013_01_natcatreview/MunichRe_III_NatCat01032013.pdf

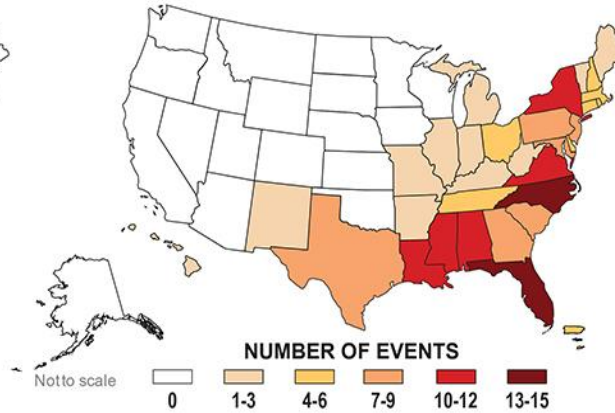
The Nation Is Weather & Climate Conscious... for Good Reason

U.S. Billion-Dollar Weather and Climate Disasters: 1980 - 2012*

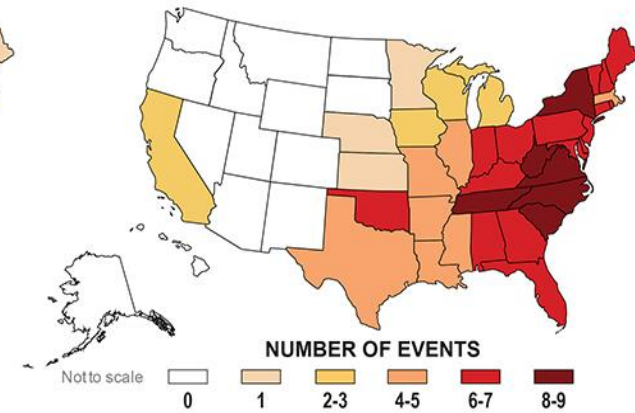
Droughts and Heat Waves



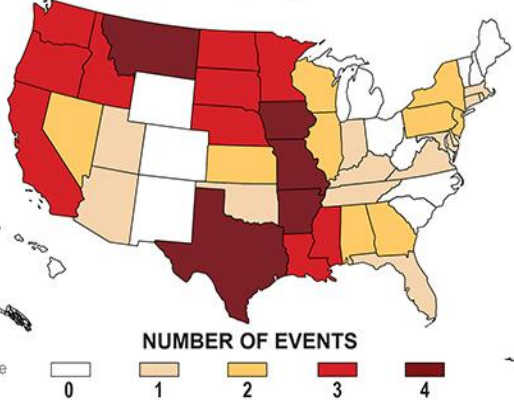
Hurricanes and Tropical Storms



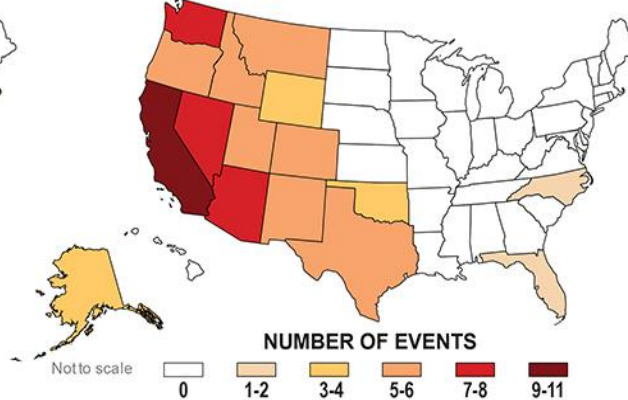
Winter Storms and Crop Freezes



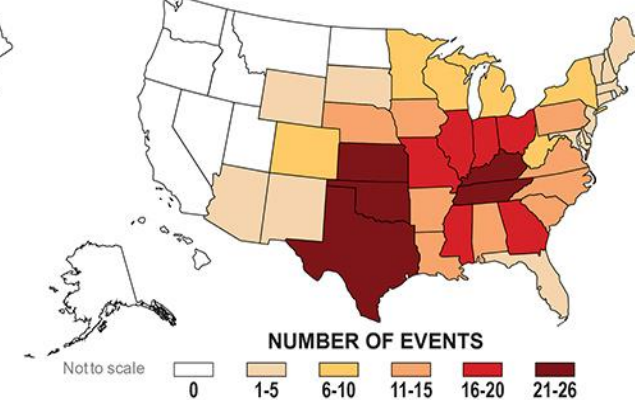
Flooding



Wildfires



Severe Local Storms



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



Source: NOAA's National Climatic Data Center

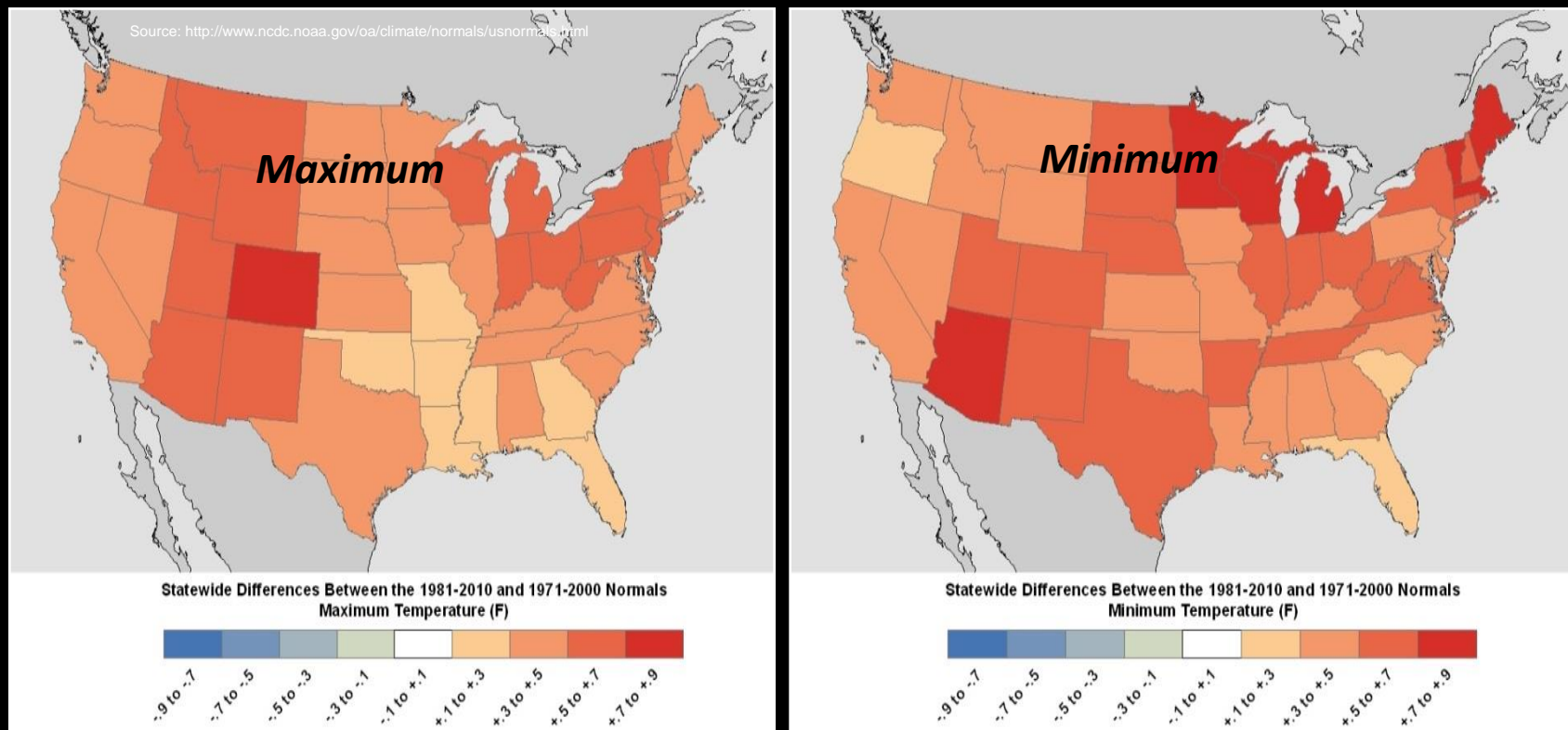
Key Issue: Temperature

- Changes in trends of maximum and minimum temperatures
- Changes in “normal” distribution of temperatures



Observed: Increasing Temperatures

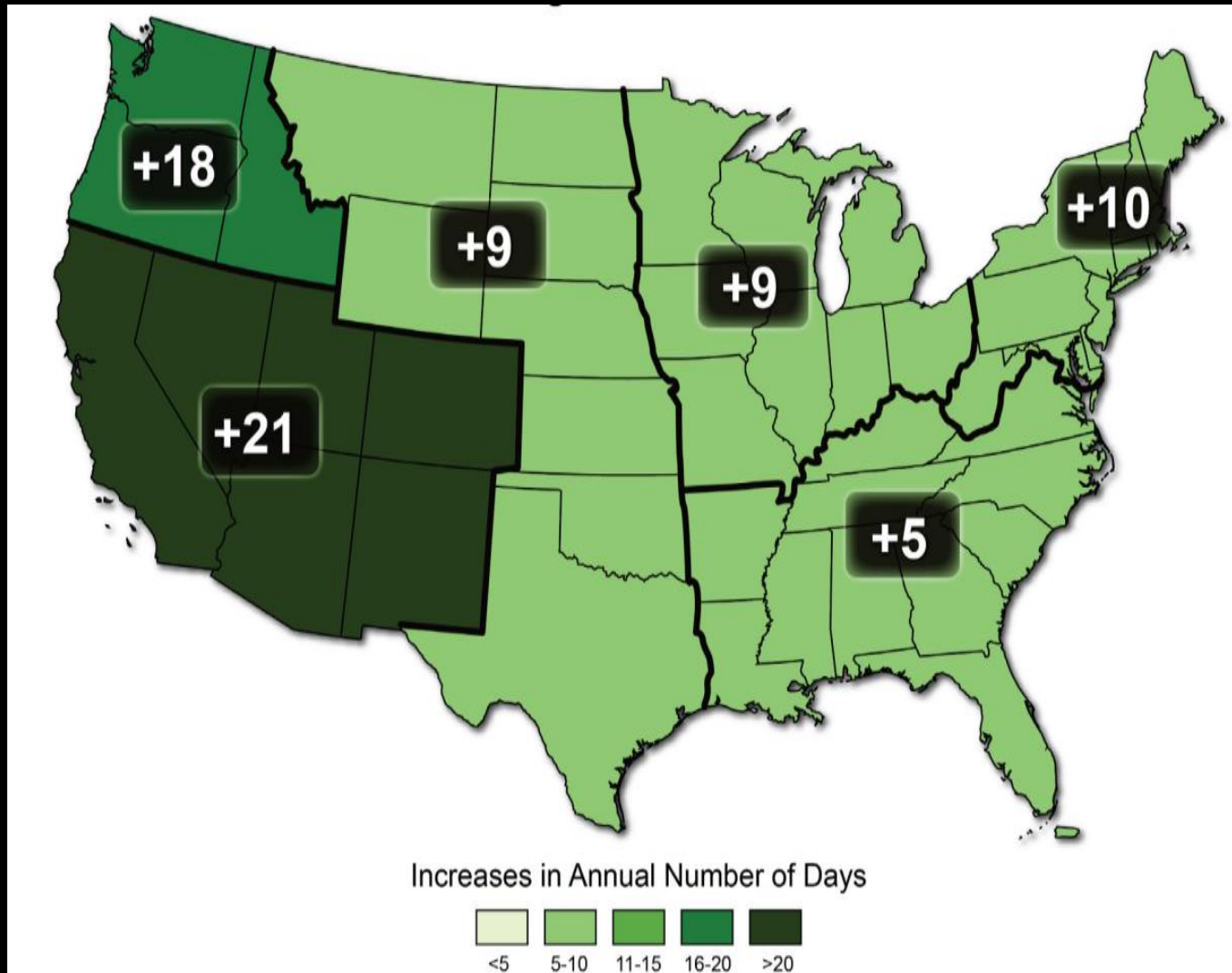
Statewide changes in annual “normal” maximum and minimum temperatures (1981-2010 compared to 1971-2000)



Every state’s annual maximum and minimum temperature increased on average – showing a distinct “shift” to a warmer “normal” temperature regime.

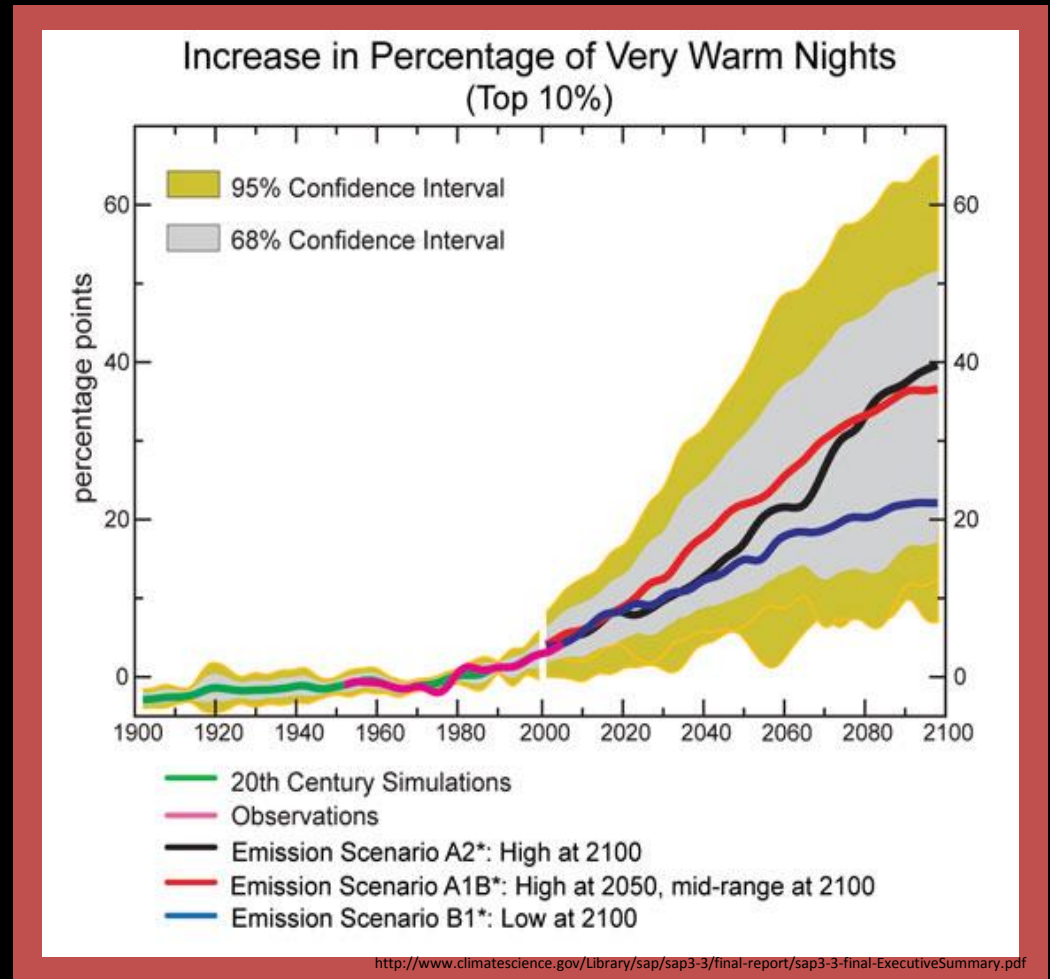
Observed Changes in Frost-Free Season Length

(1991-2011 compared to 1901-1960)



Projected: Temperature Extremes

- Warm days and warm nights – very likely more frequent.
- Cold days and cold nights – very likely much less frequent.



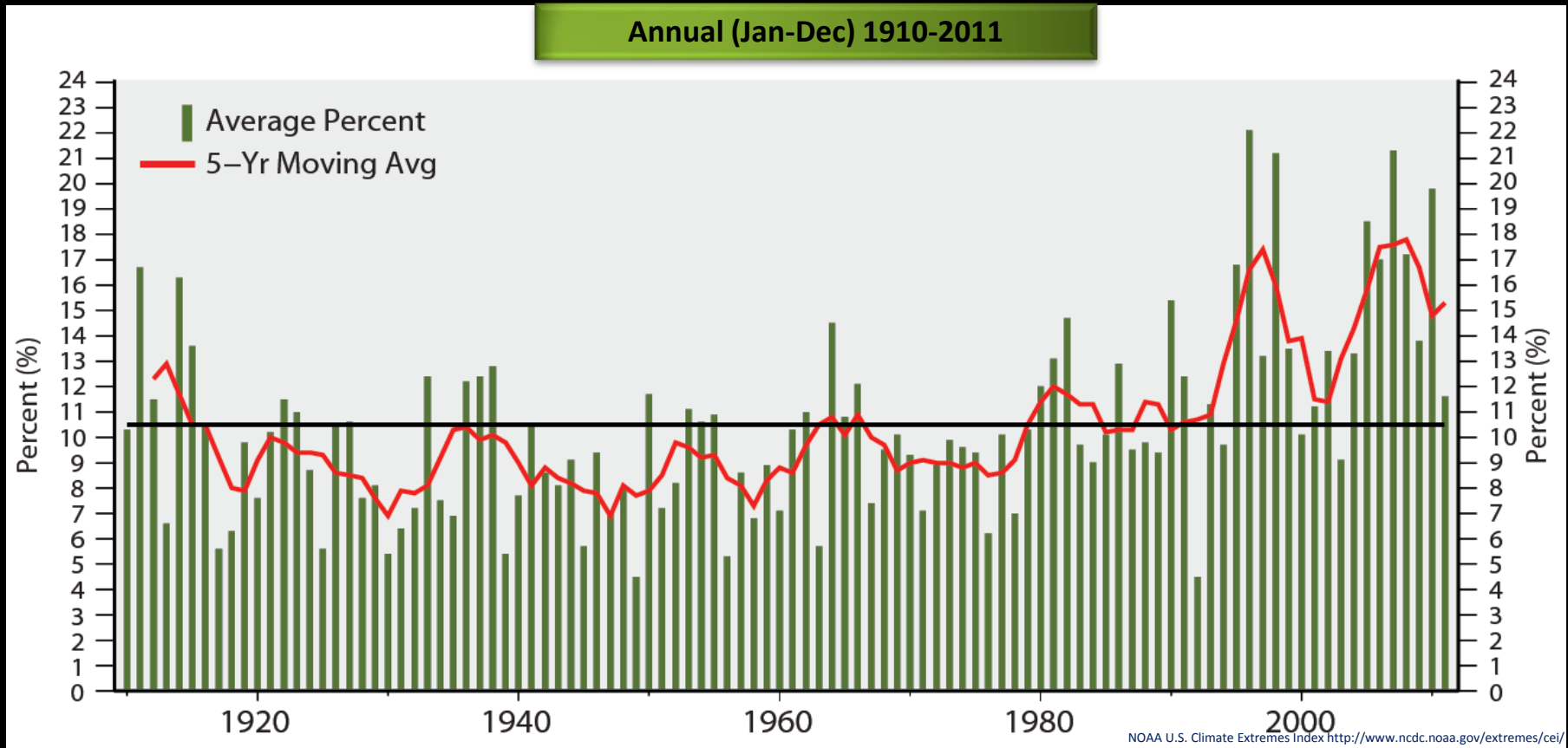
Key Issue: Precipitation

- Changes in precipitation patterns and intensity
- Changes in drought frequency, intensity, and duration
- Changes in snowpack
- Changes in precipitation type (e.g., rain vs. snow)



Observed: Precipitation Extremes

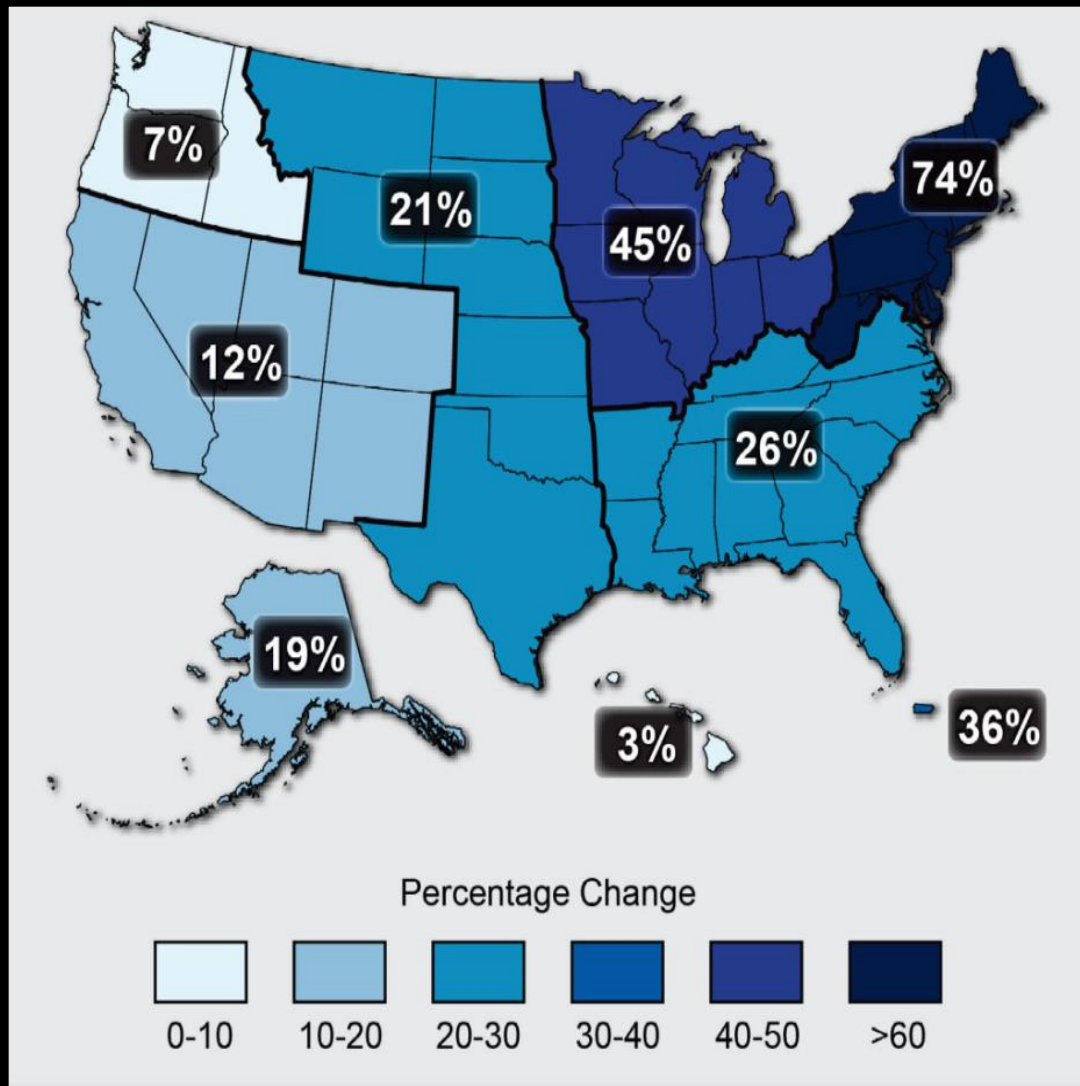
Percent of the U.S. with much above normal 1-day heavy precipitation (>2 inches)



A statistically significant increase in extremes since the late 1970s

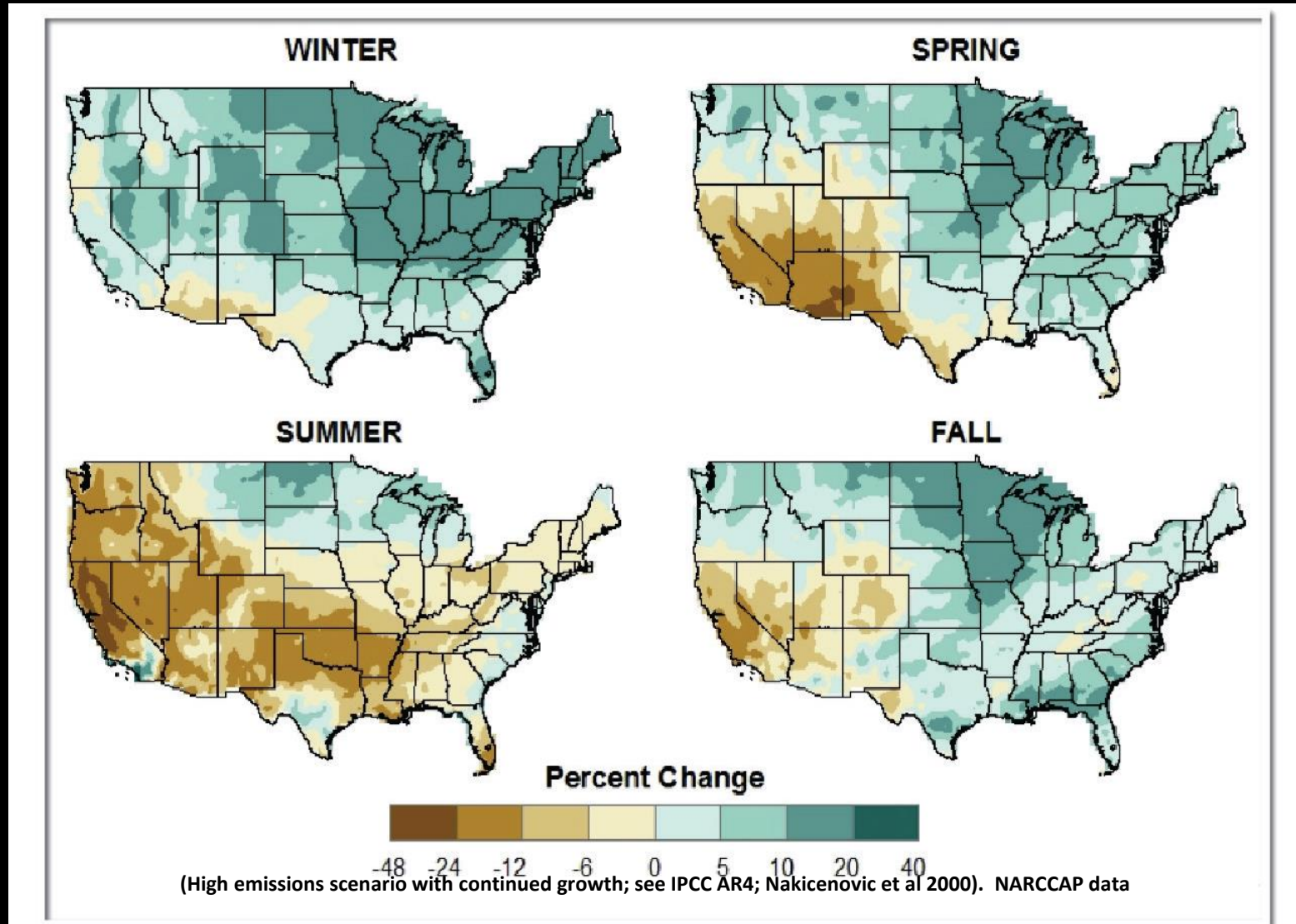
Observed: Precipitation Extremes

Percent increase in the amount of precipitation falling in very heavy events (the heaviest 1% of all daily events) from 1958 to 2011.



Projected Changes in Seasonal Precipitation

(2041–2070 compared to 1971–2000)

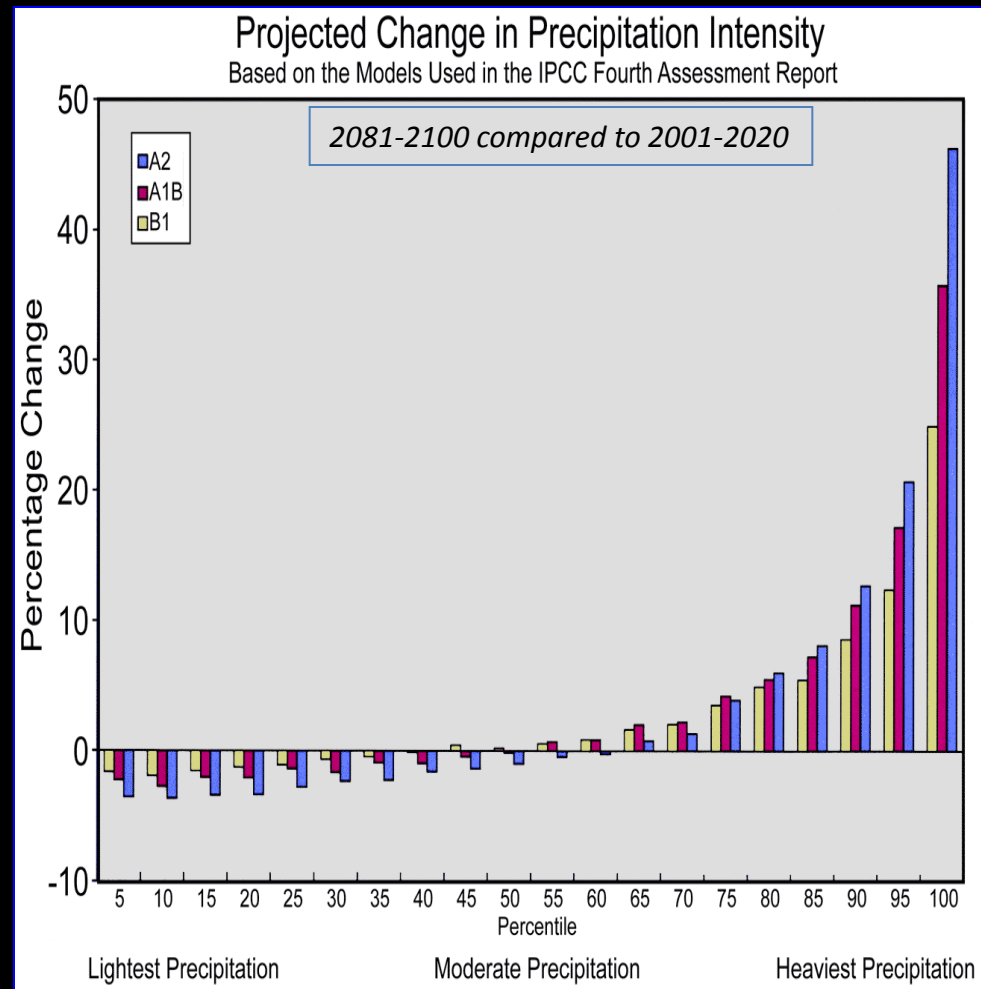


Projected: Precipitation Extremes

Lightest precipitation is projected to decrease.

Heaviest precipitation is projected to increase strongly.

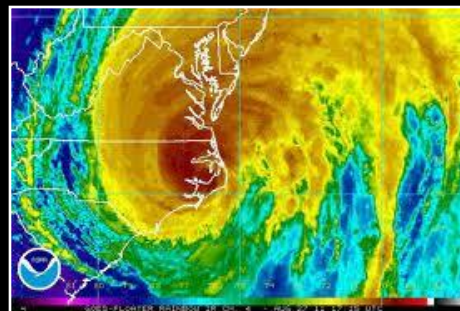
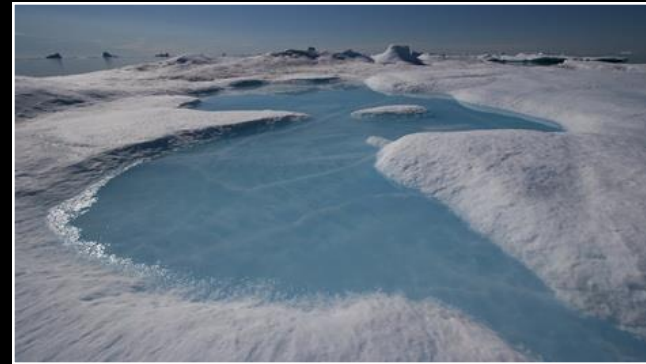
Higher greenhouse gas emission scenarios produce larger changes in extreme precipitation.



Source: <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>

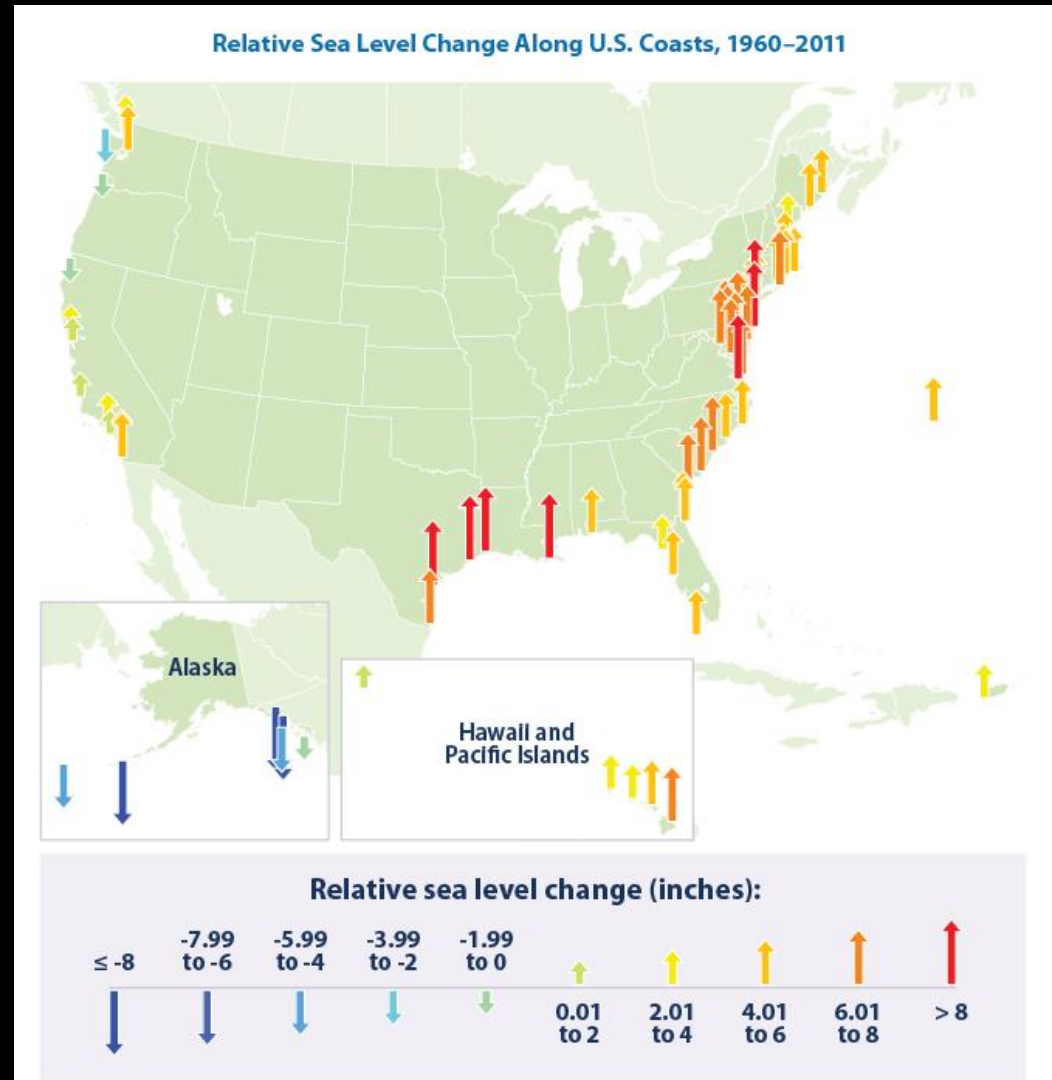
Key Issue: Coastal Vulnerability

- Sea-level change
- Increasing storm intensity
- Storm surge & flooding



Observed: Sea Level Rise

- Global sea level has risen ~8 inches since 1880
- Causes:
 - ✓ Warming-induced expansion of the oceans,
 - ✓ Melting of most of the world's glaciers,
 - ✓ Loss of the Greenland & Antarctic ice sheets.

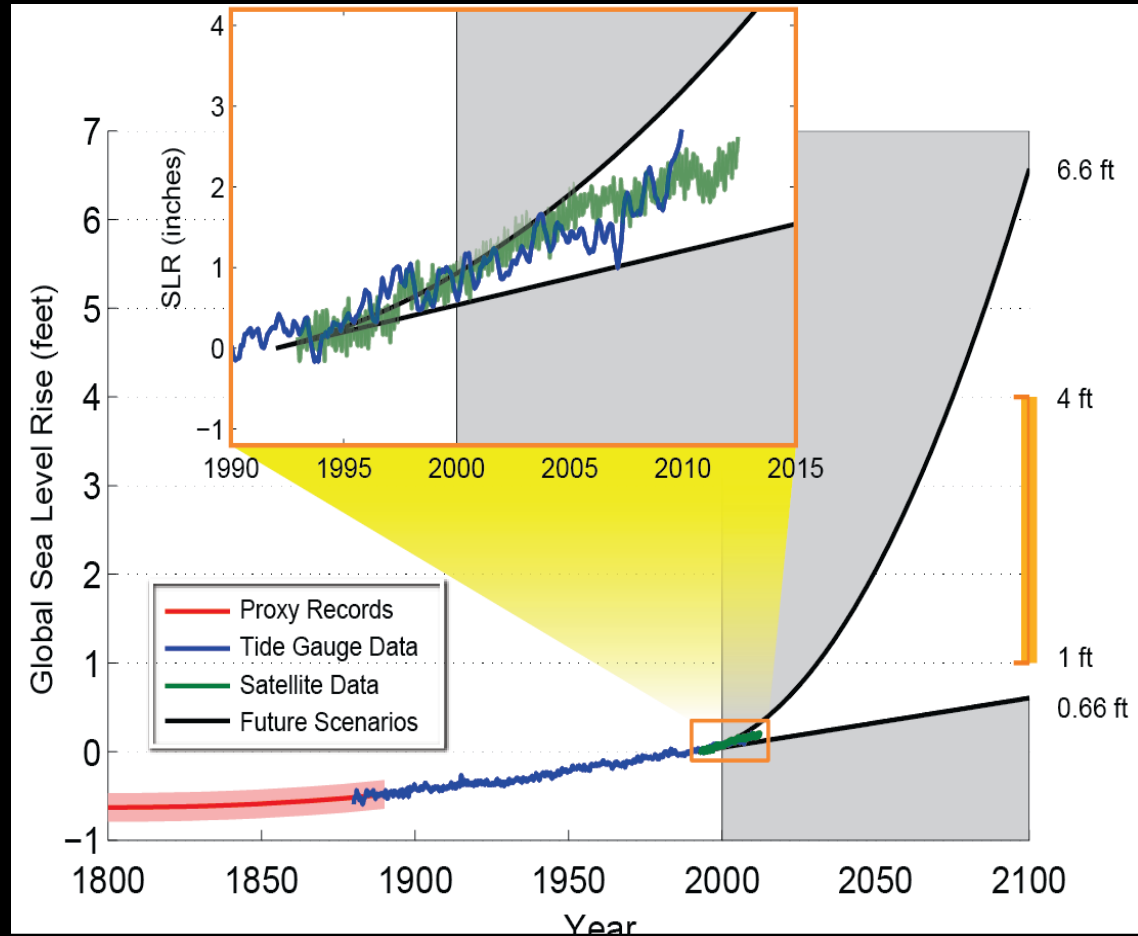


Source: <http://epa.gov/climatechange/science/indicators/>
Based on NOAA Sea Level Trends data

Projected: Sea Level Rise

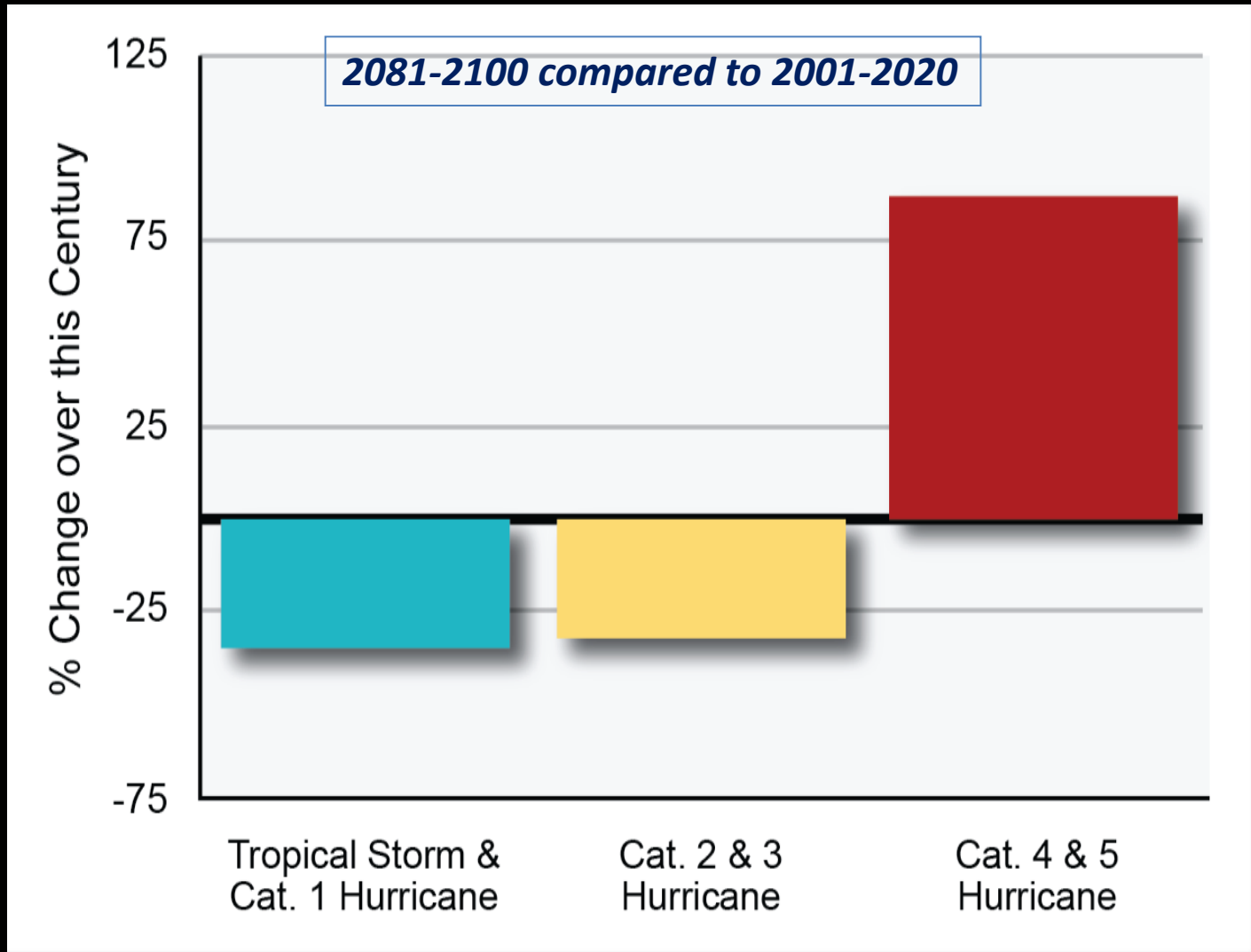
Model projections show increase of ~1– 4 feet by 2100

Where risk tolerance is low, some decision makers may wish to use ~8 in to 6.6 ft by the year 2100



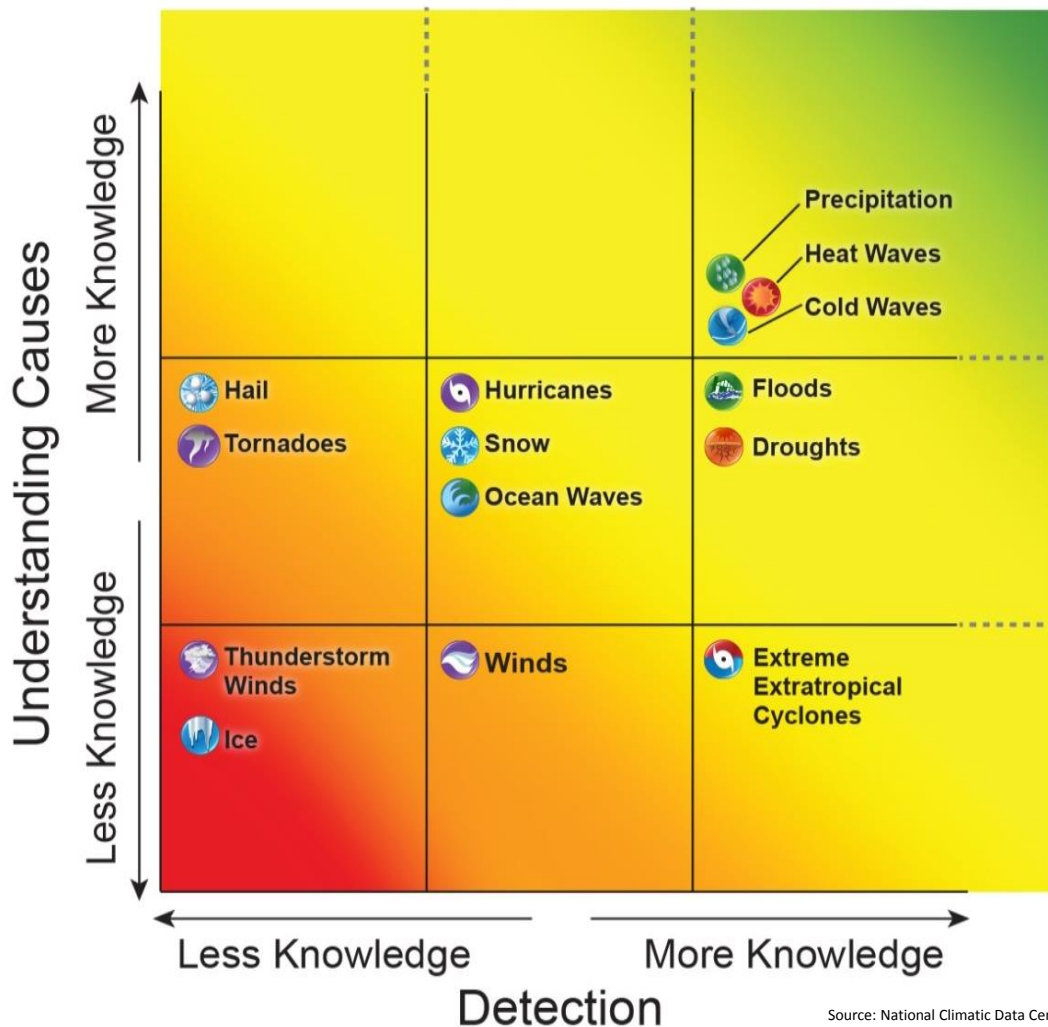
Source: <http://epa.gov/climatechange/science/indicators/>
Based on NOAA Sea Level Trends data

Projected Changes in Atlantic Hurricane Frequency by Category



State of Scientific Knowledge for Extremes

Adequacy for Detection and Understanding Causes of Changes for Classes of Extremes



Source: National Climatic Data Center

State of knowledge for various extreme phenomena is widely varying – depends on data and physical understanding

Positive correlation between detection and understanding

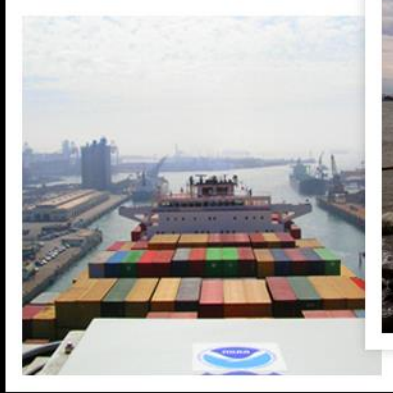
PART THREE

NOAA's Climate Strategy

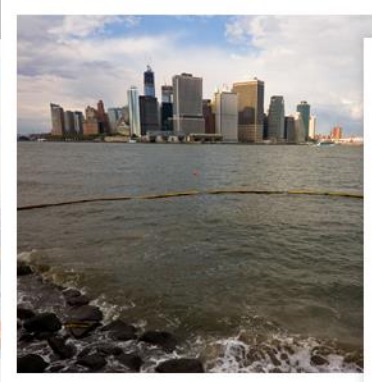


The Rising Demand for Climate Information

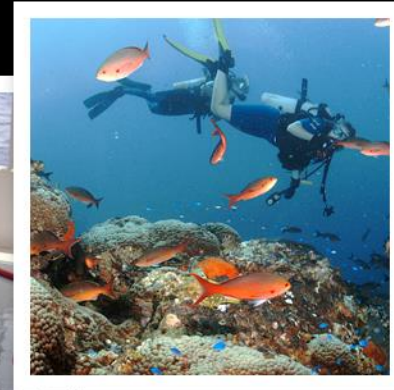
COMMERCE



COASTS



RECREATION



ECOSYSTEMS

THERE IS AN URGENT AND GROWING NEED FOR RELIABLE, TRUSTED, TRANSPARENT, AND TIMELY CLIMATE INFORMATION ACROSS ALL SECTORS OF OUR ECONOMY.



ENERGY

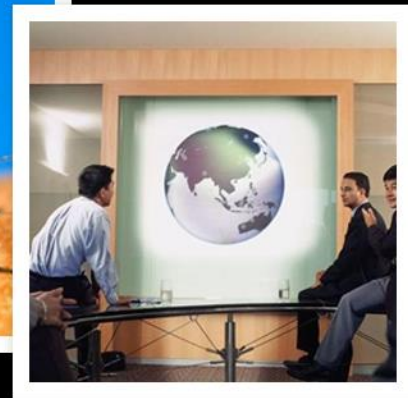
FARMING



HEALTH

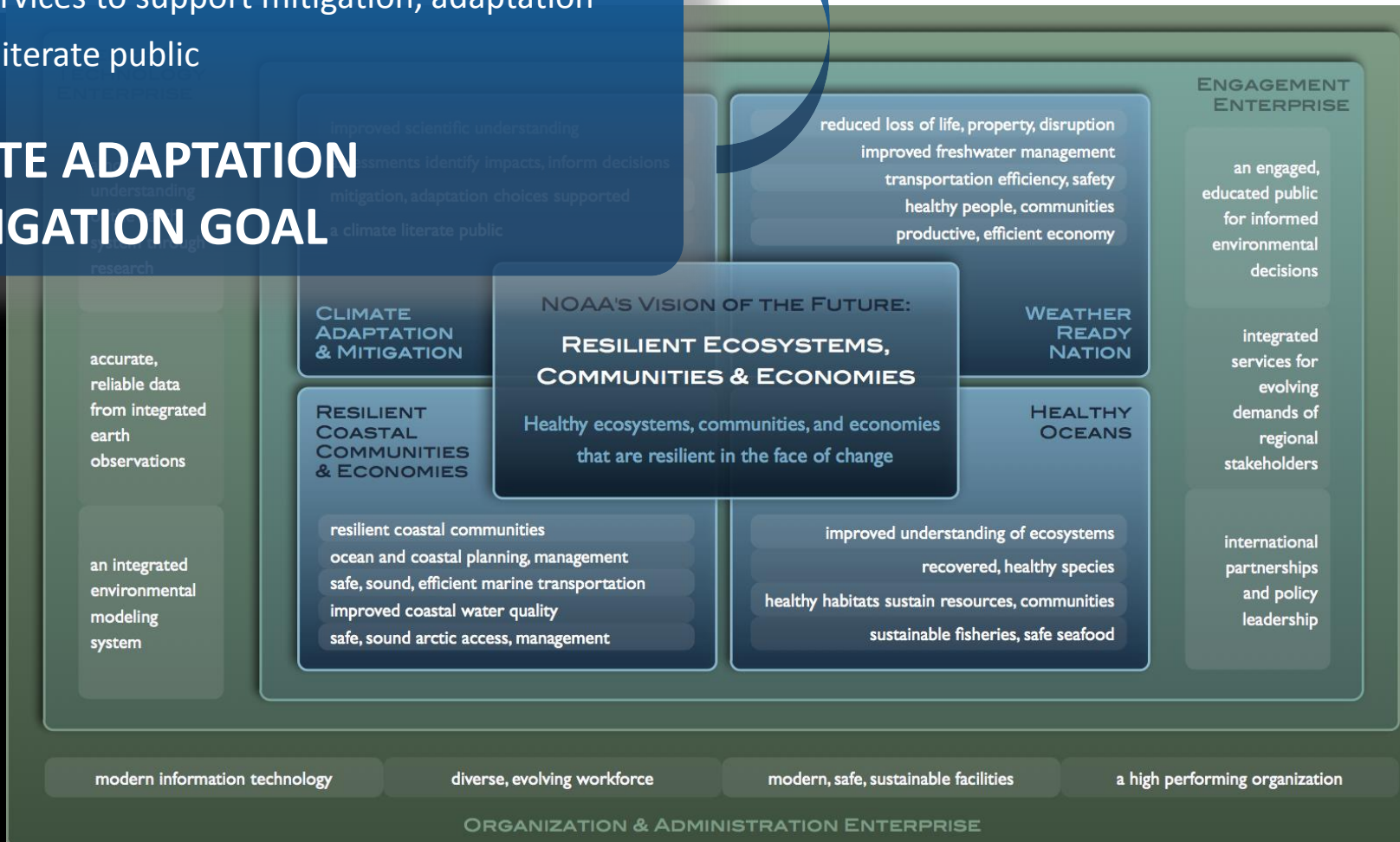


PRIVATE SECTOR



improved scientific understanding
 assessments of impacts to inform decisions
 climate services to support mitigation, adaptation
 a climate literate public

CLIMATE ADAPTATION & MITIGATION GOAL



Climate Capabilities & Societal Challenges

Climate Societal Challenges

Climate science and services areas to meet private and public sector challenges

Sustainability
of Marine
Ecosystems

Coasts and
Climate
Resilience

Climate
Impacts on
Water
Resources

Weather and
Climate
Extremes

Partnerships

NOAA / DOC

Interagency

Academia

State / Local

Private Sector

International

NGOs & Professional

Climate Capabilities



Observing Systems, Climate Monitoring, and Data Stewardship



Understanding and Modeling



Predictions and Projections



Assessments



Informing Decisions



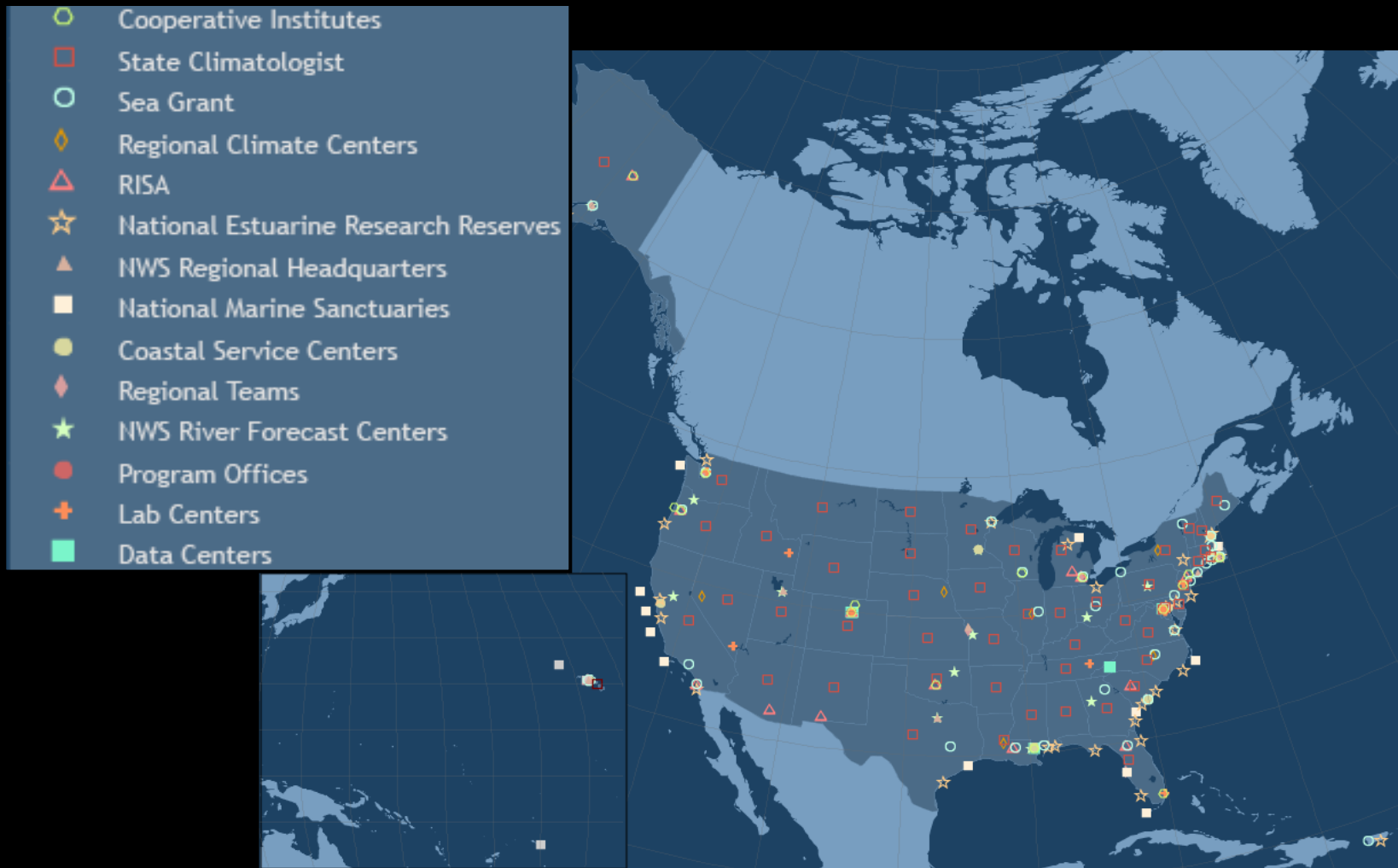
Communication and Education

Research

Services

NOAA'S Climate Presence

NOAA works nationally and internationally, but most adaptation decisions are local or regional, and NOAA is structured to have multiple entry points at regional, state, and local levels.



NOAA Climate Program Office (Foundational Capabilities)

CPO's Value Proposition

CPO's position at the intersection of NOAA's science and service missions, the climate research community, and the broader climate enterprise enables it to lead a research agenda and forge partnerships that enhance society's ability to make effective decisions.

Understanding and Modeling

Earth System Science
Predictions & Projections

Observing
Systems,
Climate
Monitoring
& Data
Stewardship

Informing Decisions

Information Systems
Regional Capacity
Communication &
Education

Foundational Capabilities

FY14 Federal Funding Opportunity Competitions

Climate Observations and Monitoring (COM)

1. *Data Sets and Indicators: Data for, and analysis of, extremes; ocean climate indicators*
2. *Paleoclimate Proxy/Multi-Proxy Reconstructions and Analyses: Characterizing historical extremes*

Earth System Science (ESS)

3. *Climate Variability and Predictability (CVP): Improved Understanding of Tropical Pacific Processes, Biases, and Climatology*
4. *AC4 - Observational Constraints on Sources and Sinks of Aerosols and Greenhouse Gases: Emissions from oil/gas extraction; emissions in the Southeast; deposition processes*

Modeling, Analysis, Prediction, and Projections (MAPP)

5. *Research to Advance Understanding, Monitoring, and Prediction of Drought: Understanding predictability of past NA droughts; advancing drought monitoring/prediction*
6. *Climate Test Bed – Research to Advance NOAA’s Operational Systems for Climate Prediction*

Climate and Societal Interactions (CSI)

7. *SARP – Climate Extreme Event Preparedness, Planning, and Adaptation: Resilience to impacts on water resources and related activities*
8. *SARP – Coping with Drought Initiative in support of NIDIS: Early warning pilots*
9. *COCA – Ecosystem Services for a Resilient Coast*

CPO Integrated Climate Research - Examples



Observations and Monitoring:

Prototype new technology, such as deep Argo floats, for the global ocean observing system



Communication and Education:

Released Climate.gov version 2.0, an integrated, online presentation of NOAA's climate science, data & information services.

- News & Features
- Maps & Data
- Supporting Decisions
- Teaching Climate
- The Dashboard



	Season 1	Season 2	Season 3	Season 4	Season 5
Global SST	●	●	●	●	●
Global prate	●	●	●	●	●
Global tmp2m	●	●	●	●	●
US prate	●	●	●	●	●
US tmp2m	●	●	●	●	●

Skill maps for 3-month means					
	Season 1	Season 2	Season 3	Season 4	Season 5
Global SST	●	●	●	●	●
Global prate	●	●	●	●	●
Global tmp2m	●	●	●	●	●
US prate	●	●	●	●	●
US tmp2m	●	●	●	●	●

Climate Modeling & Prediction

Sustained the first National Multi-Model Ensemble seasonal prediction system involving all leading U.S. climate models; running real-time since 2011.

CPO Informing Decisions - Examples

Climate and Societal Interactions Program (CSI)

Building capacity to use science

Improving the accessibility and utility of information to meet user needs

Identifying and assessing risks, impacts and opportunities

MANAGING DROUGHT IN THE SOUTHERN PLAINS

You are invited to join us in a webinar (web-based seminar) series to discuss drought conditions, impacts and resources available to help manage drought in the Southern Plains. Webinars will be held on the 2nd Thursday of each month on 10:00 A.M. Central Time. A short video briefing will also be offered on the 4th Thursday. The content is geared toward a general audience – anyone who has responsibility to manage or assist others in managing drought and its related impacts.

To register or for more information, contact: Southern Climate Impacts Planning Program <http://www.southernclimate.org> 405-325-2541 or scipp@climate.net

Webinar Topics:

- La Niña
- Cattle & Livestock
- U.S. Drought Monitor
- Ecological Impacts
- Seasonal Forecasting
- Flash Drought
- Water Supply
- Wildfire
- Drought Ready Communities
- Agricultural Impacts

Information from the webinars will be posted on a website linked through <http://www.usdroughtmonitor.gov>. A one-page summary will be produced and posted for each webinar. Please pass on this announcement to relative organizations or groups that are involved in managing or monitoring drought and its related impacts.

U.S. Drought Monitor | U.S. Drought Portal - Mozilla Firefox

U.S. Drought Portal
www.drought.gov

Current Drought and Monitoring | Impacts | Forecasting

U.S. Drought Monitor

The U.S. Drought Monitor is unique, blending numeric measures of drought and experts' best judgment into a single map every week. It started in 1999 as a federal, state, and academic partnership, growing out of a Western Governors' Association initiative to provide timely and understandable scientific information on water supply and drought for policymakers.

The Monitor is produced by a rotating group of authors from the U.S. Department of Agriculture, the National Oceanic and Atmospheric Administration, and the National Drought Mitigation Center. It incorporates review from a group of 250 climatologists, extension agents, and others across the nation. Each week the author revises the previous map based on rain, snow and other events, observers' reports of how drought is affecting crops, wildlife and other indicators. Authors balance conflicting data and reports to come up with a new map every Wednesday afternoon. It is released the following Thursday morning.

Visit the U.S. Drought Monitor for the current drought conditions...

U.S. Drought Monitor
October 15, 2013
(Revised Thursday, Oct. 17, 2013)
Mid 7 a.m. EDT

Drought Impact Tables

- DL Extreme Drought
- D4 Extreme Drought
- D3 Severe Drought
- D2 Moderate Drought
- D1 Abnormally Dry

Legend for Drought Impact Tables:
DL Extreme Drought
D4 Extreme Drought
D3 Severe Drought
D2 Moderate Drought
D1 Abnormally Dry

A Collaborative Approach to Extreme Weather and Climate Events

Responding to Extreme Weather and Climate Events
Adaptation Strategies and Information Needs

Extreme Weather Event Workshop Locations

WERF | NOAA | EPA | FEMA | USACE | NWS | NCEP | NCEM | NCEM | NCEM | NCEM

STATE OF THE CLIMATE IN 2012

Special Supplement to the Bulletin of the American Meteorological Society
Vol. 94, No. 8, August 2013

PART FOUR

NOAA's Climate Products



Climate Prediction Center Prediction and Monitoring Products

Official Outlooks focused on week-2, monthly, seasonal

- Precipitation & Temperature Outlooks
- Hazards Outlooks (US, Global Tropics)
- Seasonal Drought Outlook
- Seasonal Hurricane Outlooks (Atlantic and Eastern Pacific)
- El Nino / La Nina Prediction

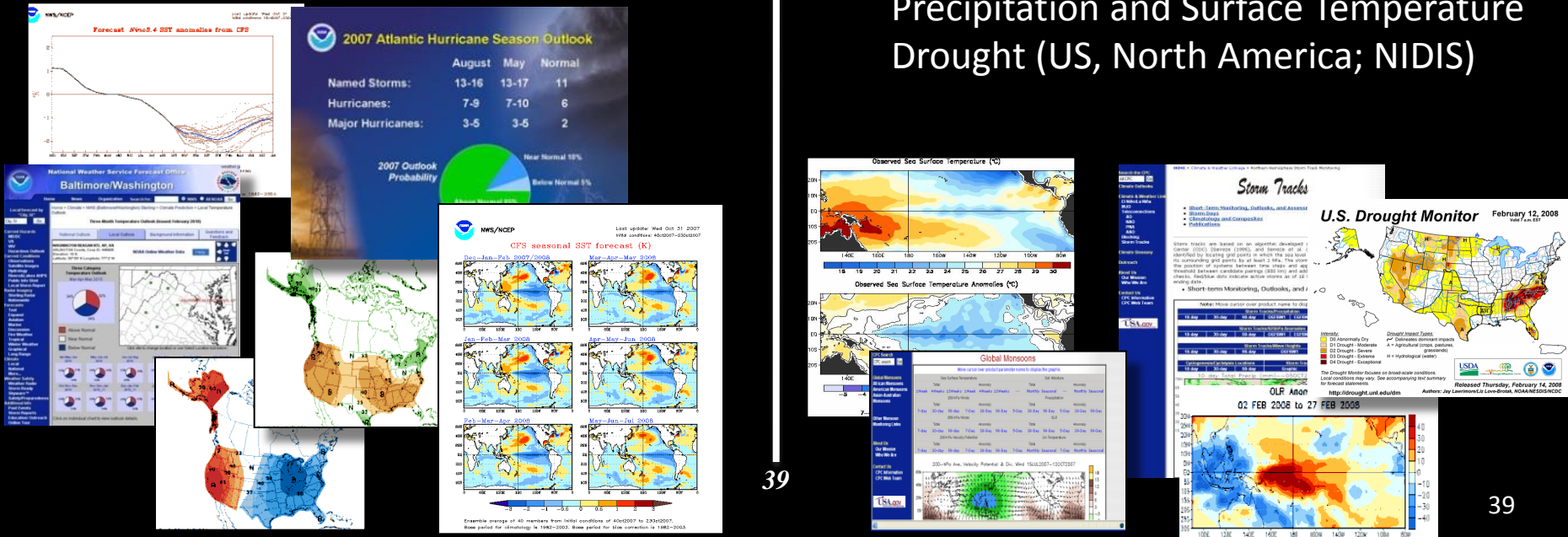
Real-time and historic monitoring of atmosphere, ocean, land surface conditions

Daily and monthly data, time series, & spatial maps

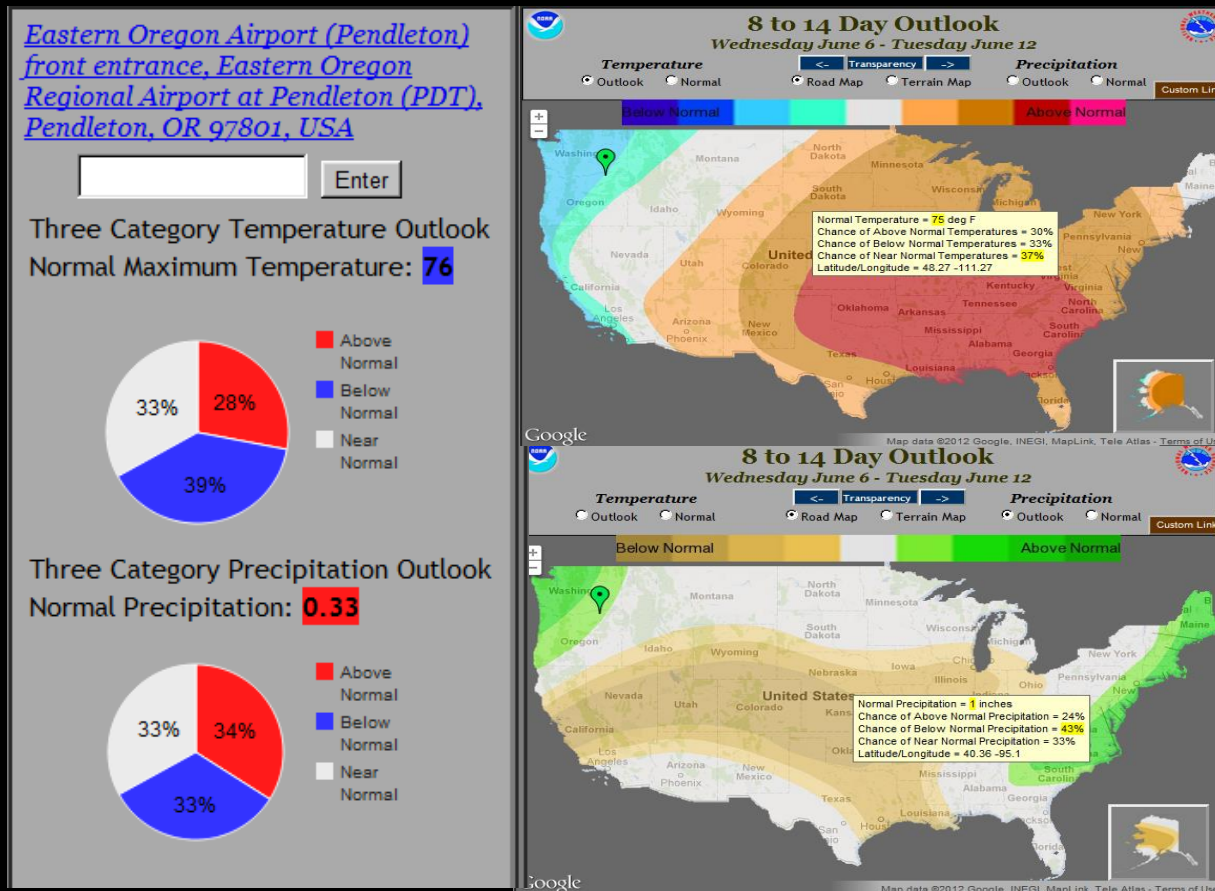
Primary modes of climate variability (ENSO, MJO, NAO, PNA, AO,...)

Storm Tracks and Blocking
Monsoons

Precipitation and Surface Temperature
Drought (US, North America; NIDIS)

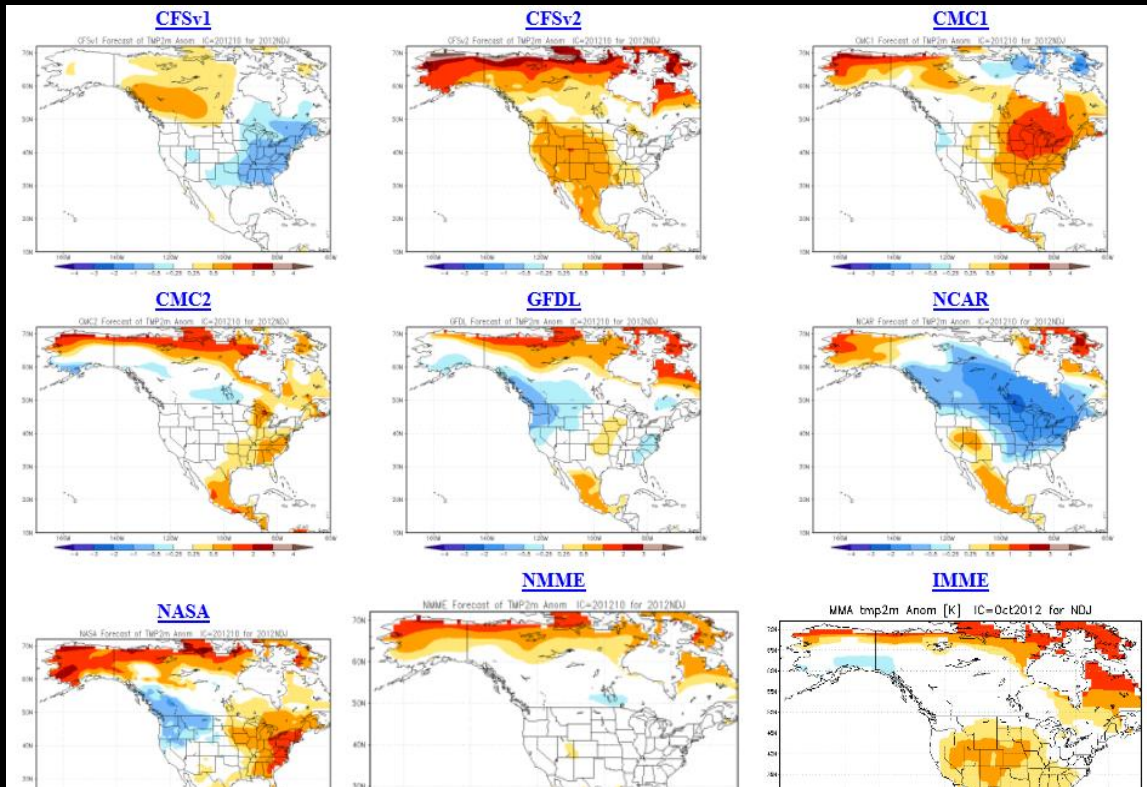


Web Interface for Climate Prediction Center Outlooks



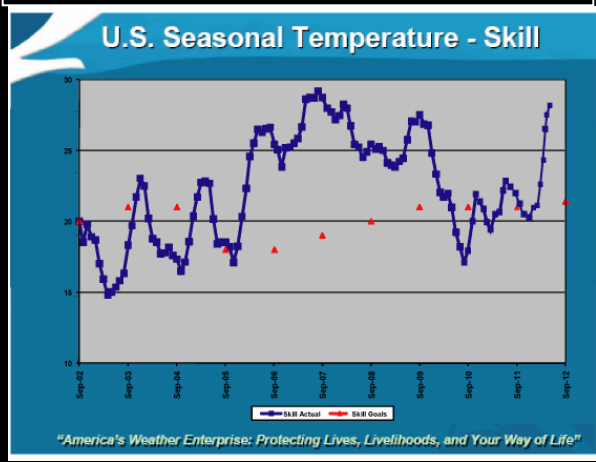
- Allows users to display CPC extended range forecasts in additional ways for specific locations
- Includes mouse over capability, pie charts and climate normals

Multi-Model Ensembles (MME)



International MME :
(EUROSIP + CFS)

National MME
(NCEP, GFDL, NCAR, NASA, IRI, COLA, U. Miami, U. Colorado, Princeton)



- **Current Products**

Monthly and seasonal mean sea surface temperature, precipitation and surface temperature for North America and for global domains, and a plume diagram for Nino3.4 sea surface temperature.

- **Future Products**

Probabilistic expressions, and skill maps for SST, precipitation and surface temp
Daily data in support of new requests (e.g. subseasonal Atlantic Hurricane Outlooks)

Demand for Climate Information is Increasing Across Space and Time Scales



NOAA and other agencies are working to provide a suite of products from near term forecasts to long term projections, tailored to stakeholders' needs.

PART FIVE

Informing Decisions



Extreme Event Workshops (NOAA, EPA, Water Orgs)

Six Case Study Workshops (2012):

“Water Resource Strategies and Information Needs in Response to Extreme Weather/Climate Events.”

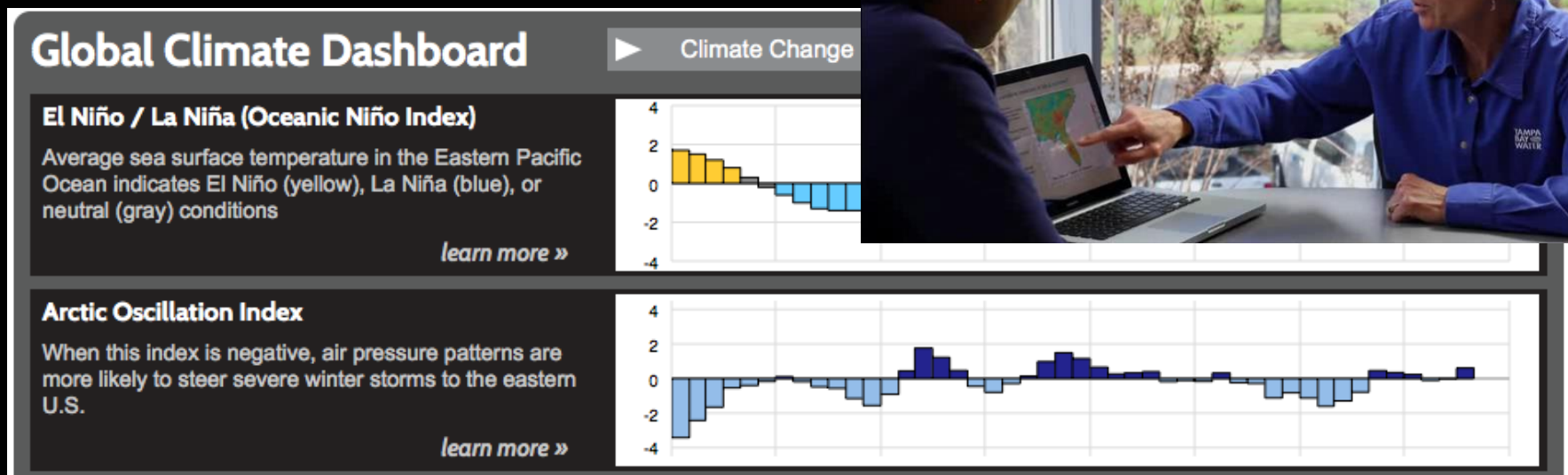


Key takeaways:

- *Cascading nature of extreme events*
- *Water services are critical and water infrastructure must be prioritized.*
- *Communities must understand their risk and define their risk tolerance.*
- *To build resilience, water utilities and communities must embrace both emergency response and long- term preparedness.*
- *Active engagement in acquiring information and tools is required.*
- *Multi-disciplinary collaboration and communication increases access to actionable information.*

Facilitating Better Decision Making:

Working with the Water and Planning Communities



NOAA is working with AMWA, the American Planning Association and a number of other water associations to find better ways of transmitting climate forecasts, information, tools, and practices to the water and urban planning communities for enhanced decision making, including dashboards with tailored information to plan for extreme events.

PART SIX

Take Away Messages



Takeaway Messages

- **Climate change is one of the key issues of our times.**
 - There is an overwhelming scientific consensus on the facts:
 - (i) Earth is warming
 - (ii) Human emission of greenhouse gases is the primary reason
 - (iii) There will be adverse consequences
 - (iv) Humans can and should mitigate and adapt to the problem
- **Links between Weather and Climate are pervasive**
 - A local manifestation of climate change is changes in the number and intensity of weather events (including extremes) in your back yard.
 - People are noticing changes and are asking questions.

Takeaway Messages

- **Some Observed and Projected trends are well documented**
 - Heavy downpours are increasing in most regions of the U.S
 - Heat waves have been most prevalent in the West; droughts in the Southwest.
 - Global sea level rise is projected to rise another 8” to 6.6 ft. by 2100, with local variations.
- **Projecting local scale impacts is difficult**
 - Regional scales of projections frustrate local decision makers.
- **NOAA & partners are working to improve delivery of useful climate information to support a variety of decisions**

Takeaway Messages

- **We recognize the essential role of water in our society and are focusing on partnerships with the water utilities.**
- **NOAA provides information that water utilities can use through various regional and local offices and personnel.**
- **We are working to improve delivery of critical climate information to planners.**
- **We look forward to continued collaboration with you.**

Questions?



Extras



Useful NOAA Tools and Resources – identified By Water Managers

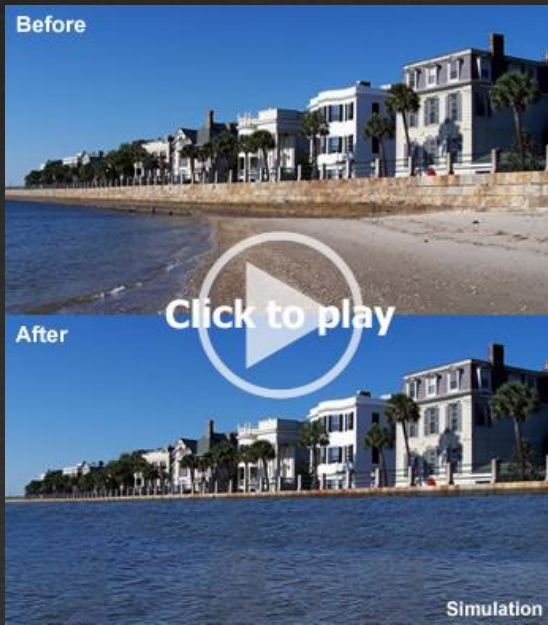
- **NWS Advanced Hydrologic Prediction Service**
- **NWS River Forecast Centers– hydrologic and meteorological data**
- **Hydrometeorological Testbeds (hmt.noaa.gov/) – information and prototype solutions**
- **National Integrated Drought Information System (NIDIS)**

Other Tools Highlighted in the Case Studies:

- **USGS GSFLOW – coupled groundwater and surface-water flow simulation**
- **CocoRaHS – volunteer precipitation mapping**
- **USGS WaterAlert and StreaMail**
- **WaterRF Climate Change Clearinghouse**
- **WARN Network**

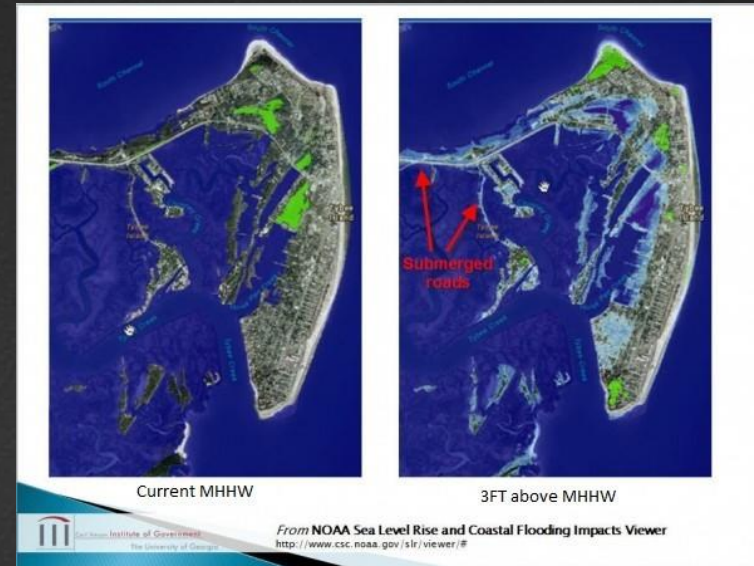
Digital Coast - www.cscNOAA.gov/digitalcoast

- Data (e.g., Coastal Lidar, Coastal Change Analysis Program Regional Land Cover)
- Tools (e.g., Climate Wizard, Critical Facilities Flood Wizard)



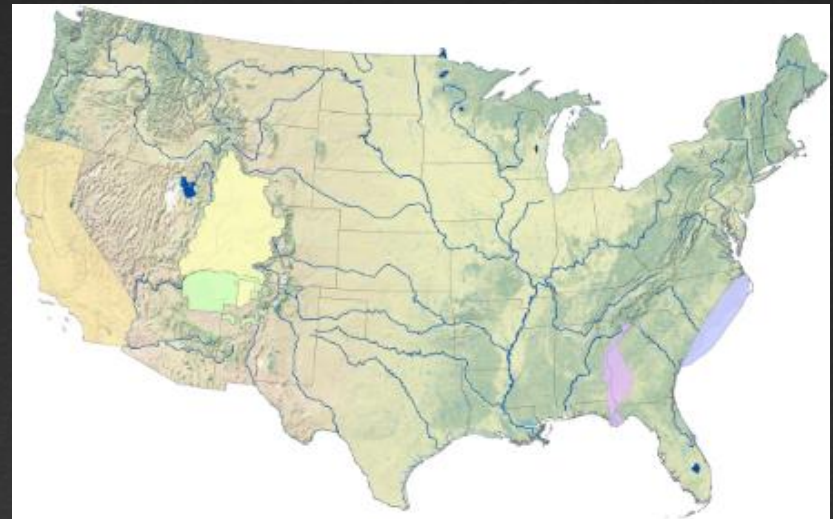
CanVis

SLR and
Coastal
Flooding
Impacts
Viewer



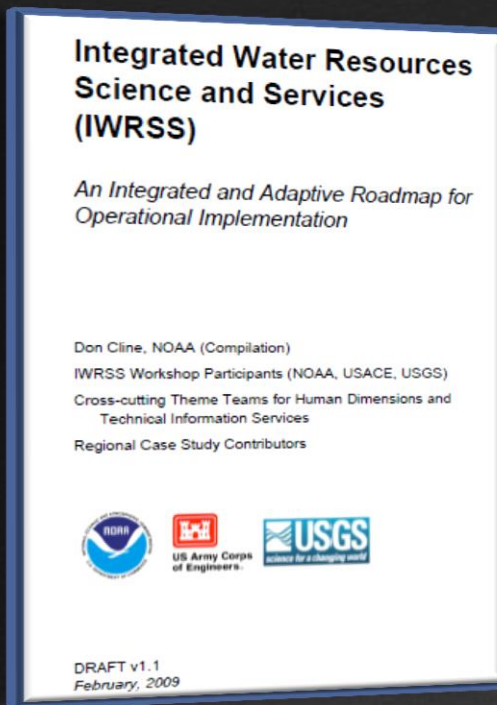
The National Integrated Drought Information System (NIDIS)

- Products (e.g., current drought and monitoring, impacts, and forecasting)
- Tools (map and data viewer, soil moisture & temp. data, etc.)
- Regional Programs
 - Drought Early Warning Systems:
 - ACF River Basin
 - Coastal Carolinas
 - Four Corners Tribal Land
 - California
 - Midwest
 - Southern Plain
 - Upper Colorado River Basin



IWRSS Roadmap and MOU

Framework to align multiple agencies with complementary water-related missions to accomplish operational goals.



MOU Signed May 11, 2011

“Collaborative Science, Services and Tools to Support Integrated and Adaptive Water Resources Management”

Signatories

- Dr. Jane Lubchenco, NOAA Administrator
- Rock Salt for Jo-Ellen Darcy, Assistant Secretary of the Army for Civil Works
- Dr. Marcia McNutt, Director of the U.S. Geological Survey

Initial Focus Areas

- High-Resolution Water Resource Forecasts
- Flood Inundation Mapping
- System Interoperability and Data Synchronization

Additional Resources

NOAA's Climate.gov: <http://www.climate.gov>

The Climate.gov video team (contact Ned.Gardiner@noaa.gov) can provide maps, visuals and information for use in on-air reports and websites.

NOAA's Climate and Societal Interactions Program:

<http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/SARPProgram/>

IPCC Website: <http://www.ipcc.ch/>

(5th Assessment report released during 2013/14)

USGCRP Website: <http://www.globalchange.gov/>

NCA Website: <http://www.globalchange.gov/what-we-do/assessment>

(Next Assessment completed in early 2014)