United States Global Change Research Program

Scientific Grand Challenges

USGCRP Perspective

World Climate Research Programme

Open Science Conference 2011

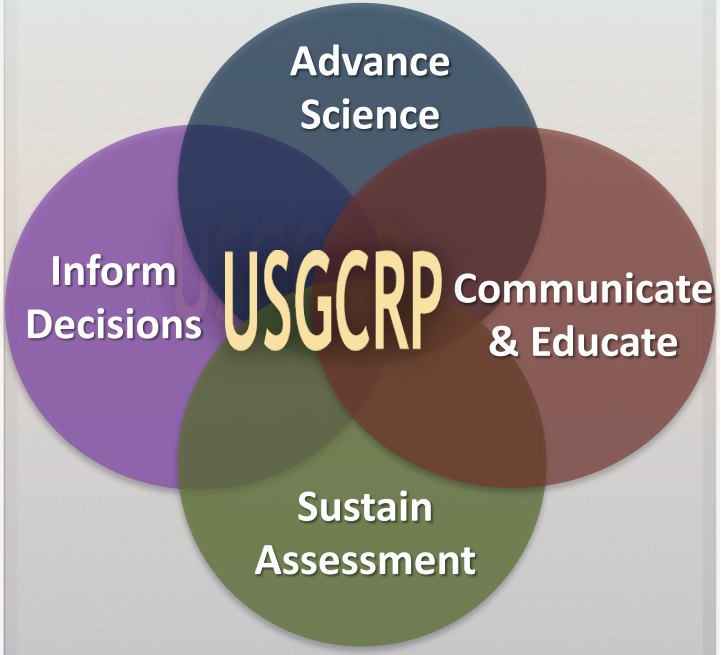
Thomas R. Karl

Chair, Subcommittee on Global Change Research

October 24, 2011

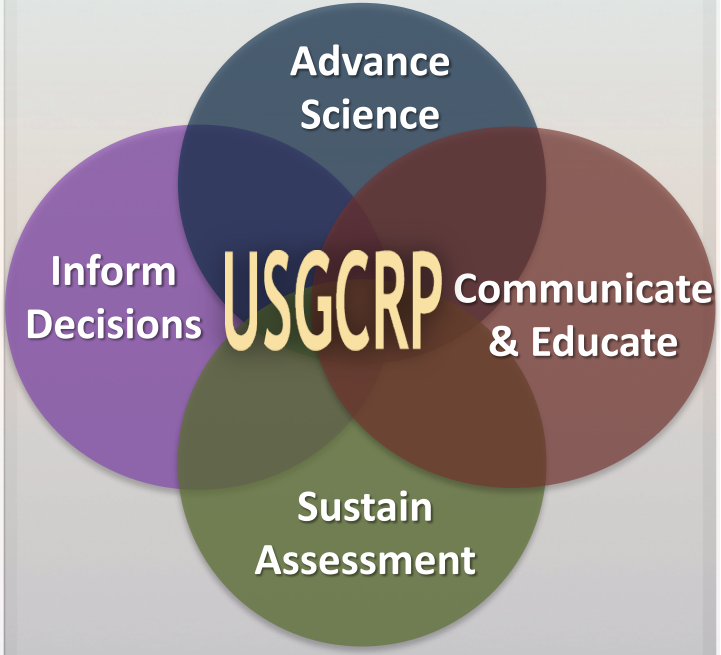
New USGCRP Decadal Strategic Plan

- Past Strategic Plans
  - Focused on natural science and emphasis on understanding, assessing and predicting
- Next Strategic Plan
  - Integrates human-natural systems
  - End-to-end science: from basic research to decision support



USGCRP Strategic Plan Goals & Objectives

Goals	Objectives
Advance Science	1.1 Earth System Understanding 1.2 Science for Adaptation and Mitigation 1.3 Integrated Observations 1.4 Integrated Modeling 1.5 Information Management and Sharing
Inform Decisions	2.1 Inform Adaptation Decisions 2.2 Inform Mitigation Decisions 2.3 Enhancing Climate Services **2.4 Enhancing International Partnerships**
Sustain Assessment	3.1 Scientific Integration 3.2 Ongoing Capacity 3.3 Inform Responses 3.4 Evaluate Progress
Communicate & Educate	4.1 Strengthen Communication and Education Research 4.2 Reach Diverse Audiences 4.3 Increase Engagement 4.4 Cultivate Workforce



USGCRP Aligns with WCRP OSC Themes

WCRP Themes	USGCRP Objectives
A1: Climate Research in Service to Society	1.2: Science for Adaptation and Mitigation 1.5: Information Management and Sharing
A2: The Climate System Components and Their Interactions	1.1: Earth System Understanding
A3: Observation and Analysis of the Climate System	1.3: Integrated Observations
A4: Assessing and Improving Model and Predictive Capabilities	1.4: Integrated Modeling
A5: Climate Assessments and Future Challenges	Goal 3: Sustain Assessments
A6: Translating Scientific Understanding of Climate System into Climate Information for Decision Makers	Goal 2: Inform Decisions
All	Goal 4: Communicate and educate

Objective 1.1:

Earth System Understanding – Example Challenges

- Roles of aerosols on regional variations and change
  - Direct, indirect effects
- Role of short-lived radiative forcing agents
  - Quantify contributions & uncertainties
- Stratosphere & surface climate
- Interface and boundary layer interactions
  - Clouds, land surface feedbacks
  - Climate-biology feedbacks
- Integration of observations into models
  - Moving toward coupled data assimilation
- Process study approach to looking at climate system
- Thresholds and tipping points

Objective 1.2: Science for Adaptation and Mitigation
Example Challenge – Weather and Climate Extremes

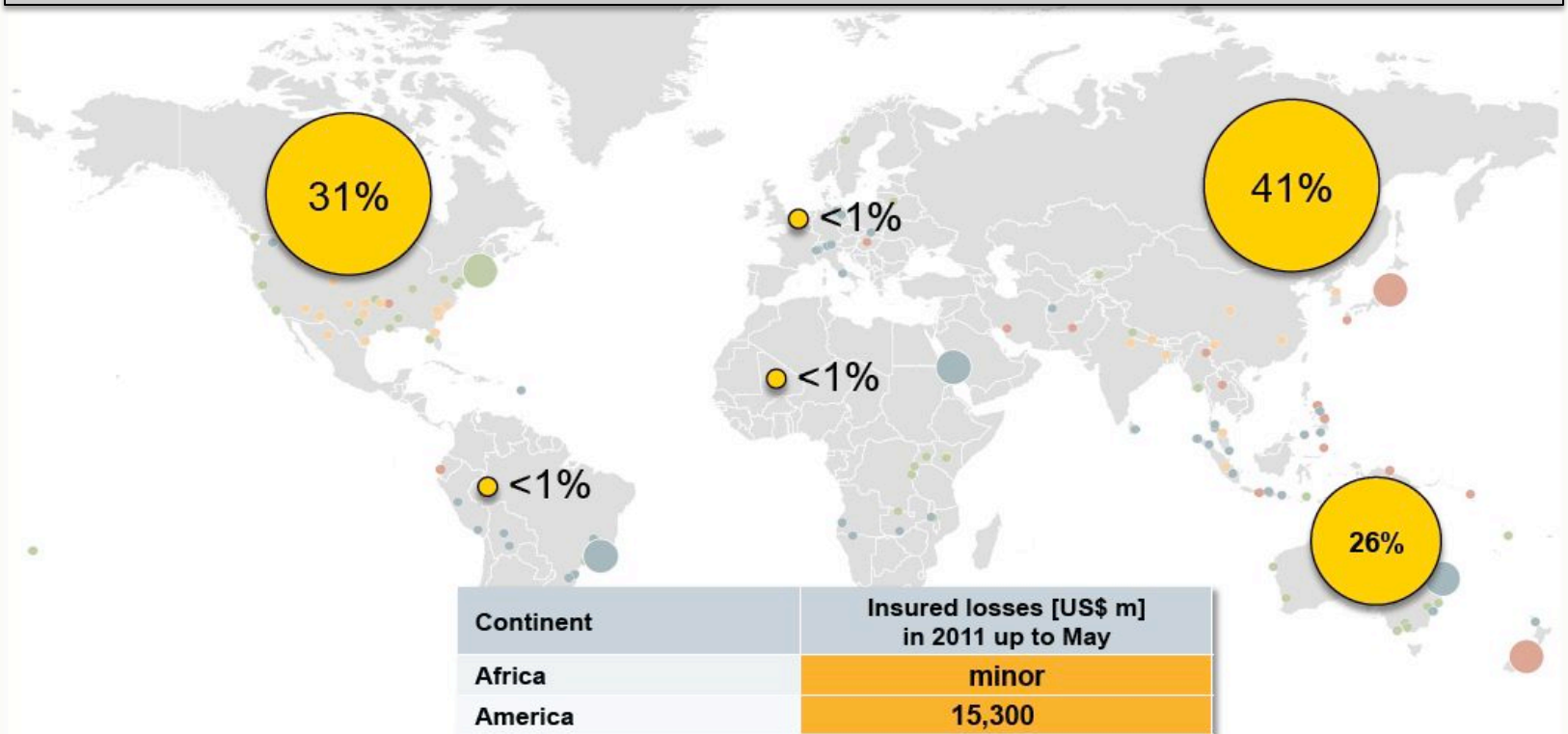
Global Natural Catastrophe Update

Worldwide Natural Disasters 2011

Percentage Distribution of Insured Losses Per Continent (January – May only)

Munich RE

Insured losses 2011 January – May: US$ 48.3 Billion



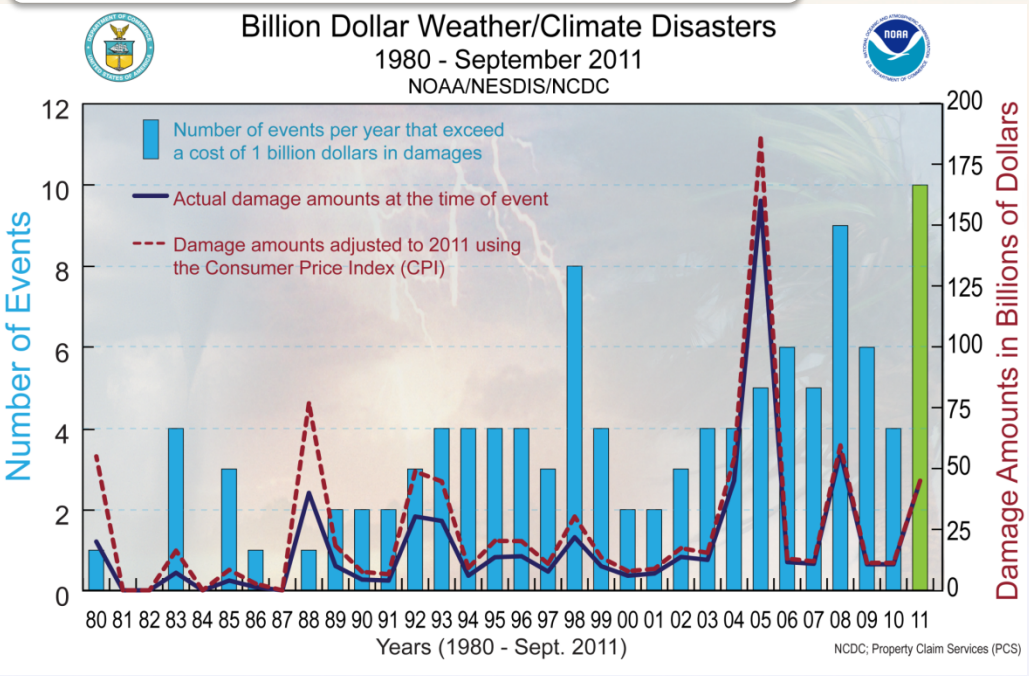
Continent	Insured losses [US$ m] in 2011 up to May
Africa	minor
America	15,300
Asia	20,000
Australia/Oceania	12,900
Europe	100

Source: MR NatCat*SERVICE*

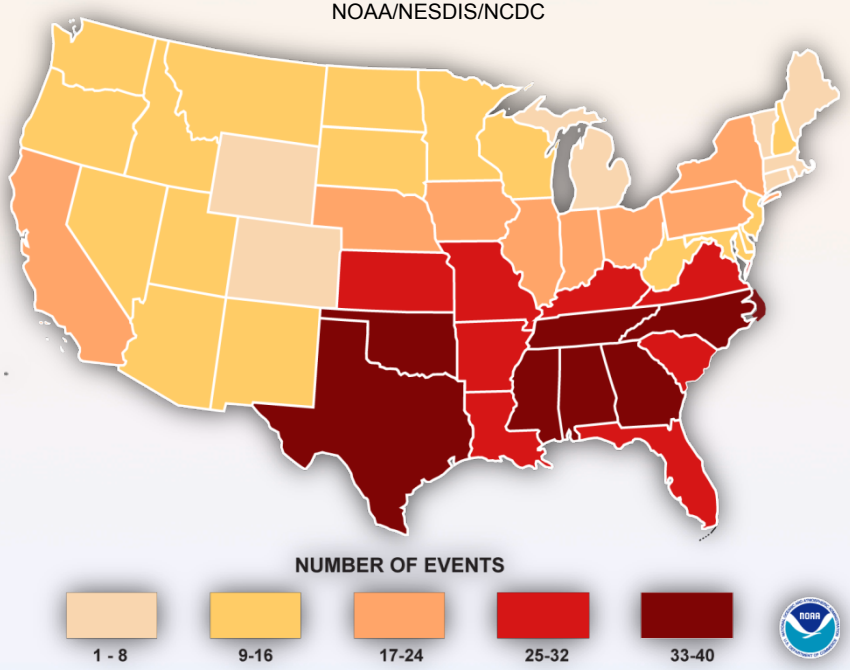
Objective 1.2: Science for Adaptation and Mitigation
Example Challenge – Weather and Climate Extremes

- Since 1980, 110 billion-dollar weather and climate disasters in U.S.
- Total losses since 1980 of billion-dollar disasters exceeds $750 billion.
- Are Nations becoming more exposed and/or sensitive to severe events?

A record 10 Disasters in the U.S. in 2011 to date



Number of Billion Dollar U.S. Weather/Climate Disasters
1980 – September 2011
NOAA/NESDIS/NCDC



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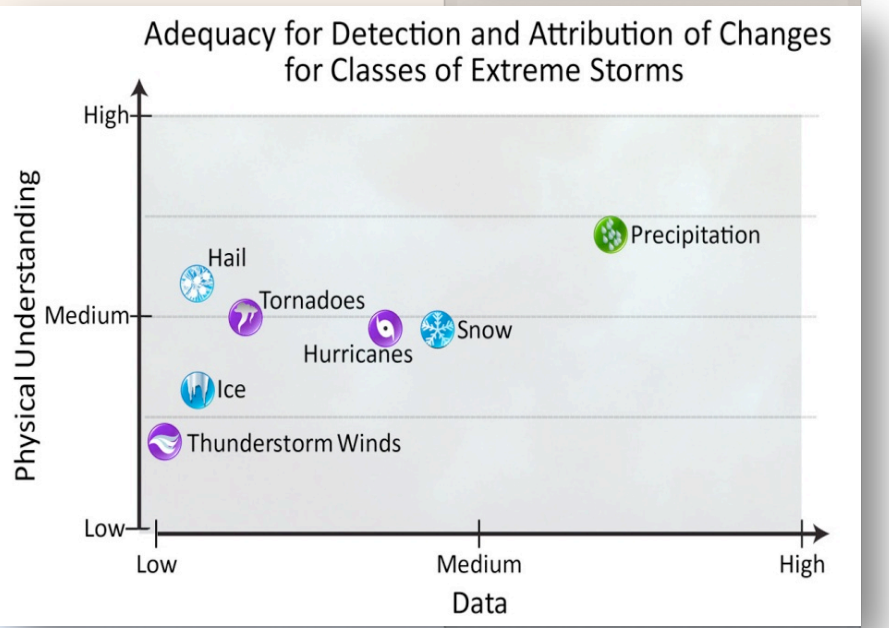
Objective 1.2: Science for Adaptation and Mitigation Example Challenge – Weather and Climate Extremes

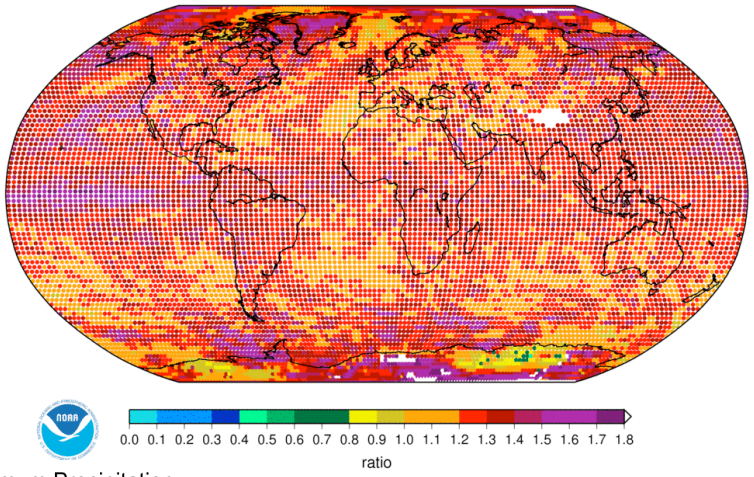
- Simultaneous (and cascading) extreme events and impacts
  - Example: Heat waves, poor air quality dispersion, severe drought, dust storms
- Detection and Attribution
  - What can we say about trends and their possible causes?
  - A challenge of rapid and scientifically rigorous explanation of and response to events
  - Need increased physical understanding; and need more accurate and lengthy historical records
  - Need better understanding of model uncertainties and implications of those uncertainties
  - ACE (Attribution of Climate-related Events)
    - Framing the question
    - A priori protocols; datasets; model simulations
    - Ensemble size consideration
  - Attribution as the pathway to improved prediction
  - Changes in the probability and severity of extreme events using heuristic models,
  - E.g., Potential Maximum Precipitation

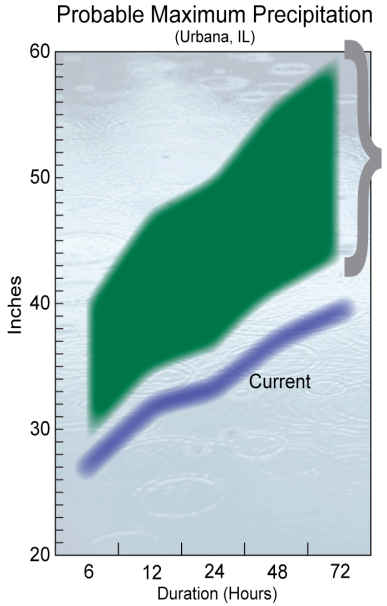


Objective 1.2: Science for Adaptation and Mitigation Example Challenge – Potential Maximum Precipitation

- Factors
  - Atmospheric moisture
  - Atmospheric convergence
  - Atmospheric vertical motion
  - Storm horizontal wind speed
- Observed storms provide empirical basis for approximate maximum values of convergence and upward motion

Ratio of Maximum Daily Precipitable Water
2071-2100 / 2001-2010





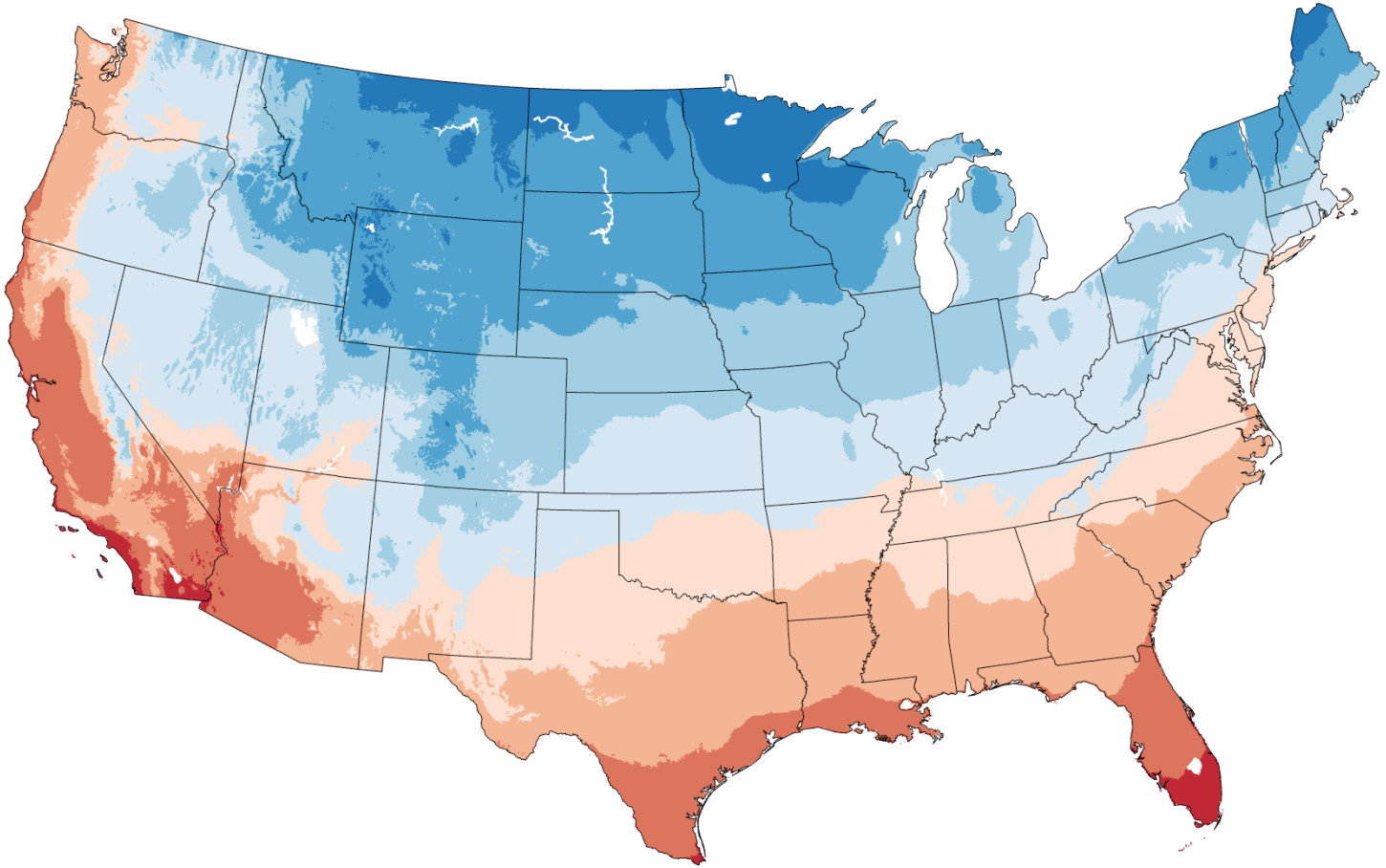
If the Earth warms between 3-13°F by 2100 (as projected)

Objective 1.2: Science for Adaptation and Mitigation Example Challenge – Use-inspired Science

- Advance use-inspired science to assess vulnerabilities
  - Sea Level Rise and Coastal Vulnerability
  - Energy Security
  - Water Resources Decision Making and Management
  - Food Security
    - Changes in planting zones

Climate-Related Planting Zones: 1971-2000

Based on Current 30-Year Normals



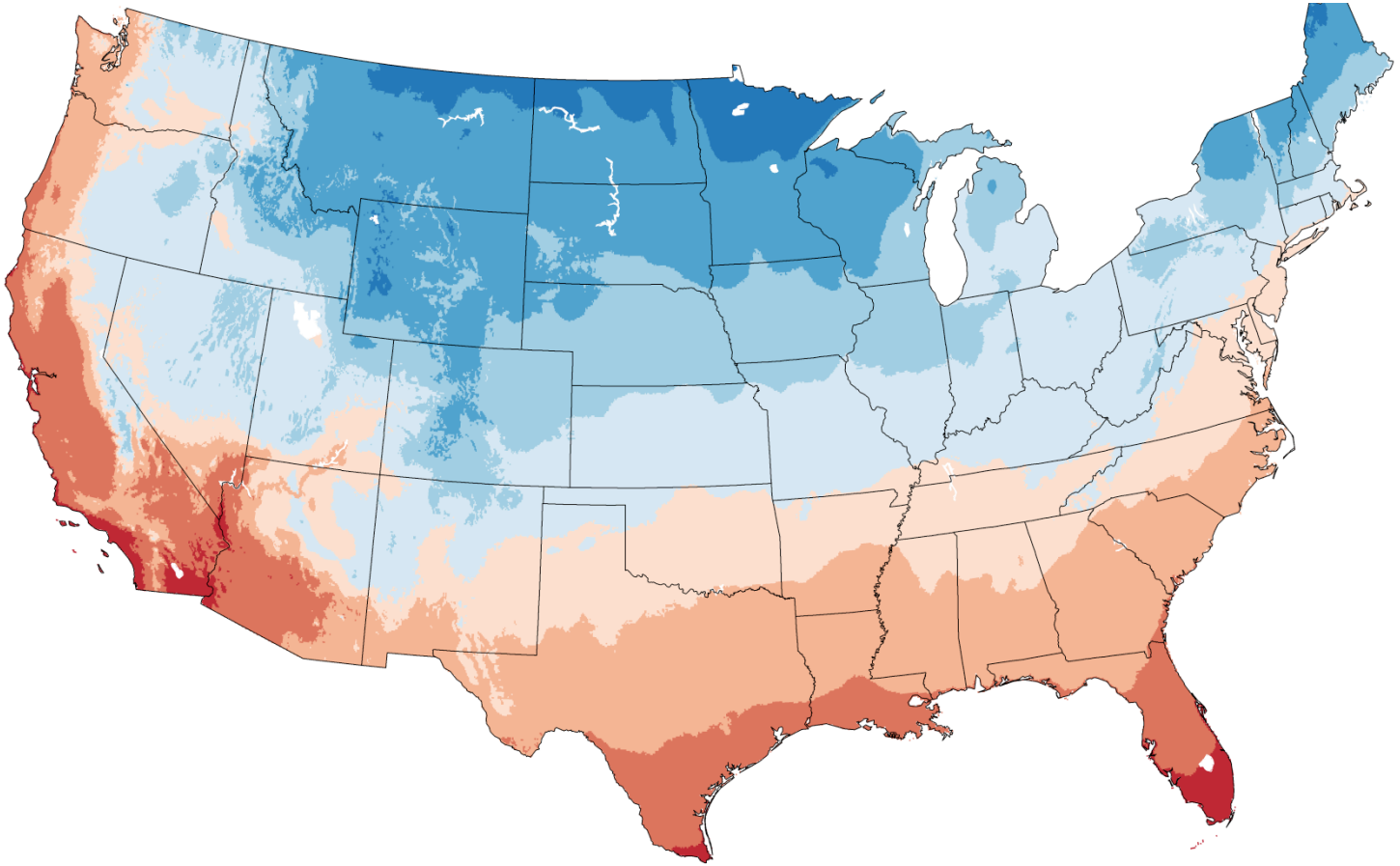
Average Annual Minimum Temperature by Climate-Related Planting Zone

- Zone 3 (-39 to -30 F)
- Zone 4 (-29 to -20 F)
- Zone 5 (-19 to -10 F)
- Zone 6 (-9 to 0 F)
- Zone 7 (1 to 10 F)
- Zone 8 (11 to 20 F)
- Zone 9 (21 to 30 F)
- Zone 10 (31 to 40 F)

Disclaimer: This illustration of nationwide patterns and changes in climate-related planting zones for gardeners was created as a special service to the American Public Gardens Association by the National Oceanic and Atmospheric Administration (NOAA). The official Plant Hardiness Zone map was prepared by the U.S. Department of Agriculture (USDA) in 1990 using data collected and distributed by NOAA. USDA is currently updating its official map, which will soon be available via the Internet.

Climate-Related Planting Zones: 1981-2010

Based on New 30-Year Normals (Published July 1, 2011)



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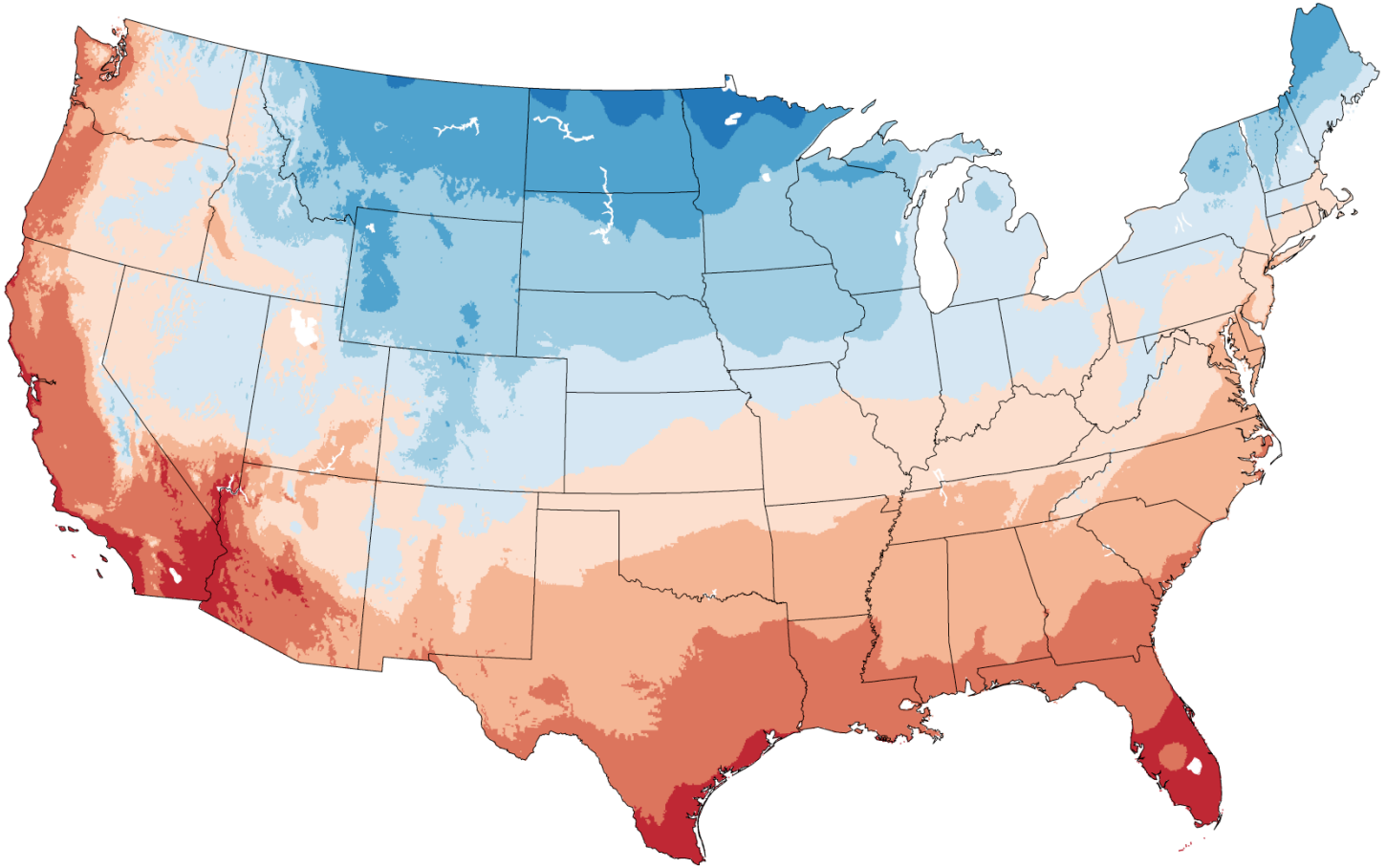
Projected Planting Zones: 2011-2040

Derived from Historical Data for 1971-2010



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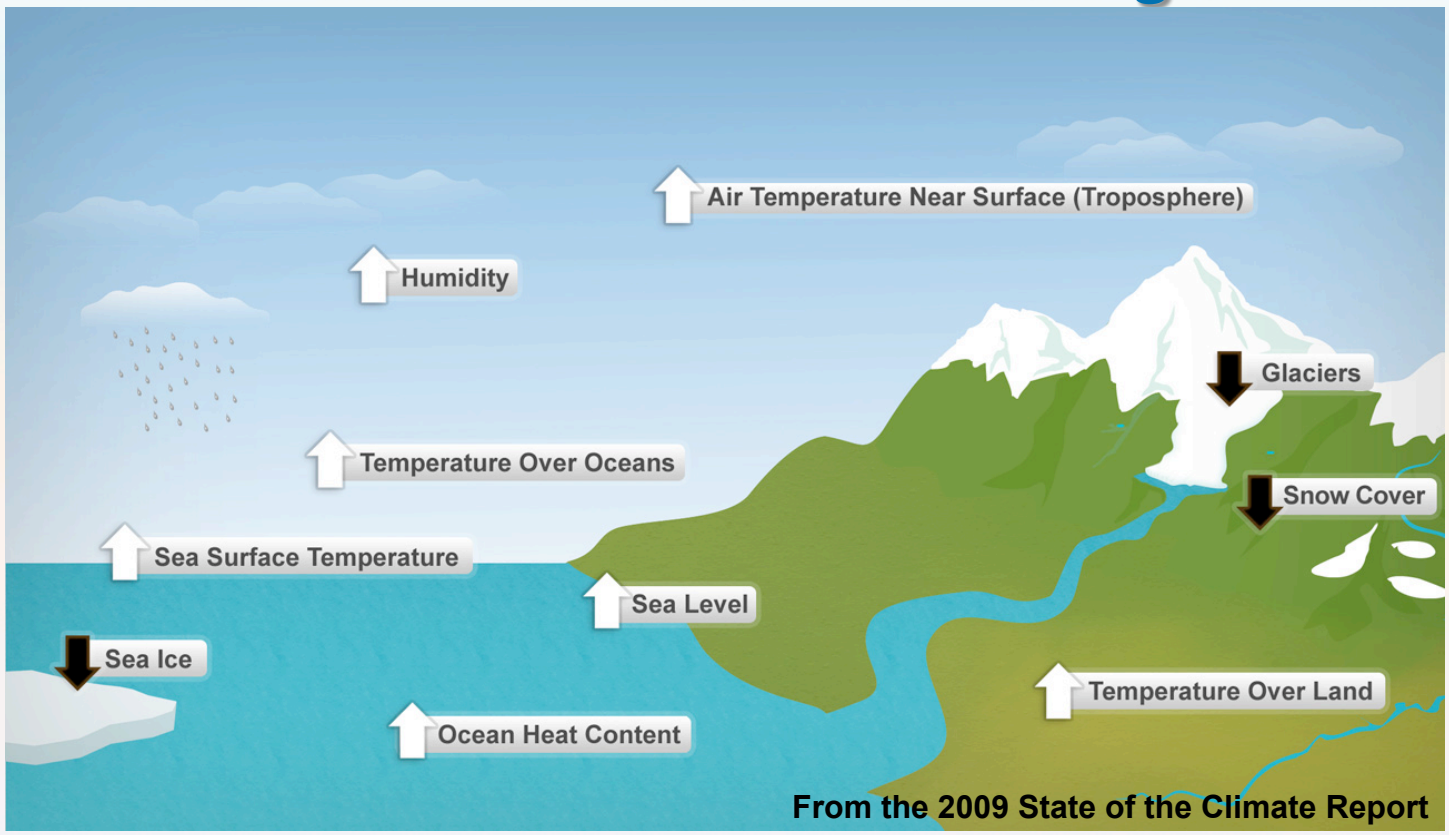
Objective 1.3:

Integrated Observations – Example Challenges

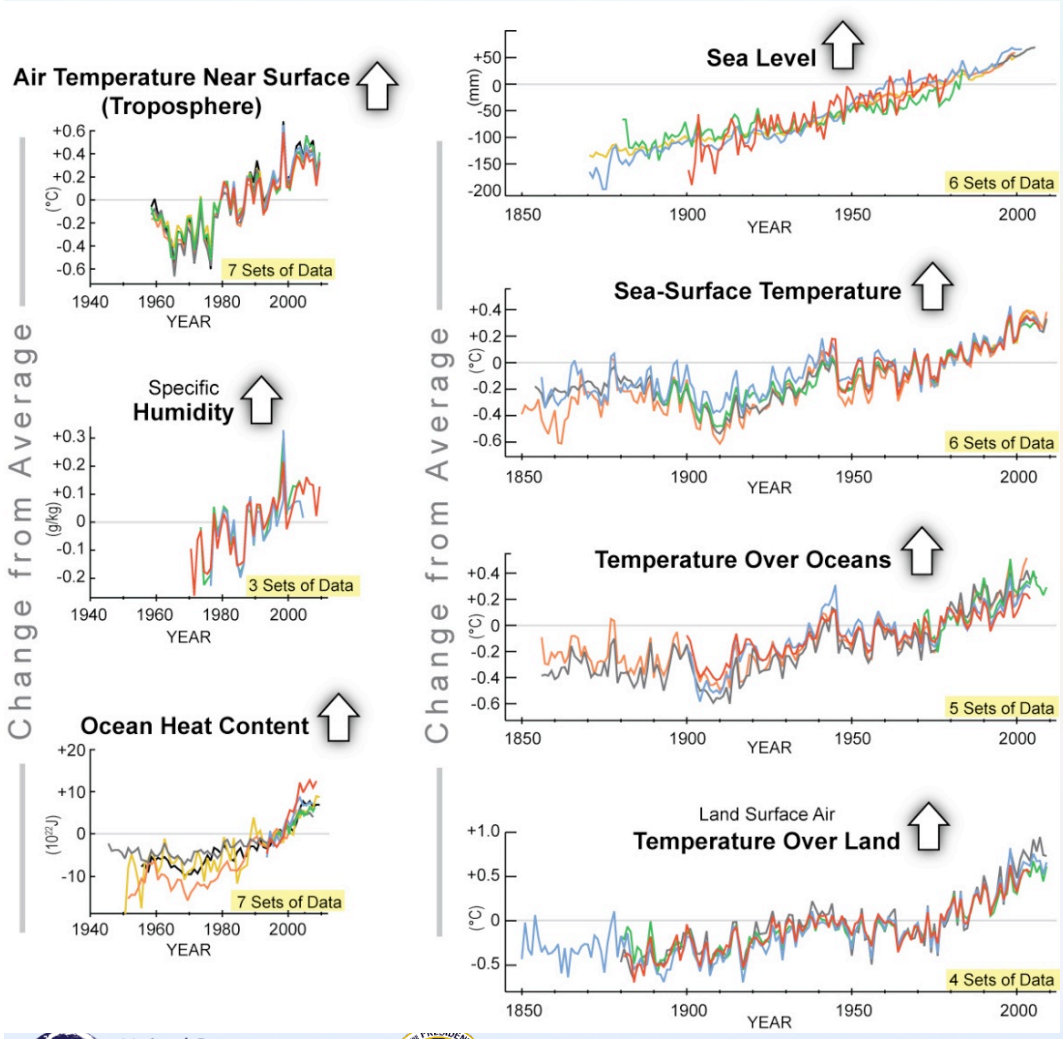
- Reference-quality in-situ observation networks
- Maintain continuity of climate record
  - Risk of gaps in the satellite records
  - Need coordinated approach - planned redundancy
- Design and operate an interdependent observing system
  - Predictive value of each system
  - Value/impact of various levels of operation of each system (e.g. TAO/ARGO)
  - Observing Systems Simulation Experiments for climate
  - Linking observing systems and modeling requirements
  - Purposeful reduction of structural and statistical monitoring errors (Example follows)

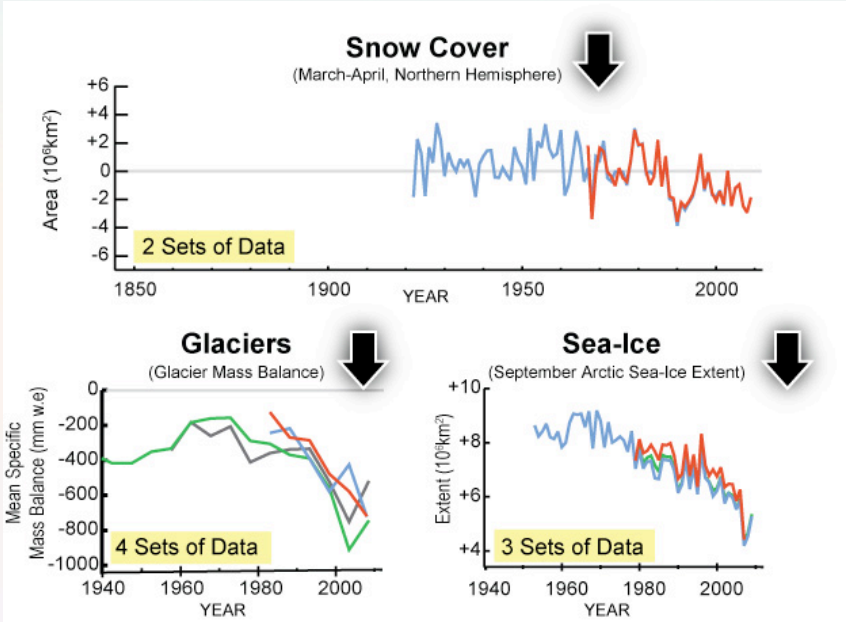
Objective 1.3: Integrated Observations Example Challenge – Purposeful reduction of structural and statistical monitoring errors



- Ten Indicators of a Warming World
- Seven of these **observed** indicators would be expected to increase in a warming world, and observations show that they are, in fact, increasing.
- Three would be expected to decrease, and they are, in fact, decreasing.

Objective 1.3: Integrated Observations
Example Challenge – Purposeful reduction of structural and statistical monitoring errors



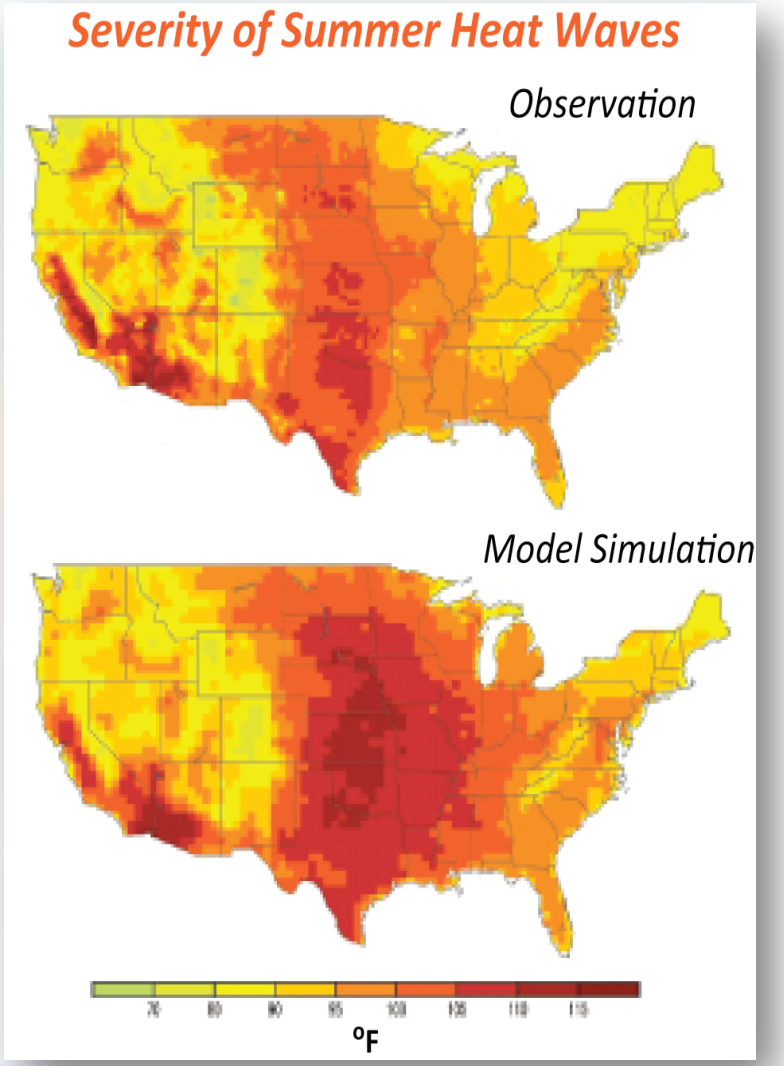


From the 2009 State of the Climate Report

Objective 1.4:

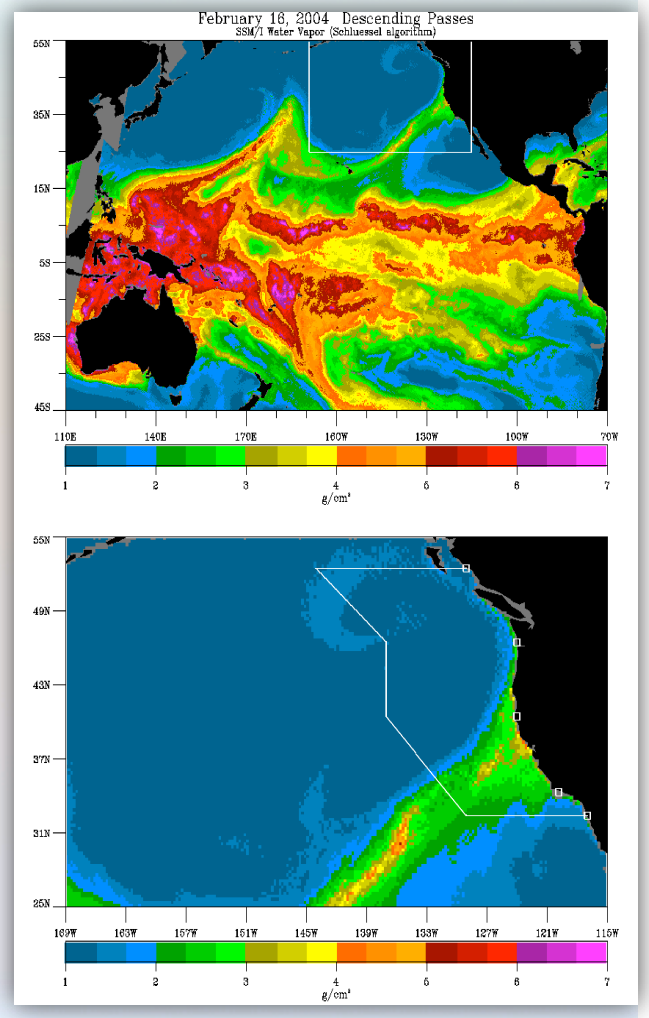
Integrated Modeling – Example Challenges

- Right scaling
  - Includes downscaling
  - Societal interest in weather-scale events, e.g. fog, ice storms, blizzards, thunderstorms, etc.
  - Physical and statistical approaches necessary
  - Model complexity linked to time and space scales
- Multi-model ensembles
  - Improve intraseasonal-to-interannual prediction skill
- Seasonal and Decadal Prediction
  - Explore and identify Sources of Predictability
    - Stratosphere – Troposphere Interactions
    - Ocean-Atmosphere Interactions
    - Land -Atmosphere Interactions
  - Anthropogenic
    - Atmosphere/ocean interactions



Objective 1.4:
Integrated Modeling – Example Challenges

- Tropical Convection
  - How can we best use variations in tropical heating as a major source of predictability?
    - Often a pervasive weakness in current models
- Important Extratropical Interactions
  - Madden-Julian Oscillation
  - "Atmospheric Rivers"
  - Blocking and Storm Tracks
- Characterization of confidence levels
- Best use of new, highly complex and high-resolution models



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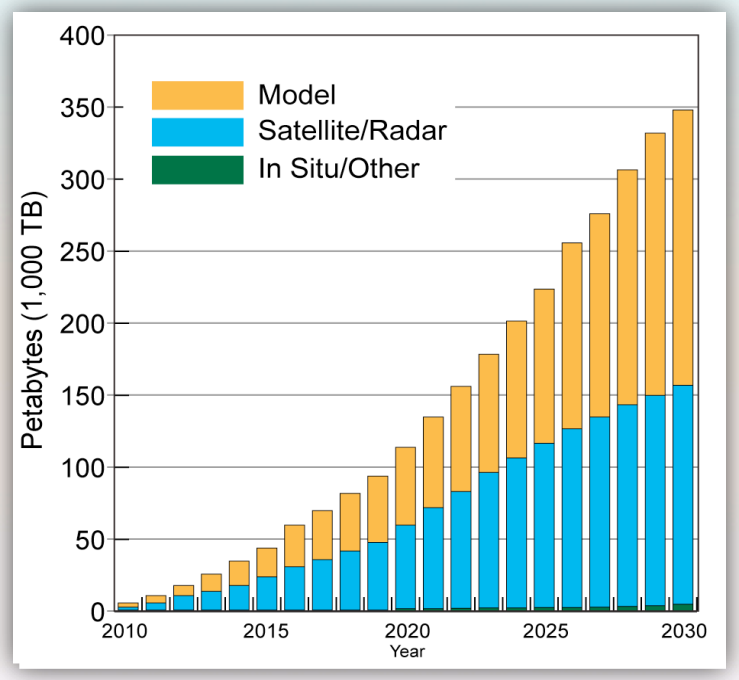
Objective 1.5:
Information Management and Sharing – Example Challenges

- Federated data sources
  - Centralized vs. Decentralized?
  - Promote sharing
  - Earth System Grid Federation
- Metadata and standards
- How to provide optimal data access for users



Goal 2:

Inform Decisions – Example Challenges

Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.

Why do people choose to live in high-risk areas?

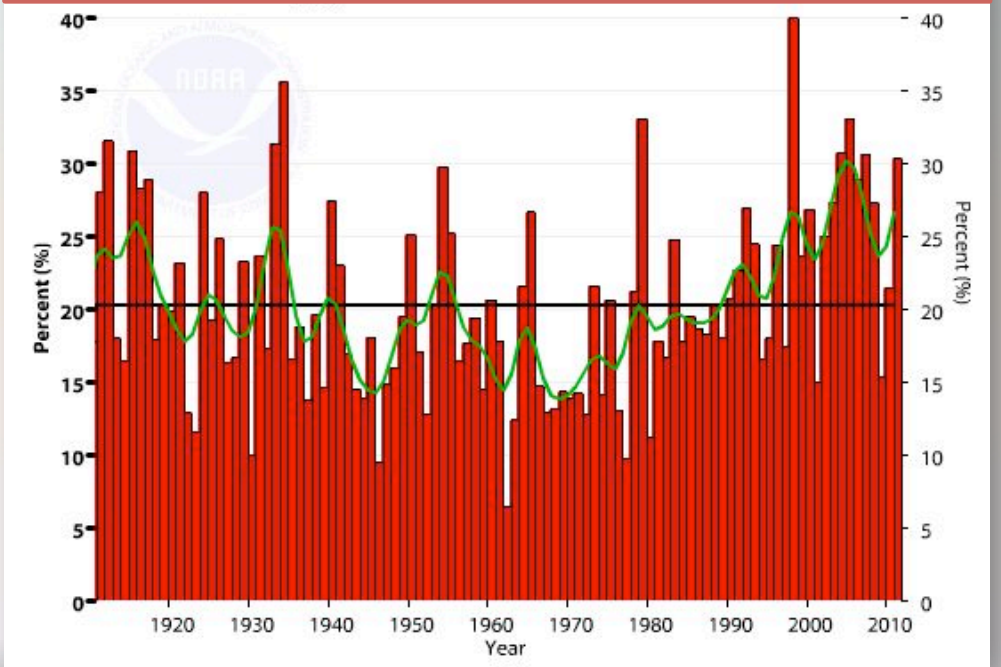
Rising sea level resulting in decreasing wildlife habitats

Goal 3:

Sustain Assessments – Example Challenges

- Sustainable process with multiple products
- Indicators
  - Physical
  - Ecosystem
  - Socioeconomic
- Assessing and communicating confidence levels
- Regional and sectoral focus

U.S. Climate Extremes Index
Jan – Sep 1910 to 2011



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Goal 4:

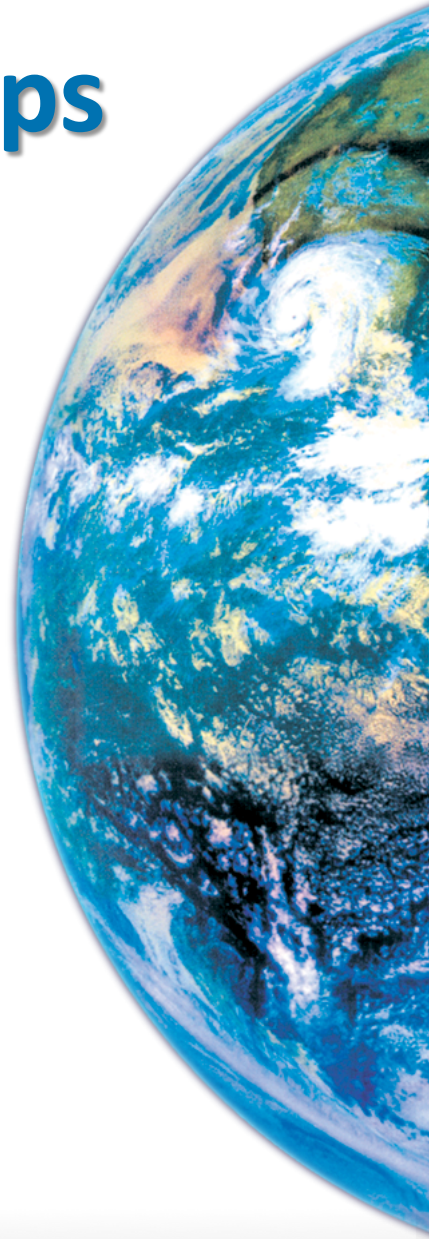
Communicate and Educate – Example Challenges

- Advance communications and education to broaden public understanding of global change, and empower the workforce of the future.

High school students attending a “Science Careers in Search of Women” conference. Credit: *NSF image.*

The Essential Principles of Climate Science (2009). USGCRP.

International Partnerships



- Recognize the strategic benefits of collaborating with international partners
- Coordinate U.S. activities with other nations and international organizations
  - On global change research projects and activities
- Promote international cooperation and access to scientific data and information
- Participate in international global change research by developing nations
- Effectively leverage existing and future scientific capabilities
  - More effectively use resources to accomplish goals and strategic priorities


Implementation Guidelines

- Ensure continuing strength at the scientific foundation of USGCRP
  - Integrated observations, modeling, and process research is used to support all four goals
- Develop a portfolio of essential foundational and new activities that:
  - Promote scientific progress that achieves results having direct societal benefit
  - Build the capacity within USGCRP for interdisciplinary research and related activities
  - Integrate between the natural science and human components of the earth system
  - Translate science for societal benefit and related risk management decision making
  - Enable discoveries through transformational research
- Build connections within and beyond USGCRP member agencies, and with other interagency bodies
  - Leverage federal investments
- Review progress regularly of interagency activities
  - Evaluate priorities and the balance between research and service goals

USGCRP Strategic Plan

Public Comment Period

- **Draft plan is available for public comment at** http://strategicplancomments.globalchange.gov/

- Public comment started September 30, 2011
  - Closes November 29, 2011