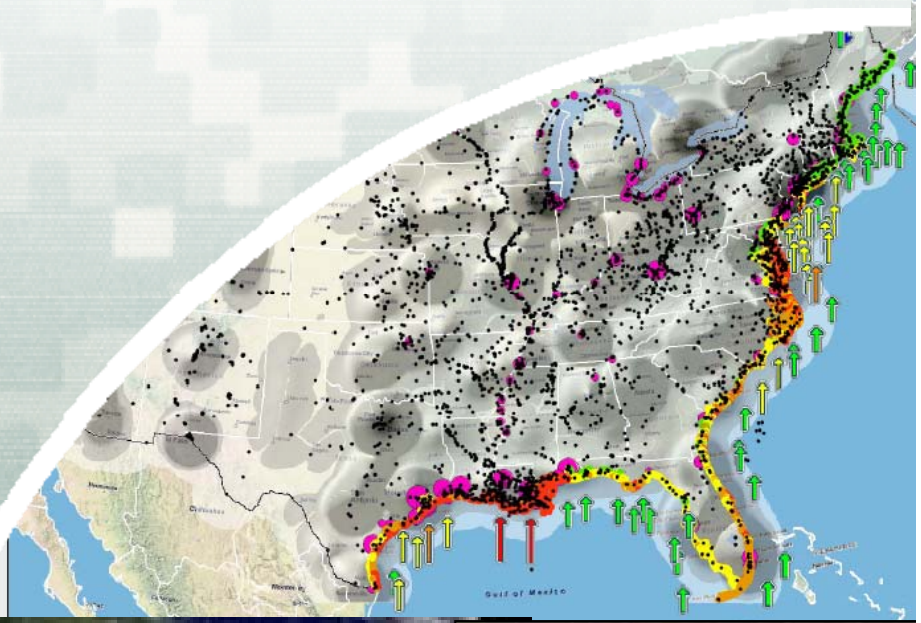
USACE Climate Change Update Part II

Ecosystem Restoration Learning Exchange
6 September 2011

Kate White, PhD, PE
Jeff Arnold, PhD
Rolf Olsen, PhD



US Army Corps of Engineers
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Recap: Summary Webinar Part I

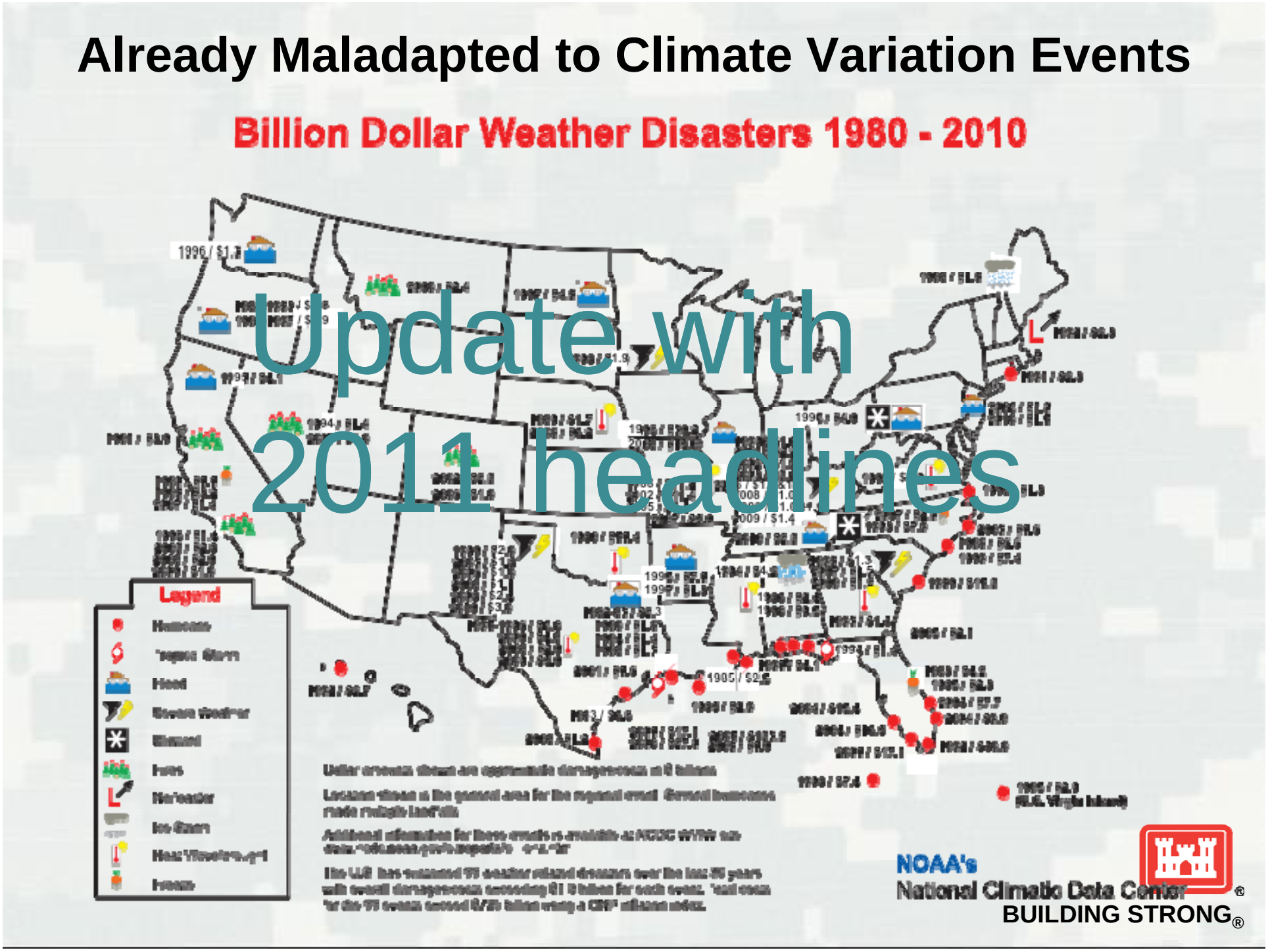
- Climate change adaptation is an active area for the USACE CW program because of lessons-learned from Hurricane Katrina and observed hydrologic and sea-level changes
- The climate change commitment requires both adaptation and mitigation
- Adaptation is challenging and has a longer time frame, but we are making progress
  - Pilots provide new knowledge
  - District-led guidance updates develop new knowledge
- More to come!

Planned Webinar Part II

- Nationwide screening-level climate change assessment of the vulnerability of CW missions, operations, programs, and projects to climate change and variability
- Progress on climate guidance
- Integration of adaptation and mitigation
- Ecosystem considerations
- FY11 adaptation pilots (35 proposals!)


APRIL 3, 2006
www.time.com AOL Keyword: TI
SPECIAL REPORT GLOBAL WARMING
TIME
BE WORRIED. BE VERY WORRIED.
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well
EARTH AT THE TIPPING POINT
The Economist
SEPTEMBER 9TH–15TH 2006
www.economist.com
The Blair leadership crisis
The new boss at Ford
An honest in-flight announcement
Catastrophe looms in Darfur
Fancy a Swedish model?
The heat is on
A special report on climate change
Why Does Time Only Move Forward? (page 48)
SCIENTIFIC AMERICAN
Therapies That Beat BREAST CANCER
Ethics and Economics of
Climate Change
Balancing Current Costs against Future Well-Being
Meteor Mystery
What Really Happened 100 Years Ago in Siberia
Trust Hormone
Neurobiology Reveals
Science
AAAS
The New York Times Magazine
The Perfect Drought
Science
POLAR SCIENCE
THE Atlantic
HOT PROSPECTS
WHO LOSES—AND WHO WINS—IN A WARMING WORLD
GREGG EASTERBROOK
COMING SOON
GREENHOUSE ACRES
Sports Illustrated
SPORTS AND GLOBAL WARMING
As the Planet Changes, So Do the Games We Play
Time to Pay Attention
PLUS
AGGIES ON A RUN
BARRY ZITO MEETS BARRY BONDS
THE HEART OF WRESTLING
BILL WALSH'S WORLD
BioScience
Audubon
SINK or SWIM on the ARCTIC

Already Maladapted to Climate Variation Events




Climate change mitigation is
about CARBON


Climate change adaptation is about WATER

USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011

SUBMITTED TO THE EXECUTIVE OFFICE OF THE PRESIDENT'S COUNCIL ON ENVIRONMENTAL QUALITY / OFFICE OF THE FEDERAL ENVIRONMENTAL EXECUTIVE ON 3 JUNE 2011

Assistant Secretary of the Army for Civil Works

US Army Corps of Engineers

USACE CLIMATE CHANGE ADAPTATION POLICY STATEMENT

As the Nation's largest and oldest manager of water resources, the US Army Corps of Engineers (USACE) has long been successfully adapting its policies, programs, projects, planning, and operations to impacts from important drivers of global change and variability. Climate change and variability, both observed and as projected for the future, are among those important drivers of global change having significant impacts to the management of US national water resources and infrastructure.[1] The Nation's water-resource infrastructure managed by USACE both protects public health and human life and annually provides billions of dollars of economic, social, and environmental benefits crucial to the continued progress of the Nation.

It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects. USACE shall continue undertaking its climate change adaptation planning, in consultation with internal and external experts and with our Districts, Divisions, and Centers, and shall implement the results of that planning using the best available – and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change information into the actionable basis for adapting its Civil Works and Military Programs missions to climate change impacts. Furthermore, USACE shall consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

These actions which USACE is now conducting and has outlined for the future are fully compatible with the guiding principles and framework of the US Federal Interagency Climate Change Adaptation Task Force and the Implementing Instructions for Federal Agency Climate Change Adaptation issued on 4 March 2011 jointly by the Executive Office of the President's Council on Environmental Quality / Office of the Federal Environmental Executive (CEQ/OFEE) and the Office of Management and Budget.[2]

Together with CEQ, USACE recognizes the very significant differences between climate change adaptation and climate change mitigation in terms of physical complexity, fiscal and material resources, level of knowledge and technical readiness, and temporal and geographic scale. Because of these differences, understanding and implementing climate adaptation policies and measures requires very different knowledge, skills, and abilities than implementing mitigation measures. Relatedly, USACE understands and is acting to integrate climate adaptation (managing the unavoidable impacts) with mitigation (avoiding the unmanageable impacts). It is the policy of USACE that mitigation and adaptation investments and responses to climate change shall be considered together to avoid situations where near-term mitigation measures might be implemented that would be overcome by longer-term climate impacts requiring adaptation, or where a short-term mitigation action would preclude a longer-term adaptation action.

The successful implementation of this USACE adaptation policy will help enhance the resilience of the built and natural water-resource infrastructure USACE manages and reduce its potential vulnerabilities to the effects of climate change and variability. This success will allow USACE to continue fulfilling its missions using Integrated Water Resource Management to safeguard the Nation's tremendous investment in the built and natural water-resource infrastructure by mainstreaming climate change adaptation in all USACE activities.

[1] USGS Circular 1331 "Climate Change and Water Resources Management: A Federal Perspective", available at http://pubs.usgs.gov/circ/1331/, a joint document by the USACE, Bureau of Reclamation, US Geological Survey, and National Oceanic and Atmospheric Administration.

[2] http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation

v

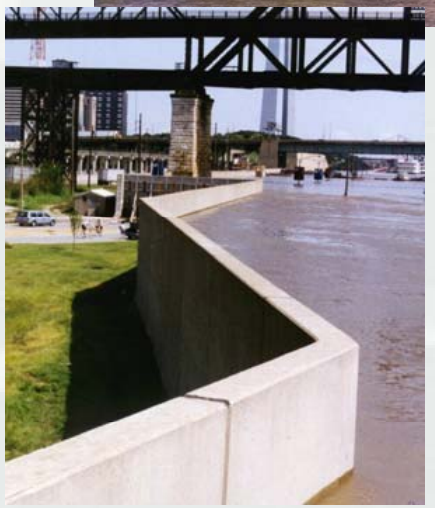
"It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects."

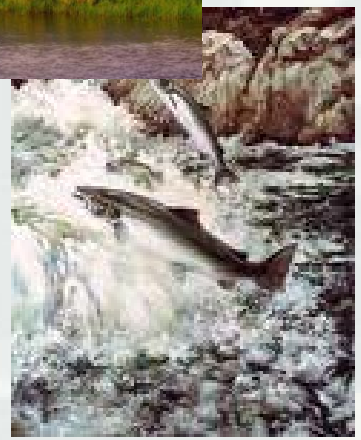
"...using the best available – and actionable – climate science and climate change information..."

"...shall consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions....."

"**Mainstreaming** climate change adaptation means that it will be considered at **every step in the project life cycle** for all USACE projects, both existing and planned... to **reduce vulnerabilities and enhance the resilience** of our water-resource infrastructure."

- USACE Policy Statement





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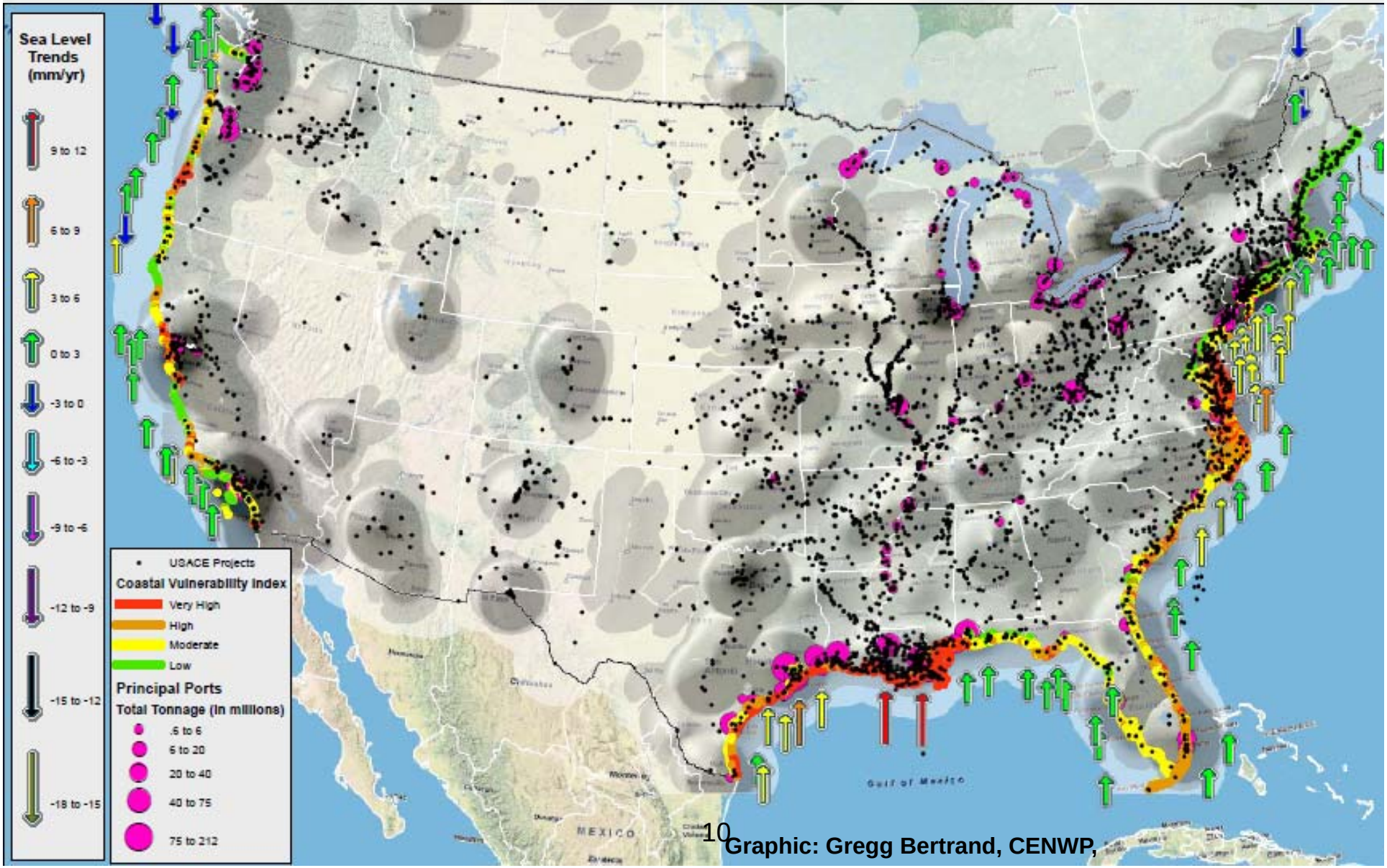
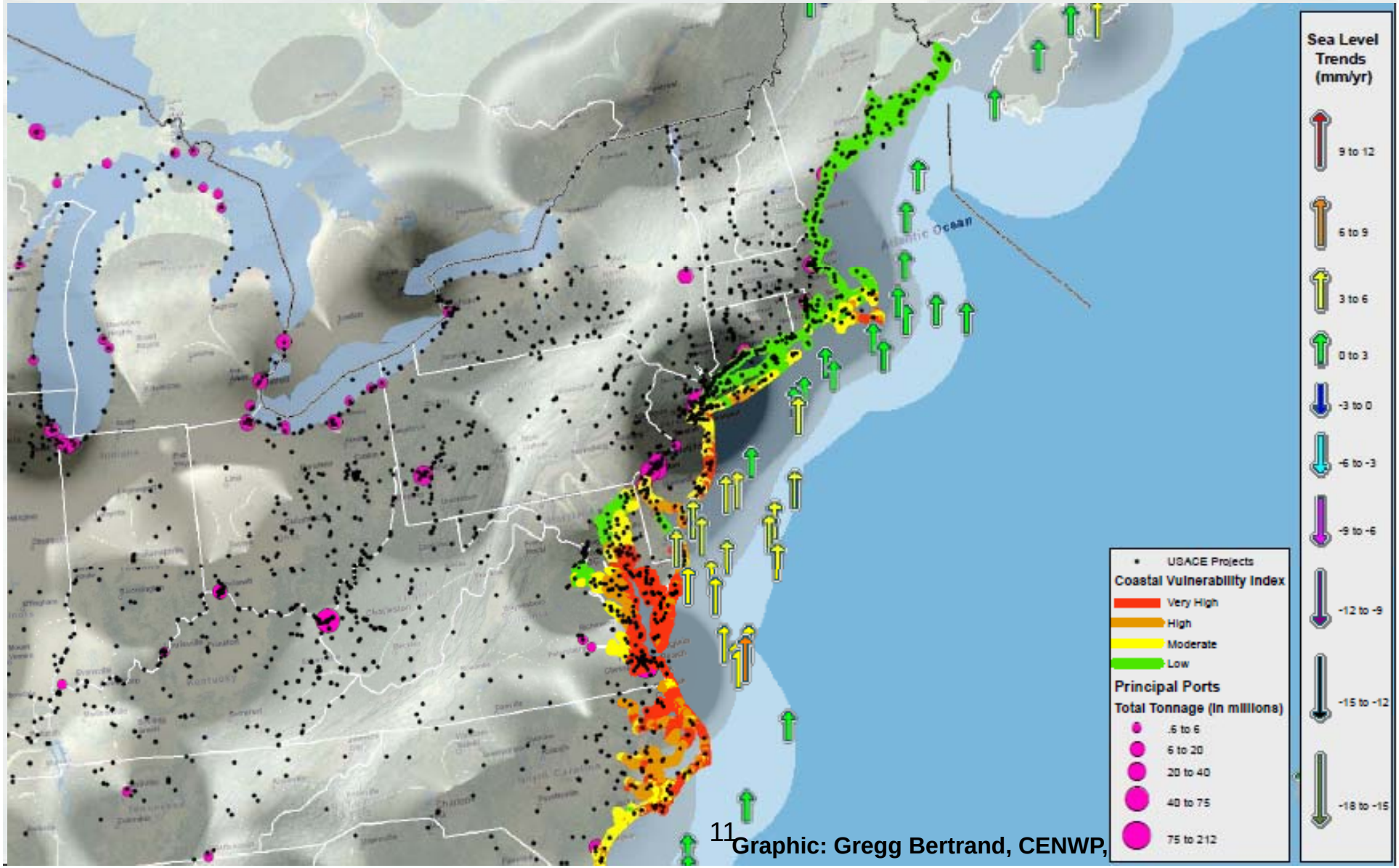
Sea Level is Changing

Observed sea-level trends (NOAA), Coastal Vulnerability Index (USGS), USACE Projects, and Port Tonnage on map of Population Density (Census)



Graphic: Gregg Bertrand, CENWP,

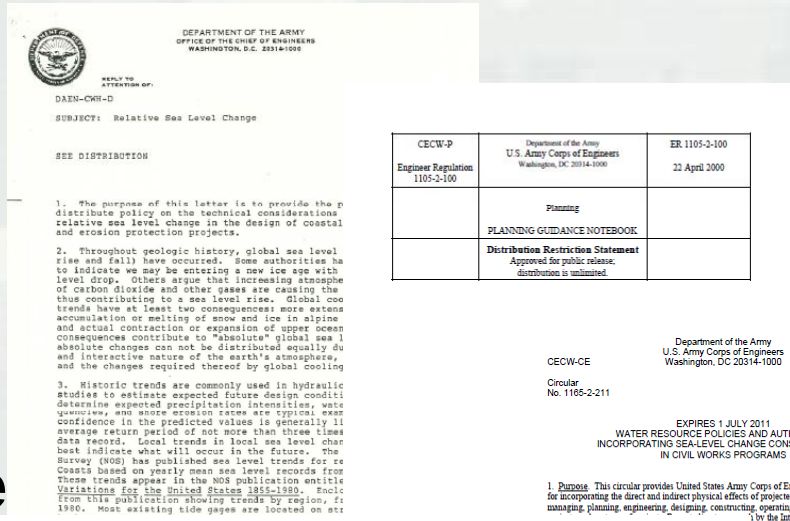
Sea Level is Changing - Close-up



Graphic: Gregg Bertrand, CENWP,

Moving Science Into Action

- 1986: observed trends
- 2000: planners consider potential for increased global sea-levels
- 2009: 3 scenarios
- 2011: adds recent science
- Adaptation early 2012



DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

DAEN-CWH-D

SUBJECT: Relative Sea Level Change

SEE DISTRIBUTION

1. The purpose of this letter is to provide the p distribute policy on the technical considerations relative sea level change in the design of coastal and erosion protection projects.

2. Throughout geologic history, global sea level rise and fall) have occurred. Some authorities ha to indicate we may be entering a new ice age with level drop. Others argue that increasing atmosphe of carbon dioxide and other gases are causing the thus contributing to a sea level rise. Global coo trends have at least two consequences: more extens accumulation or melting of snow and ice in alpine and actual contraction or expansion of upper ocean consequences contribute to "absolute" global sea l absolute changes can not be distributed equally du and interactive nature of the earth's atmosphere, and the changes required thereof by global cooling

3. Historic trends are commonly used in hydraulic studies to estimate expected future design conditi determine expected precipitation intensities, wate quantities, and shore erosion rates are typical exam Confidence in the predicted values is generally li average return period of not more than three times data record. Local trends in local sea level char best indicate what will occur in the future. The Survey (NOS) has published sea level trends for re Coasts based on yearly mean sea level records fro These trends appear in the NOS publication entitle Variations for the United States 1855-1980. Enclo from this publication showing trends by region, f 1980. Most existing tide gages are located on st

CECW-P Engineer Regulation 1105-2-100	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ER 1105-2-100 22 April 2000
	Planning PLANNING GUIDANCE NOTEBOOK	
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CECW-CE

Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

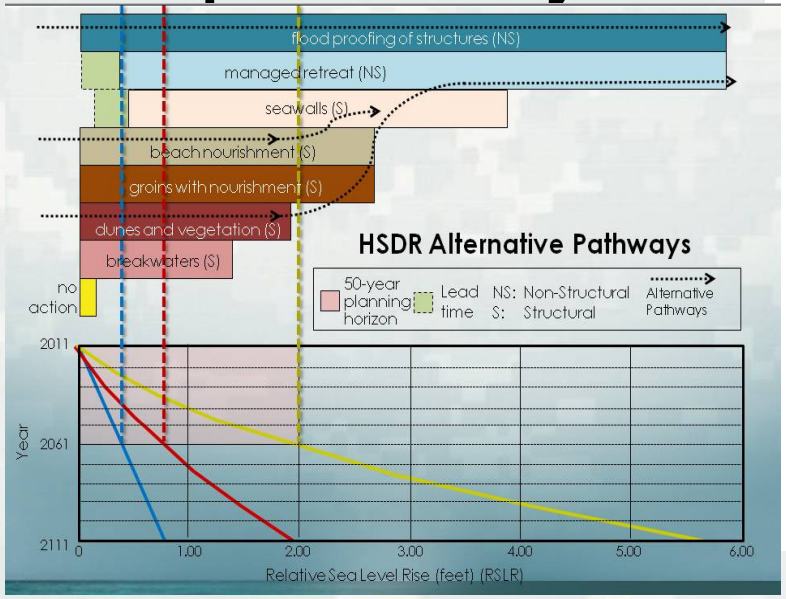
EC 1165-2-211

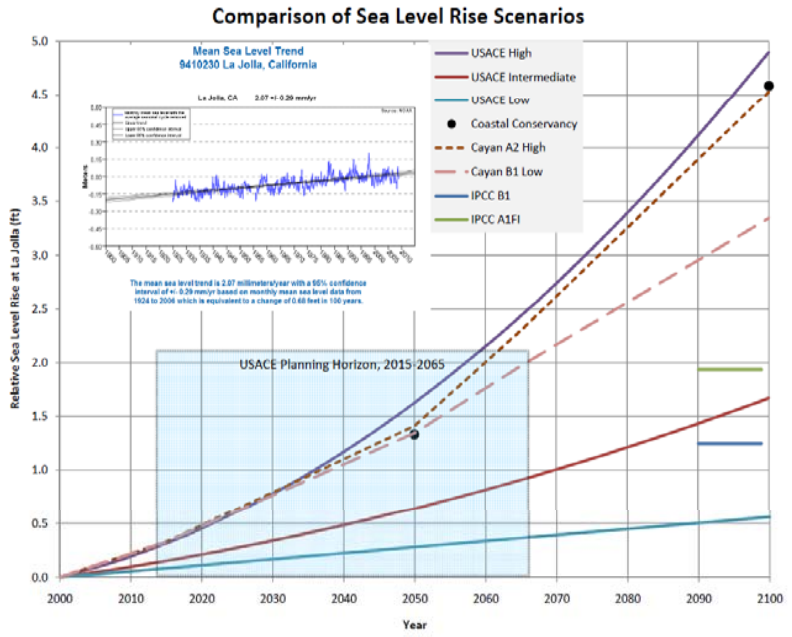
Circular
No. 1165-2-211

1 July 2009

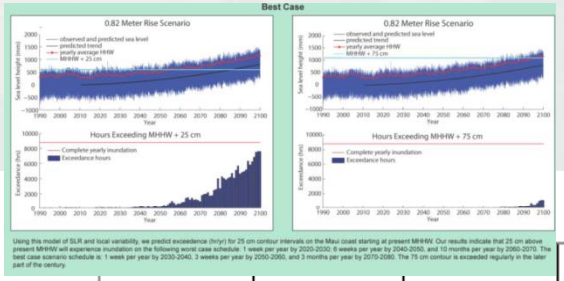
EXPIRES 1 JULY 2011
WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

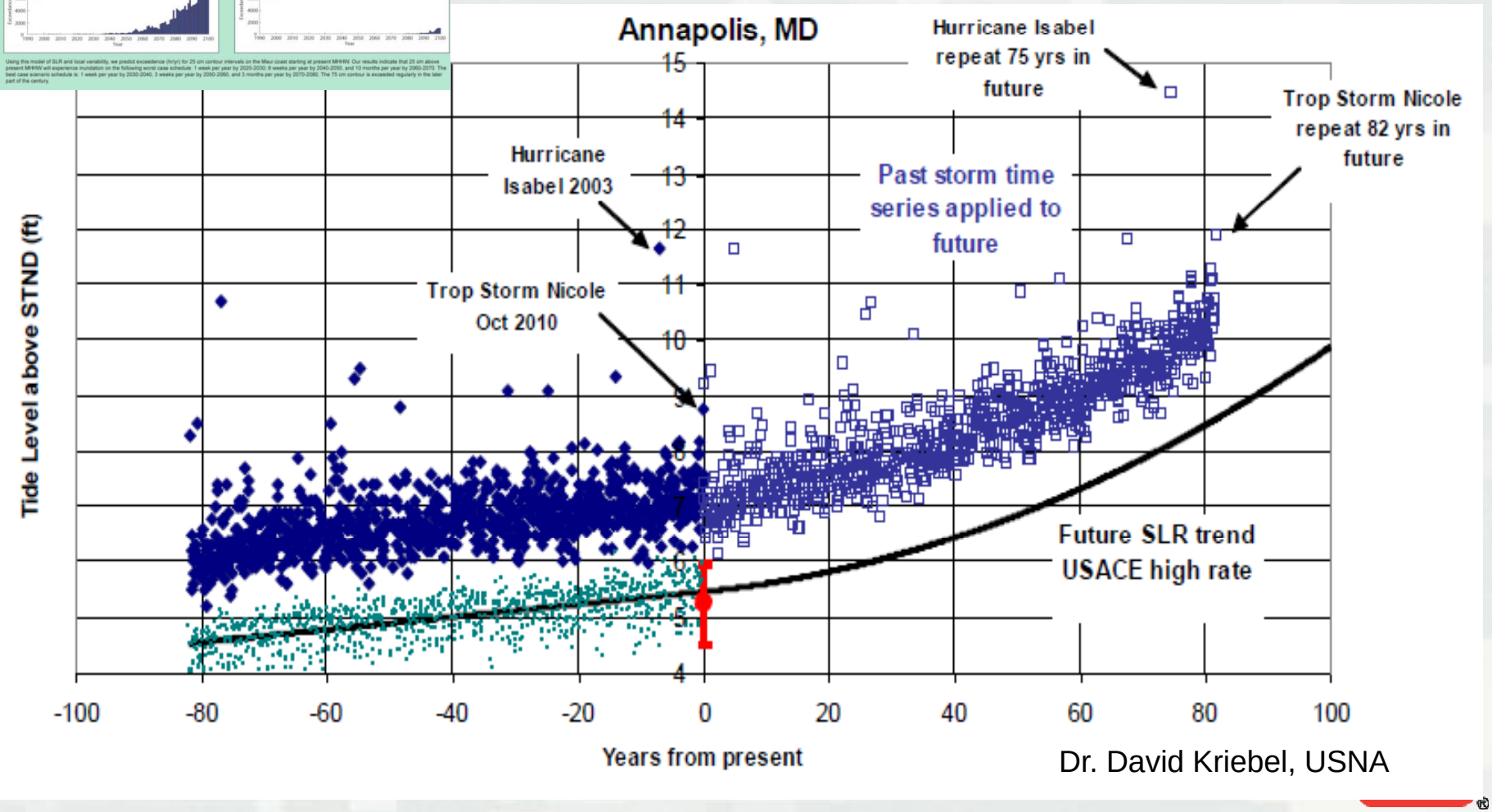
1. Purpose. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE



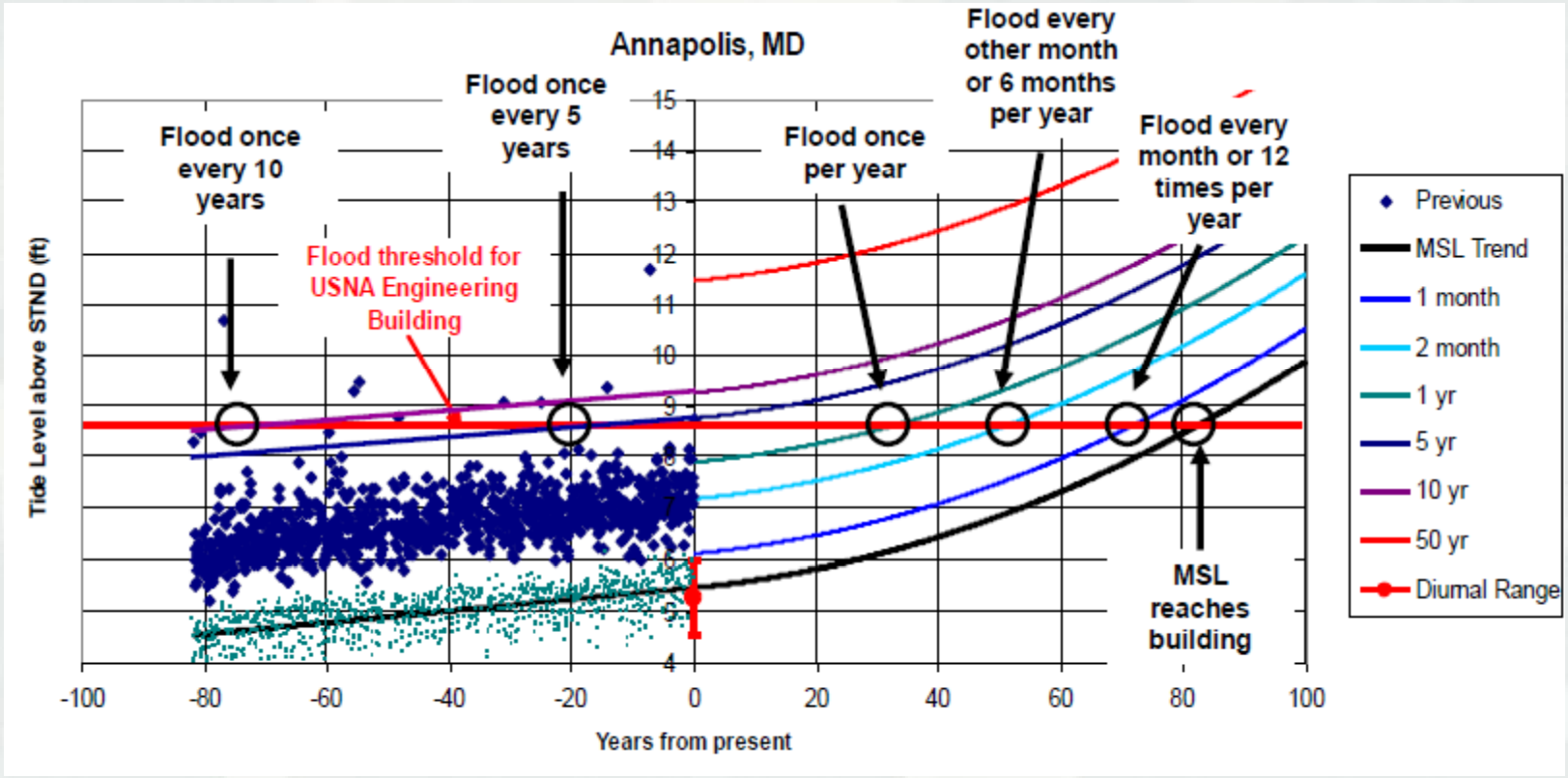


Moving Science Into Action



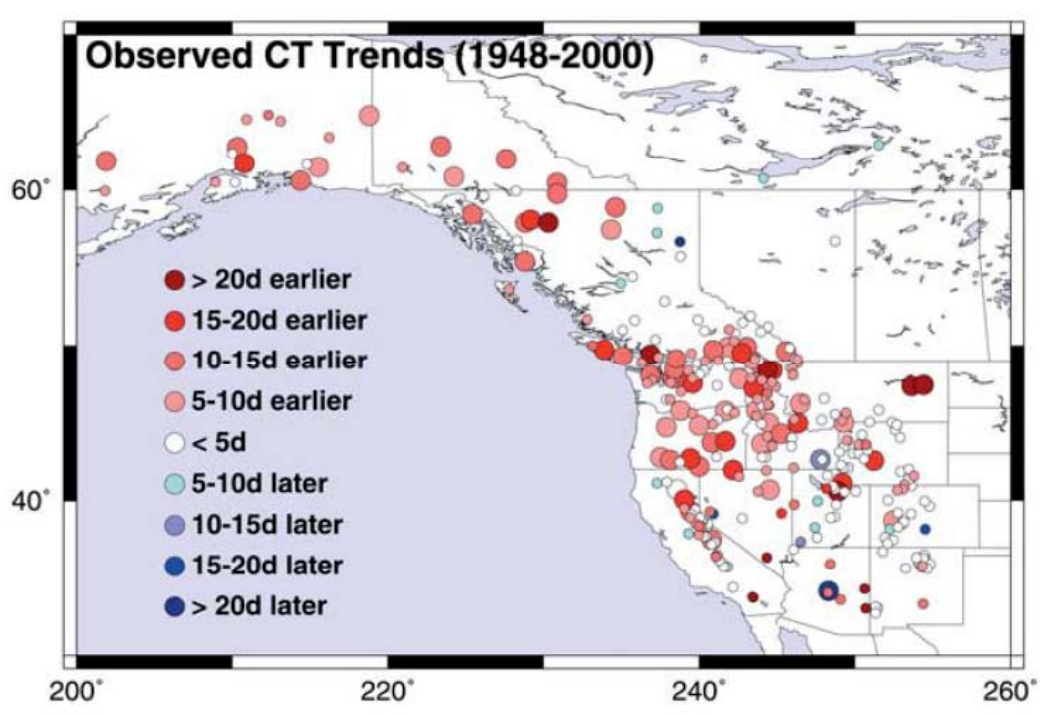


Dr. David Kriebel, USNA



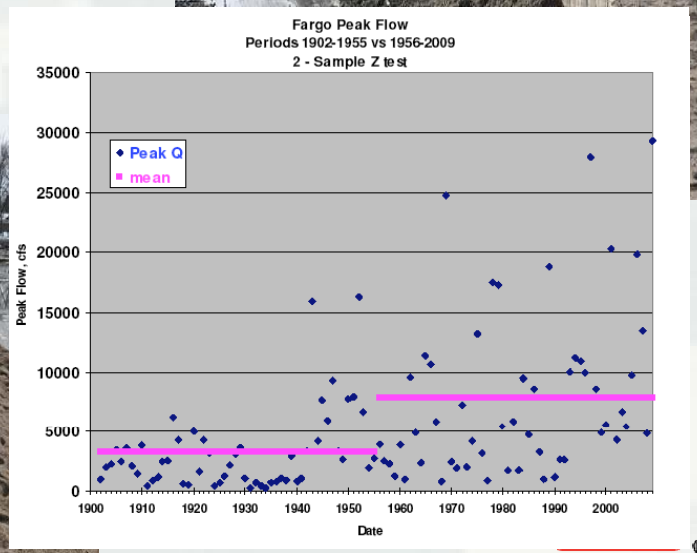
Isabel, Sept 2003

Dr. David Kriebel, USNA



CT= Center of mass of annual flow
From Stewart et al 2004

We have a reasonable science base for changes occurring in western snow-dominated watersheds



We have some science around snow-dominated watersheds in the Northern Plains

RRN 2009 flood

POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage works, and land-cover and land-use change. Two other (sometimes indistinguishable) challenges to stationarity have been externally forced, natural climate changes and low-frequency, internal variability (e.g., the Atlantic multidecadal oscillation) enhanced by the slow dynamics of the oceans and ice sheets (*2*, *3*). Planners have tools to adjust their analyses for known human disturbances within river basins, and justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design.

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate.

How did stationarity die? Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (*4*, *5*) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and possibly flood risk, where prevailing atmospheric water-vapor fluxes converge (*6*). Rising sea level induces gradually heightened risk of contamination of coastal freshwater supplies. Glacial meltwater temporarily enhances water availability, but glacier and snow-pack losses diminish natural seasonal and interannual storage (*7*).

Anthropogenic climate warming appears to be driving a poleward expansion of the subtropical dry zone (*8*), thereby reducing runoff in some regions. Together, circulatory and thermodynamic responses largely explain the picture of regional gainers and losers of sustainable freshwater availability that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (*15*). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (*16*), although attempts to detect a recent change in global flood frequency have been equivocal (*17*, *18*). Projected changes in runoff during the multidecade lifetime of major water infrastructure projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (*19*). Some regions have little infrastructure to buffer the impacts of change.

Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system (*4*, *20*).

A successor. We need to find ways to identify nonstationary probabilistic models of relevant environmental variables and to use those models to optimize water systems. The challenge is daunting. Patterns of change are complex; uncertainties are large; and the knowledge base changes rapidly.

Under the rational planning framework advanced by the Harvard Water Program (*21*, *22*), the assumption of stationarity was

[1]U.S. Geological Survey (USGS), c/o National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA. [2]USGS, Tucson, AZ 85745, USA. [3]Stockholm International Water Institute, SE 11151 Stockholm, Sweden. [4]USGS, Reston, VA 20192, USA. [5]Research Centre for Agriculture and Forest Environment, Polish Academy of Sciences, Poznań, Poland, and Potsdam Institute for Climate Impact Research, Potsdam, Germany. [6]University of Washington, Seattle, WA 98195, USA. [7]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA.

*Author for correspondence. E-mail: cmilly@usgs.gov.

Published by AAAS

Stationarity allows us to assume that the statistical properties of hydrologic variables in future time periods will be similar to past time periods

"Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks."

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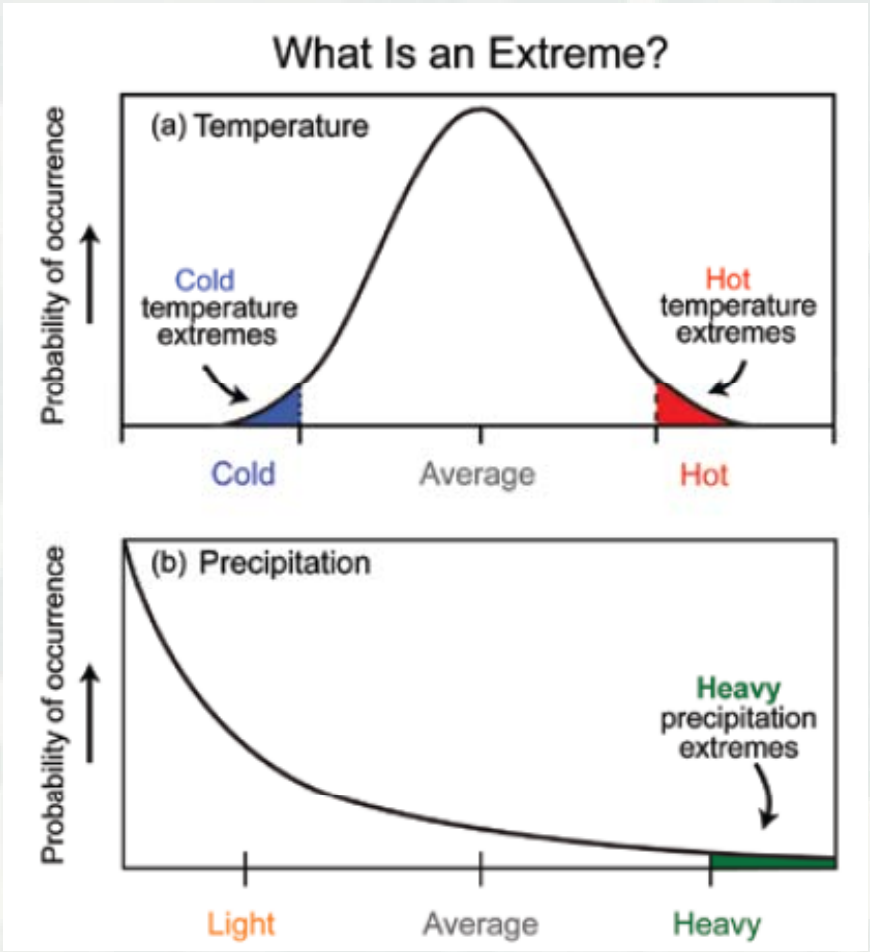
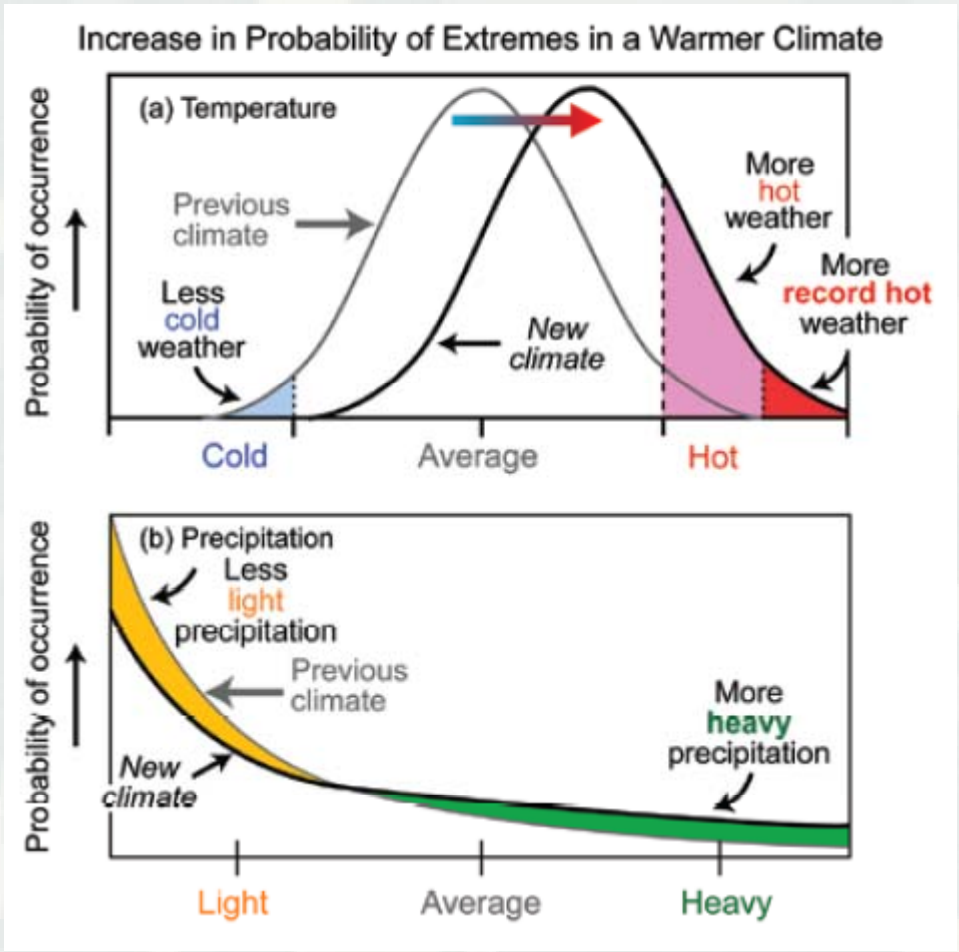
Climate impacts to weather





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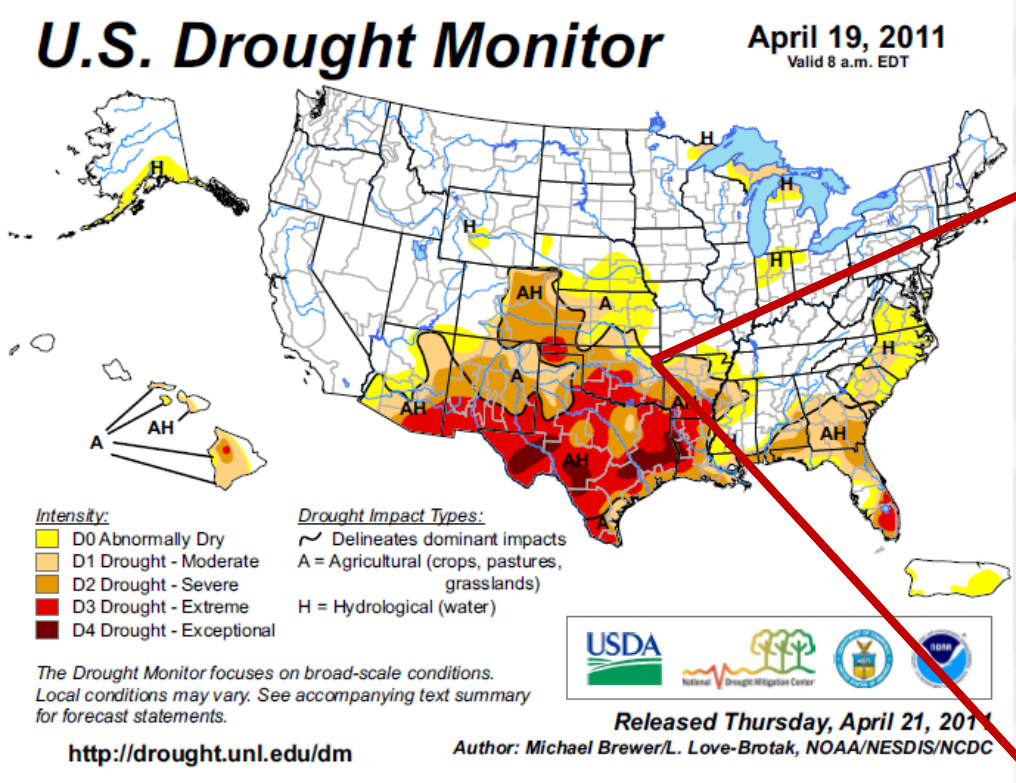
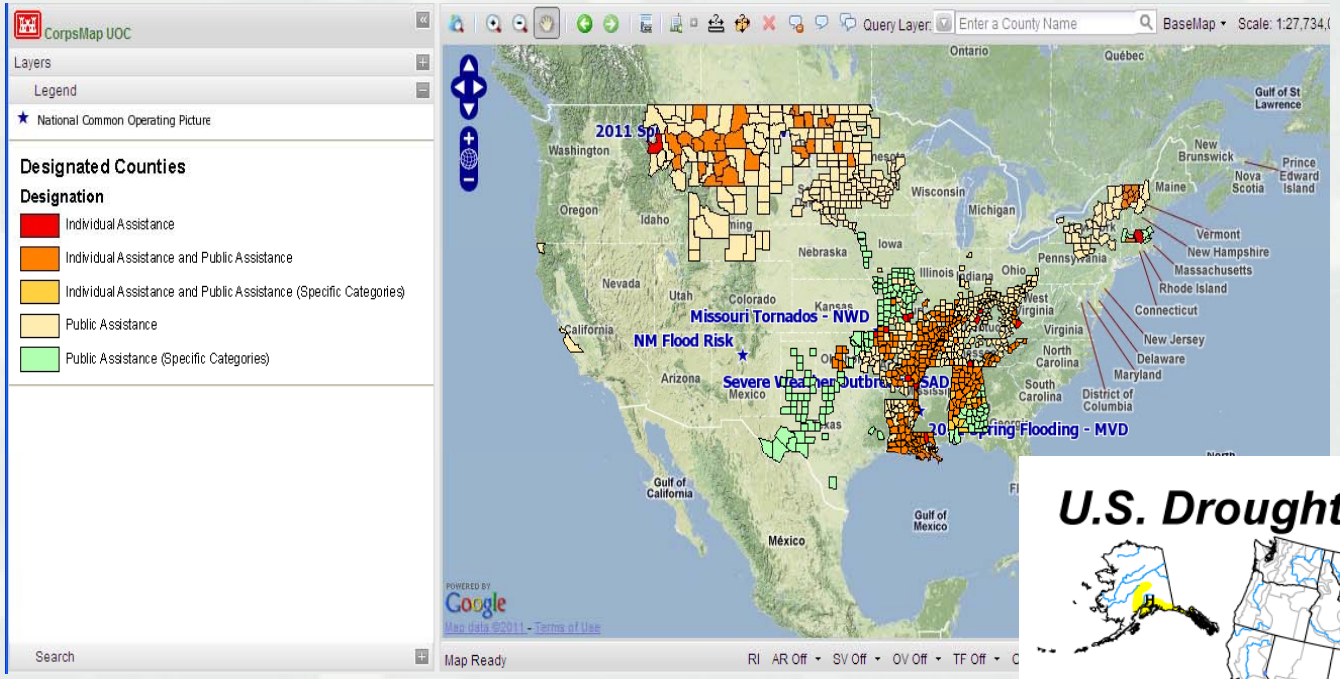
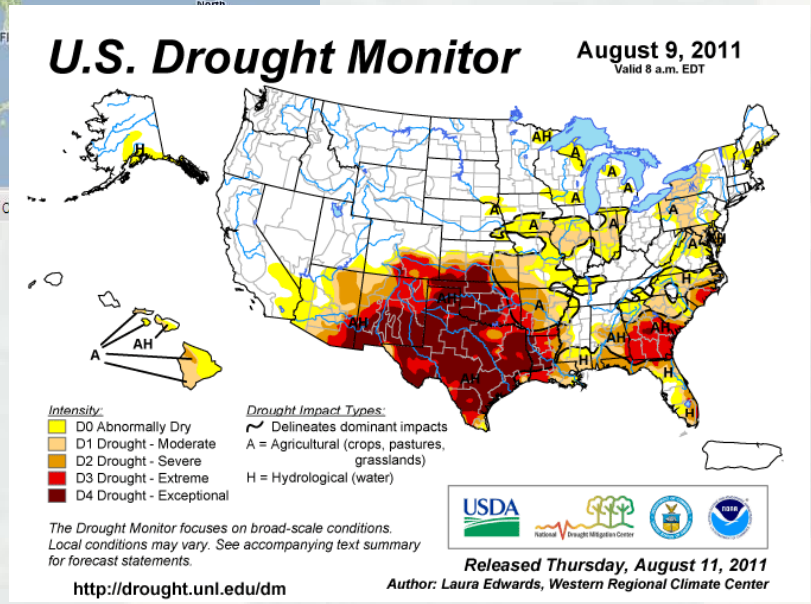


Drought doesn't protect us from floods ……

Floods don't protect us from drought ……

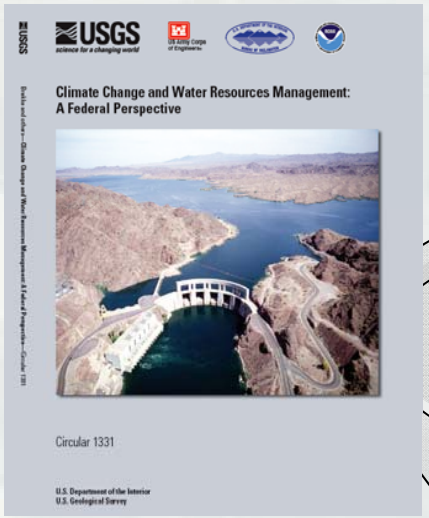


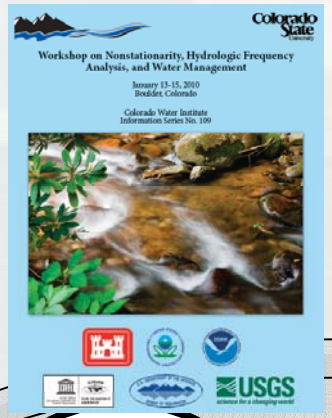


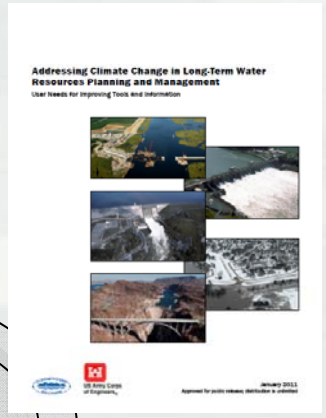
Flooding, drought hurt farm income in region

By The Associated Press on August 15, 2011

OMAHA, Neb. (AP) — The presence of drought and flooding in several Midwest and Western states is combining with higher production costs to weaken farm income.



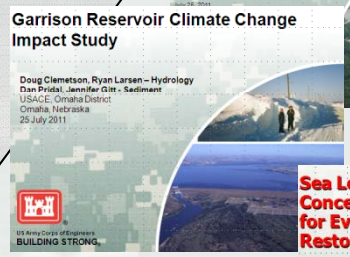


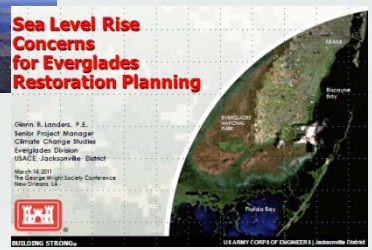


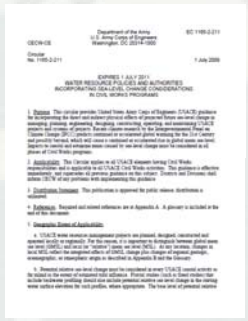
What do we know?

What don't we know?

What do the pilots tell us?







Guidance

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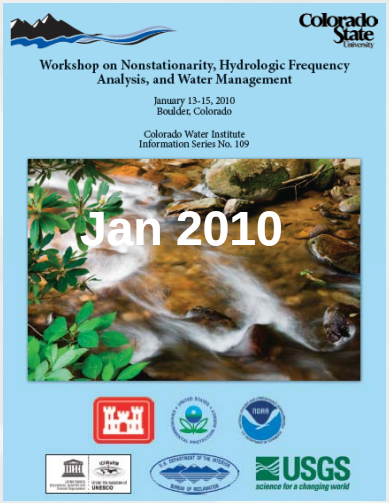
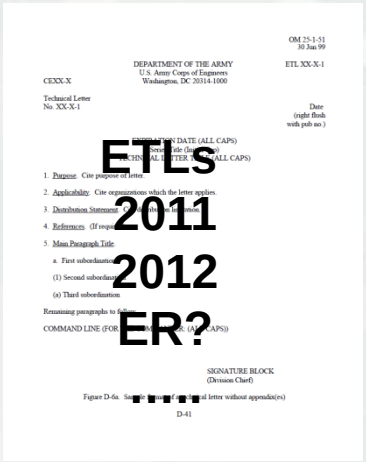
Path Forward for Hydrology…..

Workshop : Expert Opinions

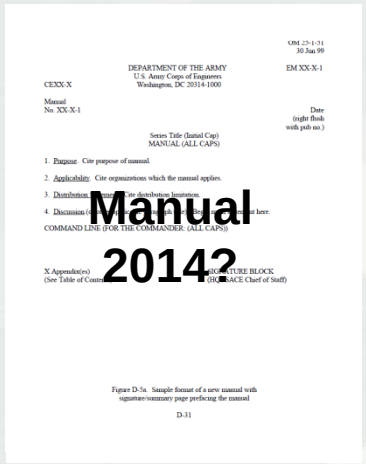


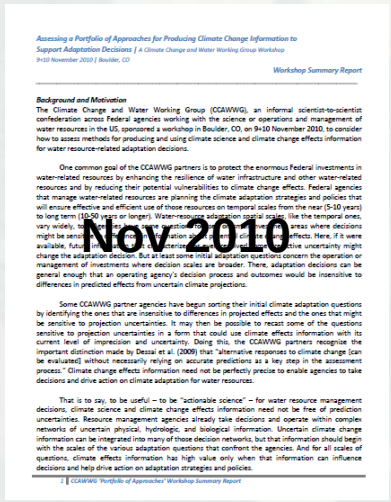
Peer-Reviewed Publication: Legally Justifiable

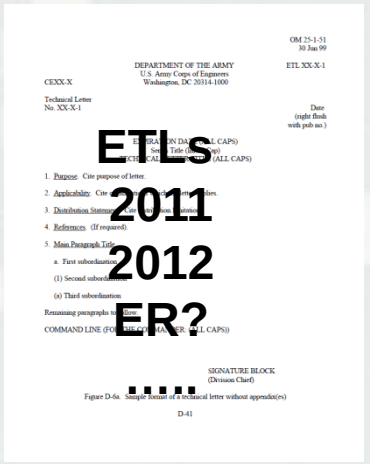
Broad Guidance

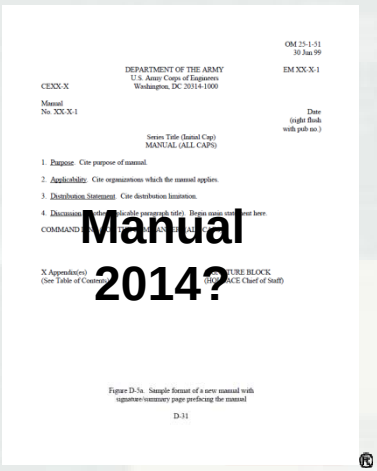


Refined Guidance









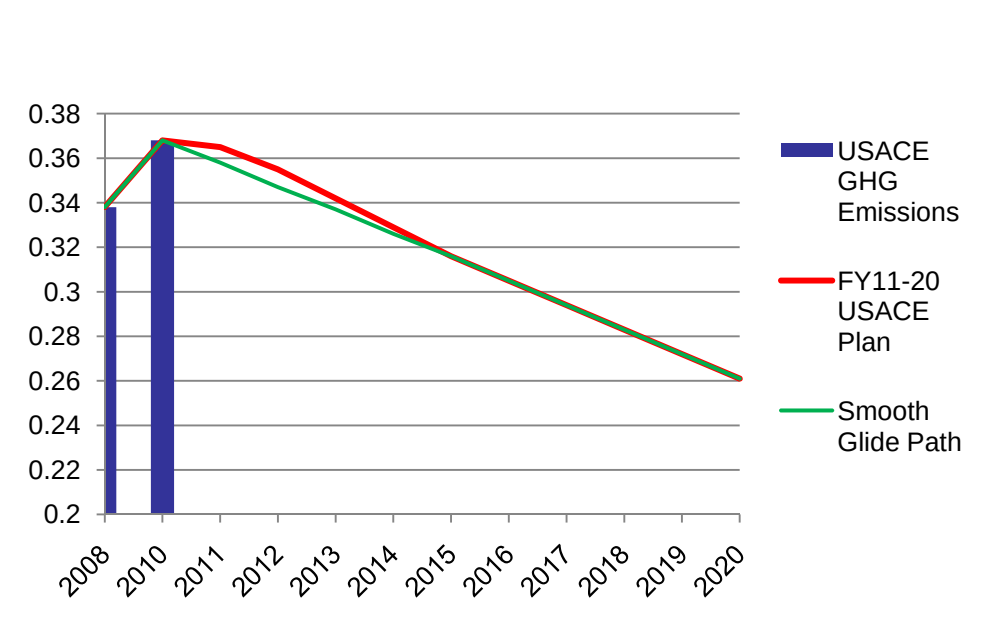

Climate change mitigation
is about CARBON

Integrating Adaptation and Mitigation

- **Adaptation: Successfully perform our missions, operations, programs, and projects in an increasingly dynamic physical, socioeconomic, and political environment**
- **Mitigation: Increase our water and energy efficiency while reducing GHG emissions**
- **Investments must be integrated**
  - **so that we don't implement near-term mitigation measures now that will be overcome by longer-term climate impacts requiring adaptation**
  - **Or that a short-term mitigation action forestalls a longer-term adaptation action**

USACE Mitigation

- **Ops POC: John Coho**
- **ECoP POC: Antonia Giardina**
- **Primarily energy and water conservation and GHG emissions reduction**
- **USACE has set targets for GHG emissions reductions by 2020**



Sustainability

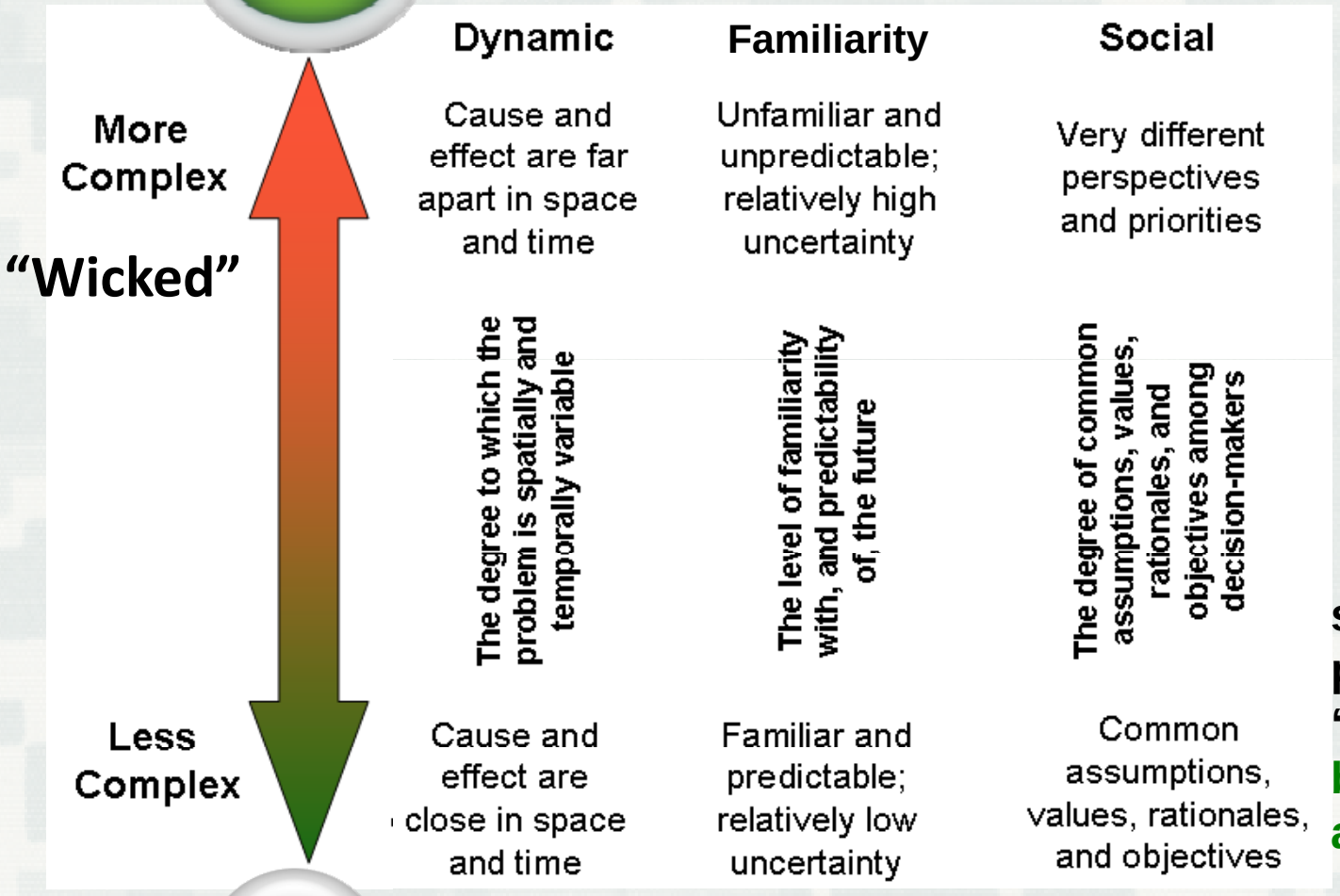
small s (Mitigation, Conservation)

- ***Avoiding the unmanageable***
- Conserving energy and water, decreasing GHG emissions
- Problem well understood, science available
- Many methods and technologies
- Inherently quantifiable (things)
- Results closely tied to implementation
- Relatively low cost

Big S (Adaptation)

- ***Managing the unavoidable***
- Ensuring robust and resilient mission and operations in an uncertain future
- Problem not well understood ("wicked problem"), little actionable science
- Methods and technologies in development
- Inherently qualitative (process)
- May have long time period between implementation and observable change; resulting changes may be difficult to ascribe to actions, requires collaborative approach that builds capacity and shares knowledge
- Low to high cost

Adaptation



solved using processes that are "systemic, emergent and participatory."

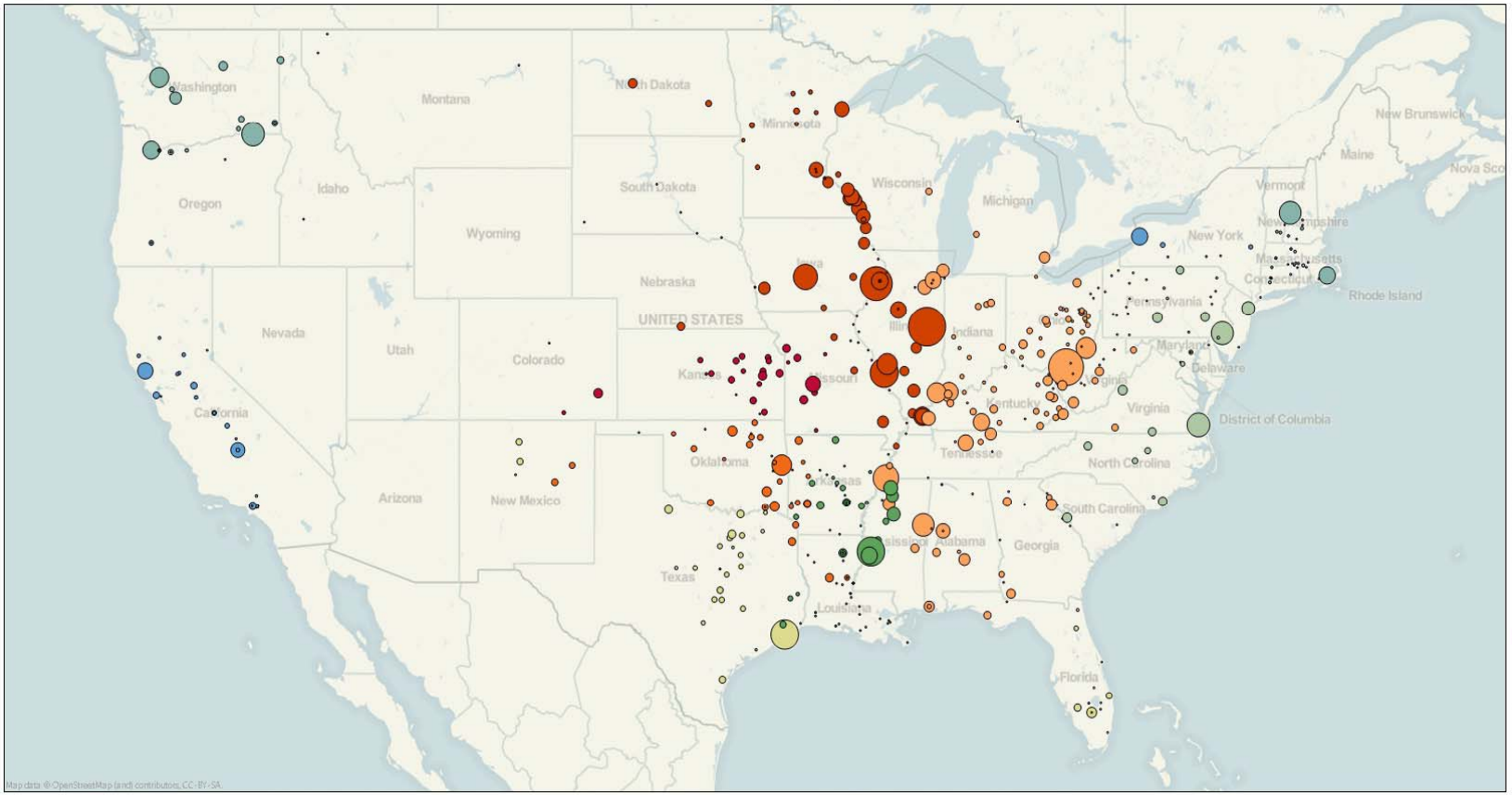
solved using processes that are "piecemeal, backward looking, and authoritarian."

Mitigation

From Kahane 2004, Solving Tough Problems

Electricity CO2 Equivalent Emissions by eGRID Region

Does Not Include Target Exempt Sources



Select Fiscal Year:

- [ ] (All)
- [x] FY08
- [ ] FY10

Select Goal Type:

- ( ) Goal Excluded
- (•) Goal Subject

Select MSCs to View:

- [ ] (All)
- [x] ERDC
- [x] LRD
- [x] MVD
- [x] NAD
- [x] NWD
- [ ] POD
- [x] SAD
- [x] SPD
- [x] SWD

Select Districts to View:

- [x] (All)
- [x] ERDC
- [x] LRB
- [x] LRC
- [x] LRE
- [x] LRH
- [x] LRL
- [x] LRN
- [x] LRP
- [x] MVK

View presents the amount of CO2 equivalent emissions for each project for **purchased electricity only** .

Each bubble represents a project and it's **size indicates the amount of CO2 released** .

The color of the bubble indicates the relative emission rate of CO2 due to the eGRID location of the project. **Green colors are in areas where generation is from cleaner sources, red is associated with higher emission fuels** .

Filter with the slider control to limit the range of emissions values displayed.

The **map extents may be fixed** or unfixed with the pushpin button in the menu bar.

Relative CO2 Emmision Rates (lb/MWh)

Determined By eGRID Location

721	1,020	1,324	1,658	1,961
724	1,135	1,490	1,822	
858	1,139	1,510	1,831	
902	1,311	1,538	1,835	
928	1,319	1,563	1,883	

CO2 Equvalent (MT)

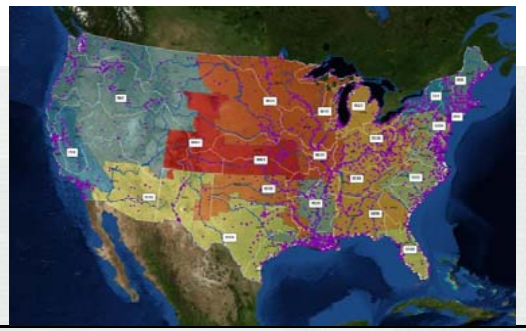
Select Range of Values to View:

0 — 3,700

CO2e (MT)

- 0
- 500
- 1,000
- 1,500
- 2,000
- 2,496

NOTE: FILTERS ACT ON ALL SHEETS. RESET ALL FILTERS WHEN MOVING TO ANOTHER SHEET BY PRESSING F12.



Ecosystems and Climate Change

- **Examples from recent research:**
  - **Loarie et al 2009: The velocity of climate change**
  - **Jones et al 2009: Committed terrestrial ecosystem changes due to climate change**
  - **McDonald-Madden et al 2011: Optimal timing for managed relocation of species faced with climate change**
  - **Chen et al 2011: Rapid range shifts of species associated with high levels of climate warming**
- **Climate change encourages us to rethink our assumptions about ecosystems, how they function, and how they change over time**

- **Chen et al 2011 "found that observed latitudinal and elevational shifts (the latter more weakly) have been significantly greater in studies with higher levels of warming"**
- **Important factors were:**
  - **Time delay in species response (e.g., habitat specialists or immobile species)**
  - **Physiological constraints (e.g., sensitive to different physical variable at different life phases**
  - **Alternate & interacting drivers of change, including nonclimatic factors**

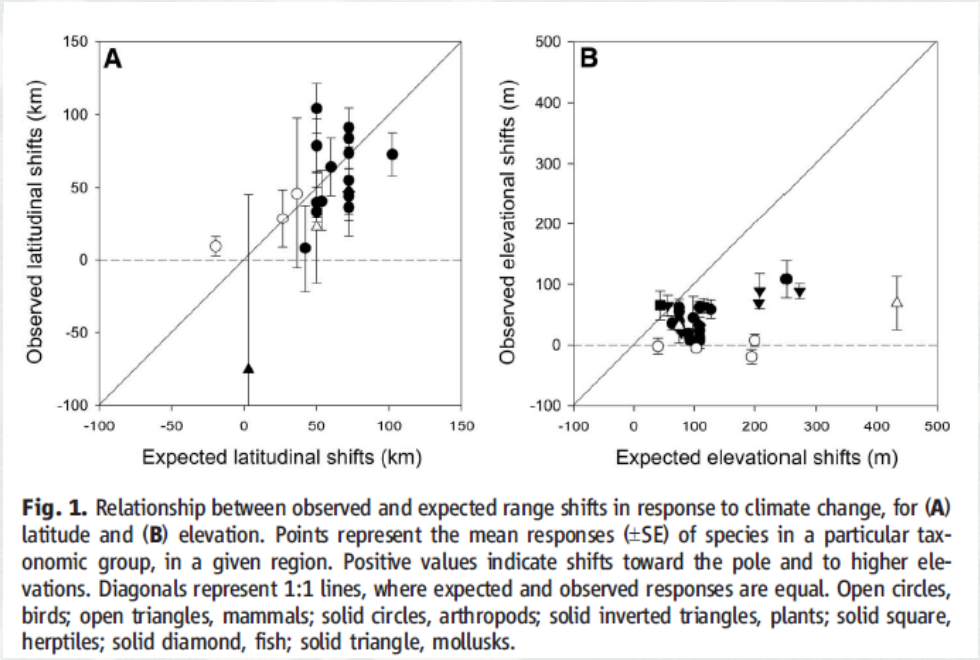
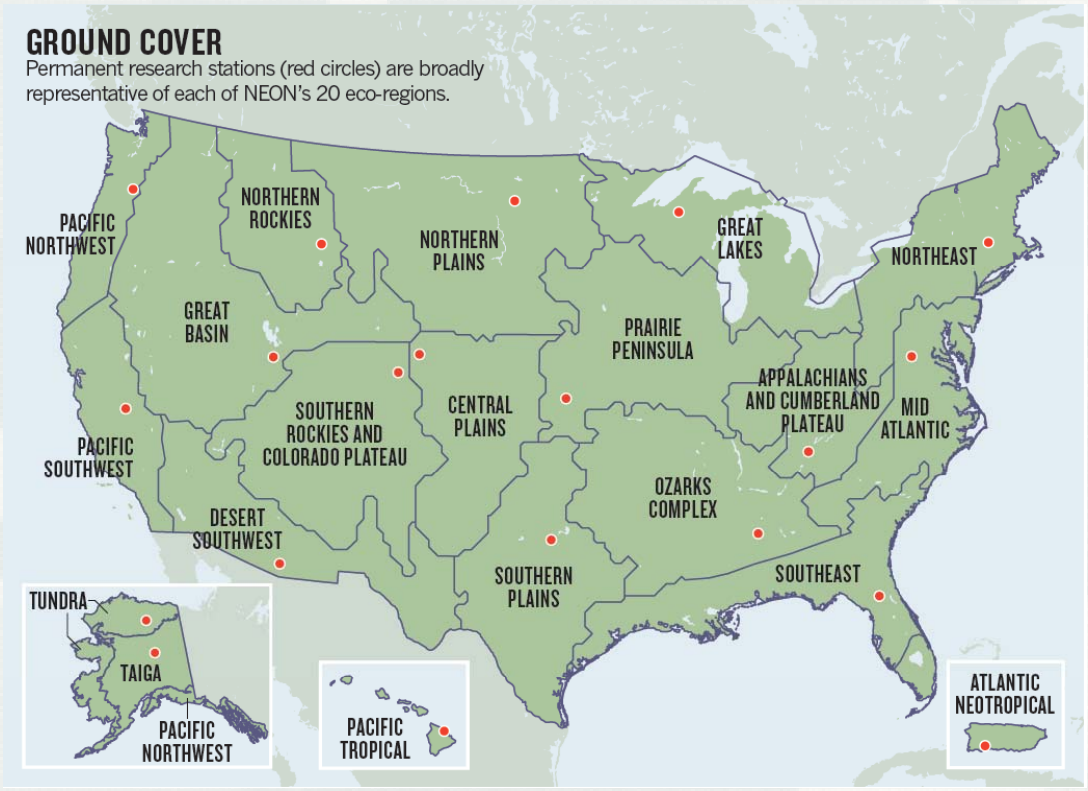


Fig. 1. Relationship between observed and expected range shifts in response to climate change, for **(A)** latitude and **(B)** elevation. Points represent the mean responses (±SE) of species in a particular taxonomic group, in a given region. Positive values indicate shifts toward the pole and to higher elevations. Diagonals represent 1:1 lines, where expected and observed responses are equal. Open circles, birds; open triangles, mammals; solid circles, arthropods; solid inverted triangles, plants; solid square, herptiles; solid diamond, fish; solid triangle, mollusks.

National Ecological Observatory Network (NEON)

- 20 core observatories representing distinct eco-regions throughout the US
- Supplemented by temporary stations that can be relocated wherever data need to be collected
- Increase our understanding of national-scale changes



FY11 Adaptation Pilots

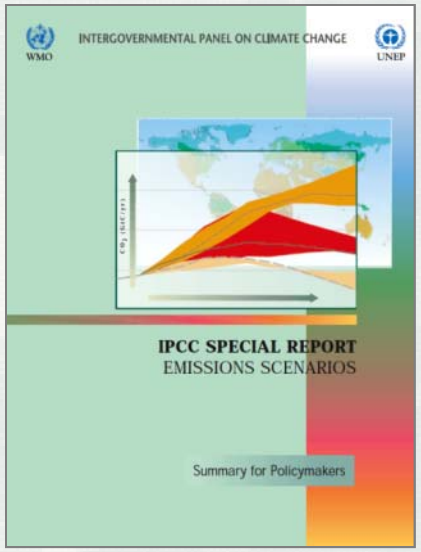
Proposal Title	Topic
Applying Risk Informed Decision-Making Framework for Climate Change to Integrated Water Resource Management (IRWM) Planning – West Maui Watershed Project	Summit to outer reef
Using Physical and Collaborative Modeling to Assess the Iowa-Cedar Watershed's Vulnerability to Climate Change and Develop Risk Informed Climate Change Adaptation Strategies	Iowa-Cedar Rivers
Upland Sediment Production and Delivery in the Great Lakes Region under Climate Change	Great Lakes
Developing a Framework for Incorporating Climate Change and Building Resiliency into Restoration Planning Case Study – Lower Columbia River Estuary	Estuary-salmon habitat restoration
Risk Informed Decision Making for Potential Sea-Level Rise Impacts on Wetland Restoration	Coastal Wetland Restoration
Red River of the North Flooding at Fargo, ND	Red River Flooding
Utilization of Regional Climate Science Programs in Reservoir and Watershed Risk-Based Impact Assessments	Watershed
Climate Change Impact Evaluation Mountain Snowpack - Accumulation and Runoff	Snow pack - Missouri River
East Rockaway Inlet to Rockaway Inlet, NY Collaboration Framework Development	Sea level

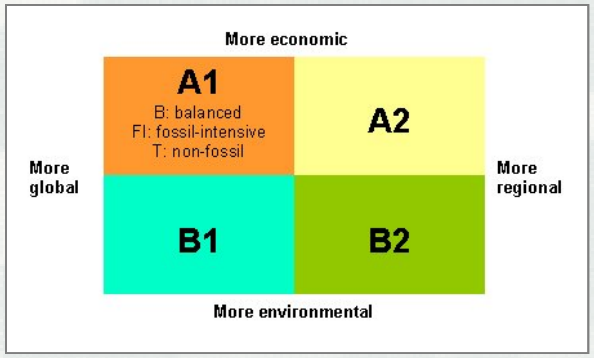
Summary

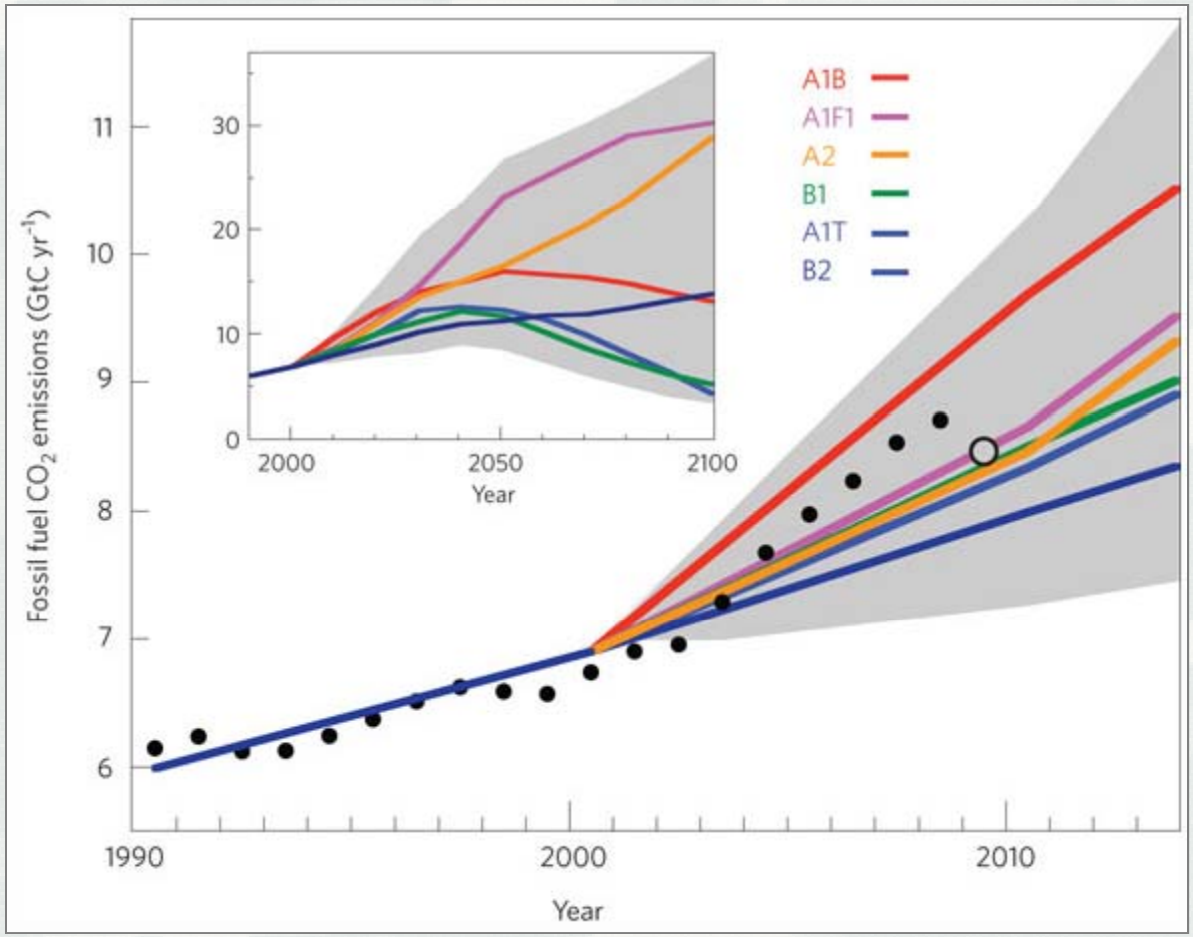
- Climate is changing, especially impacting weather extremes
- Coastal policies and guidance ahead of hydrology
- Collaborative efforts with other agencies help to identify long-tem and short-term user needs, develop consistent guidance
- Integrating adaptation and mitigation supports a portfolio management approach with mix of near-term and long-term actions
- Recent research about climate change and ecosystems encourages us to think in new ways
- Adaptation pilot projects increase our understanding and help ID gaps and areas where new guidance may be needed

Background Slides

Background: IPCC Scenarios







Manning et al 2010 "Misrepresentation of the IPCC CO_2 emission scenarios" *Nature Geoscience* 3, 376 - 377