SLIDES: Climate Change and Water Resources and RISA Regional Integrated Sciences and Assessments: Building Bridges Between Climate Sciences and Society

Brad Udall

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Climate Change and Water Resources

Climate Change and the Future of the American West: Exploring the Legal and Policy Dimensions

CU Natural Resources Law Center 27th Annual Conference
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Boulder, CO

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1917-81

Fourier
Western Water Assessment one of 8 Similar NOAA Regional Integrated Sciences and Assessments (“RISA”) Programs.

http://www.climate.noaa.gov/cpo_pa/risa/
Remedial Hydrology 101
• Science of Water Movement around Earth
  – Evaporation, Precipitation, Sublimation, Evapotranspiration, Infiltration, Runoff

- All Forms of Water:
  Vapor, Clouds, Snow, Liquid, Snow, Ice
- Largest movement of any substance

Western Water Assessment
Remedial Hydrology 101

- Excess Solar Energy moved from Equator to Poles through Hydrologic Cycle
- Huge Amounts of Water Moved Around the Planet
  - Evaporation – “Latent Heat”
  - Ocean Currents
- Condensation/Precipitation releases energy for weather

- Lessons
  - Hydrologic Cycle not just about rivers
  - Hydrologic Cycle moves energy
  - Hydrologic Cycle not distinct from weather and climate

Figure 8. Heating dynamics of the Earth (courtesy of Kevin Trembour).
Hydrologic Cycle Changes

- Extra Energy Means enhanced hydrologic cycle
  - Higher Temps Increase Atmosphere Moisture holding capacity
  - Higher Temps imply Globally Increased Evaporation
  - Precipitation must increase globally (But not necessarily regionally)
  - More Intense Precipitation - Floods
  - More Intense Drying - Drought
    - Mid-Continental Summertime Drying
    - Increased Evaporation Will Increase Water Demand
  - More Rain, Less Snow
New Temperature Extremes: Change in Mean AND Variance leads to bigger extremes

Source: IPCC, 2001
New Precipitation Extremes

Increased Atmospheric Moisture Holding Capacity = 7% / C

Increased Evap = 1% to 2% / C

Increased Precipitation Rate = ~ 4% to 7% / C
New Precipitation Extremes

- At 1C Increase, Perhaps not a problem: 4%
- At 3C ~12% to 20% increase in Precipitation rate
- Overall Picture
  - increased evap from larger areas (drought)
  - decrease in light and moderate rains, and/or
  - decrease in the frequency of rain events
  - Thus likely fewer, but more intense events (floods)
Global Average Increase Does Not Mean Regional Averages will all Increase

Winter

Summer

Source: IPCC, 2001
Declining Snowpack – Bulletin of Amer. Met. Society 2005

• Widespread Declines in Snowpack, especially since 1950.
• Models point to warming as cause.
• Consistent with rising ghg and will almost certainly continue.
• Likely that losses continue or accelerate with highest losses in milder climates and lowest losses in high peaks of northern Rockies and Southern Sierra.

Source: Mote, et al.
b) CHANGE IN DATE OF LAST SPRING FROST
DAYS PER DECADE
1948-1999

Significance
> 90% *
> 95% **
> 99% ***
Not Significant

All U.S. = -1.3 ***
Precipitation Observations

- In US, increase in precip, heavy and very heavy precip
- Warming in northern US related to reduction in spring snow cover, earlier onset of spring and summer-like weather.
- Increase in cumulonimbus clouds and general increase in thunderstorm activity and a nationwide increase in very heavy precipitation events.

Groisman, 2004
Increase in Very Heavy Daily Precipitation

Groisman, 2004
Pan Evaporation Paradox

• Consistent Downward Trend in Pan Evaporation 1950 to 1990
  – 64% of pans in US show decrease

• Multiple Theories
  – Inverse Theory – Really an increase
  – Global Dimming Theory – Really a decrease

• Will Have to Await More Science

• Highlights Aerosol Problem
Aerosols in Action

Northwest Africa and Atlantic

China, Korea, Japan

Source: NASA
Aerosols and Hydrological Cycle

- Dust, Black Carbon, Sulfates, Organic Carbon
- Tiny particles enhance scattering and absorption of light
- Can Suppress precipitation
- Can change temperature structure of atmosphere
- Can reduce light reaching surface of Earth
- Can lead to a weaker hydrological cycle
- Another great unknown of climate research
Why Flooding a Concern

• Not just the actual problems of floods
• COE makes a ‘rule curve’ based on Maximum Probable Flood for all Reservoirs
  – Use Historical Storms for MPF calcs
  – Curve Forces reservoirs to be low at times of high flood probability
• So, with heavier precip likely, reservoirs forced lower all the time with implications for water yield.
Water Quality Impacts

• Higher Water Temperatures generally reduce quality, e.g., dissolved oxygen
• Increased Low Flow Conditions
• Episodic High Flow Conditions
• Forest Fire Sediment Problems
• Increased temperatures enhances toxicity of metals and increases accumulation of toxics in organisms
• WQ Very Dependent on Land use and Overall quantity issues
Fires and Sediment

Figure 5. Debris flow into Strontia Springs Reservoir on July 12, 1996 as a result of the Buffalo Creek fire and flash flood (Photo courtesy of Denver Water).
Man Bites Dog:
How Does Water Use Affect Climate?

• Energy Used to Pump, Pressurize, Treat, Heat Water

• In California Water Use Consumes
  – 20% of all electricity
  – 30% of all natural gas,
  – Diesel for 120,000 cars/year

• Saving Water Saves Lots of Energy

• Consider: carbon caps likely at least on electric power production

• Increased Price will reduce demand, other feedbacks possible.
Inland Empire Utility Agency Energy Intensity (kwh/af)

IEUA Website, 2005
To be trained in the production and use of integrated climate
based in universities and other scientific institutions, the RISAs
private sectors, and non-profit organizations. Because they are
dialogue in close partnership with communities, the public and
of knowledge is part of integrated assessments. Another
stakeholders need to make effective decisions. Helping people
Climate information is just one of the many types of knowledge
Sustainable Decision Support
the work of translating climate sciences into
therefore one could help reduce vulnerability, the RISAs are building
who work with regional and/or local stakeholders to address
comprises experts from the biophysical and societal sciences
front and center. This research is a primary part of building and
researchers place climate processes occurring in the tropical Pacific Ocean. This
driven’ climate sciences that directly address society’s needs and
Atmospheric Administration (NOAA) in the mid-1990s, RISA
Program is helping to realign our nation’s climate research to
With each passing year, the impacts of climate variability on
Consequences of Climate Variability
Outside the United States, as well as Mexico—originate.
climate services production, and how to provide this information in forms that people can
formation can aid the public in coping with climate variability,
The NOAA Regional Integrated Sciences and Assessments Program
building bridges between climate sciences and society.

http://www.risa.nga.noaa.gov/
to be trained in the production and use of integrated climate services.

Private sectors, and nonprofit organizations. Because they are local, state, and federal agencies. The RISAs also build sustainable decision support that decision support meets the needs of stakeholders need to make effective decisions. Helping people make effective decisions. Helping people make effective decisions.

Climate information is just one of the many types of knowledge that comprise the work of translating climate sciences into climate services. Bridges that will sustain two-way flows of information between science and society. This research is a primary part of building and nurturing effective climate services. Each of the RISA projects front and center. This research is a primary part of building and nurturing effective climate services. Each of the RISA projects front and center.

Place-Based Integrated Climate Sciences

4 The RISA approach links local, national, and international scientific and societal needs and issues through regional centers that are active in climate science activities. These centers are part of distributed regional and national networks of climate knowledge and expertise. The RISA approach links local, national, and international scientific and societal needs and issues through regional centers that are active in climate science activities. These centers are part of distributed regional and national networks of climate knowledge and expertise.

For more information

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- Colorado Applications Program
- Hawaii Applications Program
- Inland Waters and Agriculture Team (IWT)
- New England Integrated Sciences and Assessments
- North Dakota Climate Service Center
- Pacific Islands Regional Climate Assessment
- Southeast Climate Assessment
- Southwest Climate Assessment
- Western Water Assessment
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Regional Program Offices:
- Arizona State University
- Colorado State University
- East-West Center
- Florida State University
- University of Arizona
- University of California, Davis
- University of Colorado
- University of Florida
- University of Georgia
- University of Hawaii
- University of Illinois
- University of Miami
- University of New Hampshire
- University of North Carolina
- University of Oregon
- University of South Carolina
- University of Tampa
- University of Washington
- University of Wisconsin
- Virginia Polytechnic Institute and State University
- Washington State University
- West Virginia University

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1100 Wayne Ave., Suite 1225
Office of Global Programs

The Regional Integrated Sciences and Assessments (RISA) Program was established in 2003 to help society make decisions in the face of climate variability and change. The RISA program supports the development of climate-related products and services that are needed to help society make decisions in the face of climate variability and change. The RISA program supports the development of climate-related products and services that are needed to help society make decisions in the face of climate variability and change.

Building Bridges Between Climate Sciences and Society

The NOAA Regional Integrated Sciences and Assessments Program

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RISA GOV:
http://www.risa.ncep.noaa.gov/

Regional Integrated Sciences and Assessments

RISA teams bring together expertise from the biological and social sciences. RISA teams bring together expertise from the biological and social sciences. The RISA Link builds relationships and partnerships with a diverse group of stakeholders from across the region. This network of local partnerships is creating a wealth of knowledge and information that is directly applicable to the needs and interests of local communities. The RISA Link builds relationships and partnerships with a diverse group of stakeholders from across the region. This network of local partnerships is creating a wealth of knowledge and information that is directly applicable to the needs and interests of local communities.

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Sustainable Decision Support
Climate sciences are not just the means by which knowledge is developed, but also the means by which knowledge is made useful to decision makers at all levels of government, as well as the non-governmental and private sectors. The Regional Integrated Sciences and Assessments (RISAs) were established to help develop, implement, and manage climate services that help society make decisions in the face of climate variability and change. The RISA program, established by the National Oceanic and Atmospheric Administration (NOAA), is helping communities weave climate information into their decision-making processes. 

Place-Based Integrated Climate Sciences
The RISA program places physical and social research in the context of local climate science needs. Following a series of workshops and site visits, each RISA develops a work plan to meet local needs. The RISAs are building bridges that will sustain two-way flows of information between scientists and society.

The regional perspectives of the RISAs offer a unique vantage point on the full range of human activities that either increase or reduce vulnerability, the RISAs are building bridges that will sustain two-way flows of information between scientists and society.

How RISAs Make a Difference
Today sciences are not just the means by which knowledge is developed, but also the means by which knowledge is made useful to decision makers at all levels of government, as well as the non-governmental and private sectors. The Regional Integrated Sciences and Assessments (RISAs) were established to help develop, implement, and manage climate services that help society make decisions in the face of climate variability and change. The RISA program, established by the National Oceanic and Atmospheric Administration (NOAA), is helping communities weave climate information into their decision-making processes.

The Regional Integrated Sciences and Assessments (RISA) Program is helping to realign our nation's climate research to ensure that the key to scientists' understanding of what kinds of climate information people need and how to provide this information in forms that people can actually use.

With each passing year, the impacts of climate variability on local, state, and federal agencies. The RISAs build sustainable decision support services that can help reduce vulnerability, the RISAs are building bridges that will sustain two-way flows of information between scientists and society.

Building Bridges Between Climate Sciences and Society

Regional Integrated Sciences and Assessments

How do we support communities in understanding and adapting to climate variability? How do we help society make decisions in the face of climate variability and change? How do we ensure that climate services are useful, accessible, and usable? How do we ensure that climate services are developed, implemented, and managed in ways that help society make decisions in the face of climate variability and change? How do we ensure that climate services are developed, implemented, and managed in ways that help society make decisions in the face of climate variability and change?

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Used Climate Services
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Credits

Regional Integrated Sciences and Assessments (RISA)

Climate Impacts Group
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http://sciencepolicy.colorado.edu/wwa/

Western Water Assessment
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http://secc.coaps.fsu.edu/

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http://secc.coaps.fsu.edu/

Western Water Assessment
University of Colorado • NOAA Climate Program Office
http://www.ispe.arizona.edu/climas/

New England Integrated Sciences and Assessments
University of New Hampshire
http://www.unh.edu/risa

Pacific Islands
South Pacific Panel
http://research.es.auckland.ac.nz/irisalsial/

Southwest Climate Consortium
University of Arizona • University of New Mexico • New Mexico State University • United States Geological Survey • U.S. Bureau of Reclamation • NREL
http://www.zebra-baker.com/CISA/

Pacific Islands
South Pacific Panel
http://research.es.auckland.ac.nz/irisalsial/

Central Integrated Sciences
University of New Mexico • New Mexico State University • University of Arizona • University of California, San Diego
http://www.cses.washington.edu/cig/

Pacifi c Islands
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Texas Panhandle
http://www.unt.edu/risa/

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FOR INFORMATION:
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RISA Payoffs

The RISA Network provides the tools and knowledge needed to include climate, ecology, and health interactions of years in the past to a hundred or more years into the future.

Climate and hydrological information stretching from thousands of years to present day is used to assess and reduce wildfire risk. The National Interagency Fire Center's Predictive Services Unit, in collaboration with RISAs, now issues fire-climate forecasts. The California Applications Program (CAP) evaluates weather and short-term forecasts, and meets these energy demands.

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Energy Demand: Trends on climate and hydrological information stretching from thousands of years to present day is used to assess and reduce wildfire risk. The National Interagency Fire Center's Predictive Services Unit, in collaboration with RISAs, now issues fire-climate forecasts. The California Applications Program (CAP) evaluates weather and short-term forecasts, and meets these energy demands.

RISA Payoffs

- Decision Support for Resource Management
- Economic and Community Benefits
- Improved Planning and Risk Reduction
- Increased Resilience
- Improved Public Understanding
- Enhanced Collaboration

Western Water Assessment

The Western Water Assessment (WWA) provides the tools and knowledge needed to include climate variability and change in water resource management. WWA supports the efforts of the many agencies and stakeholders that manage water resources, from local water districts to state agencies, from federal to international organizations. WWA provides information about climate variability, issues of forecast uncertainty, and long-term management decisions.

Lee and Y. U.S. Drought Monitor

The U.S. Drought Monitor is a weekly watch and warning service developed by the U.S. Drought Monitor of the U.S. Drought Monitor Project at the National Oceanic and Atmospheric Administration. The U.S. Drought Monitor is a weekly watch and warning service developed by the U.S. Drought Monitor of the U.S. Drought Monitor Project at the National Oceanic and Atmospheric Administration.

California Applications Program

The California Applications Program (CAP) focuses on the application of climate modeling, detection, and monitoring. CAP produces regional climate models and data products that are used by decision makers and stakeholders to assess and reduce wildfire risk. The National Interagency Fire Center's Predictive Services Unit, in collaboration with RISAs, now issues fire-climate forecasts. The California Applications Program (CAP) evaluates weather and short-term forecasts, and meets these energy demands.

Extreme Events: Drought and Prolonged Drought in the West

Extreme events such as drought and prolonged drought in the West pose significant challenges to water resource management and long-term water planning. The Western Water Assessment (WWA) provides the tools and knowledge needed to include climate variability and change in water resource management. WWA supports the efforts of the many agencies and stakeholders that manage water resources, from local water districts to state agencies, from federal to international organizations. WWA provides information about climate variability, issues of forecast uncertainty, and long-term management decisions.

Drought: Between 2013 and 2015, drought impacted nearly every state in the U.S., affecting more than 250 million people and causing more than $100 billion in crop losses. The drought resulted in decreased water supplies, increased fire risk, and economic impacts.

Public Health

Public Health programs are an essential component of climate change adaptation and mitigation. Public Health is working to promote the health of the communities in which they live, and to understand and mitigate climate change challenges and for better climate conditions.
The RISA NETWORK

For the past several years, a number of climate-related programs have emerged to address the challenges of climate variability and change. These efforts include the development of regional climate models, the integration of climate science into decision-making processes, and the creation of collaborative research initiatives. A key aspect of these efforts is the development of approaches that can help decision makers in various sectors understand and address the impacts of climate variability and change.

The goal of the RISA program is to enhance the resilience of communities, ecosystems, and economies by providing decision makers with the tools and knowledge they need to address climate variability and change. The RISA programs are designed to support decision makers in key sectors, including agriculture, water, energy, and public health, by providing them with the information they need to make informed decisions.

Agriculture

Agriculture is one of the most vulnerable sectors to the impacts of climate variability and change. Farmers need to be able to adapt to changing weather patterns and water availability in order to maintain a sustainable and productive agricultural system. The impact of climate variability and change on agriculture can be significant, with potential losses ranging from $49.2 to $92.1 billion per year. To address these challenges, the RISA programs provide scientific knowledge and tools to help farmers adapt to climate variability and change.

Wildland Fire

Wildland fire is a complex and highly variable phenomenon that is influenced by climate variability and change. The RISA programs help decision makers understand the risks associated with wildland fire and develop strategies to reduce fire risk. For example, the National Interagency Fire Center's Predictive Services uses climate forecasts to help predict fire behavior and provide timely information to decision makers.

Water

Water is a critical resource that is affected by climate variability and change. The RISA programs provide scientific knowledge and tools to help decision makers understand the risks associated with water variability and change. For example, the California Applications Program (CAP) focuses on the development of regional climate models that can help decision makers understand the potential impacts of climate variability and change on water resources.

Energy

Energy policy and management are also key sectors that are affected by climate variability and change. The RISA programs help decision makers understand the risks associated with energy variability and change and develop strategies to reduce these risks. For example, the New England Integrated Sciences and Assessment (NEISA) program provides vulnerability assessments, climate policy, and decision support for the citizens of New England.

Public Health

Public health is another sector that is affected by climate variability and change. The RISA programs help decision makers understand the risks associated with public health and develop strategies to reduce these risks. For example, the Carolinas Integrated Sciences and Assessments (CIG) program provides climate-adaptation services designed to enhance short-term water management and provide vulnerability assessments, climate policy, and decision support for the citizens of the Carolinas.

The RISA program is a key component of the U.S. Climate Services program, which aims to provide decision makers with the tools and knowledge they need to address climate variability and change.
RISA Payoffs

The region’s climate is rapidly changing, and the benefits derived from preparedness programs are dramatic even when only modestly adapted to the current climate. While there is no shortage of opportunities and challenges to meet the region’s climate-related needs, the potential for real benefits is considerable. RISAs have delivered significant payoffs to a variety of stakeholders, including:

- **Drought:** Between 2015 and 2016, drought costs exceeded $12 billion in the United States, with agriculture, ecosystem, and human health sectors all impacted. Modern drought forecasting and information can help decision makers conserve water and improve resource management.

- **Extreme Events:** The Southeast Climate Consortium (SECC) project, based at the University of South Carolina, has improved understanding of the physical processes that govern extreme events, leading to better predictions and emergency response planning. These improvements have saved lives and reduced economic losses.

- **Water Policy:** The California Applications Program (CAP) has developed a suite of decision support tools that help water resource managers make informed decisions about water allocation, storage, and infrastructure. These tools have saved billions of dollars in water infrastructure costs.

- **Climate Assessment:** The Climate Assessment for the Southwest (CLIMAS) project, based at the University of Arizona, has produced a comprehensive assessment of climate change impacts in the region, guiding policies and investments to manage climate risks.

- **Drought and Water Policy:** The Western Water Assessment (WWA) project, based at the University of Colorado, has developed drought forecasts and water policy guidance that have helped decision makers plan for future drought conditions.

- **Healthy Urban Forests:** The Carolinas Integrated Sciences and Assessments (CISA) project, based at the University of North Carolina, has developed strategies to improve the health of urban forests, reducing urban heat island effects and improving air quality.

- **Wildland Fire:** The University of Idaho’s Cooperative Institute for Research in the Environmental Sciences (CIRES) has developed a suite of fire risk assessment tools that help local communities plan for and respond to wildland fires.

- **Climate Risk Management:** The Climate Impacts Group (CIG), based at the University of Washington, has developed tools to help decision makers understand and manage climate risks, including floodplain management and coastal development.

- **Agriculture:** The Western Interagency Coordination Center (WICC) has developed a suite of tools to help agricultural managers make informed decisions about crop management, leading to increased yields and reduced water use.

- **Energy Demand:** The Energy Resources Institute (ERI) has developed a suite of tools to help decision makers understand and manage energy demand, leading to reduced emissions and improved energy security.

- **Public Health:** The Carolinas Integrated Sciences and Assessments (CISA) project, based at the University of North Carolina, has developed tools to help decision makers understand and manage climate-related health risks, leading to improved public health outcomes.

- **Public Resource Managers:** The California Applications Program (CAP) has developed tools to help public resource managers make informed decisions about forest management, leading to increased timber yields and reduced wildfire risk.

- **Sea Level Rise:** The Pacific Islands (PI) project, based at the Scripps Institution of Oceanography, has developed a suite of tools to help decision makers understand and manage sea level rise, leading to improved coastal infrastructure and reduced flood risk.
RISA Payoffs

The Northwest RISA, for example, has built a strong relationship with 21 organizations, representing over 500 scientists, who serve on a Regional Advisory Council. This council advises the RISA on its scientific strategy and budget, and meets over the long term to discuss priorities. It serves as a forum for regional stakeholders to consult on climate science and prepare the science program for the needs of the region.
Sustainable Decision Support

Climate services are a key area of knowledge that can aid decision makers in understanding current and future climate-related risks and opportunities. The Regional Integrated Sciences and Assessments (RISA) program is helping to realign our nation’s climate research to benefit from regional RISA activities. The RISAs provide a key to scientists’ understanding of what kinds of climate information and expertise are needed to address current and future climate challenges effectively.

Place-Based Integrated Climate Sciences

The RISA program uses place-based, biophysical research to better understand climate processes occurring in the tropical Pacific Ocean. This research is the area where El Niño and La Niña conditions—complex climate patterns that can impact weather and climate all over the world—originate. As climate prediction skill improves, much of the first-generation RISA success built on traditional research, experimental science, and operational climate services.

For more information

Climate services

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http://www.risa.ogp.noaa.gov

Individual RISAs

California Applications Program

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http://www.risa.ogp.noaa.gov/individual

Carolyn Integrated Sciences and Assessments

University of South Carolina - Southeast Regional Climate Center

http://www.carolyn setback.com/RISA/

Climate Assessment for the Southeast

University of North Carolina

http://www.nc-asa.uncc.edu/climate/

Climate Impacts Group

Center for Science in the Earth System - Joint Institute for the Study of the Atmosphere and Ocean - University of Maryland

http://www.nrel.colostate.edu/climate

New England Integrated Sciences and Assessments

University of New Hampshire

http://www.nh.edu

Pacific Islands

South Pacific Center

http://www.research.washington.edu/islaticri/

Southeast Climate Consortium

Florida State University - University of Florida - University of Georgia - University of Miami - University of Alabama

http://www.ispe.arizona.edu/climas/

Western Water Assessment

University of Colorado - NOAA Climate Diagnostics Center

http://ncep.campbellof.com/ewa

http://www.risa.ogp.noaa.gov/

RISA Regional Integrated Sciences and Assessments Program

The RISA program began with university-based efforts in 2007 to integrate climate sciences with society’s needs and to leverage national research capacity and expertise across many federal, academic, and non-federal institutions. The Regional Integrated Sciences and Assessments Program is helping to realign our nation’s climate research to benefit from regional RISA activities. The RISAs provide a key to scientists’ understanding of what kinds of climate information and expertise are needed to address current and future climate challenges effectively.

Building Bridges Between Climate Sciences and Society

The NOAA Regional Integrated Sciences and Assessments Program helps to create direct links between climate scientists and decision makers so that the public can get access to the science that helps them make informed decisions. The program is helping to create direct links between climate scientists and decision makers so that the public can get access to the science that helps them make informed decisions.

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