



# The U.S. Climate Resilience Toolkit and the 5-Step Planning Process

[toolkit.climate.gov](http://toolkit.climate.gov)



**David Herring**

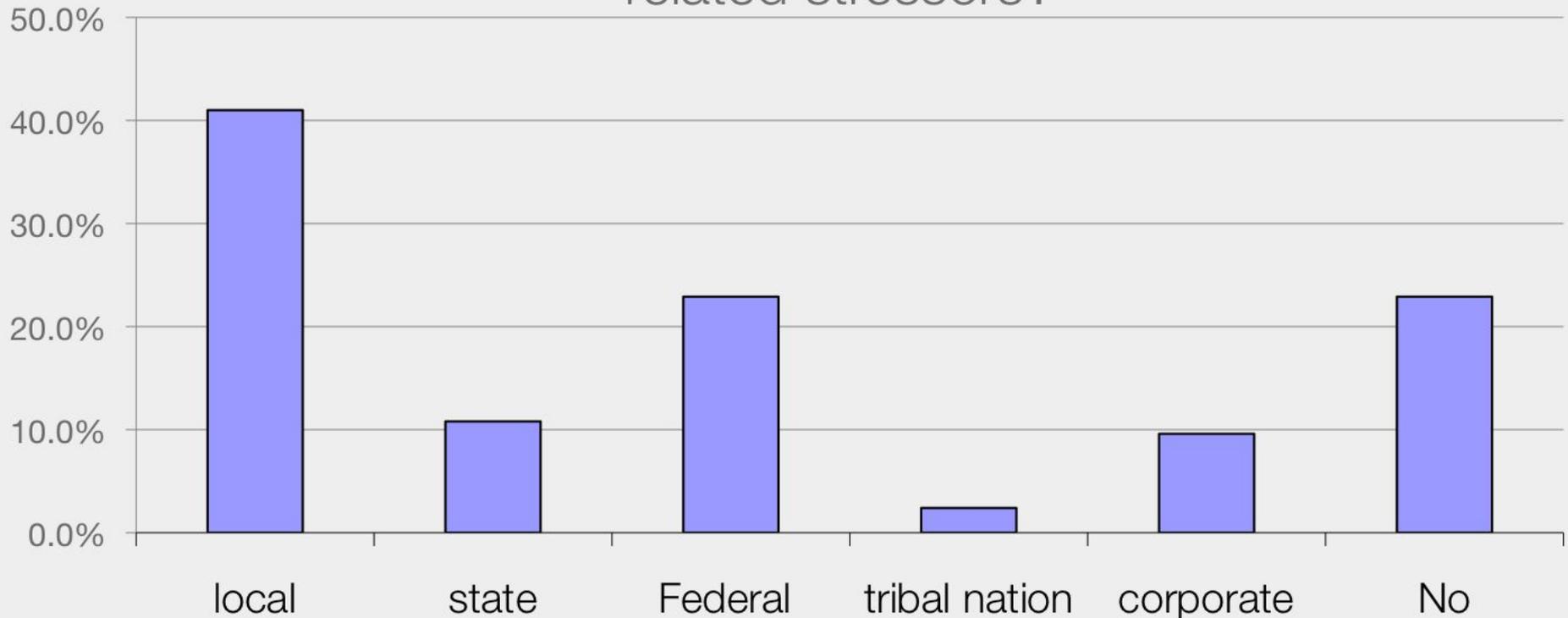
[noaa.toolkit@noaa.gov](mailto:noaa.toolkit@noaa.gov)

NOAA NWS Workshop  
May 11, 2016



# results of pre-webinar **survey**

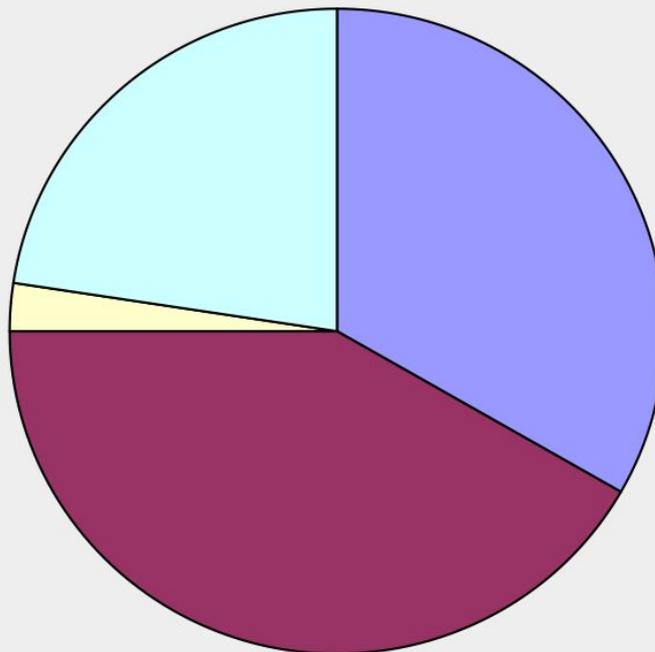
Have you led, or are you planning to lead, the development of either a climate adaptation plan or a project aimed at reducing vulnerabilities to climate-related stressors?





# results of pre-webinar **survey**

How would you categorize yourself?



■ planner or manager

■ scientific or technical advisor

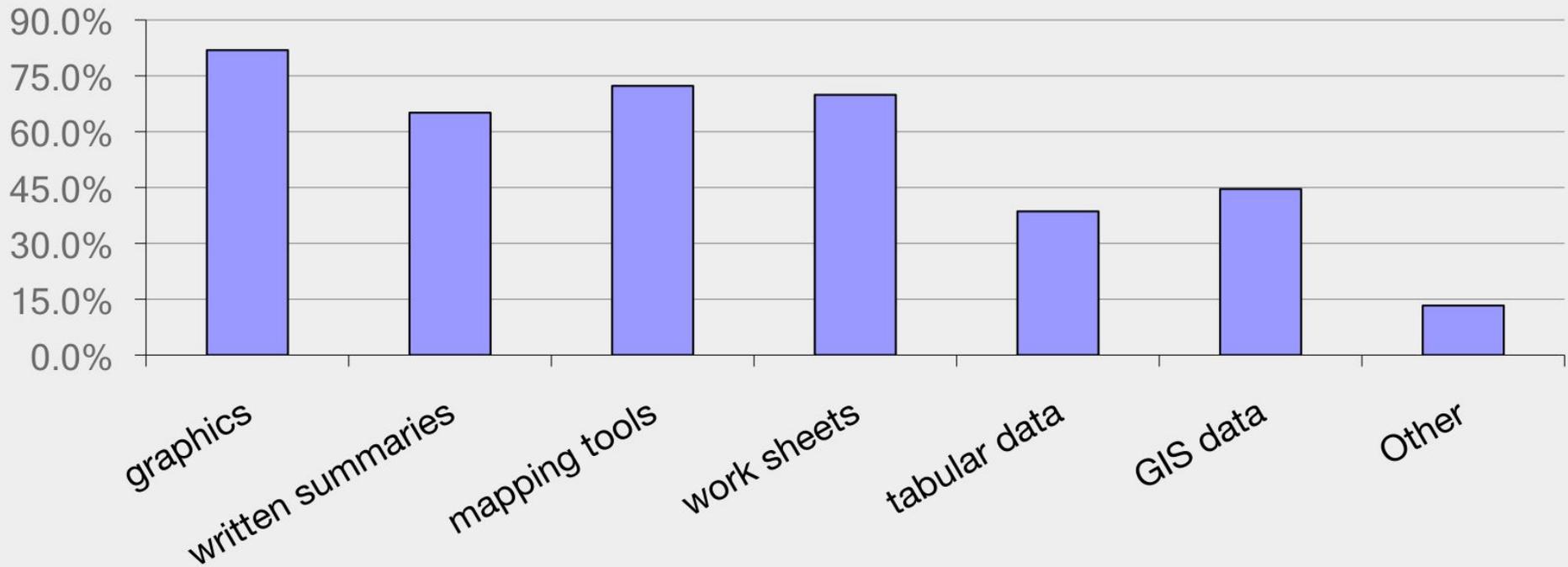
■ executive

■ Other



# results of pre-webinar **survey**

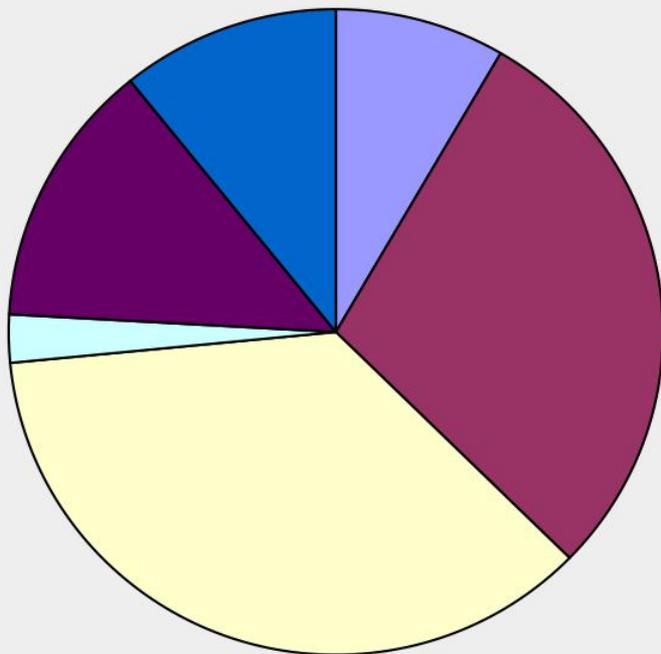
Which of the following you are seeking from the toolkit?





# results of pre-webinar **survey**

Which category best describes the assets you are most interested in protecting?

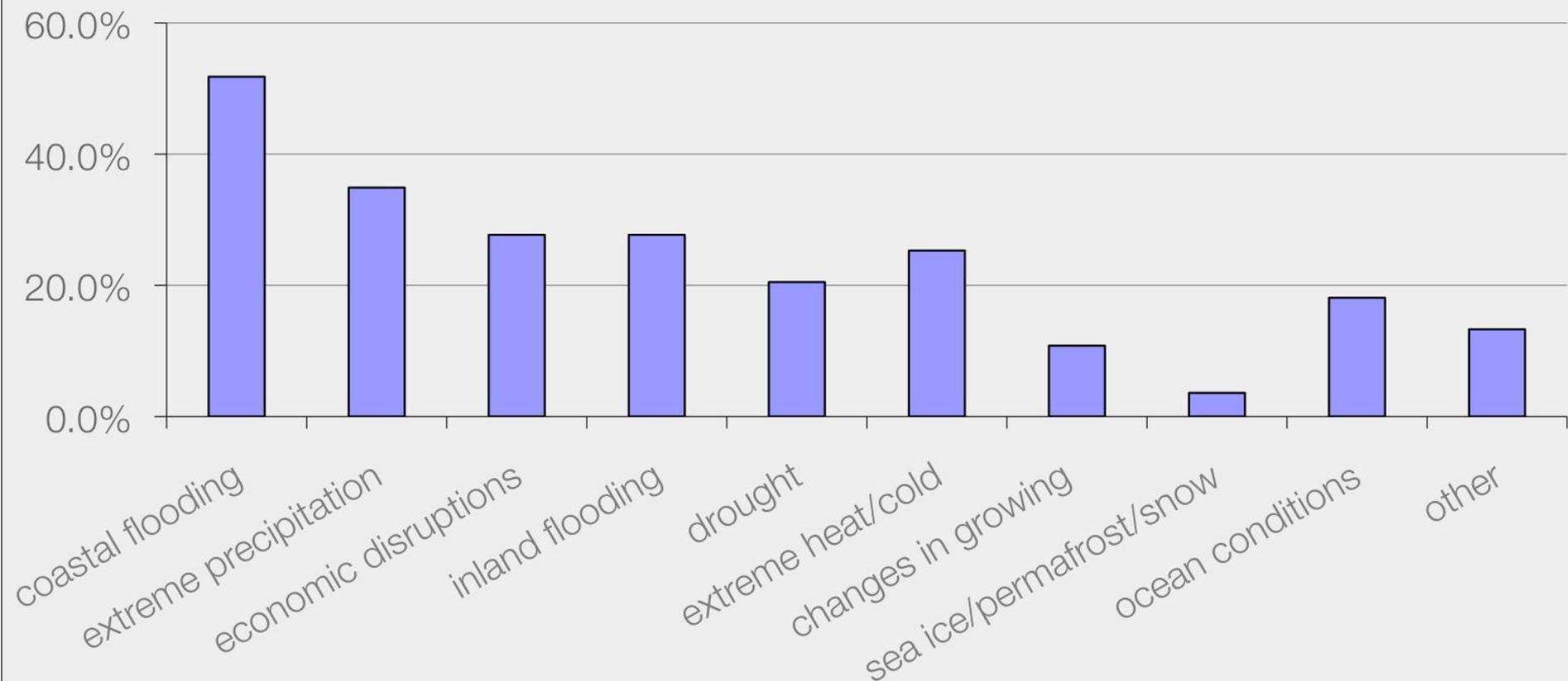


- health
- natural resources
- infrastructure
- commerce
- energy
- food
- other



# results of pre-webinar **survey**

Which two climate-related stresses concern you most?



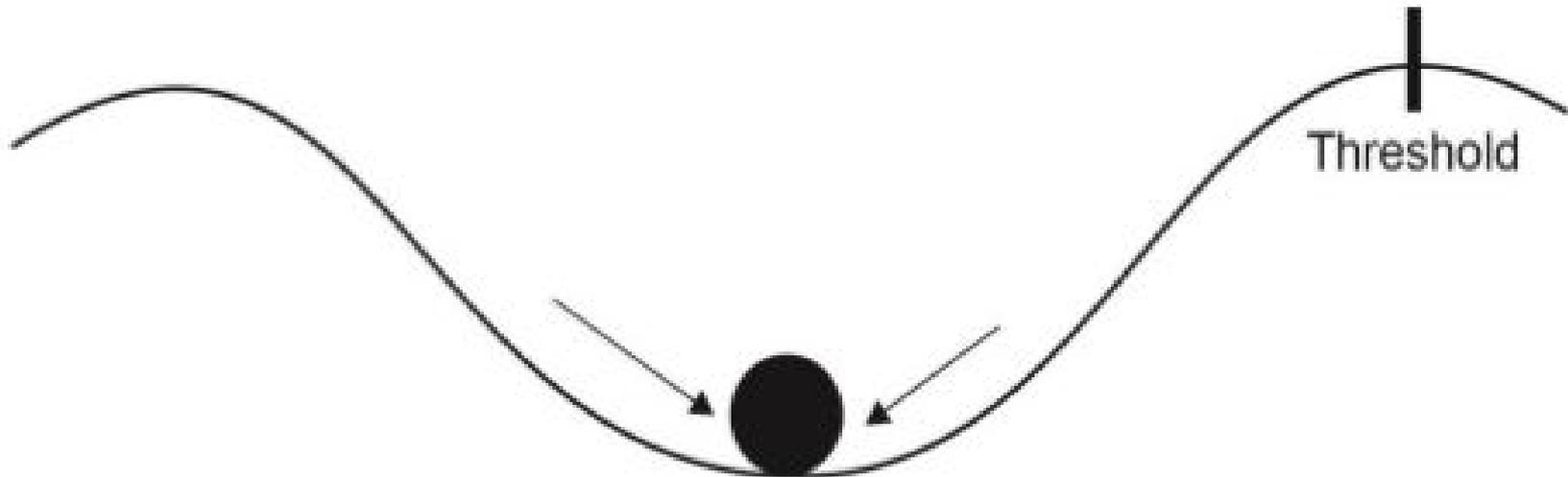


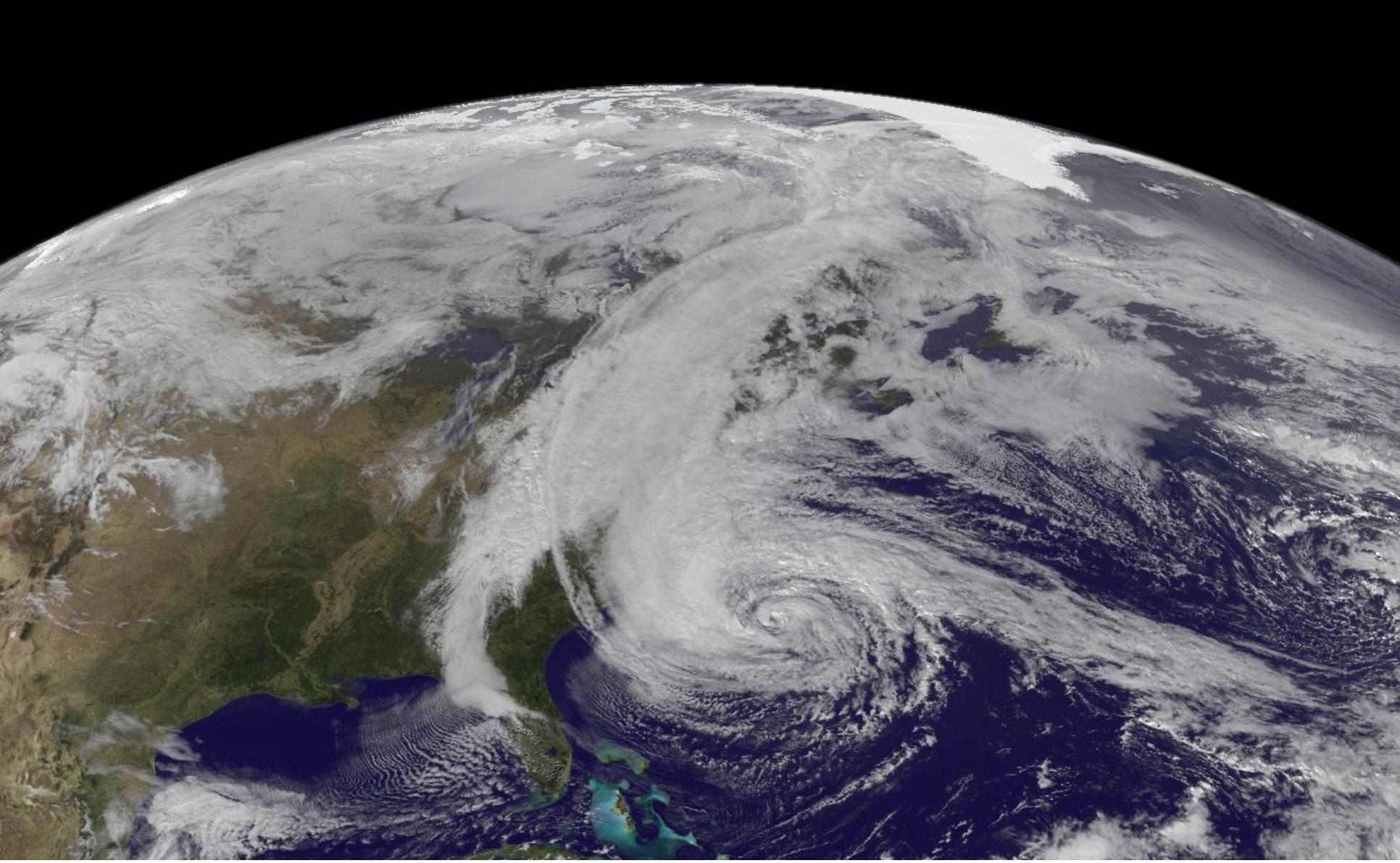
**Objective:** Help you use the CRT to meet your own needs

- Introduce tools
  - Climate Explorer
  - Climate at a Glance
- Thinking in systems
- 5-step process (Steps to Resilience)



**Resilience** is the capacity of a system (community, business, or natural environment) to withstand or recover from a disruption.

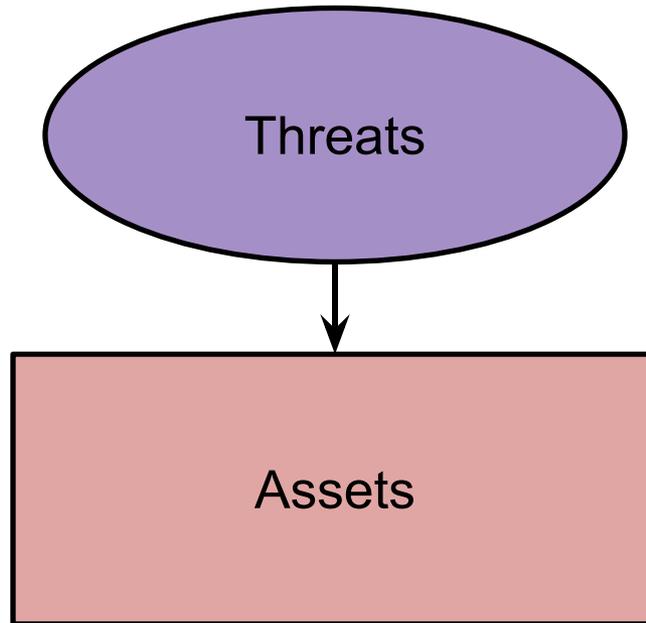








# asset-threat pairs





# exploring **asset-threat** pairs geospatially

## CLIMATE EXPLORER

LAYERS

HISTORICAL DATA

### TOPICS:

#### Coastal Flood Risk

##### Climate Stressors

Inundation from Sea Level Rise (1ft) i

Inundation from Sea Level Rise (2ft) i

Inundation from Sea Level Rise (3ft) i

##### People and Assets Impacted

Coastal Vulnerability to Sea Level Rise i

Social Vulnerability Index i

78%

Land Cover (2011) i

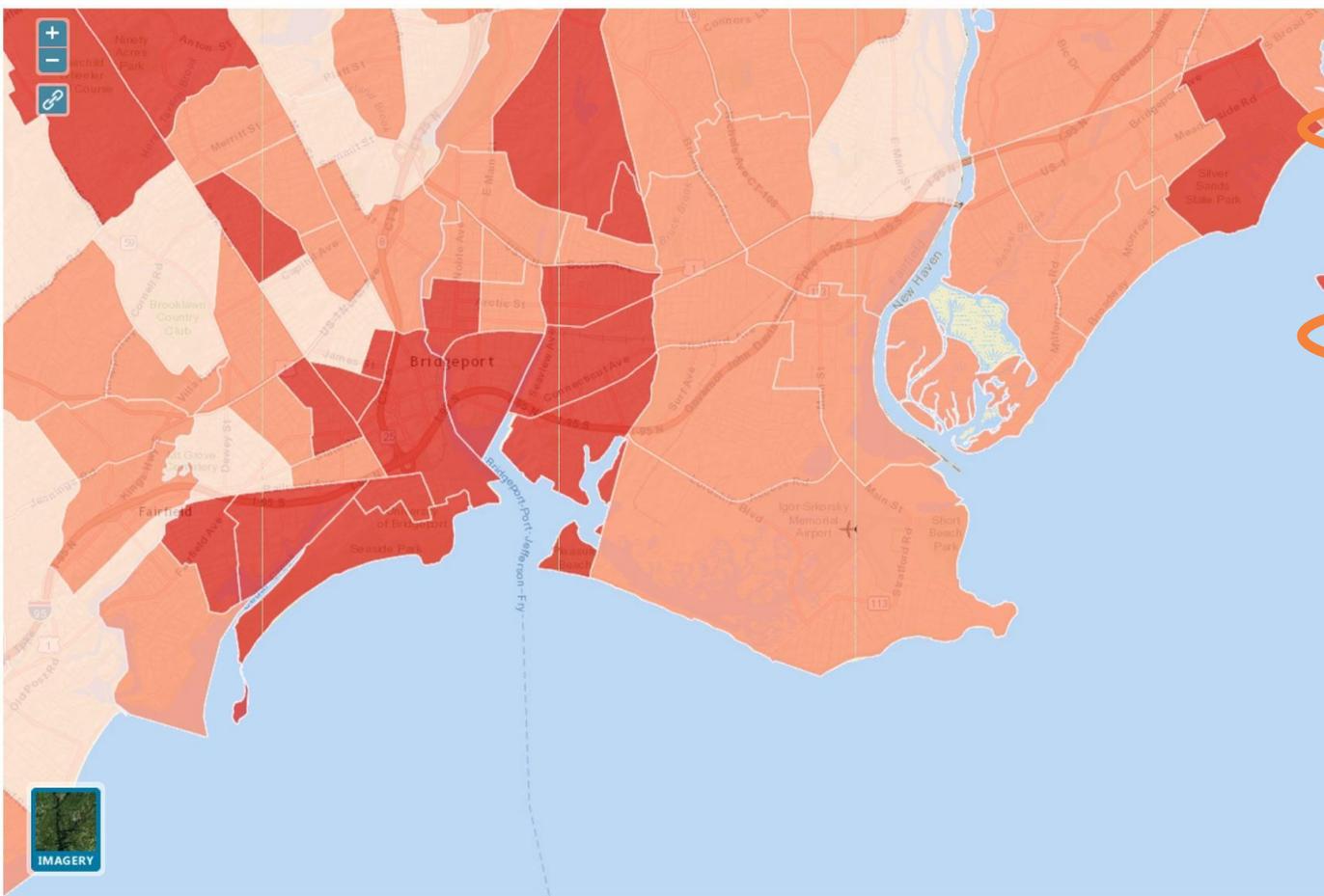
### LAYER INFORMATION

#### Social Vulnerability Index

Source: [NOAA Office For Coastal Management](#)

Social Vulnerability Index (SoVI) for Coastal States based on 2010 census tracts.

#### Social Vulnerability Index





# understanding past **threats**

## CLIMATE EXPLORER

LAYERS

**HISTORICAL DATA**

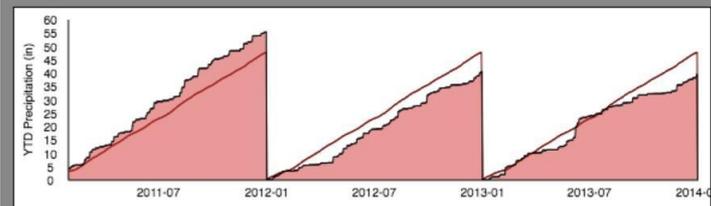
### STATION DETAIL:

TEMPERATURE

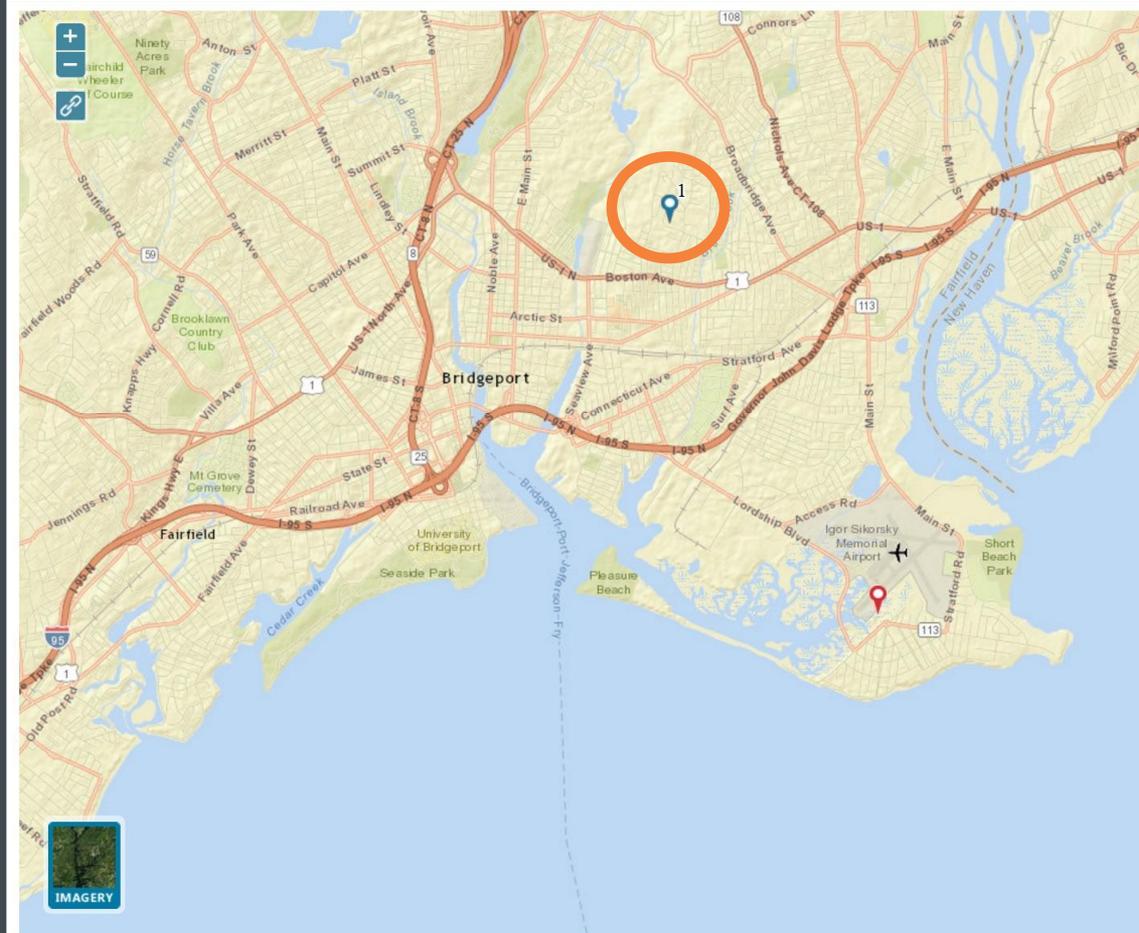
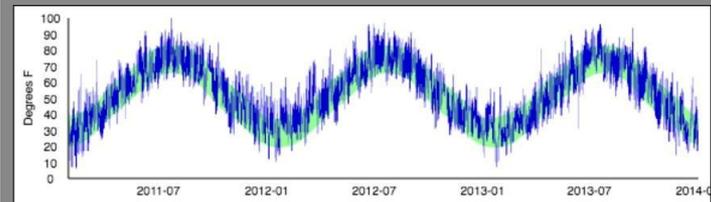
PRECIPITATION

#### (1) BRIDGEPORT-SUCCESS HILL CT

##### PRECIPITATION



##### TEMPERATURE



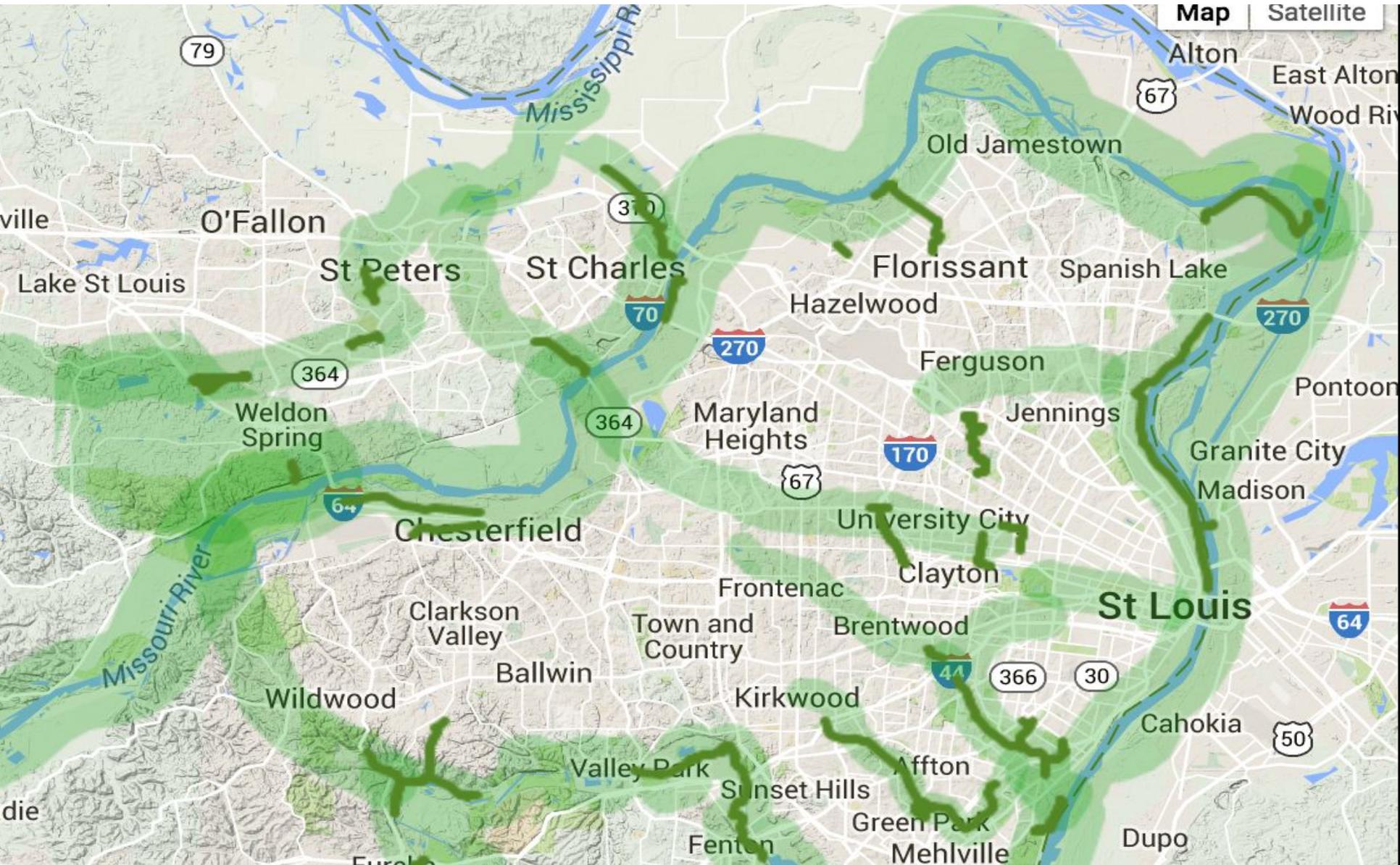




Dec 29, 2015  
St. Louis Post Dispatch



# taking action



# Identifying High-Priority Conservation Lands to Enhance Flood Mitigation

Community groups are working to establish a connected ring of conservation land around St. Louis, Missouri. They're using an innovative strategy to help them target land that can also enhance their flood mitigation efforts.

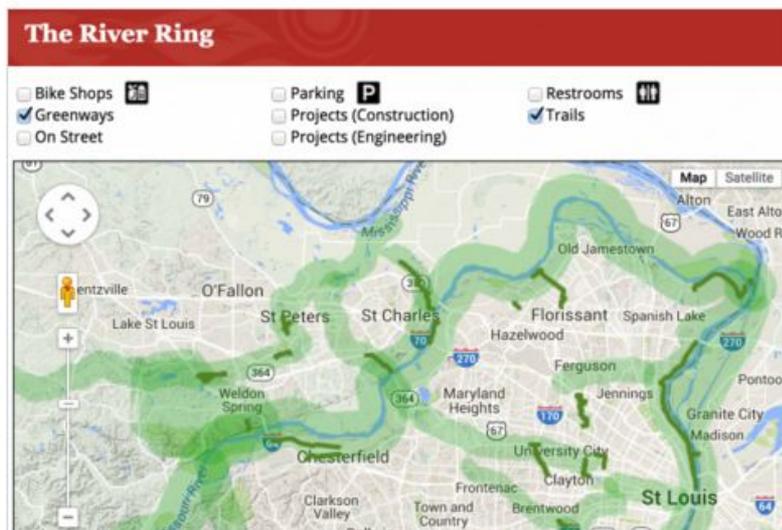


## Stressors and impacts

The St. Louis metropolitan region sits at the confluence of two of North America's great rivers—the Mississippi and Missouri—and stretches across land where the Meramec and Cuivre rivers flow. Together, the region's rivers and streams channel rain and melted snow from a huge portion of the continent. Unsurprisingly, floodplains across the region experience relatively frequent flooding, sometimes accompanied by property damage and fatalities. As climate changes, increases in heavy precipitation and earlier spring snowmelt may increase the frequency of this flooding.

## Benefits of rivers

Though the rivers are a potential source of flooding, they are also a source of jobs, and they provide recreation and connectivity across the region. In 2000, the Clean Water, Safe Parks, and Community Trails Initiative launched an effort to use rivers and floodplains to make the St. Louis region a clean, green, and connected place to live. The special district,



## Steps to Resilience:

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

## Tools:

[Hazus-MH](#)

## Topic:

[Ecosystem Vulnerability](#) >  
[Protecting and Enhancing the Resilience of Ecosystems](#)

[Water Resources](#) > [Flooding](#)

## Additional Resources:

[Great Rivers Greenway District: "The River Ring: Our vision of a clean, green, connected St. Louis region"](#)

[Ecological Economics: "Floodplain conservation as a flood mitigation strategy: Examining costs and benefits"](#)

["Measuring Resilience to Climate Change: The](#)



think in **systems**

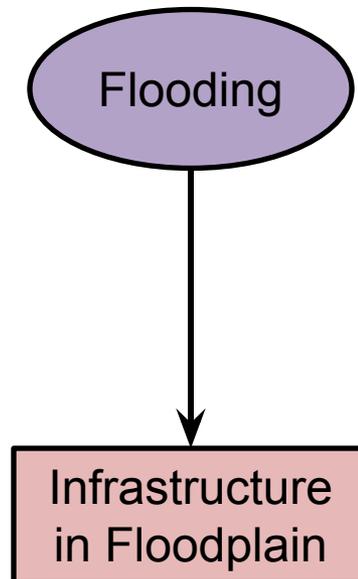
Asset >

Infrastructure  
in Floodplain



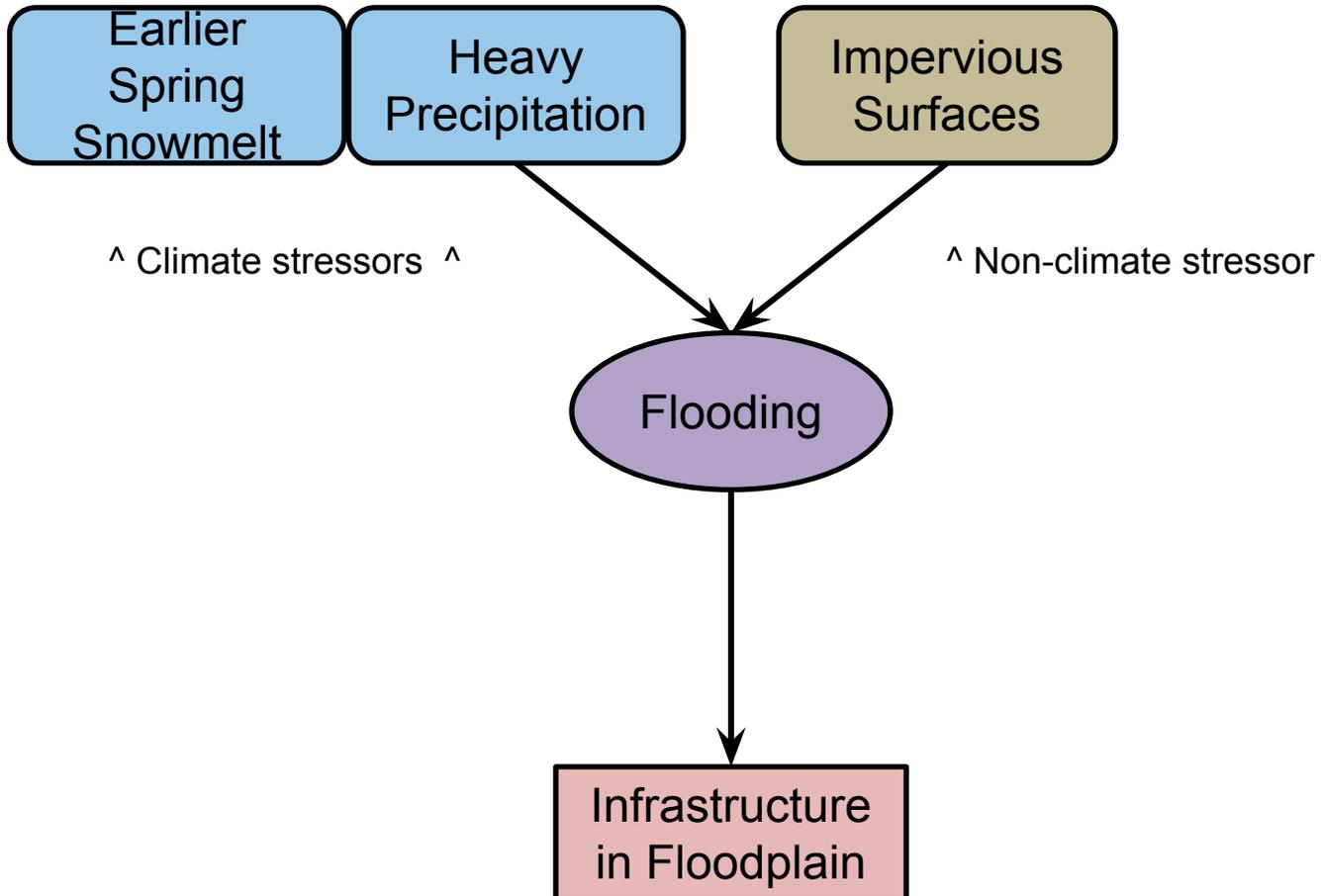
think in **systems**

Threat >



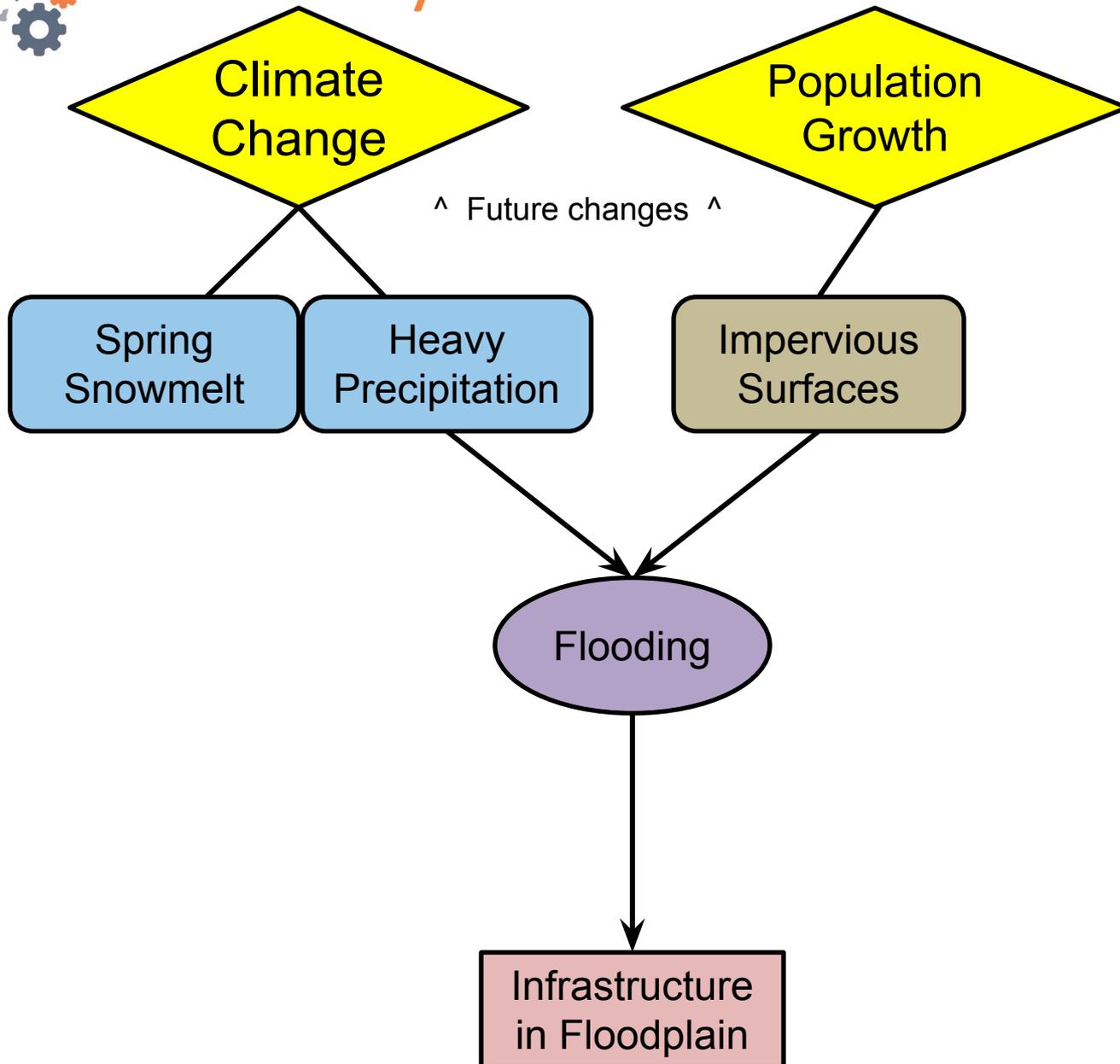


think in **systems**



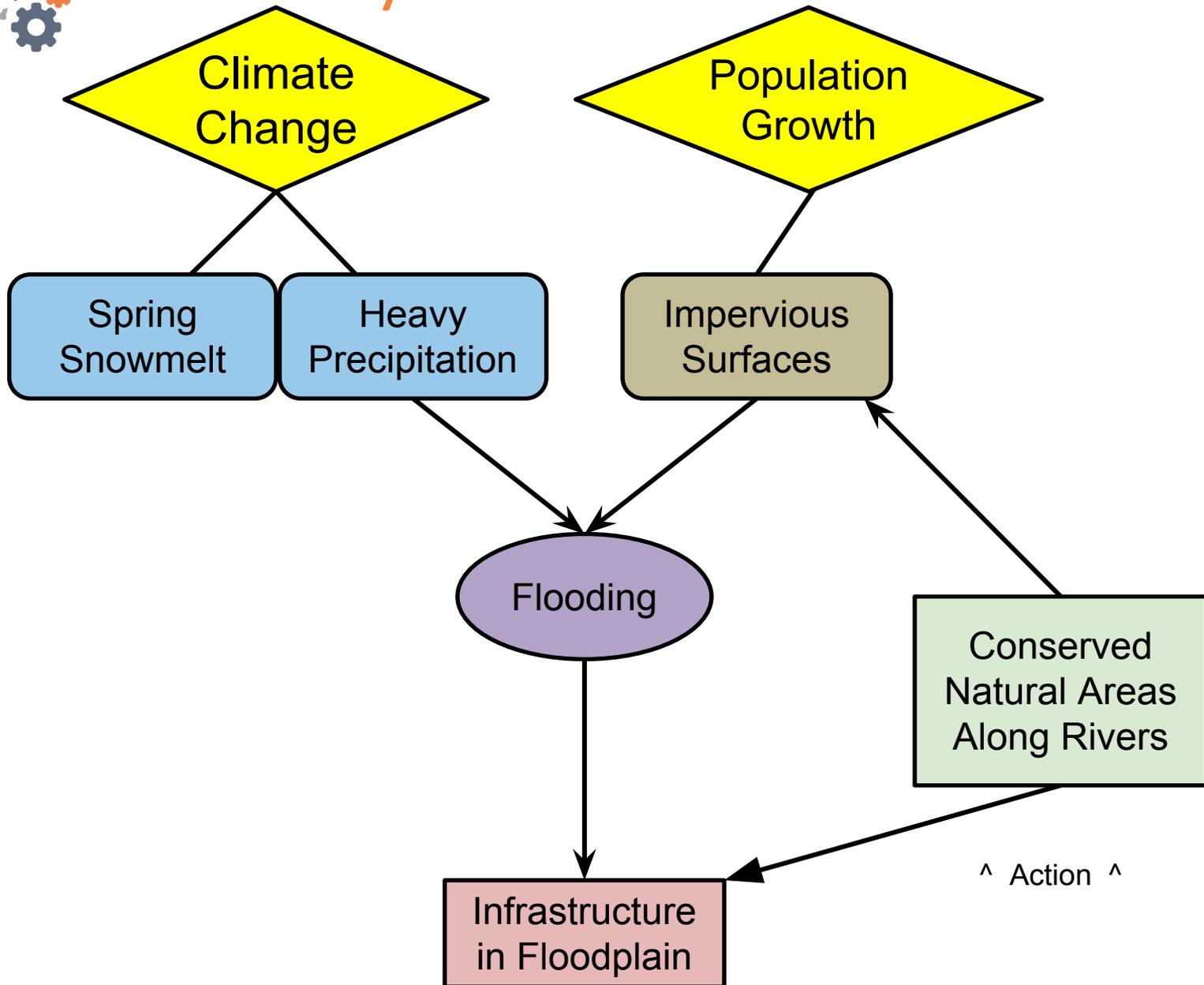


think in **systems**



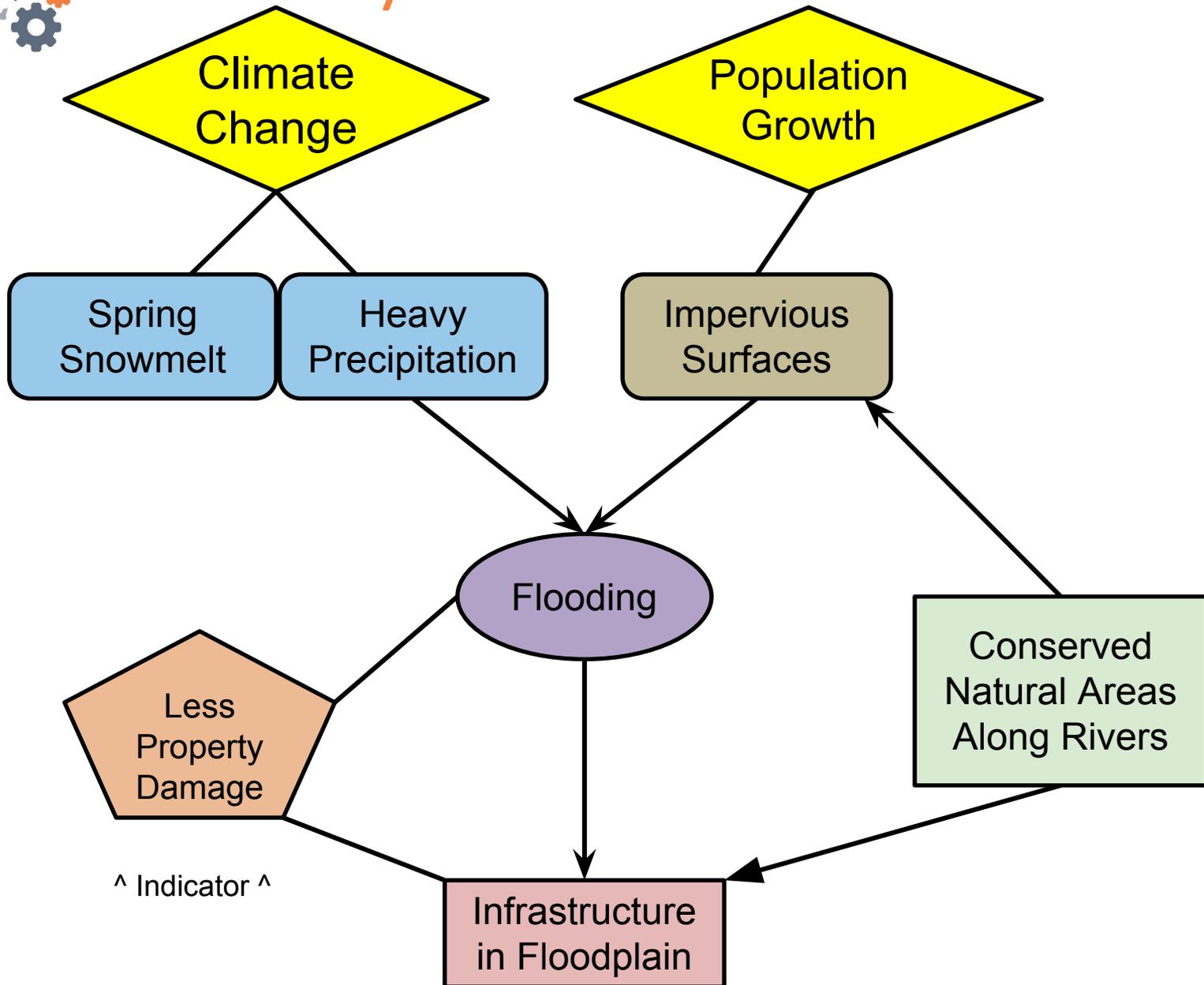


think in **systems**





think in **systems**





think in **systems**



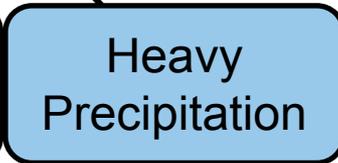
Climate Change



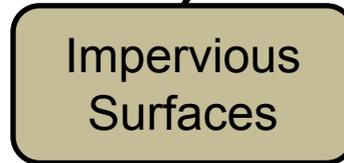
Population Growth



Spring Snowmelt



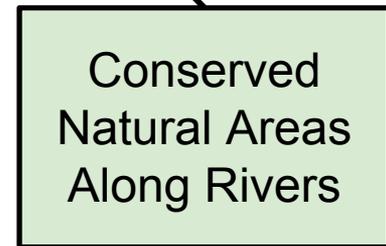
Heavy Precipitation



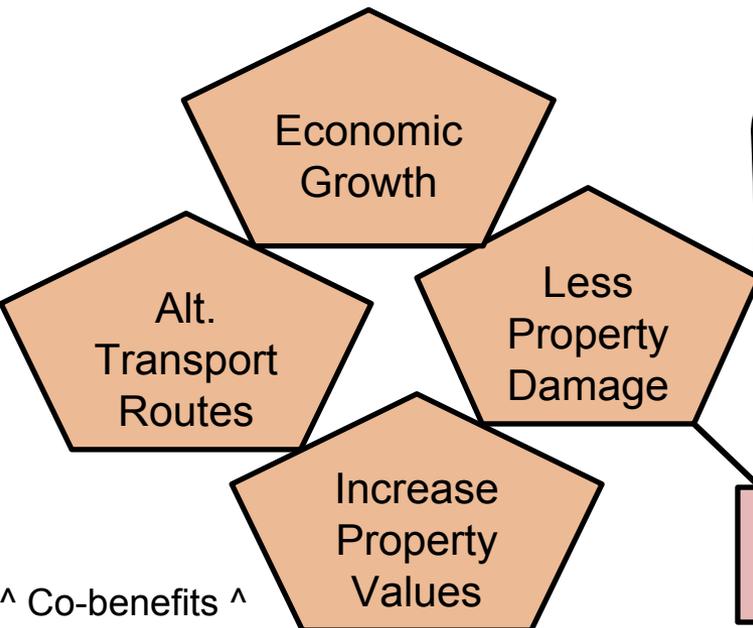
Impervious Surfaces



Flooding



Conserved Natural Areas Along Rivers

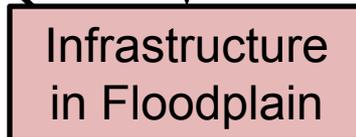


Economic Growth

Alt. Transport Routes

Less Property Damage

Increase Property Values



Infrastructure in Floodplain

^ Co-benefits ^



## Taking Action

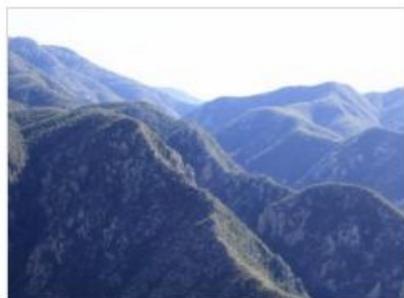
Filter by climate threat/stressor: ▼

Filter by parent topic: ▼

Filter by steps to resilience: ▼

Filter by region: ▼

Communities and businesses are taking action to reduce their vulnerability to climate-related impacts and to build resilience to extreme events. The stories below illustrate the application of the process and tools featured in this Toolkit. Browse the stories, or filter by topic, step to resilience, and/or region in the boxes above. To expand your results, click the [Clear Filters](#) link.



### Boosting Ecosystem Resilience in the Southwest's Sky Islands

Conservation organizations teamed up to document the climate vulnerability of mountain springs that support unique ecosystems. Now, the Alliance they formed facilitates restoration work to enhance habitats and improve resiliency.

[Read more >](#)



### Addressing Short- and Long-Term Risks to Water Supply

In 2012, water managers in Fredericktown, Missouri, saw their city's main source of water dwindle. They used the EPA's Climate Ready Water Utilities program to consider options and develop plans to protect their water source.

[Read more >](#)



### Exploring Adaptation Options for Water Infrastructure at Sea Level

In Massachusetts, Manchester-by-the-Sea's wastewater treatment plant is located right on the coast. The town's water utility is working with the EPA's Climate Ready Water Utilities program to consider its adaptation options.

[Read more >](#)



### Assessing a Tropical Estuary's Climate Change Risks

Puerto Rico's San Juan Bay Estuary faces multiple threats, including heavy use by urban populations and impacts of climate change. A workbook from the EPA's Climate Ready Estuaries program helped them catalog risks so they can be prioritized and addressed.

[Read more >](#)





1. Go to the site's Taking Action (case studies) section
2. Using the filters at the top of the page, select a **climate threat/stressor** that most interests/concerns you.
3. Select the U.S. **region** of interest
4. From the remaining result set, select a case study of interest
5. Bookmark the page and, when you have a moment, come back to familiarize yourself with the following...
  - a) The threat-asset pair
  - b) The relevant tools used in this case study
  - c) What solution(s) were implemented?

## Taking Action

Filter by climate threat/stressor: ▼

Filter by parent topic: ▼

Filter by steps to resilience: ▼

Filter by region: ▼

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# Climate Preparedness Workshops Provide a Head Start Toward Resilience

After a series of extreme weather events, the City of Bridgeport, Connecticut, looked for ways to prepare for future storms. Their planning process had just started when they got hit again...

## Stressors and impacts

After experiencing a tornado in June 2010, Tropical Storm Irene in August 2011, and the "Halloween nor'easter" of 2011, residents of Bridgeport, Connecticut, recognized that they could benefit by being better prepared for extreme events. City leaders sought information to begin developing a plan, and they learned that an inventory of their infrastructure and vulnerabilities could help them identify priorities for reducing potential risks. What they didn't know is that their resilience would be tested again very soon, when Hurricane Sandy arrived in October 2012.

## A community studies its options

Drawing upon training materials and expertise from a range of national and local partners, a set of community leaders and decision makers from Bridgeport participated in climate preparedness workshops. Workshop participants engaged in conversations about actions the community could take to reduce risk and increase resilience; they also examined maps showing potential flooding from extreme events and sea level rise, and then worked together to identify the community's top hazards and priorities for action.

## Ready or not, here comes Sandy

In October 2012, the community had barely begun their planning process when Hurricane Sandy struck,



## Steps to Resilience:

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

## Tools:

[Coastal Resilience >](#)

## Topic:

[Coastal Flood Risk > Sea Level Rise >](#)

[Coastal Flood Risk > Storm Surge >](#)

[Coastal Flood Risk > Inland Flooding >](#)

## Additional Resources:

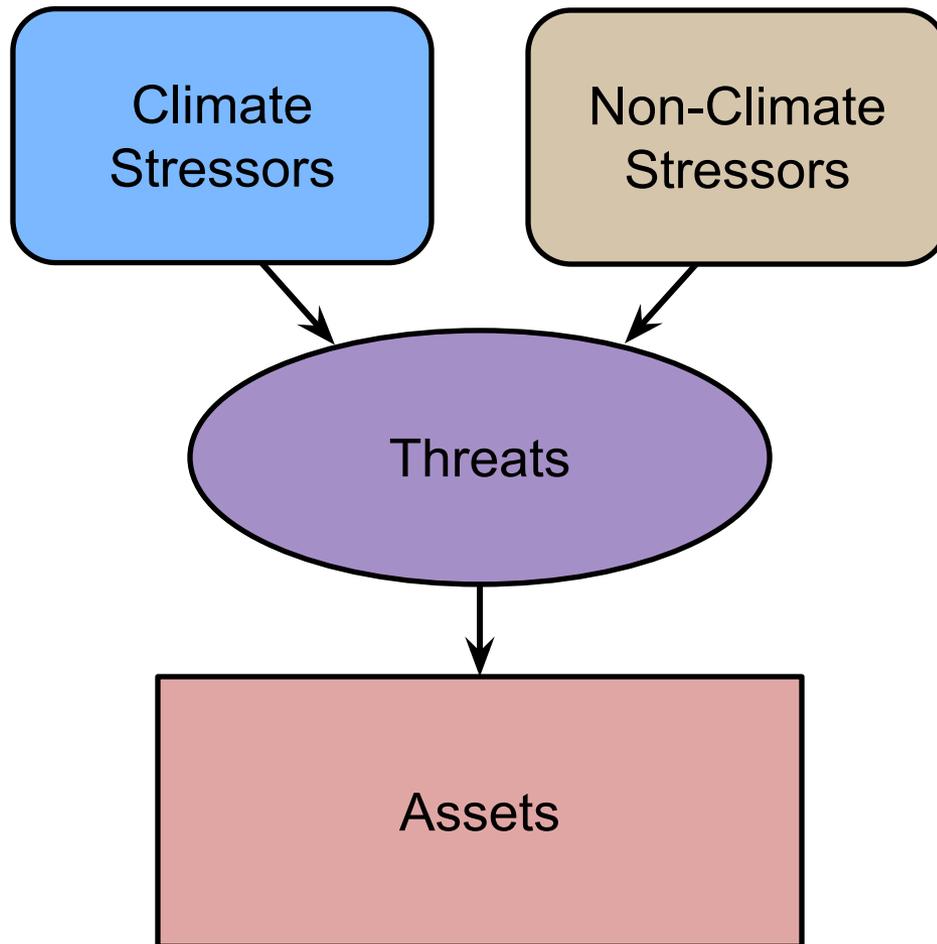
[Bridgeport Climate Preparedness Workshops Summary of Findings >](#)

[Digital Coast: Enhancing Resilience to Coastal Hazards in Connecticut >](#)

## Partners:

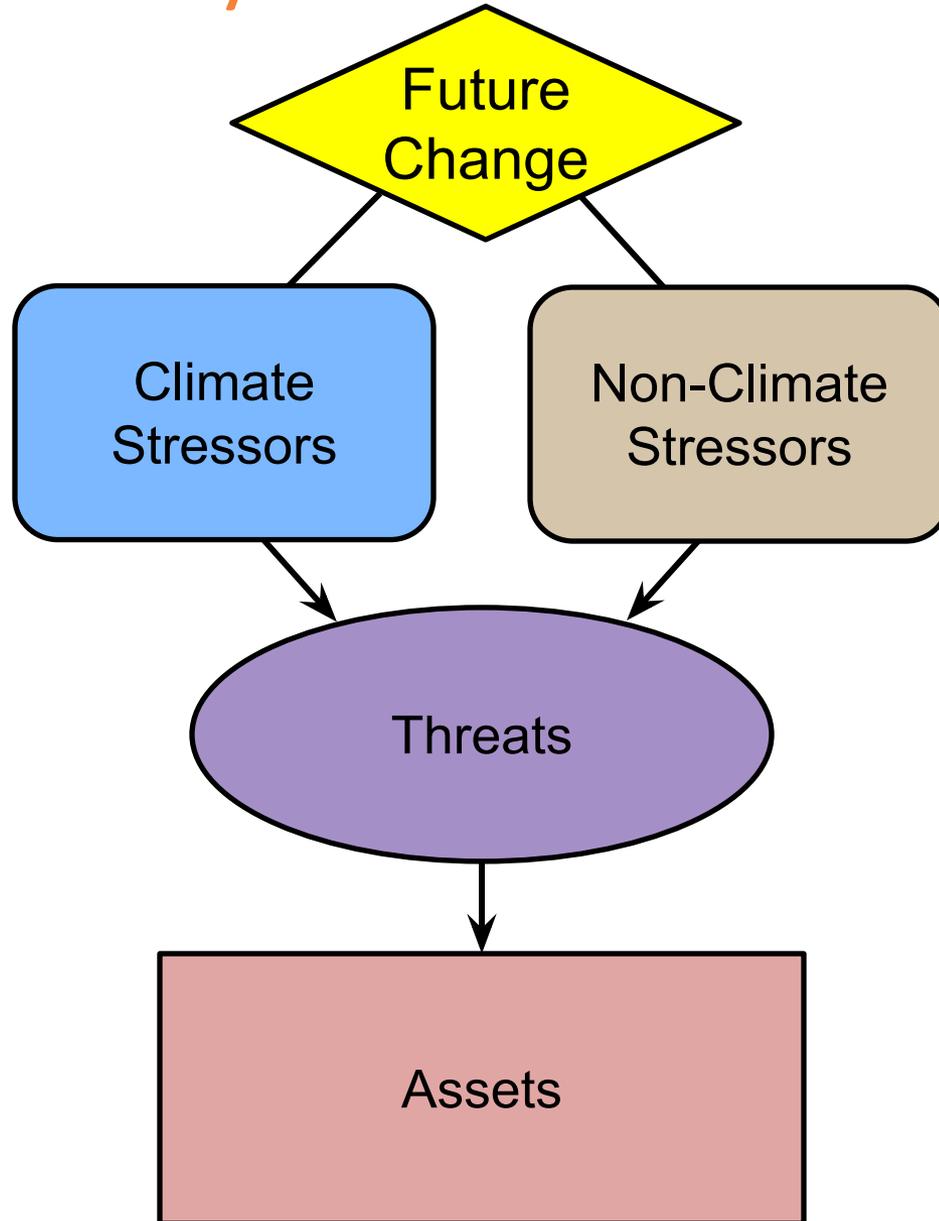


think in **systems**



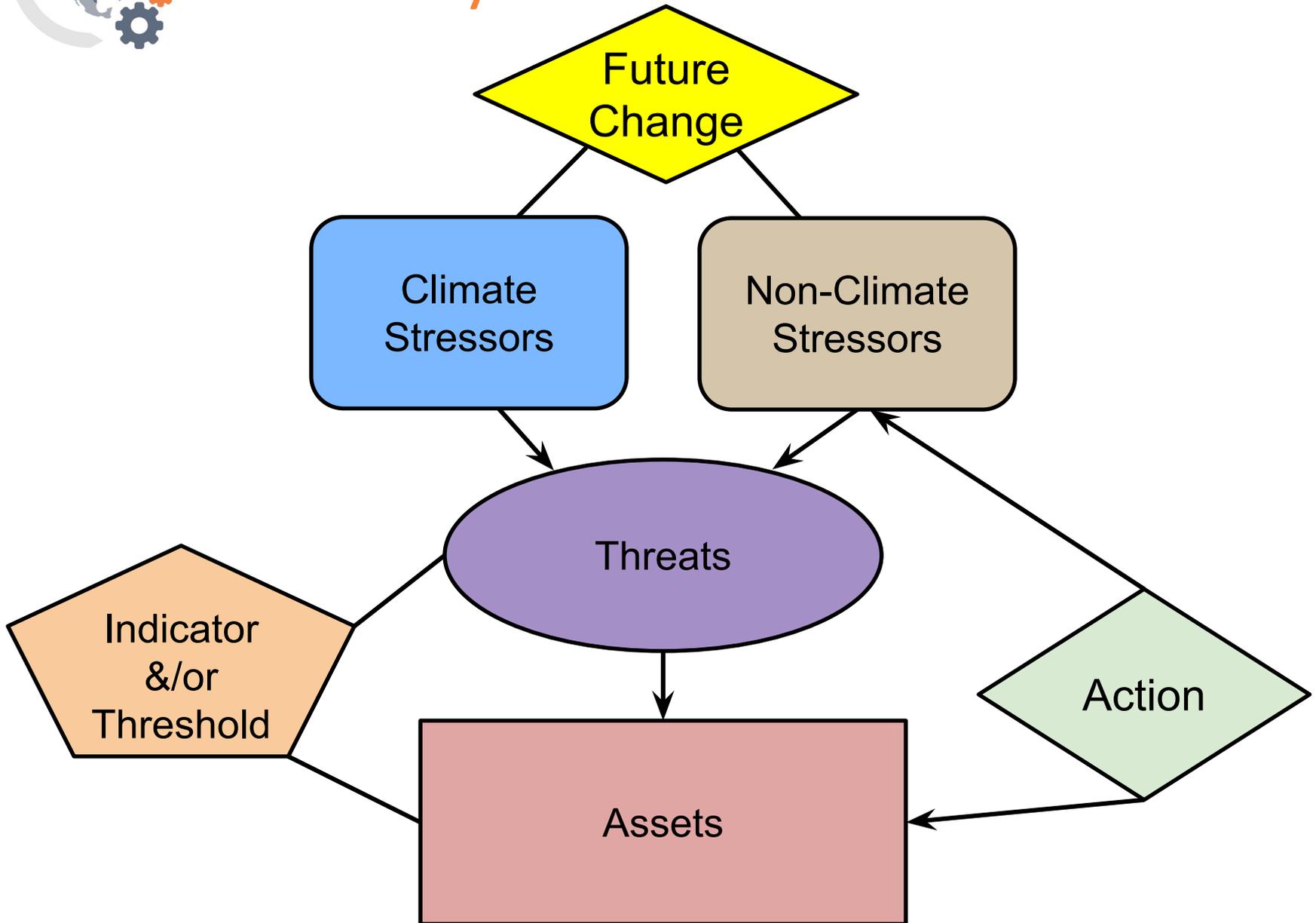


think in **systems**





think in **systems**





Step 1 : Identify the Problem

Did you know?

Step 2 : Assess your  
vulnerability

Why should we care?

Step 3 : Identify options to build  
resilience

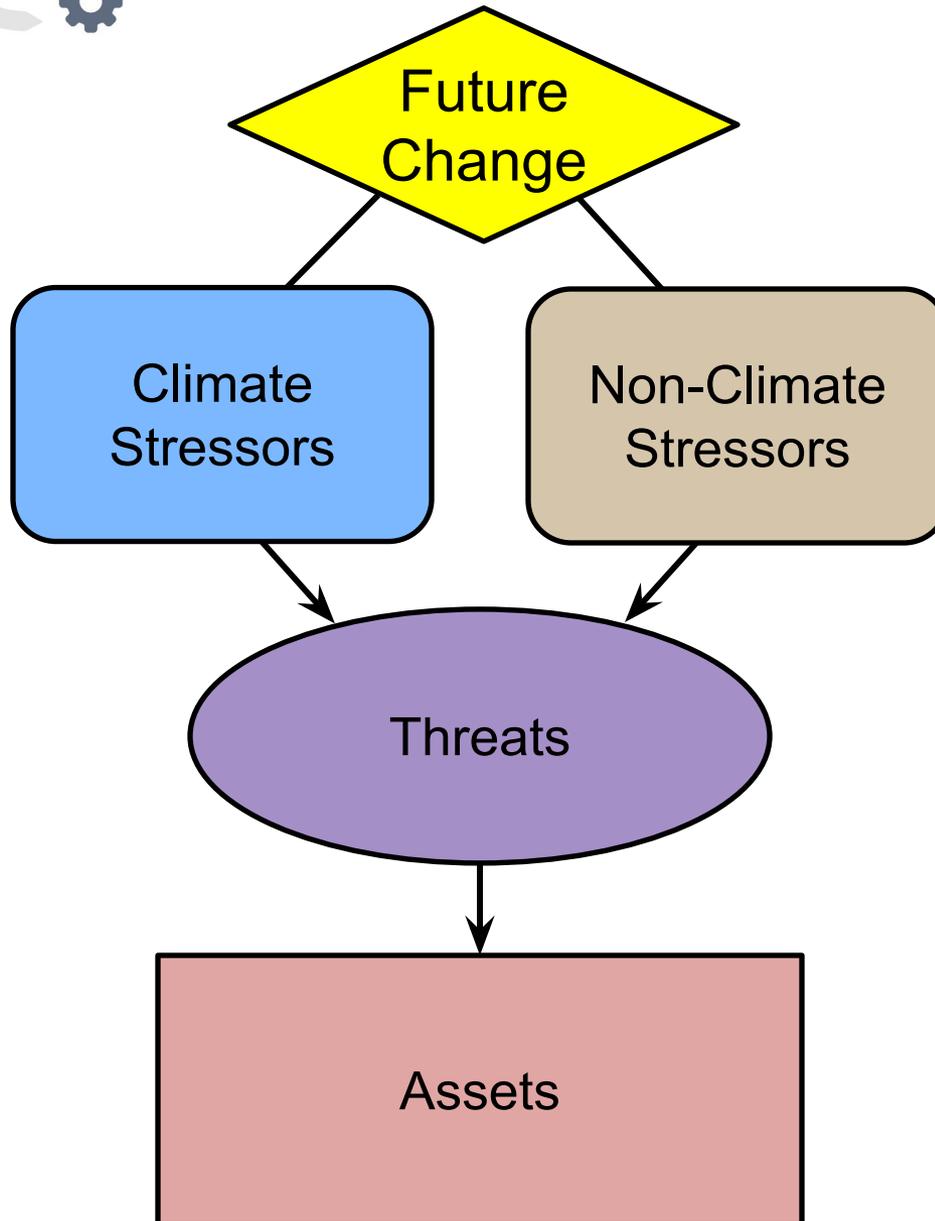
Step 4 : Evaluate the risk and  
choose the best option

What can we do about it?

Step 5 : Implement – Take  
Action!



# model helps define **steps to resilience**

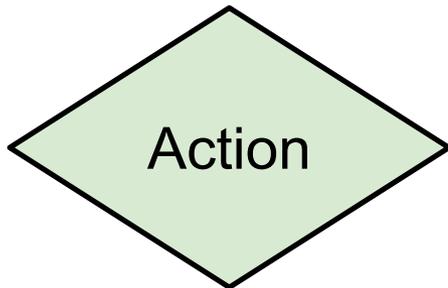
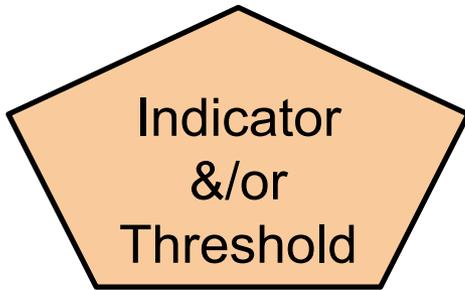


Did you know?

Why should we care?



model helps define **steps to resilience**



What can we do about it?

## Step 1: Explore Threats & Hazards

*Did you know...?*

Assemble  
stakeholders

Define goals &  
objectives

List assets of  
Concern

Identify threats to  
key assets

### **Alternatively:**

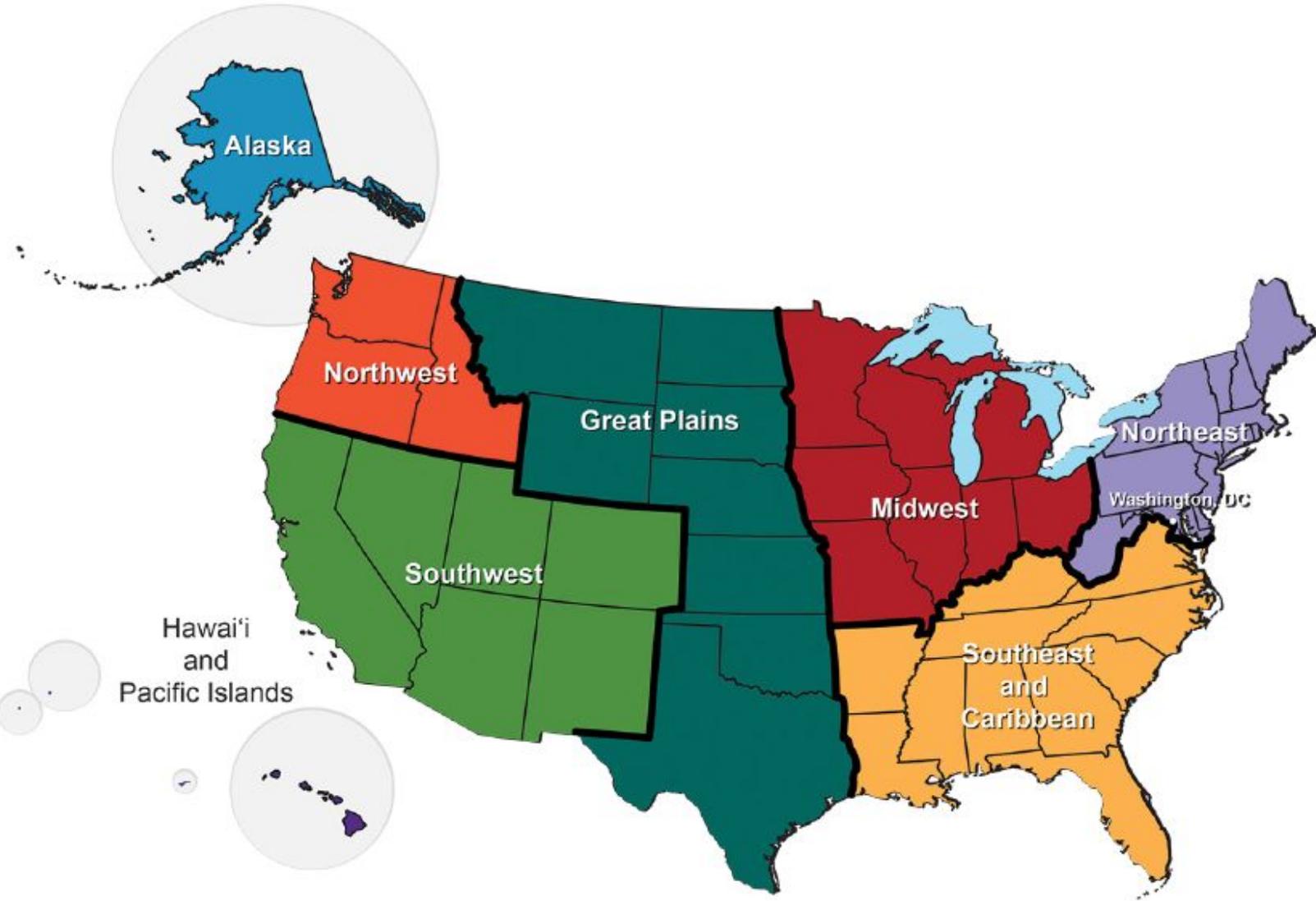
Are there climate-related  
opportunities that we might  
take advantage of?

### **Decision Point:**

Are things we care about  
threatened by climate-related  
threats and hazards?



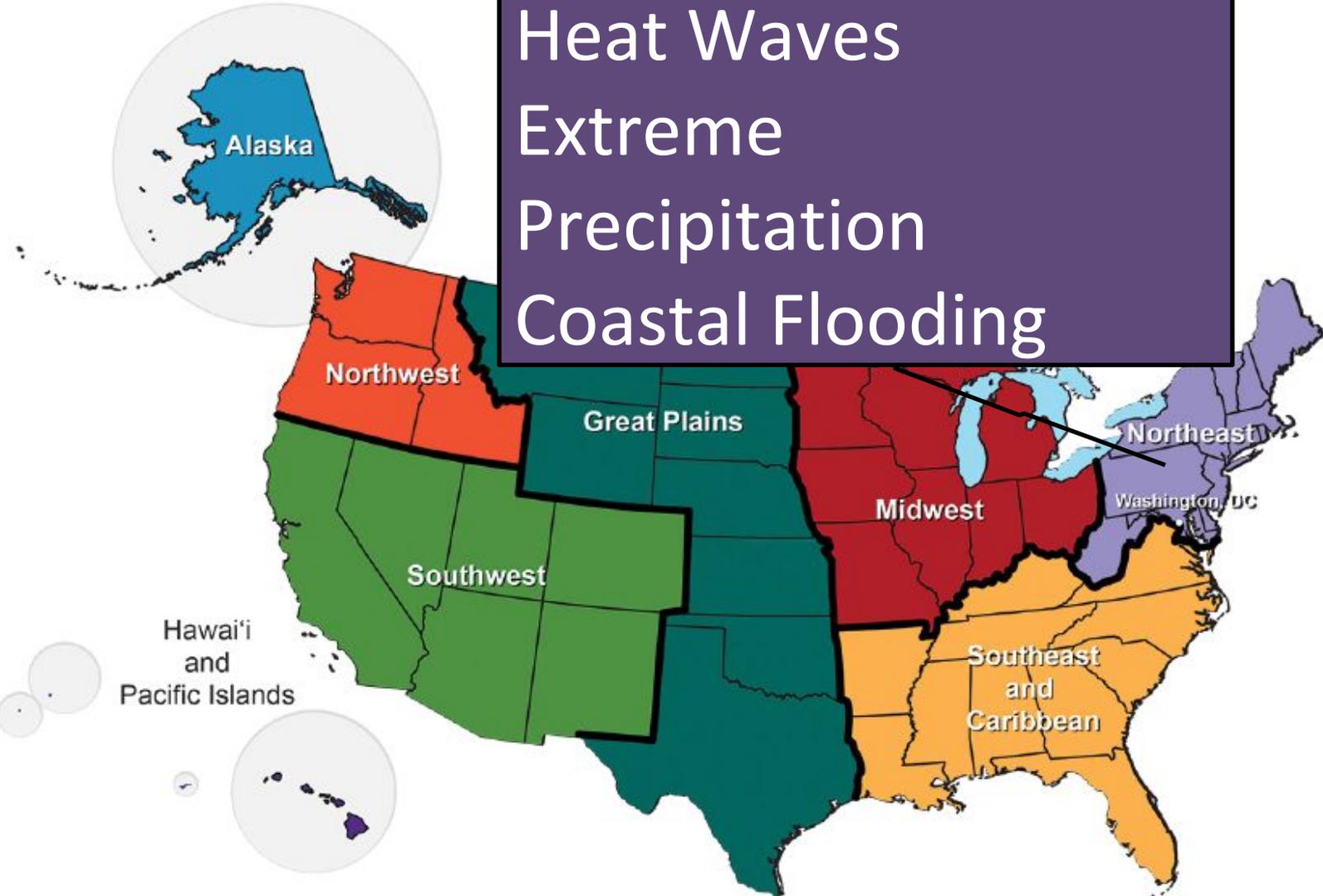
# National Climate Assessment





# National Climate Assessment

Heat Waves  
Extreme  
Precipitation  
Coastal Flooding



## Topics

Select a topic of interest below to learn about climate-related risks and opportunities.



### Coastal Flood Risk

- Sea Level Rise
- Coastal Erosion
- Storm Surge
- Tsunami
- Inland Flooding
- Shallow Coastal Flooding (Nuisance Flooding)
- Building Resilience in Coastal Communities



### Ecosystem Vulnerability

- Fire Regimes
- Water Resources
- Carbon Balance
- Invasive Species
- Biodiversity Conservation
- Protecting and Enhancing the Resilience of Ecosystems



### Energy Supply and Use

- Energy Consumption
- Energy Production
- Energy Facilities
- Building Resilience in Energy Supply and Use



### Food Resilience

- Food Production
- Food Distribution
- Food Safety and Nutrition
- International Food Security
- Building Food Resilience



### Human Health

- Extreme Heat
- Extreme Events
- Increased Levels of Air Pollutants
- Food- and Water-Related Threats
- Changing Ecosystems and Infectious Diseases
- Building Health Care Sector Resilience



### Transportation and Supply Chain

- Land-Based Transportation
- Waterborne Transportation
- Aviation
- Supply Chain Security



### Tribal Nations

- Assessment and Planning
- Adaptation
- Mitigation
- Disaster Risk Reduction
- Relocation
- Capacity Building



### Water Resources

- Municipal Water Supply
- Flooding
- Drought
- Ecosystems

Topics > Coastal Flood Risk >

## Coastal Flood Risk

### Key points:

- *The risk of flooding has increased in most coastal regions of the United States and its island territories since 1900, and that risk is projected to grow even more this century.*
- *Coastal lifelines, such as water and energy infrastructure, and nationally important assets, such as ports, tourism, and fishing sites, are increasingly vulnerable to sea level rise, storm surge, erosion, flooding, and related hazards. Socioeconomic disparities create uneven vulnerabilities.*
- *Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human stresses; climate change will result in further reduction or loss of the services that these ecosystems provide, including potentially irreversible impacts.*
- *There is no one-size-fits-all solution to reduce risk and improve resilience. Every community should develop its own plan of action, but can learn from other communities about effective approaches.*

[Adapted from the Third National Climate Assessment.](#)

### Browse Topics

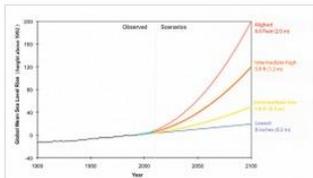
- ✓ **Coastal Flood Risk**
  - Sea Level Rise
  - Coastal Erosion
  - Storm Surge
  - Tsunami
  - Inland Flooding
  - Shallow Coastal Flooding
  - Building Resilience in Coastal Communities
- › Ecosystem Vulnerability
- › Food Resilience
- › Human Health

### Increased Impacts

Every year, at multiple locations along the coast of the United States, events such as storm surges, high tides, strong waves, heavy precipitation, increased river flow, and tsunamis cause damaging coastal floods. As global sea level rises, higher water levels will exacerbate the impacts of these incidents, resulting in deeper floods that last longer and extend further inland. Additionally, as climate changes, some coastal hazards are projected to increase. For instance, coasts may see more severe or more frequent storms and heavier rainfall events.



View of inundated areas in New Orleans following the breaking of the levees surrounding the city as the result of Hurricane Katrina.



Observed global mean sea level rise for 1900 to the present, and projected global mean sea level rise for four scenarios from the present to 2100.

Average global sea level rose eight inches

during the last century, and scientists are highly confident that it will continue rising in the future. By 2100, global sea level is projected to be between 8 inches and 6.6 feet higher than it was in 1992. At regional and smaller scales, relative sea level is also affected by vertical land movement and ocean currents, but any amount of global sea level rise will increase the frequency and magnitude of coastal flooding impacts, posing an increasing threat to people, infrastructure, and coastal





1. Go to the site's Topics section
2. Select a Topic and sub-topic of interest
3. Note the right-hand navigation items. Identify:
  - a) one case study that interests you
  - b) one tool that might be helpful to you

## Step 2: Assess Risks

Determine assets' exposure

Check sensitivities, adaptive capacities & vulnerabilities

Identify critical thresholds

Characterize risk of climate impacts

**Decision Point:**  
What is our risk of a significant loss? Can we tolerate that risk?

*Why should we care?*

## Tools

Tools are available to help you manage your climate-related risks and opportunities, and to help guide you in building resilience. This list below, or filter by topic and/or tool functionality in the boxes above. To expand your results, click the Clear Filter button.

Filter by parent topic: ▼ Filter by category: ▲

- Identify Vulnerabilities (106)
- View Past/Current Conditions (82)
- Analyze/Download Data (67)
- Check Applied Forecasts (51)
- Engage/Communicate (45)
- Find Adaptation Planning Support (42)
- Recover/Rebuild (18)
- Visualize Climate Projections (15)

Our main 'Tools' page presents more than 220 science-based decision-support tools.

Users can quickly filter by parent topic of interest or by functional category, or both.



### Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use

This toolkit presents information on 18 different land-use tools (generally used legal devices) that could be used to preemptively respond to threats that sea level rise poses to public and private coastal development and infrastructure.

[Read more >](#)



### Adaptation Workbook for Natural Resources

Forest managers, natural resource professionals, and motivated landowners can use this structured process to consider the effects of climate change on forests and related ecosystems.

[Read more >](#)



### Advanced Hydrologic Prediction Service

This comprehensive suite of graphical forecast products shows a range of information on current and projected river levels for almost 4,000 stations in the contiguous United States.

[Read more >](#)

### AgroClimate—Tools for Managing Climate Risk in Agriculture

Interactive tools and climate information provide support to improve crop management decisions and reduce production risks associated with climate variability, climate change, and extreme weather events in the southeastern United States.

[Read more >](#)



### Alaska Climate and Weather Highlights

Access information on historical or recent storms and other climate-related events in Alaska and surrounding waters.

[Read more >](#)



### Alaska Coastal Profile Tool

Explore how beach and coastal elevation profiles along Alaska's coastline have changed over time.

[Read more >](#)



### Alaska Shoreline Change Tool

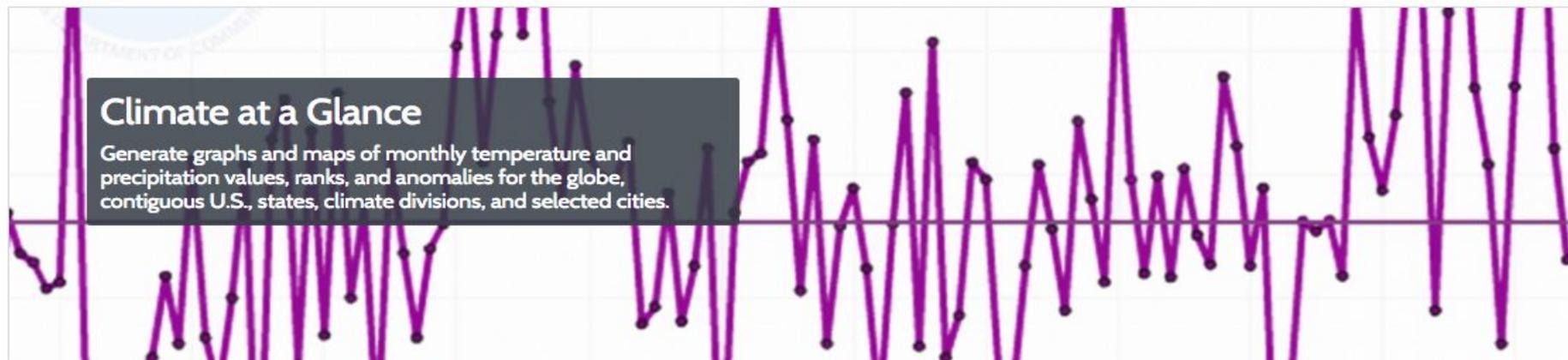
Analyses of aerial photos and satellite imagery reveal how Alaska's shoreline has changed over time. Projecting observed rates of change into the future provides predictions of where the shoreline will be in coming decades.

[Read more >](#)



### Alaska ShoreZone Coastal Mapping and Imagery

Access millions of aerial photos of the coast in Alaska and the Pacific Northwest. This habitat mapping and classification system, paired with a huge database of aerial photos, enables responders to plan an oil spill response or resource managers to identify vulnerable habitat.

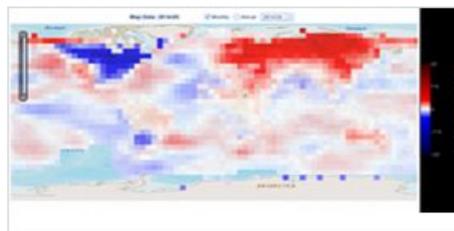


Climate at a Glance allows near-real-time analysis of monthly temperature and precipitation data across the contiguous United States. Users can request data for select cities, states, regions, and the nation as a whole to compare current conditions with the historical record. Data are available for the period 1895 to the present.

The tool is ideal for studies of climate variability and change. The tool's graphing functions allow users to determine whether, and how much, a given location or area is warming or cooling; or experiencing an overall change in precipitation. Features include:

## Global temperature anomalies

Global-scale maps of monthly and yearly temperature anomalies show where it was warmer or cooler than the long-term average from 1981 to 2010. Clicking any grid cell on the map produces a bar graph of annual temperature anomalies for that cell from the time data collection began at that location through the present.



The mapping tool shows temperature anomalies calculated from the National Climatic Data Center's merged surface temperature product, which combines land-based temperatures from the Global Historical Climatology Network-Monthly (GHCN-M) data set with sea-surface temperatures from the Extended Reconstructed Sea Surface Temperature data set (ERSST v3b). The monthly analysis begins January 1854, but due to very sparse data, no global averages are computed before 1880.

### URL:

<http://ncdc.noaa.gov/cag/> >

### Topic:

Human Health > [Extreme Heat](#) >

Human Health >  
[Food- and Water-Related Threats](#) >

Transportation and Supply Chain >  
[Land-Based Transportation](#) >

### Taking Action:

[Balancing Variable Water Supply With Increasing Demand in a Changing Climate](#) >

### Documentation:

[Background](#) >

### Partners:

[National Oceanic and Atmospheric Administration](#) | [National Centers for Environmental Information](#) >



*Have climate conditions affected you where you live?*

Here is a method to find a tool that helps you visualize **at a glance** how **climate** conditions are changing in **your city/county/state**:

1. Go to the CRT's **Tools** section and, using the filter functions (top right), select the following:

**Category » View Past/Current Conditions**

**Category » Analyze/Download Data**

1. How many tools are left? Which one(s) best match your search criteria?
2. Select "Climate At A Glance." Click to visit that website and explore its functionality.



# air conditioning in S. Florida

Parameter: Cooling Degree Days

Time Scale: Year-to-Date

Month: December

Start Year: 1895

End Year: 2016

State/Region: Florida

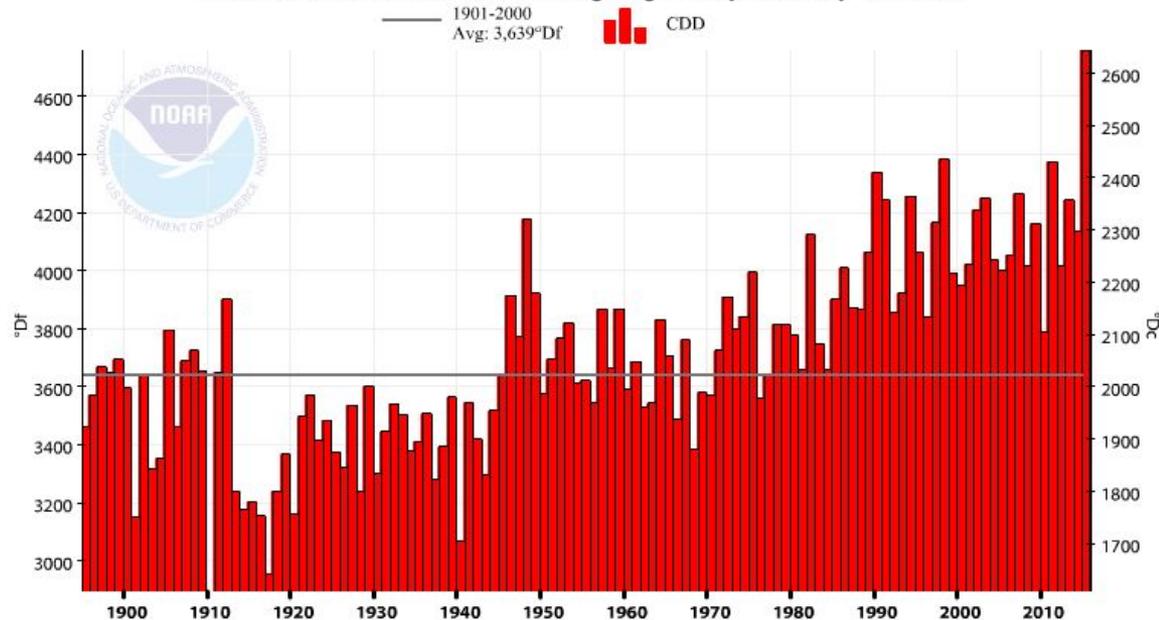
Climate Division/City: CD 6. Lower East Coast

## Options

- Display Base Period  
Start: 1901 End: 2000
- Display Trend
  - per Decade
  - per Century
  - Start: 1895 End: 2016
- Smoothed Time Series
- Binomial Filter
- LOESS

Plot

Florida, Climate Division 6, Cooling Degree Days, January-December



## Step 3: Investigate Options

*What can we do about it?*

Brainstorm options

Consider best practices

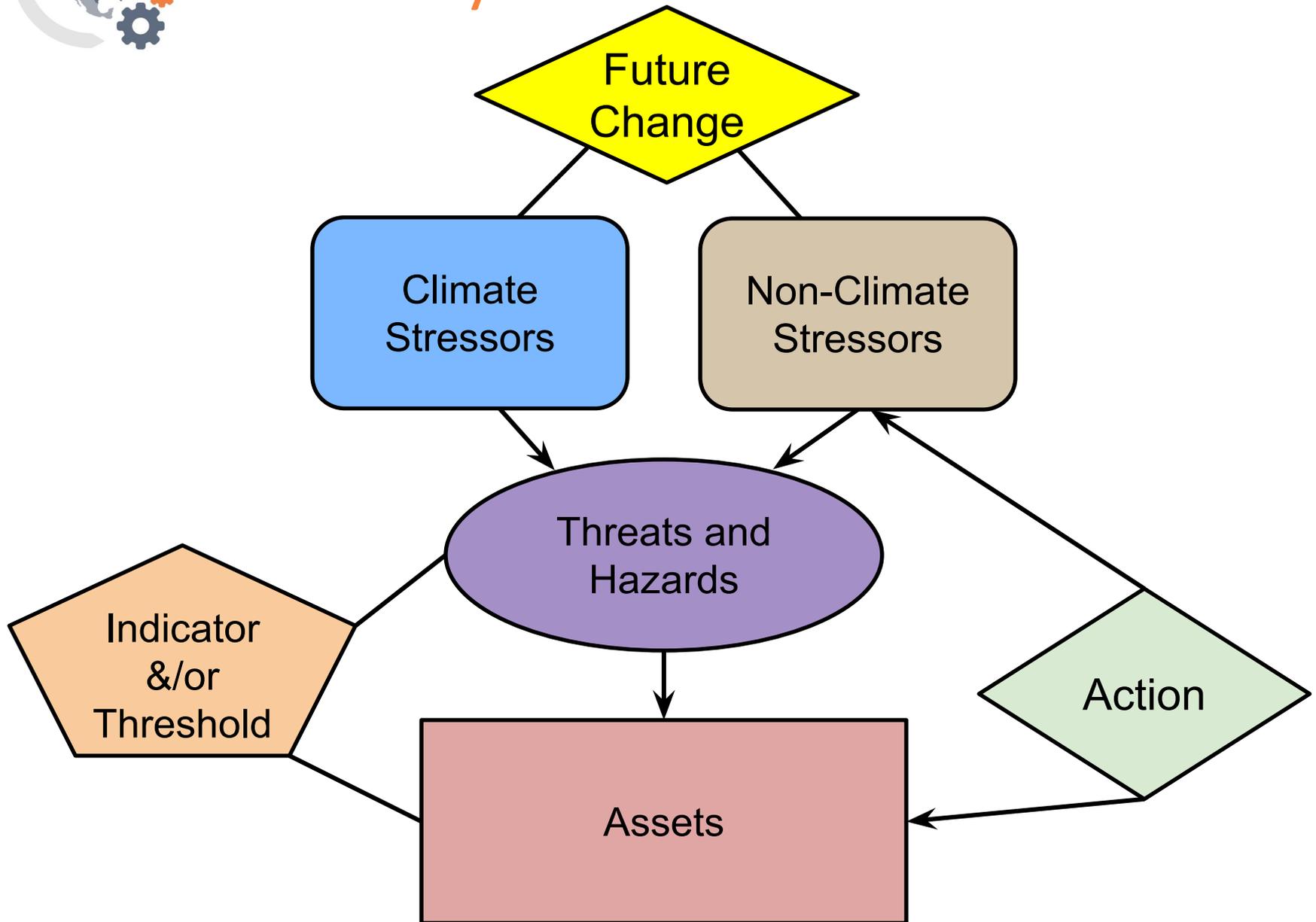
Analyze hazards

Evaluate options' feasibility, costs, and benefits

**Decision Point:**  
What actions have the potential to decrease our risk?



think in **systems**

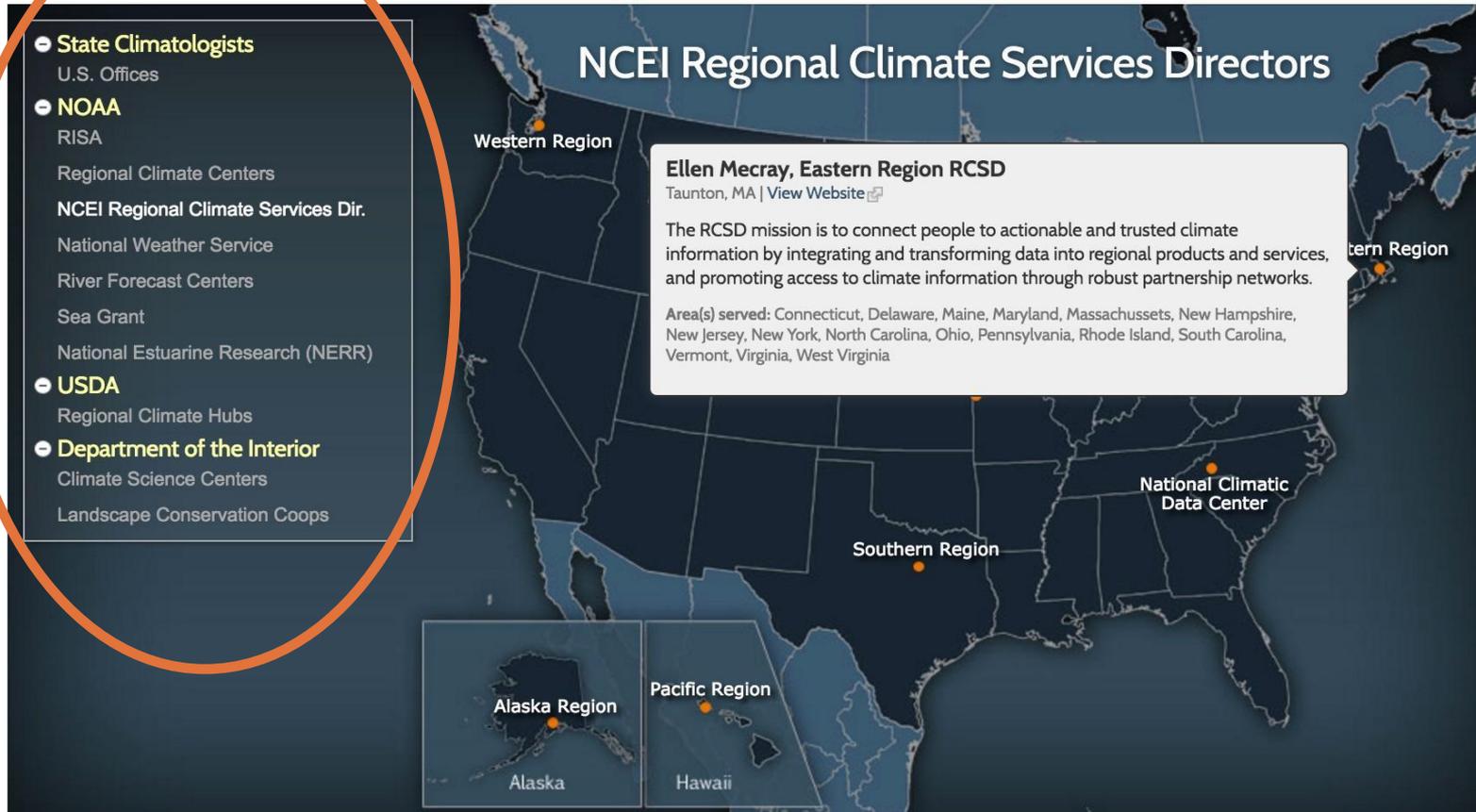


[Help](#) > [Find Experts](#) >

## Find Experts

Regional and locally-focused centers across the nation are available to help you build resilience to climate-related changes and impacts in your community. Browse the maps below, then click on an orange marker to see that office's location, the services it provides, and other information. For more information about how federal agencies collaborate, see [Federal Agency Coordination](#).

Last modified: 21 September 2015 - 12:37pm



**NCEI Regional Climate Services Directors**

**Western Region**

**Eastern Region**

**Southern Region**

**Alaska Region**

**Pacific Region**

**Alaska**

**Hawaii**

**National Climatic Data Center**

**Ellen Mecray, Eastern Region RCSD**  
Taunton, MA | [View Website](#)

The RCSD mission is to connect people to actionable and trusted climate information by integrating and transforming data into regional products and services, and promoting access to climate information through robust partnership networks.

Area(s) served: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, West Virginia

- State Climatologists
  - U.S. Offices
- NOAA
  - RISA
  - Regional Climate Centers
  - NCEI Regional Climate Services Dir.
  - National Weather Service
  - River Forecast Centers
  - Sea Grant
  - National Estuarine Research (NERR)
- USDA
  - Regional Climate Hubs
- Department of the Interior
  - Climate Science Centers
  - Landscape Conservation Coops

We offer a small but growing catalog of **Training Courses** to build climate knowledge as well as skill and capacity to use science-based tools for decision-making.

Users can easily filter by different categories, type of training, and level of difficulty.

The screenshot displays the U.S. Climate Resilience Toolkit website. At the top left is the logo, and the navigation bar includes "Get Started", "Taking Action", "Tools", "Topics", and "Expertise" (circled in orange). A search bar is on the right. Below the navigation is the "Training Courses" section, which includes a paragraph about the courses and three filter dropdowns: "Filter by category:", "Filter by type of training:", and "Filter by difficulty scale:". The "Filter by category:" dropdown is open, showing a list of categories: "Climate Products (10)", "Climate Change (11)", "Climate Variability (8)", "Climate 101 (6)", "Climate Adaptation & Mitigation (5)", "Communication (5)", "Climate Attribution & Extreme Events (1)", and "Strategic Planning (1)".

**Advanced Climate Variability and Change Course**

This three-day residence training course provides advanced knowledge in climate variability and approaches and tools for developing local climate studies.

**Category:** Climate Variability, Climate Change, Climate Products, Climate Attribution & Extreme Events  
**Type of Training:** Onsite, Instructor-Led  
**Difficulty scale:** Advanced

**Source:** National Weather Service

**An Introduction to the Downscaled Climate and Hydrology Projections Website**

These two videos serve as an introduction to the Downscaled Climate and Hydrology Projections website. This website, the result of a collaboration between several federal and non-federal partners, provides access to downscaled climate and hydrology projections for the contiguous United States and parts of Canada and Mexico, derived from contemporary global climate models. In the first video, a hydrologic engineer at the Bureau of Reclamation's Technical Service Center, in Denver, introduces the website and provides an overview of the MetEd lesson: Preparing Hydro-climate Inputs for Climate Change in Water Resources Planning. This lesson provides background information needed to use the projections site effectively to retrieve climate and hydrology projections data for impacts analysis. In the second video, another lecturer steps through the process of retrieving projections data using the website.

**Category:** Climate Change  
**Type of Training:** Online, Self-Guided  
**Difficulty scale:** Intermediate  
**Module time (hr:min):** 0:25

**Source:** MetEd UCAR Registration

**CanVis: A Tool for Visualizing Coastal Changes and Potential Adaptation Strategies**

CanVis is a tool for visualizing coastal changes and potential climate adaptation strategies. Users will learn: (1) to recognize how visualizations can change behavior; (2) the four steps for creating visualizations using CanVIS; and (3) potential applications of the software. Both instructor-led and self-guided options are offered online.

**Category:** Communication  
**Type of Training:** Online, Scheduled Lecture Series  
Online, Self-Guided  
**Difficulty scale:** Beginner  
**Module time (hr:min):** 2:00

**Source:** NOAA Digital Coast



*Where can you go to get help with resilience building?*

Many organizations are seeking help in analyzing risks and opportunities associated with climate. Here is a way to find expertise related to your concerns or region.

1. Go to the **Expertise** section.
2. Use the filters to find **training** opportunities that meet these criteria:

**Type:** Online, Self-guided

**Category:** Climate Adaptation & Mitigation

1. Find a relevant training opportunity.
2. Use the **Find Experts** map to find a land management consultant.
3. Which Department of the Interior Climate Science Center is closest to your study area?

## Step 4: Prioritize Actions

*What can we do about it?*

Consider combining  
or re-sequencing  
actions

Analyze risk  
associated with  
favored actions

Evaluate tradeoffs

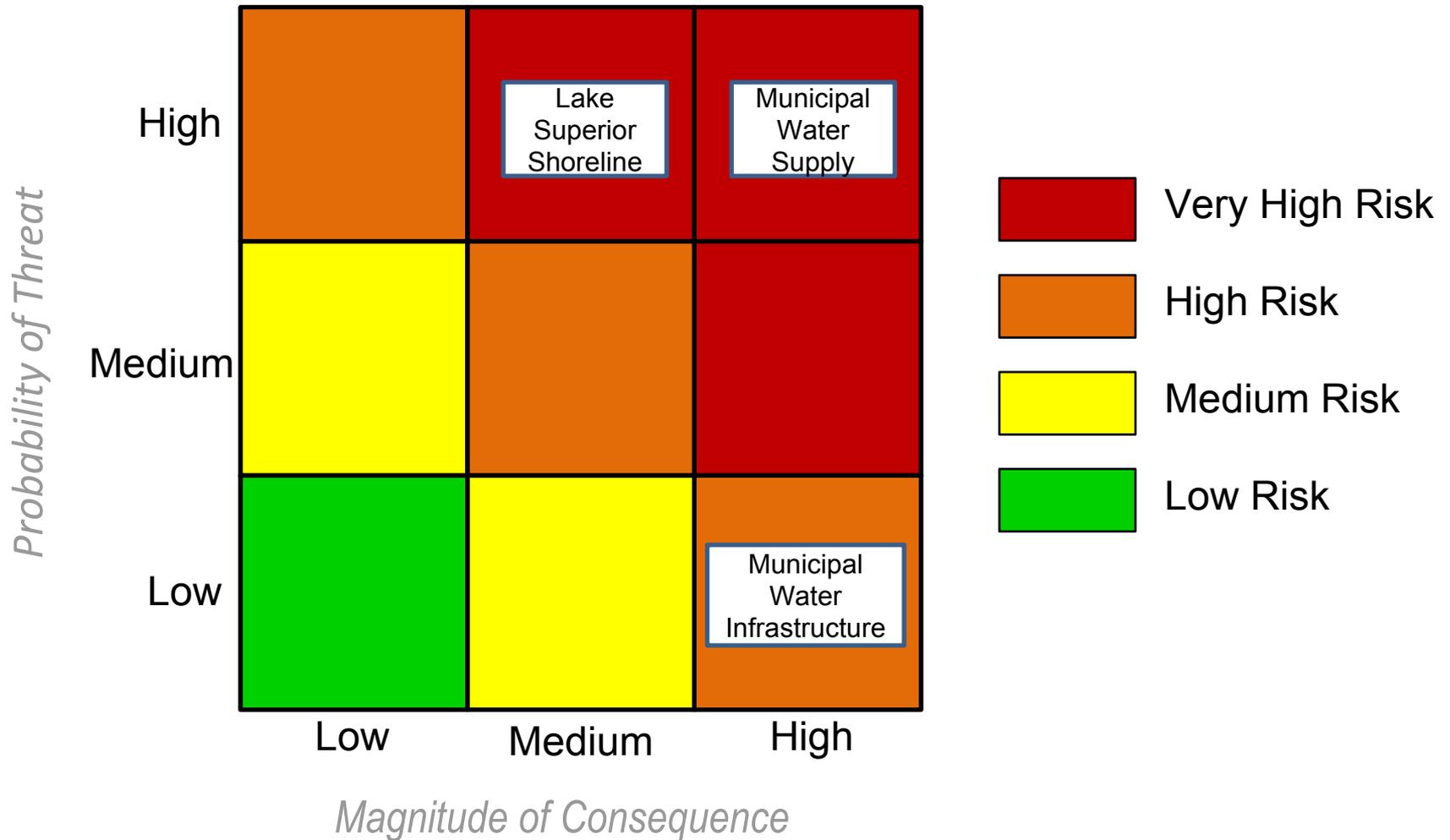
Plan the project

**Decision Point:**  
What are the best actions to  
protect what we value?

# Asset/Threat Pairs identified in Marquette, Michigan

Asset	Threat	Indicator	Stressors	Projected Change	Degree of Sensitivity / Impact	Adaptive Capacity	Critical Threshold?	Vulnerability
Municipal Water Supply	Drought	Inability to meet Demand	Extended periods	increasing	varied	low	no	medium
Municipal Water Infrastructure	Extreme Cold Snaps	Frozen Water Lines, loss of drinking water	Variability	continuing	widespread	low	yes	medium
Lake Superior Shoreline	Coastal Erosion	Road Closure	Lake Level fluctuation	continuing	widespread			high
Lake Superior Recreation	Coastal Erosion	Beach Loss						
Sands Plain Aquifer	Declining Levels	Dry wells, inland lake level decline	Climate – drought, non-climate, users	increasing	high	low	yes	high
Forested Ecosystems	Drought	Loss of species	Increased temp, invasive species					low
Forested Ecosystems	Urbanization	Loss of forest cover	Disease	increasing	moderate	low		low

# Quantifying **Risk** depends upon both Probability and Consequence



Our **Funding Opportunities** page presents a curated list of about two dozen grants offered by federal agencies & NGOs for municipalities & businesses seeking funds to help them recover from a disaster, or to build resilience to climate hazards.

Home > About >

## Funding Opportunities

Many of the strategies for increasing climate resilience come with a price tag. In the United States, a range of government entities and private foundations offer financial and technical resources to advance local adaptation and mitigation efforts. At the global scale, The World Bank and other organizations support financial strategies to build resilience. For your convenience, we have gathered information and links describing funding opportunities that may be relevant for building climate resilience. Please follow the external links to learn about any program.

- **[NOAA 2015 Regional Coastal Resilience Grant Program](#)**

The Regional Coastal Resilience Grant program will support regional approaches to undertake activities that build resilience of coastal regions, communities, and economic sectors to the negative impacts from extreme weather events, climate hazards, and changing ocean conditions. Eligible applicants include nonprofit organizations, institutions of higher education, regional organizations, private (for profit) entities, and local, state, and tribal governments. Up to \$5 million will be available; award amounts will range from \$500,000 to \$1 million. **Proposals are due by July 24, 2015.**

- **[NOAA Habitat Conservation: Coastal Ecosystem Resiliency Grants](#)**

The Coastal Ecosystem Resiliency awards will fund projects that develop healthy and sustainable coastal ecosystems through habitat restoration and conservation. NOAA anticipates that \$4 million will be available in 2015 for 1-3 year projects. Projects will primarily be funded through cooperative agreements; typical awards will range from \$500,000 to \$1 million. **Applications are due by July 2, 2015.**

- **[Building Blocks for Sustainable Communities](#)**

The EPA's Building Blocks for Sustainable Communities provides quick, targeted technical assistance to selected communities using a variety of tools that have demonstrated results and widespread application.

- **[Partnership for Sustainable Communities](#)**

The U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA) work together to help communities nationwide improve access to affordable housing, increase transportation options, and lower transportation costs while protecting the environment. The site's [map of grants](#) shows information on awards already made through Partnership programs.

- **[FEMA \(Federal Emergency Management Agency\) Preparedness \(Non-Disaster\) Grants](#)**

FEMA provides state and local governments with preparedness program funding to enhance the capacity of their emergency responders to prevent, respond to, and recover from a range of hazards.

- **[FEMA Hazard Mitigation Assistance](#)**

FEMA's Hazard Mitigation Assistance grant programs provide funding to protect life and property from future natural disasters.

- [Hazard Mitigation Grant Program \(HMGP\)](#) assists in implementing long-term hazard mitigation measures following a major disaster.
- [Pre-Disaster Mitigation \(PDM\)](#) provides funds for hazard mitigation planning and projects on an annual basis.
- [Flood Mitigation Assistance \(FMA\)](#) provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis.

- **[FEMA Disaster Survivor Assistance](#)**

Disaster survivors can find step-by-step instructions for preparing to apply for assistance, completing an application for assistance, and following up after receiving disaster assistance.

## Step 5: Take Action

*What can we do about it?*

Implement plan

Monitor progress

Iterate as needed

Share your story &  
lessons learned

### **Decision Point:**

Is the solution we chose effective?  
What else could we do?



Search > Results >

# Search

powered by webLizard

coastal flooding infrastructure



**Filter:** All Topics ▾ All Resources ▾ Show Toolkit Content First ▾

13368 documents found. You can narrow your results with the above filter settings.

## Shallow Coastal Flooding - Nuisance Flooding

 [toolkit.climate.gov](#)

inconveniences such as frequent road closures, overwhelmed storm drains, and compromised **infrastructure**, it becomes nuisance flooding. The extent of nuisance flooding depends on multiple factors, incl ...

## Sea Level Rise and Coastal Flooding Impacts Viewer

 [toolkit.climate.gov](#)

due to various possible scenarios of sea level rise. Community planners can assess what **infrastructure** is vulnerable under these conditions, and the tool enables business- and homeowners along the coa ...

## Flooding

 [toolkit.climate.gov](#)

with increasingly heavy precipitation events has the potential to overwhelm decades-old **infrastructure**, such as culverts and bridges. Higher volumes of runoff can also overflow existing retention basi ...

## Flooding

 [toolkit.climate.gov](#)

with increasingly heavy precipitation events has the potential to overwhelm decades-old **infrastructure**, such as culverts and bridges. Higher volumes of runoff can also overflow existing retention basi ...

## Grand Isle: Louisiana's First Line of Defense from Coastal Flooding

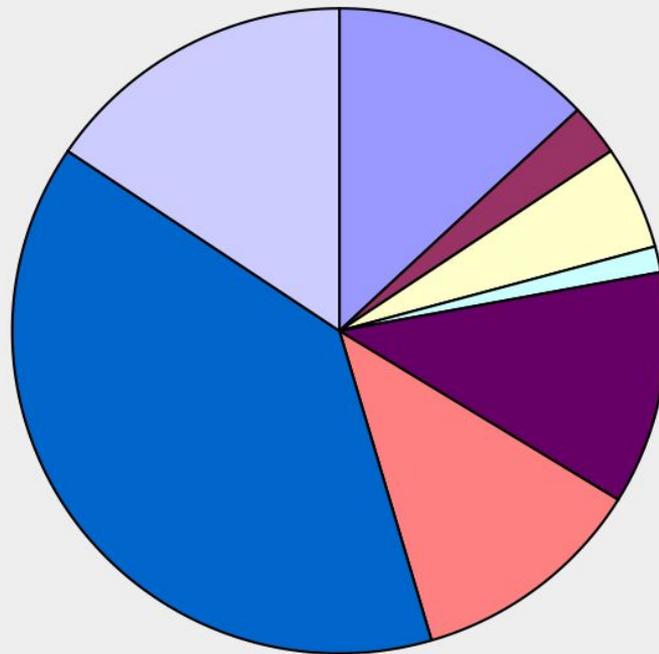
 [toolkit.climate.gov](#)

them hold their sand in place. The presence of the levees protects Grand Isle from frequent **flooding**, and helps buffer the cities behind it from the full brunt of Gulf storms. Adapting to sea level ri ...



# results of ACCO *survey*

What is the scale of your climate concerns?

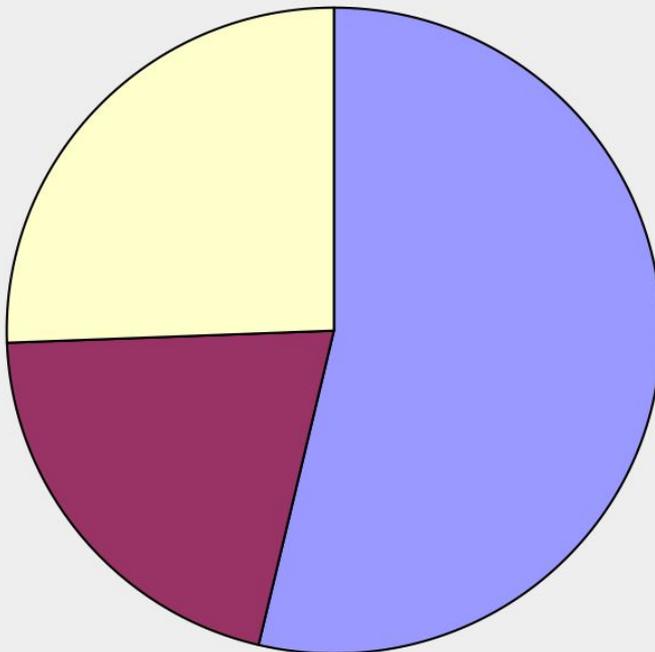


- Facility
- Section / Division
- Entire business
- Neighborhood
- City
- County
- Region
- Nation or larger



# results of ACCO **survey**

Are you seeking downscaled climate projections?



■ Yes

■ No

■ I don't know what that means.



# coming soon in **Climate Explorer 2**



[Home](#) [Menu](#)

Variable | **Mean Daily Maximum**

[Help](#) [About](#) [Definitions](#) [Credits](#)

Search by location

Mean Daily Maximum

Counties

Weather Stations

About Average Mean Temperature

## Legend

Degrees Fahrenheit

- > 105
- 90-104
- 70-89
- 50-69
- 30-49
- < 30

Source: NOAA, 2014





# climate projections at the county level

Search by location

Mean Daily Maximum

Counties  ON

Weather Stations  OFF

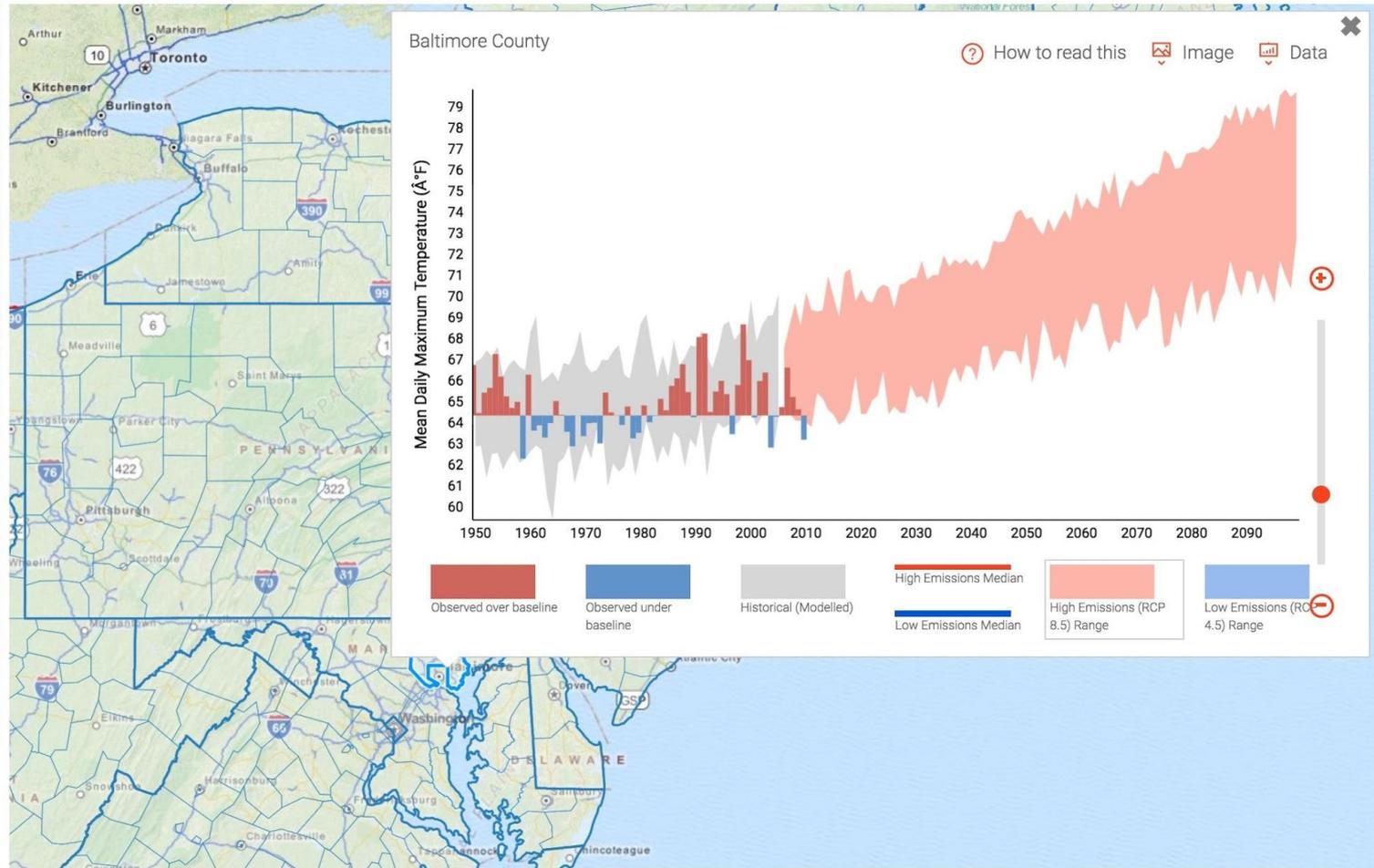
About Average Mean Temperature

Legend

Degrees Fahrenheit

- > 105
- 90-104
- 70-89
- 50-69
- 30-49
- < 30

Source: NOAA, 2014





**Objective:** help you use the CRT to meet your own needs.

- Introduce tools
  - Climate Explorer
  - Climate at a Glance
- Thinking in systems
- 5-step process

# Q & A



**David Herring**  
noaa.toolkit@noaa.gov

NWS Workshop  
May 11, 2016



# The NOAA Weather and Climate Toolkit

Mike Brewer (and Steve DelGreco and Steve Ansari)  
NOAA's National Centers for Environmental Information  
Center for Weather and Climate

May 11, 2016

NOAA Satellite and Information Service | National Centers for Environmental Information





# Overview

- Free, public domain source code
- Desktop and command-line application
- Simple visualization and data export
- Platform independent (Java-based)
- Leverages community tools and standards (NetCDF for Java, Common Data Model, etc...)



# Data

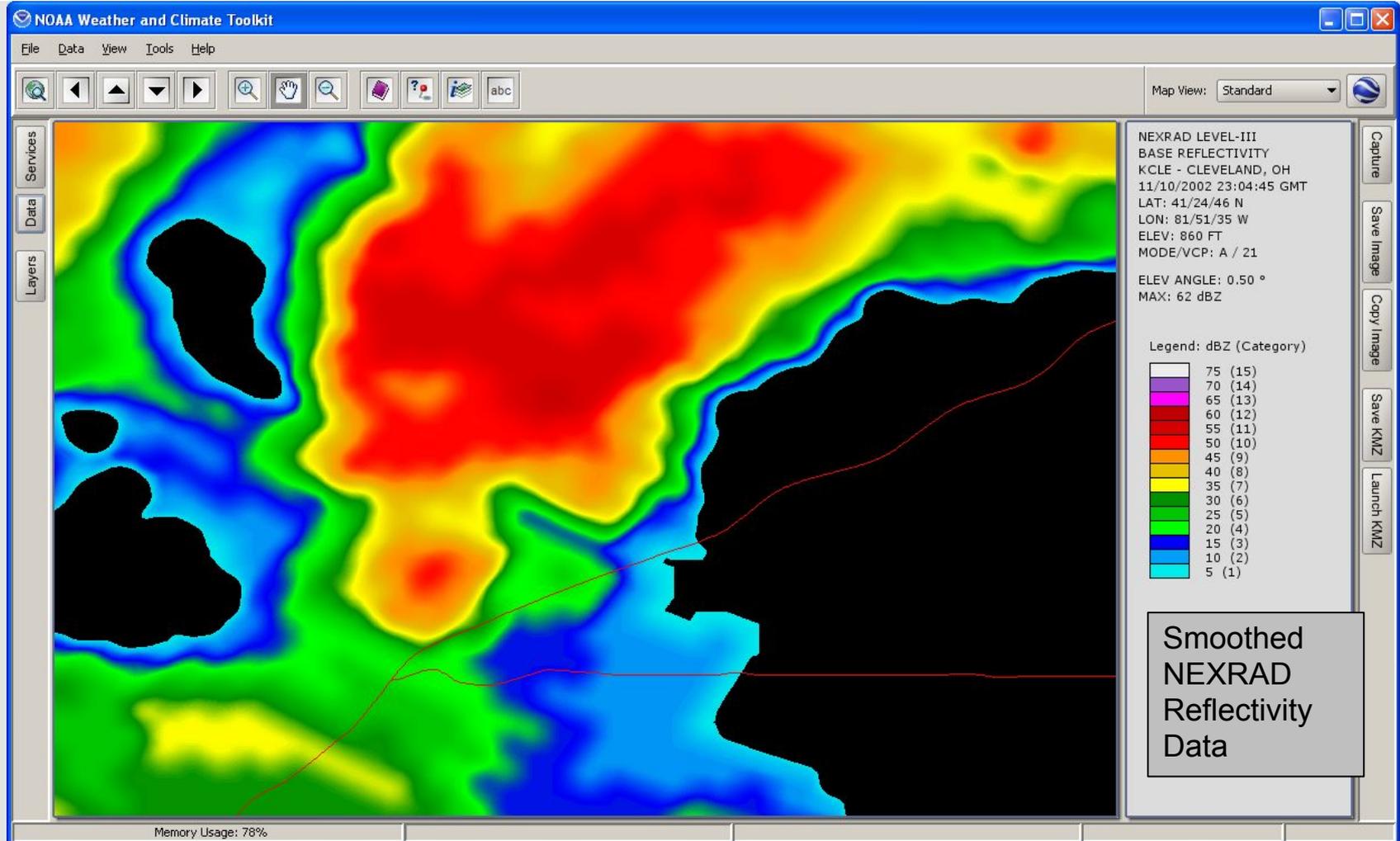
- Raw data files on disk or remote location (URL, THREDDS, OPeNDAP, etc...)
- NetCDF, GRIB, GINI, HDF, and more via Unidata Common Data Model (CDM)
  - Feature types of Grid, Swath, Radial (Time Series, Point coming soon)
- Supports
  - NEXRAD
  - GOES
  - Model Data
  - Much More



# Visualization

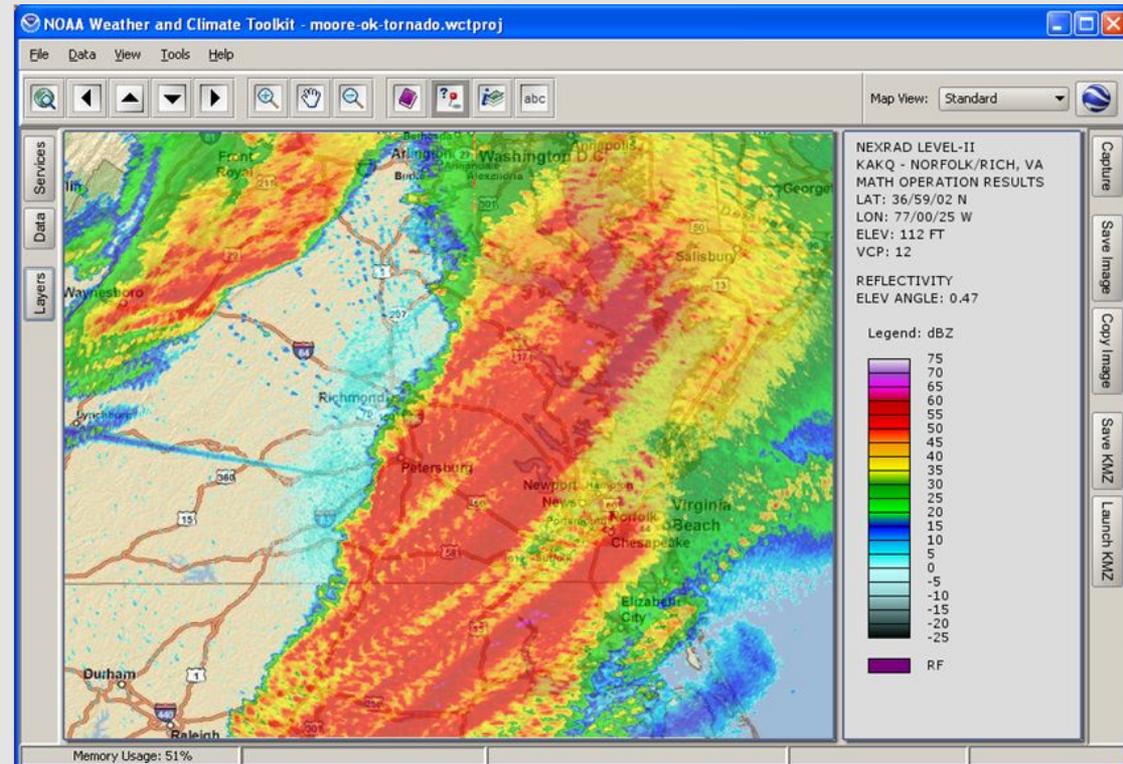
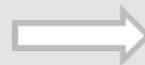
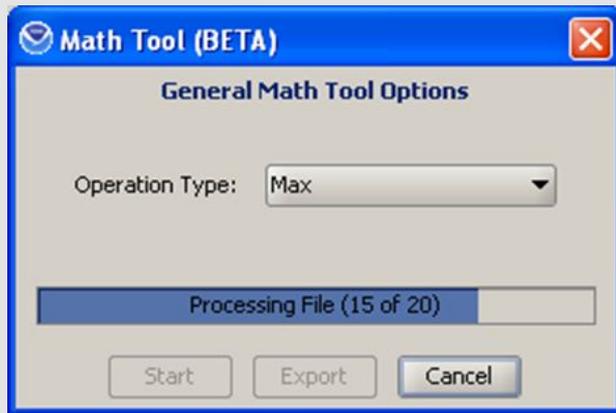
- Simple 2-D maps
- Basic Overlays included (states, counties, etc...)
- Background images from any OGC WMS
  - Shaded relief
  - Topo maps
  - Landsat
- Save images and animations
  - Animated GIF
  - AVI
  - KMZ (Google Earth)

# Visualization

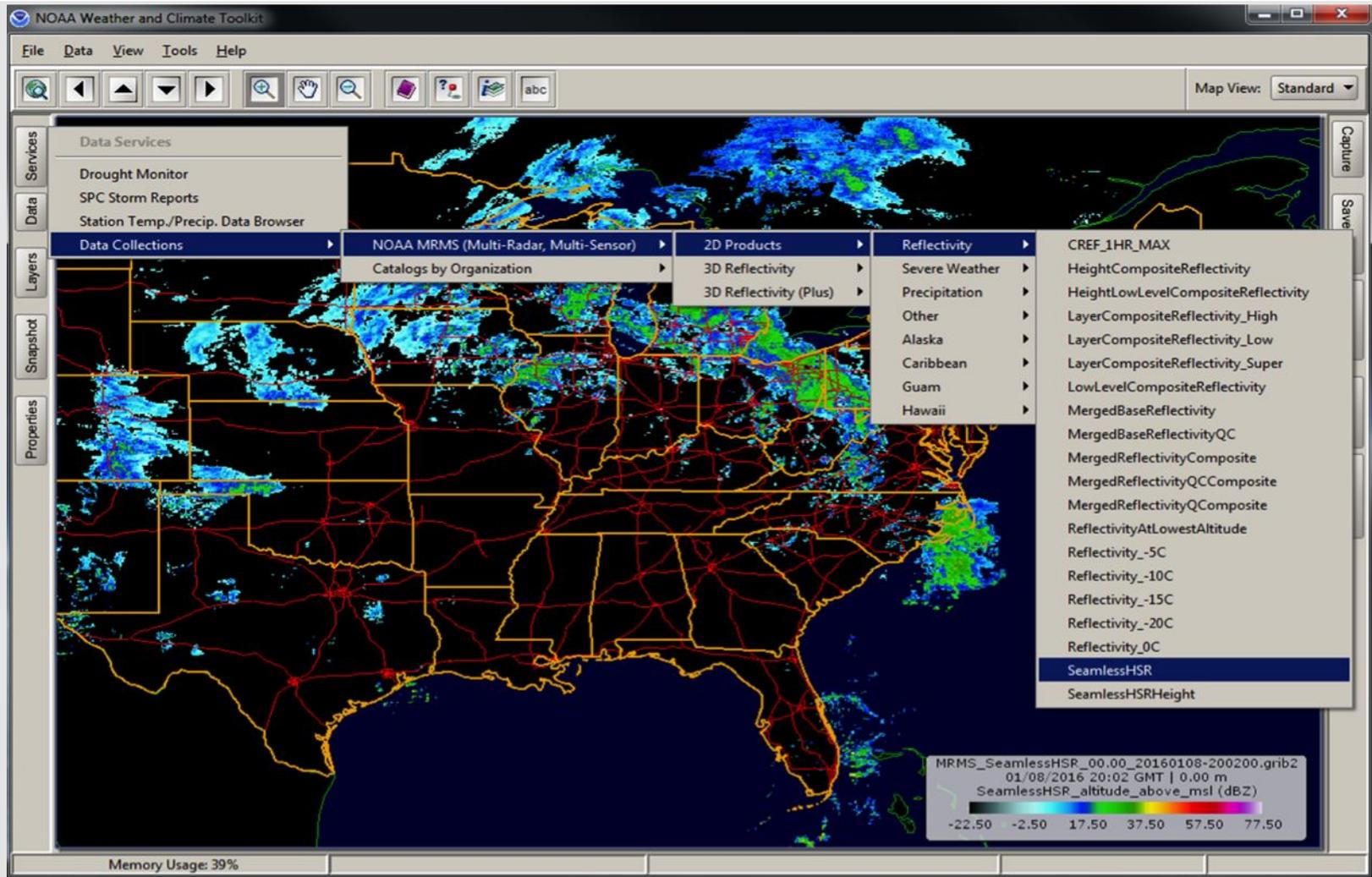


# Visualization

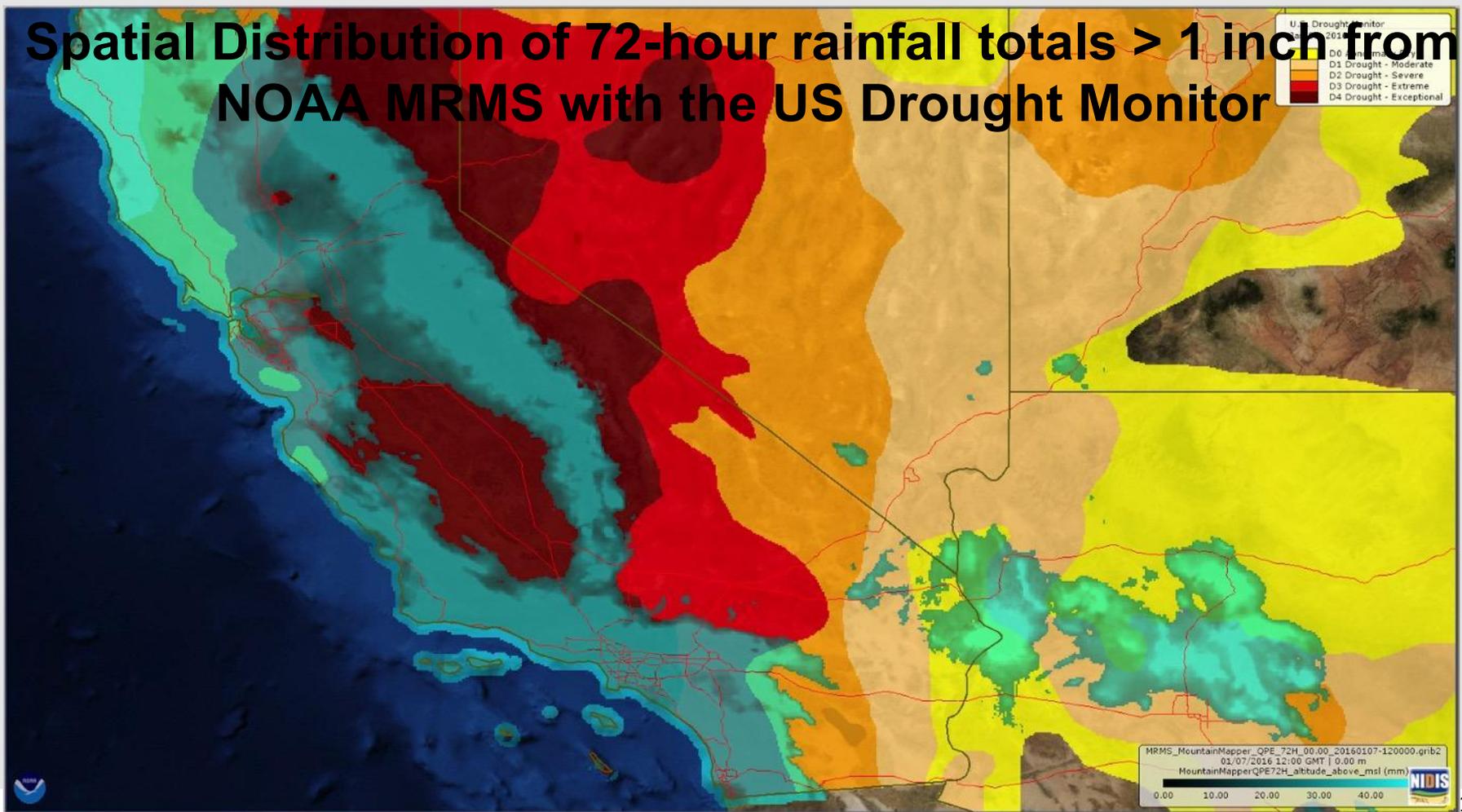
- Math tools (max, min, average, abs max, sum)
  - Under “More” on “Data Selector” or “Grid Properties”



# New Display Capability – Multi Radar multi Sensed (MRMS) Operational Products



# MRMS Overlay



# Works With Big Data

The screenshot shows the NOAA National Centers for Environmental Information website. At the top, there is a navigation bar with links for Home, Climate Information, Data Access, Customer Support, Contact, and About. A search bar is located on the right side of the navigation bar. Below the navigation bar, the breadcrumb trail reads: Home > Data Access > Radar > Radar Data in the NOAA Big Data Project.

The main content area is titled "Radar Data in the NOAA Big Data Project". It features a "Quick Links" sidebar on the left with categories: Land-Based Station, Satellite, Radar, Model, Weather Balloon, Marine / Ocean, Paleoclimatology, Severe Weather, and Blended & Global. The "Radar" category is expanded, showing sub-links for "Radar Data in the NOAA Big Data Project", "Display and Conversion Tools", "Decoding Utilities and Examples", and "Interactive Map Tool".

The main text describes the NOAA Big Data Project (BDP) as an innovative approach to publishing NOAA's vast data resources and positioning them near cost-efficient high performance computing, analytic, and storage services provided by the private sector. It mentions that this collaboration combines three powerful resources: NOAA's tremendous volume of high quality environmental data and advanced data products, private industry's vast infrastructure and technical capacity, and the American economy's innovation and energy—to create a sustainable, market-driven ecosystem that lowers the cost barrier to data publication. It refers to a "NOAA Big Data Project summary" for more information.

Below the text, it states: "Through cooperative activities as a part of NOAA's Big Data Project, NEXRAD data are now freely available through the following cloud infrastructures."

There is a section for "Amazon Web Services" which includes the Amazon Web Services logo and text stating: "The full historical archive of NEXRAD Level-2 data is available for direct download from the Amazon S3 storage or direct access from within the Amazon computing environment." It also lists links for "Amazon Documentation", "Amazon Blog", and "NCEI News Release".

# Works With Big Data

The screenshot displays the NOAA Weather and Climate Toolkit interface. The main window shows a radar map of the Amazon region with a color scale ranging from -25 to 70. A 'Data Selector' dialog box is open, showing a list of data files for 'NEXRAD Level-2' data from 'Amazon' documentation. The selected file is 'KGSP V03 20080723 00:25:47 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))'. The dialog box includes options for 'Reset Zoom', 'Data Type', and buttons for 'Load', 'Animate', 'Export', and 'More...'. The main window also has a 'Memory Usage: 9%' indicator at the bottom.

NOAA Weather and Climate Toolkit

File Data View Tools Help

Services  
Data  
Layers  
Snapshot  
Properties

Memory Usage: 9%

Data Selector

Find Data NOAA Big Data Local Disk URL Directory Single File THREDDS Catalog NCEI/CLASS Order Favorites

Access to data available from cloud collaborators in the NOAA Big Data Project [?]

NEXRAD Level-2 Amazon Amazon Documentation / NCEI News Article

List Files KGSP -- GREER, SC [map] Wed 07/23/2008 (GMT/UTC Day)

- KGSP V03 20080723 00:00:14 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- KGSP V03 20080723 00:04:31 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- KGSP V03 20080723 00:08:45 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- KGSP V03 20080723 00:13:03 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- KGSP V03 20080723 00:17:17 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- KGSP V03 20080723 00:21:32 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))
- **KGSP V03 20080723 00:25:47 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))**
- KGSP V03 20080723 00:30:02 (Level-II NEXRAD - Super Resolution (0.5 deg x 0.25 km))

Cache

Hold the 'Shift' or 'Control' keys to make multiple selections

Reset Zoom Data Type: Auto

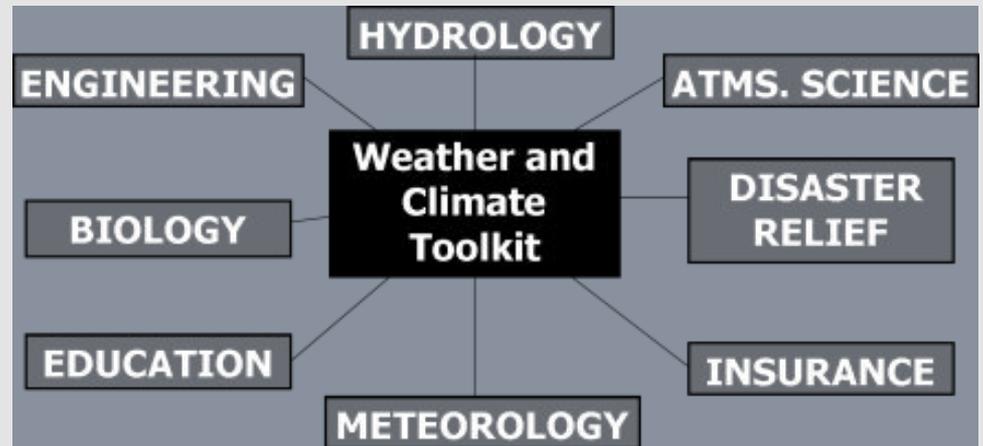
Load Animate Export More...

70  
65  
60  
55  
50  
45  
40  
35  
30  
25  
20  
15  
10  
5  
0  
-5  
-10  
-15  
-20  
-25  
RF

Save KMZ  
Launch KMZ

# Data export

- Bridge between raw weather and climate data and multiple scientific user communities

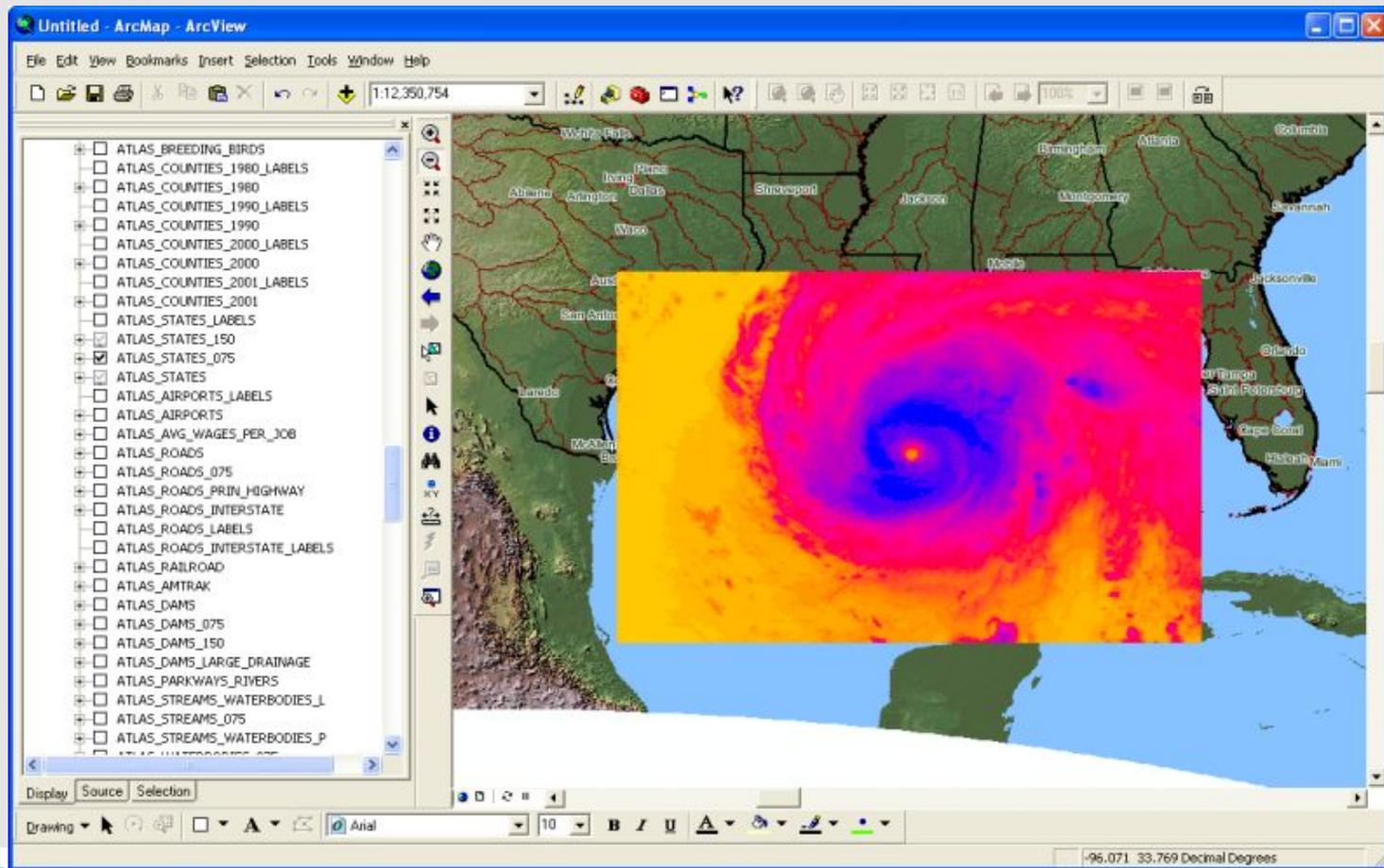


- Export data to

- Shapefile
- Well-known text
- ArcInfo ASCII GRID
- Gridded and Raw NetCDF, GeoTIFF
- KMZ (Google Earth)

# Applications

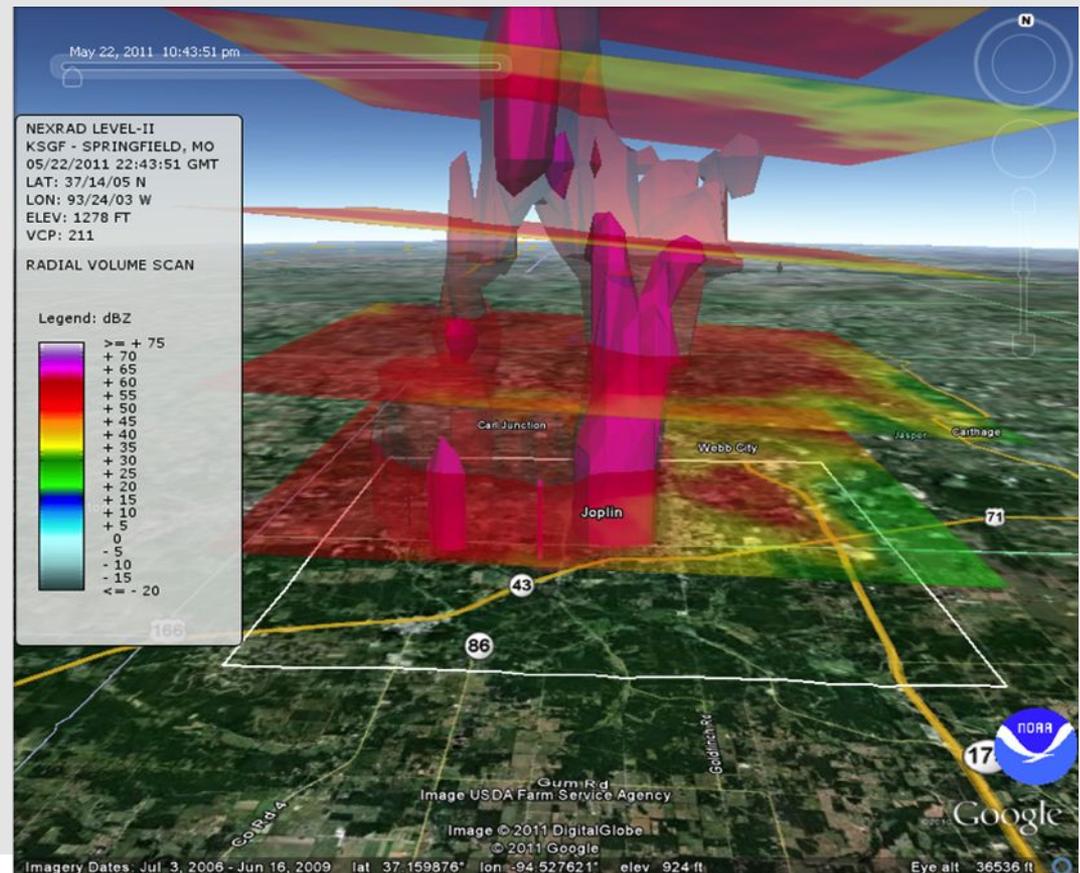
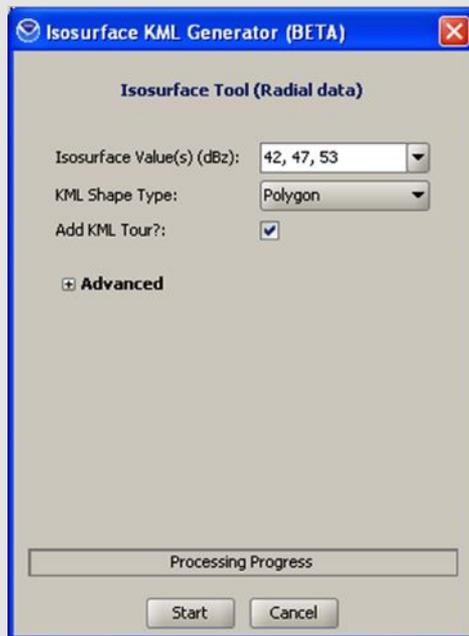
- GOES satellite imagery from hurricane Rita landfall exported as ASCII GRID, in ArcGIS



# Applications

## •3D Iso-surfaces in Google Earth

- Output of 3D polygons to KML
- Supported for Generic Radial, Level-II NEXRAD and Gridded X,Y,Z datasets



# Applications

- Command-line batch processing of data export

```
<?xml version="1.0"?>
<wctExportBatchOptions version="2">
  <!--
    Logging options: These can be 'SEVERE', 'WARNING', 'INFO',
  -->
  <logging> WARNING</logging>

  <!-- =====
  <!-- Grid Section - decoding and filtering options
  <!-- =====
  <grid>
    <gridFilter>
      <!--
        Geographic Extent Filter units of decimal degrees
      -->
      <minLat> NONE</minLat>
      <maxLat> NONE</maxLat>
      <minLon> NONE</minLon>
```

```
C:\ Command Prompt
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>wct ..\data\goes12.2004.247.212513.BAND_03
2513.BAND_03.asc asc wctBatchConfig.xml
WARNING: Environment Variable WCT_HOME is not set.
file:/E:/work/batch2/wct/./data/goes12.2004.247.212513.BAND_0
.247.212513.BAND_03.asc
0%...10%...20%...30%...40%...50%...60%...70%...80%...
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>
E:\work\batch2\wct>wct ..\data\goes12.2004.247.212513.BAND_03
2513.BAND_03.asc asc wctBatchConfig.xml
WARNING: Environment Variable WCT_HOME is not set.
file:/E:/work/batch2/wct/./data/goes12.2004.247.212513.BAND_0
.247.212513.BAND_03.asc
0%...10%...20%...30%...40%...50%...60%...70%...80%...
E:\work\batch2\wct>
```



# Application

- Public domain / Open source API

```
String source =  
    "E:\\work\\goes\\katrina\\goes12.2005.241.144513.BAND_04";  
  
GoesRemappedRaster goes = new GoesRemappedRaster();  
goes.setHeight(500);  
goes.setWidth(500);  
  
Rectangle2D.Double bounds =  
    new Rectangle2D.Double(-102.0, 17.0, 24.0, 24.0);  
  
goes.process(source, bounds);  
  
System.out.println("WRITING ASCII Grid");  
WCTRasterExport rasterExport = new WCTRasterExport();  
rasterExport.saveAsciiGrid(new File(source+".asc"), goes);
```

# Application

- Public domain / Open source API

```
String source =  
    "E:\\work\\goes\\katrina\\goes12.2005.241.144513.BAND_04";  
  
GoesRemappedRaster goes = new GoesRemappedRaster();  
goes.setHeight(500);  
goes.setWidth(500);  
  
Rectangle2D.Double bounds =  
    new Rectangle2D.Double(-102.0, 17.0, 24.0, 24.0);  
  
goes.process(source, bounds);  
  
System.out.println("WRITING ASCII Grid");  
WCTRasterExport rasterExport = new WCTRasterExport();  
rasterExport.saveAsciiGrid(new File(source+".asc"), goes);
```

# Other New Features (Version 4.1+)

- GeoJSON output format for point/line/polygon data structures
- Animations of Level III storm attribute products include selected background products
- Snapshot layers can now be exported to a Raster format
- Support NEXRAD Level III melting layer and free text message products
- Removal of embedded Google Earth plug-in (no longer supported by Google)
- Command-line export of KMX format (V3.7+)



# NOAA's National Centers for Environmental Information

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[Michael.J.Brewer@noaa.gov](mailto:Michael.J.Brewer@noaa.gov)

[\*\*www.ncei.noaa.gov\*\*](http://www.ncei.noaa.gov)



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