# Climate Impact and GIS Education Using Realistic Applications of Data.gov Thematic Datasets in a Structured Lesson-Based Workbook

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ABSTRACT: This project created a workbook which teaches Earth Science to undergraduate and graduate students through guided in-class activities and take-home assignments organized around climate topics which use GIS to teach key geospatial analysis techniques and cartography skills. The workbook is structured to the White House's Data.gov climate change themes, which include Coastal Flooding, Ecosystem Vulnerability, Energy Infrastructure, Arctic, Food Resilience, Human Health, Transportation, Tribal Nations, and Water. Each theme provides access to framing questions, associated data, interactive tools, and further reading (e.g. The US Climate Resilience Toolkit and National Climate Assessment). Lessons make use of the respective theme's available resources. The structured thematic approach is designed to encourage independent exploration. The goal is to teach climate concepts and concerns, GIS techniques and approaches, and effective cartographic representation and communication results; and foster a greater awareness of publicly available resources and datasets. To reach more audiences more effectively, a two level approach was used. Level 1 serves as an introductory study and relies on only freely available interactive tools to reach audiences with fewer resources and less familiarity. Level 2 presents a more advanced case study, and focuses on supporting common commercially available tool use and real-world analysis techniques.

# Goals and Objectives of this Study

1) Develop an Earth Science geospatial analysis ***workbook*** around climate resources and data provided through the Climate Data Initiative (CDI) website, and

2) Develop a ***workbook*** which can be used by other teachers and material developers and which highlights the utility of both CDI and CRT in such pedagogical applications

3) Report on progress from last year's presentation [Griffin et al., 2016]

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# Climate Data Initiative (CDI)

The focus of Climate.Data.gov is on providing data related to climate change that can help inform and prepare America's communities, businesses, and citizens.

CDI currently identifies **9 major topical areas** and organizes information about each based on (a) data and (b) resources available both of which are used here. *(http://www.climate.data.gov)*

**Resources** *(non-GIS\*)*  **Data** *(GIS-specific)*

\*not specifically GIS-related, many of these are however portals to access and download geospatially-referenced datasets

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# Welcome to UAH *ESS414 [Geospatial Applications]*



- Fall 2016
- 16-week class
- 14 students
- Lecture + Labs
- Focus on Earth Sciences
- Real-world Applications
- 9 CDI Themes

*Course Schedule:*



Earth System Science (ESS) 414 was formerly based around the GEO Societal Benefit Area Themes *[more to come on this]*, but was reworked to focus on the **Climate Data Initiative (CDI)** and **Climate Resilience Toolkit (CRT/NOAA)**. The goal was to continue to communicate and teach key geospatial analysis and cartographic concepts but within a new framework focused on the use of open-access federal geospatial datasets and allowing students to identify and study climate-related issues. Another goal was to demonstrate the utility of the CDI/CRT framework as a teaching tool and to provide increased visibility.

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# Climate-Focused Model for Applications



*http://www.climate.data.gov*



*http://www.globalchange.gov*

**Sector Themes:** *Coastal Flooding; Ecosystem Vulnerability; Energy Infrastructure; Food Resilience; Human Health; Transportation; Tribal Nations; Water* | **Region Themes:** *Arctic*

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# Approach: Thematic Course Modules

Nine thematic areas were divided over the course of the semester, making approximately 1.5 weeks per theme. This time was divided between identifying and discussing climate change-related issues and addressing them using CDI-catalogued datasets and GIS techniques.

Each **theme thus formed a "module"** with each module broken up as follows:

1) "**Identifying the Problem**" (from CRT)
   a) Reading and discussion of relevant *National Climate Assessment* chapters
   b) Identifying and presenting a summary of a *recent peer-reviewed case study* which uses geospatial analysis to study an aspect of the module theme, usually using Google Scholar to locate the published case study

2) "**Determining Vulnerabilities**" (from CRT)
   a) *Group discussion and presentation of resources* available through CDI's theme
   b) *Guided take-home activity* highlighting multiple resources and identifying key geographic concepts and data formats through CDI's Resources pages.
   c) *GIS-centered activity* focused on data access and download via CDI to address "problems" as identified in Step 1, requiring the use of GIS software and culminating in a map submitted.

# Workbook Guided Activities – CDI Resources

A guided series of step-by-step instructions and explanations of resources and file types, including case study locations are provided for students to review and explore data available. This is intended as a more structured version of their group activities, highlighting particular tools and data resources for them as a class.

Theme: *Coastal Flood Risk (CFR)*
1) *Review Data Formats – KML/KMZ*
2) *Differentiate between web map applications (eg ArcGIS Server or Arc Online) and downloadable data such as Google Earth files*
3) *Explore case studies using the Sea Level Rise and Coastal Flooding Impacts Viewer (NOAA)*
4) *Explore case studies using FEMA's National Flood Hazard Layer and download example pdf files showing flood zones*

*\*These activities do not rely on a commercial GIS software package like ESRI ArcGIS. Rather they use in-browser web GIS tools or free resources such as Google Earth or Adobe Acrobat to open and, in some cases, explore files.*

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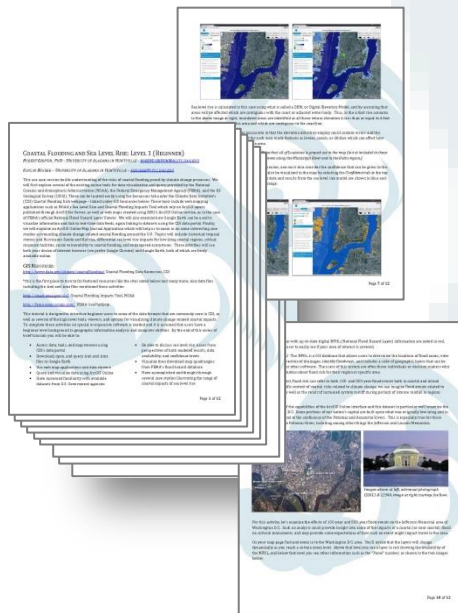
# Workbook GIS Labs – CDI-catalogued Data

**Concepts:** Social Vulnerability Index; Sea Level Rise im**pacts**
**Data Access:** SOVI, FEMA, NOAA SLR, US Census
**GIS Analyses:** raster-vector conversions, zonal statistics, symbology, cartography, projections
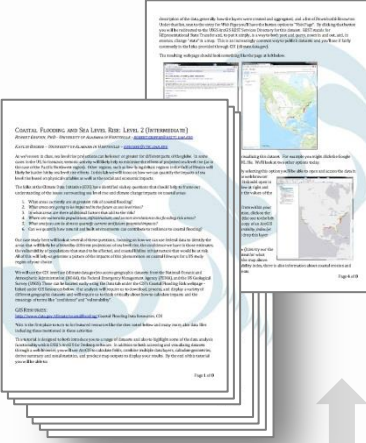
**NCA Key Message #3:**
Socioeconomic disparities create uneven exposures and sensitivities to growing coastal risks and limit adaptation options for some coastal communities, resulting in the displacement of the most vulnerable people from coastal areas.

**CDI Framing Question #4:**
Where are vulnerable populations, infrastructure, and sectors in relation to the flooding risk areas?



Social Vulnerability to Sea Level Rise

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# Arctic



Impact of Climate Change on the Arctic

These maps illustrate the impact of climate change on the Arctic. The map on the left shows the potential impact of rising temperatures on permafrost and areas of high population density. The inset map shows that there will be a larger impact on Anchorage, Alaska as permafrost melts. The map on the right presents the changing extent of sea ice for the month of May. Since 1980, there has been a decrease in sea ice extent of 18, 569 km. Sea ice provides an important habitat for polar bears.

Potential Relative Impact of Rising Temperatures on Permafrost

Relative impact
low
moderate
high

0  87.5  175      350      525      700 Miles

Sea Ice Extent for March 1980 and March 2015

Sea Ice Extent
1980
2015

0 337.5 675   1,350    2,025    2,700 Miles
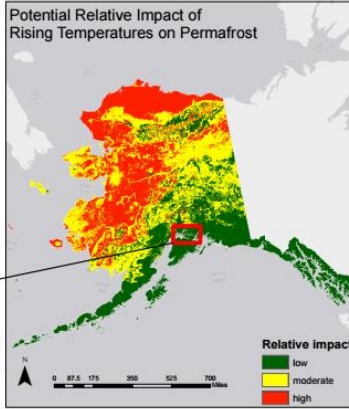
Map by:                                    Right Projection: NAD 1983 Alaska Albers; Left Projection: Stereographic North Pole
Data credits: Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community, CDC, US Census,
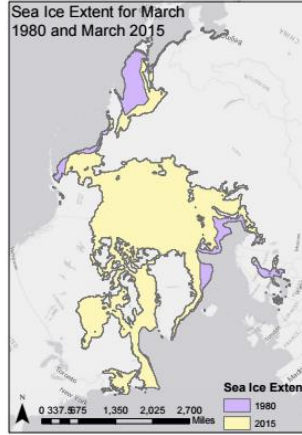
**Framing questions from CDI theme**

- To what extent are Alaska's people and infrastructure at risk from subsidence due to thawing permafrost, and how will changing climate patterns affect these potential hazards?
- How may the habitats of iconic Arctic species be affected by changes in sea ice extent over time?

**Data resources accessed through CDI**

- National Oceanic and Atmospheric Administration, (NOAA)

- National Snow  Ice Data Center (NSIDC)

- AOOS Arctic Data Integration Portal

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# Ecosystem Vulnerability
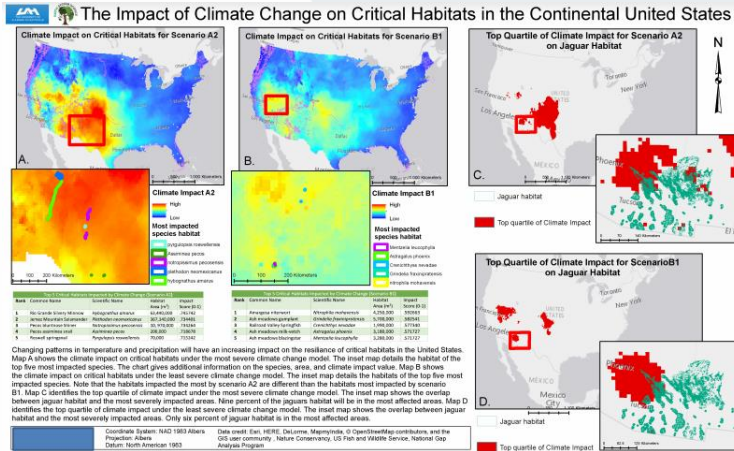


**Framing questions from CDI theme**

- What are the potential impacts of climate change on protected habitat areas?

- How might changes in climate and protected habitats impact rare and endangered species, iconic species, and their ecosystems?

**Data resources accessed through CDI**

- The Nature Conservancy Climate Wizard

- USGS National Gap Analysis Program (GAP)

- CDI Ecosystem Resources Site

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# Human Health



The Impact of Increasing Temperatures on Health in the United States
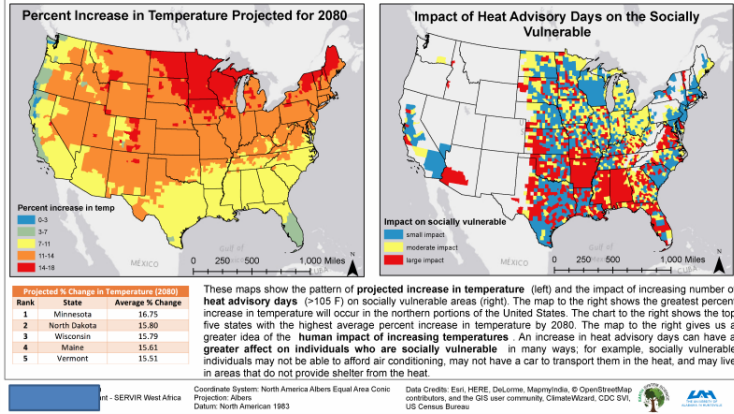
**Framing questions from CDI theme**

- What risk factors make individuals or communities more vulnerable to climate-related health effects?

- How will rising temperatures and greater heat advisory days in regions impact human health populations in those regions?

**Data resources accessed through CDI**

- The Nature Conservancy Climate Wizard

- CDC WONDER North America Land Data Assimilation System

- Social Vulnerability Index (SoVI)

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# Transportation



Hurricane Sandy and Subway Inundation in New York City

**Framing questions from CDI theme**

- How will climate trends affect transportation systems and their future design?

- What parts of the transportation system will be most vulnerable to climate change?

- How can climate information most effectively be translated for use by transportation practitioners?

- How will climate adaptation need to be integrated into existing transportation management systems?

- What tools and datasets apply broadly to different transportation users and sectors?

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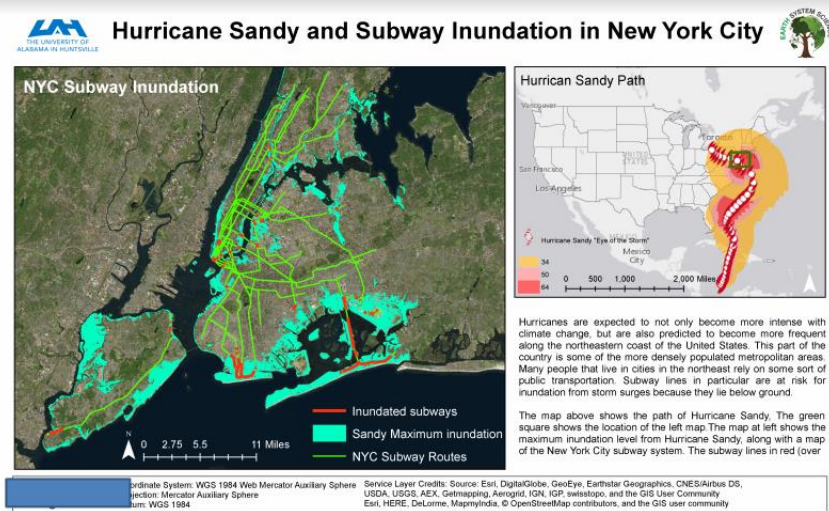
# Water



The Impact of La Nina and El Nino on Precipitation in the Continental US
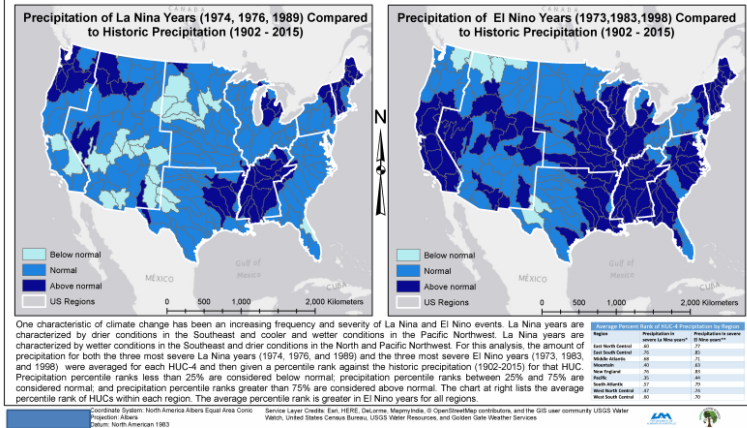
**Framing questions from CDI theme**

- How could La Nina affect runoff levels in 2017?

- How can stream runoff data be used as a proxy for the impacts of El Nino and La Nina years on precipitation patterns in the United States?

- How can runoff percentiles be used to compare data for a particular year (or month) to historical averages?

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# Coastal Flooding



**Vulnerability to Rising Sea Levels in Mobile, AL**

These maps show the potential impact of 1-foot and 6-foot sea level rise in Mobile, Alabama. Areas in red indicate the most socially vulnerable areas; these include downtown Mobile and extreme southern Baldwin County and Dauphin Island. Dowtown Mobile also has the most people at risk from sea level rise.

**Social Vulnerability by Census Tract**

most vulnerable: >0.5 std. dev.
- < 3092 people affected
- 3092 - 6185 people affected
- 6185 - 9279 people affected

midpoint: -0.5 to 0.5 std. dev.
- < 3092 people affected
- 3092 - 6185 people affected
- 6185 - 9279 people affected

least vulnerable: <-0.5 std dev
- < 3092 people affected
- 3092 - 6185 people affected
- 6185 - 9279 people affected
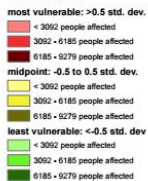
Created by ... 2016
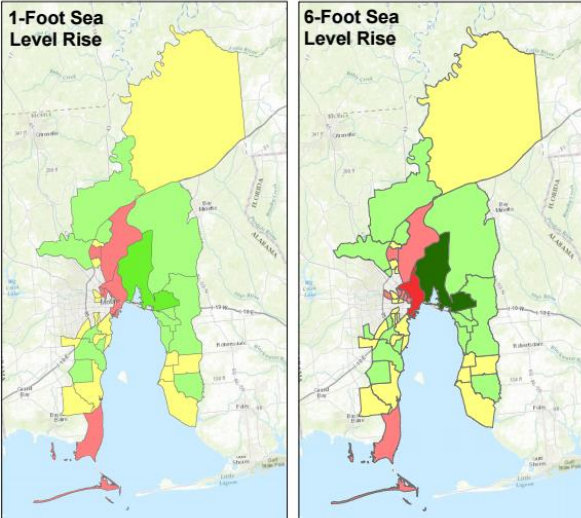Coordinate System: GCS North American 1983;
Projection: Albers;Datum: North America 1983

Data Credits: ESRI, NOAA, HERE, DeLorme, Intermap, Increment P Corp, US Census, FAO, NPS, NRCAN, OpenStreetMap contributors and the GIS User Communtiy

## Framing questions from CDI theme

- What areas are currently at greatest risk of coastal flooding?

- What areas will be affected in the future as sea level rises?

- Where are vulnerable populations, infrastructure, and sectors in relation to the flooding risk areas?

## Data resources accessed through CDI
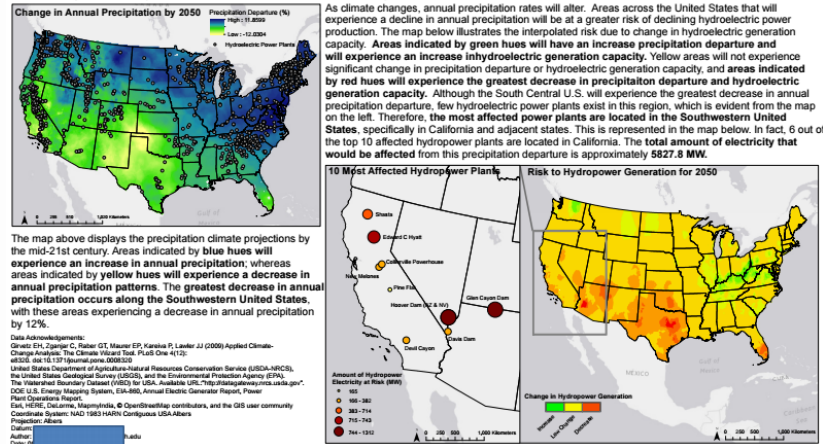
- Federal Emergency Management Agency (FEMA)

- USGS Coastal Vulnerability to Sea Level Rise

- USC Social Vulnerability Index (SoVI)

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# Energy Infrastructure



**Framing questions from CDI theme**

- How are fundamental energy resources impacted by climate?

- How might changes in climate and natural resource availability impact energy conversion infrastructure and processes?

**Data resources accessed through CDI**
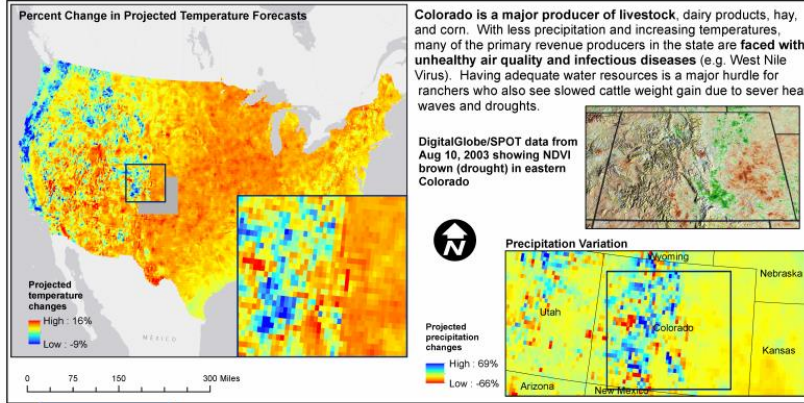
- The Nature Conservancy Climate Wizard

- USGS National Hydrography Dateset

- Department of Energy U.S. Energy Mapping System

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# Food Resilience



Vulnerability to Agriculture in the Midwest
A Look at Food Resilience with Past and Projected Climate Data to 2080

**Framing questions from CDI theme**

- How will crop yield and production of other food products be affected by changes in climate?

- What types of food and locations will be most vulnerable to changes in climate?

**Data resources accessed through CDI**

- USDA National Agricultural Statistics Service

- CDI Food Resilience Resources

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# Geospatial Concepts Teaching Results:

Geoprocessing operations and workflows; Spatial and attribute query; Projections and coordinate systems; Raster operations, calculations, and zonal statistics (spatial analysis); Map layout and cartography; Data symbology and display
*focus for these activities and GIS analysis was on ESRI ArcGIS 10.3 with Spatial Analyst extension*

# Climate Data Initiative Teaching Results:

Available data resources, tools, and featured content; Familiarity with website; Linking questions to data, analysis, then interpretation of results; Awareness of federal resources and climate change impacts; Ability to link concepts and problems identified using CRT's model with data and analysis using data query in CDI

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# Thank you, any questions?

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