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Introduction to Human-Environment Geography: A Laboratory Manual

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Introduction to Human-Environment Geography: A Laboratory Manual

Introduction to Human-Environment Geography: A Laboratory Manual

ZACHARY J. SURIANO

OMAHA, NE, USA

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https://pressbooks.nebraska.edu/humanenvironmentgeographylabmanual/

Contents

1. Lab 1: Land Use/Land Cover Change

Introduction

In the subject of Geography, much of the information presented takes the form of maps. As such, being able to locate places, describe physical features, and assess changes over time are of critical importance. This first laboratory exercise is designed to acquaint you with basic map interpretation, through the perspective of land-use/land cover change, a reoccurring topic in lecture.

For today's exercise, we will leverage the historical example of land cover change in the Hetch Hetchy Valley of California, along with the more localized change in Omaha, NE. The objectives of this lab are to:

- Become familiar with orienting on a map
- Further explore the historical decision to flood Hetch Hetchy Valley
- Approximate how land use/land cover has changed in Omaha, NE over the last century
- Contemplate the impact land use/land cover change has on the region

Background Information/Further Reading

Latitude and Longitude

Where are you right now? Most of the time, your answer to that question will be framed in the context of permanent and known locations: "I am next to the park off Harrison", or "I'm two miles north of the Adams Park Community Center", or "I'm at the intersection of Dodge and 72nd". In these cases, this assumes everyone knows where those locations are. When we scale up from Omaha to the entire globe, we need fixed and known locations which can be referenced quickly to inform us where we are. This is where latitude and longitude come in.

Every 24 hours, the Earth rotates about its axis. This axis is a ‘line’ which passes through the center of the Earth, and intersects the fixed points of the North and South Poles. If we find every point on the Earth’s surface that is equidistant from these two poles, and connect the points, we would be drawing the circumference of the planet – called the equator. Our first (of two) units to inform our location is called latitude. Latitude is the distance a location is from the equator or from the pole. It is typically measured in degrees from the equator – a measure of the interior angle produced by a line extending from the desired location to the center of the earth to the equator (see figure 1.1). Thus, the North and South Poles are both 90° from the equator. To keep things from getting confusing and to differentiate between poles, the distinction N or S is added. Thus, the North Pole is at 90°N latitude, and the South Pole is at 90°S latitude, while the latitude of the equator (aka the angle of the equator from the equator) is 0°. Take Omaha, NE as an example. It is located at approximately 41°N latitude, and that angle can be seen in Figure 1.1.

The second measure is that of longitude. The second measure is necessary because there are many points on the planet that are 41°N of the equator, and we need a way to differentiate them. Longitude is the measure of distance east-west of an internationally-agreed line called the Prime Meridian – the line which extends from the North Pole to the South Pole, and passes through Greenwich, England. This line is called 0° longitude, and other locations are measured as the angular distance east or west of this line. Omaha is located 96° west of the Prime Meridian (Figure 1.1). Putting latitude and longitude together, we can provide a unique location for any point on the surface of the earth.

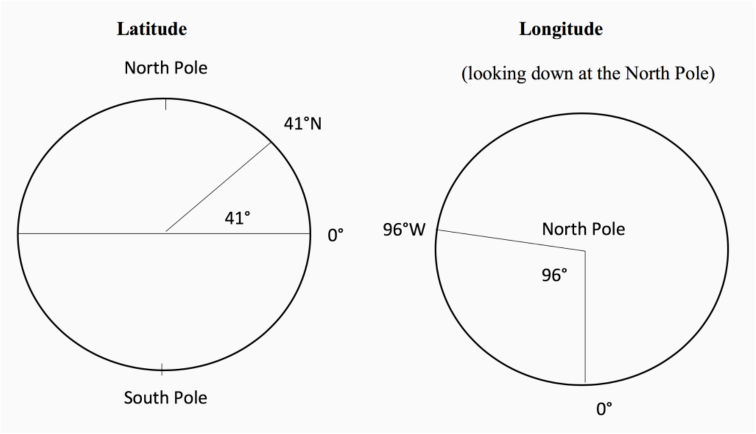


Figure 1.1. Omaha, NE is located at 41°N latitude and 96°W longitude.

Land Use/Land Cover

Land use and land cover are two of the most dominant ways in which people describe the environment. Land use denotes the activities taking place on the land surface, such as growing food, harvesting trees, or building cities. Land use shows how people use the landscape. Land cover, on the other hand, is the physical characteristics of the land surface. Is it covered by trees, concrete, soy beans, grass, water, etc. The decision to change land use/land cover from its natural (non-anthropogenic) state to something of benefit to society can have both positive and negative effects. Consider the example discussed in your textbook (Moseley) of Hetch Hetchy Valley in California (pg 18-25). In 1923, the O'Shaughnessy Dam was completed, and the Hetch Hetchy Valley was flooded to become a reservoir for supplying water to San Francisco's consumption and sanitation needs. The decision to flood the valley led to the large and growing city having the resources it needed, but at a price, the 'natural beauty' of the valley, including its ecological diversity.

Land use cannot be directly determined by using areal or satellite imagery, however land cover can. Maps of land cover provide critical information to assist managers in understanding the current landscape, but also can be leveraged over time to evaluate past management/planning strategies, and gain insights into the possible impacts of current or pending land use/land cover change decisions. Such maps can be used to assess urban growth, model water and ecological quality, predict or assess impacts from floods, track sea-level rise, prioritize areas for conservation efforts, and compare impacts with various socioeconomic influences, a topic embedded in Environment Justice (later in the course).

Google Earth – App

To assist you in your investigation of land use/land cover changes, you will be using Google Earth in Part 1, followed by the Douglas County's GIS website (https://www.dogis.org/Html5Viewer/?viewer=dogis) for Part 2. When using the Google Earth App, you can adjust your map style in the home tab (3 vertical lines). Starting with the "Exploration" or "Everything" settings is recommended. Under settings, have your units of measure be "meters and kilometers", and latitude/longitude formatting in "Decimal". Prior to coming to lab, you are welcome to play around with Google Earth (free download) to familiarize yourself with its features. This is freely available using the Google Chrome web browser. Visit https://www.google.com/earth/, and click "Launch" in the top right corner.

Within Google Earth App, you can use the latitude/longitude lines to find your location, or click on a spot to be given its location. You can also use the measuring tool (looks like a ruler) to determine linear distances between two points, or make a series of lines to find the area of a shape.

Questions

<u>Part 1 – Hetch Hetchy Valley</u>

1. Yosemite National Park is located in east-central California, east of San Francisco. Zoom to this region and find the Hetch Hetchy Valley (feel free to explore a bit). What is the lat/lon location of the middle of the O'Shaughnessy Dam?

________________ Latitude

________________ Longitude

2. Taking advantage of the 3D visualization capacities of Google Earth, zoom in on the Hetch Hetchy Valley. Take note of what the valley looks like, qualitatively. The Yosemite Valley is located south-southeast of Hetch Hetchy. Take a look at this valley as well, keeping in mind the varying topography. Visually, besides the fact one is under water, how does the Hetch Hetchy valley compare to Yosemite?

3. As noted above, and in your textbook, the Hetch Hetchy Reservoir provides water to the San Francisco area. Currently, about 25% of San Francisco's water comes from this reservoir (over 180 million gallons of water are consumed per day in S.F.). Using the measurement tool, about how far away is the reservoir from the city?

4. What do you think are some advantages and disadvantages to San Francisco using this particular water source?

5. Keeping in mind the discussion in lecture about conversation vs. preservation, visualizing the valley in Google Earth, and knowing the amount of water the reservoir has and continues to provide S.F., if you were in charge of the project, would you have authorized the building of the dam? Why or why not?

Part 2 – Omaha, NE

From the Douglas County GIS web portal (https://www.dogis.org/Html5Viewer/?viewer=dogis), find UNO's Dodge St. Campus.

6. What is the location of Arts and Sciences Hall? (Hint: click and hold your cursor at the location)

________________ Latitude

_______________ Longitude

7. Under the "measure" tab on top, select the 'Freehand Shape' or 'polygon' icon. Use this to trace an approximate boarder around campus (Dodge St. campus only). What is the area and perimeter of campus? Use kilometers (km).

Perimeter ________________ Area __________________

8. The shape of campus should now be highlighted (in some fashion). Using the image, and your knowledge of campus, what are the different types of land cover you can see on campus? List them below.

9. Roughly, how much of campus (percentage) are those land cover types from the previous question? (example: land cover type of Lake: 70%)

10. On the bottom left on the website, there is an icon with a year on it (e.g. 2020). Click that icon and select 'historical'. This allows you to scroll through a series of maps of the same location, dating back to the 1930s. In a couple sentences, describe what campus looked like in 1941? You can consult these photographs as well, if you wish (https://www.unomaha.edu/news/2015/07/dodge-campus-1938.php).

11. Quickly describe (1-2 sentences) what UNO's campus looked like

during the following years in comparison to the most current map:

1962:

1982:

2007:

12. Qualitatively, how has the land cover of campus changed over time?

13. Clear your campus outline shapes (using the ‘erase’ tool), unselect the ‘historical’ icon – going back to 2020, and zoom out to all of Omaha. On the left side, in the ‘layers’ area, you will find a checkable icon that says “City Boundaries”. By selecting it, a yellow boundary line will appear around Omaha’s official boarders. Using the ‘measure’ tool again as in #8, roughly map out the current outer limits of Omaha. Don’t spend a lot of time being super precise, just a rough cut is sufficient. Again, use km.

Perimeter ________________ Area __________________

14. What sorts of land cover types are most prominent within this region? Limit your answer to the 5 or so most common types.

15. Conduct a similar measurement of Omaha during the years 1941 and 1982. Note there are not official city boundaries during these years, you will need to approximate the boarders based on the land cover. To estimating this, typically cities’ formal boundaries end at

the outer limit of developed land. While measuring these, take a note of land cover types and the relative percentages of the total.

1941: Perimeter _________________ Area _________________

1982: Perimeter _________________ Area _________________

16. How has the town grown over time, in area, from 1941 to now, and from 1982 to now, in terms of a percent change? Show your work. A 'percent change' is calculated using the following equation:

$$\textbf{Percent Change} = \left({}^{(Final - Initial)}/_{Initial} \right) x\ 100$$

where 'final' is the most recent area (i.e. now – question 13),

and 'initial' is the area in the past (i.e. 1941 and/or 1982 – question 15).

1941-to-now:

1982-to-now:

17. What sorts of impacts might the growth and land cover change of Omaha had on the <u>environment</u>?

18. What sorts of impacts might the growth and land cover change of Omaha had on its <u>inhabitants</u>?

19. Seeing how land cover change and growth occurred, and perhaps

coupled with your prior knowledge of town, how might have you changed the development of town for the better?

2. Lab 2: Observing Weather and Climate

Introduction

The weather of a particular region is considered the state of the atmosphere at a specific time. We typically use descriptors such a temperature, humidity, winds, cloud cover, or pressure to describe the day's weather. The timing of weather, however, is relatively short, normally spanning hours to days. When we start examining the weather over time, a new term is needed: the climate. Climate is often defined as a statistical summary of the weather at a given location, over an extended period of time, often spanning multiple decades. Rather than describing the atmosphere for a specific day, the climate speaks to average, or more generalized, conditions, while also encompassing features such as variability and trends in the frequency or intensity of specific weather phenomena.

Few physical processes effect our lives on a daily basis more than weather and climate. In gaining a more robust perspective on how the weather/climate varies over time, this exercise utilizes a suite of instruments that allow us to directly measure key characteristics of the atmosphere that contribute to weather and climate. The objectives for this activity are to:

- Measure key meteorological variables (temperature, humidity, cloud cover, and wind speed)
- Explain why the observation values differ between different land cover types
- Assess how the observations compare to the climatology

Background Information/Further Reading

Measuring Temperature

To measure surface temperature, we will be using low-grade Infrared Digital Temperature guns. It works by pointing the instrument's guiding laser at the location to be observed, pulling the trigger, and recording the temperature. You do not need to put the instrument in contact with the object. **Do not point the instrument at someone's face/eyes, as the laser can cause eye damage.** Additionally, do not point the instrument directly into the sun, as this will effectively destroy the instrument.

Measuring Humidity

Atmospheric relative humidity will be measured using sling psychrometers. The procedure is relatively simple:

- Wet the cloth that is attached to one of the two glass thermometers with the water provided, being careful to not wet the other thermometer. The thermometer with the wetted cloth is the 'wet bulb thermometer' while the one without the cloth is the 'dry bulb thermometer'.
- Whirl the two thermometers about the handle in the air for about 60 seconds.
- Immediately after the whirling, read and record the temperatures. Their difference is the wet-bulb depression.
- Use the provided table as necessary to determine relative humidity.

Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Measuring Wind Speed

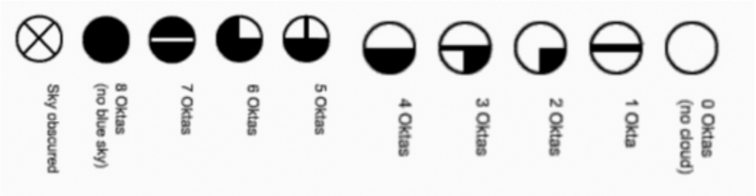
Wind speed will be measured using handheld anemometers. Hold the instrument up such that the axis of the fan points into the wind. Record the wind speed.

Measuring Cloud Cover

To measure cloud cover, the observer assesses the amount of the sky that is covered by clouds. The unit of measure is the okta, a scale from 0 to 8, where 0 represents a completely cloud-free sky, 4 is a half-cloudy sky, and an 8 is a completely cloudy, or overcast, sky. Often, manual observations use a mirror to determine the measurement, today, we will just be estimating. While this approach is very simple, it does not necessarily account for cloud type or thickness.

0 = Clear, 1-2 = Few Clouds, 3-4 = Scattered,

5-7 = Broken, 8 = Overcast, 9 = Obscured



***Policy on Broken Instruments*: if a student's negligence or purposeful action results in a broken instrument, they will be held liable for the costs of replacing it.**

Questions

Part 1 – Observation

1. Quickly describe your measurement sites. Be sure in to include information such as the land cover, positioning of any obstructions such as buildings or trees, and the nature of said obstruction (leaves on tree, overhanging roof, etc.).

2. Complete the following table using the instruments made available in lab.

Location	Surface Temperature	2m Wet Bulb	2m Dry Bulb	W.B. Depression	Rel. Humidity	Cloud Cover	2m Wind Speed

Part 2 – Analysis.

3. Which site had the warmest conditions? (consider both surface and 2m)

4. How did temperature change with height (surface to 2m) between the sites?

5. Which site had the highest relative humidity?

6. Why do you think that particular site (see question above) had the highest relative humidity?

7. What does a larger wet bulb depression mean for relative humidity?

8. Did cloud cover vary between the sites? If so, what could be the cause of that?

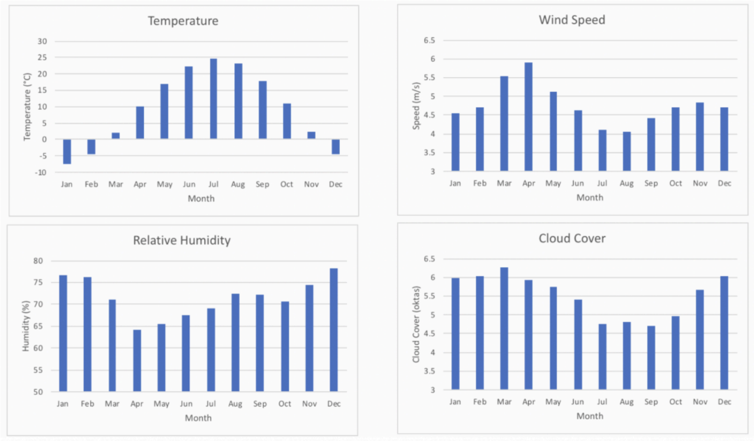
9. Which site had the windiest conditions?

10. What sorts of errors or limitations may have biased your observations and/or analysis? Be sure to indicate how the listed features may have caused errors. Consider any nearby obstructions, the instruments, the observer, the time of day, anything that could have biased your observations.

Part 3 – Climatology.

The following graphics depict average monthly conditions at

Eppley Airfield, at approximately 10 am local time, over the last 30 years. Each variable is clearly labeled.



11. In bullet or paragraph form, describe how your observations taken today compare to the climatologies of temperature, relative humidity, cloud cover, and wind speed for the Omaha area. Be sure to note any practically significant differences and if present, a discussion of why you think those differences from climatology occurred.

3. Lab 3: Biome Detective

Introduction

There are many features at come together to determine the biophysical environment, including soil characteristics, flora, fauna, water availability, and climate. Each of these features directly and indirectly shapes the others, but arguably, the climate of the particular region plays the largest role. Climate is typically shaped by the factors that control temperature and precipitation, which include: latitude, insolation of solar radiation, elevation, proximity to large bodies of water, ocean currents, and land use/land cover. We spent last lab observing the weather, and drawing comparisons to the local climate. Today, we will be using climate data and visualizations of the biophysical environment to further solidify our identification and understanding of major biomes. Recall, we have discussed 8 major global biomes:

> 1) Tropical Rainforest, 2) Savanna/Tropical Dry Forest, 3) Desert/Semi-Desert,
> 4) Mediterranean, 5) Temperate Grassland, 6) Temperate/ Deciduous Forest,
> 7) Boreal Forest, 8) Tundra

The primary objectives for today are to:

- Analyze/comprehend climographs from various locations, to grasp the climate of the area
- Use the climographs, plus visual cues, to determine the biome of a particular region
- Gain a geographic perspective as to where specific biomes are located on the planet

Background Information/Further Reading

GEOGUESSR

For this lab, we will be utilizing the online platform GEOGUESSR. This is a free platform that utilizes Google Maps – Street View. The platform works by effectively dropping you somewhere in the world, then you get to roam around on street view, looking at various visual clues to determine where you are. The game is generally considered fun, and potentially addicting.

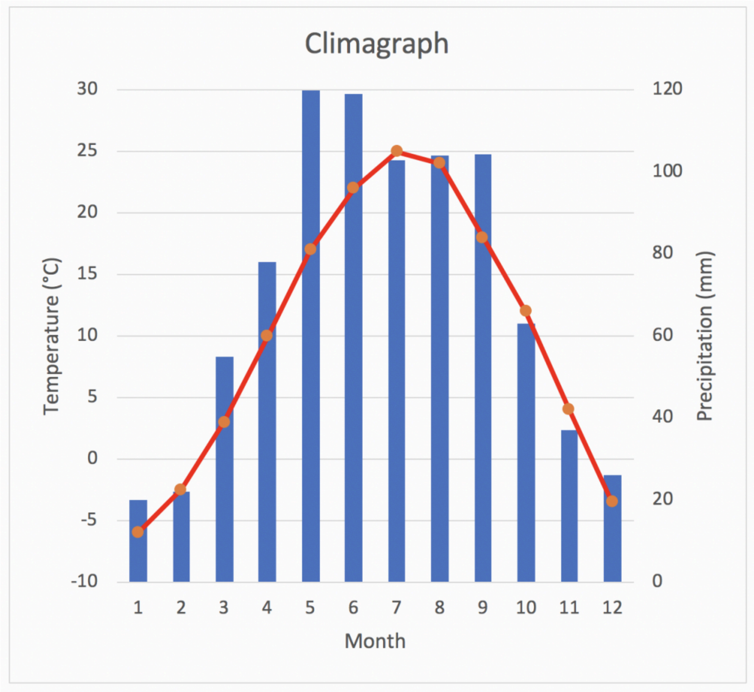
To use the specially-created maps for this lab, you will need to create an account on Geoguessr.com. It is no-cost, and relatively painless. You do NOT need a pro account. To save time in lab, please create your account prior to lab! There will be a specific link provided to you, which are for predefined locations that you will need to investigate. You are encouraged to practice using the platform **the day before lab**. Only one game can be played per day for free. Consider starting with "Omaha Metro, NE, USA": https://www.geoguessr.com/maps/5cf6940b19e12f3474502621

Climographs

Climographs are graphical representations of typical climatic conditions for a specific location. We've used some in lab 2 to compare with our meteorological observations. In this lab, two variables will be depicted on each climograph: temperature and precipitation. For both variables, average monthly conditions are shown over the 1980-2010 period. Months are on the x-axis: 01 = Jan, 02 = Feb, etc., while temperatures and precipitation magnitudes are on the y-axes.

Average temperatures (in °C) are shown as lines, while the bars show precipitation accumulation (in mm). With them, we can determine a number of critical insights, including temperature and precipitation range, warm/cool/dry/wet seasons, a likely tropical/temperate/polar distinction, and others.

Below is an example of a climograph. We can see that the average daily temperature (red line) throughout the year is highly variable, ranging between 25°C in the summer to below freezing in the winter. Precipitation (blue bars) also is seasonally variable, with larger amounts of precipitation in the warm season (May-Sept), and lesser amounts in the cool season (Oct-Apr).



Because the temperature does vary with the seasons, with only a few months of the year below freezing, we can assume it is a middle-latitude location. The magnitude of temperature variation also indicates a likely in-land, or continental, location away from the influences of Oceans. There is a relatively-dry season during the winter. Putting the temperature and precipitation together, we might hypothesize this is a temperate grassland or temperate forest biome.

Questions

Part 1 – Climographs

1. You will be provided climographs for seven different locations within the United States. Your first task is to describe the characteristics of the climate for this location. This could include information such as:

- The magnitude of temperature variation during the year

(annual range)

- Average annual temperature (i.e. tropical, polar, or midlatitude)
- The amount of precipitation (including a general distinction of wet, dry, or variable)
- The timing of precipitation (consistent all year, dry season, wet season)
- Other information you find appropriate

Climograph A:

Climograph B:

Climograph C:

Climograph D:

Climograph E:

Climograph F:

Climograph G:

Part 2 – Geoguessr

Instructions: You will be playing a game of Geoguessr for this part. You will be randomly given five locations in the United States that will match five of the seven locations of the climographs. Once you start the game, your first step will be to take a few notes about the first location. Pay specific attention to the biophysical environment, noting things such as: quantity and types of vegetation (evergreen vs. deciduous trees, shrubs, grasses, no vegetation, all the same type vs. mixture, etc.), and the color and texture of the soil (if possible). You should also take note of any other distinguishing features such as bodies of water, mountains, or man-made features.

Once you have described the location, go ahead and make a guess as to where your location is located, using the Geoguessr map, and write in the general location on this lab (nearest city, state OR lat/lon). You'll also be recording the correct location and how far away you were. Keep in mind, all locations are in the U.S. for this activity. Many locations within the same biome across the US exist. Think logically and don't panic if your answer seems REALLY far away. The link to the specific location is: https://www.geoguessr.com/maps/5cf6a503b741f87ce8ce3adf alternatively, you can search "GEOG1050 – Biome Detective, USA". As noted in the name, only locations in the USA are options.

2. Fill out the table below, following the directions given above.

Location	Description	My Location Guess	Correct Locatio
1			
2			
3			
4			
5			
Game Summary, Total Points:			

3. At this point, you have seen all seven climographs. You've also seen five of seven possible correct locations in Geoguessr. The climographs' locations roughly match the locations used in the Geoguessr game. Your last task is to determine which Geoguessr locations (i.e. question 2) correspond to which climographs (i.e. question 1). You should be able to match five of seven fairly precisely based on your answers to question 2. For the two

remaining climographs for which you do not have specific locations from Geoguessr, make an educated guess.

Climograph A: ______________________________

Climograph B: ______________________________

Climograph C: ______________________________

Climograph D: ______________________________

Climograph E: ______________________________

Climograph F: ______________________________

Climograph G: ______________________________

4. Lab 4: Environmental Hazards - Air Pollution

Introduction

Air pollution is defined as the emission or release of pollutants into the atmosphere, where the pollutants are visible or invisible particles/gases that are not a part of the normal composition of air. Perhaps the most obvious pollutants are the airborne wastes associated with fuel combustion, which are seen emitted from factories, power plants, and vehicles. Particulate matter is often the most visible source of air pollution, and is arguably the largest source of anthropogenic air pollution. However, there are also natural (non-anthropogenic) sources, such as the particulate matter and gases emitted by volcanoes, the smoke from lightning-causes fires, dust storms, and pollen. Regardless of source, particulate matter can be harmful to plant, animal, and human life and well-being.

The primary objectives for today are to:

- Develop a working definition of particulate matter and comprehend the indices used to track/monitor it
- Assess and compare air quality across the United States, in Omaha, and in other locations worldwide
- Measure air quality in different locations and make comparisons across space

Background

Sources of Air Pollution

There are three categories of anthropogenic air pollution: Point, Area, and Mobile. A point source is perhaps most simply thought of as a feature that is fixed in space that emits a large amount of pollutants, such as a factory smokestack. In contrast, area sources are a combination of multiple, less impactful, sources that when combined, emit a large amount of pollutants. An example of area sources would be a park with multiple campsites, where each site had a campfire. A single campfire itself produces small amounts of pollutants, but the combined impact of 20-30 campfires together create a substantial emission. Mobile sources are ones that move, such as those from sources of transportation (i.e. cars, trucks, trains, plains, etc.).

The Environmental Protection Agency (EPA) defines five Criteria Pollutants, pollutants for which there are established laws and standards for air quality. They are: ozone (ground level), particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Definitions of these criteria pollutants is available below, and further information can be found at: https://www.epa.gov/criteria-air-pollutants. With higher concentrations of these pollutants, there are higher health risks including: aggravated cardiovascular and respiratory illness, added stress to the heart and lungs, respiratory system cell damage, fatigue, asthma, irritation of eyes, nose, and throat, and shortness of breath.

Ozone (ground-level): Tri-atomic oxygen (O3) which forms by chemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOC) when exposed to sunlight. NOx and VOC are byproducts of various combustion reactions.

Particulate Matter (PM): Small particles in the air, such as dust, dirt, soot, or smoke. There are two varieties: PM2.5 and PM10. The number corresponds to the size of the particulates, in micrometers. PM2.5 are about 2.5 micrometers and smaller (about the 30 times larger than the thickness of a human hair. PM10 are 10 micrometers or smaller.

Carbon Monoxide (CO): A odorless and colorless gas released when something is burned, such as natural gas, gasoline, and organic matter.

Sulfur Dioxide (SO2): Compound primarily resulting from fossil-fuel-based combustion at power plants, however vehicles, mining and volcanic eruptions also emit SO2.

Nitrogen Dioxide (NO2): A highly reactive gas which is emitted to the atmosphere due to the burning of fuel such as gasoline and diesel.

Air Quality Index

To assist in determining how clean (or polluted) the air is, and inform the associated health risks, the Air Quality Index (AQI) was created. It focuses on the health impacts you may experience after a few hours or days breathing the polluted air, and is based on levels of five (of six; excludes lead) criteria pollutants. The AQI works as a running scale from 0-500, where the lower the number, the cleaner and safer the air, and the higher the number, the more polluted the air. While lower is better, values below 100 are generally considered satisfactory. The following tables outlines the AQI's values.

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

Measuring Air Quality

Hand-held instruments will be provided in class. They sample the air directly in contact with the device, and report the value onto the screen. Similar to lab 2, these are "point and click" type instruments. Please treat these with care and do not touch the sensor. Do not breathe into the sensor.

Further Information and Data used in Lab

In reaching the learning goals for today's lab, we will be utilizing data from a variety of air quality monitoring groups within the US and worldwide. AirNow, a part of the EPA (https://www.airnow.gov/), provides near real-time observations of air quality and allows for comparisons between cities, based on the last 10 years of data (https://www3.epa.gov/aircompare/). Additionally, data are available globally from World Air Quality Index project (https://waqi.info/). We will be providing you case-study data for analysis in lab, however you are welcome to explore these data on your own.

Questions

Part 1 – Real-Time Air Pollution Conditions

You will be provided with (a) AQI map of the United States, (b) AQI map of the Omaha area, (c) table of AQI criteria pollutants for Omaha area, (d) AQI map for the world, and (e) AQI data for two specific locations outside the United States.

1. Using (a), describe the AQI across the U.S. Be sure to note the general areas where AQI is not Good (i.e. where is it Moderate, USG, Unhealthy, Very Unhealthy, and/or Hazardous).

2. Where is the location with the highest AQI? What's the AQI, approximately?

3. What sort of health impacts could be expected at an 'unhealthy' or high category?

4. Using (b) and (c), answer the following:

The current AQI in Omaha is ____________________.

The current Ozone AQI is ____________________.

The current PM10 AQI is _____________________.

The current PM2.5 AQI is _____________________.

5. Examining the forecast for today and tomorrow (using (c)), do we need to be concerned about air quality? Why or why not?

6. Keeping these values in mind, let's put them into context of values across the world. Using (d), where is AQI data generally available, based on the map? Where is it not available?

7. Hypothesize why AQI data is available (or not available) where it is (or isn't).

8. Two locations, not in the United States, are provided to examine in further detail (e). Use them to answer the following questions. If you'd prefer to choose your own locations, please confirm this with your instructor prior to working.

Location 1 ________________________ AQI _____________

8a. What is the primary pollutant contributing to the AQI?

8b. The color of the clouds in the Air Quality Forecast area (slightly down the page) match the colors of the AQI. How is AQI forecasted to change over the next few days, in comparison to its current value?

8c. What about this specific location may contribute to its AQI? (hint: think about population, sources of pollution, general climate, etc.)

Location 2 ______________________ AQI ____________

8d. What is the primary pollutant contributing to the AQI?

8e. The color of the clouds in the Air Quality Forecast area (slightly down the page) match the colors of the AQI. How is AQI forecasted to change over the next few days, in comparison to its current value?

8f. What about this specific location may contribute to its AQI? (hint: think about population, sources of pollution, general climate, etc.)

Part 2 – Sampling Air Quality

Using the provided instruments, you will work as a team to measure levels of Particulate Matter (PM) at three near-by locations: in the classroom, in the atrium of DSC, outside in an open area. Fill out the tables below and answer the analysis questions.

9. Of the three locations (classroom, atrium, outside), which do you hypothesize to have the highest levels of PM? Why?

10. How could you test your hypothesis?

11. Fill out the tables below, based on your observations. Take 3 samples at each site and calculate an average for both PM 2.5 and PM 10.

PM 2.5

Site Location	Sample 1	Sample 2	Sample 3

PM 10

Site Location	Sample 1	Sample 2	Sample 3

12. Which site had the highest PM average? Was your hypothesis correct?

13. Which site had the most variation between the three PM samples?

14. Consider the outside observation. How does that compare to the PM value of the Omaha AQI values, (b) and (c)?

15. Why do you suspect our observed value in lab was (different/similar) to the value reported by AirNow?

5. Lab 5: Environmental Justice

Introduction

Environmental justice (EJ) is one of the key sub-topics of Human-Environment Geography that addresses the (in)equitable distribution of environmental burdens and benefits. We've seen definitions of EJ in lecture and in the textbook. Here, we'll see the definition used by the Environmental Protection Agency (EPA): "… the fair treatment and meaningful involvement of all peoples, regardless of race, color, origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." The lack of this protection from hazards (i.e. health and/or environmental hazards) and the lack of 'a seat at the table' in the decision process is widespread across the world, including here in Omaha. For this lab, we will examine EJ issues spatially within the city limits and assess their prevalence in different communities.

The primary objectives for today are to:

- Become familiar with different environmental and demographic indices used to assess environmental justice prevalence.
- Analyze environmental and demographic data to determine if, and where, environmental justice is of greatest concern in the Omaha area.
- Generate and analyze numerical data and graphics to support your scientific hypothesis of geographically-focused environmental justice prevalence.

Background

Environmental Justice

There are many facets to EJ, including the subsets that seek to achieve geographic, social, procedural, and generational equity. While all are critically important topics, and a part of the overall EJ social movement, we will only be examining geographic and social equity topics here in lab today. If you'd like to see some examples of generational equity, consider reading up on the Juliana v. United States court case in California. Additional examples are provided in the textbook.

EJ Screen Mapper: EPA

To visually analyze EJ in the Omaha area, we will be using the EPA's EJ Screen Mapper: https://ejscreen.epa.gov/mapper/. This platform is effectively an online Geographic Information System (GIS) maintained by the EPA. It allows the user to plot up various spatial datasets of environmental and demographic variables, then compare them. The platform maintains approximately a dozen different environmental hazards or indicators, complied from multiple data sources (Table 1).

Indicator	Place on Exposure–Risk Continuum	Key Medium
NATA Air Toxics Cancer Risk Lifetime inhalation cancer risk	Risk/Hazard	Air
NATA Respiratory Hazard Index Ratio of exposure concentration to RfC		
NATA Neurological Hazard Index Ratio of exposure concentration to RfC		
NATA Diesel PM (DPM) ($\mu g/m^3$)	Potential Exposure	
Particulate Matter ($PM_{2.5}$) Annual average ($\mu g/m^3$)		
Ozone Summer seasonal average of daily maximum 8-hour concentration in air (ppb)		
Lead Paint Indicator Percentage of housing units built before 1960		Dust/ Lead Paint
Traffic Proximity and Volume Count of vehicles (average annual daily traffic) at major roads within 500 meters, divided by distance in kilometers (km)	Proximity/ Quantity	Air/ Other
Proximity to RMP Sites Count of facilities within 5 km, divided by distance		Waste/ Water/ Air
Proximity to TSDFs Count of major TSDFs within 5 km, divided by distance		
Proximity to NPL Sites Count of proposed and listed NPL sites within 5 km, divided by distance[6]		
Proximity to Major Direct Water Dischargers Count of NPDES major facilities within 5 km, divided by distance		Water

Abbreviations:

NATA	National Air Toxics Assessment	RfC	Reference concentration from EPA's Integrated Risk Information System
NPL	National Priorities List, Superfund program	$PM_{2.5}$	Particulate matter (PM) composed of particles smaller than 2.5 microns
NPDES	National Pollutant Discharge Elimination System	$\mu g/m^3$	micrograms of $PM_{2.5}$ per cubic meter of air
RMP	Risk Management Plan	ppb	parts per billion, of ozone in air
TSDFs	Hazardous waste Treatment, Storage, and Disposal Facilities		

There are also a number of demographic indicators as well, such as total population, income levels, education, age, linguistic isolation (primary language other than English), race, and ethnicity, among others. All of these data (environmental and demographic) are displayed within different census tracks.

EJSCREEN Data

Data will be provided for various environmental and demographic indicators from EJSCREEN. Data are shown in terms of a percentile in either comparison to the state of Nebraska. A percentile is a measure to indicate the percentage of observation which are below a specific observation. For instance, if one particular sample was in the 90% percentile, 90% of the other observations would be below the level of the particular sample. Data have been provided, but if you'd like access to the original GIS, find it here: https://ejscreen.epa.gov/mapper/

Data Analysis with Excel

In addition to visually analyzing EJ datasets, you will also be providing basic statistical evidence to support or disprove your hypothesis of the spatial prevalence of EJ issues. You will be given access to an excel spreadsheet which contains the raw data observations of many environmental and demographic variables for all of the census tracts across the state of Nebraska. There is an additional sheet which describes the variables used. You will be making scatterplot graphs of different variables. There are multiple ways to generate these graphics. One way will be detailed below, but you are welcome to search online (Google, Youtube) for help, ask your instructor or a classmate, or figure it out for yourself. You may also import these data into something you are more familiar with if you wish, such as Google Sheets or Numbers. Excel is available on most University computer lab machines, and if FREE to all students through UNO ITS (https://www.unomaha.edu/information-technology-services/software-and-hardware/personal-hardware-and-software.php).

*These are written for MAC users, but the same general pathway works for PCs. To make a scatter plot, start by selecting your data. This will make an example of population (ACSTOTPOP) vs. Cancer rates. Highlight the entire columns of ACSTOTPOP and Cancer. Then, go up to 'insert' and select chart, then X-Y scatter plot. It should generate a graph that looks like Figure 1 (below). If you want to add additional data, or change the columns used, you can do such by right clicking on the graph and selecting "Select Data". A screen should pop up. On the right of the screen, there will be areas listing 'name', 'X values' and 'Y values'. You can replace the X or Y values by clicking the icon on the right, selecting the column you wish to replace it with, clicking the icon again, and selecting OK to make the graph.

When submitting your graph (in the assignment below) make sure you have a title, axis labels, and a trend line.

Questions

Part 1 – Geographic Equity

1. Using the Environmental Indicator map of PM 2.5, describe what the color bars in the legend (and on the map) represent physically?

2. Where in town are the highest PM2.5 levels?

3. The maximum value of PM2.5 within the Omaha area is approximately 8.07 ug/m^3. Thinking back to our investigation last week, how does it compare to our observations (i.e. higher/lower/about the same)?

4. Using the Environmental Indicator "Superfund Proximity", describe where are people in closest proximity to a superfund site?

5. What is the superfund site in Omaha for? Hint: https://www.epa.gov/superfund/

6. Find the tract that contains campus. This corresponds to a Superfund proximity of 0.14 facilities per kilometer. What percentile range for the state is this?

7. Choose two other environmental indicator maps from the list on

EJSCREEN. Examine the maps and describe where the highest values are within the Omaha area.

Env. Indicator 1: ______________________________

Location of Highest Values:

Env. Indicator 2: ______________________________

Location of Highest Values:

8. Across the four variables examined (#2, 4, 7a, 7b), is there overlap between the regions exposed to higher environmental/health hazards? Where is/are those region(s)?

9. Strictly in terms of geography (location within town, development of city, etc.), and temporarily disregarding demographic factors, what is unique about these regions such that they have higher proximity to environmental hazards? Aka why do you think those regions are the more hazardous regions?

10. UNO's campus used to be located in the North Omaha neighborhood, around 24th and Pratt St., prior to the 1930s. Compare the hazards the University is exposed to in its current location near Dodge and 66th, to those in its original location. Which has fewer (or lesser) environmental hazards?

Part 2 – Demographics

11. Switch over to the Demographic Indicators Data. Select the Low-Income Population Map. A 99th percentile ranking for Nebraska indicates that approximately 90% of the population would be classified as low income. Where are there highest percentages of low-income populations (95-100th percentile)?

12. Young children are particularly susceptible to environmental hazards. Using the 'under age 5' indicator, describe where the highest percentage of total population is this young-child group.

13. Looking across the city, there are likely many regions with high levels of young children. Zoom in on some of the regions along the periphery of the Omaha area. What is unique about these areas?

14. Examine the "People of Color Population" indicator. Where are the parts of town with the highest levels of this metric?

15. Examine one more demographic indicator. Describe the spatial pattern you see.

    Dem. Indicator

    ____

    Spatial Pattern:

16. Are there any consistent themes within the demographics of town? What are they?

Part 3 – Hypothesis

You will be making a scatter plot depicting the relationship between one environmental and one demographic indicator of your choice. Please consult the directions noted above ("*Data Analysis with Excel*").

17. Keeping in mind the locations you noted in #16 and #8, develop a general hypothesis surrounding the relationships between environmental hazards and demographics for the Omaha area. A hypothesis is similar to a prediction about the relationship the graph will depict.

18. What would your graph have to look like to support your hypothesis?

19. In Excel (or similar program), create a scatterplot, depicting the relationship between one environmental and one demographic indicator of your choice. You'll be submitting the graph with this lab (digital or printed) separately. As a reminder, you will need to have a title, axis labels and a trend line.
20. Which variables (indicators) did you choose?
    Env. ______________________Dem. ___________________________
21. Explain how your graph either supports or does not support your hypothesis.

22. What needs to be done to improve the quality of life for the individuals in these areas dis-proportionally impacted by environmental hazards? (i.e. how would you fix EJ issues noted in Omaha?)

6. Lab 6: Climate Change Modeling

Introduction

There is scientific consensus among climatologists that the current changes to the Earth's climate system are predominately caused by human activity. The generation of fossil-fuel-derived energy has greatly shaped global civilization and allowed for substantial advancement and prosperity. However, it has come at a price. The unintended biproduct of fossil-fuel-derived energy is the release of various carbon-based gases that alter the chemistry of the atmosphere. Increasing concentrations of these greenhouse gases in the atmosphere increases their effectiveness at absorbing and in-turn releasing thermal energy. The more greenhouse gases in the atmosphere, the more thermal energy that stays in the climate system, and the warmer conditions become. The purpose of this lab is to experiment with greenhouse gases and temperatures through a simple model.

The objectives of this lab are to:

- Examine evidence of the impact atmospheric carbon dioxide has on Earth's global average temperature
- Develop a physical connection linking carbon dioxide in the atmosphere and fossil-fuel-based emissions
- Design and test a scenario of climate change

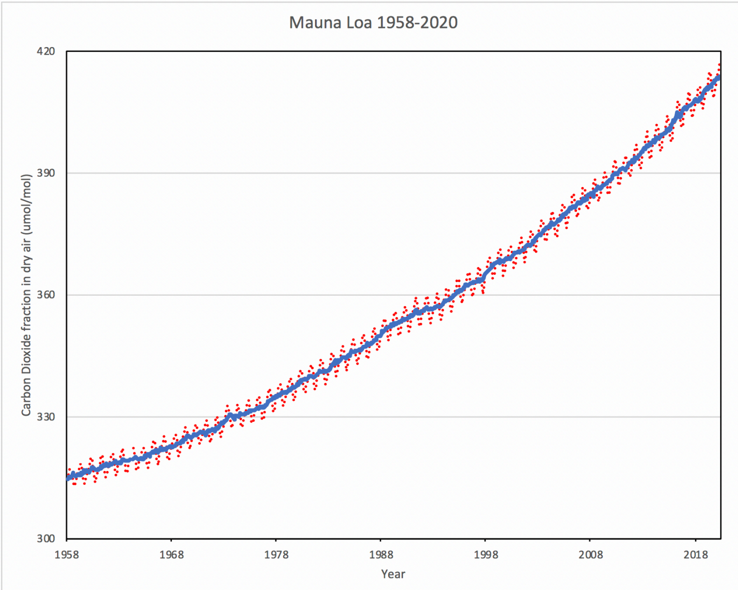
Background Information/Further Reading

Climatic Change

Since the 1880s, the average global temperature of the planet has warmed by approximately 1.2 °C (about 2.5 °F). This warming has also led to a wide-array of other changes, such as the acidification, warming, and rising of global oceans, the decrease in the spatial extent and mass of snow, ice, and glaciers, and the increase in extreme precipitation and drought frequency. Such changes have impacts on nearly every aspect of society and the environment, though not all are negative at an individual level. For those interested, a very detailed report is available from the Intergovernmental Panel on Climate Change (IPCC): https://www.ipcc.ch/report/ar5/syr/.

Greenhouse Gases

The predominant cause of current climatic change is due to human-input of greenhouse gases into the atmosphere. Gases such as carbon dioxide, methane, nitrous-oxide, and others are bi-products of combustion reactions which generate energy for human needs. These gases however, are exceedingly efficient at 'trapping' thermal energy (aka heat) from entirely escaping out to space. In moderation, greenhouse gases are very important to keeping the planet livable. Without them, the average temperature of the planet would be approximately -18°C, well-below the freezing point of water. However, with too high a concentration of greenhouse gases, excessive amounts of thermal energy (heat) are retained within the climate system, increasing the temperature. The most robust observations of carbon dioxide have occurred at the Mauna Loa Observatory in Hawaii, which has tracked the concentration in the atmosphere since the 1950s. Below, you'll see the "Keeling Curve" or a monthly timeseries of CO2 concentration. Note the increasing trend in the timeseries.



Data obtained from: Scripps CO2 Program (https://scrippsco2.ucsd.edu/data/atmospheric_co2/)

Perspectives of Change

A variety of robust evidence strongly indicates that human activity is the cause of the planet's current warming. While temperatures have fluctuated in the past, the rate at which it currently is increasing is unparalleled in the last 2000 years (https://www.europeanscientist.com/en/environment/ongoing-extent-of-global-warming-is-unparalleled/). Keep in mind how human civilization has flourished during that window, and human populations were either minimal, or non-existent, during previous hot/cold periods in Earth's geologic past.

Climate Modeling

While observations are necessary for documenting change, if we are curious about what the future might hold, models are needed. Because observations from the future just don't exist yet, models allow for an educated evaluation of what the future might hold. In climate modeling, extensive mathematical and physics-based equations are used, which are based on the fundamental understanding of things like winds, ocean currents, nutrient cycles, physics, plant growth, thermodynamics, and others. There are so many different equations that are calculated and solved over and over again, that climate models often require supercomputers.

In this lab, we will be using a very simple climate model, one that will easily run on your own [Flash player-enabled] computer, to evaluate the linkages between carbon dioxide and temperature. It is called the "VERY, VERY SIMPLE CLIMATE MODEL". https://scied.ucar.edu/simple-climate-model Due to its simplistic nature, this model does not account for other greenhouse gases, cycling of carbon into other spheres such as the oceans or biosphere, changes of land use, and wind/precipitation patterns.

The model assumes, based on extensive evidence, that temperature rises approximately 3°C for each doubling of carbon dioxide concentration. Additionally, the starting values for the model are appropriately equal to what they were in real life in the year 2000. If you'd care to explore, mathematically, the formula used by the model is:

$$T = T_0 + S \log_2 (C / C_0)$$

- T is the new/current temperature
- T_0 is the know temperature at some reference time (for example, 14.3° C in the year 2000)
- S is the "climate sensitivity" factor; we've been using 3° C (more on that below); the temperature rise as a result of CO_2 doubling
- C is the new/current atmospheric CO_2 concentration
- C_0 is the known atmospheric CO_2 concentration at some reference time (must be the same time as T_0; 368 ppm in 2000 would match the T_0 example mentioned above)

For reference, every 2.3 gigatons of carbon dioxide emissions should raise the atmospheric carbon dioxide concentration by approximately 1.0 part per million.

Questions

1. Prior to doing anything else, it is important to actually think about what the model might show us. What is the model able to show? What is it not able to show?

2. What, if any, are the uncertainties or limitations of using such a model?

3. Examining the model output graph (still without running an

experiment), describe what the various axes are (x-axis and 3 y-axes).

Part 1 – Trial Experiment

4. The default baseline emissions of CO2 are 10.5 GtC per year. According to the model, what would the Earth's temperature be in 2100 if we released the same amount of carbon dioxide into the atmosphere each year as the baseline?

5. What is the global concentration of CO_2 in 2100 from the experiment in #4?

6. Rerun the experiment (by clicking "start over"), but this time decrease the timestep to 1 year. Are the results any different? What does the timestep variable do?

Part II – Developing a Scenario

7. Do you think the experiment from part 1 is a realistic scenario of what people will actually do over the 21st century in terms of emissions? Why or why not.

8. Think about how (and why) carbon emissions might change into the future. What all do you need to consider to predict how much carbon will be emitted?

9. How do you think carbon emissions will change into the future? You'll share a more detailed outline in question 10, but for now, generalize in a sentence or two.

10. Fill out the top row of the table below with your carbon emission scenario. Then run the model using your develop scenario. Keep in mind, the amount of emissions can change at every time step, if you want them to. A 10-yr timestep is shown for ease of use.

	2010	2020	2030	2040
CO_2 emissions				
Resulting temperature				
Resulting CO_2 concentration				

11. What happened to the climate in your developed scenario?

12. Refresh the page and run an experiment where the emissions are zero moving forward. How does the climate change, both temperature and CO_2 concentration?

13. Is this a realistic experiment given the limitations and constraints of the model? How so?

7. Lab 7: Solar Energy

Introduction

The primary energy source for the Earth's climate system is solar radiation (i.e. shortwave, or visible light from the Sun). The amount of that radiation reaching the surface of the earth changes on a daily and seasonal basis due to the positioning of the earth relative to the sun, and climatic features such as cloud cover and atmospheric concentration. In determining the potential for solar energy to be used, practically, as a form of alternative energy, it is critical to know just how much solar radiation reaches the surface. Once measured, the amount of electricity the solar panel provides can be calculated, and an informed decision on if and/or where installing the panels can be made.

In today's lab, we will be measuring the incoming solar radiation at multiple locations on campus, then using those observations to determine a rough 'feasibility' figure, given average costs and efficiencies. The objectives of this lab are to:

- Confidently measure solar radiation and interpret the observations
- Calculate the electricity yield for a standard solar panel given those observations and within climatology
- Run a cost-benefit analysis of installing a solar panel suite on campus

Background Information/Further Reading

Earth-Sun Relationships

The four most important factors that determine the amount of incoming solar radiation reaches and is absorbed by the surface are: (1) the time of day (i.e. solar altitude), (2) the day of the year (i.e. solar declination; length of day light), (3) the percentage (and type) of cloud cover, and (4) surface albedo.

1. Over the course of the day, the sun's angle above the horizon (solar altitude) changes as a function of Earth's rotation on its axis. This influences the intensity of solar radiation, where the surface receives more energy from the sun at noon, compared to when the sun is rising or setting. Thus, energy from the sun is considered 'most intense' at noon. The maximum altitude of the sun depends on the time of year and latitude
2. The intensity of solar radiation varies substantially over the course of a year based on the Earth's tilt and revolution around the sun. In Nebraska (approximately 41°N latitude), average daily radiation at the top of the atmosphere varies from 150 Watts per meter squared (W/m^2) in the winter, to 450 W/m^2 in the summer.
3. Clouds, particularly liquid-based clouds, reflect a portion of incoming radiation back to space, thus less radiation reaches the surface. Liquid-based clouds are more effective at reflecting solar radiation than ice-based clouds.
4. Based on the reflectivity, or albedo, of the surface, a percentage of incoming solar radiation is reflected away and a percentage is absorbed. Lighter surfaces have a higher albedo, thus reflect more incoming solar radiation and absorb less (typically making them cooler).. Darker surfaces on the other hand have a lower albedo, thus reflect less, and absorb more (typically making them warmer).

Solar Panels

At its most basic, solar panels are a series of photovoltaic cells linked together that harnessing photons (particles of light) to generate electricity. As the photon hits the cells, electrons are excited and 'freed', then transported away via an established electric field within the cell, yielding electricity. These are the most commonly-used house-hold and commercial versions of solar power technology, but other forms, such as solar thermal and concentrated solar panels, also exist. There are a number of extending readings on these types of solar panels available online.

Today's solar panels are substantially more affordable then their previous versions from only a decade ago, however there are still upfront costs associated with installing these panels, and due to energy availability and efficiency concerns, they may or may not be a viable option for every location. Every solar panel has a maximum wattage rating, which indicates how much energy can be harnessed at ideal conditions. Naturally, conditions are not always ideal, and during these non-idealized times, the efficiency of the panel decreases. Warmer temperatures, older panels, and shaded conditions can all result in lower electricity yield.

Calculating Electricity Generation

For our purposes in this class, the amount of energy a solar panel generates at any given time can be estimated using the following equation: **E = A * H * r,** where E is the energy yielded (kW), A is the panel surface area (m2), H is the solar radiation hitting the panels (kW/m2), and r is the efficiency rate. To determine the total amount of energy a solar panel generates during a given day, we would need to integrate all energy observations over the course of a given day (aka calculate this equation for every instant for the entire day and add them up). What we will do here in class is use rounded hourly bins for convenience. Further instructions are included in the 'questions' section.

In the energy business, electricity is typically reported in kilowatt-hour (kWh). This is a measure of the amount of energy needed to power a 1,000-watt appliance for 1 hour. For instance, a 100-watt light bulb would use 1 kWh of energy in 10 hours. So for our solar panels, we'll need to convert our watts (W) to kWh. 1 kW = 1,000 W. 1 kWh is the production of 1kW continuously for a period of 1 hour. Here in Nebraska, we pay, on average, about 9.0 cents per kWh (which is one of the lowest rates in the country!).

Measuring solar radiation

To measure solar radiation, we will be using pyranometers. This instrument records the amount of solar radiation that enters the fixture, and shows the W/m^2 value in the display. These can be pointed in any direction. While they are relatively sturdy, they can break by dropping them, so please handle with care. Once you are done taking observations, please turn the sensor off!

Questions

Part 1 – Observing Solar Radiation

1. In your assigned teams, choose two locations in the surrounding area outside of lab, one should be in the shade (i.e. under a tree/ awning or next to a building) while the other should be not obstructed (i.e. open area). Complete the table below.

Location 1:	Location 2:
Site Description:	Site Description:
Sky Cover Observation (see previous labs):	Sky Cover Observation:
Time of Observation(s):	Time of Observation(s):

2. Take multiple observations (at least 3) of solar radiation at each site and record below. If the sun is visible (don't look right at the sun!), take note of this, and point the pyranometer directly at the sun. If not, point it straight upwards. Take the average of the 3 observations for each site.

Obs. #1:	Obs. #1:
Obs. #2:	Obs. #2:
Obs. #3:	Obs. #3:
Average:	Average:

Part 2 – Electrical Energy Generated

3. Assuming the following, calculate the amount of energy (in kW) a solar panel would have harnessed at the time you took observations at both sites. Use the averages you calculated in #2

as your H term. Assumptions: solar panel dimensions: 1.0m wide x 2.0m tall; panel efficiency rate: 18.5%

4. Which site generated more electricity? How much more energy did the one location produce than the other?

5. Your observations were only one instant throughout the entire day. What factors can influence the amount of electricity a solar panel can generate (consider both physical and mechanical characteristics over time)?

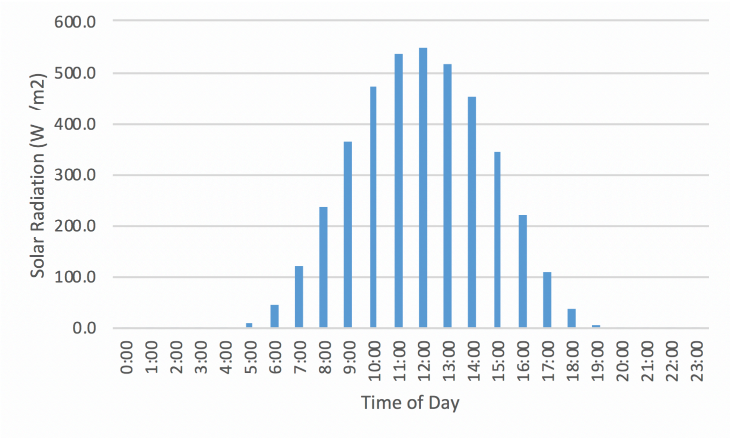
6. Given the time of observation and your answer to question 5, do you think the observations you took would represent a time of peak solar efficiency? Why or why not?

7. Over the course of the day, solar radiation varies. Peak levels occur around noon, with minimal levels overnight. The table and graphic below represents the diurnal cycle of solar radiation (in W/m2) for an average day in Omaha.

What's the average hourly radiation received of the day **in kW/m2**? Hint: first sum the hourly values, divide by the number of hours, and then scale to kW.

Time of Day	Solar Radiation (W/m^2)
0000	0.0
0100	0.0
0200	0.0
0300	0.0
0400	0.2
0500	9.7
0600	48.3
0700	124.1
0800	2376
0900	365.1
1000	472.3
1100	537.4
1200	546.1
1300	516.9
1400	451.7
1500	345.5
1600	222.1
1700	111.7
1800	39.2
1900	6.3

2000	0.1
2100	0.0
2200	0.0
2300	0.0



8. As noted in the background, electricity usage is typically reported in the units kWh. To convert from kW to kWh, you need to account for the total amount of power and the amount of time. This is simply the power (kW) * time (hours). For example, an average hourly total of 0.5 kW for a total of 24 hours would yield a daily energy use of: 0.5kW * 24 h = 12 kWh.

First, calculate how much energy is generated over the entire day from the example in question #7, in kWh, and write it in below. Hint: (hourly average * hours in the day).

Using the answer from directly above, and the same panel area and efficiency rates from question #3, calculate how much energy an average solar panel would generate in Nebraska (in kWh) per day.

Part 3 – Feasibility

9. The average Nebraskan uses approximately 33 kWh per day of electricity. Would our typical solar panel (answer to #8) generate enough electricity to cover this entire demand? If not, what percentage would it cover?

10. What is the minimum number of panels we would need to cover the demand calculated in #9?

11. A typical house roof is about 150 m^2 in area, but only about half is usable for panels. Given the this, and the number of panels needed to cover the typical Nebraskan's energy demand (i.e. #10), is there enough room on the roof? Show your work.

12. Say you're a homeowner and decided to install 25 solar panels on your roof. Using your calculations from above, how much energy would the panels generate per day? Hint: Use your answer to #8 for daily energy generated (in kWh), but scale up to 25 panels.

13. How much energy would the answer to #12 be for a 365-day year?

14. The cost of electricity is approximately 9.0 cents per kWh here in Nebraska. For a 365-day year, how much money would the electricity your solar panels generate?

15. The cost of your 25-panel solar setup was $12,000. Assuming there are no other maintenance costs or changes to electricity

pricing, how long would it take for you to make your money back on your initial investment?

16. Let's say you lived in Burlington, VT where electricity is approximately 16 center per kWh. Hypothetically, Burlington receives the same amount of solar energy as Omaha, and you built the same solar array there as you did in Omaha. Recalculate questions 14 and 15 for Burlington, determining (a) the price of the electricity generated using Burlington prices, and (b) how long it would take you to make your money back in Burlington.

17. This lab represents a very idealized scenario. What other factors (physical, mechanical, political, economic, etc.) come into play in reality when factoring in the feasibility of installing a solar panel system?

18. The data shown in question 7 is the average across many years. Within a true calendar year, how might solar radiation actual change? How could a changing climate influence these solar radiation observations?

8. Lab 8: Human Population Growth

Introduction

In 1798, Thomas Malthus published *An Essay on the Principle of Population*, where it was identified that the human population expansion was outpacing the production of food. Since then, human population has continued to grow, with advances medicine, sanitation, and food access driving down death rates and increasing life expectancy. Concurrently, the agricultural and industrial revolutions have allowed for rapid growth in the agricultural sector, increasing food production and transportation efficiency. Food can now be grown and safely shipped worldwide. However, the balancing-act of population and food is complex, and not spatially homogeneous across the world.

In today's lab, we will be researching global and country-specific population growth and population dynamics. The objectives are:

- Document and analyze differences in population dynamics between developed and developing nations.
- Interpret population pyramids, speaking to the implications of different configurations.
- Calculate a rate of global population change.

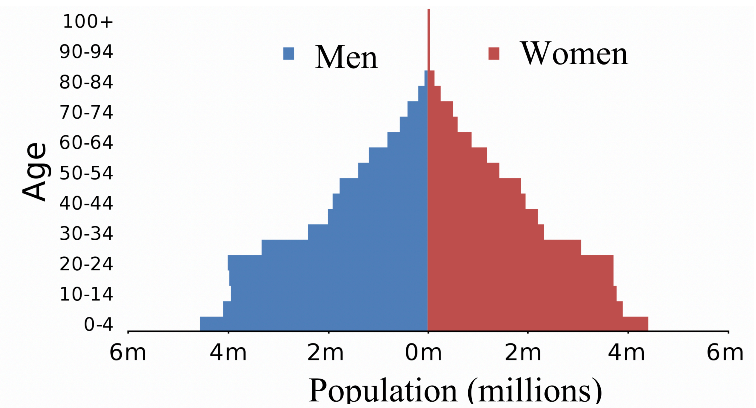
Background Information/Further Reading

Population Growth Rates

Most countries are trying to reduce the population growth rate due to social and environmental pressures/costs. A population growth rate of zero indicates that the number of people coming into the country is the same as the number leaving. This could be from a combination of people being born, immigrating, dying, and emigrating. To achieve a population growth rate of zero, each couple in that country would need to have no more than two children (one child replacing the father, one child replacing the mother), while the number of people immigrating and emigrating would need to be equal. The rate of growth in developed nations has become more constant in recent years, with some starting to experience negative growth rates (declining population). Conversely, many developing nations are still growing exponentially.

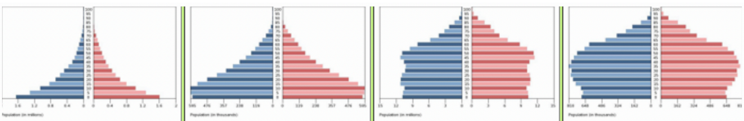
Population Pyramids

Population pyramids are a graph which depicts the distribution of population within a specific region (city, state, country, etc.) by age and gender. It allows for a quick visualization of a specific population, but also serves as a means of indicating population growth likelihood, labor potential, and even potential political instability. The figure below highlights an example pyramid.



CCBY: Raster (Wikipedia-Population Pyramid)

Along the y-axis, there are different age groups (e.g. 0-4, 10-14, etc.). The x-axis shows the magnitude of population, divided by gender. Zero is in the middle of the x-axis with positive numbers on both sides. Typically, women are on the right, men on the left, but this isn't always the case. The further from the center line the bar is, the greater the population of that gendered-age-group. For example, there approximately 4.3 million women and 4.4 million men in the 0-4 age group, but about 2.0 million men and 2.2 million women in the 40-44 age group. In this case, a majority of the population is young people (as evident by the wider bars in the lower age groups), while the older population groups are much smaller. The shape can often look like a pyramid, hence the name. However different shapes imply different meanings, and we'll showcase a few of those in this lab. Also keep in mind, these pyramids are not fixed. Over time, their shape and structure will change. Below, are examples of population pyramid shapes and indications on birth and death rates.



Expanding	Expanding	Stationary	Contracting
Concave sides	Straight sides	Convex sides	Convex sides
High birth rate	High birth rate	Declining birth rates	Very low birth rates
High death rate	Declining death rate	Low death rate	Low death rate
Short life expectancy	Increasing life expectancy	Long life expectancy	Very long life expectancy

Note: some questions require you to calculate a percent change. As a reminder, the percent change formula is:

Percent Change = ((Final – Initial) / Initial) x 100

Questions

Part 1. Global Population Dynamics Over Time

A table has been provided below showing the estimated global population, annually, based on January 1st. You'll be using these data to calculate how population has changed over time.

Year	Population	Year	Population	Year	Population
1980	4,458,003,514	1994	5,663,150,427	2008	6,789,088,686
1981	4,536,996,762	1995	5,744,212,979	2009	6,872,767,093
1982	4,617,386,542	1996	5,824,891,951	2010	6,956,823,603
1983	4,699,569,304	1997	5,905,045,788	2011	7,041,194,301
1984	4,784,011,621	1998	5,984,793,942	2012	7,125,828,059
1985	4,870,921,740	1999	6,064,239,055	2013	7,210,581,976
1986	4,960,567,912	2000	6,143,493,823	2014	7,295,290,765
1987	5,052,522,147	2001	6,222,626,606	2015	7,379,797,139
1988	5,145,426,008	2002	6,301,773,188	2016	7,464,022,049
1989	5,237,441,558	2003	6,381,185,114	2017	7,547,858,925
1990	5,327,231,061	2004	6,461,159,389	2018	7,631,091,040
1991	5,414,289,444	2005	6,541,907,027	2019	7,713,468,100
1992	5,498,919,809	2006	6,623,517,833	2020	7,794,798,739
1993	5,581,597,546	2007	6,705,946,610	2021	7,874,965,825

1. What was the world population in the year you were born? *If data is not available for your year on the table, please just select* 1980.

2. What was the world population when you turned one year old?

If data is not available for your year on the table, please just select 1981.

3. What was the **change** in world population during your first year of life?

4. What was the **percent change** in world population during your first year of life?

5. What was the **change** in population from this year to last year?

6. What is the **percent change** in population from this year to last year?

7. Compare your answers from questions 3-6. What is happening to world **population**? What is happening to the world **population growth rate**?

Part 2. Modeling Population Changes in the US

On January 1st, 2020, the U.S. population was 329,135,084. The population changes based on the following components:

(+) One birth: every 9 seconds

(−) One death: every 12 seconds

(+) Net migration: one every 47 seconds

8. Generate an equation to calculate how population in the US changes over time, using the components above.

9. Apply your equation to project what the US population would be on January 2^{nd}, 2020. Hint: One day is 86,400 seconds. Be sure to show your work.

10. Apply your equation again, this time to project what the US population will be on January 1^{st}, 2021, one year later. Be sure to show your work.

11. Using your answers to questions 8-10, calculate the percent change in population for the US specifically from Jan 1, 2020 to Jan 1 2021. Show your work. How does this compare to your answer in question 7, globally?

Part 3. Population Pyramids

Use the population pyramid and associated data provided, answer the following questions. When warranted, show your work. If you wish, countries other than those provided can be selected from the CIA's website: https://www.cia.gov/library/publications/the-world-factbook/ Talk to your TA about the requirements.

12. Describe the shape of the population pyramid in the US. What does that mean for birth and death rates?

13. Would you describe the population of the US as expanding, stationary, or contracting? Why?

14. What percentage of the overall US population is female? What percentage is male?

15. Describe the shape of the population pyramid in Japan. What does that mean for birth and death rates?

16. Describe the shape of the population pyramid in Chad. What does that mean for birth and death rates?

17. What might the implications of the current population pyramids be for the future of these two countries (Japan and Chad)? Hint: think about availability of labor force, tax revenue, financial needs of children vs elderly, ratios of women to men, etc.

Essay

18. In your opinion, what is the most important implication of population growth to human-environment geography, or society in general? Be sure to note how and why this most important implication is ‘most important’.

9. Lab 9: Water Budgets and Balances

Introduction

A water budget reflects the relationship between water inputs and outputs for a region. At its most simple, this can be examined by tracking the supply vs. demand for water. During times of more supply than demand, there is a surplus. While for the opposite, when demand exceeds supply, there is deficit. At any given point, there are many different places in the world experiencing water surplus and many others experiencing water deficit. This availability of water is critical for ecological purposes, but also for humans, in the form of consumption, sanitation, irrigation, and industrial uses. In this lab, we will examine some of the key components of water budgets, quantitatively assess their variations, and discuss the ramifications of surplus and deficits to local communities.

The objectives for this lab are:

- Assess the current water availability (surplus vs deficit) across the United States
- Describe the physical characteristics of drought and their impacts
- Leverage a model to evaluate climatological water budgets for different locations

Background Information/Further Reading

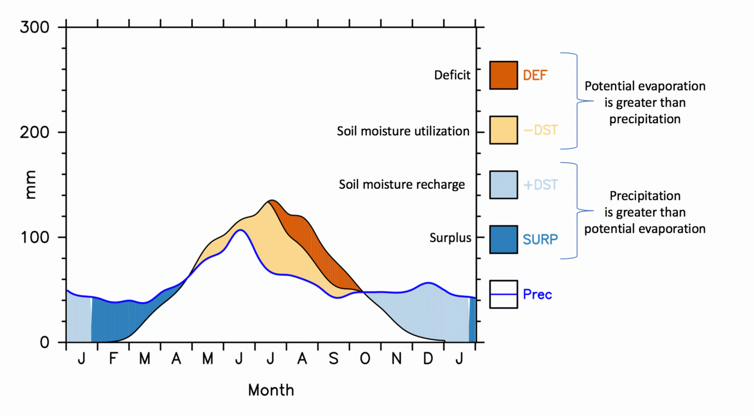
'Calculating' a Water Budget

As noted above, a water budget tracks the inputs and outputs of water into a region. While more complicated budgets exist, a simplistic budget of water is the difference between the amount of precipitation (rain, snow, sleet, etc.; i.e. supply) and the potential evapotranspiration (PET; i.e. demand for water). PET represents all of the water that could enter into the atmosphere from the surface via evaporation and transpiration if there was an unlimited supply of water; transpiration is effectively when plants uptake water through its roots, then evaporate the water from small pores in the plant's leaves. PET is based on the temperature and the amount of solar radiation available.

These two variables (precipitation and PET) are often tracked and displayed graphically, in the form of a water budget or water balance graph. For each month, a climatological average amount of precipitation and PET are graphed together. In the graph on the follow page, x-axis represents a calendar year from January to January, where each letter stands for the corresponding month (in order: J = Jan, F = Feb, M = Mar, etc.). The y-axis represents an amount of water (in millimeters). The solid blue line indicates the amount of precipitation during each month, on average. The solid black line indicates the PET.

Where the precipitation (blue line) is higher than the PET (black line), this means there is more supply than demand, and there is a surplus of water. This is noted by blue shading. When PET is higher than precipitation, this indicates deficit, and is noted by the yellow/orange shading. For reference, DEF = deficit; − DST = decreasing soil moisture; + DST = increasing soil moisture; SURP = surplus. **DST** is the estimated change in soil moisture from the end of the previous month, to the end of the current month (in mm). When negative **(−)**, water is taken from the soil to meet the needs of PET. When positive **(+)**, water is restored back to the soil via precipitation/runoff.

In this example, we can see that the location is in surplus during the late-winter/early-spring, then deficit in late summer. During autumn, soil moisture is recharged.



Using University of Delaware WebWIMP

We will be using an online model to generate water budgets at different locations. This model was developed at the University of Delaware by K. Matsuura, C. Willmott, and D. Legates in 2003 (*go Blue Hens!*), and has been updated in the past. The original version was developed by C. Willmott, D. Legates, and C. Rowe. Details of how it works are available on the introductory webpage (http://climate.geog.udel.edu/~wimp/).

The first step after reading the intro, is to click the "proceed to the world map" link. This will open a new tab for a low-resolution map. By clicking on the map, or entering coordinates in the longitude/latitude boxes, you can select a specific location to examine. Round your latitudes and longitudes to the nearest half degree (xx.0 or xx.5). Please note, do not click on a location too close to, or in, the ocean, as this will result in an error. Once the location is selected, it will open another tab, which will present a table of temperature and precipitation, along with some options to induce a 'hypothetical change'. For now, leave these all alone and scroll to the bottom of the page, clicking the link for 'Calculate the monthly water balance'.

This will generate a few tables. The one of importance for this specific lab is the 'Monthly and annual climatic water balance table'. It has monthly values for a dozen different variables. Some should be familiar (TEMP, DEF, SURP), but others may be less familiar. You can quickly figure out what they are by clicking the link associated with the variable (example, click "TEMP", and a box will pop up with a definition). You will be using this data table to answer some questions, but also using the associated graph. You can generate the graph by clicking the "graph" link at the bottom on the page. A new tab will open containing the graph.

Drought

During times of deficit, there isn't enough water to meet demand. This can indicate a drought. Droughts can have wide-ranging environmental and societal impacts, particularly to more vulnerable communities. Four different types of drought are used operationally: Meteorological Drought, Agricultural Drought, Hydrological Drought, and Socioeconomic Drought. Meteorological drought is based on how dry conditions are compared to normal and are regionally specific. Agricultural drought focuses on precipitation shortages, differences between potential and actual evapotranspiration, soil water deficits, and groundwater levels, all in application to agricultural impacts. Hydrological drought examines drought typically over longer periods of time, incorporating the frequency of intensity of precipitation, streamflow, groundwater, and lake-level shortfalls. Socioeconomic drought expands on these previous types of drought by considering the human demands for water, which often vary on multiple time-scales. Further detail on the types of drought, and drought research can be accessed at the National Drought Mitigation Center (https://drought.unl.edu/) among other locations.

One of the most common metrics for drought and moisture intensity is the Palmer Drought Severity Index (PDSI). PDSI is based on temperature and precipitation observations to estimate the degree of dryness on a unitless scale. In brief, the more positive the number, the more wet conditions are, while the more negative the number, the drier conditions are. Typically, values fall between 4.0 and -4.0, but extreme values outside of that range are possible.

The easiest way to find current PDSI in the U.S. is to use this link:

https://www.drought.gov/drought/data-maps-tools/current-conditions. *you'll have to scroll down the page a little.

There are a number of national-level drought-focused centers across the U.S., including the Climate Prediction Center (https://www.cpc.ncep.noaa.gov/products/Drought/), National Drought Mitigation Center https://drought.unl.edu/Home.aspx), and the National Integrated Drought Information System (NIDIS: https://www.drought.gov/drought/). All of these have a large wealth of information on drought, along with real-time and historical drought data.

Questions

Part 1 – Drought

1. Define what drought is. Be sure to note the 4 different types of drought.

2. Using the provided PDSI data, where are zones of severe to extreme drought? Where are there very or extremely moist conditions?

3. How does our region, eastern Nebraska, look currently in terms of PDSI? Does this make sense from your recollection of the weather in town over the last few months, why or why not?

4. Compare the current PDSI to that of 2019. What was unique about 2019?

5. Compare the current PDSI to that of 2014. What was going on in the US with respect to PDSI during this period?

Part 2 – Water Budgets

For questions 6-11, base your answers on the provided Water Balance for Omaha (latitude: 41.5 longitude: -96.0).

6. In which month(s) does Omaha generally experience a surplus?

7. In which month(s) does it experience a deficit?

8. Using the table, what are the maximum surplus and deficit observed during a typical year, in mm?

9. Are there any times of year where there is a not PET (i.e. the black line is at zero)? If so, In which month(s)?

10. What do you think a zero (or negative) value of PET mean physically? Hint: think about when this occurs and what the weather outside typically is.

11. Note the large spike in February/March. What do you think this is? Feel free to consult the table for help, or think about your experiences with water during that time of year.

Navigate to the WebWIMP portal. Select two other locations across the world to examine a water budget. Both should be outside of the U.S. In the event of technical difficulties, sample locations are available in the supplementary data.

Location #1: Lat ________ Lon ________ Name ______________________________

12. In which month(s) does it experience a water surplus?

13. In which month(s) does it experience a water deficit?

14. In which month(s) does the region's soil moisture recharge?

15.In which month(s) does the regions soil moisture decrease?

16. Is there a clear rainy or dry season? If so, in which month(s) does it occur?

Location #2: Lat ________ Lon ________ Name ______________________________

17. In which month(s) does it experience a water surplus?

18. In which month(s) does it experience a water deficit?

19. In which month(s) does the region's soil moisture recharge?

20. In which month(s) does the regions soil moisture decrease?

21. Is there a clear rainy or dry season? If so, in which month(s) does it occur?

22. Which of your three locations (Omaha, plus the other two) would have the easiest time having large agriculture productivity, independent of irrigation? Why?

23. Which location is most likely to be concerned with droughts and a lack of water availability for human needs? Why?

24. A changing global climate is very likely to result in more variable precipitation conditions world-wide, including an increase in the frequency of drought and the frequency of excessive precipitation, though not necessarily in the same places. For one of your locations, write down some possible impacts such changes could cause, and share some ideas how that community could try and prepare.

Extra Credit Question

25. Consider your initial assessment of the current drought/PDSI conditions across the United States. Using your knowledge of water budgets, hypothesize the cause of the spatial pattern of drought/excessive moisture.

10. Lab 10: Personal Water Use

Introduction

As noted in lecture, Lab #9, and your textbook, water is a critical resource in human society. It is necessary for human-life itself, but also is used for sanitation, agricultural, and industrial purposes. In many U.S. locations, water availability is minimally considered, except in times of intense drought. However, even in seemingly moisture rich regions, the actual availability of fresh, potable water is constantly considered and managed. The reduction of water overconsumption and waste is generally considered a positive thing by resource managers and environmentalists. But for many individuals, conservation seems unnecessary.

A global or even national-level conservation effort seems daunting to a single individual, but such efforts always comes down to small-scale, individual decisions to conserve, or not. To help showcase this, we will use this lab as an opportunity to self-observe our own water use habits and identify ways in which we could conserve water, if we deem it appropriate.

The objectives for this lab are:

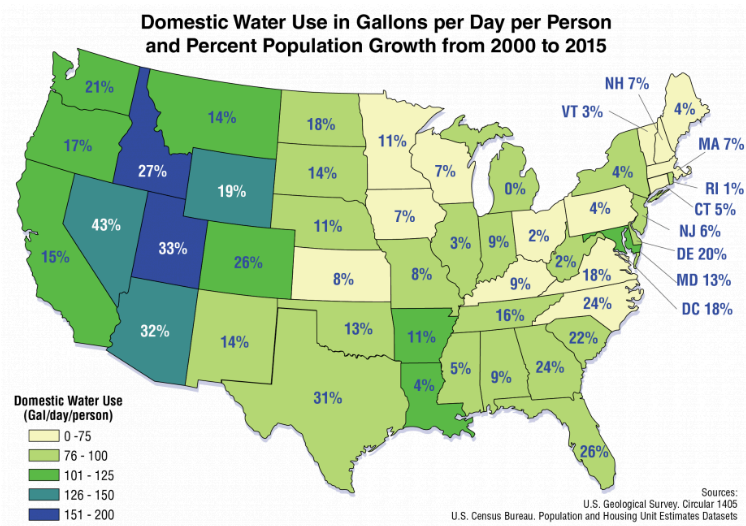
- Provide an individualized context for water resource use and availability
- Develop data collection techniques
- Analyze and summarize national-level water consumption data

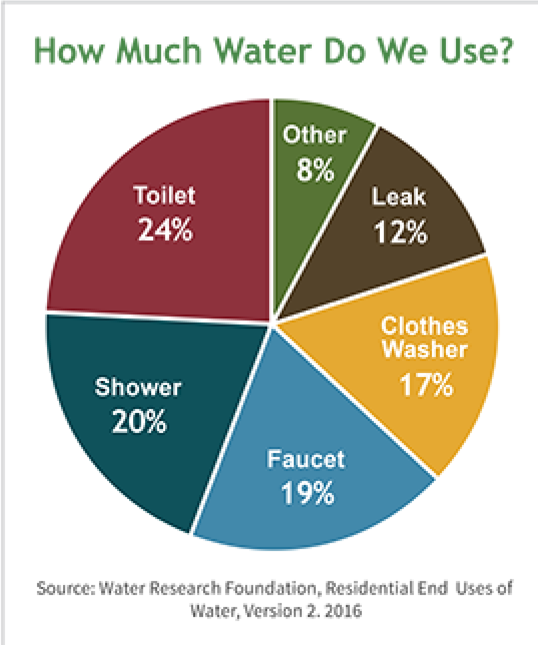
Background Information/Further Reading

How we use water in the U.S.

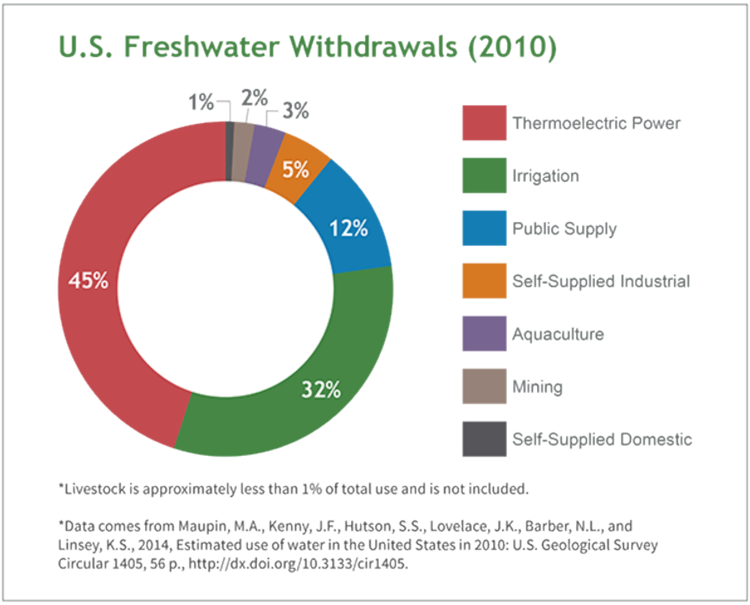
In addition to observing your own water usage, you will be investigating water usage across the United States. While you may use different sources of information if you wish, a good place to start is the EPA's water sense https://www.epa.gov/watersense/how-we-use-water.

Across the United States, the average American family consumes over 300 gallons of water per day for residential use – This is approximately 80-90 gallons per person per day. Examining the figure on the following page, we can see the domestic water use, in gallons per person per day, for each state as represented by the colors shown on the map. Also shown on this map are percent population growth from 2000 to 2015, as indicated by a number on the state.





We can also examine the consumption of water how we use. Nationally, approximately 30% of household use of water is for the irrigation of lawns and landscaping. The remaining 70% is broken down above, which shows the 6 most water consuming activities within the average American household.



Above, we incorporate all water use, not just at the household level.

Observing Personal Water Use

The primary activity in the lab is to track and record your personal water use. While you may or may not have direct access to your water meter, and/or may share it with others, you can still come up with approximate observations. An excel sheet has been provided to assist in the documentation of your water use. Please use this template.

Questions

Part 1 – National Water Usage

1. Here in the greater Omaha area, what source(s) do most of our water come from? Hint: https://www.mudomaha.com/our-company/our-services/water

2. Excluding irrigation, list the 4 largest sources of residential water use in a typical U.S. home.

3. Now incorporating all uses, based on the “U.S. Freshwater Withdrawals (2010)” graphic, what are the 3 largest sources of water use and their respective percentage of the total?

4. What sorts of negative consequences would a lack of water (or too much demand for water) have on society?

5. Examine the map of the US water use by state, where the color indicates typical Domestic Water Use in gallons per day per person. Approximately how much water does a typical Nebraskan use per day? How does it compare to the rest of the country?

6. What part of the country uses the most amount of water? Explain why this does or does not make sense.

7. Super-imposed on this map is percent population growth from 2000 to 2015. Is there any association between states’ growth and daily water consumption? What is it? What might such an association mean, physically, into the future?

Part 2 – Personal Water Use

8. Create a ‘Water Diary’ for 48 hours. Using a provided excel template, measure and record the amount of water that you use from various sources (shower, toilet, sink, dishwasher, hose, etc.). Record the amount of water used, in gallons, along with the activity and the approximate time/day. **Submit this observation ‘diary’ with the lab.**

9. How much water did you use during each day of your 48-hour period?

Day 1 __________Day 2_____________

10. What activity/source consumed the most amount of water during the 48-hour observation period?

11. Consider the pie-chart of water usage by source you examined for question #2. How do the percentages noted for the average American compare to your percentages?

12. Looking back at your water practices, how would you characterize your consumption/conservation habits in terms of maximizing the use of every drop of water?

13. What things do you think you could do differently to get the most of each gallon of water available to you?

14. On the provided Excel template, typical water-use values of "conventional" and "high efficiency" use are provided. Given your total water use numbers, calculate the difference in water used if you were to upgrade to only high efficiency use. What percentage reduction would ensue?

Part 3 – National-Scale Water Resources

15. Imagine you were appointed as the U.S. Secretary of Water Resources (if it existed), and tasked with appropriately managing

water use at a national level. Considering your answers to parts 1 and 2, what are the three most important priority areas you would focus on? What sort of evidence would you need to justify such a decision?

This is where you can add appendices or other back matter.