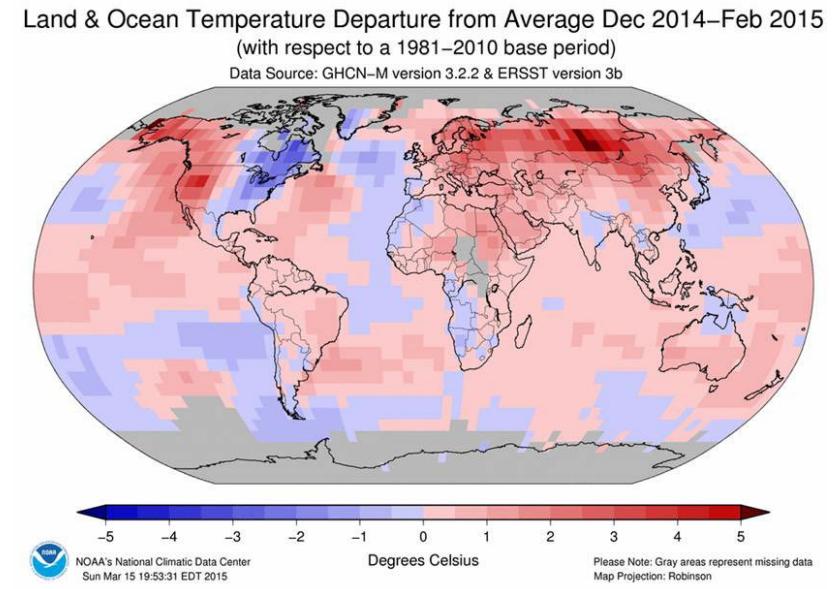


Choice and Acquisition: ‘climate’ variables for time- series analyses

Sadie J. Ryan

Choice

- Before you dive into products, or just do what someone else did:
 - Think about the biological mechanisms you might be exploring
 - Think about what meteorological or climate data corresponds to the mechanism.
- Example: mosquitoes (pick your species of choice)
 - When does temperature limit your mosquito of interest, and how?
 - Is minimum temperature likely to be most important? Maximum?
 - Create reasonable hypotheses for mechanistic processes
 - Temperate vs. tropical vs. boreal



Choice, cont.

- Scale
 - You've decided minimum temperature will be important – but when and for how long?
 - Coldest month? Minimum temperature in an hour in a day?
 - First month in which a daily minimum temperature is exceeded? (Thresholds)
 - Average v. cumulative measures (think temperature and precipitation)
 - A bit of Tobler's law – how far does the effect carry (derived from the 'law' that things that are closer are more similar)
 - Is the nearest weather station useful for your organism of interest, is interpolation of data reflecting the likely response at the location?
 - More “geographic” consideration for met/climate variables
 - Where are measurements made? Is ground surface temperature equivalent to air temperature, and when does it matter? Does rain absorb into the surface or sit on it?

Acquisition

- Making the best of things
 - Unless you specifically have a weather station logging your variables of interest next to your trapping/collecting design, you will use proxies in some way
 - Time series, so we need regularly spaced, consistent observation or modeled products
 - (Happy to talk about climate and season descriptors, other environmental variables and proxies later)
- More choices
 - Most ‘weather’ products are modeled (interpolated) in some way – read the documentation carefully, and know what it is – imperfect is often still useful, but may have important limitations
 - EOS products are also modeled, and spatiotemporal aggregations will also determine their utility – don’t be fooled by apparent consistency

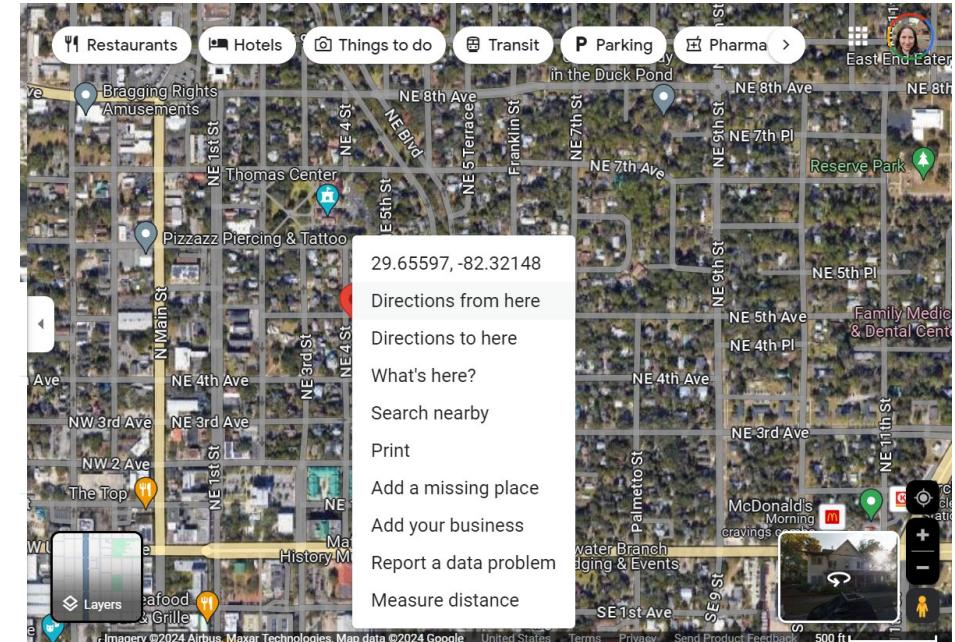
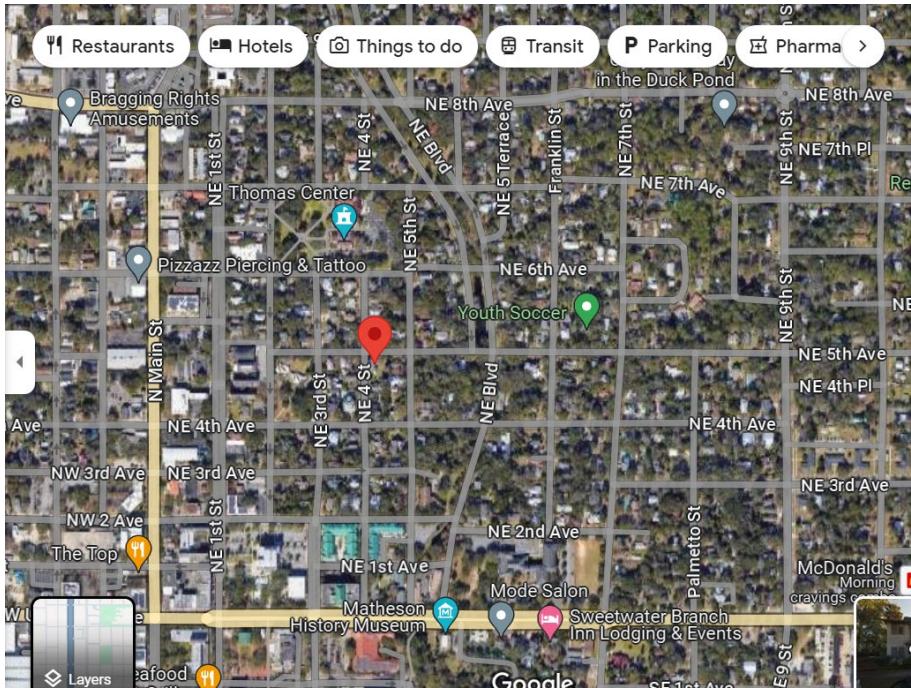
Acquisition, cont.

- Two examples:
 - Point extraction of Daymet data – useful for USA-based studies, high frequency data availability, consistency already worked out for you.
 - GEE extraction of MODIS products (EOS) – proxies for rainfall, temp, and NDVI, which can proxy both, in some circumstances
- Before you even start
 - What is the location of your vector time-series?
 - We assume absolutely perfect data, and chances are you have a coordinate pair
 - What projection is it in? Whose GPS unit was it reported from? How accurate or precise is it?
 - Throw it on Google maps and make sure it seems to be where you think it is.

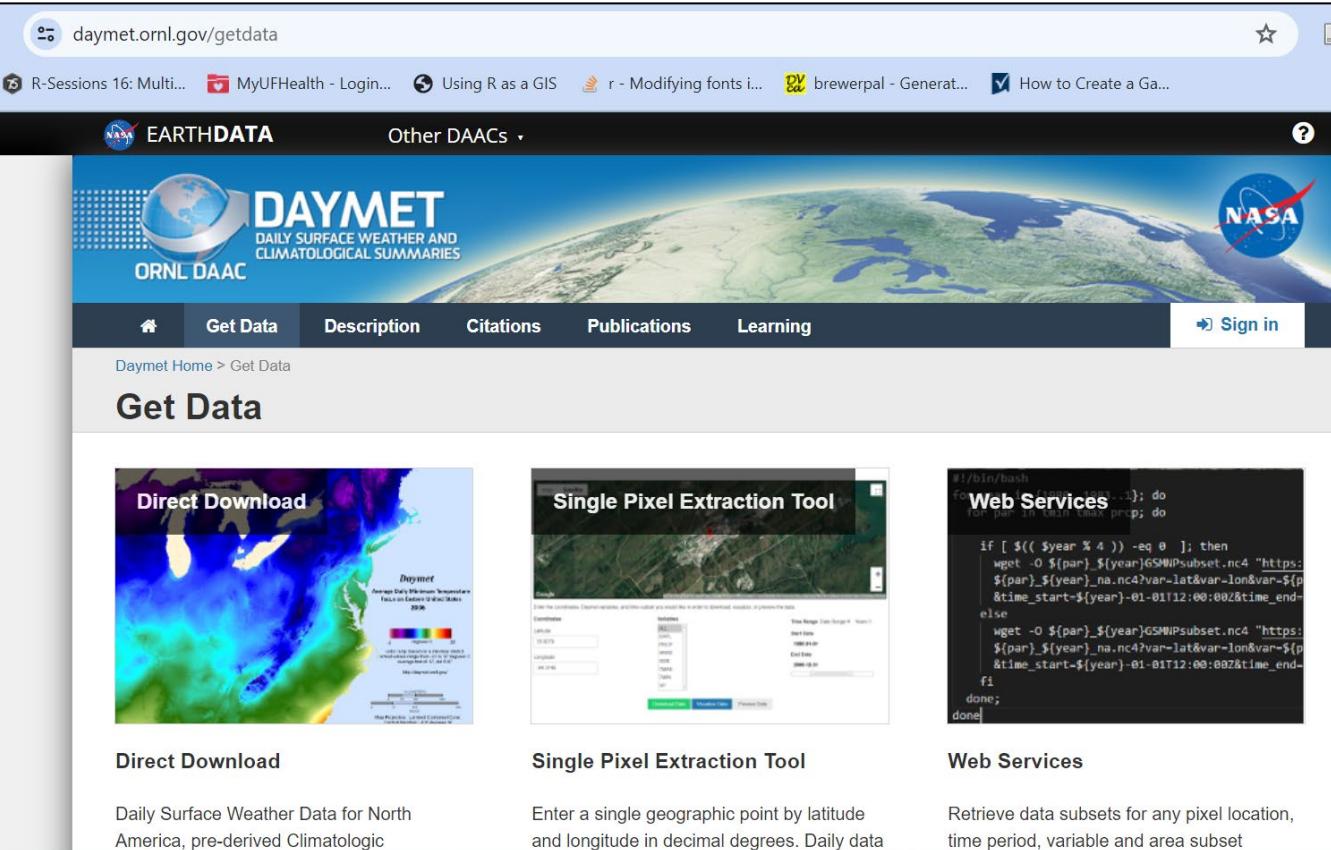
Daymet point extraction example

- Put your point in google maps, or choose an address
- 29.6557572689658, -82.32141674790877
- What is this? This is my house – 405 NE 5th Avenue, Gainesville, FL.

Right click to get coordinates



Earthdata profile with NASA – make an account – <https://urs.earthdata.nasa.gov/>



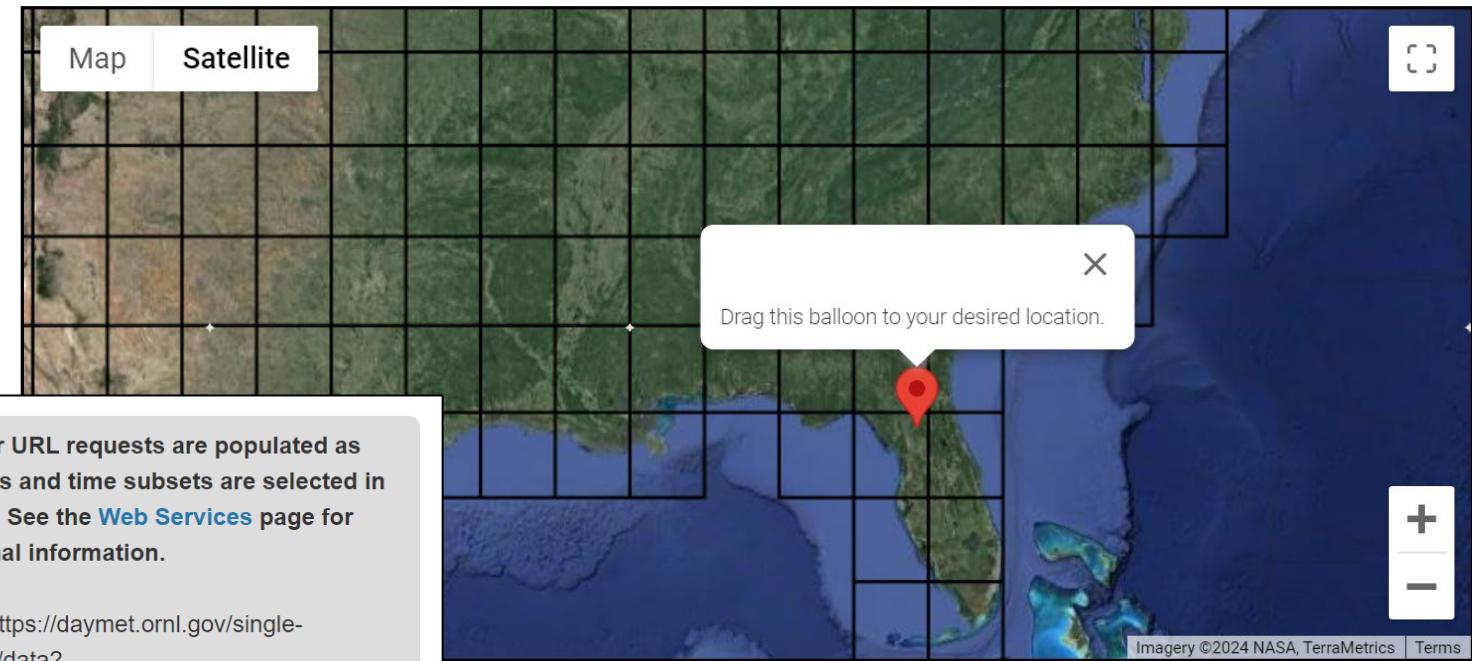
The screenshot shows the Daymet website interface. At the top, there's a navigation bar with links for "Get Data", "Description", "Citations", "Publications", "Learning", and "Sign in". Below the navigation is a large banner featuring the Daymet logo (a globe with a grid) and the text "DAYMET DAILY SURFACE WEATHER AND CLIMATOLOGICAL SUMMARIES ORNL DAAC". The main content area is titled "Get Data" and contains three sections:

- Direct Download:** Displays a map of North America with a color-coded legend for precipitation. Below it, there's a brief description: "Daily Surface Weather Data for North America, pre-derived Climatologic".
- Single Pixel Extraction Tool:** Shows a map with a red dot indicating a specific location. It includes input fields for "Latitude" (40.875), "Longitude" (105.875), and "Variable" (precipitation). Buttons for "Download" and "Print" are present.
- Web Services:** Displays a terminal window with a shell script for retrieving data subsets. The script uses wget to download files from URLs based on parameters like year, variable, and time period.



Single Pixel Extraction Tool

Coordinates for a latitude, longitude pair (in decimal degrees) can be manually entered below or automatically filled by dragging the balloon in the map. Click on a tile (within the Google Map) to see the latitude and longitude bounds for that tile.

**Coordinates:**

Latitude:

29.655757268

Longitude:

-82.32141674

Variables:

- ALL
- DAYL
- PRCP
- SRAD
- SWE
- TMAX
- TMIN
- VP

Date Range **Years**

Start Date:

2023-01-01

End Date:

2023-12-31

Browser URL requests are populated as variables and time subsets are selected in the GUI. See the [Web Services](#) page for additional information.

```
curl -J 'https://daymet.ornl.gov/single-pixel/api/data?  
lat=29.6557572689658&lon=-82.32141674790  
877&vars=dayl,prcp,srad,swe,tmax,tmin,vp&st  
art=2023-01-01&end=2023-12-31' -O
```

```
wget --content-disposition  
'https://daymet.ornl.gov/single-pixel/api/data?  
lat=29.6557572689658&lon=-82.32141674790  
877&vars=dayl,prcp,srad,swe,tmax,tmin,vp&st  
art=2023-01-01&end=2023-12-31'
```

Download Data**Visualize Data****Preview Data**

DON'T OPEN YOUR DATA IN EXCEL – demo only

Annoying/informational header lines

10669_lat_29.6557572689658_lon_-82.32141674790877_2024-07-20_13...								Search	Ryan,Sadie Jane		Comments	Share	
File	Home	Insert	Page Layout	Formulas	Data	Review	View	Automate	Help	Acrobat			
A1	Latitude:	29.6557572689658	Longitude:	-82.32141674790877									
1	Latitude:	29.6557572689658	Longitude:	-82.32141674790877									
2	X & Y on Lambert Conformal Conic:	1663970.19	-1195191.03										
3	Tile:	10669											
4	Elevation:	41 meters											
5	All years; all variables; Daymet Software Version 4.0												
6	How to cite:	Thornton, M.M.; R. Shrestha; Y. Wei; P.E. Thornton; S-C. Kao; and B.E. Wilson. 2022. Daymet: Daily Surface Weather Data on a 1-km Grid for North America; Version 4 R1. ORNL DAAC; Oak Ridge; Tennessee.											
7	year	yday	dayl(s)	prcp (mm)	srad (W/m	swe (kg/m^2)	tmax (deg c)	tmin (deg c)	vp (Pa)				
8	2023	1	36485.81	0	209.45	0	24.78	14.49	1649.28				
9	2023	2	36512.74	0	269.55	0	26.46	12.32	1431.96				
10	2023	3	36541.88	0	258.33	0	27.37	13.89	1586.09				
11	2023	4	36573.21	13.63	142.41	0	25.96	16.64	1892.82				
12	2023	5	36606.72	0	213.62	0	23.96	13.66	1563.08				
13	2023	6	36642.38	0	298.69	0	19.44	4.41	836.76				
14	2023	7	36680.17	0	340.31	0	20.92	1.9	700.48				
15	2023	8	36720.07	0	350.5	0	23.6	2.88	750.9				
16	2023	9	36762.04	0	306.36	0	23.47	7.53	1038.08				
17	2023	10	36806.07	0	302.26	0	20.83	5.67	913.64				
18	2023	11	36852.14	0	354.46	0	23.99	3.16	766.32				
19	2023	12	36900.2	13.44	258.02	0	25.63	5.92	929.53				
20	2023	13	36950.23	0	237.29	0	18.02	7.39	1028.28				
21	2023	14	37002.21	0	239.45	0	11.3	1.04	658.37				
22	2023	15	37056.1	0	342.01	0	15.13	-2.13	522.29				
23	2023	16	37111.87	0	373.9	0	19.75	-1.86	532.83				

Last notes on a Daymet pull

- For a single point, the question about what the projection is in the Daymet model should be ok, because you are not overlaying rasters, and you can see it all on google maps, both before and during your extraction
 - If you are doing this for multiple points, DEFINITELY THINK ABOUT THE PROJECTION
- User choice about how to wrangle it into R
 - Be super careful about csv formats if you open in Excel, but you probably know this at this stage in your career.
 - Generally, don't. Just pull it into R and chop off rows or subset what you need, check the classes of each variable field you'll use, make sure the units of measurement (temperature, VP, etc) are as you expect, and enjoy!

Pause – were you able to navigate this so far?

- Why is Daymet a bit deluxe? – high resolution (pixels are small), high frequency (daily availability).
- Easy UIs for data extraction
- Limitations:
 - Only continental North America (plus HI from 1980 and PR from 1950)
 - Seems to get released by calendar year (up to end of last year)

Quick example of pulling a local weather station's data using NOAA access

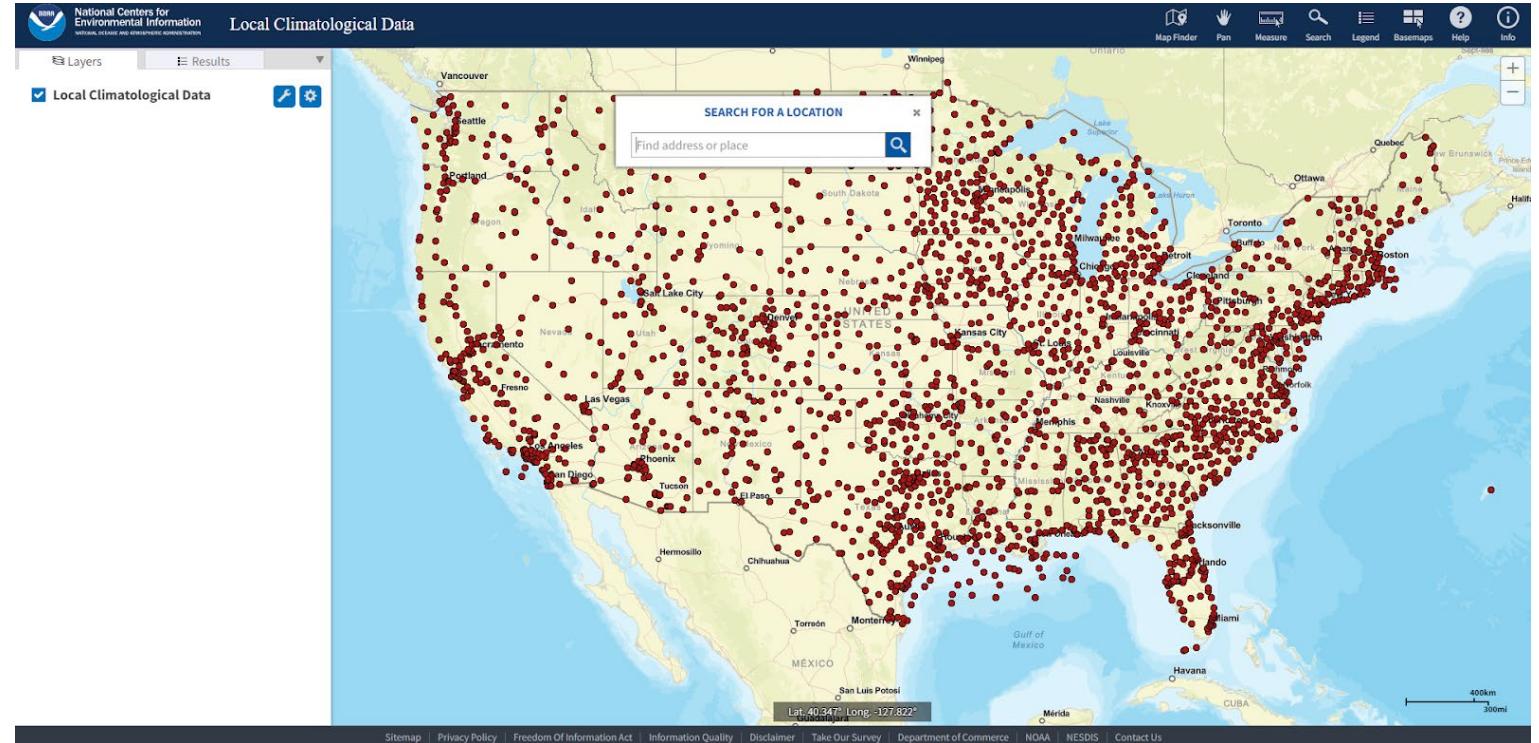
George and Wesley

How to Download Historical Weather Data from NOAA

14 Easy Steps

1. Go to

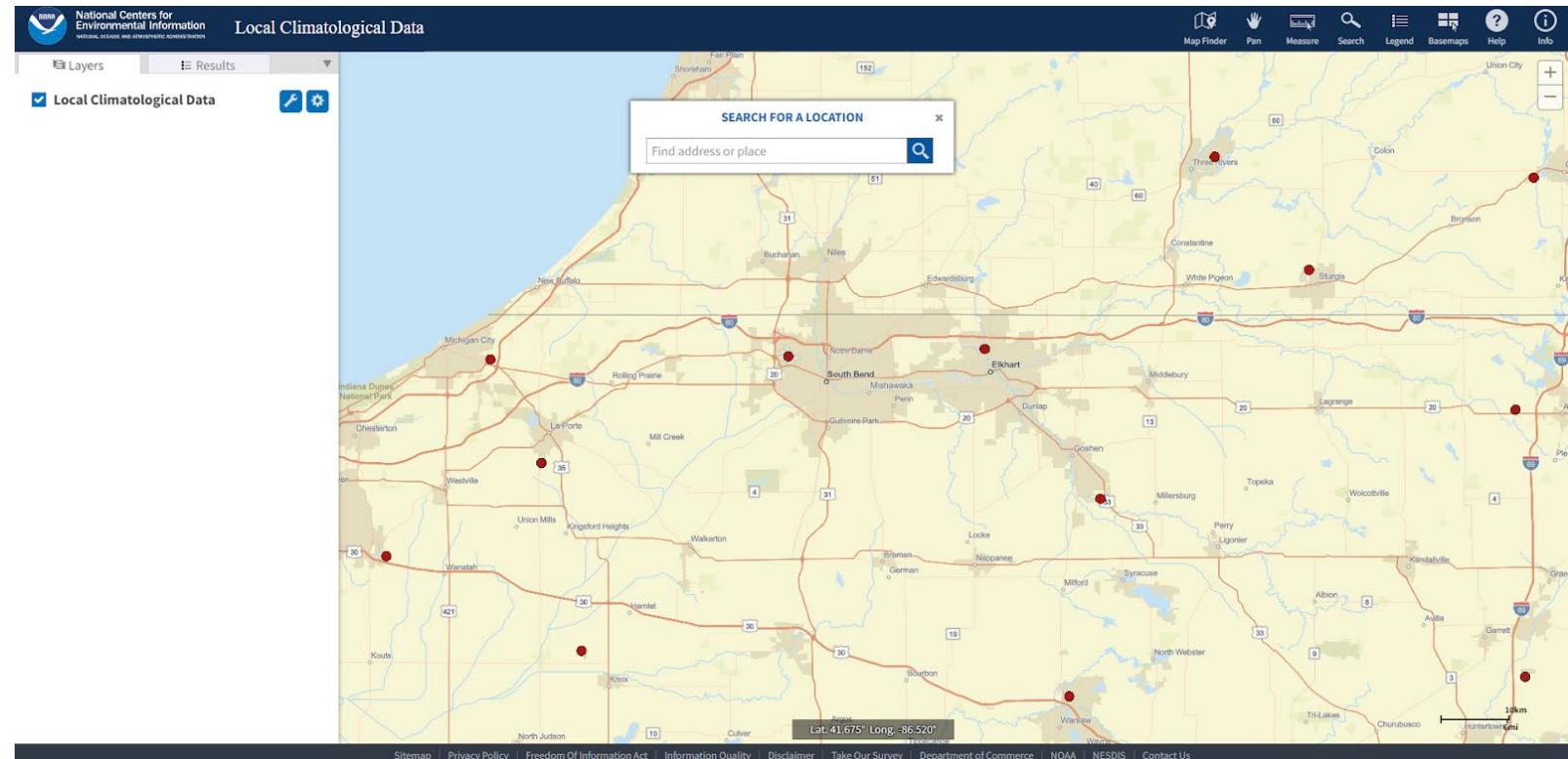
[https://www.
ncei.noaa.go
v/maps/lcd/](https://www.ncei.noaa.gov/maps/lcd/)



2

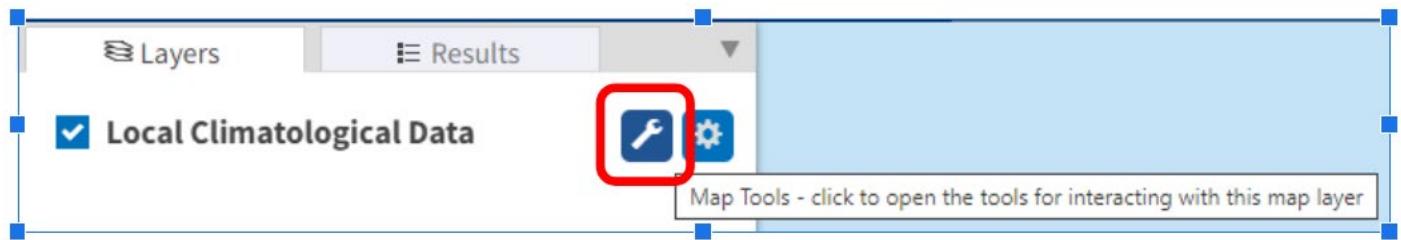
- Find the area on the map that you want weather data from. Click and drag to move around and scroll to zoom in or out.

In this example, we will retrieve weather data from South Bend.



3.

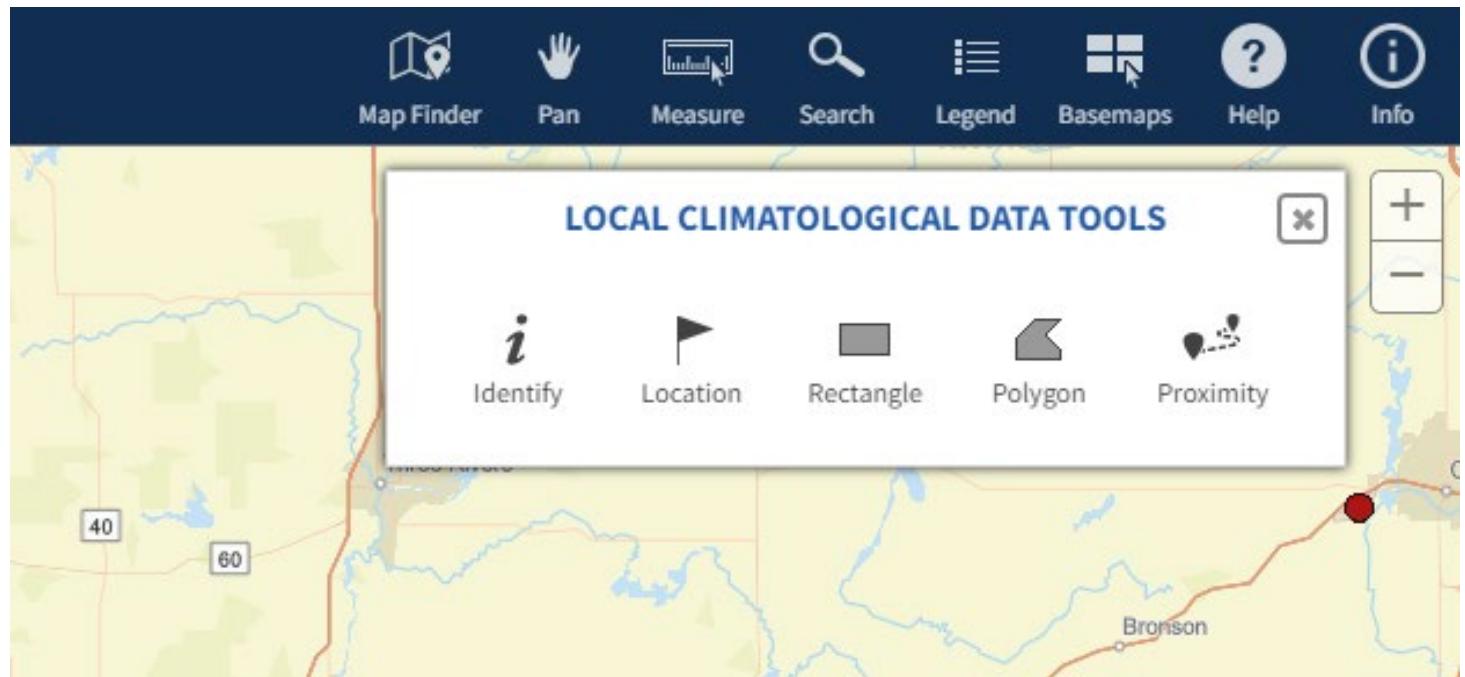
- In the “Layers” tab on the left panel, select the tools icon.



4.

Choose an option from the tools menu to select an area to get weather data from.

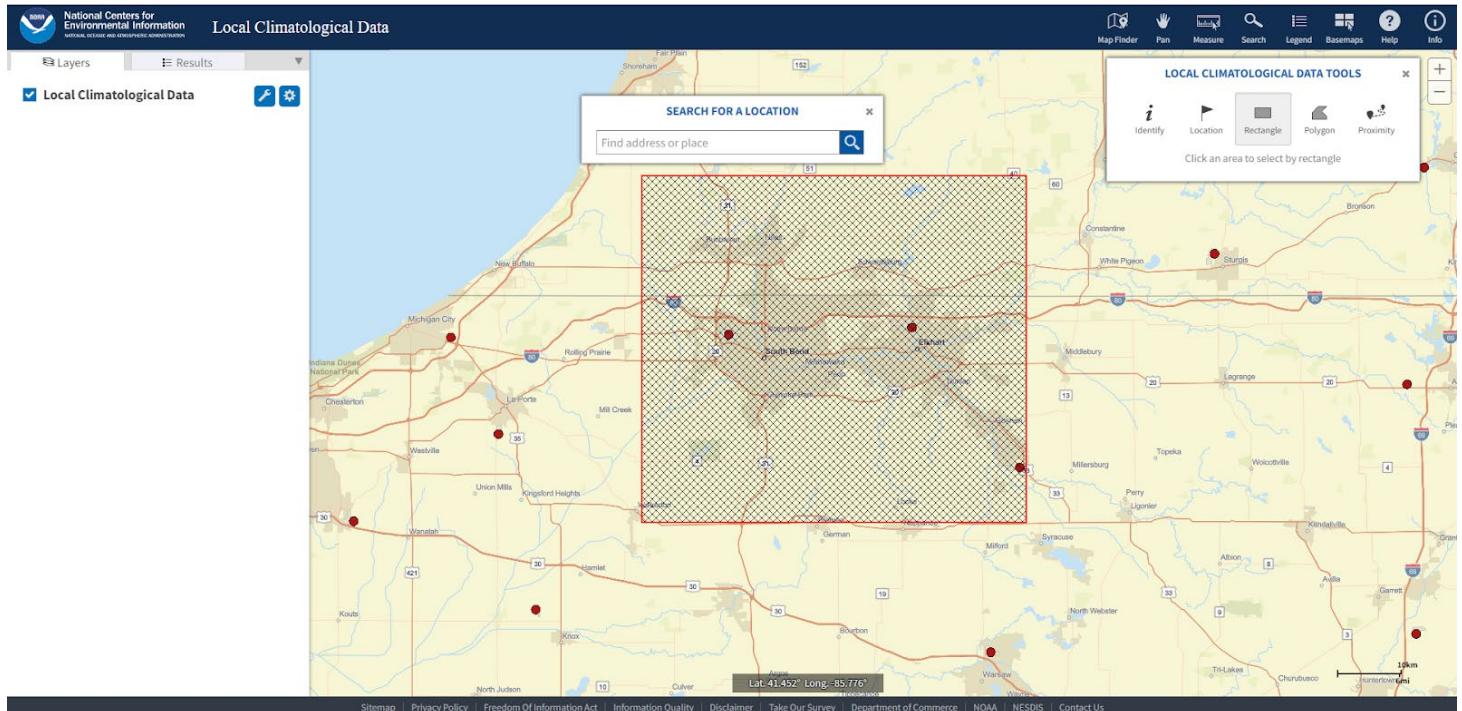
- In this case, we will use the rectangle tool.



5.

Use the selected tool to select a point or area.

With the rectangle tool, simply click and drag to form a rectangle over the area of interest.



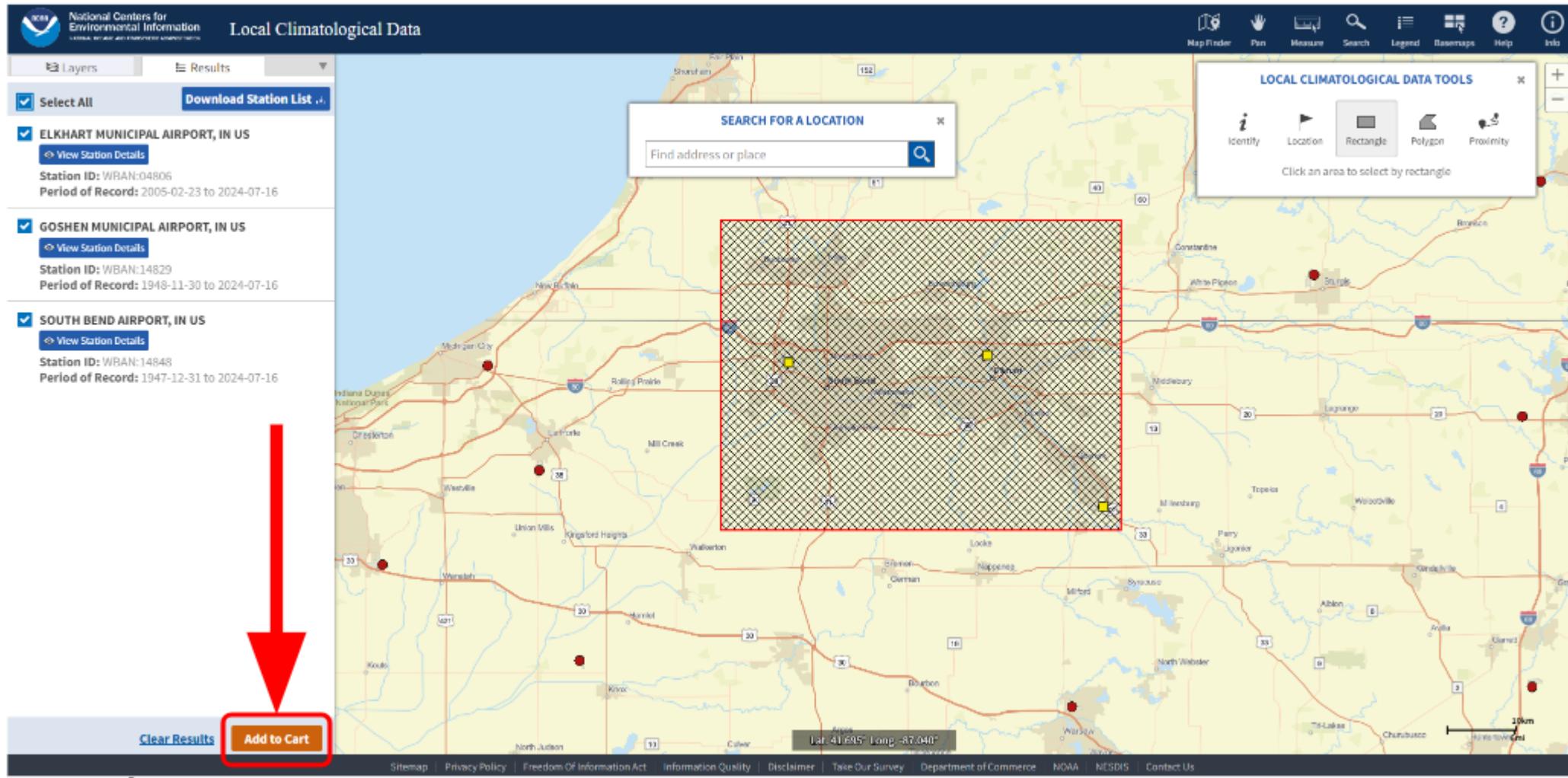
6.

- In the “Results” tab of the left panel, click the checkbox for “Select All” or select the appropriate stations that you would like to receive data from.**

The screenshot shows a software interface with a top navigation bar featuring "Layers" and "Results" tabs. Below this is a toolbar with a "Select All" checkbox (which is checked) and a "Download Station List" button. The main content area displays three entries, each representing a weather station:

- ELKHART MUNICIPAL AIRPORT, IN US**
Station ID: WBAN:04806
Period of Record: 2005-02-23 to 2024-07-16
[View Station Details](#)
- GOSHEN MUNICIPAL AIRPORT, IN US**
Station ID: WBAN:14829
Period of Record: 1948-11-30 to 2024-07-16
[View Station Details](#)
- SOUTH BEND AIRPORT, IN US**
Station ID: WBAN:14848
Period of Record: 1947-12-31 to 2024-07-16
[View Station Details](#)

7. Click the “Add to Cart” button.



8.

A new tab will open.

- In this specific step, you may likely experience technical difficulties. If you see an error page, simply reload the page until this error ceases to occur.
- Furthermore, if the page loads but you do not see the “LCD CSV” option listed, reload until you do. The page should look like this:

The screenshot shows a web browser window with the NOAA logo at the top left. The main header reads "NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION" with the subtitle "NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION". To the right is a search bar with a magnifying glass icon. Below the header, a blue navigation bar contains links for Home, Climate Information, Data Access, Contact, and About. Underneath the navigation bar, a breadcrumb trail shows "Home > Climate Data Online > Cart: Local Climatological Data". A horizontal menu bar below the breadcrumb trail includes links for Datasets, Search Tool, Mapping Tool, Data Tools, and Help. The main content area is titled "Cart: Local Climatological Data". It features a progress bar with three steps: "Step 1: Choose Options", "Step 2: Review Order", and "Step 3: Order Complete". Below the progress bar, a section titled "Select Cart Options" asks users to specify formatting options. A text block explains that users can choose from PDF, CSV, or Text formats, and provides additional options for date selection and removal. A "Select the Output Format" section contains two radio button options: "LCD PDF" (selected) and "LCD CSV". Under "LCD PDF", several checkboxes are checked: Daily Output, Hourly Output, and Hourly Precipitation Output. Under "LCD CSV", one checkbox is checked: Hourly Remarks Output (Expert Users). To the right of the main content area is a "Help" sidebar with links for Climate Data Online help, Check order status, Request assistance, and links to View data samples & documentation, NCDC Web Services, and CDO Web Services Documentation. There is also a note about needing assistance with technical documentation or assistance with systems access.

9.

Select the “LCD CSV” option.

Select the Output Format

Choose one option below to choose a type of format for download. Formats are a standard PDF format. Other formats are CSV (Comma Separated Value) and Text format, both of which can be opened with programs such as Microsoft Excel or OpenOffice Calc. Some formats have additional options which can be selected on the next page.



LCD PDF

DOC Certification Option

Daily Output

Hourly Output

Hourly Precipitation Output

Hourly Remarks Output (Expert Users)

Documentation (Included in Certification)



LCD CSV

LCD CSV

10.

Select the start and end date from which you would like to receive

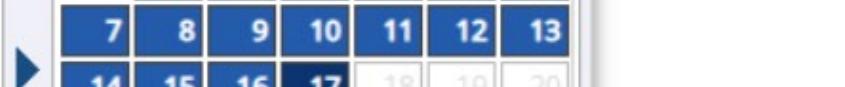
- weather data from.
- Be sure to select not only a year and a month but also a day, or the blank will not update.
- Click the “APPLY” button when finished.

Select the Date Range
Click to choose the date range below.

2024-01-01 to 2024-07-17 

2020-01-01 

SU	MO	TU	WE	TH	FR	SA
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

2024-07-17 

SU	MO	TU	WE	TH	FR	SA
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Select a year and month.
MUST CLICK ON A DAY to select.

[CLEAR CART]  Delete 

CANCEL **APPLY**

11.

Click the “Continue” button.

If nothing happens, scroll up to see the error message. The most likely error is that you selected more than ten years of data.

Review the items in your cart

[CLEAR CART]

ELKHART MUNICIPAL AIRPORT, IN US

[View Full Details](#)

Station ID: WBAN:04806

Period of Record: 2005-02-24 : 2024-07-17

Delete

GOSHEN MUNICIPAL AIRPORT, IN US

[View Full Details](#)

Station ID: WBAN:14829

Period of Record: 1948-12-01 : 2024-07-17

Delete

SOUTH BEND AIRPORT, IN US

[View Full Details](#)

Station ID: WBAN:14848

Period of Record: 1948-01-01 : 2024-07-17

Delete

CONTINUE



! *Text order size is **13 Station Years**, which exceeds our capacity of **10 Station Years**. Please select fewer stations/locations, or reduce the date range.

*Climate Data Online is experiencing technical difficulties and failed to

12.

Enter your email address so that the download link can be sent to you.

- Then click “SUBMIT ORDER”.**

Enter email address

Please enter your email address. This is the address to which your data links and information regarding this order will be sent. Please read NOAA's [Privacy Policy](#) if you have any concerns.

Email Address

Verify Email Address

Remember my email address

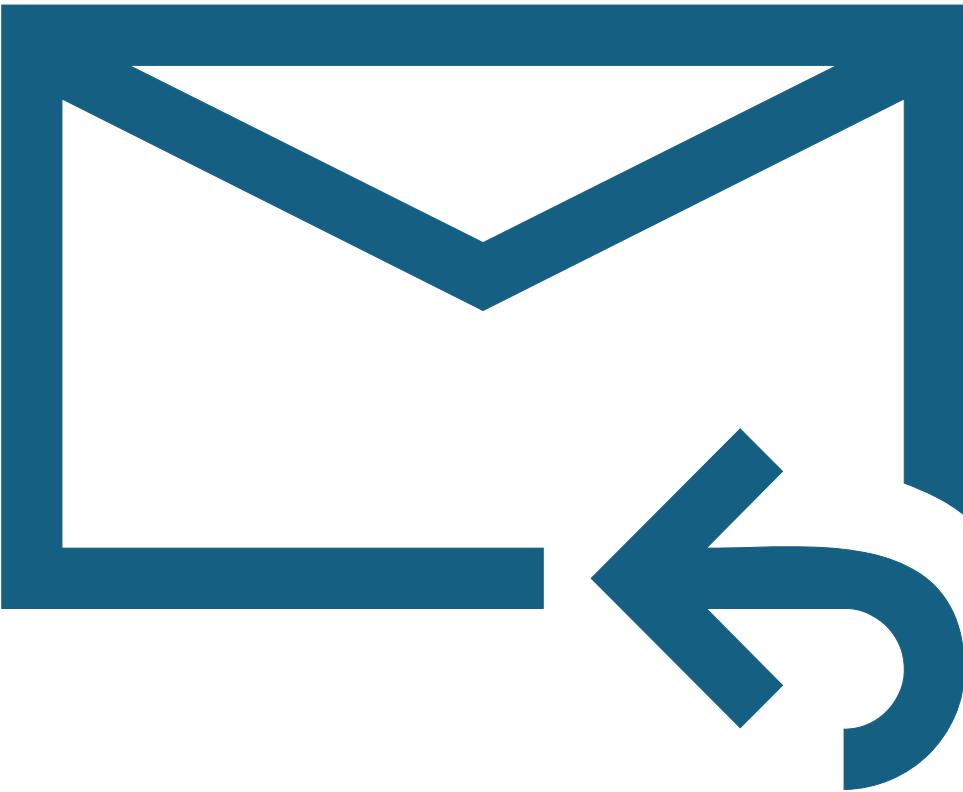
NOAA will not share your email address with anyone. The email address will not be used for any purpose other than communicating the order status.

EDIT ORDER

SUBMIT ORDER

13.

You will immediately receive an email that you don't need to do anything with. This email can be ignored.



14.

About one minute later, you should receive another email with a download link for the CSV file. Click the link.

Order Details

Order #3749019 (LCD CSV)

File	Download (Available until 2024-Jul-25)
Order ID	3749019
Date Submitted	2024-07-18 03:33
Order Summary	View Summary
Documentation	View Documentation

Success! You have now downloaded historical weather data from NOAA!

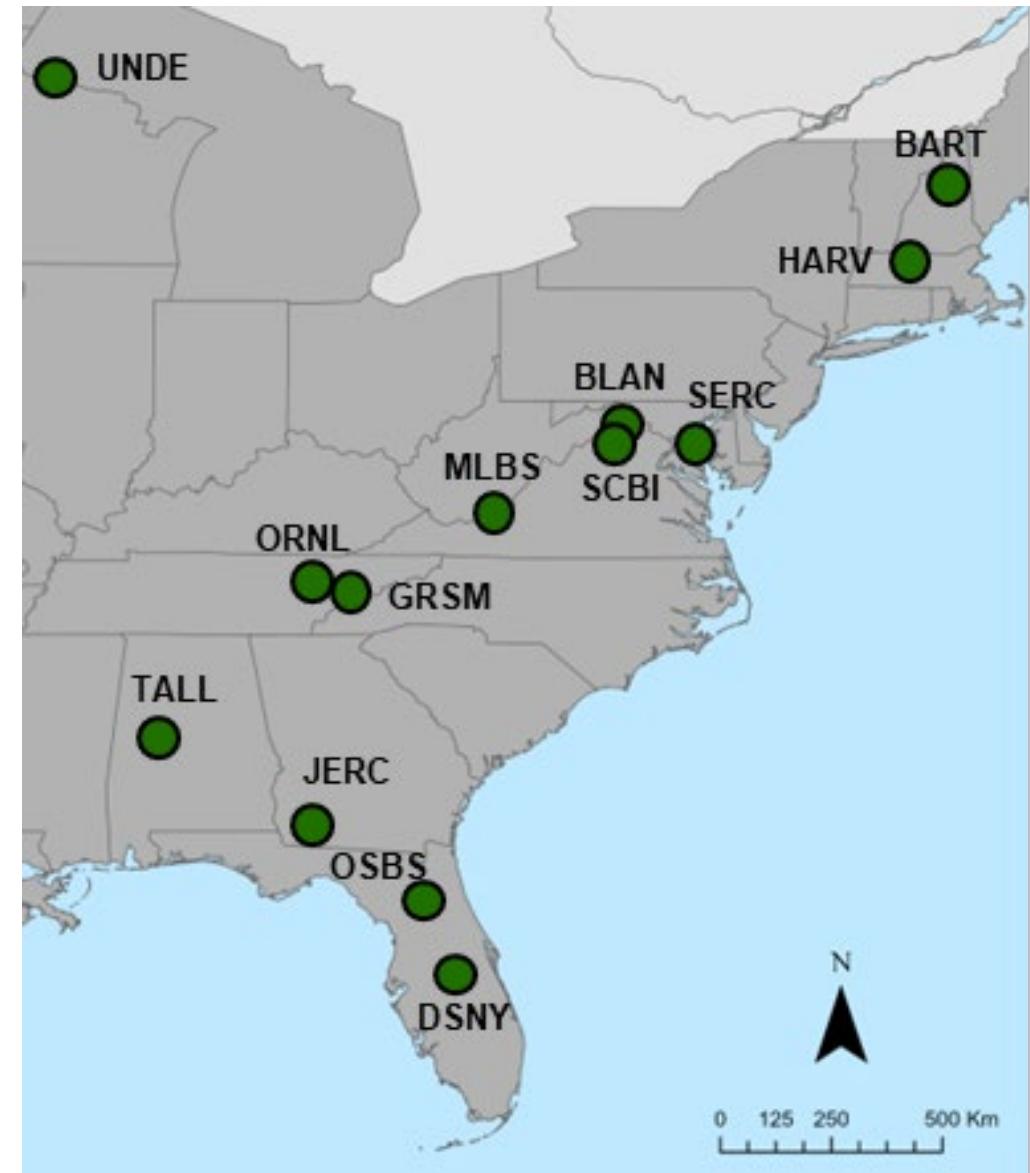
Next up: Google Earth Engine

GEE MODIS product pull

- Walking you through an example – thanks to Dr. Cat Lippi (former VByte Postdoc), and Dr. Nique Etienne for this!

What is this example about? NEON sites

- We will look at 13 NEON terrestrial sites, for which there are observation towers for data, and also tick plot sites
- Terrestrial sites
- Spanning a chunk of the Northeastern US



We realized the tick plots and the NEON climate data may not overlap a lot



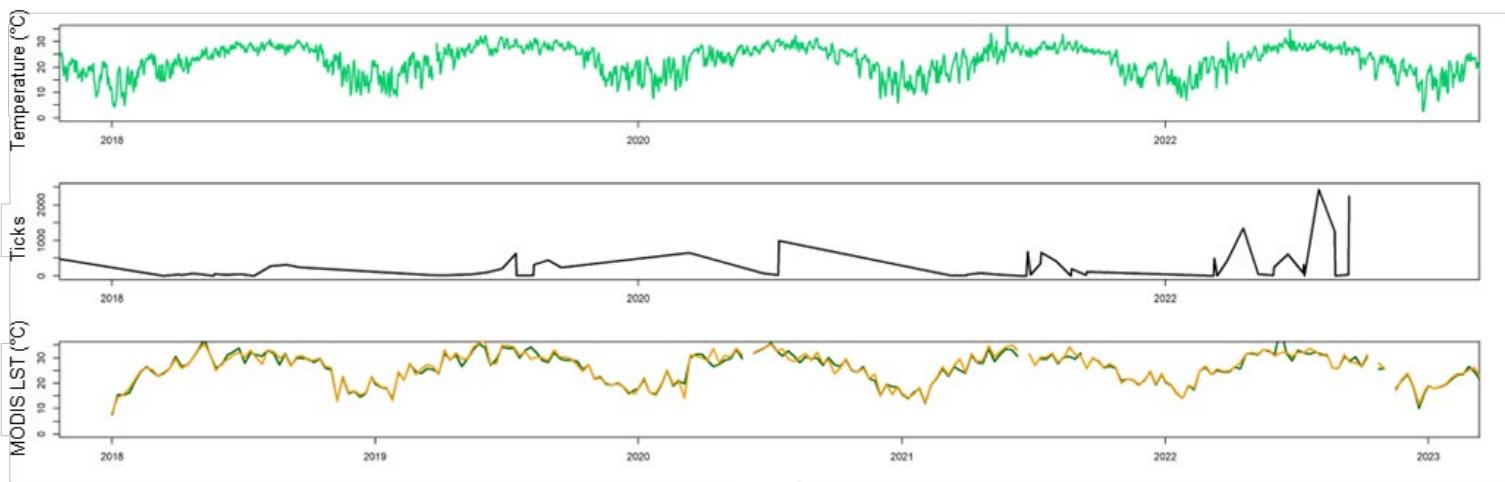
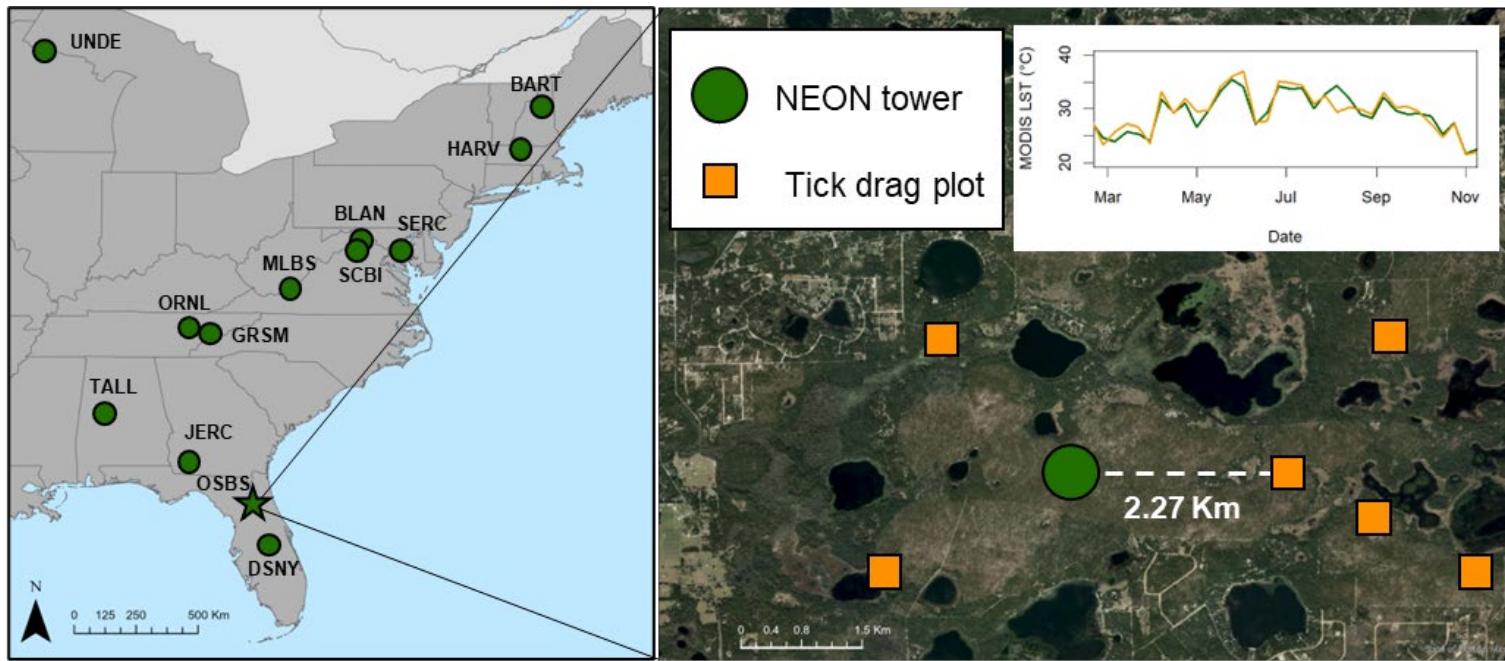
OSBS

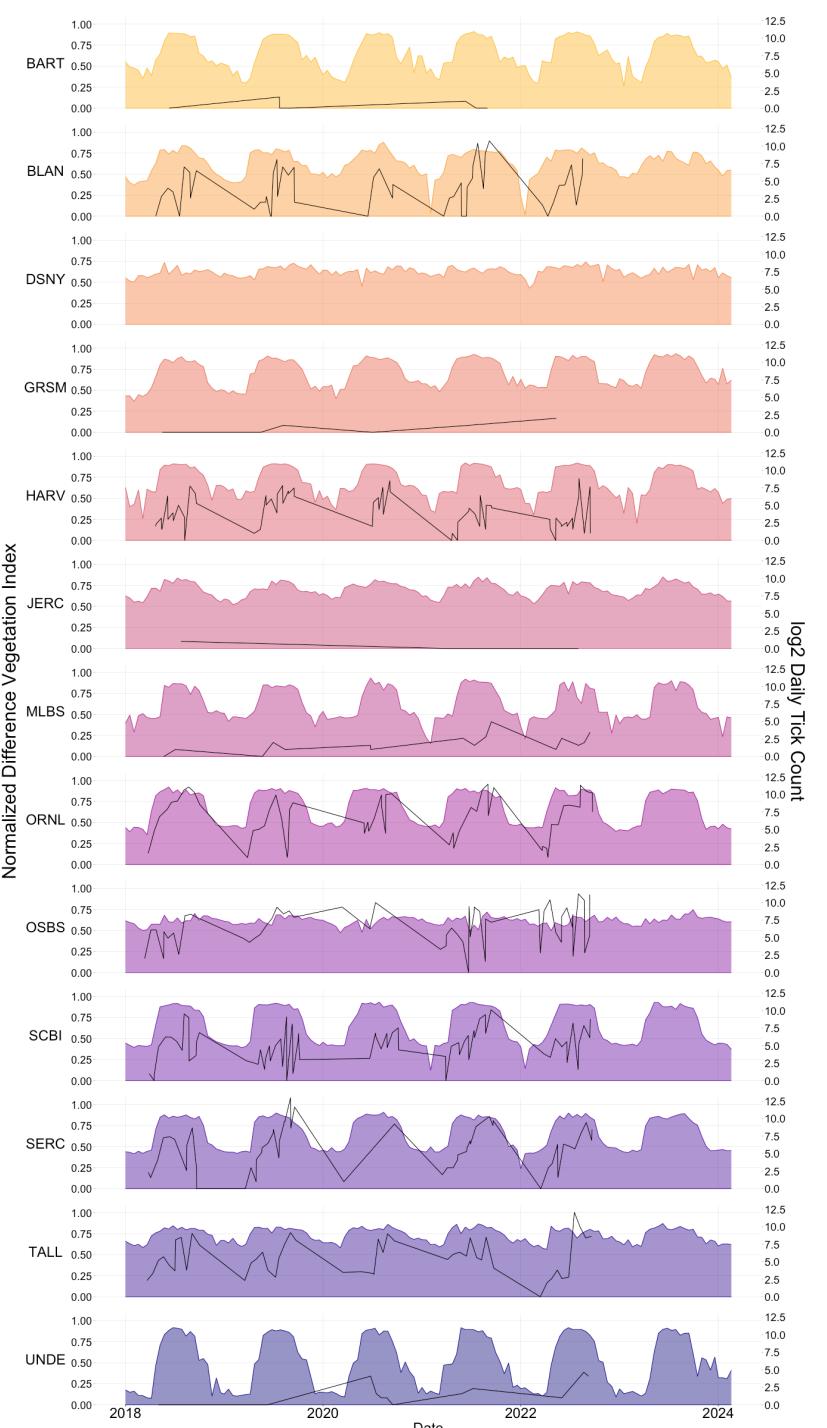
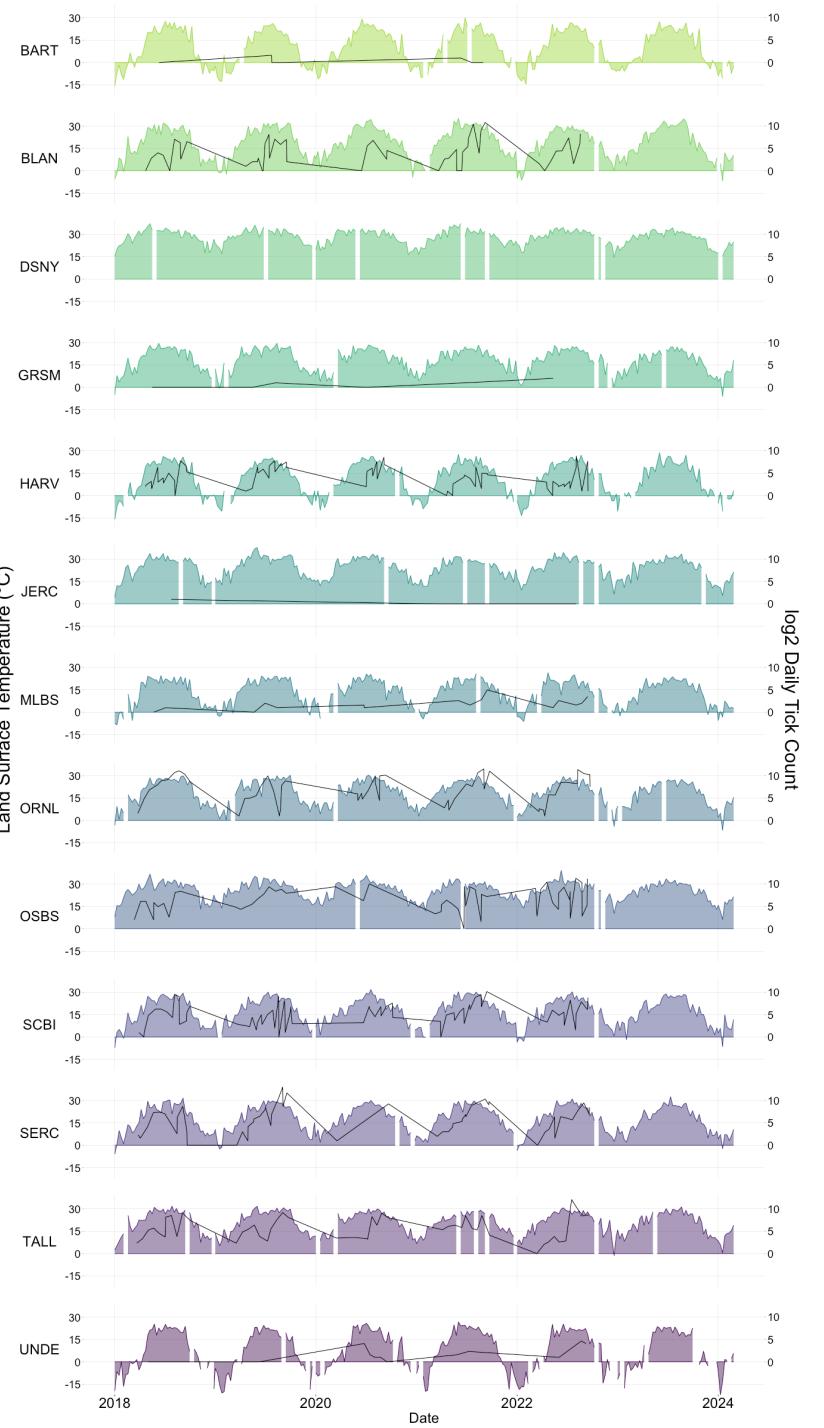
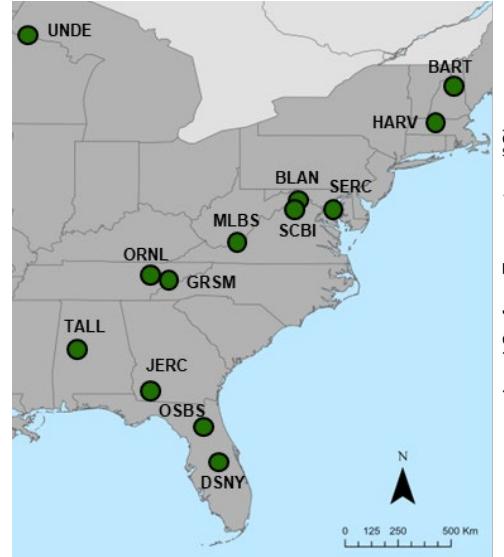


NEON tower



Tick plots

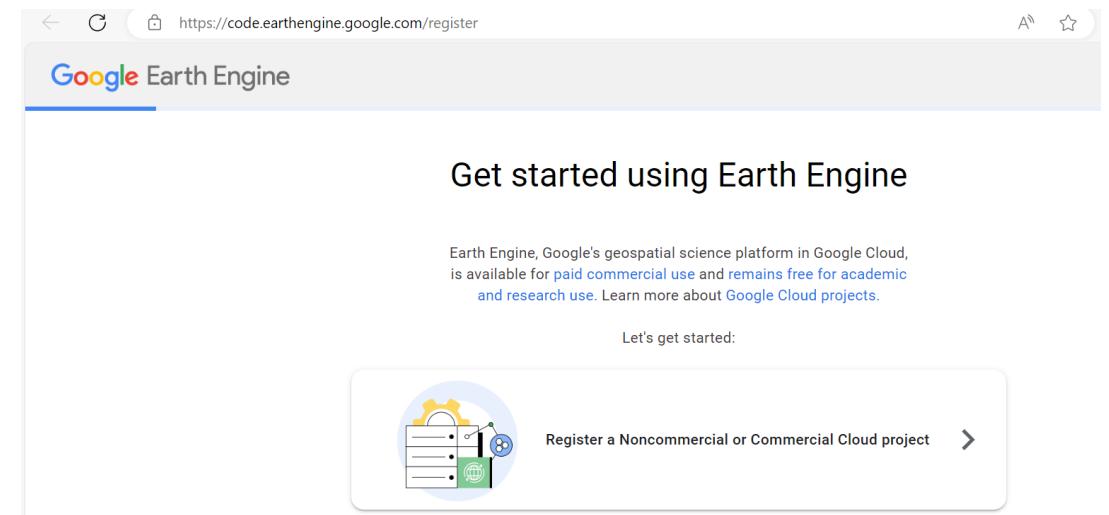
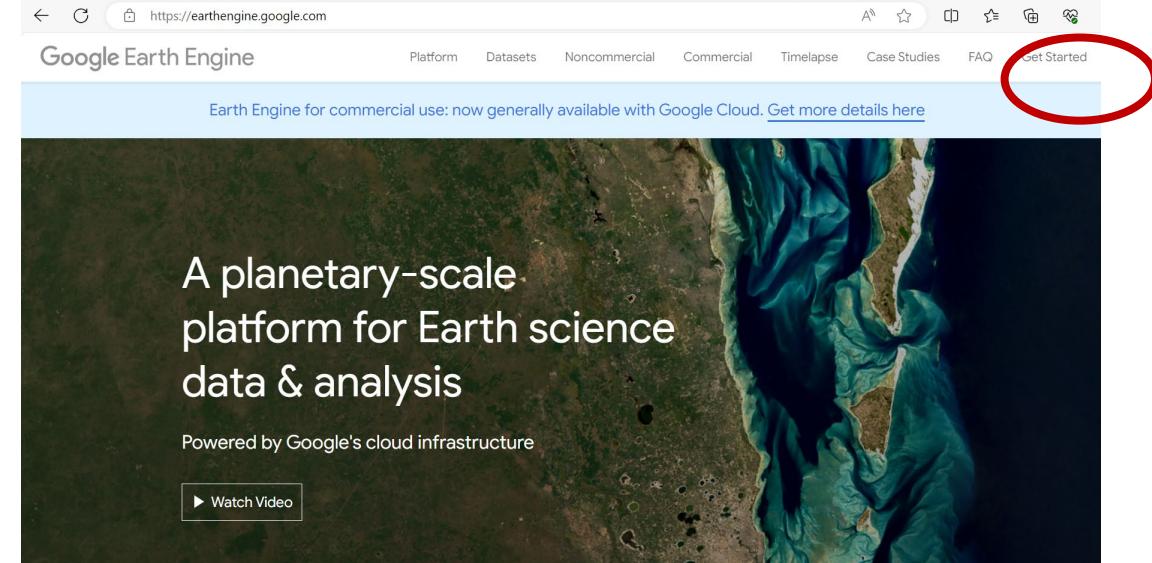




To start

- Need to create GEE account
- Can add this to existing Google/Gmail account
- Sign up for noncommercial/ academic use

[Earthengine.google.com](https://earthengine.google.com)



More things to keep in mind

This is a JavaScript editor, which is pretty good about highlighting when you have a syntax issue.

Still good to familiarize yourself with conventions (e.g., creating objects with “var”, ending functions with “;”, etc)

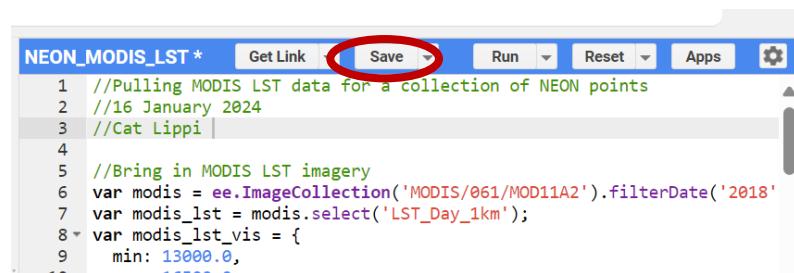
The worst part of this is that the script runs all at once (i.e., you can’t run individual lines like in R).

This can make it tricky to test code/troubleshoot, but you can still use “//” to “turn off” blocks of code (i.e., use like # in R)

Also be mindful of saving script often.

If you click to open a different script, for example, to copy and paste some code, any unsaved changes will be lost. This is dumb.

Hit the ‘Save’ button often in code editor



Navigating to the Code Editor

The screenshot shows the Google Earth Engine homepage. At the top, there is a navigation bar with icons for back, forward, and search, followed by the URL <https://earthengine.google.com>. To the right of the URL are icons for a star and a font size adjustment. Below the navigation bar, the "Google Earth Engine" logo is displayed. A red circle highlights the "Platform" tab in the top navigation menu. A red arrow points from the "Code Editor" option in the dropdown menu below the "Platform" tab to the "Code Editor" link on the main page. The main content area features a large satellite map of a coastal region. Overlaid on the map is the text: "Earth Engine for commercial users" (partially visible), "A planetary-scale platform for Earth science data & analysis", "Powered by Google's cloud infrastructure", and a "Watch Video" button. To the right of the map, there is a callout text: "Fully available with Google Cloud. Get more details here".

Code Editor

- Similar enough to RStudio

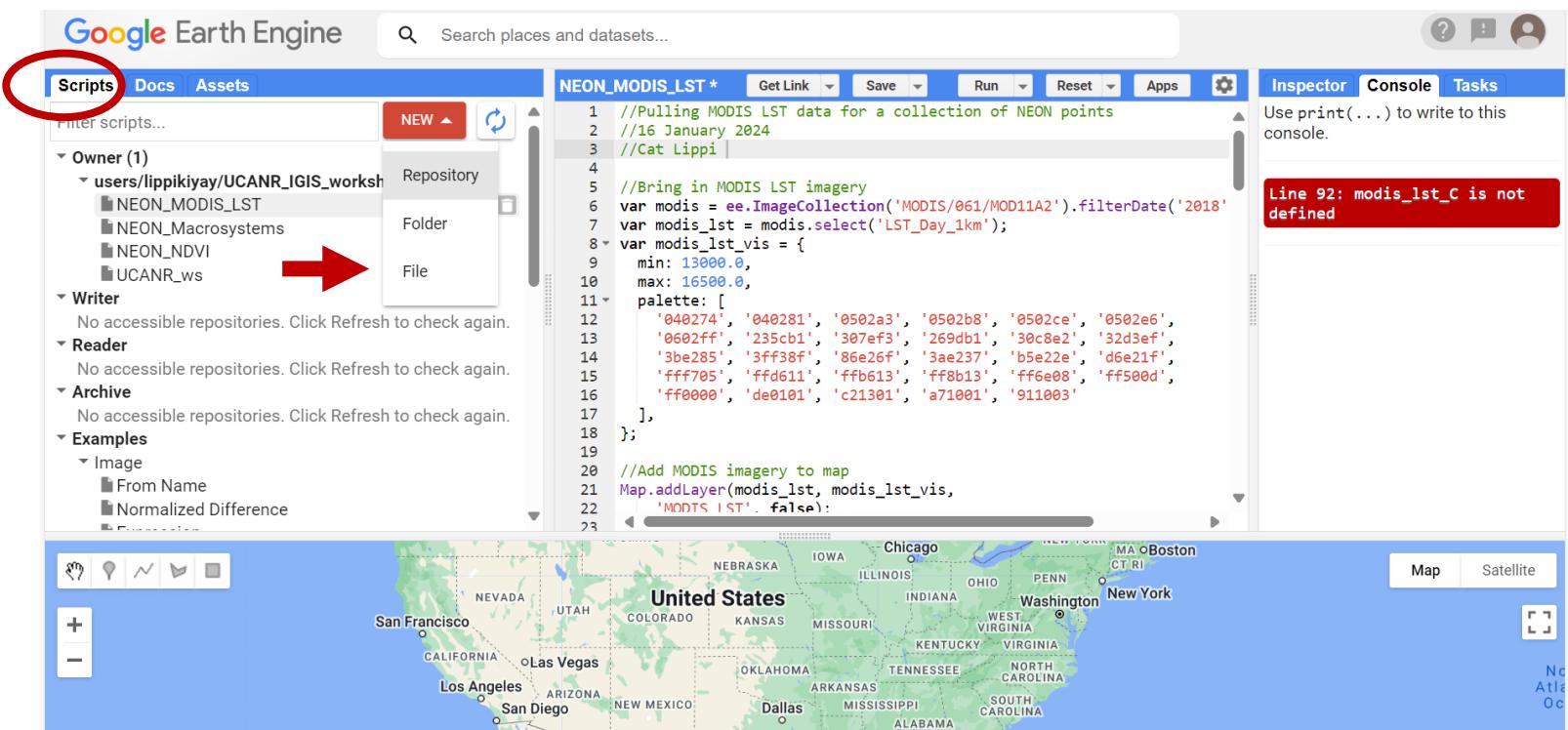
The screenshot shows the Google Earth Engine Code Editor interface. At the top, there's a browser header with the URL <https://code.earthengine.google.com>. Below it is the "Google Earth Engine" logo and a search bar. The main area has tabs for "Scripts", "Docs", and "Assets". A "NEW" button and a refresh icon are also present. On the left, a sidebar shows repository details: "Owner (1)" with "users/lippikiyya/UCANR_IGIS_workshop" containing "NEON_MODIS_LST", "NEON_Macrosystems", "NEON_NDVI", and "UCANR_ws"; "Writer" (no accessible repositories); "Reader" (no accessible repositories); "Archive" (no accessible repositories); and "Examples" with "Image" sub-options "From Name" and "Normalized Difference". The central code editor pane contains a script titled "NEON_MODIS_LST *":

```
1 //Pulling MODIS LST data for a collection of NEON points
2 //16 January 2024
3 //Cat Lippi |
4
5 //Bring in MODIS LST imagery
6 var modis = ee.ImageCollection('MODIS/061/MOD11A2').filterDate('2018'
7 var modis_lst = modis.select('LST_Day_1km');
8 var modis_lst_vis = {
9   min: 13000.0,
10  max: 16500.0,
11  palette: [
12    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
13    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
14    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
15    'ff705', 'ffd611', 'fff613', 'ff8b13', 'ffe608', 'ff500d',
16    'ff0000', 'de0101', 'c21301', 'a71001', '911003'
17  ],
18 }
19
20 //Add MODIS imagery to map
21 Map.addLayer(modis_lst, modis_lst_vis,
22   'MODIS LST', false);
23
```

A red error message in the bottom right corner states "Line 92: modis_lst_C is not defined". Below the code editor is a map of the United States showing green land cover. The map includes state and city labels like San Francisco, Los Angeles, Las Vegas, Chicago, New York, and Boston. Navigation controls and a legend are visible on the left side of the map.

Code Editor

Start a script under the ‘Scripts’ tab by clicking NEW
Can also create new project groups and folders



Docs

Docs tab has a directory of functions

Provides definitions, arguments, and snippets of code that you can copy and paste into your script

The screenshot shows the Google Earth Engine interface with the 'Docs' tab highlighted in blue and circled in red. The main area displays a hierarchical list of algorithms under 'ee.Algorithms'. To the right, a vertical sidebar lists page numbers from 47 to 68, corresponding to the items in the list. The list includes:

- ee.Algorithms.FMask
- ee.Algorithms.GeometryConstructors
- ee.Algorithms.Image
- ee.Algorithms.Landsat
- ee.Algorithms.Sentinel2
- ee.Algorithms.TemporalSegmentation
 - ee.Algorithms.CannyEdgeDetector(image, threshold, ...)
 - ee.Algorithms.Collection(features)
 - ee.Algorithms.CrossCorrelation(imageA, imageB, m...)
 - ee.Algorithms.Date(value, timeZone)
 - ee.Algorithms.Describe(input)
 - ee.Algorithms.Dictionary(input)

NEON

Page Number
47
48
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Assets – for this, 13 sites are our asset

- If there are spatial datasets that you'll use a lot, it can be more efficient to upload them as Assets
- These are stored in GEE and can be called on in your code directly, as opposed to reading in with script

***If uploading csv, MAKE SURE YOU SAVE A COPY IN utf8 FORMAT FIRST OR IT WON'T WORK

The screenshot shows the Google Earth Engine interface. At the top, there's a navigation bar with 'Scripts', 'Docs', 'Assets' (which is highlighted with a red circle), and 'ADD A PROJECT'. Below this is a search bar with 'Search places and datasets...'. The main area is divided into several sections: 'Image Upload' (GeoTIFF (.tif, .tiff) or TFRecord (.tfrecord + .json)), 'Table Upload' (Shape files (.shp, .shx, .dbf, .prj, or .zip) and CSV file (.csv)), 'Image collection', and 'Folder'. To the right, a script editor window titled 'NEON_MODIS_LST *' contains the following code:

```
1 //Pulling MODIS LST data for a collection of NEON points
2 //16 January 2024
3 //Cat Lippi
4
5 //Bring in MODIS LST imagery
6 var modis = ee.ImageCollection('MODIS/061/MOD11A2').filterDate('2018-01-01', '2018-01-16');
7 var modis_lst = modis.select('LST_Day_1km');
8 var modis_lst_vis = {
9   min: 13000.0,
10  max: 16500.0,
11  palette: [
12    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
13    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
14    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
15    'ffff05', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
16    'ff0000', 'de0101', 'c21301', 'a71001', '911003'
17  ],
18}
19
20 //Add MODIS imagery to map
21 Map.addLayer(modis_lst, modis_lst_vis,
22   'MODIS LST', false);
```

Below the code is a map of the United States showing green land cover. The bottom left of the interface has zoom controls (+, -, ×).

Loading EOS data

- Use the search bar to shop EOS products
- Click on product to open product

The screenshot illustrates the process of loading EOS data in Google Earth Engine. On the left, the search bar contains "modis lst". Below it, the "RATERS" section lists several MODIS products, with "MOD11A1.061 Terra Land Surface Temperature and Emissivity Daily Global 1km" highlighted. A red arrow points from this item to the right, where a detailed product page for "MOD11A2.061 Terra Land Surface Temperature and Emissivity Daily Global 1km" is displayed. This page includes a thumbnail image of a land surface temperature map, dataset availability (2000-02-18T00:00:00 - 2000-02-18T00:00:00), dataset provider (NASA LP DAC at the USGS EROS Center), collection snippet (code snippet), see example, tags (8-day, emissivity, global, lst, mod11a2, modis, nasa, surface-temperature, terra, usgs), documentation links (User's Guide, Algorithm Theoretical Basis Document (ATBD), General Documentation), and a map view of North America.

```
17     ],
18   };
19
20   //Add MODIS imagery to map
21   Map.addLayer(modis_lst, modis_lst_vis,
22     'MODIS LST', false);
23
24
25   // Rescale MODIS LST and convert to Celsius (C)
26   var modis_lst_C = modis_lst.map(function(image) {
27     return image
28       .multiply(0.02)
29       .subtract(273.15)
30       .copyProperties(image, ['system:time_start']);
31   });
32
33
34 }
```

You want to give it a try?

- In Materials, you can find the script “NEON_SJR_MODIS_LST.txt”, which will pull a time series of Land Surface Temperature (LST) for the 13 NEON sites – both for tower and plot locations
- You will find a csv for the 13 sites (your asset) – “NEON_tickplots_13sites_utf8”
- See if you can get it to run
- See if you can export the data and find it again!
- If you recognize the site names from other data in this workshop, you may find interesting things
- NB: beware of data missingness; even perfect data is imperfect sometimes

Using R to pull GEE

- RGEE is a package – it provides a wrapper for the code, you'll need to deal with the API piece anyway, but could be fun.
- I have not used it, so I'm not your expert! However, it looks like a good and supported option, which is nice.

EOS vs. weather station data caveats

- EOS – comes from satellites, ‘looking down’ onto things
 - LST – land surface temperature – reflectance converted to temperature
 - What if it’s a forest? Is that what your vector is experiencing?
 - What if there are lots of clouds? Worse, what if cloud cover occurs more in a specific season?
 - Lots of products available, but need to catch up to real time – not a common issue, but processing raw data is a whole different set of skills
- Weather station data
 - Point based data that gets interpolated to represent irregular region shapes – great if you have lots of them, less great when they are sparse contributors
 - Require people, so data gaps can occur during holidays and natural disasters; know the missing data protocol for whatever you are using for your specific area
 - Very much influenced by geography – hard to have globally consistent coverage, which is obscured by global products
 - Tracking down the nearest station to your observations is possible, data availability (to you) can be very mixed.

There are many products and data sources out there!

- NOAA site with lots of gridded data - <https://psl.noaa.gov/data/gridded/>
- **Daymet**
- **Merraclim** – climate products, rather than weather variables
- **Worldclim** – similarly to Merraclim, climate products and projections
- **ERA**
- **Copernicus**
- *Let's generate some sources and sites together*