

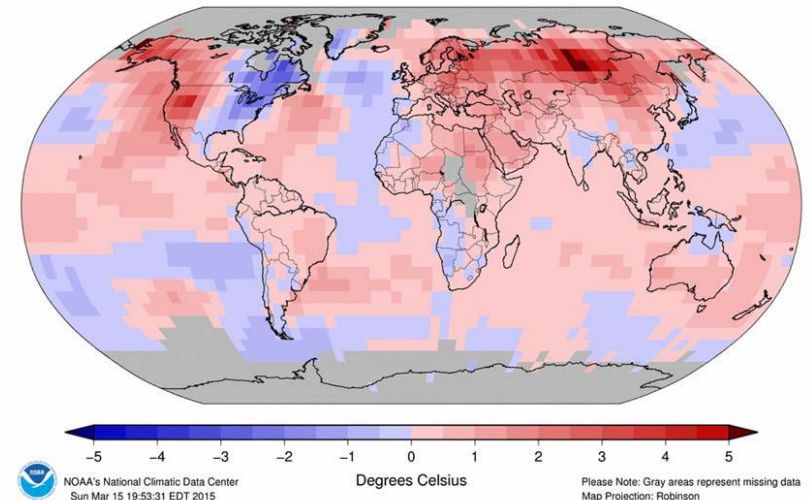
Choice and Acquisition: 'climate' variables for time- series analyses

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

Land & Ocean Temperature Departure from Average Dec 2014–Feb 2015
(with respect to a 1981–2010 base period)
Data Source: GHCN–M version 3.2.2 & ERSST version 3b



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

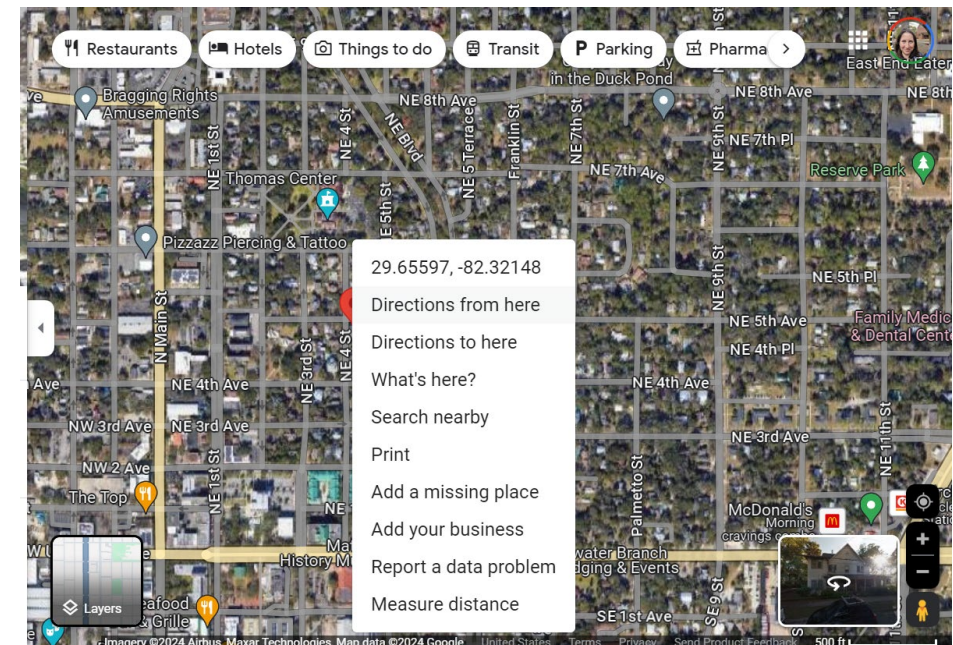
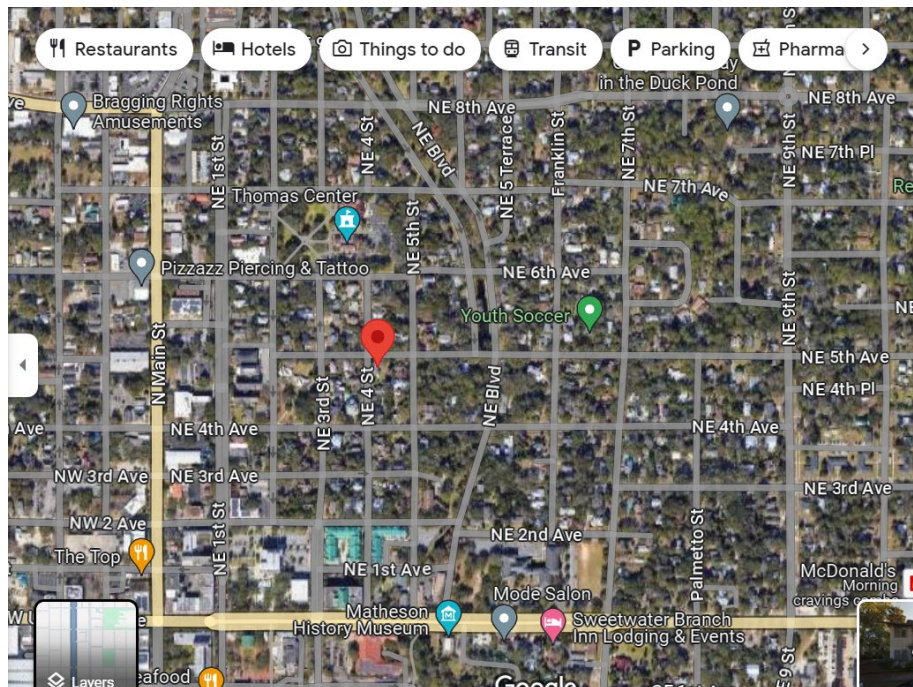
Acquisition, cont.

- 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.

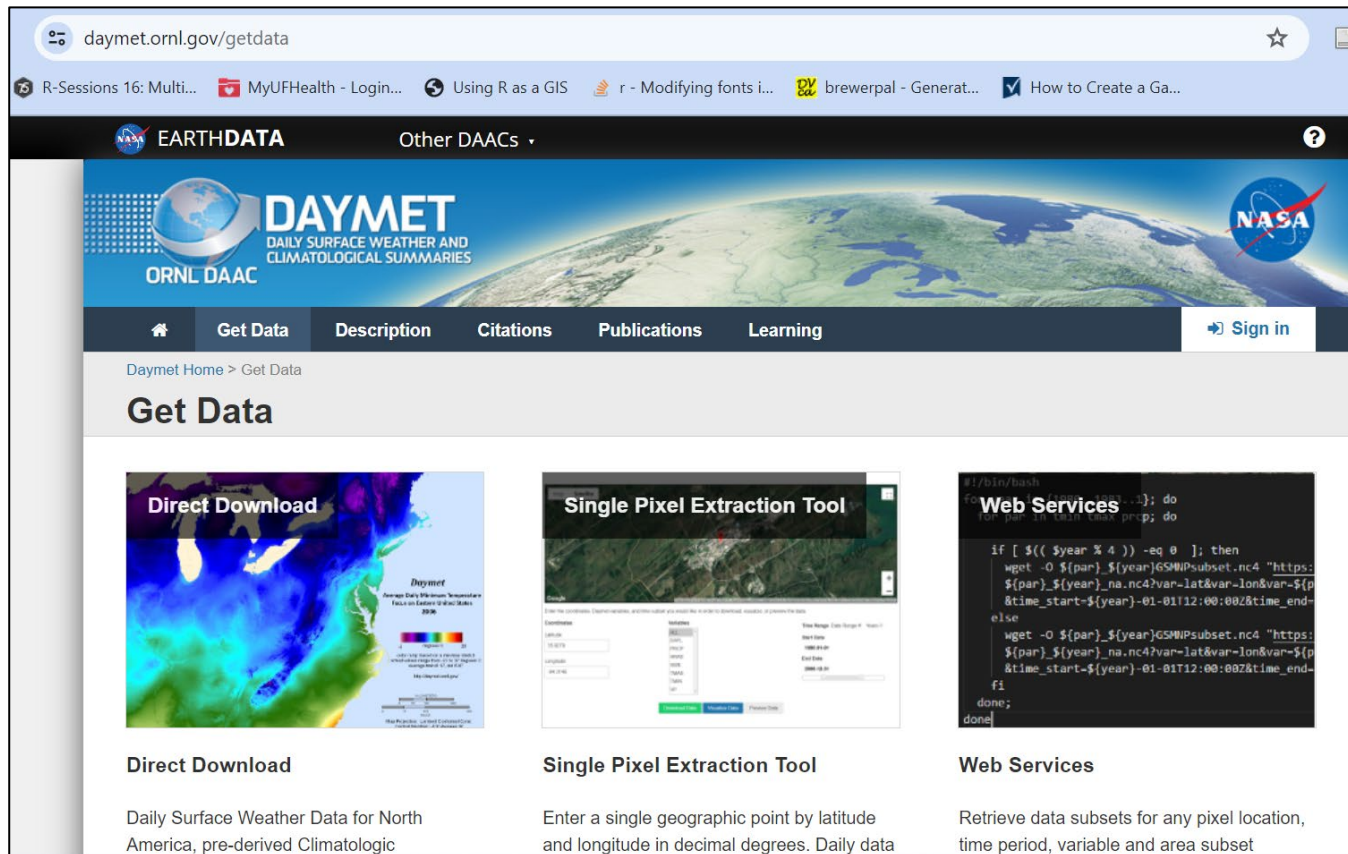
Daymet point extraction example

- 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 web browser interface for daymet.ornl.gov/getdata. The page features the NASA EarthData logo and the DAYMET logo, which stands for Daily Surface Weather and Climatological Summaries. The main navigation bar includes links for Get Data, Description, Citations, Publications, Learning, and a Sign in button. Below the navigation bar, the 'Get Data' section is highlighted, and three options are presented: Direct Download, Single Pixel Extraction Tool, and Web Services. Each option includes a representative image and a brief description of the service.

Direct Download
Daily Surface Weather Data for North America, pre-derived Climatologic

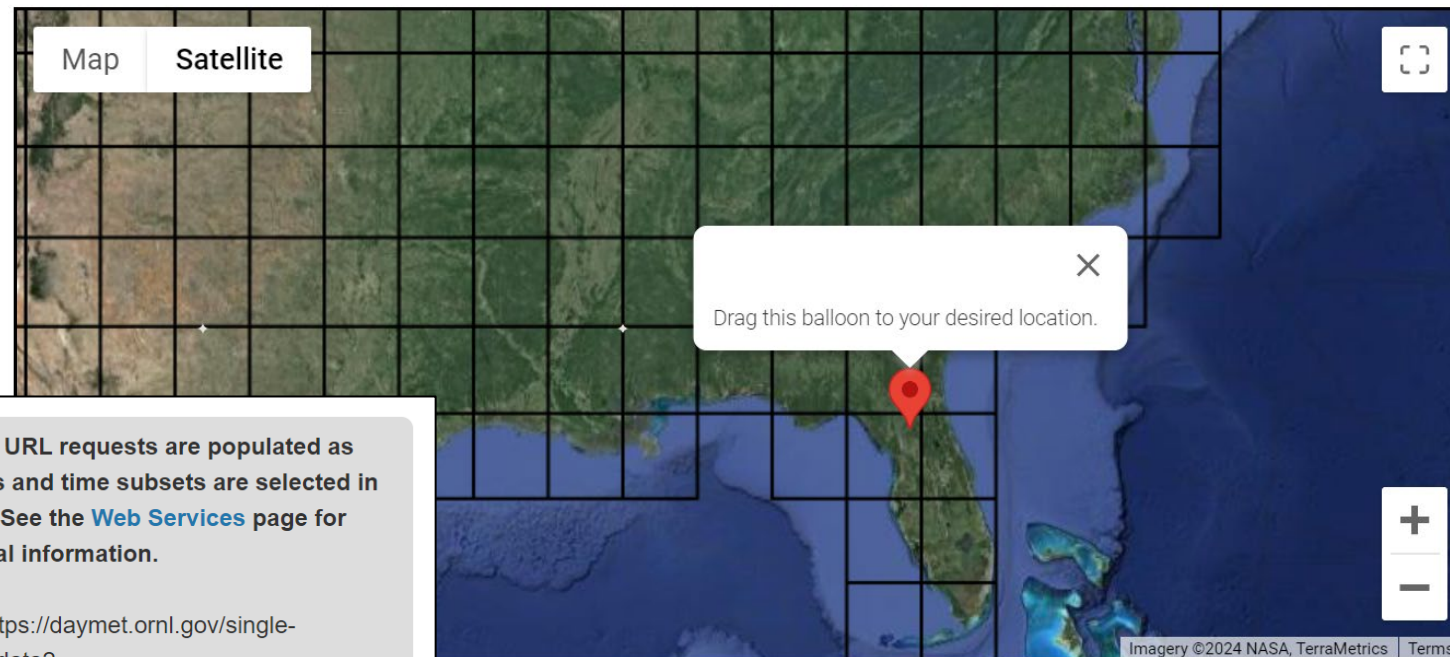
Single Pixel Extraction Tool
Enter a single geographic point by latitude and longitude in decimal degrees. Daily data

Web Services
Retrieve data subsets for any pixel location, time period, variable and area subset



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:

Longitude:

Variables:

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

Date Range Years

Start Date:

End Date:

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=-82.32141674790877&vars=dayl,prcp,srad,swe,tmax,tmin,vp&start=2023-01-01&end=2023-12-31' -O
```

```
wget --content-disposition 'https://daymet.ornl.gov/single-pixel/api/data?lat=29.6557572689658&lon=-82.32141674790877&vars=dayl,prcp,srad,swe,tmax,tmin,vp&start=2023-01-01&end=2023-12-31'
```

- [Download Data](#)
- [Visualize Data](#)
- [Preview Data](#)

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)

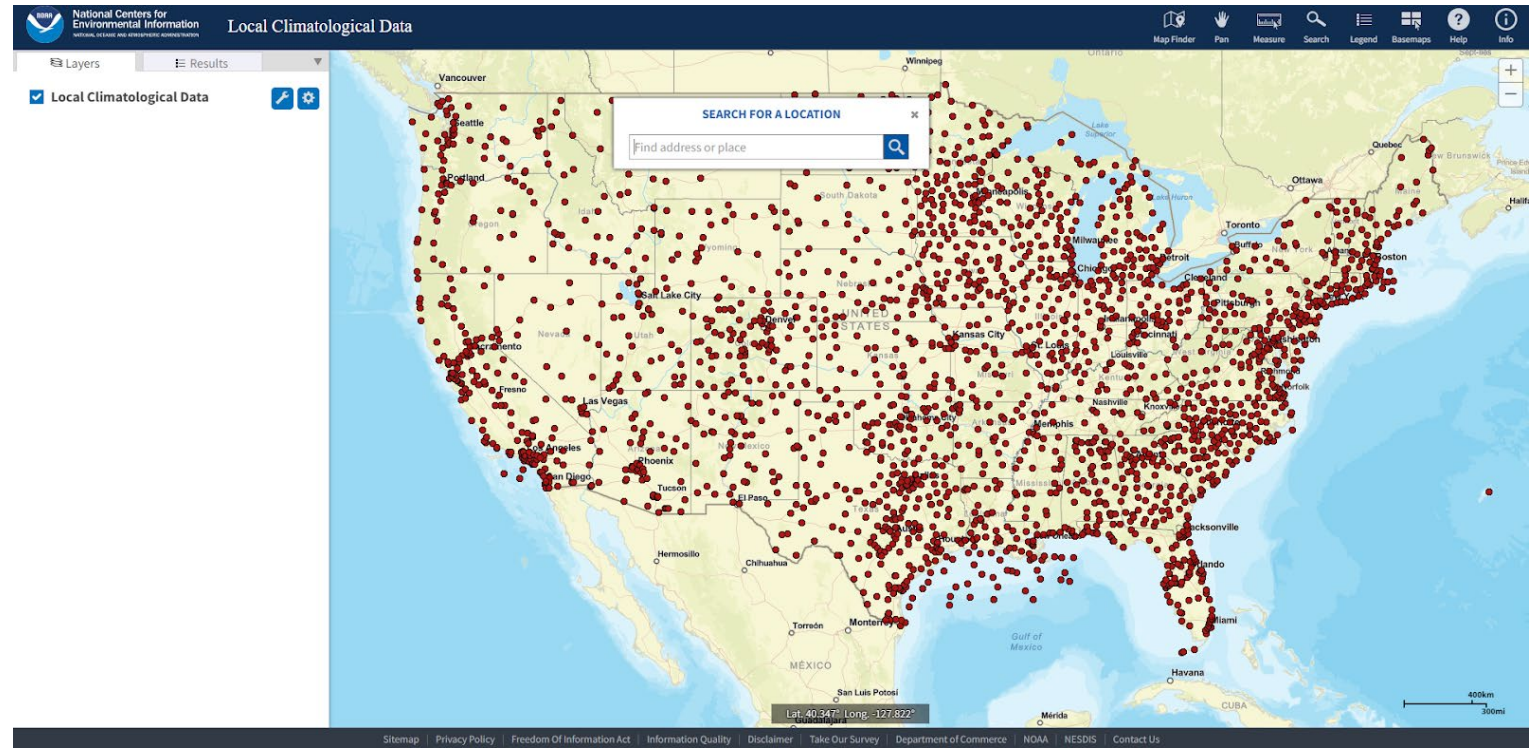
Quick example of pulling a local weather station's data using NOAA access

George and Wesley

How to Download Historical Weather Data from NOAA

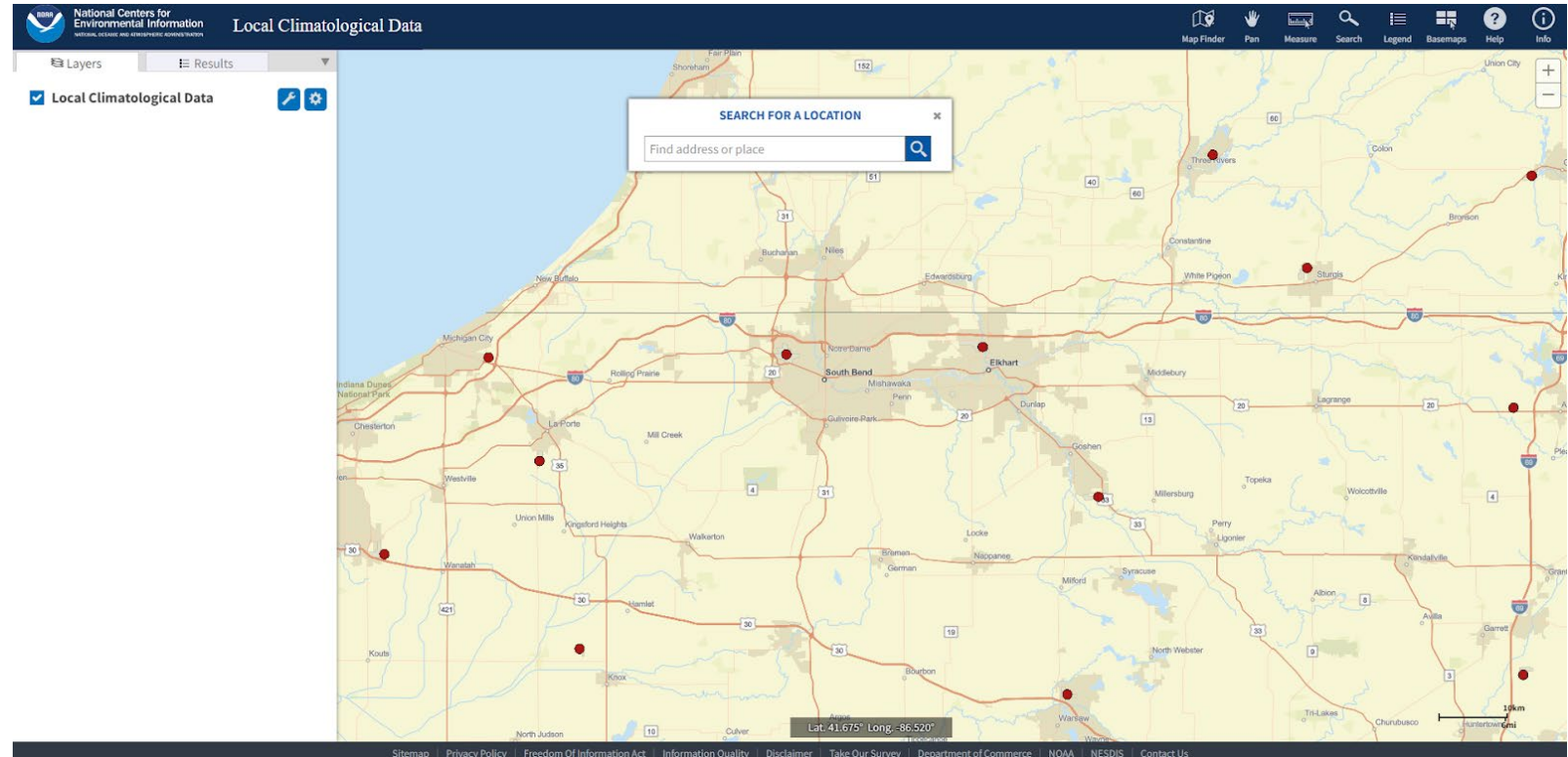
14 Easy Steps

1. Go to
<https://www.ncei.noaa.gov/maps/lcd/>



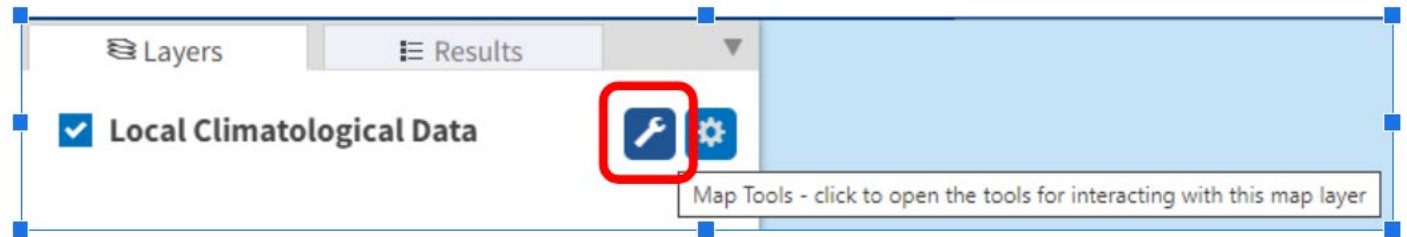
2

- **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.

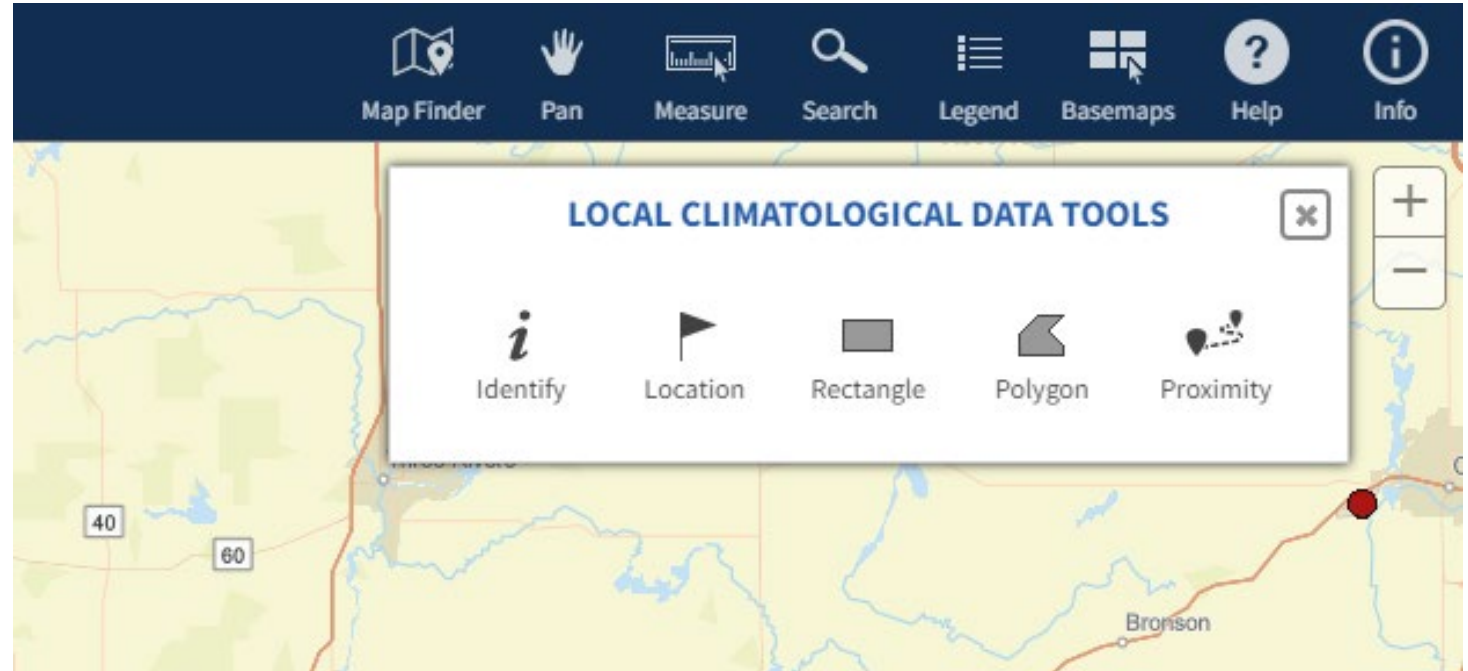
- In the “Layers” tab on the left panel, select the tools icon.



4.

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

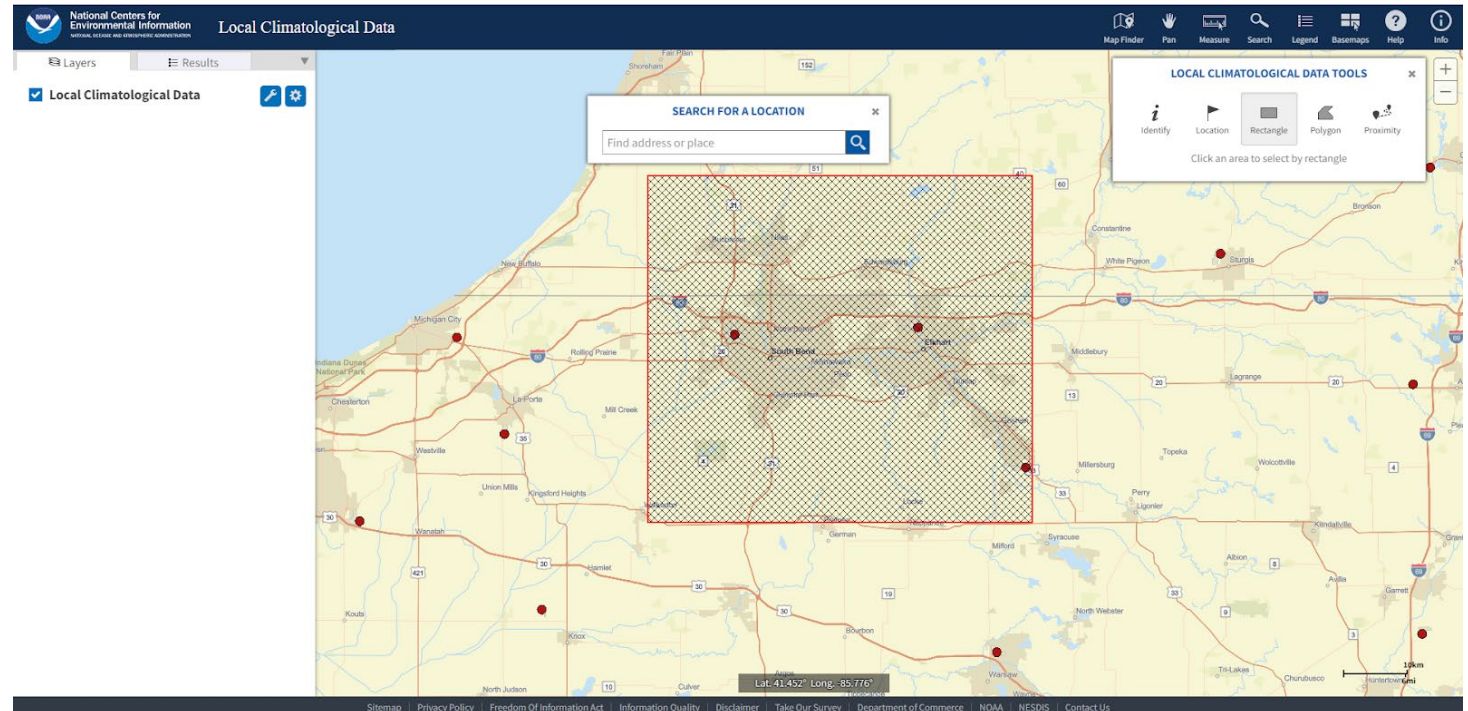
- In this case, we will use the rectangle tool.



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 web application interface with a top navigation bar containing 'Layers' and 'Results' tabs. Below the navigation bar, there is a 'Select All' checkbox and a 'Download Station List' button. The main content area displays a list of three airports, each with a 'View Station Details' button, station ID, and period of record.

Station Name	Station ID	Period of Record
ELKHART MUNICIPAL AIRPORT, IN US	WBAN:04806	2005-02-23 to 2024-07-16
GOSHEN MUNICIPAL AIRPORT, IN US	WBAN:14829	1948-11-30 to 2024-07-16
SOUTH BEND AIRPORT, IN US	WBAN:14848	1947-12-31 to 2024-07-16

7. Click the “Add to Cart” button.

National Centers for Environmental Information
Local Climatological Data

Layers Results

Select All Download Station List

ELKHART MUNICIPAL AIRPORT, IN US
View Station Details
Station ID: WBAN:04806
Period of Record: 2005-02-23 to 2024-07-16

GOSHEN MUNICIPAL AIRPORT, IN US
View Station Details
Station ID: WBAN:14829
Period of Record: 1948-11-30 to 2024-07-16

SOUTH BEND AIRPORT, IN US
View Station Details
Station ID: WBAN:14848
Period of Record: 1947-12-31 to 2024-07-16

SEARCH FOR A LOCATION
Find address or place

LOCAL CLIMATOLOGICAL DATA TOOLS
Identify Location Rectangle Polygon Proximity
Click an area to select by rectangle

Clear Results Add to Cart

Sitemap Privacy Policy Freedom Of Information Act Information Quality Disclaimer Take Our Survey Department of Commerce NOAA NESDIS Contact Us

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:*

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Home Climate Information Data Access Contact About

Home > Climate Data Online > Cart: Local Climatological Data

Search

Datasets Search Tool Mapping Tool Data Tools Help

Cart: Local Climatological Data

Step 1: Choose Options Step 2: Review Order Step 3: Order Complete

Select Cart Options

Specify the desired formatting options for the data added in the cart. These options allow more refined date selection, selection of the processed format, and the option to remove items from the cart.

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

Help

Have questions about the data? Need some assistance? Use the links below to quickly find the answers you need.

[Climate Data Online help](#)

[Check order status](#)

[Request assistance](#)

Need technical documentation or assistance with systems access?

[View data samples & documentation](#)

[NCEC Web Services](#)

[CDO Web Services Documentation](#)

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							2024-07-17						
2020		Jan					2024		Jul				
SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA
			1	2	3	4		1	2	3	4	5	6
5	6	7	8	9	10	11	7	8	9	10	11	12	13
12	13	14	15	16	17	18	14	15	16	17	18	19	20
19	20	21	22	23	24	25	21	22	23	24	25	26	27
26	27	28	29	30	31		28	29	30	31			

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

CANCEL APPLY

[CLEAR CART]

Delete







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

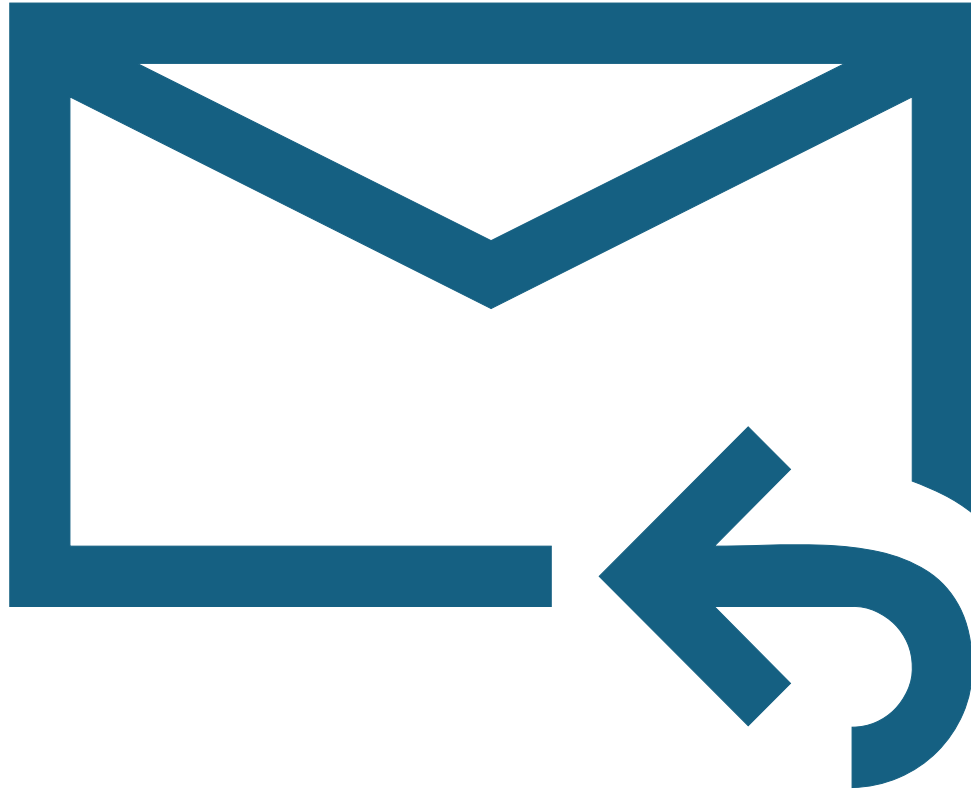
NOAA will not share your email address with anyone. The email address will not be used for any purpose other than communicating the order status.

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!

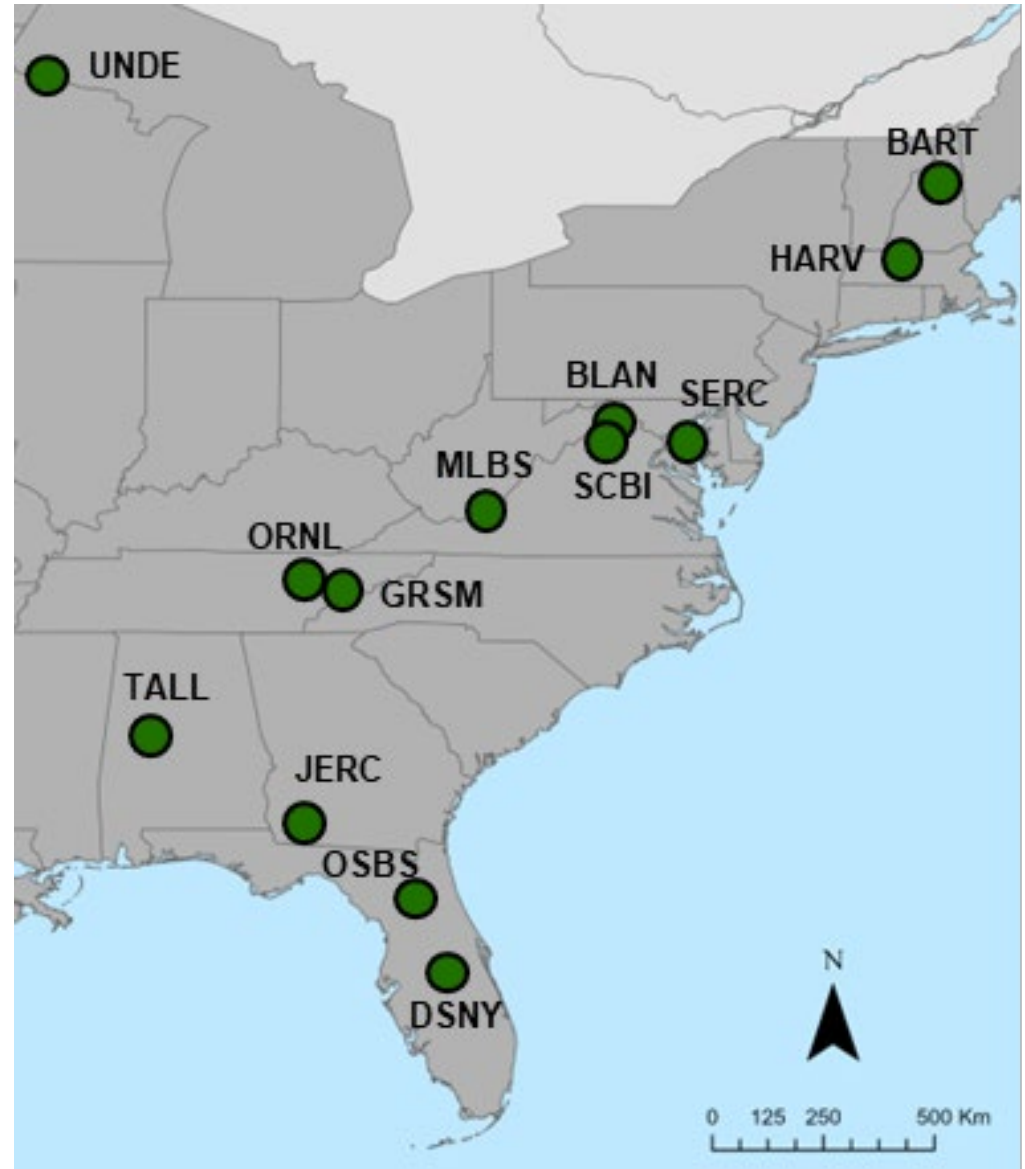
Next up: Google Earth Engine

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

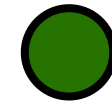
- We will look at 13 NEON terrestrial sites, for which there are observation towers for data, and also tick plot sites
- Terrestrial sites
- Spanning a chunk of the Northeastern US



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



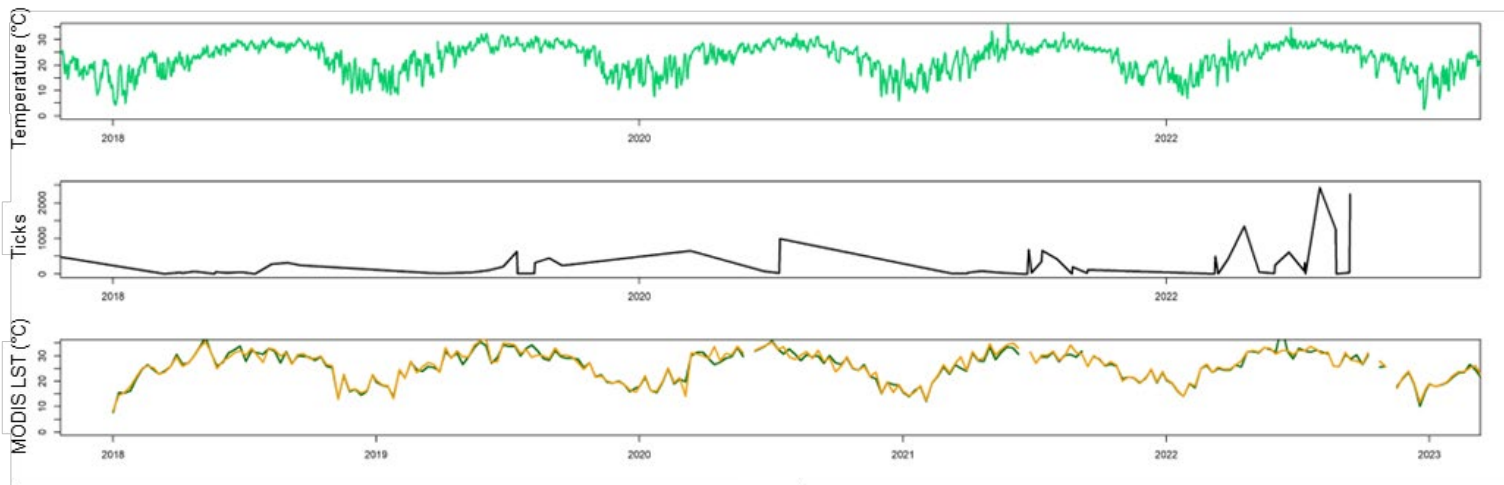
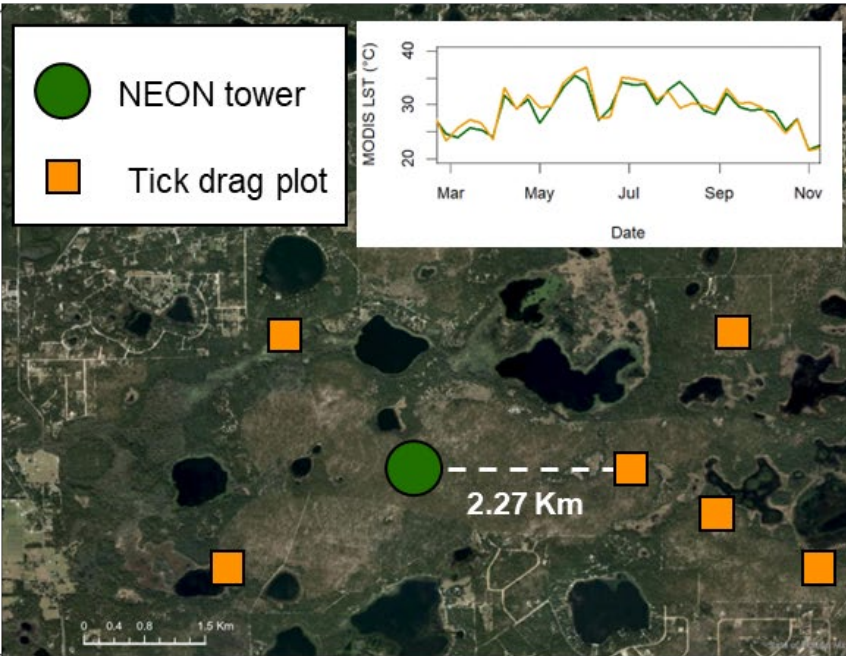
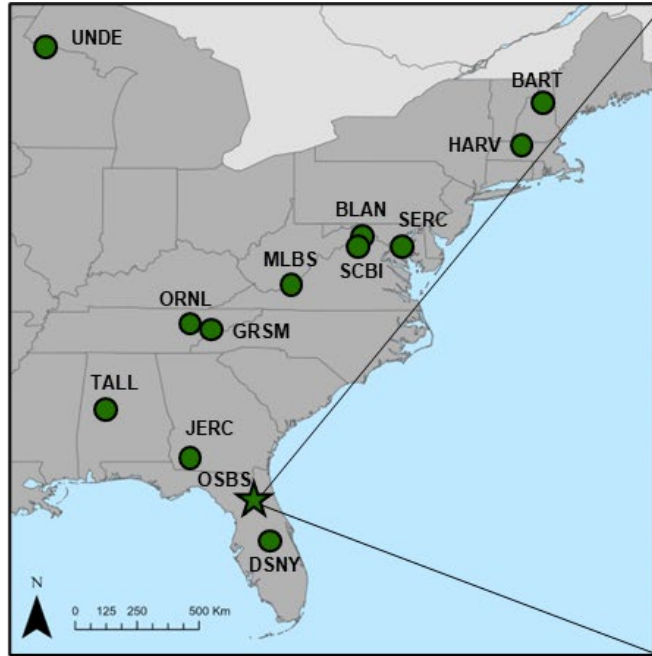
OSBS

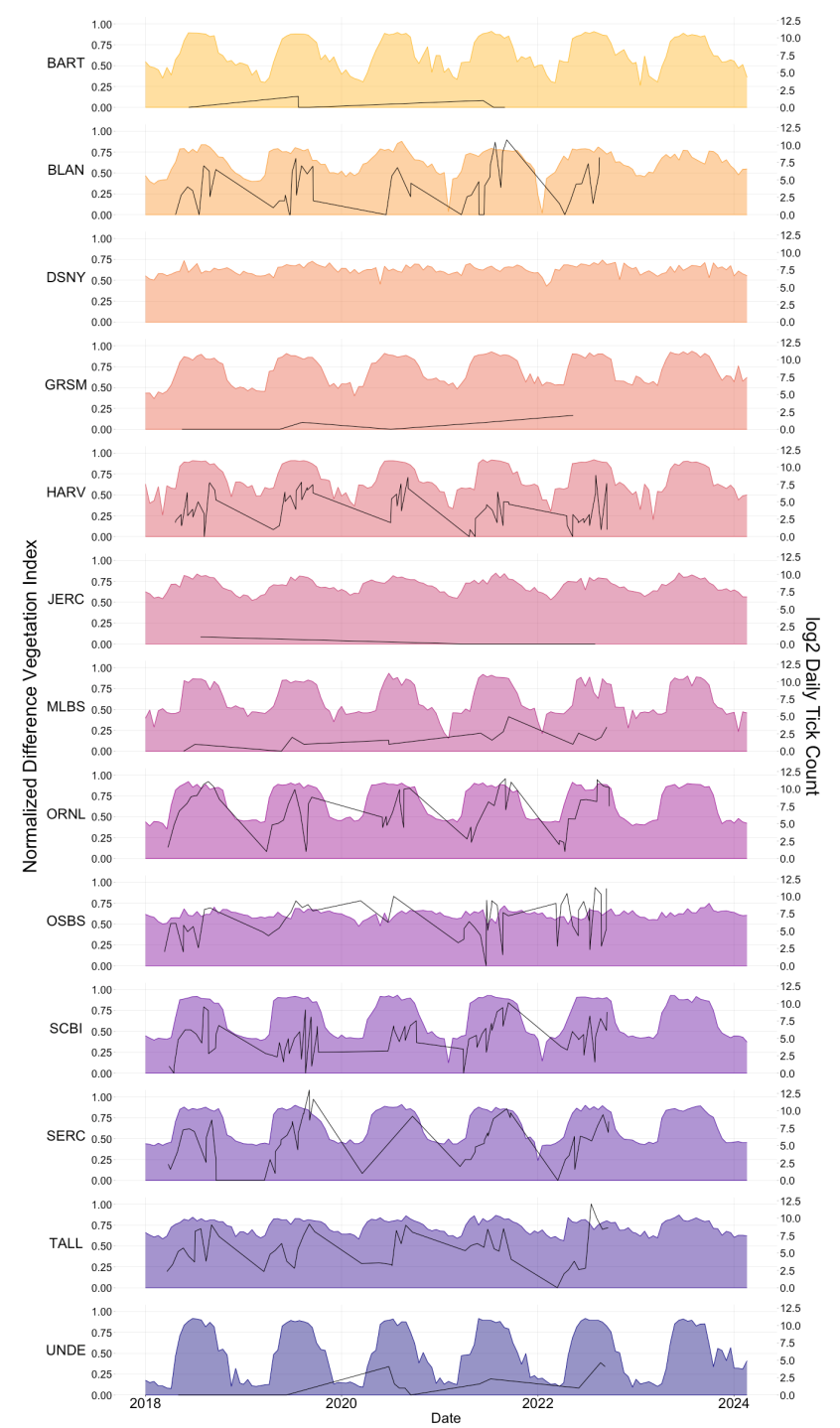
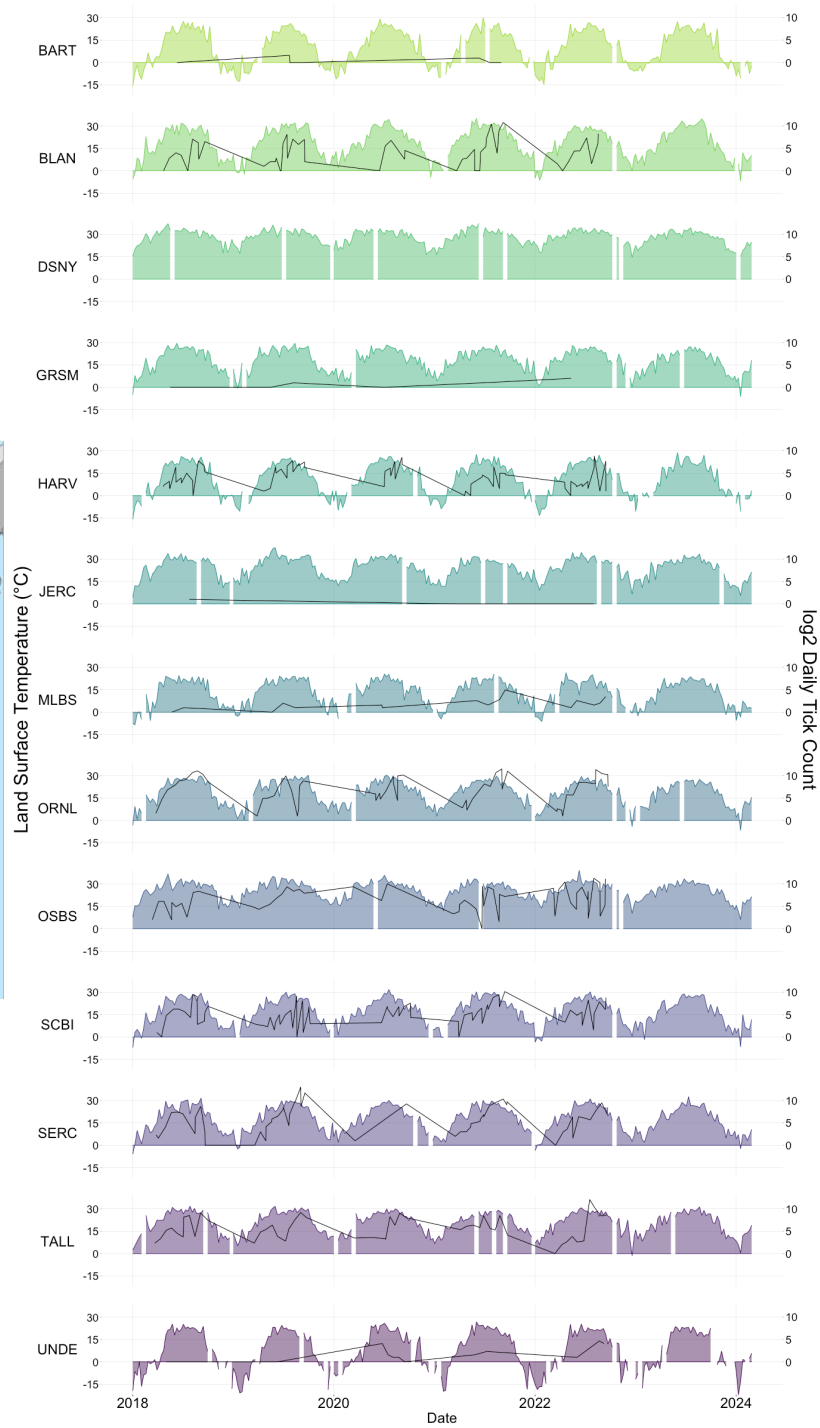
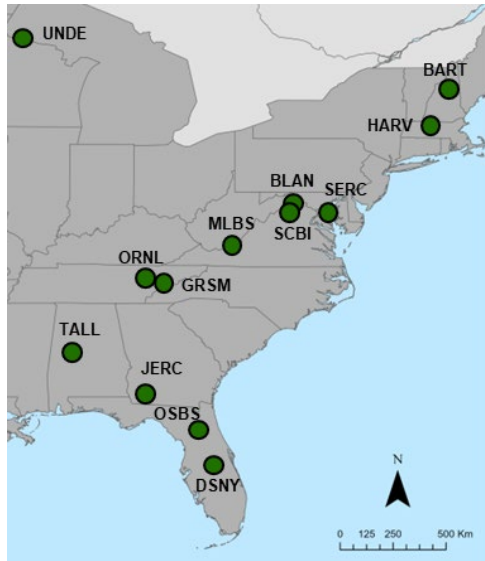


NEON tower



Tick plots

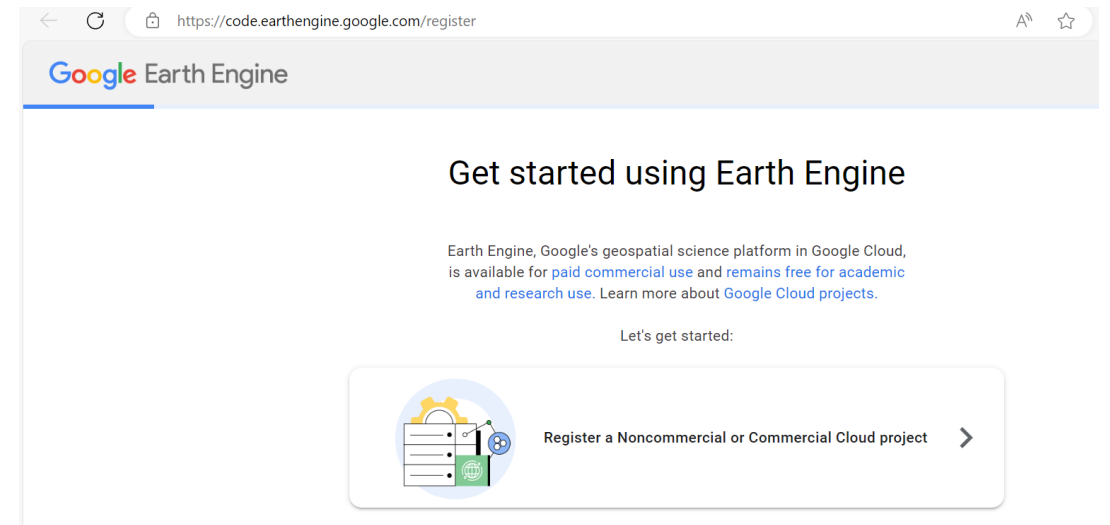
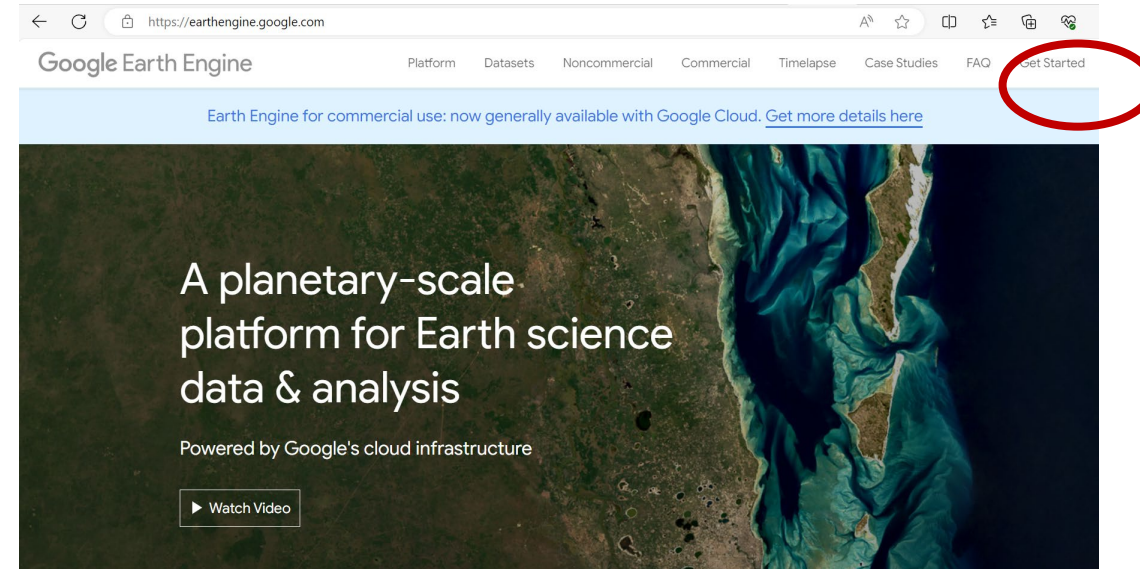




To start

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

Earthengine.google.com



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)

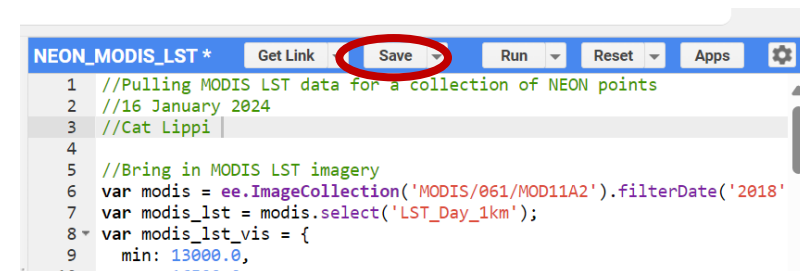
The worst part of this is that the script runs all at once (i.e., you can’t run individual lines like in R).

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



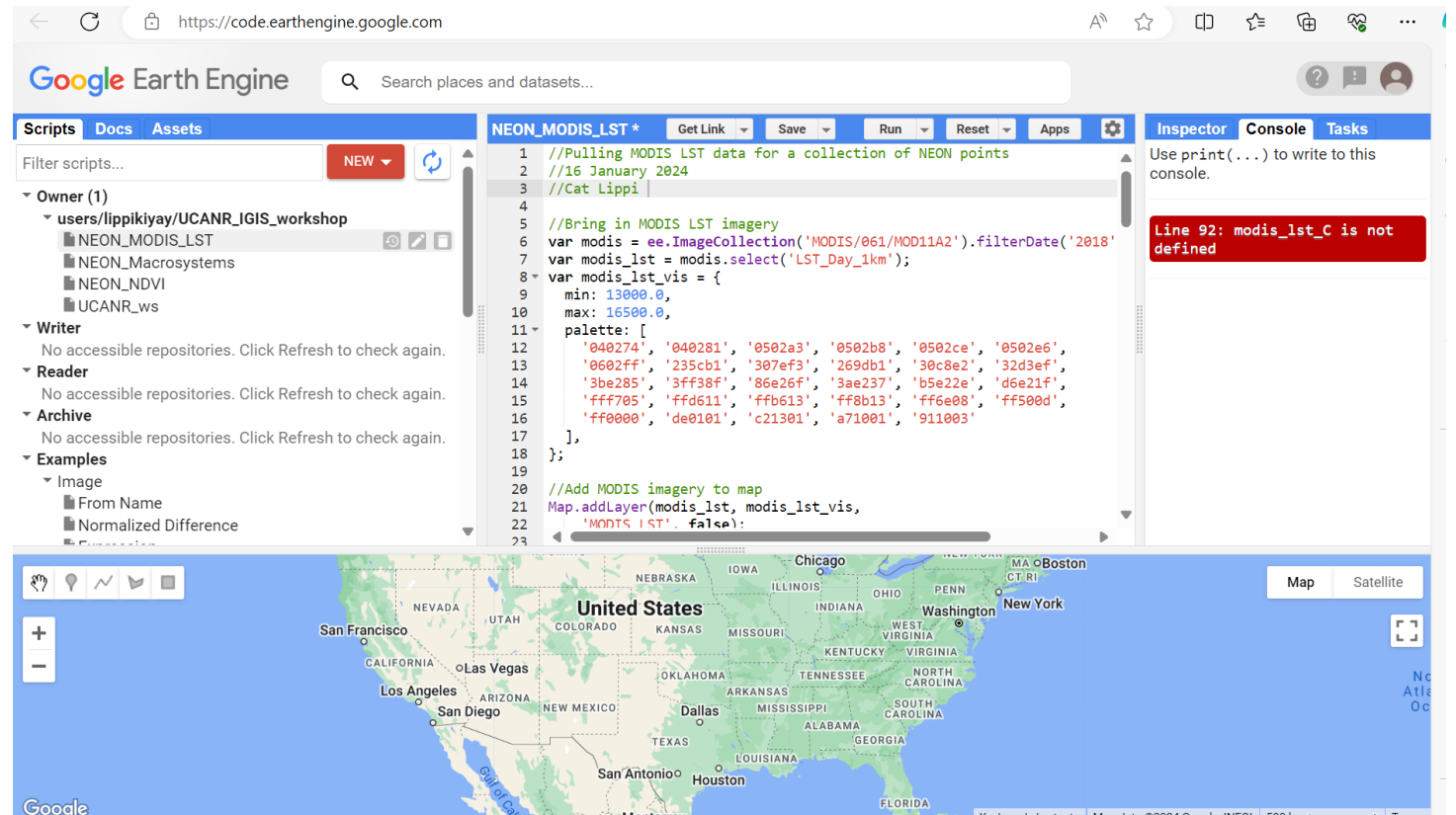
```
NEON_MODIS_LST + Get Link Save Run Reset Apps
1 //Pulling MODIS LST data for a collection of NEON points
2 //16 January 2024
3 //Cat Lippi
4
5 //Bring in MODIS LST imagery
6 var modis = ee.ImageCollection('MODIS/061/MOD11A2').filterDate('2018')
7 var modis_lst = modis.select('LST_Day_1km');
8 var modis_lst_vis = {
9   min: 13000.0,
10  max: 16000.0
```

Navigating to the Code Editor

The image shows a browser window at the URL <https://earthengine.google.com>. The page header includes the Google Earth Engine logo and a navigation menu with the following items: Platform, Datasets, Noncommercial, Commercial, Timelapse, and Case Studies. The 'Platform' item is circled in red. A dropdown menu is open under 'Platform', listing 'Overview', 'Code Editor', and 'Documentation'. A red arrow points to the 'Code Editor' option. Below the navigation menu, there is a light blue banner with the text 'Earth Engine for commercial users is now generally available with Google Cloud. [Get more details here](#)'. The main content area features a satellite-style background image of a river valley. Large white text reads: 'A planetary-scale platform for Earth science data & analysis'. Below this, smaller text says 'Powered by Google's cloud infrastructure'. At the bottom left, there is a button with a play icon and the text 'Watch Video'.

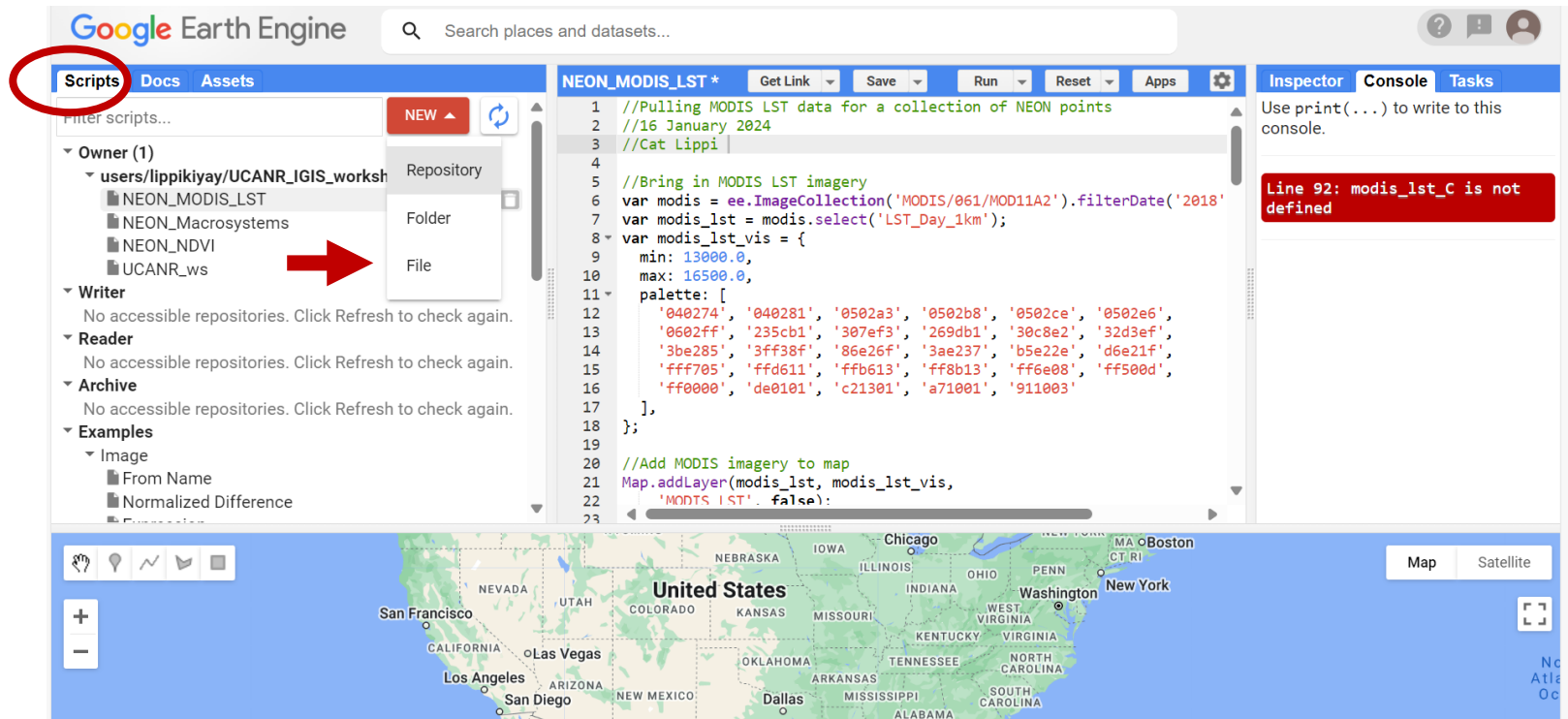
Code Editor

- Similar enough to RStudio



Code Editor

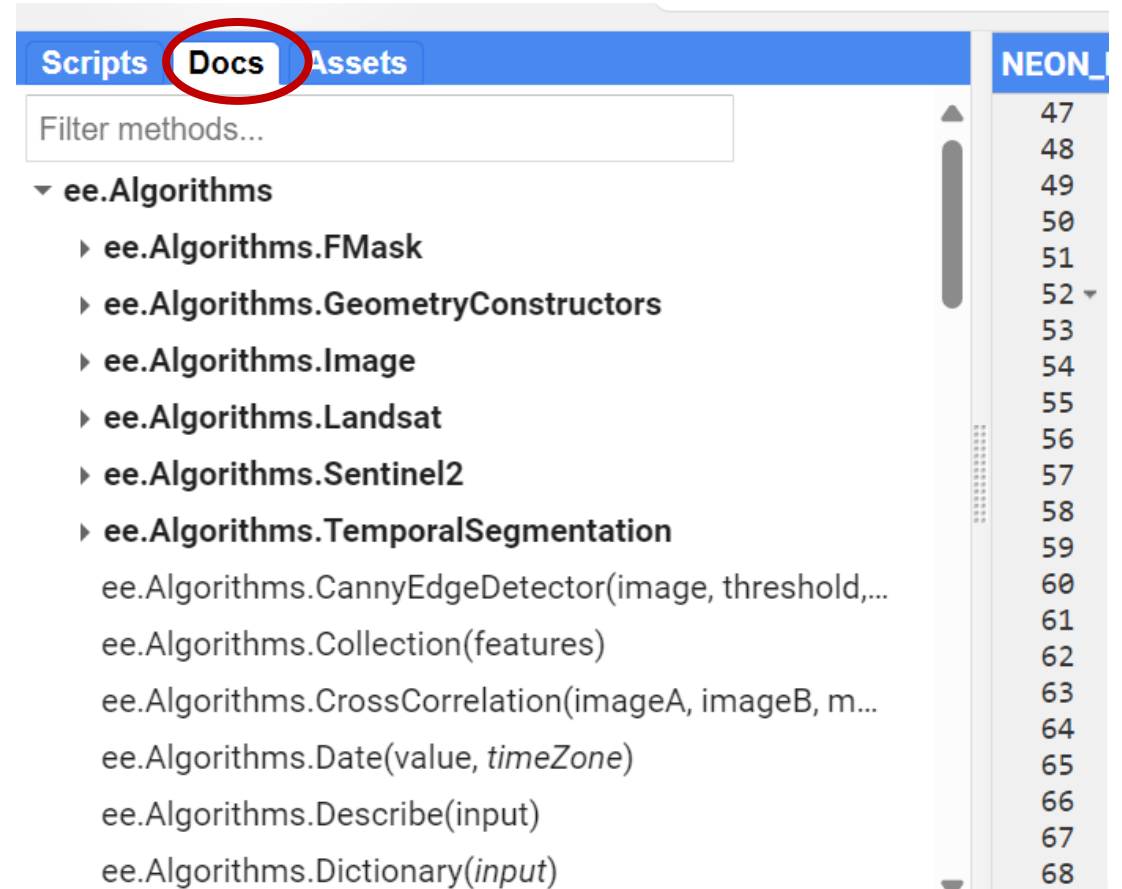
Start a script under the 'Scripts' tab by clicking NEW
Can also create new project groups and folders



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 selected and circled in red. Below the tabs is a search bar labeled 'Filter methods...'. The main content area displays a directory of functions under the 'ee.Algorithms' category. The functions listed are:

- 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)

On the right side of the interface, there is a vertical scroll bar and a list of page numbers from 47 to 68. The 'NEON_' tab is visible at the top right.

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 displays the Google Earth Engine (GEE) interface. At the top, the 'Assets' menu is open, showing options for uploading GeoTIFF, Table (Shape files or CSV), Image collection, and Folder. The code editor on the right shows a script for pulling MODIS LST data for a collection of NEON points. The script includes comments and code for filtering data by date, selecting the LST Day_1km property, and adding the imagery to the map. The map at the bottom shows the United States with various cities labeled.

```
Google Earth Engine Search places and datasets...  
Assets  
NEW ADD A PROJECT  
Image Upload Add A  
GeoTIFF (.tif, .tiff) or TFRecord (.tfrecord + .json)  
Table Upload  
Shape files (.shp, .shx, .dbf, .prj, or .zip)  
CSV file (.csv)  
Image collection  
Folder  
NEON_MODIS_LST * Get Link Save Run Reset Apps Inspector  
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    'fff705', '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);  
23  
Inspector  
Use print(  
console.  
Line 92:  
defined
```


Loading EOS data

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

The screenshot shows the Google Earth Engine search interface. The search bar contains 'modis lst'. The results are categorized into PLACES, RASTERS, and TABLES. Under RASTERS, several MODIS LST products are listed, including MOD11A1.061, MYD11A1.061, MOD11A2.061, MYD11A2.061, MOD21C1.061, MYD21C1.061, MOD21A1D.061, and MOD21A1N.061. A red arrow points from the search results to the product details panel on the right.

The screenshot shows the product details page for MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km. The page includes a thumbnail image of the product, a description, dataset availability, dataset provider, collection snippet, tags, and documentation links. A red arrow points from the search results to this panel.

MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km

DESCRIPTION BANDS TERMS OF USE CITATIONS DOIS

The MOD11A2 V6.1 product provides an average 8-day land surface temperature (LST) in a 1200 x 1200 kilometer grid. Each pixel value in MOD11A2 is a simple average of all the corresponding MOD11A1 LST pixels collected within that 8 day period. The MOD11A2 does a simple averaging of all daily LST values, without any filtering for specific QA bits. Each of the MOD11A2 QA values are set based on what majority of input daily QA values are for any given pixel.

The 8 day compositing period was chosen because twice that period is the exact ground track repeat period of the Terra and Aqua platforms. In this product, along with both the day- and night-time surface temperature bands and their quality indicator (QC) layers, are also MODIS bands 31 and 32 and eight observation layers.

Dataset Availability
2000-02-18T00:00:00 -

Dataset Provider
NASA LP DAAC at the USGS EROS Center

Collection Snippet
ee.ImageCollection("MODIS/061/MOD11A2")

See example

Tags
8-day emissivity global lst
mod11a2 modis nasa
surface-temperature terra usgs

Documentation:

- [User's Guide](#)
- [Algorithm Theoretical Basis Document \(ATBD\)](#)
- [General Documentation](#)

CLOSE **IMPORT**

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*