

Tutorial #2: Accessing Remote Sensing Data With AppEEARS

Observing Earth from Above
(Env 329) - Fall 2023
Schmid College of Science
and Technology
Chapman University

LEARNING OBJECTIVES:

Total Estimated Time - 50 minutes

1. Access and practice using the AppEEARS Interface.
2. Familiarize yourself with QGIS's toolbars, buttons, & layout.
3. Download & visualize temperature data from ECOSTRESS in QGIS.

Welcome Back!

Today, we are introducing AppEEARS, The Application for Extracting and Exploring Analysis Ready Samples, which is a web-based application designed to efficiently connect users with geospatial data that has been generated by satellite remote sensing instruments associated with agencies such as NASA and the U.S. Geological Survey. Different satellite remote sensing make their data available through different platforms, but today we are going to use AppEEARS to access data from the [ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station \(ECOSTRESS\)](#) instrument.



To begin, head over to <https://appears.earthdatacloud.nasa.gov/>. Click the *Sign In* button to register for an Earthdata account, or login if you already have an account.

[Continue >](#)

Welcome to AppEEARS!

Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)

The Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) offers a simple and efficient way to access and transform geospatial data from a variety of federal data archives. AppEEARS enables users to subset **geospatial datasets** using spatial, temporal, and band/layer parameters. Two types of sample requests are available: **point samples** for geographic coordinates and **area samples** for spatial areas via vector polygons. Sample requests submitted to AppEEARS provide users not only with data values, but also associated quality data values. Interactive visualizations with summary statistics are provided for each sample within the application, which allow users to preview and interact with their samples before downloading their data. Get started with a sample request using the Extract option above, or visit the [Help page](#) to learn more.

NASA National Aeronautics and Space Administration

Lpdaac Land Processes Distributed Active Archive Center

NSIDC National Snow and Ice Data Center Distributed Active Archive Center

Socioeconomic Data and Applications Center

ORNL DAAC DISTRIBUTED ACTIVE ARCHIVE CENTER FOR BIODIVERSITY DYNAMICS Oak Ridge National Laboratory Distributed Active Archive Center

AppEEARS is designed to allow you to download either point (i.e., data from a given latitude/longitude) or area (i.e., all of the pixels that fall within a given area) data. It also allows you to choose the timespan for the data and the type of data you wish to request.

1. To access satellite data use the *Extract* dropdown menu to select *Area*.
2. Next select *Start a New Request*.

Motivation For Today's Tutorial: Death Valley

ECOSTRESS primarily measures land surface temperatures (LST), so let's look at the thermometer at one of the hottest places on the planet: Death Valley, California. The highest recorded ground temperature was verified at 201 degrees F on July 15, 1972. However, it recently had one of the hottest months on record, where air temperatures reached upwards of 128 degrees F in July of 2023. We are going to download the land surface temperature data from ECOSTRESS for those days to see how close it was to breaking the ground surface temperature record.



NOTE: ECOSTRESS launched on July 9, 2018, so as you think about potential projects, you cannot design a project that requires data before that date.

Accessing ECOSTRESS Data through AppEEARS

Create a Request

3. Select the *Start a new request* to request data for a new area and new time period.
4. Enter a useful name for the request you are going to submit, maybe something like "Death Valley Temperature Experiment." Getting in the habit of assigning unique and relevant names will be useful when you start making many requests for data from AppEEARS.

Now, we need to specify to AppEEARS your geographic area of interest (AOI), which in this case is Death Valley National Park. This can be accomplished a few different ways:

- Using the map interface to draw a rectangle or polygon that encompasses your AOI.
- Uploading a [shapefile](#) that describes your AOI.

Today, we are going to use a shapefile describing a polygon of the park boundaries that we already drew for you in QGIS. In later tutorials, you will draw your own.

5. Download the [DeathValleyNationalPark.zip](#) shapefile and save it somewhere you can remember. A folder containing all of the files for this tutorial sounds effective and orderly.

Extract Area Sample

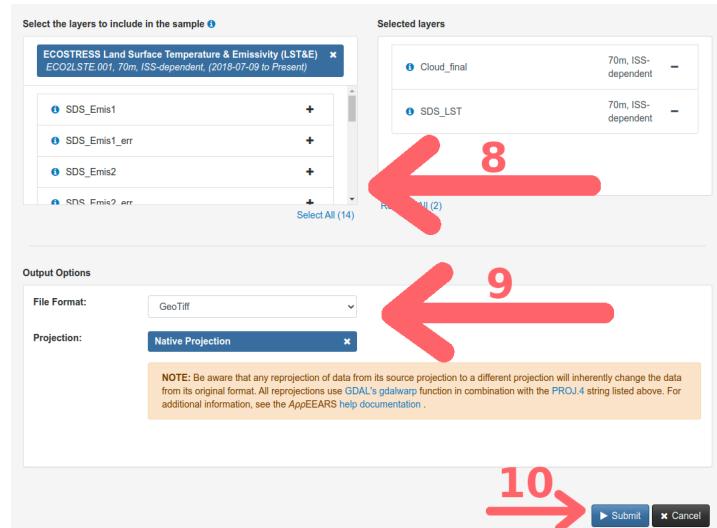
The screenshot shows the 'Extract Area Sample' page. At the top, there's a text input field labeled 'Enter a name to identify your sample' with 'Death Valley Temperature Experiment' typed in. To the right of this is a large red arrow pointing to the number '4'. Below this is a section titled 'Upload a file or draw a polygon using the ● or ■ icon' with a dashed blue border. Inside this box is another red arrow pointing to the number '6'. To the right of this section is a map of North America with a polygon drawn over the western United States. The polygon covers the area of Death Valley National Park. A red arrow points to the number '7' at the bottom right of the map. At the very bottom of the page, there's a note: 'To clear a polygon, draw a new polygon or upload a vector polygon file.'

6. Drag and drop (or use the [click here to select the file](#) link) to upload the shapefile `DeathValleyNationalPark.zip`. The map should update with a polygon encompassing Death Valley National Park.
7. Update the *Start* and *End Date* Fields for our month of interest: 07/01/2023 to 07/31/2023

Accessing ECOSTRESS Data through AppEEARS cont.

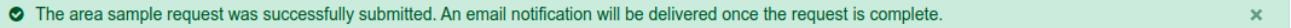
While AppEEARS provides access to a wealth of different data products, here we are primarily focusing on data from the ECOSTRESS instrument.

8. Under *Select the layers to include in the sample* type the word "ECOSTRESS" and scroll until you can click on *ECOSTRESS Land Surface Temperature & Emissivity (LST&E)*. From there, scroll until you see the *Land Surface Temperature* (*SDS_LST*) option. Click on the "+" sign to add the layer into your cart. Next, clear the current category selection using the small "x" to the right of the *ECOSTRESS Land Surface Temperature & Emissivity (LST&E)* blue box. Then search for "Cloud" and add *Cloud_final* from the *ECOSTRESS Cloud Mask Instantaneous* category to your selected layers cart.



If you want to learn more about the types and formats of the ECOSTRESS Mission data, you can find all sorts of interesting facts here: <https://lpdaac.usgs.gov/data/get-started-data/collection-overview/missions/ecostress-overview/>.

9. Under *Output Options*, we want to use *GeoTIFF* (Geographic Tagged Image File Format; essentially an image file where the corresponding geographic information is embedded in the file) and *Native Projection* for projection.
10. Click *Submit* to complete the data request. At the top, you should see a green banner:

 The area sample request was successfully submitted. An email notification will be delivered once the request is complete. ×



Since we need to wait for AppEEARS to process your request, it is a good time to get you acquainted with how we will use QGIS to run our analyses and visualize our data.

[Follow this link to complete Tutorial 3: Making Basic Maps In QGIS, while you wait.](#)

After you finish, there will be a link back here to continue to work with our data request.

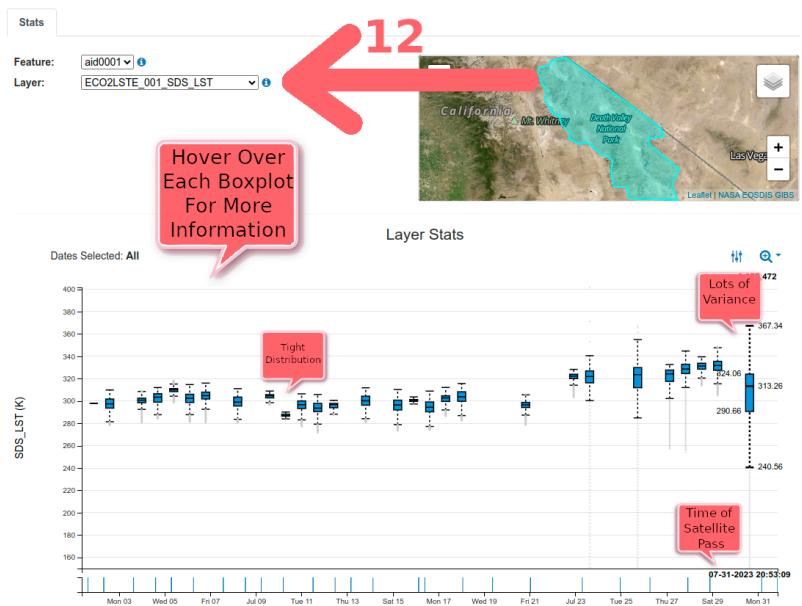
Data Check

11. It is time to check back on the status of your request. When your data is ready, you will receive an email with the subject line "AppEEARS Request Complete" at whichever email address you used when creating your EarthData login. Most small requests will take 15 minutes or less, larger ones can take upwards of an hour. You can also track the progress of your request and access the data at <https://appears.earthdatacloud.nasa.gov/explore>. Follow the Explore link in your completed request email (or via the explore menu tab on the AppEEARS homepage) to access your data.

NOTE: While using the AppEEARS interface you will occasionally encounter an error, or the system may be out-of-service for maintenance or updating. If it is the latter, there will be a banner at the top of the AppEEARS webpage with information about the timeline to restore service. If you encounter an error without a banner present, you can submit a support ticket at : <https://lpdaac.usgs.gov/lpdaac-contact-us/>.

NOTE: For these tutorials, if the AppEEARS interface is not functioning, we have provided links at the end of each page to the necessary files.

12. Before we download the files, we should preview the data using the built-in AppEEARS visualizations. First, make sure the Land Surface Temperature (LST) layer is selected. Under Layer Stats, you will see a boxplot timeseries of the temperature data across the range of dates (x-axis) and observed temperature that the instrument observed for each date (y-axis).



See the image below for what you can learn from a boxplot. Next, hover over the boxplots in the timeseries to see all sorts of useful information, including the date and time of day of the satellite pass. While 7/26/2023 had the hottest air temperature of the month, our observations of surface temperature are among the lowest! Why is that? Have we discovered some new physical property of the desert? Well no, the satellite pass was simply at 9:49 AM, which was not exactly the hottest part of the day.

Note: ECOSTRESS makes temperature observations on the Kelvin scale, not degrees Fahrenheit or Celsius.

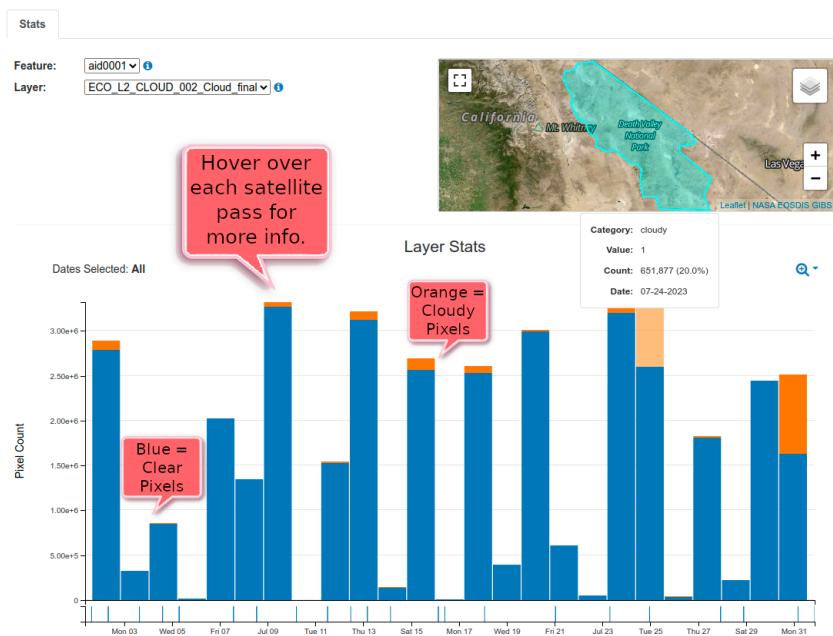
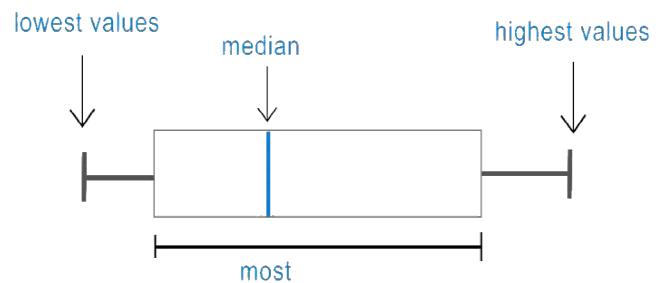
Data Check cont.

You are likely noticing that the distribution of temperatures for a given [orbital pass](#) from the instrument is quite variable. In some instances, like on Tuesday, 7/11/2023, all of the temperatures are close to the median. On other days, like Monday, 7/31/2023, the temperatures vary considerably. If this was a different locale, it could mean that there is a lot of variation in surface temperatures across this geographic area of interest. However, in this case we know Death Valley is consistently a hot desert, so it is more likely there is another culprit, clouds.

Satellite observations have many advantages, but they can not accurately measure through clouds. To account for this possibility, the ECOTRESS mission (and others) have built cloud detection algorithms and included that data in AppEEARS. Checking for the effects of cloud cover on the accuracy and precision of the results is an important part of data quality control and assurance.

13. Change the layer in the built-in AppEEARS visualizations to Cloud_final. Now, we have a different visualization, the output of the cloud detecting algorithm. The bar chart breaks down the percentage of pixels that are clear (represented in blue) and pixels that have clouds (orange). Satellite passes that are free of clouds, or have few clouds, tend to have higher quality data with fewer outliers because there is little interference. To make our temperature map, let's use data from the hottest cloud free day: 7/28/2023.

How To Read A Boxplot



Data Check cont.

Download The Data

Output data files returned by AppEEARS have the following naming convention:

<ProductShortName>.<Version>_<LayerName>_doy<Year><JulianDate>_<AppEEARSFeatureID>.<FileFormat>

Example output file name (.tif):

ECO2LSTE.001_SDS_LST_doy2023209214149_aid0001.tif

Where:

```

<ProductShortName> ..... ECO2LSTE
<Version> ..... 001
<LayerName> ..... SDS_LST
<Year> ..... 2023
<JulianDate> ..... 209
<AppEEARSFeatureID> ..... aid0001
<FileFormat> ..... tif
  
```

In this case, we are primarily concerned with the layer name, which corresponds to our variable of interest (i.e., Land surface temperature = SDS_LST), and with the time of the satellite pass (i.e. Year = 2023, Julian Date = 209).

JULIAN DATE CALENDAR
PERPETUAL

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

Select Day, In This Case 28

→

Our day of year is 209

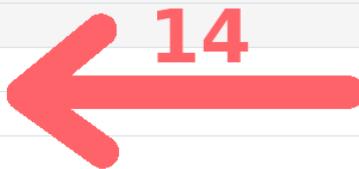
Select Month, In This Case July

←

Data Check cont.

14. Access the download page by scrolling to the top of the page, selecting the Explore menu and selecting the middle button next to your request, Download the contents of the request.  Use the Julian Calendar and file naming convention listed above to determine what filename we need to download the land surface temperature data for 7/28/2023. There can be multiple files that match the date and layer you requested, in this case there are two. Download both files into the same folder that you saved the DeathValleyNationalPark.zip shapefile.

NOTE: You can access the Julian Calendar table anytime by clicking this link. Watch out for leap years!.



2 Selected (5.62 MB)		
	Name ↑↓	Size ↑↓
<input checked="" type="checkbox"/>	 ECO2LSTE.001_SDS_LST_doy2023209214057_aid0001.tif	508.2 KB
<input checked="" type="checkbox"/>	 ECO2LSTE.001_SDS_LST_doy2023209214149_aid0001.tif	5.13 MB
<input type="checkbox"/>	 ECO2LSTE.001_SDS_QC_doy2023209214057_aid0001.tif	230.33 KB
<input type="checkbox"/>	 ECO2LSTE.001_SDS_QC_doy2023209214149_aid0001.tif	1.02 MB

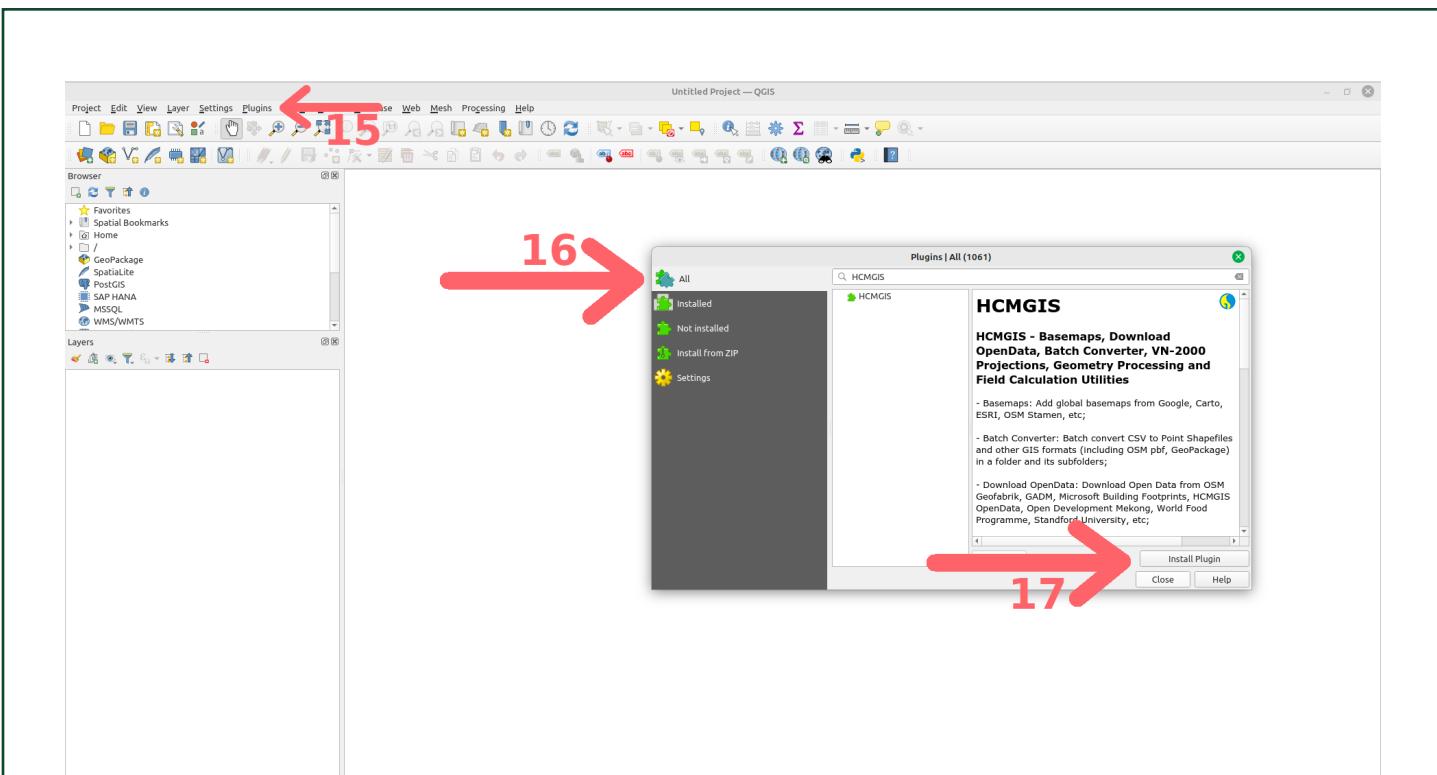
1 - 4 displayed, 4 in total

Visualizing the Death Valley Surface Temperature Data in QGIS

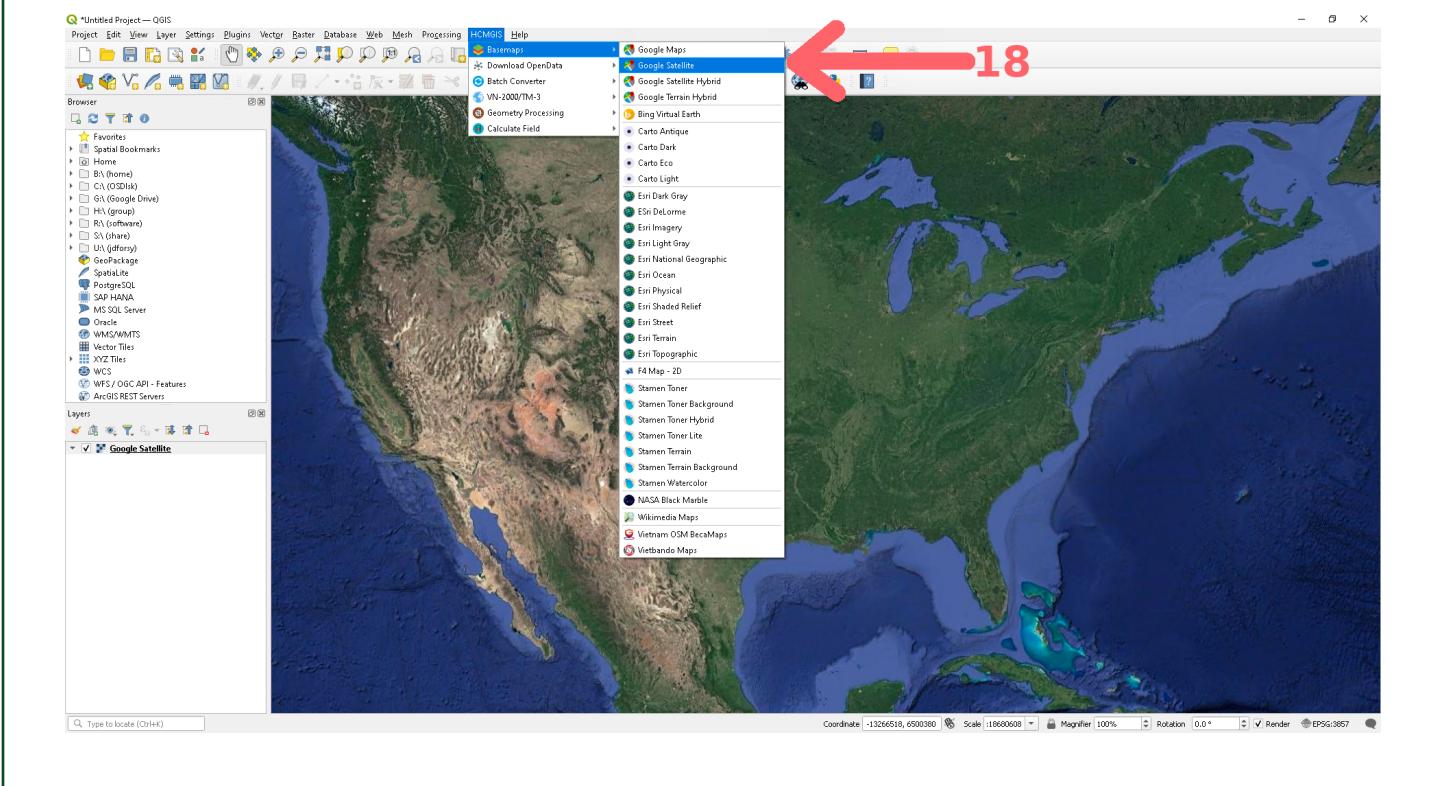
Adding a Google Satellite Basemap

In the last tutorial, we added in a simple basemap through a service included in the base QGIS installation. Today, we are going to expand QGIS's functionality by using an available plugin: HCMGIS. Plugins are external pieces of software that add useful features to QGIS.

[Continue >](#)

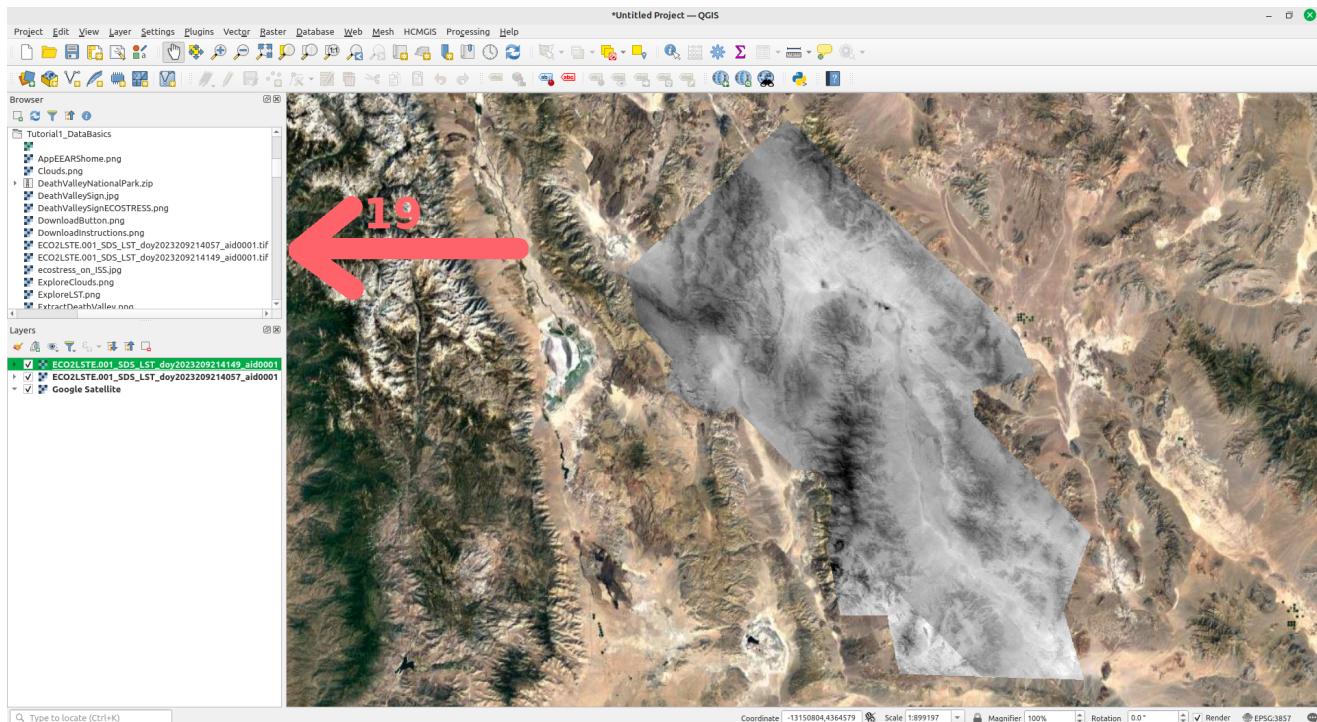


15. Open QGIS and start a new project by selecting the Project menu > then New. To install the HCMGIS plugin, click on the *Plugins* drop down menu and select *Manage and Install Plugins*.
16. In the next window, make sure All is selected in the first window pane and search for HCMGIS. HCMGIS is plugin that allows for easy imports of a wide selection of basemaps.
17. Click *Install Plugin* and wait for the installation to complete.



18. To quickly and easily add a basemap, all you need to do is find the HCMGIS menu bar, select Basemap, then pick your preferred map. For today's map, we will use Google Satellite, though you could play around with other options. Some other favorites are "ESRI Imagery", "ESRI Delorme," "Stamen Terrain," and "NASA Black Marble," though their utility depends on the goal(s) of your map. Note that clicking on a basemap type automatically adds a new layer to your map, as seen in the layer browser window.

Importing Our ECOSTRESS Death Valley Layer

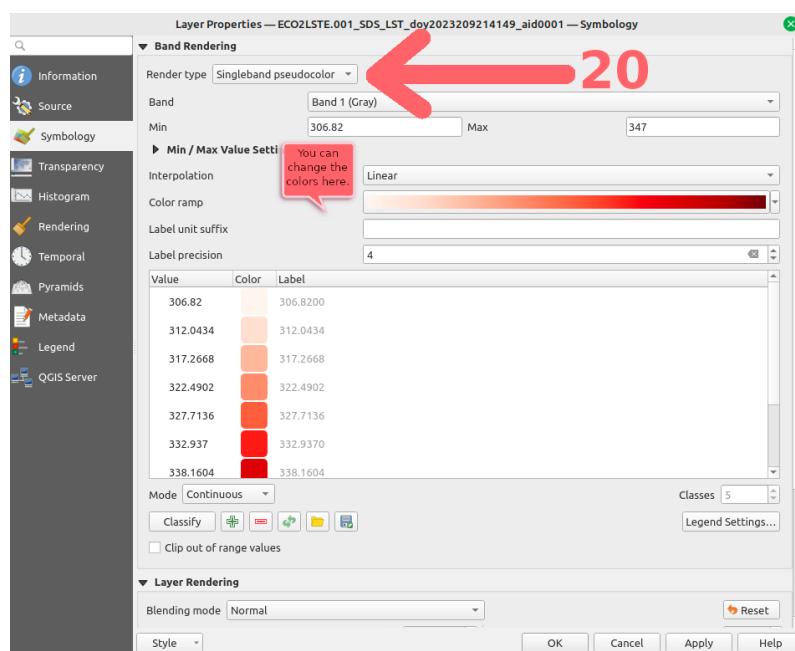


19. Use the browser window to find the folder where you saved the two land surface temperature .tif files. Double click each file to add them to your map. Again, notice they are now also listed in the Layers window.

Continue >

20. Congrats! You now have ECOSTRESS data on a map. But wait...let's make it look just a little better before you celebrate your win. QGIS doesn't know what kind of data this is and has defaulted to displaying the information in grayscale, which isn't that useful to our eyes. For each land surface temperature layer, right click on the layer name in the *Layers* window and select *Layer Properties*. On the menu bar to the left, select *Symbology* and change the *Render type* to *Singleband pseudocolor*. Since this is temperature, it is common to use a red color ramp. QGIS has automatically determined the minimum and maximum values from the datafiles; however, we have two files, so we need to make them match. Specify 306.82 as the minimum and 347 as the maximum for both layers. Click *apply*.

21. Lastly, add in the border from the DeathValleyNationalPark.zip shapefile. In the Browser window expand the zip file using the small arrow next to the filename. Double click on *Death Valley National Park.shp* to add the layer. Right click on the layer in the *Layers* window and change the symbology to *outline blue*.



22. Now we can celebrate... Your map should resemble the one to the right:

NOTE: There was not full data coverage for the entire park available, that is why the Northernmost part of the park does not have any color overlaid. This happens sometimes due to the orbit of the satellite.



[Continue >](#)

23. Save your QGIS Project into the folder with all of the other files from this tutorial by going to the Project menu bar at the top and selecting Save As.... Maintain the file format as .QGZ.

24. Finally, export your map. From the Project menu, navigate to Import/Export and select Export Map To Image. Increase the resolution to 200 dots per inch (DPI). You will submit this map, so save it into the same folder.

Congratulations! You have learned how to download ECOSTRESS instrument data from AppEEARS and make a basic map in QGIS.

MAP OF THE WEEK ASSIGNMENTS

1. Watch the YouTube Video: "[Why All Maps Are Wrong](#)"
2. Read the article [Lying With Maps](#) from the University of Minnesota.
3. Submit your timezone map and land surface temperature map from this tutorial.

Data

In case you encountered any issues with the AppEEARS database, here are copies of the ECOSTRESS GeoTIFF files for Death Valley:

- [ECO2LSTE.001 SDS LST doy2023209214149 aid0001.tif](#)
- [ECO2LSTE.001 SDS LST doy2023209214057 aid0001.tif](#)

Citation: Forsythe, Goldsmith, Fisher 2023. Tutorial 0: Observing Earth from Above. Chapman University.
<https://jeremydforsythe.github.io/icecream-tutorials/>.

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