API-231 / GIS-PubPol
Meeting 19 (“Climate-Conflict Nexus” Walk Through)

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April 9, 2024

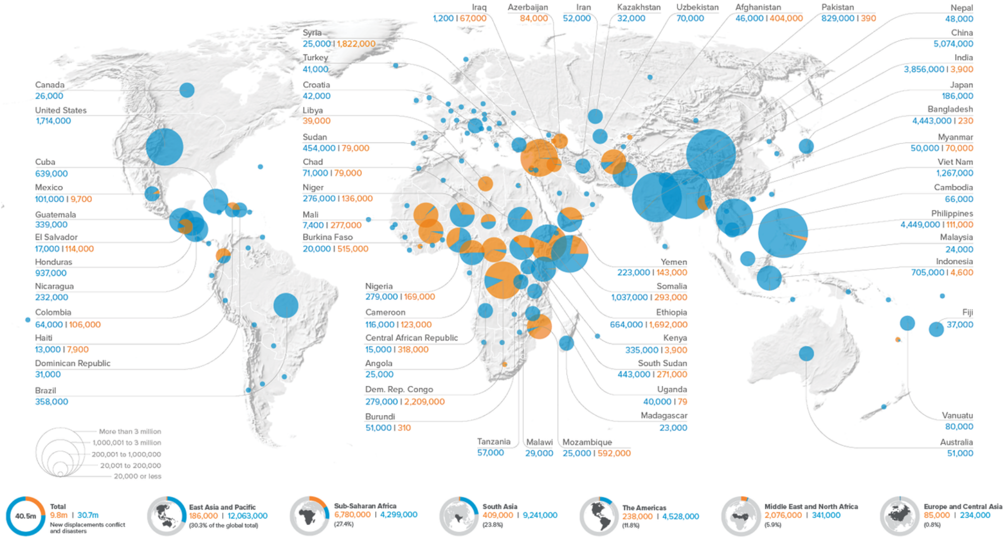

Figure 1: Displacement from natural disasters (blue) and conflict (orange) in 2020

The New York Times

Researchers Link Syrian Conflict to a Drought Made Worse by Climate Change

Share full article

Women working in fields in northeastern Syria in 2010. A new report suggests extreme drought in Syria was most likely a factor in the violent uprising that began there in 2011. Louai Beshara/Agence France-Presse — Getty Images

By Henry Fountain
March 2, 2015

Figure 2: Is this true?

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MARCH 4, 2013 | 4 MIN READ

Climate Change and Rising Food Prices Heightened Arab Spring

The effects of climate change on the food supply exacerbated the underlying tensions that have led to ongoing Middle East instability

BY INES PEREZ & CLIMATEWIRE

Environment

If the Arab Spring taught us something, it is that the effects of climate change can serve as stressors, contributing to regional instability and conflict, experts said.

In a report published last week, researchers from the Center for American Progress, the Center for Climate and Security and the Stimson Center examined the role of climate change in the Middle East's upheaval during 2010 and 2011. Looking at long-term trends in rain, crops, food prices and migration, they were able to determine how these factors contributed to social instability in the region.

"The Arab Spring would likely have come one way or another, but the context in which it did is not inconsequential. Global warming may not have caused the Arab Spring, but it may have made it come earlier," the report says.

The Middle East and North Africa region is extremely vulnerable to fluctuations in food supplies and prices. According to the report, with little arable land and scarce water supplies, the region is one of the top food

Figure 3: Let's look into this

Overview

What do we mean by "climate and weather"?

1. Long-term climate trends
   a) changes in average surface temperature
   b) changes in average precipitation
   c) sea level rise
   d) sea ice melt
2. Short-term weather "shocks"
   a) unusually hot/cold weather
   b) unusually dry/wet weather
3. DIscrete weather events
   a) extreme weather (e.g. storms, tornadoes)
   b) visibility obstructions (e.g. clouds, haze)
   c) floods
   d) droughts
   e) tsunamis

Figure 4: The storm is coming?

Applications of Meteorological Data to the Study of Conflict

Climate change as a driver of armed conflict and violence

1. Direct links between temperature, precipitation and political violence (Kevane and Gray 2008, Hendrix and Salehyan 2012, Levy and Sidel 2014, Mares and Moffett 2016)
2. Indirect effects on violence, through migration, resource competition, food insecurity (Ash and Obradovich 2020, Jones et al. 2017)
3. Impacts on social unrest in specific settings, like urban areas (Koren et al. 2021, Koubi et al. 2021)

Figure 5: A cause of war?

Short-term weather and violence

1. Cloud cover as instrumental variable for drone strikes (Mahmood and Jetter 2019, Saeed and Spagat 2021)
2. Weather shocks as instrumental variable for famine (Rozenas and Zhukov 2019)
3. Rainfall shocks as instrumental variable for economic growth (Miguel et al 2004, Miguel and Satyanath 2010, Sarsons 2015, Mellon 2023)

$$
\begin{array}{ccccc}
 & & U & & \\
 & & \downarrow & \searrow & \\
W & \longrightarrow & X_1 & \longrightarrow & Y
\end{array}
$$

Figure 6: W is the instrumental variable

What do we know?

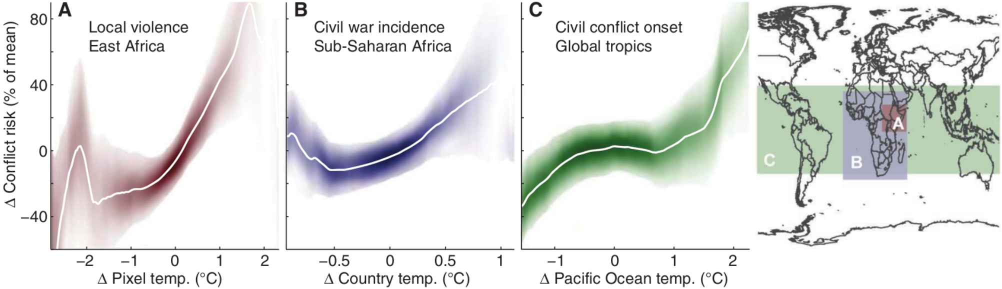


Figure 7: There is a positive correlation between higher temperatures and violence

At the macro level, civil conflict is more likely in hotter, drier times

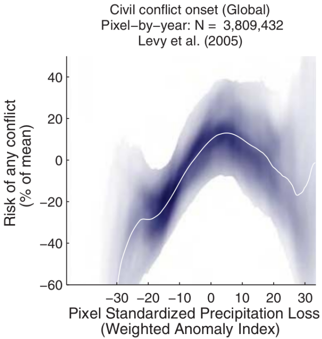


Figure 8: Around the globe

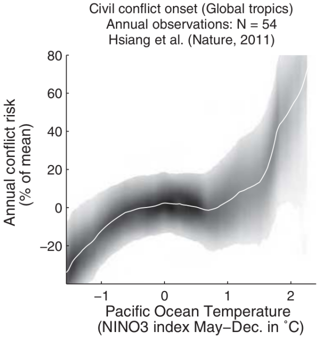


Figure 9: Conflict in tropics

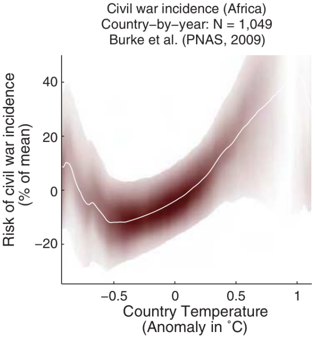


Figure 10: Civil wars in Africa

Communal and inter-group conflict also more likely in climate-stressed times

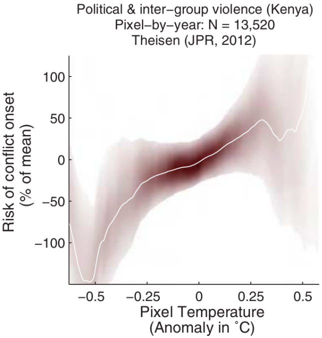


Figure 11: In Kenya

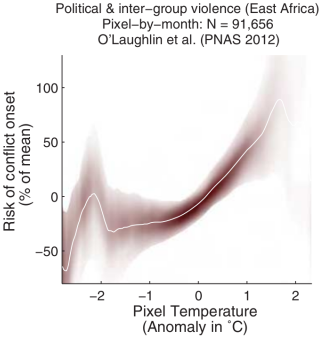


Figure 12: In East Africa

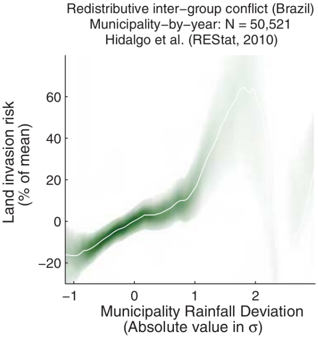


Figure 13: In Brazil

Similar correlations with other types of unrest across the globe

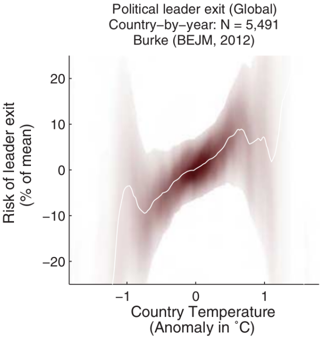


Figure 14: Regime change

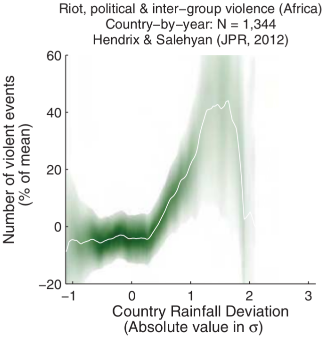


Figure 15: Riots in Africa

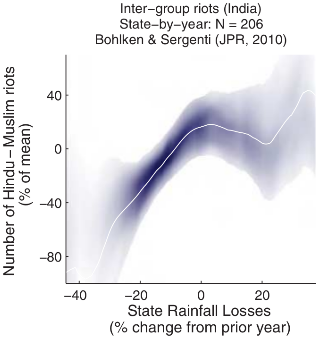


Figure 16: Riots in India

As well as for crime, sexual assault and other violence in the U.S.

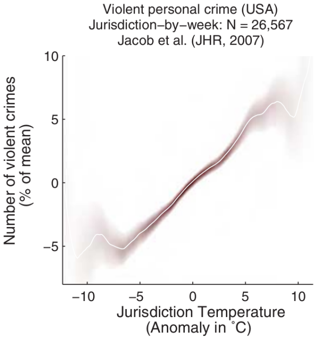


Figure 17: Crime in U.S.

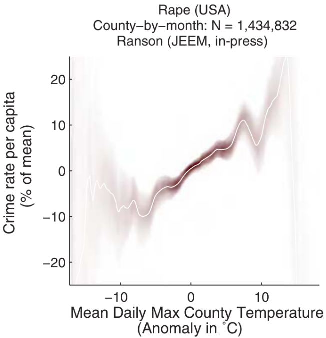


Figure 18: Rape in U.S.

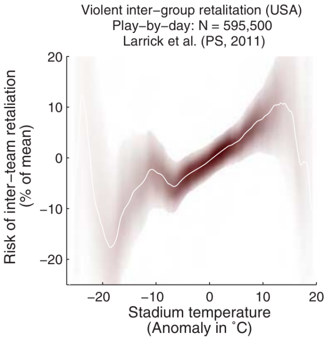


Figure 19: Fights at stadiums

Correlation $\neq$ causation

1. Emerging consensus that climate change by itself does not "cause" conflict (Hsiang and Burke 2014, Van Uexkull and Buhaug 2021)
2. Effect is likely indirect, though mechanisms like:
   a) demographic changes (McAdam 2017, Dorward and Fox 2022, Koubi et al 2021)
   b) resource competition (Njiru 2012, Harvey and Pilgrim 2011)
   c) youth bulges (Barakat and Urdal 2009, Nordas and Davenport 2013)
   d) migration (Adamson 2006, Nagabatla et al 2021, Nordas 2014, Menashe-Oren 2020)
   e) state capacity (Koren and Sarbahi 2018)

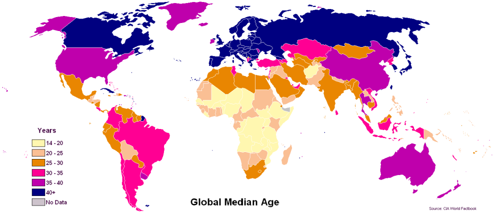


Figure 20: Demographic time bomb?

Varieties of Meteorological Data

Historical weather & climate raster data (partial list)

Source/link	Spatial resolution	Frequency	Availability	Free?	Global?
`NOAA`	0.5×0.5 degree	Monthly	1900-2014	✓	✓
`CRUTS`	0.5×0.5 degree	Monthly	1901-2022		✓
`ERA5`	0.25×0.25 degree	Hourly	1940-Present	✓	✓
`GLDAS`	0.25×0.25 degree	Hourly	1948-Present	✓	✓
`FLDAS`	0.1×0.1 degree	Monthly	1982-2016	✓	✓
`TerraClimate`	0.04×0.04 degree	Monthly	1958-2023	✓	✓

Climate model future predictions (partial list)

Source/link	**Spatial resolution**	**Free?**	**Global?**
`CESM / CIME`	0.5×0.5 degree	✓	✓
`GFDL-ESM`	1×1 degree	✓	✓
`MPAS`	Voronoi mesh	✓	✓
`GISS Model E, E2R`	1×1 degree	✓	✓
`E3SM v2`	1×1 degree	✓	✓

Greenhouse gas emissions (partial list)

Source/link	**Spatial resolution**	**Frequency**	**Availability**	**Free?**	**Global?**
`EDGAR`	0.1×0.1 degree	Annual	1970-Present	✓	✓
`ESS-DIVE`	1×1 degree	Annual	1751-2013	✓	✓
`Global Carbon Atlas`	City-level	Annual	1960-Present	✓	✓
`EPA-FLIGHT`	Facility-level	Annual	2010-Present	✓	

Extreme weather events (partial list)

Source/link	**Spatial resolution**	**Availability**	**Free?**	**Global?**
`NOAA Storm Events`	Points	1950-2023	✓	
`EM-DAT`	Points, admin units	1988-Present	✓	✓
`GDIS`	Points (centroids)	1960-2018	✓	✓

Words of caution

1. Existing research conceptualizes climate change and conflicts in diverse ways (Meierding 2013, Raleigh and Urdal 2007, Sharifi et al 2021, Van Uexkull and Buhaug 2021)
2. Complexity of causal pathways, patchy data, disagreement over measurement, analytical approaches (Adams et al 2018, Sakaguchi et al 2017, Sheffran et al 2012)
3. Differences in assumptions, data & methods lead to *vastly different conclusions* (Hsiang and Burke 2014, Buhaug et al 2014, Van Uexkull and Buhaug 2021)

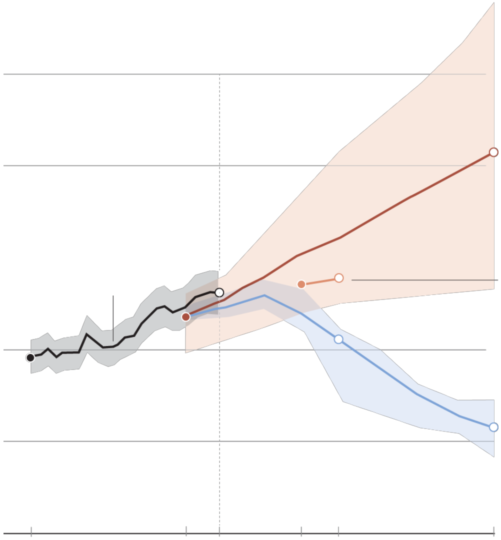


Figure 21: The answer is "it depends"

Vignettes

Overview of lab exercise

1. Changes in summer temperatures by country
2. Drought severity and violence during the 2011 Arab spring

We will compare average monthly high temperatures in July 2023 to July 1958

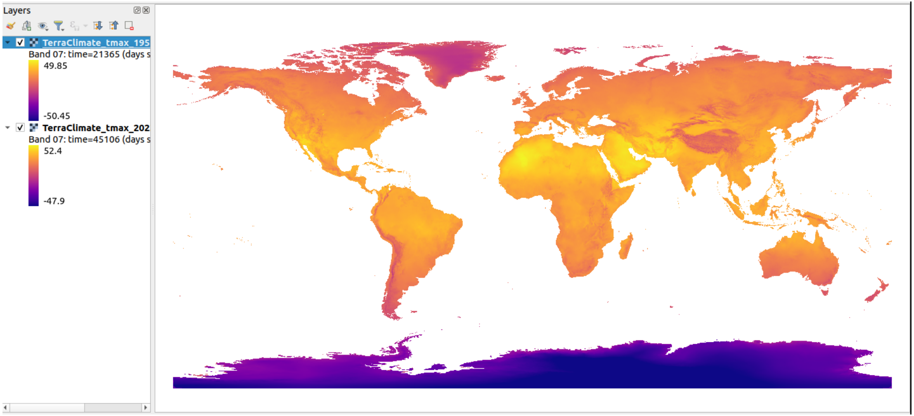


Figure 22: Vignette 1 / Step 1

And calculate a new raster that shows where the changes were lowest/highest

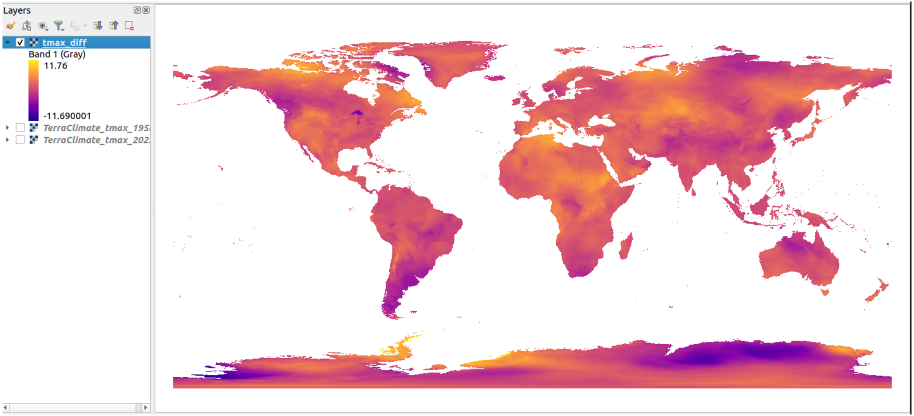


Figure 23: Vignette 1 / Step 2

We will then aggregate these changes by country, to see who was most affected

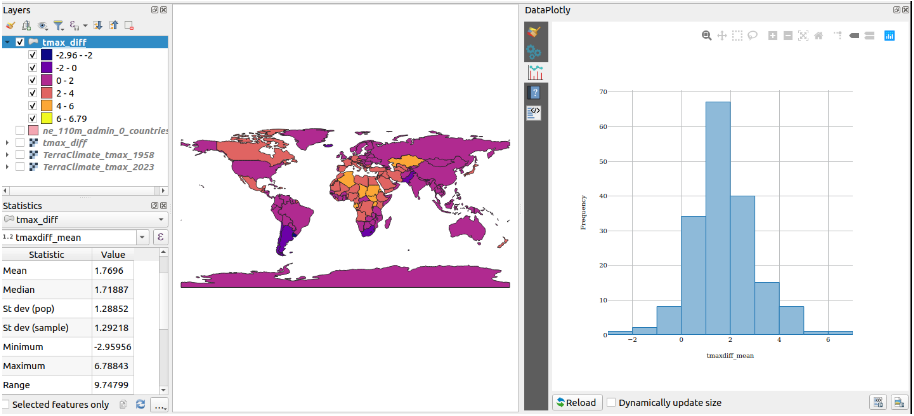


Figure 24: Vignette 1 / Step 3

We will then calculate yearly averages of severe drought indices

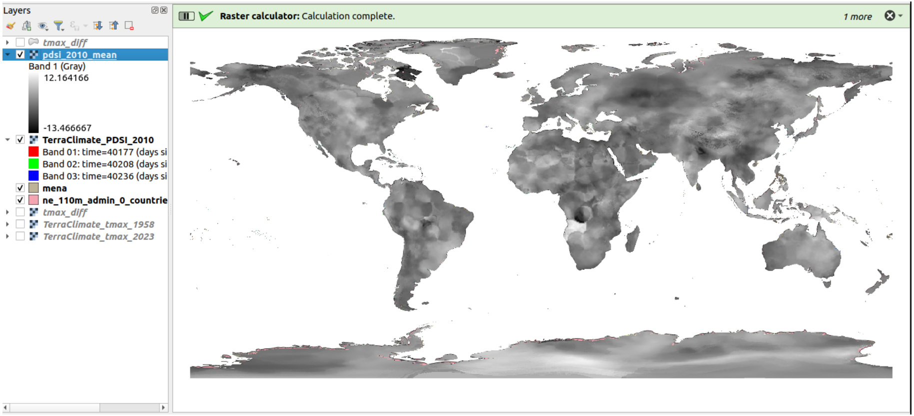


Figure 25: Vignette 2 / Step 1

We will extract drought indices for the Middle East and North Africa

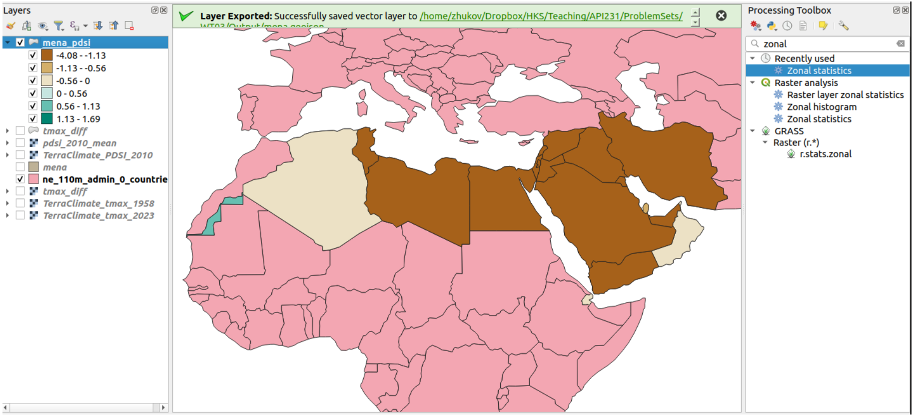


Figure 26: Vignette 2 / Step 2

And will see if countries more affected by drought saw more violence in 2011

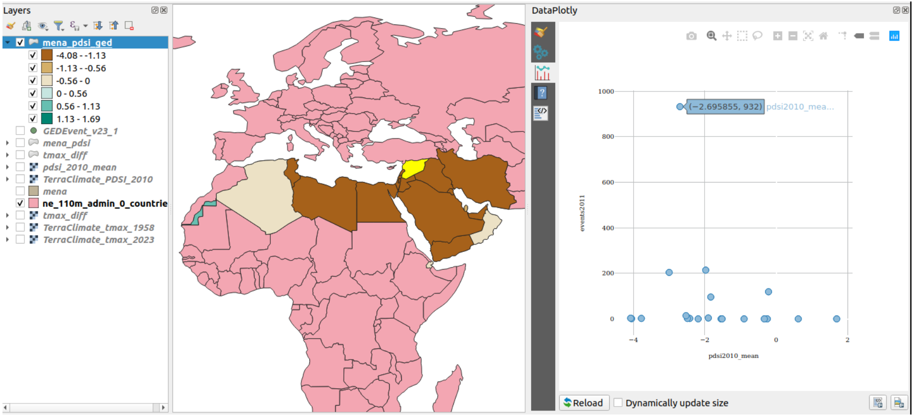
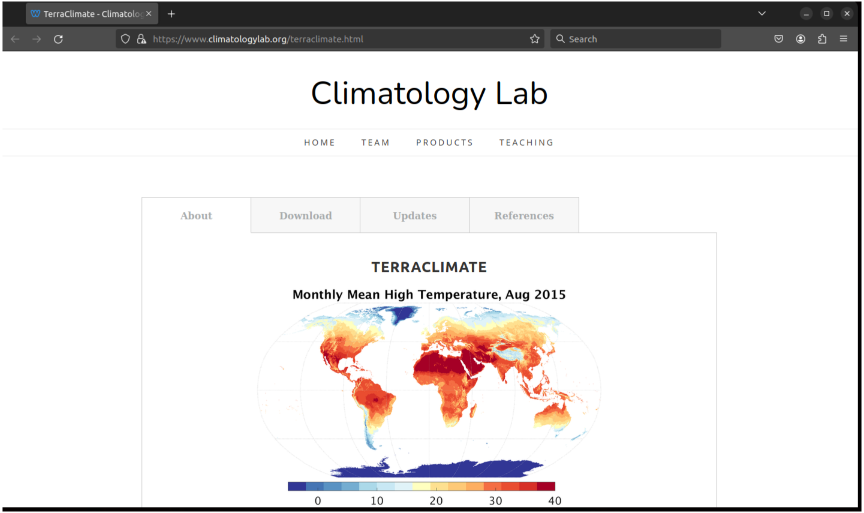
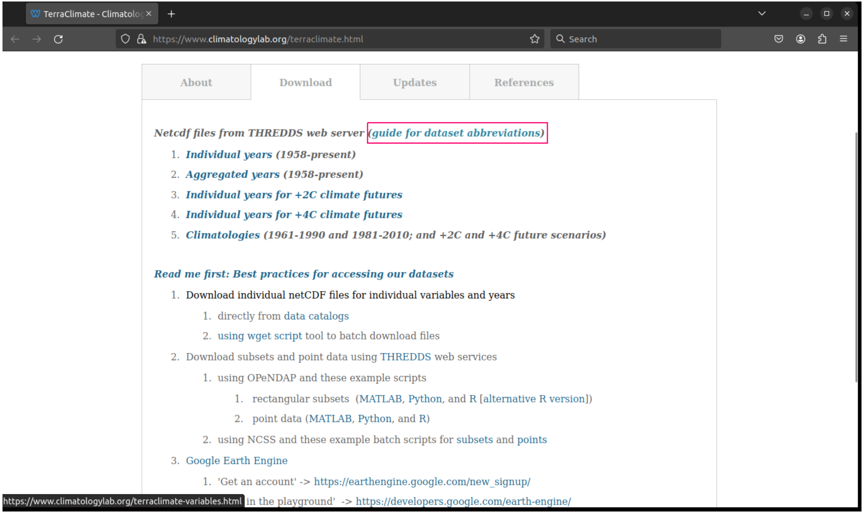


Figure 27: Vignette 2 / Step 3

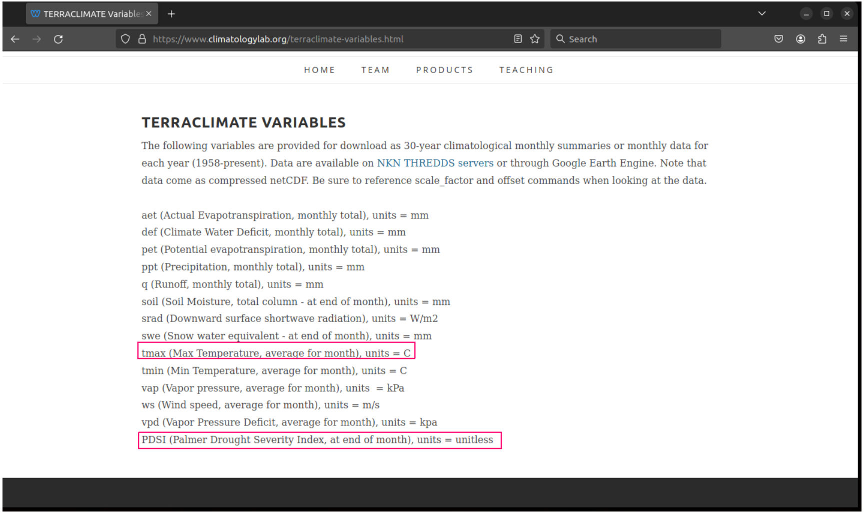
We can obtain **monthly mean high temperature data** from `climatologylab.org/terraclimate.html`



There are several types of data here. See the "guide for dataset abbreviations"



We want `tmax` (mean high temperatures) and `PDSI` (drought index)


TERRACLIMATE Variables
https://www.climatologylab.org/terraclimate-variables.html
Search

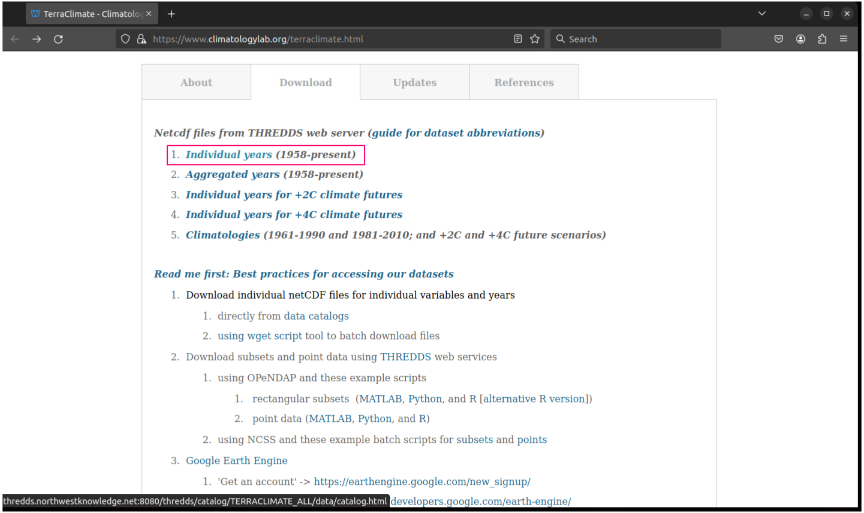
HOME TEAM PRODUCTS TEACHING

TERRACLIMATE VARIABLES

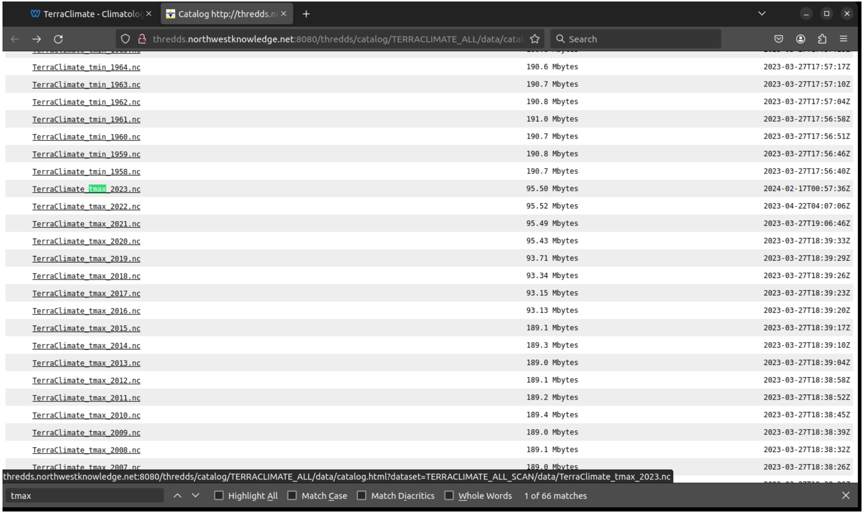
The following variables are provided for download as 30-year climatological monthly summaries or monthly data for each year (1958-present). Data are available on NKN THREDDS servers or through Google Earth Engine. Note that data come as compressed netCDF. Be sure to reference scale_factor and offset commands when looking at the data.

aet (Actual Evapotranspiration, monthly total), units = mm
def (Climate Water Deficit, monthly total), units = mm
pet (Potential evapotranspiration, monthly total), units = mm
ppt (Precipitation, monthly total), units = mm
q (Runoff, monthly total), units = mm
soil (Soil Moisture, total column - at end of month), units = mm
srad (Downward surface shortwave radiation), units = W/m2
swe (Snow water equivalent - at end of month), units = mm
tmax (Max Temperature, average for month), units = C
tmin (Min Temperature, average for month), units = C
vap (Vapor pressure, average for month), units = kPa
ws (Wind speed, average for month), units = m/s
vpd (Vapor Pressure Deficit, average for month), units = kpa
PDSI (Palmer Drought Severity Index, at end of month), units = unitless

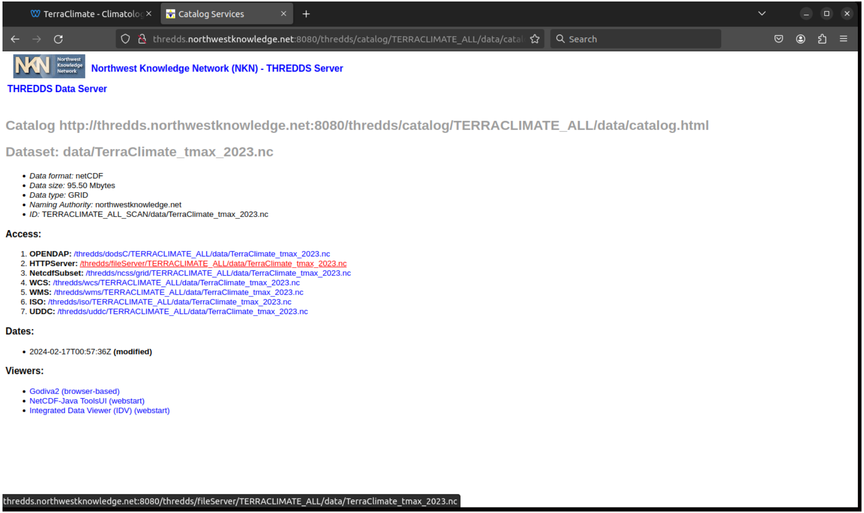
Let's download the "Individual years" data



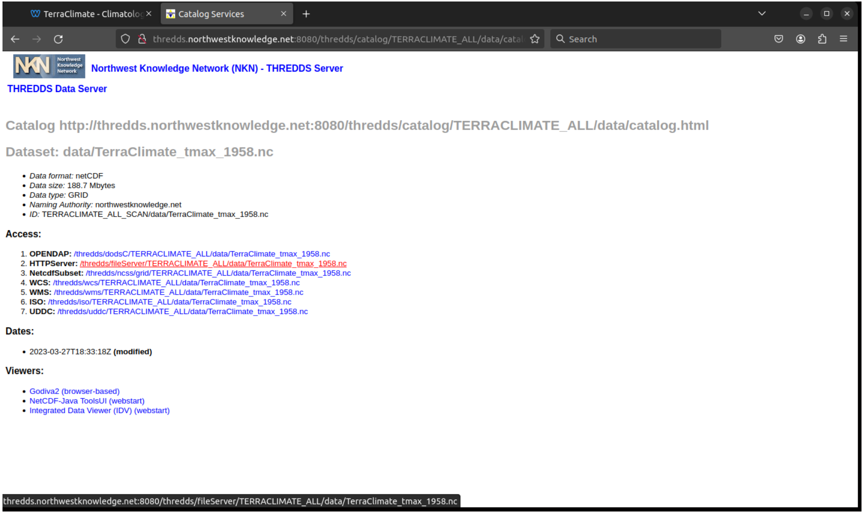
The file naming convention is `TerraClimate_[variable]_[year].nc`. Go to `TerraClimate_tmax_2023.nc`



Download this file through the `HTTPServer` link



Do the same for the 1958 temperature data `TerraClimate_tmax_1958.nc`


TerraClimate - Climatolog
Catalog Services
thredds.northwestknowledge.net:8080/thredds/catalog/TERRACLIMATE_ALL/data/catal
Search

Northwest Knowledge Network (NKN) - THREDDS Server

THREDDS Data Server

Catalog http://thredds.northwestknowledge.net:8080/thredds/catalog/TERRACLIMATE_ALL/data/catalog.html

Dataset: data/TerraClimate_tmax_1958.nc

- *Data format:* netCDF
- *Data size:* 188.7 Mbytes
- *Data type:* GRID
- *Naming Authority:* northwestknowledge.net
- *ID:* TERRACLIMATE_ALL_SCAN/data/TerraClimate_tmax_1958.nc

Access:

1. **OPENDAP:** /thredds/dodsC/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
2. **HTTPServer:** /thredds/fileServer/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
3. **NetcdfSubset:** /thredds/ncss/grid/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
4. **WCS:** /thredds/wcs/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
5. **WMS:** /thredds/wms/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
6. **ISO:** /thredds/iso/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc
7. **UDDC:** /thredds/uddc/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc

Dates:

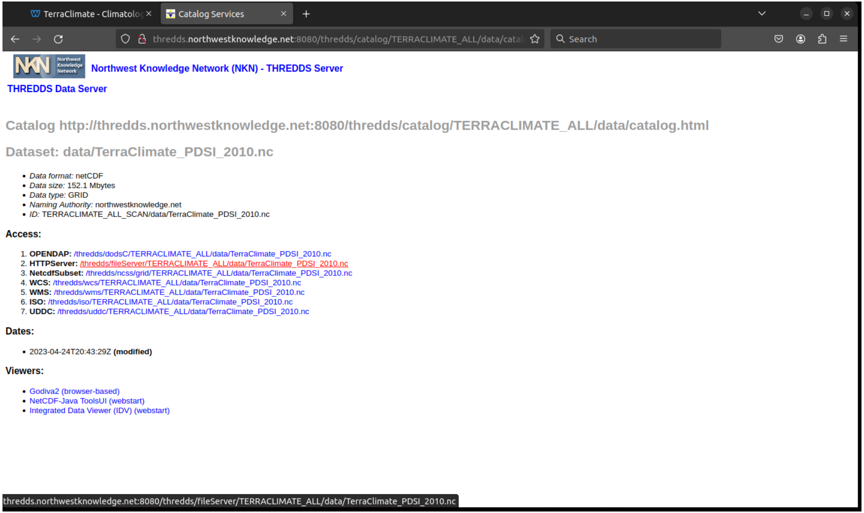
- 2023-03-27T18:33:18Z **(modified)**

Viewers:

- Godiva2 (browser-based)
- NetCDF-Java ToolsUI (webstart)
- Integrated Data Viewer (IDV) (webstart)

thredds.northwestknowledge.net:8080/thredds/fileServer/TERRACLIMATE_ALL/data/TerraClimate_tmax_1958.nc

And the 2010 drought index data `TerraClimate_PDSI_2010.nc`



Northwest Knowledge Network (NKN) - THREDDS Server

THREDDS Data Server

Catalog http://thredds.northwestknowledge.net:8080/thredds/catalog/TERRACLIMATE_ALL/data/catalog.html

Dataset: data/TerraClimate_PDSI_2010.nc

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- *Data size:* 152.1 Mbytes
- *Data type:* GRID
- *Naming Authority:* northwestknowledge.net
- *ID:* TERRACLIMATE_ALL_SCAN/data/TerraClimate_PDSI_2010.nc

Access:

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2. **HTTPServer:** /thredds/fileServer/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc
3. **NetcdfSubset:** /thredds/ncss/grid/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc
4. **WCS:** /thredds/wcs/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc
5. **WMS:** /thredds/wms/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc
6. **ISO:** /thredds/iso/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc
7. **UDDC:** /thredds/uddc/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc

Dates:

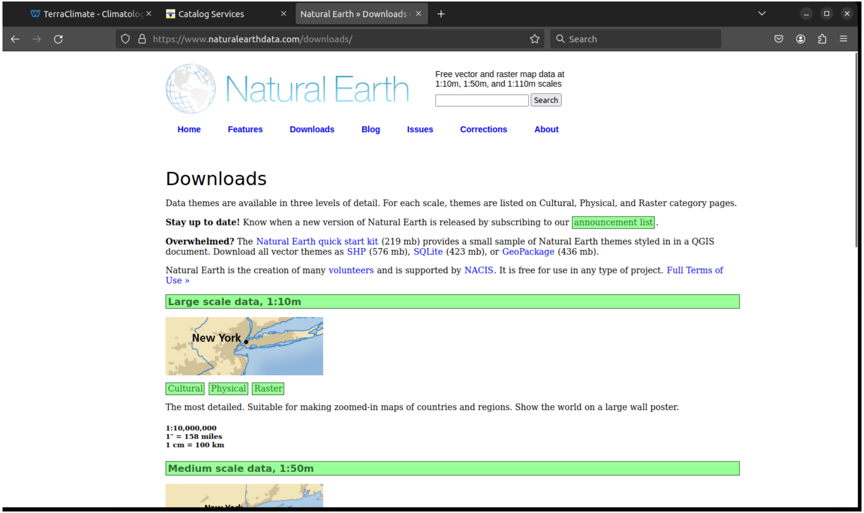
- 2023-04-24T20:43:29Z **(modified)**

Viewers:

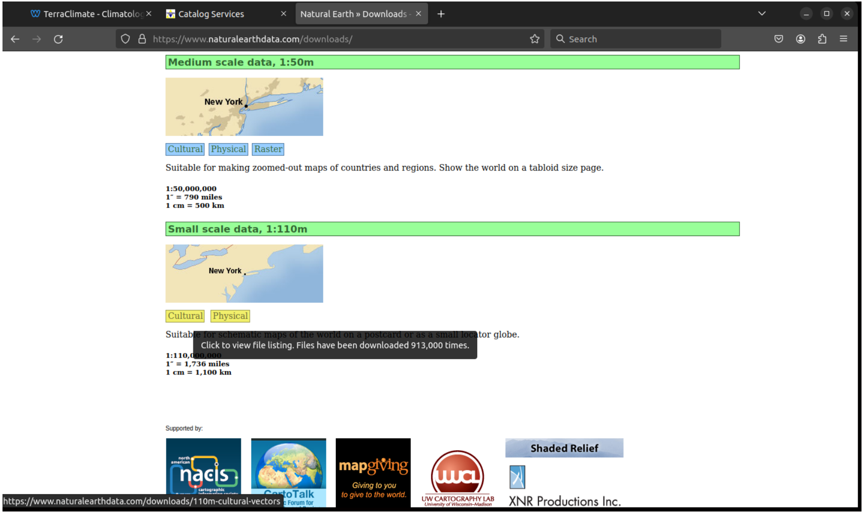
- Godiva2 (browser-based)
- NetCDF-Java ToolsUI (webstart)
- Integrated Data Viewer (IDV) (webstart)

thredds.northwestknowledge.net:8080/thredds/fileServer/TERRACLIMATE_ALL/data/TerraClimate_PDSI_2010.nc

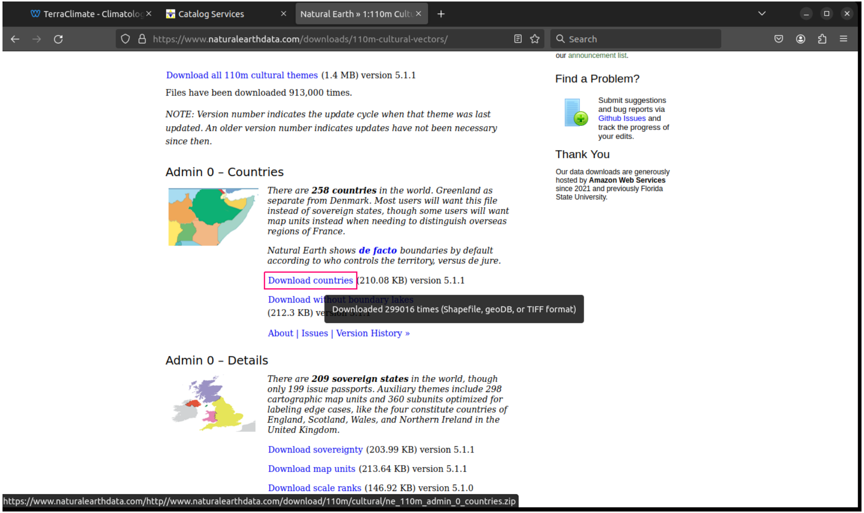
We will use global country-level boundaries data from `naturalearthdata.com`



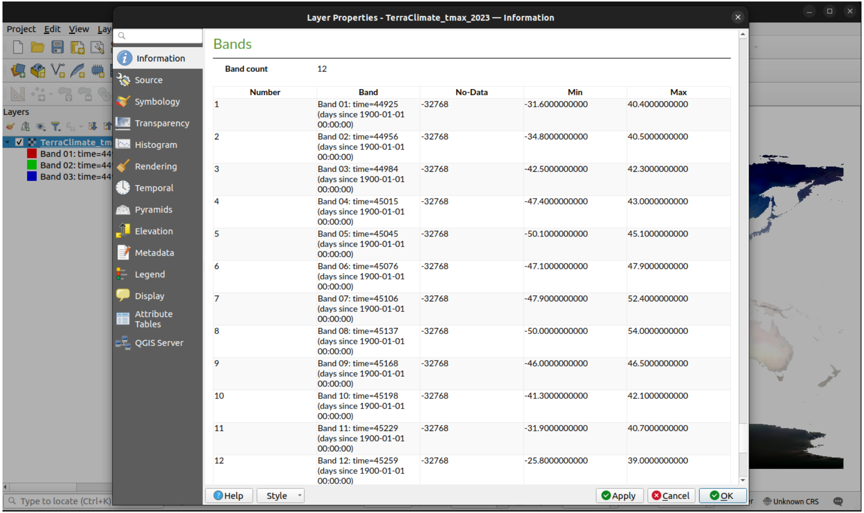
We want the "Small scale data, 1:100m". Click on the `Cultural` link



Click on the "Download countries" link under "Admin 0 - Countries" to get the zip



We will be using the same event **data on violence** as in the last two labs: UCDP GED version 23.1, in `csv` format



Here is the full list of data sources and links:

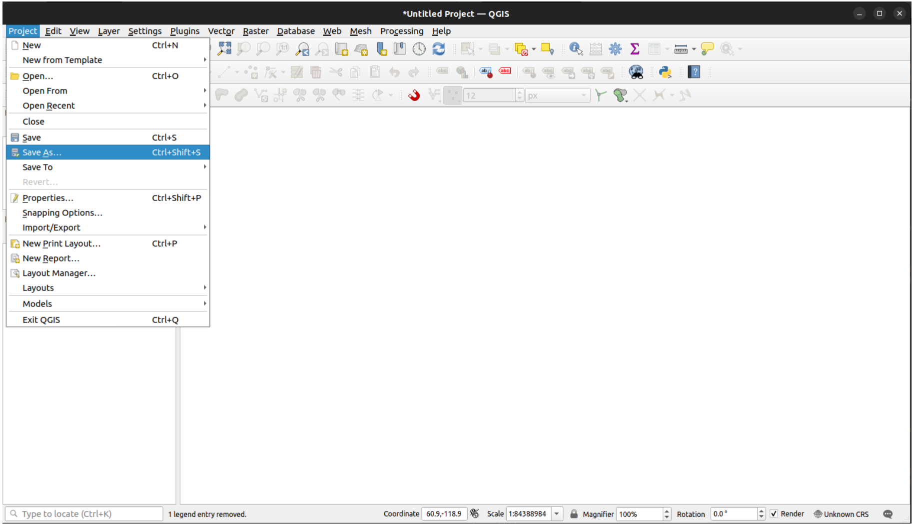
Category	Type	Format	Data source
Average monthly max temperature	Raster	`.nc`	TerraClimate
Palmer Drought Severity Index	Raster	`.nc`	TerraClimate
Country borders	Vector (polygons)	`.shp`	Natural Earth

These are all in the `WT03.zip` file posted on Canvas.

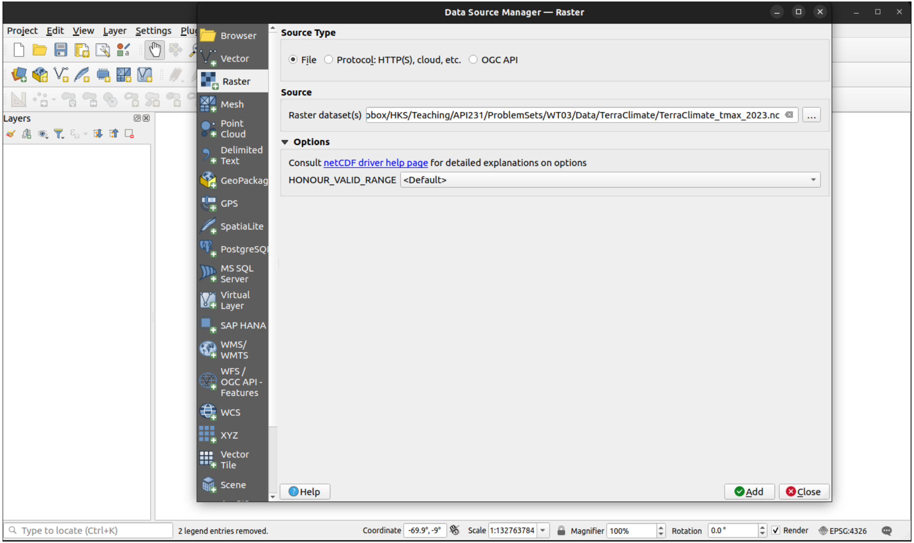
Changes in summer temperatures by country

Always save your progress!

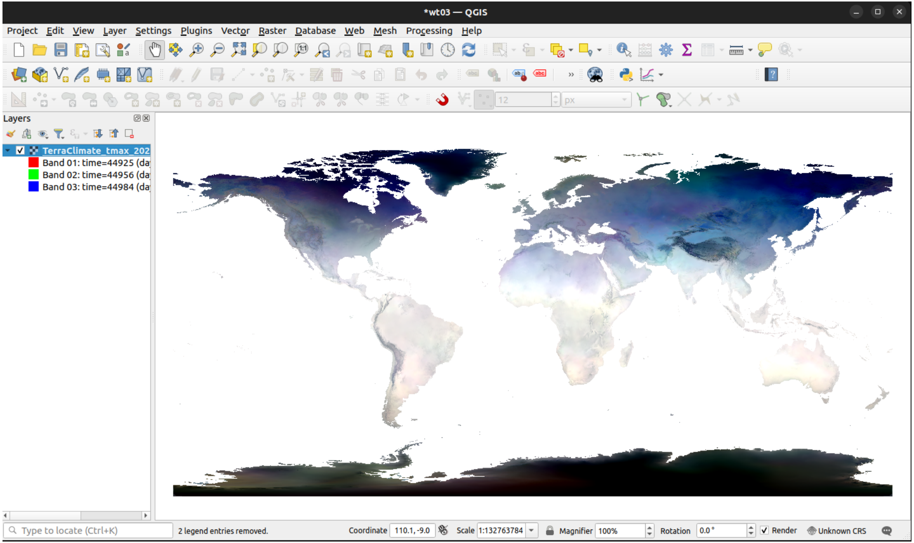
Go to `Project` → `Save As...`



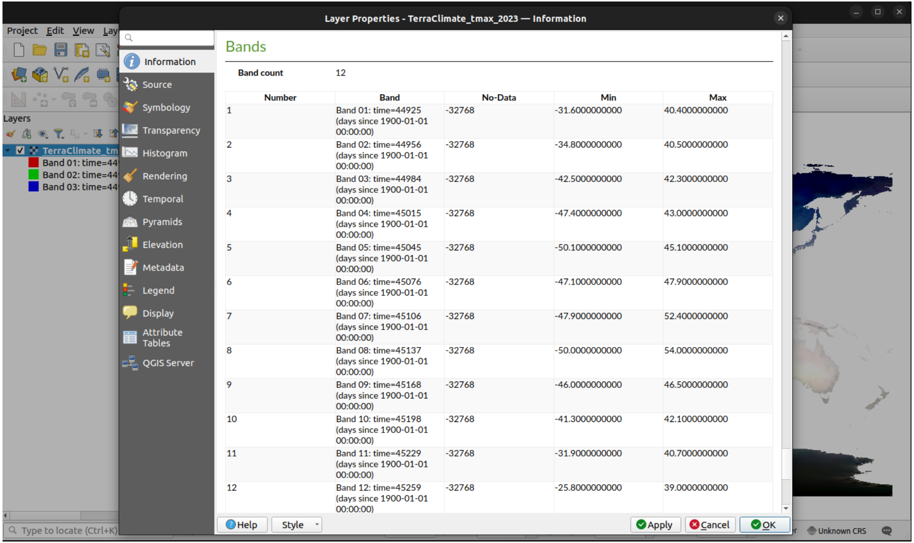
Vignette 1. Load the *2023 temperature data* (`Layer → Add Layer → Add Raster Layer`). `TerraClimate_tmax_2023.nc` file in `Data/TerraClimate`



This is a multi-band raster. Let's open up the layer `Properties` to see what these bands represent

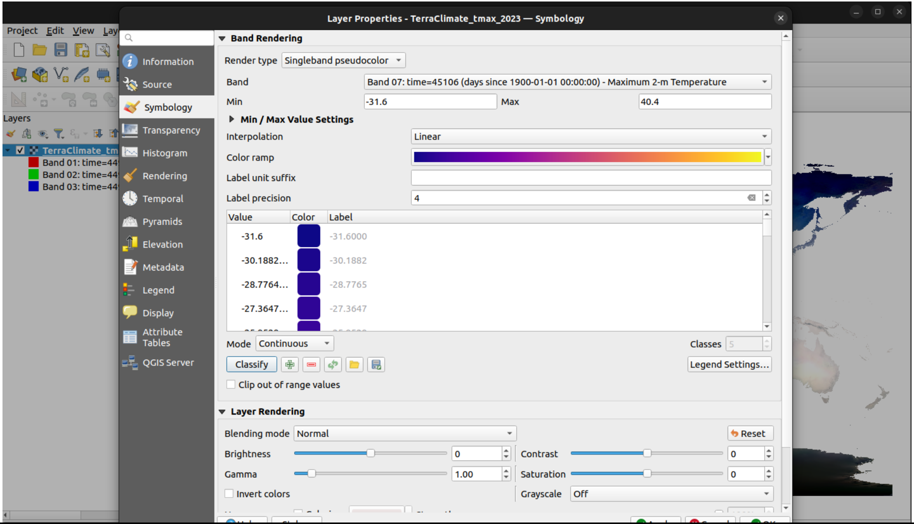


Go to the Information tab and scroll down to Bands. There are 12 bands, corresponding to months of the year (e.g. 1 = January, 12 = December)

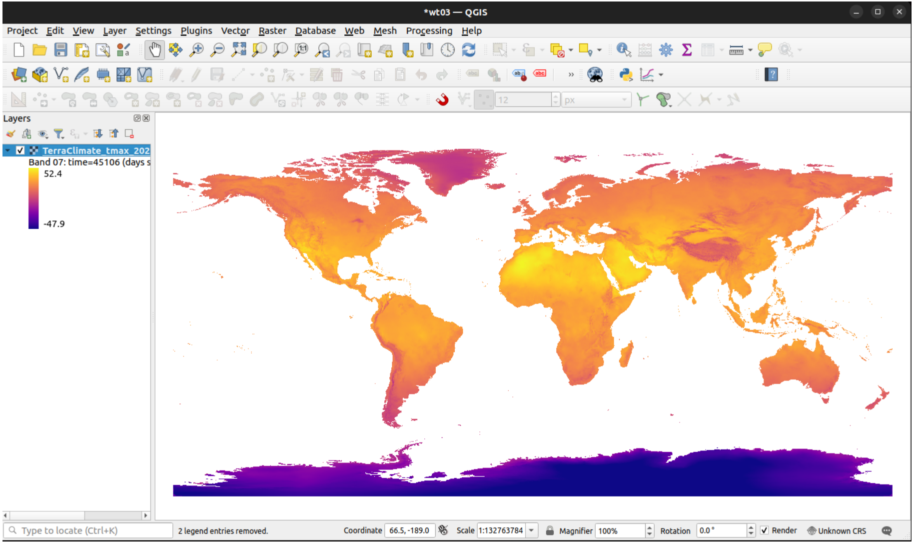


Number	Band	No-Data	Min	Max
1	Band 01: time=44925 (days since 1900-01-01 00:00:00)	-32768	-31.6000000000	40.4000000000
2	Band 02: time=44956 (days since 1900-01-01 00:00:00)	-32768	-34.8000000000	40.5000000000
3	Band 03: time=44984 (days since 1900-01-01 00:00:00)	-32768	-42.5000000000	42.3000000000
4	Band 04: time=45015 (days since 1900-01-01 00:00:00)	-32768	-47.4000000000	43.0000000000
5	Band 05: time=45045 (days since 1900-01-01 00:00:00)	-32768	-50.1000000000	45.1000000000
6	Band 06: time=45076 (days since 1900-01-01 00:00:00)	-32768	-47.1000000000	47.9000000000
7	Band 07: time=45106 (days since 1900-01-01 00:00:00)	-32768	-47.9000000000	52.4000000000
8	Band 08: time=45137 (days since 1900-01-01 00:00:00)	-32768	-50.0000000000	54.0000000000
9	Band 09: time=45168 (days since 1900-01-01 00:00:00)	-32768	-46.0000000000	46.5000000000
10	Band 10: time=45198 (days since 1900-01-01 00:00:00)	-32768	-41.3000000000	42.1000000000
11	Band 11: time=45229 (days since 1900-01-01 00:00:00)	-32768	-31.9000000000	40.7000000000
12	Band 12: time=45259 (days since 1900-01-01 00:00:00)	-32768	-25.8000000000	39.0000000000

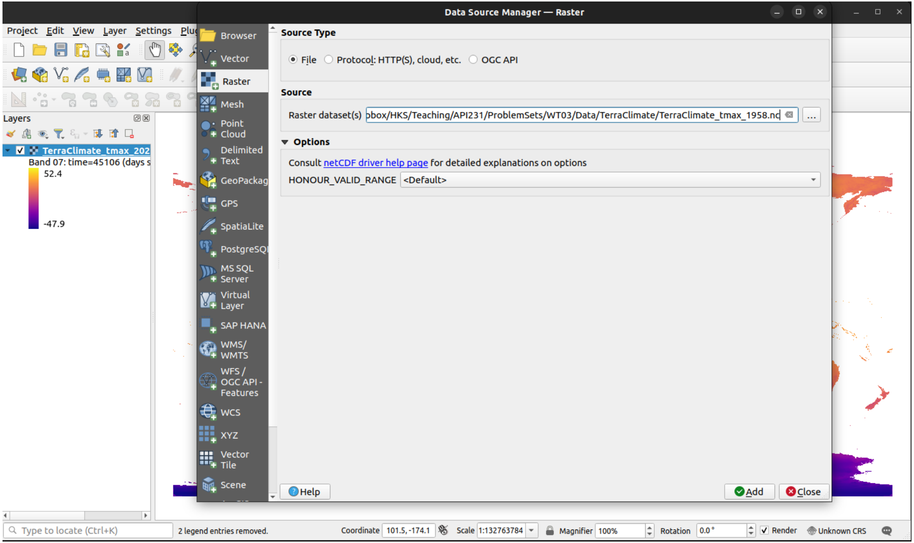
Let's display temperatures for July. In `Symbology`, change `Render type` to `Singleband pseudocolor` and set `Band` to `Band 07....` Adjust the other graphical parameters to taste.



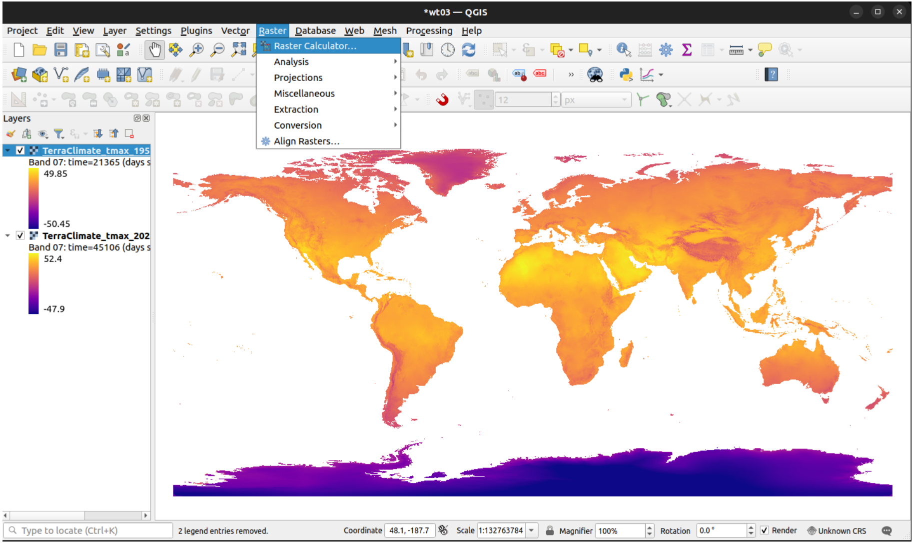
Places closer to the equator are hotter. Antarctica is very cold



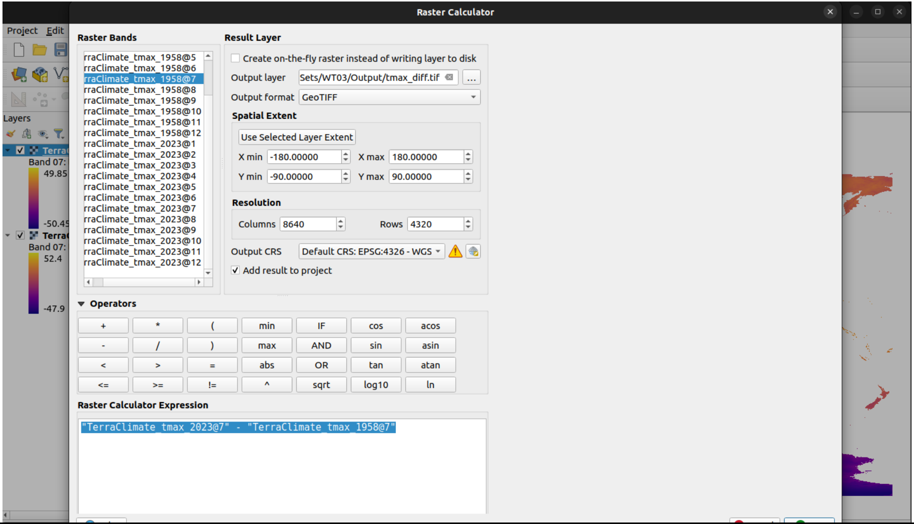
Let's also load the `tmax` raster data for 1958



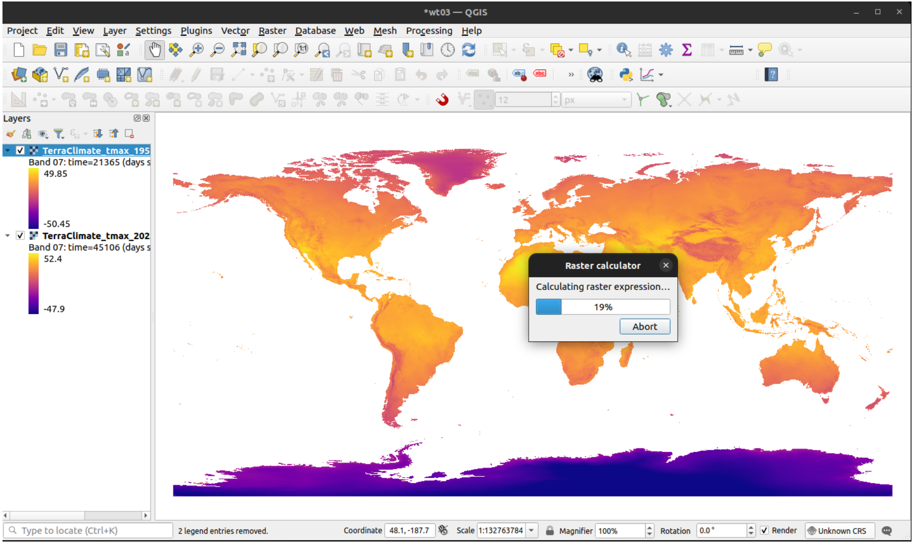
Once both rasters are loaded, open the `Raster Calculator...`



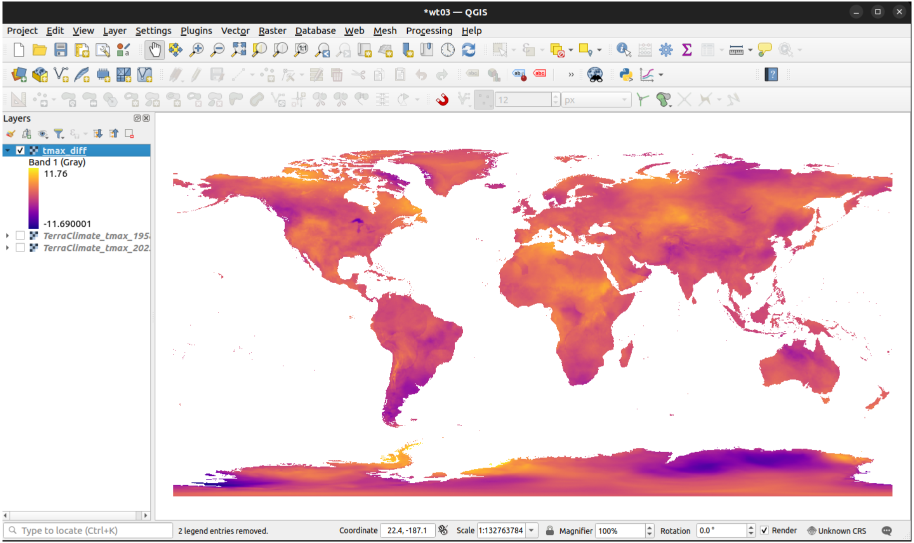
Set the Expression to `"TerraClimate_tmax_2023@7"-"TerraClimate_tmax_1958@7"` (July temp in 2023 minus July temp in 1958). Save the output as `tmax_diff.tif`



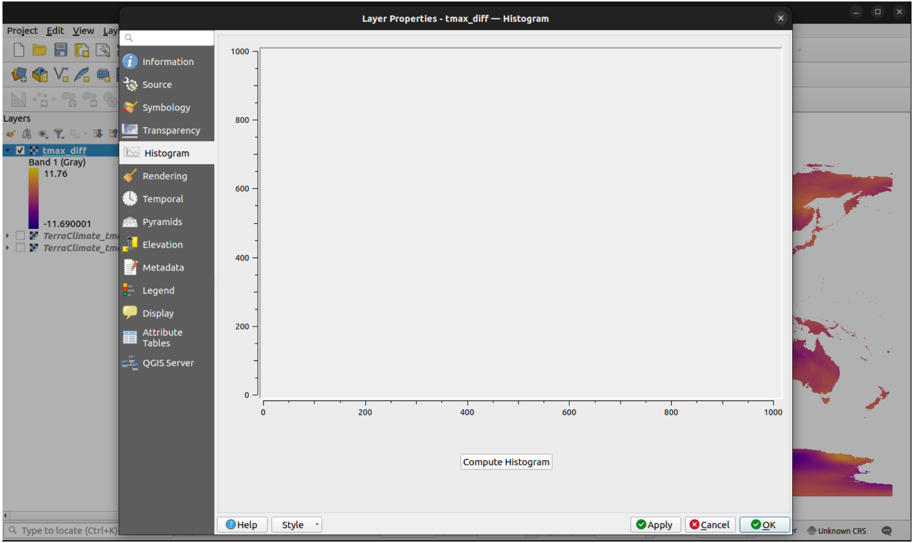
This will take a few minutes to compute



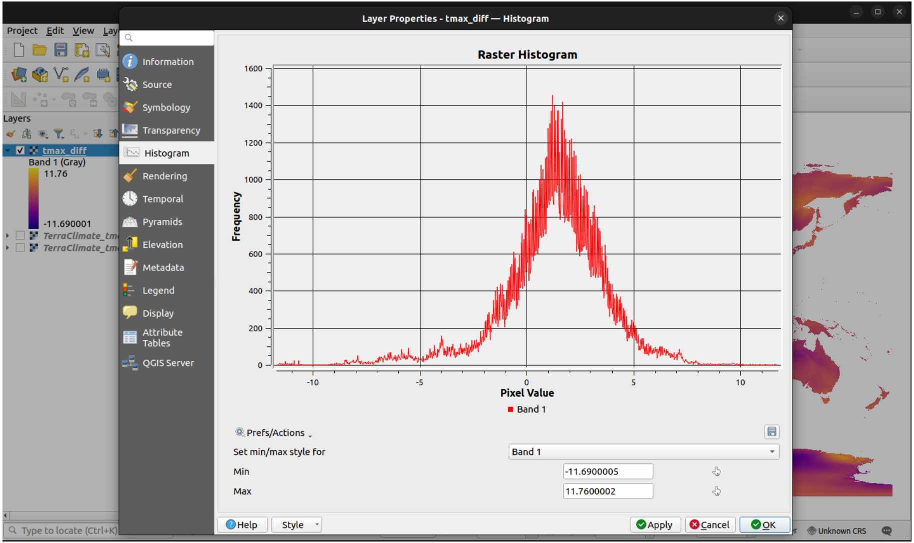
The `tmax_diff` raster should look something like this



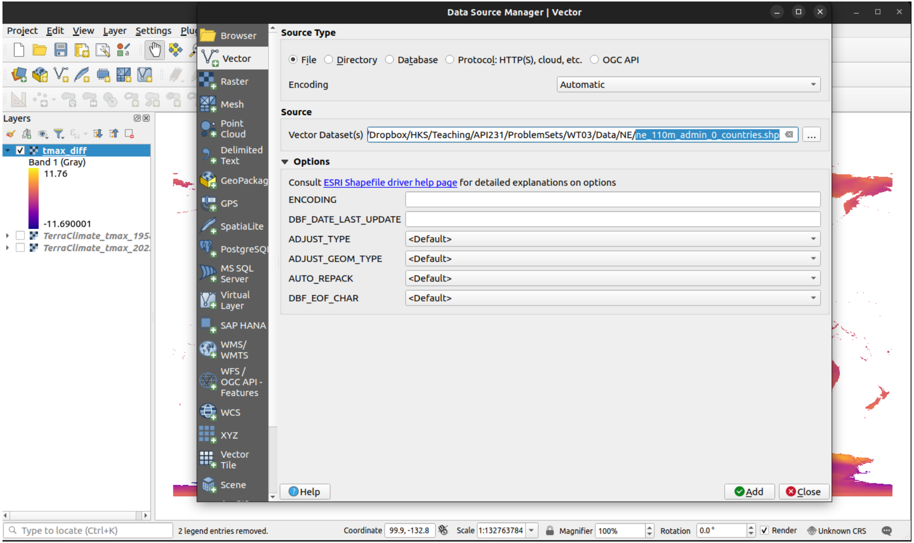
Let's examine the distribution of global temperature changes. In the layer `Properties` for `tmax_diff`, open the `Histogram` tab. Click `Compute Histogram`



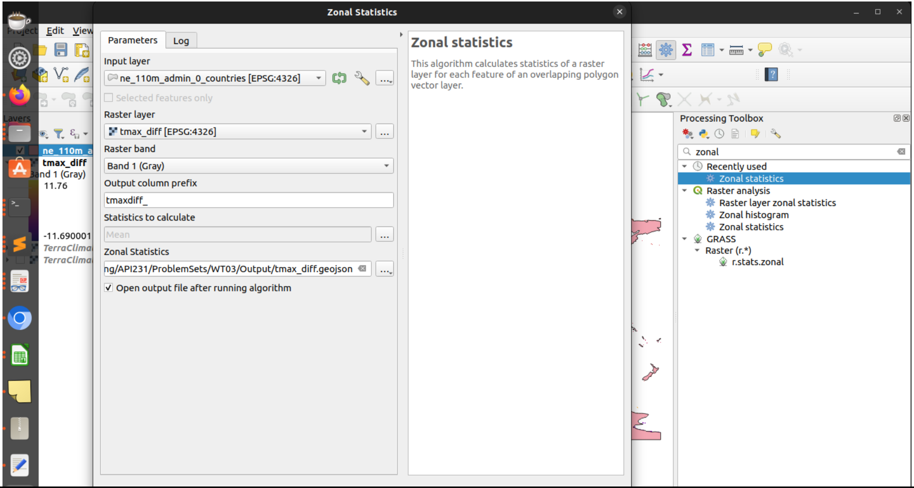
Most temperature changes were positive, with a mode around + 2 degrees Celsius



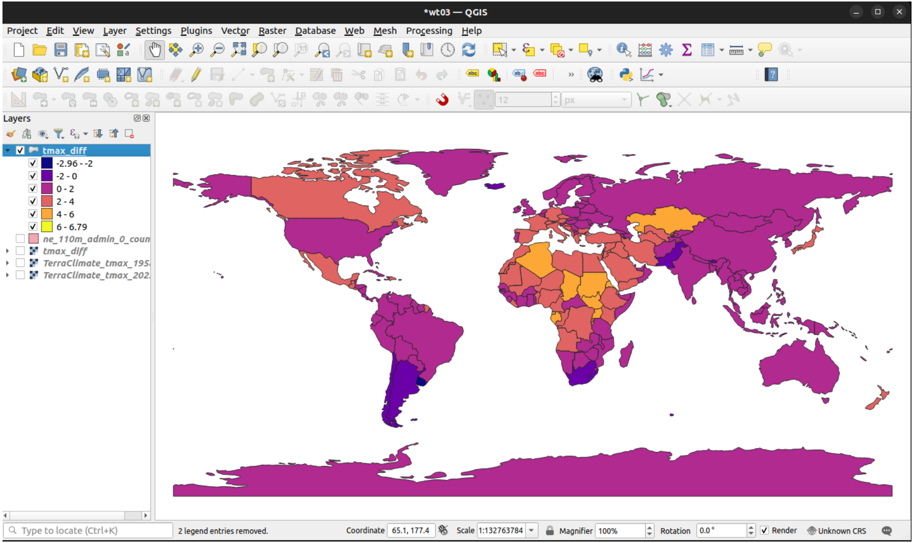
Let's calculate average changes by country. Load the `ne_110m_admin_0_countries.shp` file



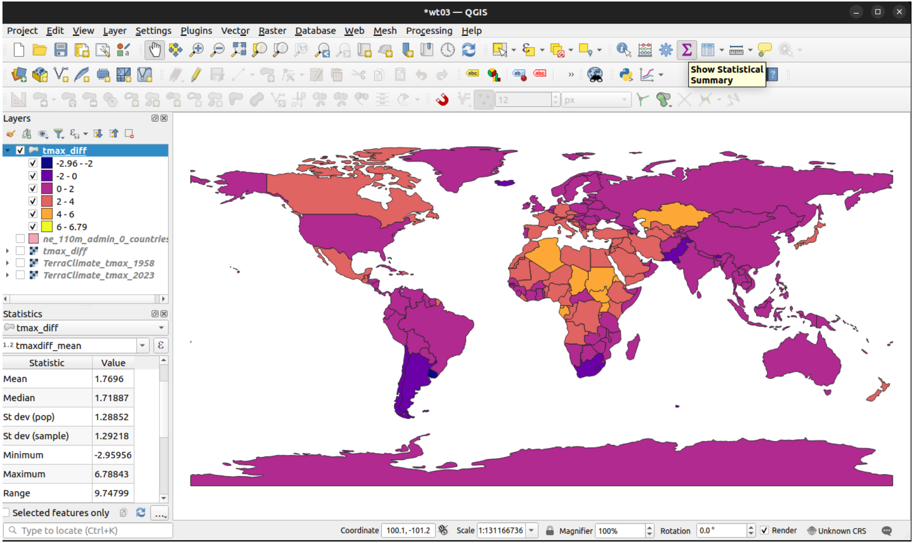
Once the borders are loaded, open `Zonal Statistics` from the `Processing Toolbox`. Set `Input layer` = `ne_110m_admin_0_countries`, `Raster layer` = `tmax_diff`, prefix = `tmax_diff_`, `Statistics to calculate` = `Mean`. Save the output as `tmax_diff.geojson`



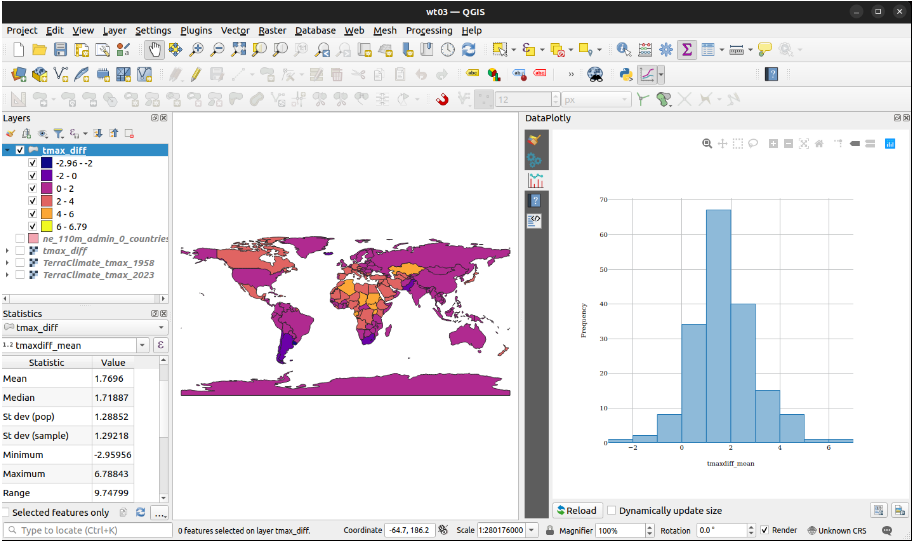
North Africa and Central Asia appear to have had the most acute increases in July temperatures



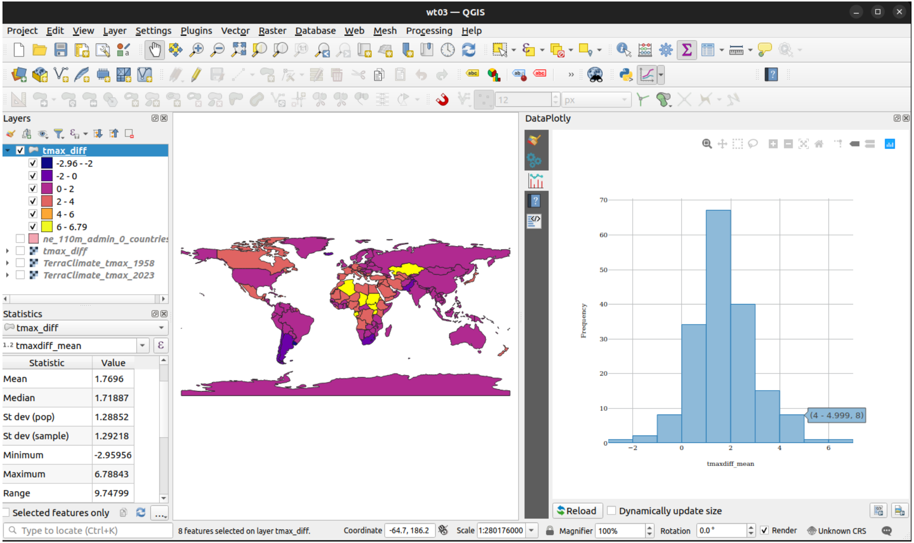
Clicking on the Σ button ("Show Statistical Summary"), we can look up some descriptive stats. The average country saw an increase of 1.77 degrees Celsius



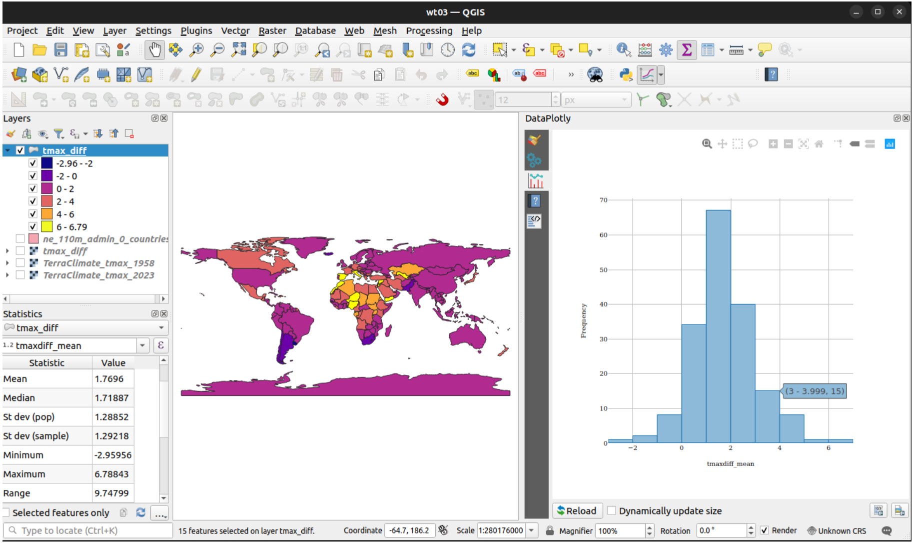
Let's create an interactive histogram with Plotly. Set `Plot type` = `Histogram`, `Layer` = `tmax_diff`, `Grouping field` = `tmaxdiff_mean`. Click `Create Plot`



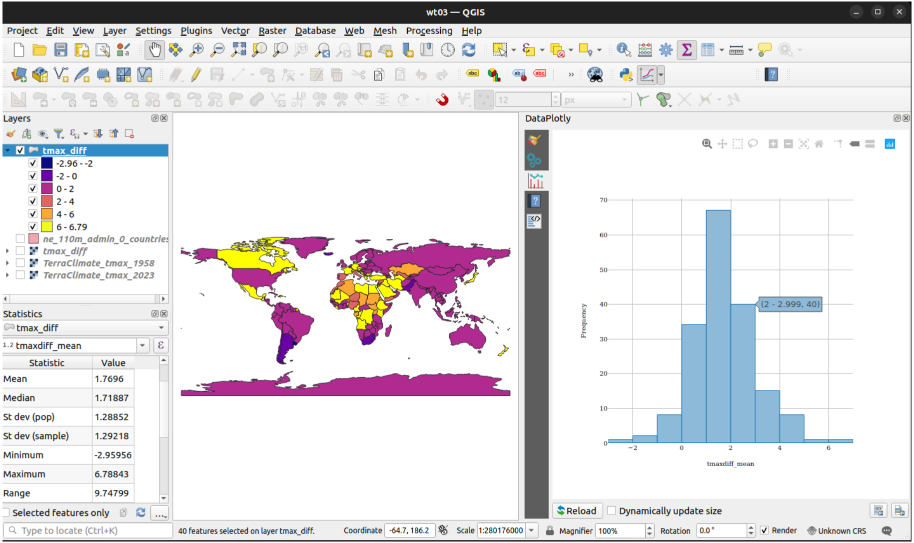
Clicking on the individual bars of the histogram will highlight the countries that fall into that bin, such as here for increases between 4 and 5 degrees



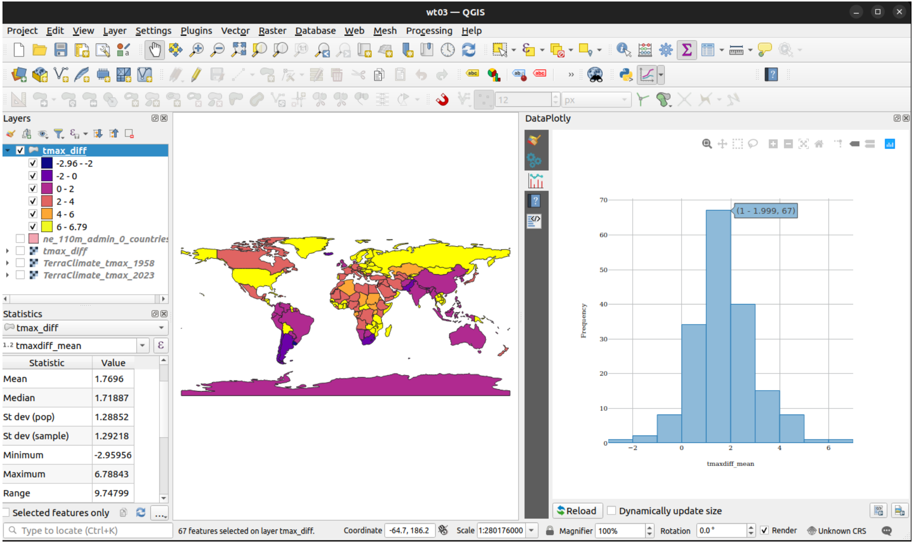
. . . increases of 3-4 degrees



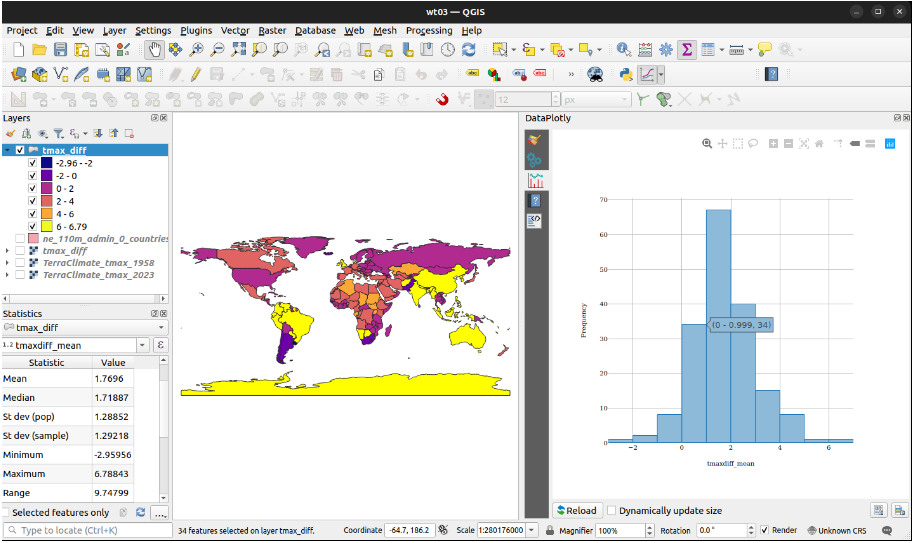
. . . increases of 2-3 degrees



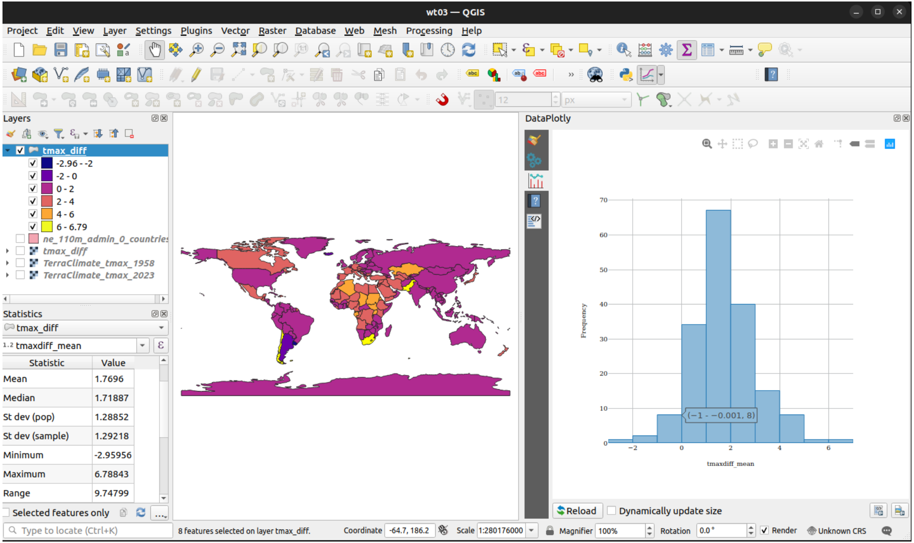
. . . increases of 1-2 degrees (the most numerous category)



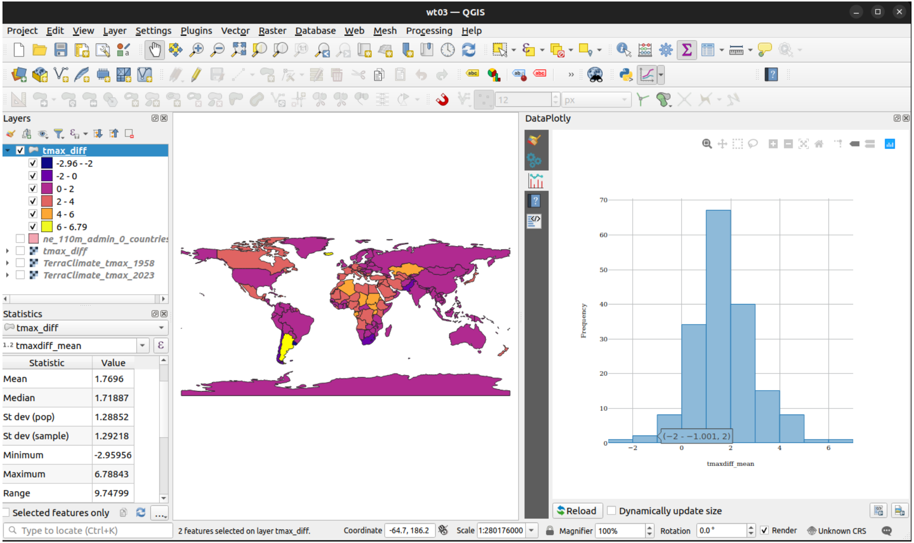
...increases between 0 and 1 degree



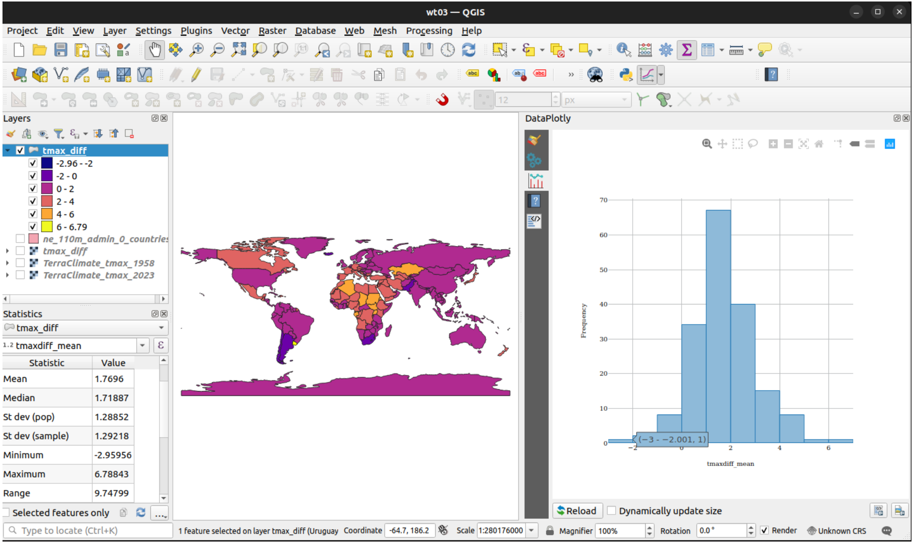
. . . decreases of 0 to 1 degree



. . . decreases of 1 to 2 degrees

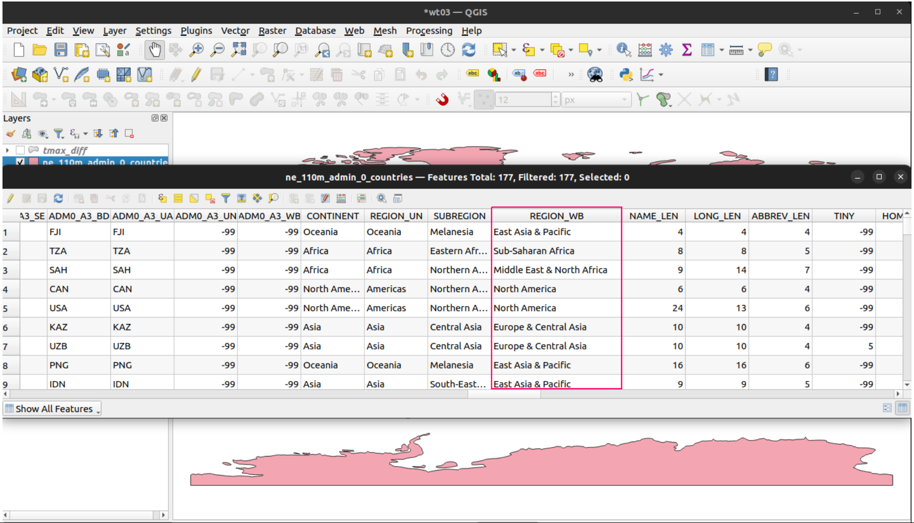


. . . and decreases of 2 to 3 degrees (just Uruguay here)



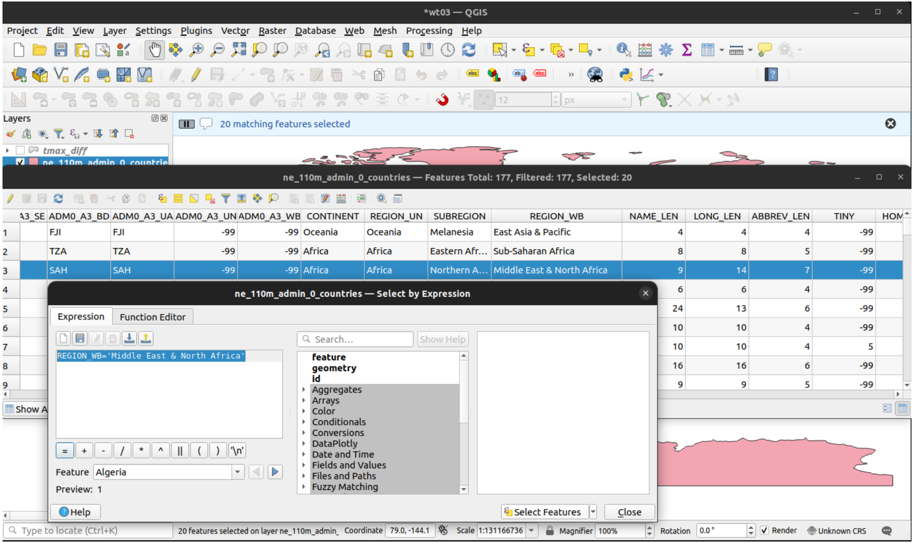
Drought severity and violence during the 2011 Arab spring

Vignette 2! Let's create a regional subset of countries. The `ne_110m...` file has a variable called `REGION_WB`, where one of the categories is "Middle East & North Africa"

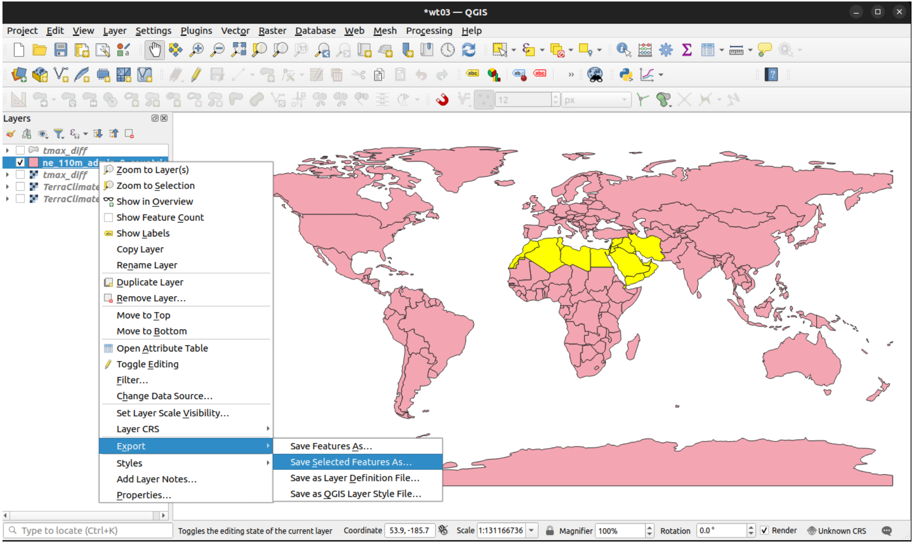


	A3_SE	ADM0_A3_BD	ADM0_A3_UA	ADM0_A3_UN	ADM0_A3_WB	CONTINENT	REGION_UN	SUBREGION	REGION_WB	NAME_LEN	LONG_LEN	ABBREV_LEN	TINY	HOM
1		FJI	FJI	-99	-99	Oceania	Oceania	Melanesia	East Asia & Pacific	4	4	4	-99	
2		TZA	TZA	-99	-99	Africa	Africa	Eastern Afr...	Sub-Saharan Africa	8	8	5	-99	
3		SAH	SAH	-99	-99	Africa	Africa	Northern A...	Middle East & North Africa	9	14	7	-99	
4		CAN	CAN	-99	-99	North Ame...	Americas	Northern A...	North America	6	6	4	-99	
5		USA	USA	-99	-99	North Ame...	Americas	Northern A...	North America	24	13	6	-99	
6		KAZ	KAZ	-99	-99	Asia	Asia	Central Asia	Europe & Central Asia	10	10	4	-99	
7		UZB	UZB	-99	-99	Asia	Asia	Central Asia	Europe & Central Asia	10	10	4	5	
8		PNG	PNG	-99	-99	Oceania	Oceania	Melanesia	East Asia & Pacific	16	16	6	-99	
9		IDN	IDN	-99	-99	Asia	Asia	South-East...	East Asia & Pacific	9	9	5	-99	

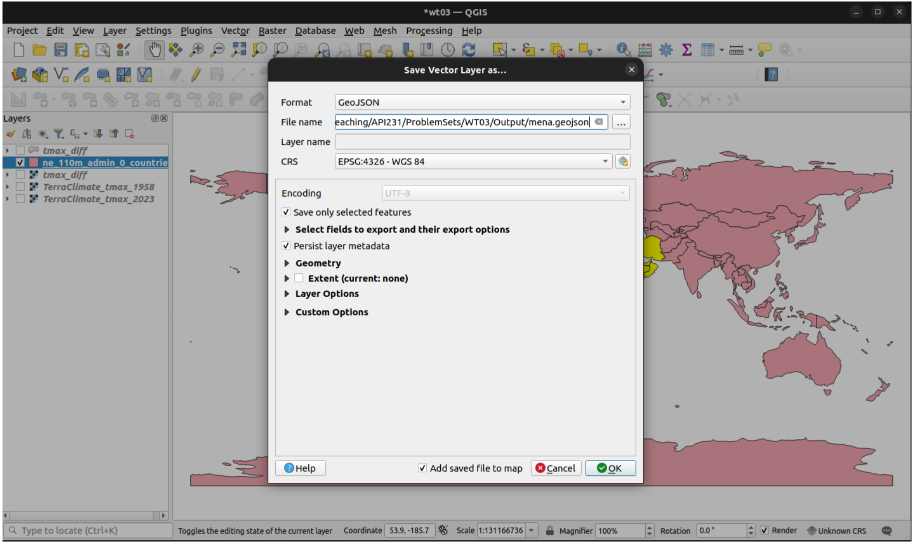
Go to `Select by Expression`, set `Expression` to `REGION_WB='Middle East & North Africa'`, and click `Select Features`



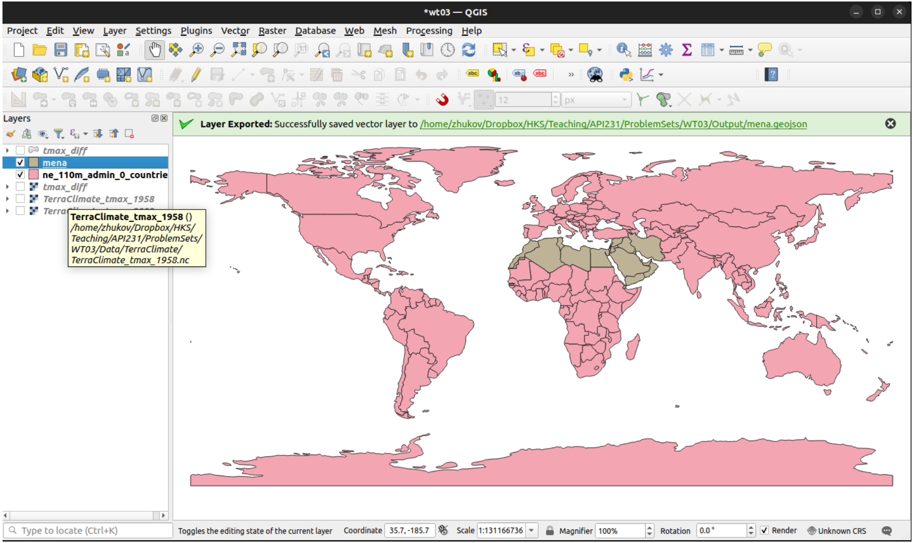
Export the selected features to a new file



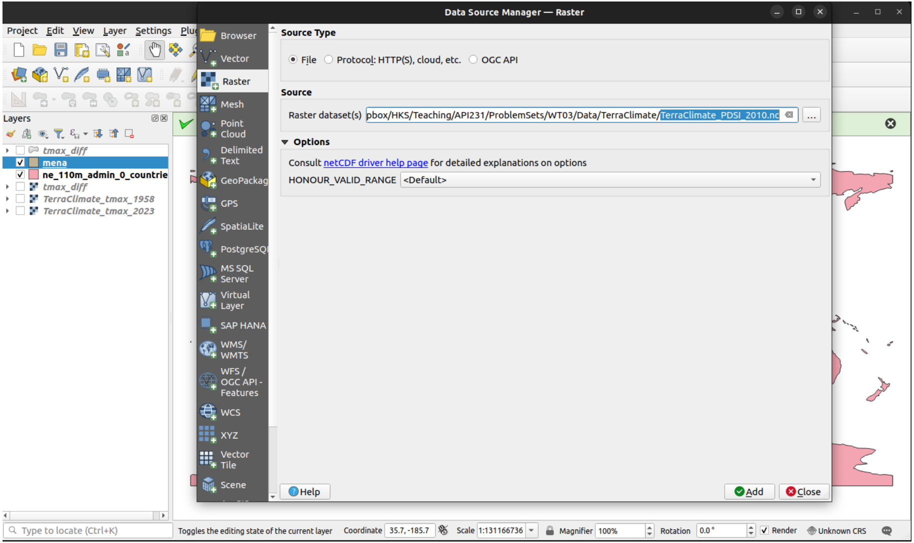
Save the layer as `mena.geojson`. Make sure the box is checked next to ✓"Save only selected features"



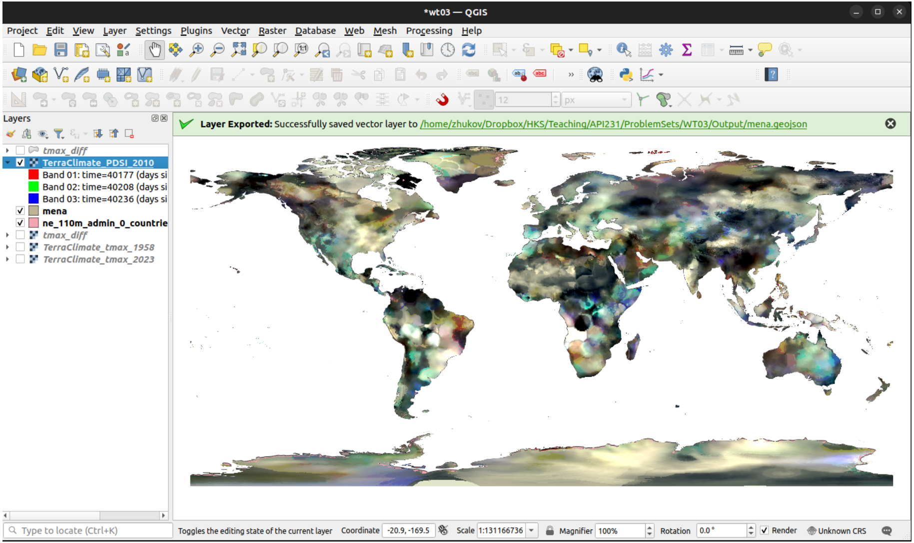
A new layer with 20 countries should appear in your project window



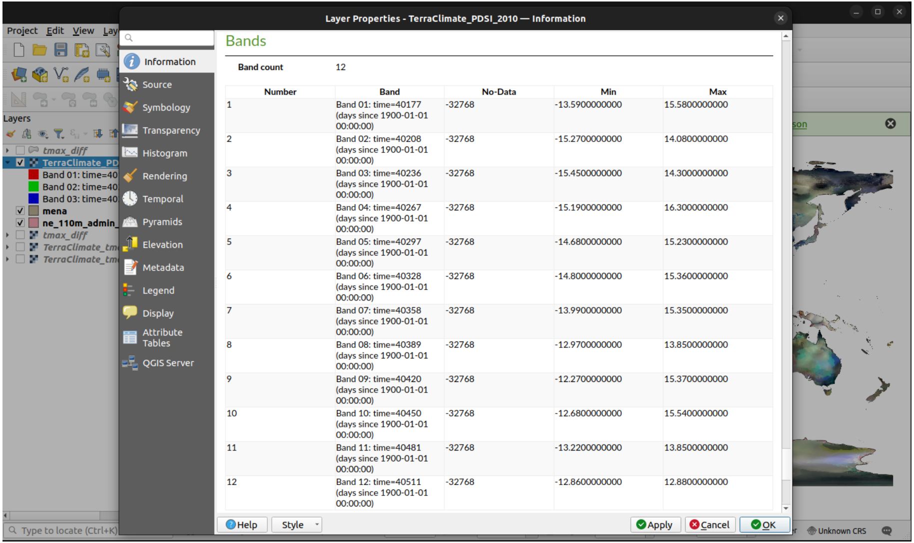
Load the drought index raster `TerraClimate_PDSI_2010.nc`



Another multiband raster. Open up the layer `Properties` to see the bands



As before, there are 12 bands here, one for each month



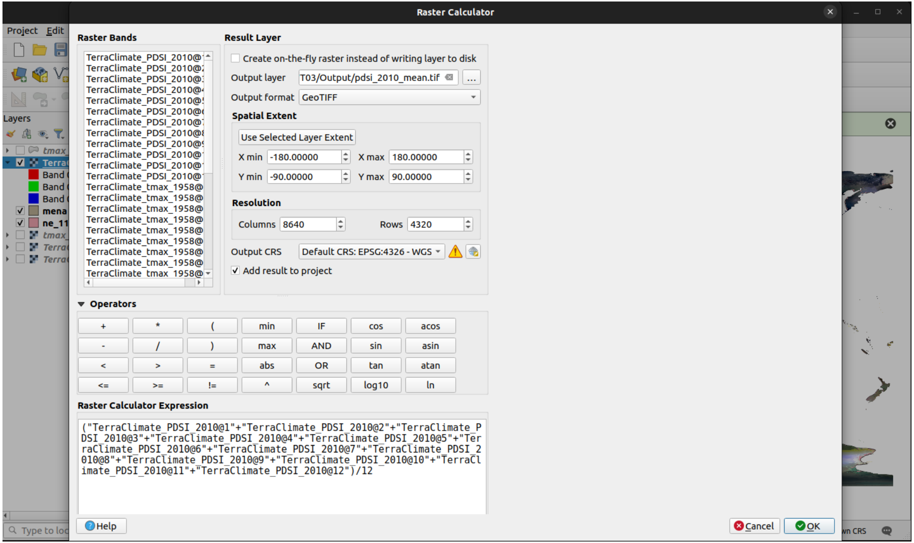
Number	Band	No-Data	Min	Max
1	Band 01: time=40177 (days since 1900-01-01 00:00:00)	-32768	-13.5900000000	15.5800000000
2	Band 02: time=40208 (days since 1900-01-01 00:00:00)	-32768	-15.2700000000	14.0800000000
3	Band 03: time=40236 (days since 1900-01-01 00:00:00)	-32768	-15.4500000000	14.3000000000
4	Band 04: time=40267 (days since 1900-01-01 00:00:00)	-32768	-15.1900000000	16.3000000000
5	Band 05: time=40297 (days since 1900-01-01 00:00:00)	-32768	-14.6800000000	15.2300000000
6	Band 06: time=40328 (days since 1900-01-01 00:00:00)	-32768	-14.8000000000	15.3600000000
7	Band 07: time=40358 (days since 1900-01-01 00:00:00)	-32768	-13.9900000000	15.3500000000
8	Band 08: time=40389 (days since 1900-01-01 00:00:00)	-32768	-12.9700000000	13.8500000000
9	Band 09: time=40420 (days since 1900-01-01 00:00:00)	-32768	-12.2700000000	15.3700000000
10	Band 10: time=40450 (days since 1900-01-01 00:00:00)	-32768	-12.6800000000	15.5400000000
11	Band 11: time=40481 (days since 1900-01-01 00:00:00)	-32768	-13.2200000000	13.8500000000
12	Band 12: time=40511 (days since 1900-01-01 00:00:00)	-32768	-12.8600000000	12.8800000000

Let's calculate the average annual drought index, over all months.

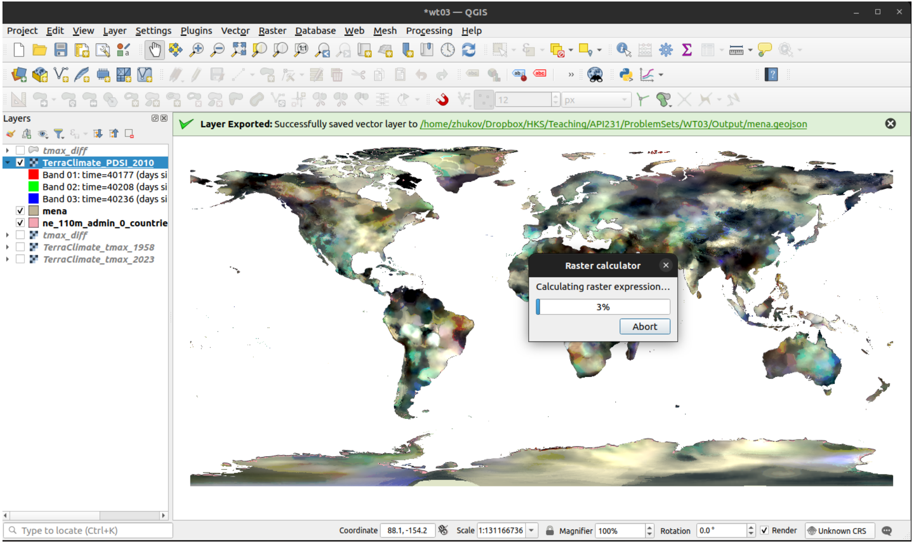
Open the `Raster Calculator` and set `Expression` to

```
("TerraClimate_PDSI_2010@1"+"TerraClimate_PDSI_2010@2"+
"TerraClimate_PDSI_2010@3"+"TerraClimate_PDSI_2010@4"+
"TerraClimate_PDSI_2010@5"+"TerraClimate_PDSI_2010@6"+
"TerraClimate_PDSI_2010@7"+"TerraClimate_PDSI_2010@8"+
"TerraClimate_PDSI_2010@9"+"TerraClimate_PDSI_2010@10"+
"TerraClimate_PDSI_2010@11"+"TerraClimate_PDSI_2010@12")/12
```

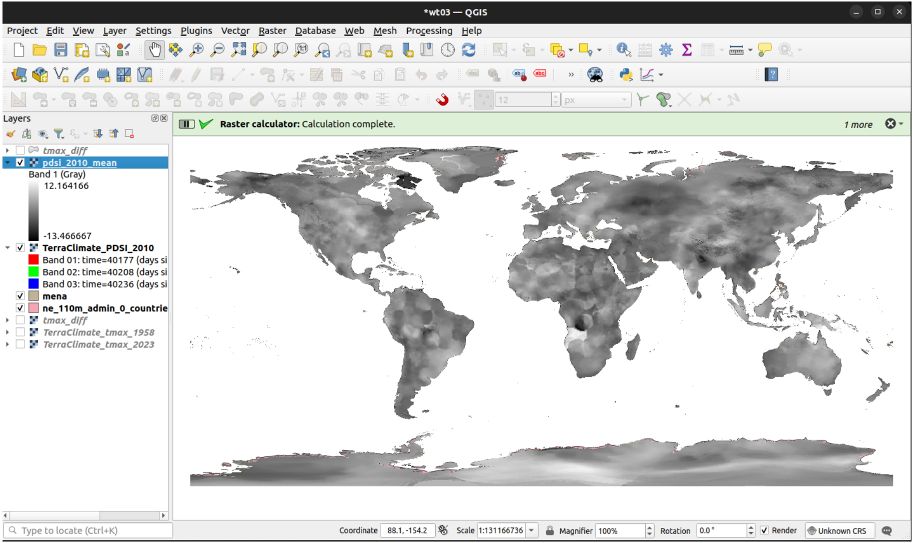
(you may want to copy and paste this one). Save the raster as `pdsi_2010_mean.tif`


Raster Calculator
Raster Bands
Result Layer
Create on-the-fly raster instead of writing layer to disk
Output layer
T03/Output/pdsi_2010_mean.tif
Output format
GeoTIFF
Spatial Extent
Use Selected Layer Extent
X min -180.00000
X max 180.00000
Y min -90.00000
Y max 90.00000
Resolution
Columns 8640
Rows 4320
Output CRS
Default CRS: EPSG:4326 - WGS
Add result to project
Operators
Raster Calculator Expression
("TerraClimate_PDSI_2010@1"+"TerraClimate_PDSI_2010@2"+"TerraClimate_PDSI_2010@3"+"TerraClimate_PDSI_2010@4"+"TerraClimate_PDSI_2010@5"+"TerraClimate_PDSI_2010@6"+"TerraClimate_PDSI_2010@7"+"TerraClimate_PDSI_2010@8"+"TerraClimate_PDSI_2010@9"+"TerraClimate_PDSI_2010@10"+"TerraClimate_PDSI_2010@11"+"TerraClimate_PDSI_2010@12")/12
Help
Cancel
OK

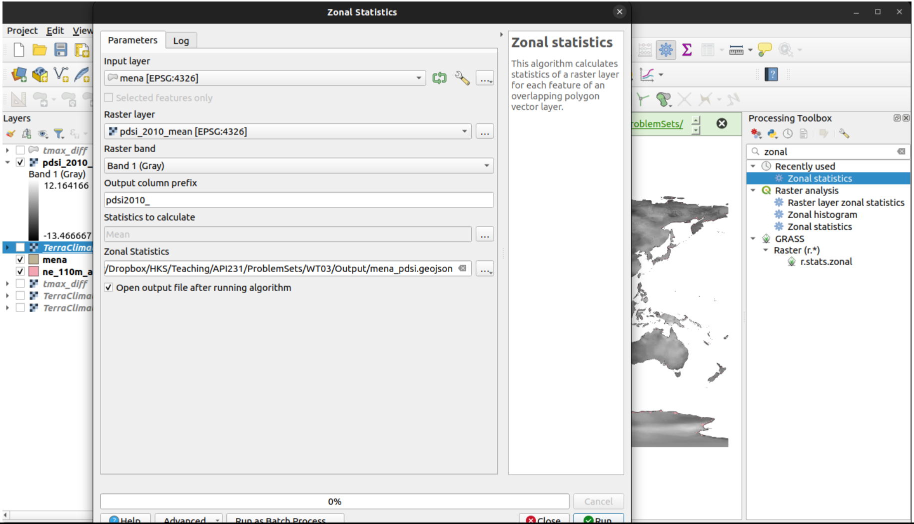
This will take a few minutes to process



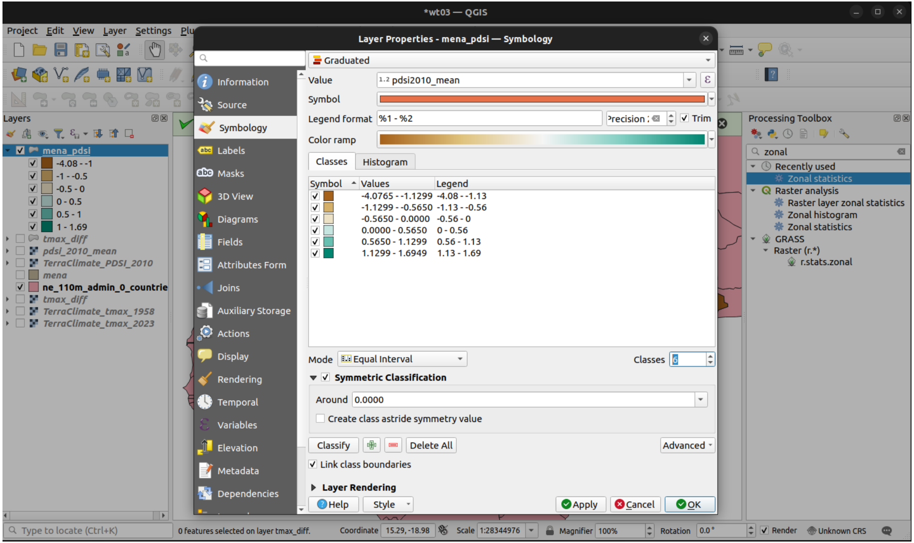
The output will look something like this: a single-band raster of averages



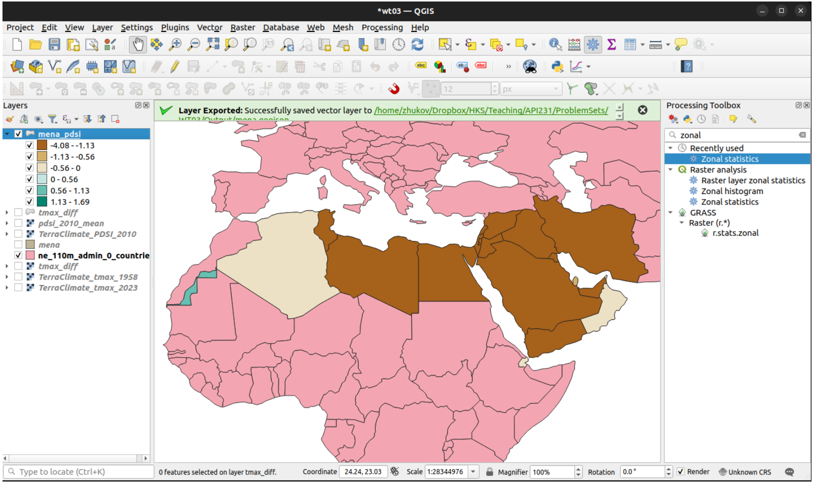
Calculate country averages. Open `Zonal Statistics`, set `Input layer` = `mena`, `Raster layer` = `pdsi_2010_mean`, prefix = `pdsi2010_`, `Statistics to calculate` = `Mean`. Save the output as `mena_pdsi.geojson`



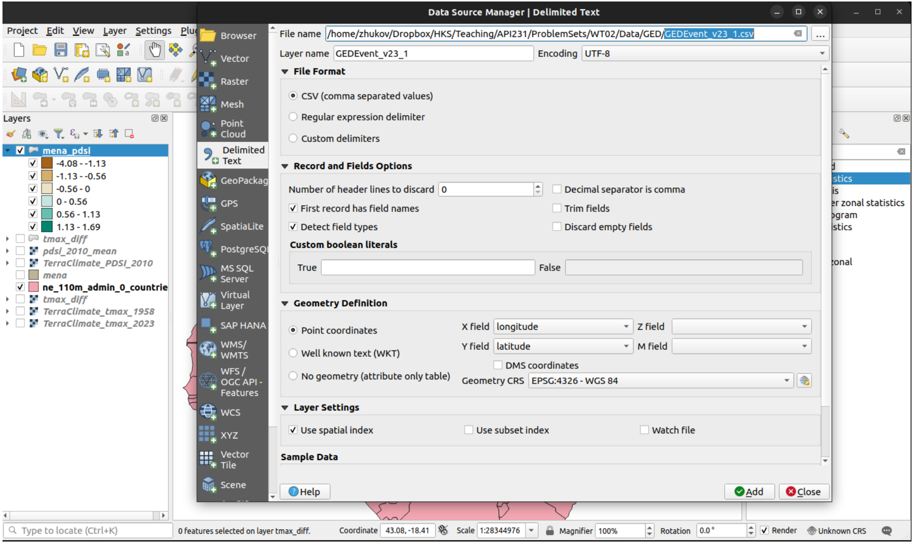
Try visualizing the country-level results. Lower index scores = worse drought



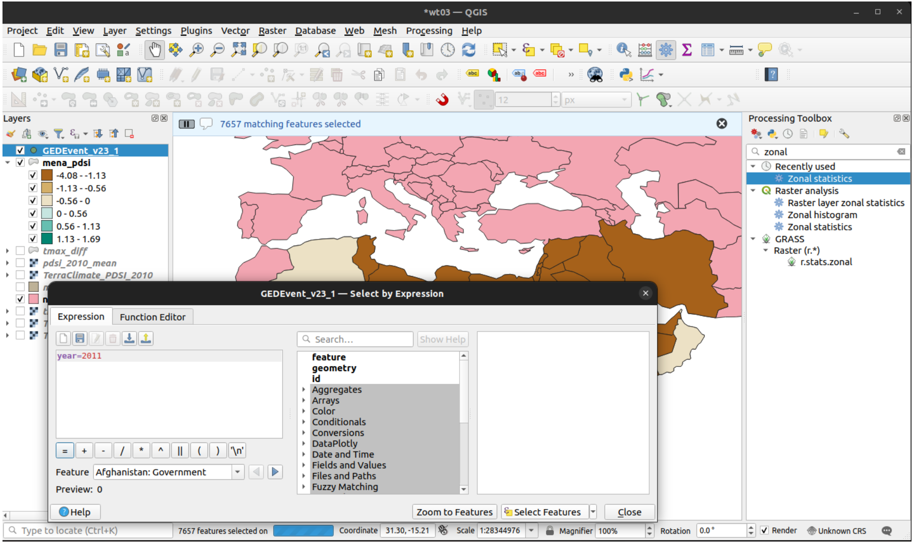
The drought index is negative virtually everywhere except Western Sahara



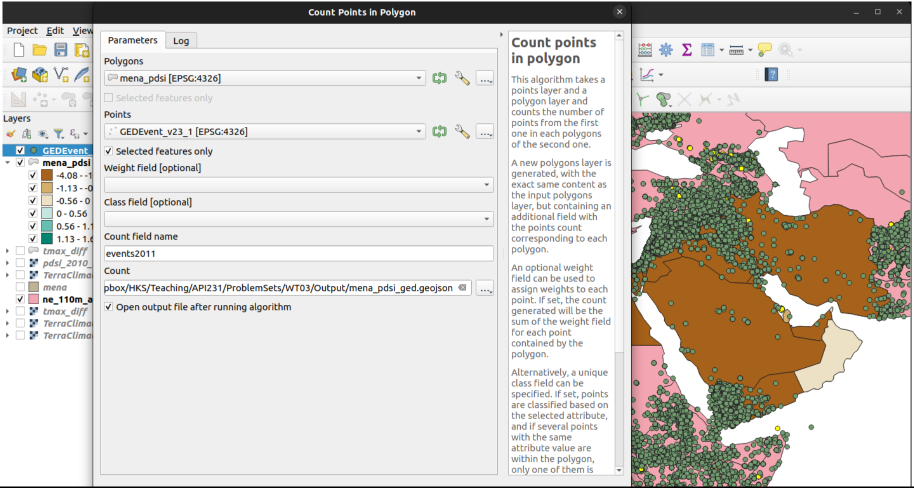
Finally, let's link this up with data on violent events. Load `GEDEvent_v23_1.csv`, with spatial index



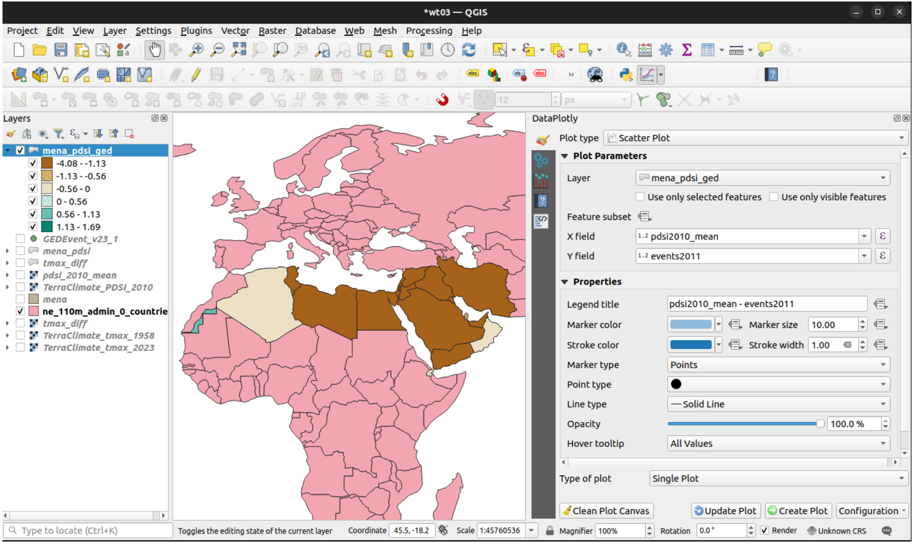
Select by `Expression`: `year=2011`. Click `Select Features`



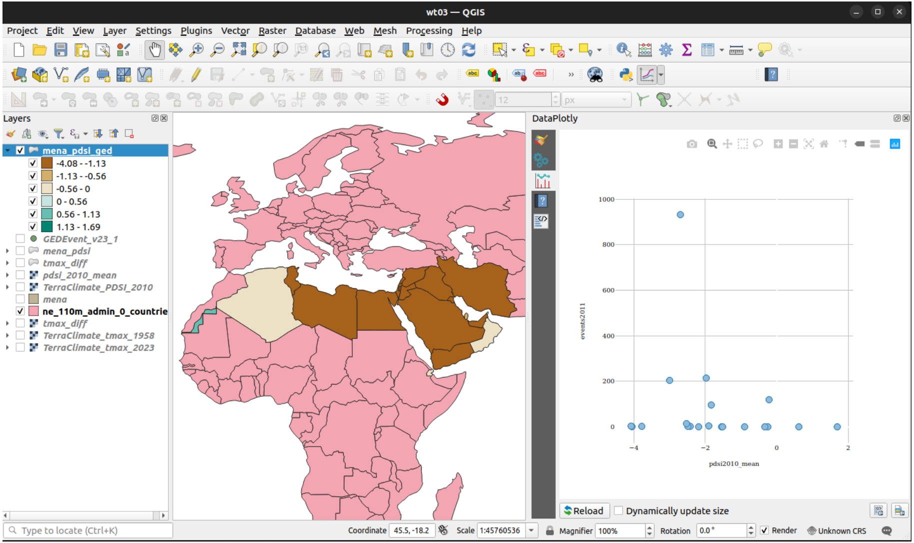
Open the `Count Points in Polygon` tool. Select `Polygons = mena_pdsi`, `Points = GEDEvent_v23_1`. Make sure the box is checked next to `Selected Features Only` for the points. Name the count field `events2011`, and save the output file as `mena_pdsi_ged.geojson`. Click `Run`



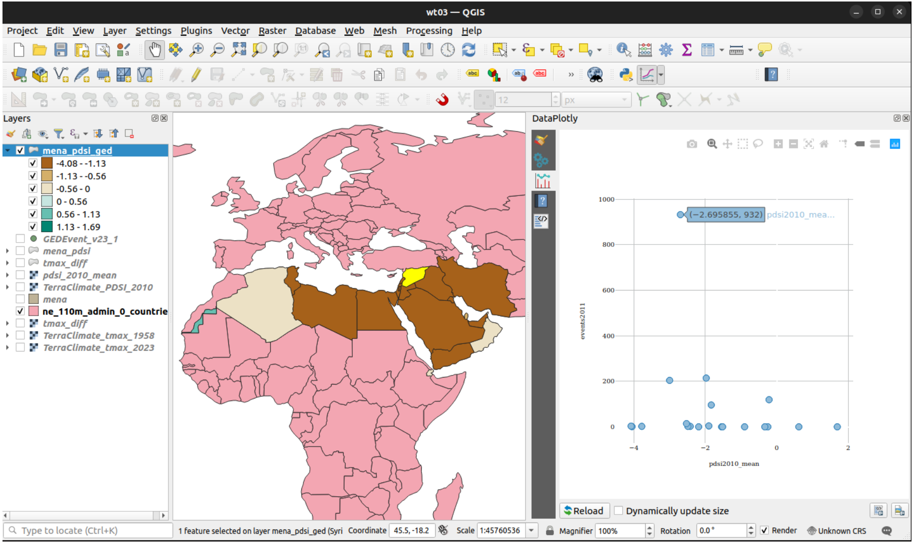
Open the Plotly tool. Set `Plot type` = `Scatter Plot`, `Layer` = `mena_pdsi_ged`, `X field` = `pdsi2010_mean`, `Y field` = `events2011`. Click `Create Plot`



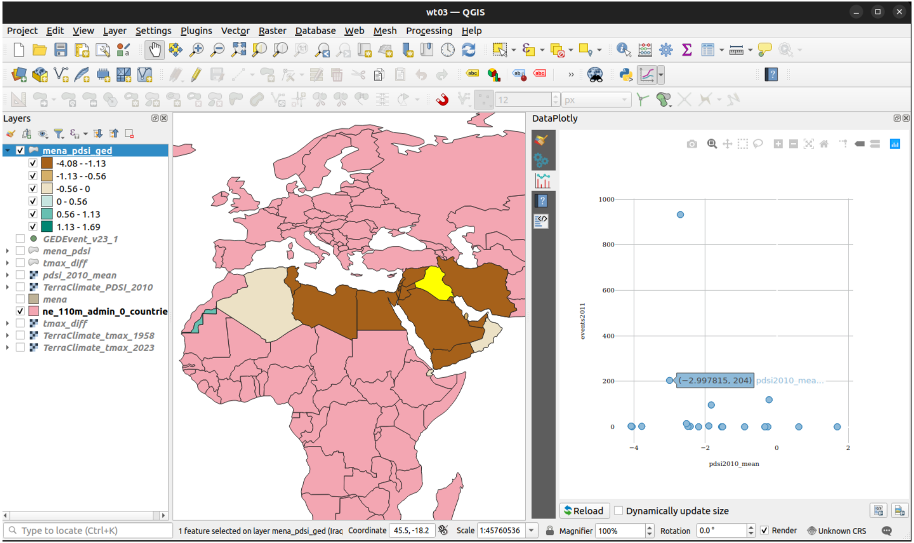
From the scatterplot, we can see that the highest levels of violence happened in countries with negative PDSI scores (more drought)



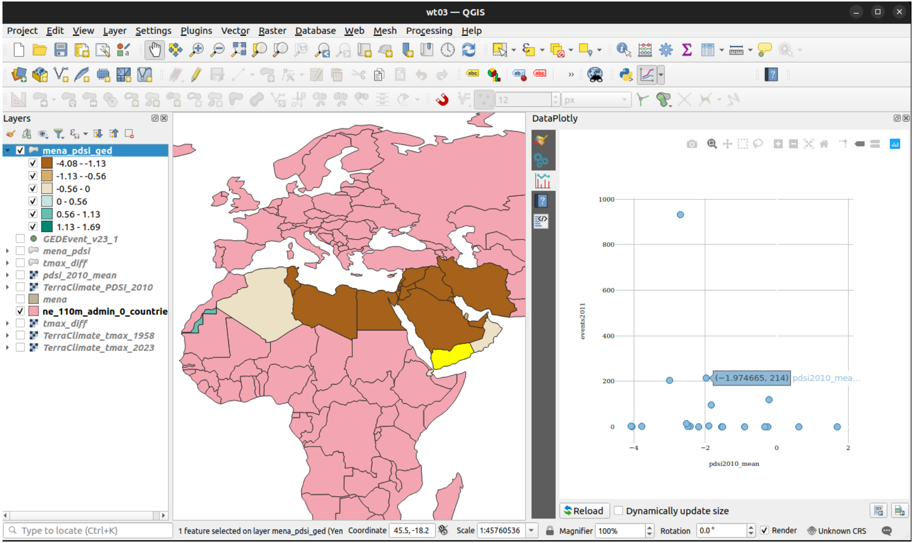
If we click on some of the points in the upper-left corner, we can see countries like Syria, which experienced severe drought in 2010 and high violence in 2011



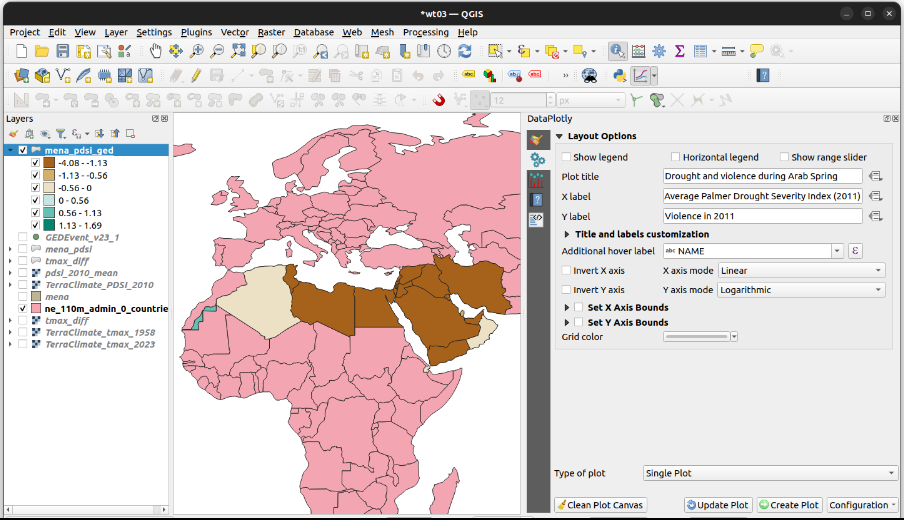
. . . or Iraq


wt03 — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
mena_pdsi_ged
-4.08 - -1.13
-1.13 - -0.56
-0.56 - 0
0 - 0.56
0.56 - 1.13
1.13 - 1.69
GEDEvent_v23_1
mena_pdsi
tmax_diff
pdsi_2010_mean
TerraClimate_PDSI_2010
mena
ne_110m_admin_0_countrie
tmax_diff
TerraClimate_tmax_1958
TerraClimate_tmax_2023
DataPlotly
1000
800
600
400
200
0
events2011
(−2.997815, 204)
pdsi2010_mea...
−4
−2
0
2
pdsi2010_mean
Reload
Dynamically update size
Type to locate (Ctrl+K)
1 feature selected on layer mena_pdsi_ged (Iraq
Coordinate 45.5, -18.2
Scale 1:45760536
Magnifier 100%
Rotation 0.0 °
Render
Unknown CRS

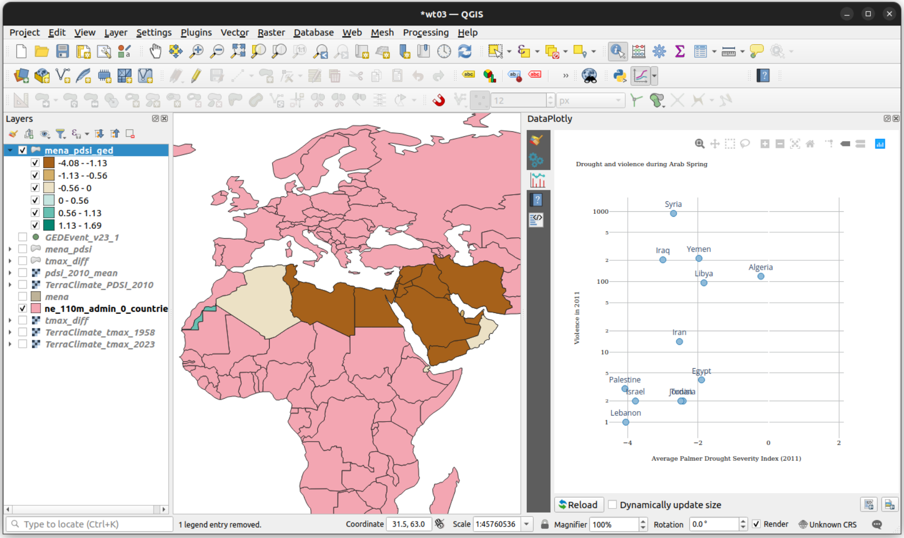
. . . or Yemen


wt03 — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
mena_pdsi_ged
-4.08 - -1.13
-1.13 - -0.56
-0.56 - 0
0 - 0.56
0.56 - 1.13
1.13 - 1.69
GEDEvent_v23_1
mena_pdsi
tmax_diff
pdsi_2010_mean
TerraClimate_PDSI_2010
mena
ne_110m_admin_0_countrie
tmax_diff
TerraClimate_tmax_1958
TerraClimate_tmax_2023
DataPlotly
1000
800
600
400
200
0
events2011
(−1.974665, 214)
pdsi2010_mea...
−4
−2
0
2
pdsi2010_mean
Reload
Dynamically update size
Type to locate (Ctrl+K)
1 feature selected on layer mena_pdsi_ged (Yen
Coordinate 45.5, -18.2
Scale 1:45760536
Magnifier 100%
Rotation 0.0 °
Render
Unknown CRS

We can adjust some of the graphical parameters to make the scatterplot more readable, like adding country labels and putting the violence variable on a logarithmic scale



Looks better now



You can also perform all these steps in R (see replication code `wt03_demo.R` in `WT03.zip`)

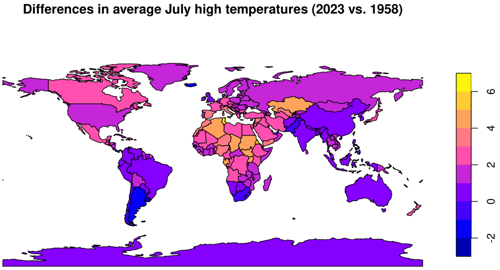


Figure 28: Vignette 1

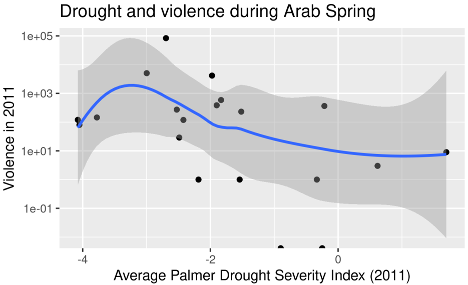
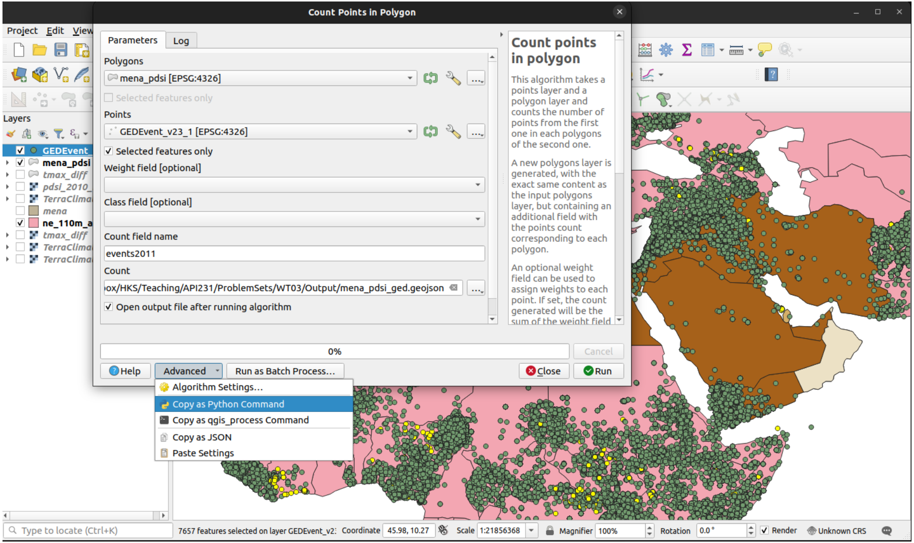


Figure 29: Vignette 2

Hot Tip: Scripting in Python QGIS

Tired on pointing and clicking? In almost every geoprocessing command, there is a menu called `Advanced`, with an option to `Copy as Python Command`



Paste it into a text file to see the code. The directory structure (`/home/username/*`) will depend on where you saved the `WT03` files

wt03.py
~/Dropbox/HKS/Teaching/API231/ProblemSets/WT03/Code

```
# Count points in polygon
processing.run("native:countpointsinpolygon", {'POLYGONS':'/home/username/Documents/WT03/Output/
mena_pdsi.geojson','POINTS':QgsProcessingFeatureSourceDefinition('file:///home/username/Documents/WT03/Data/GED/
GEDEvent_v23_1.csv?type=csv&maxFields=10000&detectTypes=yes&xField=longitude&yField=latitude&crs=EPSG:
4326&spatialIndex=yes&subsetIndex=no&watchFile=no', selectedFeaturesOnly=True, featureLimit=-1,
geometryCheck=QgsFeatureRequest.GeometryAbortOnInvalid),'WEIGHT':'','CLASSFIELD':'','FIELD':'events2011','OUTPUT'
home/username/Documents/WT03/Output/mena_pdsi_ged.geojson'})
```

Python 2 | Tab Width: 8 | Ln 3, Col 1 | INS

You can use these code snippets to assemble a Python script with all the commands we used today (see `Code/wt03_demo.py` script in the `WT04.zip` file)

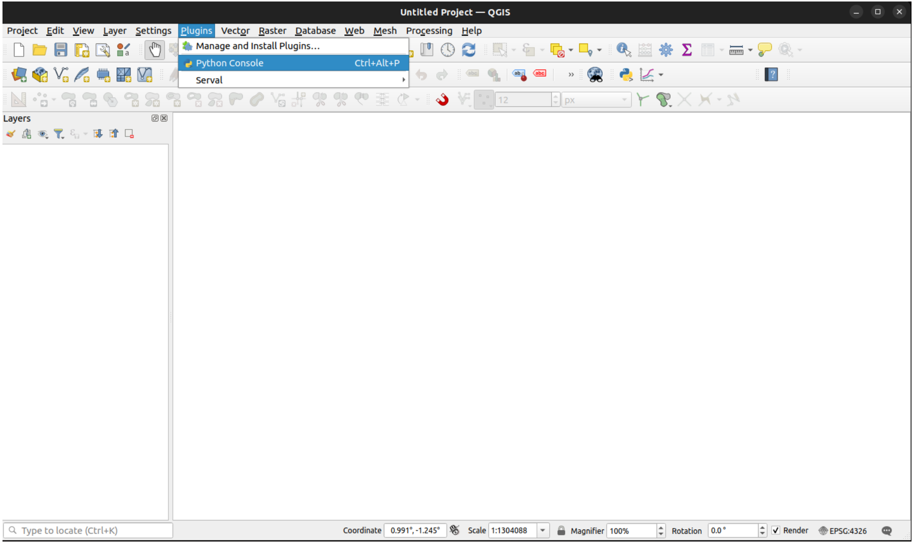
Open | *wt03_demo.py | ~/Dropbox/HKS/Teaching/API231/ProblemSets/WT03/Code | Save

wt03_pyqgis.py | *wt03_demo.py

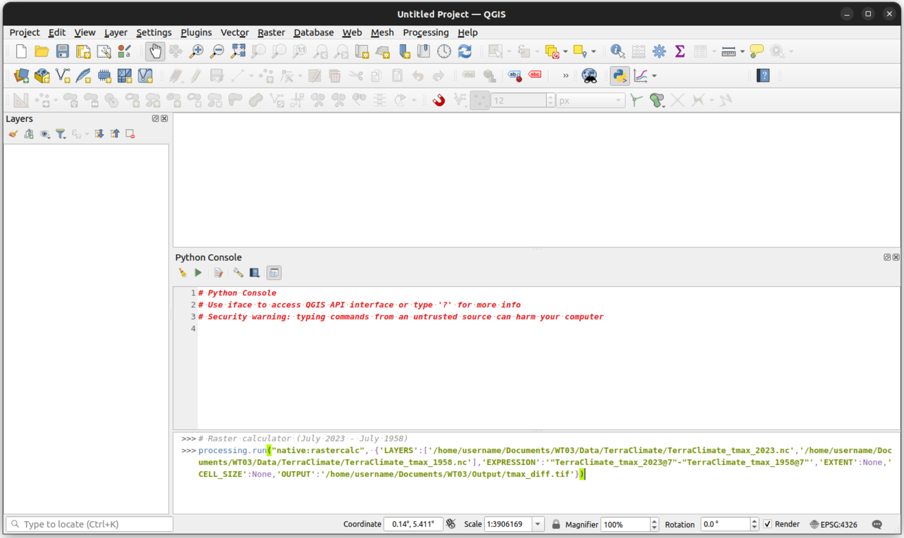
```
##########################
# Vignette 1: Temperature change
##########################
# Raster calculator (July 2023 - July 1958)
processing.run("native:rastercalc", {'LAYERS':['/home/username/Documents/WT03/Data/TerraClimate/
TerraClimate_tmax_2023.nc','/home/username/Documents/WT03/Data/TerraClimate/
TerraClimate_tmax_1958.nc'],'EXPRESSION':'"TerraClimate_tmax_2023@7"-"TerraClimate_tmax_1958@7"','EXTEN
home/username/Documents/WT03/Output/tmax_diff.tif'})
# Zonal statistics (average temperature difference by country)
processing.run("native:zonalstatisticsfb", {'INPUT':'/home/username/Documents/WT03/Data/NE/
ne_110m_admin_0_countries.shp','INPUT_RASTER':'/home/username/Documents/WT03/Output/
tmax_diff.tif','RASTER_BAND':1,'COLUMN_PREFIX':'tmax_diff_','STATISTICS':2,'OUTPUT':'/home/username/
Documents/WT03/Output/tmax_diff.geojson'})

##########################
# Vignette 2: Drought index and Arab Spring
##########################
# Raster calculator (average drought index across monthly bands in 2010)
processing.run("native:rastercalc", {'LAYERS':['/home/username/Documents/WT03/Data/TerraClimate/
TerraClimate_PDSI_2010.nc'],'EXPRESSION':'("TerraClimate_PDSI_2010@1"+"TerraClimate_PDSI_2010@2"+"Terra
12','EXTENT':None,'CELL_SIZE':None,'CRS':QgsCoordinateReferenceSystem('EPSG:4326'),'OUTPUT':'/home/
username/Documents/WT03/Output/pdsi_2010.tif'})
# Subset MENA countries
processing.run("native:extractbyexpression", {'INPUT':'/home/username/Documents/WT03/Data/NE/
ne_110m_admin_0_countries.shp','EXPRESSION':"REGION_WB='Middle East & North Africa'",'OUTPUT':'/home/
username/Documents/WT03/Output/mena.geojson','FAIL_OUTPUT':''})
# Zonal statistics (average drought index by country)
processing.run("native:zonalstatisticsfb", {'INPUT':'/home/username/Documents/WT03/Output/
mena.geojson','INPUT_RASTER':'/home/username/Documents/WT03/Output/pdsi_2010.tif','RASTER_BAND':
1,'COLUMN_PREFIX':'pdsi_','STATISTICS':[2],'OUTPUT':'/home/username/Documents/WT03/Output/
mena_pdsi.geojson'})
# Subset 2011 GED events
processing.run("native:extractbyexpression", {'INPUT':'delimitedtext://file:///home/username/
Documents/WT02/Data/GED/GEDEvent_v23_1.csv?
type=csv&maxFields=10000&detectTypes=yes&xField=longitude&yField=latitude&crs=EPSG:
4326&spatialIndex=yes&subsetIndex=no&watchFile=no','EXPRESSION':'year=2011','OUTPUT':'/home/username/
Documents/WT03/Output/events_2011.geojson','FAIL_OUTPUT':''})
# Count points in polygon
processing.run("native:countpointsinpolygon", {'POLYGONS':'/home/username/Documents/WT03/Output/
mena_pdsi.geojson','POINTS':'/home/username/Documents/WT03/Output/
events_2011.geojson','WEIGHT':'','CLASSFIELD':'','FIELD':'events2011','OUTPUT':'/home/username/
Documents/WT03/Output/mena_pdsi_ged.geojson'})
```

Bracket match found on line: 5 | Python | Tab Width: 8 | Ln 5, Col 364 | INS

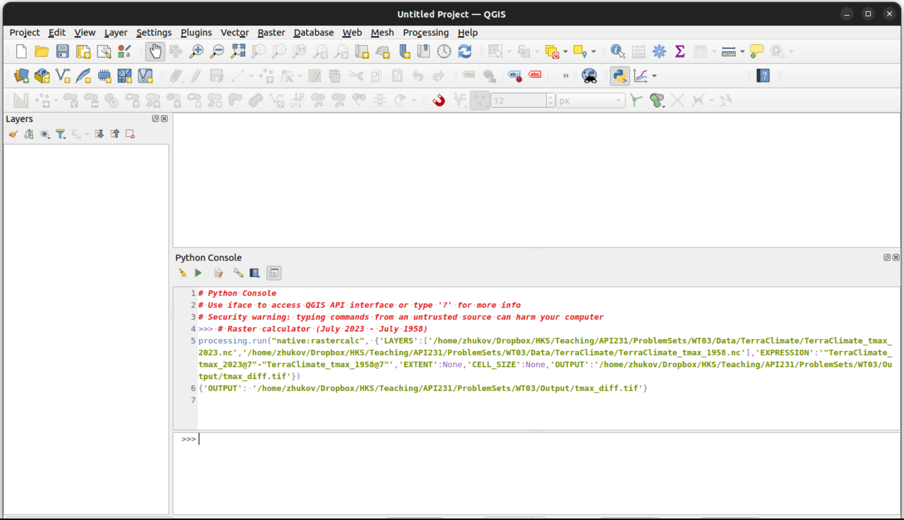
In QGIS, you can run this script through a Python console. Go to `Plugins` menu → `Python Console`



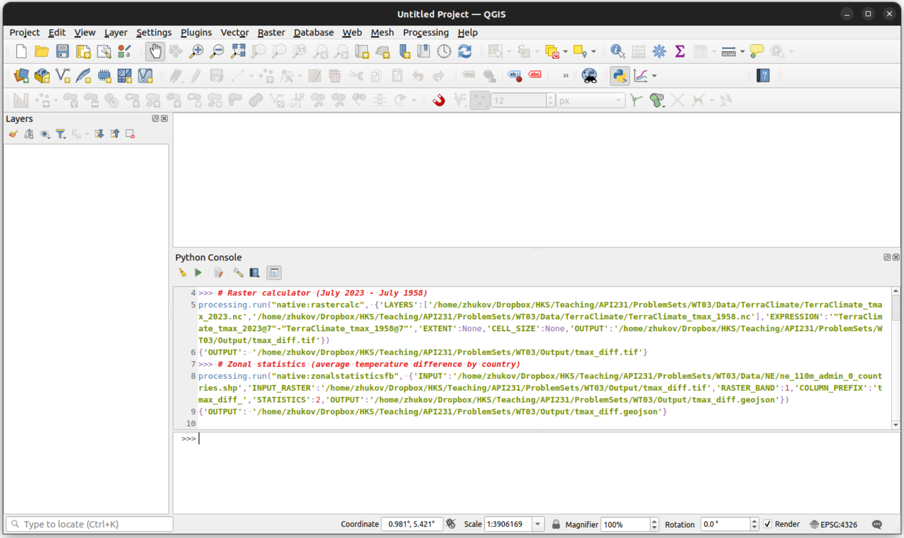
Copy a command into the console and click "Enter" (here we are re-calculating the temperature difference raster from Vignette 1)



When QGIS finishes processing, the console will print a line that starts with `'OUTPUT':...`, telling you where the output file has been saved (note that this will not load the output automatically)



We can repeat this with the next line in the code (Zonal Statistics for temperature changes by country)



When we open up the Python-generated file, and re-create the histogram, we see that the results are identical to the one we created earlier. Scripting can be very handy if you are doing batch processing with repetitive, easily-automated tasks