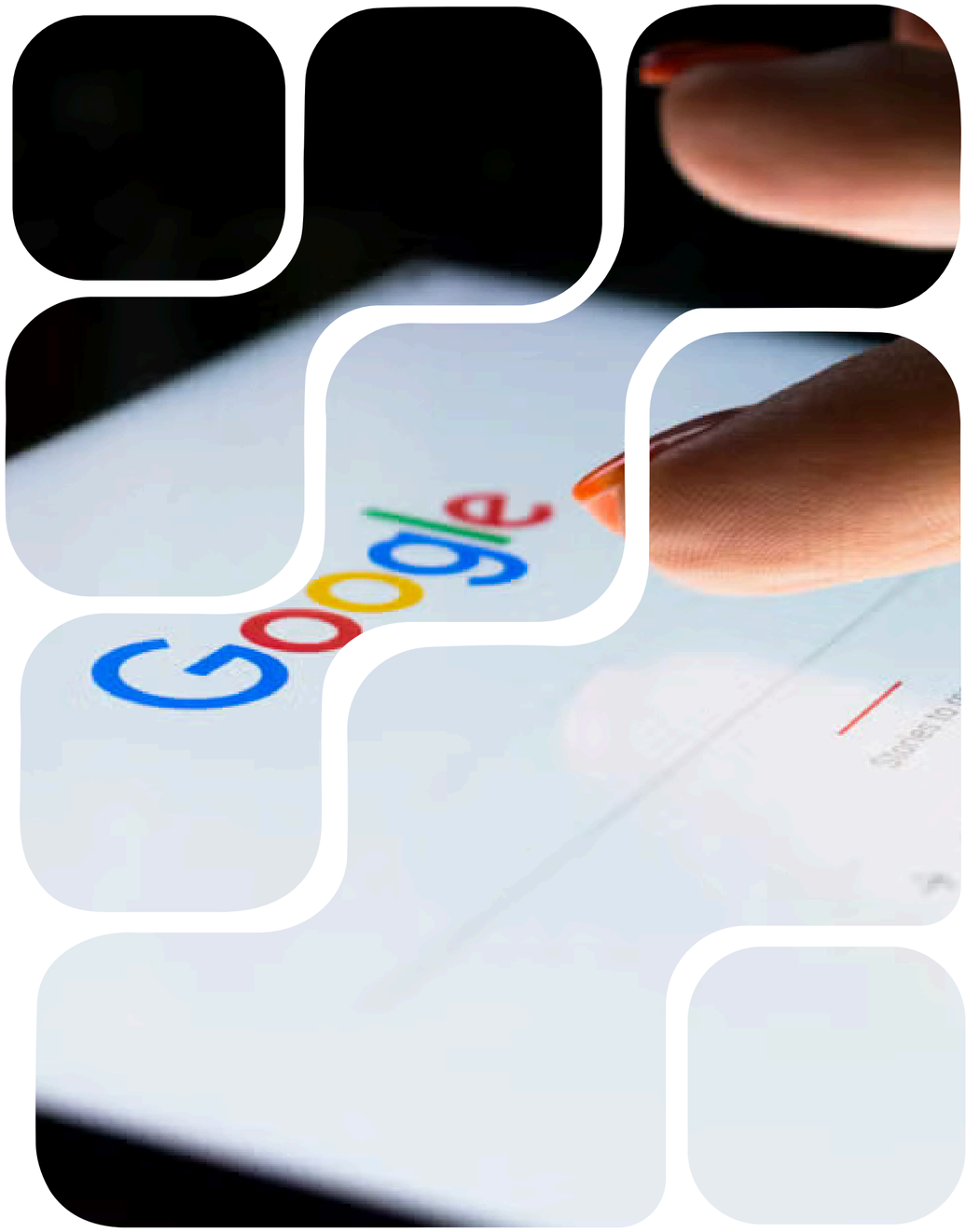


A COMPREHENSIVE GUIDE TO GOOGLE EARTH ENGINE

A STEP-BY-STEP GUIDE FOR GEOSPATIAL ANALYSIS IN ALICANTE

LAND SURFACE TEMPERATURE 7 NDVI ANALYSIS IN ALICANTE, SPAIN (2014-2023)

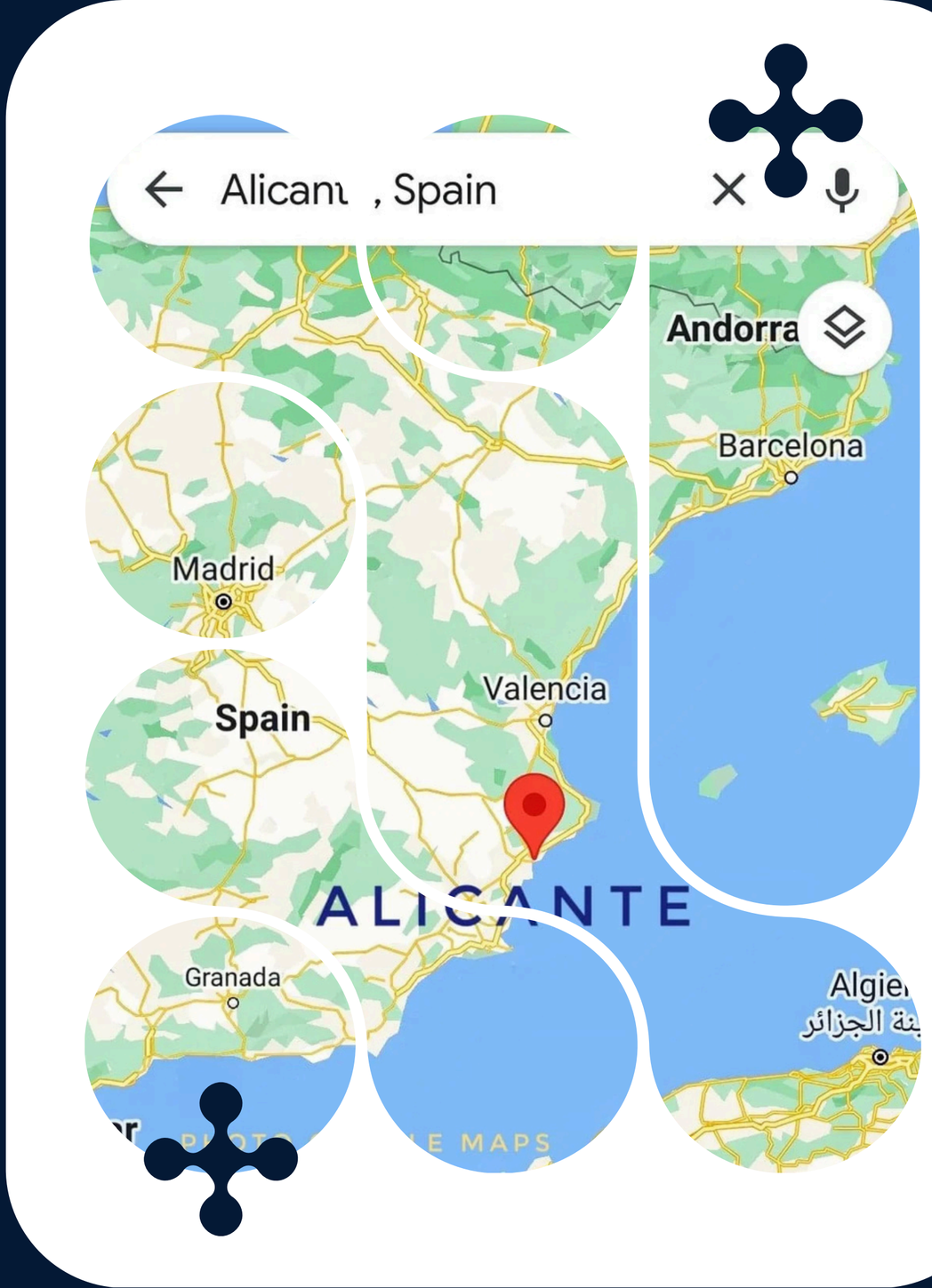
A GOOGLE EARTH ENGINE (GEE) PROJECT

MAHMUD -JULY 26, 2025

Project Objectives for GEE Analysis

Exploring Land Surface Temperature and NDVI in Alicante

The **primary goals** of this project are to utilize Google Earth Engine to analyze Land Surface Temperature and NDVI data over a 10-year period in Alicante, Spain, providing valuable insights into environmental changes.



Overview of Alicante, Spain

This section highlights key aspects of Alicante's geography and climate.

Mediterranean Climate

Alicante enjoys a **warm Mediterranean climate** ideal for diverse ecosystems.

Urban Development

The city's growth has impacted **land use patterns**, affecting environmental studies.

Rich Biodiversity

Alicante is home to various **flora and fauna**, making it a valuable study area.

WHAT IS GOOGLE EARTH ENGINE (GEE)

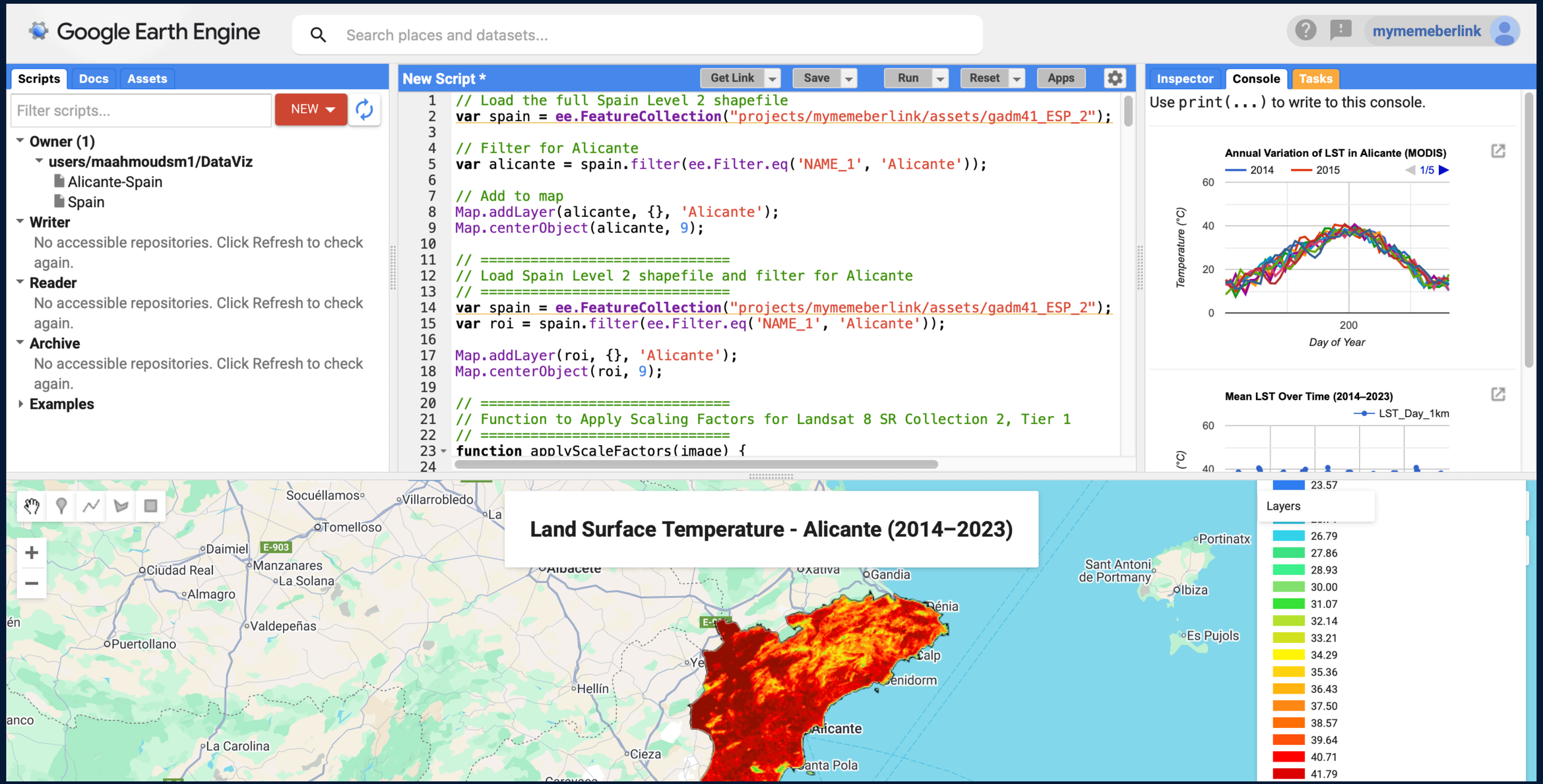
- CLOUD-BASED PLATFORM FOR PLANETARY-SCALE SATELLITE DATA ANALYSIS
- USED FOR REMOTE SENSING AND ENVIRONMENTAL MONITORING AND CLIMATE AND AGRICULTURE
- ENABLES FAST PROCESSING AND VISUALIZATION

Workflow Steps in GEE

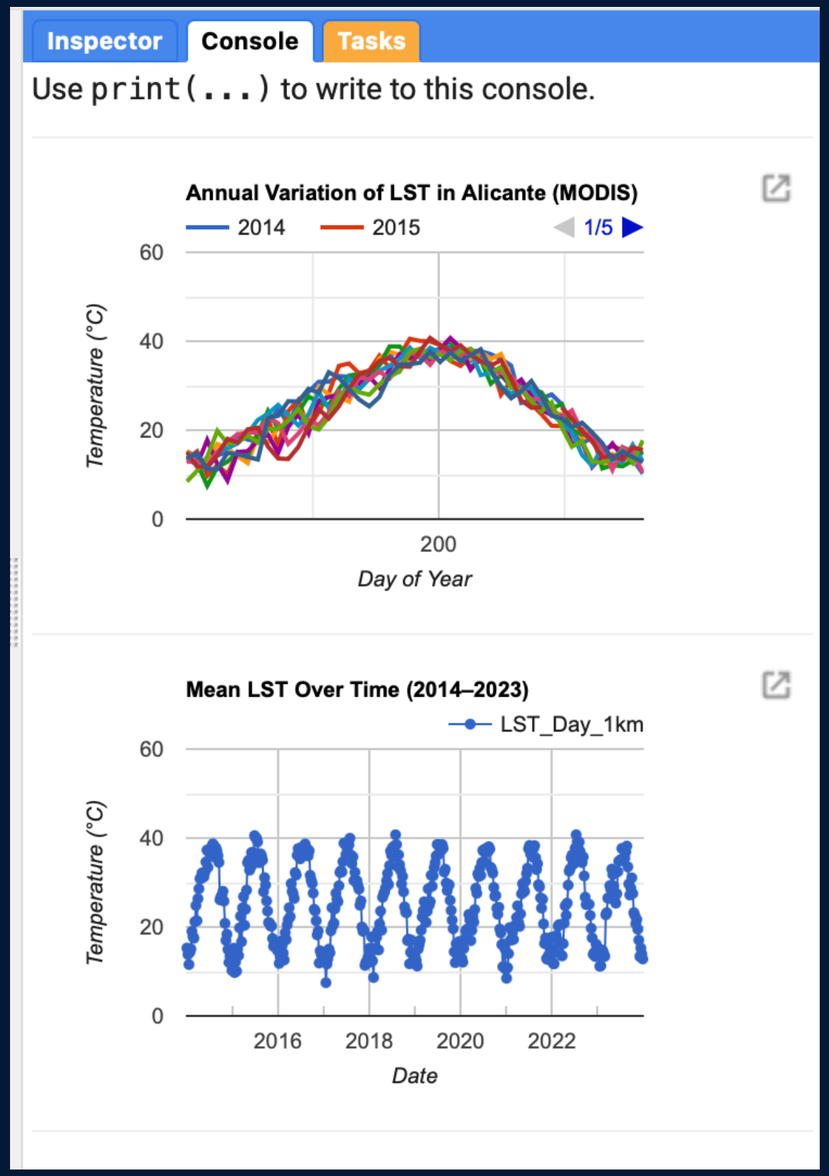
Access, process, and download environmental data efficiently

This section outlines the essential **workflow steps** for effectively accessing, processing, and downloading data using Google Earth Engine. By following these steps, you can streamline your analysis of Land Surface Temperature and NDVI for Alicante, Spain, over the past decade.

SOFTWARE IN A WHOLE



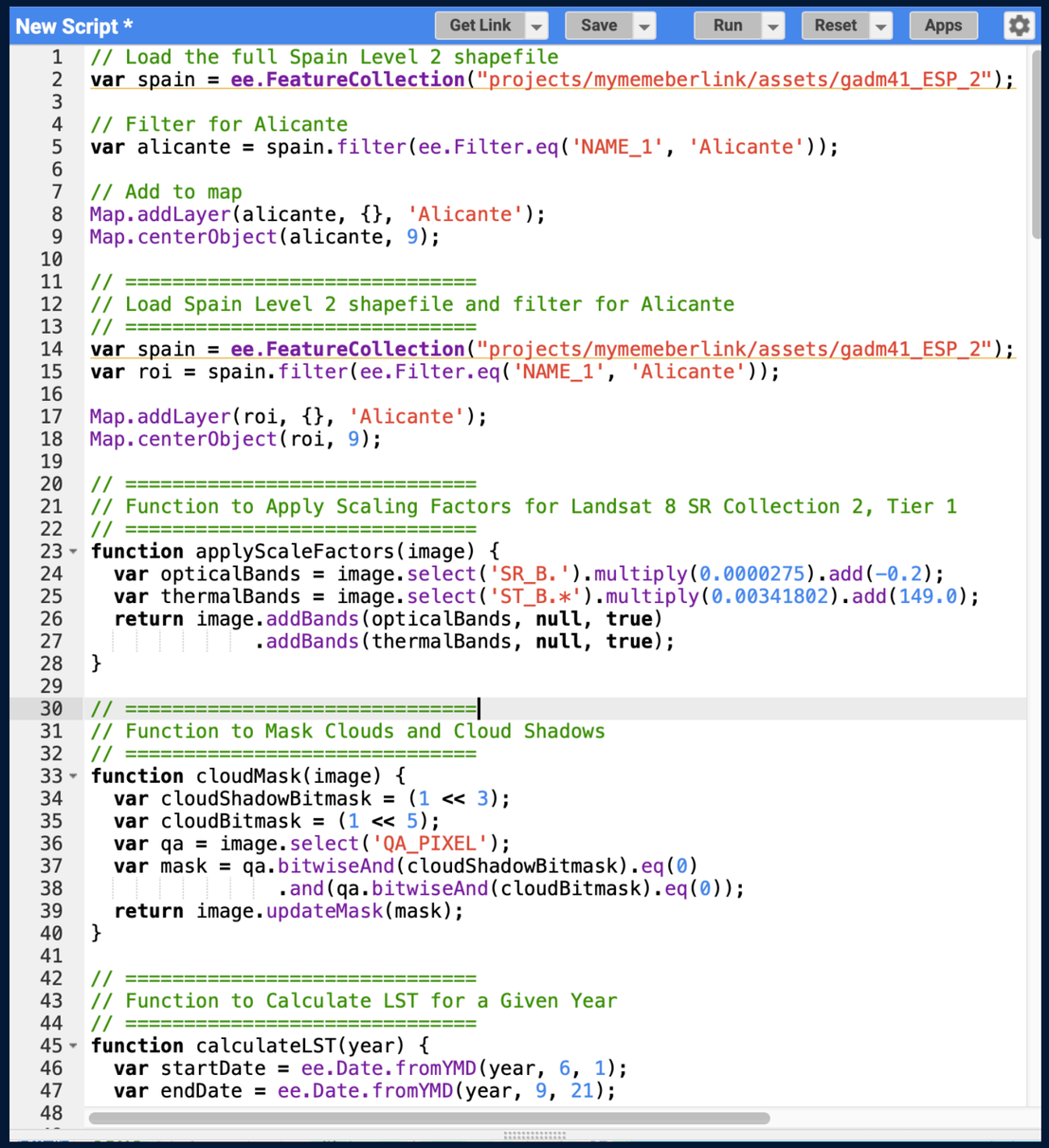
RIGHT PANEL (Console/Inspector/Tasks)



Tabs:

- Inspector: Click anywhere on the map to get pixel values (not shown here).
- Console (Active): Displays logs and charts from print() or ui.Chart.
  - Example shown:
    - Annual Variation of LST in Alicante (MODIS) — line graph of seasonal LST trends from 2014–2015.
    - Mean LST Over Time (2014–2023) — time series of monthly or yearly LST values.
- Tasks: Where export jobs (e.g., downloading images/tables) are queued and monitored.

TOP TOOLBAR & CENTER PANEL (Script Editor)



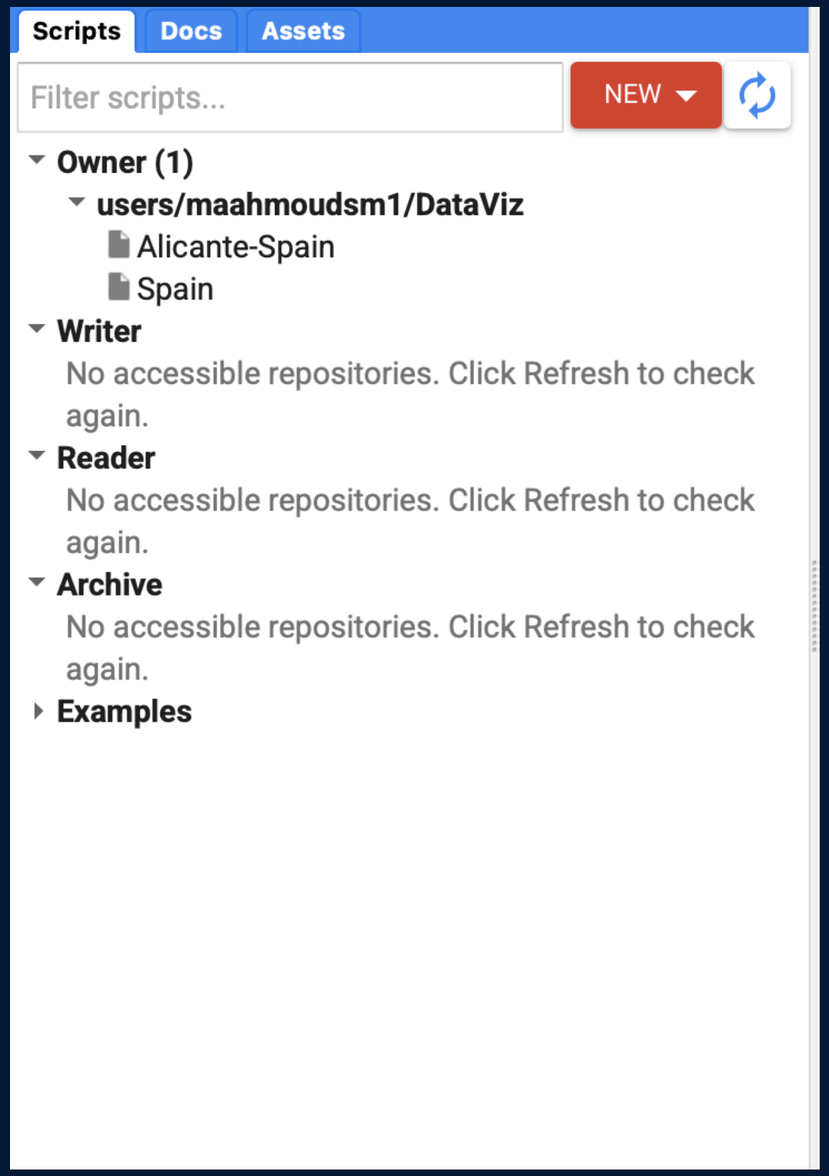
TOP TOOLBAR ("Get Link" / "Save" / "Run" / "Reset" / "Apps" / "Settings")

- **Get Link:** Share your script via a unique link.
- **Save:** Saves the script you're working on.
- **Run:** Executes the script and processes data.
- **Reset:** Clears the results or layers from the map.
- **Apps:** Lets you deploy your GEE script as a web app.
- **Settings: Toggle code suggestions, autocomplete, and syntax highlighting.**

Script Tabs ("New Script*")

- This is the Code Editor, where you write and modify your GEE JavaScript.
- You can have multiple scripts open in tabs like a browser.

LEFT PANEL (Titled "Scripts")



This is the Scripts panel where your project files are listed.

Owner / Writer / Reader / Archive / Examples

- Owner: Shows your saved scripts and assets (like shapefiles).
  - Here, you can see **Alicante-Spain** and **Spain** shapefiles under **users/maahmoudsm1/DataViz**.
- Writer: Projects where you're a collaborator.
- Reader: Projects you can view but not edit.
- Archive: Older scripts saved automatically.
- Examples: Sample code snippets and datasets from Google Earth Engine.

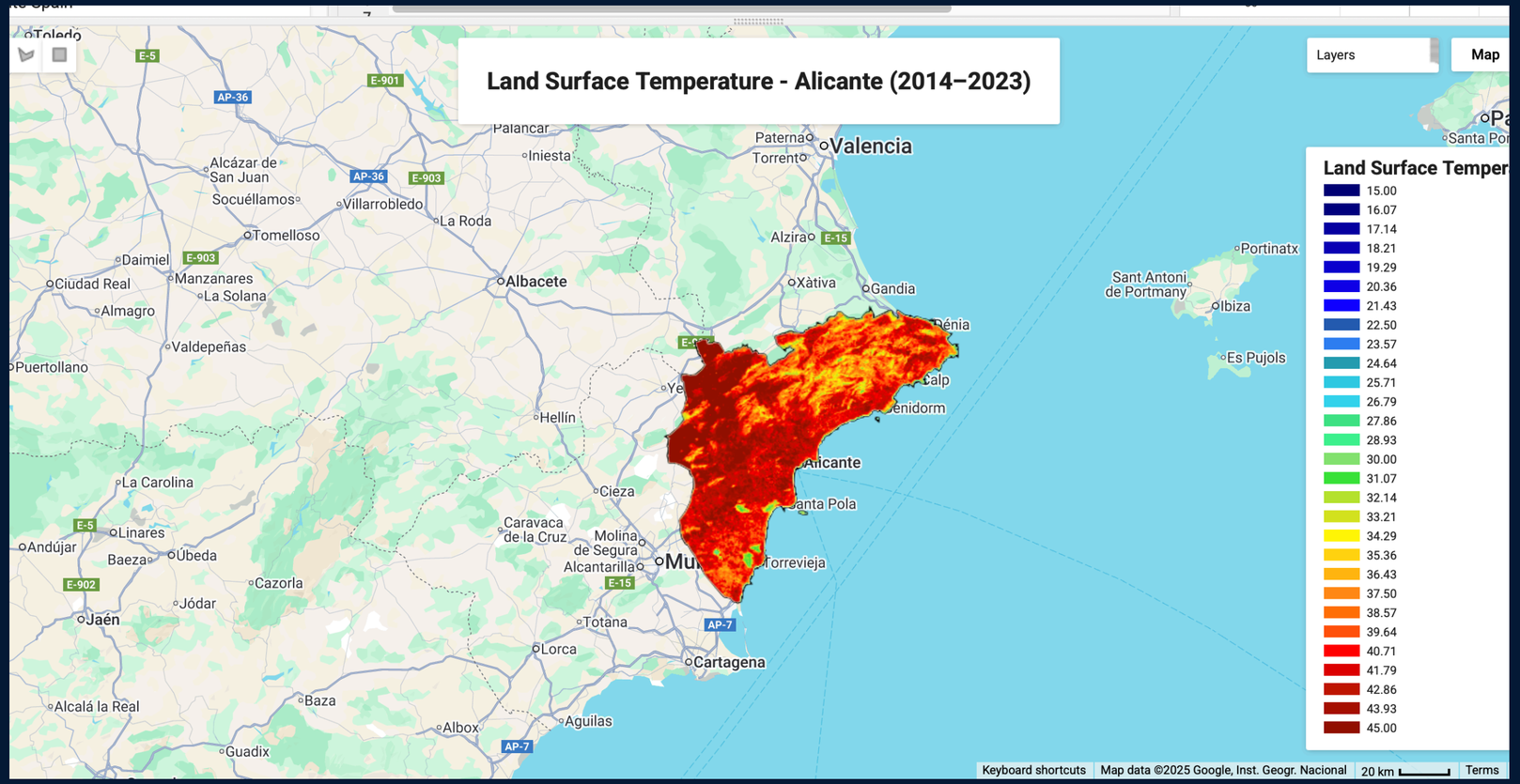
Docs – Gives you access to Earth Engine's documentation, including:

- Code snippets
- API references
- Examples for different use cases (NDVI, LST, change detection)

Assets – Where you upload or manage your personal data like:

- Shapefiles (boundaries)
- Image assets (custom rasters)
- Tables (CSV files, point data, etc.)

Map Viewer & Tools



Map Viewer

- Displays the spatial results of your analysis (e.g., NDVI, LST, boundaries).
- The map shows: LST raster heatmap over Alicante (with a color scale from 26–44°C).
- Labels like “Land Surface Temperature – Alicante (2014–2023)”.
- You can zoom, pan, and inspect values using the Inspector.

Map Tools:

- Layers button (right side): Toggle visibility, change opacity, view legend (like the temperature color scale shown).
- Capture / Options (center bottom): Take a screenshot of your map view.
- Zoom / Reset / Drag (left side tools): Navigate the map area.

Code Explanation and Instructions

This section details the step-by-step process for data analysis

Accessing Earth Engine Data

Learn how to **efficiently retrieve** satellite data for your analysis

Processing Land Surface Temperature

Step-by-step guidance on **calculating** Land Surface Temperature using GEE

Analyzing NDVI Changes

Instructions for computing and **interpreting NDVI** over the specified timeframe

STEP 1 IMPORTS & ROI

- IMPORT SHAPEFILE
- IDENTIFY (REGION OF INTREST) ROI

STEP 1 IMPORT REGION

```
1  // Load the full Spain Level 2 shapefile
2  var spain = ee.FeatureCollection("projects/mymemeberlink/assets/gadm41_ESP_2");
3
4  // Filter for Alicante
5  var alicante = spain.filter(ee.Filter.eq('NAME_1', 'Alicante'));
```

What’s Happening Here?

- We load the Spain Level 2 shapefile in GEE. (If GEE doesn't have the specific city or region, we may need to download the shapefile externally (e.g. from GADM or GeoBoundaries), then upload it manually to Earth Engine Assets.)
- It's loaded as a FeatureCollection in Earth Engine.
- Then we filter it to keep only the Alicante region.

Why?

This defines our Region of Interest (ROI) so we can:

- Focus all analysis only on Alicante
- Clip satellite images to that boundary
- Calculate NDVI/LST within this region only

STEP 2 DATA AND PREPROCESS

- LOAD LANDSAT 8 AND MODIS
- APPLY SCALING FACTORS
- APPLY CLOUD AND SHADOW MASKING

STEP 2 - Add the filtered Alicante to the Map and center the view

```
7  // Add to map
8  Map.addLayer(alicante, {}, 'Alicante');
9  Map.centerObject(alicante, 9);
```

Explanation:

- **Map.addLayer(...)**: Adds the filtered Alicante region as a visible boundary layer on the map.
- **{}**: This is the styling object (left empty here, so it uses defaults).
- **'Alicante'**: The name of the layer shown in the Layers panel.
- **Map.centerObject(alicante, 9)**: Automatically centers and zooms the map on Alicante with zoom level 9 (a decent city-level zoom).

STEP 2 - Apply scaling factors to Landsat 8 bands

```
// ================================
// Function to Apply Scaling Factors for Landsat 8 SR Collection 2, Tier 1
// ================================
function applyScaleFactors(image) {
  var opticalBands = image.select('SR_B.').multiply(0.0000275).add(-0.2);
  var thermalBands = image.select('ST_B.*').multiply(0.00341802).add(149.0);
  return image.addBands(opticalBands, null, true)
              .addBands(thermalBands, null, true);
}
```

Explanation:

- Landsat 8 Collection 2 Level 2 images are delivered as scaled integers, not reflectance/temperature directly.
- This function rescales them to real-world units:
  - Optical bands **(SR_B.)** → Surface Reflectance (0–1)
  - Thermal band **(ST_B10)** → Brightness Temperature in Kelvin
- **multiply(...)** and **add(...)** are based on Landsat documentation.
- **addBands(..., null, true)**: Adds the rescaled bands replacing the originals.

STEP 2 Cloud and shadow mask

```
30  // ================================
31  // Function to Mask Clouds and Cloud Shadows
32  // ================================
33  function cloudMask(image) {
34    var cloudShadowBitmask = (1 << 3);
35    var cloudBitmask = (1 << 5);
36    var qa = image.select('QA_PIXEL');
37    var mask = qa.bitwiseAnd(cloudShadowBitmask).eq(0)
38                 .and(qa.bitwiseAnd(cloudBitmask).eq(0));
39    return image.updateMask(mask);
40  }
```

Explanation:

- Removes clouds and shadows using the **QA_PIXEL** quality band.
- **bitwiseAnd(...)** checks specific bits:
  - Bit 3 → Shadow
  - Bit 5 → Cloud
- If both bits are 0, it means clear pixels, so we keep them.
- **updateMask(mask)**: Applies the mask so only clear pixels are used in calculations.

STEP 3 CALCULATE NDVI AND LST

- CALCULATE NDVI VEGETATION
- CALCULATE LST TEMPERATURE
- GENERATE TRUE COLOR IMAGE

STEP 3 - Load & Preprocess Landsat 8 Images

```
// ================================
// Function to Calculate LST for a Given Year
// ================================
function calculateLST(year) {
  var startDate = ee.Date.fromYMD(year, 6, 1);
  var endDate = ee.Date.fromYMD(year, 9, 21);

  var image = ee.ImageCollection("LANDSAT/LC08/C02/T1_L2")
                .filterBounds(roi)
                .filterDate(startDate, endDate)
                .map(applyScaleFactors)
                .map(cloudMask)
                .median()
                .clip(roi);
```

Explanation:

- Loads Landsat 8 Surface Reflectance Tier 1 Level 2 imagery.
- Filters it by location (**roi**, i.e., Alicante) and summer months (June 1 to Sept 21).
- Applies the scale factors and cloud masking.
- Computes the **median image** to get a clean composite.
- Clips it to the shape of Alicante.

STEP 3 - NDVI Calculation for Each Year (Main Loop)

```
var ndvi = image.normalizedDifference(['SR_B5', 'SR_B4']).rename('NDVI');

var ndviMin = ee.Number(ndvi.reduceRegion({
  reducer: ee.Reducer.min(),
  geometry: roi,
  scale: 30,
  maxPixels: 1e9
}).values().get(0));

var ndviMax = ee.Number(ndvi.reduceRegion({
  reducer: ee.Reducer.max(),
  geometry: roi,
  scale: 30,
  maxPixels: 1e9
}).values().get(0));

var pv = ((ndvi.subtract(ndviMin)).divide(ndviMax.subtract(ndviMin)))
          .pow(ee.Number(2))
          .rename('PV');

var em = pv.multiply(0.004).add(0.986).rename('EM');

var thermal = image.select('ST_B10').rename('thermal');

var lst = thermal.expression(
  '(TB / (1 + (0.00115 * (TB / 1.438)) * log(em))) - 273.15', {
    'TB': thermal.select('thermal'),
    'em': em
  }).rename('LST Alicante ' + year);

// Visualizations
Map.addLayer(image, {bands: ['SR_B4', 'SR_B3', 'SR_B2'], min: 0.0, max: 0.15}, 'True Color 432 - ' + year);
Map.addLayer(ndvi, {min: -1, max: 1, palette: ['blue', 'white', 'green']}, 'NDVI Alicante - ' + year);
Map.addLayer(lst, {
  min: 15, max: 45,
  palette: [
    '040274','040281','0502a3','0502b8','0502ce','0502e6','0602ff','235cb1','307ef3','269db1','30c8e2','32d3ef',
    '3be285','3ff38f','86e26f','3ae237','b5e22e','d6e21f','fff705','ffd611','ffb613','ff8b13','ff6e08','ff500d',
    'ff0000','de0101','c21301','a71001','911003'
  ]
}, 'LST - ' + year);
```

Calculates:
NDVI: Vegetation health (formula: (NIR-Red)/(NIR+Red))
LST: Land surface temp (requires NDVI-based emissivity, then radiative transfer eqn.)
True Color: Natural-color composite (bands 4,3,2)
Adds all three to the map for visualization.

Why:

- Computes vegetation greenness. High NDVI → dense vegetation, low NDVI → bare soil or built-up area.
- This gives you year-by-year maps of vegetation and temperature—good for studying trends and visualizing environmental changes.

STEP 4 MULTI YEAR ANALYSIS

- PROCESS EACH YEAR 2014 TO 2023
- TRACK TRENDS OVER TIME
- Legends & Map Title
- MODIS LST Time Series and Mean Map

STEP 4 - Multi-Year Analysis Loop, Legends & Map Title

Multi-Year Analysis Loop & Legends

```
// ================================
// Loop for 10 years
// ================================
var years = [2014,2015,2016,2017,2018,2019,2020,2021,2022,2023];
years.forEach(function(year) {
  calculateLST(year);
});

// ================================
// LST Legend
// ================================
var minLST = 15;
var maxLST = 45;
var palette = [
  '040274','040281','0502a3','0502b8','0502ce','0502e6','0602ff','235cb1','307ef3','269db1','30c8e2','32d3ef',
  '3be285','3ff38f','86e26f','3ae237','b5e22e','d6e21f','fff705','ffd611','ffb613','ff8b13','ff6e08','ff500d',
  'ff0000','de0101','c21301','a71001','911003'
];
var step = (maxLST - minLST) / (palette.length - 1);

var legend = ui.Panel({style: {position: 'bottom-right', padding: '8px 15px', backgroundColor: 'white'}});
legend.add(ui.Label({
  value: 'Land Surface Temperature (°C)',
  style: {fontWeight: 'bold', fontSize: '16px', margin: '0 0 4px 0'}
}));

for (var i = 0; i < palette.length; i++) {
  legend.add(ui.Panel({
    widgets: [
      ui.Label({style: {backgroundColor: '#' + palette[i], padding: '5px', margin: '0 0 5px 0', width: '30px'}}),
      ui.Label({value: (minLST + i * step).toFixed(2), style: {fontSize: '10px', margin: '0 0 5px 6px'}})
    ],
    layout: ui.Panel.Layout.Flow('horizontal')
  }));
}
Map.add(legend);
```

Explantion:

- Loops through all years, calling your analysis function for each.
- Builds a visual legend for your temperature palette (helps interpret your LST maps).
- Adds a map title so exported screenshots/maps are labeled.

Map Title

```
// ================================
// Map Title
// ================================
Map.add(ui.Panel([
  ui.Label({
    value: 'Land Surface Temperature - Alicante (2014–2023)',
    style: {fontWeight: 'bold', fontSize: '20px', padding: '8px'}
  })
], ui.Panel.Layout.Flow('vertical'), {
  position: 'top-center'
}));
```

Why:

- So you can monitor change over time essential for trend analysis.
- For clarity, especially when sharing with non-experts.

STEP 4 - MODIS LST Time Series and Mean Map

```
// ================================
// MODIS LST Time Series Chart (2014–2023)
// ================================
var collection = ee.ImageCollection('MODIS/061/MOD11A2')
  .select("LST_Day_1km")
  .filterDate('2014-01-01', '2023-12-31')
  .filterBounds(roi);

var LSTDay = collection.map(function(img) {
  return img.multiply(0.02).subtract(273.15)
    .copyProperties(img, ['system:time_start', 'system:time_end']);
});

// Chart by Day of Year
var chart = ui.Chart.image.doySeriesByYear(
  LSTDay, 'LST_Day_1km', roi, ee.Reducer.mean(), 1000)
  .setOptions({
    title: 'Annual Variation of LST in Alicante (MODIS)',
    vAxis: {title: 'Temperature (°C)'},
    hAxis: {title: 'Day of Year'}
  });
print(chart);

// ================================
// Mean LST Map from MODIS (2014–2023)
// ================================
Map.addLayer(LSTDay.mean().clip(roi), {
  min: 20.0,
  max: 40.0,
  palette: palette
}, 'Mean LST MODIS (2014–2023)');

```

Explantion:

- Loads MODIS LST (lower res, more frequent: every 8 days)
- Converts to Celsius, builds time series chart, and shows mean LST map for the whole period

Why:

- Landsat = high spatial resolution, but less frequent.
- MODIS = lower spatial, but better for temporal (trend) analysis.
- Lets you see “big picture” trends and validate your Landsat findings.

STEP 5 EXPORT RESULTS

- CALCULATE NDVI VEGETATION
- CALCULATE LST TEMPERATURE
- GENERATE TRUE COLOR IMAGE

STEP 4 - MODIS LST Time Series and Mean Map

```
  // ====== EXPORTS: Add here for each year ======

  // Export NDVI
  Export.image.toDrive({
    image: ndvi,
    description: 'NDVI_Alicante_' + year,
    folder: 'GEE_Exports',
    fileNamePrefix: 'NDVI_Alicante_' + year,
    region: roi.geometry(),
    scale: 30,
    maxPixels: 1e13,
    fileFormat: 'GeoTIFF'
  });

  // Export LST
  Export.image.toDrive({
    image: lst,
    description: 'LST_Alicante_' + year,
    folder: 'GEE_Exports',
    fileNamePrefix: 'LST_Alicante_' + year,
    region: roi.geometry(),
    scale: 30,
    maxPixels: 1e13,
    fileFormat: 'GeoTIFF'
  });

  // Export True Color (432)
  Export.image.toDrive({
    image: image.select(['SR_B4', 'SR_B3', 'SR_B2']),
    description: 'TrueColor_Alicante_' + year,
    folder: 'GEE_Exports',
    fileNamePrefix: 'TrueColor_Alicante_' + year,
    region: roi.geometry(),
    scale: 30,
    maxPixels: 1e13,
    fileFormat: 'GeoTIFF'
  });

}
```

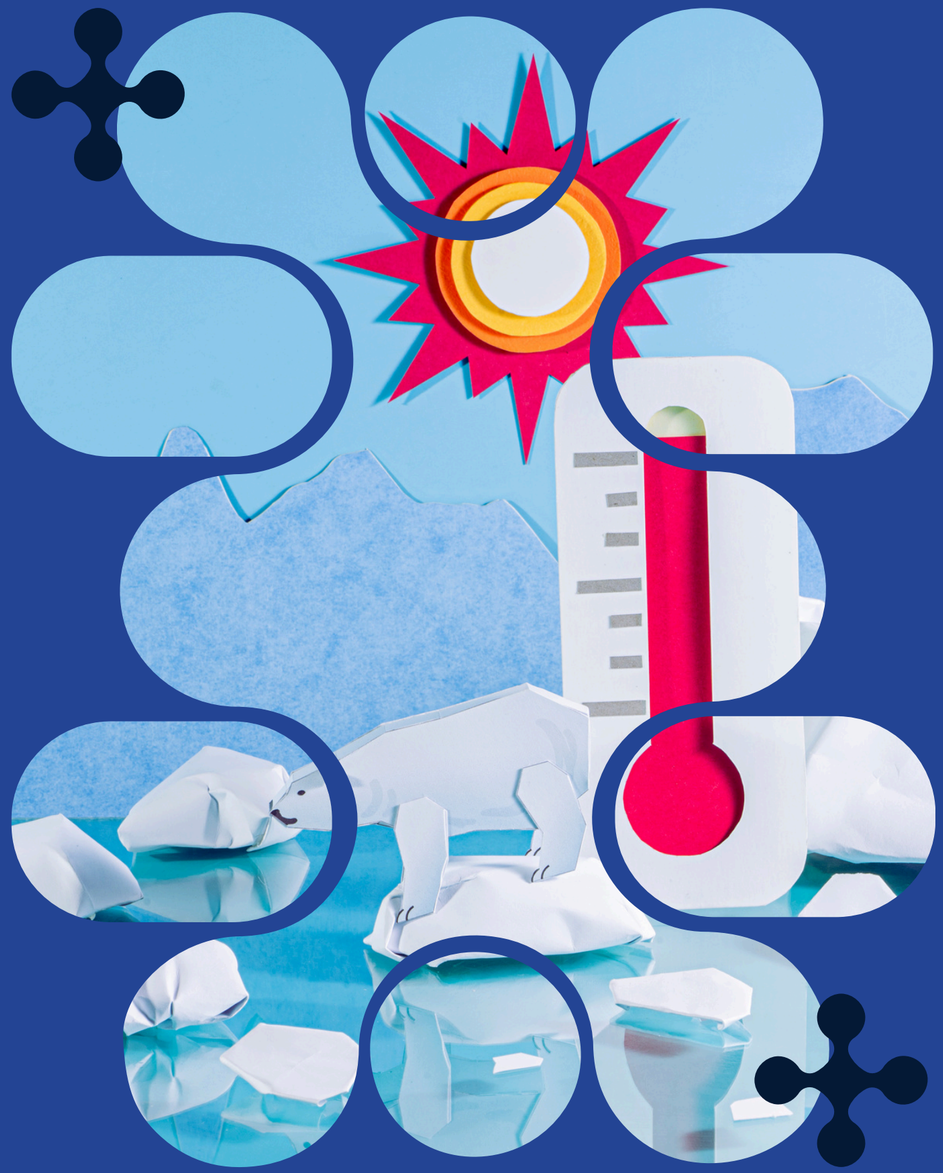
```
// ========== EXPORT: MODIS MEAN LST (2014–2023) ==========
Export.image.toDrive({
  image: LSTDay.mean().clip(roi),
  description: 'MODIS_LST_Mean_2014_2023',
  folder: 'GEE_Exports',
  fileNamePrefix: 'MODIS_LST_Mean_2014_2023',
  region: roi.geometry(),
  scale: 1000,
  maxPixels: 1e13,
  fileFormat: 'GeoTIFF'
});

// ========== EXPORT: MODIS LST Time Series Chart Data ==========
var timeseries = LSTDay.map(function(image) {
  var date = ee.Date(image.get('system:time_start')).format('YYYY-MM-dd');
  var mean = image.reduceRegion({
    reducer: ee.Reducer.mean(),
    geometry: roi,
    scale: 1000,
    maxPixels: 1e13
  }).get('LST_Day_1km');
  return ee.Feature(null, {'date': date, 'mean_LST': mean});
});
var timeseries_fc = ee.FeatureCollection(timeseries);

Export.table.toDrive({
  collection: timeseries_fc,
  description: 'MODIS_LST_Timeseries_Alicante_2014_2023',
  folder: 'GEE_Exports',
  fileNamePrefix: 'MODIS_LST_Timeseries_Alicante_2014_2023',
  fileFormat: 'CSV'
});
```

Explantion:

- Sends your selected map layer (NDVI, LST, TrueColor, mean, Time Series Chart Data) to Google Drive as a GeoTIFF.

Why:

Needed for using your results in QGIS/ArcGIS, reporting, sharing, or further analysis outside GEE.



8 out of 10

Majority of areas show increased temperature trends.

15%

Significant rise in NDVI values observed overall.

3.2°C increase

Average rise in Land Surface Temperature over the decade.

INSIGHTS & APPLICATIONS

- NDVI maps: Identify areas of healthy/dry/degraded vegetation. Spot drought, crop patterns, or urban expansion.
- LST maps: Detect heat islands, track climate/urbanization impacts, support planning for heat resilience.
- Time series: Understand long-term environmental trends and seasonality. Validate against field data or reports.

Why Use GEE for This?

- Handles big data (years, many images) fast
- Cloud-based—no downloads required to process
- Exports standard GIS formats
- Easy to automate, repeat, and share
- All satellite imagery is updated, pre-archived, and accessible

THANK YOU