Scaling climate data analysis in the cloud with Google Earth Engine

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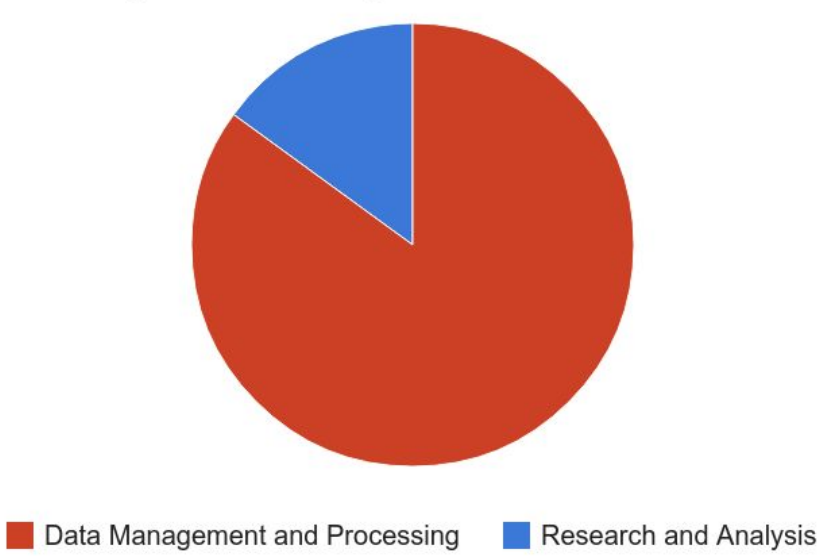
Developer Advocate, Google Earth Engine

15 March 2022

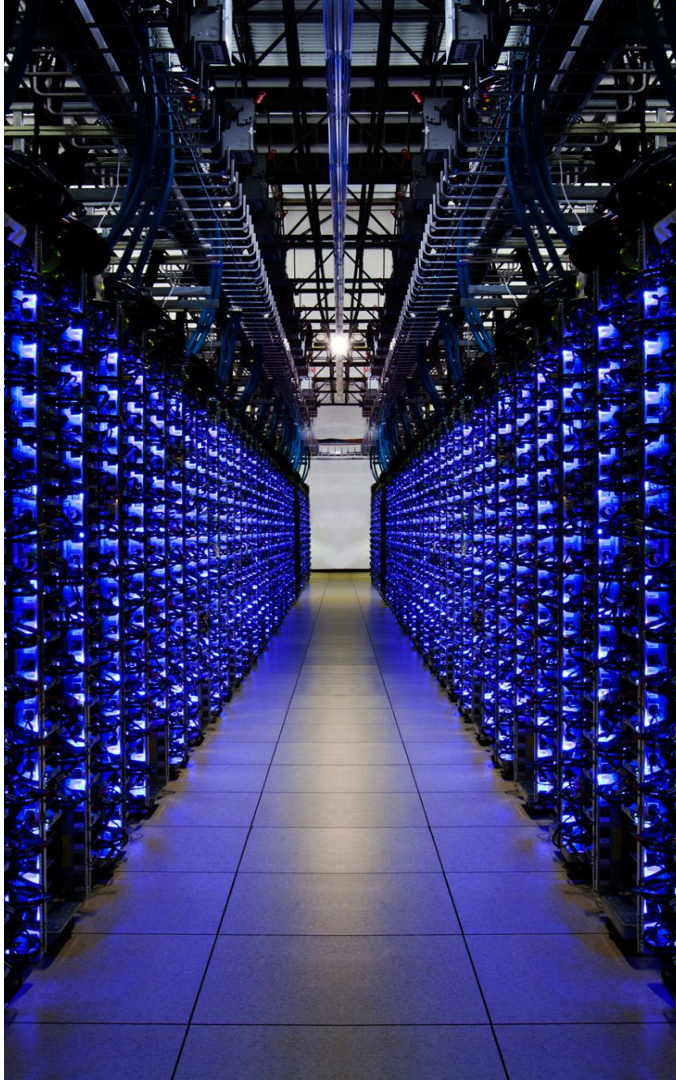
Geospatial Analysis

Many geospatial researchers spend a majority of their time doing "**IT work**."



Benefits of Cloud-based Analysis

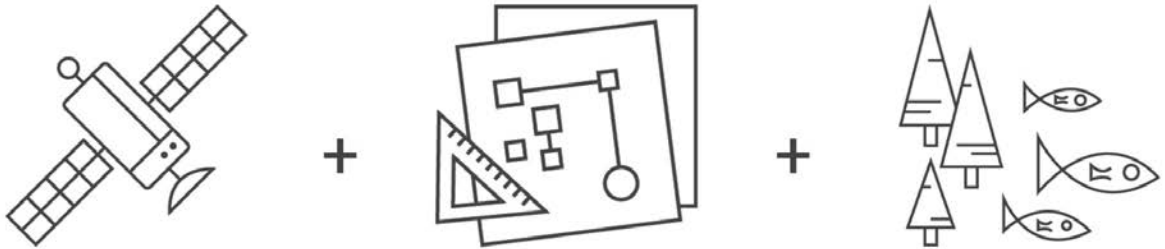
- Avoids the need to download duplicate copies of data
- Minimal setup time
- Increases the scale of possible analyses
- Improved reproducibility & replicability
- Can facilitate collaboration & sharing

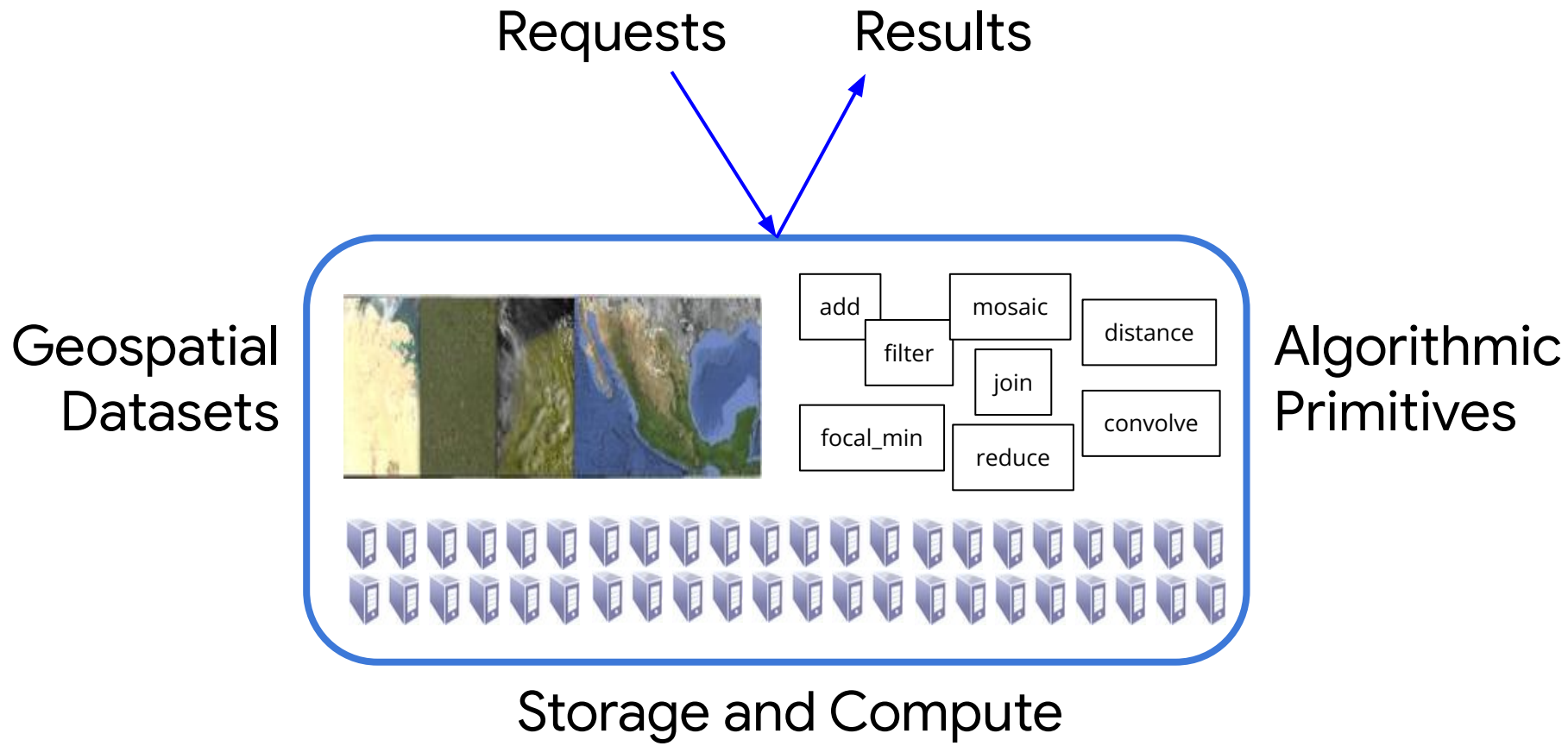


Google Earth Engine

Google's **cloud platform** for easy **petabyte-scale analysis**

of **satellite imagery** and other **geospatial data**.




Requests
Results
Geospatial Datasets
add
mosaic
distance
filter
join
convolve
focal_min
reduce
Algorithmic Primitives
Storage and Compute

Data

Public Data Catalog

Optical Imagery

Boundary Data

Terrain & Land Cover

Weather & Climate

600+ public datasets

100+ datasets added yearly

30+ petabytes of data

1+ PB of new data every month

... and upload your own vectors and rasters

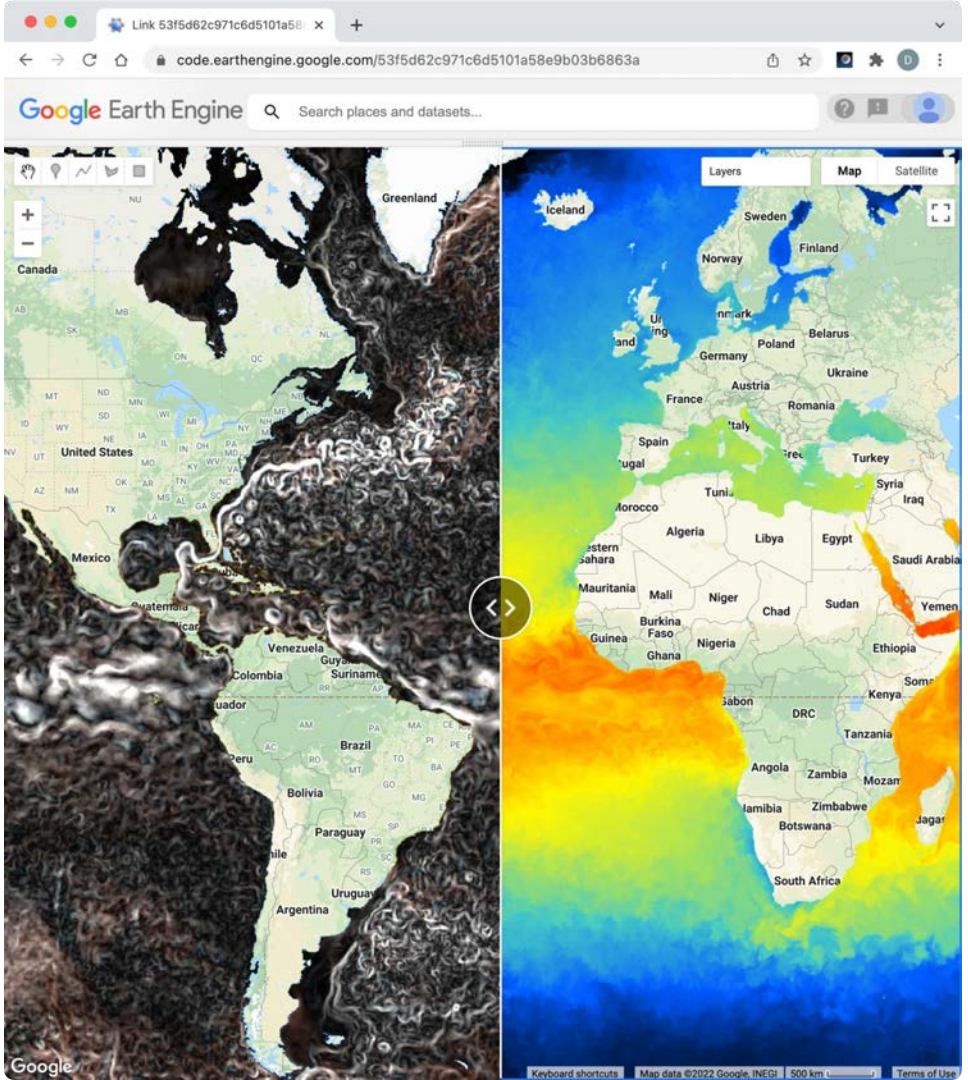
Data

Geospatial Data

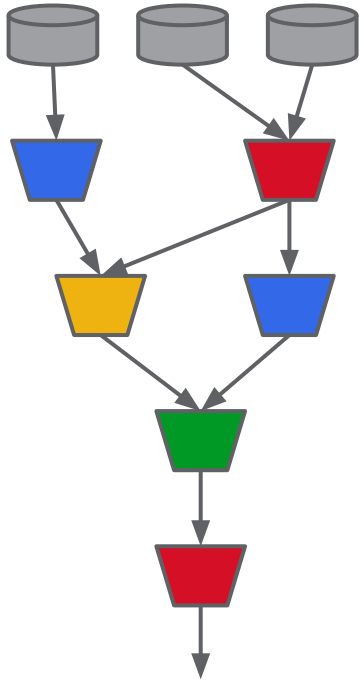
- Optical
  - **Landsat, MODIS, AVHRR**
  - **Sentinel-2, Sentinel-3**
  - **GOES-16, GOES-17**
- Boundaries
  - **USGS HUCs**
  - **WWF HydroSHEDS Basins**
  - **Rivers Network**
- Elevation
  - **SRTM30M, NASADEM**
  - **NED**
  - **ALOS DSM**
  - **MERIT**
- Precipitation
  - **GPM, TRMM, GSMaP**
  - **PERSIANN, CHIRPS**
- Weather Reanalysis
  - **CFSR**
  - **NCEP/NCAR Reanalysis**
  - **ECMWF ERA5, ERA5-Land**
- Weather Forecast
  - **GFS, CFSV2, RTMA**
  - **ECMWF CAMS**
- Climate Projections
  - **CMIP5 NEX-DCP30, NEX-GDDP**

Data

HYCOM data



Computation



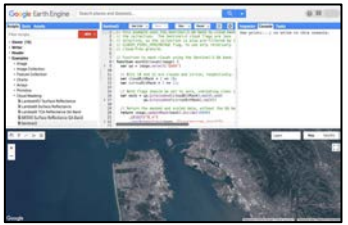
APIs

Earth Engine Backend Servers

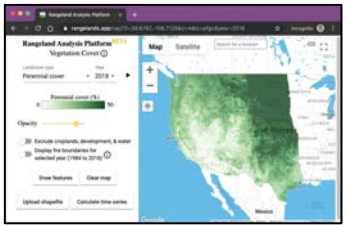
Javascript Client Library

Python Client Library

Earth Engine Code Editor

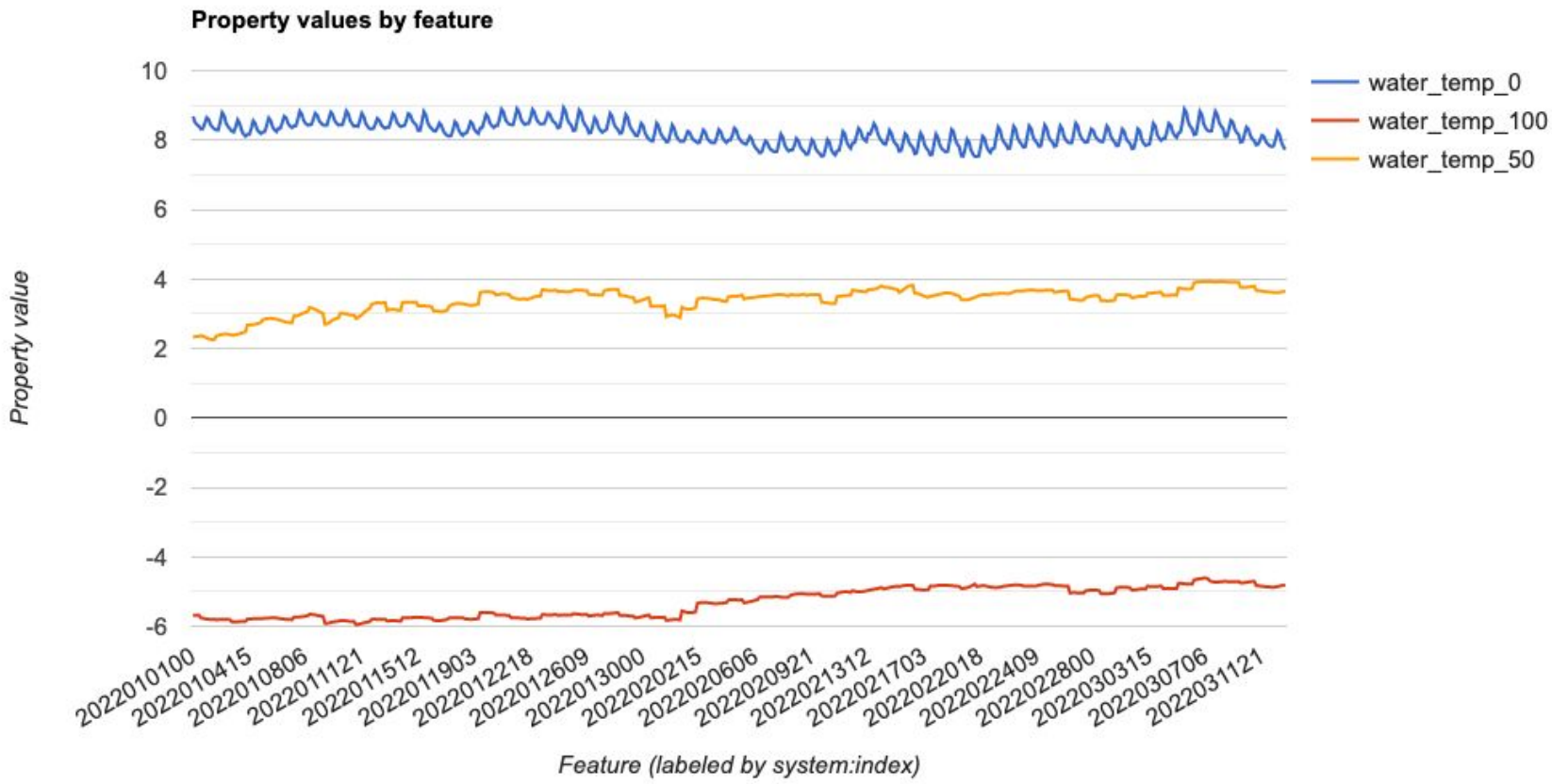


Web Application



Jupyter-based Development Environment

jupyter



Promoting Collaboration/Sharing

Time Series Visualization with Altair

File Edit View Insert Runtime Tools Help Cannot save changes

Share

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+ Code + Text Copy to Drive RAM Disk Editing

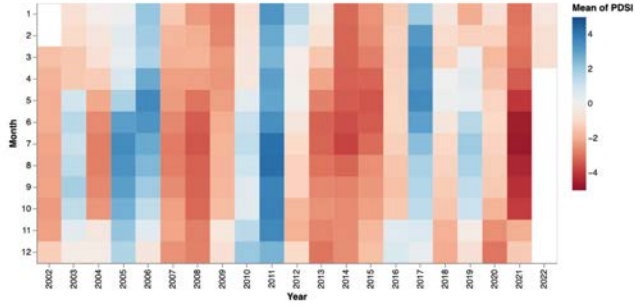
Calendar heatmap

Chart PDSI data as a calendar heatmap. Set observation year as the x-axis variable, month as y-axis, and PDSI value as color.

Note that Altair features a convenient method for aggregating values within groups while encoding the chart (i.e., no need to create a new DataFrame). The mean aggregate transform is applied here because each month has three PDSI observations (year and month are the grouping factors).

Also note that a tooltip has been added to the chart; hovering over cells reveals the values of the selected variables.

```
[18] alt.Chart(pdsi_df).mark_rect().encode(
        x='Year:O',
        y='Month:O',
        color=alt.Color(
            'mean(PDSI):Q', scale=alt.Scale(scheme='redblue', domain=(-5, 5))),
        tooltip=[
            alt.Tooltip('Year:O', title='Year'),
            alt.Tooltip('Month:O', title='Month'),
            alt.Tooltip('mean(PDSI):Q', title='PDSI')
        ]).properties(width=600, height=300)
```



The calendar heat map is good for interpretation of relative intra- and inter-annual differences in PDSI. However, since the PDSI variable is represented by color, estimating absolute values and magnitude of difference is difficult.

0s completed at 1:04 PM

code.earthengine.google.com/86c23c333938dae8d3f7b2cdbcd06f65

Google Earth Engine

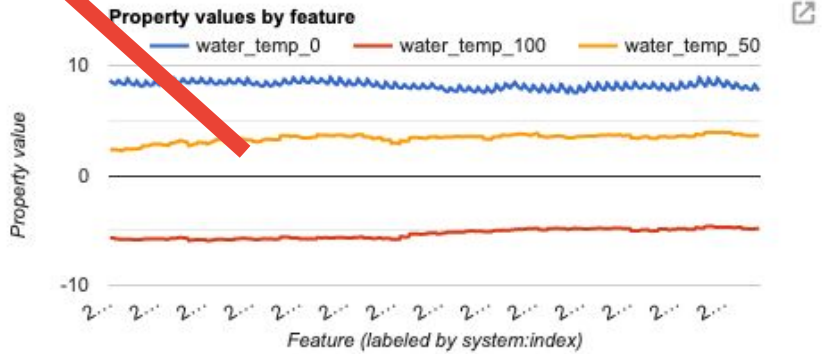
Search places and datasets...

Link b676c3a6039fe... | Get Link | Save | Run | Reset | Apps

```
Imports (1 entry)
  var geometry: Polygo  vertices
var stats = ee.ImageColle on('HYCOM/sea_temp_salinity')
    .filterDate('2022-01-01', '2023')
    .filter(ee.Filter.eq('exper ent', '930'))
    .select(['water_temp_0', 'wat  temp_50', 'water_temp_100'])
    .map(function (img) {
      return ee.Feature(null,
        img.multiply(0.001)
          .reduceRegion({
            reducer:ee.Reducer.mean(),
            geometry: geometry,
            bestEffort:true
          })
      );
    });
print(ui.Chart.feature.byFeature(stats));
```

Inspector | Console | Tasks

Us print(...) to write to this console.



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```
Imports (1 entry)
  var geometry: Polygon, 4 vert
var stats = ee.ImageCollection('HY      sea_temp_salinity')
    .filterDate('2022-01-01', '2023')
    .filter(ee.Filter.eq('experiment', '      '))
    .select(['water_temp_0', 'water_temp_50', 'water_temp_100'])
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Inspector | Console | Tasks

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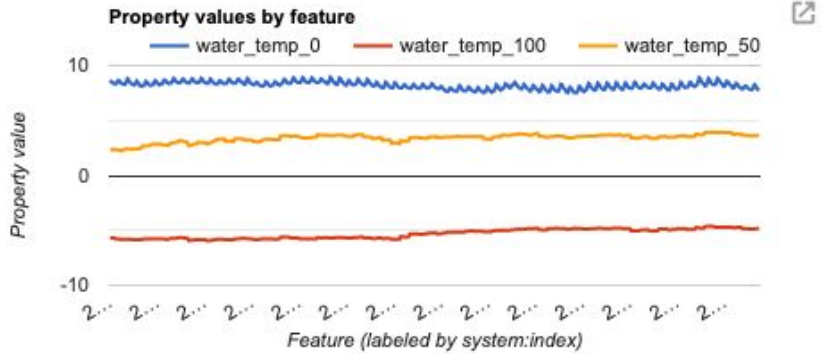
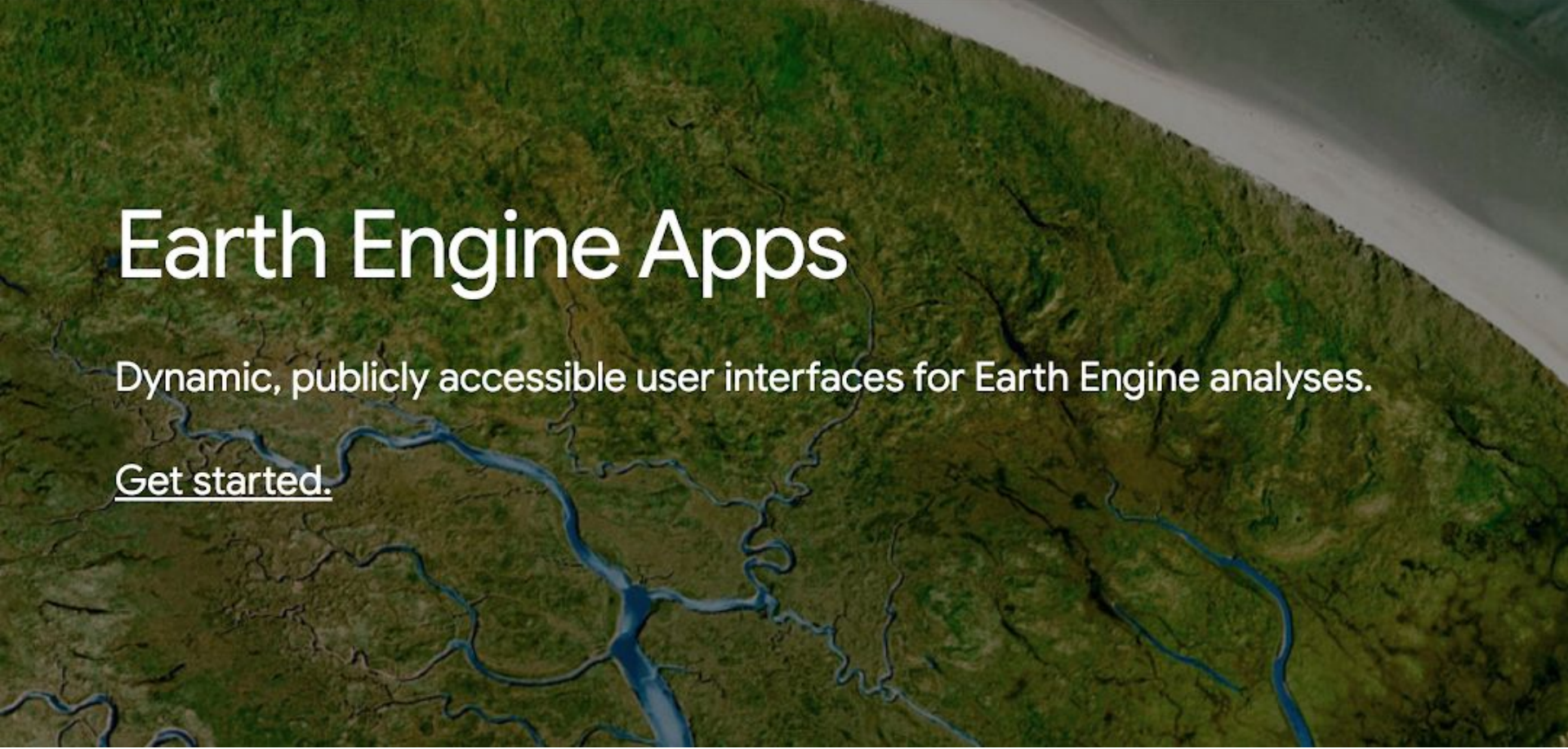


Geometry Imports

Map | Satellite



https://www.earthengine.app

https://google.earthengine.app/view/ocean

Ocean Timeseries Investigator

google.earthengine.app/view/ocean

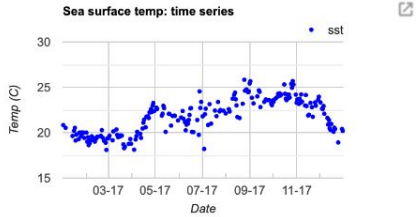
Earth Engine Apps

Search places

MODIS Ocean Temperature - Time Series Inspector

Click a location to see its time series of ocean temperatures.

lon: -19.16 lat: 22.31



Map Legend: median 2017 ocean temp (C)

0 15 30

Layers Map Satellite

Belgium Paris France Austria Hungary Moldova Romania Serbia Bulgaria Italy Rome Spain Madrid Morocco Algeria Tunisia Libya Egypt Cairo Western Sahara Mauritania Mali Niger Chad Sudan Senegal Gambia Guinea Burkina Faso Benin Togo Nigeria Ghana Cameroon Central African Republic South Sudan DRC Uganda Kenya Nairobi Rwanda Burundi Tanzania Angola Venezuela Bogotá Colombia Guyana Suriname Brazil Peru Montreal Ankara Istanbul Turkey

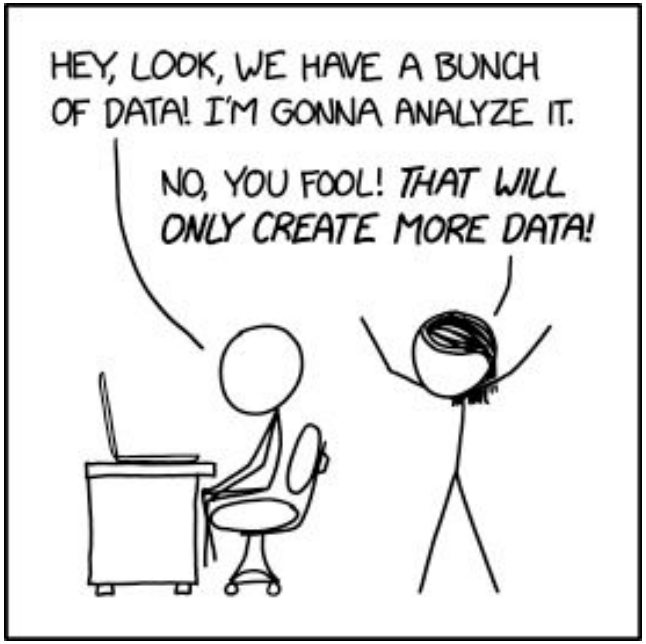
Aaron Zuspan
@aazuspan

Ever wonder where #EarthEngine analysis is taking place? 🛰️🗺️

I scraped all 57 million lines of public #GEE code to find the coordinates of every 📍 Point ever created.

Plus, some other interesting insights on the data and modules that people use 🧵...

11:37 PM · Mar 5, 2022 · Twitter Web App



source: xkcd.com/2582

Thank you!

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