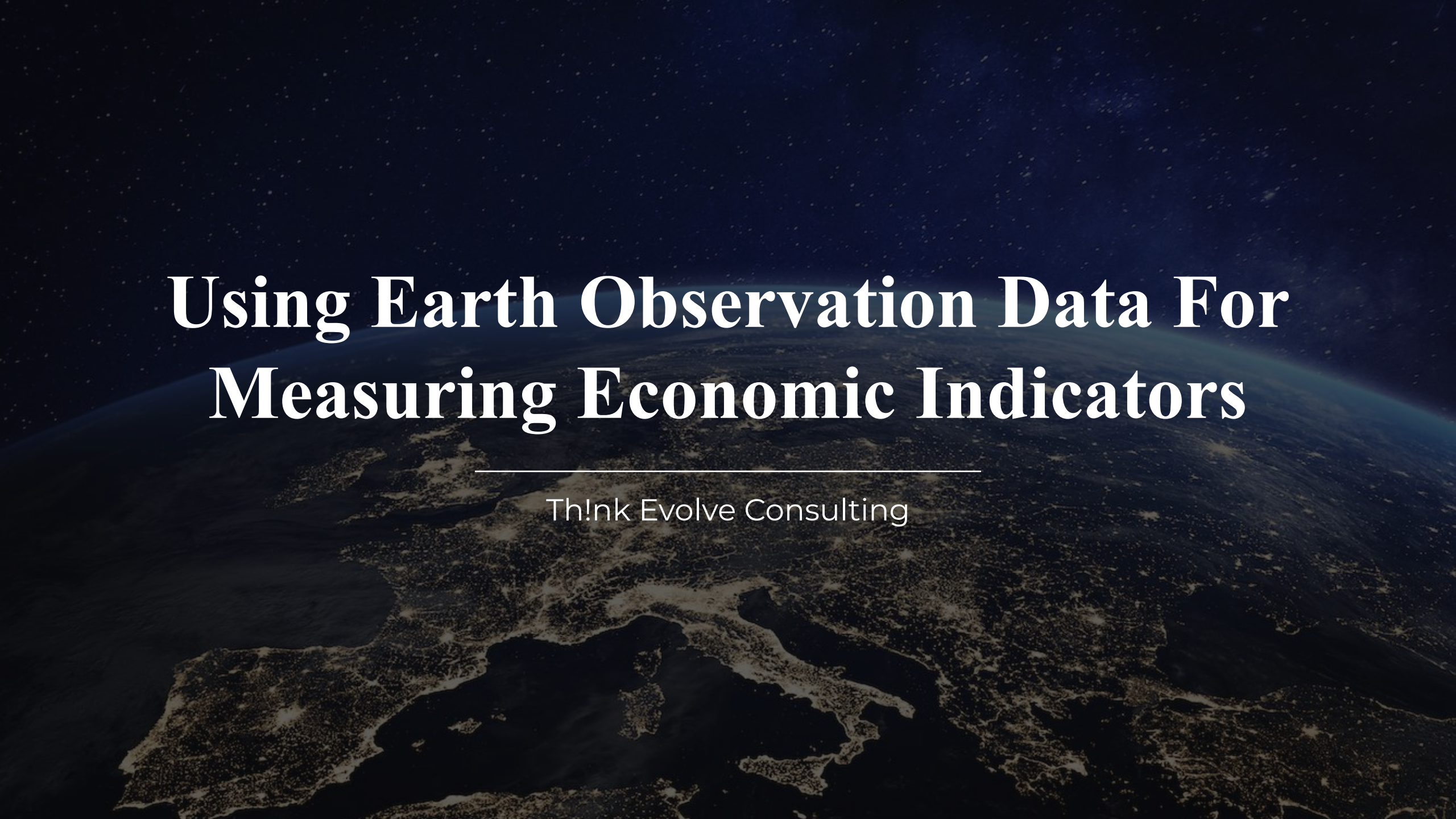

Using Earth Observation Data For Measuring Economic Indicators

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Building products for the next billion users!

Measuring Economic Activity via Earth Observations

1. Measuring pollution over major industrial belts
2. SAR (Radar) for activity monitoring of building construction
3. Measuring quality of water in major rivers in Europe
4. Impact on Agri-production in the USA
5. Monitoring airport activity by counting aero planes parked in airports

6. Measuring deforestation using vegetation indices
7. Using VHR (30cm resolution) imagery to assess changes in car distribution
8. Detecting & counting cars using Open Imagery
9. Surface Water Monitoring using Earth Engine

Aakash Gupta
Abha Porwal
& Apsal K

Using Open Earth Observations for measuring economic indicators

Conf42: Python 2021

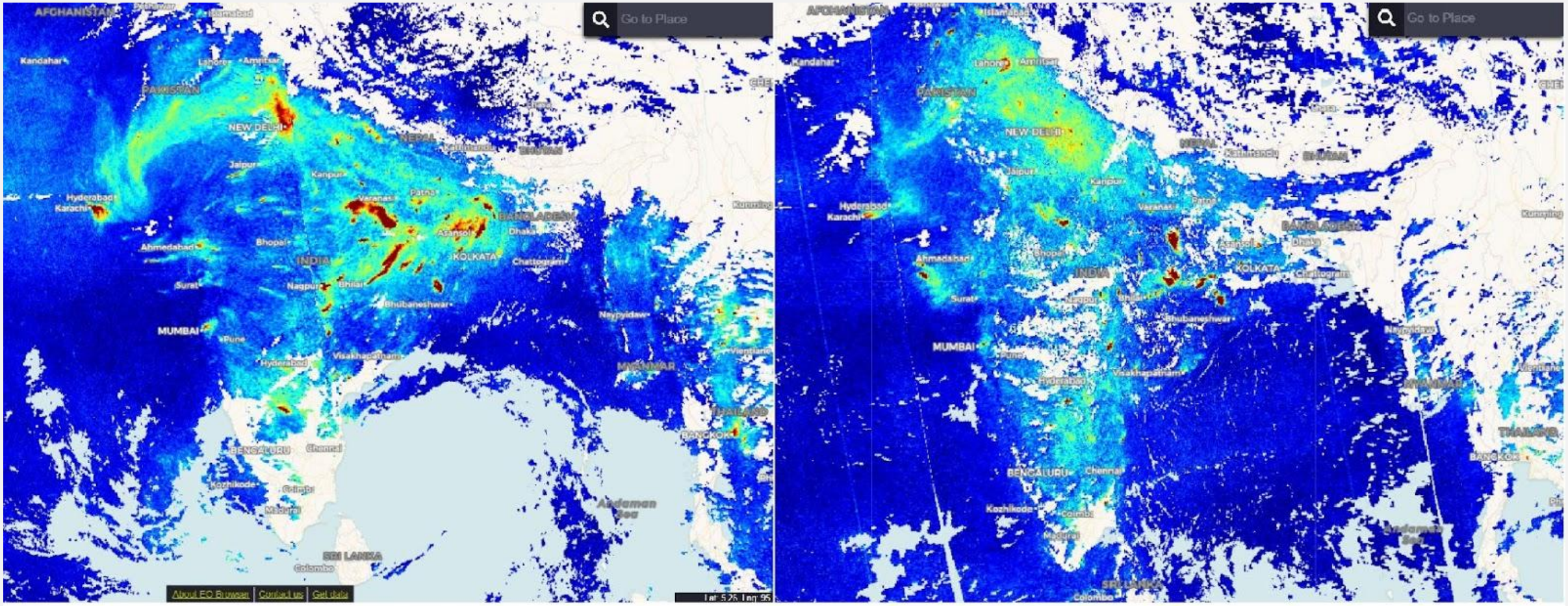
Thursday May 27 | 5PM GMT

conf42.com

Lockdown → Economic Activity → Pollution

- Our hypothesis is that economic activity causes pollution. Successful lockdowns have led to decrease in economic activity & pollution
- Retail sales/Economic activity can be construed from the number of cars parked in parking lots or streets near busy market places.
- However vehicular traffic also leads to high NO2 levels.
- We first use Sentinel-5P data to plot NO2 levels to identify any anomalies (spikes or other sudden changes) This is then collaborated with VHR imagery
- This approach basically saves costs, because we are first using Sentinel-5P data to confirm our hypothesis & then using VHR imagery to collaborate our findings.

Lockdowns initiated by countries has led to a halt in economic activity
Burning of fossil fuels (vehicles, factories etc.) lead to emission of NO2.
So a drop in NO2 levels is an indicator of fall in economic activity

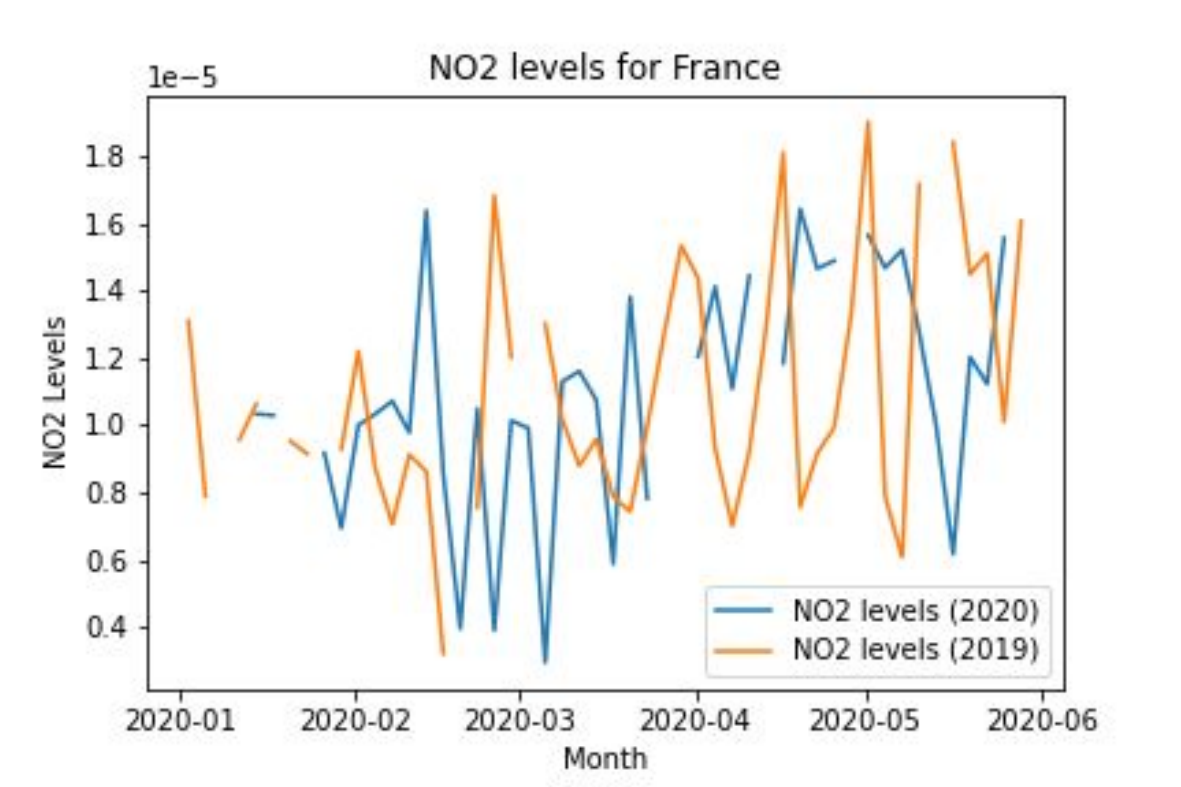


April 30th 2019

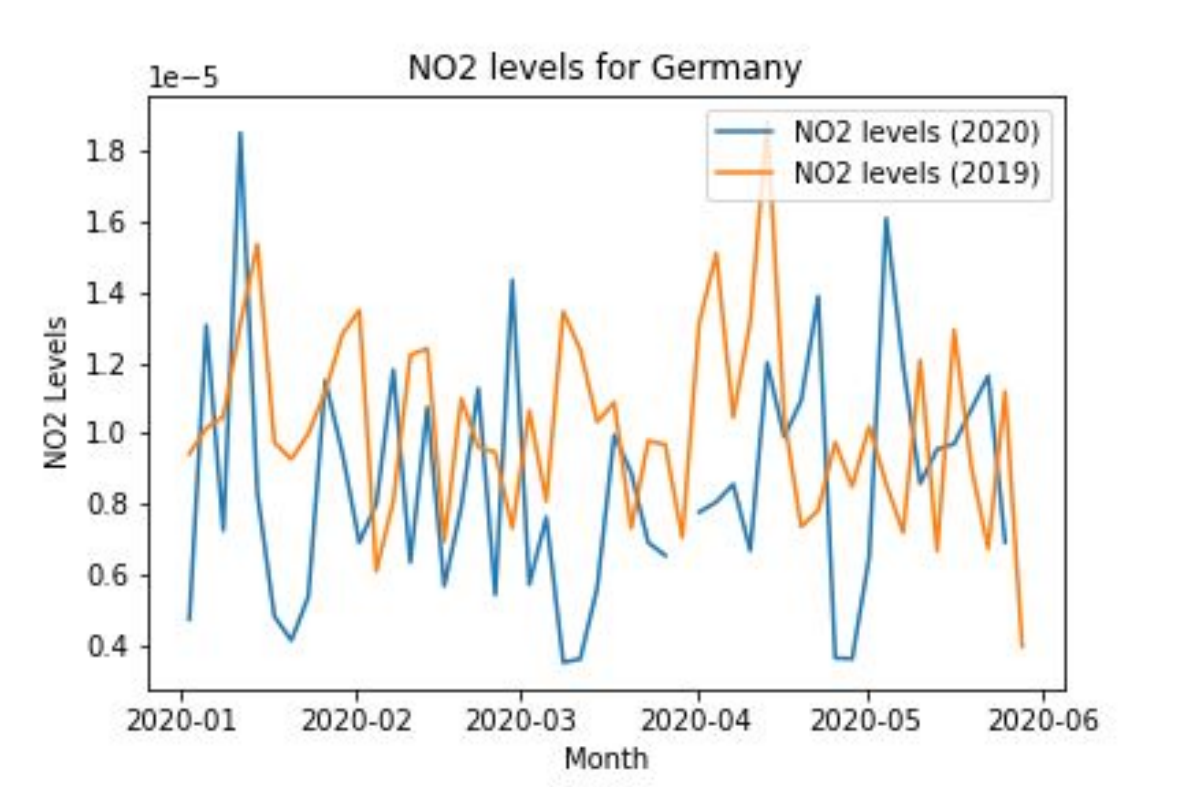
April 30th 2020

Indian sub-continent NO2 levels visualised using EO-Browser (Sentinel-Hub)

NO2 Levels Over Sample European Countries/Territories



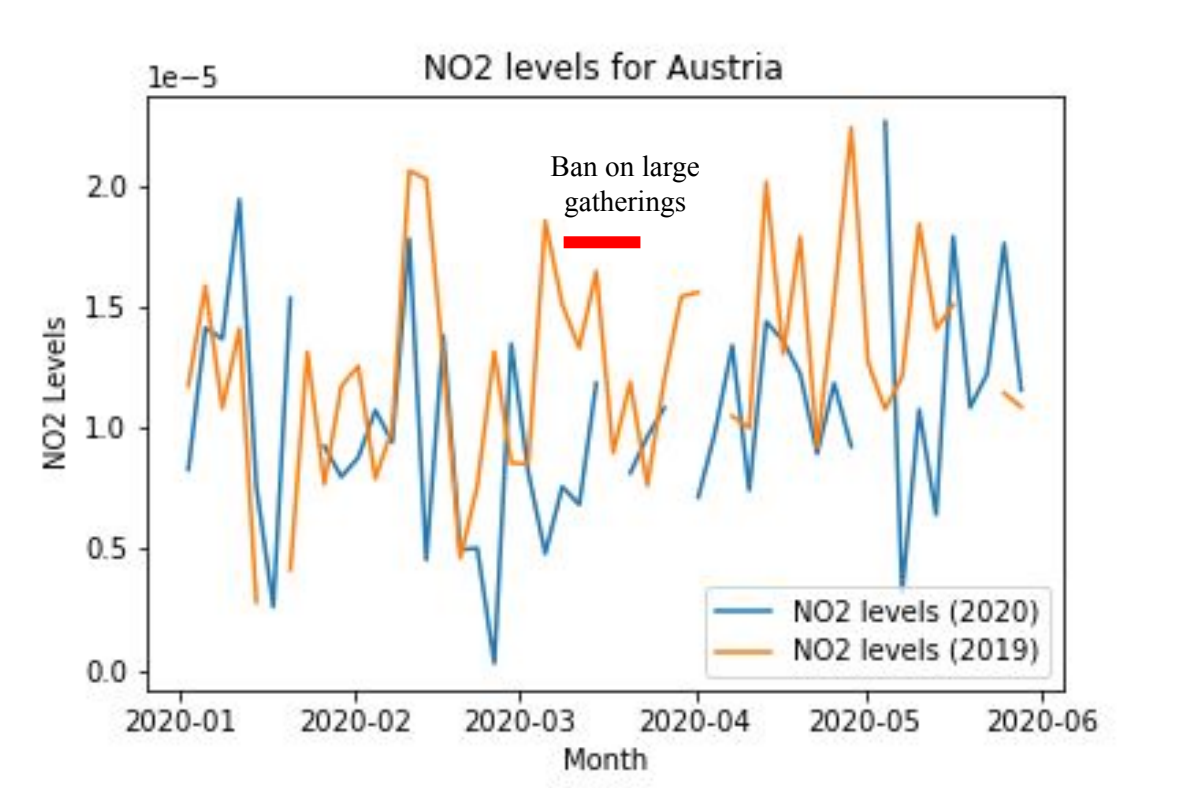
13th March - Closure of Non-essential services
16th March - Mandatory home confinements



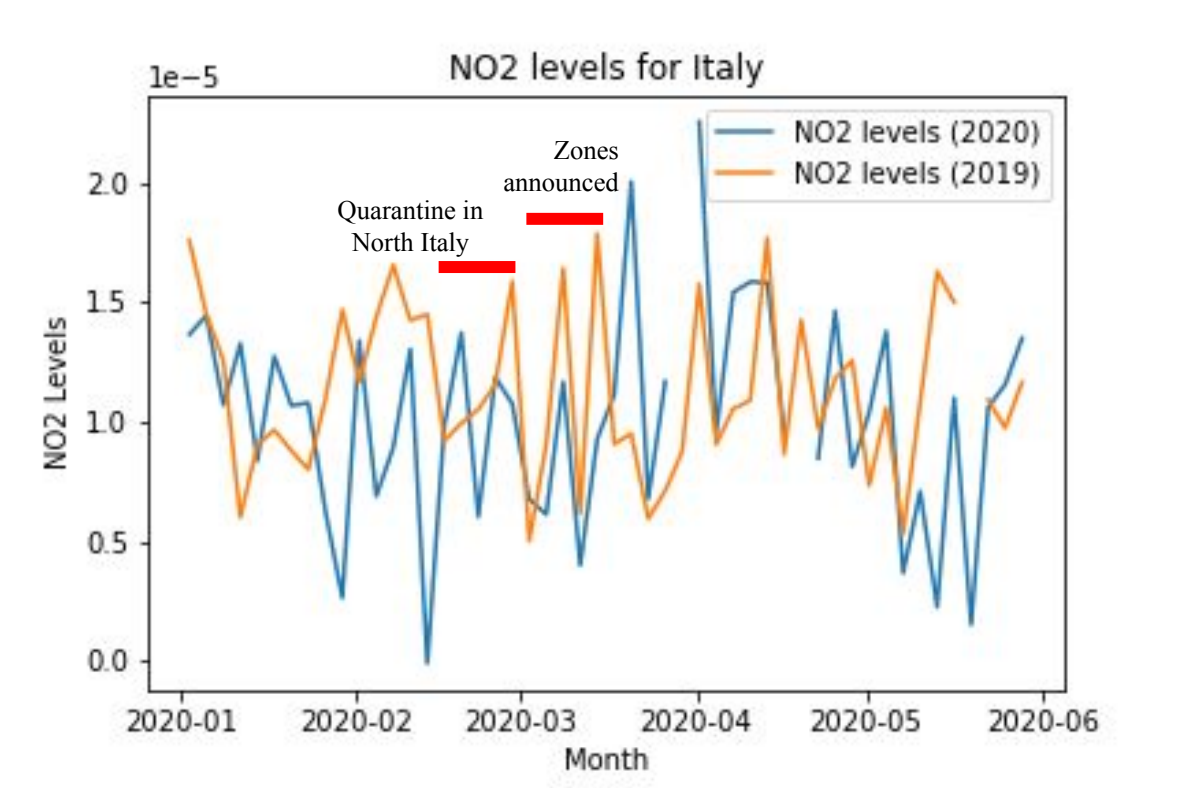
13th March - Schools closed
22nd March - Curfew imposed in 6 states

1. *Created using EOx-JupyterHub & xcube*
2. *National response to Covid-19 - Wiki entry*
3. *Contains modified Worldview data processed by Euro Data Cube.*

Graphs are affected by missing values. But it's easy to identify countries which were able to implement stricter quarantines vs those who couldn't! Germany vs Italy



15th-17th March - Ban on public gatherings



31st Jan - Appointment of Commissioner for Covid response
22nd Feb - Quarantine of northern Italy
1st March - Zones declared

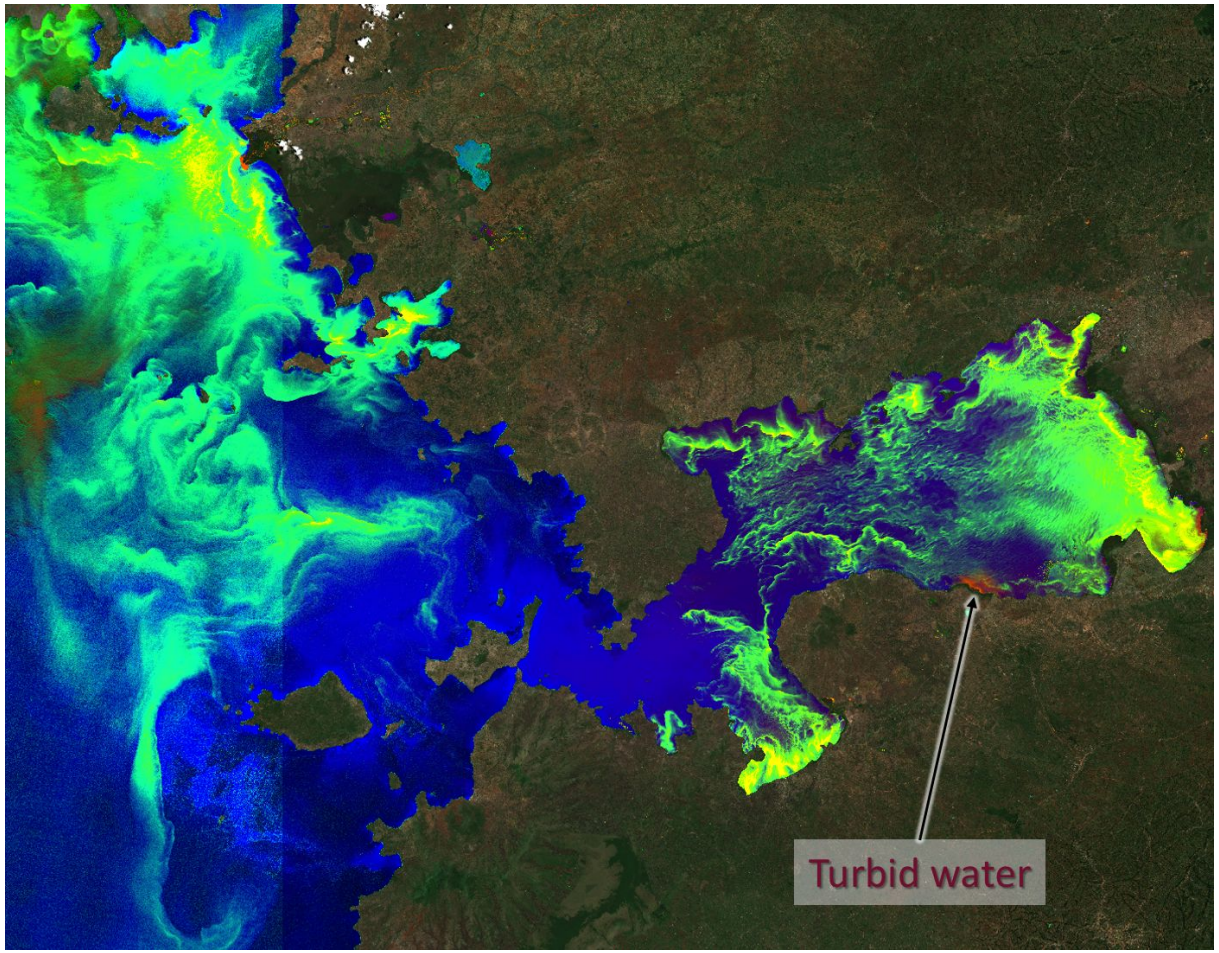
1. *Created using EOx-JupyterHub & xcube*
2. *National response to Covid-19 - Wiki entry*
3. *Contains modified Worldview data processed by Euro Data Cube.*

Measuring Quality of The Rivers in Europe

Monitoring boat traffic before/during/after covid could help understand the transportation modal shift and help businesses reorganize, as well as provide transparency to citizens and governments

Source: Foreseeing the Transportation Modal Shift, Michel Deuden

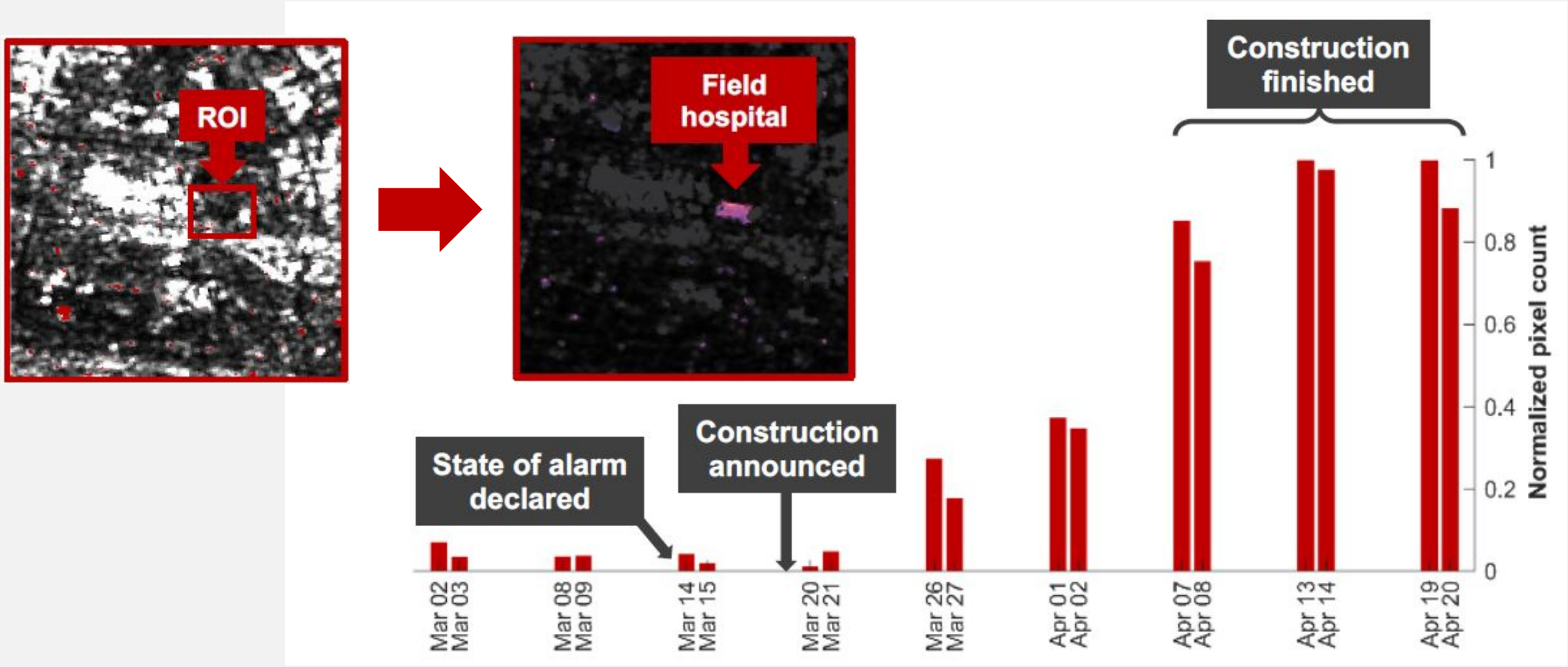
Aquatic plants & algae life in water



Using a Floating Algae Indicator (FAI) calculated from multi-spectral images obtained from Sentinel-2 L2A images

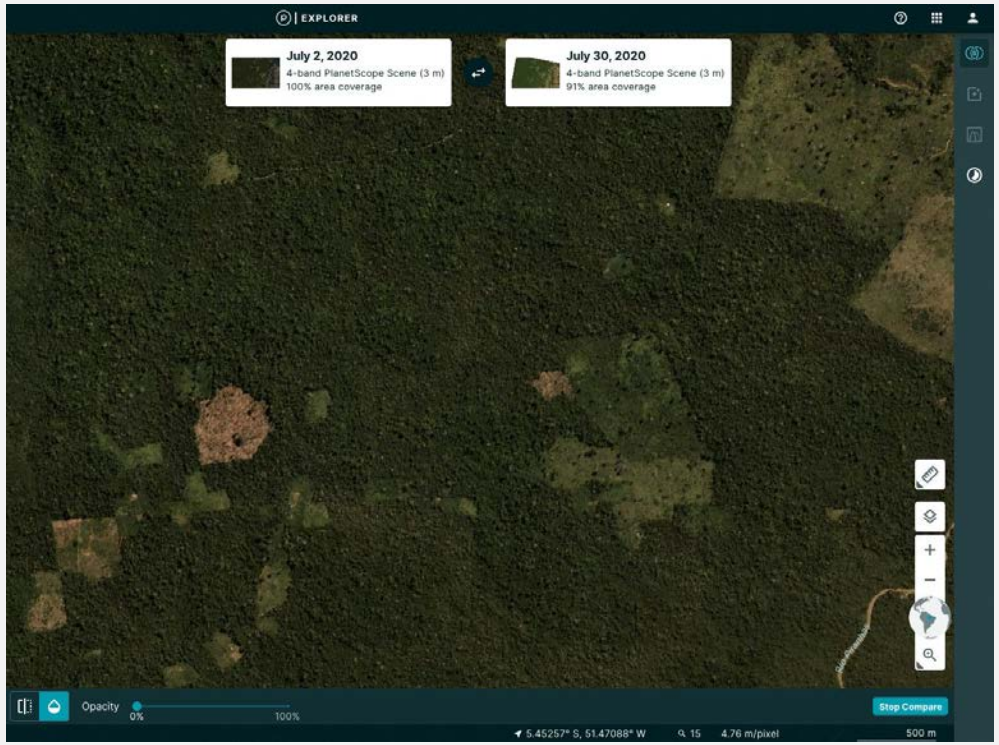
Source: The identification of aquatic plants and algae was inspired by previous research about detecting water hyacinth using remote (Thamaga and Dube, 2018) sensing and a floating algae index (FAI) designed by Hu (2009)

SAR for Monitoring Building Construction



Source: SAR for activity monitoring during COVID19, Jorge Garcia Tiscar

Measuring Deforestation



Source: Planet.com
Credit: Gilles Morain, Atanas Kozarev, Jerimiah Willhite, Kevin Lacaille, Brian Castro, Guy Ziv & Aakash Gupta

Using VHR for Measuring Car Distribution

Pre-lockdown

Post-lockdown

- Using open-source models for detecting more than 60 different classes
- Detecting cars and trucks in parking lots and highways
- Significant change in distribution of detected vehicles

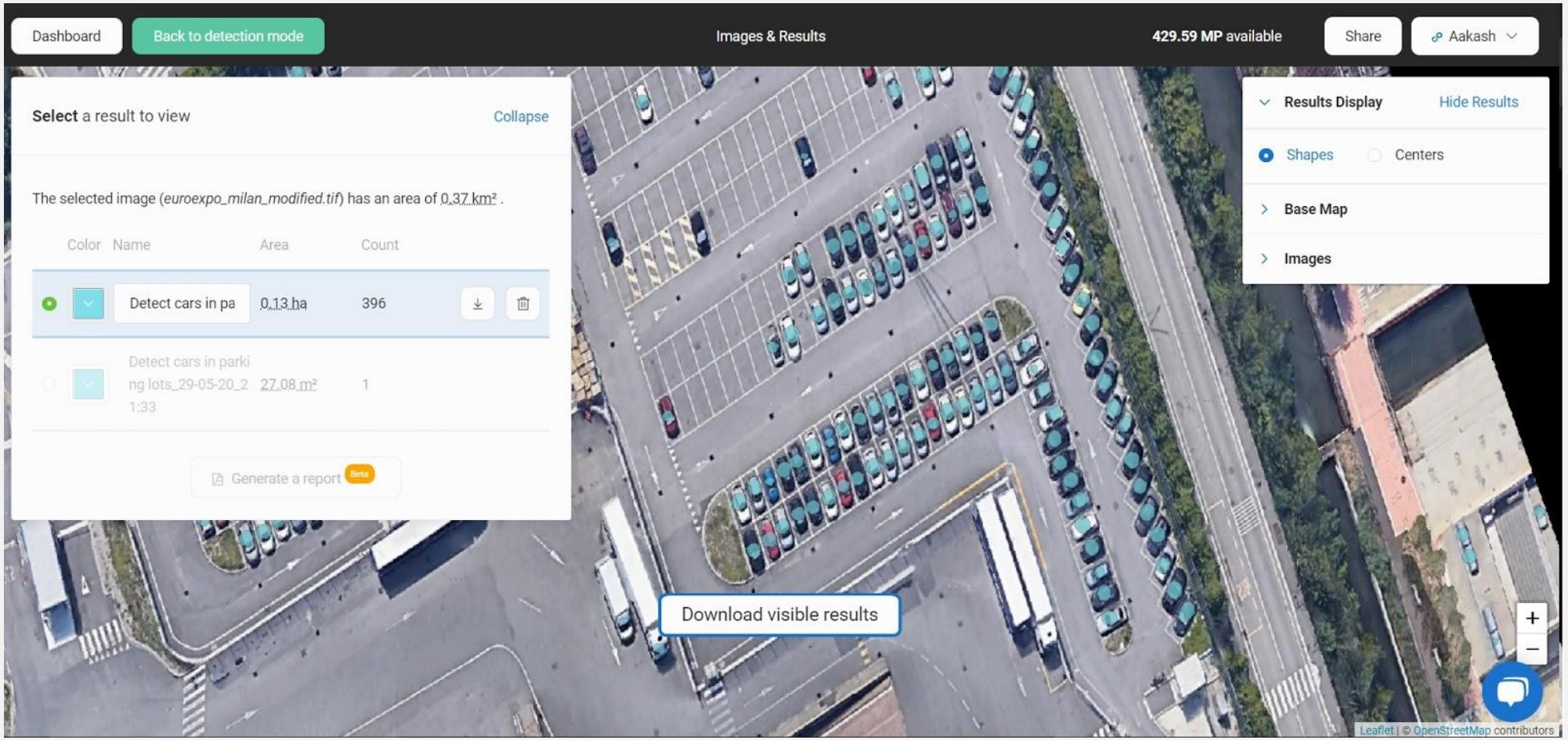
Source: Assessing lockdown impact on human activities, Domagoj Korais

Monitoring Airport Activity

- Count number of parked & flying airplanes
- Analyze temporal signals & identify anomalies.
- Unexpected changes should be reported to authorities

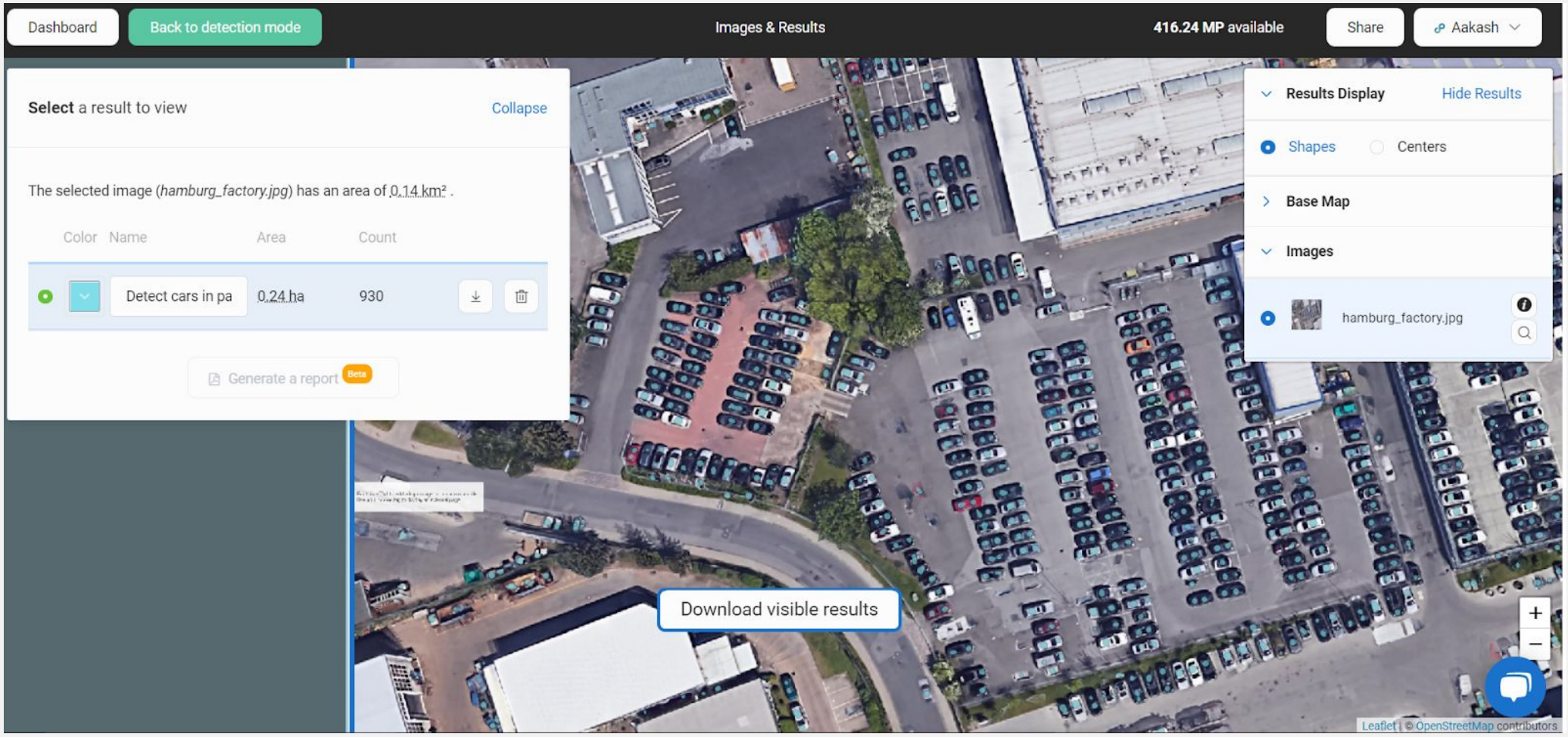
Source: Airport Activity Monitoring using Picterra - Nozhan Balafkan

Using Picterra to Detect Vehicles



1. *Milan (Italy) expo – parking lot image, Source: Google Earth Pro*
2. *Contains modified Worldview data processed by Euro Data Cube*
3. *Image processed via QGIS Desktop*

We are using off-the shelf detector algorithms to identify vehicles in VHR images
Count of vehicles shows if economic activity is taking place.



1. *Factory parking lot, Hamburg Germany (Italy) Source: Google Earth Pro*
2. *Contains modified Worldview data processed by Euro Data Cube*
3. *Image processed via QGIS Desktop*

Detecting & Counting vehicles using Open Imagery

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B.Tech Undergraduate student

Machine Learning Intern

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https://github.com/abhap12

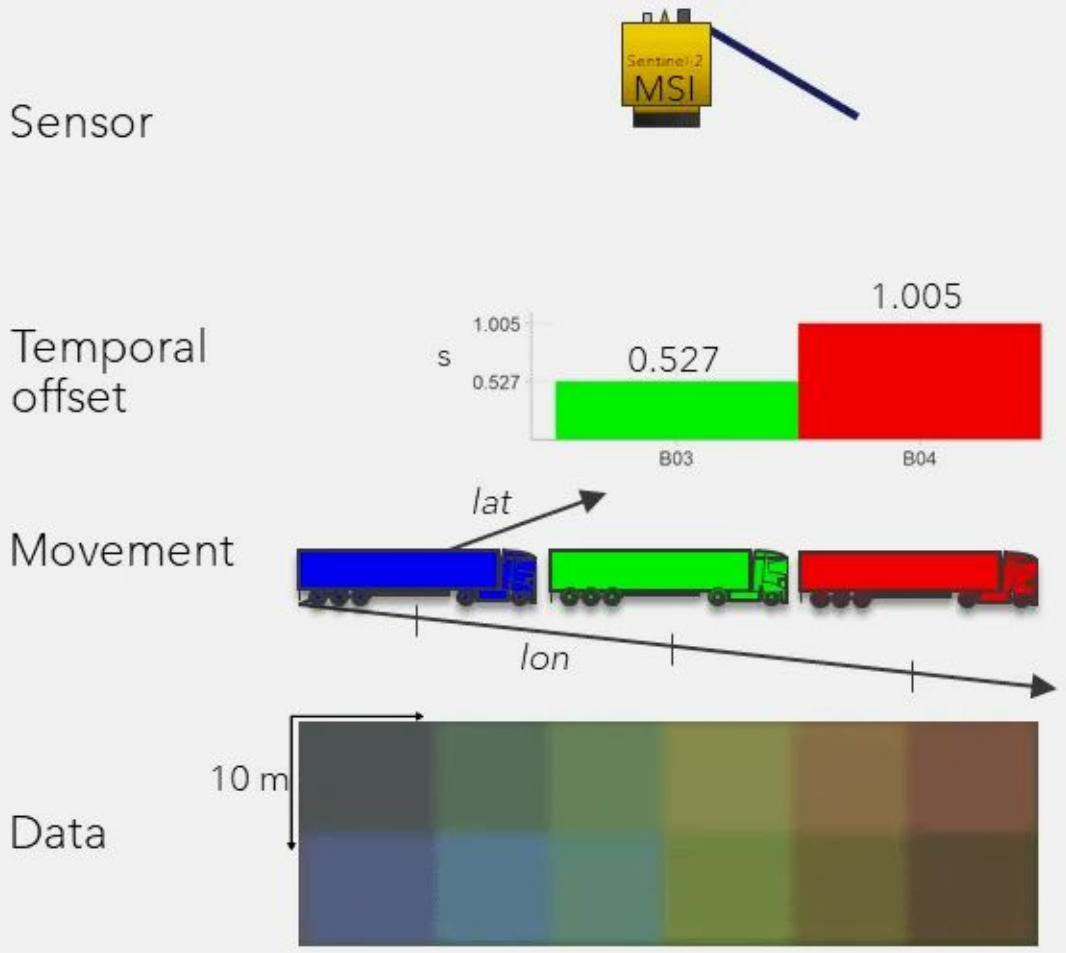
APPROACH

The configuration of sentinel -2 detectors causes two effects:

1. inter-detector,
2. inter-band parallax angles.

With the help of these two effects, the satellite detects the moving objects.

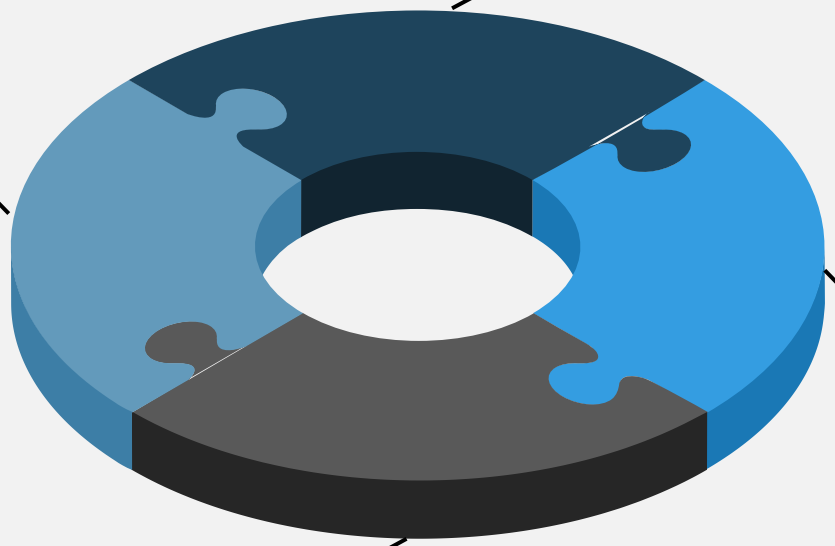
The offset of different wavelengths that moving objects have in Sentinel-2 data causes a reflectance in the RGB, which looks like a rainbow.



LIBRARY USED - PYTHON XCUBE

It extends xcube by a new Python API function xcube_sh.cube.open_cube to create data cubes from SENTINEL Hub.

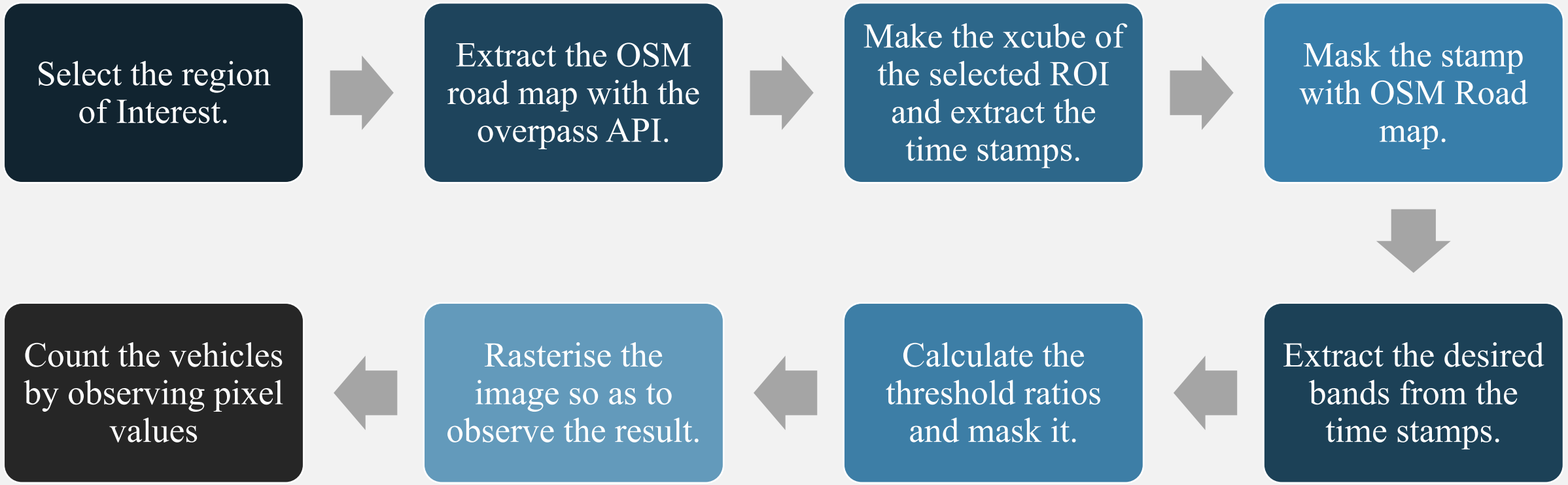
Library developed to provide Earth observation (EO) data in an analysis-ready form to users



It is based on popular data science packages such as xarray, Zarr, and Dask.

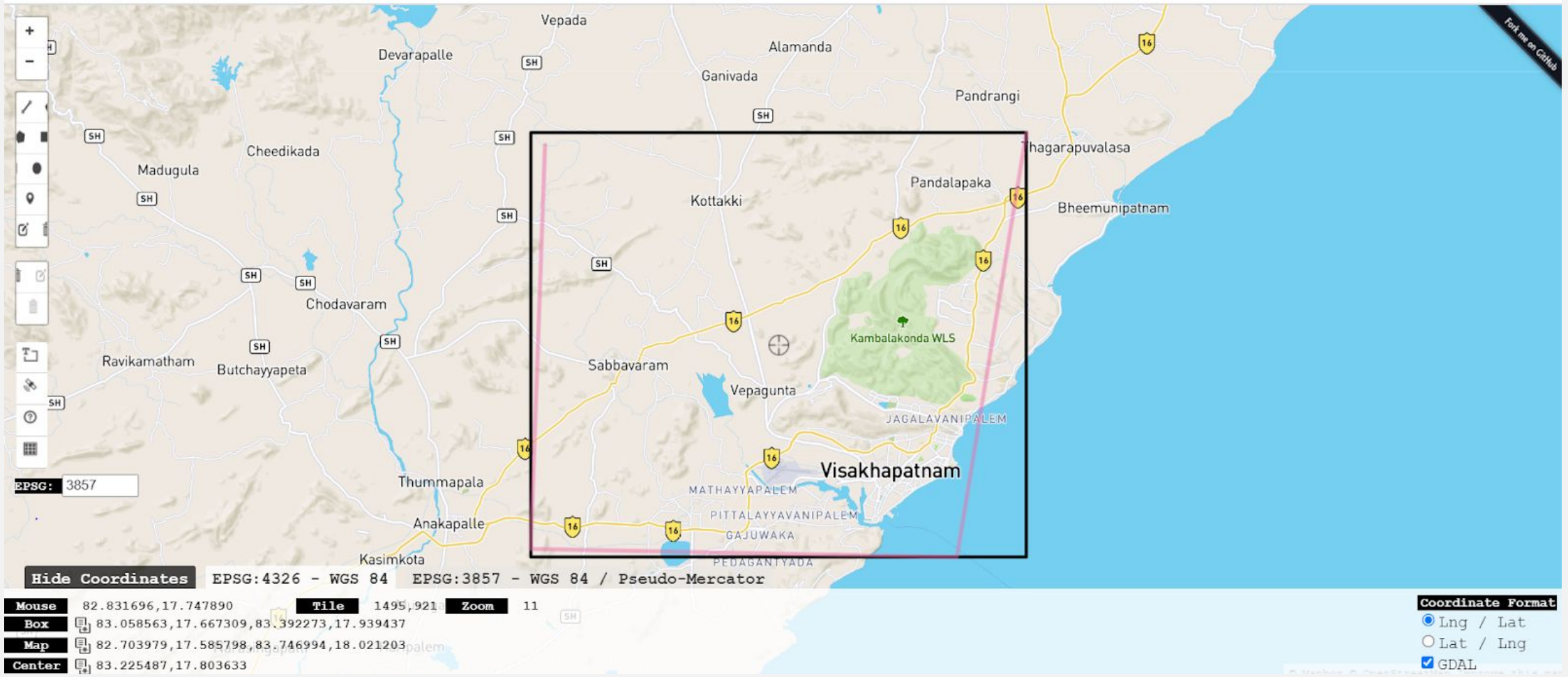
xcube_sh plugin adds support for the SENTINEL Hub Cloud API.

OVERVIEW


Select the region of Interest.
Extract the OSM road map with the overpass API.
Make the xcube of the selected ROI and extract the time stamps.
Mask the stamp with OSM Road map.
Extract the desired bands from the time stamps.
Calculate the threshold ratios and mask it.
Rasterise the image so as to observe the result.
Count the vehicles by observing pixel values

Region of Interest

Find out the coordinates of the region of interest. For example - Vishakhapatnam

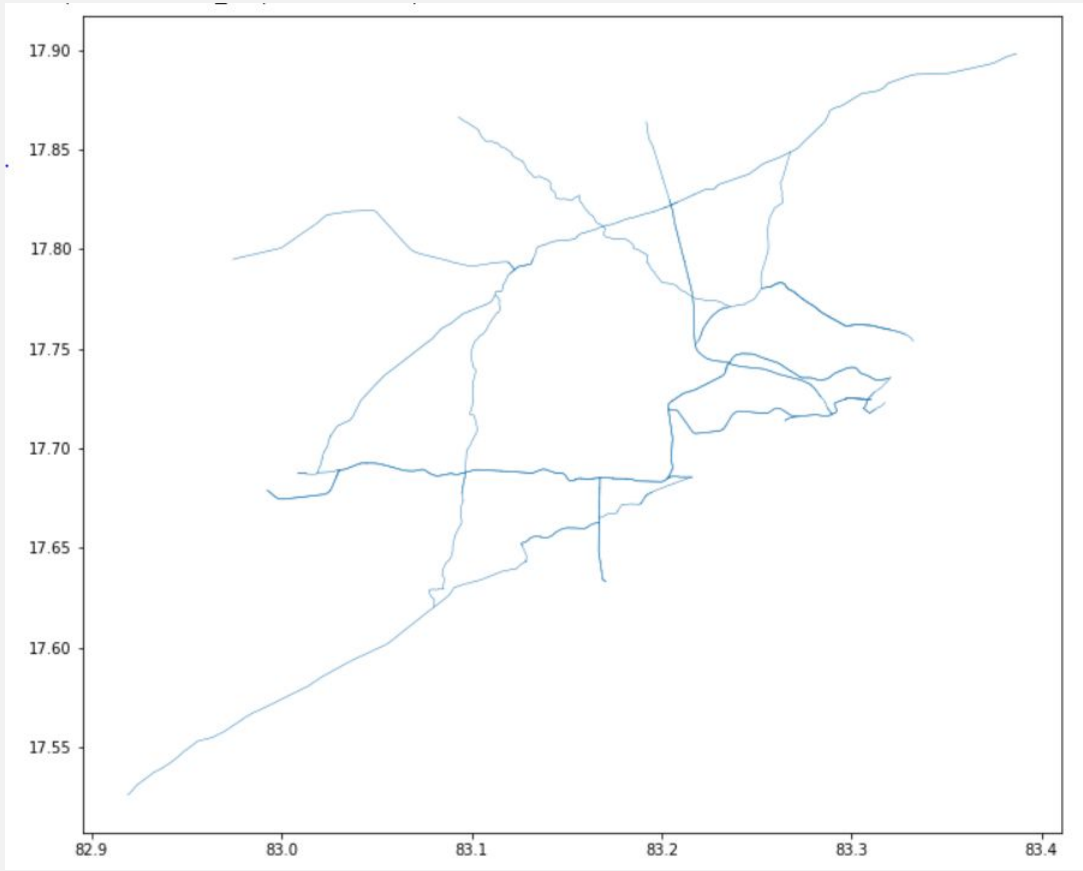


Extract The OSM Road Map with The Overpass API.

Code snippet:

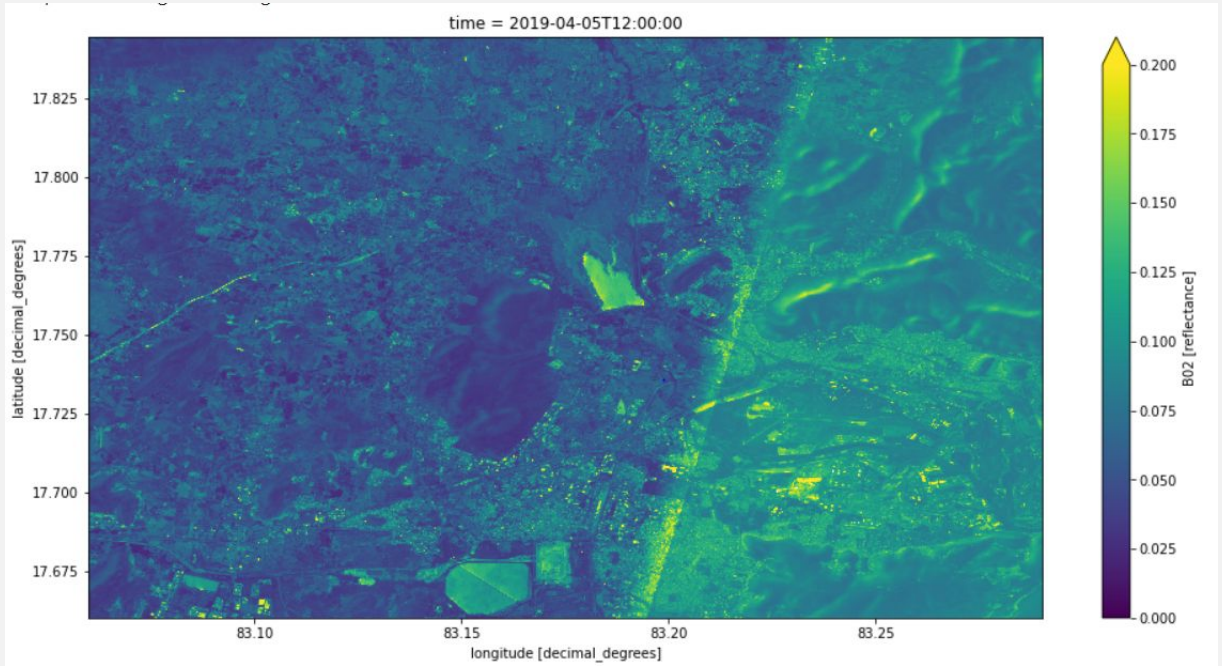
```
query = overpassQueryBuilder(bbox=bbox_osm,
                             elementType=element_type,

                             selector=selector,
                             out='body',
                             includeGeometry=True)
```



Making The Cube and Extract The Time Stamps

- Make the xcube of the selected ROI.
- Select time range of 5 Days.
- Obtain time stamps.
- Mask the stamp with OSM Road map.



Code snippet:

```
config_19 = CubeConfig(dataset_name = "S2L2A",
                       band_names = ["B02", "B03", "B04,
"B08", "B11", "SCL"],
                       tile_size = [512, 512],
                       geometry = bbox,
                       spatial_res = 0.00009,
                       time_range = [dates[0], dates[1],
                       time_period = time_period)
cube_19 = open_cube(config_19)
```

Processing The Time Stamps and Calculating The Thresholds

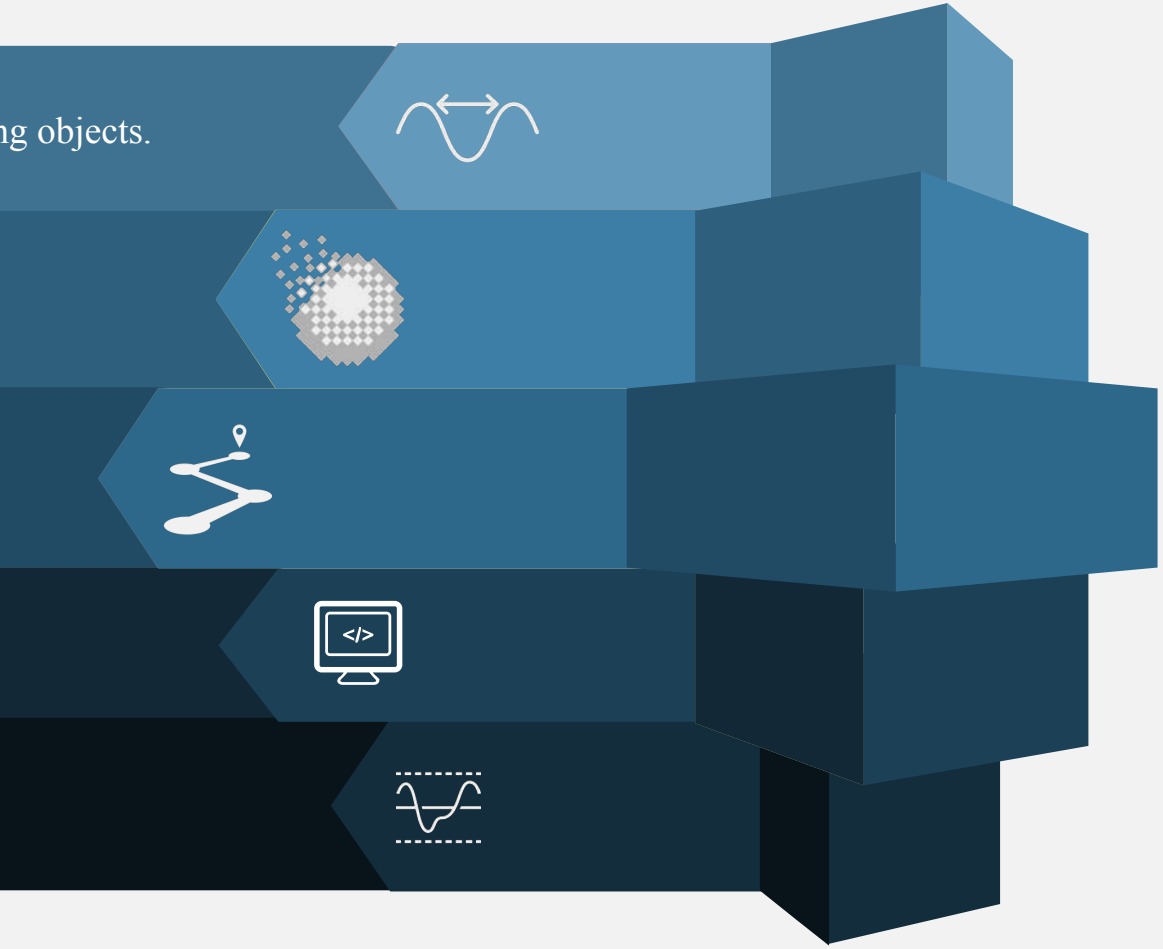
The detection exploits the offset of different wavelengths reflected by moving objects.

It targets pixels where blue is higher than green and red.

First, a road masking is done then the data is masked to these pixels.

Second, the ratios between blue and green and blue and red are calculated.

Finally, thresholds are applied to these ratios.



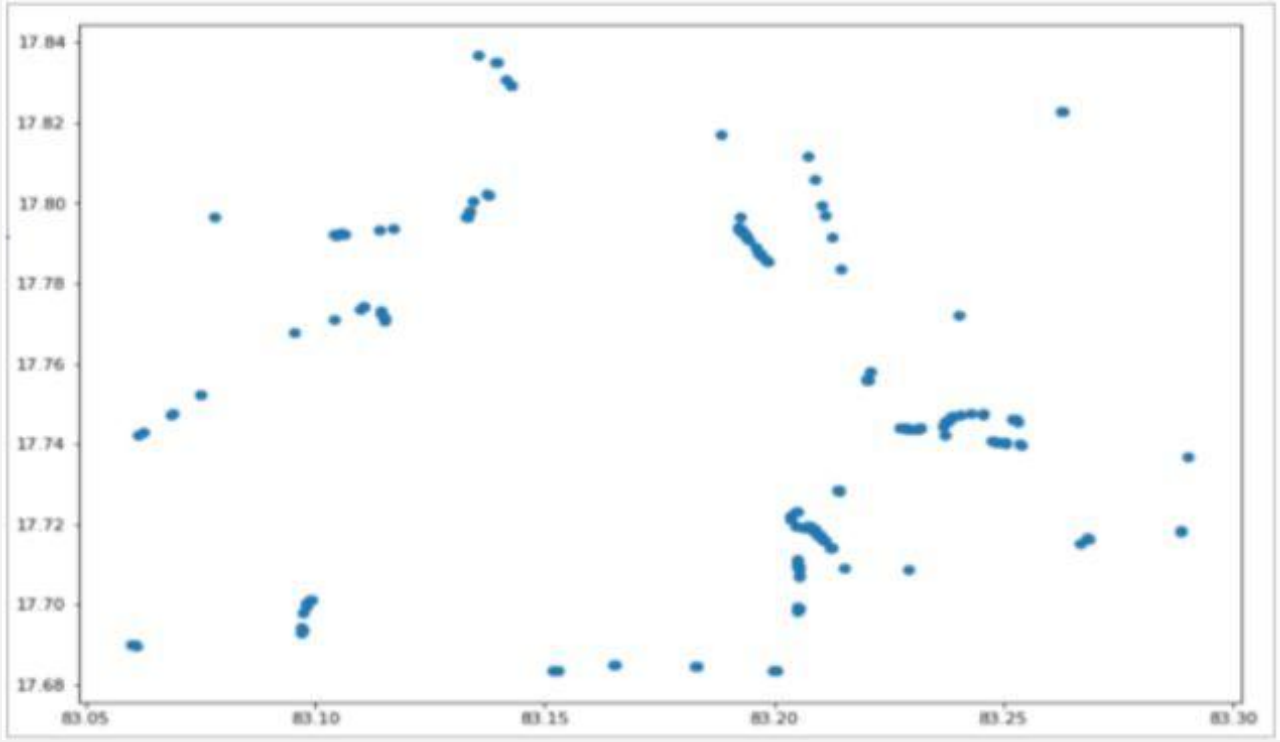
THRESHOLDS AND FORMULAS USED

CODE SNIPPET:

```
def calc_no_trucks(B02, B03, B04, B08, B11):
    th = {"min_blue":0.06,
          "min_green":0.04,
          "min_red":0.04,
          "max_red":0.15,
          "max_green":0.15,
          "max_blue":0.2,
          "max_ndvi":0.5,
          "max_ndwi":0.0001,
          "max_ndsi":0.0001,
          "min_blue_green_ratio":0.03,
          "min_blue_red_ratio":0.05,
          "max_blue_green_ratio":0.17,
          "max_blue_red_ratio":0.2}
    ndvi_mask = ratio(B08, B04) < th["max_ndvi"]
    ndwi_mask = ratio(B02, B11) < th["max_ndwi"]
    ndsi_mask = ratio(B03, B11) < th["max_ndsi"]
    low_rgb_mask = (B02 > th["min_blue"]) * (B03 > th["min_green"]) * (B04 > th["min_red"])
    high_rgb_mask = (B02 < th["max_blue"]) * (B03 < th["max_green"]) * (B04 < th["max_red"])
    no_truck_mask = ndvi_mask * ndwi_mask * ndsi_mask * low_rgb_mask * high_rgb_mask
    return no_truck_mask
```

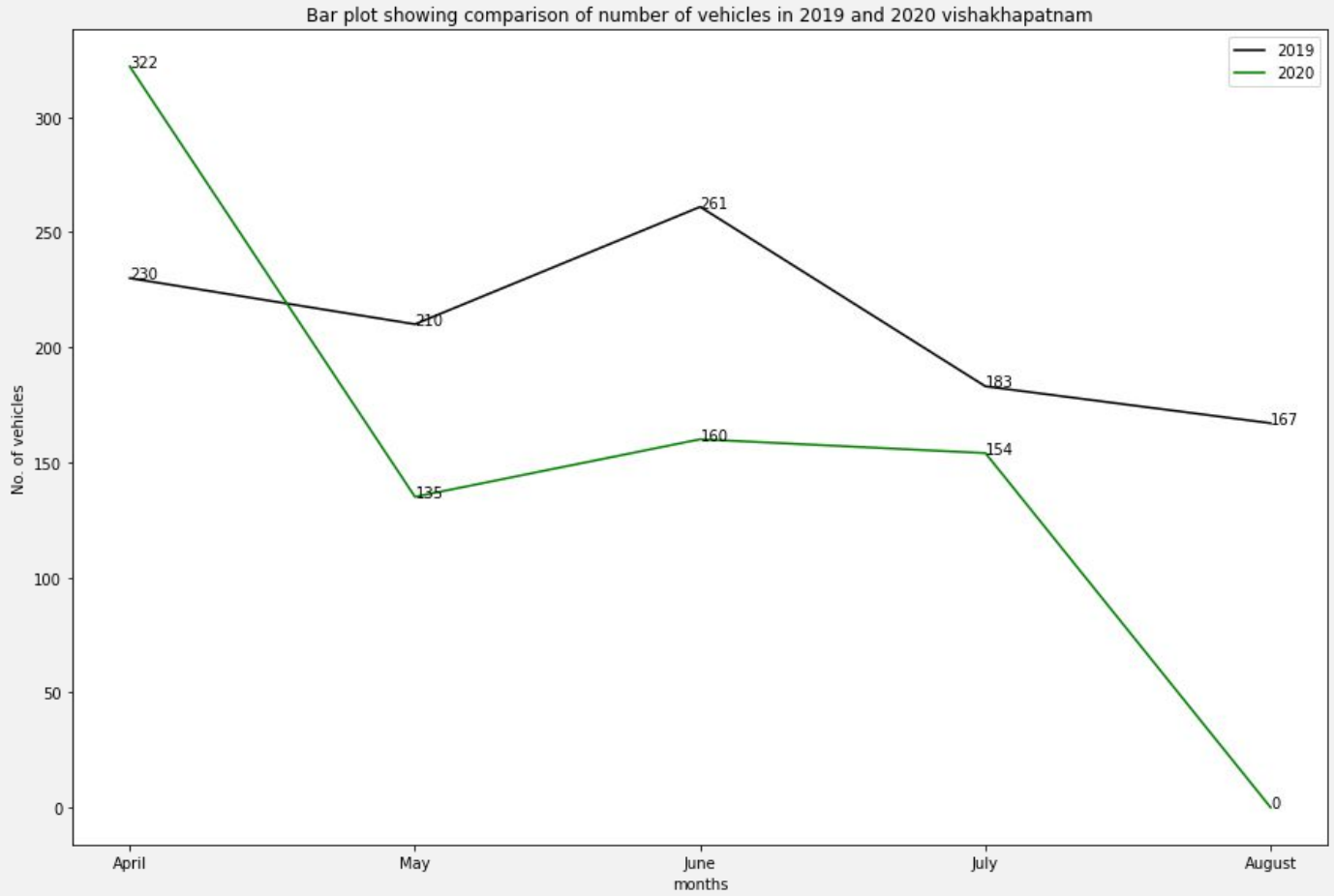
Rasterize The Image to Visualize It and Find Out The Results.

- Each truck is represented by one to three pixels with value 1 in the result.
- Rasterizing the result gives us this.



RESULTS FOR VISAKHAPATNAM

Graph showing number of trucks on some dates of the month and the comparison between before pandemic and during pandemic.



LIMITATIONS AND ASSUMPTIONS

- The major drawback is cloud acquisition, so we have to select the dates carefully having less amount of clouds to get the proper results.
- It doesn’t treat clouds and thus give the count 0 if there is some cloud acquisition.
- Also the number of trucks on the road obtained are not accurate as the minimum spatial resolution is of 10 metres.
- But we can get the approximate number. which can let us know about the relative truck density. Thus This will be very helpful in a pandemic like COVID to analyze the lockdown situation.

Surface Water Monitor using Earth Engine

Apsal S

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LinkedIn : apsals

Github : apzl

Geemap

- A Python wrapper of Google Earth Engine for interactive mapping with, ipyleaflet, and ipywidgets.
- http://geemap.org

Google Earth Engine

- Provide an interactive platform for geospatial algorithm development at scale
- geospatial APIs and an interactive app server

Normalized Difference Water Index (NDWI)

For Landsat 8,

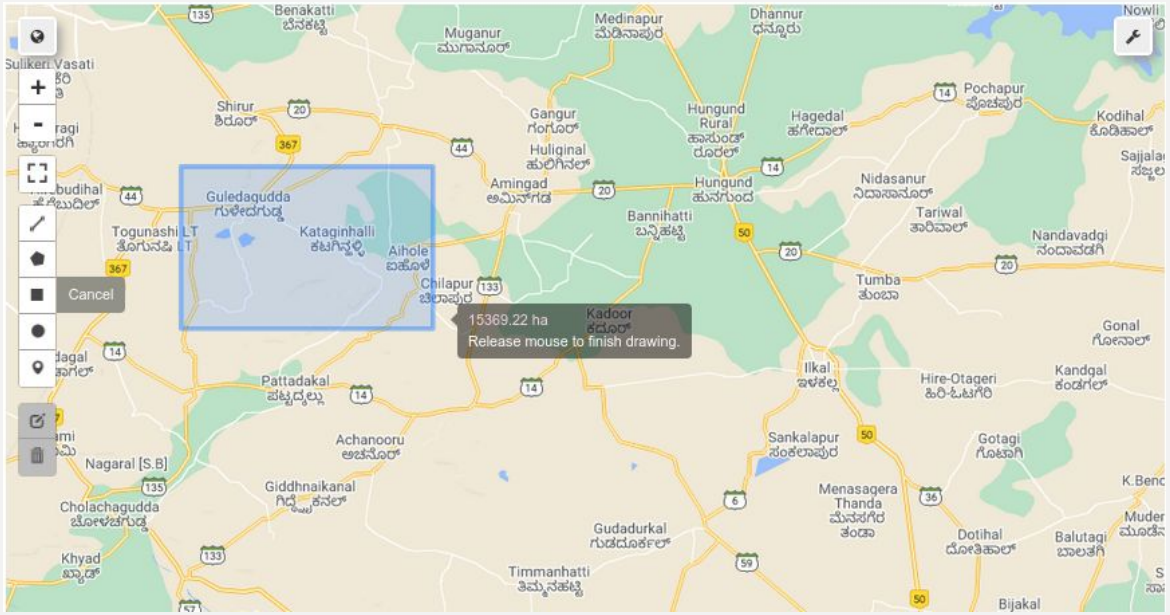
NDWI = (Band 3 – Band 6) / (Band 3 + Band 6)

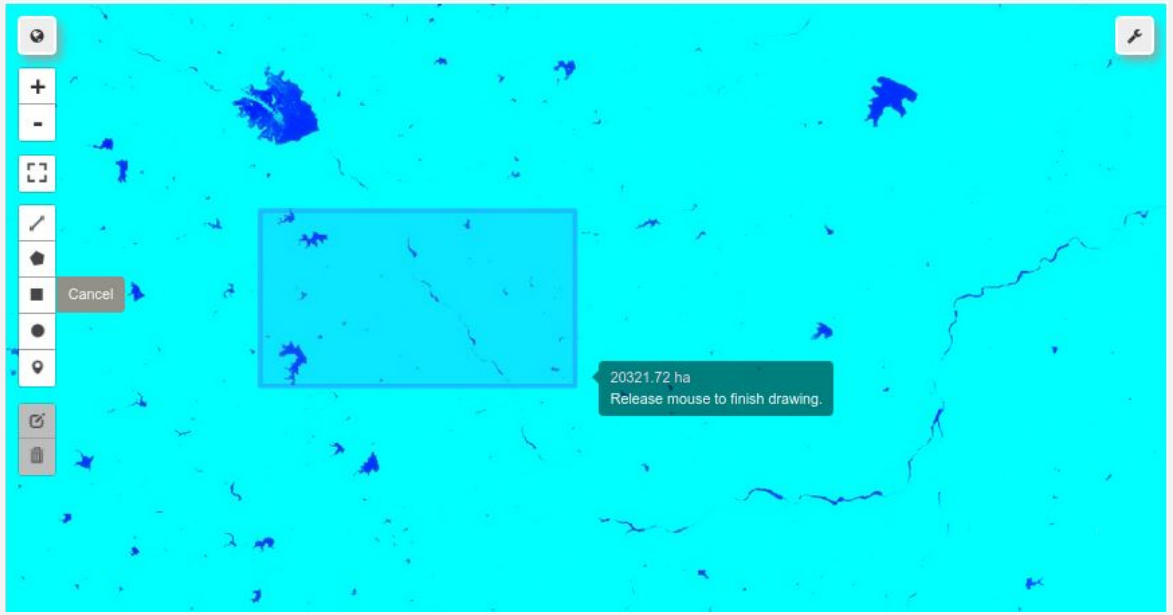
The Normalized Difference Water Index (NDWI) method is an index for delineating and monitoring content changes in surface water.

Green and Short wave infrared waves are used for this.

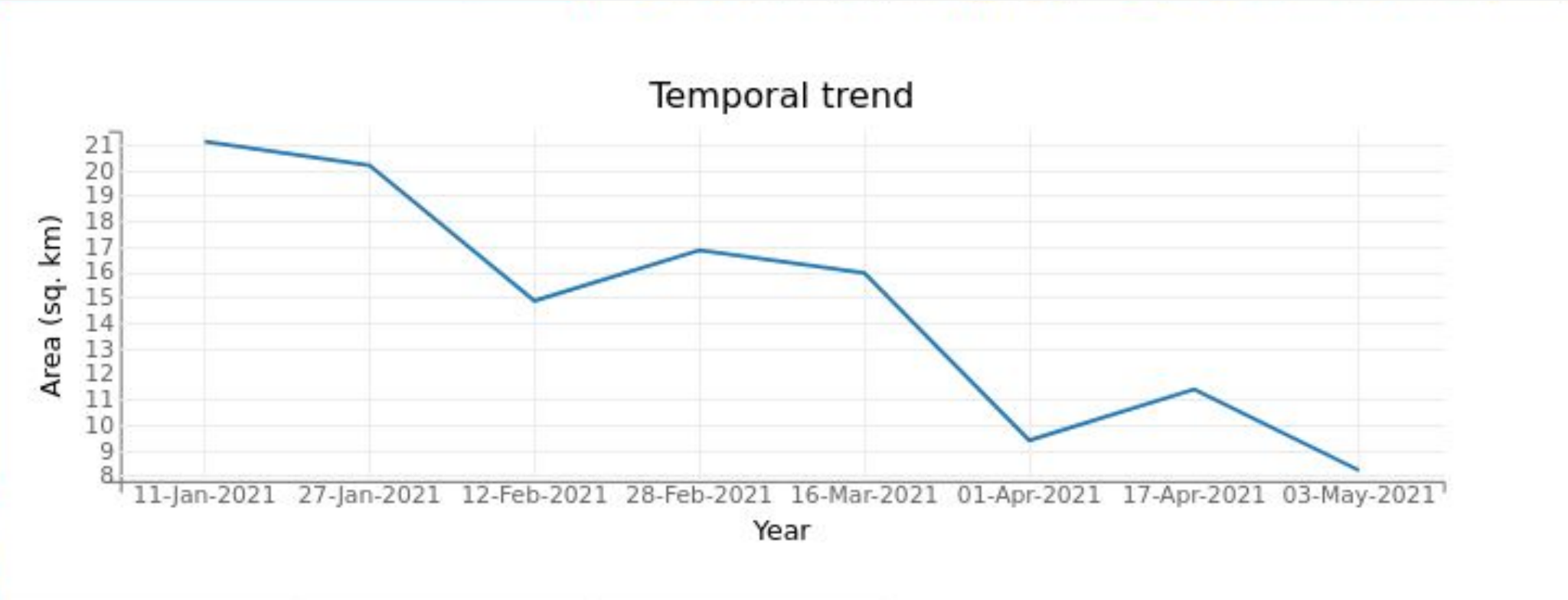
For landsat 8 they are represented by band 3 & band 6. NDWI value lies between -1 & 1.

Generally water bodies have an NDWI index > 0.3.



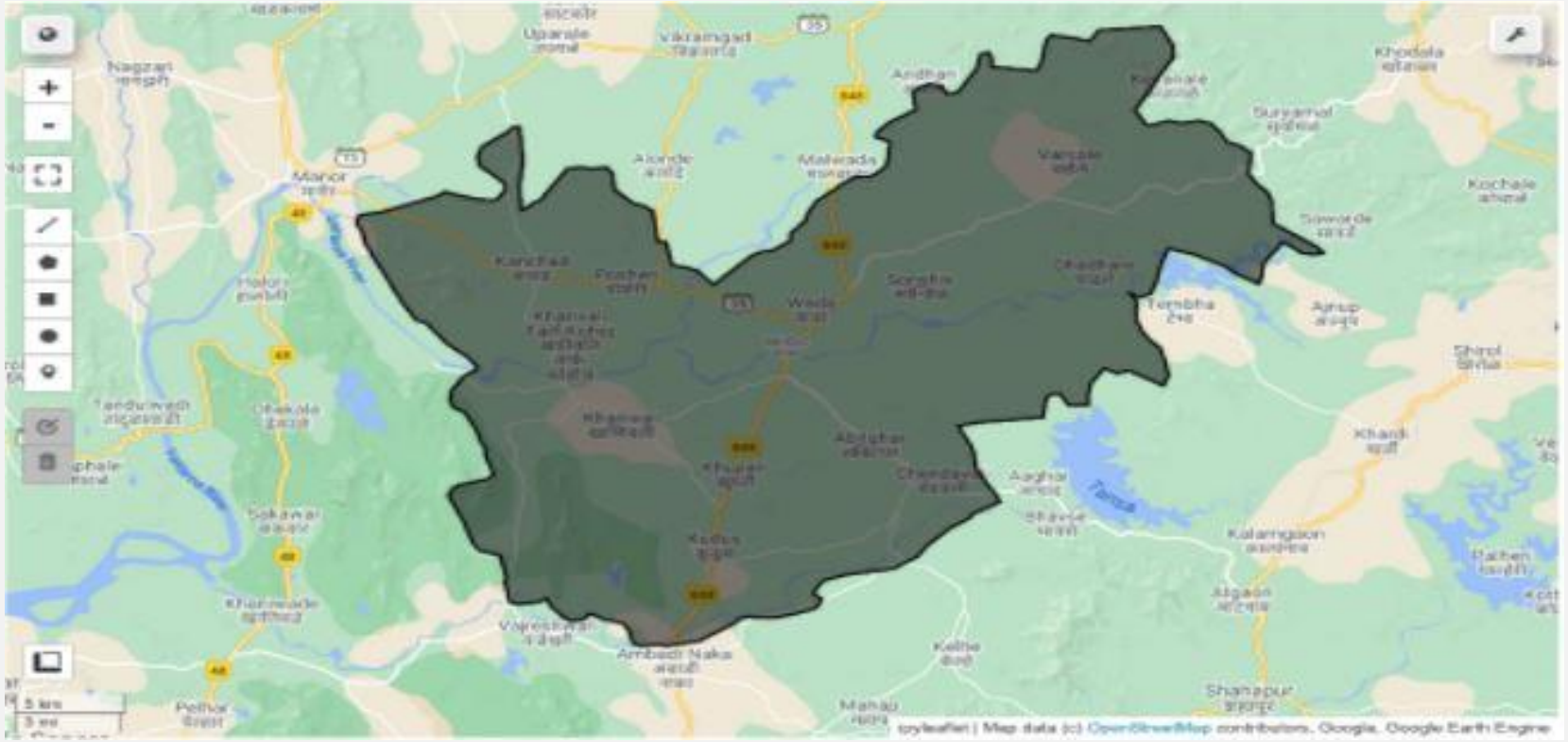


- Select region using widgets
- NDWI calculated and filter is applied on top of map

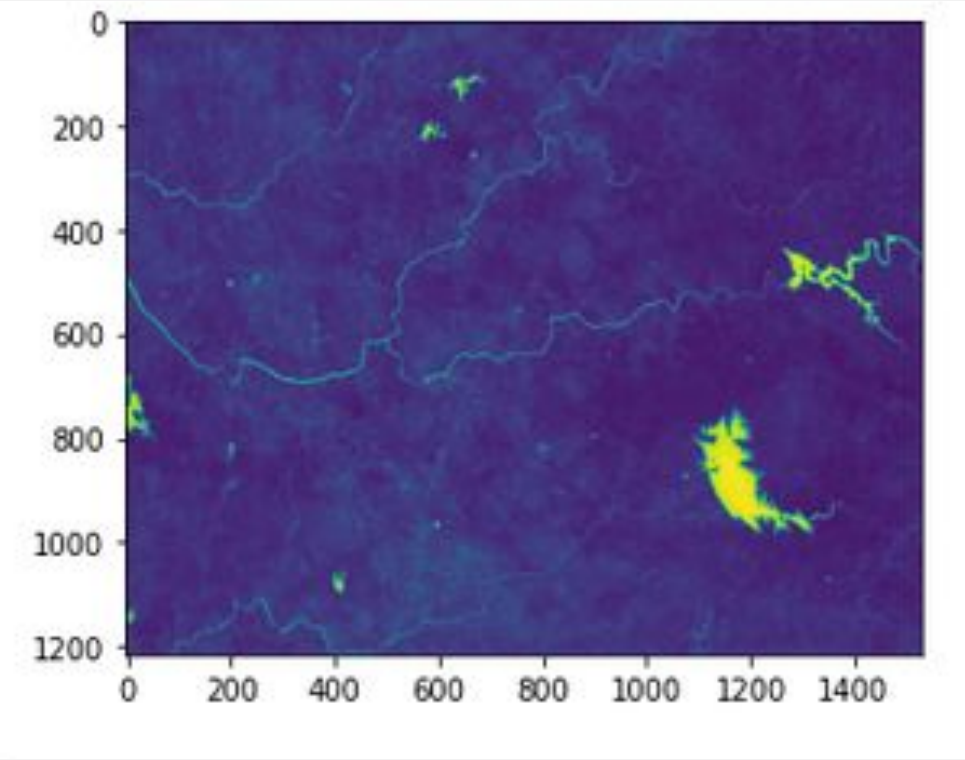


- Surface water area during a time interval is plotted

Count of Water Bodies



- A taluk is selected using level-3 shapefile



Applying connected-component analysis using OpenCV and Scikit-learn

```
In [27]: "{0}, {1} has a total area of {2} sq.kms and has {3} water bodies".format(taluk_name,state_name, area,water_number))
```

```
Vada, Maharashtra has a total area of 778.2246086393388 sq.kms and has 7 water bodies
```

Assumptions & Limitations

- Availability of data
  - Large gaps in re-visit times. Especially in rural Or remote areas
  - Sensors giving incorrect information
  - Cloud covers
- Data providers are for-profit organizations, as such it may not be possible to provide regular updates in some areas.
- You may not have an image for the period of interest.
- Vehicle detection is done on sample images and snapshots attached (for ref.)
- NDWI is sensitive to built-up land and can result in over-estimation of water bodies.
- Complex shapes and irregular areas of water bodies may also affect the accuracy when counting the number of water bodies using Connected-Component Analysis.
- Bureaucracy & access to sensitive datasets.
- Local laws & regulations

References & Attribution

- Contain modified WorldView data processed by Euro Data Cube
- Some of the images were processed via Sentinel-Hub Custom scripts
- Assessing lockdown impact on human activities, Domagoj Korais
- arVix: Objects in context in overhead imagery, Darius Lam, Richard Kuzma, Kevin McGee, Samuel Dooley, Michael Laielli, Matthew Klaric, Yaroslav Bulatov, and Brendan McCord.
- SAR for activity monitoring during COVID19, Jorge Garcia Tiscar
- Deep learning for end-to-end automatic target recognition from Synthetic Aperture Radar Imagery, Hidetoshi FURUKAWA
- Building Detection in VHR SAR Images using Fully Convolutional Networks, Muhammad Shahzad ; Michael Maurer ; Friedrich Fraundorfer ; Yuanyuan Wang ; Xiao Xiang Zhu
- Foreseeing the Transportation Modal Shift, Michel Deuden
- Visualizing ship movements across the globe, https://www.shipmap.org
- Lettuce, Labour and Food Security, Monitoring lettuce production in the Yuma County Arizona
- Airport Activity Monitoring using Picterra - Nozhan Balafkan
- PlanetHack 2020 challenge repo, https://github.com/kevinlacaille/planet_hack_2020_deforestation