Department of Mechanical and Aerospace Engineering
University of Strathclyde, Glasgow UK
January Semester, 2021/2022

ME975 Assessment

Individual Project Guidelines

March 15, 2022

Submission date ..... April 19, 2022, at 12:00 pm (midday)
Authored by ..... Dr Annalisa Riccardi
Marks returned by ..... May 9, 2022
Final mark weighting 60%

1 Introduction

The main goal of the individual project is to give the possibility to students to consolidate their practical skills of retrieving, processing and analysing *satellite data*. Last but not least, students will be given the possibility to practice written project report. Academic marker will provide feedback on technical content and project writing.

2 Project task

The task assigned is to analyse the levels of Nitrogen Dioxide (NO2) in the year before and after COVID restrictions in Scotland, to understand how these levels have changed in relation with lockdown restrictions and population density.
NO2 primarily gets in the air from the burning of fuel, so NO2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment.
The data sets on Google Earth Engine to be used for the task are

- `FAO/GAUL/2015/level2` [Link]: to extract the geometric boundaries of the 12 districts in Scotland: *Borders, Central, Dumfries and Gal, Fyfe, Grampian, Highland, Lothian, Orkney, Shetland Islands, Strathclyde, Tayside, Western Isles*

- `Sentinel-5P OFFL NO2` [Link]: to access the information on NO2 concentrations. You must consider only the band *tropospheric_NO2_column_number_density* that contains the tropospheric vertical column of NO2, so the concentrations at the lower level of the atmosphere, closer to the Earth's surface.
- `GHSL: Global Human Settlement Layers`[Link]: to access information on population spatial distribution. You must consider the band *population_count* and the 2015 yearly asset that can be accessed as an image with the command

  `ee.Image('JRC/GHSL/P2016/POP_GPW_GLOBE_V1/2015')`

The following information must be computed for every district in Scotland:

- **Average NO2 concentrations for years 2019, 2020, 2021**: this analysis is aiming at computing the average NO2 concentration for every districts in Scotland for the year before covid (2019), the year of covid outbreak (2020) and the year of recovering after full lock down (2021). This means that for every district in Scotland you must compute three values, representing the NO2 average concentrations in that district in year 2019, 2020 and 2021. Each of these values can be computed by using a reduce method. The steps are
  - Filter the GEE Image Collection of Sentinel5P data, between the 1st of January 20XX and the 31st of December 20XX, and compute the *mean* composite to obtain the corresponding GEE Image that we are here naming `no2`.
  - On the obtained GEE Image (`no2`) apply a mean reducer on the geometry of a district in Scotland, that we are here naming (`roi`). Use the values: *scale*=1000, *maxPixels*=1e09, for the Reducer (see Tutorial 3 on Reduce). A code snippet is given below

    ```
    res = no2.reduceRegion(**{
        'reducer': ee.Reducer.mean(),
        'geometry': roi,
        'scale': 1000,
        'maxPixels':1e9
      })
    ```

    `res` is the value of average NO2 concentrations for district `roi` and year 20XX
- **Population density**: compute the population density for each district of Scotland as the ration between the total population and the district area. The steps are
  - Initialise a GEE Image from the GHSL dataset as explained above, that we are here naming it `pop`
  - Apply on Image `pop` a sum reducer on the geometry of a district in Scotland, that we named (`roi`) (see Tutorial 3 on Reduce). Use the values: *scale*=250, *maxPixels*=1e09, for the Reducer. A code snippet is given below

    ```
    res = pop.reduceRegion(**{
        'reducer': ee.Reducer.sum(),
        'geometry': roi,
    ```

```
    'scale': 250,
    'maxPixels':1e9
  })
```

- Get the value of the district area by accessing the property *Shape_Area* of the FAO GAUL Level 2 feature represented by `roi` (see Tutorial2 on FeatureCollection)
- Divide population count `res` by 1e06 (to scale it to a million unit), and divide the resulting value by the district area

3 Plotting

You can plot the maps of the average NO2 levels across the year 2019, 2020, 2021 using the following visualisation parameters

```
viz = {
  'min': 0,
  'max': 0.00008,
  'palette': ['black', 'blue', 'purple', 'cyan', 'green', 'yellow', 'red']
}
```

The values extracted for population density and NO2 levels across the three years, you can plot them, for each district as histograms, line plots and/or just report them in a table. You can use the tool you prefer to generate the plots (MS Excel, Matlab, Python, ...).
How you decide to present the results, and how informative they are, it will be part of the evaluation criteria presented below.

4 Report outline

The project report shall include an abstract and be structured in the following sections (between brackets it is provided an indication of the percentage, of the total word count, that each section should cover)

- **Introduction** (5%): introduce project scope and objectives, meaning what you are aiming to achieve with your analysis and in general why NO2 monitoring is important.
- **Literature review** (10%): provide a literature review on existing research work that have completed a similar analysis using satellite data and contextualise your work in this research landscape.
- **Methodology** (15%): describe the approach adopted to gather and analyse all the necessary data. Source code developed must be included as appendix to the report and does not count towards total word count. The methodology section should include as a minimum, a description of the datasets used and the process completed to assimilate and analyse them.
- **Results** (40%): report the results obtained for each district in Scotland. Use plots and tables to present your results.

- **Discussion** (20%): discuss the results obtained within the single district and across the different districts.
- **Conclusion**(10%): summarise the results achieved, conclusions that can be drawn, limitation of the approach and provide some recommendation for future work and development.

5 Marking scheme

The following marking scheme, that sums up to 100, will be used

- 10 marks: *Structure and style*. Report structure (division in sections/subsections) and presentation (as by department guidelines, meaning for example: references in text, figures and referenced in text, captions, ...).
- 10 marks: *Literature review*. Completeness of literature review work (at least 5 relevant research papers cited in text).
- 20 marks: *Methodology*. Clarity, completeness and conciseness of the presentation of the methodology.
- 30 marks: *Results*: Completeness and correctness of the results obtained. Clarity of presentation of the results for the discussion.
- 30 marks: *Discussion*: Depth and soundness of the discussion provided for the results.

6 Submission Requirements

You are requested to submit a report of **minimum 2500 words and maximum 5000 words** and to use the report template that you can find under the same myplace section as these guidelines.

In order to complete this part of the class assessment you are requested to

- **Submit a copy of your original work through myplace by the 19th of April 2022 at midday** - pdf copy preferred.

All work submitted to the University, should be your own. This assignments will be submitted through Turnitin. The originality check feature of Turnitin will be used to assess your work for originality.

Any loss of data, reports or logbooks is your responsibility. Please do not work from a USB stick or unbacked up machine, instead work from a remote (iDrive) or cloud synced folder such as OneDrive, Google Drive, Dropbox etc.

Please consult the provided documents on department guidelines for **report writing** and university policy on **plagiarism** (under the Departmental guidelines folder on myplace).

Marks will be returned within three/four weeks from the submission deadline to allow for any possible extension granted.