Imperial College London

Department of Earth Science and Engineering

MSc in Applied Computational Science and Engineering

Independent Research Project

Project Plan

Seagrass mapping using satellite data on Google Earth Engine

by

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GitHub repository: https://github.com/acse-2019/irp-acse-ws4418

1. Introduction

Seagrasses are plants living in the water and play significant ecological roles in the coastal ecosystem because they can form broad habitats near the continental shelf (Traganos et al.; 2018a, Traganos et al., 2018b). In this area, other species are benefiting from the nutrients provided by seagrasses. Meanwhile, seagrass meadows can prevent excessive erosion and absorb the greenhouse gas via photosynthesis, which reduce 15% of ocean's carbon (Traganos et al., 2018; Nordlund, 2016). In that way, they make a huge contribution to the biodiversity and element balance of the ecosystem. Furthermore, the content of organic matter produced by seagrasses is far more than the amount of organic matter needed for their growth, so they can mitigate the impact of climate change (Traganos et al.; 2018).

In the north Aegean Sea, there are one of the most important oxygen sources from the ecosystem, Posidonia oceanica seagrass. This kind of seagrass distributed around the coast of the north Aegean Sea in sheltered areas such as harbours, estuaries, lagoons, and bays. Posidonia oceanica in the north Aegean Sea is declining drastically because of human activities such as reclamation, over-fishing, construction, boating, dredging, tourism and sewage with high nutrients. The amount of Posidonia oceanica decrease 10% compared with the last 100 years (MedWet, 2017). This situation is more significant in urbanized areas, which may increase the content of heavy metal elements in the seawater around these areas. Seagrasses can reduce the speed of water flow and allow heavy metal elements to accumulate in their body. As the accumulation of heavy metal elements increases, the seagrass's ability to fix nitrogen will decrease, thereby reducing its viability. In the past few decades, 30,000 km^2 of seagrass has been lost globally, which is equal to 18% of the global area. So, protecting seagrass is one of the most important environmental problems we need to solve.

Globally, there are treaties related to the protection of sustainable development, and also legislations for the protection of seagrass habitats such as the Sustainable Development Goals (SDG) of the UN's 2030 Agenda for Sustainable Development and "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean" (Traganos et al.; 2018). These measures are designed to protect the world's seagrass and thus protect the environment from climate change.

With more applications of optical and computer disciplines, the mapping of seagrass no longer depends on traditional methods like filed trips. Optical satellite remote sensing is a convenient method used to map and monitor seagrasses. From the images of the satellite, it is easy to get the reflectance of each pixel at different wavelengths, which is called a spectrum of the pixel. The spectral characteristics of each type of substance are different, so it is probably to use this feature to find the distribution of the seagrasses in the remote sensing image and then apply analysis on it. This is the basic principle of mapping seagrasses based on remote sensing images. However, the use of satellite remote sensing for large-scale mapping lacks in-situ data. Such data is often not as time sensitive as remote sensing data and covers a relatively small range. In the existing in-situ data sets, only a few data sets can provide valuable spatial information for image analysis (Traganos et al.; 2018). Mapping seagrasses faces other challenges such as the lack of extensive records of seagrass species diversity and changes in water quality over time, which may affect the accuracy of the extraction of seagrass information (Traganos et al.; 2018).

In the past, large-scale seagrass mapping mainly used Landsat satellite data on the local scale. However, with the innovation of cloud computing and big data technology, cloud platforms like Google Earth Engine (abbreviated as GEE) have emerged. GEE is a cloud computing platform that can store, process, and analyse many datasets. It is open source so users can access the dataset conveniently (Mutanga & Kumar, 2019). It integrated various remote sensing datasets from different satellite and can also store geographic information data such as vector boundaries and weather. Users are also allowed to create their datasets. GEE can be applied in vegetation mapping and monitoring, disaster management, landcover mapping, and earth science related applications (Mutanga & Kumar, 2019). For instance, researchers have produced the status and distribution of forests in a global scale and also have mapped the cropland in Africa.

The objective of the project is to develop a workflow based on the GEE platform that can map and monitor the seagrass (Posidonia oceanica) habitats in the Lemnos (in the north part of the north Aegean Sea) and can be extended to the global scope. This project also emphasizes the importance of seagrass protection and calls on humans to use different methods to protect seagrass from different aspects, thereby protecting the global environment.

2. Project Plan

2.1. Study Area

In the north part of the north Aegean Sea, there is an island called Lemnos, where a kind of seagrass Posidonia oceanica grows on the north east of the Lemnos. The area of the island is 476 square kilometres.

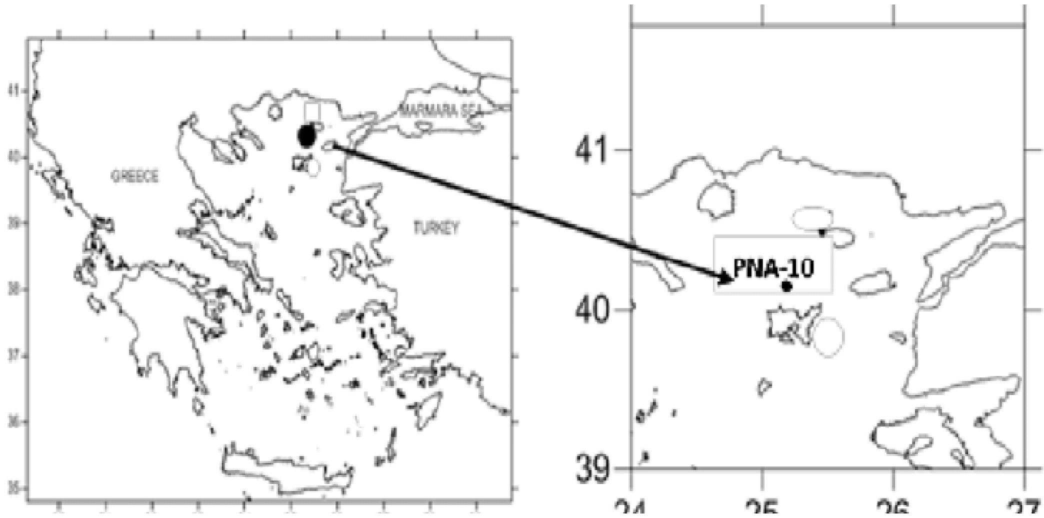

Figure 1. Geographical location of the study area Lemnos in north Aegean Sea (Pappa et al., 2019)

2.2. Remote sensing Data

The remote sensing image that will be used in this study comes from Sentinel-2 in the GEE platform and there are twin polar-orbiting which are Sentinel-2A launched on 23 June 2015 and Sentinal-2B launched on 07 March 2017. Sentinel-2 consists of 13 bands with b1-coastal aerosol, b2-blue, b3-green, b4-red, b5.6.7-vegetation red edge, b8-NIR, b8A-vegetation red edge, b9-water vapour, b10.11.12-SWIR. Band1, band9, and band 10 are 60m spatial resolution, while band 5, 6, 7, 8A, 11, and 12 are 20m spatial resolution, and band 2, 3, 4, 8 are 10m spatial resolution. Sentinel-2 can be used to detect vegetation growth, soil coverage to evaluate the environment of the detected area. It is not only important for planning the forestry, predicting grain output, and ensuring food security but can also be used to monitor natural disasters such as landslides, floods and volcanic eruptions to aid with humanitarian relief.

2.3. Filed Data

2.3.1. Machine learning Data

The training data will be collected through digitization from the base map of the Lemnos. Some unified digital polygons will be represented as seagrass. For validation data, it should be collected from the website.

2.3.2. *Auxiliary Data*

Auxiliary data such as bathymetry data can be used to support bathymetry estimation, and subsequent validation.

2.4. Methodology

The workflow consists of three parts: pre-processing, classification and accuracy assessment as shown below in Figure 2.

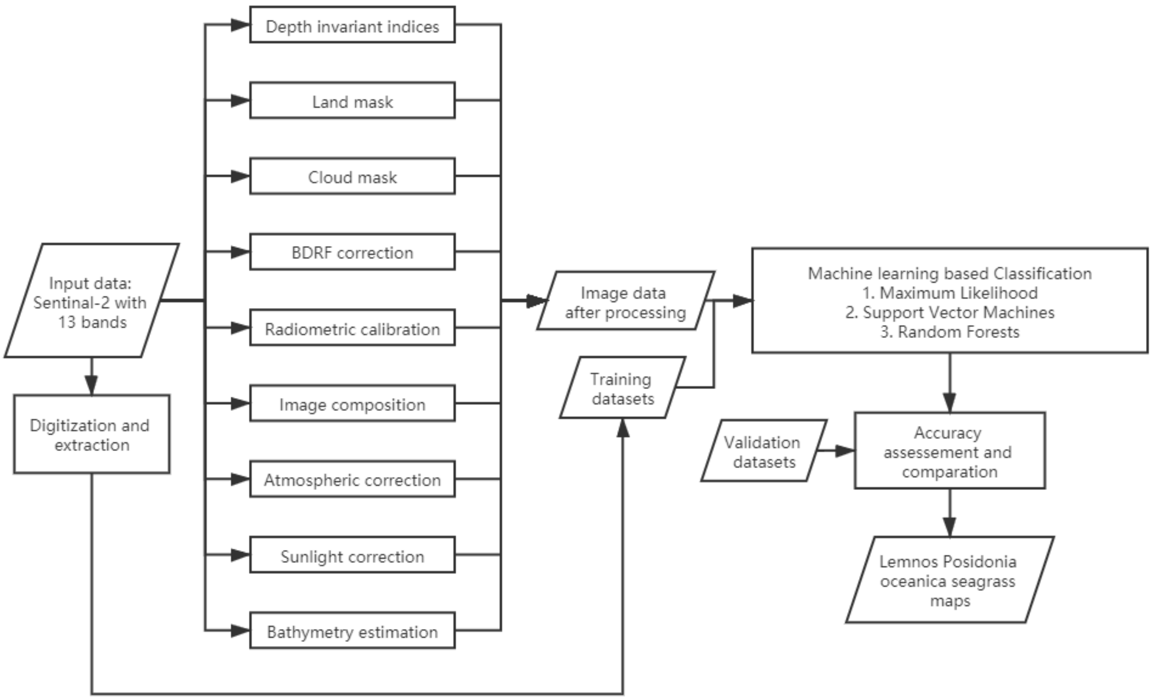

Figure 2. Methodological workflow (derived from processon) based on the Google Earth Engine.

2.4.1. *Pre-processing*

Nine processing will be performed to Sentinal-2 image in the pre-processing part including depth invariant indices calculation, land mask, cloud mask, BDRF correlation, radiometric calibration, image composition, atmospheric correction, sunlight correction and bathymetry estimation.

2.4.2. *Classification*

In the classification part, three different supervision classifications will be considered, which are maximum likelihood, support vector machine, and random forest. After performing the classification, the results will be compared and the classifier with the highest qualitative and quantitative output accuracy for seaweed extraction will be selected. 75% of the digitally extracted seagrass polygon data is used as the training set and 25% is used as the verification set.

2.4.3. Accuracy assessment

Accuracy assessment is the most important part of remote sensing-related research because accuracy meets the requirements only when the results match the actual situation. After performing the classification on the validation data record from Natura 2000 sites, an accuracy can be obtained, and evaluated through the analysis to obtain the mapping result.

2.5. Schedule

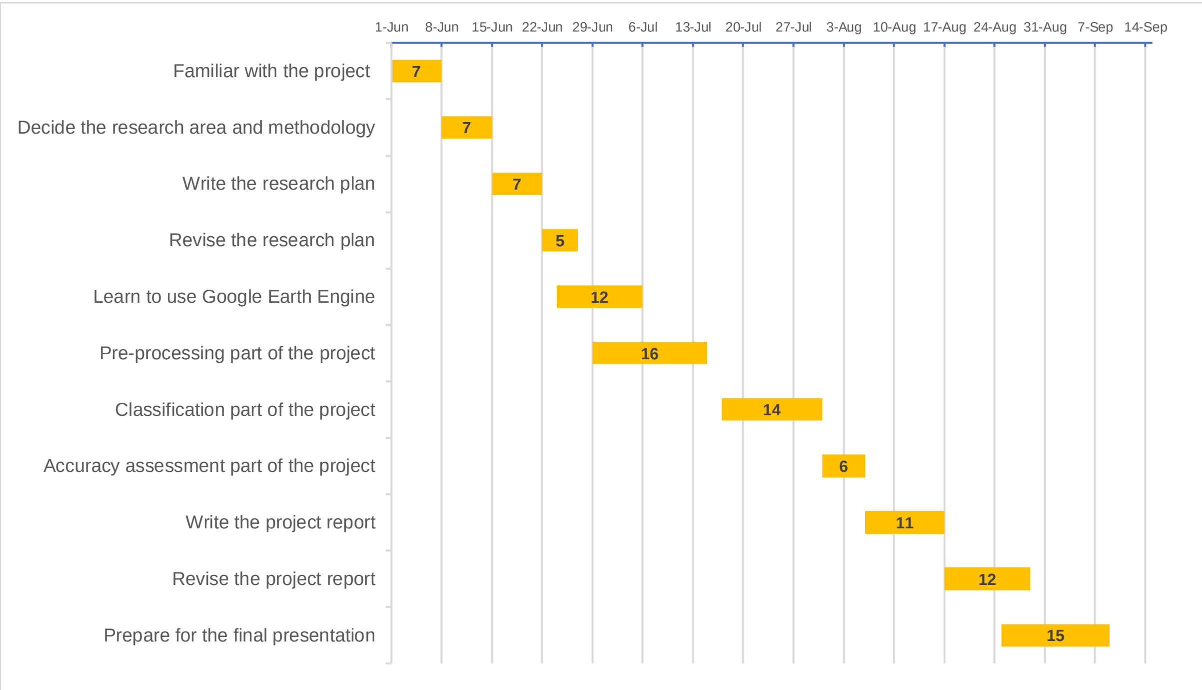

Chart 1. The schedule of the project

2.6. Risk management

There are probable reasons which may cause the project to fail: 1. The data provided from the study area does not meet requirements of the project. For example, the visibility and turbidity of the seagrass may influence the recognition of the seagrass. Potential solution for this problem may select the alternative study areas as quickly as possible. 2. There may be unknown errors in the program. When encountering such problems, try to solve bugs with the help from the supervisors or try other implementation methods.

3. References

1. Mutanga, O.; Kumar, L. Google Earth Engine Applications. *Remote Sens.* **2019**, *11*, 591.

2. Nordlund, M.L.; Koch, E.W.; Barbier, E.B.; Creed, J.C. Seagrass Ecosystem Services and Their Variability across Genera and Geographical Regions. PLoS ONE **2016**, 11, e0163091.

3. Pappa, F.K. & Kyriakidis, G. & Tsabaris, Christos & Patiris, Dionisis & Androulakaki, E.G. & Kaberi, Helen & Zervakis, Vassilis & Kokkoris, M. & Vlastou, R. & Krasakopoulou, Evangelia. (2019). Temporal variation of 137Cs profiles in Lemnos deep basin, North Aegean Sea, Greece. HNPS Proceedings. 23. 79. 10.12681/hnps.1910.

4. Traganos D, Reinartz P. Mapping Mediterranean seagrasses with Sentinel-2 imagery. Mar Pollut Bull. **2018**;134:197-209. doi:10.1016/j.marpolbul.2017.06.075

5. Traganos, D.; Aggarwal, B.; Poursanidis, D.; Topouzelis, K.; Chrysoulakis, N.; Reinartz, P. Towards Global-Scale Seagrass Mapping and Monitoring Using Sentinel-2 on Google Earth Engine: The Case Study of the Aegean and Ionian Seas. *Remote Sens.* **2018**, *10*, 1227.

4. Bibliography

1. Congedo Luca (**2016**). Semi-Automatic Classification Plugin Documentation. DOI: http://dx.doi.org/10.13140/RG.2.2.29474.02242/1

2. Immordino, Francesco & Barsanti, Mattia & Candigliota, Elena & Cocito, Silvia & Delbono, Ivana & Peirano, Andrea. (**2019**). Application of Sentinel-2 Multispectral Data for Habitat Mapping of Pacific Islands: Palau Republic (Micronesia, Pacific Ocean).
3. Koedsin, W.; Intararuang, W.; Ritchie, R.J.; Huete, A. An Integrated Field and Remote Sensing Method for Mapping Seagrass Species, Cover, and Biomass in Southern Thailand. *Remote Sens.* **2016**, *8*, 292.
4. Lyons, Mitchell & Roelfsema, Chris & Kennedy, Emma & Kovacs, Eva & Borrego ‐ Acevedo, Rodney & Markey, Kathryn & Roe, Meredith & Yuwono, Doddy & Harris, Daniel & Phinn, Stuart & Asner, Gregory & Li, Jiwei & Knapp, David & Fabina, Nicholas & Larsen, Kirk & Traganos, Dimos & Murray, Nicholas. (2020). Mapping the world's coral reefs using a global multiscale earth observation framework. Remote Sensing in Ecology and Conservation. 10.1002/rse2.157.