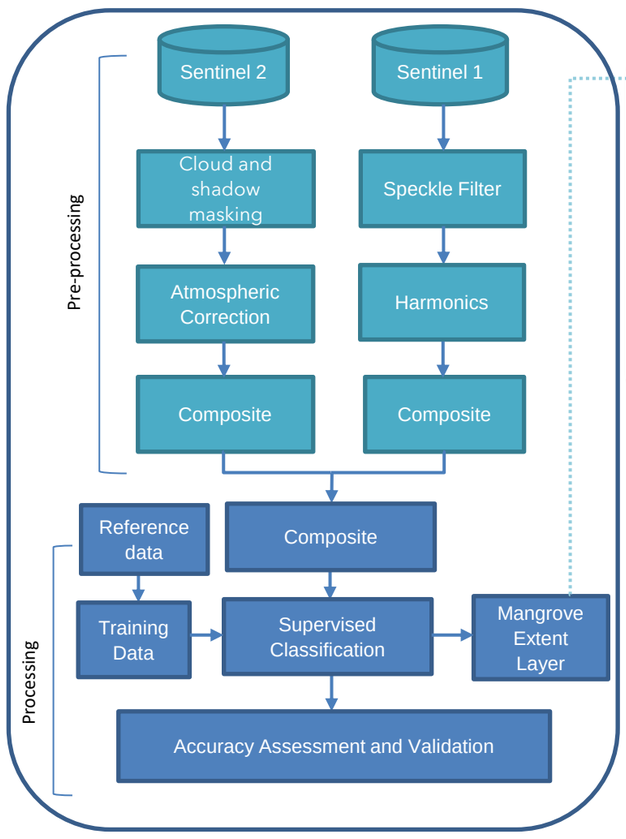
MAPPING MANGROVE FORESTS: PROCESSING AND VISUALIZATION OF MULTI-SENSOR EARTH OBSERVATION DATA FOR THE COLOMBIAN PACIFIC COAST

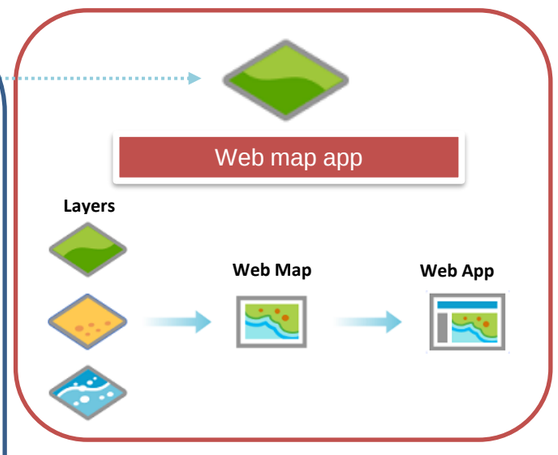
Master Thesis

Sayana de Gorostizaga Moxon

OBJECTIVES AND WORKFLOW

1. Explore and process multi-sensor Earth Observation data to generate a spatially continuous mangrove forest cover map in an area of very high cloud cover persistence using the Copernicus Sentinel-1 and 2 imagery;
2. Combine optical and radar data to evaluate whether classification accuracy is improved
3. Explore transferability and reproducibility in other locations
4. Present the results of the analysis in the form of a web map application

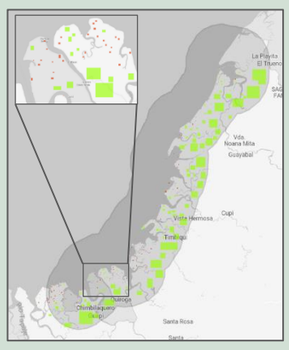




The Colombian Pacific coast mangrove extent was mapped primarily based on the workflow and semi-automated mangrove mapping methods applied by Shapiro et al. (2018). The analysis structure and methods were further supported and adapted according to approaches applied by Yancho et al. (2020) within the Google Earth Engine Mangrove Mapping Methodology. The mangrove cover extent was obtained by applying a pixel-based supervised classification approach and a Random Forest classifier. The data used for the classification were composites derived from a combination of Sentinel-1 and Sentinel-2 images and a set of indices. Finally, the results are presented in the form of simple web map products for easy access.

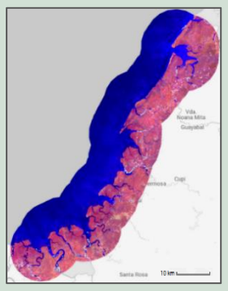
METHODOLOGY - Classification

Due to the atmospheric conditions of the region, the optical-radar fusion approach was applied with Sentinel-1 and Sentinel-2 imagery. After the filtering steps were applied, the optical and radar mosaics were built and stacked together with the pre-processed indices. Subsequently, a land cover classification and validation were performed through the implementation of a random forest algorithm, all within the GEE platform.



Training sites

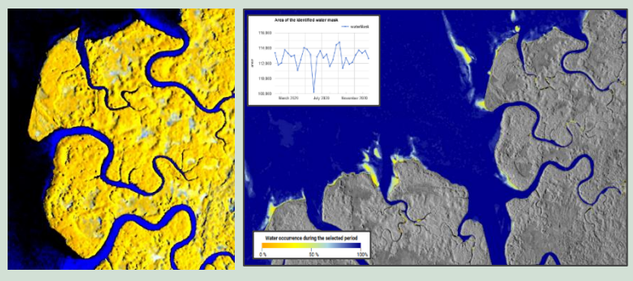
Sentinel-2 Cloud-free composites and indices



SR	Simple ratio
R48	Red/Nir band ratio
R118	Swir/Nir band ratio
NDVI	Normalized Vegetation Index
CMRI	Combined Mangrove Recognition Index
MMRI	Modular Mangrove Recognition Index
NDMI	Normalized Difference Mangrove Index
MVI	Mangrove Vegetation Index
NDWBI	Normalized Difference Water Band Index
MNDWI	Modified Normalized Difference Water Index
OSAVI	Optimized Soil-Adjusted Vegetation Index
LSWI	Land Surface Water Index

Sentinel-2 composite and list of indices used in the classification model

Sentinel-1 median composites and water occurrence

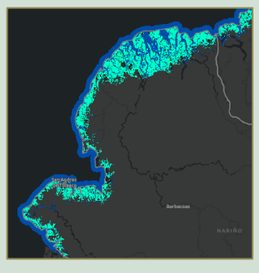


Sentinel-1 median composite and water occurrence during the year 2020

METHODOLOGY - Visualization

Processing in ArcGIS Pro → ArcGIS Online → Connect to Web AppBuilder → Web map app publication

In the fields of natural resource monitoring, management and conservation, web map applications are increasingly being used to effectively convey spatial-related information. Thus, the aim was to find an appropriate solution to implement a simple web map for presenting the overall results from the analysis in Colombian pacific coast mangrove forests. A solution to this is to resort to cloud-based platforms that provide their own server for storing and publishing the information. The process involved the use of ESRI's ArcGIS pro, ArcGIS online and Web App Builder.



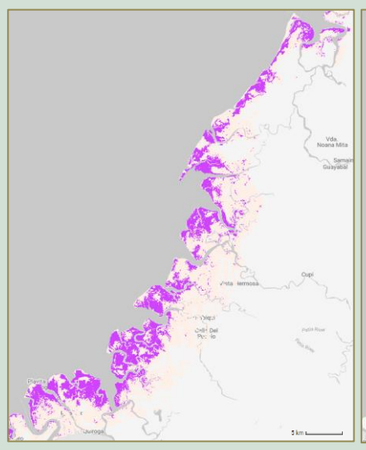
RESEARCH QUESTIONS

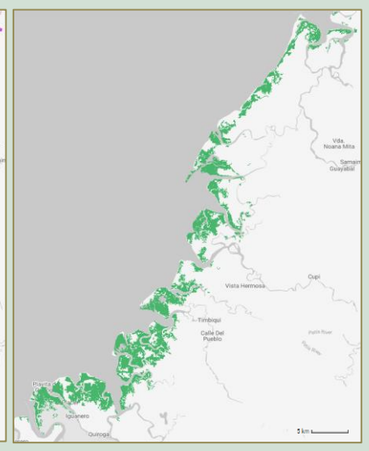
a) Does the combination of Sentinel-2 optical with Sentinel-1 radar data improve classification accuracies?

b) Is the model transferable to other locations and years?

c) What is an appropriate solution for visualizing the classification outputs?

RESULTS - Classification





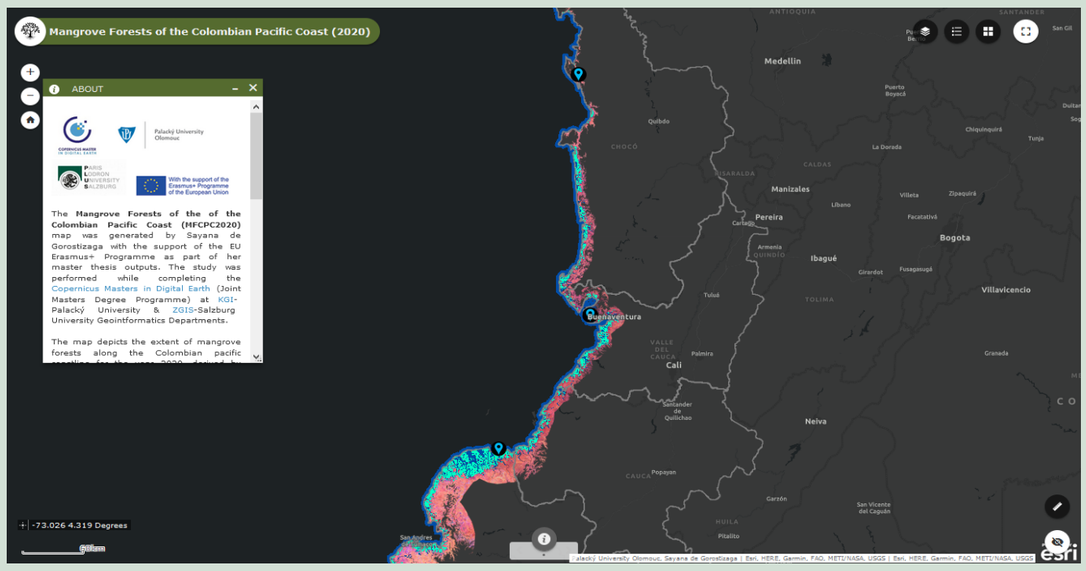
All the models achieved accuracies between 90% and 97%. Considering the conditions of the region, the annual composite-based models performed better than expected and were able to map mangrove cover quite accurately. Comparing the two different sensors alone, Sentinel-2 models outperformed the Sentinel-1 model. Although the Sentinel-1 model was able to distinguish mangrove cover quite well, it has a higher tendency to misclassify non-mangrove pixels into mangrove pixels, which was reflected in the 75% producer's and accuracy for that class. consumer's

Department	Year	Overall accuracy	Mangrove extent (ha)
Chocó	2020	0.96	42,651
Valle del Cauca	2020	0.92	29,688
Cauca	2020	0.97	17,805
Nariño	2020	0.97	106,534

The mangrove cover distributions were mapped and their extents for the year 2020 was derived. Consequently, a mangrove forest layer was generated for each of the four departments in the study area (Chocó, Valle del Cauca, Cauca, and Nariño).

RESULTS - Visualization

The final web map application contains the generalized mangrove classification layers from the year 2020 for the entire Colombian Pacific coast. The application is open to the public and presents a simple user interface for visualizing mangrove extents and distribution across the Colombian Pacific coast.



CONCLUSION

Considering the classification results, it was possible to determine that if annual data is available, the effort required for obtaining a cloud free image may be reduced by applying the greenest pixel method.

ArcGIS Online and the Web AppBuilder covered what was needed for producing the expected web map application within this study's scope.

Overall, this study contributes to the application of the GEE cloud-computing platform and Copernicus Sentinel-1 and Sentinel-2 satellite data, and their potential for monitoring and mapping mangrove forest cover. It also acknowledges the importance of considering ways to better visualize and present the results considering the map purpose, the data and the user requirements.

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