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Delgado-Altes B., Geomatics & Surveying Engineering Degree Student**Supervisor: Prof. Dr. Jorge Delgado-García, Assistant Professor, Dpt. Cartographical, Geodetical and Photogrammetric Eng.***(Universidad de Jaén, Jaén, Spain)***RANDOM FOREST CLASSIFICATION OF S1/S2 IMAGERY FOR
DEFORESTATION MONITORING IN UPPER PARAGUAY REGION (2015-2022)**

According to FAO (2020), one of the main environmental problems of our society is deforestation and forest degradation. The magnitude of the problem is so important that the UN within the Agenda for Sustainable Development establishes one goal directly related to the environment (SDG 15), having relationships with other objectives. One of the most important characteristics of deforestation is its spatio-temporal component; they are dynamic phenomena that can affect large areas of land in a short period of time, causing serious problems. For this reason, that for several decades the initiatives for the control of deforestation through the application of remote sensing techniques have been a constant, since the initial works of, among others, Iverson et al. (1989) and Baltaxe (1986). The improvement in the quality of the images, as well as the greater availability of them, and the advances in computer systems and software, have led to the widespread use of these techniques as tools for global monitoring.

In this paper, an example of application for the monitoring is presented. The proposed methodology is based on open access information (Sentinel imagery) and which has been processed by means of open-source software (SNAP, ESA 2022) using a personal computer. The methodology combines multispectral and RADAR images in order to have a deforestation monitoring of an area located in northern Paraguay, affected by strong deforestation processes in the period between 2015 and the present.

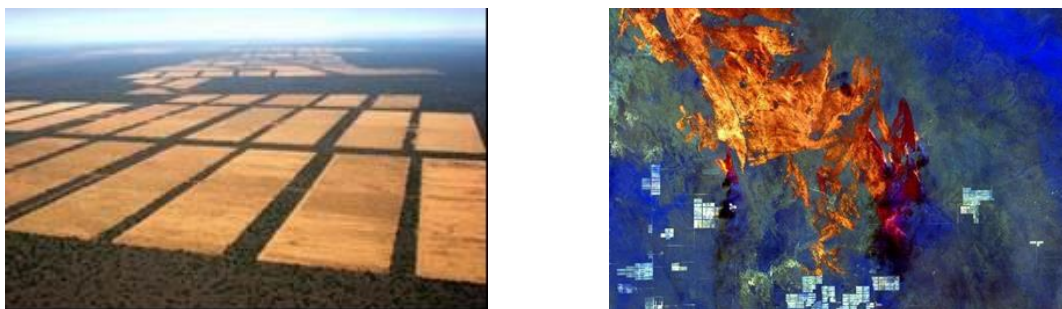


Figure 1. Left: Cultivated fields in deforested areas in Paraguay (World Land Trust, 2014), Right: Examples of forest fires in the study area (Sentinel 2A-MSIL2A image 2019/09/7) RGB (12, 11, 8A).

The area selected for this study corresponds to the Teniente Pico and Teniente Martínez areas of the Mariscal José Félix Estegarríbia municipality, in the province of Boquerón in the Republic of Paraguay. This is a province that has serious deforestation problems, and Global Forest Watch identifies a loss of 902km² of forest cover in this area in 2021, equivalent to 18.2Mt of CO₂ emissions. The area has an approximate surface of 12.500km².

One of the objectives of this study is the use of free use information, and images from the Copernicus program (<https://www.copernicus.eu/en>) have been used for the analysis of deforestation. Taking into account the problems of cloudiness in this area (something frequent in forest areas) a methodology has been chosen that combines a total of 7 images from the RADAR S1 (GRD-IW VV+VH) sensor with 7 images from the multispectral S2 sensor, one per year, between 2015 and 2022. In all cases, the image was taken in August to facilitate the

comparison. One of the objectives of this study is the use of free use information, and images from the Copernicus program (<https://www.copernicus.eu/en>) have been used for the analysis of deforestation. Taking into account the problems of cloudiness in this area (something frequent in forest areas) a methodology has been chosen that combines a total of 7 images from the RADAR S1 sensor with 7 images from the multispectral S2 sensor, one per year, between 2015 and 2022. In all cases, the image was taken in August to facilitate the comparison. The proposed methodology is show in figure 2.

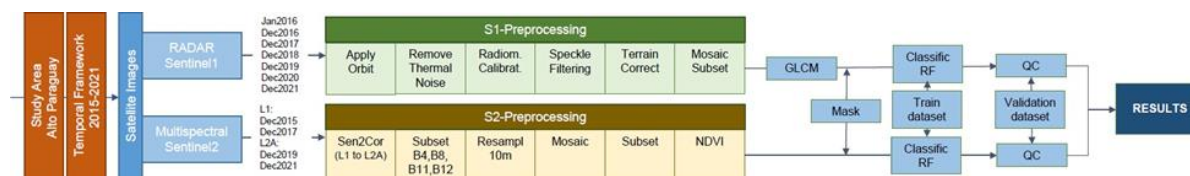


Figure 2. General schema of proposed methodology.

Figure 3 shows an example of the classification results corresponding to the multispectral and RADAR images of both 2015 and 2021 and the deforestation evolution. In the 2015-2022 period, the cultivated plots in the area of interest have increased by 50%, which means around 4900 km² of new crops that have displaced the natural vegetation. The average classification accuracy levels are equal to 98.43% por S1 and 99.43% for S2, and the use of additional variables (GLCM for S1 and NDVI for S2) is considered of great interest in the improvement of the classification. The differences between the results obtained from S1 and S2 are less than 5% in all years, with mean values of 1.67%. In 2017 in which the images only differed by one day, the difference was only, 0.36%.

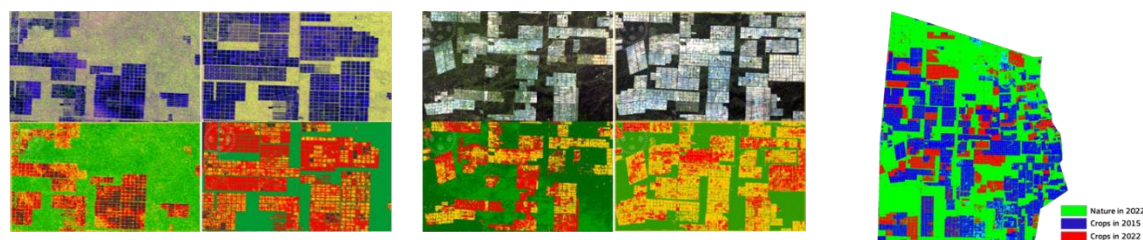


Figure 3. Left and middle: Imagery 2015 and 2022 (top) and classification (bottom), S1 (left), S2 (middle); Right: Deforestation evolution.

The main conclusion that can be drawn from this work is the capacity of Remote Sensing to monitor spatio-temporal dynamic phenomena. Used methodology, which combines multispectral images with RADAR images, is considered to be an optimal solution for areas where the presence of clouds is common. On the other hand, the supervised classification using the RF method allows obtaining high quality results in terms of semantic segmentation of the different land uses. The use of additional variables (NDVI and GLCM statistics) is considered of great interest in the improvement of the classification itself.

References

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