Classification of vegetation types with Sentinel-1 radar data C

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This document is the road map of the practical realized the 6th of July 2017 at Vilnius in the frame of the ESA Training Course on Radar and Optical Remote Sensing.

I. Introduction
This practical aims to produce a classification of vegetation types over an area near Macapa (state of Amapa, Brazil) based on the use of 3 Sentinel-1 acquisitions realized the in IW (Interferometric Wide) mode, realized the 2015/09/29, 2015/12/22, and 2016/05/03, in VV and VH polarizations. This practical is decomposed in two steps:
1) The Sentinel-1 are pre-processed, *i.e.* calibrated in σ^0, ortho-rectified, and filtered to reduce the speckle. Color composite images (R: VV, G: VH; B: VH/VV) for each acquisitions are also produced.
2) The classification based on the Random Forest algorithm is performed.

All the practical is performed under under the QGIS 2.18 version (Las Palmas) which in addition has integrated the Orefo Toolbox software as well as some python libraries that are used in scripts dedicated to Sentinel-1 IW (Interferometric Wide) mode acquisitions in GRDH (Ground Range Detected High Resolution) format. This customisez version is available on
http://teledetection-radar.u-pem.fr/software/QGIS_RemoteSensing_64bits.exe
The concerned dataset is available on : http://teledetection-radar.u-pem.fr/data/tp_Macapa.tar.gz.

Importan technical remark:

In order to avoid any problems due to file names, be sure that no any special characters (space, accents,...) are used in the file names as well as in the whole path of your files. You can, for example, replace the space character by "-" or "_".

I. QGIS customized software

Download http://teledetection-radar.u-pem.fr/software/QGIS_RemoteSensing_64bits.exe
and execute it. It installs the customized QGIS software as well as additional software, like C++, …
At the end of the installation, control that the software is well installed in the folder
C:\QGIS_RemoteSensing_64bits
Run this software by double clicking the icon on the desktop called "QGIS Remote Sensing"

II. Sentinel1 data pre-processing

0. *Calibration and Ortho-rectification* of each acquisitions over the study area

Sentinel1 data are freely available on ESA Scientific Data Hub website :
https://scihub.copernicus.eu/dhus/#/home
The data of this practical session are available at
http://teledetection-radar.u-pem.fr/data/tp_Macapa.tar.gz

Download and unzip this file in the following foder : C:\tp_Macapa [1]
In the folder *C:\tp_Macapa\Sentnel1\originales* unzip the 3 files with the extension .zip into the folder that you create *C:\tp_Macapa\Sentnel1\unzip*. Check that this folder contains three subfolders, which names of each of them finishes by the extension *.SAFE*

1. ***Calibration and Ortho-rectification*** of each acquisitions over the study area

This is done over a predifined region of interest (already define by the
C:\tp_Macapa\vecteurs\clip_zone.shp polygone). The orthorectification requires a DEM that must over extents the region of the polygon. Without any more accurate DEM, the SRTM (Shuttle Radar Topographic Mission) 1 arc sec (*i.e.* 30 m of resolution) has been downloaded from the USGS (United States Geological Survey) Earth Exporer website https://earthexplorer.usgs.gov/. They are stored in the folder *C:\tp_Macapa\mnt_srtm*[2].
The resulting files will be stored in the Folder (that you have to create):
C:\tp_Macapa\Sentnel1\ortho_cal
In *Processing → Toolbox → scripts → Sentinel-1 IW Batch Processing* double click on
1b GRD products calibration orthorectification over polygon

> Input Folder: *C:\tp_Macapa\Sentnel1\unzip*
> Input polygon file: *C:\tp_Macapa\vecteurs\clip_zone.shp*
> DEM Folder: *C:\tp_Macapa\mnt_srtm*
> Calibration type: *Sigma0*
> Output EPSG: *EPSG:32622*
> Output Resolution: *10*[3]
> Output Data File: *C:\tp_Macapa\Sentnel1\ortho_cal*
> RAM: 1000 (if you have a computer with 4 Gb of RAM)[4]

The resulting files are strored in three subfolders (one per acquisition date) located in *C:\tp_Macapa\Sentnel1\ortho_cal*. Each of these subfolders contain 2 Tiff files; the acquisition in VV and VH polarisations, calibrated and orthorectified over the polygon of interest.

2. *Generation of the color composite images*

This step is performed for a better visual interpretation, in order to allow the creation of the polygons defining the different classes for the classification process. The imges are generated in logarithmic scale (dB) which dynamics is better suited for human vision. The resulting files are stored in the Output Folder. This latter contains three subfolder (one per acquisition date). Each og them contains faur files : 3 Tiff files corresponding to VV, VH and the ration VH/VV, and one virtual file (.vrt) allowing the visualisation of the three tiff files according to the convention :

R : VV – G : VH – B : VH/VV

In *Processing → Toolbox → scripts → Sentinel-1 IW Batch Processing* double click on *GRD Products Dual Polar Color Composition*.

You can vizualize each of the 3 color compoite images bu loading each of the three .vrt file into QGIS.
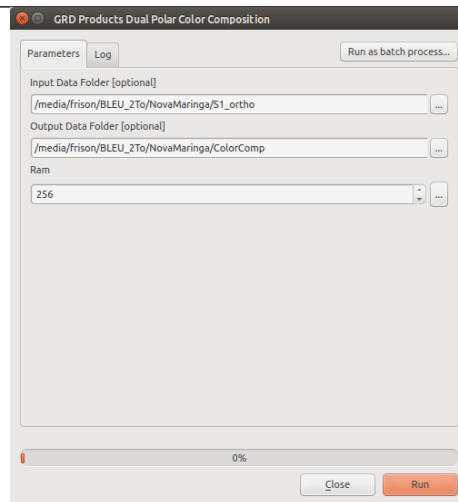
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1 With window10, unlesss special settings, the length of the characters string containing the whole path+the file name must be lower than 264 characters. Consequently it is recommended to have the tp_*Macapa* folder near the root folder.
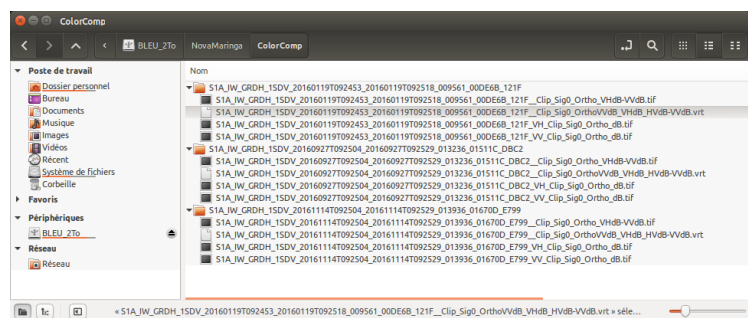2 This folder must only contain the dem files, uncompressed, in Tiff format.
3 This value is in the units of the Reference Cartographic System. Here, RCS = WGS 84, UTM zone 22N, the units are in meters
4 Generally enter the 1/4th of the RAM of your computer

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Generation of Color Composite Images	
Structure of the Output Folder	

3. *Speckle filtering*

The data resulting of the previous 1b processing (located in *C:\tp_Macapa\Sentinel1\ortho_cal* can now be filtered in order to reduce the speckle noise. The Lee filter (only on the spatial domain) and/or the spatio-temporal filter (Quegan, 01) can be applied with the script *2 – Temporal Filtering*. The neighbrhood size in the spatial domain involved in the temporal filter is associated to the parameter *Spatial Window Size for Temporal Filter*, set to 7 by default.

In addition, in order to reinforce the filtering, you can also choose to apply, prior to the spatio-temporal filter, a Lee filter (the check box *Apply Lee PreFiltering* is activated by default). In that case, the size of the spatial neighborhoud corresponds to *Spatial Window Size for Lee Filter* (set to 5 by default), and the number of Looks to *Looks Number for Lee Filter* (set by deafult to 5, i.e., the corresponding number of looks of GRD products).

By default, the images are processed in a logarithmic scale (dB). You can let the natural scale by The processing images are stored in the folder *C:\tp_Macapa\Sentnel1\filtered_data* that you have previously to create. They are stored in 3 subfolders under Tiff format.
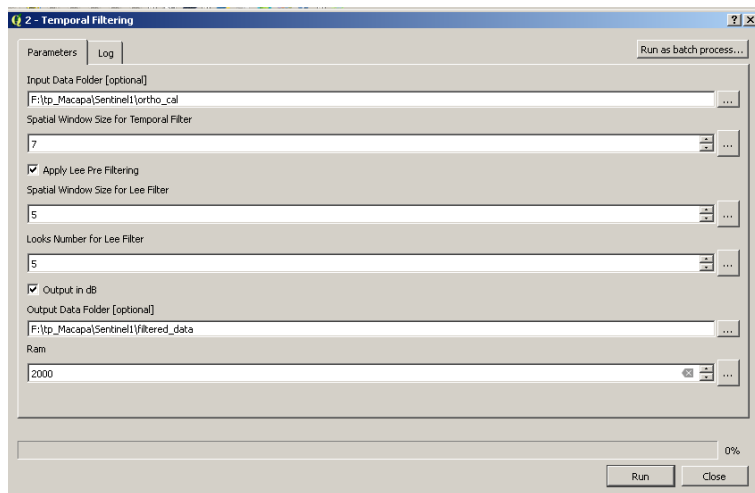
You have all the necessary images for running the classification algorithm.

III. Classification

1. Generation of a multi-band image file

The goal here is to create a virtual image containing all the images that will be taken into account in the classification algorithm. In the present case, we want to use for each acquisition date, the 3 polarisations file (VV, VH and the ration VH/VV), *i.e.* resulting in 9 bands (= 3 dates * 3 polaristions). The files that have to be considered for the classification algorithm are those correspondong to speckle noise filtered data.
Load into QGIS these 9 tiff files.
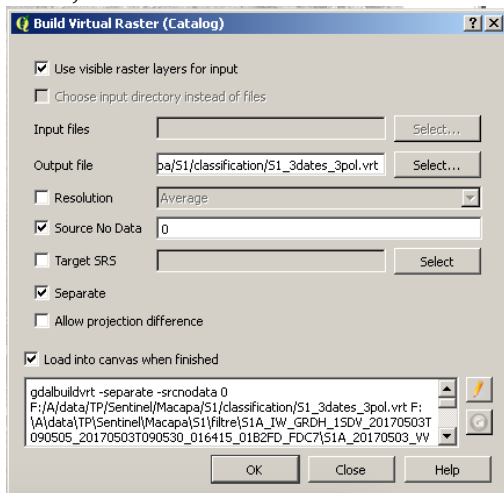Order them, from 2015/09/29 to 2016/05/03. For each date order accoding the following sequence:
VV
VH
VH/VV

Be sure that only these nine files are visible (the associate visualisation box must be checked).
Then, **Raster → Miscellaneous → Build Virtual Raster**

Save the *Output File **S1_3dates_3pol.vrt*** in the folder **C:\tp_Macapa\Sentinel1\classification** that you have previously created.
Be sure that the RCS of your project is the same (EPSG: 32622) than the ortho-rectified images.

2. *Generation of polygons defining the classes*

These polygons will be defined from 1 or the three color composite images generated II. 2.
Create these polygons in a new shapefile that you create: *C:\tp_Macapa\Sentinel1\classification*.
The polygon shape must contain one field, called **class_numb** defined as a *whole number (integer)* of *length 2*.

## 3. *Generation of the training model of the classifier*

The classification method is the Radom Forest algorithm. As every supervised classification algorithm, first a classification model is generated from the polygons defined at the previous step (in fact, only part of the pixels belonging to these polygons are used for this training phase. Other part is used to estimate the performance of the classification).

In the **Toolbox panel**, within the menu *1- Classification* in the menu *Orfeo Toolbox* Double click on *2 – Train Random Forest Image Classifier*
Fill the fields as hereafter:
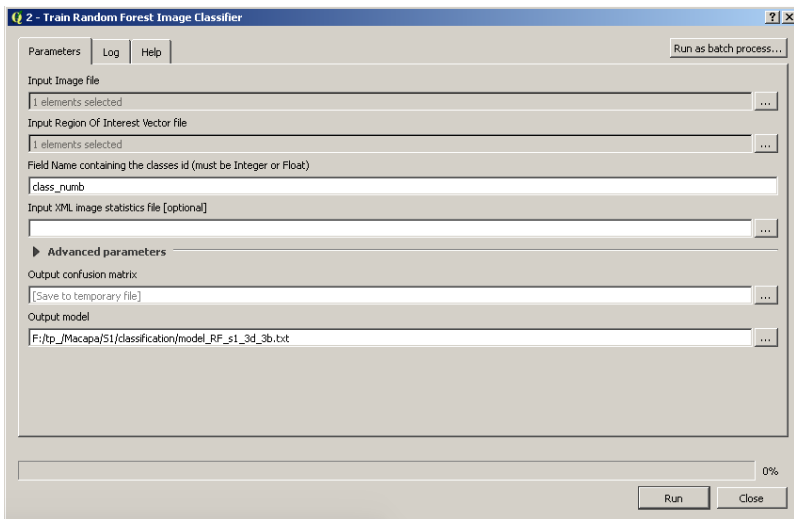
4. *Generation of the classification model to the whole image*

- Double click on sur *3 – CreateImage classification*
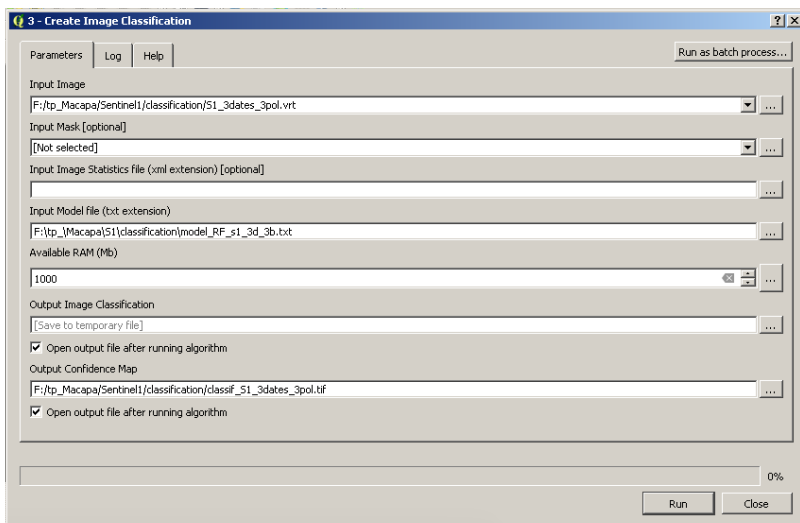
The classification image is loaded automatically in QGIS. Change the style (*Single Band Pseudo Color*) to have the same colors that the ones to the corresponding class polygone.

Tou can sieve the result (***Raster* → *Analysis* → *Sieve***) if you want to remove small pixels agregates.