1. Contact details

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2. Idea

Guest software: GRASS GIS
Title: GRASS GIS module for Sentinel-2 cloud and shadow detection

Optical sensors are unable to penetrate clouds leading to related incorrect reflectance values. Unlike Landsat images, Sentinel 2 datasets do not include thermal and Quality Assessment bands that simplify the detection of clouds avoiding erroneous classification.
Moreover, also clouds shadows on the ground lead to anomalous reflectance values which have to be taken into account during the image processing.
The project aim is the coding of a specific module for GRASS GIS application which implements the procedure, for clouds and shadow detection, developed within my Ph.D. research. The procedure allows to automatically identify clouds and their shadows in Sentinel 2 images.
The proposed procedure consists of the following main steps:

1. the application of some rules on reflectance values to obtain a rough classification of clouds and shadows,
2. the use of an adapted shape index to refine the result about the shadows classification from the previous step,
3. spatial relation between clouds and shadows to check the final results.

The applied rules represent essentially values thresholds, comparisons and calculations between bands and they lead to two different rough maps of clouds and shadows which require further improvements and elaborations (e.g. transformation from raster to vector, cleaning geometries, removing small areas, checking topology, etc.) carried out in the subsequent steps of the procedure. These rules have been defined starting from rules found in literature (*Parmes et. al 2017*) and conveniently refined.
Regarding the detection of shadows, some misclassification can occur. Often shadows and water have in fact similar reflectance values which can lead to erroneous classification of water bodies as shadows. In order to avoid these anomalous results, an adapted shape index is applied exploiting the difference between water and shadow shapes (usually thin and elongated the former and thick and rounded the latter).
Finally, in order to increase the accuracy of final results, a control check is implemented. Clouds and shadows are spatially intersected in order to remove misclassified areas. This means that all those shadow geometries which do not intersect a cloud geometry are removed and vice versa.
The final outputs are two different vector files (OGR standard format), one for clouds and one for shadows.

To date, only a specific module for Landsat automatic cloud coverage assessment is available within GRASS GIS (i.landsat.acca). This module uses the Landsat thermal bands to identify clouds with the premise that clouds are colder than the ground surface. Because

of the lack of thermal bands in Sentinel 2 images, this module cannot be used nor adapted. Therefore, the detection of clouds has to be manually performed.
Regarding shadows, no specific module is available.
With my module I want to provide an automatic method to detect both clouds and shadows within Sentinel 2 images. It consists of the python script for computations, the graphical user interface with default suggested values and parameters and a detailed user documentation.
The aim is to provide a tool which can be easily used by inexpert users, taking advantage of the suggested parameters, or by more expert users that can modify default values according to their needs.
Starting from my research activity, the module can constantly be updated and upgraded following the progress of the research. For instance, I'm studying a proper method to validate the procedure proposed above. I'd like to implement also the validation process in a future release of the module in order to provide users with a solid accuracy assessment of the computed clouds and shadows maps.

3. Timeline

At the moment I have no known time conflicts during the official coding period. Therefore I'd like to propose the following timeline for all the activities related to the development of the proposed GRASS GIS module.

<table>
<tr><th>Project Time Line</th><th colspan="2">Task Description</th><th>Deliverables</th><th>GSoC Time Line</th></tr>
<tr><td>To date already developed</td><td>0</td><td>Implementation of a GIS procedure for clouds and shadows detection</td><td></td><td></td></tr>
<tr><td rowspan="2">April 23 - May 4</td><td>1.1</td><td>Communication to dev/community mailing list of the beginning of works</td><td rowspan="5"></td><td rowspan="5">April 23 - May 14 (Community Bonding)</td></tr>
<tr><td>1.2</td><td>tests phase in order to reach a final procedure version</td></tr>
<tr><td rowspan="3">May 5 - May 13</td><td>1.3</td><td>Setup of a testing github repository</td></tr>
<tr><td>1.4</td><td>Improvement of my knowledge about GRASS Python Scripting Library</td></tr>
<tr><td>1.5</td><td>Update of the OSGeo wiki page with the project idea and progress</td></tr>
<tr><td>May 14 - June 3</td><td>2.1</td><td>"Translation" of the final procedure in a GRASS Python Script</td><td rowspan="2"></td><td rowspan="2">May 14 - June 15 (Coding)</td></tr>
<tr><td>June 4 - June 11</td><td>2.2</td><td>Tests and bug fixing</td></tr>
</table>

June 12 - June 15	2.3	Check script with mentors	GRASS Python Script without GUI	June 11 - 15 (First evaluation)
June 16 - June 24	3.1	Addition of a first Graphical User Interface to obtain a module prototype		June 15 - July 9 (Coding)
June 25 - July 1	3.2	Discussing with mentors about module prototype		
July 2 - July 9	3.3	Compiling the user documentation (GRASS GIS help page)		
July 9 - July 13	3.4	Publication of the module prototype as a GRASS add-on (svn official repository) and communication to “dev mailing list”	GRASS add-on module prototype	July 9 - 13 (Second evaluation)
July 14 - July 31	4.1	Tests, bug fixing and possible changes in GUI (following feedback from community)		July 13 - August 6 (Coding)
Aug. 1 - Aug. 14	4.2	Improvement of the user documentation (following feedback from community)		
	4.3	Re-submission of the module last version	Final GRASS module with GUI and documentation	August 6 - 14 (Submission)

4. Studies

I got my master's degree in Landscape Architecture in March 2011 at the University of Genoa, Faculty of Architecture.

During my studies, I approached the use of Open Source GIS software applied to environmental analysis and then I improved my knowledge taking part to training courses and an internship at Edmund Mach Foundation – Research and Innovation Centre, San Michele all'Adige, Trento, Italy).

At the moment, I’m attending a Ph.D. course in Environmental and Infrastructure Engineering - Geodesy and Geomatic area at Politecnico of Milan. I’m strongly increasing my knowledge about Remote Sensing and Earth Observation data in GIS environment.

My research project focuses on the study of Sentinel 2 images, their limits and potential applications with respect to the identification of plant species. In particular, I’m focusing on the evaluation of image quality considering the intrinsic errors due to atmosphere, orography and clouds which can affect further elaborations.

I have already dealt with other preprocessing tasks like atmospheric and topographic corrections of Sentinel 2 images but to date, the clouds and shadows detection is the main topic of my research.

5. Programming and GIS

Computing experience:

- Excellent Knowledge and daily use of the Open Source Operating System Linux.
- Good knowledge of bash scripting in GRASS GIS and basic knowledge of GRASS Python Script implementation.
- Excellent knowledge of the programming language JavaScript and of the JavaScript libraries OpenLayers, ExtJS e GeoExt for WebGIS development.
- Excellent Knowledge of the Open Source applications server MapServer, GeoServer and Qgis Server (and its related client interfaces Qgis Web Client and LizMap).
- Excellent knowledge of HTML and CSS.

GIS experience as a user:
Since the end of the studies, I have always worked as a GIS consultant within geographic information systems and analysis of components of landscape using Open Source GIS software (especially GRASS GIS and QGIS) collaborating with both universities and companies.

I also have a considerable experience as a teacher of GIS courses (GRASS GIS and QGIS) in both academic and professional fields.

6. GSoC participation

I have never participated to GSoC before.

I want to submit only this proposal in response to the idea published on the GRASS Google Summer of Code 2018 wiki page that matches with my research project.