Multitemporal Sentinel-2 data – remarks and observations

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Available for over a year the Sentinel-2A data enables to create a detailed Land Cover database on a global scale. Sentinel-2 system is relatively new, therefore time is needed to stabilize and improve all pre-processing algorithms. This is possible due to the efforts of the European Space Agency (ESA) and the data end users' observations and feedback. However, all eventual imperfections have strong influence on the result of multitemporal observations.

Sentinel-2 Global Land Cover (S2GLC)

S2GLC is a ESA SEOM project aiming at deriving scientific roadmap and recommendations towards automatic production of land cover maps on a global scale based on Sentinel-2 imagery. The project consortium is led by the Space Research Centre of the Polish Academy of Sciences and includes three partners IABG mbH Friedrich-Schiller-Universität, and EOXPLORE UG and.

A multitemporal analysis of a time series of satellite imagery requires highly accurate and reliable data because all anomalies and defects may have significant influence on the final results of the performed analysis. Therefore, an overview and usability testing of Sentinel-2 data is a crucial preliminary step in performing image processing aimed, for example, at the land cover classification. Prior Sentinel-2 data review and definition of possible issues might be crucial in the process of creating an automatic processing chain to secure reliability of the process and making it possible to fully operate without the need for manual inspection of Sentinel-2 data.

The Sentinel-2 data analyzed so far cover areas of the tests sites defined in the S2GLC project. These test sites are scattered throughout the globe providing opportunity for testing

Sentinel-2 data at different climate and landscape conditions, combinations of land cover classes and various degree of cloudiness. They are placed in China, Colombia, Germany, Italy and Namibia.

Hundreds of images registered for the locations of test sites have been reviewed within the project and pre-processed to prepare the dataset for classifications. On the basis of an overview of Sentinel-2 images available after the first year of collecting them and sharing by ESA, certain observations have been made concerning their quality and processing possibilities.

Misregistration

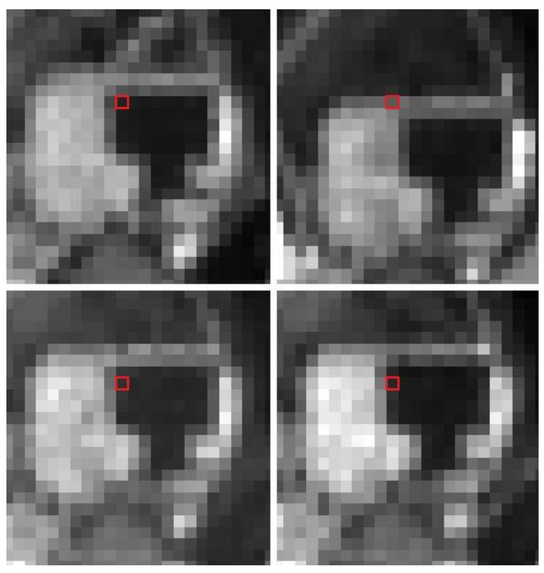


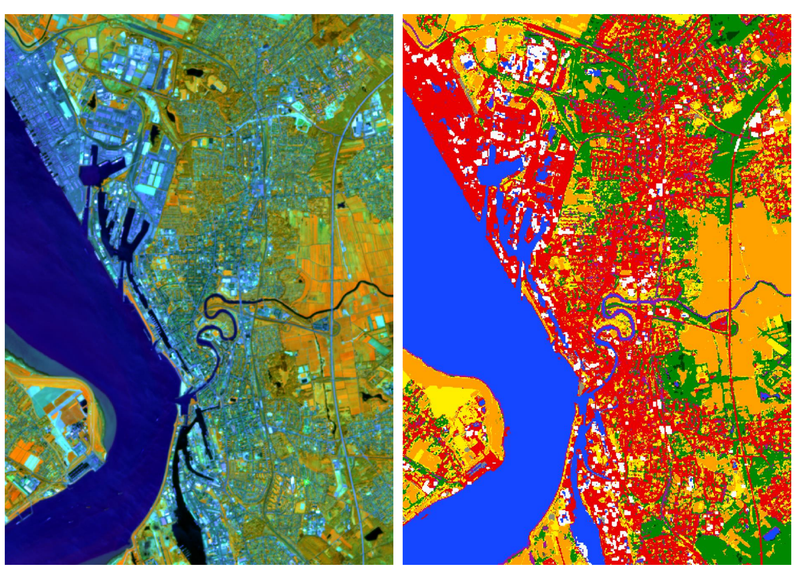
Image of building on different acquisitions collected from the same path (band 4 of Sentinel-2 images).

While pre-processing and reviewing Sentinel-2 data it has been observed that time series of images acquired over the same area are not co-registered properly. The misregistration error ranges from 1 to 5 pixels regardless of whether the images has been acquired from the same or a neighboring path.

ESA is going to implement a geometric refinement step which will improve the repetitiveness of the image geolocation, in order to reach the multi-temporal geolocation requirement (< 0.3 pixel at 95%) as soon as the Global Reference Image and the final validation of the refining algorithm will be ready.

PCI Geomatica developed a fully automatic algorithm which allows to geometrically correct a set of Sentinel-2 images.

Incorrect cloud mask over artificial surfaces

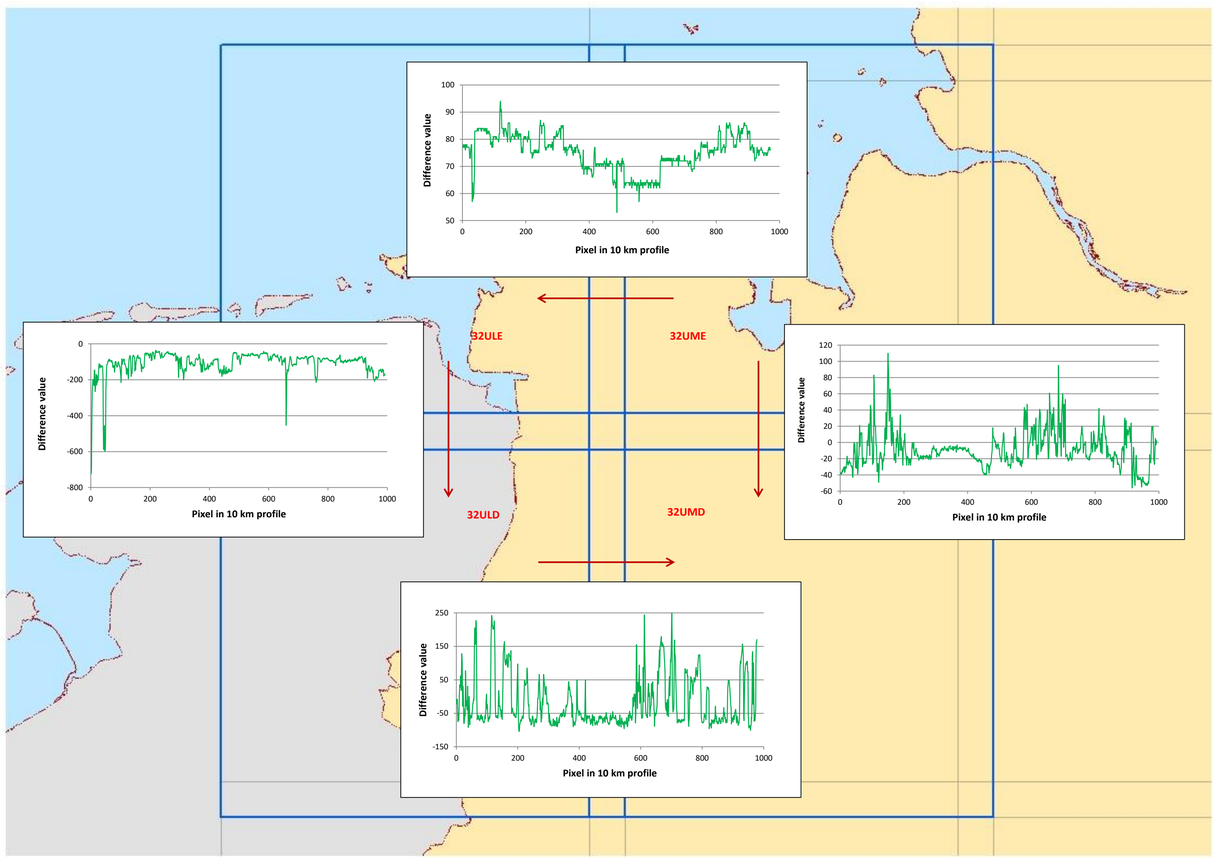


Cloud free Sentinel-2 image (left) compared to result of classification aggregations with errors of cloud mask with medium and high probability (white pixels).

Performing atmospheric correction of Sentinel-2 data with a dedicated software (Sen2Core) revealed a problem with the resulting cloud cover mask. It was found that three classes from the mask representing clouds present incorrect classification of artificial surfaces which tend to have higher reflectance than surrounding objects.

This results in masking out a considerable part of a built-up area when atmospherically corrected data is used even in a cloud free period.

Spectral differences before and after atmospheric correction

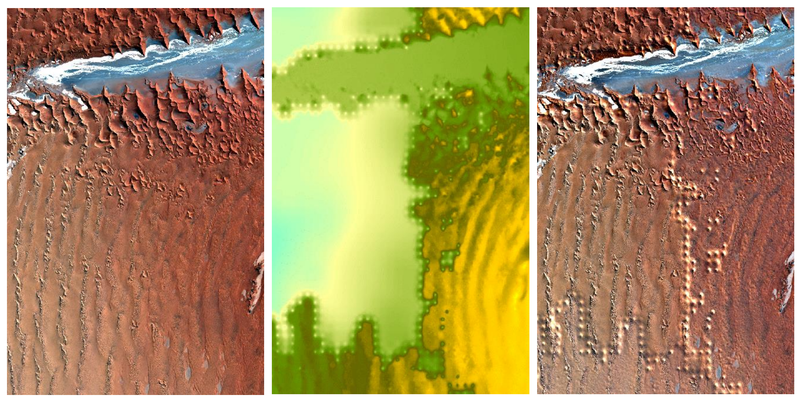


Difference between pixel value (band 4) in overlaping area before and after atmospheric correction.

Disagreement between spectral values of pixels in overlapping areas of two tiles (granule) has been spotted while analysing original and post-atmospherically corrected images. The problem occurs due to the fact that each Sentinel-2 tile is being corrected separately. Therefore, differences occur even between tiles that originate from the same acquisition (captured at the same time and from the same path).

This error appears due to the Sen2Cor algorithm which process each tile of Sentinel-2 data separately, thus does not consider climate condition and image statistics from the neighbouring tiles. Usage of images without atmospheric correction might be considered.

SRTM error – bright spots

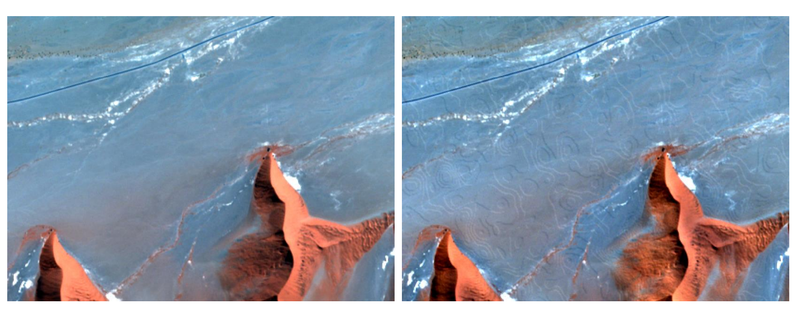


Bright spots at L2A product caused by errors in SRTM (3sec). Granule T33JWN.

Regions of erroneous values in the SRTM DEM dataset strongly influence atmospheric correction process. Effect of this problem may be seen on the edges of erroneous regions as shown on the L2A product in the form of brighter spots as compared to neighbouring areas.

This error has been reported to ESA, however, it mainly concerns the quality of the SRTM DEM rather then Sentinel-2 products. As a possible solution to this issue the ASRTER GDEM or other local DEM might been used instead of SRTM DEM. This however, makes the atmospheric correction process less automated.

SRTM DEM defects – contour lines



Results of atmospheric correction with SRTM.

Contour lines-like effects appear at post-atmospheric correction product (L2A), which were not visible at Sentinel-2 image before correction (L1C product). This is caused by SRTM DEM inheritance of the 3sec resolution.

This problem was reported to ESA and it has been corrected in the latest release of Sen2Cor software.

CONCLUSIONS

All the pre-processing algorithms are being improved constantly by ESA. The biggest challenge for the multitemporal analysis is to deal with errors caused directly by the chain of pre-processing of raw Sentinel-2 data to the level L1C – misregistration of pixels. Another problem to overcome while aggregating a series of classifications is the incorrect clouds mask over artificial structures resulting from atmospheric correction performed with Sen2Cor software. Presented errors have direct influence on the overall accuracy of classifications performed in S2GLC project which are going to be implemented as a fully automatic process.

Project founded by ESA: ESRIN/AO/1-8216/15/I-SBo
"Scientific Exploitation of Operational Missions (SEOM) S2-4Sci Land and Water" Study 3: Classification